

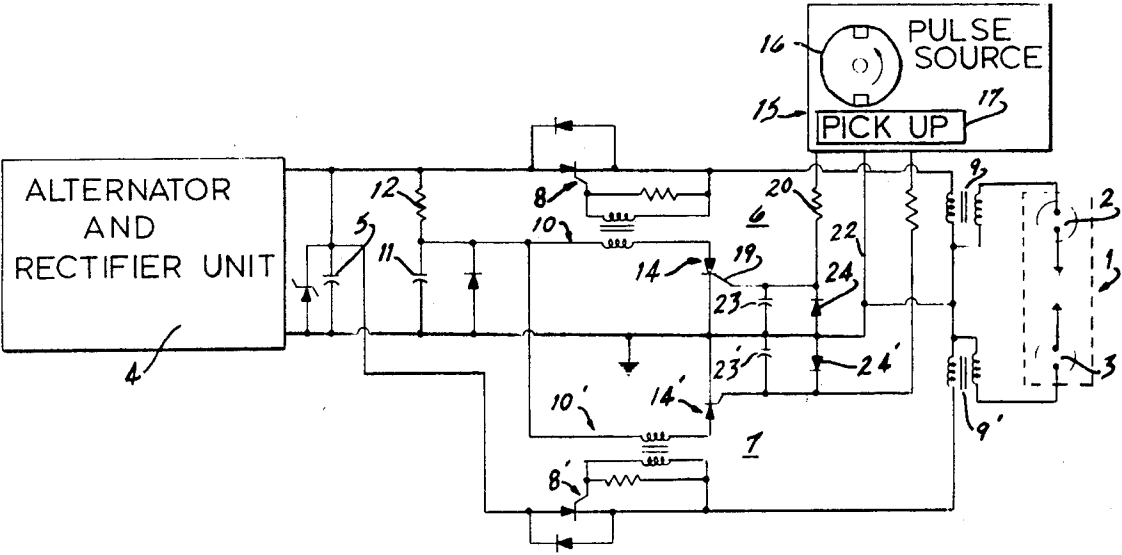
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[21] Appl. No. **865,050**
[22] Filed **Oct. 9, 1969**
[45] Patented **Oct. 12, 1971**
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Continuation-in-part of application Ser. No.
772,127, Oct. 31, 1968.

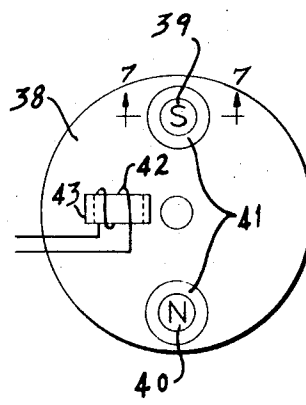
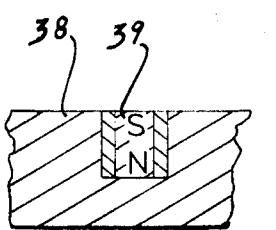
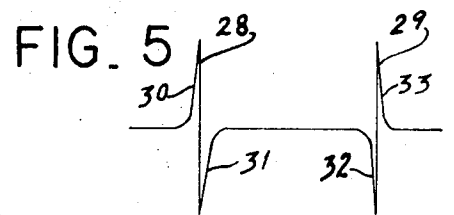
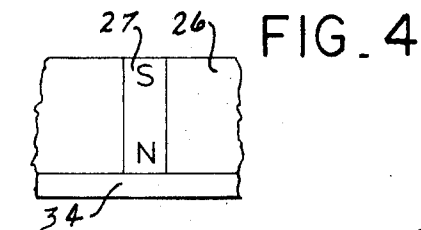
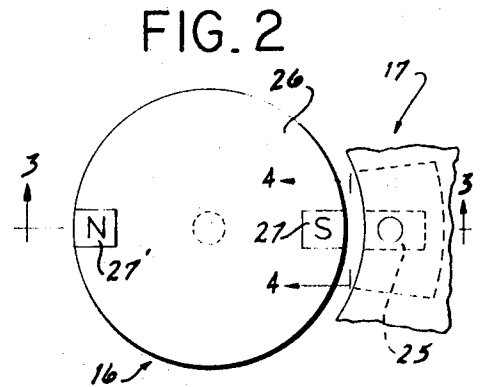
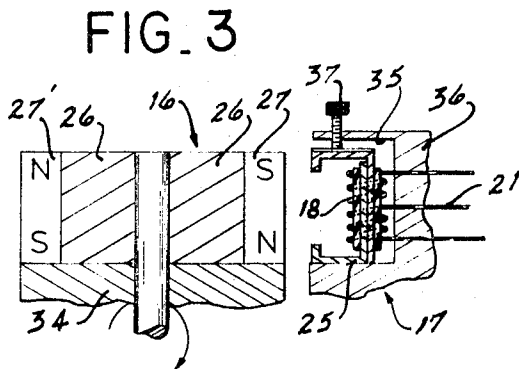
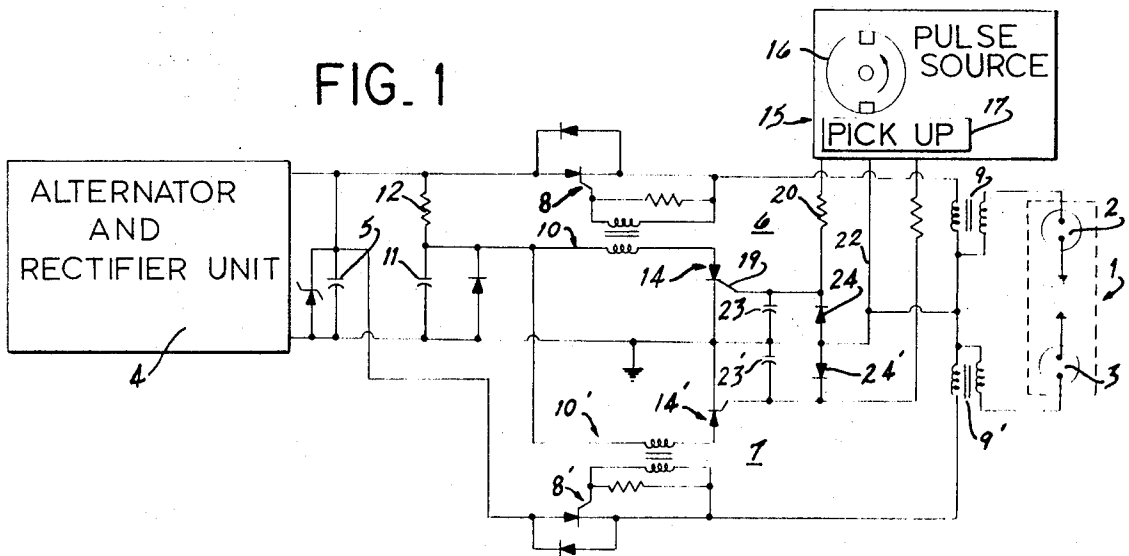
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[54] **ELECTRICAL PULSE TRIGGERED SYSTEMS**
23 Claims, 16 Drawing Figs.
[52] U.S. Cl..... **315/209 R,**
315/209 SC
[51] Int. Cl..... **H05b 37/02**
[50] Field of Search..... **315/209**
CD, 209 SC, 209 T; 310/156
[56] **References Cited**
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ABSTRACT: This disclosure relates to a capacitor discharge ignition system for an internal combustion engine employing alternately fired controlled rectifiers for discharging of a capacitor to the engine sparkplugs. The opposite ends of a single winding are connected respectively to the gates of the controlled rectifiers. A pair of permanent magnets are sequentially coupled to the winding with successive magnets being oppositely polarized to generate time-spaced alternating current signals in the winding. The signals are alternately of opposite polarity sequence and automatically apply the proper polarity signal to the gates in alternate sequence.





