March 16, 1965 R. C. McLAUGHLIN 3,173,410

ELECTRICAL SYSTEM

Filed Nov. 29, 1962

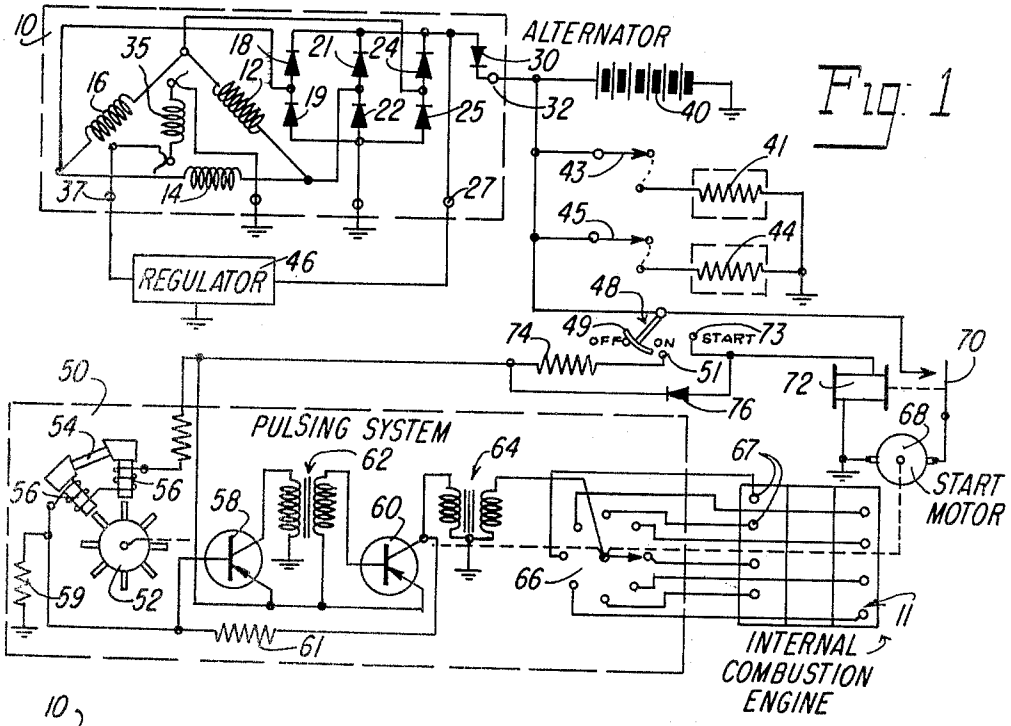



Fig. 1

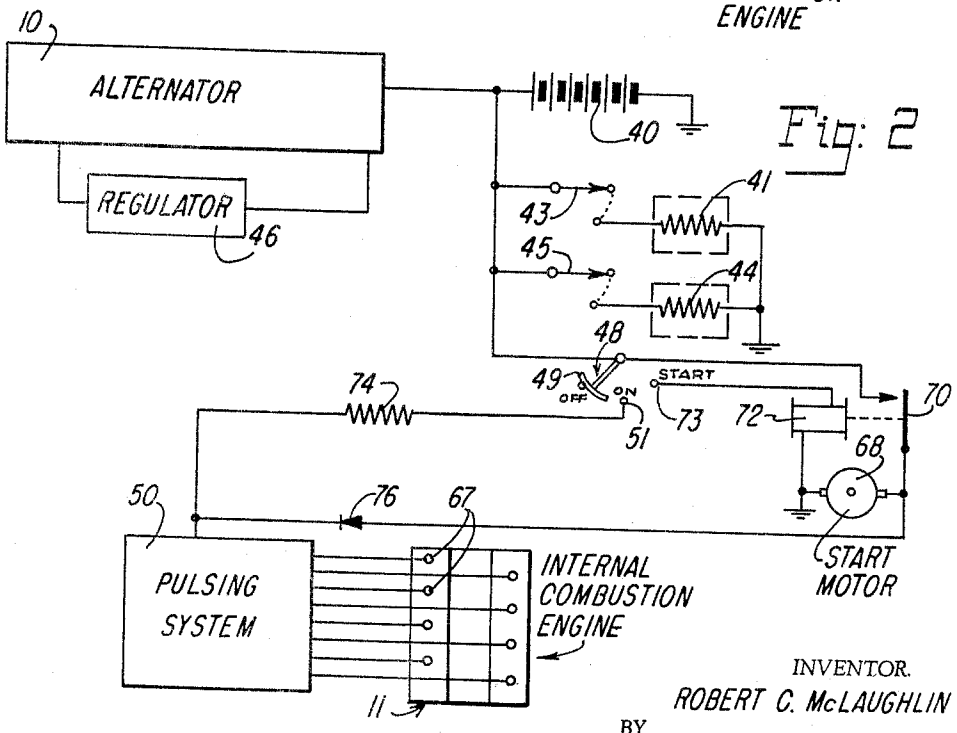



Fig. 2

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United States Patent Office 3,173,410 Patented Mar. 16, 1965



3,173,410

# ELECTRICAL SYSTEM

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Filed Nov. 29, 1962, Ser. No. 240,830
5 Claims. (Cl. 123—179)

This invention relates to ignition systems for internal combustion engines, such as are used in automobiles, and more particularly to such an ignition system having improved starting characteristics. This is a continuation in part of my co-pending application Serial No. 210,965, filed July 19, 1962, now abandoned.

