April 13, 1965 F. J. McKENDRY 3,178,608

TRANSISTOR IGNITION CIRCUITS WITH A CONTROL TRANSFORMER

Filed May 16, 1961 3 Sheets-Sheet 1

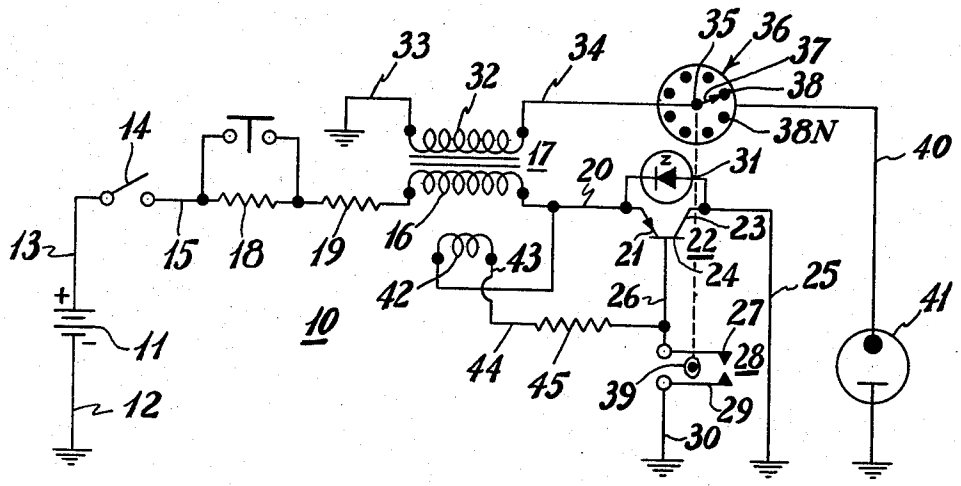


Fig. 1

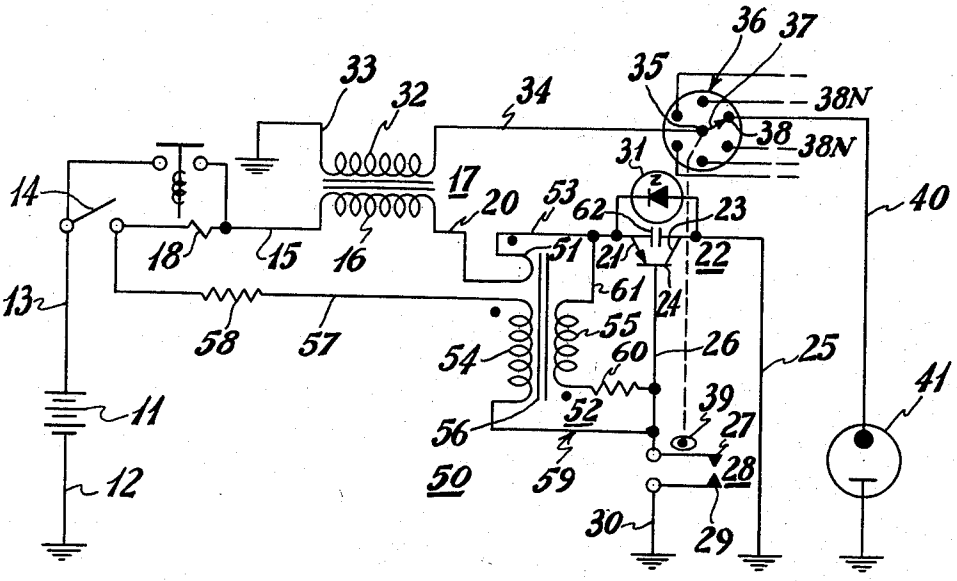


Fig. 2

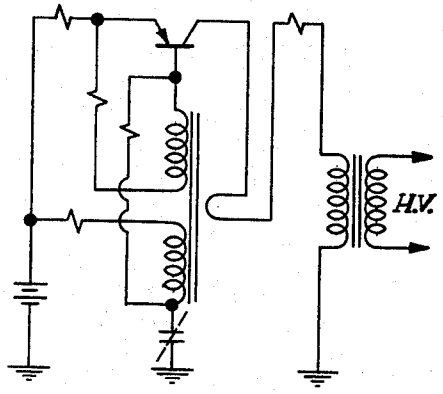
