Jan. 21, 1964 I. M. BRUNTIL ETAL 3,119,022

PULSE GENERATOR

Filed March 10, 1958

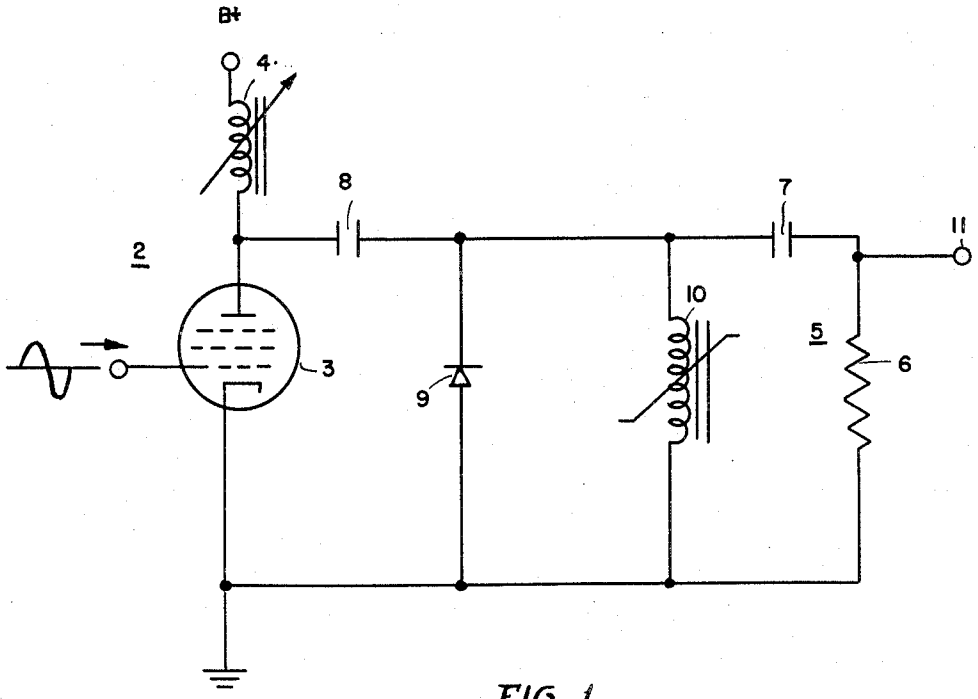

FIG. 1

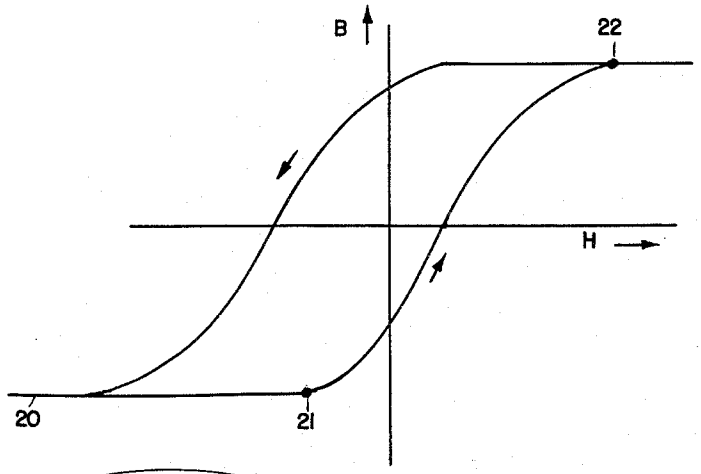

FIG. 2

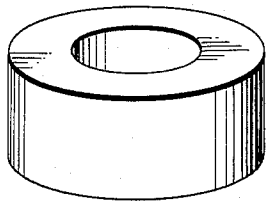

FIG. 3

INVENTORS

IRWIN M. BRUNTIL

JONAS M. SHAPIRO

BY Daniel Jay Tick

Alfred E. Miller

ATTORNEYS

United States Patent Office 3,119,022 Patented Jan. 21, 1964

3,119,022

PULSE GENERATOR

Irwin M. Bruntil, Norwalk, and Jonas M. Shapiro, Stamford, Conn., assignors to Manson Laboratories, Incorporated, Stamford, Conn., a corporation of Connecticut

Filed Mar. 10, 1958, Ser. No. 720,225
11 Claims. (Cl. 307—88)

The present invention relates to pulse generators. More particularly, the invention relates to pulse generating circuit arrangements of the type utilizing an inductor coil wound on a core.