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FIG. 8

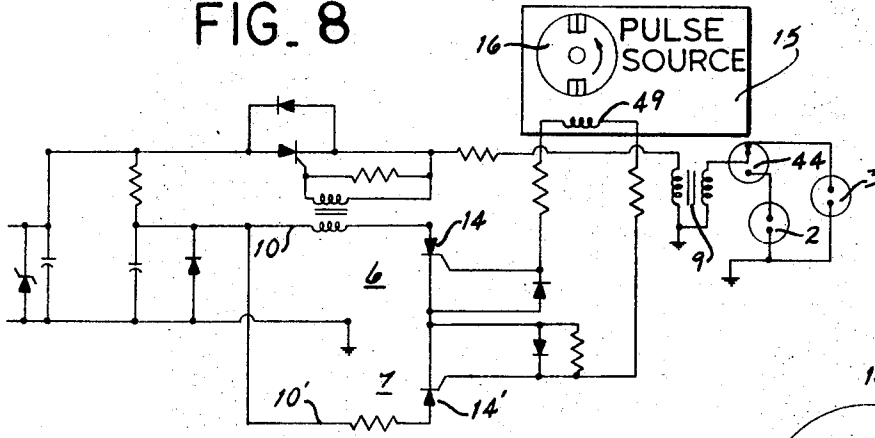


FIG. 9

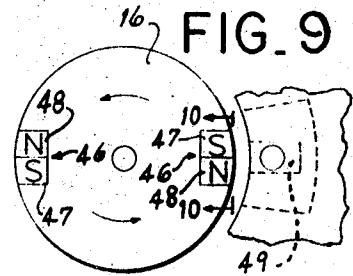


FIG. 11

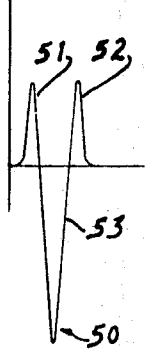


FIG. 11a

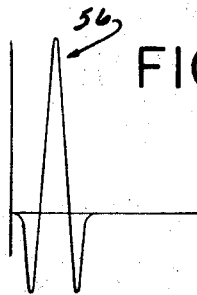


FIG. 10

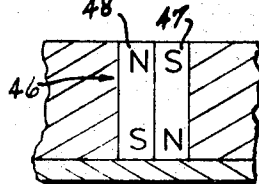


FIG. 12

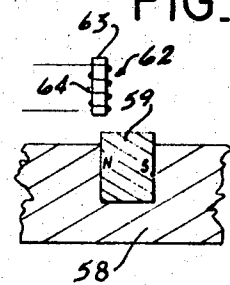


FIG. 15

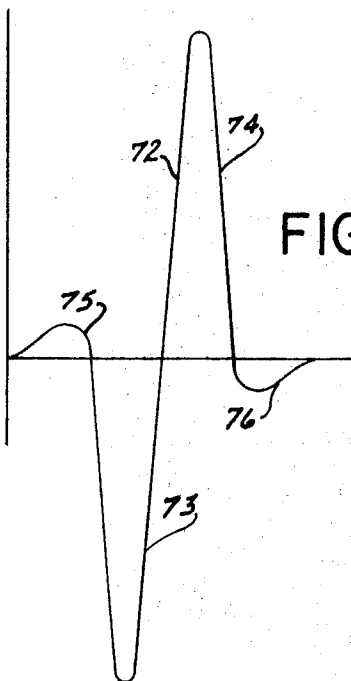


FIG. 13

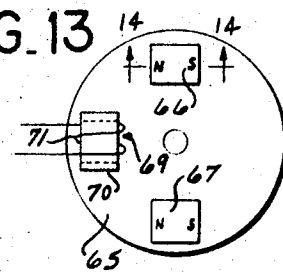
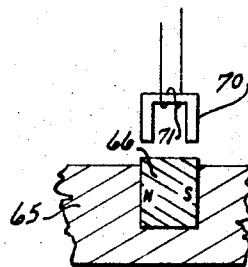


FIG. 14



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ELECTRICAL PULSE TRIGGERED SYSTEMS

This invention relates to pulse triggered electrical systems and particularly to ignition systems employing alternately fired triggered switch means for discharging of a capacitor or other storage means. This application is a continuation-in-part of my copending application entitled Triggered Ignition Systems which was filed on Oct. 31, 1968 with Ser. No. 772,127.

