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G. A. ESPERSEN

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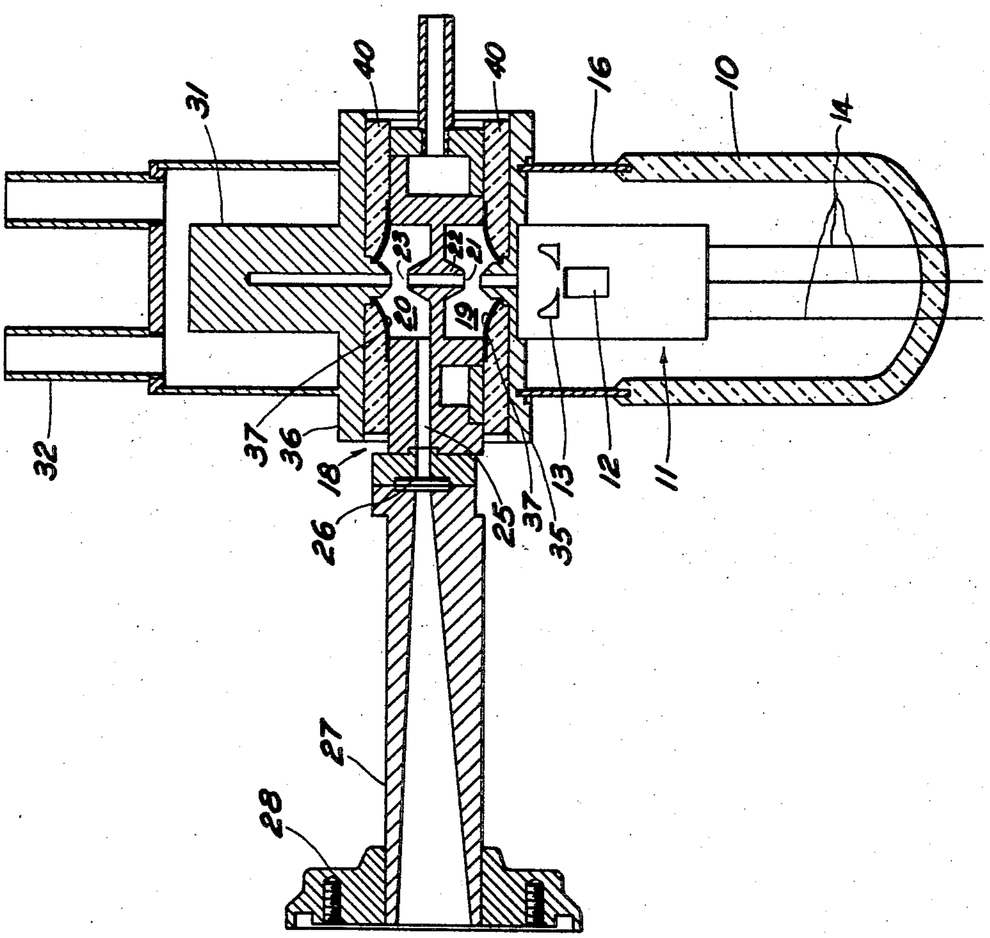

INVENTOR.
GEORGE A. ESPERSEN.
BY
Fred M. Vogel
AGENT.

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KLYSTRON TUBE

George Andrew Espersen, Dobbs Ferry, N. Y., assignor to North American Philips Company, Inc., New York, N. Y., a corporation of Delaware

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This invention relates to klystron discharge tubes, and, in particular, to klystron tubes employing flexible diaphragms as tuning or adjusting means.

Most klystron tubes employ a flexible diaphragm as part of the resonant cavity for adjusting the interaction gap and thus altering the resonant frequency of the cavity. One of the chief drawbacks of tubes of this type has been its excessive noise during normal operation. Extensive investigation of the source of the noise has led to the conclusion that microphonism is the chief offender, which can now be definitely attributed to the flexible diaphragms within the tube.

