**Valve Seating**

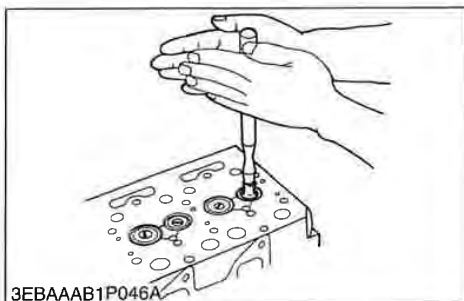
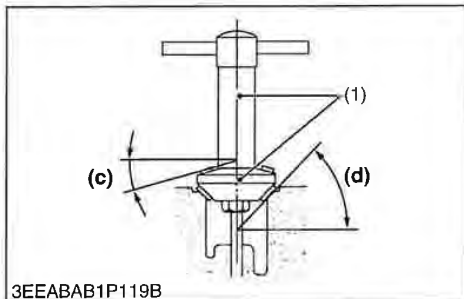
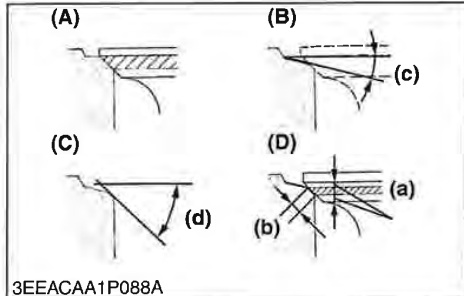
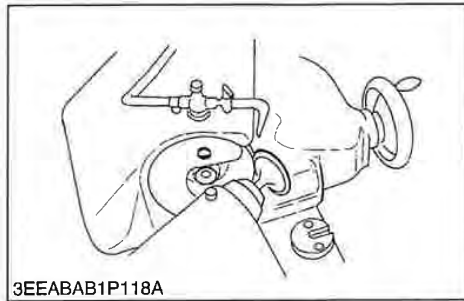
1. Coat the valve face lightly with prussian blue and put the valve on its seat to check the contact.
2. If the valve does not seat all the way around the valve seat or the valve contact is less than 70 %, correct the valve seating as follows.
3. If the valve contact does not comply with the reference value, replace the valve or correct the contact of valve seating.

Valve seat width	Factory specification	2.12 mm 0.0835 in.
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(1) Correct
(2) Incorrect

(3) Incorrect

9Y1210318ENS0092US0



Correcting Valve and Valve Seat

NOTE

- Before correcting the valve and seat, check the valve stem and the I.D. of valve guide section, and repair them if necessary.
- After correcting the valve seat, be sure to check the valve recessing.

1) Correcting Valve

1. Correct the valve with a valve refacer.

Valve face angle	Factory specification	0.79 rad 45 °
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2) Correcting Valve Seat

1. Slightly correct the seat surface with a 0.79 rad (45 °) valve seat cutter.
2. Fitting the valve, check the contact position of the valve face and seat surface with prussian blue. (Visual check) [If the valve has been used for a long period, the seat tends to come in contact with the upper side of the valve face.]
3. Grind the upper surface of the seat with a 0.26 rad (15 °) valve seat cutter until the valve seat touches to the center of the valve face (so that (a) equals (b) as shown in the figure.)
4. Grind the seat with a 0.79 rad (45 °) valve seat cutter again, and visually recheck the contact between the valve and seat.
5. Repeat steps 3 and 4 until the correct contact is achieved.
6. Continue lapping until the seated rate becomes more than 70 % of the total contact.

Valve seat angle	Factory specification	0.79 rad 45 °
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(1) Valve Seat Cutter

(a) Identical Dimensions

(A) Check Contact

(b) Valve Seat Width

(B) Correct Seat Width

(c) 0.26 rad (15 °)

(C) Check Seat Surface

(d) 0.79 rad (45 °)

(D) Check Contact

9Y1210318ENS0093US0

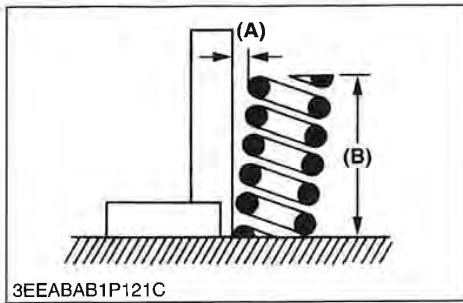
Valve Lapping

1. Apply compound evenly to the valve lapping surface.
2. Insert the valve into the valve guide. Lap the valve onto its seat with a valve flapper or screwdriver.
3. After lapping the valve, wash the compound away and apply oil, then repeat valve lapping with oil.
4. Apply prussian blue to the contact surface to check the seated rate. If it is less than 70 %, repeat valve lapping again.

IMPORTANT

- When valve lapping is performed, be sure to check the valve recessing and adjust the valve clearance after assembling the valve.

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Free Length and Tilt of Valve Spring

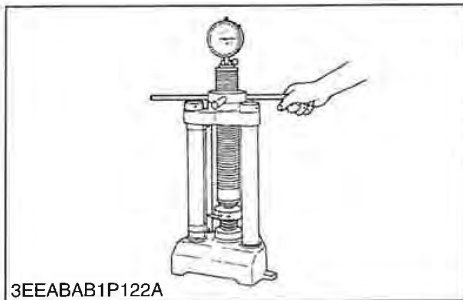
1. Measure the free length **(B)** of valve spring with vernier calipers. If the measurement is less than the allowable limit, replace it.
2. Put the spring on a surface plate, place a square on the side of the spring.
3. Check to see if the entire side is in contact with the square. Rotate the valve spring and measure the maximum tilt **(A)**. If the measurement exceeds the allowable limit, replace it.
4. Check the entire surface of the valve spring for scratches. If there is any defect, replace it.

Tilt (A)	Allowable limit	1.0 mm 0.039 in.
Free length (B)	Factory specification	31.3 to 31.8 mm 1.24 to 1.25 in.
	Allowable limit	28.4 mm 1.12 in.

(A) Tilt

(B) Free length

9Y1210318ENS0095US0



Valve Spring Setting Load

1. Place the valve spring on a tester and compress it to the same length it is actually compressed in the engine.
2. Read the compression load on the gauge.
3. If the measurement is less than the allowable limit, replace it.

Setting load / setting length	Factory specification	65 N / 27.0 mm 6.6 kgf / 27.0 mm 15 lbf / 1.06 in.
	Allowable limit	55 N / 27.0 mm 5.6 kgf / 27.0 mm 12 lbf / 1.06 in.

9Y1210318ENS0096US0



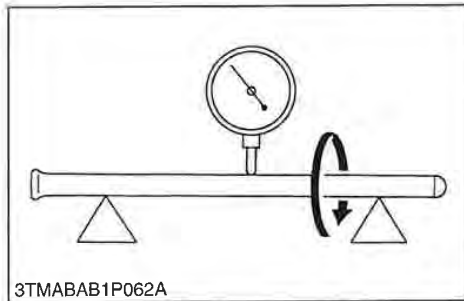
Oil Clearance between Rocker Arm and Rocker Arm Shaft

1. Measure the rocker arm shaft O.D. with an outside micrometer.
2. Measure the rocker arm I.D. with an inside micrometer, and then calculate the oil clearance.
3. If the oil clearance exceeds the allowable limit, replace the rocker arm and measure the oil clearance again. If it still exceeds the allowable limit, replace also the rocker arm shaft.

Oil clearance between rocker arm and rocker arm shaft	Factory specification	0.016 to 0.045 mm 0.00063 to 0.0017 in.
	Allowable limit	0.15 mm 0.0059 in.

Rocker arm shaft O.D.	Factory specification	10.473 to 10.484 mm 0.41233 to 0.41275 in.
Rocker arm I.D.	Factory specification	10.500 to 10.518 mm 0.41339 to 0.41409 in.

9Y1210318ENS0097US0

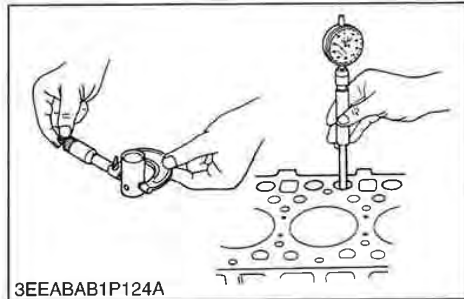


Push Rod Alignment

1. Place the push rod on V blocks.
2. Measure the push rod alignment.
3. If the measurement exceeds the allowable limit, replace the push rod.

Push rod alignment	Allowable limit	0.25 mm 0.0098 in.
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9Y1210318ENS0098US0



Oil Clearance between Tappet and Tappet Guide Bore

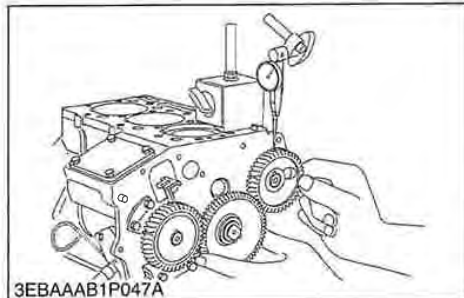
1. Measure the tappet O.D. with an outside micrometer.
2. Measure the I.D. of the tappet guide bore with a cylinder gauge, and calculate the oil clearance.
3. If the oil clearance exceeds the allowable limit or the tappet is damaged, replace the tappet.

Oil clearance between tappet and tappet guide bore	Factory specification	0.016 to 0.052 mm 0.00063 to 0.0020 in.
	Allowable limit	0.10 mm 0.0039 in.

Tappet O.D.	Factory specification	17.966 to 17.984 mm 0.70733 to 0.70803 in.
Tappet guide bore I.D.	Factory specification	18.000 to 18.018 mm 0.70867 to 0.70937 in.

9Y1210318ENS0099US0

(2) Timing Gear and Camshaft



Timing Gear Backlash

1. Set a dial indicator (lever type) with its tip on the gear tooth.
2. Move the gear to measure the backlash, holding its mating gear.
3. If the backlash exceeds the allowable limit, check the oil clearance of the shafts and the gear.
4. If the oil clearance is proper, replace the gear.

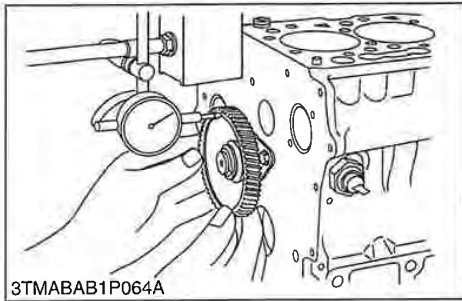
Backlash between idle gear and crank gear	Factory specification	0.0430 to 0.124 mm 0.00170 to 0.00488 in.
	Allowable limit	0.15 mm 0.0059 in.

Backlash between idle gear and cam gear	Factory specification	0.0470 to 0.123 mm 0.00185 to 0.00484 in.
	Allowable limit	0.15 mm 0.0059 in.

Backlash between idle gear and injection pump gear	Factory specification	0.0410 to 0.124 mm 0.00162 to 0.00488 in.
	Allowable limit	0.15 mm 0.0059 in.

Backlash between oil pump drive gear and crank gear	Factory specification	0.0410 to 0.123 mm 0.00162 to 0.00484 in.
	Allowable limit	0.15 mm 0.0059 in.

9Y1210318ENS0100US0

**Idle Gear Side Clearance**

1. Set a dial indicator with its tip on the idle gear.
2. Measure the side clearance by moving the idle gear to the front and rear.
3. If the measurement exceeds the allowable limit, replace the idle gear collar.

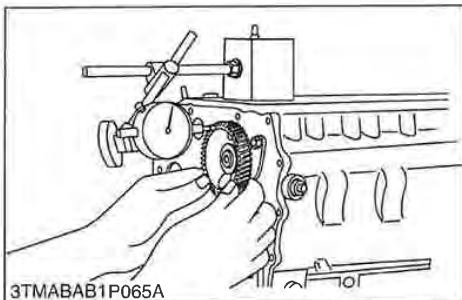
[WG752-G/GL-E3]

Idle gear side clearance	Factory specification	0.20 to 0.46 mm 0.0079 to 0.018 in.
	Allowable limit	0.60 mm 0.024 in.

[WG972-G/GL-E3]

Idle gear side clearance	Factory specification	0.20 to 0.51 mm 0.0079 to 0.020 in.
	Allowable limit	0.80 mm 0.031 in.

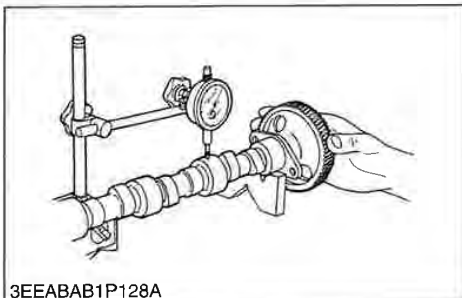
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**Camshaft Side Clearance**

1. Set a dial indicator with its tip on the camshaft.
2. Measure the side clearance by moving the cam gear to the front and rear.
3. If the measurement exceeds the allowable limit, replace the camshaft stopper.

Camshaft side clearance	Factory specification	0.15 to 0.31 mm 0.0059 to 0.012 in.
	Allowable limit	0.50 mm 0.020 in.

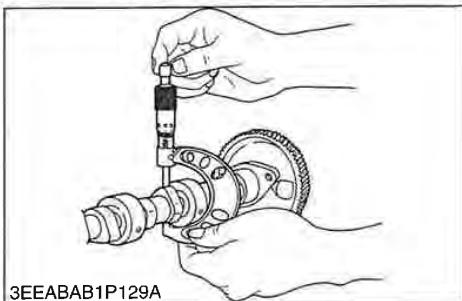
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**Camshaft Alignment**

1. Support the camshaft with V blocks on the surface plate at both end journals.
2. Set a dial indicator with its tip on the intermediate journal.
3. Measure the camshaft alignment.
4. If the measurement exceeds the allowable limit, replace the camshaft.

Camshaft alignment	Allowable limit	0.01 mm 0.0004 in.
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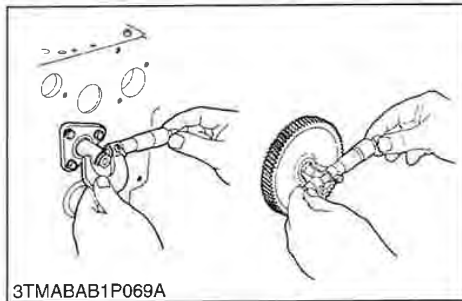
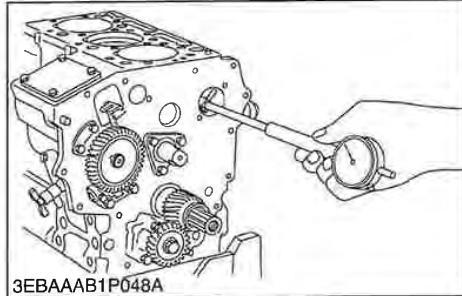
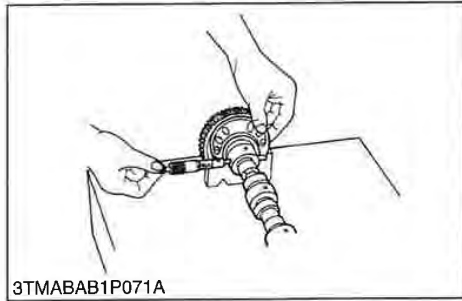
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**Cam Height**

1. Measure the height of the cam at its highest point with an outside micrometer.
2. If the measurement is less than the allowable limit, replace the camshaft.

Cam height of intake and exhaust	Factory specification	26.88 mm 1.058 in.
	Allowable limit	26.83 mm 1.056 in.

9Y1210318ENS0104US0



Oil Clearance of Camshaft Journal

1. Measure the camshaft journal O.D. with an outside micrometer.
2. Measure the cylinder block bore I.D. for camshaft with a inside micrometer, and calculate the oil clearance.
3. If the clearance exceeds the allowable limit, replace the camshaft.

Oil clearance of camshaft journal	Factory specification	0.050 to 0.091 mm 0.0020 to 0.0035 in.
	Allowable limit	0.15 mm 0.0059 in.

Camshaft journal O.D.	Factory specification	32.934 to 32.950 mm 1.2967 to 1.2972 in.
Camshaft bearing I.D. (Cylinder block bore I.D.)	Factory specification	33.000 to 33.025 mm 1.2993 to 1.3001 in.

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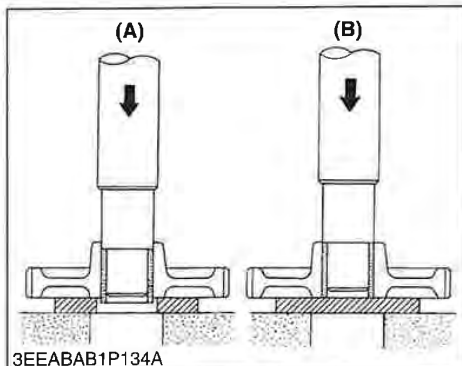
Oil Clearance between Idle Gear Shaft and Idle Gear Bushing

1. Measure the idle gear shaft O.D. with an outside micrometer.
2. Measure the idle gear bushings I.D. with an inside micrometer, and calculate the oil clearance.
3. If the oil clearance exceeds the allowable limit, replace the bushing.
4. If it still exceeds the allowable limit, replace the idle gear shaft.

Oil clearance between idle gear shaft and idle gear bushing	Factory specification	0.020 to 0.084 mm 0.00079 to 0.0033 in.
	Allowable limit	0.10 mm 0.0039 in.

Idle gear shaft O.D.	Factory specification	19.967 to 19.980 mm 0.78611 to 0.78661 in.
Idle gear bushing I.D.	Factory specification	20.000 to 20.051 mm 0.78741 to 0.78940 in.

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Replacing Idle Gear Bushing

(When removing)

1. Press out the used idle gear bushing using an idle gear bushing replacing tool.

(When installing)

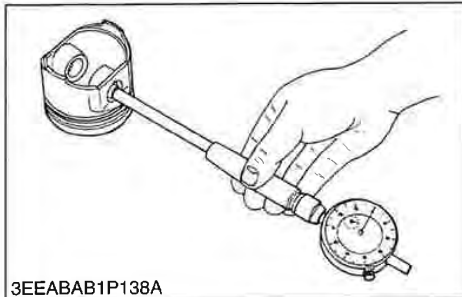
1. Clean a new idle gear bushing and idle gear bore, and apply engine oil to them.
2. Press in a new bushing using an idle gear bushing replacing tool, until it is flush with the end of the idle gear.

(A) When Removing

(B) When Installing

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(3) Piston and Connecting Rod

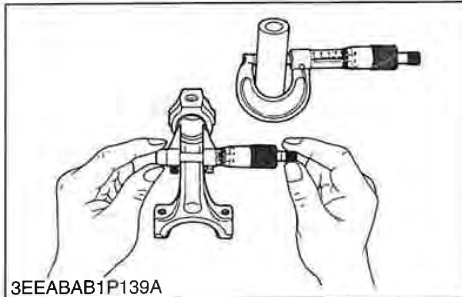


Piston Pin Bore I.D.

1. Measure the piston pin bore I.D. in both the horizontal and vertical directions with a cylinder gauge.
2. If the measurement exceeds the allowable limit, replace the piston.

Piston pin bore I.D.	Factory specification	20.000 to 20.013 mm 0.78741 to 0.78791 in.
	Allowable limit	20.05 mm 0.7894 in.

9Y1210318ENS0108US0



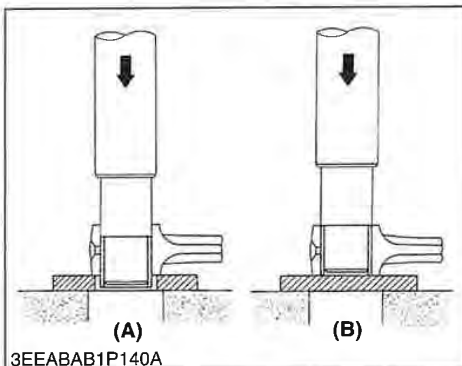
Oil Clearance between Piston Pin and Small End Bushing

1. Measure the O.D. of the piston pin where it contacts the bushing with an outside micrometer.
2. Measure the small end bushing I.D. with an inside micrometer, and calculate the oil clearance.
3. If the oil clearance exceeds the allowable limit, replace the bushing. If it still exceeds the allowable limit, replace the piston pin.

Oil clearance between piston pin and small end bushing	Factory specification	0.012 to 0.038 mm 0.00048 to 0.0014 in.
	Allowable limit	0.10 mm 0.0039 in.

Piston pin O.D.	Factory specification	20.002 to 20.013 mm 0.78748 to 0.78791 in.
Small end bushing I.D.	Factory specification	20.025 to 20.040 mm 0.78839 to 0.78897 in.

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Replacing Small End Bushing

(When removing)

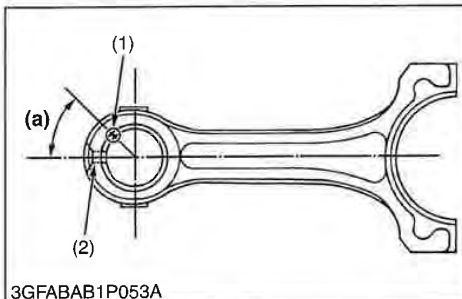
1. Press out the used bushing using a small end bushing replacing tool. (Refer to "SPECIAL TOOLS".)

