Dec. 9, 1947.

W. H. HEWITT, JR

2,432,097

ULTRA-HIGH-FREQUENCY DETECTOR

Filed Sept. 25, 1943

FIG. 1

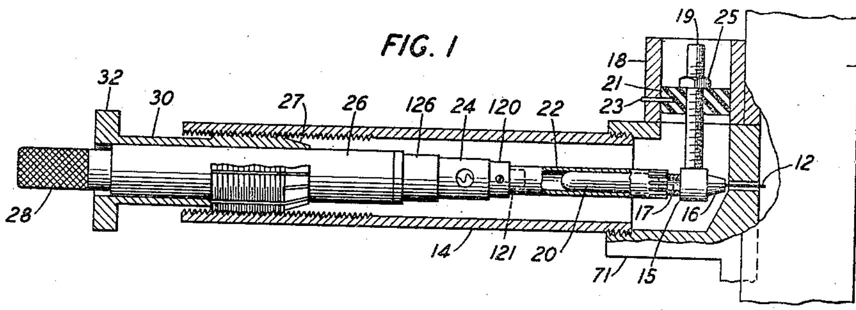


FIG. 3

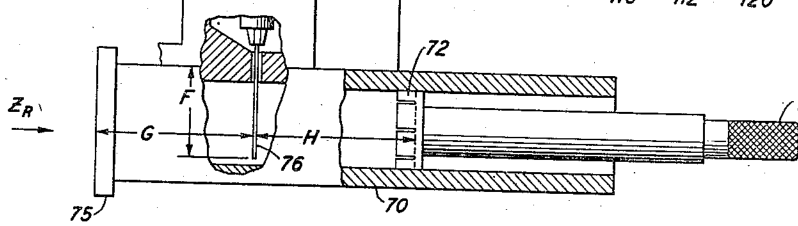


FIG. 2

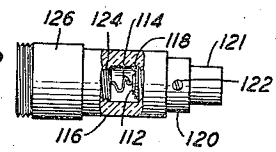


FIG. 4

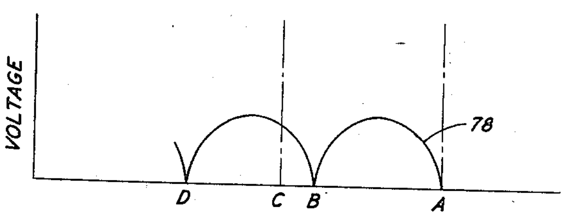
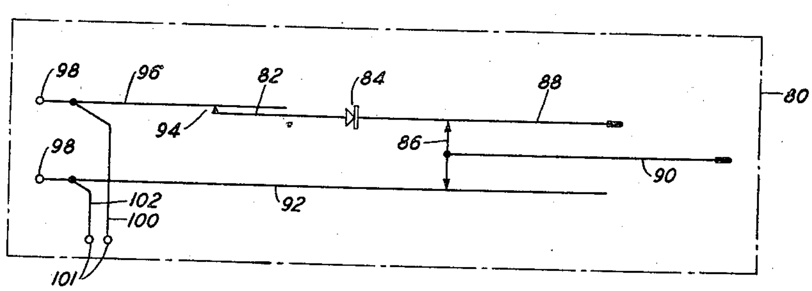


FIG. 5



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ULTRA HIGH FREQUENCY DETECTOR

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Application September 25, 1943, Serial No. 503,763

6 Claims. (Cl. 250—31)

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This invention relates to improved ultra-high frequency radio energy detectors. More particularly, it relates to detectors which are completely tunable and to detectors, employing crystals or similar non-linear elements, in which adjustment for maximum efficiency may be easily effected and in which the rectifying element can be conveniently and quickly replaced. It further relates to improved detectors for systems such as these which employ short pulses of ultra-high frequency wave energy and in which it is desired to detect the full range of video frequency energy in order to preserve without distortion the true contour or wave shape of the energy pulses or the full frequency spectrum of modulations present on the ultra-high frequency wave.

In the illustrative embodiments of the invention, described in detail hereinunder, the use of a crystal detector or similar element having the non-linear characteristics of a detecting element, incorporated in a tunable section of transmission line in such a way that the detector may be positioned at the most favorable point of the tuned line section is taught. Furthermore, the structures of the invention teach the tapping of the tunable section of transmission line at a low impedance point for the efficient abstraction of the full range of video frequency currents.

