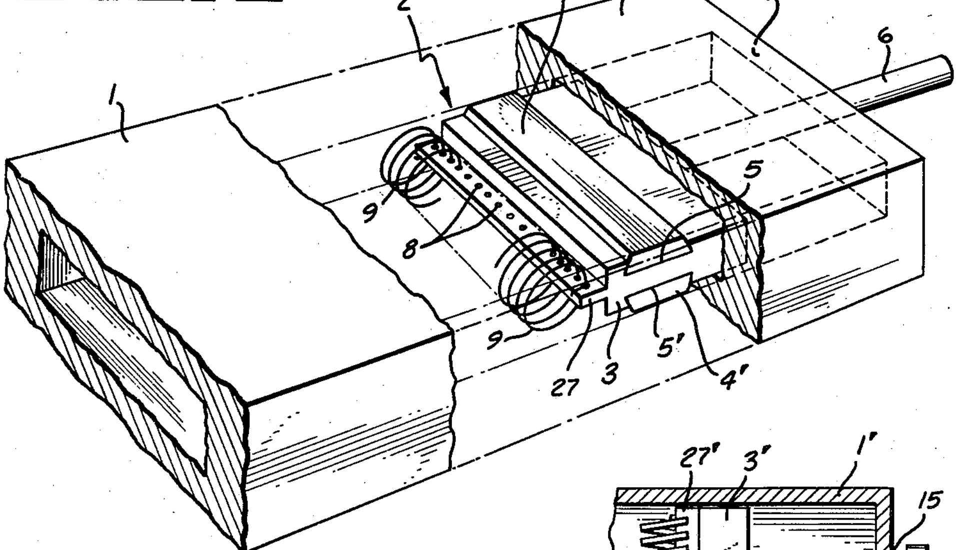
April 1, 1958 S. R. HENNIES ET AL 2,829,352

TUNABLE WAVEGUIDE SHORT

Filed Dec. 24, 1953

FIG_1



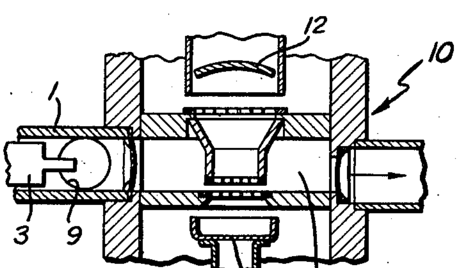


FIG_2

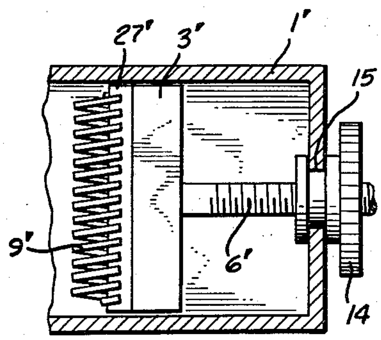


FIG_3

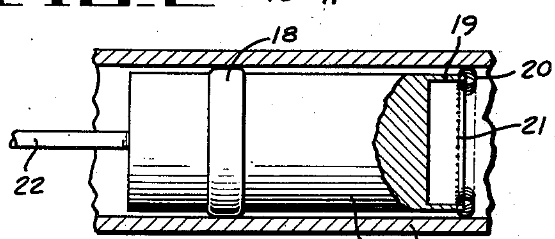


FIG_4

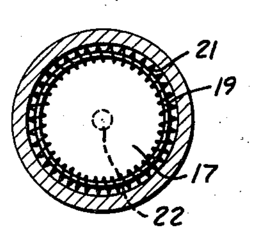


FIG_5

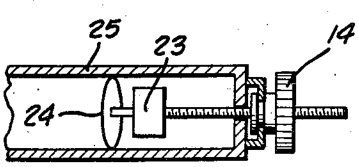


FIG_6

INVENTORS
STUART R. HENNIES &
JACK A. BROWN
BY Paul B. Hunter
ATTORNEY

United States Patent Office 2,829,352
Patented Apr. 1, 1958

2,829,352

TUNABLE WAVEGUIDE SHORT

Stuart R. Hennies and Jack A. Brown, Palo Alto, Calif., assignors to Varian Associates, San Carlos, Calif., a corporation of California

Application December 24, 1953, Serial No. 400,308
5 Claims. (Cl. 333—98)

This invention relates generally to adjustable means for shorting waveguides and the invention has reference, more particularly, to a novel tunable waveguide short suitable for tuning connected resonant circuits such as the resonant cavities of klystron tubes.

Heretofore it has been common to employ movable plungers with spring fingers engaging in the walls of a waveguide for effecting the short circuit of the guide at any desired point. While this type of short circuit is suitable for the larger sizes of waveguide, it is not suited for smaller guides because it is extremely difficult to build such shorting units in small sizes at reasonable expense. Also, this common type of short has not been entirely satisfactory in use because the spring fingers in time lose their resiliency and fail to make good contact with the walls of the guide and hence the efficiency of such shorts deteriorates with time.

