MF35

service manual

Service Manual for all MF35 tractors

MASSEY-FERGUSON

35 TRACTOR

WORKSHOP SERVICE MANUAL

SECTION A

INTRODUCTION

FE-35 TRACTOR

SECTION B

GENERAL SPECIFICATION AND DATA

This specification initially gives data of the normal width agricultural tractor, less engine. For Engine Data see pages B19 (Petrol), B27 (V.O.), B29 (L.O.), and B29 (23C Diesel), and B43, 3-A-152 Diesel.

For data of other FE-35 Tractors, Vineyard, Industrial, etc. see Section T.

Tractor Codes:

Chassis	Standard S Vineyard V Industrial J
Engines	Petrol G High Altitude Petrol H Diesel (23C) D Diesel (3-A-152) N Vaporising Oil K Lamp Oil L
Other Variations	Single Clutch F Dual Clutch M

The De Luxe version of the Tractor is fitted with Dual Clutch, live P.T.O., Tractormeter, and cushion seat.

Overall Dimensions

Wheelbase	72" (1830 mm.)
Normal Track	Front — 48" (1219 mm.) Rear — 52" (1320 mm.)
Track Adjustment	Front — 48" — 80" (1219 mm. — 2032 mm.) Rear — 48" — 76" (1219 mm. — 1930 mm.)
Turning Circle Diameter	Using Independent Brakes 17′ 6" (5334 mm.) Without Brakes 19′ 3" (5867 mm.) (with track widths 48" front and rear).
Ground Clearance	Under centre — 12⅝" (321 mm.) Under axle — 21" (533 mm.)
Overall Length	117" (2972 mm.)
Overall Width	At normal track 64" (1630 mm.)
Overall Height	54" (1372 mm.)

Tyres

Tyre Pressures	Front — 4 × 19 — 26 lbs. (1.8 kg.) Rear — 10 × 28 — 12 lbs. (0.8 kg.)

Weight (with fuel, oil and water)

	Basic Model	De Luxe Model
Diesel (23C)	3158 lbs. (1432 kg.)	3198 lbs. (1451 kg.)
Diesel (3-A-152)	3175 lbs. (1440 kg.)	3185 lbs. (1445 kg.)
Carburettor	2982 lbs. (1352 kg.)	3022 lbs. (1371 kg.)

Fill-Up Data

Engine Sump	12 pints (6.8 litres)
Transmission	6.6 Imp. gallons (30.28 litres)
Air Cleaner	¾ pint (.43 litres)
Steering	1.8 pints (.946 litres)
Belt Pulley	1½ pints (.852 litres)

	Cooling System	Fuel Tanks
Diesel (23C)	15 pints (8.5 litres)	7½ Imp. gallons (34 litres)
Diesel (3-A-152)	10½ pints (5.96 litres)	8½ Imp. gallons (39 litres)
Petrol	15 pints (8.5 litres)	9¼ Imp. gallons (42 litres) including 1 Imp. gallon (4.5 litres) reserve.
V.O.	15 pints (8.5 litres)	V.O. — 8¼ Imp. gallons (37.5 litres) Petrol — 1 Imp. gallon (4.5 litres)
L.O.	17 pints (9.66 litres)	L.O. — 8¼ Imp. gallons (37.5 litres) Petrol — 1 Imp. gallon (4.5 litres)

Performance	**Diesel**		**Petrol**		**V.O.**	**L.O.**
	23C	**3-A-152***	**6.0 : 1**	**6.6 : 1**		
Brake H.P. (Bare Engine)	37.25	37	37.25	38.0	30.5	29 0
Belt H.P. (Bare Engine)	35.9	—	34.5	36.2	28.8	26.3
Drawbar H.P.	31.5	—	29.5	30.5	23.3	20.7
H.P. available at P.T.O.	34	35	34	35	27.5	26

*Subject to official confirmation

TIGHTENING TORQUES

	lbs./ft	kg./m.
Front Axle		
Centres to Right-hand and Left-hand Axles	90 — 100	12.443 — 13.83
Spindle Arm	45 — 50	6.221 — 6.913
Radius Rod to Axle	90 — 100	12.443 — 13.83
Clamp—Steering Drag Link	6 — 8	.830 — 1.106
Front Axle Pin	75 — 80	10.369 — 11.060
Tool Box to Radius Arm	10	1.383
Front Engine Support	75 — 80	10.369 — 11.060
Rear Axle		
Battery Carrier to Axle	45 — 50	6.221 — 6.913
P.T.O. Bearing Retainer	45 — 50	6.221 — 6.913
Differential Case	47 — 53	6.498 — 7.328
Crown Wheel	80 — 90	11.060 — 12.443
Oil Trough, Differential Housing	6 — 8	.830 — 1.106
Bearing Retainer Stud	45 — 50	6.221 — 6.913
Check Chain Anchor	45 — 50	6.221 — 6.913
Step Board Attachment	45 — 50	6.221 — 6.913
Fenders and Wheels		
Front Wheel Hub	55 — 60	7.604 — 8.295
Rim to Disc	90 — 100	12.443 — 13.83
Wheel Disc—Rear	90 — 100	12.443 — 13.83
Fenders to Axle	60 — 70	8.295 — 9.678
Brake and Clutch Linkage		
Shoulder Bolt, Clutch Pedal	24 — 26	3.318 — 3.595
Left Hand Brake Pedal Attachment	45 — 50	6.221 — 6.913
Clutch Pedal	45 — 50	6.221 — 6.913
Combined Brake Arm	45 — 50	6.221 — 6.913
Centre Housing		
Axle Shaft Housing to Centre Housing—$\frac{1}{2}$" Studs	70 — 75	9.678 — 10.369
$\frac{7}{16}$" Studs	45 — 50	6.221 — 6.913
Hydraulic Lift Cover (Seat Studs)	45 — 50	6.221 — 6.913
Upper Link Attachment	45 — 50	6.221 — 6.913
Hydraulic Lift Arm	30 min.	4.148 min.
Hydraulic Lift Cover	45 — 50	6.221 — 6.913
Side Cover to Centre Housing	30 — 35	4.148 — 4.839
Transmission Case		
Steering Housing to Transmission Case	30 — 35	4.148 — 4.839
Steering Tube Housing Steering Unit	24 — 26	3.318 — 3.595
Starter Motor to Case (Diesel)	45 — 50	6.221 — 6.913
Transmission Case to Engine	45 — 50	6.221 — 6.913
Radius Rod to Transmission Case	45 — 50	6.221 — 6.913
Centre Housing to Transmission Case	45 — 50	6.221 — 6.913
Transmission Case to Engine	45 — 50	6.221 — 6.913
Starter Motor to Case (Petrol)	45 — 50	6.221 — 6.913
Hydraulics		
Valve Chamber Clamp Bolts.	50 — 55	6.913 — 7.604

DIMENSIONS AND TOLERANCES

Component Details	Dimensions New Ins.	Dimensions New mm.	Clearances New Ins.	Clearances New mm.	Remarks
Transmission					
Selector Mechanism					
Shifter Rail Dia.	.7475	18.986			
	.7465	18.961			
			.004	.1016	
			.001	.0254	
Shifter Rail: Bore in Casing	.7485	19.012			
	.7505	19.063			
Plunger Spring Details ...	Free Length $1\frac{1}{32}$" (26.19 mm.)				
	Solid Length .68" (17.27 mm.)				
	Fitted Load 15 lbs. ± 1 lb.		(6.80 kg. ± .454 kg.)		
	Nominal fitted length .81" (20.57 mm.)				
Thickness of Change Speed Shifter Forks at Pressure Faces	.308	7.823			
	.304	7.722			
			.010	.254	
			.002	.0508	
Width of Groove in Coupling Connectors	.314	7.976			
	.310	7.874			
Thickness of Planetary Shifter Fork at Pressure Face ...	.308	7.823			
	.304	7.722			
			.010	.254	
			.002	.0508	
Width of Groove in Planetary Coupling	.314	7.976			
	.310	7.874			
Sliding Spur Gears					
Mainshaft: Spline for Intermediate and High Speed and Low Speed Gears ...	18 teeth	Minor Diameter	1.6913	42.959	
			1.6915	42.964	
		Major Diameter	1.965	49.911	
			1.960	49.784	
Spline in Mainshaft Gears ...	18 teeth	Minor Diameter	1.700	43.18	
			1.705	43.31	
		Major Diameter	2.0240	51.410	
			2.0390	51.791	
Countershaft Spline for Gears	17 teeth	Minor Diameter	1.9710	50.063	
			1.9535	49.619	
		Major Diameter	2.2398	56.891	
			2.2328	56.713	
Spline in Countershaft Gears	17 teeth	Minor Diameter	2.005	50.927	
			2.000	50.800	
		Major Diameter	2.250	57.150	
			2.260	57.404	
Gearbox Ratios:					
Constant Mesh P.T.O. and Transmission Gears Ratio: 2.78 : 1					
Silding Spur Gears	1st	3 : 1			
	2nd	2 : 1			
	3rd	1.09 : 1			
	Reverse	2.20 : 1			
Epicyclic Reduction Unit ...	4 : 1				
Backlash between mating gears	.003"-.007" (.076-.178 mm.).				
Endfloat	Shafts are supported in ball bearings, require no shims, pre-load or adjustment.				

Component Details	Dimensions New Ins.	Dimensions New mm.	Clearances New Ins.	Clearances New mm.	Remarks
Main Shaft Front Bearing					
Housing Bore for Bearing ...	3.1495 3.1501	79.997 80.013			
			—.0001 +.010	—.003 +.254	
Bearing Ext. Dia.	3.1496 3.1491	80.000 79.987			
Bearing Int. Dia.	1.5743 1.5748	39.987 40.000			
			—.0009 +.0001	—.023 +.003	
	1.5752 1.5747	40.010 39.997			
Main Shaft Rear Bearing					
Housing Bore for Bearing ...	3.5432 3.5440	89.997 90.017			
			+.0013 —.0001	+.033 —.003	
Bearing Ext. Dia.	3.5433 3.5427	90.000 89.985			
Bearing Int. Dia.	1.9685 1.9680	50.000 49.987			
			+.0001 —.0009	+.003 —.023	
Shaft	1.9689 1.9684	50.010 49.997			
Countershaft Front Bearing					
Housing Bore for Bearing ...	3.9377 3.9369	100.017 99.997			
			+.0013 —.0001	+.033 —.003	
Bearing Ext. Dia.	3.9370 3.9364	100.000 99.984			
Bearing Int. Dia.	2.1648 2.1654	54.986 55.002			
			+.0001 —.0011	+.003 —.028	
Shaft	2.1659 2.1653	55.014 54.998			
Countershaft Rear Bearing					
Housing Bore for Bearing ...	3.5440 3.5432	90.018 89.997			
			+.0013 —.0001	+.033 —.003	
Bearing Ext. Dia.	3.5433 3.5427	90.000 89.985			
Bearing Int. Dia.	1.9680 1.9685	49.987 50.000			
			+.0001 —.0009	+.003 —.023	

Component Details	Dimensions New Ins.	Dimensions New mm.	Clearances New Ins.	Clearances New mm.	Remarks
Shaft	1.9689 1.9684	50.010 49.997			
Countershaft Forward Auxiliary Bearing (De Luxe Tractors Only)					
Bearing Bore in Housing ...	3.1500 3.1490	80.010 79.985			
			+.0009 —.0006	+.023 —.015	
Bearing Ext. Dia.	3.1496 3.1491	80.000 79.987			
Bearing Int. Dia.	1.5743 1.5748	39.987 40.000			
			+.0001 —.0008	+.003 —.020	
Shaft	1.5751 1.5747	40.008 39.997			
Clutch Pilot Bearing					
Recess in Flywheel for Clutch Pilot Bearing	1.573 1.574	39.954 39.980			
			—.0013 —.0008	—.033 —.020	
Pilot Bearing Ext. Dia. ...	1.5743 1.5748	39.987 40.000			
Pilot Bearing Int. Dia. ...	.6689 .6694	16.990 17.003			
			.0003 .0012	.007 .030	
Main Drive Shaft Pinion Spigot Dia.	.6686 .6682	16.982 16.972			
Main Drive Shaft Retainer					
Bore in Retainer for front and middle bearings (De Luxe Tractors only)	3.1503 3.1493	80.018 79.992			
			+.0012 —.0003	+.030 —.008	
Bearings Ext. Dia.	3.1496 3.1491	80.000 79.987			
Bearings Int. Dia.	1.9680 1.9685	49.987 50.000			
			+.0001 —.0009	+.002 —.023	
Dia. of P.T.O. Main Drive Shaft Pinion	1.9689 1.9684	50.010 49.997			
Bore in Retainer for Rear Bearing Assy. (Standard and De Luxe Tractors) ...	3.1503 3.1493	80.018 79.992			
			+.0012 —.0003	+.030 —.008	

Component Details	Dimensions New Ins.	Dimensions New mm.	Clearances New Ins.	Clearances New mm.	Remarks
Bearing Ext. Dia.	3.1496 3.1491	80.000 79.987			
Bearing Int. Dia.	1.5743 1.5748	39.987 40.000			
			+.0001 —.0008	+.003 —.020	
Dia. of Main Drive Shaft Pinion	1.5751 1.5747	40.008 39.997			
Oil Seals					
Bore in Main Drive Shaft Retainer for Front Oil Seal (De Luxe Tractors) ...	2.251 2.249	57.175 57.125			
			—.011 —.005	—.279 —.127	
Oil Seal Ext. Dia.	2.260 2.256	57.404 57.302			
Oil Seal Int. Dia.	1.75	44.45			Mean Dia.
P.T.O. Main Drive Shaft Pinion	1.747 1.753	44.374 44.526			
Bore in Main Drive Shaft Retainer for Front Oil Seal (Standard Tractors) ...	2.251 2.249	57.175 57.125			
			—.011 —.001	—.279 —.0254	
Oil Seal Ext. Dia.	2.260 2.252	57.404 57.201			
Oil Seal Int. Dia.	1.125	28.575			Mean Dia.
P.T.O. Main Drive Shaft Pinion Dia.	1.128 1.122	28.651 28.499			
Bore in P.T.O. Main Drive Shaft Pinion for Oil Seal (De Luxe Tractors) ...	1.563 1.561	39.700 39.649			
			.000 .012	.000 .300	
Oil Seal Ext. Dia.	1.573 1.563	39.954 39.700			
Oil Seal Int. Dia.	1.125	28.575			Mean Dia.
Main Drive Shaft Pinion ...	1.128 1.122	28.651 28.499			
Epicyclic Assembly					
Bore in Epicyclic Carrier for Planetary Pinion Shaft ...	.748 .749	18.999 19.025			
			—.0018 —.0011	—.046 —.028	
Dia. of Shaft	.7501 .7498	19.053 19.045			
Dia. of Rollers	.1244 .1242	3.160 3.155			

Component Details	Dimensions New Ins.	mm.	Clearances New Ins.	mm.	Remarks
Dia. of Planetary Pinion Washer	.990 .984	25.146 24.993	.0158 .0093	.401 .236	
Planetary Pinion Int. Dia. ..	.9998 .9993	25.315 25.382			
Reverse Shaft Cluster					
Inside Dia. of Gears	1.2524 1.2530	30.531 30.556			
Dia. of Roller Bearings ...	.1260 .1258	3.200 3.195			
Dia. of Shaft	1.000 .9995	25.4 25.387			

Hydraulic Pump

Constant running, positive displacement four cylinder, scotch-yoke piston type pump "floating" in the tractor centre housing.

Speed ... ... .36 × engine speed. Oscillating control valve.

Earlier Type (Fitted up to Tractor Serial No. 65684).

Bore ... ... .80" (20.32 mm.)

Test Data ... ... Minimum delivery to be 2.8 Imp. gallons (12.72 litres) per minute at zero/lb. sq. in. at 720 pump r.p.m. (2000 engine r.p.m.).

Later Type (Fitted to Tractor Serial No. 65685 and subsequent).

Bore ... ... .915" (23.24 mm.)

Test Data ... ... Minimum delivery to be 3.333 Imp. gallons (15.14 litres) at 1500 p.s.i. (105.5 kg./sq. cm.) at 720 pump r.p.m. (2000 engine r.p.m.) with oil at a maximum viscosity of 250 S.U.S.

Note : Approximate oil temperatures corresponding to a maximum viscosity of 250 S.U.S.

S.A.E. 80 — 130°F. (54.4°C.)
S.A.E. 40 — 135°F. (57.2°C.)
S.A.E. 50 — 150°F. (65.6°C.)

Hydraulic System Safety Relief Valve

Nominal Setting ... ... 2,500 lb. sq. in. (175.8 kg./sq. cm.)

Test Data ... ... The valve must begin to open at a minimum static pressure of 2300 lb/sq. in. (161.7 kg/sq.cm.) The maximum pressure must not exceed 2800 lb. sq. in. (196.9 kg./sq. cm.) when by-passing 2 Imp. gallons (9.1 litres) per minute. S.A.E. 50 oil at 110°-140°F. (43.3°-60°C.).

Lifting Capacity—Lower Links

	Early Tractors (Up to Serial No. 65684)	Later Tractors (Serial No. 65685 onwards)
Max. Weight which can be lifted from the lowest position	1,500 lbs. (680.4 kg.)	2,500 lbs. (1134 kg.)
Recommended Max. Weight for field work and slow speed transport ...	1,700 lbs. (771 kg.)	2,600 lbs. (1179.3 kg.)
Recommended Max. Weight for road work in transport position	1,270 lbs. (576 kg.)	1,800 lbs. (816.5 kg.)

Component Details	Dimensions New Ins.	Dimensions New mm.	Clearances New Ins.	Clearances New mm.	Remarks
Hydraulic Tapping Points					
Three Pick-Up Points in lift cover—					
Thread Sizes—Top	3/8" N.P.S.M.				
Laterals ...	3/8" N.P.T.F.				
Oil Capacity					
(Supplying Hydraulic System, Transmission and Rear Axle)	6.6 Imp. gallons (30.28 litres) Maximum of $1\frac{1}{2}$ gallons (6.81 litres) may be withdrawn for operating external services.				
Hydraulic Lift Assembly					
Breakout Spring	Free Length	$6\frac{13}{16}$" (173.038 mm.)			
	Solid Length	$3\frac{11}{16}$" (93.663 mm.)			
	Rate:	To support 38 lbs. $\pm 2\frac{3}{4}$ lbs. (17.24 kg. $\pm$1.247 kg.) at a length of 4.75" (120.65 mm.)			
		To support $47\frac{1}{4}$ lbs. $\pm 3\frac{1}{4}$ lbs. (21.432 kg. $\pm$ 1.474 kg.) at a length of 4.25" (107.95 mm.)			
Control Spring	Free Length	5.38" (136.652 mm.) 5.32" (135.128 mm.)			
	Rate:	7,700 lb. in. $\pm$ 700 lb. in. (8,870 kg. cm. $\pm$807 kg. cm.)			
Hydraulic Cylinder					
Earlier Type (Fitted up to Tractor Serial No. 65684)					
Hydraulic Cylinder Bore ...	2.5010 2.4995	63.525 63.487			
			.0040 .0015	.1016 .038	
Hydraulic Cylinder Piston Dia.	2.497 2.498	63.4238 63.4492			
Piston Ring Groove Width ...	.1255 .1265	3.1877 3.2131			
			.0035 .0015	.089 .038	
Piston Ring Width	.124 .123	3.1496 3.1242			
Piston Ring Gap (closed) ...	.0025 .0075	.0635 .1905			
Later Type (Tractor Serial No. 65685 and subsequent)					
Hydraulic Cylinder Bore ...	2.9995 3.001	76.187 76.225			
			.0040 .0015	.1016 .038	
Hydraulic Cylinder Piston Dia.	2.998 2.997	76.149 76.124			
Piston Ring Groove Width...	.1255 .1265	3.188 3.213			
			.0035 .0015	.089 .038	
Piston Ring Width	.124 .1235	3.150 3.136			
Piston Ring Gap (closed) ...	.0075 .0025	.1905 .0635			

Component Details	Dimensions New Ins.	Dimensions New mm.	Clearances New Ins.	Clearances New mm.	Remarks
Camshaft					
Bore for Bearing in Front and Rear Housings	1.6208 1.6198	41.168 41.143			
			—.0002 —.0017	—.005 —.043	
Bearing Outside Dia. ...	1.6215 1.6210	41.186 41.174			
Bearing Internal Dia. ...	1.3780 1.3775	35.001 34.988			
			.0035 .0025	.089 .064	
Shaft Dia.	1.3750 1.3745	34.925 34.912			
Control Valve					
Bore in Rear Housing for Control Valve Washers ...	.926 .924	23.520 23.470			
			.004 .001	.102 .025	
Outside Dia. of Control Valve Washers	.923 .922	23.444 23.419			
Internal Dia. of Control Valve Washers	.5002 .5000	12.705 12.700			
			.0006 .0002	.015 .005	Selectively assembled to a mean clearance of .0004" (.010 mm.)
Control Valve Dia.	.4998 .4996	12.695 12.690			
Cam Blocks and Pistons					
Piston (Inside Dia.)	2.322 2.325	58.979 59.055			
			.008 .002	.203 .051	
Cam Block	2.320 2.317	58.928 58.852			
Pistons and Valve Chambers Inlet and Outlet Valves					
Bore in Inlet Valve Stem ...	.157 .156	3.988 3.962			
			.003 .001	.076 .025	
Outlet Valve Stem	.155 .154	3.940 3.912			
Earlier Pumps (Up to Tractor Serial No. 65684)					
Diameter of Piston	.8010 .8005	20.345 20.333			
			.0025 .001	.064 .025	
Diameter of Bore	.802 .803	20.371 20.396			

Component Details	Dimensions New Ins.	Dimensions New mm.	Clearances New Ins.	Clearances New mm.	Remarks
Later Pumps (Tractor Serial No. 65685 onwards)					
Diameter of Piston	.9130	23.19			
	.9125	23.18			
			.0025	.064	
			.001	.025	
Diameter of Bore	.914	23.22			
	.915	23.24			
Power Take-Off Shaft					
No. of Splines	6				
Major Diameter	1.371/1.373″ (34.82/34.87 mm.)				
Minor Diameter	1.098/1.108″ (27.89/28.14 mm.)				
Width of Splines	.338/.340″ (8.58/8.64 mm.)				
Length suitable for Drive Attachment	2.78″ (70.6 mm.)				
Diameter of hole	21/64″ (8.33 mm.)				
Distance of hole from Shaft End	.625″ (15.88 mm.)				
Dimensions of Groove ...	Bottom dia. 1.160/1.155″ (29.46/29.34 mm.) Radius .265″ (6.73 mm.)				
Distance of Groove from Shaft End	1⅛″ (28.6 mm.)				
Width of Groove in P.T.O. Pinion (Ground speed P.T.O. driven gear) ...	.375	9.525			
	.379	9.626			
			.011	.279	
			.003	.076	
Dia. of P.T.O. Coupler at Pressure End	.372	9.449			
	.368	9.347			
Ground Speed P.T.O. ...	Backlash between ground P.T.O. driven gear and ground P.T.O. drive gear: .003/.007″ (.076/.178 mm.).				
Rear Bearing and Seal					
Bore in centre housing for P.T.O. Seal Retainer ...	3.252	82.601			
	3.250	82.550			
			.007	.1778	
			.002	.0508	
P.T.O. Seal Retainer Outside Dia.	3.248	82.499			
	3.245	82.423			
P.T.O. Seal Retainer Inside Dia.	2.687	68.250			
	2.685	68.199			
			—.0075	—.1905	
			—.0025	—.0634	
P.T.O. Seal Outside Dia. ...	2.6925	68.390			
	2.6895	68.313			
Housing Bore for Bearing ...	2.9533	75.014			
	2.9527	74.999			
			+.001	+.025	
			—.0001	—.003	
Bearing—Outside Dia. ...	2.9528	75.001			
	2.9523	74.987			

Component Details	Dimensions New Ins. mm.	Clearances New Ins. mm.	Remarks
Single Clutch			
Diameter	Carburettor Engine Tractors ...	9" (228.6 mm.)	
	Diesel Engine Tractor (23C) ...	10" (254 mm.)	
	Diesel Engine Tractor (3-A-152)...	11" (279 mm.)	
Clutch Springs	9" Clutch	9 black clutch springs Fitted Load 150/160 lb. (68.04/72.57 kg.)	
	10" Clutch	12 green clutch springs Fitted Load 105/115 lb. (47.63/52.2 kg.)	
	11" Clutch	12 yellow clutch springs Fitted Load 84 lb. (38.1 kg.) ± 5%	
Clutch Pedal Free Movement	¾" (19 mm.) This dimension taken between upper side of pedal and underside of footrest bracket.		
Toggle Release Levers ...	Height (from flywheel face)		
	9" Clutch	1.895" (48.133 mm.)	
	10" Clutch	1.995" (50.673 mm.)	
	11" Clutch	$4\frac{13}{32}'' {}^{+.0625}_{-.0000}$ $\left(111.919 {}^{+1.588\text{ mm.}}_{-.000\text{ mm.}}\right)$	
	Height (from spacer segments)		
	11" Clutch	2.65"-2.72" (67.310-69.088 mm.)	
Movement of Lever Ends ...	9" and 10"	.531" (13.49 mm.)	
	11"	.654" (16.61 mm.)	
	Variation in toggle lever height should not exceed .015" (.381 mm.)		
Dual Clutch			
87 mm. and 23C Engines			
Transmission Disc	11" dia. (279.4 mm.)		
P.T.O./Hydraulic Pump Disc	9" dia. (228.6 mm.)		
Thrust Springs	2, Belleville Type Load (see Fig. 5, page I.4) at .075" (1.905 mm.) deflection 510/440 lb. (231.33/199.58 kg.) at .065" (1.651 mm.) deflection 1080/960 lb. (489.89/435.45 kg.)		
Clutch Pedal Free Movement	⅜" (9.5 mm.) This dimension taken between upper side of pedal and underside of footrest bracket.		
Toggle Release Levers ...	Height (from flywheel face) $3\frac{25}{32}''$ (96 mm.) Movement of lever ends .531 (13.49 mm.) Variation in toggle lever height should not exceed .015" (.381 mm.)		
Adjusting Screws	Clearance between screw heads and rear pressure plate (P.T.O./Hydraulic pump drive) .088/.092" (2.24/2.34 mm.)		
3-A-152 Engine			
Transmission Disc	11" dia. (279.4 mm.)		
P.T.O./Hydraulic Pump Disc	9" dia. (228.6 mm.)		
Thrust Springs	11" disc operated by 12 yellow clutch springs. Fitted load 84 lb. (38.1 kg.) ± 5%. 9" disc operated by Belleville spring. Load—released position .75" (19.05 mm.) height: 510-440 lb. (231-200 kg.) Load—engaged position .065" (1.65 mm.) deflection 1080-960 lb. (490-435 kg.)		
Clutch Pedal Free Movement	⅜" (9.5 mm.) This dimension taken between upper side of pedal and underside of footrest bracket.		
Toggle Release Levers ...	Height (from flywheel face) $4\frac{13}{32}'' {}^{+.0625}_{-.0000}$ $\left(111.919 {}^{+1.588\text{ mm.}}_{-.000\text{ mm.}}\right)$ Height (from spacer segments) 2.65-2.72" (67.310-69.088 mm.) Movement of lever ends .654" (16.61 mm.). Variation in toggle lever height should not exceed .015" (.381 mm.)		

Component Details	Dimensions New Ins.	Dimensions New mm.	Clearances New Ins.	Clearances New mm.	Remarks
Adjusting Screws	Clearance between screw heads and rear pressure plate (P.T.O./Hydraulic pump drive) .088/.092" (2.24/2.34 mm.)				
Rear Axle					
Crown Wheel and Pinion Ratio	6.16 : 1				
Backlash—Crown Wheel and Pinion	.008-.016" (.203-.406 mm.)				
Clearance between thrust block and crown wheel	.013-.020" (.330-.508 mm.) Controlled by shims between thrust block and housing				
Axle Shaft Bearing end float	.002-.008 (.051-.203 mm.) Controlled by shims between brake backplate and axle housing gaskets				
Rear Axle Half Shafts and Axle Housings					
Half Shaft Dia.	2.252 2.251	57.200 57.175			
			—.000 —.002	—.000 —.051	
Inside Dia. of Bearing ...	2.251 2.250	57.175 57.150			
Outside Dia. of Bearing ...	4.126 4.125	104.800 104.775			
			—.0025 —.0005	—.0635 —.0127	
Bore for Bearing in Retainer Assembly	4.1245 4.1235	104.762 104.737			
Bore for Oil Seal in Retainer Assembly	3.6215 3.6245	91.986 92.062			
			—.0095 —.0015	—.216 —.038	
Outside Dia. of Oil Seal ...	3.630 3.626	92.202 92.100			
Half Shaft Dia. at Oil Seal ...	2.749 2.751	69.825 69.875			
Half Shaft Dia. for Collar ...	2.2515 2.2510	57.188 57.175			
			—.008 —.006	—.203 —.152	
Collar	2.2450 2.2435	57.023 56.985			
Recess in Axle Housing for Inner Oil Seal	2.876 2.874	73.050 73.000			
			—.007 —.001	—.1778 —.0254	
Outside Dia.—Inner Oil Seal	2.881 2.877	73.177 73.075			
Half Shaft Dia. at Inner Oil Seal	2.128 2.123	54.051 53.924			
Clearance between ends of axles	.002"-.008" (.051-.203 mm.)				
Differential					
Axle Housing Bores for Bearing Assys.	4.4365 4.4355	112.687 112.662			
			—.003 —.001	—.076 —.025	

Component Details	Dimensions New Ins.	Dimensions New mm.	Clearances New Ins.	Clearances New mm.	Remarks
Bearing—Outside Dia. ...	4.4385	112.738			
	4.4375	112.713			
Bearing—Inside Dia. ...	2.6256	66.690			
	2.6250	66.675			
			—.0035	—.089	
			—.0014	—.036	
Differential Gear Case Dia. for Bearings	2.6285	66.764			
	2.6270	66.726			
Pinion Pilot Bearing					
Bore in Centre Housing ...	2.440	61.976			
	2.439	61.951			
			.0028	.071	
			.0006	.015	
Bearing—Outside Dia. ...	2.4384	61.925			
	2.4372	61.905			
Bearing—Inside Dia. ...	1.1811	30.000			
	1.1807	29.900			
			—.0012	—.031	
			—.0003	—.008	
Pinion Dia.	1.1819	30.020			
	1.1814	30.008			
Driving Pinion Sleeve and Bearing Assembly					
Sleeve—Inside Dia.	3.749	95.225			
	3.748	95.199			
			—.003	—.076	
			—.001	—.025	
Bearing Cup — Outside Dia.	3.751	95.275			
	3.750	95.250			
Bearing—Inside Dia. ...	1.7500	44.450			
	1.7506	44.465			
			—.0004	—.010	
			—.002	—.051	
Pinion Dias. for Bearings ...	1.751	44.475			
	1.752	44.501			
			.0005	.013	
			.0016	.041	
	1.7495	44.437			
	1.7490	44.425			
Front Axle					
Front Axle and Centre Pin Assembly (Up to Tractor Serial No. 4859)					
Centre Axle Bore for Bush ...	1.912	48.565			
	1.910	48.514			
			—.0055	—.140	
			—.002	—.051	
Centre Bush Ext. Dia. ...	1.9155	48.654			
	1.914	48.616			
Centre Bush Int. Dia. ...	1.7615	44.742			
	1.7675	44.895			
			.021	.533	
			.014	.356	
Pin Dia.	1.7480	44.399			
	1.7465	44.361			
Bores for Pin in Front Axle Support	1.748	44.399			
	1.750	44.450			

Component Details	Dimensions New Ins.	Dimensions New mm.	Clearances New Ins.	Clearances New mm.	Remarks
(Tractor Serial No. 4860)					
Centre Axle Bore for Bush...	2.058	52.273			
	2.057	52.248			
			—.0055	—.140	
			—.003	—.076	
Centre Bush Ext. Dia. ...	2.0625	52.388			
	2.0610	52.349			
Centre Bush Int. Dia. ...	1.7615	44.742			
	1.7675	44.894			
			.0135	.343	
			.021	.533	
Pin Dia.	1.7480	44.399			
	1.7465	44.361			
Bores for Pin in Front Axle	1.748	44.399			
Support	1.750	44.450			
Front Axle and Spindle Assemblies					
Bore of Outer Axle for	1.3745	34.912			Hand Press Fit
Spindle Bushes	1.3735	34.889			
Ext. Dia. Spindle Bushes ...	1.3745	34.912			
	1.3735	34.889			
Int. Dia. Spindle Bushes ...	1.250	31.750			
	1.249	31.725			Reamed in position
			.0035	.089	
			.005	.127	
Spindle Shaft Dia.	1.2455	31.636			
	1.2450	31.623			
Hub					
Bore for Oil Seal	2.685	68.199			
	2.683	68.148			
			—.009	—.229	
			—.005	—.127	
Oil Seal Outside Dia. ...	2.692	68.377			
	2.690	68.326			
Bore for Inner Bearing ...	2.4395	61.963			
	2.4405	61.989			
			—.0025	—.064	
			—.0005	—.013	
Inner Bearing—Outside Dia.	2.442	62.027			
	2.441	62.001			
Inner Bearing—Inside Dia. ...	1.2505	31.763			
	1.2500	31.750			
			—.001	—.025	
			—.000	—.000	
Shaft Dia.	1.2500	31.750			
	1.2495	31.737			
Bore for Outer Bearing ...	1.9365	49.187			
	1.9375	49.212			
			—.012	—.292	
			—.0005	—.013	
Outer Bearing—Outside Dia.	1.948	49.479			
	1.938	49.225			

Component Details	Dimensions New Ins.	Dimensions New mm.	Clearances New Ins.	Clearances New mm.	Remarks
Outer Bearing—Inside Dia.	.7500	19.050			
	.7505	19.062			
			.000	.000	
			.001	.025	
Shaft Dia.	.7500	19.050			
	.7495	19.037			

Steering

The permissible backlash between the worm spindle and the ball nut should not exceed ½" measured at the rim of the steering wheel.

The backlash between the two gears should be held to a maximum of .002" in the straight ahead position of the steering.

Component Details	Dimensions New Ins.	Dimensions New mm.	Clearances New Ins.	Clearances New mm.	Remarks
Inside Dia. Spherical Ball Ring	.8445	21.450			
	.8435	21.425			
			—.001	—.025	
			+.001	+.025	
Steering Column (Inner) Dia.	.8450	21.463			
	.8435	21.425			
			.061	1.549	
			.068	1.727	
Inside Dia. Spherical Ball Race	.906	23.012			
	.911	23.139			
Steering Box					
Bore for bushes in Steering	1.378	35.001			
Box and Cover Plate ...	1.379	35.027			Press fit in housing
Outside Dia. of Bush ...	1.378	35.001			
	1.379	35.027			
Inside Dia. of Bush	1.2495	31.737			
	1.2485	31.711			
			.003	.076	Finished in position
			.001	.025	
Shaft	1.2475	31.687			
	1.2465	31.661			
Belt Pulley Attachment					
Backlash between driving gears	.004"-.006" (.102-.152 mm.)				
Preload on Pinion Shaft ...	2 to 4 in. lb. (2.3-4.6 kg. cm.)				
Drive Pulley Housing Bore ...	2.4414	62.012			
	2.4408	61.996			
			+.0011	+.028	
			—.0001	—.003	
Outside Dia. Bearing ...	2.4409	62.000			
	2.4403	61.984			
Inside Dia. Bearing	1.1811	29.997			
	1.1807	29.990			
			+.0001	+.003	
			—.0007	—.018	
Pulley Drive Shaft	1.1814	30.008			
	1.1810	29.997			
Pulley Drive Gear Dia. ...	1.7500	44.450			
	1.7495	44.437			

Component Details	Dimensions New Ins.	Dimensions New mm.	Clearances New Ins.	Clearances New mm.	Remarks
Needle Roller Bearing — Outside Dia.	2.1255 2.1245	53.988 53.962			
			+.001 —.0005	+.0254 —.0127	
Input Bearing Housing—Bore for bearing and oil seal ...	2.1250 2.1245	53.975 53.962			
			—.002 —.0065	—.0508 —.1651	
Oil Seal—Outside Dia. ...	2.131 2.127	54.127 54.026			
Pulley Drive Housing Assy. Bore for Inner Bearing ...	2.8745 2.8735	73.012 72.987			
			—.0005 —.0025	—.0127 —.0635	
Inner Bearing—Outside Dia.	2.875 2.876	73.025 73.050			
Inner Bearing—Inside Dia.	1.3755 1.3750	34.938 34.925			
			—.0005 —.0015	—.0127 —.038	
Pulley Drive Pinion ...	1.3760 1.3765	34.950 34.963			
Pulley Drive Housing Assy. Bore for Outer Bearing ...	2.7165 2.7155	68.999 68.973			
			—.0005 —.0025	—.013 —.064	
Outer Bearing—Outside Dia.	2.7180 2.7170	69.037 69.012			
Outer Bearing—Inside Dia.	1.3756 1.3750	34.940 34.925			
			+.0009 —.0002	+.023 —.005	
Pulley Drive Pinion ...	1.3752 1.3747	34.930 34.917			
Pulley Drive Housing Assy. Recess for Oil Seal ...	2.751 2.749	69.875 69.825			
			—.0052 —.0028	—.132 —.071	
Oil Seal—Outside Dia. ...	2.7542 2.7538	69.957 69.946			

87 MM. PETROL ENGINE

No. of Cylinders	4
Bore	87 mm.
Stroke	92 mm.
Piston Displacement	2186.5 c.c. (133.4 cu. in.)
Compression Ratio	6.0 : 1 or 6.6 : 1
Firing Order	1, 3, 4, 2.

	6.0 : 1 Ratio	6.6 : 1 Ratio
Brake H.P. (Bare Engine)	37.25	38.0
Belt H.P. (Bare Engine)	34.5	36.2
Equivalent Crankshaft Torque	99 lb. ft. at 1280 r.p.m.	105.3 lb. ft. at 1200 r.p.m.

TIGHTENING TORQUES

	lbs./ft.	kg./m.
Camshaft Locating Plate Attachment	18 — 20	2.489 — 2.765
Caps—Connecting Rod	50 — 55	6.913 — 7.604
Caps—Main Bearings	85 — 90	11.752 — 12.443
Clutch Attachment—Single	20	2.765
Clutch Attachment—Dual	22 — 24	3.042 — 3.318
Cover Plate to Rear Face of Combustion Head	18 — 20	2.489 — 2.765
Cylinder Head	60 — 65	8.295 — 8.987
Dynamo Bracket Assembly to Cylinder Block	18 — 20	2.489 — 2.765
Dynamo to Bracket	18 — 20	2.489 — 2.765
End plates, Timing Cover, Dynamo Bracket Attachments 353 528 X1	12 — 14	1.659 — 1.936
End plates, Timing Cover, Dynamo Bracket Attachments 354 614 X1	16 — 18	2.212 — 2.489
End plates, Timing Cover, Dynamo Bracket Attachments 354 616 X1	18 — 20	2.489 — 2.765
Fan and Pulley to Hub	18 — 20	2.489 — 2.765
Fan Pulley Hub to Water Pump Spindle	12 — 14	1.659 — 1.936
Filter to Sump	12 — 14	1.659 — 1.936
Flywheel Attachment to Crankshaft	42 — 46	5.807 — 6.360
Governor Attachment to Chainwheel	8 — 10	1.106 — 1.383
Link to Dynamo	18 — 20	2.489 — 2.765
Manifold Attachment	22 — 24	3.042 — 3.318
Oil Filter Attachment	22 — 24	3.042 — 3.318
Oil Filler Body to Block	18 — 20	2.489 — 2.765
Oil Pump Attachment	12 — 14	1.659 — 1.936
Rear Oil Seal Attachment etc.	8 — 10	1.106 — 1.383
Rocker Pedestal	22 — 24	3.042 — 3.318
Starter Motor Attachment	37 — 40	5.116 — 5.530
Sump Attachment	16 — 18	2.212 — 2.489
Timing Chain Wheel Attachment to Camshaft	22 — 24	3.042 — 3.318
Water Pump Bearing Housing to Body	22 — 24	3.042 — 3.318
Water Pump to Combustion Head	26 — 28	3 595 — 3.871

DIMENSIONS AND TOLERANCES

Component Details	Dimensions New Ins.	Dimensions New mm.	Clearances New Ins.	Clearances New mm.	Remarks
Main Bearings					
Housing Bore	2.6255 2.625	66.688 66.675			For checking housing or bearing bores fit bearing cap and tighten to specified torque.
Radial Thickness of Bearings	.07225 .0720	1.835 1.829			

Component Details	Dimensions New Ins.	Dimensions New mm.	Clearances New Ins.	Clearances New mm.	Remarks
Bearing Bore Dia. (fitted) ...	2.4815 2.4805	63.030 63.005			
			.0025 .0010	.064 .025	Similar tolerances for re-ground crankshaft to .010", .020", .030", (.254, .508, .762 mm.) undersize.
Crankshaft					
Journal Dia.	2.479 2.4795	62.967 62.979			
Crankshaft Fillet Radii ...	Standard Undersize	.085" (2.16 mm.) .095" (2.41 mm.)			
Crankshaft End Float					
Centre Journal Length ...	1.7507 1.7498	44.468 44.445			
			.0117 .0048	.297 .122	
Centre Bearing Cap Width ...	1.559 1.557	39.599 39.548			
Thrust Washer Thickness (2 off)	.093 .091	2.362 2.311			Thrust washers also available .005" (.127 mm.) oversize.
Big End					
Crankpin Dia.	2.0866 2.0861	53.000 52.987			Similar tolerances for re-ground crankshaft to .010", .020", .030",
			.0024 .0006	.061 .015	.040", (.254, .508, .762, 1.016 mm.) undersize.
Bearing Bore Dia. (fitted) ...	2.0885 2.0872	53.048 53.015			For checking big-ends or bearing bores assemble connecting rod and tighten to specified setting.
Connecting Rod Bore Dia. ...	2.2335 2.2327	56.731 56.710			
Radial Thickness of Bearings	.0727 .0725	1.846 1.841			
Connecting Rod End Float					
Crankpin Length	1.1915 1.1865	30.264 30.137			
			.014 .007	.356 .178	
Connecting Rod Width ...	1.1795 1.1775	29.959 29.909			
Small End					
Bore for Bush	1.0000 .9995	25.400 25.387			Heat piston in boiling oil for removal and fitting of gudgeon pin
			—.0035 —.0050	—.09 —.13	
Bush External Dia.	1.0045 1.0035	25.514 25.489			
Bush Internal Dia.	.8752 .8748	22.230 22.220			*Specified clearances using drawing
			*+.00035 —.00030	+.009 —.008	sizes but desired fit of gudgeon pin obtained by selective assembly
Gudgeon Pin Dia.	.8751 .8748	22.228 22.220			
			*+.00045 —.00005	+.011 —.001	

Component Details	Dimensions New Ins.	Dimensions New mm.	Clearances New Ins.	Clearances New mm.	Remarks
Gudgeon Pin Holes in Piston	.8753	22.233			
	.8750	22.226			
Pistons and Sleeves					
Piston Diameter (Thrust side top skirt)					
F. Grade	3.4213	86.901			Oversize pistons +.020" (.508 mm.) available
	3.4209	86.891			
G. Grade	3.4217	86.911			
	3.4213	86.901			
H. Grade	3.4221	86.921			
	3.4217	86.911			
			.0042	.107	
			.0035	.089	
Sleeve Bore (parallel)					
F. Grade	3.4251	86.998			
	3.4248	86.990			
G. Grade	3.4255	87.008			
	3.4252	87.000			
H. Grade	3.4259	87.018			
	3.4256	87.010			
Clearance, Bottom of Piston Skirt (thrust side) ...			.0027	.069	Thrust side piston skirt tapered .0015" (.038 mm.) on dia.
			.0020	.051	
Top Land Dia.	3.408	86.56			
	3.404	86.46			
Ring Groove Width Top and 2nd	.081	2.057			**Note:** 2 Compression and 2 oil control rings per piston, oil control rings one above and one below gudgeon pin
	.080	2.032			
			.0023	.058	
			.0013	.033	
Compression Ring Width ...	.0787	1.999			
	.0777	1.974			
Ring Groove Width 3rd and 4th	.190	4.826			Similar tolerances for oversize rings +.010" (.254 mm.), +.200" (.508 mm.), +.030" (.762 mm)., +.040" (1.016 mm.).
	.189	4.801			
			.0035	.089	
			.0015	.038	
Slotted Scraper Ring Width 3rd and 4th	.1875	4.763			
	.1865	4.737			
Ring Gap (closed)			.015	.381	
			.010	.254	
Clearance between Top Flange of Sleeve and Upper Block:					
Upper Block Dia.	4.140	105.156			
	4.125	104.775	.045	1.143	
			.015	.381	
Top Flange of Sleeve Dia. ...	4.110	104.394			
	4.095	104.013			
Clearance between Sleeve Spigot and Lower Block:					
Lower Block Dia.	3.6570	92.887			
	3.6555	92.849			
			.003.	.0762	
			0005	.0127	
Sleeve Spigot Dia.	3.655	92.837			
	3.654	92.812			
Cylinder Block (Top face to seating face for sleeve ...	4.501	114.325			
	4.499	114.274			

Component Details	Dimensions New Ins.	Dimensions New mm.	Clearances New Ins.	Clearances New mm.	Remarks
Gasket thickness (uncompressed)	.021 .019	.533 .483			
Cylinder Sleeve (Top face to seating face)	4.488 4.487	113.995 113.970			
Stand out of sleeve above cylinder block (Liner gasket uncompressed)			.010 005	.254 .127	
Water Pump					
Housing Bore for Bearings ...	1.5749 1.5744	40.002 39.990			
			+.0006 —.0004	+.015 —.010	
Bearing Case Ext. Dia. ...	1.5748 1.5742	40.000 39.987			
Spindle Dia.	.6264 .6256	15.911 15.890			
			—.0034 —.0021	—.086 —.053	
Impellor Bore Dia.	.6235 .6230	15.837 15.824			

Thermostat

Makers No. X 43570/19 (Fitted up to Engine No. SF16861EL)

Valve begins to open ...	60°C. (140°F.)	
Valve fully open	65°C. (150°F.)	
Valve lift	.375"	9.5 mm.

Makers No. 85035/60 (Fitted Engine No. SF16862EL onwards)

Valve begins to open ...	58°C.-63°C. (136°F.-145°F.)	
Valve fully open	67°C.	(152°F.)
Valve lift	.312"	7.94 mm.

Makers No. 85035/78 (Fitted Engine No. SF19919EH onwards)
Fitted to 6.6 : 1 ratio engines only

Valve begins to open ...	76°C.-81°C. (169°F.-178°F.)	
Valve fully open	95°C.	(203°F.)
Valve lift	.312"	7.94 mm.

Oil Pump

Approx. capacity of pump at 50 lb. sq. in. (3.515 kg. sq. cm.) using SAE 10 oil at 150°F: 3.95 galls (17.957 litres) per min., at 2000 r.p.m. oil pump. (Oil pump runs at half engine speed).

Oil Pressure ... ... 25-60 lb. sq. in. (1.758-4.218 kg. sq. cm.)

Component Details	Dimensions New Ins.	Dimensions New mm.	Clearances New Ins.	Clearances New mm.	Remarks
Outer Rotor, Outside Dia...	1.5975 1.5965	40.577 40.551			
			.008 .006	.203 .152	
Housing, Int. Dia.	1.604 1.603	40.741 40.716			
Bore, Inner Rotor	.4987 .4993	12.667 12.682			
			.0013 0002	.033 .005	

Component Details	Dimensions New Ins.	Dimensions New mm.	Clearances New Ins.	Clearances New mm.	Remarks
Pump Shaft Dia.	.4985 .4980	12.661 12.649			
			.003 .001	.076 .025	
Housing Bore Int. Dia. ...	.501 .4995	12.725 12.687			
Rotor Depth — Inner and Outer	.9990 .9985	25.375 25.362			
			.001 .0025	.025 .064	A combined worn clearance of .005" (.127 mm.) indicates need of cover and housing face lapping.
Housing Depth	1.001 1.000	25.425 25.400			
Inner Rotor, Major Dia. ...	1.172 1.171	29.769 29.743			
Inner Rotor, Minor Dia. ...	.731 .729	18.567 18.517			
Clearance on Rotors ...			.004 .0005	.102 .012	Measured when major dia. of inner rotor and minor dia. of outer rotor are in line; when this clearance exceeds .010" (.254 mm.) new parts should be fitted.
Camshaft					
Bore in Block for Front Journal	2.1913 2.1905	55.659 55.639			
Radial thickness of Bearings	.1303 .1285	3.310 3.264			
Bearing Bore Dia. (fitted) ...	2.0623 2.0605	52.372 52.337			
			.001 .0033	.025 .084	
Front Journal Dia.	2.0595 2.0590	52.311 52.298			
Bore in block for centre, intermediate and rear journals	1.8445 1.8435	46.850 46.825			
Radial thickness of Bearings	.1279 .1247	3.249 3.167			
Bearing Bore Dia. (fitted) ...	1.7188 1.7167	43.659 43.605			
			.001 .004	.025 .102	
Journal Dia. (Centre, Intermediate and Rear) ...	1.7157 1.7152	43.580 43.567			
Camshaft End Float					
Locating Groove	.1876 .1874	4.765 4.760			
			.0056 .0039	.142 .099	
Locating Plate	.1835 .1820	4.661 4.623			

Component Details	Dimensions New Ins.	Dimensions New mm.	Clearances New Ins.	Clearances New mm.	Remarks
Tappets and Valves					
Tappet Bore in Block ...	.9380	23.825			
	.9373	23.807			
			.0013	.033	
			.0002	.005	
Tappet Dia.	.9371	23.802			
	.9367	23.792			
Valve Tip Clearances (Cold)					
Inlet...	.012	.305			
Exhaust	.008	.203			
Inlet Valve Stem Dia. ...	.311	7.900			
	.310	7.874			
			.003	.076	
			.001	.025	
Inlet Valve Guide Bore Dia....	.3130	7.950			
	.3120	7.925			
Exhaust Valve Stem Dia. ...	.3732	9.479			
	.3727	9.467			
			.003	.076	
			.0013	.033	
Exhaust Valve Guide Bore Dia.	.3755	9.538			
	.3745	9.512			
Valve Head Dia.					
Inlet	1.331	33.807			
	1.327	33.705			
Exhaust	1.238	31.445			
	1.234	31.344			
Guide projection above spring seat	.59	14.986			
Valve lift	.270	6.858			
Valve Seating Angle on valve head	45°				
Valve Seat Angle in new cylinder head	44½° but serviced at 45°.				
Inlet and Exhaust Valve Seat Inserts available for service purposes.					
Valve Springs					
Free Length	1.787	45.390	Fitted load	...38 lb. +2 lb. —1 lb. (17.237 kg. +.91 kg. —.45 kg.)	
Fitted Length	1.321	33.554	Full lift load	... 60 lb. (27.216 kg.)	
Valve Timing (Crankshaft Degrees)					
Exhaust Opens	40° before B.D.C.				
Exhaust Closes	T.D.C.				
Inlet Opens	T.D.C.				
Inlet Closes	40° after B.D.C.				
Timing holes in flywheel and crankcase when aligned with tommy bar locate No. 1 and No. 4 T.D.C.					
Flywheel					
Spigot Dia. (for Starter Gear Ring)	13.406	340.512			
	13.403	340.436			
			.031	.7874	
			.023	.5842	

Component Details	Dimensions New Ins.	Dimensions New mm.	Clearances New Ins.	Clearances New mm.	Remarks
Starter Gear Ring (Inside Dia.)	13.380 13.375	339.852 339.725			
Crankshaft Spigot Dia. ...	4.0002 3.9995	101.605 101.587			
			+.0012 —.0004	+.031 —.010	
Flywheel Dia. for Spigot ...	4.0007 3.9998	101.618 101.595			

Run out of clutch contact face at outer diameter should not exceed .003" (.076 mm.)

Carburettor—Zenith Type 28G

Adjustments—Main Jet $1\frac{3}{4} \pm \frac{1}{4}$ turns
S.R. Jet $1\frac{3}{4}$ turns

One of the following:—

C. 1542

Identification ... ... Stamped C-1542. Dab of yellow paint on F.C. cover

Data:
- Choke Tube Dia. ... ... 19 mm.
- Main Jet ... ... 245 c.c.
- Air Jet ... ... .70 mm.
- S.R. Jet 70
- Needle Seating ... ... 2.0 mm.
- Fuel Level ... ... 17 mm. at 18" head (measured from top face of carburettor bowl).

C. 1575

Identification ... ... Stamped C-1575. Dab of blue paint on F.C. cover, dab of green on bowl.

Data:
- Choke Tube Dia. ... ... 19 mm.
- Main Jet ... ... 245 c.c.
- Air Jet ... ... .70 mm.
- S.R. Jet 55
- Needle Seating ... ... 2.0 mm.
- Fuel Level ... ... 17 mm. at 18" head. (measured from top face of carburettor bowl).

C. 1608

Identification ... ... Stamped C-1608. Dab of white paint on F.C. cover, dab of brown on bowl.

Data:
- Choke Tube Dia. ... ... 19 mm.
- Main Jet ... ... 245 c.c.
- Air Jet ... ... .70 mm.
- S.R. Jet 70
- Needle Seating ... ... 2.0 mm.
- Fuel Level ... ... 17 mm. at 18" head. (measured from top face of carburettor bowl).

Battery ... ... 12 volt. 1 off.
GTW 7A, GT 7A, GTZ 7A
BTW 7A, BT 7A, BTZ 7A

Ampere Hour Capacity
at 10 hour rate 38 amp. hour
at 20 hour rate 43 amp. hour
fully charged at 60°F. (16°C.)

Distributor D3A4 V160

Static Setting ... ... Up to Engine Serial No. SF 3818 E—1° B.T.D.C.
Engine Serial No. SF 3519 E onwards—5° B.T.D.C.

Component Details	Dimensions New (Ins. / mm.)	Clearances New (Ins. / mm.)	Remarks
Spark Plug	Champion L.10.	Lodge CN	
Thread Dia.	14 mm.	14 mm.	
Reach	.5" (12.7 mm.)	.5" (12.7 mm.)	
Gap	.030"-.032" (.76-.81 mm.)	.025"-.028" (.635-.710 mm.)	
Starter Motor	M 35 G		
No. of teeth flywheel gear ring and starter pinion	145 and 10 respectively.		
Distance of front mounting flange to rear face of flywheel gear ring ...	1.563" (39.7 mm.)		
Dynamo	C 39 P2	Runs at 1.9 x engine speed.	
Governor			
Range	400 - 2000 r.p.m. Engine		
Governor Lever Spring			
Free length (inside hooks) ...	3.80" (96.52 mm.)		
Rate	18 lb. in. (20.74 kg. cm.) +5%		
No. of coils	26		
Load at 1" (25.4 mm.) deflection	25 lb. ± 1lb. (11.34 kg. ±.454 kg.)		
Initial wound-in load	7 lb. (3.175 kg.)		
Governor Compensator Spring			
Free length (inside hooks) ...	3.125" (79.375 mm.)		
Rate	64 lb. in. (73.74 kg. cm.) ±5%		
No. of Coils	11½		
Load at ½" (12.7 mm.) deflection	38 lb. ±1½ lb. (17.24 kg. ±.681 kg.)		
Initial wound-in load	6 lb. (2.722 kg.)		

87 MM. V.O. ENGINE

No. of Cylinders	4
Bore	87 mm.
Stroke	92 mm.
Piston Displacement	2186.5 c.c. (133.4 cu. in.)
Compression Ratio	5.0 : 1
Firing Order	1, 3, 4, 2.
Brake H.P. (Bare Engine)	30.5
Belt H.P. (Bare Engine)	28.8
Equivalent Crankshaft Torque ...	84.0 lb. ft. at 1150 r.p.m.

DIMENSIONS AND TOLERANCES

Component Details	Dimensions New Ins.	Dimensions New mm.	Clearances New Ins.	Clearances New mm.	Remarks
Pistons and Sleeves					
Piston Dia. (Thrust side top skirt)					
F. Grade	3.4213 3.4209	86.901 86.891			Oversize pistons ÷ 020" (.508 mm.) available
G. Grade	3.4217 3.4213	86.911 86.901			
H. Grade	3.4221 3.4217	86.921 86.911			
			.0042 .0035	.107 .089	
Sleeve Bore (Parallel)					
F. Grade	3.4251 3.4248	86.998 86.990			
G. Grade	3.4255 3.4252	87.008 87.000			
H. Grade	3.4259 3.4256	87.018 87.010			
Clearance—Bottom of Piston Skirt (Thrust side) ...			.0027 .0020	.069 .051	Thrust side piston skirt tapered .0015" (.038 mm.) on diameter.
Top Land Dia.	3.408 3.404	86.563 86.462			
Ring Groove Width Top and 2nd	.083 .082	2.108 2.083			**Note:** Three compression and two oil control rings per piston. Oil control rings located one above and one below gudgeon pin.
			.005 .003	.1270 .0762	
Compression Ring Width ...	.0787 .0777	1.999 1.974			
			.004 .002	.1016 .0508	
Ring Groove Width, 3rd ...	.082 .081	2.083 2.060			

Component Details	Dimensions New Ins.	Dimensions New mm.	Clearances New Ins.	Clearances New mm.	Remarks
Ring Groove Width, 4th and 5th	.1905 .1895	4.839 4.813			
			.004 .002	.102 .051	
Slotted Scraper Ring Width	.1875 .1865	4.763 4.737			
Ring Gap (closed)			.015 .010	.381 .254	

Thermostat

Makers No. X 43570/25 (Fitted up to Engine Serial No. SG 5983 E)

Valve begins to open	75°C.-80°C. (167°F.-176°F.)
Valve fully open	95°C. (203°F.)
Valve lift	.312" (7.93 mm.)

Makers No. 85035/78 (Fitted Engine Serial No. SG 5984 E onwards)

Valve begins to open	76°C.-81°C. (169°F.-178°F.)
Valve fully open	95°C. (203°F.)
Valve lift	.312" (7.93 mm.)

Carburettor ... ... Zenith Type 28G. Adjustments: Main Jet 2 ± $\frac{1}{4}$ turns
S.R. Jet 1$\frac{3}{4}$ turns

One of the following:

C.1575

Identification	Stamped C-1575. Dab of blue paint on F.C. cover, dab of green on bowl.
Data: Choke Tube Dia.	19 mm.
Main Jet	245 c.c.
Air Jet	.70 mm.
S.R. Jet	55
Needle Seating	2.0 mm.
Fuel Level	17 mm. at 18" head (measured from top face of carburettor bowl)

C.1578

Identification	Stamped C-1578. Dab of brown paint on F.C. cover, and on bowl.
Data: Choke Tube Dia.	19 mm.
Main Jet	245 c.c.
Air Jet	.70 mm.
S.R. Jet	80
Needle Seating	2.0 mm.
Fuel Level	17 mm. at 18" head. (measured from top face of carburettor bowl)

Sparking Plug	Champion N7 or N21	Lodge BL 14
Thread Dia.	14 mm.	14 mm.
Reach	$\frac{3}{4}$"	$\frac{3}{4}$"
Gap	.028"-.032" (0.71-0.81 mm.)	.025"-.028" (.635-.711 mm.)

For other details and data—Refer to 87 mm. bore petrol engine. Pages B19 to B26.

87 MM. LAMP OIL ENGINE

No. of Cylinders	4
Bore	87 mm.
Stroke	92 mm.
Displacement	2186.5 c.c (133.4 cu. in.)
Compression Ratio	4.3 : 1
Firing Order	1, 3, 4, 2
Brake H.P. (Bare Engine)	29.0
Belt H.P. (Bare Engine)	26.3
Equivalent Crankshaft Torque ...	76.5 lb. ft. at 1200 r.p.m.

Thermostat
Makers No. X 43570/25 (Fitted up to Engine Serial No. SH 406 E)

Makers No. 85035/78 (Fitted Engine Serial No. SH 407 E onwards)

Carburettor ... ... Zenith Type 28G. Adjustments: Main Jet $2\frac{1}{2} \pm \frac{1}{4}$ turns
S.R. Jet $1\frac{3}{4}$ turns

For other details and data—Refer to 87 mm. V.O. engine. Pages B27 to B28.

23C DIESEL ENGINE

No. of Cylinders	4
Bore	$3\frac{5}{16}$" (84.137 mm.)
Stroke	4" (101.6 mm.)
Displacement	137.89 cu ins.(2259 c.c.)
Compression Ratio	20 : 1
Firing Order	1, 3, 4, 2.
Brake H.P. (Bare Engine)	37.25
Belt H.P. (Bare Engine)	35.9
Equivalent Crankshaft Torque ...	100 lb. ft. at 1600 r.p.m.

TIGHTENING TORQUES

	lbs./ft.	kg.m.
Bearing Housing to Block—Centre	39 — 42	5.392 — 5.807
Bearing Housing to Block—Front	18 — 20	2.489 — 2.765
Bearing Housing—Upper to Lower	25 — 30	3.456 — 4.148
Bearing Housing (Rear) and Cover Attachment	18 — 20	2.489 — 2.765
Camshaft Chain Wheel to Centre	18 — 20	2.489 — 2.765
Clutch Attachment—Single	26 — 28	3.595 — 3.871
Clutch Attachment—Dual	22 — 24	3.042 — 3.318
Connecting Rod Bolts	65 — 70	8.987 — 9.678
Cylinder Head—Manifolds	22 — 24	3.042 — 3.318
Injectors	12 — 14	1.659 — 1.936
Rocker Shaft Oil Feed	16 — 18	2.212 — 2.489
Cylinder Head Attachment to Block	100 — 105	13.830 — 14.521
Dynamo Bracket to Cylinder Block	18 — 20	2.489 — 2.765
Dynamo Mounting	26 — 28	3.595 — 3.871

TIGHTENING TORQUES

Dynamo to Bracket	18 — 20	2.489 — 2.765
Exhaust Pipe Attachment	22 — 24	3.042 — 3.318
Fan Hub to Water Pump Spindle—Nyloc Nut ...	16 — 18	2.212 — 2.489
—$\frac{5}{16}$" UNF Nut ...	12 — 14	1.659 — 1.936
Fan Pulley to Hub	18 — 20	2.489 — 2.765
Flywheel Attachment	90 — 100	12.443 — 13.830
Fuel Pump Attachment	12 — 14	1.659 — 1.936
Injector Pump Drive Casing to Block—Setscrew ...	18 — 20	2.489 — 2.765
—Bolt	16 — 18	2.212 — 2.489
Injection Pump Mounting	22 — 24	3.042 — 3.318
Injector Clamp	18 — 20	2.489 — 2.765
Oil Filter to Cylinder Block	26 — 28	3.595 — 3.871
Oil Pump Attachment	16 — 18	2.212 — 2.489
Oil Pump to Front Bearing Housing	12 — 14	1.659 — 1.936
Oil Suction Pipe Bracket to Cylinder Block	18 — 20	2.489 — 2.765
Oil Sump Attachment—Bolts and Setscrews	16 — 18	2.212 — 2.489
—Nut	14 — 16	1.936 — 2.212
Rocker Cover and Pedestal	3 — 5	.415 — .691
Rocker Pedestal	22 — 24	3.042 — 3.318
Rocker Shaft to Pedestal	8 — 10	1.106 — 1.383
Starter Motor Attachment to Cylinder Block ...	37 — 40	5.116 — 5.530
Tappet Cover Attachment	18 — 20	2.489 — 2.765
Thermostat—Elbow to Thermostat Body and Body to Cylinder Head	18 — 20	2.489 — 2.765
Timing Cover	18 — 20	2.489 — 2.765
Timing Chain Tensioner Attachment	8 — 10	1.106 — 1.383
Water Pump Attachment	22 — 24	3.042 — 3.318
Water Pump Attachment to Cylinder Block	26 — 28	3.595 — 3.871

DIMENSIONS AND TOLERANCES

Component Details	Dimensions New Ins.	Dimensions New mm.	Clearances New Ins.	Clearances New mm.	Remarks
Main Bearing Housings					
Front					
Housing Spigot Ext. Dia. ...	5.0615 5.0605	128.562 128.537			Crankshaft bearings are available in the following undersizes: .010" (.254 mm.), .020" (.508 mm.), .030" (.762 mm.), .040" (1.016 mm.),
			.0030 .0005	.076 .013	
Bore in Cylinder Block ...	5.0635 5.0620	128.613 128.575			
Centre					
Housing Spigot Ext. Dia. ...	6.8115 6.8105	173.012 172.987			
			.0035 .0005	.089 .013	
Bore in Cylinder Block ...	6.8140 6.8120	173.076 173.025			
Rear					
Housing Spigot Ext. Dia. ...	6.8740 6.8730	174.600 174.574			
			.0035 .0006	.089 .015	
Bore in Cylinder Block ...	6.8765 6.8746	174.663 174.613			

Main Bearings					
Housing Bores: Front Centre and Rear	2.9195 2.9190	74.155 74.143			For checking bore dia. assemble both halves with ring dowels fitted and screws tightened to 29-31 lbs. ft. (3.5-4.1 Kg.m.)
Radial thickness of Bearings (Front, Centre and Rear) ...	.08250 .08225	2.096 2.089			
Bearing Bore Dia. (Front, Centre and Rear)	2.755 2.754	69.977 69.951			With bearing fitted in housing, tighten to specified torque setting.
Crankshaft Clearance ...			.0035 .0020	.089 .051	Desired clearance when assembled
Crankshaft					
Journal Dias.	2.7520 2.7515	69.901 69.888			Similar tolerances for re-ground crankshaft to .010" .020", .030", .040" (.254, .508, .762, 1.016 mm.) undersize.
Crankshaft Fillet Radii					
(Up to Engine No. SJ 114020E, Engine Nos. SJ 110521E to SJ 110538E, and Engine Nos. SJ 111386 to SJ 111413E).					
Crankpins	.185/.175	4.70/4.45			
Journals—Front/Rear ...	.110/.100	2.79/2.54			These radii must be maintained if crankshaft is re-ground.
Centre	.150/.160	3.81/4.06			
(Engine Nos. SJ 110421E to SJ 110520E, Engine Nos. SJ 110539E to SJ 111385E, and Engine No. SJ 111414E and future).					
Crankpins	.185/.175"	4.70/4.45			
Journals—Rear	.110/.100	2.79/2.54			These radii must be maintained if crankshaft is re-ground.
Front/Centre ...	.160/.150	4.06/3.81			
Crankshaft End Float					
Rear Journal Length ...	1.7507 1.7498	44.468 44.445			Big end bearings are available in the following undersizes: .010" (.254 mm.), .020" (.504 mm.), .030" (.762 mm.), .040" (1.016 mm.)
			.0117 .0048	.297 .122	
Rear Bearing Housing Width	1.559 1.557	39.599 39.548			
Thrust Washer Thickness ...	.093 .091	2.362 2.311			.005" (.127 mm.) oversize thrust washer available.
Big End					
Crankpin Dia.	2.3115 2.3110	58.712 58.699			Similar tolerances for re-ground crankshaft to .010", .020", .030", .040", (.254, .508, .762, 1.016 mm.) undersize.
			.0035 .0020	.089 .051	
Bearing Bore Dia.	2.3145 2.2135	58.788 58.763			
Con. Rod Bore Dia..	2.4575 2.4570	62.421 62.408			For checking bearing bores—assemble con. rod and tighten to specified setting.
Radial thickness of Bearings	.07175 .07150	1.822 1.816			

Component Details	Dimensions New Ins.	Dimensions New mm.	Clearances New Ins.	Clearances New mm.	Remarks
Connecting Rod End Float					
Crankpin Length	1.4390	36.551			Ovality or wear of any crankshaft
	1.4370	36.500			journal must not exceed .002"
			.012	.305	(.050 mm.)
			.008	.203	
Width of Connecting Rod ...	1.429	36.296			
	1.427	36.245			
Small End					
Bore for Bush	1.251	31.775			
	1.250	31.750			
			—.005	—.127	
			—.002	—.064	
Bush External Dia.	1.255	31.877			
	1.2535	31.838			
Bush Internal Dia.	1.1248	28.570			
	1.1252	28.580			*Specified clearance using drawing
			*+.0003	+.008	sizes but bore of bush machined to
			—.0003	—.008	suit gudgeon pin for the required
					fit.
Gudgeon Pin Dia.	1.12515	28.579			
	1.12485	28.571			
			†+.0003	+.008	
			—.0005	—.013	
Gudgeon Pin Holes in Piston	1.12515	28.579			†Specified clearance using drawing
	1.12465	28.566			sizes but desired fit of Gudgeon Pin in Piston obtained by selective assembly. Heat Piston in hot oil for fitting.
Pistons, Sleeves and Inserts					
Cylinder Liners					
Sleeve Bore (Parallel):					
F. Grade	3.3135	84.163			
	3.3130	84.150			
G. Grade	3.3140	84.176			
	3.3135	84.163			
H. Grade	3.3145	84.188			
	3.3140	84.176			
Clearance between top flange of sleeve and upper block:					
Upper Block — recess for	3.718	94.437			
Flange Dia.	3.716	94.386			
			.008	.2032	
			.004	.1016	
Top Flange of Sleeve Dia. ...	3.712	94.285			
	3.710	94.234			
Clearance between sleeve spigot and lower blocks:					
Lower Block Dia.	3.5343	89.771			
	3.5338	89.759			
			.0021	.053	
			.0008	.020	
Sleeve Spigot Dia.	3.5330	89.738			
	3.5322	89.718			
Thickness of Flange	.440	11.176			
	.439	11.151			

Component Details	Dimensions New Ins.	mm.	Clearances New Ins.	mm.	Remarks
Depth of Bore in Cylinder Block	.438 .436	11.125 11.074			
Stand out of liner above Cylinder Block			.004 .001	.102 .025	
Pistons (Automotive Engineering)					Alternative to Wellworthy Pistons and Sleeves graded F, G, and H. Replacement pistons and sleeves available as standard size only (i.e., no provision made for re-boring and fitting oversizes).
Piston Skirt Dia. Top (Oval Ground Tapered Skirt)					
F. Grade	3.3075 3.3071	84.010 84.000			
G. Grade	3.3080 3.3076	84.023 84.013			
H. Grade	3.3085 3.3081	84.036 84.026			
Piston/Sleeve Clearance—Top of Skirt Thrust Side ...			.0064 .0055	.163 .140	
Piston Skirt Dia. (at Grading Position)					
F. Grade	3.3095 3.3091	84.061 84.051			Grading position is at right angles to the gudgeon pin and 1.209" (30.72 mm.) from bottom of piston skirt.
G. Grade	3.3100 3.3096	84.074 84.064			
H. Grade	3.3105 3.3101	84.087 84.077			
Piston/Sleeve Clearance (at Grading Position)			.0044 .0035	.112 .089	
Piston/Sleeve Clearance Bottom of Skirt—Thrust Side			.0044 .0035	.112 .089	
Ovality—Top of Skirt ...	.011 .009	.279 .230			
Ovality—Bottom of Skirt ...	.019 .016	.483 .406			
Pistons (Wellworthy)					Alternative to Automotive Engineering Pistons and Sleeves graded F, G and H. Replacement pistons and sleeves available as standard size only, (i.e. no provision made for reboring and fitting oversizes).
Piston Skirt Dia. Top (Oval Ground Tapered Skirt)					
F. Grade	3.3075 3.3071	84.010 84.000			
G. Grade	3.3080 3.3076	84.023 84.013			
H. Grade	3.3085 3.3081	84.036 84.026			
Piston/Sleeve Clearance (at Grading Position) ...			.0064 .0055	.163 .140	Grading position at top of piston skirt, at right angles to the gudgeon pin and 1.4375" (36.51 mm.) from bottom of piston skirt.
Piston Skirt Dia. Max.					
F. Grade	3.3085 3.3081	84.036 84.026			
G. Grade	3.3090 3.3086	84.049 84.038			
H. Grade	3.3095 3.3091	84.061 84.051			

Component Details	Dimensions New Ins.	Dimensions New mm.	Clearances New Ins.	Clearances New mm.	Remarks
Piston Skirt Dia. (Bottom)					
F. Grade	3.3082	84.028			
	3.3078	84.018			
G. Grade	3.3087	84.041			
	3.3083	84.031			
H. Grade	3.3092	84.053			
	3.3088	84.043			
Clearance—Bottom of Piston			.0057	.145	
Skirt—Thrust Side ...			.0048	.122	
Ovality—Top of Skirt ...	.018	.457			
	.019	.482			
Ovality—Bottom of Skirt ...	.0095	.241			
	.0105	.266			

Piston Rings

Three compression rings and one Duaflex oil control ring.
The top compression ring is a chromium plated parallel type and may be fitted either way up, the 2nd and 3rd compression rings have a taper face and are not chromium plated. To facilitate assembly the word "TOP" is etched on the narrower face and must always be fitted upwards.

