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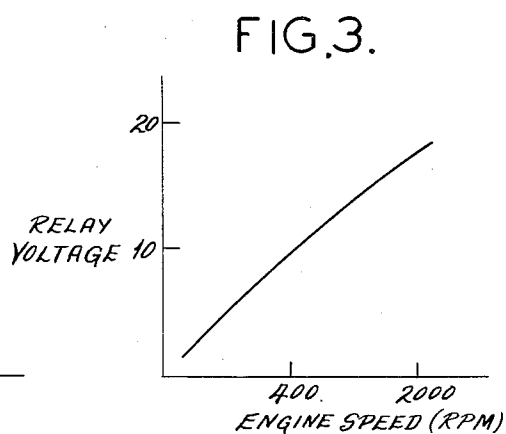
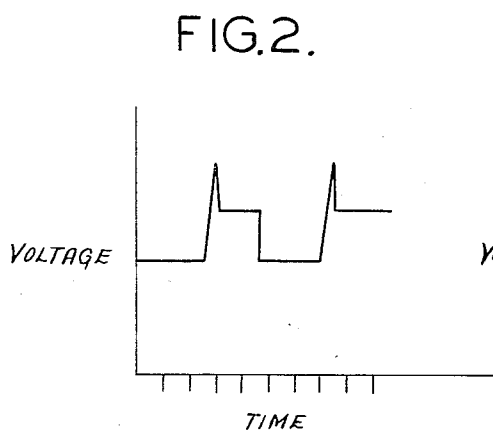
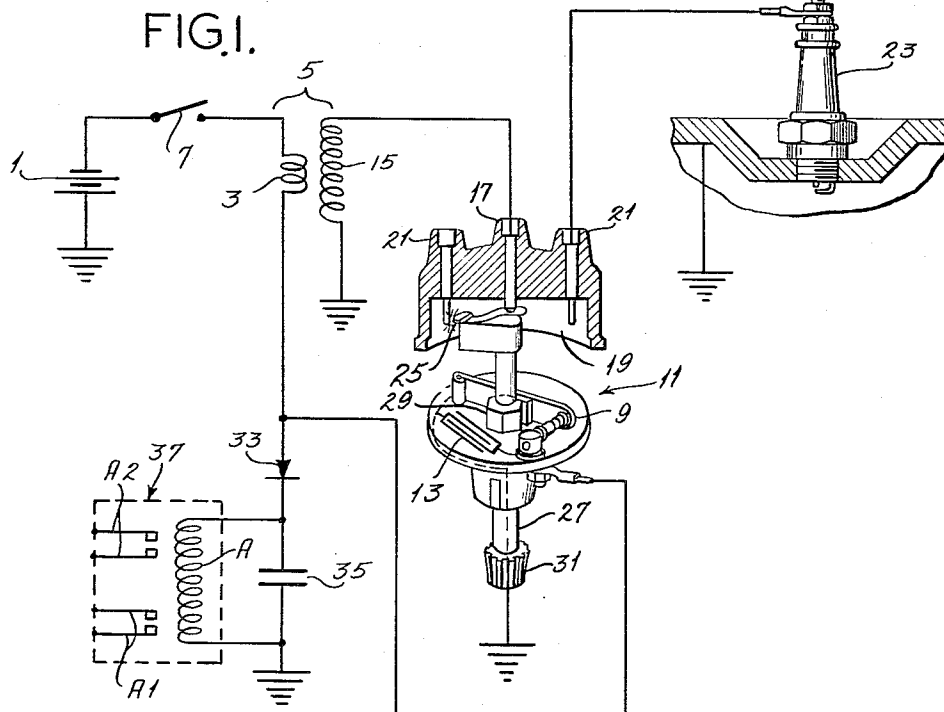
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2,761,538

