United States Patent [19]

Gamble

[11] **3,879,601**

[45] **Apr. 22, 1975**

[54] **ELECTROMAGNETICALLY POWERED DRIVE FOR A HIGH SPEED COUNTER**

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[22] Filed: **Jan. 29, 1973**

[21] Appl. No.: **327,716**

[52] **U.S. Cl.** .... **235/92 C;** 235/92 R; 335/266

[51] **Int. Cl.** **G06m 1/10**

[58] **Field of Search** .... 235/92 C, 1 C, 91 M; 335/266

[56] **References Cited**

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[57] **ABSTRACT**

An electromagnetic operator comprises a plurality of identical solenoids mounted on a common base and having magnetic circuits which are independent of each other. The solenoids attract a common armature and are connected in parallel electrical circuit relationship with the paralleled solenoids connected in series with a single resistor to provide a faster acting armature with lower power consumption.

6 Claims, 4 Drawing Figures

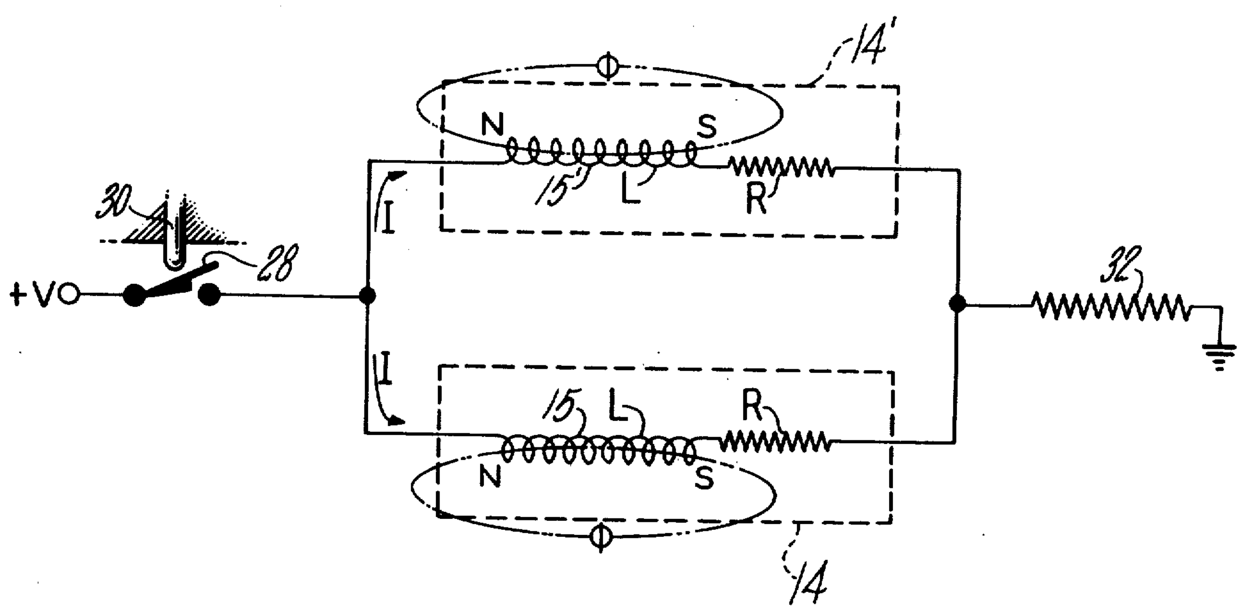


FIG. 1