Component Details	Dimensions New Ins.	Dimensions New mm.	Clearances New Ins.	Clearances New mm.	Remarks
Piston Rings					
Ring Groove Width, Top ...	.0998	2.535			On earlier assemblies ring groove width was .098/.097" (2.489/2.464 mm.) and .0983/.0973" (2.497/2.472 mm.)
	.0988	2.510			
			.007	.1778	
			.005	.1270	
Compression Ring Width, Top	.0938	2.383			
	.0928	2.357			
Ring Gap	.017	.432			
	.012	.305			
Ring Loading Data (Automotive Eng. Co.) ...	Tangential Load 3.88/5.5 lb.	(2.09/2.49 kg.)			
	Wall Pressure 24.9/35.4 lbs./in.^{2}	(1.75/2.47 kg./cm.^{2})			
(Wellworthy)	Cylinder Wall Pressure 23.9/34.3 lbs./in.^{2}	(1.68/2.41 kg./cm.^{2})			
	Diametrical Load 9.75/14.0 lb.	(4.42/6.35 kg.)			
	Tangential Load 3.70/5.30 lb.	(1.67/2.4 kg.)			
Ring Groove Width 2nd and 3rd	.0983	2.497			On earlier assemblies ring groove width was .098/.097" (2.489/2.464 mm.)
	.0973	2.471			
			.0055	.1397	
			.0035	.0890	
Compression Ring Width 2nd and 3rd	.0938	2.383			
	.0928	2.357			
Ring Loading Data (Automotive Eng. Co.) ...	Tangential Load 2.7/3.84 lbs.	(1.22/1.741 kg.)			
	Wall Pressure 17.4/24.6 lbs./in.^{2}	(1.22/1.73 kg./cm.^{2})			
(Wellworthy)	Cylinder Wall Pressure 20.8/29.4 lbs./in.^{2}	(1.46/2.07 kg./cm.^{2})			
	Diametrical Load 8.5/12.0 lbs.	(3.90/5.44 kg.)			
	Tangential Load 3.2/4.5 lbs.	(1.45/2.04 kg.)			
Ring Groove Width 4th ...	.1915	4.864			
	.1905	4.839			
Duaflex Ring Width 4th ...	.1915	4.864			Fitted Width. Ring expands and occupies full width of groove.
	.1905	4.839			
Ring Loading Data	Tangential Load 7.5/10.5 lbs.	(3.40/4.76 kg.)			
			.0051	.130	
			.0031	.079	

Component Details	Dimensions New Ins.	Dimensions New mm.	Clearances New Ins.	Clearances New mm.	Remarks
Scraper Ring Width	.1874	4.760			Alternative to Duaflex
	.1864	4.735			
			.0065	.165	
			.0035	.089	
Scraper Ring Width ...	.187	4.750			Alternative to Duaflex
	.185	4.699			
Ring Groove Width 5th ...	.1915	4.864			
	.1905	4.839			
Fitted Gaps—Rings					
1st			.009	.229	
			.017	.432	
2nd and 3rd			.009	.229	
			.014	.356	
Duaflex			.037	.940	
			.018	.457	
Scraper Ring			.015	.381	Alternative to Duaflex
			.010	.254	
Flywheel and Starter Ring Gear					
Spigot Dia. for Starter Ring ...	13.094	332.588			
	13.091	332.511			
			—.031	—.787	
			—.023	—.584	
Inside Dia. of Starter Ring ...	13.068	331.927			
	13.063	331.800			
Flywheel mounting face Dia.	4.0007	101.618			Run out of clutch contact face at outer diameter should not exceed .003" (.076 mm.)
	3.9998	101.595			
Spigot Dia. of Crankshaft ...	4.0002	101.605			
	3.9995	101.588			
Camshaft					
Bore in Cylinder Block for	2.0007	50.818			
Front Bearing	1.9998	50.795			Provision made for the vernier setting of the valve timing with camshaft chain wheel on centre.
			.0014	.036	
			.0000	.000	
Outside Dia. of Front Bearing	1.9998	50.795			
	1.9993	50.782			
Inside Dia. of Front Bearing	1.5635	39.713			
	1.5620	39.675			
			.0045	.114	
			.0025	.064	
Dia. of Front Camshaft Journal	1.5595	39.611			
	1.5590	39.599			
Length of Front Journal ...	1.3775	34.989			
	1.3750	34.925			
			.0075	.191	Camshaft End Float .004"-.008" (.1016-.2032 mm.)
			.0020	.051	
Length of Front Bearing ...	1.3730	34.874			
	1.3700	34.798			
Outside Dia. of Rear Shell	1.8170	46.152			
Bearings	1.8155	46.114			
			—.0025	—.064	
			—.0048	—.122	

Component Details	Dimensions New Ins.	Dimensions New mm.	Clearances New Ins.	Clearances New mm.	Remarks
Bore in Cylinder Block for Centre and Rear Shell Bearings	1.8122 1.8130	46.030 46.050	—.002 —.0043	—.051 —.109	
Outside Dia. of Centre Shell Bearing	1.8165 1.8150	46.140 46.101			
Inside Dia. on Centre and Rear Shell Bearings ...	1.6873 1.6855	42.857 42.812	.003 .001	.076 .025	
Dia. of Centre and Rear Journals	1.6845 1.6840	42.786 42.774			
Timing Chain					
Pitch of Timing Chain ...	.375" (9.525 mm.)				
No. of Pitches	62				
Type of Chain	Endless roller				
Water Pump					
Housing Bore for Bearing ...	1.5749 1.5744	40.003 39.990	+.0007 —.0004	+.018 —.010	
Bearing—Outside Dia. ...	1.5748 1.5742	40.000 39.987			
Outside Dia. of Spindle for Impellor	.6264 .6256	15.910 15.890	—.0034 —.0021	—.086 —.053	
Inside Dia. of Impellor ...	.6235 .6230	15.837 15.824			
Dia. of Impellor Shaft for Bearings	.6299 .6296	15.999 15.992	+.0007 —.0004	+.018 —.010	
I/D of Bearings	.6303 .6295	16.010 15.990			

Thermostat

Makers No. X 43570/21 (Fitted up to Engine No. SJ 51167 E)

Valve begins to open ...	154° to 163°F. (68°C. to 73°C.)
Valve fully open	185°F. (85°C.)
Valve lift	.312" (7.94 mm.)

Makers No. 85035/70 (Fitted from Engine No. SJ 51168 E and future)

Valve begins to open ...	154°F. to 163°F. (68°C. to 73°C.)
Valve fully open	185°F. (85°C.)
Valve lift	.312" (7 94 mm.)

Makers No. 1572221 (Alternative, fitted from Engine No. SJ 51168 E and future)

Valve begins to open ...	156°F. to 165°F. (69°C. to 74°C.)
Valve fully open	185°F. (85°C.)
Valve lift	.36/.41" (9.1/10.4 mm.)

Component Details	Dimensions New Ins.	Dimensions New mm.	Clearances New Ins.	Clearances New mm.	Remarks
Tappets					
Bore in Cylinder Block ...	.5630	14.300			
	.5623	14.282			
			.0012	.031	
			.0002	.005	
Tappet Stem Dia.	.5621	14.277			
	.5618	14.270			
Valves and Guides					
Inlet					
Outside Dia. of Inlet Valve Guide	.502	12.751			
	.501	12.725			
			.002	.051	
			.0002	.005	
Bore in Combustion Head ...	.5008	12.720			
	.5000	12.700			
Pressed in below top face of Combustion Head ...	.5000	12.700			
Inside Dia. of Inlet Valve Guide	.3130	7.950			
	.3120	7.925			
			.0023	.058	
			.0008	.020	
Dia. of Inlet Valve Stem ...	.3112	7.905			
	.3107	7.892			
Dia. of Inlet Valve Head ...	1.515	38.481			
	1.511	38.379			
Overall Length	4.352	110.541			
	4.342	110.287			
Valve lift	.349	8.865			
Exhaust					
Outside Dia. of Exhaust Valve Guide	.5333	13.546			
	.5323	13.520			
			.000	.000	
			—.002	—.051	
Bore in Combustion Head ...	.5323	13.520			
	.5313	13.495			
Pressed in below top face of Combustion Head ...	.32	8.128			
Inside Dia. of Exhaust Valve Guide	.3755	9.538			
	.3745	9.512			
			.0028	.071	
			.0013	.033	
Dia. of Exhaust Valve Stem ...	.3732	9.479			
	.3727	9.466			
Dia. of Exhaust Valve Head ...	1.220	30.988			
	1.216	30.886			
Overall Length	4.3565	110.655			
	4.3465	110.401			
Valve lift	.330	8.382			
Working Valve Tip Clearances (Cold)					
Inlet	.012	.305			Inlet valves fitted with loose caps
Exhaust	.008	.203			"Free" type exhaust valves

Component Details	Dimensions New Ins.	Dimensions New mm.	Clearances New Ins.	Clearances New mm.	Remarks
Valve seating angle on valve head 45°.					
Valve seat angle in new cylinder head 44½°, but serviced at 45°.					
Valve Springs:					
Free Length Inner	1.6	40.64			
Free Length Outer	1.7	43.18			
Fitted Length Inner	1.222	31.038			
Fitted Length Outer	1.316	33.426			
Rate ... Inner	56.8 lb. in. (65.44 kg. cm.)				
Rate ... Outer	106 lb. in. (122 kg. cm.)				
Hand of Helix Inner	Left				
Hand of Helix Outer	Right				
Valve Timing (Crankshaft Degrees):					
Exhaust opens	45½° before B.D.C.				With rocker clearances set at .015" (.381 mm.) Inlet (cold) and .015" (.381 mm.) Exhaust (cold).
Exhaust closes	10½° after T.D.C.				
Inlet opens	10½° before T.D.C.				
Inlet closes	37½° after B.D.C.				
Exhaust Valve Seat Insert					
Outside Dia. of Seat Insert ...	1.5035	38.189			
	1.5025	38.164			
			—.0045	—.114	
			—.0025	—.064	
Bore in Combustion Head ..	1.500	38.1			
	1.499	38.075			
Depth of Seat Insert ..	.250	6.350			
	.248	6.299			
			+.002	+.051	
			—.002	—.051	
Depth of recess in Combustion Head	.250	6.350			
	.248	6.299			
Inlet Valve Seat Insert (Available for Service purposes).					
Outside Dia. of Seat Insert ...	1.6835	42.761			
	1.6826	42.738			
			—.0026	—.066	* Bore out to this dimension, concentric with valve guide bore.
			—.0045	—.114	
Bore in Combustion Head ...	*1.680	42.672			
	*1.679	42.647			
Depth of Seat Insert ...	.250	6.350			
	.248	6.299			
			.041	1.041	
			.039	.991	
Depth of recess in Combustion Head	*.291	7.391			
	*.289	7.340			
Ricardo Pre-combustion Chamber					
Dia. of Flange	1.4085	35.776			
	1.4075	35.750			
			—.003	—.076	
			—.001	—.025	
Bore in Combustion Head ...	1.4065	35.725			
	1.4055	35.700			

Component Details	Dimensions New Ins.	mm.	Clearances New Ins.	mm.	Remarks
Depth of Bore in Combustion Head	.188 .182	4.775 4.623			
			+.002* —.006	+.051 —.152	*Due to chamfer on flange, hot plug will not stand proud of cylinder head face by more than .002".
Flange Depth	.188 .186	4.775 4.724			
Rocker Gear					
Bore in Rocker	.6805 .6793	17.285 17.254			
			+.0005 —.0007	+.013 —.018	
Outside Dia. of Rocker Bush	.6800	17.272			Press fit in housing
Inside Dia. of Rocker Bush when reamed in position ...	.6252 .6248	15.880 15.870			
			.0020 .0011	.051 .028	
Rocker Shaft Dia.	.6237 .6232	15.842 15.829			
Oil Pump	Approx. capacity at 50 lb. sq. in. (3.52 kg. sq. cm.) is 3.95 galls (16.94 litres) per min. at 2000 engine r.p.m. (Oil pump runs at engine speed).				
Oil Pressure	40 to 60 lbs. sq. in. (2.8 to 4.2 kg. sq. cm.).				
Outer rotor, Outside Dia. ...	1.5965 1.5975	40.551 40.577			
			.0075 .0055	.191 .140	
Bore in Pump Housing ...	1.604 1.603	40.742 40.716			
Major Dia. of Outer Rotor ...	1.417 1.412	35.992 35.865			Inner and outer rotors to be serviced as matched pairs.
Minor Dia. of Outer Rotor ...	.953 .954	24.206 24.232			
Major Dia. of Inner Rotor ...	1.172 1.171	29.769 29.743			
Minor Dia. of Inner Rotor ...	.731 .729	18.567 18.516			
Min. clearance on rotors ...			.004 .0005	.102 .0127	
					Measured when minor dia. of inner rotor and minor dia. of outer rotor are in line. Where clearance exceeds .010" (.254 mm.) new parts should be fitted.
Depth of Bore in Pump Body	.841 .840	21.361 21.336			
Depth of Bore in Front Bearing Housing	.157 .156	3.988 3.962			
Thickness of Joint Washer ...	.006	.152			

Component Details	Dimensions New Ins.	mm.	Clearances New Ins.	mm.	Remarks
Total depth including one Joint Washer	1.004 1.002	25.502 25.451			
			.0035 .001	.089* .025	*End clearance allowing for .002". (.051 mm.) compression of gasket A combined worn clearance of .005" (.127 mm.) indicates need of facing bearing housing recess.
Rotor Depth—Inner and Outer	.999 .998	25.375 25.349			
Outside Dia. of Oil Pump Bushes	.625	15.875			
			+.0005 —.0002	+.0127 —.0051	
Bore for Bushes	.6255 .6248	15.888 15.870			
Inside Dia. of Bush	.4995 .4990	12.687 12.674			
			.0015 .0005	.038 .013	End float of pump drive shaft must not exceed .010" (.254 mm.)
Dia. of Oil Pump Drive Shaft	.4985 .4980	12.661 12.649			
Injection Pump Drive					
Bore of Idler Gear	.7502 .7498	19.055 19.045			
			.0022 .0008	.056 .020	
	.749 .748	19.025 18.999			
Inside Dia. of Idler Gear Bush	.5005 .4995	12.713 12.687			
			.0017 .0002	.043 .005	
Dia. of Idler Gear Spindle ...	.4993 .4988	12.682 12.669			
Width of Idler Gear Bush ...	.756 .754	19.202 19.151			
			.007 .003	.178 .076	Idler gear backlash: 004" to .006" (.1016 mm. to .1524 mm.)
Width of Idler Gear Hub ...	.751 .749	19.075 19.025			
Inside Dia. of Bush	1.0005 .9998	25.412 25.395			
			.0025 .0008	.064 .020	
Driving Gear Spigot Dia. ...	.999 .998	25.375 25.349			
Outside Dia. of Bush for Driving Gear	1.2513 1.2509	31.783 31.772			
			—.0015 —.0004	—.038 —.010	
Housing Bore	1.2505 1.2498	31.763 31.745			
Rear Oil Seal					
Rear Cover	5.126 5.124	130.200 130.150			
			—.009 —.003	—.229 —.076	

Component Details	Dimensions New Ins.	Dimensions New mm.	Clearances New Ins.	Clearances New mm.	Remarks
Oil Seal	5.133 5.129	130.378 130.277			
Oil Seal Inside Dia.	4.000	101.6			
			—.0002 +.0005	—.005 +.013	
Crankshaft	4.0002 3.9995	101.605 101.587			
Crankshaft Pulley					
Inside Dia. of Pulley Hub ...	1.1255 1.1248	28.588 28.570			
Dia. of Front End of Crank-shaft	1.1248 1.1243	28.570 28.557			
Outside Dia. of Pulley ...	5.75	146.05			

Injectors

Early engines—without heat shields. Up to Engine No. SJ 86045E.

Nozzle Holders ... ... CAV type BKB 40S 697

Nozzles ... ... CAV type BDN 12SP 6169.
Working pressure 130 ats.
Initial Setting (new injectors) 135 ats.

Engines fitted with heat shields. Engine No. SJ 86046E to SJ 125724E.

Nozzle Holders ... ... CAV type BKB 40S 697K

Nozzles ... ... CAV type BDN 12SP 6169 A or BDN 12SP 6262.
Working pressure 130 ats.
Initial Setting (new injectors) 135 ats.

Engine No. SJ 125725E and subsequent.

Nozzle Holders ... ... CAV type BKB 40S 697K

Nozzles ... ... CAV type BDN 12SP 6290.
Working pressure 130 ats.
Initial Setting (new injectors) 135 ats.

Pintaux Nozzles ... ... Pintle Angle 12° Seat Angle 60° Orifice Sizes: Main .0846/.0728"
Auxiliary 0.2 mm. ±.015 mm.

Injection Pump ... ... D.P.A. 3240011, D.P.A. 3240012, D.P.A. 3240013, D.P.A. 3240015, Injection timing 19° before T.D.C.

D.P.A. 3242643 (fitted with light load advance), D.P.A. 3242645 (fitted with light load advance). Injection timing 13° before T.D.C.

Timing hole in flywheel and cylinder block when aligned with $\frac{1}{4}$" dia. tommy bar locates engine at 16° before T.D.C

Governor ... ... Variable speed mechanical type, integral with injection pump.

Fuel Lift Pump ... ... A.C. type Y.D., driven off eccentric at rear of camshaft
Delivery Pressure: 4-7 lbs./sq. in. (.28-.49 kg. sq. cm.).

Cold Starting Equipment ... C.A.V. Thermostart, fitted to inlet manifold; or Ki-gass equipment.

Air Cleaner ... ... A.C. Oil Bath Type.

Starter Motor ... ... M 45 G. with self-indexing plate clutch drive.
Out of mesh clearance between starter pinion and flywheel gear ring. $\frac{1}{8}$" $\pm\frac{3}{32}$" (3.17 $\pm$2.38 mm.).
No. of Teeth in flywheel gear ring and starter pinion 113 and 11 respectively.

Component Details	Dimensions New Ins. mm.	Clearances New Ins. mm.	Remarks
Batteries	2 off, 6 volt. connected in series MHF 115E, MHF.P 115E, MHF.PZ 115E Amp. hour capacity: at 10 hour rate—38 amp. hour. at 20 hour rate—43 amp. hour.		
Dynamo	C39P2. Type: 2 Pole, 2 Brush, Shunt wound, compensated voltage control. Runs at 1.72 x engine speed.		

3-A-152 DIESEL ENGINE

No. of Cylinders	3.
Bore	3.6″ (91.44 mm.)
Stroke	5″ (127 mm.)
Cubic Capacity	152.7 cu. ins. (2,502 c.c.)
Compression Ratio	17.4 : 1.
Firing Order	1, 2, 3.
Brake H.P. (Bare Engine) ...	37. *
Belt H.P.	
Equivalent Crankshaft Torque ...	

*Subject to official confirmation

TIGHTENING TORQUES

Cylinder Head Nuts	55 - 60 lbs. ft. (7.60 - 8.29 Kg. m.)
Connecting Rod Nuts	70 - 80 lbs. ft. (9.68 -11.06 Kg. m.)
Main Bearing Setscrews	110 -120 lbs. ft. (15.21 -16.59 Kg. m.)
Flywheel Setscrews	75 lbs. ft. (10.37 Kg. m.)
Balance Weight Setscrews ...	50 - 55 lbs. ft. (6.91 - 7.60 Kg. m.)
Nozzle Cap Nuts	50 lbs. ft. (6.91 Kg. m.)

DIMENSIONS AND TOLERANCES

Component Details	Dimensions New		Clearances New		Remarks
	Ins.	mm.	Ins.	mm.	
Main Bearings					
Housing Bores	2.9165 2.9175	74.079 74.104			
Main Bearing Bore ... ... (Ref. only)	2.75126 2.75276	69.8819 69.920			
Crankshaft Clearance ...			.00226 .00426	.05730 .11810	Measured assembled.
Crankshaft					
Main Journal Dia.	2.7490 2.7485	69.824 69.811			
Crankshaft Endfloat					
Rear Main Width	1.87725 1.87425	47.682 47.6059			
Crank Endfloat			.002 .011	.0508 .279	

Component Details	Dimensions New Ins.	Dimensions New mm.	Clearances New Ins.	Clearances New mm.	Remarks
Thrust Washer Thickness ...	.123	3.124			
(Top and Bottom) ...	.125	3.175			
Thrust Washer Dia. ...	3.552	90.220			
(Top and Bottom) ...	3.562	90.475			
			.002	.0508	
			—.020	—.508	
Cylinder Block Recess for	3.572	90.729			
Thrust Washer	3.564	90.526			
Dowel—Main Bearing Cap	.750	19.050			
Diameter	.751	19.075			
			—.0015	—.038	
			+.00075	+.019	
Cylinder Block Bore for	.75075	19.069			
Dowel	.7495	19.037			
Big End					
Crankpin Diameter	2.249	57.125			
	2.2485	57.112			
			.00325	.0825	
			.00175	.0444	
Bearing Bore	2.25175	57.1944			
	2.25075	57.1690			
Conn. Rod Bore	2.3955	60.846			
	2.3950	60.833			
Conn. Rod Big End Width ...	1.5525	39.434			
	1.5502	39.375			
Big End Endfloat			.0095	.2413	
			.0148	.3759	
Crankpin Width	1.565	39.751			
	1.562	39.674			
Small End					
Small End Bore	1.37475	34.918			
	1.37620	34.955			
			—.00525	—.1333	
			—.0023	—.0584	
Small End Bush	1.3785	35.014			
(External Dia.)	1.3800	35.052			
Small End Bush	1.2505	31.763			
(Internal Dia.)	1.2515	31.788			
			.0005	.0127	
			.00175	.0444	
Gudgeon Pin Dia.	1.250	31.75			
	1.24975	31.743			
			—.0005	—.0127	
			—.00025	—.0063	
Gudgeon Pin Holes in Piston	1.250	31.75			
	1.2495	31.737			

Component Details	Dimensions New Ins.	Dimensions New mm.	Clearances New Ins.	Clearances New mm.	Remarks
Rod Alignment between Big and Small-end bores with small-end bush fitted.	At 5" Centres (127 mm.)		±.005" (.127 mm.)		Measured on each side of axis of rod on test mandrel.
Cylinder Block and Liners					
Cylinder Block Bore ...	3.6875 3.6885	93.662 93.687			
			+.001 —.001	+.0254 —.0254	
Liner	3.6885 3.6875	93.687 93.662			
Top Flange of Liner ... ... (Thickness)	.045 .040	1.143 1.016			
			.001 .009	.0254 .2286	Below block top face.
Recess for Top Flange of Liner	.046 .049	1.1684 1.2446			
Liner—Top Dia. (Flange) ...	3.810 3.805	96.774 96.647			
			.005 .015	.127 .381	
Cylinder Block—Top Bore for Liner	3.815 3.820	96.901 97.028			
Total Height of Cyl. Block ...	13.7445 13.7395	349.110 348.983			
Pistons and Sleeves					
Liner Bore	3.6015 3.6025	91.478 91.503			
Ring Groove Width ... (Top, 2nd and 3rd)	.0957 .0967	2.4307 2.4561			Three compression and one scraper fitted above the gudgeon pin and one scraper fitted below.
			.0019 .0039	.0482 .099	
Compression Ring Width ... (Top, 2nd and 3rd) ...	.0938 .0928	2.382 2.357			
Scraper Ring Groove Width	.252 .253	6.400 6.426			
			.002 .004	.0508 .1016	
Scraper Ring Width ...	.250 .249	6.35 6.324			
Fitted Gaps—Rings, Compression and Scraper ...	.009 .013	.2286 .3302			
Camshaft					
Journal Dia. (No. 1) Front ...	1.870 1.869	47.498 47.472			
			.004 .008	.1016 .2032	
Housing Bore (No. 1) Front	1.877 1.874	47.675 47.599			

Component Details	Dimensions New Ins.	Dimensions New mm.	Clearances New Ins.	Clearances New mm.	Remarks
Journal Dia. (No. 2) Centre	1.860 1.859	47.244 47.218			
			.004 .008	.1016 .2032	
Housing Bore (No. 2) Centre	1.867 1.864	47.421 47.345			
Journal Dia. (No. 3) Rear ...	1.840 1.839	46.736 46.710			
			.004 .008	.1016 .2032	
Housing Bore (No. 3) Rear ...	1.847 1.844	46.913 46.837			
Camshaft Spigot Dia. ...	1.9995 1.9985	50.787 50.761			
			.0000 .0025	.0000 .0635	
Camshaft Gear Bore... ...	2.001 1.9995	50.825 50.787			
Camshaft Endfloat					Controlled by leaf spring affixed at rear of timing case front cover.
Cam Lift	.3085 .3165	7.836 8.039			
Tappets and Valves					
Bore in Head	.62575 .6245	15.894 15.862			
			.00075 .0035	.019 .088	
Tappet Stem Dia.	.62375 .62225	15.843 15.805			
Valve Tip Clearance					
Inlet (Cold)			.012	.3048	
Exhaust (Cold)			.012	.3048	
Valve Stem Dia. ... ... (Inlet and Exhaust) ...	.311 .312	7.899 7.924			
			.002 .0045	.0508 .1143	
Valve Guide Bore ... ... (Inlet and Exhaust) ...	.3155 .3140	8.013 7.975			
Valve Guide—Outside Dia....	.501 .5005	12.725 12.712			
			.0000 .0015	.0000 .0381	
Cylinder Head Hole for Guide	.5005 .4995	12.712 12.688			
Valve Head (Inlet and Exhaust) Clearance below Cylinder Head Face (New)	.070	1.778			Not to exceed .140" (3.556 mm.) after regrinding.

Component Details	Dimensions New Ins.	Dimensions New mm.	Clearances New Ins.	Clearances New mm.	Remarks
Valve Head Dia.					
Inlet	1.536	39.014			
	1.532	38.913			
Exhaust	1.317	33.452			
	1.313	33.350			
Guide Projection above Spring Seat—					
Inlet	.59375	15.081			
Exhaust	.59275	15.056			
Valve Seating Angle on Valve Head	90° inclusive				
Valve Seat Angle on New Cylinder Head	88° inclusive				
Valve Springs					
Fitted Length: Inner ...	1.1875	30.162			Free Length: Inner 1.365" (34.671 mm.) 1.405" (35.687 mm.)
Outer ...	1.5	38.100			Outer 1.803" (45.796 mm.) 1.783" (45.289 mm.)
Fitted Load: Inner ...	8 lb. ± 1 lb.	3.629 ± .454 kg.			
Outer ...	22.75 ± 2 lb.	10.319 ± .907 kg.			
Full Lift Load:	Inlet				Outlet
Inner ...	23 ± 2 lb.	10.433 ± .907 kg.			23 ± 2 lb. 10.433 ± .907 kg.
Outer ...	50 ± 2 lb.	22.68 ± .907 kg.			50 ± 2 lb. 22.68 ± .907 kg.
Rocker Shaft Dia.	.62375	15.843			
	.62225	15.805			
			.00075	.019	
			.0035	.088	
Bush Rocker Lever Bore ...	.6245	15.862			
	.62575	15.894			
Timing Gear					
Crankshaft Dia. for Gear ...	1.5005	38.1127			
	1.500	38.100			
			—.001	—.0254	
			+.001	+.0254	
Crankshaft Gear Bore ...	1.501	38.1254			
	1.4995	38.087			
Crankshaft Dia. for Crank Pulley	1.5005	38.1127			
	1.500	38.100			
			.00025	.00635	
			.00175	.04445	
Crankshaft Pulley	1.50175	38.1444			
	1.50075	38.119			
Pulley—Crankshaft Seal Dia.	2.255	57.277			
	2.250	57.15			

Component Details	Dimensions New Ins.	mm.	Clearances New Ins.	mm.	Remarks
Crankshaft—Rear Seal Dia....	2.800 2.799	71.12 71.0946			
Idler Gear Hub Dia. ...	2.1238 2.123	53.944 53.924			
			.0012 .0036	.0304 .0913	
Idler Gear Bore	2.125 2.1266	53.975 54.016			
Idler Gear Hub Width ...	1.3275 1.3325	33.718 33.845			
Idler Gear Endfloat			.005 .015	.127 .381	
Idler Gear Width	1.3225 1.3175	33.591 33.464			
Idler Gear Hub Dia. ...	.8745 .8737	22.212 22.191			
			.000 .002	.000 .508	
Cylinder Block Bore ...	.87575 .8745	22.244 22.212			
Idler Retaining Plate Thickness	.140 .110	3.556 2.794			
Water Pump					
Shaft Diameter	.6267 .6262	15.918 15.905			
			—.0028 —.0015	—.0711 —.0381	
Pulley Bore	.6239 .6247	15.847 15.867			
Shaft Diameter	.6267 .6262	15.918 15.905			
			—.0017 —.00045	—.0431 —.0114	
Impeller	.62575 .6250	15.894 15.875			
Shaft Bearing Dia.	1.1811 1.1806	29.999 29.987			
			—.0011 —.0001	—.02794 —.00254	
Body-Bore for Bearing ...	1.1800 1.1805	29.972 29.984			
Fuel Pump Drive					
Gear Bore	1.750 1.751	44.45 44.475			
			.003 .0012	.0762 .0304	
Hub Gear Dia.	1.7488 1.7480	44.419 44.399			

Component Details	Dimensions New Ins.	Dimensions New mm.	Clearances New Ins.	Clearances New mm.	Remarks
Lubricating Oil Pump					
Idler Gear Bore	.750 .751	19.050 19.075			
			—.0032 —.0012	—.0762 —.0304	
Idler Gear Bush—Outside Dia.	.7532 .7522	19.131 19.105			
Idler Gear Bush—Inside Dia.	.6572 .6562	16.692 16.667			
			.00085 .00245	.0215 .0622	
Shaft—Idler	.65535 .65475	16.645 16.630			
			—.00185 —.00025	—.064 —.00635	
Pump Body Bore	.6545 .6535	16.624 16.598			
Endfloat of Idler on Hub ...			.013 .004	.330 .1016	
Oil Pump Driver Gear Bore	.4964 .4972	12.608 12.628			
			—.0021 —.0008	—.0533 —.0203	
Oil Pump Drive Shaft ...	.4985 .4980	12.661 12.649			
			.003 .0015	.0762 .0381	
Housing Bore—Oil Pump ...	.501 .500	12.725 12.700			
Housing—Rotor Pocket Depth	.751 .750	19.075 19.050			
Housing—Rotor Pocket Dia.	1.603 1.604	40.716 40.741			
Driver Gear Boss Thickness	.515 .485	13.081 12.319			

MASSEY-FERGUSON

35 TRACTOR

WORKSHOP SERVICE MANUAL

SECTION C

ENGINE

ENGINE

Section C

CONTENTS

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CONTENTS—*continued*

CONTENTS—*continued*

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LIST OF ILLUSTRATIONS

3A-152 DIESEL ENGINE

Note.—Figures 38 to 99 held in reserve.

23C DIESEL ENGINE

LIST OF ILLUSTRATIONS—*continued*

3A-152 DIESEL ENGINE

THE 3A-152 ENGINE (Refer Figure 1)

The 3A-152 diesel engine is, as its numerical identification suggests, a 3-cylinder unit with a capacity of 152 cub. ins. (2·5 litres). This engine, by virtue of its combustion chamber design and nozzle location, combines the advantages of direct and indirect injection types.

This section is concerned with engine removal, overhaul and re-installation and, where applicable, includes reference to special toolage recommendations. Note that reference is made exclusively to the basic engine only, as the various components of the cooling, electrical and fuel systems are dealt with elsewhere in this Manual.

An important and often neglected aspect of engine reclamation work is the necessity for absolute cleanliness. Many cases of unsatisfactory performance and short engine life, following reconditioning, can be directly attributed to inadequate attention to cleanliness.

It is considered prudent to mention that the continued use of an engine due for overhaul can be neither satisfactory nor economic, and cannot justify the increasing risk of total failure and additional repair charges.

The repair instructions covered within this section assume that the engine has been removed from the tractor.

Reference to left and right hand should be interpreted as seen from the driving seat.

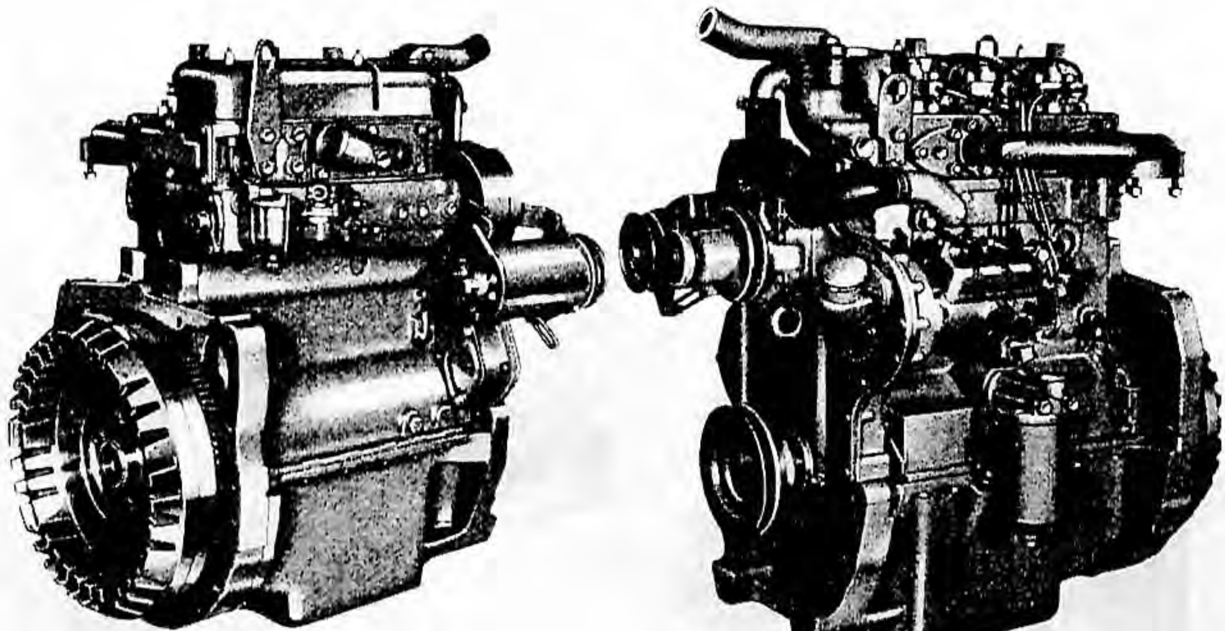


FIGURE 1
GENERAL VIEWS OF 3A-152 ENGINE

FIRST ISSUE

REMOVING THE ENGINE

Drain off water from radiator and cylinder block.

Remove hood and cowl assembly.

Disconnect and remove batteries.

Remove fuel tank.

Remove radiator.

Disconnect fuel supply lines to engine.

Disconnect throttle and stop control links.

Disconnect starter motor and generator connections.

Remove starter motor.

Disconnect steering drag links to left and right hand track arms.

Apply parking brake and chock rear wheels.

Support engine and gearbox.

Remove front axle assembly.

Remove nuts and bolts securing engine to transmission housing.

Using special engine removal rig or, alternatively, a block and tackle, separate engine from transmission housing.

Assemble in reverse order.

When offering up engine clutch centre plate to the gearbox primary shaft it may be found advantageous to turn the crankshaft to permit the primary shaft and centre plate splines to line up.

Note.—It will be necessary to bleed the fuel system before attempting to start the engine.

THE CYLINDER HEAD

REMOVING THE CYLINDER HEAD

(Refer Figures 1 and 2)

Release hose clip securing breather pipe to rocker cover, and slide connecting hose clear of rocker cover.

Release the two clips which attach breather pipe to engine, and remove breather pipe.

Slacken off hose clips connecting thermostat housing to water pump, and remove rubber hose.

Remove oil feed pipe connecting cylinder head to camshaft chamber.

Remove injector pipe clip.

Remove injector pipes and leak-off pipes, and seal off all fuel unions.

Remove the injectors.

Remove the rocker cover.

Remove the rocker shaft, ensuring that the middle two nuts are released first.

Slacken off and remove the cylinder head nuts in reverse sequence to that shown in Figure 2. Note that a plain washer is fitted to the waisted stud (No. 15).

Lift off the cylinder head and cylinder head gasket.

Remove the thermostat from the water outlet body.

Remove the inlet and exhaust manifolds. The cylinder head may be skimmed if required providing its thickness is not reduced below 2·98".

DISMANTLING THE ROCKER SHAFT ASSEMBLY (Refer Figure 3)

The removal of the retaining circlips at either end of the rocker shaft will enable the rockers, springs and pedestal brackets to be withdrawn.

Examine all components and renew as necessary.

If rocker tips are worn it is advisable to fit new rockers.

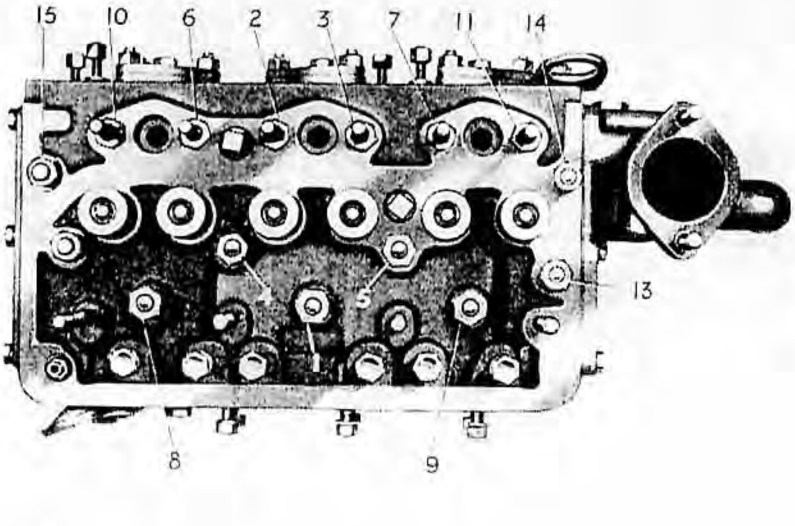


FIGURE 2
SEQUENCE OF TIGHTENING CYLINDER HEAD NUTS

FIRST ISSUE

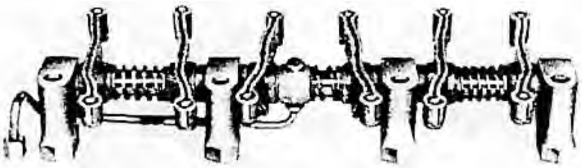


FIGURE 3
THE ROCKER SHAFT ASSEMBLY

REMOVING THE VALVES (Refer Figure 4)

Using a suitable Service Fixture or, alternatively, a valve spring compressor, remove valve cotters, valve caps, springs and valves.

Place valves and springs in a special stand or arrange them on the bench in the order in which they were dismantled. If the valves, after re-facing, are considered fit for further service, they must be returned to their original locations.

VALVE SPRINGS (Refer Figure 4)

Two coil springs are fitted to each valve. Inlet and exhaust springs are identical, and as no damper coils are incorporated they may be fitted either way up. Before re-use, however, all valve springs should be carefully examined, with particular regard to squareness of ends. The fitted length of the inner spring is 1·1875" (30·16 mm.) developing a load of 8 lbs. (3·62 kgs.). The fitted length of the outer spring is 1·5" (38·1 mm.) developing a load of 22·75 lbs. (10·31 kgs.).

The valve and spring assembly is illustrated in Figure 4.

VALVE GUIDES (Refer Figure 5)

The valve guides are a press fit in the cylinder head. Their location being determined by a machined step in their outer diameter.

REMOVING VALVE GUIDES (Refer Figure 5)

Valve guides can be removed and replaced using Service Tool P.D. 1A as illustrated in Figure 5.

When new valve guides are fitted the seats must be re-cut to ensure concentricity of the seat to the valve.

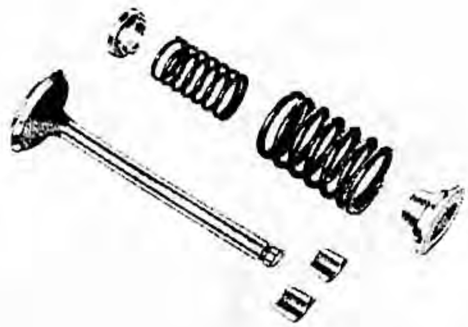
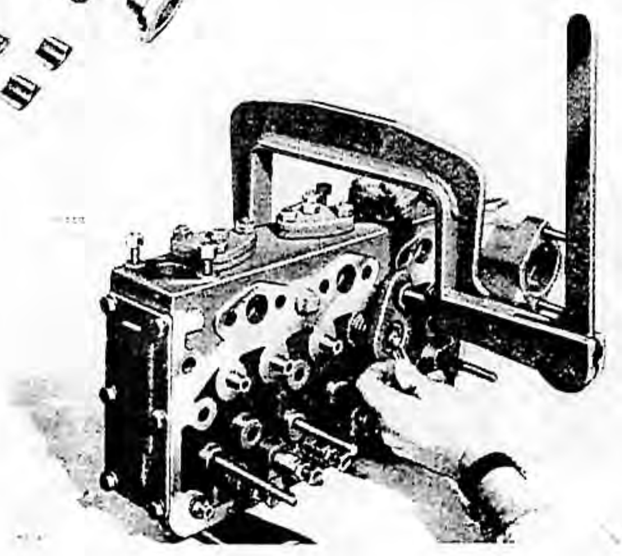


FIGURE 4
REMOVING THE VALVES



FIRST ISSUE

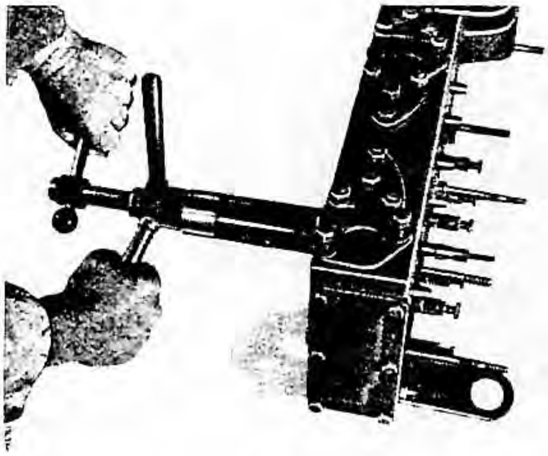


FIGURE 5
FITTING VALVE GUIDES

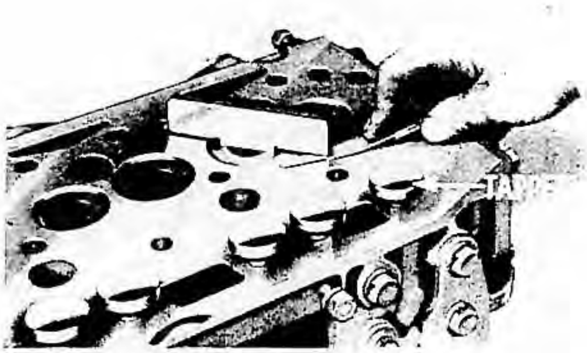


FIGURE 7
CHECKING VALVE HEAD DEPTH

VALVE SEATS (Refer Figures 6 and 7)

If the valve seats in the cylinder head show signs of pitting, burning or other evidence of leakage, they must be re-faced or re-ground according to their condition. Hand grinding is a finishing process and excessive grinding must be avoided, otherwise the seat angle may be altered and the seat width increased. Excessive grinding will result in "grooving" of the valve face.

FIGURE 6
RE-CUTTING VALVE SEATS

Valve seat reconditioning may be carried out using a proprietary seat grinding machine with a 44° stoned face. Figure 6 shows a valve seat being re-faced by means of a hand cutter.

When stoning or re-cutting valve seats, the minimum of metal should be removed to ensure that the seating face width is maintained as near as possible to original design and not necessarily increased.

Note that the maximum clearance between the cylinder head face and the valve head must not exceed 0·140" (3·556 mm.). This dimension can be checked using Service Tool P.D.17A as shown in Figure 7.

Valve seat inserts are not fitted to production engines. It is possible in most cases, however, to fit inserts to service engines where necessary, i.e., where the existing valve seat is worn or damaged to the point where re-cutting would place the relationship of the valve head to the cylinder head face beyond the service limits of ·066"-·140" (1·676-3·556 mm.). This dimension applies equally to inlet and exhaust valves.

FIRST ISSUE

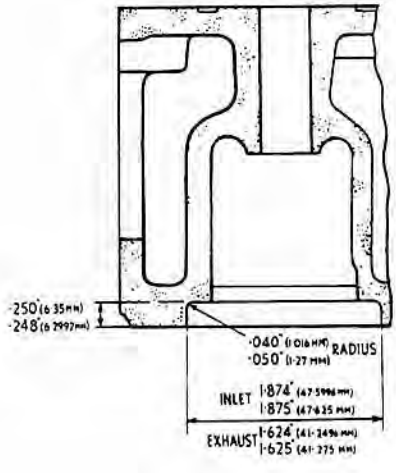


FIGURE 7A
MACHINING DIMENSIONS FOR VALVE SEAT INSERTS

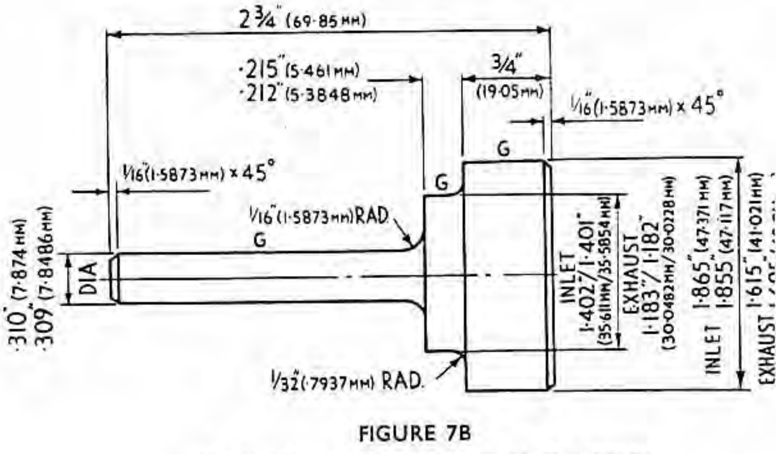


FIGURE 7B
TOOL FOR FITTING VALVE SEAT INSERTS

To fit valve seat inserts proceed as follows :—

(1) Withdraw valve guide and thoroughly clean valve guide bore in cylinder head.

(2) Press new valve guide into position.

(3) Using the new valve guide as a pilot, machine the recess in the cylinder head face to the dimensions given in Figure 7A.

(4) Remove all swarf and thoroughly clean the insert recess, taking care to ensure that all burrs are removed.

(5) With the insert and fitting tool assembled as shown in Figure 7C, press insert into position. Note that the insert must be pressed, and not hammered into place. Lubricant should not be employed.

(6) Visually inspect to ensure that the insert has been pressed in squarely and that it is in hard contact with the bottom of the recess.

(7) Cut or grind valve seat face on insert as normal procedure.

Note.—A valve head depth of ·140" (3·556 mm.) is outside the engine production limits, but it represents the maximum permitted depth on service engines. When cutting insert face, it is therefore policy to work as closely as possible to the minimum figure of ·066" (1·676 mm.) in order to permit further re-cutting during subsequent overhauls.

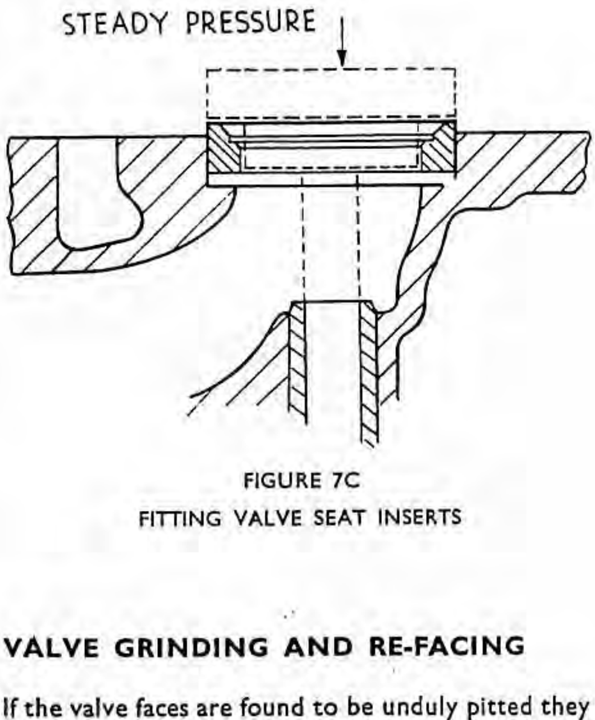


FIGURE 7C
FITTING VALVE SEAT INSERTS

VALVE GRINDING AND RE-FACING

If the valve faces are found to be unduly pitted they should be re-faced on a suitable valve re-facing machine set to 45°.

The re-facing should continue until the face is true, and free from pitting. Excessive grinding will thin the edge of the valve head and render the valve unfit for service, or will unduly lower the valve in its seating, and pocketing will result. If a valve tends towards thinness at the edges, it must be discarded. Valves which are badly burred, burnt, distorted or which have previously been ground to their limits must never be reclaimed.
Always hand grind valves before assembly.

HAND GRINDING

With the valves removed apply a small quantity of medium or fine grinding paste (depending on condition of valve and seat faces) to the valve face and insert valve into guide.

Using a suitable suction tool, rotate valve alternately in clockwise and anti-clockwise directions, occasionally raising the valve off its seat and revolving it a quarter turn before lowering it again. A light spring of suitable length, inserted between the valve head and guide will facilitate this operation.

Add more grinding paste as necessary, and continue as described above until an even, clean, matt-grey finish is obtained on a seating between $\frac{1}{16}''$-$\frac{3}{32}''$ (1·58-2·38 mm.) in width. If such a condition cannot be obtained, it will be necessary to re-face or re-cut the valve and/or seat.

After grinding in the valves carefully, remove all traces of grinding paste.

TAPPETS (Refer Figure 7)

The tappets are of the mushroom foot type and operate directly in the cylinder head. With the cylinder head removed, it is necessary to remove the tappet adjusting screw and locknut before the tappets can be withdrawn. Note that the tappets must be free to rotate and capable of sliding in the cylinder head under their own weight. Tappet faces must not be re-ground. Damaged faces will necessitate the fitting of new tappets.

COMBUSTION CHAMBER CAPS
(Refer Figure 1)

The removal of the combustion chamber caps and the cleaning of the throat passages should be undertaken as a matter of course when cylinder head overhaul is carried out.

Care must be taken on replacing these caps to ensure that they are tightened up evenly. Where possible, new gaskets should be employed. The old gaskets, however, may be used, providing they are first annealed.

DECARBONISING

It is difficult to state a specific period at which decarbonising would be desirable. Provided the fuel system and injection equipment are properly maintained and a reputable grade of fuel is used, it is difficult to imagine the cylinder head being lifted purely for this purpose. Generally the need for decarbonising will not arise before the valves require attention.

To decarbonise the engine, proceed as follows :—

Remove cylinder head as previously described.

The valves, guides, rockers, etc., must be cleaned, examined and serviced as required.

Absolute cleanliness must be observed if particles of carbon, etc., are to be prevented from scoring cylinder walls, pistons, bearings, etc.

Carefully clean all carbon from the cylinder head and cylinder block faces and all cylinder head valve parts, ensuring that no burrs exist or are made on the machined faces.

With No. 1 piston midway down its bore, apply a smear of grease inside the top of No. 1 cylinder, and rotate crankshaft until No. 1 piston is at T.D.C. The grease serves as a seal between the piston crown and cylinder walls and prevents carbon becoming trapped between the piston and cylinder.

Cover No. 2 and 3 bores, and all water and oilways.

Using a suitable scraper, remove carbon from No. 1 piston crown, taking care not to scratch the piston and ensuring that a ring of carbon is left round the periphery of the piston crown.

Repeat the above operation for the remaining two pistons.

Clean all piston crowns and cylinder bores with a non-fluffy rag moistened in kerosene.

Lubricate piston crowns and bores and assemble cylinder head.

ASSEMBLING THE CYLINDER HEAD
(Refer Figures 2 and 8)

Thoroughly clean cylinder head and all components.

Lubricate valves, guides and tappets and assemble in head.

Refit induction and exhaust manifolds using new gaskets.

Lightly smear both faces of new cylinder head gasket with a suitable jointing compound.

Place gasket over cylinder head studs, noting that it is marked "Top front".

Fit and tighten cylinder head nuts in recommended sequence (Figure 2), ensuring that a plain washer is fitted to waisted stud No. 15.

Cylinder head nuts should be tightened to a torque of 55/60 lbs./ft. and rechecked after the engine has been run.

Replace the rocker assembly, ensuring that the slot at the rear end of the rocker shaft is in line with the punch mark on the rear pedestal bracket (Figure 8). The relationship of this slot to the

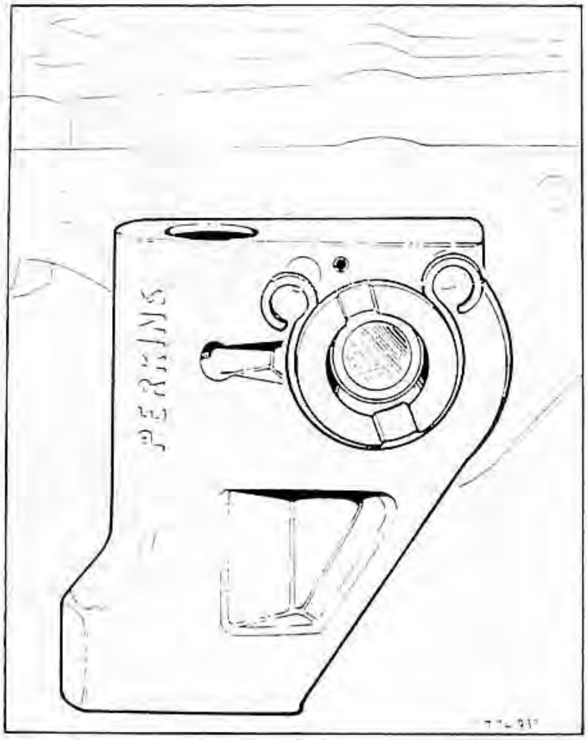


FIGURE 8
ROCKER SHAFT LOCATION MARK

punch mark determines the quantity of oil delivered to the rockers and bearings. Oil flow may be increased or decreased by rotating the shaft in a clockwise or anti-clockwise direction as required. It will generally be found that with the shaft slot and punch mark aligned the oil supply is most satisfactory.

Adjust valve clearances to 0·012" (0·305 mm.) inlet and exhaust.

Refit oil feed pipe between cylinder head and camshaft housing.

Replace injectors, using new washers, and connect up injector pipes and leak-off pipes.

Tighten injectors evenly.

Fit rocker cover and joint.

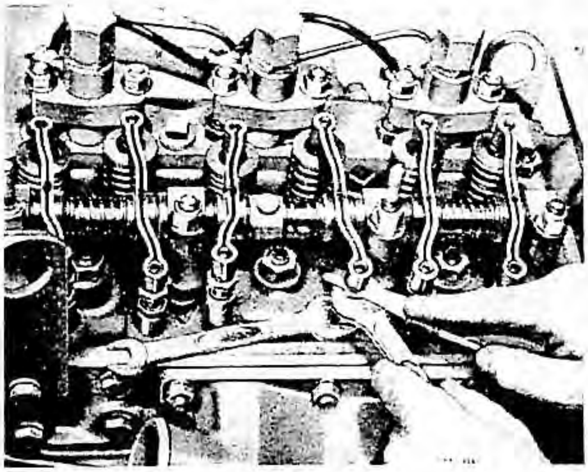


FIGURE 9
ADJUSTING TAPPETS

ADJUSTING VALVE CLEARANCE
(Refer Figure 9)

The three throw 120° crankshaft makes it necessary to adopt a slightly different sequence for tappet adjustment to the normal accepted procedure for four and six cylinder engines.

To adjust tappets proceed as follows :—

Remove the rubber plug in the inspection hole in the left front side of the transmission housing adaptor plate.

Rotate crankshaft until the T.D.C. line on the flywheel is in the centre of the inspection hole and No. 1 piston is on compression stroke (both valves fully closed).

Check and adjust clearances as necessary on Nos. 1, 2, 3 and 5 valves (Figure 9).

Turn crankshaft one revolution (360°) and repeat for Nos. 4 and 6 valves. (T.D.C. mark visible through inspection hole).

Replace rubber plug in adaptor plate.

Valve clearances for both inlet and exhaust should be set to 0·010" (0·254 mm.) hot, and 0·012" (0·305 mm.) cold.

THE LUBRICATING SYSTEM

The lubricating system is of the force feed type, the oil being circulated under pressure by a rotor type pump bolted to the front main bearing cap and driven via an idler gear by the crankshaft gear. Oil is drawn through a sump filter screen and a suction pipe before entering the oil pump, from whence it is pumped through a delivery pipe to a drilling in the cylinder block and to a full flow filter in the left hand side of the engine.

A plunger type relief valve is incorporated in the oil pump body. This relief valve is set to 50-65 p.s.i.

From the full flow filter the oil passes into the main oil gallery in the cylinder block. Passages in the main bearing webs of the crankcase carry the oil from the oil gallery to the main bearings.

The cylinder bores and gudgeon pins are splash lubricated. A transverse drilling at the front of the cylinder block feeds oil from the main oil gallery to an external pipe on the right hand side of the engine. This pipe feeds the centre camshaft bearing. Another external feed pipe connects the camshaft to the rocker assembly.

The camshaft is lubricated by oil draining from the rocker assembly through two oil-ways situated on either side of the centre camshaft bearing. A drilling connects the two chambers. The oil level is controlled by a weir in the front chamber.

Above No. 1 camshaft bearing there is a drilling which serves as a breather to the camshaft chamber and permits a free flow of oil passing over the weir. A drilling under the rear bearing of the camshaft prevents pressure build up between the rear camshaft journal and the tachometer housing seal.

The overflow from the camshaft weir is directed to lubricate the timing gears.

The flow of oil to the rocker assembly can be regulated by rotating the rocker shaft to align or restrict the oil feed passages.

LUBRICATING OIL FILTERS

The oil filters consist of : oil filler strainer, oil sump strainer, and main full flow oil filter.

THE OIL FILLER STRAINER (Refer Figure 10)

This is a coarse wide mesh strainer situated at the base of the oil filler tube.

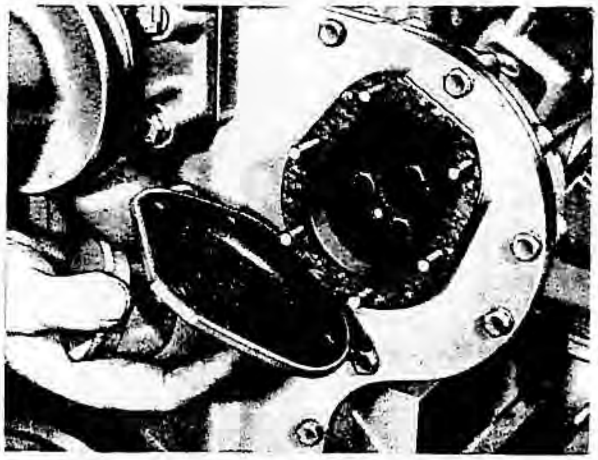


FIGURE 10
THE OIL FILLER STRAINER

THE SUMP STRAINER (Refer Figure 11)

The sump strainer consists of a perforated gauze wire strainer welded to the pressed steel cover at the bottom of the sump.

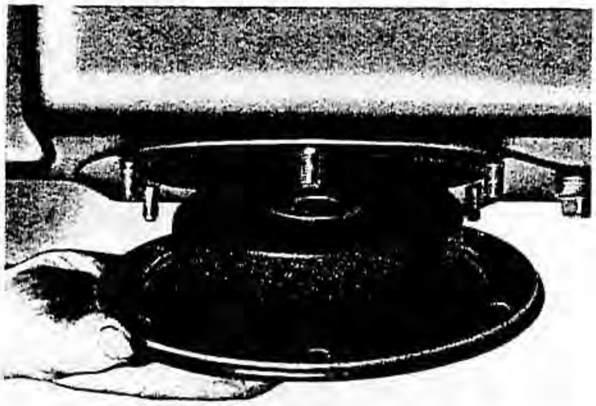


FIGURE 11
THE SUMP STRAINER

THE MAIN FULL FLOW FILTER

The main full flow filter is mounted on the left hand side of the engine crankcase. A replaceable type element is employed to extract foreign bodies from the circulating oil.

FIRST ISSUE

OPERATION

The inlet side of the filter body connects to the outside of the filter element. Oil pumped under pressure is forced through the element. Foreign bodies, grit, etc., are removed from the oil as it passes through the filter. The inside of the element connects to the engine and the filtered oil is thus recirculated through the engine.

Should the element become clogged and the passage of oil severely restricted, pressure will build up in the inlet port and will open the spring loaded ball valve in the by-pass assembly, and permit unfiltered oil to reach the engine. Regular oil changing and attention to filter maintenance and element renewal periods will prevent this occurring.

The spring loaded ball valve opens when the difference between inlet and outlet pressures exceeds 13-17 p.s.i.

DISMANTLING THE MAIN FILTER ASSEMBLY (Refer Figure 12)

Unscrew the centre bolt at the bottom of the filter bowl and lower bowl and centre bolt together. The bolt cannot be withdrawn completely, nor can the seal retainer and spring located over the bolt inside the bowl be removed from the bolt.

Remove the two sealing rings from the recess in the filter head. Release and remove the by-pass plug, washer, spring and ball from the head.

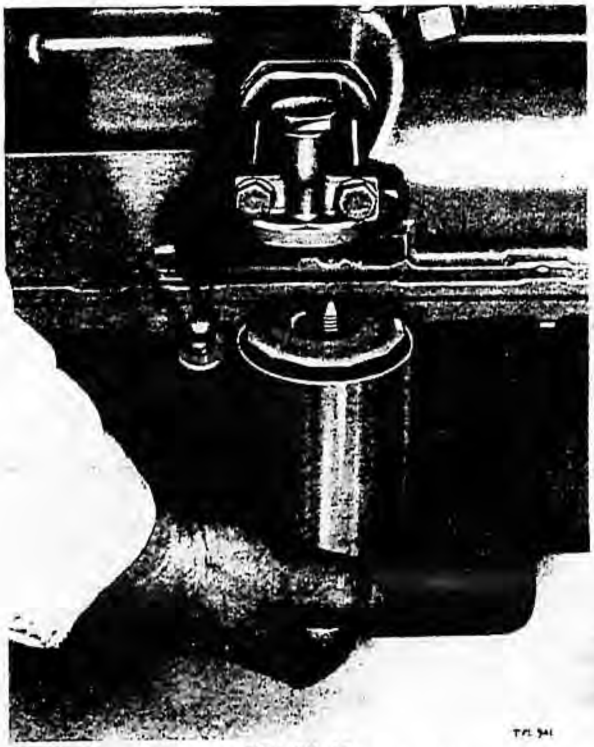


FIGURE 12
DISMANTLING MAIN OIL FILTER ASSEMBLY

ASSEMBLING THE MAIN FILTER

Replace the ball and spring in the by-pass passage and secure with the plug and fibre washer. Locate the large ring seal and the smaller inner seal in the head. Place the filter element over the centre bowl and offer up the bowl assembly to the head, ensuring that the bowl seats properly within the head recess. Tighten the centre bolt to a torque of 10 lb./ft.

THE ENGINE SUMP

The engine sump is of high duty cast iron, has a capacity of 10·5 Imperial pints, and is fitted with a drain plug and dipstick.

A pressed steel cover containing the sump strainer is fitted to the bottom of the sump. This cover enables the strainer to be cleaned without removing the sump.

REMOVING THE SUMP

To remove the sump it is necessary to support the engine, using either an overhead block and tackle or an engine stand. With the engine supported, release the front of the sump from the bolster bracket by removing three setscrews and three nuts and bolts. Release the rear of the sump from the transmission housing adaptor plate by removing the six bolts which secure the sump, adaptor plate, and transmission housing.

The sump can now be removed as follows :—

Remove the two nuts and spring washers from the studs at the front of the sump. These studs go through the sump into the bottom of the timing case.

Remove the two long setscrews and copper washers from the rear of the sump.

The twelve setscrews which hold the sump may now be removed from the cylinder block.

Remove the sump.

Remove the pressed steel cover from the bottom of the sump.

REPLACING THE SUMP

When replacing the sump new joints should be used throughout, *i.e.* between the sump and crankcase flanges and the cork seals at the front and rear of the sump.

Offer up the sump to the crankcase and refit setscrews and nuts. The two long setscrews at the rear of the sump should be fitted with new copper washers.

FIRST ISSUE

Tighten the securing bolts by working from the centre to front and rear.

Refit the pressed steel cover, ensuring that the oil pump suction pipe is properly locating in the strainer mesh.

Affix the bolster bracket and transmission housing adaptor plate.

THE OIL PUMP (Refer Figure 13)

The oil pump is secured to the front main bearing cap by three thin-headed setscrews, a protrusion of the idler gear shaft locating in a hole in the bearing cap for positive location.

A bushed idler gear, which is free to rotate on a shaft, and is retained in position by a circlip, transmits the drive from the crankshaft to the oil pump.

The oil pump drive gear is keyed and pressed on to the pump drive shaft. At the other end of the pump drive shaft a four lobed rotor is fitted. This rotor meshes with a five lobed rotor which is free to rotate inside the oil pump body.

As the rotors rotate, the pockets formed between the lobes increase and decrease in volume, causing oil to be transferred from the suction to the pressure side of the pump.

A pressure relief valve mounted on the delivery side of the pump body controls the maximum oil pressure to within 50-65 p.s.i.

The oil pump delivers 5·35 gallons per minute at an engine speed of 2,000 r.p.m.

REMOVING THE OIL PUMP (Refer Figure 13)

Remove the sump.

Remove the two setscrews securing the bridge piece to the block.

Remove the three setscrews securing the bridge piece to the front cover.

Remove the bridge piece.

Remove oil pump idler gear circlip and slide idler gear forward.

Remove the three setscrews securing oil pump and withdraw oil pump.

Assemble in reverse order.

DISMANTLING THE OIL PUMP
(Refer Figures 14 and 15)

With the oil pump suitably held in a vice, remove the pump drive gear using Service Tool P.D.155 (Figure 14).

Remove the key from the keyway of the drive shaft.

Remove the three screws attaching end plate to pump body and withdraw end plate.

Carefully remove the drive and driven rotor from the pump body.

Dismantle the relief valve by removing the split pin and shims where fitted, the spring retaining cap, spring and plunger.

Remove the 'O' sealing ring from the pump body (Figure 15).

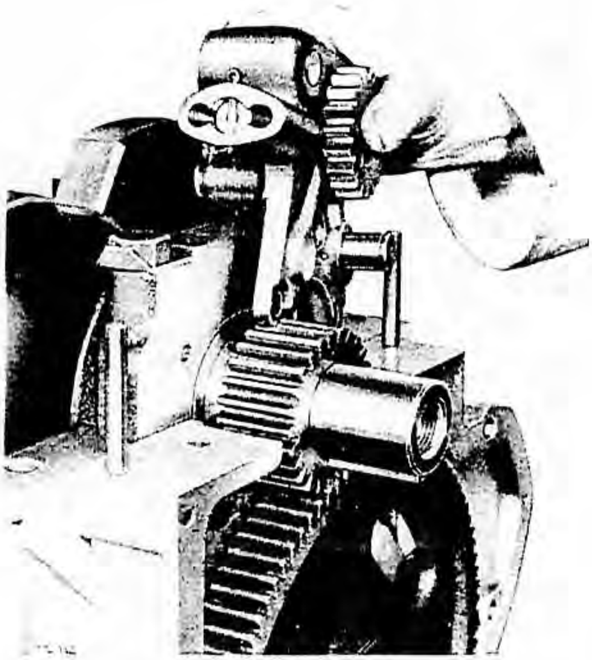


FIGURE 13
THE OIL PUMP

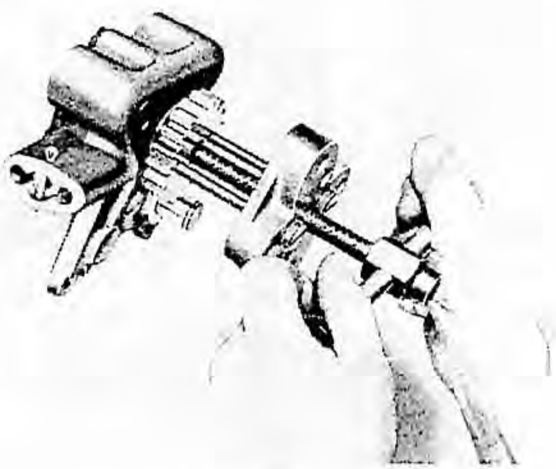


FIGURE 14
REMOVING OIL PUMP DRIVE GEAR

FIRST ISSUE

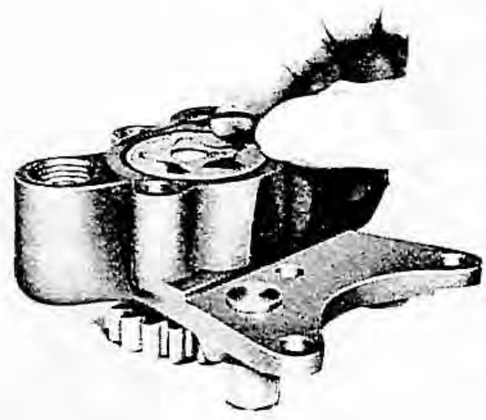


FIGURE 15
REMOVING OIL PUMP 'O' SEALING RING

FIGURE 17
CHECKING CLEARANCE BETWEEN OUTER ROTOR AND OIL PUMP BODY

INSPECTION (Refer Figures 16-18)

Thoroughly clean all components.

Examine rotors for cracks or scoring.

Install the drive and driven rotors in the pump body, ensuring that the chamfered edge of the outer rotor enters the pump body first.

Check the clearance between the maximum diameter of the inner rotor and the minimum diameter of the outer, or driven rotor at all points (Figure 16).

If this clearance exceeds 0·006" (0·1524 mm.) a new oil pump should be fitted.

