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Lewis

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[54] **MICROWAVE FREQUENCY MEMORY DEVICE**

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[52] **U.S. Cl.** **325/6,** 250/71.5, 250/199, 325/11, 325/13, 325/14, 329/144, 350/6, 350/7

[51] **Int. Cl.**.....**H04b 7/14**

[58] **Field of Search** 250/71, 71.5, 199; 325/6, 9, 325/11, 13, 14; 329/145, 144; 350/6, 7, 275, 266; 307/88.3

[56] **References Cited**

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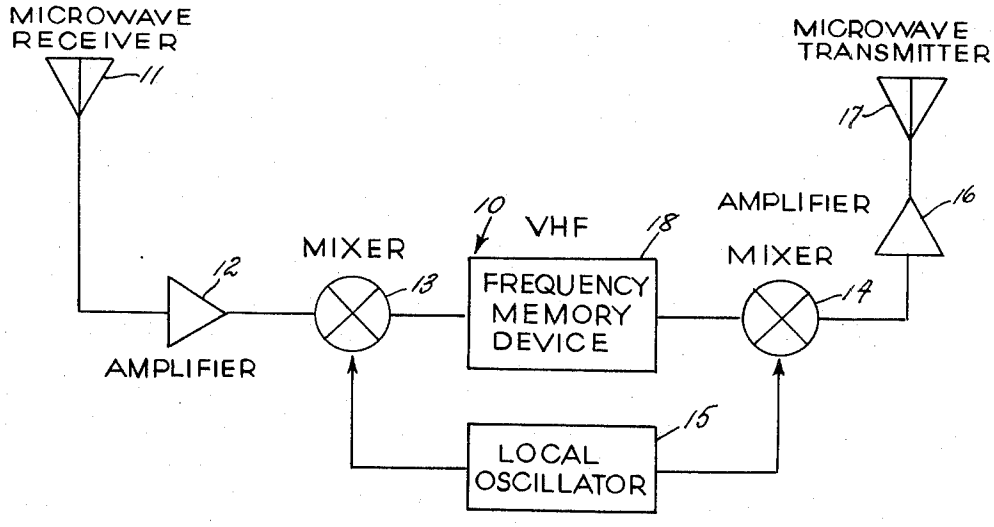
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[57] **ABSTRACT**

A frequency memory device wherein the cycle by cycle waveform of a short pulse of microwave energy is recorded electro-optically. This recording is then read or played back over and over again thereby achieving a semi-continuous "tone" at the exact microwave frequency that was received. The device has a variety of uses, including the production of signals for "jamming" hostile radar.

