# United States Patent [19]

Peterson

[11] 3,844,266

[45] Oct. 29, 1974


[54] **CAPACITOR DISCHARGE IGNITION CIRCUIT**


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[22] Filed: **Oct. 10, 1972**

[21] Appl. No.: **296,059**

[52] **U.S. Cl.** ..... **123/148 ICD,** 123/148 E

[51] **Int. Cl.** ..... **F02p 1/00**

[58] **Field of Search** ..... 123/148 E, 148 ICD



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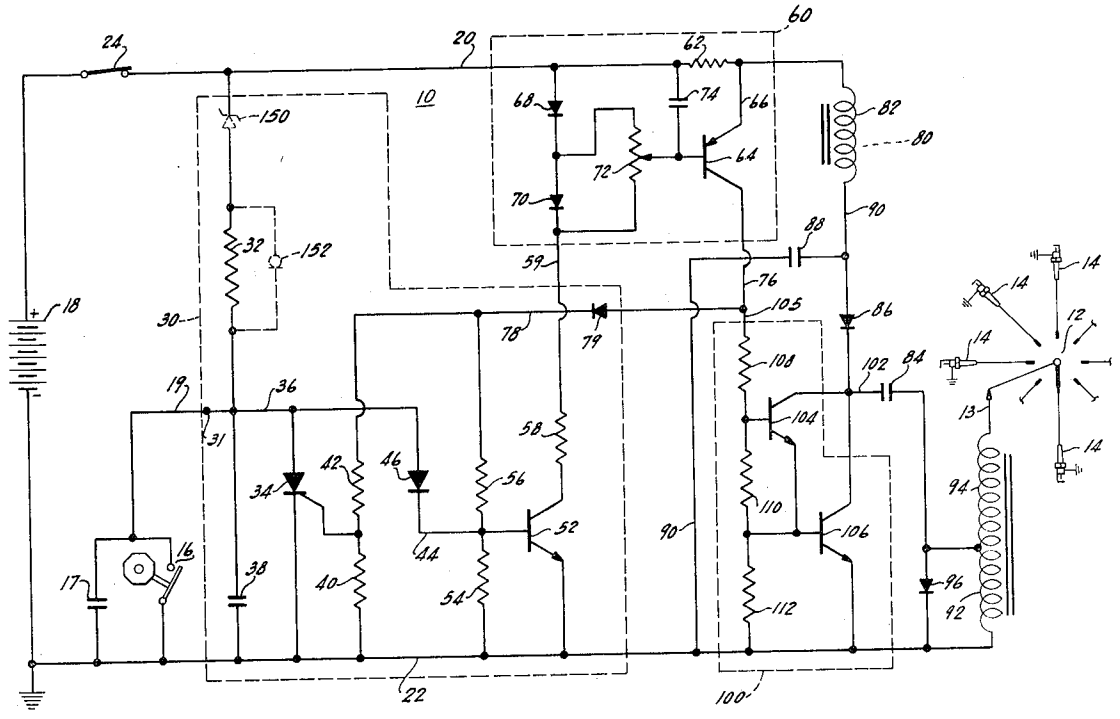
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[57] **ABSTRACT**

A capacitor discharge ignition circuit includes an inductor and a capacitor connected in series with the ignition coil. A transistor means is connected across the capacitor and ignition coil for providing a current flow path through the inductor and a capacitor discharge path through the ignition coil. The transistor means is operated by a control means which initiates capacitor discharge and inductor current flow upon point contact opening. The control means includes a sensing means which terminates current flow through the inductor when a predetermined magnitude of electrical energy has been generated in the inductor. The energy of the inductor is then transferred to the capacitor by operation of the transistor means.