Capacitor discharge ignition systems have recently been suggested and developed on a commercial scale for internal combustion engines and the like. Generally, they employ a distributor for sequentially applying the power to the several sparkplugs. Alternately, a plurality of parallel firing circuits may interconnect the main firing capacitor through separate triggered switches for sequentially discharging the capacitor to the several sparkplugs or other firing means. For example, the above copending application discloses a capacitor discharge ignition system which has been satisfactorily applied to two-cylinder internal combustion engines for snowmobiles and the like. In that circuit, a main firing capacitor is connected to be charged from an alternator driven by the internal combustion engine. A pair of paralleled discharge circuits, one for each of the sparkplugs of the two cylinder engine, are connected across the capacitor and each includes a silicon-controlled rectifier as a triggered switch for selective and alternate firing of the sparkplugs. A triggering or control capacitor is connected in series with an isolating resistor across the main firing capacitor and provides a pulse source for controlled firing of the two controlled rectifiers. A pair of trigger circuits, one for each rectifier, is parallel connected across the control capacitor and each includes a coupling pulse transformer and a second controlled rectifier connected across the control capacitor. The pulse transformers are connected respectively to the controlled rectifiers in the main discharge circuits. The second controlled rectifiers are alternately fired to alternately discharge the control capacitor through the two pulse transformers and thereby provide alternately firing of the first controlled rectifiers and related sparkplugs.

The present invention is particularly directed to a novel and reliable pulse forming means for alternately triggering a pair of trigger switch means such as the electronic switch means of the ignition system shown in applicant's previously referred to copending application. The present invention may, however, be advantageously employed to control any polarity sensitive control means of a switching circuit to control the circuit connection from a common source in response to the signal having a predetermined polarity sequence.

Generally, in accordance with the present invention, an exciting means is coupled to a flux responsive pickup means to generate spaced alternating current signals which are connected in a switching circuit having polarity sensitive control means controlling a circuit connection and includes a phase inversion means such that the connection is made in response to a signal having a predetermined polarity sequence. The signals may be simultaneously applied to a pair of pulse responsive switch means, one of which responds to one polarity portion of the signal and the other of which responds to the opposite polarity portion of the signal. The switch means are connected in the circuit whereby the firing of one switch means effectively disables the operation of the other switch means. The pickup means is selected and constructed whereby the spaced alternating current pulses are phase shifted by 180°. In the train of pulses, therefore, a first pulse will have a positive leading half cycle and a negative trailing half cycle. The positive half cycle will be effective to trigger one of the of means. Although the negative half cycle will subsequently trigger the opposite switch means the effectiveness of such triggering has been effectively disabled by the triggering of the first switch means. The next pulse provides a negative leading half cycle and consequently triggers the last triggered or fired switch means. Although the following positive half cycle of the second pulse will also trigger the switch means first fired during the previous pulse, the negative leading half cycle has fired the second switch means and thereby effectively disabled the first switch means.

In particular as applied to a capacitor discharge ignition system the triggered switch means may be silicon-controlled rectifiers or other similar functioning pulse responsive devices. The controlled rectifiers are connected in parallel circuits to a common capacitor and each circuit would include a suitable pulse transfer means such as a transformer or the like. The discharge time constant of the capacitor discharge circuits is selected to be essentially no greater than the half cycle of each pulse. As a result, regardless of which control rectifier is first turned "on," the capacitor discharges during the corresponding half cycle and the firing of the alternate rectifier is ineffective, because the energy in the capacitor has already been dissipated or transferred to a suitable output circuit.

In accordance with a particularly novel aspect of the present invention a single winding means is provided with the opposite ends connected respectively to the gates or other input means of the triggered switch means. A plurality of permanent magnets or other magnetic means are sequentially coupled to the winding with successive magnets being oppositely polarized to generate time-spaced alternating current pulses in the winding means. The pulses are thereby alternately of opposite phase and automatically apply the proper polarity signal to the gates in alternate sequence.

Suitable steering diode means may be provided in the current return circuit from each of the gate circuits to the opposite end of the winding means. In a particularly novel circuit, the winding means is formed as a center tapped winding, with the center tap connected as a common return from a common connection to the trigger switch means.

The present invention has been found to provide a simple, reliable and inexpensive triggering means for the alternate firing of a pair of triggered switch means or the like.

The drawings furnished herewith illustrate the best modes presently contemplated by the inventor for carrying out the subject invention and disclose the above advantages and features as well as others which will be readily understood from the following description. In the drawings:

FIG. 1 is a schematic circuit diagram of a capacitor discharge ignition system applied to a two-cylinder engine and employing a pulse generating means constructed in accordance with the present invention;

FIG. 2 is a top plan view of the pulse source or generating unit employed in the circuit of FIG. 1;

FIG. 3 is a sectional view of the pulse source or generating unit taken generally on line 3—3 of FIG. 2;

FIG. 4 is a vertical view taken generally on line 4—4 of FIG. 2;

FIG. 5 is a graphical illustration of a pair of succeeding pulses formed by one complete revolution of the pulse generating unit of FIG. 2 through 4 rotating in either direction;

FIG. 6 is a top plan view of an alternative physical construction of a pulse forming unit providing an output as shown in FIG. 5;

FIG. 7 is a fragmentary vertical section taken generally on line 7—7 of FIG. 6;

FIG. 8 illustrates an alternative construction of a pulse source and its connection to alternately fire a pair of triggered switch means in accordance with the present invention;

FIG. 9 is a plan view of the pulse source employed in the circuit of FIG. 8;

FIG. 10 is a vertical section taken generally on line 8—8 of FIG. 9;

FIG. 11 is a graphical illustration of a pulse formed by the pulse source of FIGS. 9 and 10;

FIG. 11a is a graphical illustration of a similar pulse formed by the pulse source of FIGS. 9 and 10 with reverse rotation;

FIG. 12 is a view similar to FIG. 9 illustrating a further embodiment providing an output as shown in FIGS. 11 and 11a;

FIG. 13 is a view similar to FIG. 2 illustrating a further modification to the pulse-forming unit;

FIG. 14 is a fragmentary vertical section taken generally on line 14—14 of FIG. 13; and

FIG. 15 is a graphical illustration of the output of the pulse source of FIGS. 13—15 rotating in either direction.

Referring to the drawings and particularly to FIG. 1 the present invention is shown applied in an ignition circuit for a two-cylinder, internal combustion engine 1 having a pair of sparkplugs 2 and 3. For example, the present invention has been applied to such an engine forming a part of a snowmobile. An alternator 4 is coupled to and driven in synchronism with the engine 1. The output of the alternator 4 is connected to charge a main firing capacitor 5 which is interconnected through separate paralleled discharge circuits 6 and 7 to the sparkplugs 2 and 3.