The chief object of the invention is to provide a klystron tube with flexible diaphragms in which practically all noise due to microphonism of the diaphragms has been eliminated.

In accordance with the invention, this object is attained by encasing or casting the diaphragms while the tube is operating in the desired mode and at the desired power condition in a non-shrinkable, hardenable material capable of wetting the material of the diaphragm and the surrounding portions of the tube and adhering firmly thereto upon solidification. This construction, it has been found, reduces the noise of the tube by several orders of magnitude; in some cases, the noise is reduced below the measuring ability of the measuring system. A suitable material for this purpose is a plastic resin of the epoxy group known under the trademark "Araldite."

The invention will now be described in connection with the accompanying drawing wherein the sole figure is a cross-sectional view of one form of klystron according to the invention.

Referring to the drawing, the klystron tube of the invention comprises a vacuum-tight envelope including a glass portion 10 enclosing an electron gun 11. The gun 11 contains the usual electron-emissive cathode 12 and focussing electrode 13. Terminals 14 for the gun 11 pass through the glass portion of the envelope 10 for connection to an external circuit.

By means of a Kovar ring 16, the glass member 10 is sealed to a copper anode system 18 incorporating a pair of resonant cavities 19, 20. The klystron illustrated in the drawing is of the two-cavity oscillator type in which oscillations present in the first or input cavity modulate an electron beam passing across an interaction gap 21 associated with the input cavity 19. Thereafter, the modulated beam passes along a drift tube 22 where is becomes velocity-modulated or bunched. The bunched beam traverses an interaction gap 23 associated with the second or output cavity 20 transferring energy thereto to produce oscillations therein. To maintain the oscillatory system, part of the energy in the output cavity is coupled by way of an aperture (not shown) in the dividing wall back to the first or input cavity. Energy may be abstracted from the output cavity by way of a wave guide transformer section 25, actually an aperture in the anode block communicating with the output cavity 20. The other end of the section 25 is sealed off by a radiation-transparent, vacuum-tight, mica window 26. The remainder of the transmission system includes a tapered section 27 having an end 28 adapted for coupling to a conventional wave guide of the correct dimensions. After the electron beam has traversed the output interaction gap 23, it is collected by a collector electrode 31 having the shape illustrated to facilitate cooling thereof by means of water or the like. The couplings for conveying the water to the collector are illustrated at 32.

In order to secure proper operation of such a klystron, the output cavity must be tuned to a frequency specifically correlated to the resonant frequency of the input cavity. To change the frequency of the oscillations produced, it is thus necessary to change the resonant frequency of both cavities. This is generally accomplished by adjusting the length of the input and output interaction gaps 21, 23. To that end, the rear and front walls 35, 36 of the anode system are mounted on flexible diaphragms 37 constituted of, for example, thin, resilient, copper-plated, Monel metal, which diaphragms also constitute part of the vacuum enclosure of the tube. By means of elaborate tuning mechanisms (not shown) the positions occupied by these walls may be altered, thereby altering the interaction gaps and the resonant frequency of the tube. However, when the correct resonant frequencies of the cavities have been obtained, a further displacement of the diaphragms is no longer necessary, unless a further change in frequency is desired.

The present invention is based on the discovery that most of the noise produced by the klystron may be attributed to microphonism of the flexible diaphragm structure. Hence, to eliminate that noise, when the diaphragm structure has been set at the desired position with the tube excited by suitable operating potentials, the diaphragm structure is then surrounded by a liquid, hardenable, non-shrinking material capable of wetting and adhering to the surfaces which is engages. Thereafter, the material is hardened, thereby bonding the flexible diaphragm to the surrounding rigid parts of the tube. This is illustrated in the drawing by reference numeral 40. The presence of the bonding material 40 permanently fixes the position of the diaphragms in the tube, and thus the length of the interaction gaps and the operating frequency and power output of the tube. The tube is therefore no longer tunable. However, for some applications, radar systems being one example thereof, a fixed frequency tube is quite suitable. Though some tuning, initially, is essential to achieve the desired operation, once that operation is obtained, the tuner construction is no longer necessary. Hence, it may be permanently encased in a hardened bonding material, and the tube will otherwise perform quite satisfactorily. In point of fact, aside from the advantage of less noise, it would have an additional advantage that further adjustments are no longer necessary for operation in the mode fixed by the bonding material. The application of potentials alone to the tube will automatically set it into oscillation at the correct frequency with the desired power output.

