# United States Patent [19]

**Huang**

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[45] **Dec. 24, 1974**


[54] **MICROWAVE ACOUSTIC DELAY LINE**


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[52] **U.S. Cl.** ..... **333/30 R,** 333/1.1, 333/7 R

[51] **Int. Cl.**..... **H03h 7/30,** H01p 1/10, H01p 1/32

[58] **Field of Search** ..... 333/30 R, 30 M, 31 R, 29, 333/33, 1.1, 7 R, 10, 31 A



[56] **References Cited**

OTHER PUBLICATIONS

Olson–'Todays Acoustic (Bulkwave) Delay Lines' in 'The Microwave Journal' Vol. 13, No. 3, March 1970; pp. 67–76.



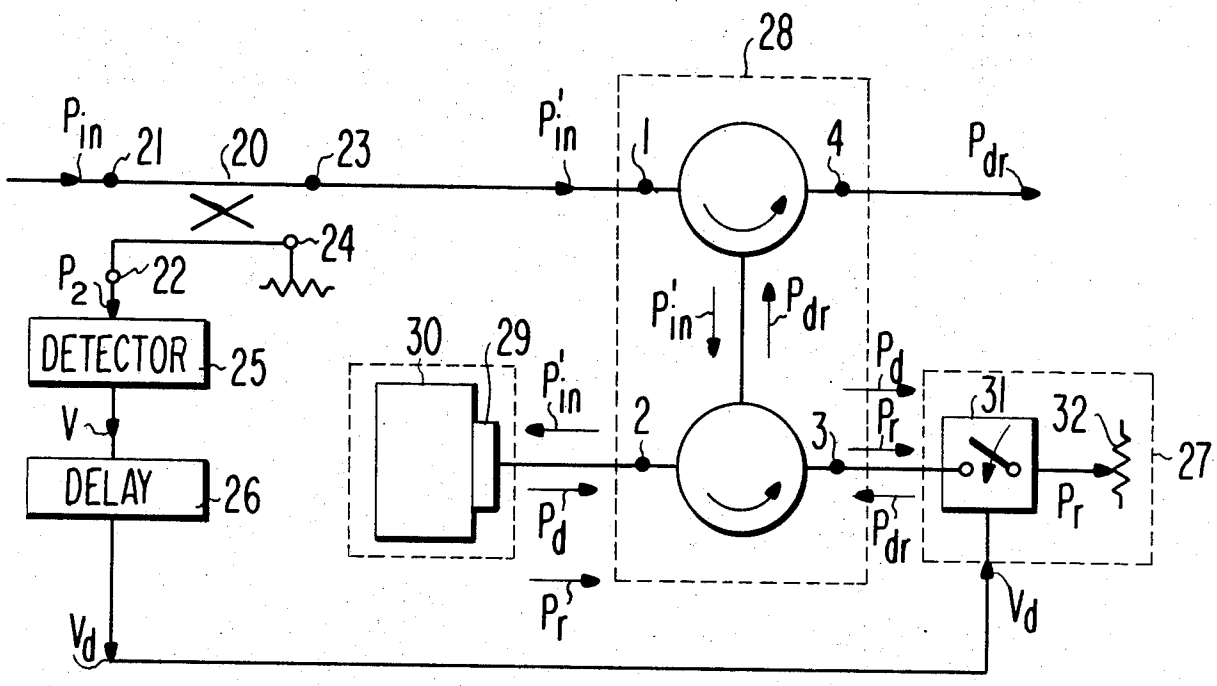
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[57] **ABSTRACT**

A microwave signal is delayed for a predetermined time period with a minimal production of undesired spurious RF signals by providing a resistive termination for undelayed input microwave signals reflected by an acoustic delay means and an output conductive path from the input microwave signals delayed by the acoustic delay means.