One object of the present invention is to provide a novel tunable waveguide short that is of relatively inexpensive construction and especially suitable for the adjustable shorting small sizes of waveguide, the said novel short employing spring contact means that will not deteriorate with time.

Another object of the present invention is to provide a novel tunable waveguide short comprising essentially a coiled spring carried by a movable plunger, said spring being so disposed within the guide that opposite loops thereof engage opposite walls of the waveguide, the spring being preferably under slight compression so that a firm and permanent contact is made both at the upper and lower walls of the guide.

Another object of the present invention is to provide a tunable waveguide short that is especially suited for tuning cavity resonators such as those employed in klystron tubes thereby varying the output frequency of the tube.

Other objects and advantages of this invention will become apparent from the specification, taken in connection with the accompanying drawings wherein the invention is embodied in concrete form.

In the drawings,

Fig. 1 is a perspective view with parts broken away showing the novel tunable waveguide short of this invention mounted in a waveguide,

Fig. 2 is a fragmentary section view illustrating the short employed in connection with tuning a reflex klystron,

Fig. 3 is a plan view with parts broken away showing a slightly modified construction of short,

Fig. 4 illustrates a further modified construction of short especially adapted for circular waveguides,

Fig. 5 is an end view of the construction shown in Fig. 4, and

Fig. 6 illustrates another modification.

Similar characters of reference are used in the above figures to designate corresponding parts.

Referring now to Fig. 1 of the drawings, there is

shown a waveguide **1** of rectangular cross-section within which is contained a novel tunable waveguide short **2** of this invention. This short comprises essentially a transversely extending piston member **3** of rectangular cross-section and somewhat smaller in dimensions than the inner dimensions of the waveguide **1**. The piston **3**, which is of a conducting material such as copper or brass, is shown provided with upper and lower transversely extending bearing members **4** and **4'** made of insulating material such as Teflon or polystyrene. These bearings are set into and retained within recesses **5** and **5'** provided in the upper and lower surfaces of the piston **3**. An adjusting rod **6** extends longitudinally of the guide **1** through the end wall **7** thereof and is attached to the piston **3** as by being threaded thereinto. By moving the rod **6** longitudinally the connected piston **3** is moved within the guide **1**, the bearing members **4** and **4'** serving to position the piston **3** accurately within the guide without the metallic portions of the piston actually touching the guide.

The piston **3** is provided with a forward central lip extension **27** substantially midway of the height thereof which lip is provided with a series of mutually spaced apertures **8** arranged in a transverse line. A coil spring **9** of conducting material is threaded through the apertures **8** and is of such dimensions as to press both against the upper and lower inner walls of the guide **1** thereby making good electrical contact with these walls of the guide. Owing to the elasticity of the material of spring **9** and to the fact that the loops of the spring extend completely across the interior of the guide the upper and lower portions of these loops bear firmly against the walls of the guide and do not lose this resilient bearing pressure regardless of the age of the short which is not true of those types of shorts employing spring fingers since such spring fingers act as cantilevers and lose their resiliency with age. It will be noted that since the loops of the spring **9** extend substantially parallel to the electric vectors of the field within the guide when the guide is excited in its dominant mode this spring acts as a very effective short circuit. By merely moving the rod **6** manually the point of short circuit within the guide can be varied longitudinally thereof.

If desired, the distance between the points of contact of the spring with the upper and lower walls of the guide to the forward edge of the bearings **4** and **4'** may be made substantially equal to a quarter wave length of the operating frequency of the guide in which case the bearings **4** and **4'** can be made substantially a quarter wave length in width and similarly the portion of the plunger of the piston **3** to the rear of the bearings **4** and **4'** can be made substantially a quarter wave length long thereby forming a low pass filter having three sections serving to prevent any outward escape of energy beyond the piston which might tend to set up undesired reflections. In some instances, however, the use of a low pass filter is unnecessary inasmuch as the spring **9** provides a very effective short circuit.

Fig. 2 shows such a tunable short employed for tuning the cavity of a klystron **10** of the reflex type, the said waveguide **1** being coupled into the side of the resonator **11** of this tube, the beam of the tube passing from cathode **13** through the resonator toward reflector **12** from whence it is reflected back to the resonator in a manner well known to those skilled in the art. By moving the plunger piston **3** the position of the short circuit within the guide **1** is varied thereby varying the frequency of operation of the tube **10** by virtue of changing the effective dimensions of the resonator cavity **11**. Owing to the use of the simple spring **9** the short of the present invention can be made in very small sizes to accommodate the small waveguides coupled to ultrahigh frequency tubes, although the short can also be used for larger size waveguides.

