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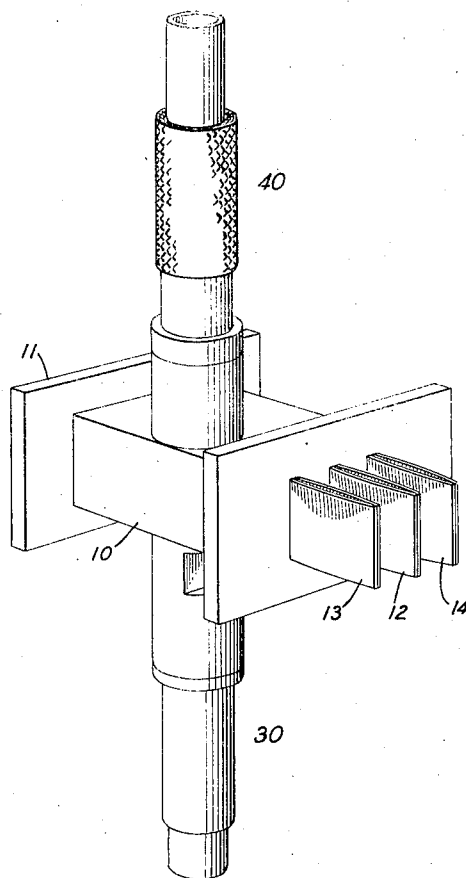
2,438,521

CRYSTAL FREQUENCY CONVERTER

Filed Feb. 15, 1945

2 Sheets-Sheet 1

FIG. 1



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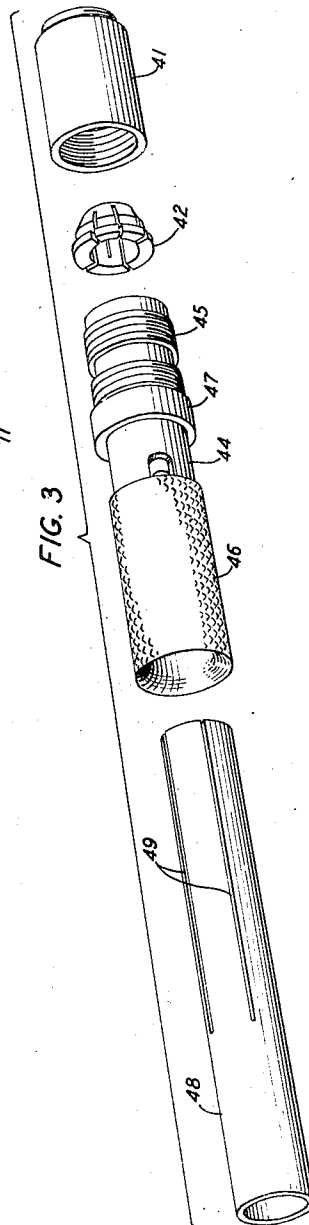
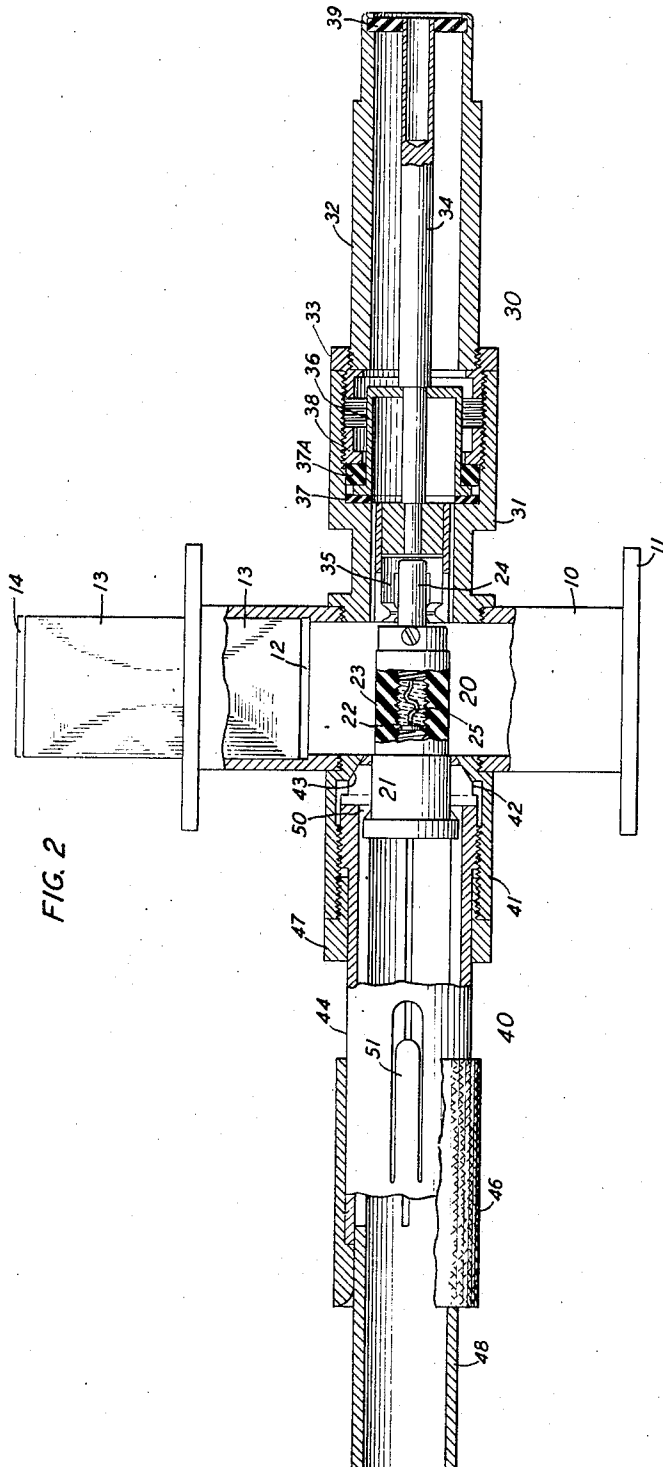
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CRYSTAL FREQUENCY CONVERTER