**10 Claims, 5 Drawing Figures**



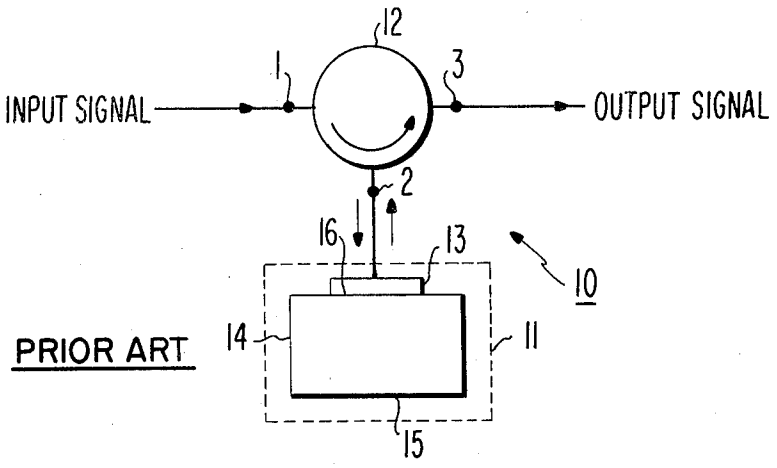



FIG. 1

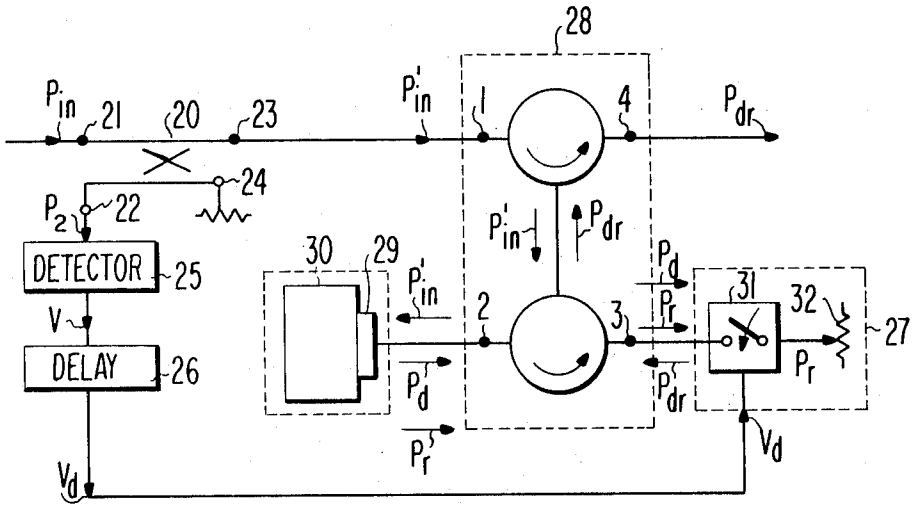



FIG. 2

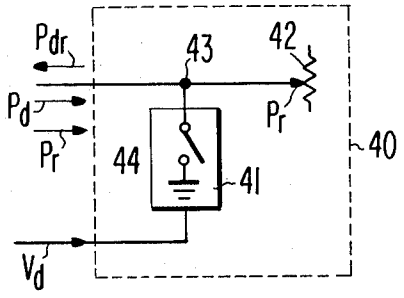



FIG. 3

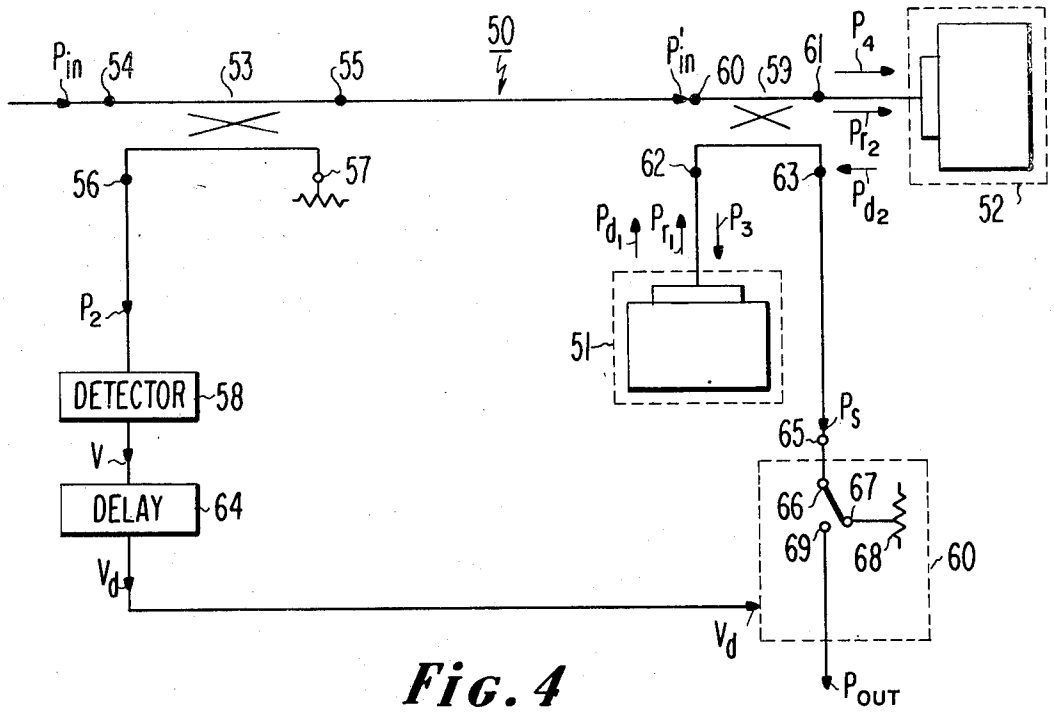

$P_{in}$
54
53
55
50
$P'_{in}$
60
59
61
$P_4$
$P'_{r_2}$
52
56
57
62
63
$P'_{d_2}$
$P_{d_1}$
$P_{r_1}$
$P_3$
51
$P_2$
DETECTOR
58
V
DELAY
64
$V_d$
$P_s$
65
66
67
69
68
60
$V_d$
$P_{OUT}$

*FIG. 4*

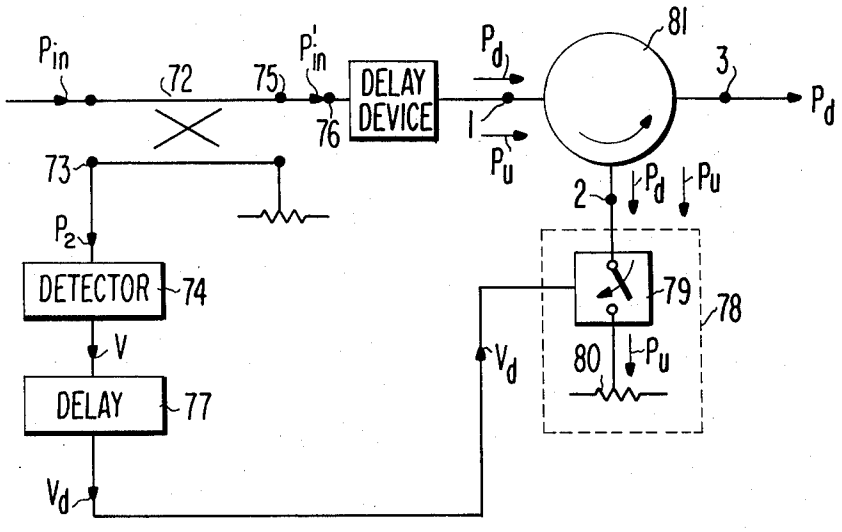

$P_{in}$
72
75
$P'_{in}$
76
DELAY DEVICE
$P_{d_1}$
1
$P'_u$
81
3
$P_d$
2
$P_d$
$P_u$
73
$P_2$
DETECTOR
74
V
DELAY
77
$V_d$
79
78
80
$P_u$
$V_d$

*FIG. 5*

# MICROWAVE ACOUSTIC DELAY LINE

The invention described herein was made in the course of or under a contract or subcontract thereunder with the Department of the Air Force.

## BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to delay lines and, more particularly to microwave acoustic delay lines.

2. Description of the Prior Art

Prior art microwave acoustic delay lines include an acoustic delay device having a transducer capable of converting input microwave energy to acoustic energy and an acoustic medium coupled to the transducer for propagating the acoustic energy in the form of acoustic waves. The prior art acoustic delay device provides a relatively long delay time per unit length of acoustic medium for input microwave signals. However, the prior art transducer also presents a relatively large magnitude impedance mismatch which reflects a substantial portion of the input microwave signal. Thus, a substantial undelayed portion of the microwave input signal is reflected to the delay line output terminal. For certain applications in the area of microwave communications, particularly electronic countermeasures, the transducer reflected, undelayed microwave signals are most undesirable.

A prior art solution to this problem has been to arrange various microwave matching circuitry between the microwave input signal source and the transducer for reducing the transducer impedance mismatch. This solution has not been entirely successful over relatively wide operating bandwidths since the operating bandwidth of prior art microwave matching circuitry is limited due to the dynamic impedance characteristic of the transducer. Thus, it is most desirable to suitably arrange microwave components including a microwave acoustic delay device in a microwave delay line which provides a predetermined delay for microwave signals over a relatively wide frequency bandwidth without reflecting undelayed microwave signals to the delay line output terminal.

## SUMMARY OF THE INVENTION

A predetermined delay for input signals is provided by a delay line having input and output terminals with sampling means coupled to the input terminal for sampling a predetermined portion of the input signal. Detector means coupled to the sampling means detect and convert the sampled input signal to a D.C. voltage signal. A first delay means coupled to the detector means delays the D.C. voltage signal for the desired time period. Signal directing means having a first terminal coupled to the sampling means and a second terminal coupled to a second delay means provide a conductive path for the input signal from the sampling means to the second delay means. The second delay means is arranged to delay the input signal for the desired time period. Switching means having terminals coupled to the first delay means, the directing means, and the output terminal is arranged to operate in response to the delayed D.C. voltage signal for selectively providing either a resistive termination for undelayed input signals reflected by the second delay means or a conductive path to the output terminal for the delayed input signal.



## BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a schematic of a prior art microwave acoustic delay line having a one port acoustic delay device.

FIG. 2 is a schematic of a microwave acoustic delay line having a one port acoustic delay device arranged according to one embodiment of the invention.

FIG. 3 is a schematic of an alternative switching circuit.

FIG. 4 is a schematic of a microwave acoustic delay line having a one port acoustic delay device arranged according to another embodiment of the invention.

FIG. 5 is a schematic of a microwave acoustic delay line having a two port acoustic delay device arranged according to another embodiment of the invention.

## DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1, there is shown a simplified schematic of a prior art microwave delay line **10** using a suitable acoustic device **11** for providing a predetermined delay time for input microwave signals coupled to port **1** of circulator **12.** An example of device **11** is an acoustic bulk-wave device having transducer **13** with a surface **16** in contact with acoustic medium **14.** Transducer **13** is arranged, as known in the art, to convert microwave or electromagnetic energy to acoustic energy. The acoustic energy is then propagated in medium **14** in the form of acoustic waves having relatively short acoustic wavelengths which provide relatively long propagation delay per unit length of medium **14.** Thus, a relatively short length of acoustic medium **14** is capable of providing relatively long signal delay. The acoustic waves in medium **14** are reflected back to transducer **13** by a suitable reflective surface **15** or interface at an end of medium **14** opposite transducer surface **16.** For example the interface or boundary between air and medium **14** will reflect acoustic waves. The reflected acoustic energy is then converted back to electromagnetic energy by transducer **13.** Thus, the total delay provided by device **11** is substantially determined by the time required for the input signal to be converted to acoustic energy for propagation in the acoustic medium **14** and reflected back to the transducer **13** which converts the acoustic energy back to electromagnetic energy.

Delay line **10** includes a prior art three port circulator **12** arranged to propagate an input signal along a predetermined, non-reciprocal, path from input port **1** to an adjacent port. Circulator **12** is shown in FIG. **1** as directing an input signal in a counterclockwise direction from port **1** to adjacent port **2,** and signals present at port **2** are directed in a counterclockwise direction to adjacent output port **3.** Thus, under operating conditions, an input microwave signal coupled to port **1** is directed to port **2** where microwave energy is converted to acoustic energy by transducer **13** terminating port **2.** As previously mentioned, the acoustic energy is then propagated in the form of acoustic waves through medium **14** until reflected back to transducer **13** by reflective surface **15.** The reflected acoustic waves are converted back to microwave or electromagnetic energy by transducer **13** and the delayed microwave signal is transmitted from port **2** to a load, not shown, terminating output port **3.** It will be apparent to those skilled in the art that undelayed microwave signals reflected by

device 11 are also transmitted from port 2 to port 3. Device 11 and delay line 10 is further described in an article entitled "Today's Microwave Acoustic (Bulk Wave) Delay Lines" by Frank A. Olson, published in Microwave Journal, Vol. 13, March 1970.

At microwave frequencies, transducer 13 and medium 14 present a highly reflective load having an impedance with a reactance which must be matched to a signal source impedance for optimum conversion efficiency and minimum signal reflection. It is most undesirable for device 11 to reflect a substantial portion of the undelayed input signal from port 2 to output port 3. Prior art attempts to solve this problem have concentrated on circuits for improving the impedance mismatch or Voltage Standing Wave Ratio (VSWR) presented by device 11. Such prior art matching circuits have not been entirely successful. Substantial portions of the undelayed input signal are still reflected by device 11 from port 2 to output port 3.

Referring to FIG. 2, there is shown a schematic of a microwave acoustic delay line according to one embodiment of the invention. Microwave input signal, $P_{in}$, is coupled to sampling means for sampling a predetermined portion of the input signal. An example of a sampling means is a prior art four terminal directional coupler 20 arranged to have input terminal 21, first output terminal 22, second output terminal 23 and isolated or resistive terminated terminal 24. Coupler 20 is arranged to have a coupling coefficient which permits a relatively small portion of input signal $P_{in}$, or signal $P_2$ to be fed to detector means 25 connected to terminal 22 and the remainder of input signal $P_{in}$ to be fed to four port circulator 28. Detector 25 is a prior art device such as a crystal or diode detector arranged to detect and convert microwave signals to a corresponding D.C. voltage signal, V. The D.C. voltage signal, V, from detector 25 is coupled to a suitable video delay line 26 arranged to delay the D.C. voltage signal, V, for a predetermined time. The delayed D.C. voltage signal, $V_d$, is a bias signal suitable for activating or operating switching circuit 27. Thus, it is understood that the coupling coefficient of coupler 20 and the sensitivity of detector 25 are selected to provide a D.C. voltage having a polarity and magnitude suitable for operating switching circuit 27. The function of switching circuit 27 will be described below.

The signal $P'_{in}$ is the portion of input signal $P_{in}$ which is fed from coupler terminal 23 to port 1 of circulator 28. Circulator 28 is a signal directing means arranged to provide a first non-reciprocal conductive path from circulator port 1 to delay device 30 terminating circulator port 2 and a second non-reciprocal path from delay device 30 to switching circuit 27. The function of circulator 28 is as follows. Signal $P'_{in}$ is fed in a counterclockwise direction along a non-reciprocal path from port 1 to port 2 of circulator 28. The transducer 29 of a prior art acoustic delay device 30, similar to device 11 in FIG. 1, is coupled to port 2 of circulator 28. Delay device 30 is arranged to provide substantially the same delay for microwave signals as delay circuit 26 provides for D.C. signal V. Transducer 29 includes a prior art matching circuit, not shown, arranged to transform the impedance at port 2 of circulator 28 to the impedance of device 30 at the frequency, $f_o$, of the input signal $P'_{in}$. Part of the input signal coupled to device 30 is converted to acoustic energy by transducer 29 and part of the input signal is reflected back to port 2 of circulator 28. The reflected, and undelayed portion of the input signal, $P_r$, is fed in a counterclockwise direction along a non-reciprocal path from port 2 of circulator 28 to switching circuit 27 coupled to port 3 of circulator 28.

Switching circuit 27 includes a suitable single pole single throw switch 31 arranged to be in a normally closed position in the absence of D.C. bias signal $V_d$. Thus, in the absence of D.C. bias signal, $V_d$, switch 31 provides a conductive path to resistive or signal absorbing load 32 for undelayed signal $P_r$. As previously mentioned, the D.C. bias signal $V_d$ for switching circuit 27 is delayed by video delay line 26 for a time period substantially equal to the delay provided by device 30 and switch 31 is in a normally closed position permitting the undelayed reflected signal $P_r$ and any other undesired microwave signal leaked from port 1 to port 3 of circulator 28 to be absorbed by load 32.

At the end of the delay time provided by device 30, a delayed microwave signal, $P_d$, is fed from port 2 to switching circuit 27 terminating port 3 of circulator 28. It should be noted that since the delay provided by delay circuit 26 is substantially equal to the delay provided by delay device 30, the switching circuit bias signal, $V_d$, and the delayed microwave signal, $P_d$, are simultaneously coupled to switch 31. The bias signal, $V_d$, causes switch 31 to open and present an open circuit or a relatively large magnitude reflective impedance to delayed microwave signal, $P_d$. The signal, $P_{dr}$, reflected by switching circuit 27 is fed in a counterclockwise direction along a non-reciprocal path from port 3 to the output port or port 4 of circulator 28.

Referring to FIG. 3, there is shown a schematic of a switching circuit 40 arranged as an alternative embodiment to switching circuit 27 in FIG. 2. Switch 41 is a single pole single throw switch having an input terminal 43 connected both to resistive termination or signal absorber 42 and port 3 of circulator 28 in FIG. 2 and an output terminal 44 connected to ground potential. Under operating conditions, switch 41 is in a normally open position in the absence of applied bias signal, $V_d$, from delay circuit 26. Thus, the signal, $P_r$, is fed along a conductive path to signal absorbing load 42. As described in FIG. 2, the delayed microwave signal, $P_d$, from device 30 is fed from port 2 to switching circuit 40 terminating port 3 of circulator 28. The delayed bias signal, $V_d$, and the delayed microwave signal, $P_d$, are simultaneously coupled to switch 41. The applied bias signal $V_d$, causes switch 41 to close and present a relatively low impedance path to ground potential or a reflective mismatch at port 3 of circulator 28. The delayed signal, $P_d$, is reflected by the reflective mismatch presented by switching circuit 40 at port 3 and is fed as signal $P_{dr}$ from port 3 to a load, not shown, terminating output port 4 of circulator 28.

Referring to FIG. 4, there is shown a schematic of another embodiment of a microwave acoustic delay line according to the invention. Microwave acoustic delay line 50 has first and second substantially similar bulk wave acoustic delay devices 51 and 52 arranged to provide substantially the same delay for applied microwave signals. Microwave input signal, $P_{in}$, is coupled to sampling means 53 or a prior art four terminal directional coupler 53 arranged to have input terminal 54, first output terminal 56, second output terminal 55 and isolated or resistive terminated terminal 57. Coupler 53 is formed to have a coupling coefficient similar to that

of coupler **20** in FIG. **2** so that a relatively small portion of input signal, $P_{in}$, or signal $P_2$ is fed to prior art detector **58** (described in FIG. **2**) connected to terminal **56.** The signal $P'_{in}$ is the portion of input signal $P_{in}$ which is fed to input terminal **60** of prior art directional coupler **59.** As described in FIG. **2,** detector **58** converts microwave signals to a corresponding D.C. voltage signal, V, which is in turn coupled to a suitable video delay line **64.** Video delay line **64** is arranged, as known in the art, to delay voltage signal V for a predetermined time. The delay provided by delay line **64** is substantially equal to the delay provided by devices **51** and **52.** The polarity and magnitude of delayed voltage signal, $V_d$, from delay line **64** is suitable for activating or operating switching circuit **60.** The function of switching circuit **60** will be described below.

Directional coupler **59** is arranged to have input terminal **60,** first output terminal **62,** second output terminal **61** and isolated terminal **63.** Unlike couplers **53** and **20,** coupler **59** is formed to provide a transmission path for substantially equal portions of signal $P'_{in}$ from input terminal **60** to first and second output terminals **61** and **62** respectively. Thus, signal $P_3$ at terminal **62** is substantially equal in magnitude to signal $P_4$ at terminal **61.** Also, the relative phase difference between the signal $P_3$ at terminal **62** and the signal $P_4$ at terminal **61** is substantially 90°.

It is well known in the art that directional coupler **59** described above, will sum two input signals ($P_{d\,1}$ and $P_{d\,2}$ or $P_{r\,1}$ and $P_{r\,2}$) simultaneously coupled to output terminals **61** and **62** provided such signals have a relative phase difference of substantially 90°. The sum of signals $P_{d\,1}$ and $P_{d\,2}$ or $P_{r\,1}$ and $P_{r\,2}$ is fed to terminal **63** as signal $P_s$. $P_{d\,1}$ is the delayed portion of signal $P_3$ reflected back to terminal **62** by device **51** and signal $P_{d_2}$ is the delayed portion of signal $P_4$ reflected back to terminal **61** by device **52.** Similarly, signal $P_{r\,1}$ is the undelayed portion of signal $P_3$ reflected back to terminal **62** by device **51** and signal $P_{r\,2}$ is the undelayed portion of signal $P_4$ reflected back to terminal **61** by device **52.** Coupler **59** and devices **51** and **52** are arranged, as known in the art, so that the relative phase difference between signals $P_{r_1}$ and $P_{r\,2}$ and the relative phase difference between $P_{d\,1}$ and $P_{d\,2}$ is substantially 90°. Therefore, as described above, the sum of $P_{r\,1}$ and $P_{r2}$ and the sum of $P_{d\,1}$ and $P_{d\,2}$ is fed to coupler terminal **63.**

Input terminal **65** of switching circuit **60** is coupled to coupler terminal **63.** Switching circuit **60** includes a single pole double throw switch **66** having a first output terminal **67** coupled to a resistive termination **68** and a second output terminal **69** coupled to a delay line terminating load, not shown. Switching circuit **60** operates to provide a selectable conductive path between terminal **65** and either terminal **67** or **69** in response to delayed D.C. voltage signal, $V_d$, from video delay line **64.**

