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[73] Assignee **Sperry Rand Corporation**

[54] **COAXIAL LINE REED SWITCH FAST RISE SIGNAL GENERATOR WITH ATTENUATION MEANS FORMING OUTER SECTION OF THE LINE**
8 Claims, 2 Drawing Figs.

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[51] **Int. Cl.** **H01p 1/22,** H03k 3/66, H01h 9/00
[50] **Field of Search** ..... 333/97 (S), 81 (A), 81, 97, 3,000, 7, 70; 307/106, 108, 93, 136; 200/153.18, 166 (L), 144, 2100

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ABSTRACT: A hollow cylinder of electromagnetic energy-absorbing material forms a portion of the outer conductor of a coaxial transmission line, the portion encompassing a mercury-wetted, magnetic field operated, reed switch that joins center conductor portions of input and output coaxial lines. When actuated by an externally generated magnetic field, the reed switch is operated to cause a relatively undistorted, sharp voltage step signal to flow along the output coaxial line.

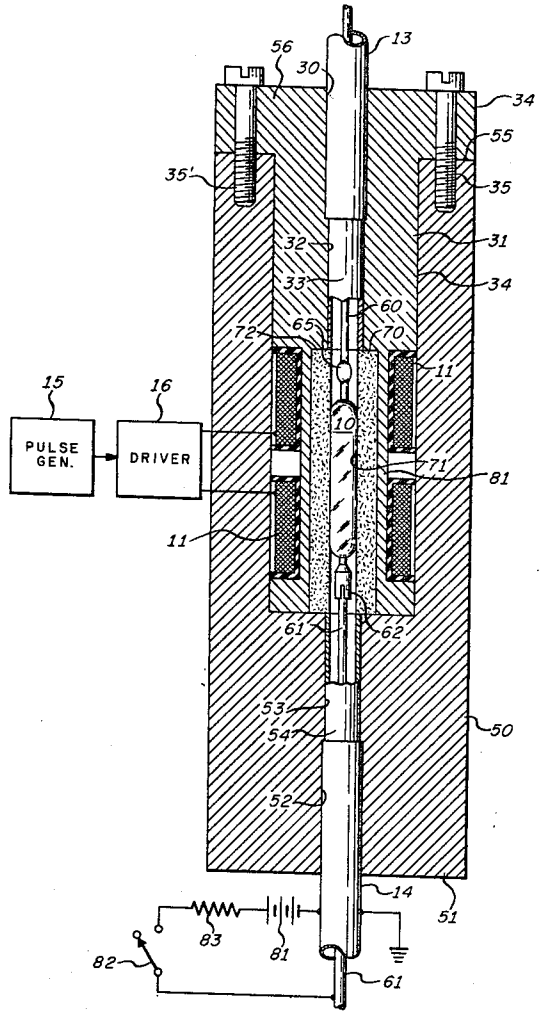
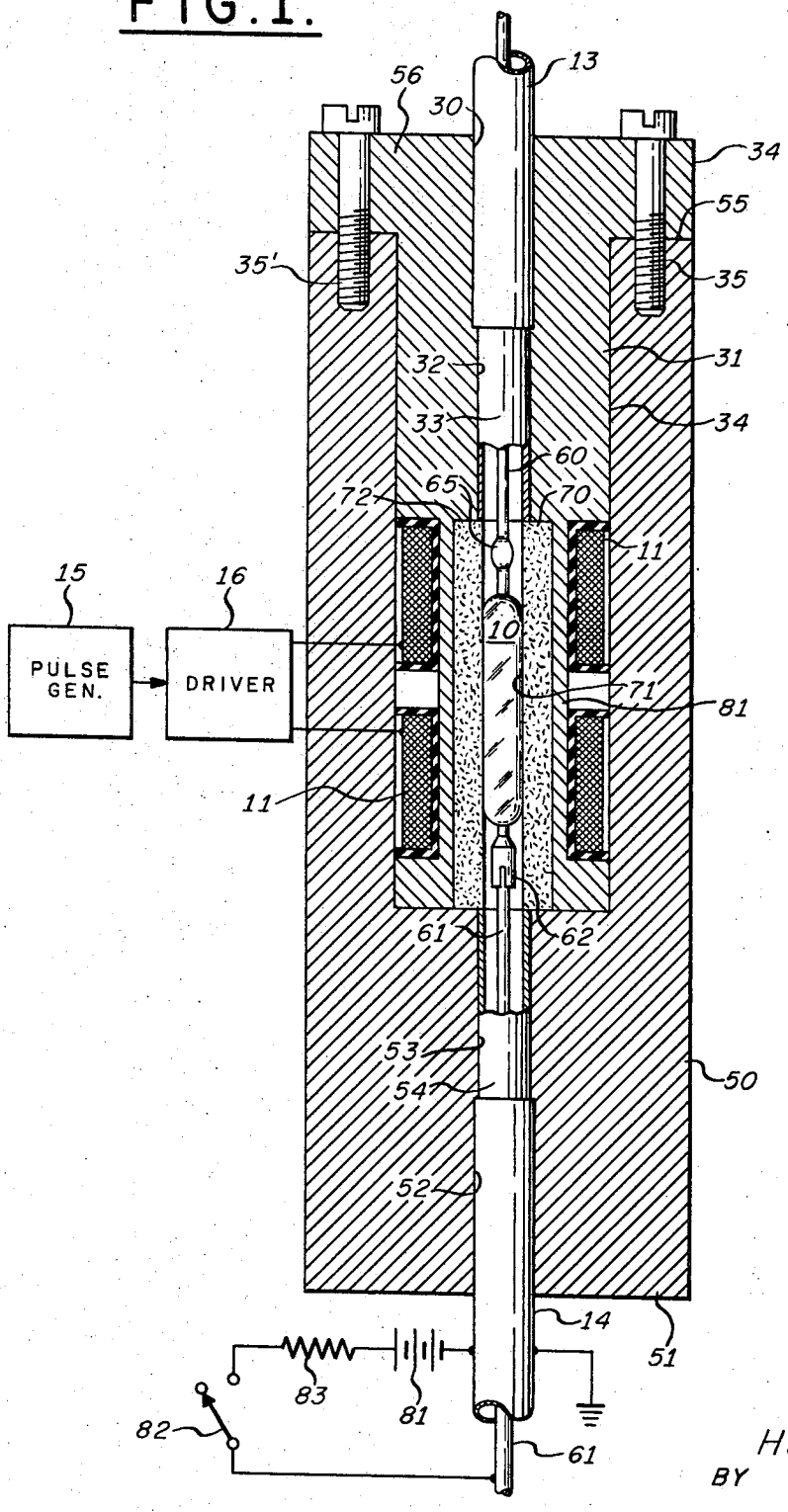