FIGURE 16
CHECKING CLEARANCE BETWEEN DRIVING AND DRIVEN ROTOR

The clearance between the driven rotor and the pump body (Figure 17) must not exceed 0·010" (0·254 mm.). The clearance between the top of the rotors and the surface of the pump body (Figure 18) must not exceed 0·003" (0·0762 mm.).

Note.—If the pump is considered faulty it must be replaced by a complete unit. Component parts are not available as spares.

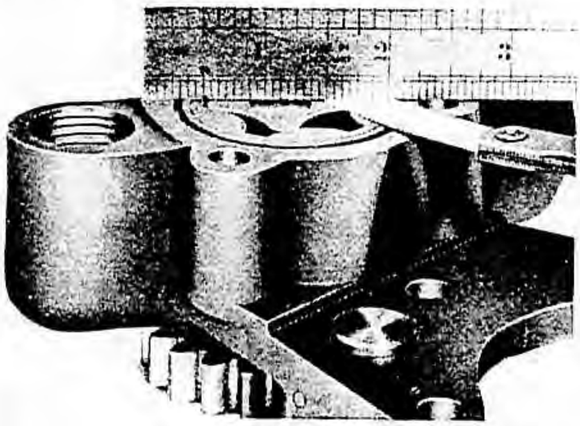


FIGURE 18
CHECKING CLEARANCE BETWEEN ROTOR FACES AND PUMP BODY

ASSEMBLING THE OIL PUMP

Fit the drive and driven rotors in the body, entering the chamfered end of the outer rotor to the body first and replace the 'O' sealing ring and end plate. Replace the three "Philips" screws.

Replace the key in the keyway of the drive shaft, and refit the drive gear, with its flat face outwards. This face should be flush with the end of the drive shaft.

Replace the relief valve and component parts and check that the relief valve lifts at 50-65 p.s.i. This may be checked using suitable hydraulic test equipment or by utilising compressed air.

TIMING CASE COVER AND CRANKSHAFT FRONT OIL SEAL

REMOVING TIMING CASE COVER

Using Service Tool P.D.46B, remove starter dog and washer.

Remove fan belt and generator.

Remove crankshaft pulley.

Remove breather pipe.

Remove generator brackets and adjustable linkage.

Slacken off hose clips connecting water pump to engine.

Remove setscrews securing timing cover.

Two long bolts pass through the timing case to secure a cover at the rear of the timing case, blanking off the power take off bore. In addition to the two long bolts passing through the timing case to secure the generator brackets, a long bolt is also fitted above the position of the generator brackets. The bottom setscrew below the front oil seal is fitted with a copper washer.

Withdraw timing case cover, taking care not to damage the front oil seal located in the timing case cover.

RENEWING CRANKSHAFT FRONT O L SEAL

Carefully prise out old seal from timing case cover. Locate new seal in position, ensuring that lip of seal is adjacent to inner face of timing case.

Using a suitable dolly, carefully tap new seal into position, ensuring that seal is square in timing cover bore.

ASSEMBLING TIMING CASE COVER

Clean mating faces of timing cover and timing case.

Fit new joint and offer up timing cover to engine, taking care not to damage the oil seal as it passes over the crankshaft.

Centralize timing cover using crankshaft pulley, and clamp timing cover in position.

Remove crankshaft pulley and fit and tighten the remaining timing cover setscrews.

Fit breather pipe.

Fit crankshaft pulley and secure in position with washer and starter dog.

Refit water pump hoses to engine and tighten hose clips.

Replace generator bracket, generator, and fan belt.

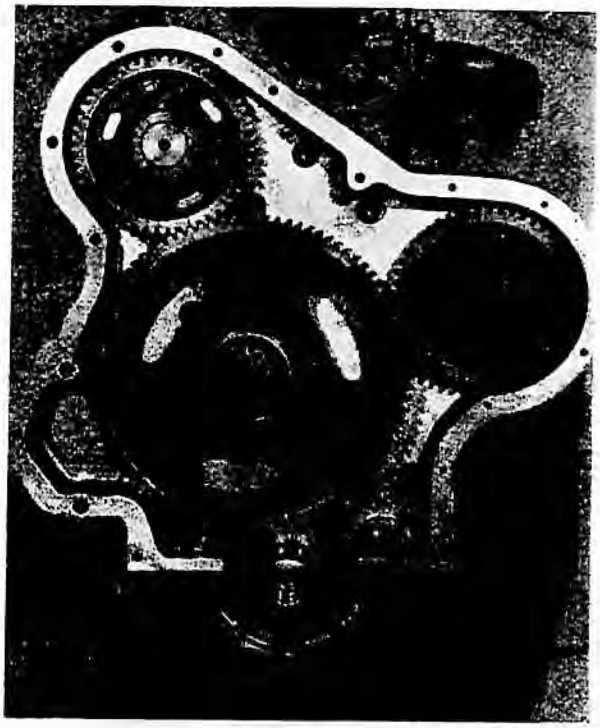


FIGURE 19
TIMING GEAR AND MARKING

TIMING GEARS (Refer Figure 19)

The camshaft and fuel pump gears are driven by the crankshaft gear through an idler gear. All gears are suitably marked during production to facilitate re-timing, the marks being in line when No. 1 piston is at top dead centre (T.D.C.) on its compression stroke, as illustrated in Figure 19. It will be appreciated that these markings will not align at every rotation of the crankshaft where No. 1 piston is at T.D.C. on its compression stroke.

CHECKING TIMING GEAR BACKLASH (Refer Figure 20)

Remove timing case cover as previously described. Using a feeler gauge, check backlash. Idler gear backlash between camshaft, crankshaft and fuel pump gears should be within 0·003"-0·006" (0·076-0·152 mm.) (Figure 20). Backlash between crankshaft and oil pump idler gear should be 0·012"-0·018" (0·305-0·457 mm.).

Excessive backlash can only be corrected by fitting new gears. Replacement gears are marked on production.

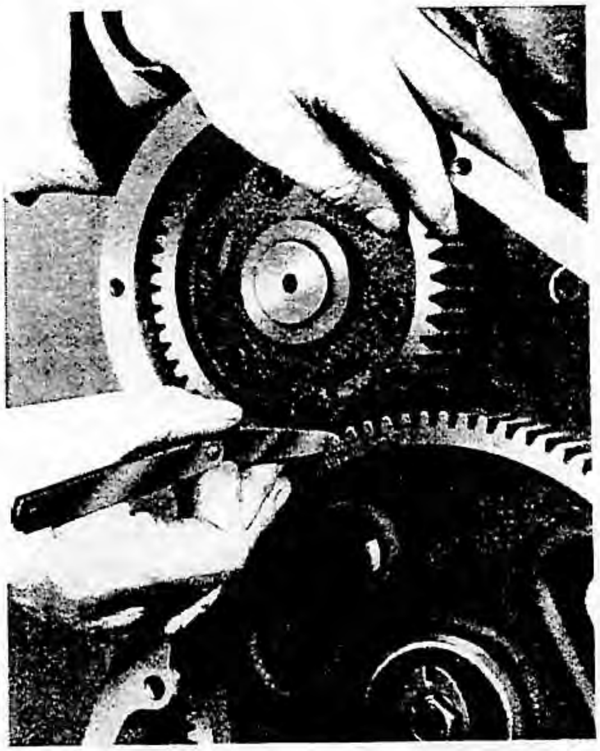


FIGURE 20
CHECKING CAMSHAFT AND IDLER GEAR BACKLASH

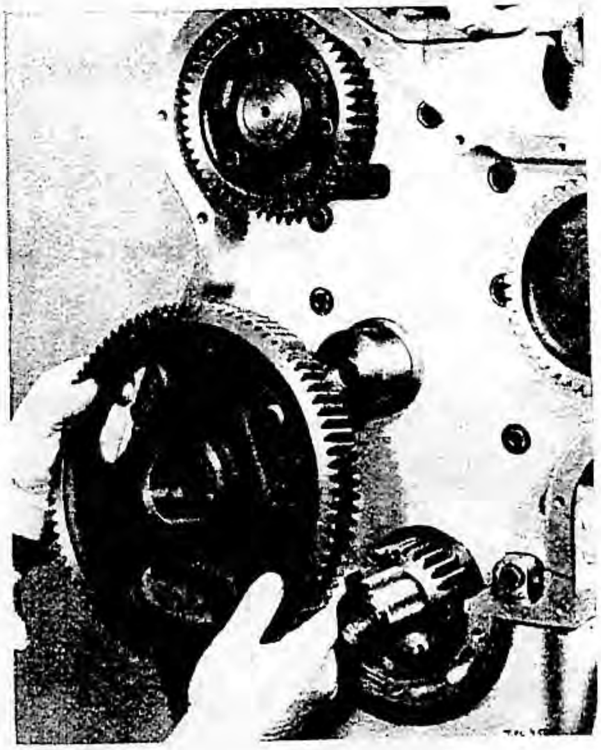


FIGURE 21
REMOVING IDLER GEAR FROM SPIGOT

REMOVING IDLER GEAR AND SPIGOT
(Refer Figures 21 and 22)

Remove timing case cover.

Straighten out lock washer on setscrew, securing idler gear.

Remove setscrew, locking washer and idler gear retaining plate.

Remove idler gear from spigot (Figure 21).

Remove idler gear spigot (Figure 22).

REPLACING IDLER GEAR AND SPIGOT
(Refer Figures 21 and 22)

Place idler gear spigot in position, ensuring that the small locating peg is entered into the through drilling in the spigot (Figure 22). When correctly in position, the spigot flange should be flush with the timing case.

Fit idler gear to spigot, ensuring that timing marks align (Figure 21).

Fit idler gear retaining plate, locking washer, and setscrew.

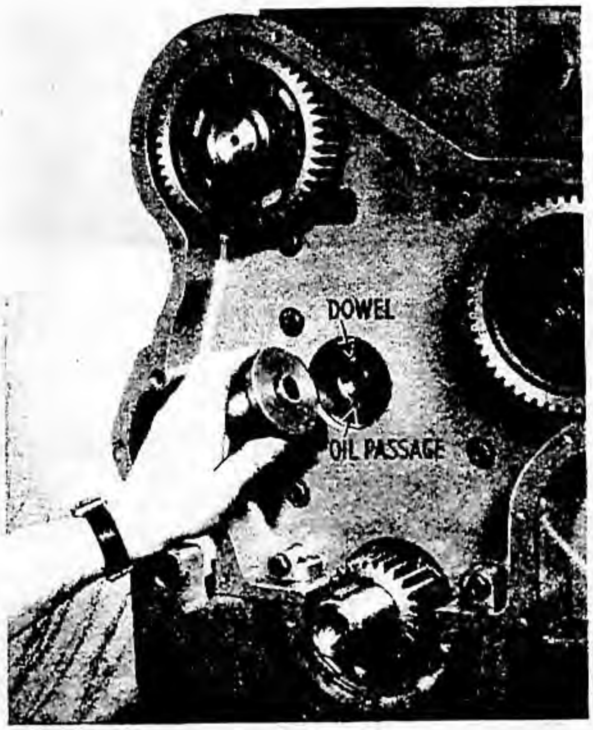


FIGURE 22
REMOVING IDLER GEAR SPIGOT

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Tighten setscrew and bend lock washer into position.

Idler gear end float should be within 0·005"-0·015" (0·127-0·381 mm.).

REMOVING CAMSHAFT GEAR
(Refer Figure 23)

Remove the three setscrews and washers securing gear to camshaft.

Withdraw camshaft gear (Figure 23).

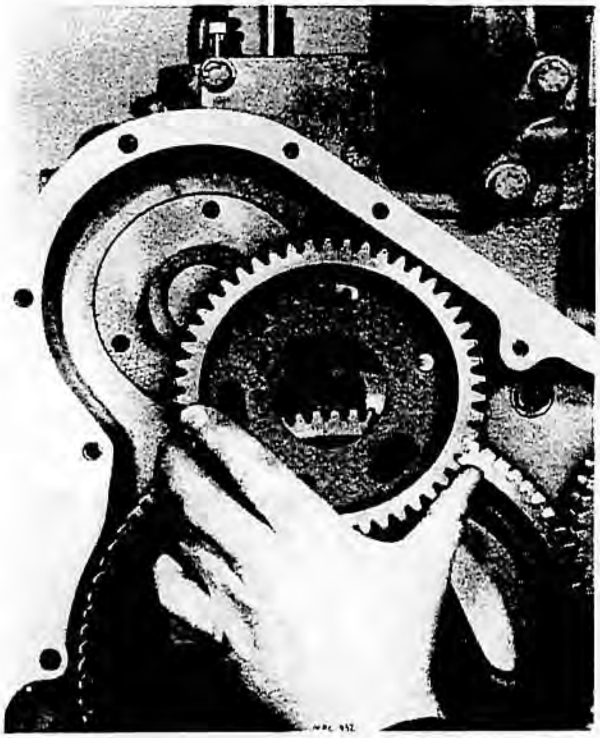

FIGURE 23
REMOVING CAMSHAFT GEAR

FITTING CAMSHAFT GEAR (Refer Figure 23)

Remove idler gear.

Release rocker assembly to facilitate turning of camshaft.

On the hub of the camshaft and the camshaft gear will be seen the letter 'D' stamped adjacent to a fixing hole (Figure 23).

Offer up camshaft gear to camshaft, ensuring that the holes adjacent to the letter 'D' are aligned. On no account must the slotted holes be used to attach the gear to the camshaft.

Fit and tighten the three setscrews and washers.

Fit idler gear and align all timing marks.

Replace rocker assembly and adjust tappets.

REMOVING FUEL PUMP GEAR
(Refer Figure 24)

Rotate crankshaft until timing marks align.

Remove idler gear.

Remove setscrews securing fuel pump gear.

Remove fuel pump gear, taking care not to damage the locating dowel (Figure 24).

Assemble in reverse order, ensuring timing marks align.

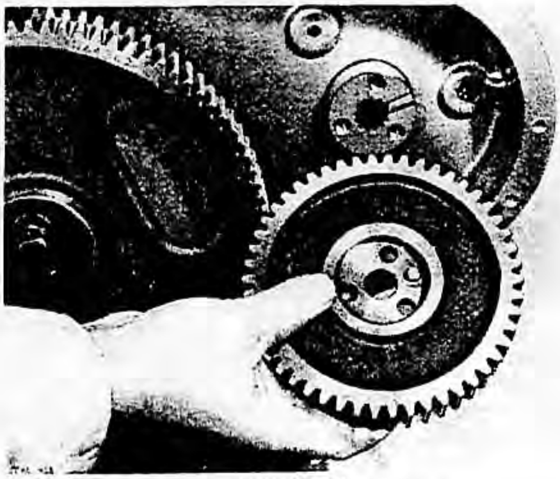

FIGURE 24
REMOVING FUEL PUMP GEAR

REMOVING THE CAMSHAFT
(Refer Figure 25)

FIGURE 25
REMOVING THE CAMSHAFT

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Remove rocker shaft assembly.

Remove timing case cover.

Remove fuel lift pump.

Remove idler gear.

Raise tappets and carefully withdraw camshaft (Figure 25) continually turning the shaft.

Assemble in reverse order, ensuring that timing marks are correctly aligned.

Note.—Camshaft end float is controlled by a spring riveted to the timing case cover.

REMOVING THE TIMING CASE

Remove rocker shaft assembly.

Remove timing case cover.

Remove idler gear and spigot.

Remove fuel lift pump.

Remove camshaft.

Remove fuel pump driving gear.

Remove all links and pipes from fuel injection pump.

Remove the three nuts, spring washers and plain washers securing fuel pump flange to timing case.

Withdraw fuel injection pump. Ensure that all fuel line connections and pipes are effectively sealed.

Remove sump.

Remove setscrews and shakeproof washers securing timing case to engine block.

Withdraw timing case.

REPLACING TIMING CASE (Refer Figure 26)

To ensure correct location of the timing case, it is advisable to fit and fully locate the idler gear hub to the cylinder block.

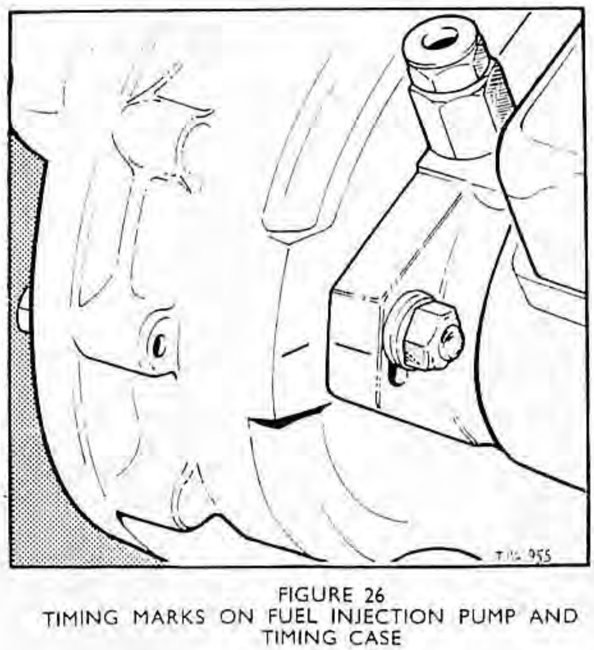

FIGURE 26
TIMING MARKS ON FUEL INJECTION PUMP AND TIMING CASE

Fit new joint and offer up timing case to engine block.

Fit and tighten timing case setscrews.

Fit fuel injection pump to timing case, ensuring scribed lines on pump flange and timing case are in line (Figure 26).

Rotate crankshaft until No. 1 piston is at T.D.C. (Key on crankshaft at T.D.C.).

Fit fuel pump gear to fuel pump, ensuring dowel is properly located.

Raise tappets and carefully insert camshaft.

Fit idler gear to spigot (long tapered flange of gear towards cylinder block and timing marks on crankshaft gear, fuel pump gear, camshaft gear and idler gear in line).

Fit sump.

Fit all fuel pipes and links to fuel injection pump.

REMOVING CRANKSHAFT REAR OIL SEAL

Remove flywheel.

Remove adaptor plate from rear of cylinder block and sump.

Remove the two long bolts and self-locking nuts clamping the oil seal housing halves together.

Unscrew the three setscrews securing each half housing, and withdraw housings.

FITTING NEW ROPE TYPE SEALS

Replacement seals should be soaked in clean engine oil for an hour before fitting.

Hand press seals into their respective grooves in housings, leaving 0·010″-0·020″ (0·254-0·508 mm.) projecting above each end of groove. This projection serves to ensure intimate contact between the ends of the seals when the housing halves are clamped together. Any gap existing between the mating faces of seal ends will defeat the purpose of the oil seal. A projection exceeding that recommended must be avoided, as excessive overlap may spread and prevent the housing halves from seating properly.

Each rope type seal is of the correct length and must not be trimmed.

A round bar may be employed with advantage to bed the seal into position.

FITTING THE SEAL HOUSINGS

Remove all traces of the old joint between the top half of the housings and the cylinder block, and between the bottom half of the housings and the rear main bearing cap. Smear the exposed inside surfaces of the asbestos seals with a graphited grease and lightly coat the housing abutment faces with jointing compound.

Using new joints, fit the half housings to the cylinder block and rear main bearing cap. Locate, but do not tighten the six securing screws.

Fit and tighten the two long clamping bolts, using new self-locking nuts.

Tighten the housing securing screws.

Fit the transmission adaptor plate to rear of cylinder block, ensuring dowels are correctly located.

Fit flywheel and check for "run-out" and concentricity.

FLYWHEEL AND RING GEAR

REMOVING THE FLYWHEEL

Straighten out tabs on flywheel lock plates.

Remove the six setscrews securing flywheel to crankshaft flange.

Withdraw flywheel.

The pilot bearing can be removed by gently tapping it from the crankshaft flange side.

REMOVING STARTER RING GEAR

The starter ring gear is shrunk onto the flywheel. To remove it, partly cut through the gear with a hacksaw, taking care not to mark the flywheel, and split the ring gear with a chisel.

FITTING STARTER RING GEAR

Thoroughly clean ring gear location on flywheel.

Evenly heat new ring gear to an approximate temperature of 475°F.

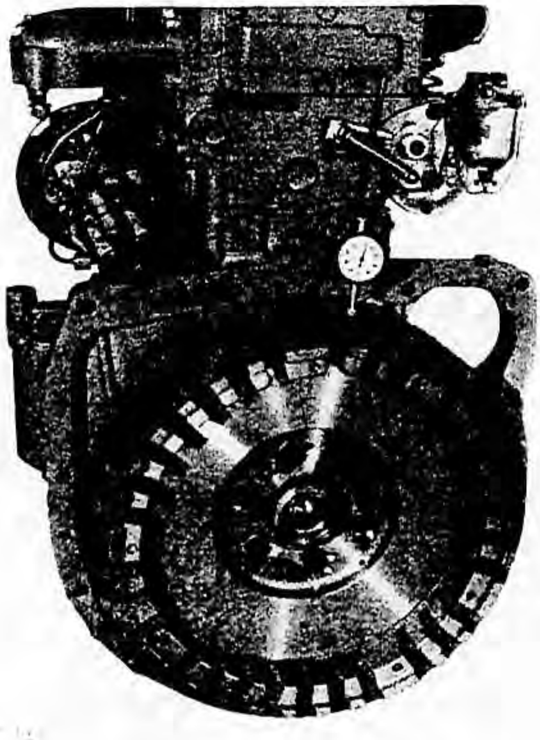

FIGURE 27
CHECKING FLYWHEEL FOR CONCENTRICITY

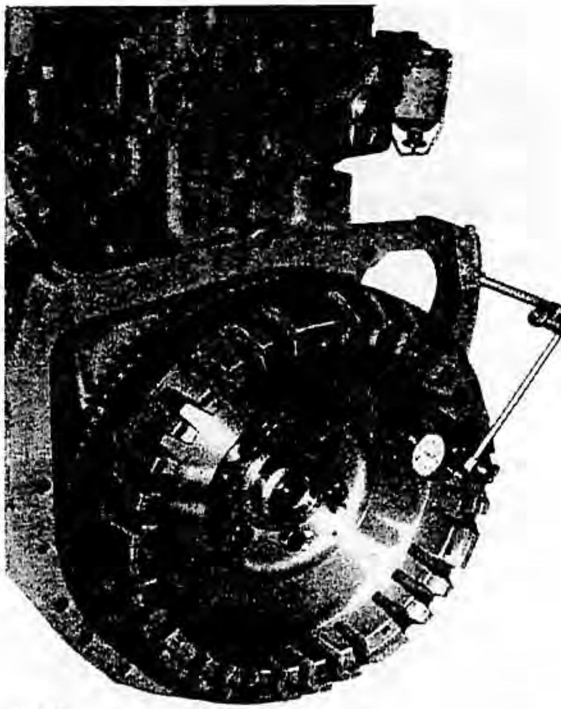

FIGURE 28
CHECKING FLYWHEEL FOR RUN-OUT

Gently lay ring gear in position on flywheel and allow to cool.

Note.—Leading edge of gear teeth must face towards engine.

REPLACING THE FLYWHEEL

(Refer Figures 27 and 28)

It is essential that the crankshaft flange and flywheel mounting faces are scrupulously clean and devoid of burrs.

There are six tapped holes in the crankshaft flange and one untapped hole. This untapped hole must coincide with the staggered hole in the flywheel. This ensures that the flywheel timing marks are correctly related to the crankshaft.

Fit new locking plates and evenly tighten the six setscrews to a torque of 75 lbs./ft. Do not bend over lockplates at this stage.

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Using a dial indicator (Figure 27) carefully check the flywheel for concentricity. The total indicator reading should not exceed 0·008" (0·2032 mm.).

Using dial indicator (Figure 28), check flywheel for run-out. This should not exceed 0·001" (0·0254 mm.) per radius inch (25·4 mm.) from flywheel centre to dial indicator stylus.

Tighten securing screws and re-check torque to 75 lbs./ft.

Bend over tabs of locking plates.

Before fitting clutch assembly check that flywheel pilot bearing is a clearance fit on gearbox primary shaft.

Pack bearing with H.M.P. grease.

Note.—When checking "run-out" it is advisable to apply thrust to the centre of the flywheel to prevent false readings, due to crankshaft end float.

PISTONS AND CONNECTING RODS

In factory built engines, pistons and connecting rods are numbered to correspond to the cylinders to which they are fitted. When dismantling an engine, it is advisable to ensure that an unmarked component has not been substituted during service.

Connecting rods, in addition to being marked for their respective cylinders, are also marked to indicate their weight grading. Should it be necessary to fit a new connecting rod, it must carry the same etched marking as the old rod. The etched number on the displaced rod must be quoted when ordering a replacement (Figure 30).

FIGURE 29
REMOVING PISTON AND CONNECTING ROD

REMOVING CONNECTING RODS AND PISTON ASSEMBLIES (Refer Figure 29)

Remove cylinder head and sump.

Rotate crankshaft until piston selected for removal is at the bottom of its stroke. If necessary, remove oil pump inlet and delivery pipes.

Carefully remove any carbon that may have built up round the top of the cylinder bore.

Remove the self-locking nuts from big end bolts and withdraw bearing cap, lower bearing half and the big end bolts.

Turn crankshaft to bring piston to top of its stroke.

Raise connecting rod clear of crankshaft and remove upper bearing half.

Withdraw piston and connecting rod from cylinder (Figure 29).

Fit bearing shells, cap, bolts and nuts to connecting rod.

Repeat above procedure for the remaining two pistons.

REMOVING PISTON FROM CONNECTING ROD

Remove piston and connecting rod from engine.

Thoroughly clean piston and connecting rod and check that they are correctly numbered for their relevant position in the engine.

Remove the two gudgeon pin circlips.

Immerse piston in warm oil or water and push gudgeon pin clear of connecting rod bush.

FIGURE 30
PISTON AND CONNECTING ROD

PISTON RINGS

Three compression rings and two oil control rings are fitted to each piston, as follows :—

Top Compression : Cast Iron. Parallel faced.

Second Compression : Cast Iron. Taper faced. Marked 'T' for 'Top'.

Third Compression : Cast Iron. Taper faced. Marked 'T' for 'Top'.

First oil control (above gudgeon pin) : Cast iron scraper.

Second oil control (below gudgeon pin) : Cast iron scraper.

When fitting new piston rings into new cylinder liners the ring gap for compression and oil control should be within 0·009"-0·013" (0·229-0·33 mm.) measured in a ring gauge of 3·6" diameter.

ALIGNING CONNECTING RODS

(Refer Figure 31)

Connecting rods must always be checked for truth before re-assembly or before attempting to ream a small end bush.

Large and small end connecting rod bores must be square and parallel with each other within the limits of plus or minus 0·005" (0·127 mm.) measured 5" (127 mm.) each side of the axis of the rod on test mandrel as shown in Figure 31. When checking alignment with gudgeon pin bush fitted the limit plus or minus 0·005" (0·127 mm.) is reduced to plus or minus 0·0015" (0·0381 mm.).

When fitting and reaming connecting rod small end bushes, a reaming fixture must be employed. Service Tools 6200A and P.D.39A are recommended for this purpose.

Note.—Misaligned connecting rods must be discarded and a new one of similar weight group fitted.

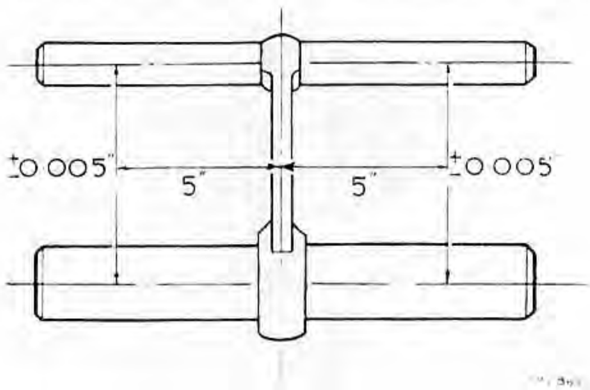

FIGURE 31
CHECKING CONNECTING ROD ALIGNMENT

ASSEMBLING PISTONS TO CONNECTING RODS

If the original pistons are being used they must be assembled to the same connecting rods in their original positions.

Thoroughly clean piston and connecting rod.

Fit one circlip in position to facilitate gudgeon pin location.

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Immerse piston in clean hot oil or water to permit easy entry of the gudgeon pin.

Insert connecting rod between piston bosses, ensuring that piston and connecting rod markings are correctly related.

Insert gudgeon pin in position and fit the second circlip.

Ensure that both circlips are properly located in their respective grooves.

Fit piston rings.

FITTING PISTONS AND CONNECTING RODS (Refer Figures 32 and 33)

Thoroughly clean out cylinder bore and apply a generous coating of clean engine oil.

Lubricate piston.

Locate piston rings so that ring gaps are staggered and evenly spaced.

Fit piston assembly ring, Service Tool P.D.107, to piston, entering it from underside of piston with chamfered edge towards piston crown.

Remove bearing cap, big end bolts and bearing shells. If the old shells are to be re-used, they must not be interchanged.

FIGURE 32
FITTING PISTON TO ENGINE

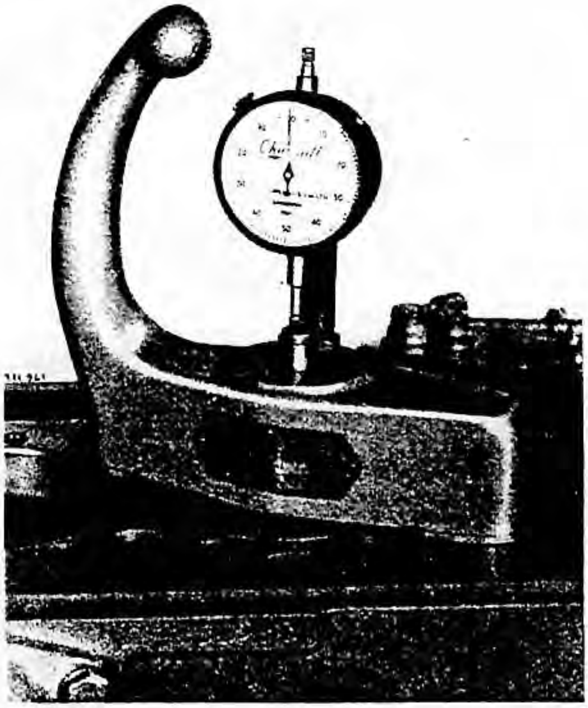


FIGURE 33
CHECKING PISTON HEIGHT

Check that number on connecting rod is to fuel pump side of engine.

Insert connecting rod and piston into cylinder bore.

Gently press piston through assembly ring into cylinder bore (Figure 32).

Turn crankshaft until appropriate crankpin is at B.D.C.

Fit big end bolts and upper bearing half, ensuring that tongue is correctly located.

Lubricate top bearing half and crankpin.

Draw connecting rod into position on crankpin.

Place bottom bearing half in bearing cap.

Lubricate bearing and fit cap to connecting rod, taking care that the position of the connecting rod bolts is not disturbed and that the cap marking coincides with the connecting rod.

Fit new self-locking nuts and evenly tighten to a torque of 70-80 lbs./ft.

With the crankshaft at T.D.C. the proximity of the piston crown to the cylinder block face should be within zero to — 0·005". Pre-top pistons should be within — 0·010" to + 0·004" (Figure 33).

CYLINDER LINERS

REMOVING CYLINDER LINERS
(Refer Figure 34)

Remove the cylinder head and sump.

Remove pistons and crankshaft.

Remove cylinder head studs.

Using Service Tool No. P.D.50C and adaptor P.D.50C-3, withdraw cylinder liners (Figure 34).

FIGURE 34
REMOVING CYLINDER LINERS

FITTING CYLINDER LINERS
(Refer Figure 35)

Using clean engine oil, lubricate the cylinder bore and the external surfaces of the cylinder liner. This oil should be applied with a pressure gun, or by hand. A brush or cloth must not be used for this purpose.

FIGURE 35
FITTING CYLINDER LINERS

PREPARATION FOR FITTING NEW LINERS

Care must be taken in the handling, transit, and storage of cylinder liners, as the slightest damage or burr can cause considerable distortion when the liner is pressed into position.

After removing the old liner, the parent bore must be thoroughly cleaned, and particular attention given to the top recess for the liner flange.

Ensure that the new liner is thoroughly cleaned. If kerosene has been used for this purpose, the liner must be dried before fitting.

Press or draw cylinder liner into position. Figure 35 shows Service Tool No. P.D.50C being used for this purpose.

It is advisable to allow a settling in period to elapse before checking the fitted internal bore of the liner. The acceptable limits are 3·6015"-3·6025" (91·48-91·504 mm.).

Each liner should be checked in three positions—top, centre and bottom.

When fully in position, the top face of the liner flange should be 0·001"-0·009" (0·0254-0·2286 mm.) below the top face of the cylinder block.

FIRST ISSUE

CRANKSHAFT & MAIN BEARINGS

MAIN BEARING CAPS (Refer Figure 36)

The main bearing caps are of high duty cast iron, and are located on ring dowels in the cylinder block. Two high tensile setscrews are fitted per cap and are locked by tab washers. The tab washers should be used once only.

In production, the main bearing parent bores are machined with the caps in position. If, therefore, a main bearing cap becomes damaged for any reason, it will be necessary to replace the complete cylinder block.

All bearings caps are numbered and must be returned to their original positions.

Main bearing and connecting rod bearings are supplied in undersizes of 0·010" (0·254 mm.), 0·020" (0·508 mm.) and 0·030" (0·762 mm.).

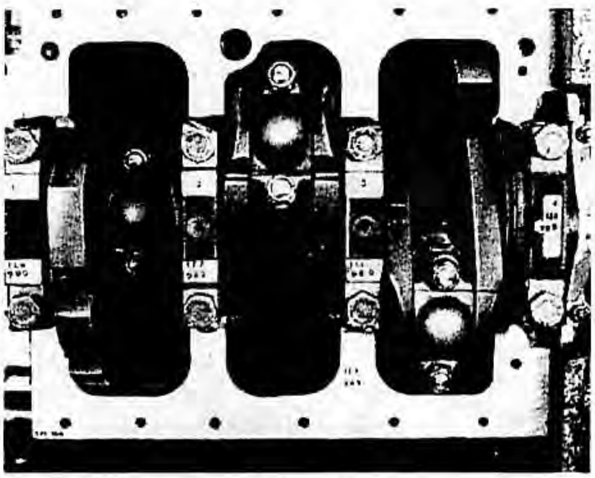


FIGURE 36
THE CRANKSHAFT AND BEARINGS

THE CRANKSHAFT

The crankshaft is forged from chrome molybdenum steel, and is fitted with two cast iron balance weights. These balance weights are matched as a pair and secured in position by two setscrews held in position by tab washers. The setscrews are tightened to a torque of 50-55 lbs./ft.

The rear of the crankshaft is machined to provide an oil thrower and an oil return scroll formed by single right hand helix machined to a depth of 0·004"-0·008" (0·1016-0·2032 mm.).

REMOVING THE CRANKSHAFT
(Refer Figures 36 and 37)

Remove flywheel, transmission housing adaptor plate, sump and timing case cover.

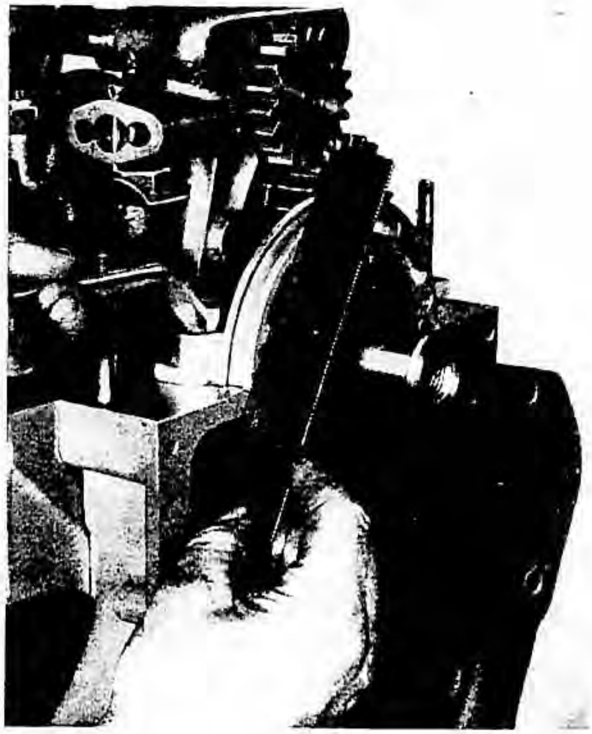


FIGURE 37
FITTING TIMING CASE BOTTOM COVER

Remove lubricating oil pump and idler gear.

Remove timing case bottom cover (Figure 37).

Remove bolts and self-locking nuts clamping the rear main oil seal housings.

Remove connecting rod caps and big end bearings.

Straighten out tabs on main bearing lockplates, and remove bearing cap setscrews.

Withdraw main bearing caps complete with lower bearing shells.

Remove crankshaft thrust washers.

Ensure that bearings—unless renewal is intended—are all identified with their location in the cylinder block and their respective bearing cap.

REPLACING THE CRANKSHAFT
(Refer Figure 36)

Locate upper, main bearing halves in their block positions.

Ensure all oilways and passages are clear and lubricate bearings.

Place thrust washers in position in block, oil grooves facing outwards. A light smear of grease will help retain them in position.

Carefully lower crankshaft into position.

Fit lower bearing halves to main bearing caps.

Fit lower thrust washers to rear main bearing cap.

Place main bearing caps in position, ensuring they are correctly located (Figure 36).

Evenly tighten main bearing caps to a torque of 110-120 lbs./ft.

Secure setscrews by bending over new tab washers.

Fit rear main bearing oil seal housings complete with new oil seals.

Fit timing case bottom cover.

CRANKSHAFT MAIN JOURNAL DIA.

Standard	2·7485″-2·7490″
Undersizes	—0·010″, —0·020″, —0·030″
Width of Nos. 2 and 3 Journals	1·21475″-1·22275″
Width of No. 4 Journal	1·87425″ to 1·87725″
Max. permissible width of No. 4 Journal	1·89125″
Radius on all Journals (must be maintained)	0·09375″-0·109375″

CRANKPIN DIA.

Standard	2·2485″-2·2490″
Undersizes	—0·010″, —0·020″, —0·030″
Width of Crankpin	1·565″-1·5620″
Max. permissible width of crankpin after grinding	1·5785″
Radius of Crankpin	0·1563″-0·1719″

The surface finish on all surfaces must not exceed 16 micro-inches as measured by a profilometer. Radii on journals and crankpins must be maintained as quoted, otherwise fatigue fracture is likely to occur. After grinding, the sharp corners on the oil holes must be removed, and the shaft crack detected and demagnetised.

DATA

Bore	3·6″ (91·44 mm.).
Stroke	5″ (127 mm.).
Number of Cylinders	3.
Cubic Capacity	152·7 cu. ins. (2·5 litres).
Combustion System	Swirl Chamber.
Compression Ratio	17·4 : 1.
Firing Order	1, 2, 3.
Location of No. 1 Cylinder	Front of Engine.
Cylinder Liners	Chrome Plated.
Fuel Pump Static Timing	18° B.T.D.C.
Letter on Fuel Pump Rotor	E.
Letter on Hydraulic Head No. 1 Deliver Port ...	W.
Inlet Valve Opens	13° B.T.D.C.
Exhaust Valve Closes	10° A.T.D.C.
Valve Overlap	23°.
Valve Lift	0·36″ (9·14 mm.)
Tappet Setting (Hot)	0·010″ (·254 mm.)
Tappet Setting (Cold)	0·012″ (·305 mm.)

TORQUE TIGHTENING FIGURES

Cylinder Head Nuts	55-60 lbs./ft.
Con. Rod Nuts	70-80 lbs./ft.
Main Bearing Setscrews	110-120 lbs./ft.
Flywheel Setscrews	75 lbs./ft.
Balance Weight Setscrews	50-55 lbs./ft.
Flywheel Diameter	14·75″ (374·65 mm.)
Flywheel Run-out, Clutch Face	·001″ per inch radius from flywheel centre to the dial indicator.
Flywheel Run-out, Periphery	·008″.
Number of Teeth on Starter Ring Gear	115.
One Inch on Flywheel Rim equals	7·773°.
One Degree on Flywheel Rim equals	·1287″ (3·269 mm.)
Starter Ring Gear Retention	Shrunk on.
Fuel Injection Pump	C.A.V.
Pressure Setting	120 Atmospheres.
Sprays of Atomiser	Twin Spray at 30° and 80° from the Vertical.
Fuel Lift Pump	A.C. Delco Diaphragm Type.
Fuel Filters	Purolator and C.A.V.
Lubricating Oil Pump	Rotor Type.
Pumping Capacity	Approximately 4·5 galls./min. at 2,000 r.p.m. Engine Speed.
Operating Oil Pressure	25-30 p.s.i. or more at Normal Speeds.
Relief Valve Setting	50-65 p.s.i.
Sump Capacity	10½ pints.
Lubricating Oil Filter Type	Tecalemit Full Flow.
Filter By-pass Valve Opens	13-17 p.s.i.
Thermostat Type	A.C. Delco 1572233.
Thermostat Opening Temperature	176°F.
Backlash in Timing Gears	·003″/·006″ (·0762-·1524 mm.)
Backlash, Lubricating Oil Pump Gears	·012″/·018″ (·305-·4572 mm.)

FIRST ISSUE

SUMMARY OF TOOLAGE RECOMMENDATIONS

PD.1A	Valve Guide Remover and Replacer.
PD.41	Piston Height Gauge.
PD.50C-3	Cylinder Liner Remover and Replacer.
D.6513 and R6 6513-1	Valve Spring Remover and Replacer.
PD.155	Gear Remover.
316 and PD.317	Valve Seat Refacer.
PD.17A	Valve Head Depth Gauge.
PD.107	Piston Assembly Ring.
6200A	Connecting Rod Fixture.
PD.39A	Reamer Set for Small End Bush.

FIRST ISSUE

23C DIESEL ENGINE

INTRODUCTION

The 23C Diesel engine is of the indirect injection type, with Ricardo Comet combustion chambers. It is fitted with Pintaux injectors, which have an auxiliary spray hole to assist starting. The fuel injection pump is of the DPA distributor type incorporating a built-in mechanical governor.

On Diesel engines the higher compression ratio and greater fluctuations in pressure transmitted to the bearing, crankshaft etc., necessitate stronger materials and a more robust engine. To this end the crankshaft is barrel mounted so that each of its three bearing housings form stiffening webs for the crankcase, while special consideration has been given to the design of the crankshaft and connecting rods.

The following instructions assume the use of the specially designed Dismantling Stand and the full range of Service Tools and Equipment.

Where more detailed instructions on the application of certain Service Tools is considered desirable, the tool manufacturers supply the necessary information with the tool kit. These instructions, therefore, are not repeated in detail.

Note.—When working with Diesel equipment, mechanics are advised always to protect their hands with a barrier cream.

LUBRICATION SYSTEM

OIL DISTRIBUTION

Oil is drawn from the sump through a primary gauze filter and fed under pressure to the full flow oil filter which is mounted on the L.H. side of the cylinder block. The pressure relief valve in the filter head operates at 60 lb. sq. in. (4.2 kg. sq. cm.) and oil controlled at that pressure passes to the main oil gallery running the length of the cylinder block, the rear end of which has the pressure gauge connection.

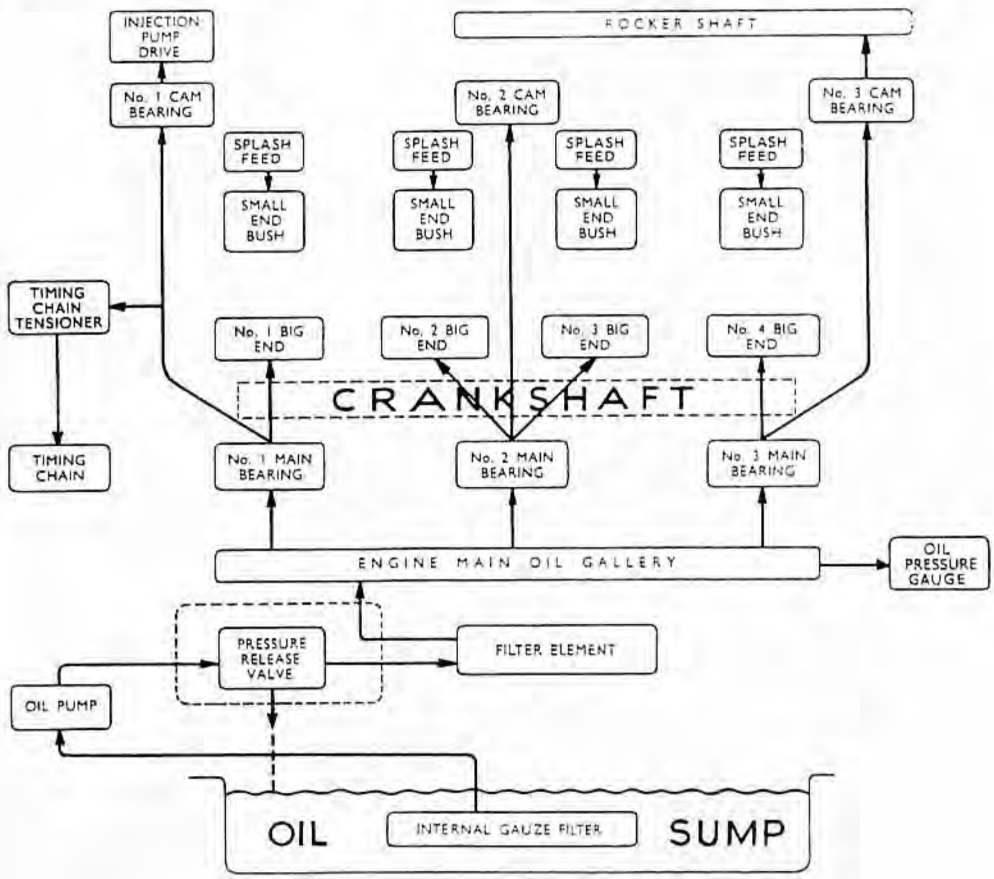


FIG. 100
DIAGRAM OF LUBRICATING SYSTEM

Front, centre and rear journals of the crankshaft are connected by drillings directly to the oil gallery while oil arrested by the crankshaft rear oil seal drains through the rear bearing housing to the sump.

Continuous lubrication of the big end bearings is provided by high pressure oil transmitted through the drillings in the crankshaft connecting with the annular grooves in the main bearing shells. The cylinder walls, pistons, small end bushes and gudgeon pins are splash lubricated.

An annular groove in the bore of each main bearing housing is connected by drillings through the housing and cylinder block to the camshaft journals.

A groove encircles the camshaft rear journal and connects two flats machined on the journal in positions such that, as the shaft revolves, one approaches the oil drilling from the rear main bearing housing, while the other approaches a second drilling through the cylinder block and head to the rocker shaft rear pedestal. Momentarily, during each revolution of the camshaft, both holes are uncovered by the flats and oil under pressure passes along the spiral groove and up the hollow rocker shaft where it is distributed through drillings to the rocker bushes. Oil is directed through relief holes from rockers on to the push rods, returning by gravity through tappet chambers to the sump.

A drilling from the front main bearing housing supplies oil under pressure to the hydraulic timing chain tensioner. This oil lubricates the chain, timing and oil pump gears through a bleed hole in the tensioner head before returning to the sump through transfer holes in the front face of the cylinder block.

The gears and shafts contained in the fuel injection pump drive housing are lubricated by oil fed from the front camshaft bearing. A baffle was incorporated at Engine No. SJ 26827 in the casing, between gears and filler neck, to prevent oil being thrown out by the gears.

LUBRICATING OIL PUMP

The oil pump, illustrated in Fig. 101 is spigoted and flange bolted to the front main bearing housing and driven by a helical spur gear from the crankshaft.

It will be seen from Fig. 101, that the outer rotor has five lobes while the eccentrically mounted inner rotor has four. Thus, as the shaft turns, oil from the vacant space over the inlet port is transferred to the outer port, from which it is expelled as the lobes engage.

The pump and drive gear can be removed and dismantled when the timing cover has been removed.

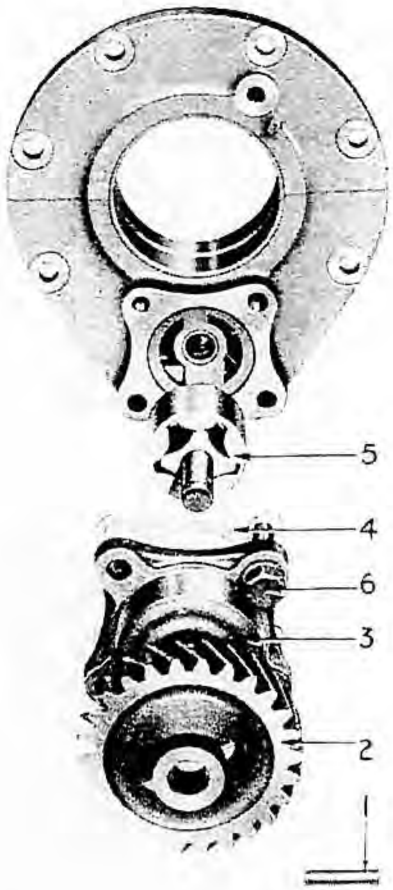


FIG. 101 OIL PUMP AND FRONT MAIN BEARING HOUSING

To Dismantle

1. Tap out the pin (1) retaining the drive gear (2) and pull the driving member off the shaft.
2. Remove the four bolts from the pump body (3) and pull off, together with gasket (4) and rotors (5) which run directly in the pump body.

Fitting New Bushes

The oil pump spindle bush situated in the pump body and that in the main bearing housing can be removed, when necessary, with the aid of Service Tool MF129. (See Figs. 102 and 103). Fit a new bush, with long taper leading in both the bearing housing and pump body with the aid of Service Tool MF130. A shoulder is provided on the spigot of this tool to ensure that the bush does not protrude and foul the inner rotor, and the bush in the pump body should therefore be fitted from the inside. See also note under "Front Bearing Housing".

Reaming Oil Pump Spindle Bushes

Before re-assembling the pump, new spindle bushes must be reamed through using Reaming Equipment MF147 as follows

FIG. 102 REMOVING OIL PUMP SPINDLE BUSH. SERVICE TOOL MF129

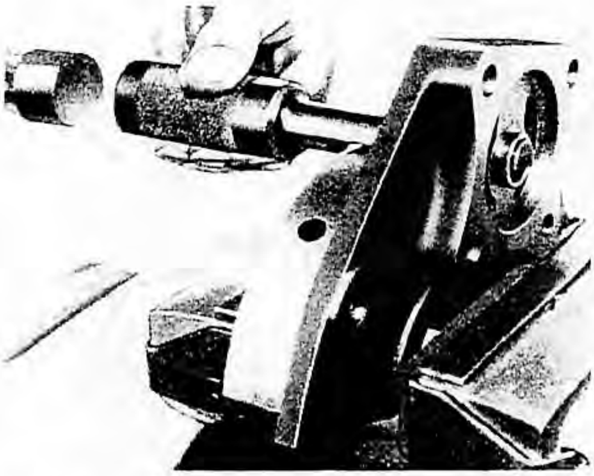


FIG. 103 REMOVING THE ROTOR SHAFT BUSH FROM THE LOWER HALF BEARING HOUSING. SERVICE TOOL MF129

Front Bearing Housing Bush
Fit the short spigot of the jig into the oil pump recess with the dowel inserted into the top right-hand screw hole, *i.e.*, that used to locate the pump body. Secure jig in position with screw and bolt, using a flat washer between the bearing housing and nut lockwasher. With the jig firmly located, ream through the spindle bush carefully until the reamer end bottoms in the bearing housing. Remove jig and blow out swarf.

Oil Pump Body Bush
For this bush the opposite side of the jig is used. This has the longer spigot and is also recessed to accommodate the mounting spigot of the pump body. The dowel fits into the hole for the locating screw, shown (6), Fig. 101. Secure in position with nuts and bolts through diagonally opposite fixing holes. With the jig firmly located, ream through the bush carefully and blow out swarf after completion.

Re-assembly
1. When assembling the rotors ensure that the chamfered edge of the outer rotor is facing outwards, *i.e.*, away from the front bearing housing.

2. Replace pump body assembly, using new gasket, with spigot of body in the recess of the front bearing housing. The body is located by the top right-hand fixing screw (6) which has a fitting shank of larger diameter. Screw in all screws evenly on lockwashers finger tight, commencing with the locating screw, before tightening down by diagonal selection to a torque reading of 16 to 18 lb. ft. (2.2 to 2.5 kg.m.).

3. Replace driving gear on shaft and refit securing pin.

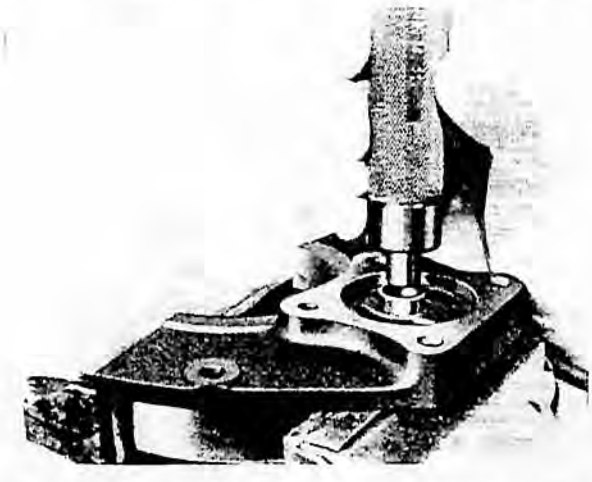


FIG. 104 FITTING NEW ROTOR SHAFT BUSH TO LOWER HALF BEARING HOUSING. SERVICE TOOL MF130

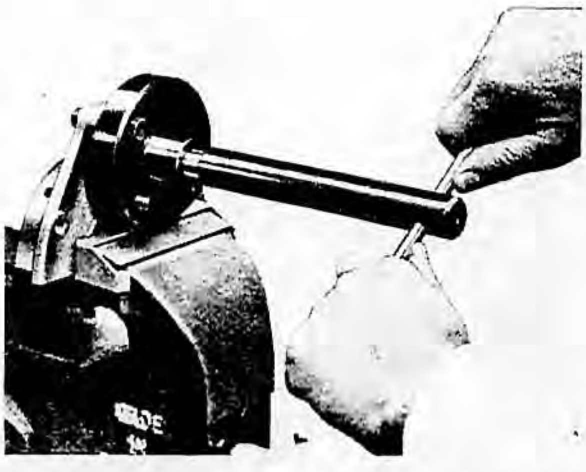


FIG. 105 REAMING OIL PUMP SPINDLE BUSH. SERVICE TOOL MF147

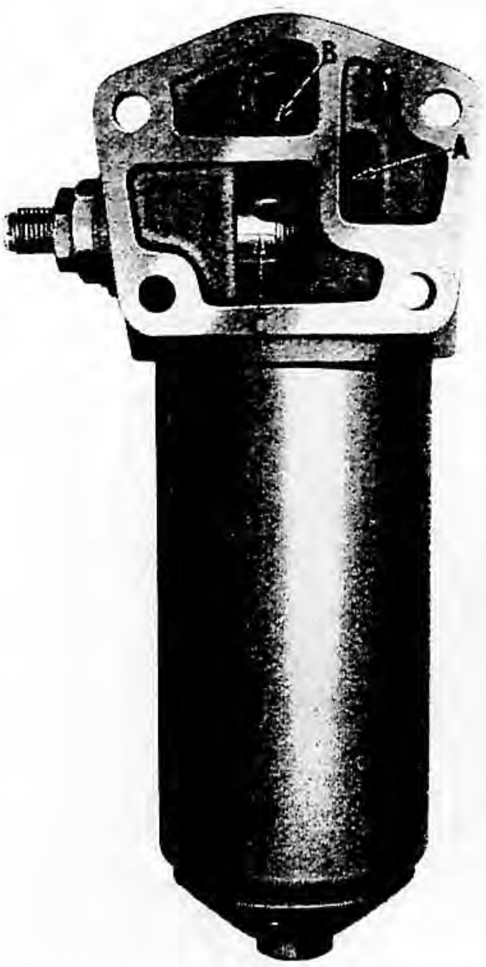


FIG. 106 LUBRICATING OIL FILTER

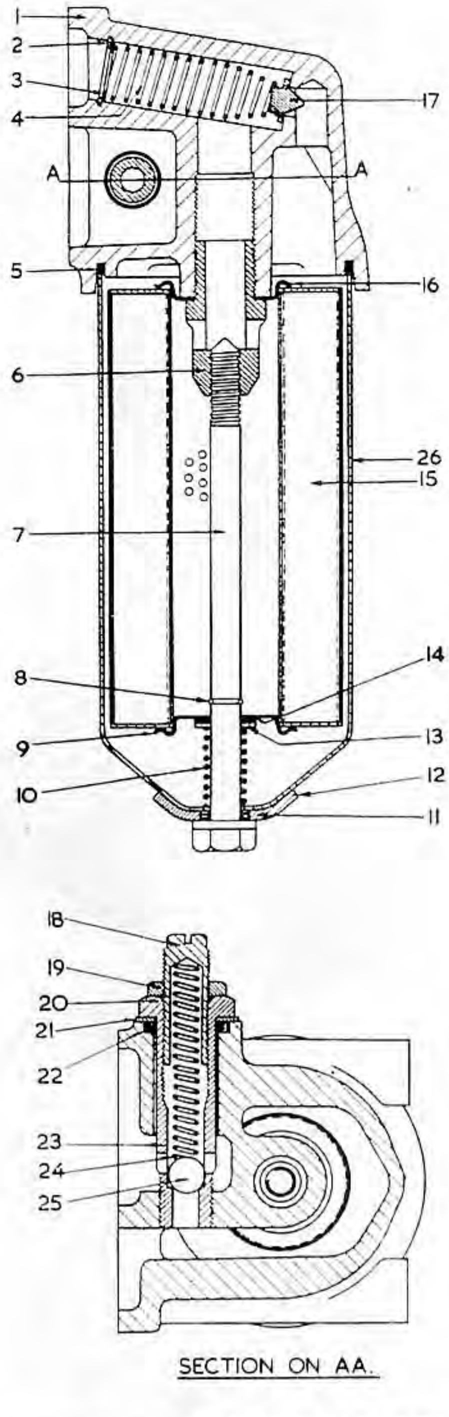


FIG. 107 SECTIONAL VIEW OF LUBRICATING OIL FILTER

LUBRICATING OIL FILTER

A replaceable cartridge type oil filter mounted on the left-hand side of the crankcase, prevents any dirt or foreign matter in the lubricating oil from reaching working and bearing surfaces.

Operation

Oil is pumped from the sump through port A to the outside of the filter element. Particles are removed as the oil passes through to the inside of the element and escapes to the gallery through diagonal port B. If tightness of bearings or high viscosity of oil causes the pressure in the system to rise above 60 lbs. sq. in. (4.2 kg. sq. cm.), unfiltered oil passes back to the sump as the pressure relief valve opens. Should the element become clogged and the passage of oil severely restricted, oil in the diagonal port B and gallery will be at a lower pressure than that in the outside of the element, opening a by-pass at the lower end of port B and allowing unfiltered oil to pass into the gallery.

Description

The filter consists of a sump (26) positioned by a centre bolt (7) to a filter head (1). The bolt screws into a centre tube (6) which retains the element guide (16). The sump beds on a seal (5) carried in a groove in the head. The lower end of the centre bolt is fitted with a spring (10), washer (13), seal (14) and an element guide (9) retained by a circlip (8). The base of the sump has a reinforcing washer (12) bored to accommodate a seal (11).

The filter head is formed with inlet and outlet passages, the latter containing the by-pass valve (17) loaded by a spring (4) retained by a washer (3) and circlip (2). The engine relief valve is assembled in a bore in the filter head and consists of a body (23) screwed into the head against a washer (21) which beds on a seal (22). The bore of the body is fitted with a ball (25) and spring (24) retained by an adjusting screw (18) secured by a locknut (19) which beds on a lead washer (20).

Dismantling

1. Unscrew the centre bolt (7) from the centre tube (6), withdraw the sump (26), extract the seal (5) from the filter head (1) and remove the element (15).
2. Remove the circlip (8), slide the lower element guide (9), seal (14), washer (13) and spring (10) off the centre bolt and withdraw the sump; collect the reinforcing washer (12) and seal (11).
3. Extract the circlip (2) and collect the washer (3), spring (4) and by-pass valve (17).
4. Unscrew the locknut (19) and the adjuster (18) and collect the spring (24) and ball (25). Unscrew the relief valve body (23) and collect the washer (21) and seal (22).

Re-assembly

1. Place the washer (21) and seal (22) on the engine relief valve body (23) and screw the latter firmly into the filter head (1) ensuring that the seal is correctly assembled in its recess.
2. Position the ball (25) in the body, place the spring (24) in the adjuster (18) and screw the latter into the relief valve body to an approximate setting, *i.e.*, about 8-10 threads exposed above the locknut. Fit a new lead seal (20) over the adjuster and secure by means of the locknut (19).
3. Fit the by-pass valve (17) in the smaller end of the spring (4) and position the assembly in the filter head; place the washer (3) on the spring and fit the circlip (2).
4. Pass the seal (11) and reinforcing plate (12) over the centre bolt (7) followed by the sump (26). Slide the spring (10), washer (13), seal (14) and lower element guide (9), recess foremost, over the centre bolt and fit the circlip (8).
5. Place the filter element in the sump so that it rests on the lower element guide, refill container one third full with clean engine oil, fit the seal (5) in its groove in the filter head and offer up the sump to the head.
6. Screw the centre bolt into the centre tube firmly enough to ensure that there will be no leakage past the seals, (5, 11).

Re-fitting

Coat both sides of the joint washer with "Wellseal" jointing compound and position this on the joint face of the filter head. The complete filter unit is then attached to the cylinder block with four bolts and lockwashers, the longer bolts occupying the rear positions.

Correct adjustment of the oil pressure relief valve can only be made whilst the engine is running and after it has reached its normal working temperature. The procedure is as follows:

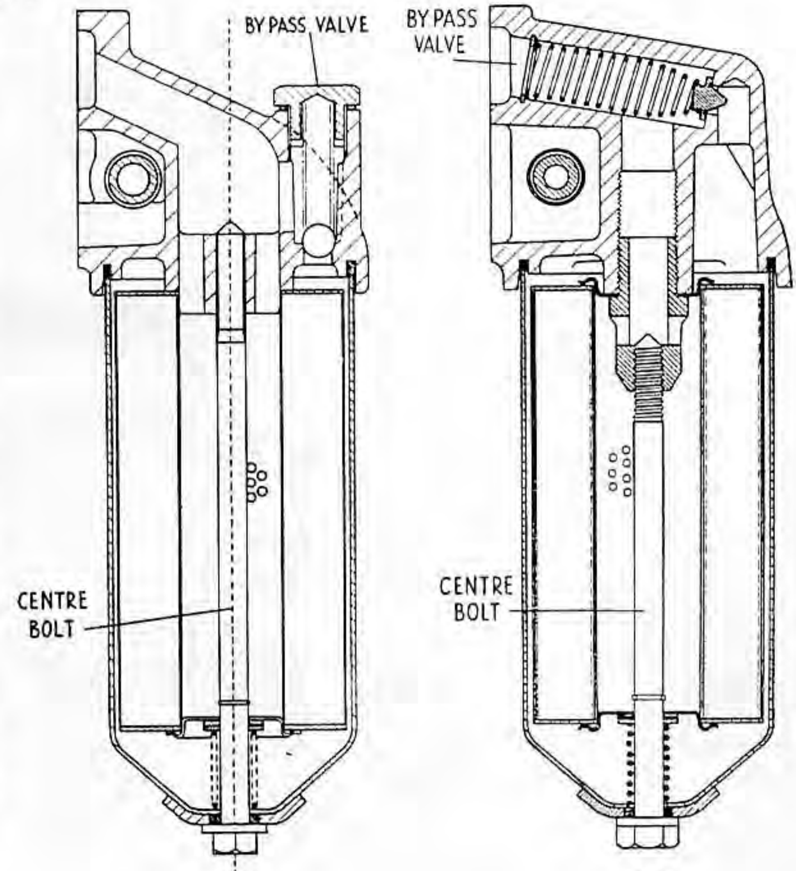


FIG. 108 MODIFIED FILTER NEW OLD

1. Whilst the adjusting screw (18) is held with a screwdriver, release the locknut (19).
2. Speed-up the engine to approximately 2,000 r.p.m. and observe the pressure registered on the oil gauge. This should be between 57-63 lbs. sq. in. (4.007-4.429 kg. sq. cm.). If adjustment is necessary, the oil pressure is increased by screwing the adjuster IN and reduced by screwing it OUT.
3. When adjustment is satisfactory, hold the adjusting screw and firmly tighten the lock nut.

MODIFIED FILTER Fig. 108

At Engine No. SJ 33114E and future a modified Purolator oil filter with a redesigned by-pass valve, and a revised method of fixing the centre bolt securing the canister, was introduced in production. The by-pass valve is now a ball type vertical in the head casting and can be removed by unscrewing the adaptor cap. Interchangeability is not affected as an assembly.

OVERHAUL OF CYLINDER HEAD ASSEMBLY

DECARBONISATION AND VALVE GRINDING

By dissolving the carbon deposits, detergent additive engine oils, as recommended for this engine, considerably reduce the otherwise heavy residuals left by the combustion of Diesel fuel. The carbon dissolved is held in suspension in the lubricating oil, causing early discoloration and the impression that the oil requires changing, this is normal and indicates that the detergent additives are working.

Any loss of compression, resulting from carbon accumulation, affecting the seating of the valves or causing valves to stick in their guides will obviously have a distinctly adverse effect on the performance of this type of engine.

At cranking speed the compression pressure in each cylinder should be in the region of 450 lb. sq. in. (31.64 kg. sq. cm.) when the engine is warm.

Before investigating any pressure loss, make sure that the valve tip clearances are set accurately. See page C.112.

Decarbonisation and valve grinding normally become necessary after the first 300 hours and subsequently every 1,000 working hours, dependent upon the type of work undertaken. Under light load conditions these periods may have to be reduced.

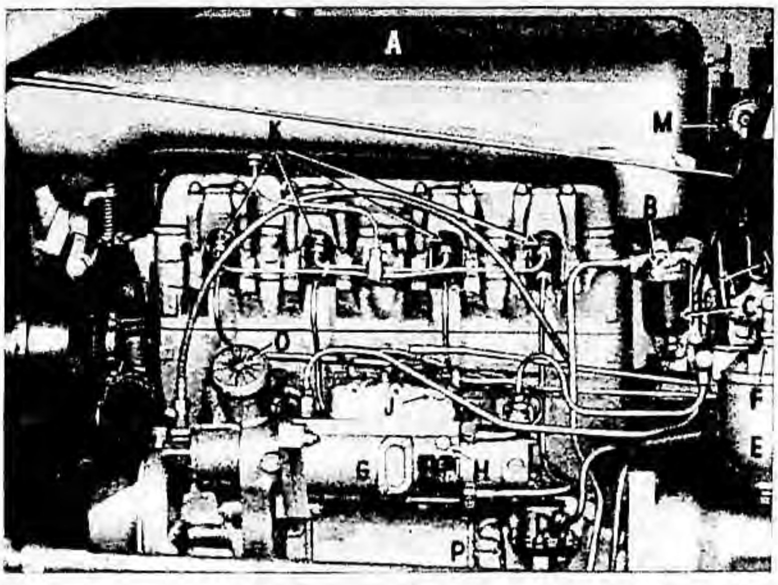
The general condition of the engine can be deduced by examination of the structure of the carbon. A heavy formation of hard coke tends to indicate that the engine is burning excessive lubricating oil. The fuel injection equipment should be checked if a heavy soft sooty accumulation is found.

CLEANLINESS

Before starting to dismantle the engine, suitable caps or masking tape should be available for blanking off all open fuel connections as soon as a union has been removed. Scrupulous cleanliness must always be observed when handling fuel connections.

FIG. 109 L.H. SIDE OF ENGINE

A. Fuel Tank.
B. Fuel Tap.
C. Sediment Bowl.
D. Feed Pump
E. Fuel Filter.
F. Filter Vent Plug
G. Injector Pump.
H. & J. Vent Plugs.
K. Injectors.
L. Leak Off Pipe.
M. Reservoir Tank.
N. Circulation Pipe—Fuel Filter to Reservoir Tank.
O. Engine Oil Filler.
P. Dipstick.



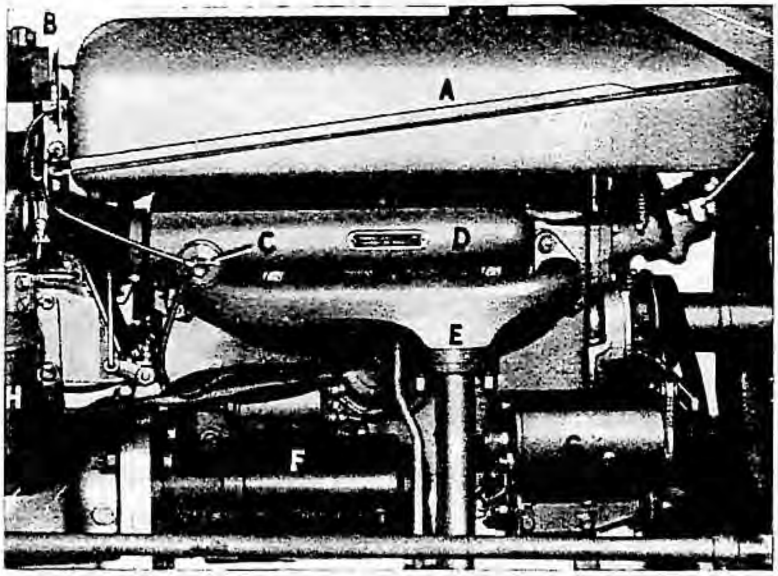


FIG. 110 R.H. SIDE OF ENGINE

A. Fuel Tank.
B. Reservoir Tank.
C. Thermostart.
D. Inlet Manifold.
E. Exhaust Manifold.
F. Starter Motor.
G. Dynamo.
H. Air Cleaner.

PREPARATIONS FOR LIFTING THE CYLINDER HEAD

1. Remove hood.
2. Open both drain taps and remove filler cap to drain radiator and cylinder block.
3. Disconnect positive lead from battery mounted on L.H. side of the driver's seat.
4. Turn off fuel tap.
5. Disconnect the following fuel pipes:
   Reservoir tank to filter—at filter.
   Reservoir tank to Thermostart—at Thermostart.
   Reservoir tank to main fuel tank—at main fuel tank.
   Fuel return pipe—at main fuel tank.
   Main fuel pipe—below sediment bowl.
6. Remove thermostart reservoir tank with fuel pipes attached.
7. Remove two set screws securing rear of fuel tank to battery carrier. Slacken two spring-loaded bolts securing front of fuel tank to thermostat housing. Slide fuel tank rearwards to disengage from spring-loaded bolts. Remove fuel tank.
8. Slacken two nuts securing each injector, and remove injectors, copper washers and bridge pieces, and leak off pipes.
9. Remove breather pipe at wire clip.
10. Remove exhaust pipe.
11. Detach starter switch connection at Thermostart. Detach air cleaner hose from manifold.
12. Remove exhaust manifold, inlet manifold and manifold gaskets.
13. Detach radiator tie rod from thermostat flange, radiator top hose and elbow from thermostat flange, and remove gasket. Lift out thermostat. Remove by-pass hose.

REMOVING AND DISMANTLING CYLINDER HEAD

1. Remove rocker cover and gasket.
2. Remove rocker gear, working from the centre to slacken the four nuts. Remove push rods and valve caps and carefully place them in order of removal for replacement in their original positions.
3. Loosen the cylinder head set screws and nuts in reverse order to that shown in Fig. 120. Remove cylinder head complete with thermostat housing. Remove cylinder head gasket.