**27 Claims, 4 Drawing Figures**



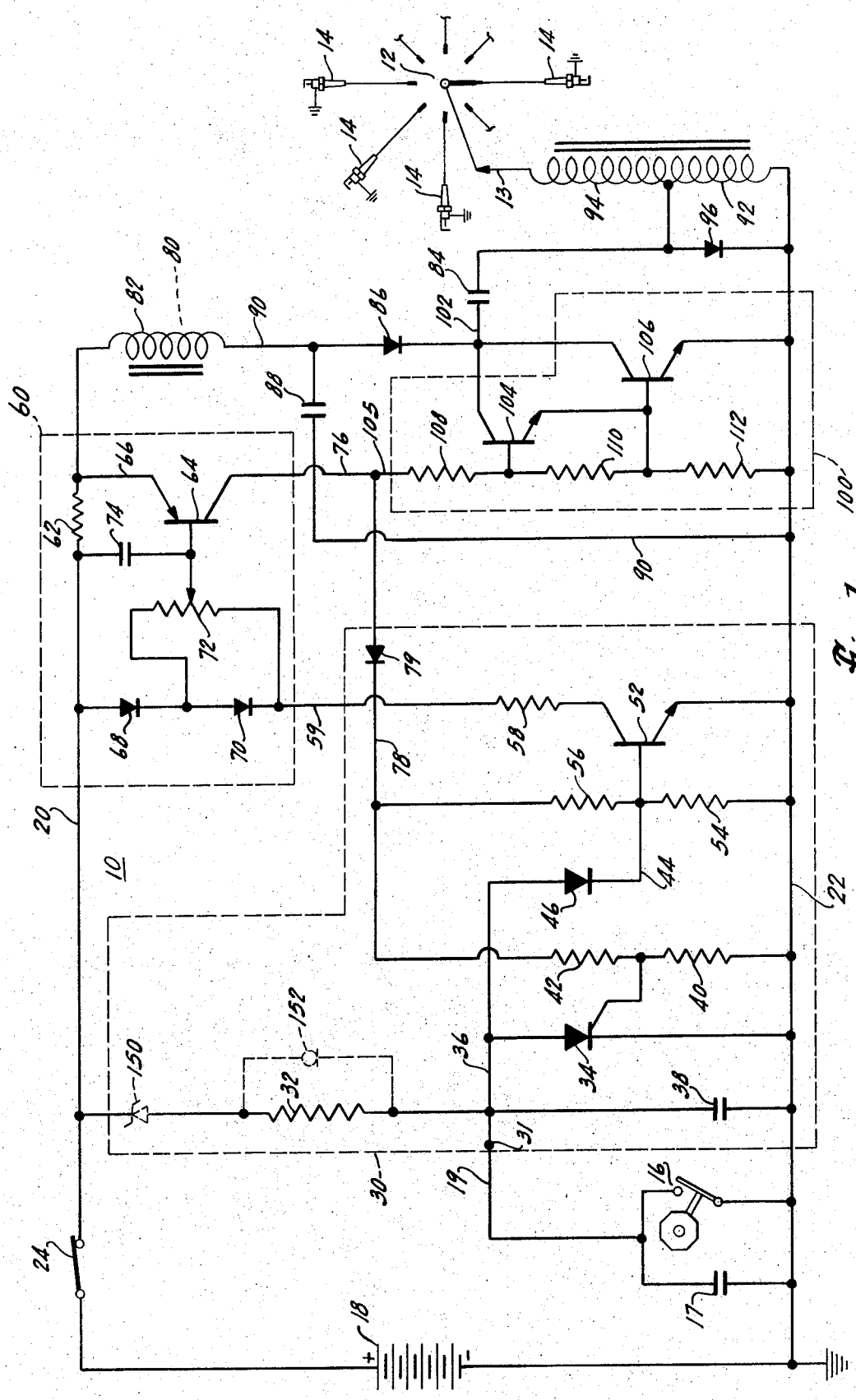

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Fig. 1

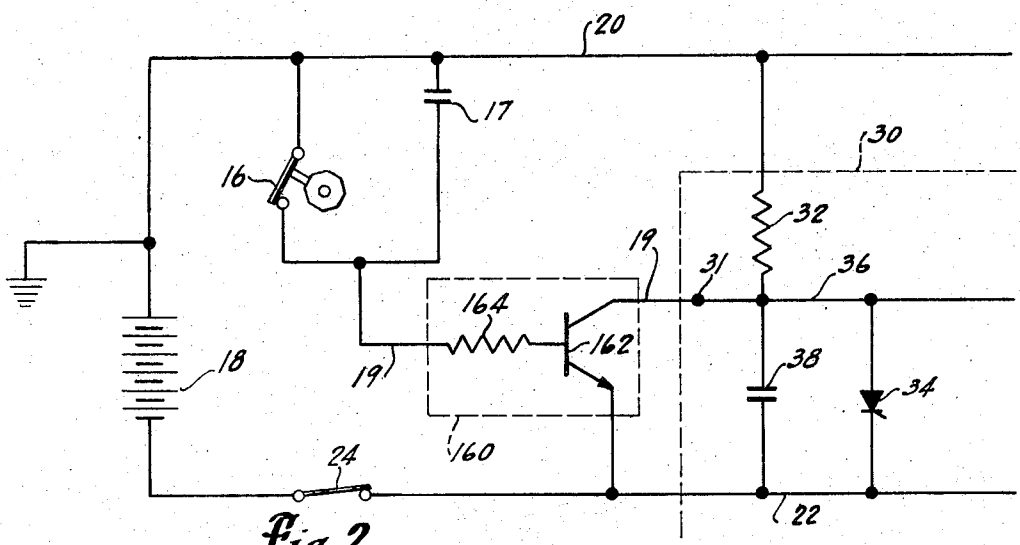



Fig. 2

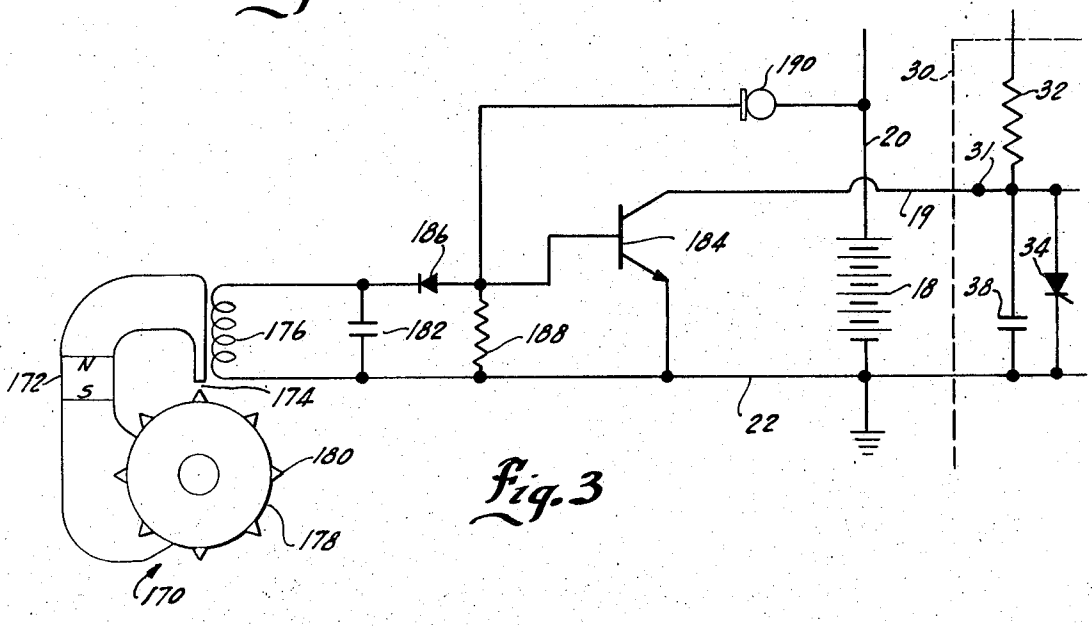



Fig. 3

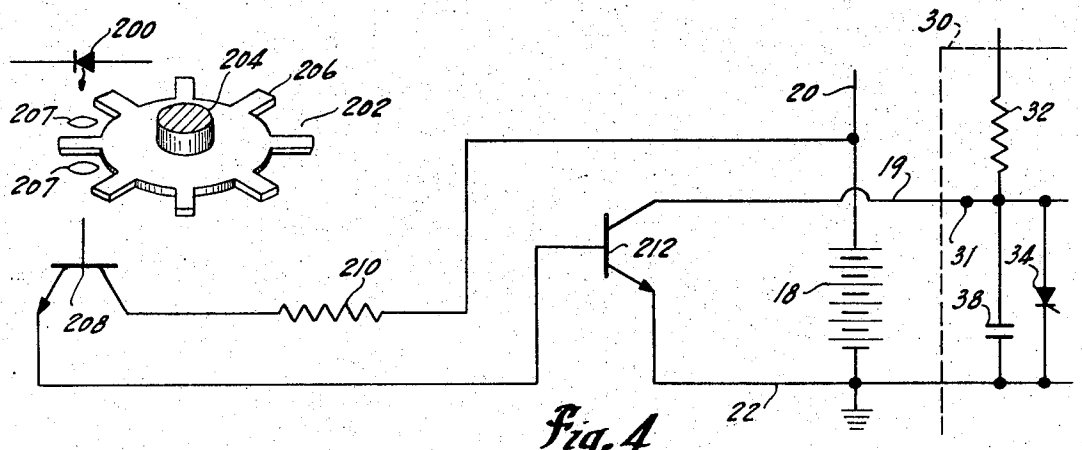



Fig. 4

# CAPACITOR DISCHARGE IGNITION CIRCUIT

## BACKGROUND OF THE INVENTION — FIELD OF THE INVENTION

The present invention relates to a capacitor discharge ignition circuit for providing sparking energy to spark plugs.

## BACKGROUND AND SUMMARY OF THE PRESENT INVENTION

With the advent of reliable semi conductor components, electronic ignition circuits have been made available. These circuits employ the current amplifying or controlling characteristics of such components to permit a small magnitude signal at the engine breaker points or other timing device to control a much larger power applied to the engine spark plugs. This technique reduces deterioration of the point contacts, increases spark plug life, allows firing of fouled spark plugs, eliminates high speed misses, and provides easier starting and numerous other advantages.

In simple forms of such circuits, the control element of the semiconductor component, for example, the base of a transistor or the gate of a controlled rectifier, is connected to the points to operate the power elements of the device connected directly to the coil or other portions of the engine ignition system.

In more elaborate embodiments of electronic ignition circuitry, energy is stored in a capacitor. At the appropriate instant, as determined by the engine timing device, the capacitor is discharged into the coil by altering the conductive state of a semiconductor. Such circuits are usually termed capacitor discharge circuits. Capacitor discharge circuits are generally more efficient than other types, producing better spark and requiring less power from te battery. These circuits develop higher peak voltages than other types. The higher peak voltages are developed over a considerably wider range of engine speed.

The present invention relates to an improved ignition circuit of the capacitor discharge type. More specifically, the present invention is directed to an improved ignition circuit which does not require the dc—dc voltage converter utilized in prior art systems to produce the potential energy necessary to charge the capacitor. The present invention does not utilize a controlled rectifier to control discharge of the capacitor thereby avoiding the turn off, spurious firing and other problems associated with such devices. The unit is small in size and employs only solid state components.

The capacitor discharge ignition circuit of the present invention is temperature stabilized. The circuit is reliable in operation and is capable of providing substantially trouble free operation for substantial periods of time. It prevents false firing or other malfunctions of the ignition system due to erratic point operation or other causes. The ignition circuit also requires no starting boost circuits and ballast resistors during running.

The capacitor discharge ignition circuit of the present invention may operate in either positive or negative ground ignition systems and may operate with a plurality of different types of input signal generators through the use of simple adaptors. Such transducers may include the conventional mechanical breaker point contacts or optical, electrical, magnetical, or other equivalents thereof. There is insignificant battery drain