(When installing)

1. Clean a new small end bushing and bore, and apply engine oil to them.
2. Using a small end bushing replacing tool, press in a new bushing (service parts) taking due care to see that the connecting rod hole matches the bushing hole.

[Servicing parts dimension]

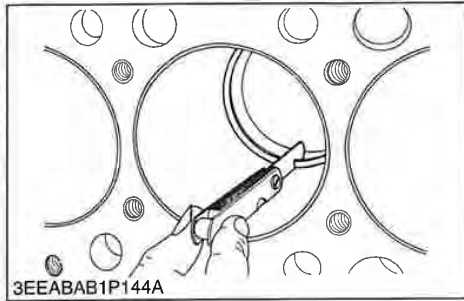
Oil clearance between piston pin and small end bushing (Spare parts)	Factory specification	0.013 to 0.075 mm 0.00052 to 0.0029 in.
	Allowable limit	0.15 mm 0.0059 in.
Small end bushing I.D. (Spare parts)	Factory specification	20.026 to 20.077 mm 0.78843 to 0.79043 in.



- (1) Seam
(2) Oil Hole

- (A) When Removing
(B) When Installing
(a) 0.79 rad (45 °)

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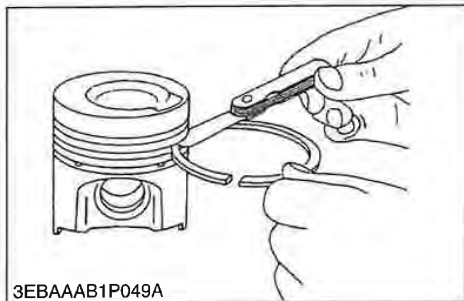


Piston Ring Gap

1. Insert the piston ring into the lower part of the cylinder (the least worn out part) with a piston ring compressor and piston.
2. Measure the ring gap with a feeler gauge.
3. If the measurement exceeds the allowable limit, replace the piston ring.

Piston ring gap	Top ring	Factory specification	0.15 to 0.35 mm 0.0059 to 0.013 in.
		Allowable limit	1.25 mm 0.0492 in.
	Second ring	Factory specification	0.30 to 0.45 mm 0.012 to 0.017 in.
		Allowable limit	1.25 mm 0.0492 in.
	Oil ring	Factory specification	0.20 to 0.70 mm 0.0079 to 0.027 in.
		Allowable limit	1.25 mm 0.0492 in.

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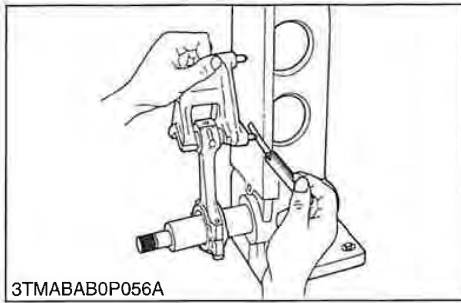


Clearance between Piston Ring and Piston Ring Groove

1. Clean the rings and the ring grooves, and install each ring in its groove.
2. Measure the clearance between the ring and the groove with a thickness gauge.
3. If the clearance exceeds the allowable limit, replace the piston ring.
4. If the clearance still exceeds the allowable limit with new ring, replace the piston.

Clearance between piston ring and piston ring groove	Top ring	Factory specification	0.080 to 0.12 mm 0.0032 to 0.0047 in.
		Allowable limit	0.15 mm 0.0059 in.
	Second ring	Factory specification	0.065 to 0.10 mm 0.0026 to 0.0039 in.
		Allowable limit	0.15 mm 0.0059 in.
	Oil ring	Factory specification	0.060 to 0.15 mm 0.0024 to 0.0059 in.
		Allowable limit	0.20 mm 0.0079 in.

9Y1210318ENS0112US0



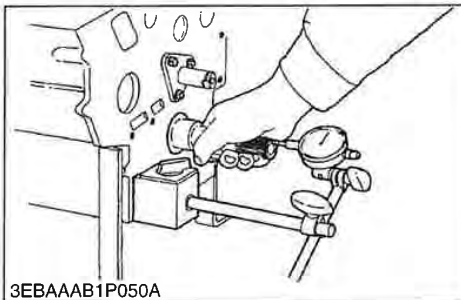
Connecting Rod Alignment

1. Remove the crankpin bearing, and install the connecting rod cap.
2. Install the piston pin in the connecting rod.
3. Install the connecting rod on the connecting rod alignment tool.
4. Put a gauge over the piston pin, and move it against the face plate.
5. If the gauge does not fit squarely against the face plate, measure the space between the pin of the gauge and the face plate.
6. If the measurement exceeds the allowable limit, replace the connecting rod.

Space between gauge pin face plate	Allowable limit	0.05 mm 0.002 in.
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9Y1210318ENS0113US0

(4) Crankshaft



Crankshaft Side Clearance

1. Set a dial indicator with its tip on the end of the crankshaft.
2. Measure the side clearance by moving the crankshaft to the front and rear.
3. If the measurement exceeds the allowable limit, replace the thrust bearings.
4. If the same size bearing is useless because of the crankshaft journal wear, replace it with an oversize one referring to the table and figure.

Crankshaft side clearance	Factory specification	0.15 to 0.31 mm 0.0059 to 0.012 in.
	Allowable limit	0.50 mm 0.020 in.

(Reference)

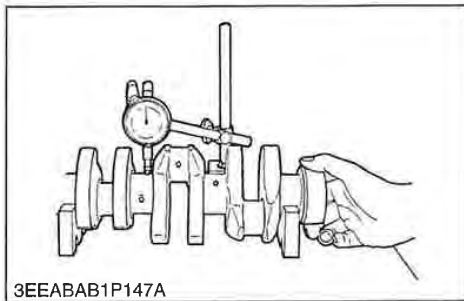
- Oversize thrust bearing

Oversize	Bearing	Code Number	Marking
0.2 mm 0.008 in.	Thrust bearing 1 02	15261-23950	020 OS
	Thrust bearing 2 02	15261-23970	020 OS
0.4 mm 0.02 in.	Thrust bearing 1 04	15261-23960	040 OS
	Thrust bearing 2 04	15261-23980	040 OS

- Oversize dimensions of crankshaft journal

Oversize	0.2 mm 0.008 in.	0.4 mm 0.02 in.
Dimension A	46.10 to 46.30 mm 1.815 to 1.822 in.	46.30 to 46.50 mm 1.823 to 1.830 in.
Dimension B	23.40 to 23.45 mm 0.9213 to 0.9232 in.	23.60 to 23.65 mm 0.9292 to 0.9311 in.
Dimension C	1.8 to 2.2 mm radius 0.071 to 0.086 in. radius	1.8 to 2.2 mm radius 0.071 to 0.086 in. radius
The crankshaft journal must be fine-finished to higher than Rmax = 0.8S		

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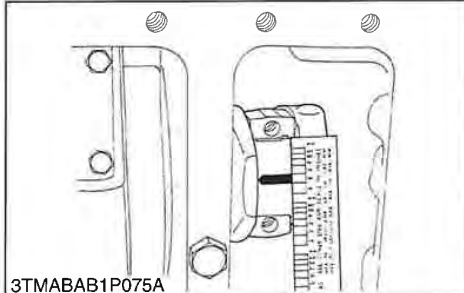


Crankshaft Alignment

1. Support the crankshaft with V blocks on the surface plate at both end journals.
2. Set a dial indicator with its tip on the intermediate journal.
3. Measure the crankshaft alignment.
4. If the measurement exceeds the allowable limit, replace the crankshaft.

Crankshaft alignment	Allowable limit	0.02 mm 0.0008 in.
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Oil Clearance between Crankpin and Crankpin Bearing

1. Clean the crankpin and crankpin bearing.
2. Put a strip of plastigage on the center of the crankpin.
3. Install the connecting rod cap and tighten the connecting rod screws to the specified torque, and remove the cap again.
4. Measure the amount of the flattening with the scale, and get the oil clearance.
5. If the oil clearance exceeds the allowable limit, replace the crankpin bearing.
6. If the same size bearing is useless because of the crankpin wear, replace it with an undersize one referring to the table and figure.

NOTE

- Never insert the plastigage into the crankpin oil hole.
- Be sure not to move the crankshaft while the connecting rod screws are tightened.

Oil clearance between crankpin and crankpin bearing	Factory specification	0.020 to 0.051 mm 0.00079 to 0.0020 in.
	Allowable limit	0.15 mm 0.0059 in.

Crankpin O.D.	Factory specification	33.959 to 33.975 mm 1.3370 to 1.3375 in.
Crankpin bearing I.D.	Factory specification	33.995 to 34.010 mm 1.3384 to 1.3389 in.

(Reference)

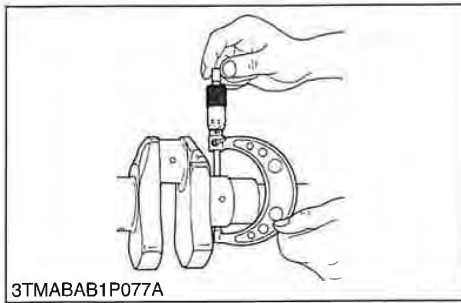
- Undersize crankpin bearing

Undersize	Bearing	Code Number	Marking
0.2 mm 0.008 in.	Crankpin bearing 02	15861-22970	020 US
0.4 mm 0.02 in.	Crankpin bearing 04	15861-20980	040 US

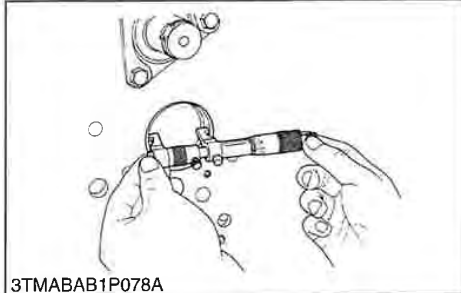
- Undersize dimensions of crankpin

Undersize	0.2 mm 0.008 in.	0.4 mm 0.02 in.
Dimension A	2.3 to 2.7 mm radius 0.091 to 0.10 in. radius	2.3 to 2.7 mm radius 0.091 to 0.10 in. radius
*Dimension B	1.0 to 1.5 mm relief 0.040 to 0.059 in. relief	1.0 to 1.5 mm relief 0.040 to 0.059 in. relief
Dimension C	33.759 to 33.775 mm dia. 1.3291 to 1.3297 in. dia.	33.559 to 33.575 mm dia. 1.3213 to 1.3218 in. dia.
The crankpin journal must be fine-finished to higher than Rmax = 0.8S *Holes to be de-burred and edges rounded with 1.0 to 1.5 mm (0.040 to 0.059 in.) relief.		

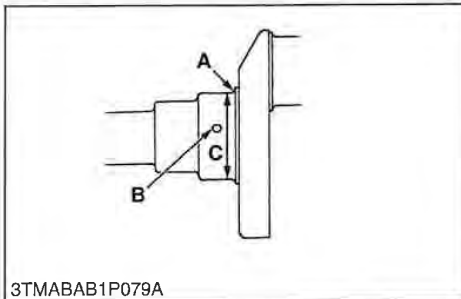
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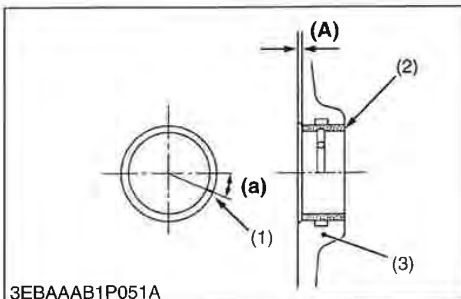
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Oil Clearance between Crankshaft Journal and Crankshaft Bearing 1

1. Measure the O.D. of the crankshaft front journal with an outside micrometer.
2. Measure the I.D. of the crankshaft bearing 1 with an inside micrometer, and calculate the oil clearance.
3. If the oil clearance exceeds the allowable limit, replace the crankshaft bearing 1.
4. If the same size bearing is useless because of the crankshaft journal wear, replace it with an undersize one referring to the table and the figure.

Oil Clearance between crankshaft journal and crankshaft bearing 1	Factory specification	0.0340 to 0.106 mm 0.00134 to 0.00417 in.
	Allowable limit	0.20 mm 0.0079 in.

Crankshaft journal O.D.	Factory specification	43.934 to 43.950 mm 1.7297 to 1.7303 in.
Crankshaft bearing 1 I.D.	Factory specification	43.984 to 44.040 mm 1.7317 to 1.7338 in.

(Reference)

- Undersize crankshaft bearing 1

Undersize	Bearing	Code Number	Marking
0.2 mm 0.008 in.	Crankshaft bearing 1 02	1G460-23910	020 US
0.4 mm 0.02 in.	Crankshaft bearing 1 04	1G460-23920	040 US

- Undersize dimensions of crankshaft journal

Undersize	0.2 mm 0.008 in.	0.4 mm 0.02 in.
Dimension A	1.8 to 2.2 mm radius 0.071 to 0.086 in. radius	1.8 to 2.2 mm radius 0.071 to 0.086 in. radius
*Dimension B	1.0 to 1.5 mm relief 0.040 to 0.059 in. relief	1.0 to 1.5 mm relief 0.040 to 0.059 in. relief
Dimension C	43.734 to 43.750 mm dia. 1.7219 to 1.7224 in. dia.	43.534 to 43.550 mm dia. 1.7140 to 1.7145 in. dia.

The crankshaft journal must be fine-finished to higher than $R_{max} = 0.8S$

*Holes to be de-burred and edges rounded with 1.0 to 1.5 mm (0.040 to 0.059 in.) relief.

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Replacing Crankshaft Bearing 1

(When removing)

1. Press out the used crankshaft bearing 1 using a crankshaft bearing 1 replacing tool.

(When installing)

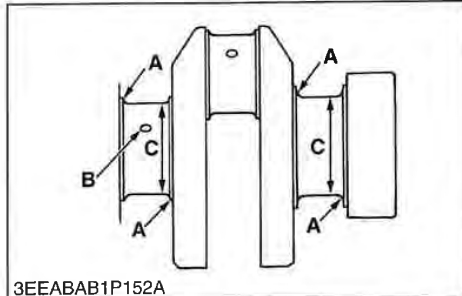
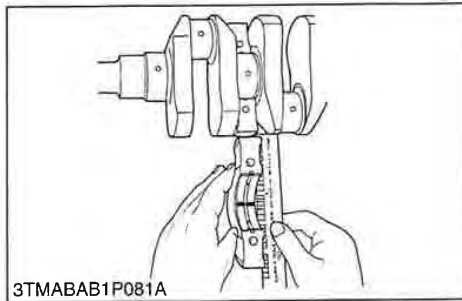
1. Clean a new crankshaft bearing 1 and crankshaft journal bore, and apply engine oil to them.
2. Using a crankshaft bearing 1 replacing tool, press in a new bearing 1 (2) so that its seam (1) directs toward the exhaust manifold side. (See figure.)

Dimension (A)	Factory specification	0 to 0.3 mm 0 to 0.01 in.
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- (1) Seam
(2) Crankshaft Bearing 1
(3) Cylinder Block

(A) Dimension
(a) 0.37 rad (21 °)

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Oil Clearance between Crankshaft Journal and Crankshaft Bearing 2 (Crankshaft Bearing 3)

1. Put a strip of plastigage on the center of the journal.
2. Install the bearing case and tighten the bearing case screws 1 to the specified torque, and remove the bearing case again.
3. Measure the amount of the flattening with the scale, and get the oil clearance.
4. If the oil clearance exceeds the allowable limit, replace the crankshaft bearing 2 (crankshaft bearing 3).
5. If the same size bearing is useless because of the crankshaft journal wear, replace it with an undersize one referring to the table and figure.

NOTE

- Be sure not to move the crankshaft while the bearing case screws are tightened.

Oil clearance between crankshaft journal and crankshaft bearing 2 (crankshaft bearing 3)	Factory specification	0.028 to 0.059 mm 0.0011 to 0.0023 in.
	Allowable limit	0.20 mm 0.0079 in.

Crankshaft journal O.D. (Flywheel side)	Factory specification	43.934 to 43.950 mm 1.7297 to 1.7303 in.
Crankshaft bearing 2 I.D.	Factory specification	43.978 to 43.993 mm 1.7315 to 1.7320 in.

Crankshaft journal O.D. (Intermediate)	Factory specification	43.934 to 43.950 mm 1.7297 to 1.7303 in.
Crankshaft bearing 3 I.D.	Factory specification	43.978 to 43.993 mm 1.7315 to 1.7320 in.

(Reference)

- Undersize crankshaft bearing 2 and 3

Undersize	Bearing	Code Number	Marking
0.2 mm 0.008 in.	Crankshaft bearing 2 02	15694-23930	020 US
	Crankshaft bearing 2F 02	1G460-07530	
	Crankshaft bearing 3 02	1G460-07580	020 US
	Crankshaft bearing 3F 02	1G460-07630	
0.4 mm 0.02 in.	Crankshaft bearing 2 04	15694-23940	040 US
	Crankshaft bearing 2F 04	1G460-07540	
	Crankshaft bearing 3 04	1G460-07590	040 US
	Crankshaft bearing 3F 04	1G460-07640	

- Undersize dimensions of crankshaft journal

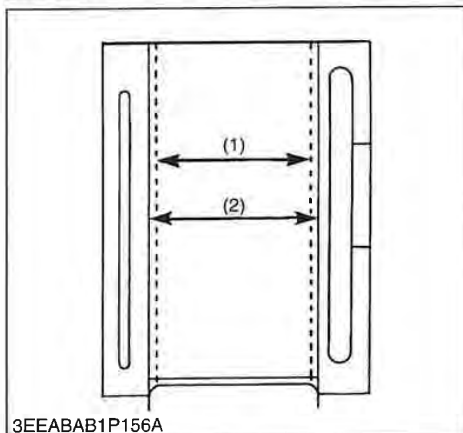
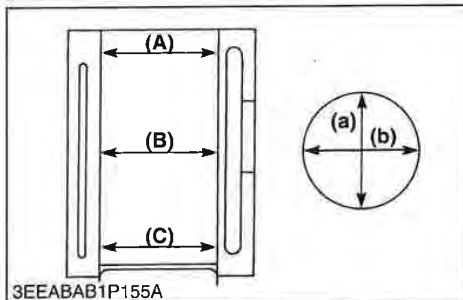
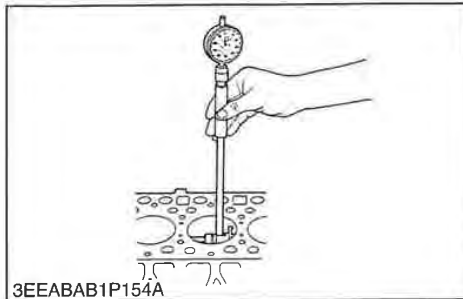
Undersize	0.2 mm 0.008 in.	0.4 mm 0.02 in.
Dimension A	1.8 to 2.2 mm radius 0.071 to 0.086 in. radius	1.8 to 2.2 mm radius 0.071 to 0.086 in. radius
*Dimension B	1.0 to 1.5 mm relief 0.040 to 0.059 in. relief	1.0 to 1.5 mm relief 0.040 to 0.059 in. relief
Dimension C	43.734 to 43.750 mm dia. 1.7219 to 1.7224 in. dia.	43.534 to 43.550 mm dia. 1.7140 to 1.7145 in. dia.

The crankshaft journal must be fine-finished to higher than Rmax = 0.8S

*Holes to be de-burred and edges rounded with 1.0 to 1.5 mm (0.040 to 0.059 in.) relief.

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(5) Cylinder



Cylinder Wear

1. Measure the I.D. of the cylinder at the six positions (see figure) with a cylinder gauge to find the maximum and minimum I.D.'s.
2. Get the difference (Maximum wear) between the maximum and the minimum I.D.'s.

Cylinder I.D.	Factory specification	74.500 to 74.519 mm 2.9331 to 2.9338 in.
	Allowable limit	74.669 mm 2.9397 in.

- (A) Top
(B) Middle
(C) Bottom (Skirt)

- (a) Right-Angled to Piston Pin
(b) Piston Pin Direction

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Correcting Cylinder (Oversize)

1. When the cylinder is worn beyond the allowable limit, bore and hone it to the specified dimension.

Cylinder liner I.D.	Factory specification	75.000 to 75.019 mm 2.9528 to 2.9535 in.
	Allowable limit	75.150 mm 2.9587 in.
Finishing	Hone to 2.2 to 3.0 μ mRz (0.000087 to 0.00011 in.Rz)	

2. Replace the piston and piston rings with oversize ones.
Oversize : 0.5 mm (0.02 in.)
Marking : 05

NOTE

- When the oversize cylinder is worn beyond the allowable limit, replace the cylinder block with a new one.

- (1) Cylinder I.D. (Before Correction) (2) Cylinder I.D. (Oversize)

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(6) Oil Pump

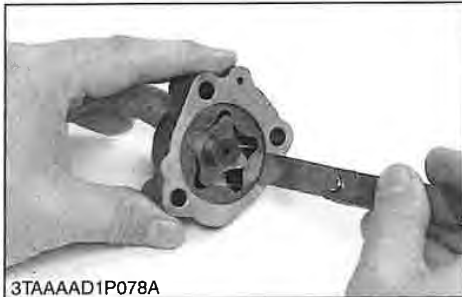


Rotor Lobe Clearance

1. Measure the clearance between lobes of the inner rotor and the outer rotor with a thickness gauge.
2. If the clearance exceeds the factory specifications, replace the oil pump rotor assembly.