Most ignition systems are supplied current from a storage battery which is charged by an alternator or generator when the internal combustion engine is running. During starting, the terminal voltage of the battery is usually quite low because of the high current drain of the starter motor. Thus the ignition system must be optimized for low voltage operation to insure good starting. Once the engine has started, however, the battery voltage rises and some sort of compensation is required. A ballast resistor placed between the battery and the ignition system provides a way of dropping the voltage to the ignition system to prevent over-saturation of the ignition coil and yield a sharp pulse.

Of course introduction of a ballast resistor drops the starting voltage as well, and to avoid this many systems provide an extra contact on the ignition switch and a lead connected thereto for bypassing the ballast resistor during starting. Such a contact may unnecessarily complicate the circuitry, and of course adds to the cost of the ignition switch. Furthermore, in automobiles having no such provision for bypassing the ballast resistor, replacement of the existing ignition switch may be too expensive.

Accordingly, it is an object of this invention to provide an ignition system for use with an internal combustion engine which system has an improved circuit for bypassing a ballast resistor during starting.

Another object of the invention is to provide a low cost simple circuit for bypassing the ballast resistor in an ignition system for use with an internal combustion engine.

A feature of the invention is the provision of an ignition system for use with an internal combustion engine which system utilizes a diode connected to bypass the ballast resistor during starting, the diode being poled to prevent loading of the ignition by the starter motor during normal operation of the engine.

Another feature of the invention is the provision of a diode connected for bypassing the ballast resistor of an ignition system, so that the ballast resistor is bypassed during starting and so that reverse conduction to the starter motor during regular operation of the engine is prevented.

In the drawing:

FIG. 1 is a schematic diagram of an electrical system utilizing the invention; and,

FIG. 2 is a schematic diagram of a system utilizing another embodiment of the invention.

In a particular form of the invention, an electrical system for an internal combustion engine is provided including an ignition system having a ballast resistor connected in series between the source of current and the pulsing circuit, and a starting circuit for starting the internal combustion engine connected to a start contact on the ignition switch. A diode is connected to bypass the ballast resistor and supply current to the pulsing circuit directly from the current source when the start contacts on the ignition switch are closed. The diode is poled to prevent conduction in the reverse direction so that when



the start contacts are reopened to de-energize the starter motor after the engine has started, current cannot flow from the ballast resistor into the starting circuit. The diode may be connected either directly to the start contacts or to the starter motor to be energized when the starter motor operates.

In FIG. 1, there is shown an electrical system for an automobile utilizing an internal combustion engine **11**. The battery **40** of the system is charged by an alternator **10**, which may be driven by the internal combustion engine **11**, and which includes armature windings **12**, **14** and **16** connected in delta. As an alternative a Y connection could also be used. The corners of the delta are connected to the respective interconnections of semiconductor power rectifier pairs **18**, **19**, and **21**, **22**, and **24**, **25**. One side of each of rectifiers **19**, **22** and **25** is connected to a common reference ground potential which may conveniently be the alternator frame, while one side of each of rectifiers **18**, **21** and **24** is connected to an output terminal **27** of the alternator. The rectifiers are poled to produce full wave rectification of the three phase output of the alternator. The direct current so produced (positive with respect to the reference ground in the illustrative circuit shown) appears at output terminal **27** of alternator **10**.

An isolation diode **30**, which may be formed as a structural part of alternator **10**, is connected between output terminal **27** and an additional output terminal **32**. Diode **30** is poled to provide conduction from the rectified output of the alternator to output terminal **32**. Alternator **10** also includes a field winding **35** connected through the usual slip rings and brushes to the reference ground and to a field current supply terminal **37**.

The output terminal **32** of alternator **10** is connected to the storage battery **40** for charging same, and to a plurality of electrical accessories on the vehicle, represented by resistors **41**, **44** which are operably connected by switches **43** and **45**. These loads could represent such items as lights, radio and other electrically operated accessories common on motor vehicles utilizing internal combustion engines. A voltage regulator **46** is connected from output terminal **27** to the field current supply terminal **37**. Regulator **46** controls the strength of current through field **35** according to the voltage of the battery alternator system. This insures that the output voltage of alternator **10** will hold the battery in the proper charged condition and not exceed safe levels.

