

Feb. 18, 1969

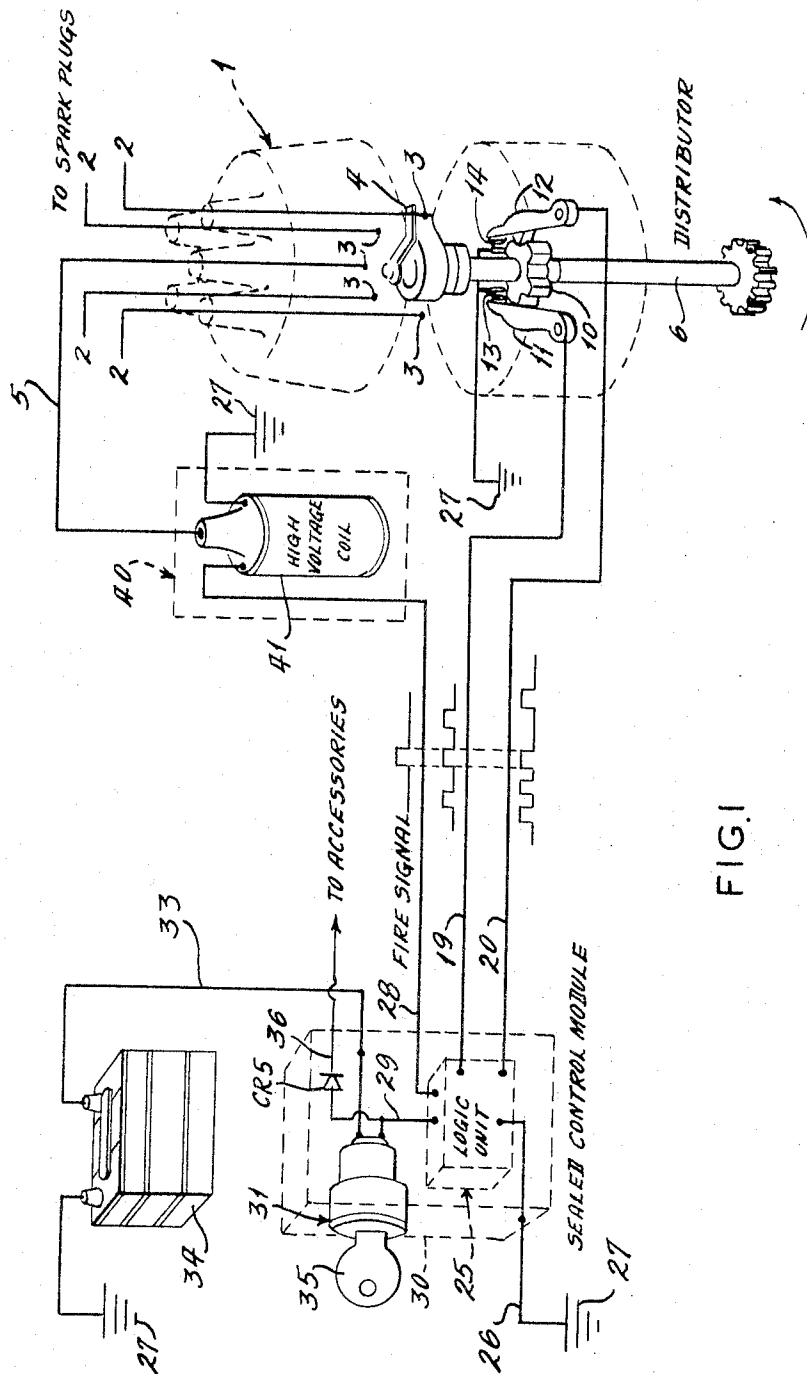
L. A. WATTS

3,428,033

PULSE CONTROLLED MECHANISM SECURITY SYSTEM

Filed June 1, 1967

Sheet 4 of 5



INVENTOR:
LOUIS A. WATTS
BY  ATTORNEY,

Feb. 18, 1969

L. A. WATTS

3,428,033

PULSE CONTROLLED MECHANISM SECURITY SYSTEM

Filed June 1, 1967

Sheet 2 of 5

