Section F

Transmission

Service Manual - Backhoe Loader

Publication No.
9803/3290-16

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Service Tools

Numerical List

The tools listed in the table are special tools required for testing, removal and replacement of transmission assemblies. These tools are available from JCB Service or, in some instances, can be manufactured locally from specifications given in this section.

Some tools are supplied as kits. Cross references are given to tables showing kit contents.

Note: *Tools other than those listed will be required. It is expected that such general tools will be available in any well equipped workshop or be available locally from any good tool supplier.*

Part Number	Description	Tool Detail Reference
460/15708	Flow test adaptor - Powershift - Other components required, see tool detail	⇨ *Fig 2. (F-2)*
721/10885	Interconnecting cable - Use with 892/01033	⇨ *Fig 14. (F-5)*
892/00253	Hydraulic pressure test kit	⇨ *Fig 4. (F-3)*
892/00268	Flow monitoring unit - Other components required, see tool detail	⇨ *Fig 3. (F-3)*
892/00301	Flow test adaptor - Synchro Shuttle - Other components required, see tool detail	⇨ *Fig 1. (F-2)*
892/00812	Drive coupling spanner	⇨ *Fig 5. (F-4)*
892/00822	Splined bolt socket	⇨ *Fig 6. (F-4)*
892/00913	Grease gun attachment - Use where access to the grease nipple is restricted E.g. Axle driveshaft universal joints	⇨ *Fig 8. (F-4)*
892/00964	Test point 1/8 BSP - Powershift	⇨ *Fig 9. (F-4)*
892/00965	Test point 3/8 BSP - Powershift	⇨ *Fig 10. (F-4)*
892/00966	Test point 1/4 BSP - Synchro Shuttle	⇨ *Fig 11. (F-4)*
892/01033	Electronic service tool kit - also requires 721/10885	⇨ *Fig 12. (F-5)*
892/01094	Transmission jack - support plates also required, see tool detail	⇨ *Fig 15. (F-6)*
892/01096	Speed sensor test harness - Powershift	⇨ *Fig 13. (F-5)*
892/01110	Torque converter alignment tool	⇨ *Fig 19. (F-8)*
992/04000	Torque multiplier	⇨ *Fig 7. (F-4)*

Tool Detail Reference

Note: *Not all service tools are illustrated.*

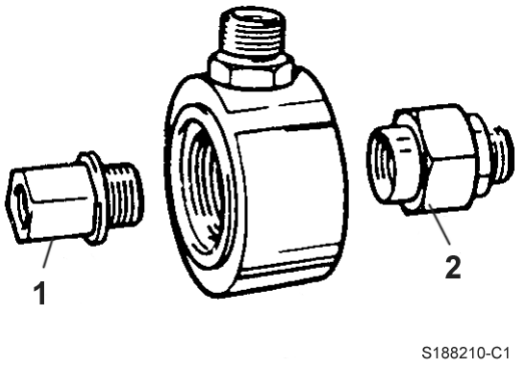


Fig 1. 892/00301 Flow Test Adaptor

Note: *Components listed as follows also required*	
Item	Description
1	892/00920 Adaptor
2	892/00302 Adaptor

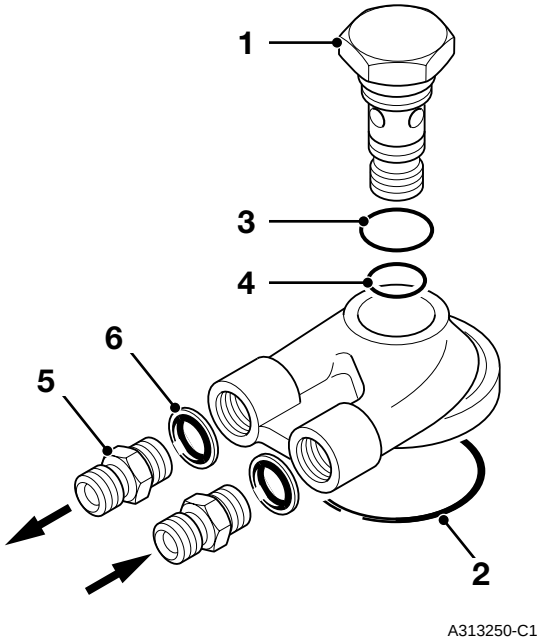


Fig 2. 460/15708 Flow Test Adaptor

Note: *Components listed below also required*	
Item	Description
1	460/15707 Banjo bolt
2	2401/0222 O-ring
3	2403/0110 O-ring
4	2403/0108 O-ring
5	1604/0004 Adaptor - 2 off
6	1406/0018 Sealing washer - 2 off

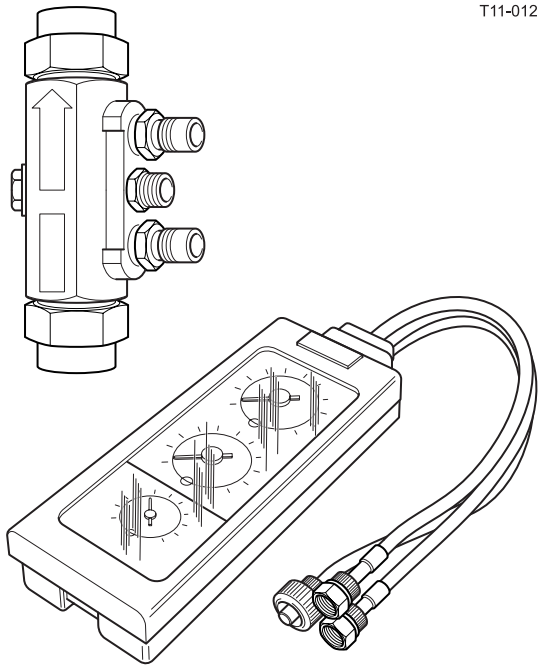


Fig 3. Flow Test Equipment

892/00268	Flow Monitoring Unit
892/00269	Sensor Head 0 - 100 l/min (0 - 22 UK gal/min)
892/00273	Sensor Head 0 - 380 l/min (0 - 85.5 UK gal/min)
892/00293	Connector Pipe
892/00270	Load Valve
1406/0021	Bonded Washer
1604/0006A	Adapter 3/4 in M x 3/4 in M BSP
1612/2054	Adapter 3/4 in F x 3/4 in M BSP
892/00271	Adapter 3/4 in F x 5/8 in M BSP
892/00272	Adapter 5/8 in F x 3/4 in M BSP
816/20008	Adapter 3/4 in F x 1/2 in M BSP
892/00275	Adapter 1/2 in F x 3/4 in M BSP
892/00276	Adapter 3/4 in F x 3/8 in M BSP
892/00277	Adapter 3/8 in F x 3/4 in M BSP
1606/0015	Adapter 1.1/4 in M BSP x 1 in M BSP
892/00078	Connector 1 in F x 1 in F BSP
1604/0008	Adapter 1 in M x 1 in M BSP
1604/0008	Adapter 1 in M x 3/4 in M BSP
816/20013	Adapter 3/4 in F x 1 in M BSP

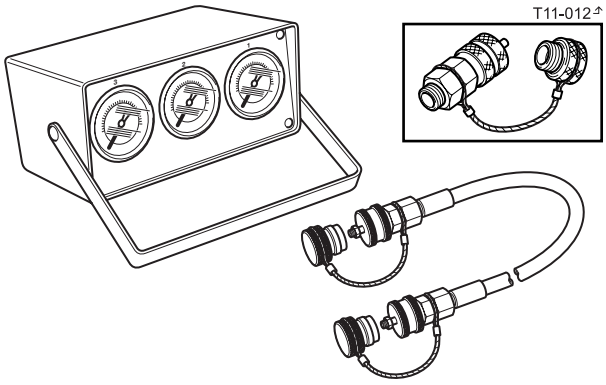


Fig 4. 892/ 00253 Hydraulic Circuit Pressure Test Kit

892/00201	Replacement Gauge 0-20 bar (0-300 lbf/in^2)
892/00202	Replacement Gauge 0-40 bar (0-600 lbf/in^2)
892/00203	Replacement Gauge 0-400 bar (0-6000 lbf/in^2)
892/00254	Replacement Hose
993/69800	Seal Kit for 892/00254 (can also be used with probe 892/00706)
892/00706	Test Probe
892/00347	Connector - Hose to gauge

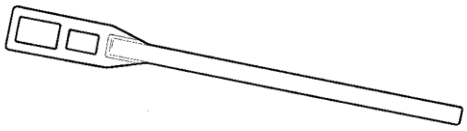


Fig 5. 892/00812 Drive Coupling Spanner

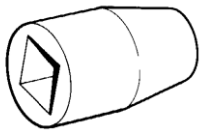


Fig 6. 892/00822 Splined Bolt Socket

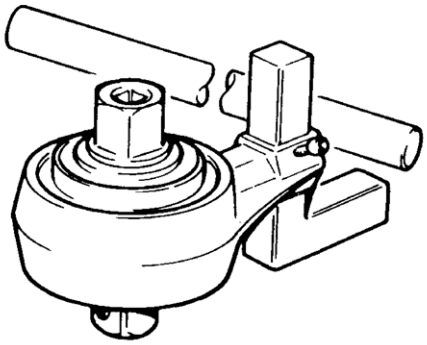


Fig 7. 992/04000 Torque Multiplier

Fig 8. 892/00913 Grease Gun Attachment

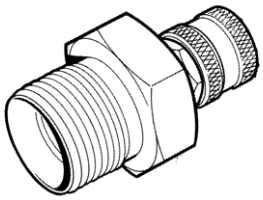


Fig 9. 892/00964 Test Point 1/8 BSP

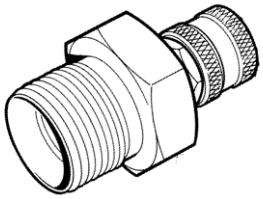


Fig 10. 892/00965 Test Point 3/8 BSP

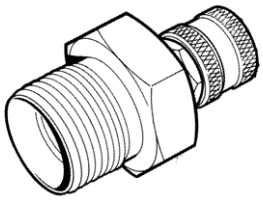


Fig 11. 892/00966 Test Point 1/4 BSP

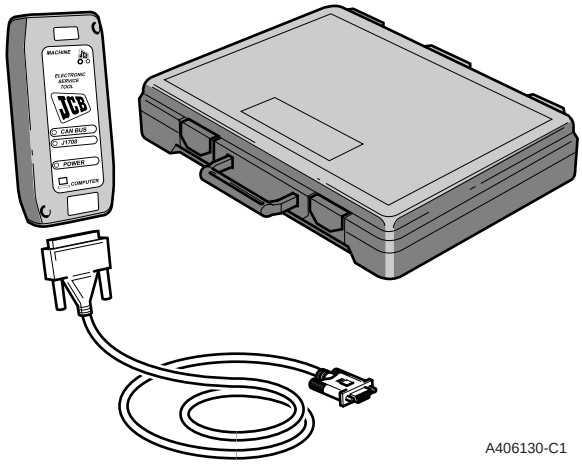


Fig 12. 892/01033 Electronic Test Kit

Note: *Also requires 721/10885 interconnecting cable*

Item	Description
1	Data Link Adaptor (DLA), enables data exchange between the machine ECU (Electronic Control Unit) and laptop PC loaded with the applicable ShiftMaster diagnostics software
2	Interconnecting cable, DLA to laptop PC. Several cables are included to enable compatibility with different PC port types
3	Kit carrying case

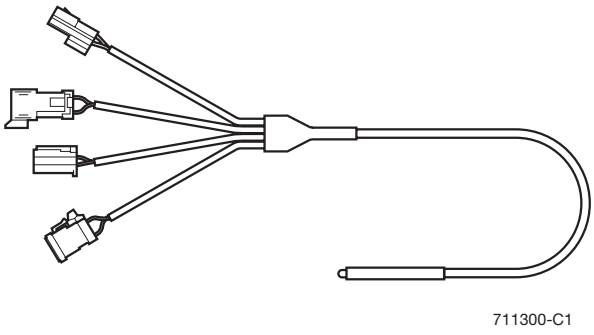


Fig 13. 892/01096 Speed Sensor Test Harness

Fig 14. 721/10885 Interconnecting Cable

Use with 892/01033

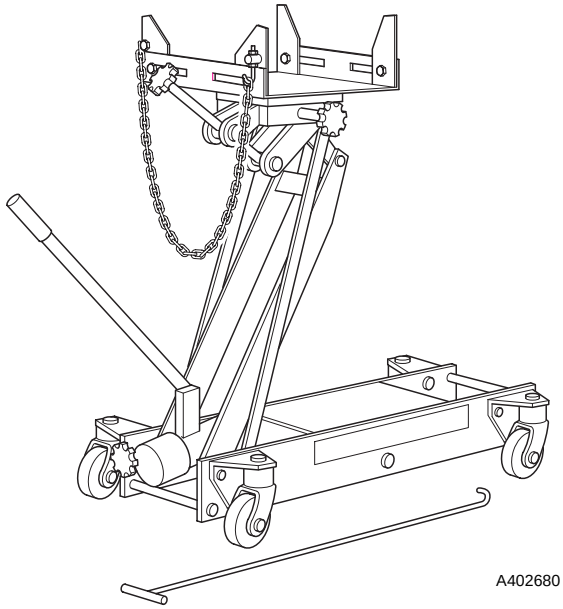


Fig 15. 892/01094 Transmission Jack

When removing the Powershift gearbox use of a special transmission jack is strongly recommended. This jack can also be used when removing Synchro Shuttle gearboxes.

Note: *The jack must be used with special support plates. Manufacture the plates locally, refer to Figs 16,17 and 18.*

Rear Jack Plate - 4 and 6 speed Powershift - Manufacture locally from 5 mm thick mild steel plate.

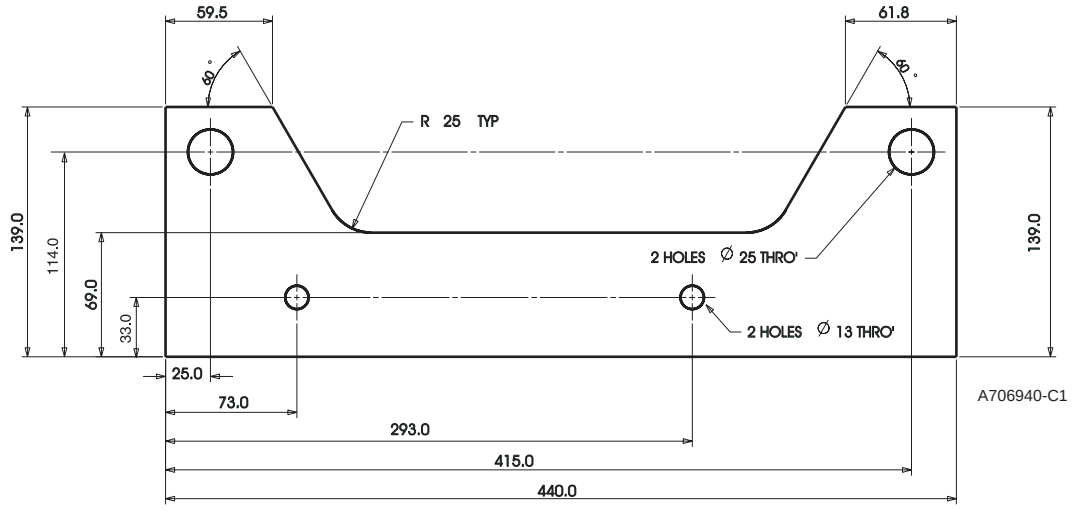


Fig 16.

Front Jack Plate - 6 speed Powershift - Manufacture locally from 5 mm thick mild steel plate.

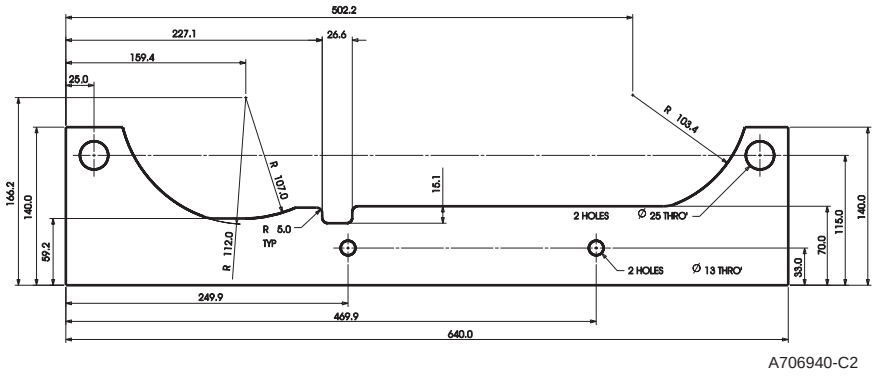


Fig 17.

Front Jack Plate - 4 speed Powershift - Manufacture locally from 5 mm thick mild steel plate.

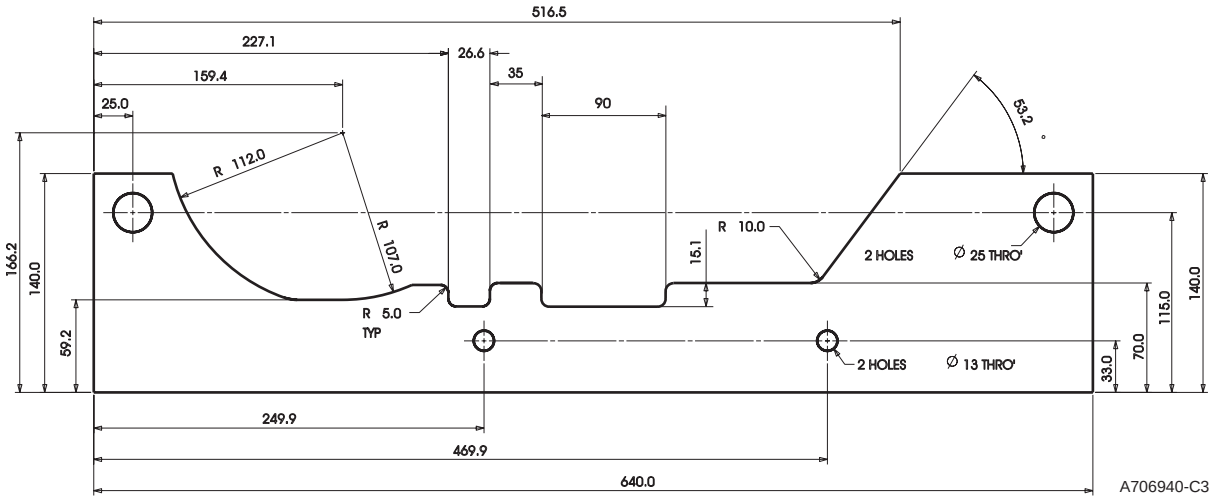


Fig 18.

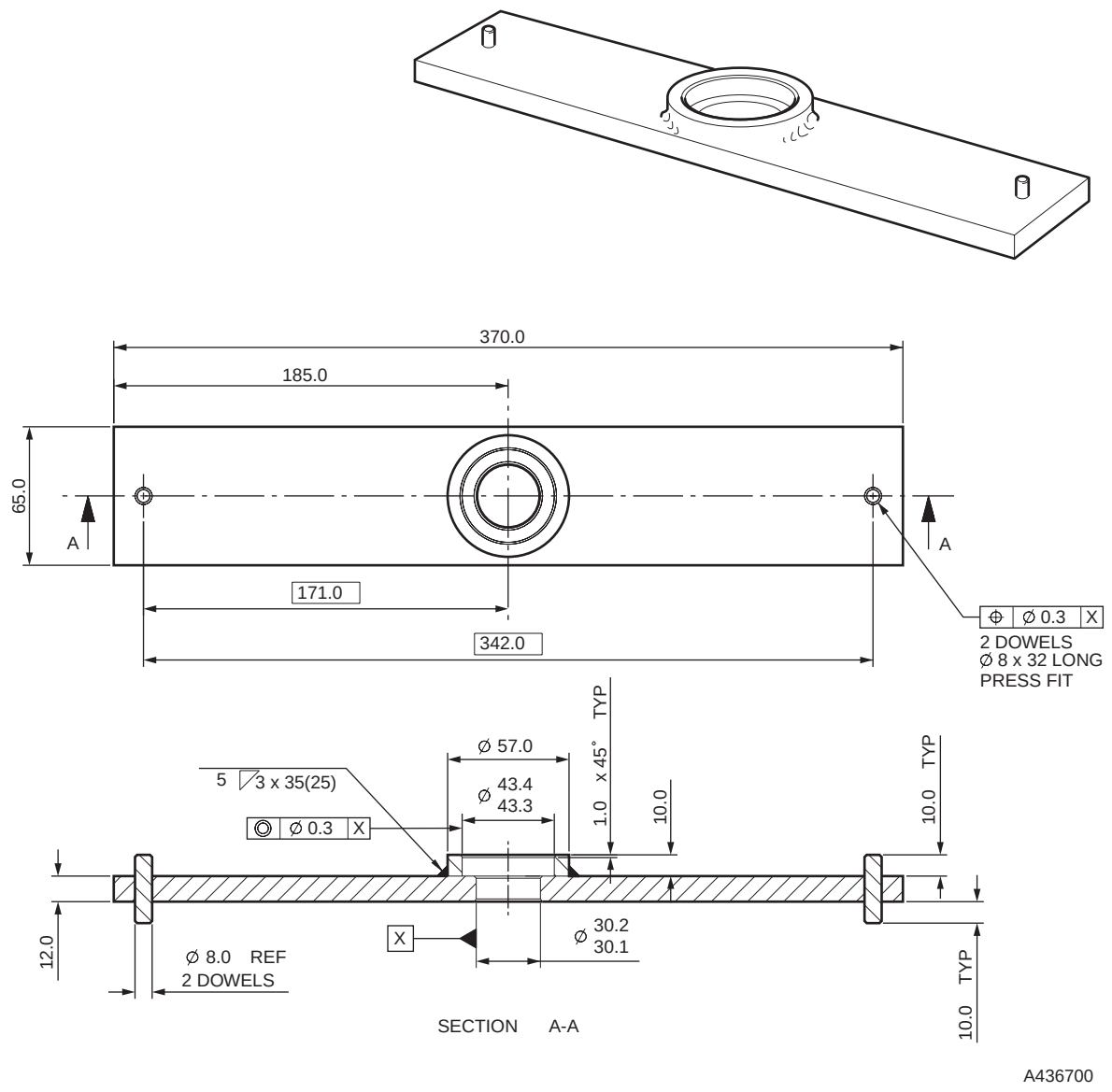


Fig 19. 892/01110 Torque Converter Alignment Tool

Note: *Use with 12" and W300 torque converters*

Technical Data

Tyre Sizes and Pressures

Table 1. All Wheel Steer Machines - Front and Rear

Item	Size x Ply	Pattern	Make	Name	Pressure	
					bar	lbf/in^2
1(1)	14.9x24x12	INDUSTRIAL	GOODYEAR	INDUSTRIAL SURE GRIP	2.75	40
2(1)	16.9x24x12	INDUSTRIAL	TITAN	R4 TL INDUSTRIAL LUG	2.6	38
3	16.9x24x12	INDUSTRIAL	GOODYEAR	INDUSTRIAL SURE GRIP	2.6	38
4(1)	16.9x24x12	INDUSTRIAL	GOODYEAR	INDUSTRIAL SURE GRIP	2.6	38
5(1)	16.9x24x12	INDUSTRIAL	FIRESTONE	R4 ALL TRACTION UTILITY	2.6	38
6(1)	16.9x24x12	INDUSTRIAL	GALAXY	R4 EZ RIDER	2.6	38
7(1)	460/70R24	TRACTION	GOODYEAR	IT520	2.6	38
8	15.5x25R	TRACTION	MICHELIN	XTLA	2.5	36
9(1)	17.5x25x12	INDUSTRIAL	GOODYEAR	SURE GRIP LUG	2.3	33
10(1)	16.9x28x12	INDUSTRIAL	GOODYEAR	INDUSTRIAL SURE GRIP	2.6	38
11(1)	16.9x28X12	INDUSTRIAL	TITAN	R4 TL INDUSTRIAL LUG	2.6	38
12(1)	16.9x28x12	INDUSTRIAL	FIRESTONE	R4 ALL TRACTION UTILITY	2.6	38
13(1)	16.9x28x12	INDUSTRIAL	GALAXY	R4 EZ RIDER	2.6	38
14(1)	16.9x28x12	INDUSTRIAL	JCB	SITEMASTER	2.6	38
15(1)	440/80R28	TRACTION	MICHELIN	XMCL	2.4	35
16(1)	440/80R28	INDUSTRIAL	GOODYEAR	IT530	2.4	35
17(1)	500/70R28	TRACTION	GOODYEAR	IT520	2.1	30

(1) Items 1, 2, 4, 5, 6, 7, 9, 10, 11, 12, 13, 14, 15, 16, 17 above must have steering lock restriction stops fitted.

***Note:** 12 ply tyres must be fitted on rear wheels when any backhoe attachment is used. For the correct pressure see the table.*

***Note:** All tyres are tubeless unless otherwise stated.*

Table 2. Two Wheel Steer, 2 Wheel Drive Machines - Front

Item	Size x Ply	Pattern	Make	Name	Pressure	
					bar	lbf/in^2
1	11Lx16x12	ROAD	TITAN	F3 TL CONTRACTOR	4.4	64
2	11Lx16x12	INDUSTRIAL SPECIAL	FIRESTONE	F3	4.4	64
3	11Lx16x12	RIBBED	GALAXY	F3	4.4	64
4	11x16x12	RIBBED	FIRESTONE	RIB TRACTOR	4.1	60
5	11x16x12	RIBBED	GOODYEAR	MULTI-RIB	4.2	61
6	12.5x18x10	INDUSTRIAL	JCB	SITEMASTER	3.0	43.5

Note: *All tyres are tubeless unless otherwise stated.*

Table 3. Two Wheel Steer, 4 Wheel Drive Machines - Front

Item	Size x Ply	Pattern	Make	Name	Pressure	
					bar	lbf/in^2
1(2)	14x17.5x10	ROAD	TITAN	TL NHS CONTRACTOR	3.8	55
2(2)	14x17.5x10	ROAD	TITAN	SKID MASTER	3.8	55
3(2)	14x17.5x10	INDUSTRIAL	GOODYEAR	SURE GRIP LUG	3.8	55
4(2)	14x17.5x10	INDUSTRIAL	SOLIDEAL	SKS	3.8	55
5(2)	14x17.5x10	INDUSTRIAL	FIRESTONE	SUPER TRACTION DUPLEX	3.8	55
6(2)	14x17.5x10	INDUSTRIAL	GALAXY	R4 MARATHONER	3.4	50
7(1)	12x18x10	INDUSTRIAL	GALAXY	BEEFY BABY R4	3.1	46
8(1)	12.5x18x10	INDUSTRIAL	JCB	SITEMASTER	3.0	43.5
9(1)	12.5/80x18x10	INDUSTRIAL	GOODYEAR	SURE GRIP LUG	4.25	62
10(1)	340/80x18R	TRACTION	MICHELIN	XMCL	4.0	58
11(1)	400/70x18R	INDUSTRIAL	GOODYEAR	IT530	2.6	38
12(1)(2)	12.5x20x10	INDUSTRIAL	GOODYEAR	MPT SURE GRIP	3.0	43.5
13(1)(2)	340/80x20R	TRACTION	MICHELIN	XMCL	3.2	46
14(1)(2)	16.0/70x20x10	TRACTION	GOODYEAR	SURE GRIP ALL SERVICE	3.4	50
15(1)(2)	16.0/70x20x10	INDUSTRIAL	GOODYEAR	SURE GRIP LUG	3.4	50
16(1)(2)	400/70R20	TRACTION	GOODYEAR	IT520	3.0	43.5
17(1)(2)	400/70R20	INDUSTRIAL	GOODYEAR	IT530	3.0	43.5
18(1)(2)	400/70R20	TRACTION	MICHELIN	XMCL	3.6	52

(1) Items 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18 above must have steering lock restriction stops fitted.
(2) Items 5, 6, 12, 13, 14, 15, 16, 17, 18 above must have rear axle spacers fitted.

Note: *12 ply tyres must be fitted on rear wheels when any backhoe attachment is used. For the correct pressure see the table above.*

Note: *All tyres are tubeless unless otherwise stated.*

Table 4. Two Wheel Steer Machines - Rear

Item	Size x Ply	Pattern	Make	Name	Pressure	
					bar	lbf/in^2
1	16.9x24x10	INDUSTRIAL	TITAN	R4 TL INDUSTRIAL LUG	2.2	32
2	16.9x24x12	INDUSTRIAL	GOODYEAR	INDUSTRIAL SURE GRIP	2.6	38
3	16.9x24x12	INDUSTRIAL	SOLIDEAL	SL R4	2.6	38
4	17.5Lx24x10	INDUSTRIAL	TITAN	R4 TL INDUSTRIAL LUG	2.2	32
5	19.5Lx24x10	INDUSTRIAL	TITAN	R4 TL INDUSTRIAL LUG	1.9	28
6	19.5Lx24x12	INDUSTRIAL	TITAN	R4 TL INDUSTRIAL LUG	2.3	33
7	19.5Lx24x12	INDUSTRIAL	GOODYEAR	IT525	2.3	33
8	19.5Lx24x12	INDUSTRIAL	FIRESTONE	R4 ALL TRACTION UTILITY	2.3	33
9	19.5Lx24x12	INDUSTRIAL	GALAXY	R4 EZ RIDER	2.3	33
10	21x24x12	INDUSTRIAL	GOODYEAR	IT525	2.2	32
11	21Lx24x12	INDUSTRIAL	GALAXY	R4 EZ RIDER	2.2	32
12	18.4x26x12	TRACTION	JCB	SITEMASTER TZ19	2.4	35
13	18.4/15x26x12	INDUSTRIAL	GOODYEAR	SURE GRIP INDUSTRIAL	2.2	32
14	18.4x26x12	INDUSTRIAL	GALAXY	BACKHOE INDUSTRIAL LUG	2.5	36
15	18.4x26x12	INDUSTRIAL	JCB	SITEMASTER	2.5	36
16	480/80xR26	INDUSTRIAL	GOODYEAR	IT530	2.0	29
17	480/80xR26	TRACTION	GOODYEAR	IT520	2.0	29
18	16.9/14x28x12	INDUSTRIAL	GOODYEAR	INDUSTRIAL SURE GRIP	2.2	32
19	16.9x28x12	INDUSTRIAL	JCB	SITEMASTER E58	2.4	35
20	16.9x28x12	INDUSTRIAL	JCB	SITEMASTER	2.6	38
21	440/80R28	TRACTION	MICHELIN	XMCL	2.3	33
22	500/70xR28	TRACTION	GOODYEAR	IT520	2.1	30
23(1)	18.4x30x14	INDUSTRIAL	GOODYEAR	SURE GRIP LUG	2.0	32

(1) Tube tyre.

Note: *All tyres are tubeless unless otherwise stated.*

Front Axles

Note: *It is essential that the correct ratio axle in relationship to the gearbox ratio is fitted to the machine. Do not fit a new axle with a different ratio to the axle being replaced.*

All Wheel Steer Machines

Unit Identification

The axle serial number is stamped on the unit identification plate **A** as shown.

When ordering replacement parts, always quote the details on the unit identification plate. In the case of gear replacements, always check the part number stamped on the gear, and the number of teeth.

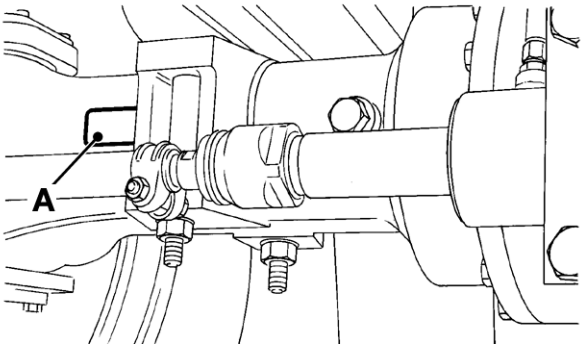


Fig 20.

Designation

SD80 1 Piece Axle	
Hubs	80 Series
Hub swivels and drive shafts	55 Series
Drive head	80 Series 1 piece

Specification

Table 5. SD80 Axle

Type	JCB spiral bevel input with epicyclic hub reduction
Installation	Centre pivot
Weight (dry, with no steer rams and without wheels)	385 kg (850 lbs) approximately
Overall Gear Ratio	18.16:1
Crownwheel and Pinion Ratio	3.364:1
Hub Reduction	5.4:1
Crownwheel Teeth	37
Pinion Teeth	11
Input Type	Yoke
Oscillation	5°
Toe - in	0°
Castor Angle	0°
Camber Angle	1°
King - pin inclination	0°

2 Wheel Steer Machines (4 Wheel Drive)

Unit Identification

The axle serial number is stamped on the unit identification plate **A** as shown.

When ordering replacement parts, always quote the details on the unit identification plate. In the case of gear replacements, always check the part number stamped on the gear, and the number of teeth.

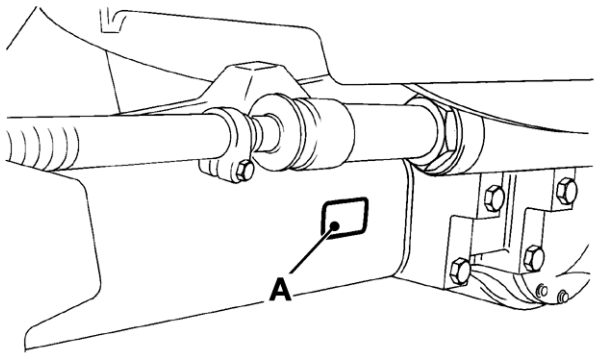


Fig 21.

Designation

SD55 1 Piece Axle	
Hubs	55 Series
Hub swivels and drive shafts	55 Series
Drive head	55 Series 1 piece

Specification

Table 6. SD55 Axle

Type	JCB spiral bevel input with epicyclic hub reduction			
Installation	Centre pivot			
Weight (dry, with no steer rams and without wheels)	330 kg (728 lbs) approximately			
Hub Reduction	5.4:1			
Input Type	Yoke			
Oscillation	5°			
Toe - in	0°			
Castor Angle	0°			
Camber Angle	1°			
King - pin inclination	0°			
Ratios	OPTION 1	OPTION 2	OPTION 3	OPTION 4
Overall	16.2:1	19.2:1	14.123:1	15.78:1
Crownwheel and Pinion	3:1	3.556:1	2.615:1	2.923:1
Crownwheel Teeth	33	32	34	38
Pinion Teeth	11	9	13	13

2 Wheel Steer Machines (2 Wheel Drive)

Unit Identification

The axle serial number is stamped on the unit identification plate **A** as shown.

When ordering replacement parts, always quote the details on the unit identification plate. In the case of gear replacements, always check the part number stamped on the gear, and the number of teeth.

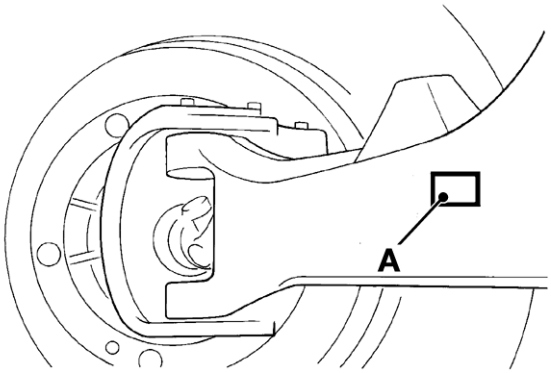


Fig 22.

Designation

Dead Steer 1 Piece Axle	
Hubs	Dead Steer

Specification

Table 7. Dead Steer Axle

Type	JCB centre oscillation, non driven
Installation	Centre pivot
Weight (dry, with no steer rams and without wheels)	239 kg (525 lbs) approximately
Oscillation	5°
Toe - in	0°
Castor Angle	0°
Camber Angle	3° positive

Rear Axles

Note: *It is essential that the correct ratio axle in relationship to the gearbox ratio is fitted to the machine. Do not fit a new axle with a different ratio to the axle being replaced.*

All Wheel Steer Machines

Unit Identification

The axle serial number is stamped on the unit identification plate **A** as shown.

When ordering replacement parts, always quote the details on the unit identification plate. In the case of gear replacements, always check the part number stamped on the gear, and the number of teeth.

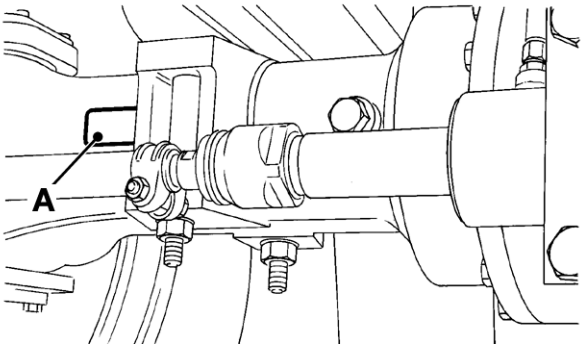


Fig 23.

Designation

SD80 3 Piece Axle	
Hubs	80 Series
Hub swivels and drive shafts	55 Series
Drive head	80 Series 3 piece

Specification

Table 8. SD80 Axle

Type	3 piece, JCB spiral bevel input with epicyclic hub reduction and inboard braking. Pinion mounted park brake disc (synchro shuttle machines only).		
Installation	Rigid pad mount		
Weight (dry, with no steer rams and without wheels)	410 kg (904 lbs) approximately		
Half (Axle) Shaft Braking/Type	5 friction plate, 6 counter plates (each half shaft)		
Input Type	Yoke		
Oscillation	5°		
Toe - in	0°		
Castor Angle	0°		
Camber Angle	1°		
King - pin inclination	0°		
Hub Reduction	5.4:1		
Ratios	OPTION 1	OPTION 2	OPTION 3
Overall	15.78:1	18.16:1	13.7:1
Crownwheel and Pinion	2.923:1	3.363:1	2.538:1
Crownwheel Teeth	38	37	33
Pinion Teeth	13	11	13

2 Wheel Steer Machines

Unit Identification

The axle serial number is stamped on the unit identification plate **A** as shown.

When ordering replacement parts, always quote the details on the unit identification plate. In the case of gear replacements, always check the part number stamped on the gear, and the number of teeth.

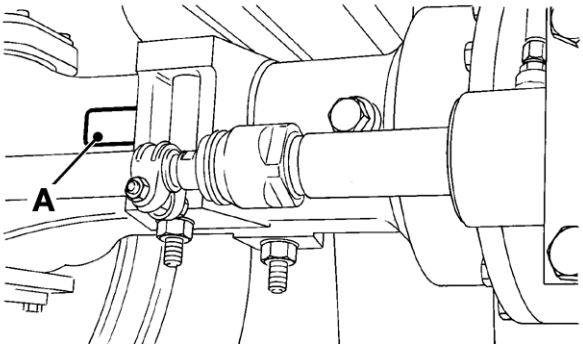


Fig 24.

Designation

PD70 3 Piece Axle	
Hubs	55 Series
Drive shafts	70 Series
Drive head	80 Series 3 piece

Specification

Table 9. PD70 Axle

Type	3 piece, JCB spiral bevel input with epicyclic hub reduction and inboard braking. Pinion mounted park brake disc (synchro shuttle machines only).		
Installation	Rigid pad mount		
Weight (dry, with no steer rams and without wheels)	386 kg (851 lbs) approximately		
Half (Axle) Shaft Braking/Type	5 friction plate, 6 counter plates (each half shaft)		
Input Type	Yoke		
Hub Reduction	5.4:1		
Ratios	OPTION 1	OPTION 2	OPTION 3
Overall	15.78:1	18.16:1	13.7:1
Crownwheel and Pinion	2.923:1	3.363:1	2.538:1
Crownwheel Teeth	38	37	33
Pinion Teeth	13	11	13

Synchro Shuttle Gearbox

SS700 Manual Gearbox

Unit Identification

The gearbox serial number is stamped on the unit identification plate **25A** as shown.

When ordering replacement parts, always quote the details on the unit identification plate. In the case of gear replacements, always check the part number stamped on the gear, and the number of teeth.

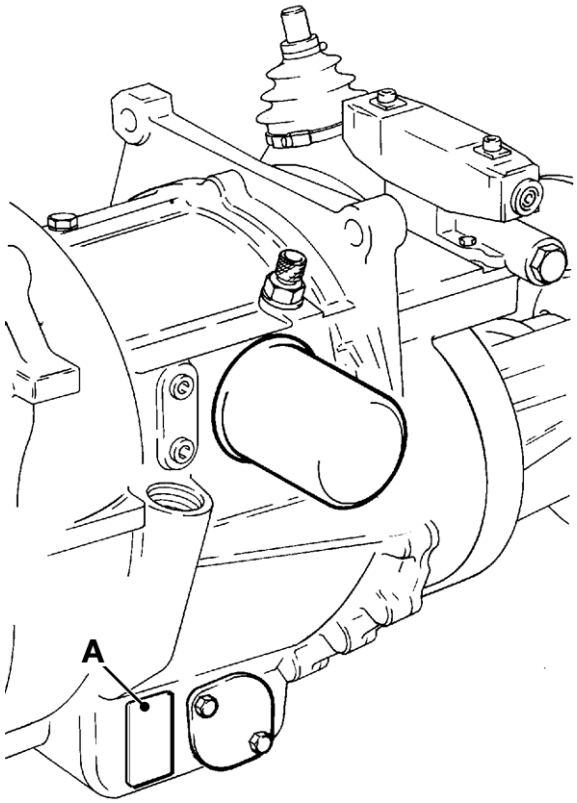


Fig 25.

Designation

There is more than one SS700 gearbox design variant.

Designation	Identification feature
SS700	Layshaft access cover **26A**
SS700 Type 2	Enclosed layshaft (no access cover) **27A**

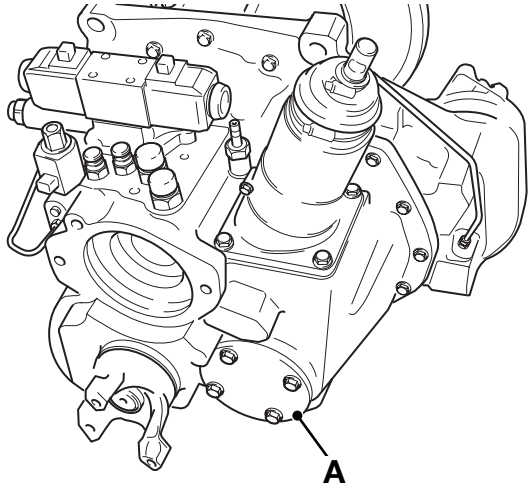


Fig 26.

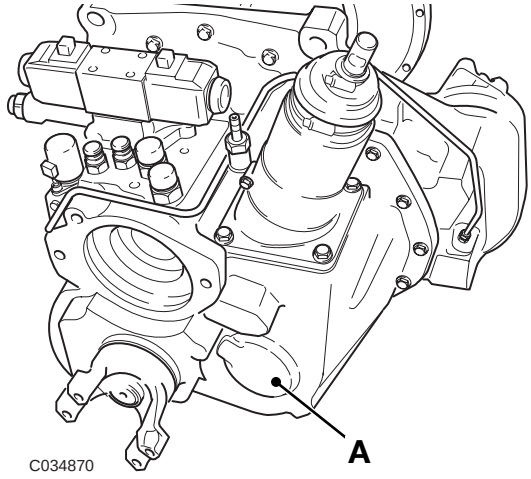


Fig 27.

Specification

Table 10. SS700

Description	Combined torque converter, reverser, and gearbox unit. Synchromesh manual gear selection. Electro hydraulic selection of forward and reverse.		
Weight (dry)	2WD	170 kg (375 lb)	
	4WD	200 kg (441 lb)	
Gear Ratios			
		Std Ratio	Low Ratio
	1st	5.56:1	6.56:1
	2nd	3.45:1	4.06:1
	3rd	1.83:1	1.90:1
	4th	1.00:1	1.00:1
Torque Converter			
	Torque Converter Dia.	310 mm (12.2 in.)	
	Torque Converter Identification	04/600784	04/600786
	Torque Multiplication at Stall	2.52:1	3.01:1

Converter Pressures (in neutral)		**bar**	**kgf/cm²**	**lbf/in²**
Converter In at 50 °C	1000 rev/min	1.5 - 2.5	1.5 - 2.5	22 - 36
	2000 rev/min	5.3 - 6.7	5.4 - 6.8	77 - 97
Converter In at 100 °C	1000 rev/min	0.5 - 1.3	0.5 - 1.3	7 - 19
	2000 rev/min	4.1 - 4.9	4.2 - 5.0	59 - 71
Converter Out at 50 °C	1000 rev/min	0.8 - 1.6	0.8 - 1.6	12 - 23
	2000 rev/min	3.0 - 4.0	3.1 - 4.1	43 - 58
Converter Out at 100 °C	1000 rev/min	0.3 - 0.9	0.3 - 0.6	4 - 9
	2000 rev/min	2.1 - 2.9	2.1 - 3.0	30 - 42

Table 11. SS700

Lubrication Pressures (in neutral)		**bar**	**kgf/cm²**	**lbf/in²**
At 50 °C	1000 rev/min	0.3 - 0.9	0.3 - 0.9	4 - 13
	2000 rev/min	1.8 - 2.4	1.8 - 2.4	26 - 35
At 100 °C	1000 rev/min	0.1 - 0.3	0.1 - 0.3	1 - 4
	2000 rev/min	1.3 - 2.1	1.3 - 2.1	19 - 30
Main Line Pressure (in neutral)		**bar**	**kgf/cm²**	**lbf/in²**
At 50 °C	1000 rev/min	11.0 - 13.0	11.2 - 13.3	159 - 188
	2000 rev/min	13.0 - 15.6	13.3 - 16.0	188 - 226
At 100 °C	1000 rev/min	10.2 - 12.2	10.4 - 12.4	148 - 177
	2000 rev/min	11.4 - 14.0	11.8 - 14.3	165 - 203
Clutch Pressures	All clutch pressures should be the same as Mainline Pressure to within 0.7 bar (10 lbf/in²)			
Flow Rates (in neutral)		**L/min**	**US gal/min**	**UK gal/min**
Cooler at 50 °C	1000 rev/min	7.7 - 11.0	2.0 - 2.9	1.7 - 2.4
	2000 rev/min	13.9 - 20.0	3.6 - 5.3	3.0 - 4.4
Cooler at 100 °C	1000 rev/min	5.2 - 8.2	1.1 - 2.2	1.1 - 1.8
	2000 rev/min	14.5 - 17.5	3.8 - 4.6	3.2 - 3.8
Pump at 50 °C	1000 rev/min	11.5 - 15.5	3.0 - 4.1	2.5 - 3.4
	2000 rev/min	24.0 - 33.0	6.7 - 8.8	5.3 - 7.3

Powershift Gearbox

PS764 4 Speed

Unit Identification

The gearbox serial number is stamped on the unit identification plate **A** as shown.

When ordering replacement parts, always quote the details on the unit identification plate. In the case of gear replacements, always check the part number stamped on the gear, and the number of teeth.

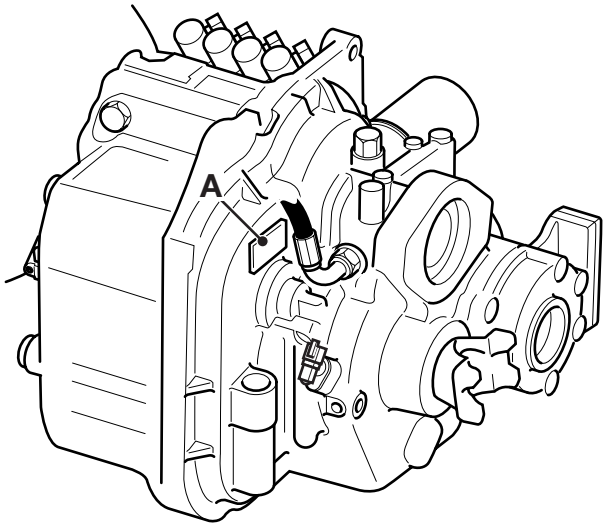


Fig 28.

Designation

PS764 **2005** (4 wheel drive)

Specification

Table 12. PS764 2005

Description	Full electro-hydraulic transmission unit with input, reverse, layshaft, mainshaft, and 4 wheel drive clutch packs giving 4 forward and 4 reverse speeds. Electrically (relay) controlled gear selection (electronically controlled gear selection on lock up torque converter variant). Integral wet multi-plate park brake.		
Weight (dry)			
	4WD	242 kg (533 lb)	
Gear Ratios		Forward	
	1st	7.97:1	
	2nd	4.29:1	
	3rd	1.86:1	
	4th	1.00:1	

Torque Converter		
Torque Converter Dia.	310 mm (12.2 in.)	
Torque Converter Identification	04/600784	04/600786
Torque Multiplication at Stall	2.52:1	3.01:1

Lock Up Torque Converter		
Torque Converter Dia.	310 mm (12.2 in.)	
Torque Converter Identification	04/600785	
Torque Multiplication at Stall	2.52:1	

Table 13. PS764 2005

Converter Pressures (in neutral)		bar	kgf/cm^2	lbf/in^2
Converter In at 50 ^{0}C	1000 rev/min	1.4 - 2.2	1.4 - 2.2	20.3 - 31.9
	2000 rev/min	5.8 - 6.9	5.9 - 7.0	84.1 - 100.0
Converter In at 100 ^{0}C	1000 rev/min	0.5 - 1.3	0.5 - 1.3	7.2 - 18.9
	2000 rev/min	2.5 - 3.5	2.5 - 3.7	36.2 - 50.8
Converter Out at 50 ^{0}C	1000 rev/min	0.6 - 1.6	0.6 - 1.6	8.7 - 23.2
	2000 rev/min	2.8 - 3.8	2.9 - 3.9	40.6 - 55.1
Converter Out at 100 ^{0}C	1000 rev/min	0.2 - 1.0	0.2 - 1.0	2.9 - 14.5
	2000 rev/min	1.0 - 1.9	1.0 - 1.9	14.5 - 27.6
Converter Inlet Relief Pressure (max.)		7.1	7.2	103.0
Lubrication Pressure (in neutral)				
Oil at 50 ^{0}C	1000 rev/min	0.2 - 0.9	0.2 - 0.9	2.9 - 13.1
	2000 rev/min	1.1 - 2.1	1.1 - 2.1	16.0 - 30.5
Oil at 100 ^{0}C	1000 rev/min	0.1 - 0.4	0.1 - 0.4	1.5 - 5.8
	2000 rev/min	0.4 - 1.4	0.4 - 1.4	5.8 - 20.3
Main Line Pressure (in neutral)				
Oil at 50 ^{0}C	1000 rev/min	11.0 - 13.0	11.2 - 13.3	159.5 - 188.5
	2000 rev/min	13.0 - 15.2	13.3 - 15.5	188.5 - 220.5
Oil at 100 ^{0}C	1000 rev/min	10.2 - 12.2	10.4 - 12.4	147.9 - 176.9
	2000 rev/min	11.4 - 14.5	11.6 - 14.8	165.3 - 210.3
Clutch Pressure	All clutch pressures should be the same as mainline pressure to within 0.7 bar (10 lbf/in^2) [4WD clutch pressure within 1.4 bar (20 lbf/in^2]			

Flow Rates (in neutral)		L/min	US gal/min	UK gal/min
Cooler oil flow at 50 ^{0}C	1000 rev/min	8.5 - 11.0	2.1 - 2.9	1.9 - 2.4
	2000 rev/min	17.0 - 25.1	4.5 - 6.6	3.7 - 5.5
Cooler oil flow at 100 ^{0}C	1000 rev/min	6.2 - 9.5	1.6 - 2.5	1.4 - 2.1
	2000 rev/min	15.0 - 19.5	4.0 - 5.2	3.3 - 4.3
Pump oil flow at 100 ^{0}C	1000 rev/min	11.5 - 15.6	3.0 - 4.1	2.5 - 3.4
	2000 rev/min	24.0 - 33.0	6.3 - 8.7	5.3 - 7.3
Control Solenoid Valves	3 way, 2 position, normally closed, integral suppression diode.			
Initial coil current draw	1.68 amps @ 12 volts & 20 ^{0}C			

PS766 6 Speed

Unit Identification

The gearbox serial number is stamped on the unit identification plate **A** as shown.

When ordering replacement parts, always quote the details on the unit identification plate. In the case of gear replacements, always check the part number stamped on the gear, and the number of teeth.

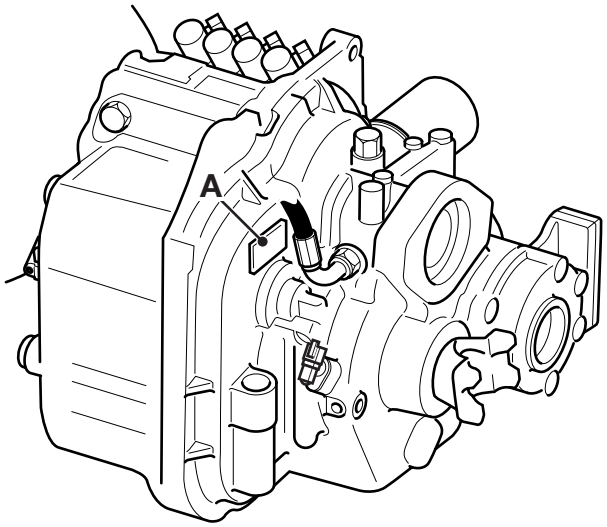


Fig 29.

Designation

PS766 **2005** (4 wheel drive)

Specification

Table 14. PS766 2005

Description	Full electro-hydraulic transmission unit with input, reverse, layshaft, mainshaft, 6 speed and 4 wheel drive clutch packs giving 6 forward and 4 reverse speeds. Electronically controlled gear selection. Integral wet multi-plate park brake.		
Weight (dry)			
	2WD	T.B.A.	
	4WD	T.B.A.	
Gear Ratios		Forward	Reverse
	1st	8.17:1	6.45:1
	2nd	4.90:1	4.76:1
	3rd	3.62:1	1.78:1
	4th	2.25:1	1.31:1
	5th	1.35:1	-
	6th	1.00:1	-

Torque Converter		
Torque Converter Dia.	310 mm (12.2 in.)	
Torque Converter Identification	04/600784	04/600786
Torque Multiplication at Stall	2.52:1	3.01:1

Lock Up Torque Converter		
Torque Converter Dia.	310 mm (12.2 in.)	
Torque Converter Identification	04/600785	
Torque Multiplication at Stall	2.52:1	

Converter Pressures (in neutral)		**bar**	**kgf/cm²**	**lbf/in²**
Converter In at 50 ^{0}C	1000 rev/min	2.0 - 4.95	2.0 - 5.0	29 - 72
	2000 rev/min	4.0 - 6.8	4.1 - 6.9	58 - 99
Converter Out at 50 ^{0}C	1000 rev/min	0.6 - 2.25	0.6 - 2.3	8.7 - 33
	2000 rev/min	1.25 - 2.50	1.3 - 2.6	18 - 36
Converter Inlet Relief Valve Pressure (max.)		7.1	7.2	103

Table 15. PS766 2005

Lubrication Pressures (in neutral)				
At 50 ^{0}C	1000 rev/min	0.25 - 1.0	0.26 - 1.0	3.6 - 14.5
	2000 rev/min	0.50 - 1.0	0.51 - 1.0	7.3 - 14.5
Main Line Pressure (in neutral)				
At 50 ^{0}C	1000 rev/min	11.4 - 15.7	11.6 - 16.0	165 - 228
	2000 rev/min	12.4 - 17.0	12.6 - 17.3	180 - 246
Flow Rates (in neutral)		L/min	US gal/min	UK gal/min
Cooler at 50 ^{0}C	1000 rev/min	14.0 MIN	3.7 MIN	3.1 MIN
	2000 rev/min	17.0 MIN	4.5 MIN	3.7 MIN
Pump at 50 ^{0}C	1000 rev/min	16.0 MIN	4.2 MIN	3.5 MIN
	2000 rev/min	34.0 MIN	9.0 MIN	7.5 MIN
Control Solenoid Valves	3 way, 2 position, normally closed, integral suppression diode.			
Coil Resistance	7.5 Ohm @ 20 ^{0}C			

Engine Stall Speed Combinations - SA, SB Type Engines

The stall speed figures are intended as a guide to assist with machine fault diagnosis. The figures relate to tests conducted at an ambient of 25 ^{0}C and barometric pressure of 100 kPa (sea level). Note that changes in ambient temperature, pressure and humidity and fuel grade will affect engine power and hence the stall figures.

As an example, at 10,000 ft the power reduction of a naturally aspirated engine could be 29% and for a turbo engine 8%.

Stall figures are given in tabular format as follows:

⇨ *Table 16. 2 Wheel Steer, 84 H.P. Naturally Aspirated (F-32)*

⇨ *Table 17. 2 Wheel Steer, 92 H.P. Turbocharged (F-33)*

⇨ *Table 18. 2 Wheel Steer, 100 H.P. Turbocharged (F-34)*

⇨ *Table 19. All Wheel Steer, 92 H.P. Turbocharged (F-35)*

⇨ *Table 20. All Wheel Steer, 100 H.P. Turbocharged (F-36)*

Table 16. 2 Wheel Steer, 84 H.P. Naturally Aspirated

	214e, 3C	214e, 3C	3CX 14 Std. Lift	3CX 14 Std Lift, 214 Hi. Lift	214 Hi. Lift					
Engine Stall Speeds r.p.m.										
Converter Only - Max r.p.m	2200	2190	2260	2250	2235					
Converter Only - Min r.p.m	2090	2075	2145	2130	2115					
Converter + M.R.V. - Max r.p.m.	1430	1420	1785	1775	1760					
Converter + M.R.V. - Min r.p.m.	1210	1195	1625	1615	1600					
Build Specification										
Converter type:										
W300 - 3.01:1	●	●	●	●	●					
Hydraulic pump size (cc/rev):										
29/33	●	●								
33/23			●	●	●					
Fan ratio:										
0.85			●							
1.0	●			●						
1.16		●			●					
Air conditioning:										
None (Europe)			●	●						
None (R.O.W.)	●			●						
Air con (Europe)				●						
Air con (R.O.W.)		●		●	●					

Table 17. 2 Wheel Steer, 92 H.P. Turbocharged

	214e, 3C	214e, 3C	3CX T 14 Std. Lift	3CX T 14 Std. Lift	3CX T 14 Hi. Lift	3CX T 14 Hi. Lift	214 Hi. Lift, 215E	214 Hi. Lift, 215E		
Engine Stall Speeds r.p.m.										
Converter Only - Max r.p.m	2250	2245	2145	2130	2145	2130	2260+	2260+		
Converter Only - Min r.p.m	2150	2140	2040	2030	2040	2030	2170	2165		
Converter + M.R.V. - Max r.p.m.	1695	1695	1785	1770	1770	1765	1885	1880		
Converter + M.R.V. - Min r.p.m.	1540	1535	1945	1640	1640	1630	1745	1740		
Build Specification										
Converter type:										
W300 - 3.01:1	●	●					●	●		
W300 - 2.52:1			●	●	●	●				
Hydraulic pump size (cc/rev):										
29/33	●	●								
36/26			●	●						
36/29					●	●	●	●		
Fan ratio:										
1.0			●		●					
1.16	●			●		●	●			
1.25		●						●		
Air conditioning:										
None (Europe)			●		●					
None (R.O.W.)	●		●		●		●			
Air con (Europe)			●		●					
Air con (R.O.W.)		●		●		●		●		

Table 18. 2 Wheel Steer, 100 H.P. Turbocharged

	3CX Contractor 14	3CX Contractor 14, 214 Hi. Lift	3CX Contractor 14, 214 Hi. Lift	3CX Contractor 15	3CX Contractor 15, 214, 217	3CX Contractor 15, 214, 217				
Engine Stall Speeds r.p.m.										
Converter Only - Max r.p.m	2200	2190	2185	2185	2175	2170				
Converter Only - Min r.p.m	2100	2090	2080	2085	2070	2065				
Converter + M.R.V. - Max r.p.m.	1860	1855	1850	1845	1835	1825				
Converter + M.R.V. - Min r.p.m.	1730	1720	1715	1710	1700	1695				
Build Specification										
Converter type:										
W300 - 2.52:1	●	●	●	●	●	●				
Hydraulic pump size (cc/rev):										
36/29	●	●	●							
37/33				●	●	●				
Fan ratio:										
1.0	●			●						
1.16		●			●					
1.25			●			●				
Air conditioning:										
None (Europe)	●			●						
None (R.O.W.)		●			●					
Air con (Europe)		●								
Air con (R.O.W.)			●			●				

Table 19. All Wheel Steer, 92 H.P. Turbocharged

	3CX Super Std. Lift	3CX Super Std. Lift	3CX Super Hi. Lift	3CX Super Hi. Lift						
Engine Stall Speeds r.p.m.										
Converter Only - Max r.p.m	2145	2130	2145	2130						
Converter Only - Min r.p.m	2040	2030	2040	2030						
Converter + M.R.V. - Max r.p.m.	1785	1770	1770	1765						
Converter + M.R.V. - Min r.p.m.	1645	1640	1640	1630						
Build Specification										
Converter type:										
W300 - 2.52:1	●	●	●	●						
Hydraulic pump size (cc/rev):										
36/26	●	●								
36/29			●	●						
Fan ratio:										
1.0	●		●							
1.16		●		●						
Air conditioning:										
None (Europe)	●									
None (R.O.W.)	●		●							
Air con (Europe)	●		●							
Air con (R.O.W.)		●		●						

Table 20. All Wheel Steer, 100 H.P. Turbocharged

	4CX 14, 4C	4CX 14, 4C, 214S	4CX 14, 4C, 214S	4CXS 15	4CXS 15, 215S, 217S	4CXS 15, 215S, 217S	4CX, 4CXS	4CX, 4CXS	4CX, 4CXS	
Engine Stall Speeds r.p.m.										
Converter Only - Max r.p.m	2200	2190	2185	2185	2175	2170	2235	2230	2225	
Converter Only - Min r.p.m	2100	2090	2080	2085	2070	2065	2140	2130	2125	
Converter + M.R.V. - Max r.p.m.	1860	1855	1850	1845	1835	1825	n/a	n/a	n/a	
Converter + M.R.V. - Min r.p.m.	1730	1720	1715	1710	1700	1695	n/a	n/a	n/a	
Build Specification										
Converter type:										
W300 - 2.52:1	●	●	●	●	●	●	●	●	●	
Hydraulic pump size (cc/rev):										
36/29	●	●	●							
37/33				●	●	●				
74 variable							●	●	●	
Fan ratio:										
1.0	●			●			●			
1.16		●			●			●		
1.25			●			●			●	
Air conditioning:										
None (Europe)	●			●			●			
None (R.O.W.)		●			●			●		
Air con (Europe)		●			●			●		
Air con (R.O.W.)			●			●			●	

Engine Stall Speed Combinations - SD, SF Type Engines

The stall speed figures are intended as a guide to assist with machine fault diagnosis. The figures relate to tests conducted at an ambient of 25 ^{0}C and barometric pressure of 100 kPa (sea level). Note that changes in ambient temperature, pressure and humidity and fuel grade will affect engine power and hence the stall figures.

As an example, at 10,000 ft the power reduction of a naturally aspirated engine could be 29% and for a turbo engine 8%.

Stall figures are given in tabular format as follows:

⇨ *Table 21. 2 Wheel Steer, 84 H.P. Turbocharged (F-38)*

⇨ *Table 22. 2 Wheel Steer, 92 H.P. Turbocharged (F-39)*

⇨ *Table 23. 2 Wheel Steer, 100 H.P. Turbocharged and Intercooled (F-40)*

⇨ *Table 24. All Wheel Steer, 92 H.P. Turbocharged (F-41)*

⇨ *Table 25. All Wheel Steer, 100 H.P. Turbocharged and Intercooled (F-42)*

Table 21. 2 Wheel Steer, 84 H.P. Turbocharged

	3C	3C	3C	3C	3C 14	3C 14	3CX Std Lift	3CX Std Lift, 3CX 14	3CX Std Lift, 3CX 14	3CX Std Lift
Engine Stall Speeds r.p.m.										
Converter Only - Max r.p.m	2210	2195	2200	2190	2175	2165	2235	2240	2225	2225
Converter Only - Min r.p.m	2110	2095	2100	2090	2075	2065	2125	2135	2120	2120
Converter + M.R.V. - Max r.p.m.	1830	1815	1820	1810	1930	1920	1855	1865	1850	1855
Converter + M.R.V. - Min r.p.m.	1690	1665	1680	1665	1805	1795	1715	1730	1715	1715
Build Specification										
Converter W300 - 3.01:1	●	●	●	●	●	●	●	●	●	●
Hydraulic pump size (cc/rev):										
33	●	●	●	●						
29/23					●	●				
33/23							●	●	●	●
20" Fan size	●	●	●	●	●	●	●	●	●	●
Fan ratio 0.85 Fixed	●									
Fan ratio 1.0 Fixed			●		●			●		
Fan ratio 1.16 Fixed						●			●	
Fan ratio 1.16 Viscous		●					●			
Fan ratio 1.25 Viscous				●						●
Air conditioning:										
None (Europe)	●						●			
None (R.O.W.)			●		●			●		
Air con (Europe)		●					●			
Air con (R.O.W.)				●		●			●	●

Table 22. 2 Wheel Steer, 92 H.P. Turbocharged

	3C	3C	3C	3C	3C 14	3C 14	3CX Std Lift	3CX Std Lift	3CX Std Lift	3CX Std Lift	3CX Std Lift	3CX Hi Lift	3CX Hi Lift	3CX Hi Lift	3CX Hi Lift	3CX Hi Lift	3CX 14, 3C 15	3CX 14, 3C 15
Engine Stall Speeds r.p.m.																		
Converter Only - Max r.p.m	2125	2105	2115	2110	2225	2220	2140	2135	2135	2130	2125	2135	2135	2135	2125	2125	2270	2260
Converter Only - Min r.p.m	2025	2005	2015	2010	2125	2120	2035	2030	2030	2025	2020	2035	2030	2030	2025	2020	2170	2165
Converter + M.R.V. - Max r.p.m.	1810	1790	1800	1795	1995	1990	1805	1805	1805	1800	1795	1795	1795	1795	1790	1785	1900	1895
Converter + M.R.V. - Min r.p.m.	1675	1655	1665	1660	1880	1875	1670	1675	1675	1665	1665	1660	1665	1665	1655	1655	1775	1770
Build Specification																		
Converter W300 - 3.01:1					●	●											●	●
Converter W300 - 2.52:1	●	●	●	●			●	●	●	●	●	●	●	●	●	●		
Hydraulic pump size (cc/rev):																		
33	●	●	●	●														
29/23					●	●												
36/26							●	●	●	●	●							
36/29												●	●	●	●	●	●	●
20" Fan size	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Fan ratio 1.0 Fixed	●																	
Fan ratio 1.16 Fixed			●		●				●					●			●	
Fan ratio 1.16 Viscous							●					●						
Fan ratio 1.25 Fixed				●		●				●					●			●
Fan ratio 1.25 Viscous								●					●					
Fan ratio 1.37 Viscous		●									●					●		
Air conditioning:																		
None (Europe)	●						●					●						
None (R.O.W.)			●		●			●	●				●	●			●	
Air con (Europe)		●						●					●					
Air con (R.O.W.)		●		●		●				●	●				●	●		●

Table 23. 2 Wheel Steer, 100 H.P. Turbocharged and Intercooled

	3CX Hi Lift	3CX Hi Lift, 3CX 14	3CX 15' 6"	3CX 15' 6", 3CX 15, 3CX 17						
Engine Stall Speeds r.p.m.										
Converter Only - Max r.p.m	2160	2155	2150	2140						
Converter Only - Min r.p.m	2060	2050	2045	2040						
Converter + M.R.V. - Max r.p.m.	1845	1840	1830	1825						
Converter + M.R.V. - Min r.p.m.	1725	1715	1705	1700						
Build Specification										
Converter W300 - 2.52:1	●	●	●	●						
Hydraulic pump size (cc/rev):										
36/29	●	●								
37/33			●	●						
21" Fan size	●	●	●	●						
Fan ratio 1.16 Fixed		●		●						
Fan ratio 1.16 Viscous	●		●							
Air conditioning:										
None (Europe)	●		●							
None (R.O.W.)		●		●						
Air con (Europe)	●		●							
Air con (R.O.W.)	●	●	●	●						

Table 24. All Wheel Steer, 92 H.P. Turbocharged

	3CX Super Std. Lift	3CX Super Std. Lift	3CX Super Hi. Lift	3CX Super Hi. Lift						
Engine Stall Speeds r.p.m.										
Converter Only - Max r.p.m	2140	2135	2135	2130	2125	2135	2135	2135	2125	2125
Converter Only - Min r.p.m	2035	2030	2030	2025	2020	2035	2030	2030	2025	2020
Converter + M.R.V. - Max r.p.m.	1805	1805	1805	1800	1795	1795	1795	1795	1790	1785
Converter + M.R.V. - Min r.p.m.	1670	1675	1675	1665	1665	1660	1665	1665	1655	1655
Build Specification										
Converter W300 - 2.52:1	●	●	●	●	●	●	●	●	●	●
Hydraulic pump size (cc/rev):										
36/26	●	●	●	●	●					
36/29						●	●	●	●	●
20" Fan size	●	●	●	●	●	●	●	●	●	●
Fan ratio 1.16 Fixed			●					●		
Fan ratio 1.16 Viscous	●					●				
Fan ratio 1.25 Fixed				●					●	
Fan ratio 1.25 Viscous		●					●			
Fan ratio 1.37 Viscous					●					●
Air conditioning:										
None (Europe)	●					●				
None (R.O.W.)		●	●				●	●		
Air con (Europe)		●					●			
Air con (R.O.W.)				●	●				●	●

Table 25. All Wheel Steer, 100 H.P. Turbocharged and Intercooled

	4CX	4CX	4CX	4CX 15	4CXS 15, 4CXS 17	4CXS 15, 4CXS 17				
Engine Stall Speeds r.p.m.										
Converter Only - Max r.p.m	2160	2155	2150	2140	2195	2190				
Converter Only - Min r.p.m	2060	2050	2045	2040	2100	2085				
Converter + M.R.V. - Max r.p.m.	1845	1840	1830	1825	n/a	n/a				
Converter + M.R.V. - Min r.p.m.	1725	1715	1705	1700	n/a	n/a				
Build Specification										
Converter W300 - 2.52:1	●	●	●	●	●	●				
Hydraulic pump size (cc/rev):										
36/29	●	●								
37/33			●	●						
74 variable					●	●				
21" Fan size	●	●	●	●	●	●				
Fan ratio 1.16 Fixed		●		●		●				
Fan ratio 1.16 Viscous	●		●		●					
Air conditioning:										
None (Europe)	●		●		●					
None (R.O.W.)		●		●		●				
Air con (Europe)	●		●		●					
Air con (R.O.W.)	●	●	●	●	●	●				

Basic Operation

Introduction

This section describes how each main transmission assembly works. All the main component parts and assemblies are identified and all mechanical, electrical and hydraulic aspects are described as applicable.

Front Axle - Steer Drive Type SD55, SD80

Component Identification

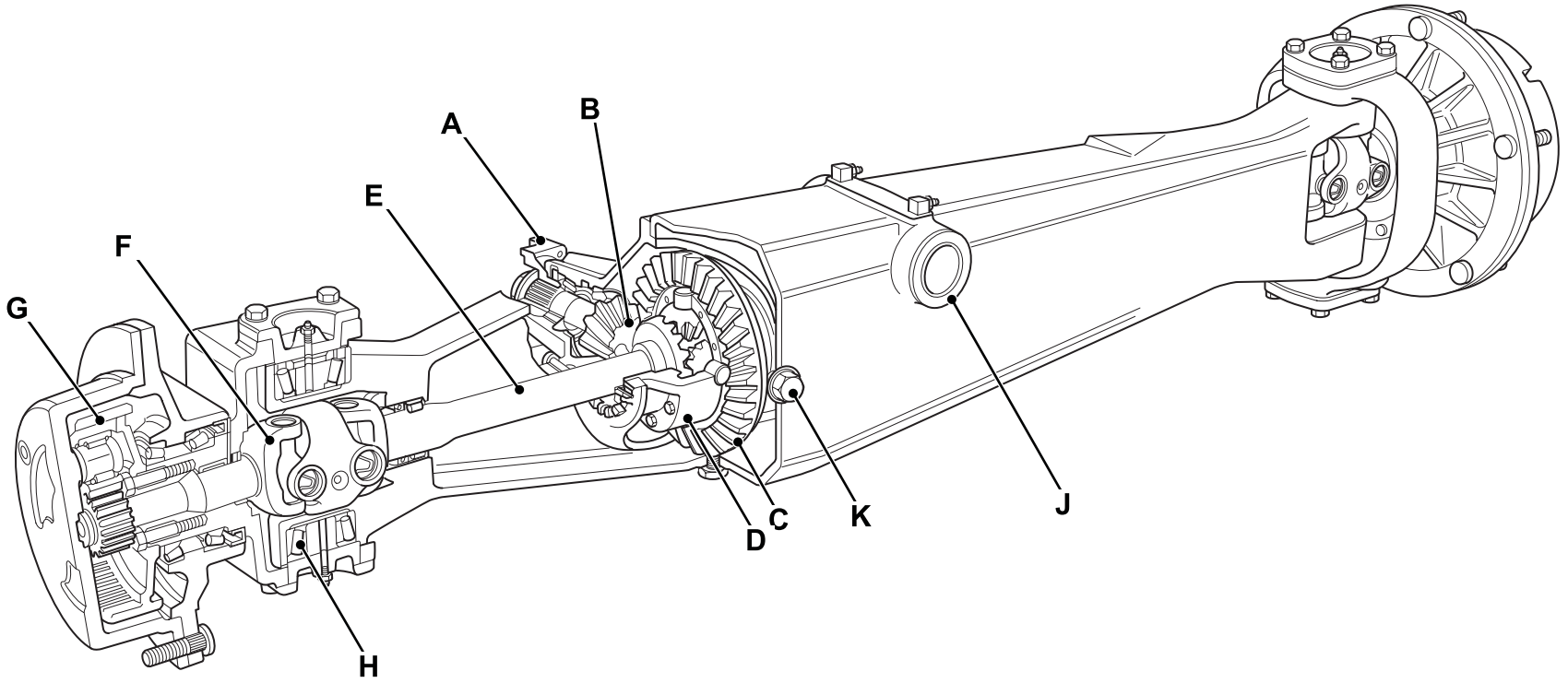


Fig 30. Typical Steer Drive Front Axle

- **A** Yoke connection to propshaft
- **B** Pinion
- **C** Crownwheel
- **D** Differential unit
- **E** Drive shaft
- **F** Universal coupling
- **G** Reduction gear hub
- **H** Steer swivel trunnion bearings
- **J** Axle pivot
- **K** Oil fill and drain plugs

Rear Axle - Steer Drive Type SD80

Component Identification

⇒ *Fig 31. (F-46)*. The illustration shows a typical steer drive rear axle. 2WS machines are fitted with non steer axles (PD70). These axles are similar to the axle shown but do not feature steer swivels or drive shaft universal joints.

A(1) Park brake disc. The disc is fitted to the pinion instead of a yoke. The propshaft is bolted to the centre of the disc. The axle casing also carries a bracket for location of the park brake caliper.

B Pinion

C Crownwheel

D Differential.

Note: *Items A, B, C and D form the `drive head' part of the axle.*

E Drive shaft

F Universal coupling

G Reduction gear hub

H Steer swivel trunnion bearings

L In-board oil immersed multi-plate disc brakes

M Brake actuating piston

N Hydraulic brake lines

(1) The park brake disc is only fitted to machines with Synchro Shuttle gearboxes.

F-45

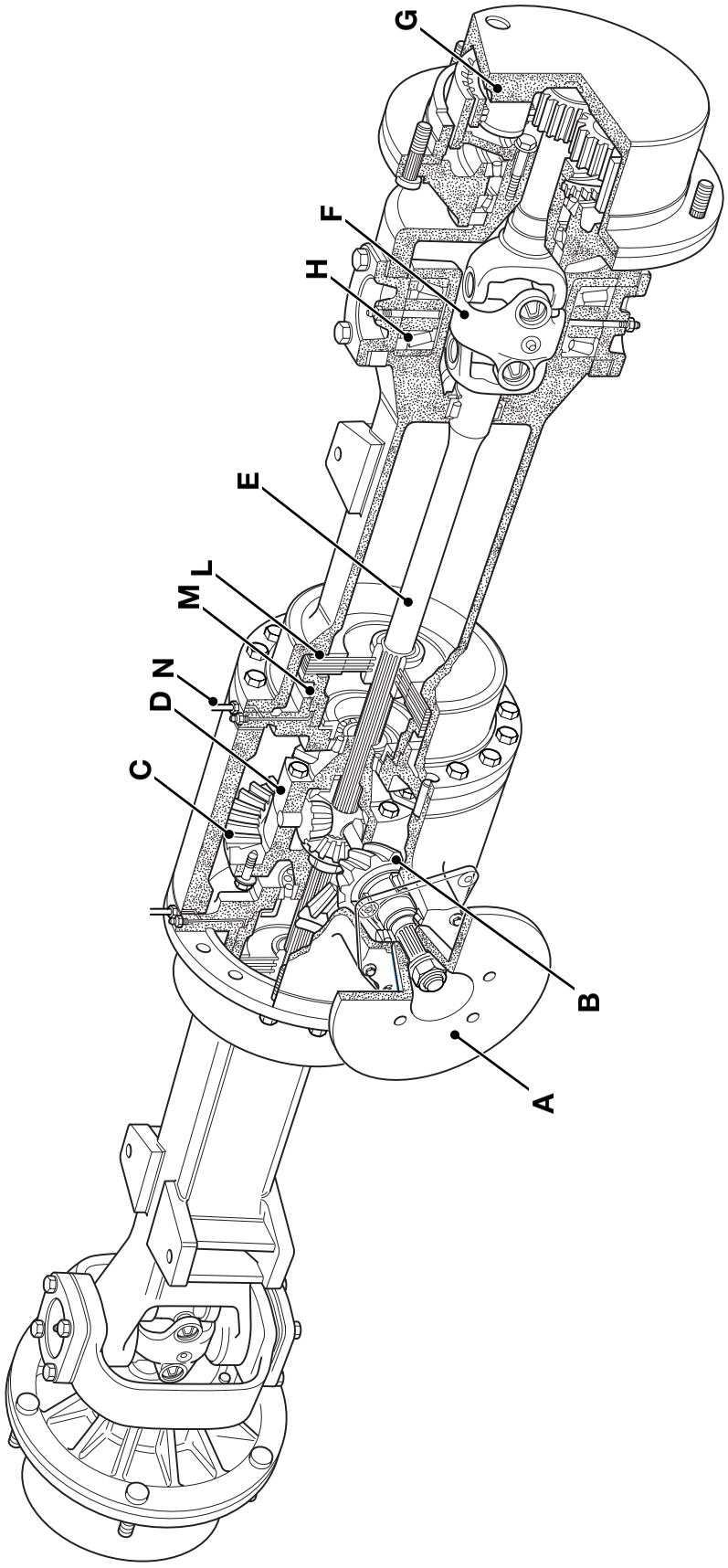


Fig 31. Typical Steer Drive Rear Axle

Synchro Shuttle Gearbox

Component Identification

⇒ *Fig 32. (F-48)*.

A	Forward/reverse clutch unit
B	Transmission oil pump
C	Torque converter pressure regulating valve
D	Oil pressure maintenance valve
E	Solenoid control valve
F	Mainshaft
G	Synchromesh unit - 3rd/4th gears
H	Layshaft
J	Synchromesh unit - 1st/2nd gears
K	Transfer gear, output shaft and yoke
L	4WD output yoke (if fitted)
M	2/4WD clutch unit (if fitted)
N	4WD solenoid control valve (if fitted)
P	Oil strainer
Q	Oil filter
R	Gear selection turret assembly
S	Torque converter
T	Driveshaft (drives machine main hydraulic pump)
U	Hydraulic pump mounting face
V	Torque converter relief valve
W	Oil pressure switch
X	Hose connection - to cooler
Y	Hose connection - from cooler
Z	Gearbox oil cooler

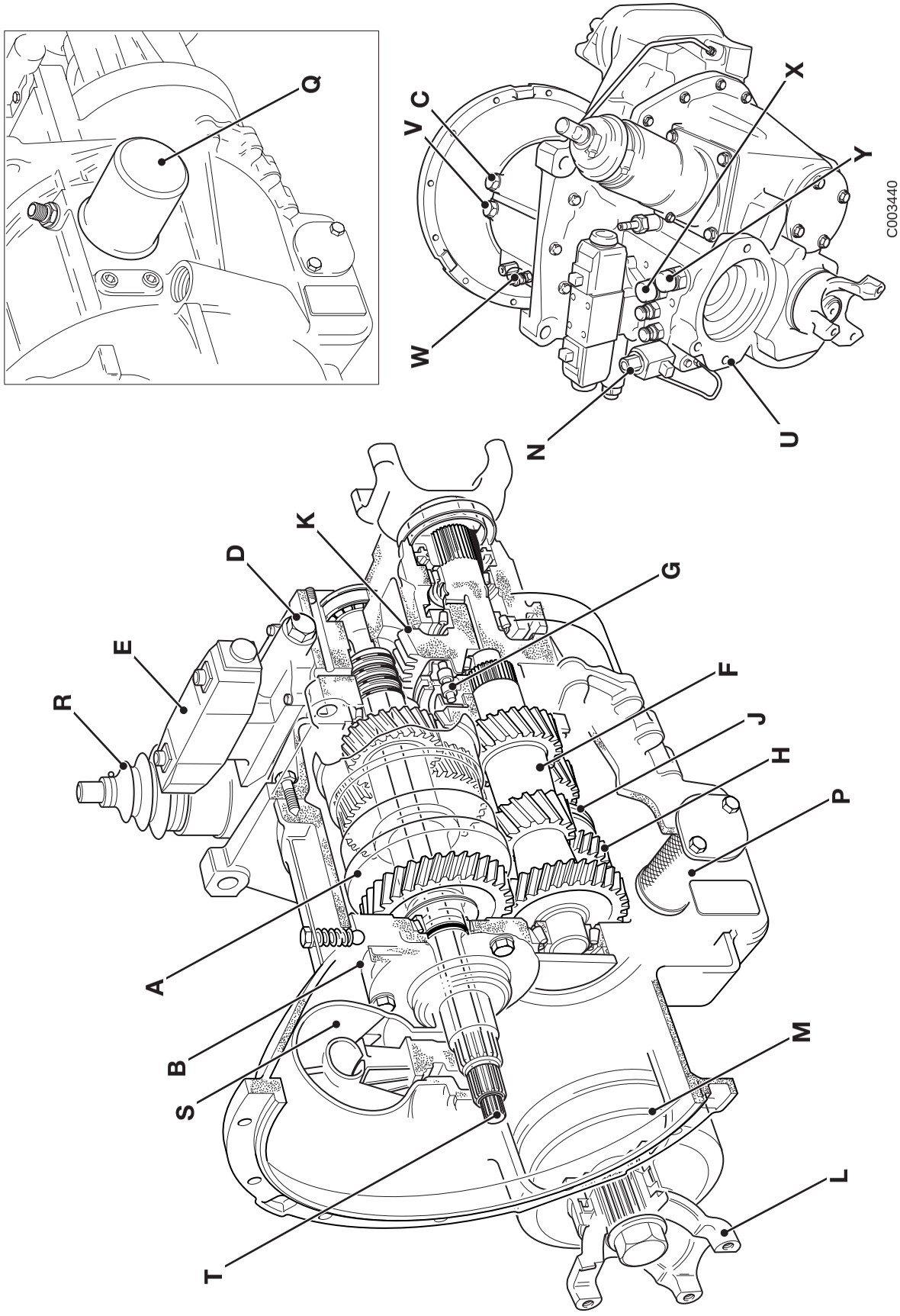


Fig 32. Synchro Shuttle Gearbox

Principle of Operation

⇒ *Fig 32. (F-48)*. The illustration shows a typical JCB Synchro Shuttle which consists of a torque converter, hydraulic reverser unit, and integral manual 4-speed gearbox.

The reverser unit **A** has a pair of hydraulically operated clutches giving forward - neutral - reverse drive. Oil pressure is provided by a crescent type pump **B** driven at engine speed by the drive lugs of the torque converter. The oil pressure is controlled by maintenance valve **D**, and clutch selection is achieved by means of an electric solenoid valve **E**.