Structures of the invention are designed to take full advantage of the discoveries that a crystal detector element has appreciable reactive impedance components and is most efficient when its position in the tuned circuit with which it is employed and its effect in the tuned circuit can be accurately controlled. It is, of course, well known that appreciable capacitative impedances shunting the video output circuit seriously degrade the contour or wave shape of energy pulses and complex waves which it is an object of this invention to preserve without deformation. Such capacitative shunt impedances are decreased considerably by the arrangements of the invention.

Among the objects of the invention are the provision, for use in ultra-high frequency systems, of completely tunable detectors employing crystal rectifying elements, of detectors having maximum efficiency and drawing a minimum amount of power from the source under test, of detectors providing for the abstraction of the entire video frequency range without substantial distortion, of detectors having substantially ideal impedance characteristics and of detectors of the above described characteristics which can be conveniently manufactured, adjusted and renewed. Further objects will become apparent

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during the course of the following description and from the appended claims.

The principles of the invention will be more readily understood from the detailed description, hereinunder, of illustrative embodiments, in conjunction with the accompanying drawings, in which:

Fig. 1 is a schematic diagram of a detector of the invention;

Fig. 2 shows in detail a silicon crystal and cat's-whisker assembly suitable for use in the structure of Fig. 1;

Fig. 3 illustrates the adaptation of the structure of Fig. 1 to service as a terminating converter for a wave guide transmission line;

Fig. 4 illustrates schematically the voltage distribution in the structure of Fig. 3; and

Fig. 5 illustrates an application of the principles of the invention to a Lecher wire resonant structure.

In more detail in Fig. 1, wave guide 10 may be of any of the numerous well-known cross-sectional contours, for example, of rectangular cross-section as described in connection with Figs. 1 and 2 of the United States Patent 2,129,669, issued September 13, 1938, to A. E. Bowen, and is assumed by way of illustration to be conducting an ultra-high frequency wave which may be either a continuous wave modulated by a video wave or a pulsed wave modulated by a video wave.

In television systems the video wave modulations will, of course, represent a combination of the picture currents and the synchronizing pulses being transmitted, while in object location systems of the pulse-reflection type the video modulations will determine the contour or wave shape of the pulses being transmitted, such pulses in the usual cases being of squared contour and having a duration of from 1/4 to several microseconds each.

A particular object of the invention is to provide a simple, easily adjustable, easily maintained, completely tunable, efficient crystal-detector assembly for determining the presence and characteristics of video modulation on an ultra-high frequency wave. Waves in the centimeter range, as to wavelength, are those herein referred to as "ultra-high frequency." The video modulation of such waves, as required in television and short squared pulse transmission systems, usually includes energy within the frequency range of from 20 cycles per second up to several (2 to 4) megacycles per second.

The structure directly to the left of wave guide 10, including probe 12 extending slightly into the wave guide, comprises a preferred illustrative embodiment of a video modulation detector of the invention. It consists of a section of concentric transmission line having an outer conductor 14 and an inner conductor consisting of conducting member 26, crystal detector 24, and conducting members 22, 20 and 12. A short-circuiting member 30 connects through slidable contacting fingers 27 the member 26 and the outer conductor 14. The position of the member 30 is adjustable longitudinally by means of threads on member 30 which engage threads on the inner surface of member 14. A ring-shaped knob 32 on the left end of member 30 facilitates turning the latter to effect longitudinal adjustment. By this arrangement the length of the concentric line is tuned to the ultra-high frequency being transmitted through wave guide 10.

Detector 24 can comprise, for example, the device shown in detail in Fig. 2 which consists of the following structure: A small silicon crystal 112 held in a conductive mounting 118 attached to the left end of member 22 by tightly fitting stud 121 which in turn is held by collar 120 and set screw 122. A "cat's-whisker," or fine wire of conductive material, 114 held in a second conductive mounting 124—126. The left end of member 126 is threaded to fit a matching internally threaded portion at the right end of member 26. A tubular member of porcelain 116 internally threaded at each end serves to hold the crystal and "cat's-whisker" mountings by external threads thereon in proper relation. Appropriate adjustment of the "cat's-whisker" is, of course, required to give maximum sensitivity of detection.