FIG. 1.



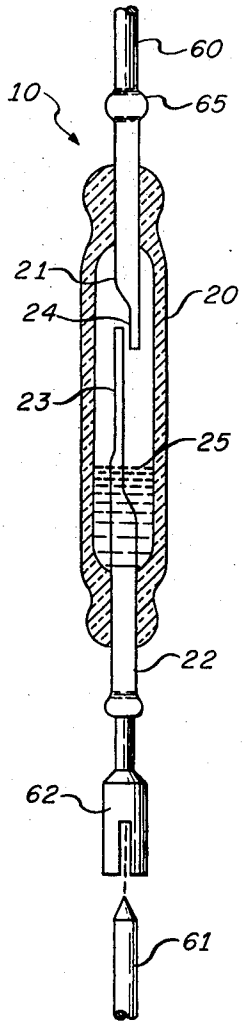


FIG. 2.

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COAXIAL LINE REED SWITCH FAST RISE SIGNAL GENERATOR WITH ATTENUATION MEANS FORMING OUTER SECTION OF THE LINE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention pertains to means for producing test or other signals of the voltage step type in transmission line circuits and more particularly to reliable and inexpensive means for producing abrupt signals in coaxial line transmission circuits with very sharp rise times and with minimum ringing or overshoot perturbations distorting the top of the step signal.

2. Description of the Prior Art

Prior art methods of generating unidirectional voltage step signals for laboratory, test, and other uses have not been found entirely satisfactory in many ways. Such prior art methods have not reliably produced sharp, clean leading edges when used to generate step voltage signals, but produce waves with distorted leading edges having relatively long rise times. When the step signal has reached the value at which it should properly begin to hold a constant value, ringing and/or overshoot phenomena occur, so that the resultant signal does not have a clean, flat top. Certain pulse generators in the prior art are additionally not capable of generating step voltage signals of relatively high amplitudes or at a high repetition rate and suffer severely shortened lives when operated at high amplitude levels or repetition rates. While prior art apparatus has been of material value as a test and research aid, new requirements for precise generation of sharp-fronted, flat-topped step signals are being imposed by current use of such signal generators in new applications.

