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CONTINUOUSLY VARIABLE PULSE DELAY SYSTEM

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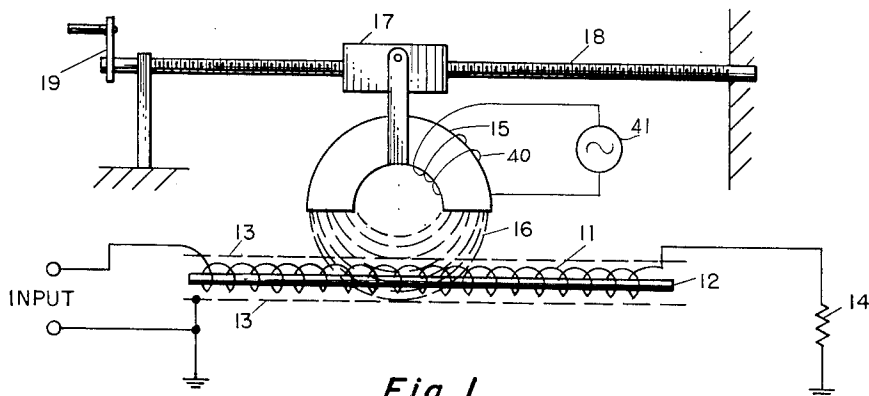


Fig. 1

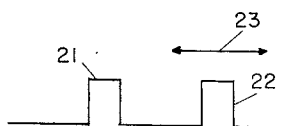


Fig. 2

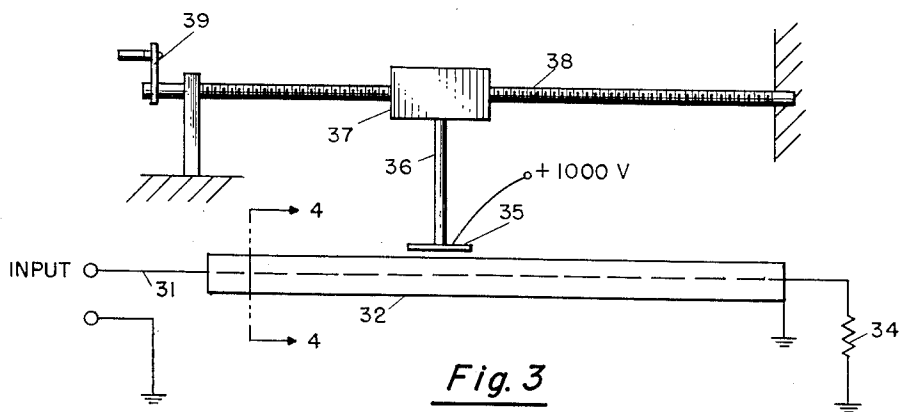


Fig. 3

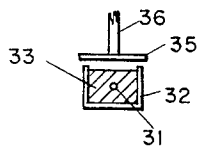


Fig. 4

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CONTINUOUSLY VARIABLE PULSE DELAY SYSTEM

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7 Claims. (Cl. 333—31)

This invention relates to a pulse delay system and more specifically to such a system in which the amount of the pulse delay is continuously variable over a predetermined range.

It has been customary in producing delayed pulses to employ delay lines using either lumped or distributed constants. In such an arrangement taps on the delay line have been provided and connected to a selector switch which would thus provide for different fixed amounts of delay.

Another common arrangement employs a long helically wound coil having a sliding contact arrangement adapted to contact the individual turns of the coil. This latter arrangement has the advantage of enabling a finer degree of control of the delay introduced since it provides essentially a tap on each turn of the coil. It has the disadvantage, however, that the sliding contact tends to wear the conductor resulting in poor contact.

My invention contemplates the use of a transmission or delay line constructed of saturable material together with means for saturating the saturable material at any point along the length of the line to thereby provide a discontinuity and cause reflection of a pulse applied to the line at the point of discontinuity. The reflected pulse appears at the input to the line, delayed by the time required for the pulse to travel to the discontinuity and be reflected back to the input.

It is an object of my invention to provide a pulse delay system wherein the amount of delay is continuously variable over a wide range.

It is another object of my invention to provide such a system which employs a transmission line of saturable material together with means for saturating the material at any point along the line.

It is a further object of my invention to provide a continuously variable pulse delay system while eliminating the use of sliding contact members.