The illustrated ignition circuit essentially corresponds to that shown in applicant's previously referred to copending application and is only briefly described herein to provide a clear and full understanding of the present invention. Further, the discharge circuits 6 and 7 are essentially identical and consequently circuit 6 for sparkplug 2 is described in detail with the corresponding elements of circuit 7 for sparkplug 3 identified by corresponding primed numbers.

The circuit 6 includes a silicon-controlled rectifier 8 defining a triggered switch means connected in series with a pulse transformer 9 across the capacitor 5. The output of pulse transformer 9 is connected to the sparkplug 2 and transfers the energy from capacitor 5 to the sparkplug 2 when the rectifier 8 is fired.

A pulse forming network 10 is connected to selectively supply a firing pulse to the gate circuit of the controlled rectifier 8. The pulse forming network 10 which is disclosed in applicant's copending application includes a common trigger or control capacitor 11 connected in series with an isolating resistor 12 across the main firing capacitor 5 and the output of the alternator 4. The pulse forming networks 10 and 10' for each of the rectifiers 8 and 8' are parallel connected across the capacitor 11 and each includes a pulse transformer 13 connected in series with a trigger circuit or second silicon-controlled rectifier 14 directly across the capacitor 11. By alternately firing the second controlled rectifiers 14 and 14' in the pulse-forming networks 10 and 10', the energy of the control capacitor 11 is alternately applied to the gate circuits of the controlled rectifiers 8 and 8'. The latter, in turn, discharge the main firing capacitor 5 through the pulse transformers 9 and 9' to alternately fire sparkplugs 2 and 3.

The present invention is particularly directed to a pulse source or generating means 15 connected to the gate circuits of the controlled rectifiers 14 and 14' for the alternate and sequential firing thereof.

In the embodiment of the invention illustrated in FIG. 1, the pulse generating means 15 includes a rotor unit 16 coupled to the engine crank shaft, not shown, and a pickup unit 17 connected to fire the rectifiers 14 and 14'. The pickup unit 17 includes a magnetic core and center-tapped winding 18, shown in FIG. 3, forming a common pickup means which has the one end connected to the gate 19 of the controlled rectifier 14 in series with a resistor 20. The center tap 21 of the winding 18 is connected to a common ground line 22 which, in turn, is interconnected to the cathodes of both rectifiers 14 and 14'. The opposite end of the winding 18 is connected to the gate 19' of the rectifier 14' in series with a resistor 20'. Thus, one-half of the winding 18 is connected across the gate to cathode circuit of the one controlled rectifier 14 and the opposite half of the winding 18 is connected across the gate to cathode circuit of the other controlled rectifier 14'.

A protective capacitor 23 and paralleled diode 24 may be connected across the gate to cathode circuit of the rectifier 14. The capacitor 23 protects against transient voltages in the circuit, and the diode 24 bypasses possibly damaging reverse voltages from appearing across the gate to cathode circuit.

As diagrammatically shown in FIG. 1, and more fully disclosed in FIGS. 2-4, the winding 18 is wound on a U-shaped core 25 and mounted adjacent the rotor unit 16. The core 25 is mounted axially of the rotor unit 16 with the core opening adjacent the periphery. The rotor unit 16 includes a support 26 rotatably coupled to the alternator and having a pair of diametrically opposed permanent magnets 27 and 27' secured

thereto. In FIGS. 2-4, the magnets 27 and 27' are mounted axially of the rotor support 26 and are oppositely polarized in the axial direction. Thus, the one magnet 27, shown immediately adjacent the core 25 and winding 16, has its north pole adjacent the lower surface of the rotor and the south pole adjacent the upper surface. The opposite magnet 27' shown to the opposite side of the support 26 has its south pole adjacent the lower rotor surface and the north pole adjacent the upper surface.

Rotation of the rotor support 26 results in the generation of an alternating current pulse having a positive half cycle and a negative half cycle each time one of the magnets 27 or 27' moves past the winding. Thus, as magnet 27 moves past core 25, the flux increases to a maximum level in one direction and then reduces to zero. Similarly, as magnet 27' moves past core 25, the flux increases to a maximum level in the opposite or negative direction and then reduces to zero. The pulses are timed spaced in accordance with the rotational speed of the support, which is rotated in synchronism with the engine and thereby provides a pair of properly timed-spaced pulses for sequentially transferring the energy stored in the capacitor 5 to the sparkplugs 2 and 3.

In FIG. 5 a pair of timed-spaced alternating current pulses 28 and 29 are illustrated which result from each complete rotation of the rotor 26. The first pulse 28 is assumed to have been generated by the flux pulse from magnet 27 and as illustrated includes a positive-going leading half cycle 30 and a negative-going following or trailing half cycle 31. The second pulse 29 which is generated by the second magnet 27', however, is phase shifted 180° and has a negative-going leading half cycle 32 and a positive-going trailing half cycle 33 as a result of the relative opposite polarization and therefore flux pattern of the magnet 27' with respect to winding 18. In operation, the generation of the first pulse 28 in winding 18 provides a positive polarity signal applied to the gate of the first controlled rectifier 14 which forward biases the rectifier and permits to conduction. The opposite end of the winding 18 is at a relatively negative potential with respect to the ground and back biases the rectifier 14'. This positive half cycle 30 of the first pulse 28 appearing across the second half of the winding 18 between the ground line 22 and the right end of the winding is bypassed through the diode 24' to prevent any damaging reverse biases on the controlled rectifier 14'. The controlled rectifier 14 is therefore fired and rapidly discharges the capacitor 11 through the pulse forming network 10. The discharge time is selected to be essentially no greater than the period of the positive half cycle 30 of the first pulse 28. During the negative half cycle 31 of the first pulse 28, the opposite end of the winding 18 is relatively positive with respect to the opposite end and biases the second controlled rectifier 14' to conduct. However, the capacitor 11 has been essentially completely discharged and no power is available for the pulse forming network 10'. Consequently, the silicon-controlled rectifier 14' and the pulse forming network 10' has been effectively disabled. As described in applicant's copending application, the isolating resistor 12 prevents transfer of sufficient power from the capacitor 5 or the alternator 4 to the network 10' to fire the main rectifier 8'.