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5 Claims. (Cl. 250—31)

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This invention relates to ultra-high frequency systems and particularly to modulators therefor such as first detectors or frequency converters in multiple detection radio receivers.

Many characteristics of the crystal type rectifying device have made its use very desirable in the microwave range, for example, at wavelengths ten centimeters and shorter. In my co-pending application Serial No. 483,607, filed April 19, 1943, now Patent No. 2,436,830, dated March 2, 1948, there are disclosed various technics for the efficient and effective use of this type of rectifier in this frequency range. One feature of converter design brought out in that application is the design and adjustment of the tuned input line to provide such a control of the relative amplitudes and phasing of the fundamental and harmonic components of the input wave as to give an optimum relation between signal and noise output. In the specific structure shown in that application this tuned input line is of the coaxial type. For signals in the shorter wavelength portion of the range it is often more desirable to employ a wave guide rather than a coaxial line. While the same general design principles are applicable in such cases quite different methods of applying the principles are dictated by the structural differences.

An object of the invention is to provide the proper control of the phase of the fundamental and harmonic components in a wave guide input to a frequency converter.

Another object of the invention is to provide separate adjustable controls of the fundamental and harmonic terminations of a tuned wave guide.

In addition to the problems arising directly from the electrical aspects of the converter design and operation there are certain aspects where the factors of mechanical design assume considerable proportions. One such problem is that of overcoming the difficulty of removing and changing crystals. Because of the frequencies involved, the dimensions of the crystal and its associated contact point must be kept very small. While some of the difficulties arising from this fact have been overcome by permanently mounting the crystal in a cartridge, the same factors that limited the size of the crystal also impose limits on the cartridge size. This fact as well as the susceptibility of the crystals to damage by mechanical shock create a considerable problem in the mounting of the crystal so that when in place it will be firmly held with good electrical reproducible contacts and still be suscep-

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tible of being readily removed so that it may be replaced in case of failure.

Another object of the present invention is to provide a mounting for the crystal unit of ultra-high frequency radio equipment that will permit the ready removal and replacement of crystal units.

In accordance with a specific preferred embodiment of the present invention in a first detector or converter unit for an ultra-high frequency radio receiver there is provided a signal input system of the wave guide type with a crystal rectifier unit mounted across the guide which is terminated to permit adjustment of the relative phase of the fundamental and harmonic components of the signal input. This termination is provided by the use of a number of adjustable septa. One of these septa is so located as to divide the wave guide into sections of such cross-section that the cut-off frequency of each is such that the fundamental frequency of the signal wave will not be transmitted. In so far as the fundamental component is concerned such a septum has the same effect as a piston terminating the wave guide at substantially the position of the end of the septum. For the termination of the wave guide for the harmonic components there are provided other septa dividing the wave guide sections formed by the first septum into further compartments of such cross-section as to have a cut-off such that selected harmonics are not transmitted. By adjusting the individual septa the guide can be given different terminations for different component frequencies of the signal wave thus permitting such a proportioning of the phases of the fundamental and harmonics as will result in an optimum signal-to-noise ratio in the converter output.