Note.—The use of certain specialist tools for grinding in valves, etc., may also necessitate removal of the thermostat housing from the cylinder head.

4. With cylinder head mounted in Service Fixture MFB9 using the appropriate seating plate, compress valve springs and remove split cones and collars. On removing valves and springs, carefully place them in their correct positions on the Service Fixture, to facilitate replacement in their original positions.

Note.—The rotation of the free valve may produce a burr on the tip, just below the cap. Remove this before drawing the valve through the guide, otherwise there is a danger of scoring the guide bore.

PISTONS AND SLEEVES

It is important that cylinder liner retainers—Service Tool MF169— are fitted immediately after the cylinder head is lifted and before turning the crankshaft unless it is also necessary to remove the cylinder liners.

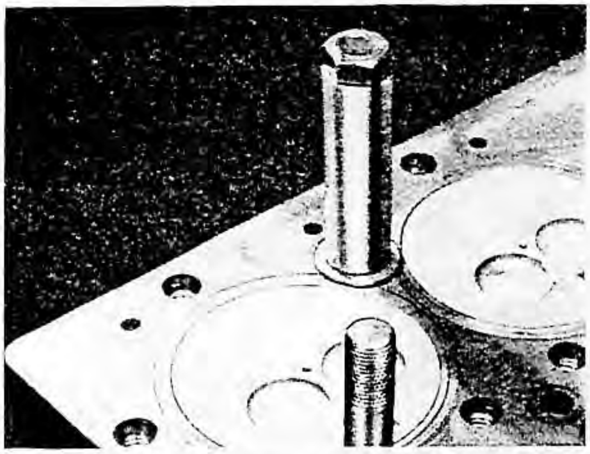


FIG. 111 CYLINDER LINER RETAINER (SERVICE TOOL MF169) IN POSITION

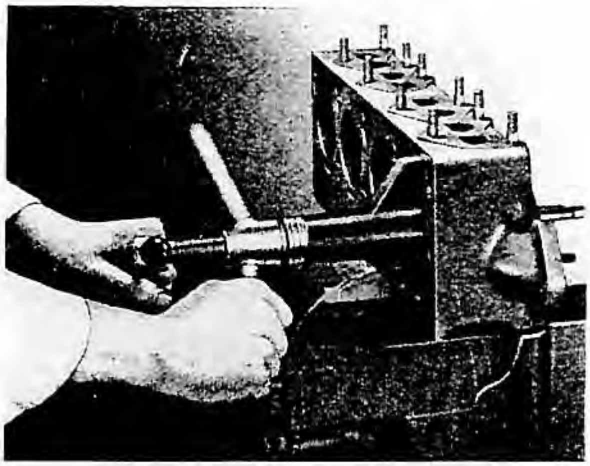


FIG. 112 REMOVING VALVE GUIDE USING SERVICE TOOL MF60A

1. Position crankshaft with two pistons at top dead centre, and blank off with rags remaining cylinders and ports to prevent entry of carbon scrapings.
2. Carefully remove carbon from piston crown leaving a ridge around piston edge.
3. Repeat for remaining pistons. Scrape off dirt, grit or sealing compound from top of cylinder block and wipe piston crowns with petrol-moistened rag.

CYLINDER HEAD AND EXHAUST MANIFOLD

1. Examine cylinder head for signs of porosity and fur deposits.
2. Remove all carbon from combustion head, valve ports, seats and guides. Carefully clean out all displaced carbon.
3. Remove old manifold gaskets and clean off dirt or grit from head faces.

INJECTORS

All injectors should be dismantled, cleaned and, after examination, re-assembled and adjusted in accordance with separate instructions.

VALVE SPRINGS

Clean valve springs and examine them for fatigue and distortion, and if they appear serviceable, check their "free" and "fitted" lengths against the following dimensions before refitting.

Inner Spring	free length 1.6" (40.6 mm.) approx. fitted length 1.22" (31 mm.)
Outer Spring	free length 1.7" (43.2 mm.) approx. fitted length 1.32" (32.5 mm.)

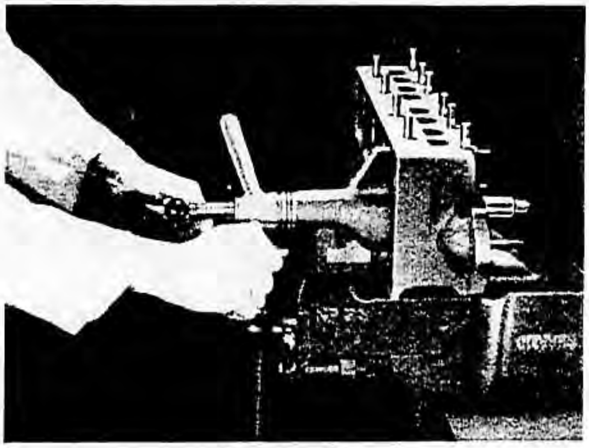


FIG. 113 REPLACING VALVE GUIDE USING SERVICE TOOL MF60A

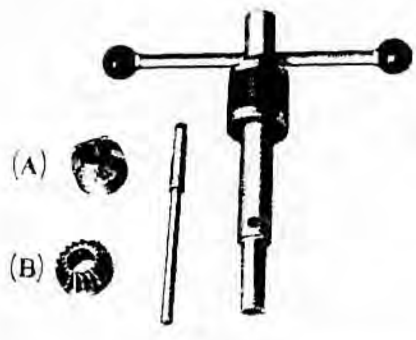


FIG. 114 VALVE SEAT SERVICE KIT

VALVE GUIDES

Should excessive wear necessitate the replacement of valve guides, the used guides should be removed and the replacements fitted in one operation by utilising Service Tool MF60A. The valve guides are drawn in from below the underface of the combustion head until they are 0.5" (12.7 mm.) inlet; 0.32" (8.128 mm.) exhaust below the rocker cover mounting face on top of the combustion head.

Important.—Whenever a new valve guide is fitted the valve seat must be recut to ensure concentricity.

FIG. 116 REMOVING VALVE SEAT INSERT SERVICE TOOL MF540

VALVES AND VALVE SEATS

Remove all carbon from each head and stem. Examine seating faces. Valves and seats which have been extensively worn should be replaced.

Refacing Valve Seats

It is particularly important with the compression ignition engine to ensure that there is no compression loss through badly seating valves. For this reason it is strongly recommended that both valve seats and cylinder head seatings are always faced with the appropriate cutters—removing only sufficient metal to confirm that there is an even seat without distortion—before proceeding to "grind-in" the valves with a fine paste.

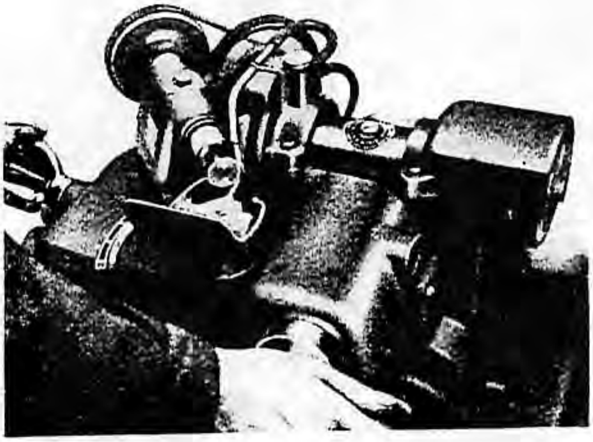


FIG. 115 REGRINDING VALVES

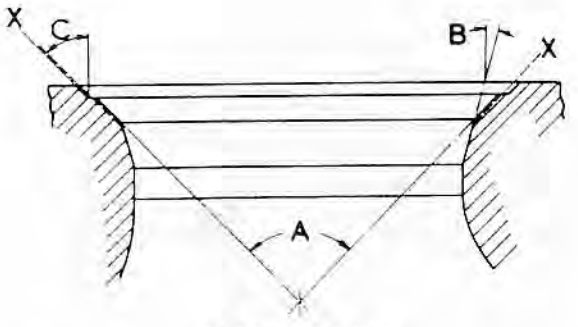
It is also necessary to recut a seat if a new valve guide has been fitted.

Note.—The least possible amount of steel should be removed from valve seats, consistent with the removal of pitting and distortion. A valve should be discarded if refacing treatment reduces the head thickness above the seating below $\frac{1}{32}$" (1 mm.). If the head is too thin the edges are apt to curl up when the valve becomes hot.

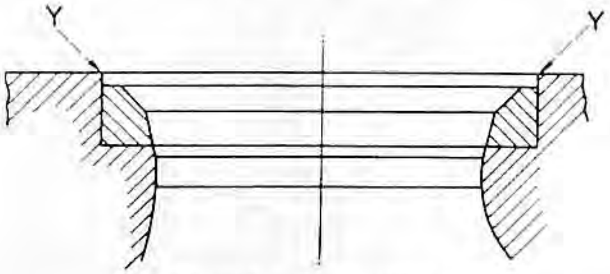
To facilitate cutting cylinder head seats, it is advisable first to skim **lightly** the top face, using Glaze Breaker 317G-22, see Fig. 114, to remove the hard surface produced by the hammering of the valves.

Inlet Valve Seat Inserts

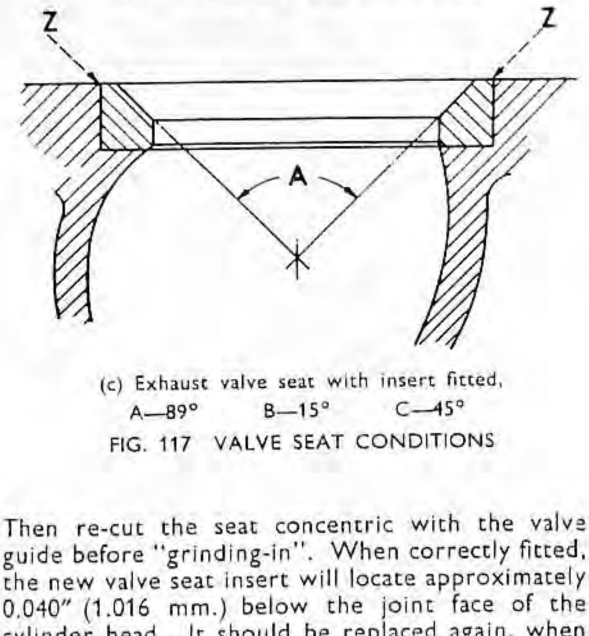
The maximum amount which can be removed from the seat is such that only a perceptible "step" remains, as shown by the dotted line "X" at (a), Fig. 117. If the amount removed is insufficient to produce a gas-tight seal between valve and seat, then it will be necessary to bore out the old seating, using Service Tool 6056 with suitable adaptor and fit a new valve seat insert, as shown at (b), Fig. 117.



(a) Inlet valve seat.



(b) Inlet valve seat with insert fitted.



(c) Exhaust valve seat with insert fitted.

A—89° B—15° C—45°

FIG. 117 VALVE SEAT CONDITIONS

Then re-cut the seat concentric with the valve guide before "grinding-in". When correctly fitted, the new valve seat insert will locate approximately 0.040" (1.016 mm.) below the joint face of the cylinder head. It should be replaced again, when after further servicing, a 45° cutter contacts the point "Y" Fig. 117 (b).

To provide sufficient clearance between the head of the valves and piston crowns, the inlet valve seats are machined approximately 0.040" (1.016 mm.) below the cylinder head joint face.

Exhaust Valve Seat Inserts

The existing valve seat inserts can be withdrawn for renewal if required, using Service Tool MF540; it is recommended that the head is heated to permit the inserts to be withdrawn more easily. When refitting inserts use Service Tool MF6057 with the appropriate adaptor to ensure that the inserts are placed squarely in position. Peen over the outer edge and finally reface with a 45° cutter. The insert must not be cut beyond the point "Z", Fig. 117 (c).

Important.—In cases where both the valve and seat have been re-cut to their maximum limits, the valve will in consequence sink too deeply into the cylinder head. The dimension between the top of the valve and the cylinder head joint face must not exceed 0.1" (2.54 mm.). Dimensions in excess of this figure will necessitate the renewal of either, or both, valve seat insert and valve.

Valve Grinding

After all valves, valve guides and valve seats have received attention, each valve should be ground-in to its seat.

Proceed as follows:

1. Mount cylinder head on wooden blocks with combustion chambers uppermost.

FIG. 118 VALVE GRINDING

2. Insert one valve into its guide, and lightly coat the bevelled face with grinding paste, the grade of paste depending on the condition of the seat.
3. Using rubber suction type grinding tool at even pressure, rotate valve back and forward as shown in Fig. 118.
4. To ensure even grinding lift valve and press down in another position.
5. Proceed, examining valve at intervals, until a smooth dull ring forms around seating face.
6. Carefully clean all grinding paste from valve and seat. Coat valve seating with a thin film of mechanics blue or other suitable colouring, and

start by pressing down on to seating, **turning very slightly.** Lift valve and examine; a true seat will be indicated by a thin unbroken line corresponding to the dull ring already observed.

7. Repeat for remaining valves.

Precautions Before Re-assembly

Before re-assembling the ground-in valves, all traces of paste should be removed from the valve head, stems and seats in the cylinder head. Ensure that no paste remains in the valve guide bores by dipping valve stems in petrol and passing up and down in the guides.

1. Insert valves in correct guides and mount cylinder head with valve stems uppermost on Service Fixture MFB9, with appropriate seating plate.
2. Assemble each valve by placing springs and collars over stem, compress springs, refit split cones and allow springs to expand.

At this point the Rocker Assembly and Combustion chambers maybe serviced if required. See page C112.

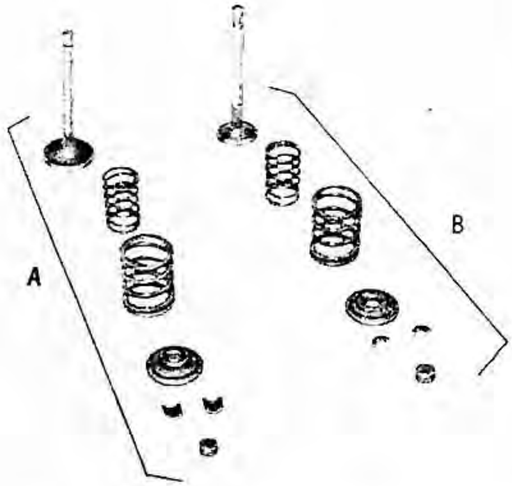


FIG. 119 VALVE ASSEMBLIES A. INLET B. EXHAUST

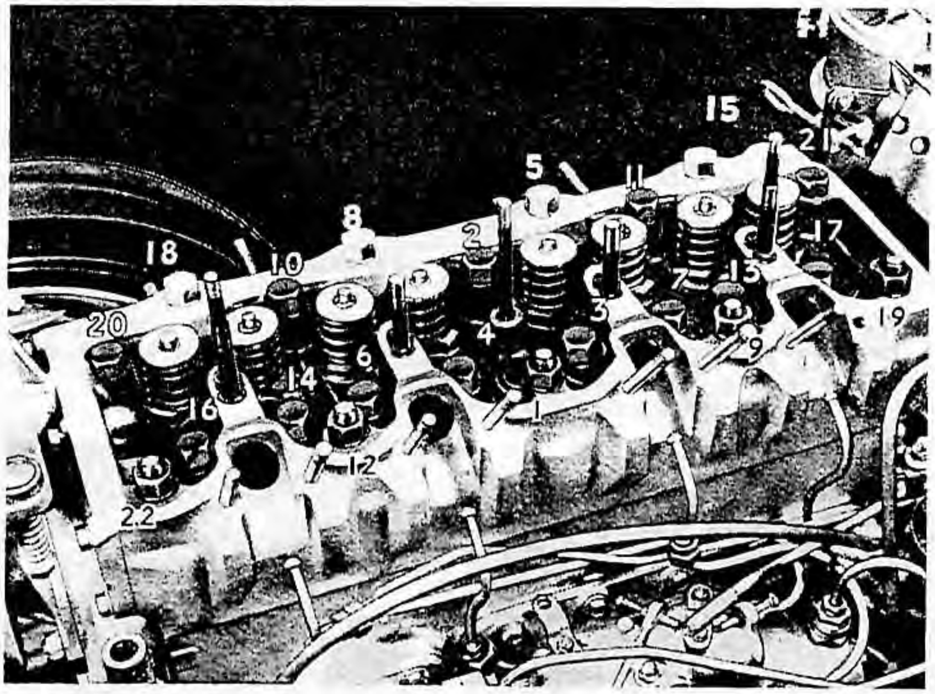


FIG. 120 ORDER OF TIGHTENING CYLINDER HEAD SET SCREWS

REPLACEMENT OF CYLINDER HEAD ASSEMBLY

1. Remove all rags.
2. Carefully locate new cylinder head gasket accurately over cylinder block studs WITH **"TOP"** MARK UPWARDS, *i.e.*, copper face downwards.
3. Check that pre-combustion chambers are correctly located in their bores in the cylinder head. Remount cylinder head, and tighten set screws and nuts gradually in the order recommended in Fig. 120, to a torque loading of 90-105 lb.ft. (12.4-14.5 kg.m.).

Precaution.—Before fitting the push rods and rocker shaft assembly, IT IS MOST IMPORTANT THAT ALL TAPPET ADJUSTERS ARE SLACKENED BACK COMPLETELY. Because of the small clearances between valves and pistons, serious damage can result from turning the engine if this precaution is not observed.

4. Insert push rods in their original bores. See that they are located correctly in tappet block.
5. Position caps over respective valve ends. Larger caps fit on exhaust valves, smaller caps on inlet valves.
6. Locate rocker ends on valve stems and ends of adjusting screws in push rod cups. Replace nuts and washers on pedestals and tighten down firmly.
7. Adjust inlet and exhaust valve clearances to .008" (.203 mm.) exhaust and .012" (.305 mm.) inlet by means of rocker adjuster screws and lock nuts, as shown in Fig. 121.
8. Refit rocker cover and new gasket, and tighten nuts.

TO COMPLETE ASSEMBLY

1. Replace thermostat housing if previously removed from cylinder head.
   Refit thermostat, top hose, and water outlet elbow with new gasket.
2. Fit breather pipe.
3. Fit new manifold gaskets to cylinder head. Refit manifolds, inlet manifold first, and tighten nuts as shown in Fig. 122. Refit exhaust pipe with new gasket.
4. Connect air cleaner hose to inlet manifold.
5. Refit all injectors, using new copper washers, refit bridge pieces, **tighten both nuts down evenly,** torque loading 18-20 lb.ft. (2.5-2.8 kg.m.). Fit fuel return pipe and high pressure pipes to all injectors.

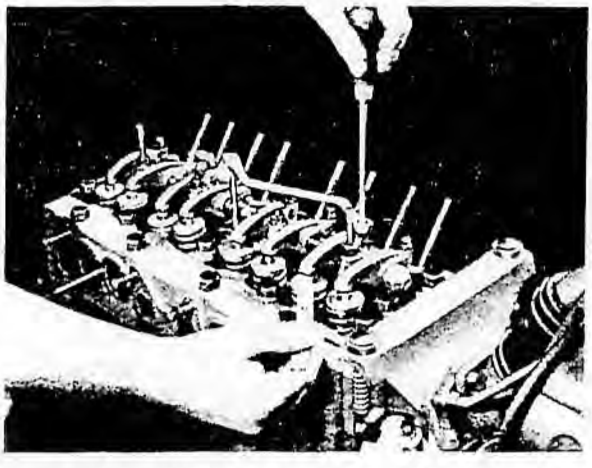


FIG. 121 SETTING VALVE TIP CLEARANCES

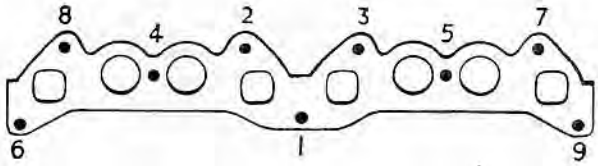


FIG. 122 ORDER OF TIGHTENING MANIFOLD NUTS

6. Remount main fuel tank, fitting rubber mounting pads between tank brackets and battery carrier, and entering fuel return pipe carefully into fuel tank.
7. Remount reservoir tank with pipes, fitting rubber mounting pad between main fuel tank bracket and reservoir tank mounting plate. Reconnect pipes between reservoir tank and main fuel tank; reservoir tank and fuel filter; and reservoir tank and Thermostart.
8. Reconnect lead from starter switch at Thermostart.
9. Reconnect battery lead.
10. Close drain taps and refill radiator.
11. De-aerate fuel system in accordance with instructions, see Fuel System, Section E.
12. Start up engine and check system for leaks, etc. Replace hood.

ROCKER SHAFT ASSEMBLY

This is serviced as follows:

To Dismantle

Drift the Mill's pin from the collar at each end of the shaft and remove both collars. Withdraw the locating screw from the rear pedestal and remove all components from the shaft.

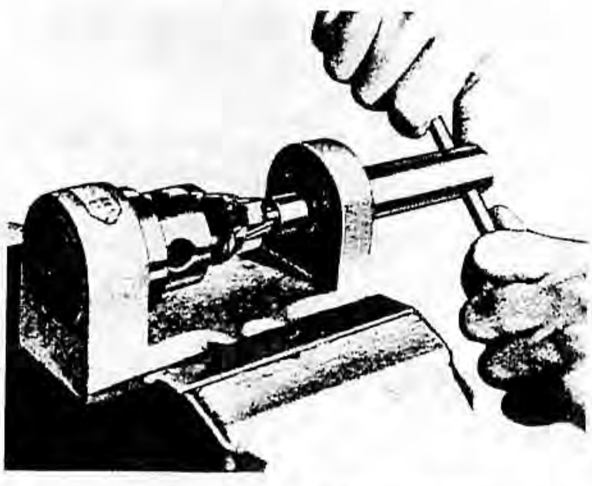


FIG. 123 REAMING ROCKER BUSHES
REAMER AND ADAPTOR MF125. FIXTURE No. 6100

To Renew Rocker Bushes

Drift out worn and unserviceable bushes. After aligning the oil feed holes, press the new bush into position and, using Service Tool MF125 with 6100 fixture, ream the new bush, as shown in Fig. 123.

To Assemble

Locate the rear pedestal on the shaft and, after aligning the locating hole in the shaft with the tapped hole in the pedestal, insert and tighten the screw. Assemble the remaining parts and insert a Mill's pin through each end collar.

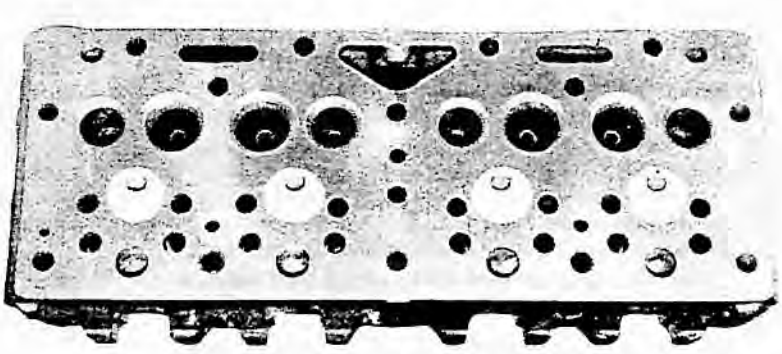


FIG. 125 SHOWING SWIRL CHAMBERS POSITIONED IN COMBUSTION HEAD

RICARDO SWIRL CHAMBER (Fig. 124.)

The Ricardo Comet Mk. V swirl chamber is comprised of two parts. The upper portion, containing the port for the injector, is cast in the combustion head, whilst the lower portion, which incorporates the gas port, is a dowel-located press fit. Replacement of this lower part will be necessary when the edges of the gas port are burnt and the throat area is thus increased.

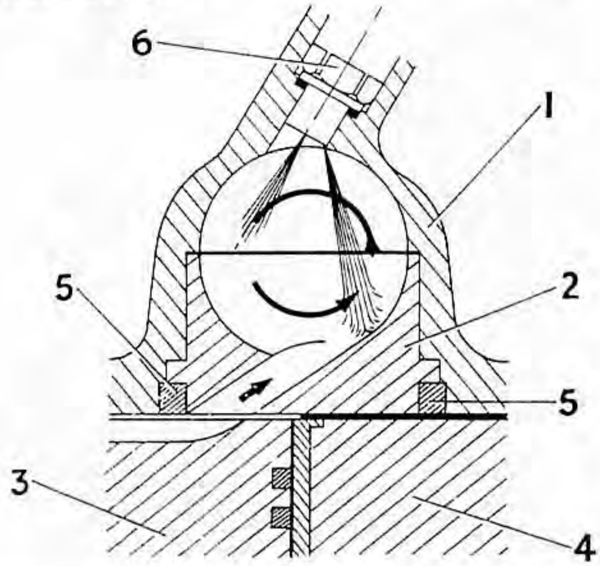


FIG. 124 SECTION THROUGH THE RICARDO COMET MK. V SWIRL CHAMBER

1. Cylinder head and upper half of swirl chamber.
2. Lower half of swirl chamber.
3. Piston.
4. Cylinder Block.
5. Dowels.
6. Fuel Injector.

Removal

The lower half of the swirl chamber can be drifted out of the combustion head by use of a curved $\frac{1}{4}''$ (6.35 mm.) diameter bar inserted through the injector port.

Replacement

Locate the swirl chamber dowel in a corresponding groove in the combustion head and press the chamber squarely into its housing. Check to ensure that the surface is flush or just below the cylinder head face.

TAPPETS AND PUSH RODS

The mushroom shaped tappets can only be extracted through the crankcase when the sump and camshaft have been removed. After removal, examine each tappet in turn.

FIG. 126 TAPPETS

Face markings illustrated "B" Fig. 126 illustrate that the tappet has not been turning in its bore, while that illustrated "A" indicates satisfactory turning, thus ensuring even wear and satisfactory rocker adjustment. Tappets which have not been turning should either be renewed or relocated in another bore where satisfactory rotation has taken place. If a push rod is bent or has a worn seating, it should be replaced.

CAMSHAFT AND TIMING MECHANISM

TO REMOVE AND REPLACE CAMSHAFT

Removal of Timing Cover

1. Support engine at rear of sump using Trolley Jack with cradle Pt. 63 located either side on the sump flange, as shown in Fig. 143. Remove hood together with front axle and radiator assembly. See page C.124.
2. Remove fan belt and fan, which is secured to the fan pulley by 4 set screws with lockwashers.

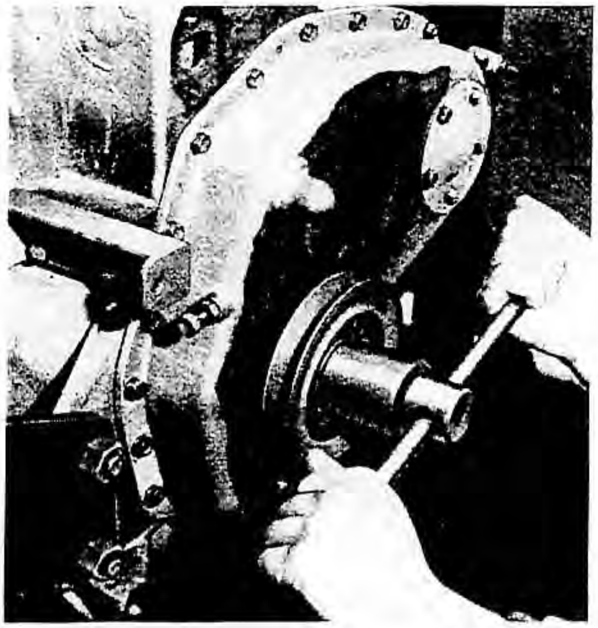


FIG. 127 REMOVING STARTER JAW (SERVICE TOOL MFB16)

FIG. 128 REMOVING CRANKSHAFT FRONT OIL SEAL USING SERVICE TOOL MF44B WITH HANDLE No. 550

3. Remove starter dog with shim pack using Service Tool MFB16, with long lever. Bend back the tabs of the starting dog locking plate and then proceed to strike the lever to slacken the starter dog.
4. Withdraw the pulley from the front end of the crankshaft and remove Woodruff key.
5. Remove sixteen set screws and lockwashers from flange of timing cover. Withdraw the bolt and lockwasher from centre of timing cover and pull timing cover and gasket free from the two locating dowels.
6. The timing cover houses the crankshaft front oil seal which should be replaced as a matter of routine during engine overhaul.

Removal and Replacement of Crankshaft Oil Seal

1. The crankshaft front oil seal situated in the timing cover can be removed with the aid of Service Tool MF.44B and Universal Handle No. 550. See Fig. 128.
2. Fit new oil seal, lip inwards, using replacer adaptor MF.103A. Do not use undue force otherwise the seal will be damaged and the bore in which it seats will be distorted.

OPERATION OF THE CHAIN TENSIONER

The hydraulic self-adjusting chain tensioner fitted to the non-driving side of the chain, is designed to make light contact with the latter and damp out any side thrash. The construction and operation is shown in Fig. 129.

Oil entering at (2) from the front main bearing housing fills up the inside of the body (1) and then forces out the inner cylinder (4) and with it the plate (5) to which it is attached. The composition block (6) being bonded to the plate (5) is thus forced into contact with the timing chain.

As the inner cylinder is moved out under hydraulic pressure, the pin (8) attached to it contacts the smooth edge of a helical slot formed in the adjuster (11). This, combined with the influence of the spring (7) which is interposed between the adjuster and inner cylinder, causes the adjuster to rotate.

When hydraulic pressure is released, the pin (8) is moved against the serrated edge of the helical slot and prevents the inner cylinder (4) from returning to its original position in the bore. The chain therefore, is always tensioned and, as wear takes place, the adjuster overcomes this by rotating to a new position. Oil escaping from a bleed hole drilled through the bearing block and into the inner cylinder, serves to lubricate the chain and oil pump driving gears.

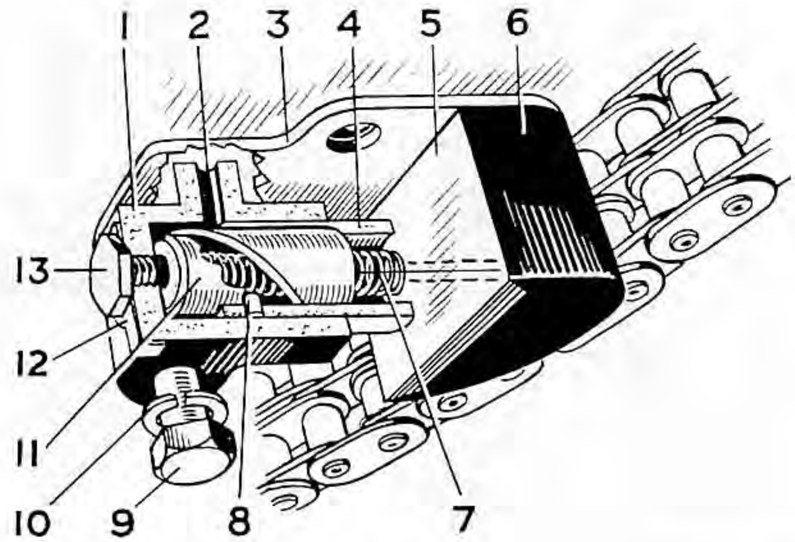


FIG. 129
OPERATION OF CHAIN TENSIONER

1. Hydraulic Chain Tensioner Body.
2. Oil Inlet Port.
3. Distance Plate.
4. Inner Cylinder.
5. Pressure Plate.
6. Composition Block.
7. Compression Spring.
8. Lock Pin.
9. Bolt, securing tensioner and distance plate to Cylinder Block.
10. Lock Washer.
11. Adjusting Cylinder.
12. Lock Plate.
13. Blanking Screw.

Removal and Replacement of Chain Tensioner

Removal

Release the tab washer and remove the screwed end plug (13). Insert a No. 4 Allen key as shown in Figure 130 and turn inner cylinder clockwise, thus releasing the chain tension. Remove the chain tensioner and backing plate after unscrewing the attachments (9) and (10).

Re-assembly and Replacement

With the blanking plug (13) and the lock plate (12) removed, insert a No. 4 Allen key into the housing (1) through the screwed plug hole and assemble the adjuster (11) on to the Allen key, followed by the spring (7) and the inner cylinder assembly (4). Rotate the Allen key anti-clockwise and simultaneously push the components into the bore of the housing.

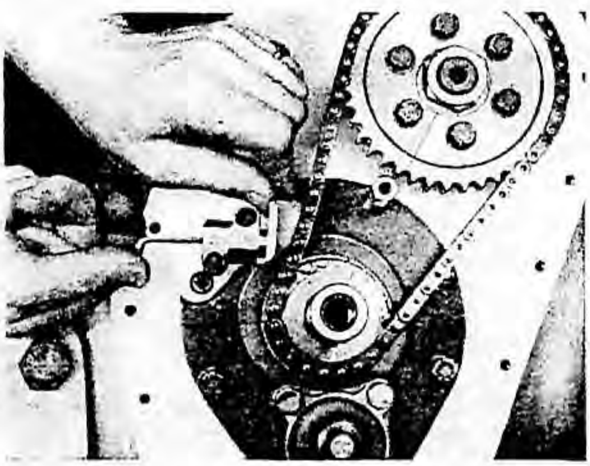


FIG. 130. SETTING THE CHAIN TENSIONER

Without releasing this assembly, offer it and the plate (3) up to the front face of the cylinder block and, after securing it with the bolts (9) and lock washers (10), adjust the tensioner by turning the Allen key clockwise sufficiently to take up the slack, as shown in Fig. 130. Finally fit the screwed end plug and tab washer to the body and turn up the locking tabs.

REMOVAL OF CAMSHAFT

1. Temporarily refit starting handle jaw to facilitate turning the engine.
2. Set the crankshaft key at 3 o'clock, this will position Nos. 1 and 4 pistons 90° anti-clockwise from T.D.C. and ensure no damage can be done by valves striking the pistons while the timing chain is off.
3. Draw off oil deflector and oil pump driving gear from the crankshaft key.
4. Extract Mill's pin and withdraw oil pump driven gear from the pump spindle. The oil pump assembly can now be removed if required—4 set screws on lockwashers. See page C.102.
5. Remove chain tensioner. See above.
6. If the camshaft chainwheel has to be extracted separately without its centre, first confirm that the chainwheel and centre are marked as indicated in Fig. 131, if not, mark both parts with punch dots as shown, otherwise resetting will be necessary. However, should the timing chain be renewed, resetting will probably be required, see "Camshaft Chainwheel and Centre", page C.118.
7. Bend forward corners of locking washer and remove camshaft chainwheel, 6 set screws on lock and flat washers, and timing chain.
8. The crankshaft chainwheel can now be withdrawn if so desired.

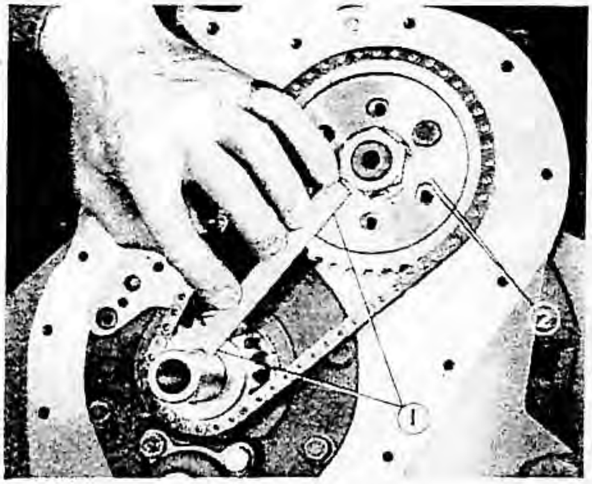


FIG. 131 TIMING MARKS
1. Scribed Lines 2. Centre Punch Marks

9. Remove fuel tank, rocker cover, rocker shaft assembly and lift out push rods.

10. Remove fuel injection pump and drive housing, first ensuring that a scribed line on the top of the injection pump mounting flange is transferred to the drive housing flange. Then remove three attachment nuts with lockwashers and withdraw the pump, joint washer and quill shaft from the drive housing. Remove the six attachment bolts with lockwashers, and withdraw the drive housing from the locating dowels. The amount of drive gear backlash is controlled by one or more joint washers, which are available in two thicknesses. Therefore a note should be made of the quantity and thickness of those removed so that correct replacements can be fitted on re-assembly.

Note.—The quill shaft which couples the shaft to the engine is mated with the pump with which it is supplied, and is not interchangeable. At Engine Serial No. SJ 33286, a quill shaft providing a shear section to give protection to the pump drive gears and camshaft in the case of injection pump failure, was introduced. Provision is made for these later quill shafts to be fitted to earlier pumps—consult your CAV agent.

11. Remove injectors, high pressure fuel pipes, spill pipes and breather pipe.

12. Remove tappet cover assembly. To prevent the tappets dropping into the engine while the camshaft is taken out, fit clips MF140 over each tappet as shown in Fig. 132. On the front tappet the shorter leading edge of the clip should be towards the cylinder block.

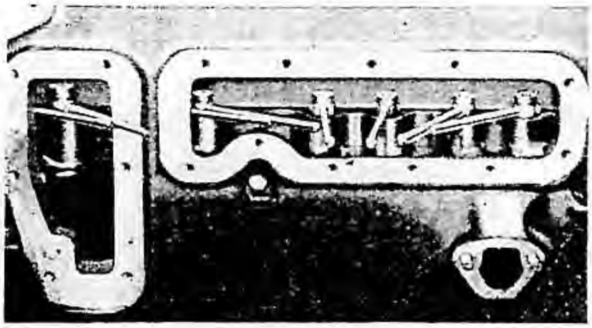


FIG. 132 RETAINING TAPPETS BY CLIPS MF140 WHILE CAMSHAFT IS REMOVED

13. Unscrew the two bolts securing the front camshaft bearing to the cylinder block, and remove the lockwashers. The camshaft can now be withdrawn.

14. With camshaft held in a soft jawed vice, chainwheel centre and front bearing can now be drawn off, after bending back tab washer and removing lock nut. Collect the Woodruff key.

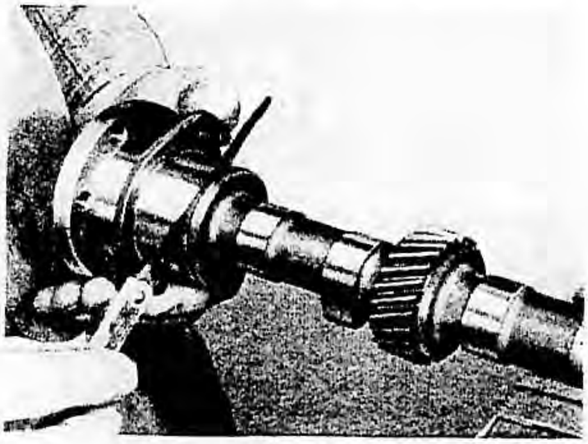


FIG. 133 FRONT CAMSHAFT BEARING END-FLOAT

Re-assembly

1. After lubricating the front bearing sleeve, slide this on to the front camshaft journal and ensure that it is free to rotate. Next insert the two set screws into the front camshaft bearing, as shown in Fig. 133 and after inserting the Woodruff key, fit the driving hub, followed by the lock plate and the securing nut. With the camshaft held in a soft jawed vice, tighten the securing nut and check the front bearing end float, which should be between 0.004" and 0.006" (.102-.152 mm.), as shown in Fig. 133. If there is insufficient end float with a new bush, it should be removed and carefully rubbed down on emery cloth, until the correct end float is obtained. Finally secure the nut by turning the lock plate tabs.

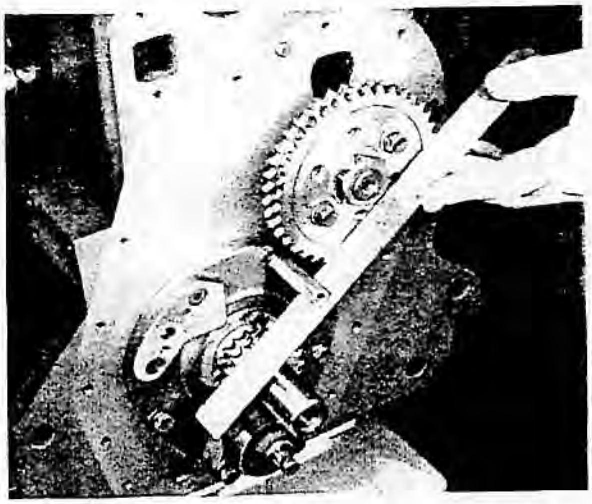


FIG. 134 CHECKING ALIGNMENT OF TIMING SPROCKETS

2. After lubricating the bearings, the camshaft can now be replaced in the cylinder block with front bearing oil holes downwards and the two front bearing attachment bolts tightened down.

3. Remove tappet retaining clips, replace push rods, locating ball ends in tappet cups; refit tappet cover assembly.

4. Loosen off adjusters and replace rocker gear.

If any of the chainwheels have been renewed, remove crankshaft chainwheel key then temporarily refit chainwheel by itself. Check crankshaft chainwheel alignment by placing a straight edge across the front faces of the wheels—see Fig. 134. Adjust by adding or subtracting shims behind the crankshaft chainwheel. Refit crankshaft chainwheel complete with key.

5. Reset valve timing. See this page.

6. Refit oil pump driven gear and secure with pin.

7. Refit oil pump driving gear over key and oil deflector, concave outwards.

8. Replace injector pump and drive housing with timing marks aligning as recorded during dismantling. Ensure that correct thickness of joint washers is fitted between the drive housing and crankcase. Steel shims, .006" (.15 mm.) and .010" (.25 mm.) thick respectively are available for adjustment of meshing of the gears, these are not subject to compression when tightening bolts, and the procedure of adjusting backlash is therefore simplified. It is recommended that these steel shims are fitted as replacements for the paper gaskets fitted on earlier assemblies. It will, however, be necessary to fit a paper gasket at each side of the steel shim pack to provide an oil seal.

9. Replace fuel pipes, injectors etc.

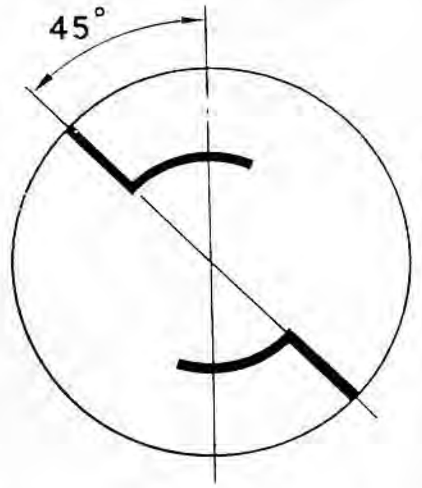


FIG. 135 ARRANGEMENT OF STARTER JAW FOR BEST CRANKING POSITION

10. Fit timing cover and gasket. These can be guided into position by means of two $\frac{5}{16}$" diameter pegs—$2\frac{1}{2}$" long, and threaded $\frac{5}{16}$" N.C. on end, fitted in the cylinder block at opposite ends of the timing cover flange. Tighten top and bottom fixing screws on either side of the dowels first.

11. Replace pulley, fan belt and fan, locating balance piece with "BALANCER" to the front and with drilled holes in line. Note that fan blades should be to the rear of central mounting plate.

12. Replace starter jaw, shimming as necessary to present the easiest position for cranking the engine as shown in Fig. 135.

13. Replace fuel tank, front axle, radiator assembly etc.

VALVE TIMING

Warning.—It is important that before timing operations commence the pistons should be set mid-way up the cylinder bores, *i.e.*, 90° anti-clockwise from T.D.C., otherwise due to the very small operating clearances between the valves and piston crowns at T.D.C., serious damage can be caused during timing operations.

A. The following procedure assumes that the adjacent teeth of the camshaft and crankshaft chainwheels are marked as shown in Fig. 131.

1. First ensure that Nos. 1 and 4 pistons are positioned 90° anti-clockwise from T.D.C. Temporarily remount starter jaw to facilitate turning the engine.

2. To facilitate rotating the camshaft, fit Service Tool MF.117 on face of camshaft centre and set valve tip clearances to .012" (.305 mm.) inlet and .008" (.203 mm.) exhaust.

3. Turn camshaft until both valves of No. 1 cylinder are fully closed and those of No. 4 cylinder are just open. Then remove camshaft rotating tool.

4. Turn crankshaft clockwise through 90° and set keyway accurately at B.D.C. thereby bringing Nos. 1 and 4 pistons to T.D.C. Note also that the centre line on the key passes straight through the tooth diametrically opposite.

5. Fit chain, securing camshaft chainwheel to centre, with punch dots coinciding, by means of six set screws on flat and lockwashers, accurately aligning scribe marks on crankshaft and camshaft chainwheels as shown in Fig. 131.

6. Ensuring that all the slack links in the chain are on the chain tensioner side, refit chain tensioner and adjust, see page C.115.

7. Recheck alignment of timing marks, see "Camshaft Chainwheel and Centre" below.

B. The following procedure assumes that neither crankshaft nor camshaft chainwheels nor the camshaft centre are marked as shown in Fig. 131.

1. First ensure that Nos. 1 and 4 pistons are positioned 90° anti-clockwise from T.D.C. Temporarily mount starter jaw to facilitate turning the engine.

2. To facilitate rotating the camshaft, fit Service Tool MF117 on face of camshaft centre.

3. Set inlet and exhaust valves on No. 4 cylinder for setting purposes only to:
   Inlet .025" (6.35 mm.)
   Exhaust .023" (5.95 mm.)
   Set clearances with caps in position.
   Increasing the gap clearance from the standard prevents the valves from being held open 10½° at T.D.C. on the exhaust stroke and the gaps specified have been calculated so that at T.D.C. the inlet valve will be on the point of opening and the exhaust valve on the point of closing and the exact position for the camshaft, *i.e.*, as the valves rock, is therefore easy to establish.

4. After setting valve tip clearances rotate the camshaft until the valves of No. 4 cylinder are on the "rock", this position will have been reached when both push rods are equally loaded or nipped, and can be rotated. The camshaft is now phased for No. 1 piston at T.D.C. of firing stroke.

5. Carefully remove camshaft rotating tool.

6. Bring Nos. 1 and 4 pistons to T.D.C. by turning the crankshaft clockwise until the arrow on the flywheel is aligned with a similar mark on the cylinder block, and the camshaft sprocket key is accurately set at B.D.C.

   Note.—The centre line of the keyway passes straight through the middle of the tooth directly opposite.

7. Offer up the timing chain and sprocket wheel taking care not to disturb the camshaft setting.

A position must now be found wherein the camshaft chainwheel can be secured to its centre, with the chain rollers seating snugly, without strain, between the engaging chainwheel teeth.

8. Select this position by swivelling the camshaft chainwheel within the chain, until, with the above conditions applying, the positive locating screw hole aligns with one of the six holes in the chainwheel centre. During this operation, ensure that all the slack links in the chain are on the chain tensioner side. Record the correct position by marking chainwheel and centre as shown in Fig. 131. Fit remainder of screws over flat and lockwashers.

9. Mark camshaft and crankshaft chainwheels as shown in Fig. 131.

10. Fit chain tensioner, see page C.115.

11. Recheck alignment of timing marks.

12. Set all cylinders, including No. 4 to .012" (305 mm.) inlet and .008" (.203 mm.) exhaust.

CAMSHAFT CHAINWHEEL AND CENTRE

It will be found, on well-run-in engines, that tensioning of the timing chain will tend to misalign the original timing marks owing to the chain having stretched and "bedded-in".

To cater for this and allow for variations in chain length both in production and when fitting a service replacement, the chainwheel is secured to its centre by fixing screws and their spacing allows for 1½° stages of vernier adjustment. The chainwheel has one positive hole and five elongated slots, punch dots as shown in Fig. 131, indicate the relationship.

Note.—Adjustment to the camshaft chainwheel and centre relationship will tend to alter the injection pump timing. Check and adjust in accordance with separate instructions.

PISTONS, CONNECTING RODS AND LINERS

REMOVAL OF PISTONS AND CONNECTING RODS

Preliminary Dismantling

1. Drain oil sump, radiator and cylinder block water jacket.

2. Remove:
   (a) Hood, main fuel tank, rocker cover, rocker shaft assembly and push rods. See page C.107.
   (b) Cylinder head.

3. Remove filter and gasket from sump, six nuts from studs with lockwashers.

4. Remove sump with gasket, 20 set screws with lockwashers. Remove oil suction pipe.

Release lockplates and unscrew the big-end bolts. Remove each piston and liner as an assembly by pushing its con-rod out through the top of the cylinder liner bore. Replace the bearings and caps to their respective con-rods. If required, the pistons and con-rods can be removed without disturbing the cylinder liners.

Important.—If the pistons, liners and bearings are likely to be assembled for further use, it is most important that these components again occupy their original positions. Therefore, to enable this to be accomplished, suitably mark these items before they are completely dismantled.

Having withdrawn each piston from its cylinder liner, remove the circlips from each end of the gudgeon pin and push the gudgeon pin out of the piston, thus releasing the latter from the con-rod.

PISTON ASSEMBLIES

The piston has been so designed that at working temperature the gudgeon pin is fully floating in the connecting rod bush and piston. Consequently, at normal room temperature the fit of the gudgeon pin in the piston will be very tight. To facilitate refitting gudgeon pins, an approximation to engine working temperature must be brought about, so that the piston will expand sufficiently to enable an easy insertion of the gudgeon pin. Accuracy of piston fit in cylinder liner is ensured by grading these components in three sizes, stamped either "F", "G" or "H", which is marked on the piston crown and on the side of the liner.

A piston should on no account be fitted in a liner of different grade, although it is, of course, permissible to use paired pistons and liners of different grades in the same engine.

PISTON RINGS

Each piston carries three compression rings and one compound oil control ring, all mounted above the gudgeon pin. The top ring groove is occupied by a chromium plated full-faced compression ring and the next two lower ones by tapered compression rings. To facilitate their correct assembly, the tapered periphery of these rings is stamped with the letter "T" which must be placed towards the crown of the piston.

The Wellworthy Duaflex oil control ring fitted to the bottom groove above the gudgeon pin, is a multi-ring assembly comprising five components.

The crimped rail which is positioned between the second and bottom horizontal rail, whilst exerting sufficient pressure to push the outer members against the limiting sides of the groove, also allows the oil wiped from the cylinder bores to pass through holes in the piston skirt.

The expander rail, positioned vertically between the horizontal rails and the inside of the piston ring groove, applies radial pressure to the horizontal rails, thus moulding them to the shape of the cylinder wall and centralising the piston.

CONNECTING ROD ASSEMBLIES

Equalisation of Weights

The maximum permissible variation in connecting rod weights must not exceed 1½ ozs. (42.5 gms.).

A replacement must, therefore, match those fitted to within this limit. For identification purposes the connecting rods are stamped with a code letter indicating their approximate weight.

Codes, "T", "U", "X", "P", "Q", "S" ; each letter indicating a weight range in 1½ ozs. (42.5 gms.) increments between 3 lbs. 2½ ozs. and 3 lbs. 10 ozs. (1432-1644 gms.) and replacements will normally be the same grade letter as those already fitted.

However, since rods in production are selected to within 4 drachms, while replacements although of the same weight grade will only be to within 1½ ozs. it may be necessary, on the first change to compensate for this situation by removing each connecting rod assembly, then weighing them and re-arranging them as follows:

No. 3 Cylinder	—	Heaviest
No. 4 Cylinder	—	Next Heaviest
No. 1 Cylinder	—	Next Heaviest
No. 2 Cylinder	—	Lightest

Any re-arrangement of the rods must be recorded by removing the existing cylinder number from the rod and caps and re-numbering, adding the letter "W" to indicate the presence of a service replacement.

Fine adjustment to connecting rod weights is obtained by removing metal off the web on the cap.

DISMANTLING AND RE-ASSEMBLY OF PISTONS AND CONNECTING RODS

Piston Assembly

After removal of assemblies proceed as follows:

1. Remove piston rings.
2. Scrape off carbon and wash in paraffin. Pay particular attention to the piston ring grooves and oil return holes.
3. Using piston ring Gauge MF185 check the fitted gap of all rings with a feeler gauge as follows:
   (a) Check that the ring gap is free from carbon.
   (b) Place ring gauge on a flat metal surface plate and press ring into the gauge against the plate so that the ring is square in the bore.
   (c) The gap of a new ring should be within .012"-.017" (.305-.432 mm.). If the gap exceeds .029" (.737 mm.) the ring must be scrapped.

   Important.—Ring gaps cannot accurately be gauged in the liner bore. The liners are manufactured within limits and are graded; piston rings are made to a nominal size and the gaps can only be measured with accuracy in the correct ring gauge.
4. Replace rings ensuring that tapered compression rings are fitted with "T" mark upwards.

FIG. 136 CHECKING PISTON RING GAP USING RING GAUGE MF185

Removing and Replacing Gudgeon Pin Bush

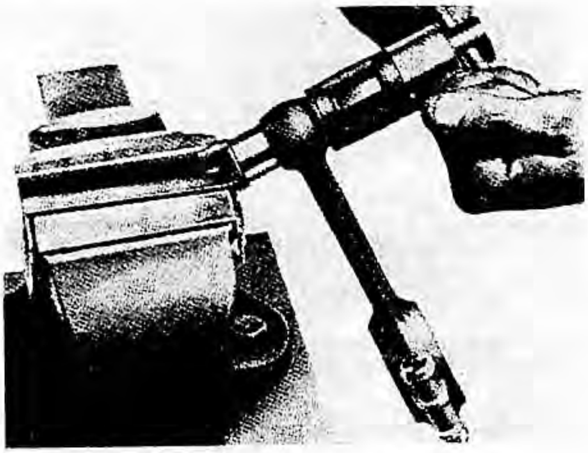


FIG. 137 RENEWING GUDGEON PIN BUSH. SERVICE TOOL MF6201 WITH ADAPTORS

In addition to examining visually the connecting rod for damage, the small end bush should be checked for condition and the fit of its gudgeon pin. Should renewal of the bush be necessary, proceed as follows:

1. Using Service Tool MF6201, with adaptors 9 and 10 mounted in a vice as shown in Fig. 137, remove old bush by pressing the replacement

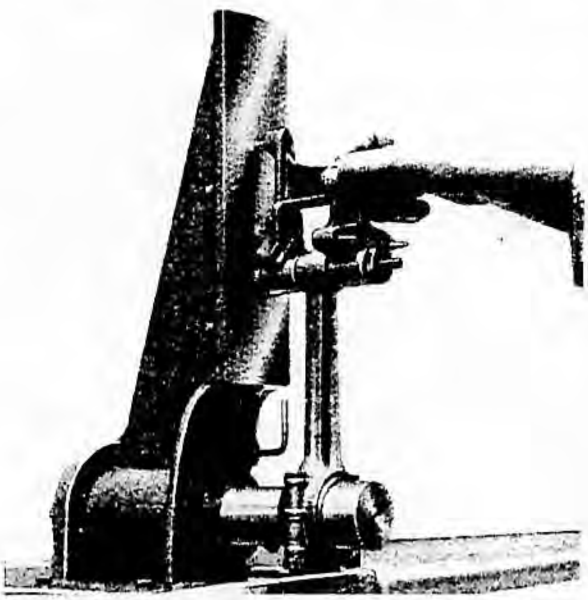


FIG. 138 CHECKING ALIGNMENT OF CONNECTING ROD WITH ALIGNING JIG No. 335, ARBOR MF335A, DUMMY GUDGEON PIN AND INDICATOR No. 6202

into position. The oil hole in the new bush must first be carefully aligned with the drilling feed in the shank of the connecting rod.

2. Treat remaining rods similarly, each time making sure that the bush previously withdrawn has been extracted from the remover.

Before reaming new gudgeon pin bushes it is essential to check the connecting rod for misalignment.

To Align Connecting Rods

A connecting rod dismantled from an engine should always be checked for straightness and alignment before re-assembly and also before attempting to ream a small end bush. Refer to Fig. 138.

1. Remove big-end bearing liners, wash connecting rod in paraffin and mount vertically on the largest diameter of Arbor MF335A.
2. Fit coned ended halves of Dummy Gudgeon Pin No. 6202, into each side of the small end bush and secure on the threaded shaft by the thumb screws.
3. Place Indicator "Sealion" horizontally across Dummy Gudgeon Pin. Any misalignment in the vertical plane will be apparent between the surface plate of the jig and the indicator studs. By reversing the Indicator any misalignment in the lateral plane will be shown.
4. To correct a misaligned rod, locate the appropriate jaw of Wrench No. 30A, approximately centrally about the rod and bend or twist as necessary.

To Ream Gudgeon Pin Bush

It is essential that the connecting rod is first tested for misalignment and if necessary, correctly aligned, see above.

Using Fixture MF6200A and Reamer Set MF6200AD proceed as follows with reference to Fig. 139.

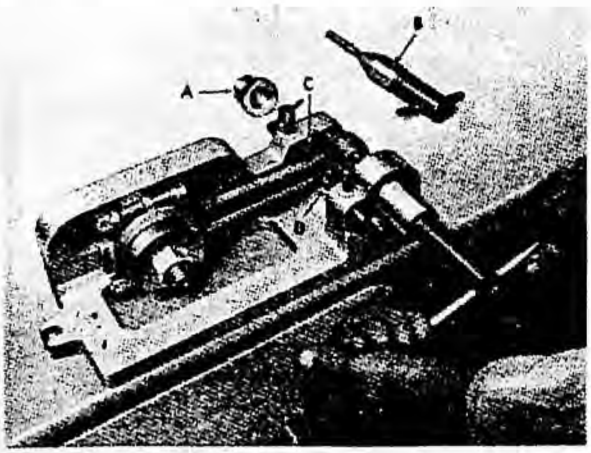


FIG. 139 REAMING GUDGEON PIN BUSH. FIXTURE 6200A WITH REAMER SET MF6200AD

1. Assemble connecting rod in fixture and secure nut adjoining angular collar, leaving nut at back of fixture finger tight.
2. Remove slip bush (A) and pass centraliser (B), with bearing surfaces oiled, through bushes of fixture and small end bush of connecting rod until there is a small even clearance between small end and centraliser.
3. Bring support (C) into contact with the small end boss of connecting rod (not the bush) and clamp.
4. Twist centraliser and at the same time apply as much forward pressure as possible.
5. Securely tighten nut at rear of fixture.
6. Bring support (D) into contact with the connecting rod and tighten clamp.
7. Remove centraliser.
8. Obtain reamer marked "ROUGH".
   Apply thin oil to pilots and insert reamer into bushes in fixture, Apply paraffin to cutting teeth and in the small end bush.
9. Proceed with the cut, applying a slight forward pressure until the cutting edge is protruding as far as possible through the small end bush, taking care that front of teeth do not foul the small bush in fixture. Then remove swarf from teeth and withdraw by continuing to turn in clockwise direction and applying a slight backward pressure. Take care that teeth are not damaged against the hardened steel bushes.
10. Repeat 8 and 9, using a reamer marked **"low"**.
11. Loosen nut adjoining angular collar and supports, swing up connecting rod and attempt to fit the gudgeon pin. If satisfactory, proceed with paragraph 17. Otherwise proceed to next paragraph.
12. If gudgeon pin was too tight, centralise again and repeat paragraphs 8 and 9, using **"low"** reamer a second time.
13. As paragraph 11.
14. If gudgeon pin was too tight, centralise again and repeat paragraphs 8 and 9, using **"high"** reamer.
15. As paragraph 11.
16. If gudgeon pin was still too tight, centralise again and repeat paragraphs 8 and 9 using a **"high"** reamer for a second time.
17. Remove connecting rod.

Great care and patience has been given to the sizes and design of these reamers and it is most important that the same is accorded to the reaming operation, to obtain the very accurate fit required by the gudgeon pin. A good fit can best be con-into position. The oil hole in the new bush must first be carefully aligned with the drilling feed in the shank of the connecting rod.

2. Treat remaining rods similarly, each time making sure that the bush previously withdrawn has been extracted from the remover.

Before reaming new gudgeon pin bushes it is essential to check the connecting rod for misalignment.

To Align Connecting Rods

A connecting rod dismantled from an engine should always be checked for straightness and alignment before re-assembly and also before attempting to ream a small end bush. Refer to Fig. 138.

1. Remove big-end bearing liners, wash connecting rod in paraffin and mount vertically on the largest diameter of Arbor MF335A.
2. Fit coned ended halves of Dummy Gudgeon Pin No. 6202, into each side of the small end bush and secure on the threaded shaft by the thumb screws.
3. Place Indicator "Sealion" horizontally across Dummy Gudgeon Pin. Any misalignment in the vertical plane will be apparent between the surface plate of the jig and the indicator studs. By reversing the Indicator any misalignment in the lateral plane will be shown.
4. To correct a misaligned rod, locate the appropriate jaw of Wrench No. 30A. approximately centrally about the rod and bend or twist as necessary.

To Ream Gudgeon Pin Bush

It is essential that the connecting rod is first tested for misalignment and if necessary, correctly aligned, see above.

Using Fixture MF6200A and Reamer Set MF6200AD proceed as follows with reference to Fig. 139.

FIG. 139 REAMING GUDGEON PIN BUSH. FIXTURE 6200A WITH REAMER SET MF6200AD

1. Assemble connecting rod in fixture and secure nut adjoining angular collar, leaving nut at back of fixture finger tight.
2. Remove slip bush (A) and pass centraliser (B), with bearing surfaces oiled, through bushes of fixture and small end bush of connecting rod until there is a small even clearance between small end and centraliser.
3. Bring support (C) into contact with the small end boss of connecting rod (not the bush) and clamp.
4. Twist centraliser and at the same time apply as much forward pressure as possible.
5. Securely tighten nut at rear of fixture.
6. Bring support (D) into contact with the connecting rod and tighten clamp.
7. Remove centraliser.
8. Obtain reamer marked "ROUGH".
   Apply thin oil to pilots and insert reamer into bushes in fixture, Apply paraffin to cutting teeth and in the small end bush.
9. Proceed with the cut, applying a slight forward pressure until the cutting edge is protruding as far as possible through the small end bush, taking care that front of teeth do not foul the small bush in fixture. Then remove swarf from teeth and withdraw by continuing to turn in clockwise direction and applying a slight backward pressure. Take care that teeth are not damaged against the hardened steel bushes.
10. Repeat 8 and 9, using a reamer marked **"low"**.
11. Loosen nut adjoining angular collar and supports, swing up connecting rod and attempt to fit the gudgeon pin. If satisfactory, proceed with paragraph 17. Otherwise proceed to next paragraph.
12. If gudgeon pin was too tight, centralise again and repeat paragraphs 8 and 9, using **"low"** reamer a second time.
13. As paragraph 11.
14. If gudgeon pin was too tight, centralise again and repeat paragraphs 8 and 9, using "**high**" reamer.
15. As paragraph 11.
16. If gudgeon pin was still too tight, centralise again and repeat paragraphs 8 and 9 using a "**high**" reamer for a second time.
17. Remove connecting rod.

Great care and patience has been given to the sizes and design of these reamers and it is most important that the same is accorded to the reaming operation, to obtain the very accurate fit required by the gudgeon pin. A good fit can best be con-

To Dismantle Drive Housing
Refer to Fig. 140.

(a) Withdraw the two screws (2) and lockwashers (3) and remove the blanking plate (4) from the front of the housing (1).

(b) Unscrew and remove the adaptor peg (5), lock washer (6) and plain washer (7), then withdraw the thrust piece (8) and the pump driving gear (9) from the rear of the housing.

(c) Remove the bolt (10), copper washer (11) and plain washer (12) from the front of the housing, then eject the idler gear shaft (13) rearwards. The idler gear (14) together with its bush (15) and two thrust washers (16) can be then withdrawn from the side of the housing.

(d) Unscrew the nyloc nut (17) from the end of the spindle (13) and remove the copper washer (18) and the "O" ring retainer (19). Remove the "O" ring (20) from the retainer if it is known to be defective.

(e) Complete the dismantling by pressing the pump drive gear bush (21) out of the housing.

To Re-assemble Drive Housing
Press the driving gear bush (21) into the housing (1). Install a new rubber "O" ring (20) on the retainer (19) and attach this to the threaded end of the spindle (13) with a nyloc nut (17) and copper washer (18).

Placing the dimpled side of each thrust washer (16) towards the idler gear, position one on the spindle against the "O" ring retainer and the other in a recess in the housing.

Insert the bush (15) into the idler gear (14) and position this in the housing with its larger boss to the front. Feed the idler gear spindle assembly into the housing from the rear and secure it at the front with the bolt (10), copper washer (11) and plain washer (12).

At this stage the backlash of the idler gear, which is specified as 0.004"-0.006", must be checked when in mesh with the camshaft gear. Proceed as follows:

(a) Locate the previously used joint washers (or their equivalent) on the mounting face of the cylinder block.

(b) Offer up the pump drive housing, locating it on two dowels and secure it firmly with two bolts.

(c) Check the backlash of the idler gear; it should just be felt but not to any marked degree. Adjust the backlash by the addition or subtraction of joint washers.

(d) Remove the housing from the cylinder block and observe the number of joint washers used.

Fit the pump drive gear into its bush, then feed in the thrust piece (8) so that the location hole aligns with that in the housing. Secure in position with the adaptor peg.

Fit injection pump in accordance with instructions on "Timing and Installation of Fuel Injection Pump", Section E.

USE OF DISMANTLING STAND

For all subsequent dismantling and assembly operations described in this section, the engine should be removed from the tractor. The use of the Tractor Dismantling Stand 27B—with suitable adaptors—is strongly recommended and will be assumed.

ENGINE REMOVAL AND REPLACEMENT

The figures in this section do not show the 23C Diesel Engine, they are, however, sufficiently typical to illustrate the correct use of the Dismantling Stands.

First Operation Figure 141.

1. Remove hood and exhaust pipe.
2. Disconnect lead from battery mounted under hood and remove battery. Drain radiator and cylinder block by opening drain taps and removing radiator filler cap.
3. Lay long rail Pt. 1 centrally beneath tractor, extending rearwards from just behind engine to transmission mounting flange and with rail link pins to the front.

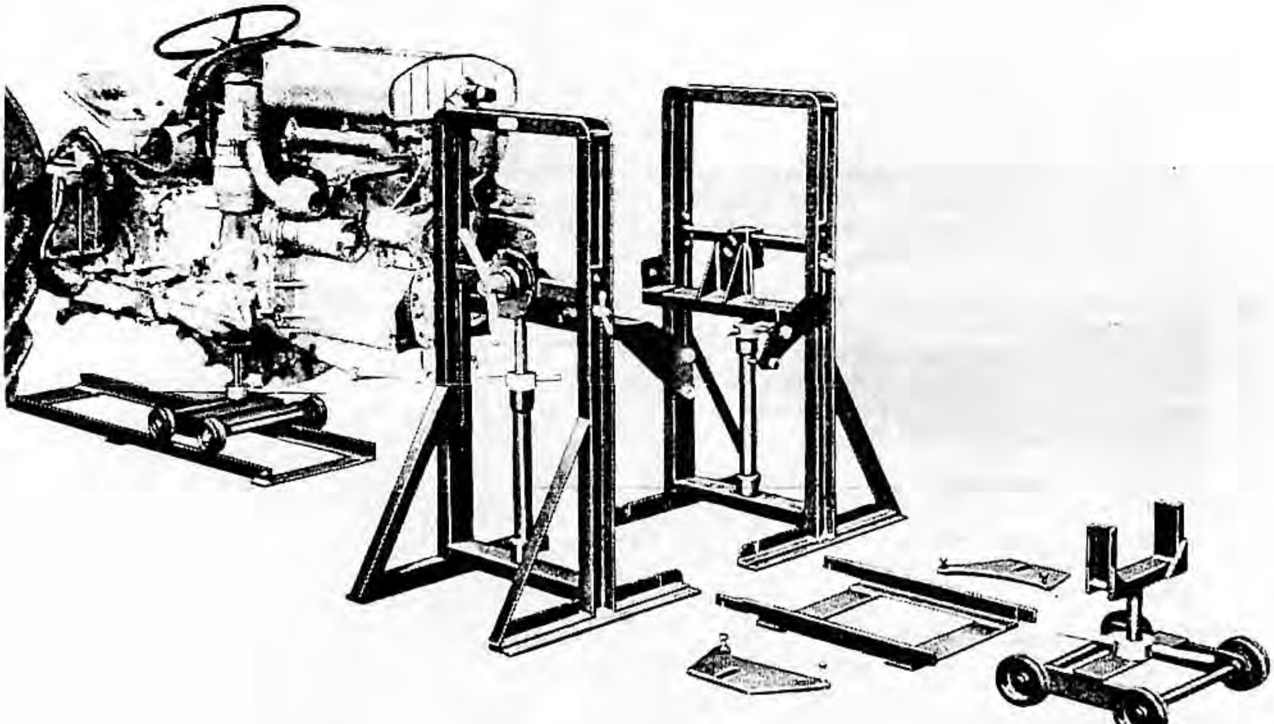


FIG. 141 MOUNTING ENGINE ON STAND—FIRST OPERATION

4. Place trolley jack with cup shaped cradle Pt. 47, underneath the transmission front drain plug and raise until weight is only just relieved from the front wheels—check by feel of steering wheel. Throughout the entire splitting and re-assembly, adjustment of this jack must not be altered—see Note below.
5. Disconnect radiator tie-rod, and top and bottom hoses.
6. Disconnect steering drag links at rear from drop arm taper pins. Until drag links are reconnected on assembly care should be taken that the drop arms and steering wheel are not disturbed.
7. Disconnect radius rods at rear by removal of footrests.
8. Remove six large and two smaller bolts securing front axle support to crankcase and sump respectively.
9. Draw assembly, comprising front axle, radiator, radius rods and track rods clear.

Prepare Engine for Uncoupling from Transmission as follows:

1. Remove main fuel tank and reservoir tank. See page C.107.
2. Disconnect:
   Fuel pipes to injector pump at fuel filter.
   Fuel cut-off control, and throttle control at injector pump, and pull rods rearwards.
   Electrical lead and fuel line connection at Thermostart.
   Hose securing air cleaner to inlet manifold.
   Electrical leads at dynamo and starter motor.
3. Remove:
   Water pump and fan assembly.
   Dynamo and mounting bracket.
   Starter motor.
   Oil gauge pipe from oil gallery.

Second Operation Figure 142.

1. Position stands, with Engine Brackets fitted, on each side of the engine, fixed mounting plates to the front. The rear, detachable, plates should be removed until the engine has been uncoupled from the tractor.
2. Using stand wing nuts, accurately adjust brackets to the engine height and secure front mounting plates to crankcase with four of the large bolts previously removed from the front axle support. Do not use spring washers. Ensure all four bolts are located before tightening stand wing nuts.
3. Roll tractor rearwards, drawing stands towards front of long rail, and lay short Pt. 66 between the feet, located in the slots, and link on to the first rail.

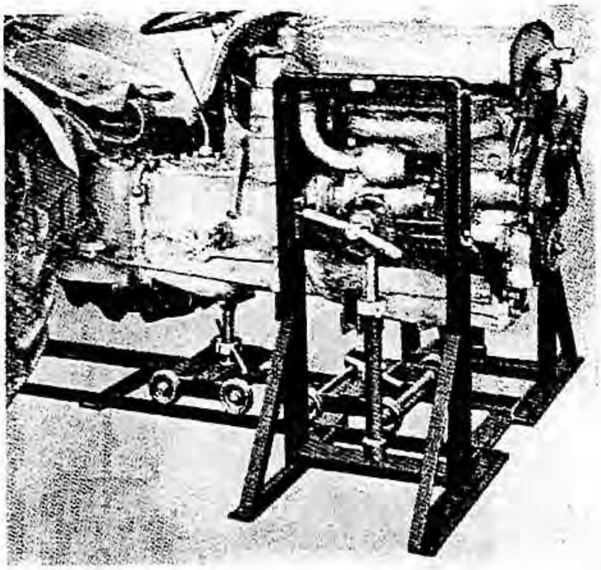


FIG. 142
MOUNTING ENGINE ON STAND—SECOND OPERATION

4. First remove four screws on flat washers attaching rear of sump to transmission flange, then position trolley jack with cradle Pt. 63 under engine sump, adjust so that support comes in contact with flange at rear of sump and raise until load is only just felt.