3 Claims, 3 Drawing Figures



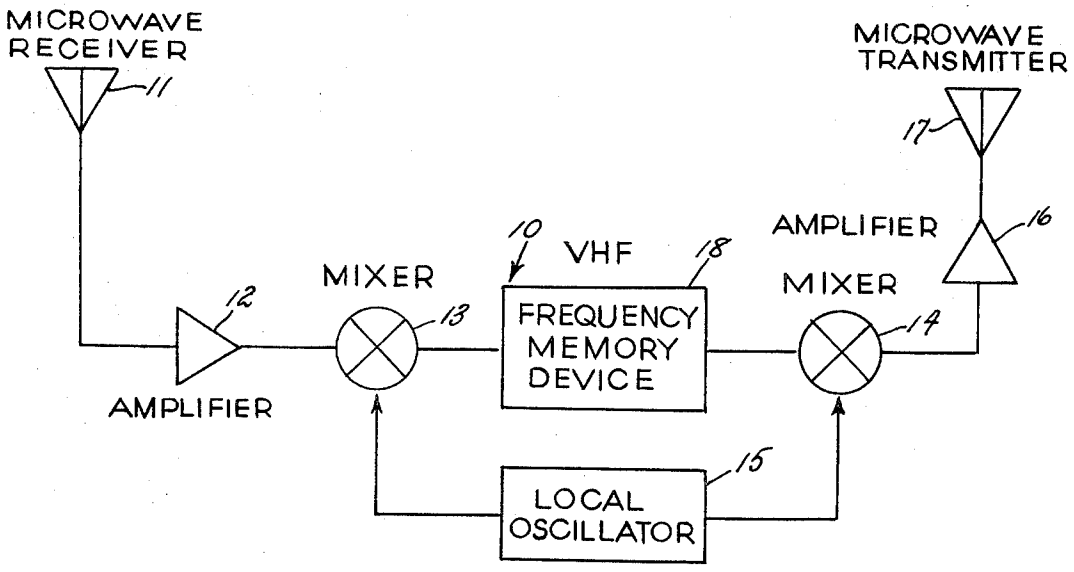


Fig. 1

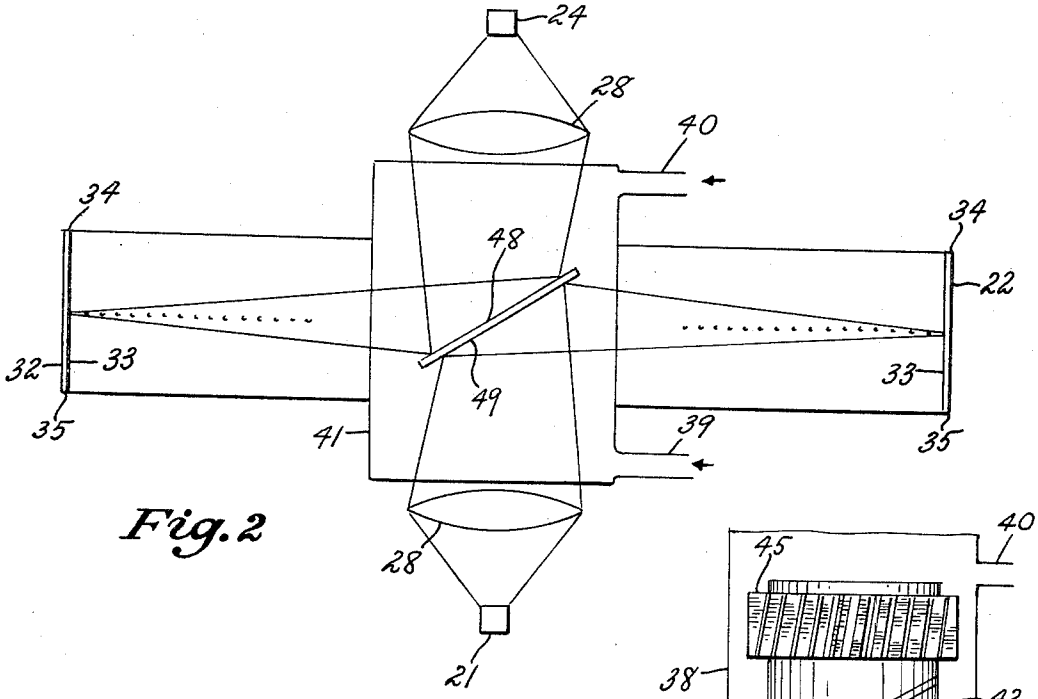


Fig. 2

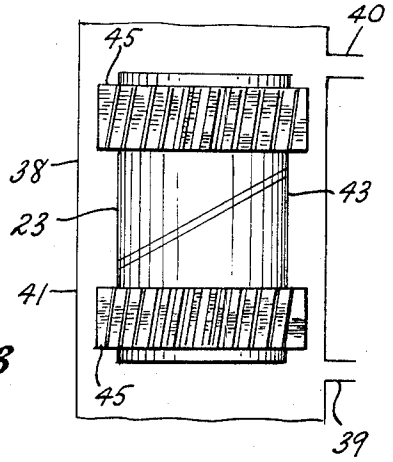


Fig. 3

MICROWAVE FREQUENCY MEMORY DEVICE

This invention relates generally to the field of microwave frequency memory devices, adapted to receive a short pulse of microwave energy, and repeat the same, for the purpose of distorting hostile radar signals and the like.

SUMMARY OF THE PRIOR ART

In the prior art, the above function is usually implemented by means of a microwave delay line with a feed back amplifier which puts the microwave pulse back into the delay line after making up for line losses. However, in such devices, the microwave tone degenerates into noise in tens of microseconds, and has an added disadvantage in that the delay line and amplifier are not only expensive, but very bulky.