The bonding material 40 that may be utilized in the invention must satisfy a number of requirements. First, it must not shrink during hardening or the change from the liquid to the solid state. It must be remembered that the material is applied in liquid form to the tube while it is excited and is operating at precisely the desired frequency and power conditions. If the material shrank, or for that matter expanded, during the hardening process, the diaphragms might be displaced producing a change in operating conditions. Hence, non-shrinkability of the material is essential. Secondly, the material must be capable of wetting the diaphragms and the surrounding portions of the tube. This is essential because, unless these portions of the tube, which are usually of high conductive metal such as copper, are wetted by the material, no adherence will occur. Thus, the diaphragms will still be capable of vibration and noise. Finally, the material must be available in liquid state and be capable of being conveniently hardened. One such material, which performed most satisfactorily, is a bonding resin of the epoxy type known under the registered trade-mark of "Araldite." One such material is sold by the Ciba Company, Inc. as "Araldite AN-101," which is a cold setting adhesive, for bonding or joining non-absorbent matermials, which sets to a hard, strong, bonding resin at room temperature. In practicing the invention, while the tube was operating, the diaphragm structure was potted or encapsulated in the epoxy resin. Thereafter, while still operating, it was left at room temperature for about 3 hours, to thus permenently set the resin in a hardened condition. By comparison measurements with the same tube with a conventional tuner, it was found that the noise of a tube of the invention, measured as a R. M. S. frequency deviation, was reduced from about 5.3 kilocycles to 0.288 kilocycle, a tremendous reduction in the resultant noise.

It will be obvious that the invention is not limited to two-resonator klystrons as illustrated in the drawing, but may be used with any velocity-modulated tube employing a flexible diaphragm construction for changing the resonant frequency of a cavity. For example, the invention may also be used with reflex (single resonator) klystrons, and multi-resonator tubes having more than two cavities. It will be further observed that, in order to change the operating frequency, the bonding material may be removed, the diaphragms reset at the desired positions, and the latter once again encased in the bonding material.

While I have described my invention in connection with specific embodiments and applications, other modifications thereof will be readily apparent to those skilled in this art without departing from the spirit and scope of the invention as defined in the appended claims.

What is claimed is:

1. A method for fixing the operating frequency and reducing the noise of a klystron tube having flexible diaphragm means associated with its resonant cavity, which comprises the steps of applying operating potentials to said tube, adjusting the position of the diaphragm to secure the desired operation, thereafter casting the diaphragm in a non-shrinking, hardenable, liquid material capable of wetting the diaphragm and the adjacent portions of the tube, thereafter hardening the material to permanently set it while the operating potentials are still applied to the tube, and finally removing the operating potentials.

2. A method as set forth in claim 1 wherein a material is used capable of being hardened substantially at room temperature, and the hardening step is carried out substantially at room temperature.

3. A velocity-modulated electron discharge device comprising an enclosure defining a cavity, means to generate and inject a beam of electrons into said cavity, a metal diaphragm within said cavity for adjusting the resonant frequency of the same, and a non-shrinkable synthetic resin surrounding and securing said diaphragm to said enclosure.

4. A velocity-modulated electron discharge device as claimed in claim 3 in which the synthetic resin is an epoxy resin.

5. A velocity-modulated electron discharge device comprising an enclosure defining a pair of interconnected cavities, means to generate and inject a beam of electrons into one of said cavities, a metal diaphragm in each of said cavities for adjusting the resonant frequency of each cavity, and a non-shrinkable synthetic resin surrounding and securing said diaphragm to said enclosure.

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