

[54] **FUEL INJECTION SYSTEM**

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[58] Field of Search **123/139 AW, 139 AJ, 131; 158/116**

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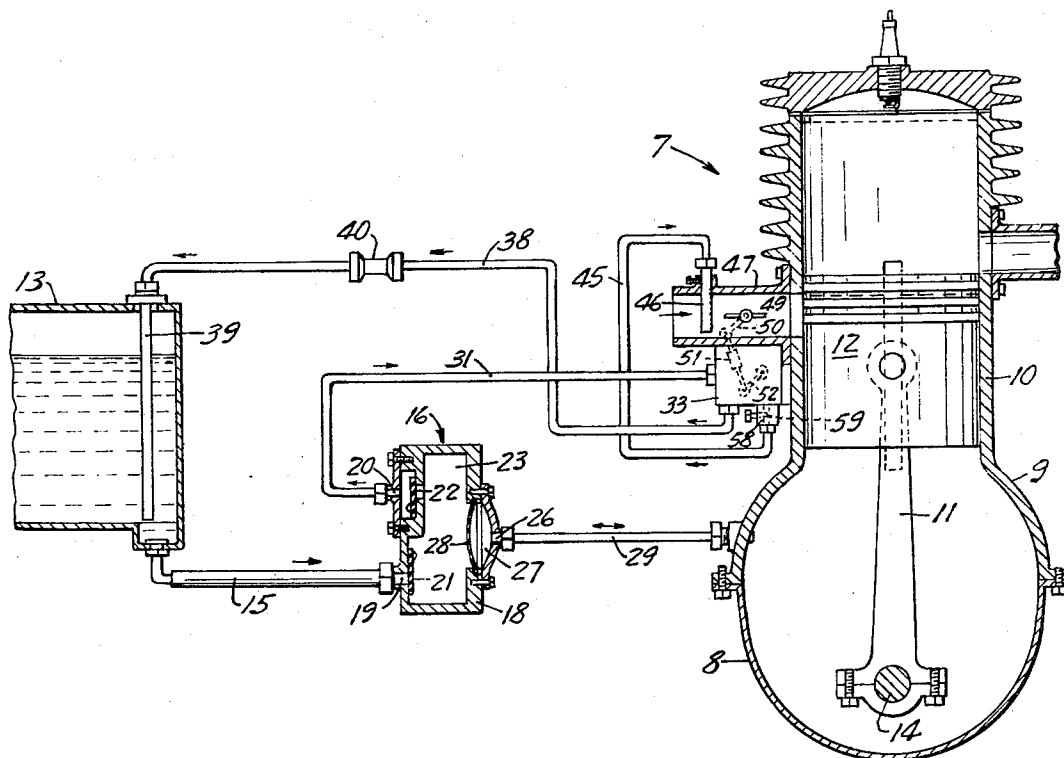
