CATERPILLAR®

FORM NO. SENR3078

Specifications
Systems Operation
Testing & Adjusting

3500 Series Engines
Hydramechanical
Protective System

⚠ WARNING

IMPORTANT SAFETY NOTICE

Proper repair is important to the safe and reliable operation of this product. This Service Manual outlines basic recommended procedures, some of which require special tools, devices or work methods. Although not necessarily all inclusive, a list of additional skills, precautions and knowledge required to safely perform repairs is provided in the SAFETY section of this Manual.

Improper repair procedures can be dangerous and could result in injury or death.

READ AND UNDERSTAND ALL SAFETY PRECAUTIONS AND WARNINGS BEFORE PERFORMING REPAIRS

Basic safety precautions, skills and knowledge are listed in the SAFETY section of this Manual and in the descriptions of operations where hazards exist. Warning labels have also been put on to provide instructions and identify specific hazards which if not heeded could cause bodily injury or death to you or other persons. These labels identify hazards which may not be apparent to a trained mechanic. There are many potential hazards during repair for a untrained mechanic and there is no way to label the product against all such hazards. These warnings in the Service Manual and on the product are identified by this symbol:

⚠ WARNING

Operations that may result only in mechanical damage are identified by labels on the product and in the Service Manual by the word **NOTICE.**

Caterpillar can not anticipate every possible circumstance that might involve a potential hazard. The warnings in this Manual are therefore not all inclusive. If a procedure, tool device or work method not specifically recommended by Caterpillar is used, you must saftisfy yourself that it is safe for you and others. You should also ensure that the product will not be damaged or made unsafe by the procedures you choose.

IMPORTANT

The information, specifications and illustrations in this book are on the basis of information available at the time it was written. The specifications, torque, pressures of operation, measurements, adjustments, illustrations and other items can change at any time. These changes can affect the service given to the product. Get the complete and most current information before you start any job. Caterpillar Dealers have the most current information available. For a list of the most current modules and form numbers available for each Service Manual, see the SERVICE MANUAL CONTENTS MICROFICHE REG1139F.

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INDEX

SPECIFICATIONS

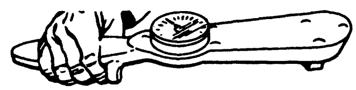
SYSTEMS OPERATION

TESTING AND ADJUSTING

SHUTOFF CONTROL GROUP IDENTIFICATION					
Engine Model		3508, 3512, 3516			
Rated Engine RPM		900-1100	1101-1300	1301-1650	1651-1800
Shutoff Control Group	OS*	5N6050	5N6051	5N5338	5N5608
	LOP,* HWT, OS	5N5328	5N5329	5N5330	5N1960

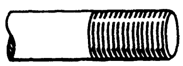
*OS - Overspeed
LOP - Low Oil Pressure
HWT - High Water Temperature

GENERAL TIGHTENING TORQUE FOR BOLTS, NUTS AND TAPERLOCK STUDS



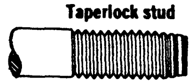
The following charts give the standard torque values for bolts, nuts and taperlock studs of SAE Grade 5 or better quality. Exceptions are given in other sections of the Service Manual where needed.

Standard thread



Use these torques for bolts and nuts with standard threads (conversions are approximate).

THREAD DIAMETER		STANDARD TORQUE	
inches	**millimeters**	**lb. ft.**	**N·m***
1/4	6.35	9 ± 3	12 ± 4
5/16	7.94	18 ± 5	25 ± 7
3/8	9.53	32 ± 5	45 ± 7
7/16	11.11	50 ± 10	70 ± 15
1/2	12.70	75 ± 10	100 ± 15
9/16	14.29	110 ± 15	150 ± 20
5/8	15.88	150 ± 20	200 ± 25
3/4	19.05	265 ± 35	360 ± 50
7/8	22.23	420 ± 60	570 ± 80
1	25.40	640 ± 80	875 ± 100
1 1/8	28.58	800 ± 100	1100 ± 150
1 1/4	31.75	1000 ± 120	1350 ± 175
1 3/8	34.93	1200 ± 150	1600 ± 200
1 1/2	38.10	1500 ± 200	2000 ± 275
		Use these torques for bolts and nuts on hydraulic valve bodies.	
5/16	7.94	13 ± 2	20 ± 3
3/8	9.53	24 ± 2	35 ± 3
7/16	11.11	39 ± 2	50 ± 3
1/2	12.70	60 ± 3	80 ± 4
5/8	15.88	118 ± 4	160 ± 6
Taperlock stud		Use these torques for studs with Taperlock threads.	
1/4	6.35	5 ± 2	7 ± 3
5/16	7.94	10 ± 3	15 ± 5
3/8	9.53	20 ± 3	30 ± 5
7/16	11.11	30 ± 5	40 ± 10
1/2	12.70	40 ± 5	55 ± 10
9/16	14.29	60 ± 10	80 ± 15
5/8	15.88	75 ± 10	100 ± 15
3/4	19.05	110 ± 15	150 ± 20
7/8	22.23	170 ± 20	230 ± 30
1	25.40	260 ± 30	350 ± 40
1 1/8	28.58	320 ± 30	400 ± 40
1 1/4	31.75	400 ± 40	550 ± 50
1 3/8	34.93	480 ± 40	650 ± 50
1 1/2	38.10	550 ± 50	750 ± 70



***1 newton meter (N·m) is approximately the same as 0.1 mkg.**

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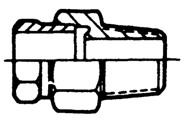
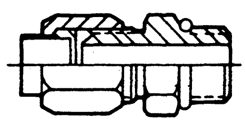
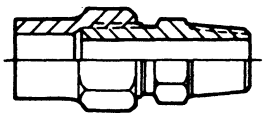
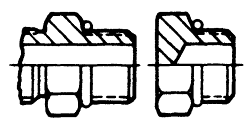
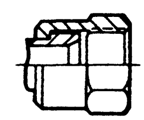
TORQUE FOR FLARED AND O-RING FITTINGS

The torques shown in the chart that follows are to be used on the part of 37° Flared, 45° Flared and Inverted Flared fittings (when used with steel tubing), O-ring plugs and O-ring fittings.

 INVERTED 45° FLARED	 37° FLARED	 45° FLARED	 O-RING FITTING – PLUG	 SWIVEL NUTS

TUBE SIZE (O.D.)						
mm	3.18	4.78	6.35	7.92	9.52
in.	.125	.188	.250	.312	.375
THREAD SIZE (in.)	5/16	3/8	7/16	1/2	9/16 5/8
TORQUE N·m	5 ±1	11 ±1	16 ±2	20 ±2	25 ±3
TORQUE lb.in.	45 ±10	100 ±10	145 ±20	175 ±20	225 ±25

TUBE SIZE (O.D.)								
mm	12.70	15.88	19.05	22.22	25.40	31.75	38.10	50.80
in.	.500	.625	.750	.875	1.000	1.250	1.500	2.000
THREAD SIZE (in.)	3/4	7/8	1 1/16	1 3/16 1 1/4	1 5/16	1 5/8	1 7/8	2 1/2
TORQUE N·m	50 ±5	75 ±5	100 ±5	120 ±5	135 ±10	180 ±10	225 ±10	320 ±15
TORQUE lb.ft.	35 ± 4	55 ± 4	75 ± 4	90 ± 4	100 ± 7	135 ± 7	165 ± 7	235 ± 10

ASSEMBLY OF FITTINGS WITH STRAIGHT THREADS AND O-RING SEALS

1. Put locknut (3), backup washer (4) and O-ring seal (5) as far back on fitting body (2) as possible. Hold these components in this position. Turn the fitting into the part it is used on, until backup washer (4) just makes contact with the face of the part it is used on.

NOTE: If the fitting is a connector (straight fitting) or plug, the hex on the body takes the place of the locknut. To install this type fitting tighten the hex against the face of the part it goes into.

2. To put the fitting assembly in its correct position turn the fitting body (2) out (counterclockwise) a maximum of 359°. Tighten locknut (3) to the torque shown in the chart.

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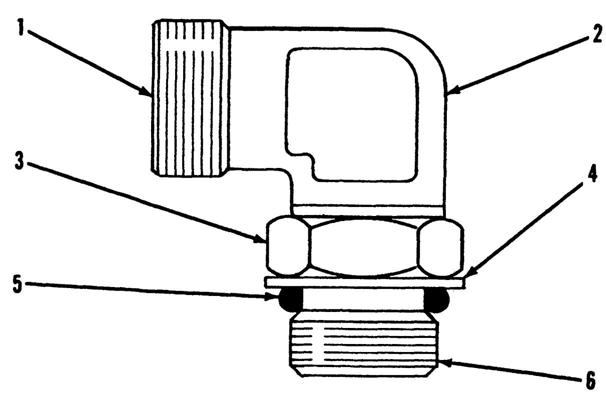
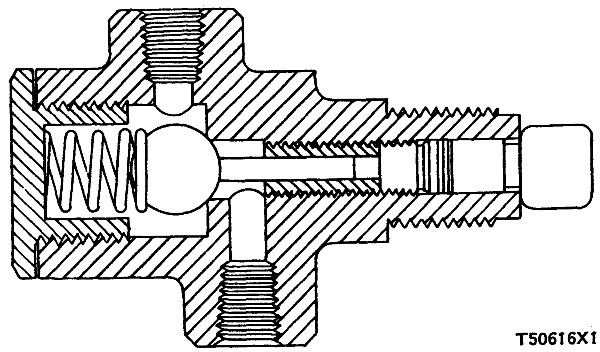


ELBOW BODY ASSEMBLY

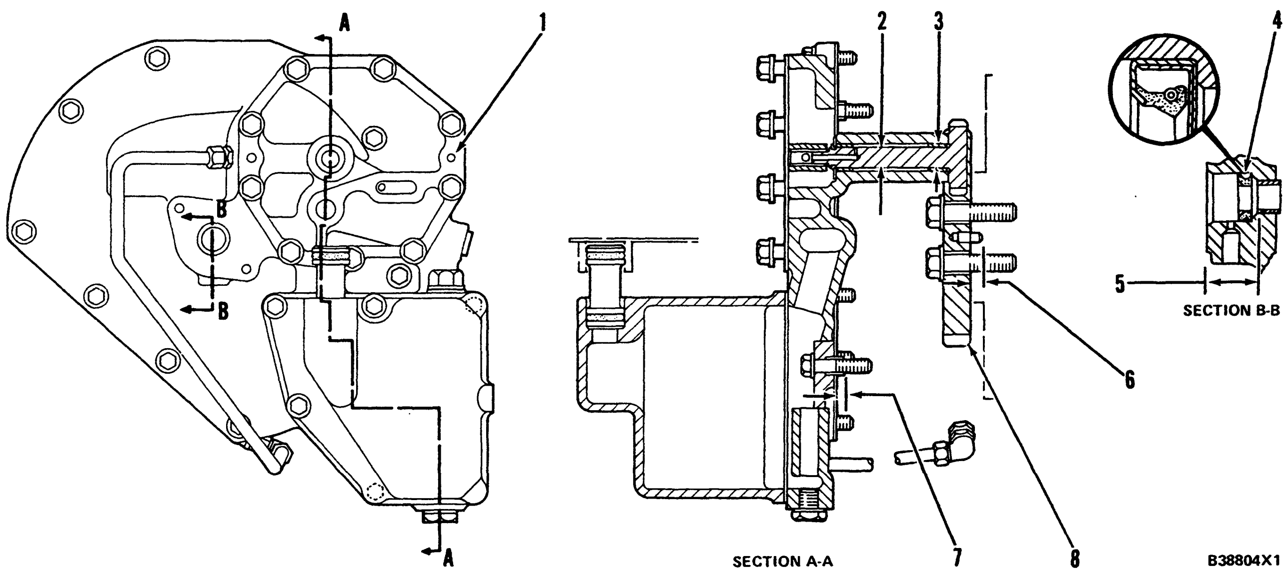
1. End of fitting body (connects to tube). 2. Fitting body. 3. Locknut. 4. Backup washer. 5. O-ring seal. 6. End of fitting that goes into other part.

THERMOSTATIC PILOT VALVE
(4L7108)

Temperature at which valve opens .... 99 ± 2°C (210 ± 3°F)



ACCESSORY (SHUTOFF) DRIVE GROUP



(1) Distance dowels extend from housing .... 6.0 ± 0.5 mm (.236 ± .020 in.)

(2) Diameter of gear shaft (new) .... 15.890 ± 0.013 mm (.6256 ± .0005 in.)

Bore in bearings for gear shaft .... 16.027 ± 0.013 mm (.6310 ± .0005 in.)

(3) Diameter of bearings .... 20.70 ± 0.013 mm (.8150 ± .0005 in.)

Bore in housing for the bearings .... 20.66 ± 0.03 mm (.813 ± .001 in.)

Distance bearings are installed from ends of bore .... 1.5 ± 0.5 mm (.059 ± .020 in.)

(4) Install the seal with the lip toward the engine as shown. Put clean engine oil on the lip of the seal.

(5) Distance bearing is installed .... 26 ± 1 mm (1.02 ± .04 in.)

(6) Distance dowels extend from gear .... 9.5 ± .0.5 mm (.374 ± .020 in.)

(7) Distance two dowels extend from housing .... 6.0 ± 0.5 mm (.236 ± .020 in.)

(8) Drive gear. Tighten the bolts that hold drive gear (8) and the camshaft drive gear as follows:

a. Pin both camshafts and put the camshaft drive gear in position on camshaft taper. For correct timing, all gear clearance (backlash) must be removed. Turn the camshaft drive gear in the same direction as crankshaft rotation and hold in this position.

b. Install drive gear (8) to hold camshaft drive gear to the camshaft.

c. Tighten the bolts in steps to a torque of 100 ± 15 N•m (75 ± 11 lb.ft.).*

d. Hit the face of drive gear (8) and tighten the bolts to a torque of 100 ± 15 N•m (75 ± 11 lb.ft.).*

e. Again hit the face of drive gear (8) and again tighten the bolts to a torque of 100 ± 15 N•m (75 ± 11 lb.ft.).*

*NOTE: On later engines with one bolt camshaft drive gears, the correct torque is .... 360 ± 50 N•m (265 ± 35 lb.ft.)

NOTE: If necessary, repeat the steps above until the bolts hold torque (cannot be moved) to make sure the camshaft drive gear is in full contact with the taper of the camshaft.

NOTE: FOR TORQUE VALUES NOT GIVEN, SEE THE FIRST PAGE OF SPECIFICATIONS FOR GENERAL TIGHTENING TORQUES

SHUTOFF CONTROL GROUP

(1) Torque for 6K9194 Elbow .... 11 ± 3 N•m (8 ± 2 lb.ft.)

(2) Torque for 321267 Connectors .... 11 ± 3 N•m (8 ± 2 lb.ft.)

(3) Torque for 5M6213 Plugs .... 11 ± 3 N•m (8 ± 2 lb.ft.)

(4) Torque for 321268 Elbows .... 11 ± 3 N•m (8 ± 2 lb.ft.)

(5) Spring for overspeed adjustment: See OVERSPEED SPRING CHART.

OVERSPEED SPRING CHART			
Part No.	**7B7714**	**2N7029**	**5N5297**
Length under test force	18.3 mm (.72 in.)	31.0 mm (1.22 in.)	20.3 mm (.80 in.)
Test force	34.7 to 40.9 N (7.8 to 9.2 lb.)	18 N (4 lb.)	16 ± .05 N (3.6 ± .1 lb.)
Free length after test	33.7 mm (1.33 in.)	50.0 mm (1.97 in.)	37.3 mm (1.47 in.)
Outside diameter	11.94 mm (.470 in.)	9.53 mm (.375 in.)	9.22 mm (.363 in.)
Used with Shutoff Control Group	5N1960 5N5608	5N5329 5N6051	5N5328 5N5330 5N5338 5N6050

(6) Dimension from end of speed sensing valve to the seat .... 117.21 ± 0.25 mm (4.615 ± .010 in.)

(7) Torque for eight cover bolts .... 3.4 ± 0.5 N•m (31 ± 4 lb.in.)

(8) Speeder Spring: See SPEEDER SPRING CHART.

(9) Thickness of geroter assembly .... 25.000 ± 0.006 mm (.9843 ± .0002 in.)

Depth of counterbore .... 25.033 ± 0.006 mm (.9856 ± .0002 in.)

(10) Diameter of shaft .... 14.750 ± 0.013 mm (.5807 ± .0005 in.)

Diameter of bore in cover .... 14.801 ± 0.013 mm (.5827 ± .0005 in.)

(11) Diameter of shaft .... 12.000 ± 0.013 mm (.4724 ± .0005 in.)

Diameter of bore in housing .... 12.051 ± 0.013 (.4744 ± .0005 in.)

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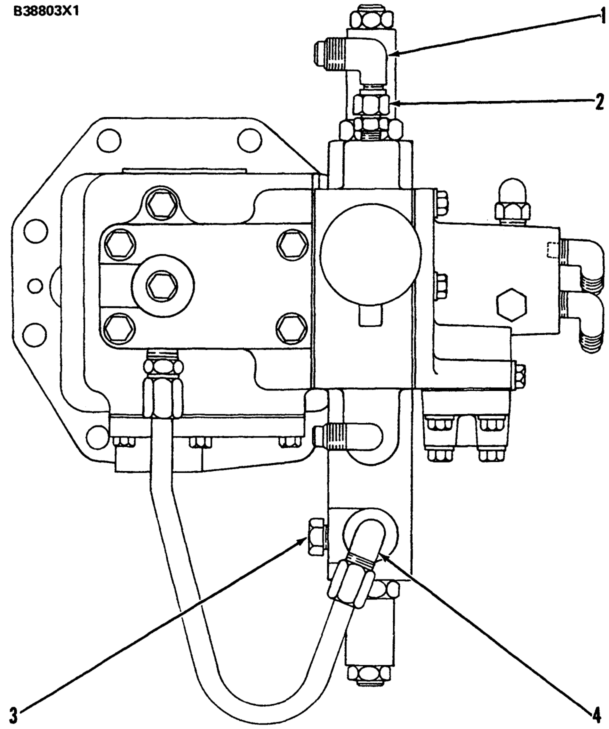

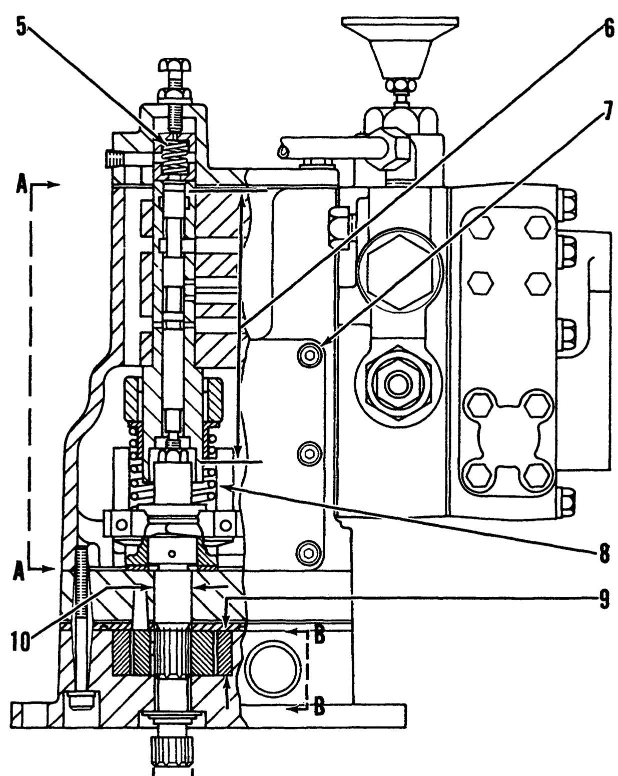

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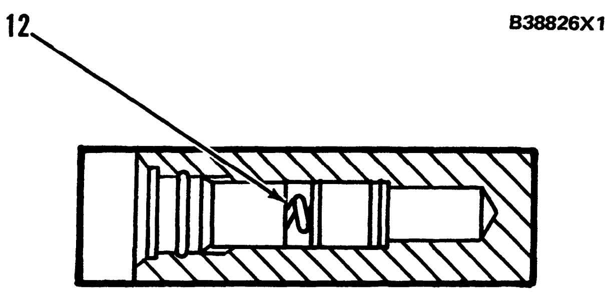
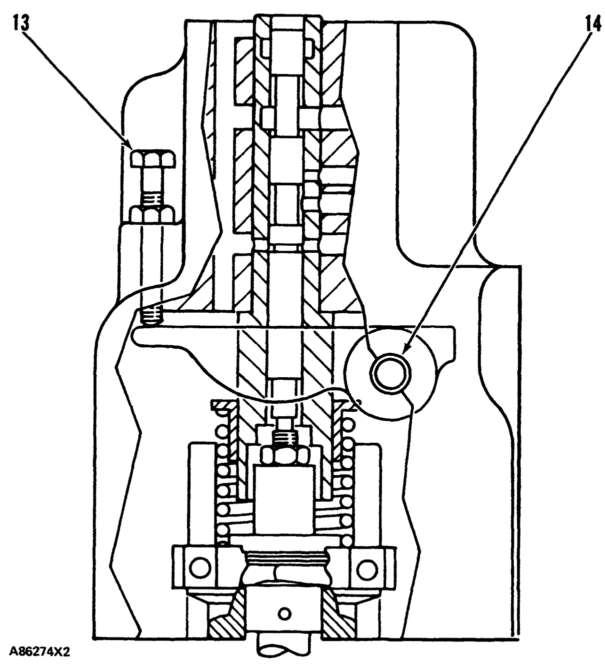
Shutoff Control Group (Cont.)

SPEEDER SPRING CHART					
Spring Part No.	8M1682	3N5751	3N8403	5N5296	6N2129
Put a force on spring of	–	–	–	–	8.9 N (2.00 lb.)
Then add more force to make spring shorter by	–	–	–	–	17.8 mm (.70 in.)
Total test force	–	–	–	–	36.92 ± 0.89 N (8.307 ± .200 lb.)
Length under test force	15.8 mm (.62 in.)	38.2 mm (1.50 in.)	38.2 mm (1.50 in.)	38.2 mm (1.50 in.)	–
Test force	44.5 ± 3.6 N (10 ± .8 lb.)	14.2 N (3.2 lb.)	6.23 N (1.4 lb.)	8.01 N (1.8 lb.)	–
Free length after test	41.2 mm (1.62 in.)	45.0 mm (1.77 in.)	41.2 mm 1.62 in.)	45.72 mm (1.80 in.)	44.2 ± 0.5 mm (1.74 ± .02 in.)
Outside diameter	35.33 mm (1.391 in.)	35.00 mm (1.378 in.)	35.00 mm (1.378 in.)	34.60 mm (1.362 in.)	37.84 mm (1.490 in.)
Used with Shutoff Control Group	5N6051	5N1960 5N5608	5N5330 5N5338	5N5328 5N5060	5N5329



SECTION B-B



VIEW A-A

(12) 5N6449 Spring for oil pump relief valve:
- Length under test force .... 41.25 mm (1.624 in.)
- Test force .... 226.9 N (51 lb.)
- Free length after test .... 53.37 mm (2.101 in.)
- Outside diameter .... 10.59 mm (.417 in.)

(13) Speeder spring adjustment bolt used with two step oil pressure protection function.

(14) Install shaft so end is even with side of housing within .... ± 0.25 mm (± .010 in.)

NOTE: FOR TORQUE VALUES NOT GIVEN, SEE THE FIRST PAGE OF SPECIFICATIONS FOR GENERAL TIGHTENING TORQUES

Shutoff Control Group (Cont.)

(15) 3N5757 Spring for selector valve:
- Length under test force .... 25.50 mm (1.004 in.)
- Test force .... 9.8 N (2.20 lb.)
- Free length after test .... 37.69 mm (1.484 in.)
- Outside diameter .... 8.81 mm (.347 in.)

(16) 3N5738 Spring for low range oil pressure valve:
- Length under test force .... 30.17 mm (1.188 in.)
- Test force .... 39.1 N (8.79 lb.)
- Free length after test .... 66.62 mm (2.623 in.)
- Outside diameter .... 12.62 mm (.497 in.)

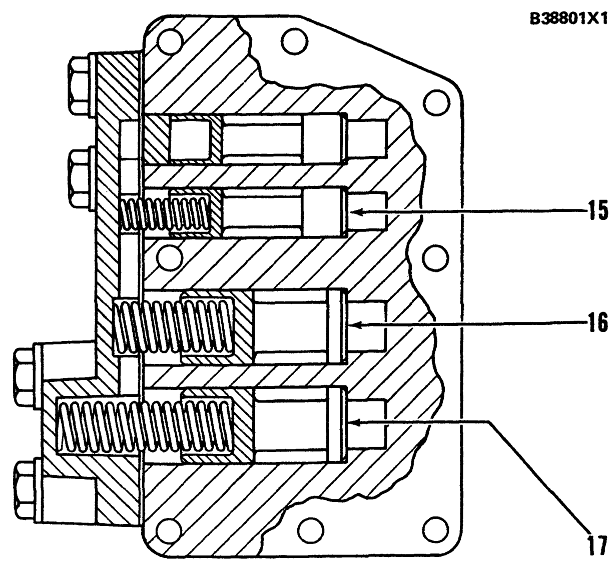
(17) 3N5739 Spring for high range oil pressure valve:
- Length under test force .... 44.45 mm (1.750 in.)
- Test force .... 68.9 N (15.5 lb.)
- Free length after test .... 111.56 mm (4.392 in.)
- Outside diameter .... 11.99 mm (.472 in.)