Drive is transferred from the reverser unit by helical gears to the mainshaft **F**, which carries the 3rd/4th synchromesh unit **G**, and to the layshaft **H**, which carries the 1st/2nd synchromesh unit **J**. Synchromesh unit **G** is of the 'Blocking Pin' type, a full description of which is given in this section. Synchromesh unit **J** features rings and cones with a sliding sleeve.

Drive is transmitted finally via the output shaft **K** to the rear axle. If 4 wheel drive is selected, the front wheels are also driven via 4 wheel drive output yoke **L**.

Driveshaft **T** is permanently driven by the engine and runs through the hollow forward/reverse unit shaft to the back of the gearbox. The shaft (**T**) drives the gearbox mounted machine main hydraulic pump.

Gearbox oil is cooled by an air blast cooler **Z**. The cooler is part of the front mounted machine `cooling pack'.

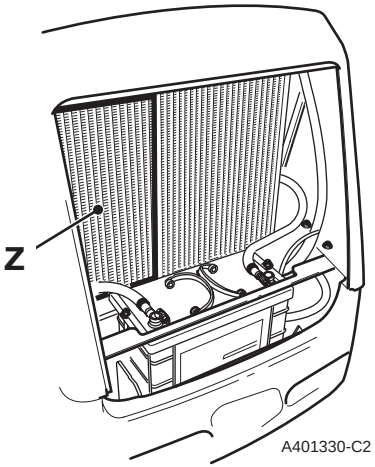


Fig 33.

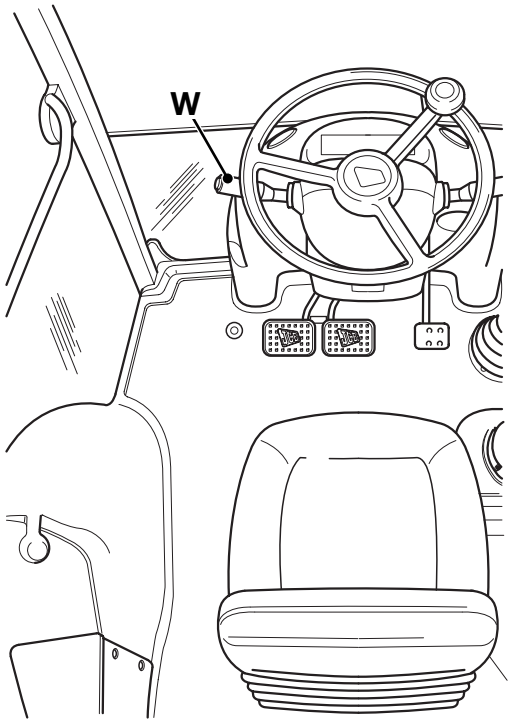


Fig 34.

Hydraulic and Electrical Operation

Key

⇒ *Fig 35. (F-51)*.

A	Forward/reverse clutch unit
A1	Forward clutch
A2	Reverse clutch
A3	Forward/reverse front shaft
A4	Forward/reverse front shaft bearing
B	Transmission oil pump
C	Torque converter pressure regulating valve
D	Oil pressure maintenance valve
E	Solenoid control valve
F	Idler gear bearing
K	Output shaft bearing
L	4WD output yoke (if fitted)
M	2/4WD clutch unit (if fitted)
N	4WD solenoid control valve (if fitted)
P	Oil strainer
Q	Oil filter
S	Torque converter
V	Torque converter relief valve
Z	Oil cooler

Key to Oil Flow & Pressure
Full Pressure
Pressure
Lubrication
Exhaust

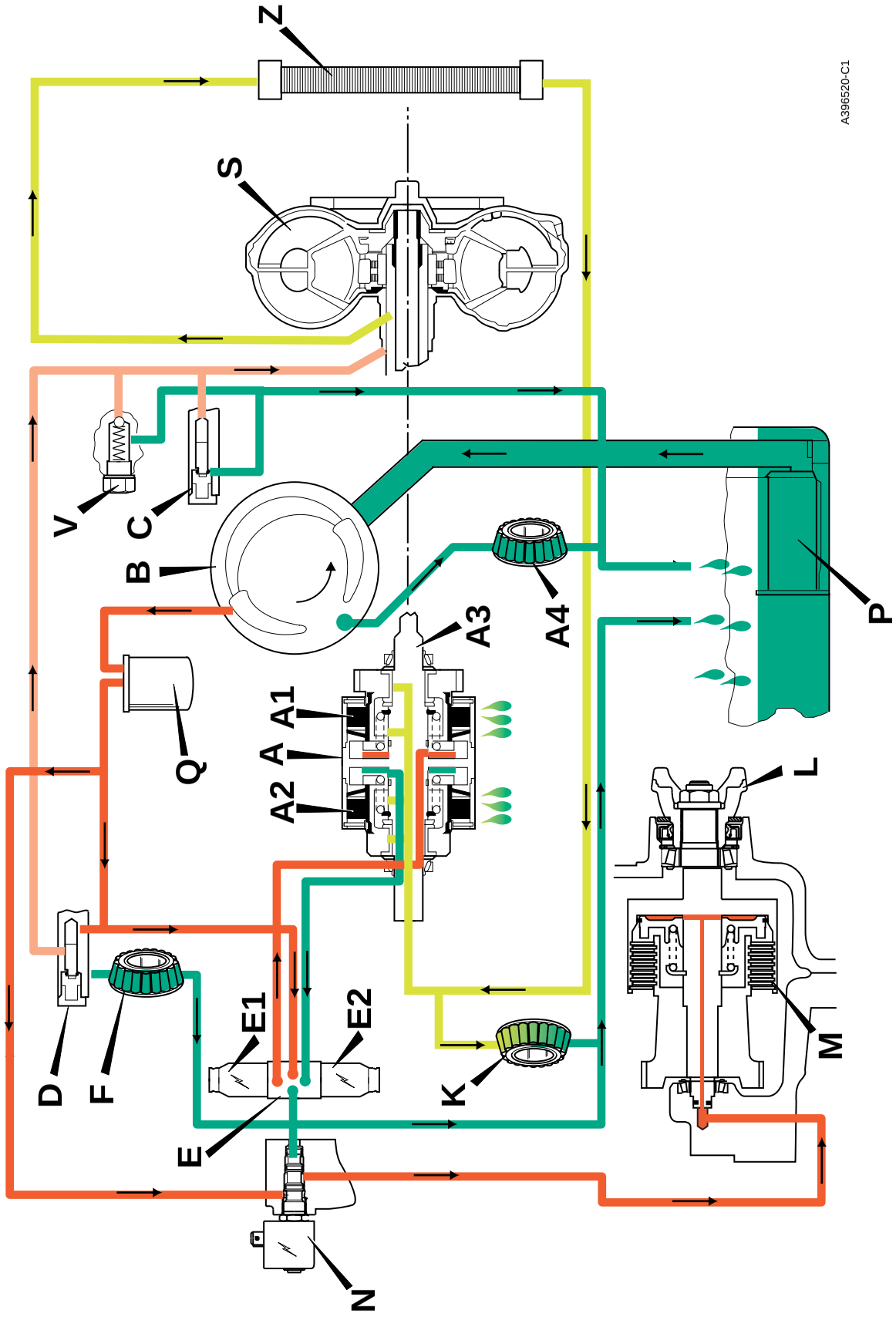


Fig 35. Hydraulic and Electrical Operation

Hydraulic Operation

Oil from the pump **B** is fed through an internal passage via the filter to the pressure maintenance valve **D**, which maintains pressure to the solenoid valve **E** for clutch selection. Excess oil from the maintenance valve flows back through the casing to the torque converter **S**. Oil enters the converter between the converter hub and the stator support, and leaves between the stator and the input shaft. Pressure in the converter is controlled by a regulating valve **C** which dumps oil from the converter line back to the sump.

Torque converter relief valve **V** acts as a safety valve should the system pressure suddenly rise above normal, protecting the torque converter from being damaged.

Oil from the torque converter **S** flows out of the transmission to the external oil cooler **Z**, returning at the rear of the transmission unit to pass through the centre of the reverser shaft for clutch lubrication.

Lubrication oil is also provided via a pump drain line to the forward/reverse front shaft bearing **A4**. The drain from pressure maintenance valve **D** also provides lubrication for idler gear bearing **F**.

Pressurised oil at the solenoid valve **E** is used to control the forward/reverse clutches **A1** and A**2**.

Solenoid Valve (E) Operation

Forward: In the diagram, electrical solenoid **E1** is energised by the forward/reverse control lever in the cab. Pressurised oil is diverted to the forward clutch **A1** and forward is selected. A restrictor orifice in the feed to the solenoid valve modulates the pressure to the clutch to smooth engagement. At the same time oil from reverse clutch **A2** is diverted back to the sump via solenoid valve **E**.

Reverse: When the reverse is selected electrical solenoid **E2** is energised and pressurised oil is diverted to the reverse clutch **A2**. At the same time oil from clutch **A1** is diverted back to the sump.

Neutral: When neutral is selected (via the control lever or the transmission dump button), the flow of the pressurised oil is blocked at the solenoid valve. No solenoids are energised and no clutches engaged.

The 2/4WD unit **M** is controlled by solenoid valve **N**.

A detailed description of clutch operation is given in the following pages:

Forward and Reverser Clutch Operation

⇨ *Fig 36. (F-54)*. The forward and reverser clutch unit **1** transfers drive from the input shaft **A3** to either gear **G1** or gear **G2** depending on which of the two clutches (**A1** or **A2**) is engaged, giving forward or reverse drive. When neither clutch is engaged, neutral is selected.

The clutches are of the wet, multi plate type.

The clutch housings and input shaft are a one piece assembly **A3**. The assembly is permanently driven by the engine via the torque converter. Clutch counter plates **3** are also permanently driven via meshing teeth inside the clutch housings.

Clutch friction plates **4** are meshed with the gear plate carriers (**G1** and **G2**).

In the diagram, clutch **A1** is engaged. The counter plates **3** and friction plates **4** are pressed together by hydraulically actuated piston **5**. Drive is then transmitted from the input shaft to the gear **G1**. Clutch **A2** is disengaged and no drive is transmitted to gear plate carrier **G2**. The gear is also free to rotate on the input shaft assembly.

Actuation of the hydraulic pistons **10** and **5** is controlled via three position solenoid valve **E**.

When neutral is selected, solenoids **E1** and **E2** are deactivated and the flow of pressurised oil to the clutches is blocked. Springs **8** and **9** move the pistons away from the clutch plates and oil from both pistons is vented to the sump.When either forward or reverse is selected, the solenoid valve **E** diverts pressurised oil via cross drillings inside the input shaft **A3** to the appropriate clutch (piston **10** or **5**) in the unit. Pressure from the other clutch is vented to the sump via the solenoid valve spool. Oil is prevented from leaking by seals **6** on the pistons and ring seals **7** on the input shaft **A3**.

The valve **E** is shown using symbols. For an explanation of how the symbols work, see Section E, ***Introduction to Hydraulic Schematic Symbols***.

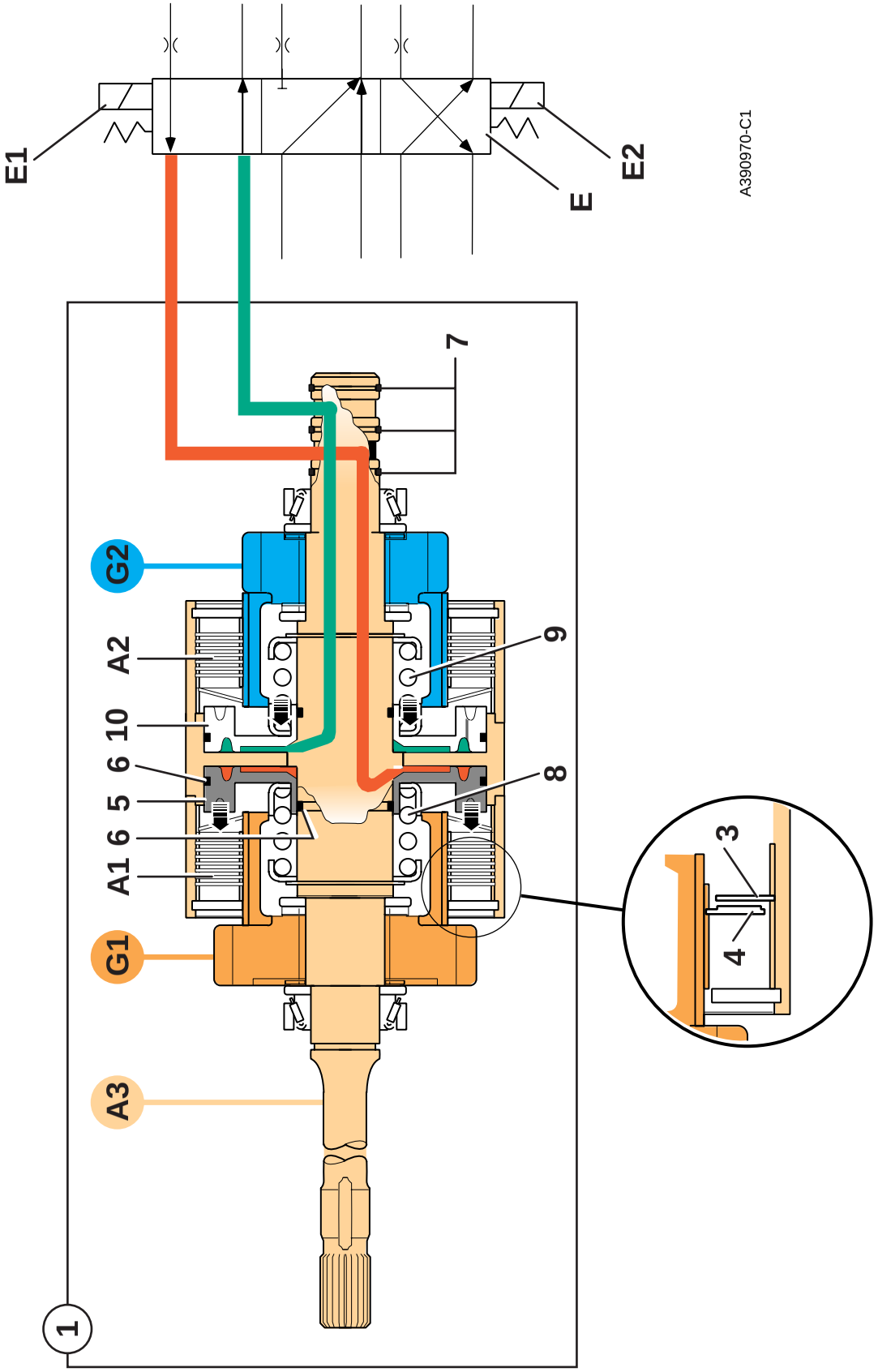


Fig 36. Forward and Reverser Clutch Operation

2 and 4 Wheel Drive Clutch (4WD Pressure ON) Operation

4 Wheel Drive Selected

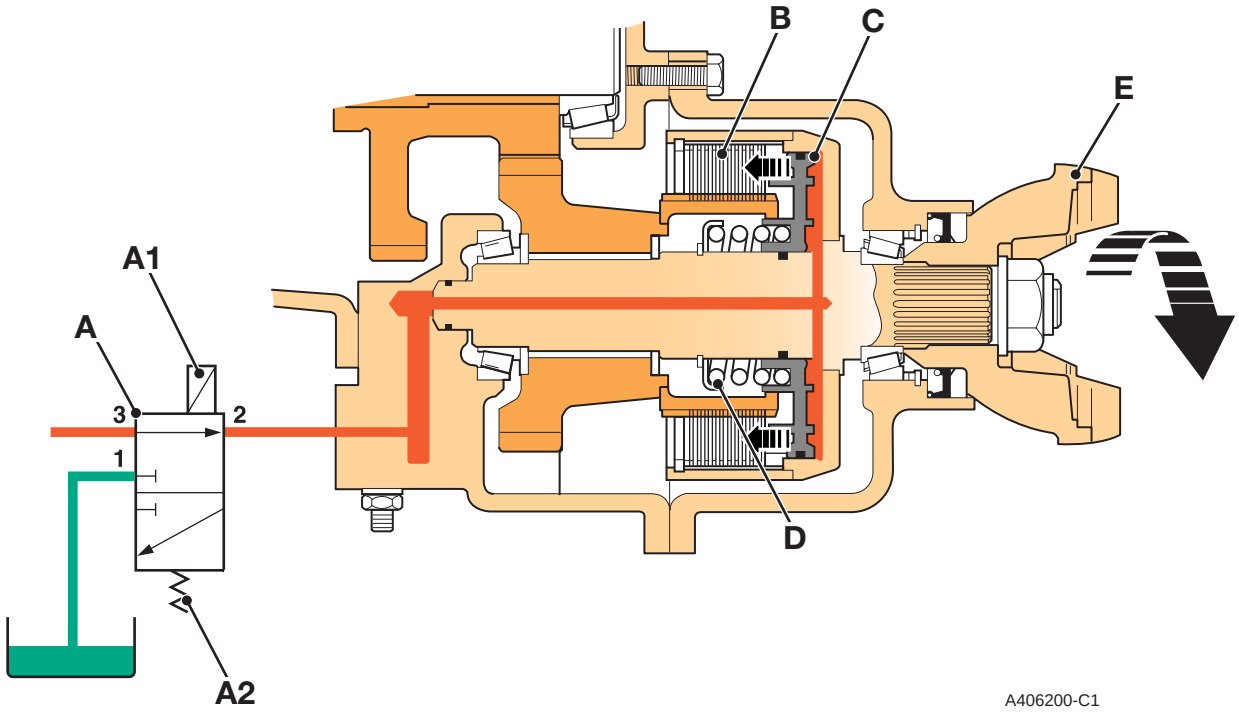


Fig 37.

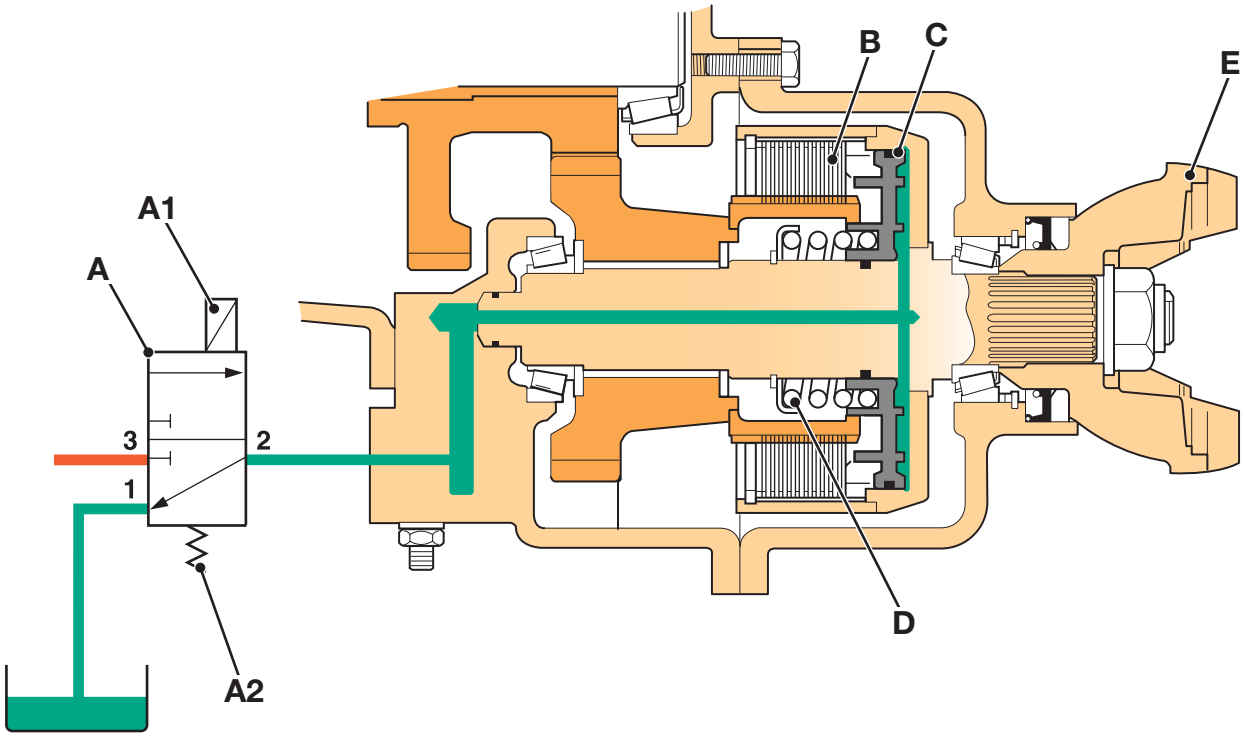
This type of clutch is engaged by oil pressure for 4 wheel drive, and disengaged by spring force for 2 wheel drive. The clutch operates by introducing or dumping pressurised oil behind piston **C** via a solenoid valve **A**. The solenoid valve is operated by a selector switch in the cab.

When 4 wheel drive is selected, the solenoid **A1** is energised. The solenoid moves the valve spool to connect ports **3** and **2**. Pressurised oil is then directed to the piston **C**.

Because of the oil pressure behind piston **C**, the piston moves against spring **D** to press the clutch friction/counter plates **B** together, thus driving the output yoke **E**.

Note: *4 wheel drive is automatically selected when the brake pedals are pressed to give 4 wheel braking. For more information see* ***Section G, Brakes****.*

2 Wheel Drive Selected



A406210-C1

Fig 38.

When 2 wheel drive is selected, the solenoid **A1** is de-energised. The force of the spring **A2** moves the valve spool to block the oil supply to the piston **C** (shown at port **3**). At the same time oil vents from the back of piston **C** to the sump via ports **1** and **2**.

Because there is no oil pressure behind piston **C**, the clutch friction/counter plates **B** now freely rotate on the output shaft, thus disengaging drive to the front axle.

Synchromesh (Blocking Pin Type)

The gearbox is fitted with 'Blocking Pin' synchromesh, comprising the following parts:

SYNCHRO HUB (A) controls the operation of the synchromesh unit and gear selection, the selector fork fitting into the outer groove. Internal dog teeth link the selected gear to the drive shaft. Through the synchro hub centre are two sets of holes for the blocker pins **C** and the split energiser pins **D**, spaced alternately.

SYNCHRO RINGS (B) are rigidly joined by the blocker pins, with the split energiser pins held, in counterbores, between the two synchro rings.

BLOCKER PINS (C) have a narrow neck in the centre, against which the synchro hub transmits radial drive during gear changes. The edges of the blocker pin neck and their mating synchro hub holes are designed so that, as the radial loads are reduced, the synchro hub can slide over the shoulder of the blocker pin.

SPLIT ENERGISER PINS (D) take the initial axial load of the synchro hub on the shoulder of the split energiser pin neck. As the axial load reaches approximately 400 N (40.8 kg; 90 lb) the internal springs allow the split energiser pin to collapse and the synchro hub to move axially.

SYNCHRO CUPS (E) take the frictional drive from the synchro ring on their inner faces. The synchro cups are splined to drive their respective gears whilst synchronisation is taking place.

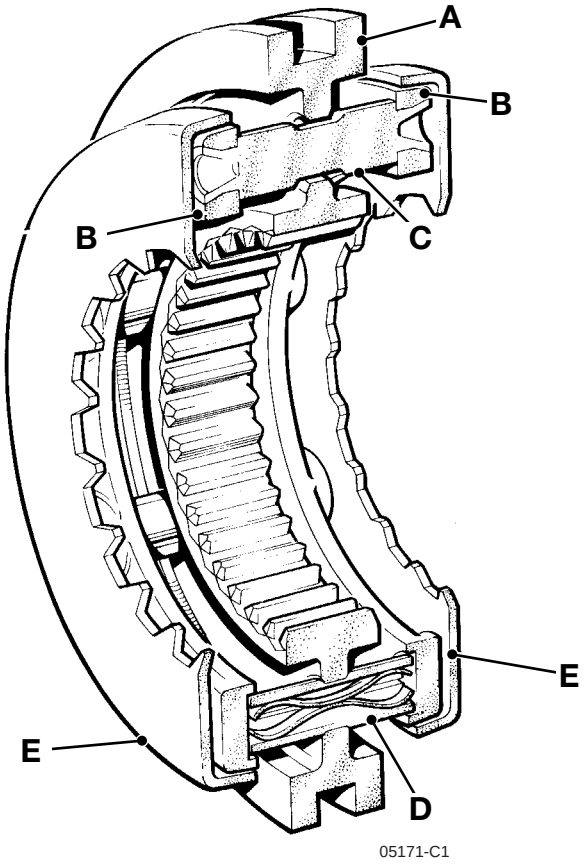


Fig 39.

Synchromesh Operation

⇨ *Fig 40. (F-59)*. Diagram **F** shows the gearbox with first gear engaged. Synchro ring **B** is in contact with synchro cup **E** and the synchro hub dog teeth are linking first gear to the shaft gear. In this position the split energiser pins **D** are 'collapsed'.

When selecting second gear the synchro hub **A** slides along the split energiser pins until the pin recess and the synchro hub flange are in line. At this point the split energiser pins open and the synchro rings are moved by the synchro hub pushing on the split energiser pin shoulder.

Initial contact between the synchro ring and the synchro cup starts to synchronise the speed of the shaft and second gear. The rotational force of the synchro ring is taken by the blocker pin against the edge of the synchro hub hole, as at **G**.

As the axial load on the synchro hub increases, the split energiser pin 'collapses' and the conical faces of the blocking pin and synchro hub hole come into contact, as at **H**.

Further increases in the axial loads increase the frictional grip of the synchro ring and the synchro cup, causing the shaft and gear speeds to synchronise.

As the speeds are synchronised the radial load on the blocker pin and the synchro hub is reduced. This allows the synchro hub to slide freely along the blocker pin and engage its dog teeth with second gear, see diagram **J**.

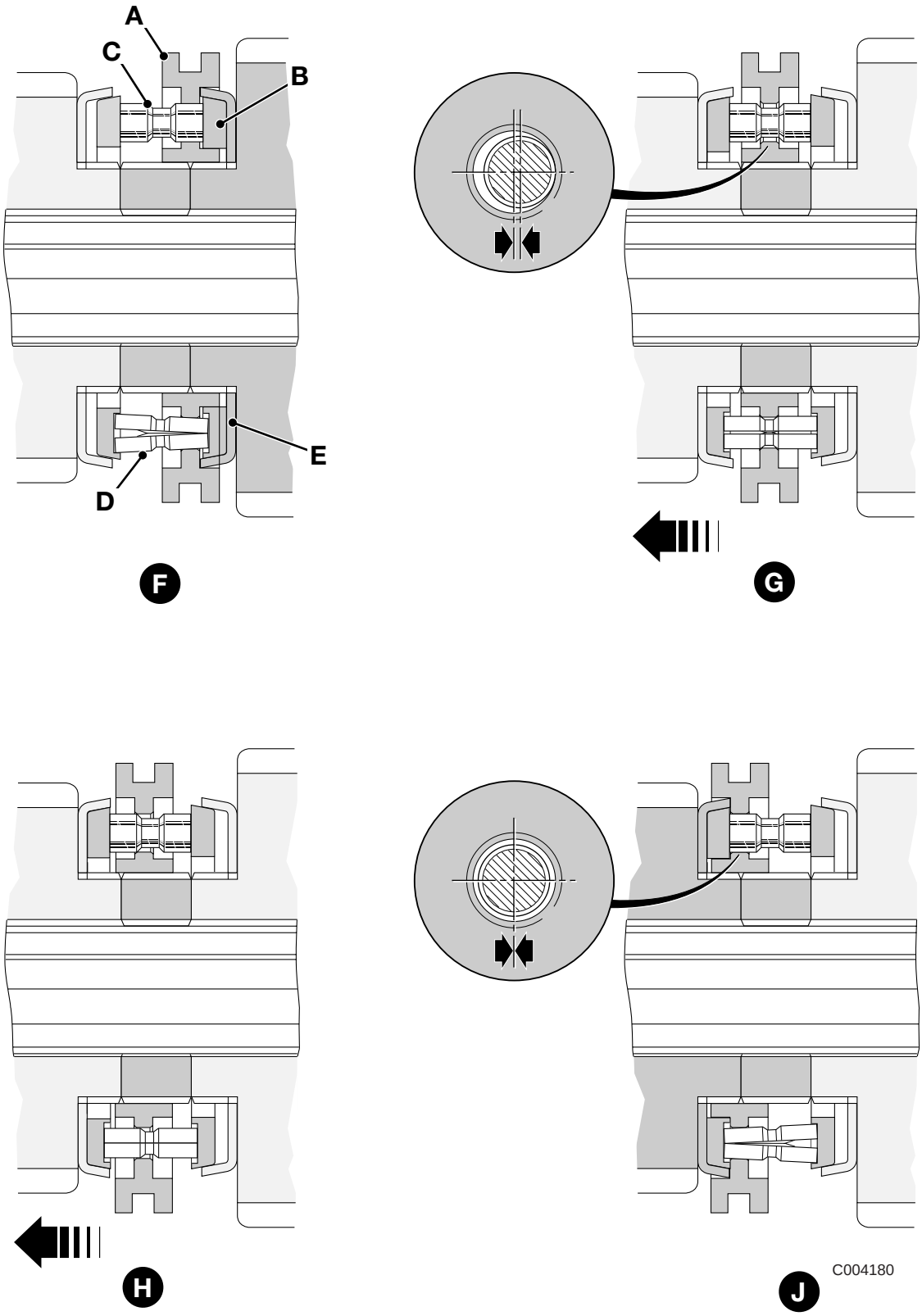


Fig 40. Synchromesh Operation

Powershift Gearbox

Component Identification

⇒ *Fig 41. (F-61)*

A	Torque converter
B	Forward/input clutch assembly
C	Reverse clutch assembly
D	Mainshaft assembly
E	Layshaft assembly
F	2/4 wheel drive clutch assembly
G	Torque converter relief valve
H	Oil pressure maintenance valve
J	Transmission oil pump
K	Park brake actuator
L	Park brake pack
M	Hose connection - to oil cooler
N	Hose connection - from oil cooler
P	6-Speed assembly (if fitted)
Q	Oil filter
R	Driveshaft (drives machine main hydraulic pump)
S	Gear drive to reverse unit clutch assembly
T	Solenoid control valves
U	Transmission oil pressure switch
V	Speed sensor
W	Steering column mounted gear selection switch
X	Gearbox oil cooler

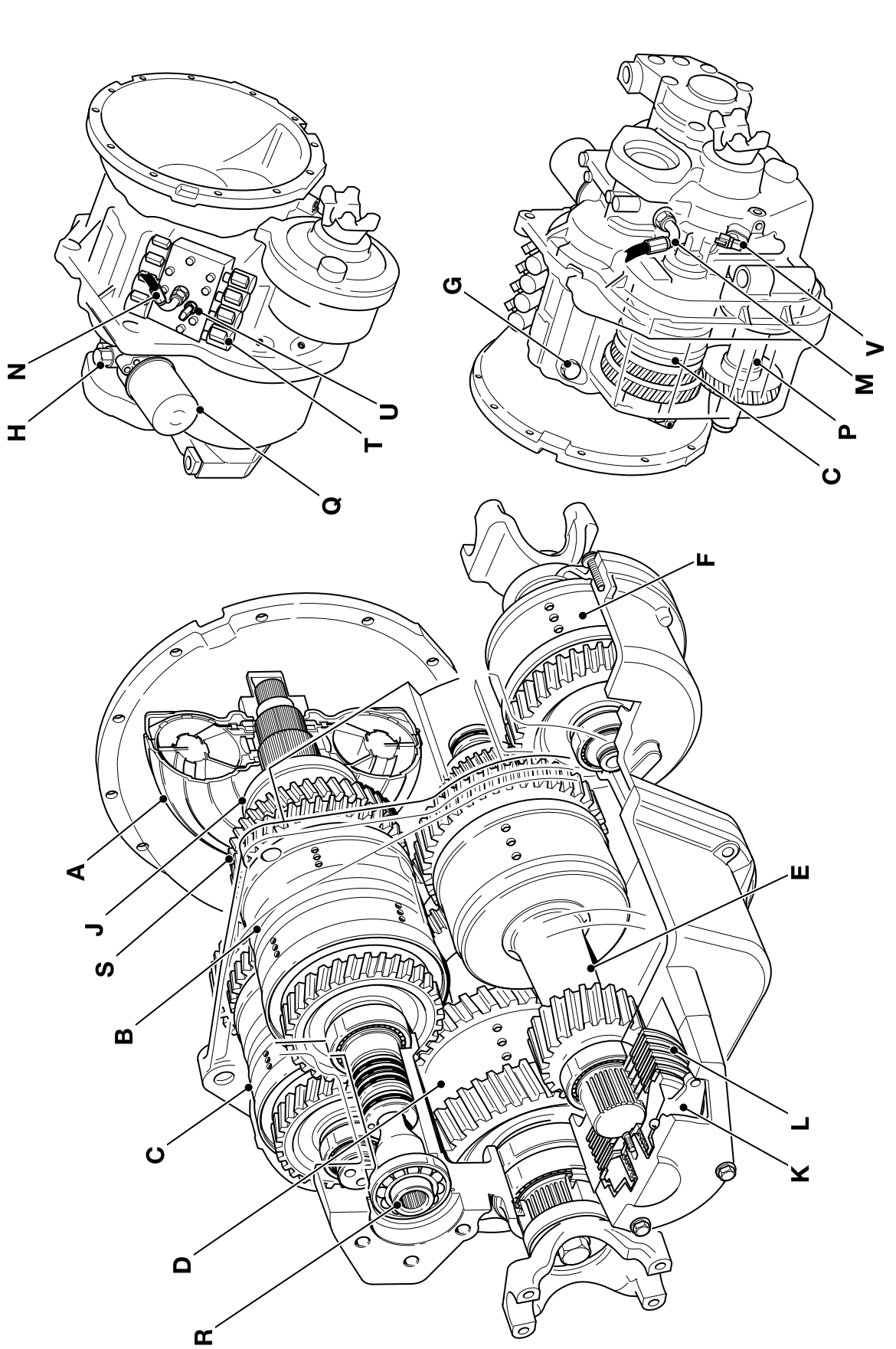


Fig 41. Component Identification

Principle of Operation

⇒ *Fig 41. (F-61)*. The JCB Powershift is an electro-hydraulic transmission unit. Gear shifting and direction selection are controlled using multi-disc clutch packs.

Electrically operated solenoid valves **T** divert pressurised oil (provided by pump **J**) to the selected clutch packs.

A combined lever/swivel switch **W** on the steering column actuates both gear ratio and direction solenoids.

The Powershift unit consists of a torque converter **A**, forward clutch assembly **B**, reverse clutch assembly **C**, layshaft assembly **E**, mainshaft assembly **D**, 2/4 wheel drive clutch assembly **F**. 6 speed gearboxes incorporate a `6 speed' shaft and clutch assembly **K**.

The forward clutch assembly **B** is driven by the torque converter **A**. The reverse clutch assembly **C** is permanently driven via constant meshing of spur gears **S**. On 6 speed gearboxes the 6 speed assembly is also driven via meshing gears **S**.

Driveshaft **R** is permanently driven by the engine and runs through the hollow forward/reverse unit shaft to the back of the gearbox. The shaft (**R**) drives the gearbox mounted machine main hydraulic pump.

Strainer **P** and filter **Q** are used to prevent potential system contamination by filtering dirt particles.

Gearbox oil is cooled by an air blast cooler **X.** The cooler is part of the front mounted machine `cooling pack'.

The gearbox incorporates an integral multiplate park brake **L**. The brake is housed inside the gearbox casing and is wet (immersed in gearbox oil). the brake is mechanically operated via a cable attached to actuator **K** and acts on the layshaft **E**.

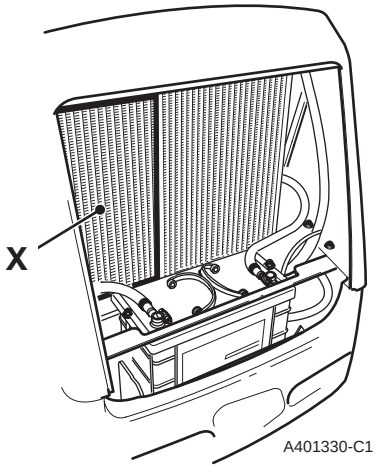


Fig 42.

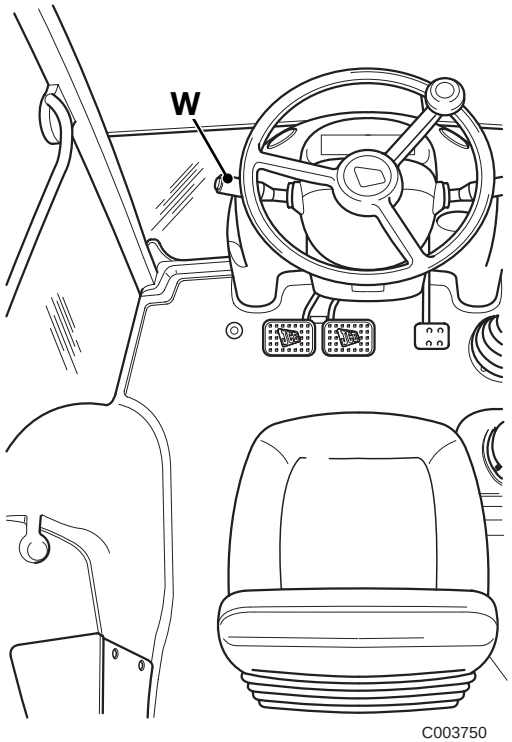


Fig 43.

Hydraulic and Electrical Operation

Key

⇒ *Fig 44. (F-64)* and ⇒ *Fig 45. (F-66)*

A Torque converter
B Forward clutch assembly
C Reverse clutch assembly
D Mainshaft assembly
E Layshaft assembly
F 2/4 wheel drive clutch assembly
G Torque converter relief valve
H Oil pressure maintenance valve
J Transmission oil pump
K 6 speed assembly (if fitted)
L 4WD output yoke
M Hose connection - to oil cooler
N Hose connection - from oil cooler
P Oil strainer
Q Oil filter
R Drive shaft (drives machines main hydraulic pump)
S 2/4WD clutch
Ss 2/4WD clutch solenoid
T Forward low ratio clutch
Ts Forward low ratio clutch solenoid
U Forward high ratio clutch
Us Forward high ratio clutch solenoid
V Reverse high ratio clutch
Vs Reverse high ratio clutch solenoid
W Reverse low ratio clutch
Ws Reverse low ratio clutch solenoid
X 6 speed clutch (6 speed gearbox only)
Xs 6 speed clutch solenoid (6 speed gearbox only)
Y Mainshaft clutch
Ys Mainshaft clutch solenoid
Z Layshaft clutch
Zs Layshaft clutch solenoid
1 Speed sensor
5 Solenoid valve manifold block
6 Gearbox oil cooler

Key to Oil Flow & Pressure
Full Pressure
Pressure
Lubrication
Exhaust

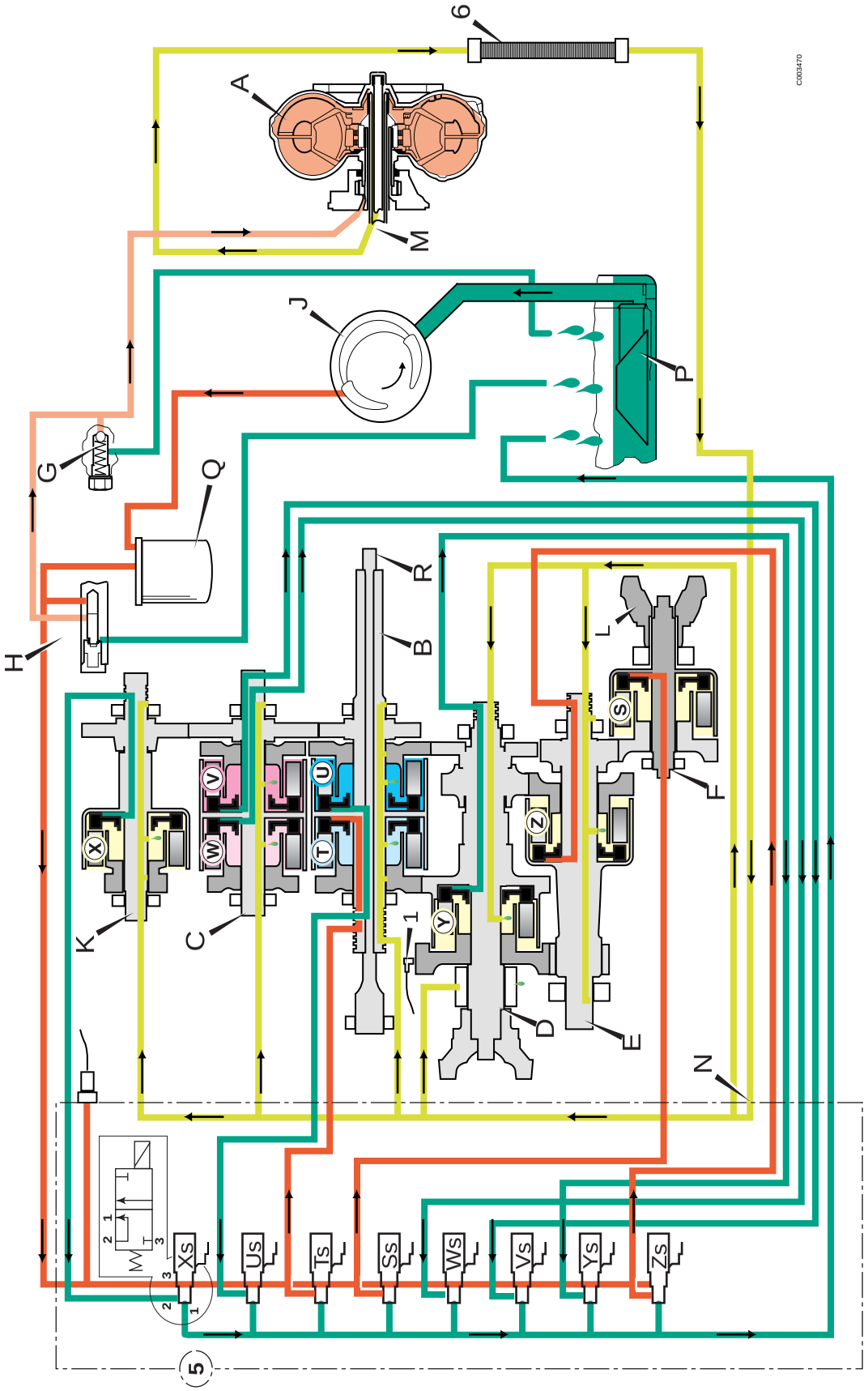


Fig 44. Electrical and Hydraulic Operation

Hydraulic and Electrical Operation

⇨ *Fig 44. (F-64)* and ⇨ *Fig 45. (F-66)*

Oil pump **J** is directly driven by the engine via the torque converter.

Oil from the pump **J** is fed through an internal passage via the filter **Q** to the pressure maintenance valve **H**, which maintains pressure to the solenoid valve block for clutch selection. Excess oil from the maintenance valve flows back through the casing to the torque converter **A**. Pressure in the converter is controlled by a relief valve **G** which dumps oil from the converter line back to the sump.

Oil from the torque converter **A** flows out of the gearbox at position **M** to the external oil cooler **6**, returning to the solenoid valve manifold block **5** at position **N**. The oil then flows through internal oilways providing lubrication for clutches and bearings before returning to the gearbox sump.

The torque converter **A** is a fluid coupling bolted to a drive plate which in turn is bolted to the engine flywheel. As the engine starts to rotate, the converter gives smooth power take off gradually increasing the torque transmitted. This torque is transferred from the converter assembly to the clutch/gear assemblies via input shaft on the forward clutch assembly **B**.

Forward clutch assembly **B** contains two hydraulically operated clutches; one clutch (**T**) provides a forward low ratio drive and the other (**U**) a forward high ratio drive. Each clutch is controlled by a 2-position solenoid valve. When the applicable solenoid is energised, pressurised oil is directed to either the forward low (solenoid **Ts**) or forward high (solenoid **Us**) clutch.

The reverse clutch assembly **C** is similar to the forward clutch assembly. It contains two hydraulically operated clutches; one clutch (**W**) provides a reverse low ratio drive and the other (**V**) a reverse high ratio drive. 2-position solenoid valves when energised, direct pressurised oil to either the reverse low (solenoid **Ws**), or reverse high (solenoid **Vs**) clutch.

Both the mainshaft and the layshaft assemblies have a single clutch each. Solenoid valve **Zs,** when energised, directs pressurised oil to the layshaft clutch **Z**. Solenoid valve **Ys**, when energised, directs pressurised oil to the mainshaft clutch **Y**.

On 6 speed gearboxes, the 6 speed clutch **X** is controlled via solenoid valve **Xs**.

Note: *All the clutches work on the same principle. A detailed description of clutch operation is given in the following pages:*

The 2/4 wheel drive unit **F** also has a single clutch **S**. When 4WD is selected, pressurised oil is directed via solenoid valve **Ss** to the 4WD clutch. When 2WD is selected a connection from the clutch to the transmission sump is made.

When a gear is selected via the control switch in the cab, 2 clutches are always engaged. By selecting different pairs of clutches different gear ratios are engaged. On 4 speed - non lock up torque converter gearboxes, the solenoids are electrically controlled using relays. On Shiftmaster gearboxes the solenoids are controlled by an electronic control unit (ECU) mounted in the cab. Speed sensor **1** is used to enable the gear selection to be managed automatically as required.

Example - 2nd gear forward 4WD (6 speed gearbox)

In the schematic, the gearbox is shown with 2nd gear forward engaged. 2nd gear forward requires the forward low clutch **T** and layshaft clutch **Z** to be engaged. When the gear selection switch is moved to 2nd gear forward, the electrical control system energises solenoid valves **Ts** and **Zs**. Pressurised oil is diverted to the back of pistons in both clutches to engage the drive. At the same time all other solenoids are de-energised, diverting oil from the back of the other clutch pistons to the gearbox sump. 4WD clutch **S** is also energised to give 4 wheel drive.

Clutches and solenoids engaged for each gear selection are shown in tabular format as follows:

⇨ *Table 26. (F-66)*

⇨ *Table 27. (F-66)*

Note: *Solenoid valve **Xs** controls clutch **X**, solenoid valve **Zs** controls clutch **Z** and so on.*

Table 26.

4 Speed Powershift		
Gear	**Clutches engaged**	
	Forward	**Reverse**
1st	**T**, **Z**	**W**, **Z**
2nd	**U**, **Z**	**V**, **Z**
3rd	**T**, **Y**	**W**, **Y**
4th	**U**, **Y**	**V**, **Y**

Table 27.

6 Speed Powershift		
Gear	**Clutches engaged**	
	Forward	**Reverse**
1st	**X**, **Z**	**W**, **Z**
2nd	**T**, **Z**	**V**, **Z**
3rd	**U**, **Z**	**W**, **Y**
4th	**X**, **Y**	**V**, **Y**
5th	**T**, **Y**	-
6th	**U**, **Y**	-

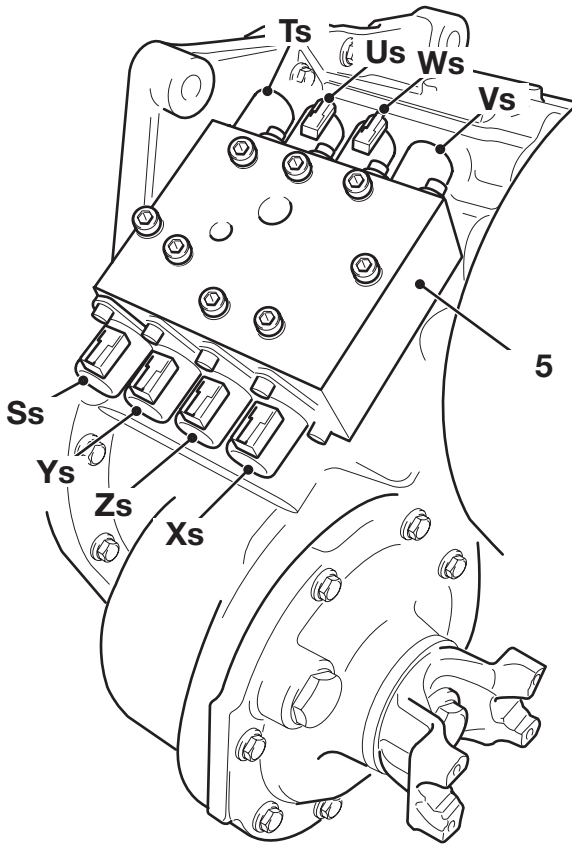


Fig 45. Solenoids

Forward and Reverser Clutch Operation

⇨ *Fig 46. (F-68)*. The forward and reverse clutch units are very similar in design and operate in the same way. The following description refers to one unit and can be applied to either the forward or reverse clutch units.

The clutch **1** transfers drive from the input shaft **A3** to either gear **G1** or gear **G2** depending on which of the two clutches (**A1** or **A2**) is engaged, transferring drive to the mainshaft. When neither clutch is engaged, neutral is selected.

The clutches are of the wet, multi plate type.

The clutch housings and input shaft are a one piece assembly **A3**. The assembly is permanently driven by the engine via the torque converter. Clutch counter plates **3** are also permanently driven via meshing teeth inside the clutch housings.

Clutch friction plates **4** are meshed with the gear/plate carriers (**G1** and **G2**).

In the diagram, clutch **A1** is engaged. The counter plates **3** and friction plates **4** are pressed together by hydraulically actuated piston **5**. Drive is then transmitted from the input shaft to the gear **G1**.

Clutch **A2** is disengaged and no drive is transmitted to gear/plate carrier **G2**. The gear is also free to rotate on the input shaft assembly.

Actuation of the hydraulic pistons **10** and **5** is controlled via two position solenoid valves **E1** and **E2**.

When neutral is selected, solenoids **E1** and **E2** are deactivated and the flow of pressurised oil to the clutches is blocked. Springs **8** and **9** move the pistons away from the clutch plates and oil from both pistons is vented to the sump.

When for example clutch **A1** is selected to be engaged, solenoid valve **E1** is energised and solenoid valve **E2** is de-energised. Pressurised oil is diverted via cross drillings inside the input shaft **A3** to the clutch piston **5**. Pressure from clutch **A2** is vented to the sump via the solenoid valve spool **E2**. Oil is prevented from leaking by seals **6** on the pistons and ring seals **7** on the input shaft **A3**.

The valve **E** is shown using symbols. For an explanation of how the symbols work, see ***Section E***, ***Introduction to Hydraulic Schematic Symbols***.

Mainshaft, Layshaft and 6 Speed Clutch Operation

The mainshaft, layshaft and 6 speed units all incorporate one clutch and not two, as in the forward and reverse units. The operation of the single clutches is the same as for one clutch in the forward or reverse units.

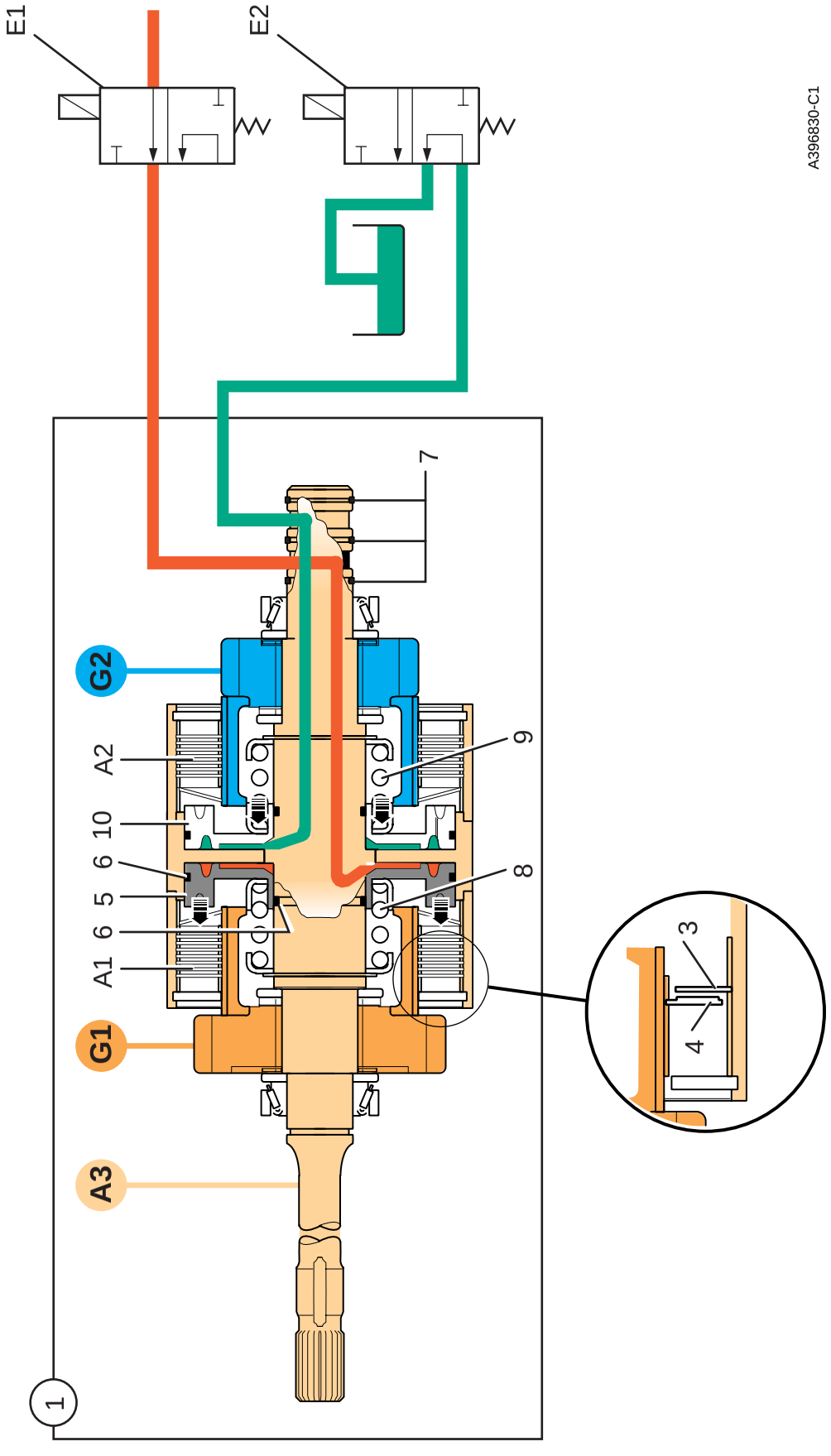


Fig 46. Forward and Reverser Clutch Operation

2 and 4 Wheel Drive Clutch (4WD Pressure ON) Operation

4 Wheel Drive Selected

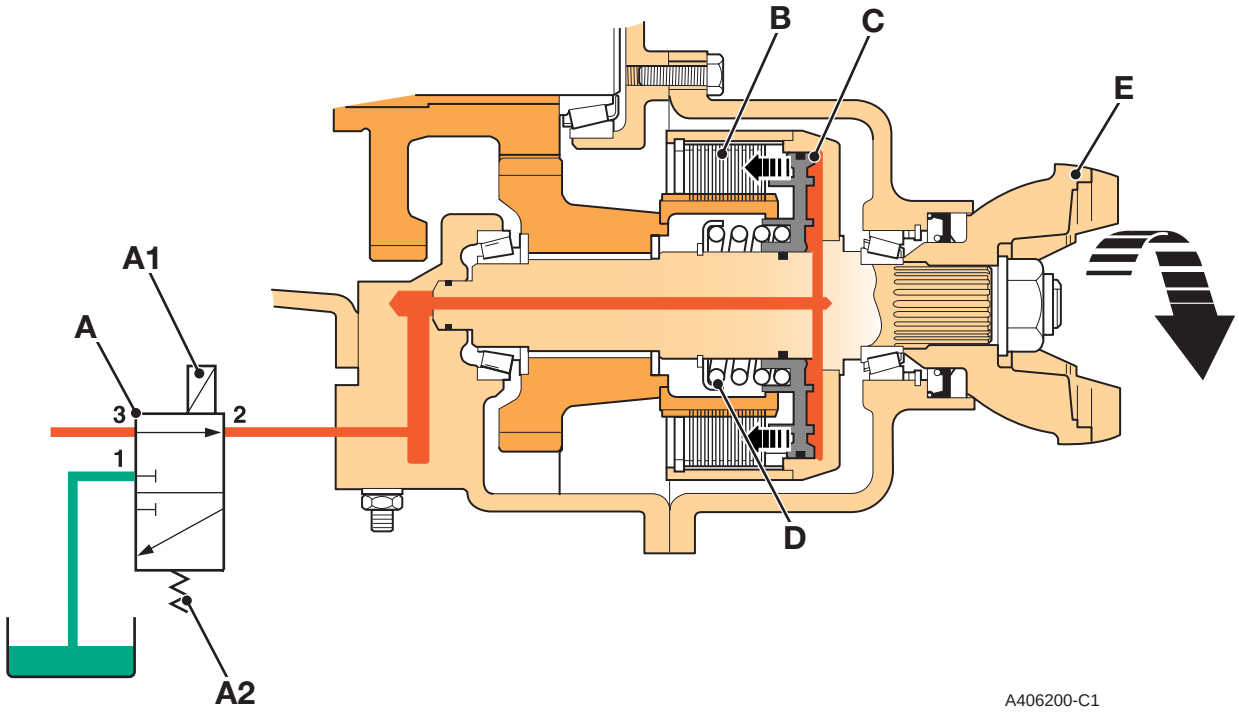


Fig 47.

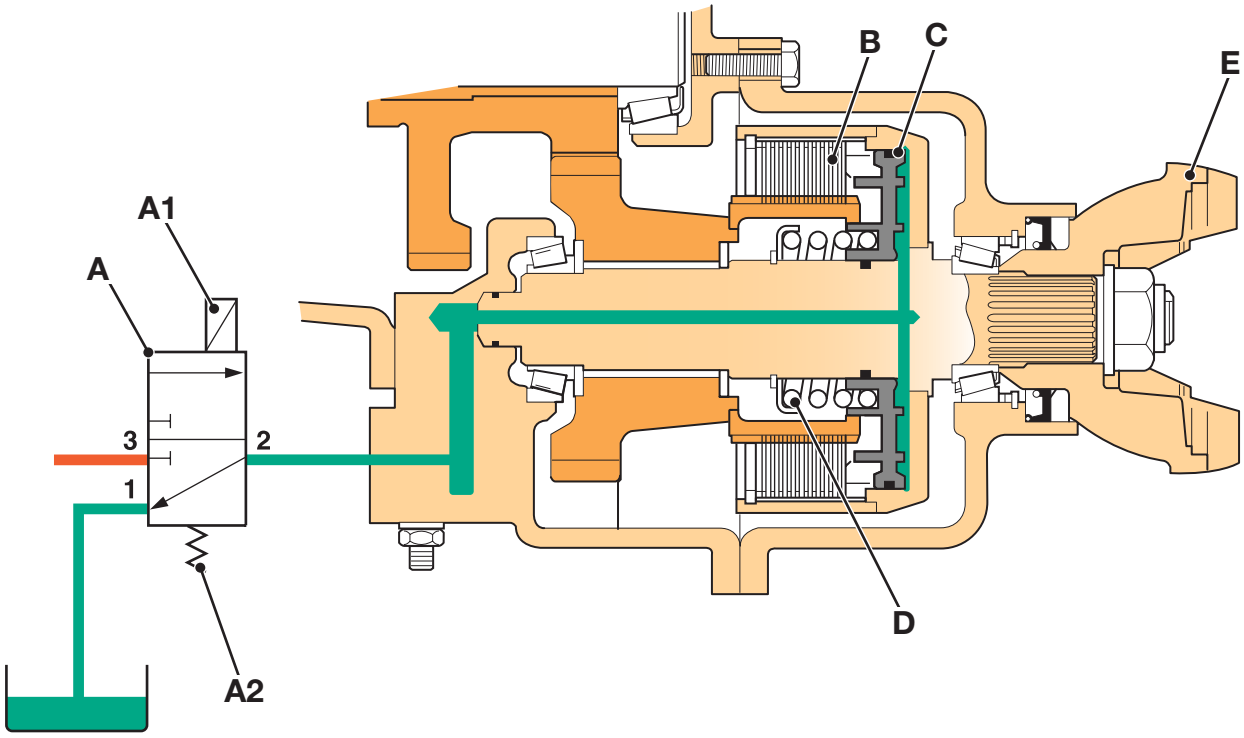
This type of clutch is engaged by oil pressure for 4 wheel drive, and disengaged by spring force for 2 wheel drive. The clutch operates by introducing or dumping pressurised oil behind piston **C** via a solenoid valve **A**. The solenoid valve is operated by a selector switch in the cab.

When 4 wheel drive is selected, the solenoid **A1** is energised. The solenoid moves the valve spool to connect ports **3** and **2**. Pressurised oil is then directed to the piston **C**.

Because of the oil pressure behind piston **C**, the piston moves against spring **D** to press the clutch friction/counter plates **B** together, thus driving the output yoke **E**.

Note: *4 wheel drive is automatically selected when the brake pedals are pressed to give 4 wheel braking. For more information see* ***Section G, Brakes****.*

2 Wheel Drive Selected



A406210-C1

Fig 48.

When 2 wheel drive is selected, the solenoid **A1** is de-energised. The force of the spring **A2** moves the valve spool to block the oil supply to the piston **C** (shown at port **3**). At the same time oil vents from the back of piston **C** to the sump via ports **1** and **2**.

Because there is no oil pressure behind piston **C**, the clutch friction/counter plates **B** now freely rotate on the output shaft, thus disengaging drive to the front axle.

2 and 4 Wheel Drive Clutch (4WD Spring ON) Operation

4 Wheel Drive Selected

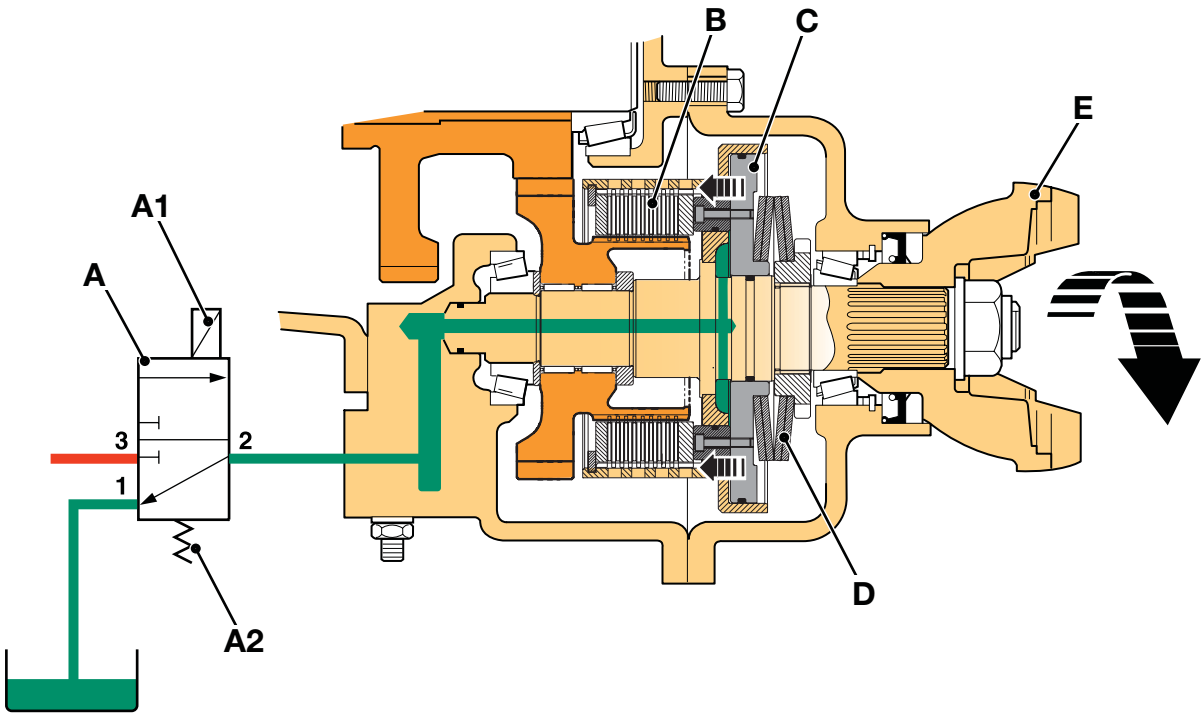


Fig 49.

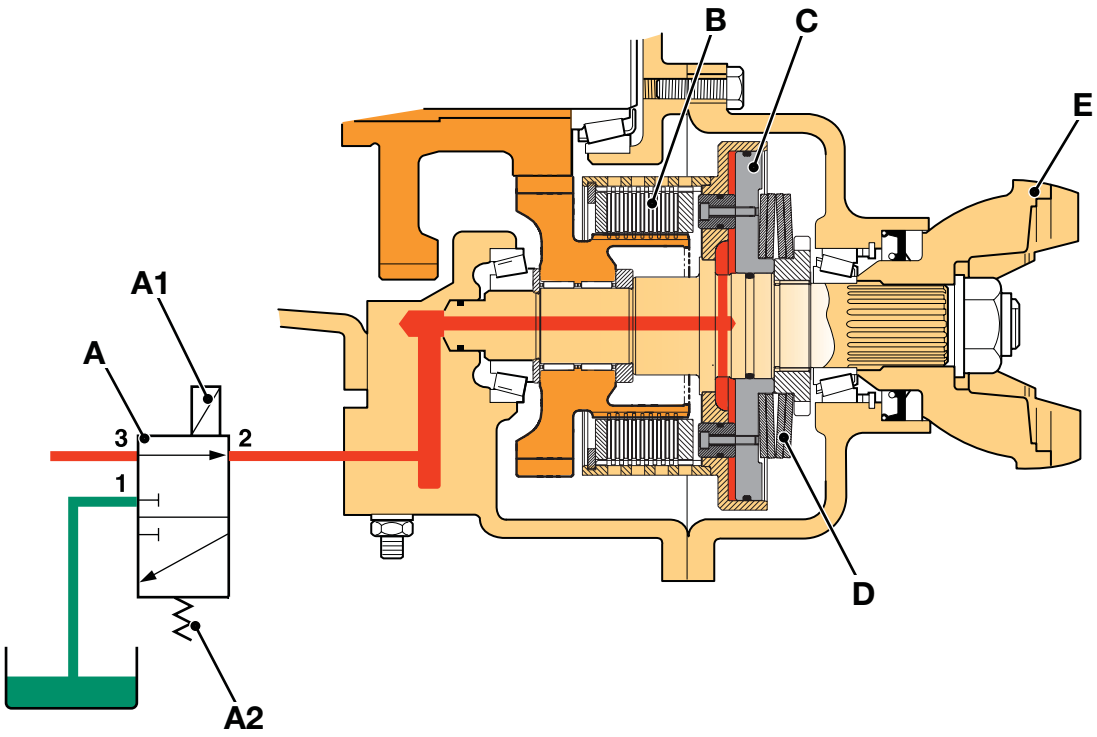
This type of clutch is engaged by spring force for 4 wheel drive, and disengaged by oil pressure for 2 wheel drive. The clutch operates by introducing or dumping pressurised oil behind piston **C** via a solenoid valve **A**. The solenoid valve is operated by a selector switch in the cab.

When 4 wheel drive is selected, the solenoid **A1** is de-energised. The force of the spring **A2** moves the valve spool to block the oil supply to the piston **C** (shown at port **3**). At the same time oil vents from the back of piston **C** to the sump via ports **1** and **2**.

Because there is no oil pressure behind piston **C**, the force of the disc springs **D** press the clutch friction/counter plates **B** together, thus driving the output yoke **E**.

Note: *4 wheel drive is automatically selected when the brake pedals are pressed to give 4 wheel braking. For more information see* ***Section G, Brakes****.*

2 Wheel Drive Selected



C093201

Fig 50.

When 2 wheel drive is selected, the solenoid **A1** is energised. The solenoid moves the valve spool to connect ports **3** and **2**. Pressurised oil is then directed to the piston **C**.

Because of the oil pressure behind piston **C**, the piston moves against the disc springs **D**, releasing the spring force on the clutch friction/counter plates **B**. The clutch friction/counter plates now freely rotate on the output shaft, thus disengaging drive to the front axle.

ShiftMaster Operation Characteristics

⇨ *Fig 51. (F-73)*. Central to the system is the ShiftMaster ECU (Electronic Control Unit) **A**. The unit receives `inputs' from electrical devices such as the gear select switch **B**. Depending on the input signals the ECU `outputs' energise electrical devices such as gearbox solenoid control valves **C**. For a full description of how the ShiftMaster electrical system works see ***Electrical Connections - ShiftMaster***.

Start Up

When the starter switch is set to the ON position the ECU performs a series of self checks. If the checks are valid **three** beeps sound. After the checks the ECU selects neutral even if forward or reverse is selected on the column lever. To select forward or reverse the operator must cycle the lever through neutral.If the checks fail, **1 or 2 beeps** will sound and the ECU will enter an appropriate limp mode (see ⇨ *Limp modes (F-73)*.

`Manual' gear select

The operator can `manually' select 1st, 2nd, 3rd and 4th (**4 speed gearbox only**) gears using the column switch. When down shifting (say from 3rd to 2nd) the ECU checks to see if the machine road speed is suitable before down shifting the gearbox. If the road speed is too high a **single double beep** is sounded.

When the road speed reduces to a pre-set value the ECU down shifts the gearbox and the beeps will stop.

Kick down operation (6 speed gearbox only)

A floor mounted kickdown switch enables the operator to down shift to the next lowest gear. The ECU checks to see if the machine road speed is suitable before down shifting the gearbox. If the road speed is too high a single double beep is sounded.

Pressing the kick down switch a second time causes the ECU to select the previous gear.

`Automatic' gear selection (6 speed gearbox only)

When A (auto) and F (forward) are selected on the column switch, the ECU selects 4th, 5th or 6th gears, mainly according to road speed. The gearbox will automatically up shift and down shift. 2WD will also be selected.

To enable up shifts the accelerator pedal must be pressed, this prevents up shifting when coasting down hill for example, thus ensuring maximum machine control.

Note that the ECU does not automatically shift gears in response to engine load.

When A (auto) and R (reverse) are selected the ECU selects 4th gear and 2WD. There is no automatic gear shifting in reverse.

On machines with 4WB (4 wheel brake), if the operator has selected 4WB the ECU will automatically select 4WD (4 wheel drive) when the brake pedal is pressed.

Park brake ON

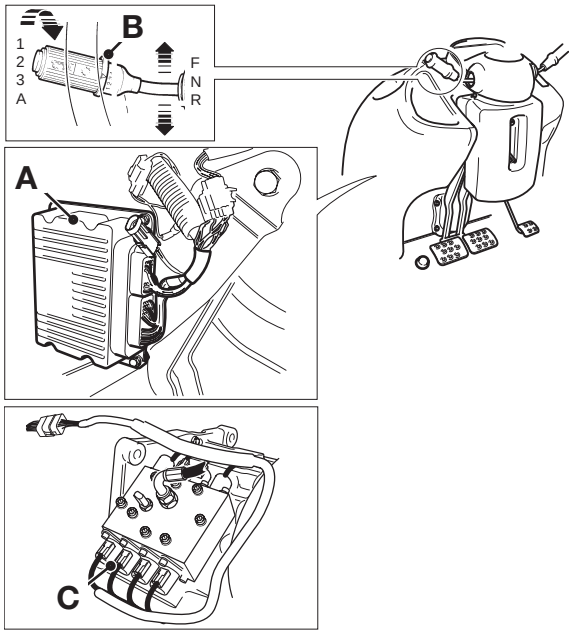
When the park brake is on, the ECU will hold the gearbox in neutral even if forward or reverse are selected. A **continuous tone** is sounded.

Transmission dump

When the operator presses the dump switch the ECU selects neutral by de-energising one clutch only. This enables smooth re-engagement of gears when the dump button is released.

Limp modes

When necessary the ECU will provide alternative gear selection should faults occur. This enables the machine to be moved (`limped') under its own power. For full details of the limp modes see ***Fault Finding - Powershift Gearbox***.

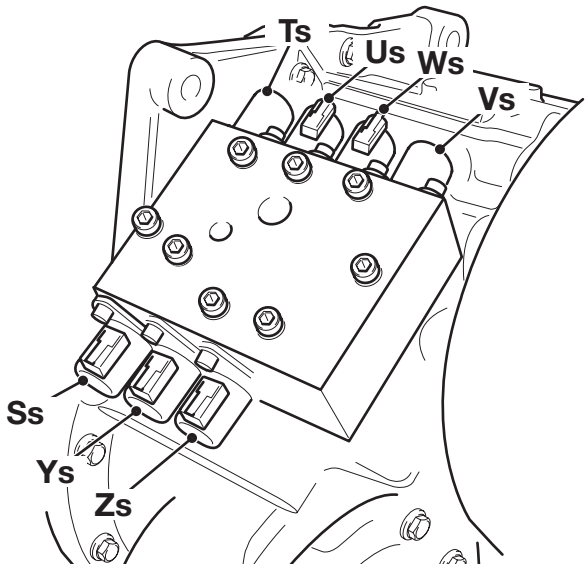


A405710-C3

Fig 51.

Drivepaths - 4 Speed

Forward



1F ⇨ *Fig 52. (F-75)*

1st GEAR FORWARD (4 wheel drive)

Clutches Engaged		Solenoids Energised
T	Forward Low	**Ts**
Z	Layshaft	**Zs**
S	2/4 Wheel Drive	**Ss**

2F ⇨ *Fig 54. (F-75)*

2nd GEAR FORWARD (4 wheel drive)

Clutches Engaged		Solenoids Energised
U	Forward High	**Us**
Z	Layshaft	**Zs**
S	2/4 Wheel Drive	**Ss**

3F ⇨ *Fig 53. (F-75)*

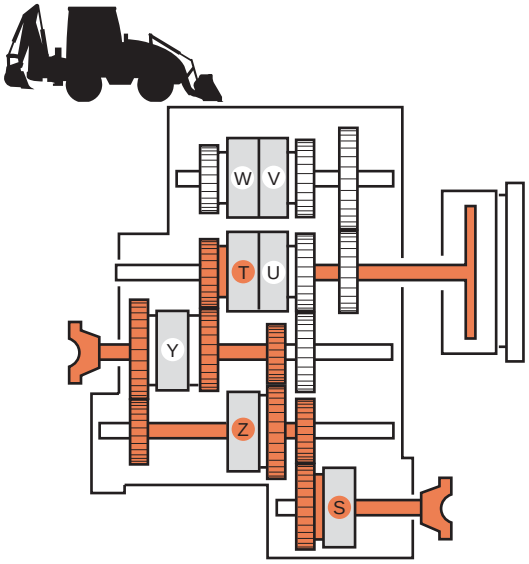
3rd GEAR FORWARD (4 wheel drive)

Clutches Engaged		Solenoids Energised
T	Forward Low	**Ts**
Y	Mainshaft	**Ys**
S	2/4 Wheel Drive	**Ss**

4F ⇨ *Fig 55. (F-75)*

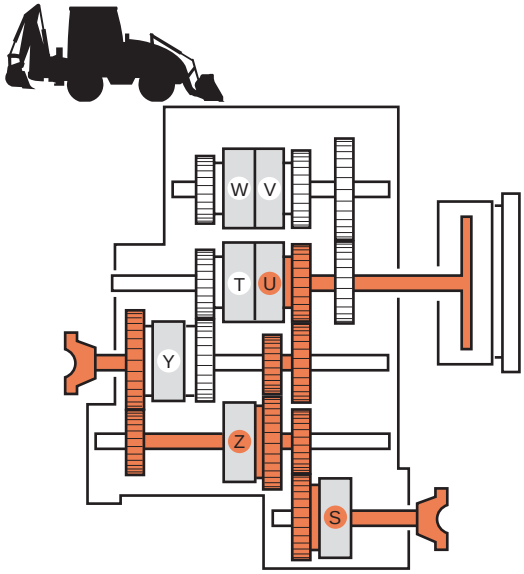
4th GEAR FORWARD (4 wheel drive)

Clutches Engaged		Solenoids Energised
U	Forward High	**Us**
Y	Mainshaft	**Ys**
S	2/4 Wheel Drive	**Ss**



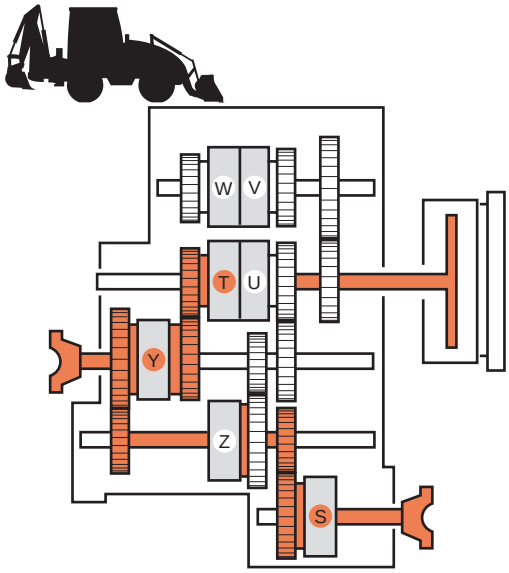
A396660-C1

Fig 52. 1F



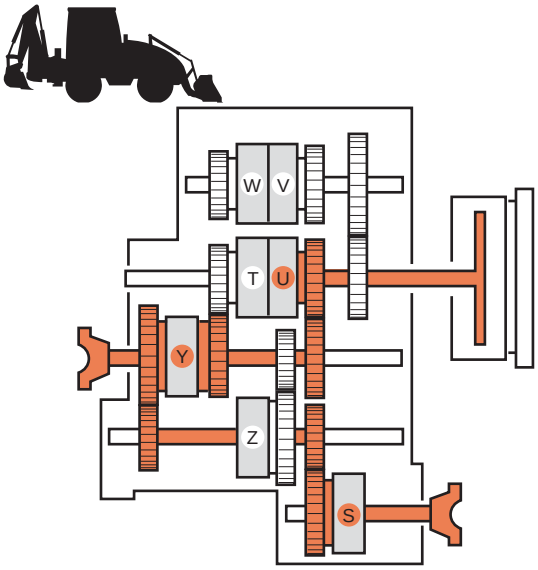
A396670-C1

Fig 54. 2F



A396680-C1

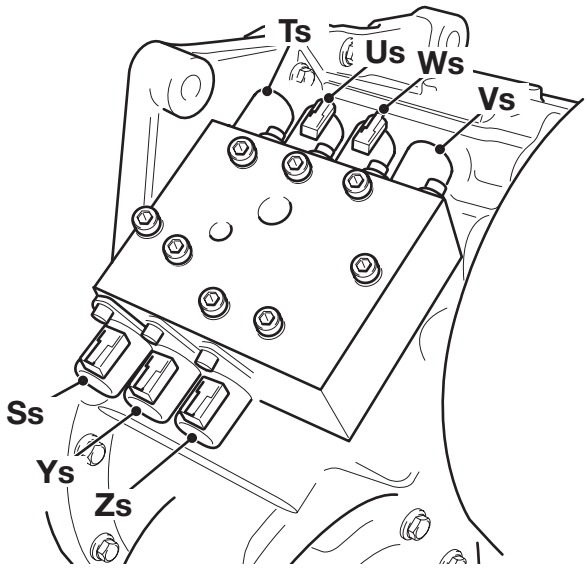
Fig 53. 3F



A396690-C1

Fig 55. 4F

Reverse



1R ⇨ *Fig 56. (F-77)*

1st GEAR REVERSE (4 wheel drive)

Clutches Engaged		Solenoids Energised
W	Reverse Low	**Ws**
Z	Layshaft	**Zs**
S	2/4 Wheel Drive	**Ss**

2R ⇨ *Fig 58. (F-77)*

2nd GEAR REVERSE (4 wheel drive)

Clutches Engaged		Solenoids Energised
V	Reverse High	**Vs**
Z	Layshaft	**Zs**
S	2/4 Wheel Drive	**Ss**

3R ⇨ *Fig 57. (F-77)*

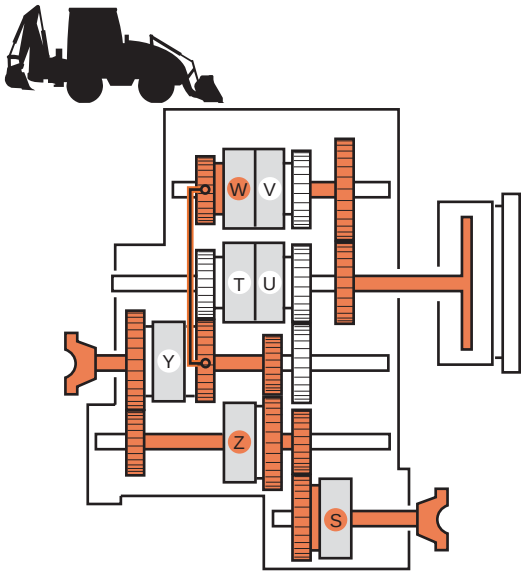
3rd GEAR REVERSE (4 wheel drive)

Clutches Engaged		Solenoids Energised
W	Reverse Low	**Ws**
Y	Mainshaft	**Ys**
S	2/4 Wheel Drive	**Ss**

4R ⇨ *Fig 59. (F-77)*

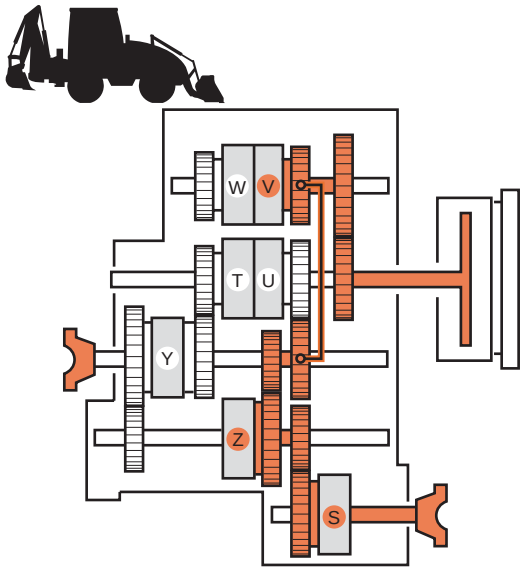
4th GEAR REVERSE (4 wheel drive)

Clutches Engaged		Solenoids Energised
V	Reverse High	**Vs**
Y	Mainshaft	**Ys**
S	2/4 Wheel Drive	**Ss**



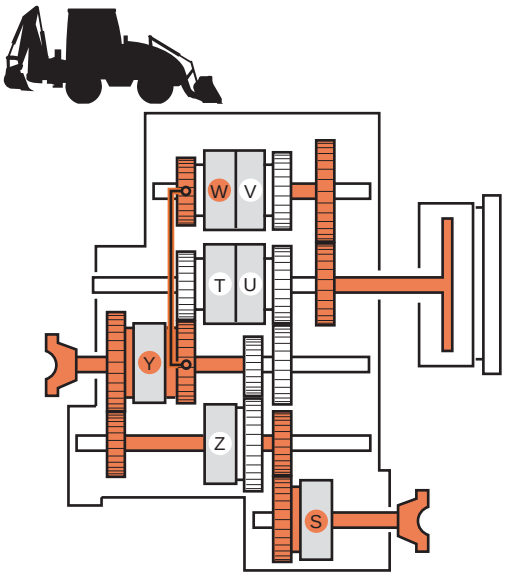
A396700-C1

Fig 56. 1R



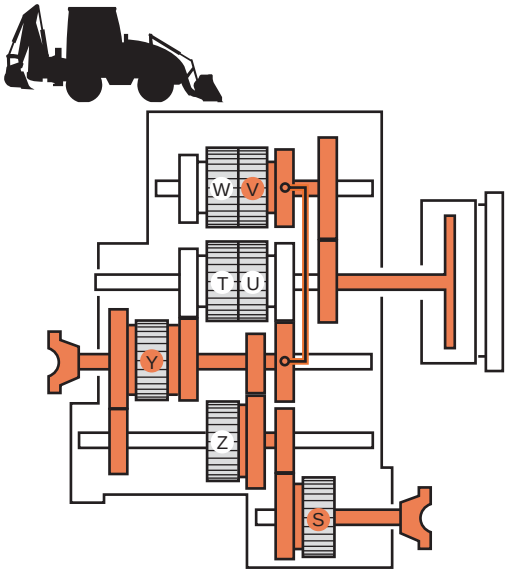
A396710-C1

Fig 58. 2R



A396720-C1

Fig 57. 3R



A396730-C1

Fig 59. 4R

Drivepaths - 6 Speed

Forward

1F ⇨ *Fig 61. (F-79)*

1st GEAR FORWARD (4 wheel drive)

Clutches Engaged		Solenoids Energised
X	`6 Speed'	Xs
Z	Layshaft	Zs
S	2/4 Wheel Drive	Ss

2F ⇨ *Fig 63. (F-79)*

2nd GEAR FORWARD (4 wheel drive)

Clutches Engaged		Solenoids Energised
T	Forward Low	Ts
Z	Layshaft	Zs
S	2/4 Wheel Drive	Ss

3F ⇨ *Fig 62. (F-79)*

3rd GEAR FORWARD (4 wheel drive)

Clutches Engaged		Solenoids Energised
U	Forward High	Us
Z	Layshaft	Zs
S	2/4 Wheel Drive	Ss

4F ⇨ *Fig 64. (F-79)*

4th GEAR FORWARD (4 wheel drive)

Clutches Engaged		Solenoids Energised
X	`6 Speed'	Xs
Y	Mainshaft	Ys
S	2/4 Wheel Drive	Ss

5F ⇨ *Fig 65. (F-80)*

5th GEAR FORWARD (4 wheel drive)

Clutches Engaged		Solenoids Energised
T	Forward Low	Ts
Y	Mainshaft	Ys
S	2/4 Wheel Drive	Ss

6F ⇨ *Fig 66. (F-80)*

6th GEAR FORWARD (4 wheel drive)

Clutches Engaged		Solenoids Energised
U	Forward High	Us
Y	Mainshaft	Ys
S	2/4 Wheel Drive	Ss

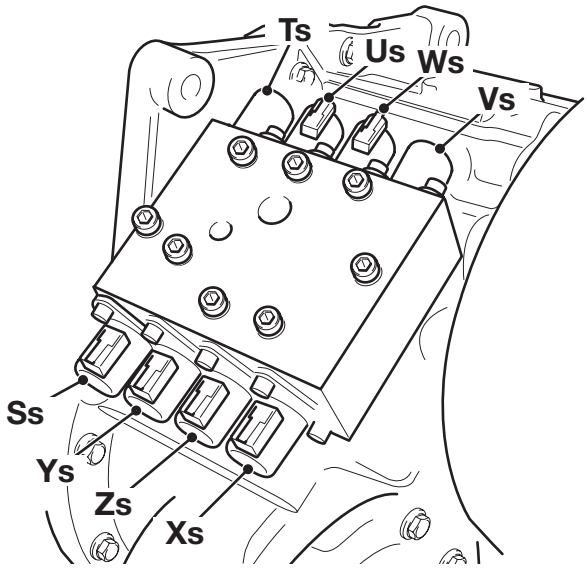


Fig 60.