   Note.—Subsequent uncoupling of the engine will be facilitated if alignment of the weight is maintained by the weight being evenly distributed between the two jacks.

5. Remove remainder of engine mounting screws and nut off stud on top of flange, all with lockwashers.

Push tractor rearwards, separating the transmission from the engine off two dowels in the engine flange.

Third Operation Figure 143.

1. Fit rear attachment plates, securing engine with $4-\frac{7}{16}'' \times 1\frac{1}{2}''$ bolts and nuts.

2. Ensure stand wing nuts are tight with the latch engaged, then remove jack from beneath engine sump.

The engine can now be pivoted and locked in the required position.

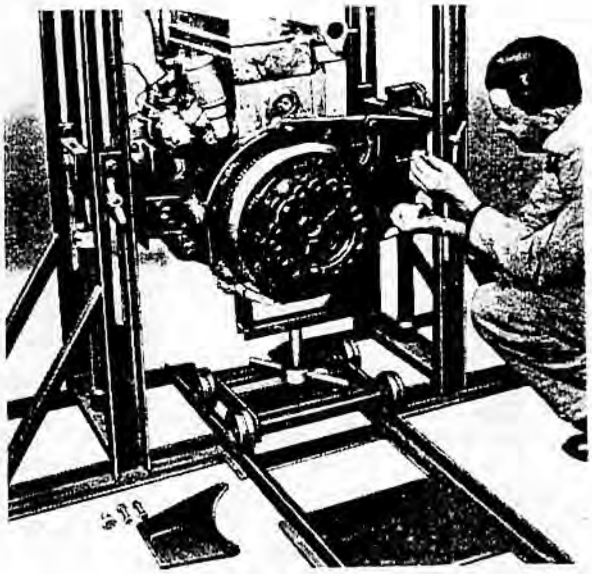


FIG. 143
MOUNTING ENGINE ON STAND—THIRD OPERATION

CRANKSHAFT AND MAIN BEARING HOUSINGS

Whenever crankshaft or main bearings are to be removed, the engine should be completely dismantled for renewal of oil seals and cleaning of all components connected with oil and water distribution.

Advantage should also be taken of the crankshaft reconditioning service operated by the makers. Journal and crankpin bearing liners are available .010", .020", .030", .040", (.254, .508, .762, 1.016 mm.) undersize.

Preliminary Dismantling

Remove:

Engine and mount on dismantling stand, see page C.123.

Clutch—6 set screws on lockwashers.

Cylinder head and associated parts. See page C107.

Fuel injection pump and drive housing. See page C.116.

Timing cover, crankshaft pulley, oil pump driving gears, chain tensioner, timing chain and gears, camshaft and front bearing. See page C.114.

Fuel lift pump.

Dipstick, Purolator oil filter, and tappet cover.

Oil sump and primary filter.

Big-end bearings, pistons and liners. Remove big-end caps and connecting rod bolts. Remove each piston and liner as an assembly by pushing its connecting rod out through the top of the cylinder liner bore. Replace the bearings and caps to their respective connecting rods.

Important.—If the pistons, liners and bearings are likely to be re-assembled for further use it is most important that these components again occupy their original positions. Therefore to enable this to be accomplished, suitably mark these items BEFORE they are completely dismantled.

Flywheel.

Front bearing housing and oil pump.

Removal of Crankshaft and Main Bearing Housing

1. Remove set-screws securing front bearing housing and withdraw housing and joint washer from cylinder block.

2. Remove rear oil seal cover with gasket—8 set screws with lockwashers. Renew oil seal as recommended below.

3. Invert engine in stand and remove the centre bearing locating bolt.

It is recommended that the crankshaft assembly is drawn out of the crankcase with the aid of a hoist, with the sling fastened on to the end of the flywheel spigot by means of a suitable attachment plate held by two screws, see Fig. 144. This will avoid the risk of damaging the bearing housing or crankcase by attempting to lift the heavy assembly out manually.

4. With the rear of the crankcase upended in the stand, carefully draw the crankshaft assembly upwards, guiding webs through centre partition.

5. Using Service Tool MF113, shown in Fig. 148, unscrew socket screws attaching upper and lower halves of all bearing housings and extract bearing liners, also extract thrust washers and rubber sealing plugs which are fitted in front and rear bearing housings only.

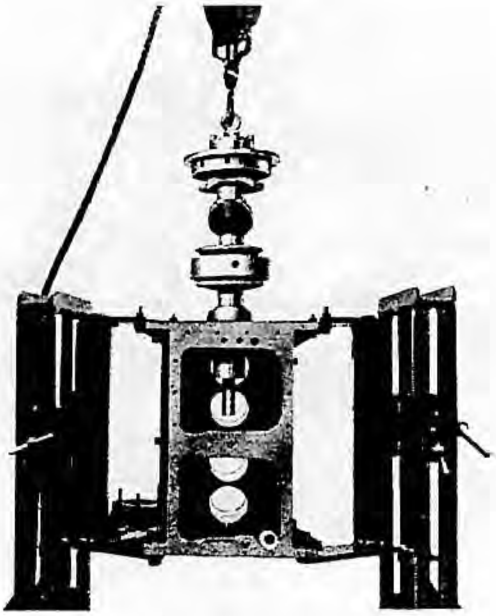


FIG. 144 LIFTING CRANKSHAFT ASSEMBLY FROM CYLINDER BLOCK

Camshaft Bearings

At this point when the cylinder block is stripped completely, the camshaft bearings may be renewed. See page C.129.

Renewal of Crankshaft Rear Oil Seal

1. Drive out oil seal from cover, using Remover Adaptor, Service Tool MF104, with Universal Handle No. 550, as shown in Fig. 145.

FIG. 145 REMOVING CRANKSHAFT REAR OIL SEAL USING SERVICE TOOL MF104

FIG. 146 FITTING NEW REAR OIL SEAL ON TO ADAPTOR MF105C/2 USING MF105C/1 AS GUIDE

Important.—Before fitting, the new seal must initially be opened out by passing it up over the taper of Service Tool MF105C/1, oiled, with **lip trailing.** This will ensure the leather is not creased during assembly.

2. Then mount MF105C/1 over Replacer Adaptor MF105C/2 as shown in Fig. 146. Using taper of the former as a guide, press new seal, **lip leading,** on to the Replacer Adaptor.

3. With seal mounted on the Adaptor MF105C/2, using Handle No. 550 drive seal into place from inside of cover. The replacement is, in principle, similar to removing.

Warning.—To prevent damaging the seal during replacement, it is most important to use the appropriate replacer. MF105C/2 incorporates a stop, which butts on the front cover, just before the seal contacts the shoulder.

Front Bearing Housing

Examine the oil pump recess in the front bearing housing. It is most important for this recess to be free from grooves or wear as the oil inlet and outlet ports are adjacent and seepage across the face of the pump inner rotor will mean loss of oil pressure. See Fig. 101.

REPLACEMENT OF CRANKSHAFT AND MAIN BEARINGS

Before re-assembly of the engine, closely examine all machined faces of crankshaft and cylinder block and remove all traces of dirt, carbon, sealing compound or old gasket material. After thoroughly washing in paraffin, blow out all oil galleries and passages with compressed air. (See Lubrication System, page C.101). Remove oil gallery plugs from cylinder block before blowing out.

Re-assembly should not commence until you are absolutely certain that cylinder block and crankcase are absolutely clean.

Before fitting crankshaft, bearing housings, new bearing liners and thrust washers, they should be washed thoroughly in paraffin and smeared with engine oil. All oilways in crankshaft and bearing housings must be completely clear and blown through with compressed air. Check also that the aluminium plugs fitted in the webs adjacent to each connecting rod crankpin are tight. Do not remove these when blowing crankshaft oilways.

Proceed as follows:

Important.—It is essential to use a torque spanner set to 25-30 lb. ft. (3.5-4.1 kg.m.) with Service Tool MF113 when tightening the socket screws securing the two halves of all bearing housings. By this means only can the correct fit of the main bearings on the crankshaft journals be obtained.

1. Place each main bearing liner in position by locating their notches in grooves in the two halves of the bearing housings.

2. **Rear Main Bearing Housing** Figure 147.
   (a) Place thrust washers, oil grooves outwards, in recesses on either side of the two halves of the bearing housing, note top thrust washers have no locating tags.

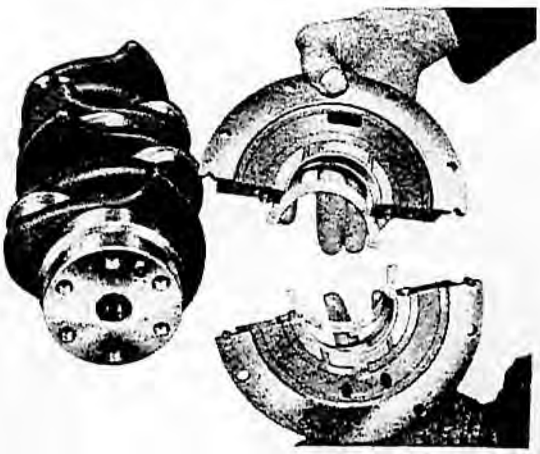


FIG. 147 REAR MAIN BEARING HOUSING ASSEMBLY WITH THRUST WASHERS AND CRANKSHAFT

   (b) Mount top and bottom halves—flange to the rear—over crankshaft rear journal, with rubber dowels fitted between mating faces of mounting flange to prevent oil leaking along these surfaces, and with hollow dowels in socket screw recesses.

(c) Tighten socket screws on flat and lock-washers to the specified torque.

3. **Centre Main Bearing Housing**
   (a) Mount both halves of the centre main bearing housing located by hollow dowels—with liners—over crankshaft centre journal, stamped numbers, marked on the web, on the same side, and bottom locating screw offset towards the rear.
   (b) Tighten socket screws on flat and lock-washers to the specified torque.

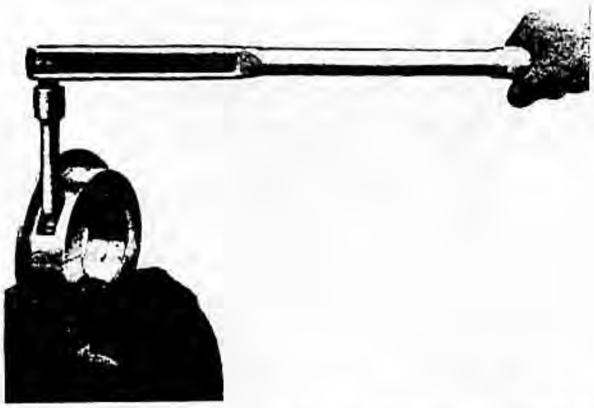


FIG. 148 TIGHTENING SOCKET SCREWS OF FRONT BEARING HOUSING USING SERVICE TOOL MF113 WITH TORQUE WRENCH

4. **Front Main Bearing Housing**
   (a) Using soft jawed vice, assemble both halves located by hollow dowels, with bearing liners, tightening socket screws on lock and flat washers to the specified torque.
   (b) After carefully positioning housing gasket to align with fixing screw holes, mount assembly on front face of crankcase and secure with fixing screws and spring washers.

5. Insert cylinder liners, pistons and connecting rods. (See page C.122).

6. **Crankshaft**
   (a) Lubricate all bearing surfaces and carefully fit gasket over rear bearing housing mounting face to align with the unevenly spaced fixing screw holes.
   (b) Rear bearing housing must have the two drain holes towards the sump and small oil drilling towards the camshaft.
   (c) Position centre bearing housing with oil drillings towards the camshaft and base fixing screw hole at the bottom.
   (d) With the rear of the crankcase upended in the stand, gently lower the crankshaft assembly into position with the aid of a hoist, as previously recommended when removing, guiding webs through the centre partition and carefully inserting front journal into its bearing. See Figure 144.
   (e) Line up accurately the centre bearing housing; and, taking care not to cross the threads, insert base fixing screw with lock-washer. Tighten to a torque reading of 39-42 lb.ft. (5.39-5.81 kg.m.).
   (f) Carefully align rear bearing housing and gasket—holes are unevenly spaced to ensure correct assembly.

7. Fix gasket on flange mounting face of crankshaft rear oil seal cover, carefully aligning the unevenly spaced screw holes.

8. Slide rear oil and cover assembly on to spigot of crankshaft, using Service Tool MF105C/1, well oiled, as guide to prevent damaging the seal. See Figure 149.

9. After carefully aligning holes, insert fixing screws and secure rear bearing housing and oil seal cover assembly to the cylinder block.

10. Check crankshaft for "tight-spots".

CRANKSHAFT END FLOAT

Thrust washers—top and bottom halves—.005" (.127 mm.) oversize are available and should be used if necessary to correct excessive crankshaft end float to within the limits specified. The top and bottom halves of a pair of thrust washers must, of course, be of the same thickness, it is, however, permissible to use one pair oversize and the other pair standard

FIG. 149 GUIDING REAR OIL SEAL AND COVER ASSEMBLY ON TO CRANKSHAFT WITH SERVICE TOOL MF105C/1

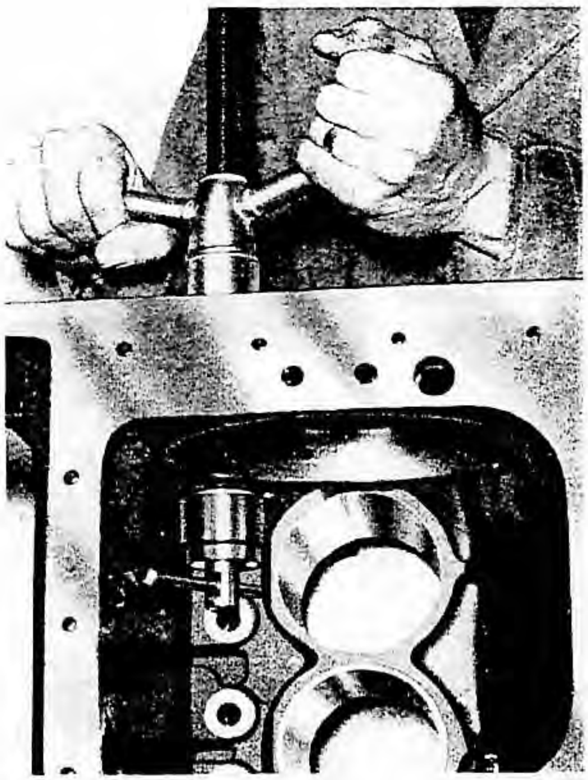


FIG. 150. REMOVING REAR CAMSHAFT BEARING

on different sides of the rear main bearing housing or, if required, oversize pairs on both sides. See Figure 147.

The end float should be between .006" and .008" (.152 and .203 mm.).

CAMSHAFT BEARINGS

When the cylinder block is stripped completely, the camshaft bearings can be renewed using a Churchill Multi-purpose tool with Adaptors S32-1, as shown in Figure 150.

Procedure

Remove locating bolts and plain washers securing centre and rear camshaft bearings, and securing washer located behind rear bearing. The bearings can then be removed.

When fitting new bearings, align the oil feed holes and locating screw holes with matching holes in the cylinder block. When drawing the bearings into position, take every precaution to ensure that the bearing does not turn and so mis-align the holes. Before securing each bearing, ensure that its locating hole is centrally disposed in the tapped hole which accommodates the locating screw. Failure to observe this instruction may result in the bearing becoming distorted when the locating screw is tightened.

FLYWHEEL

The starter ring gear is an interference fit and is shrunk on to the flywheel during initial assembly. If damaged or unserviceable it can be removed by drilling a $\frac{5}{16}$" hole as near as possible to the inside edge of the ring, and cutting through the remaining outer section with a hacksaw.

The starter ring gear should be replaced cold as instructed below, in order to ensure long life and maintain the hardness of the ring. Immersion of the ring in boiling water will assist this operation but greater heat must not be applied.

Place the flywheel on a solid base and offer the ring gear squarely on to the spigot. Fit four "G" clamps spaced equally around the circumference of the ring as shown in Fig. 151.

Tap the ring gear lightly on to the flywheel spigot by means of a soft metal drift, keeping it square and following its progress on to the spigot by tightening the "G" clamps. Having effectively started the ring on to the spigot, dispense with the clamps and drive gear fully home against its flange.

Note.—When correctly positioned, the leading edge of the gear ring teeth should be at the same side as the starter motor.

To refit flywheel

Having first ensured that the flywheel mounting face and the corresponding face of the crankshaft are clean and free from burrs, rotate the crankshaft to bring Nos. 1 and 4 pistons to T.D.C., then continue as follows:

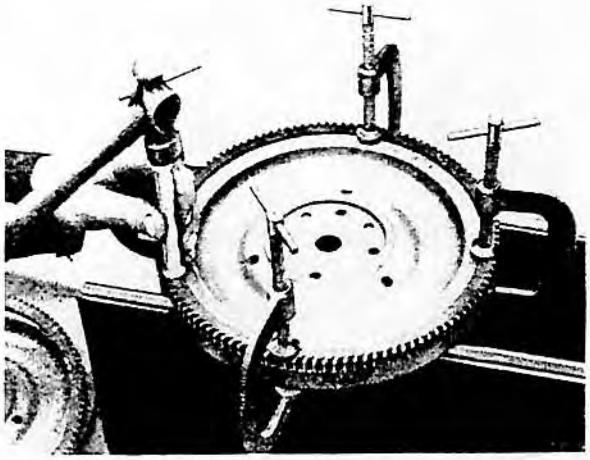


FIG. 151 FITTING RING GEAR TO FLYWHEEL

(a) With T.D.C. mark uppermost, offer up and locate the flywheel on to a dowel attached to the mounting face of the crankshaft.

(b) Insert the six bolts with three lock plates and secure the flywheel by tightening the bolts to the specified torque.

(c) Using a dial indicator, check the run-out of the flywheel clutch face. If the maximum tolerance of .003" (.0762 mm.) is exceeded, then the cause must be established and corrected before finally turning up the ends of the lock plates.

Completion of Engine Re-assembly

This procedure is a reverse of that given for preliminary dismantling.

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WORKSHOP SERVICE MANUAL

Section D

COOLING SYSTEM

COOLING SYSTEM

Section D

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LIST OF ILLUSTRATIONS

COOLING SYSTEM

INTRODUCTION (Refer Figures 1 and 2)

The components and layout of the engine cooling system, follows conventional practice as illustrated in Figures 1, 2 and 3.

Water circulation is by a belt driven pump, cooling being further assisted by the radiator, fan shroud, and fan.

The capacity of the cooling system is 15 pints (87 mm. and 23C engines). (18 pints 3-A-152 engine).

THE RADIATOR (Refer Figures 1 and 2)

The radiator is protected by the hood and cowl assembly and is secured in position by two studs and a single tie rod. Drain cocks are provided in the engine cylinder block and radiator.

Pressurised cooling is employed; *i.e.* the cooling system is sealed and is not open to atmosphere, thus water temperature can rise to 115°C. before boiling will occur.

The radiator cap assembly incorporates a spring-loaded relief valve which will not operate below 7 p.s.i.

Note that the cooling system cannot be drained unless the radiator cap assembly is first removed. Care must be taken to ensure that the engine is cool before attempting to remove the radiator cap.

REMOVING THE RADIATOR

(Refer Figures 1 and 2)

Remove radiator filler cap.

Open radiator and cylinder block drain cocks.

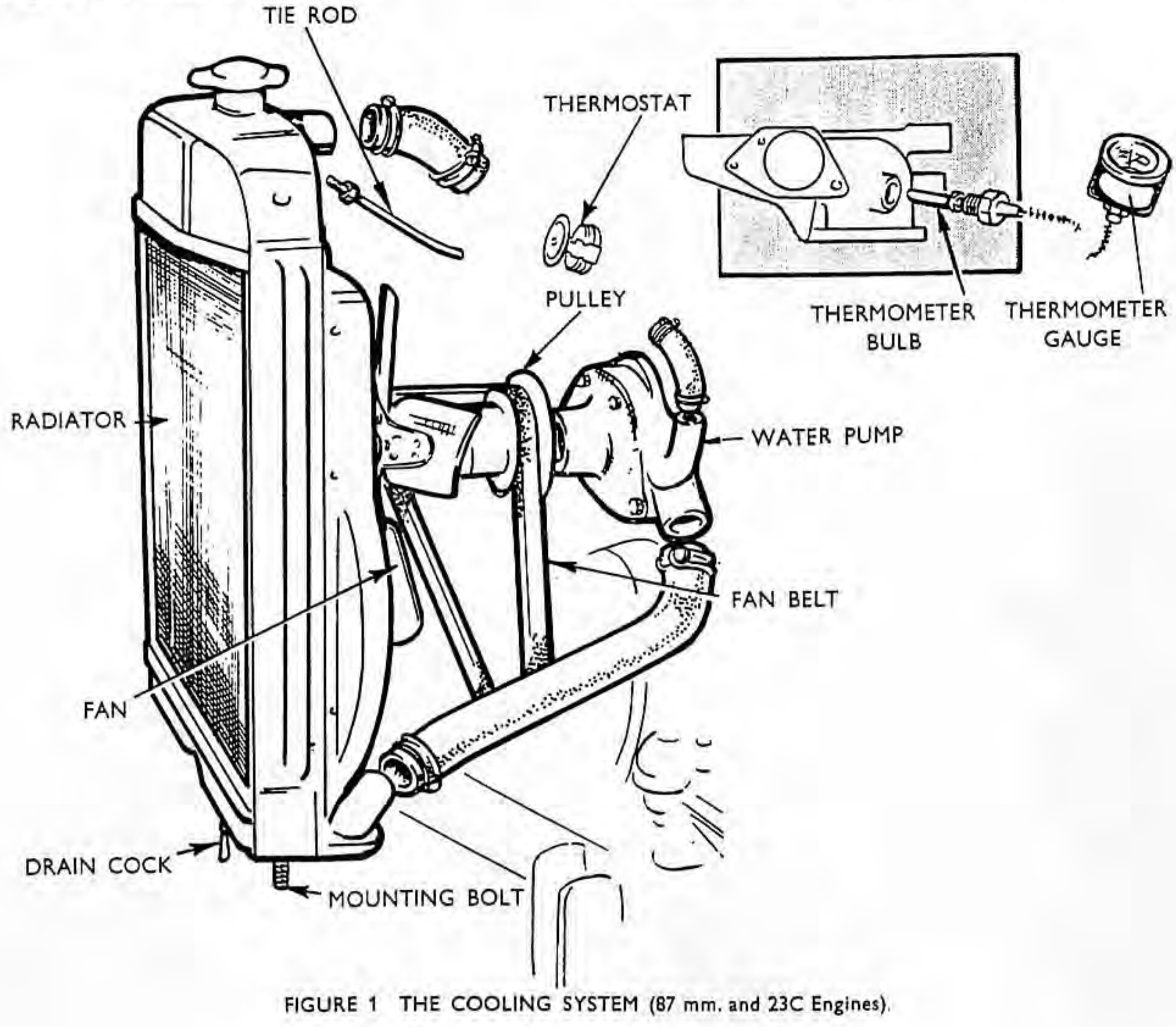

FIGURE 1 THE COOLING SYSTEM (87 mm. and 23C Engines).

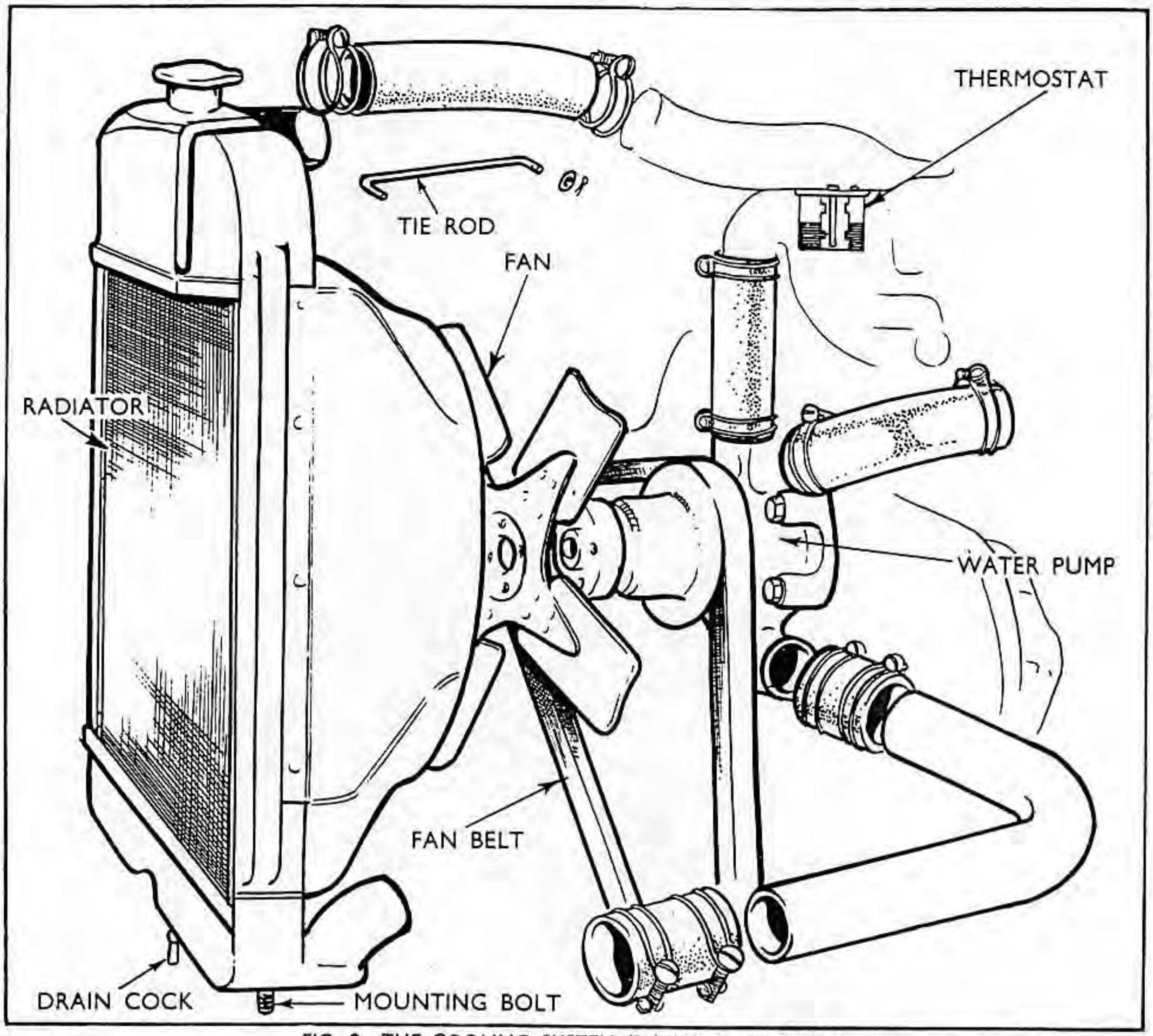

FIG. 2 THE COOLING SYSTEM (3-A-152 Diesel Engine).

Slacken off wing nuts securing rear end of hood.
Remove hood pivot bolts and lift off hood.
Disconnect top and bottom radiator hoses.
Slacken off and remove the two nuts, spring washers, and plain washers on underside of radiator.
Release radiator tie rod from thermostat housing.
Lift off radiator.
The fan shroud may be removed by releasing the six self-tapping screws which secure it to the radiator.
Replace radiator in reverse order to above, ensuring that the radiator lower packing pieces are in position and that the engine cranking handle can be engaged without fouling the radiator lower tank strap.

THE TEMPERATURE GAUGE

(Petrol/V.O. and L.O. Machines only). (Refer Figure 1)

The temperature gauge is fitted to visually record the temperature of the cooling water and thus provide the operator with a ready means of ascertaining engine operating temperature.

With petrol/V.O. or petrol/L.O. machines it is most important that the engine is permitted to run on petrol until it is thoroughly warmed up before switching over to V.O. or L.O. The premature introduction of V.O. or L.O. to a cool engine will result in improper fuel vaporization, reduced engine performance, increased engine wear, and contamination of the engine sump oil content. It cannot be too strongly emphasised that the engine must be permitted to operate on petrol until the needle of the temperature gauge has properly entered the 'normal' area.

THE THERMOSTAT (Refer Figures 1 and 2)

The thermostat, incorporated in the cylinder head water outlet elbow is fitted to enable the engine to more quickly attain working temperature, and to prevent the engine from running too cool. Reference to Figures 1 and 2 will indicate that the position of the thermostat valve will determine the path of the circulating water.

The action of the thermostat valve is controlled by the bellows assembly, to which the valve is linked. The normal position of the bellows is fully contracted, thereby holding the valve tight on its seat and compelling the water to circulate from the cylinder head to the water pump and not through the radiator. The small bleed hole in the valve head eliminates the possibility of air locks when an empty system is being filled, and reduces the chance of the radiator core freezing in extreme conditions when the tractor is lightly loaded and nosing into a cold head wind. This latter possibility can be avoided by the intelligent use of a radiator blanking plate.

The action of heat on the thermostat bellows causes it to expand, thereby permitting water to flow through the radiator and be cooled.

The temperature at which the thermostat valve opens is given below.

THERMOSTAT DATA

87 mm. PETROL ENGINE

(Up to Engine Serial No. SG 5983E)

Valve opens	75-80°C.	(167-176°F.)
Valve fully open	95°C.	(203°F.)
Valve lift	·312″	(7·93 mm.)

(From Engine Serial No. SG 5984E)

Valve opens	76-81°C.	(169°F.-178°F.)
Valve fully open	95°C.	(203°F.)
Valve lift	·312″	(7·93 mm.)

87 mm. V.O. ENGINE

(Up to Engine Serial No. SH 406E)

Valve opens	75-80°C.	(167-176°F.)
Valve fully open	95°C.	(203°F.)
Valve lift	·312″	(7·93 mm.)

(From Engine Serial No. SH 407E)

Valve opens	76-81°C.	(169-178°F.)
Valve fully open	95°C.	(203°F.)

23C DIESEL ENGINE

Valve opens	154-163°F.	(68-73°C.)
Valve fully open	185°F.	(85°C.)
Valve lift	·312″	(7·94 mm.)

3-A-152 DIESEL ENGINE

Valve opens	176°F.	
Valve fully open	199°F.	
Valve lift	·34″	(8·65 mm.)

REMOVING THE THERMOSTAT

(Refer Figures 1 and 2)

Remove radiator filler cap.

Open radiator and cylinder block drain cocks.

Release wing nuts securing hood, and swing hood forward.

Remove the fuel tank. (Section E).

Remove the rubber hose connecting radiator to cylinder head.

Remove the two nuts and washers securing thermostat housing cover, and lift off cover.

Withdraw thermostat.

Replace in reverse order, ensuring that the housing faces are clean and that the gasket is in sound condition.

TESTING THE THERMOSTAT

Immerse the thermostat in a container partially filled with clean water.

Gradually heat water, checking the temperature rise at frequent intervals with an accurate thermometer.

The precise moment at which the valve opens may be checked by gently easing the valve from its seat and trapping a ·002″ (·05 mm.) feeler gauge between the valve and seat. Suspend the thermostat by the feeler, which will be released the instant the bellows start to expand.

If the thermostat does not function properly it must be replaced with a new one. Repairs must not be attempted.

WATER PUMP DRIVE BELT

The water pump and generator drive belt must be kept adequately tensioned if the generator and water pump are to function efficiently.

Adjustment is made by slackening off four bolts; swivelling the generator, and retightening the four bolts. Two of these bolts are located on the generator mounting bracket and two on the generator adjusting link. When carrying out belt adjustment the generator must not be forced into a new position with the aid of a lever, otherwise the belt will be overtaut. Too tight a drive belt will impose excessive loading on the generator armature bearings.

Should the belt show signs of fraying or deterioration a replacement should be fitted. The operation of the tractor without a fan belt can have serious and expensive consequences.

FITTING A WATER PUMP DRIVE BELT

Slacken off generator mounting, and adjusting link bolts.
Move generator towards engine in order to obtain maximum belt slack.
Detach belt from generator pulley.
Detach belt from crankshaft pulley.
Withdraw belt from water pump pulley, fan, and radiator cowl.
Replace new belt in reverse order to above procedure.
Note that the belt must be placed or carefully fed on to the pulleys and not prised into position.

REMOVING THE WATER PUMP

(23C DIESEL and 87 mm. PETROL and V.O. ENGINES). (Refer Figures 1 and 3)

Remove radiator filler cap.
Open drain cocks on radiator and cylinder block and run off water.
Remove hood and cowl assembly.
Remove radiator and fan shroud assembly.
Release rubber hoses connecting water pump to engine.
Slacken off and remove water pump and dynamo drive belt.
Slacken off and remove bolts securing water pump to engine.
Remove water pump.
Replace in reverse order.

DISMANTLING THE WATER PUMP

(23C DIESEL and 87 mm. PETROL and V.O. ENGINES). (Refer Figure 3)

The water pump fitted to the 23C diesel engine and the 87 mm. petrol, and V.O. units have the same internal parts, therefore the following instructions apply to all three engine types.
Remove the four bolts and lock washers securing water pump pulley to hub.
Withdraw pulley, hub extension, balance piece and fan.
Remove self-locking nut and cotter pin from fan

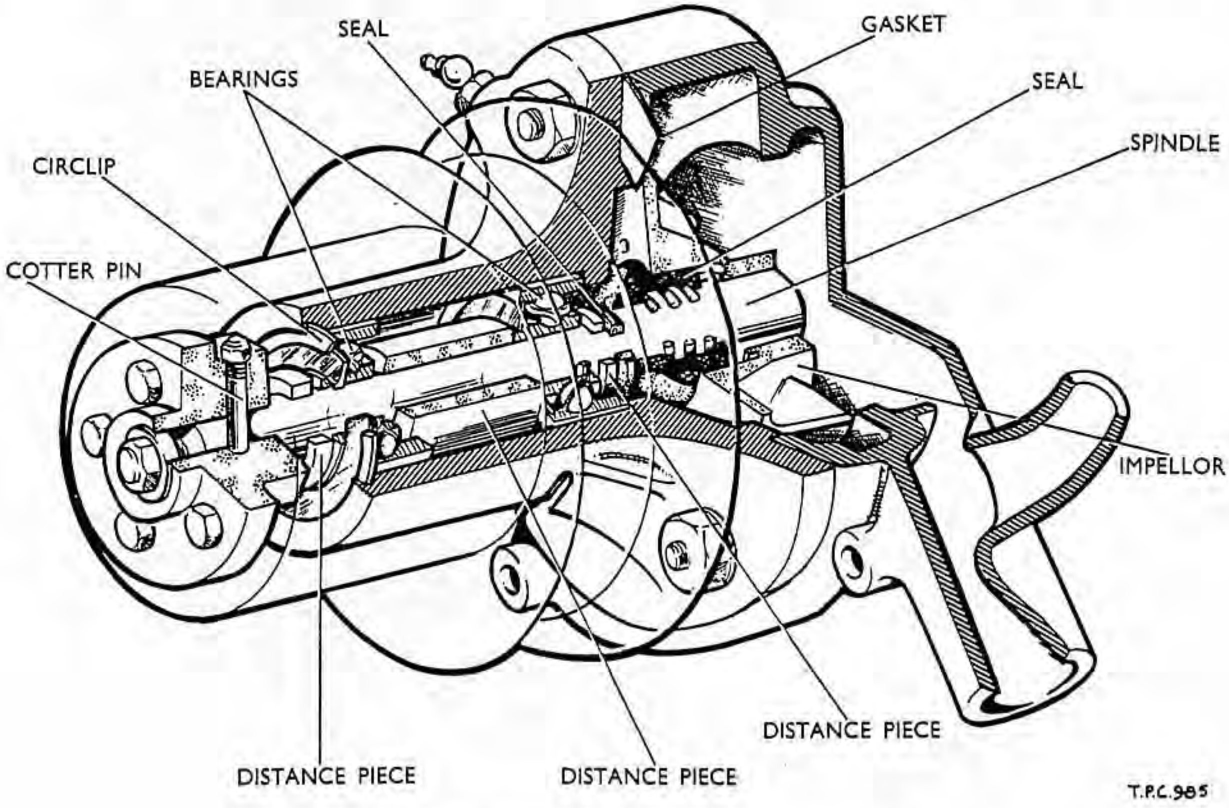

FIGURE 3 THE WATER PUMP (23C and 87 mm. ENGINES).

FIGURE 4 REMOVING THE IMPELLER (23C and 87 mm. ENGINES).

pulley hub, press or draw off hub and remove distance piece.
Using Service Tools MF.200 and MF.200-11 mount water pump with lip of split pressure plate under impeller and press off impeller (Figure 4). Remove seal.
Remove snap ring from front of housing and tap out spindle, bearings, and seals.
To remove bearings and distance piece, remove retaining circlip and abutment washer, then press off spindle. To reface contact bearing face of housing, mount bearing housing in vice. Insert Service Tool 6300 and mount appropriate adaptor of MF.126, thrust bearing and tensioner, with ball race end of

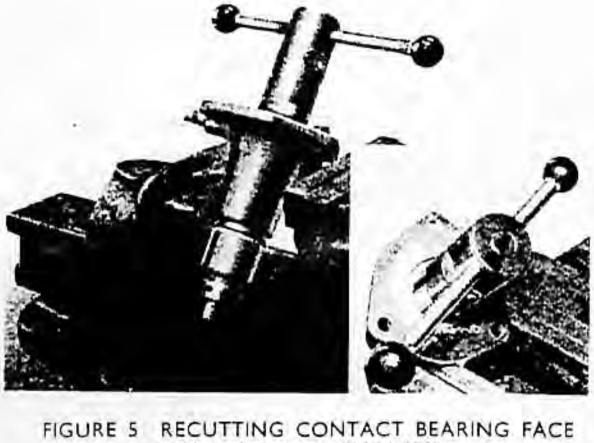

FIGURE 5 RECUTTING CONTACT BEARING FACE (23C and 87 mm. ENGINES).

thrust bearing against the tensioner (Figure 5). Tighten tensioner using tommy bar provided. Rotate tool, tightening tensioner to maintain load on cutter.
Remove only sufficient metal to give a smooth surface to housing face.

ASSEMBLING THE WATER PUMP

(23C DIESEL and 87 mm. PETROL V.O. ENGINES).

Thoroughly clean all components.
Lightly smear bores of bearing housing and pulley hub with a reputable bearing grease.
Locate circlip in groove in spindle.
Place the thinner of the two abutment washers against circlip and press in bearings. (Shield side of bearings on opposite side to bearing distance piece).
Locate bearings in position with washer and circlip.
Place snap ring over end of spindle and mount the thick abutment washer before pressing on pulley hub.
Tighten self-locking nut on spindle before tightening pulley hub cotter pin.
Locate rubber bearing seal on spindle against inner end of bearing.

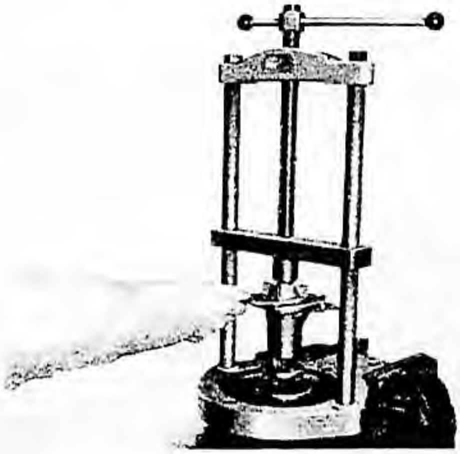

FIGURE 6 CHECKING IMPELLER CLEARANCE (23C and 87 mm. ENGINES).

Fit bearing and spindle assembly into housing bore, locating snap ring groove in housing.
Fit water pump seal.
Using Service Tools MF.200 and MF.200-11, fit impeller.

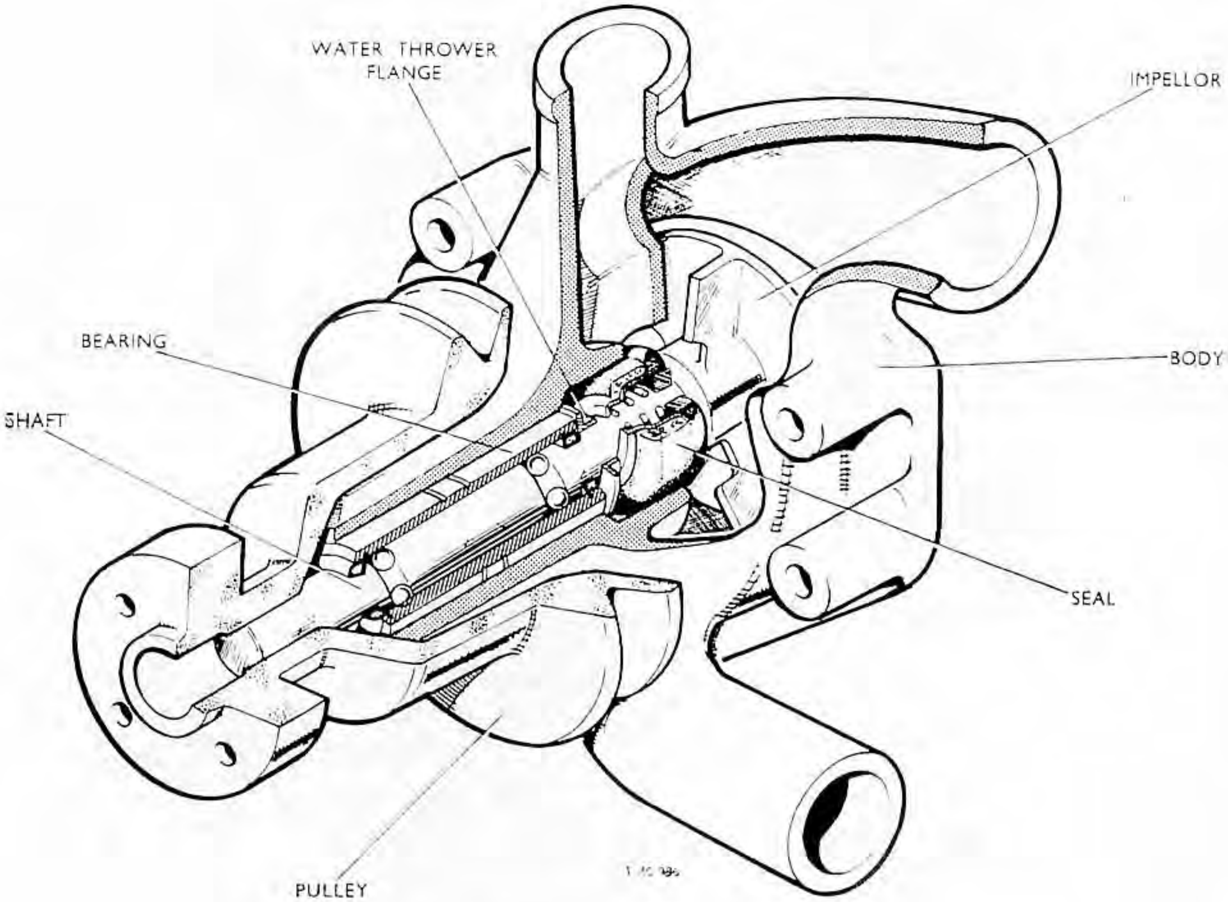

FIGURE 7 THE WATER PUMP (3-A-152 ENGINE)

Screw threaded end of water pump shaft into support ring and mount split pressure plate in hand press frame.
Mount impeller on spindle and with centre screw adaptor over spindle end, press on impeller. Ensure that a clearance of 0·080 - 0·090 ins. (2·03 - 2·29 mm.) exists between the impeller and housing (Figure 6).
To ensure a good seal between impeller and spindle, the end should be dipped in low melting point solder. (Min. 150°C.).
Note that clean surfaces are essential to ensure proper solder application.

REMOVING THE WATER PUMP

(3-A-152 DIESEL ENGINE). (Refer Figure 7)
Remove radiator filler cap.
Open radiator cylinder block drain cocks, and run off water.
Remove the hood and cowl assembly.
Remove radiator hoses.
Release radiator mounting and tie bar.
Lift off radiator.
Slacken the dynamo adjusting locking screw and the two mounting bolts, and move dynamo towards engine.
Detach fan belt.
Remove the two hoses connecting the water pump to engine.
Remove the four bolts securing the water pump to timing case cover.
Remove water pump and gasket.
Assemble in reverse order, ensuring that all four bolts are fitted with copper washers and that the longest bolt is fitted in the top right-hand position.

DISMANTLING THE WATER PUMP

(3-A-152 DIESEL ENGINE). (Refer Figures 8 and 9)
Straighten out tab washers on setscrews securing fan to hub, and remove fan.

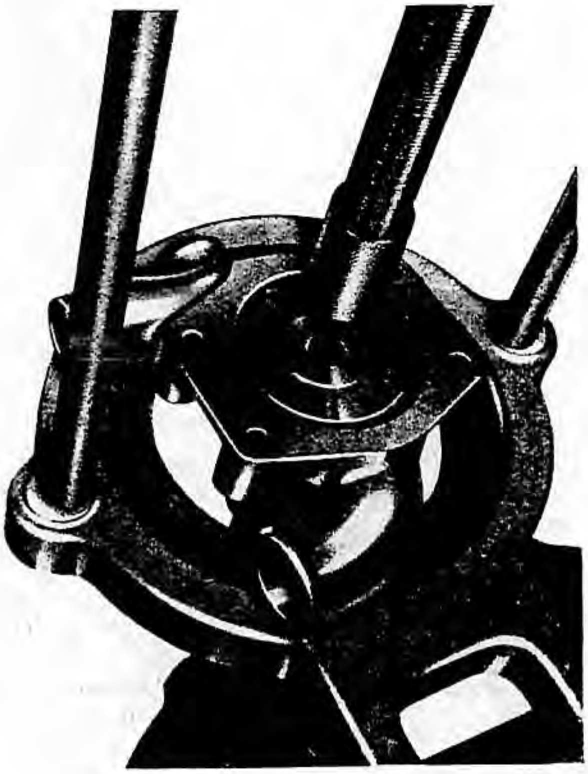

FIGURE 8 REMOVING SHAFT, BEARINGS, AND IMPELLER (3-A-152 ENGINE).

Using a suitable extractor remove pump pulley.
Press the shaft and bearings from the body by applying pressure at the impeller end of the shaft. Service Tool No. MF.200 is suitable for this purpose. (See Figure 8).
Remove the rear seal and water thrower flange.

FIGURE 9 CHECKING WATER PUMP IMPELLER CLEARANCE (3-A-152 ENGINES)

Note that the shaft and bearings form one complete unit and cannot be separated.

INSPECTION

If the shaft shows signs of wear and/or there is play in the bearings, then the shaft assembly must be renewed.
Examine the impeller and pump casing for damage and cracks.

ASSEMBLING THE WATER PUMP

(Refer Figures 7 and 9)
Press shaft and bearing assembly into housing, (long end of shaft towards impeller end of pump) until the bearing is flush with the housing.
Insert the four securing setscrews (pump to timing case) in the pump body.
Use new copper washers and ensure that the longest bolt is fitted in the top right hand position.
Press the pulley on to the front end of the shaft until the fan face of the pulley is $5\frac{17}{32}$" (140·5 mm). from the rear end of the pump body. As a guide, the end of the shaft should be $\frac{11}{16}$" (17·5 mm.) below the front face of the pulley.
Fit the water thrower flange (flange end first) on to shaft.
Fit the water pump seal, (thrust face towards impeller).
Press the impeller on to the shaft until a clearance of ·010"-·020" (·254-·51 mm.) is obtained between the impeller blades and the housing face (Figure 9). The face of the boss on the rear of the impeller should be flush with the rear of the housing.
Ensure that there is no lateral movement of the shaft within the pump body.

FROST PRECAUTIONS

For obvious reasons, precautions must be taken to safeguard the engine and cooling system against the ravages of frost. There are three methods whereby protection may be afforded. These are listed below.

1. Draining the cooling system after each day's work.
   This method offers economy, but can be inconvenient, and leaves the cooling system unprotected during idle periods.
   In extreme unfavourable conditions the cooling system can freeze in a very short time.
   Radiators have been known to freeze while the engine was running. Depending on the water used, the formation of silt, with the

inevitable restriction of water passages, and possible increased corrosion of the water pump impeller, must be accepted.
Under these conditions the saving is debatable.

2. The use of heated premises, engine or sump heaters.
   Possesses disadvantages similar to (1) *i.e.* during the working day no protection is afforded if the tractor is standing idle.

3. The use of anti-freeze.
   Probably the most universally accepted method of frost prevention. Anti-freeze solutions possess powers of penetration not common to water and the entire cooling system must be thoroughly flushed and checked before anti-freeze is used. All hoses, clips and joints must be in sound condition if expensive loss is to be avoided.

A leaky cooling system and frequent 'topping up' will reduce the protection afforded to dangerous limits.
It is advised that only suitable and reputable brands of anti-freeze be employed.
The cooling system should be drained and flushed when the risk of frost damage has passed.
For the location of engine and radiator drain cocks refer Figures 1 and 2 .

FAULT DIAGNOSIS

The diagnosis of faults contributing to overheating of the engine must be undertaken carefully, and all external causes thoroughly investigated. An apparent cooling system defect may, for example, be cured by adjusting the ignition or injection setting, or by tightening the fan belt.
It is not intended, to cover in this section, the engine defects which may contribute towards overheating.
The faults listed on page 9 are cooling system faults which of course can be accentuated by engine deficiencies, conditions, and the handling of the tractor.

FAULTS DIAGNOSIS CHART

SYMPTOM	POSSIBLE CAUSE	REMEDY
Coolant Boils	Insufficient water in radiator.	Top up radiator.
	Leaking radiator filler cap.	Rectify.
	Leaking hoses or joints.	Rectify.
	Leaking water pump seal.	Rectify.
	Weak or broken spring. Defective valve seat in radiator filler cap.	Renew filler cap.
	Fan blades incorrectly fitted.	Rectify.
	Slack or worn fan belt.	Adjust or renew belt.
	Incorrect gear selection. (Engine slogging or racing)	Select correct gear to suit operation requirements.
	Faulty thermostat. (Remaining closed or not opening sufficiently)	Renew thermostat.
	Perished cooling system hoses.	Renew hoses.
	Choked radiator core or Restricted water passages.	Flush out cooling system (reversed flushing advised) or fit replacement radiator.
	Damaged or corroded water pump impeller	Fit new impeller.
	Radiator choked with mud, or chaff.	Clean radiator and grill.
Engine runs too cool.	Faulty thermostat. (Remaining open or not closing sufficiently).	Renew thermostat.
	Operating conditions. (Cold head winds, etc.)	Blank off portion of radiator.

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WORKSHOP SERVICE MANUAL

SECTION E

FUEL SYSTEM

FUEL SYSTEM

SECTION E

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FUEL SYSTEM. PETROL ENGINE TRACTOR

FUEL SYSTEM.
VAPORISING OIL AND LAMP OIL TRACTORS

CONTENTS—*continued*

NOTE.—Pages 11-100 Held in Reserve.

FUEL SYSTEM. DIESEL ENGINE TRACTOR

CONTENTS—*continued*

FUEL SYSTEM 3A-152 ENGINE

CONTENTS—*continued*

LIST OF ILLUSTRATIONS

FUEL SYSTEM

PETROL ENGINE TRACTOR

The petrol tank is situated over the engine and petrol, supplied by gravity feed from the tank, passes through a two-way valve and sediment bowl to the carburettor. Air supplied to the carburettor and to the crankcase passes through an air cleaner mounted on the R.H. side of the engine and protected from engine heat by a sheet metal shield.

PETROL TANK

The petrol tank capacity is $9\frac{1}{4}$ Imperial gallons (42.05 litres), of which one gallon is held in reserve by a two-way valve. Spill-off plates are fitted to both sides of the fuel tank, these protect the electrical equipment from splashes of petrol during re-fueling, thus avoiding deterioration of insulation and risk of fire.

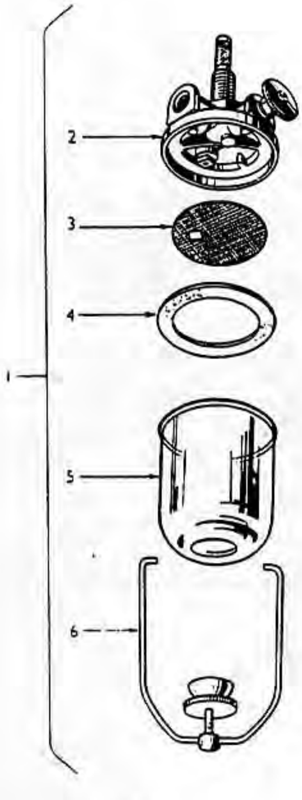


FIG. 1
EXPLODED VIEW OF SEDIMENT BOWL

To Remove and Replace Petrol Tank

First remove hood and battery. The petrol tank can then be removed, after disconnecting the fuel pipe, by removing the two set screws securing the rear of the tank to the battery carrier, and slackening the two spring-loaded bolts securing the front of the tank to the thermostat housing. Slide tank rearwards and remove. Re-mounting the tank is a reversal of the above procedure.

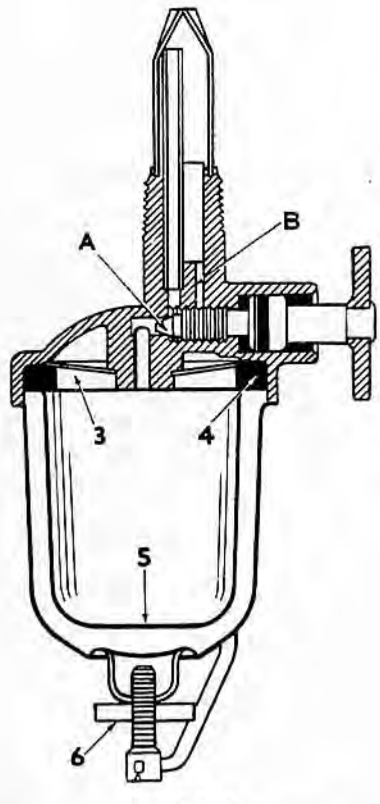


FIG. 2
SECTION OF SEDIMENT BOWL

FUEL VALVE AND SEDIMENT BOWL ASSEMBLY

The two-way valve and sediment bowl assembly is shown in Fig. 1. It consists of a fuel valve assembly (2) to which is attached a sediment bowl (5) by means of a retainer. Located between the bowl and the filter are a filter gauze (3) and a gasket (4). A cross section through the valve and sediment bowl assembly is shown in Fig. 2.

Function of the Fuel Valve and Sediment Bowl (Fig. 2)

When the valve stem seats at (A) petrol is cut off. When the valve stem is unscrewed two turns—main petrol supply flows through the stand pipe. When the valve stem is screwed back to its limit—reserve petrol supply flows through (B).

The direction of the petrol flow through screen (3) is upwards so that sediment falls from the screen to collect in the bottom of the sediment bowl (5). Water in the fuel will also accumulate in the bottom of the bowl.

To Remove Sediment Bowl

It is periodically necessary to clean the sediment bowl and screen by washing in petrol. The bowl is easily detachable by unscrewing knurled nut (6).

To Replace Sediment Bowl

Hold the bowl loosely in position and allow to fill before tightening knurled nut. This allows air to escape from the bowl preventing an air lock.

THE AIR CLEANER

The purpose of the air cleaner is to filter the air entering the carburettor, to protect the engine from dust or other abrasives. The air cleaner inlet is situated behind the instrument panel. The air inlet hose is detachable for cleaning. (See Fig. 3).

The air cleaner unit consists of a cleaner element and body with top cover and an oil container.

A section through the air cleaner is shown in Fig. 4.

Air entering from the top of the central air duct (A) passes through the oil bath (B) and cleaner element (C) to the outlet pipe which is connected to the engine by rubber hoses.

When the oil container at the base of the air cleaner is filled to the correct level, the bottom of the centre tube (A) inside deflector ring (D) is immersed. Air passing down the centre tube must displace the oil contained in this ring in order to pass into the cleaner element. The ring forces the air, travelling at high velocity from duct (A), to make a sharp 180° turn to pass through the cleaner element to the outlet pipe. Centrifugal force due to the sudden change of direction of the air throws a large proportion of foreign particles down into the oil. Holes around the top of the deflector ring allow for a continuous flow of oil back into the central ring, while the foreign material is deposited in the oil outside the ring, and settles to the bottom of the cup. The air, with any remaining foreign material continues up through the packing material around the central pipe, the packing acting as a filter and removing the remaining foreign material. The oil carried up into the packing by the air washes the foreign matter off the packing and carries it back down into the oil cup where it

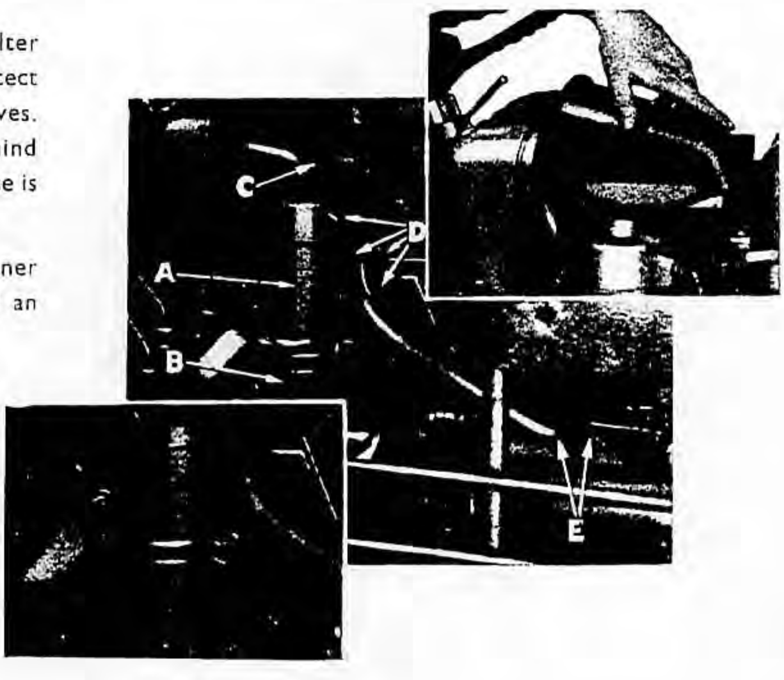


FIG. 3
AIR CLEANER AND CONNECTIONS

A. Air Cleaner
B. Air Cleaner Bowl
C. Air Cleaner Inlet
D. & E. Hoses and Unions

settles to the bottom. The clean air reaches the top of the air cleaner and passes into a steel tube, (E) connected by flexible hoses to the carburettor.

NOTE.—Most of the oil is drawn up into the cleaner element when the engine is running.

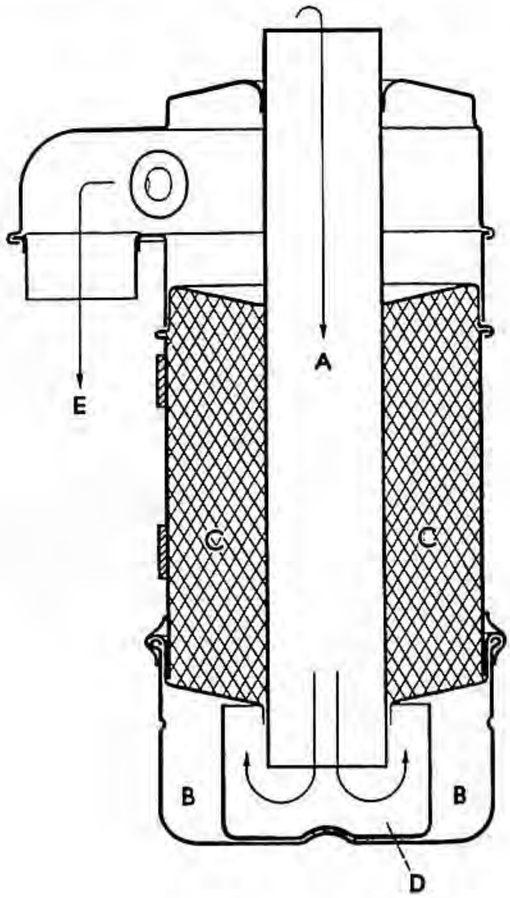


FIG. 4
SECTION OF AIR CLEANER

Service Recommendations

1. The oil container should be cleaned and refilled every 10 hours, or daily—in dusty conditions twice daily.

2. Use oil of engine grade. It is permissible to recommend the use, in very cold weather, of 25% paraffin so that the oil may flow freely.

3. Do not overfill the oil container, inspect the inside of the air inlet pipe at carburettor for oil carried over due to high oil level or the use of oil which is too heavy. The depression in the carburettor air system caused by an overfilled container or a dirty cleaner element will enrich the fuel mixture and increase fuel consumption.

4. Ensure that there is no restriction to the air flow through the air inlet hose. This should be removed and cleaned at intervals.

5. The entire cleaner unit should be occasionally removed from the tractor and thoroughly washed with petrol.

6. Ensure that the hose connections between the air cleaner and the carburettor and the crankcase are air tight and the hoses are not cracked or swollen.

7. Inspect for broken seams which allow air to by-pass the cleaner. Paint worn away at unusual points will indicate probable leaks.

8. Inspect for loose oil container or worn bracket.

CRANKCASE VENTILATION

An air breather valve assembly is fitted in the rocker cover and connected to the inlet manifold. Through this valve is induced a bleed of warm oil-saturated air, from the chamber enclosed by the rocker cover assisting carburation and providing upper cylinder lubrication. The consequent depression in the rocker cover creates a flow of air through the push rod passages from the crankcase, which is replaced by air from the small outlet of the air cleaner.

To Remove and Replace Air Breather Valve Assembly

It is necessary first to remove the fuel tank. The air breather valve assembly can then be removed from the rocker cover and inlet manifold. When replacing, ensure that no possibility of a leak exists.

28G CARBURETTOR

Adjustments
Petrol Engine Tractor

Main Jet	... $1\frac{3}{4}$ turns open, $\pm\frac{1}{4}$ turn
Slow Running Jet	... $1\frac{3}{4}$ turns open approx.

Petrol Engine Tractors will be found to be fitted with one of the following carburettors:

C-1542

Identification: Stamped C-1542. Dab of yellow paint on F.C. cover.

Data:

Choke Tube Dia.	19 mm.
Main Jet	245 c.c.
Air Jet	.70 mm.
S.R. Jet	70
Needle Seating	2.0 mm.
Fuel Level	17 mm. at 18" head

(measured from top face of carburettor bowl)

C-1575

Identification: Stamped C-1575. Dab of blue paint on F.C. cover, dab of green on bowl.

Data:

Choke Tube Dia.	19 mm.
Main Jet	245 c.c.
Air Jet	.70 mm.
S.R. Jet	55
Needle Seating	2.0 mm.
Fuel Level	17 mm. at 18" head

(measured from top face of carburettor bowl)

C-1608

Identification: Stamped C-1608. Dab of white paint on F.C. cover, dab of brown on bowl.

Data:

Choke Tube Dia.	19 mm.
Main Jet	245 c.c.
Air Jet	.70 mm.
S.R. Jet	70
Needle Seating	2.0 mm.
Fuel Level	17 mm. at 18" head

(measured from top face of carburettor bowl)

General Description

The 28G carburettor is a dustproof vertical unit of robust design and construction, capable of high angle operation.

Principle of Operation (Fig. 5)

Fuel enters the carburettor at the banjo union (7) and the float chamber through the needle and seating assembly (14). It will be observed that the float chamber is of special construction, embodying a dual float (12) system, so that as the fuel rises in the chamber the floats will be lifted until, at the predetermined fuel level, they will lift the needle on to its seating and thus prevent the entry of more fuel.

From the float chamber the fuel passes around the adjusting needle (13), through the main jet (19), and rises in the main discharge tube (9), slow running jet (10) passage, and main air bleed (6) passage, to the predetermined level.

Starting from Cold

By pulling out the choke control the strangler (18)

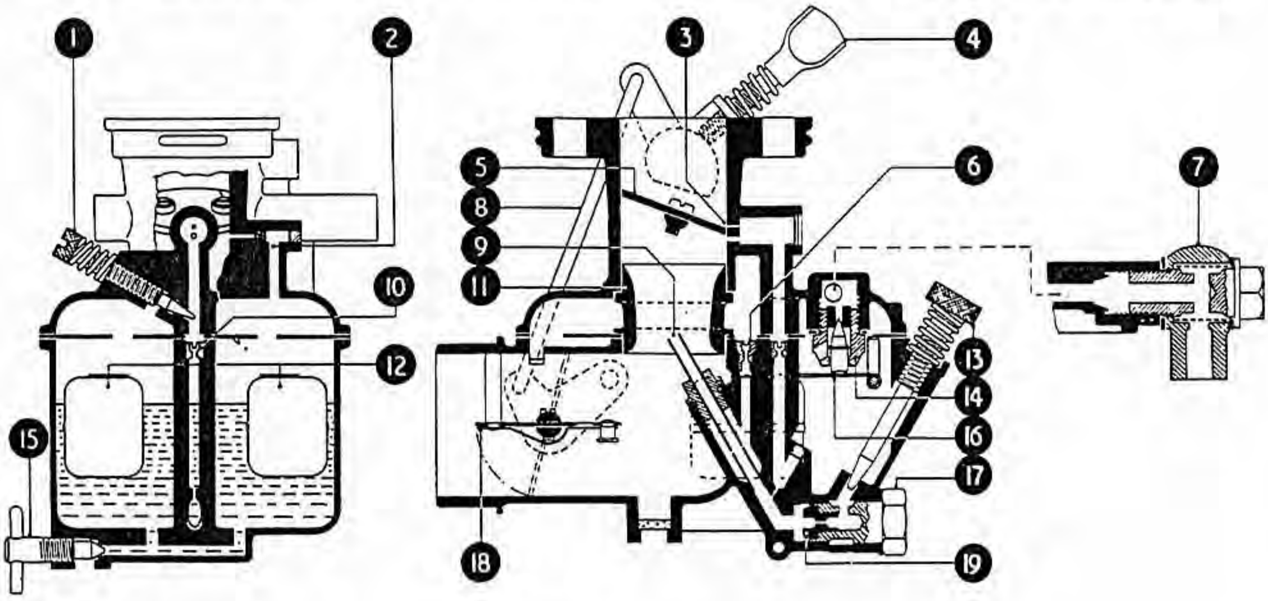


FIG. 5

CROSS SECTION OF CARBURETTOR

is turned on its spindle, and closes off the air intake of the carburettor. In so doing the inter-connection mechanism automatically opens the throttle (5) to a degree found most suitable for starting purposes. When the engine is rotated a very rich mixture passes to the engine to provide the necessary fuel for starting purposes. Once the engine fires, the extra depression on the engine side of the strangler causes the blade in the strangler, to open and close rapidly against the engine pul-sations. This ensures that the engine will continue to run at a good speed without stalling itself due to lack of air. As soon as normal working temperature has been reached the strangler should be released and fuel will then be obtained from the slow running system with the throttle back to the normal idling position.

Idling

Fuel is drawn from the well beneath the idling jet (10), is measured on passing through the jet and enters the bore of the carburettor through the drilling (3) on the engine side of the throttle. Progressive opening up from idling is ensured by the provision of a second feed hole, slightly below the first in the idling outlet near the throttle edge.

Main Carburettor

Once the throttle is opened, fuel in the channel beneath the air bleed (6) will have been taken in to the engine, and the main air bleed is now effective over the whole speed range. Fuel passing from the float chamber is measured on going through the main jet (19) and will then enter the bore of the carburettor from the main discharge tube (9). At this point the fuel is taken up by the air from the intake of the carburettor and the mixture then proceeds to the engine.

ADJUSTMENTS

Slow Running Adjustment

This should be carried out when the engine is hot, the minimum running speed being set at 145 to 165 P.T.O. r.p.m. (400 to 450 engine r.p.m.) by adjustment of the throttle stop screw (4) and the mixture regulating screw (1) to ensure that the engine speed and fuel mixture is correct to obtain steadiness when idling.

Turning the regulating screw (1) in a clockwise direction provides a richer mixture for idling and vice versa. The screw should be turned until a slight hunting (i.e. richness) occurs, and then turned back slowly approximately one turn until the engine runs evenly. If the screw is turned back too far the engine will stall.

The throttle stop screw (4) is turned inwards to increase and outwards to decrease idling speed.

Main Jet

The combination of choke tube, main jet and air jet should be as specified, and therefore it should not be necessary to alter any of these parts when dealing with ordinary maintenance.

Main Jet Setting

Turn needle (13) gently clockwise until seated and then unscrew requisite number of turns (see above).

The main jet setting given above is approximate only for normal work as fuels tend to vary in different countries. $\frac{1}{4}$ turn more or less is permissible for rich or weak mixture respectively or to suit fuel variations.

The use of a setting weaker than recommended is a false economy, and may result in burnt exhaust valves.

General Maintenance

As with all carburettors, the keynote of reliable and efficient service is absolute internal cleanliness. It is recommended that the float chamber drain tap (15) should be opened occasionally when the tractor is in use, in order to clear away any foreign matter collecting at the bottom of the float chamber.

NOTE. The channel 2 in Fig. 5 is blanked off as shown. On this model, air release to the float chamber is from the drilling inside the air intake via the annular space about the choke tube, to the carburettor float chamber.

To Remove Carburettor

1. Turn off petrol and disconnect petrol supply pipe banjo union (E) from carburettor.
2. Remove knob and locknut from choke control rod (F) at bulkhead.
3. Disconnect throttle control tie rod (G) from governor lever by removing pin from fork.
4. Disconnect rubber hose (H) between carburet-tor air intake and air cleaner pipe.

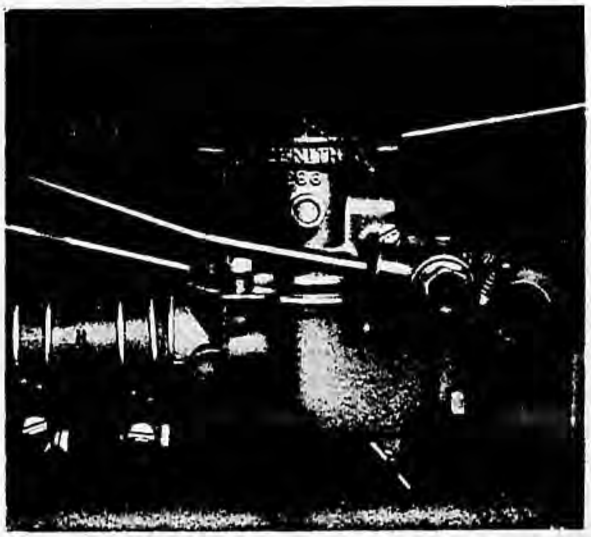


FIG. 6
28G CARBURETTOR

5. Remove the two nuts (J) and lockwashers from the studs in the carburettor flange. Lift clear carburettor assembly with control rods and remove flange gasket.
6. Disconnect choke control rod and throttle control tie-rod from carburettor by removal of cotter pins.