In known pulse generating circuit arrangements of the type utilizing an inductor coil wound on a core, a magnetic tape is peripherally wound on a supporting bobbin to provide a core for a coil which is then toroidally wound about the bobbin and tape as a unit. The bobbin, being of non-magnetic material, acts as an air gap in the turns of coil wound about it. The air gap reduces the magnetic properties of the core by increasing the minimum saturated permeability and thereby severely restricting the switch action of the coil in operation. Furthermore, the edges of the tape have a tendency to short-circuit adjoining edges of the tape and to short-circuit with the bobbin itself. The extreme fragility of the tape and the tendency of the tape to lose its magnetic alignment at the least mechanical disturbance make it commercially impractical, if not impossible, to produce a tape wound core without a supporting bobbin. Furthermore, the great fragility of the tape and the small dimensions of the core make manufacturing costs very high. Aside from the great cost of manufacture, the performance of such cores in operation is very unreliable, not only because of their great fragility and tendency to lose their magnetic alignment, but due to their great susceptibility to temperature change and their degradation to slow rise times and low permeability when improperly handled.

The present invention eliminates all of the above-noted difficulties of known core arrangements by eliminating the supporting bobbin and the tape and by providing a mechanically, magnetically and electrically sound core of ferrite material.

The principal object of the present invention is the provision of a ferrite core for a pulse generating circuit.

An object of the present invention is the provision of a relatively low cost and highly reliable core for a pulse generating circuit.

Another object of the present invention is the provision of a mechanically sound core for a pulse generating circuit.

Another object of the present invention is the provision of a magnetically sound core for a pulse generating circuit.

Another object of the present invention is the provision of an electrically sound core for a pulse generating circuit.

Another object of the present invention is the provision of a core which is substantially unaffected by temperature change for a pulse generating circuit.

Another object of the present invention is the provision of a core which is very inexpensive to manufacture and which is manufactured with great facility for a pulse generating circuit.

Still another object of the present invention is the provision of a pulse generating circuit arrangement utilizing a ferrite core for producing pulses of milli-microsecond duration and of substantially high amplitude which are substantially free from jitter.

These and other objects of the invention are realized by the pulse generating circuit arrangement of the present invention.

In accordance with the present invention, a core of ferrite material is provided for an inductance of a pulse generating circuit. In the example shown, the inductance

comprises a core of ferrite material and a coil wound about said core and interposed between a high impedance input source and a resistance-capacitance output circuit.

In order that the invention may be readily carried into effect, it will now be described with reference to the accompanying drawing, wherein:

FIG. 1 is a schematic diagram of an embodiment of a pulse generating circuit arrangement utilizing a ferrite core in accordance with the present invention;

FIG. 2 is a graphical presentation of a typical B—H loop for the inductance 10 of FIG. 1; and

FIG. 3 is a perspective view of an embodiment of a ferrite core of the present invention.

FIG. 1 may comprise any suitable pulse generating circuit arrangement of the type utilizing an inductance wound on a core.

In FIG. 1, input oscillations, which are preferably sinusoidal in form, are applied to a high impedance source 2. The high impedance source 2 comprises a pentode electron discharge device 3 and a choke coil 4 connected to each other in series circuit arrangement. The input oscillations are applied to a suitable electrode of the pentode 3, preferably the control grid, through an input terminal 1 and an anode bias voltage may be applied at the point B+ of the series circuit arrangement.

A resistance-capacitance circuit 5 is connected in parallel with the high impedance source 2. The resistance-capacitance circuit 5 comprises a load impedance 6 and a capacitance 7 connected to each other in series circuit arrangement. The resistance-capacitance circuit 5 is coupled across the pentode 3 through a capacitor 8 which serves to resonate with the inductance 4 at the input frequency to keep the current of the high impedance source 2 sinusoidal.

The capacitor 7 and the impedance 6 have relatively small capacitance and resistance values, respectively, the magnitudes of which determine the form of the output. In a suitable circuit arrangement the capacitor 7 had a capacitance value of 50 micro-microfarads and the impedance 6 had a resistance value of 200 ohms. A unidirectionally conducting device 9, such as, for example, a rectifier unit, is coupled across the pentode 3 through the capacitor 8 and serves to convert the oscillations produced by the high impedance source 2 into a train of pulses of single polarity.