produced by the circuit unless it is operating. During operation the battery drain is very low due to the high efficiency of the circuit. The energy applied to the ignition coil is regulated and is not dependent on battery voltage, thereby avoiding insulation breakdown on high voltage components and aiding starting. The capacitor discharge ignition circuit of the present invention is utilizable with a standard ignition coil and provides an automatic predetermined limit to engine speed to prevent engine overspeed damage.

Briefly, the present invention contemplates an ignition circuit of the capacitor discharge type in which the capacitor is connected in series with an inductor and the ignition coil across a power supply, such as a battery. A semiconductor control means shunts the capacitor and the ignition coil. An input logic circuit initiates conduction of the semiconductor means responsive to the point contacts of the engine to discharge the capacitor into the ignition coil and commence current flow through the inductor. A current limiter circuit terminates conduction of the semiconductor means to terminate inductive current flow and charge the capacitor when the inductor current reaches a predetermined magnitude.

## BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a schematic diagram of the ignition circuit of the present invention including portions of an associated internal combustion engine.

FIG. 2 is a partial schematic diagram of the input portions of the ignition circuit shown in FIG. 1 illustrating connection of the ignition circuit to an ignition system of positive ground.

FIG. 3 is a partial schematic diagram showing connection of the ignition circuit of the present invention to a magnetic input signal generator.

FIG. 4 is a partial schematic diagram showing connection of the input circuit of the present invention to an optical input signal generator.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

1. Construction of Ignition Circuit

a. Logic Circuit

Conductor **19** containing the signal from point contacts **16** is connected to input terminal **31** of ignition circuit **10.** Input terminal **31** is located in logic circuit **30.** A series connected resistor **32** and controlled rectifier **34** are connected across power supply buses **20** and **22.** Conductor **36** is connected to the anode of controlled rectifier **34** so that when point contacts **16** are closed, conductor **36** is effectively connected to power supply bus **22** by the action of the point contacts thereby by passing controlled rectifier **34.** Capacitor **38** is also connected between conductor **36** and power supply bus **22.**

Conductor **36** is connected to the anode of diode **46.** Conductor **44** is connected to the cathode of diode **46,** to the base of transistor **52** and to resistors **56** and **54.** The emitter of transistor **52** is connected to power supply bus **22** and the collector is connected to conductor **59** having resistor **58** interposed therein. Conductor **59** provides the logic circuit output signal.