To Fit Carburettor

Before fitting the carburettor to the manifold, the choke control rod (F) and the throttle control tie-rod (G) should, if necessary, be disconnected from their respective housings in the bulkhead and governor lever. This will facilitate the attachment of these rods by means of cotter pins to the appropriate levers on the carburettor.

1. Offer the carburettor, with gasket, to the manifold flange, locating the choke control rod in the bulkhead.
2. Fit lockwashers and nuts (J) and tighten nuts evenly on studs in manifold flange.
3. Replace locknut and knob on choke control rod, and pin and cotter in fork attachment to governor lever.
4. Attach hose (H), ensure that no air is admitted at the joints between the air cleaner pipe and the carburettor.
5. Attach petrol supply pipe with banjo connection (L).
6. Before attempting to start the engine subsequent to refitting the carburettor, it is a good practice to check the throttle control, and inter-connection linkage to make quite sure that the correct amount of travel is obtained.

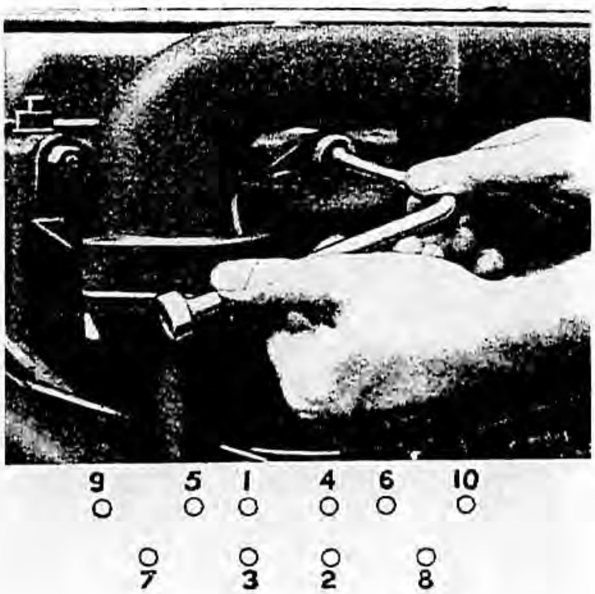


FIG. 7
ORDER OF TIGHTENING MANIFOLD NUTS

MANIFOLD

The inlet and exhaust manifolds are attached to the right-hand side of the cylinder head and are cast as one unit, with exhaust branches below the inlet, therefore reducing the heating of fuel in the tank. The inlet valves are served by independent ports providing equal distribution of a uniform mixture at all speeds. A sheet metal heat shield is fitted to deflect manifold heat from the petrol tank and air cleaner.

The manifold assembly is located on studs in the cylinder head and secured by nuts with lockwashers. A gasket is fitted between the manifold and the cylinder head.

To Remove Manifold Assembly

1. Remove hood.
2. Remove battery.
3. Turn off fuel. Disconnect fuel pipe at sediment bowl. Remove bolts securing rear of fuel tank, slacken two spring-loaded bolts securing front of tank to thermostat housing. Slide fuel tank rearwards to disengage from spring-loaded bolts. Remove tank. Remove manifold shield and breather pipe.
4. Disconnect carburettor linkage, petrol pipe, and loosen hose connections—See "To Remove Carburettor".
5. The carburettor can be removed, either individually or with the manifold assembly.
6. Disconnect air bleed tube from rocker cover and manifold.
7. Disconnect exhaust pipe at manifold flange.
8. Using manifold nut wrench, Fig. 7, remove nuts and lockwashers from manifold securing studs in cylinder head.
9. Remove manifold assembly and gasket.

To Replace Manifold Assembly

1. Ensure that the faces of the manifold flanges and exhaust pipe flanges are clean and true before assembly.
2. If gaskets show any sign of damage or "Blowing" —discard and renew.
3. Tighten manifold and exhaust pipe securing nuts gradually and evenly until dead tight. The order in which to tighten the manifold nuts is shown in Fig. 7.

EXHAUST ASSEMBLY

The exhaust pipe, silencer and tail pipe form an assembly supported forward at the right-hand side of the crankcase and rearward at the right-hand axle housing flange.

The silencer is secured to the pipe by a clip.

FUEL SYSTEM

VAPORISING OIL AND LAMP OIL TRACTORS

GENERAL

Vaporising Oil and Lamp Oil tractor engines are designed to operate on low octane fuels which require a minimum engine temperature of 75°C. (167°F) for efficient combustion. Since at lower engine temperatures the use of these fuels will cause sump oil dilution, with risk of resultant liner and bearing wear and loss of oil pressure, provision is made for the use of petrol when the tractor is on work involving numerous engine stops and for starting and warming up.

The thermostat setting of these engines is higher than that of the petrol engine and a temperature gauge is fitted. This gauge is marked to indicate the temperature (75°C.) at which the change from petrol to V.O. or L.O. may be made.

In order to afford additional protection to the engine against damage resulting from possible sump oil dilution, a heavier grade engine oil is recommended, and the period between engine oil renewals is halved.

While the fuel system of the V.O. and L.O. engines is similar in principle to that of the petrol engine, certain modifications, relative to the requirements of these engines, have been incorporated. The main differences are as follows:—

FUEL TANK AND SEDIMENT BOWL ASSEMBLY

The fuel tanks of V.O. and L.O. tractors are fitted with a smaller compartment for petrol—serving both for cold starting and reserve. This small tank has a capacity of one Imperial gallon. Capacity of main fuel tank is $8\frac{1}{4}$ gallons (37.5 litres). Selection is made by a three-way tap which connects the two compartments to the fuel system. The illustration shows the tap in the OFF position.

It is necessary to remove the sediment bowl periodically, and clean the sediment bowl and screen by washing in petrol. See page E.2.

28G CARBURETTOR

V.O. Tractor

Main Jet	2 turns open, $\pm\frac{1}{4}$ turn
Slow Running Jet ...	$1\frac{3}{4}$ turns open approx.

L.O. Tractor

Main Jet	$2\frac{1}{2}$ turns open, $\pm\frac{1}{4}$ turn
Slow Running Jet ...	$1\frac{3}{4}$ turns open approx.

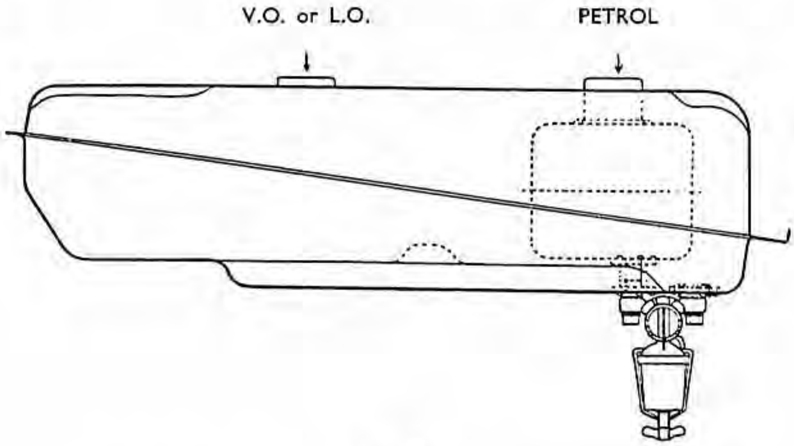


FIG. 8
V.O. OR L.O. FUEL TANK AND SEDIMENT BOWL ASSEMBLY

The carburettors fitted to the Vaporising Oil and Lamp Oil Engine Tractors are similar to those fitted on the Petrol Engine version. One of the following will be found to be fitted:

C-1575

Identification: Stamped C-1575. Dab of blue paint on F.C. cover, dab of green on bowl.

Data:

Choke Tube Dia.	19 mm.
Main Jet	245 c.c.
Air Jet	.70 mm.
S.R. Jet	55
Needle Seating	2.0 mm.
Fuel Level	17 mm. at 18″ head

(measured from top face of carburettor bowl)

C-1578

Identification: Stamped C-1578. Dab of brown on F.C. cover, and on bowl.

Data:

Choke Tube Dia.	19 mm.
Main Jet	245 c.c.
Air Jet	.70 mm.
S.R. Jet	80
Needle Seating	2.0 mm.
Fuel Level	17 mm. at 18″ head

(measured from top of the carburettor bowl)

MANIFOLDS

The inlet and exhaust manifolds are attached to the right-hand side of the engine cylinder and form a single casting. Thus, heat from the exhaust gases is conducted to the inlet manifold, pre-heating the mixture passing from the carburettor to the combustion chambers.

The manifold assembly is located on studs in the cylinder head and secured by nuts with lockwashers. A gasket is fitted between the manifold and the cylinder head. A clearance exists between the exhaust and induction manifold flanges to allow for their different expansion rates.

A heat shield is fitted over the manifolds, and this also assists in the retention of engine heat, providing a stable and relatively higher working temperature at the inlet manifold.

CARBURETTOR ENGINE FUEL SYSTEM FAULT TABLE

FAULT	POSSIBLE CAUSE	ATTENTION REQUIRED
Will not start.	Fuel supply restricted.	Ensure that fuel is turned ON and that float needle valve is not sticking. Examine filter screens, strainers and filler cap vent for blockage. Examine sediment bowl for air-lock.
	Choke plate not closing fully.	Inspect and adjust as instructed.
	Incorrect adjustment of inter-connecting linkage between throttle and choke.	Inspect and adjust as instructed.
	Too rich a mixture due either to use of choke when engine is hot, or "pumping" throttle hand lever when operating starter.	Push choke control fully home. Open throttle hand lever to its limits and operate starter. After first few revolutions of the engine, excess fuel will be cleared. Reset controls and engine should start.
Difficult starting—Poor idling	Incorrect setting of either or both of the idler adjust screws.	Re-adjust as instructed.
	Dirt below idler jet.	Remove jet and clean by blowing out.
	Air leak due to loose carburettor bowl.	Tighten bolts. Renew gasket if defective.
	Air leak at induction manifold, carburettor unions, throttle spindle bushes or hose connections to air cleaner.	Tighten nuts, renew seals, gaskets or hoses as necessary.
	Sticking float needle.	See "Fuel supply restricted".
Poor response from engine on opening throttle.	Non-standard main jet.	Fit correct main jet.
	Incorrect main jet adjustment.	Adjust according to instructions.
	Choke plate not opening fully when dash control is released.	Inspect and adjust linkage.
	Jets not screwed down tightly.	Check jets for tightness.
	Fuel level in float chamber too low.	Re-adjust flqat setting as required.
	Air cleaner oil bath over-filled or cleaner element dirty.	Wash out air cleaner and refill oil bath to correct level with clean oil.

FAULT	POSSIBLE CAUSE	ATTENTION REQUIRED
Leakage and Flooding.	Grit on float needle seating.	Caused by damaged filter screens in carburettor or fuel sediment bowl. Inspect and clean or renew screens where necessary. Remove needle and clean seating by blowing out. When re-assembling ensure that all washers are perfect and tightened adequately.
	Fuel level in float chamber too high.	Re-adjust setting as required.
	Leaking float.	Replace.

FUEL SYSTEM

DIESEL ENGINE TRACTOR—23C

GENERAL

The fuel tank, of $7\frac{1}{2}$ gallon (34 litre) capacity, is situated over the engine, and from it the fuel is piped to a mechanically operated diaphragm type feed pump, wherein it passes through a gauze filter and is then delivered under light pressure through the main fuel filter to the injector pump and injectors.

A return pipe is fitted which allows unused fuel to flow back to the main fuel filter. This also serves to permit any air which may be in the fuel or originally contained in the pump to be carried out with the fuel.

A "circulation pipe" from the filter to the reservoir tank provides a permanent leak back to the main fuel tank whilst the tractor is operating. By this means the fuel is kept in constant circulation, and any air in the system is automatically bled away.

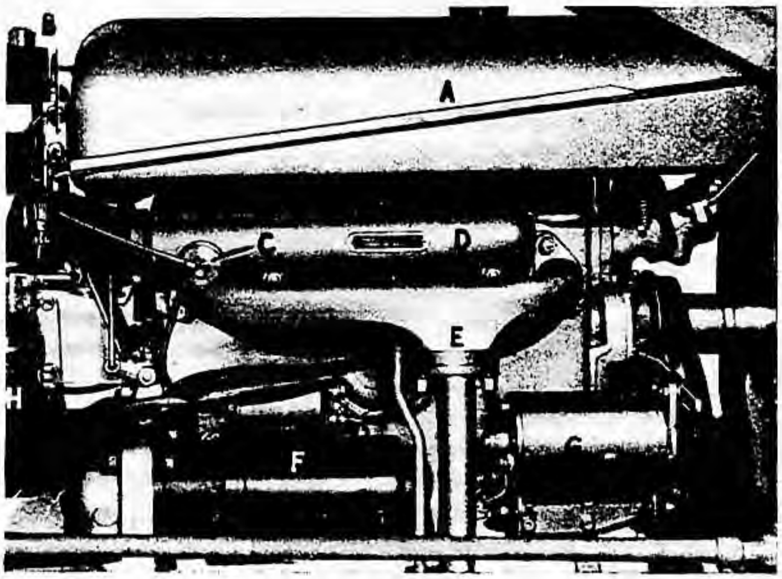


FIG. 101 R.H. SIDE OF ENGINE

A gauze filter and sediment bowl assembly is fitted at the tank outlet, and is easily dismantled for cleaning whenever sediment or water collects.

It is most important that water is not allowed to remain in the fuel system, as very severe damage could occur if water finds its way into the precision built injection pump.

A fuel tap is fitted at the tank outlet above the sediment bowl assembly.

The moving parts of the distributor type injection pump are lubricated by the fuel passing through the pump and no additional lubrication is required.

All air entering the combustion chambers passes first through the air cleaner mounted on the R.H. side of the engine, thus protecting the engine from dust and other abrasives.

The crankcase is ventilated by a breather tube which extends from the rocker cover down the right-hand side of the engine and is open to atmosphere; or, on early tractors, by a canister type filter mounted on the left-hand side of the engine.

A Thermostart is fitted to provide for easy starting particularly in temperatures below 32°F. (0°C.).

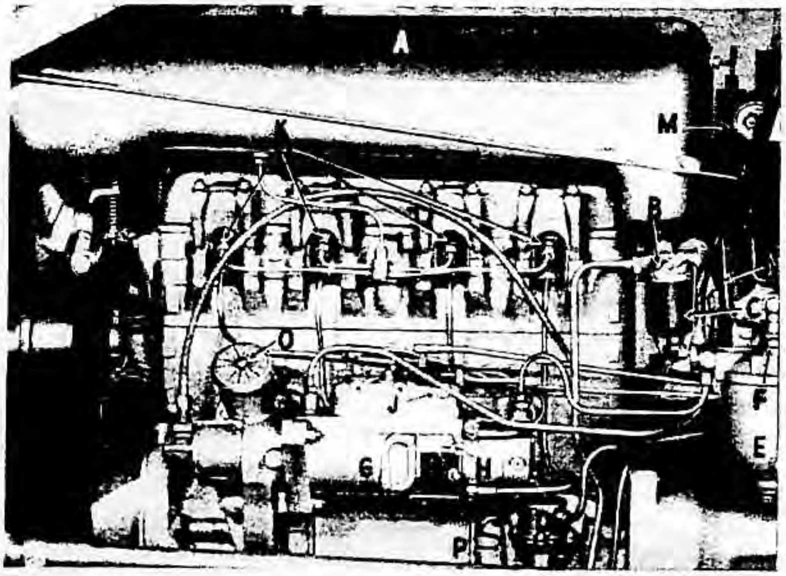


FIG. 102. L.H. SIDE OF ENGINE

CRANKCASE VENTILATION

There are two alternative methods of crankcase ventilation. On one, the crankcase is ventilated up past the push rods into the rocker cover and then out to atmosphere through a shielded tube which goes down along the right side of the engine.

This tube also prevents any dust or grit from entering the engine, the dirt being trapped on the oily inside walls of the tube and then washed down and out. The vent tube can be removed for cleaning without disturbing the fuel tank or rocker cover.

It is most important to keep this vent tube free from any form of blockage, *i.e.* soil or mud; failing to do so will result in high crankcase pressure, and possible increased oil consumption.

On engines fitted with the alternative method of crankcase ventilation the engine is vented through a canister type breather mounted on the left-hand side of the crankcase. There is no breather tube from the rocker cover on these engines.

To Remove and Replace Crankcase Breather Filter

Remove retaining screw in cover. The cover, element, screen and washers may now be lifted out.

N.B.—Care should be taken to prevent the ingress of foreign matter into the crankcase when the filter is removed. Clean all parts of the filter in clean paraffin, and lightly impregnate the element with thin oil before re-assembly.

Re-assemble in reverse order, taking care not to over-tighten the centre bolt as this may result in distortion of the mesh screen.

DE-AERATION OF THE FUEL SYSTEM

Should air enter the system, due to unexpected emptying of the fuel tank, dismantling of the fuel filter, sediment bowl or feed pump for cleaning or any other reason, the fuel system must be de-aerated before any attempt is made to start the engine.

Adopt the following procedure:—

(*a*) Check all fuel line connections for tightness, other than those which will be slackened during the process of bleeding.

(*b*) Unscrew the filter vent plug "F" and operate the feed pump hand priming lever until fuel, free from air bubbles, emerges from the vent hole. Tighten vent plug.

(c) Slacken vent plugs "H" and "J" on injector pump and operate feed pump hand priming lever until fuel, free from air bubbles, emerges from hole "H". Retighten plug "H". Continue to operate lever until fuel, free from air bubbles, emerges from hole "J". Retighten plug "J". (On some pumps it may be necessary to remove these plugs to obtain a flow of fuel). It is *most* important that the screwdriver type plug adjacent to the pump inlet should not, under any circumstances, be removed.

(d) Slacken feed pipe at D.P.A. pump inlet. Operate priming lever and vent. Retighten.

(e) Slacken off union nuts at two of the most convenient injectors. Operate starter to crank engine. When fuel emerging from union is free from air bubbles, retighten unions.

NOTE.—If the engine starts on the two remaining cylinders when operation (e) is being conducted, this is in no way detrimental, but stop engine before tightening union nuts. Although it is recommended that only two injector pipes are loosened, it is permissible, if considered desirable, to loosen all four.

(f) Finally ensure that all fuel lines are free from leaks.

FUEL TANK

The capacity of the main fuel tank is 7½ Imperial gallons (34 litres). It is designed to ensure that there is a constant head of fuel, even when the tractor is tilted. There is no reserve supply.

Spill-off plates are fitted to both sides of the fuel tank. These protect the electrical equipment from splashes of fuel during re-fuelling thus avoiding deterioration of insulation and risk of fire.

At the rear of the main fuel tank a small reservoir tank is fitted. This tank acts as a header tank for the Thermostart (see page E.123). It is automatically topped up with clean fuel, when the engine is running, via the circulation connection from the main fuel filter, and there is a further connection to the main fuel tank. This completes the fuel return circuit, by means of which any air in the fuel system is automatically bled away while the tractor is operating.

To Remove and Replace Fuel Tanks

i. Remove hood.

ii. Disconnect positive lead from battery mounted on L.H. side of the driver's seat.

iii. Turn off fuel tap.

iv. Disconnect the following fuel pipes:
Reservoir tank to filter—at filter.
Reservoir tank to Thermostart—at Thermostart.
Reservoir tank to main fuel tank—at main fuel tank.
Fuel return pipe—at main fuel tank.
Main fuel pipe—below sediment bowl.

v. Remove reservoir tank with fuel pipes attached.

vi. Remove two set screws securing rear of fuel tank to battery carrier. Slacken two spring-loaded bolts securing front of fuel tank to thermostat housing. Slide fuel tank rearwards to disengage from spring-loaded bolts. Remove fuel tank.

Replacement should be made in reverse order, fitting rubber mounting pads between tank brackets and battery carrier, and entering fuel return pipe carefully into fuel tank. Remount reservoir tank with pipes, fitting rubber mounting pad between main fuel tank bracket and reservoir tank mounting plate. Reconnect pipes between reservoir tank and main fuel tank, reservoir tank and fuel filter, and reservoir tank and Thermostart.

Reconnect battery lead, and replace hood.

FUEL VALVE AND SEDIMENT BOWL ASSEMBLY

The fuel valve and sediment bowl assembly is shown in Fig. 103. It consists of a fuel valve assembly (1), to which is attached a sediment bowl (2), by means of a retainer. Located between the bowl and the filter is a filter gauze (4), and a gasket (5). A cross section through the valve and sediment bowl assembly is shown in Fig. 104.

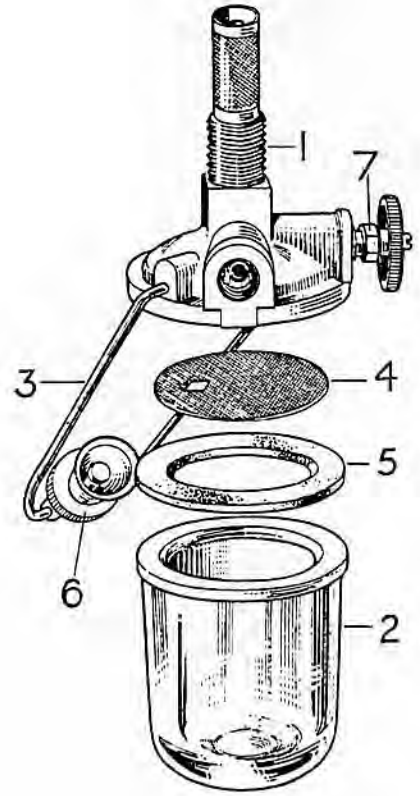


FIG. 103
EXPLODED VIEW OF FUEL VALVE AND SEDIMENT BOWL ASSEMBLY

The direction of the fuel flow through screen (4) is upwards so that sediment falls from the screen to collect in the bottom of the sediment bowl (2). Water in the fuel will also accumulate in the bottom of the bowl.

To Remove Sediment Bowl

It is periodically necessary to clean the sediment bowl, and screen. The bowl is easily detachable by unscrewing knurled nut (6).

To Replace Sediment Bowl

Hold the bowl loosely in position and allow to fill before tightening knurled nut (6). This allows air to escape from the bowl preventing an air lock.

FUEL FEED PUMP

After passing through the fuel valve and sediment bowl assembly, the fuel is piped to the mechanically operated, diaphragm type feed pump. The pump is mounted on the L.H. side of the cylinder block and is driven by the engine camshaft. It delivers the fuel under light pressure through the fuel filter to the injection pump. A hand lever is provided on the pump to enable the fuel system to be primed manually during de-aeration (see page E.102).

Details of Operation (See Fig. 105)

As the engine camshaft (G), revolves, the eccentric (H), lifts the pump rocker arm (D), pivoted at (E), which pulls the rod (F), together with the diaphragm (A), downward against spring pressure (C), thus creating a vacuum in the pump chamber (M). Fuel is drawn from the tank and enters at (J), into the sediment chamber through filter gauze (L), suction valve (N), into the pump chamber (M).

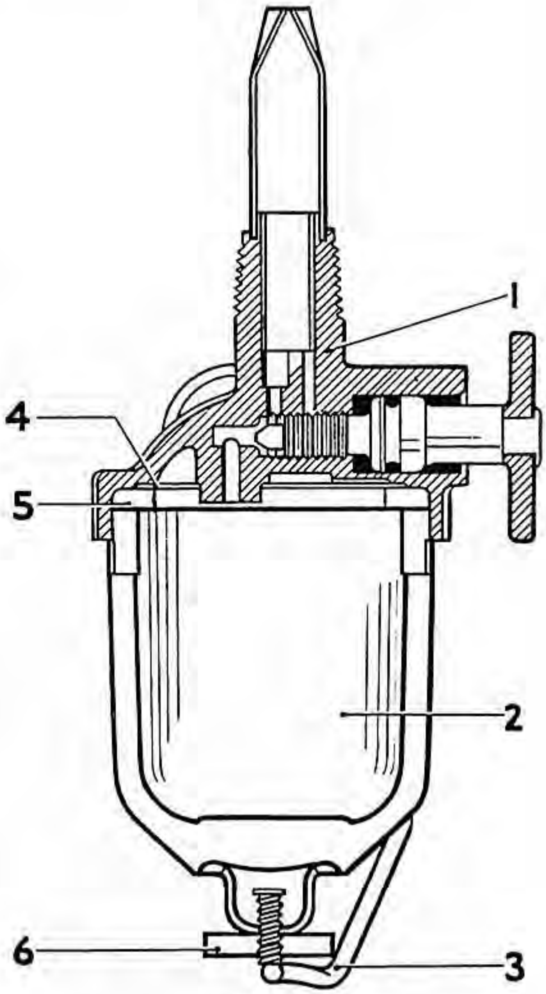


FIG. 104
CROSS SECTION OF FUEL VALVE AND SEDIMENT BOWL ASSEMBLY

On the return stroke the spring pressure (C), pushes the diaphragm (A) upwards, forcing fuel from chamber (M), through the delivery valve (O), and opening (P), to the main fuel filter and injection pump.

Delivery of fuel is automatically regulated according to engine requirements, as when the flow is small, spring (C), can only give a correspondingly reduced movement of the pump diaphragm.

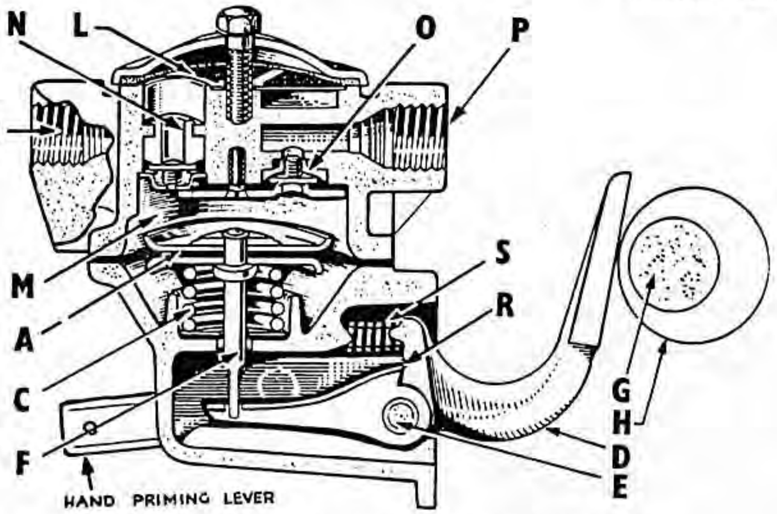


FIG. 105 SECTION VIEW OF FUEL FEED PUMP

The rocker arm (D), operates the connecting link by making contact at (R), and this construction allows idling movement of the rocker arm when, there is little or no movement of the diaphragm. Spring (S), keeps the rocker arm (D), in constant contact with the eccentric (H), to eliminate noise.

Cleaning Filter

The filter should be examined every week and cleaned if necessary. Under conditions of dust laden atmosphere this interval should be reduced as conditions dictate. Access to the filter is gained by removing the dome cover, after unscrewing the retaining screw, when the filter gauze itself may be lifted off its seating. Clean filter gauze with air jet. The cork gasket under the filter cover should be renewed if broken or if it has hardened. When refitting the cover, make certain that the fibre washer is replaced under the head of the screw. Tighten the filter cover retaining screw just sufficiently to make a tight joint.

Check pump engine mounting set screws and fuel pipe unions for tightness.

Servicing

Should a fault be suspected:—

First check that there is sufficient fuel in the tank and see that all joints and pipes are perfectly air tight, as any leak will cause the feed pump to deliver insufficient fuel.

Uncouple the pipe from the outlet union and operate the hand priming lever. Fuel free of bubbles should spurt from the union at each stroke of the priming lever. A weak or irregular supply of fuel at the injector pump, provided it is not due to an inadequate fuel supply, air locks or kinked pipes, indicates a faulty feed pump. A new pump should be fitted.

Removing from Engine

Turn off fuel, disconnect the pipe unions, and unscrew the two set screws fixing the fuel pump at the engine, after which the fuel pump will come away readily.

Inspection of Parts

First, all parts must be thoroughly cleaned to ascertain their condition. Wash all parts in the locality of the valves in a clean paraffin bath, separate from that employed for the other and dirtier components.

Diaphragm and pull rod assemblies should normally be replaced unless in entirely sound condition without any signs of cracks or hardening of the diaphragm layers.

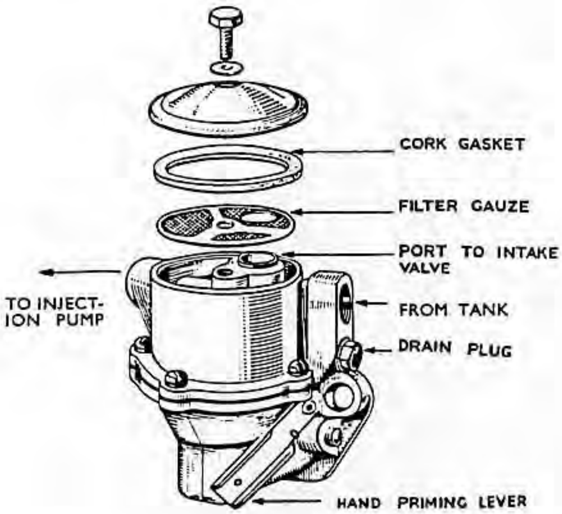


FIG. 106
EXTERNAL VIEW OF FUEL FEED PUMP

Upper and lower castings should be examined for cracks or damage, and if diaphragm or engine mounting flanges are distorted these should be lapped to restore their flatness. All badly worn parts should be replaced, and very little wear should be tolerated on rocker arm pins (18), the holes and engagement slot in link (14), holes in rocker arm (16). On the working surface of the rocker arm, which engages with the engine eccentric, slight wear is permissible, but not exceeding .010" in depth.

The valve seat incorporated in valve plate (7) should be examined and if at all rough should be carefully lapped, first on a smooth carborundum stone; similarly, the corresponding outlet valve seat incorporated in the upper casting (24) should be examined, and if worn unevenly to the slightest degree, both the upper casting and valve seat assembly must be replaced. It is not practicable to refit new valve seats into the castings as this calls for special equipment. Fuel pump valves (2 and 4) should be replaced if at all worn, although in an emergency they can be turned over to provide a fresh surface to the valve seat. Valve springs should preferably be replaced, although they can be refitted providing they do not bear undue evidence of rubbing away on the outside diameter. In no circumstances should valve springs be stretched in an endeavour to increase their strength. Diaphragm spring (22), seldom calls for replacement but, where necessary, ensure that the replacement spring has the same identification colour and consequently the same strength as the original. All gaskets and joint washers should be replaced as a matter of routine.

To Re-assemble Fuel Pump

The following procedure should be adopted, dealing with the upper portion of the pump first:—

Valves should be swilled in clean paraffin before re-assembly.

Apart from the cleaning effect this improves the sealing between the valve and seat. Fit

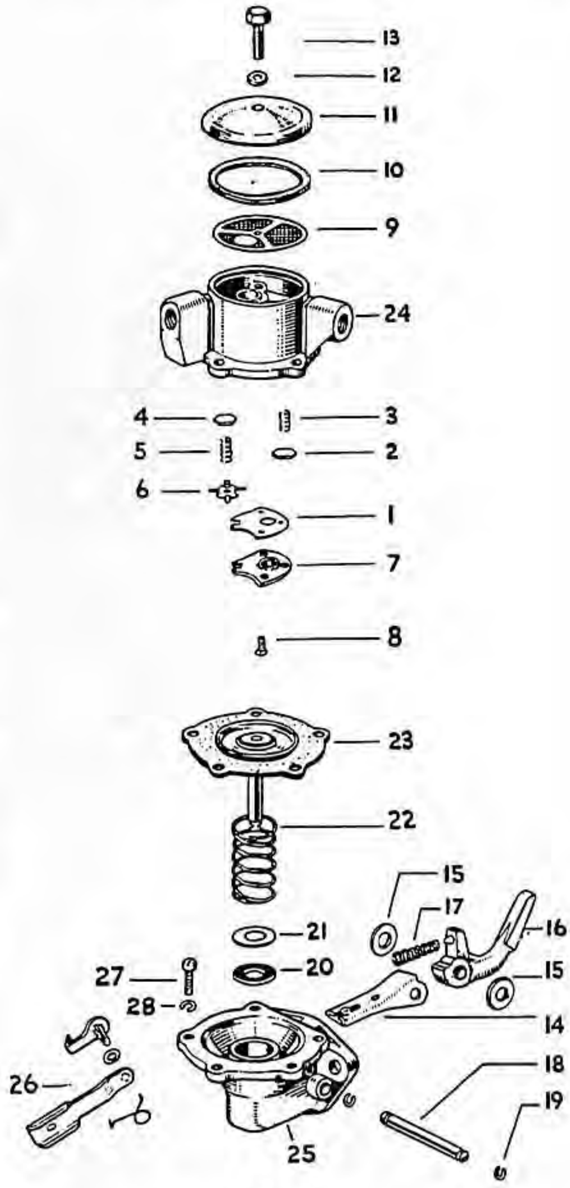


FIG. 107
EXPLODED VIEW OF FUEL FEED PUMP

outlet valve spring in the centre of the four cast webs.

Place outlet valve (2) on spring (3).

Place inlet valve (4), on valve seat located in the upper casting.

Place valve spring (5) on centre of inlet valve.

Place retainer (6) on top of inlet valve spring.

Place valve plate gasket (1), in position.

Place valve plate (7) in position and secure with the three screws (8). (At this stage use a piece of wire to make sure that valves work freely).

Place filter screen (9), in position on top of casting, making certain that it fits snugly.

Fit cork gasket (10), cover (11), fibre washer (12), and retaining screws (13), as previously detailed under "Cleaning Filter".

To assemble the lower half, proceed as follows:—

Assemble link (14), packing washer (15), rocker arm (16), and rocker arm spring (17), in the body (25).

Insert rocker arm pin (18) through hole in body, at the same time engaging the packing washers, link, and the rocker arm, then spring the retaining clips (19), into the grooves on each end of the rocker arm pin. The rocker arm pin should be a tap fit in the body, and if due to wear it is freer than this, the ends of the holes in the body should be burred over slightly.

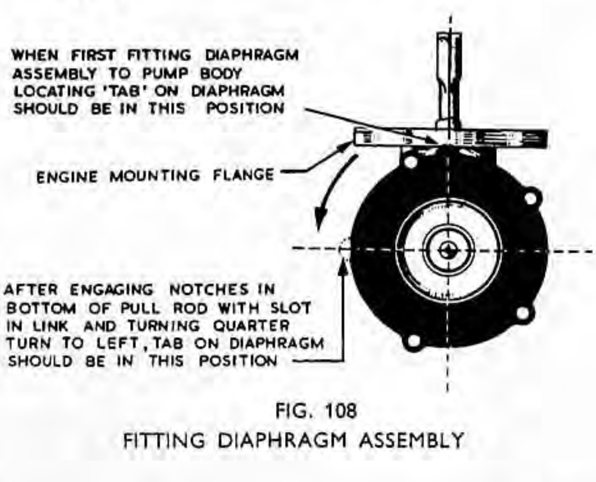


FIG. 108
FITTING DIAPHRAGM ASSEMBLY

NOTE.—The fitting of the rocker arm pin can be simplified by first inserting a piece of .240" diameter rod through the pin hole in one side of the body far enough to engage the rocker arm washers and link, and then pushing the rocker arm pin in from opposite side, removing the temporary rod as the pin takes up its proper position.

To fit the diaphragm assembly to the pump body:

Insert fabric washer (20), metal washer (21), and place the diaphragm spring (22), in position in the pump body. Place the diaphragm assembly (23), over the spring, the pull rod being downwards, and centre the upper end of the spring in the lower protector washer. Press downwards on the diaphragm, at the same time turning the assembly to the left in such a manner that the slots on the pull rod will engage the fork in the link, ultimately turning the assembly a complete quarter turn to the left, which will place the pull rod in the proper working position in the link, and at the same time permit the matching up of the holes in the diaphragm with those on the pump body flanges. When first inserting the diaphragm assembly into the pump body, the locating "tab" on the outside of the diaphragm should be in the 12 o'clock position. After turning the diaphragm assembly a quarter turn to the left the "tab" should be at the 9 o'clock position.

The two sub-assemblies of the pump are now ready for fitting together, and this is carried out as follows:—

Push the rocker arm towards the pump until the diaphragm is level with the body flanges. Place the upper half of the pump in the proper position, as shown by the mark made on the flanges before dismantling.

Install the cover screws and lock washers and tighten only until the heads of the screws just engage the washers. Use a screwdriver to hold the rocker arm at its outward position, and while so held tighten the cover screws diagonally and securely.

Testing of Fuel Pump after Assembly

The best method is by using an A.C. bench test stand, on which the suction side of the pump is piped to a tin of paraffin at floor level and the outlet side of the pump connected to a stop tap and pressure gauge.

First, flush the pump through to wet the valve and seats, and then completely empty it again by continuing to operate the rocker arm by hand with the suction pipe clear of the paraffin. Again operate pump. Not more than 20 strokes should be necessary to secure delivery of paraffin from the pump outlet.

With the same apparatus a second test can be made by working the pump with the tap on the delivery side closed, pressure then being recorded on the gauge. After ceasing to work the pump it should take several seconds for this pressure to return to zero, thus denoting that the valves are seating properly.

Also, while there is pressure, the outer edge of the diaphragm—visible between the two clamping flanges—should be carefully examined for leakage and the retaining screws tightened if necessary.

When working the pump by hand a somewhat longer stroke is obtained and the pressure developed is apt to be higher than when fitted to the engine.

When the apparatus is not available, the fuel pump should be tested, using a pan of clean paraffin as follows:—

> First, flush the pump by immersing it in the paraffin and working the rocker arm half a dozen times, then empty the pump by continuing to operate it while held above the bath. Then with the pump clear of the paraffin bath place a finger over the inlet union (marked "in") and work the rocker arm several times. Upon removing the finger a distinct suction noise should be heard, denoting that the pump had developed a reasonable degree of suction.

Afterwards the finger should be placed over the outlet union, and after pressing the rocker arm inwards the air drawn into the pump chamber should be held under compression for two or three seconds; this should also be done with the pump immersed in paraffin and the clamping flanges of the diaphragm watched for any signs of air leakage.

Refitting to Engine

Reverse the procedure outlined for removal from engine. Ensure that the rocker arm is correctly positioned against the cam. After refitting to the engine, the pump should run for a short time, and the pipe unions and pump examined for the possibility of fuel leakage.

FUEL FILTER

To prevent harmful abrasives finding their way into the vital working parts of the injector pump or the injectors and causing excessive wear, a C.A.V. type fuel filter is incorporated in the fuel system. The filter element, which consists of plastic impregnated paper, is not washable and must be changed at intervals. Fuel, delivered under light pressure by the fuel feed pump, passes through the filter element to the clean side of the filter, and to the injection

FUEL FILTER

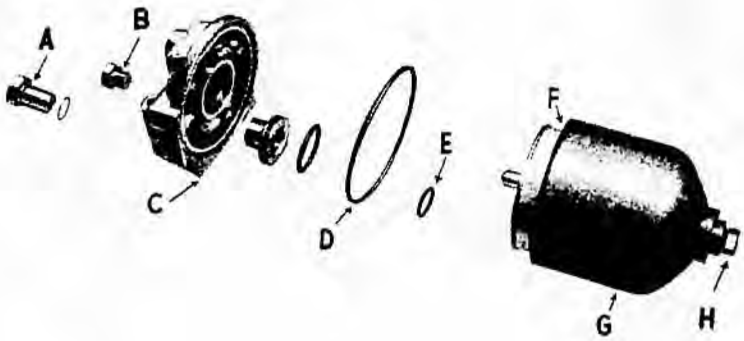


FIG. 109
EXPLODED VIEW OF C.A.V. FUEL FILTER

A. Union.
B. Vent Plug.
C. Head Assembly.
D. Sealing Ring.
E. Filter Sealing Ring.
F. Filter Element.
G. Filter Bowl
H. Drain Plug.

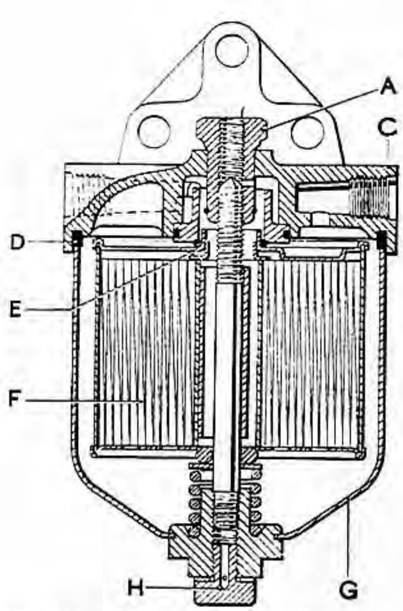


FIG. 110 CROSS SECTION OF C.A.V. FUEL FILTER. (See key of Fig. 109)

pump. Excess fuel is returned from the injection pump to the clean side of the filter. From this chamber under the filter head, there is a circulation connection to the reservoir tank, which provides a permanent leak back to the main tank whilst the tractor is operating. The fuel is therefore kept in constant circulation and any air in the system is automatically bled away.

To Service C.A.V. Fuel Filter

Before changing the filter element, clean the exterior of the filter assembly carefully and turn off the fuel supply tap. Loosen vent plug and slacken drain plug to allow fuel to drain from the filter bowl. Unscrew central top cap to release filter bowl. Remove and discard filter element. Thoroughly clean filter bowl and fit new element and new rubber sealing rings.

Refit filter bowl to filter, engaging the cap nut with the centre stud and screwing up firmly. Do not over-tighten. Close drain plug.

On completion, de-aerate the whole fuel system as instructed on page E.102.

NOTE.—Ensure that the fuel lines are flushed out before refitting the filter sump.

DUAL FUEL FILTERS (Special Order Only)

For certain territories, tractors are supplied fitted with Dual Fuel Filters. On these tractors, an additional Purolator type filter is connected in series with the C.A.V. filter. The element of the Purolator filter, which is in the primary position, should be changed every 480 working hours. Access to the filter element is gained by removing the head nut and detaching the filter sump. Thoroughly clean the interior of the sump and head and ensure that all seals are in good condition before fitting a replacement element and re-assembling.

When Dual Filters are fitted the secondary (C.A.V. type) filter should not normally require attention between overhaul periods.

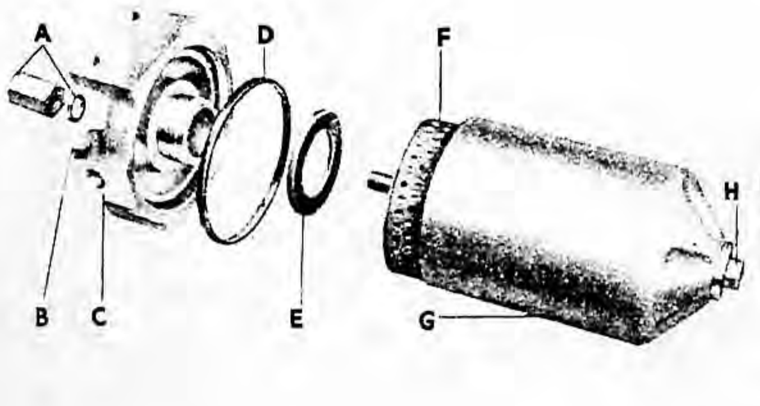


FIG. 111. EXPLODED VIEW OF PUROLATOR FUEL FILTER

A. Head Nut and Washer.
B. Vent Plug.
C. Filter Head.
D. Seal—Filter Head.
E. Top Seal—Filter Element.
F. Filter Element.
G. Filter Sump.
H. Drain Plug.

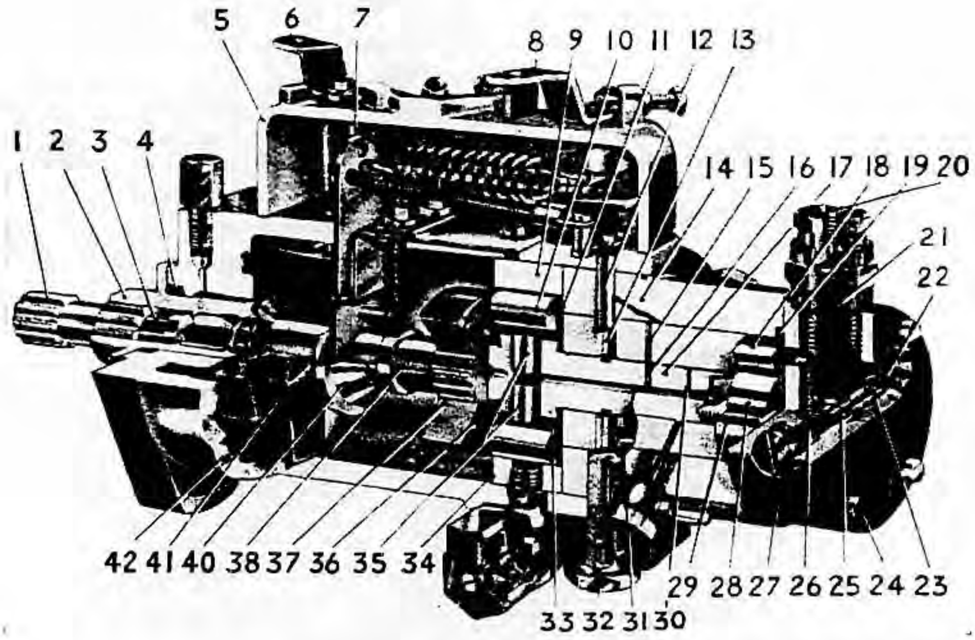


FIG. 112 D.P.A. TYPE FUEL INJECTION PUMP

THE D.P.A. TYPE FUEL INJECTION PUMP

The D.P.A. type fuel injection pump is mounted on the drive housing assembly which is attached to a machined face on the side of the cylinder block and is driven at half engine speed by the camshaft.

Description

The D.P.A. injection pump may be briefly described as a single element, opposed plunger, inlet metering, distributor type pump. It is relatively simple in design and contains no ball or roller bearings, gears, or highly stressed springs. The number of working parts remains the same, regardless of the number of engine cylinders it serves.

A mechanical governor is embodied in the pump and is completely contained within the pump housing. Fig. 112 shows the pump and mechanical governor, in section. See also Section F.

The pump is a self-contained, oil tight unit, which requires no external lubrication system. Oil pressure, which is maintained inside the pump housing, ensures the adequate lubrication of all the working parts, and prevents the ingress of dust, water or any other foreign matter which could impair the efficiency of the pump. No special lubricating oil is used, as the pump is lubricated entirely by fuel oil.

A single pumping element, having twin opposed plungers, is carried in a central rotating member which also acts as a distributor, the charges of oil being distributed in correct order to the nozzles through the pressure connections arranged round the pump body. The pump plungers operate in a transverse bore in the rotor through the action of

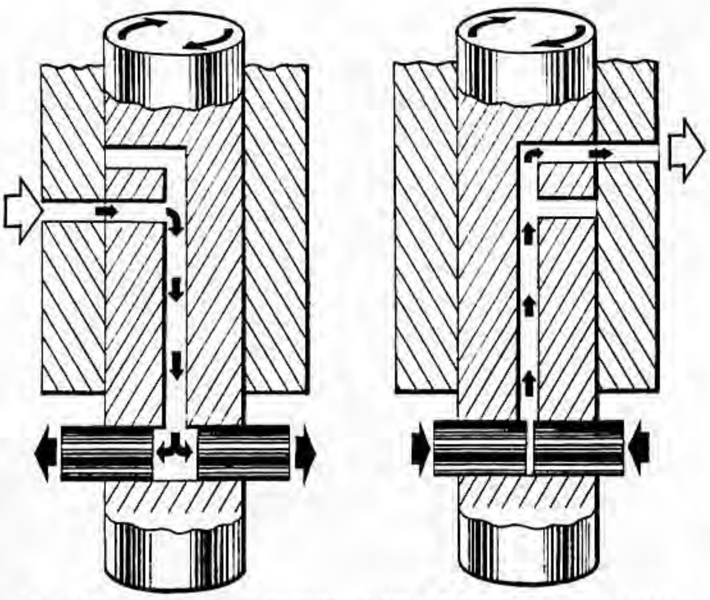


FIG. 113a WORKING PRINCIPLE OF D.P.A. PUMP FIG. 113b

rollers and shoes carried in slots in the rotor flange. The plungers are actuated through the rollers by means of a stationary cam ring, carried in the pump housing, the ring having as many lobes as there are cylinders to be served. The plungers move inwards simultaneously as the rollers contact cam lobes which are diametrically opposite, but no return springs are fitted, the plungers being returned by the pressure of inflowing fuel.

The working principle of the pump can be followed readily by the simple diagrams, Figs. 113a and 113b. In Fig. 113a, the rotor, referred to as the pumping and distributing rotor, is seen in the stationary member, known as the hydraulic head, in the "inlet" position. The pump plungers are seen moving outwards, under pressure from fuel flowing in from a port in the hydraulic head known as the metering port, through a radial inlet hole in the rotor to a central axial passage opening to the pump bores.

As the rotor turns, the inlet port is cut off (Fig. 113b) and the pump plungers begin to be forced inwards by their rollers bearing on a pair of cam lobes. A second radial hole in the rotor, known as the distributor port, now comes into register with an outlet port in the hydraulic head, and fuel is forced by the plungers up the central bore and out to one of the injectors.

In the actual pump, there are as many inlet or charging ports as there are engine cylinders, and the one distributor port also comes into register with the same number of ports leading to the injectors. A sliding vane type transfer pump, carried on the rotor inside the hydraulic head, supplies fuel oil from the pump inlet at an intermediate pressure through a duct to the pumping element. The flow of fuel is regulated by a metering valve before it has reached the element, the valve being actuated by the engine control lever or by the governor.

Since the opposing pump plungers are separated by inflowing fuel, the outward displacement of the plungers is determined by the amount of fuel delivered to the plunger chamber, which varies in accordance with the setting of the fuel metering valve and the speed at which the pump is rotating. In consequence, the rollers which operate the plungers do not follow the contour of the internal cam ring but will contact the cam lobes at varying positions in accordance with the amount of plunger displacement. The maximum amount of fuel delivered at one charge can thus be regulated by restricting the outward limit of travel of the plungers. Ears on the cam roller shoes register with eccentric slots machined in the top and bottom adjusting plates. The top plate, which is located to the bottom plate by lugs, is secured to the pumping and distributing rotor through elongated slots. Rotation of the plates in relation to the rotor provides the means of varying the limit of travel of the roller shoes and therefore the plungers, and thus limits the maximum fuel injected.

The contour of the cam provides for relief of the pressure in the injector line at the end of the injection cycle, and prevents "dribble" at the nozzles.

The timing interval between pump injections is governed by the accurate spacing of the cam lobes and of the delivery ports. Equality of delivery to each engine cylinder is an inherent feature of the pump since each cylinder is supplied by the same pumping element. The problem of placing and balancing the delivery for each injector, is therefore eliminated.

The pump rotor is rotated by means of a drive shaft, splined at the ends, and driven from the engine camshaft through a suitably splined coupling.

The end of the pump, mounted on the hydraulic head, houses a priming and regulating valve assembly, the functions of which are given in detail later.

Pump Operation

Fuel passes first to the transfer pump, there being a connection to the regulating valve (located in the end cover). The transfer pump pressurises the fuel and this pressure is applied to both the metering valve and the regulating valve piston.

The capacity of the transfer pump is many times the maximum requirements of the injection pump, so that a large proportion of the fuel is directly bypassed through the regulating valve back to the inlet side.

The metering valve is of the semi-rotary type, the valve has a longitudinal slot cut in its surface, and this registers with the metering port. The action of the governor weights rotates the valve, thus admitting more or less fuel to the pump according to speed variations.

A return line is provided between the pump cam housing and the fuel tank, for fuel flowing through the lower portion of the pump for lubricating purposes.

Details of Construction (Refer to Fig. 112)

General Assembly

The pump housing (42) contains the pumping and distributing rotor (17), the hydraulic head (14), and the cam ring (9). It also houses the driving hub (2), which transmits to the rotor through a drive shaft (38).

The hydraulic head and the cam rings are stationary components and are located and secured in the pump housing by screws. The driving hub is coupled to the engine by a splined quill shaft (1), a master spline being provided to ensure correct location. The drive shaft (38), is splined at either end, and carries the mechanical governor flyweight assembly (39-41). The transmission to the pumping and distributing rotor is effected by a splined drive plate (37) secured to the base of the rotor.

The lever springs and shafts of the governor mechanism are contained in an oil-tight cover (5), attached to the pump body. The transfer pump is housed within the hydraulic head, and is of the sliding vane type, the elliptic liner (18), being located in the hydraulic head, while the rotor (28) is attached to the pumping and distributing rotor.

Pumping and Distributing Rotor

The rotor (17) is a high precision lapped fit in the bore of the hydraulic head, and the two parts are regarded as a matched pair; neither being replaced as an individual unit. The lower part of the rotor is of enlarged diameter and is bored transversely to form the pump barrels. In these the two opposed pump plungers (35), operate in unison. They are in contact with shoes (33), sliding in guide slots in the base of the rotor, and carrying rollers (10), which are operated by the fixed internal cam ring (9). There is no spring between the plungers, for, as previously stated, these are forced outwards on their return stroke by the fuel which enters at metering pressure.

Lugs on the roller shoes, which register in profiled slots in top and bottom adjusting plates (36 and 11), provide the means of limiting the outward travel of the plungers. This provides the maximum fuel adjustment, as already mentioned.

The rotor has a central axial passage which connects the pumping space between the plungers with ports which are drilled radially in the rotor and provide for fuel inlet and delivery. One radial hole (30), in the upper end of the rotor is the distributing port; as the rotor turns, the distributing port aligns successfully with the outlet ports in the hydraulic head from which the injectors are fed via external high pressure pipes.

At an intermediate level a number of radial holes (16), are spaced round the rotor, the number corresponding with the number of engine cylinders. These are the inlet ports, and as the rotor turns, they align successfully with a single port in the hydraulic head, this is the fuel inlet or metering port (15).

The top end of the pumping and distributing rotor carries the rotor of the transfer pump (28), which is screwed into it. The transfer pump rotor also locates the main rotor in the hydraulic head in an endwise direction.

The lower end of the rotor carries a splined drive plate (37), which meshes with the end of the drive shaft and thus drives the rotor.

The Hydraulic Head

The hydraulic head (14), is located in the pump housing and secured by screws. As already stated it is mated with the pumping and distributing rotor; at its upper end it houses the transfer pump and carries the fuel line delivery connections (31), equally spaced about its circumference. In a transverse bore (13), it holds the metering valve (12), which controls the amount of fuel entering the pump. The head also contains the drilled passages from the transfer pump leading to the metering valve and thence to the inlet port. The pump end plate (27), is mounted on its upper face, and is secured by four screws (24). An annular groove at the lower end contains the "O" seal to make the joint between the head and the pump housing.

Transfer Pump

The transfer pump rotor, on the pumping and distributing rotor carries a pair of sliding vanes (29), running in an elliptically contoured liner (18). The liner is located by a dowel in the end plate which engages with a slot in its periphery.

The End Plate

The end plate (27), carries inlet connection (20) from the main fuel filter, and houses a gauze filter (21), and by-pass priming and regulating valve (25). The end plate is attached to the hydraulic head by four unequally spaced screws (24), an "O" seal (19), being located in a groove in the head.

Pressure Regulating Valve

The by-pass or pressure regulating valve (25) has two functions. First, it regulates the pressure of the fuel from the transfer pump; when the injection pump is in operation, pressure of fuel from the transfer pump forces the piston back against the regulating spring uncovering the regulating port. The transfer pressure is thus controlled by a balance between the regulating spring pressure and the setting of the metering valve at any moment.

Secondly, the valve provides the means of by-passing the transfer pump when hand-priming at starting. The priming pressure forces the valve piston down against the priming spring and uncovers the priming port enabling fuel to by-pass the stationary transfer pump to fill the system.

TO REMOVE INJECTION PUMP

First ensure that the scribed line on the injection pump flange is transferred to the drive housing flange. Remove three attachment nuts with lock-washers and withdraw the pump, joint washer and quill shaft from the driving housing.

NOTE.—The quill shaft which couples the shaft to the engine is mated with the pump with which it is supplied and is not interchangeable. At Engine Serial No. SJ 33286E, a quill shaft with a groove providing a shear section to give protection to the pump drive gears and camshaft in the case of injection pump failure, was introduced. Provision is made for these later quill shafts to be fitted to earlier pumps—consult your C.A.V. agent.

To Remove Injection Pump Drive Assembly

Remove the six attachment bolts with lockwashers and withdraw the drive housing from the locating dowels. Note that the backlash between the driving gears is controlled by steel shims and paper washers mounted between the injection pump drive assembly and the cylinder block; therefore note the thickness of these so that correct replacements can be fitted during re-assembly.

FUEL INJECTION PUMP TIMING

The following procedure is recommended for timing the Fuel Injection Pump to the Engine.

Procedure

1. Position the engine at 16° before T.D.C. with number one cylinder on compression. To do this, turn the flywheel in direction of engine rotation until the locating hole in the near side rear flange aligns with the hole in the flywheel. Lock the flywheel in this position by inserting a $\frac{1}{4}$" dia. (6.35 mm.) tommy bar. Care must be taken to maintain tension on the drive side of the timing chain.

2. Fit the Injection Pump Drive Assembly to the cylinder block with the master spline of the drive gear inclined towards the engine at an angle of 45° from the vertical. The setting is not extremely critical at this stage, as correction can be made later by rotating the slotted mounting flange of the Fuel Injection Pump on the mounting studs.

NOTE.—The shims between the Injection Pump Drive Assembly and cylinder block must be adjusted to eliminate unnecessary backlash between the camshaft drive gear and the Injection Pump Drive Assembly idler gear. Steel shims .006" (.15 mm.) and .010" (.25 mm.) thick respectively are available for this purpose.

A paper gasket must be fitted on each side of the shim pack in order to prevent oil leakage. At the same time, care must be taken to prevent the gear over meshing. Backlash is specified as .004"/.005" (.102-.127 mm.)

3. Mount the Fuel Injection Pump to the flange, mating the quill shaft with the internal spline of the drive gear—this gives an approximate setting for the pump timing. Ensure that the circlip type quill shaft retainer is fitted on the quill shaft. Fit the attachment nuts but do not tighten.

4. Wipe clean the fuel injection pump body and remove the inspection cover. Carefully rotate the fuel injection pump about its mounting studs until the scribe mark "G" on the drive plate coincides exactly with the datum mark on the circlip timing ring. The accurate alignment of the circlip mark with the mark "G" is very important—mis-alignment of the "G" mark of 0.020" (½ mm.) is equivalent to 2° (crankshaft).

5. Advance injection timing 1° (crankshaft) by swivelling the pump anti-clockwise (viewed from front end) 0.020" (½ mm.) measured on the radius of the mounting flange. This should align existing timing marks as scribed in production assembly. Tighten the fuel injection pump attachment nuts and scribe a line, if necessary, on the drive case flange in line with the mark on the pump flange. The injection pump timing is now set at 17° before T.D.C.

   It is essential during this procedure that tension on the drive side of the chain be maintained and all backlash from pump drive gears be removed. This is done by removing the front cover plate or tractormeter gearbox from the drive housing, inserting service tool MFS.149, and exerting pressure anti-clockwise as seen from the front of the engine.

Checking Procedure

Before checking the timing, note should be made of the exact position of the "G" mark in relation to the circlip mark. The datum mark on the circlip timing ring should now be .010" (.25 mm.) above the "G" mark.

6. Remove the tommy bar and turn the engine two revolutions in direction of normal rotation until it is possible to re-insert the tommy bar.

7. Insert service tool MFS.149 and exert pressure anti-clockwise as seen from the front of engine to remove all backlash in the timing chain and gear drive.

   The original positions of the circlip mark and "G" mark should be found.

NOTE.—It should be understood that the characteristics of individual engines may require an injection timing slightly in advance of 17° before T.D.C. and some engines received will have production settings of up to 19° before T.D.C. Under no circumstances, however, should the timing mark on the pump be advanced further than .040" (1 mm.) i.e. a setting of 19° before T.D.C.

SETTING ENGINE SPEEDS

First check that the throttle linkage stop beneath the instrument panel and that on the pump are effective at the same time, otherwise strain may be imparted to the linkage. Adjust by placing the throttle lever (B) in the fully closed position, loosen the clamp bolt (A)—refer to Fig. 114A at the base of the throttle shaft so that the hand lever assembly may be turned independently of the link rod (C) until the notch in the friction plate (D) comes into contact with the stop (E) in the bracket. Retighten clamp bolt.

The idling and maximum no-load speeds are set by the adjustment of two screws (C and D, Fig. 114) on the injection pump body.

The maximum speed adjustment is set and sealed at the manufacturers and should not be touched, but check to see that the maximum speed under no-load conditions of 790 Engine P.T.O. r.p.m. (2,200 Engine r.p.m.) can be obtained. The idling speed can be increased by turning screw (C) anti-clockwise (out) to reduce speed and clockwise (in) to increase speed. The screw should be adjusted until an idling speed of between 160 and 180 Engine P.T.O. r.p.m. (440 and 495 Engine r.p.m.) is obtained.

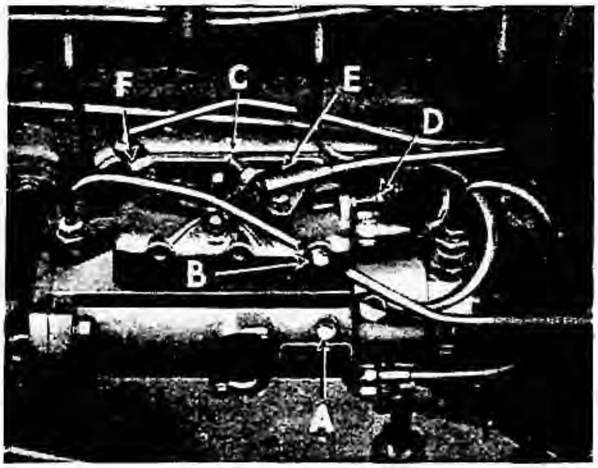
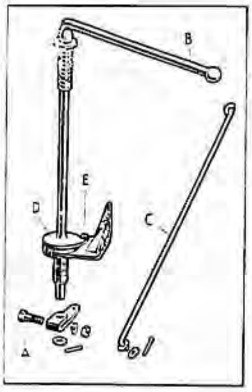


FIG. 114 SETTING ENGINE SPEEDS



A. and **B.** VENT PLUGS.
C. IDLING SPEED ADJUSTING SCREW.
D. MAXIMUM SPEED ADJUSTING SCREW.
E. THROTTLE CONTROL ROD.
F. FUEL CUT-OFF CONTROL.

FIG. 114A. THROTTLE LINKAGE ADJUSTMENT.

A. CLAMP BOLT.
B. THROTTLE LEVER.
C. LINK ROD.
D. FRICTION PLATE.
E. STOP.

INJECTION PUMP ADJUSTMENTS

Any adjustment to the fuel injection pump must be carried out by your local C.A.V. agent.

INJECTORS

Injectors perform the function of injecting the fuel, in the form of a fine spray, into the pre-combustion chambers at the moment when the air in the pre-combustion chamber has been compressed, heated as a result of this compression, and is at a temperature sufficient to ignite the incoming fuel.

The injector comprises two principal parts, the nozzle with its valve, and the nozzle holder.

The Nozzle and Nozzle Valve

The nozzle valve takes the form of a plunger, accurately lapped into the nozzle body to the closest possible fit, within which it will work freely. The inner end of the nozzle valve is reduced in diameter to produce a stem upon which a valve face is formed, while the outer end is provided with a stalk.

Fuel is fed to the mouth of the nozzle through small holes drilled vertically in the nozzle body, which terminate in an annular gallery (or reservoir) just above the valve seating. The nozzle valve is raised from its seating in the nozzle body by the pressure of fuel fed from the injection pump. Thus the fuel in the gallery is forced by the movement of the plunger in the pump, through the holes in the nozzle, to form a spray in the engine combustion chamber.

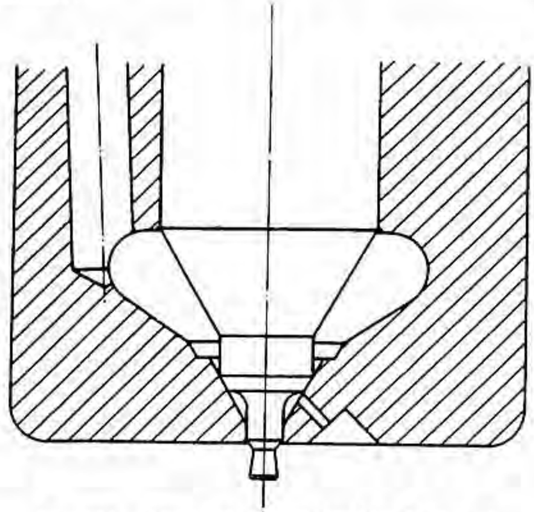


FIG. 115 SECTION OF PINTAUX NOZZLE

The Pintaux nozzle was specifically designed for use with the Ricardo "Comet" type of cylinder head. It is a development of the pintle type, on which the extended stem protrudes through the mouth of the nozzle body in the form of a pintle, giving a hollow, cone-shaped spray. In addition, the Pintaux nozzle has an auxiliary spray hole to assist easy starting under cold conditions. At engine starting speeds the needle valve is not lifted sufficiently to clear the pintle hole and fuel is discharged through the auxiliary hole.

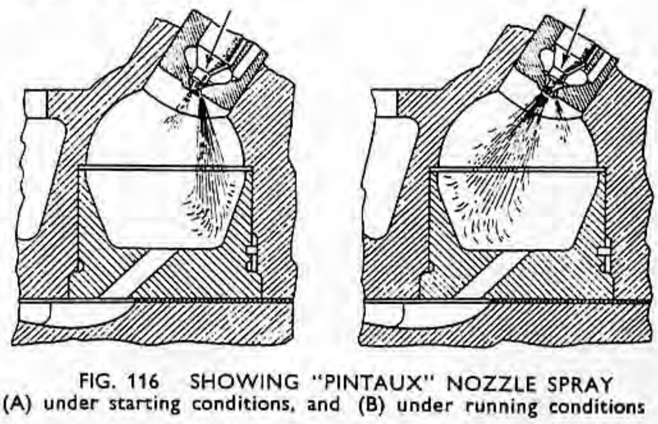


FIG. 116 SHOWING "PINTAUX" NOZZLE SPRAY
(A) under starting conditions, and (B) under running conditions

At normal running speeds, however, when pressures in the fuel system are higher, the needle valve is withdrawn from the pintle hole, allowing the bulk of fuel to be discharged through it. Compare Figs. 116A and B.

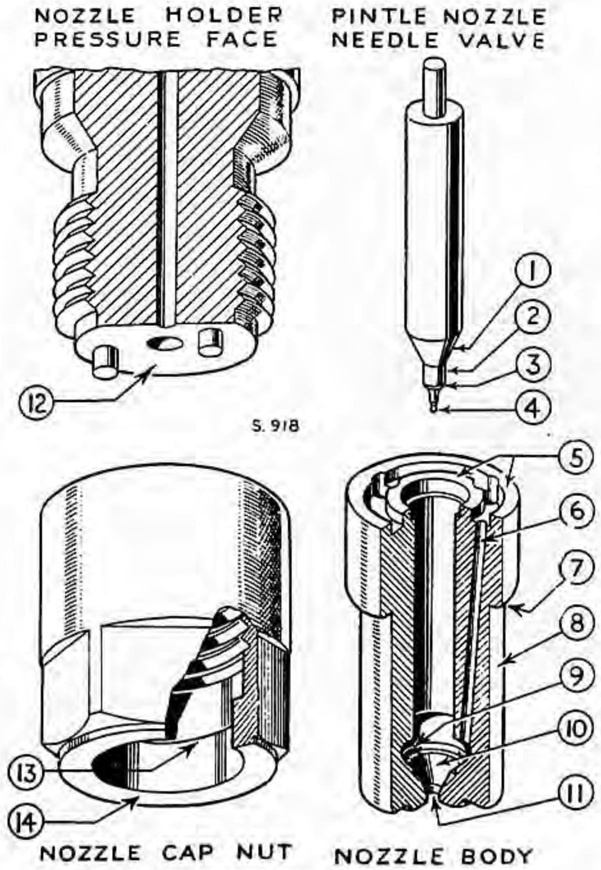


FIG. 117 Injector Nozzle Details

The Nozzle Holder

The nozzle holder locates the nozzle in the correct position in the engine cylinder head. A valve spring and spindle are incorporated, by means of which the nozzle valve is held down on its seat. At the lower end of the holder is a highly ground face which forms a joint with the ground face of the nozzle body when tightened by means of the nozzle cap nut. Oil is fed from the fuel inlet connection through a boring in the nozzle holder to the annular groove in the face of the nozzle body.

The slight leakage of oil which accumulates within the nozzle holder is sufficient to lubricate the nozzle and any excess is led back to the main fuel tank by the injector leak-off pipe.

Compression on the valve spring can be adjusted and the pressure at which the nozzle is forced off its seat can be regulated, by tightening or loosening the spring cap nut.

The fit of the nozzle holder in the cylinder head is of considerable importance and the use of the correct type of copper jointing washer is essential.

INJECTOR MAINTENANCE

The performance of the engine is dependent upon the efficiency of the injectors, and it is most important to make sure that the engine never runs with any of its injectors out of order.

Injectors should be removed from the engine and serviced at intervals of not less than 480 hours.

If a fault develops in service, it may be indicated either by cylinders knocking, engine overheating, loss of power, smoky exhaust or excessive fuel consumption. However, these troubles may also result from other causes connected with the fuel system or engine lubrication system, and it is advisable to check these other possible sources of trouble, before dismantling the injectors.

To Locate a Faulty Injector

With the engine running, eliminate each nozzle in turn, by releasing its pipe union nut, and observe the effect on the engine idling performance. Where there is little or no change, unscrew the clamp nuts and withdraw the complete unit (i.e. nozzle and nozzle holder) from the cylinder head.

To Test the Nozzle

Turn round the withdrawn unit with the pipe, nozzle outwards, "unwiped", and retighten the unions. After slackening the unions of the other nozzle holder pipes (to prevent fuel being sprayed into the cylinders), the engine should be turned until the nozzle sprays into the air. At cranking speed the spray from the auxiliary hole set to one side of the pintle should be well formed and free from splits and distortions. A slight centre core may be disregarded.

At normal engine speed, 1500 r.p.m., the spray from the main hole should be well atomised and free from large splits or distortion. A slight centre core may be disregarded.

If there is any doubt, similarly withdraw and turn round one or more of the nozzles and compare the sprays.

NOTE.—Great care should be taken to prevent the hands from getting into contact with the spray, as the working pressure will cause oil to penetrate the skin. Mechanics should always protect their hands with a suitable hand preserving compound when handling Diesel fuel. After fitting the spare nozzle holder and nozzle unit, wrap the faulty unit in clean grease-proof paper or rag, and put aside for attention at the maintenance bench.

Cleaning, Setting and Testing of Injectors

The most suitable bench for nozzle maintenance is one that is zinc or linoleum covered, absolutely free from dust, dirt, filings, grease or acids, where no other work is done and where the use of cotton waste and fluffy rags is forbidden. It should also be provided with a small vice (the jaws being protected with clean soft copper or aluminium shields) and a dust-proof drawer for holding the nozzle cleaning tools, etc., described below.

Tools Required

Note : Prefix 7044 and 7144 are alternatives to prefix ET.

ET.122PA	Nozzle Setting Outfit and Pintaux Test Rig ET.872.
ET.116	Spanner for "S" type nozzle cap nut.
ET.117	Spanner for "S" type nozzle spring cap nut.
ET.119	Spanner for compression screw.
ET.427	Flushing device for short stem nozzles.
ET.142	Safety petrol container.
ET.537	Bench plate.
ET.141B	Cleaning kit for pintle nozzles only.