(18) 5N5755 Fuel (Rack) Shutoff Circuit Sequence Valve:
- Tighten valve to a torque of .... 58 ± 4 N•m (43 ± 3 lb.ft.)
- Set valve to bypass at .... 806 ± 28 kPa (117 ± 4 psi)
- at .... 7.57 liter/min (2 U.S. gpm)

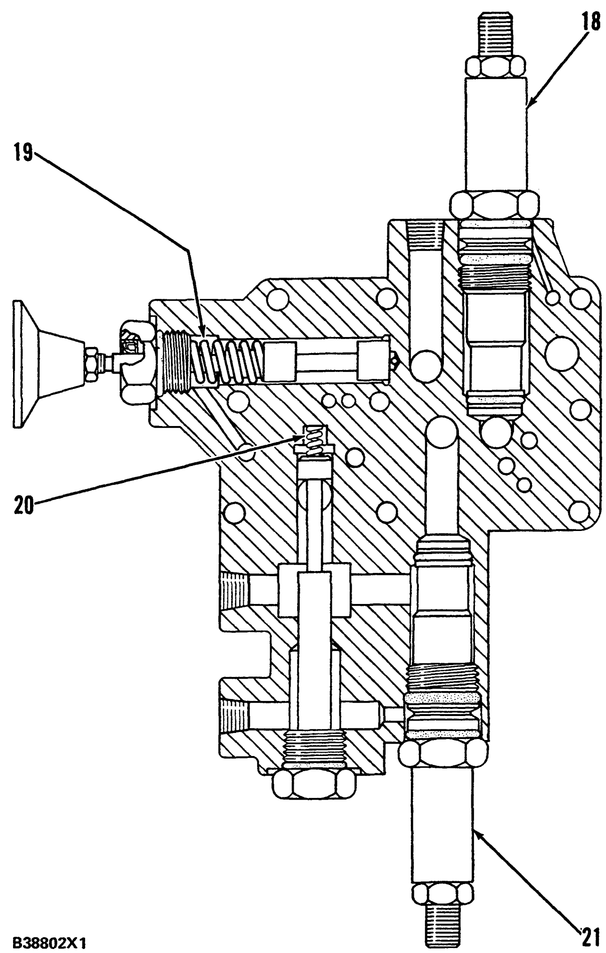
(19) 5N6096 Spring for manual shutoff valve:
- Length under test force .... 25.50 mm (1.004 in.)
- Test force .... 19.6 N (4.4 lb.)
- Free length after test .... 48.77 mm (1.920 in.)
- Outside diameter .... 13.82 mm (.544 in.)

(20) 8H8731 Spring for pilot valve:
- Length under test force .... 17.86 mm (.703 in.)
- Test force .... 4.3 N (.95 lb.)
- Free length after test .... 22.23 mm (.875 in.)
- Outside diameter .... 5.94 mm (.234 in.)

(21) 5N4749 Air Inlet Shutoff Circuit Sequence Valve:
- Tighten valve to a torque of .... 58 ± 4 N•m (43 ± 3 lb.ft.)
- Set valve to bypass at .... 103 ± 14 kPa (15 ± 2 psi)

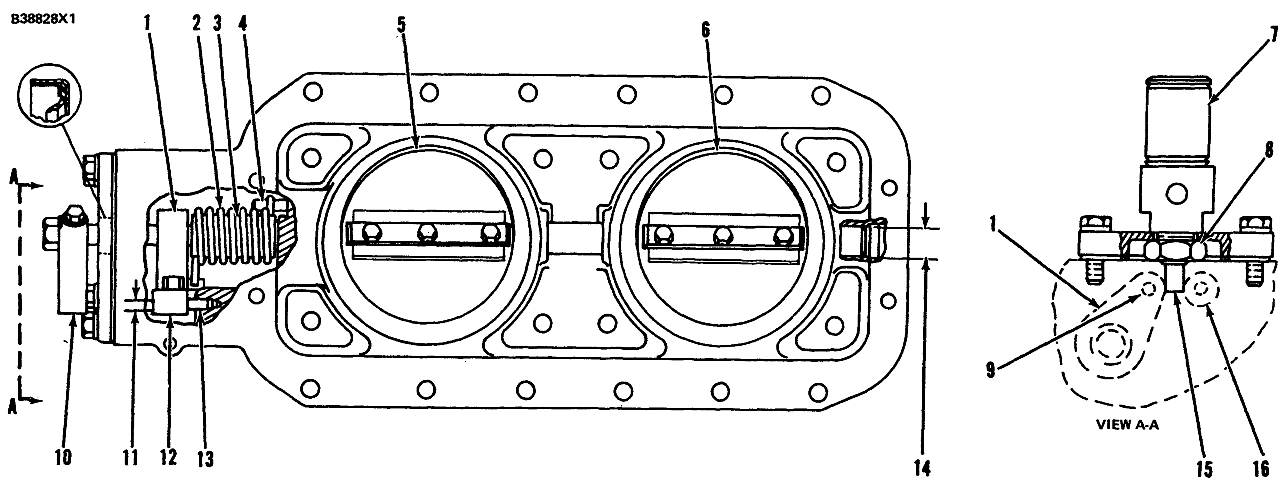


ACTUATOR VALVE



PRESSURE CONTROL VALVE

AIR INTAKE SHUTOFF
(5N9060)



(1) Install shaft assembly in housing as follows:

a. Install spacer (3) and spring (2) on shaft assembly (1).

b. Install the assembly in the housing. Turn spring (2) until it engages correctly with pin (4).

c. Install handle (10) on the shaft assembly (1). Turn shaft assembly (1) upward and install pin (13) so handle (10) can rest on pin (13).

d. With the shaft assembly and handle (10) in contact with pin (13), install plate assemblies (5) and (6) on the shaft assembly.

e. Remove pin (13) to release the handle and let plate assemblies (5) and (6) move to the "shutoff" position. A 0.08 mm (.003 in.) feeler gauge should not pass between each plate assembly and the housing.

f. Remove handle (10) and install spacer assembly (12), pin (13), the gasket, cover assembly and handle(10).

(2) Spring.

(3) Spacer for spring (2):

Bore in spacer for shaft .... 20.80 ± 0.25 mm (.819 ± .010 in.)

Diameter of shaft .... 18.94 ± 0.02 mm (.746 ± .001 in.)

(4) Pin.

(5) Plate assembly.

(6) Plate assembly.

(7) Hydraulic cylinder must be installed before the air shutoff can be installed on the engine. Put the air shutoff group in the "open" position and install the gasket, flange and cylinder with cylinder shaft (15) between the spacer assembly in the shaft lever and spacer assembly (16). The bolts that hold the unit to the aftercooler housing can now be installed.

(8) Torque for nut that holds cylinder to flange .... 45 ± 7 N•m (33 ± 5 lb.ft.)

(9) Diameter of pin .... 6.299 ± 0.008 mm (.2480 ± .0003 in.)

Bore in spacer bushing for pin (after assembly) .... 6.314 ± 0.011 mm (.2486 ± .0004 in.)

Bore in spacer for bushing .... 7.938 ± 0.013 mm (.3125 ± .0005 in.)

(10) Handle.

(11) Diameter of pin (13) .... 6.299 ± 0.008 mm (.2480 ± .0003 in.)

Bore in housing for pin .... 6.408 ± 0.051 mm (.2523 ± .0020 in.)

Bore in spacer bushing for pin (after assembly) .... 6.314 ± 0.011 mm (.2486 ± .0004 in.)

Bore in spacer for bushing .... 7.938 ± 0.013 mm (.3125 ± .0005 in.)

(12) Spacer.

(13) Pin.

(14) Diameter of shaft .... 18.94 ± 0.02 mm (.746 ± .001 in.)

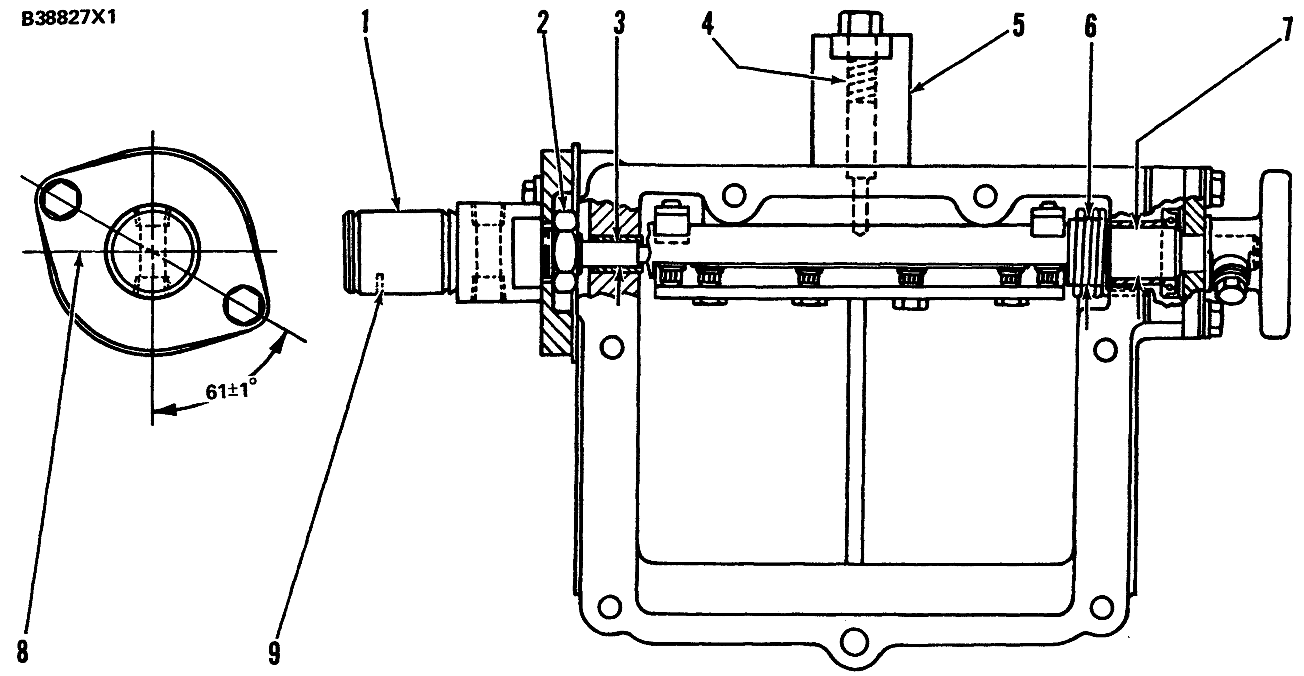
Inside diameter of bushings for shaft .... 19.050 ± 0.044 mm (.7500 ± .0017 in.)

(15) Hydraulic cylinder shaft.

(16) Spacer assembly.

NOTE: FOR TORQUE VALUES NOT GIVEN, SEE THE FIRST PAGE OF SPECIFICATIONS FOR GENERAL TIGHTENING TORQUES

AIR INTAKE SHUTOFF
(2W7163)



(1) Hydraulic shutoff cylinder. Make an alignment of cylinder port and vent hole (9) in a vertical downward position at assembly.

(2) Torque for nut that holds cylinder (1) to the flange .... 45 ± 7 N•m (33 ± 5 lb.ft.)

(3) Diameter of cylinder rod .... 7.920 ± 0.013 (.3118 ± .0005 in.)

Bore in bushing after assembly .... 7.996 ± 0.044 mm (.3148 ± .0017 in.)

Bore in housing for bushing .... 9.525 ± 0.013 mm (.3750 ± .0005 in.)

Install bushing with split along centerline (8) toward front or rear.

(4) 2V244 Spring for shutoff actuator pin:

Length under test force .... 29.2 mm (1.15 in.)

Test force .... 8.9 ± 0.7 N (2.00 ± .16 lb.)

Free length after test .... 54.6 mm (2.15 in.)

Outside diameter .... 9.04 mm (.356 in.)

(5) Torque for carrier (put 2P2506 Thread Lubricant on the threads) .... 70 ± 10 N•m (50 ± 7 lb.ft.)

(6) Bore in spring bushing .... 19.30 ± 0.25 mm (.760 ± .010 in.)

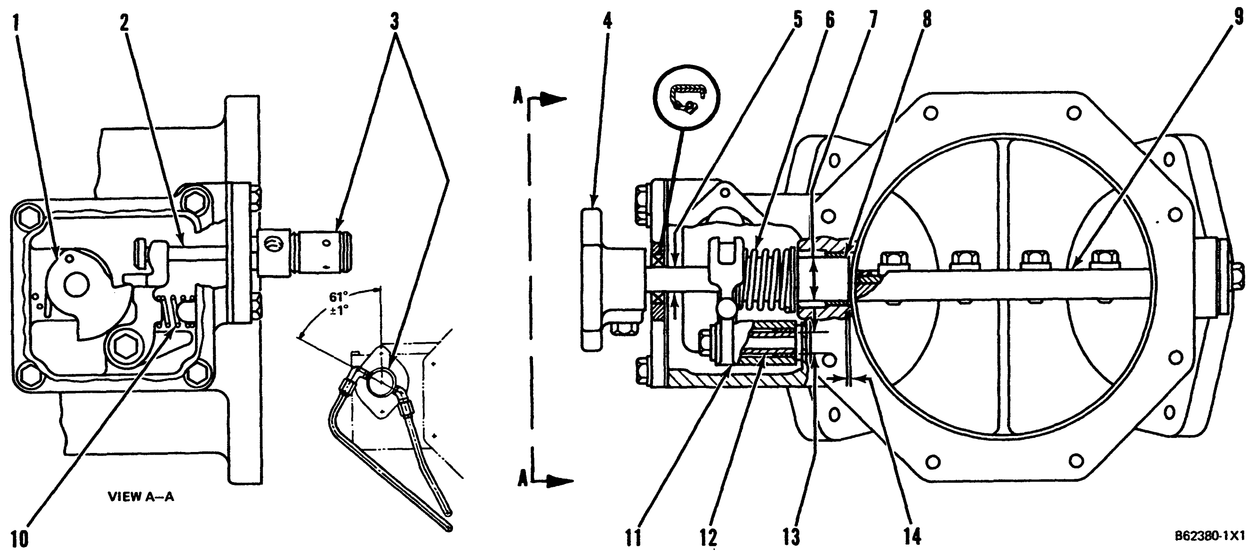
Diameter of shaft .... 18.97 ± 0.02 mm (.747 ± .001 in.)

(7) Diameter of shaft .... 18.97 ± 0.02 mm (.747 ± .001 in.)

Bore in two shaft bushings (after assembly) .... 19.050 ± 0.044 mm (.7500 ± .0017 in.)

Bore in housing for bushings .... 22.205 ± 0.013 mm (.8742 ± .0005 in.)

AIR INTAKE SHUTOFF
(2W5216)



(1) Latch.

(2) Shutoff cylinder rod.

(3) Install shutoff cylinder as follows:

a. Assemble shutoff cylinder on the flange at the angle shown.

b. Tighten the nut that holds the shutoff cylinder to the flange to a torque of .... 45 ± 7 N•m (33 ± 5 lb.ft.)

c. Install the flange on the air shutoff housing. Make sure cylinder rod (2) is engaged in the notch of lever (11).

NOTE: The cylinder vent hole, between the ports, must be in the downward position.

(4) Knob.

(5) Diameter of shaft assembly at seal .... 15.88 ± 0.05 mm (.625 ± .002 in.)

(6) Air shutoff spring.

(7) Diameter of shaft assembly .... 24.88 ± 0.02 mm (.980 ± .001 in.)

Bore in bushings for shaft assembly (after assembly) .... 25.017 ± 0.040 mm (1.0035 ± .0016 in.)

Bores in housing for bearings .... 27.997 ± 0.010 mm (1.1230 ± .0004 in.)

(8) Shaft assembly.

(9) Plate assembly.

NOTE: With plate assembly (9) in the closed (shutoff) position, a 0.8 mm (.03 in.) feeler gauge must not pass between the plate assembly and the housing bore at any position.

(10) Lever return spring.

(11) Lever.

(12) Sleeve.

(13) Diameter of sleeve .... 14.945 ± 0.009 mm (.5995 ± .0004 in.)

Bore in bushing (after assembly) .... 15.024 ± 0.034 mm (.6026 ± .0014 in.)

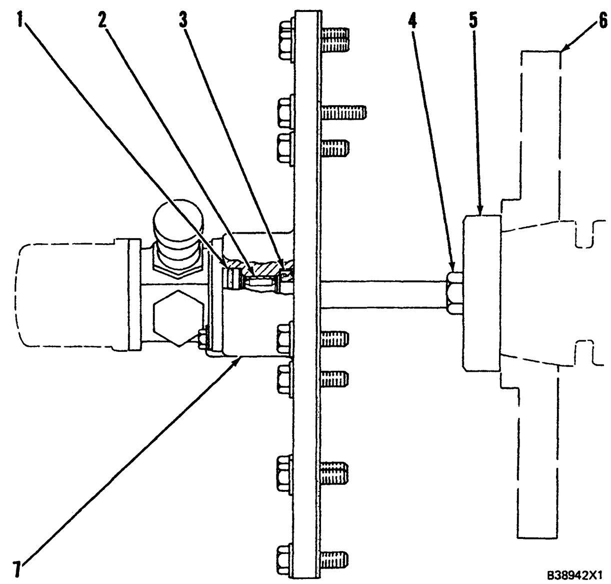
Bore in lever for bushing .... 17.009 ± 0.009 mm (.6823 ± .0004 in.)

NOTE: Install both bushings to a dimension of 0.8 ± 0.3 mm (.03 ± .01 in.) below the surface of lever ends.

(14) Dimension to install end of two bushings from machined housing bore .... 0.35 ± 0.15 mm (.014 ± .006 in.)

NOTE: FOR TORQUE VALUES NOT GIVEN, SEE THE FIRST PAGE OF SPECIFICATIONS FOR GENERAL TIGHTENING TORQUES

TACHOMETER AND SERVICE METER DRIVE



(1) Put clean engine oil or glycerin on the O-ring seal at assembly.

(2) Bearing.

(3) Install seal in cover (7) with the lip of the seal toward bearing (2). Put clean engine oil on the lip of the seal after it is installed.

(4) Tighten bolts in steps to a torque of .... 100 ± 15 N•m (75 ± 11 lb.ft.)

Hit face of adapter (5) and tighten bolts in steps to a torque of .... 100 ± 15 N•m (75 ± 11 lb.ft.)

Again hit face of adapter (5) and again tighten bolts in steps to a torque of .... 100 ± 15 N•m (75 ± 11 lb.ft.)

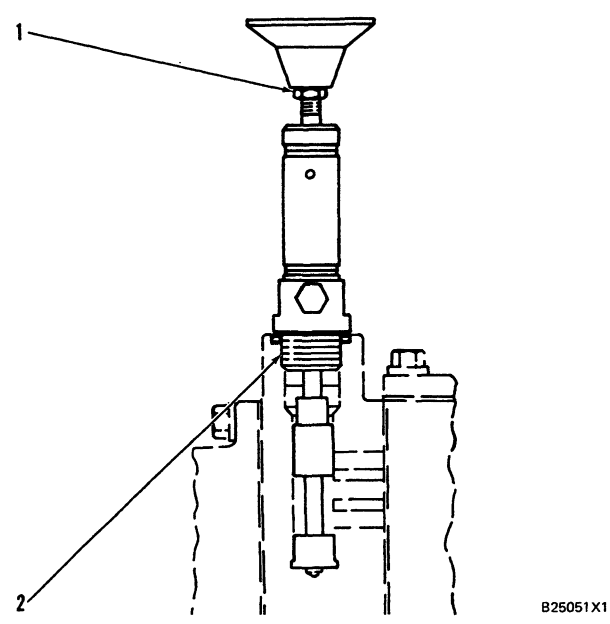
NOTE: On later engines with one bolt camshaft drive gears, the correct torque is .... 360 ± 50 N•m (265 ± 35 lb.ft.)

(5) Tachometer drive adapter.

(6) Camshaft drive gear.

(7) Cover.

REMOTE SHUTOFF VALVE GROUP



(1) Locknut.

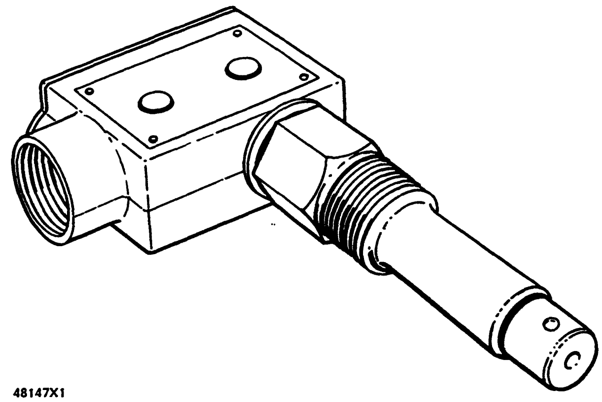
(2) Cylinder threads.

Clean threads of cylinder and locknut (1) thoroughly. Put 9S3265 Retaining Compound on threads of cylinder and locknut at assembly.

ELECTRICAL SWITCHES

5N8597 Contactor (Coolant)

Switch operates when temperature increases
to .... 98.3 ± 0.6°C (208 ± 1°F)



48147X1

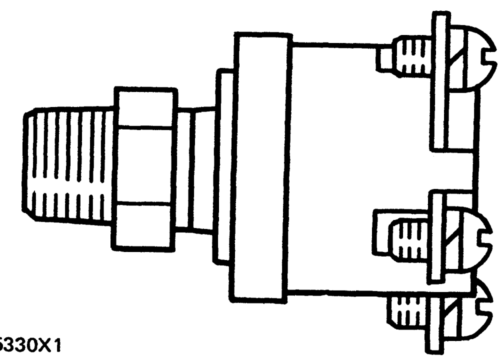
7N5946 Pressure Switch

Circuit 1: normally closed

Circuit 2: normally open

With an increase in pressure, circuit 1 opens and circuit 2 closes at .... 145 kPa (21 psi) max.

With a decrease in pressure, circuit 2 opens and circuit 1 closes at .... 75 ± 20 kPa (11 ± 3 psi)

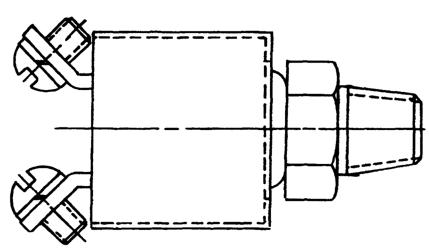


A65330X1

9D7032 Pressure Switch

With an increase in pressure, switch closes
at .... 517 ± 35 kPa (75 ± 5 psi)

With a decrease in pressure, switch opens
at .... 415 ± 35 kPa (60 ± 5 psi)



A18826X1

NOTE: FOR TORQUE VALUES NOT GIVEN, SEE THE FIRST PAGE OF SPECIFICATIONS FOR GENERAL TIGHTENING TORQUES

HYDRAMECHANICAL PROTECTIVE SYSTEM

The hydramechanical protective system is designed as a self contained system separate from the engine governor. This system is used to activate an alarm or shutdown an engine for low oil pressure, high coolant temperature or engine overspeed conditions.

OVERSPEED

In general, an overspeed condition is the result of a fuel system that fails to operate correctly. This in turn allows the combustion system to get more fuel than the engine load needs. The excess fuel can accelerate the engine to a point that engine failure can be the result.

The rate of engine acceleration is controlled by several factors. Friction horsepower, attached inertial loads and operating loads make up the main affects on acceleration. In most all cases, the protective system must have a response time of less than one second. Response time is the time interval between the overspeed and the actuation of the protective system. The protective system must provide this response under different conditions such as engine start up at extreme ambient temperatures and under full load operation.

For an overspeed condition the fuel control linkage is moved to the "SHUTOFF" position and the engine combustion air supply is stopped.

LOW ENGINE OIL PRESSURE

As engine speed increases, the required oil pressure for main bearing protection increases. The engine oil pump is a positive displacement type pump, therefore, engine oil pressure varies in direct proportion to speed until the pump goes on controlled bypass.

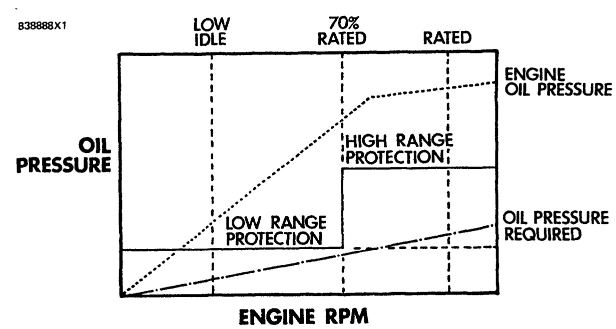


FIGURE 1. TWO-STEP OIL PRESSURE PROTECTION

From Figure 1, it can be seen that if only the low range oil pressure protection level was used for the full speed range, the engine could operate at rated speed with oil pressure below the required level. Also, if only the high range oil pressure protection level was used for the full speed range, the system would shutdown the engine at low idle, since the engine oil pump develops lower pressure at that speed. Therefore, the protective system must operate between the required oil pressure curve and the engine oil pressure curve. This is done with a step action of pressure versus speed.

The hydramechanical protective system operates within the two ranges of engine oil pressure. As engine speed increases, the minimum oil pressure needed at the main bearings also increases. At low engine speed, an alarm or fuel shutoff actuator will activate when oil pressure is reduced to within 140 ± 35 kPa (20 ± 5 psi). At high engine speeds, an alarm or fuel shutoff actuator will activate when oil pressure is reduced to within 205 ± 35 kPa (30 ± 5 psi).