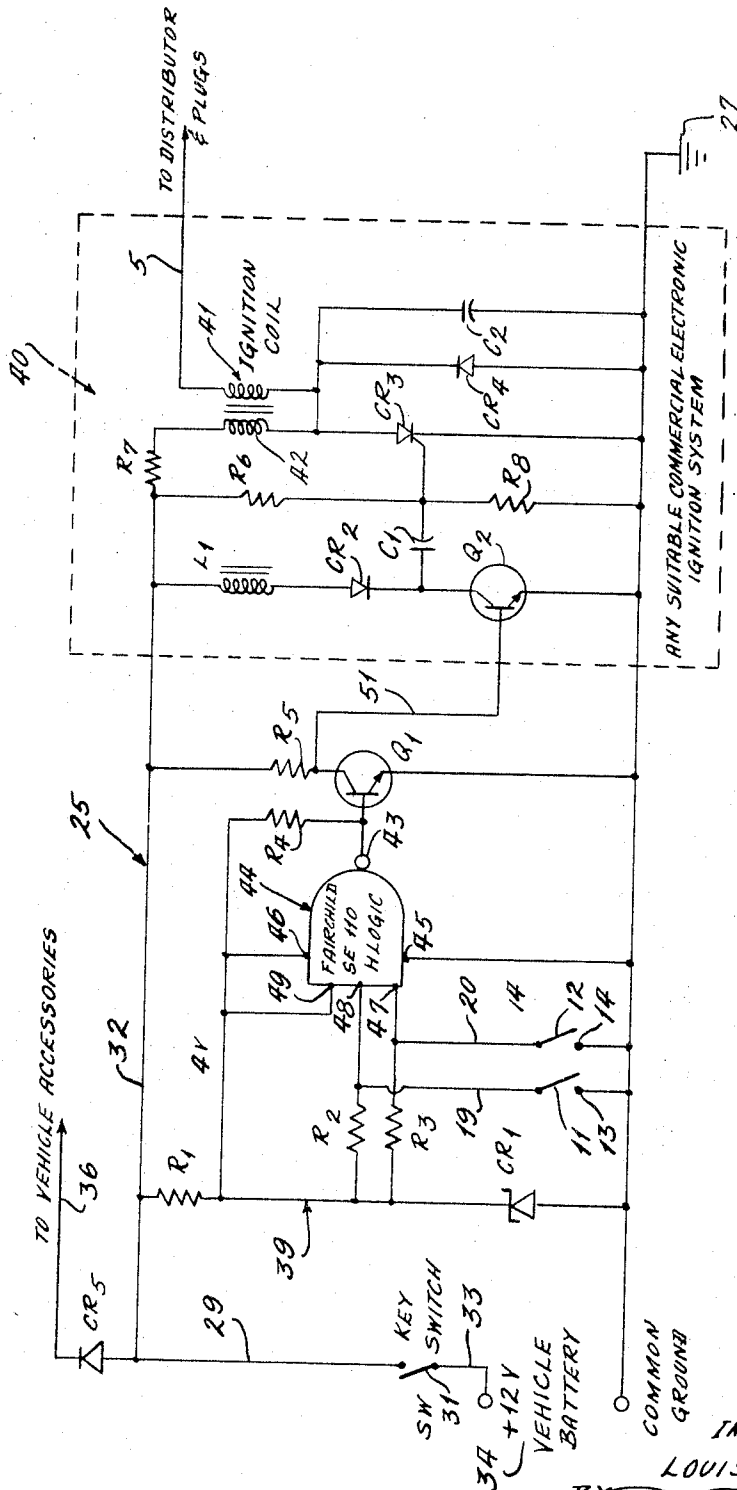


FIG. 2

INVENTOR:
LOUIS A. WATTS
BY *[Signature]*
ATTORNEY,

Feb. 18, 1969

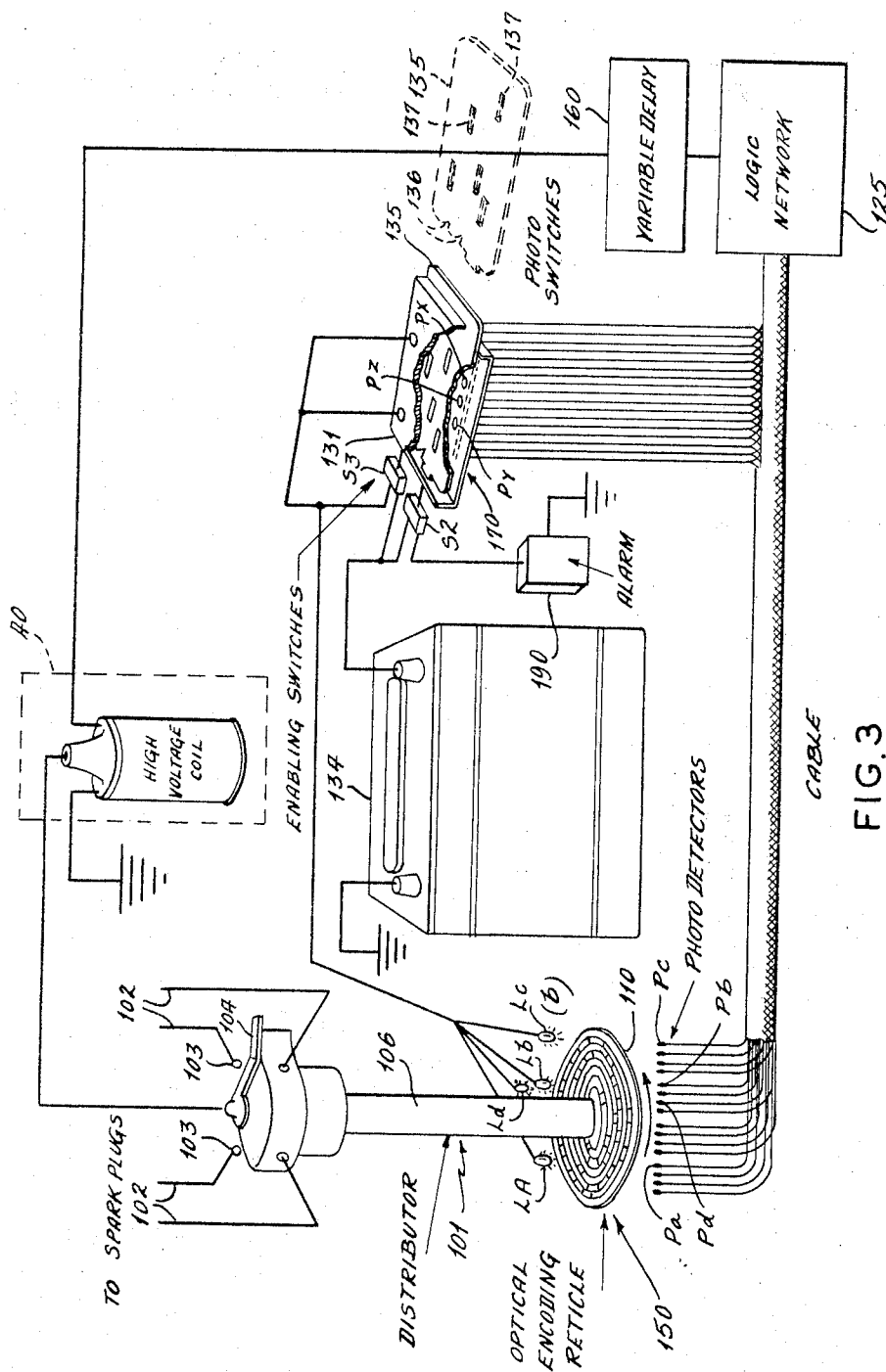
L. A. WATTS

3,428,033

PULSE CONTROLLED MECHANISM SECURITY SYSTEM

Filed June 1, 1967

Sheet 3 of 5



INVENTOR:
BY LOUIS A. WATTS
[Signature]
ATTORNEY,