(1)	Brass wire brush	ET.068
(2)	Pintle hole cleaner with probes...	ET.069
(3)	Nozzle body seat scraper ...	ET.070
(4)	Nozzle body groove scraper ...	ET.071
(5)	Nozzle pin cleaner	ET.072
(6)	Probing tool with cleaning wires	ET.120

Method of Cleaning Nozzles

1. Check complete injector on nozzle setting outfit ET.122PA for nozzle pressure setting and seating leakage.

2. If nozzle is faulty, release pressure on nozzle holder spring by undoing adjusting screw, then remove nozzle cap nut and nozzle with spanner ET.116.

3. Examine nozzle for carbon and whether the valve lifts out freely. Brush all carbon from outside with brass wire brush ET.068. Place body and valve in clean petrol, fuel oil, Shell Fusis "A" or Magnus 755, to soak and soften carbon.

NOTE.—The nozzle should be free from all damage and it is important that it is not "blued" due to overheating. All polished surfaces should be relatively bright without scratches or dull patches. It is essential that the pressure surfaces "5" and "12" (Fig. 117) are absolutely clean, as these must register together to form a high pressure joint between the nozzle holder and nozzle.

4. Clean out small feed channel bores "6" with drill or wire of 1.70 mm. diameter. These bores are rarely choked and insertion of a drill or wire by hand will be sufficient.

5. Insert special groove scraper ET.071 until nose locates in fuel gallery "9", press hard against side of cavity and rotate to clear all carbon deposit from this area.

6. With seat scraper ET.070, clean all carbon from valve seating "10" by rotating and pressing tool on to the seating.

7. (*a*) Clear auxiliary hole by use of cleaning tool ET.120 fitted with appropriate size cleaning wire. The cleaning wire should be fitted in the tool chuck so that it protrudes for only about $\frac{1}{16}''$ thus offering maximum resistance to bending. Extreme care must be taken to obviate the danger of the wire breaking in the hole as such particles are almost impossible to remove.

   Enter wire into hole, pushing and rotating gently until hole is cleared.

(*b*) Select the appropriate size probe from the pocket of the cleaning kit, ET.141B, and insert this in the nozzle body pintle hole cleaner ET.069. Pass the probe down the bore of the nozzle until it protrudes through the orifice, then turn with a rotary motion until all carbon is cleared. To clean the pintle end of the pintle valve, use the wire brush ET.068, dislodging any hard pieces of carbon with a piece of wood or brass strip. It is important that care is exercised with the nozzle valve, and in particular the pintle, to prevent damage to either, as a scratch or burr may cause valve leakage or spray distortion.

8. Assemble the nozzle into flushing tool ET.427 with the nozzle end towards the smaller thread connector which should be coupled to the nozzle setting outfit ET.122PA. The flushing tool should be arranged with the open end pointing downwards to facilitate particles being washed out.

   Force test oil through vigorously. This is most important, as it has the effect not only of thoroughly cleaning out the inside on the body cavity and bores, but also washes away any loose particles of carbon that may still be present in the spray holes.

9. Clean needle valve tip carefully by brushing away carbon with brass wire brush ET.068. To assemble valve into nozzle, immerse both items in clean fuel oil or Shell Fusis "A" oil and fit them together under the surface, so as to prevent the closely fitting lapped surfaces being touched by hand.

NOTE.—If the nozzle is blued or the seating has a dull circumferential ring indicating wear or pitting, the complete unit should be set aside for special attention by a C.A.V. depot or agent. In no circumstances must an attempt be made to lap the nozzle valve and body, as this is a specialized process and any attempt to perform this may render any subsequent effort useless.

Ensure that the lapped pressure faces "5" on the nozzle and "12" on the holder are clean and free from dirt or metallic particles. If the holder has been dismantled, all parts should be thoroughly washed in petrol, fuel oil or Shell Fusis "A" oil before re-assembly, and particular care given to the pressure face.

Place the nozzle on the pressure face of its holder and secure in position by the nozzle cap nut. It is important to remove tension of the nozzle holder spring during this process, as otherwise false locations may be obtained and damage sustained by the pressure faces. Finally, tighten cap nut with spanner ET.116, taking care not to over-tighten as this will cause distortion and lead to seizure of the nozzle valve. Fit assembled unit to nozzle setting outfit and adjust setting in accordance with instructions on page E.119. If the nozzle is to be stored, smear lightly with Vaseline before packing away.

Nozzle Holder Maintenance

The nozzle holder should be washed in clean paraffin, care being taken to protect the pressure face. This face must register with the nozzle pressure faces cleanly and squarely to form a high pressure joint, and should be handled in such a way as to avoid damage to it. The exterior of the nozzle holder should be cleaned of dirt and rust in the usual manner.

Valve Holder Spring

To avoid damage to spring by moisture corrosion during storage and handling, or by condensation due to temperature change in service it is recommended that these springs are inspected, cleaned and greased whenever the nozzles are removed.

To dismantle, proceed as follows:—

1. Mount nozzle holder on bench plate ET.537.
2. Remove nozzle holder cap nut.
3. Unscrew locknut and spring nut, and remove.
4. Take out spring and spindle.
5. Thoroughly clean all parts in Fusis oil.
6. To reassemble, re-insert spindle and spring and screw on spring cap nut and locknut.
7. Adjust spring pressure by screwing spring cap nut.

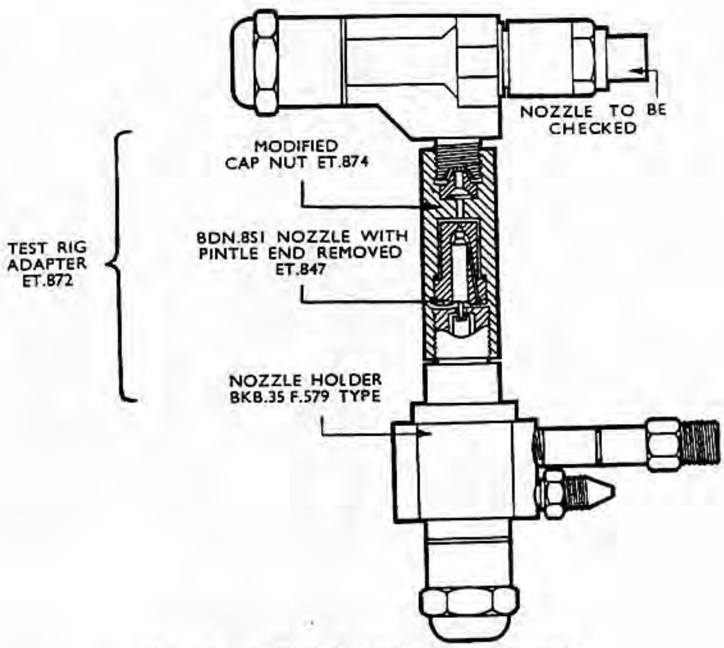


FIG. 118 TEST RIG AND ADAPTOR ET.872

Test Procedure

The injection rate and delivery of a Pintaux nozzle can be checked on the normal Nozzle Test Rig by using a special Test Rig Adaptor ET.872 (Fig. 118).

The Test Rig Adaptor comprises a Nozzle Holder (BKB35F579), a BDN8S1 Nozzle with pintle end removed (ET.847) and a modified Cap Nut (ET.874). The Adaptor is connected to the Nozzle Test Rig in place of the normal nozzle holder.

The modified Cap Nut enables the Injector, complete with Pintaux nozzle under test, to be screwed into the end as shown in Fig. 118. By setting the opening pressure of the BDN8S1 nozzle to a value where its closing pressure is higher than the opening pressure of the Pintaux nozzle, a sufficiently high rate of injection can be obtained on hand test to determine the quality and form of atomisation of both main and auxiliary sprays.

Injectors and nozzles should be tested before and after servicing to enable a comparison of performance to be made.

The Nozzle Setting Outfit should be suitably mounted on a bench so that the spray from the nozzles is directed away from the operator. It should, however, be so arranged that the spray can be carefully observed.

Remember always to protect the manometer from varying fluctuations of pressure by closing the check valve when operating the pump rapidly, and before releasing pressure by disconnecting units after testing.

Setting and Testing

Check that the nozzle is free from all damage, and that all polished surfaces are free from scratches or dull patches. Check that the pressure surfaces of the nozzle and of the nozzle holder are absolutely clean, as these must register together to form a high pressure joint.

Proceed as follows:—

1. **Leak Forward i.e. Seat Tightness.** The Injector Assembly under test complete with Pintaux nozzle is connected directly to the Nozzle Test Rig. Set the opening pressure to 130 atmospheres and atomise several times to expel air from the system. Wipe the face of the nozzle dry, pump to a pressure of 120 atmospheres and hold at this pressure for ten seconds, reject the nozzle if a blob of fuel or drips occur—a slight wetness of the nozzle face can be ignored.

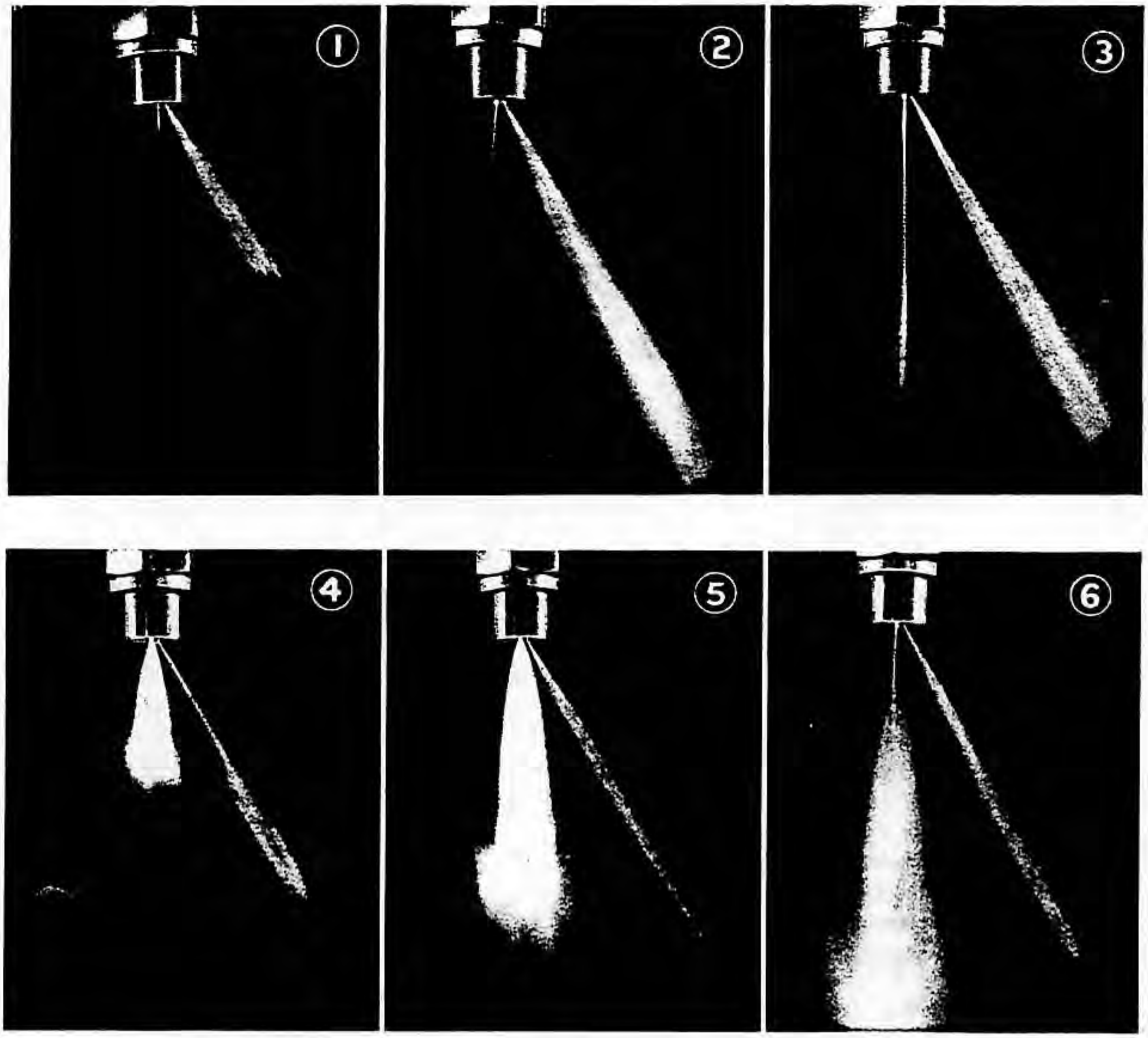


FIG. 119 PINTAUX NOZZLE SPRAY

2. **Atomisation—Auxiliary Spray.** Connect the Test Rig Adaptor ET.872 to the Nozzle Test Rig and set to an opening pressure of 220 atmospheres.

   Mount the Injector complete with Pintaux Nozzle on the Test Rig Adaptor and atomise several times to expel air from the system. Operate the Nozzle Test Rig at a minimum frequency of 60 strokes per minute and observe the spray from the auxiliary hole. This should be well formed and free from splits or distortions — a slight centre core may be disregarded. See Fig. 119. (1, 2 and 3).

3. **Atomisation—Main Spray.** Leave the Injector as for Test 3 and operate the hand lever at 140 strokes per minute. The spray form should be well atomised, free from splits, distortions, or a well defined core centre—a slight centre core can be disregarded. See Fig. 119 (4, 5 and 6).

4. **Operating Pressure Setting.** Disconnect the Injector with Pintaux nozzle and connect directly to the Nozzle Test Rig. Set the opening pressure to 130 atmospheres and operate the hand lever several times to settle down the components.

N.B.—No attempt should be made to lap the nozzle valve and body.—A defective unit should be returned to C.A.V. for attention.

Refitting Injectors

When effecting replacement of injectors in the cylinder head, it is important that only the correct C.A.V. washer Part No. 5339/423 is used to make the joint between the nozzle cap nut end and the cylinder head. Normal sparking plug type washers must not be used. The joint washer should be an easy, but not loose fit for the nozzle body. The metal of the cylinder head, the faces of the copper joint ring and the face of the nozzle cap nut should be cleaned in order to ensure a leak proof joint. Always use a new washer when replacing injectors after cleaning.

The injector should be an easy fit in the cylinder head tunnel and on the holding down studs, capable of being placed on the copper joint washer without force of any kind. The nuts on the flange should be tightened down evenly one half turn at a time to prevent the nozzle fouling the combustion chamber orifice, causing distortion of the nozzle, resulting in its failure. Care should however be taken to tighten the securing nuts evenly, as inadequate tightening may cause low breaking pressure of the injector.

FUEL PIPES

It is necessary that fuel pipe lines should be maintained in good order. Regular inspections should be carried out to ensure that all fuel line connections are tight and that pipes and union nuts are free from cracks or any other damage.

With the flexible type of fuel pipe there is danger that when finally tightening up the unions, a twist may be imparted to the pipe, deforming it and restricting flow. Checks should be made on all flexible fuel pipes, particularly between main and auxiliary fuel tanks and between auxiliary fuel tank and feed pump or filters. Leakage at the unions of the high pressure pipes between pump and injectors may be caused by split or distorted nipples resulting from over-tightening of the union nuts. These joints have to withstand considerable pressure and only a perfect joint will be satisfactory.

FUEL STORAGE

The fuel pump and injectors may easily be damaged by particles of dirt in the fuel, and it is essential that only clean fuel is allowed to reach them.

The design of the tractor provides for really efficient fuel filtration provided that the instructions regarding inspection and maintenance of these filters is carefully followed. Care should be taken that fuel poured into the tractor tank is as clean as possible, and that suitable fuel storage is provided. The following advice is offered to promote satisfactory fuel handling and storage:—

1. Never use galvanised containers.

2. Never clean the inside of container or any component of the fuel system with a fluffy cloth.

3. The size of the bulk storage tank should be such that intervals between draining and refilling are not too long.

4. The storage tank should be under cover, supported on cradles of sufficient height to enable the tractor fuel tank to be filled by gravity, and should have a suitable manhole cover to provide access for cleaning. The final outlet cock should be located so as to allow 3" (76 mm.) settling depth for water and sludge; it should feed through a detachable filter with a 120 mesh screen. There should be a fall of about ½" per foot (13 mm. per 300 mm.) towards the sludge drain plug.

5. Where possible, each consignment of fuel should remain undisturbed for three days after delivery, to allow suspended particles to settle to the bottom of the tank.

6. Always drain water and sludge just before delivery of a fresh supply of fuel.

7. The tank vent pipe should have an inserted intake with a coarse mesh filter.

8. Where provision is made for fuel to be pumped from the top of a storage tank, the bottom of the suction pipe should always be at least 6" from the bottom of the tank.

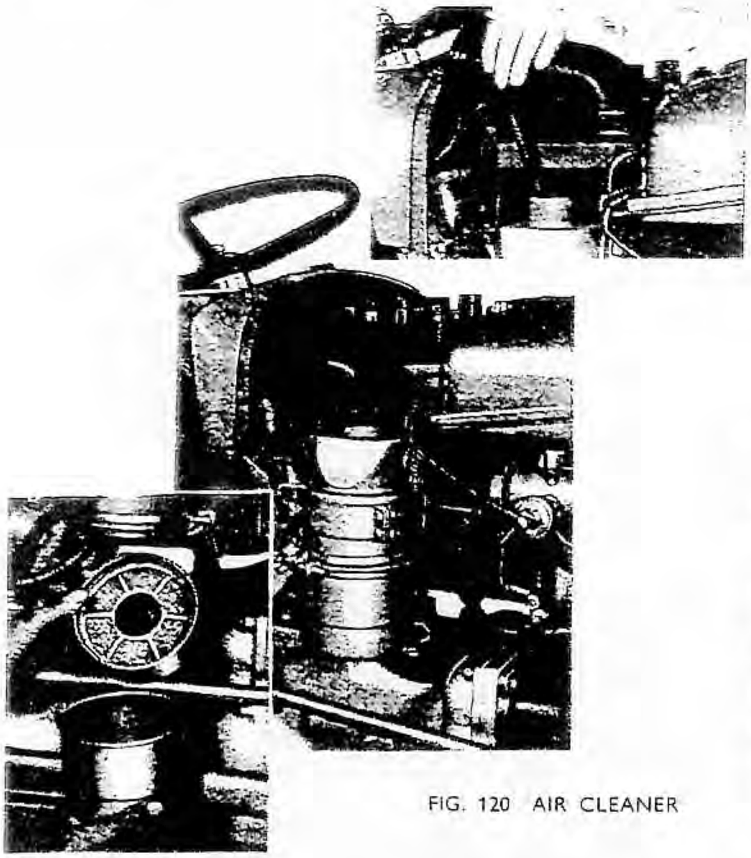


FIG. 120 AIR CLEANER

9. Where a storage tank is not available, fuel can be stored in barrels, kept under cover. Barrels should be mounted almost horizontally, with the outlet tap slightly higher than the other end, so that any water or sediment in the fuel will settle in the well thus formed. It is recommended that barrels are strapped to the stand to prevent them being tipped when almost empty.

10. All cans, funnels and strainers must be kept scrupulously clean. Any spilt fuel should be wiped up immediately. Fuel oil does not evaporate and will collect dirt and dust.

RECOMMENDED FUEL — British Isles & Overseas

Diesel Fuels, meeting British Standard Specification 209 : 1947 for "A" class fuel. For example:

Esso Diesel Medium, Shell Gas Oil, B.P. Diesolite.

These may be referred to as "regular" grade Diesel fuels.

also

Diesel Fuels, meeting American Specifications A.S.T.M. Grade No. 1.D, or Grade No. 2.D.

No. 1.D may be called a "premium grade" high speed Diesel fuel and No. 2.D a "regular" grade Diesel fuel.

AIR CLEANER

The main body of the air cleaner which houses an oil bath type dust extractor is situated at the right-hand side of the engine to the rear.

The air cleaner inlet is behind the instrument panel, and the air inlet hose is detachable for cleaning. (See Fig. 120). A section through the air cleaner is shown in Fig. 121. Air entering from the top of the central air duct (A) passes through the oil bath (B) and cleaner elements (C and D), to the outlet pipe which is connected to the engine by a rubber hose.

The air, passing down the centre tube, displaces the oil contained in the deflector ring in order to pass into the cleaner element. The ring forces the air, travelling at high velocity from duct (A) to make a sharp turn to pass through the cleaner elements to the outlet pipe. Centrifugal forces due to a sudden change of direction of the air throws a large proportion of foreign particles down into the oil. The air continues up through the oil-wetted metallic mesh elements which filter out any remaining particles. These return with the oil carried into the elements by the air, down into the oil cup where they settle to the bottom. The clean air reaches the top of the air cleaner and passes into the inlet manifold.

Service Recommendations

1. The oil container and detachable element (D) should be removed, cleaned and the container refilled to the correct level every ten hours, or daily. In very dusty conditions, twice daily.

2. Use oil of engine grade. It is permissible to recommend the use in very cold weather of 25% paraffin so that the oil may flow freely.

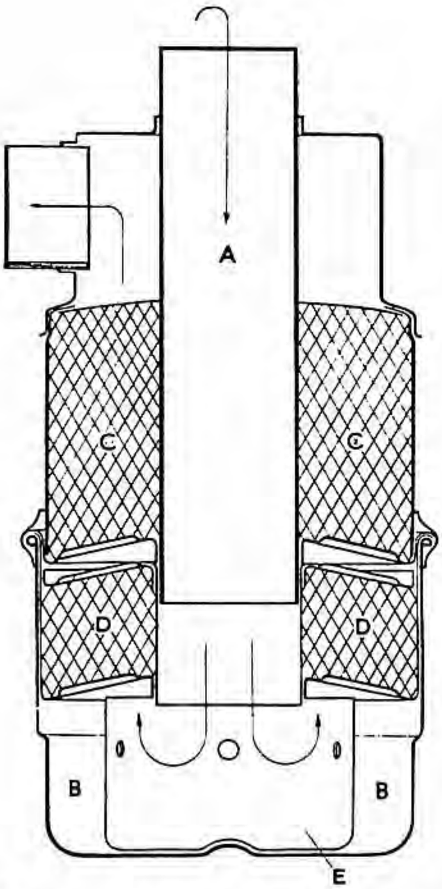


FIG. 121 CROSS SECTION OF AIR CLEANER

3. The oil container should be filled up to the level mark in the wall.

   N.B.—Do not overfill the oil container. The outlet pipe should be inspected for traces of oil, carried over due to high oil level or the use of oil which is too heavy, as this will impair the efficiency of the engine.

4. The entire cleaner unit should occasionally be removed from the tractor and washed with clean paraffin. The elements afterwards being thoroughly dried out with an air jet or similar means.

5. Check that all hose connections are air-tight and the hoses not cracked or swollen. Inspect for broken seams which allow air to by-pass the cleaner.

6. Inspect for loose oil container or worn bracket.

Air Cleaner fitted with Vertical Air Intake

Tractors are available fitted with a vertical air intake mounted above the hood. This prevents dust entering the engine in particularly dusty conditions.

EASY STARTING EQUIPMENT

The system is equipped with easy starting equipment to provide pre-heating and priming of the inlet manifold and combustion chambers particularly applicable to temperatures below 32°F. (0°C.). It is operated by a starter switch mounted on the instrument panel and consists of a combined heating and vaporising coil—"Thermostart"—mounted in the inlet manifold. With the first movement anti-clockwise of the starter switch fuel flows from the reservoir tank, mounted at the rear of the main fuel tank, (See page E.103), through the heater, wherein it is vaporised and then ignited by the heater coil.

A further movement anti-clockwise operates the starter motor, and the ignited fuel is drawn into the engine.

Description (Fig. 122)

Basically, the Thermostart consists of a core (3, Fig. 122), a solenoid (6), a spring-loaded plunger (4), fitted with a special rubber insert (5), which butts against a valve seat (7), a coil carrier (8), bearing two heater coils (9, 10) and a circular shield having large perforations (11) on one side, small perforations (13) on the other and a small flange (12), running along its outer surface.

Fuel oil from the container fills the pipe, adaptor (1), filter (2), hollow plunger (4), and the groove in the surface of the plunger. With the first movement anti-clockwise of the starter switch, the solenoid (6) and coils (9, 10) are energised. Magnetism induced in the plunger (4) and adaptor (1), by the solenoid, draws the plunger and rubber insert off the valve seat (7). Fuel then flows at a controlled rate along and around the coil (9), which vaporises it. Coil (10), reaches the ignition temperature of the fuel vapour.

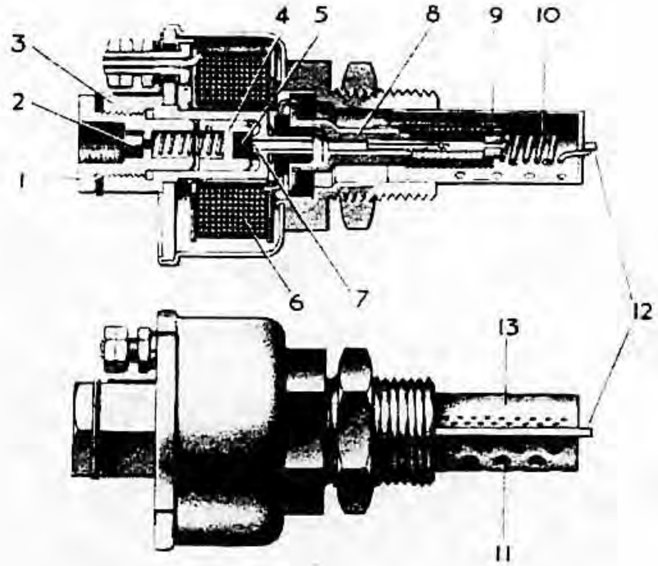


FIG. 122 CROSS SECTION OF THERMOSTART

As soon as the engine is cranked, fresh air drawn into the inlet manifold enters the circular shield through the small perforations (13), and mixes with the vaporised fuel inside it. The resulting mixture is ignited by coil (10), and so heats the air for combustion as it is drawn into the cylinders, promoting easier ignition of the injected fuel.

The flange (12), running along the outer surface of the shield provides a sheltered zone around the outlet holes (11), and protects the flame from the incoming air stream.

Removal and Replacement of Thermostart

When replacing the Thermostart in the inlet manifold, it is important that the arrow (See Fig. 123) points in the direction of the air flow along the manifold. In this position the smaller holes in the element are facing the air entering the manifold.

MANIFOLDS

The inlet and exhaust manifolds are attached to the right-hand side of the engine cylinder head, located on studs and secured by nuts and lockwashers. Gaskets are fitted between the manifolds and the cylinder head.

The Thermostart is mounted in the inlet manifold.

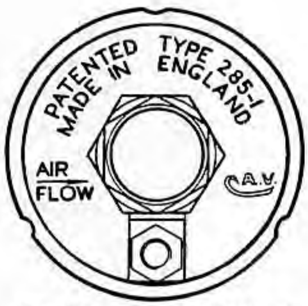


FIG. 123 THERMOSTART

To Remove Manifolds

1. Remove hood.
2. Disconnect positive lead from battery mounted on L.H. side of the driver's seat.
3. Turn off fuel tap.
4. Disconnect the following fuel pipes:—
   Reservoir tank to filter—at filter.
   Reservoir tank to Thermostart—at Thermostart.
   Reservoir tank to main fuel tank—at main fuel tank.
   Fuel return pipe—at main fuel tank.
   Main fuel pipe—below sediment bowl.
5. Remove reservoir tank with fuel pipes attached.

6. Remove two set screws securing rear of fuel tank to battery carrier. Slacken two spring-loaded bolts securing front of fuel tank to thermostat housing. Slide fuel tank rearwards to disengage from spring-loaded bolts. Remove fuel tank.

7. Remove breather pipe at wire clip, and sump securing bracket.

8. Remove exhaust pipe.

9. Detach starter switch connection at Thermostart.
   Detach air cleaner hose from manifold.

10. Remove exhaust manifold, inlet manifold and manifold gaskets.

To Replace Manifolds

1. Refit manifolds with gaskets, inlet manifold first, and tighten nuts as shown in Fig. 123. Refit exhaust pipe with new gasket.

2. Connect air cleaner hose to inlet manifold.

3. Refit air breather pipe.

4. Remount main fuel tank, fitting rubber mounting pads between tank brackets and battery carrier, and entering fuel return pipe carefully into fuel tank.

5. Remount reservoir tank with pipes, fitting rubber mounting pad between fuel tank bracket and reservoir tank mounting plate. Reconnect pipes between reservoir tank and main fuel tank; reservoir tank and fuel filter; and reservoir tank and Thermostart.

6. Re-connect lead from starter switch at Thermostart.

7. Re-connect battery lead.

8. De-aerate fuel system (See page E.102).

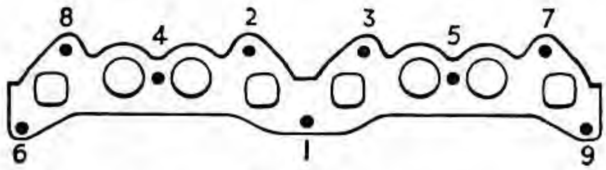


FIG. 123
ORDER OF TIGHTENING MANIFOLD NUTS

Exhaust Assembly

The exhaust pipe, silencer and tail pipe form an assembly supported forward at the right-hand side of the crankcase and rearward at the right-hand axle housing flange.

DIESEL FUEL SYSTEM FAULT TABLE

FAULT	POSSIBLE CAUSE	ADJUSTMENT REQUIRED
A. Engine will not start.	1. Unsuitable Fuel.	Use only recommended fuels.
	2. Fuel Stoppage.	Check fuel pipes for obstructions. Check lift pump and pipe connections. Check fuel filters for choking. De-aerate fuel system.
	3. Fuel Pump Worn.	Renew pump.
	4. Faulty Injectors.	Service Injectors.
	5. Injection Timing Incorrect.	Adjust as necessary.
	6. Thermostart not functioning correctly.	Check switch. Check electrical connections. Check fuel flow to Thermostart.
	7. Dirty Air Cleaner.	Clean air filter. Clean canister and refill with clean oil.
	8. Restriction in Exhaust System.	Clear obstruction.
	Loss of Power can be caused by most of the faults listed in the above table.	
B. Excessive Black Smoke.	1. Air Supply restricted.	Clear restriction, see table A.
	2. Excessive Fuel.	Correct maximum fuel adjustment.
	3. Injectors not functioning correctly.	Service injectors.
	4. Injection Timing incorrect.	Adjust as necessary.
	5. Unsuitable Fuel.	Use only recommended fuel.
C. Overheating.	1. Injection Timing Incorrect.	Adjust as necessary.
	2. Injectors not functioning correctly.	Service Injectors.
	3. Restriction in Exhaust System.	Clear restriction.

FUEL SYSTEM

DIESEL ENGINE TRACTOR 3A-152

INTRODUCTION

The layout of the fuel system and components of '35' Tractors fitted with 3A-152 engines is basically similar to previous diesel engine machines. Figure 125 illustrates the 3A-152 fuel system arrangement.

THE AIR CLEANER AND FUEL COCK

(Refer to Figure 125)

The instructions relating to the air cleaner and fuel cock given in the 23C engine fuel section apply also to the 3A-152 engine.

THE FUEL TANK (Refer to Figure 126)

The fuel tank, as in previous models, is positioned above the engine and is located on rubber mounting pads by four bolts. It has a capacity of $8\frac{1}{4}$ Imperial gallons.

REMOVING FUEL TANK

(Refer to Figures 125 and 126)

Remove hood and cowl assembly.
Close fuel cock.
Disconnect fuel lift pump supply line at fuel cock.
Disconnect tank fuel return line from starting tank.
Slacken off and remove the four bolts securing fuel tank.

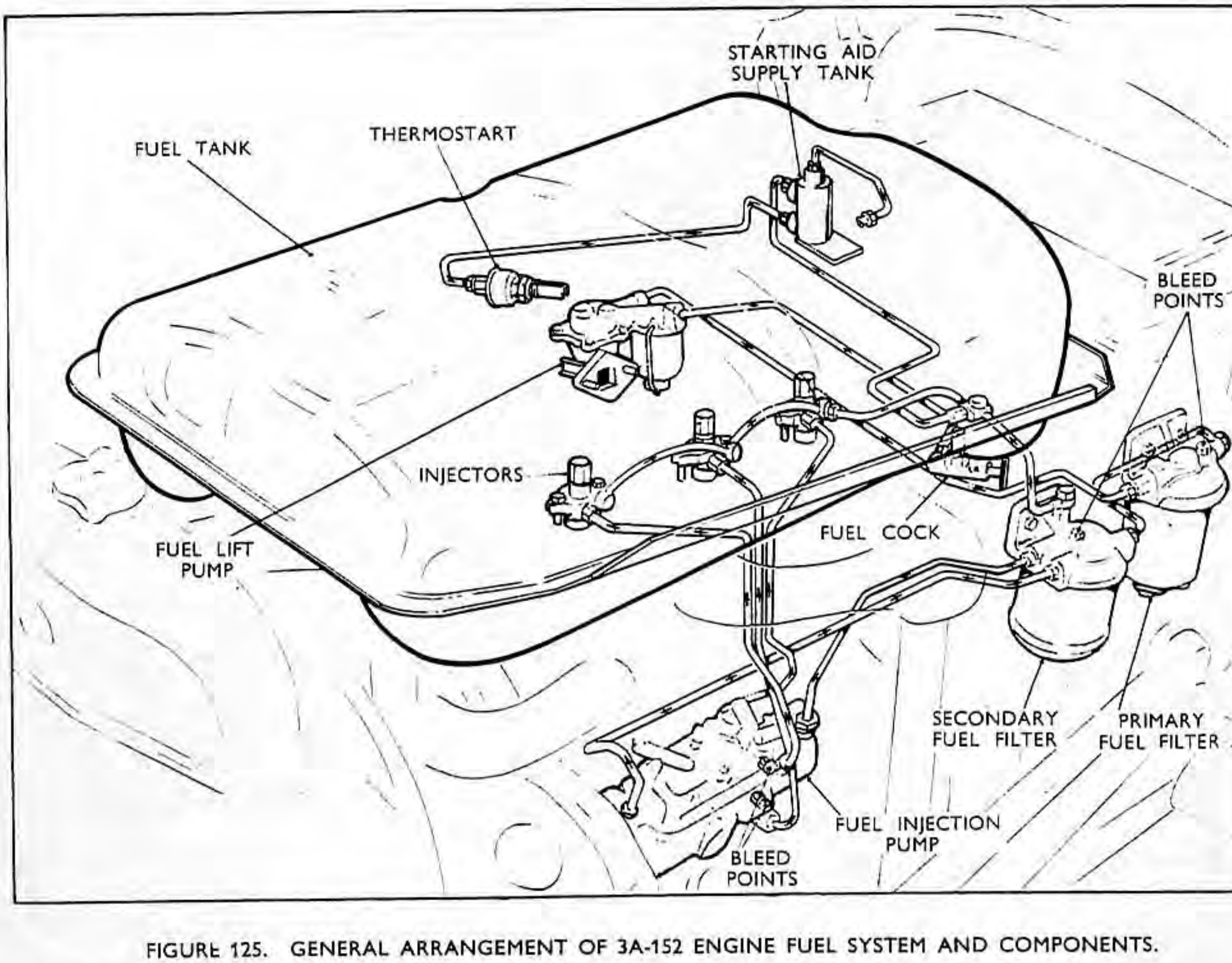


FIGURE 125. GENERAL ARRANGEMENT OF 3A-152 ENGINE FUEL SYSTEM AND COMPONENTS.

FIRST ISSUE

Remove fuel tank.

Replace in reverse order, ensuring that the rubber mounting pads are correctly located.

THE FUEL LIFT PUMP

(Refer to Figures 125 and 128)

A mechanical diaphragm type fuel lift pump, operated by the engine camshaft and incorporating a visual sediment bowl and hand primer lever, is fitted. This pump is installed between the fuel cock and the primary fuel filter. A gauze strainer, located above the sediment bowl, safeguards the non-return valves positioned in the top body assembly.

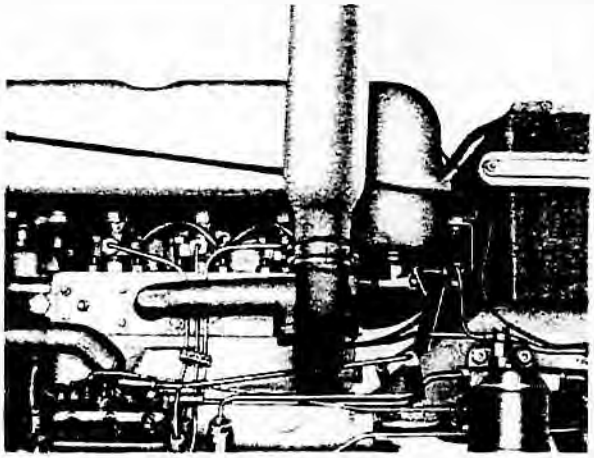


FIGURE 126. THE FUEL TANK AND MOUNTING BOLTS.

REMOVING THE SEDIMENT BOWL

(Refer to Figure 127)

Close fuel cock.

Slacken off nut at base of sediment bowl, swing stirrup to side, and remove sediment bowl.

Withdraw rubber sealing ring and gauze strainer.

Flush out bowl and strainer in clean paraffin or fuel oil. Do not use rags.

Replace in reverse order, ensuring that strainer and sealing ring are in good condition. A defective or hardened seal can prevent the pump from delivering fuel.

Before finally tightening stirrup nut it is advisable to open the fuel cock and prime the sediment bowl.

REMOVING THE FUEL LIFT PUMP

Close fuel cock.

Disconnect fuel pipe at fuel lift pump inlet.

Disconnect fuel pipe at fuel lift pump discharge.

Slacken off and remove the two nuts and spring washers securing fuel pump to cylinder block.

Withdraw fuel pump.

Replace in reverse order, ensuring that the pump and cylinder block mounting faces are clean and that a new gasket is fitted.

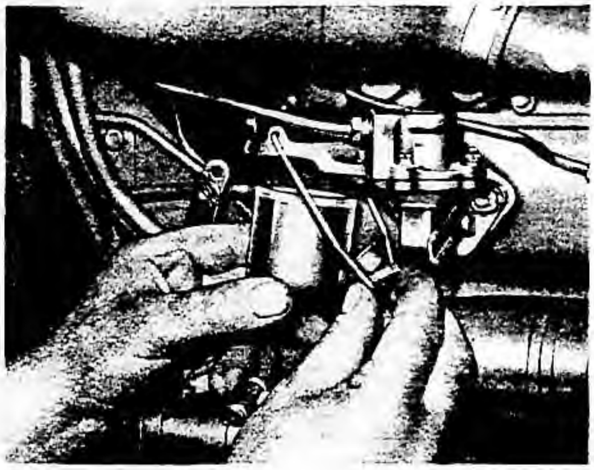


FIGURE 127. REMOVING SEDIMENT BOWL FROM FUEL LIFT PUMP.

DISMANTLING THE FUEL LIFT PUMP

(Refer to Figure 128)

Remove fuel lift pump from engine.

Thoroughly clean fuel pump exterior.

Remove sediment bowl stirrup, sediment bowl, sealing ring and gauze strainer.

Carefully scribe edges of upper and lower body flanges to ensure correct reassembly.

Slacken off and remove the screws and spring washers clamping upper and lower body assemblies.

Rotate diaphragm boss 90° and remove diaphragm, spring and seal from lower pump body. The diaphragm assembly, once disturbed, should be renewed.

Should there be evidence of weak or broken springs, or wear on the rocker shaft, or pump body, the lower pump body assembly should be renewed.

The non-return valves in the upper body can be renewed only as complete assemblies.

ASSEMBLING THE FUEL LIFT PUMP

(Refer to Figure 128)

Thoroughly clean all components.

Slide spring and seal on to diaphragm shaft.

Locate diaphragm assembly in position in lower pump body.

FIRST ISSUE

Rotate diaphragm boss 90°.

Ensure end of diaphragm shaft is properly located and that the holes on the perimeter of the diaphragm correctly align with the tapped holes in the lower body flange.

Align scribe marks on upper and lower bodies.

Locate screws and spring washers in position.

Evenly tighten screws, ensuring that the diaphragm is not creased or wrinkled but is properly clamped in position.

Place gauze strainer and rubber sealing ring in position above sediment bowl, ensuring that they are properly seated. Fit sediment bowl and stirrup and tighten nut.

FIGURE 128. THE FUEL LIFT PUMP (DISMANTLED).

TESTING FUEL LIFT PUMP AFTER ASSEMBLY

Special equipment is available for the testing of the fuel lift pump and, where possible, its use is advised before fitting the pump to the engine.

Where testing equipment is not available, a rough guide to fuel pump efficiency may be obtained by sealing the outlet fuel union with finger or thumb, operating the rocker lever to draw the diaphragm downward and releasing the rocker lever. If the valves or diaphragm are faulty the diaphragm will immediately return to its upper position. Should the thumb be placed over the inlet union and the rocker lever operated, a depression should be felt by the thumb and resistance offered to the rocker lever. When the rocker lever is operated with both inlet and outlet fuel unions clear of obstruction a croaking noise should be heard. Note: the diaphragm and valve assemblies should be moist with fuel before conducting tests or before the pump is fitted to the engine.

FIRST ISSUE

THE PRIMARY FUEL FILTER

(Refer to Figure 125)

The primary fuel filter, fitted between the fuel lift pump and the C.A.V. filter is provided with an air vent and a drain plug. An expendable cartridge type filter element is employed. This element should be discarded and replaced by a new one every 500 hours. No attempt must be made to clean, or in any way reclaim the old element. It is recommended that periodic flushing be carried out by removing the drain plug and operating the priming lever on the fuel lift pump. When this operation is completed the fuel system will require to be bled.

REMOVING THE PRIMARY FUEL FILTER

(Refer to Figure 129)

Slacken off and unscrew bolt at base of filter body.

Withdraw filter body complete with element.

Remove element.

Replace in reverse order, ensuring that sealing rings are in good condition and are properly located.

Prime and bleed fuel system after assembly.

FIGURE 129. REMOVING PRIMARY FILTER ELEMENT.

THE SECONDARY FUEL FILTER

(Refer to Figures 125 and 130)

The C.A.V. filter is the secondary fuel filter and is fitted between the primary filter and the fuel pump.

Again an expendable type cartridge element is employed. The outer case of the cartridge forms the middle section of the filter housing as shown in Figure 130. Cartridge renewal should be undertaken every 1,000 hours. No attempt must be made to clean or reclaim the element.

REMOVING THE SECONDARY FUEL FILTER (Refer to Figures 125 and 130)

Slacken off and remove the filter body centre bolt on the top of the filter.

Withdraw filter base and element.

Replace in reverse order, ensuring that sealing rings are renewed or are in good condition and are properly located.

Prime and bleed fuel system after assembly.

FIGURE 130. THE SECONDARY FUEL FILTER.

THE FUEL INJECTION PUMP

(Refer to Figures 125 and 131)

The C.A.V. D.P.A. distributor type fuel pump with mechanical governor is gear driven from the engine timing case and is positioned as shown in Figure 131.

REMOVING THE FUEL INJECTION PUMP

(Refer to Figures 131 and 132)

Turn engine to T.D.C. No. 1 cylinder on compression.

Remove fuel injection pipes and blank off unions.

Remove fuel feed pipes and seal off unions.

Disconnect throttle and stop controls.

Remove setscrews securing oil filler and gauze strainer to front timing cover.

Withdraw oil filler and gauze.

Remove the three setscrews and spring washers securing the drive gear to the fuel pump. Care must be taken when removing these setscrews to ensure that they do not drop into the timing case.

Check that a scribed line on the rear of the timing case coincides with the scribed line on the fuel injection pump mounting flange (Figure 132).

Remove the three nuts and plain and spring washers securing the flange of the injection pump to the timing case.

Withdraw the fuel injection pump. This will result in the fuel pump driving gear being left in the timing case. The driving gear cannot be removed from mesh at this stage but it is advisable not to turn the engine until the fuel injection pump has been replaced.

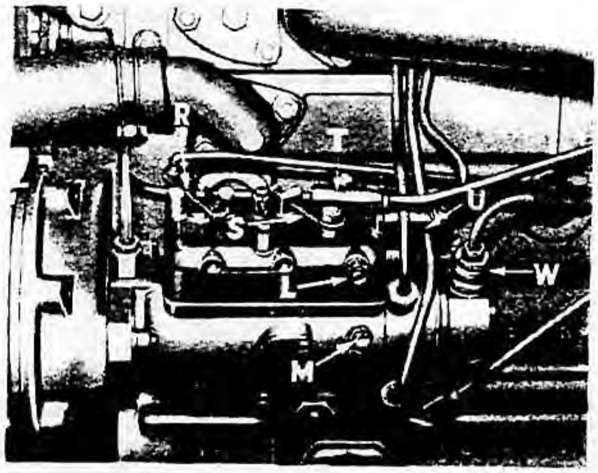


FIGURE 131. THE FUEL INJECTION PUMP.

KEY

L & M	Vent Plugs.	T	Throttle Control Rod.
R	Fuel Cut-off Control.	U	Maximum Speed Adjusting Screw.
S	Idling Speed Adjusting Screw.	W	Pump Inlet Pipe Union.

REPLACING THE FUEL INJECTION PUMP

(Refer to Figures 131 and 132)

Position the slot in the fuel injection pump drive so that it will align with the dowel in the fuel pump drive gear.

FIRST ISSUE

Offer up pump to engine, locating the mounting flange in the three studs, and ensuring that the pump shaft and drive gear are aligned.

Fit plain washers, spring washers and nuts to fuel pump mounting studs.

Align scribed lines on timing case and pump mounting flange and tighten the three securing nuts.

Replace and tighten the three screws retaining drive gear to pump shaft.

Fit oil filter and gauze to timing case, ensuring that gasket is in sound condition.

Fit and tighten fuel injection pipes.

Fit and tighten fuel lines.

Replace throttle and stop controls.

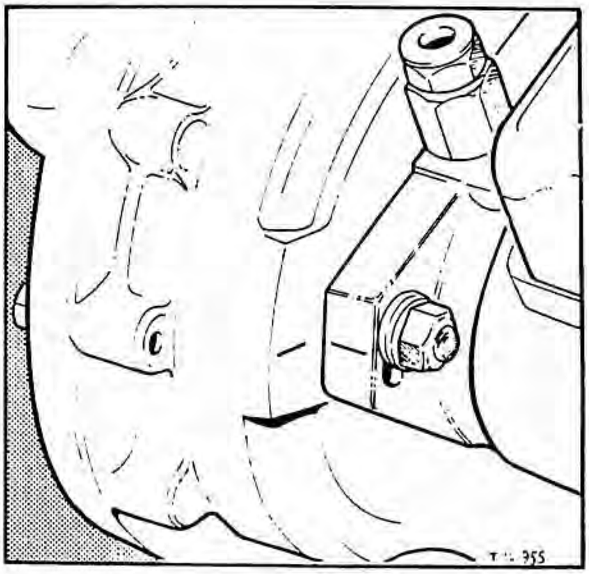


FIGURE 132. TIMING MARKS ON FUEL INJECTION PUMP AND TIMING CASE.

CHECKING FUEL INJECTION PUMP TIMING (Refer to Figures 131 and 133)

Remove the rubber plug from the inspection hole in the transmission housing.

Position the engine crankshaft at T.D.C. No. 1 cylinder on compression.

Remove the inspection cover from the side of the fuel injection pump.

Turn the engine crankshaft back through 90°, then bring it forward until the mark SPILL 18, marked in the front face of the flywheel, appears in the middle of the inspection hole. The object of turning the flywheel back 90° and bringing it forward again is to take up the backlash in the gear train.

With the crankshaft set at 18° B.T.D.C., the scribed line E on the fuel injection pump rotor should align with the scribe line on the lobe of the circlip (Figure 133).

Important.—The breaking of the seal on the inspection cover of the fuel injection pump must only be carried out by authorised experienced personnel who must re-seal the pump with a suitable identifiable seal.

Should these scribed marks not align, slacken off the three nuts securing the pump mounting flange to the back of the engine timing case and move the body of the fuel pump in the required direction.

The outlet port of the fuel pump which connects with No. 1 cylinder, is marked with the letter 'W' and the dowel location between the fuel pump gear and the fuel pump shaft is in approximate alignment with the No. 1 outlet port marked 'W' when the engine crankshaft is at T.D.C. with No. 1 cylinder compression. Looking into the front of the timing case the dowel will appear at approximately 2 o'clock. This instruction assumes that the timing gears have been correctly assembled with their respective timing marks aligned.

SETTING ENGINE SPEEDS

The fuel injection pump and governor mechanism are sealed on assembly and should normally require no adjustment between overhaul periods. Engine speed is controlled between 440-495 r.p.m. (idling) and a maximum no load speed of 2,200 r.p.m. The principle of operation is as outlined for the 23C engine fuel injection pump, described elsewhere in this section.

Adjustments to the 3A-152 engine fuel pump—other than those mentioned below — must not be attempted unless proper facilities, equipment, and skilled staff are available.

THROTTLE AND LINKAGE ADJUSTMENT

Ensure that the throttle stop beneath the instrument panel and the stop adjustment on the fuel pump are effective at the same time, otherwise strain may be imposed on the linkage. Adjust by fully closing the throttle lever, slackening off the clamp bolt at the end of the throttle shaft and moving the hand lever assembly independently on the link rod until the notch in the friction plate is in contact with the stop on the bracket.

Idling speed adjustment can be altered by rotating the idling screw adjustment as required. Engine idling speed should be within 440-495 r.p.m. No attempt must be made to alter the maximum speed setting.

THE FUEL INJECTION PIPES

(Refer to Figure 125)

The fuel injection pipes connect the fuel injection pump to the injectors. These pipes have a working pressure of approximately 1,760 p.s.i. from which it will be evident that correctly aligned and fitted unions are essential. A leak, however slight, must inevitably result in reduced output from the cylinder affected. Injection pipes must not be forced or twisted out of shape.

Note that the fuel injection pump port marked 'W' must always be connected to the No. 1 injector.

FIGURE 133
FUEL INJECTION PUMP ROTOR TIMING MARKS

THE INJECTORS (Refer to Figure 125)

The injectors deliver to the engine combustion chambers the precise quantity of atomised fuel oil determined by engine throttle setting and load.

Injector operating pressure is 120 atmospheres. The servicing of injectors must not be attempted unless proper facilities and equipment are available. Servicing is advised at least every 500 hours. Attention will be required more frequently if insufficient care is given to fuel cleanliness or the engine cooling system is neglected.

A crude but effective method of checking the operation of a suspected defective injector is to run the engine at slightly above idling speed and slacken off the injection pipe unions at each injector in turn. An even drop in engine revolutions would indicate that the injectors are functioning evenly.

Should the slackening of a particular injector union result in only a slight drop in engine revolutions, that injector must be removed for servicing, or a replacement injector fitted. When one injector is found defective it is advisable to remove all three for reconditioning or replacement.

REMOVING THE INJECTORS

Access to the injectors necessitates the removal of the fuel tank and this must first be carried out.

Slacken off and remove the fuel injection pipes.

Slacken off and remove the leak-off pipes.

Evenly slacken off and remove the two nuts and plain washers securing each injector.

Gently and evenly prise injectors out of position.

Replace in reverse order, ensuring that the copper sealing washer is renewed and that the securing nuts are evenly tightened down.

BLEEDING THE FUEL SYSTEM

(Refer to Figure 125)

The presence of air in the fuel filters, fuel lines, or the fuel injection pump will result in poor, improper engine performance and may prevent the engine from functioning. It is for this reason that the fuel system must be freed of air whenever a fuel filter or fuel union is disturbed. The fuel system may be bled as follows.

Open air vent plug on top of primary fuel filter.

Operate hand priming lever on fuel lift pump until fuel free of air bubbles issues from primary filter vent plug.

Close primary filter vent plug.

Slacken off the two vent plugs on the fuel injection pump and operate hand priming lever until both vent plugs cease to exude air.

Still operating hand primer, close the lower and then the upper vent plug.

Slacken feed pipe at D.P.A. pump inlet and operate hand primer. Tighten feed pipe.

Air present in the fuel injection pipes will be exhausted when the engine is "motored" on the starter.

Note.—If during servicing the fuel supply pipes to the Thermostart are removed, the fuel system should be primed by operating the fuel lift pump hand primer lever and slackening the fuel supply union at the Thermostart until fuel flows freely. This union must be tightened after use.

FIRST ISSUE

THE STARTER TANK (Refer to Figure 125)

The starter tank is a small container situated between the fuel tank and the battery. This tank serves as a reservoir for the engine thermostart and a junction for the C.A.V. fuel filter, fuel injection pump and injection leak-off pipes. It contains no valves and requires no maintenance other than ensuring that there are no leaks at the unions.

THE THERMOSTART (Refer to Figure 125)

The thermostart, fitted to the engine induction manifold, comprises a screwed housing fitted with a jet and a small electric heating coil. When in use the manifold depression draws fuel through the start aid jet into the glowing heating coil, where it is ignited.

It is important to ensure that the start aid fuel supply cock—where fitted—is turned off when the cold starting equipment is not in use.

MASSEY-FERGUSON

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WORKSHOP SERVICE MANUAL

SECTION F

GOVERNOR CONTROL

MECHANICAL GOVERNOR
DIESEL ENGINE

The 23C Diesel engine is governed by a mechanical governor which is embodied in the DPA fuel injection pump and is completely contained within the pump housing.

Figure 100 shows the pump and mechanical governor, in section.

The mechanical governor is of the flyweight type, the weights (B) carried in a retainer clamped between the driving hub and a step on the driving shaft. The weights are a sliding fit in the pockets of the retainer, and are shaped so that in operation they pivot about one sharp edge. As the weights move in or out according to pump speed each pivoting on one edge, they operate a thrust sleeve (A) which is a sliding fit on the drive shaft, moving it axially.

The axial movement of the thrust sleeve is transmitted to the fuel metering valve (O) through a simple system of linkages and springs, the mechanism being enclosed by the governor control housing mounted on the pump housing. A gasket makes the seal between the housing and the pump body. Throttle and fuel cut-off shafts project through the housing and the respective control levers are mounted externally.

The governor control arm (C), consists of a flat steel plate, cut at one end to fit the drive shaft, and arranged to rest on the thrust sleeve of the governor. The other end of the control arm is connected to the governor control spring and the linkage attached to the fuel metering valve.

The governor mechanism only is shown in detail in Fig. 101. Governor thrust sleeve (A) and flyweights (B) are carried on shaft (T), the sleeve (A) being in contact with control arm (C).

A flat steel bracket (R), secured to the upper face of the pump body, provides a pivot for the governor control arm, and at its other end forms a guide (not shown) for the fuel shut-off bar (E). This is a flat steel bar operated by a cranked fuel shut-off shaft (F) and linking up with the metering valve (O); it is arranged that by turning the shut-off shaft by

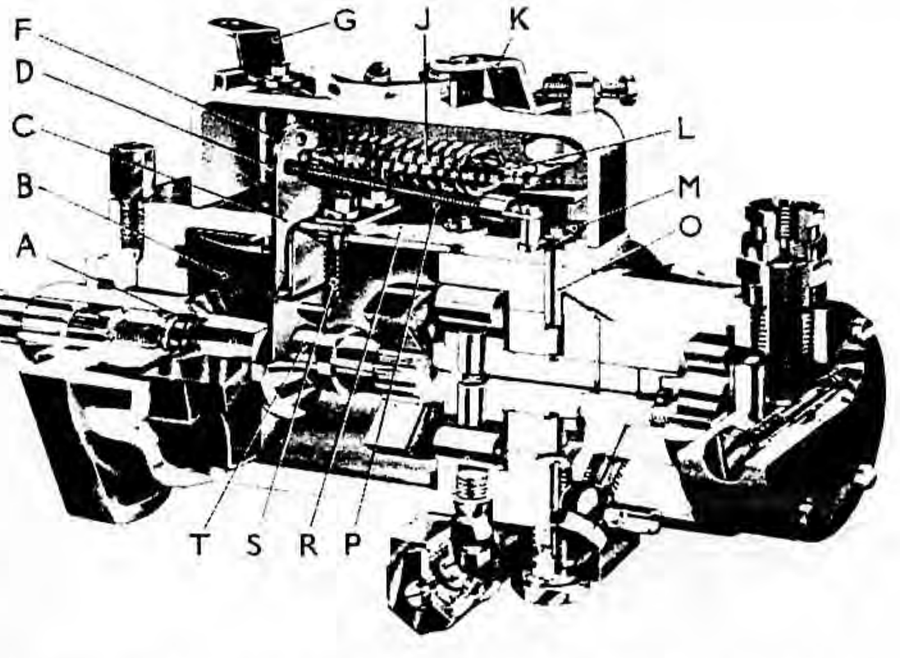

FIG. 100 SECTIONAL VIEW OF FUEL PUMP AND MECHANICAL GOVERNOR

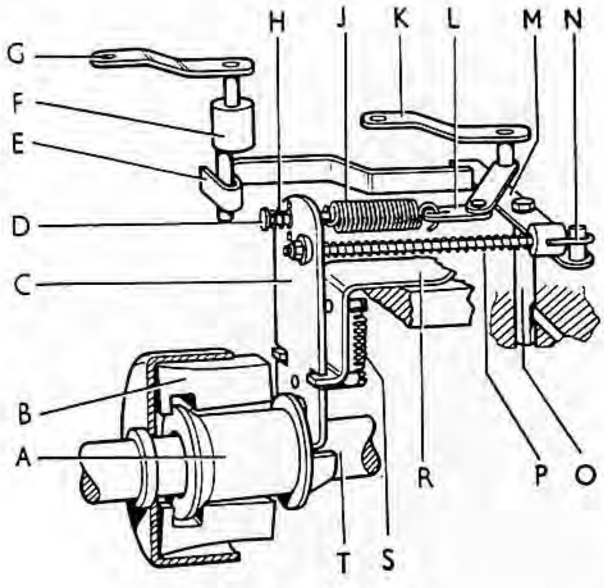

FIG. 101 GOVERNOR

means of the fuel shut-off lever (G) the bar can turn the metering valve against the pressure of a light spring (P), and thus stop the engine.

The linkage attached to the control arm comprises the governor linkage hook (N), connected to a small lever (M) on the fuel metering valve, and the governor control spring (J), which is attached to linkage (L) connected to the throttle shaft and lever (K). The governor linkage hook is threaded through the light spring (P); movement of the governor control arm is controlled by the fly-weights, but this spring link enables the fuel shut-off to be operated irrespective of the pressure of the main governor spring.

The governor control spring is attached to the control arm through the idling spring guide (D), which passes through the governor control arm and is spring-loaded by the light idling spring (H). The idling spring guide has three positions. At its other end the control spring is attached to a link (L) which also has three positions and which is attached to the throttle shaft.

The metering valve itself (O) consists of a small shaft, slotted on one side to provide a port. The valve is situated in a chamber in the hydraulic head (see Injection Pump) through which the fuel passes from the transfer pump to the metering port in hydraulic head and from there to inlet ports of the rotor. Rotation of the valve in its chamber varies the position of the slot relative to the oblique fuel port, thus regulating the supply of fuel to the pump.

OPERATION OF THE MECHANICAL GOVERNOR

Variations in speed of the engine, and therefore of the pump, are transmitted by the flyweight to the thrust sleeve, and thence to the governor control arm. This is spring-loaded during idling by the idling spring only, but as speed increases, the main control spring comes into action.

When starting, the throttle lever is put hard over, putting the metering valve in the full fuel position. As the engine picks up speed, the lever is brought back and the governor is in operation.

Movement of the throttle lever adjusts the load on the governor control spring, bringing about a change in the position of the control arm, and hence of the metering valve, admitting more or less fuel to the pump as required. For any setting, the governor will maintain the speed within close limits.

At any moment the engine can be shut down by means of the fuel shut-off lever. The shut-off bar can over-ride the governor and rotate the metering valve to the 'no fuel' position independently of the position of the throttle lever.

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WORKSHOP SERVICE MANUAL

SECTION G

ELECTRICAL SYSTEM

ELECTRICAL SYSTEM

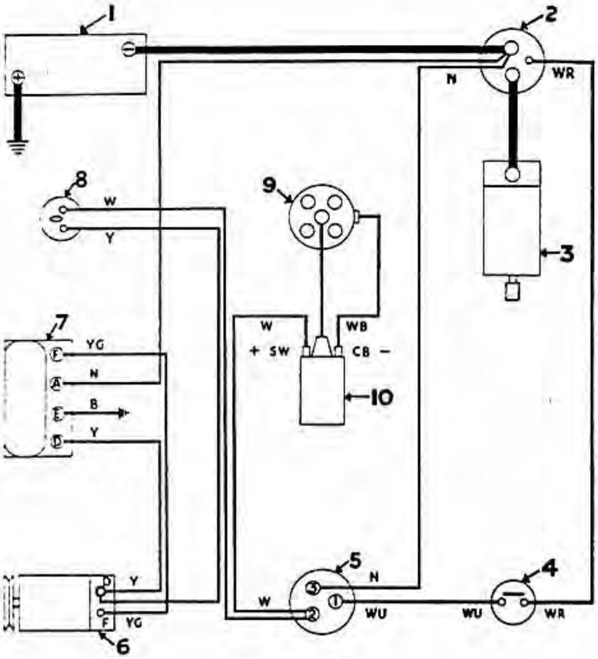


DIAGRAM A

Key for Wiring Diagrams.

Ferguson MF 35 fitted with Carburettor Engine (A)

1. 12 Volt Battery.
2. Starter Solenoid Switch.
3. Starter Motor.
4. Neutral Gear Safety Switch.
5. Combined Ignition and Starter Switch.
6. Dynamo.
7. Control Box.
8. Ignition Warning Light.
9. Distributor.
10. Ignition Coil.

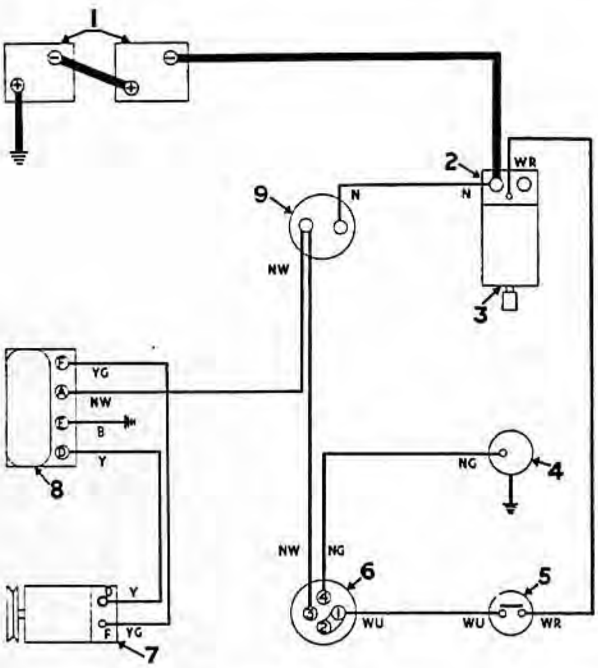


DIAGRAM B

Ferguson MF 35 fitted with Diesel Engine (B)

1. Two—6 Volt Batteries.
2. Starter Solenoid Switch.
3. Starter Motor.
4. Thermostart.
5. Neutral Gear Safety Switch.
6. Starter and Heater Switch.
7. Dynamo.
8. Control Box.
9. Ammeter.

CABLE COLOUR CODE—WIRING DIAGRAMS.

B	BLACK	S	SLATE
U	BLUE	W	WHITE
N	BROWN	Y	YELLOW
G	GREEN	D	DARK
P	PURPLE	L	LIGHT
R	RED	M	MEDIUM

SPECIFICATION AND TEST DATA

BATTERY

Diesel Engine Tractor

Models ... ... MHF.115E, MHF.P115E, MHF.PZ115E, 6 volt 2 off, connected in series.

Ampere hour capacity
- at 10 hour rate ... ... 115 ampere hour.
- at 20 hour rate ... ... 131 ampere hour.

Carburettor Engine Tractors

Models ... ... GTW.7A, GT.7A, GTZ.7A, 12 volt, 1 off.

Ampere hour capacity
- at 10 hour rate ... ... 38 ampere hour.
- at 20 hour rate ... ... 43 ampere hour.

DYNAMO

Model ... ... C39P-2 Part No. 22259. 12 volt.

Type: 2 Pole 2 Brush ... ... Shunt-wound, compensated voltage control.

Connections.—Larger dynamo terminal to 'D' terminal on voltage control box, smaller dynamo terminal to 'F' terminal on voltage control box. Cross connections will cause serious damage to regulator in control box.

Performance Data

- Cutting-in speed ... ... 1050-1200 r.p.m. at 13.0 generator volts.
- Maximum test output ... ... 19 amperes at 1900-2150 r.p.m. at 13.5 generator volts with a resistance load of 0.71 ohms, connected between 'D' terminal and earth.
- Continuous maximum output ... 11 amps.
- Field resistance ... ... 6.1 ohms.
- Rotation ... ... Clockwise (driving end).
- Brush tension ... ... 22-25 ozs.. (0.62-0.70 kg.) Renew springs if tension is below 16 ozs. (0.45 kg.).
- Brushes ... ... Renew brushes when worn to $\frac{11}{32}$" (8.73 mm.).

STARTER MOTOR

Diesel Engine Tractor

Model ... ... M45G Part No. 26133 12 volt.

Type: 4 pole, 4 Brush ... ... Earth return-series parallel field.

Performance Data

(a) Light running current ... ... 90 amperes at 8,000-9,000 r.p.m.

(b) Lock torque ... ... 32.5 lbs. ft. (4.49 kgm.) with 900 amperes at 6.4 terminal volts.

(c) Torque at 1,000 r.p.m. ... ... 15.5 lbs. ft. (2.14 kgm.) with 500 amperes at 8.8 terminal volts.

Note.—The figures given at (a) (b) and (c) are based on the use of a fully charged 12 volt battery having a capacity of 115 ampere hours at the 10 hour rate.

Brush tension ... ... 30-40 ozs. (0.85-1.13 kg.) renew springs if tension is below 25 ozs. (0.71 kg.).

Brushes ... ... Renew brushes when worn to $\frac{5}{16}$" (7.94 mm.).

Starter Drive

Type ... ... Self-indexing plate clutch drive.

Rotation ... ... Clockwise (driving end).

Slipping torque ... ... 800-900 lbs. ins. (9.2-10.9 kgm.).

Starter Drive (*continued*)

Adjustment	Shims.
Out of mesh clearance	$\frac{1}{8}'' \pm \frac{3}{32}''$ (3.17 ± 2.38 mm.).

Solenoid

Model	6/S (fitted on 26133 A, B & C.).

Performance Data

Closing coil resistance	0.23-0.27 ohms.
Hold-on coil resistance	0.71-0.88 ohms.
Spring pressure to close contacts ...	7-9 lbs. (3.17-4.08 kg.).
Spring pressure to push plunger home	13-18 lbs. (5.9-8.16 kg.).
Plunger movement to close contacts	0.545″-0.555″ (13.84-14.1 mm.).
Total plunger movement	0.606″-0.663″ (15.39-16.84 mm.).

Solenoid

Model	7/S (fitted on 26133 D.).

Performance Data

Closing coil resistance	0.14-0.16 ohms.
Hold-on coil resistance	0.68-0.79 ohms.
Spring pressure to close contacts ...	3-5 lbs. (1.36-2.26 kg.).
Spring pressure to push plunger home	9.5-14.5 lbs. (4.31-6.58 kg.).
Plunger movement to close contacts	0.116″-0.189″ (2.95-4.8 mm.).
Total plunger movement	0.263″-0.273″ (6.67-6.93 mm.).

STARTER MOTOR

Carburettor Engine Tractors

Model	M35G. Part No. 25038. 12 volt.
Type: 4 Pole 4 Brush	Earth return series parallel field.

Performance Data

(a) Light running current	45 amperes at 8,000-9,000 r.p.m.
(b) Lock torque	7.6 lbs. ft. (1.05 kgm.) with 330-350 amps. at 7.2-7.6 volts.
(c) Torque at 1,000 r.p.m.	4.6 lbs. ft. (.64 kgm.) with 240-260 amps at 8.65-8.25 volts.
Brush tension	15-25 ozs. (.425-.709 kg.)

DISTRIBUTOR

Carburettor Engine Tractors

Models	D.3A.4. V.160. Part No. 40243—Petrol and V.O. engines. D.3A.4. V.157. Part No. 40229—L.O. engines.

Design Data

(a) Contact Breaker Gap	0.014″-0.016″ (.356-.406 mm.)
(b) Contact Breaker spring tension measured at contacts	18-24 ozs. (.51-.68 kg.)
(c) Open period	30° ± 3°.
Closed period	60° ± 3°.
(d) Firing angles	0°, 90°, 180°, 270°, ± 1°.
(e) Condenser capacity	0.2 Microfarad.

Static Ignition Setting

Tractor Engine Type	Earlier Setting B.T.D.C.	Later Setting B.T.D.C.	Change Introduced at Engine No.
Petrol	1°	5°	SF.3519 E
V.O.	6°	8°	SG.1058 E
L.O.	1½°	2°	SH.66 E

Distributor and Automatic Timing Control Details

Engine 87 mm.	Distributor	Service No.	Timing Crankshaft Degrees	Maximum Advance	Automatic Advance	
					Springs	Shaft and Action Plate
Petrol	D3A4 V.160	40243F	5° B.T.D.C.	14°-16° at 1300 dist. r.p.m.	419130	418097
V.O.	D3A4 V.160	40243F	8° B.T.D.C.	14°-16° at 1300 dist. r.p.m.	419130	418097
L.O.	D3A4 V.157	40229F	2° B.T.D.C.	16°-18° at 1240 dist. r.p.m.	416111	420749

Automatic Timing Control Test Data

	Part No. 40243 Petrol Engine and V.O. Engine	Part No. 40229 L.O. Engine
Set at zero degrees at less than:	100 r.p.m.	100 r.p.m.
Accelerate distributor to: Advance to be:	2100 r.p.m. 14° - 16°	1700 r.p.m. 16° - 18°
Check advance at following decelerating speeds:	1175 r.p.m. 13° - 15° 450 ,, 4½° - 6½° 350 ,, 2° - 5° 275 ,, ½° - 3½° 225 ,, 0° - 1½°	1150 r.p.m. 14½° - 17° 800 ,, 8½ - 11° 350 ,, ½° - 3½°
No advance below:	—	175 r.p.m.

IGNITION COIL

Performance Data

Type LA.12
Primary resistance at 20°C. ... ... 3.2-3.4 ohms.
Spark gap for slow-speed test ... ... 0.40 ins. (10 mm.).
Distributor speed for high speed test ... 3,000 r.p.m.
Maximum test voltage ... ... 12.5 volts.
Earth polarity for test ... ... + V.E.

CONTROL BOX

Model ... ... R.B. 108. Part No. 37228

(a) Cut-out

Cut-in Voltage ... ... 12.7-13.3 volts.
Drop-off Voltage ... ... 8.5-11.0 volts.
Reverse current ... ... 3.0-5.0 amps.

Control Box (*continued*)

(b) Regulator

Setting on open circuit relative to ambient temperature:

10°C. (50°F.)	15.9-16.5 volts.
20°C. (68°F.)	15.6-16.2 volts.
30°C. (86°F.)	15.3-15.9 volts.
40°C. (104°F.)	15.0-15.6 volts.