The crystal cartridge is mounted through the wave guide. For this purpose a jack is provided in one wall of the guide and insulated therefrom terminating the high frequency circuit by a trap or filter and forming the intermediate frequency output circuit. The small end of the cartridge terminating the crystal contact point plugs into this jack. The other terminal of the crystal cartridge is held by a screw operated chuck mounted in the opposite wall of the guide. In order to facilitate the insertion and removal of the crystal cartridge there is provided an elongated handle member with a spring chuck at the end which engages the base of the cartridge at a position removed from the point at which it is held in the screw-operated chuck.

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These as well as other objects, features and aspects of the invention may be better understood by reference to the following detailed description in connection with the drawing in which:

Fig. 1 is a perspective view of a crystal converter embodying the invention;

Fig. 2 is a cross-sectional view of the converter of Fig. 1 on an enlarged scale; and

Fig. 3 is an exploded view of the crystal holder 10 of the converter of Figs. 1 and 2.

The converter comprises a main body in the form of a wave guide section 10. A flange 11 is provided for connecting to the wave guide system (not shown) of the receiver through which the signal and beating oscillations are introduced into the converter.

The wave guide 10 is terminated by means of the septa 12, 13 and 14 extending into the rear end and parallel to the short walls of the guide. These septa are arranged to make good contact with the bottom and top of the guide. For this purpose each septum is formed of two curved strips of resilient material mounted back to back with their edges riding in milled grooves in the walls of the guide, as shown. The effect of the septum 12 is to divide the guide into two sections of such dimensions that the cut-off frequency of each section is above the fundamental frequency of the input signal wave. This septum therefore acts to terminate the guide for this fundamental frequency in much the same way as if the guide were terminated by a short-circuiting piston at a point near the inner edge of the septum. The two smaller wave guide sections on each side of the septum 12 have such dimensions that harmonics of the signal wave may be transmitted therethrough.

The septa 13 and 14 serve to divide the two wave guide sections formed by the septum 12 and to terminate those sections for higher frequencies in the same way that the septum 12 terminated the main wave guide for the fundamental signal frequency. Since all of the septa 12, 13 and 14 are individually adjustable it is possible not only to adjust the effective length of the wave guide for the fundamental frequency but also independently for harmonic frequencies. Thus by the adjustments of the secondary septa 13 and 14 the phase of the reflected harmonics may be varied.

While three septa equally spaced across the guide are shown here it should be understood that a different number of septa with other spacings may be employed depending upon the design factors in any particular case.

The crystal element is mounted through the wave guide at an appropriate point. It has been found that the positioning of the crystal side-wise in the wave guide controlled the effective conductive loading to the guide of the crystal. The most effective position for any particular construction may be determined by experiment. As shown in Fig. 1 it will usually be found to be somewhere off the center of the guide. For convenience in handling and replacement the crystal 22 is permanently mounted in a cartridge 20. This comprises a base member 21 to which the crystal 22 is attached, an insulating sleeve 23 and a tip member 24 to which the crystal contact 25 is attached. Mechanical support for the cartridge 20 as well as electrical connections to the crystal are provided by the intermediate frequency output coaxial line 30 and the crystal holder 40.

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The intermediate frequency output coaxial line 30 comprising an outer sleeve 31 which has a threaded shoulder portion at one end that screws into a threaded hole in the wall of the wave guide 10 forming a flush surface with the inner surface of the wave guide wall. The main outer conductor is secured to the other end of the outer sleeve 31 by means of the threaded locking ring 33. The inner conductor 34 is provided on one end with a spring contact jack 35 which receives the tip 24 of the crystal cartridge. At an intermediate point on the inner conductor 34 a skirt 36 is secured thereto. The open end of the skirt 36 is flanged. This permits the inner conductor to be mounted within the sleeve 31 by being clamped between the washers 37 and 37A against a shoulder on the inner surface of the sleeve 31 by means of the locking ring 38. The outer end of the conductor 34 is supported by an insulator 39 spun into the end of the outer conductor 32. A hole in the outer end of the inner conductor 34 and a shoulder in the outer conductor 32 permit the attachment of a section of flexible coaxial line (not shown) leading to the intermediate frequency amplifier.