Feb. 18, 1969

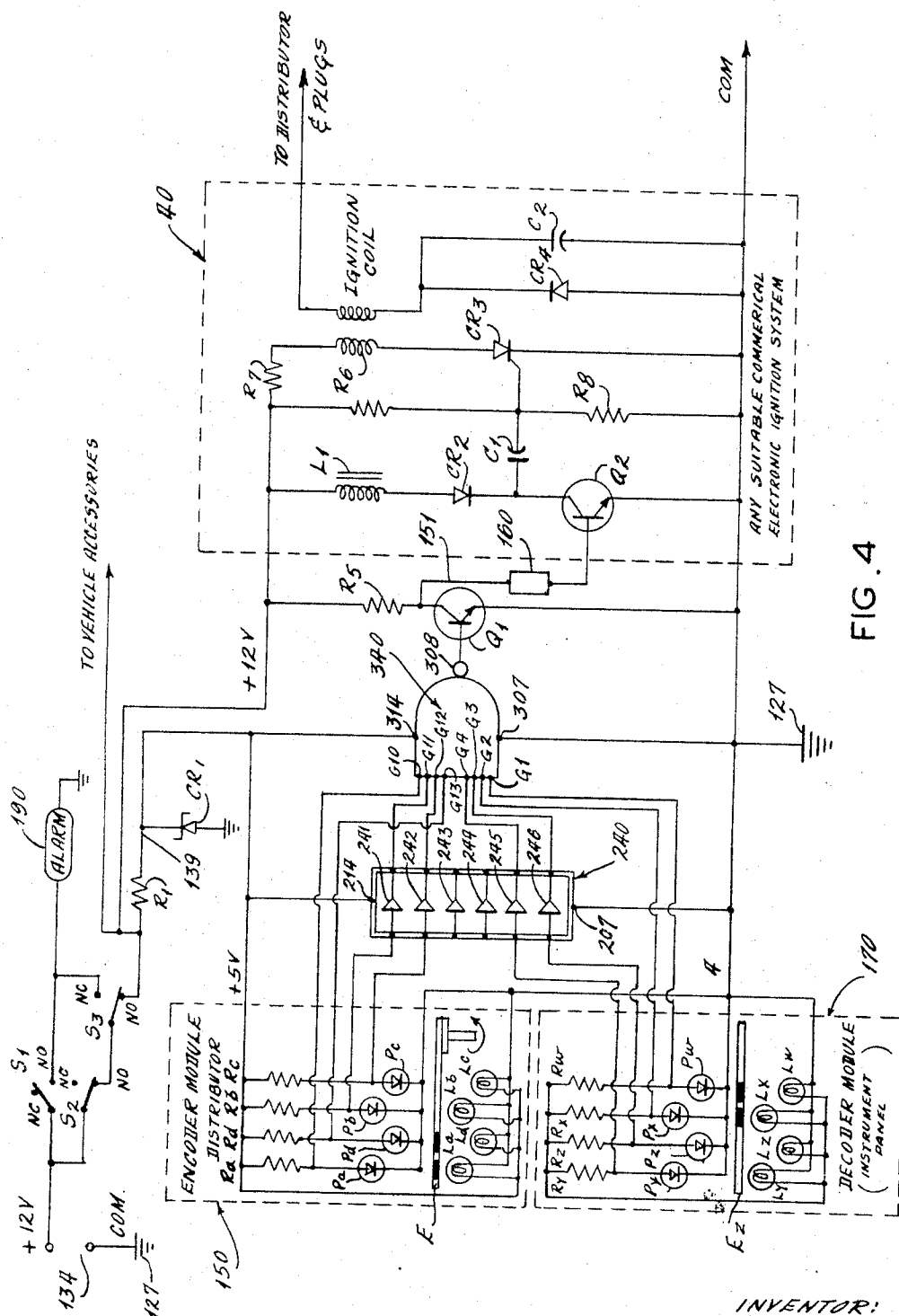
L. A. WATTS

3,428,033

PULSE CONTROLLED MECHANISM SECURITY SYSTEM

Filed June 1, 1967

Sheet 4 of 5



4
FIG

INVENTOR:
LOUIS A. WATTS
BY 
ATTORNEY,

Feb. 18, 1969

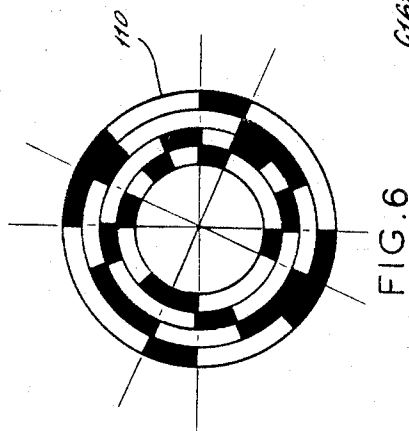
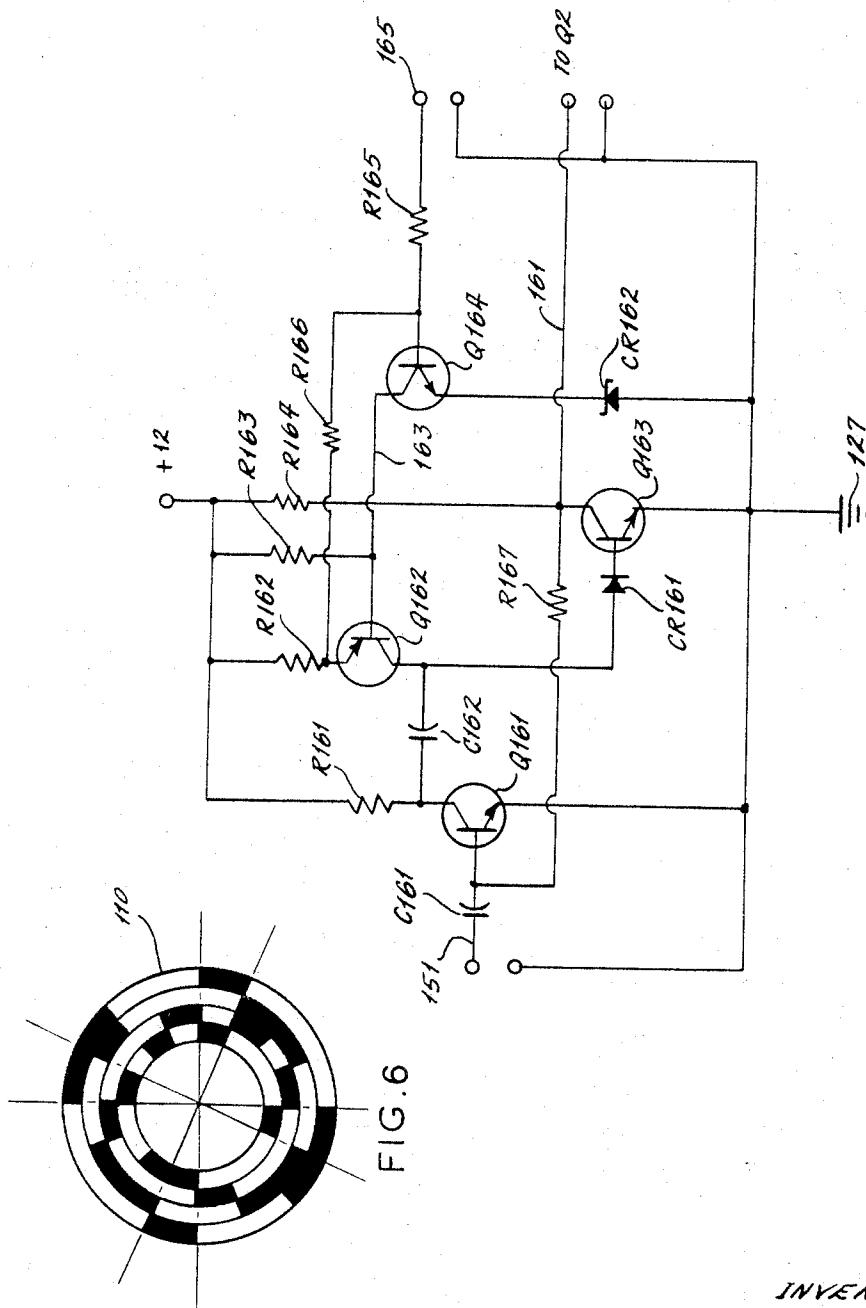
L. A. WATTS