BRIEF SUMMARY OF THE INVENTION

The present invention contemplates the provision of an electro-optical microwave frequency memory device, in which the microwave tone burst or pulse is suitably amplified and fed to a light-emitting diode or so-called solid state laser which typically emits in the near infrared region, and has nanosecond rise and fall times.

The wide beam output of the diode is converged by a lens and reflected off a very rapidly revolving inclined mirror, so that the result is a swept beam of light pulsating at the microwave frequency. This swept beam is intercepted by a phosphorescent-material coated cylinder. The coating is excited by the infra-red illumination, and a relatively long persistance string of bright dots is obtained. A detector (photo diode or photoconductor which is sensitive at the phosphor emission wavelength) scans the phosphor by using the other side of the revolving mirror and a suitable lens. The electrical output of this detector is a train of microwave tone bursts which repeat until the image on the phosphor fades away. The most important advantage of this technique is that the microwave frequency is stored for many milliseconds (up to tens of milliseconds) depending upon phosphor persistance.

BRIEF DESCRIPTION OF THE DRAWINGS

In the drawings, to which reference will be made in the specification, similar reference characters have been employed to designate corresponding parts throughout the several views.

FIG. 1 is a schematic diagram of an embodiment of the invention.

FIG. 2 is a schematic elevational view, partly in section of the memory device forming a part of the embodiment.

FIG. 3 is a schematic side elevational view of the rotating mirror element which comprises a part of the memory device.

DETAILED DESCRIPTION OF THE EMBODIMENT

In accordance with the invention, the device, generally indicated by reference character **10**, comprises broadly: signal reception means **11**, a signal amplifier **12**, a first mixer **13**, a second mixer **14**, a local oscillator **15**, an output amplifier **16**, an output antenna **17**, and a frequency memory element **18**.

The frequency memory element **18** includes a light-emitting diode element **21**, a recording cylinder element **22**, a rotating mirror element **23** and a photo detector element **24**.

The light-emitting diode element is of a Gallium Arsenide type, and is used to provide about 100 milliwatts of 9000 Ang. monochromatic light. The beam diverges with about a 60° cone from a typical light-emitting diode, and since virtually all of this output should converge on the phosphor in a very small spot, a lens **28** is placed in front of the same. The light-emitting diode converts its input current into infra-red light. The light is pulsated at the signal radio frequency rate by driving the diode with the amplified input signal. The signal is not detected first, the actual sinusoidal microwave voltage variation being employed to turn the diode on and off. The rise time of the diode is typically one nanosecond. Thus, the highest frequency that can be converted to light at full efficiency is approximately 250 MHz. Higher frequencies suffer a 6 dB per octave reduction in brightness for a given drive current.

The recording cylinder element **22** is bounded by an outer surface **32**, and an inner surface **33** as well as an upper edge **34** and a lower edge **35**. The inner surface **33** is coated with a phosphor which is phosphorescent and is stimulable by infra-red light. The phosphor fluoresces in the visible portion of the spectrum, ranging from yellow/orange to yellow/green, with an after glow of several milliseconds. Phosphors currently available in the art require pre-excitation by short wavelength light (in or near the ultra-violet region), and where required, this light may be supplied by separate means (not shown).

The brightness and repition frequency requirements of the ultra-violet charging depends on the phosphor selected, typically the flash from a small xenon strobe light (1 watt second) approximately every 10 seconds is normally sufficient.

The grain size of the phosphor must be small (less than 5 microns) if ultra-high frequencies are to be recorded. The phosphor grains do not crosstalk, so there is normally no problem of image spreading. The phosphor powder is preferably either cemented to the inner surface (by dusting it on wet adhesive) or suspending the same in a transparent lacquer and painting the same on the surface.