Logic circuit **30** includes a feedback hold-on circuit which includes conductor **78.** Diode **79** is interposed in conductor **78.** Resistors **56** and **54** are connected between conductor **78** and power supply bus **22** and have

their common junction connected to conductor 44 and the base of transistor 52. Resistors 42 and 40 are also connected in series between conductor 78 and power supply bus 22. The common connection of resistors 42 and 40 is connected to the control gate of controlled rectifier 34.

b. Current Limiter Circuit

Current limiter circuit 60 includes resistor 62 connected in power supply bus 20 for providing a signal corresponding in magnitude to the current flowing in the bus. Current limiter circuit 60 also includes transistor 64, the emitter of which is connected to the load side of resistor 62 by conductor 66. The base circuit of transistor 64 includes a pair of series connected, reference signal diodes 68 and 70 located in conductor 59. Conductor 59 extends from the collector of transistor 52 in logic circuit 30 to power supply bus 20. Potentiometer 72 is connected in parallel with diode 70. The wiper of potentiometer 72 is connected to the base of transistor 64. Capacitor 74 is connected between the power supply side of resistor 62 and the base of transistor 64.

The output of current limiter circuit 60 is provided at the collector of transistor 64 in conductor 76. Conductor 76 is connected to conductor 78 to provide a feedback signal to logic circuit 30.

c. Energy Transformer Circuit

Energy transformer circuit 80 includes inductor 82 in bus 20. Inductor 82 is connected in series with capacitor 84 through conductor 90, diode 86 and conductor 102 for changing the capacitor in a manner hereinafter described. The capacitance of capacitor 84 is selected in accordance with the impedance of coil 13. A peak voltage regulating capacitor 88 is connected between conductor 90 and power supply bus 22. The primary winding 92 of coil 13 is connected in series with capacitor 84 and bus 22. A shunting diode 96 is connected across primary winding 92. The secondary winding 94 of coil 13 is connected to distributor 12.

d. Power Switcher Circuit

Power switcher circuit 100 is connected between conductor 102 and bus 22.

Power switcher circuit 100 includes transistor 104 and 106, connected in a configuration commonly termed a Darlington pair. This transistor connection provides sufficient gain to efficiently insure operation of transistor 106. For satisfactory operation of ignition circuit 10, it is desirable that transistors 104 and 106 comprise high voltage switching transistors.

The input to the Darlington pair is provided to the base of transistor 104 by means of conductor 105 and resistor 108 which are connected to the output of current limit circuit 60 by conductor 76. The bases of transistors 104 and 106 are shunted by resistors 110 and 112 interposed between conductor 105 and bus 22. The base of transistor 104 is connected intermediate resistors 108 and 110. The collector of transistor 104 is connected to conductor 102 intermediate diode 86 and capacitor 84. The emitter of transistor 104 is connected to the base of transistor 106. The base of transistor 106 is also connected intermediate resistors 110 and 112. The collector of transistor 106 is connected to conductor 102 while the emitter is connected to power supply bus 22.

2. Operation of the Ignition Circuit

In summary, the operation of ignition circuit 10 of the present invention is as follows. Current is made to flow through inductor 82 creating a surrounding magnetic field. When this current reaches a predetermined level, selected in accordance with the desired energy accumulation level in the inductor, the current flow is interrupted. The kinetic energy induced in inductor 82 converts to potential energy which is transferred to potential energy in capacitor 84. When point contacts 16 open to call for a spark on one of the spark plugs 14, the potential energy in capacitor 84 is transferred to coil 13 to provide the desired spark. Simultaneously current begins flowing through inductor 82 to recommence recharging of capacitor 84 for the next operative cycle.

More specifically, with transistors 104 and 106 in power switcher circuit 100 conductive, electron current flows from power supply bus 22 through inductor 82 to power supply bus 20. Resistor 62 of current limiter circuit 60 in bus 20 senses the magnitude of the inductor current. When the current reaches a preselected magnitude, current limiter circuit 60 causes power switcher circuit 100 to switch off. This causes the transfer of the accumulated energy in inductor 82 to capacitor 84. The polarity of battery 18 is such ss to aid in the charging of capacitor 84. Capacitor 84 is thus charged to a state of predetermined potential energy.

Logic circuit 30 senses the timing signal provided by point contacts 16. When point contacts 16 open to call for a spark at plugs 14, logic circuit 30, through current limiter circuit 60 switches transistors 104 and 106 back on, creating the necessary discharge path for capacitor 84 through primary winding 92 of ignition coil 13 and recommencing current flow through inductor 82. Current limiter circuit 60 provides a feedback signal to logic circuit 30 which causes the logic circuit to hold the power switcher circuit on until a predetermined current signifies completion of inductor charging. The logic circuit also prevents any input signals to ignition circuit 10 until the logic circuit is reset by completion of inductor charging. The logic circuit also requires closure of point contacts 16 in the resetting of ignition circuit 10 thus eliminating the possibility of false firing. After the completion of the operative cycle of ignition circuit 10 and the closure of point contacts 16, a reopening of the point contacts 16 will re-initiate the operation of ignition circuit 10.

A detailed description of ignition circuit 10 is as follows. It may be assumed that point contacts 16 are closed in preparation for generating a spark upon opening. Under such conditions, controlled rectifier 34 in logic circuit 30 is shunted by closed point contacts 16 and controlled rectifier 34 is non conductive. The signal voltage in conductor 36 is essentially zero. The voltage in bus 22, applied through closed point contacts 16, is such as to bias transistor 52 in logic circuit 30 off as the emitter of that transistor is also connected to buss 22. Electron current flows between power supply bus 22 and power supply bus 20 through closed point contacts 16 and resistor 32.

Transistor 64 in current limiter circuit 60 is also non conductive as no logic circuit output signal is developed in conductor 59 connected to the collector of transistor 52. No reference signal is thus applied to the base of transistor 64 through diodes 68 and 70 and potentiometer 72. Little or no current is flowing in bus 20 through inductor 82 and diode 86. Capacitor 84 is fully charged from the previous cycle. Transistors 104 and 106 are non-conductive as no signal is being applied in

conductors 76 and 105. The non-conductivity of transistors 104 and 106 places primary winding 92 of coil 13 in the quiscent state.

When the point contacts 16 are opened by rotation of the distributor shaft, indicating that a spark is desired at one of the spark plugs 14, conductor 36 is no longer tied to power supply bus 22. Current flow through point contacts 16 terminates and current commences to flow from power supply bus 22 through resistor 54, conductor 44, diode 46, conductor 36 and resistor 32 to power supply bus 20.

