United States Patent [19]

Wessel et al.

[11] **3,754,537**

[45] **Aug. 28, 1973**

[54] **FUEL INJECTION SYSTEM ESPECIALLY FOR MULTI-CYLINDER INTERNAL COMBUSTION ENGINES**

[75] Inventors: **Wolf Wessel,** Schwieberdingen; **Josef Wahl,** Stuttgart, both of Germany

[73] Assignee: **Robert Bosch, GmbH,** Gerlingen-Schillerhone, Germany

[22] Filed: **Mar. 3, 1972**

[21] Appl. No.: **231,500**

[30] **Foreign Application Priority Data**

Mar. 12, 1971 Germany .... P 21 11 814.9

[52] **U.S. Cl.** .... **123/32 EA,** 123/32 R

[51] **Int. Cl.** **F02b 3/00**

[58] **Field of Search** .... 123/32 EA

[56] **References Cited**

UNITED STATES PATENTS

3,500,801	3/1970	Long	123/32 EA
3,500,802	3/1970	Long	123/32 EA
3,612,011	10/1971	Monpetit	123/32 EA
3,702,601	11/1972	Gordon	123/32 EA
3,032,025	3/1970	Long	123/32 EA

Primary Examiner—Laurence M. Goodridge
Assistant Examiner—Ronald B. Cox
Attorney—Flynn & Frishauf

[57] **ABSTRACT**

To provide proper allocation of fuel injected under electronic control, a sequence of electrical pulses, controlled by rotation of the engine are provided, the passage opening electromagnetic valves through which fuel can be injected. A signalling circuit which is inductively or capacitively coupled to an ignition wire provides a signal synchronized with ignition pulses, this signal being coupled to an electronic counter which steps in synchronism with the ignition pulses and the output counts of which control application of the valve pulses to the respective fuel injection valve associated with the cylinders of the internal combustion engine.