Rotor lobe clearance	Factory specification	0.030 to 0.14 mm 0.0012 to 0.0055 in.
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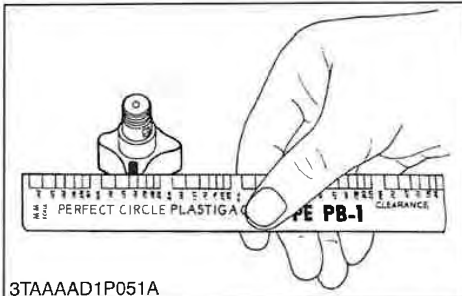


Clearance between Outer Rotor and Pump Body

1. Measure the clearance between the outer rotor and the pump body with a thickness gauge.
2. If the clearance exceeds the factory specifications, replace the oil pump rotor assembly.

Clearance between outer rotor and pump body	Factory specification	0.070 to 0.15 mm 0.0028 to 0.0059 in.
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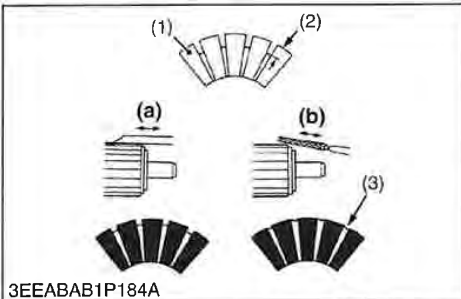
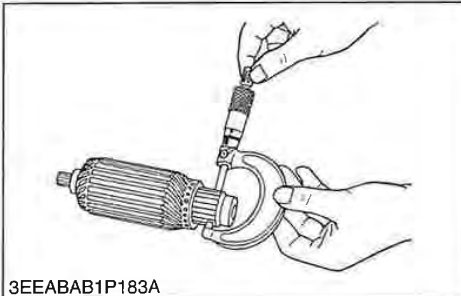
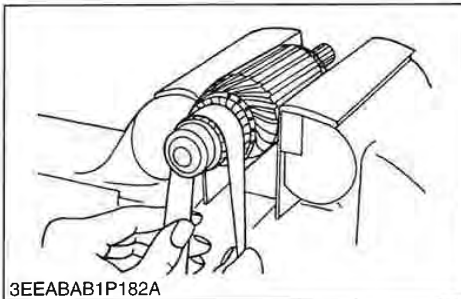
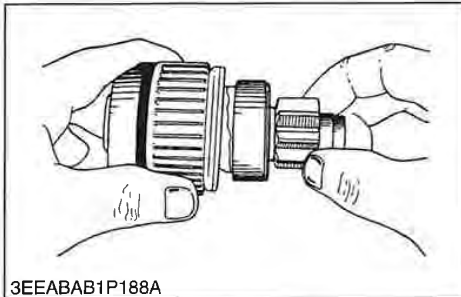


Clearance between Rotor and Cover

1. Put a strip of plastigage onto the rotor face with grease.
2. Install the cover and tighten the screws.
3. Remove the cover carefully, and measure the amount of the flattening with the scale and get the clearance.
4. If the clearance exceeds the factory specifications, replace oil pump rotor assembly.

Clearance between rotor and cover	Factory specification	0.0750 to 0.135 mm 0.00296 to 0.00531 in.
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(7) Starter**Overrunning Clutch**

1. Inspect the pinion for wear or damage.
2. If there is any defect, replace the overrunning clutch assembly.
3. Check that the pinion turns freely and smoothly in the overrunning direction and does not slip in the cranking direction.
4. If the pinion slips or does not rotate in the both directions, replace the overrunning clutch assembly.

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Commutator and Mica

1. Check the contact face of the commutator for wear, and grind the commutator with emery paper if it is slightly worn.
2. Measure the commutator O.D. with an outside micrometer at several points.
3. If the minimum O.D. is less than the allowable limit, replace the armature.
4. If the difference of the O.D.'s exceeds the allowable limit, correct the commutator on a lathe to the factory specification.
5. Measure the mica undercut.
6. If the undercut is less than the allowable limit, correct it with a saw blade and chamfer the segment edges.

[WG752-G/GL-E3]

Commutator O.D.	Factory specification	32.0 mm 1.26 in.
	Allowable limit	31.0 mm 1.22 in.

Difference of O.D.'s	Factory specification	Less than 0.05 mm 0.002 in.
	Allowable limit	0.4 mm 0.02 in.

Mica under cut	Factory specification	0.5 to 0.8 mm 0.02 to 0.03 in.
	Allowable limit	0.4 mm 0.02 in.

[WG972-G/GL-E3]

Commutator O.D.	Factory specification	28.0 mm 1.10 in.
	Allowable limit	27.0 mm 1.06 in.

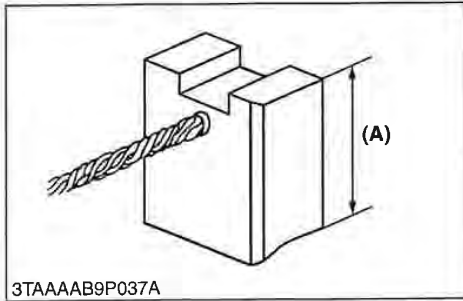
Difference of O.D.'s	Factory specification	Less than 0.05 mm 0.002 in.
	Allowable limit	0.4 mm 0.02 in.

Mica under cut	Factory specification	0.45 to 0.75 mm 0.018 to 0.029 in.
	Allowable limit	0.2 mm 0.008 in.

- (1) Segment
(2) Undercut
(3) Mica

- (a) Good
(b) Bad

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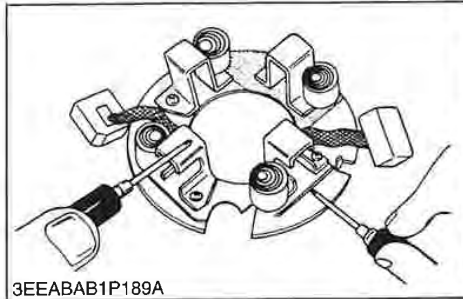
**Brush Wear**

1. If the contact face of the brush is dirty or dusty, clean it with emery paper.
2. Measure the brush length (A) with vernier calipers.
3. If the length is less than the allowable limit, replace the yoke assembly and brush holder.

Brush length (A)	Factory specification	14.0 mm 0.551 in.
	Allowable limit	11.1 mm 0.437 in.

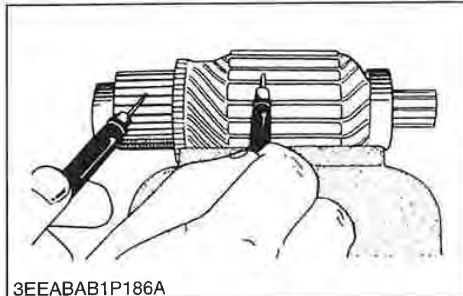
(A) Brush Length

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**Brush Holder**

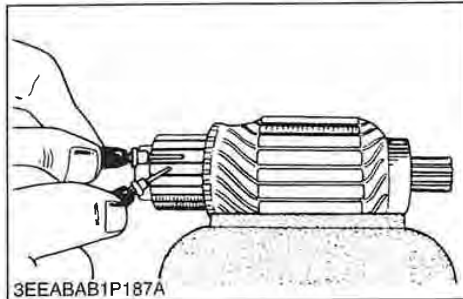
1. Check the continuity across the brush holder and the holder support with an ohmmeter.
2. If it conducts, replace the brush holder.

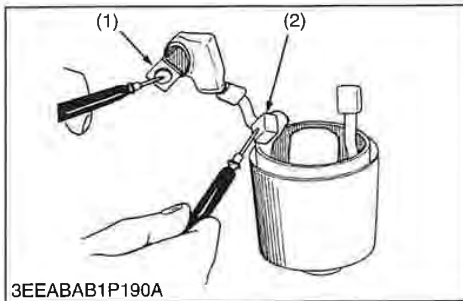
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**Armature Coil**

1. Check the continuity across the commutator and armature coil core with an ohmmeter.
2. If it conducts, replace the armature.
3. Check the continuity across the segments of the commutator with an ohmmeter.
4. If it does not conduct, replace the armature.

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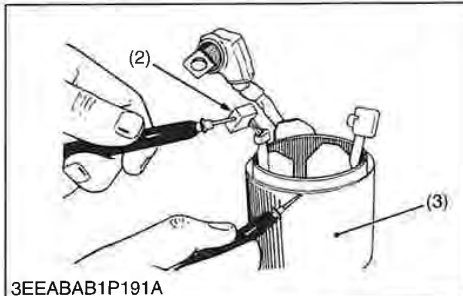
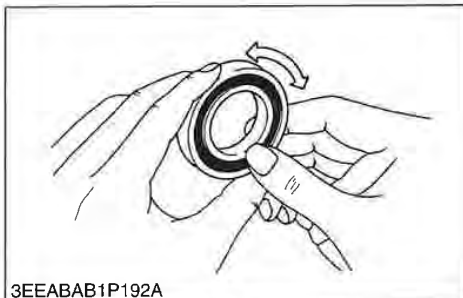
**Field Coil**

1. Check the continuity across the lead (1) and brush (2) with an ohmmeter.
2. If it does not conduct, replace the yoke assembly.
3. Check the continuity across the brush (2) and yoke (3) with an ohmmeter.
4. If it conducts, replace the yoke assembly.

(1) Lead
(2) Brush

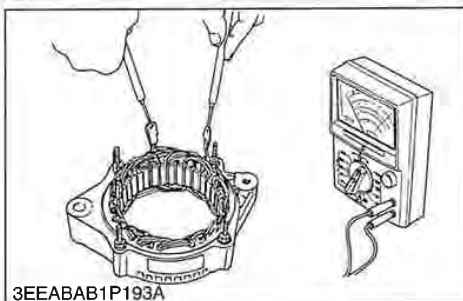
(3) Yoke

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**(8) Alternator****Bearing**

1. Check the bearing for smooth rotation.
2. If it does not rotate smoothly, replace it.

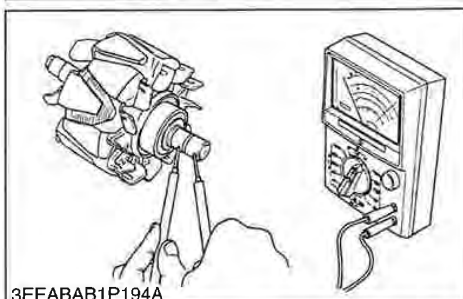
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**Stator**

1. Measure the resistance across each lead of the stator coil with resistance range of circuit tester.
2. If the measurement is not within factory specification, replace it.
3. Check the continuity across each stator coil lead and core with resistance range of circuit tester.
4. If infinity is not indicated, replace it.

Resistance	Factory specification	Less than 1.0 Ω
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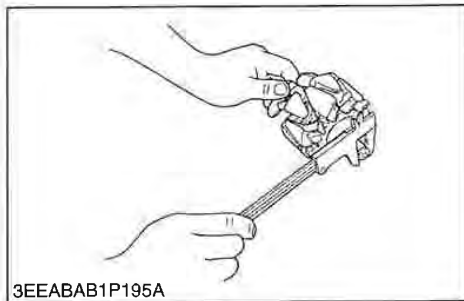
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**Rotor**

1. Measure the resistance across the slip rings.
2. If the resistance is not the factory specification, replace it.
3. Check the continuity across the slip ring and core with resistance range of circuit tester.
4. If infinity is not indicated, replace it.

Resistance	Factory specification	2.9 Ω
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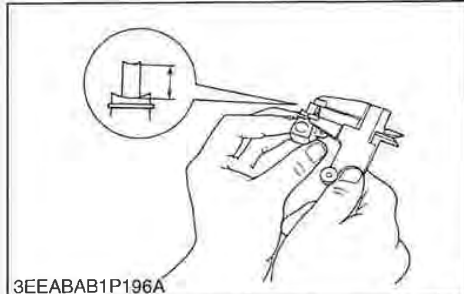
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**Slip Ring**

1. Check the slip ring for score.
2. If scored, correct with an emery paper or on a lathe.
3. Measure the O.D. of slip ring with vernier calipers.
4. If the measurement is less than the allowable limit, replace it.

Slip ring O.D.	Factory specification	14.4 mm 0.567 in.
	Allowable limit	14.0 mm 0.551 in.

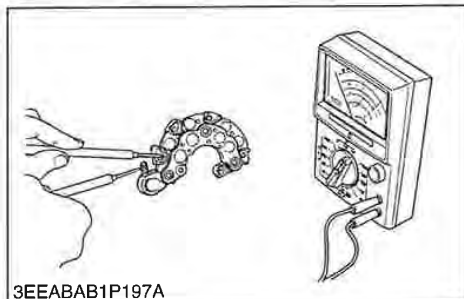
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**Brush Wear**

1. Measure the brush length with vernier calipers.
2. If the measurement is less than allowable limit, replace it.
3. Make sure that the brush moves smoothly.
4. If the brush is defective, replace it.

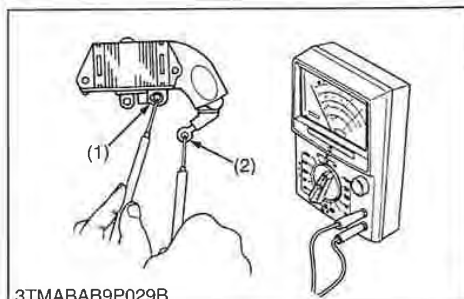
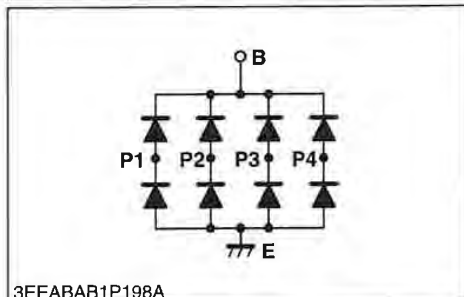
Brush length	Factory specification	10.5 mm 0.413 in.
	Allowable limit	8.4 mm 0.33 in.

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**Rectifier**

1. Check the continuity across each diode of rectifier with resistance range of circuit tester.
2. The rectifier is normal if the diode in the rectifier conducts in one direction and does not conduct in the reverse direction.

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**IC Regulator**

1. Check the continuity across the B terminal (2) and the F terminal (1) of IC regulator with resistance range of circuit tester.
2. The IC regulator is normal if the conducts in one direction and does not conduct in the reverse direction.

(1) F Terminal

(2) B Terminal

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EXHIBIT 1012



US005161496A

United States Patent [19]**Matsushima et al.**[11] **Patent Number:** **5,161,496**[45] **Date of Patent:** **Nov. 10, 1992****[54] FUEL INJECTION SYSTEM FOR INTERNAL COMBUSTION ENGINES****[75] Inventors:** Seiya Matsushima; Yukio Sugimoto; Ryuichi Kimata; Ryhei Tamamoto; Megumi Tanaka, all of Wako, Japan**[73] Assignee:** Honda Giken Kogyo Kabushiki Kaisha**[21] Appl. No.:** 713,133**[22] Filed:** Jun. 10, 1991**[30] Foreign Application Priority Data**

Jun. 11, 1990 [JP] Japan 2-153182

[51] Int. Cl.⁵ F02N 5/02; F02M 37/04; F02P 1/02**[52] U.S. Cl.** 123/185.3; 123/508; 123/599; 123/149 D; 123/478**[58] Field of Search** 123/478, 185.3, 185, 123/185 BA, 149 C, 149 D, 417, 476, 480, 599, 149 R, 472, 185 A**[56] References Cited****U.S. PATENT DOCUMENTS**

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Primary Examiner—Tony M. Argenbright**Assistant Examiner**—Thomas N. Moulis**[57] ABSTRACT**

A fuel injection system for an internal combustion engine comprises at least one fuel injection valve for supplying fuel into the intake passage of the engine, an electronic control unit responsive to operating conditions of the engine for controlling a time period over which the fuel injection valve is opened and timing for opening the fuel injection valve, a generator responsive to rotation of a flywheel for generating electric power, the generator being connected to an ignition device and the electronic control unit and forming power supplies for driving the ignition device and the electronic control unit, a fuel pump arranged to be driven in unison with the flywheel by torque transmitted from the flywheel, and a pressure regulator for controlling pressure of fuel supplied from the fuel pump to the fuel injection valve.

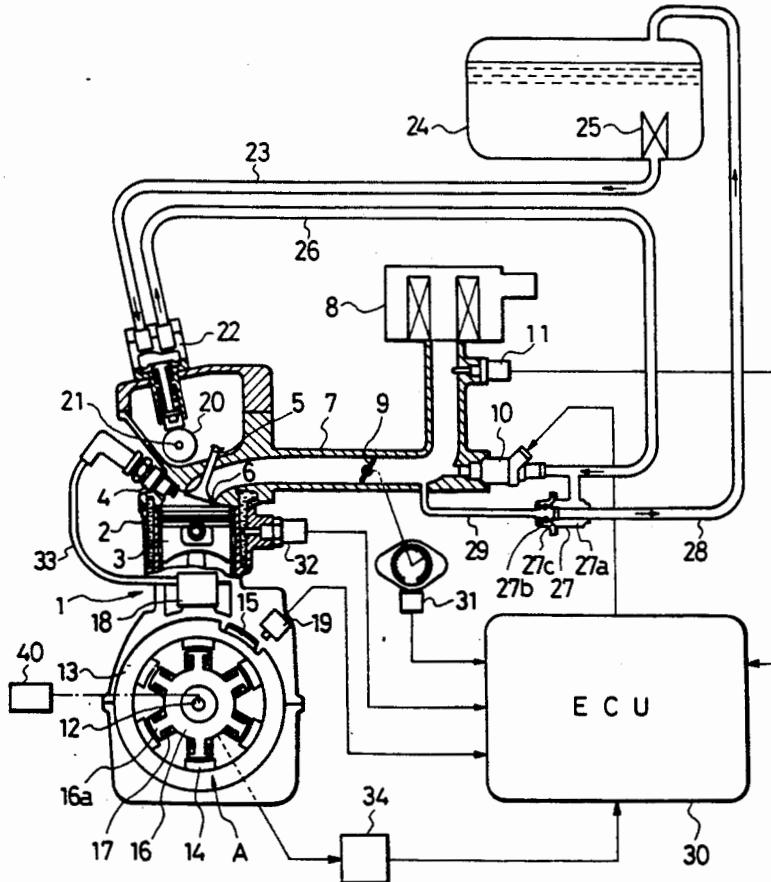
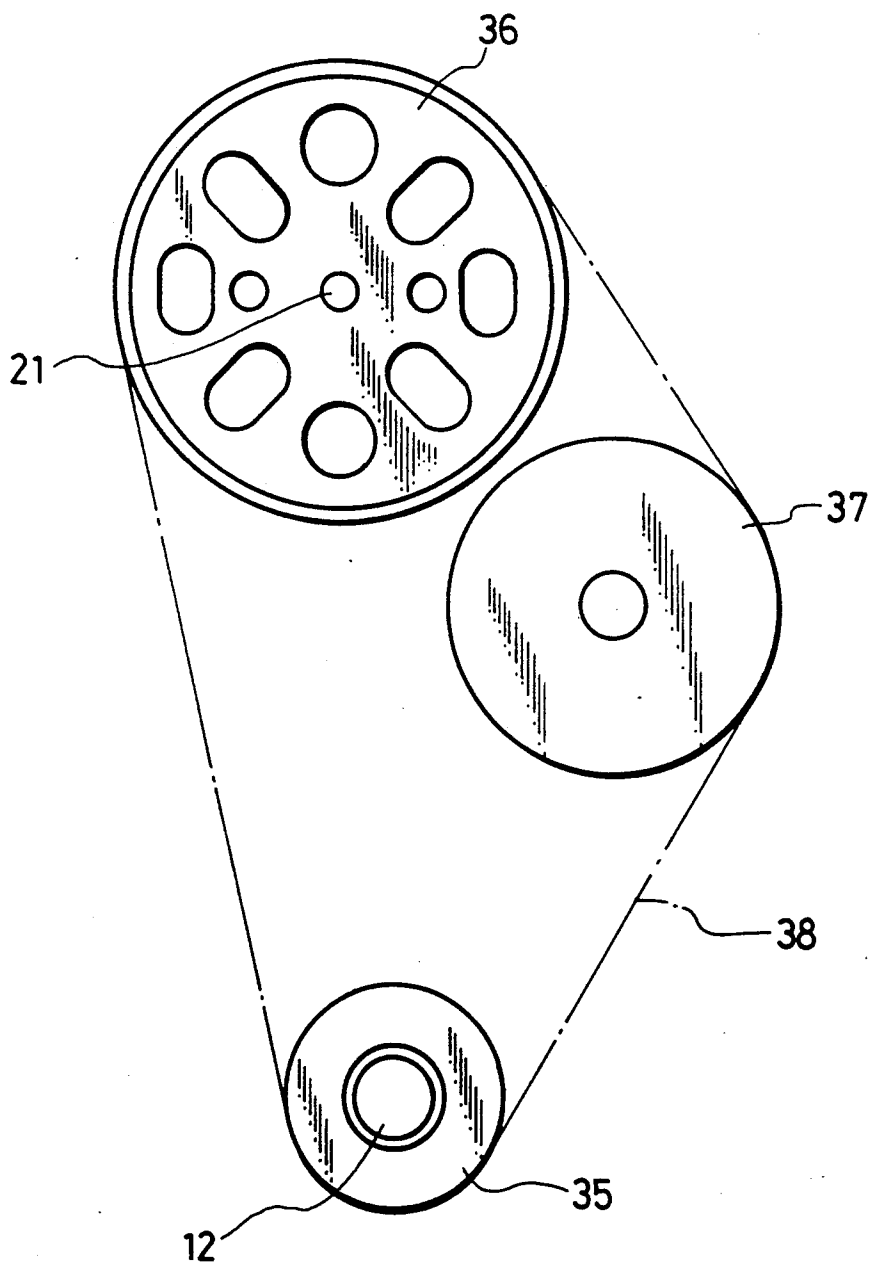
8 Claims, 2 Drawing Sheets

FIG. 2

FUEL INJECTION SYSTEM FOR INTERNAL COMBUSTION ENGINES

BACKGROUND OF THE INVENTION

This invention relates to a fuel injection system for an internal combustion engine for supplying fuel to an intake system thereof, and more particularly to an electronically-controlled fuel injection system of this kind which is adapted for use in small-sized engines equipped with no battery.