For a low oil pressure condition, the protective system activates an alarm or moves the fuel control linkage, through the governor, to the "SHUTOFF" position. The combustion air supply is not shutoff for this condition.

HIGH COOLANT TEMPERATURE

If the coolant temperature of an engine goes above a set limit, the protective system activates an alarm or moves the fuel control linkage to the "SHUTOFF" position to shutdown the engine. The combustion air supply is not stopped under this condition.

SYSTEM COMPONENTS

The system consists of an emergency manual shutoff, a shutoff control group, a diverter valve, a thermostatic pilot valve, an air inlet shutoff and a fuel shutoff actuator for the governor.

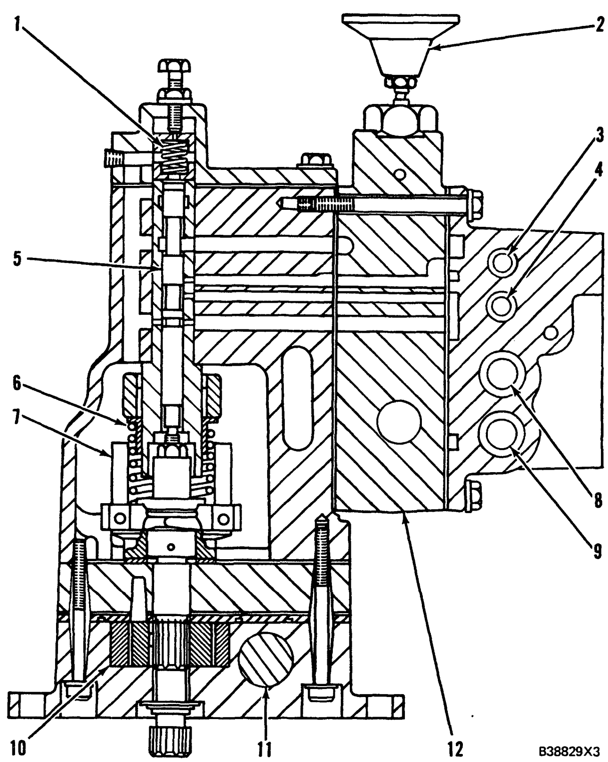
The air and fuel shutoff systems are separate from each other to give complete engine shutdown for an overspeed condition. If the engine fuel is held in the "ON" position, the air inlet shutoff must work to shutdown the engine.

Emergency Manual Shutoff

This shutoff is used under emergency conditions to shutdown the engine manually. When operated, this shutoff simulates an engine overspeed condition in the protective system. Thus, the air and fuel to the combustion chambers is stopped. The shutoff is also used to check the protective system for correct operation at regular engine maintenance periods.

The emergency manual shutoff can be operated at the engine or from a remote location. For remote operation, either air or electric power can be used.

Shutoff Control Group



SHUTOFF CONTROL GROUP

1. Spring for overspeed adjustment. 2. Emergency manual shutoff valve. 3. Valve spool (not used). 4. Selector valve. 5. Speed sensing valve spool. 6. Speeder spring. 7. Flyweights. 8. Low speed oil protection valve. 9. High speed oil protection valve. 10. Oil pump. 11. Oil pressure relief valve. 12. Pressure control valve group which consists of: the fuel and air inlet sequence valves, the two-way pilot operated valve and emergency manual shutoff valve (2).

A flyweight controlled, speed sensing valve spool is used to feel engine speed. The speed sensing valve spool is moved by flyweights which are turned by a drive shaft. The drive shaft is driven by the engine camshaft through an accessory drive group that has an oil reservoir for the shutoff system. When engine speed increases, the flyweights move out and push the speed sensing valve spool out to open and close passages to put oil pressure into the correct system circuits. This gives correct protective system operation under the two engine oil pressure ranges.

Diverter Valve

If there is a low oil pressure, high coolant temperature or engine overspeed condition, the diverter valve moves to put system oil pressure in the fuel shutoff circuit. This moves the governor and fuel control linkage to the "SHUTOFF" position to shutdown the engine.

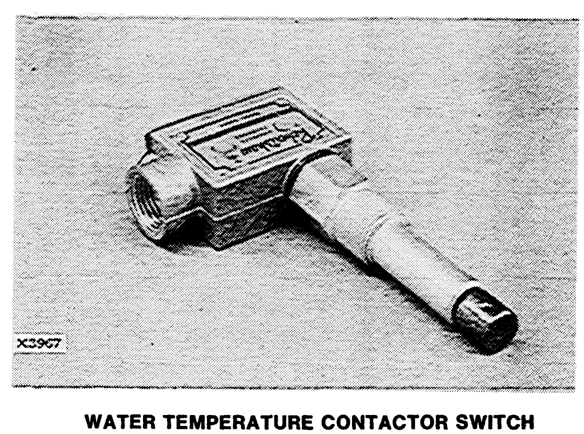
Thermostatic Pilot Valve

This valve is used to feel engine coolant temperature. If the coolant temperature goes above the limit of the thermostatic pilot valve, the valve opens and causes engine shutdown through the fuel shutoff circuit of the protective system.

Water Temperature Contactor

The contactor switch for water temperature is installed in the water manifold housing (below the regulator housing). This is normally where the thermostatic pilot valve is installed. No adjustment to the temperature range of the contactor can be made. The element feels the temperature of the coolant and then operates a micro switch (in the contactor) when the coolant temperature is too high. The element must be in contact with the coolant to operate correctly. If the cuase for the engine being too hot is because of low coolant level or no coolant, the contactor switch will not operate.

The switch is connected to an alarm system and activates an alarm under high coolant temperature conditions. When the temperature of the coolant lowers to the operating range, the contactor switch opens automatically.



WATER TEMPERATURE CONTACTOR SWITCH

Air Inlet Shutoff

The air inlet shutoff consists of a shutoff valve in the engine air inlet housing and a hydraulic actuator that holds the shutoff valve in the "OPEN" position.

If an engine is operated in a combustible atmosphere, such as an oil or gas blow out on an oil rig, the air supply must be stopped to give a positive method of engine shutdown. If only the fuel control linkage was moved to the "SHUTOFF" position, the engine may continue to run on the air-oil-gas mixture pulled into the engine air intake.

The hydramechanical protective system closes the air inlet shutoff valve to stop combustion air supply to the engine in an overspeed condition, to give a more positive shutdown. The air inlet shutoff valve is also closed when the emergency manual shutoff is operated.

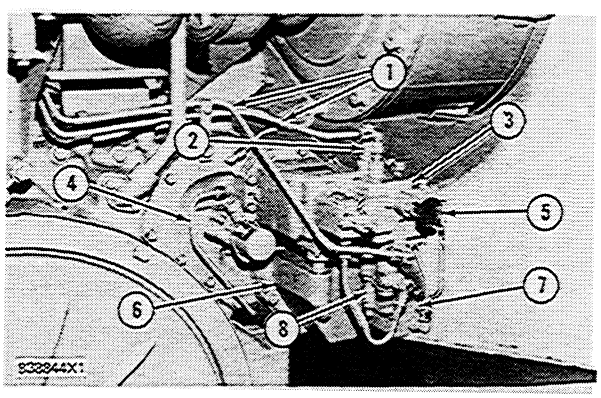
Since overspeed is a serious occurrence, the air inlet shutoff must be manually reset. This action requires a person to physically go to the engine and see if any damage has occurred.

Fuel Shutoff Actuator

This actuator is located on top of the Woodward UG-8 or the Caterpillar 3161 Governor. The actuator can be either an electric or hydraulic actuator that is operated any time the hydramechanical protective system causes engine shutdown.

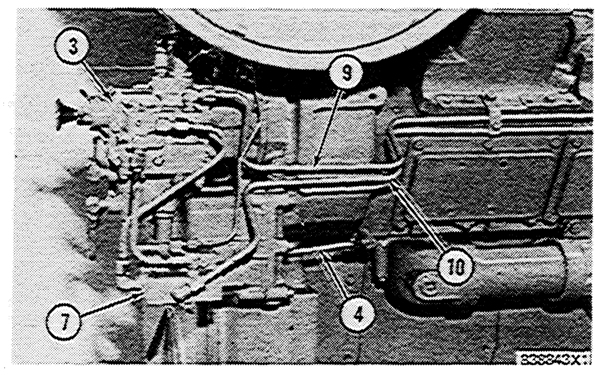
When operated by the diverter valve, the actuator moves the governor shutoff strap which causes the governor to move the engine fuel control linkage to the "SHUTOFF" position.

COMPONENT LOCATIONS ON ENGINE



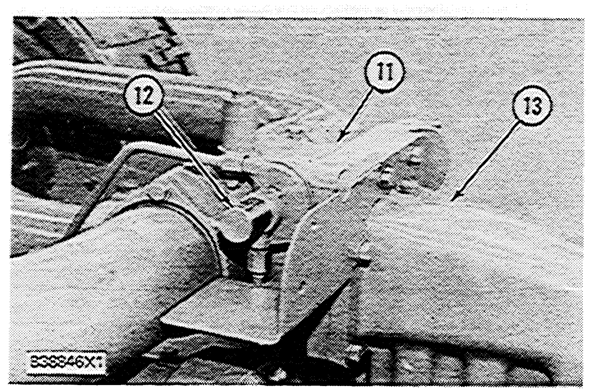
SHUTOFF CONTROL GROUP

1. Oil lines to air inlet shutoff actuator. 2. Rack sequence valve. 3. Shutoff control group. 4. Engine oil pressure line. 5. Emergency manual shutoff valve. 6. Cover (oil reservoir). 7. Diverter valve. 8. Air inlet sequence valve.



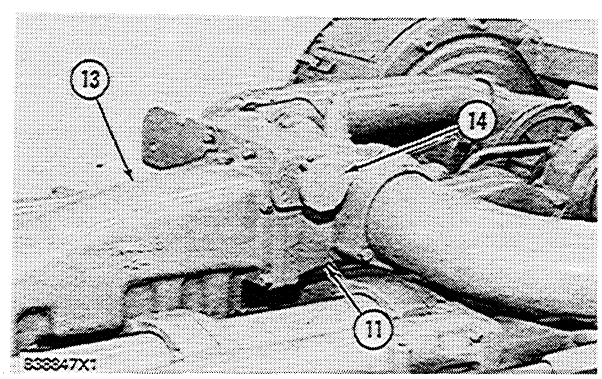
SHUTOFF CONTROL GROUP

3. Shutoff control group. 4. Engine oil pressure line. 7. Diverter valve. 9. Oil line to thermostatic pilot valve. 10. Oil line to fuel shutoff actuator.



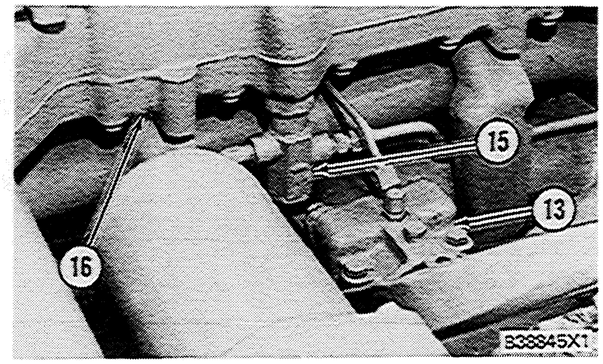
AIR INLET SHUTOFF

11. Air inlet shutoff housing. 12. Air inlet shutoff actuator. 13. Aftercooler housing.



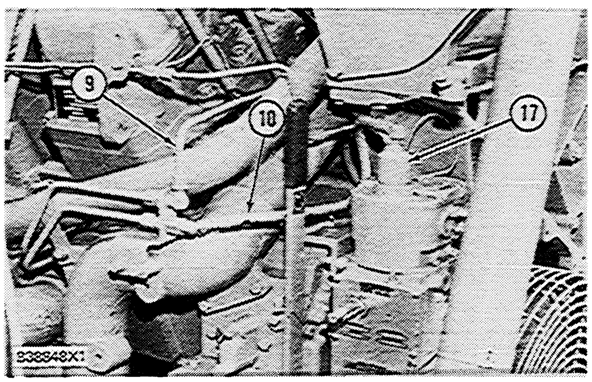
AIR INLET SHUTOFF

11. Air inlet shutoff housing. 13. Aftercooler housing. 14. Reset knob.



COOLANT TEMPERATURE PROTECTION

13. Aftercooler housing (coolant inlet). 15. Thermostatic pilot valve. 16. Housing (below regulator housing).



GOVERNOR SHUTOFF ACTUATOR
(Woodward UG-8 Governor Shown)

9. Oil line to thermostatic pilot valve. 10. Oil line to fuel shutoff actuator. 17. Fuel shutoff actuator.

SYSTEM HYDRAULICS

Engine lubrication oil (under pressure) is sent to the oil reservoir for the shutoff control. The reservoir keeps the correct level of oil for the system and drains the excess oil back into the engine. This gives a constant oil supply to the system.

An oil pump and pressure relief valve (located in the shutoff control group) supplies oil flow and pressure for the protective system hydraulic circuits.

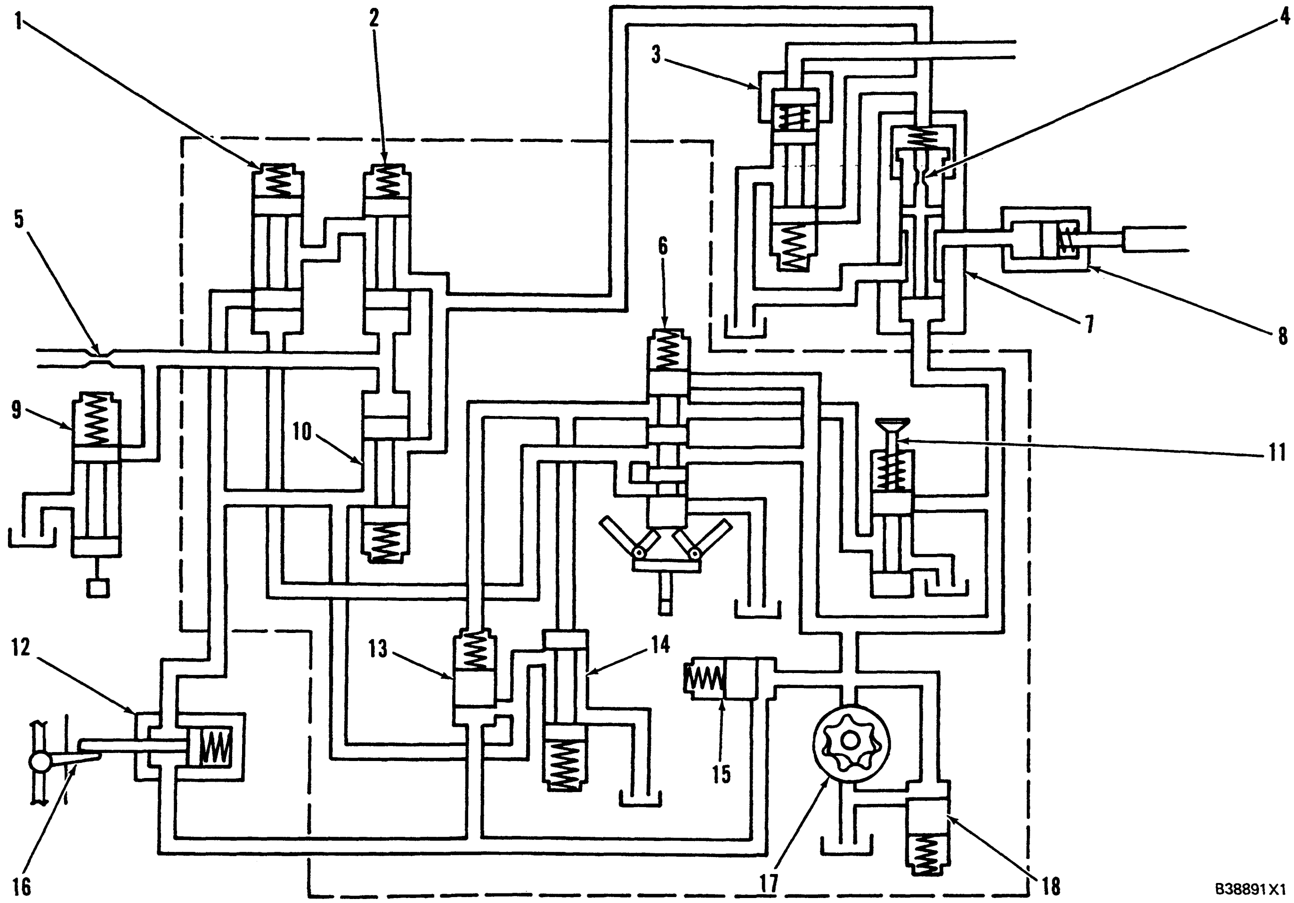
There are two main hydraulic circuits in the protective system. One circuit is for the fuel shutoff and the other is for air inlet shutoff. A constant flow of oil through the air inlet shutoff circuit removes (bleeds) air and keeps the lines full of oil to give a minimum time for system response. If a fault condition occurs, the oil pressure in one or both hydraulic circuits is increased to operate an actuator to shutdown an engine or activate an alarm.

HYDRAULIC CIRCUITS (EARLIER)

(Without Check Valves In Diverter Valve)

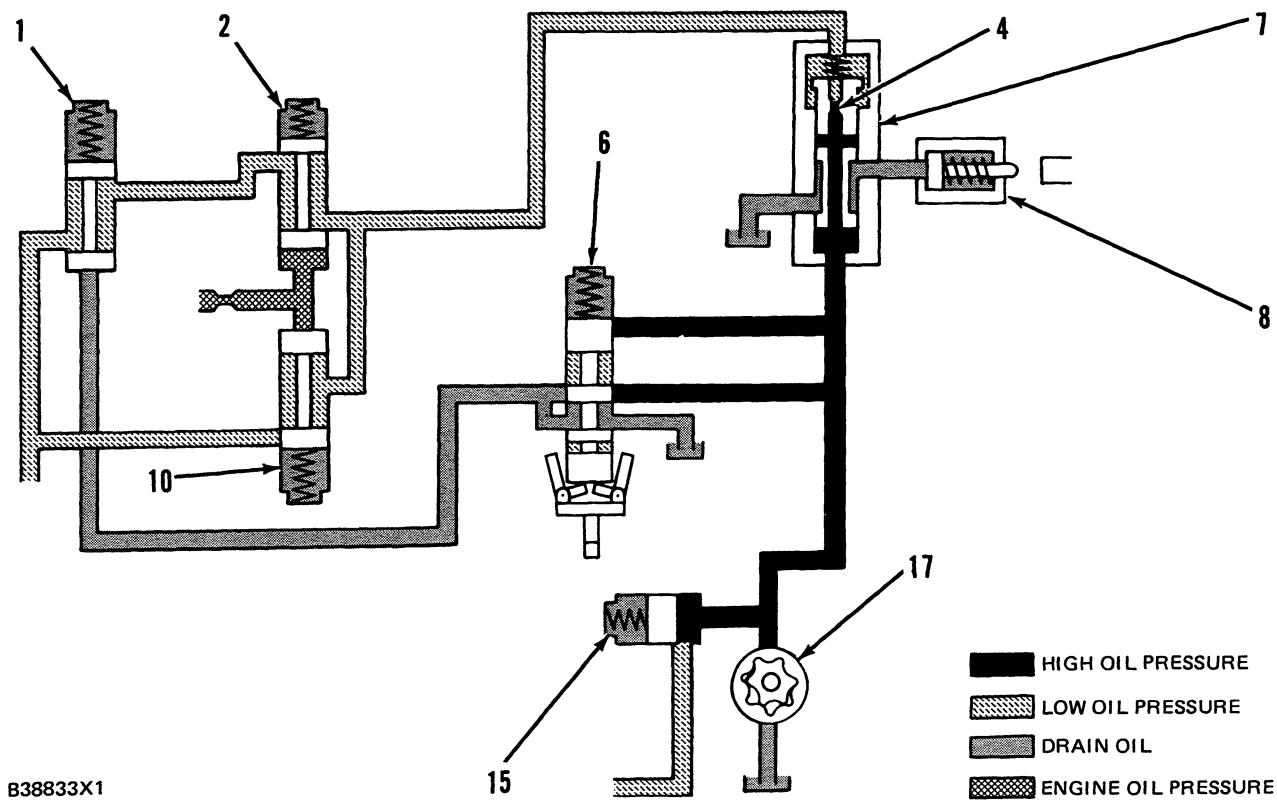
The schematics that follow, show only hydraulic actuators that are filled to cause engine shutdown. The fuel shutoff actuator can be replaced with an electric solenoid that is operated by the system hydraulics with the use of a pressure switch.

NOTE: Some of the schematics show only the components needed for explanation and do not show the complete hydramechanical protective system circuits.



SCHEMATIC NO. 1 (COMPLETE HYDRAMECHANICAL PROTECTIVE SYSTEM)

1. Selector valve. 2. Low speed oil protection valve. 3. Start-up override valve. 4. Diverter valve orifice. 5. Engine oil pressure orifice. 6. Speed sensing valve spool. 7. Diverter valve. 8. Fuel shutoff actuator. 9. Thermostatic pilot valve. 10. High speed oil protection valve. 11. Emergency manual shutoff valve. 12. Air inlet shutoff actuator. 13. Air inlet sequence valve. 14. Pilot operated two-way valve. 15. Fuel shutoff sequence valve. 16. Air inlet shutoff valve. 17. Oil pump. 18. Oil pressure relief valve.



SCHEMATIC NO. 2 (LOW ENGINE OIL PRESSURE CIRCUIT)
(Low Speed Range)

1. Selector valve. 2. Low speed oil protection valve. 4. Diverter valve orifice. 6. Speed sensing valve spool. 7. Diverter valve. 8. Fuel shutoff actuator. 10. High speed oil protection valve. 15. Fuel shutoff sequence valve. 17. Oil pump.

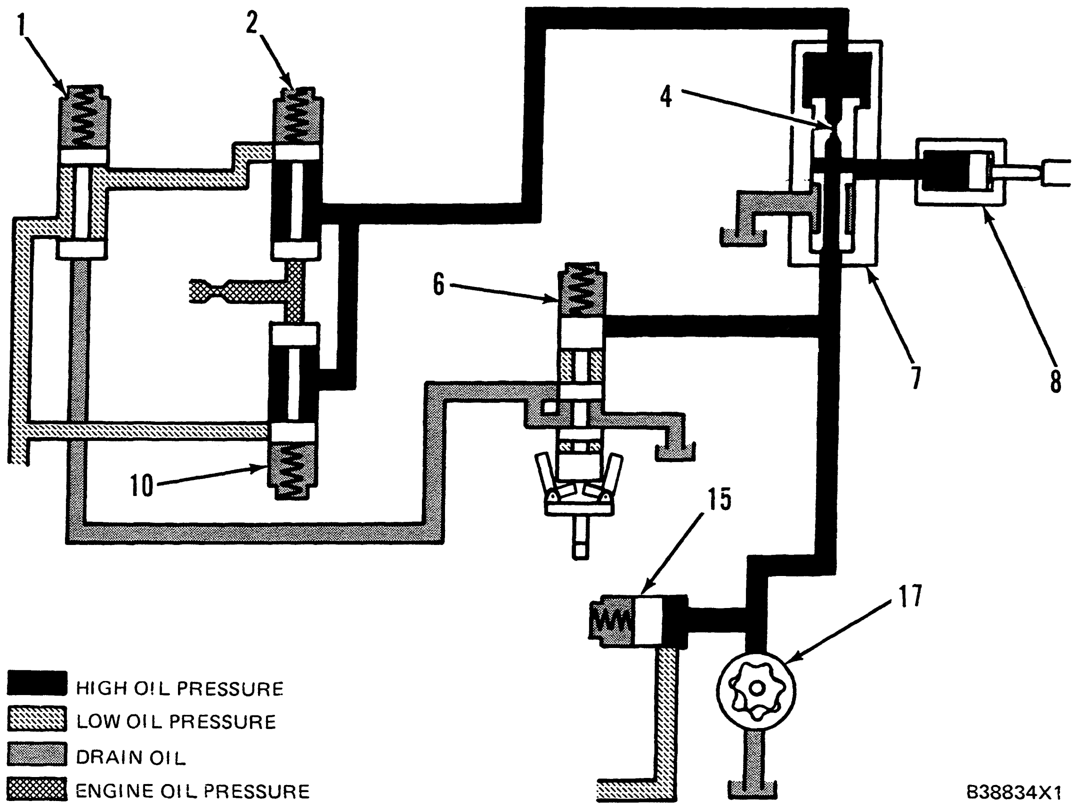
LOW SPEED RANGE (NORMAL ENGINE OIL PRESSURE)

Make Reference to Schematic No. 2

When an engine is started and speed increases, engine oil pressure moves low speed oil protection valve (2) open. At the same time, oil in the protective system flows from oil pump (17) to fuel shutoff sequence valve (15) and diverter valve (7). Fuel shutoff sequence valve (15) keeps the inlet pressure to diverter valve (7) at 760 kPa (110 psi) and then directs the remainder of oil flow through the air inlet shutoff circuit. Most of the air inlet shutoff circuit has been left out since it is not directly in use at this point.

At diverter valve (7), the oil flows through orifice (4) which causes a pressure difference across both ends of the valve spool. The valve spool is then moved by system oil pressure, against a spring force, to keep the fuel shutoff actuator from being operated. The oil then flows from diverter valve (7) to drain through low speed oil protection valve (2) and selector valve (1).