7 Claims, 7 Drawing Figures

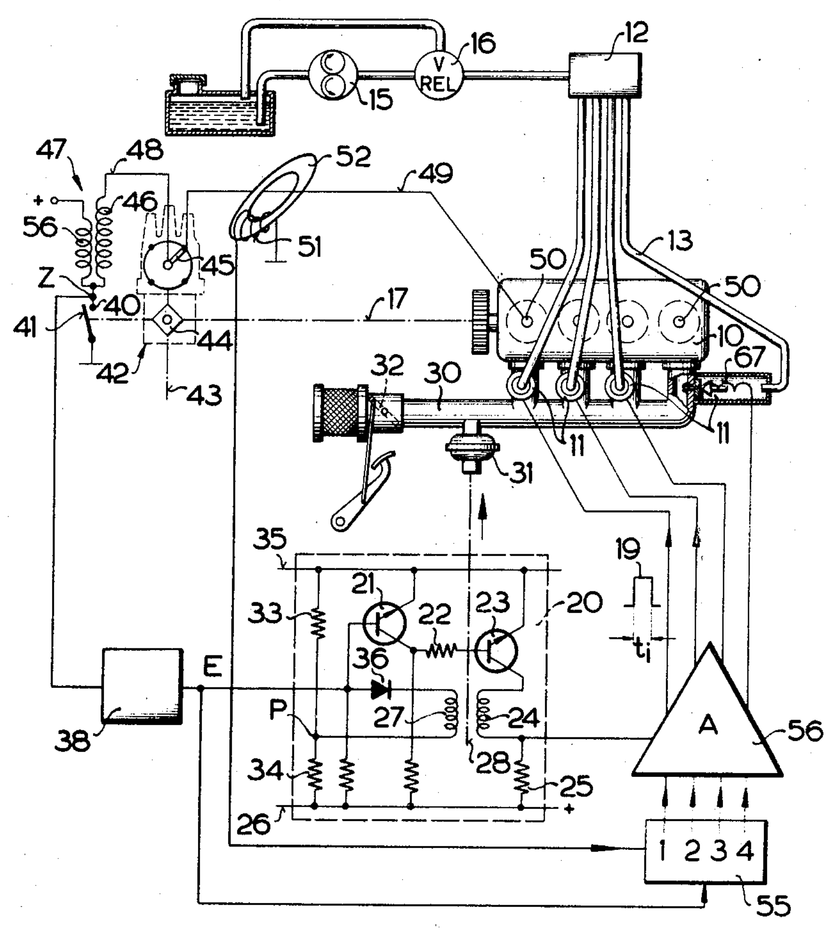


FIG.1

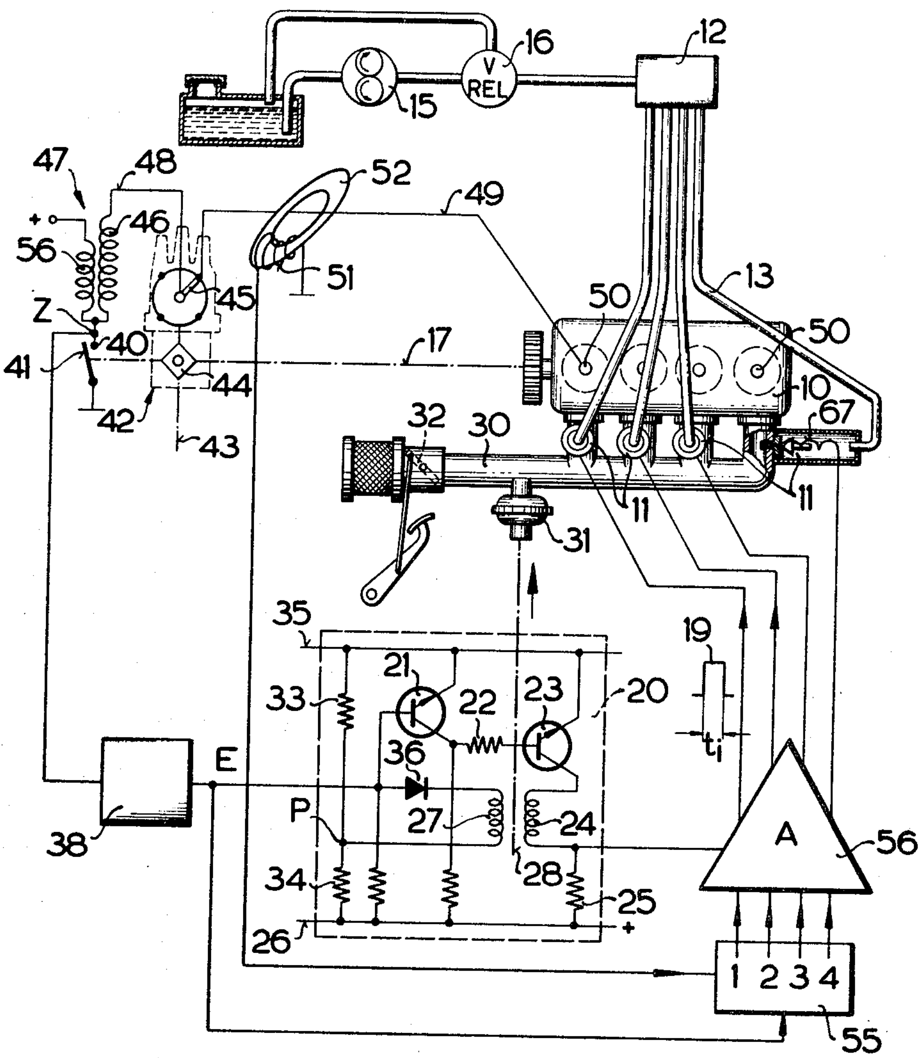

12
16
V
REL
15
47
48
52
49
+
46
56
51
45
50
13
Z
40
17
50
41
44
10
42
43
32
30
67
11
11
31
35
19
21
23
20
33
22
36
tᵢ
E
P
27
24
A
56
38
34
28
25
26
+
1 2 3 4
55