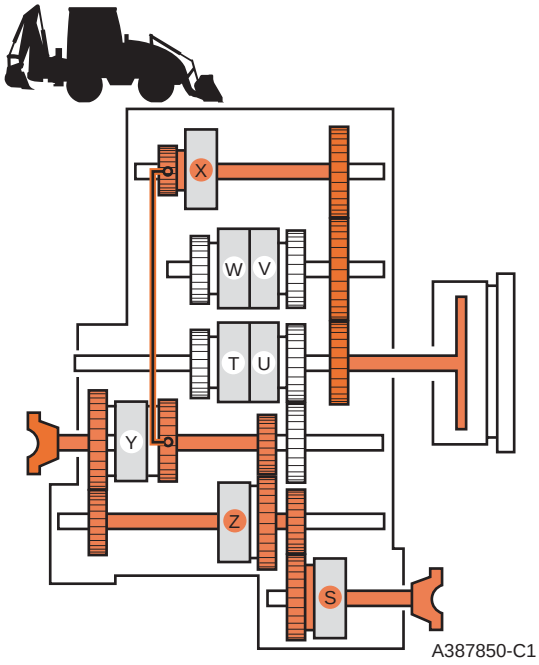


Fig 61. 1F

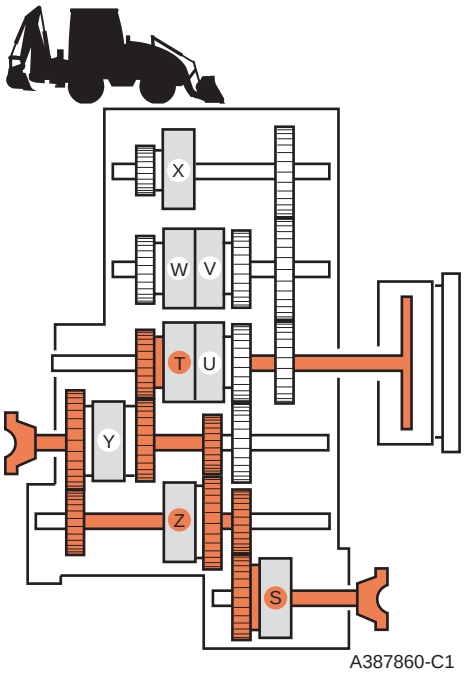


Fig 63. 2F

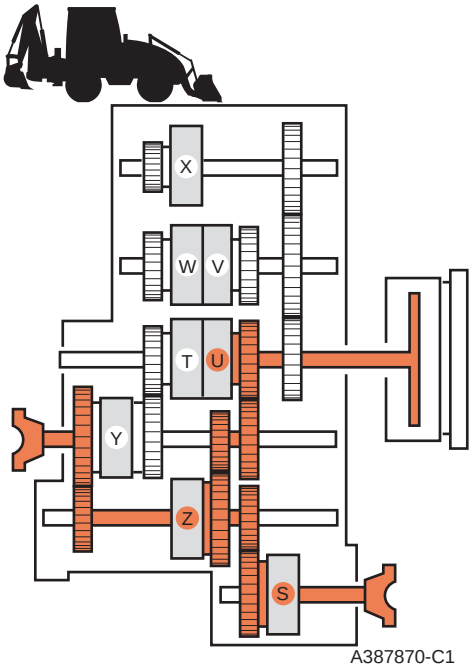


Fig 62. 3F

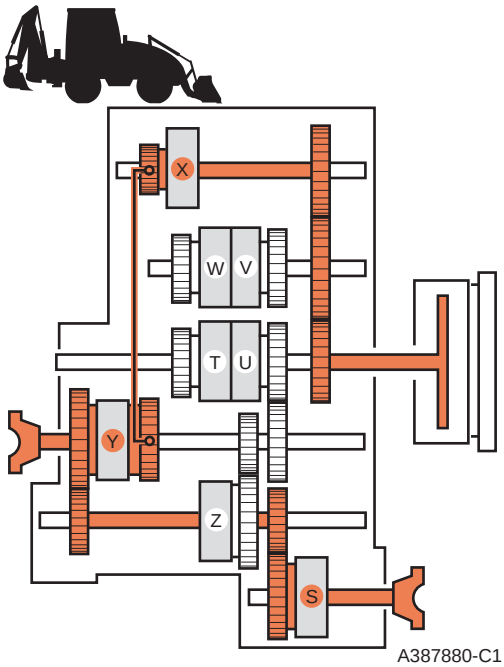
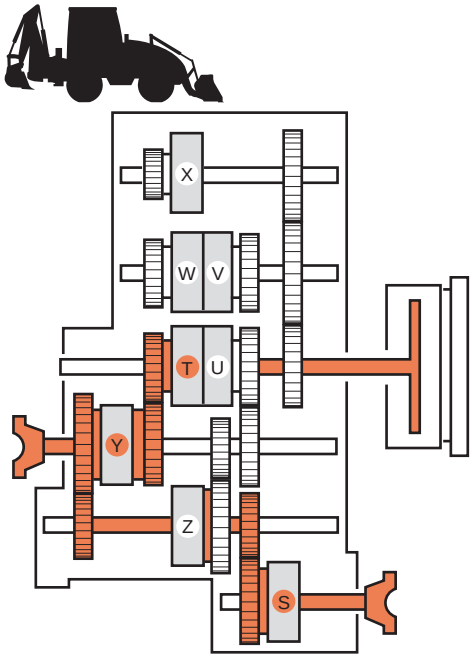
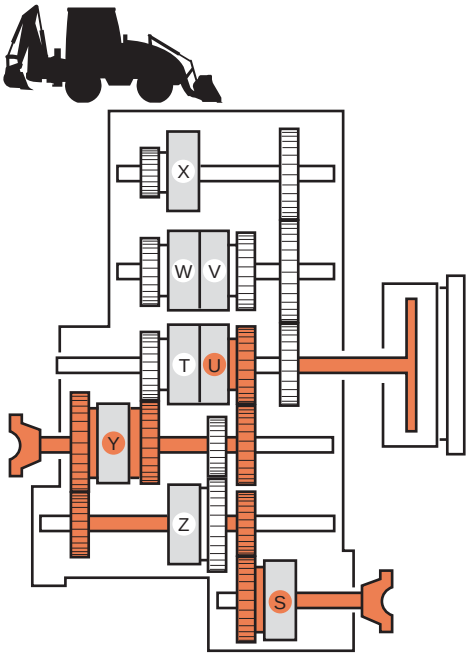


Fig 64. 4F



A387890-C1

Fig 65. 5F



A387900-C1

Fig 66. 6F

Reverse

1R ⇨ *Fig 68. (F-82)*

1st GEAR REVERSE (4 wheel drive)

Clutches Engaged		Solenoids Energised
W	Reverse Low	**Ws**
Z	Layshaft	**Zs**
S	2/4 Wheel Drive	**Ss**

2R ⇨ *Fig 70. (F-82)*

2nd GEAR REVERSE (4 wheel drive)

Clutches Engaged		Solenoids Energised
V	Reverse High	**Vs**
Z	Layshaft	**Zs**
S	2/4 Wheel Drive	**Ss**

3R ⇨ *Fig 69. (F-82)*

3rd GEAR REVERSE (4 wheel drive)

Clutches Engaged		Solenoids Energised
W	Reverse High	**Ws**
Y	Mainshaft	**Ys**
S	2/4 Wheel Drive	**Ss**

4R ⇨ *Fig 71. (F-82)*

4th GEAR REVERSE (4 wheel drive)

Clutches Engaged		Solenoids Energised
V	Reverse High	**Vs**
Y	Mainshaft	**Ys**
S	2/4 Wheel Drive	**Ss**

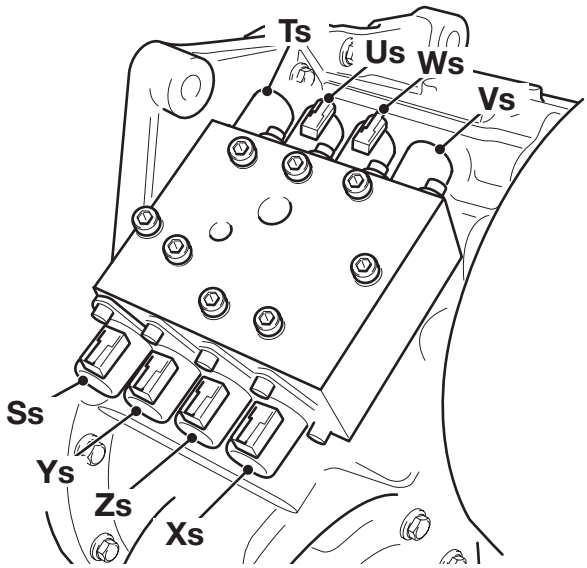


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Fig 67.

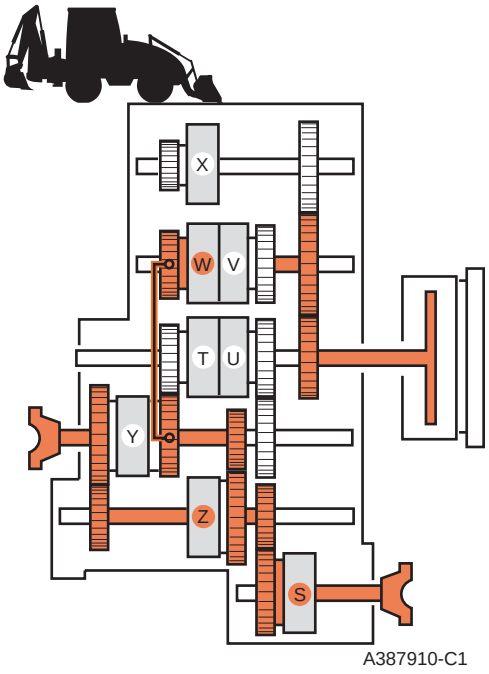

Fig 68. 1R

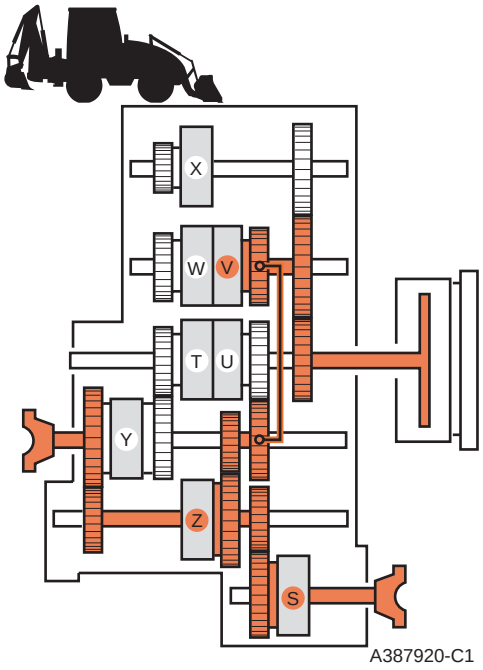

Fig 70. 2R

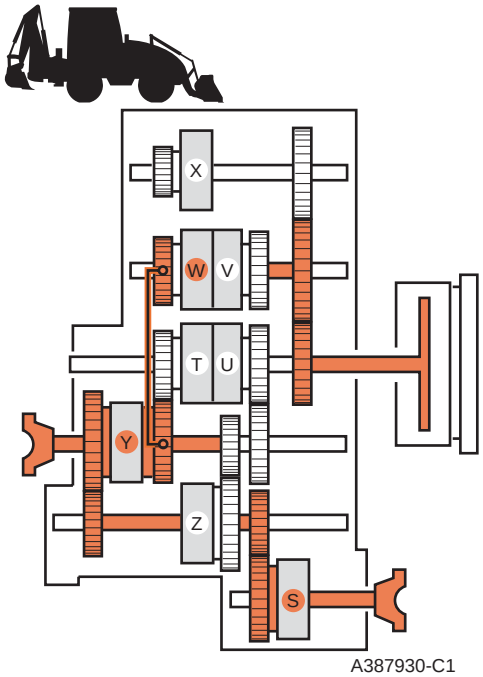

Fig 69. 3R

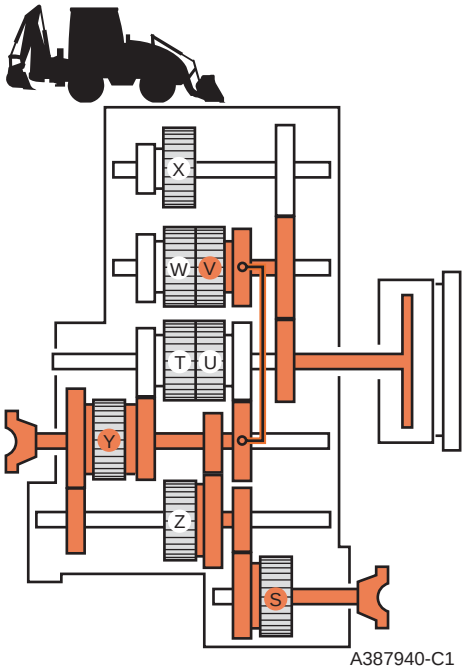

Fig 71. 4R

Torque Converter

Principle of Operation

⇨ *Fig 72. (F-84)*. The torque converter is similar to a fluid coupling, which utilises the centrifugal force exerted in the transmission oil to transmit power from the engine to the gearbox. It multiplies the torque from the engine and functions as a combined clutch and infinitely variable reduction gearbox.

The torque converter is enclosed in a casing and consists of three basic parts, the impeller **A**, reaction member **C**, and turbine **B**.

Impeller **A** is driven by the engine.

Reaction member **C** does not rotate. Its hub engages with a splined tube on the gearbox oil pump and is held stationary.

Turbine **B** is engaged with the splined end of the gearbox input shaft.

The impeller **A**, driven by the engine, forms one set of shaped blades, it can be likened to a centrifugal pump imparting energy to the transmission oil. This energy is transferred to another set of shaped blades, which form the turbine **B** The turbine is connected to the gearbox and converts the energy back to a mechanical torque.

When the impeller **A** is rotating faster than the turbine **B**, the fixed reaction member **C** causes some of the energy in the oil to be transferred back to the impeller **A**. This has the effect of multiplying the torque available.

When the impeller **A** (input) is running much faster than the turbine **B** (output) there is a substantial circulation of transmission oil around the blades. The oil circulation is maximum when the turbine (output) is stalled, and is almost zero when the impeller and turbine speeds are equal i.e. the ratio is near 1:1. If the turbine (output) is stalled whilst the impeller (input) is revolving, all the power is dissipated as heat.

Because of the absence of a direct mechanical connection between the engine and the gearbox therefore, the flexibility of the torque converter drive greatly reduces wear on the transmission, absorbing shocks and torsional vibration from the engine. The engine cannot be stalled due to overload, as the fluid coupling slips.

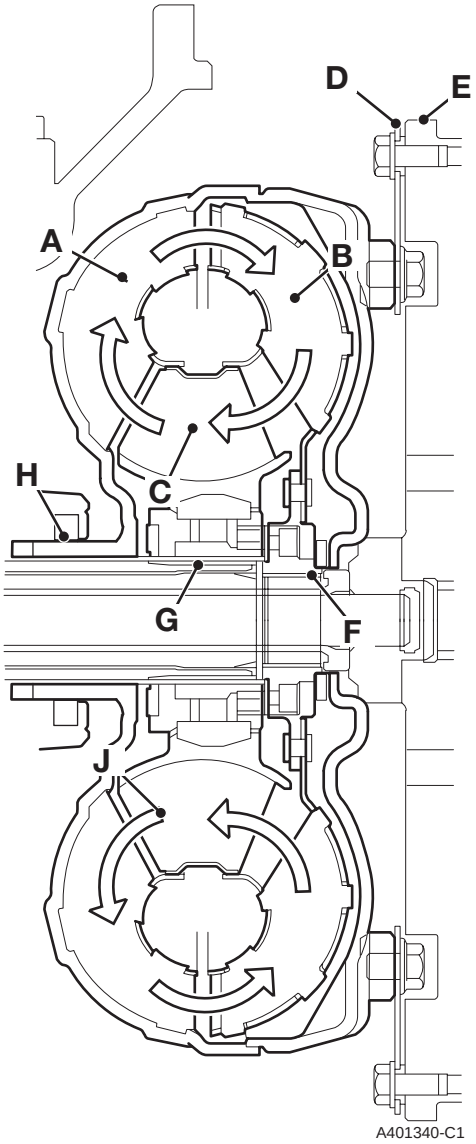

Fig 72.

Component Key:

A Impeller

B Turbine

C Reaction member

D Drive plate

E Engine flywheel

F Drive to gearbox input shaft

G Spline location for reaction member

H Direct drive from the engine to the gearbox oil pump

J Direction of oil flow

Lock Up Torque Converter

The lock up torque converter incorporates a clutch which, when engaged, enables a direct mechanical connection between the engine and the gearbox. This eliminates any slippage in the drive line and results in improved efficiency. The system is only available on Powershift machines.

Principle of Operation

⇨ *Fig 73. (F-86)*. The lock up clutch assembly **A** is fixed to the turbine **D** (output section) of the torque converter. The turbine is connected to the gearbox input shaft **E** via a splined hub. For a description of how the turbine is driven see ***Torque Converter, Principle Of Operation.***

The clutch is engaged and disengaged hydraulically by utilising the normal oil flow through the torque converter. Solenoid control valve **F** changes the direction of oil the flow to engage or disengage the clutch as applicable.

The solenoid control valve **F** is energised via an electrical output from the gearbox ECU **J** (electronic control unit) The ECU **J** receives inputs from the gear select lever **K**, engine speed sensor **H** and gearbox output shaft speed sensor **G**. An output from the ECU energises the solenoid control valve **F** (enabling torque converter lock up) under the following conditions:

4th gear forward (4speed gearbox) or A - 5th or 6th (6 speed gearbox) must be selected, AND the speed difference between the engine flywheel and gearbox output drive shaft must be within pre-determined values.

⇨ *State 1, Torque Converter Unlocked (F-87)*

⇨ *State 2, Torque Converter Locked (F-89)*

Component Key:

A	Lock up clutch
B	Clutch friction material
C	Torque converter casing
D	Turbine
E	Gearbox input drive shaft
F	Solenoid control valve
G	Speed sensor, gearbox output shaft
H	Speed sensor, engine crankshaft pulley
J	ECU (electronic control unit)
K	Gear select lever
L	Lubrication bypass valve (part of item **F**)
Y	Test Point - Converter inlet and converter relief valve pressure

Note: *For lock up torque converter test procedure, see* ***Service Procedures, Powershift Gearbox (ShiftMaster)****.*

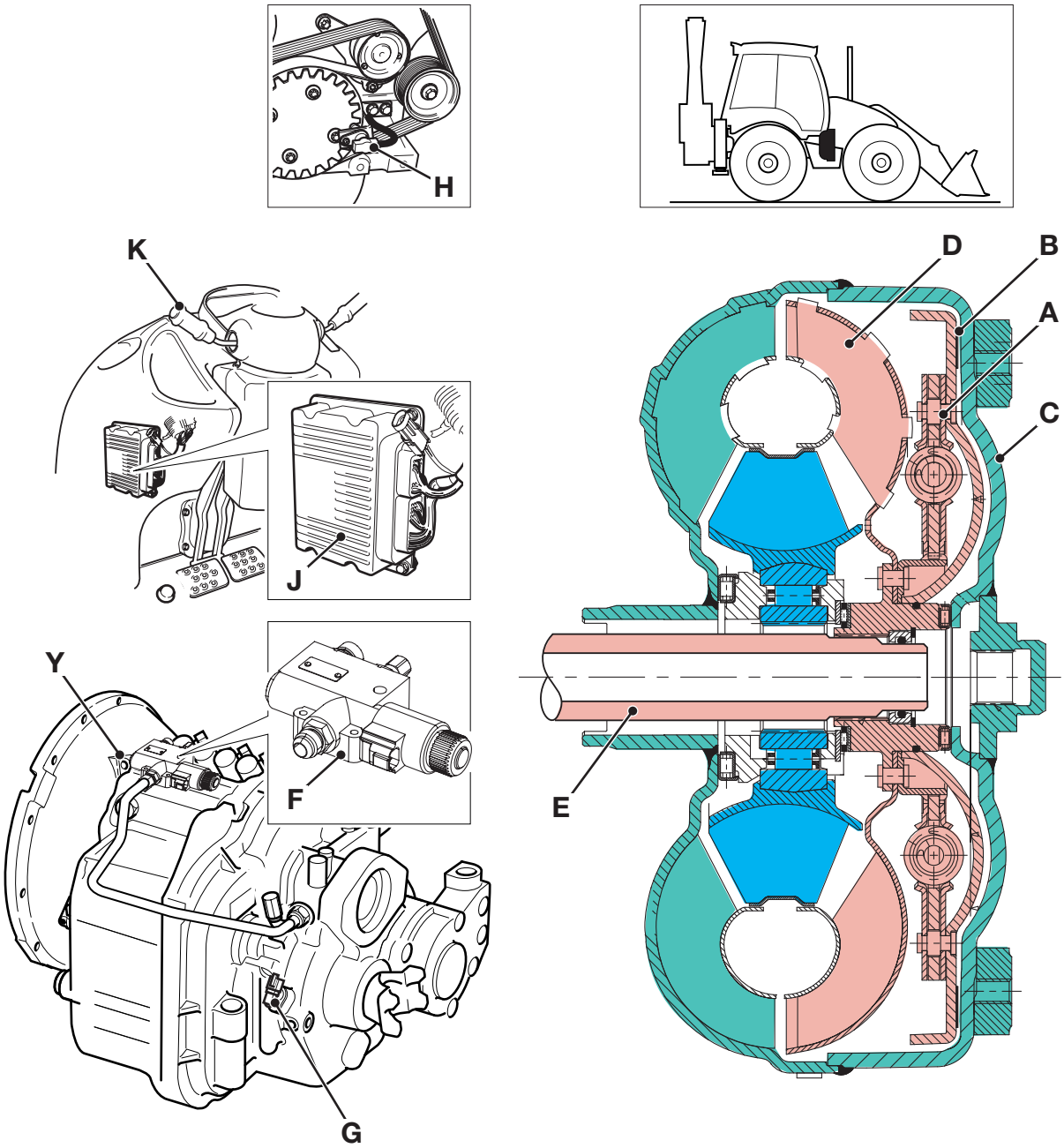

Fig 73. Component Identification

State 1, Torque Converter Unlocked

⇒ *Fig 74. (F-88)*. When inputs to the ECU **J** from the gear select lever **K** and speed sensors **G** and **H** are outside pre-determined values, solenoid control valve **F** is not energised and oil enters the converter casing nearest the flywheel via the centre of the gearbox input shaft **E**. Oil then flows past the front of the clutch assembly **A**. This causes the clutch assembly **A** to move on its splined hub away from the torque converter casing **C**. Oil leaves the torque converter via ports in the oil pump assembly and then passes through the oil cooler **M** via the control valve **F**. The torque converter operates in the normal way.

Note: *Although the torque converter operates in the normal way, it should be noted that the oil flow to and from the converter is opposite to the normal system.*

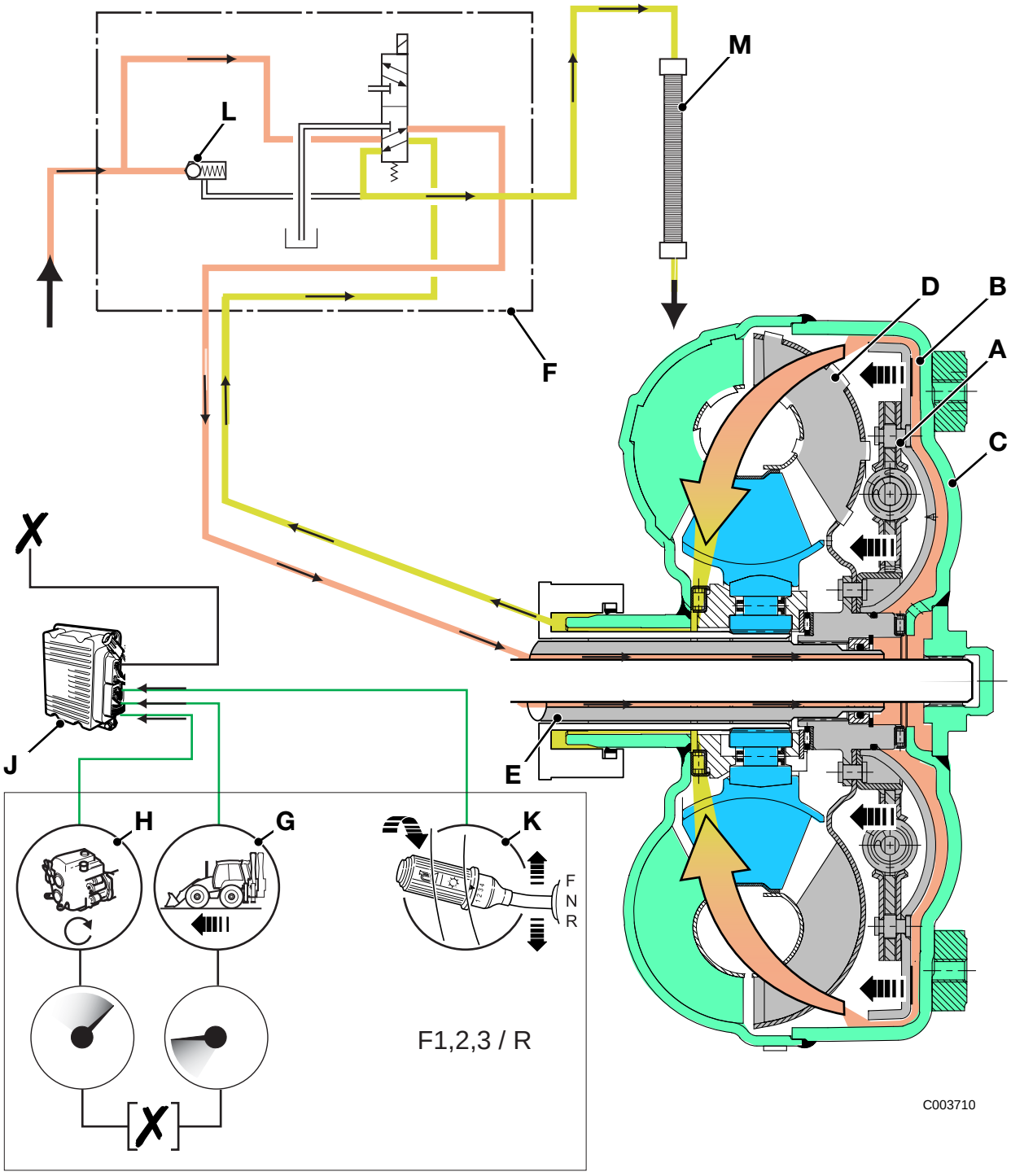

Fig 74. Torque Converter Unlocked

State 2, Torque Converter Locked

⇒ Fig 75. (F-90). When inputs to the ECU **J** from the gear select lever **K** and speed sensors **G** and **H** are within pre-determined values, an output from the ECU energises solenoid control valve **F.** Oil enters the converter via ports in the oil pump assembly and into the converter casing nearest the gearbox. Oil pressure forces the clutch assembly **A** to move on its splined hub, engaging the clutch friction material **B** with the inside of the torque converter casing **C**. Drive from the engine is now transmitted from the converter casing, through clutch **A** and directly to the gearbox input shaft **E** via the turbine **D**.

Small bleed holes allow a small flow of oil past the clutch assembly **A** through the converter, providing oil cooling and preventing hydraulic locks. Lubrication bypass valve **L** is pushed of its seat and oil flows through the cooler **M** and into the gearbox lubrication system in the normal way.

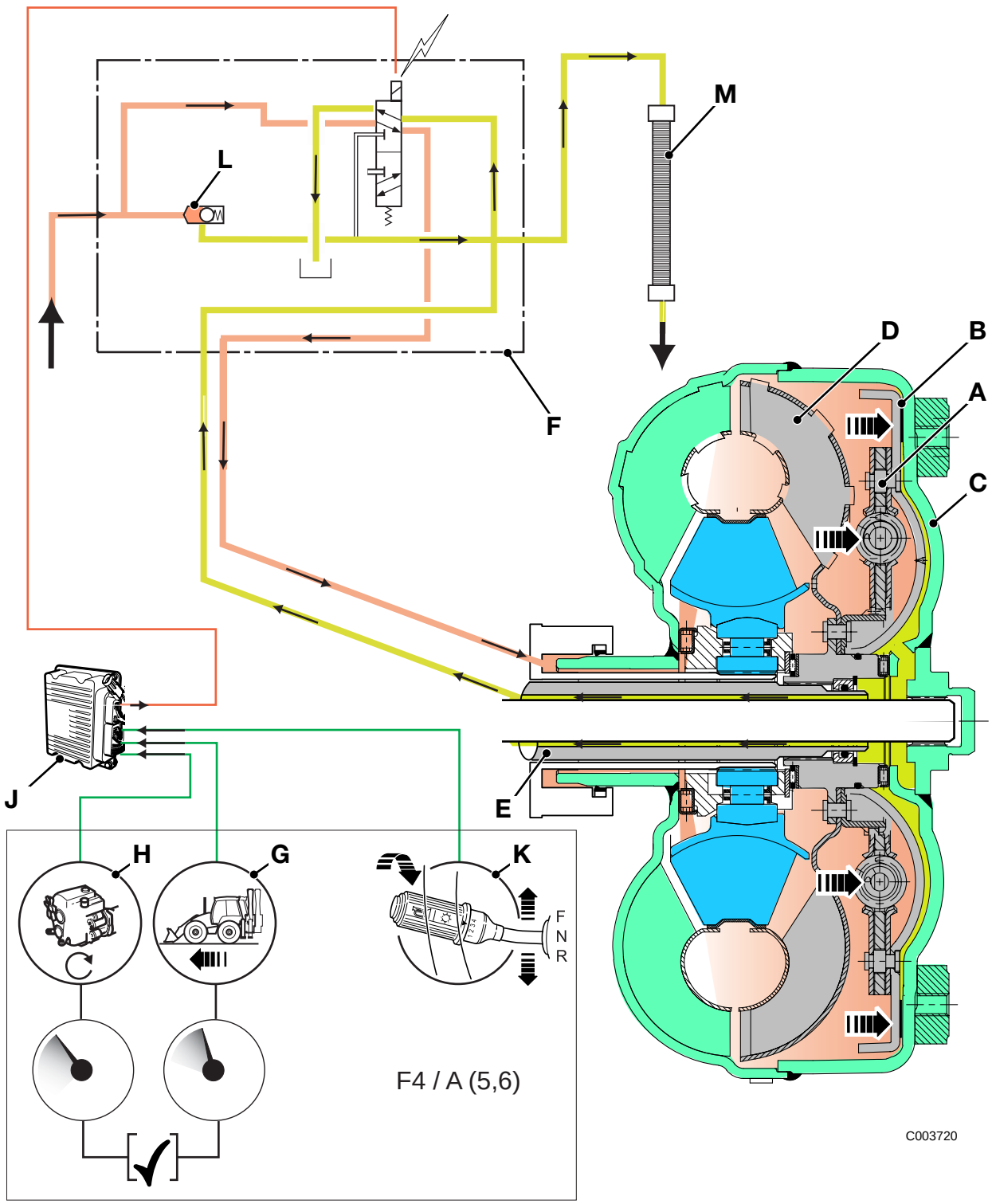

Fig 75. Torque Converter Locked

Electrical Connections

Synchro Shuttle Gearbox

Introduction

This section explains how the electrical system works when the following gearbox functions are operated:

Forward

Neutral

Reverse

Transmission dump

Park brake switch

Note: *4 Wheel Drive operation is not covered in this section, see Section G, Brakes for explanation (4 Wheel Brake).*

⇨ *Fig 76. (F-92)*. The Synchro Shuttle gearbox is controlled using conventional relays. The relays at **A** are operated via the column mounted forward/reverse lever **B**. The transmission dump switches **C** or park brake switch **D** also operate a relay at **A**. The contacts inside the relays energise the gearbox mounted solenoid control valves **E**.

Diode gate **F** is also used as a logic switch.

To access the relays and connectors it is necessary to remove the front/steering console panel **X** and side panels **Y**, refer to Section B for the correct procedure

Component Key

⇨ *Fig 76. (F-92)*

Item	Description
A	Relays
B	Forward, reverse lever
C	Transmission dump switches
D	Park brake switch
E	Gearbox solenoid control valves
X	Steer console panel
Y	Side panels

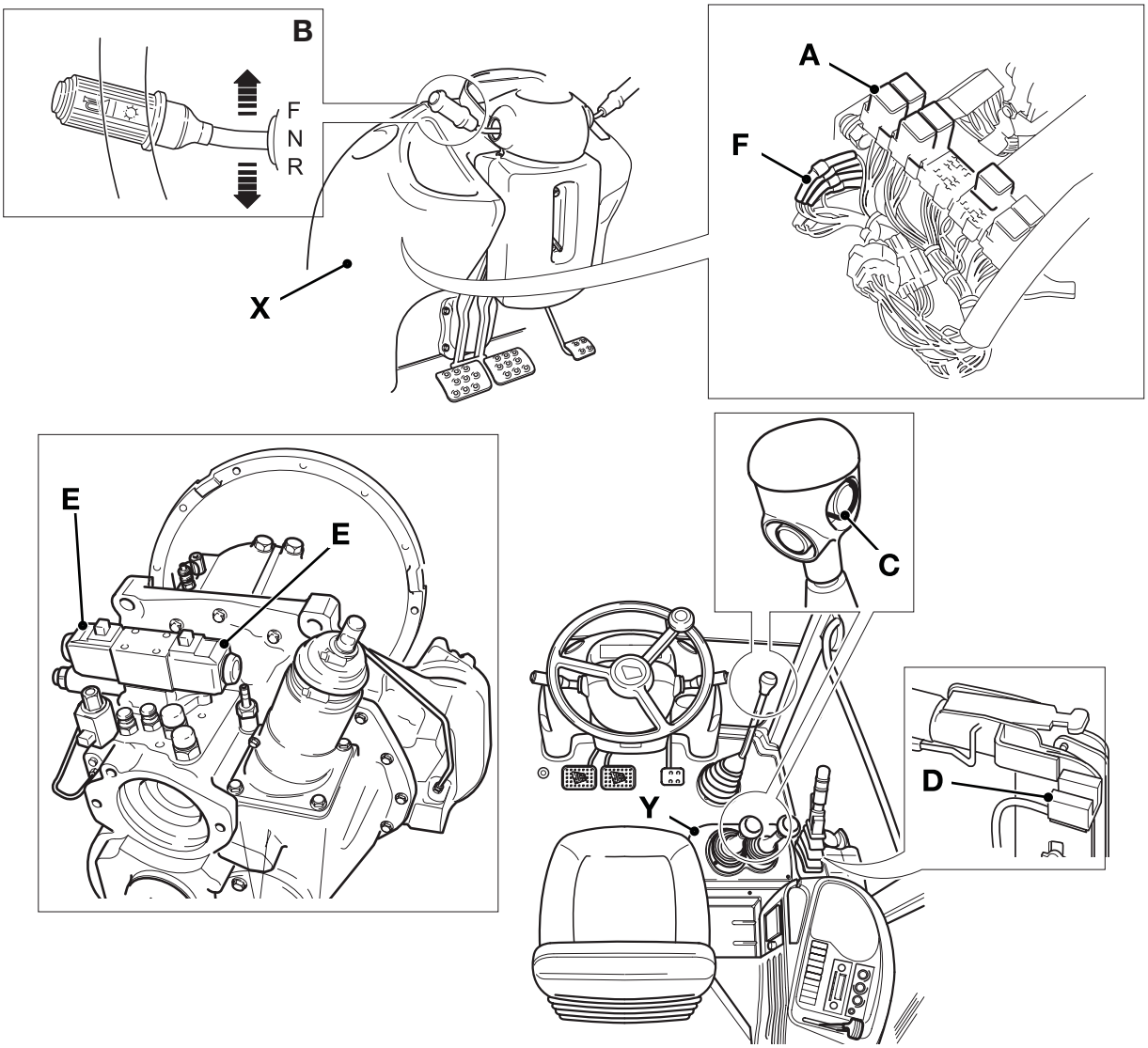

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Fig 76. Electrical Components

Quick Reference

Electrical connectors ⇨ *Fig 77. (F-94)*.

Electrical connections for switch positions together with energised relay and gearbox solenoids for each gearbox function are shown ⇨ *Table 28. (F-95)*. The numbers show which contacts are `live' and also relate to the actual connector pin numbers.

When fault finding it should be remembered that the system relies on the dump switch and park brake switches functioning correctly, failure of these switches will prevent forward or reverse gears being selected. From the table it is possible to see common relay functions which can help trace faults ⇨ *Table 28. (F-95)*.

Note that a non functioning relay or solenoid may not indicate a faulty component, the associated wires and connectors may have failed. For wire and connector details see the relevant schematic.

Electrical circuits for the gearbox control. Shown with `Forward' selected. `Live feed' wires are coloured red and feed to earth are green ⇨ *Fig 78. (F-96)*.

Electrical circuits for the gearbox control. Shown with `Reverse' selected. `Live feed' wires are coloured red and feed to earth are green ⇨ *Fig 79. (F-97)*.

Note: *Solenoid S is the 2 and 4WD solenoid. The 2 and 4WD select electrical system is not described in this section. See* ***Section G, Brakes*** *for explanation (4 Wheel Brake).*

Note: *FD1 and FE1 relays are common with the Powershift gearbox and are used in this instance as a means of link between the forward and reverse relays FD2, FE2 and gearbox solenoids GB and GC. Relays FD1 and FE1 are not energised in this application.*

Component Key

Item	Description
C50	Reverse alarm
DW	Park brake switch
FL	Column switch connector
FK	Diode gate connector
FG	Transmission dump relay
FD1	Forward Hi/Lo relay
FD2	Forward relay
FE1	Reverse Hi/lo relay
FE2	Reverse relay
NG	Dump switch (Gear Lever)
GD	Dump switch (Loader)
GB	Forward solenoid
GC	Reverse solenoid

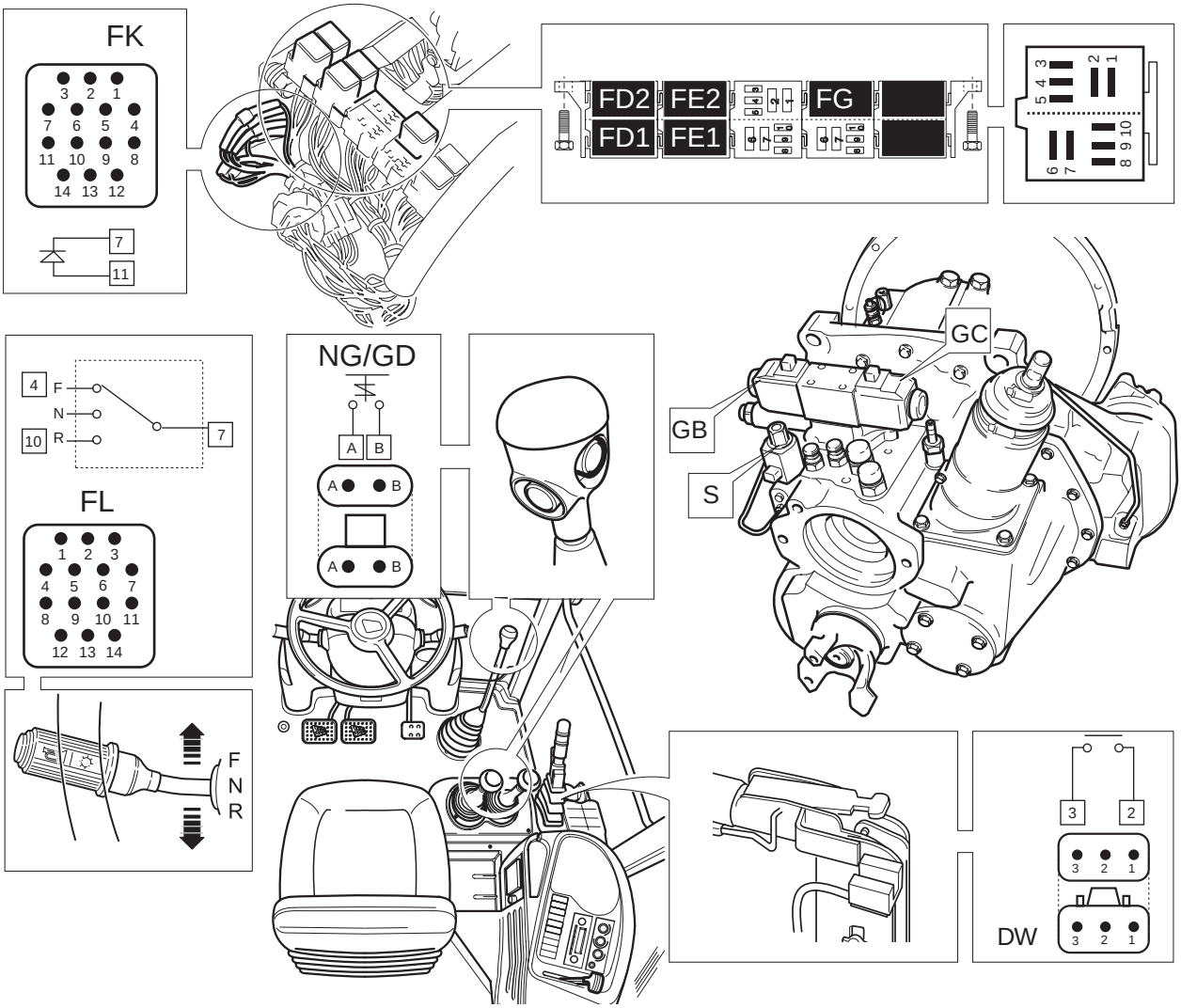

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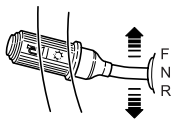
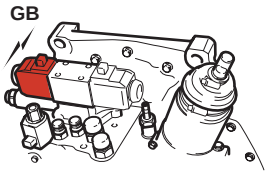
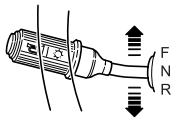
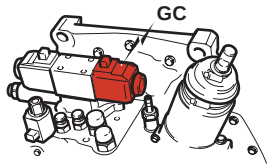
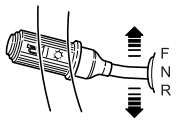
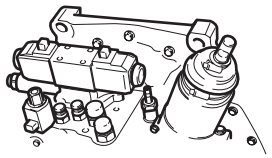
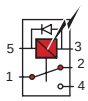
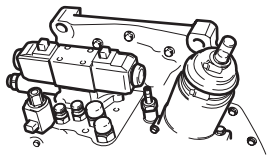
Fig 77. Electrical Connectors

Table 28.

Gearbox Function	Column Switch FL	Relay FG Dump	Relay FD2 Forward	Relay FE2 Reverse	Relay FD1 Forward Hi/Lo	Relay FE1 Reverse Hi/Lo	Gearbox Solenoid
FORWARD	7-4	1-4	3-5, 1-2	1-4	6-9	6-9	GB
							
REVERSE	7-10	1-4	1-4	3-5, 1-2	6-9	6-9	GC
							
NEUTRAL			1-4	1-4	6-9	6-9	-
							
TRANS DUMP / PARK BRAKE ON		5-3, 1-2					-
							

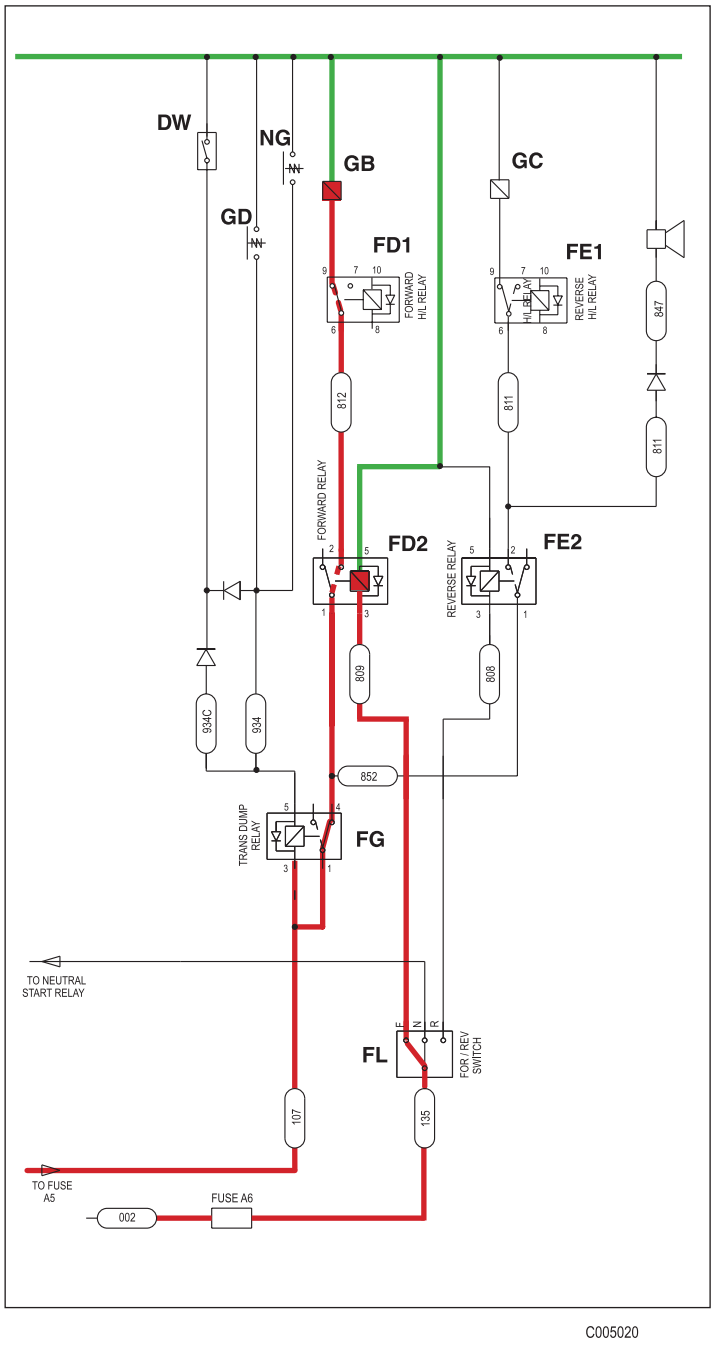


Fig 78. Electrical Schematic - Forward Selected

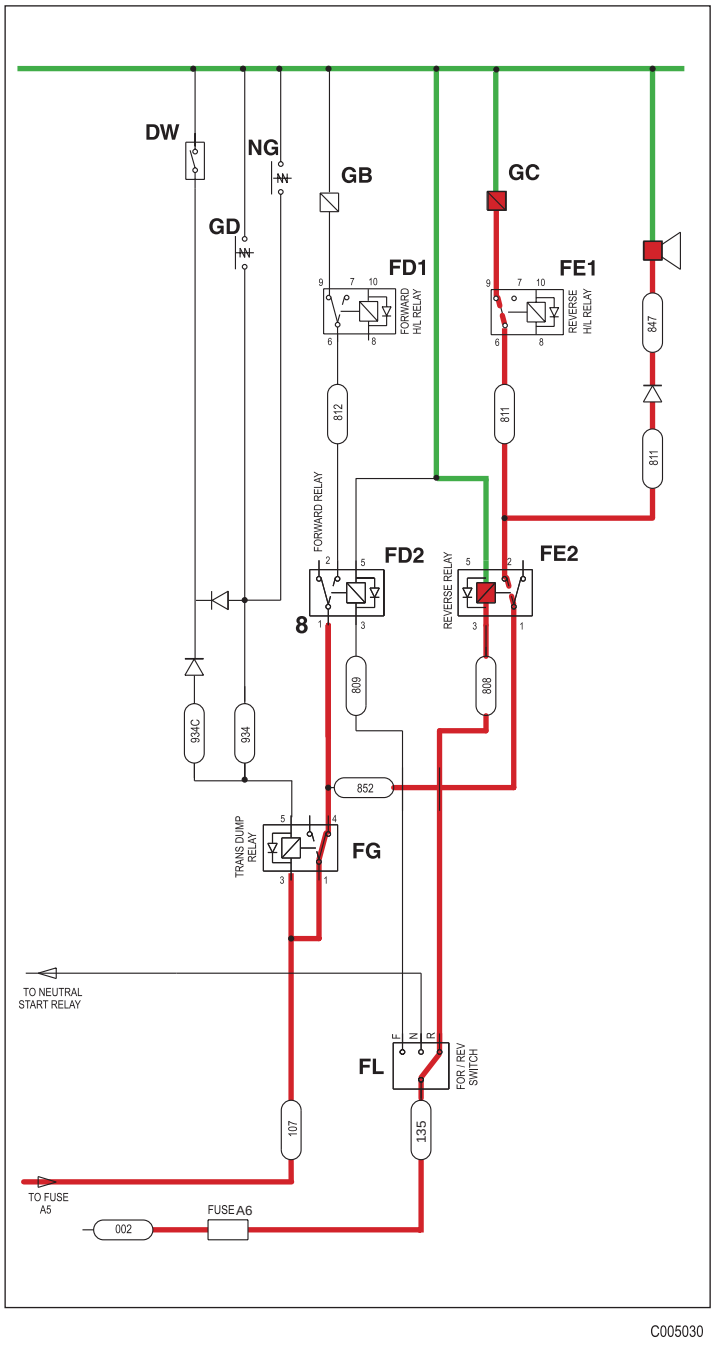


Fig 79. Electrical Schematic - Reverse Selected

Wires and Connectors

Although the system is straight forward in design it is never the less fairly complex in practice. For this reason schematics are divided into 2 parts: **Relay Actuation** and gearbox **Solenoid Actuation**.

On the electrical diagrams the electrical connectors (example, FA to CB) are shown looking on the mating face of each connector when they are disconnected ⇒ *Fig 81. (F-100)*.

The wire numbers and colours, where appropriate, are shown as an aid to identification whilst fault finding.

Before fault finding make sure that you understand how the the electrical circuits work. Most potential faults can be traced using a multimeter to carry out continuity checks on wires, switches and solenoid coils.

Relay Actuation

For gearbox solenoid actuation ⇒ *Solenoid Actuation (F-101)*

Earth Points

Faults may be caused by poor earth connections. Although earth connections are shown, it must be remembered that the cab assembly is earthed via further earth strap and cable connections. For details of these connections see Section C, ***Machine Earth Connections***.

Component Key (Relay Actuation)

The following key identifies the component connectors, ⇒ *Fig 80. (F-99)* and ⇒ *Fig 81. (F-100)*. Note that the wires coloured red show the electrical `live feed' to the column gear lever.

h1	Harness - Front console
h2	Harness - Cab & Side console
h6	Harness - Transmission

Note: For harness drawings see Section C.

Connectors (h1)

FA	h1 - h2
FB1	Earth point
FD1	Forward Hi/Lo relay
FD2	Forward relay
FE1	Reverse Hi/Lo relay
FE2	Reverse relay
FG	Transmission dump relay
FK	Diode gate
FL	Column gear lever

Connectors (h2)

CB	h2 - h1
CCA	Fuses
DR2,3,5	Earth point
DW	Park brake switch
EA	Immobiliser
EAB	Link - immobiliser (if immobiliser is not fitted)
EW	h2 - h6
NG	Transmission dump switch (Loader)

Connectors (h6)

GA	h6 - h2
GD	Transmission dump switch (Gear lever)

Splices (h1)

SA

SK

SS

ST

SX

Splices (h2)

SC

TF

TH

TN

UD

UE

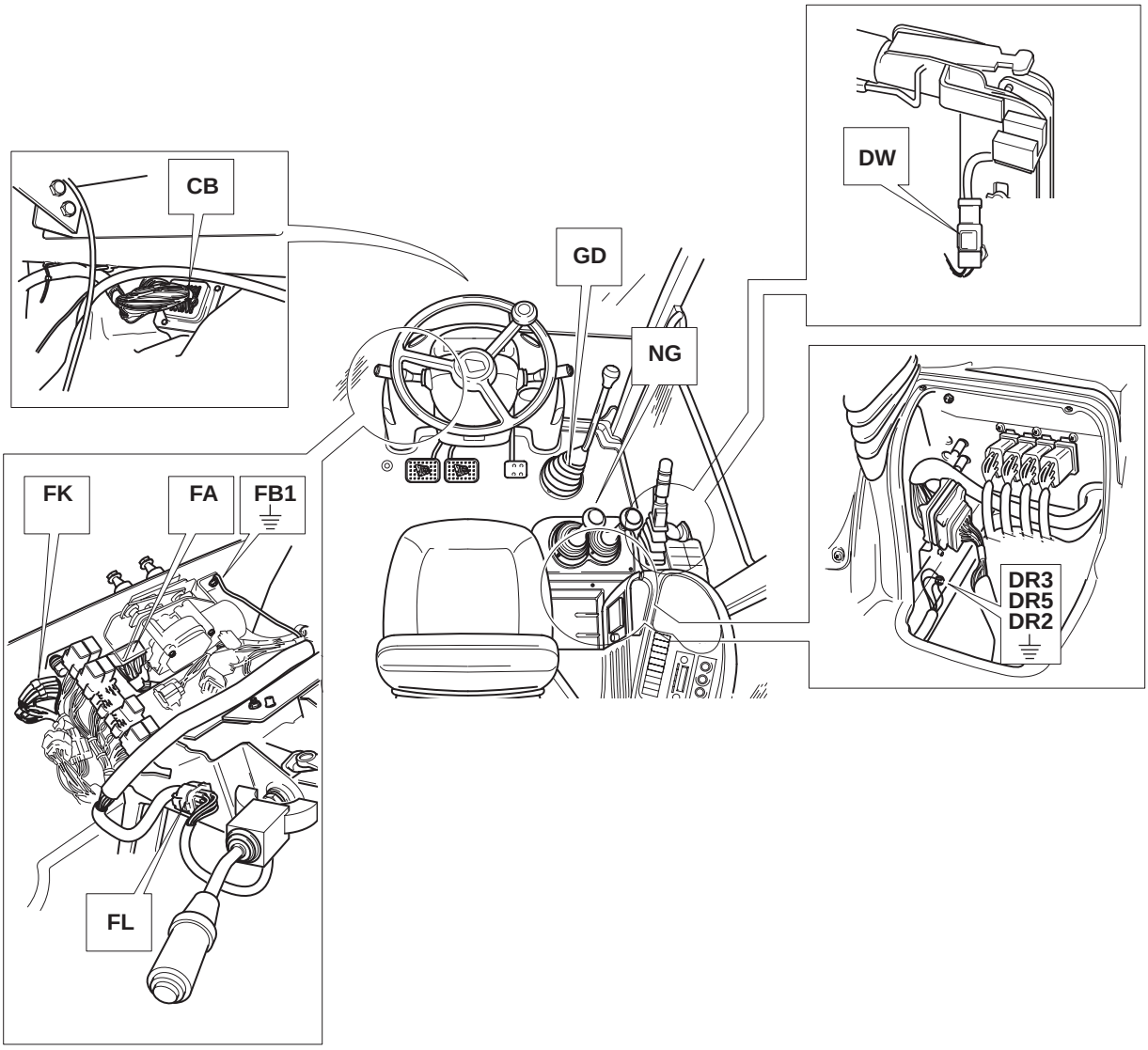


Fig 80. Electrical Connectors, Relay Actuation

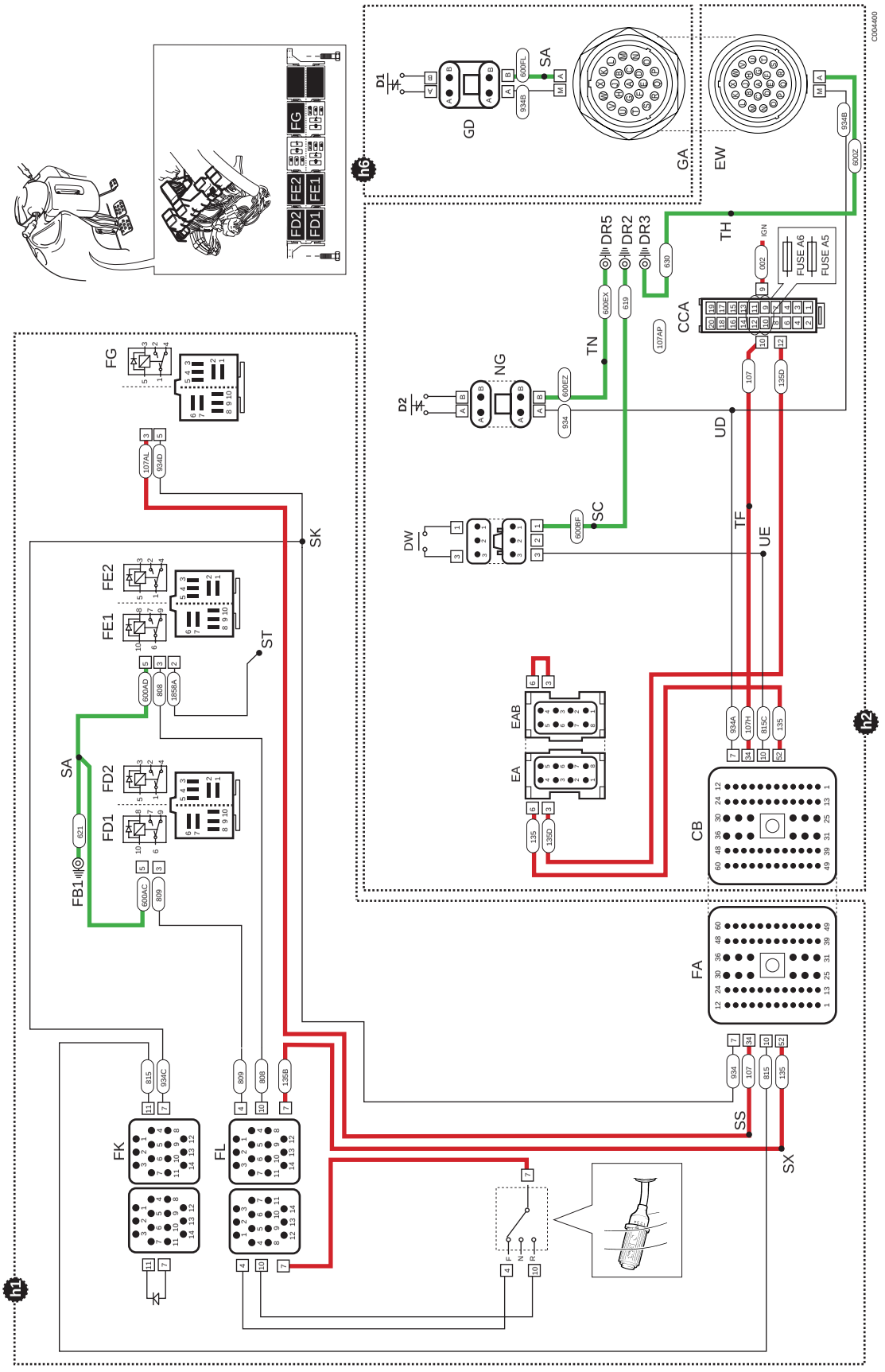


Fig 81. Relay Actuation

Solenoid Actuation

For relay activation ⇨ ***Relay Actuation (F-98)***.

Earth Points

Faults may be caused by poor earth connections. Although earth connections are shown, it must be remembered that the cab assembly is earthed via further earth strap and cable connections. For details of these connections see Section C, ***Machine Earth Connections***.

Component Key

The following key identifies the component connectors, ⇨ ***Fig 82. (F-102)*** and ⇨ ***Fig 83. (F-103)***. Note that the wires coloured green show the electrical `feed to earth' for the gearbox mounted solenoids. Live feed (wires coloured red) to the relay switches is supplied via the dump relay FG. Note that the destination for wire 107 from splice SS is shown on the relay actuation diagram ⇨ ***Fig 81. (F-100)***.

h1	Harness - Front console
h2	Harness - Cab and side console
h6	Harness - Transmission

Note: For harness drawings see Section C.

Connectors (h1)

FB1	Earth point
FD1	Forward Hi/Lo relay
FE1	Reverse Hi/Lo relay
FD2	Forward relay
FE2	Reverse relay
FG	Transmission dump relay
EW	h1 - h2
X	For wire 107 destination see Relay Actuation ⇨ ***Fig 81. (F-100)***

Connectors (h2)

CB	h2 - h1
DR3	Earth point
EW	h2 - h6

Connectors (h6)

GA	h6 - h2
GB	Gearbox solenoid F
GC	Gearbox solenoid R

Splices (h1)

SS

ST

Splices (h2)

TH

Splices (h6)

SA

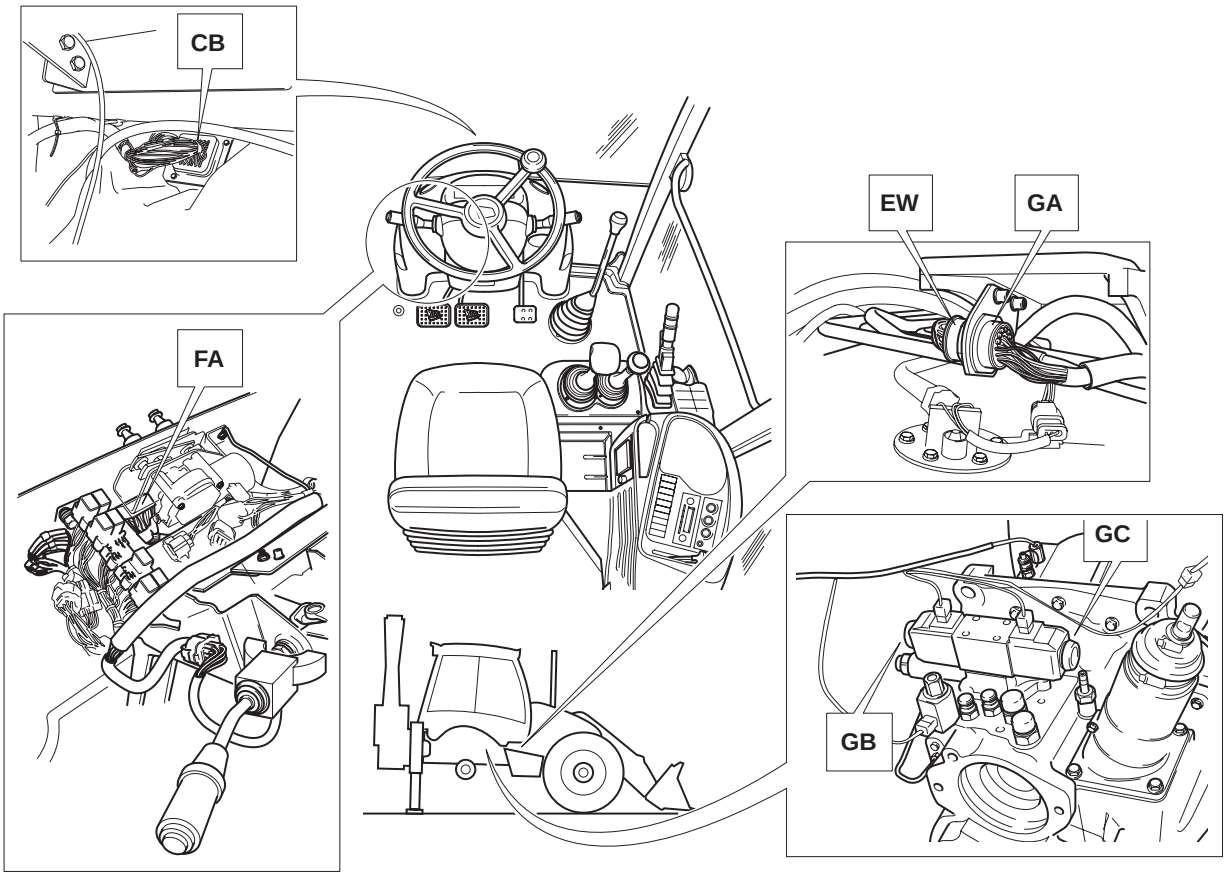


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Fig 82. Electrical Connectors, Solenoid Actuation

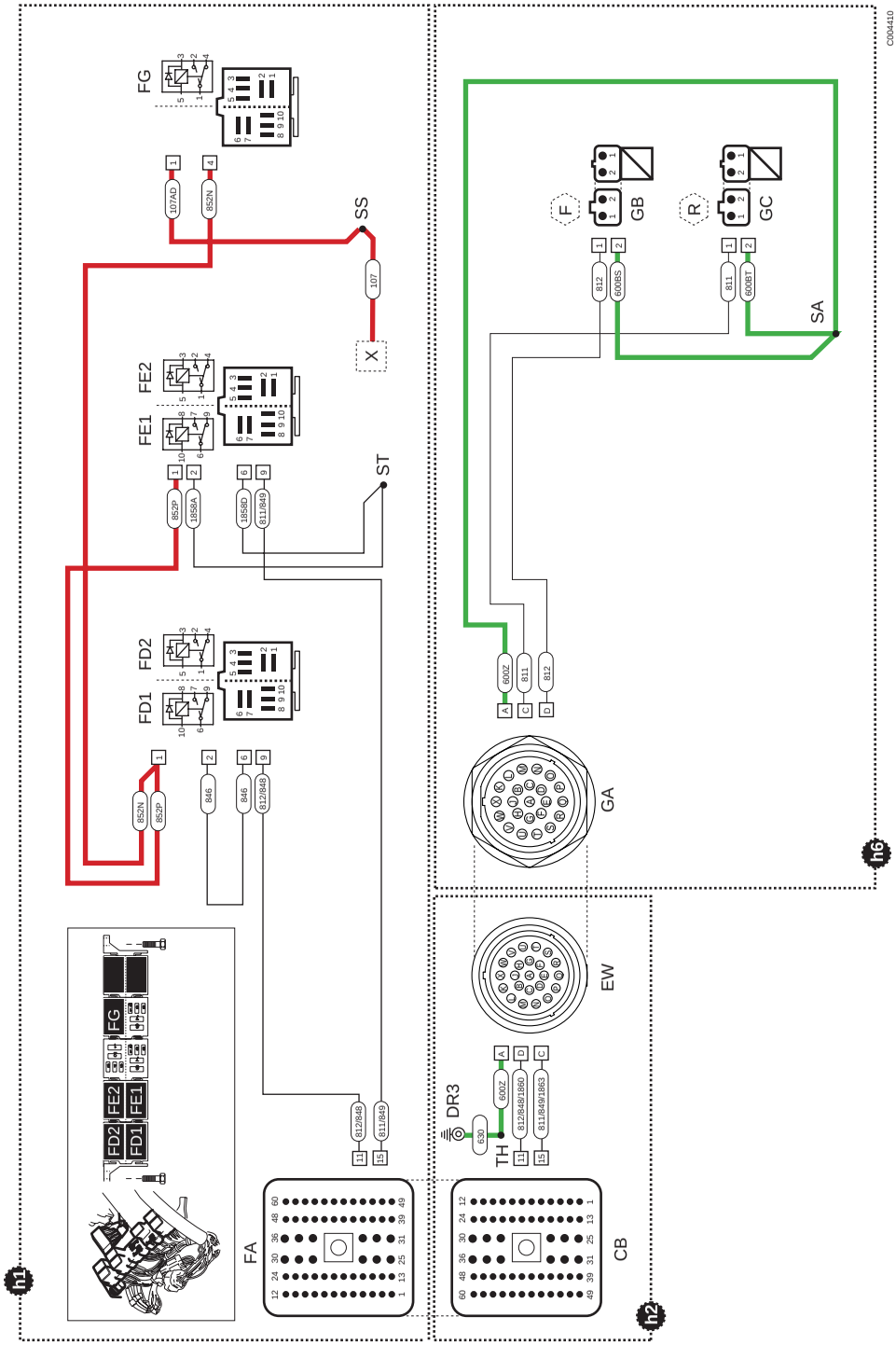

Fig 83. Solenoid Actuation

Powershift Gearbox

Introduction

Note: *This section relates to the relay controlled Powershift gearbox. For the electronically controlled variant* ***⇨ Powershift Gearbox (ShiftMaster) (F-119)****.*

This section explains how the electrical system works when the following gearbox functions are operated:

1st, 2nd, 3rd and 4th gears forward

Neutral

1st, 2nd, 3rd and 4th gears reverse

Transmission dump

Park brake switch

For relevant electrical components ***⇨ Fig 84. (F-105)***.

The 4-speed powershift gearbox is controlled using conventional relays. The relays at **A** are operated via the column mounted gear and forward/reverse lever **B**. The transmission dump switch **C** or park brake switch **D** also operate a relay at **A**. The contacts inside the relays energise the gearbox mounted solenoid control valves **E**.

Diode `gates' **F** are also used as logic switches.

To access the relays and connectors it is necessary to remove the front/steering console panel **X** and side panels **Y**, refer to Section **B** for the correct procedure.

Component Key

Item	Description
A	Relays
B	Forward, reverse lever
C	Transmission dump switch
D	Park brake switch
E	Solenoid control valves
F	Diode pack
X	Steer console panel
Y	Side console panel

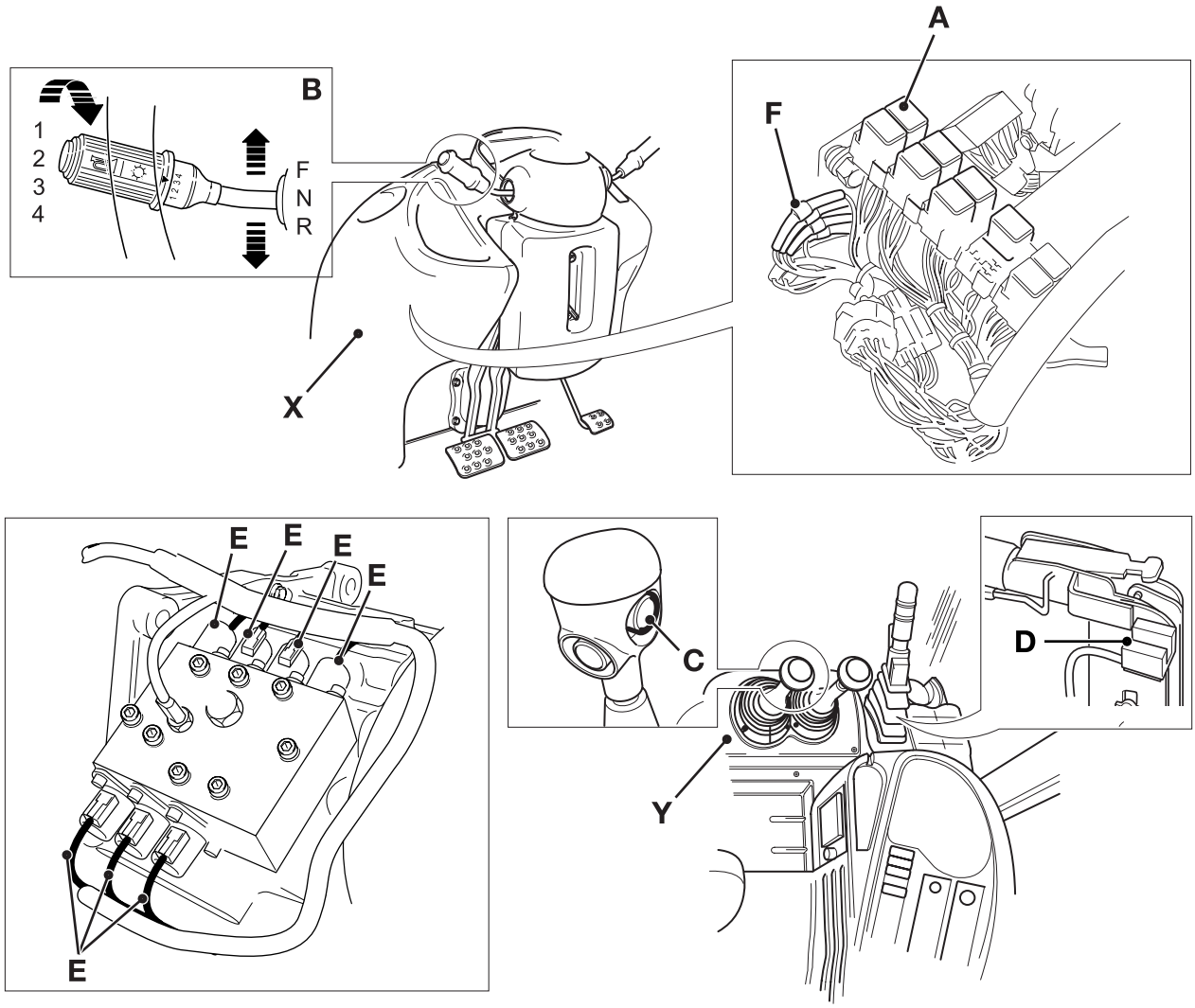

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Fig 84. Electrical Components

Quick Reference

Electrical connectors ⇨ *Fig 85. (F-107)*.

Electrical connections are shown in a tabular format as follows:

Forward Gears ⇨ *Table 29. (F-108)*.

Neutral Selected ⇨ *Table 30. (F-109)*.

Transmission Dump, Park Brake ON ⇨ *Table 31. (F-109)*

Reverse Gears ⇨ *Table 32. (F-110)*.

The tables show switch positions together with energised relay and gearbox solenoids for each gearbox function The numbers show which contacts are `live' and also relate to the actual connector pin numbers.

Electrical circuit for gearbox control. Shown with 3rd gear forward selected. `Live feed' wires are coloured red and feed to earth are green ⇨ *Fig 86. (F-111)*.

Electrical circuit for gearbox control. Shown with 3rd gear reverse selected. `Live feed' wires are coloured red and feed to earth are green ⇨ *Fig 87. (F-112)*.

When fault finding it should be remembered that the system relies on the dump switch and park brake switches functioning correctly, failure of these switches will prevent forward or reverse gears being selected. From the tables it is possible to see common relay functions which can help trace faults. For example we can see that relay FF2 is energised to engage 1st or 2nd gear. Failure of these gears to select may indicate a fault with relay FF2.

Note that a non functioning relay or solenoid may not indicate a faulty component, the associated wires and connectors may have failed. For wire and connector details see the relevant schematic.

Component Key

Item	Description
C50	Reverse alarm
DW	Park brake switch
FL	Column switch connector
FK	Diode gate connector
FG	Transmission dump relay
FD1	Forward Hi/Lo relay
FD2	Forward relay
FE1	Reverse Hi/lo relay
FE2	Reverse relay
FF1	Interlock relay
FF2	Mainshaft, layshaft relay
NG	Dump switch (Gear Lever)
Gearbox Solenoids	
S	2 and 4 wheel drive solenoid(1)
T	Forward low
U	Forward high
Y	Mainshaft
Z	Layshaft

(1) The 2 and 4WD select electrical system is not described in this section. See Section G, Brakes for explanation (4 Wheel Brake).

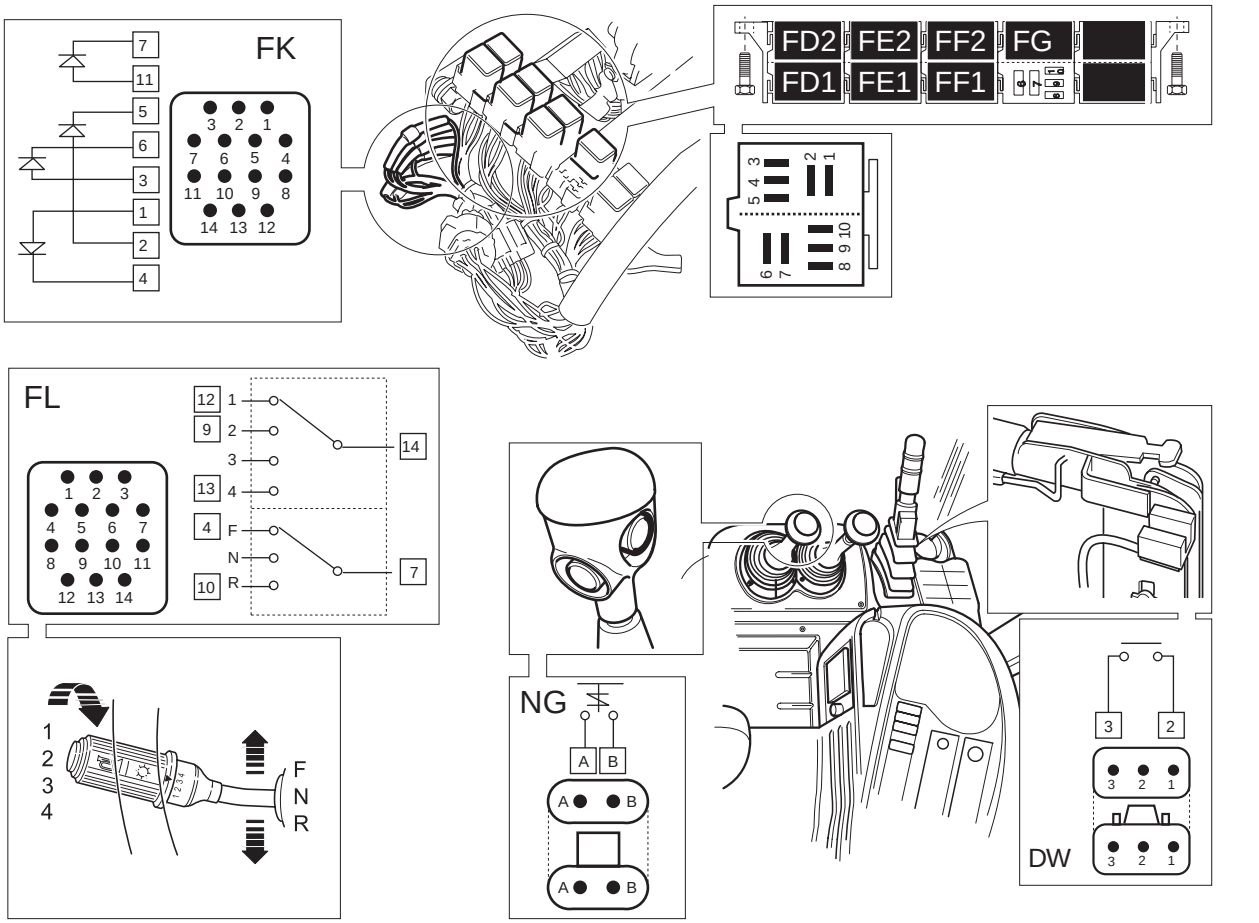

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Fig 85. Electrical Connectors

Table 29. Forward Gears

Gearbox Function	Column Switch FL	Relay FG Dump	Relay FD2 Forward	Relay FE2 Reverse	Relay FF1 Interlock	Diode Gate FK	Relay FD1 Forward Hi/ Lo	Relay FF2 Mainshaft, Layshaft	Gearbox Solenoids
1st GEAR	14-12	1-4				4	6-9	3-5, 1-2	
FORWARD	7-4		3-5, 1-2	1-4	9-6				
1F									
2nd GEAR	14-9	1-4				2-5, 1-4	8-10, 6-7	3-5, 1-2	
FORWARD	7-4		3-5, 1-2	1-4	9-6				
2F									
3rd GEAR		1-4					6-9	1-4	
FORWARD	7-4		3-5, 1-2	1-4	9-6				
3F									
4th GEAR	14-13	1-4				3-6	8-10, 6-7	1-4	
FORWARD	7-4		3-5, 1-2	1-4	9-6				
4F									

Table 30. Neutral Selected

Gearbox Function	Column Switch FL		Relay FD2 Forward	Relay FE2 Reverse				
NEUTRAL			1-4	1-4				
N								

Table 31. Transmission Dump - Park Brake ON

Gearbox Function		Relay FG Dump						
TRANSMISSION DUMP - PARK BRAKE ON		5-3, 1-2						

Table 32. Reverse Gears

Gearbox Function	Column Switch FL	Relay FG Dump	Relay FD2 Forward	Relay FE2 Reverse	Relay FF1 Interlock	Diode Gate FK	Relay FE1 Reverse Hi/ Lo	Relay FF2 Mainshaft, Layshaft	Gearbox Solenoids
1st GEAR	14-12	1-4				4	6-9	3-5, 1-2	
REVERSE	7-10		1-4	3-5, 1-2	8-10, 7-6				
1R									
2nd GEAR	14-9	1-4				2-5, 1-4	8-10, 6-7	3-5, 1-2	
REVERSE	7-10		1-4	3-5, 1-2	8-10, 7-6				
2R									
3rd GEAR		1-4					6-9	1-4	
REVERSE	7-10		1-4	3-5, 1-2	8-10, 7-6				
3R									
4th GEAR	14-13	1-4				3-6	8-10, 7-6	1-4	
REVERSE	7-10		1-4	3-5, 1-2	8-10, 7-6				
4R									

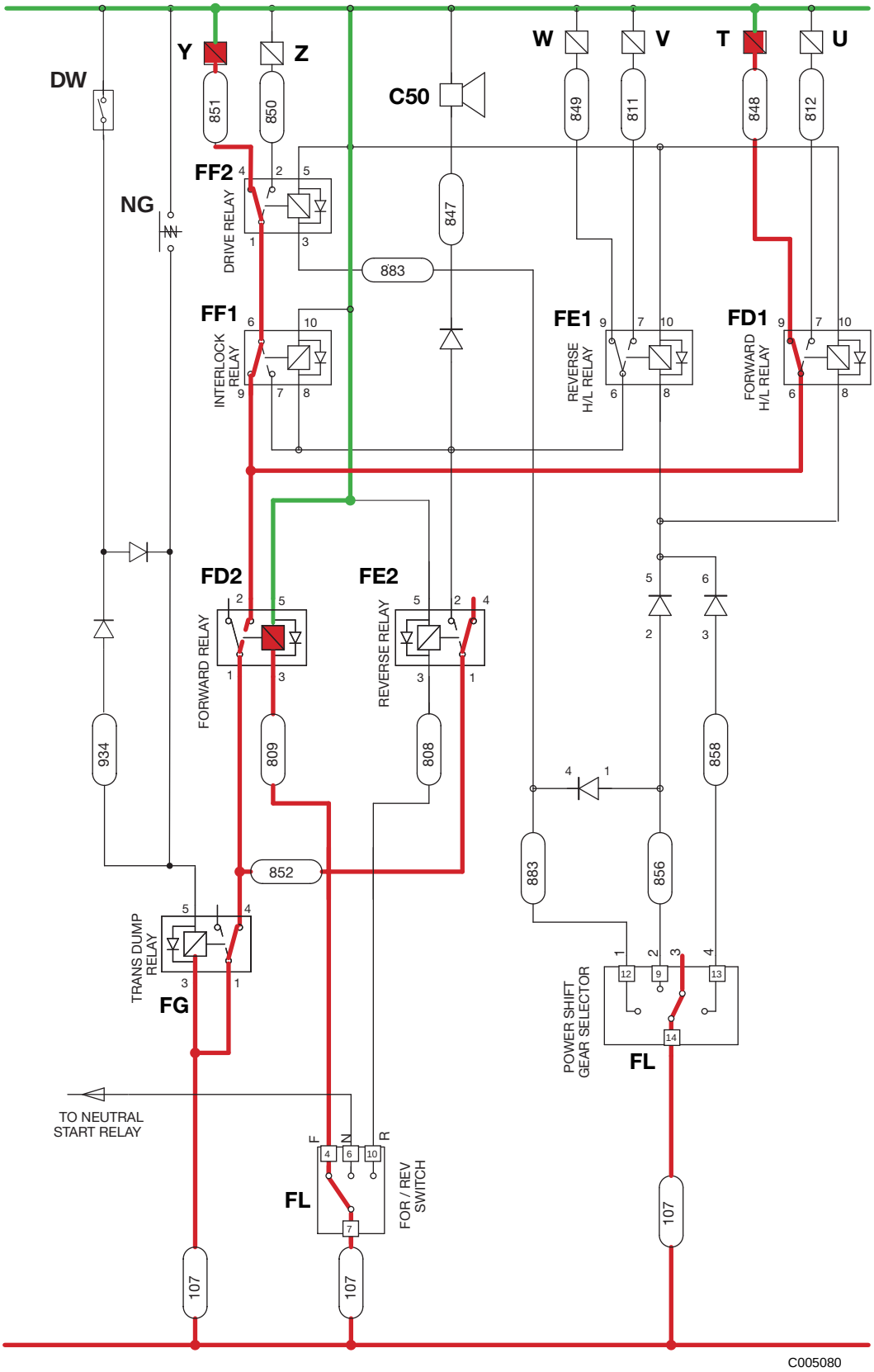

Fig 86. Electrical Schematic - 3rd Gear Forward Selected

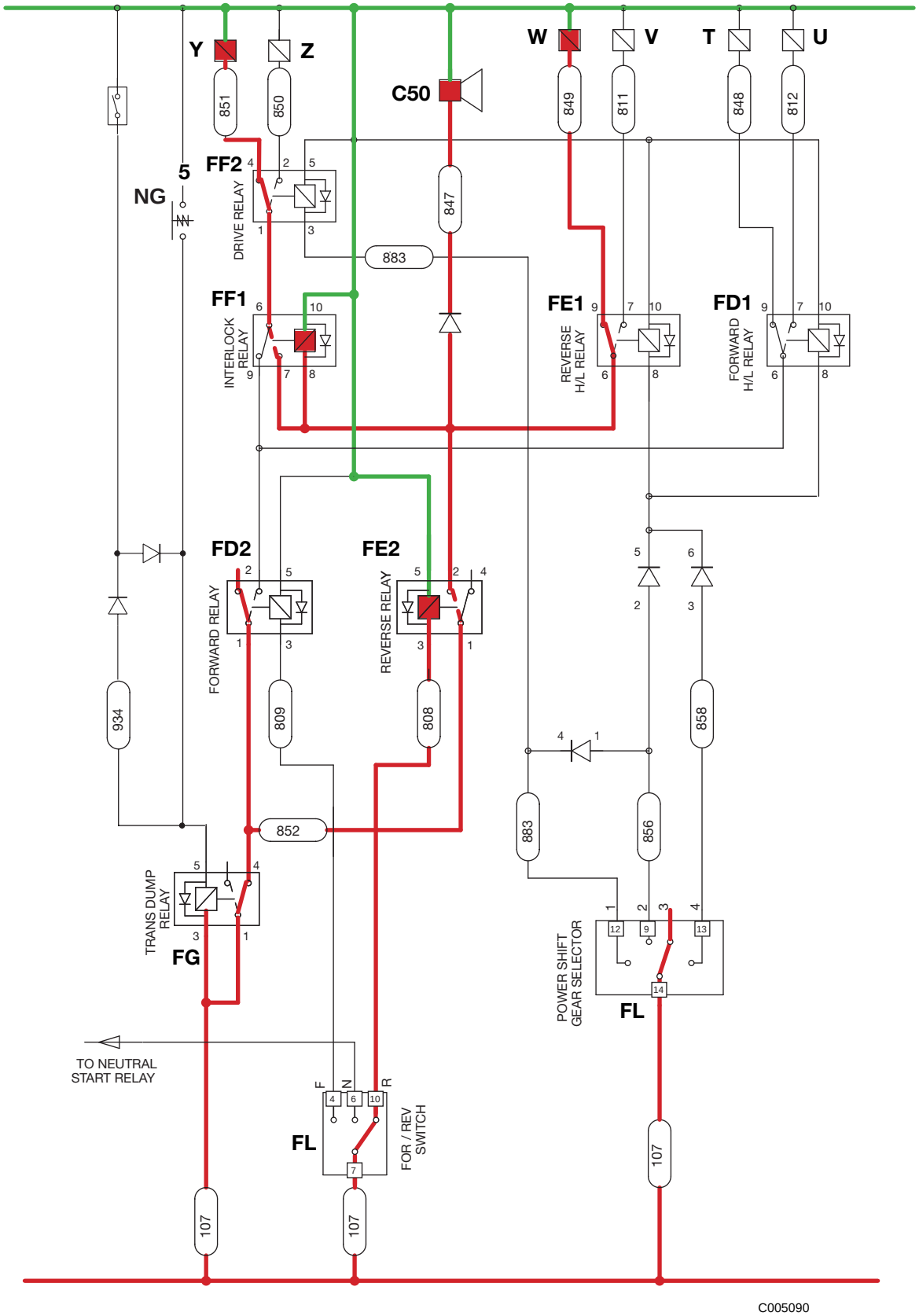

Fig 87. Electrical Schematic - 3rd Gear Reverse Selected

Wires and Connectors

Although the system is straight forward in design it is never the less fairly complex in practice. For this reason schematics are divided into 2 parts: **Relay Actuation** and Gearbox **Solenoid Actuation**.