The current flow turns on transistor 52 generating a current flow in conductor 59 from emitter-collector of transistor 52 through resistor 58, diodes 70 and 68, and potentiometer 72, to power supply bus 20. The current flow through diodes 70 and 68 establishes a voltage reference sigal based on the forward voltage drop characteristics of the diodes. Potentiometer 72 provides a selected portion of this voltage as a reference bias voltage to the base of transistors 64 to render transistor 64 conductive.

The turn on of transistor 64 establishes current flow in conductor 76, conductor 105, and resistors 108, 110 and 112 which current flow biases transistors 104 and 106 to switch to the conductive state. The turn on of transistors 104 and 106 creates a discharge path for capacitor 84 and simultaneously therewith a charge path for inductor 82. The discharge path of capacitor 84 commences from the negative side of the capacitor through primary winding 92 of ignition coil 13, power supply bus 22, the emitter-collector circuits of transistors 104 and 106 to the positive side of capacitor 84. The discharge current of capacitor 84 through primary winding 92 of coil 13 generates a negative high voltage in secondary winding 94 and provides a spark at the one of spark plugs 14 selected by disctributor 12. After the initial discharge of capacitor 84 through primary winding 92, diode 96 provides for a continuation of the inductive current flow resulting from collapse of the magnetic field of coil 13 to prolong the duration of the spark.

The turn on of transistor 64 and current limiter circuit 60 also provides a current flow in the feedback circuit for logic circuit 30. Specifically, the turn on of transistor 64 provides a current flow in conductor 76. The current through diode 79, conductor 78 and resistors 54 and 56 insures that transistor 52 in logic circuit 30 will remain in the conductive state. This, in turn, insures that the desired voltage reference signal will be provided to the base of transistor 64 in current limiter circuit 60. The current flow through resistors 40 and 42 to conductor 78 gates controlled rectifier 34 into the conductive state. The turn on of controlled rectifier 34 insures that any operational phenomena of point contacts 16 will have no effect on iginition system 10 until the points have reclosed and the operative cycle of ignition circuit 10 is complete. Placing controlled rectifier 34 in the conductive state and/or closure of point contacts 16 will not remove the base bias to transistor 52 because of the presence of gating diode 46. This assures that transistor 52 and current limiter circuit 60, and power switcher circuit 100 controlled thereby, will be uneffected by the condition of controlled rectifier 34 and/or point contacts 16 until inductor charging is completed.

Simultaneously with the discharge of capacitor 84 into primary winding 92 of coil 13, current starts flowing from power supply bus 22 through the emitter-collector circuit of transistors 106 and 104, diode 86, inductor 82, and resistor 62, to power supply bus 20. Because the high current in the emitter-collector circuits of transistors 106 and 104 produced by the discharge of capacitor 84 will have subsided by the time significant current flow through inductor 82 commences, transistors 106 and 104 are not subjected to both these current magnitudes at the same time. Rather, transistors 106 and 104 handle first the capacitor 84 discharge current flow and thereafter the current flow through inductor 82, thereby reducing the electrical load on transistors 106 and 104.

The current flowing in inductor 82 produces inductive energy in the inductor through the creation of a magnetic field. As the inductor-field producing current through resistor 62 rises, transistor 64 will be biased off by the signal produced at its emitter by the voltage drop across resistor 62 in conductor 66 with respect to the preselected base bias on the base of transistor 64. The inductor current level at which transistor 64 will be biased off is selected by adjusting the base bias to the transistor by means of the wiper of potentiometer 72.

As transistor 64 is turned off, the current in conductors 76 and 78 decreases, eliminating the holding base current to transistor 52 established by resistor 56, tending to turn off transistor 52. The reduction in the conductance of transistor 52 reduces the voltage reference bias signal to transistor 64 which, in turn, drives transistor 64 further toward the non conductive state. Thereafter, transistors 104 and 106 are rendered non conductive as the input signal in conductors 76 and 105 is removed from the base of transistor 104. The turn off of transistors 106 and 104 interrupts the path for the inductive current flowing through inductor 82. However, due to its inductive characteristics, inductor 82 reverses its polarity and acts as a power source in series with power supply 18 and its current continues to flow in the same direction as its magnetic field collapses. This current charges capacitor 84.

The capacitor charging current is supplied by inductor 82 and power supply 18 which are connected in series across capacitor 84. The path for the capacitor charging current extendings from bus 22 through diode 96, capacitor 84, conductor 102, diode 86, conductor 90, and inductor 82. Diode 96 bypasses the current from primary winding 92 of coil 13. This current flow charges capacitor 84 to potential energy equal to the kinetic energy of inductor 82 plus the potential energy of power supply 18, placing capacitor 84 in a charged condition for providing another spark to coil 13 when required. Gating diode 86 serves as a disconnect means to prevent capacitor 84 from discharging when the potential energy of the charging circuit falls below its peak value.

The voltage on capacitor 84 attained during charging, and hence the energy provided to ignition coil 13 for spark generation may be derived from the following equations. The energy of the inductor is equal to $LI^2/2$. The energy of the capacitor is equal to $CV^2/2$. Inasmuch as the entire energy of the inductor is transferred to the capacitor the equation $LI^2/2 = CV^2/2$ may be established. Removing the factor 2 from the denominator and solving the equation for voltage, yields $V = \sqrt{LI^2/C}$. Since, as noted, supra, inductor 82 and battery 18 are connected in series during charging of ca-

pacitor 84, the final voltage of the capacitor is $V_{cap} = \sqrt{LI^2/C} + V_{bat}$.

Even though the gating signal to controlled rectifier 34 is removed with the removal of the signal in conductor 78, controlled rectifier 34 remains conductive, preventing the application of any input signals to ignition circuit 10 until point contacts 16 have closed. The closure of point contacts 16 shorts controlled rectifier 34 and returns the controlled rectifier to the non conductive state. Capacitor 38, in addition to suppressing electrical noise at the input of ignition system 10 insures that controlled rectifier 34 will not refire through control of its *dv/dt* characteristics. Thereafter, ignition circuit 10 is in condition to recommence another operative cycle to provide another spark to one of spark plugs 14.