FIG.6

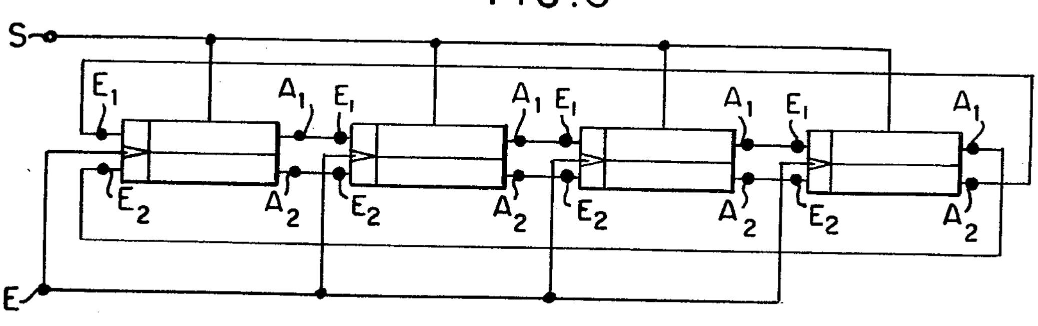

S
E₁
A₁
E₁
A₁
E₁
A₁
E₁
A₁
E₂
A₂
E₂
A₂
E₂
A₂
E₂
A₂
E

FIG. 2

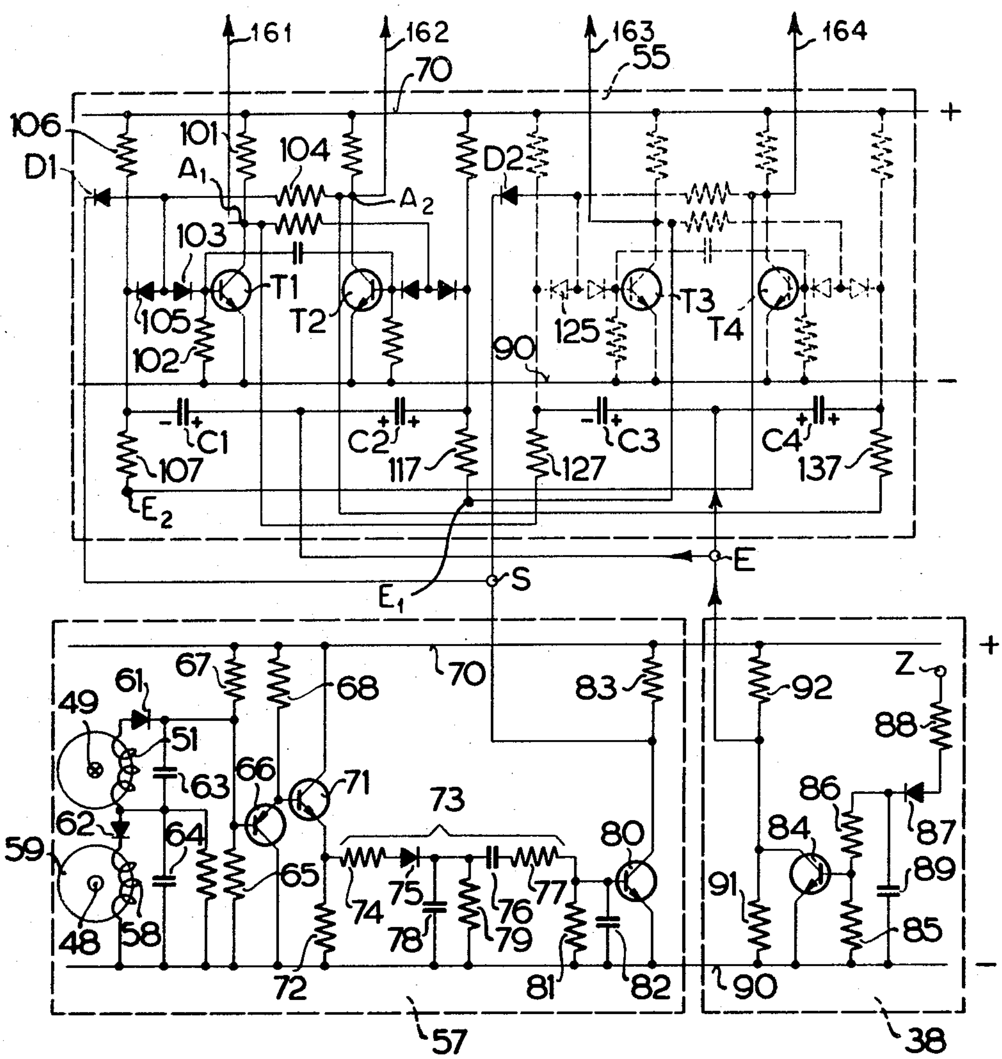

161
162
163
164
70
55
106
D1
101
104
A1
A2
D2
103
T1
T2
T3
T4
105
102
125
90
C1
C2
C3
C4
107
117
127
137
E2
E1
S
E
67
68
83
92
Z
88
49
61
51
63
66
71
73
86
87
84
62
64
80
59
65
74
75
77
76
91
89
48
58
78
79
85
72
81
82
57
38
+
−