3,428,033

PULSE CONTROLLED MECHANISM SECURITY SYSTEM

Filed June 1, 1967

Sheet 5 of 5



INVENTOR:
LOUIS A. WATTS
BY *[Signature]*
ATTORNEY,

1

2

3,428,033

PULSE CONTROLLED MECHANISM SECURITY SYSTEM

Louis A. Watts, Santa Barbara, Calif., assignor to Emerson Electric Co., St. Louis County, Mo., a corporation of Missouri

Filed June 1, 1967, Ser. No. 642,946
U.S. Cl. 123—146.5
Int. Cl. F02p 11/04; H01h 27/00, 47/00

9 Claims

ABSTRACT OF THE DISCLOSURE

An ignition system for electrically fired internal combustion engines which includes a decoder key card in place of the conventional key, which, when inserted in a decoder receptacle energizes part of a circuit in an encoding reticle station. The insertion of a wrong key card actuates an alarm. An encoding reticle is mounted for rotation on a distributor shaft to expose detectors to patterned sequential energization. The pulsed energy from the detectors is fed into a logic network, thence through a variable delay to a high voltage coil connected to the distributor. The decoder key card also is arranged to cause the selective actuation of certain of the detector circuits and to prevent the actuation of others of the detector circuits. The pulses to the logic network are translated into a timed "fire" command in turn for each cylinder.

Background of the invention

Auto theft is universally recognized as a continuing major problem. The great majority of automobiles stolen are stolen by relative novices who intend to use the stolen car for joy riding. They generally rely on some simple means to jump the ignition switch. Even among professional car thieves, however, the most common means of theft appears to be the use of "hot wiring" techniques. In present ignition systems, a set of breaker points driven by a cam on the distributor shaft sequentially interrupts the battery voltage to pulse the ignition coil, thereby transforming the low voltage D.C. battery voltage to a high voltage impulse. These high voltage pulses are routed to sparkplugs in the cylinders of the engine by a set of contacts operated from the distributor shaft. Since the timing and sequencing of the engine firing order are established only by the geometric configuration of the distributor, any means of connecting the vehicle battery or an auxiliary battery to the primary terminal of the spark coil will defeat a conventional key lock.

One of the objects of this invention is to provide an ignition system in which a key circuit does not admit of simple by-passing.

Another object is to provide a security system applicable to machines, different from internal combustion engine ignition systems, which are, or can be controlled by electrical pulses.

Still another object is to provide such a security system in which a computer can be used to assign, embody and remember unique individual codes for each machine.

Other objects will become apparent to those skilled in the art in the light of the following description and accompanying drawing.

Summary of the invention

In accordance with this invention, generally stated, a pulse controlled mechanism security system is provided for machines which are or can be controlled by electrical pulse, such, for example as an internal combustion engine having electrical explosion initiating means in cylinders of the engine. The system includes electric pulse-generating means driven in response to and as a function of the

speed of the machine, the pulse generating means producing a cyclic pulse pattern, which, however, is not a direct function of the cycle to be controlled and which also produces confusion patterns. The pulse generating means are electrically connected to a logic network which converts the pulse pattern to sequential firing signals. The logic network is electrically connected to control the operation of the machine, as, for example by controlling the energization of the electrical explosion actuating means in an internal combustion engine in proper firing order, when the proper pulse pattern is transmitted to the logic network.

An example of this basic system is the provision, in an automobile internal combustion engine, of a multi-faceted cam and multiple breaker points instead of the conventional cam and breaker point assembly, and the connection of these breaker points to a logic unit sealed into a module, with a conventional ignition lock. In this arrangement, the ignition lock serves only to complete a circuit, inside the sealed module, to the logic unit. The pulses from the breaker points trigger a firing signal to the spark coil at the moment the distributor reaches the distributor point for each spark plug. This system renders the common key-switch hot-wire proof, since connecting the battery to the coil will permit no interruption of the D.C. voltage which is necessary to transform the low-potential signal to a high-voltage spark, and connecting wiring from the breaker points to the spark coil directly, by-passing the decoding action of the logic unit, will cause improper timing and misfiring of the engine. This system, however, has the disadvantage that a master key will operate the system just as a master key now will operate the ignition system. It also has the disadvantage, with the multi-faceted cam and breaker points located in a distributor, that the pulse pattern of the breaker points can be determined either by inspection or by a simple testing device, and, conceivably, an auxiliary "master" logic module could be devised to defeat the system.

A system less vulnerable to the master key problem is one in which 25 to 100 two-position switches are mounted in a switch matrix for push button control. This system has the disadvantage that the driver must remember the proper combination, and push a plurality of buttons to actuate the ignition system. It has the advantage, in addition to its providing many millions of possible combinations, that it can be made so that it must be cleared to stop the engine.

Still another embodiment, and the preferred embodiment, involves the use of a decoder key card, instead of an ordinary key, to combine the advantages of the multi switch arrangement with the simplicity of an ordinary key. It also involves the substitution for the multi-faceted cam and breaker points, of a multiplicity of solid-state photo cells with a patterned rotating disc or reticle between the photo cells and a light source. The light source is actuated when the proper key card is inserted in a decoder receptacle. An alarm is actuated when the wrong key card is inserted. The completion of the circuits from the reticle photo cells beyond a logic network is controlled by photo switches actuated in response to the positioning of the key card. A variable delay device can be interposed in the electrical circuit between the logic network and the spark coil to permit electronic control of the spark timing in response to demands of the engine, which may involve inputs derived from engine load, revolutions per minute, temperature, altitude or even type of fuel, in addition to the normally used manifold vacuum pressure.

An example of another application of the device is in an SCR controlled electric automobile.

Brief description of the drawing

In the drawing:

FIGURE 1 is a somewhat schematic view of a simple

3

form of security system of this invention applied to an internal combustion engine;

FIGURE 2 is a diagrammatic view of the essential part of the electrical circuit of the system of FIGURE 1;

FIGURE 3 is a somewhat schematic view of the preferred form of security system of the invention applied to an internal combustion engine;

FIGURE 4 is a diagrammatic view of most of the electrical circuit of the system of FIGURE 3;

FIGURE 5 is a diagrammatic view of an electrical circuit of a simple programmable variable delay unit indicated schematically as being a part of the system of FIGURES 3 and 4; and

FIGURE 6 is a top plan view of an optical encoding reticle used in the embodiment of the system shown in FIGURE 3.