One hundred and eighty degrees later, the second alternating current pulse 29 is established. This pulse 29, however, first establishes the leading negative-going half cycle 32 which is phase inverted by the center-tapped structure and which is, therefore, effective as a positive pulse to fire the second controlled rectifier 14' and discharge the energy of the capacitor 11 through a pulse forming network 10'. In turn, this power fires the controlled rectifier 8' to discharge the energy of the main firing capacitor 5 through the pulse transformer 9' and supply firing power to the sparkplug 3. The discharge of the capacitor 11 is essentially fully completed during the negative half cycle 32 of the second alternating current pulse 29. When the positive-going half cycle 33 of the second pulse 29 is created, the controlled rectifier 14 is biased to conduct. The capacitor 11, however, is essentially completely discharged and network 10' cannot then fire rectifier 8.

The operation of the embodiment of the invention illustrated in FIGS. 1-4 may be briefly summarized as follows. The rotor unit 16 is coupled to and driven in synchronism with the alternator 4. The alternator 4 provides a source of energy for charging of the main firing capacitor 5 and the trigger or control capacitor 11 between the periods of the leading half cycles of triggering pulses 28 and 29 of the pulse generating means 15. The rotation of the rotor unit 16 generates the time spaced pulses 28 and 29 to sequentially and alternately fire the rectifiers 14 and 14' and discharge the capacitor 5 through the related pulse transformers 13 and 13'. The outputs of transformers 13 and 13' fire the corresponding controlled rectifiers 8 and 8' in sequence.

After each discharge of the capacitors and after sufficient time for rectifiers 8 or 8' to turn off, the alternator 4 may begin to charge the capacitor 5. The current through the resistor 12 may then flow to recharge capacitor 11 if the gate signal has ceased on both rectifiers 14 and 14', or flow to the pulse forming network 10. If this gate signal is present, charging of capacitor 11 will begin when such gate signal ceases because resistor 12 limits the current to a value below the holding current of the controlled rectifiers 14 or 14'. Consequently, the discharge circuits and particularly all rectifiers 8, 8', 14 and 14' reset after the termination of the alternating current trigger pulse until the next or succeeding pulse. During the dwell period between the alternating current pulses, the capacitors are again fully charged.

Although the rotor unit 15 may be driven in synchronism with the engine in any suitable manner, it may advantageously be incorporated as a part of the rotating part of the internal combustion engine such as the fly wheel, fan blade unit or the like, as diagrammatically shown in FIGS. 2-4. For example, the magnets 27 and 27' were embedded in the periphery of a fan blade support 34 connected to the engine shaft in a snowmobile. The support 34 was made of aluminum and thus provided a convenient nonmagnetic supporting member. The magnets were oriented with axial polarization. The one magnet 27 has the north pole at the lower end and the opposite magnet 27' has the north pole at the upper end.

Core 25 is generally U-shaped and formed of a pair of similar, generally L-shaped stamped members having overlapping adjacent vertical legs 25a and oppositely disposed parallel legs 25b. Small depending aligned legs 25c on the outer ends of the latter parallel legs terminate in spaced relation. The L-shaped members may be stamped from suitable cold-rolled steel. The winding 18 is wound on a tubular insulating bobbin 25d into which the legs project, and with the airgap or open side of the core 25 spaced slightly outwardly of and in alignment with the periphery of the blade support 34. As the support 34 rotates, the magnets 27 and 27' move past the core 25 and essentially bridge the airgap. This establishes a flux path through the core 25, generating the alternating current pulses 28 and 29 as previously described.

The core 25 and winding 18 are shown adjustably mounted within a slot 35 in a fixed portion 36 of the engine. A suitable locking screw 37 or the like is shown for selectively locking the core in a selected angular orientation with respect to the support 34. This permits adjustment of the core and winding for timing purposes in accordance with the usual timing theory.

Further, the physical arrangements of the rotor and the magnets may, of course, take any one of the great number of different constructions. For example, FIGS. 6 and 7 illustrate a possible alternative construction to that of FIGS. 2-4. In FIGS. 6 and 7, a flywheel 38 made of steel is provided with recesses in diametrically spaced points of the top surface. Suitable permanent magnets 39 and 40 are mounted one in each recess. Because of the steel flywheel, aluminum sleeves 41 surround the magnets 39 and 40 to prevent effective shorting of the magnets. A coil 42 is wound on a suitable U-shaped core 43 and mounted in adjustable fixed radial relationship above the flywheel 38 and opening downwardly. The one leg of core 43 is aligned with the circumference of the rotor including the magnets 39 and 40. The rotation of the flywheel

38 results in the sequential time-spaced movement of the magnet 39 and 40 past the core 43. This, in turn, generates time-spaced alternating current pulses such as shown in FIG. 5 with a corresponding functioning of FIG. 1.

In the illustrated embodiment of FIG. 1, the circuits 6 and 7 constitute pulse or signal amplifying states. If the main rectifier 8 or other switching devices have sufficient sensitivity, the trigger or common pickup winding may be connected directly to such switching devices to produce the desired circuit operation. Further, the center tapped winding in FIG. 1 and the bypass diodes to the opposite ends of the winding of the winding of FIG. 8 provide for the desired phase inversion of the signal with respect to the opposite ends of the winding of the winding of FIG. 8 provide for the desired phase inversion of the signal with respect to the phase sensitivity control means such that the switching circuit is responsive to a signal of a proper or selected phase sequence. Other circuits employing a Triac or complementing transistors and the like may, of course, be employed with the same function and response.

The circuit of FIG. 1 will properly fire the engine for either direction of engine rotation and thereby produce a direct reversing internal combustion engine. Thus, each magnet 27 and 27' generates the same flux in core 25 with either direction of rotation and consequently generates the corresponding electrical pulses shown in FIG. 5 to properly fire the engine. This may be desirable for certain outboard motors, snowmobiles and similar applications.

In a circuit of the above type, the circuit may be modified to avoid the reverse acting by using a distributor and discharging of the control capacitor 11 into a dummy load in response to reverse rotation, for example, as shown in FIG. 8.

Although the center-tapped winding 18 with the common ground return 22 provides a highly satisfactory pulse control, a single untapped winding may be connected directly across the gate circuits, for example, as shown in FIG. 8. In FIG. 8, only the portion of the circuit of FIG. 1 which is modified to show the alternative circuit is illustrated. The balance of the circuit, not shown, may correspond to that shown in FIG. 1. Further, corresponding elements in FIGS. 1 and 8 are correspondingly numbered for simplicity and clarity of explanation. The circuit of FIG. 1 may also be operated from an end of an untapped winding with the other end connected to ground and with any desired phase inversion means inserted between the input and the rectifier 14' or with rectifier 14' replaced with an appropriate switching device being sensitive to a negative input pulse.