SUMMARY OF THE INVENTION

The invention concerns a coaxial line switching system for employment in precision step wave generators, the active switch element comprising an encapsulated mercury-wetted reed device placed in a coaxial line and operated so as to start passage of current flow through the central conductor of the transmission line. In particular, the switch may be used for the rapid discharge of energy stored in coaxial transmission lines to form very fast rise time voltage step signals. In the invention, undesired ringing and/or overshoot which might otherwise be associated with the step voltage signal because of the presence of small impedance perturbations in the transmission line, especially in the vicinity of the reed switch, are reduced by the provision of special absorbing means encompassing the reed switch. That absorbing means simultaneously serves as the outer conductor of the coaxial transmission line in the vicinity of the reed switch for enabling the propagation of the desired step wave.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a view front elevation partially in cross section of a switching means incorporating the present invention, and,

FIG. 2 is an enlarged view of the mercury-wetted reed switch 10 of FIG. 1.

DESCRIPTION OF THE INVENTION

The present invention concerns a step signal generator circuit having broad application in the testing of high frequency apparatus, in analytical research, and also as a signal source for certain nonexperimental purposes. For example, the invention has application as a signal source in the rapidly expanding field of time domain research, a technology in which coherent signals of great reliability and precision are required in order to exploit sampling methods of measurement. The invention has, for example, application as a signal source in the study of the transient behavior of high frequency circuits.

Referring now to FIG. 1, a view of the preferred embodiment of a step voltage generator apparatus constructed in accordance with the present invention is shown including a glass encapsulated reed switch 10 and magnetic field generating coil 11. Flow of energy along first coaxial line portion 14 and through second coaxial line portion 13 is determined by the state of operation of pulse generator 15 and driver circuit 16 and the consequent state of switch 10 as will be discussed in greater detail hereinafter.

Referring to FIGS. 1 and 2, switch 10 is preferably constructed as a sealed switch comprising a glass capsule 20 in which a first electrode 21 of magnetic material is sealed in one end of the glass capsule, while a second electrode 22 of magnetic material is sealed in the opposite end of capsule 20. Electrode 22 has attached to it a thin magnetic reed 23. As shown, reed switch 10 is a single pole, single throw switch with the free end of reed 23 positioned adjacent but separated from a mating contact surface 24 in the open circuit condition.

In some applications, a small amount of mercury 25 is placed in the capsule 20. When present, the mercury tends to rise by capillary or other action to the upper tip of reed 23 and serves to wet the contracting surface thereon. After a short operating time, mercury is also transferred to the contact surface 24 of electrode 21. With both contacting surfaces wetted with mercury, switch 10, when closed, has a very low contact resistance of the order of 50 milliohms or less and is therefore particularly suited for use in the present invention.

First coaxial line portion 13 is supported within a central bore 30 in inner metallic body element 31. Bore 30 preferably has substantially the same diameter as the outer diameter of coaxial line portion 13; in fact, a relatively good friction fit may be used to hold coaxial line portion 13 within bore 30. A continuation of coaxial line portion 13 extends farther into body 31 where it lies within a smaller bore 32; in this extension, the insulation cover of coaxial line portion 13 is removed, so that the outer surface 33 of the outer conductor of the continuation of coaxial line portion 13 makes good contact with the electrically conducting surface of bore 32.

A second or outer metallic body element 50 telescopes over an outer wall 34 of first body element 31. The end 51 of body element 50 supports second coaxial line portion 14 within a central bore 52. Bore 52 has substantially the same diameter as that of coaxial line portion 14; in fact, a relatively good friction fit may again be employed to hold coaxial line portion 14 within bore 52. A continuation of coaxial line portion 14 extends farther into body 51, where it lies within a smaller bore 53; in this extension, the insulation cover of coaxial line portion 14 is removed, so that the outer surface 54 of the outer conductor of the continuation of coaxial line portion 14 makes good electrical contact with bore 53.