Description of the preferred embodiments

Referring now to FIGURES 1 and 2 for a simple form of security system of this invention, reference numeral 1 indicates a distributor of a four cylinder internal combustion engine, with electrical conductors 2 leading to four spark plugs, not here shown. The conductors 2 are electrically connected to the usual distributor points 3, which are swept by the usual distributor arm 4, with which a high voltage coil lead 5 is in electrical contact. The distributor arm 4 is mounted for rotation on and with a distributor shaft 6, driven by a conventional timing gear. In all of these respects, the distributor 1 is conventional.

A multi-lobe cam 10 is mounted for rotation on and with the shaft 6. Spring biased breaker point arms 11 and 12, with cam followers biased against the lobed cam 10, are pivotally mounted to move against and away from breaker points 13 and 14 respectively. Breaker points 13 and 14 are electrically connected to common ground 27. The breaker arms 11 and 12 are electrically connected by means of conductors 19 and 20 respectively, to a logic unit 25 which, in the embodiment shown, is embedded in a sealed control module 30. A ground connection 26, electrically connected to a logic unit circuit, extends from the control module and is electrically connected to a common ground 27. A fire signal conductor 28, electrically connected to the logic unit, also extends from the sealed module and is electrically connected to a standard commercial electronic ignition system 40, which includes a high voltage coil 41, and an electric circuit which consists essentially of a typical coil driving circuit, illustrated in FIGURE 2.

A switch lead 29 is electrically connected to the logic unit 25 and to one side of a key operated switch 31 which, like the logic unit, is embedded as part of the sealed control module 30. A conductor 32, electrically connected to the other side of the switch 31, is electrically connected, by way of a conductor 33, to one side of a battery 34. The other side of the battery 34 is connected to the ground 27. A conventional ignition switch key 35 serves to open and close the switch 31. A conductor 36, electrically connected through an interposed silicon diode CR5 to the conductor 29, leads to vehicle accessories.

Referring now to FIGURE 2 for a more detailed description of the electrical components of the system, the battery 34 is connected through the switch 31, through a resistor R1 and Zener-diode CR1 to the ground 27, forming a supply voltage network 39. This network 39 provides, in the embodiment being described, a stabilized four volt power level to the logic unit. The resistor-diode network 39 is electrically connected to a supply voltage terminal 46 of a conventional three-input NAND-gate 44, and to an unused gate terminal 49. Two other gate terminals 47 and 48 are electrically connected to the network 39 through resistors R2 and R3 respectively, and in parallel, are connected to conductors 19 and 20 respectively from breaker arms 11 and 12 respectively. A ground terminal 45 of the NAND-gate 44 is electrically con-

4

nected to the common ground 27. An output terminal 43 of the NAND-gate 44 is electrically connected, through a resistor R4 to the four volt supply network 39, and, in parallel with resistor R4 to a transistor Q1 which, with a resistor R5 constitutes an amplifier and logic output signal inverter. The collector of the transistor Q1 is connected, in series with the resistor R5, to the twelve volt conductor 32, the emitter, to the ground 27. A conductor 51 is connected electrically between the transistor Q1 and the resistor R5, and to the base of a transistor Q2 which forms a part of the electronic ignition system 40. As has been indicated, the electronic ignition system 40 illustrated is simply typical of suitable commercial electronic systems.

In this illustration, the ignition system 40 includes besides the transistor Q2, a high current diode CR2, a silicon gate controlled switch CR3, silicon diode CR4, capacitors C1 and C2, inductor L1, resistors R6, R7 and R8, and the ignition coil 41. The inductor L1 and diode CR2 are connected in series with one another between the collector of the transistor Q2 and the twelve volt source conductor 32. The capacitor C1 is connected electrically between the transistor Q2 and the diode CR2, and to a conductor between the resistors R6 and R8 which are connected in series with one another between the twelve volt supply conductor 32 and the ground 27, and to the gate of the silicon gate control switch CR3. The silicon gate control switch CR3 is electrically connected to the ground 27 and to a primary coil 42 of the high voltage coil 41, and, in series with the primary of the coil, through the resistor R7, to the twelve volt supply line 32. It is also connected, in parallel, to the secondary of the ignition coil, to the diode CR4 and capacitor C2, the latter two being electrically connected on the other side directly to the common ground 27. The secondary of the ignition coil is, of course, electrically connected to the conductor 5 to the distributor and, ultimately to the spark plugs and ground.

In the operation of this embodiment of system, when the switch 31 is closed, the battery is connected through the resistor R1 and Zener-diode CR1 to the ground, as has been indicated, to provide a stabilized four volt supply voltage to the logic unit. It also connects the vehicle accessories to the vehicle battery, the diode CR5 being used to prevent "sneak-path" currents from other vehicles accessories from feeding back and activating the ignition system while the key switch is in the "off" position.

The NAND-gate 44 is of the type in which the output on the output terminal 43 will remain at the high level of plus four volts if any of the gates 7, 8 and 9 is at ground potential, and this output will drop from plus four volts to ground potential if and only if all three gates are connected to plus four volts. When either or both of the breaker points 11 and 12 are closed, the gate to which the closed point is connected, will be clamped to ground level. Thus, it is only when the opening of both breaker points coincides, that all gates will be pulled up to a high potential, and the output at the output terminal 43 will drop to ground potential, which signals the firing of the ignition circuit. The lobes on the cam 10 are such as to provide this coincidence only at the proper firing times. During the time when the breaker points are not open coincidentally, the transistor Q1 conducts heavily, causing transistor Q2 to be turned off. The resulting charging current through the capacitor C1 turns on the silicon gate control switch CR3. The capacitor C1 will charge to a voltage level that is dependent upon the energy stored in inductor L1 from the previous cycle; in this instance, generally 25 to 30 volts.

When the breaker points open simultaneously, transistor Q2 will be turned on and capacitor C1 will discharge through the gate circuit with a polarity that will turn the silicon gate control switch CR3 off. The resultant interruption of current through the primary 42 of igni-

tion coil 41 will allow a rapid collapse of the magnetic field in the coil and thus will allow generation of the proper ignition voltage in the secondary of the coil.

Resistor R6, connected to the gate of the silicon gate control switch CR3 will perform the function of turning that switch back on after the capacitor C1 has discharged, even before the points have closed again. This allows more time for energy storage in the ignition coil with a resultant substantial improvement in high speed ignition performance over a conventional system.

