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TRAVELING WAVE THERMIONIC TUBE

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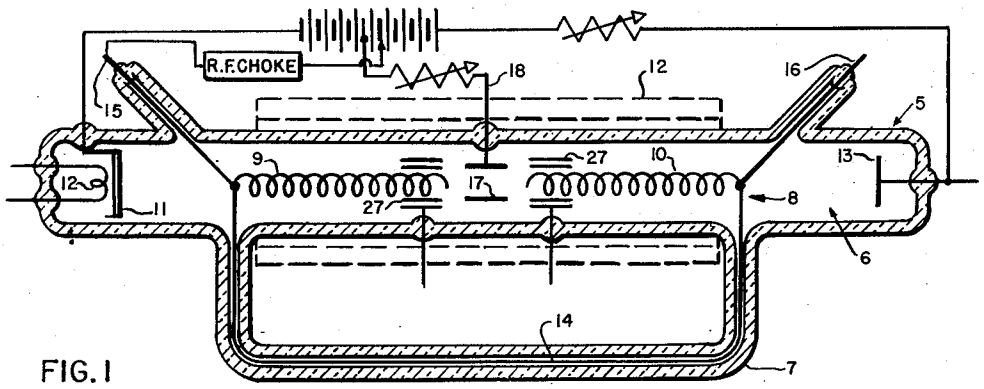

FIG. 1

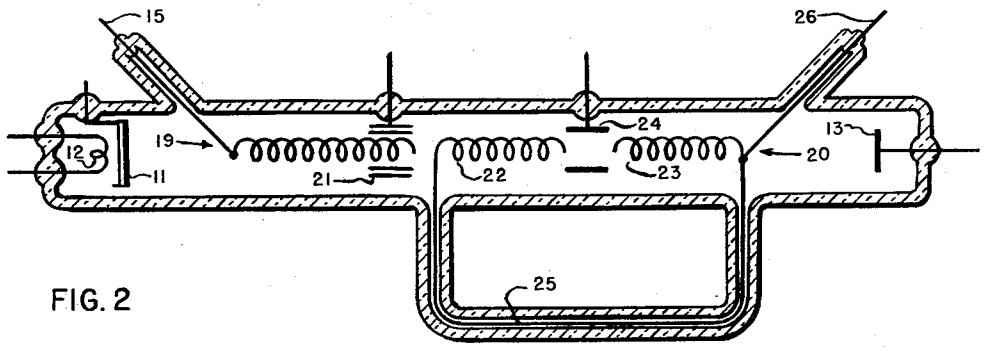

FIG. 2

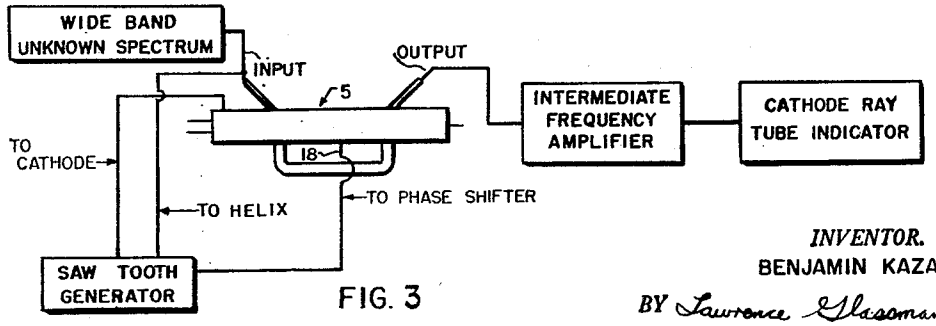

FIG. 3

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TRAVELING WAVE THERMIONIC TUBE

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2 Claims. (Cl. 315—3.6)

(Granted under Title 35, U. S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government for governmental purposes without the payment of any royalty thereon.

This invention relates to apparatus for analyzing a band of frequencies and is particularly adapted to analysis of a selected relatively broad band in the high frequency spectrum.

The invention provides a very simple and efficient device which possesses wide flexibility in permitting the analysis of a broad section of the spectrum at one time which is of great advantage in reducing the complexity of apparatus and in addition the invention provides for the scanning of the band electronically with great speed.