At the right end of member 22 of Fig. 1, the tube includes contacting fingers at its right end, as shown, which slide over the member 20. The assembly including members 26, 24, 22, et al., can be completely withdrawn to the left to permit replacement of crystal unit 24 conveniently, as required. The member 20 is tubular and is held in position by a ring member 15 on the end of conducting member 19, which is the inner conductor of a coaxial pair 18, 19 comprising the video output connection. Through the center of member 20 is the tubular cavity 17 and at its extreme right end are the contacting fingers 16, which fingers hold the small probe 12. The fingers 16 and cavity 17 permit probe 12 to be adjusted longitudinally, to accurately fix its protrusion into wave guide 10. Member 26 extends to the left through contacting finger members 27 of shorting tube 30 and member 26 is provided with a knob 28 at its left end to facilitate independent longitudinal adjustment of member 26. Member 26 has a sliding fit with member 30. As is apparent from the above description, adjustment of member 26 will also effect the longitudinal positioning of crystal detector 24, the fingers of member 22 maintaining contact with member 20 as member 26 is moved longitudinally.

The proper adjustment of the detector structure can be determined by noting the crystal position and shorting member position for which the video frequency output is greatest. As the detecting action represents the absorption of some power, a small amount of traveling wave energy will be present in the tuned detector structure. This energy provides the full video range of frequencies in the video output.

The video output is taken, as indicated above, from a point near the right end by connecting inner conductor 19 of concentric line 18, 19 through ring 15 to member 20. This point is chosen near the right end of the detector structure so that its coupling thereto is "electrically loose" and will not substantially damp the resonant operation of the detector structure.

Probe 12, as previously indicated, is adjusted to protrude a small distance into wave guide 10. It should absorb a very small portion of the total ultra-high frequency energy transmitted along the wave guide so that the transmission through the wave guide is not appreciably affected. The complete tuning of the over-all detector device and the adjustment of the crystal to a position giving maximum video output make it practicable to obtain satisfactory indications with an extremely small amount or "sample" of the total energy being transmitted along wave guide 10. This is highly desirable since the desired measurements can then be effected without any appreciable reaction upon the normal transmission of energy along wave guide 10.

The tapping in of the video output lead 19 at a point of small impedance, likewise, insures that the action of the concentric line resonator 14, 26, et al., will not be appreciably affected by the abstraction of the video energy for operation of appropriate indicating apparatus. A small washer type insulator 21, held in place by pin 23, serves with nut 25 to support the inner lead 19 centrally within outer conductor 18 of the concentric video output pair. Conductors 18, 19, thus form a concentric line type of jack which can be readily extended by a concentric line as is well known in the art, to suitable indicating apparatus for determining the amplitude and characteristics of the video energy, which are of interest. It should be particularly noted that this construction avoids the shunting of the video output by any appreciable capacity to by-pass the higher frequencies of the video frequency range and cause serious distortion of pulse contour or video energy wave shape.

For pulse-reflection object-locating systems the shape of the pulse can be accurately determined by viewing it on a cathode ray oscilloscope the horizontal sweep of which is synchronized with the pulsing rate, the video energy output being impressed across the vertical deflection plates. Line 18, 19 and concentric lines extending therefrom to the indicating apparatus should have a substantially constant resistive impedance over the video frequency range and since, as noted above, in the arrangement of the invention, no substantial shunt capacity is introduced across this line by the method of connecting it to the concentric resonant device 14, 26, et al., there will be no appreciable degradation of the video frequency energy and a true indication of its characteristics, particularly its wave shape, will be obtained.

The presence of appreciable capacity across the video frequency output would, as noted above, by-pass much of the high frequency energy which in turn would seriously affect the contour or wave shape of the energy as viewed, for instance, on a cathode ray oscilloscope. By way of example, the sharp squared pulse desired for pulse reflection object detection systems must contain substantially the entire video range of frequencies and if much of the higher frequency energy of the video range is by-passed, the contour of the pulse will appear distorted even though pulses of the desired character are in fact being transmitted along wave guide 10.