Merely by way of illustration, and not of limitation, the components of the system of the embodiment just described, may have the following values or descriptions:

Reference—Value or Description

C1	—2.0 microfarads.
C2	—0.25 microfarad.
R1	—10 ohms.
R2	—10K ohms.
R3	—10K ohms.
R4	—1K ohm.
R5	—1K ohm.
R6	—120 ohms.
R7	—10 ohms.
R8	—47 ohms.
CR1	—Four-volt reference diode, typically 1N3994.
CR2	—High current diode, typically 1N4001.
CR3	—Silicon gate controlled switch, typically MGCS-924.
CR4	—Silicon diode, typically 1N4005.
CR5	—Silicon diode, typically MR1200.
L1	—Inductor, typically 12 mh., 25 ohms.
uL1	—Three-input NAND gate, typically SE110.
Q1	—Silicon transistors, typically 2N2218.
Q2	—Silicon transistor, typically 2N2218.
41	—Automotive ignition coil, typically Delco Remy 087.

Referring now to FIGURES 3, 4 and 5 for a more sophisticated system of this invention, reference numeral 101 indicates a distributor for a four cylinder internal combustion engine, which, like the distributor 1 of the first embodiment described, has conductors 102 leading to the spark plugs of the engine, and electrically connected to distributor points 103, swept by a distributor arm 104. The distributor arm is mounted on a distributor shaft 106 which is rotated by timing gears not here shown. In this embodiment, however, there are no cams or breaker points. Instead, an optical encoding reticle 110 is fixed to the shaft 106, projecting perpendicularly to the axis of the shaft. The reticle 110 is in the form of a thin disc of transparent plastic with areas of opacity, leaving a pattern of transparent areas, as shown in FIGURE 6.

On one side of the reticle 110 four lamps La, Lb, Lc and Ld are positioned. On the other side of the reticle 110, photo detectors or sensors Pa, Pb, Pc and Pd are positioned to receive light from the lamps La, Lb, Lc and Ld when a light transmitting area of the reticle 110 is interposed between them. In the embodiment shown, twelve of sixteen sensors are either dummies or interconnected in groups of four. The lamps, reticle and sensors are mounted in a sealed container, and together constitute an encoder module 150.

The photo detectors Pa, Pb, Pc and Pd are electrically connected to a logic network 125, which is in turn electrically connected to a variable delay circuit 160, hence to an electronic ignition system 40 which in the illustrative embodiment shown, is identical in all respects with the ignition system 40 shown in FIGURES 1 and 2 and described in connection with the first embodiment described.

Also electrically connected to the logic network 125 are photo detectors or sensors Pw, Px, Py and Pz. These sensors and a decoder receptacle 131 in which they are mounted, form parts of a decoder module 170. The de-

coder module also includes infrared lamps Lw, Lx, Ly and Lz, also mounted in the receptacle 131, spaced from the sensors Pw, Px, Py and Pz sufficiently to permit the interposition of a decoder key card 135. The decoder receptacle 131 also contains switch toggles of switches S1, S2, and S3. In FIGURE 3, only switches S2 and S3 are illustrated because only S2 and S3 must be actuated to energize the ignition system. The switches are connected to a battery 134, to an alarm 190, to the lamps La, Lb, Lc and Ld, Lw, Lx, Ly and Lz, to the variable delay circuit 160 and to the logic network 125.

The decoder key card 135 is a generally rectangular plate of plastic or the like with notches 136 in one edge, and with a series of near infrared light-transmitting windows 137 in it, arranged in a predetermined pattern.

Referring now to FIGURE 4 for a more detailed description of the electrical components of the system of this embodiment, the battery 134 is connected on one side to the switches S1, S2 and on the other side to a common ground 127. Switches S1, S2, and S3, which are shown in their ignition circuit-completing alarm circuit open position, are inter-wired so as to conduct power from battery 134 to the ignition system, and to leave open the circuit to the alarm, only when the proper combination of switches is simultaneously activated by a notch pattern in the edge of the decoder key card 133. In this specific embodiment, when the proper notch pattern is employed, switches S2 and S3 will be activated and S1 will remain in the normal state. A conductor from battery 134 is connected to the armatures of switches S1 and S2. The "normally open" contact of switch S1 is connected via a conductor to the alarm 190. The NO contact of switch S2 is connected in series with the armature of S3, and the NO contact of S3 is connected to the vehicle power supply terminal. It can be seen that a card with the wrong notches, which would move switch S1 to the NO position or switch S2 to the NO and leave switch S3 in its NC position, would close the circuit from the battery to the alarm, and leave the ignition circuit uncompleted.

As in the first embodiment, a resistor R1 and Zener-diode CR1 are used to form a supply voltage network 139, which, in this embodiment, supplies a stable five volt power.

Each of the encoder module sensors Pa, Pb, Pc and Pd, and each of the decoder module sensors Pw, Px, Py and Pz is connected in series with a pull up resistor (Ra, Rb, Rc and Rd, Rw, Ry and Rz, respectively) across the power supply. Thus when not illuminated, the sensors will be "open" and will not conduct current to ground, and the gate connection at the junction of the resistor and the sensor will be at a high potential. When illuminated, the photo switch (sensor) will close and the gate current will sink to ground potential.

In this embodiment, the logic circuit includes two common integrated micro electronic modules 240 and 340. The module 240 contains six separate inverter stages 241, 242, 243, 244, 245 and 246. The other module 340 is a single eight-input NAND gate. Like the NAND gate 44 of the first embodiment, the NAND gate 340 is of the "current sinking" type, so that if any or all of the gates are connected through a low impedance to ground or the low state, the output will be at the high state. When all gates are simultaneously raised to the high state, the output of the NAND gate drops to ground, triggering the ignition system in exactly the same way as the NAND gate 44 of the first embodiment described.

In this embodiment, the sensors Pa and Pd, Pw and Px are electrically connected to gate terminals G10 and G13, G1 and G2, respectively. Sensors Pb and Pc, Py and Pz, are connected electrically to the inverters 241, 242, 245 and 246 respectively, which are, in turn, electrically connected to gate terminals G11, G12, G4 and G3 respectively. The module 240 is electrically connected to the five volt supply network at a terminal 214, and, to the common ground 127 at a terminal 207. Similarly, the

NAND gate 340 is electrically connected to the five volt supply network through a terminal 314, and to the common ground through a ground terminal 307. An output terminal 308 of the NAND gate is connected to the base of a silicon transistor Q1, the collector of which is connected, in series with a resistor R5, to the twelve volt supply line from the battery. The emitter of the transistor Q1 is electrically connected to the common ground 127. The resistor R5 and transistor Q1 are exact counterparts of those elements in the first embodiment. However, an electrical conductor 151 connected between the transistor Q1 and the resistor R5, in this embodiment, is connected to the variable delay circuit 160, thence to the ignition 40.