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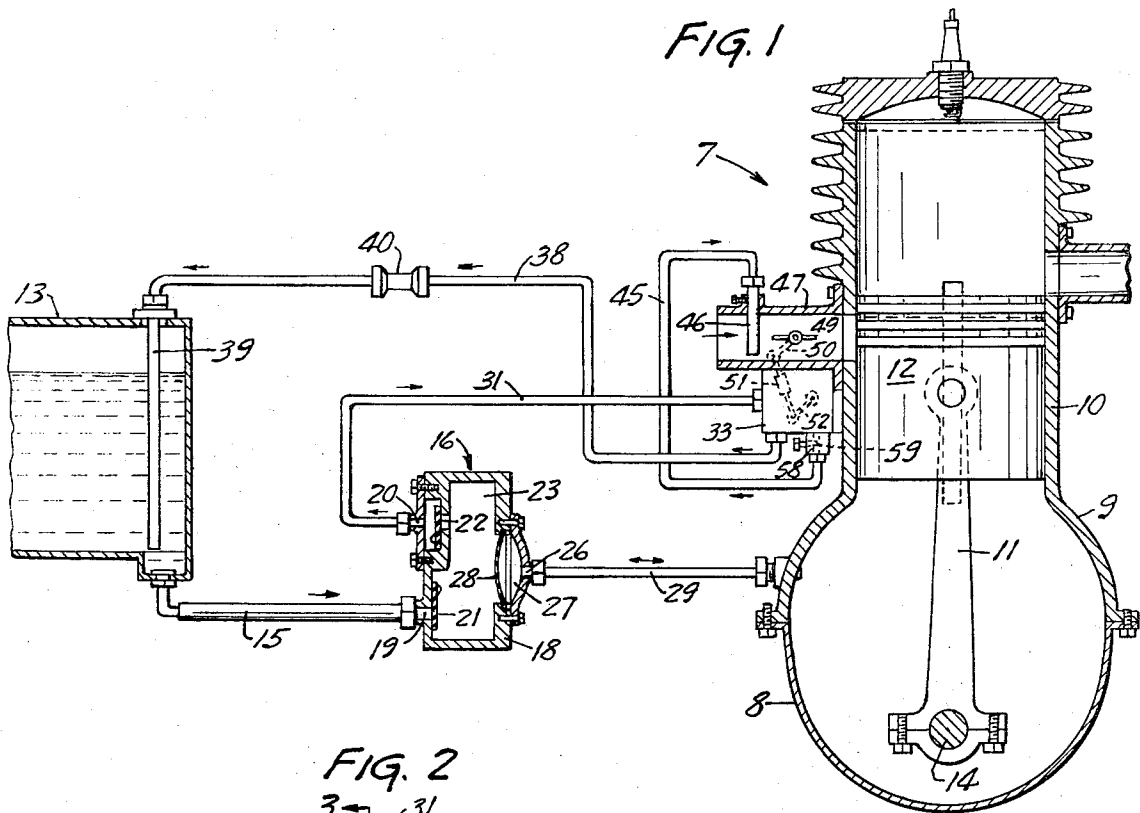
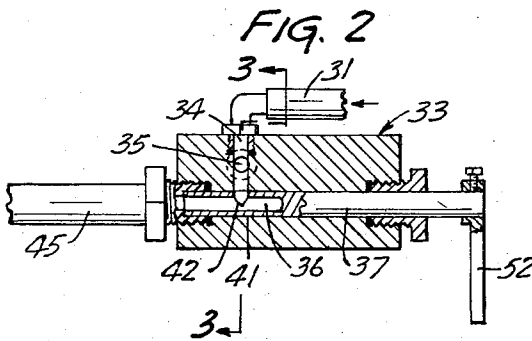
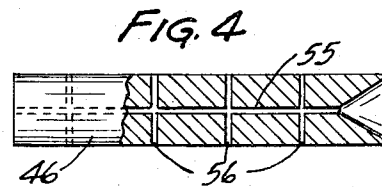
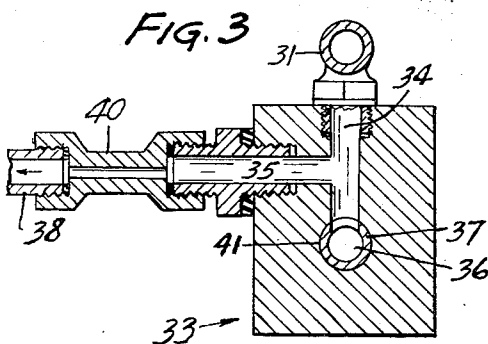
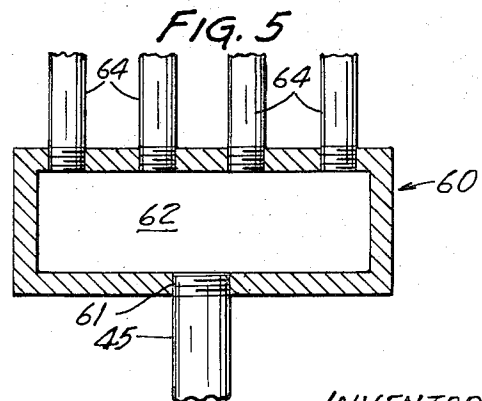
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ABSTRACT