An electronically-controlled fuel injection system for an internal combustion engine is conventionally known, which comprises fuel injection valves arranged in an intake system, and control means for controlling a time period over which the fuel injection valves are opened in accordance with operating conditions of the engine.

Such a conventional electronically-controlled fuel injection system requires the use of a battery for supplying electric power thereto for driving, fuel injection valves, a control circuit for controlling the valves, and a fuel pump. Therefore, the conventional electronically-controlled fuel injection system cannot be used in small-sized engines which are equipped with no battery (hereinafter referred to as "batteryless engines" unless otherwise specified).

Under the circumstances, it has been proposed e.g. by Japanese Provisional Patent Publication (Kokai) No. 63-93440, to utilize output power from a generator driven by an engine for electronically controlling fuel supply to the engine, during operation thereof. However, insofar as the problems of fuel supply and power supply at the start of the engine are concerned, there is no disclosure except that the engine is equipped with a small battery which consumes only a small amount of electric power and can be charged by the use of part of electric power generated by a flywheel magneto.

Further, concerning the above problems, Japanese Provisional Patent Publication (Kokai) No. 63-170541 discloses the use of a battery having a small capacity, such as a dry cell, for starting a batteryless engine.

Also, Japanese Provisional Patent Publication (Kokai) No. 63-259127 discloses the technique of metering fuel by a device operated by intake vacuum.

Thus, the above prior art publications concerning the electronically-controlled fuel injection system having no conventionally-used battery merely disclose respective techniques which are not related to each other, and no disclosure has been made as to how to combine these separately-proposed individual techniques. More specifically, no disclosure has been made as to relationships between the starting operation of the engine, and fuel supply operation and timing therefor, or relationships between ignition, operation of fuel injection valves, and power supply, etc.

SUMMARY OF THE INVENTION

It is an object of the invention to provide an electronically-controlled fuel injection system which is capable of reliably starting an engine without using a battery or a dry cell.

It is a further object of the invention to provide an internal combustion engine which is equipped with a generator for supplying electric power to both an electronically-controlled fuel injection system and an ignition system in such a manner that a supply voltage to one of the two systems is not affected by fluctuations in

a supply voltage to the other system to thereby enable to operate the systems in an efficient and stable manner.

To attain the first-mentioned object, according to a first aspect of the invention, there is provided a fuel injection system for an internal combustion engine including a recoil starter, a flywheel rotatable by operation of the recoil starter, an ignition device, and an intake passage.

The fuel injection system according to the first aspect of the invention is characterized by comprising:

at least one fuel injection valve for supplying fuel into the intake passage;

control means responsive to operating conditions of the engine for controlling a time period over which the fuel injection valve is opened and timing for opening the fuel injection valve;

generator means responsive to rotation of said flywheel for generating electric power, the generator means being connected to the ignition device and the control means and forming power supplies for driving the ignition device and the control means;

a fuel pump arranged to be driven in unison with the flywheel by torque transmitted from the flywheel; and a pressure regulator for controlling pressure of fuel supplied from the fuel pump to the fuel injection valve.

Preferably, the generator means comprises first and second power generating systems responsive to rotation of the flywheel for generating electric power, the first and second power generating systems being provided independently of each other, one of the first and second power generating systems forming a power supply for driving the ignition device, and the other power generating system forming a power supply for driving the control means. More preferably, the power supply for driving the control means comprises at least one first magnet mounted on an inner periphery of the flywheel, a stator core, and a plurality of windings wound on the stator core and disposed to face the first magnet during rotation of the flywheel.

Also preferably, the power supply for driving the ignition device comprises at least one second magnet mounted on an outer periphery of the flywheel, and an ignition device unit disposed to face the second magnet during rotation of the flywheel.

To attain the second-mentioned object, according to a second aspect of the invention, there is provided an internal combustion engine comprising:

a recoil starter;
a flywheel rotatable by operation of the recoil starter;
an ignition device;
an intake passage;
at least one fuel injection valve for supplying fuel into the intake passage;

control means responsive to operating conditions of the engine for controlling a time period over which the fuel injection valve is opened and timing for opening the fuel injection valve;

generator means responsive to rotation of the flywheel for generating electric power, the generator means being connected to the ignition device and the control means and forming power supplies for driving the ignition device and the control means;

a fuel pump arranged to be driven in unison with the flywheel by torque transmitted from the flywheel; and a pressure regulator for controlling pressure of fuel supplied from said fuel pump to said fuel injection valve.

Preferably, the generator means comprises first and second power generating systems responsive to rotation of the flywheel for generating electric power, the first and second power generating systems being provided independently of each other, one of the first and second power generating systems forming a power supply for driving the ignition device, and the other power generating system forming a power supply for driving the control means.

More preferably, the power supply for driving the control means comprises at least one first magnet mounted on an inner periphery of the flywheel, a stator core, and a plurality of windings wound on the stator core and disposed to face the first magnet during rotation of the flywheel.

Also preferably, the power supply for driving the ignition device comprises at least one second magnet mounted on an outer periphery of the flywheel, and an ignition device unit disposed to face the second magnet during rotation of the flywheel.

The above and other objects, features, and advantages of the invention will become more apparent from the ensuing detailed description taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic diagram showing the arrangement of an internal combustion engine and a control system therefor according to an embodiment of the invention; and

FIG. 2 is a view useful in explaining a mechanism for transmitting the torque of a crankshaft to a camshaft.

DETAILED DESCRIPTION

The invention will now be described in detail with reference to the drawings showing an embodiment thereof.

FIG. 1 shows the arrangement of an internal combustion engine and a control system therefor according to an embodiment of the invention. An engine 1 has at least one cylinder 2, in which are arranged a piston 3 and a spark plug 4. An intake valve 5 is arranged in an intake port 6 which opens into an upper portion of the cylinder 2. The intake port 6 is communicated with the atmosphere via an intake pipe 7 and an air cleaner 8. A throttle valve 9 is arranged in the intake pipe 7, and a fuel injection valve 10 and an intake air temperature sensor 11 for detecting intake air temperature are arranged in the intake pipe at respective locations upstream of the throttle valve 9. The fuel injection valve 10 injects fuel into the intake pipe 7 at a location upstream of the throttle valve 9.

A flywheel 13 is rigidly fixed to a crankshaft 12 of the engine 1. An AC generator A comprises the flywheel 13 as a rotor having six first magnets 14 and one second magnet 15 which are mounted on the inner peripheral surface and outer peripheral surface of the flywheel 13, respectively, a stator core 16 having six projections 16a disposed to face the first magnets 14, and windings 17 wound around the respective projections 16a. The first magnets 14, the stator core 16, and the windings 17 of the generator A form a power supply unit for driving the fuel injection valve 10. An ignition device unit 18 having a built-in ignition coil, not shown, and a crank angle sensor 19 are disposed such that they can be brought into facing relation to the second magnet 15. The ignition coil of the ignition device unit 18 is electrically connected to the spark plug 4 via a wire 33. In the

present embodiment, the ignition device unit 18 is formed of a conventional self-triggering type ignition device such as ones described in U.S. Pat. No. 3,878,452, and Japanese Patent Publication (Kokoku) No. 57-27310.

Arranged above the cylinder 2 are a fuel pump 22 for pressurizing fuel to be supplied to the fuel injection valve 10, and a cam 20 for driving the fuel pump 22. A cam pulley 36 is rigidly mounted on a cam shaft in which the cam 20 is secured, as shown in FIG. 2. A timing belt 38 is engaged over the cam pulley 36 and a crankshaft pulley 35 rigidly mounted on the crankshaft 12 for driving the former by the latter. Further, in the present embodiment, a water pump pulley 37 for driving a water pump, not shown, is rotatively driven by the crankshaft pulley via the timing belt 38. Thus, with rotation of the crankshaft 12, the water pump and the fuel pump 22 are driven.

The fuel pump 22 is connected to a fuel tank 24 via a conduit 23, and also to the fuel injection valve 10 and a pressure regulator 27 via a conduit 26. A fuel filter 25 is disposed in the fuel tank 24 such that it covers an open end of the conduit 23 which opens into the fuel tank 24. Fuel in the fuel tank 24 is supplied to the fuel pump 22 via the fuel filter 25 and the conduit 23. Pressurized fuel from the fuel pump 22 is supplied via the conduit 26 to the fuel injection valve 10. The pressure regulator 27 comprises a negative pressure chamber 27b, a fuel chamber 27a, and a diaphragm 27c having a valve body, which separates the negative pressure chamber 27b and the fuel chamber 27a from each other. Connected to the fuel chamber 27a are the conduit 26 and a conduit 28 connected to the fuel tank 24. On the other hand, the negative pressure chamber 27b is connected to a portion of the intake pipe 7 in the vicinity of a nozzle of the fuel injection valve 10 via a conduit 29. Thus, the pressure regulator 27 operates to return a portion of fuel supplied from the fuel pump 22 to the fuel tank 24 in response to negative pressure prevailing in the vicinity of the nozzle of the fuel injection valve 10 to thereby regulate the pressure of fuel supplied to the fuel injection valve 10.

The windings 17 of the AC generator A are electrically connected to a power supply circuit 34 for rectifying, smoothing and stabilizing output voltage from the AC generator A. The power supply circuit 34 supplies supply voltage to an electronic control unit (hereinafter referred to as "the ECU") 30.

Further, there are provided a throttle valve opening sensor 31 for detecting the opening of the throttle valve 9 and an engine coolant temperature sensor 32 for detecting the temperature of an engine coolant circulating through the walls of the cylinder 2. Output signals from the sensors 31 and 32 are supplied to the ECU 30 together with output signals from the intake air temperature sensor 11 and the crank angle sensor 19.

The ECU 30 controls the timing for opening the fuel injection valve 10 and the duration over which the fuel injection valve 10 is opened, by generating a signal for driving the fuel injection valve 10 to open same, to thereby allow fuel to be injected into the intake pipe 7.

Further, a recoil starter 40 for directly rotating the crankshaft 12 by manual operation at the start of the engine is mounted on an end of the flywheel 13 which is exposed to the outside of the engine unit. The recoil starter 40 may be of such a known type as described in U.S. Pat. Nos. 2,692,589, 2,742,887, and 3,465,740.

The operation of the engine and the control system therefor having the above-described construction will be described below.

When the recoil starter 40 is manually operated to rotate the crankshaft 12, the torque of the crankshaft 12 is transmitted via the crankshaft pulley 35, timing belt 38, cam pulley 36, cam shaft 21 to the cam 20 to rotate same. As a result, almost simultaneously with manual operation of the recoil starter 40, the fuel pump 22 starts to pressurize fuel to be supplied to the fuel injection valve 10. Therefore, supply of fuel is not delayed as in the prior art case where intake negative pressure is utilized. Further, simultaneously with the manual operation of the recoil starter 40, the flywheel 13 is rotated together with rotating of the crankshaft 12 so that voltage is generated across the windings by rotation of the flywheel 13, whereby the generated voltage is supplied to the ECU 30 via the power supply circuit 34. At the same time, voltage is generated across the ignition coil of the ignition device unit 18, which is supplied to the spark plug 4 to drive same.

As described above, immediately upon manual operation of the recoil starter 40, the fuel pressure can be increased to a sufficient level for operation of the fuel injection valve 10, by immediate starting of the fuel pump 22 interlocked with the recoil starter 40, and at the same time the ECU 30 becomes ready to supply driving signals to the fuel injection valve 10 and the spark plug 4. This enables to start the engine reliably and easily even within a relatively short time period during which the flywheel 13 rotates by inertia.

Further, the system comprising the first magnets 14 and the windings 17 for obtaining generator power for driving the fuel injection valve 10, and the system comprising the second magnet 15 and the ignition device unit 18 for obtaining generator power for driving the spark plug 4, are provided separately from each other, so that large fluctuations in the supply voltage for driving the spark plug 4 which occur whenever the spark plug is ignited do not directly affect the supply voltage for driving the fuel injection valve 10, and hence there is no mutual interference between the supply voltages for driving the fuel injection valve 10 and the spark plug 4. This makes it possible to efficiently and stably operate the fuel injection valve 10 and the spark plug 4 by relatively small energy or electric power obtained from kinetic energy of inertial rotation of the flywheel 13.

What is claimed is:

1. An electronically-controlled fuel injection system with no battery for an internal combustion engine including a recoil starter, a flywheel fixed to an output shaft of said engine for rotation therewith and rotatable by operation of said recoil starter, an ignition device, and an intake passage, said fuel injection system comprising:

at least one fuel injection valve for supplying fuel into said intake passage;
control means responsive to operating conditions of said engine for controlling a time period over which said fuel injection valve is opened and timing for opening said fuel injection valve;
generator means provided integrally on said flywheel and responsive to rotation of said flywheel for generating electric power, said generator means being connected to said ignition device and said control means and forming power supplies for driving said ignition device and said control means;

a fuel pump arranged to be driven in unison with said flywheel by torque transmitted from said flywheel for pressurizing fuel supplied to said fuel injection valve; and

a pressure regulator for controlling pressure of fuel supplied from said fuel pump to said fuel injection valve.

2. An electronically-controlled fuel injection system with no battery according to claim 1, wherein said generator means comprises first and second power generating systems responsive to rotation of said flywheel for generating electric power, said first and second power generating systems being provided independently of each other, one of said first and second power generating systems forming a power supply for driving said ignition device, and the other power generating system forming a power supply for driving said control means.

3. An electronically-controlled fuel injection system with no battery according to claim 2, wherein said power supply for driving said control means comprises at least one first magnet mounted on an inner periphery of said flywheel, a stator core, and a plurality of windings wound on said stator core and disposed to face said first magnet during rotation of said flywheel.

4. An electronically-controlled fuel injection system with no battery according to claim 2 or 3, wherein said power supply for driving said ignition device comprises at least one second magnet mounted on an outer periphery of said flywheel, and an ignition device unit disposed to face said second magnet during rotation of said flywheel.

5. An internal combustion engine comprising:

a recoil starter;

a flywheel fixed to an output shaft of said engine for rotation therewith and rotatable by operation of said recoil starter;

an ignition device;

an intake passage;

at least one fuel injection valve for supplying fuel into said intake passage;

electronic control means with no battery and responsive to operating conditions of said engine for controlling a time period over which said fuel injection valve is opened and timing for opening said fuel injection valve;

generator means provided integrally on said flywheel and responsive to rotation of said flywheel for generating electric power, said generator means being connected to said ignition device and said control means and forming power supplies for driving said ignition device and said control means;

a fuel pump arranged to be driven in unison with said flywheel by torque transmitted from said flywheel for pressurizing fuel supplied to said fuel injection valve; and

a pressure regulator for controlling pressure of fuel supplied from said fuel pump to said fuel injection valve.

6. An internal combustion engine according to claim 5, wherein said generator means comprises first and second power generating systems responsive to rotation of said flywheel for generating electric power, said first and second power generating systems being provided independently of each other, one of said first and second power generating systems forming a power supply for driving said ignition device, and the other power gener-

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ating system forming a power supply for driving said control means.

7. An internal combustion engine according to claim 6, wherein said power supply for driving said control means 7 comprises at least one first magnet mounted on an inner periphery of said flywheel, a stator core, and a plurality of windings wound on said stator core and

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disposed to face said first magnet during rotation of said flywheel.

8. An internal combustion engine according to claim 6 or 7, wherein said power supply for driving said ignition device comprises at least one second magnet mounted on an outer periphery of said flywheel, and an ignition device unit disposed to face said second magnet during rotation of said flywheel.

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EXHIBIT 1013



US006213083B1

(12) **United States Patent**
Winberg

(10) **Patent No.:** **US 6,213,083 B1**
(45) **Date of Patent:** **Apr. 10, 2001**

(54) **FUEL SHUTOFF SYSTEM**

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Milwaukee, WI (US)

(*) Notice: Subject to any disclaimer, the term of this
patent is extended or adjusted under 35
U.S.C. 154(b) by 0 days.

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Primary Examiner—John Kwon

(74) *Attorney, Agent, or Firm*—Michael Best & Friedrich
LLP

(21) Appl. No.: **09/487,754**

(22) Filed: **Jan. 19, 2000**

Related U.S. Application Data

(63) Continuation-in-part of application No. 08/780,338, filed on
Jan. 8, 1997, now abandoned.

(51) **Int. Cl.**⁷ **F02B 77/00**

(52) **U.S. Cl.** **123/198 DB; 123/198 DC**

(58) **Field of Search** 123/DIG. 11, 198 DC,
123/198 DB

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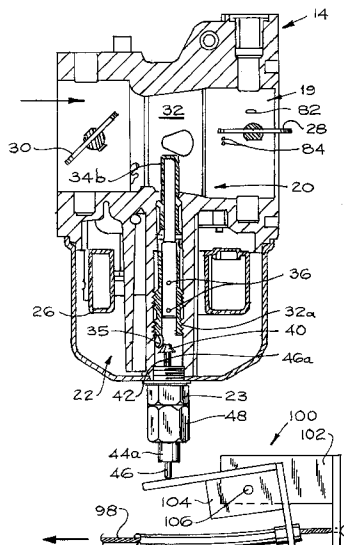
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(57) **ABSTRACT**

A fuel shutoff system that is usable on engines without a battery, and is inexpensive to manufacture. The fuel shutoff system operates without interfering with the engine governor, and effectively blocks the fuel flow downstream of the fuel bowl upon engine shutdown. One aspect of the invention is a fuel shutoff system for an internal combustion engine, wherein the engine has a carburetor with a fuel bowl and a fuel nozzle, an intake valve, and a fuel conduit between the fuel bowl and the intake valve. The invention includes a blocking member for selectively blocking the fuel conduit downstream of the fuel bowl to substantially prevent passage of fuel to the intake valve, and a manually-operable control for actuating the blocking member. In each embodiment, the engine includes a gas passageway through which a gas may pass to an intake valve of the engine, and the engine has a throttle valve disposed in the passageway, and the blocking member is distinct from the throttle valve. One embodiment of the invention includes a mechanically operated blocking member for selectively blocking fuel from flowing into the fuel nozzle. Another embodiment of the invention includes a blocking member disposed in the gas passageway. Another aspect of the invention is an ignition grounding system of the engine wherein the fuel shutoff system and the grounding system are both actuated by operation of the same mechanical means.