In the simple embodiment of variable delay circuit 160 shown in FIGURE 5, the conductor 151 is connected to a capacitor C161 which is connected electrically in series with the base of input transistor Q161. Also connected to the base of input transistor Q161 is feedback resistor R167, which in turn is connected electrically to the collector of a transistor Q163. Output of the system is taken from the collector of transistor Q163 by way of a conductor 161 to the base of the transistor Q2 of the ignition system 40.

The collector of the transistor Q161 is connected in series with a resistor R161 to the twelve volt power line, and in parallel, between the resistor 161 and the transistor Q161 to a capacitor C162, which in turn, is electrically connected to the collector of a transistor Q162 and to a diode CR161. The diode CR161 is electrically connected to the base of the transistor Q163, the emitter of which is connected to the common ground 127 and the collector of which is connected in series with a resistor R164 to the twelve volt power source and output to the transistor Q2. The emitter of the transistor Q162 is connected in series with a resistor R162 with the twelve volt power line, and between the transistor Q162 and the resistor R162, through a resistor 166, to the base of a transistor Q164, which base is connected in series with a resistor R165 to a control signal terminal 165. The collector of the transistor Q164 is electrically connected to the base of the transistor Q162 by a conductor 163. A resistor R163 is connected between the twelve volt supply line and the conductor 163 intermediate the transistors Q162 and Q164. The emitter of the transistor Q164 is connected, through a Zener diode CR 162 to ground 127.

Merely by way of example, and not of limitation, the components (except for the ignition system 40) of the system of the embodiment just described, may have the following values or descriptions:

SECOND EMBODIMENT WITHOUT VARIABLE DELAY CIRCUIT

Reference—Value or Description

Ra—10,000 ohms.
Rb—10,000 ohms.
Rc—10,000 ohms.
Rd—10,000 ohms.
Rw—10,000 ohms.
Rx—10,000 ohms.
Ry—10,000 ohms.
Rz—10,000 ohms.
R1—10 ohms.
R5—1000 ohms.
CR1—5 volt reference diode, typically 1N3995.
240—Hex inverter microcircuit, typically Fairchild 9936.
340—8 input NAND gate microcircuit, typically Fairchild 9007.
Q1—Silicon transistor, typically 2N2218.
S1—SPDT miniature push switch, typically LICON 18-40421.
S2—SPDT miniature push switch, typically LICON 18-40421.
S3—SPDT miniature push switch, typically LICON 18-40421.

La—Miniature lamp, 5 v.; typically Chicago Miniature #CM8-713.
Lb—Miniature lamp, 5 v.; typically Chicago Miniature #CM8-713.
5 Lc—Miniature lamp, 5 v.; typically Chicago Miniature #CM8-713.
Ld—Miniature lamp, 5 v.; typically Chicago Miniature #CM8-713.
Lw—Miniature lamp, 5 v.; typically Chicago Miniature #CM8-713.
10 Lx—Miniature lamp, 5 v.; typically Chicago Miniature #CM8-713.
Ly—Miniature lamp, 5 v.; typically Chicago Miniature #CM8-713.
15 Lz—Miniature lamp, 5 v.; typically Chicago Miniature #CM8-713.
Pa—Silicon light activated switch, typically TI LSX-515.
Pb—Silicon light activated switch, typically TILSX-515.
Pc—Silicon light activated switch, typically TI LSX-515.
20 Pd—Silicon light activated switch, typically TI LSX-515.
Pw—Silicon light activated switch, typically TI LSX-515.
Px—Silicon light activated switch, typically TI LSX-515.
Py—Silicon light activated switch, typically TI LSX-515.
Pz—Silicon light activated switch, typically TI LSX-515.

VARIABLE DELAY CIRCUIT

Reference—Value or Description

C161—.01 microfarad.
C162—0.16 microfarad.
30 R161—1000 ohms.
R162—1000 ohms.
R163—1000 ohms.
R164—1000 ohms.
R165—12,000 ohms.
35 R166—10,000 ohms.
R167—10,000 ohms.
CR161—Silicon diode, typically 1N482.
CR162—5-4 volt silicon Zener diode, typically 1N762.
Q161—Silicon transistor, typically 2N2221.
40 Q162—Silicon transistor, typically 2N1131.
Q163—Silicon transistor, typically 2N2221.
Q164—Silicon transistor, typically 2N2221.

The decoder key card in the preferred embodiment is made of a plastic material which transmits light flux at wave lengths greater than 0.7 micron. Since the human eye is insensitive to this spectral region, the card will appear uniformly opaque, even when only certain areas have been rendered opaque to the infrared wave lengths produced by the lamps Lw, Lx, Ly and Lz.

Inasmuch as the reticle 110 is sealed and not accessible visually, a heavy plastic photographic film can be used to make the desired pattern. If a four track pattern is printed concentrically around the face of the reticle, the sensors in the encoding reticle can be arranged in groups of four, the sensors in each group being along a radius. The sensors in the decoder receptacle are conveniently arranged in ranks and files, to make computerizing of the decoder key card patterns simple.

60 In the operation of the illustrative embodiment shown in FIGURES 3-5, the decoder key card is inserted in the receptacle, with the notched edge forward. The notch defining surfaces of the card move the toggles of switches S2 and S3 to ignition circuit completing position, as shown in FIGURE 4, and leave toggle S1 undisturbed. This action completes the circuit from the twelve volt battery 134 to the lamps in both the decoder module and the encoding module, as well as to the sensors, the logic network, variable delay circuit, and ignition system. The pattern of near infrared light transmitting areas in the decoder key card is such as to permit sensors Py and Pz to be illuminated, and Px and Pw to be blacked out. The nature of the sensors is such that an illuminated sensor (Py and Pz) conducts to ground and produces at the
75 inverter input terminal to which it is electrically con-

nected a ground voltage level which is then inverted to provide at the logic gate terminals G3 and G4 a plus five volt level. The unilluminated sensors Px and Pw do no conduct, hence produce a plus five volt level at the gates G1 and G2. Accordingly, when the proper decoder card is inserted, four of the eight gates of the NAND gate 340 are fixed at the required five volt level. The other four gates will achieve the five volt level only when sensors Pa and Pd are dark and Pb and Pc are illuminated, i.e. when one of the properly patterned segments is interposed between a lamp and an active set of sensors Pa, Pb, Pc and Pd in the course of rotation of the reticle 110. When these all coincide, the output of the NAND gate 340 will switch to ground level, triggering the ignition system in exactly the same way in which the ignition system was triggered in the first embodiment described.