In Fig. 3 the piston **3'** is shown of rather narrow width and is not provided with any bearing support whatsoever. In this case the spring **9'** is shown in the form of a metallic ribbon which affords even better contact with the upper and lower walls of the guide than that provided with the round wire spring **9**. In Fig. 3 the spring **9'** serves as a bearing support for the piston **3'** and preferably the loops of the spring **9'** are fixed within the apertures provided on the lip extension **27'**. A tuning nut **14** is shown threaded upon the rod **6'** connected to piston **3'**. The tuning nut **14** has a reduced portion **15** engaging the end of the guide **1'** so that by turning the nut **14** the rod **6'** and hence the piston **3'** can be adjusted longitudinally within the guide **1'**.

In Figs. 4 and 5 the invention is shown applied for use in a circular type of waveguide. In these figures the circular guide **16** is adapted to receive the piston **17** of cylindrical shape which piston is shown provided with an insulating annular bearing **18** for engaging the inner surface of the guide **16**. The piston **17** is provided with a forwardly extending annular lip **19** provided circumferentially with a number of apertures **21** through which a coil spring **20** is threaded, the said spring being adapted to engage the inner wall of the waveguide. If desired, the spring **20** may have its successive loops fixed firmly within the apertures **21** thereby obtaining an even better contact pressure against the inner walls of the guide. Longitudinal movement of the rod **22** serves to vary the position of the short within the guide.

In the form of the structure shown in Fig. 6 the coil is shown in the form of a flat ribbon **24** of substantially oval shape and the piston **23** carrying this ribbon is shown as of relatively narrow cross-section. The use of the flattened spring **24** provides a very definite short circuit and at the same time use of the ribbon instead of round wire provides a better contact with the inner walls of the guide **25**.

In all forms of the invention the coil spring structure provides a firm contact with the walls of the waveguide which is permanent in nature and will not yield as time goes on. Also as above pointed out, since the loops of the coil are substantially parallel to the electric vector of the propagated energy an effective short circuit is provided.

Since many changes could be made in the above construction of the novel tunable waveguide short of this invention and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. A tunable waveguide short comprising a conducting waveguide, a piston member movable longitudinally within the waveguide, said piston member having a cross-sectional area slightly less than that of the cross-sectional area within the waveguide, a forwardly projecting lip on the forward end of said piston having a series of apertures therein, a coil spring of conducting material mounted on the lip, the loops of said coil passing through the apertures and engaging the walls of the waveguide to provide an effective short for electromagnetic energy therein, and non-conducting bearing means embedded in said piston member and engaging the inner walls of the waveguide, said bearing means serving as a sliding contact between said piston member and the inner walls of the waveguide.

2. A waveguide short as claimed in claim 1 wherein said piston member, bearings, lip and coil spring are positioned longitudinally along said waveguide such that the distance between the contacting surface of said coil and the forward edge of said bearing, the distance between the forward edge of said bearing and the rear edge of said bearing, and the distance between the rear edge of said bearing and the rear edge of the piston member are all substantially equal to a quarter wavelength of the operating frequency of the guide such that a three section low pass filter is formed behind the short.

3. A tunable waveguide short as claimed in claim 1 wherein said coil spring is of ribbon cross-sectional configuration.

4. A tunable waveguide short comprising a rectangular conducting waveguide, a rectangular piston member movable longitudinally within the waveguide, said piston member having a cross-sectional area slightly less than that of the cross-sectional area within the waveguide, a forwardly projecting lip on the forward end of said piston having a series of apertures therein, said lip extending along the widest direction of the forward surface of the rectangular piston member, a coil spring of conducting material mounted on the lip, the loops of said coil passing through the apertures and engaging the walls of the waveguide to provide an effective short for electromagnetic energy therein, and non-conducting bearings embedded in at least two walls of said piston member and engaging the inner walls of the waveguide, said bearings serving as sliding contacts between said piston member and the inner walls of the waveguide.

5. In combination, a klystron including a reentrant cavity resonator having a wave energy permeable opening therein and a tunable waveguide short comprising a conducting waveguide coupled to the cavity resonator at said opening, a piston member movable longitudinally within the waveguide, said piston member having a cross-sectional area slightly less than that of the cross-sectional area within the waveguide, a forwardly projecting lip on the forward end of said piston having a series of apertures therein, a coil spring of conducting material mounted on the lip, the loops of said coil passing through the apertures and engaging the walls of the waveguide to provide an effective short for electromagnetic energy therein, and non-conducting bearing means embedded in said piston member and engaging the inner walls of the waveguide, said bearing means serving as a sliding contact between said piston member and the inner walls of the waveguide.

References Cited in the file of this patent

UNITED STATES PATENTS

2,327,941	Tauber	Aug. 24, 1943
2,379,047	Thomas	June 26, 1945
2,429,811	Guarrera	Oct. 28, 1947
2,716,222	Smullin	Aug. 23, 1955

FOREIGN PATENTS

586,122	Great Britain	Mar. 7, 1947