In Fig. 3, a modification of the structure of Fig. 1 is shown which constitutes a terminating converter for a wave guide which will present a pure resistive impedance to the wave guide which it terminates.

In Fig. 3 the tuned detector unit, including base member 71, is identical with the detector unit of Fig. 1, except that the probe 76 extends nearly across wave guide 70, its length being determined in accordance with the well-known theory of dipole and pseudo-dipole antennas to provide an impedance which is nearly a pure resistance and is substantially equal to the purely resistive impedance of the wave guide transmission line 70. The small distributed capacity inherent in the antenna thus formed may be tuned out by adjusting the short-circuiting plunger 72, having handle 74, so that the antenna member 76 will be situated at a point, with respect to the standing waves of the system, which provides a small inductive impedance component. This situation is illustrated by Fig. 4 wherein curve 78 represents the standing wave established by reflection from member 72 and point C provides the necessary inductive impedance required to tune out the antenna capacity. The wave guide is extended to the left a convenient distance and provided with a flange 75 to facilitate connection to a like wave guide transmission line. The device illustrated by Fig. 3 has been found to be a substantially ideal terminating converter for a wave guide transmission line.

Fig. 5 is a schematic diagram representation of the Lecher wire equivalent of the structure of Fig. 1.

The Lecher system, of course, comprises conductor 92 and the conductor including conducting elements 96, 94, 82 and 88 and the crystal detector 84. Shorting plug 86 having handle 90 is adjusted to tune the Lecher system to an ultra-high frequency applied to its terminals 98 and the combination including conductive members 94, 82 and 88 and crystal detector 84 are adjusted to place the detector 84 at the optimum point. Detector 84 can be of the type illustrated in Fig. 2 modified for convenient mechanical assembly between conductors 82 and 88. Video output leads 100, 102 are connected to the Lecher system at a point near the terminals 98 where the impedance is low so that no serious damping of the Lecher system is produced. The Lecher system can be enclosed within a shield 80 to prevent radiation, if desired.

Numerous other modifications embodying the principles of the invention will readily occur to those skilled in the art, the above-described embodiments being illustrative. The scope of the invention is defined in the following claims.

What is claimed is:

1. An ultra-high frequency energy, completely tunable, detecting device comprising a tunable

resonant device including an inner conductor, a non-linearly conductive element inserted in series relation in said inner conductor, means for longitudinally positioning said element with respect to said inner conductor, and non-capacitative means for abstracting video frequency energy from said detecting device at a low impedance point thereof.

2. In an ultra-high frequency system, a device for use in accurately determining the frequency and shape of ultra-high frequency energy pulses comprising a section of concentric transmission line provided with a longitudinally adjustable short-circuiting member at one end and a pick-up device for ultra-high frequency energy at the other end, a non-linear conductive element inserted in series relation in the inner conductor of said line, a section of said inner conductor including said non-linear element being independently adjustable longitudinally without substantially altering the electrical properties of said inner conductor, and a connection near a low impedance point of said line for abstracting video energy therefrom.

3. In an ultra-high frequency system, the combination of a section of transmission line having an inner conductor and an outer conductor, a conductive member near one end of said line adjustable longitudinally with respect to the line and connecting the inner and outer conductors of the line, a crystal detector electrically in series with said inner conductor and mechanically forming part of said conductor, a section of said inner conductor including said crystal detector being adapted for independent longitudinal adjustment without substantially affecting the electrical continuity of said inner conductor, a pick-up device at the free end of said line for introducing ultra-high frequency energy into the line, and a low impedance connection near the pick-up end of said line for abstracting video frequency energy from said line.

4. In a high frequency system, a transmission line section adjustable to be resonant at any frequency within a particular band of frequencies, said line including a conductor in which a crystal detector is serially incorporated both electrically and mechanically, and means for adjusting the position of said crystal detector longitudinally with respect to the conductor in which it is incorporated without substantially affecting the electrical properties of said conductor per se.

5. The arrangement of claim 4 and a low impedance connection to said section of line for abstracting video frequency energy from said section of line.

6. The arrangement of claim 4, the transmission line section comprising a Lecher wire system.

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