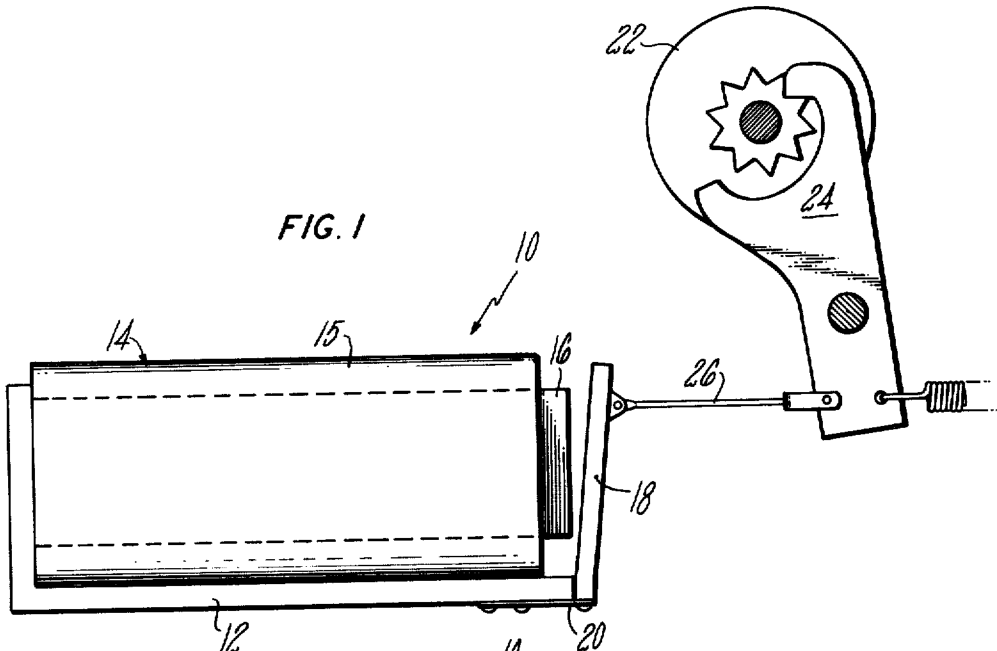


FIG. 2

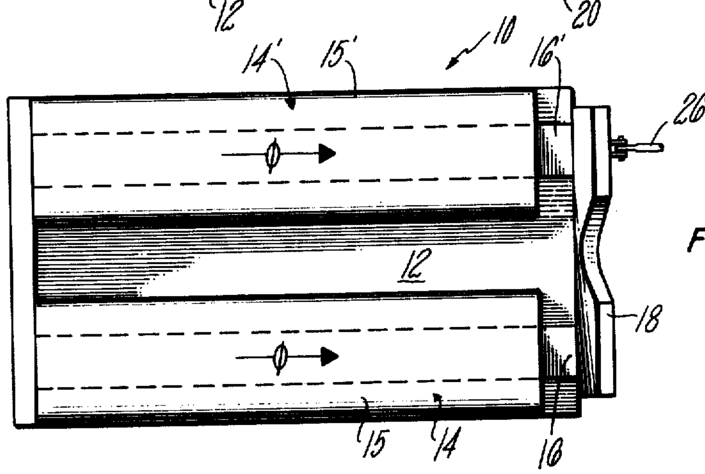


FIG. 3

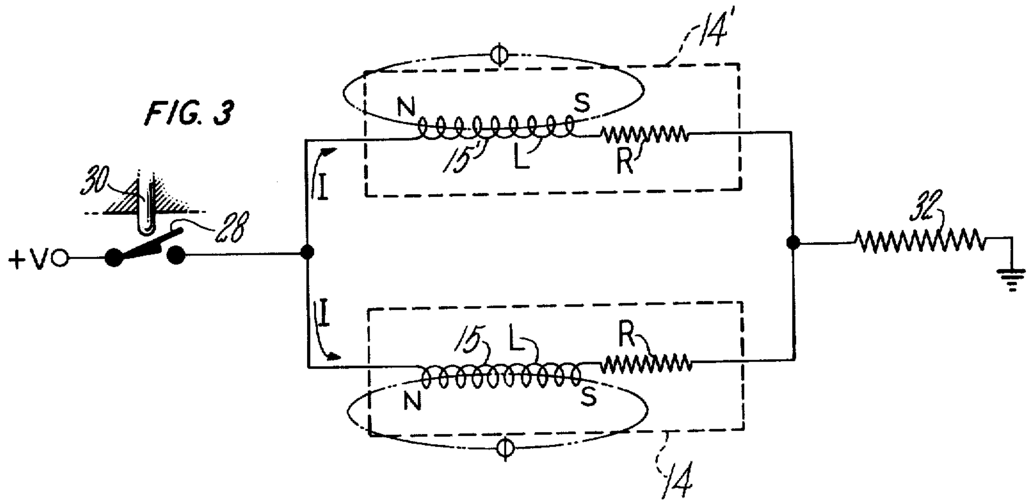
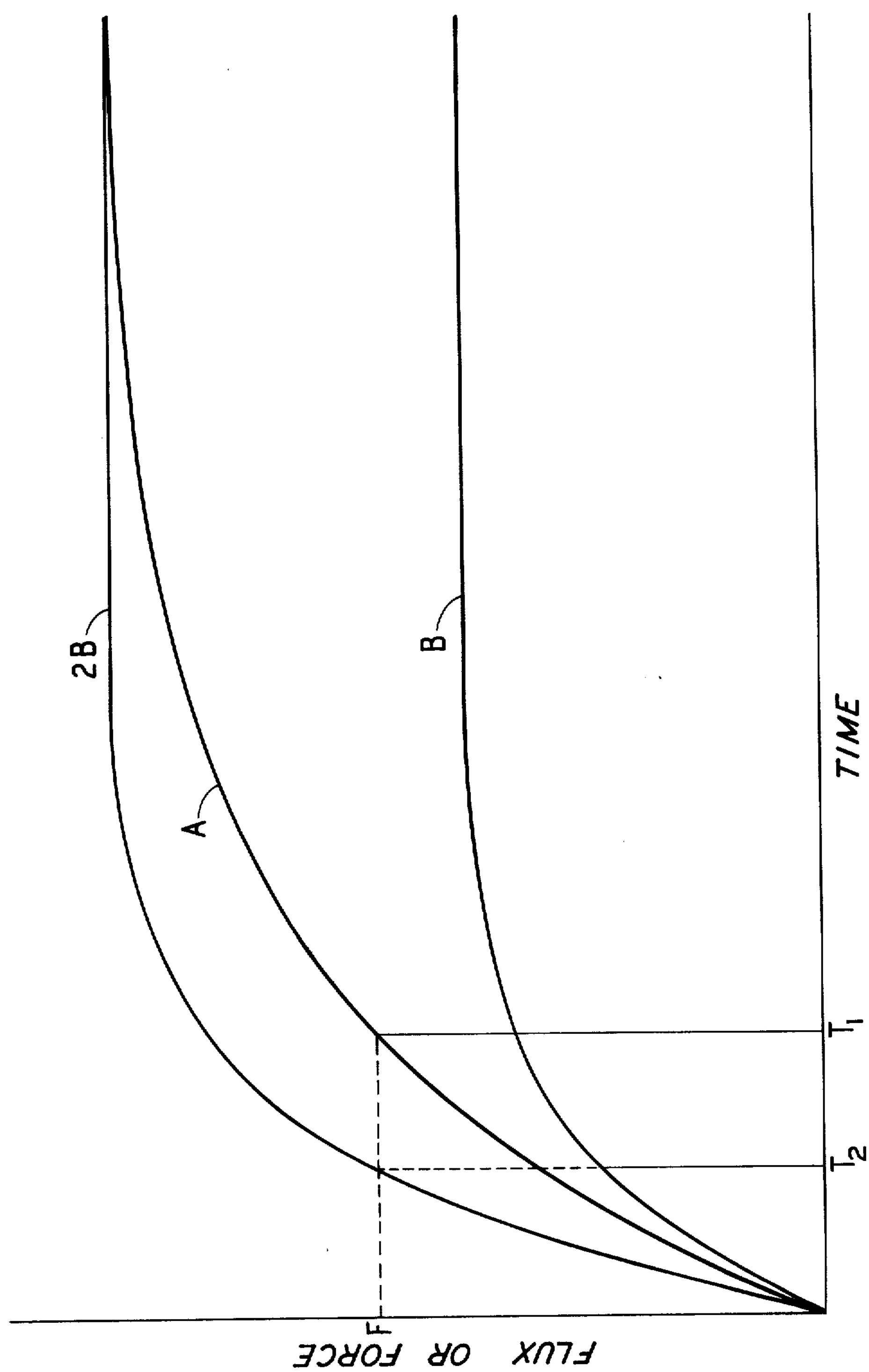


FIG. 4



ELECTROMAGNETICALLY POWERED DRIVE FOR A HIGH SPEED COUNTER

This invention relates to an electromagnetically powered drive and is especially concerned with such a drive for actuating a high speed counter such as disclosed in the U.S. Pat. No. 3,578,954 assigned to the assignee of the present invention.

A drive for a high speed electromagnetically powered counter should provide for a rapid build-up of mechanical power when a pulser energizes the solenoid operator of the counter in response to a functioning of a pulser which is responsive to movements to be counted. This requires a high rate of flux generation in the solenoid to provide a rapid build-up of magnetic forces to attract the armature in accordance with Coulomb's Law. However, the inductance of the electrical coil of the solenoid causes a counter EMF to be generated in the coil which, in accordance with Lenz's Law, is in a direction to oppose the applied voltage. Such counter EMF is proportional to the rate of change of flux in the solenoid which is greatest when the pulser first functions to energize the coil and delays the current build-up in the solenoid.

In the past, electromagnetically powered operators for high speed actuation have had an increased voltage applied across their windings to increase their speed of operation. However, this increased the counter EMF when the coil was first energized to decrease the rate of current build-up. Since, for a given solenoid, flux is proportional to current and the mechanical force attracting the armature is proportional to flux, such an increase in applied voltage was accompanied by an increase in the build-up of mechanical force but required a disproportionate increase in power to increase the speed of operation. In addition, this resulted in greater shock impact of the armature on the core of the solenoid of the operator which in turn caused armature "bounce" or rebound producing an instability of operation and increased wear and significantly decreased life. When used as a drive for a high speed counter, the instability sometimes caused false counts and erratic operation. This invention overcomes these problems by providing a stable, high speed electromagnetically powered drive suited for actuating a high performance high speed counter without an increase in power.

It is the primary object of this invention to provide an electromagnetically powered drive wherein the rate of build-up of mechanical forces attracting the armature is increased.

Another object of this invention is to provide an electromagnetically powered drive having a reduced time for substantially increasing the build-up of attracting force on the armature wihtout an increase in the voltage applied to the solenoid of the drive.

Still another object of this invention is to provide a high performance counter having a soft high speed electromagnetically powered drive.

A further object of this invention is to provide a soft stable high speed electromagnetically powered drive.

Other objects will be in part obvious and in part pointed out more in detail hereinafter.

A better understanding of the invention will be obtained from the following detailed description and the accompanying drawing of an illustrative application of the invention.

In the drawings,

FIG. **1** is a fragmentary side view of a high performance counter incorporating an exemplary electromagnetically powered drive of this invention;

FIG. **2** is a partial top view of the drive of FIG. **1**;

FIG. **3** is a schematic electrical circuit suitable for the practice of the invention; and

FIG. **4** is a graph representative of the build-up of flux in an electromagnetic drive and a prior art drive.

As shown in the drawings, an electromagnetic drive **10** is provided with an L-shaped base **12** on which a solenoid **14** having a winding **15** and an iron core **16** is mounted. An armature **18** hinged to the base **12** at **20**, is connected to a ratchet wheel **22** of a counter through a verge **24** and a pull rod **26** for advancing the count indicated by the counter in discrete steps indicative of the number of movements being counted. A pulser, e.g., switch contacts **28**, is provided for closing and opening the electrical circuit for energizing the solenoid winding **15** in response to the movements to be counted which cause the closure of the switch **28** by a switch actuator **30**.

As best shown in FIG. **2** the electromagnetic drive **10** includes a second solenoid **14'** having a winding **15'** and an iron core **16'** mounted on L-shaped base **12** to the side of the first solenoid **14**. Preferably, in the practice of this invention, solenoids **14** and **14'** have the same number of turns, N, of the same wire size, and the iron cores **16** and **16'** have the same magnetic reluctance. The L-shaped base **12** together with the armature **18** and the cores **16, 16'** form two independent magnetic circuits for the two coils.

As shown in FIG. **3**, the windings **15** and **15'** are also connected in parallel across the applied voltage and have a resistance R and an inductance L.

Schematically, a resistor **32** is shown as being connected in series with the paralleled windings **14** and **14'**.

When a voltage, V, is applied to a normal electromagnetic operator having a single solenoid such as solenoid **14**, a current, I, flows through the winding **15**, to cause the current through the winding to build-up to steady state conditions.

It is well known that the self-inductance, L, of a solenoid is stated by the equation:

$$1)\quad L = \frac{N\phi}{I},$$

where N is the number of turns of the winding, I is the current, and ϕ is the flux.

It is also well known that the time constant, T_c, for a coil, that is the time required for the current to reach 63.2% of its steady state value after voltage, V, is applied, is given by the equation:

$$2)\quad T_c = \frac{L}{R},$$

where L is the self-inductance of the coil and R is resistance.

Substituting the value of L in equation (1) for L in equation **2**, the resulting equation is obtained:

$$3)\quad T_c = \frac{\frac{N\phi}{I}}{R}, \text{ or } \frac{N\phi}{IR}$$

Since ϕ is proportional to I, equation 3 can be expressed as:

$$4)\quad T_r \alpha \frac{N}{R}.$$

Curve A of FIG. 4 illustrates the build-up of flux in a prior art electromagnetic operator having a single solenoid with T_1 indicating the time constant, T_r of the operator at a fixed circuit reluctance and connected across a given voltage, V.

In accordance with this invention, I have provided a plurality of solenoids which exert independent attraction or pull on the armature to provide an operator capable of reliable operation at increased speed or at the same speed with less wear requiring less power.

As disclosed above, the illustrated embodiment is provided with two solenoids **14, 14'**, which are connected in parallel with each other and in series with pulser **28** across a source of voltage, V. Solenoids **14, 14'** have magnetic circuits which are isolated from each other and have no magnetic coupling. As shown, a resistor **32** is connected in series with the paralleled solenoids **14, 14'**.

Since each of the solenoids **14, 14'** attract the armature **18**, their attracting force is added mechanically, and accordingly each needs to contribute only one-half the mechanical force required to power the armature. To achieve this, the steady state voltage applied across solenoid **14** and solenoid **14'** need be only one-half which it would be if only a single solenoid of identical electrical and magnetic properties were used. To reach this result, resistor **32** is sized to produce one-half the steady state voltage drop with voltage, V, applied to the same operator **10** having a single identical solenoid **14.** The steady state voltage drop across each of the solenoids **14, 14'** will also be one-half the voltage, V.

With such an arrangement as shown in FIG. **3**, curve B of FIG. **4** represents the build-up of flux for attracting the armature by one of the solenoids **14, 14'**. It will be appreciated that, under the circumstances indicated, the current through each of the solenoids **14, 14'** will be one-half the total current since these solenoids are electrically connected in parallel so that each carries only one-half the current which passes through resistor **32** which limits the steady state current to the same current level as in the representative prior art operator described above.

As shown, in FIG. **4**, T_1 indicates the time constant, T_r, for a single one of the indentical solenoids **14, 14'**, and graphically illustrates that its time constant is one-half that of the prior art operator using an identical solenoid as represented by point T_1 of curve A.

Since solenoid **14** and solenoid **14'** are acting on the armature **18** simultaneously, their pull or attractive force on armature **18** is double that of either one alone. This is represented graphically by curve **2B** which demonstrates that the time T_2 required to develop a given flux level for attracting armature **18** is one-half as long for two solenoids **14, 14'** arranged in accordance with this invention as when an identical solenoid is used alone to power a prior art operator as described above.

Accordingly, for a given level of attractive force on the armature **18** the use of a pair of identical solenoids having independent magnetic circuits and connected electrically in parallel and in series with a resistor having a resistance value equal to that of one of the solenoids will produce a faster acting armature than a single identical solenoid acting alone.

It is further apparent that if a plurality, P, of magnetically isolated solenoids are connected in parallel electrically to power a common armature, the force required of each solenoid will be 1/P times that of one of the solenoids acting alone. This will result in a further reduced time constant for the operator which may be represented by a fraction in which the numerator is 1 and the denominator is the number, P, of solenoids powering the common armature.

As will be apparent to persons skilled in the art, various modifications, adaptations and variations of the foregoing specific disclosure can be made without departing from the teachings of the present invention.

I claim:

1. An electromagnetically powered drive comprising a source of pulses, a plurality of solenoids having magnetic circuits which are independent of each other and a common armature means attracted by said solenoids simultaneously, said solenoids being connected in series with said source of pulses and in parallel electrical circuit relationship with each other, and a resistor to decrease the time constant of the solenoids and limit the steady state current therethrough electrically connected in series with said paralleled solenoids.

2. The drive of claim **1** wherein the number of turns and the resistances of said solenoids are substantially equal.

3. The drive of claim **1** wherein the solenoids share a common base.

4. The drive of claim **3** wherein said common base for said solenoids forms independent magnetic flux path for each of said solenoids.

5. The device of claim **1** including a mechanical counter connected to said armature to be actuated thereby.

6. The device of claim **1** wherein the resistor is sized to produce a steady-state voltage drop equal to the voltage drop across the solenoids.

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