The inductance 10 is connected in parallel with the resistance-capacitance circuit 5 between the high impedance source 2 and said resistance-capacitance circuit; said inductance being connected across the rectifier 9 and across the said resistance-capacitance circuit and being interposed between said rectifier and the said resistance-capacitance circuit.

The inductance 10 comprises, in accordance with the present invention, a core of ferrite material. A ferrite may be defined as a ferromagnetic material having a composition corresponding approximately to MFe_2O_4, in which M is one or more bivalent metals such as manganese, magnesium, nickel, zinc, copper, cobalt or iron. The core material preferably comprises a magnesium manganese ferrite. The ferrite core may be of any suitable form or dimensions for use in a pulse generating circuit arrangement. Applicants have found that substantially toroidal ferrite cores having a thickness ranging from .015 to .060 inch, an inner diameter ranging from .030 to .120 inch and an outer diameter ranging from .050 to .230 inch are suitable; a preferred core having a thickness of .025 inch, an inner diameter of .050 inch and an outer diameter of .080 inch. The inductance 10 further comprises a coil wound about said core. A ferrite core of the present invention is shown in FIG. 3.

Output pulses may be derived from an output terminal

11 connected to the resistance-capacitance circuit 5; the impedance or resistance 6 constituting the load impedance.

The operation of the pulse generating circuit arrangement of FIG. 1 may be better understood by reference to the typical B—H loop of the inductance 10, as shown in FIG. 2. When the generator current is at its negative maximum point 20, the generator current increases toward zero and the coil 10 current travels from point 20 toward point 21. The small change in flux with the change in current results in small voltage across the coil 10 and output circuit 6. In other words, the coil 10 is a small inductance. Beyond point 21 the coil 10 suddenly becomes a large inductance. The high impedance input source 2 prevents any abrupt modification of the generator current, so most of it is forced into the resistance-capacitance circuit 5, building up a large voltage. Meanwhile, the coil 10 current changes from point 21 to a point near point 22. Here the inductance suddenly becomes very small again, and the capacitor 7 discharges rapidly, the high amplitude discharge current flowing in the coil 10 and the impedance 6. The wave form of the current pulse is determined by the resistance value of the impedance 6 and the capacitance value of the capacitor 7 and the residual inductance of the coil 10. When the capacitor 7 is discharged, the system is ready to repeat in the reverse direction.

A pulse generating circuit arrangement utilizing a ferrite core in accordance with the present invention has the following important necessary characteristics:

(1) A high generator input impedance to harmonics is provided for a large voltage build-up on the capacitor 7 and for an undistorted discharge pulse.

(2) The coil 10 behaves like a switch between a very large and a very small inductance for efficient operation.

(3) The most important characteristic of the driving generator current is its rate of change while the coil 10 is being driven from saturation in one direction to saturation in the other. Beyond that region, the large discharge current takes control. The loop is not independent of the drive speed and wave form. Eddy currents make the loop fatter, so the magnetizing force to attain saturation (point 22) moves out as one increases the speed of drive.

(4) Both the amplitude and form of the discharge depend critically on the discharge capacitor 7 and the impedance 6. For a given input circuit and coil 10 the discharge capacitor 7 is small enough to be charged up to a high voltage by the drive current, but large enough to supply the power for a high amplitude current pulse. The discharge closely resembles the free discharge of a capacitor in a simple LRC circuit. The resistance value of the impedance 6 is selected so that the circuit is nearly critically damped. If the resistance value of the impedance 6 is too small, an oscillation made of repeated pulses results every cycle; if too large, a very broad, low amplitude pulse results.

The rise time of the output pulses derived from the output terminal 11 and the maximum pulse repetition rate are a function of the number of turns wound on the ferrite core and the volume of the ferrite core. The decay time of the output pulses derived from the output terminal 11 depends upon the capacitance value of the capacitor 7 and the resistance of the impedance 6. The amplitude of the output pulses derived from the output terminal 11 is affected by the volume of the ferrite core, the number of turns wound on the ferrite core and the size of the capacitor 7 and the impedance 6.

With a suitable circuit arrangement, output pulses of 10 milli-microseconds duration at half amplitude have been obtained, said pulses having a rise time of 7 milli-microseconds and and amplitude of 35 volts. The output pulses obtained were free from jitter and had a pulse repetition rate of one megacycle per second when the circuit arrangement was driven by a one megacycle per second sine wave.

While the invention has been described by means of a specific example and in a specific embodiment, we do not wish to be limited thereto for obvious modifications will occur to those skilled in the art without departing from the spirit and scope of the invention.