FIG.2a

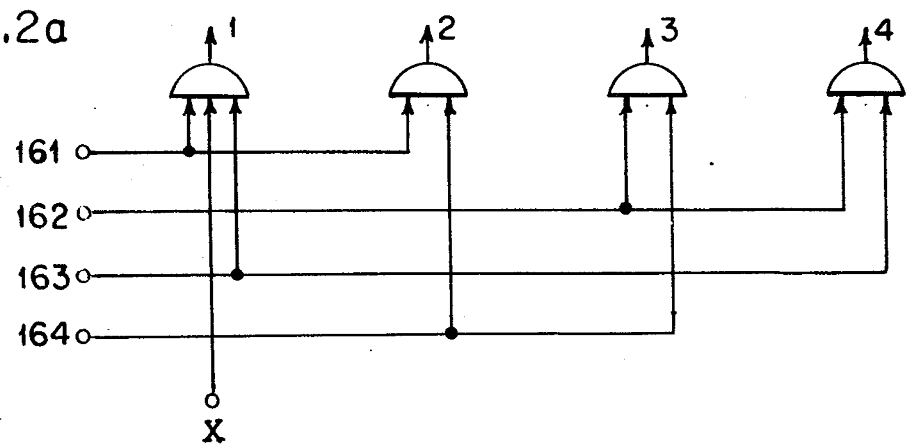

1
2
3
4
161
162
163
164
X

FIG. 3

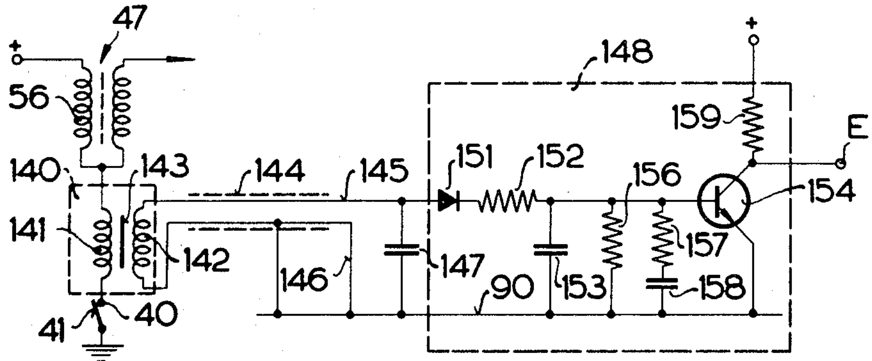


FIG. 4

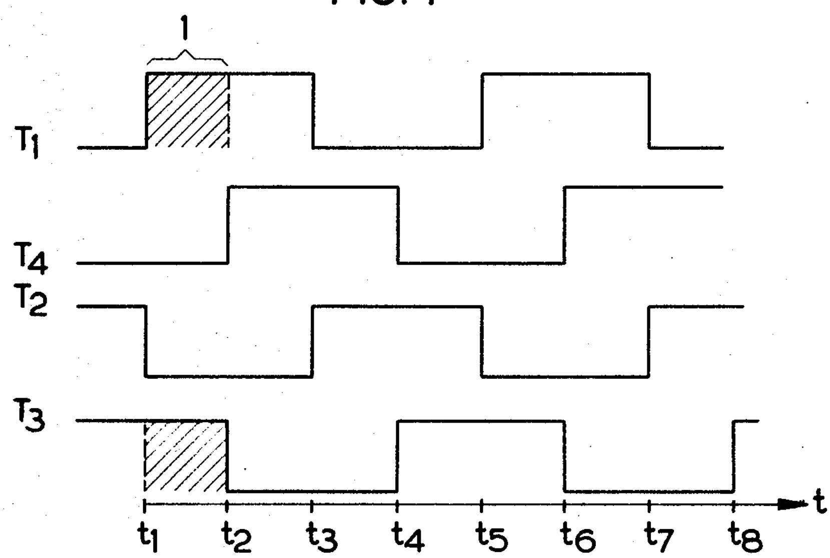
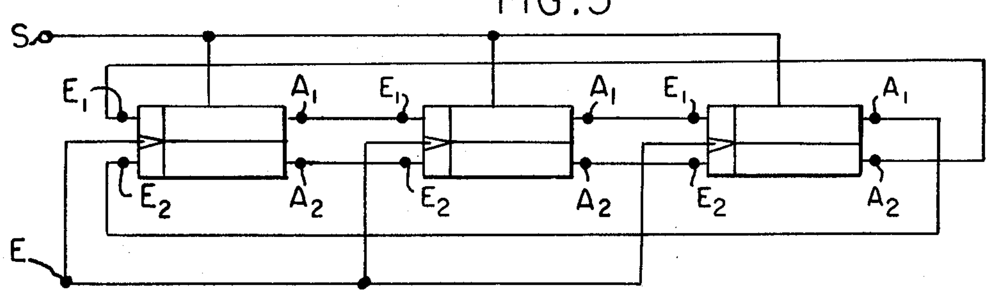


FIG. 5



FUEL INJECTION SYSTEM ESPECIALLY FOR MULTI-CYLINDER INTERNAL COMBUSTION ENGINES

Cross-Reference to Related U.S. Pats. Nos.

3,448,728
3,463,130
3,470,854
3,430,616
3,452,727
3,490,424
3,533,381

The present invention relates to a fuel injection system for internal combustion engines, and more particularly to a fuel injection system in which electromagnetically operated valves are opened for a predetermined period of time under control of an electric controller, the valves being opened for a predetermined period of time to the supply fuel, under pressure, to the cylinders of electrically fired internal combustion engines. Preferably, the internal combustion engine has a number of cylinders, and the electrical signals which control the opening duration of the fuel injection valves are pulses which are generated in synchronism with the rotation of the engine.

Fuel injection arrangements for example of the types referred to in the cross-referenced patents, usually provide injection valves which are joined in two groups, the injection valves being alternatively operative, and each injection valve being associated with a plurality of cylinders in the multicylinder internal combustion engine. Each injection valve is supplied wiht an operating pulse, usually a square wave pulse, the duration (or pulse with) of which determines the amount of fuel to be injected by a specific valve. An electronic controller provides the pulses for the fuel injection valves. The controller itself is controlled by the operating parameters of the internal combustion engines, such as pressure (or, rather, vacuum) in the intake manifold, engine speed, engine operating temperature, or other ambient and operating temperatures, as detailed in the cross-reference patents. The injection of fuel is triggered in synchronism with rotation of the engine, obtained by a switching device which may be driven, for example, from the shaft which drives the ignition distributor. An additional cam with a single cam rise can be placed on the distributor shaft, the rise of the cam alternately operating one or the other of a pair of switch arms. Slight inaccuracies of the switching time of the mechanical switches do not greatly affect the operation of the engine since more than one cylinder is supplied with fuel during injection of fuel; the actual time of occurrence of the injection is insufficiently in advance of the suction stroke and thus of the subsequent ignition itself. The advance time of injection, before the opening of the suction stroke, is different for the cylinders associated with any one fuel injection valve. If, however, it is desired to associate injection of fuel with the respective cylinders of a multicylinder internal combustion engine, it is of advantage that the fuel injection occur in the same sequence as the ignition, and be associated with a fixed angle of rotation of the crank shaft, in advance of ignition. Thus, it is necessary to provide the triggering signals for the fuel injection valves at a proper phase angle with respect to the instantaneous position of the crank shaft, so that the injection of fuel, and the subsequant operation of the

internal combustion engine be correctly matched with respect to time.

It is an object of the present invention to provide fuel injection system in which fuel injection is properly associated with the operation of the various cylinders, and which is free from mechanical contacts.

Subject Matter of the Present Invention

Briefly, a signalling circuit is provided which is inductively or capacitively coupled to the ignition system of the internal combustion engine, for example by inductively coupling a signal winding with one or more of the ignition wires. In one example, the signal winding can be placed on a toroidal core, preferably of ferrite, which is slipped over one of the ignition wires. The signalling winding may, however, also be constructed as the secondary winding of a transformer, the primary of which is coupled to one of the ignition winding. Independently of the respective construction of the signal source associated with the signal winding, the signal winding can derive its pulses by coupling with the primary, that is the low voltage circuit, or with the secondary, that is the high voltage circuit of the ignition system of the internal combustion engine, by magnetic coupling. This permits application of triggering signals to the various cylinders utilizing only electronic techniques. The triggering signals, which derive from the ignition wire of a single cylinder, can be applied to the input of a ring counter which has a count number corresponding to the numger of cylinders of the internal combustion engine. Thus, after the counter has stepped through the counts for all the cylinders, it is reset to the first cylinder. The counter is synchronized by connecting the signalling winding (or another signalling winding) with that count stage of the counter corresponding to the cylinder which is to fire when the counter has activated the specific count number; in other words, since the firing order of sequential cylinders is usually determined by the design of the engine and is not in sequence of the actual engine construction, the count of the counter has to be associated with a specific cylinder, and the synchronization of the counter is obtained from the ignition wire leading to the spark plug of that specific cylinder.

