Oct. 25, 1949. J. A. RYLES 2,485,778

PULSE GENERATOR

Filed Aug. 25, 1947

FIG. 1

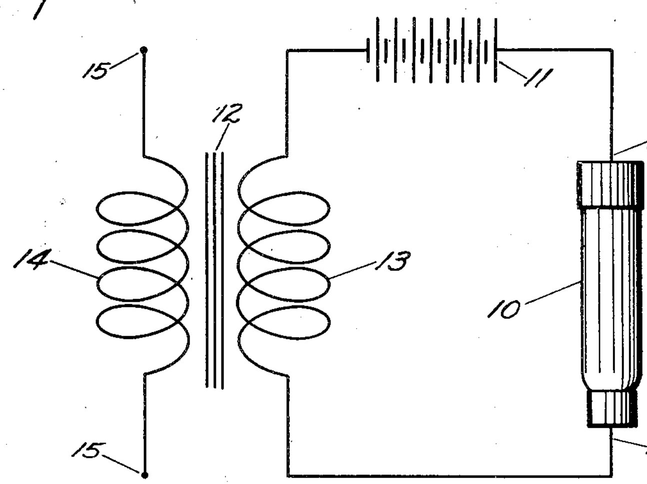


FIG. 2

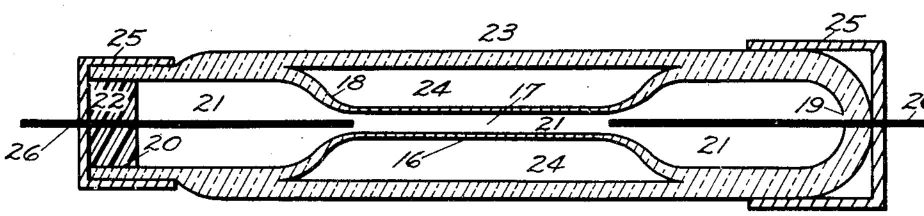
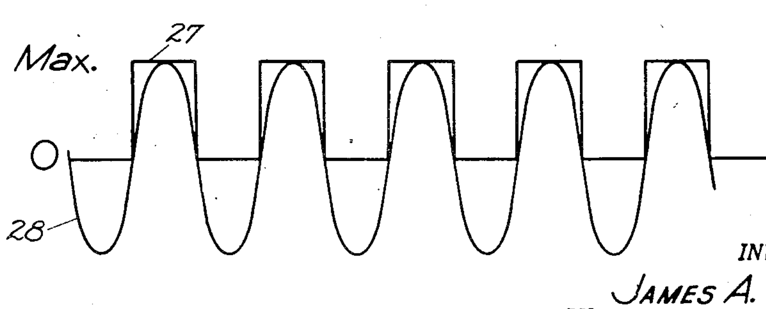


FIG. 3



INVENTOR.

JAMES A. RYLES

BY

Huebner, Maltby & Beehler

Patented Oct. 25, 1949 2,485,778

UNITED STATES PATENT OFFICE

2,485,778

PULSE GENERATOR

James A. Ryles, Fresno, Calif., assignor of one-half to Lewis A. Follansbee, Fresno, Calif.

Application August 25, 1947, Serial No. 770,371

8 Claims. (Cl. 200—113)

1

The present invention relates to pulse generators and more particularly to thermally responsive means for periodically interrupting current flow.

Modern requirements for alternating and pulse current have led to the development of numerous circuit interrupting devices directed to the supplying of electrical energy of desired alternating or pulse form from sources of direct current energy. Not only are alternating and pulse currents required because of properties intrinsic to their particular wave forms, but of even greater significance, because of the expeditious manner in which such currents are subjected to amperage and voltage ratio control.

An exemplary circuit requiring the providing of pulse or alternating current from a source of direct current is the energizing of an automotive radio receiving set from an automobile battery. Conventionally this is accomplished by means of a structure known as a vibrator in which mechanical movement is electrically induced in a structure providing electrical contacts periodically opened and closed by the mechanical movement. Vibrators are subject to frequent electrical and mechanical inaccuracies and failure. The contacts fuse, pit, arc, and for these and other reasons are not entirely satisfactory. To obviate these difficulties experimentation has been conducted resulting in circuit interrupters utilizing the properties of certain materials that conduct electrical energy in one physical condition but conduct very poorly or not at all when changed to another physical condition. Such circuit interrupters generally employ a liquid conducting material and means for periodically heating the material to vaporization. Conventionally such devices employ an elongated holder containing a liquid conductor and an electrical heating coil wound about the holder. Electrodes are provided in electrical communication with the fluid conductor at opposite sides of the heating coil. The coil is generally wound in electrical series with the liquid conductor so that heating effect of the coil is interrupted upon vaporization of the conductor. When electrical energy is impressed across such interrupters the heating coil transmits heat through the holder to the liquid conductor and raises the temperature thereof. When the temperature is increased sufficiently, the conductor vaporizes and passage of current through the liquid conductor and heating coil is interrupted. Upon the cessation of the application of heat to the conductor, the temperature thereof declines and subsequently the vaporized

2

conductor condenses and the electrical communication through the conductor is reestablished. In this manner, interrupters of this latter type operate successively to interrupt and to reestablish electrical communication.