The rotating mirror element **23** is preferably in the form of a small air turbine, resembling that used in high speed dental drills, and is caused to rotate at extremely high speeds. In order to ensure separation of bright dots on the phosphor at signal frequencies of up to 200 MHz, the mirror must rotate at 100K rps. No electric motors or ordinary bearings would survive very long at this speed. Instead, the air bearing turbine is disposed within a glass envelope **38**, having a lower air input **39** and an upper air exhaust **40** interconnected to a medial portion **41** of somewhat greater diameter. The rotor of the turbine (see FIG. 3) is in the form of a glass cylinder **43**, the outer surface **44** of which is provided with turbine blades **45**. The cylinder **43** is cut on a 45° angle through the center of gravity thereof, the cut surfaces being polished and aluminized. The cylinder parts are then cemented together again, to form an upper reflecting surface **48** and a lower reflecting surface **49**. The cylinder **43** is suspended within the medial portion **41** and rotated by air flow.

The detector element **24** is of a high speed photodiode or photo-conductive type. Many silicon photodiodes have a rise time of only a few nanoseconds, and are sensitive at the emission wavelengths of the phosphor. However, any detector which has these characteristics is suitable, including a vacuum photo-tube with an EIA spectral response of S3 (Ag–O–Rb) or S4 (Cs–Sb).

FIG. 1 illustrates the use of the element **18** as an active electronic countermeasure apparatus. In this application, the incoming short duration widely spaced enemy radar pulses are received and "printed" on the phosphor cylinder. Suitable light-emitting diode gating circuits or phosphor erasing techniques prevent the introduction of a new radar pulse until the previous image has faded away. This serves to avoid image overlap which would render the technique useless. The frequency memory element serves as a semi-continuous "oscillator" at radar frequency with periodic update to accommodate frequency agile radar apparatus.

As the disclosed embodiment is particularly adapted to serve as a means of recording the frequency of a short radar pulse, the quantitative discussions above reflect the parameters of this particular signal. However, with different mirror rotation speeds, phosphor type, and phosphor cylinder circumference, signals at much lower frequencies and/or longer pulse widths may be recorded.

The radar signal is a burst of sinusoids. The time duration of this burst (called pulse widths) is normally between 0.1 and 10 microseconds. The sinusoidal frequency may be anywhere from several tens of MHz to tens of thousands of MHz. The frequency may be intentionally varied over the pulse interval (commonly called chirp). The frequency may be intentionally changed from pulse to pulse (called frequency hopping). The pulse width may be intentionally changed from pulse to pulse.

The disclosed device records the frequency (and chirp, if any) and pulse duration, and makes it available for rebroadcast starting almost immediately and lasting for more than the signal pulse to pulse interval, typically up to several milliseconds.

Where the anticipated signal frequency is higher tan 200 MHz, the heterodyne circuit formed by the first mixer **13** and local oscillator **15** is used to down convert the signal to less than 200 MHz. The lower signal, after passing through the frequency memory element **18** is then up converted using the same oscillator **15** and second mixer **14** so that the transmitted frequency is exactly the same as the signal that was received earlier.

I wish it to be understood that I do not consider the invention limited to the exact details of structure shown and set forth in this specification, for obvious modifications will occur to those skilled in the art to which the invention pertains.

I claim:

1. A microwave frequency memory device for creating a semi-continuous tone from a microwave tone burst at the exact microwave frequency that is received comprising: signal receiving means including a light-emitting diode element, a hollow cylinder having a phosphor coated inner surface, a rotating mirror element, and a photo sensitive detector element; said rotating mirror element having a principal axis of rotation, and a pair of reflective oppositely disposed surfaces positioned at 45° with respect to said axis, said surfaces being positioned within said phosphor coated surface with said axis of rotation substantially coaxially positioned with respect to the axis of curvature of said cylinder; said light-emitting diode element being positioned to cast light rays on one of said reflective surfaces, said photo sensitive detector element being positioned to receive light rays from the other of said reflective surfaces; whereby upon the reception of a microwave pulse, said light-emitting diode may record a series of luminous dots upon said phosphor coated surface to be read by said photo sensitive detector with rotation of said mirror element during the period of phosphor excitation.

2. Structure in accordance with claim **1**, in which said rotating mirror element is in the form of an air powered turbine.

3. Structure in accordance with claim **1**, including a heterodyne circuit connected to said memory device to lower the frequency of a received signal for entry into the light-emitting diode, and reconverting the output of said detector to the original received frequency.

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