NOTE: Engine oil pressure is not high enough at this point to move valve (10) against the force of the spring.



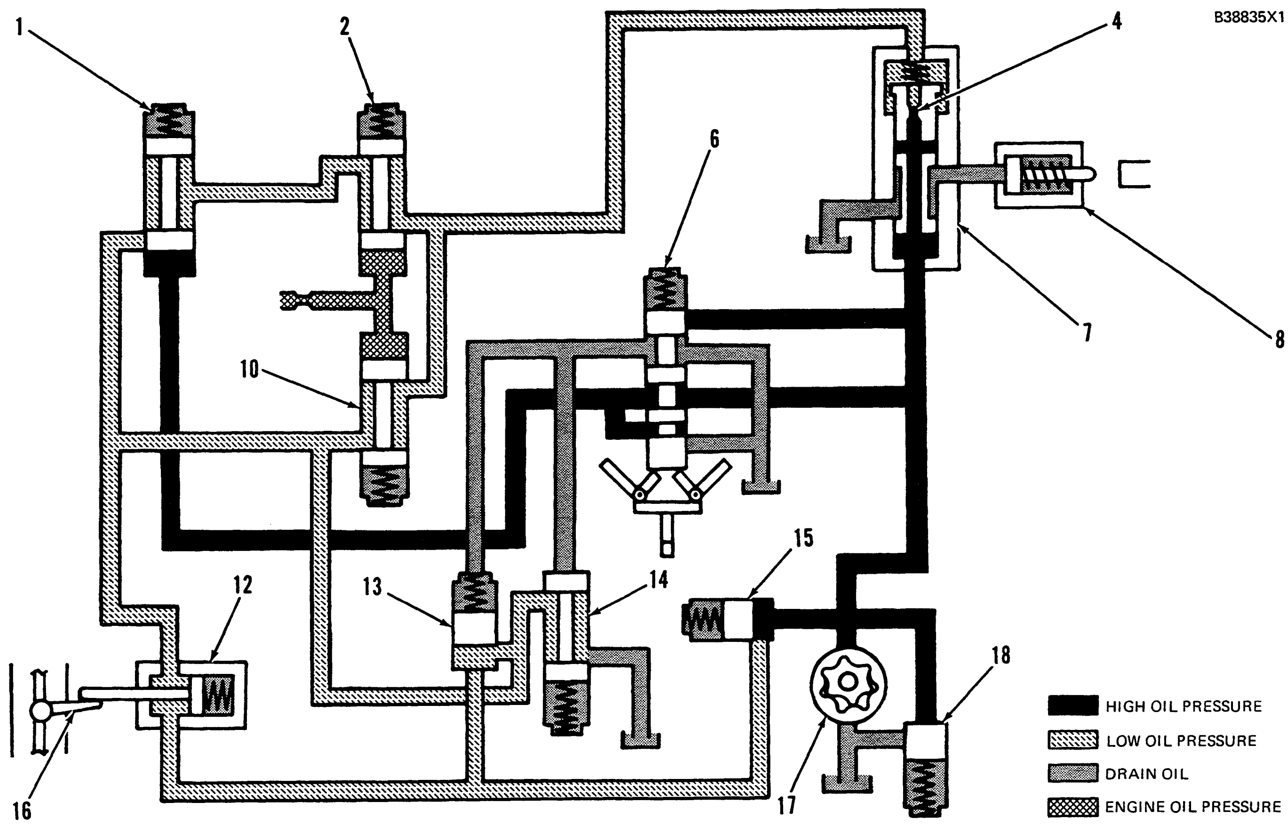
SCHEMATIC NO. 3 (LOW ENGINE OIL PRESSURE FAULT)
(Low Speed Range)

1. Selector valve. 2. Low speed oil protection valve. 4. Diverter valve orifice. 6. Speed sensing valve spool. 7. Diverter valve. 8. Fuel shutoff actuator. 10. High speed oil protection valve. 15. Fuel shutoff sequence valve. 17. Oil pump.

LOW SPEED RANGE (LOW ENGINE OIL PRESSURE FAULT)

Make Reference to Schematic No. 3

If the engine oil pressure goes below 105 kPa (15 psi), the spring force on low speed oil protection valve (2) will close the valve. The oil flow in the circuit is then stopped and can not flow to drain. The pressure of the oil will become equal on both sides of diverter valve orifice (4). Spring force will move the valve spool of diverter valve (7) down so that there is alignment with the passage that leads to fuel shutoff actuator (8). Oil pressure will now activate the fuel shutoff actuator, which will cause the governor to move the fuel control linkage to the "SHUTOFF" position and shutdown the engine.



SCHEMATIC NO. 4 (LOW ENGINE OIL PRESSURE CIRCUIT)
(High Speed Range)

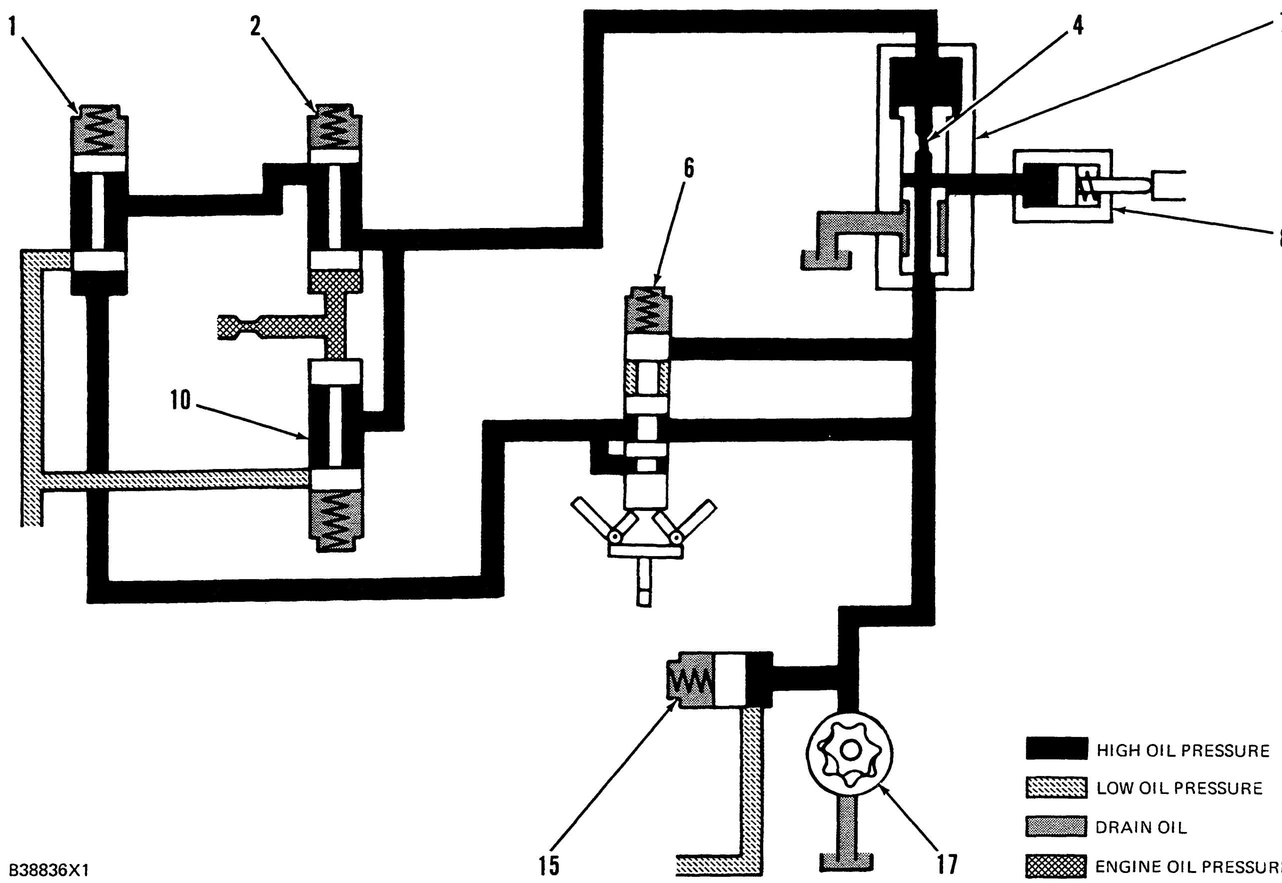
1. Selector valve. 2. Low speed oil protection valve. 4. Diverter valve orifice. 6. Speed sensing valve spool. 7. Diverter valve. 8. Fuel shutoff actuator. 10. High speed oil protection valve. 12. Air inlet shutoff actuator. 13. Air inlet sequence valve. 14. Pilot operated two-way valve. 15. Fuel shutoff sequence valve. 16. Air inlet shutoff valve. 17. Oil pump. 18. Oil pressure relief valve.

HIGH SPEED RANGE (NORMAL ENGINE OIL PRESSURE)

Make Reference to Schematic No. 4

At approximately 70% of engine full load speed, the oil pressure protection changes from the low speed range to the high speed range. At this point engine oil pressure is high enough to open high speed oil protection valve (10).

System oil flow to diverter valve (7) is the same as it is for the low speed range except speed sensing valve spool (6) has been shifted. When the engine speed increases to the high speed range, speed sensing valve spool (6) will be moved up by the flyweights. This directs system oil pressure at 760 kPa (110 psi) to selector valve (1). The valve closes to remove low range oil pressure protection valve (2) from the circuit. The oil now flows from diverter valve (7) to drain through high speed oil protection valve (10) and pilot operated two-way valve (14).



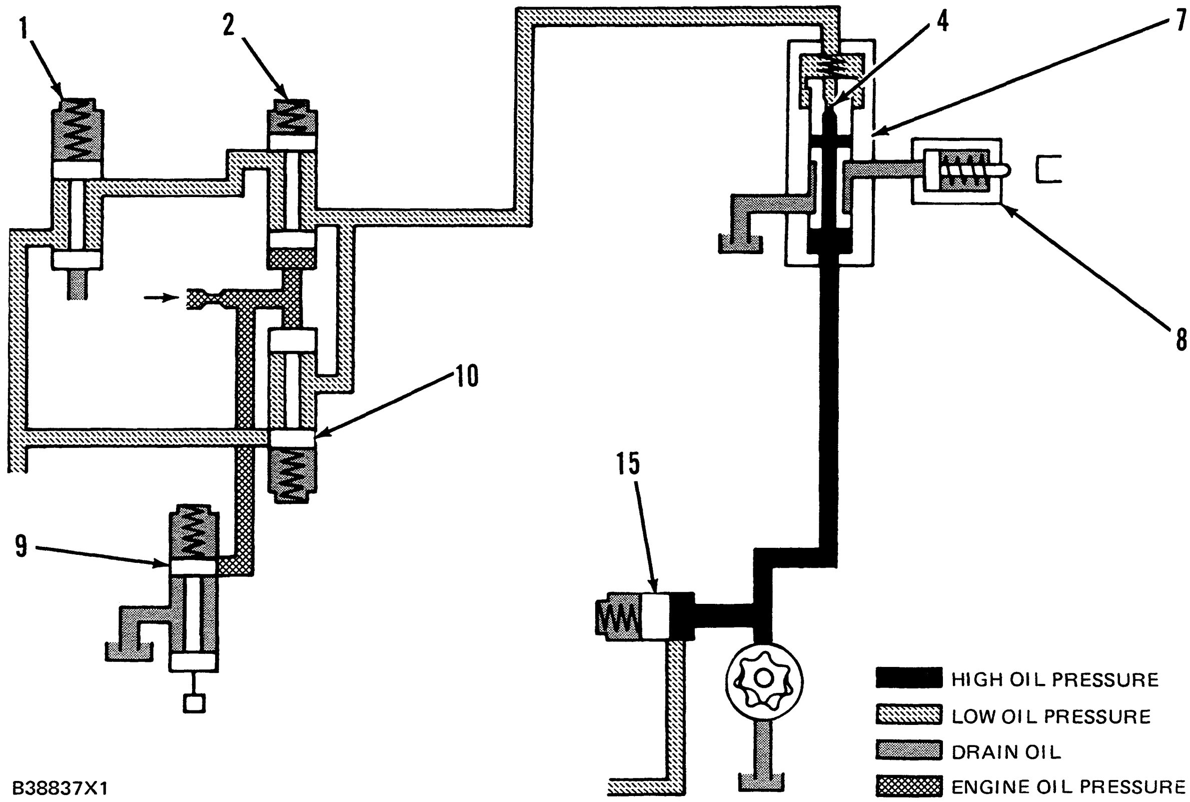
SCHEMATIC NO. 5 (LOW ENGINE OIL PRESSURE FAULT)
(High Speed Range)

1. Selector valve. 2. Low speed oil protection valve. 4. Diverter valve orifice. 6. Speed sensing valve spool. 7. Diverter valve. 8. Fuel shutoff actuator. 10. High speed oil protection valve. 15. Fuel shutoff sequence valve. 17. Oil pump.

HIGH SPEED RANGE (LOW ENGINE OIL PRESSURE FAULT)

Make Reference to Schematic No. 5

When engine oil pressure decreases to 175 kPa (25 psi), the spring force on high speed oil protection valve (10) will move the valve to stop oil flow to the drain. The difference in oil pressure across diverter valve orifice (4) will now go to zero. The valve spool of diverter valve (7) will move down by spring force, which will cause alignment of the ports to fuel shutoff actuator (8). The actuator now causes the governor to move the fuel control linkage to the "SHUTOFF" position and shutdown the engine.



SCHEMATIC NO. 6 (ENGINE COOLANT TEMPERATURE CIRCUIT)
(Low Speed Range Shown)

1. Selector valve. 2. Low speed oil protection valve. 4. Diverter valve orifice. 7. Diverter valve. 8. Fuel shutoff actuator. 9. Thermostatic pilot valve. 10. High speed oil protection valve. 15. Fuel shutoff sequence valve.

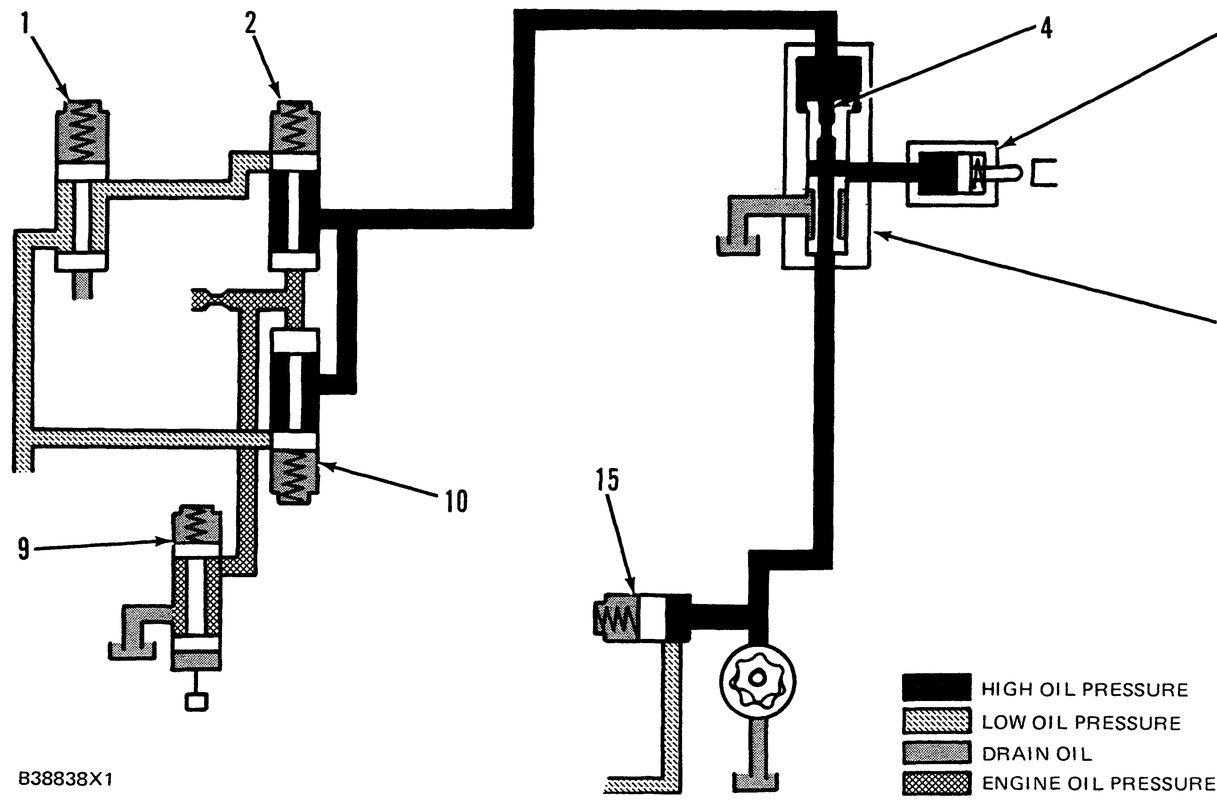
HIGH ENGINE COOLANT TEMPERATURE CIRCUIT (NORMAL CONDITIONS)

Make Reference to Schematic No. 6

Under high coolant temperature conditions, the low engine oil pressure circuits are used to shutdown an engine. The schematic shows the low speed range engine oil pressure circuit in use and the coolant temperature circuit added to the engine oil pressure line. Engine temperature is normal and thermostatic pilot valve (9) is closed.

Oil flow through the system is the same as in the low and high speed range of the LOW ENGINE OIL PRESSURE CIRCUIT.

NOTE: The sensor of the thermostatic pilot valve (9) must be below the water level in the coolant manifold to operate.



SCHEMATIC NO. 7 (HIGH ENGINE COOLANT TEMPERATURE FAULT)

1. Selector valve. 2. Low speed oil protection valve. 4. Diverter valve orifice. 7. Diverter valve. 8. Fuel shutoff actuator. 9. Thermostatic pilot valve. 10. High speed oil protection valve. 15. Fuel shutoff sequence valve.

HIGH ENGINE COOLANT TEMPERATURE CIRCUIT (FAULT CONDITION)

Make Reference to Schematic No. 7

When engine coolant temperature increases to 99°C (210°F), thermostatic pilot valve (9) will open. This will let engine oil in the circuit drain and cause a decrease in oil pressure on low speed oil protection valve (2) and high speed oil protection valve (10). Valves (2) and (10) will close and stop oil flow from diverter valve (7). The difference in oil pressure across diverter valve orifice (4) will now go to zero. The valve spool of diverter valve (7) will move down by spring force, which will cause alignment of the ports to fuel shutoff actuator (8). The actuator now causes the governor to move the fuel control linkage to the "SHUTOFF" position and shutdown the engine.

OVERSPEED CIRCUIT (NORMAL CONDITIONS)

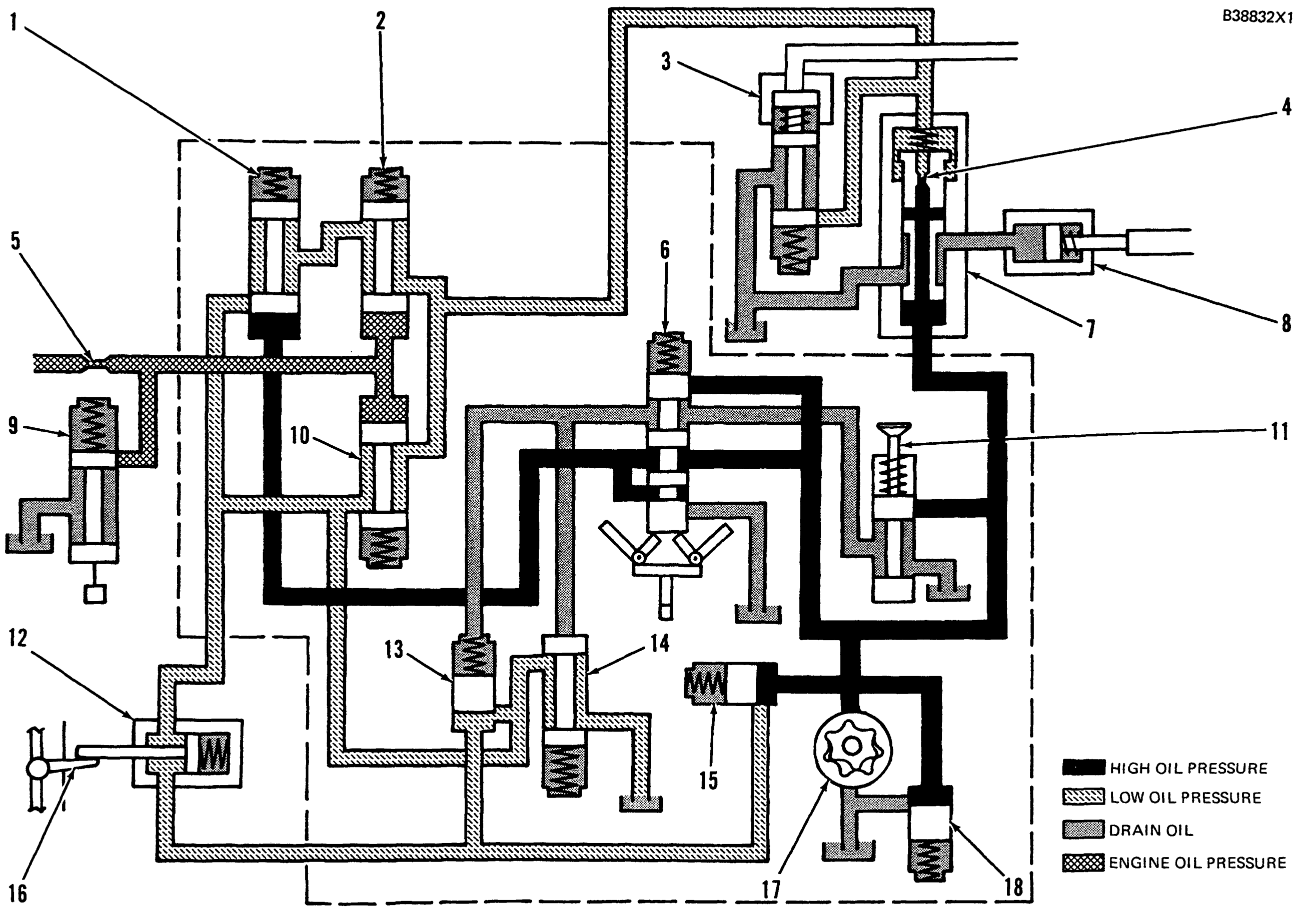
Make Reference to Schematic No. 8

When an engine is started and speed increases, engine oil pressure opens low speed oil protection valve (2) and high speed oil protection valve (10). At the same time, oil in the protective system flows from oil pump (17) to fuel shutoff sequence valve (15), speed sensing valve spool (6) and diverter valve (7). Fuel shutoff sequence valve (15) keeps the oil pressure to diverter valve (7) and speed sensing valve spool (6) at 760 kPa (110 psi) and then directs the remainder of oil flow through the air inlet shutoff circuit. At higher engine speeds, speed sensing valve spool (6) directs oil pressure to close selector valve (1).

Oil in the air inlet shutoff circuit is directed to air inlet sequence valve (13) and air inlet shutoff actuator (12). Air inlet sequence valve (13) keeps the oil pressure in air inlet shutoff actuator (12) at 105 kPa (15 psi) and then directs the remainder of oil flow to drain through pilot operated two-way valve (14), which is normally open. Pilot operated two-way valve (14) is held open by spring force and the pilot oil pressure is connected to the drain through speed sensing valve spool (6).

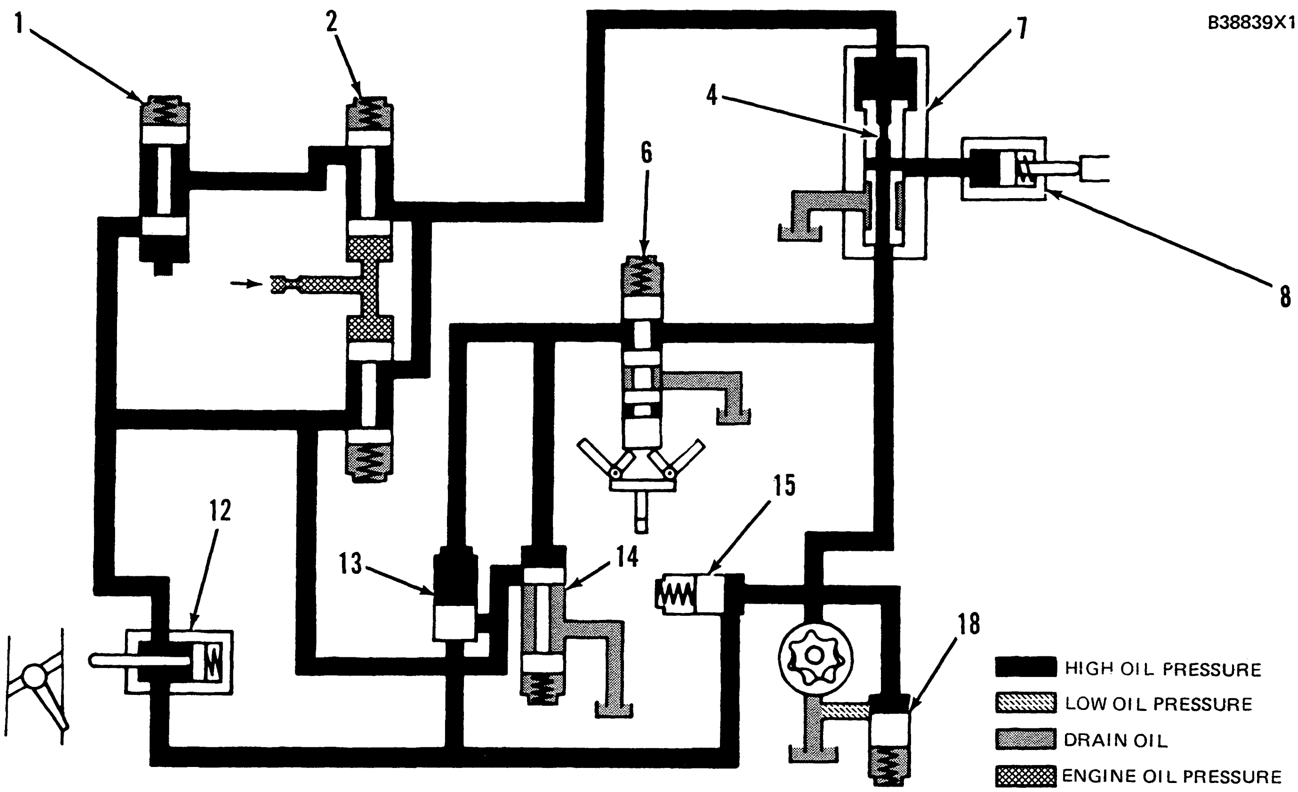
At diverter valve (7), the oil flows through orifice (4) which causes a pressure difference across both ends of the valve spool. The valve spool is then moved by system oil pressure, against a spring force, to keep the fuel shutoff actuator from being operated. The oil then flows from diverter valve (7) to drain through high speed oil protection valve (10) and pilot operated two-way valve (14).