Heretofore, to analyze wide bands of frequencies it has been necessary to employ tuned cavities or resonant circuits which required cumbersome mechanical means to shift frequencies during the scanning process.

The invention overcomes the limitations of prior devices by utilizing the great versatility of the traveling wave tube to accomplish the desired result. The tube is constructed in such a manner that its operating frequency can be shifted electronically over a relatively wide band.

With a band of known frequencies as a reference standard the band to be analyzed is heterodyned therewith to produce an intermediate frequency which is changing with time and in accordance with the input signal including the band to be analyzed.

The I. F. frequencies are then applied to a cathode ray tube for observation or they are measured and/or observed in any desired manner.

It is apparent that the invention provides a very efficient and rapid means for analyzing a band of frequencies.

A further object of the invention is to provide an apparatus capable of analyzing a relatively wide band of frequencies.

A still further object of the invention is to provide a spectrum analyzing apparatus in which a broad unknown band of frequencies may be electronically scanned.

A further object of the invention is to provide an apparatus in which an observing frequency may be selected which is particularly suitable to observing a given characteristic or characteristics in the unknown band.

A further object of the invention is to provide spectrum analyzing apparatus in which unwanted feedback from the apparatus to the input device is reduced to a minimum.

Other objects and features of the invention will appear more fully from the following specification in connection with the accompanying drawing in which:

Fig. 1 is a diagrammatic illustration of a preferred embodiment of the invention.

Fig. 2 is a diagrammatic representation of a modified form of the invention and Fig. 3 illustrates a specific use of the invention.

The invention desirably assumes the general form of a traveling wave tube but may be constructed in any manner which will embody the principles of the invention as herein set forth.

Referring to the specific device shown in Fig. 1, the elements thereof are inclosed in an evacuated envelope 5 having a main elongated chamber 6 and a tubular loop section 7 communicating therewith. The chamber 6 has a helix 8 of conducting material which desirably is divided into two sections 9 and 10. Also within the chamber 6 is an electron gun including a cathode 11 of conventional form having a suitable heater 12 and a collector electrode 13. The cathode and collector are so aligned that the electron beam which is produced thereby will traverse the helix 8. A suitable source of power is supplied to the electron gun.

The ends of the helix 8 are connected to a feedback loop 14 situated within the section 7 of the envelope and the outer ends of the helix are provided with an input terminal 15 and an output terminal 16.

The inner ends of each of the helix sections are spaced apart and a phase shifter 17 is placed therebetween. The phase shifter desirably is in the form of a hollow cylinder having a terminal 18 extending outside the envelope. Power dissipating means 27 may also be provided at the inner ends of the helixes 9 and 10 to suppress reflections at those points.

It may be desirable under certain operating conditions to provide a magnetic field generator 12 shown in dotted lines surrounding chamber 6 and which is supplied with a suitable source of power to support the action of the tube.

It should be pointed out that certain basic conditions must be fulfilled to cause the tube to function. Namely, the helix must be designed to be dispersive; that the frequency at which radio frequency amplification takes place is controlled by the voltage applied between the cathode and the helix and that the oscillating condition is satisfied for a given cathode voltage by adjusting the voltage on the phase shifter 17 so that the transit time of the radio frequency wave from the beginning of the helix 9, through the phase shifter 17, through helix 10 and through the feed back line 14, is an integral number of cycles of the radio frequency of oscillation.

In operation power is supplied to the electron gun which acts in conjunction with the helix 8 to generate radio frequency power at its output terminal 16. Some of this power is in turn fed back to the input of the helix 15 by the loop 14. When the circuit elements are properly coordinated as above pointed out the feedback will act to sustain oscillations in the well known manner.

The invention provides means for shifting the output frequency of the device electronically. The space between the inner ends of the helix sections 9 and 10 constitutes a transit time space into which the phase shifter 17 is introduced. A variable potential source is connected to the phase shifter which in turn provides an efficient and extremely flexible means for varying the transit time of electron travel throughout the helix.