The invention will be described by way of example with reference to the accompanying drawings, wherein:

FIG. 1 is a higly schematic diagram of the fuel injection system in accordance with the present invention;

FIG. 2 is a more detailed, schematic diagram illustrating the triggering circuit, the ring counter, and the synchronization circuit in greater detail;

FIG. 2*a* is a schematic logic diagram illustrating interconnection between ring counter and the distributor circuit;

FIG. 3 is a schematic diagram of another embodiment of the signalling circuit, having a transistor switching stage;

FIG. 4 illustrates, in lines **T1, T4, T2, T3** a timing diagram schematically illustrating the state of the switching transistors in the ring counter of FIG. 2;

FIG. 5 is a schematic representation of a ring counter for a six cylinder engine;

FIG. 6 is a schematic representation of a ring counter for an eight cylinder engine.

The present invention will be described specifically in connection with a four cylinder engine. Modification of embodiment described to apply the principles of the present invention to other multi-cylinder engines, such as six or eitht cylinder engines, will be referred to later. A four cylinder engine, generally shown at **10,** has four electromagnetically operated fuel injection valves **11,** each connected to a fuel valve **13** which derives fuel, such as gasoline, under pressure from a distributor manifold **12.** An electrically driven supply pump **15** provides fuel from a tank T to a pressure regulator **16** where fuel under uniform pressure is applied to the manifold distributor **12.** The cam shaft, schematically shown at **17,** provides, over apparatus to be described, opening pulses schematically shown at **19** and of duration t_i, which are square wave pulses, to the several injection valves **11.** The injection valves must be opened slightly before the suction stroke of the associated cylinder, in the ignition sequence of the internal combustion engine. The duration of opening period t_i determines the duration of fuel injection and thus the amount of fuel being injected to a specific cylinder.

The opening pulse **19** is derived by a monostable control multivibrator **20,** which has an input transistor **21.** Input transistor **21** is normally conductive, and has its collector connected over a resistance **22** with a base of an output transistor **23,** normally blocked. A timing circuit, determining the pulse duration t_i, in the present example of the control multivibrator, includes a transformer which has a primary winding **24** connected in series with a collector of transistor **23** and collector resistance **25.** The secondary winding **27** is inductively connected to the primary winding by means of a movable core **28** which provides a movable coupling element, the position of the core **28** being controlled by the pressure (or, rather, vacuum) in the intake manifold **30** of the internal combustion engine **10.** A diaphragm transducer **31** converts vacuum in the intake manifold to movement of core **28.** If the absolute pressure in intake manifold decreases, for example, due to closing of the throttle **32,** the core **28** is lifted in the direction of the arrow **31'.** As the pressure in the intake manifold **30** increases, the core **28** is dropped, for example, under action of springs (not shown) and thus increases the inductivity of the transformer acting as a timing element. The secondary winding **27** is connected to the junction point P of a pair of resistances **33, 34,** acting as a voltage divider and connected between a chassis or ground bus **35** and a positive bus **26.** The other end of secondary winding **27** is connected over a diode **36** to the base of input transistor **21.** The emitter of input **21** (which, like output transistor **23** is the npn-type) is connected to the chassis bus **35.**

Control multivibrator **20** (which may be much more complicated and built in various types, as referred to in the cross-referenced patents) is not triggered as customary by a mechanical switch, but rather by a trigger circuit **38** which is coupled to the ignition system of the internal combustion engine. Trigger circuit **38** is controlled, in turn, directly by connection to a fixed contact **40** of the ignition breaker **41.** The ignition breaker contacts are conventionally arranged in the housing of the distributor **42** which has a four-rise cam **44** secured to the distributor shaft **43,** operating the breaker contact springs **41.** Additionally, the distributor shaft **43** has the distributor arm **45** which is centrally connected over the main ignition wire **48** with the high tension or secondary winding **46** of ignition coil **47.** Upon each pulse of breaker contact **41,** ignition potential is distributed to one of four ignition cables, of which only ignition cable **49** is shown, the ignition cable being connected to respective spark plugs **50** of the internal combustion engine. The connections from the distributor to the internal combustion engines of all cylinders but the first have been omitted for clarity from the drawing.