Referring particularly to FIG. 8, the ignition system employs a circuit 6 essentially corresponding to the circuit 6 shown in FIG. 1. The output transformer 9 of the associated circuit, however, is connected to the respective cylinders 2 and 3 through a suitable distributor 44.

The portion of the circuit generally related to the circuit 7 of FIG. 1 is changed to eliminate the discharge circuit from the capacitor 5 and transformer 9' of FIG. 1 for purposes of firing sparkplug 3. The trigger portion of the circuit 7 is retained with the transformer 13' of FIG. 1 replaced by a suitable dummy load shown as a resistor 45.

Consequently, when the silicon-controlled rectifier 14' is fired, the energy of the capacitor 11 is dumped into and dissipated in the resistor 45 for purposes more fully developed hereinafter.

The triggering alternator or pulse source 15 is especially constructed in the embodiment of FIG. 8 to prevent reverse rotation of the engine as more clearly shown in FIGS. 9 and 10 and described as follows:

A pair of magnetic units 46 and 46' are provided, one each in the diametrically opposite sides of the rotor 16. Each unit 46 and 46' is similarly formed as a double or dual magnet assembly either by employing a pair of separate magnets 47 and 48, or a single block suitably polarized to define the pair of permanent magnets. The alternator rotor 16 is shown mounted for counterclockwise rotation as in FIG. 1. As shown in FIGS. 9 and 10, the leading magnet 47 of each pair is axially

polarized in the illustrated embodiment of the invention with a bottom north pole and an upper or top pole. The adjacent trailing magnet 48 of the pair is oppositely axially polarized. Thus, in the embodiment of the invention shown in FIG. 8, the counterclockwise rotation provides successive similar pulse signals in the alternator winding. The first magnets 47 and 47' are essentially the same as magnet 27 of FIGS. 2-4 and tend to generate a flux pattern and a signal similar to that shown at 28 in FIG. 5. The immediately adjacent magnets 48 form an immediately following signal similar to the trailing signal 29 of FIG. 5. The adjacent mounting of the magnets 47 and 48 results in a merging of the trailing portion of the signal of magnet 47, and the leading portion of magnet 48 such that the signal of each unit 46 and 46' is typically as shown at 50 in FIG. 11. The signal 50 includes similar leading and trailing positive pulses 51 and 52 of a corresponding magnitude with an intermediate oppositely polarized or negative pulse 53 of a substantially great magnitude, for the assume counterclockwise rotation. The opposite or clockwise rotation establishes a similar signal 54 but with the several pulses of an opposite polarity as a result of the reversal of the adjacent magnets 47 and 48 in each of the units 46 and 46'. The polarity of the signals generated by the units 46 and 46' are therefore sensitive to the direction of rotation and may be employed to prevent reverse rotation of the engine. In the circuit of FIG. 8, the relatively small leading and trailing pulses must be of sufficient amplitude over the engine operating speed range to trigger or fire the control rectifiers 14 and 14'.

With counterclockwise rotation, the succeeding magnet units 46 and 46' sequentially discharge the capacitor 5 through the transformer 9 with the energy being distributed to the cylinders 2 and 3 by the distributor 44. However, as previously described, only the first positive pulse of the leading signal is operative as it triggers the related rectifier 14 resulting in the discharge of a capacitor 11 and the sequential discharge of the capacitor 5 through the transformer 9 for purposes of firing the engine.

Reverse or clockwise rotation results in the trailing magnet 48 and 48' being first applied to the alternator winding 49 and consequently, results in the oppositely phased pulse signal 56. As a result, the leading portion of the signal 56 from the magnetic units 46 and 46' is now a negative pulse which is effective to trigger the rectifier 14' and thereby transfer the energy of capacitor 11 into the dummy load resistor 45. As a result, the following positive pulse or portion, which is applied to the trigger or fire rectifier 14 to turn it on are ineffective and to the trigger or fire rectifier 14 to turn it on are ineffective and capacitor 5 remains charged. Energy is therefore not transferred through the transformer 9 and distributor 38 to the sparkplugs 2 and 3. As a result, the engine 1 will not operate.

In FIG. 8, the controlled rectifiers 14 and 14' are shown interconnected in similar triggering pulse forming networks 10 and 10', but the pulse forming or generating unit 15 of FIG. 8 includes a single nontapped winding 49 coupled to the exciting magnets. Winding 49 may be wound on the core 25 which is mounted adjacent the rotor support 26, as shown in FIG. 3 for the center-tapped winding. The opposite ends of the winding 49 are connected respectively to the gates 19 and 19' of the controlled rectifiers 14 and 14'. A first diode 54 is connected across the gate to cathode circuit of the controlled rectifier 14 and is polarized to conduct from the cathode to the gate. A similar second diode 55 is connected across the gate to cathode circuit of the controlled rectifier 14' and is similarly polarized to conduct from the cathode to the gate of the second controlled rectifier 14'. A resistor 55a may be connected across the diode 55 to increase the high-temperature stability of the rectifiers 14 and 14'.

In operation, the rotor rotation generates time-spaced alternating current pulses in winding 49, as previously described. With the assumed polarity, the initial portion of the signal is a positive pulse and is applied to fore the controlled rectifier 14. Power or current flows from the left end of the winding 49 through the gate to cathode circuit and then through the diode

55 to the opposite end of the winding 44. The following negative portion or pulse 53 of the signal flows from the right end of the winding 49 through the gate to cathode circuit of the second controlled rectifier 14' and through the diode 54 to the left end of the winding 49. Both rectifiers 14 and 14' are biased, in sequence, to conduct by the signal 50. However, the first firing of the controlled rectifier 14 by pulse 51 effectively removes the power during the positive half cycle from the pulse forming networks 10 and 10' and again effectively disables the effective operation of the firing of the controlled rectifier 14'.

The reverse rotation of the engine and the associated rotor 16, reverses the polarity of the signal, as shown by signal 56 in FIG. 11a, and the first pulse generated by the normal trailing magnet 48 is a negative-going pulse. The signal now is applied to flow through the gate 19' of the controlled rectifier 14' and returns through the cathode circuit and the diode 55 to the left end of the winding 49. This pulse triggers the controlled rectifier 14' and only after the discharge of the energy of capacitor 11 is the positive-going portion of the signal 56 effective to fire the other controlled rectifier 14. This results in discharge of the stored energy of capacitor 11 into the dummy load resistor 45.