What we claim is:

1. A pulse generating circuit arrangement comprising a high impedance source, means for applying a substantially sinusoidal oscillation to said high impedance source, a resistance-capacitance circuit connected in parallel with said high impedance source, an inductance connected in parallel with said resistance-capacitance circuit and interposed between the said resistance-capacitance circuit and said high impedance source, said inductance comprising a substantially toroidal core of ferrite material and a coil wound about said core, and means for deriving output pulses from said resistance-capacitance circuit.

2. A pulse generating circuit arrangement comprising a high impedance source, means for applying a substantially sinusoidal oscillation to said high impedance source, a resistance-capacitance circuit connected in parallel with said high impedance source, an inductance connected in parallel with said resistance-capacitance circuit and interposed between the said resistance-capacitance circuit and said high impedance source, said inductance comprising a substantially toroidal core of ferrite material and a coil wound about said core, said core having a thickness in the range of .015 to .060 inch, an inner diameter in the range of .030 to .120 inch and an outer diameter in the range of .050 to .230 inch, and means for deriving output pulses from said resistance-capacitance circuit.

3. A pulse generating circuit arrangement comprising a high impedance source, said high impedance source comprising a pentode discharge device having a plurality of electrodes and a first inductance connected in series circuit arrangement with said discharge device, means for applying a substantially sinusoidal oscillation to an electrode of said discharge device, a resistance-capacitance circuit connected in parallel with said discharge device, a second inductance connected in parallel with said resistance-capacitance circuit and interposed between the said resistance-capacitance circuit and said discharge device, said second inductance comprising a core of ferrite material and a coil wound about said core, and means for deriving output pulses from said resistance-capacitance circuit.

4. A pulse generating circuit arrangement comprising a high impedance source, said high impedance source comprising a pentode discharge device having a plurality of electrodes and a first inductance connected in series circuit arrangement with said discharge device, means for applying a substantially sinusoidal oscillation to an electrode of said discharge device, a resistance-capacitance circuit connected in parallel with said discharge device, a second inductance connected in parallel with said resistance-capacitance circuit and interposed between the said resistance-capacitance circuit and said discharge device, said second inductance comprising a substantially toroidal core of ferrite material and a coil wound about said core, and means for deriving output pulses from said resistance-capacitance circuit.

5. A pulse generating circuit arrangement comprising a high impedance source, said high impedance source comprising a pentode discharge device having a plurality of electrodes and a first inductance connected in series circuit arrangement with said discharge device, means for applying a substantially sinusoidal oscillation to an electrode of said discharge device, a resistance-capacitance circuit connected in parallel with said discharge device, a second inductance connected in parallel with said resistance-capacitance circuit and interposed between the said resistance-capacitance circuit and said discharge device, said second inductance comprising a substantially toroidal core of ferrite material and a coil wound about said core, said core having a thickness in the range of .015 to .060 inch, an inner diameter in the

range of .030 to .120 inch and an outer diameter in the range of .050 to .230 inch, and means for deriving output pulses from said resistance-capacitance circuit.

6. A pulse generating circuit arrangement comprising a high impedance source, said high impedance source comprising a pentode discharge device having at least a control electrode and an anode and a first inductance connected in series circuit arrangement with said discharge device, means for applying a substantially sinusoidal oscillation to said control electrode of said discharge device, a resistance-capacitance circuit, means connecting said resistance-capacitance circuit in parallel with said discharge device, said connecting means comprising a capacitor coupling said anode of said discharge device to said resistance-capacitance circuit, a second inductance connected in parallel with said resistance-capacitance circuit and interposed between the said resistance-capacitance circuit and said discharge device, said second inductance comprising a core of ferrite material and a coil wound about said core, and means for deriving output pulses from said resistance-capacitance circuit.

7. A pulse generating circuit arrangement comprising a high impedance source, said high impedance source comprising a pentode discharge device having at least a control electrode and an anode and a first inductance connected in series circuit arrangement with said discharge device, means for applying a substantially sinusoidal oscillation to said control electrode of said discharge device, a resistance-capacitance circuit, means connecting said resistance-capacitance circuit in parallel with said discharge device, said connecting means comprising a capacitor coupling said anode of said discharge device to said resistance-capacitance circuit, a second inductance connected in parallel with said resistance-capacitance circuit and interposed between the said resistance-capacitance circuit and said discharge device, said second inductance comprising a substantially toroidal core of ferrite material and a coil wound about said core, and means for deriving output pulses from said resistance-capacitance circuit.