NOTE: Low engine oil pressure or high coolant temperature conditions do not change the oil flow in the air inlet shutoff circuit.



SCHEMATIC NO. 8 (OVERSPEED CIRCUIT)

1. Selector valve. 2. Low speed oil protection valve. 3. Start-up override valve. 4. Diverter valve orifice. 5. Engine oil pressure orifice. 6. Speed sensing valve spool. 7. Diverter valve. 8. Fuel shutoff actuator. 9. Thermostatic pilot valve. 10. High speed oil protection valve. 11. Emergency manual shutoff valve. 12. Air inlet shutoff actuator. 13. Air inlet sequence valve. 14. Pilot operated two-way valve. 15. Fuel shutoff sequence valve. 16. Air inlet shutoff valve. 17. Oil pump. 18. Oil pressure relief valve.



SCHEMATIC NO. 9 (OVERSPEED FAULT)

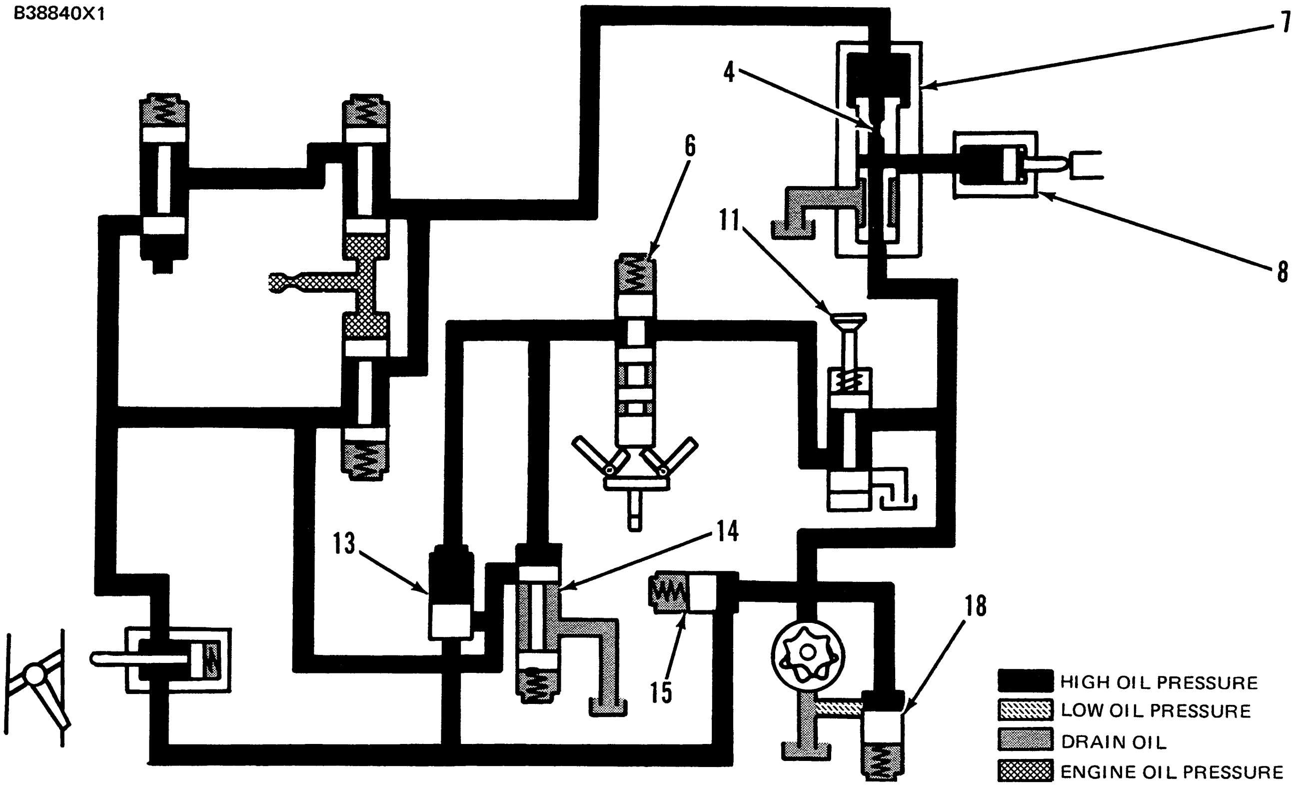
1. Selector valve. 2. Low speed oil protection valve. 4. Diverter valve orifice. 6. Speed sensing valve spool. 7. Diverter valve. 8. Fuel shutoff actuator. 12. Air inlet shutoff actuator. 13. Air inlet sequence valve. 14. Pilot operated two-way valve. 15. Fuel shutoff sequence valve. 18. Oil pressure relief valve.

OVERSPEED CIRCUIT (OVERSPEED FAULT)

Make Reference to Schematic No. 9.

When the engine speed is 18% above full load speed, speed sensing valve spool (6) will be moved up by the flyweights. This will send oil to pilot operated two-way valve (14) and to the spring side of air inlet sequence valve (13). The oil pressure will close both valves and oil in the air inlet shutoff system can not go to drain. The oil pressure in the system will increase until oil pressure relief valve (18) opens at 1720 kPa (250 psi). The increased pressure will move air inlet shutoff actuator (12), which will release the air inlet shutoff valve. This stops the combustion air supply to the engine. Fuel shutoff circuit oil also can not go to drain. The difference in oil pressure across diverter valve orifice (4) will now go to zero. The valve spool of diverter valve (7) will move down by spring force, which will cause alignment of the ports to fuel shutoff actuator (8). Now, oil pressure in the fuel shutoff circuit will activate fuel shutoff actuator (8), which will cause the governor to move the fuel control linkage to the "SHUTOFF" position.

NOTE: Because the air inlet shutoff is the most positive way to shutdown an engine, air inlet shutoff actuator (12) is activated by the protective system before fuel shutoff actuator (8) is activated.



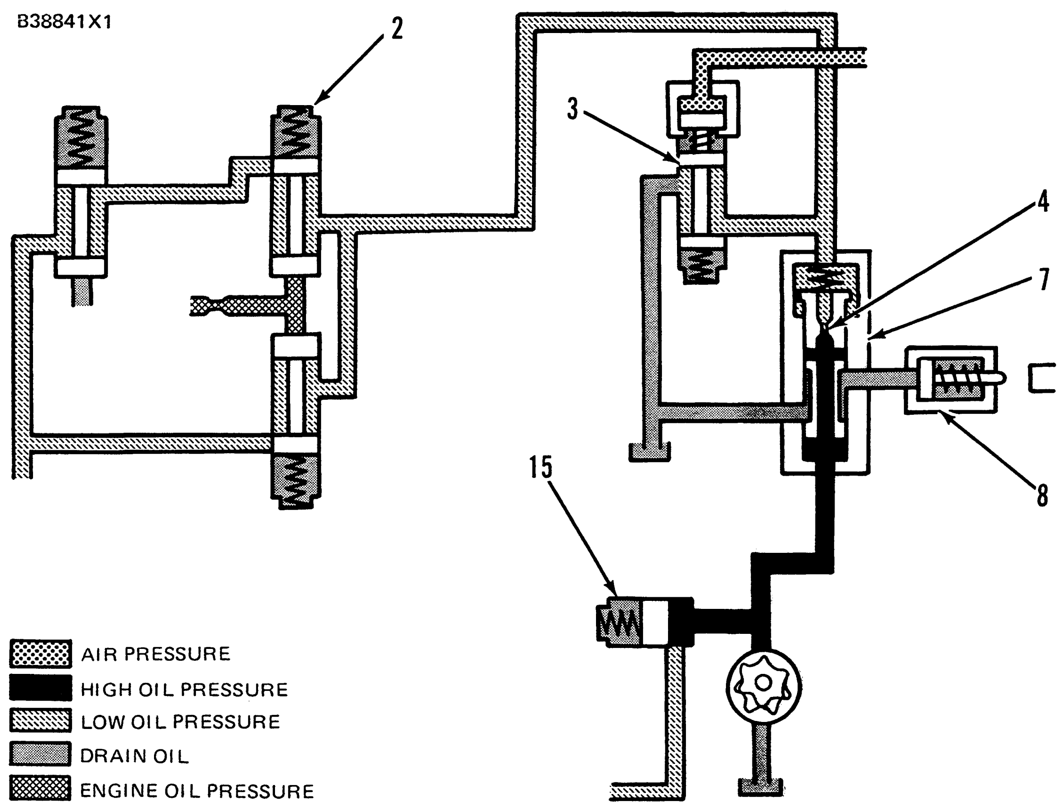
SCHEMATIC NO. 10 (EMERGENCY MANUAL SHUTOFF)

4. Diverter valve orifice. 6. Speed sensing valve spool. 7. Diverter valve. 8. Fuel shutoff actuator. 11. Emergency manual shutoff valve. 13. Air inlet sequence valve. 14. Pilot operated two-way valve. 15. Fuel shutoff sequence valve. 18. Oil pressure relief valve.

EMERGENCY MANUAL SHUTOFF

Make Reference to Schematic No. 10

When the knob on emergency manual shutoff (11) is pulled, system oil flow is directed to pilot operated two-way valve (14) to close the valve. This stops oil flow to drain in both the fuel and air inlet shutoff circuits. The protective system then, shuts down the engine in the same sequence as for an overspeed fault condition. The combustion air supply is stopped and the fuel control linkage is moved to the "SHUT-OFF" position to shutdown the engine.



SCHEMATIC NO. 11 (START-UP OVERRIDE)

2. Low speed oil protection valve. 3. Start-up override valve. 4. Diverter valve orifice. 7. Diverter valve. 8. Fuel shutoff actuator. 15. Fuel shutoff sequence valve.

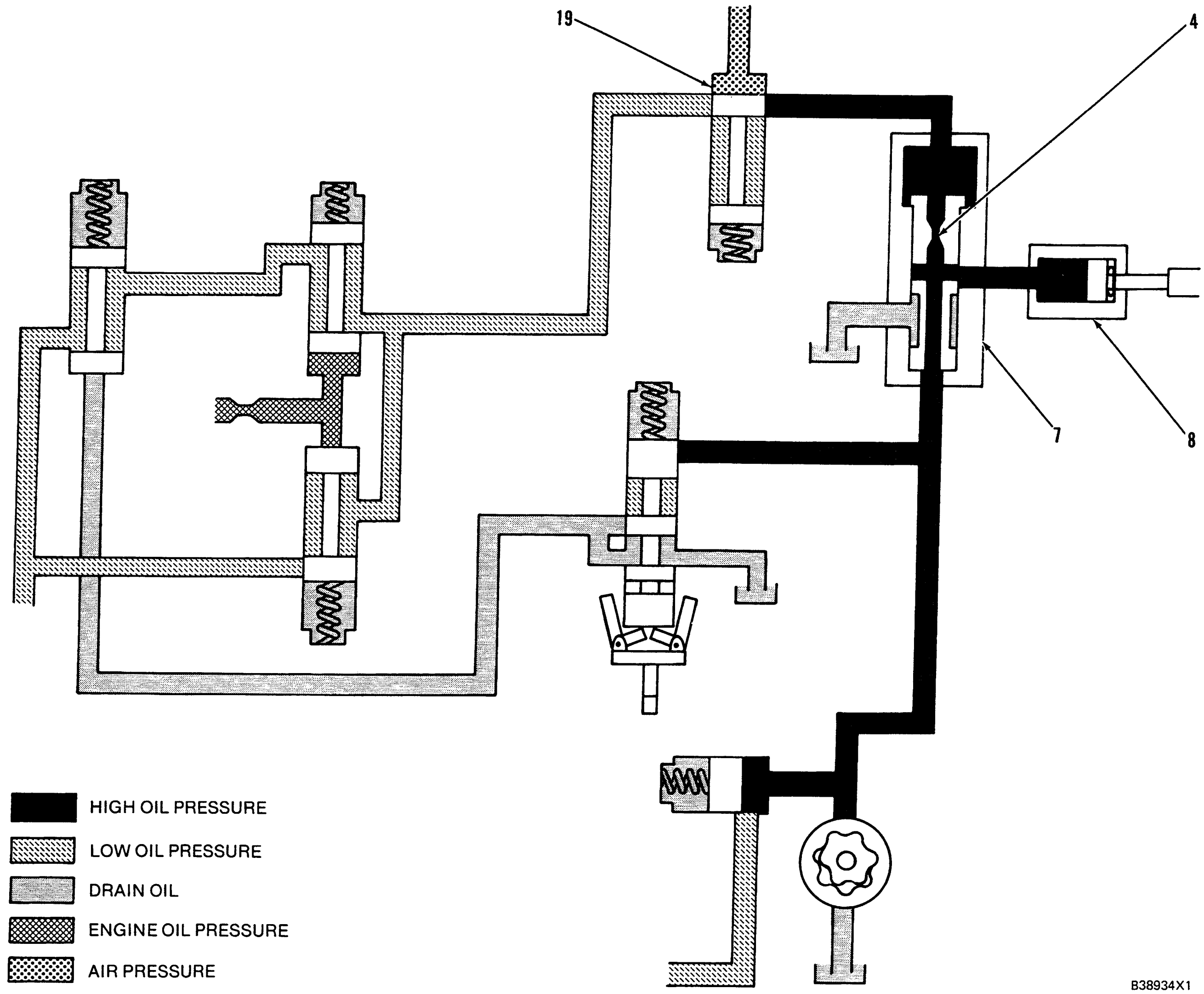
START-UP OVERRIDE OF LOW ENGINE OIL PRESSURE

Make Refeence to Schematic No. 11

On a hot restart, after severe operating conditions, the engine oil pressure can increase slowly. If the rate of pressure increase is too slow, the protective system activates fuel shutoff actuator (8) to move the fuel control linkage to the "SHUTOFF" position because of a low engine oil pressure fault condition. Therefore, an override of the engine oil pressure circuit is needed in the protective system.

An electric solenoid or air operated start-up override valve (3) is installed in the diverter valve return line. The valve is normally closed. When start-up override valve (3) is operated, the outlet of the diverter valve is connected to drain. This maintains a pressure drop across diverter valve orifice (4) and does not let the diverter valve shift to the shutdown position.

When start-up override valve (3) is not in use, the engine oil circuit is put back into normal operation as in Schematics No. 2 and No. 4.



SCHEMATIC NO. 12 (REMOTE NORMAL SHUTOFF)

4. Diverter valve orifice. 7. Diverter valve. 8. Fuel shutoff actuator. 19. Remote normal shutoff valve.

REMOTE NORMAL SHUTOFF

Make Reference to Schematic No. 12.

The remote normal shutoff is an option that can be used with the hydramechanical protective system. An air or electric operated remote normal shutoff valve (19) is installed in the diverter valve return line. When remote normal shutoff valve (19) is operated, the outlet of the diverter valve is stopped. The oil pressure becomes equal on both sides of diverter valve orifice (4). Spring force will move the valve spool of diverter valve (7) to make an alignment of the oil passage with the oil line to fuel shutoff actuator (8). Oil pressure can now activate fuel shutoff actuator (8) which causes the governor to move the fuel control linkage to the "SHUTOFF" position and shutdown the engine.

HYDRAULIC CIRCUITS (LATER)

(With Check Valves in Diverter Valve)

Later hydramechanical protective systems have hydraulic circuits that use check valves to hold hydraulic pressure on (lock) the fuel shutoff actuator in the "SHUTOFF" position, after the engine has been shutdown. In this system, the start-up override valve must be operated to release the hydraulic pressure from the fuel shutoff actuator before the engine can be started. Also, make sure the air inlet shutoff is in the open position before the engine is started.

The operation of these hydraulic circuits is the same as that of the earlier hydraulic circuits except for the check valves in the diverter valve for the fuel shutoff circuit.

START-UP OVERRIDE

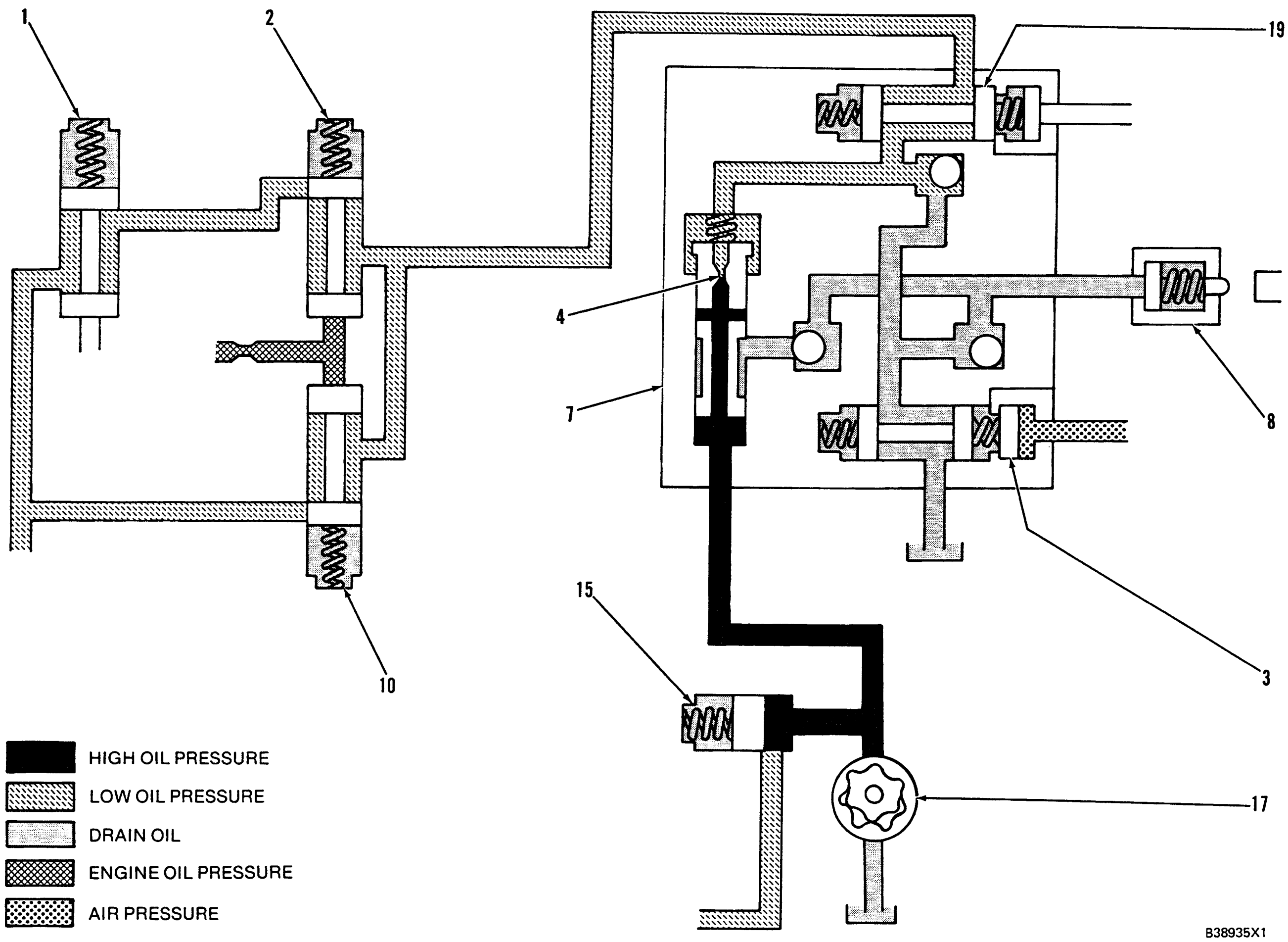
Make Reference to Schematic No. 13

When operated, the start-up override valve connects the fuel shutoff actuator circuit to drain. This removes any hydraulic pressure on the actuator so the governor can move the fuel control linkage and the engine can be started.

Also, on hot restart, after severe operating conditions, the engine oil pressure can increase slowly. If the rate of pressure increase is too slow, the protective system activates actuator (8) to move the fuel control linkage to the "SHUTOFF" position because of a low engine oil pressure fault. Therefore, an override of the low engine oil pressure circuit is needed in the protective system.

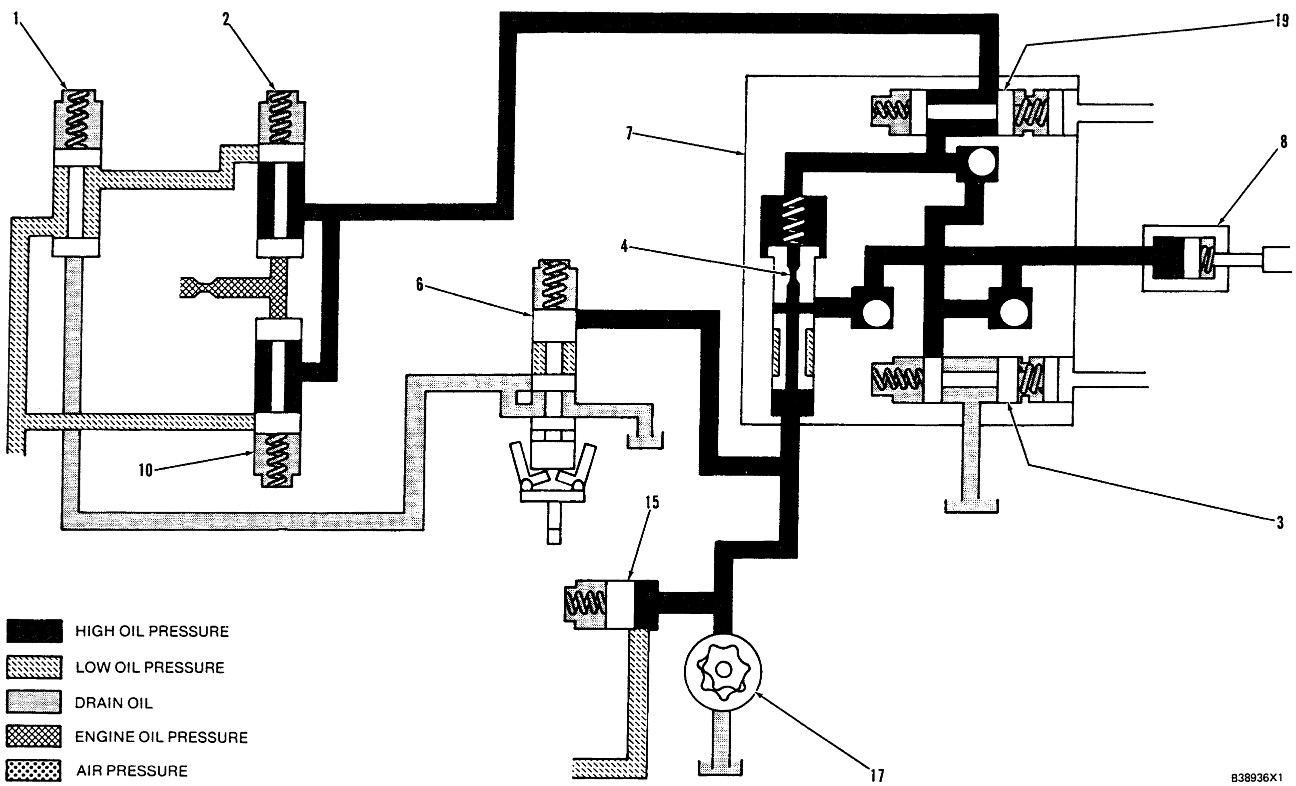
An electric solenoid or air operated start-up override valve (3) is installed in the diverter valve return line. The valve is normally closed. When start-up override valve (3) is operated, the outlet of the diverter valve is connected to drain. This maintains a pressure drop across orifice (4) and does not let the diverter valve shift to the shutdown position. The fuel shutoff actuator line is also connected to drain to make sure fuel shutoff actuator (8) does not hold the governor shutoff strap in the off position.

When start-up override valve (3) is not in use, the engine oil circuit is put back into normal operation as in Schematics No. 2 and No. 4.