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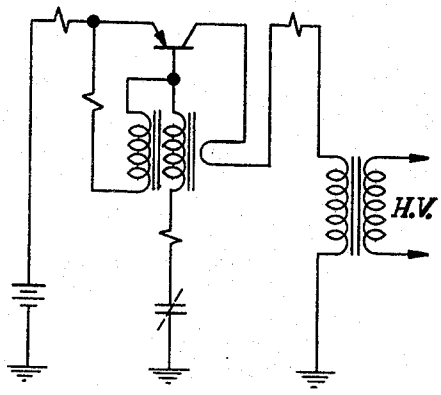
TRANSISTOR IGNITION CIRCUITS WITH A CONTROL TRANSFORMER

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Fig. 3
COMMON EMITTER

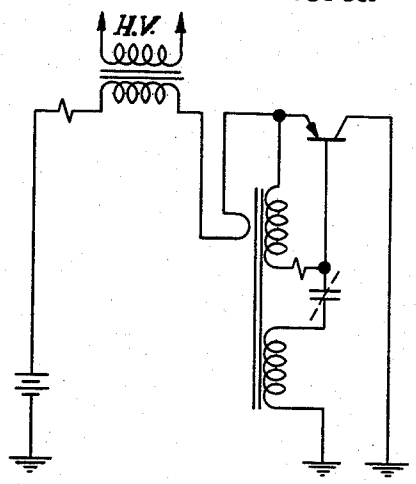


(a)

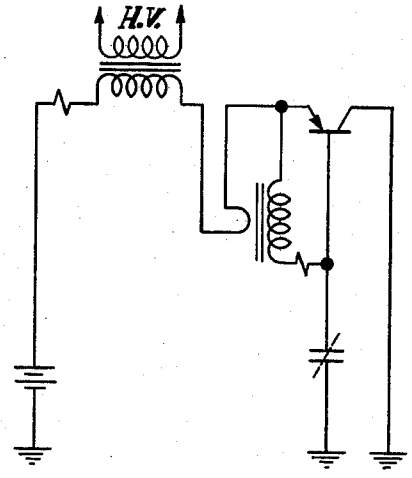


(b)

Fig. 4
COMMON COLLECTOR



(a)



(b)