On the electrical diagram the electrical connectors (example, FA to CB) are shown looking on the mating face of each connector when they are disconnected ⇒ *Fig 89. (F-115)*.

The wire numbers and colours, where appropriate, are shown as an aid to identification whilst fault finding.

Before fault finding make sure that you understand how the the electrical circuits work. Most potential faults can be traced using a multimeter to carry out continuity checks on wires, switches and solenoid coils. Gearbox solenoid coils can be checked for the correct resistance value as given in Technical Data. See Section C, ***Service Procedures, Electrical Testing Methods*** for more details.

Relay Actuation

For gearbox solenoid actuation ⇒ *Solenoid Actuation (F-116)*.

Earth Points

Faults may be caused by poor earth connections. Although earth connections are shown, it must be remembered that the cab assembly is earthed via further earth strap and cable connections. For details of these connections see ***Section C, Machine Earth Connections***.

Component Key

The following key identifies the component connectors, ⇒ *Fig 88. (F-114)* and ⇒ *Fig 89. (F-115)*. Note that the wires coloured red show the electrical `live feed' to the column gear lever.

h1	Harness - Front console
h2	Harness - Cab & Side console

Note: For harness drawings see Section C.

Connectors (h1)

FA	h1 - h2
FB1	Earth point
FD1	Forward high/low relay
FD2	Forward relay
FE1	Reverse high/low relay
FE2	Reverse relay
FF1	Interlock relay
FF2	Mainshaft/layshaft relay
FG	Transmission dump relay
FK	Diode gate
FL	Column gear lever

Connectors (h2)

CB	h2 - h1
CCA	Fuses
DR2, 5	Earth point
DW	Park brake switch
EA	Immobiliser
EAB	Link - immobiliser (if immobiliser is not fitted)

Splices (h1)

SA
SC
SH
SK
SL
SS
ST
SU

Splices (h2)

TF
TN
SC
UD
UE

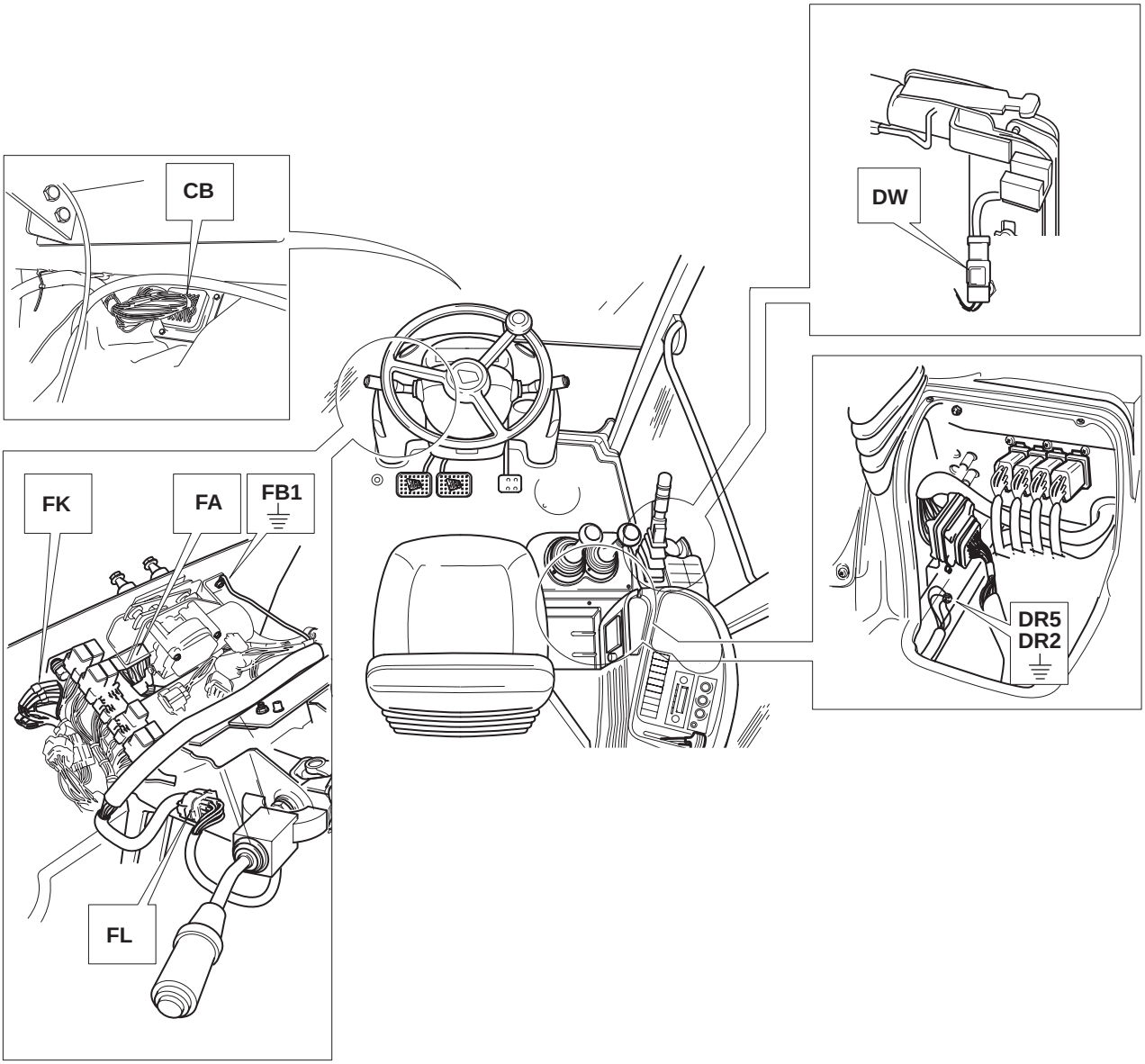

Fig 88. Electrical Connectors, Relay Actuation

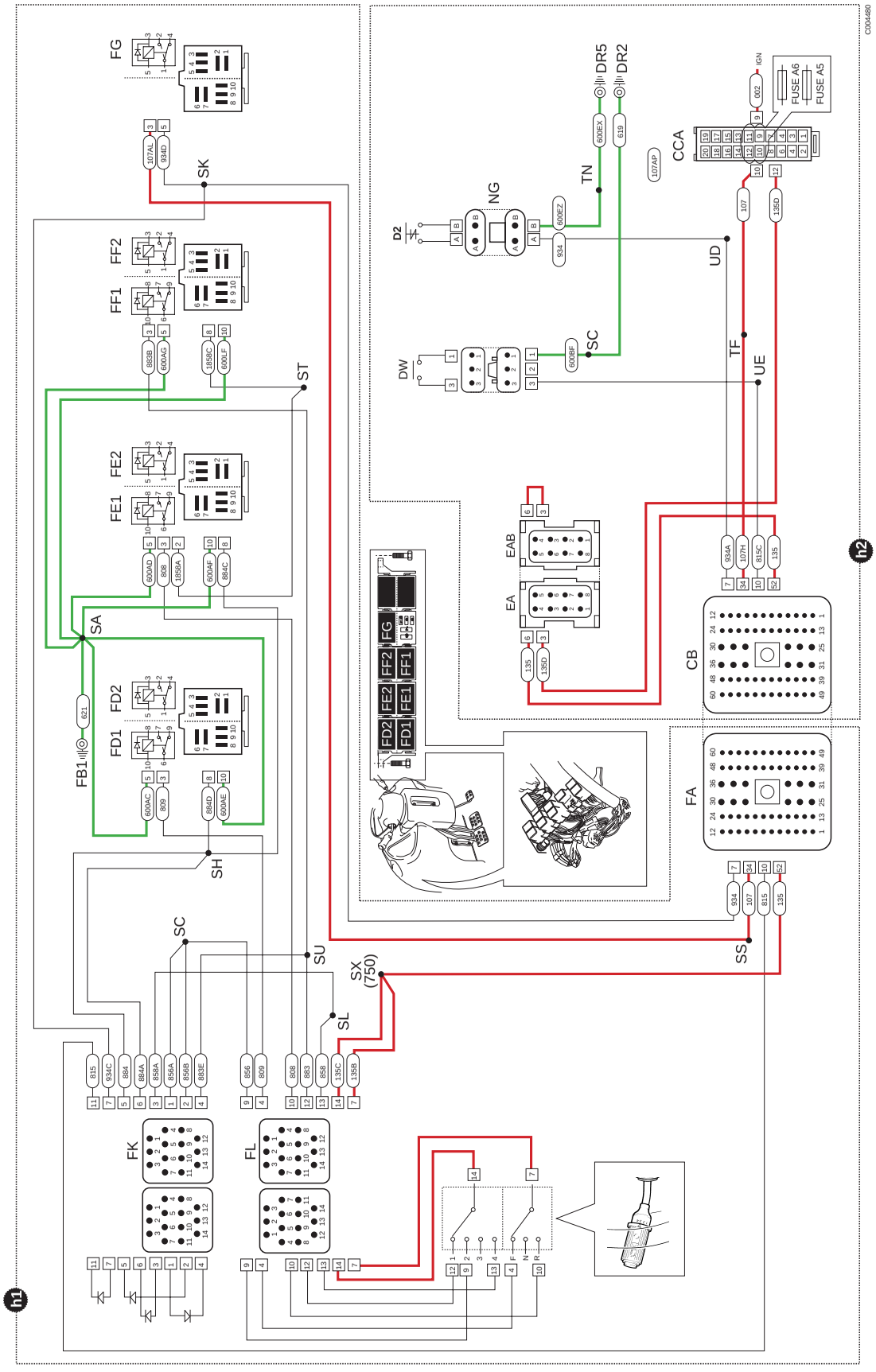

Fig 89. Relay Actuation

Solenoid Actuation

For relay activation ⇨ ***Relay Actuation (F-113)***.

Earth Points

Faults may be caused by poor earth connections. Although earth connections are shown, it must be remembered that the cab assembly is earthed via further earth strap and cable connections. For details of these connections see Section C, ***Machine Earth Connections***.

Component Key

The following key identifies the component connectors, ⇨ ***Fig 90. (F-117)*** and ⇨ ***Fig 91. (F-118)***. Note that the wires coloured green show the electrical `feed to earth' for the gearbox mounted solenoids. Live feed (wires coloured red) to the relay switches is supplied via the dump relay FG. Note that the destination for wire 107 from splice SS is shown on the relay actuation diagram, ⇨ ***Fig 89. (F-115)***.

h1	Harness - Front Console
h5	Harness - Cab and Side Console
h6	Harness - Transmission

Note: For harness drawings see Section C.

Connectors (h1)

FA	h1 - h2
FD1	Forward high/low relay
FD2	Forward relay
FE1	Reverse high/low relay
FE2	Reverse relay
FF1	Interlock relay
FF2	Mainshaft/layshaft relay
FG	Transmission dump relay
X	For wire 107 destination ⇨ ***Fig 89. (F-115)***

Connectors (h2)

CB	h2 - h1
DR3	Earth point
EW	h2 - h6

Connectors (h6)

GA	h5 - h1
GB	Gearbox solenoid U
GC	Gearbox solenoid V
GH	Gearbox solenoid T
GJ	Gearbox solenoid W
GK	Gearbox solenoid Z
GL	Gearbox solenoid Y

Splices (h1)

SS

ST

Splices (h2)

TH

Splices (h6)

TH

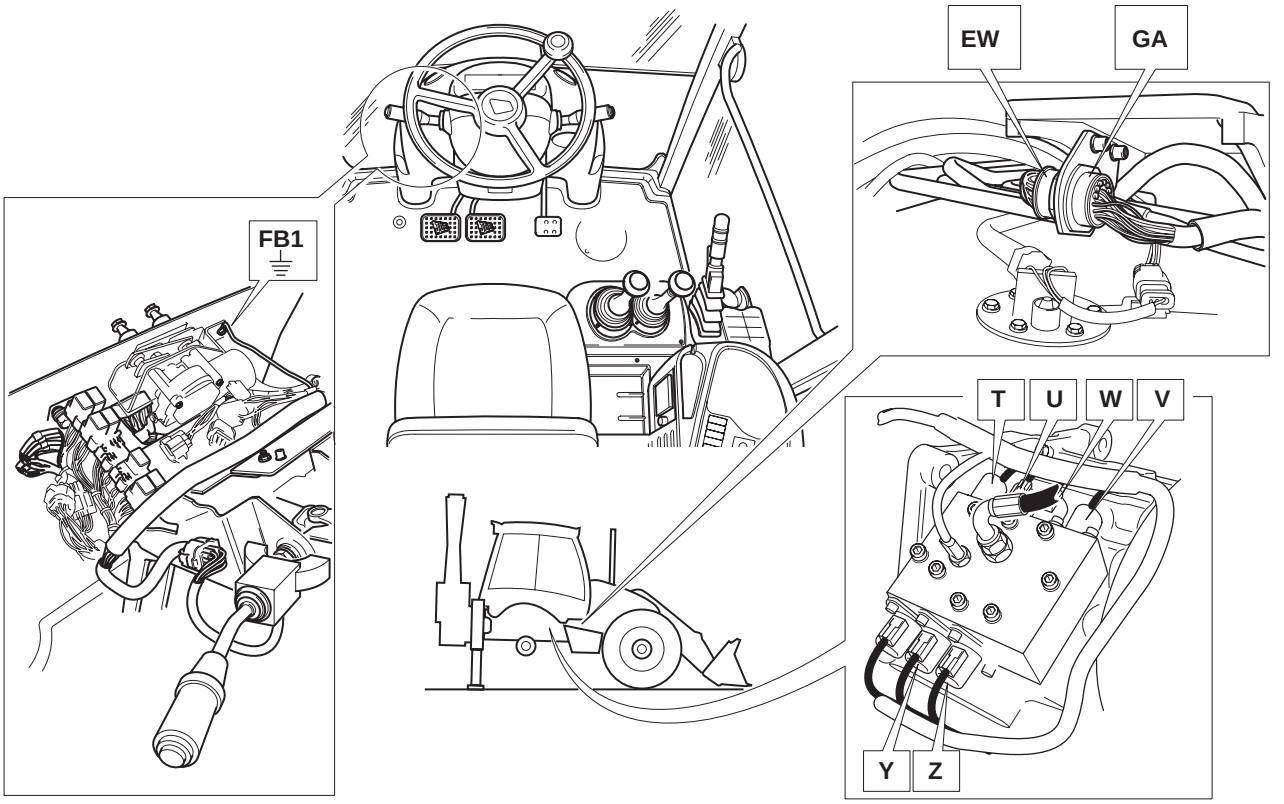

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Fig 90. Electrical Connectors, Solenoid Actuation

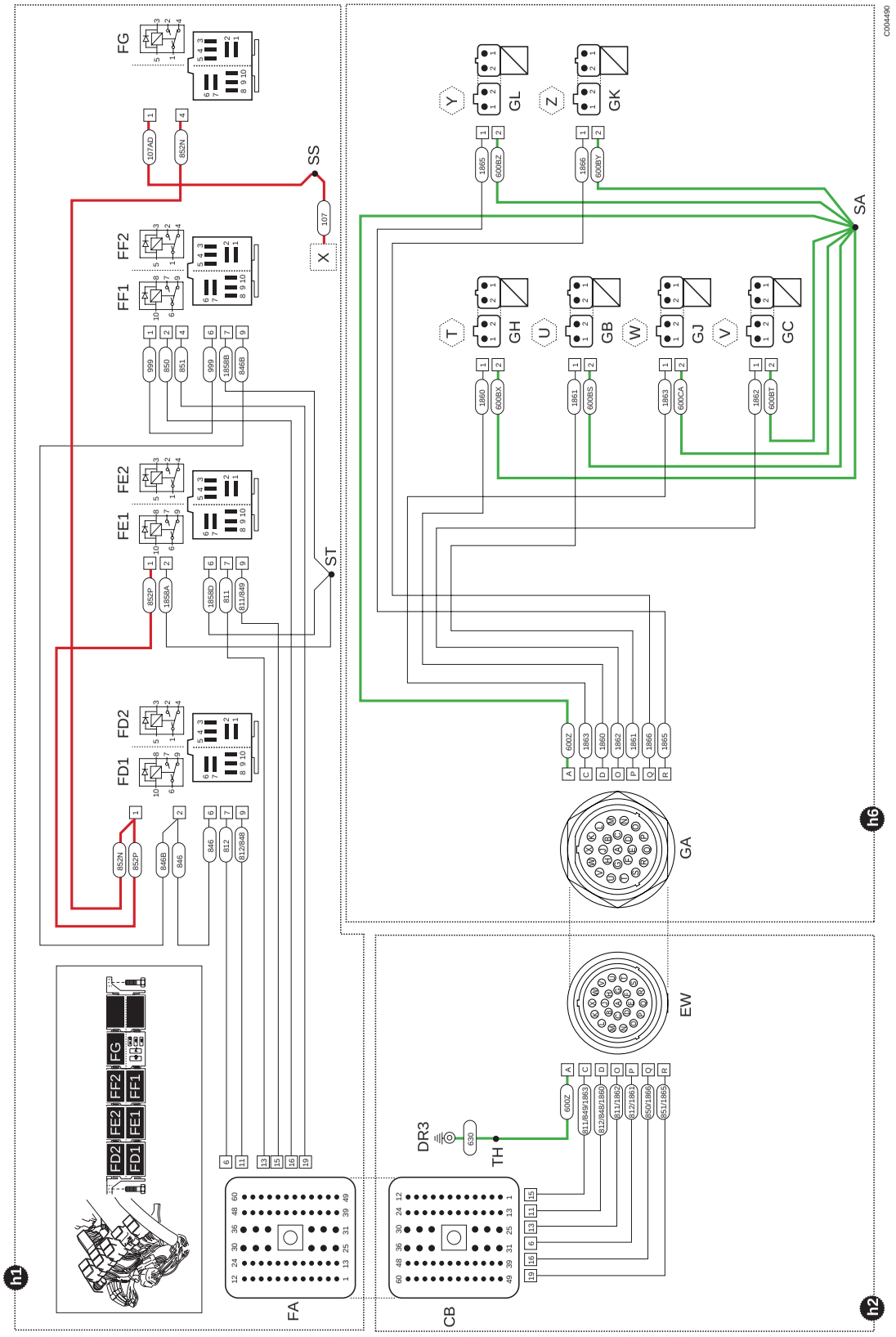

Fig 91. Solenoid Actuation

Powershift Gearbox (ShiftMaster)

Introduction

This section explains how the Powershift 4 and 6 speed ShiftMaster electrical system works.

Note: *This section does not include electrical connections for the operation of the lock up torque converter variant.* ***⇒ Lock Up Torque Converter (F-138)***

Central to the system is the ShiftMaster ECU (Electronic Control Unit) **1**. The unit receives `inputs' from electrical devices such as the gear select switch **B**. Depending on the input signals the ECU `outputs' energise electrical devices such as gearbox solenoid control valves **2**. The ECU can be connected to diagnostics software loaded on a laptop PC. The communications link is facilitated via diagnostics socket **3** ***⇒ Fig 92. (F-120)***. See also ***Powershift Gearbox - ShiftMaster Diagnostics - User Guide***.

Component Key

ECU Input Devices

B	Gear select switch
C	Forward/Neutral/Reverse select switch
D	Transmission dump switch
E	Gearbox oil temperature switch
F	Park brake switch
G	Transmission dump relay
H	Speed sensor - gearbox mounted
J	Kick down switch(1)
K	Throttle switch(1)
L	Gearbox oil pressure switch

(1) 6 speed only.

ECU Output - Activated Devices

N	In-cab warning light(1) - high gearbox oil temperature
P	In-cab warning light(1) - low gearbox oil pressure
R	In-cab master warning light and buzzer(1)
S-Z	Gearbox solenoid control valves

(1) For identification of in-cab warning lights see the machine Operator Handbook.

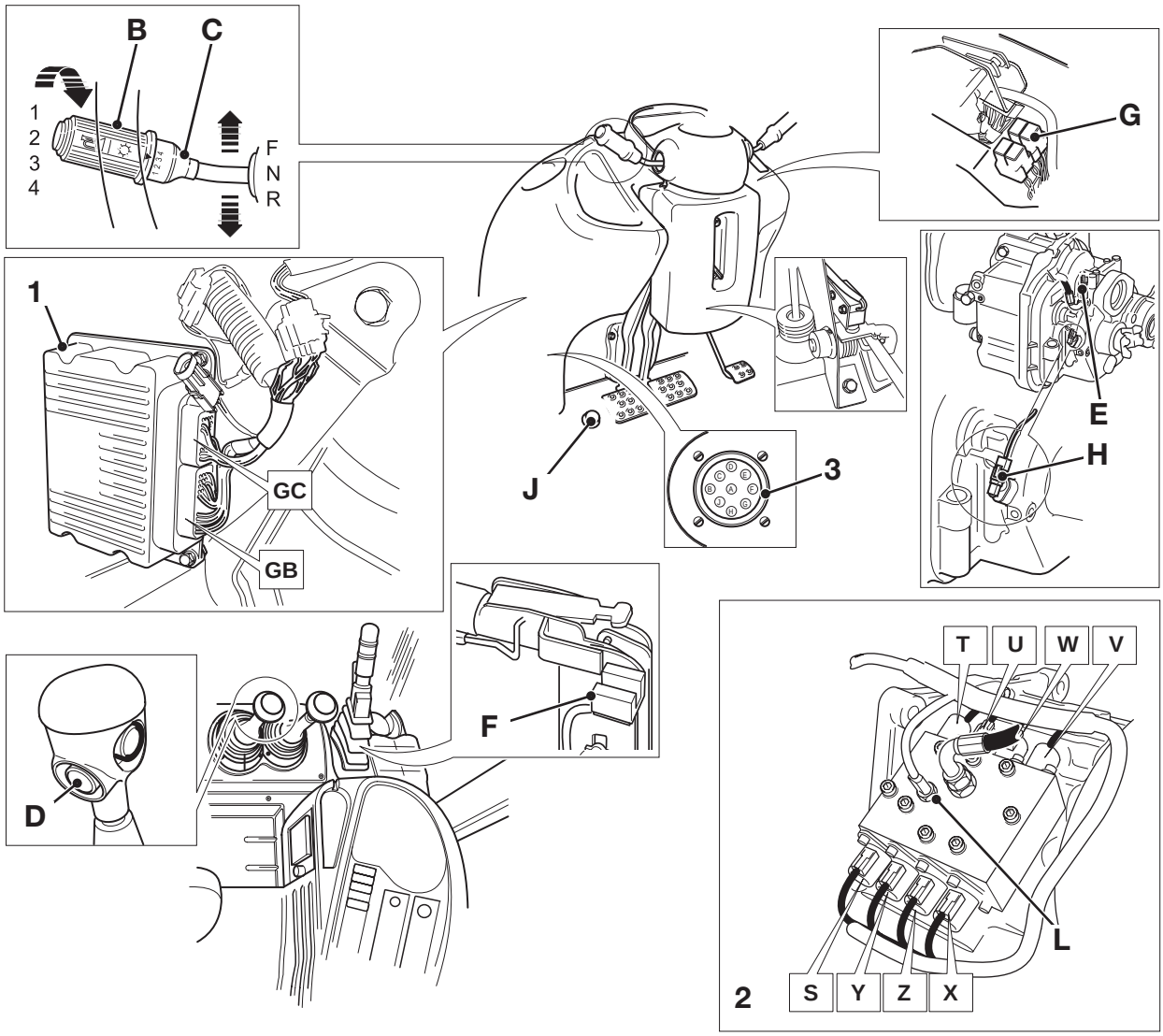

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Fig 92. Electrical Components

ECU Electrical Connections

Electrical connections at the ECU ⇒ *Fig 93. (F-122)*. Connections are divided into two groups;

GB Connections to components mounted on the gearbox

GC Connections to components mounted elsewhere on the machine.

Note: *When fault finding DO NOT use a multimeter on the ECU connector pins. Only test the associated wiring, uncouple connectors GB and GC and then use a multimeter at the pins inside these connectors as applicable. Use the ShiftMaster Diagnostics system to identify possible faults with the ECU See Powershift Gearbox - ShiftMaster Diagnostics - User Guide.*

Component Key

ECU Connector GB

GB1	Feed from GC10
GB2	12v Feed
GB4	12v Feed
GB6	Diagnostics connector
GB7	Forward switch
GB8	2nd gear switch
GB13	Warning lamp - low transmission oil pressure
GB14	Speedometer input
GB17	4th - Auto gear switch
GB18	1st gear switch
GB19	Throttle switch(1)
GB20	Foot brake switch (4WD - 4 wheel brake)(2)
GB24	Diagnostics connector
GB25	Master warning lamp
GB26	ECU Earth
GB27	3rd gear switch
GB28	Neutral switch
GB30	Parkbrake ON switch
GB36	ECU Earth
GB37	Transmission dump switch
GB38	Reverse switch
GB39	Kickdown switch(1)

ECU Connector GB

GB40	4WD switch(2)

(1) 6 speed only
(2) The 2 and 4WD select electrical system is not described in this section. See Section G, Brakes for explanation (4 Wheel Brake).

ECU Connector GC

GC3	Speed sensor - input
GC4	Output - Z solenoid
GC6	Output - U solenoid
GC10	Feed to GB1
GC11	Switch Low transmission oil pressure
GC12	Output - X solenoid
GC13	ECU Earth
GC15	Output - Y solenoid
GC18	Output - S 4WD(2)
GC20	Output - V solenoid
GC21	Switch - transmission oil temperature
GC23	Output - W solenoid
GC24	Output - T solenoid

ECU Input Devices

B	Gear select switch
C	Forward/Neutral/Reverse select switch
D	Transmission dump switch
E	Gearbox oil temperature switch
F	Park brake switch
H	Speed sensor - gearbox mounted
J	Kick down switch(1)
K	Throttle switch (1)
L	Gearbox oil pressure switch

ECU Output - Activated Devices

P	In-cab warning light- low gearbox oil pressure
R	In-cab master warning light and buzzer
S-Z	Gearbox solenoid control valves

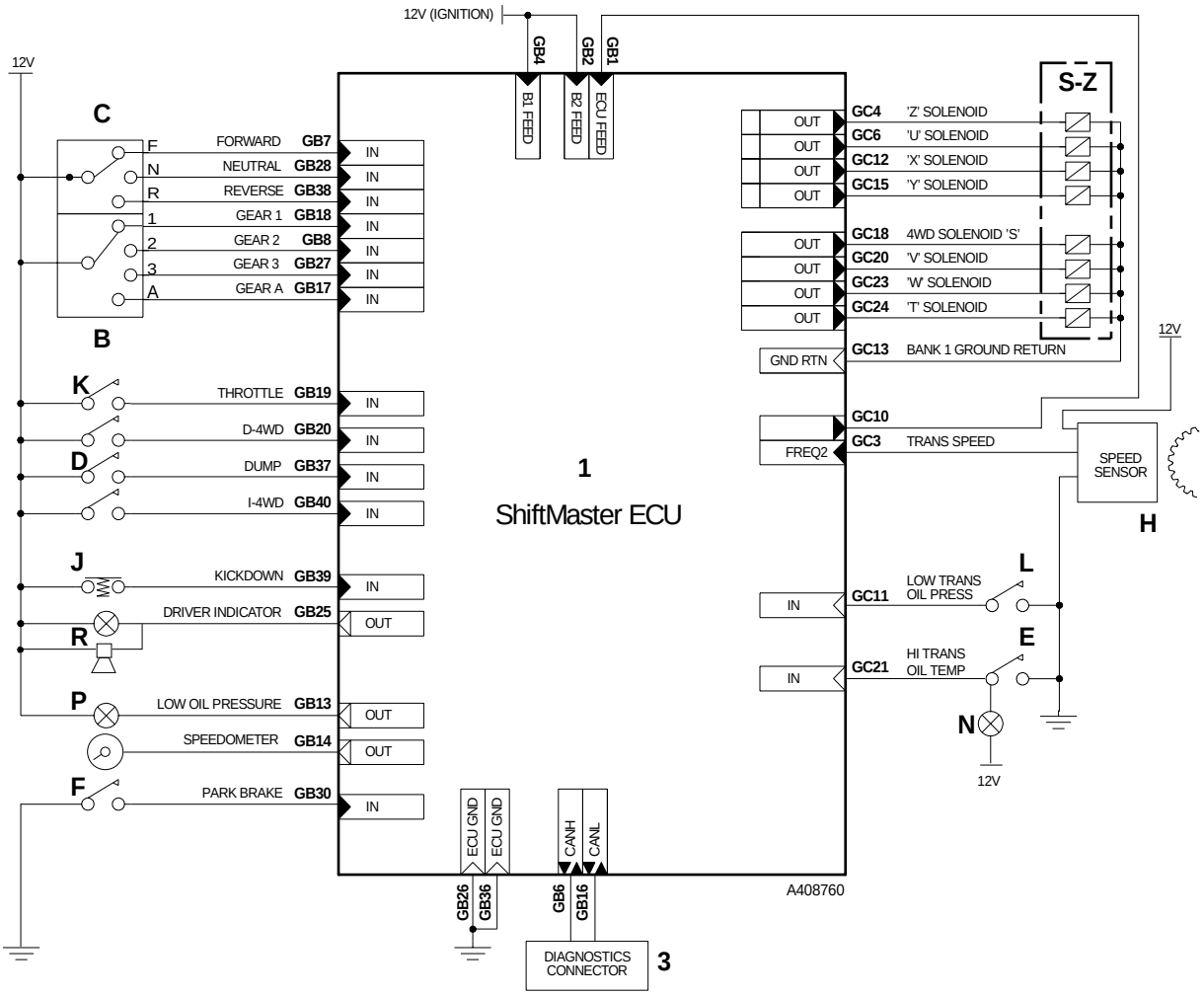

Fig 93. ECU Connections

Quick Reference

Electrical connectors ⇒ *Fig 94. (F-124)*

Electrical connections are shown in tabular format as follows:

E.C.U. feeds and earths ⇒ *Table 33. (F-125)*.

Transmission Dump ⇒ *Table 34. (F-125)*.

Park Brake ON ⇒ *Table 35. (F-125)*.

1, 2, 3, 4 Forward (4 Speed) ⇒ *Table 36. (F-126)*.

1, 2, 3, Forward (6 Speed) ⇒ *Table 37. (F-127)*.

4(A), 5(A), 6(A) Forward (6 Speed) ⇒ *Table 38. (F-128)*

Neutral ⇒ *Table 39. (F-128)*

1, 2, 3, 4 Reverse ⇒ *Table 40. (F-129)*.

Electrical circuit for the gearbox control. Shown with neutral selected and the park brake ON. `Live feed' wires are coloured red and feed to earth are green ⇒ *Fig 95. (F-130)*.

Electrical circuit for the gearbox control. Shown with 1st gear reverse selected. `Live feed' wires are coloured red and feed to earth are green ⇒ *Fig 96. (F-131)*.

The information is intended as an aid when checking for faulty wires or connectors by means of continuity tests using a multimeter. DO NOT use a multimeter on the ECU connector pins (connectors A and B). Only test the associated wiring, uncouple connectors **GB** and **GC** and then use a multimeter at the pins inside these connectors as applicable. Use the ShiftMaster Diagnostics system to identify possible faults with the ECU. See ***Powershift Gearbox - ShiftMaster Diagnostics - User Guide***.

Note: *Interconnecting harness connectors are not shown here. For full details see the relevant expanded harness schematic in this section.*

Note: *Identify dump relay FG1 by locating wire 1873 at pin 2 of the corresponding relay base.*

Component Key

A	Gearbox solenoids
C50	Reverse alarm
CM	Park brake warning light relay
DW	Park brake switch
FL	Column switch
FG1	Transmission dump relay
FG2	Reverse alarm relay
GB	Harness connector - ECU - A
GC	Harness connector - ECU - B
GG	Throttle switch(1)
LE	Kick down switch(1)
NG	Transmission dump switch

(1) 6 speed only

ECU Connector GB

GB1	Feed from GC10
GB2	12v Feed
GB4	12v Feed
GB6	Diagnostics connector
GB7	Forward switch
GB8	2nd gear switch
GB13	Warning lamp - low transmission oil pressure
GB14	Speedometer input
GB17	4th - Auto gear switch
GB18	1st gear switch
GB19	Throttle switch
GB20	Foot brake switch (4WD - 4 wheel brake)
GB24	Diagnostics connector
GB25	Master warning lamp
GB26	ECU Earth
GB27	3rd gear switch
GB28	Neutral switch
GB30	Parkbrake ON switch
GB36	ECU Earth
GB37	Transmission dump switch
GB38	Reverse switch

ECU Connector GB

GB39 Kickdown switch

GB40 4WD switch

ECU Connector GC

GC3 Speed sensor - input

GC4 Output - Z solenoid

GC6 Output - U solenoid

GC10 Feed to GB1

GC11 Switch Low transmission oil pressure

ECU Connector GC

GC12 Output - X solenoid

GC13 ECU Earth

GC15 Output - Y solenoid

GC18 Output - S 4WD

GC20 Output - V solenoid

GC21 Switch - transmission oil temperature

GC23 Output - W solenoid

GC24 Output - T solenoid

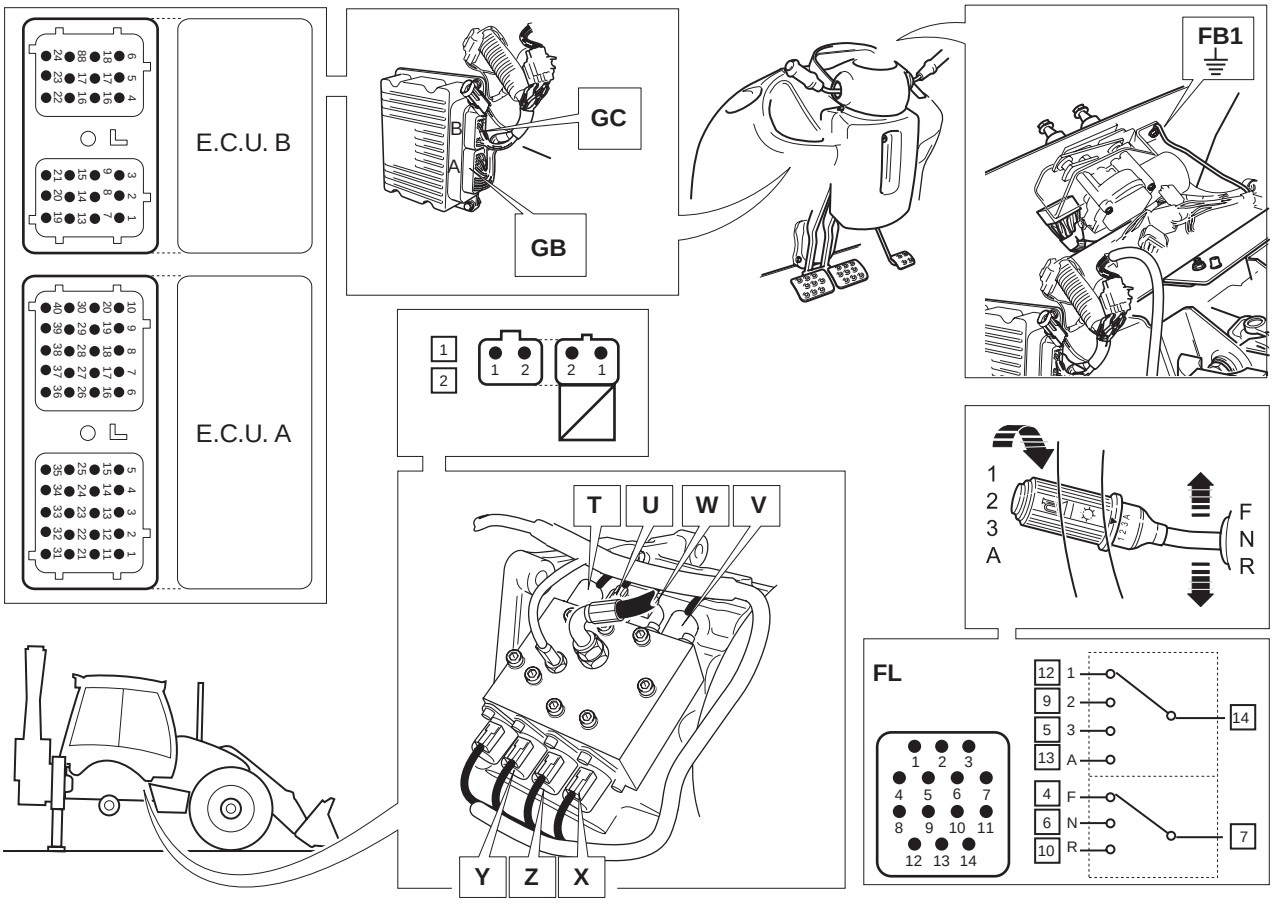

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Fig 94. Electrical Connectors

Table 33. ECU Feeds and Earths

ECU Power Supply and Earths	Fuse	ECU Connector GB	ECU Connector GC	Earth Point
POWER FEED I	A5	4		
POWER FEED II	A7	2		
EARTH I		26		FB 1
EARTH II		36		FB 1
EARTH III			13	FB 1

Table 34. Transmission Dump

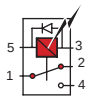
Gearbox Function	Dump Switch NG	Relay FG1	E.C.U. GB
TRANSMISSION DUMP	+A, B (DR5)	3-5, 1-2	37
			

Table 35. Park Brake ON

Gearbox Function	Park Brake Switch DW	E.C.U. GB
PARK BRAKE ON	+1, 3 (DR2)	30

Table 36. 1, 2, 3, 4 Forward (4 Speed)

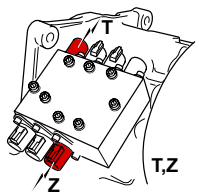
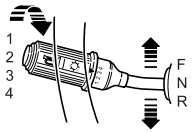
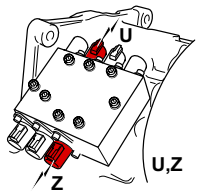
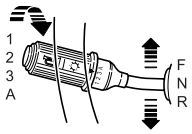
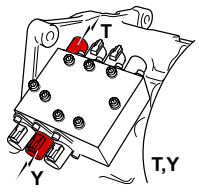
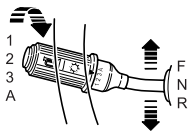
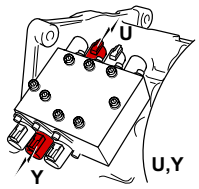
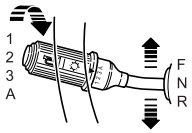
Gearbox Function	Column Switch FL	E.C.U. GB (Inputs)	E.C.U. GC (Outputs)	Solenoid Connectors	Gearbox Solenoid
1st GEAR	14-12	38	24(T), 4(Z)	+1, 2 ⊣⊪(DR3)	
FORWARD	7-4	7			
1F					
2nd GEAR	14-9	8	6(U), 4(Z)	+1, 2 ⊣⊪(DR3)	
FORWARD	7-4	7			
2F					
3rd GEAR	14-5	27	24(T), 15(Y)	+1, 2 ⊣⊪(DR3)	
FORWARD	7-4	7			
3F					
4th GEAR	14-13	17	6(U), 15(Y)	+1, 2 ⊣⊪(DR3)	
FORWARD	7-4	7			
4F					

Table 37. 1, 2, 3 Forward (6 Speed)

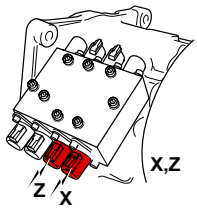
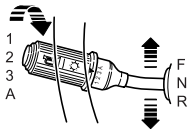
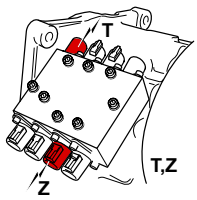
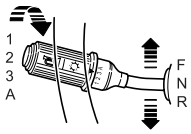
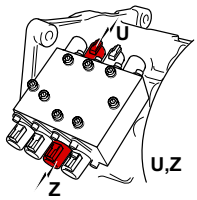
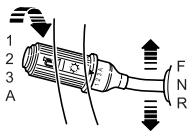
Gearbox Function	Column Switch FL	E.C.U. GB (Inputs)	E.C.U. GC (Outputs)	Solenoid Connectors	Gearbox Solenoids
1st GEAR	14-12	18	4(Z), 12(X)	+1, 2 (DR3)	
FORWARD	7-4	7			
1F					
2nd GEAR	14-9	8	4(Z), 24(T)	+1, 2 (DR3)	
FORWARD	7-4	7			
2F					
3rd GEAR	14-5	27	4(Z), 6(U)	+1, 2 (DR3)	
FORWARD	7-4	7			
3F					

Table 38. 4(A), 5(A), 6(A) Forward (6 Speed)

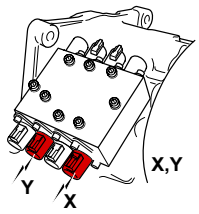
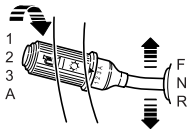
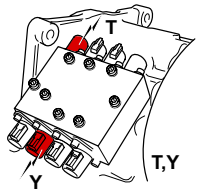
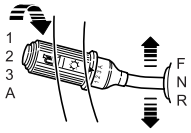
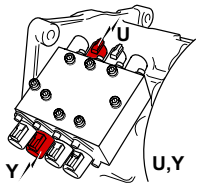
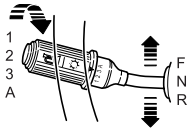
Gearbox Function	Column Switch FL	E.C.U. GB (Inputs)	E.C.U. GC (Outputs)	Solenoid Connectors	Gearbox Solenoids
4th GEAR (A)	14-13	17	15(Y), 12(X)	+1, 2 (DR3)	
FORWARD	7-4	7			
A					
5th GEAR (A)	14-13	17	15(Y), 24(T)	+1, 2 (DR3)	
FORWARD	7-4	7			
A					
6th GEAR (A)	14-13	17	15(Y), 6(U)	+1, 2 (DR3)	
FORWARD	7-4	7			
A					

Table 39. Neutral

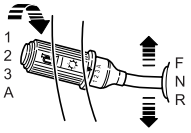
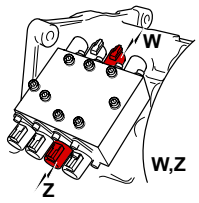
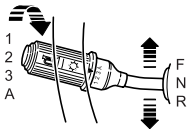
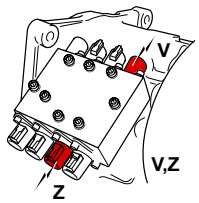
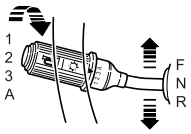
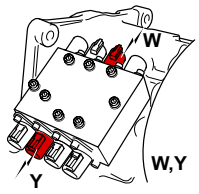
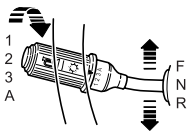
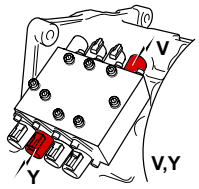
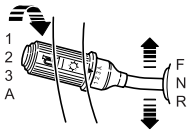
Gearbox Function	Column Switch FL	E.C.U. GB
NEUTRAL	7-6	28
N		

Table 40. 1, 2, 3, 4 Reverse

Gearbox Function	Column Switch FL	E.C.U. GB (Inputs)	E.C.U. GC (Outputs)	Solenoid Connectors	Gearbox Solenoid
1st GEAR	14-12	18	4(Z), 23(W)	+1, 2 ⊣⊪(DR3)	
REVERSE	7-10	38			
1R					
2nd GEAR	14-9	8	4(Z), 20(V)	+1, 2 ⊣⊪(DR3)	
REVERSE	7-10	38			
2R					
3rd GEAR	14-5	27	15(Y), 23(W)	+1, 2 ⊣⊪(DR3)	
REVERSE	7-10	38			
3R					
4th GEAR	14-13	17	15(Y), 20(V)	+1, 2 ⊣⊪(DR3)	
REVERSE	7-10	38			
4R(A)					

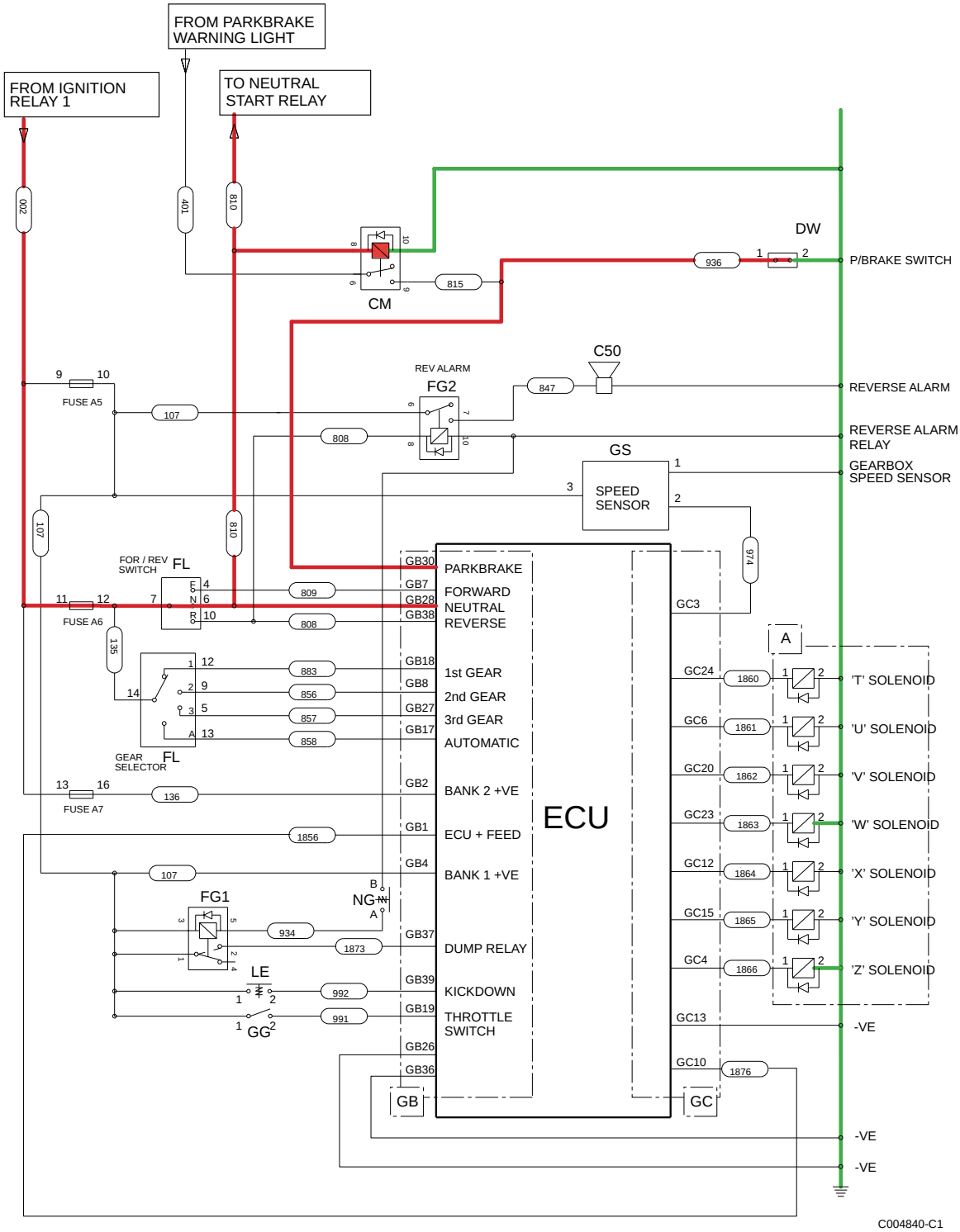


Fig 95. Electrical Schematic, Neutral Selected - Park Brake ON.

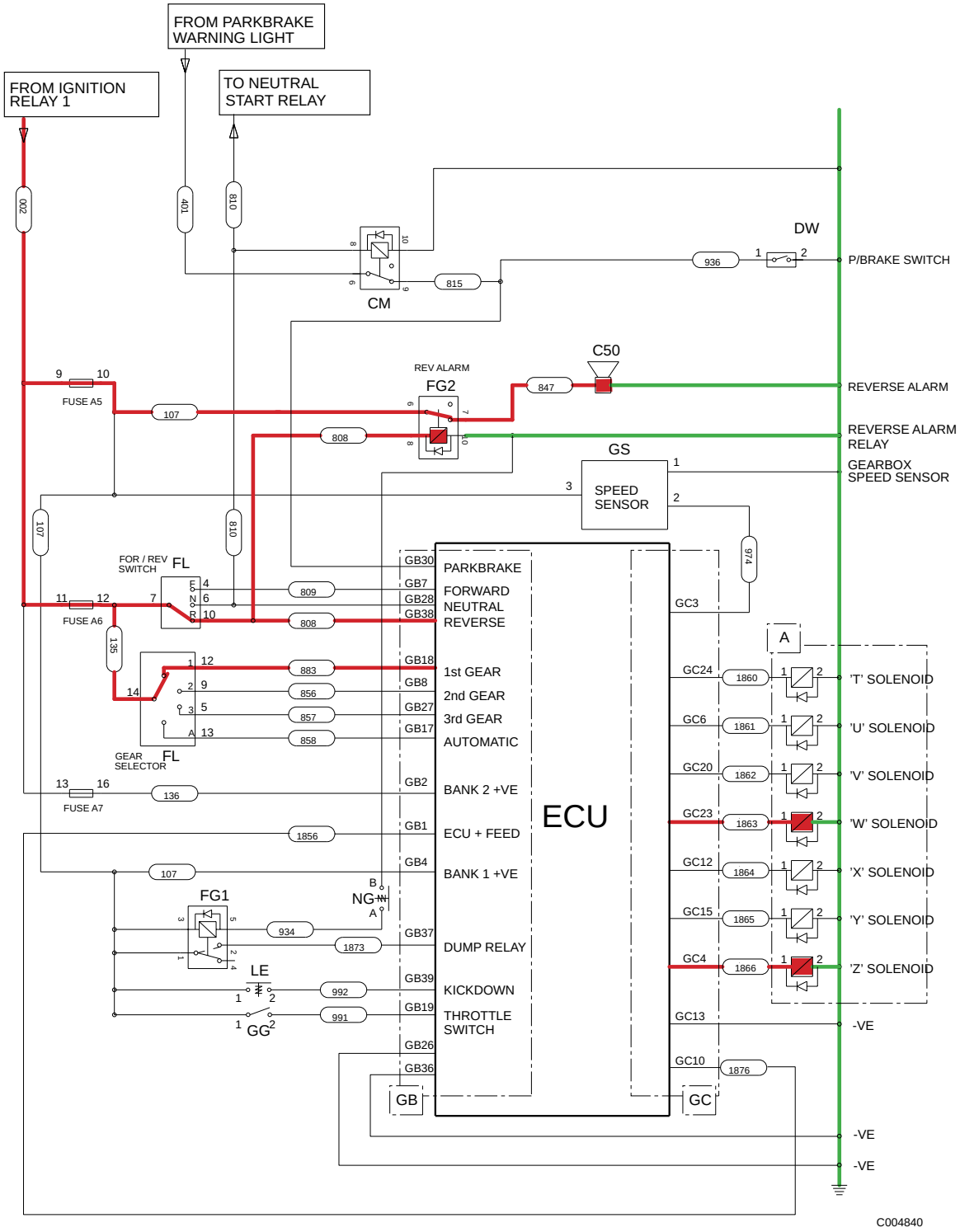


Fig 96. Electrical Schematic - 1st Gear Reverse Selected.

Wires and Connectors

Schematics are divided into 2 parts: **Input Controls** and gearbox **Solenoid Actuation**.

On the electrical diagrams the electrical connectors (example, FA to CB) are shown looking on the mating face of each connector when they are disconnected ⇒ *Fig 98. (F-134)*. The wire numbers and colours, where appropriate, are shown as an aid to identification whilst fault finding.

Before fault finding make sure that you understand how the the electrical circuits work. The most effective method of fault finding is by means of ShiftMaster Diagnostics software and a laptop PC, see ***Service Procedures, Powershift Gearbox- ShiftMaster Diagnostics - User Guide***. Having identified a faulty system, use the schematics to identify the relevant wires and connectors, continuity checks can then be carried out using a multimeter. Gearbox solenoid coils can be checked for the correct resistance value as given in ***Technical Data***. See Section C - ***Service Procedures***, for more details.

Input Controls

For gearbox solenoid actuation ⇒ *Solenoid Actuation (F-135)*.

Earth Points

Faults may be caused by poor earth connections. Although earth connections are shown, it must be remembered that the cab assembly is earthed via further earth strap and cable connections. For details of these connections see Section C, ***Machine Earth Connections***.

Component Key

The following key identifies the component connectors, ⇒ *Fig 97. (F-133)* and ⇒ *Fig 98. (F-134)*. Note that the wires coloured red show the electrical `live feed' to the column gear lever and gearbox E.C.U.

h1 Harness - Front console

h2 Harness - Cab & Side console

h6 Harness - Transmission

Note: For harness drawings see Section C.

Connectors (h1)

FA h1 - h2

FB1 Earth point

FG Transmission dump relay

Note: Identify dump relay FG by locating wire 1873 at pin 2 of the corresponding relay base.

FL Column gear lever

GB E.C.U. connector A

GC E.C.U. connector B

GG Throttle switch(1)

Connectors (h2)

CB h2 - h1

CCA Fuses

DR2 Earth point

DW Park brake switch

EA Immobiliser

EAB Link - immobiliser (if immobiliser is not fitted)

NG Transmission dump switch (Loader lever)

Connectors (h6)

GA h6 - h2

GD Kick-down switch(1)

GS Speed sensor

Splices (h1)

SA **SJ**

SC **SL**

SF **SS**

Splices (h2)

SC **TH**

TF **UD**

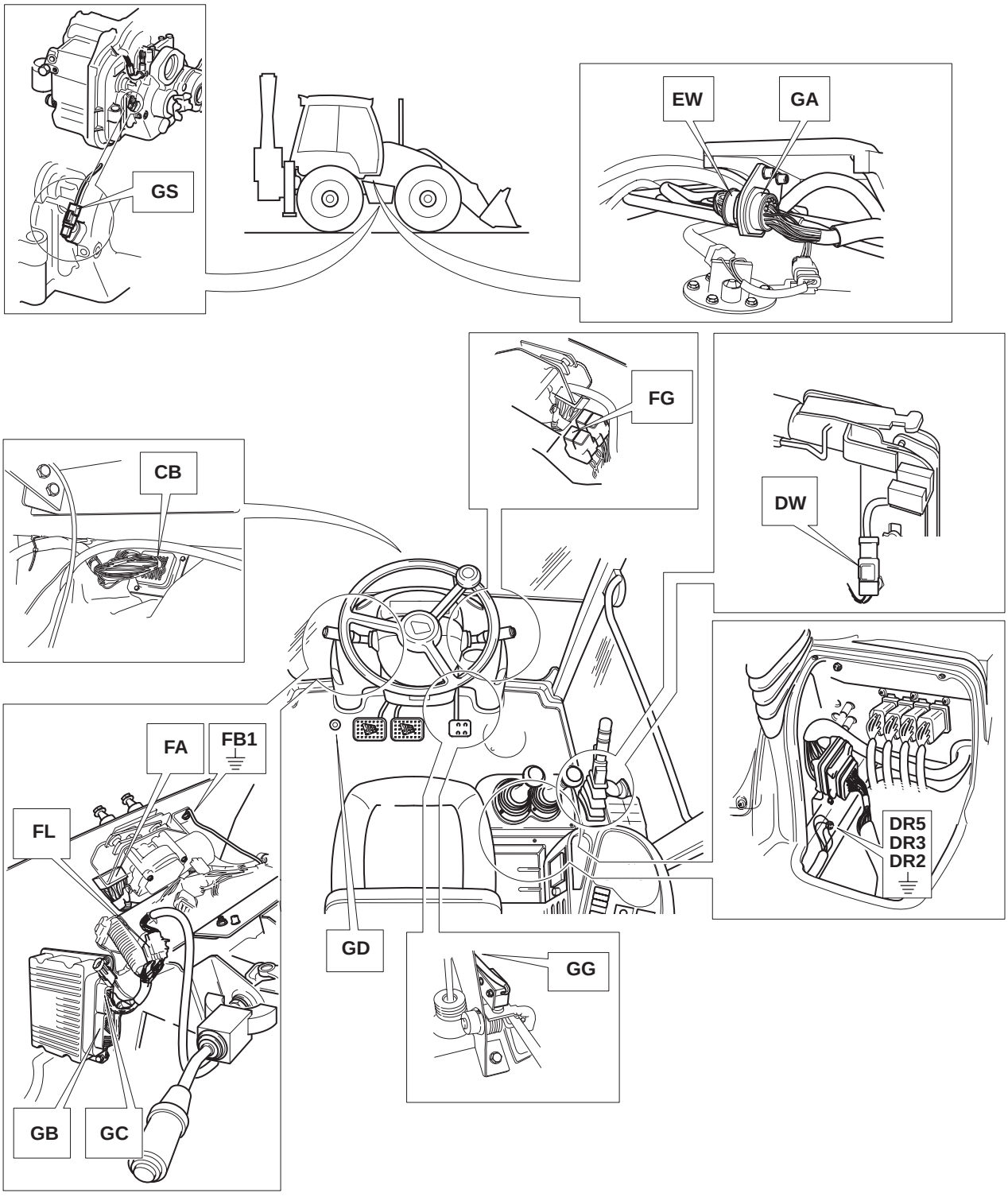
TN **UE**

TN

Splices (h5)

SA **SB**

(1) 6 speed only



C006140-C1

Fig 97. Electrical Connectors

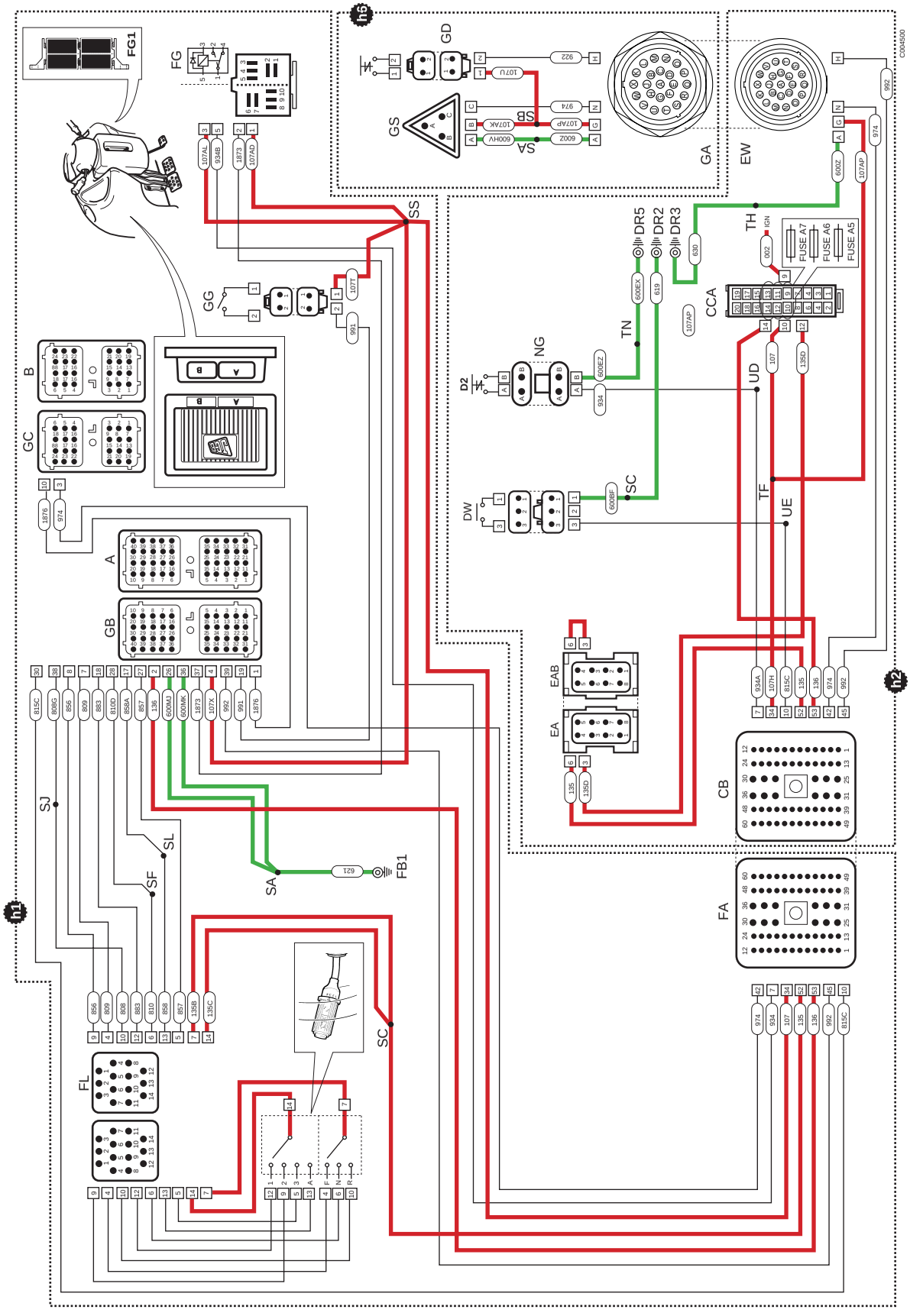


Fig 98. ECU Inputs

Solenoid Actuation

For input controls ⇨ *Input Controls (F-132)*.

Earth Points

Faults may be caused by poor earth connections. Although earth connections are shown, it must be remembered that the cab assembly is earthed via further earth strap and cable connections. For details of these connections see Section C, ***Machine Earth Connections***.

Component Key

The following key identifies the component connectors, ⇨ *Fig 99. (F-136)* and ⇨ *Fig 100. (F-137)*. Note that the wires coloured green show the electrical `feed to earth' for the gearbox mounted solenoids and gearbox ECU.

h1	Harness - Front console
h2	Harness - Cab & Side console
h6	Harness - Transmission

Note: For harness drawings see Section C.

Connectors (h1)

GB	h1 - h5
GC	E.C.U. connector B
FB1	Earth point

Connectors (h2)

CB	h2 - h1
DR3	Earth point
EW	h2 - h6

Connectors (h6)

C20	Gearbox solenoid U
C30	Gearbox solenoid T
C40	Gearbox solenoid Y
C50	Gearbox solenoid Z
C60	Gearbox solenoid W
C70	Gearbox solenoid V
C90	Gearbox solenoid X
GA	h5 - h1

Splices (h1)

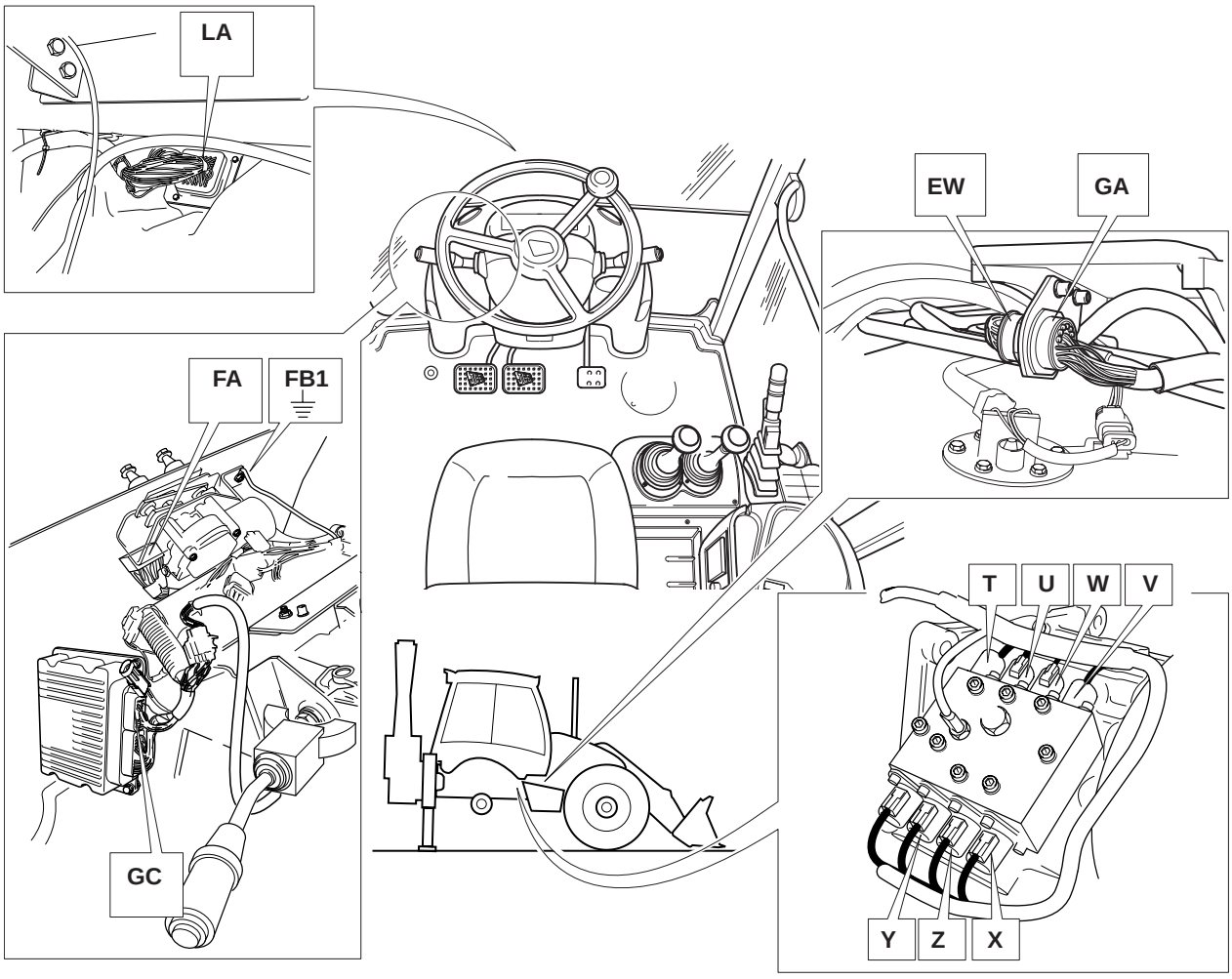
SA

Splices (h2)

TH

Splices (h5)

SA



C006470-C7

Fig 99. Electrical Connectors

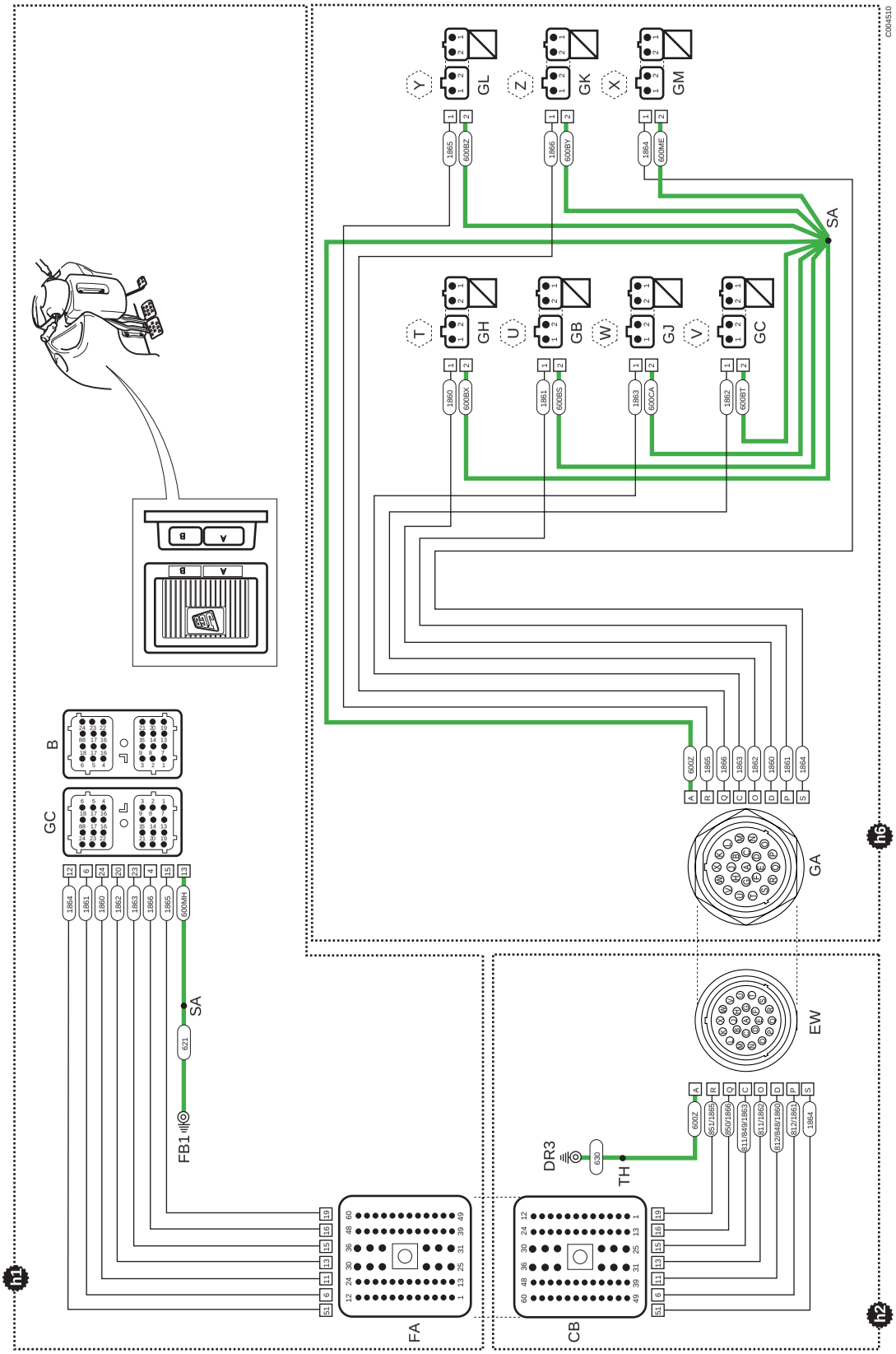


Fig 100. Solenoid Actuation

Lock Up Torque Converter

Introduction

This section explains how the Lock Up Torque Converter electrical system works.

Central to the system is the ShiftMaster ECU (Electronic Control Unit) **1**. The unit receives `inputs' from electrical devices such as the engine speed sensor **B**. Depending on the input signals an ECU `output' energises the lock up torque converter solenoid control valve **2**. The ECU can be connected to diagnostics software loaded on a laptop PC. The communications link is facilitated via diagnostics socket **3** ⇨ ***Fig 101. (F-139)***. See also ***Powershift Gearbox - ShiftMaster Diagnostics - User Guide***.

Component Key

1 ECU

ECU Input Devices

A Gear select switch

B Engine speed sensor

C Transmission speed sensor

ECU Output - Activated Devices

D Lock up torque converter solenoid control valve

E In-cab warning light(1) - torque converter lock up

(1) For identification of in-cab warning lights see the machine Operator Handbook.

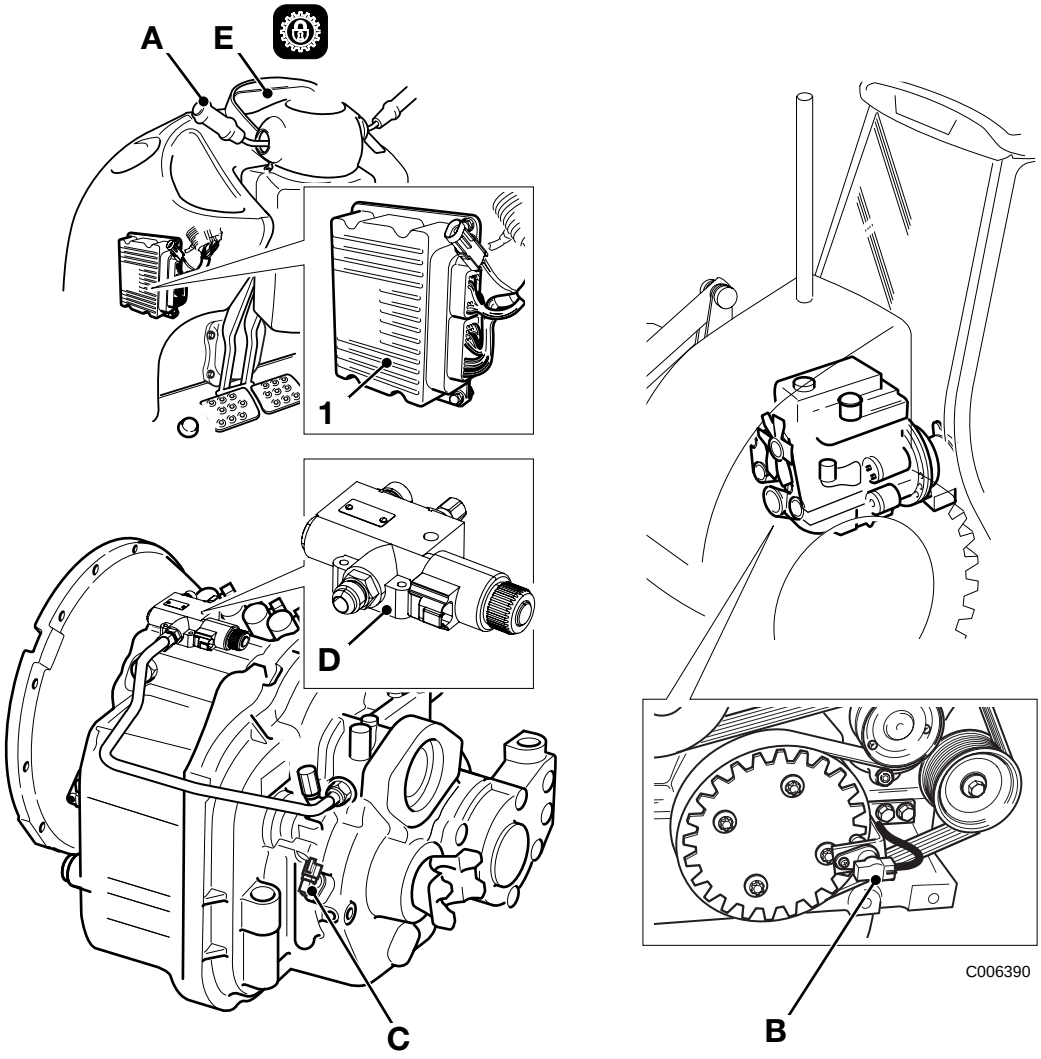


Fig 101. Electrical Components

Quick Reference

Electrical connectors ⇨ *Fig 102. (F-141)*

Electrical circuit for lock up torque converter control. Shown with torque converter LOCKED. `Live feed' wires are coloured red and feed to earth are green ⇨ *Fig 103. (F-142)*.

The information is intended as an aid when checking for faulty wires or connectors by means of continuity tests using a multimeter. DO NOT use a multimeter on the ECU connector pins (connectors A and B). Only test the associated wiring, uncouple connectors **GB** and **GC** and then use a multimeter at the pins inside these connectors as applicable. Use the ShiftMaster Diagnostics system to identify possible faults with the ECU See ***Powershift Gearbox - ShiftMaster Diagnostics - User Guide***.