Further, although diodes 54 and 55 are shown in FIG. 8 for bypassing of the gate to cathode circuit during the alternate half cycles, if sufficient power is available, bypass resistors may be employed in place of diodes. The power available must be increased, however, to compensate for the loss in the resistor elements.

The circuit and pulse source may be constructed by suitable shaping of the poles or magnet or the like, such that the intermediate pulse of each signal generated by units 46 and 46' is of a sufficient amplitude to fire a rectifier but the leading and trailing pulses are not. The ignition system may then employ the single discharge 6 with complete elimination of discharge 7. The poles and/or magnets may also be suitably shaped to establish a desirable timing versus r.p.m. relationship.

The pulse signal derived from the pulse source of FIGS. 9 and 10 may be obtained from other rotor and stator constructions as shown in FIG. 12, for example.

In FIG. 12, the flywheel 58, of which only a portion is shown, is assumed to be formed of aluminum or the like. Recesses are again provided in diametrically opposite portions of the flywheel. A permanent magnet 59 is mounted within the one recess with the polarization generally along a chordal line. A similar magnet, not shown, may be mounted in an opposite recess with a similar chordal line polarization but of an opposite directional polarity. A coil unit 52 is mounted above the flywheel 58 on the radius traversed by the rotation of the flywheel. In the embodiment shown in FIG. 12, the coil unit 62 includes a generally straight rod-shaped core 63 which extends vertically of the rotor. The trigger or common pickup winding 64 is wound about the core 63. As the flywheel rotates, alternating current pulses essentially corresponding to that of FIG. 11 are generated in the winding 64 which can be applied as shown in FIG. 8 to provide the desired alternate sequential firing of the controlled rectifiers or any other similar polarity sensitive means.

In FIGS. 13 and 14, still a further modified construction of the rotor unit 15 within the scope of this invention is illustrated. In FIGS. 13 and 14, a flywheel 65 is assumed to be formed of aluminum. Recesses are provided in diametrically opposite portions of the flywheel. A permanent magnet 66 is mounted within the one recess with the polarization generally along a chordal line. A similar magnet 67 is mounted in the opposite recess with a similar chordal line polarization but of an opposite directional polarity. A coil unit 69 is mounted above the flywheel 58 on the radius traversed by the rotation of the flywheel.

In the embodiment shown in FIGS. 13 and 14, the coil unit 69 includes a generally U-shaped core 70 which opens downwardly with the legs spaced in accordance with the spacing of the pole pieces 68 and oriented to align the core legs

with the pole pieces 68 as the latter pass. The trigger winding 71 is wound on the base position of the core 70. As the flywheel 58 rotates, alternating current pulses are generated in the winding 71 which are typical as shown at 72 in FIG. 15. The waveform of the signal 72 of the system shown in FIGS. 13 and 14 includes a high-amplitude alternating signal having a leading negative portion 73 and a trailing positive portion 74. The waveform is essentially the same as that of FIG. 5 except for a small positive pulse 75 at the leading portion and a similar small negative pulse 76 at the trailing portion of each of the pulse signals. Generally, the amplitude of the pulses 75 and 76 are of such a minor nature that they will be insufficient to affect the operation of the circuit, and only the pulses 73 and 74 are usable. Further, the system of FIG. 13 is similar to FIG. 5 in that the sequence of any given magnet is not sensitive to the direction of rotation.

The illustrated wave shapes and the several portions thereof which are shown in the drawing for purposes of explaining the several forms of alternating current trains or signals generated by the respective magnetics may be altered or shaped with shaped pole pieces or the like, if desired.

The present invention has been found to provide a reliable and relatively inexpensive pulse generating means for alternate firing of a pair of pulse-responsive switch means and, in particular, for the discharging of a capacitor in paralleled output circuits of a capacitor discharge ignition system for the alternate firing of sparkplugs of a two-cylinder engine.

I claim:

1. An ignition system for the energizing of an engine firing means of an internal combustion engine comprising an energy source connection means,

a pickup means,

a pair of separate exciting means physically mounted in spaced relation to each other by a distance such that with one exciting means aligned with the pickup means the other is spaced therefrom, means to establish relative movement between said pickup means and said exciting means with said pickup means thereby sequentially and periodically coupled to each of said spaced exciting means in time-spaced relation to sequentially induce correspondingly time-spaced alternating current signals separated by essentially zero current periods, each of said signals including a pair of opposite polarity pulses and successive time-spaced signals having pulses of opposite polarity sequence in said pickup means, and

a switching circuit having a pair of polarity sensitive control means controlling the connection of the energy source connection means to said firing means to supply energy source connection means to said firing means to supply energy to said firing means and being connected to said pickup means and including a phase inversion means to operatively energize both of said polarity sensitive means in response to each of said alternating current signals with the first of said control means supplying the energy to said firing means whereby firing is established only in response to an alternating current signal having a predetermined polarity sequence.

2. The ignition system of claim 1 wherein said exciting means establishes a signal in the pickup means which reverses with a reversal in the relative movement of the exciting means and the pickup means.

3. The ignition system of claim 1 wherein said pair of exciting means induces an alternating current signal consisting of only a first polarity pulse and a following opposite polarity pulse in response to each coupling to said pickup means.

4. The ignition system of claim 1 wherein said exciting means establishes an alternating current signal in said pickup means having a leading and trailing pulse of the same polarity and an intermediate pulse of an opposite polarity.

5. The ignition system of claim 4 wherein said leading and trailing pulses are of a substantially lesser peak voltage amplitude than said intermediate pulse.

6. The ignition system of claim 4 wherein said phase sensitive control means respond to the leading portion of the signal.

7. The ignition system of claim 1 wherein said exciting means establishes successive oppositely phased alternating signal portion in said pickup means including similar relatively low amplitude leading and trailing pulse portions with intermediate relatively high amplitude intermediate pulse portions.

8. The ignition system of claim 1 wherein said pair of exciting means is a pair of magnetic members of opposite polarity and said common pickup means is a winding having the opposite ends thereof connected to said polarity sensitive control means and said winding constituting said phase inversion means.

9. The ignition system of claim 1 wherein said exciting means are connected in spaced relation to a common support movably mounted adjacent the pickup means to periodically and cyclically establish said signals.