Temperature stabilization in ignition circuit 10 is obtained by the bridge circuit connection of the emitter-base junction of transistor 64 and the diode 68. For example, as ambient temperature increases, the voltage drop across diode 68 decreases, decreasing the base voltage applied to transistor 64. However, the same temperature increase decreases the emitter-base voltage drop in transistor 64, causing the level of current which initiates turn off of transistor 64 to remain unchanged. The temperature stabilization features of the present invention may be enhanced by selecting both transistor 64 and diode 68 from the same semiconductor material, such as silicon.

The ignition circuit 10 of the present invention provides an automatic predetermined limit to engine speed in the following manner. As noted, supra, when transistor 64 is rendered conductive at the commencement of an operative cycle of ignition circuit 10, a signal is applied through conductors 76 and 78 to the gate of controlled rectifier 34. This signal turns controlled rectifier 34 on and, in effect, shorts out the input to ignition circuit 10. Under these conditions, subsequently applied signals in conductor 19 by point contacts 16 can have no effect on the operation of ignition circuit 10.

When the operative cycle of ignition circuit 10 has been completed, the turn off of transistor 64 removes the gate signal from controlled rectifier 34. When point contact 16 closes in preparation for providing another firing signal to ignition circuit 10, controlled rectifier 34 is shorted out and becomes non-conductive. With controlled rectifier 34 in the non-conductive state the input to logic circuit 30 will again be receptive to the opening of point contacts 16.

It is thus seen that once the operation of ignition circuit 10 is initiated, the input signals from point contacts 16 can have no further effect on ignition circuit 10 until the gate signal is removed from controlled rectifier 34 by the completion of the operation of ignition system 10 and closure of point contacts 16.

If input signals from point contacts 16 are applied to the input of logic circuit 30 at a rate more rapid than the rate of operation of ignition circuit 10 not every input signal will render ignition circuit 10 operative. For example, only every other input signal may render the ignition circuit operative. This means that only every other cylinder in the internal combustion engine will be fired, reducing the power output of the internal combustion engine. In addition, those cylinders which are not fired will be loaded by the compression of the unfired charge in the cylinder, further reducing the power output of the engine. Inasmuch as every other cylinder is fired, dangerous build up of unfired fuel-air mixture in the exhaust manifold is prevented and the unfired charges are harmlessly burned in the exhaust manifold.

The magnitude of resistor 32 may be selected to prevent operation of the ignition system at battery voltages which are inadequate to establish sufficient inductor current to operate ignition circuit 10. Under such conditions of low battery voltage, ignition circuit 10 might initially turn on but could never turn off because sensing circuit 60 does not receive a sufficient signal. To avoid this, the magnitude of resistor 32 may be selected to hold the base emitter current of transistor 52 below turn on under conditions of inadequate battery voltage.

Or, a zener diode 150 may be connected in series with resistor 32. In the event the battery voltage is so low as to not overcome the breakdown voltage of the zener diode no operation of ignition circuit 10 can be obtained and the circuit is protected against low voltage operation.

Resistor 32 may be replaced by current regulating diode 152, either with or without zener diode 150, thereby to lessen the effect of variations in battery voltage on the operation of ignition circuit 10. Specifically, the use of a current regulating diode stabilizes the base current of transistor 52 over a wide range of battery voltages and fluctuations of the battery voltage.

In another modification of the ignition system, ignition switch 24 may be placed in series with resistor 32 rather than in power supply bus 20. The ignition switch is thus in the low current portions of the portions of the ignition circuit rather than being subjected to full battery current, thereby reducing power losses and wiring.

The capacitor discharge ignition circuit 10 of the present invention may operate in either positive or negative ground ignition systems. FIG. 1 shows the ignition circuit 10 in a common negative ground ignition system. FIG. 2 shows the input portions of ignition system 10 in a positive ground ignition system. In accordance with conventional automotive practice, point contacts 16 are connected to the grounded side of the battery or to power supply bus 20. The output of point contacts 16 is provided to a polarity adaptor 160 interposed in conductor 19. Point contacts 16 are connected to the base of transistor 162 through resistor 164. Transistor 162 is of the NPN type having the emitter connected to the ungrounded negative voltage power supply bus 22 and having the collector connected to input terminal 31 of logic circuit.

In operation, when point contacts 16 open to request a spark at spark plugs 14, transistor 162 is rendered non conductive by the removal of the base bias. This commences the flow of current from power supply bus 22 through resistor 54, conductor 44, diode 46, conductor 36 and resistor 32 to power supply bus 20. Thereafter the operation of logic circuit 10 is identical to that described above in connection with a negative grounded ignition system.

The ignition circuit of the present invention may operate with a plurality of different types of signal generators in addition to point contacts 16 through the use of adaptors. In FIG. 3 there is shown a magnetical means in place of conventional mechanical point 16 and associated lobed distributor cam.

In FIG. 3 distributor 170 contains a means having a variable reluctance flux path. In a typical distributor 170 the variable reluctance flux path includes a source of magnetomotive force such as permanent magnet 172. An extension of one pole, for example, the north pole of magnet 172 extends to define one side of air gap 174. A pick up winding 176 is associated with the pole extension. The other side of air gap is formed by rotor 178 magnetically coupled to magnet 172. Rotor 178 has a plurality of projections 180 equal in number to the number of cylinders of the internal combustion engine. Rotor 178 is mounted on the distributor shaft for timed rotation with the internal combustion engine.

The reluctance of the magnetic path of distributor 170 varies from a low reluctance state when one or projections 180 is adjacent air gap 174 to a high reluctance state when the projection is removed from the air gap. Variations in reluctance of the flux path induce voltages in magnetic pick up coil 176. Pick up coil 176 is shunted by capacitor 182 which provides noise suppression and peak voltage limiting to the circuit. One side of pick up coil 176 is connected to the base of transistor 184 through diode 186 while the other side is connected to the emitter of transistor 184. The emitter-base junction of transistor 184 is shunted by resistor 188 which prevents diode leakage currents from affecting the operation of the circuit. The positive terminal of battery 18 is connected through a current regulating diode 190 to the base of transistor 184 while the negative terminal of battery 18 is connected to the emitter of transistor 184. The collector of transistor 184 is connected to input terminal 31.