A fuel injection system for internal combustion engines wherein the fuel is injected under pressure into a nozzle disposed in the air intake passageway. The discharge pressure of the fuel is controlled by a pump responsive to the intermittent crank case pressures and the amount of fuel carried to the nozzle and carried into the cylinder on the intake stroke is regulated by a speed control valve in the fuel line between the pump and the nozzle. A minimum pressure is maintained by a restriction in a bypass return line.

9 Claims, 5 Drawing Figures





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FUEL INJECTION SYSTEM

This is a continuation of application Ser. No. 146,627, filed May 25, 1971, now abandoned.

BACKGROUND OF THE INVENTION

This invention relates generally to fuel control systems for internal combustion engines and in one aspect to an improved fuel control system where the fuel is injected under pressure into the intake manifold.

Fuel control systems for internal combustion engines have generally used a diaphragm-type fuel pump which will pump fuel at a nearly continuous rate to a carburetor fuel bowl. The level of fuel in the fuel bowl is generally controlled by a float. With either downdraft or horizontal intake carburetors the fuel is drawn from the fuel bowl into the intake manifold by atomization using a venturi throat located at the outlet opening of the fuel bowl, thus drawing the fuel into the intake air. The decreased pressure at the venturi is used to draw the fuel from the bowl and supposedly atomizes the fuel before it is injected into the cylinders. These systems depend on the engine vacuum to draw the air through the venturi and to draw the fuel into the cylinders. Further, as the speed of the engine increases, the fuel control systems of the prior art make the engine less efficient since the venturi restricts the amount of air that can be drawn into the engine.

The present invention provides an improved fuel control system in that the fuel is discharged under pressure from a nozzle disposed in the intake manifold mounted on the engine. Except for the presence of the nozzle itself the intake manifold is not incumbered by the presence of the venturi at the fuel inlet. The fuel system of the present invention increases the flow of fuel into the nozzle and increases the pressure with which the fuel is placed in the nozzle as the speed of the engine increases and as the amount of air allowed into the cylinder increases under control of the throttle.

It is an object of the present invention to increase the efficiency of the engine and to afford a positive fuel injection into the intake manifold in response to increased demands of the engine. This is afforded in part by the fuel being pumped at varying pressures responsive to the crank case pressures driving the fuel pump. When so pumped, the pressure variations serve to time the fuel injection.

SUMMARY OF THE INVENTION

The fuel control system of the present invention utilizes fuel pump means preferably driven and responsive to varying pressure in the engine crank case. Fuel is pumped by the pump means from a reservoir to a flow control valve. The flow control valve receives the fuel pumped thereto from the outlet of the diaphragm pump and comprises a variable flow control valve member at one outlet for metering the quantity of fuel directed to an injection nozzle disposed in the intake manifold. A second outlet from the valve affords a bypass to return excess fuel to the reservoir or fuel tank. A restriction is placed in the return line to the fuel tank to maintain a supply of fuel to the nozzle at a pressure above a minimum. Discharge of the fuel from the control valve to the nozzle is throttle-regulated and operates in conjunction with the air metering valve disposed in the intake manifold permitting the air fuel mixture to enter the engine. The amount of fuel and the pressure under

which the fuel enters the injection nozzle is responsive to engine crank case pressures. The nozzle of this fuel control system comprises a slender tubular member having a reduced or restricted central bore and a plurality of passageways or bores disposed transverse to and communicating with said central bore. Fuel is inserted into one end of the nozzle and directed through the central bore and as the intake air moves over the tubular member, which is preferably cylindrical, the air draws the fuel from the transverse bores, atomizes it and carries it into the combustion chamber of the engine. An additional high speed fuel metering valve may be disposed between the flow control valve and the nozzle to obtain the ideal fuel and air ratio at open throttle position. This high speed metering valve is preferably adjustable to tune the high speed operation of the engine.

DESCRIPTION OF THE DRAWING

The present invention will be more fully described with reference to the accompanying drawing wherein:

FIG. 1 is a schematic view of a fuel control system constructed according to the present invention;

FIG. 2 is a detailed view of a fuel flow control valve of the system;

FIG. 3 is a further detail view of the control valve taken along the line 3—3 of FIG. 2;

FIG. 4 is a detailed view of the injection nozzle having portions thereof broken away and portions illustrated in section; and

FIG. 5 is a detail view of a distributor for use in the fuel system on a multicylinder engine.

DESCRIPTION OF THE INVENTION

Referring now to the drawing, there is illustrated a single cylinder two-cycle internal combustion engine 7. The engine 7 includes a crank case 8 secured to a head or frame 9 formed with the cylinder wall 10. A piston 12 is connected by a rod 11 with a crank of a crank shaft 14. The head 9 is also formed with cooling fins and suitable manifolds for intake and exhaust.