A signal transducer is magnetically coupled to the ignition cable **49** in order to provide a synchronized distribution of the opening pulses **19** derived from the ignition control circuit **20.** The transducer essentially consists of a toroidal ferrite core **52** which is slipped over the ignition cable. A signal winding **51** connected at one end to chassis (ground) is wound on the core **52.** Winding **51** is used to synchronize an electronic counter **55,** connected to triggering circuit **38.** Counter **38** has its outputs connected to a multi-channel gated amplifier **56.** Counter **55** energizes the specific channel which is associated with the specific fuel injection valve which should be opened at a specific, instantaneous position of the crank shaft (corresponding to a position of the cam shaft **17**) in synchronism with the simultaneously triggered opening pulse **19.**

Counter **55** is illustrated in detail in FIG. **2,** in which the various electronic elements are schematically shown; it can be built as one integrated circuit. FIG. **2** additionally illustrates the construction of trigger circuit **38** and of a synchronizing stage **57.**

Synchronizing stage **57** is coupled to the signal winding **51** (FIG. **1**) which, in turn, is coupled to the ignition cable **49.** Thus, at each four ignition pulses from the ignition coil **47,** one pulse will be induced due to the ignition current flowing in cable **49.** The other ignition cables may, due to stray fields, interfere with, and create noise in the ignition cable. In order to prevent interference, a second signal winding **58** (FIG. **2**) is provided, which is wound on a core **59.** Core **59** is slipped over the common ignition cable **48** connecting the ignition coil **47** to the center of the distributor **45.** Each of the two signal windings **51, 58** have an associated diode **61, 62** in series therewith; condensers **63, 46** are connected in parallel with the series circuit formed of the signal winding and the diode. The synchronizing voltages across the condenser **63** together with the compensation voltage across condenser **64** provide the resulting voltage which is applied to the tap point of a voltage divider formed of resistances **67, 65** and connected between positive bus **70** and chassis bus **90** of the supply. The tap point is further connected to the base of an npn-type transister **66.** The emitter is connected to emitter resistance **68** and to the base of an npn-type transister **71,** which has an emitter resistance **72.** The emitter of transistor **71** is connected to a condenser-diode-resistance network **73** having, in its longitudinal branch connected to the emitter of transister **71,** a resistance **74,** a diode **75,** a condenser **76** and a resistance **77,** the resistance **77** being connected to the base of a synchronizing transister **80** (npn-type). The two cross-branches of network **73** are formed by a condenser **78** and a parallel resistance **79,** a resistance **81,** and condenser **82.** Synchronizing transistor **80** has its collector carried to a junction point S and, otherwise, is connected to the positive bus **70** over collector resistance **83.**

The triggering circuit **38** includes an npn switching transistor **84** connected with its base to the common chassis bus **90.** Its base is connected over resistance **85,** likewise to chassis bus **90.** A resistance **86,** in series with a diode and a resistance **88** connects to a terminal

Z (FIGS. **1** and **2**), terminal Z being connected to the primary winding **56** of ignition coil **47**, ahead of the breaker contact **41**. A condenser **89** connects between resistance **86** and diode **87** and chassis bus **90**, so that this condenser will be parallel with both resistances **85**, **86**. The collector of transistor **84** is connected to the tap point of a voltage divider formed of resistances **91**, **92**, connected across the voltage supply. The collector is further carried up to a terminal E, forming the input terminal to ring counter **55** (FIGS. **1**, **2**). Ring counter **55** essentially includes a pair of bistable multi-vibrators, each having a pair of transistors, T_1, T_2 and T_3, T_4. The second multi-vibrator is essentially identical in construction to that of the first multi-vibrator, and, to the extent that the construction is identical, is shown in broken lines only.

Both multi-vibrators are symmetrically constructed, and thus only the circuit in connection with the first transistor T_1 will be described in detail, since it is identically repeated with respect to the other transistors. Transistor T_1 (npn) has its collector connected to a terminal A, and to a load resistance **101** which, in turn, is connected to positive bus **70**; its base is connected over a base resistance **102** with the common chassis bus **90**. Additionally, the base is connected to the cathode of a diode **103**. The anode of diode **103** is connected over a feedback resistance **104** to the collector of the second npn transistor T_2 and a terminal A_2. Second diode **105** is connected to the feedback resistor **104**. The cathode of diode **105** is connected to a resistance **106**, the other end of which is connected to the positive bus **70**. The cathode of diode **105** additionally is connected to a resistance **107** which is one of a group of resistances **107**, **117**, **127**, **137**. Terminals E_2 and E_1 appear at the other ends of resistances **107**, **117**. Resistance **107**, forming a feedback resistance, is connected to the collector of resistor T_4 of the second multi-vibrator. The cathode of diode **105** additionally is connected to one electrode of a coupling condenser C_1, the other electrode of which is connected to terminal E and from this terminal to the collector of the switching transistor **84** in trigger circuit **38**.

One of the two transistors T_1, T_2 are alternatively conductive in the first multi-vibrator during any one of the operating conditions, the conductive transistor holding the other transistor in blocked state. At the second operating stage, the previously blocked transistor becomes conductive and then holds the other previously conductive transistor in blocked condition. The two transistors T_3, T_4 operate similarly.

