April 23, 1968 W. B. LUNT ET AL 3,380,008

INDUCTIVE-KICK SUPPRESSION SOLENOID

Filed Dec. 2, 1965

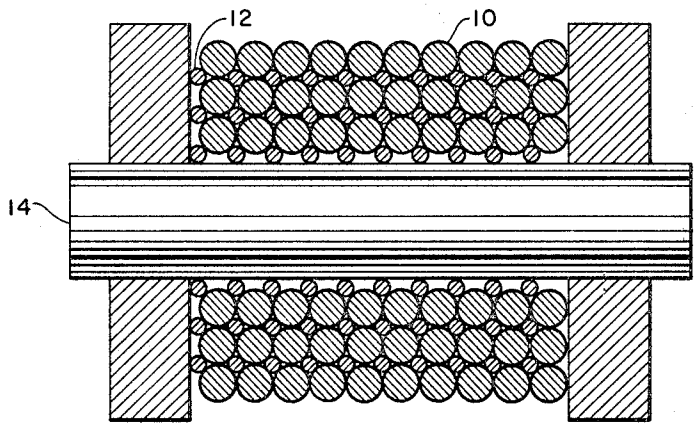


FIG. 1

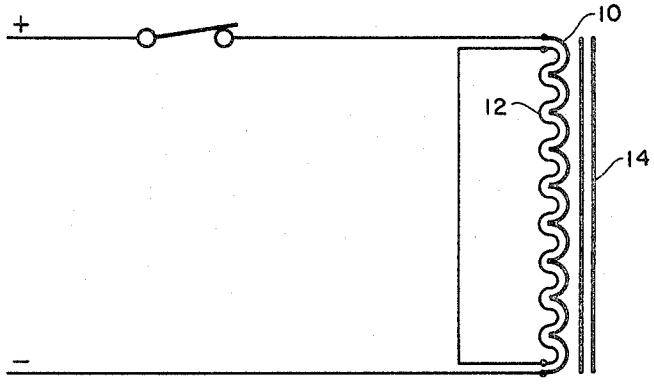


FIG. 2

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United States Patent Office 3,380,008
Patented Apr. 23, 1968

3,380,008

INDUCTIVE-KICK SUPPRESSION SOLENOID

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Filed Dec. 2, 1965, Ser. No. 511,566
2 Claims. (Cl. 336—73)

ABSTRACT OF THE DISCLOSURE

A solenoid having inductive-kick suppression by use of a permanently shorted secondary winding of smaller wire size simultaneously wound in the interstices of the larger wire size primary winding and which also allows the windings to be very closely coupled and better withstand environs of vibration and temperature.

The invention herein described may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

The present invention relates to solenoid windings and more particularly to a solenoid having inductive-kick suppression.

When current is flowing in an inductor, energy computed by $\frac{1}{2}LI^2$ joules is stored in its magnetic field. When the current circuit is interrupted by the opening of a switch, the magnetic field collapses and by a self-inductive action in which the collapsnig field cuts the many turns of the coil, an EMF is generated whose amplitude is instantaneously measured by $(-)L\frac{di}{dt}$. Since this measures the voltage drop across the inductor, the minus sign is included to indicate that the inductor has switched roles from that of a load to that of a generator and in order that external cricuit current flow be in the same direction its polarity has reversed—thus "back" EMF. If the current interruption is fast and clean, and the rate of change of current is thus high, the back EMF may rise to extremely high values; in the practical case, however, the voltage rises only until an arc is formed somewhere that allows a restart of some part of the original current flow. Though in some cases this breakdown may occur across the turns of the solenoid itself, and damagingly so, again in the practical case the breakdown usually occurs across the opening switch. When this happens, the current is restarted, collapse of the inductor magnetic field is slowed or stopped and the high voltages disappear. Immediately then, and aided by extremely high frequency oscillations due to small distributed capacities, the arc extinguishes, the high voltages reappear, the arc reappears and the cycle is repeated. A kind of modulated relaxation oscillator is formed which continues until the inductor-stored energy is largely dissipated in heat and light at the arcing points. The total result is a burst of high potential hash, with high amplitude components commonly in the megacycle or even hundreds of megacycles region. This hash not only appears on the power line but may capacitively couple into otherwise completely isolated circuits. This problem has in general dictated the use of an electronic component in many circuit designs to suppress the inductive kick. The function of such a component is always to provide a path for the continued solenoid current flow on switch opening and thereby allow the inductor to dissipate its stored energy over a longer period of time without the need for the creation of a high-voltage arc. There are many ways in which this suppression can be accomplished, the techniques varying widely in efficiency and reliability. The means or components most commonly employed for inductive kick suppression are capacitors

or capacitor-resistor combinations, diodes, or varistors, etc.