An ignition switch **48** includes a movable contact **49** connected to battery **40**, and a fixed contact **51** connected to a pulsing system **50**. Pulsing system **50** includes a rotating toothed wheel **52** which varies the strength of a magnetic circuit including a permanent magnet **54**, through a pair of coils **56**. As the strength of the magnetic circuit is varied by wheel **52**, pulses are produced in coils **56** which are applied to a circuit including transistors **58** and **60**, and transformers **62** and **64**. Resistor **59** connects the base of transistor **58** to ground, and resistor **61** is connected to provide regenerative feedback to transistor **58**. The output of transistor **60** is applied to the primary winding of transformer **64** to produce a sharp pulse in the secondary winding of said transformer. This pulse is applied to the rotating distributor **66**, which selectively conducts pulses to the various spark plugs **67** of internal combustion engine **11**.

A starting circuit serves to start the internal combustion engine. This circuit includes a starter motor **68** connected to drive internal combustion engine **11** during starting, as is well known in the art. A starter switch **70** connects starter motor **68** to battery **40**. Switch **70** is actuated by solenoid or relay **72** which is energized by battery **40** through the start contact **73** on ignition switch **48**. Thus,

to start internal combustion engine 11, switch 48 is moved to close both contacts 49 and 73. This energizes relay 72 which closes switch 70 to energize starter motor 68.

A ballast resistor 74 connects the output of battery 40 and alternator 10 to pulsing system 50. Resistor 74 is selected to limit the voltage applied to the pulsing system to optimize its operation. As the speed of internal combustion engine 11, and hence the output of alternator 10, varies over a relatively wide range, there will be variations in the voltage applied to the pulsing system 50.

Because resistor 74 is included for limiting the voltage supplied to the pulsing system during higher speed operation, some difficulties may be encountered during starting. This is due to the fact that normally a storage battery, without being recharged, will drop in terminal voltage over a period of time. Furthermore, there is an added drain on battery 40 during starting because in addition to supplying current to pulsing system 50, battery 40 must also drive starter motor 68, which requires substantial current. In order that pulsing system 50 may receive a sufficiently high voltage during starting under such circumstances, a circuit for bypassing the ballast resistor is included.

In the present improved system, ballast resistor 74 is bypassed by connecting the start contact 73 on ignition switch 48 directly to pulsing system 50. Without more in the circuit, once internal combustion engine 11 had started, even though the start contacts of the ignition switch had re-opened, current would flow from the current source through relay 72 to ground. The result would probably be a "chatter" or even a complete closing of starter switch 70, causing undesirable operation of starter motor 68. To prevent this, diode 76 is placed in series between contact 73 and pulsing system 50. Diode 76 is poled to prevent conduction from the source of current through resistor 74 and relay 72 to ground. This prevents the switch 70 from closing and still permits current flow in the opposite direction during starting to bypass ballast resistor 74.

In another embodiment of the present system, shown in FIG. 2 ballast resistor 74 is bypassed by connecting starter switch 70 directly to pulsing system 50. Without more in the circuit, once internal combustion engine 11 had started, even though switch 70 had reopened, current would flow from the current source through resistor 74 to starter motor 68. Such an occurrence would very likely burn out ballast resistor 74, since starter motor 68 would act as a short circuit. To prevent this, diode 76 is placed in series between starter motor 68 and pulsing system 50. Diode 76 is poled to prevent conduction from the source of current through resistor 74 to starter motor 68. This prevents the ballast resistor 74 from damage and still permits current flow in the opposite direction during starting to bypass ballast resistor 74.

Thus, in both embodiments shown, during starting, relay 72 will be energized to close starter switch 70 causing battery 40 to drive starter motor 68. Diode 76 permits current to flow directly from battery 40 to pulsing system 50, bypassing ballast resistor 74. When switch 48 is moved from the start position to the normal operating position, relay 72 will be de-energized, opening switch 70 to disconnect starter motor 68 from battery 40. Current will then flow from battery 40 through ballast resistor 74 to pulsing system 50. Diode 76 will prevent current flow from resistor 74 into the starting circuit.

Other possible ways of connecting diode 74 to bypass the ballast resistor of this or similar electrical systems will now be apparent to those skilled in the art. The use of diode 76 to bypass ballast resistor 74 provides numerous advantages, among these being the elimination of extra switch contacts or relays which can be unreliable and costly. A properly selected diode should have no difficulty in providing trouble free operation for the life of the automobile. Such diodes may be added with a simple procedure to many conventional systems which do not have provision for bypassing the ballast resistor. In some existing models of automobiles, connecting to the relay terminal of the ignition switch as in FIG. 1, may be easier than connecting to the starter motor as in FIG. 2, since the starter motor may be buried deep beneath the other "under the hood" components.