Although conventional liquid circuit interrupters obviate the contact and mechanical movement difficulties experienced in vibrators they have failed to supplant the vibrators for general use because of other serious shortcomings. With such interrupters it has been impossible to achieve high frequency pulse or alternating current. The magnitude of the liquid conducting material employed, the characteristics of the holders, and the heating properties of the coils have caused the heating periods to be unnecessarily protracted. Residual heat of the coils, holders and conductors have caused the cooling periods to be of undesirable duration. No provision has been made for constant vaporization positioning and irregular operation has resulted. The frequencies of the pulse and alternating currents provided by such liquid circuit interrupters have fluctuated widely in response to even small atmospheric temperature variations. Cool and warm air current so affect the performance of conventional liquid circuit interrupters as to make accurate prediction of their electrical output characteristics difficult.

It is an object of the present invention to provide an improved circuit interrupter adapted to supply pulse or alternating current from a source of direct current.

Another object is to provide a circuit interrupter having dependable output characteristics.

Another object is to provide a thermally responsive circuit interrupter suited to high frequency operation.

Another object is to provide a simple, efficient and reliable circuit interrupter suited to the periodic interrupting and reestablishing of electrical communication.

Another object is to provide a sturdy and durable means for periodically interrupting direct electrical current that is substantially free from operational deterioration.

Another object is to provide a device for interrupting electrical current transmitted through said device by the successive vaporization and condensation of an electrically conducting element of the device.

Another object is to provide a device of the character described in which the vaporization is restricted to a predetermined location therein.

Another object is to provide a thermally responsive interrupter substantially insensitive to temperature variations in its environmental atmosphere.

Another object is to provide a circuit interrupter operable at low electrical current and potential factors.

A further advantage is to provide a circuit interrupter having a square wave pulse current output when activated by a direct current input.

Other objects and advantages will become apparent in the subsequent description in the specification.

Referring to the drawing:

Fig. 1 illustrates the employment of a circuit interrupter of the present invention in a characteristic electrical circuit.

Fig. 2 is a section of the interrupter of the present invention taken on line 2—2 of Fig. 1.

Fig. 3 is a diagrammatic representation of characteristic electrical outputs made available by the device of the present invention.

Referring in greater detail to the drawing:

In Fig. 1 the device of the present invention is indicated generally at 10. A battery 11 is employed as a source of direct current electrical energy. A transformer 12 having a primary coil 13 and a secondary coil 14 is energized by connecting the primary thereof in series with the battery 11 and the interrupter of the present invention 10. The output of the transformer 12 is conveniently designated at 15.

In Fig. 2, the structure of the interrupter of the present invention is clearly shown in cross-section. An inner tube 16 having a constricted medial portion 17 and reservoirs 18 at opposite ends thereof is formed of glass or other suitable insulating material preferably possessing a high rate of heat conductivity. The inner tube is conveniently cylindrical in form, it being understood that any other suitable form may be employed. Particular attention is directed to the thickness of the walls of the inner tube 16 which are preferably of substantial thickness coextensive with the reservoirs 18 and thin at the medial portion 17. As will soon become apparent, the thinner the walls of the tube in the medial portion the higher the frequency of the pulse or alternating currents attainable by the interrupter. In practice, the walls of the medial portion of the tube 16 are made as thin as possible in keeping with the supporting of its own weight and that of contained material presently described. The inner tube is provided with a closed end portion 19 and an open opposite end portion 20.

The inner tube 16 is filled with any suitable material characterized by an ability to conduct electrical energy in one physical condition but an inability efficiently to conduct electricity in another physical condition. A suitable material, such as mercury, is conveniently indicated at 21. The mercury, in liquid form, is an excellent conductor of electrical energy and in gaseous form substantially a non-conductor. It is to be understood other suitable fluid materials may be employed. The open end portion 20 of the inner tube 16 is sealed by means of a plug 22 of wax. The wax plug is sufficiently resilient to accommodate minute volume increases of the mercury due to temperature increases and vaporization. The thin-walled medial portion 17 also possesses a degree of resiliency allowing for expansion of the mercury.