Operation: As soon as breaker contact **41**, upon closing the breaker points, touches the fixed breaker contact **40**, switching transistor **84** in the trigger circuit **38** becomes conductive and then, in alternate sequence, causes change of state of one of the two multi-vibrators. The alternating change of the operating condition of the transistors is shown in more detail in the timing diagram of FIG. **4**. The upper curve shows the voltage at the collector of the transistor T_1; the other curves labeled T_4, T_2, T_3 indicate the collector potentials at the respective transistors T_4, T_2, T_3, the sequence being selected for an internal combustion engine which has an ignition firing sequence of cylinders 1–4–2–3. The example assumes that transistors T_1 at the first closing time t_1 of the breaker is conductive, and thus, that its collector has a voltage which corresponds to voltage **0** of chassis bus **90**. Correspondingly, the collector potential of transistor T_2 will be in the opposite operating condition, thus close to the voltage of positive bus **70**. At the first closing time t_1, the first multi-vibrator changes its operating condition, causing transistor T_1 to block and T_2 to become conductive. At the subsequent closing time t_2 of the breaker, the second multi-vibrator changes its operating state, the previously conductive transistor T_4 being transferred into blocked condition, so that its collector will have positive voltage, whereas transistor T_3 becomes conductive and the collector will be essentially at the voltage of chassis bus **90**. At the third closing time t_3 of the breakers, the first multi-vibrator switches back to its initial state, transistor T_1 becoming conductive. The second multi-vibrator is not influenced; only the fourth time does t_4 cause it to revert to its previous state, at which transistor T_4 becomes conductive and transistor T_3 blocks.

The various overlapping operating conditions of the two multi-vibrators can be set forth in the following table; if blocked condition is assigned state ONE, and conductive condition state ZERO, in binary notation, and if a pair of transistors in states ZERO ONE are noted as A, and in state ONE ZERO as B, the relationship will be as follows:

T_1 and T_3 blocked = Position 1 1010 BB
T_1 and T_4 blocked = Position 2 1001 BA
T_2 and T_4 blocked = Position 3 0101 AA
T_2 and T_3 blocked = Position 4 0110 AB
T_3 and T_1 blocked = Position 1 1010 BB
T_1 and T_4 blocked = Position 2 1001 BA

The cyclical sequence is constrained by coupling resistances **107**, **117**, **127**, **137**. This can be seen in connection with the explanation which will be given with respect to the operating condition at the first closing time t_1, in which transistor T_1 is conductive, T_2 is blocked, T_3 is blocked, and T_4 is conductive. (Position **4**, in advance of position **1**.)

The collector voltage of transistor T_4 is at chassis, and thus the input E connected to the collector of the switching transistor **84** can place positive voltage to the right electrode of coupling condenser C_1, so that the right electrode will change with positive voltage. This is so, since switching transistor **84**, until just before the first closing time t_1, have been blocked. The other electrode of condenser C_1 is connected over resistance **107**, and the conductive emitter-collector path of the conductive transistor T_4 to the negative bus **90**, so that it can charge negatively. Coupling resistance **127**, associated with the second multi-vibrator, holds the third coupling condenser C_3 at negative voltage over the conductive emitter-collector path of transistor T_1, so that its other electrode can charge likewise over the input E to the counter and the resistance **92** of the triggering circuit **38** with positive voltage. The voltages at that point are indicated on the diagram of FIG. **2**. The two coupling condensers C_1, C_3 at the first closing time t_1, are connected with their positively charged electrodes to negative voltage by the switching transistor **84**. The negatively charged electrodes of coupling condensers C_1, C_3, over coupling resistances **107**, **127** apply over diodes **105**, **125**, respectively, a highly negative voltage with respect to negative bus **90**, on the bases of the two transistors T_1, T_3. Transistor T_3 is not influenced thereby since it was already in blocked position at this point of time; transistor T_1, however, transfers to blocked condition which puts the collector of transistor T_1 at positive voltage. This has the effect that condenser T_3 is connected to positive voltage at both electrodes.

To transfer transistor T_4 at the second closing point T_2 in its blocked condition, coupling condenser C_4 has to be able to be negatively charged with the electrode connected with the resistance **137** at the period of time t_2. The conductive transistor T_2 enables this switchover, since transistor T_1 is then blocked, both electrodes of condenser C_3, as noted above, are at positive voltage. Condenser C_2, likewise, has both its electrodes at positive voltage whereas condenser C_1 can charge on its electrode connected to the collector of conductive transistor T_4 over resistance **107.** When transistor **84** at time t_3 becomes conductive, the charge on condenser C_1 has no effect on the already blocked transistor T_1, whereas it will transfer transistor T_4 into blocked condition, which, in accordance with the well-known operation of this circuit causes transistor T_3 to become conductive.

The repeated switching of counter **55** continues cyclically as determined by the closing operation of the breaker contacts. The pulses of the synchronizing circuit **38** are not, however, as yet, associated a specific count condition of the counter with the various cylinders.

The association of the counts to the various cylinders is effected by the synchronizing unit **57** and diodes D_1, D_2 connected to the first and third transistors T_1, T_3. Diodes D_1, D_2 have cathodes connected to terminal S. When current flows into ignition cable **49,** transistor **80** will become conductive, which has as a result that transistor T_1 as well as transistor T_3 are blocked, unless they are already in a blocked state. This forces positioning the counter in position 1 (see above table), so that the counter at the next closing times of the breaker contact, can cyclically step through its count, being reset after position 4 back to position 1, in synchronized rhythm, to continue counting. After synchronization is first obtained, it would be possible to disconnect the synchronizing state. Since triggering of the firing circuit **38** is derived from the primary of the ignition coil, misfirings or gaps in firing will not interfere with stepping of the counter. Leaving the synchronizing state in circuit, however, provides an additional control and supervisory function for increased reliability.