25 Claims, 11 Drawing Sheets



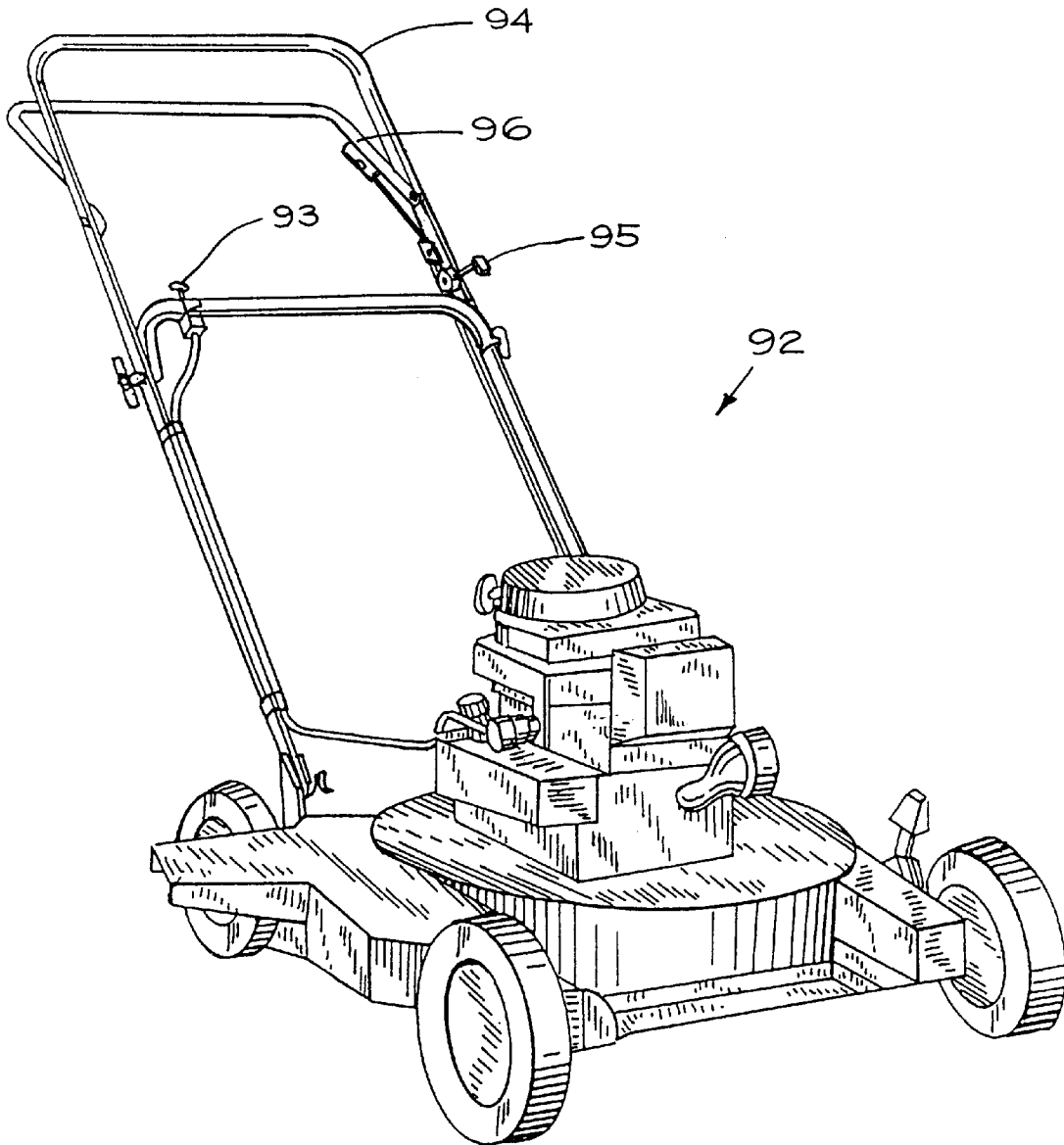


Fig. 1

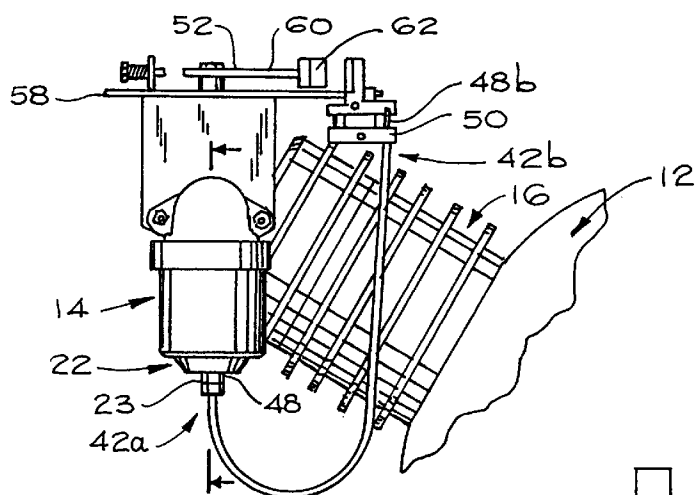


Fig. 2

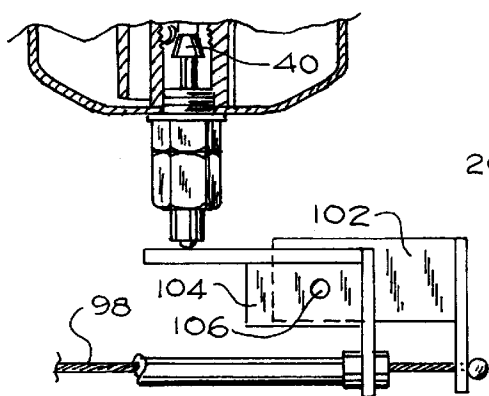


Fig. 3A

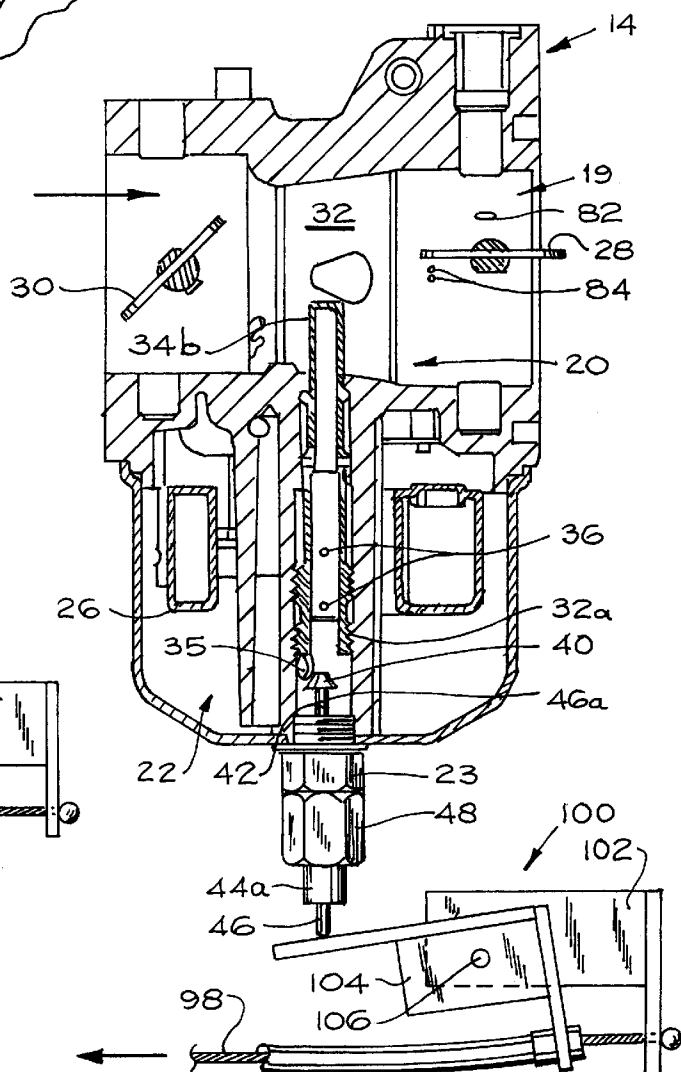


Fig. 3

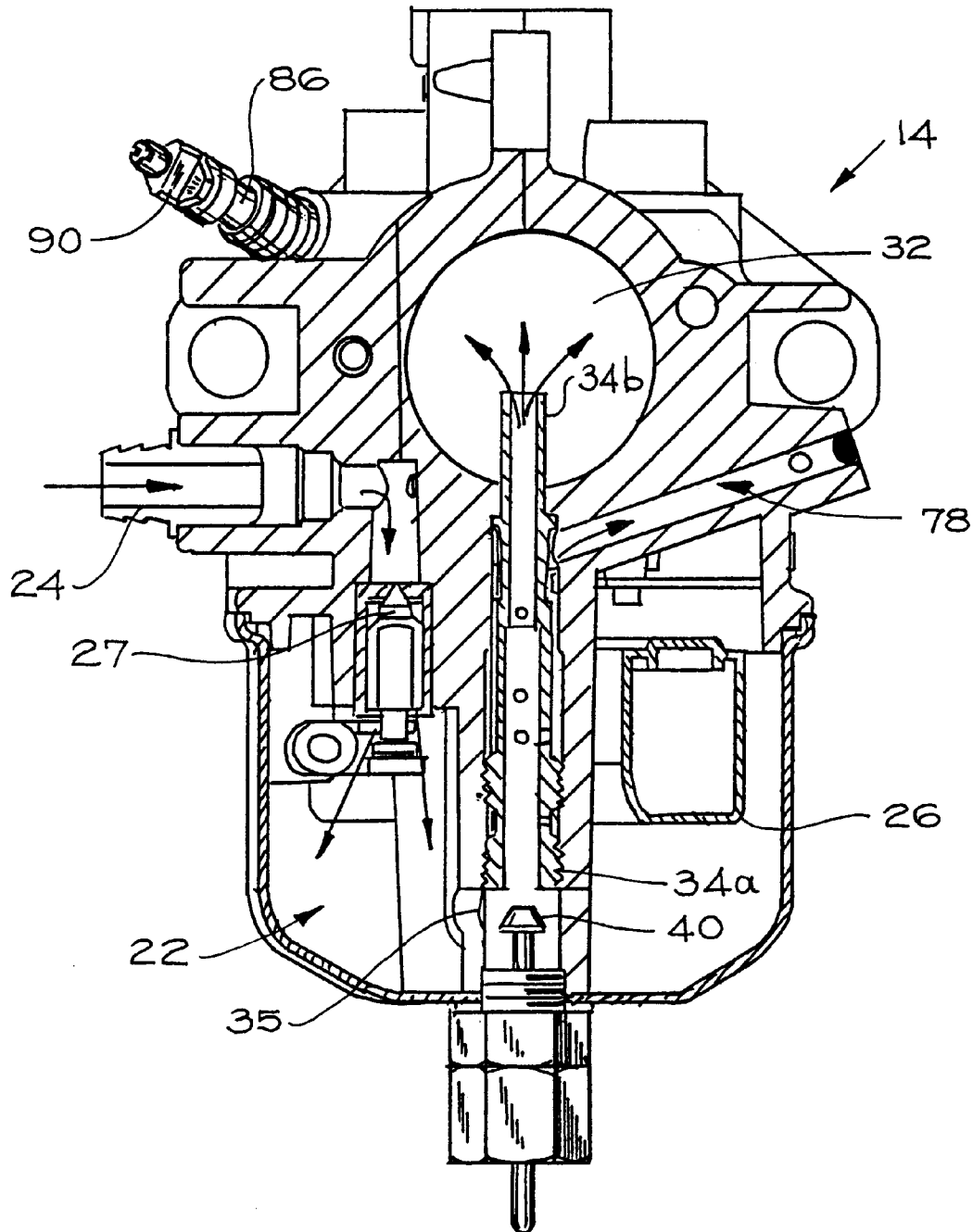


Fig 4

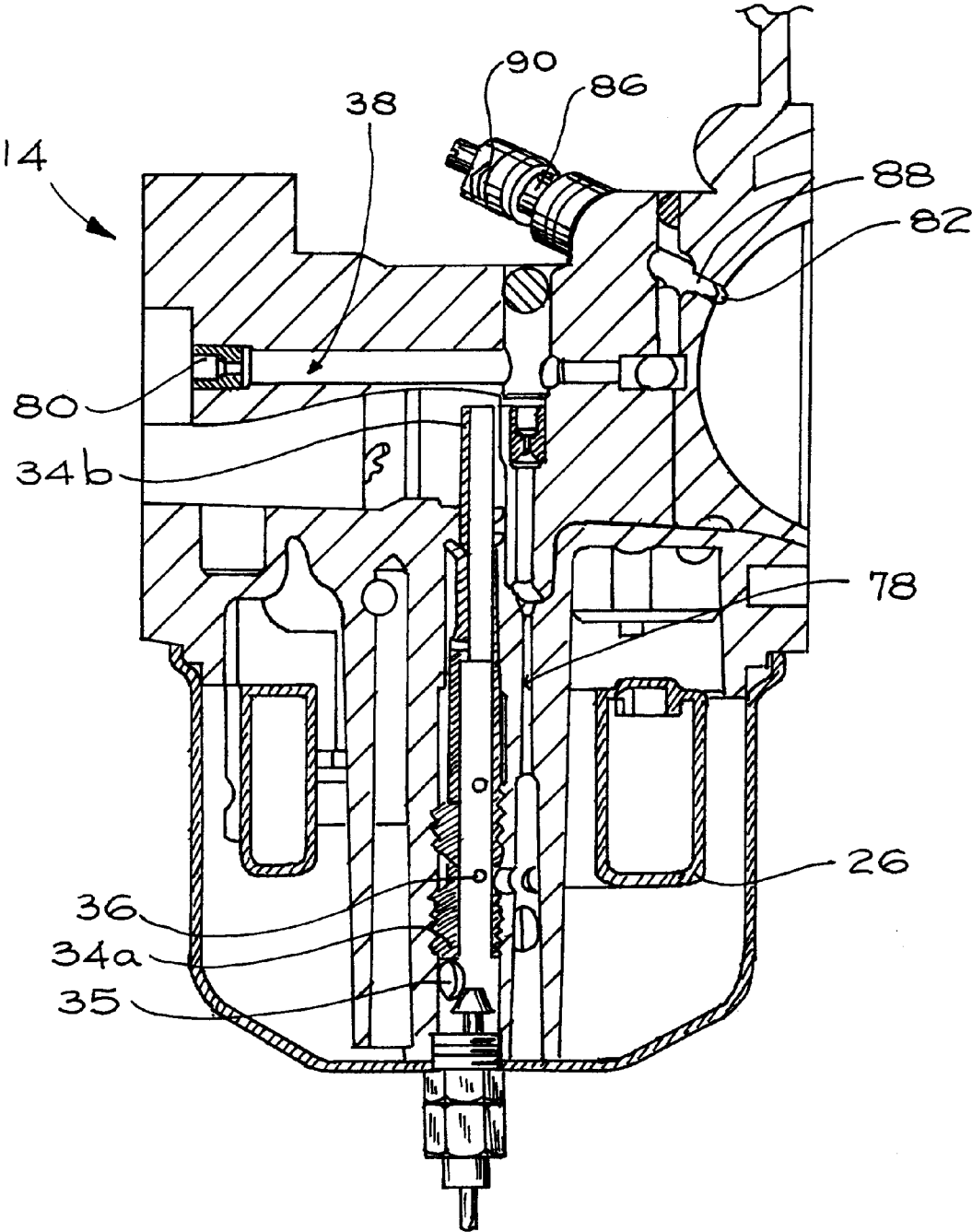


Fig. 5

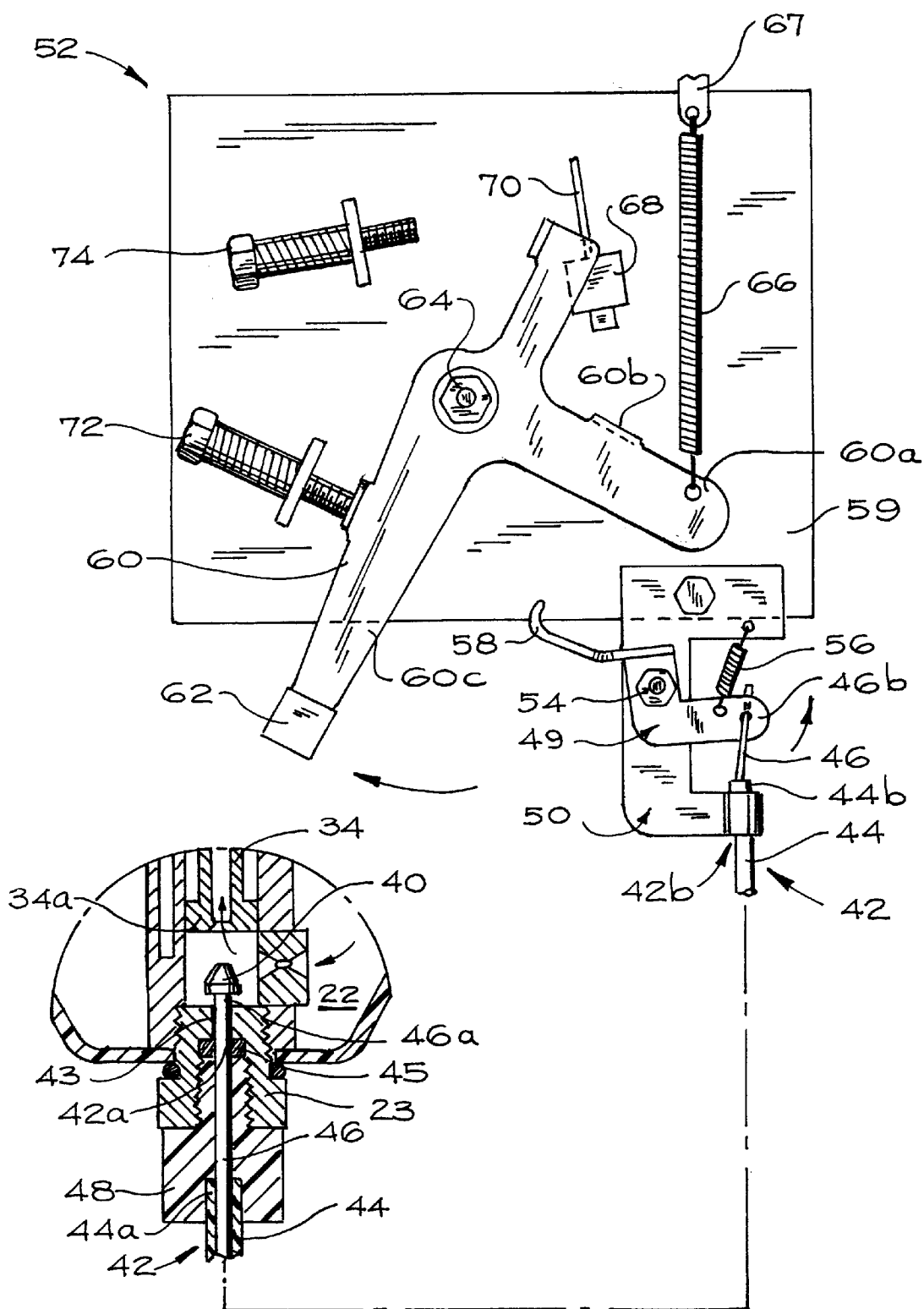
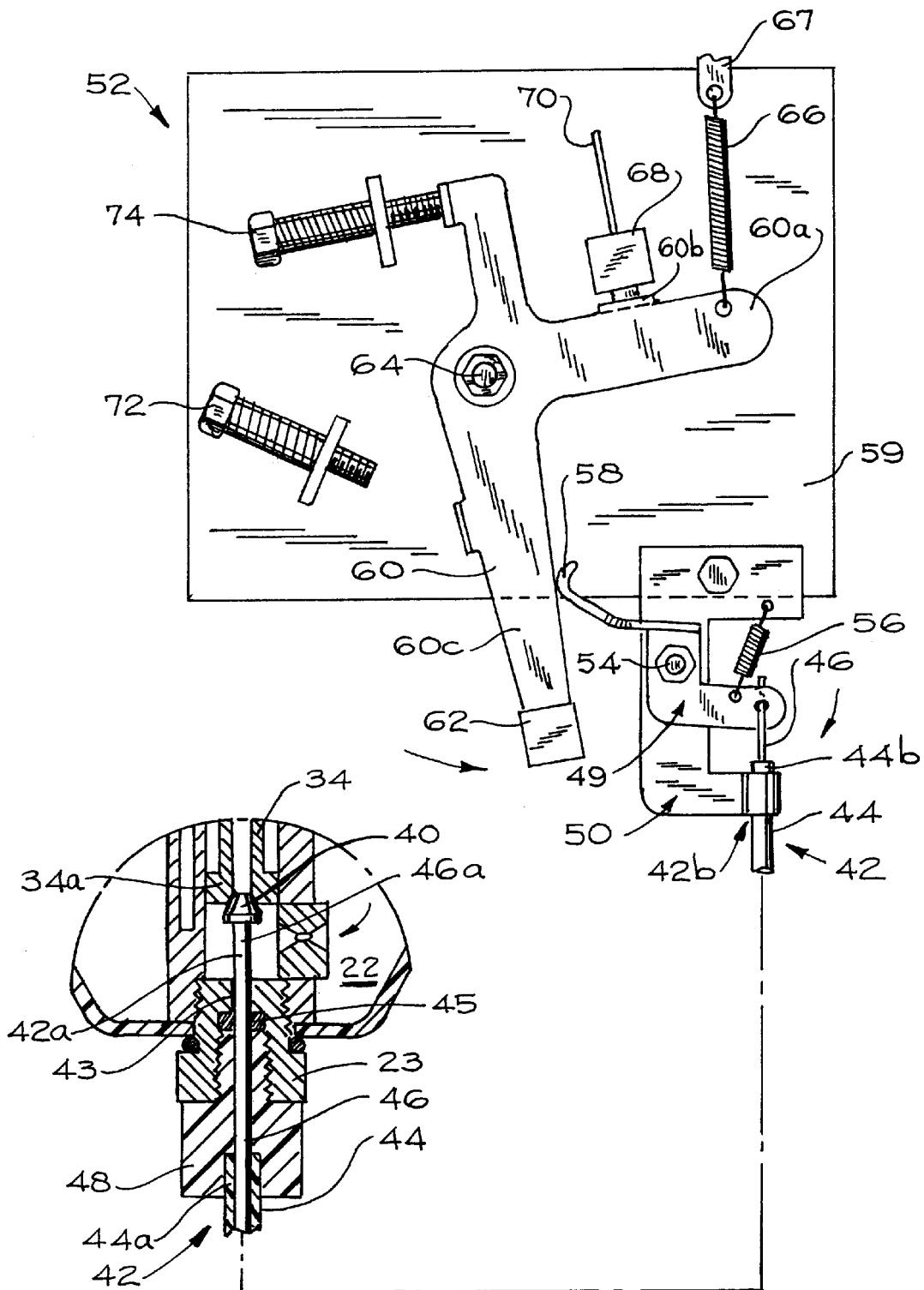