An outer protective tube or casing 23 receives the inner tube 16 and provides two particularly significant functions. The outer tube shields the

medial portion 17 of the inner tube 16 protecting the same from shocks and jars, and provides support for the inner tube. Further the casing houses a gaseous cushioning reservoir 24 circumjacent said medial portion. The reservoir of gas dissipates heat from the medial portion 17 and protects said portion from abnormally rapid temperature changes in an environmental atmosphere. Like the inner tube, the outer tube 23 is conveniently formed of glass and is secured in fluid tight interconnecting relation to the reservoirs 18 of the inner tube and in concentric relation thereto. It has been found convenient to protect the device of the present invention by metallic shielding caps 25 slideably receiving opposite end portions of the inner and outer tubes 16 and 23 respectively.

Electrodes 26 are extended through the caps 25 into the mercury 21 contained in the inner tube 16, preferably terminating in spaced relation to each other within the constricted medial portion 17, as shown. The electrodes are interposed in an electrical circuit to be interrupted periodically, such as that shown in Fig. 1. Connection may be made to the electrodes as by soldering, spring clips engaged to the metal caps, or by any other suitable means.

Fig. 3 schematically represents a pulse current 27 characteristic of the pulse current experienced in the series circuit of Fig. 1 containing the interrupter 10, the source of current 11, and the primary 13 of the transformer. It is to be observed that the pulse current 27 possesses a square wave admirably suited to the many specialized radio transmission, radar, multiplex signalling and other modern electronic requirements. Also in Fig. 3 a wave, substantially of sine character, is indicated at 28 characteristic of an alternating current experienced at the outputs 15 of the transformer 12. The conversion of a pulse current to an alternating current by means of a transformer is conventional and not described in greater detail at this point.

Operation

The operation of the present invention is clearly apparent and is briefly summarized. When a direct current is impressed upon the interrupter 10 of the present invention as by an electrical system, such as that shown in Fig. 1, electrical energy is transmitted between the electrode 26 by the mercury 21 contained in inner tube 16. The constricted portion 17 of the inner tube preferably is of fine bore. It is apparent that the diameter of the bore affects the conductivity of the mercury contained therein. That is, the smaller the diameter of the bore, the greater the resistance offered to the passage of current through the mercury, the faster the mercury is vaporized and condensed, and the higher the frequency in the resultant pulse current. Although the present invention is not limited to any given diameter for the bore, inside diameters ranging from .0005 to 0.13 of an inch at the constricted portion 17 have been found excellently suited to radio use, employment in automobile ignition systems, and in other equipment subjected to from 2 to 6 volts. The mercury 21 contained in the medial constricted portion thus is of the form of a fine thread and may be considered, when in liquid form, a mercury filament. As electrical energy passes between the electrodes by way of said mercury filament a heating effect of the mercury incident to I^2R loss is experienced. Due to the fine quality of said filament, heat is rapidly generated sufficient to vaporize the mercury within the medial portion intermediate the reservoirs. Vaporization of the mercury 21 interrupts the flow of electrical energy between the electrodes.

The thin-walled construction of the medial portion 17 and the high rate of heat conductivity possessed by the glass are conducive to the rapid conduction and radiation of heat from the vaporized mercury contained therein. The gas cushion 24 contained in the casing 23 assists in the dissipation of the heat from the medial portion by convectional currents, conduction and radiation. The casing, acting as an envelope for the gas cushion not only serves mechanically to protect the medial portion from shocks and jars and to contain the cushioning gas about the medial portion but further assists in the dissipation of heat from the medial portion by radiation of heat from peripheral areas thereof.

Particular significance is attached to certain features of the present invention enabling the same to produce high frequency pulse current from a source of direct current in a dependable, uniform and reliable manner. First, the mercury filament contained in the constricted portion 17 is of such small cross section as to offer sufficient resistance to electrical current to heat the mercury to its vaporization point without an additional heater. This permits the avoiding of residual heat in supplementary heaters as conventionally known in liquid interrupters. Second, the medial portion 17 as protected by the gaseous reservoir 24 and casing 23, is exceedingly thin walled and is conducive to the rapid dissipation of heat caused by the transmission of electrical energy between the electrodes and thus rapid re-establishing of interrupted current flow occurs by prompt cooling and condensing of the mercury vapor. Third, the gaseous cushion 24 protects the thin-wall medial section from sudden temperature changes of an environmental atmosphere conventionally causing unpredictable operation of the interrupter. The present invention is substantially free from operational deterioration and substantially insensitive to environmental temperature variations. Fourth, the outer tube gives the device a sturdy quality desirable in circuit interrupters.

The interrupter or pulse generator of the present invention is simple, efficient and economical. It is suited to high frequency operation heretofore not achieved by interrupters designated as liquid circuit-interrupters. The fine character of the mercury filament enables the device of the present invention to operate effectively at extremely low electrical current and potential factors. Vaporization of the mercury due to heat generated by electrical transmission therethrough is localized within the medial portion. This is conducive to uniformity of operation.