It should be noted at this time that in a traveling wave tube the frequency at which it functions depends directly upon the voltage applied between its cathode and the helix and for each voltage applied there is a corresponding output frequency.

In the present invention, therefore, to change the output frequency of the device the potential between cathode and helix is shifted to establish the required operating frequency and the phase shifter potential is shifted to establish the in phase relationship of the helix wave and its feed back component, as above set forth. The tube will then operate at the new frequency.

If now the shift of voltage upon the cathode is synchronized with the shift in voltage upon the element 17 relatively wide range of frequencies may be obtained

from the output **16** and moreover this shift may be obtained rapidly electronically.

This facility of the apparatus is used to scan a wide band of frequencies which it is desired to analyze. The band is fed to the input **15** where it heterodynes with the oscillation frequency to produce an intermediate frequency. This intermediate frequency may now be deployed by swinging the oscillation frequency through a range sufficient to embrace the input frequency band. Thus the characteristics of the spectrum will be reproduced by the I. F. output in the time sequence set up by the scanning means.

The apparatus of the invention is desirably used in connection with certain auxiliary apparatus such as that shown in the block diagram in Fig. 3 wherein the phase shifter **17** and the cathode **11** are connected to a voltage shifting device such as a conventional saw tooth generator. Thus the frequency delivered by the tube output is varied automatically according to a known pattern involving time sequence.

The output at the terminal **16** or the collector **13** is then fed to an intermediate frequency amplifier having a relatively narrow band pass characteristic and a known center frequency. The output of the intermediate frequency amplifier will indicate a signal corresponding to a segment of the band of incoming signals. The particular band of radio frequency signals indicated in the intermediate frequency will be determined by the instantaneous oscillating frequency of the traveling wave device as well as the intermediate frequency amplifier center frequency and band width. This output signal may then be fed to the control grid of a cathode ray tube which will indicate and trace a wave form graphically showing all the frequencies of the input signal band. In other words, as the traveling wave oscillator frequency is electronically modulated as a function of time, the intermediate frequency output will indicate in the same time sequence a signal corresponding to the various portions of the radio frequency input signal.

By synchronizing the horizontal deflection position of the spot on the cathode ray tube with the frequency of repetition of the saw tooth generator and applying the output of the intermediate frequency amplifier to the vertical deflection plate of the cathode ray tube a picture of the spectrum of the radio frequency of the incoming signal will appear on the face of the tube. Other means than the saw tooth generator may be used to modulate the oscillation frequency.

A modification of the invention is shown in Fig. 2 wherein the helix is divided into an input section **19** and an output section **20**. The input section **19** in this form of the invention is composed of two portions, a first portion having its outer end connected to an input terminal **15** and desirably having an absorption type termination **21** at its inner end. This first portion is loosely coupled to the other portion **22**.

The output section **20** is spaced apart from the input and has a phase shifter **24** positioned therebetween in the same manner as that described in connection with Fig. 1. The outer ends of the sections **22** and **23** are connected by a loop **25**. The section **23** is provided with an output terminal **26** and the tube is supplied with a beam of electrons by an electron gun composed of the cathode **11** and a collector **13** which direct the electron beam along the various helix sections.

The tube is supplied with the necessary sources of power not shown and functions in a similar manner to the device shown in Fig. 1. In the modified device, however, the oscillation frequency in the helix section **20** is largely prevented from feeding power back into the section **19** and thence to the input apparatus by reason of the loosely coupled relationship between input and output.

What is claimed is:

1. A thermionic discharge tube comprising an exhausted envelope for containing its elements, a high frequency wave slowing system consisting of an input section and an output section axially aligned and physically separated to create a drift space therebetween, said input section being physically divided into a first and second portion, said first portion having its outer end extended to the outside for connection to an input device and its second portion extending to said drift space and having a feedback connection from its outer end to the outer end of said output section, an electron gun positioned to project a beam of electrons along said wave slowing system, an electrically charged electrode in said drift space in position to control the velocity of said electron beam and an output connection.

2. A thermionic discharge tube according to claim 1 together with an absorption termination at the inner end of the first portion of the said input section.

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