10. The ignition system of claim 1 wherein said exciting means are mounted in immediately adjacent relation upon a common support and moved relative to the exciting means whereby the exciting means and pickup means are coupled with each exciting means producing a corresponding effect during the corresponding leading and trailing portion of the movement past the pickup means and a superimposed effect during the intermediate period.

11. The ignition system of claim 1 wherein each of said exciting means are oppositely polarized magnetic units and said pickup means is a center-tapped winding wound on a core mounted with the respective magnetic units establishing oppositely directed flux therethrough and thereby generating a single cycle alternating current signal consisting of a first portion of one polarity and a second portion of an opposite polarity, the reverse polarity sequence being established by the second magnetic unit, a pair of similar polarity-sensitive switch means each having a pair of input elements, and means connecting one-half of the winding to said one pair of input elements and connecting the opposite half of the winding to the second pair of input elements.

12. The ignition system of claim 1 wherein said pickup means is a winding, said exciting means including at least one pair of magnetic elements mounted in adjacent relation for movement past the winding, a pair of similar polarity-sensitive switch means each having a pair of input elements, means connecting the opposite ends of said winding to a corresponding first input element of the switch means and to the second input element in series with an impedance element, said first switch means being connected in a circuit between said firing means and source, and said second switch means being connected in a circuit between said source and a dummy load.

13. The ignition system of claim 1, wherein said exciting means and pickup means includes a rotor and a stator and each signal includes in succession a first polarity portion, a second opposite portion and a third polarity portion corresponding to the first polarity portion and reversing in polarity sequence in response to reversing of the movement of said rotor.

14. The ignition system of claim 13, wherein said rotor includes a plurality of similar magnetic units, each of which includes a pair of adjacent oppositely polarized magnets sequentially impressed upon said pickup means for generating said opposite polarity signals in response to opposite movement of the exciting means relative to said pickup means.

15. A capacitor discharge ignition system having a pair of alternately energized polarity-sensitive switch means for discharging of a main capacitor, the firing of one switch means to conduct rapidly discharging said capacitor and effectively disabling the operation of the other switch means, a common pickup means coupled to the switch means, and oppositely polarized exciting means mounted and correspondingly moved relative to said common pickup means with the pickup means aligned with said exciting means and then spaced from all of said exciting means to induce time-spaced alternating current pulses in said common pickup means with essentially zero current and voltage between pulses and the successive pulses being of opposite phase polarity sequences in response to a change in the direction of movement of the pickup means

relative to said exciting means and establishing pulses in said pickup means so as to fire said switch means from said common pickup means, each pulse including alternate half cycles of opposite polarity and said capacitor being

16. The capacitor discharge ignition system of claim 15, wherein output means are connected to a common trigger capacitor, and the firing of one switch means transfers the energy from said trigger capacitor during the periods of a trigger pulse and thereby effectively disables the operation of the other switch means.

17. The capacitor discharge ignition system of claim 16, wherein said switch means are gate-controlled rectifiers and connected in series with the corresponding output means to define a discharge circuit connected across said trigger capacitor, said discharge circuit having a time constant no greater than one-half cycle of an alternating current pulse of said train.

18. The capacitor discharge ignition system of claim 15, wherein said pickup means includes a winding having the opposite ends connected one to each of said switch means and a return circuit means whereby the corresponding half cycles of each pulse energizes the corresponding switch means.

19. The capacitor discharge ignition system of claim 15, wherein said pickup means includes a winding having the opposite ends connected one to each of said switch means, and a common return connection between said switch means and an intermediate turn of said winding means.

20. The capacitor discharge ignition system of claim 15, wherein said switch means are triggered switches having gate means for controlling conduction and connected in series with the corresponding output means to define a discharge circuit

connected across said trigger capacitor, said discharge circuit having a discharge time no greater than one-half cycle of said alternating current pulse, said pickup means including a winding having one end connected to the gate means of the one triggered switch and the opposite end connected to the gate means of the second triggered switch, and diode means connected across each of the gate means and polarized to bypass the one-half cycle from the corresponding triggered switch.

21. The pulsed electrical system of claim 20, wherein said diode means includes a first diode connected across the gate means of the first switch and polarized to conduct the half cycle of each pulse which triggers the second switch, and a second diode connected across the gate means of the second switch and polarized to conduct the half cycle of each pulse which triggers the first switch.

22. The capacitor discharge ignition system of claim 15 including an alternator driven from a two-cylinder alternate firing engine having a flywheel, said exciting means including a pair of permanent magnets mounted in diametrically opposed portions of said flywheel, said magnets being oppositely polarized, and said pickup means including a winding means disposed adjacent to the path of said magnets and coupled to the field of the passing magnets such that each magnet establishes a polarized unidirectional magnetic field through said winding means to fire the cylinders in proper sequence without a distributor.

23. The capacitor discharge ignition system of claim 22, wherein said winding means is adjustably mounted for selective movement about the flywheel for adjusting the timing of the generation of said pulses.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,612,948 Dated October 12, 1971

Inventor(s) FLOYD M. MINKS

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, Line 26, after "sparkplug" cancel
the comma (,) and insert a
period --- . ---;

Column 1, Line 66, before "means" cancel "of"
and insert --- switch ---;

Column 6, Line 6, cancel "states" and insert
--- stages ---;

Column 6, Line 13, cancel "opposite ends of the
winding of the";

Line 14, cancel this line in its
entirety;

Line 15, cancel "the signal with
respect to the";

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,612,948 Dated October 12, 1971

Inventor(s) FLOYD M. MINKS

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

(Continuation)

Column 7, Line 47, after "and" cancel "to";
Line 48, cancel this line in its
entirety;

Column 8, Line 49, after "unit" cancel "52"
and insert --- 62 ---;

Column 9, Line 4, cancel "typical" and insert
--- typically ---;

Column 9, Line 49, cancel this line in its
CLAIM 1 entirety;
Line 50, at the beginning of the line
cancel "energy";

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,612,948 Dated October 12, 1971

Inventor(x) FLOYD M. MINKS

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

(Continuation)

Column 11, Line 4, after "being" insert ---
CLAIM 15
substantially discharged
within a half cycle of each
pulse for firing a corres-
ponding switch means, each
one of said pulses sequen-
tially firing both of said
switch means. ---

Signed and sealed this 16th day of May 1972.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents