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KEYED FILTER

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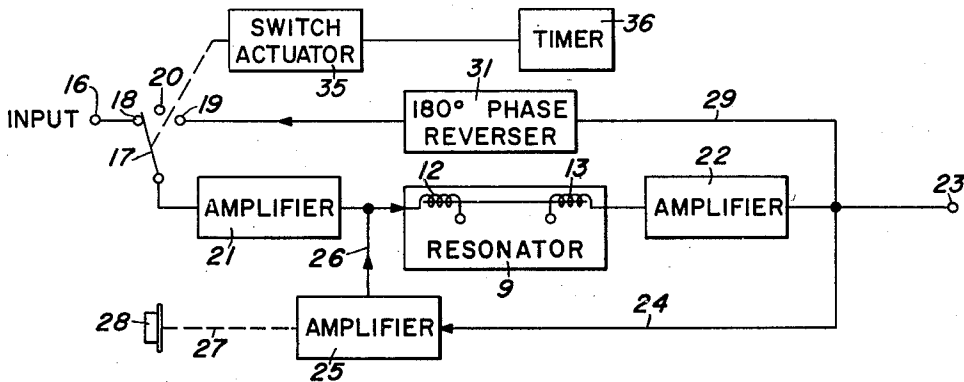
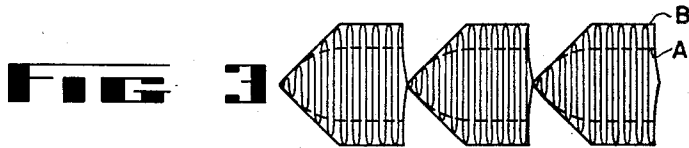
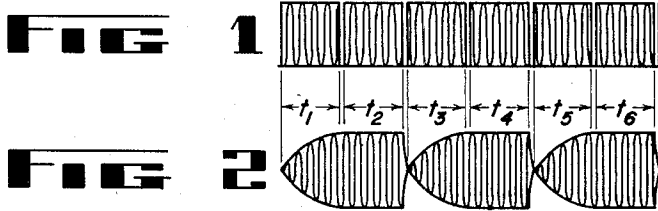


FIG 4

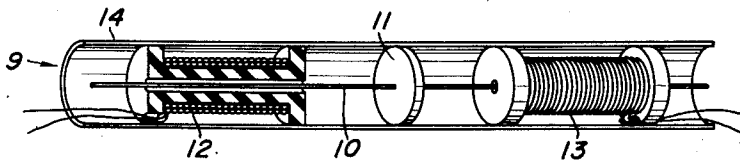


FIG 5

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4 Claims. (Cl. 250—27)

This invention relates in general to communication systems and in particular to apparatus for use with communication systems utilizing the principles of ideal detection according to Patent No. 2,676,245, entitled "Polar Communication System," which issued on April 20, 1954. The co-pending patent application Serial No. 502,045, filed April 18, 1955, by Melvin L. Doelz entitled "High Speed Transmission of Messages" also utilizes ideal detection and the apparatus of this invention. These systems are designed to transmit maximum intelligence with a particular bandwidth and power. Oftentimes under bad weather conditions communication is interrupted by static, fading, and other effects. The above referenced systems maintain communications under these borderline conditions.

One of the ways to communicate under poor conditions is to construct a detecting means which has a characteristic identical to the wave shape of the expected incoming signal, and multiply the incoming signal of this wave of identical shape in the detecting means and integrate the product. This maximizes the chance of obtaining usable intelligence under poor conditions.

It is an object of this invention, therefore, to provide a detecting means which has a controllable response so that it may be adjusted to accomplish the above-defined results.

Another object of this invention is to provide an electro-mechanical filter with controllable feedback wherein a desired frequency response may be obtained.

Another object is to provide a perfect weighting function for a square wave.

A feature of this invention is found in the provision for a filter which has an input signal applied thereto and which has a first additive feedback path so as to shape the output of the filter, and a second feedback path which is negative for quenching the output of the filter.

Further features, objects and advantages of this invention will become apparent from the following description and claims when read in view of the drawings, in which:

Figure 1 illustrates a plurality of square information carrying pulses,

Figure 2 illustrates the response characteristic of a filter which has been uncompensated according to the present invention;

Figure 3 illustrates a compensated filter wherein the response has been corrected to produce the desired results;

Figure 4 illustrates a filter in a circuit utilizing the principles of the present invention; and,

Figure 5 illustrates an electromechanical resonator that may be used as a filter element in the present invention.

With reference to Figure 1, let it be assumed for explanatory purposes that a square wave signal carries intelligence in a communication system. For example, this might be a series of pulses which is formed from an R. F. carrier tone modulated and wherein the tone is switched

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in phase. Such a system is described in Patent No. 2,676,245 and the co-pending application previously referenced. To detect pulses of this shape according to the principles of ideal detection requires that the incoming signal be multiplied by its expected wave shape and the product integrated. This may be accomplished by electromechanical resonators of low decrement, such as shown in Figure 5.

It comprises a magnetostrictive rod 10 which might be made of nickel or other suitable material. The length of the rod is varied until it is resonant at the frequency of the tone, for example, 20,000 cycles. A supporting disc 11 supports the rod 10 at a nodal point which might be at the center. It is to be realized, of course, that the length and diameter of the rod determine the resonant frequency. A driving coil 12 is mounted about the rod and the incoming signal is supplied thereto. An output coil 13 is also mounted about the rod and the output is removed therefrom. The resonator is mounted in a suitable container 14 which may be cylindrical in shape. The rod may be made of nickel, which is a magnetostrictive material and it can thus be driven by magnetostriction.

The frequency response of a resonator of high Q such as shown in Figure 5 normally has the shape shown in Figure 2. This is an exponential curve of the form:

$$y=A(1-e^{-\alpha t}) \quad (1)$$

where alpha is the time constant, t is time, and A is the maximum amplitude of vibration at the resonant frequency. However, if a square wave signal is being received and it is to be multiplied by another square wave and the product integrated, the output would be triangular in shape instead of an exponential. Thus, if an uncorrected resonator were used, toward the end of each cycle the output would be too low.

For example, as shown in the co-pending application of Melvin L. Doelz entitled "High Speed Transmission of Messages" a plurality of pulses are transmitted which are square wave in shape. A tone or a plurality of tones are modulated on the carrier and the phase of each tone determines the intelligence being transmitted. Intelligence may be encoded on a 20,000 cycle per second tone by periodically reversing the phase of the tone so that when succeeding pulses are compared at the detector adjacent pulses which are in phase produce a "space"; whereas, if a change in phase occurs between adjoining pulses, a "mark" is recognized. Thus, as shown in the co-pending application, if two resonators tuned to the same frequency are utilized and a first pulse is fed to the first one and a second pulse to the second one and so on, alternately switching the input from the first to the second resonator, the phase between adjoining pulses may be compared. This is accomplished by allowing the first resonator to continue to ring or oscillate during the time that the second pulse is being fed to the second resonator.

A phase detector may be connected to the output of the resonators to measure the relative phase between the outputs. Thus, the ringing resonator which was energized by the preceding pulse remembers the phase of the preceding pulse and allows the intelligence to be decoded. At the start of the third pulse the first resonator is quenched in a fashion to be subsequently described, and it is once again energized with a new signal. At the end of the third pulse the second resonator is quenched, etc.

To take advantage of the principle of ideal detection the build-up of the resonators should produce a triangular wave shape instead of the exponential shown in Figure 2. It is to be noted that the curve of Figure 2 is broken into two parts, the first being the build-up from zero amplitude to the maximum amplitude during the time t_1 , and

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a ringing period occurring during the time t_2 during which the resonator continues to oscillate, even though it is unenergized. The oscillator is quenched in the interval between pulses 2 and 3, and is once again energized by the incoming pulse during the time t_3 . It is to be realized that a second resonator is energized during the time t_2 and rings during time t_3 etc., according to the principles of the referenced co-pending application.

The present invention corrects the response of the magnetostrictive resonator so as to produce the wave form shown in Figure 3, wherein the exponential build-up of the resonators has been changed so as to obtain a triangular wave shape. It is to be noted that the first curve A corresponds to that shown in Figure 2, and the triangular-shaped curve B remains straight at the later times so as to form a triangular wave shape.

This is the same as saying that the resonators have infinite Q. This is accomplished by positive feedback which results in the desired characteristic.

The response of Figure 3 is accomplished with the circuit of Figure 4. The incoming signal is supplied to terminal 16 periodically with alternate pulses being received at this point and the other pulses being fed to a second resonator, not shown. Terminal 16 is connected to a switch 17 that moves between three contacts 18, 19, and 20. The switch 17 that contacts 18, 19, and 20 would actually comprise a gating circuit such as shown in the referenced co-pending application; however, for the purposes of this invention it is merely shown as a switch which is controlled by a switch actuator 35 so that it moves between the contacts 18, 19, and 20. The actuator 35 receives an input from the timer 36, the movable switch 17 is connected to an amplifier 21 that amplifies the incoming signal and connects it to the driving coil 12 of the resonator 9. The output coil 13 of the resonator is connected to another amplifier 22 which has its output connected to a terminal 23. A feedback path is provided by a lead 24 which is connected to the input of an amplifier 25 that supplies its output by a lead 26 to the input of the resonator 9. The gain control shaft 27 of the amplifier 25 has a knob 28 mounted on one end thereof. Another lead 29 connected to the output of amplifier 22 is connected to a phase reverser 31 that has its output connected to the contact 19. This path provides the quenching action.