Fig. 6



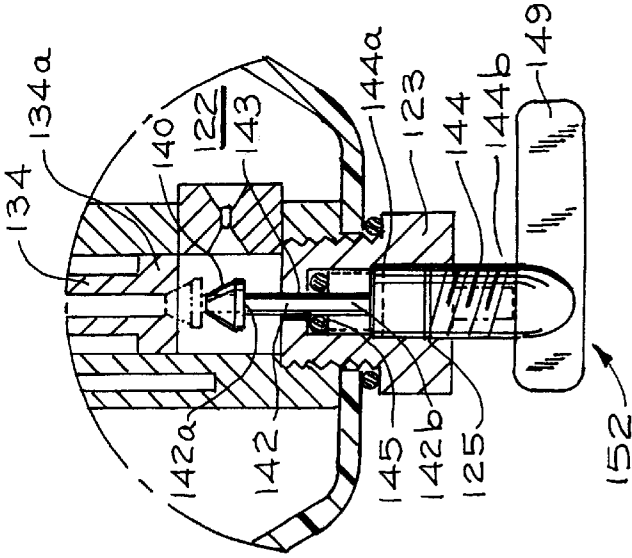


Fig. 8

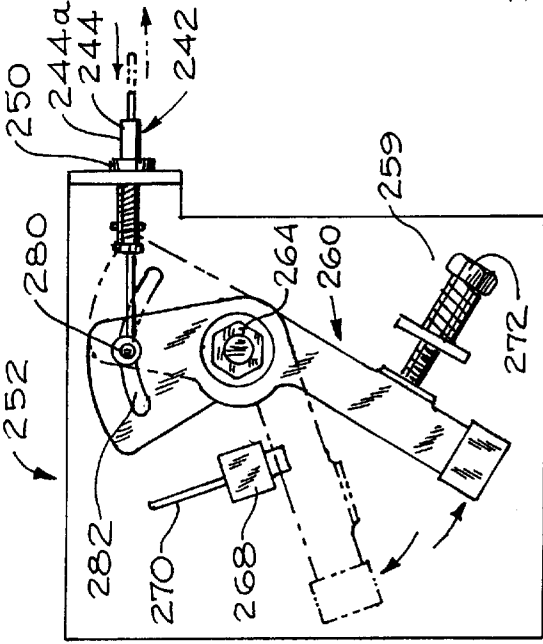


Fig. 9

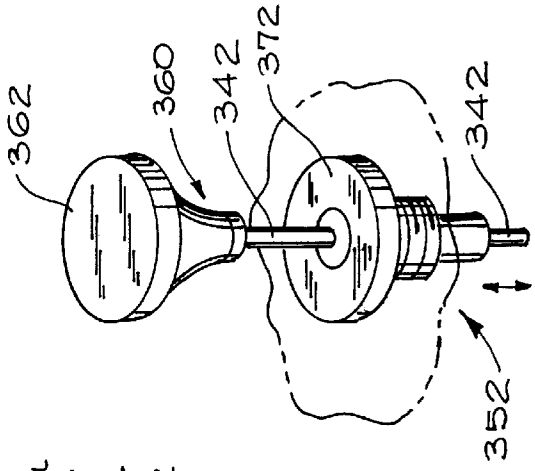


Fig. 10

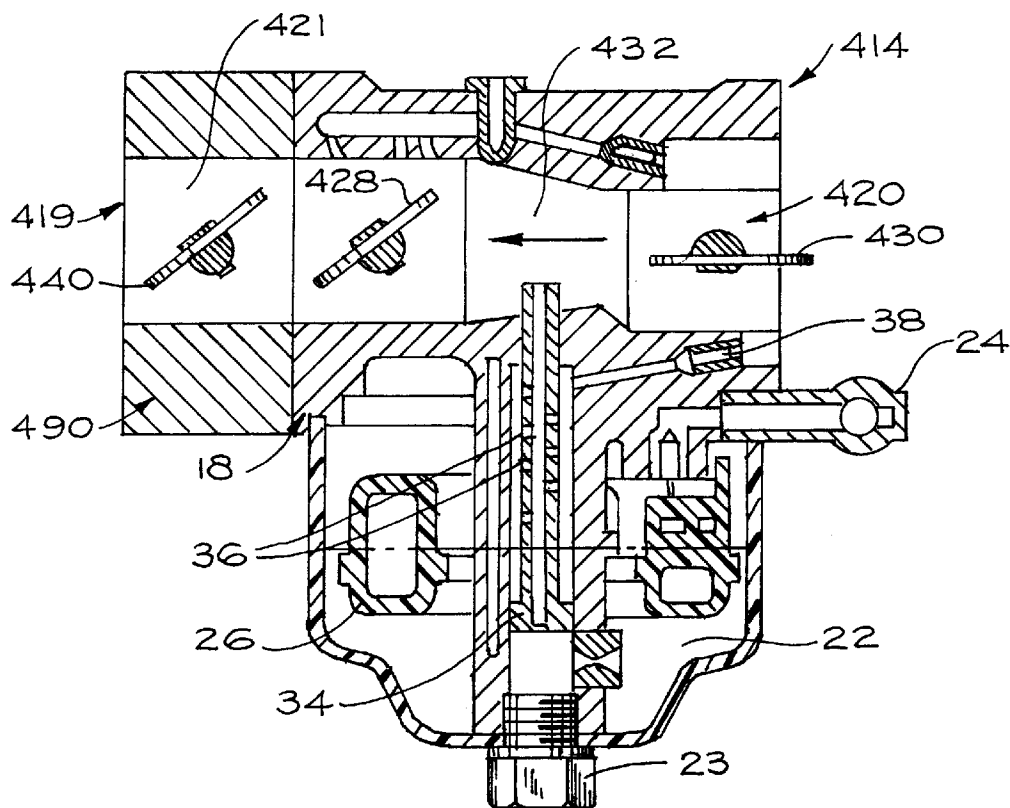


Fig. 11

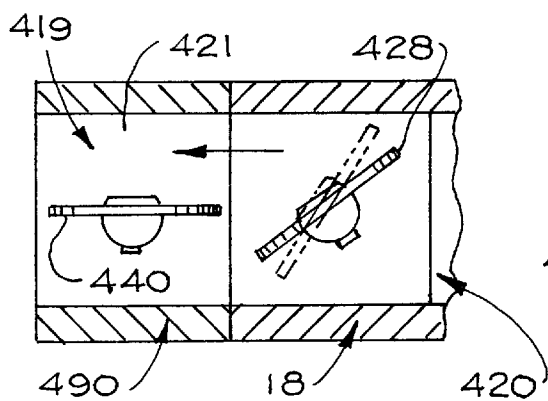


Fig. 12A

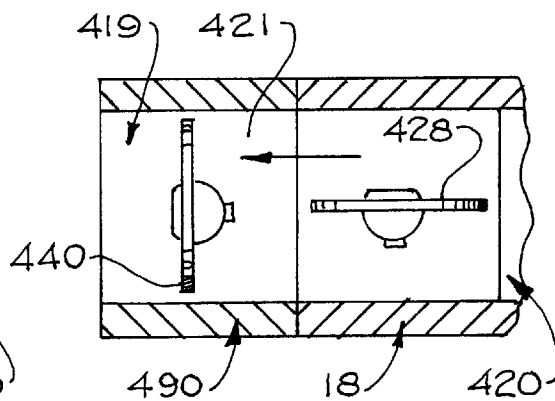


Fig. 13A

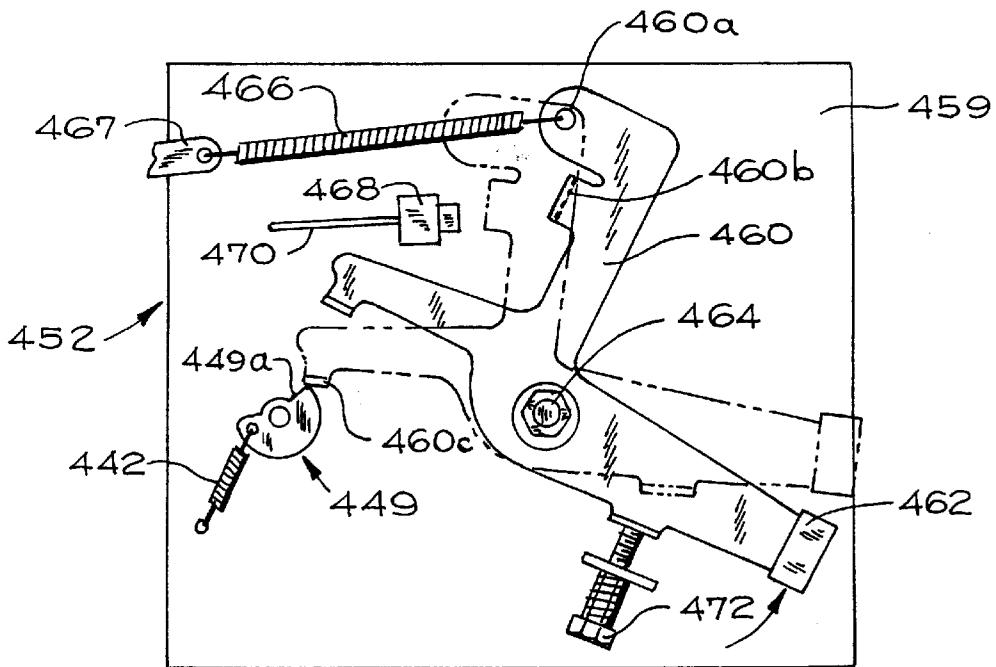


Fig. 12

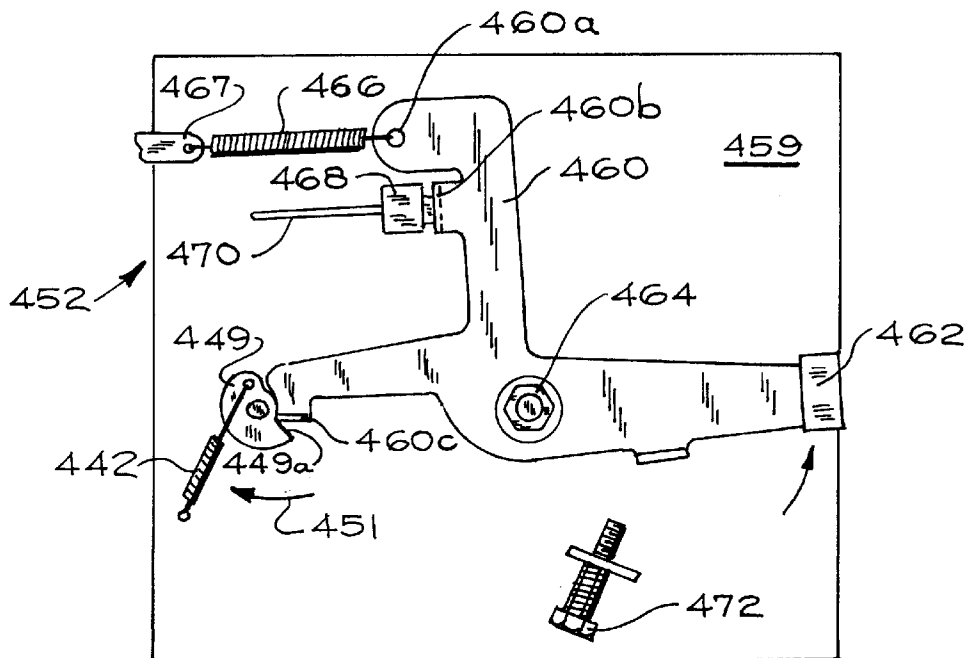
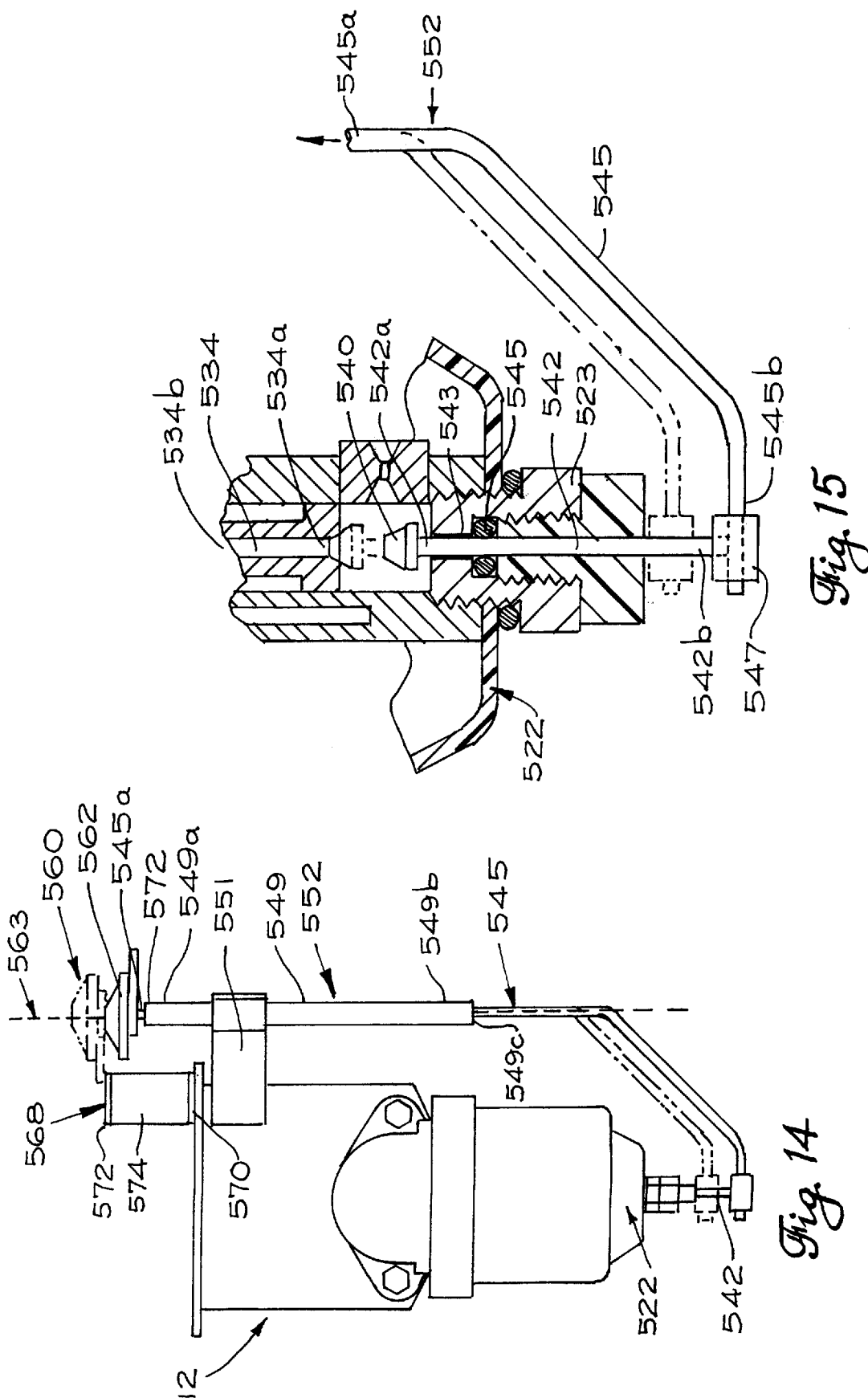


Fig. 13



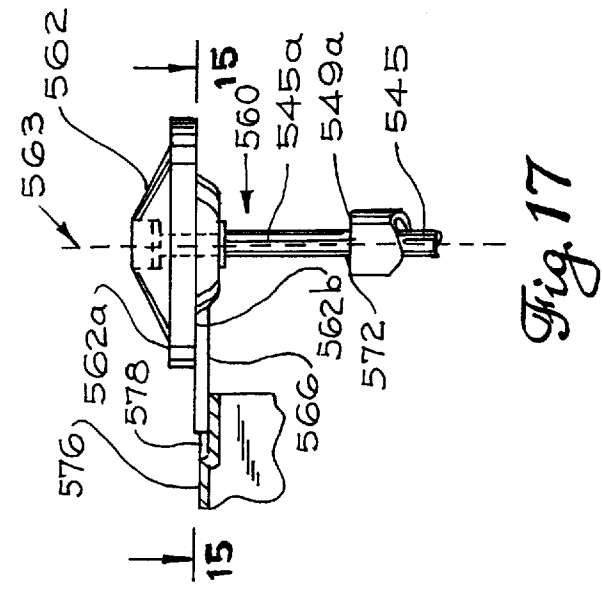


Fig. 17

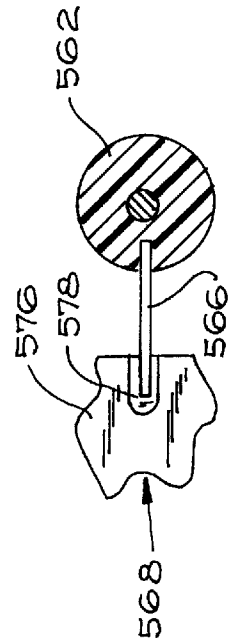


Fig. 18

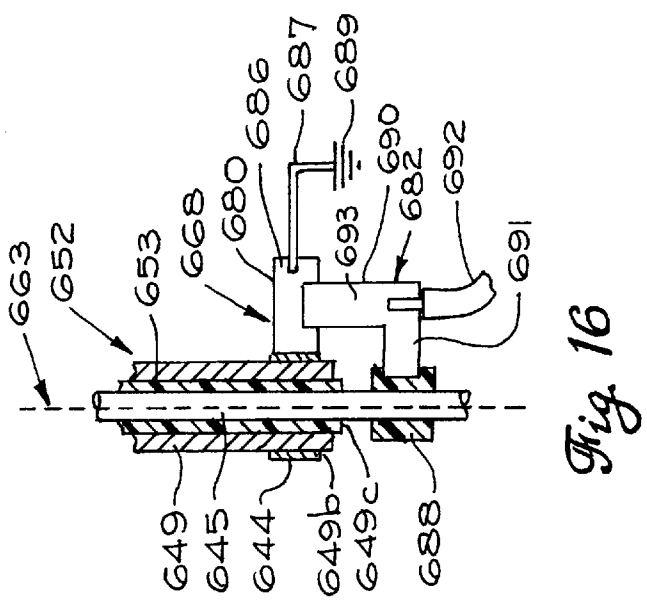


Fig. 16

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FUEL SHUTOFF SYSTEM

This application is a continuation-in-part of application Ser. No. 08/780,338, filed Jan. 8, 1997, now abandoned.

FIELD OF THE INVENTION

The present invention generally relates to the field of internal combustion engines and, more particularly, to internal combustion engines that utilize fuel shutoff systems upon engine shutdown.

BACKGROUND OF THE INVENTION

Internal combustion engines are used in a variety of applications, such as lawn mowers, generators, pumps, snow blowers, and the like. Such engines often have carburetors wherein fuel received from a fuel source is mixed with air and supplied to a combustion chamber for ignition. The fuel mixture is drawn from the carburetor into the combustion chamber due to a low pressure created in the combustion chamber by the rotation of the engine. The products of combustion are then expelled from the combustion chamber into the exhaust manifold during the exhaust stroke of the engine.

An operator of an engine may shut the engine down by grounding the electrical ignition system, thereby causing the spark plug to cease firing. After shutdown, the engine does not immediately stop rotating. During the continued rotation or coasting of the engine after ignition shutdown, unburned fuel and air are drawn from the carburetor into the combustion chamber, and expelled into the exhaust system.

The continued draw of unburned fuel into the combustion chamber and exhaust manifold after engine shutdown causes problems. Fuel is wasted, and unburned fuel is released into the environment, thereby increasing exhaust emissions. Additionally, the muffler or muffler with catalytic converter often get very hot, and the unburned fuel may ignite when it contacts these components, thereby causing backfiring or afterburning. Backfiring and afterburning can shorten the useful life of the catalytic converter and of the muffler itself. Likewise, the presence of unburned fuel in the combustion chamber may cause dieseling.

To alleviate these problems, fuel shutoff mechanisms have been devised to control the flow of fuel after ignition shutdown. For instance, U.S. Pat. No. 5,301,644 to Olmr discloses a fuel shutoff mechanism which includes a solenoid valve. However, the '644 system, as well as other apparatus which use solenoids, typically require a battery to function. The addition of a battery to engines adds to the weight and cost of the engine. Additionally, solenoids, or other electric actuating devices, are expensive and are expensive to replace. In the small utility engine industry, for example, the additional cost, weight, and complexity are very undesirable.

Other fuel shutoff devices, such as the one disclosed in U.S. Pat. No. 5,092,295 to Kobayashi, use the throttle of the engine to act as a fuel blocker upon engine shutdown. This is done by adding structure which overrides the governor of the engine and closes the throttle valve upon shutdown. The problem with these devices, however, is that they are complex, and must be added onto and may disturb the delicate balance of the engine governor.

Yet other devices, such as U. S. Pat. No. 4,510,739 to Dluhosch, use a fuel shutoff valve which stops the flow of fuel into the fuel bowl. The disadvantage of these devices is that a substantial amount of fuel remains in the fuel bowl

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after the engine ignition is shut down, and can still be drawn into the combustion chamber and exhaust system after shutdown.