SCHEMATIC NO. 13 (START-UP OVERRIDE)

1. Selector valve. 2. Low speed oil protection valve. 3. Start-up override valve. 4. Diverter valve orifice. 7. Diverter valve. 8. Fuel shutoff actuator. 10. High speed oil protection valve. 15. Fuel shutoff sequence valve. 17. Oil pump. 19. Remote normal shutoff valve.



SCHEMATIC NO. 14 (LOW ENGINE OIL PRESSURE FAULT) (Low Speed Range)

1. Selector valve. 2. Low speed oil protection valve. 3. Start-up override valve. 4. Diverter valve orifice. 6. Speed sensing valve spool. 7. Diverter valve. 8. Fuel shutoff actuator. 10. High speed oil protection valve. 15. Fuel shutoff sequence valve. 17. Oil pump. 19. Remote normal shutoff valve.

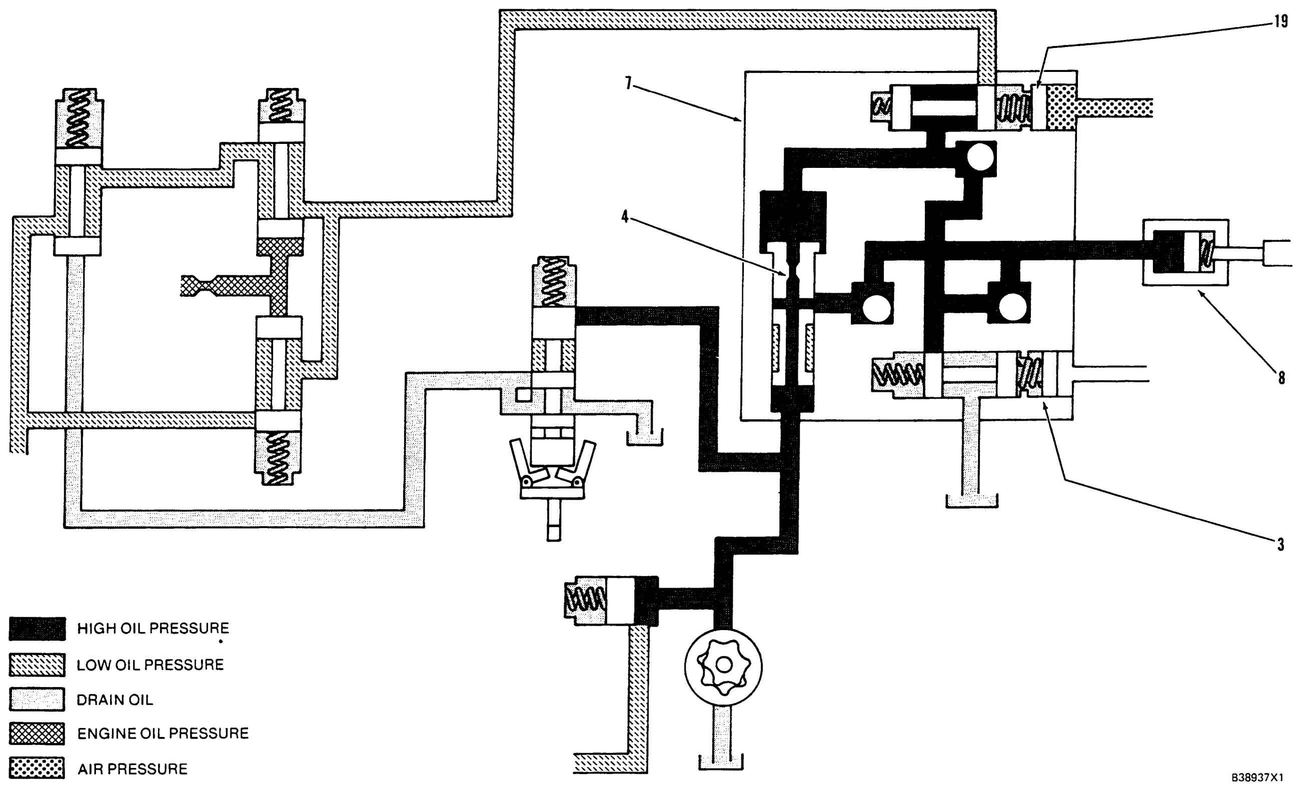
LOW SPEED RANGE (LOW ENGINE OIL PRESSURE FAULT)

Make Reference to Schematic No. 14

If the engine oil pressure goes below 140 kPa (20 psi), the spring force on low speed oil protection valve (2) will close the valve. The oil flow in the circuit is then stopped and can not flow to drain. The pressure of the oil will become equal on both sides of diverter valve orifice (4). Spring force will move the valve spool of diverter valve (7) down so that there is alignment with the passage that leads to fuel shutoff actuator (8). Oil pressure will now move the fuel shutoff actuator which will cause the governor to move the fuel control linkage to the "SHUTOFF" position and shutdown the engine.

As the crankshaft rpm becomes slower, the governor feels the speed reduction and moves the terminal shaft and linkage in the fuel "ON" direction, against fuel shutoff actuator (8). This moves the protective system oil back toward the system oil pump. The check valves in diverter valve (7) move to stop this oil flow and keep the engine from surging.

NOTE: The start-up override valve (3) must be operated to release the fuel shutoff actuator hydraulic pressure before the engine can be started.



SCHEMATIC NO. 15 (REMOTE NORMAL SHUTOFF)

3. Start-up override. 4. Diverter valve orifice. 7. Diverter valve. 8. Fuel shutoff actuator. 19. Remote normal shutoff valve.

REMOTE NORMAL SHUTOFF

Make Reference to Schematic No. 15

The remote normal shutoff is an option that can be used with the hydramecahnical protective system. An air or electric operated remote normal shutoff valve (19) is installed in the diverter valve return line. When remote normal shutoff valve (19) is operated, the outlet of the diverter valve is stopped. The oil pressure becomes equal on both sides of diverter valve orifice (4). Spring force will move the valve spool of diverter valve (7) to make an alignment of the oil passage with the oil line to fuel shutoff actuator (8). Oil pressure can now activate the fuel shutoff actuator, which causes the governor to move the fuel control linkage to the "SHUTOFF" position and shutdown the engine.

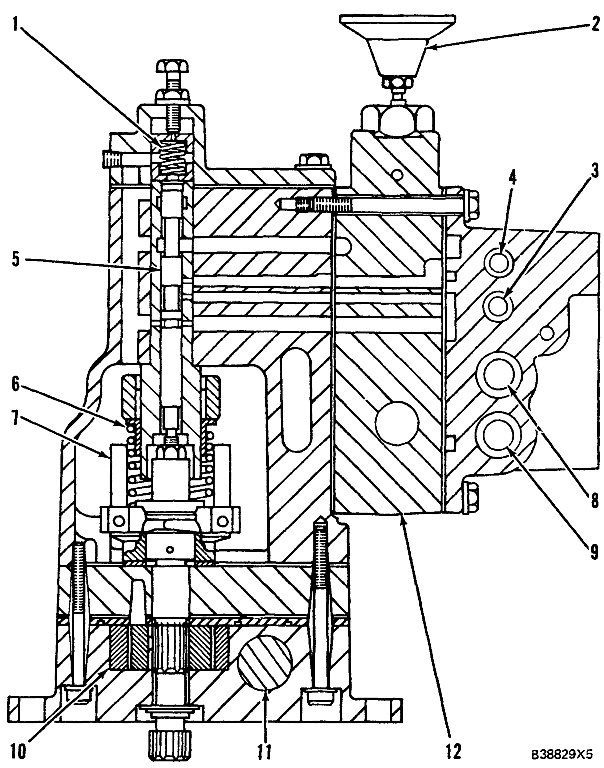
As the crankshaft rpm becomes slower, the governor feels the speed reduction and moves the terminal shaft and linkage in the fuel "ON" direction, against fuel shutoff actuator (8). This moves the protective system oil back toward the system oil pump. The check valves in diverter valve (7) move to stop this oil flow and keep the engine from surging.

NOTE: The start-up override valve (3) must be operated to release the fuel shutoff actuator hydraulic pressure before the engine can be started.

LATER HYDRAULIC CIRCUITS WITH AN ALARM SYSTEM

This hydramechanical protective system is designed to give automatic engine shutdown from an overspeed condition only. An alarm is activated for low engine oil pressure and high coolant temperature conditions.

The main difference between this system and systems shown in the EARLIER and LATER HYDRAULIC CIRCUITS, is that the fuel shutoff circuit oil return from the diverter valve is connected with the air inlet shutoff circuit return, and not to the normal fuel shutoff return port on the shutoff control group. A normally open pressure switch (13) is installed in the shutoff control group at the location the diverter valve oil return line is normally connected. Also, there is an orifice plug [orifice (14)] installed in the shutoff control group. The orifice plug is located in the valve body that holds valves (4), (8) and (9). In the hydraulic circuit, this orifice is between the oil pressure supply and the low and high oil pressure protection valves (8) and (9).



SHUTOFF CONTROL GROUP

1. Spring for overspeed adjustment. 2. Emergency manual shutoff valve. 3. Selector valve. 4. Valve spool (not used). 5. Speed sensing valve spool. 6. Speeder spring. 7. Flyweights. 8. Low speed oil protection valve. 9. High speed oil protection valve. 10. Oil pump. 11. Oil pressure relief valve. 12. Pressure control valve group which consists of: the fuel and air inlet sequence valves, the two-way pilot operated valve and emergency manual shutoff valve (2).

OVERSPEED CIRCUIT (NORMAL CONDITIONS)

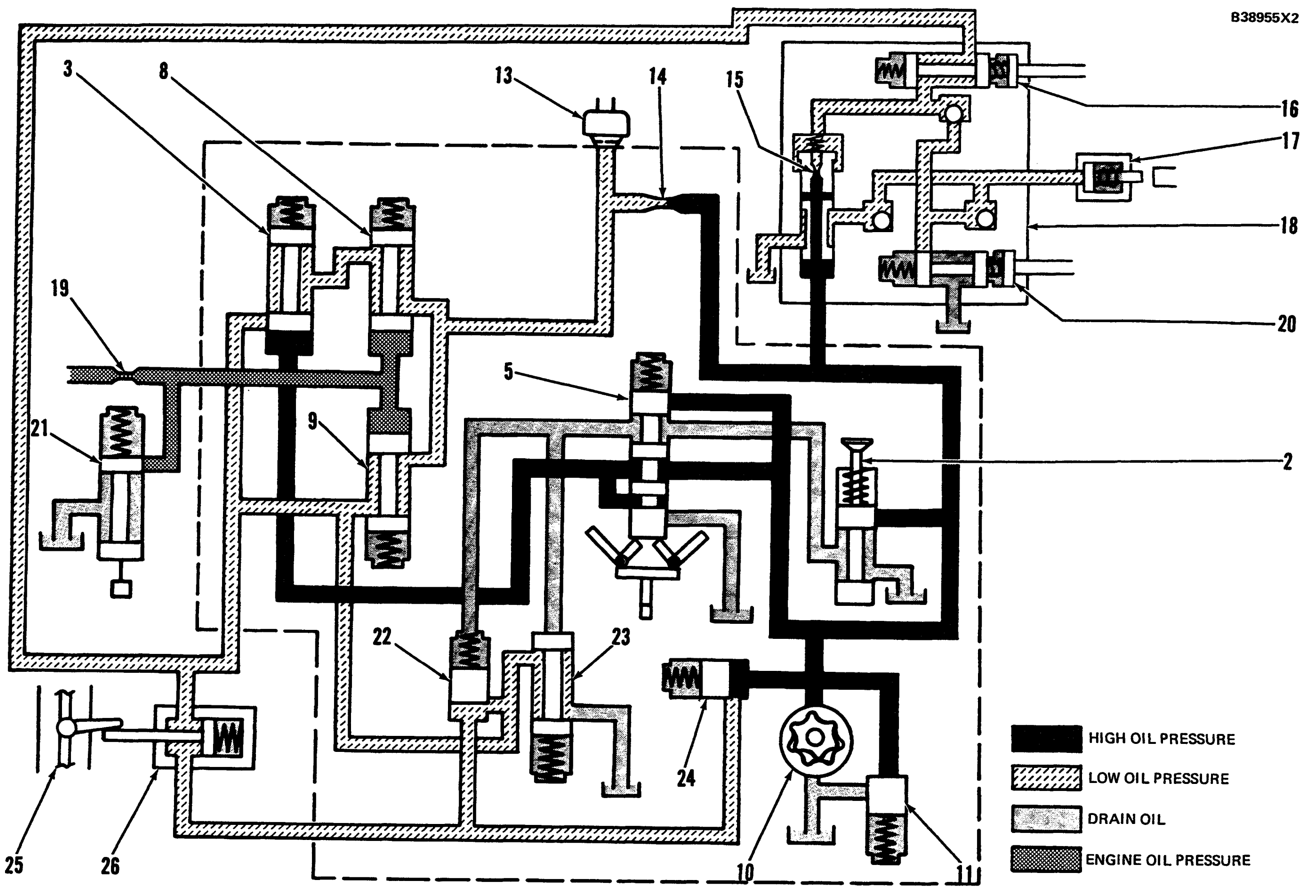
Make Reference to Schematic No. 16

When an engine is started and speed increases, engine oil pressure opens low speed oil protection valve (8) and high speed oil pressure protection valve (9). At the same time, oil in the protective system flows from oil pump (10) to fuel shutoff sequence valve (24) and is divided between the fuel shutoff and air inlet shutoff circuits. Fuel shutoff sequence valve (24) keeps the oil pressure at the start of the fuel shutoff circuit at 760 kPa (110 psi).

Oil in the air inlet shutoff circuit is directed to air inlet sequence valve (22) and air inlet shutoff actuator (26). Air inlet sequence valve (22) keeps the oil pressure in air inlet shutoff actuator (26) at 105 kPa (15 psi) and then directs the remainder of oil flow to drain through pilot operated two-way valve (23) which is normally open. Pilot operated two-way valve (23) is held open by spring force and the pilot oil pressure is connected to drain through speed sensing valve spool (5).

Oil flow in the fuel shutoff circuit is divided into different directions as follows:

1. Oil from fuel shutoff sequence valve (24) goes to speed sensing valve spool (5) and is stopped at low engine speeds. When engine speed is high enough, speed sensing valve spool (5) moves to direct the oil pressure and close selector valve (3). This changes the oil flow in the alarm circuit from the low speed range to the high speed range and connects system oil pressure to drain through high speed oil protection valve (9) and pilot operated two-way valve (23).
2. Oil flow from fuel shutoff sequence valve (24) goes through orifice (14), low speed oil protection valve (8) or high speed oil protection valve (9) and to drain through pilot operated two-way valve (23). This circuit has an oil pressure switch (13), that is normally open. Switch (13) is connected to the alarm circuit oil pressure after orifice (14) and senses the lower system oil pressure. The switch activates an alarm, without engine shutdown, if there is a low engine oil pressure or high coolant temperature condition. (Make reference to Schematic No. 18).



SCHEMATIC NO. 16 (OVERSPEED CIRCUIT)

2. Emergency manual shutoff valve. 3. Selector valve. 5. Speed sensing valve spool. 8. Low speed oil protection valve. 9. High speed oil protection valve. 10. Oil pump. 11. Oil pressure relief valve. 13. Oil pressure switch. 14. Orifice. 15. Diverter valve orifice. 16. Remote normal shutoff valve. 17. Fuel shutoff actuator. 18. Diverter valve. 19. Engine oil pressure orifice. 20. Start-up override valve. 21. Thermostatic pilot valve. 22. Air inlet sequence valve. 23. Pilot operated two-way valve. 24. Fuel shutoff sequence valve. 25. Air inlet shutoff. 26. Air inlet shutoff actuator.

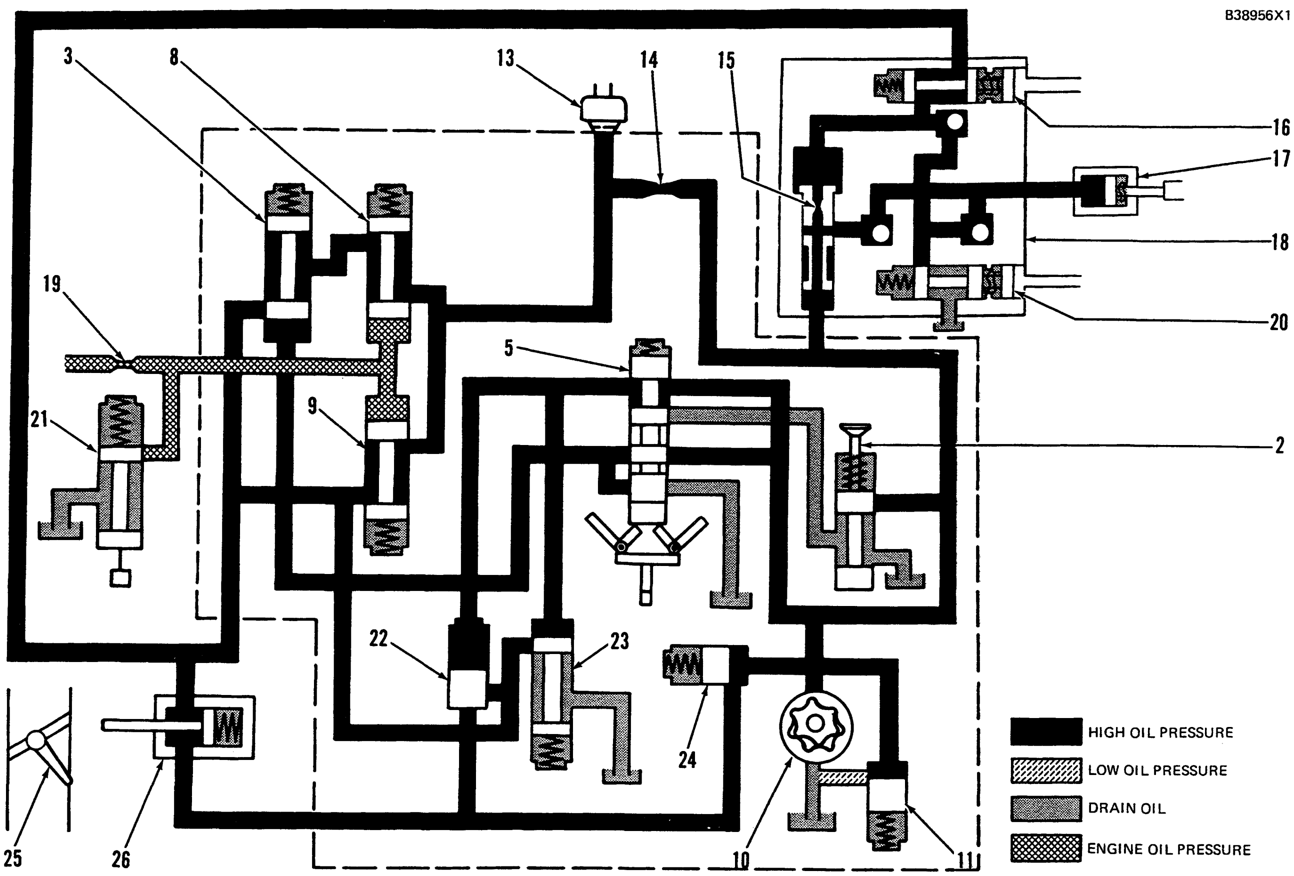
3. Oil from fuel shutoff sequence valve (24) goes to the inlet of diverter valve (18) then to orifice (15) in the valve spool. The oil goes through orifice (15) and goes to the system drain through two-way pilot operated valve (23). The pressure of the oil is lowered after the oil goes through orifice (15), this causes the oil pressure to move the diverter valve spool against a spring force and connect the fuel shutoff actuator oil circuit to the system drain. Thus, the actuator will not shutdown the engine. Engines with electric shutoff solenoids on the governors have a pressure switch installed in the diverter valve outlet for the shutoff actuator. The pressure switch will not shutdown the engine until system oil pressure is directed to it.

OVERSPEED CIRCUIT (OVERSPEED FAULT)

Make Reference to Schematic No. 17

When the engine speed is 18% above full load speed, speed sensing valve spool (5) will be moved up by the flyweights. This will send oil to pilot operated two-way valve (23) and to the spring side of air inlet sequence valve (22). The oil pressure will close both valves and oil in the air inlet shutoff system can not go to drain. The oil pressure in the system will increase until oil pressure relief valve (11) opens at 1720 kPa (250 psi). The increased pressure will move air inlet shutoff actuator (26), which will release air inlet shutoff valve (25). This stops the combustion air supply to the engine. Fuel shutoff circuit oil also can not go to drain. The difference in oil pressure across orifices (14) and (15) will now go to zero. The valve spool of diverter valve (18) will move down by spring force, which will cause alignment of the ports to the fuel shutoff actuator (17). The blocked oil pressure in the fuel shutoff circuit will activate fuel shutoff actuator (17), which will cause the governor to move the fuel control linkage to the "SHUTOFF" position. Also, oil pressure switch (13) will be closed by the higher pressure oil and will activate an alarm.

When the emergency manual shutoff knob is pulled, system oil flow is directed to pilot operated two-way valve (23) and the spring side of air inlet sequence valve (22). Valve (23) stops oil flow to drain in both the fuel and air inlet shutoff circuits. The protective system then, shuts down the engine in the same sequence as for an overspeed fault condition. The combustion air supply is stopped and the fuel control linkage is moved to the "SHUTOFF" position to shutdown the engine.



SCHEMATIC NO. 17 (OVERSPEED FAULT)

2. Emergency manual shutoff valve. 3. Selector valve. 5. Speed sensing valve spool. 8. Low speed oil protection valve. 9. High speed oil protection valve. 10. Oil pump. 11. Oil pressure relief valve. 13. Oil pressure switch. 14. Orifice. 15. Diverter valve orifice. 16. Remote normal shutoff valve. 17. Fuel shutoff actuator. 18. Diverter valve. 19. Engine oil pressure orifice. 20. Start-up override valve. 21. Thermostatic pilot valve. 22. Air inlet sequence valve. 23. Pilot operated two-way valve. 24. Fuel shutoff sequence valve. 25. Air inlet shutoff. 26. Air inlet shutoff actuator.

LOW OIL PRESSURE OR HIGH COOLANT TEMPERATURE FAULT

Make Reference to Schematic No. 18

Under normal operation at low engine speeds, the engine oil pressure must be 105 kPa (15 psi) to move low speed oil protection valve (8). The fuel shutoff circuit oil can then flow from pump (10) at 760 kPa (110 psi) through orifice (14), oil pressure switch (13), low speed oil protection valve (8), selector valve (3) and pilot operated two-way valve (23) to drain.

If the engine oil pressure goes below 105 kPa (15 psi), the spring force on low speed oil protection valve (8) will close the valve. The oil flow in the circuit is then stopped and can not flow to drain. The pressure of the oil will become equal on both sides of orifice (14) and oil pressure switch (13) senses 760 kPa (110 psi). The normally open switch closes and activates an alarm.

At approximately 70% of engine full load speed, the oil pressure protection changes from the low speed range to the high speed range.

When the engine speed increases to the high speed range, speed sensing valve spool (5) will be moved up by the flyweights. This will send pilot oil to selector valve (3). This will close selector valve (3) and remove low speed oil protection valve (8) from the circuit. The oil must now flow to drain through high speed oil protection valve (9) and pilot operated two-way valve (23).

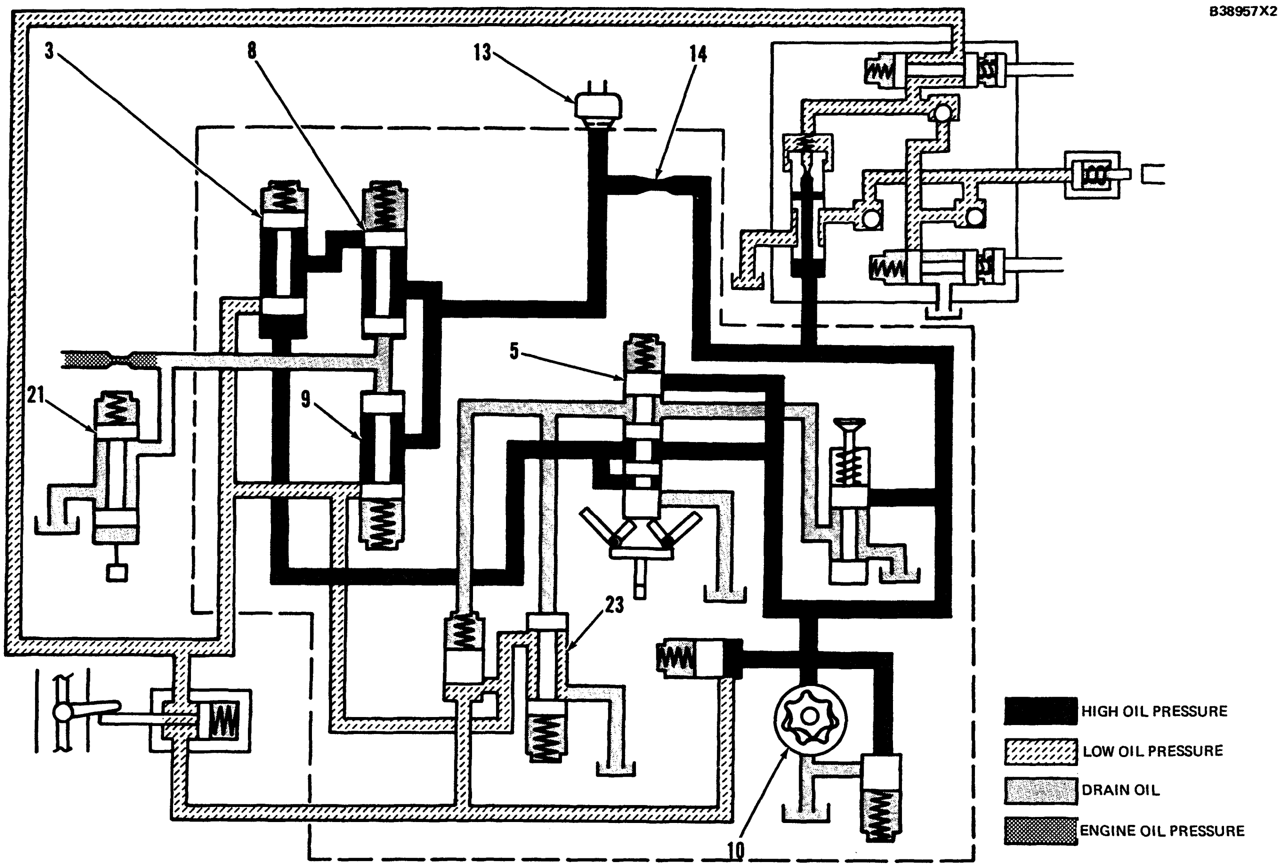
If the engine oil pressure decreases to 175 kPa (25 psi), the spring force on high speed oil protection valve (9) will move the valve and stop the oil flow to drain. The pressure of the oil will become equal on both sides of orifice (14) and oil pressure switch (13) senses 760 kPa (110 psi). The normally open switch closes and activates an alarm.