Although I have herein shown and described my invention in what I have conceived to be the most practical and preferred embodiment, it is recognized that departures may be made therefrom within the scope of my invention, which is not to be limited to the details disclosed herein, but is to be accorded the full scope of the claims so as to embrace any and all equivalent devices.

Having described my invention, what I claim as new and desire to secure by Letters Patent is:

1. A pulse generator comprising spaced electrodes, a closed thin-walled constricted tubular member interconnecting the electrodes, a filament of fluid electrical conducting material contained by the tubular member, filling the same, and in communication between the electrodes, a closed housing member surrounding the tubular member, and a cushoning and heat dissipating reservoir of gas contained by the housing member in enveloping relation to the tubular member.

2. A thermally activated pulse generator comprising in combination a closed fluid container having a constricted portion, the walls of said constricted portion being characterized by a high rate of heat conductivity, electrical conducting material which is liquid at working temperatures filling the container and extended through the constricted portion thereof, means for applying a difference in electrical potential to the conducting material at opposite sides of the constricted portion of the container, a closed protective envelope mounted in circumjacent relation to the constricted portion, and a reservoir of gas constrained by the envelope in cushioning and heat dissipating relation to the constricted portion of the container.

3. A thermally activated pulse generator comprising a pair of reservoirs of electrical conducting material which is liquid at working temperatures; a thin-walled tubular member confining the conducting material, completely filled thereby, and having a constricted opening interconnecting the reservoirs in fluid communication; means for passing electrical current between the reservoirs through the liquid conducting material in the thin-walled tubular member whereby the conducting material is vaporized by heat generated in response to resistance of the liquid conducting material offered to current flow therethrough, and the passage of current interrupted; a gaseous envelope in sustaining and cushioning relation to the tubular means serving to dissipate heat therefrom and to shield said tubular means from abnormally rapid temperature changes in the environmental atmosphere, and a housing in shielding relation to the tubular means and in constraining relation to the gaseous envelope.

4. In a thermally activated pulse generator a substantially fluid tight casing; a substantially liquid tight hollow tube contained in the casing and having enlarged, closed end portions and a constricted medial portion, said medial portion being of thin-walled, heat conducting material; mercury contained by the tube and filling the same in communication with the end portions through the constricted portion of the tube; electrodes spacially positioned within the constricted portion; and means for applying a difference in electrical potential to the electrodes whereby current is caused to pass through the mercury in the constricted portion when the same is in liquid condition in an extent sufficient to heat the mercury to a temperature of vaporization resulting in an interruption of current flow, and whereby heat is rapidly dissipated from the vaporized mercury through the thin-walls of the medial portion resulting in prompt condensing thereof and reestablishment of the current flow.

5. A pulse generator comprising a hollow inner glass tube having sealed, enlarged end portions and a thin-walled constricted portion intermediate the end portions, mercury contained in the inner tube and filling the same in communication between the end portions through the intermediate portion, electrodes in electrical communication with the mercury in the opposite end portions of the inner tube, a tubular casing con-

centrically arranged with relation to the inner tube in fluid tight communication with opposite end portions of said inner tube, and a gaseous reservoir contained by the casing in protective and heat dissipating relation to the constricted portion of the inner tube.

6. A thermally activated pulse generator comprising a closed container of electrically non-conducting material having enlarged end cavities and a constricted passage interconnecting said cavities, an electrical conducting material which is liquid at working temperatures filling the cavities and the constricted passage of the container, means for imparting differences in electrical potential to the electrically conducting liquid in the end cavities, a sealed envelope enclosing the container, and a cushioning and heat dissipating body of gas confined by the envelope in circumscribing relation to the container at the constricted passage therein.

7. A pulse generator comprising a closed container of electrically non-conducting material having a pair of spaced cavities therein and an interconnecting constricted passage; mercury contained by and completely filling the container; electrodes individually in electrical communication with the mercury in the cavities; a gas tight housing containing the container, rigidly mounting the same therein, and spaced from the portion of the container through which the passage extends; and a cushioning and heat dissipating body of gas confined by the housing in circumscribing relation to said portion of the container through which the passage is extended.

8. A thermally activated pulse generator comprising a hollow inner tube of electrically non-conducting and heat conducting material having closed end portions and a constricted medial portion, mercury substantially filling the hollow interior of the tube, electrodes in electrical communication with the mercury at opposite sides of the constricted portion of the inner tube, a gas tight housing containing the inner tube and rigidly interconnecting opposite end portions thereof, said housing being radially spaced from the constricted medial portion of the inner tube, and a cushioning and heat dissipating body of gas confined by the housing in surrounding relation to said constricted medial portion of the inner tube.

JAMES A. RYLES.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,699,769	Virey et al.	Jan. 22, 1929