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TRANSISTOR IGNITION CIRCUITS WITH A CONTROL TRANSFORMER

Filed May 16, 1961 3 Sheets-Sheet 3

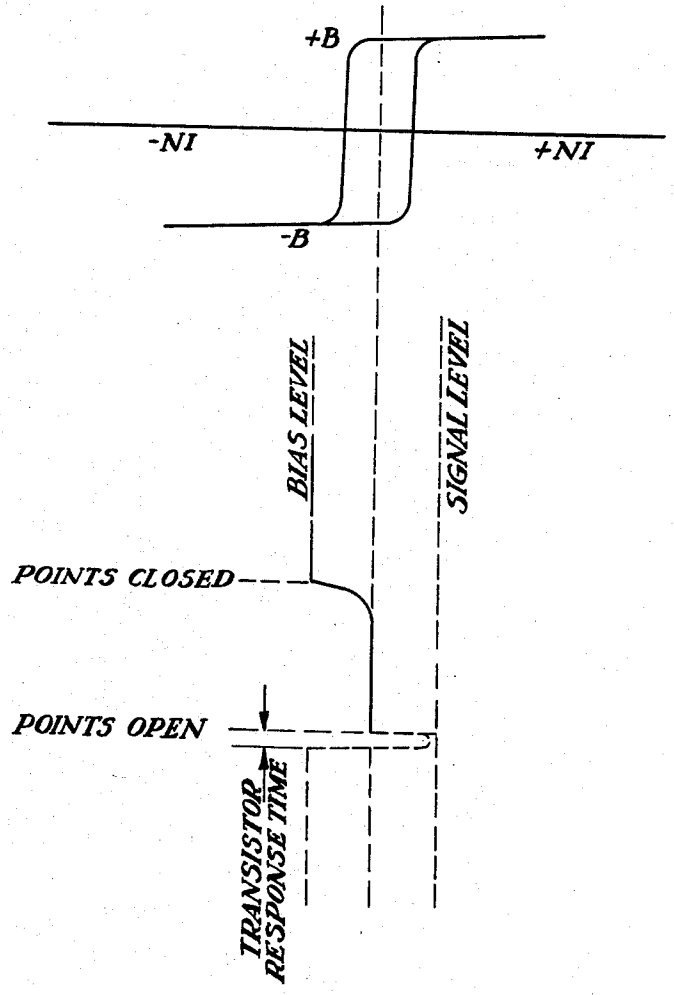


Fig. 5

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3,178,608

TRANSISTOR IGNITION CIRCUITS WITH A CONTROL TRANSFORMER

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6 Claims. (Cl. 315—206)

The present invention relates to electrical circuits and more particularly to electrical circuits adapted for use in ignition circuits.

Ignition circuits operate on the principle of stored inductive energy transfer. In the circuit presently employed in most ignition systems, the points or switch, located in the distributor, when closed allows current to flow in the primary winding of the ignition coil. The energy stored in the primary winding is determined by the current flowing through it. Upon the switch or points being opened, in synchronism with mechanical events of the engine to which it is coupled, the electrical inertia of the primary winding to a change in current causes a large voltage buildup across the primary winding. This voltage is coupled by transformer action to the high voltage or secondary winding. Systems using the above methods are objectionable in that the breaker points are subject to excessive wear as they are required to interrupt high currents flowing into a highly inductive load. Further such a system has poor starting properties as the voltage introduced in the high voltage or secondary winding varies with the rate at which the current is interrupted by the action of the points which move the slowest at cranking speeds. Also a non-uniform high voltage is fed into varying loads, such as from clean to dirty spark plugs.

The present invention provides a circuit in which a transistor controls the current flowing in the primary winding. The switch or points are required only to turn the transistor on or off, thus the wear on the points is greatly reduced as they now see an essentially resistive load that is only a small part of the load formerly handled. Further the transistorized systems provide high energy impulses, even at cranking speeds, as the transistor switches off rapidly regardless of breaker speed.

It is an object of the invention to provide an improved electrical circuit.

Another object of the invention is to provide an improved ignition system.

Another object of the invention is to provide an electrical circuit having a fast response.

Another object of the invention is to provide a novel high voltage circuit.

Another object of the invention is to provide an improved ignition system for an internal combustion engine.

Another object of the invention is to provide an ignition system that reduces the wear on the contacts.

The above and other objects and features of the invention will appear more fully hereinafter from a consideration of the following description taken in connection with the accompanying drawings wherein several embodiments are illustrated by way of example.

In the drawing:

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FIGURE 1 is a schematic diagram of a transistorized ignition system.

FIGURE 2 is a schematic diagram of a preferred embodiment of an ignition system.

FIGURES 3 and 4 are schematic diagrams of various modifications of the circuit of FIGURE 2.

FIGURE 5 is a curve explaining the operation of the circuit of FIGURE 2.

Referring now to the drawing wherein similar parts in the various figures have been assigned the same reference numbers, in FIGURE 1 an ignition system is indicated generally by the numeral **10** and is of a type adapted for use in motor vehicles. A source of power, for purposes of illustration, is indicated as a battery **11** and has one terminal connected by a conductor **12** to ground. The other terminal of the battery **11** is connected by conductor **13** to one side of a switch **14**. The other side of the switch **14** is connected by conductor **15** to one side of a winding **16** of a transformer **17**. Resistors **18** and **19** may be inserted in the conductor **15**.