Note: *Interconnecting harness connectors are not shown here. For full details see the relevant expanded harness schematic in this section.*

Component Key

FL	Column switch
FR	Converter `locked' warning light
GB	Harness connector - ECU - A
GC	Harness connector - ECU - B
GS	Transmission speed sensor
GT	Torque converter lock up solenoid control valve
GW	Engine speed sensor

ECU Connector GB

GB7	Forward switch
GB17	4th - Auto gear switch

ECU Connector GC

GC3	Transmission speed sensor - input
GC14	Engine speed sensor - input
GC1	Lock up torque converter control valve solenoid - output

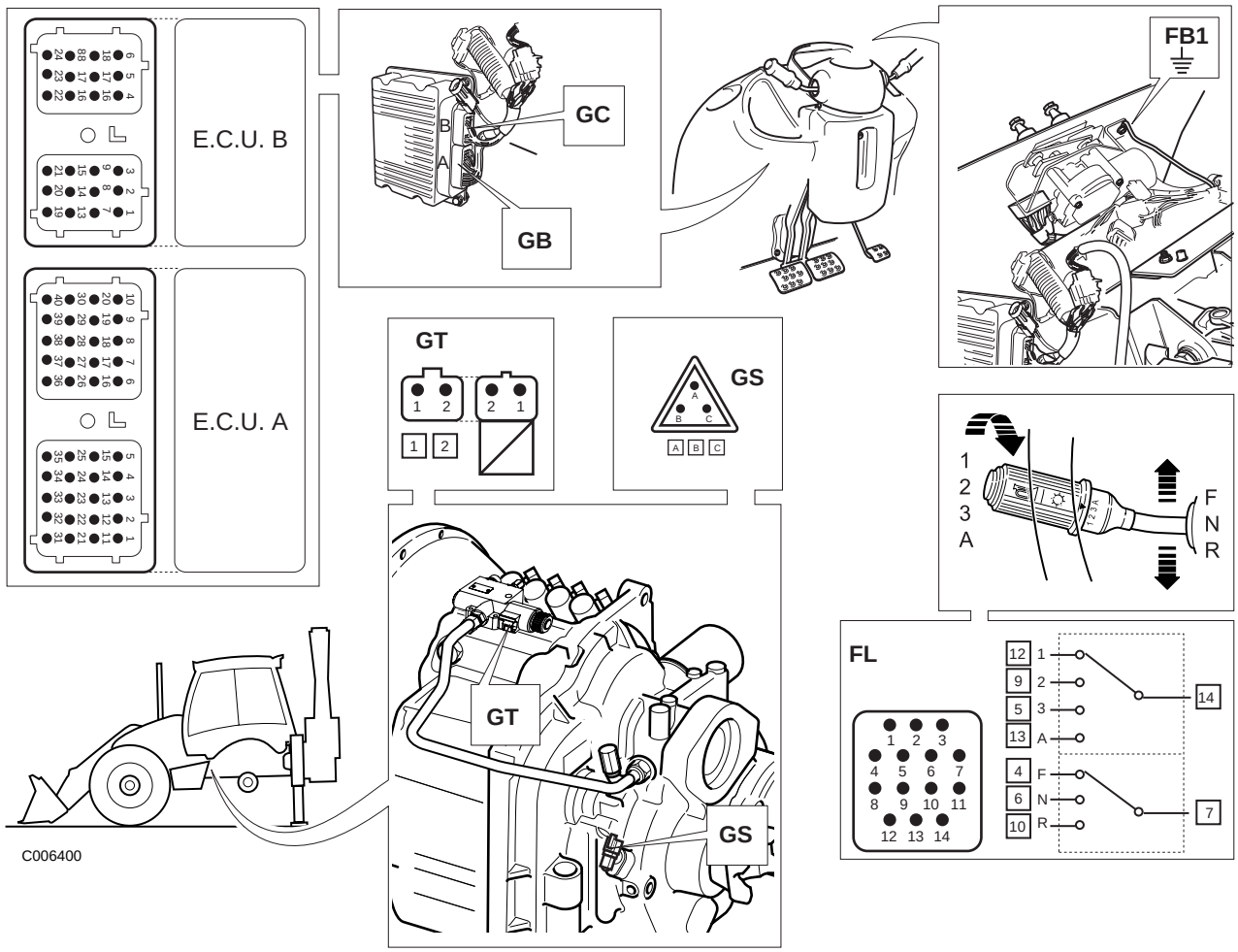


Fig 102. Electrical Components - Connectors

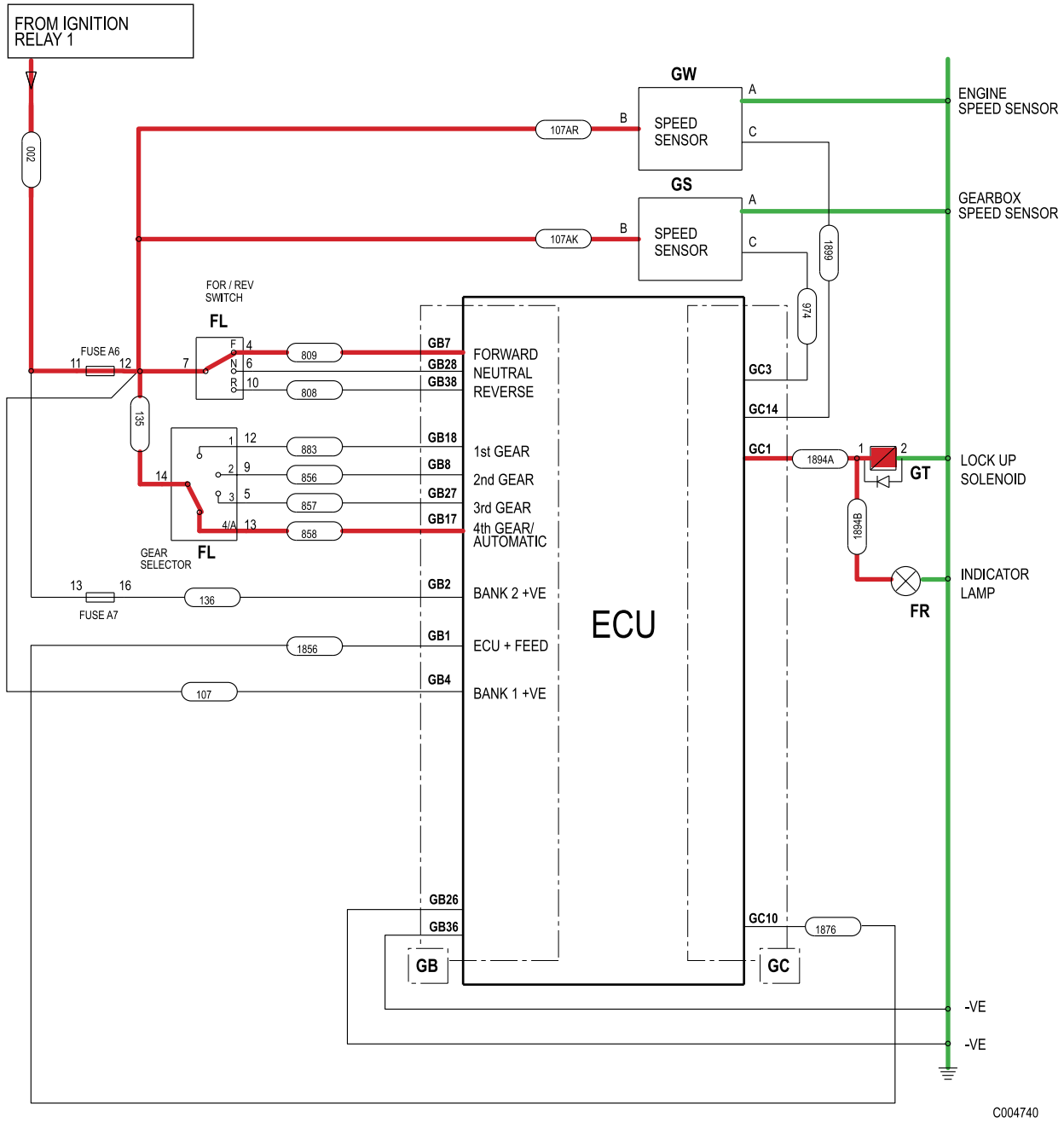


Fig 103. Electrical Schematic - Torque Converter `Locked'

Wires and Connectors

On the electrical diagram the electrical connectors (example, FA to CB) are shown looking on the mating face of each connector when they are disconnected ⇒ *Fig 105. (F-145)*. The wire numbers and colours, where appropriate, are shown as an aid to identification whilst fault finding.

Before fault finding make sure that you understand how the the electrical circuits work. The most effective method of fault finding is by means of ShiftMaster Diagnostics software and a laptop PC, see ***Service Procedures, Powershift Gearbox - ShiftMaster Diagnostics - User Guide***. Having identified a faulty system, use the schematics to identify the relevant wires and connectors, continuity checks can then be carried out using a multimeter. Gearbox solenoid coils can be checked for the correct resistance value as given in ***Technical Data***. See Section C - ***Service Procedures***, for more details.

Electrical Diagram

Earth Points

Faults may be caused by poor earth connections. Although earth connections are shown, it must be remembered that the cab assembly is earthed via further earth strap and cable connections. For details of these connections see Section C, ***Machine Earth Connections***.

Component Key

The following key identifies the component connectors, ⇒ *Fig 104. (F-144)* and ⇒ *Fig 105. (F-145)*. Note that the wires coloured red show the electrical `live feed' and wires coloured green show the electrical `feed to earth' for the relevant components.

h1	Harness - Front console
h2	Harness - Cab & Side console
h6	Harness - Transmission

Note: For harness drawings see Section C.

Connectors (h1)

FA	h1 - h2
FB1	Earth point
FL	Column gear lever
FR	In-cab warning light - lock up torque converter
GC	E.C.U. connector B

Connectors (h2)

CB	h2 - h1
CCA	Fuses
DR3	Earth point
DW	Park brake switch
EW	h2 - h6

Connectors (h6)

GA	h6 - h2
GS	Transmission speed sensor
GT	Lock up torque converter control valve solenoid
GW	Engine speed sensor

Splices (h1)

SA

TB

Splices (h2)

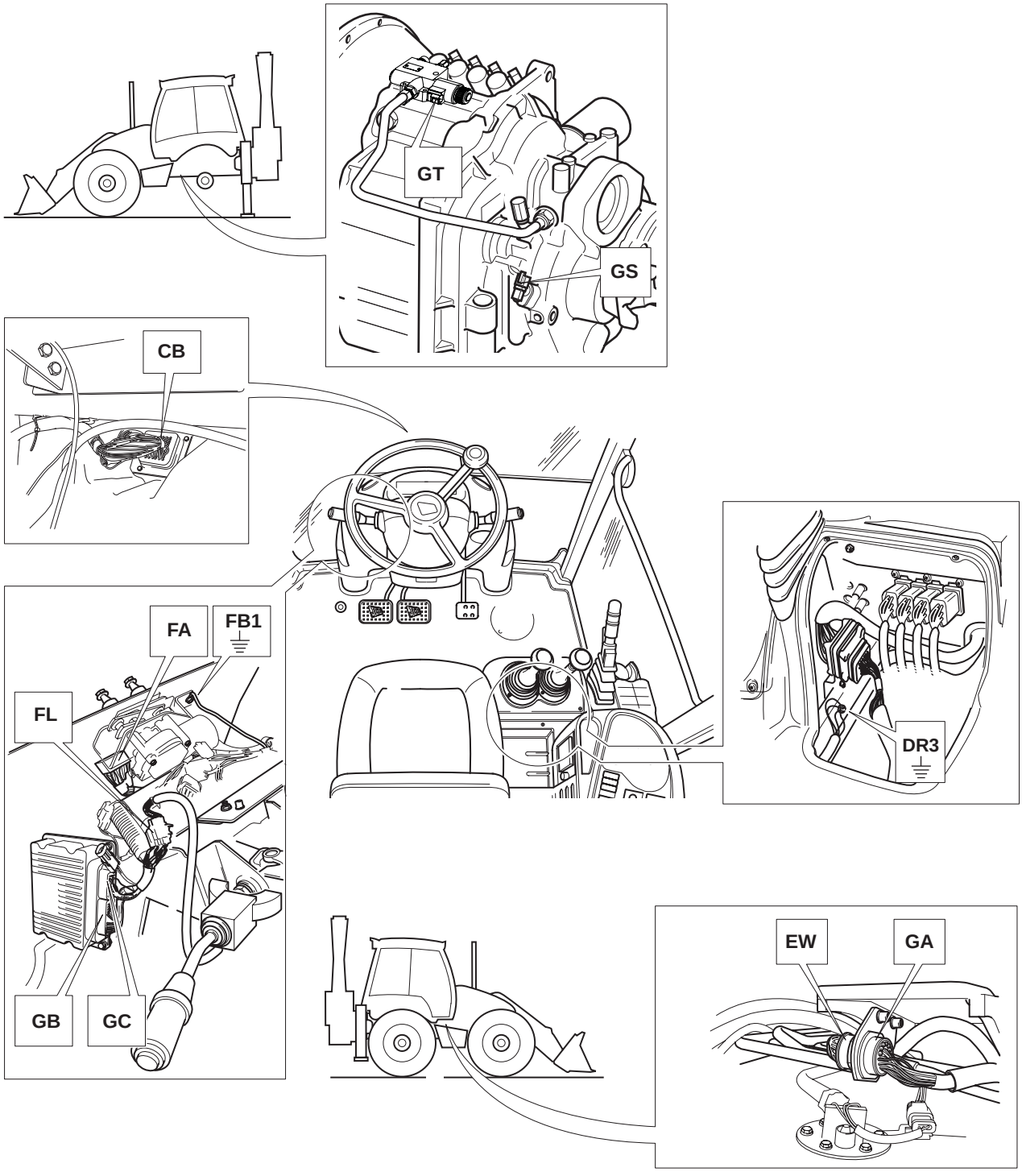
TF

TH

Splices (h6)

SA

SB



C006440-C1

Fig 104. Electrical Connectors

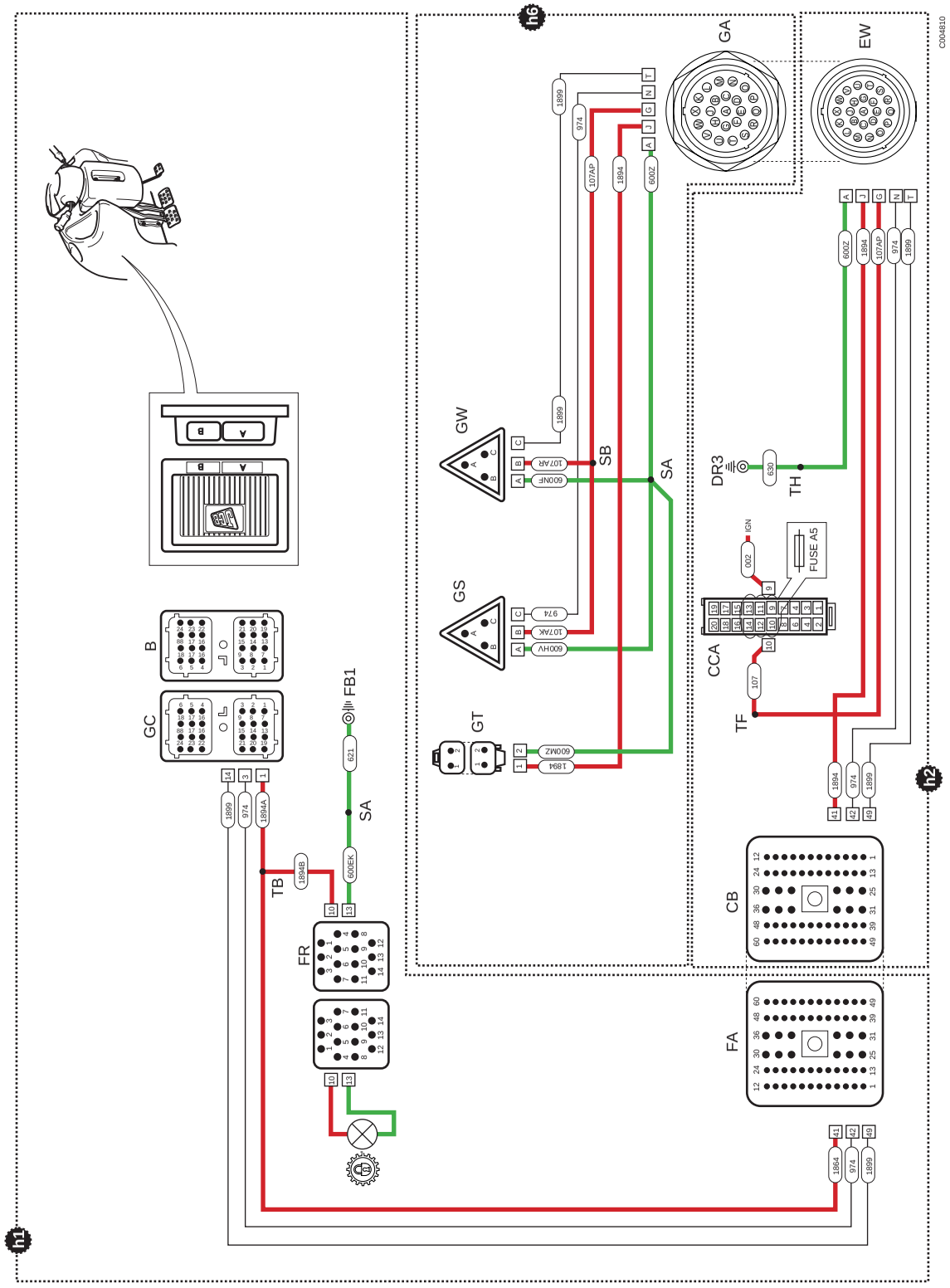


Fig 105. Electrical Diagram

Service Procedures

Front Axles SD55 and SD80

Renewing the Pinion Oil Seal

⇨ *Fig 107. (F-147)*. The pinion oil seal **3** may be renewed without removing the axle from the machine.

⚠ WARNING

A raised and badly supported machine can fall on you. Position the machine on a firm, level surface before raising one end. Ensure the other end is securely chocked. Do not rely solely on the machine hydraulics or jacks to support the machine when working under it.

Disconnect the battery, to prevent the engine being started while you are beneath the machine.

GEN-1-1

1 Remove the roadwheels and disconnect the axle propshaft.

2 Using a locally manufactured tool, measure the axle rolling torque as shown in ⇨ *Fig 106. (F-146)* and record the reading.

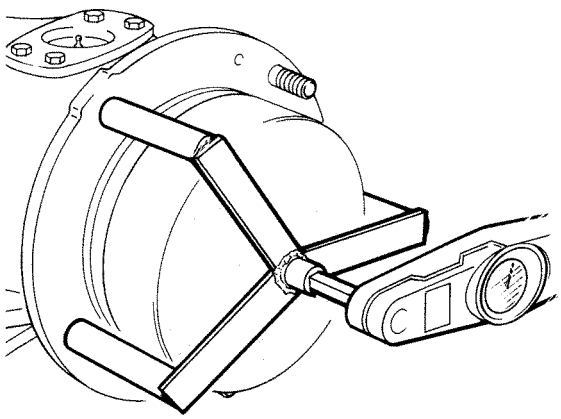


Fig 106. Rolling Torque Measuring Tool

3 Mark the relative positions of the pinion shaft **4** and stake nut **2** with a scriber, then using a drive coupling spanner (see ***Service Tools***), remove the stake nut **2** and yoke **1**.

4 Remove the seal **3** and fit a new one. Be sure not to damage the seal housing. Pack between the lips of the new seal with grease before fitting.

5 Check the sealing surface on the yoke **1** for wear or damage. Renew the yoke if necessary.

6 Fit the yoke **1** and temporarily fit the old stake nut **2**. Tighten the nut with a torque wrench, aligning the scriber marks made at step 3. Note the tightening torque required.

7 Remove and discard the old stake nut. Fit a new stake nut and tighten to the torque determined at step 6.

a Measure the axle rolling torque. The reading should be 0.5 to1Nm (0.37 to 0.74lbf ft; 0.05 to 0.1kgf m) more than that recorded in Step 2 (see **Note:**).

b If necessary, progressively torque tighten the stake nut to a maximum of 300 Nm (221 lbf ft) to achieve correct rolling torque.

Note: *If the rolling torque figure (new pinion seal fitted) exceeds the reading recorded in step 2 by 1Nm (0.74 lbf ft; 0.1 kgf m) or more, or a minimum torque of 250 Nm (184 lbf ft) cannot be achieved then the pinion assembly must be rebuilt using a solid spacer, see the appropriate axle assembly procedure.*

c Stake the nut **2** using a square ended staking tool.

8 Refit the roadwheels and connect the propshaft.

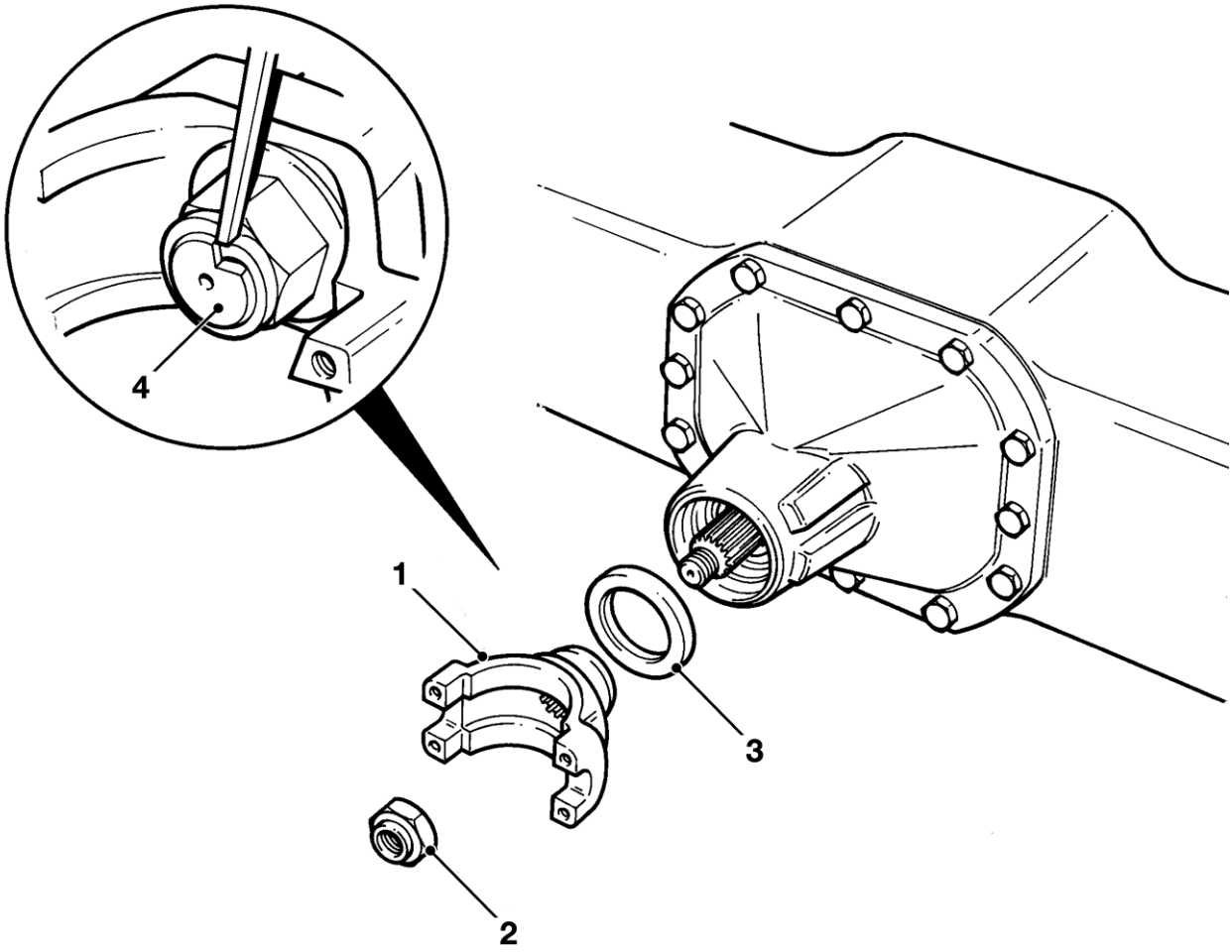


Fig 107. Renewing the Pinion Oil Seal (Typical axle shown)

Rear Axles PD70 and SD80

Renewing the Pinion Oil Seal

Refer to ⇨ ***Front Axles SD55 and SD80 (F-146)***.

The rear axle pinion oil seal is renewed using the same procedure as described for the front axle but note the following:

On synchro shuttle machines, the rear axle is fitted with a brake disc and drive flange in place of the yoke on front axles. For the brake disc removal procedure, see ***Section G, Brakes - Service Procedures***.

Testing for Brake Piston Seal Leakage

Refer to ***Section G, Brakes - Service Procedures***.

Synchro Shuttle Gearbox

Flushing the Transmission Oil

If the transmission oil has been contaminated with water or incorrect oil types, the transmission must be flushed to effectively remove the contaminated oil.

Flush the transmission as described below:

1 Drain the oil. Remove the suction strainer, refer to ***Section 3, Routine Maintenance***.

2 Clean the suction strainer with a suitable solvent. Follow the solvent manufacturer's instructions on safety.

3 Refit the suction strainer.

4 Renew the oil filter, refer to ***Section 3, Routine Maintenance***.

5 Fill the transmission with fresh JCB Special Transmission Fluid. Check the oil level, refer to ***Section 3, Routine Maintenance***.

6 Start the engine and run the machine until the normal operating temperature is reached (between 50 - 100 °C).

7 Stall the torque converter for 5 seconds, refer to ***Torque Converter Stall Test***.

DO NOT stall the torque converter for longer than 10 seconds or the transmission oil will overheat.

8 Continue running the engine under normal conditions for 5 minutes then repeat step 7. Continue this procedure for 30 minutes, if possible during machine operation.

9 Allow the machine to cool then drain the transmission oil through the suction strainer aperture.

10 Test the oil for contamination. If the oil is still contaminated, repeat the flushing procedure from step 2.

11 If the oil is clean, refit the suction strainer, fit a new oil filter and refill the transmission with fresh JCB Special Transmission Fluid. Check the oil level, refer to ***Section 3, Routine Maintenance***.

Torque Converter Stall Test

Ensure that the engine and transmission are at normal working temperature. Run engine at maximum speed and check the **High Idle Speed**, see ***Engine Technical Data*** for correct figure; adjust if necessary.

Apply parking brake and footbrake firmly, select 4th Speed Forward and open throttle fully. Engine speed should be as specified at **Torque Converter Stall** in ***Transmission Technical Data***. Select Reverse and repeat test.

Note: *When fully engaged, the parking brake electrically disconnects the transmission drive; this prevents the machine from being driven with the parkbrake on. Therefore, so that we can complete the test, move the parkbrake lever fractionally forward until the warning light is just extinguished; hold the lever in this position for the duration of the test. DO NOT move the lever too far forward, otherwise the parkbrake will not be fully operational. Alternatively, disconnect the switch at the park brake.*

DO NOT stall the converter for longer than 10 seconds or the transmission fluid will overheat.

If engine speeds are higher than the stated figures check the transmission for clutch slippage or internal leakage.

If engine speeds are below the stated figures either the engine is losing power and should be serviced/overhauled or the torque converter reaction member clutch is slipping. To check the engine, select Neutral, open throttle fully and operate an excavator service to 'blow off' the main relief valve. Engine speed should fall to slightly above the **Maximum Governed Speed**, see ***Engine Technical Data***. If engine speed is correct the torque converter is faulty.

Note: Maximum Governed Speed *is a datum figure only. It cannot be adjusted or checked with the engine installed in the machine.*

Pressure and Flow Tests

⇨ *Fig 108. (F-152)*.

Note: *The tests must be carried out only in the following order, step by step.*

⚠ WARNING

Take care when disconnecting hydraulic hoses and fittings as the oil will be HOT.

TRANS-1-2

1 Stop engine, remove transmission filter and filter head adapter. Fit adapter **A** (892/00920) into the gearbox casing. Fit test adapter **B** (892/00301) and secure with adapter **C** (892/00302). Connect flowmeter **D** (892/00229) as shown and connect a 0-20 bar (0-300 lbf/in2) pressure gauge to test connector **E** (see ***Service Tools, Section 1***).

2 Start engine and run at 1000 rev/min. The flowmeter will show the **Pump Flow** which should be as shown in ***Technical Data***. A low reading indicates a worn pump or blocked suction strainer. The pressure gauge will show the **Main Line Pressure** (see ***Technical Data***). A low reading can be caused by either a faulty pressure maintenance valve or a worn pump. A high reading indicates a faulty pressure maintenance valve or, if the pump flow is low, the oil cooler may be blocked.

3 Stop engine, remove flow test adapters and refit filter. Connect pressure gauge and flowmeter into converter out line as shown at **F**. Run engine at 1000 rev/min with transmission in Neutral and note **Converter Out Pressure** and **Oil Cooler Flow**, which should be as shown in ***Technical Data***. A high pressure together with low flow could be caused by a blocked oil cooler. (See also check 7.)

4 With parking brake and footbrake firmly applied, select Forward and check flow reading, which should not fall by more than 4.5 litres (1 UK gal; 1.2 US gal) per minute. A low reading indicates a high leakage rate in that particular clutch, which could be caused by worn or broken piston seals or shaft sealing rings. Select Reverse and repeat the test.

5 If the clutch leakage rate is high, the **Clutch Pressures** may be checked by connecting the pressure gauge into ports **G** and **H** and repeating test **4**. A low reading (see ***Technical Data***) would confirm a high leakage rate in the particular clutch selected.

6 Stop engine, connect the pressure gauge into port **J** in the transmission, and fit a load valve **L** into the converter out line (see **Note**).

Note: *Make sure that the load valve **L** has been screwed fully out before starting the engine, otherwise the converter seals will be damaged.*

Start engine, run at 1000 rev/min and slowly screw down the load valve whilst observing the gauge reading, which should rise to the setting of the **Converter Relief (Safety) Valve** (see ***Technical Data***). DO NOT allow the pressure to exceed 10.3 bar (150 lbf/in2) or damage to the converter seals will be caused.

If the reading is higher than specified, the relief (safety) valve must be faulty. A low reading indicates a faulty relief (safety) valve, leaking converter 'piston ring' type seal or leaking pump seal.

7 Stop engine and connect pressure gauge and flowmeter into return line from oil cooler to transmission as shown at **K**. Start engine, and with transmission in Neutral check flowmeter reading, which will show the **Cooler Flow Rate** (see ***Technical Data***). The pressure gauge will show the **Lubrication Pressure** (see ***Technical Data***). Low flow and pressure readings could indicate a blocked oil cooler

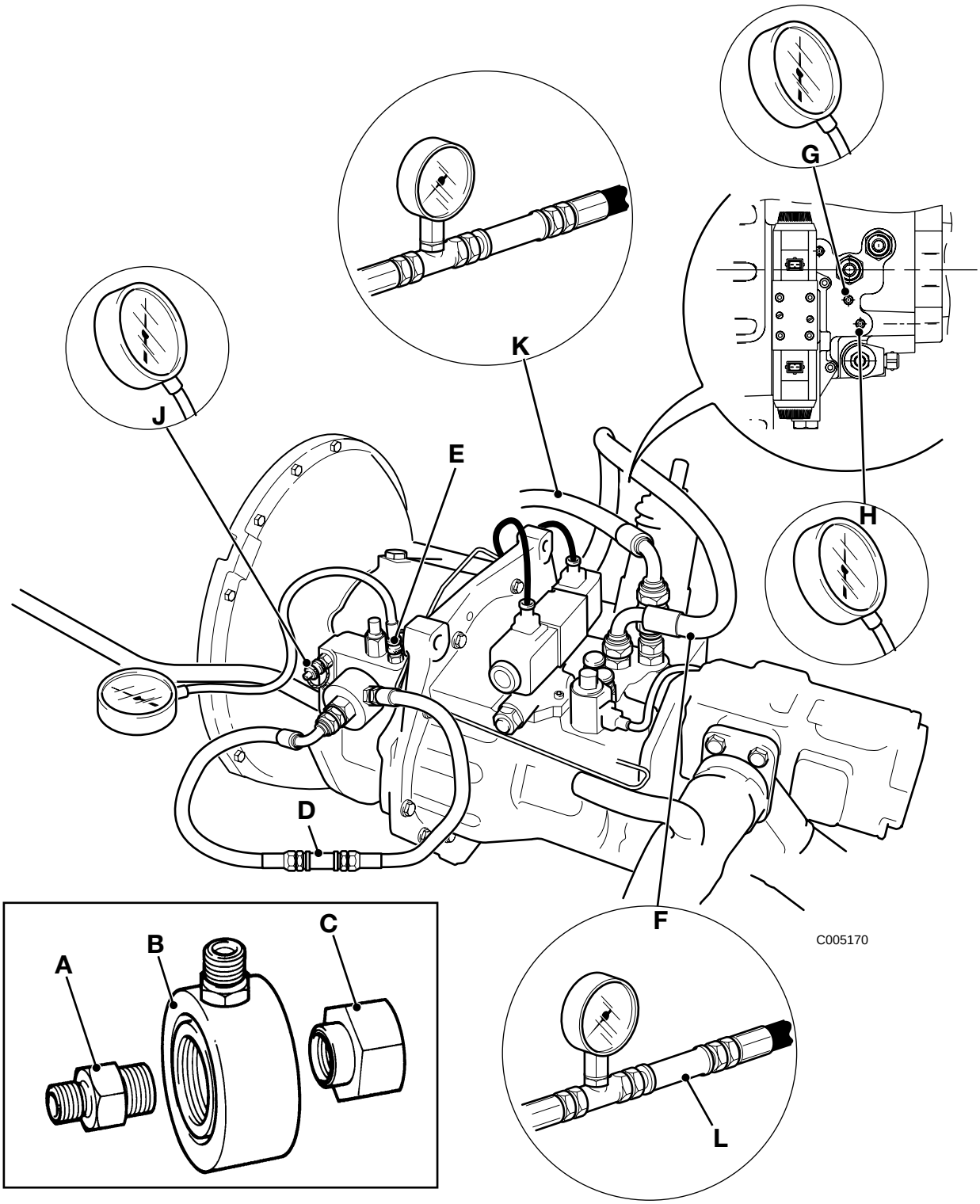


Fig 108. Pressure and Flow Tests

Forward and Reverse Solenoid Control Valve - Solenoid Coil

The solenoid control valve is fitted with 2 solenoid coils, forward solenoid coil **A** and reverse solenoid coil **B**. The removal and replacement procedure is identical for both solenoid coils.

Removal

1 Uncouple the electrical connector at the solenoid coil **A**.

Note: *If both solenoid coils are to be removed, label the electrical connectors to ensure correct assembly.*

2 Unscrew the knurled nut **C** and remove 'O' ring **D**. Withdraw the solenoid coil **A** and 'O' ring **E**.

Replacement

Replacement is the reversal of the removal procedure.

Make sure that `O' rings **D** and **E** are undamaged and correctly located.

Table 41. Torque Settings

Item	Nm	kgf m	lbf ft
C	10 - 15	1 - 1.5	8 - 10

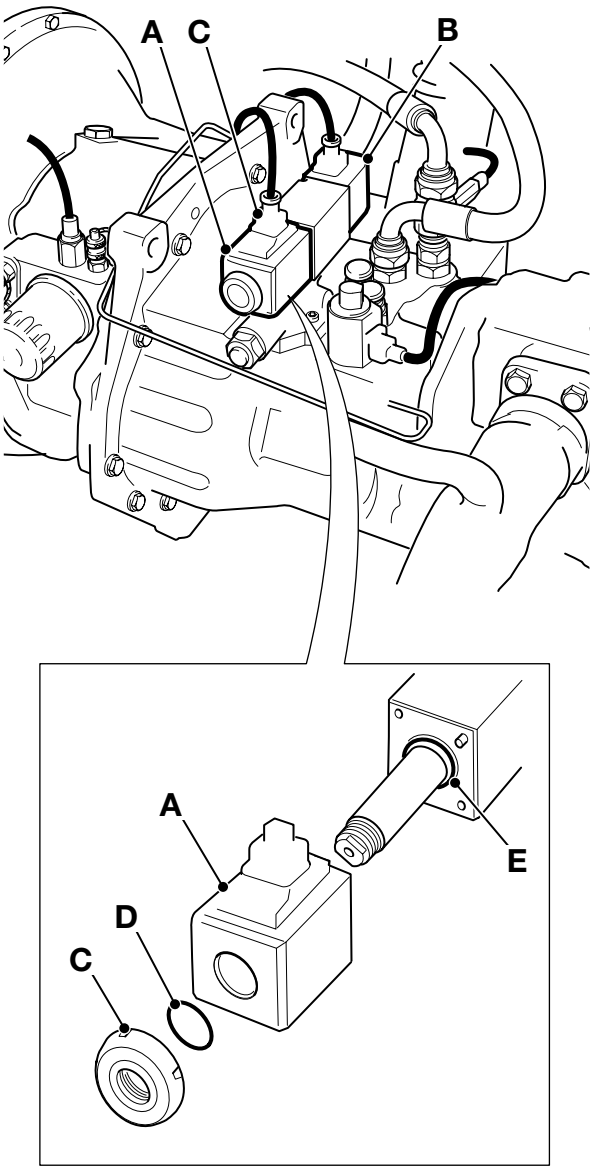


Fig 109.

Forward and Reverse Solenoid Control Valve

Dismantle

1 Unscrew the knurled nut **2** and remove 'O' ring **3**, withdraw the solenoid **4** and 'O' ring **5**.

2 Hold the solenoid valve body **6** in a vice, using the spanner flats **A**, remove spindle **7** and 'O' ring **8**.

3 Pull out actuating pin **9**, spring **10**, spring retainer **11**, and spool **12**.

4 Inspect the spool and spool bore for signs of wear, nicks scratches etc.

Assemble

Assembly is reversal of the dismantle procedure.

Renew all 'O' rings.

Lightly lubricate all parts with clean transmission fluid before assembling.

Check that the flying leads are secure and that the connectors are intact.

Table 42. Torque Settings

Item	Nm	kgf m	lbf ft
2	10 - 15	1 - 1.5	8 - 10

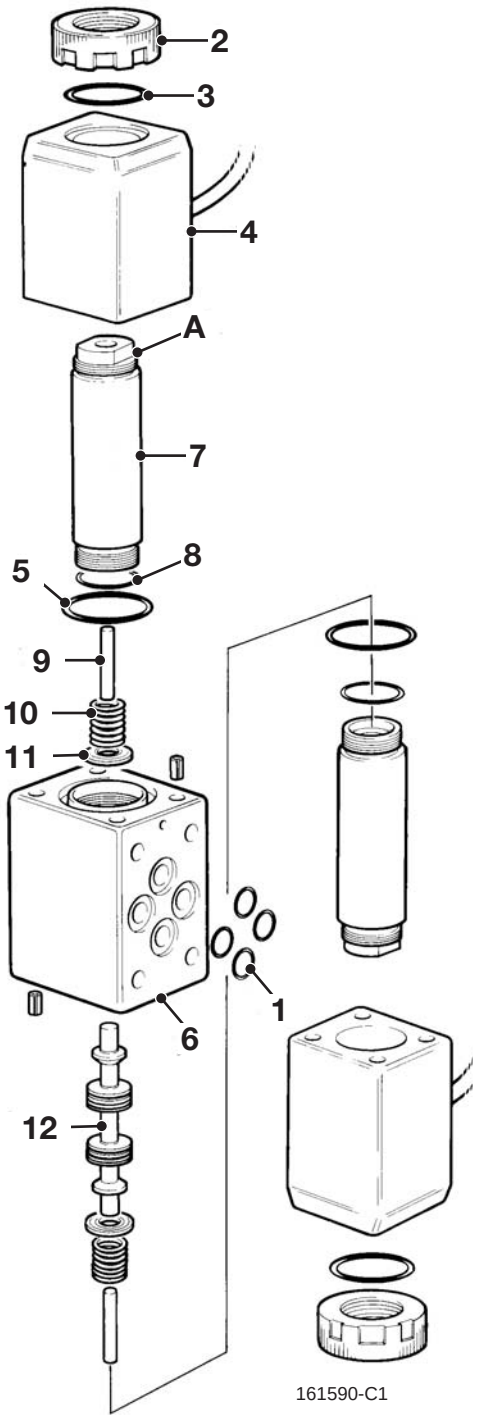


Fig 110.

Oil Pressure Switch

Removal

1 Clean off all debris, dirt and grit from around the pressure switch **A**. There must be no ingress of debris, dirt or grit inside the gearbox.

2 Uncouple the electrical connector **B**.

3 Unscrew the pressure switch and discard the sealing washer **C**.

4 Cap the open port on the gearbox.

Replacement

Replacement is the reversal of the removal procedure. Note the following:

The oil pressure switch is a non serviceable component. If it is faulty or damaged, it must be renewed.

Renew the sealing washer **C**.

Torque tighten the pressure switch.

Table 43. Torque Settings

Item	Nm	kgf m	lbf ft
A	16	1.6	12

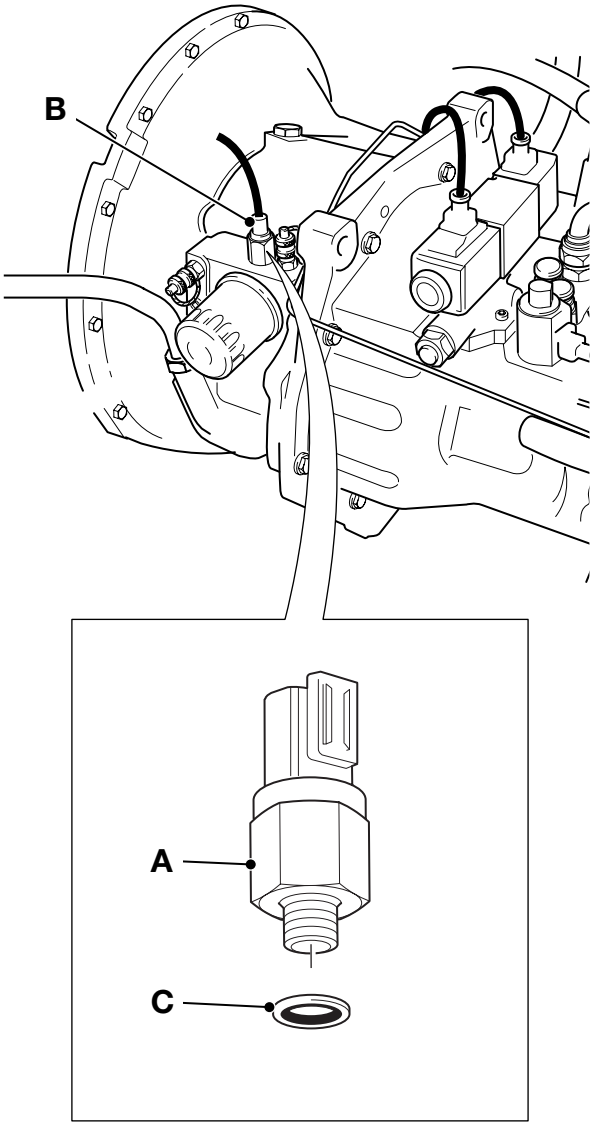


Fig 111.

Oil Temperature Switch

Removal

1 Clean off all debris, dirt and grit from around the temperature switch **A**. There must be no ingress of debris, dirt or grit inside the gearbox.

2 Uncouple the electrical connector **B**.

3 Unscrew the temperature switch and discard the sealing washer **C**.

4 Cap the open port on the adaptor.

Replacement

Replacement is the reversal of the removal procedure. Note the following:

The oil temperature switch is a non serviceable component. If it is faulty or damaged, it must be renewed.

Renew the sealing washer **C**.

Torque tighten the temperature switch.

Table 44. Torque Settings

Item	Nm	kgf m	lbf ft
A	16	1.6	12

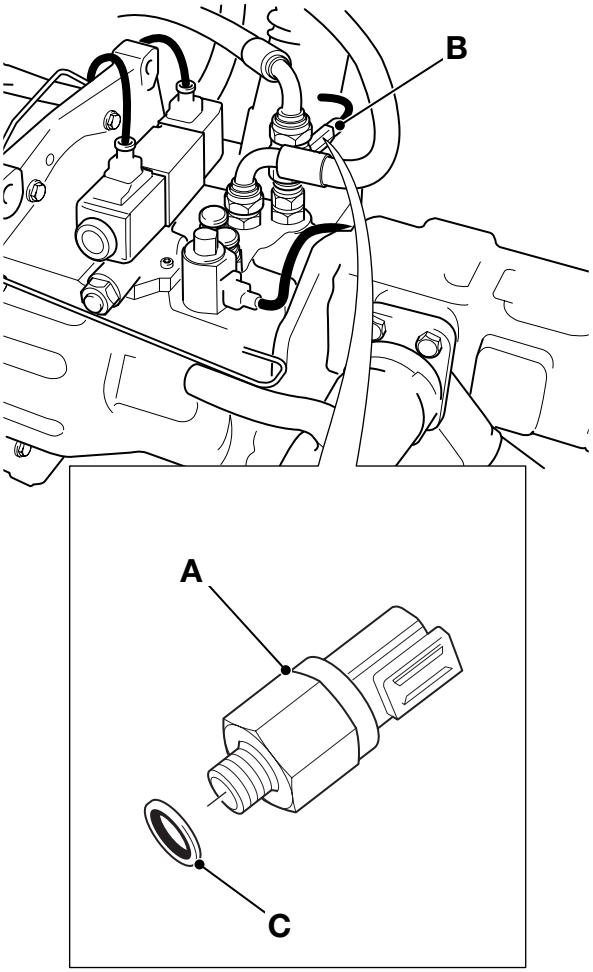


Fig 112.

Powershift Gearbox

Flushing the Transmission Oil

The procedure for flushing the powershift gearbox transmission oil is identical to that described for the synchro shuttle gearbox, refer to ⇨ ***Flushing the Transmission Oil (F-149)***.

Torque Converter Stall Test

The purpose of the stall test is to check the performance of the transmission by `stalling' the torque converter. This is the point at which, due to torque applied by the engine the torque converter stops transmitting drive to the gearbox. The engine speed at which `stalling' occurs is compared to speeds recorded for a machine in normal condition (given in ***Technical Data***). Abnormal stall speed results can be used to identify a number of possible faults with the transmission, typically gearbox hydraulic and clutch faults.

Note: *DO NOT stall the converter for longer than 10 seconds or the transmission fluid will overheat. Make sure that the oil level is correct and at normal operating temperature.*

Before completing the following test, remove the transmission dipstick. If there is any sign of smoke emitting from the dipstick tube STOP THE TEST IMMEDIATELY and dismantle the transmission for servicing.

By performing the tests in the first 3 gears in forward and reverse we can see from the tables below that all the clutches in the gearbox will be engaged, ensuring faults will be easy to identify. Record the test results in a check list. Use the Transmission Technical Data Check List given in ***Fault Finding - Powershift Gearbox.*** Alternatively, draw a table as shown below.

Stall Test Results - 6 Speed Powershift				
Gear	**Clutches engaged**			
	Forward	Rev/min	Reverse	Rev/min
1st	X, Z		W, Z	
2nd	T, Z		V, Z	
3rd	U, Z		W, Y	

Stall Test Results - 4 Speed Powershift				
Gear	**Clutches engaged**			
	Forward	Rev/min	Reverse	Rev/min
1st	T, Z		W, Z	
2nd	U, Z		V, Z	
3rd	T, Y		W, Y	

1 Ensure that the engine and transmission are at normal working temperature (the transmission oil must be above 50°C). Run engine at maximum speed and check the **High Idle Speed**, see ***Engine Technical Data*** for correct figure; adjust if necessary.

2 Apply parking brake and footbrake firmly. If necessary, set the machine against a fixed obstruction.

Note: *When fully engaged, the parking brake electrically disconnects the transmission drive; this prevents the machine from being driven with the parkbrake on. Therefore, so that we can complete the test, move the parkbrake lever fractionally forward until the warning light is just extinguished; hold the lever in this position for the duration of the test. DO NOT move the lever too far forward, otherwise the parkbrake will not be fully operational. Alternatively, disconnect the switch at the park brake.*

3 Select 1st speed forward drive and open throttle fully. Record the engine speed from the tachometer. Repeat the test for 2nd and 3rd speed forward and record the readings.

4 Repeat step 3 except this time select 1st, 2nd and 3rd gear reverse drive respectively. Record the readings.

5 All recorded readings should be as specified at **Torque Converter Stall** in ***Transmission Technical Data***.

Key to Clutches:

T - Forward low ratio clutch pressure
U - Forward high ratio clutch pressure
V - Reverse high ratio clutch pressure
W - Reverse low ratio clutch pressure
X - 6 speed clutch pressure (6 speed gearbox only)
Y - Mainshaft clutch pressure
Z - Layshaft clutch pressure

Interpreting the Test Results

If all the engine speeds are below the stated figures either the engine is losing power and should be serviced/ overhauled or the torque converter reaction member clutch is slipping. To check the engine, select Neutral, open throttle fully and operate an excavator service to 'blow off' the main relief valve. Engine speed should fall to slightly below the **Maximum Governed Speed**, see ***Engine Technical Data***. If engine speed is correct the torque converter reaction member clutch is slipping.

If all the engine speeds are higher than the stated figures in all gears the torque converter safety relief valve may be faulty. Alternatively there may be internal oil leakage.

If engine speeds are higher than the stated figures in some gears, check the transmission for clutch slippage or internal leakage. Look at the example below and see how the results can be used to isolate a suspect clutch.

Stall Test Results - 6 Speed Powershift				
Gear	**Clutches engaged**			
	Forward	Rev/min	Reverse	Rev/min
1st	X, Z	1990	W, Z	1980
2nd	**T, Z**	**2060**	V, Z	**1975**
3rd	U, Z	1985	W, Y	1990

In the example shown, we can see that the engine speed is abnormally high when 2nd gear forward drive is selected, indicating a slipping clutch, possibly **T** or **Z**. We can now use the results to determine which clutch is at fault.

From the table we can see that there is no problem with clutch **Z** since it is engaged in other gears, the stall speeds for those gears are normal. This indicates that clutch **T** is slipping.

A clutch can slip because of an internal oil leakage fault. To test for internal oil leakage, carry out a pressure test on the clutches. ⇨ ***Clutch Leakage Tests (F-167)***.

Pressure and Flow Tests

⇨ *Fig 113. (F-161)*.

Before completing any of the transmission pressure/flow tests, make sure that the oil level is correct and at normal operating temperature (not less than 50°C).

All gauges etc used in the following pressure/flow tests are shown in ***Service Tools***.

⚠ WARNING

Fluid Under Pressure

Fine jets of fluid at high pressure can penetrate the skin. Keep face and hands well clear of fluid under pressure and wear protective glasses. Hold a piece of cardboard close to suspected leaks and then inspect the cardboard for signs of fluid. If fluid penetrates your skin, get medical help immediately.

INT-3-1-10_2

⚠ WARNING

Take care when disconnecting hydraulic hoses and fittings as the oil will be HOT.

TRANS-1-2

⚠ WARNING

Do not go underneath the machine with the engine running. Switch off the engine, apply the park brake and block both sides of all wheels before going underneath the machine.

TRANS-2-1

⚠ WARNING

If a 4 wheel drive machine is to be raised and the engine/transmission run, make sure all four wheels are off the ground and supported by axle stands. If only one pair of wheels is raised, the machine could still drive through the other axle.

TRANS-2-2_2

⚠ WARNING

Under no circumstances must the engine be run with the transmission in gear and only one driving wheel jacked clear of the ground, since the wheel on the ground will move the machine.

INT-3-1-16

Test Points:

A - Mainline pressure

B - Converter inlet and converter relief valve pressure

B1 - Converter inlet and converter relief valve pressure - **Lock up torque converter variant**

C - Converter outlet pressure (to cooler)

C1 - Converter outlet pressure (to cooler) - **Lock up torque converter variant**

F - Pump flow (remove filter and fit adapters)

J - Lubrication pressure

Clutches:

S - 2 and 4 wheel drive clutch pressure

T - Forward low ratio clutch pressure

U - Forward high ratio clutch pressure

V - Reverse high ratio clutch pressure

W - Reverse low ratio clutch pressure

X - 6 speed clutch pressure (6 speed gearbox only)

Y - Mainshaft clutch pressure

Z - Layshaft clutch pressure

Other Items:

L - Torque converter relief valve

M - Pressure maintenance valve

Test Procedures:

Pump Flow

Mainline Pressure

Converter in Pressure

Converter Relief (Safety) Valve Pressure

Converter Out Pressure and Oil Cooler Flow Rate

Lubrication Pressure

Clutches:-

Isolating a Suspect Clutch

Individual Clutch Leakage Test

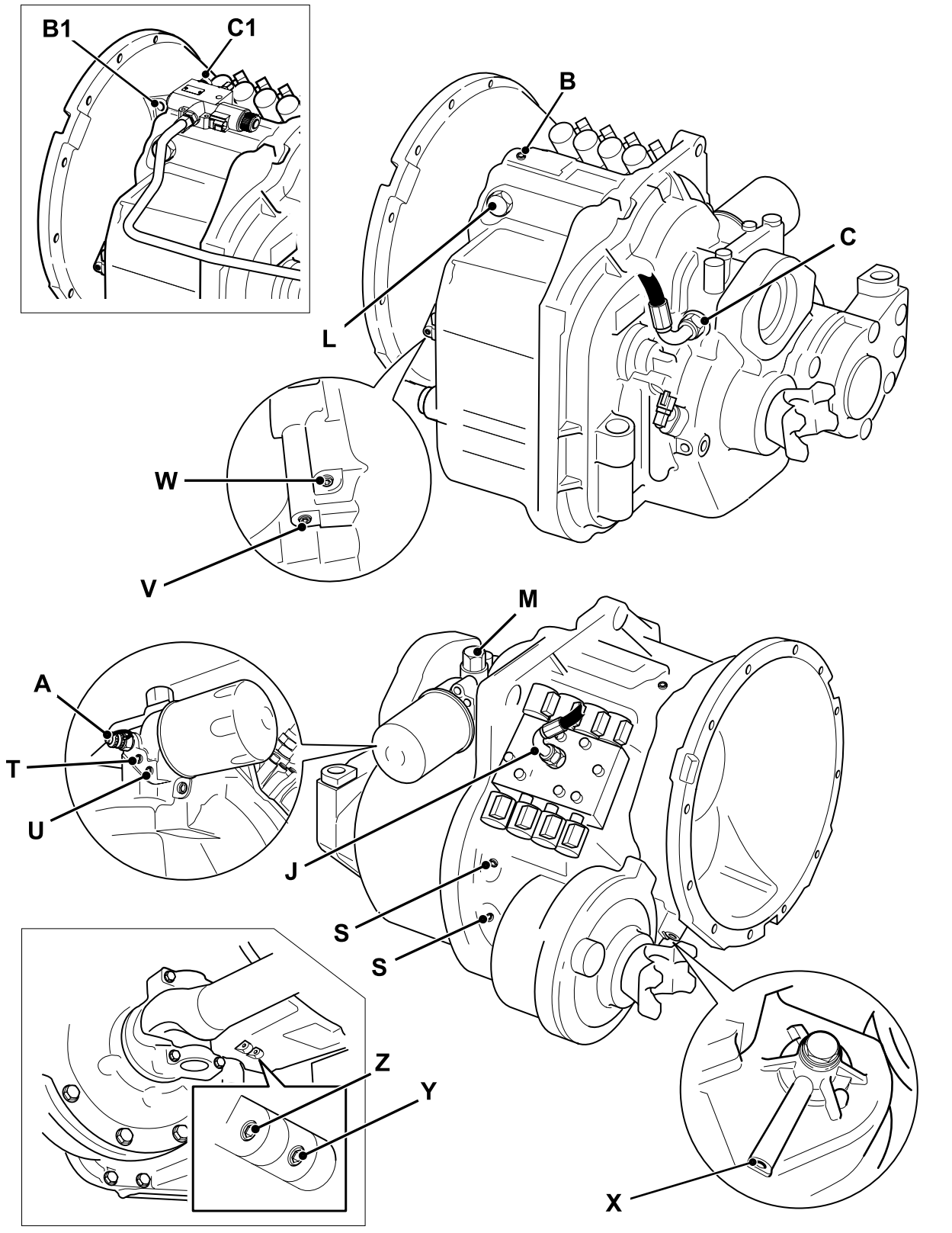


Fig 113. Pressure and Flow Tests

Pump Flow

⇨ *Fig 114. (F-162)*.

1 Stop engine, remove the gearbox oil filter and fit adapter **X** (460/15708) into the gearbox casing. Connect flowmeter **W** (892/00268).

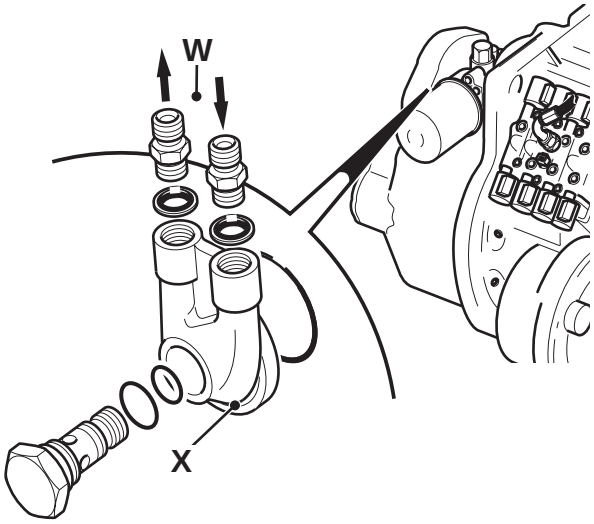


Fig 114.

2 Start engine and run at 1000 rev/min. With the transmission in neutral the flowmeter will show the **Pump Flow** which should be as shown in ***Technical Data***. A low reading indicates a worn pump or blocked suction strainer.

3 Repeat step **2** and note gauge readings with engine running at 2000 rev/min.

4 Stop engine and remove test adapters, refit filter.

Mainline Pressure

⇨ *Fig 115. (F-163)*.

1 Stop engine, connect a 0-20 bar (0-300 lbf/in2) pressure gauge to test connector **A**.

2 Start engine and run at 1000 rev/min. With the transmission in neutral the pressure gauge will show the **Main Line Pressure** which should be as shown in ***Technical Data***. A low reading can be caused by either a faulty pressure maintenance valve or a worn pump. A high or low reading may indicate a faulty pressure maintenance valve.

3 Repeat step **2**, with engine running at 2000 rev/min note gauge readings which should be as shown in ***Technical Data***.

4 Stop engine and remove test gauge.

Converter In Pressure

⇨ *Fig 115. (F-163)*.

Note that the converter in pressure is affected by the torque converter relief valve operation. Before carrying out tests check the operation of the relief valve ⇨ *Converter Relief (Safety Valve) Pressure (F-164)*.

1 Stop engine, connect a 0-20 bar (0-300 lbf/in^2) pressure gauge to test point **B** (or **B1** for lock up torque converter variant).

Note: *A pressure test kit (998/10650) is available to enable easier pressure gauge connection, refer to* ***Service Tools****.*

2 Start the engine and run at 1000 rev/min. With the transmission in neutral the pressure gauge will show **Converter In Pressure** which should be as shown in ***Technical Data***. A high or low reading could indicate a faulty converter relief valve.Stop engine and remove pressure test gauge.

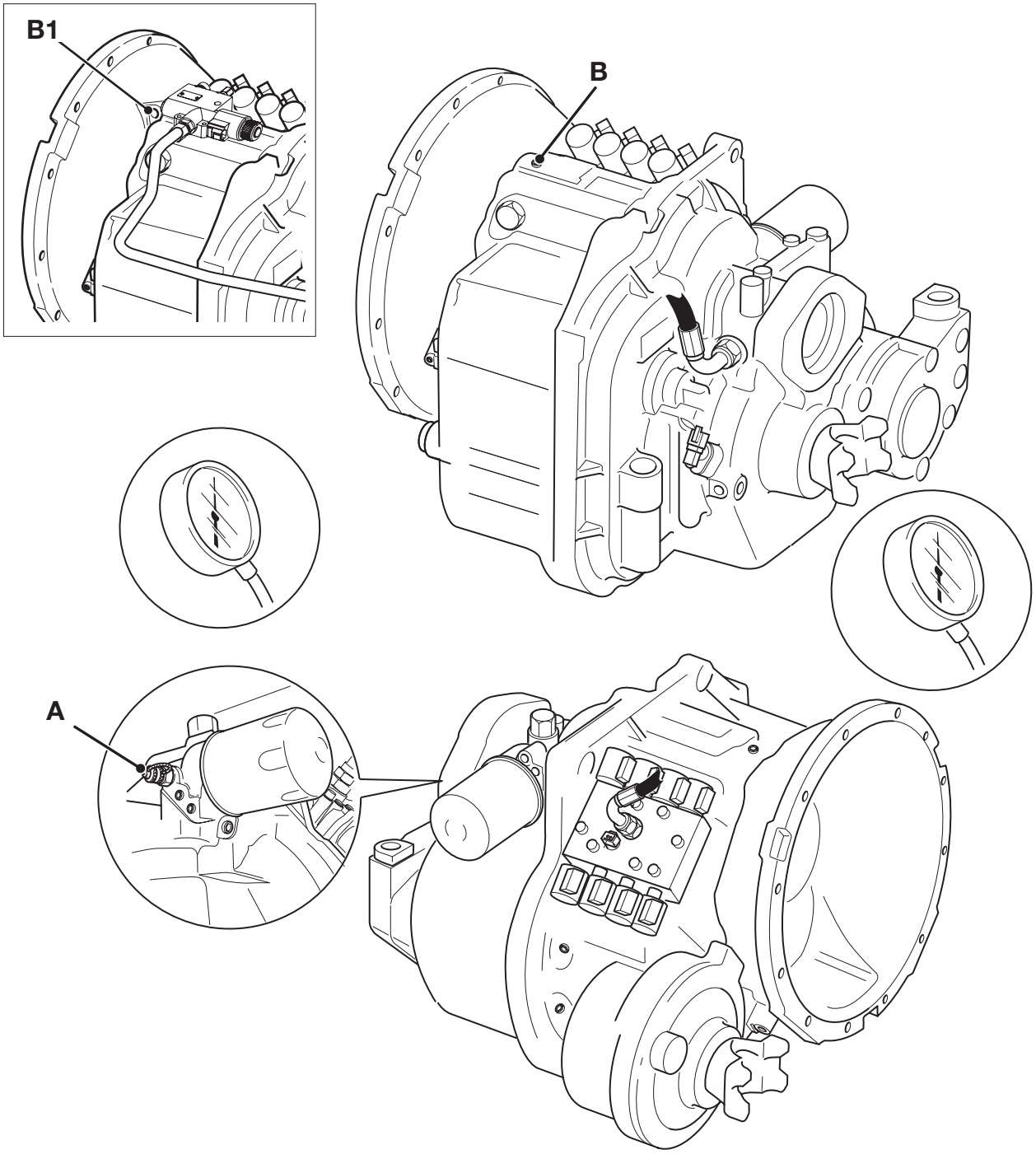


Fig 115. Pressure and Flow Tests

Converter Relief (Safety Valve) Pressure

⇒ Fig 116. (F-166).

The purpose of the torque converter relief valve is to protect the torque converter from excessive oil pressure. Excessive oil pressure can be generated when the transmission oil temperature is below 50°C and/or the engine is run at over 2000 rev/min. In this event the relief valve opens and returns oil directly to the transmission sump, bypassing the torque converter, cooler and clutch lubrication circuits, protecting against damage due to excessive pressure. For this reason it is essential that the transmission oil is above 50°C and the engine is run between idle and 1000 rev/min when testing the relief valve.

1 Connect a 0-20 bar (0-300 lbf/in^2) pressure gauge to test point **B** (or **B1** for lock up torque converter variant).

Note: *A pressure test kit (998/10650) is available to enable easier pressure gauge connection, refer to* ***Service Tools****.*

2 Fit a load valve **P** into the converter out line.

⚠ CAUTION

Make sure the load valve is in the OPEN position, (the adjusting knob screwed fully OUT), before starting the following pressure test. Failure to do this could damage the pump.

HYD-4-4_1

DO NOT allow the pressure to exceed 8.3 bar (120 lbf/in^2) or damage to the converter seals will be caused.

3 Start the engine and run at 1000 rev/min. With the transmission in neutral, slowly screw down the load valve **P** whilst observing the gauge reading which should rise to the **Converter Relief (Safety) Valve** setting as specified in ***Technical Data***.

Note: *The gauge pressure will fall once the valve has opened. This is normal relief valve operation and does not indicate a fault. If necessary reset the load valve* ***P*** *and perform the test again, watching the pressure gauge carefully.*

4 If the converter relief valve opens at a pressure higher than specified then the valve is faulty. A low opening pressure indicates a leaking pump to casing seal or a faulty converter relief valve.

5 Stop engine, remove test gauges and load valve. Refit hoses to original position.

Converter Out Pressure and Oil Cooler Flow Rate

⇒ Fig 116. (F-166).

Note that the converter out pressure and oil cooler flow rate are affected by the torque converter relief valve operation. Before carrying out tests check the operation of the relief valve *⇒ Converter Relief (Safety Valve) Pressure (F-164)*.

1 Stop engine, connect a 0-20 bar (0-300 lbf/in^2) pressure gauge and flowmeter **K** into the converter out line **C** (or **C1** for lock up torque converter variant).

2 Run the engine at 1000 rev/min with transmission in neutral. The pressure gauge indicates the **Converter Out Pressure** and the flowmeter indicates the **Oil Cooler Flow Rate**, both readings should be as specified in ***Technical Data***. A high pressure together with low flow could be caused by a blocked oil cooler or internal leakage.

3 Repeat step **2**, with engine running at 2000 rev/min note gauge readings which should be as shown in ***Technical Data***.

4 Stop engine, remove test gauges and refit hoses to original position.

Lubrication Pressure

⇒ Fig 116. (F-166).

Note that the lubrication pressure is affected by the torque converter relief valve operation. Before carrying out tests check the operation of the relief valve *⇒ Converter Relief (Safety Valve) Pressure (F-164)*.

1 Stop engine, connect a suitable pressure gauge into the return line from the oil cooler to the transmission as shown at **J**.

2 Start the engine and run at 1000 rev/min. With the transmission in neutral the pressure gauge will indicate the **Lubrication Pressure** which should be as specified in ***Technical Data***.

3 Repeat step **2** and note gauge readings with engine running at 2000 rev/min. If the pressure is high the oil cooler may be blocked *⇒ Converter Out Pressure and Oil Cooler Flow Rate (F-165)*.

4 Stop engine and remove pressure gauge.

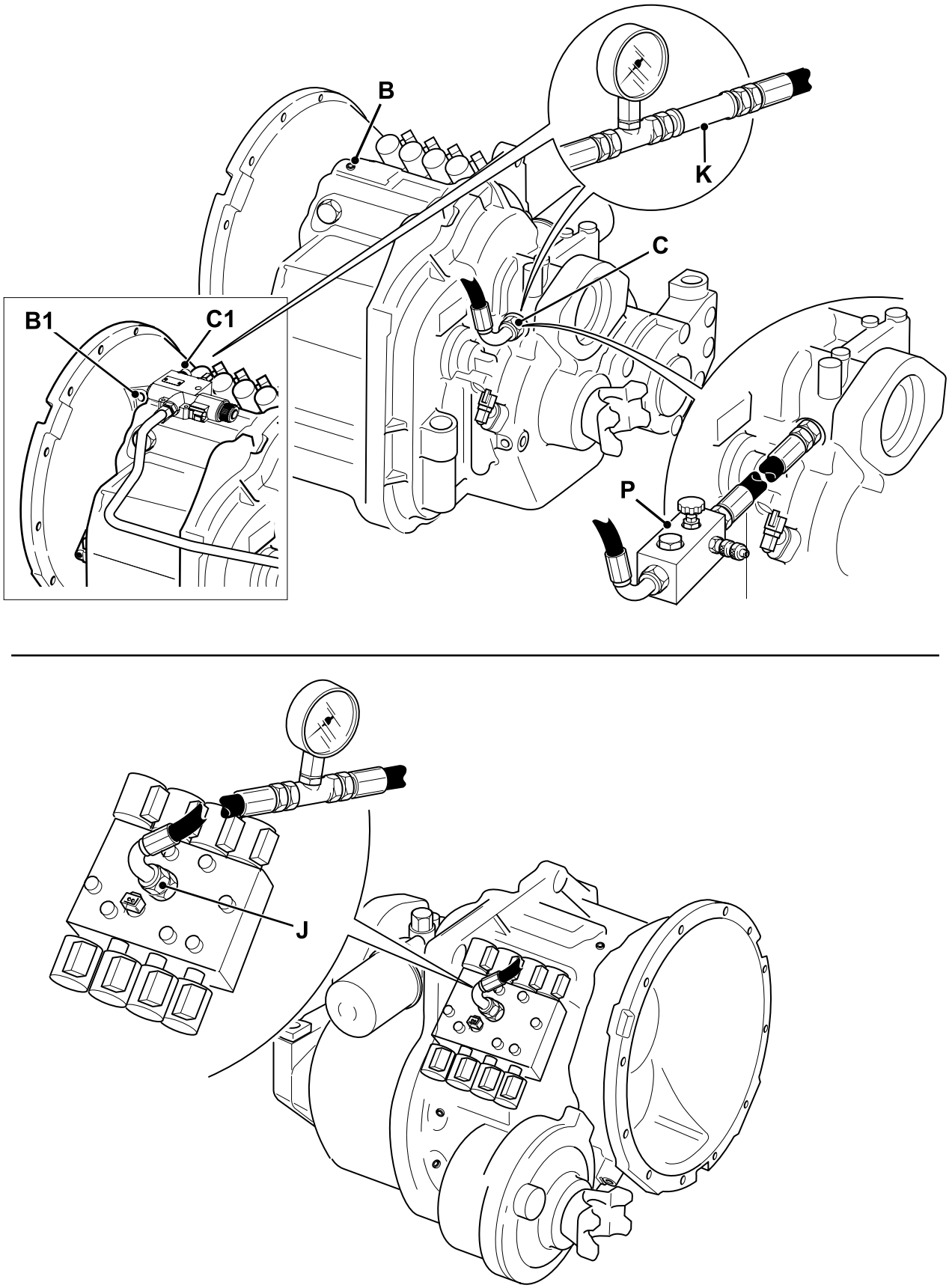


Fig 116. Pressure and Flow Tests

Clutch Leakage Tests

Isolating a Suspect Clutch

By performing the tests in the first 3 gears in forward and reverse all the clutches in the gearbox will be engaged, ensuring any clutch leakage will be easy to identify. Draw a table as shown so that you can record the results.

Clutch Pressure Test Results - 6 Speed Powershift						
Gear	**Clutches engaged**					
	Forward	bar	lbf/in²	Reverse	bar	lbf/in²
1st	X, Z			W, Z		
2nd	T, Z			V, Z		
3rd	U, Z			W, Y		

Clutch Pressure Test Results - 4 Speed Powershift						
Gear	**Clutches engaged**					
	Forward	bar	lbf/in²	Reverse	bar	lbf/in²
1st	T, Z			W, Z		
2nd	U, Z			V, Z		
3rd	T, Y			W, Y		

1 ⇨ ***Fig 118. (F-170)***. Stop engine, connect a 0-20 bar (0-300 lbf/in²) pressure gauge to test connector **A** (mainline pressure test point).

2 Make sure that both sides of all four wheels are chocked. Apply the footbrake and parking brake.

Note: *When fully engaged, the parking brake electrically disconnects the transmission drive; this prevents the machine from being driven with the parkbrake on. Therefore, so that we can complete the test, move the parkbrake lever fractionally forward until the warning light is just extinguished; hold the lever in this position for the duration of the test. DO NOT move the lever too far forward, otherwise the parkbrake will not be fully operational. Alternatively, disconnect the switch at the park brake.*

3 Start engine and run at 1000 rev/min, engage 1st gear forward. Record the pressure reading. Repeat the test for 2nd and 3rd gears forward and 1st, 2nd and 3rd gears reverse. Record the pressure readings as shown in the following example:

Clutch Pressure Test Results - 6 Speed Powershift						
Gear	**Clutches engaged**					
	Forward	bar	lbf/in²	Reverse	bar	lbf/in²
1st	X, Z	13.4	194	W, Z	13.4	194
2nd	**T, Z**	**12.0**	**175**	V, Z	13.6	197
3rd	U, Z	13.5	195	W, Y	13.5	195

Readings should not vary between clutches by more than 0.7 bar (10 lbf/in²). In the example shown, we can see that pressure is low when 2nd gear forward is selected, indicating clutch leakage.

From the table we can see that the layshaft clutch **Z** is working normally (1st and 3rd gear forward, 1st and 2nd gears reverse all show normal operating pressure). We can assume that the forward low clutch **T** is leaking.

By carrying out `Individual Clutch Leakage Tests', we can confirm that the forward low clutch **T** is leaking. ⇨ ***Individual Clutch Leakage Test (F-168)***.

Individual Clutch Leakage Test

When testing individual clutch pressures it is necessary to isolate the clutch being tested. So for instance, on a 6 speed gearbox, to check the **forward low clutch T** we must select 2nd gear forward - this would energise the **forward low (T) and layshaft (Z)** clutches. Because we only want to check the **forward low (T)** clutch pressure and not the **layshaft (Z)** clutch pressure, disconnect the electrical connector at the **layshaft** clutch solenoid **Zs** BEFORE selecting 2nd gear.

Use the tables to determine which solenoid electrical connectors should be disconnected when pressure testing individual clutches. Note that as the first 3 forward and reverse gears utilise all clutches, there is no need to select other gears when testing for leakage.

6 Speed Gearbox		
Gear Selected	**Clutches Engaged (Solenoids Energised)**	
1st Forward	6 Speed and Layshaft - X,Z	(Xs,Zs)
2nd Forward	Forward Low and Layshaft - T,Z	(Ts,Zs)
3rd Forward	Forward High and Layshaft - U,Z	(Us,Zs)
1st Reverse	Reverse Low & Layshaft - W,Z	(Ws,Zs)
2nd Reverse	Reverse High & Layshaft - V,Z	(Vs,Zs)
3rd Reverse	Reverse Low & Mainshaft - W,Y	(Ws,Ys)

4 Speed Gearbox		
Gear Selected	**Clutches Engaged (Solenoids Energised)**	
1st Forward	Forward Low & Layshaft - T,Z	(Ts,Zs)
2nd Forward	Forward High & Layshaft - U,Z	(Us,Zs)
3rd Forward	Forward Low & Mainshaft - T,Y	(Ts,Ys)
1st Reverse	Reverse Low & Layshaft - W,Z	(Ws,Zs)
2nd Reverse	Reverse High & Layshaft - V,Z	(Vs,Zs)
3rd Reverse	Reverse Low & Mainshaft - W,Y	(Ws,Ys)

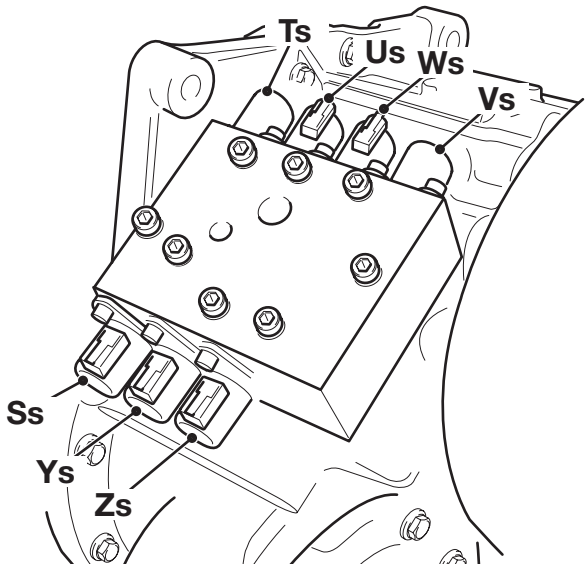


Fig 117.

In the following procedures the forward low clutch (**T**) is tested, therefore in step **2** a pressure gauge is connected to the forward low clutch test point.

When testing other suspect clutches connect a gauge to the relevant suspect clutch test point. Because the forward low clutch is suspect, a gear must be selected that will use the forward low clutch, in this instance 2nd gear forward.

1 ⇒ *Fig 118. (F-170)*. Stop engine, connect a 0-20 bar (0-300 lbf/in²) pressure gauge to test connector **A**, (mainline pressure test point).

2 Connect a 0-20 bar (0-300 lbf/in²) pressure gauge to test connector **T** (forward low ratio clutch test point).

3 Disconnect the electrical connector at the layshaft clutch solenoid **Zs**. This will make sure that only the forward low clutch solenoid **Ts** is energised when 2nd gear forward is selected.

4 Make sure that both sides of all four wheels are chocked. Apply the footbrake and parking brake.

Note: *When fully engaged, the parking brake electrically disconnects the transmission drive; this prevents the machine from being driven with the parkbrake on. Therefore, so that we can complete the test, move the parkbrake lever fractionally forward until the warning light*

is just extinguished; hold the lever in this position for the duration of the test. DO NOT move the lever too far forward, otherwise the parkbrake will not be fully operational. Alternatively, disconnect the switch at the park brake.

5 Start engine and run at 1000 rev/min, select 2nd gear forward. Note the pressure readings on both gauges, which should not vary by more than 0.7 bar (10 lbf/in^2). If the difference on the gauges is greater than 0.7 bar (10 lbf/in^2) do the following:

a Stop the engine and interchange the gauges.

b Start the engine and run at 1000 rev/min, select 2nd gear forward. If the difference on the gauges is still greater than 0.7 bar (10 lbf/in^2) dismantle the forward low clutch for servicing.

c If after interchanging the gauges, the readings are different than at step **5**, have the gauges calibrated and repeat the testing procedure.

ShiftMaster Machines with ECU 2.2

On ShiftMaster machines with ECU 2.2 it is possible to energise each transmission solenoid individually via a laptop computer using the **ShiftMaster Diagnostics** software. ⇨ ***Solenoid Test Mode Page (ECU 2.2 only) (F-200)***.

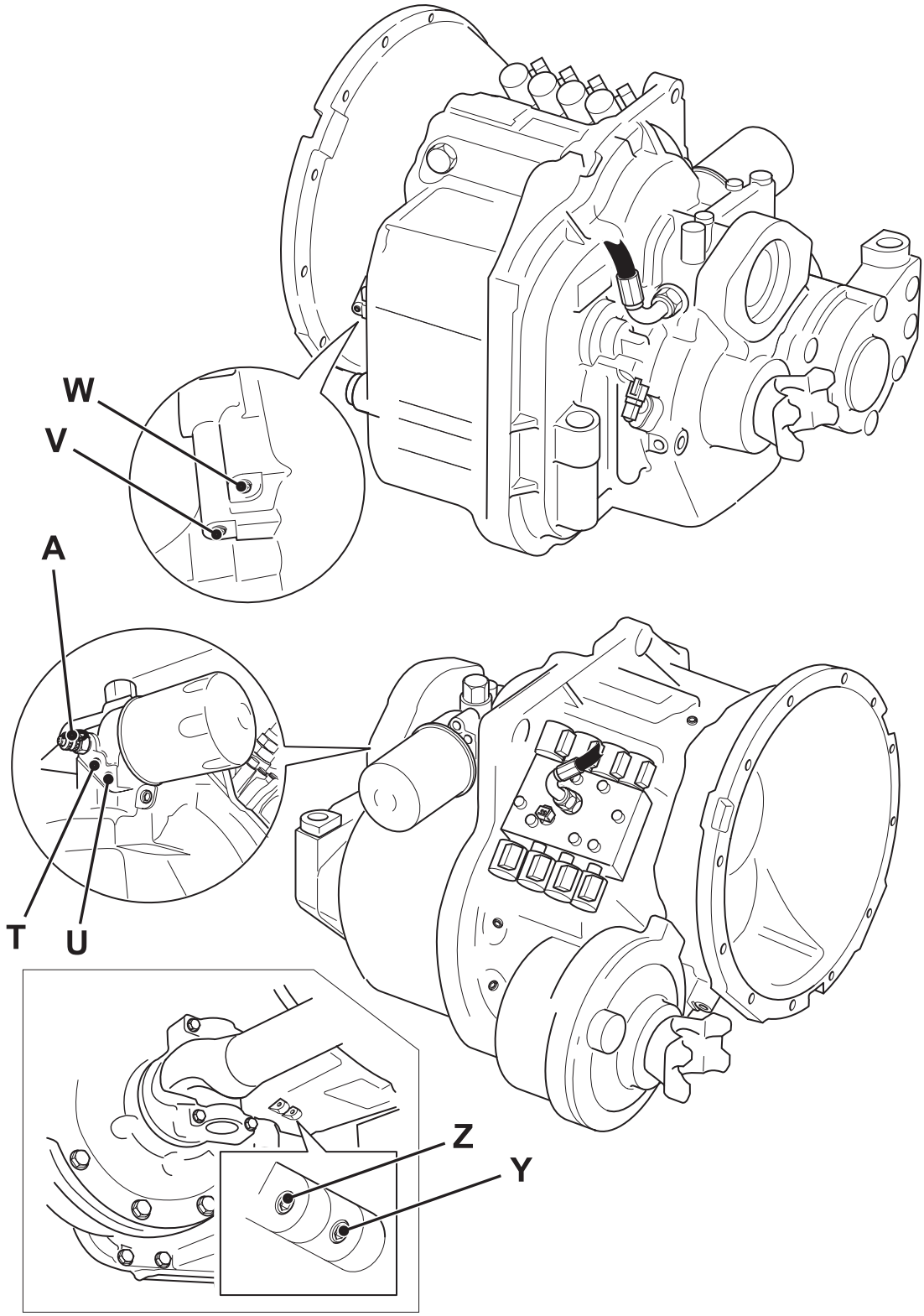


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Fig 118. Test Points for Individual Clutches

Solenoid Control Valve Cartridge - Solenoid Coil

Removal and Replacement

The solenoid coil is an integral part of the valve cartridge. If the solenoid coil is faulty the complete valve cartridge must be renewed. ⇨ ***Solenoid Control Valve Cartridge - Single Fixing Type (F-172)***.

Solenoid Control Valve Cartridge - Single Fixing Type

The gearbox control valve assembly features 7 (4 speed) or 8 (6 speed) solenoid control valve cartridges **A**. The removal and replacement procedure is identical for all valve cartridges.

Removal

1 Clean off all debris, dirt and grit from around the solenoid control valves. There must be no ingress of debris, dirt or grit inside the valve block **H**.

Important: *Cleanliness is of the utmost importance when working on the gearbox. Any ingress of dirt or grit inside the valve block can cause serious damage to the control valves and gearbox.*

2 Uncouple the electrical connector **B**.

Note: *If more than 1 valve cartridge is to be removed, label the electrical connectors to ensure correct assembly.*

3 Note the phasing of the electrical connector block **G** to ensure correct assembly.

4 Undo screw **C** and remove clamp **D**.

5 Pull the valve cartridge **A** from the valve block. DO NOT grip the unit by its electrical connector block **G**. The connector block is not designed as a leverage point.

Replacement

Replacement is the reversal of the removal procedure. Note the following:

Make sure that the 3 `O' ring seals **E** are undamaged. If the seals are damaged, or the valve is leaking, renew the complete valve cartridge assembly.

Before inserting the valve cartridge lubricate the 3 `O' ring seals **E** and sealing bores **F** in the valve block with gearbox oil.

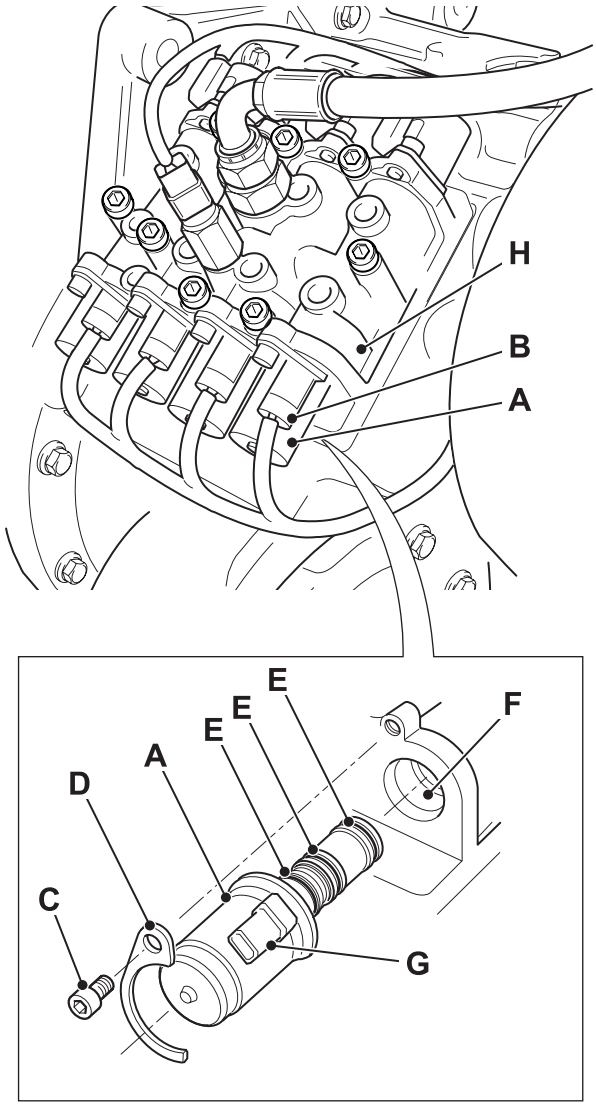


Fig 119.

Table 45. Torque Settings

Item	Nm	kgf m	lbf ft
C	10 - 12	1 - 1.2	8 - 9

Solenoid Control Valve Cartridge - Twin Fixing Type

The gearbox control valve assembly features 7 (4 speed) or 8 (6 speed) solenoid control valve cartridges **A**. The removal and replacement procedure is identical for all valve cartridges.

Removal

1 Clean off all debris, dirt and grit from around the solenoid control valves. There must be no ingress of debris, dirt or grit inside the valve block **H**.

Important: *Cleanliness is of the utmost importance when working on the gearbox. Any ingress of dirt or grit inside the valve block can cause serious damage to the control valves and gearbox.*

2 Uncouple the electrical connector **B**.

Note: *If more than 1 valve cartridge is to be removed, label the electrical connectors to ensure correct assembly.*

3 Note the phasing of the electrical connector block **G** to ensure correct assembly.

4 Undo screws **C**.

5 Pull the valve cartridge **A** from the valve block. DO NOT grip the unit by its electrical connector block **G**. The connector block is not designed as a leverage point.