In operation, transistor 184 is normally conductive. However, when the reluctance of air gap 174 is varied by the presence of one of projections 180, the voltage induced in winding 176 turns transistor 184 off commencing the operative cycle of ignition circuit 10. More specifically, under conditions of high reluctance in air gap 174 current will flow from power supply bus 22, through the emitter-base of transistor 184 and current regulating diode 190 to power supply bus 20. Input terminal 31 connected to the collector of transistor 162 is thus connected to power supply bus 22 so that signal conditions at input terminal 31 are analogous to those existing under closed point contact conditions.

As one of projections 180 approaches air gap 174, decreasing the reluctance of the magnetic circuit, a positive voltage is applied to the cathode of diode 186. Diode 186 blocks the application of voltage to the base of transistor 184 so that the signal condition of input terminal 31 is not affected.

As the movement of projection 180 past air gap 174 causes variations in reluctance to first cease and thereafter resume as air gap reluctance increases, an abrupt change from positive to negative voltage occurs in winding 176 and at the cathode of diode 186. This negative voltage produces a current which passes through dode 186 to the base of transistor 184 in opposition to the current regulated emitter-base hold on current and renders the transistor momentarily non-conductive, applying an input signal to input terminal 31 which triggers the operation of ignition circuit 10. The operation of the foregoing input circuitry is stabilized and exactly controlled by the precise establishment of electrical conditions on the base and emitter of transistor 184. The electrical condition of the base is controlled by current regulating diode 190 while the electrical condition of the collector is controlled by controlled rectifier 34.

In another embodiment an optical signal generating means may be utilized. As shown in FIG. 4, a source of light, such as light emitting diode 200 is provided on one side of mask 202 connected to the distributor shaft 204. Mask 202 has a plurality of projections 206 corresponding to the number of cylinders in the internal combustion engine. On the other side of mask 202 is located light sensitive transistor 208. A lens system 207 may be employed in connection with light emitting diode 200 and phototransistor 208. The collector of transistor 208 is connected to positive voltage power supply bus 20 through resistor 210 while the emitter of transistor 208 is connected to the base of transistor 212. The emitter of transistor 212 is connected to negative power supply bus 22 while the collector is connected to conductor 19 and input terminal 31 of ignition circuit 10.

In operation when light from light emitting diode 200 passes mask 202, transistor 208 is rendered conductive. This renders transistor 212 conductive and no input signal is applied to logic circuit 10. When the light beam is broken by one of projections 206, the removal of light from the base of transistor 208 renders that transistor and transistor 212 non-conductive and provides an input signal to ignition circuit 10.

Various modes of carrying out the invention are contemplated as being within the scope of the following claims particularly pointing out and distinctly claiming the subject matter which is regarded as the invention.

I claim:

1. A capacitor discharge ignition circuit for intermittently supplying electrical pulses to a spark plug energization means from a primary electrical source, said circuit being triggerable by periodic operation of a switch means and comprising:

an inductor connectable to one side of the primary electrical power source for generating electrical energy in said inductor responsive to current flow therethrough;

a capacitor connected in series with said inductor and connectable to the spark plug energization means and to the other side of the primary electrical power source for receiving and storing the electrical energy generated in said inductor;

semiconductor means including an output circuit having conductive and non conductive states and a signal responsive input circuit for controlling the duration of the conductive state of the output circuit in accordance with the duration of a conduction signal applied to the input circuit, said output circuit being connected intermediate said inductor and capacitor and in parallel with the series connected capacitor and spark plug energization means for providing a discharge path for the stored electrical energy of the capacitor into the spark plug energization means when in the conductive state, said output circuit permitting the transfer of electrical energy from said inductor to said capacitor when in the non conductive state;

an input logic circuit having an input connectable to the switch means for providing an output signal upon the operation of the switch means; and

sensing means having an output connected to said semiconductor means input circuit, said sensing

means having an input connected to said input logic circuit and being responsive to said output signal for initiating a conduction signal to said semiconductor input circuit, said sensing means input being further coupled to said inductor and being responsive to the magnitude of current flow through the inductor for terminating the conduction signal to said semiconductor input circuit when the current flow through said inductor reaches a predetermined magnitude.

2. The capacitor discharge ignition circuit of claim 1 wherein said sensing means is further defined as including a current sensor coupled to said inductor for providing a signal corresponding to the magnitude of current flow through the inductor and controllable conduction means having a power circuit controlled by a signal responsive control circuit, said power circuit being connected to the input circuit of said semiconductor means, said control circuit being connected to said input logic circuit and responsive to said output signal for causing said power circuit to initiate a conduction signal to said semiconductor means input circuit, said control circuit being further coupled to said current sensor for causing said power circuit to terminate the conduction signal to said semiconductor means input circuit when current flow through the inductor reaches a predetermined magnitude.

3. The capacitor discharge ignition circuit of claim 2 including a feedback signal path from said controllable conduction means power circuit to said input logic circuit for maintaining the output signal from said input logic circuit to said controllable conduction means control circuit during the periodic operation of said controllable conduction means.

4. The capacitor discharge ignition circuit of claim 2 wherein said sensing means includes means providing thermal stability to said sensing means.

5. The capacitor discharge ignition circuit of claim 2 wherein said input logic circuit is connectable to the primary electrical power source and includes means responsive to the voltage of the power source for preventing operation of the ignition circuit at unusably low voltages of the power source.

6. The capacitor discharge ignition circuit of claim 2 wherein said input logic circuit is connectable to the primary electrical power source and includes means for stabilizing the operation of the ignition circuit against fluctuations in battery voltage.

7. The capacitor discharge ignition circuit of claim 2 wherein said input logic circuit includes an ignition switch for rendering the ignition circuit operative.

8. The capacitor discharge ignition circuit of claim 2 wherein said input logic circuit is responsive to input signals of one polarity and the operation of switch means provides signals of the opposite polarity and wherein the ignition circuit includes means interposed between the switch means and said input logic circuit for converting the opposite polarity signals into signals of the desired polarity.