Under operating conditions, switch **66** provides a conductive path for the sum of undelayed reflected signals $P_{r\,1}$ and $P_{r\,2}$ from terminal **65** to resistive termination **68** in the absence of delayed bias voltage $V_d$. In response to delayed D.C. voltage, $V_d$, switch **66** is biased to provide a conductive path from switch terminal **65** to output terminal **69.** Thus, since the delay provided by video delay line **64** is substantially equal to the delay provided by each of delay devices **51** and **52,** the switch bias voltage, $V_d$, and the sum of the delayed signals $P_{d1}$ and $P_{d\,2}$ are simultaneously coupled to switching circuit **60** causing switch **66** to provide a conductive path for the sum of delayed signals $P_{d\,1}$ and $P_{d\,2}$ from terminal **65** to output terminal **69.**

Referring to FIG. **5,** there is shown a microwave acoustic delay line **70** having a prior art two port microwave acoustic delay device **71** for providing a predetermined delay time for input microwave signals, $P_{in}$. Delay line **70** includes a sampling means or directional coupler **72** having a first output terminal **73** coupled to detector **74** and a second output terminal **75** coupled to input port **76** of delay device **71.** Directional coupler **72** is arranged to operate similar to directional couplers **20** and **53** described in FIGS. **2** and **4.** Thus, coupler **72** directs a predetermined portion, $P_2$, of the input signal, $P_{in}$, to detector **74** which in turn detects and converts signal $P_2$ to a D.C. voltage signal V. The remainder of the input signal $P_{in}$, represented as signal $P'_{in}$, is coupled to input port **76** of delay device **71.**

The voltage signal V from detector **74** is coupled to video delay line **77** arranged to delay the D.C. voltage V signal for a predetermined time. The delayed D.C. voltage signal, $V_d$, is a bias signal suitable for activating or operating switching circuit **78.** Thus, similar to FIGS. **2** and **4,** it is understood that the coupling coefficient of coupler **72** and the sensitivity of detector **74** are selected to provide a D.C. voltage having a polarity and magnitude suitable for operating switching circuit **78** coupled to port **2** of circulator **81.** The function of switching circuit **78** will be described below.

The signal $P'_{in}$ is delayed by the microwave acoustic delay device **71** for a period equal to the delay provided by video delay line **77.** The delayed output signal, $P_d$, from delay device **71** is coupled to port **1** of a suitable circulator **81** arranged to provide a non-reciprocal conductive path for signal $P_d$ from port **1** to switching circuit **28** coupled to circulator port **2.** Delay device **71** and circulator **81** are arranged so that the delayed output signal $P_d$ from delay device **71** and the delayed D.C. bias signal, $V_d$, from video delay line **77** are simultaneously coupled to switching circuit **78.** Under operating conditions, switching circuit **78** selectively provides either a conductive path to signal absorber **80** or a reflective mismatch. Switching circuit **78** includes a single pole, single throw switch **79** which, in the absence of a D.C. voltage signal, is in a normally closed position. Therefore, since the D.C. bias signal, $V_d$, is delayed and not yet coupled to switch **79,** a conductive path is provided for undelayed portions of signal $P'_{in}$ (referred to as $P_u$) to load or signal absorber **80** terminating switch **79.** Switch **79** is in a normally open position in response to an applied D.C. bias signal. Thus, an open circuit or reflective mismatch is presented by switching circuit **78** in response to the applied D.C. bias voltage signal $V_d$. The reflective mismatch terminating port **2** of circulator **81** then reflects the delayed signal $P_d$ from port **2** to a load, not shown, terminating circulator port **3.**

In summary, a microwave acoustic delay line is described in FIGS. **2, 4** and **5** which provides a resistive termination **32** and **68** or absorption of undelayed microwave signals reflected by an acoustic delay device **30, 51** and **52** and a conductive path to an output port for microwave signals delayed for a predetermined time, $T_1$, by the microwave acoustic delay device **30, 51** and **52.** The microwave acoustic delay line is arranged to provide means **20** and **53** for sampling a predeter-

mined portion of the input microwave signal and means **25** and **58** for detecting the sampled input microwave signal to a D.C. voltage signal, V. The D.C. voltage signal, V, is first delayed by a video delay line **26** and **64** for the predetermined delay time, $T_1$, and then coupled to a switching circuit **27** and **60.** In the absence of D.C. voltage signal, $V_d$, the switching circuit **27** and **60** is arranged to provide a conductive path to resistive termination **32** and **68** or microwave signal absorber for the undelayed signals, $P_r$, $P_{r\,1}$ and $P_{r\,2}$ reflected by the acoustic delay device **30, 51** and **52.** Upon the simultaneous application of delayed D.C. bias voltage $V_d$ and delayed microwave signal $P_d$, $P_{d\,1}$ and $P_{d_2}$, the switching circuit **27** and **60** provides a conductive path for the delayed microwave signal to a delay line output terminal.

