July 15, 1958 R. C. HERGENROTHER 2,843,794

TUNING MEANS FOR REFLEX KLYSTRONS

Filed Oct. 14, 1954 2 Sheets-Sheet 1

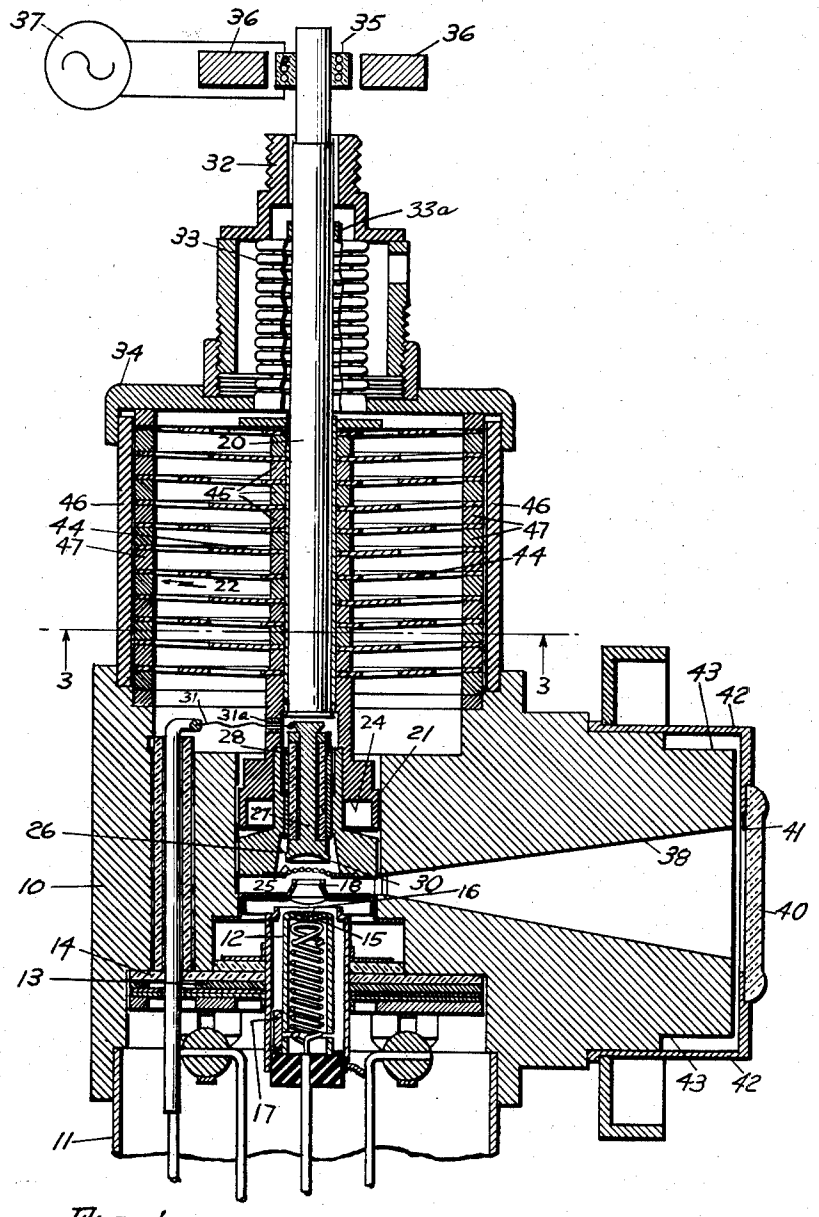



FIG. 1

INVENTOR
RUDOLF C. HERGENROTHER
BY Elmer J. Gorn
ATTORNEY

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2 Sheets-Sheet 2

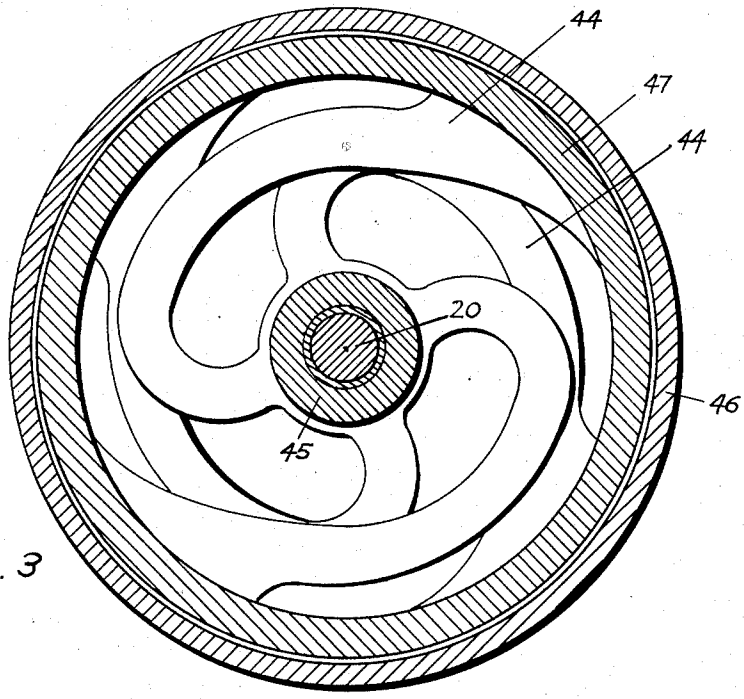



FIG. 3

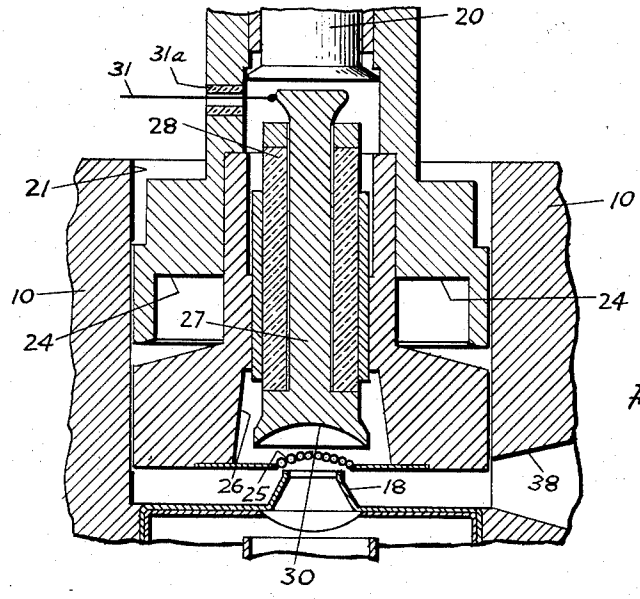



FIG. 2

INVENTOR
RUDOLF C. HERGENROTHER
BY Elmer J. Gorn
ATTORNEY

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2,843,794

# TUNING MEANS FOR REFLEX KLYSTRONS

Rudolf C. Hergenrother, West Newton, Mass., assignor to Raytheon Manufacturing Company, Waltham, Mass., a corporation of Delaware

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4 Claims. (Cl. 315—5.22)

This invention relates to rapid mechanical tuning structures for reflex klystrons.

In some applications of radio frequency local oscillators, such as in a search radar receiver, it is desirable to tune the oscillator over its entire usable frequency range in a short time interval. The conventional internal-cavity reflex klystron can be tuned over a relatively small part of its tuning range by means of its repeller voltage but a major change in frequency requires a change in the effective cavity size. This is accomplished by a mechanical tuning mechanism. Usually this tuning mechanism produces an elastic deformation of some component part of the cavity, and the tube is severely limited as to the speed of the tuning operation and the total number of tuning operations which can be performed before the elastic fatigue causes mechanical failure.

This invention provides a tuning mechanism for an internal-cavity reflex klystron that permits the tube to be operated for more than 100,000,000 tuning cycles at speeds as high as 60 complete sweeps of the entire tuning frequency range in one second. This is accomplished by the use of capacity tuning across an adjustable interaction-gap spacing. This gap spacing is made adjustable by forming the roof of the cavity as a non-contacting short-circuiting piston that carries the second interaction-gap grid and the repeller. The piston is sufficiently broad band to cover the required tuning range.

Other and further objects and advantages of the invention will be apparent as the description thereof progresses, reference being had to the accompanying drawings wherein:

Fig. 1 is a sectional view of a klystron constructed according to the invention;

Fig. 2 is an enlarged view of the tuning structure shown in Fig. 1; and

Fig. 3 is a section taken along the line 3—3 of Fig. 1.

In Fig. 1 the reference numeral **10** designates the anode block formed from a piece of conductive material such, as copper, to which is attached a base **11**, shown broken away, through which the different electrodes are connected to the outer circuit. A cathode sleeve **12** is mounted in a disc **13** that is insulatedly mounted on the anode block **10** by means of a dielectric disc **14**. The cathode is formed with an inwardly curved spherical surface **15** which carries the emissive coating **16**. A filament **17** is mounted within the cathode sleeve **12** to provide the necessary heat. The anode proper is in the form of a first grid **18** with the center portion bent upward away from the cathode **15**. A plunger **20** is mounted within an opening **21** in the anode block **10** and is supported by a spring assembly **22** in such a manner that it may be moved axially within the opening without touching the walls of the opening **21**. The lower end **24** of the plunger **20** is formed of two pieces so shaped as to provide a broad band non-contacting short circuit for the coaxial transmission line formed by the plunger **20**



and the anode block **10** that provides a short circuit at the operating frequency while keeping the plunger free to move relative to the anode block. The radio frequency short is provided to prevent leakage of the energy past the plunger. This non-contacting short circuit can best be designed as described in an article entitled "Broad band non-contacting short circuits for coaxial lines," by William H. Huggins in the Proceedings of the I. R. E. for September 1947, at page 906. A grid **25** is mounted across the bottom of an axial opening **26** in the plunger **20**. A repeller electrode **27** is mounted within the opening **26** and insulated from the plunger **20** by a dielectric sleeve **28**. The repeller electrode is preferably formed with a cup **30** at its lower end. The repeller is connected to a source of potential by means of a conductor **31** passing through an insulating bushing **31***a* in the plunger **20**.

The construction of the plunger **20** and the repeller **27** are best seen in Fig. 2. The manner in which the plunger **20** is mounted on the anode block **10** by means of the spring assembly **22** is best seen in Fig. 3. The plunger **20** is brought out to the outside through a bushing **32** and is attached to a sylphon bellows **33** by means of a collar **33***a*. The bellows is in turn attached to the cylindrical housing **34** of the spring assembly **22**. This housing is in turn attached to the anode block **10** by means of a series of vacuum tight seals formed in any of the well-known ways. The plunger **20** is driven axially by a coil **35** attached to its upper end and mounted in the field of a magnet **36**. The coil **35** is supplied with an alternating current at the desired modulating frequency which may conveniently be 60 cycles per second from a source **37**. The driving means shown is intended to operate like that of a loud speaker. However, any convenient means for producing a reciprocating axial motion of the plunger may be used. The output of the klystron oscillator is most conveniently obtained through a wedge-shaped opening **38** in the anode block **10** with the apex of the wedge-shaped opening **38** at the space between the grids **18** and **25**. This opening **38** is sealed hermetically by a glass window **40** in an iris **41** formed in a metallic cap **42**. A groove **43** is formed in the anode block **10** about the opening **38** and so dimensioned as to form a choke at the operating frequency of the oscillator so that a wave guide may be attached to the iris to transmit the oscillator output to other equipment where it may be used.

The spring assembly **22** shown in Fig. 3 is composed of a series of S-shaped springs **44** attached at their mid-portion to the plunger **20** by means of rings **45** and at their outer ends to a cylindrical shell **46** by means of rings **47**. This mounting structure is designed as an elastic system having a high compliance along the axis of the tube and a low compliance in the perpendicular direction. The elastic limit should, of course, exceed the expected displacement of the plunger which, in a representative case, is of the order of one thousandths of an inch. The resonant frequency of the structure should exceed the expected highest modulation rate. As the springs **44** form part of the heat conduction path from the second grid to the anode block, the total cross-sectional area of the springs should be as large as required to transmit the expected heat. However, the cross-sectional area of a single spring also affects the compliance of the spring. The two factors can be balanced to dissipate the required heat through a spring structure of the required compliance.

This invention is not limited to the particular details of construction, materials and processes described, as many equivalents will suggest themselves to those skilled

in the art. It is accordingly desired that the appended claims be given a broad interpretation commensurate with the scope of the invention within the art.

What is claimed is:

1. A mechanically tunable klystron oscillator comprising a cathode, an anode, first and second grids, a reflector, a plunger movably mounted in an opening in said anode, the inner end of said plunger being formed with a cavity opening to the outer surface of the plunger and so diminished as to form a non-contacting short across the opening in the anode, said reflector being insulatedly mounted on said plunger, said second grid being mounted on said plunger, and means for causing axial movement of said plunger so as to move the second grid with respect to the first grid to vary the operating frequency.

2. A mechanically tunable klystron oscillator comprising a cathode, and anode, first and second grids, a reflector, a plunger movably mounted in an opening in said anode, the inner end of said plunger being formed with a cavity opening to the outer surface of the plunger and so diminished as to form a non-contacting short across the opening in the anode, said reflector being insulatedly mounted on said plunger, said second grid being mounted on said plunger, and means for causing axial movement of said plunger so as to move the second grid with respect to the first grid to vary the operating frequency comprising a coil attached to said plunger and mounted within the field of a magnet and supplied with alternating curent.

3. A mechanically tunable klystron oscillator comprising a cathode, and anode, first and second grids, a reflector, a plunger movably mounted in an opening in said anode by means of at least one S-shaped spring, the inner end of said plunger being formed with a cavity opening to the outer surface of the plunger and so diminished as to form a non-contacting short across the opening in the anode, said reflector being insulatedly mounted on said plunger, said second grid being mounted on said plunger, and means for causing axial movement of said plunger so as to move the second grid with respect to the first grid to vary the operating frequency.



4. A mechanically tunable klystron oscillator comprising a cathode, an anode, first and second grids, a reflector, a plunger movably mounted in an opening in said anode by means of at least one S-shaped spring, the inner end of said plunger being constructed to form a non-contacting short with said opening, said reflector being insulatedly mounted on said plunger, said second grid being mounted on said plunger, and means for causing axial movement of said plunger so as to move the second grid with respect to the first grid to vary the operating frequency comprising a coil attached to said plunger and mounted within the field of a magnet and supplied with alternating current.

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