In this embodiment, however, the variable delay circuit is interposed between the transistor Q1 and the ignition system. The variable delay circuit illustrated can only delay the firing signal and cannot advance it. Therefore the reticle and sensors are positioned so as to fire at the maximum advance position with respect to the cylinder position. Then, as a voltage derived from a vacuum sensor, temperature sensor, fuel type selector, altitude sensor, etc. is applied through the terminal 165 to the resistor R165, the spark timing can be delayed to an optimum firing time. Assume that typical engine speeds range from 500 to 6,000 r.p.m., and that the maximum advance-retard range should be 15° about top-dead-center. Therefore, assuming standard 2:1 distributor drive ratio, the range of maximum time delays in the reticle position will be from two milliseconds to seven milliseconds for crank shaft speeds of 6,000 to 500 r.p.m. respectively. The circuit shown in FIGURE 5 will provide such delays in the ignition pulse with a control voltage range of plus 0.46 to 0 volt.

The function of the circuit shown in FIGURE 5 is to provide a pulse the width of which is voltage controlled and is variable from 2 ms. to 7 ms. The transistors Q162 and Q163 form a standard monostable multivibrator which is triggered by a positive going wave form at the input to the capacitor C161. The output is a positive going pulse at the collector of the transistor Q163.

The transistor Q162 provides a constant current source to charge the capacitor C162. In the standard multivibrator, the transistor Q2 is replaced by a charging resistor which gives a rising exponential voltage wave form at the base of the transistor Q163. By using the transistor Q162, to provide a constant current source, the voltage wave form is linear. The higher the value of the current source the faster will be the rise time of the ramp and thus the shorter will be the pulse width. Current source magnitude is determined by the voltage at the emitter of the transistor Q162 divided by the value of the emitter resistor. The voltage at the emitter is determined by the voltage amplifier transistor Q164.

The emitter of the transistor Q164, in the illustrative embodiment, is biased at plus 5.4 volts in order to allow for the connection of negative feedback to the base. The feedback resistor is resistor R166, and the input control resistor is resistor R165. These two resistors form a voltage divider which provides a potential close to six volts at the base of the transistor Q164.

If the control signal is zero volt, the voltage drop across the emitter resistor R162 is at a minimum of one volt so as to maintain a voltage of 6.0 at the base of the transistor Q164. Under this condition, the current source is at a minimum and the pulse width is 7 ms.

As the control signal voltage increases the drop across the emitter resistor R162 must increase to maintain six volts at the base of the transistor Q164. When the control signal is 4.2 volts, the voltage across the resistor R162 is 4.6 volts, the current source is at its maximum value, and the pulse width is two milliseconds.

Numerous variations in the construction of the system of this invention, within the scope of the appended claims, will be apparent to those skilled in the art in the light of the foregoing disclosure. Merely by way of example, in the embodiment shown in FIGURE 3, different numbers of photo detectors can be used, and they need not be aligned radially in the encoding module, nor in ranks and files in the decoder receptacle. An almost infinite variety of reticle patterns can be used. The reticle pattern can be such as to permit a 1:1 speed ratio of crank shift speed to the "distributor" shaft speed, which eliminates the need for timing gears. The timing can be derived directly from the engine fly wheel, crank shaft or other existing common rotating member. Single lamp sources can be used, either with a kind of mask, or with light pipes. Other triggering circuits may be used. For example, magnetically activated distributors lead themselves well to use in the system. The system of this invention can be applied to ignition systems which use separate ignition means for each cylinder, cf. Gibbs et al. U.S. Patent No. 3,311,783. The system can be used with internal combustion engines of any numbers of cylinders, or in such applications as SCR controlled electric motors for electric automobiles, which depend upon a pulsed control signal. These are merely illustrative.

Having thus described the invention, what is claimed as desired to be secured by Letters Patent is:

1. An ignition system for an internal combustion engine having electrical explosion initiating means in cylinders, comprising electric pulse-generating means having a part driven in response to the operation of the engine and as a function of the speed of the engine, said pulse-generating means being adapted to produce a plurality of pulse patterns, said pulse-generating means being electrically connected to a logic network adapted to convert a part of said pulse patterns to timed sequential firing signals, said logic network being electrically connected to control the energization of said electrical explosion initiating means in proper firing order when the proper pulse pattern is transmitted to the logic network, and switch means electrically connected to the logic network for completing and breaking the logic network circuit.

2. The ignition system of claim 1 wherein the switch means comprises a multiplicity of switches electrically connected to complete the logic network circuit when selected ones of said switches are closed.

3. The ignition system of claim 2 wherein the switch means includes a plurality of photo sensitive receptor-switches, a source of light adapted to energize said receptor-switches, and a key card having selected light-permeable areas and other, opaque, areas interposable between and removable from between said receptor switches and said light source.

4. The ignition system of claim 1 wherein the pulse-generating means includes a plurality of photosensitive receptors, a light source adapted to energize said receptors, and a reticle rotatably mounted between said light source and said receptors.

5. The ignition system of claim 4 wherein the switch means includes a plurality of photosensitive receptor-switches, a source of light adapted to energize said receptor-switches and a key card having selected light-permeable and light-impermeable areas, said key card being interposable between and removable from between said receptor-switches and said light source.

6. The ignition system of claim 1 wherein the switch means and logic network are encapsulated.

7. The ignition system of claim 1 wherein the logic network output is electrically connected to a variable delay device which in turn is electrically connected to an ignition circuit including a spark coil, said variable delay device being adapted to retard the spark in response to requirements of the engine.

8. A security system for a machine the operation of which is governed by a pulsing mechanism, comprising

11

electric pulse generating means different from said pulsing mechanism, said pulse generating means having a part driven in response to the operation of the machine and as a function of at least one of the speed and timing of the machine, said pulse-generating means being adapted to produce a plurality of pulse patterns, said pulse generating means being electrically connected to a logic network adapted to convert a part of said pulse patterns to timed firing signals, said logic network being electrically connected to control the energization of the pulsing mechanism in proper pulsing order and timing when the proper pulse pattern is transmitted from the pulse generating means to the logic network, and switch means electrically connected to the logic network for completing and breaking the logic network circuit.

9. The security system of claim 8 wherein the pulse

12

generating means includes a patterned disk connected to be driven by said machine and sensors adjacent said disk, responsive to the passage of specific areas of said patterned disk to produce pulses.

References Cited

UNITED STATES PATENTS

3,136,307	6/1964	Richard	-----	123—179
3,237,620	3/1966	Hetzler et al.	-----	123—148

LAURENCE M. GOODRIDGE, *Primary Examiner.*

U.S. Cl. X.R.

70—237; 307—10; 317—134; 200—61.66