When used in connection with a transistorized ignition system, a diode bypass may be safer because it does not completely short out the ballast resistor. That is, there will be a slight voltage drop across diode, for example 1 volt, which protects the transistors from blowing out in the event of excessively high initial cranking voltages.

It may therefore be seen that the invention provides an ignition system for use with an internal combustion engine which system has an improved, low cost, simple circuit for bypassing the ballast resistor during starting. In existing ignition systems which do not have provision for bypassing the ballast resistor during starting, the invention provides a simple way of doing so by connecting a diode in the described manner.

I claim:

1. An electrical system for use with an internal combustion engine, including in combination, a source of current, a starter motor for starting the internal combustion engine, an ignition system for providing high voltage firing pulses to the internal combustion engine, said ignition system including an ignition coil and a transistor in series therewith for interrupting current flow in said ignition coil, an ignition switch and a ballast resistor connected in series between said source of current and said ignition system for providing current to said ignition system during normal operation of the internal combustion engine, a starter switch normally open and series connecting said source of current to said starter motor for energizing the same, a relay for operating said starter switch, a relay switch connecting said source of current to said relay for energizing the same, and a diode connected from the juncture between said relay switch and said relay to the juncture between said ballast resistor and said ignition system to complete a circuit from said source of current through said starter switch to said ignition system, bypassing said ballast resistor when said relay switch is closed and providing a voltage drop to protect said transistor, said diode preventing current flow from said ballast resistor to said relay when said relay switch is open, so that when said ignition switch is closed, said starter motor will not be energized, whereby when said relay switch is closed to close said starter switch and energize said starter motor said diode will conduct directly from said source of current to said ignition system, bypassing said ballast resistor.

2. An electrical system for use with an internal combustion engine, including in combination, a source of current, a starter motor for starting the internal combustion engine, a transistor ignition system for providing high voltage firing pulses to the internal combustion engine, a ballast resistor series connecting said source of current with said transistor ignition system, a starter switch series connecting said source of current with said starter motor, means energizable to close said starter switch, an ignition switch series connected between said ballast resistor and said source of current, said ignition switch also being operable to energize said means to close said starter switch, and diode means connecting the juncture between said starter switch and said starter motor to the juncture between said ballast resistor and said transistor ignition system to provide a circuit from said source of current through said starter switch to said transistor ignition system bypassing said ballast resistor during starting, said diode serving to isolate said starter motor from said source of current when said starter switch is open.

3. An electrical system for use with an internal combustion engine, including in combination, a source of current, a starter motor for starting the internal combustion engine, a transistor ignition system for provid-

ing high voltage firing pulses to the internal combustion engine, an ignition switch and a ballast resistor connected in series between said source of current and said transistor ignition system for providing current to said transistor ignition system during normal operation of the internal combustion engine, a starter switch normally open and series connecting said source of current to said starter motor for energizing the same, a relay for operating said starter switch, a relay switch connecting said source of current to said relay for energizing the same, and a diode connected from the juncture between said starter switch and said starter motor to the juncture between said ballast resistor and said transistor ignition system to provide a circuit from said source of current through said starter switch to said transistor ignition system bypassing said ballast resistor when said starting switch is closed, said diode preventing current flow from said ballast resistor to said starter motor when said starter switch is open so that when said ignition switch is closed, said starter motor will not be energized, whereby when said relay switch is closed to close said starter switch and energize said starter motor, said diode will conduct directly from said source of current to said transistor ignition system bypassing said ballast resistor.

4. In an electrical system for use with an internal combustion engine, which system has means for supplying current and starter means for starting the internal combustion engine, the combination including, a transistor ignition system for providing high voltage firing pulses for the internal combustion engine, resistor means connected in series with said transistor ignition system for connection to the current supply means, switch means closable during starting and having a first conductor for connection to the current supply means and a second conductor for connection to the starter means and which is energized when said switch means is closed, and a



diode connected from said second conductor to the juncture between said resistor means and said transistor ignition system, said diode providing a circuit bypassing said resistor means for supplying current to said transistor ignition system during starting and further providing a voltage drop to protect said transistor ignition system from excessively high starting voltages, said diode being poled to prevent current flow from said resistor means to the starter means.

5. An electrical system for use with an internal combustion engine, including in combination, current supply means, an ignition system for providing high voltage pulses for the internal combustion engine, said ignition system including an ignition coil and a transistor in series therewith for interrupting current flow in said coil, resistance means connected in series with said ignition system to the current supply means, starter means for starting the internal combustion engine, switch means connected in series from said starter means to the current supply means and closable during starting, and diode means connecting the junction between said switch means and said starter means to the junction between said resistance means and said ignition system to provide a circuit from said source of current through said switch means to said ignition system, bypassing said resistance means for supplying current to said ignition system during starting.

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