For the engine coolant temperature circuit, a thermostatic pilot valve (21) is connected to the engine oil pressure supply. Thermostatic pilot control valve (21) is normally closed.

NOTE: The sensor of thermostatic pilot valve (21) must be below the water level in the coolant manifold to operate correctly.

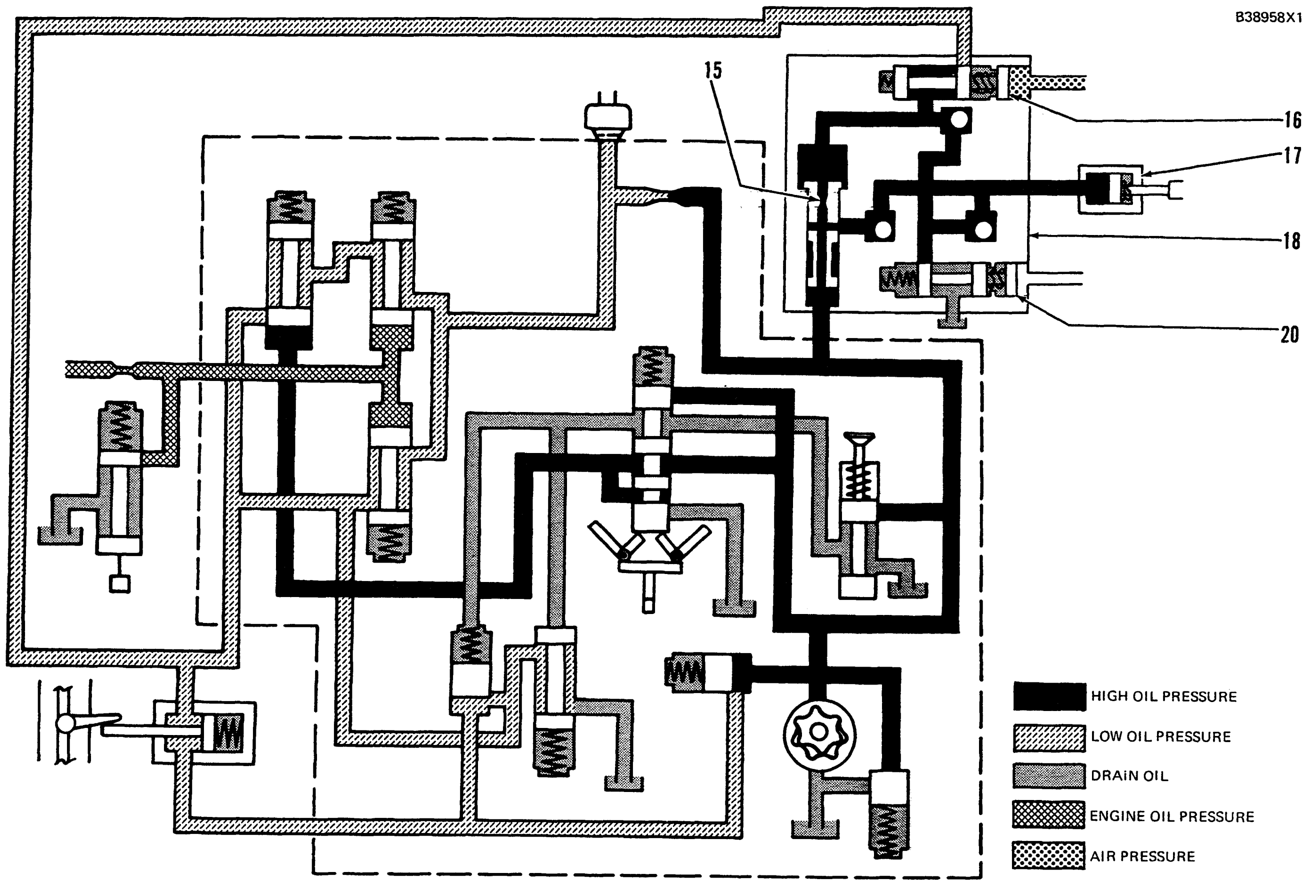
When coolant temperature increases to 99°C (210°F), thermostatic pilot valve (21) will open. This will let oil in the circuit go to drain and cause a decrease in engine oil pressure at low speed oil protection valve (8) and high speed oil protection valve (9). The valves close and stop oil flow through orifice (14). The pressure of the oil will become equal on both sides of orifice (14) and oil pressure switch (13) senses 760 kPa (110 psi). The normally open switch closes and activates an alarm.

NOTE: When the engine is started, the low oil pressure - high coolant temperature alarm will be activated for a short time until the engine has enough oil pressure to open low speed oil protection valve (8) or high speed oil protection valve (9).



SCHEMATIC NO. 18 (LOW OIL PRESSURE OR HIGH COOLANT TEMPERATURE FAULT)
(High Speed Range)

3. Selector valve. 5. Speed sensing valve spool. 8. Low speed oil protection valve. 9. High speed oil protection valve. 10. Oil pump. 13. Oil pressure switch. 14. Orifice. 21. Thermostatic pilot valve. 23. Pilot operated two-way valve.



SCHEMATIC NO. 19 (REMOTE NORMAL SHUTOFF)

15. Diverter valve orifice. 16. Remote normal shutoff valve. 17. Fuel shutoff actuator. 18. Diverter valve. 20. Start-up override valve.

REMOTE NORMAL SHUTOFF

Make Reference to Schematic No. 19

The remote normal shutoff is an option that can be used with the hydramechanical protective system. An air or electric operated remote normal shutoff valve (16) is installed in the diverter valve return line. When remote normal shutoff valve (16) is operated, the outlet of the diverter valve is stopped. The oil pressure becomes equal on both sides of diverter valve orifice (15). Spring force will move the valve spool of diverter valve (18) to make an alignment of the oil passage with the oil line to fuel shutoff actuator (17). Oil pressure can now activate fuel shutoff actuator (17), which causes the governor to move the fuel control linkage to the "SHUTOFF" position and shutdown the engine.

TROUBLESHOOTING

Troubleshooting can be difficult. On the following pages there is a list of possible problems. To make a repair to a problem, make reference to the cause and correction.

This list of problems, causes, and corrections, will only give an indication of where a possible problem can be, and what repairs are needed. Normally, more or other repair work is needed beyond the recommendations in the list.

Remember that a problem is not normally caused only by one part, but by the relation of one part with other parts. This list can not give all possible problems and corrections. The serviceman must find the problem and its source, then make the necessary repairs.

TROUBLESHOOTING INDEX

Item **Problem**

1. Engine Will Not Start.
2. Engine Will Start, But Shuts Down When Oil Pressure Override is Released.
3. Engine Will Only Run Below 70% of Rated Speed.
4. Air Inlet Shutoff Activates on Load Rejection.
5. Air Inlet Does Not Close.
6. Engine Will Not Restart After Operation of Emergency Manual Shutoff.
7. Engine Will Not Shutdown When Checking Low Engine Oil Pressure Protection Circuit.
8. Shutoff Control Unit Does Not Operate.

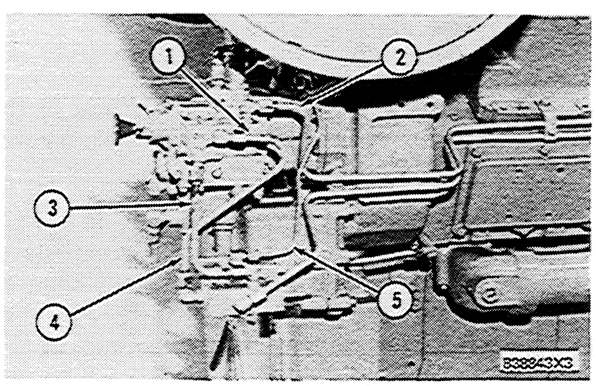


FIGURE 1.PROTECTIVE SYSTEM OIL LINES

1. Plug. 2. Oil line to thermostatic pilot valve. 3. Oil return line from diverter valve. 4. Oil supply line to diverter valve. 5. Oil drain line from diverter valve.

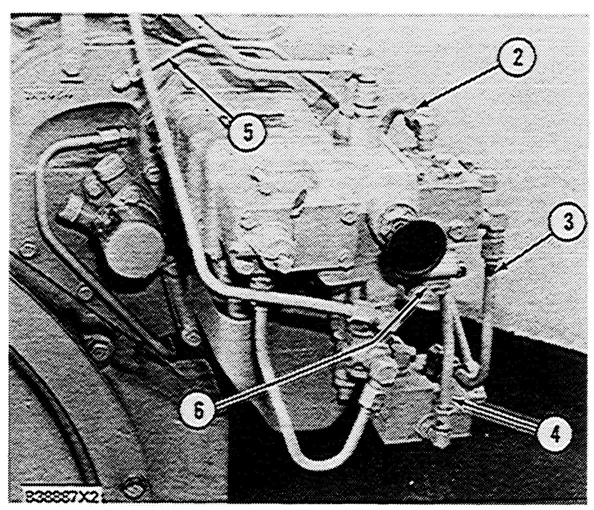


FIGURE 2. PROTECTIVE SYSTEM OIL LINES

2. Oil line to thermostatic pilot valve. 3. Oil return line from diverter valve. 4. Oil supply line to diverter valve. 5. Oil drain line from diverter valve. 6. Cover on actuator valve body.

1. ENGINE WILL NOT START

Cause	Correction
Engine Start-Up Override Not By-Passing Oil Pressure By Shutoff Control Group To Drain	Disconnect drain line (5), See Figure 1. Operate the override (push button switch for electric, push button valve for air) and crank the engine. Oil should flow from drain line. If not, inspect the solenoid or air operated two-way valve and the push button switch or push button air valve and lines.
Fuel Shutoff Actuator Stuck In The Shutoff Position	Make sure that the start-up override system is operating correctly. Operate the start-up override and crank the engine. Check the governor linkage and fuel control linkage to see if they are in the run position. If not, check the shutoff actuator for binding.

2. ENGINE WILL START, BUT SHUTS DOWN WHEN START-UP OVERRIDE IS RELEASED

Cause	Correction
Engine Oil Pressure Is Too Low	Install a pressure gauge in oil line (2) or in port (1) behind oil supply line (4), see Figure 1. Operate the start-up override and start the engine. Engine oil pressure must be 175 kPa (25 psi) minimum at low idle and 240 kPa (35 psi) minimum at rated speed.
Engine Oil Pressure Sensing Orifice Plugged	Remove the control group from the engine to disassemble and clean orifice if necessary.
The Oil Return Line Between Diverter Valve And Shutoff Control Group Is Plugged	Disconnect oil return line (3) at the shutoff control group, see Figure 1. Crank the engine without using the start-up override valve. Oil should flow out of the oil return line. Check the oil line for damage and clean or replace as needed.
Remote Normal Shutoff Still Activated	Disconnect oil return line (3) at the shutoff control group, see Figure 1. Crank the engine without using the start-up override valve. Oil should flow out of the oil return line. If there is no oil flow and the line is not plugged or damaged, check the remote normal shutoff system. Make a repair or replacement of worn or damaged parts and clean the valve if necessary.
Engine Oil Pressure Is Drained Through Thermostatic Pilot Valve	Check drain side of valve. Replace valve, if flow is present at cranking and engine coolant temperature is normal.
Engine Oil Pressure Sensing Portion Of The Control Group Has Malfunctioned	Remove cover (6), see Figure 2. Inspect the valve spools in the actuator valve body to make sure valves are not stuck. Replace cover (6) after inspection. Check the engine oil pressure. Install a pressure gauge in oil line (2) or in port (1) behind oil supply line (4), see Figure 1. Operate start-up override and start the engine. If the engine oil pressure is equal to or greater than 175 kPa (25 psi) at low idle and 240 kPa (35 psi) at rated speed, replace the oil pressure sensing group (part of the shutoff control group).

3. ENGINE WILL ONLY RUN BELOW 70% OF RATED SPEED

Cause	Correction
Engine Oil Pressure Is Not High Enough In The High Speed Range	Check engine oil pressure in oil line (2), see Figure 1. A minimum of 240 kPa (35 psi) is required in high speed range. Clean the engine oil pressure line to the shutoff control group, if needed. Also, engine repair may be needed.

4. AIR INLET SHUTOFF ACTIVATES ON LOAD REJECTION

Cause	Correction
Governor Overshoot Lets Engine Speed Exceed Overspeed Setting	Correct governor overshoot. If this can not be done, increase overspeed setting to a maximum of 25% of rated speed.

5. AIR INLET DOES NOT CLOSE

Cause	Correction
Tube Fittings At Hydraulic Actuator Are Installed Too Far. The End Of The Fitting Is Binding The Cylinder Rod	Turn fittings out until cylinder rod is free to move.
Air Inlet Valve Shaft Sticking Or Binding	Check for corrosion on shaft bearing surfaces or improper alignment.

6. ENGINE WILL NOT RESTART AFTER OPERATION OF EMERGENCY MANUAL SHUTOFF

Cause	Correction
The 5N5880 Remote Emergency Manual Shutoff Did Not Fully Return To The Run Position When Switch Or Valve Was Released	Check for binding of 5N5878 valve in the valve bore.
Fuel Shutoff Actuator Stuck In The Shutoff Position	Remove the actuator. Check surface finish of bore and polish, if necessary. Put a small amount of clean oil in the bore and on the seal. Move the rod and piston in the actuator cylinder to check for free movement. Replace actuator, if necessary.
Air Inlet Valve Shaft Sticking Or Binding	Check for corrosion on shaft bearing surfaces or improper alignment.

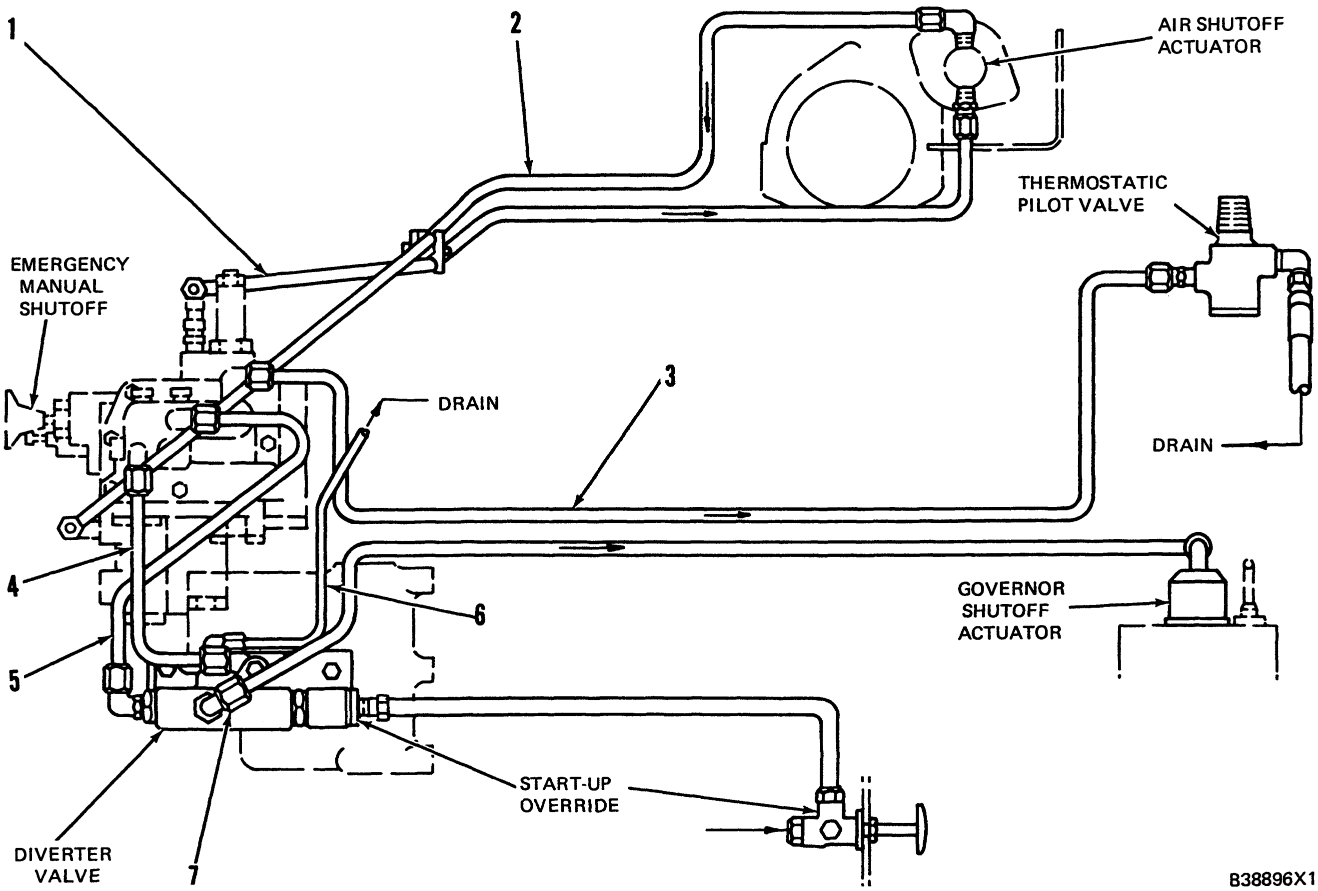
7. ENGINE WILL NOT SHUTDOWN WHEN CHECKING LOW ENGINE OIL PRESSURE PROTECTION CIRCUIT

Cause	Correction
Fuel Shutoff Actuator Stuck In The Run Position	Remove the actuator. Check surface finish of bore and polish, if necessary. Put a small amount of clean oil in the bore and on the seal. Move the rod and piston in the actuator cylinder to check for free movement. Replace actuator, if necessary.
Orifice Plugged In Diverter Valve	Disconnect oil return line (3) at the diverter valve. Crank the engine without using the start-up override valve. Oil should flow from the diverter valve outlet port.
Orifice Not Installed In Control Group	Remove control group from engine and disassemble. Install or replace orifice if needed.
Oil Flow To Drain Is Not Enough To Create A Fault Condition	Install a manual operated ball or gate valve in the engine oil pressure sensing line. Slowly close the valve to add more restriction to flow. If engine shutdown does not occur, the shutoff control group needs repair.

8. SHUTOFF CONTROL UNIT DOES NOT OPERATE

Cause	Correction
Drive Coupling Failure	Start the engine and run at low idle. Loosen the nut that holds oil supply line (4) at the shutoff control group, see Figure 1. Oil under pressure should be present. If not, remove shutoff control group and inspect the drive coupling. Make a replacement of parts as needed. A pressure gauge installed in oil supply line (4) [see Figure 1] can also be used to make this check. A minimum pressure of 590 kPa (85 psi) at high idle should be the reading.
Not Enough System Oil Pressure	Make sure there is oil in the reservoir for the system. Low oil pressure can be caused by a faulty oil pump relief valve (18) or fuel shutoff sequence valve (15), see Schematic No. 1 in the System Operation section for part locations. Make a replacement or repair as needed.

HYDRAMECHANICAL PROTECTIVE SYSTEM



PROTECTIVE SYSTEM WITH ENGINE SHUTDOWN FOR ALL FUNCTIONS (LOP, HWT, OS)

1. Oil line to air inlet shutoff actuator. 2. Return line from air inlet shutoff actuator. 3. Oil line to thermostatic pilot valve. 4. Return line from diverter valve. 5. Oil line to diverter valve. 6. From two-way valve at the diverter valve to drain. 7. From diverter valve to governor (fuel) shutoff actuator.

Many engines run thousands of hours in continuous-duty applications without any operation of the protective system shutoff actuators, valves and alarms (if so equipped).

Every 500 Service Meter Units, the emergency manual shutoff should be operated. This will check the protective system for correct operation.

NOTICE

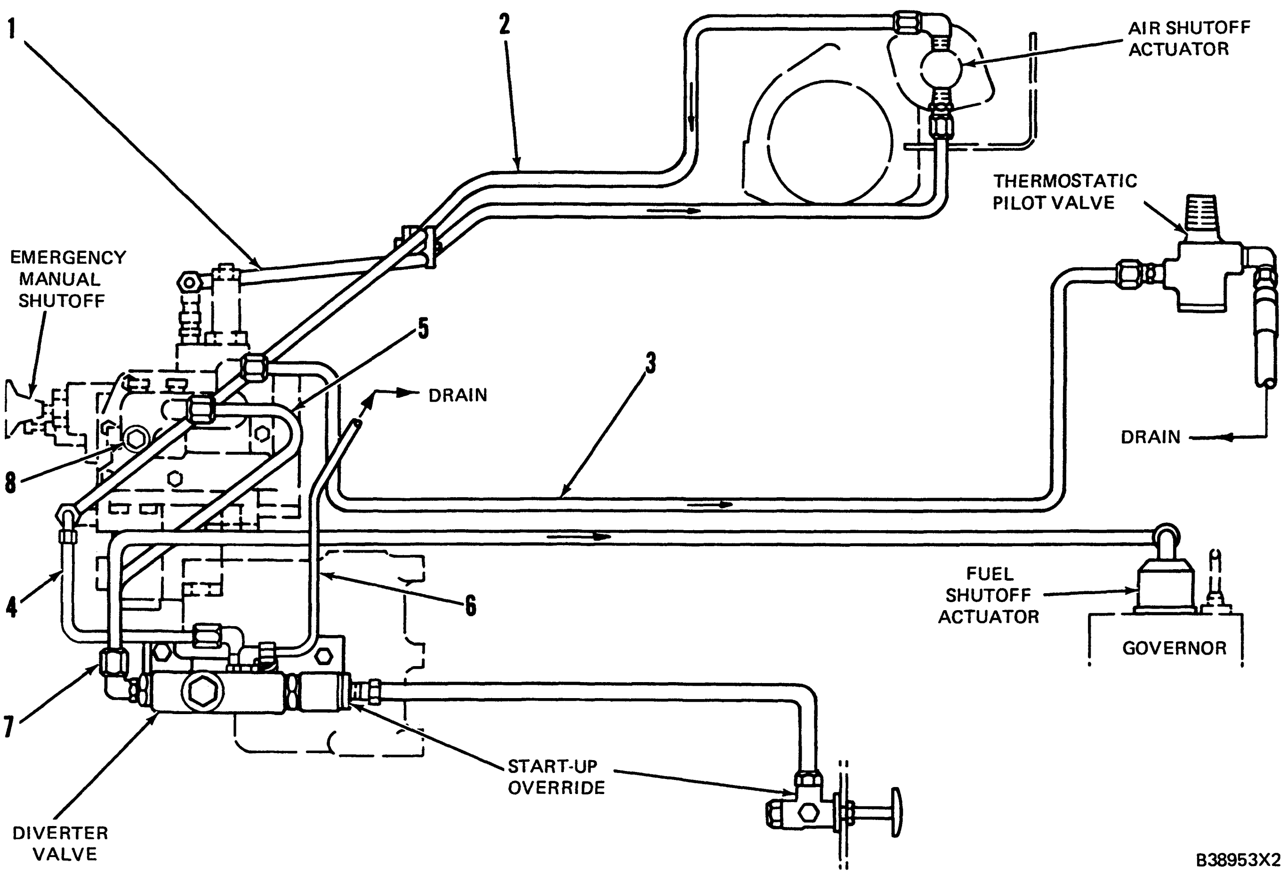
After the emergency manual shutoff has been operated, the air inlet shutoff valve must be opened. Also, the start-up override must be operated to release hydraulic pressure from the fuel shutoff actuator before the engine can be started again.

If no engine shutdown occurs, further inspection of the system is needed. The drive coupling and the two-way, 5N6411 Valve (palm valve) can be tested while the engine is operating under full load. However, tests of the air inlet shutoff and the (fuel) shutoff are done with the engine at low idle. Use the following procedures to check the system more completely.