In operation, assume that the switch 17 engages the contact 18 during the time t_1 . The incoming signal will be amplified by the amplifier 21 and energizes the resonator 9. The oscillations in the resonator 9 will start to build up in amplitude and the output will be coupled by the output coil 13 to amplifier 22 and to the output terminal 23. A portion of this output will be fed back by the lead 24 to the amplifier 25 and into the input of the resonator. By adjusting the gain of the amplifier 25 with the knob 28 this positive feedback can prevent the curvature of the build-up during time t_1 . Thus, by adjusting the knob 28 the build-up of the resonator 9 may be made substantially linear. This adjustment may be made by observing the output of the resonator on an oscilloscope and adjusting gain in amplifier 25 with knob 28 until the desired characteristic is obtained.

After the time t_1 has elapsed the input will be removed move from terminal 16 and applied to another resonator, not shown. During time t_2 the resonator 9 will continue to oscillate and its output will be used to determine the phase relationship between adjacent pulses. During this time switch 17 engages open contact 20. At the end of time t_2 switch 17 will be moved to engage contact 19 and the output of the resonator which has continued to ring from its previous build-up will be fed through the negative feedback path lead 29 and phase reverser 31 into the input of the resonator. This will quickly quench the resonator. The switch 17 is then moved to engage contact 18 and the resonator will build up again during time

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t_3 . This will continue as long as intelligence is being received.

The keyed filter receives timing information in the form of pulses defining the transition between received pulses and uses this information to do a better job of detecting the signal. By removing all energy from the resonator with the quench circuit at the transition points the possibility of cross talk between successive pulses is removed.

It should be realized that this is a keyed filter. In other words, a means has been provided for introducing the timing information existing in a synchronous system to produce a substantial improvement in the filtering and detection processes by matching in time as well as in shape the incoming pulse with a locally derived weighting function composed of the resonator and the quenching circuit.

It is seen that this invention provides apparatus for shaping the response characteristic of a mechanical resonator, and although it has been described with respect to a particular embodiment thereof, it is not to be so limited as changes and modifications may be made therein which are within the full intended scope of the invention as defined by the appended claims.

We claim:

1. Apparatus for controlling the response of a resonator comprising a switch, the movable contact of said switch connected to the input of said resonator, a first amplifier connected to the output of said resonator, a second amplifier connected to the output of the resonator, the output of said second amplifier connected to the input of said resonator, a 180 degree phase reverser connected to the output of the first amplifier and to said switch so as to periodically quench the resonator and a switch activator connected to said switch to move it in synchronism with the incoming signal.

2. Apparatus for controlling the response of a resonator comprising, a switch, the movable contact of said switch connected to the input of said resonator, a first amplifier connected to the output of said resonator, a second amplifier connected to the output of the resonator, the output of said second amplifier connected to the input of said resonator, a 180 degree phase reverser connected to the output of the first amplifier and to said switch so as to periodically quench the resonator, a switch activator connected to the movable contact of said switch, a timer connected to said switch activator, and said movable contact controlled in synchronism with an incoming signal.

3. An electronic wave-shaping circuit including a resonator, said resonator having input terminals and output terminals, an incoming signal circuit, a first feedback amplifier circuit including a 180° phase reverser connected to said output terminal, a second feedback amplifier circuit connected between said output terminal and said input terminal for applying signal in phase from said output terminal to said input terminal, switching means operated repeatedly in synchronism with signal applied to said incoming signal circuit for successively connecting said incoming signal circuit, then disconnecting said incoming signal circuit, and after a predetermined interval connecting said first feedback amplifier circuit to said input terminals for applying 180° out-of-phase quenching signal.

4. A wave-shaping circuit having an electromechanical resonator, said resonator comprising a hollow cylindrical member, a support disc mounted in said cylindrical member, a magnetostrictive rod supported at a nodal point by said support disc within the cylindrical member, a driving coil and an output coil supported in said cylindrical member about said magnetostrictive rod; a signal input circuit, an output circuit connected to said output coil, a first amplifier circuit connected between said output coil and said driving coil for applying signal in phase from said output coil to said driving coil, a second am-

plifier circuit connected to said output coil for developing out-of-phase signal, switching means operated in synchronism with signal applied to said input circuit, said switching means during each operation successively connecting said signal input circuit to said driving coil, disconnecting said input circuit from said driving coil, and after a predetermined interval connecting said second amplifier circuit to said driving coil for applying out-of-phase signal voltage.

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