Replacement

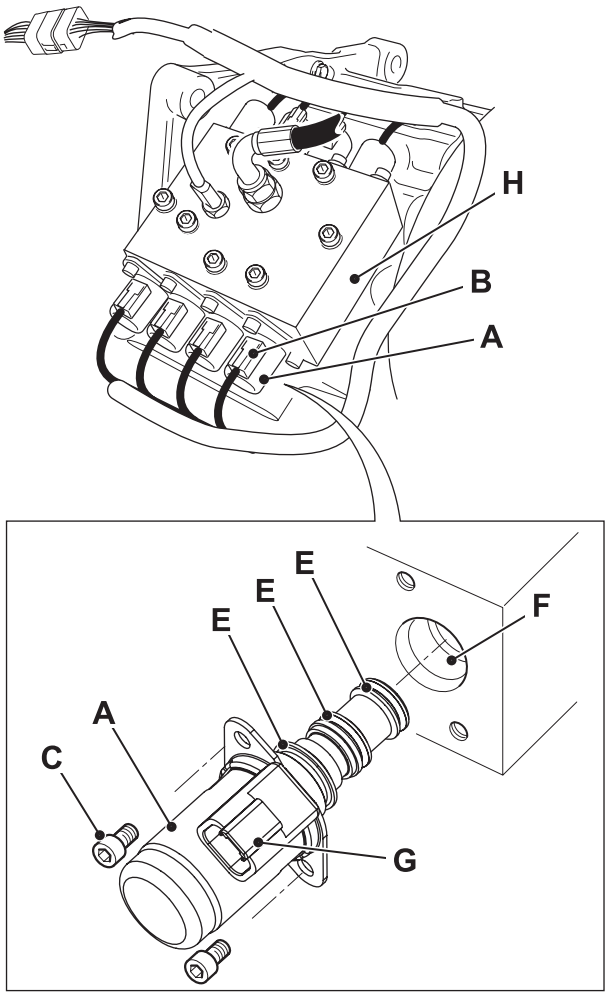
Replacement is the reversal of the removal procedure. Note the following:

Make sure that the 3 `O' ring seals **E** are undamaged. If the seals are damaged, or the valve is leaking, renew the complete valve cartridge assembly.

Before inserting the valve cartridge lubricate the 3 `O' ring seals **E** and sealing bores **F** in the valve block with gearbox oil.

Table 46. Torque Settings

Item	Nm	kgf m	lbf ft
C	3 - 4	0.3 - 0.4	2.2 - 3



C090650

Fig 120.

Oil Pressure Switch

Removal

1 Clean off all debris, dirt and grit from around the pressure switch **A**. There must be no ingress of debris, dirt or grit inside the gearbox.

2 Uncouple the electrical connector **B**.

3 Unscrew the pressure switch and discard the sealing washer **C**.

4 Cap the open port on the gearbox.

Replacement

Replacement is the reversal of the removal procedure. Note the following:

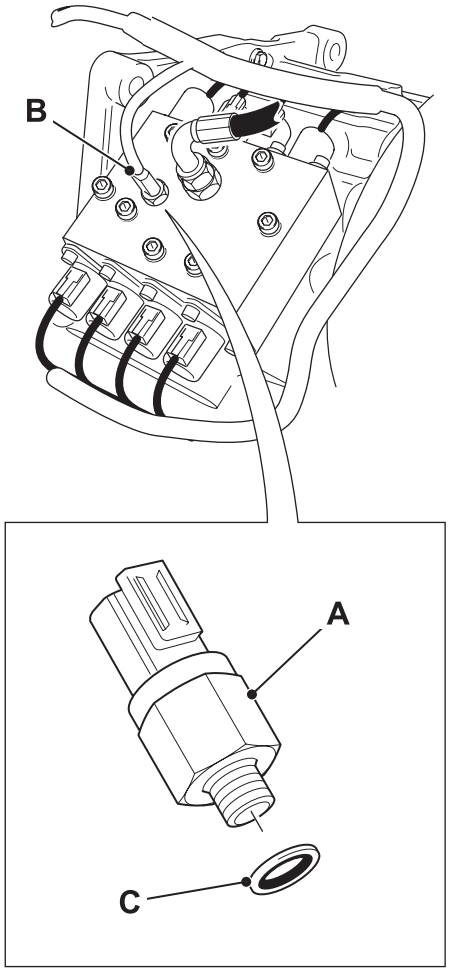
The oil pressure switch is a non serviceable component. If it is faulty or damaged, it must be renewed.

Renew the sealing washer **C**.

Torque tighten the pressure switch.

Table 47. Torque Settings

Item	Nm	kgf m	lbf ft
A	10	1.0	7.4



C090660

Fig 121.

Oil Temperature Switch - Non Lock Up Torque Converter Variants

Removal

1 Clean off all debris, dirt and grit from around the temperature switch **A**. There must be no ingress of debris, dirt or grit inside the gearbox.

2 Uncouple the electrical connector **B**.

3 Unscrew the temperature switch and discard the sealing washer **C**.

4 Cap the open port on the gearbox.

Replacement

Replacement is the reversal of the removal procedure. Note the following:

The oil temperature switch is a non serviceable component. If it is faulty or damaged, it must be renewed.

Renew the sealing washer **C**.

Torque tighten the pressure switch.

Table 48. Torque Settings

Item	Nm	kgf m	lbf ft
A	16	1.6	12

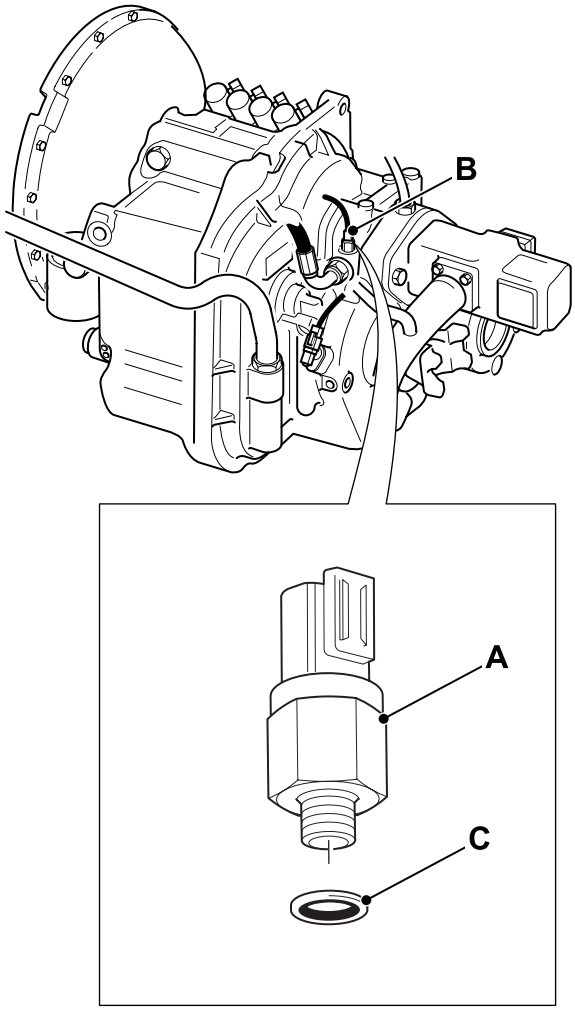


Fig 122.

Oil Temperature Switch - Lock Up Torque Converter Variants

Removal

1 Clean off all debris, dirt and grit from around the temperature switch **A**. There must be no ingress of debris, dirt or grit inside the gearbox.

2 Uncouple the electrical connector **B**.

3 Unscrew the temperature switch and discard the sealing washer **C**.

4 Cap the open port on the gearbox.

Replacement

Replacement is the reversal of the removal procedure. Note the following:

The oil temperature switch is a non serviceable component. If it is faulty or damaged, it must be renewed.

Renew the sealing washer **C**.

Torque tighten the pressure switch.

Table 49. Torque Settings

Item	Nm	kgf m	lbf ft
A	16	1.6	12

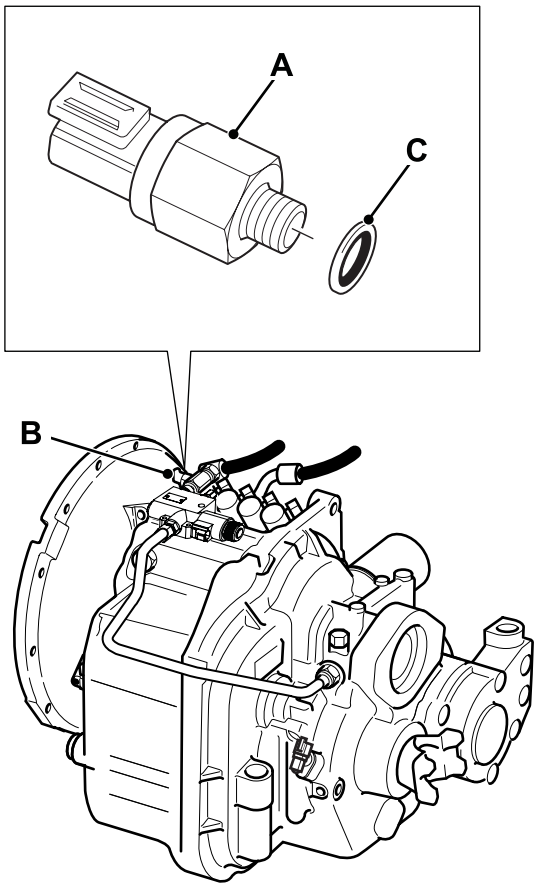


Fig 123.

Powershift Gearbox (ShiftMaster)

Speed Sensors

The gearbox electronic control system incorporates a gearbox speed sensor. Transmissions with a lock up torque converter (Torque Lock) are fitted with an additional speed sensor to measure engine speed.

Gearbox Speed Sensor

⇨ *Fig 124. (F-178)*. Powershift machines fitted with an electronic control unit (ShiftMaster ECU) or a speedometer have a speed sensor **D** fitted. The speed sensor detects the speed of rotation of the gearbox output shaft and relays this information to the ECU or speedometer as applicable.

The sensor detects the passing of the gear teeth on the output gear. When adjacent to the top of a gear tooth the sensor electrical output turns ON, when adjacent to a gap between the teeth the sensor output turns OFF. In this way the frequency of the electrical signal changes according to the speed of gear rotation and therefore machine road speed.

The ShiftMaster ECU uses the input from the speed sensor to determine gear shift points. Failure of the speed sensor or its wiring will enable an ECU `Limp Mode', preventing the use of 4th, 5th, and 6th gears. See ***Fault Finding - Powershift Gearbox***.

Testing

The speed sensor can be tested in-situ without removing it by means of service test harness 892/01096.

1 Park the machine on firm level ground, engage the parking brake and set the transmission to neutral. Lower the loader arms to the ground. Switch OFF the engine and remove the starter key.

2 Connect the test harness **E** as shown. Tie back and secure the wires clear of the driveshaft and other moving components, in a position where the light emitting diode (LED) can be seen while operating the machine.

3 Turn the engine ON and drive the machine forward approximately 2 m (6 ft), make sure it is clear in front. Alternatively raise the wheels off the ground. If the sensor is operating correctly the LED will illuminate as the gear teeth pass the sensor, when the speed increases the LED will flash at a greater frequency until becoming continuously illuminated at higher speeds.

4 If the LED fails to illuminate carefully check the relevant wires and connectors for damage. Repair as required and re-test the sensor as described above. It should be noted that the speed sensor is normally a reliable component and a fault is more likely attributed to damaged wires or electrical connectors, see ***Electrical Connections - Powershift Gearbox (ShiftMaster)***.

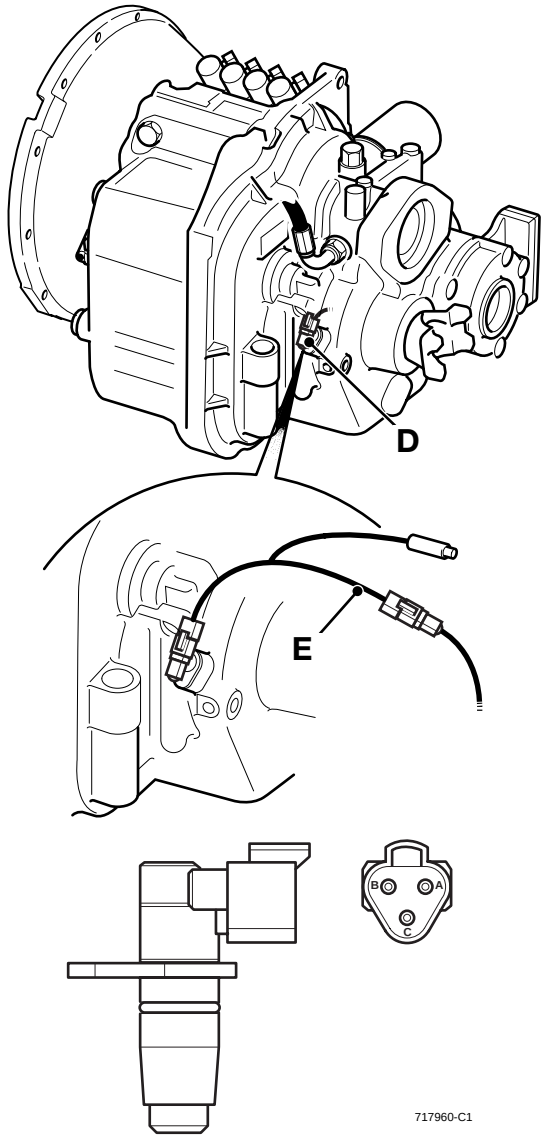


Fig 124. Speed Sensor

Key:

A Ground

B +V

C Output

Engine Speed Sensor

⇒ *Fig 125. (F-179)*. ShiftMaster machines fitted with a lock up torque converter (Torque Lock) have an engine speed sensor **A** fitted. The speed sensor detects the speed of rotation of the engine crank shaft and relays this information to the ECU.

The sensor detects the passing of teeth on a target disc **B**. The target disc is bolted to the engine crank shaft pulley. When adjacent to a tooth the sensor electrical output turns ON, when adjacent to a gap between the teeth the sensor output turns OFF. In this way the frequency of the electrical signal changes according to the speed of rotation and therefore engine speed.

The ShiftMaster ECU uses the input from the speed sensor as part of the control logic for operation of the lock up clutch in the torque converter. Failure of the speed sensor or its wiring will disable lock up operation. See ***Fault Finding - Powershift Gearbox***.

Testing

The speed sensor can be tested in situ without removing it by means of service test harness 892/01096.

1 Park the machine on firm level ground, engage the parking brake and set the transmission to neutral. Raise the loader arms and fit the safety strut.

2 Connect the test harness **C** as shown. Tie back and secure the wires clear of the engine drive pulleys, cooling fan and other moving components. make sure that the light emitting diode (LED) **D** can be seen.

3 Start the engine. If the sensor is operating correctly the LED will illuminate as the target disc teeth pass the sensor, when the speed increases the LED will flash at a greater frequency until becoming continuously illuminated at higher speeds.

Note: *If the LED flashes with irregular frequency the target disc may be dirty or bent. This can cause false speed readings, or no input at the ECU.*

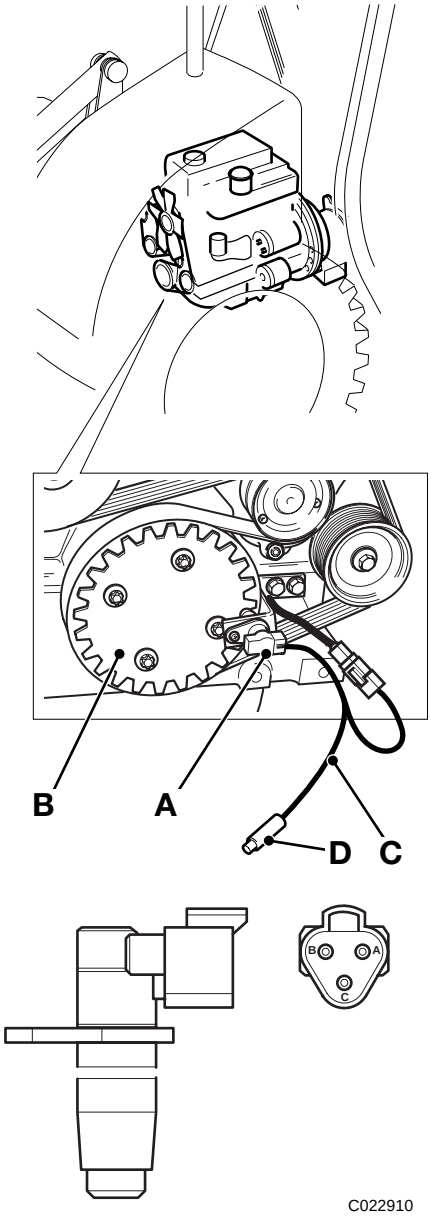


Fig 125.

Key:

A	Ground
B	+V
C	Output

4 If the LED fails to illuminate correctly carry out the following procedures in order, re-testing the speed sensor as applicable:

Note: *It should be noted that the speed sensor is normally a reliable component and a fault is more likely attributed to factors such as a damaged target disc, damaged wires or electrical connectors.*

a Inspect the target disc **126C** for excessive accumulations of rust or dirt. Clean the disc if necessary.

b Inspect the target disc **126C** for signs of damage. Carefully straighten any bent teeth. If in doubt renew the disc.

c Check the speed sensor target disc clearance **126X**. The measurement is factory set between 0.5 mm and 1.8 mm (0.02 in to 0.07 in). If adjustment is required undo the speed sensor mounting bracket fixing bolts **126A** and add or subtract shims **126B** as required. The shims are 0.25 mm (0.01 in) thick.

d Carefully check the relevant wires and connectors for damage, see ***Electrical Connections - Powershift Gearbox (ShiftMaster)***.

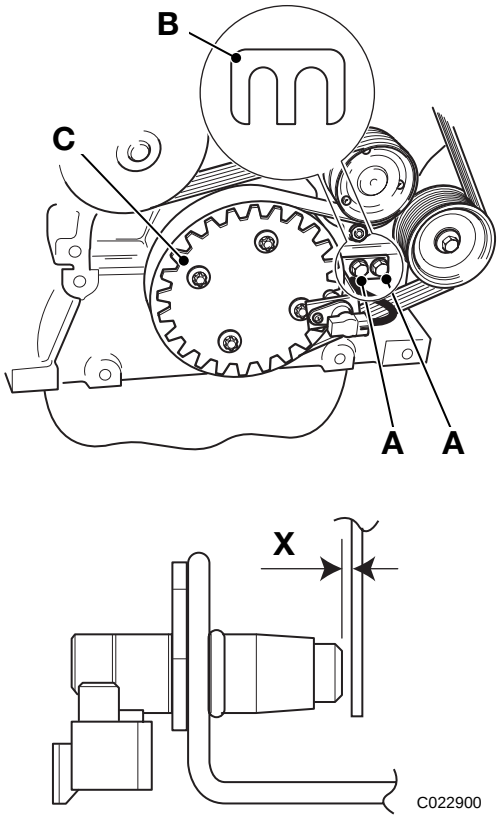


Fig 126.

Electronic Control Unit

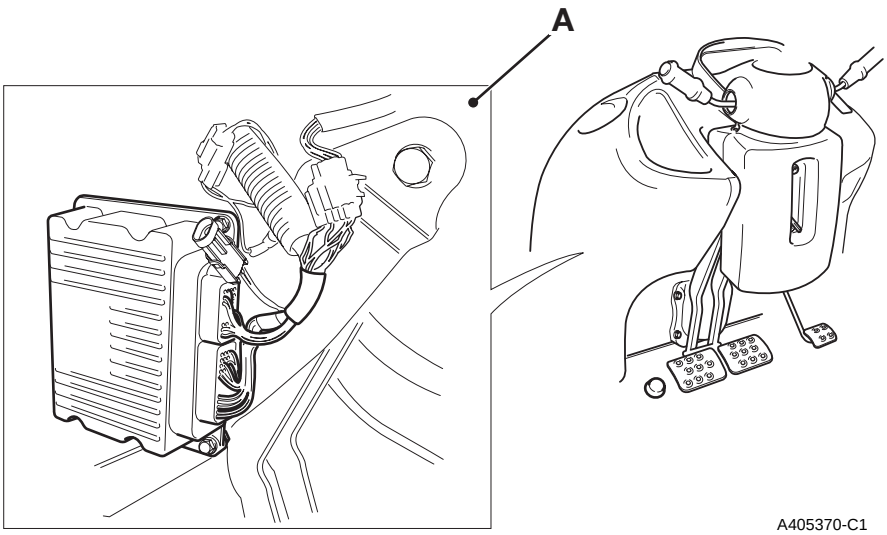


Fig 127.

The ShiftMaster gearbox is controlled by an Electronic Control Unit (ShiftMaster ECU). The ECU is located behind the front console as shown at **A**.

The ECU is housed in a rugged case protected from ingress of dirt and moisture. Gearbox faults are more likely to be caused by faulty or damaged wiring, electrical components or hydraulic faults than by failure of the ShiftMaster ECU.

Fault Finding

When fault finding note the following:

Make sure you understand the normal operation characteristics of the ShiftMaster gearbox. Some characteristics may be interpreted as faults by some operators. See ***ShiftMaster Operation Characteristics***.

The ShiftMaster ECU incorporates `Limp Modes'. These modes can operate in response to other gearbox faults. Make sure you understand the characteristics of the `Limp Modes' ⇨ ***Gearbox `Limp Modes' (F-182)***.

The simplest and best way to fault find the ECU controlled gearbox electrical system, (including the ECU) is by using ShiftMaster Diagnostics software and a laptop PC. See ***Diagnostics User Guide***. This diagnostics system enables the engineer to quickly identify faults with specific electrical circuits or devices. The devices electrical connections, locations and wire identifications are given in ***Electrical Connections - Powershift Gearbox (ShiftMaster)***. See also ***Section C - Harness Data.***

If the facilities to use the ShiftMaster Diagnostics software system are not available, the gearbox and ECU can still be checked using a conventional multimeter, see ***Electrical Connections - Powershift Gearbox (ShiftMaster)***. See also ***Section C - Harness Data***.

Software Upgrades

From time to time a ShiftMaster ECU `Application Software' upgrades may be made available by JCB Service. If necessary `Application Software' can be loaded into the ECU flash memory using a laptop PC and the **ShiftMaster Flash Programmer** application. This application is part of the **JCB Service Master** package found on the JCB Service Technical Information CD's. The Flash Programmer application includes comprehensive help files.Note that the ECU contains 2 sets of software, `Application Software' and `Setup Data'. The `Setup Data' is specific to a machine variant and can not be changed or replaced.

Renewing the ECU

Before renewing the ECU note the following:

The ShiftMaster ECU is a **non serviceable part**. Any units returned under warranty found to have been tampered with will invalidate any claim.

ECU's are configured at the factory for each machine variant and are not interchangeable between machines. Although the part numbers may be the same, the internal software may not be. **DO NOT interchange ECU's between machines**.

Before renewing the ECU carry out all the relevant fault finding and diagnostics to **confirm ECU failure**. Units returned under warranty found not to be faulty will invalidate any claim.

Gearbox `Limp Modes'

When applicable the ShiftMaster ECU provides restricted or modified gearbox operation if faults are detected by the ECU. Typical `Limp Mode' forms of operation are:

Mode	Possible Reason
Limp Mode 1 (2 Beeps at power-up)	Internal `Setup Data' ECU fault.
Machine autoshifts at different road speeds than normal.	If on power-up the ECU detects an internal fault with its `Setup Data' it will revert to use of a default set of values.
Limp Mode 2 (1 Beep at power-up)	Error with ECU `Application Software'.
Machine remains in neutral at all times.	If on power-up the ECU detects an internal fault with its `core operating software' it will prevent operation of the gearbox.
Limp Mode 3 (Machine will not autoshift)	Error reading transmission speed.
Only 1st, 2nd, and 3rd gears available.	If the ECU does not detect any input from the speed sensor it will prevent selection of any gear above 3rd.
Limp Mode 4 (Repeating beeps until ECU power is reset)	Error reading transmission speed.
Machine holds a gear.	If the ECU detects an error with the speed sensor while operating it prevents autoshifting.

Note: *On power-up the ECU will normally sound 3 beeps. These beeps can be masked by other audible warnings on start-up.*

ShiftMaster Diagnostics 2.2 - User Guide

Introduction

The **ShiftMaster Diagnostics** software tool is part of the **JCB Service Master** software suite. The diagnostics software is designed to be an easy to use fault finding tool for Powershift PS760 series electronically controlled gearboxes.

ShiftMaster Diagnostics employs the graphical strengths of the Microsoft Windows operating environment to simplify electrical fault finding within the gearbox ECU control system.

ShiftMaster Diagnostics is only intended for use with ECU 2 and ECU 2.2 controlled PS760 gearboxes. The system is not compatible with relay controlled gearboxes. Older versions of Powershift Controllers used on the PS750 series gearboxes are not supported.

This software is intended for use on IBM Compatible Personal Computers **(PCs)** running **Windows 9x**, **Windows2000** and **WindowsXP** operating systems but is not compatible with either earlier versions of **Windows 3.x**. Ideally the computer should be a laptop type.

Care and Safety

⚠ WARNING

Be sure to read and follow any on screen instructions. Failure to follow correct procedure could result in death or injury.

2-4-5-5

Fig 128.

Installing ShiftMaster Diagnostics

The **ShiftMaster Diagnostics** tool is fully integrated within JCB Service Master. To use ShiftMaster diagnostics you must install **JCB Service Master** onto a suitable laptop computer.

For full instructions on how to install **JCB Service Master** software please refer to the documentation which accompanies JCB Service Master.

Connecting ShiftMaster Diagnostics

To use ShiftMaster Diagnostics your laptop computer must be connected to the machine transmission ECU diagnostics connector ⇨ *Fig 130. (F-185)* or ⇨ *Fig 131. (F-186)* as applicable. Connection is made using Diagnostic Link Adapter (DLA) **129C** and the applicable cables.

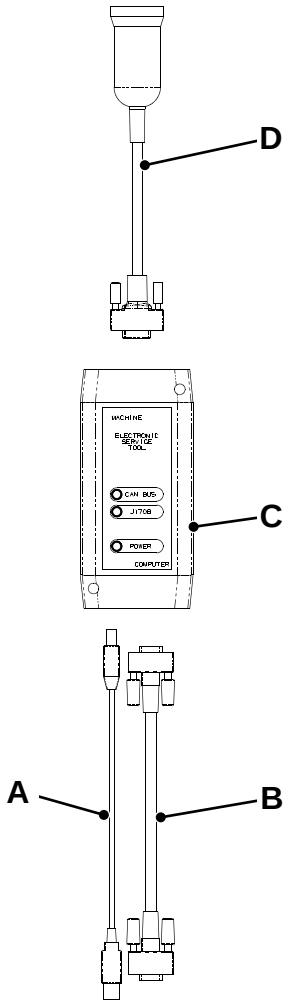


Fig 129.

A	USB PC Cable	718/20235
B	Serial PC Cable	718/20236
C	USB DLA	728/26500
D	Machine Cable	718/20237

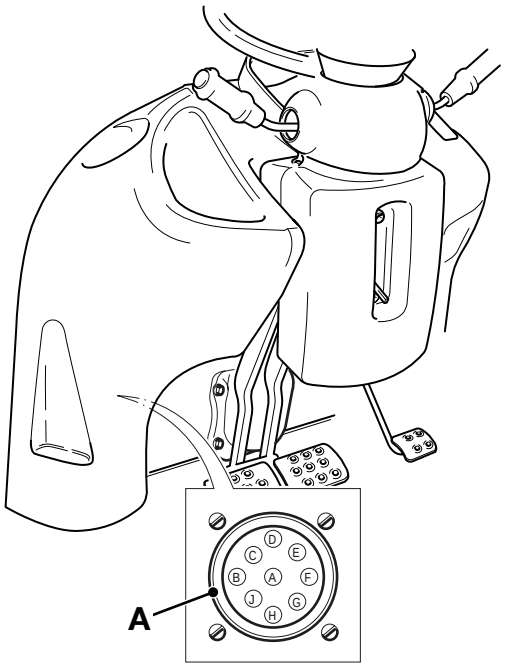
Kit 892/01174 (includes items A,B,C and D)

1 Connect either the 'Serial PC Cable' **129B** (718/20236) or the 'USB PC Cable' **129A** (718/20235) between the DLA **129C** and a free port on your laptop computer.

The 'Serial PC cable' has a 9-way D-type connector on one end and a 25-Way D-type connector on the other. Plug the 25-way male connector into the DLA and the other connector into a free port on your laptop PC, remembering to tighten any thumb-screws appropriately.

2 Connect the 'Machine Cable' **129D** between the DLA and the machines' Diagnostic Connector **130A** or **131A** as applicable.

The 'Machine Cable' has a 15-way D-type connector on one end and a 9-way CAN connector on the other. Plug the 15-way connector into the DLA and tighten the thumb-screws, then connect the 9-way CAN connector into the machines' Diagnostics Connector and twist the lock-ring to secure it.



A405350-C3

Fig 130. Diagnostics Connector - Early Machines

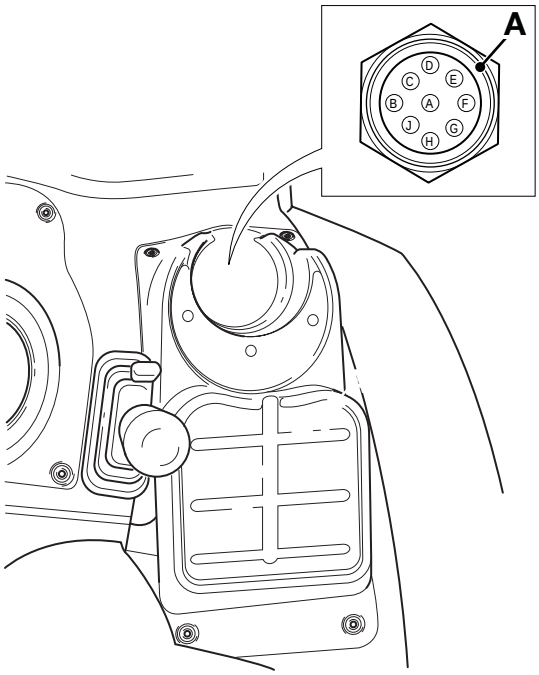


Fig 131. Diagnostics Connector - Later Machines

Starting ShiftMaster Diagnostics

1 Turn ON the machine ignition and additionally start the engine if required (taking normal precautions).

2 Start **JCB Service Master** on the laptop computer.

Fig 132.

3 Make sure that the correct DLA is selected in the chooser. Click on `Utilities', DLA Setup. The DLA Chooser window opens. Check the button to match to the Current Device. Click `Apply' ⇒ *Fig 133. (F-187)*.

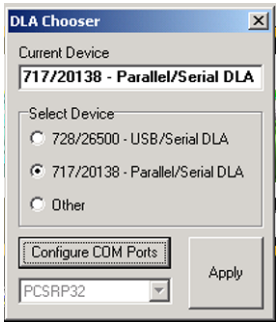


Fig 133.

4 Select `Backhoe Loader' from the drop down list ⇒ *Fig 132. (F-187)* and then start the diagnostics tool running by clicking on the **ShiftMaster Diagnostics** icon ⇒ *Fig 134. (F-187)*.

Fig 134.

5 Warning message appears ⇒ *Fig 135. (F-187)*. Read and understand the Warning message. If you can comply with the requirements press the `Accept' button.

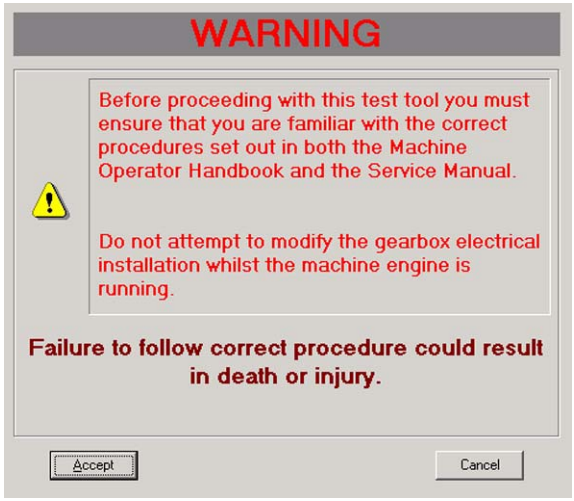


Fig 135.

6 The **ShiftMaster Diagnostics** tool will then open up displaying the main window ⇒ *Fig 136. (F-187)*.

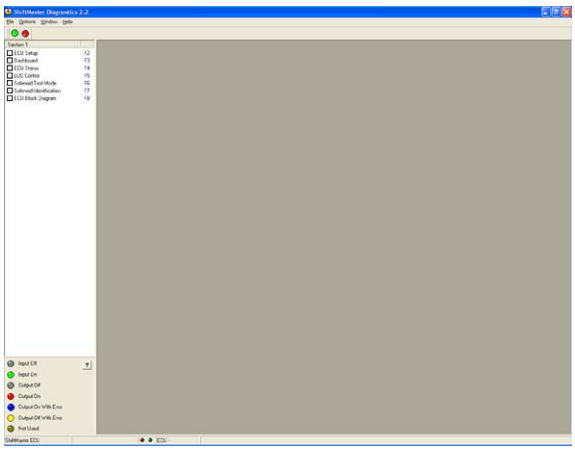


Fig 136.

ShiftMaster Diagnostics Overview

There are several key elements to the **Diagnostics** tool. These can be seen labelled below. Each element is explained in detail in later sections.

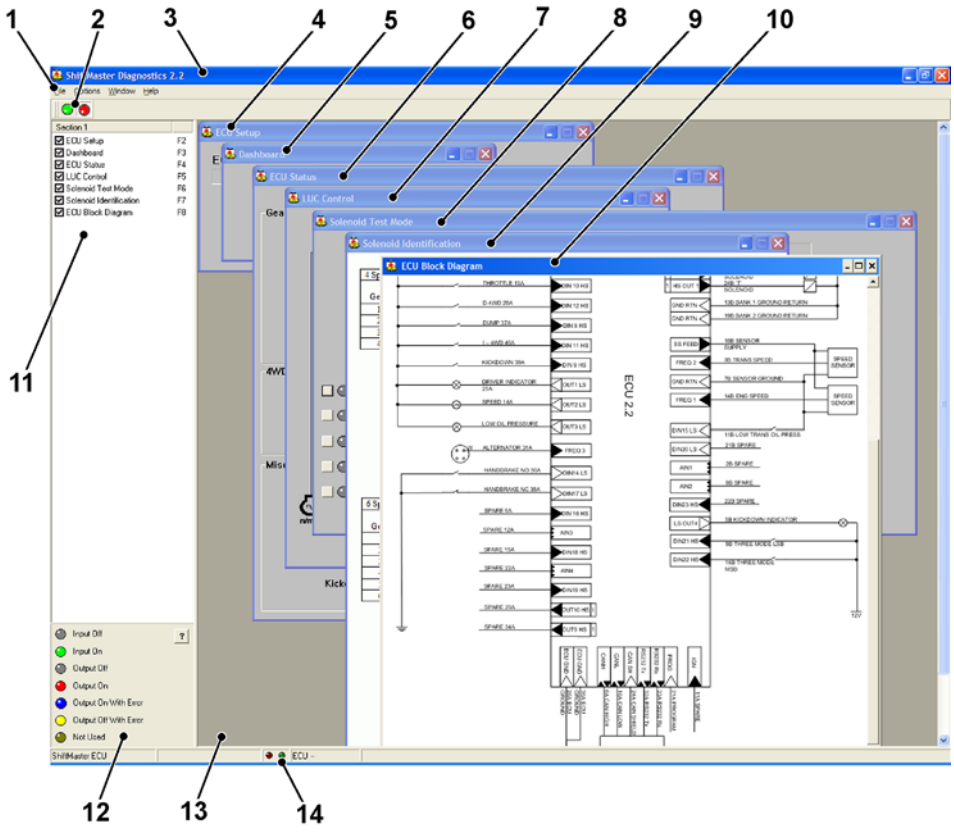


Fig 137.

Key:

1	Menu Bar	⇨ F-189)	8	Solenoid Test Mode Page	⇨ F-200)
2	Start and Stop Buttons	⇨ F-192)	9	Solenoid Identification Page	⇨ F-201)
3	Main Window		10	ECU Block Diagram Page	⇨ F-201)
4	ECU Setup Page	⇨ F-194)	**11**	Page List(1)	⇨ F-193)
5	Dashboard Page	⇨ F-195)	12	LED Status Key	⇨ F-196)
6	ECU Status Page	⇨ F-196)	**13**	Page Display Area	
7	LUC Page(2)	⇨ F-198)	**14**	Status Bar	⇨ F-193)

(1) The page list differs depending on the type of ECU connected (ECU 2 or ECU 2.2)
(2) Lock up torque converter page. Some gearboxes are not fitted with a lock up torque converter. The diagnostics software always displays the page even if it is not applicable.

Navigating within ShiftMaster Diagnostics

Navigation is designed to be via a mouse. On Laptop PCs this may take the form of a small joystick or touch sensitive pad and some buttons, usually located near to the keyboard.

As with most Windows based programs, it is possible to navigate the **ShiftMaster Diagnostics** software using the keyboard by pressing certain combinations of keys.

Note: *This can be particularly useful for certain Laptop computers where the mouse/joystick can be over-sensitive. Try out the following, it may come in useful one day.*

There are two main methods of navigation described below;

- Pressing the **ALT** key will cause the File option on the Menu Bar to be highlighted. You can then use the arrow keys to navigate the menus.
- Notice that all the menu items on the Menu Bar have a letter that is underlined (e.g. the 'F' in **File**). Holding down the ALT key and pressing the required letter key will activate that option (i.e. either open the menu or execute a function). For example, if you wish to open the Preferences Dialogue this can be done by pressing **ALT + O** (to open the **Options** menu) then **ALT + P** (to execute the **Preferences** option).

Menu Bar - File Menu

The File Menu contains an Exit option to close down the program ⇨ *Fig 138. (F-189)*.

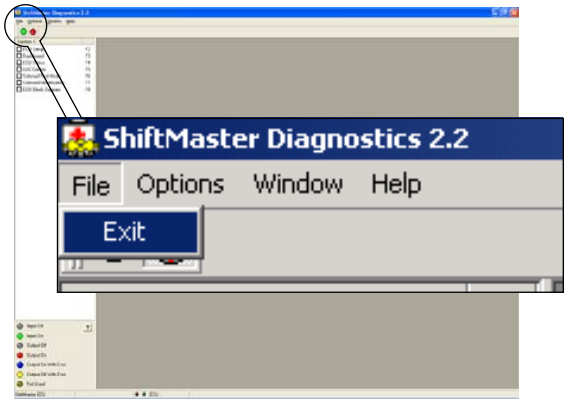


Fig 138.

On exiting the program communications with both ECU and DLA are shut down.

Menu Bar - Options Menu

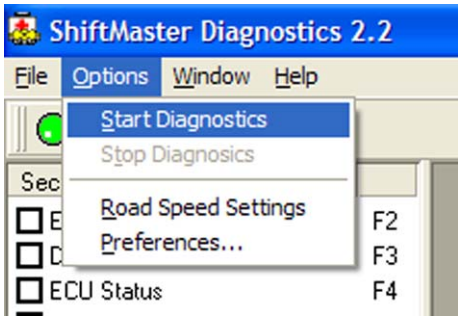


Fig 139.

– **Start Diagnostics** to commence communications with the ShiftMaster ECU ⇒ *Fig 139. (F-190)*.

– **Stop Diagnostics** to cease communications ⇒ *Fig 139. (F-190)*.

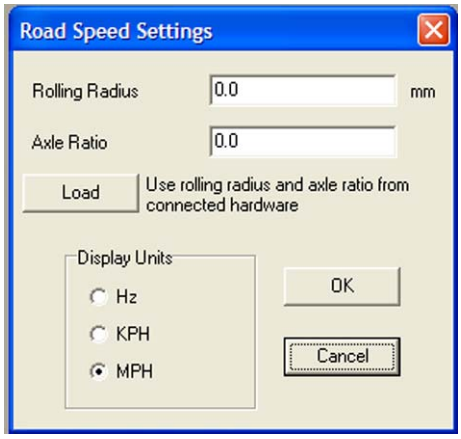


Fig 140.

– **Road Speed Settings** (ECU 2.2 only) Opens up the Road Speed Settings window ⇒ *Fig 140. (F-190)*.

– Press the `**Load**' button to upload the data from the ECU.

– If the rolling radius of the wheel has been changed (due to a tyre fitment change for example) input the rolling radius and the associated axle ratio.

– To change the speed units displayed by the diagnostics software check the required button on the **Display Units** panel.

– Press the `**OK**' button to save the settings and close the window.

Fig 141.

– **Preferences** option opens up the Preference Dialogue ⇒ *Fig 141. (F-190)*.

Fig 142.

– From the Preferences Dialogue there is support for multiple languages. Use the drop-down menu and scroll bar to chose the required language ⇒ *Fig 142. (F-190)*. Languages presently on offer are

– **English (Canada)**

– **English (United Kingdom)**

– **French (France)**

– **German (Germany)**

– **Italian (Italy)**

– **Portuguese (Portugal)**

– **Spanish (International Sort)**

Note: *The language option only effects text within the Main Window (e.g. Page List, LED Status Key, etc). Language support is not available for the text within the page displays.*

Fig 143.

– The Preferences Dialogue also offers the ability to change the background colour of the Page displays. Select the required background colour using the radio buttons ⇨ *Fig 143. (F-191)*.

Note: *When using a laptop PC it can often be difficult to see the screen in bright sunlight. Changing the background colour can help improve the contrast (especially with the different LED colours) and so make viewing the screen easier.*

Once your preferences have been selected either:

Click on the **OK** button to apply them or click on the **Cancel** button to leave them unchanged.

Menu Bar - Window Menu

⇨ *Fig 144. (F-191)*

Fig 144.

Like most other Windows based programs where there are multiple sub-windows or Pages used, there are usually options to organise how they are laid-out. ShiftMaster Diagnostics software is no different and offers the following options;

– **Cascade**
– **Tile Horizontally**
– **Tile Vertically**

Menu Bar - Help Menu

⇨ *Fig 145. (F-192)*

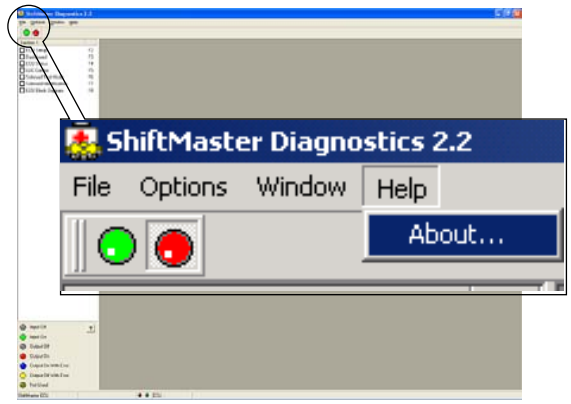


Fig 145.

– **About**: Opens a window showing the part number and the version number of the installed copy of the **Diagnostics** software ⇨ *Fig 146. (F-192)*.

Fig 146.

Start and Stop Buttons

These offer the same function as the **Start Diagnostics** and **Stop Diagnostics** options within the Options Menu.To start the **Diagnostics** tool communicating with the gearbox ECU simply click on the **Start Button** (large green LED) at the top of the Main Window.Similarly, click on the **Stop Button** (large red LED) to cease communications ⇨ *Fig 147. (F-192)*.

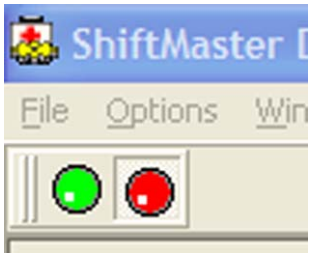


Fig 147.

Page List

In the top left corner of the main window is displayed a list of pages which can be displayed ⇨ *Fig 148. (F-193)*.

Note: *The page list differs depending on the type of ECU connected (ECU 2 or ECU 2.2).*

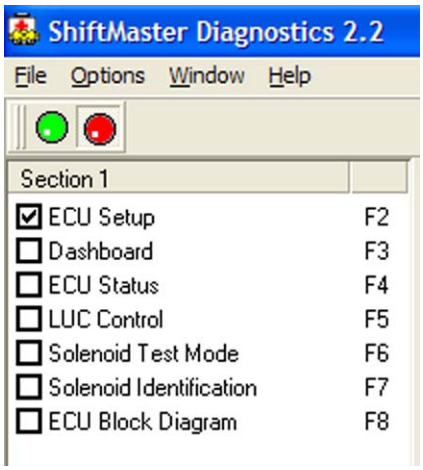


Fig 148.

Clicking in the box next to the required page will make that page appear in the main window display area. (A tick will also appear in the box to show it is being displayed.) At any time the user may swap between displayed pages simply by clicking in the check box of the required page in the page list. The function keys, F2, F3 etc. can also be used to select pages as required.

Status bar

There are 2 items of interest displayed on the **Status Bar**, which is located along the bottom of the Diagnostics main window.

Connected ECU: The type of ECU connected to the Diagnostics tool is indicated on the far left side of the Status bar ⇨ *Fig 149. (F-193)*.

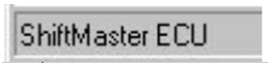


Fig 149.

CAN communications: Two small LEDs indicate data being transmitted (red) and received (green) over the CAN communications link ⇨ *Fig 150. (F-193)*.

Fig 150.

These LEDs can be seen to be flashing rapidly as data is transported. This can be another useful aid to determining the state of any established communications.

ECU Setup Page

This page displays crucial information about the ECU configuration ⇨ *Fig 151. (F-194)*.

Fig 151.

It is always useful to confirm that this is the correct configuration for the machine before commencing any fault finding.

The ECU Setup Page displays the following information;

ECU Setup Description: As well as its' operating software, the gearbox ECU also stores a group of **Setup Data** (or Settings). This Setup Data is used to tailor how a certain ECU part number functions. The Setup Data is loaded during the manufacturing process and has been approved for use in the intended application.

Contained as part of the Setup Data is a Description. This Description is what is displayed here. The engineer can use this description to verify that the correct Setup Data is being used.

The ShiftMaster Setup software tool is designed to view current setup data. In certain circumstances the tool can also be used to up load, or down load, a setup file from and to the ECU. See ***ShiftMaster Setup 2.2, User Guide***.

Application Code Part Number: During normal operation the application code is displayed. If there are communications errors present then this will contain either:

a) `'**NO DLA COMMS**' if there are problems in communication with the DLA, or

b) `'**NO ECU COMMS**' if the DLA is working but the ShiftMaster ECU is not responding.

Note: *For help on fixing communication problems, see* ⇨ *Connection Problems (F-202)*.

Hardware Version: The hardware version is a reference to the build level of the electronics. Future developments may mean that hardware upgrades are required. This may effect which software can be used.

Software Version: The software version refers to the issue level of the ECU operating software. Again, future developments may require software revisions.

Dashboard Page

⇨ *Fig 152. (F-195)*

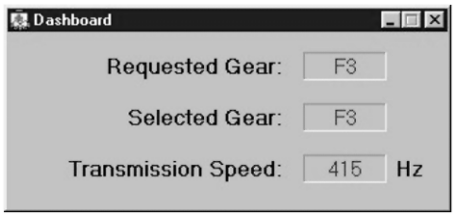


Fig 152.

- **Requested Gear:** This is the demand from the operator.
- **Selected Gear:** This is the actual gear being selected by the ECU.

Note: *The operator* ***Requested Gear*** *is not always the same as the Selected Gear, e.g. when the ECU blocks shifts when offering protection.*

- **Transmission Speed:** This is the current transmission output speed which is directly related to the road speed (through axle ratio and tyre size). The transmission speed sensor is located next to the output gear and detects the passing of the gear teeth. The sensor has a fixed installation, no adjustment is necessary. This signal is used by the ECU to determine gear-shifting and protection strategies.
- ECU 2.2 only. The speed may be displayed as a frequency value or, alternatively, road speed in MPH or KPH. Use the Options Menu, Road Speed Settings to select the required units. ⇨ *Menu Bar - Options Menu (F-190)*.

ECU Status Page

This page gives a detailed picture of how the ECU is operating.

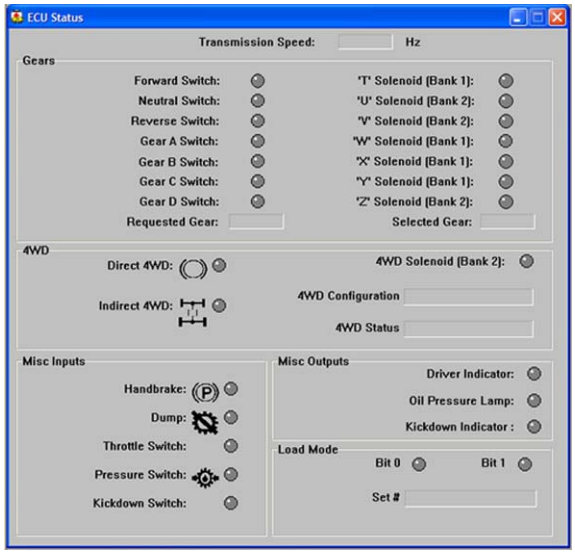


Fig 153.

Information in this display is constantly updated in real-time. The status of the ECU electrical inputs and outputs is displayed using simulated LED's. The LED's change colour depending on the status of the inputs and outputs. A key in the bottom left corner of the main window explains the colours.

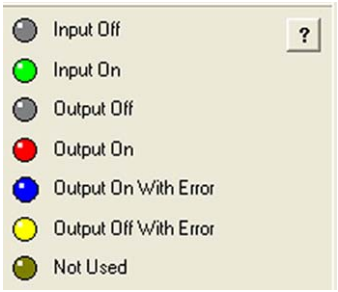


Fig 154.

The following is a brief explanation of each feature.

Transmission Speed

This is exactly the same signal as explained in the previous section.

Gears

- **Inputs:** The items on the left show the signal lines connected to the gear selection lever. This lever is the left hand half of the control lever assembly mounted on the steering column. The input status is indicated by a coloured LED, grey - input OFF, green - input ON.
- **Outputs:** The items on the right are the power outputs to the transmission solenoid valves. The output status is indicated by a coloured LED, grey - output OFF, red - output ON (solenoid energised). The ECU and Diagnostics software proactively scans the solenoids for electrical open and short circuits. In the event of a circuit problem the corresponding solenoid output LED will be coloured yellow when ON, or blue when OFF.

Note: *During certain gear-shifts the gearbox ECU will perform electrical* ***Modulation*** *to improve gear-shift quality. The ECU does this by adding delays to off-going and/or on-coming clutches and so overlapping energised outputs. These delays are in the order of a few hundred milli-seconds but it is sometimes long enough to be observed on the status LEDs. Thus, during certain shifts it is quite normal to observe more than 2 outputs ON at any one time.*

4WD

- **Direct 4WD**: An ECU input which is usually derived from the machine footbrake switch (which also controls the brake lights). Whenever this signal is present the 4WD Solenoid output is energised.
- **Indirect 4WD**: An ECU input which is usually derived from a command from a console mounted '4WD selector' switch. (However, this switch arrangement may change between machines.)
- **4WD Solenoid (Bank 2)**: An ECU output to the transmission 4WD solenoid. The output status is indicated by a coloured LED, grey - output OFF, red - output ON (solenoid energised). The ECU and Diagnostics software proactively scans the solenoids for electrical open and short circuits. In the event of a circuit problem the corresponding solenoid output LED will be coloured yellow when ON, or blue when OFF.
- **4WD Configuration**: Depending on the type of 4WD clutch fitted 4wheel drive OR 2 wheel drive may be selected when the `4WD' solenoid is energised. The

clutch may be a `**Spring Applied**' or `**Pressure Applied**' type.

– **4WD Status**: Indicates if 4WD is `**Engaged**' or `**Disengaged**'.

Misc Inputs

These inputs are derived from the remaining operator controls. The input status is indicated by a coloured LED, grey - input OFF, green - input ON.

– **Handbrake Switch:** Signal derived from the Parkbrake switch. Used to hold the transmission in Neutral if the parkbrake is applied.
– **Dump Switch:** (or Transmission Disconnect) Signal usually derived from a momentary switch. Temporarily selects Neutral when pressed (usually to divert engine power to hydraulics).
– **Throttle Switch:** Signal derived from a switch fitted to the machine throttle pedal. Used to interact with the Automatic Mode of gear-shifting.
– **Pressure Switch:** Signal derived from the transmission mounted Low Oil Pressure Switch.
– **Kickdown Switch: Signal derived from** a momentary button used to temporarily select the next lowest gear.

Misc Outputs

These are the additional ECU outputs, generally used to control cab instrumentation such as a **Driver Indicator** (lamp and buzzer where fitted), low **Oil Pressure Lamp** and **Kickdown Indicator**. The output status is indicated by a coloured LED, grey - output OFF, red - output ON.

Load Mode (ECU 2.2 only)

Some machines utilise transmission `modes'. The transmission can be configured to change the shift pattern data depending on the machines mode of operation. The operator is able to preselect different transmission modes using a selector switch in the cab. TRANSMISSION MODES ARE NOT AVAILABLE FOR BACKHOE LOADERS - THEREFORE ONLY ONE DATA SET IS USED.

– **Bit 0**: An ECU input signal derived from a mode selection switch.
– **Bit 1**: An ECU input signal derived from a mode selection switch.
– **Set #**: Indicates the transmission shift pattern data sets selected. There can be upto three different data set combinations selected by the ECU depending on the combination of inputs at Bit 0 and Bit 1.

Note: *The shift pattern data sets can be viewed using the ShiftMaster Setup software tool. See* ***ShiftMaster Setup 2.2, User Guide***

Torque Converter Lock Up (TCLU) Page

The TCLU control page displays information relating to the torque converter lock up operation ⇒ *Fig 155. (F-198)*.

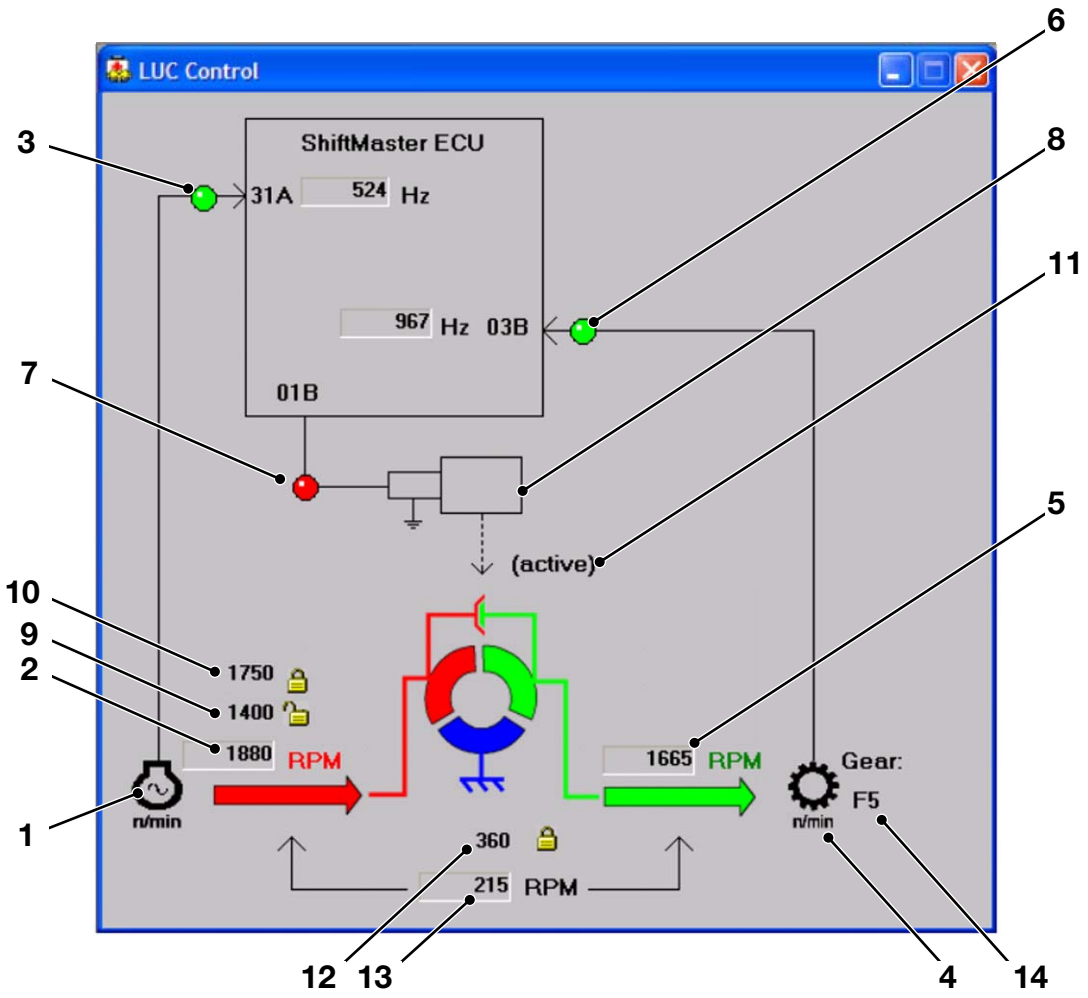


Fig 155.

Key

1	Engine speed sensor
2	Engine speed r.p.m. (real time)
3	Engine speed sensor input status LED
4	Transmission output speed sensor
5	Transmission speed r.p.m. (real time)
6	Transmission speed sensor input status LED
7	Lock up clutch solenoid status LED
8	Lock up clutch solenoid valve symbol
9	Engine speed - lock up clutch `OFF' value
10	Engine speed - lock up clutch `ON' value
11	Lock up clutch system `active' or `inactive'
12	Reference value - engine, transmission speed differential
13	Engine, transmission speed differential (real time)
14	Current gear selected

For operation of the lock up clutch two speed references are required by the E.C.U.

Engine speed (n/min) is read from the input side of the transmission. The engine speed input is connected to the E.C.U. (pin 31A) and a green input LED **155-3** indicates the signal status.

Fig 156.

Transmission output speed is taken from the same signal source described in Dashboard ⇨ *F-195)*. The transmission output speed is connected to the E.C.U. (pin 03B) and a green input LED **155-6** indicates the signal status.

Two padlock symbols can be seen above the engine speed display. The locked padlock indicates the speed at which the lock up clutch (LUC) is switched `ON' and the unlocked padlock indicates when the LUC is switched `OFF'.

Fig 157.

The circular graphic represents the torque converter and its elements ⇨ *Fig 158. (F-199)*.

1 Stator
2 Turbine
3 Impeller
4 Lock up clutch

Real time engine and transmission output speed are also displayed on the graphic ⇨ *Fig 155. (F-198)*.

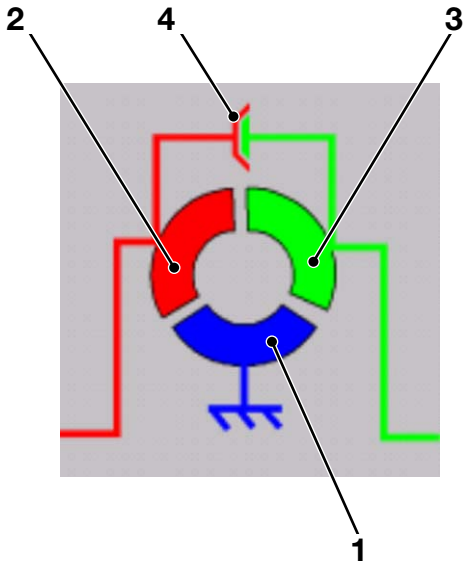


Fig 158.

The central graphic **155-8** attached to E.C.U. output 01B depicts the lock up clutch solenoid. The red LED **155-7** indicates its status. Reference in brackets **155-11** displays as (active) if the gear selected is valid for LUC operation, or (inactive) if gear selected is not valid. The current gear selected is shown under the label `Gear'.

A maximum differential speed reference value **155-12** is indicated next to a padlock symbol. If all the other interlocks are observed and the differential speed **155-13** is below that of the reference value, in this case 360 then the LUC is enabled.

Solenoid Test Mode Page (ECU 2.2 only)

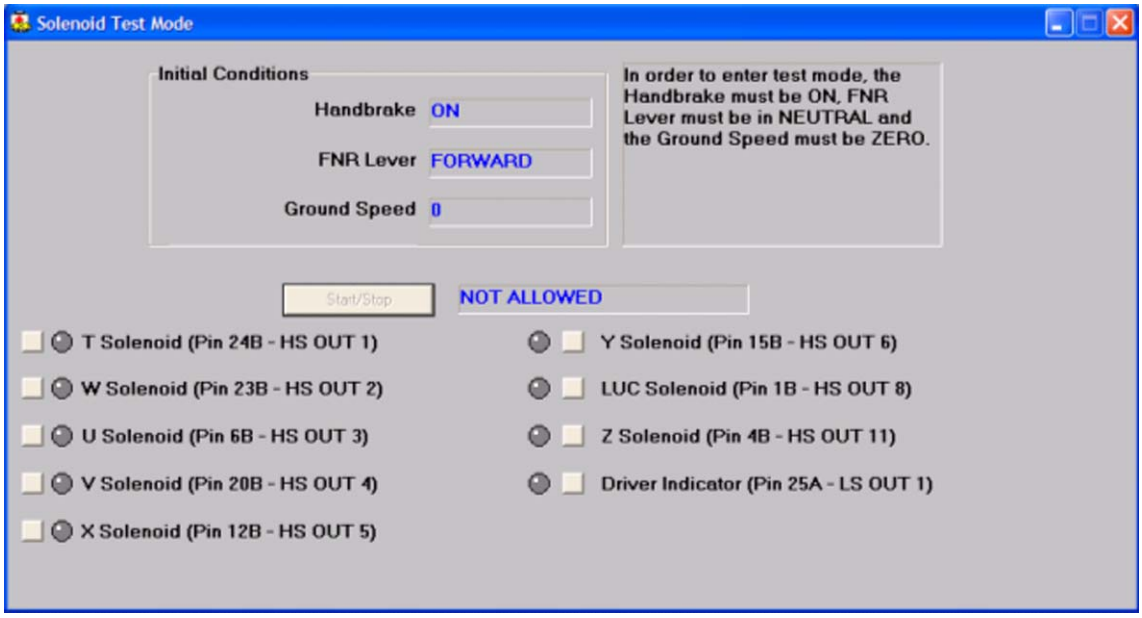


Fig 159.

The Solenoid Test Mode page allows testing of each transmission solenoid individually. Since gear selection always requires two solenoid valves to be energised the tests can be carried out with the transmission in neutral. For electrical tests the engine does not have to be running. For hydraulic clutch pressure testing the engine must be running, before using the Test Mode facility disconnect the drive shafts at the gearbox.

Important: *It is possible that the gearbox may have developed a fault causing a clutch to be permanently engaged. If a second clutch is engaged (by using the Test Mode facility for instance) the gearbox will engage a gear unexpectedly.* ***Before using the Test Mode facility disconnect the drive shafts at the gearbox.***

- **Initial Conditions**: To enable the test mode the handbrake must be ON, the FNR lever set to NEUTRAL and the road speed must be ZERO. The conditions are displayed in the Initial Conditions panel.
- **Start/Stop Button**: Press the button to toggle the test mode either on or off as required. `TEST MODE READY' or `TEST MODE ACTIVE' is displayed as applicable. If the initial conditions are not compatible with the test mode the Start/Stop button is disabled and `NOT ALLOWED' is displayed.
- **To test a solenoid**: If tests are being carried out with the engine running, make sure that the drive shafts are disconnected at the gearbox. Click the appropriate button using the mouse. The ECU is `forced' to output power to the selected solenoid. The output status is indicated by a coloured LED, grey - output OFF, red - output ON (solenoid energised). The ECU and Diagnostics software proactively scans the solenoids for electrical open and short circuits. In the event of a circuit problem the corresponding solenoid output LED will be coloured yellow when ON, or blue when OFF.
- **To test the Driver Indicator**: Click the appropriate button using the mouse. While the button is held down the ECU is `forced' to output power to the indicator and or warning devices. The output status is indicated by a coloured LED, grey - output OFF, red - output ON. If the devices are working they will illuminate and, or sound, as applicable.

Note: *If the test mode is not enabled make sure that the START button is pressed (large green `LED' at the top left corner of the screen).*

Solenoid Identification Page (ECU 2.2 only)

The solenoid identification page is for reference only ⇒ *Fig 160. (F-201)*.

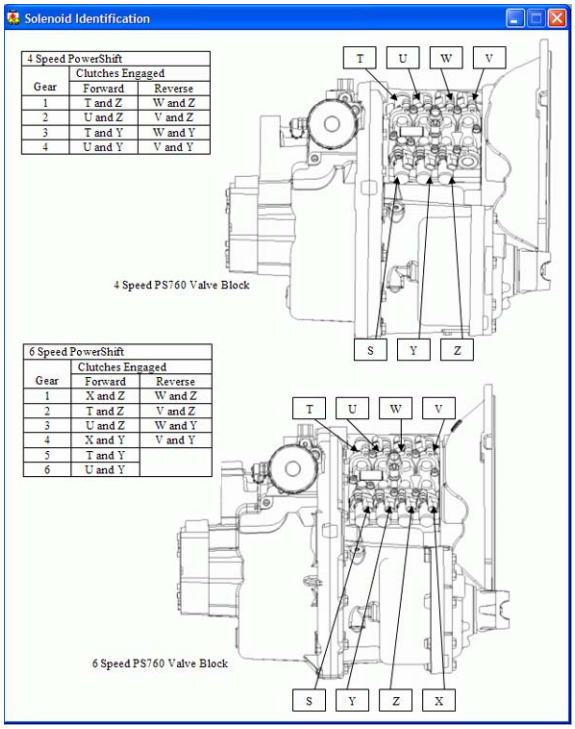


Fig 160.

ECU Block Diagram Page (ECU 2.2 only)

The ECU block diagram page is for reference only ⇒ *Fig 161. (F-201)*.

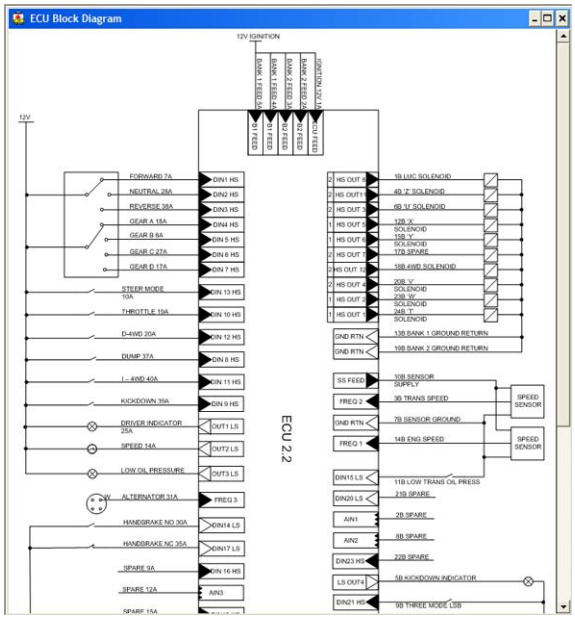


Fig 161.

Connection Problems

In general, whenever there are problems communicating with the DLA there will be an error message displayed.The following section although not exhaustive attempts to identify the more common ECU communication problems.

ShiftMaster PC Service Tools must use the authorised Data Link Adaptor (DLA) contained in the Electronic Service Tool Kit. The latest versions of both the hardware and software can be obtained through authorised suppliers. ShiftMaster software has been designed to run on the Windows 9.X, Windows 2000 and Windows XP operating systems.

A number of reasons can generate software problems and assistance from an Information Technology engineer is advised. In particular, laptop PCs can suffer serial communications conflicts were the PC hardware does not allow the Diagnostic software access to the communication ports. In the majority of cases conflicts are caused by either software already running on the PC, or by certain 'driver' files not releasing the COM port(s).

The PC Service Tools for example ShiftMaster Diagnostics indicate the existence of an ECU communication problem that can reside in two areas indicated in the type of displayed error message. The first message is generated when the problem exists between the PC and DLA then the `Error Connecting to DLA' will be displayed. ⇒ *Fig 162. (F-202)*

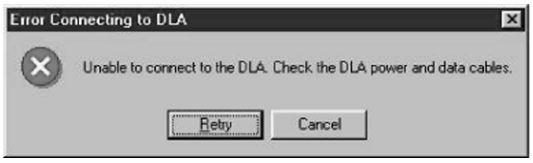


Fig 162.

Confirmation of this error can be found in the `ECU Setup Page' with 'NO DLA COMMS' being displayed in the `ECU Part Number' box. ⇒ *Fig 163. (F-202)*

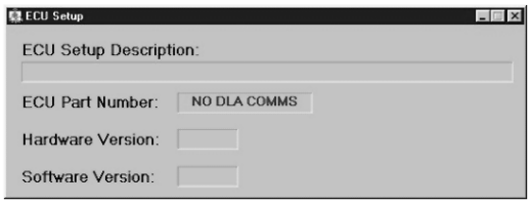


Fig 163.

The second is generated when no communications can be established with the DLA and the ECU usually through a hardware problem. No power supply from the machine, indicated by the DLA's power LED will display the 'NO ECU COMMS' message. ⇒ *Fig 164. (F-202)*. Another source could be related to resistance of the two data communication wires making up the machine's harness for the ECU's CAN connection to the Deutsch 9 way round diagnostic connector. The wiring must have two 120 Ohm resistors fitted to either end of this run of cable to give a 60 Ohm impedance. If the impedance is incorrect then `NO ECU COMMS' message will displayed. ⇒ *Fig 164. (F-202)*

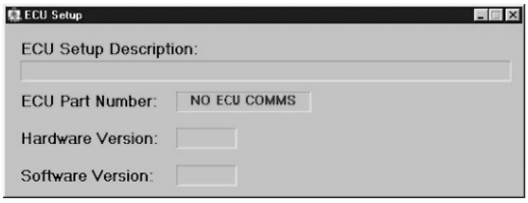


Fig 164.

Note: *The ECU must be powered for communications to work, i.e. the machine ignition must be ON (but the engine need not be running).*

If a problem is experienced it can take one of three forms, a constant failure to establish communications, drop out during communications or intermittent communication connection. However, the source has a tendency to be of the `NO DLA COMMS' type and thus related to the user's PC. Contributory factors to communication errors could be related to the following items:

– **DLA Drivers**. The DLA and PC are programmed with software `drivers' which handle communications. Ensure the latest drivers are installed on the PC and

DLA (contained in the latest version of Service Master).

- **PC Power Management**. Previous experiences have shown that some laptops' Power Management software can disrupt the COM ports. Turning off the power management software may resolve the problem.
- **IR Drivers**. If the PC has an InfraRed (IR) communications port then disabling the driver may help.
- **Modem Drivers**. Modem drivers could cause communication conflicts and temporary disabling to establish if the software is conflicting with the port may establish this source.

If the aforementioned information fails to resolve the situation then the following contacts may be able to provide further assistance;

- Information Technology (IT) engineer.
- Authorised machine dealer or agent.
- Machine OEM. The Original Equipment Manufacturer (OEM) will make the relevant enquires.

General Information

For all enquiries about the **ShiftMaster Diagnostics** tool please follow your normal channels of enquiry. This ensures that useful information can filter through to JCB personnel at all levels.

ShiftMaster Setup 2.2 - User Guide

Introduction

The **ShiftMaster Setup** software tool is part of the **JCB Service Master** software suite.

ShiftMaster Setup employs the graphical strengths of the Microsoft Windows operating environment to communicate with the gearbox ECU control system used on Powershift PS760 series gearboxes.

ShiftMaster 2 transmission ECU features 2 programs stored in a flash memory.

- The first is the main core application code and carries the file extension .vsf. This file defines and maps all the relationships between the input and output functions of the ECU. During normal service this file does not need to be changed.
- The second program is the Setup file and carries the extension .ets. The Setup file is used to tailor variable parameters in the application code to configure gearbox shift parameters for use in different machines.

ShiftMaster Setup software is a service tool designed to enable the following:

- Download a Setup data file (.ets) from a transmission ECU to a laptop computer and view the data.
- Open a Setup data file (.ets) stored on a computer and view the data.
- Upload a Setup data file (.ets) to the flash memory of a transmission ECU.
- View a Setup file description.

For service engineers it can be useful to view setup file data when fault finding. From time to time a new setup file may be made available to improve machine performance. ShiftMaster Setup enables loading of the new file to the ECU.

ShiftMaster Setup is only intended for use with ECU 2 and ECU 2.2 controlled PS760 gearboxes. The system is not compatible with relay controlled gearboxes. Older versions of Powershift Controllers used on the PS750 series gearboxes are not supported.

The software is intended for use on IBM Compatible Personal Computers **(PCs)** running **Windows 9x**, **Windows2000** and **WindowsXP** operating systems but is not compatible with either earlier versions of **Windows 3.x**. Ideally the computer should be a laptop type.

Care and Safety

⚠ WARNING

Be sure to read and follow any on screen instructions. Failure to follow correct procedure could result in death or injury.

2-4-5-5

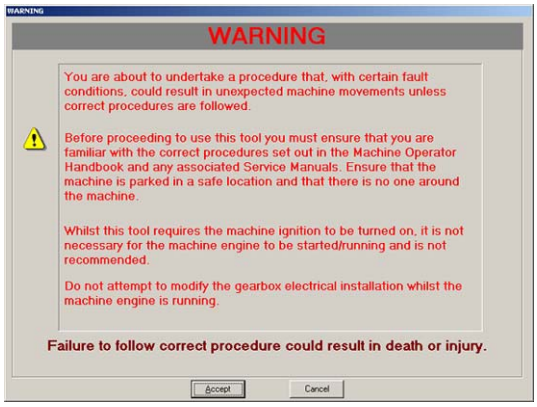


Fig 165.

Installing ShiftMaster Setup

The **ShiftMaster Setup** tool is fully integrated within JCB Service Master. To use ShiftMaster Setup you must install **JCB Service Master** onto a suitable laptop computer.

For full instructions on how to install **JCB Service Master** software please refer to the documentation which accompanies JCB Service Master.

Connecting ShiftMaster Setup

To use ShiftMaster Setup your laptop computer must be connected to the machine transmission ECU diagnostics connector ⇨ *Fig 167. (F-206)* or ⇨ *Fig 168. (F-207)* as applicable. Connection is made using Diagnostic Link Adapter (DLA) **166C** and the applicable cables.

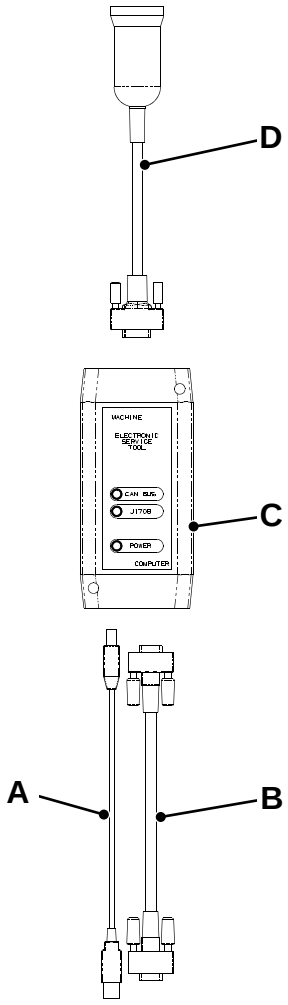


Fig 166.

A	USB PC Cable	718/20235
B	Serial PC Cable	718/20236
C	USB DLA	728/26500
D	Machine Cable	718/20237

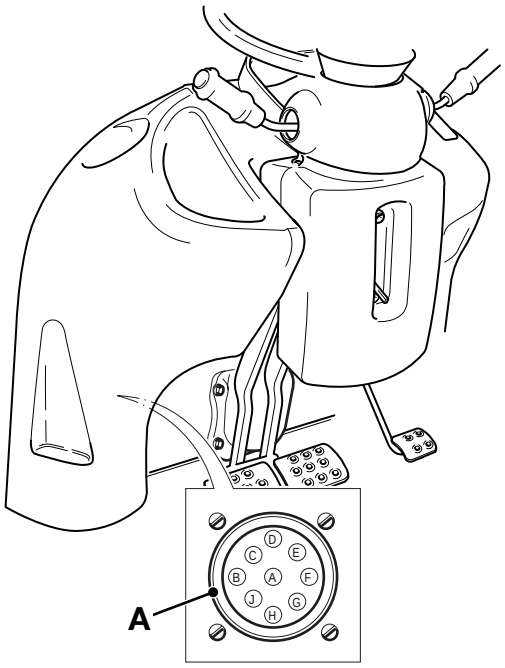
Kit 892/01174 (includes items A,B,C and D)

1 Connect either the 'Serial PC Cable' **166B** (718/20236) or the 'USB PC Cable' **166A** (718/20235) between the DLA **166C** and a free port on your laptop computer.

The 'Serial PC cable' has a 9-way D-type connector on one end and a 25-Way D-type connector on the other.Plug the 25-way male connector into the DLA and the other connector into a free port on your laptop PC, remembering to tighten any thumb-screws appropriately.

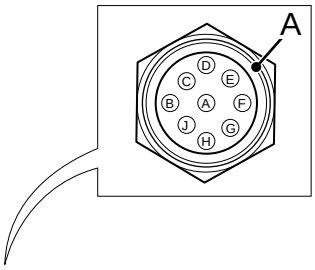
2 Connect the 'Machine Cable' **166D** between the DLA and the machines' Diagnostic Connector **167A** or **168A** as applicable.

The 'Machine Cable' has a 15-way D-type connector on one end and a 9-way CAN connector on the other. Plug the 15-way connector into the DLA and tighten the thumb-screws, then connect the 9-way CAN connector into the machines' Diagnostics Connector and twist the lock-ring to secure it.



A405350-C3

Fig 167. Diagnostics Connector - Early Machines



C085840

Fig 168. Diagnostics Co nnector - Later Machines

Menu Bar - File Menu

⇒ *Fig 175. (F-210)*.

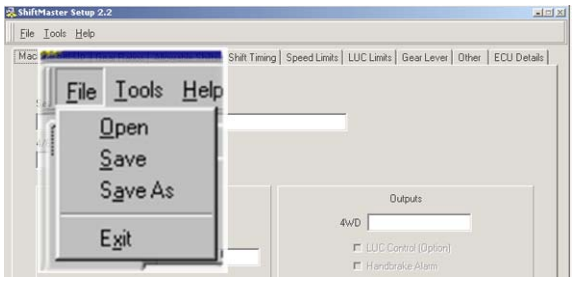


Fig 175.

– **Open**: Opens a setup data file. ⇒ *Open a Setup File (F-215)*.
– **Save**: Saves the current setup data as a setup data file.
– **Save As**: Saves the currently open data file as another file.
– **Exit**: To close down the program.

Menu Bar - Tools Menu

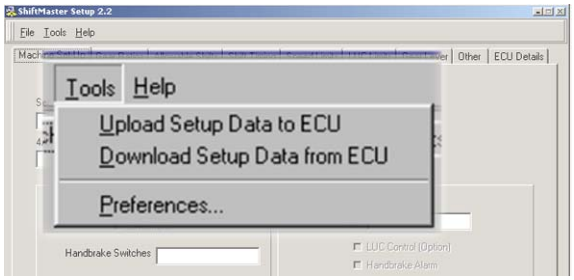


Fig 176.

– **Upload Setup Data to ECU**: Used to copy the opened setup file into the ECU flash memory. ⇨ ***Upload Setup Data to ECU (F-214)***.

– **Download Setup Data from ECU**: Used to retrieve setup data from an ECU. ⇨ ***Download Setup Data from ECU (F-213)***.

Fig 177.

– **Preferences** option opens up the Preference Dialogue ⇨ ***Fig 177. (F-211)***.

– **Select Language**: Use the drop-down menu and scroll bar to select the required language.

– **English (Canada)**

– **English (United Kingdom)**

– **French (France)**

– **German (Germany)**

– **Italian (Italy)**

– **Portuguese (Portugal)**

– **Spanish (International Sort)**

Once your preferences have been selected either:

Click on the **OK** button to apply them or click on the **Cancel** button to leave them unchanged.

Menu Bar - Help Menu

– Opens a window showing the part number and the version number of the installed copy of the **ShiftMaster Setup** software. ⇨ *Fig 178. (F-212)*.

Fig 178.

Download Setup Data from ECU

Before ECU setup data can be viewed the set up file must be downloaded to the connected PC using the ShiftMaster Setup software.

1 Turn ON the machine ignition. Do not start the engine.

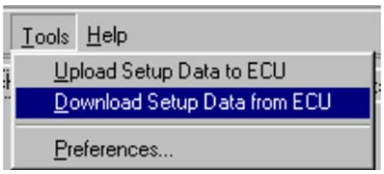


Fig 179.

2 Select **Tools** from the menu bar followed by **Download Setup Data from ECU**. ⇨ *Fig 179. (F-213)*

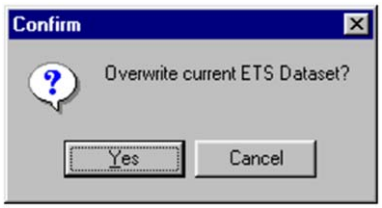


Fig 180.

3 If a setup file has been loaded previously a confirm message is displayed. Click **Yes** to overwrite the current data. ⇨ *Fig 180. (F-213)*

4 ShiftMaster Setup will down load the setup file. The progress bar appears at the bottom of the window. ⇨ *Fig 181. (F-213)*.

Fig 181.

5 If the download was successful a message is displayed. Click OK to continue. ⇨ *Fig 182. (F-213)*

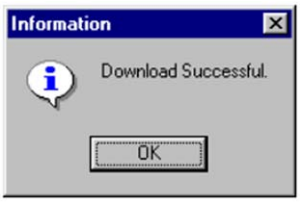


Fig 182.

6 The setup file data can now be viewed.

7 If required save a copy of the setup file to a computer location. This enables viewing of the data at a later date without the need to connect to the transmission ECU. Use the **Save As** option from the file menu. A setup file with the extension .ets is created.

Note: *The download function does not remove the setup file from the ECU. The setup file data is copied to the Setup software.*

If Setup Data cannot be downloaded successfully see ⇨ *Connection Problems (F-230)*.

Upload Setup Data to ECU

Note: *When a new setup file is uploaded to the ECU the original file is erased. If necessary download the existing data and make a copy setup file before uploading a new file.* ⇨ ***Download Setup Data from ECU (F-213)***

1 Turn ON the machine ignition. Do not start the engine.

2 Apply the machine parkbrake. Set the FNR lever to neutral.

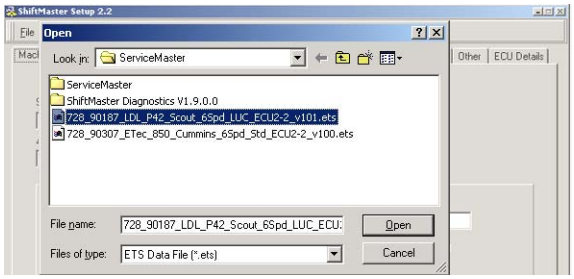


Fig 183.

3 Open the required setup file. Select **File** and **Open** from the menu bar. The Open window appears. Navigate to the location of the required setup file (.ets). Double click on the file to open it into ShiftMaster Setup. ⇨ ***Fig 183. (F-214)***

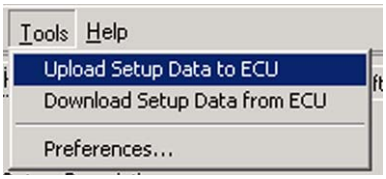


Fig 184.

4 ShiftMaster Setup software is now ready to upload the setup file to the ECU. Select **Tools** and **Upload Setup Data to ECU** from the menu bar. ⇨ ***Fig 184. (F-214)***

5 A warning message appears. Read and understand the warning. If you can comply click the Accept button to proceed. ⇨ ***Fig 185. (F-214)***

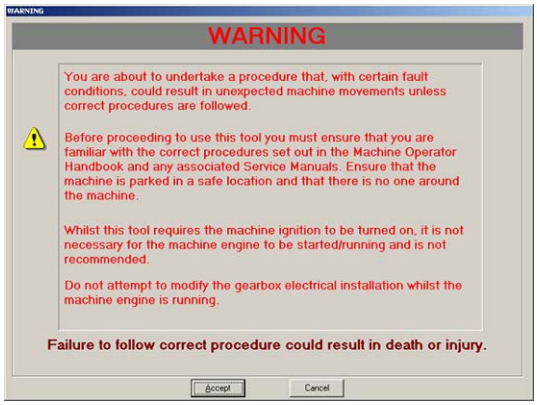


Fig 185.

6 A confirmation message appears. Read and understand the message. If you can comply click the OK button to proceed. ⇨ ***Fig 186. (F-214)***

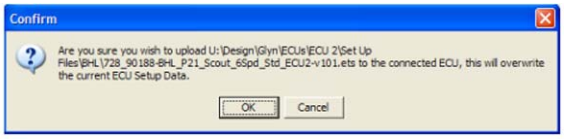


Fig 186.

7 ShiftMaster Setup will now upload the setup file to the ECU. The progress bar appears at the bottom of the window. ⇨ ***Fig 187. (F-214)***

Fig 187.

8 When the upload is complete a message is displayed. Click OK. ⇨ ***Fig 188. (F-214)***

Fig 188.

If Setup Data cannot be uploaded successfully see ⇨ ***Connection Problems (F-230)***.

Open a Setup File

You can open and view setup files (.ets) stored on a computer using ShiftMaster Setup software. The PC does not need to be connected to a transmission ECU.

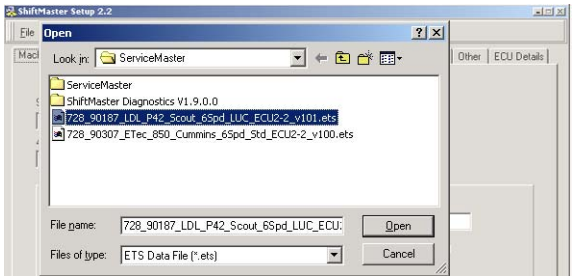


Fig 189.

1 Open the required setup file. Select File and Open from the menu bar. The Open window appears. Navigate to the location of the required setup file (ets). Double click on the file to open it into ShiftMaster Setup. ⇨ ***Fig 189. (F-215)***

2 The setup file data can now be viewed.

Setup File Description

In certain circumstances service personnel will require information about the Setup file loaded on the transmission ECU.

Note: *The Setup file description can also be accessed using the ShiftMaster Diagnostics software, see* ***Shiftmaster Diagnostics - User Guide, ECU Setup Page.***

1 Connect the PC to the ECU and start the ShiftMaster Setup software.

2 Turn ON the machine ignition. Do not start the engine.

3 Download Setup data from the ECU. ⇨ ***Download Setup Data from ECU (F-213)***.

4 The description appears on the Machine Setup page in the Setup Description window ⇨ ***Fig 190. (F-215)***. You can copy and paste the description using your PC or alternatively, copy by hand. The Set-up Description contains part numbers and codes. ⇨ ***Machine Setup (F-217)***

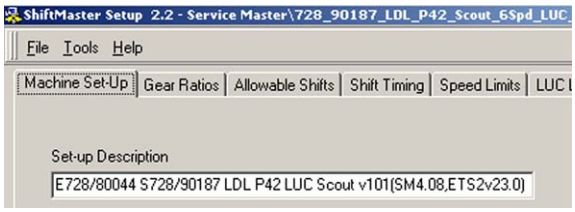


Fig 190.

Data Pages

The data pages display all the parameters in the loaded setup file. The parameters determine the gearbox shift characteristics. The relevant data page is displayed by clicking on its tab.

For service engineers the data pages can assist in fault finding. Shift combinations can be seen for all operating parameters. By analysing the data it is possible to confirm gearbox shift characteristics as valid or faulty.

Data is displayed on pages as follows:

⇨ *Machine Setup (F-217)*
⇨ *Gear Ratios (F-219)*
⇨ *Allowable Shifts (F-220)*
⇨ *Shift Timing (F-221)*
⇨ *Speed Limits (F-222)*
⇨ *TCLU Limits (F-224)*
⇨ *Gear Lever (F-226)*
⇨ *Other (F-228)*
⇨ *ECU Details (F-229)*

Machine Setup

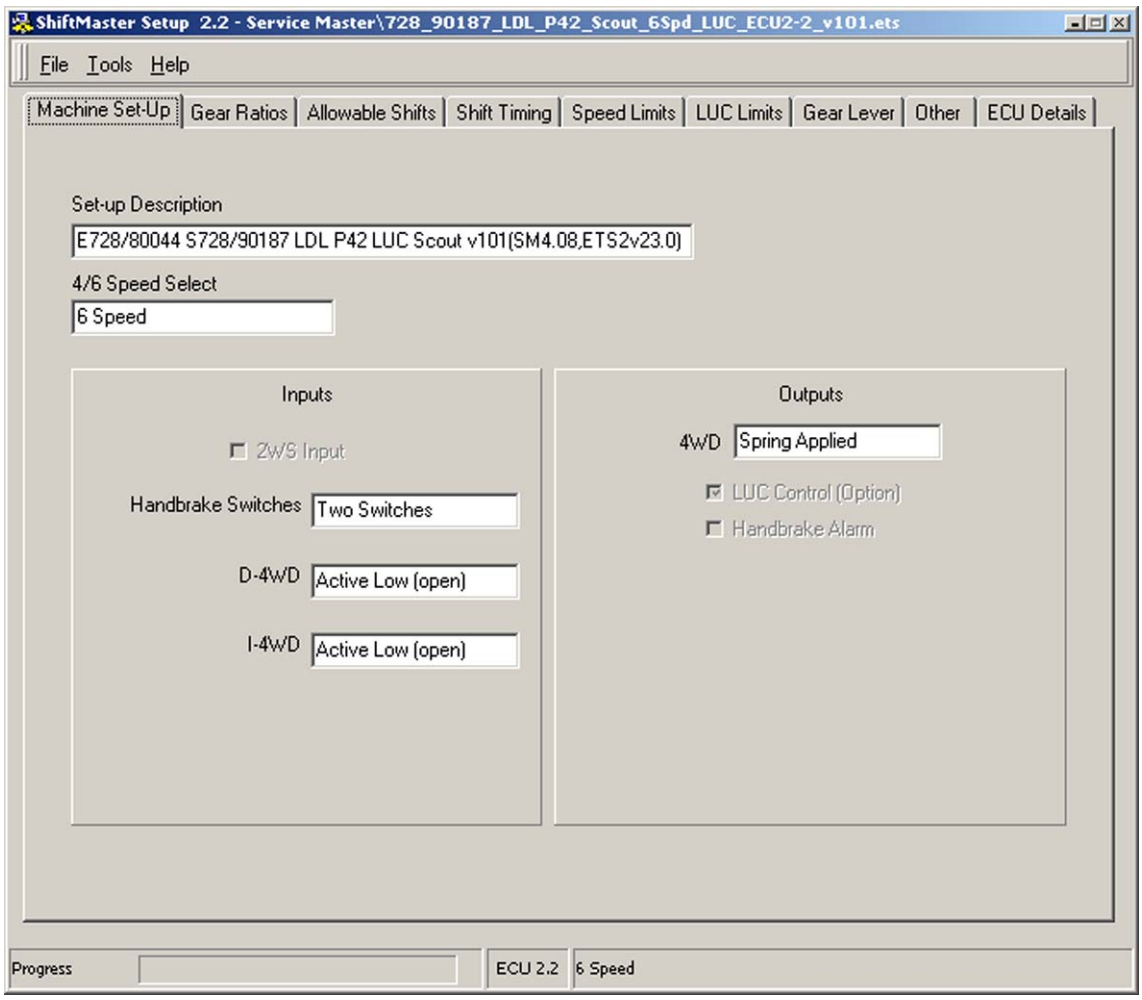


Fig 191.

The **Machine Setup** page appears by default when ShiftMaster Setup software is started. The page shows the general feature options which are enabled by the loaded Setup Data. It is normal for the check boxes and labels in the inputs and outputs list to be shown as greyed-out. Values are still displayed correctly (i.e. a tick when enabled). The text fields will contain no information if no setup file has been loaded ⇒ *Fig 191. (F-217)*.

1 **Setup Description**: Contains information related to the machine application. By checking this description field you can verify that the correct setup file is loaded. The description line is usually formatted as follows:

ECU part number, example E728/80044

Setup File part number, example S728/90187

OEM identification code, example LDL P42

Type of gearbox, lock up torque converter (LUC) or standard (std)

Setup file software version, example (SM4.08,ETS2v23.0)

2 **4/6 Speed Select**: Shows gearbox supported, 6 Speed or 4 Speed.

3 **Inputs**: Lists inputs expected.

4 **Outputs**: Lists outputs expected.

Gear Ratios

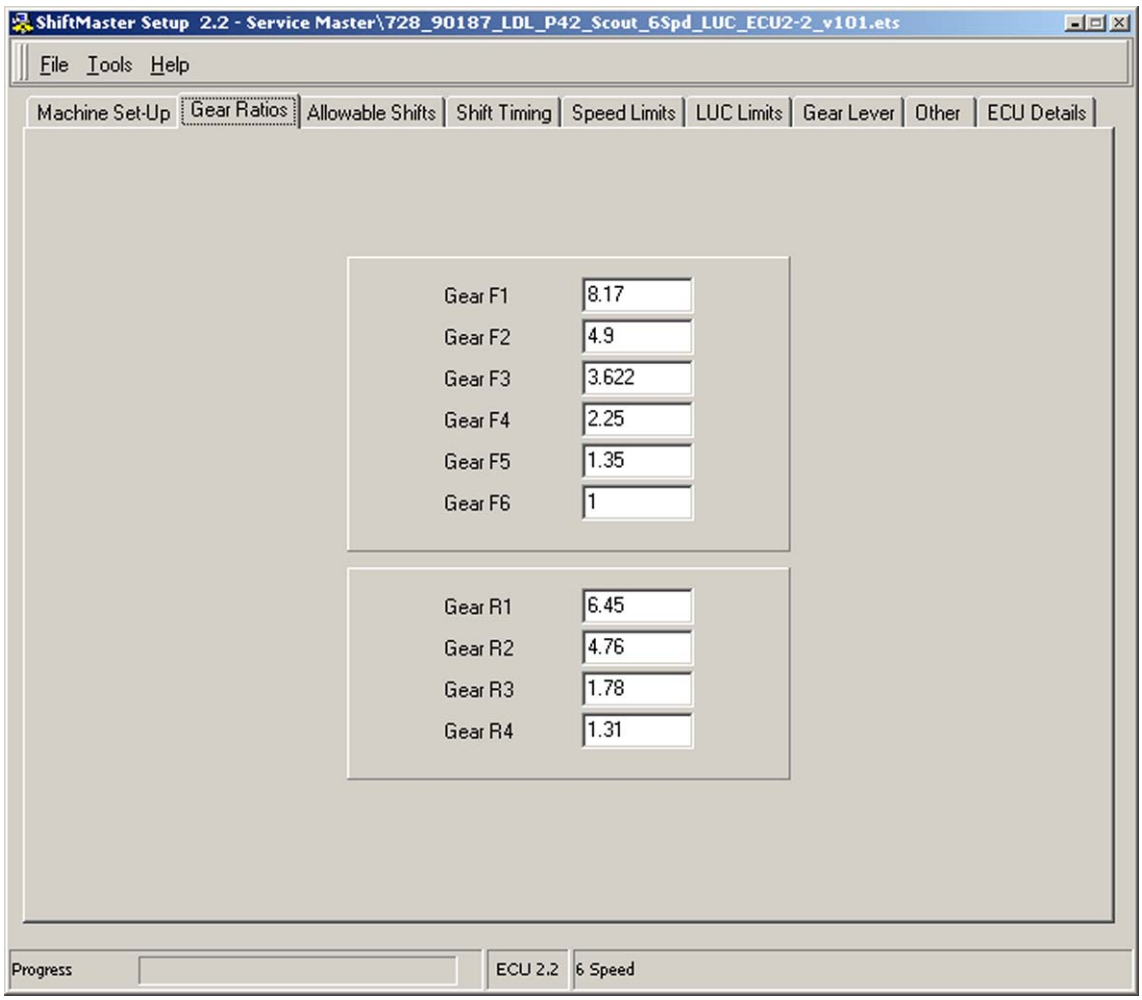


Fig 192.

The **Gear Ratios** page shows the transmission ratio for each gear, forward and reverse. These values are used by the ECU for internal calculations and are dictated by the type of gearbox being controlled. *Fig 192. (F-219)*

Allowable Shifts

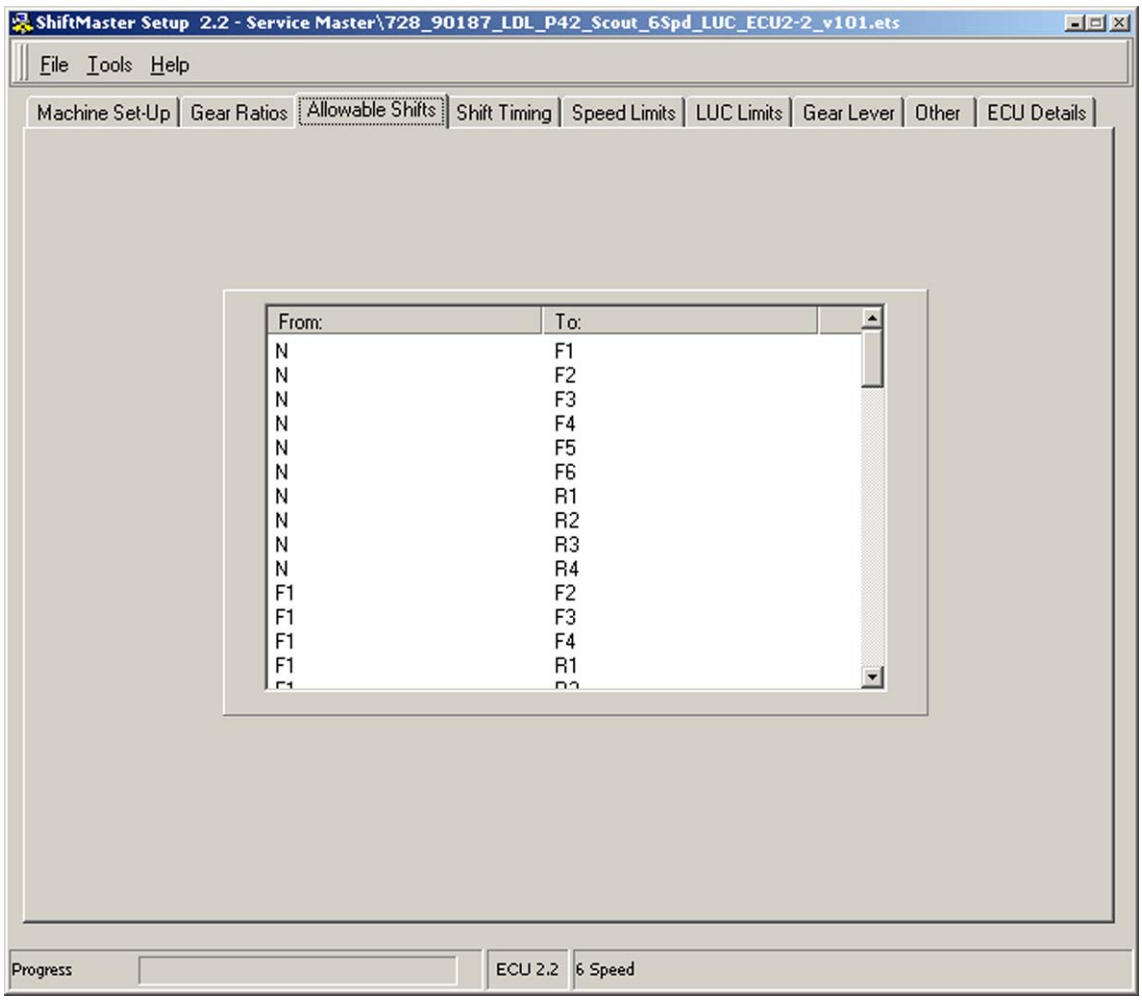


Fig 193.

The **Allowable Shifts** page contains a list of all gear shifts which the ECU can enable. The ECU uses this data to prevent the selection a potentially harmful shift.

Note: *Double-clicking on a particular shift will jump the application to the `Shift Timing' page. The selected shift timing is displayed* ***⇨ Shift Timing (F-221)***

Shift Timing

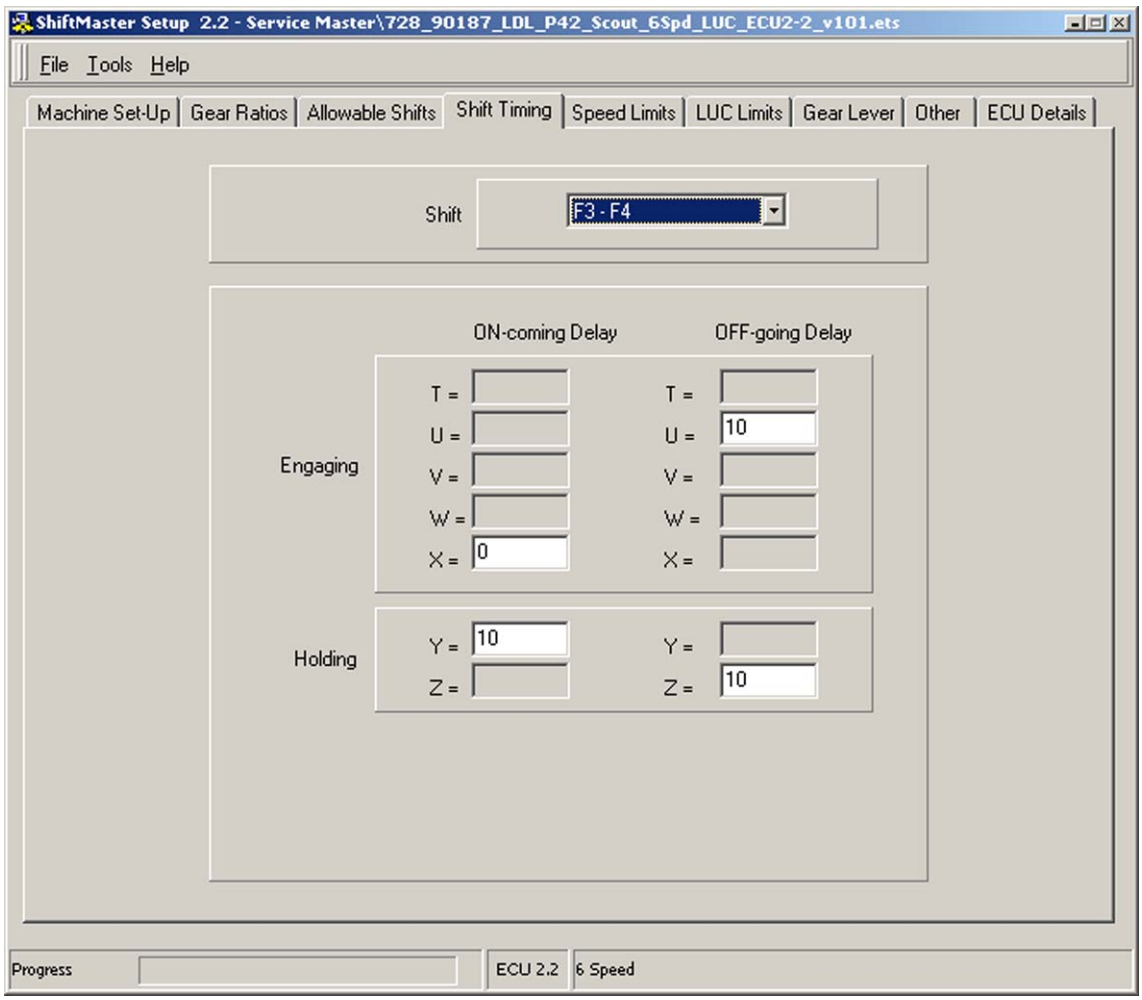


Fig 194.

During gear shifts the clutch solenoids on and off timing relationships are set to achieve the smoothest possible gear shift. This ensures minimum transmission wear and maximum operator comfort.

1 **Shift**: Use the drop down list to select the required shift. Example: F3-F4.

2 **ON-coming Delay**: Displays the time delays for the on coming clutches. Example: X and Y (clutches required to select F4). Delay for X = 0 and Y = 10.

3 **OFF-going Delay**: Displays the time delays for the off going clutches. Example: U and Z (F3). Delay for U = 10 and Z = 10.

4 **Engaging**: The range of clutches always engaging. Example, 2nd gear requires clutches T and Z to be engaged, 3rd gear requires U and Z. T and U are `engaging' clutches.

5 **Holding**: The range of clutches usually holding. Example, 2nd gear requires clutches T and Z to be engaged, 3rd gear requires U and Z. Z is a `holding' clutch.

Speed Limits

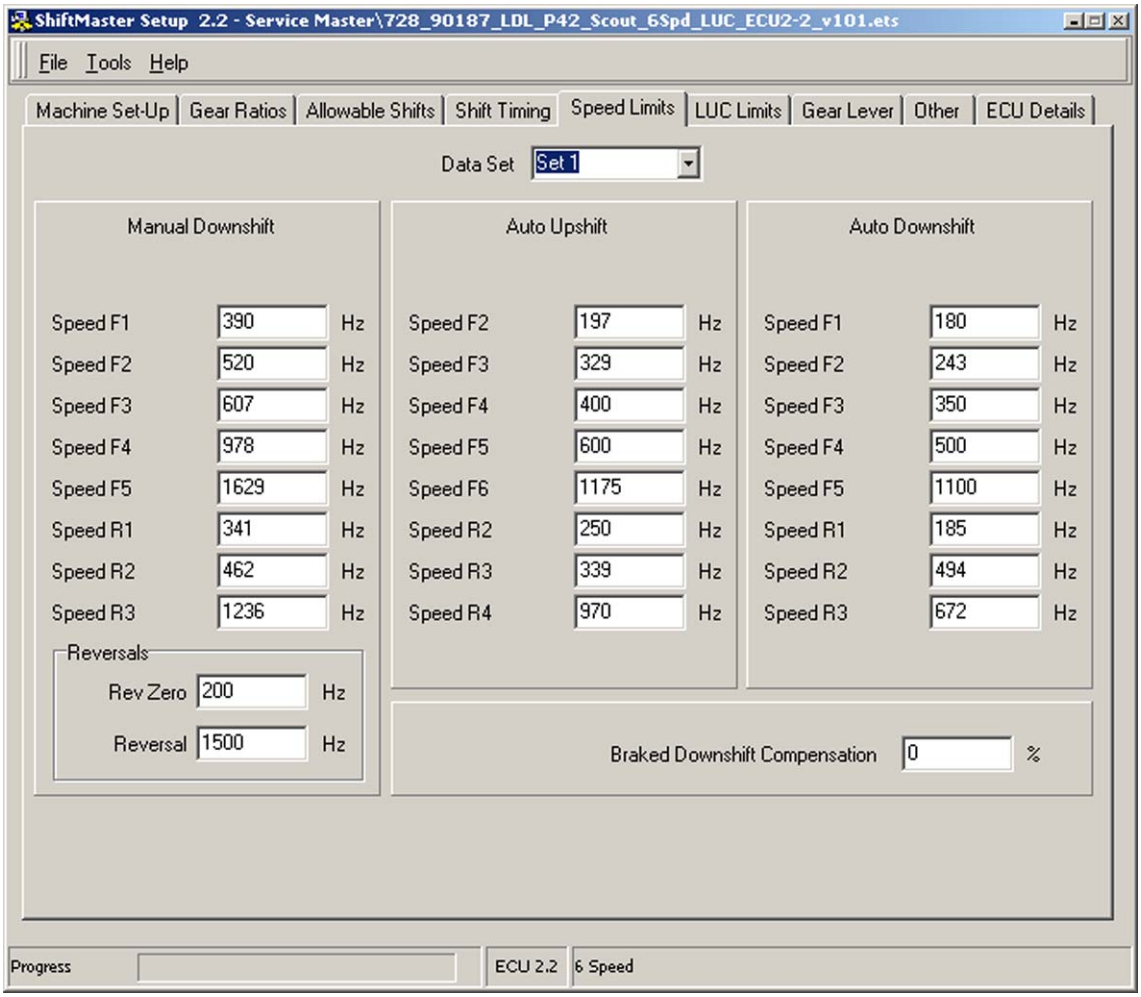


Fig 195.

The ShiftMaster ECU prevents downshifts to a lower gear if the machine is travelling too fast. This ensures minimum transmission wear and maximum operator comfort.

All speed values are quoted in Hertz (Hz), or pulses per second. The gearbox speed sensor detects the passing of gear teeth on the gearbox output gear. Hence speed values are effectively measures in teeth per second. The actual road speed value is dependant on the ratio of the axle and size of tyres fitted. ⇨ *Fig 195. (F-222)*

1 **Data Set**: (ECU 2.2 only) Use the drop down list to select the required Data Set. Some machines utilise transmission `modes'. The operator is able to preselect an appropriate transmission mode using a selector switch in the cab. When the ECU detects a mode change input a different **Speed Limits** data set is selected. Upto three data sets are available. THIS FEATURE IS NOT AVAILABLE FOR BACKHOE LOADERS.

2 **Manual Downshift**: Displays the maximum speed at which the gear will be engaged. If the speed is higher

than the set value the ECU will prevent selection until the speed falls to the set value. Example: F1 will not be selected unless the speed is less than or equal to 390 Hz.

3 **Reversals, Rev Zero**: Fixed value for all applications.

4 **Reversals, Reversal**: Displays the maximum speed at which the ECU will select F to R or R to F. If the speed is higher than the set value the ECU will prevent selection until the speed falls to the set value.

5 **Auto Upshift**: Displays the speed at which the gear will be engaged. Example: The ECU will perform an automatic upshift from F1 to F2 when the speed reaches 197 Hz.

6 **Auto Downshift**: Displays the speed at which the gear will be engaged. Example: The ECU will perform an automatic downshift from F2 to F1 when the speed falls to180 Hz.

7 **Braked Compensation**: Not used. (Value is always zero.)

TCLU Limits

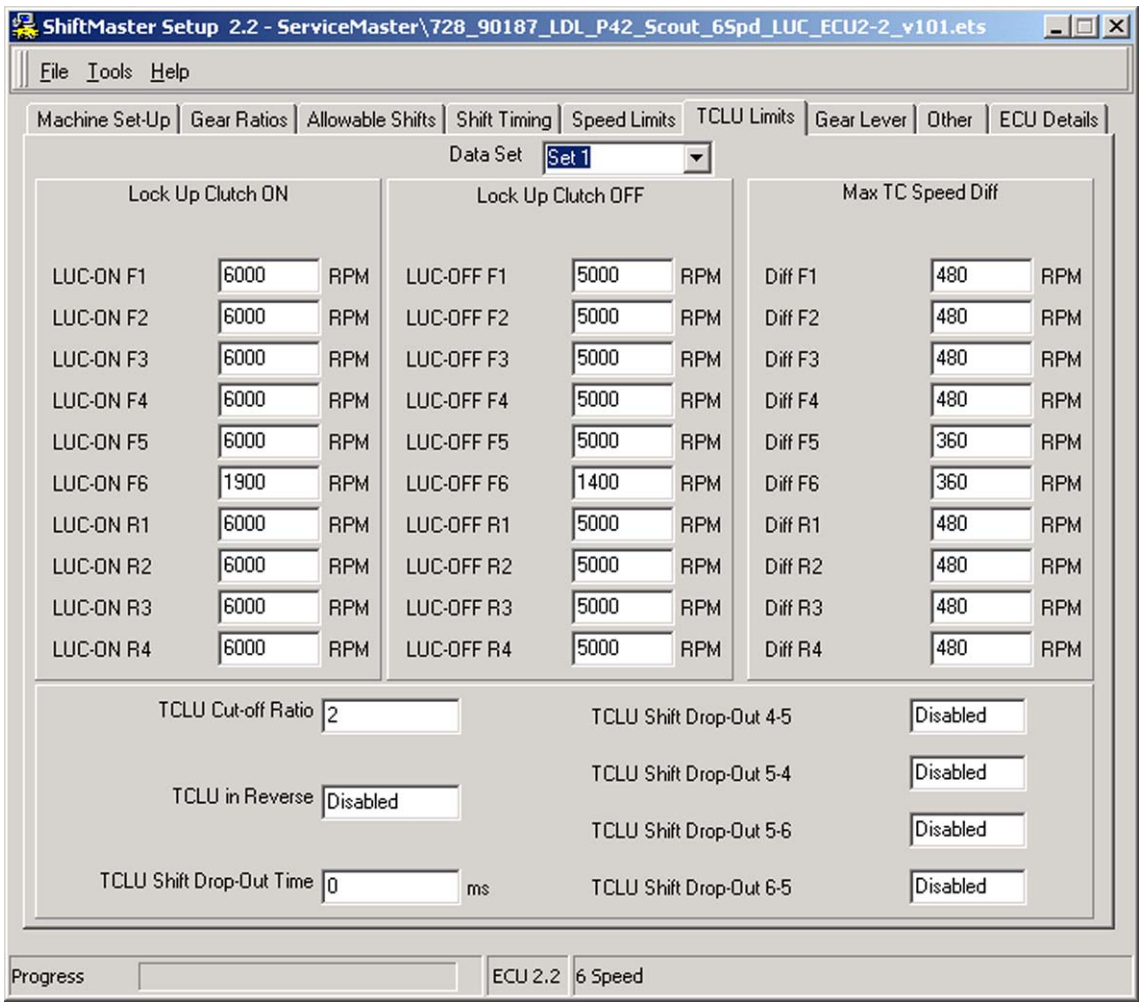


Fig 196.

This page defines the operation of the optional Torque Converter Lock-Up (TCLU). ⇨ *Fig 196. (F-224)*

1 **Data Set**: (ECU 2.2 only) Use the drop down list to select the required Data Set. Some machines utilise transmission `modes'. The operator is able to preselect different transmission modes using a selector switch in the cab. When the ECU detects a mode change input a different **TCLU Limits** data set is selected. Upto three data sets are available. TRANSMISSION MODES ARE NOT AVAILABLE FOR BACKHOE LOADERS - THEREFORE ONLY ONE DATA SET IS USED.

2 **Lock Up Clutch ON**: Displays the engine speed at which the lock up clutch engages. Example: With F6 engaged the lock up clutch engages when the engine speed is 1900 RPM or higher. Since the engine can not reach 6000 RPM the clutch will not engage when any other gear is selected.

3 **Lock Up Clutch OFF**: Displays the engine speed at which the lock up clutch disengages. Example: With F6 engaged the lock up clutch disengages when the engine speed falls to 1400 RPM.

4 **Max TC Speed Diff**: Displays the maximum speed difference between the engine and the transmission

in RPM. The value represents torque converter slippage. Example: With F6 selected the lockup clutch will only engage if the speed difference is less than or equal to 360 RPM. This condition is true even if the engine speed is 1900 RPM or above, see ***Lock Up Clutch ON***.

5 **TCLU Cut-off Ratio**: Maximum gear ratio at which clutch will operate. Example, 2. ⇨ ***Gear Ratios (F-219)***

6 **TCLU In Reverse**: Enabled, clutch can operate when reverse gears are engaged within the set limits. Disabled, clutch does not operate when any reverse gear is engaged.

7 **TCLU Shift Drop-Out Time**: Clutch operating time delay to ensure smooth operation.

8 **TCLU Shift Drop-Out 4-5**: Clutch operating time delay to ensure smooth operation.

Gear Lever

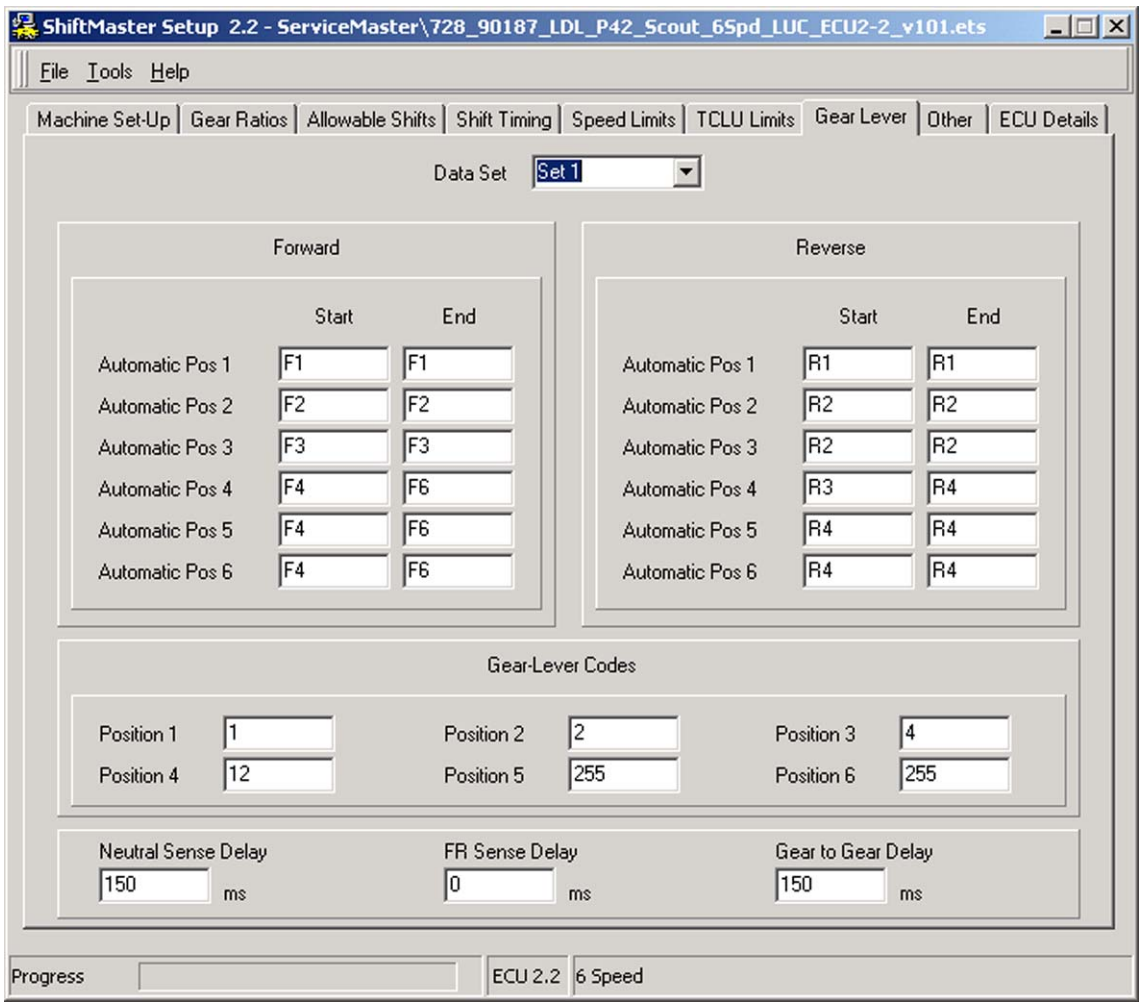


Fig 197.

This page shows gear lever information and defines how the ECU interacts with the machine's gear-shift lever. ⇨ *Fig 197. (F-226)*

1 **Data Set**: (ECU 2.2 only) Use the drop down list to select the required Data Set. Some machines utilise transmission `modes'. The operator is able to preselect different transmission modes using a selector switch in the cab. When the ECU detects a mode change input a different **Gear Lever** data set is selected. Upto three data sets are available. TRANSMISSION MODES ARE NOT AVAILABLE FOR BACKHOE LOADERS - THEREFORE ONLY ONE DATA SET IS USED.

2 **Forward**: Displays the automatic gear selection range for each gear lever position (maximum of six positions). Example: **Automatic Pos 1**, **Start** F1, **End** F1. Gear lever position 1 operates in `manual' mode. No automatic gear shifts are enabled. Example: **Automatic Pos 4**, **Start** F4, **End** F6. Gear lever position 4 enables automatic gear shifts between F4, F5 and F6.

3 **Reverse**: Displays the automatic reverse gear selection range in the same way as the **Forward** data.

4 **Gear Lever Codes**: Displays the code for each gear lever position (maximum of six positions). The codes represent binary numbers dependant on the type of gear selection switch used.

5 **Neutral Sense Delay**: Displays the time delay factor when the gear lever is set to N. This value is set to prevent false inputs from spurious signals. Values are also shown for **FR Sense Delay** and **Gear to Gear Delay**.

Other

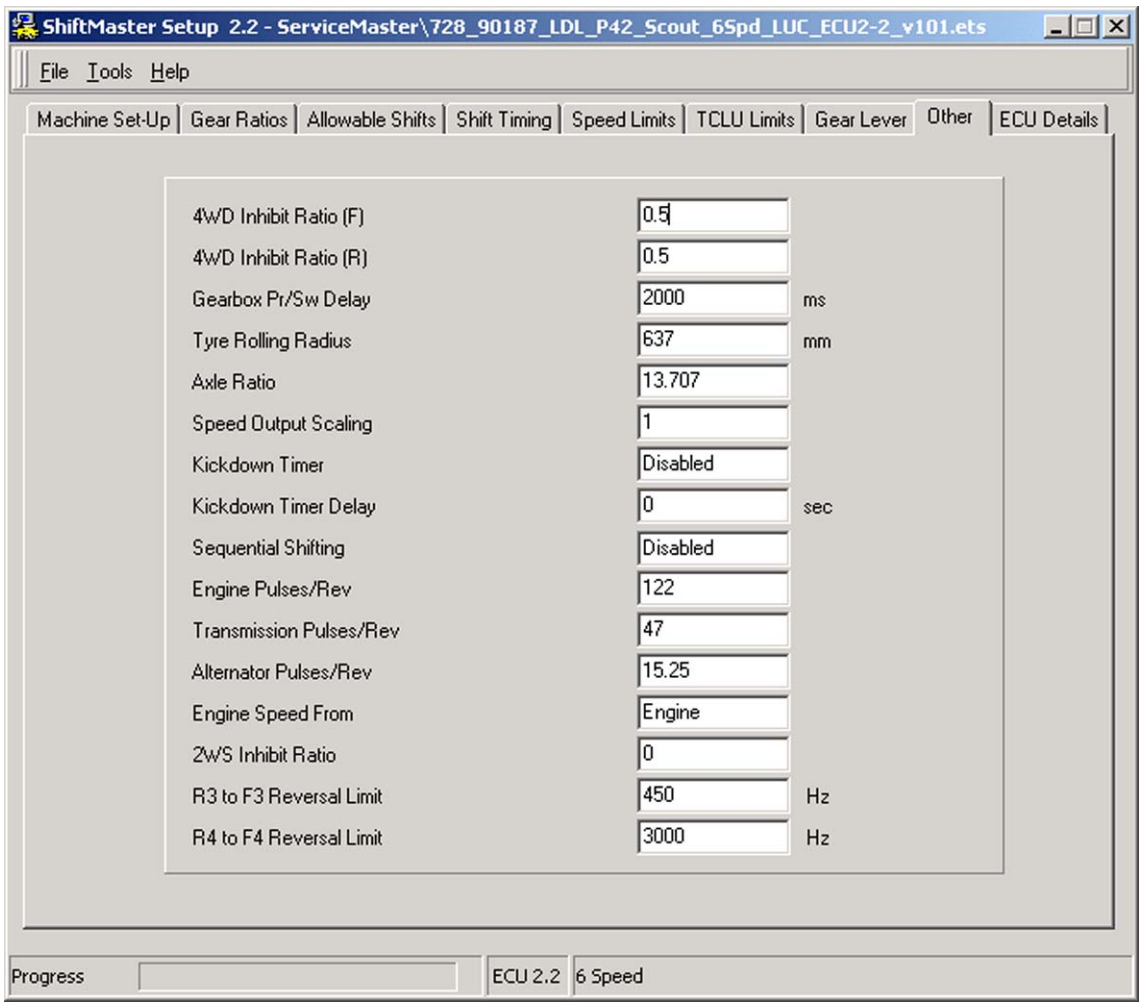


Fig 198.

This page contains all the miscellaneous setup data which cannot be categorised into any of the above pages. Data includes information used for rpm calculation, kickdown operation, setting up of transmission and engine speed inputs and reversal limits. ⇒ ***Fig 198. (F-228)***

ECU Details

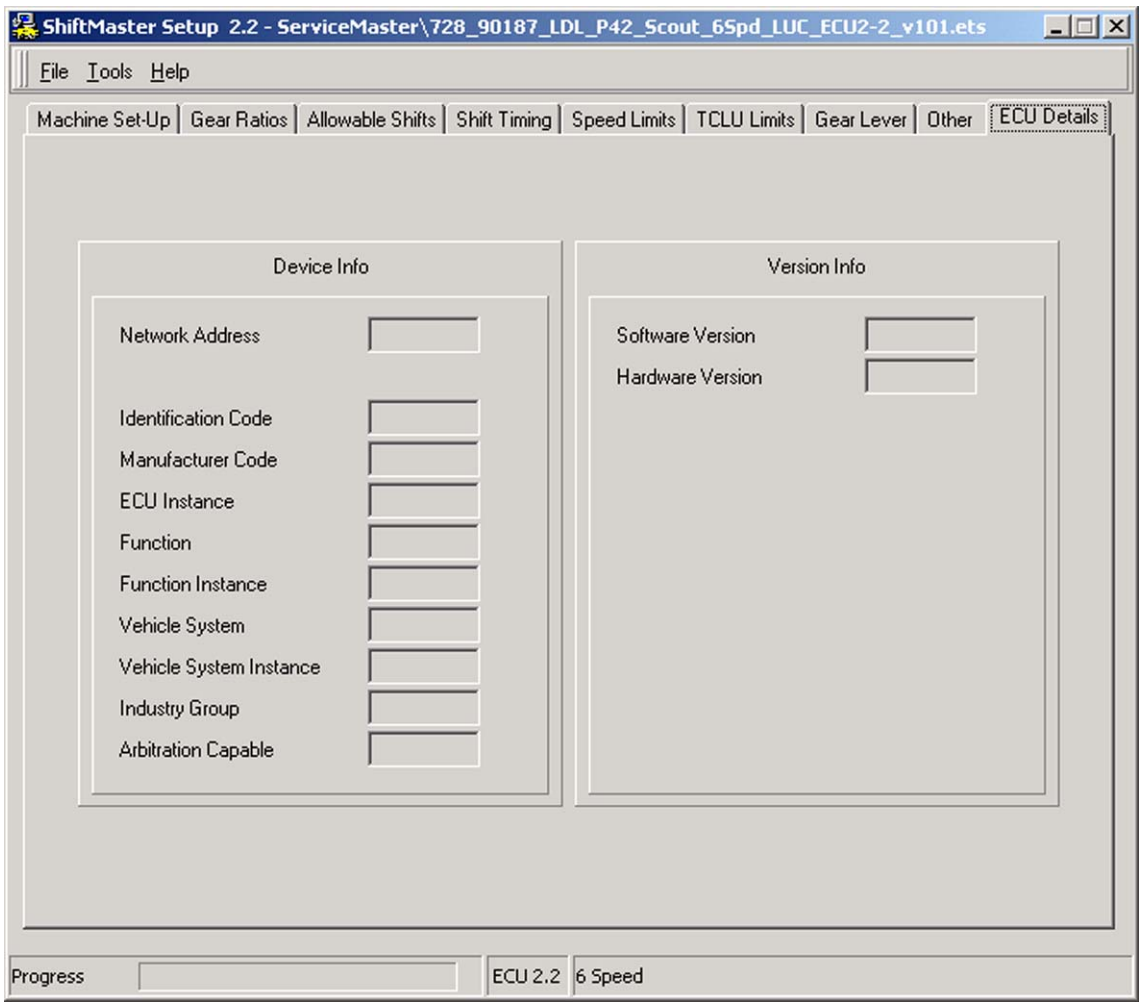


Fig 199.

This page displays the details of the connected ShiftMaster ECU. These values are NOT part of the setup files and are only included for the completeness of this document.
⇨ *Fig 199. (F-229)*

Connection Problems

In general, whenever there are problems communicating with the DLA there will be an error message displayed.The following section although not exhaustive attempts to identify the more common ECU communication problems.

ShiftMaster PC Service Tools must use the authorised Data Link Adaptor (DLA) contained in the Electronic Service Tool Kit. The latest versions of both the hardware and software can be obtained through authorised suppliers. ShiftMaster software has been designed to run on the Windows 9.X, Windows 2000 and Windows XP operating systems.

A number of reasons can generate software problems and assistance from an Information Technology engineer is advised. In particular, laptop PCs can suffer serial communications conflicts were the PC hardware does not allow the Diagnostic software access to the communication ports. In the majority of cases conflicts are caused by either software already running on the PC, or by certain 'driver' files not releasing the COM port(s).

The PC Service Tools for example ShiftMaster Diagnostics indicate the existence of an ECU communication problem that can reside in two areas indicated in the type of displayed error message. The first message is generated when the problem exists between the PC and DLA then the `Error Connecting to DLA' will be displayed. ⇒ *Fig 200. (F-230)*

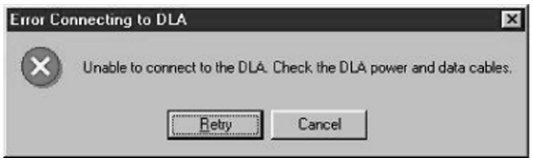


Fig 200.

Confirmation of this error can be found in the `ECU Setup Page' with 'NO DLA COMMS' being displayed in the `ECU Part Number' box. ⇒ *Fig 201. (F-230)*

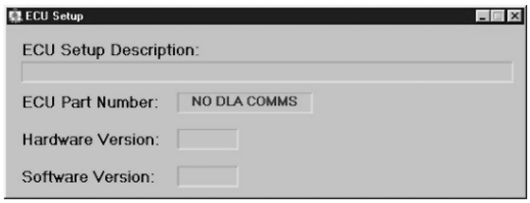


Fig 201.

The second is generated when no communications can be established with the DLA and the ECU usually through a hardware problem. No power supply from the machine, indicated by the DLA's power LED will display the 'NO ECU COMMS' message. ⇒ *Fig 202. (F-230)*. Another source could be related to resistance of the two data communication wires making up the machine's harness for the ECU's CAN connection to the Deutsch 9 way round diagnostic connector. The wiring must have two 120 Ohm resistors fitted to either end of this run of cable to give a 60 Ohm impedance. If the impedance is incorrect then `NO ECU COMMS' message will displayed. ⇒ *Fig 202. (F-230)*

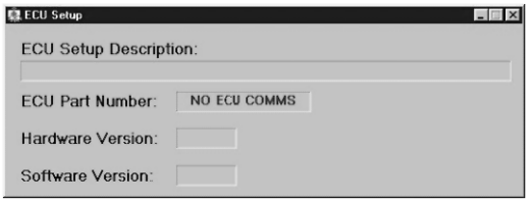


Fig 202.

Note: *The ECU must be powered for communications to work, i.e. the machine ignition must be ON (but the engine need not be running).*

If a problem is experienced it can take one of three forms, a constant failure to establish communications, drop out during communications or intermittent communication connection. However, the source has a tendency to be of the `NO DLA COMMS' type and thus related to the user's PC. Contributory factors to communication errors could be related to the following items:

– **DLA Drivers**. The DLA and PC are programmed with software `drivers' which handle communications. Ensure the latest drivers are installed on the PC and

DLA (contained in the latest version of Service Master).

- **PC Power Management**. Previous experiences have shown that some laptops' Power Management software can disrupt the COM ports. Turning off the power management software may resolve the problem.
- **IR Drivers**. If the PC has an InfraRed (IR) communications port then disabling the driver may help.
- **Modem Drivers**. Modem drivers could cause communication conflicts and temporary disabling to establish if the software is conflicting with the port may establish this source.

If the aforementioned information fails to resolve the situation then the following contacts may be able to provide further assistance;

- Information Technology (IT) engineer.
- Authorised machine dealer or agent.
- Machine OEM. The Original Equipment Manufacturer (OEM) will make the relevant enquires.

General Information

For all enquiries about the **ShiftMaster Setup** tool please follow your normal channels of enquiry. This ensures that useful information can filter through to JCB personnel at all levels.

ShiftMaster Flash Programmer - User Guide

Introduction

The **ShiftMaster Flash Programmer** software tool is part of the **JCB Service Master** software suite.

ShiftMaster Flash Programmer employs the graphical strengths of the Microsoft Windows operating environment to allow easy updating of the transmission ECU operating software.

ShiftMaster Flash Programmer is only intended for use with ECU 2 and ECU 2.2 controlled PS760 gearboxes. The system is not compatible with relay controlled gearboxes. Older versions of Powershift Controllers used on the PS750 series gearboxes are not supported.

This software is intended for use on IBM Compatible Personal Computers **(PCs)** running **Windows 9x**, **Windows2000** and **WindowsXP** operating systems but is not compatible with either earlier versions of **Windows 3.x**. Ideally the computer should be a laptop type.

Care and Safety

⚠ WARNING

Be sure to read and follow any on screen instructions. Failure to follow correct procedure could result in death or injury.

2-4-5-5

Fig 203.

Installing ShiftMaster Flash Programmer

The **ShiftMaster Flash Programmer** tool is fully integrated within JCB Service Master. To use ShiftMaster Flash Programmer you must install **JCB Service Master** onto a suitable laptop computer.

For full instructions on how to install **JCB Service Master** software please refer to the documentation which accompanies JCB Service Master.

Connecting ShiftMaster Flash Programmer

To use ShiftMaster Flash Programmer your laptop computer must be connected to the machine transmission ECU diagnostics connector ⇒ *Fig 205. (F-234)* or ⇒ *Fig 206. (F-235)* as applicable. Connection is made using Diagnostic Link Adapter (DLA) **204C** and the applicable cables.

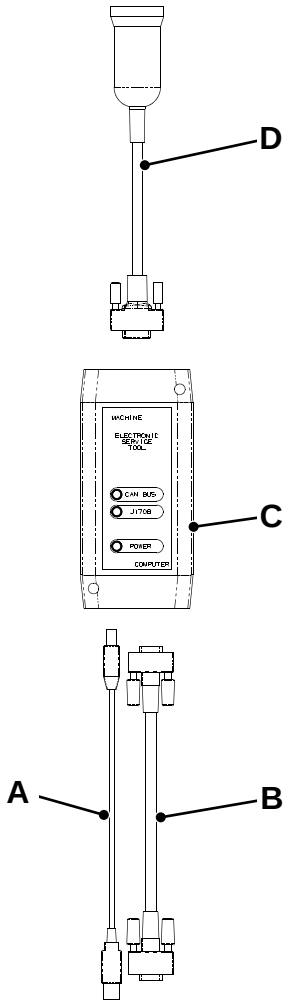


Fig 204.

A	USB PC Cable	718/20235
B	Serial PC Cable	718/20236
C	USB DLA	728/26500
D	Machine Cable	718/20237

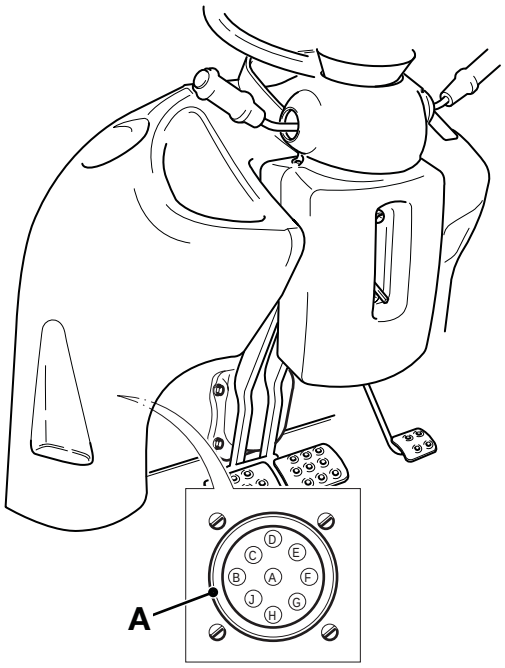
Kit 892/01174 (includes items A,B,C and D)

1 Connect either the 'Serial PC Cable' **204B** (718/20236) or the 'USB PC Cable' **204A** (718/20235) between the DLA **204C** and a free port on your laptop computer.

The 'Serial PC cable' has a 9-way D-type connector on one end and a 25-Way D-type connector on the other. Plug the 25-way male connector into the DLA and the other connector into a free port on your laptop PC, remembering to tighten any thumb-screws appropriately.

2 Connect the 'Machine Cable' **204D** between the DLA and the machines' Diagnostic Connector **205A** or **206A** as applicable.

The 'Machine Cable' has a 15-way D-type connector on one end and a 9-way CAN connector on the other. Plug the 15-way connector into the DLA and tighten the thumb-screws, then connect the 9-way CAN connector into the machines' Diagnostics Connector and twist the lock-ring to secure it.



A405350-C3

Fig 205. Diagnostics Connector - Early Machines

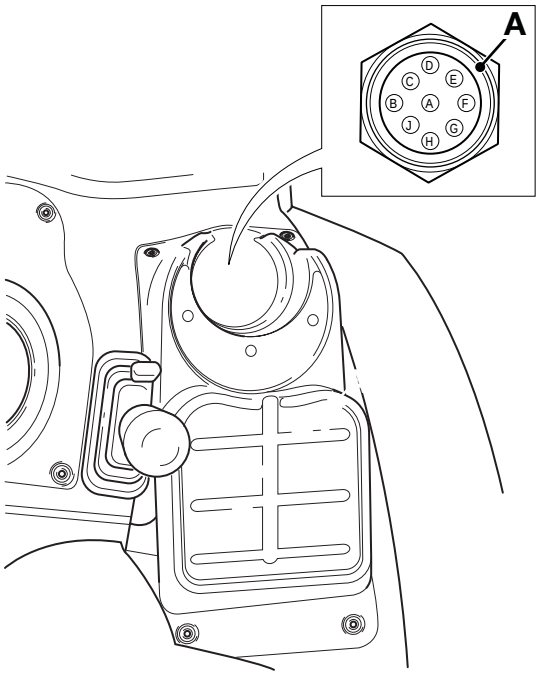


Fig 206. Diagnostics Connector - Later Machines

Starting ShiftMaster Flash Programmer

1 Turn ON the machine ignition.

2 Start **JCB Service Master** on the laptop computer.

Fig 207.

3 Make sure that the correct DLA is selected in the chooser. Click on `Utilities', DLA Setup. The DLA Chooser window opens. Check the button to match to the current device. Click on **Apply** ⇒ *Fig 208. (F-236)*.

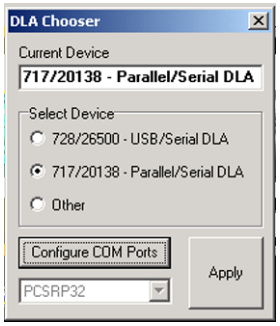


Fig 208.

4 Select `Backhoe Loader' from the drop down list ⇒ *Fig 207. (F-236)* and then start the software tool running by clicking on the **ShiftMaster Flash Programmer** icon ⇒ *Fig 209. (F-236)*.

Fig 209.

5 Warning message appears ⇒ *Fig 210. (F-236)*. Read and understand the Warning message. If you can comply with the requirements press the **Accept** button.

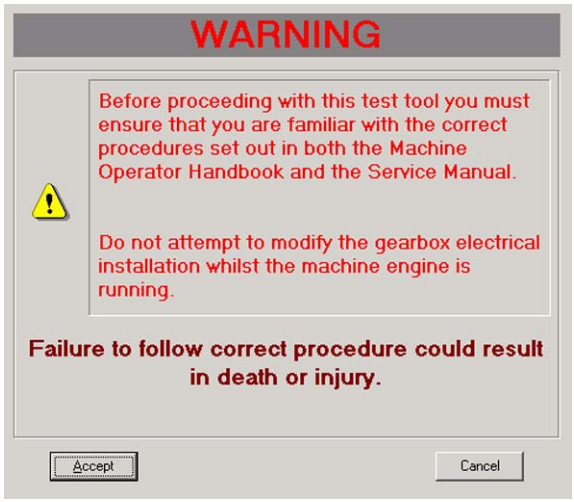


Fig 210.

6 The **ShiftMaster Flash Programmer** tool will then open up displaying the main window ⇒ *Fig 211. (F-236)*. The program will automatically scan for any transmission ECU resident on the CAN connection.

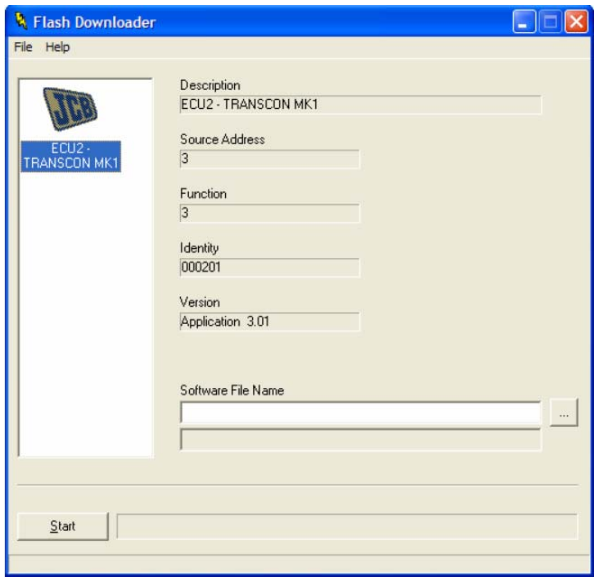


Fig 211.

If ShiftMaster Flash Programmer cannot be started successfully see ⇨ ***Connection Problems (F-244)***.

ShiftMaster Flash Programmer Overview

There are several key elements to the **Flash Programmer** tool. These can be seen labelled below. Each element is explained in detail in later sections.

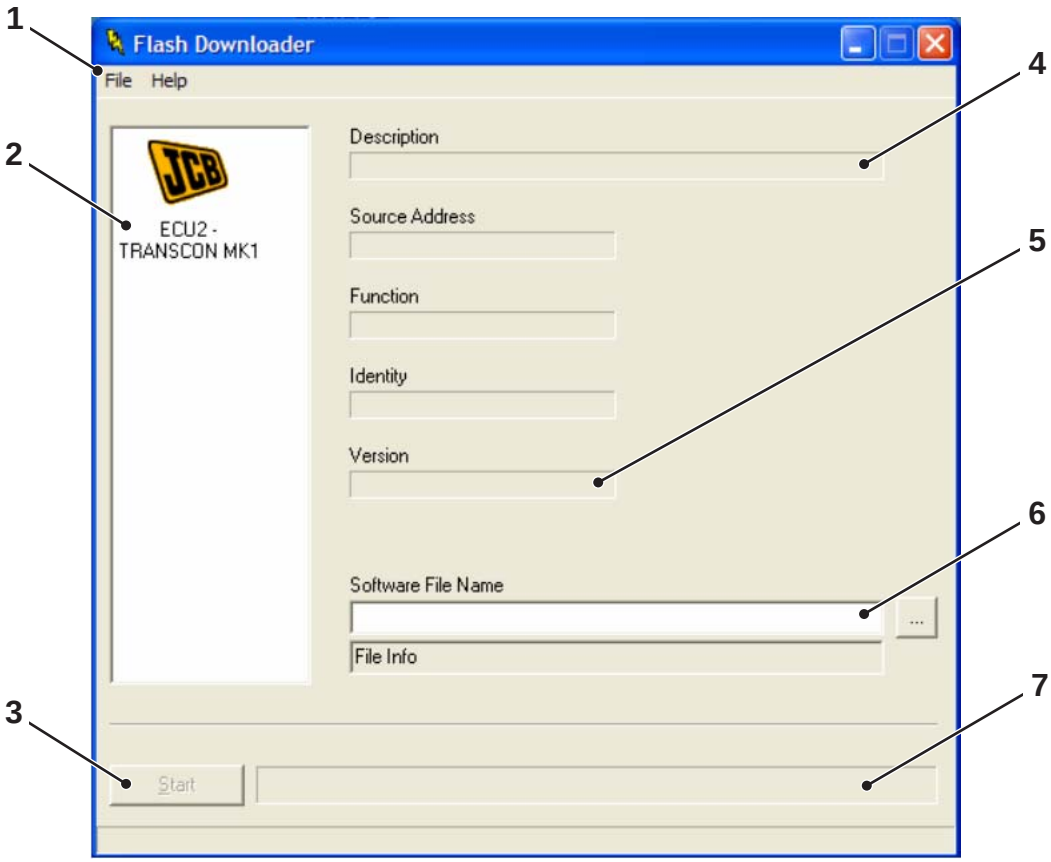


Fig 212.

Key:

1 Menu Bar
2 ECU List
3 Download Start and Stop Button
4 ECU Description
5 Resident ECU Software Version
6 Flash File Selection
7 Progress Indicator

Menu Bar - File Menu

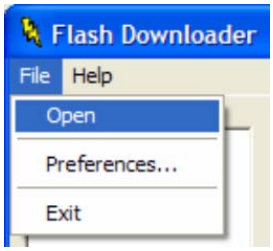


Fig 213.

– **Open**: To locate and select the required flash file.

Note: *This functions in the same way as the* ***Browse*** *button in the main window.*

– **Exit**: To close down the program. On exiting the communications with both the ECU and DLA are shutdown.

Fig 214.

– **Preferences** option opens up the Preference Dialogue ⇨ ***Fig 214. (F-239)***.
– **Select Language**: Use the drop-down menu and scroll bar to select the required language.
– **English (Canada)**
– **English (United Kingdom)**
– **French (France)**
– **German (Germany)**
– **Italian (Italy)**
– **Portuguese (Portugal)**
– **Spanish (International Sort)**

Once your preferences have been selected either:

Click on the **OK** button to apply them or click on the **Cancel** button to leave them unchanged.

ECU List

When the transmission ECU is connected a JCB icon will appear in the ECU list. ⇨ ***Fig 215. (F-240)***.

Fig 215.

Note: *If communications with the transmission ECU cannot be established, then this area of the screen will remain blank. For help on fixing communications problems, see* ⇨ ***Connection Problems (F-244)***.

ECU Details

Click on the JCB icon in the ECU list area to display the ECU details in the text boxes. ⇨ *Fig 216. (F-241)*.

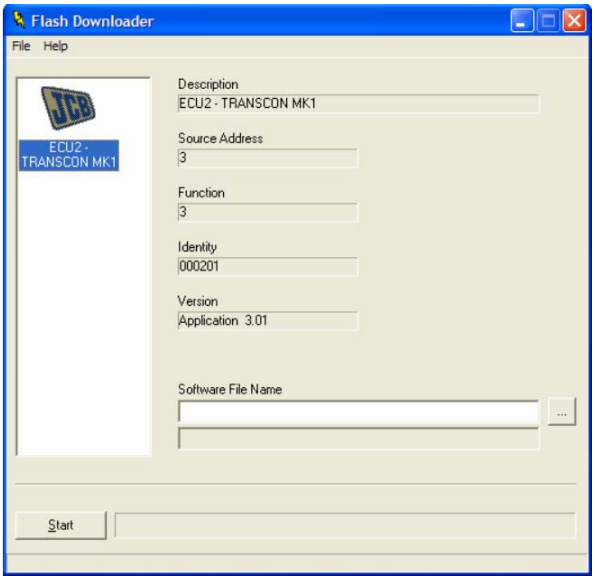


Fig 216.

When the transmission ECU is interrogated by the **ShiftMaster Flash Programmer** tool, both hardware and software application data is transmitted. This information is displayed in several text boxes. **Description** (same data as below the JCB icon in the ECU list), **Source Address**, **Function** and **Identity**.

If an operating software upgrade is necessary, the most useful information is in the **Version** text box. This displays the current version of the operating software installed in the ECU.

Note: *If, after clicking on the JCB icon, none of the text boxes contain data, then this indicates that a communications problem may exist. For help on fixing communications problems, see* ⇨ *Connection Problems (F-244)*.

Flash File Selection

This area of the screen allows the user to navigate and open a flash file which contains the ECU operating software.

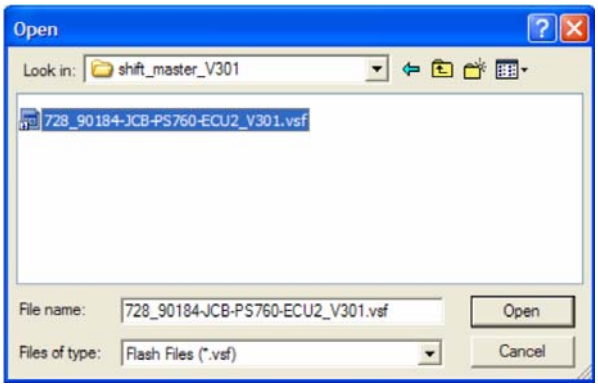


Fig 217.

1 Click on the **Browse** button in the main window to bring up the Open dialogue window. ⇒ *Fig 217. (F-242)*.

2 Using the dialogue window, navigate to the required flash file. Click on the required file to select it, the file will become highlighted.

Note: *The ShiftMaster Flash Programmer tool supports two types of file (.hex and .vsf). All transmission ECU operating software is distributed as .vsf files, therefore make sure that the Flash Files (*.vsf) type is selected when browsing for files. If not the file will be invisible in the dialogue window.*

3 Click on the **Open** button to open the flash file into the **ShiftMaster Flash Programmer** tool, or click on the **Cancel** button to abort file selection.

4 After opening, the main window will display the details of the flash file selected ⇒ *Fig 218. (F-242)*.The white area will display the file name and path of the selected file. The grey area displays the version and the release date of the file.

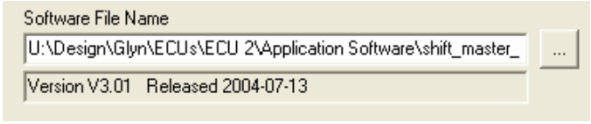


Fig 218.

Note: *When downloading new ECU operating software from the JCB Techweb website, save the file (.vsf file) to the computer desktop.*

Loading Software to the ECU

IMPORTANT NOTE: Before attempting to load any software to the transmission ECU you should have a clear justification and/or instruction for carrying out this activity. As with any similar exercise there are always associated risks. If you are not fully familiar with the software updating process please do not attempt to update any software.

1 Open the required ECU operating software flash file (.vsf file) into the **ShiftMaster Flash Programmer** ⇨ *Flash File Selection (F-242)*.

2 Click on the **Start** button in the main window to begin loading the new software.

Note: *If the flash file is selected but there is no ECU communications, then the* ***Start*** *button will appear 'greyed out'.*

3 A message will appear asking you to confirm if this is the correct file to load into the ECU. Click on the **Yes** button to confirm, or click on the **No** button to cancel the download. ⇨ *Fig 219. (F-243)*.

Fig 219.

4 After confirmation, the **ShiftMaster Flash Programmer** will start loading the flash file to the ECU. The progress bar will appear at the bottom of the window. ⇨ *Fig 220. (F-243)*.

Fig 220.

Note: *Typically, the file may take around 15 to 20 seconds to load to the ECU.*

CAUTION: DO NOT interrupt the loading process by clicking on the **Stop** button. This button is intended only to abort loading in the unlikely event that a communications problem occurs. If ECU communications fail during the loading process, then wait for 5 to 10 minutes before clicking on the **Stop** button.

5 When the progress bar has scrolled fully across, the transmission ECU will reset. Three warning beeps will then sound on the machine's warning buzzer to alert the user that the ECU has powered-up. If the flash programming was successful a message is displayed. Click on the **OK** button to continue. ⇨ *Fig 221. (F-243)*.

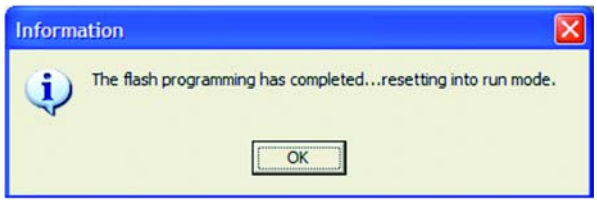


Fig 221.

Connection Problems

In general, whenever there are problems communicating with the DLA there will be an error message displayed.The following section although not exhaustive attempts to identify the more common ECU communication problems.

ShiftMaster PC Service Tools must use the authorised Data Link Adaptor (DLA) contained in the Electronic Service Tool Kit. The latest versions of both the hardware and software can be obtained through authorised suppliers. ShiftMaster software has been designed to run on the Windows 9.X, Windows 2000 and Windows XP operating systems.

A number of reasons can generate software problems and assistance from an Information Technology engineer is advised. In particular, laptop PCs can suffer serial communications conflicts were the PC hardware does not allow the Diagnostic software access to the communication ports. In the majority of cases conflicts are caused by either software already running on the PC, or by certain 'driver' files not releasing the COM port(s).

The PC Service Tools for example ShiftMaster Diagnostics indicate the existence of an ECU communication problem that can reside in two areas indicated in the type of displayed error message. The first message is generated when the problem exists between the PC and DLA then the `Error Connecting to DLA' will be displayed. ⇨ *Fig 222. (F-244)*

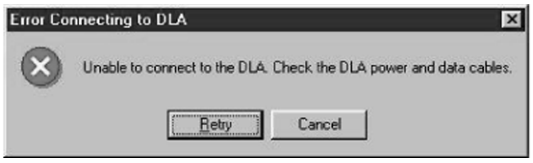


Fig 222.

Confirmation of this error can be found in the `ECU Setup Page' with 'NO DLA COMMS' being displayed in the `ECU Part Number' box. ⇨ *Fig 223. (F-244)*

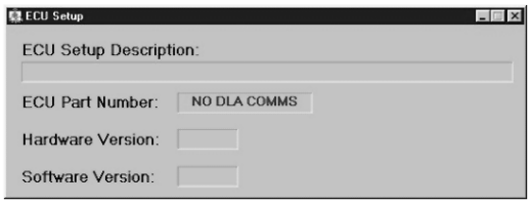


Fig 223.

The second is generated when no communications can be established with the DLA and the ECU usually through a hardware problem. No power supply from the machine, indicated by the DLA's power LED will display the 'NO ECU COMMS' message. ⇨ *Fig 224. (F-244)*. Another source could be related to resistance of the two data communication wires making up the machine's harness for the ECU's CAN connection to the Deutsch 9 way round diagnostic connector. The wiring must have two 120 Ohm resistors fitted to either end of this run of cable to give a 60 Ohm impedance. If the impedance is incorrect then `NO ECU COMMS' message will displayed. ⇨ *Fig 224. (F-244)*

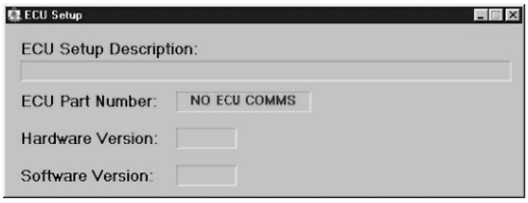


Fig 224.

Note: *The ECU must be powered for communications to work, i.e. the machine ignition must be ON (but the engine need not be running).*

If a problem is experienced it can take one of three forms, a constant failure to establish communications, drop out during communications or intermittent communication connection. However, the source has a tendency to be of the `NO DLA COMMS' type and thus related to the user's PC. Contributory factors to communication errors could be related to the following items:

– **DLA Drivers**. The DLA and PC are programmed with software `drivers' which handle communications. Ensure the latest drivers are installed on the PC and

DLA (contained in the latest version of Service Master).

- **PC Power Management**. Previous experiences have shown that some laptops' Power Management software can disrupt the COM ports. Turning off the power management software may resolve the problem.
- **IR Drivers**. If the PC has an InfraRed (IR) communications port then disabling the driver may help.
- **Modem Drivers**. Modem drivers could cause communication conflicts and temporary disabling to establish if the software is conflicting with the port may establish this source.

If the aforementioned information fails to resolve the situation then the following contacts may be able to provide further assistance;

- Information Technology (IT) engineer.
- Authorised machine dealer or agent.
- Machine OEM. The Original Equipment Manufacturer (OEM) will make the relevant enquires.

General Information

For all enquiries about the **ShiftMaster Flash Programmer** tool please follow your normal channels of enquiry. This ensures that useful information can filter through to JCB personnel at all levels.

Testing the Lock up Torque Converter

Before attempting to test the lock up function of the torque converter you must be familiar with how the system works. Read and understand the following information in this document:

Basic Operation, Lock Up Torque Converter.

Electrical Connections, Lock Up Torque Converter.

ShiftMaster Diagnostics, User Guide. ⇨ *Torque Converter Lock Up (TCLU) Page (F-198)*.

The lock up clutch components are integral with the torque converter and are non serviceable parts. Before renewing the transmission E.C.U. or lock up torque converter make sure that all the associated electrical, electronic and hydraulic systems are functioning correctly. Proceed as follows:

By far the most effective way to check the system is by using the ShiftMaster Diagnostics software and a laptop computer.

1 Use the loader and stabiliser controls to raise all 4 wheels clear of the ground.

2 Connect a laptop computer to the E.C.U. diagnostics connector. ⇨ *ShiftMaster Diagnostics 2.2 - User Guide (F-183)*.

3 Start the ShiftMaster Diagnostics software and select the Torque Converter Lock Up Control page. ⇨ *Torque Converter Lock Up (TCLU) Page (F-198)*.

Important: *Make sure that all personnel are well clear of the machine.*

4 Start the engine and engage forward `4th' (4 speed) or `A' (6 speed) as applicable. The following E.C.U. inputs should be indicated on the diagnostics page:

- **a** Engine speed sensor status LED **225A** illuminated.
- **b** Transmission speed sensor status LED **225B** illuminated.

5 If the diagnostics software indicates no input from one or both speed sensors stop the engine and check the associated wiring and sensors for damage. See ***Electrical Connections, Lock Up Torque Converter***.

6 If input from the speed sensors is confirmed, slowly increase the engine speed using the throttle pedal (do not use the hand throttle) until the lock up clutch solenoid is energised (lock up clutch solenoid status LED **225C** illuminated). The engine speed at which the lock up clutch is energised is shown on the diagnostics page, **225D**.

Note: *There will be a slight jolt in the transmission if the lock up clutch is engaging normally. Also the indicator light in the cab should also illuminate.*

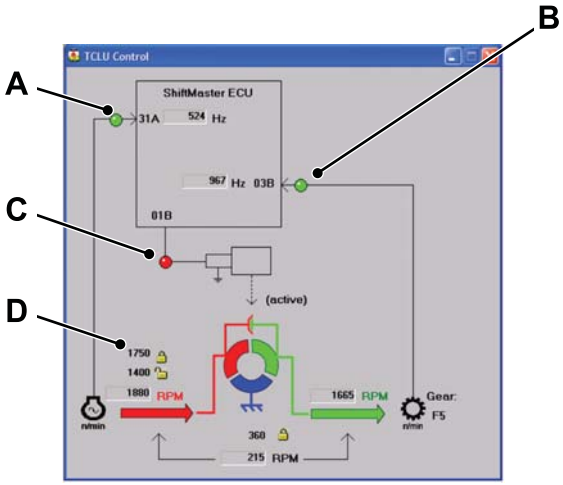


Fig 225.

7 If the diagnostics software does not indicate the lock up clutch solenoid being energised at, or just above the correct engine speed, stop the engine and check the associated wiring and solenoid coil for damage. See ***Electrical Connections, Lock Up Torque Converter***.

Note: *The lock up clutch control valve solenoid can be accessed by removing the blanking cover **226A** from the cab floor.*

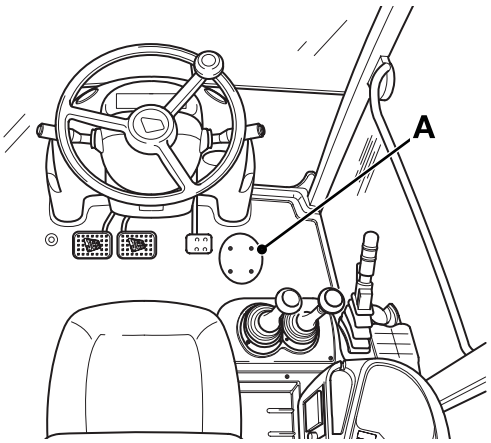


Fig 226.

8 If energising of the lock up clutch solenoid is confirmed, there may be a control valve hydraulic fault, or the lock up clutch in the torque converter may be faulty.

9 Stop the engine. Remove the blanking plug (or the temperature switch - if fitted) and connect a 0-20 bar (0-300 lbf/in^2) pressure gauge at test point **227A**.

Also, connect a 0-20 bar (0-300 lbf/in^2) pressure gauge at test point **227B**. Make sure that the gauge hoses are long enough to get clear of the machine.

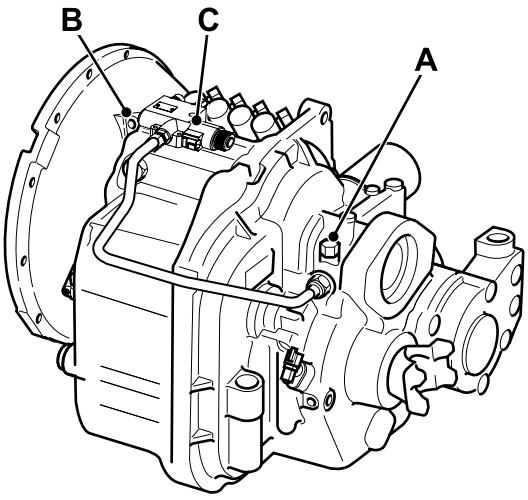


Fig 227.

10 Select neutral and run the engine at 1000 rev/min. Note the pressure readings on both gauges. The pressure at test point **227A** will read approximately 1 bar (15 lbf/in^2) less than the pressure at test point **227B**.

11 Select 4th or `A' forward and increase the engine speed until the lock up clutch solenoid **227C** is energised. Note the pressure readings on both gauges. The pressure at test point **227A** will read zero. The pressure at test point **227B** will be the same as in step 10.

If the pressure at test point **227A** does not go to zero, the lock up clutch control valve **227C** is faulty. Replace the control valve. See ***Powershift Gearbox, Dismantle and Assembly.***

If the pressure does go to zero, but road tests confirm that the lock up feature of the torque converter is not functioning, the torque converter is faulty. Remove the gearbox and replace the torque converter. See ***Torque Converter, Removal and Replacement.***

Speedometer - if fitted

Some machines may be fitted with a speedometer as an option.

Calibration Procedure

Note: *In this example, the procedure shows how to change the calibration figure from 204260 to 312130.*

Calibration Figures (1)	
4-Speed machines	312130
6-Speed machines	283450

(1) These figures are only applicable to machines fitted with currently approved tyres.

1 With the calibration button **A** depressed, turn the ignition key switch to the `IGN' position, but do not start the engine.

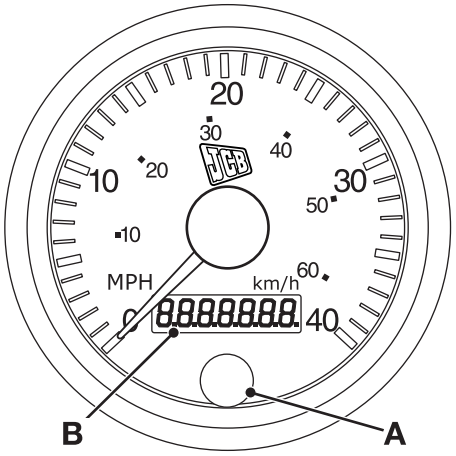
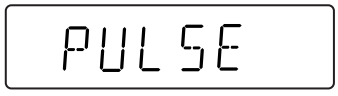
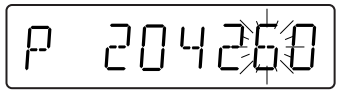


Fig 228.

Keep the button pressed until the digital display **B** on the speedometer reads "PULSE", then release the button.



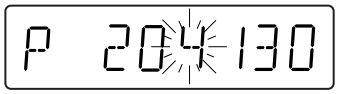
2 After approximately three seconds, the display changes to show the current calibration figure with the digit before the last one flashing (the last digit cannot be altered).



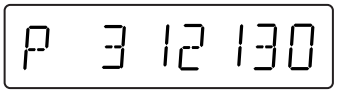
3 Enter the correct calibration figure. Each digit is entered in turn by pressing button **A** the required number of times; in this example the digit must be changed to `3'. Press button **A** three times.

After a pause, the display automatically changes to show the next digit flashing.

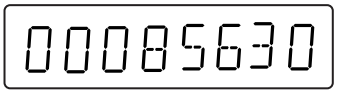
The next digit required is `1'. Press button **A** once. The next digit flashes.



Continue in this way until all the digits have been entered.



4 Once the complete calibration figure has been entered, the display changes to total or partial distance display.



Calibration is now complete.

Fault Finding

Powershift Gearbox

Introduction

The fault finding procedures are given in the form of tables. The tables are designed to identify possible causes by performing checks and where applicable, specific tests on the gearbox. Having identified a cause the suggested remedy is given. The tables are designed to identify causes through a process of elimination, starting with the simplest, most easily rectified faults.

Gearbox faults may be caused by faulty electrical connectors or components as indicated in the fault finding tables. Full explanations of the relevant electrical systems for both 4 speed and 6 speed gearboxes are given in ***Electrical Connections***.

Due to the time and effort involved in removing, dismantling, assembling and replacing a gearbox, it is recommended that fault finding procedures are carried out until a fault can be identified with a good degree of certainty.

Full details of the test procedures referred to in the tables are given in ***Service Procedures***, **Powershift Gearbox**.

Transmission Technical Data Check List

To help with fault identification, record the test results in a check list. This section includes a blank check list to copy and use as required ⇨ ***Fig 229. (F-250)***. The check list will help the engineer to identify the cause of a gearbox fault, and if required, can be sent to the JCB Technical Service Team via e-mail.

Fault Finding Tables

Fault Descriptions		
1	Machine drives but lacks power in all gears. Gearbox oil may also be overheating.	⇨ ***Table 50. (F-251)***.
2	Machine does not drive in any gear.	⇨ ***Table 51. (F-253)***.
3	Some gears fail to engage or lack power.	⇨ ***Table 52. (F-254)***.
4	Gearbox overheating.	⇨ ***Table 53. (F-255)***.
5	Noisy operation.	⇨ ***Table 54. (F-256)***.
6	Cannot engage 4 wheel drive (4WD Pressure ON clutch).	⇨ ***Table 55. (F-257)***.
7	Cannot engage 2 wheel drive (4WD Pressure ON clutch).	⇨ ***Table 56. (F-258)***.
8	Cannot engage 4 wheel drive (4WD Spring ON clutch).	⇨ ***Table 57. (F-259)***.
9	Cannot engage 2 wheel drive (4WD Spring ON clutch).	⇨ ***Table 58. (F-260)***.
10	Gearbox oil contaminated with water.	⇨ ***Table 59. (F-261)***.
11	Machine does not achieve maximum speed when travelling on the highway (lock up torque converter variants only).	⇨ ***Table 60. (F-263)***.
12	Shiftmaster fails to function normally or shifts at incorrect road speed. Fails to autoshift (6 speed only).	⇨ ***Table 61. (F-264)***.

Transmission Technical Data Checklist

Please refer to the relevant section of Transmission Service Manual for reference data.

Company ..…… Contact Name ..…….

Transmission Serial Number…… E-mail address & ..…….
Tel Number ..…….

Machine Make/Model …….. Installation Date ..…….

M/C Serial …… Machine Hours ..…….

Oil Used …… Oil Sample Available Yes/No

1. Stall Test results

Stall Test Results	**RPM**	
Gear	Forward	Reverse
1st		
2nd		
3rd		
4th		

2. Pressures (in neutral) at 50^0C

	1000rpm	2000rpm
Converter In		
Converter Out		
Lubrication		
Mainline		
Forward High Clutch		
Forward Low Clutch **		
Reverse High Clutch		
Reverse Low Clutch **		
Layshaft Clutch **		
Mainshaft Clutch **		
5th or 6th Spd Clutch ##		
2/4 wd Clutch		
Converter Inlet Relief Valve		

** not applicable to synchromesh transmissions
only applicable to PS750 5spd or PS760 6spd

3. Flow Rates (in neutral) @ 50^0C

	1000rpm	2000rpm
Cooler		
Pump		

4. Summary of symptoms / fault / previous history

……

……

……

……

Signature …… Date ……

Fig 229.

Table 50.

Fault	Possible Cause	Action
Machine drives but lacks power in all gears. Gearbox oil may also be overheating.	Gearbox oil level low.	Check for leaks and top up oil level as required.
	Gearbox oil contaminated or wrong grade.	Investigate the reason for the contamination and rectify as required. Drain the oil and flush the gearbox, refer to ***Service Procedures - Powershift Gearbox, Flushing the Transmission Oil***.
	Suction strainer restricted or blocked.	Remove the suction strainer and clean or renew as applicable, refer to Section 3 ***Routine Maintenance***.
	Pressure maintenance valve defective.	Carry out oil pressure and flow tests, refer to ***Pressure and Flow Tests - Mainline Pressure***.
		Remove the pressure maintenance valve and inspect for signs of damage or excessive wear. Clean or renew as applicable.
	Torque converter relief valve defective.	Carry out oil pressure and flow tests, refer to ***Pressure and Flow Tests - Converter IN Pressure***.
		Remove the torque converter relief valve and inspect for signs of damage or excessive wear. Clean or renew as applicable.
	Oil cooler lines restricted or blocked. Internal blockage within the oil cooler matrix due to contamination.	Carry out oil pressure and flow tests, refer to ***Pressure and Flow Tests - Converter OUT Pressure*** and **Lubrication Pressure**.
		Clear the restriction. Inspect the hose routing and renew the hoses or oil cooler matrix as applicable.
	Faulty torque converter.	Carry out torque converter stall tests to confirm stall speeds are within specification, refer to ***Torque Converter Stall Tests***.
		Remove the gearbox and renew the torque converter. Note that the torque converter assembly is a non serviceable item.
	Failure of oil pump assembly.	Carry out oil pressure and flow tests, refer to ***Pressure and Flow Tests - Pump Flow***.

Fault	Possible Cause	Action
	Gearbox internal leakage fault.	Remove the gearbox and inspect the oil pump for signs of damage or excessive wear. Renew oil pump as applicable. Carry out oil pressure and flow tests, refer to ***Pressure and Flow Tests - Converter OUT Pressure***. Remove and dismantle the gearbox. Inspect all components for signs of damage or excessive wear. In particular, check the seals and renew as applicable.

⇨ *Fault Finding Tables (F-249)*.

Table 51.

Fault	Possible Cause	Action
Machine does not drive in any gear.	Gearbox oil level low.	Check for leaks and top up oil level as required.
	Park brake switch or transmission dump switch defective.	Check the function of the park brake switch and transmission dump switch.
		Inspect the condition of the associated electrical wiring, plugs and connectors for damage and check that the relevant fuses are intact. Refer to ***Electrical Connections*** for details of the electrical circuit and connections.
	Gear selector column switch defective.	Check the function of the gear selector column switch, refer to ***Electrical Connections***.
		Inspect the condition of the associated electrical wiring, plugs and connectors for damage and check that the relevant fuses are intact. Refer to ***Electrical Connections*** for details of the electrical circuit and connections.
	Low mainline oil pressure.	Carry out oil pressure and flow tests, refer to ***Pressure and Flow Tests - Mainline Pressure***.
	Failure of oil pump assembly.	Carry out oil pressure and flow tests, refer to ***Pressure and Flow Tests - Pump Flow***.
		Remove the gearbox and inspect oil pump for signs of damage or excessive wear. Renew oil pump as applicable.

⇨ *Fault Finding Tables (F-249)*.

Table 52.

Fault	Possible Cause	Action
Some gears fail to engage or lack power.	Gear selector column switch defective.	Check the function of the gear selector column switch, refer to ***Electrical Connections***.
		Inspect the condition of the associated electrical wiring, plugs and connectors for damage and check that the relevant fuses are intact. Refer to ***Electrical Connections*** for details of the electrical circuit and connections.
	The relevant solenoid valve is not being energised.	Inspect the condition of the associated electrical wiring, plugs and connectors for damage and check that the relevant fuses are intact. Refer to ***Electrical Connections*** for details of the electrical circuit and connections.
	Solenoid coil faulty.	Check the solenoid for open or short circuits. Measure the solenoid coil resistance.
		Renew the solenoid coil.
	Clutch operating oil pressure low.	Carry out oil pressure and flow tests, refer to ***Pressure and Flow Tests - Pressure Testing Clutches***.
	Failure of clutch assembly.	Check for clutch internal leakage. Carry out oil pressure and flow tests, refer to ***Pressure and Flow Tests - Pressure Testing Clutches***.
		Check for clutch slippage. Carry out torque converter stall tests to confirm stall speeds are within specification, refer to ***Torque Converter Stall Tests***.
		Remove and dismantle gearbox. Inspect relevant clutch components for signs of damage or excessive wear. Renew as applicable.

⇒ *Fault Finding Tables (F-249)*.

Table 53.

Fault	Possible Cause	Action
Gearbox oil overheating.	Oil cooler heat exchanger matrix clogged with dirt particles or chaff.	Clean the oil cooler matrix.
	Gearbox oil level incorrect i.e. Too low or too high.	Adjust the oil level to the correct level, refer to Section 3 ***Routine Maintenance***.
	Gearbox oil contaminated or wrong grade.	Investigate the reason for the contamination and rectify as required. Drain the oil and flush the gearbox, refer to ***Service Procedures - Powershift Gearbox, Flushing the Transmission Oil***.
	Suction strainer restricted or blocked.	Remove the suction strainer and clean or renew as applicable, refer to Section 3 ***Routine Maintenance***.
	Oil cooler hoses kinked or trapped.	Clear the restriction. Inspect the hose routing and reroute or renew the hoses as applicable.
	Machine being operated incorrectly i.e. Incorrect gear range.	Educate the operator.
	Torque converter relief valve defective.	Carry out oil pressure and flow tests, refer to ***Pressure and Flow Tests - Converter IN Pressure***.
	Failure of oil pump assembly.	Carry out oil pressure and flow tests, refer to ***Pressure and Flow Tests - Pump Flow***.
		Remove the gearbox and inspect oil pump for signs of damage or excessive wear. Renew oil pump as applicable.

⇨ *Fault Finding Tables (F-249)*.

Table 54.

Fault	Possible Cause	Action
Noisy operation.	Gearbox oil level low.	Check for leaks and top up oil level as required.
	Gearbox oil contaminated or wrong grade.	Investigate the reason for the contamination and rectify as required. Drain the oil and flush the gearbox, refer to ***Service Procedures - Powershift Gearbox, Flushing the Transmission Oil***.
	Suction strainer restricted or blocked.	Remove the suction strainer and clean or renew as applicable, refer to Section 3 ***Routine Maintenance***.
	Low lubrication oil pressure.	Carry out oil pressure and flow tests, refer to ***Pressure and Flow Tests - Lubrication Pressure***.
	Gearbox components damaged or excessively worn.	Remove and dismantle the gearbox. Inspect all components for signs of damage or excessive wear. In particular, check shaft seals and bearings. Renew as applicable.

⇨ *Fault Finding Tables (F-249)*.

Table 55.

Fault	Possible Cause	Action
Cannot engage 4 wheel drive (Pressure ON clutch).(1)	Gearbox oil level low.	Check for leaks and top up oil level as required.
	4WD selector switch defective.	Check the function of the 4WD selector switch.
		Inspect the condition of the associated electrical wiring, plugs and connectors for damage and check that the relevant fuses are intact. Refer to ***Electrical Connections*** for details of the electrical circuit and connections.
	4WD solenoid valve is not being energised.	Inspect the condition of the associated electrical wiring, plugs and connectors for damage and check that the relevant fuses are intact. Refer to ***Electrical Connections*** for details of the electrical circuit and connections.
	Solenoid coil faulty.	Check the solenoid for open or short circuits. Measure the solenoid coil resistance.
		Renew the solenoid coil.
	4WD solenoid valve spool is sticking in the 2 wheel drive position due to contamination.	Remove and inspect the solenoid valve cartridge. Clean the valve or renew as applicable.
	Clutch operating oil pressure low.	Carry out oil pressure and flow tests, refer to ***Pressure and Flow Tests - Pressure Testing Clutches***.
	Failure of clutch assembly.	Check for clutch internal leakage. Carry out oil pressure and flow tests, refer to ***Pressure and Flow Tests - Pressure Testing Clutches***.
		Remove the 4WD clutch assembly, refer to ***4WD Clutch - Removal and Replacement***. Inspect the clutch components for signs of damage or excessive wear. Renew as applicable.

(1) This type of clutch is engaged by oil pressure for 4 wheel drive, and disengaged by spring force for 2 wheel drive.

⇨ ***Fault Finding Tables (F-249)***.

Table 56.

Fault	Possible Cause	Action
Cannot engage 2 wheel drive (Pressure ON clutch).(1)	4WD solenoid valve spool is sticking in the 4 wheel drive position due to contamination.	Remove and inspect the solenoid valve cartridge. Clean the valve or renew as applicable.
	Solenoid coil permanently energised.	Check the function of the 4WD selector switch.
		Inspect the condition of the associated electrical wiring, plugs and connectors for damage and check that the relevant fuses are intact. Refer to ***Electrical Connections*** for details of the electrical circuit and connections.
	Failure of clutch assembly.	Remove the 4WD clutch assembly, refer to ***4WD Clutch - Removal and Replacement***. Inspect the clutch components for signs of damage or excessive wear. Renew as applicable.

(1) This type of clutch is engaged by oil pressure for 4 wheel drive, and disengaged by spring force for 2 wheel drive.

⇨ ***Fault Finding Tables (F-249)***.

Table 57.

Fault	Possible Cause	Action
Cannot engage 4 wheel drive (Spring ON clutch).(1)	4WD solenoid valve spool is sticking in the 2 wheel drive position due to contamination.	Remove and inspect the solenoid valve cartridge. Clean the valve or renew as applicable.
	Solenoid coil permanently energised.	Check the function of the 4WD selector switch.
		Inspect the condition of the associated electrical wiring, plugs and connectors for damage and check that the relevant fuses are intact. Refer to ***Electrical Connections*** for details of the electrical circuit and connections.
	Failure of clutch assembly.	Remove the 4WD clutch assembly, refer to ***4WD Clutch - Removal and Replacement***. Inspect the clutch components for signs of damage or excessive wear. Renew as applicable.

(1) This type of clutch is engaged by spring force for 4 wheel drive, and disengaged by oil pressure for 2 wheel drive.

⇨ ***Fault Finding Tables (F-249)***.

Table 58.

Fault	Possible Cause	Action
Cannot engage 2 wheel drive (Spring ON clutch).(1)	Gearbox oil level low.	Check for leaks and top up oil level as required.
	4WD selector switch defective.	Check the function of the 4WD selector switch.
		Inspect the condition of the associated electrical wiring, plugs and connectors for damage and check that the relevant fuses are intact. Refer to ***Electrical Connections*** for details of the electrical circuit and connections.
	4WD solenoid valve is not being energised.	Inspect the condition of the associated electrical wiring, plugs and connectors for damage and check that the relevant fuses are intact. Refer to ***Electrical Connections*** for details of the electrical circuit and connections.
	Solenoid coil faulty.	Check the solenoid for open or short circuits. Measure the solenoid coil resistance.
		Renew the solenoid coil.
	4WD solenoid valve spool is sticking in the 4 wheel drive position due to contamination.	Remove and inspect the solenoid valve cartridge. Clean the valve or renew as applicable.
	Clutch operating oil pressure low.	Carry out oil pressure and flow tests, refer to ***Pressure and Flow Tests - Pressure Testing Clutches***.
	Failure of clutch assembly.	Check for clutch internal leakage. Carry out oil pressure and flow tests, refer to ***Pressure and Flow Tests - Pressure Testing Clutches***.
		Remove the 4WD clutch assembly, refer to ***4WD Clutch - Removal and Replacement***. Inspect the clutch components for signs of damage or excessive wear. Renew as applicable.

(1) This type of clutch is engaged by spring force for 4 wheel drive, and disengaged by oil pressure for 2 wheel drive.

⇨ ***Fault Finding Tables (F-249)***.

Table 59.

Fault	Possible Cause	Action
Gearbox oil contaminated with water. (1)	Water ingress during filling or topping-up.	Drain the oil and flush the gearbox, refer to ***Service Procedures - Powershift Gearbox, Flushing the Transmission Oil***.
	Missing or incorrect dipstick. Damaged filler tube.	Renew missing, incorrect or damaged parts.
		Drain the oil and flush the gearbox, refer to ***Service Procedures - Powershift Gearbox, Flushing the Transmission Oil***.
	Machine operated in deep water.	Drain the oil and flush the gearbox, refer to ***Service Procedures - Powershift Gearbox, Flushing the Transmission Oil***.
	Gearbox casings damaged.	Inspect the gearbox casing. Renew missing or damaged parts.
		Drain the oil and flush the gearbox, refer to ***Service Procedures - Powershift Gearbox, Flushing the Transmission Oil***.
	Gearbox oil circuit pipework or hoses damaged.	Inspect the pipework and hoses. Renew missing or damaged parts.
		Drain the oil and flush the gearbox, refer to ***Service Procedures - Powershift Gearbox, Flushing the Transmission Oil***.
Consequential Faults. (2)		
a Pressurisation of gearbox casing. Dipstick blows out and oil escapes from dipstick tube.	Water in the oil combined with heat from torque converter causes steam.	Replace or renew the dipstick.
		Drain the oil and flush the gearbox, refer to ***Service Procedures - Powershift Gearbox, Flushing the Transmission Oil***.
b Clutch failure due to friction lining separation.	Water ingress.	Remove and dismantle gearbox. Inspect relevant clutch components for signs of damage or excessive wear. Renew as applicable.
	Overheating transmission oil.	⇨ *Table 53. (F-255)*
c Badly worn or noisy bearings.	Water ingress.	Remove and dismantle the gearbox. Inspect all components for signs of damage or excessive wear. Renew components as applicable.

Fault	Possible Cause	Action
	Insufficient lubrication.	Drain the oil and flush the gearbox, refer to ***Service Procedures - Powershift Gearbox, Flushing the Transmission Oil***. Carry out oil pressure and flow tests, refer to ***Pressure and Flow Tests - Lubrication Pressure***.

(1) Carefully inspect the gearbox oil for signs of water contamination. Contaminated oil will contain water droplets or be visibly emulsified. Water droplets may be visible on the dipstick or inside the filler tube. For oil analysis purposes, the maximum permissible water content of the oil is 0.10%. If the gearbox oil has been contaminated with water, faults or damage to the gearbox may be apparent as a result. Before remedying, thoroughly investigate and rectify the cause of the water contamination.

(2) Gearbox faults caused typically by water contamination and other factors related to the gearbox oil.

⇨ ***Fault Finding Tables (F-249)***.

Table 60.

Fault	Possible Cause	Action
Machine does not achieve maximum speed when travelling on the highway (Lock up torque converter variants only).	Operator error.	Educate the operator. Ensure operator fully understands the characteristics of the lock up function.
	Lock up torque converter solenoid not being energised.	Inspect the condition of the associated electrical wiring, plugs and connectors for damage and check that the relevant fuses are intact. Refer to ***Electrical Connections*** for details of the electrical circuit and connections.
	Lock up torque converter solenoid coil faulty.	Check the solenoid for open or short circuits. Measure the solenoid coil resistance.
		Renew the solenoid coil.
	Engine or transmission speed sensor faulty.	Use the Shiftmaster Diagnostics software to check the ECU inputs and outputs. Refer to ***Service Procedures - Powershift Gearbox, Diagnostics User Guide***.
		Inspect the condition of the associated electrical wiring, plugs and connectors for damage and check that the relevant fuses are intact. Refer to ***Electrical Circuit Schematic*** for details of the electrical circuit and connections.
		Renew the speed sensor.
	Faulty lock up torque converter.	Remove the gearbox and renew the lock up torque converter. Note that the torque converter assembly is a non serviceable item.

⇨ *Fault Finding Tables (F-249)*.

Table 61.

Fault	Possible Cause	Action
Shiftmaster fails to function normally or shifts at incorrect road speed. (1)	Gear selector column switch, kickdown switch or throttle switch defective.	Check the function of the gear selector column switch, kickdown switch and throttle switch.
Fails to autoshift (6 speed only). (2)		Inspect the condition of the associated electrical wiring, plugs and connectors for damage and check that the relevant fuses are intact. Refer to ***Electrical Connections*** for details of the electrical circuit and connections.
	Transmission speed sensor faulty.	Check the function of the speed sensor.
		Inspect the condition of the associated electrical wiring, plugs and connectors for damage and check that the relevant fuses are intact. Refer to ***Electrical Connections*** for details of the electrical circuit and connections.
		Renew the speed sensor. Refer to ***Service Procedures - Powershift Gearbox, Speed Sensor***.
	Gearbox electronic control unit (ECU) defective. (3)	Use the Shiftmaster Diagnostics software to check the ECU inputs and outputs. Refer to ***Service Procedures - Powershift Gearbox, Diagnostics User Guide***.
		Inspect the condition of the associated electrical wiring, plugs and connectors for damage and check that the relevant fuses are intact. Refer to ***Electrical Connections*** for details of the electrical circuit and connections.
		Renew the ECU. ***Refer to Service Procedures - Powershift Gearbox, Electronic Control Unit***.

(1) The simplest and best way to fault find the ECU controlled gearbox electrical system is by using the Shiftmaster Diagnostics software and a laptop PC, refer to `Service Procedures - Powershift Gearbox, Diagnostics User Guide'. This diagnostics system enables the engineer to quickly identify faults with specific electrical circuits or devices. The devices electrical connections, locations and wire identifications are given in `Electrical Connections - Powershift Gearbox, Shiftmaster'. See also `Section C Harness Data'.

(2) Note that on 6 speed gearboxes, 4th, 5th and 6th gears utilise clutches used for 1st, 2nd and 3rd gears. If 4th, 5th or 6th gears fail to engage, check that the lower 3 gears function correctly before investigating a possible Shiftmaster fault, refer to `Fault Table - Some gears fail to engage or lack power'.

(3) In response to certain faults the ECU will enter a `Limp Mode'. For a detailed description of the Limp Modes, refer to `Service Procedures - Powershift Gearbox, Electronic Control Unit'.

⇨ ***Fault Finding Tables (F-249)***.

Synchro Shuttle Gearbox

Introduction

The fault finding procedures are given in the form of tables. The tables are designed to identify possible causes by performing checks and where applicable, specific tests on the gearbox. Having identified a cause the suggested remedy is given. The tables are designed to identify causes through a process of elimination, starting with the simplest, most easily rectified faults.

Gearbox faults may be caused by faulty electrical connectors or components as indicated in the fault finding tables. Full explanations of the relevant electrical systems are given in ***Electrical Connections***.

Due to the time and effort involved in removing, dismantling, assembling and replacing a gearbox, it is recommended that fault finding procedures are carried out until a fault can be identified with a good degree of certainty.

Full details of the test procedures referred to in the tables are given in ***Service Procedures***, **Synchro Shuttle Gearbox**.

Fault Finding Tables

Fault Descriptions		
1	Machine drives but lacks power in all gears. Gearbox oil may also be overheating.	⇨ ***Table 62. (F-266)***.
2	Machine does not drive in any gear.	⇨ ***Table 63. (F-268)***.
3	Gearbox overheating.	⇨ ***Table 64. (F-270)***.
4	Noisy operation.	⇨ ***Table 65. (F-271)***.
5	Cannot engage 4 wheel drive (4WD Pressure ON clutch).	⇨ ***Table 66. (F-272)***.
6	Cannot engage 2 wheel drive (4WD Pressure ON clutch).	⇨ ***Table 67. (F-273)***.
7	Gearbox oil contaminated with water.	⇨ ***Table 68. (F-274)***.

Table 62.

Fault	Possible Cause	Action
Machine drives but lacks power in all gears. Gearbox oil may also be overheating.	Gearbox oil level low.	Check for leaks and top up oil level as required.
	Gearbox oil contaminated or wrong grade.	Investigate the reason for the contamination and rectify as required. Drain the oil and flush the gearbox, refer to ***Service Procedures - Synchro Shuttle Gearbox, Flushing the Transmission Oil***.
	Suction strainer restricted or blocked.	Remove the suction strainer and clean or renew as applicable, refer to Section 3 ***Routine Maintenance***.
	Pressure maintenance valve defective.	Carry out oil pressure and flow tests, refer to ***Pressure and Flow Tests - Mainline Pressure***.
		Remove the pressure maintenance valve and inspect for signs of damage or excessive wear. Clean or renew as applicable.
	Torque converter relief valve defective.	Carry out oil pressure and flow tests, refer to ***Pressure and Flow Tests - Converter IN Pressure***.
		Remove the torque converter relief valve and inspect for signs of damage or excessive wear. Clean or renew as applicable.
	Oil cooler lines restricted or blocked. Internal blockage within the oil cooler matrix due to contamination.	Carry out oil pressure and flow tests, refer to ***Pressure and Flow Tests - Converter OUT Pressure*** and **Lubrication Pressure**.
		Clear the restriction. Inspect the hose routing and renew the hoses or oil cooler matrix as applicable.
	Faulty torque converter.	Carry out torque converter stall tests to confirm stall speeds are within specification, refer to ***Torque Converter Stall Tests***.
		Remove the gearbox and renew the torque converter. Note that the torque converter assembly is a non serviceable item.
	Failure of oil pump assembly.	Carry out oil pressure and flow tests, refer to ***Pressure and Flow Tests - Pump Flow***.

Fault	Possible Cause	Action
	Gearbox internal leakage fault.	Remove the gearbox and inspect the oil pump for signs of damage or excessive wear. Renew oil pump as applicable. Carry out oil pressure and flow tests, refer to ***Pressure and Flow Tests - Converter OUT Pressure***. Remove and dismantle the gearbox. Inspect all components for signs of damage or excessive wear. In particular, check the seals and renew as applicable.

⇨ *Fault Finding Tables (F-265)*.

Table 63.

Fault	Possible Cause	Action
Machine does not drive in any gear.	Gearbox oil level low.	Check for leaks and top up oil level as required.
	Park brake switch or transmission dump switch defective.	Check the function of the park brake switch and transmission dump switch.
		Inspect the condition of the associated electrical wiring, plugs and connectors for damage and check that the relevant fuses are intact. Refer to ***Electrical Connections*** for details of the electrical circuit and connections.
	Forward, reverse selector column switch defective.	Check the function of the forward, reverse selector column switch, refer to ***Electrical Connections***.
		Inspect the condition of the associated electrical wiring, plugs and connectors for damage and check that the relevant fuses are intact. Refer to ***Electrical Connections*** for details of the electrical circuit and connections.
	Forward, reverse solenoid valve is not being energised.	Inspect the condition of the associated electrical wiring, plugs and connectors for damage and check that the relevant fuses are intact. Refer to ***Electrical Connections*** for details of the electrical circuit and connections.
	Solenoid coil faulty.	Check the solenoid for open or short circuits. Measure the solenoid coil resistance.
		Renew the solenoid coil.
	Forward, reverse clutch operating oil pressure low.	Carry out oil pressure and flow tests, refer to ***Pressure and Flow Tests - Pressure Testing Clutches***.
	Low mainline oil pressure.	Carry out oil pressure and flow tests, refer to ***Pressure and Flow Tests - Mainline Pressure***.
	Failure of oil pump assembly.	Carry out oil pressure and flow tests, refer to ***Pressure and Flow Tests - Pump Flow***.
		Remove the gearbox and inspect oil pump for signs of damage or excessive wear. Renew oil pump as applicable.
	Failure of forward, reverse clutch assembly.	Check for clutch internal leakage. Carry out oil pressure and flow tests, refer to ***Pressure and Flow Tests - Pressure Testing Clutches***.

Fault	Possible Cause	Action
		Check for clutch slippage. Carry out torque converter stall tests to confirm stall speeds are within specification, refer to ***Torque Converter Stall Tests***. Remove and dismantle gearbox. Inspect forward, reverse clutch components for signs of damage or excessive wear. Renew as applicable.

⇨ *Fault Finding Tables (F-265)*.

Table 64.

Fault	Possible Cause	Action
Gearbox oil overheating.	Oil cooler heat exchanger matrix clogged with dirt particles or chaff.	Clean the oil cooler matrix.
	Gearbox oil level incorrect i.e. Too low or too high.	Adjust the oil level to the correct level, refer to Section 3 ***Routine Maintenance***.
	Gearbox oil contaminated or wrong grade.	Investigate the reason for the contamination and rectify as required. Drain the oil and flush the gearbox, refer to ***Service Procedures - Synchro Shuttle Gearbox, Flushing the Transmission Oil***.
	Suction strainer restricted or blocked.	Remove the suction strainer and clean or renew as applicable, refer to Section 3 ***Routine Maintenance***.
	Oil cooler hoses kinked or trapped.	Clear the restriction. Inspect the hose routing and reroute or renew the hoses as applicable.
	Machine being operated incorrectly i.e. Incorrect gear range.	Educate the operator.
	Torque converter relief valve defective.	Carry out oil pressure and flow tests, refer to ***Pressure and Flow Tests - Converter IN Pressure***.
	Failure of oil pump assembly.	Carry out oil pressure and flow tests, refer to ***Pressure and Flow Tests - Pump Flow***.
		Remove the gearbox and inspect oil pump for signs of damage or excessive wear. Renew oil pump as applicable.

⇨ *Fault Finding Tables (F-265)*.

Table 65.

Fault	Possible Cause	Action
Noisy operation.	Gearbox oil level low.	Check for leaks and top up oil level as required.
	Gearbox oil contaminated or wrong grade.	Investigate the reason for the contamination and rectify as required. Drain the oil and flush the gearbox, refer to ***Service Procedures - Synchro Shuttle Gearbox, Flushing the Transmission Oil***.
	Suction strainer restricted or blocked.	Remove the suction strainer and clean or renew as applicable, refer to Section 3 ***Routine Maintenance***.
	Low lubrication oil pressure.	Carry out oil pressure and flow tests, refer to ***Pressure and Flow Tests - Lubrication Pressure***.
	Gearbox components damaged or excessively worn.	Remove and dismantle the gearbox. Inspect all components for signs of damage or excessive wear. In particular, check shaft seals and bearings. Renew as applicable.

⇨ *Fault Finding Tables (F-265)*.

Table 66.

Fault	Possible Cause	Action
Cannot engage 4 wheel drive (Pressure ON clutch).(1)	Gearbox oil level low.	Check for leaks and top up oil level as required.
	4WD selector switch defective.	Check the function of the 4WD selector switch.
		Inspect the condition of the associated electrical wiring, plugs and connectors for damage and check that the relevant fuses are intact. Refer to ***Electrical Connections*** for details of the electrical circuit and connections.
	4WD solenoid valve is not being energised.	Inspect the condition of the associated electrical wiring, plugs and connectors for damage and check that the relevant fuses are intact. Refer to ***Electrical Connections*** for details of the electrical circuit and connections.
	Solenoid coil faulty.	Check the solenoid for open or short circuits. Measure the solenoid coil resistance.
		Renew the solenoid coil.
	4WD solenoid valve spool is sticking in the 2 wheel drive position due to contamination.	Remove and inspect the solenoid valve cartridge. Clean the valve or renew as applicable.
	Clutch operating oil pressure low.	Carry out oil pressure and flow tests, refer to ***Pressure and Flow Tests - Pressure Testing Clutches***.
	Failure of clutch assembly.	Check for clutch internal leakage. Carry out oil pressure and flow tests, refer to ***Pressure and Flow Tests - Pressure Testing Clutches***.
		Remove the 4WD clutch assembly, refer to ***4WD Clutch - Removal and Replacement***. Inspect the clutch components for signs of damage or excessive wear. Renew as applicable.

(1) This type of clutch is engaged by oil pressure for 4 wheel drive, and disengaged by spring force for 2 wheel drive.

⇨ ***Fault Finding Tables (F-265)***.

Table 67.

Fault	Possible Cause	Action
Cannot engage 2 wheel drive (Pressure ON clutch).(1)	4WD solenoid valve spool is sticking in the 4 wheel drive position due to contamination.	Remove and inspect the solenoid valve cartridge. Clean the valve or renew as applicable.
	Solenoid coil permanently energised.	Check the function of the 4WD selector switch.
		Inspect the condition of the associated electrical wiring, plugs and connectors for damage and check that the relevant fuses are intact. Refer to ***Electrical Connections*** for details of the electrical circuit and connections.
	Failure of clutch assembly.	Remove the 4WD clutch assembly, refer to ***4WD Clutch - Removal and Replacement***. Inspect the clutch components for signs of damage or excessive wear. Renew as applicable.

(1) This type of clutch is engaged by oil pressure for 4 wheel drive, and disengaged by spring force for 2 wheel drive.

⇨ ***Fault Finding Tables (F-265)***.

Table 68.

Fault	Possible Cause	Action
Gearbox oil contaminated with water. (1)	Water ingress during filling or topping-up.	Drain the oil and flush the gearbox, refer to ***Service Procedures - Synchro Shuttle Gearbox, Flushing the Transmission Oil***.
	Missing or incorrect dipstick. Damaged filler tube.	Renew missing, incorrect or damaged parts.
		Drain the oil and flush the gearbox, refer to ***Service Procedures - Synchro Shuttle Gearbox, Flushing the Transmission Oil***.
	Machine operated in deep water.	Drain the oil and flush the gearbox, refer to ***Service Procedures - Synchro Shuttle Gearbox, Flushing the Transmission Oil***.
	Gearbox casings damaged.	Inspect the gearbox casing. Renew missing or damaged parts.
		Drain the oil and flush the gearbox, refer to ***Service Procedures - Synchro Shuttle Gearbox, Flushing the Transmission Oil***.
	Gearbox oil circuit pipework or hoses damaged.	Inspect the pipework and hoses. Renew missing or damaged parts.
		Drain the oil and flush the gearbox, refer to ***Service Procedures - Synchro Shuttle Gearbox, Flushing the Transmission Oil***.
Consequential Faults. (2)		
a Pressurisation of gearbox casing. Dipstick blows out and oil escapes from dipstick tube.	Water in the oil combined with heat from torque converter causes steam.	Replace or renew the dipstick.
		Drain the oil and flush the gearbox, refer to ***Service Procedures - Synchro Shuttle Gearbox, Flushing the Transmission Oil***.
b Clutch failure due to friction lining separation.	Water ingress.	Remove and dismantle gearbox. Inspect relevant clutch components for signs of damage or excessive wear. Renew as applicable.
	Overheating transmission oil.	⇨ ***Table 64. (F-270)***.
c Badly worn or noisy bearings.	Water ingress.	Remove and dismantle the gearbox. Inspect all components for signs of damage or excessive wear. Renew components as applicable.

Fault	Possible Cause	Action
	Insufficient lubrication.	Drain the oil and flush the gearbox, refer to ***Service Procedures - Synchro Shuttle Gearbox, Flushing the Transmission Oil***. Carry out oil pressure and flow tests, refer to ***Pressure and Flow Tests - Lubrication Pressure***.

(1) Carefully inspect the gearbox oil for signs of water contamination. Contaminated oil will contain water droplets or be visibly emulsified. Water droplets may be visible on the dipstick or inside the filler tube. For oil analysis purposes, the maximum permissible water content of the oil is 0.10%. If the gearbox oil has been contaminated with water, faults or damage to the gearbox may be apparent as a result. Before remedying, thoroughly investigate and rectify the cause of the water contamination.

(2) Gearbox faults caused typically by water contamination and other factors related to the gearbox oil.

⇨ ***Fault Finding Tables (F-265)***.

Propshafts

Removal and Replacement

Important: *When disconnecting propshafts the park brake will become ineffective, or operate only on two wheels (depending on machine variant). Before disconnecting any propshaft chock all four wheels.*

Removal: Before removing propshafts always mark both companion flanges and also mark the sliding joints prior to removal.

Replacement: After lubricating sliding joints with JCB MPL Grease, align the shafts against identification marks previously made or, in the case of a shaft being renewed, use the manufacturer's alignment markings.

Note: *Some machines have capscrews **A** fitted instead of setscrews **B**. DO NOT mix setscrews and capscrews on the same driveshaft installation.*

Retaining straps **C** stretch with use, therefore these straps must always be replaced with new ones.

Synchro Shuttle Machines: Apply JCB Threadlocker and Sealer to threads of all flange bolts **D**.

The propshaft must have both ends exactly on the same plane as shown at **X**. The yokes must not be at right angles as at **Y** or at an intermediate angle as at **Z**.

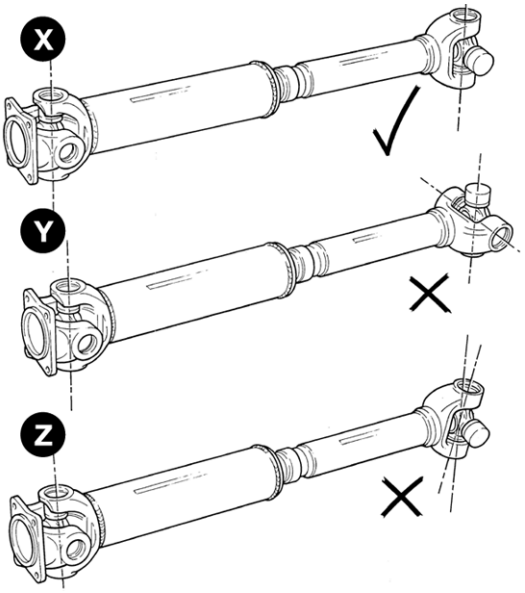


Fig 230.

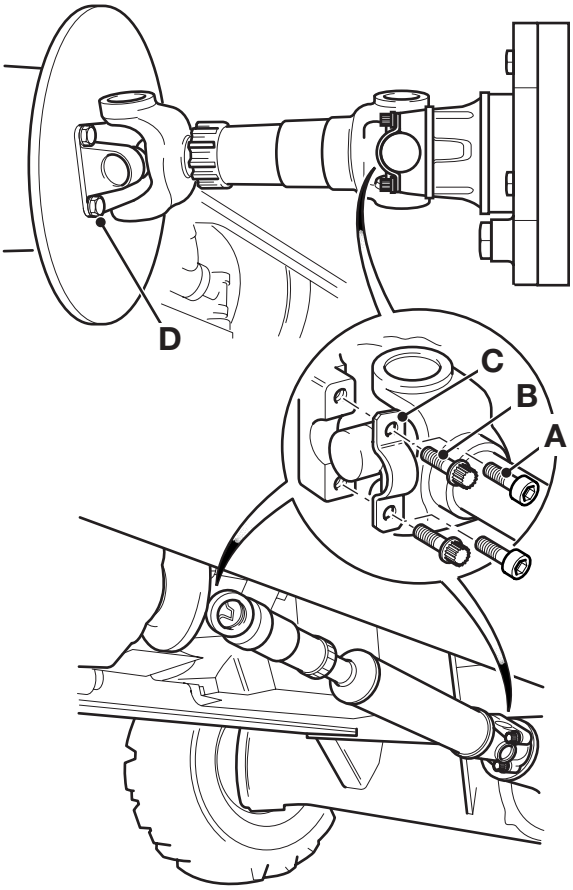


Fig 231.

Table 69. Torque Settings

Item	Nm	kgf m	lbf ft
A	70	7	52
B	70	7	52
D	118	12	87

Front Axle Dead Steer

Removal and Replacement

The removal and replacement procedures for the dead steer 2 wheel drive axle (beam type) are the same as described for the 4 wheel drive axle, see ***Front Axles SD55 and SD80***. Disregard any information which is not pertinent to the 2 wheel drive axle.

Note: *When using a `cradle' to remove the axle from the machine, the balance point of the axle on 2 wheel drive machines will be the centre of the axle, NOT offset as described.*

Dismantle and Assemble

The procedures for dismantling and assembly are described in a separate publication, see ***Transmissions Service Manual*** (Publication No. 9803-8610) which includes procedures for the axle sub-assemblies. Make sure that you identify the axle assemblies correctly, see ***Technical Data - Designation*** in this section for details.

Front Axles SD55 and SD80

Removal and Replacement

Note: *The following procedure can be applied to both AWS and 2WS machines. Disregard information not applicable to your machine type, for instance, 2 wheel steer machines will not have steering proximity switches fitted.*

⚠ WARNING

A raised and badly supported machine can fall on you. Position the machine on a firm, level surface before raising one end. Ensure the other end is securely chocked. Do not rely solely on the machine hydraulics or jacks to support the machine when working under it.

Disconnect the battery, to prevent the engine being started while you are beneath the machine.

GEN-1-1

Removal

⇨ *Fig 233. (F-281)*.

⚠ WARNING

If it is necessary to work with the loader arms raised, then the loader arm safety strut must be fitted.

4-3-2-8

1 Remove the front grille.

2 Remove the cover **K** from the proximity switch and then remove the bracket and switch assembly.

3 Using tool 892/00822 remove bolts **A** to disconnect the drive shaft from the axle.

4 Disconnect the hydraulic pipes **B** from the steer rams, blank off all exposed connections.

5 Disconnect remote grease nipple hose **H**.

6 Loosen the road wheel retaining nuts **D**.

7 Make sure that the rear wheels are blocked, use the loader arms to raise the front end of the machine.

8 Prop the machine on each side as shown at **C**.

9 Remove the front road wheels.

10 Position a jack underneath the balance point (see **Note**) of the axle and support the axle weight.

Note: *Because the drive head assembly is offset, the balance point of the axle is not the centre of the axle. Attach a 'cradle' to the jack that will partially embrace the axle.*

11 Remove nut **E** and pivot pin retaining bolt **F**.

12 Remove pivot pin **G** seals, use slide hammer (tool no. 993/68100) and remove the pivot pin **G** and axle shims.

13 Lower the jack so that the axle is clear of the mounting yoke and remove the axle.

Replacement

Replacement is the reverse of the removal sequence.

⚠ WARNING

If, for whatever reason, a wheel stud is renewed, all the studs for that wheel must be changed as a set, since the remaining studs may have been damaged.

2-3-2-8

Whenever a wheel has been removed, check the wheel nut torques every two hours until they stay correct.

Apply JCB Threadlocker and Sealer to the threads of bolts **A**.

The front axle must be shimmed to give a maximum fore and aft movement of 0.5 mm (0.020 in).

Nylon shims must be fitted as follows:

AWS Machines:

1 Fit a 5.0 mm thick master shim (coloured blue) between the front of the axle and the yoke plate as shown at **X**.

2 Measure the fore and aft movement and subtract 0.5 mm to obtain the required shim thickness. Fit the correct thickness shim between the rear of the axle and the yoke plate as shown at **Y**.

2WS Machines:

1 Fit a 5.0 mm thick master shim (coloured blue) between the rear of the axle and the yoke plate as shown at **Y**.

2 Measure the fore and aft movement and subtract 0.5 mm to obtain the required shim thickness. Fit the correct thickness shim between the front of the axle and the yoke plate as shown at **X**.

Note: *DO NOT fit more than 2 shims (including the master shim). To assist assembly, use the double sided tape ring supplied to retain the shims on the yoke plate.*

If the setting of the steering proximity switch has been disturbed, then complete the front axle proximity switch setting procedure, see Section H Steering ***Service Procedures***.

Table 70. Torque Settings

Item	Nm	kgf m	lbf ft
A	70	7	52
D	680	69	500

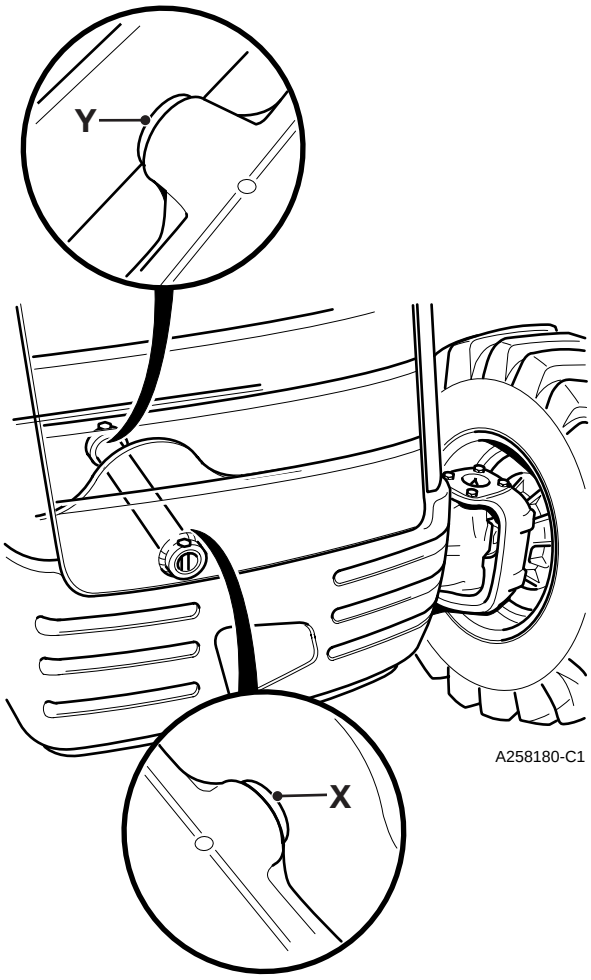


Fig 232.

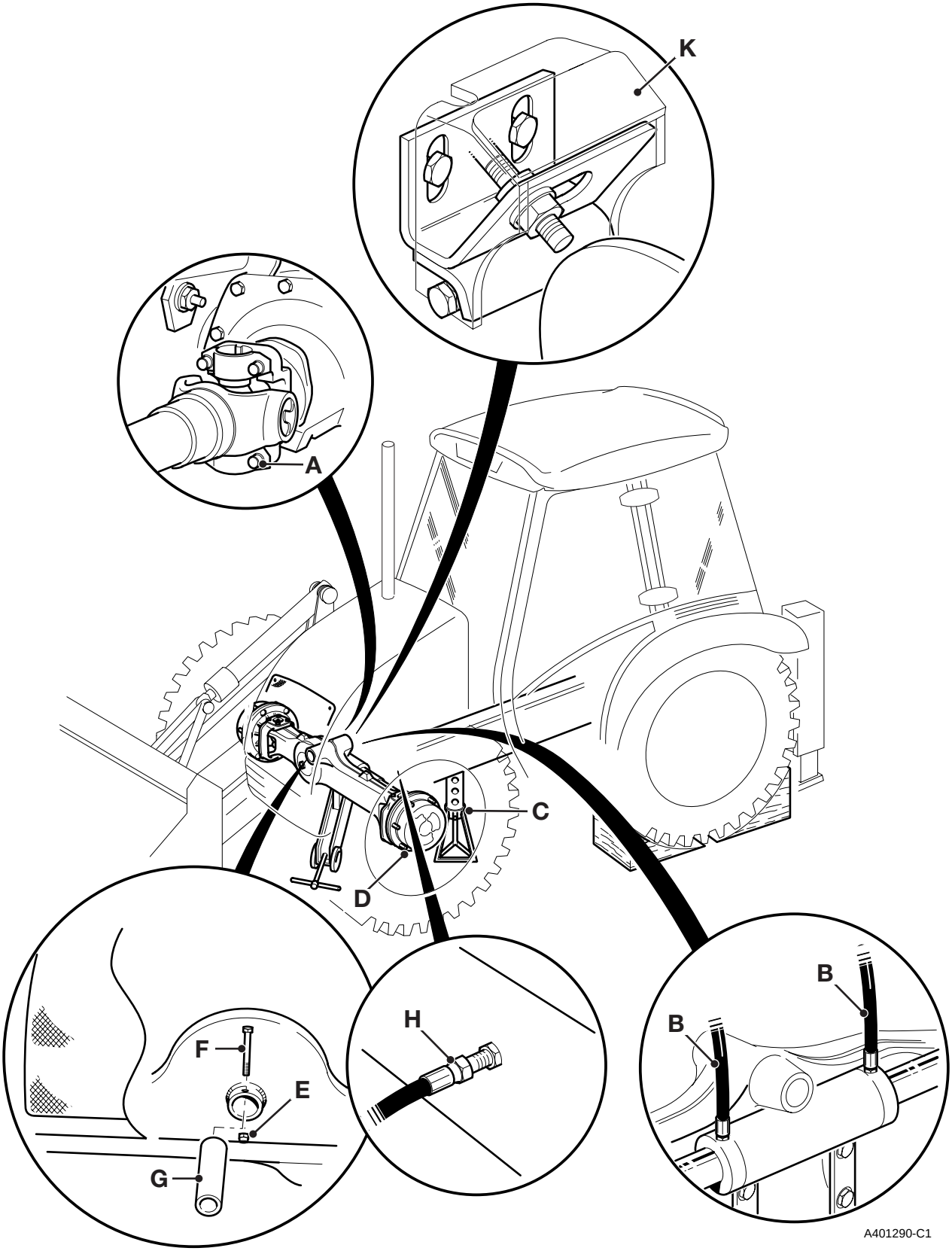


Fig 233. Front Axle

Dismantle and Assemble

The procedures for dismantling and assembly are described in a separate publication, see ***Transmissions Service Manual*** (Publication No. 9803-8610) which includes procedures for the axle sub-assemblies. Make sure that you identify the axle assemblies correctly, see ***Technical Data - Designation*** in this section for details.

Rear Axles PD70 and SD80

Removal and Replacement

⚠ WARNING

A raised and badly supported machine can fall on you. Position the machine on a firm, level surface before raising one end. Ensure the other end is securely chocked. Do not rely solely on the machine hydraulics or jacks to support the machine when working under it.

Disconnect the battery, to prevent the engine being started while you are beneath the machine.

GEN-1-1

Removal

⇨ *Fig 234. (F-285)*.

⚠ WARNING

When the driveshaft is disconnected the park brake will no longer function. The machine must be securely blocked to prevent any machine movement before disconnecting the driveshaft.

TRANS-1-3

1 **Synchro Shuttle machines only;** Release the parking brake. Loosen the parking brake cable bulkhead nuts at the bracket **L**. Disconnect the cable from the calliper **M**. Tie the cable up, out of harms way.

2 Remove bolts **A** to disconnect the drive shaft from the axle.

3 Disconnect the brake pipes from the brake piston housings, shown at **H**. Remove tee piece **B** retaining bolt and remove the tee piece. Blank off exposed connections.

4 **SD 80 Steer axles only;** Remove the cover **C** from the proximity switch and then remove the bracket and switch assembly.

5 **SD 80 Steer axles only;** Label and then disconnect hydraulic pipes **D** from the steer rams, blank off all exposed connections.

6 Loosen the road wheel retaining nuts **E**.

7 Make sure that the front wheels are blocked, use the stabiliser legs to raise the rear end of the machine with the wheels and tyres clear of the ground.

8 Prop the machine on each side as shown at **F**.

9 Remove the rear road wheels.

10 Position a jack underneath the balance point (centre) of the axle and support the axle weight.

Note: *Attach a 'cradle' to the jack that will partially embrace the axle.*

11 Remove nuts **G**, bolts **J** and washers **K**.

12 Lower the jack and remove the axle.

Note: *Some machines may be fitted with packers under the axle mounts **Z** on both sides, depending on wheel combinations.*

Replacement

Replacement is the reverse of the removal sequence.

⚠ WARNING

If, for whatever reason, a wheel stud is renewed, all the studs for that wheel must be changed as a set, since the remaining studs may have been damaged.

2-3-2-8

Whenever a wheel has been removed, check the wheel nut torques every two hours until they stay correct.

⚠ WARNING

Bleed the brake system before driving the machine.

BRAK-1-6

Bleed the brake system as described in Section G Brakes ***Service Procedures***.

Synchro Shuttle Machines Only; Check and adjust the operation of the parking brake as described in Section G Brakes ***Service Procedures***.

Apply JCB Threadlocker and Sealer to the threads of bolts **A**.

SD 80 Steer axles only; If the setting of the steering proximity switch has been disturbed, then complete the rear axle proximity switch setting procedure, as described in Section H Steering ***Service Procedures***.

Table 71. Torque Settings

Item	Nm	kgf m	lbf ft
A	70	7	52
E	680	69	500
G	607	62	448

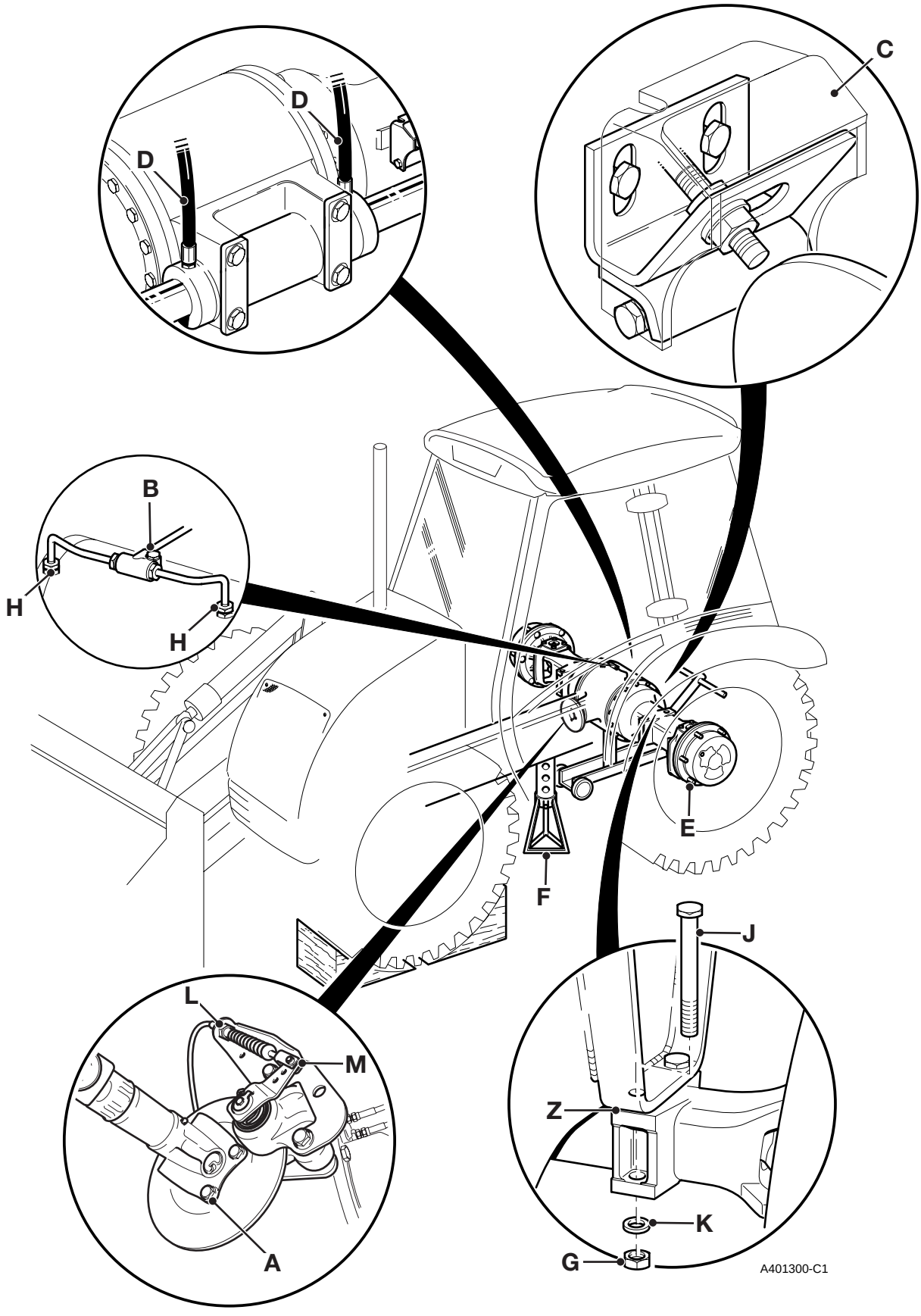


Fig 234. Rear axle

Dismantle and Assemble

The procedures for dismantling and assembly are described in a separate publication, see ***Transmissions Service Manual*** (Publication No. 9803-8610) which includes procedures for the axle sub-assemblies. Make sure that you identify the axle assemblies correctly, see ***Technical Data - Designation*** in this section for details.

Synchro Shuttle Gearbox

Removal and Replacement

Important: *The gearbox is heavy. Unless it is safely supported during removal and replacement it could fall and cause injury. Make sure that you have access to suitable jacks and a gearbox locating `cradle' before attempting to remove the gearbox.*

⚠ WARNING

A raised and badly supported machine can fall on you. Position the machine on a firm, level surface before raising one end. Ensure the other end is securely chocked. Do not rely solely on the machine hydraulics or jacks to support the machine when working under it.

Disconnect the battery, to prevent the engine being started while you are beneath the machine.

GEN-1-1

Removal

⇨ *Fig 235. (F-289)*.

1 Park the machine on firm level ground. The gearbox is heavy. If the ground is soft or uneven it will not be possible to remove the gearbox safely.

2 Loosen the right side rear wheel nuts. Rest the shovel on the ground and lower the stabilisers to raise the rear of the machine. Check dimension **X** which must be at least 800 mm. This will allow the gearbox to be pulled clear. Block and support the machine.

Note: *On sideshift machines, suitable lengths of steel channel can be used as safety struts between the stabiliser feet and chassis, one at each stabiliser.*

3 Remove the right hand side rear wheel.

4 Remove the bonnet, see Section 3 ***Routine Maintenance***.

5 Disconnect the gearshift from the top of the gearbox, as shown at **A**.

6 Remove the rear axle propshaft, see ***Propshafts***.

7 Disconnect the front axle driveshaft bolts **B** (use tool 892/00822).

8 Drain the hydraulic tank and remove the main hydraulic pump (see Section E Hydraulics ***Service Procedures and Main Hydraulic Pump***). Tie the suction hose up clear of the gearbox.

9 Drain the gearbox oil, see Section 3 ***Routine Maintenance***.

10 Remove the access cover plate at the bottom of the flywheel housing. Through the access hole, loosen and remove the torque converter to engine flywheel retaining bolts **D**.

11 At a later stage the gearbox and engine assembly is tilted to allow access to fixing bolts. To prevent damage as the engine is tilted components must have their fixings removed as follows:

a Fuel sediment bowl assembly **E**.

b Air filter assembly **F**.

c Radiator fan cowl **G**.

It is not necessary to remove these components, only release them from their fixings.

12 Support the gearbox using a suitable trolley jack and cradle. The gearbox must be securely located on the cradle as shown at **Y**.

13 Make sure that the weight of the gearbox is supported by the trolley jack and then remove the gearbox mounting bolts **H**.

14 Using the trolley jack, lower the gearbox and engine to gain access to the top torque converter housing to engine retaining bolts **J**. Put a support under the engine as shown at **Z** to prevent it from dropping when the gearbox is removed.

15 Undo the four bolts **J** at the top of the torque converter housing. Note the position of the electrical earth cable and harness clip.

16 Pull off the breather tube **K**. Undo the gearbox dipstick fixing nut **L** and then remove the dipstick tube.

17 Uncouple the forward and reverse solenoid valve connectors **M**, oil pressure sender **N** and temperature sender **P** (if fitted). Label the connectors for identification when refitting.

18 Disconnect the gearbox oil cooler hoses **R**.

19 On 4 wheel drive machines, uncouple the electrical connector at the 4WD solenoid **S**.

20 Remove the torque converter housing to engine bolts **T**.

21 Manoeuvre the gearbox with the torque convertor clear of the engine flywheel housing.

22 Lower the trolley jack and pull the gearbox and torque convertor clear of the machine.

Replacement

Replacement is a reversal of the removal procedure but note the following:

1 **Hydraulic Pump,** ⇨ *Fig 237. (F-290)*.

Before replacing the gearbox remove circlip **5** and withdraw the pump driveshaft **6** together with its bearing **7** approximately 50 mm (2.0 in). The shaft can then be engaged after the gearbox has been fitted, making replacing the gearbox easier. Remember to engage the pump drive shaft, refit the bearing and circlip after the gearbox has been fitted.

2 Set the torque converter as described in ***Torque Converter, Removal and Replacement***.

3 **Align the Torque Converter,** ⇨ *Fig 236. (F-290)*.

It is vitally important that the torque converter is fitted at the gearbox and engine flywheel correctly. Failure to locate the converter correctly will result in damage to the gearbox oil pump on engine start up. Proceed as follows:

Make sure that the torque converter drive dogs **1** are correctly engaged with the pump **2** on the gearbox. Temporarily tie the converter onto the gearbox. Use wire tied at a drive plate bolt hole to a convenient point on the outside of the gearbox.

Take note of the flywheel and drive plate fixing hole phasing. The heads of the bolts **3** will foul the flywheel **4** if phasing is incorrect.

Before bolting the torque converter housing to the engine make sure the mating faces are fully together (DO NOT USE FORCE). The drive plate **8** should also be mated close to the flywheel. Do not force the components together with the fixing bolts.

Make sure that the torque converter is free to rotate slightly within the clearance of the location bolt holes. If you cannot rotate the converter it is trapped either by bolt heads **3** or by incorrectly located pump drive dogs. Make sure that all is well before tightening the bolts.

4 Fill the gearbox with the specified amount and type of oil (see Section 3 ***Routine Maintenance***). Leave hose **N** off until the filling operation is complete. After filling refit hose **N**.

Table 72. Torque Settings

Item	Nm	kgf m	lbf ft
B	79	8	58
D	44	4.5	32
H	237	24	175
J, T	98	10	72

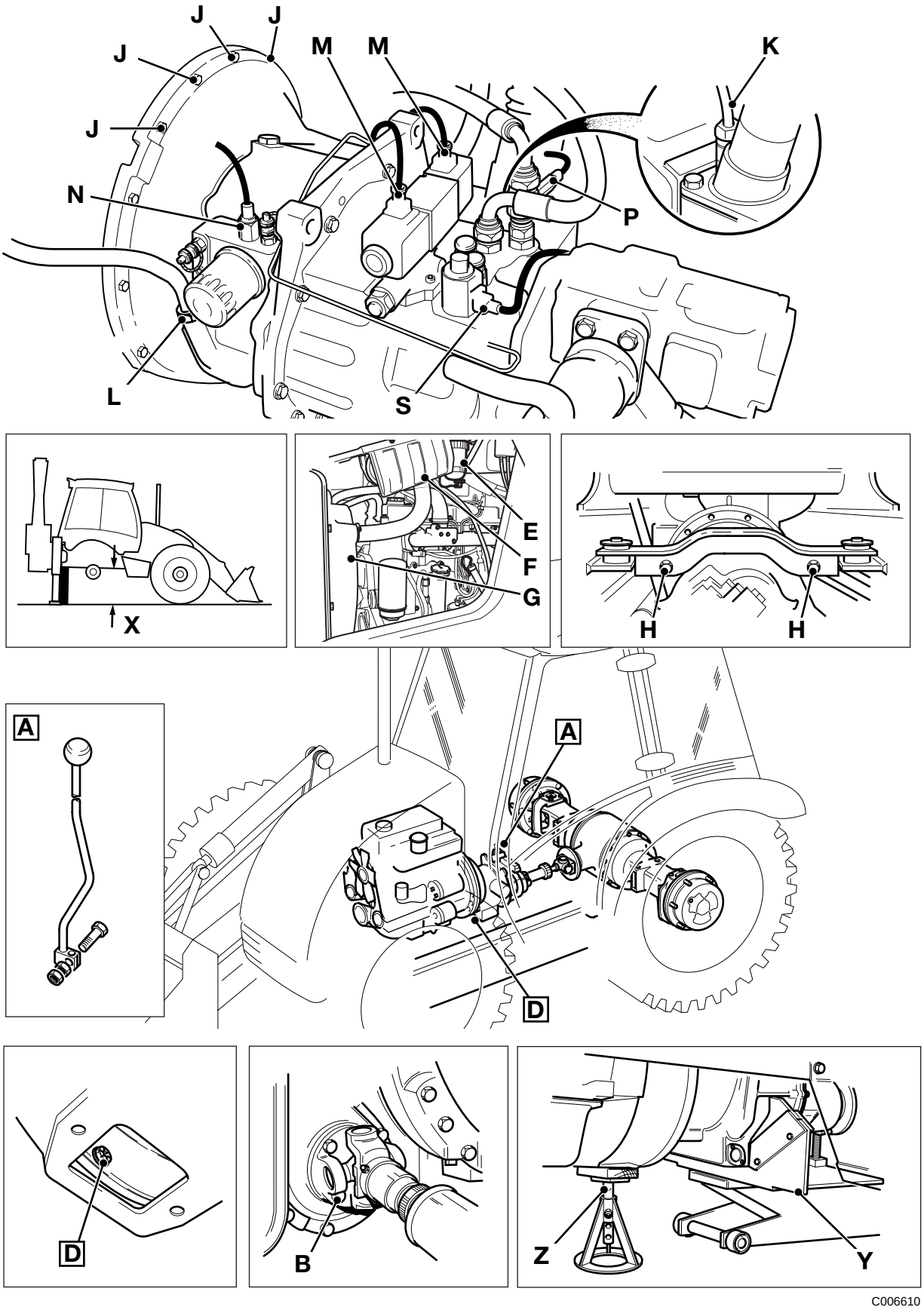


Fig 235. Synchro Shuttle Gearbox

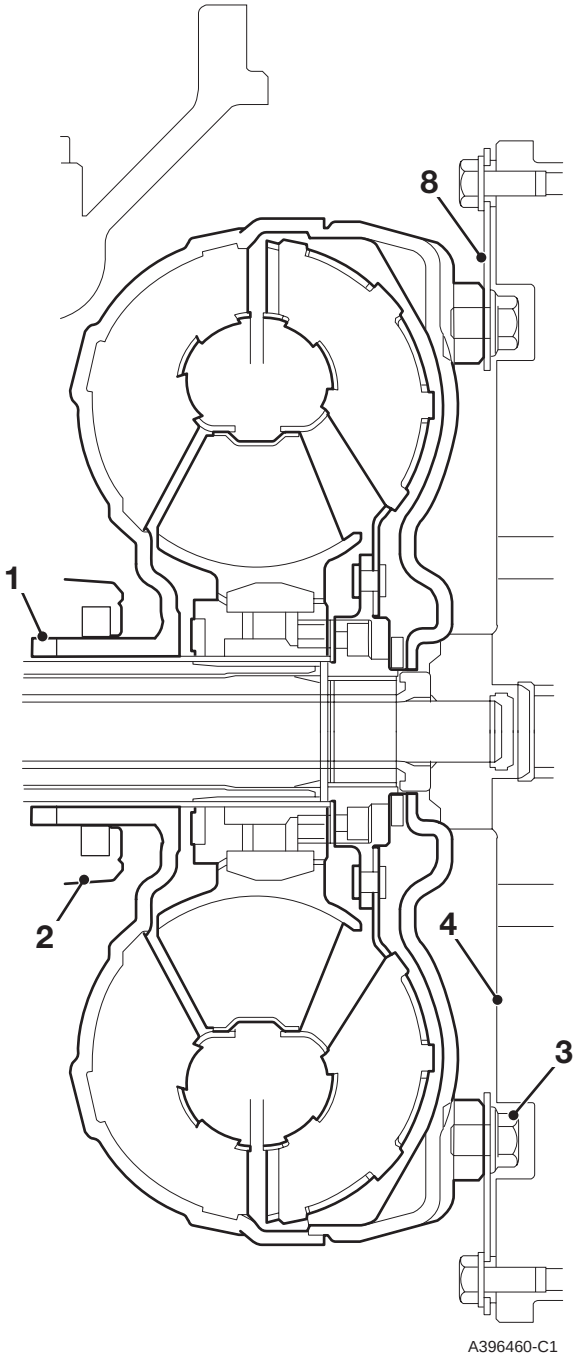


Fig 236. Torque Converter Interface

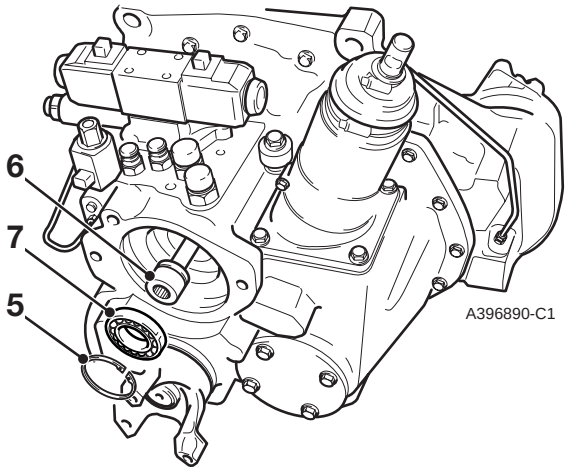


Fig 237. Hydraulic Pump Interface

Dismantle, Inspection and Assembly

The procedures for dismantling, inspection and assembly are described in a separate publication, see ***Transmissions Service Manual*** (Publication No. 9803-8610) for full details. Make sure that you identify the gearbox correctly, see ***Technical Data - Designation*** in this section for details

Powershift Gearbox

Removal and Replacement

Important: *The gearbox is heavy. Unless it is safely supported during removal and replacement it could fall and cause injury. Make sure that you have access to suitable jacks and a gearbox locating `cradle' before attempting to remove the gearbox.*

⚠ WARNING

A raised and badly supported machine can fall on you. Position the machine on a firm, level surface before raising one end. Ensure the other end is securely chocked. Do not rely solely on the machine hydraulics or jacks to support the machine when working under it.

Disconnect the battery, to prevent the engine being started while you are beneath the machine.

GEN-1-1

Removal

⇒ ***Fig 239. (F-295)***.

1 Park the machine on firm level ground. The gearbox is heavy. If the ground is soft or uneven it will not be possible to remove the gearbox safely.

2 Loosen the right side rear wheel nuts. Rest the shovel on the ground and lower the stabilisers to raise the rear of the machine. Check dimension **X** which must be at least 800 mm. This will allow the gearbox to be pulled clear. Block and support the machine.

Note: *On sideshift machines, suitable lengths of steel channel can be used as safety struts between the stabiliser feet and chassis, one at each stabiliser.*

3 Remove the right hand side rear wheel.

4 Remove the bonnet, see ***Section 3 Routine Maintenance***.

5 Disconnect the park brake cable at the gearbox, see ***Section G, Brakes***.

6 Remove the rear axle propshaft, see ***Propshafts***.

7 Disconnect the front axle driveshaft bolts **B** (use tool 892/00822).

8 Drain the hydraulic tank and remove the main hydraulic pump (see ***Section E Hydraulics, Service Procedures and Main Hydraulic Pump***). Tie the suction hose up clear of the gearbox.

9 Drain the gearbox oil, see ***Section 3, Routine Maintenance***.

10 Remove the access cover plate at the bottom of the flywheel housing. Through the access hole, loosen and remove the torque converter to engine flywheel retaining bolts **D**.

11 At a later stage the gearbox and engine assembly is tilted to allow access to fixing bolts. To prevent damage as the engine is tilted components must have their fixings removed as follows:

a Fuel sediment bowl assembly **E**.

b Air filter assembly **F**.

c Radiator fan cowl **G**.

It is not necessary to remove these components, only release them from their fixings.

12 Support the gearbox using a suitable trolley jack and cradle. The gearbox must be securely located on the cradle as shown at **Y**.

13 Make sure that the weight of the gearbox is supported by the trolley jack and then remove the gearbox mounting bolts **H**.

14 Using the trolley jack, lower the gearbox and engine to gain access to the top torque converter housing to engine retaining bolts **J**. Put a support under the engine as shown at **Z** to prevent it from dropping when the gearbox is removed.

15 Undo the four bolts **J** at the top of the torque converter housing. Note the position of the electrical earth cable and harness clip.

16 Pull off the breather tube **K**. Undo the gearbox dipstick fixing nut **L** and then remove the dipstick tube.

17 Label and then uncouple the solenoid control valve electrical connectors **M**, speed sensor **S** and oil pressure sender **N.**

18 **Non Lock Up Torque Converter Variants**. Uncouple the electrical connector at the oil temperature sender **P**. Disconnect the gearbox oil cooler hoses **R**.

19 **Lock Up Torque Converter Variants**. Uncouple the electrical connector at the oil temperature sender **238-A** and lock up torque converter solenoid **238-B**. Disconnect the gearbox oil cooler hoses **238-C**.

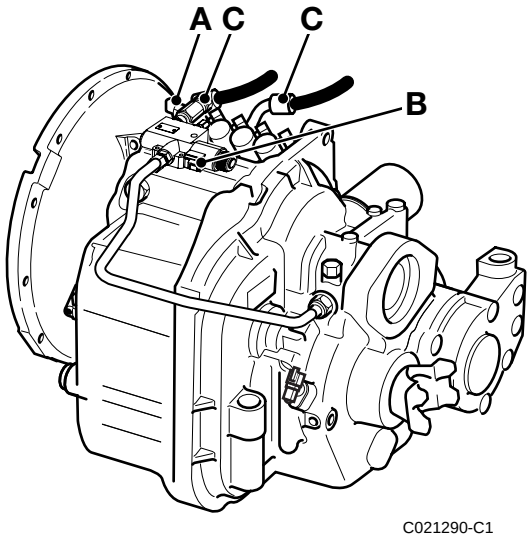


Fig 238.

20 Remove the flywheel housing to engine bolts **T**.

21 Manoeuvre the gearbox with the torque convertor clear of the engine flywheel housing.

22 Lower the trolley jack and pull the gearbox and torque convertor clear of the machine.

Replacement

Replacement is a reversal of the removal procedure but note the following:

1 **Hydraulic Pump,** ⇨ *Fig 241. (F-296)*.

Before replacing the gearbox remove circlip **5** and withdraw the pump driveshaft **6** together with its bearing **7** approximately 50 mm (2.0 in). The shaft can then be engaged after the gearbox has been fitted, making replacing the gearbox easier. Remember to engage the pump drive shaft, refit the bearing and circlip after the gearbox has been fitted.

2 Set the torque converter as described in ***Torque Converter, Removal and Replacement***.

3 **Align the Torque Converter,** ⇨ *Fig 240. (F-296)*.

It is vitally important that the torque converter is fitted at the gearbox and engine flywheel correctly. Failure to locate the converter correctly will result in damage to the gearbox oil pump on engine start up. Proceed as follows:

Make sure that the torque converter drive dogs **1** are correctly engaged with the pump **2** on the gearbox. Temporarily tie the converter onto the gearbox. Use wire tied at a drive plate bolt hole to a convenient point on the outside of the gearbox.

Take note of the flywheel and drive plate fixing hole phasing. The heads of the bolts **3** will foul the flywheel **4** if phasing is incorrect.

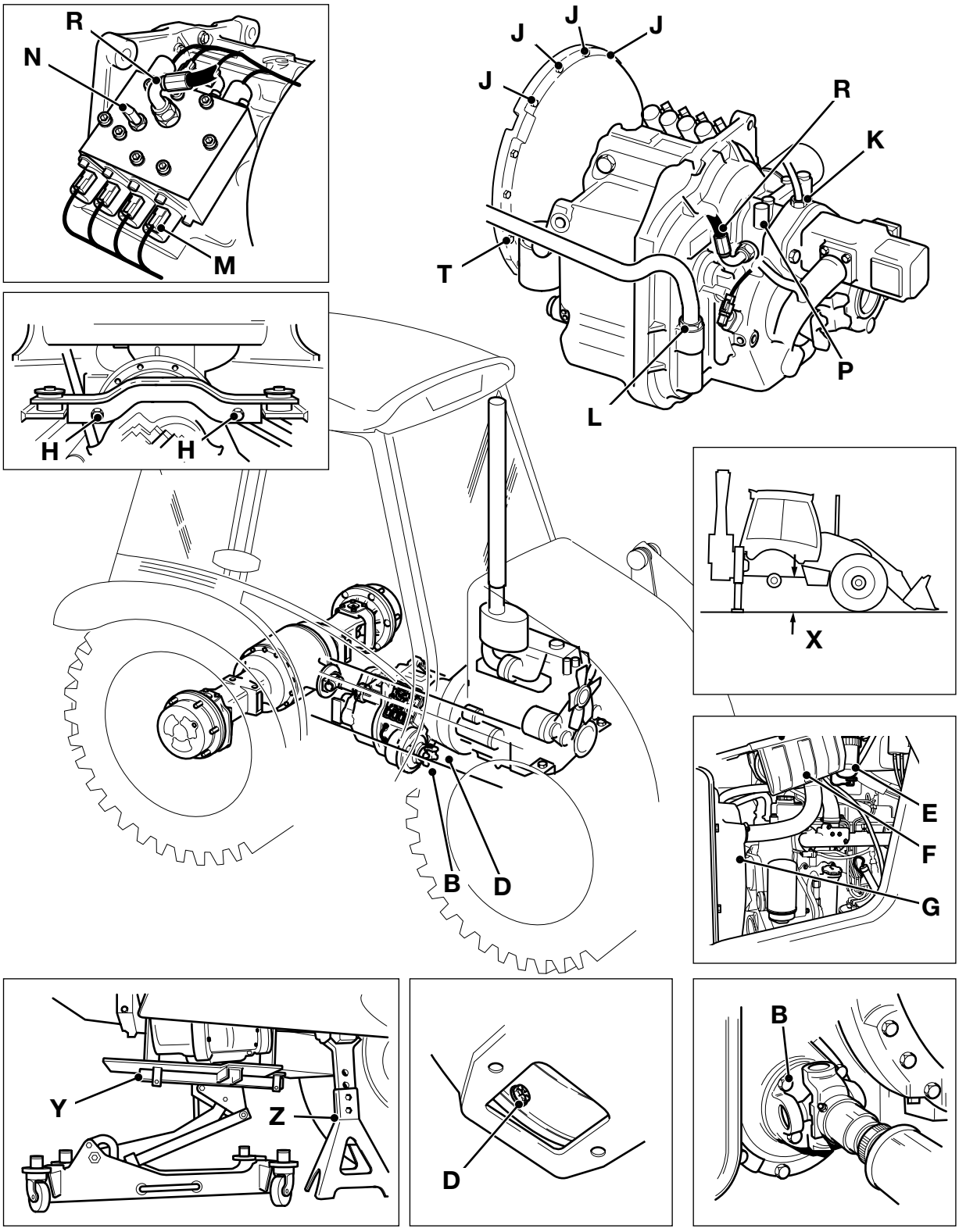
Before bolting the torque converter housing to the engine make sure the mating faces are fully together (DO NOT USE FORCE). The drive plate **8** should also be mated close to the flywheel. Do not force the components together with the fixing bolts.

Make sure that the torque converter is free to rotate slightly within the clearance of the location bolt holes. If you cannot rotate the converter it is trapped either by bolt heads **3** or by incorrectly located pump drive dogs. Make sure that all is well before tightening the bolts.

4 Fill the gearbox with the specified amount and type of oil (see ***Section 3, Routine Maintenance***). Leave hose **R** off until the filling operation is complete. After filling refit hose **R**.

Table 73. Torque Settings

Item	Nm	kgf m	lbf ft
B	70	7	52
D	44	4.5	32
H	237	24	175
J, T	98	10	72



C006620-C3

Fig 239. Powershift Gearbox

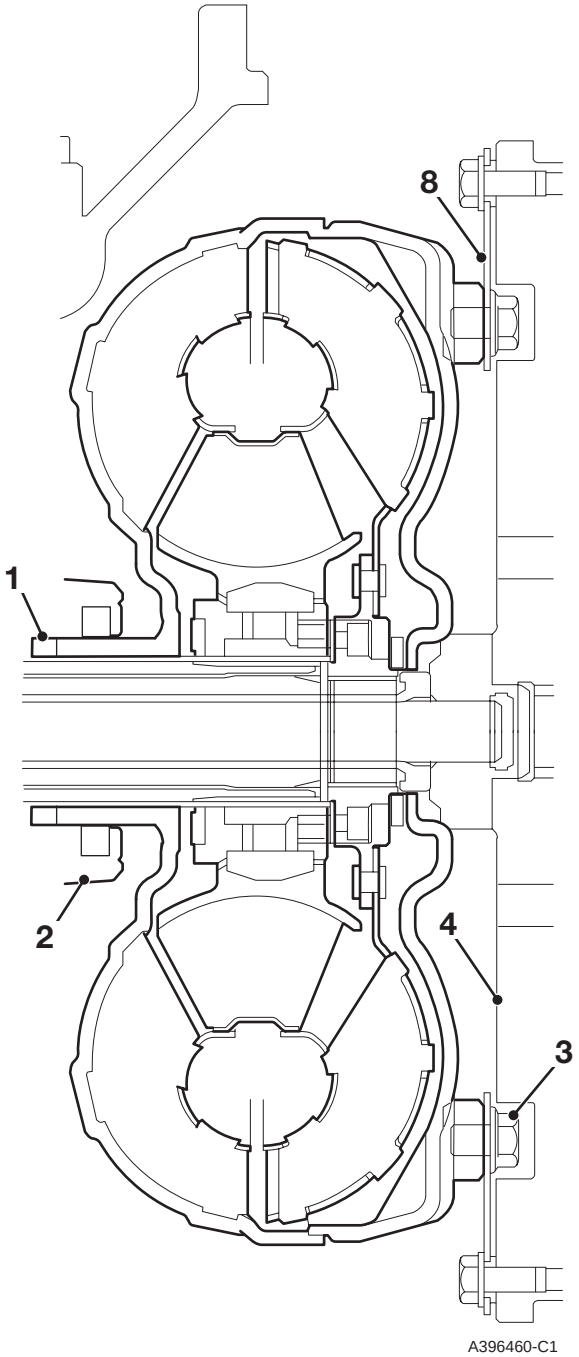


Fig 240. Torque Converter Interface

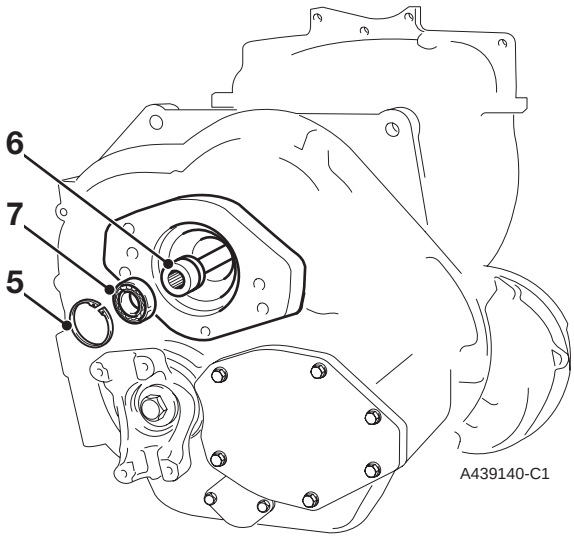


Fig 241. Hydraulic Pump Interface

Dismantle, Inspection and Assembly

The procedures for dismantling, inspection and assembly are described in a separate publication, see ***Transmissions Service Manual*** (Publication No. 9803-8610) for full details. Make sure that you identify the gearbox correctly, see ***Technical Data - Designation*** in this section for details.

Torque Converter

Removal and Replacement

Removal

See the relevant gearbox removal procedure for torque converter removal.

When Replacing

1 Ensure that flywheel face, flexible drive plate, and hardware are clean and free from burrs or other surface imperfections.

2 Offer the flexible drive plate **1** to the torque converter.

3 Place the torque converter alignment tool **A** (service tool 892/01110, refer to ***Service Tools***) over the torque converter spigot. Note that the alignment tool is used one way round for the 12" and the other way round for W300 torque converters. Make sure that the tool locates in two of the converter bolt holes as shown.

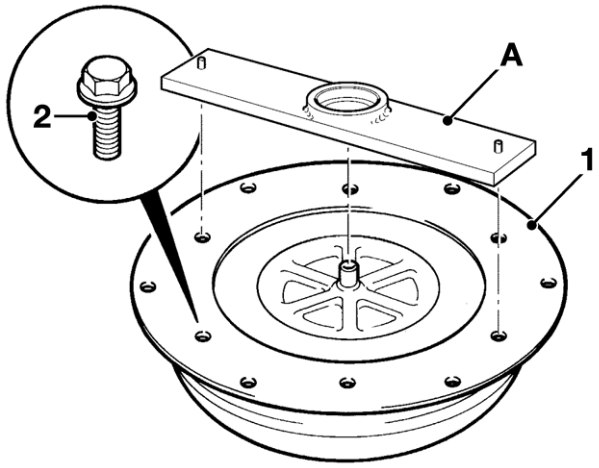


Fig 242.

Note: *It is important that the converter drive tube is protected against damage or contamination at all times.*

4 Fit two of the flanged bolts **2** and torque tighten to 50 Nm (37 lbf ft). Remove the alignment tool and fit the remaining two retaining bolts **2**.

5 Offer the torque converter and drive plate assembly to the flywheel, bolt the drive plate to the flywheel (use only 3 bolts). Check the converter run out as shown at **B**, which should not exceed 0.38mm (0.015 in).

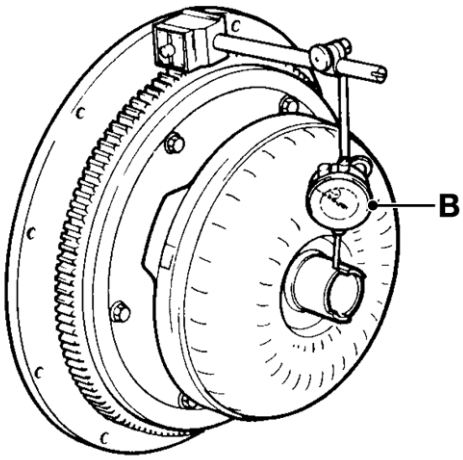


Fig 243.

Note: *In the unlikely event that the run-out exceeds 0.38 mm (0.015 in), remove the converter and check the spigot for burrs, remove the drive plate and rotate it 180° on the torque converter, repeat steps 2 to 4.*

6 Remove the torque converter and drive plate assembly from the flywheel.

7 Install the torque converter with its drive plate assembly onto the transmission input shaft, make sure that the dogs on the converter pump drive shaft engage with the recesses in the pump, also take care not to damage the oil seal.Rotate the engine flywheel so that one bolt hole is in a six O' clock position.

8 Rotate the torque converter and drive plate assembly so that one bolt hole is in a six O' clock position.

9 Install the transmission and torque converter assembly to the engine. See the relevant gearbox replacement procedure. **It is vitally important that the torque converter is fitted at the gearbox and**

engine flywheel correctly. Failure to locate the converter correctly will result in damage to the gearbox oil pump on engine start up.

10 Apply JCB Threadlocker and Sealer to flanged bolts **3**. Remove the access plate from the bottom of the engine flywheel housing and through the access hole fit and hand tighten one flanged bolt (item **3**) in the six 'O' clock position.

11 Rotate the flywheel until the next bolt hole is accessible, fit and hand tighten the next bolt **3**. Repeat the operation until all bolts are fitted. Finally torque tighten bolts **3** to 44 Nm (32.5 lbf ft), rotating the flywheel each time to align bolts **3** with access hole. Refit access plate.

Note: *Machines from serial no. 974058 have a new version flexible drive plate. On earlier machines, if the torque converter is removed for any reason, it is recommended that the new version drive plate is fitted.* *⇨ Fig 245. (F-299)**. Make sure the drive plate is fitted the correct way round.*

Table 74. Torque Settings

Item	Nm	kgf m	lbf ft
2	50	5.1	37
3	44	4.5	32.5

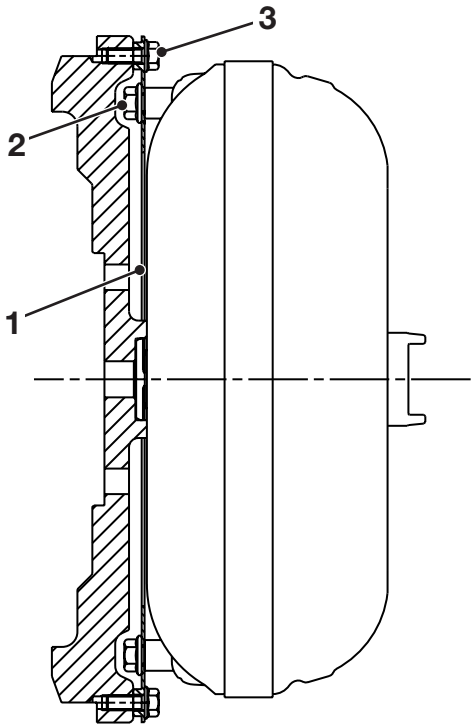


Fig 244. Machines to serial no. 974057

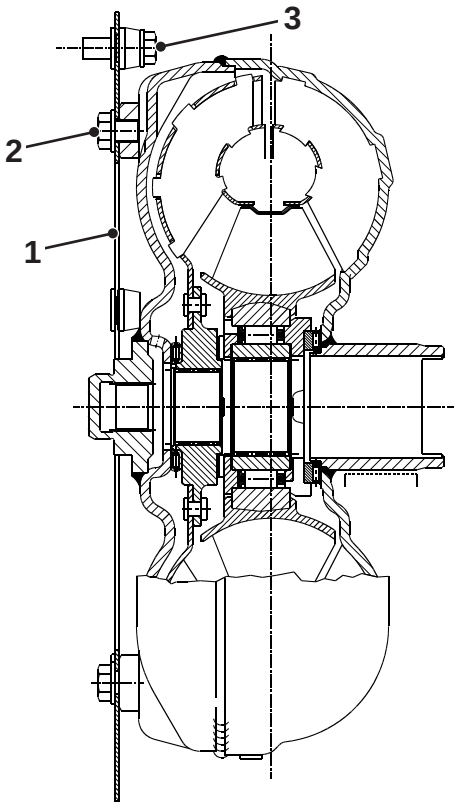


Fig 245. Machines from serial no. 974058

Oil Cooler Matrix

Removal and Replacement

The transmission oil cooler is part of a combined oil cooler matrix, which also incorporates the hydraulic oil cooler. For removal and replacement procedures, see ***Section E, Hydraulics***.