Other objects and features of the invention will become apparent when the following description is considered in connection with the annexed drawings, in which,

Figure 1 is a partly diagrammatic side elevation showing one embodiment of the invention;

Figure 2 represents certain wave forms involved in practicing the invention;

Figure 3 is a side elevation of a second embodiment of the invention; and

Figure 4 is a transverse cross-sectional view of the device of Figure 3, the section being taken on the plane of the line 4—4 of Figure 3.

Referring now to the drawings and particularly to Figure 1 there is shown therein an embodiment of my invention in which the transmission line comprises a long helically wound coil 11 which coil is wound on a core 12 of saturable magnetic material. The coil 11 is surrounded by a shield 13 which may be a shielding braid and is terminated in its characteristic impedance 14.

A magnet 15 is mounted for movement longitudinally

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of the transmission line and produces a magnetic field 16. The magnet may be either a permanent magnet or an electromagnet excited by a winding 40 energized from a source 41 but in either event serves to produce a discontinuity resulting from the saturation of the core by the magnetic field. In order that the magnet 15 may be positioned at any desired point along the transmission line it is mounted on a carrier such as 17 which is in turn mounted upon the screw-threaded rod 18. Thus by rotation of the crank 19 the carrier 17 may be caused to move along the rod 18 to position the magnet at any desired point along the transmission line.

It will be clear that pulses which, in the absence of the saturating magnetic field will travel to the end of the transmission line and be absorbed in the terminating resistor without reflection, will, due to the discontinuity brought about by the presence of the saturating field, be reflected at the point of saturation and delayed for a time interval proportioned to the distance from the input to the point of reflection.

The magnetic field may be static thus producing equal delay of pulses of a sequence or may be dynamic in order to produce amplitude modulation.

It may sometimes be preferable to have the lines of force of the magnetic field coincide with the direction of the pulse or signal field in the line so that saturation may be produced more readily.

In Figure 2 there has been shown the wave form occurring at the input to the line as it would appear on an oscillograph. In this figure 21 represents a pulse applied to the line and 22 represents the pulse reflected by the discontinuity brought about by the magnetic field. It will be obvious that by shifting the position of the magnetic field longitudinally the reflected pulse may be displaced in time from the input pulse through any interval such as that indicated at 23.

Referring now to Figures 3 and 4, there is shown therein a second embodiment of the invention in which saturation of a dielectric material such as a barium titanate by application of an electrostatic field causes a discontinuity and pulse reflection. In this embodiment the transmission or delay line comprises a channel member 32 (sometimes referred to as a "slotted line"), the channel being substantially filled with dielectric material 33 which has a conductor 31 centrally located therein. A plate 35 is fixed to an insulating member 36, the member 36 being in turn fastened to a carrier 37. Carrier 37 is similar to that shown in Fig. 1 as 17 and is mounted on a screw-threaded rod 38 which may be rotated by the crank 39. This arrangement operates in a manner similar to that heretofore described, that is, by rotating the crank 39 the carrier nut 37 is caused to move along the rod and the plate 35 thus caused to move longitudinally along the transmission line. As is indicated in the drawing a high voltage relative to the channel 32 is applied to the plate 35 and this voltage saturates the dielectric around conductor 31 and produces a discontinuity in the line causing reflection of the pulse as hereinbefore mentioned.

While I have described specific embodiments of my invention it will be apparent that many modifications may be made and I wish therefore not to be limited by the foregoing description, but on the contrary only by the claims granted to me.

What is claimed is:

1. A continuously variable delay line which comprises a pair of input terminals, a helical coil wound on a core of saturable magnetic material and surrounded by a conductive shield member, means for applying a magnetic field through said shielding and said coil to saturate a given narrow incremental area of said core intermediate the ends thereof, and means for moving said magnetic

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field longitudinally along said coil, said helical coil being connected to one of said input terminals and said conductive shield member being connected to the other of said input terminals.

2. The device of claim 1 in which said magnetic field is produced by a permanent magnet.

3. The device of claim 1 in which said magnetic field is produced by an electromagnet.

4. The device of claim 1 in which said magnetic field is static.

5. The device of claim 1 in which said magnetic field is variable.

6. A continuously variable delay line comprising a pair of input terminals, an electrical conductor wound on a core of saturable magnetic material, means changing the permeability of a narrow incremental area of said core intermediate the ends thereof to vary the propagation constant of said conductor, said means being movable

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longitudinally along and adjacent said conductor, and conductive shielding means surrounding a major portion circumferentially of said conductor said means changing the permeability being exterior to said shielding means, said conductor being connected to one of said input terminals and said conductive shielding means being connected to the other of said input terminals.

7. The device of claim 6 in which said delay line is terminated in its characteristic impedance.

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