FIG. 3 illustrates an alternative embodiment in which the control multi-vibrator is triggered by a contactless signaling transducer utilizing a small transformer **140,** having a primary winding **41** connected between the primary winding **56** of the ignition coil and the breaker contacts **40, 41** of the distributor. Secondary winding **142** is connected to a control circuit **145, 146,** suitably shielded as schematically indicated at **144.** The lines **145, 146** connect with a firing circuit **148,** having a cross connected condenser **147.** Firing circuit **148** includes a npn-type switching transistor **154** having a collector connected to the input terminal E of the counter **55** and to the input of the control multivibrator. The base of transistor **154** is connected by means of a diode **151** and a resistance **152,** having a condenser **153** connected behind, a resistance **156,** and a series circuit formed of resistance **157, 158** there across the elements **153, 156, 158** being connected to the common chassis bus **90.** The load resistance **159** corresponds to resistance **92** of the firing circuit **38** (FIG. 2) and connects the collector of transistor **154** with the positive bus **70** of the common operating source.

The firing circuit **148** is similar to that of firing circuit **38** in operation.

Rather than utilizing conductive coupling between the ignition wire **49** and coil **51,** capacitative coupling could also be used, for example by placing the conductive element along the ignition wire and suitably connecting this element to transistor **66** of the synchronization circuit.

The outputs from the ring counter are taken from the collectors of transistors T_1, T_2, T_3, T_4 and are indicated at lines **161, 162, 163, 164.** Other suitable points in the counter may be selected These outputs are connected to a logic network (FIG. 2a) which comprises a series of multi-input AND-gates suitably connected in accordance with the table above given, to provide the output at lines **1, 2, 3, 4,** corresponding to the energization of the fuel injection valves of the respective cylinders, in their respective firing orders. The AND-gates may be three-input AND-gates, as shown schematically only with respect to the first AND-gate, having an additional input marked X which can be connected to the output **20'** from the control multi-vibrator **20,** thus effecting gating function directly with the logic network of the counter; alternatively, the outputs **1, 2, 3, 4** can be connected each to an input of a multi-channel amplifier, having an additional input **20'** from the control multivibrator for the various channels.

The logic of the output taken from the collector is determined by the firing order of the cylinders. For six or eight cylinders, the counter of FIG. **2** can be expanded as well known in the art; if used with six cylinder engine, the reset must occur after the sixth count, corresponding to six firings, that is, six ignition pulses; for an eight cylinder engine, a binary counter with three groups of multi-vibrators can step completely through eight possible counts. Such counter circuits, and their resets even in advance of the final ultimate count, are well known and need not be described in detail; reference is made, for example, to "General Electric Transistor Manual"; "High Speed Computing Devices" (McGraw-Hill, 1950); "Scott: Analog and Digital Computer Technology", chapters on Counters and specifically Ring Counters (McGraw-Hill); "Pulse and Digital Circuits" (McGraw-Hill 1956), by Millman and Taub.

Various changes and modifications may be made within the inventive concept.

The ring counter of FIG. **5** is a 2 × 3 ring counter; the crossing at the output of the flip flops, only schematically indicated, provides for the reset. The block representation in FIG. **5** of the counter stages correspond, for example, to the full line left half of the circuit of FIG. **2,** in which the terminals are labeled similarly to the terminal labeling of FIG. **2.**

We claim:

1. Fuel injection system for multicylinder internal combustion engines (**10**) having an ignition system including an ignition coil (**47**), a distributor (**44, 45**), a secondary coil - distributor wire (**48**) connecting the distributor in the secondary circuit of the ignition system, each cylinder having at least one spark plug wire (**49**) associated therewith and connected to the distributor, and spark plugs (**50**);

a plurality of cyclically operating fuel injection valves (**11**);

means (**20, 56**) controlled by the rotation of the engine and connected to said valves to generate, in sequence, electrical pulses (**19**) to open said valves upon application of the pulse, the duration of a pulse determining the opening period of said valves (**11**), and

a signaling circuit comprising

a pair of windings (**51, 58**), one of the windings (**51**) being coupled to one of the spark plug wires (**49**) and the other of the windings (**58**) being coupled to the coil-distributor wire (**48**) of the ignition system having a pulse appearing there on for each firing of a spark plug of the engine the output of said signaling circuit being coupled to said pulse generating and connection means (**20, 56**) to control the distribution of the pulse to the valves.

2. System in accordance with claim **1,** wherein (FIG. **1**) the signaling circuit comprises a toroidal ferrite core (**52**), the wire carrying ignition passing through the core;

and a winding (**51**) wound on the core.

3. System in accordance with claim **1,** including rectifier means (**61, 62**) interconnecting said windings, said rectifier means being oppositely poled to provide mutually blocking rectified potentials from said windings.

4. System in accordance with claim **1,** comprising a ring counter (**55**) having a count output corresponding to the number of cylinders and then resetting, the output of the other of said windings (**58**) being applied to said ring counter; the output of the first of said windings (**49**) being connected to the counter to synchronize the counter.

5. System in accordance with claim **4,** wherein said first winding (**51**) is coupld to a specific one of the ignition wires (**49**) of the engine corresponding to a specific cylinder in a specific firing order;

and said winding (**51**) is connected to the counter at a stage having a count which is representative of the specific one of the fuel injection valves associated with said specific cylinder.

6. System in accordance with claim **4,** including a trigger circuit (**38**) interposed between the signaling circuit and the counter.

7. System in accordance with claim **6,** wherein the triggering circuit comprises a switching transistor (**84**), a voltage divider, the tap point of which is connected to the base of the switching transistor, and a condenser (**89**) connected across the voltage divider;

and a diode (**87**) interconnecting the signaling circuit and the counter.

* * * * *