ELECTROMAGNETIC CONTROLS

Filed Aug. 12, 1953

2 Sheets-Sheet 1



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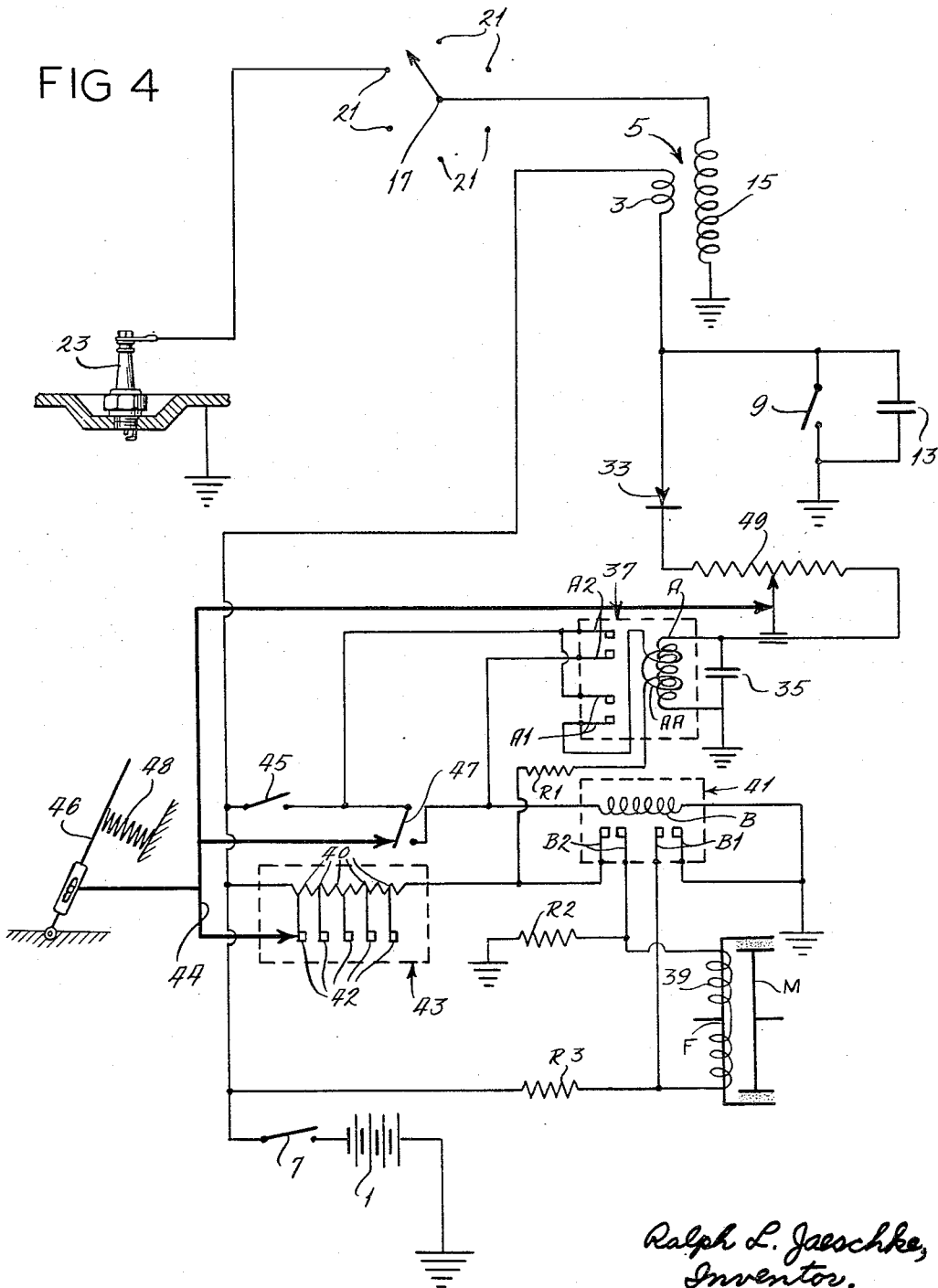
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2 Sheets-Sheet 2

FIG 4



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2,761,538

ELECTROMAGNETIC CONTROLS

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Application August 12, 1953, Serial No. 373,704

3 Claims. (Cl. 192—21.5)

This invention relates to electromagnetic controls and more particularly to speed-responsive and residual magnetism cancellation controls such as may be used, for example, in excitation circuits of electric clutches and the like on automotive vehicles.

Among the several objects of this invention are the provision of speed-responsive switch controls which are particularly useful in connection with vehicle engines; the provision of controls of this type which are inexpensive in construction and reliable in operation; the provision of such controls which may be conveniently adjusted; and the provision of controls which cancel the residual magnetic effects in electromagnetic couplings. Other objects and features will be in part apparent and in part pointed out hereinafter.

Briefly, the invention is directed to a speed-responsive switch control comprising a rectifier unit, an electrical relay having a coil and at least one pair of electrical contacts and a condenser connected across the relay coil. The relay coil and rectifier are series-connected across the distributor circuit interrupter or contact breaker of an internal combustion engine so that, when the engine speed exceeds a predetermined value, the relay contacts are actuated. The invention is also directed to control apparatus for electromagnetic couplings such as brakes or clutches which provide a reverse current flow through an exciting coil of coupling during decoupled periods which cancels residual magnetic effects in the members of the coupling.

The invention accordingly comprises the constructions hereinafter described, the scope of the invention being indicated in the following claims.

In the accompanying drawings, in which several of various possible embodiments of the invention are illustrated,

Fig. 1 is a diagram showing a speed-responsive switch control of the present invention associated with the ignition system of a motor vehicle;

Fig. 2 is a graphic representation of the voltage across a circuit interrupter plotted as a function of time;

Fig. 3 is a graphic representation of the relay voltage plotted as a function of motor speed; and,

Fig. 4 is a circuit diagram of a second embodiment of the invention connected in an automotive vehicle clutch-control circuit and including control apparatus for cancellation of residual magnetic effects in the clutch.

Corresponding reference characters indicate corresponding parts throughout the several views of the drawings.

The engine-speed-responsive switches in general use today are usually controlled by centrifugal governors. Such switches are relatively expensive and are not conveniently adjustable. In accordance with the present invention, I have devised speed-responsive switch controls which derive their actuating signal from pulses generated in the coil-ignition system of an internal-combustion motor. These controls are inexpensive, reliable and easily adjustable.

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Referring now more particularly to Fig. 1, a source of electromotive force such as a storage battery of the type conventionally employed in motor vehicles is indicated by reference numeral 1. One terminal of a primary winding 3 of a high-tension induction transformer 5 is connected through an ignition switch 7 to battery 1. The other terminal of primary 3 is connected to a circuit interrupter or contact-breaker 9 of a standard automotive distributor 11. A condenser 13 of the type usually employed in distributors is connected across breaker 9. The electrical series circuit including battery 1, ignition switch 7, primary 3 and breaker 9 is completed through the illustrated ground connections. A conventional ignition resistor may also be connected in series with this circuit, if desired. A secondary winding 15 of transformer 5 is connected between ground and a central terminal 17 of a head 19 of distributor 11. Other terminals 21 are connected to spark plugs of an internal-combustion engine, one of which is illustrated at reference numeral 23. The high-tension or secondary circuit includes secondary winding 15, a distributor brush 25, distributor terminals 17 and 21, plugs 23 and the ground return. The lower terminal of winding 15 can be made electrically common to the lower terminal of primary 3 rather than being grounded, but is not shown, being a well-known alternative. Brush 25 is mounted on one end of a distributor shaft 27 which also carries a cam 29 for intermittently opening the contacts of breaker 9. Shaft 27 is driven by the internal-combustion engine, usually by the camshaft through a gear such as is indicated at reference numeral 31.

A series circuit, comprising rectifier unit 33 and a condenser 35, is connected across the contacts of breaker 9. Coil A of a relay 37, having contacts A-1 and A-2, is connected in parallel with condenser 35.

Operation is as follows:

Upon closing the ignition switch 7, the primary circuit of transformer 5 is completed and a direct current will flow through winding 3 and breaker 9. When the internal-combustion engine is started, shaft 27 is rotated at the motor speed and will cause intermittent opening and closing of breaker 9 in response to movement of cam 29. A signal voltage is thereby developed across the contacts of breaker 9, such as is exemplified in Fig. 2. The developed signal voltage, which during normal operation may have an amplitude on the order of 60 volts at engine idling speed, consists of a series of substantially square-wave pulses. This signal is impressed across rectifier 33 and the R-C circuit comprising the resistance of relay coil A and the capacitance of condenser 35. This signal is relatively constant in amplitude and has a frequency which is a function of engine speed. As the speed of the engine increases, the voltage impressed across relay coil A (due to the increased frequency of the signal fed to this R-C circuit) increases substantially proportionately, as shown in Fig. 3.

The amplitude of the voltage across coil A is determined by several factors, including the amplitude and pulse frequency of the signal; the capacitance of condenser 35; and the resistance of coil A. The contacts A-1 and A-2 of relay 37 will be actuated to a closed position when the amplitude of this voltage across coil A exceeds that at which relay 37 is designed to be energized. Conversely, when the amplitude of this voltage across coil A falls below the value necessary to keep contacts A-1 and A-2 actuated, they will be deactivated.

Relay 37 may be selected from any of the semi-sensitive types of relays known to the art. It should have a coil with a relatively high D. C. resistance, so that the coil ignition circuit will not be adversely affected by the load thereof. Exemplary values for this coil are 5,000–10,000 ohms and for condenser 35 are 0.1–1.0 mfd.

Rectifier 33, which is preferably a diode type rectifier, prevents discharge of condenser 35 during the time that the contacts of breaker 9 are closed.

The secondary circuit of transformer 5 functions in its usual capacity to supply timed high-tension-pulses to distributor 11 for sequentially energizing the respective plugs.

It can be seen, therefore, that the actuation of the relay contacts in response to engine speed can be utilized in controlling various operations in an automotive vehicle in response to engine speed. An exemplary embodiment of my control in clutch apparatus is illustrated in Fig. 4.

In Fig. 4, reference numeral 39 indicates a field coil, preferably of an electromagnetic clutch of a type having inherent self-modulating characteristics adapted for non-slip or minimum slip operation after modulated engagement. The clutch comprises an armature M and a field member F. Examples of clutches of this general type are disclosed in U. S. Patents 2,519,449, 2,525,571, 2,543,394 and 2,580,869. Patents 2,519,449 and 2,543,394 show electromagnetic couplings including relatively rotary armature and field members with a magnetic gap therebetween containing magnetizable fluid or flowable material.

Clutch field coil 39 is connected to battery 1 through contacts B-1 and B-2 of a relay 41, a sequential-contact or "caterpillar" type modulating current controller 43, ignition switch 7, and a ground return. The current controller has a series of contacts 42 normally spaced from one another and adapted to be sequentially closed by movement of an actuator 44 in the direction indicated progressively to short-circuit resistor segments 49. Actuator 44 in turn is mechanically coupled to an accelerator 46 of the motor vehicle so that the controller 43 is actuated in the direction indicated as the accelerator is depressed against the bias of spring 48. A circuit utilizing such a controller is described in more detail in the copending U. S. application of Andrew S. Gill, Jr., Serial No. 280,086, filed April 2, 1952, now Patent No. 2,688,388, issued September 7, 1954.

The actuation of contacts B-1 and B-2 is controlled by a coil B of relay 41 which is connected to battery 1 by a circuit including ignition switch 7, a shift switch means 45, an accelerator position switch 47, and a ground return connection.

Shift switch means 45 is responsive to initiation and completion of a manual shifting operation of a conventional shift lever of a motor vehicle. For example, it may be a switch mechanism such as described in the aforementioned copending application Serial No. 280,086. Switch 45, therefore, will be normally closed except from the time the movement of the switching lever is initiated until the time the switch lever is released.

Switch 47 is mechanically coupled to the motor vehicle accelerator pedal 46 through a suitable actuator 44, so that its contacts are closed only when accelerator 46 is depressed from its idling position. A by-pass circuit is provided across controller 43 consisting of a resistor R-1, an auxiliary relay coil AA associated with relay 37, contacts A-1 and switch 45. Contacts A-2 are shunt-connected across switch 47. A pair of residual cancellation resistors R-2 and R-3 is connected to the opposite ends of clutch coil 39. These two resistors R-2 and R-3 and contacts B-1 and B-2 comprise control apparatus for canceling residual magnetic effects in the coupling members associated with the exciting means or field coil 39.

The speed-responsive switch control employed in Fig. 4 to cooperate in controlling the action of clutch coil 39 is similar to that described in Fig. 1, except that it includes the auxiliary winding AA and an adjustable resistor 49 connected in series with rectifier 33 and relay coil A.

Operation of the apparatus of Fig. 4 is as follows:

With the ignition switch 7 closed and the motor ve-

hicle shift lever in low-gear position (switch 45 being closed), initial depression of the accelerator will close switch 47 and complete the circuit to energize relay coil B from battery 1. This action actuates contacts B-1 and B-2 to a closed condition and completes the electrical circuit from battery 1 to clutch coil 39 via controller 43 and contacts B-2 and B-1. Increased depression of the accelerator will decrease the resistance of controller 43 and thereby increase the current flow through clutch coil 39 to couple the driving engine to the transmission. If the transmission is of the automatic type, the transmission will change gears automatically as the vehicle speed increases. If the transmission is manually controlled (as is shown in the aforesaid copending U. S. application Serial No. 280,086), then the gears are manually changed and the clutch coil deenergized during each shifting operation by the opening of shift switch 45. In either event, when the engine speed exceeds the predetermined value necessary to energize relay 37, the contacts A-1, A-2 are actuated to a closed position. Contacts A-2 complete a "holding" circuit across switch 47 so that release of the accelerator at engine speeds in excess of the predetermined value will not deenergize coil B (which would otherwise deenergize clutch coil 39). Contacts A-1 close the by-pass circuit (including resistance R-1, auxiliary winding AA and switch 45) across the controller 43, which ensures that releasing the accelerator at motor vehicle speeds in excess of the predetermined value will not decrease current flow through coil 39 below a point necessary to retain adequate clutch coupling.

Current flow through auxiliary winding AA decreases the differential of relay 37. By differential, I mean the difference between the potential across relay 37 necessary to actuate its contacts (as the engine speed increases) and the potential below which the actuated relay will become deactuated (as the engine speed decreases to a value below the predetermined value). By employing such an auxiliary series winding and energizing it to produce a field in opposition to that of coil A, the contacts A-1 and A-2 will open at substantially the same value of voltage (across coil A) as was initially necessary to close the contacts. It will be noted that, if the accelerator is fully depressed (thus effectively shunting out all the resistance of controller 43), no current will flow through auxiliary winding AA. This is desirable under certain conditions. And, in any event, the differentiating effect of auxiliary winding AA is primarily useful only when the engine speed is decreased below its predetermined value. This is not likely to be the case when the accelerator is fully depressed. This auxiliary coil is only energized during the period when the contacts A-1 and A-2 are closed. By use of this auxiliary winding, very inexpensive relays can be used, rather than the high-cost relays which are designed to have a low differential. Upon the engine speed decreasing below the predetermined value, contacts A-1 and A-2 will open. However, clutch coil 39 will remain energized until switch 47 is opened by releasing the accelerator, or until switch lever 45 is opened by movement of the switch lever. When either of these switches is opened (at speeds below the predetermined value), the circuit to clutch 39 will be broken by the opening of relay 41.

Resistor 49 functions to increase or decrease the sensitivity (i. e., current flow through coil A) of relay 37 so that the predetermined value of engine speed which will produce the voltage level needed to actuate A-1 and A-2 may be varied conveniently. This adjustable resistance may be physically located in the motor vehicle at a position from which it may be readily manually adjusted. Also, the resistance of resistor 49 may be responsive to the positioning of the accelerator 46 by connecting the arm of this resistor through any of a linkage to the accelerator as illustrated in Fig. 4. This arrangement would be particularly useful in motor vehicles having automatic transmissions where variable gear changes are required, dependent upon engine speed and accelerator positioning.

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The point at which A-1 and A-2 are actuated in such an instance would be a function of both the engine speed and accelerator position. In such a case actuation of the contacts of relay 37 is increasingly delayed with increased accelerator displacement. Alternatively, instead of varying the sensitivity of relay 37 by resistor 49 (either manually or in response to accelerator position), the actuation point could be varied by providing multiple coils for relays 37 to add to or subtract from the effect of coil A. By the use of a conventional switching system, the sensitivity of relay 37 could be changed so that in one position contacts A-1 and A-2 would be actuated at a first predetermined value of engine speed (with a first combination of the multiple coils) and in a second switch position the contacts would be actuated at a second predetermined value of engine speed (with a second combination of the multiple coils).

In order to ensure very rapid decoupling and cancellation of residual magnetism of the electromagnetic clutch, control apparatus including resistors R-2 and R-3 is provided. It will be noted that when contacts B-1 and B-2 open, a reversed current is caused to flow from battery 1 via resistor R-3 through clutch coil 39 and resistor R-2. This current flow is sufficient to cancel the residual magnetism of the clutch, but is not sufficient to reengage or couple the clutch members. The values of these resistors R-2 and R-3 are relatively high (as compared to them (when contacts B-1 and B-2 are closed) is only a few percent (e. g., 2%-10%) of the energy supplied to coil 39.

These resistors may be omitted if the remanence of the clutch members is of only slight consequence or if the speed of clutch release is sufficiently rapid without them. Rapid decoupling also can be obtained by providing reverse current flow through coil 39 for only an instant after contacts B-1 and B-2 are opened. The details of such arrangements are described more fully in the aforementioned U. S. application Serial No. 280,086.

In view of the above, it will be seen that the several objects of the invention are achieved and other advantageous results attained.

As various changes could be made in the above constructions without departing from the scope of the invention, it is intended that all matter contained in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

I claim:

1. Control apparatus for an electromagnetic coupling 50

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having relatively rotary armature and field members with a magnetic gap therebetween containing magnetic fluid, said field member carrying exciting means having first and second input terminals adapted when electrically energized to couple said members, and a source of electric current having first and second oppositely polarized terminals adapted to energize said exciting means; said control apparatus comprising a first pair of contacts adapted to interconnect said first input terminal and said first polarized terminal, a second pair of contacts adapted to interconnect the second input terminal and the second polarized terminal, a first resistor connected between said first input terminal and said second polarized terminal, and a second resistor connected between said second input terminal and said first polarized terminal, whereby on actuation of both pairs of said contacts current is caused to flow in one direction through said exciting means to couple said members and on deactuation of both pairs of said contacts current is caused to flow in a reverse direction through said exciting means.

2. Control apparatus as set forth in claim 1 wherein the resistance of each of said resistors is substantially greater than the resistance of said exciting means, whereby the current caused to flow through said exciting means when said pairs of contacts are actuated is substantially greater than the value of reverse excitation current.

3. Control apparatus as set forth in claim 1 wherein the resistance of said exciting means is not greater than approximately 10% of the resistance of each of said resistors whereby the reverse current caused to flow through said exciting means is substantially less than the value of excitation current and cancels residual magnetism of said members.

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