The present invention provides a means for effectively suppressing the inductive-kick without the use of electronic components.

In the present invention, at the time of winding the coil of a D.C. solenoid, a secondary full coil of smaller wire is also wound simultaneously. Optimum wire size of the secondary winding may require adjustment, but in general a secondary coil wire size about six wire gage numbers smaller than the primary has proven very effective. By simultaneously winding the two coils on the solenoid core production time is very little increased and the smaller secondary wire tends to fall in the interstices of the primary coil turns, thus only slightly increasing the overall coil volume required. After winding, the ends of the secondary coil are permanently connected together. In operation, when the primary coil power line is opened, the permanently shorted secondary coil absorbs the energy stored in the primary and thereby suppresses the inductive-kick.

It is an object of the invention to provide an inductive-kick suppression solenoid.

Another objective of the invention is to provide a solenoid coil having inductive-kick suppression with substantially no increase in total size.

A further object of the invention is to provide a solenoid requiring no additional or costly electronic components for suppression of inductive-kick.

Other objects and many of the attendant advantages of this invention will become readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

As illustrated in FIGS. 1 and 2 of the drawings, the solenoid is constructed by simultaneously winding a primary winding **10** and a secondary winding **12** on the solenoid core **14**. The ends of secondary winding are connected together as shown in FIG. 2.

Since the two windings are wound simultaneously, their wire lengths are equal. Optimum effectiveness of the secondary winding **12** is achieved by adjusting its wire size. From a technical standpoint, too large a wire gives too low a secondary resistance to dissipate the stored energy in the short time permitted, while the high resistance of a too-small wire does not allow the secondary to effectively load the primary. A secondary consideration is that secondary winding wire of equal or larger size than the primary would greatly increase the total volume of wire required. For the ranges of voltage (25–135 v. D.C.) and power (20–40 watts) often employed for solenoids, it turns out that a highly effective secondary winding can be achieved using a wire size which is nominally six standard wire gage numbers smaller in diameter than the primary. For certain solenoids, such a wire size ratio produces an inductive kick suppression equal to or better than that accomplished by an appropriate varistor, heretofore the most commonly used suppression method.

The much smaller diameter secondary winding wire **12**, when wound simultaneously with the primary winding wire **10**, permits efficient utilization of the total volume allowable for the wire, as can be seen from FIG. 1, and allows closer coupling. The addition of secondary winding **12** does increase the size of the solenoid approximately 15 percent over the single winding solenoid. If the primary winding **10** of the present solenoid has the same number of turns as a regular single winding solenoid, the tractive force of the solenoid is not compromised by the presence of the secondary winding **12**.

When the solenoid power line is opened, the collapsing

magnetic field couples the energy stored in the primary to the shorted secondary. The secondary provides a path of moderate resistance for the current generated in the secondary by the collapsing magnetic field of the primary. The energy is therefore dissipated in the secondary without the creation of deleterious high potentials or the need for an added electric component to permit energy dissipation in the primary circuit.

The advantage of the extra winding **12** wound along with the primary winding **10** of the solenoid is the elimination of any required electronic components and the costly process of installing them. In addition, diodes are polarity sensitive and may be destroyed if the solenoid voltage is accidentally reversed. Varistors are susceptible to overheating and subsequent failure. Another advantage is that the two closely coupled windings of the instant solenoid permit it to withstand all the environs of vibration, temperature, and the like. The simultaneous wrapping of the two windings of disparate wire size are integral chartcteristics of this invention, and no alternatives to this method are suggested if this invention is to be properly applied.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A solenoid device which also effectively suppresses inductive-kick without the use of electronic components, comprising:

(a) a solenoid core,

(b) first and second closely coupled wire windings simultaneously wound on said core,

(c) the ends of said first winding capable of being connected to a power source for operation of the solenoid,

(d) said second winding having its ends permanently connected together in a direct short for providing a path of moderate resistance for current generated therein,

(e) said first and second windings having the same number of turns and substantially equal lengths,

(f) said second winding being of smaller wire size than said first winding and wound simultaneously therewith with said second winding occupying the interstices of the turns of the first winding for efficient utilization of total wire volume, and the effectiveness of said second winding being varied by adjusting the ratio of its wire size to the wire size of said first winding,

wherein the collapsing of a magnetic field created by power in said first winding couples the energy stored in the first winding to the shorted second winding for dissipating said energy in the second winding without creation of deleterious high potentials.

2. A device as in claim **1** wherein the wire of said second winding is six standard gage sizes smaller in diameter than the wire of said first winding.

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