The fuel control system of the present invention for the engine 7 serves to inject fuel under pressure into an open throat of the intake manifold which is joined to the intake opening in the cylinder wall. The fuel control system includes a storage reservoir 13 for a supply of fuel. A line 15 is connected to the discharge opening of the reservoir 13 and carries fuel to an inlet opening of a fuel pump 16. The fuel pump 16 is a diaphragm pump and is formed with a housing 18 formed with an inlet opening 19 and an outlet opening 20. A spring-loaded check valve 21 is disposed adjacent the inlet opening to permit fuel to enter the pump and a spring-loaded check valve 22 permits fuel to be ejected under pressure from the pump through the outlet opening 20. The check valve 21 at the inlet opening 19 permits movement of the fuel into an inner cavity 23 of the pump but prevents the movement of fuel out through the inlet opening 19. The check valve 22 in the outlet opening 20 permits fluid to leave the inner chamber 23 but not to enter therein through the pump outlet opening. The housing 18 of the pump is also provided with a passageway 26 which permits air to enter a chamber 27 separated from the chamber 23 by means of a diaphragm 28. Passageway 26 is connected by means of a line 29 to the crank case of the engine 7. Pressure within the

crank case then communicates through the passage 26 with the chamber 27 to move the diaphragm 28. The decreasing fluid pressure in the crank case of the engine 7 causes the diaphragm to move into the chamber 27 drawing fuel through the inlet opening 19 and check valve 21 into the chamber 23. During this action the outlet check valve is closed. The increasing fluid pressure in the crank case chamber on the next portion of the cycle of the engine causes fluid pressure to enter the chamber 27 to move the diaphragm into the chamber 23 thus driving fuel in the chamber out through the check valve 20 into a fuel supply line 31.

The fuel supply line 31 leads to a control valve 33 having an inlet port 34 and a pair of discharge passageways 35 and 36. The discharge passageway 35 is connected by a return line 38 to a standing fuel line 39 disposed in the supply reservoir. The line 39 is directed to the bottom of the tank 13 and fuel is returned against the liquid pressure head in the tank. Within the fuel line 38 is disposed a restriction means 40 in the form of a reduced union as shown in detail in FIG. 3. This restriction 40 serves to maintain an injection pressure in the fuel supply system. The restriction could alternatively be on a fitting disposed in the outlet opening 35.

The other outlet opening 36 is disposed behind a movable flow control valve member 37 in the control valve 33. As illustrated, the flow control valve member 37 is a rotatable cylindrical member disposed rotatably in a bore 41 in the valve 33. A central axial bore is formed in the member 37 and the member 37 is formed with a cut-away portion defining an opening 42 in the wall thereof. The opening 42 is disposed to vary the flow of fuel between the inlet port 34 and discharge passageway 36. The rotation of the cylindrical rod causes the opening 42 to close or open the flow of fuel from the inlet port 34 to the fuel supply line 45. The supply line 45 leads to at least one injection nozzle 46.

The injection nozzle 46 is disposed within and normal to the axis of the inlet manifold 47. The inlet manifold 47 is disposed on the head 9 and communicates with an inlet opening into the cylinder to permit the intake of the fuel and air mixture into the crank case to be transferred by the piston bypass ports to the compression chamber upon completion of the power stroke. The intake manifold may be provided with an intake horn to enhance the flow of air into the intake manifold 47. The intake manifold is otherwise cylindrical, hollow and of generally uniform inside diameter and has a diameter not less than the inlet opening into the engine.

Disposed in the intake manifold adjacent the cylinder wall is an air metering valve means. As illustrated, the air metering valve means is in the form of a butterfly valve 49 supported by a rotatable shaft connected by a radial crank arm 50 to an adjustable link 51. Movement of the link causes movement of the crank arm 50 and rotation of the butterfly valve 49 to control the amount of air flow into the engine.

The other end of the adjustable link 51 is connected to a crank arm 52 which operates the movable control valve member 37 of the control valve 33. The shaft supporting the butterfly valve is also connected to the throttle and rotated as desired to afford a change in engine speed.