The other side of the winding **16** is connected by a conductor **20** to emitter **21** of a transistor **22**. In addition to the emitter **21**, the transistor **22** has a collector **23** and base **24** and may be a PNP or NPN of sufficient size to handle the current. The device may have a fast inherent turn off time such as Bendix 2N1073 series or 2N1650 series. The collector **23** is connected by a conductor **25** to ground. The base **24** of the transistor **22** is connected by conductor **26** to a contact **27** of switch **28**. The switch **28** may be the points or breaker of an internal combustion engine and in addition to the contact **27** has a mating contact **29** which is connected by conductor **30** to ground. A zener diode **31** may be connected across the transistor **22** as a shunt for high voltages.

The transformer **17** also has a winding **32**, one end of which is connected by conductor **33** to ground. The other end of the winding **32** is connected by conductor **34** to center terminal **35** of a rotary switch or distributor **36**. The distributor **36** has a movable contact **37** adapted for engaging contacts **38**, **38N**. The contact **37** is mechanically connected to be driven by the engine (not shown). Also driven by the engine in proper sequence with the distributor **36** is a cam **39** for actuating the points **28**. The contacts **38**, **38N** are connected by conductors **40**, **40N** to spark plugs **41**, **41N**. The other side of the spark plugs are connected to ground. While only one plug has been illustrated it is understood that it is not limited thereto but may be a plurality.

In addition to the windings **16** and **32**, the transformer **17** has a feed-back winding **42**, one side of which is connected by conductor **43** to the emitter **21** of the transistor **22**. The other side of the winding **42** is connected by conductor **44** and resistor **45** to the base **24** of the transistor **22**.

In operation the aforenoted system has the advantage over the present ignition systems in that the breaker points are only required to supply base current to the transistor **22**. This is only a small fraction of the current previously switched and further is supplied to an essentially resistive load. Point life is increased to such a degree that mechanical wear now actually determines point life.

While the aforenoted circuit has many advantages over standard ignition systems it is subject to two basic disadvantages, first in the response time for developing the feed-back voltage in the winding **42** of the transformer **17**; and second in that high power transients are applied to the transistor during turnoff. These problems are a direct result of the response time of the system. FIGURE 2 is a modification of the aforenoted system in which the response time is decreased to increase the speed of turnoff of the transistor with an increase in ignition voltage and reduction of transients on the transistor.

In FIGURE 2 an ignition system is indicated generally by the numeral **50**. A source of power, for purposes of illustration is indicated as a battery **11**, one terminal of which is connected by conductor **12** to ground. The other terminal of the battery **11** is connected by conductor **13** to one side of switch **14**. The other side of switch **14** is connected by conductor **15** to one side of a winding **16** of transformer **17**. A resistor **18** may be inserted in the conductor **15**.

The other side of the winding **16** is connected by conductor **20** to one side of a winding **51** of a transformer **52**. The other side of the winding **51** is connected by conductor **53** to emitter **21** of a transistor **22**. The transistor **22** also has a collector **23** and base **24**. The collector **23** is connected by conductor **25** to ground and the base **24** is connected by conductor **26** to a contact **27** of a switch **28**. The switch **28** has a contact **29**, adapted to mate with the contact **27**, and is connected to ground by conductor **30**. A zener diode **31** may be connected across the transistor **22** to protect it from high voltages by shunting voltages above the breakdown voltage of the diode around the transistor.

The transformer **17** has a secondary winding **32**, one end of which is connected by conductor **33** to ground. The other side of the winding is connected by conductor **34** to the center terminal **35** of a rotary switch or distributor **36**. The distributor **36** has a movable contact **37** adapted for engaging contacts **38**, **38N**. The contact **37** is mechanically connected to be driven by the engine (not shown). Also driven by the engine in proper sequence with the contact **37** is a cam **39** for actuating the points **28**. The contacts **38**, **38N** are connected by respective conductors **40** to spark plugs **41**, **41N**. The other side of the plugs **41**, **41N** are connected to ground. Only one of the plugs **41** have been illustrated but it is understood that it may be a plurality thereof.

The transformer **52** has windings **54** and **55** coupled to the winding **51** by a fast response magnetic core **56**. One end of the winding **54** is connected by conductor **57** and resistor **58** to one terminal of the switch **14**. The other end of the winding **54** is connected by conductor **59** to the base **24** of the transistor **22**. One end of the winding **55** is connected by a resistor **60** to the base **24** of the transistor **22** and the other end of the winding **55** is connected by conductor **61** to the emitter **21** of the transistor **22**. A capacitor **62** may be connected across the transistor **22**.