Outer body element 50 is held in a position telescoped over inner body element 31 by virtue of annular flange 34 at the end 56 of body 31, flange 31 being provided with screws 35, 35' passing through cooperating holes in flange 34 and threaded into the end 55 of outer body element 50.

Outer body element 50 and inner body element 31 together define a concentrically located central cavity in which primary features of the invention are placed in concentric relation about reed switch 10. Switch 10 is supported, in part, because its electrodes 21 and 22 are respectively connected to the inner conductors 60 and 61 of coaxial line portions 13 and 14. Electrode 21 is connected directly by brazing or soldering at 65 to inner conductor 60. The opposed electrode 22 is supplied with a conventional split-spring female electrical connector 62 which is slid over the end of inner conductor 61 of coaxial line portion 14 during the assembly of outer body element 50 and inner body element 31.

Reed switch 10 is further held in place by a surrounding drilled-out block or tube 70 of soft carbon or similar electromagnetic energy absorbing material. The hollow absorber tube 70 may be constructed from any of several types of carbon readily available on the market, such as pure laboratory grades of carbon sold by National Carbon as its high density type ZTA, or as its ultrapure AUC grades.

The inner diameter of the bore 71 passing through absorber tube 70 is substantially the same as the outer diameter of reed switch 10. It also is substantially the same in diameter as the

diameter of bores **32**, **53**. The carbon tube **70** extends somewhat past each end of the switch **10** so as to encompass all impedance discontinuities present because of the dimensional irregularities of the conducting parts of switch **10**, and because of the presence of glass capsule **20** and the mercury globule **25**. These irregularities generate undesired impedance discontinuities in the transmission line system wherever they appear. The carbon absorber tube **70** may have a relatively thin wall though, in practice, this dimension is limited by practical considerations imposed upon the machinability of the carbon material by its inherent physical characteristics.

By virtue of the above described construction of absorber tube **70** and the associated coaxial line portions **13** and **14**, there is thus provided an inner surface of an outer conductor of a coaxial line which is substantially of constant diameter and continuous through coaxial line portion **13**, the region occupied by switch **10** and absorber tube **70**, and coaxial line portion **14**. This condition advantageously serves to aid the relative constancy of the characteristic impedance seen by energy traversing the switch **10** and lines **13**, **14**.

Absorber tube **70** is supported on a thin metal tubular extension **81** projecting concentrically from an end face **72** of inner body element **31**. Tubular extension **81** further functions as a support for magnet coil **11** wound about its outer surface; coil **11** is driven by current pulse source elements **15** and **16** in any desired manner to open and close reed switch **10** according to a predetermined desired program. The current pulse generator represented by elements **15** and **16** is not in itself a feature of the present invention, and can take any one of several conventional forms. For example, coil **11** may be connected in series with a simple battery and knife switch (not shown); switch **10** then remains closed as long as current is to flow through coil **11**.

A feature of the invention lies in the aforedescribed arrangement of elements respectively associated with inner body **31** and outer body **50** which facilitates removal and replacement of switch **10**. It is observed that switch **10** is very simply withdrawn from the instrument by withdrawing coaxial line portion **13** from inner body element **31**, since switch **10** readily separates from the inner conductor **61** of coaxial line portion **14** at connector **62**. Switch **10** may thus be examined, replaced, or returned to its operating location by the reverse process.

A further primary feature of the invention may be appreciated by understanding the operation of the invention. By way of example, consider the operation of the invention in the formation of a voltage step to be supplied via coaxial line portion **13** to apparatus being tested (not shown). In generating a step voltage, it is common practice for example, to charge the coaxial transmission line portion **14** by placing a battery or other voltage source **81** in series with a relatively high resistance **83** across the inner conductor **61** and outer conductor **54** simply, for instance, by manually closing switch **82** while contacts **23** and **24** are separated. In this situation, the voltage supplied by battery **81** appears between contact **23** and the inner surface **71** of the inner wall of tubular absorber element **70**.

To supply a step voltage to apparatus under test connected to the output of coaxial line portion **13**, the pulse generator **15** and driver **16** or other suitable apparatus are caused suddenly to excite coil **11**. Instantaneously, the contact of reed **23** is forced against contact **24**. When this event occurs, a step function voltage wave travels into coaxial line portion **13** and on into the utilization apparatus. In this operation, electrical energy has flowed from battery **81** into coaxial line portion **14**, through the coaxial transmission line defined by the electrodes **21**, **22** of switch **10** and the wall **71** of absorber **70**, and along coaxial line portion **13** to the utilization apparatus. Until contacts **23**, **24** are closed, the energy has been stored as a static electric field within the transmission line system between battery **81** and the open contacts **23**, **24**. When contacts **23**, **24** are forced to close, a step wave of a coaxial line transmission type starts to propagate, i.e., the electric field lines of the propagating field are everywhere substantially perpendicular to the continuous coaxial inner conductor formed within switch **10** when reed **23** contacts surface **24**.

While switch **10** is selected for the purpose of as nearly as possible representing a continuous constant diameter center conductor when its contacts are closed, it is apparent that it does not actually have such a characteristic. Throughout the region occupied by switch **10**, impedance discontinuities are present. Each spatial variation in size of the electrodes **23** and **24** produces stray capacitive effects. The mercury globule **25**, depending in shape and in size upon the amount of material not migrated up to the contacts of electrodes **22**, **21**, generates stray capacitive and/or inductive effects. The effective dielectric constant of the volume encompassed by the transmission line system changes in the region of switch **10** by virtue of the presence of the glass of the encapsulating means **20**.

Absorber tube **70** acts to attenuate undesired signals such as the ringing and/or overshoot distortions and other spurious responses placed on the desired and otherwise abrupt voltage step signal generated by the transmission line system of the invention when the contacts of switch **10** are closed. Experimental evidence shows that ringing and overshoot effects that would otherwise be caused by the irregular shape of switch **10** are reduced to a desirable minimum, while the rise time of the step wave is not seriously affected. The traveling wave propagated through coaxial transmission line portion **13** to the load is a plane wave with only a mildly distorted wave front, significant undesired distortion being controlled by the resistive surface of absorber **70**.

While the invention has been described in its preferred embodiment, it is to be understood that the words which have been used are words of description rather than limitation and that changes within the purview of the appended claims may be made without departure from the true scope and spirit of the invention in its broader aspects.

I claim:

1. In a coaxial transmission line system,
- switch means for launching a traveling step wave in said coaxial transmission line system,
- said switch means having at least two possible states,
- said switch means being adapted, in one of said states, to form a portion of a continuous inner conductor of said coaxial transmission line system,
- said switch means being characterized by impedance perturbations capable of causing undesirable distortion of said step wave,
- tubular means encompassing said switch means and forming a portion of said coaxial transmission line system,
- the portion of said tubular means adjacent said switch means being formed of material for reducing the said undesirable distortion of said step wave, and
- means coupled to said switch means for changing the state of said switch means.

2. Apparatus of the kind described in claim **1**, wherein said switch means comprises a glass encapsulated, normally open, single pole, single throw, reed switch.

3. Apparatus of the kind described in claim **2**, wherein said means coupled to said switch means for changing the state of said switch means comprises magnetic field generating means.

4. Apparatus of the kind described in claim **1**, wherein said material for reducing the said distortion of said step wave is selected from the class of solid materials capable of converting electromagnetic energy into heat.

5. Apparatus of the kind described in claim **1**, wherein said material for reducing the said distortion of said step wave is carbon.

6. Apparatus of the kind described in claim **1**, wherein said portion of said tubular means adjacent said switch means for reducing said undesired distortion of said step wave lies concentrically about said switch means and is longer than the distance between the two most separated impedance discontinuities of said switch means.

7. Apparatus of the kind described in claim 1, wherein substantially all of said impedance perturbations in said coaxial line transmission system are disposed within said tubular means encompassing said switch means.

8. A transmission line device including first, second, and third transmission line portions,

said first and third transmission line portions each having center conductors,

said second transmission line portion including switch means with first and second electrodes means

said first electrode means being conductively connected to said center conductor of said first transmission line portion,

said second electrode means being conductively connected to said center conductor of said third transmission line portion,

tubular electromagnetic energy absorbing means encompassing said switch means and being adapted for absorbing substantially all undesired electromagnetic energy tending to distort energy propagated in said transmission line device,

said energy absorbing means forming, along with the outer conductors of said first and third transmission line portions, the outer conductor for a continuous coaxial transmission line device for transmission therethrough of desired electromagnetic energy in coaxial transmission line mode, and

means for actuating said switch means.