The length of the skirt 36 is substantially one-quarter wavelength at the frequency of the signal wave so that it forms a trap or filter for the signal currents preventing their transmission through the line 30 while permitting the transmission of currents of the intermediate frequency as is understood in the art. The length of the jaw detail is also a quarter wavelength so the complete assembly is effectively a double-quarter wavelength trap, giving a low impedance or short-circuit for the high frequency at the wave guide surface.

The crystal holder 40 is shown not only in the sectional view of Fig. 2 but also in the exploded view of Fig. 3. An outer sleeve 41 has a threaded shoulder at one end which screws into a hole in the outer wall of the wave guide 10 diametrically opposite to the hole into which the sleeve 31 is threaded. A slotted chuck 42 is carried inside the sleeve 41 bearing against the taper seat 43 into which the chuck 42 may be clamped. A tubular member 44 is provided near its inner end with an enlarged threaded portion 45 that screws into the internally threaded outer end of the sleeve 41. A knurled tube 46 press-fitted over the opposite end of the member 44 provides a grip by which the member 44 can be screwed into the sleeve 41 to press the chuck 42 into the seat 43 clamping the crystal cartridge or loosened to free the cartridge. A locking ring 47 threaded into the end of the sleeve 41 limits the movement of the member 44 preventing its removal.

There is also provided a handle 48 for inserting and removing the crystal cartridge. This handle is provided with a plurality of slots or saw cuts 49 and its inner end is shaped to provide a gripping jaw 50. In the process of installing a crystal cartridge the handle 48 is removed from the assembly and the end of the cartridge inserted in the jaw 50. The handle 48 is then manipulated to insert the cartridge through the tube 44 until its tip 24 is engaged in the jack 35. The tube 44 is then screwed in forcing the chuck 42 against the seat 43 so that the head 21 of the cartridge is gripped by the chuck 42 establishing a firm mounting for the cartridge and good reproducible electrical connection to the crystal. A spring tongue 51 in the wall of the tube 44 prevents a rattling movement of the handle 48.

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It is to be understood that the present invention is not limited to the particular design shown here for the purpose of illustration and is capable of various modifications. In particular, the crystal holder is not limited in its application to a guide with the septa termination but may be used with the usual solid termination of the wave guide. Also if it is desired to eliminate the harmonics or to reduce their amplitude instead of reflecting them back into the guide, the metallic septa may be replaced by septa composed wholly or partly of resistance material.

What is claimed is:

1. A crystal converter comprising a rectangular wave guide, a plurality of septa extending into one end of said guide parallel to the narrow wall thereof, a cylindrical crystal cartridge having a tip end of reduced diameter, a spring jack mounted in one wall of said guide, a sleeve member mounted in the opposite wall thereof and having a taper chuck set in its inner end and being internally threaded, a spring chuck mounted in said seat, a threaded clamping tube carried by the internal threaded portion of said sleeve for clamping said chuck in said seat, and a handle member fitting within said clamping tube and provided with a spring jaw at one end for gripping the large end of said cartridge so that said cartridge may be inserted through said chuck so that said tip end engages said spring jack.

2. In combination, a wave guide, a translating device associated with said wave guide, and

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a reflecting termination for said wave guide comprising a plurality of septa extending longitudinally into said guide and separately adjustable in their longitudinal positions.

3. In combination, a rectangular wave guide, a translating device associated therewith, and a plurality of septa mounted parallel to the short dimension of said guide and extending longitudinally therein from one end and separately adjustable in their longitudinal positions.

4. In combination, a rectangular wave guide, a translating device associated therewith, and a plurality of septa mounted parallel to the short dimension of said guide extending longitudinally therein from one end and separately adjustable in their longitudinal positions, and so spaced as to divide said guide into a plurality of portions having cut-off frequencies higher than harmonics of the operating frequency.

5. In a crystal cartridge holder a sleeve member having an inner seat, a spring chuck carried in said seat, a tubular clamping member threaded on the inner surface of said sleeve member for clamping said chuck in said seat, and a handle member having a spring jaw at one end for gripping the crystal cartridge and adapted to be inserted within said tubular clamping member to insert and remove the crystal cartridge from said spring chuck.

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