SUMMARY OF THE INVENTION

The invention is a fuel shutoff system that solves the problems of the prior art. More particularly, the invention includes a fuel shutoff system that is usable on engines without a battery, and is reliable, simple and less expensive than electrically operated solenoids. Additionally, the fuel shutoff operates without interfering with the engine governor, and effectively blocks the fuel flow downstream of the fuel bowl on engine shutdown.

One aspect of the invention is a fuel shutoff system for an internal combustion engine, wherein the engine has a carburetor with a fuel bowl, an intake valve, and a fuel conduit between the fuel bowl and the intake valve. The invention includes a blocking member for selectively blocking the fuel conduit downstream of the fuel bowl to substantially prevent passage of fuel to the intake valve, and a manually-operable control for actuating the blocking member. In each embodiment, the engine includes a throttle and a fuel metering device, and the blocking member is distinct from the throttle and the fuel metering device calibration.

In one embodiment of the invention, the engine includes a carburetor having a fuel nozzle, and the fuel shutoff system includes a mechanically operated blocking member for selectively blocking fuel from flowing from the fuel bowl into the fuel nozzle. In one form, the blocking member is selectively positioned adjacent the fuel nozzle in a first position wherein the blocking member blocks the fuel from flowing into the fuel nozzle, and in a second position wherein the blocking member allows the fuel to flow into the fuel nozzle. By blocking the fuel flow downstream of the fuel bowl, restarting the engine is simplified. The fuel bowl does not have to be refilled before starting.

In another embodiment of the invention, the engine has a passageway through which a gas (the fuel/air mixture) may pass to an intake valve of the engine, and the engine has a throttle valve disposed in the passageway. The blocking member is disposed in the passageway and can be selectively positioned in a first open position, and in a second closed position upon engine shutdown to substantially block the flow of gas or fuel/air mixture to the intake valve and to the combustion chamber.

Another aspect of the invention is an ignition grounding device for grounding the ignition system of the engine wherein the fuel shutoff system and the grounding device are both actuated by the same mechanical operation.

An important feature and advantage of the invention is that the invention reduces the amount of unburned fuel which is wasted and released into the environment since all fuel flow is shut off upon engine shutdown.

Another feature and advantage of the invention is that the fuel shutoff, particularly at the fuel nozzle, enables the engine to be transported with fuel and oil without the fuel passing through the engine into the crankcase, thereby avoiding oil dilution and hydraulic lock.

Another feature and advantage of the invention is that the fuel shutoff, particularly at the fuel nozzle, enables the engine to be transported with fuel without the fuel flowing into the carburetor during transport, thereby avoiding the potential for engine flooding.

Other features and advantages of the invention will become apparent to those skilled in the art upon review of the following detailed description, claims and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a lawn mower including an internal combustion engine incorporating one embodiment of the present invention.

FIG. 2 is a partial side view of an internal combustion engine depicting a first embodiment of the present invention.

FIG. 3 is a cross sectional side view of a carburetor used in the first embodiment.

FIG. 3A is an enlarged partial view of FIG. 3.

FIG. 4 is a cross sectional front view of the carburetor in FIG. 3.

FIG. 5 is another cross sectional view of the carburetor in FIG. 3.

FIG. 6 is a schematic view of the first embodiment in the run position.

FIG. 7 is a schematic view of the first embodiment in the stop position.

FIG. 8 is a partial side view of a blocking member used in a second embodiment of the invention, shown in partial section, depicting a rotatable lever arm interconnected with the blocking member.

FIG. 9 is a schematic view of a control lever used in a third embodiment of the invention, depicting a bowden wire directly connected to the control lever.

FIG. 10 is a perspective view of a push pull motion type lever-bowden cable assembly of a fourth embodiment of the invention.

FIG. 11 is a cross sectional side view of a carburetor according to a fifth embodiment of the invention, depicting a blocking member in the gas passageway.

FIG. 12 is a schematic view of a control lever of the fifth embodiment, in the run position.

FIG. 12A is an exploded side view of the blocking member according to the fifth embodiment, depicted in the run position.

FIG. 13 is a schematic view of the control lever of the fifth embodiment of the invention, in the shutoff position.

FIG. 13A is an exploded side view of the blocking member according to the fifth embodiment, depicted in the shutoff position.

FIG. 14 is a partial side view of an internal combustion engine depicting a sixth embodiment of the present invention.

FIG. 15 is a partial cross-sectional view of a carburetor used in the sixth embodiment of the invention.

FIG. 16 is a partial side view of an ignition ground switch that may be used in the sixth embodiment of the invention.

FIG. 17 is a side view of the push/pull motion type lever-link arm assembly used in the sixth embodiment of the invention.

FIG. 18 is a top cross-sectional view of the push/pull knob, taken along line 18—18 in FIG. 17.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIGS. 1 through 18 illustrate a number of embodiments of the present invention. Each of the illustrated embodiments of the invention is used with an internal combustion engine having a carburetor and a combustion chamber. In FIGS. 2 and 3, engine 12 has a gas passageway 19 through which gas (the fuel/air mixture) may pass to an intake valve (not shown) of the engine 12. Carburetor 14 has a carburetor

body 18 having a throat 20 extending therethrough, and a fuel bowl 22 secured to carburetor body 18 by a carburetor bowl mounting screw 23. Throat 20 has a throttle valve 28 and a choke valve 30 disposed therein. Throat 20 also has a reduced diameter portion or venturi 32 disposed therein, and one end which is interconnected with an intake manifold (not shown) in fluid flow communication with an intake valve (not shown). Gas passageway 19 includes throat 20 of carburetor 14 and the intake manifold (not shown). The intake valve (not shown) regulates the flow of air and fuel into a combustion chamber 16.

The illustrated embodiments (see FIG. 4) also include a fuel feed line 24 that acts as a passageway for fuel to flow from a fuel tank (not shown) to carburetor 14, and into fuel bowl 22. Carburetor 14 has a float 26 which floats on fuel in fuel bowl 22 and actuates a valve 27 which blocks fuel from flowing into the fuel bowl 22 when fuel bowl 22 is full. A fuel nozzle 34 extends from fuel bowl 22 to venturi 32, having one end 34a in fuel bowl 22, and another end 34b in venturi 32. Fuel nozzle 34 has multiple apertures for air 36 disposed in the side thereof. The fuel nozzle 34 also includes at least one, and possibly more, fuel supply jets 35 that supply fuel to the end 34a. As will be described below, the fuel nozzle 34 acts as a high speed fuel circuit when fuel exits at end 34b. Fuel nozzle 34, throat 20, and the intake manifold (not shown) comprise a fuel conduit between fuel bowl 22 and the intake valve (not shown). When engine 12 is running, fuel flows from the fuel tank (not shown), through the fuel feed line 24, into the fuel bowl 22, up through at least a portion of the fuel nozzle 34, into the gas passageway 19, into the intake manifold (not shown), through the intake valve (not shown), and into combustion chamber 16.

As best seen in FIG. 5, an air bleed circuit 38 is disposed in the carburetor body 18. The air bleed circuit 38 communicates with an idle and transition fuel circuit 78 adjacent the fuel nozzle 34. The idle and transition fuel circuit 78 also comprises part of the fuel conduit and communicates with the nozzle 34 at the bottom-most aperture 36. Fuel enters at nozzle end 34a and can get to the intake valve via the nozzle 34, the idle and transition fuel circuit 78 or a combination of both.

When the engine 12 is idling, the throttle valve 28 substantially blocks the throat 20. Atmospheric pressure air enters the air bleed circuit 38 through restrictor 80, flows through the air bleed circuit 38 due to the lower pressure created by the engine 12 and exits through the (see FIGS. 3 and 5) idle circuit aperture 82 in the passageway 19. As the air passes over the idle and transition circuit 78, fuel is drawn upward, via the commonly known venturi effect, into the idle and transition circuit 78 where it mixes with air flowing through the air bleed circuit 38 and exits through the idle aperture 82, which is on the engine side of the closed throttle valve 28.

When the throttle valve 28 begins to open for higher engine speed or the application of a load, transition apertures 84 (FIG. 3) are exposed. The transition apertures 84 also communicate with the idle and transition circuit 78. As the engine speed increases, the pressure differential in the air bleed circuit 38 increases, which draws the air through the air bleed circuit 38 faster, which in turn draws more fuel upward into the idle and transition circuit 78. The fuel exits through the idle aperture 82 and the transition apertures 84 to provide the increased amount of fuel necessary to accommodate the higher operational speed.

As the throttle valve 28 opens more, for even higher engine speeds, the pressure differential becomes great

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enough that air passes through the venturi 32, and over the nozzle end 34b in the direction of the arrow shown in FIG. 3. Fuel is now drawn upward through the nozzle 34 and eventually ceases to be drawn upward through the idle and transition circuit 78. When this occurs, the fuel passes only through the nozzle 34 and exits only at end 34b. This is referred to as the high speed fuel circuit. At one point, however, fuel is drawn up both the high speed fuel circuit and the idle and transition circuit 78.

The amount of fuel drawn into the idle and transition circuit 78 can be adjusted by a fuel metering device. As shown in FIGS. 4 and 5, the fuel metering device is an air adjustment screw 86 that adjusts the air flow through the air bleed circuit 38. The air adjustment screw 86 includes a needle end 88 that extends into the idle aperture 82. As the air adjustment screw 86 is manually turned, the needle end 88 can be inserted or retracted from inside the idle aperture 82. By changing the size of the idle aperture 82, the pressure differential in the air bleed circuit 38 is changed. This allows the manufacturer or user to adjust the amount of fuel drawn into the idle and transition circuit 78. As such, the air adjustment screw 86 acts as a fuel metering device for adjusting the air/fuel mixture. In the illustrated embodiment, the air adjustment screw 86 is capped with a limiter cap 90 that limits the adjustability of the screw 86. Limiter caps are commonly used due to governmental engine emissions standards.

Each of the illustrated embodiments in FIGS. 1 through 18, as described below, also includes a blocking member for selectively blocking the fuel conduit downstream of the fuel bowl to substantially prevent the passage of fuel to the intake valve. The blocking member is distinct from both the throttle valve 28 and the fuel metering device.

FIGS. 1 through 7 illustrate a first embodiment of the present invention. Referring to FIGS. 2 through 7, a blocking member or plunger 40 is located in fuel bowl 22 adjacent to an input end 34a of fuel nozzle 34. Plunger 40 is selectively movable between a stop position in which plunger 40 blocks the flow of fuel into fuel nozzle 34, as shown in FIGS. 3A and 7, and a run position in which plunger 40 does not block the flow of fuel into fuel nozzle 34, as shown in FIGS. 3 and 6. Plunger 40 is preferably in the shape of a truncated cone for better sealing with the input end 34a of fuel nozzle 34. Additionally, plunger 40 is preferably made of material such as a metal, plastic or rubber that is insoluble in and impervious to fuel.

Although the blocking member has been depicted and described as a plunger blocking the input end of the fuel nozzle, it is apparent that the blocking member may have a different shape (eg. a plate, or sphere), and that it could be placed at the output end of the fuel nozzle or in a slot in the nozzle between the input and output ends.

As shown in FIGS. 2, 6 and 7, plunger 40 in the first embodiment is selectively movable between the stop or blocking position, and the run or non-blocking position through the use of a bowden cable 42 interconnected with a lever assembly 52. Bowden cable 42 has one end 42a attached to plunger 40 and extends from plunger 40 through an aperture 43 drilled through carburetor bowl mounting screw 23. Bowden cable 42 then extends to and has a second end 42b interconnected with an actuating lever assembly 52.

Plunger 40 is directly attached to one end 42a of bowden cable 42, and in one embodiment, plunger 40 and bowden cable 42 are at least partially made of metal, and bowden cable 42 is attached by soldering or other means to plunger 40. A tight seal is created between bowden cable 42 and

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carburetor bowl mounting screw 23, such that fuel cannot leak from fuel bowl 22 through aperture 43 in carburetor bowl mounting screw 23. An O-ring 45 or other similar means is used to create such a seal. In the first embodiment, the O-ring 45 may be supplied by National O-Ring, 11634 Patton Road, Downey, Calif. 90241.

Bowden cable 42 has an outer sheath 44 and an inner wire 46. Inner wire 46 is slightly longer than outer sheath 44, and is attached to plunger 40 on one end 46a and to an actuator lever 49 on the other end 46b. The outer sheath 44 surrounds the inner wire 46 and has an end 44a nearest the plunger 40 that is locked into position by a jam nut 48 which is attached to carburetor bowl mounting screw 23. The end 44b of the outer sheath 44 that is interconnected with the actuating lever assembly 52 is locked into position by a bowden cable clamp 50. One suitable bowden cable 42 is supplied by Capro Inc., 300 South Cochran, Willis, Tex. 77378.

As shown in FIGS. 6 and 7, the major components of actuating lever assembly 52 include actuator lever 49, a control lever 60, and a mounting plate 59.

In FIGS. 6 and 7, actuator lever 49 includes a first pivot 54, a return spring 56, and an engagement arm 58. First pivot 54 mounts actuator lever 49 to bowden cable clamp 50, which is in turn mounted to mounting plate 59. First pivot 54 allows actuator lever 49 to pivot between a run position as illustrated in FIG. 3, and a stop position as illustrated in FIG. 7. Because actuator lever 49 is interconnected with plunger 40 via bowden cable 42 when in the run position, actuator lever 49 pulls bowden cable 42 so that plunger 40 is in a non-blocking position. When in the stop position, actuator lever 49 pushes bowden cable 42 so that plunger 40 is in the blocking position.

Actuator lever 49 is moved between the run and the stop positions through the selective engagement of engagement arm 58 with control lever 60. Engagement arm 58 acts as a lever to pivot actuator lever 49 between the run and stop positions. Return spring 56 is interconnected between actuator lever 49 and bowden cable clamp 50, and returns actuator lever 49 to the run position when engagement arm 58 is not engaged with the control lever 60. In an alternate embodiment, actuator 49 may be spring biased to the closed or off position so that the engine may be transported without fuel spillage.

As shown in FIGS. 6 and 7, control lever 60 is preferably a rotary motion lever that has a handle or tab 62, and a second pivot 64. Of course, other types of levers may be used.

Second pivot 64 mounts control lever 60 to mounting plate 59 and allows for rotary motion of control lever 60 in relation to mounting plate 59. Control lever 60 has one portion 60a that is interconnected with a governor spring 66, another portion 60b which is selectively engageable with an ignition ground switch 68, and another portion 60c that is selectively engageable with engagement arm 58.

Governor spring 66 is interconnected between a governor arm 67 and control lever 60 and acts to adjust the speed of engine 12 (FIG. 2) as control lever 60 is rotated. As control lever 60 is rotated in a clockwise direction, as illustrated in FIG. 3, governor spring 66 is tightened, throttle valve 28 (FIG. 3) is moved to a more open position, and the engine runs faster. As control lever 60 is rotated in a counter-clockwise direction, as illustrated in FIG. 7, governor spring 66 is loosened, throttle valve 28 (FIG. 3) is moved to a more closed position, and the engine runs slower. Therefore, control lever 60 is a manually-operable control that controls both the throttle valve 28 and the blocking member or plunger 40.

In fixed speed applications, such as generators and the like, the throttle position is often not manually-controllable. In these applications, control lever 60 would only control the blocking member, and governor spring 66 would not be interconnected with control lever 60.

Ignition ground switch 68 is interconnected with an ignition wire 70, and selectively grounds the ignition system (not shown) of engine 12 (FIG. 2) to stop the engine. The fuel shutoff system of the present invention should stop the engine without the ignition ground switch. When control lever 60 engages ignition ground switch 68, ignition ground switch 68 grounds the ignition system, and the engine stops. In the preferred embodiment, the ignition ground switch 68 may be supplied by Fastex Division, 195 Algonquin Road, Des Plaines, Ill. 60016.

Control lever 60 only engages ignition ground switch 68 and engagement arm 58 when it is in the fully counter-clockwise position illustrated in FIG. 7. Therefore, the ignition system is grounded and plunger 40 is moved to the blocking position only when control lever 60 is in the fully counter-clockwise position. Plunger 40 is fully closed and ignition ground switch 68 are actuated at substantially the same time by control lever 60.

Referring again to FIGS. 6 and 7, two adjustable stops 72 and 74 are on mounting plate 59, and limit the rotary motion of control lever 60. First stop 72 stops the control lever 60 in an engine run position, as illustrated in FIG. 3. Second stop 74 stops control lever 60 in an engine stop position, as illustrated in FIG. 7.

FIG. 1 illustrates a remotely operated version of the first embodiment in combination with a lawn mower 92. The lawn mower 92 includes a handle 94 having a remote primer 93, which is pushed to inject raw fuel into the carburetor throat 20 prior to starting, a throttle lever 95, which opens and closes the throttle valve 28 to affect engine speed, and a deadman lever or switch 96 as is commonly known. The deadman switch 96 is coupled to the actuator lever assembly 100 illustrated in FIGS. 3 and 3A. A bowden cable 98 preferably couples the deadman switch 96 to the actuator assembly 100, however other methods of coupling may be employed. Actuator assembly 100 includes a fixed member 102, fixed to the engine 12, and a movable member 104, movable relative to fixed member 102. Preferably, the movable member 104 pivots about pivot point 106 to actuate the plunger 40 either by pulling it down to the run position, or by pushing it up to the stop position. When the deadman lever 96 is held in the run position, the bowden cable 98 is taut. The sheath of the bowden cable 98 is fixed to the movable member 104 causing the actuator lever assembly 100 to be in the run position as shown in FIG. 3. When the deadman switch 96 is released, the bowden cable 98 slacks inside the sheath and the actuator lever 100 pivots to the stop position in FIG. 3A. Bowden cable 98 can also be interconnected to an ignition grounding switch (not shown), but this need not be the case.

Variations of the remotely operated embodiment shown in FIG. 1 can also be utilized with generators, pumps, snow blowers and the like. In the case of generators for example, the engine controls are often remotely located from the engine on a frame. The fuel shutoff device can also be remotely actuated using a push/pull knob, as described below with respect to FIG. 10, or any other suitable actuation device.

FIG. 8 illustrates a blocking member or plunger 140 and a mechanical actuating means used in a second embodiment of the invention. As in the first embodiment, plunger 140 is

located in a fuel bowl 122 adjacent to an intake end 134a of a fuel nozzle 134. Plunger 140 is selectively movable between a first, stop position in which plunger 140 blocks the flow of fuel into fuel nozzle 134 (shown in phantom in FIG. 8), and a second, run position in which plunger 140 does not block the flow of fuel into fuel nozzle 134 (shown by the solid lines in FIG. 8).

Although blocking member 140 has been depicted and described as a plunger 140 blocking input end 134a of fuel nozzle 134, it is apparent that blocking member 140 may have a different shape (eg. a plate), and that it could be placed at the output end 134b (FIG. 8) of fuel nozzle 134 or in a slot in the fuel nozzle between input end 134a and output end 134b (FIG. 8).

Plunger 140 in FIG. 8 is selectively movable between the stop or blocking position, and the run or non-blocking position through the use of a connecting member 142 interconnected with a rotating actuating lever assembly 152. Connecting member 142 has one end 142a attached to plunger 140, and extends from plunger 140 through an aperture 143 drilled through the center of the carburetor bowl mounting screw 123. Connecting member 142 then extends to and has a second end 142b interconnected with a rotating actuating lever assembly 152.

A tight seal is created between connecting member 142 and carburetor bowl mounting screw 123, such that fuel cannot leak from fuel bowl 122 through aperture 143. As in the first embodiment, an O-ring 145 or other similar means is used to create such a seal.

Carburetor bowl mounting screw 123 has an internally threaded bore 125 therein, and the actuating lever assembly 152 includes a threaded member 144 which is threaded into threaded bore 125. One end 144a of threaded member 144 is connected to connecting member 142, and the other end 144b of threaded member 144 is connected to a lever arm 149. When lever arm 149 is rotated such that the pitch of the thread in threaded bore 125 advances threaded member 144 further into threaded bore 125, plunger 140 is advanced towards the intake end 134a of fuel nozzle 134 via connecting member 142. When plunger 140 contacts or substantially contacts the intake end 134a of fuel nozzle 134, plunger 140 blocks or substantially blocks the flow of fuel into fuel nozzle 134, and is therefore in the stop or blocking position.

As lever 149 arm is rotated such that the pitch of the thread in threaded bore 125 moves threaded member 144 further out of threaded bore 125, plunger 140 is moved away from intake end 134a of fuel nozzle 134 via connecting member 142. When plunger 140 is not in contact or substantial contact with intake end 134a of fuel nozzle 134, plunger 140 does not block or substantially block fuel from flowing into fuel nozzle 34, and is therefore in the run or non-blocking position.

FIG. 9 illustrates an actuating lever assembly 252 used in a third embodiment of the invention. In the actuating lever assembly 252 of the third embodiment, a bowden cable 242 is directly attached to a rotary motion control lever 260 via an adjustment bolt 280. Adjustment bolt 280 is attached to control lever 260 at an elongated opening or adjustment slot 282 in the control lever 260. For calibration of the embodiment, the attachment point of bowden cable 242 to control lever 260 can be adjusted by repositioning adjustment bolt 280 in adjustment slot 282. By repositioning the attachment point of bowden cable 242 to control lever 260, the movement of bowden cable 242 in relation to the movement of control lever 260 is adjusted. Additionally, the end 244a of an outer sheath 244 of bowden cable 242 is held

in position by a second jam nut **250** which is connected to the mounting plate **259**, rather than by a bowden cable clamp **50** (FIGS. **6** and **7**) as in the first embodiment.