9. The capacitor discharge ignition system of claim 2 wherein the operation of the switch means produces a varying voltage timing signal wave form and wherein the ignition circuit includes wave shaping circuitry interposed between the switch means and said input logic circuit means for providing a periodic signal suitable for application to said input logic circuit.

10. The capacitor discharge ignition circuit of claim 2 wherein the operation of the switch means produces a bi-polarity voltage timing signal and wherein the ignition circuit includes polarity responsive circuitry interposed between the switch means and said input logic circuit for providing a periodic signal for application to said input logic circuit.

11. The capacitor discharge ignition circuit of claim 10 wherein said polarity responsive circuitry comprises means for obtaining the bi-polarity voltage timing signal and control means including an output circuit connected to said input logic circuit and having conductive and non conductive states for operating the input logic circuit, said control means further including an input circuit connected to said obtaining means and responsive to the polarity of the timing signal for controlling the conduction state of the output circuit.

12. The capacitor discharge ignition circuit of claim 11 wherein said control means comprises a transistor having the emitter-collector output circuit connected to said input logic circuit and the base-emitter input circuit connected to said means for obtaining the bi-polarity voltage timing signal, said base-emitter circuit includes a diode for providing voltage polarity responsiveness to said input circuit.

13. The capacitor discharge ignition circuit of claim 12 wherein said base-emitter input circuit of said control means is connectable to the primary electrical power source and includes a current regulating means for providing a fixed bias to said input circuit.

14. The capacitor discharge circuit of claim 2 wherein said sensing means includes a voltage responsive conduction means having a power circuit of alterable conductance connected to said semiconductor means input circuit and a voltage responsive control circuit for controlling the condition of the power circuit, said sensing means including bias means for providing a fixed bias voltage to said control circuit responsive to the input logic circuit means output signal for providing a conduction signal to said semiconductor means input circuit for placing said semiconductor means output circuit in the conductive state, said current sensor comprising a resistor connected in series with said inductor for providing a voltage proportional to inductor current to said control circuit for removing said conduction signal to said semiconductor means input circuit when the voltage signal proportional to current obtains a predetermined value relative to the bias voltage.

15. The capacitor discharge ignition circuit of claim 14 wherein said input logic circuit includes an input means connected to said power circuit of said voltage responsive conduction means and responsive to the conductance condition thereof and an output connected to said bias means for providing said fixed bias voltage to said control circuit of said voltage responsive conduction means.

16. The capacitor discharge ignition circuit of claim 14 wherein said voltage responsive control circuit and said bias means have complementary thermal characteristics for providing thermal stability to said sensing means.

17. The capacitor discharge ignition circuit of claim 1 including a diode interposed between said inductor and said capacitor for permitting energy to flow only from said inductor to said capacitor.

18. The capacitor discharge ignition circuit of claim 1 wherein said spark plug energization means includes an ignition coil having a primary winding connectable in series with said inductor and capacitor, said ignition circuit including a diode connectable in parallel with the primary winding.

19. The capacitor discharge ignition circuit of claim 1 wherein said semiconductor means includes transistor means having input circuit connected to said sensing means output and an output circuit having conductive and non-conductive states.

20. The capacitor discharge ignition circuit of claim 19 wherein said transistor means includes a pair of transistors connected in a Darlington pair.

21. The capacitor discharge ignition circuit of claim 19 wherein said semiconductor means includes transistor means having input circuit connected to said sensing means output and an output circuit having conductive and non conductive states, said transistor means having the characteristics of a Darlington pair.

22. The capacitor discharge ignition circuit of claim 1 wherein said sensing means output is further coupled to said input logic circuit for retaining said output signal to said sensing means input during the operative period of said sensing means.

23. The capacitor discharge ignition circuit of claim 22 wherein control of the degree of conduction during the conductive state of said semiconductor means is in accordance with the magnitude of the conduction signal applied to said semiconductor means input circuit and wherein said sensing means is further defined as including amplification means for amplifying said input logic circuit output signal to provide a conduction signal to said semiconductor means input circuit sufficient in magnitude to provide the desired degree of conduction in said semiconductor means.

24. The capacitor discharge ignition circuit of claim 18 wherein said input logic circuit includes input means connected to said sensing means output and responsive to the operational state thereof for rendering said input logic circuit means unresponsive to said switch means when said sensing means is in the operative state.

25. The capacitor discharge ignition circuit of claim 24 wherein the periodic operation of the switch means comprises an opening and closing of the switch means and wherein the input means of said input logic circuit is further defined as a resettable means responsive to the opening of said switch means and reset by the closure of said switch means.

26. The capacitor discharge ignition circuit of claim 25 wherein the input means includes a controlled rectifier connectable across the switch means, said controlled rectifier having a control terminal connected to said sensing means for rendering said controlled rectifier conductive when said sensing means becomes operative.

27. The capacitor discharge ignition circuit of claim 24 wherein the inductance of said inductor is selected in accordance with the voltage of primary electrical power source to provide a predetermined period of cyclical operation to the ignition circuit, thereby to provide engine overspeed protection.

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# UNITED STATES PATENT OFFICE

# CERTIFICATE OF CORRECTION

PATENT NO. : 3,844,266

DATED : October 29, 1974

INVENTOR(S) : DONOVAN F. PETERSON

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

| | | |
|---|---|---|
| Col. 1 | line 36 | after "from" delete "te" and substitute therefor ---the--- |
| Col. 3 | line 31 | after "102 for" delete "changing" and substitute therefor ---charging--- |
| Col. 4 | line 23 | after "such" delete "ss" and substitute therefor ---as--- |
| Col. 5 | line 36 | after "selected by" delete "disctributor" and substitute therefor ---distributor--- |
| Col. 14 (Claim 24) | line 5 | delete "18" and substitute therefor ---22--- |
| Col. 14 (Claim 24) | line 8 | after "circuit" delete "means" |

Signed and Sealed this

*sixth* Day of *April 1976*

[SEAL]

*Attest:*

**RUTH C. MASON**
*Attesting Officer*

**C. MARSHALL DANN**
*Commissioner of Patents and Trademarks*