8. A pulse generating circuit arrangement comprising a high impedance source, said high impedance source comprising a pentode discharge device having at least a control electrode and an anode and a first inductance connected in series circuit arrangement with said discharge device, means for applying a substantially sinusoidal oscillation to said control electrode of said discharge device, a resistance-capacitance circuit, means connecting said resistance-capacitance circuit in parallel with said discharge device, said connecting means comprising a capacitor coupling said anode of said discharge device to said resistance-capacitance circuit, a second inductance connected in parallel with said resistance-capacitance circuit and interposed between the said resistance-capacitance circuit and said discharge device, said second inductance comprising a substantially toroidal core of ferrite material and a coil wound about said core, said core having a thickness in the range of .015 to .060 inch, an inner diameter in the range of .030 to .120 inch and an outer diameter in the range of .050 to .230 inch, and means for deriving output pulses from said resistance-capacitance circuit.

9. A pulse generating circuit arrangement comprising a high impedance source, said high impedance source comprising a pentode discharge device having at least a control electrode and an anode and a first inductance connected in series circuit arrangement with said discharge device, means for applying a substantially sinusoidal oscillation to said control electrode of said discharge device, a resistance-capacitance circuit, means connecting said resistance-capacitance circuit in parallel with said discharge device, said connecting means comprising a capacitor coupling said anode of said discharge device to said resistance-capacitance circuit, a second inductance connected in parallel with said resistance-capacitance circuit and interposed between the said resistance-capacitance circuit and said discharge device, said second inductance comprising a core of ferrite material and a coil wound about said core, means for converting oscillations produced by said high impedance source into a train of pulses of single polarity, said converting means being connected in parallel with said second inductance and interposed between the said second inductance and said discharge device, and means for deriving output pulses from said resistance-capacitance circuit.

10. A pulse generating circuit arrangement comprising a high impedance source, said high impedance source comprising a pentode discharge device having at least a control electrode and an anode and a first inductance connected in series circuit arrangement with said discharge device, means for applying a substantially sinusoidal oscillation to said control electrode of said discharge device, a resistance-capacitance circuit, means connecting said resistance-capacitance circuit in parallel with said discharge device, said connecting means comprising a capacitor coupling said anode of said discharge device to said resistance-capacitance circuit, a second inductance connected in parallel with said resistance-capacitance circuit and interposed between the said resistance-capacitance circuit and said discharge device, said second inductance comprising a substantially toroidal core of ferrite material and a coil wound about said core, means for converting oscillations produced by said high impedance source into a train of pulses of single polarity, said converting means being connected in parallel with said second inductance and interposed between the said second inductance and said discharge device, and means for deriving output pulses from said resistance-capacitance circuit.

11. A pulse generating circuit arrangement comprising a high impedance source, said high impedance source comprising a pentode discharge having at least a control electrode and an anode and a first inductance connected in series circuit arrangement with said discharge device, means for applying a substantially sinusoidal oscillation to said control electrode of said discharge device, a resistance-capacitance circuit, means connecting said resistance-capacitance circuit in parallel with said discharge device, said connecting means comprising a capacitor coupling said anode of said discharge device to said resistance-capacitance circuit, a second inductance connected in parallel with said resistance-capacitance circuit and interposed between the said resistance-capacitance circuit and said discharge device, said second inductance comprising a substantially toroidal core of ferrite material and a coil wound about said core, said core having a thickness in the range of .015 to .060 inch, an inner diameter in the range of .030 to .120 inch and an outer diameter in the range of .050 to .230 inch, means for converting oscillations produced by said high impedance source into a train of pulses of single polarity, said converting means being connected in parallel with said second inductance and interposed between the said second inductance and said discharge device, and means for deriving output pulses from said resistance-capacitance circuit.

References Cited in the file of this patent

UNITED STATES PATENTS

2,419,201	Crump	Apr. 22, 1947
2,436,395	Manley	Feb. 24, 1948
2,439,389	Hussey	Apr. 13, 1948
2,452,529	Snoek	Oct. 26, 1948
2,704,842	Goodell	Mar. 22, 1955
2,773,184	Rolf	Dec. 4, 1956
2,819,395	Jones	Jan. 7, 1958
2,827,575	Smith	Mar. 18, 1958
2,849,625	Germain	Aug. 26, 1958
2,929,942	Shepard	Mar. 22, 1960
2,964,637	Keizer	Dec. 13, 1960