The microwave acoustic delay line according to the invention is preferably operated in response to a pulsed input microwave signal. However, the acoustic delay line may operate in response to a C.W. or continuous wave input microwave signal providing the duration of the C.W. signal does not exceed the delay provided by the acoustic device **30, 51** and **52.**

Embodiments of the invention have been shown and described in FIGS. **2** and **4** only by way of example. Various other embodiments and modifications thereof will be apparent to those skilled in the art, and will fall within the scope of the invention as defined in the following claims.

What is claimed is:

**1.** A delay line having an input terminal and an output terminal for providing a predetermined delay for input signals, comprising:

sampling means coupled to said input terminal for sampling a predetermined portion of said input signal;

detector means coupled to said sampling means for detecting and converting said sampled input signal to a D.C. voltage signal;

first delay means coupled to said detector means for delaying said D.C. voltage signal, for said predetermined delay;

second delay means providing a delayed portion and an undelayed portion of said input signal;

signal directing means having a first terminal coupled to said sampling means and a second terminal coupled to said second delay means, said directing means providing a conductive path for said input signal from said sampling means to said second delay means; and

switching means coupled to said first delay means, a third terminal of said directing means and said output terminal, said switching means operating in response to said delayed D.C. voltage signal to selectively provide a signal absorbing termination for said undelayed portion of said input signal and a conductive path to said output terminal for said delayed portion of said input signal.

**2.** A delay line according to claim **1,** wherein said sampling means is a directional coupler.

**3.** A delay line according to claim **1,** wherein said detector means is a diode detector.

**4.** A delay line according to claim **1,** wherein said first delay means is a video delay line.

**5.** A delay line according to claim **1,** wherein said second delay means is an acoustic delay means.

**6.** A delay line according to claim **5,** wherein said acoustic delay means is a one port microwave acoustic bulk delay line.

**7.** A delay line according to claim **1,** wherein said switching means is a single pole double throw switch operating in response to said delayed D.C. voltage signal and having an input terminal coupled to said third terminal of said directing means and first and second selectable output terminals, said switch having said second output terminal connected to said signal absorbing termination and said first output terminal connected to a reflective termination for said delayed portion of said input signal whereby, said switch provides a conductive path for said delayed portion of said input signals from said switch input terminal to said reflective termination in the presence of said delayed D.C. voltage signal and a conductive path for said undelayed portion of said input signals from said switch input terminal to said signal absorbing load at all other times.

**8.** A delay line according to claim **1,** wherein said signal directive means is a four port circulator means directing said input and said delayed portion of said input signals along predetermined non-reciprocal paths, said circulator means having a first terminal coupled to said sampling means, a second terminal coupled to said second delay means, a third terminal coupled to said switching means and a fourth terminal for coupling out said delayed portion of said input signal.

**9.** A delay line having an input terminal and an output terminal for providing a predetermined delay for input signals transmitted between said input and output terminals, comprising:

sampling means coupled to said input terminal for sampling a predetermined portion of said input signal;

detector means coupled to said sampling means for detecting and converting said sampled input signal to a D.C. voltage signal;

first delay means coupled to said detector means for providing said predetermined delay for said D.C. voltage signal;

second delay means for delaying said input signal for said predetermined delay;

directive means having first, second, third and fourth terminals, said first terminal being coupled to said sampling means and said second terminal being coupled to said second delay means, said directive means providing a directive non-reciprocal path for said input signal to said second terminal of said directive means; and

switching means coupled to said first delay means and said third terminal of said directive means, said switching means operating in response to said delayed D.C. voltage signal to selectively provide a signal absorbing termination for undelayed input signals reflected by said second delay means and a conductive path from said third terminal to said fourth terminal of said directive means for said delayed input signal.

**10.** In combination,

an acoustic delay means which provides in response to an input signal applied thereto a first signal which is said input signal delayed a predetermined time period and a second signal which is a portion of said input signal undelayed by said delay means,

means for applying said input signal to said delay means,

means for sampling said input signal to provide a control signal and for delaying said control signal said predetermined time period, and

means coupled to said acoustic delay means and to said sampling and delaying means to provide in response to said control signal and a signal absorbing termination for said second signal and an output path from said delay means to a utilization means for said first signal.

* * * * *