The nozzle 46, as most clearly shown in FIG. 4, is a slender cylindrical rod formed with an axial center bore 55. One end of the rod is formed with a counter sink bore to form an inlet end to the axial bore 55. A plurality of transverse bores 56 connect the outer surface of the rod with the central bore. The rod is disposed in the intake manifold 47 in a direction with its axis generally normal to the axis of the manifold and to the path of the air through the intake manifold. It is preferable that the transverse bores 56 are also disposed normal to the direction of the moving air through the intake manifold as this aids in drawing the fuel from the central bore of the nozzle into the air stream after the fuel is injected under pressure into the nozzle.

A second fuel metering valve 58 may be disposed in the fuel line 45 leading from the control valve 33 to the nozzle 46. This metering valve 58 is an adjustable valve used to obtain the ideal fuel and air ratio at open throttle conditions. The valve comprises a housing and an adjustable restrictor 59 in the passageway provided therein to afford the selected metering for fine tuning.

In operation as the piston 12 moves in the cylinder 10 the fluid pressure in the crank case is changed. As the piston moves downward in the cylinder during the power and exhaust stroke pressure in the crank case increases forcing the air/gas mixture therein into the chamber above the piston and the increase in pressure causes the diaphragm 28 to be expanded into the chamber 23 to drive fuel into the flow control valve 33. The next part of the cycle moves the piston upward drawing in air through the intake manifold 47 as permitted by the butterfly or air metering valve 49. The pressure of the fuel pumped by the fuel pump into the control valve also drives fuel against the restriction 40 out through the outlet opening 36 into the nozzle 46. The fuel thus pumped under pressure into the nozzle is discharged therefrom into the intake air and is drawn into the engine. The upward movement of the piston thus decreases the pressure in the crank case and this pressure decrease operates the diaphragm 28 to draw fuel into the chamber 23 of the diaphragm pump 16.

As it is desired to increase the speed of the engine the movable valve member 37 in the control valve 33 further opens the opening 42 increasing the amount of fuel directed under the pressure of the diaphragm pump into the nozzle 46.

This pump 16 will deliver fuel to the nozzle at pressures between 2 and 6 pounds gauge. The air intake passageway of the intake manifold 47 has an internal diameter of about 1 5/8 inches and an injection nozzle made out of 1/4 inch round stock provides a very small restriction within the inlet passageway allowing sufficient air to be drawn into the engine. The axial bore 55 of the nozzle 46 is generally about 0.040 inch in diameter as are the transverse bores 56 communicating therewith. Thus, fuel injected between 2 to 6 pounds pressure gauge into the nozzle is discharged through the transverse bores or the axial bore, and the incoming air draws the fuel from the discharge openings and carries it into the engine. The amount of fuel which is permitted to reach the nozzle is controlled by the movable valve member 37 in the control valve.

To maintain the fuel in the valve 33 at a pressure at all times and to drive it to the nozzle, the restriction 40 is placed between the outlet 35 and the fuel reservoir 30 to permit recirculation or return of the excess fuel

pumped to the valve 33. The restriction 40 will also maintain a minimum fuel pressure at the nozzle. This restriction 40 is in the form of a nipple with a reduced central bore having the same relative size as the axial bore 55 and the transverse bores 56 in the injection nozzle 46. This restriction 40 could be alternatively in the form of a spring check valve but the spring would be balanced and the restriction illustrated towards a cheaper method. The size of the axial bore 55 and transverse bores 56 in the nozzle may vary depending on the size of the engine 7. For example, in a 90cc engine the bore diameters may be 0.010 inch; for the 400cc engine the bore diameters may be 0.030 inch, and with a 650cc engine the bore diameters may be between 0.070 and 0.090 inch. Thus the range of bore size and restriction size may vary between 0.010 inch to 0.090 inch.

A distributor 60 (see FIG. 5) may be placed in the fuel line 45 to distribute fuel from the metering or flow control valve 33 to a plurality of cylinders in an engine. The distributor would have a housing with a single inlet opening 61, leading to a chamber 62, to which chamber 62 is connected a number of fuel lines 64 corresponding to the number of cylinders on the engine. Each line 64 would lead to an injection nozzle 46 associated with the intake manifold of each cylinder.

The present invention is not limited to use with two-cycle reciprocating internal combustion engines but may be used with rotary and four-cycle engines. The impulse for operating the fuel pump may be received from the intake and exhaust pressures developed in the engines and would continue to be responsive to variations in engine pressures.

Having thus described the present invention by reference to the embodiment illustrated in the accompanying drawing, it will be appreciated that various modifications may be made without departing from the spirit or scope of this invention as defined in the appended claims.

What is claimed is:

1. A fuel flow control system for internal combustion engines comprising
 - an intake manifold having a length and a given internal diameter and adapted at one end for attachment to a said engine,
 - valve means for controlling the flow of air through said intake manifold,
 - injection nozzle means comprising a slender hollow cylindrical rod disposed within and positioned normal to the axis of said intake manifold, said rod having at least one bore positioned transverse thereto and axially of said intake manifold, for dispensing fuel into the air drawn through said intake manifold,
 - a fuel line connected to said nozzle means,
 - a flow control valve connected to said fuel line to meter the amount of fuel to pass through the line to said nozzle means, said valve comprising a movable valve member and means connected to said valve means for controlling the flow of air and to said valve member to increase the amount of fuel metered to said fuel line and said nozzle means as said valve means is moved to increase the air flow through said intake manifold, and
 - pump means operative in response to air pressure fed thereto for pumping fuel into said flow control valve to be metered by said movable valve member

to said nozzle means at a pressure responsive to internal pressures of said engine.

2. A fuel control system according to claim 1 wherein said pump means comprises a diaphragm-type fuel pump adapted to be connected to and driven in response to changes in crank case pressure in said engine.

3. A fuel control system according to claim 1 wherein said cylindrical rod has a plurality of parallel bores therein spaced along said rod and positioned parallel to the axis of said intake manifold.

4. A fuel control system according to claim 1 wherein said pump means for pumping fuel to said injection nozzle means comprises

a diaphragm-type fuel pump adapted to be driven in response to changes in internal pressure within said engine, and said system comprises

means defining a flow restricting bypass line connected between said fuel pump and said valve means for maintaining a given pressure on said fuel to be injected into said nozzle means and affording a return line to a fuel reservoir for excess fuel.

5. A fuel injection control system for internal combustion engines having an intake manifold of a given internal diameter, said system comprising

a nozzle extending into said intake manifold and positioned normal to the axis of said intake manifold, said nozzle comprising a tubular member having a restricted central bore extending therethrough and having a plurality of restricted bores positioned normal to said central bore and communicating between said central bore and the outer surface of said tubular member whereby the air entering said engine draws fuel from said bores and atomizes the fuel pumped thereto,

a fuel pump for pumping fuel from a reservoir into a fuel line at a pressure less than 6 pounds gauge, a fuel line connected to said nozzle and said fuel pump,

flow control valve means disposed in said fuel line between said fuel pump and said nozzle for metering fuel directed from said pump to said nozzle,

air intake metering means disposed in said intake manifold for controlling the amount of air to pass through said intake manifold to said engine, and

means connecting said flow control valve means and said air intake metering means to increase said quantity of fuel metered to said nozzle when said air intake metering means is moved to increase the quantity of air permitted to pass through said intake manifold to said engine.

6. A fuel injection control system according to claim 5 wherein said nozzle has an external diameter of about 1/4 inch and said central bore and said transverse bores have a diameter of between 0.010 to 0.090 inch.

7. A fuel injection control system according to claim 5 wherein said system comprises means defining a restricted bypass between said pump and said flow control valve means to direct excess fuel pumped to said flow control valve means back to a fuel tank.

8. A fuel control system according to claim 7 wherein said restricted bores and said restriction in said restricted bypass means have equivalent diameters of between 0.010 and 0.090 inch.

9. A fuel control system according to claim 5 wherein said pump will deliver fuel at a pressure between 2 and 6 pounds gauge.

* * * * *

**UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION**

Patent No. 3,800,770 Dated April 2, 1974

Inventor(s) Ronald O. Baribeau and Russell A. Baribeau

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

Column 1, line 2, after "abandoned." insert --
Continuation-in-part applications Serial No. 318,376, filed
December 26, 1972 and Serial No. 351,480, filed April 16,
1973 relate to subject matter disclosed herein. --.

Signed and sealed this 6th day of May 1975.

(SEAL)
Attest:

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