The actuating lever assembly **252** in the third embodiment also includes an ignition ground switch **268** interconnected with an ignition wire **270**, an adjustable stop **272**, and a second pivot **264**, which are similar to the corresponding components discussed above in the first embodiment.

FIG. **10** illustrates yet another actuating lever assembly **352** used in a fourth embodiment of the invention. In the fourth embodiment, actuating lever assembly **352** includes a remote control lever **360** which is a push/pull motion type lever. Control lever **360** includes a push/pull knob **362**, a connecting member **342**, and a stop **372**. Connecting member **342** may be connected to a bowden cable **342**, which in turn is interconnected with the blocking member **40** (FIGS. **3** and **7**), or connecting member **342** may be connected directly to blocking member **40** (FIGS. **3** and **7**). When the push/pull knob **360** is pulled out in relation to the stop **372**, blocking member **40** (FIGS. **3** and **7**) is positioned such that it does not block the fuel flow in the fuel conduit, and the embodiment is in the run or non-blocking position. When the push/pull knob **362** is pushed-in in relation to the stop **372**, blocking member **40** (FIGS. **3** and **7**) is positioned such that it blocks the fuel flow in the fuel conduit, and the embodiment is in the stop or fuel blocking position.

In the fourth embodiment, an ignition ground switch **68** (FIGS. **2** and **6**) is also interconnected with the actuating lever assembly **352**. The ignition ground switch **68** (FIGS. **2** and **6**) may be interconnected with the actuating lever assembly **352** via bowden cable **342**, or may be directly attached to actuating lever assembly **352**. When the push/pull knob **360** is pushed-in to the stop position, the ignition ground switch **68** (FIGS. **2** and **6**) is actuated, and grounds the ignition system of the engine.

FIGS. **11** through **13A** depict a fifth embodiment of the present invention. As best shown in FIG. **11**, a blocking member or fuel/air mixture blocking valve **440** is disposed in a gas passageway **419** of the engine **12** (FIG. **2**). A throttle valve **428** and a choke valve **430** are also disposed in the gas passageway **419**, and are distinct from blocking member **440**. Air flows through the gas passageway **419** in the direction of the arrows in FIGS. **11**, **12A** and **13A**. In FIG. **11**, a spacer block **490** is located between the carburetor **414** and the intake manifold (not shown). Spacer block **490** has a hollow bore **421** therethrough, and is positioned such that hollow bore **421** is included in gas passageway **419**. Carburetor throat **420**, having a venturi **432**, is also part of the gas passageway **419**. Fuel blocking valve **440** is disposed within hollow bore **421** of spacer block **490**.

Fuel blocking valve **440** is selectively movable between a first, stop position in which blocking valve **440** blocks the flow of the air/fuel mixture in gas passageway **419**, as illustrated in FIG. **13A**, and a second, run position in which blocking valve **440** does not block the flow of the air/fuel mixture in gas passageway **419** as illustrated in FIG. **12A**. Fuel blocking valve **440** is preferably in the form of a butterfly valve, and is sized such that when in a blocking position, fuel blocking valve **440** blocks, or substantially blocks, the flow of the air/fuel mixture through gas passageway **419**. (FIG. **13A**).

Fuel blocking valve **440** in the fifth embodiment is selectively movable between the blocking position and the non-blocking position through the use of an actuating lever assembly **452** interconnected with fuel blocking valve **440**. Referring to FIGS. **12** and **13**, the major components of

actuating lever assembly **452** include a control lever **460**, an actuator cam **449**, a cam spring **442** and a mounting plate **459**.

As depicted in FIGS. **12** and **13**, control lever **460** is a rotary motion lever that has a handle or tab **462**, and a second pivot **464**. Of course, other types of levers may be used. Control lever **460** has one portion **460a** that is interconnected with a governor spring **466**, another portion **460b** which is selectively engageable with an ignition ground switch **468**, and another portion **460c** that is selectively engageable with actuator cam **449**. As control lever **460** is rotated so as to engage actuator cam **449**, actuator cam **449** is rotated in a clockwise direction, as shown by arrow **451**.

In the fifth embodiment, there is a direct mechanical link between actuator cam **449** (FIGS. **12** and **13**) and fuel blocking valve **440** (FIGS. **12A** and **13A**). The link may be a shaft, a rack and pinion apparatus, or gears, as is well known in the trade. Other embodiments of the invention may link actuator cam **449** and fuel blocking valve **440** through the use of a bowden cable, or other similar means.

As actuator cam **449** is rotated in a clockwise direction through engagement with control lever **460**, fuel blocking valve **440** is moved from a non-blocking to a blocking position via the direct mechanical link between fuel blocking valve **440** and actuator cam **449**. The use of actuator cam **449** allows for efficient switching of fuel blocking valve **440** between the blocking and non-blocking positions. Due to the profile of cam surface **449a** of the actuator cam **449**, once speed control lever **460** engages actuator cam **449**, a small amount of angular movement of control lever **460** results in a large amount of angular movement of fuel blocking valve **440**, thereby reducing the amount of control lever movement needed to actuate fuel blocking valve **440** into a blocking position. By comparing FIGS. **12** through **13A**, it is apparent that a rotation of cam **449** of less than 45 degrees from the open position (FIG. **12**) to the closed position (FIG. **13**) results in a 90 degree rotation of fuel blocking valve **440** from the open position (FIG. **12A**) to the closed position (FIG. **13A**). Fuel blocking valve **440** is spring loaded so that fuel blocking valve **440** remains in the fully open or non-blocking position when control lever **460** is not engaging actuator cam **449**.

Ignition ground switch **468** in the fifth embodiment is similar to ignition ground switch **68** (FIGS. **6** and **7**) discussed above in the first embodiment. Additionally, the structure relating to the governor spring **466** and its attachment between governor spring **467** and control lever **460** in the fifth embodiment is substantially the same as in the first embodiment discussed above. As in the first embodiment, the governor spring is not attached to control lever **460** in most fixed speed applications.

The operation of the fifth illustrated embodiment of the invention is best shown by comparing FIGS. **12** and **12A** with FIGS. **13** and **13A**. FIG. **12** and **12A**, in combination, illustrate the fifth embodiment of the invention in the run, non-blocking and non-grounding position. Control lever **460** is in a position such that it does not engage actuator cam **449**. In this position, actuator cam **449** is held in a run position by cam spring **442**. Fuel blocking valve **440** remains in a non-blocking position, thereby allowing the air/fuel mixture to flow through gas passageway **419** and to the intake valve. In this position, control lever **460** does not engage ignition ground switch **468**, so the ignition system of the engine is not grounded. Additionally, governor spring **466** is pulled, thereby moving throttle valve **28** into a more open position, making the engine **12** run faster.

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The phantom lines in FIGS. 12 and 12A illustrate the fifth embodiment in a slow run position, with throttle valve 28 partially closed, fuel blocking valve 440 in a non-blocking position, and ignition ground switch 468 and actuator cam 449 not actuated by control lever 460. The solid lines in FIGS. 12 and 12A illustrate the fifth embodiment in the fast run position, with control lever 460 engaging stop 472, throttle valve 428 more open, fuel blocking valve 440 in a non-blocking position, and ignition ground switch 468 and actuator cam 449 not actuated by control lever 460.

FIGS. 13 and 13A illustrates the fifth embodiment of the invention in the stop, blocking and grounding position. Control lever 460 is rotated as far counter-clockwise as possible so that control lever 460 engages actuator cam 449. In this position, control lever 460 engages actuator cam 449 such that fuel blocking valve 440 is rotated to the blocking position, thereby substantially blocking the air/fuel mixture from flowing through gas passageway 419 into the intake valve. Control lever 460 engages ignition ground switch 468, so that the ignition system of the engine is grounded. Additionally, governor spring 466 is loosened thereby moving throttle valve 428 into a fully open position.

Control lever 460 only engages ignition ground switch 468 and actuator cam 449 when it is in or substantially close to the fully counter-clockwise position illustrated in FIG. 13. Therefore, ignition ground switch 468 is actuated and fuel blocking valve 440 is in the blocking position only when control lever 460 is in the fully counter-clockwise position. Actuator cam 449, and therefore fuel blocking valve 440 as well as ignition ground switch 468, are actuated at substantially the same time by control lever 460.

FIGS. 14 through 18 illustrate a mechanical actuating means used in a sixth embodiment of the invention using a link arm lever assembly 552. As shown in FIG. 15, plunger 540 is located in a fuel bowl 522 adjacent to an intake end 534a of a fuel nozzle 534. Plunger 540 is selectively movable between a first, stop position in which plunger 540 blocks the flow of fuel into fuel nozzle 534 (shown in phantom in FIG. 15), and a second, run position in which plunger 540 does not block the flow of fuel into fuel nozzle 534 (shown by the solid lines in FIG. 15).

Although blocking member 540 has been depicted and described as a plunger 540 blocking input end 534a of fuel nozzle 534, it is apparent that blocking member 540 may have a different shape (eg. a plate), and that it could be placed at the output end 534b of fuel nozzle 534 or in a slot in the fuel nozzle between input end 534a and output end 534b.

Plunger 540, as shown in FIG. 15, is selectively movable between the stop or blocking position, and the run or non-blocking position through the use of a connecting member 542 interconnected with a link arm lever assembly 552. Connecting member 542 has one end 542a attached to plunger 540, and extends from plunger 540 through an aperture 543 drilled through the center of the carburetor bowl mounting screw 523. Connecting member 542 then extends to and has a second end 542b interconnected with the link arm lever assembly 552.

A tight seal is created between connecting member 542 and carburetor bowl mounting screw 523, such that fuel cannot leak from fuel bowl 522 through aperture 543. As in the first embodiment, an O-ring 595 or other similar means is used to create such a seal.

The link arm lever assembly 552 includes a generally L-shaped link arm 545 having a first end 545a and a second end 545b. The second end of link arm 545b is interconnected

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with the second end of connecting member 542b. As shown in FIG. 12, the second end of link arm 545b and the second end connecting member 542b are interconnected by an interconnecting member 547. In the alternative, the link arm 545 and the connecting member 542 can be interconnected by other interconnecting means known in the art, such as welding, or may be integrated together into a single part.

As shown in FIG. 14, a guide member 549 is attached to engine 12 by guide member retainer bracket 551. Guide member 549 is an elongated tube having an elongated bore 549c extending therethrough about axis 563. Guide member 549 has a first end 549a and a second end 549b. Link arm 545 extends through and is slidably engaged with bore 549c from second end 549b to first end 549a about axis 563.

The first end of link arm 545a extends from the first end of guide member 549a and is interconnected with a push/pull motion type lever 560. The lever 560 includes a push/pull motion knob 562, and a stop 572. Referring to FIG. 17, knob 562 is rotatably mounted on first end 545a such that knob 562 can generally rotate about axis 563. Knob 562 is a generally disc shaped member having a top edge 562a and a bottom edge 562b. A locking member 566 is mounted to the bottom edge 562b, and extends horizontally therefrom.

As shown in FIG. 17, the first end of guide member 549a acts as the stop 572 for lever 560. In other embodiments, a separate stop member can be employed.

Referring to FIG. 14, a locking bracket 568 is mounted to the engine 12 substantially adjacent to knob 562. Bracket 568 is a generally C-shaped member having a first arm 570, a second arm 572 and a web 574 interconnecting arms 570 and 572 respectively. First arm 570 is attached to the engine 12. Second arm 572 has a top surface 576 having a recess 578 therein as shown in FIGS. 17 and 18.

As shown in phantom in FIGS. 14 and 15, as the push/pull knob 562 is pulled out in relation to the stop 572, plunger 540 is advanced towards the intake end 534a of fuel nozzle 534 via link arm 545 and connecting member 542. When plunger 540 contacts or substantially contacts the intake end 534a of fuel nozzle 534, plunger 540 blocks or substantially blocks the flow of fuel into fuel nozzle 534, and is therefore in the stop or blocking position. As shown in FIGS. 17 and 18, and as shown in phantom in FIG. 14, the knob 562 can then rotated about axis 563 such that locking member 566 is engaged with locking bracket 568 and fits within recess 578. In this position, the plunger 540 is held substantially in the stop position.

To unlock the locking member, the knob is rotated such that locking member 566 does not engage the locking bracket 568. As shown in FIGS. 14 and 15, as the push/pull knob 562 is pushed-in in relation to the stop 572, plunger 540 is moved away from intake end 534a of fuel nozzle 534 via link arm 545 and connecting member 542. When plunger 540 is not in contact or in substantial contact with intake end 534a of fuel nozzle 534, plunger 540 does not block or substantially block fuel from flowing into fuel nozzle 534, and is therefore in the run or non-blocking position.

FIG. 16 depicts an ignition ground switch that may optionally be used with the sixth embodiment discussed above. In FIG. 16, ignition ground switch 668 is interconnected with the link arm lever assembly 652. In FIG. 16, the ground switch assembly includes an elongated tube shaped guide member 649 having an elongated bore 649c extending therethrough about axis 663. The guide member includes a second end 649b. The ground switch assembly may also include an interior surface 651 of bore 649a being coated

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with a non-conductive layer **653**. Non-conductive layer **653** can be made of rubber or plastic, or any other non-conductive material known in the art. Link arm **645** extends through and slidably engages the non-conductive layer within bore **649c** about axis **663**.

The ignition ground switch **668** includes an upper portion **680** and a lower portion **682**. Upper portion **680** includes an upper ground clip **684** attached to the second end of guide member **649b**. An upper engagement member **686** made of conductive material is attached to upper ground clip **684** and extends substantially horizontally from guide member **649**. The conductive material can include conductive metal known in the art, such as iron, steel, aluminum, and copper, or may include other conductive material. A ground wire **687** is connected to the engagement member **686** and extends to a grounding point **689**.

Lower portion **682** includes a lower ground clip **688** made of substantially non-conductive material attached to link arm **645**. Lower ground clip **688** is attached to link arm **645** at a point below guide member **649** such that when link arm **645** is in the stop or blocking position, the lower ground clip **688** nearly engages the second end **649b** of guide member **649**, and when link arm **645** is in the run or non-blocking position, the lower ground clip **688** is spaced substantially from the second end **649b** of guide member **649**. A substantially L-shaped lower engagement member **690** made of conductive material is attached to lower ground clip **688**. Lower engagement member **690** has a first, horizontally extending portion **691**, and a second vertically extending portion **693**. The conductive material can include conductive metal known in the art, such as iron, steel, aluminum, and copper, or may include other conductive material. An ignition wire **692** is connected to the engagement member **690**.

As shown in FIG. 16, when the link arm lever assembly **652** is in the stop or blocking position, the vertically extending portion **693** of lower engagement member **690** engages the upper engagement member **686**, and grounds the ignition system of the engine. When the link arm lever assembly **652** is in the run or non-blocking position, the vertically extending portion **693** of lower engagement member **690** does not engage the upper engagement member **686**, and the ignition system of the engine is not grounded.

While several embodiments of the present invention have been shown and described, other embodiments will be apparent to those skilled in the art and are within the intended scope of the present invention. The present invention includes any manually-operated means for blocking the flow of fuel or an air/fuel mixture, downstream of the fuel bowl and upstream of the engine intake valve upon engine shutdown. Therefore, the scope of the present invention is to be limited only by the following claims.

I claim:

1. A fuel shutoff system for an internal combustion engine, the engine having a carburetor with a fuel bowl and a fuel nozzle, a throttle valve, a fuel metering device for calibrating an air/fuel mixture, a fuel conduit communicating with the fuel bowl, and a fuel inlet pathway communicating with the fuel nozzle and having one end defined by at least one fuel inlet and another end defined by an inlet end of the fuel nozzle, the shutoff system comprising:

a blocking member distinct from the throttle valve and the fuel metering device, said blocking member being adjacent the fuel inlet pathway and being manually operable to selectively block entry of fuel into the inlet end of the fuel nozzle to substantially prevent passage of fuel through the fuel conduit; and

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a manually operable control that moves said blocking member to block entry of fuel into the inlet end of the fuel nozzle.

2. The fuel shutoff system of claim 1, wherein said blocking member is selectively positioned adjacent said fuel nozzle in a stop position wherein said blocking member blocks the fuel from flowing into the fuel nozzle, and in a run position wherein said blocking member allows the fuel to flow into the fuel nozzle.

3. The fuel shutoff system of claim 2, wherein said blocking member moves between said stop and run positions in a substantially vertical direction.

4. The fuel shutoff system of claim 2, wherein said blocking member comprises a plunger and wherein said plunger is positioned adjacent to said inlet end of said fuel nozzle when said plunger is in said stop position.

5. The fuel shutoff system of claim 1, wherein said manually operable control is positioned remote from said blocking member.

6. The fuel shutoff system of claim 5, wherein said manually operable control is actuated by a deadman switch.

7. The fuel shutoff system of claim 1, wherein said manually operable control includes

a lever;

a cam interconnected between said blocking member and said lever such that operation of said lever selectively moves said cam, said cam causing said blocking member to move between a stop position and a run position; and

an actuating assembly interconnecting said control and said blocking member.

8. The fuel shutoff system of claim 7, wherein said manually operable control comprises one of a rotary motion lever, a push-pull motion lever and a pushbutton.

9. The fuel shutoff system of claim 1, wherein said manually operable control includes

an actuator comprising at least one of a lever and a switch; and

a bowden cable interconnecting between said blocking member and said actuator;

wherein operation of said actuator selectively moves said blocking member between a stop position and a run position.

10. The fuel shutoff system of claim 9, wherein said switch is a deadman switch.

11. The fuel shutoff system of claim 9, wherein said manually operable control comprises one of a rotary motion lever, a push-pull motion lever and a pushbutton.

12. The fuel shutoff system of claim 1, wherein said engine also has a throttle control lever that includes said manually operable control.

13. A fuel shutoff system for an internal combustion engine, the engine having a carburetor with a fuel bowl, a throttle valve, a fuel conduit communicating with the fuel bowl and including a fuel nozzle and a throat through which a gas may pass to an intake valve of the engine, and a fuel inlet pathway communicating with the fuel nozzle and having one end defined by at least one fuel jet and another end defined by an inlet end of the fuel nozzle, the shutoff system comprising:

a blocking member adjacent the fuel inlet pathway and manually operable to selectively block entry of fuel into the inlet end of the fuel nozzle to substantially prevent passage of fuel through the fuel conduit, said blocking member being positioned such that no portion of said blocking member intersects the throat.

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14. The fuel shutoff system of claim 13, wherein the carburetor further includes a fuel metering device and said blocking member is distinct from the fuel metering device.

15. The fuel shutoff system of claim 13, wherein said blocking member is selectively positioned adjacent the inlet 5 end in a stop position wherein said blocking member blocks the fuel from flowing into the fuel nozzle, and in a run position wherein said blocking member allows the fuel to flow into the fuel nozzle, said blocking member being positioned such that no portion of said blocking member is in the inlet end when said blocking member is in said run position. 10

16. The fuel shutoff system of claim 15, wherein said blocking member moves between said stop and run positions in a substantially vertical direction. 15

17. The fuel shutoff system of claim 15, wherein said blocking member comprises a plunger and wherein said plunger is positioned adjacent said inlet end of said fuel nozzle when said plunger is in said stop position.

18. The fuel shutoff system of claim 13, further including a manually operable control for actuating said blocking member to block the fuel conduit. 20

19. The fuel shutoff system of claim 18, wherein said manually operable control is positioned remote from said blocking member.

20. The fuel shutoff system of claim 19, wherein said manually operable control is actuated by a deadman switch. 25

21. The fuel shutoff system of claim 18, wherein said manually operable control includes

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a lever;

a cam interconnected between said blocking member and said lever such that operation of said lever selectively moves said cam, said cam causing said blocking member to move between a stop position and a run position; and

an actuating assembly interconnecting said control and said blocking member.

22. The fuel shutoff system of claim 21, wherein said manually operable control comprises one of a rotary motion lever, a push-pull motion lever and a pushbutton.

23. The fuel shutoff system of claim 18, wherein said manually operable control includes

an actuator comprising at least one of a lever and a switch; and

a bowden cable interconnected between said blocking member and said actuator;

wherein operation of said actuator selectively moves said blocking member between a stop position and a run position.

24. The fuel shutoff system of claim 23, wherein said manually operable control comprises one of a rotary motion lever, a push-pull motion lever and a pushbutton.

25. The fuel shutoff system of claim 18, wherein said engine also has a throttle control lever that includes said manually operable control.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 6,213,083 B1
DATED : April 10, 2001
INVENTOR(S) : James R. Winberg

Page 1 of 1

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

Column 13,

Line 59, delete "fuel inlet" and insert -- fuel jet --.

Column 14,

Line 65, delete "blowing" and insert -- blocking --.

Signed and Sealed this

Twenty-third Day of April, 2002

Attest:

A handwritten signature in black ink, appearing to read "James E. Rogan", with a long horizontal flourish extending from the bottom of the signature.

Attesting Officer

JAMES E. ROGAN
Director of the United States Patent and Trademark Office

EXHIBIT 1014