FIGURES 3 and 4 are modifications of the aforenoted circuits. In view of the detailed explanation above, it is believed that a detailed explanation is not necessary in that the modification would be understood by one skilled in the art.

In operation, closing the switch **14** connects the system to the source of energy. Means may be provided to short out the resistor **18** in order to provide a "hotter" spark for starting.

When the contacts **27**, **29** of the switch **28**, which is connected mechanically to the engine to produce the opening and closing of the contacts **27** and **29** in the proper sequence, are closed, the transistor **22** is turned on by grounding the base (or supplying on drive in the case of common emitter circuits). The opening of the contacts **27**, **29** removes the path of current flow and the

low impedance path across the base-emitter junction causes the transistor **22** to go to an off condition or zero current flow. This sudden drop in current flowing through the winding **16** of the transformer **17** causes a large voltage to be developed having a magnitude of $E=L(di/dt)$. This voltage by transformer action induces a voltage in the winding **32** which is the high voltage winding of the transformer **17** and is connected to the distributor which in turn connects to the proper spark plug. While the foregoing will generate a high voltage in the winding **32**, the addition of the fast response transformer **52** substantially improves the action. The transformer **52** is normally biased at —B (see FIGURE 5). In other words the NI of the winding **54** is negative. Upon the switch or points **28** being closed, the transistor **22** becomes conductive and the current through the winding **51** increases such that the NI of the winding **54** minus the NI of the winding **51** is approximately zero. Upon the points **28** opening, the surge of current in the winding **51** is such that the transformer **52** is driven in a +B direction with a drive equivalent to a step function of current. This drive creates a voltage in the winding **55** which is in a direction to turn off the transistor **22**. The high voltage in the winding **32** of the transformer **17** is developed by the fast switching time of the transistor **22** in interrupting the current flow in the winding **51** of the transformer **52**. As the current in the winding **51** drops to near zero, the voltage across the winding **55** falls to zero. The low impedance path of the winding **55** and resistor **60** causes the transistor **22** to remain off after the voltage across the winding has fallen to zero. The transformer **52** upon the points being closed is again biased in a —B direction by the winding **54** and is ready for the next cycle. Although only the common collector circuits have been described in detail, it is understood that the common emitter circuits illustrated would operate in a similar manner. In some applications, the common emitter circuit might be desirable in that the points would see a smaller voltage than in the common collector circuits.

Although several embodiments have been illustrated and described, various changes in the form and relative arrangement of the parts, which will now appear to those skilled in the art, may be made without departing from the scope of the invention.

What is claimed is:

1. An ignition system for an internal combustion engine comprising a transistor, a control transformer, a high voltage transformer, said control transformer having a bias winding, a load winding and a control winding, circuit means connecting said high voltage transformer and said load winding in series with said transistor, breaker points for energizing said bias winding to cause said transistor to conduct, and means including said control winding for biasing said transistor to a non-conducting state upon said breaker points being opened whereby the sudden collapse of current flowing in said load winding induces a high voltage in said high voltage transformer.

2. The combination as set forth in claim 1 in which a zener diode is connected across said transistor.

3. The combination as set forth in claim 1 in which a capacitor is connected between the emitter and collector of said transistor.

4. An ignition system for an internal combustion engine having a plurality of spark plugs comprising a step-up transformer having a primary and a secondary winding, a control transformer having a load winding and a control winding, a transistor, circuit means connecting said transistor in series with said primary winding and said load winding, means including a switch when in a closed position for biasing said transistor to conduct and cause current to flow in said load winding, means including said control winding to turn off said transistor

upon said switch being opened causing the current to collapse in said load winding and thereby induce a high voltage in said step-up transformer, and means including a distributor for connecting said secondary winding in a predetermined sequence with said switch to said spark plugs.

5. The combination as set forth in claim 4 in which said control transformer has a fast response time.

6. The combination as set forth in claim 4 in which a zener diode is connected between the emitter and collector of said transistor.

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