DRIVE COUPLING CHECK

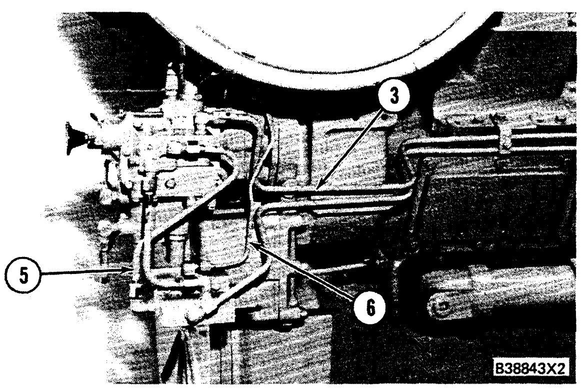
Put a rag around the fitting to prevent oil spray on oil supply line (5) at the diverter valve.

Operate the engine at low idle and loosen the nut on the fitting at the diverter valve one-half to three-quarters of a turn. Shake the line to break the paint. If any oil comes out under pressure, the shutoff is being driven through the coupling. Tighten the nut.



PROTECTIVE SYSTEM WITH ENGINE SHUTDOWN FOR OVERSPEED ONLY, ALARMS FOR OTHER FUNCTIONS (LOP, HWT)

1. Oil line to air inlet shutoff actuator. 2. Return line from air inlet shutoff actuator. 3. Oil line to thermostatic pilot valve. 4. Return line from diverter valve. 5. Oil line to diverter valve. 6. From two-way valve at the diverter valve to drain. 7. From diverter valve to governor (fuel) shutoff actuator. 8. Oil pressure switch for alarms.



PROTECTIVE SYSTEM OIL LINES

3. Oil line to thermostatic pilot valve. 5. Oil line to diverter valve. 6. From two-way valve (at the diverter valve) to drain.

START-UP OVERRIDE VALVE CHECK

On an engine with an air start system, start and operate the engine at low idle. Loosen the drain line from the two-way (palm) valve. There should be no oil present. If there is any oil flow, the valve has failed and replacement is necessary.

AIR INLET SHUTOFF CHECK

Operate the engine at low idle and pull the red, emergency knob. The air inlet shutoff valve must close and stop the engine. Low oil pressure and high coolant temperature alarms should also be activated, if so equipped.

The fuel shutoff actuator must also move the governor and fuel control linkage to the "SHUTOFF" position.

NOTICE

After this test has been performed, the air inlet shutoff valve must be opened. Also, the start-up override valve must be operated to release hydraulic pressure from the governor shutoff actuator before the engine can be started again.

FUEL SHUTOFF TEST

Hold open the air inlet shutoff valve with a length of wire. (If another person is present, the valve can be held open by hand.)

Pull the red, emergency knob. Since the air inlet shutoff valve has been held open, the fuel shutoff actuator should stop the engine. The low oil pressure, high coolant temperature alarms should also be activated, if so equipped.

NOTICE

Before starting the engine, make sure the air inlet shutoff is reset so the protective system can operate, if needed, and to prevent damage to the engine at start up.

LOW OIL PRESSURE TEST

Disconnect the oil supply line that is installed between the thermostatic pilot valve and the shutoff control group, at the control group. Attach a 3N4847 Hose Assembly to the control. Use a 7D5363 Connector to adapt a 3R3837 Shutoff Valve to the end of the hose.

NOTE: If the engine is not equipped with a thermostatic pilot valve, remove the plug from where line (4) would connect to the shutoff control group.

Close the valve and start the engine and operate it at low idle. The engine will run normally.

Place the end of the hose in a bucket or other container and open the valve to drain approximately one-half liter (one U.S. pint) of oil to lower the oil pressure.

This will actuate the low oil pressure protection circuit and cause engine shutdown through the fuel shutoff actuator or activate the low oil pressure, high coolant temperature alarms, if so equipped. The air inlet shutoff should not be activated by this test.

NOTE: The fuel shutoff actuator **will not** be activated in a protective system that gives overspeed protection only, when a low oil pressure fault is simulated.

If the fuel shutoff actuator is not activated by this test, check the actuator, oil lines or electrical connections, and the shutoff control group for defects. Make repairs or replacements of parts as needed.

If the alarms fail to activate, make sure the pressure switch on the control valve group, the wiring and alarms work correctly to locate and repair parts as needed.

Remove the hose assembly, connector and shutoff valve from the engine. Connect the oil supply to the thermostatic pilot valve.

All of the above tests are performed at low idle. Successful shutdowns and alarms at low idle indicate correct operation. Therefore, it is not necessary to perform the tests at high idle.

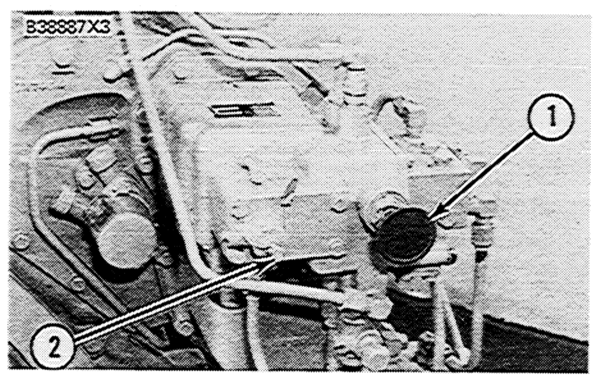
SHUTOFF SPEED SETTING ADJUSTMENT

NOTE: When major disassembly or adjustment of the shutoff control group is needed, see CATERPILLAR FUEL INJECTION TEST BENCH BOOK, FORM NO. SEHS7466 for the complete specifications and test bench procedures to use.

NOTICE

A mechanic with training in governor adjustments is the ONLY one that should perform the following procedure. Severe engine damage could occur if this procedure is not followed. Also, check the capabilities of driven equipment to make sure damage will not occur if run at overspeed.

1. Check and make sure the engine fuel settings are correct. See FUEL SETTING CHECK in the Engine TESTING AND ADJUSTING section of this Service Manual.
2. Start the engine and operate it at low idle.



SHUTOFF CONTROL GROUP

1. Emergency manual shutoff. 2. Overspeed setting adjustment bolt.

3. Before any adjustment to the shutoff control overspeed setting is made, check for correct operation of the hydramechanical protective

system. Pull emergency manual shutoff knob (1). Successful shutdown of intake air and fuel indicate correct operation.

NOTICE

After the emergency manual shutoff has been operated, the air inlet shutoff valve must be opened. Also, the start-up override must be operated to release hydraulic pressure from the fuel shutoff actuator before the engine can be started again.

4. Remove seal and wire from the bolts and remove the cover from over the high idle adjustment screw on the Caterpillar 3161 Governor, or the seal wire from high idle screw lock nut on Woodward UG-8L Governor.

5. Connect a tachometer of known accuracy to the engine.

NOTE: Some types of engine driven equipment, such as generators, pumps or compressors, can be damaged if operated at 18% above full load speed. If so, the driven equipment must be disconnected from the engine during this test. If this cannot be done, adjustment of the shutoff control group can be made on the CATERPILLAR FUEL INJECTION TEST BENCH. See Form No. SEHS7466 for the complete test bench procedures.

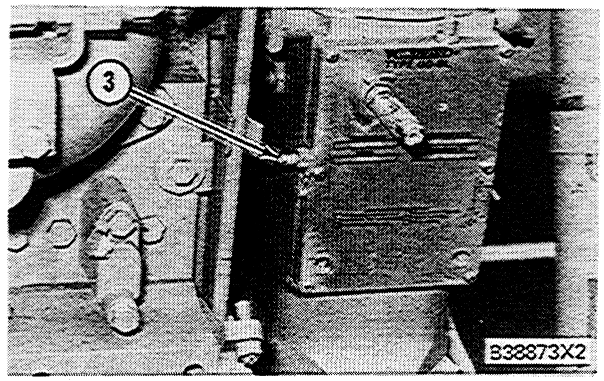
6. Start the engine again and operate it at high idle with no load.

7. Turn the governor high idle adjustment screw **slowly** to increase engine rpm. The air inlet shutoff must close and the fuel must be shut off through the governor and fuel control linkage at 18% ± 25 rpm above full load rpm. For example, this is 2124 ± 25 rpm for an engine rated at 1800 rpm.

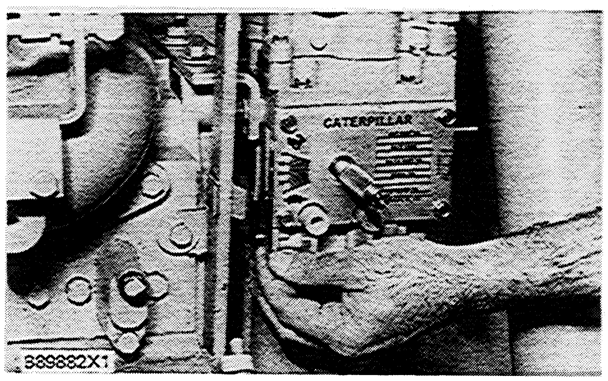
NOTICE

After the hydramechanical protective system has been activated, the air inlet shutoff valve must be opened. Also, the start-up override must be operated to release hydraulic pressure from the fuel shutoff actuator before the engine can be started again.

8. If engine shutdown does not occur at 18% ± 25 rpm above full load rpm, **slowly** increase engine rpm 50 rpm more. For example, this is 2174 rpm for an engine rated at 1800 rpm. If engine shutdown still does not occur, decrease the engine rpm and remove the seal and lockwire and turn overspeed adjusting bolt (2) one turn counterclockwise. Again, **slowly** increase the engine rpm to check for engine shutdown at 18% ± 25 rpm above full load rpm.



UG-8L GOVERNOR
3. High idle adjustment screw.



ADJUSTMENT OF HIGH IDLE ON 3161 GOVERNOR

NOTE: If engine shutdown occurs before 18% ± 25 rpm of full load rpm, turn overspeed adjusting bolt (2) clockwise to increase the shutoff control group overspeed setting.

9. Repeat the above procedure until engine shutdown occurs at the correct rpm.

10. Adjust engine high idle to the specifications shown on the Engine Information Plate which is attached to one of the right side camshaft inspection covers. If the Engine Information Plate is missing, see the FUEL SETTING AND RELATED INFORMATION FICHE for the correct specifications to use.

11. Install the seals and lockwires for the shutoff control group and the governor high idle adjustment screw.

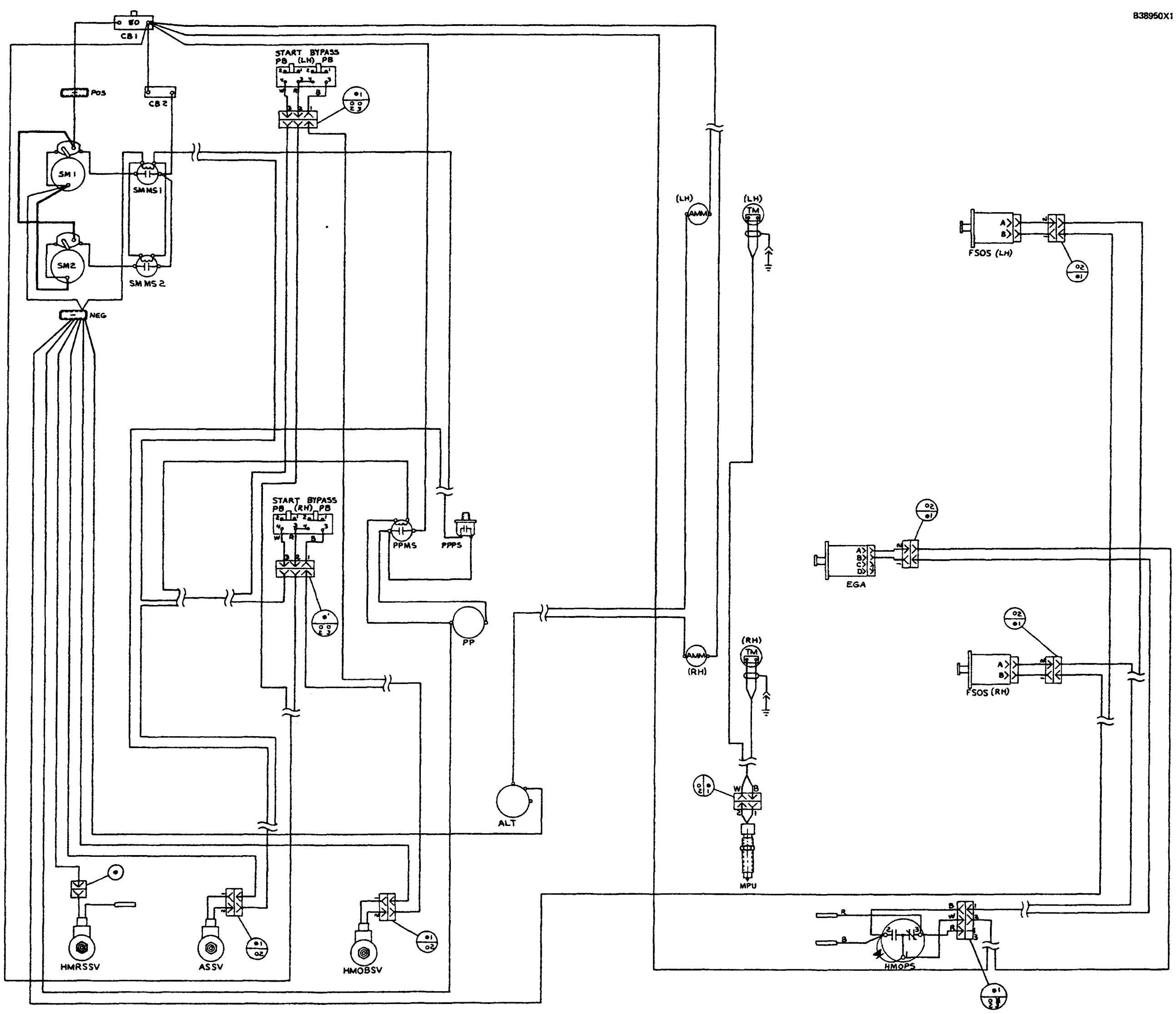
HYDRAMECHANICAL PROTECTIVE SYSTEM WIRING DIAGRAMS

COMPONENT ABBREVIATIONS

ALT	ALTERNATOR
AMM	AMMETER
ASOS	AIR SHUTOFF SOLENOID
ASSV	AIR START SOLENOID VALVE
B–	BATTERY NEGATIVE
B+	BATTERY POSITIVE
BATT	BATTERY
CB	CIRCUIT BREAKER
EGA	ELECTRIC GOVERNOR ACTUATOR
EGC	ELECTRIC GOVERNOR CONTROL
ENCL	ENCLOSER
FSOS	FUEL SHUTOFF SOLENOID
HM	HOUR METER
HMMPU	HOUR METER MAGNETIC PICK-UP
HMOBSV	HYDRAMECHANICAL OIL BYPASS SOLENOID VALVE
HMOPS	HYDRAMECHANICAL OIL PRESSURE SWITCH
HMRSSV	HYDRAMECHANICAL REMOTE SHUTOFF SOLENOID VALVE
HWTAS	HIGH WATER TEMPERATURE ALARM SWITCH
LOPAS	LOW OIL PRESSURE ALARM SWITCH
LWTAS	LOW WATER TEMPERATURE ALARM SWITCH
MGOPG	MARINE GEAR OIL PRESSURE GAGE
MGOPSU	MARINE GEAR OIL PRESSURE SENDING UNIT
MGOTAS	MARINE GEAR OIL TEMPERATURE ALARM SWITCH
MPU	MAGNETIC PICK-UP
OPG	OIL PRESSURE GAGE
OPS	OIL PRESSURE SWITCH
OPSU	OIL PRESSURE SENDING UNIT
PB	PUSH BUTTON
PP	PRELUBE PUMP
PPMS	PRELUBE PUMP MAGNETIC SWITCH
PPPS	PRELUBE PUMP PRESSURE SWITCH
RNS	REMOTE NORMAL SHUTOFF SWITCH
SM	STARTER MOTOR
SMMS	STARTER MOTOR MAGNETIC SWITCH
TM	TACHOMETER
TMMPU	TACHOMETER MAGNETIC PICK-UP
TS	TERMINAL STRIP
WTG	WATER TEMPERATURE GAGE
WTS	WATER TEMPERATURE SWITCH
WTSU	WATER TEMPERATURE SENDING UNIT

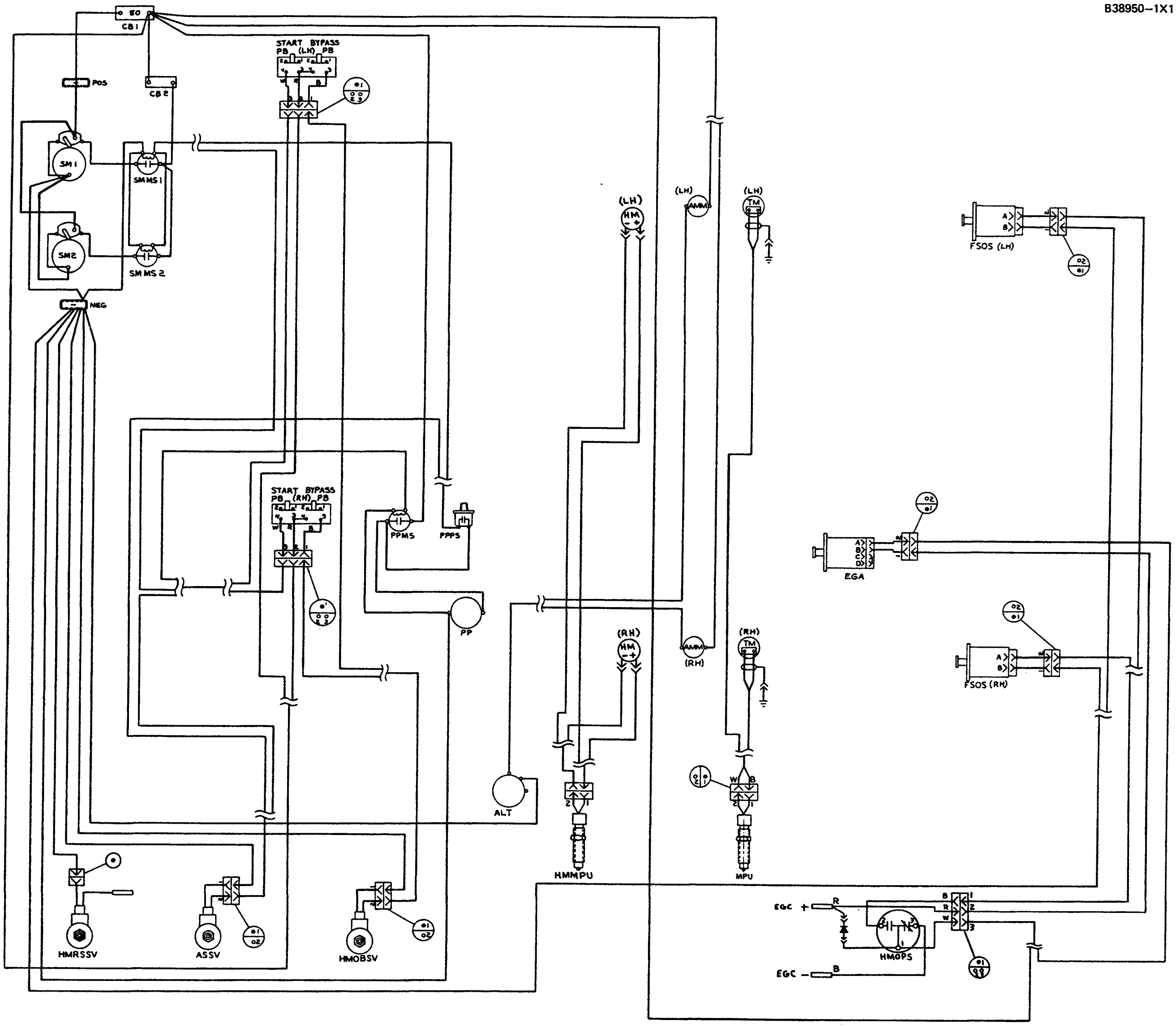
WIRE COLOR CODE ABBREVIATIONS

B	BLACK
BR	BROWN
B/W	BLACK WITH WHITE STRIPE
CU	COPPER (BARE WIRE)
DK BL	DARK BLUE
DK GR	DARK GREEN
GR	GREEN
LT BL	LIGHT BLUE
O	ORANGE
O/B	ORANGE WITH BLACK STRIPE
P/B	PINK WITH BLACK STRIPE
PU/W	PURPLE WITH WHITE STRIPE
R	RED
W	WHITE
W/O	WHITE WITH ORANGE STRIPE
W/R	WHITE WITH RED STRIPE
Y	YELLOW
Y/BR	YELLOW WITH BROWN STRIPE

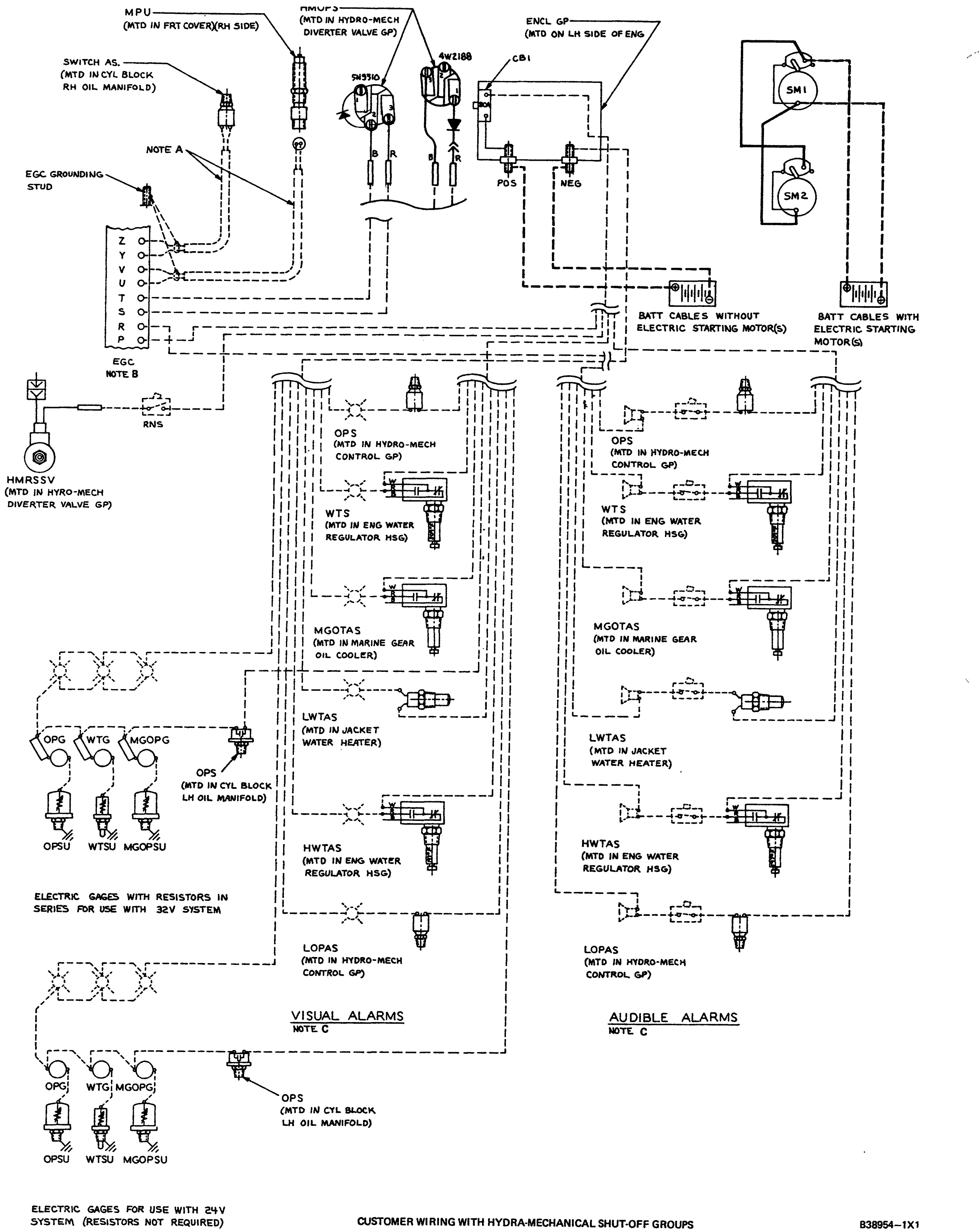


3500 ENGINE WIRING DIAGRAM (REF. 5N8944)
(Earlier Systems With 5N9310 Pressure Switch Assembly)

B38950–1X1



3500 ENGINE WIRING DIAGRAM (REF. 5N8944)
(Later Systems With 4W2188 Pressure Switch Assembly)



CUSTOMER WIRING WITH HYDRA-MECHANICAL SHUT-OFF GROUPS

B38954–1X1

SEE NOTES ON PAGE THAT FOLLOWS

NOTE A: Magnetic pick-up and oil pressure switch to be wired to electric governor control (Woodward 2301) with a two conducter shielded cable (Belden Corp. type 8780 or equivalent). Shields are to be grounded at electric governor control grounding stud. Each shield should not have more than one ground connection.

NOTE B: Woodward 2301 Electric Governor Control terminal identification chart:

SYMBOL	FUNCTION	STAND-BY TS NO.
P	Batt +	2
R	Batt –	1
S	EGA +	6
T	EGA –	5
U	Mag Pick-up	7
V	Mag Pick-up	8
Y	Oil Pressure Speed Limiter	9
Z	Oil Pressure Speed Limiter	10

NOTE C: Caterpillar alarm and prealarm contacts are rated for a maximum of 3 amps inductive at the charging system voltage.

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Printed in U.S.A. (6/86)