SPARK PLUG

Carburettor Engine Tractors

Model **V.O. and L.O.**	**Petrol**
Champion No. N.21 or N.7, 14 mm.	Champion No. L-10, 14 mm.
Gap Setting .028"-.032" (0.71-0.81 mm.)	Gap Setting .030"-.032" (0.76-0.81 mm.)

COMBINED IGNITION AND STARTER SWITCH

Carburettor Engine Tractors

Model ... . S.60. Part No. 31573A.

STARTER SOLENOID SWITCH

Carburettor Engine Tractors

Model ... ... ST.950. Part No. 76443

COMBINED STARTER AND HEATER SWITCH

Diesel Engine Tractors

Model ... ... S.60. Part No. 31629E.

NEUTRAL SAFETY SWITCH

Model ... ... SS.10. Part No. 31601A.

AMMETER

Diesel Engine Tractors

Model ... ... CZU.26. Part No. 36047E.

THERMOSTART

Type ... ... C.A.V.

IGNITION WARNING LIGHT

Carburettor Engine Tractors

Part No. 031431A

ELECTRICAL SYSTEM SERVICE INSTRUCTIONS

BATTERIES

Carburettor Engine Tractors
Models GTW7A, GT7A, and GTZ7A.

1. GENERAL

These batteries are of the semi-linkless type, the short intercell connectors being partially exposed, to enable testing of individual cells to be carried out. Batteries models GTW.7A and GT7.A are supplied dry and uncharged, and battery model GTZ.7A supplied dry but with its plates in a charged condition. Routine maintenance is the same for all three models.

Note.—GTW.7A batteries have wood separators. GT.7A and GTZ.7A batteries have porous rubber separators.

Ampere-hour capacity (all models).
at 10-hour rate—38 amp./hr.
at 20-hour rate—43 amp./hr.

2. ROUTINE MAINTENANCE AND SERVICING

This will be the same as detailed on Pages G6—G9 for MHF.115E, MHF.P.115E and MHF.PZ.115E batteries except for the following:—

Para. 3 (b). **Recharging from an External Supply.**
Read. "charged at the rate of 4 amperes" and **NOT** 12 amperes.
"taking a current of 4 amperes" and **NOT** 12 amperes.

Para. 4. **Preparing New Unfilled, Uncharged Batteries**
Read: Models GTW.7A and GT.7A and **NOT** MHF.115E and MHF.P.115E.

Para. 4. (c). **Initial Charge.**
Read: "charging rate is 2.5 amperes" **NOT** 8 amperes.

Para. 5. **Preparing New "Dry Charged Batteries"**
Read Model GTZ.7A and **NOT** MHF.PZ.115E.

Para 5. (b). **Freshening Charge**
Read: "charge should be 4 amperes" **NOT** 12 amperes.

Diesel Engine Tractors
Models MHF 115E, MHF P.115E, MHF PZ.115E.

1. GENERAL

Batteries models MHF.115E, MHF.P.115E, are supplied dry and uncharged, and battery model MHF. PZ.115E supplied dry but with its plates in a charged condition. Routine maintenance is the same for all three models.

Note.—MHF.115E batteries have wood separators. MHF.P.115E and MHF.PZ115E batteries have porous rubber separators.

Ampere/hour capacity (all models).
at 10-hour rate—115 amp./hr.
at 20-hour rate—131 amp./hr.

2. ROUTINE MAINTENANCE

(a) Wipe away any foreign matter or moisture from the top of the battery, and ensure that the connections and the fixings are clean and tight.

(b) Once a week, or daily in hot weather, examine the level of the electrolyte in the cells. If necessary add distilled water to bring the level up to the top of the separators.

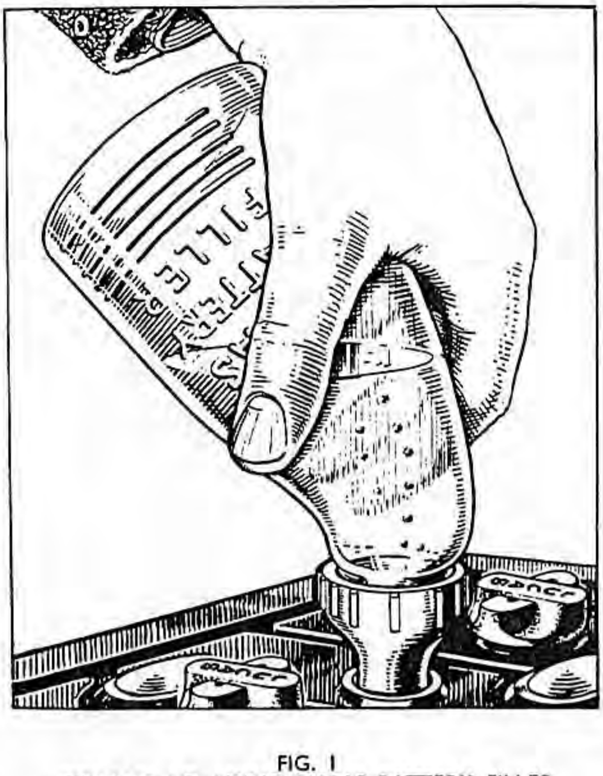


FIG. 1
TOPPING UP, USING LUCAS BATTERY FILLER

The use of a Lucas Battery Filler will be found helpful in this topping-up process, as it ensures that the correct electrolyte level is obtained automatically and also prevents distilled water from being spilled over the battery top.

Distilled water should always be used for topping-up. In an emergency however, drinking water, clean rain water or melted snow may be used. Salt water, chlorinated water, chemically softened water and stagnant water must not be used.

N.B.—Never use a naked light when examining a battery, as the mixture of oxygen and hydrogen given off the battery when on charge and to a lesser extent when standing idle, can be dangerously explosive.

3. SERVICING

(a) Battery persists in low state of charge

First consider the conditions under which the battery is used. If the battery is subjected to long periods of discharge without suitable opportunities for re-charging, a low state of charge can be expected. A slipping dynamo belt, a fault in the dynamo or regulator, or neglect of the battery during a period of low or zero mileage may also be responsible for the trouble.

Vent Plugs

See that the ventilating holes in each vent plug are clear.

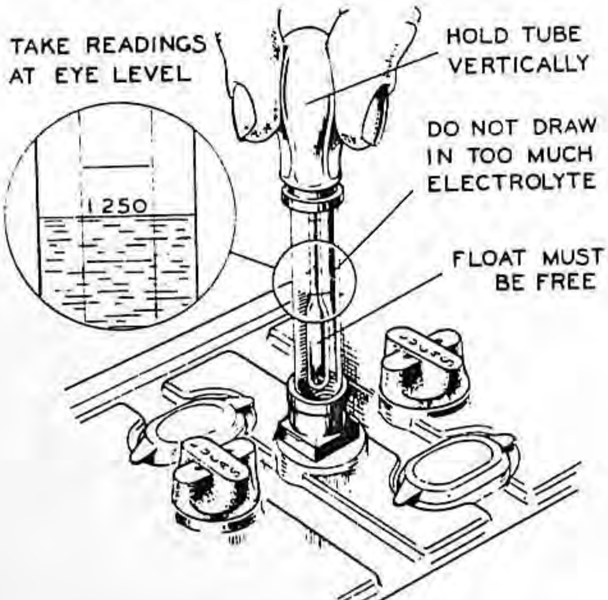


FIG. 2
CHECKING SPECIFIC GRAVITY OF ELECTROLYTE

Level of Electrolyte

The surface of the electrolyte should be level with the tops of the separators. If necessary, top up with distilled water. Any loss of acid from spilling or spraying (as opposed to the normal loss of **water** by evaporation) should be made good by dilute acid of the same specific gravity as that already in the cell.

Cleanliness

See that the top of the battery is free from dirt or moisture which might provide a discharge path. Ensure that the battery connections are clean and tight.

Hydrometer Tests

Measure the specific gravity of the acid in each cell in turn with a hydrometer. To avoid misleading readings, do not take hydrometer readings immediately after topping-up.

The readings given by each cell should be approximately the same. If one cell differs appreciably from the others, an internal fault in the cell is indicated.

The appearance of the electrolyte drawn into the hydrometer when taking a reading gives a useful indication of the state of the plates. If the electrolyte is very dirty, or contains small particles in suspension, it is possible that the plates are in a bad condition.

STATE OF CHARGE	SPECIFIC GRAVITY OF ELECTROLYTE (CORRECTED TO 60°F.)
Home, and Climates ordinarily below 90° F. (32° C.)	
Fully charged ...	1.270 - 1.290
About half discharged	1.190 - 1.210
Completely discharged	1.110 - 1.130
Climates frequently over 90° F. (32° C.)	
Fully charged ...	1.210 - 1.230
About half discharged	1.120 - 1.150
Completely discharged	1.050 - 1.070

The specific gravity of the electrolyte varies with the temperature, therefore for convenience in comparing specific gravities, this is always corrected to 60°F., which is adopted as a reference temperature. The method of correction is as follows.

For every 5°F. **below** 60°F. **deduct** .002 from the observed reading to obtain the true specific gravity at 60°F.

For every 5°F. **above** 60°F., **add** .002 to the observed reading to obtain the true specific gravity at 60°F.

The temperature must be that indicated by a thermometer actually immersed in the electrolyte, and not the air temperature.

Compare the specific gravity of the electrolyte with the value given in the table and so ascertain the state of charge of the battery.

If the battery is in a discharged state, it should be re-charged, either on the vehicle by a period of daytime running or on the bench from an external supply.

Discharge Test

A heavy discharge tester consists of a voltmeter, 2 or 3 volts full scale, across which is connected a shunt resistance capable of carrying a current of several hundred amperes. Pointed prongs are provided for making a contact with the inter-cell connectors.

Press the contact prongs against the exposed positive and negative terminals of each cell. A good cell will maintain a reading of 1.2-1.5 volts, depending on the state of charge, for at least 6 seconds. If, however, the reading rapidly falls off, the cell is probably faulty, and a new plate assembly may have to be fitted.

(b) Recharging from an External Supply

If the above tests indicate that the battery is merely discharged, and is otherwise in a good condition, it should be recharged, either on the vehicle by a period of daytime running or on the bench from an external supply.

If the latter, the battery should be charged at the rate of 12 amperes until the specific gravity and voltage show no increase over three successive hourly readings. During the charge the electrolyte must be kept level with the tops of the separators by the addition of distilled water.

A battery that shows a general falling-off in efficiency, common to all cells, will often respond to the process known as "cycling". This process consists of fully charging the battery as described above and then discharging it by connecting to a lamp board, or other load, taking a current of 12 amperes. The battery should be capable of providing this current for at least 10 hours before it is fully discharged, as indicated by the voltage of each cell falling to 1.8. If the battery discharges in a shorter time, repeat the "cycle" of charge and discharge.

4. PREPARING NEW, UNFILLED, UNCHARGED BATTERIES

(Models MHF.115E, and MHF.P.115E.).

(a) Preparation of Electrolyte

Batteries should not be filled with acid until required for initial charging.

Specific Gravity of Acid Required when Filling

BATTERY	SPECIFIC GRAVITY OF ACID (CORRECTED TO 60°F.)
Home and Climates ordinarily below 90° F. (32° C.)	
MHF.115E	1.340
MHF.P.115E	1.270
Climates frequently over 90° F. (32° C.)	
MHF.115E	1.290
MHF.P.115E	1.210

Electrolyte of the specific gravity required is prepared by mixing distilled water and concentrated sulphuric acid, usually of 1.835 S.G. The mixing must be carried out either in a lead-lined tank or in suitable glass or earthenware vessel. Slowly add the acid to the water, stirring with a glass rod. **Never add water to the acid,** as the resulting chemical reaction causes violent and dangerous spurting of the concentrated acid. The approximate proportions of acid and water are indicated in the following table:—

To obtain Specific Gravity (corrected to 60°F.) of:	Add 1 vol. of acid of 1.835 S.G. (corrected to 60°F.) to:
1.340	2.0 volumes of water
1.290	2.7 volumes of water
1.270	2.9 volumes of water
1.210	4.0 volumes of water

Heat is produced by the mixture of acid and water, and the electrolyte should be allowed to cool before taking hydrometer readings—unless a thermometer is used to measure the actual temperature, and a correction applied to the reading as described on page G.7—and before pouring the electrolyte into the battery.

(b) Filling the Battery

The temperature of the acid, battery and filling-in room must not be below 32°F.

Carefully break the seals in the filling holes and **half-fill** each cell with electrolyte of the appropriate specific gravity. Allow the battery to stand for at least six hours, in order to dissipate the heat generated by the chemical action of the acid on the plates and separators. Allow to stand for a further two hours and then proceed with the initial charge.

(c) Initial Charge

The initial charging rate is 8 amperes. Charge at this rate until the voltage and specific gravity readings show no increase over five successive hourly readings. This will take from 40 to 80 hours, depending on the length of time the battery has been stored before charging.

Maximum Permissible Electrolyte Temperature During Charge

Home and Climates normally below 90°F. (32°C.) ...	100°F. (37.7°C.)
Climates frequently over 90°F. (32°C.)	120°F. (48.8°C.)

Keep the current constant by varying the series resistance of the circuit or the generator output. **This charge should not be broken by long rest periods.** If, however, the temperature of any cell rises above the permissible maximum quoted in table, the charge must be interrupted until the temperature has fallen at least 10° below that figure. Throughout the charge, the electrolyte must be kept level with the top of the separators by the addition of acid solution of the same specific gravity as the original filling-in acid, until specific gravity and voltage readings have remained constant for five successive hourly readings. If the charge is continued beyond that point, top up with distilled water.

At the end of the charge carefully check the specific gravity in each cell to ensure that, when corrected to 60°F., it lies within the specified limits. If any cell requires adjustment, some of the electrolyte must be siphoned off and replaced either by distilled water or by acid of the strength originally used for filling-in, depending on whether the specific gravity is too high or too low. Continue the charge for an hour or so to ensure adequate mixing of the electrolyte and again check the specific gravity readings. If necessary, repeat the adjustment process until the desired reading is obtained in each cell. Finally, allow the battery to cool, and siphon off any electrolyte above the tops of the separators.

5. PREPARING NEW "DRY-CHARGED" BATTERIES (MODEL MHF.PZ.115E) FOR SERVICE

Specific Gravity of Acid Required when Filling

BATTERY	SPECIFIC GRAVITY OF ACID (CORRECTED TO 60°F.)
Home and Climates ordinarily below 90° F. (32° C.)	
MHF.PZ.115E	1.270
Climates frequently over 90° F. (32° C.)	
MHF.PZ.115E	1.210

(a) Filling the Cells

Carefully break the seals in the filling holes and fill each cell with correct specific gravity acid to the top of the separators in one operation. The temperature of the filling room, battery and acid should be maintained at between 60°F. and 100°F. If the battery has been stored in a cool place, it should be allowed to warm up to temperature before filling.

(b) Freshening Charge

Batteries filled in this way are up to 90% charged, and capable of giving a starting discharge one hour after filling. When time permits however, a short freshening charge will ensure that the battery is fully charged.

Such a freshening charge should be 12 amperes for not more than 4 hours.

During the charge the electrolyte must be kept level with the top edge of the separators by the addition of distilled water. Check the specific gravity of the electrolyte at the end of the charge; if 1.270 acid was used to fill the battery, the specific gravity should now be between 1.270 and 1.290; if 1.210 acid, between 1.210 and 1.230.

(c) Maintenance in Service

After filling, a dry-charged battery needs only the attention normally given to all lead-acid type batteries.

DYNAMO

Model C39P-2. Part No. 22259.
Fitted to Carburettor and Diesel Engine Tractors

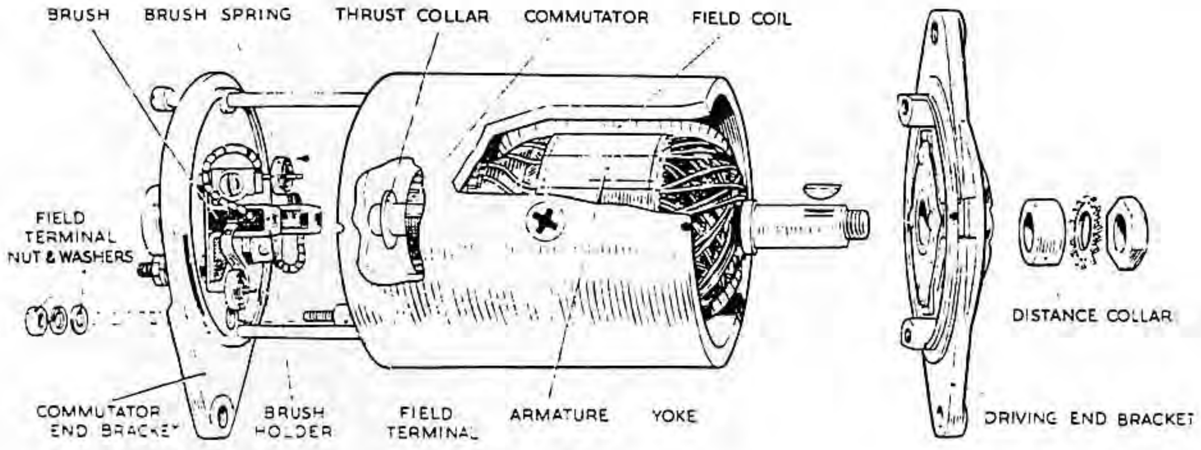


FIG. 3
DYNAMO DISMANTLED

1. GENERAL

The dynamo is a shunt-wound two-pole two-brush machine, arranged to work in conjunction with a compensated voltage control regulator unit. The machine is 3.9 in. in diameter, non-ventilated and has a ball bearing at the driving end and a porous bronze bush at the commutator end.

The output of the dynamo is controlled by the regulator unit and is dependent on the state of charge of the battery and the loading of the electrical equipment in use. When the battery is in a low state of charge, the dynamo gives a high output, whereas if the battery is fully charged, the dynamo gives only sufficient output to keep the battery in good condition without any possibility of over-charging. An increase in output is given to balance the current taken by lamps and other accessories when in use.

When fitting a new control box, it is important to use only an authorised replacement. An incorrect replacement can result in damage to the dynamo.

2. ROUTINE MAINTENANCE

(a) Lubrication

Every 120 hours, inject a few drops of Oiline BBB, or any high quality medium viscosity (S.A.E. 30) engine oil into the hole marked "OIL" at the end of the bearing housing.

(b) Inspection of Brushgear

Every 500 hours the brushgear should be inspected by a competent electrician.

(c) Belt Adjustment

Occasionally inspect the dynamo driving belt and, if necessary, adjust to take up any undue slackness by turning the dynamo on its mounting. Care should be taken to avoid overtightening the belt, the tension needed being approx. $\frac{3}{4}''$ depression midway between dynamo and crankshaft pulleys. See that the machine is properly aligned, otherwise undue strain will be thrown on the dynamo bearings.

3. SERVICING

(a) Testing in Position to Locate Fault in Charging Circuit

In the event of a fault in the charging circuit adopt the following procedure to locate the cause of trouble.

(i) Inspect the driving belt and adjust if necessary.

(ii) Check that the dynamo and control box are connected correctly. The larger dynamo terminal must be connected to control box terminal "D" and the smaller dynamo terminal to control box terminal "F". Check the earth connection to control box terminal "E".

(iii) Switch off all lights and accessories, disconnect the cables from the terminals of the dynamo.

(iv) Start the engine and set to run at normal idling speed.

(v) Connect voltmeter from terminal "D" to "F" and speed up engine. Voltmeter should read 2-4 volts. This indicates armature and brushes are satisfactory. If zero reading, free brushes and re-check. If reading is still zero armature is faulty.

(vi) Leave voltmeter as for (v) and connect ammeter from terminal "D" (large terminal) to terminal "F" (small terminal). Raise engine speed slowly. Voltage should rise with speed. Adjust voltmeter by speed variation to read exactly 12 volts. Ammeter should then read 20 amperes. 2-4 volts indicate broken field. 12 volts but 4 amps. on ammeter indicates earthed field.

If voltage does not rise rapidly and without fluctuation the unit must be dismantled.

Note.—Excessive sparking at the commutator in the above test indicates a defective armature which should be replaced.

If the dynamo is in good order, remove the link from between the terminals and restore the original connections, taking care to connect the larger dynamo terminal to control box terminal "D" and the smaller dynamo terminal to control box terminal "F".

(b) Dismantling

(i) Take off the driving pulley.

(ii) Unscrew and withdraw the two through bolts.

(iii) The commutator end bracket can now be withdrawn from the dynamo yoke.

(iv) The driving end bracket together with the armature can now be lifted out of the yoke. Take care not to lose the fibre thrust washer or collar.

(v) The driving end bracket, which on removal from the yoke has withdrawn with it the armature and armature shaft ball-bearing, need not be separated from the shaft unless the bearing is suspected and requires examination, or the armature is to be replaced; in this event the armature should be removed from the end bracket by means of a hand press.

(c) Brushgear

(i) Lift the brushes up into the brush boxes and secure them in that position by positioning the brush spring at the side of the brush.

(ii) Fit the commutator end bracket over the commutator and release the brushes.

(iii) Hold back each of the brush springs and move the brush by pulling on its flexible connector. If the movement is sluggish, remove the brush from its holder and ease the sides by lightly polishing on a smooth file. Always refit brushes in their original positions. If the brushes are badly worn, new brushes must be fitted and bedded to the commutator. The minimum permissible length of brush is $\frac{11}{32}$" (8.7 mm.).

(iv) Test the brush spring tension using a spring scale. The tension of the springs when new is 22-25 oz. (.62-.71 kg.). In service, it is permissible for this value to fall to 15 oz. (.43 kg.) before performance may be affected. Fit new springs if the tension is low.

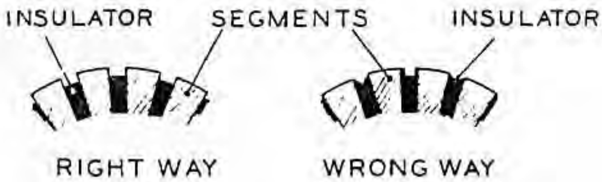


FIG. 4
INSULATORS

(d) Commutator

A commutator in good condition will be smooth and free from pits or burned spots. Clean the commutator with a petrol-moistened cloth. If this is ineffective, carefully polish with a strip of fine glass paper while rotating the armature. To remedy a badly worn commutator, mount the armature, with or without the drive end bracket, in a lathe, rotate at high speed and take a light cut with a very sharp tool. Do not remove more metal than is necessary. Polish the commutator with a very fine glass paper. Emery cloth must not be used on the commutator. Undercut the insulators between the segments to a depth of $\frac{1}{32}$" (.79 mm.) with a hacksaw blade ground to the thickness of the insulator.

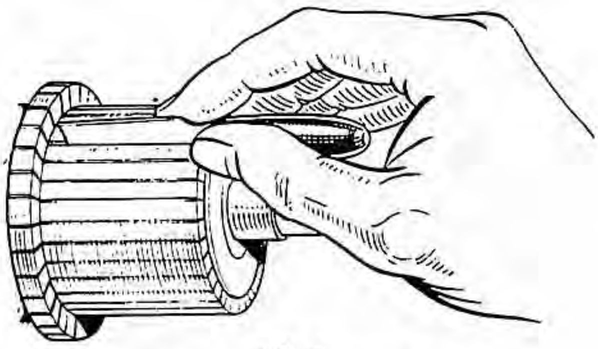


FIG. 5
UNDERCUTTING INSULATORS

(e) **Armature**

Indication of an open-circuited armature winding will be given by burnt commutator segments. If armature testing facilities are not available, an armature can be checked by substitution.

To remove the armature shaft from the drive end bracket bearing, support the bearing retaining plate firmly and press the shaft out of the drive end bracket. When fitting the new armature, support the inner journal of the ball bearing, using a mild steel tube of suitable diameter, whilst pressing the armature shaft firmly home.

No attempt should be made to machine the armature core or to true a distorted armature shaft.

(f) **Field Coils**

Measure the resistance of the field coils, without removing them from the dynamo yoke, by means of an ohm meter connected between the field terminals and the yoke.

The correct value of resistance for the field coil is 6.1 ohms.

If an ohm meter is not available, connect a 12 volt d.c. supply between the field terminal and dynamo yoke with an ammeter in series. The ammeter reading in each case should be approximately 2 amperes. Zero reading on the ammeter or an "Infinity" ohm meter reading indicates an open circuit in the field winding.

If the current reading is more than 2 amperes, or the ohm meter reading much below 6 ohms, it is an indication that the insulation of one of the field coils has broken down.

In either event, unless a substitute dynamo is available, the field coils must be replaced. To do this, carry out the procedure outlined below:—

(i) Drill out the rivet securing the field coil terminal assembly to the yoke, and unsolder the field coil connections.

(ii) Remove the insulation piece which is provided to prevent the junction of the field from contacting with the yoke.

(iii) Mark the yoke and pole shoes so that the latter can be refitted in their original positions.

(iv) Unscrew the two pole shoe retaining screws by means of a wheel-operated screwdriver.

(v) Draw the pole shoes and coils out of the yoke and lift off the coils.

(vi) Fit the new coils over the pole shoes and place them in position inside the yoke. Take care to ensure that the taping of the field coils is not trapped between the pole shoes and the yoke.

(vii) Locate the pole shoes and field coils by lightly tightening the fixing screws.

(viii) Fully tighten the screws by means of the wheel-operated screwdriver and lock them by caulking.

(ix) Replace the insulation piece between the field coil terminal tags and re-rivet the terminal assembly to the yoke.

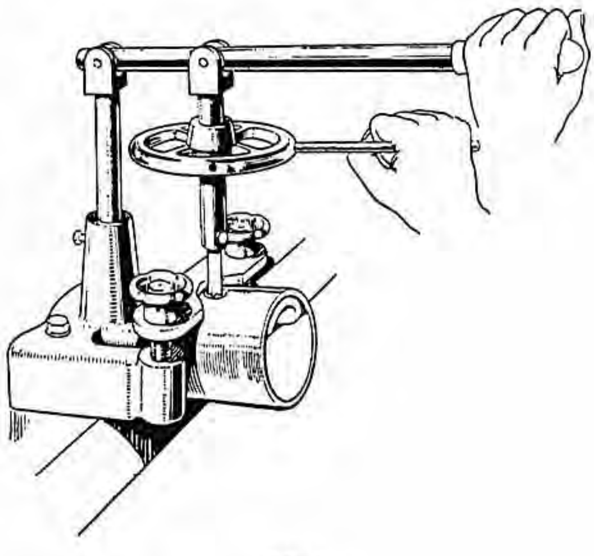


FIG. 6
TIGHTENING POLE SHOE RETAINING SCREWS

(g) **Bearings**

Bearings which are worn to such an extent that they will allow side movement of the armature shaft must be replaced.

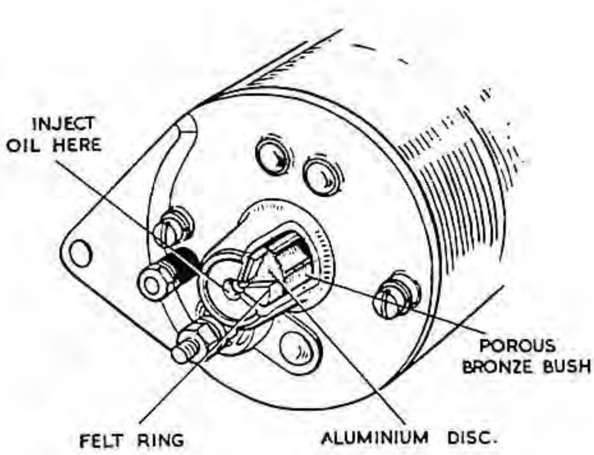


FIG. 7
COMMUTATOR END BEARING ASSEMBLY

To replace the bearing in a commutator end bracket proceed as follows:—

(i) Remove the old bearing bush from the end bracket. The bearing can be withdrawn with a suitable extractor or by screwing a $\frac{5}{8}$" (16 mm.) tap into the bush for a few turns and pulling out the bush with the tap. Screw the tap squarely into the bush to avoid damage to the bracket.

(ii) Insert the felt ring aluminium disc in the bearing housing then press the new bearing bush into the end bracket, using a shouldered, highly polished mandrel of the same diameter as the shaft which is to fit the bearing, until the visible end of the bearing is flush with the inner face of the bracket.

Porous bronze bushes must not be opened out after fitting, or the porosity of the bush may be impaired.

Note.—Before fitting the new bearing bush it should be allowed to stand for 24 hours completely immersed in a good grade thin engine oil; this will allow the pores of the bush to be filled with lubricant.

The ball bearing at the driving end is replaced as follows:—

(i) Drill out the rivets which secure the bearing retaining plate to the end bracket and remove the plate.

(ii) Press the bearing out of the bracket, and remove the corrugated washer, felt washer and oil retaining washer.

(iii) Before fitting the replacement bearing see that it is clean and pack it with high melting point grease, such as Energrease R.B.B. 3.

(iv) Place the oil retaining washer, felt washer and corrugated washer in the bearing housing in the end bracket.

(v) Locate the bearing in the housing and press it home.

Fit the bearing retaining plate, insert the new rivets from the inside of the end bracket and open the rivets by means of a punch to secure the plate rigidly in position.

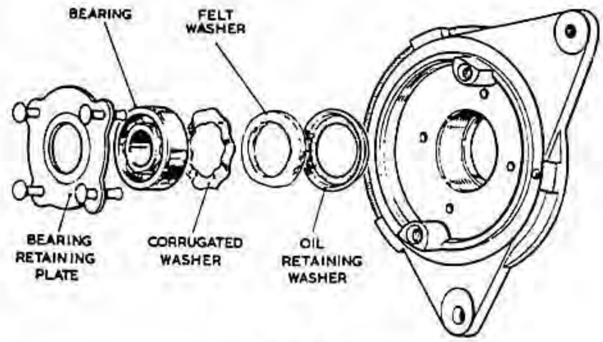


FIG. 8
DRIVING END BEARING ASSEMBLY

(h) Re-assembly

In the main the re-assembly of the dynamo is a reversal of the operations described on page G.11.

(i) Fit the drive end bracket to an armature shaft. The inner journal of the bearing **must** be supported by a suitable tube. Mild steel tubes approx. 4 in. long (101.6 mm.), and $\frac{1}{8}$" (3.2 mm.) thick can be used, the internal diameter being $\frac{5}{8}$" (15.9 mm.).

Do not use the drive end bracket as a support for the bearing whilst fitting an armature.

(ii) Fit the yoke to the drive end bracket.

(iii) Lift the brushes up into the brush boxes and secure them in that position by positioning the brush spring at the side of the brush.

(iv) Fit the commutator end bracket on the armature shaft until the brush boxes are partly over the commutator. Place a thin screwdriver on top of each brush in turn and press the brush down on the commutator. The brush springs should then position themselves on top of the brushes.

(v) Fit the commutator end bracket to the yoke so that the projection on the bracket locates in the yoke.

(vi) Refit the two through bolts.
After reassembly lubricate the commutator end bearing. See Fig. 7.

PRE-ENGAGED STARTER MOTOR WITH SELF INDEXING DRIVE

Model M45G 12 Volt Part No. 26133/A/B/C-6S Part No. 26133/D-7S.

Fitted to Diesel Engine Tractor

1. GENERAL

This starter motor is a four-pole, four-brush earth return machine with series-parallel connected field coils.

A solenoid-operated pre-engaged drive assembly is carried on an extension of the armature shaft. The main features of this type of drive are as follows:—

(a) Positive pinion engagement, preventing the pinion being thrown out of mesh whilst starting.

(b) Dual-purpose plate-clutch incorporated in the drive assembly giving over-speed and over-load protection.

(c) Self-indexing pinion to ensure smooth engagement between the pinion and the flywheel teeth before the starter motor begins to rotate.

(d) Armature braking system to ensure rapid return to rest when the starter button is released.

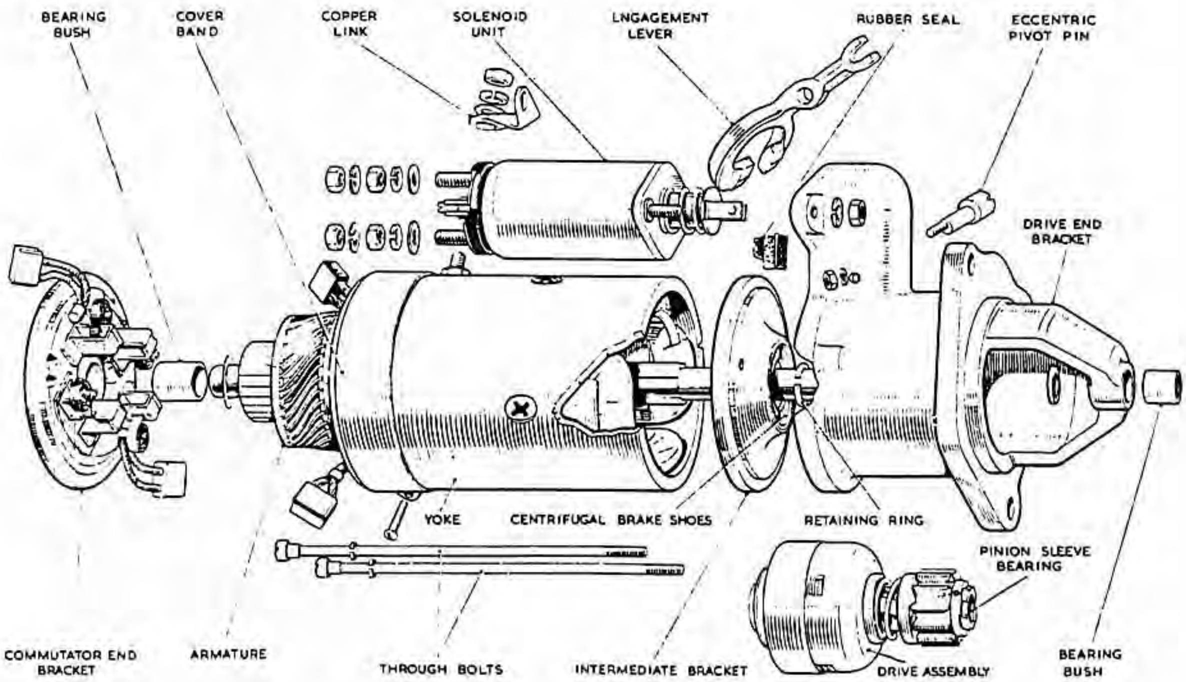


FIG. 9
M45G STARTER MOTOR DISMANTLED

OPERATION

On turning the starter switch, a solenoid unit mounted on the starting motor yoke is energised and actuates a forked lever to engage the drive pinion with the engine flywheel. On occasions of tooth-to-tooth abutment, axial movement of the pinion is arrested whilst a helically splined sleeve in which the pinion is carried, continues to move forward. This causes the pinion to rotate relative to the flywheel. When the teeth become aligned, spring pressure slides the pinion into mesh with the flywheel.

When the pinion is properly engaged with the flywheel teeth a pair of contacts are closed in the rear of the unit. Closure of the contacts connects the motor to the battery, the armature rotates and the starter pinion commences to crank the engine.

When the engine fires and the starter switch is released, the solenoid unit is de-energised and the spring-loaded plunger withdraws the starter pinion to its out-of-mesh position. The armature is brought rapidly to rest by the centrifugal action of a pair of spring-loaded brake shoes bearing against a brake drum inside the intermediate bracket.

Provision is made to ensure that in the case of the pinion jamming in mesh (this may occur with an engine which fails to start) there is sufficient slack in the engagement lever-to-solenoid plunger linkage to permit the solenoid switch contacts to open.

In the event of the drive remaining in mesh with the flywheel after the engine has run up to speed the starter motor armature is protected from over-speeding by the plate clutch assembly. This clutch allows torque to be transmitted from the starter motor to the engine but not in the reverse direction which is free running.

The clutch is set to slip at between two and three times normal starting torque, thus providing over-load protection for the starter motor. Back-firing is a typical example of overloading.

2. ROUTINE MAINTENANCE

(a) The starter motor requires no routine maintenance beyond the occasional inspection of the electrical connection which must be clean and tight, the brush gear, and the commutator.

(b) **Major Overhaul**

After the starter motor has been in service for some time, remove the starter motor from the engine and submit it to a thorough bench inspection.

(i) Brush wear (this is a fair indication of the amount of work done). Renew brushes worn to, or approaching, $\frac{5}{16}$" (7.9 mm.) in length.

(ii) Brush spring tension. Correct tension is 30-40 ozs. (.85-1.13 kg.) Renew springs if tension has dropped below 25 ozs. (.71 kg.)

(iii) Skim commutator if it is pitted or badly worn.

(iv) Check bearings for excessive side play of armature shaft.

(v) Check pinion movement.

(vi) Clean and lubricate the indented bearing inside the pinion sleeve using a bentonite based grease for this purpose.

(vii) Clean and lubricate the indented bronze bearing in the intermediate bracket. Use Ragosine 'Molypad' Molybdenised non-creep oil for this purpose.

3. SERVICING

(a) **Testing in Position**

Switch on the lamps. If the tractor is not equipped with lighting, then connect on 0.20 voltmeter across the battery terminals before proceeding. Operate the starter control and watch for the following symptoms:—

(i) *The lamps dim, or voltmeter reading drops to about 6 volts, and the motor does not crank the engine.*

Check battery (must be at least half-charged) and battery lugs, (clean and a good earth connection). Check by hand-cranking that the engine is not abnormally stiff.

(ii) *The lamps do not dim, the voltmeter reading remains steady at about 12 volts, and the motor does not crank the engine.*

Connect voltmeter from solenoid terminal 'BAT', and starter yoke, operate starter:—

No volts indicated.

(a) Poor lug connections at battery.

(b) Bad earth connection.

(c) Broken starter lead, battery to starter

Full volts *i.e.*, 12-14 volts indicated.

(a) Faulty solenoid switch.

(b) Open circuit in starter—check brushes.

(b) **Bench Testing**

(i) **Removing the starter motor from the engine**

Disconnect the battery. Disconnect and remove the starter motor from the engine.

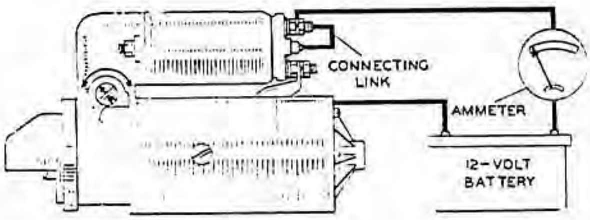


FIG. 10
MEASURING LIGHT RUNNING CURRENT

(ii) **Measuring the light running current**

With the starter motor securely clamped in a vice and using a 12 volt battery, check the light running current which should be 90 amperes at 8,000-9,000 r.p.m. If there appears to be excessive sparking at the commutator, check that the brushes are clean and free to move in their boxes, and that the spring pressure is correct.

(iii) **Measuring lock torque and lock current**

Carry out a torque test, should be 32.5 lbs. ft. (4.5 kg.m.) with 900 amps. at 6.4 terminal volts. If a constant voltage supply is used it is important to adjust this to be 6.4 volts at the starter terminal when testing.

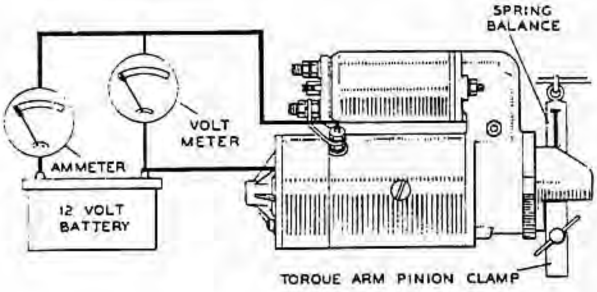


FIG. 11
MEASURING LOCK TORQUE AND LOCK CURRENT

(iv) **Fault diagnosis**

An indication of the nature of the fault, or faults, may be deduced from the results of the no-load and lock torque tests, as follows:—

(a) *Speed, torque current consumption correct.*
Assume motor to be in normal operating condition.

(b) *Speed, torque and current consumption low.*
High resistance in brush gear, e.g., faulty connections, dirty or burned commutator causing poor brush contact.

(c) *Speed and torque low, current consumption high.*
Tight or worn bearings, bent shaft, insufficient end play, armature fouling a pole shoe, or cracked spigot on drive end bracket. Short-circuited armature, earthed armature or field coils.

(d) *Speed and current consumption high, torque low.*
Short-circuited windings in field coils.

(e) *Armature does not rotate, no current consumption.*
Open circuited armature, field coils, or solenoid unit. If the commutator is badly burned there may be poor contact between brushes and commutator.

(f) *Armature does not rotate, high current consumption.*
Earthed field winding or short circuited solenoid unit. Armature physically prevented from rotating.

(g) *Excessive brush movement causing arcing at commutator.*
Defective armature windings, sticking brushes or dirty commutator.

(c) **Dismantling**

(i) Disconnect the copper link between the lower solenoid terminal and the starter motor yoke.

(ii) Remove the solenoid unit securing nuts. Withdraw the solenoid from the drive end bracket casting, carefully disengaging the solenoid plunger from the starter drive engagement lever.

(iii) Remove the cover band and lift the brushes from their holders.

(iv) Unscrew and withdraw the two through bolts from the commutator end bracket. The commutator end bracket and yoke can now be removed from the intermediate and drive end brackets.

(v) Extract the rubber seal from the drive end bracket.

(vi) Remove the nut securing the eccentric pin on which the starter drive engagement lever pivots and withdraw the pin.

(vii) Separate the drive end bracket from the armature and intermediate bracket assembly.

(viii) Remove the washer from the end of the armature shaft extension and slide the drive assembly and engagement lever off the shaft.

(ix) If it is necessary to dismantle the drive assembly, proceed as described on page G.20.

(x) Remove the intermediate bracket retaining ring from the armature shaft extension and slide the bracket and brake assembly off the shaft.

(d) **Bench Inspection**

(i) **Solenoid**

The solenoid unit contains two coils; a closing coil which is by-passed when the plunger is drawn fully home, and a hold-on-coil to retain the plunger in the fully home position. To check the individual coils, remove the existing connections and using a constant-voltage 4 volt d.c. supply with cables of adequate size, proceed as follows:—

Closing coil

Connect the supply between the solenoid terminal marked 'STA' and the small centre terminal. This should actuate the plunger and cause a current to pass of 14.8 - 17.4 amperes for the 6S, or 24.0 - 28.0 amperes for the 7S.

Hold-on-coil

Connect the supply between the solenoid body and the small centre terminal. This should actuate the plunger and cause a current to pass of 4.5 - 5.6 amperes for the 6S, or 5.1 - 5.8 amperes for the 7S.

N.B.—Do not carry out these tests while the solenoid unit is hot.

If a constant voltage supply is not available check the coil resistances, using an accurate method of measuring low resistance values such as the Wheatstone Bridge. Connect the measuring instrument as for measuring the current and compare resistances which should be:—

Closing coil resistance	0.23-0.27	ohms-6S
	0.14-0.16	ohms-7S
Hold-on-coil ,,	0.71-0.88	ohms-6S
	0.68-0.79	ohms-7S

If after testing, the solenoid is found to be faulty it should be replaced. Do not attempt to repair a faulty solenoid.

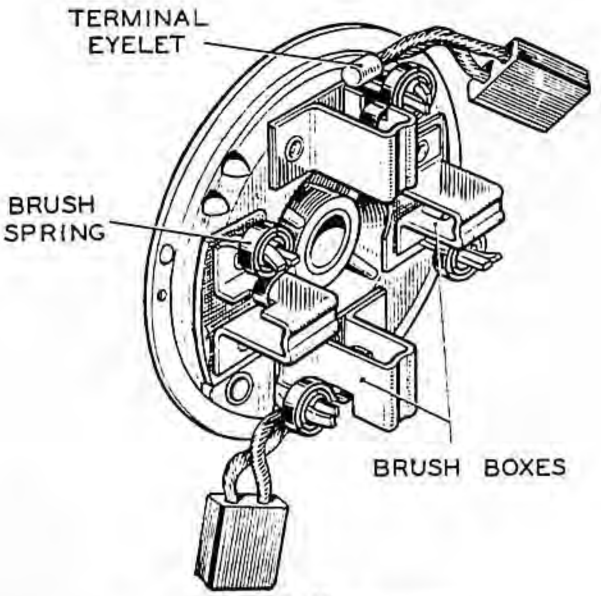


FIG. 12
COMMUTATOR END BRACKET

(ii) **Replacement of Brushes**

The flexible connectors are soldered to terminal tags: two are connected to brush boxes, and two are connected to free end of the field coils. Unsolder these flexible connectors and solder the connectors of the new brush set in their place. The brushes are pre-formed so that "bedding" to the commutator is unnecessary. Check that the new brushes can move freely in their boxes.

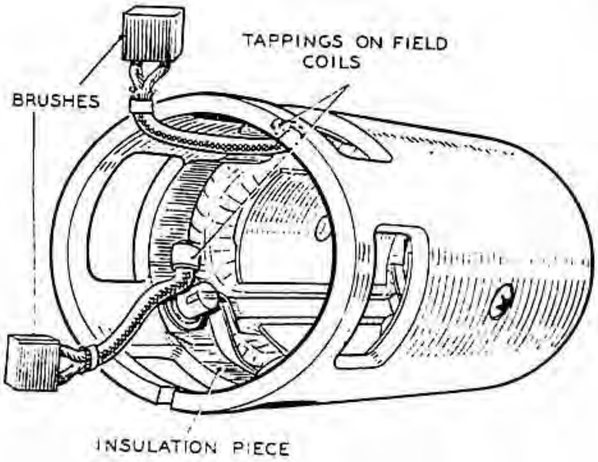


FIG. 13
FIELD COILS AND YOKE

(iii) **Commutator**

A commutator in good condition will be burnished and free from pits or burned spots. Clean the commutator with a petrol-moistened cloth. Should this be ineffective spin the armature and polish the commutator with a fine glass paper; remove all abrasive dust with a dry air blast. If the commutator is badly worn, mount the armature between centres on a lathe, rotate at high speed and make a light cut with a very sharp tool. Do not remove more metal than is necessary. The INSULATORS between the commutator segments MUST NOT BE UNDERCUT.

(iv) **Armature**

Lifted conductors

If the armature conductors are found to be lifted from the commutator risers, over speeding is indicated. In this event, check that the clutch assembly is disengaging correctly when the engine fires.

Fouling of armature core against the pole face

This indicates worn bearings or a distorted shaft. A damaged armature must in all cases be replaced and no attempt should be made to machine the armature core or to true a distorted armature shaft.

Insulation Test

To check armature insulation, use a 110 volt a.c. test lamp. The test lamp must not light when connected between any one commutator segment and the armature shaft. This should be done after cleaning off brush dust.

If a short circuit is suspected, check the armature on a "growler". Overheating can cause blobs of solder to short circuit the commutator segments.

(v) **Field Coils**

Continuity Tests

Connect a 12 volt test lamp and battery between the insulated terminal on the yoke and each individual brush (with the armature removed from the yoke). Ensure that both brushes and their flexible connectors are clear of the yoke. If the lamp does not light, an open circuit in the field coils is indicated. Replace defective coils.

Insulation Test

Connect a 110 volt a.c. test lamp, between the terminal post and a clean part of the yoke. The test lamp lighting, indicates that the field coils are earthed to the yoke and must be replaced.

When carrying out this test, check also the insulated pair of brush boxes on the commutator end bracket.

Clean off all traces of brush deposit before testing. Connect the 110 volt test lamp between each insulated brush box and end bracket. If the lamp lights this indicates faulty insulation and the end bracket must be replaced.

Replacing the field coils

Unscrew the four pole-shoe retaining screws using a wheel-operated screwdriver.

Remove the insulation piece which is fitted to prevent the inter-coil connectors from contacting the yoke.

Draw the pole-shoes and coils out of the yoke and lift off the coils.

Fit the new field coils over the pole-shoes and place them in position inside the yoke. Ensure that the taping of the field coils is not trapped between the pole-shoes and the yoke.

Locate the pole-shoes and field coils by lightly tightening the retaining screws.

Replace the insulation piece between the field coil connections and the yoke.

Finally, tighten the screws by means of the wheel-operated screwdriver while the pole pieces are held in position by a pole-shoe expander, or a mandrel of suitable size.

(vi) **Bearing and Bearing Replacement**

The commutator and drive end brackets are each fitted with a porous bronze bush and the intermediate bracket is fitted with an indented bronze bearing. Replace bearings which are worn to such an extent that they will allow excessive side play of the armature shaft.

The bushes in the intermediate and drive end brackets can be pressed out, whilst that in the commutator end bracket is best removed by inserting a $\frac{11}{16}''$ (17 mm.) tap squarely into the bearing and withdrawing the bush with the tap.

Before fitting a new porous bronze bearing bush, immerse it for 24 hours in clean engine oil. In cases of extreme urgency, this period may be shortened by heating the oil to 100°C. for 2 hours and then allowing the oil to cool before removing the bush.

Fit new bushes by using a shouldered, highly polished mandrel approximately 0.0005" (.013 mm.) greater in diameter than the shaft which is to fit in the bearing. Porous bronze bushes must not be reamed out after fitting, as the porosity of the bush will be impaired.

After fitting a new intermediate bearing bush, lubricate the bearing surface with Ragosine Molybdenised Non-creep oil.

(e) **Re-assembly**

After cleaning all parts, re-assembly of the starter motor is a reversal of the dismantling procedure; the following special points should be noted.

(i) To facilitate fitting the solenoid unit to the drive end bracket ease the drive assembly forward along the armature shaft.

(ii) Set the pinion movement before tightening the eccentric pivot pin securing nut.

(f) **Setting pinion movement**

After completing assembly of the starter motor connect the small centre terminal on the solenoid unit by way of a switch to a 12 volt supply. Connect the other side of the battery to one of the solenoid fixing studs.

Close the switch (this throws the drive assembly forward into the engaged position) and measure the distance between the pinion and the washer on the armature shaft extension. Make this measurement with the **pinion pressed lightly towards the armature** to take up any slack in the engagement linkage. For correct setting this distance should be 0.020"-0.030" (0.51-0.76 mm.).

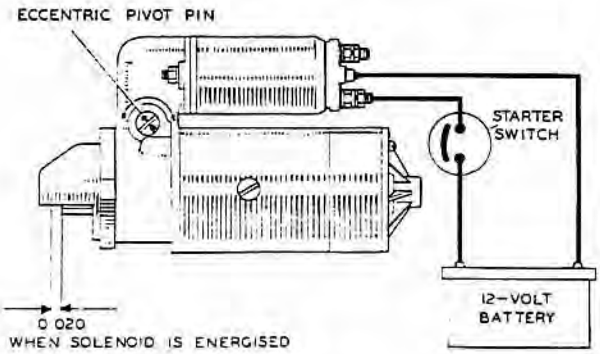


FIG. 14
SETTING PINION MOVEMENT

To adjust the setting, slacken the eccentric pivot pin securing nut and turn the pin until the correct setting is obtained. Note that the arc of the adjustment is 180° and the head of the arrow marked on the pivot pin should be set only between the arrows on the arc described on the drive end bracket casting. After setting, tighten the securing nut to retain the pin in position.

Note.—In the event of a replacement motor or drive end bracket being fitted, check the out-of-mesh clearance when assembling the starter motor to the engine. This should be $\frac{1}{8}''$ (3.17 mm.) between the leading edge of the pinion and the engine flywheel with a tolerance each way of $\frac{3}{32}''$ (2.38 mm.).

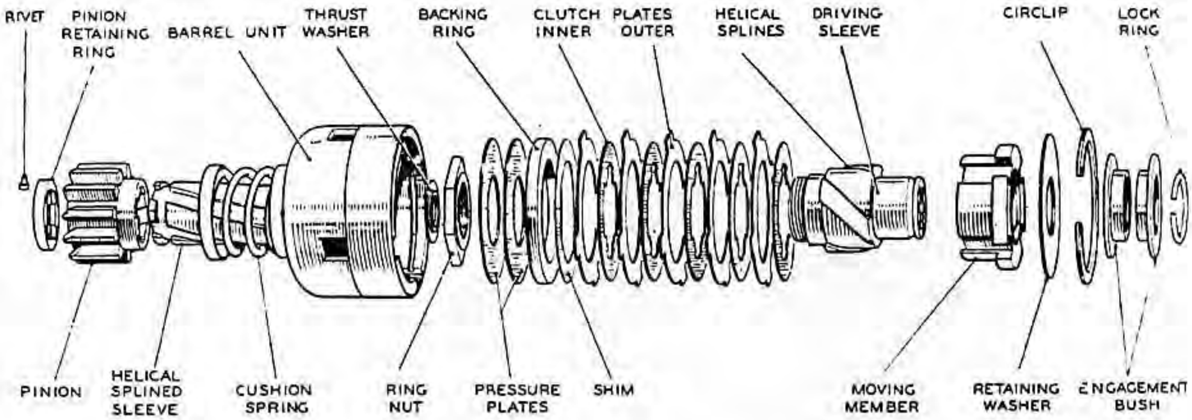


FIG. 15
STARTER DRIVE ASSEMBLY

4. STARTER DRIVE ASSEMBLY

(a) General Operation

The drive assembly is mounted on the armature shaft extension with the clutch driving sleeve splined to the shaft. When the starter switch is operated the engagement lever pushes the drive assembly along the shaft to engage the pinion with the flywheel.

The pinion is carried on a helically splined sleeve which is cleated to the barrel unit containing the plate clutch assembly. In the event of tooth-to-tooth engagement the forward movement of the pinion ceases while the helical splined sleeve continues to be pushed forward.

This rotates the pinion relative to the flywheel ring gear. When the teeth become aligned for meshing, the compressed cushion spring slides the pinion into mesh with the flywheel.

When the armature shaft rotates the drive, torque is transmitted from the shaft through the clutch driving sleeve, plate clutch assembly and barrel unit, to the driving pinion. The clutch is engaged by pressure from the moving member which rides up the helical splines on the drawing sleeve when the armature shaft rotates.

The movement clamps the clutch plates together and torque is transmitted to the barrel unit.

If, after the engine fires, the torque reverses direction, the moving member releases its pressure on the clutch plates and the clutch automatically disengages and releases the armature shaft, only the pinion and barrel unit are driven by the engine.

If the clutch is overloaded it slips at a torque two or three times greater than the maximum developed by the motor. This overload protection feature is effected by shim-setting the engagement pressure on the clutch plates.

When the moving member exerts pressure on the clutch plates, pressure plates are compressed by the backing ring. This compression determines the amount of torque which can be transmitted by the clutch plates, and is pre-set by shims inserted between the backing ring and the clutch plates.

(b) Dismantling

(i) Remove the drive assembly from the armature shaft.

(ii) Remove the lock ring from driving sleeve.

(iii) Lift two halves of the engagement bush off the driving sleeve.

(iv) Using a suitable circlip extracting tool, extract the clutch retaining circlip from the barrel unit and withdraw the driving sleeve and clutch unit.

(v) The clutch assembly can now be dismantled by removing all the parts from the driving sleeve with the exception of the two pressure plates which are held in position by the ring. To remove the ring nut, slide the driving sleeve on to the splined armature shaft and, using soft metal jaw plates, clamp the armature in a vice. File away the peened rim and use a spanner measuring $1\frac{5}{16}$" (33.3 mm.) across the flats to remove the ring nut. When re-assembling, fit a new ring nut and peen the rim over the notch in the driving sleeve to lock the nut in position.

(vi) To remove the pinion from the helically splined sleeve, knock out the rivet which secures the pinion retaining ring. The retaining ring, pinion, cushion spring with cup washers and the sleeve can now be separated.

(c) Re-assembly

Reverse the dismantling procedure above noting the following important points:—

(i) The correct cushion spring tension is 11 lbs. (4.99 kg.) measured with the spring compressed to $\frac{7}{8}$" (22.2 mm.) in length and 16 lbs. (7.26 kg.) with the spring compressed to $\frac{1}{2}$" (12.7 mm.) in length.

(ii) Check the slipping torque of the clutch as follows:—

Fit the drive assembly on the splined armature shaft and clamp the armature between soft metal jaw plates in a vice. Apply an anti-clockwise torque to the pinion with a suitable 'torque wrench' fastened to the pinion teeth. The clutch should slip between 800-950 lbs. in. (902-1095 kg. cm.).

If the clutch slips at too low a torque figure dismantle again and add shims one at a time until the correct figure is obtained.

If the clutch does not slip between the torque limits given, again remove the circlip, dismantle and remove shims one at a time until the torque test gives correct figures.

The correct adjusting shims are:—

Part No.	Thickness
291374	0.006" (0.152 mm.)
291378	0.005" (0.127 mm.)
291379	0.004" (0.102 mm.)

(iii) The assembled clutch unit and lever mechanism must be capable of being pushed to the full extent of the set travel. The assembly must move along the armature shaft extension smoothly and freely, but without slackness.

(iv) Before fitting the drive assembly to the armature shaft lightly smear the shaft and pack the space between the indented bearings inside the pinion sleeve, with a bentonite based grease such as Ragosine 'Bentone'.

STARTER MOTOR

Model M.35 G. Part No. 25038

Fitted to Carburettor Engine Tractors.

1. GENERAL

The electric starter motor is a series-wound four pole, four-brush machine having an extended shaft which carries the inboard type engine engagement gear, or starter drive as it is more usually named. The diameter of the yoke is 3½".

2. ROUTINE MAINTENANCE

The only maintenance normally required by the starter motor is the occasional checking of brush-gear and commutator.

3. SERVICING

Servicing, Dismantling and Replacement of Brushes and Field coils. See page G.15. See also tests under "Switches" Page G.32.

4. STARTER DRIVE ASSEMBLY

"Eclipse" Pattern

(a) General Operation

The pinion is carried on a barrel type assembly which is mounted on a screwed sleeve. This sleeve is carried on a centre sleeve and is secured to the armature shaft by means of a peg and a key. The barrel assembly is arranged so that it can move along the shaft against a compression spring to reduce the shock loading at the moment engagement takes place.

When the starter switch is operated the armature shaft and screwed sleeve rotate. Owing to the inertia of the barrel assembly, the latter is caused to move along the sleeve until the pinion comes into engagement with the flywheel ring. The starter will then turn the engine.

As soon as the engine fires and commences to run under its own power the flywheel will be driven faster by the engine than the starter. This will cause the barrel assembly to be screwed back along the sleeve, so drawing the pinion out of mesh with the flywheel teeth. In this manner the drive safeguards the starter against damage due to being driven at high speeds.

A pinion restraining spring is incorporated in the drive, this spring prevents the pinion vibrating into mesh when the engine is running.

(b) Routine Maintenance

If any difficulty is experienced with the starter motor not meshing correctly with the flywheel, it

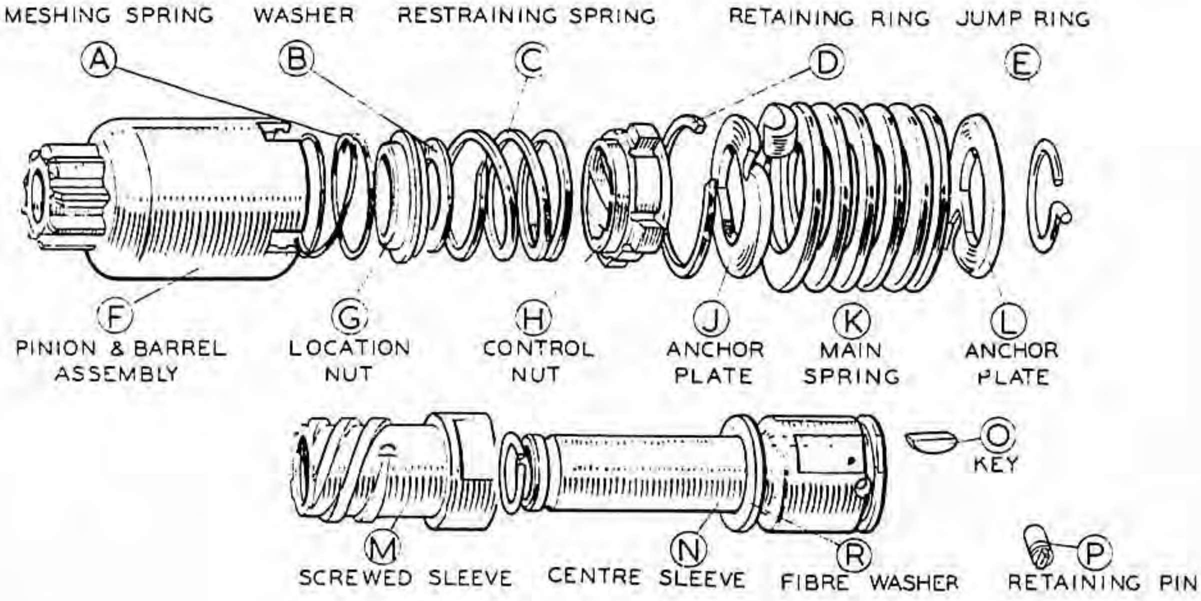


FIG. 16
ECLIPSE PATTERN STARTER DRIVE DISMANTLED

may be that the drive requires cleaning. The barrel assembly should move freely on the screwed sleeve; if there is any dirt or other foreign matter on the sleeve wash it off with paraffin.

In the event of the pinion becoming jammed in mesh with the flywheel, it can usually be freed by turning the starter motor armature by means of a spanner applied to the shaft extension at the commutator end. This is accessible by removing the cap which is either a push fit or is secured by two screws.

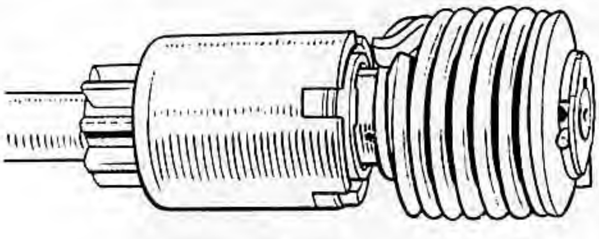


FIG. 17
ECLIPSE PATTERN STARTER DRIVE

(c) Dismantling and Re-assembly

Having removed the armature as described in the section dealing with starter motors, the drive can be removed from the armature as follows:—

(i) Dismantling

Press in the anchor plate (L) and main spring (K) and pull out the retaining pin (P) and then slide the drive back along the shaft and remove the key (O). Withdraw the drive unit from the shaft.

Remove the retaining ring (D) from inside the end of the pinion and barrel assembly (F) and meshing spring (A). Unscrew the location nut (G). This nut is held in position on the centre sleeve (N) by caulking. When re-assembling therefore, it will be necessary to fit a new sleeve.

Remove the washer (B), restraining spring (C), control nut (H) and withdraw the screwed sleeve (M).

Remove the anchor plate (J), main spring (K) and fibre washer (R). The other anchor plate (L) can be removed from the centre sleeve assembly (N) by withdrawing the jump ring (E).

(ii) Re-assembly

Re-assemble the drive and fit to the starter shaft by reversing the above procedure. Take care to caulk the centre sleeve to the location nut.

DISTRIBUTOR

Model D3 A4

Part No. 40243, Petrol & V.O. Engines. Part No. 40229, L.O. Engine.

Fitted to Carburettor Engine Tractors

1. GENERAL

The coil ignition equipment comprises a high tension induction coil, and a combined distributor, contact breaker and automatic timing control assembly driven at half engine speed via the camshaft. Current flowing through the primary or low tension winding of the coil sets up a strong magnetic field about it. This current is periodically interrupted by a cam-operated contact breaker, driven from the engine and subsequent collapse of the magnetic field across the secondary winding of the coil induces a high voltage in it. At the same time a distributor arm in the distributor connects the secondary winding of the coil with one of a number of metal electrodes, from which cables lead to the sparking plugs in the engine cylinders. Thus, a spark is arranged to occur in the cylinder under compression at the exact moment required to produce combustion of the mixture.

Mounted on the distributor driving shaft, immediately beneath the contact breaker, is an automatic timing control mechanism. It consists of a pair of spring-loaded governor weights, linked by lever action to the contact breaker. At low engine speeds, the spring force maintains the contact breaker cam in a position in which the spark is slightly retarded. Under the centrifugal force imparted by high speeds, the governor weights swing out, against the spring pressure to advance the cam and thereby the spark, to suit engine conditions at the greater speed.

Fitted over the cam spindle is a dust-excluding plate. In its central hole is a felt sealing ring, providing a moisture and dust-proof enclosure for the contact breaker mechanism and automatic control.

2. ROUTINE MAINTENANCE

In general, lubrication and cleaning constitute normal maintenance procedure.

(a) Checking Contact Breaker— After first 25 hours

The contact breaker gap should measure 0.014" -0.016" when fully opened. Access to the contact breaker is gained by springing back the two side clips and lifting off the moulded cover.

To check the setting, turn the engine slowly by hand until a position of maximum opening is reached and then insert a feeler gauge between the contacts. Due to the initial bedding-in of a new contact set, the gap may need resetting.

To do this, slacken two screws which secure the fixed contact plate. Reposition the plate—which has two slotted holes and rotates about the contact breaker lever pivot post—until the gauge can be inserted as a sliding fit between the contacts. Re-tighten the two screws.

After adjustment, it is advisable to re-check the gap to ensure that no movement has taken place whilst tightening the screws. Refit the moulded cover.

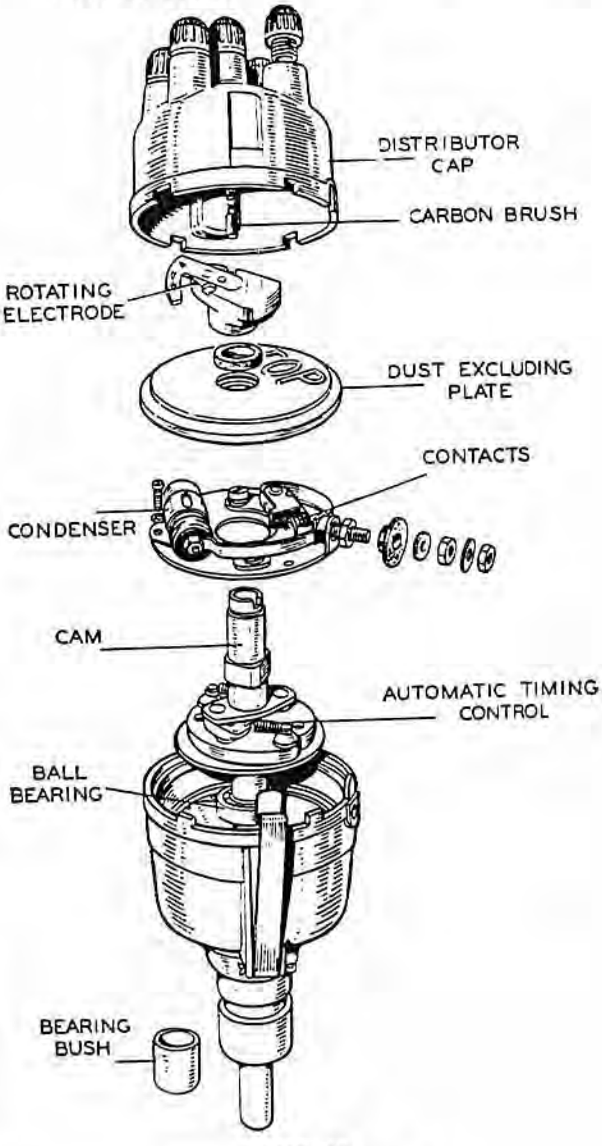


FIG. 18
DISTRIBUTOR DISMANTLED

(b) **Lubrication—Every 120 hours' running**

Take great care to prevent oil or grease from getting on or near the contacts.

Lift off the distributor arm by pulling vertically and apply to the spindle a few drops of thin engine oil to lubricate the cam bearing. It is not necessary to remove the exposed screw, since it is either drilled or affords a clearance to permit passage of oil.

Lift off the dust-excluding plate. Lightly smear the cam with a small quantity of Mobilgrease No 2, or clean engine oil, and apply a drop of oil to the top of the pivot on which the contact breaker lever works.

A few drops of thin engine oil should be applied, through the hole in the contact breaker base through which the cam passes, to lubricate the automatic timing control mechanism. Replace the dust-excluding plate.

Replace the distributor rotor arm carefully, locating its moulded projection in the keyway in the spindle and pushing it on as far as it will go, in order to avoid the risk of the moulded cap being burned or tracked.

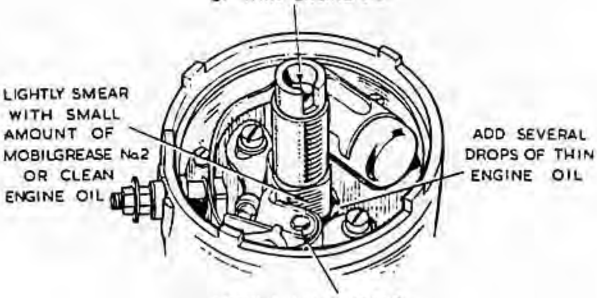


FIG. 19
DISTRIBUTOR LUBRICATION

(c) **Cleaning—Every 200 hours' running**

Thoroughly clean the moulded distributor cap inside and out, with a soft dry cloth, paying particular attention to the spaces between the metal electrodes. Ensure that the small carbon brush moves freely in its holder.

Examine the contact breaker. The contacts must be quite free from grease or oil. If they are burned or blackened, clean them with a very fine carborundum stone or emery cloth then wipe clean with a petrol-moistened cloth.

Cleaning is facilitated by removing the contact breaker lever. This can be done by slackening the nuts on the terminal post and lifting off the spring, which is slotted for this purpose. It is necessary to remove the two outer nuts on the terminal post, together with the spring washer, plain washer and rubber grommet; a 2 B.A. box spanner can then be used to slacken the third securing nut and the spring lifted off.

After cleaning, check the contact breaker setting.

3. SERVICING

Before starting to test, make sure that the battery is not fully discharged, as this will often produce the same symptoms as a fault in the ignition circuit.

(a) **Testing in Position to Locate Cause of Uneven Firing**

Run the engine at a fairly fast idling speed. Short circuit each plug in turn with the blade of an insulated screwdriver, placed across the terminal to contact the cylinder head. Short circuiting the defective plug will cause no noticeable change in the running note. On the others, however, there will be a pronounced increase in roughness. Having thus located the defective cylinder, stop the engine and remove the cable from the sparking plug terminal.

Restart the engine and hold the cable end about $\frac{3}{16}$" from the cylinder head. If sparking is strong and regular, the fault lies with the sparking plug, and it should be removed, cleaned and adjusted or a replacement fitted.

If, however, there is no spark, or only weak, irregular sparking, examine the cable from the plug to the distributor for deterioration of the insulation, renewing the cable if the rubber is cracked or perished.

Check the distributor rotor arm for free movement of the spring governor.

Clean and examine the distributor moulded cap for free movement of the carbon brush. If tracking has occurred, indicated by a thin black line, usually between two or more electrodes, fit a replacement distributor cap.

(b) **Testing in Position to Locate Cause of Ignition Failure**

Spring back the clips on the distributor head, remove the moulded cap and lift off the rotor. Remove the dust-excluding plate. Check the contacts for cleanliness and correct gap setting.

To check ignition circuit proceed as follows:

(i) Connect voltmeter between SW terminal on ignition coil and earth. Turn ignition switch "ON", voltmeter should read 12 volts. Zero volts indicates broken wire between switch and coil or faulty switch.

(ii) Connect voltmeter between CB terminal on coil and earth. Turn engine until contact heel is on tip of cam lobe and contacts are open.

Voltmeter should then read 12 volts.

No reading with contacts open indicates:

(a) Earthed wire coil to distributor.

(b) Broken primary winding in coil. This can be checked by removing wire from CB terminal of coil.

(c) Condenser shorting. Check by disconnecting condenser.

(iii) Leave voltmeter as test (ii) and turn engine until contacts close. Voltmeter reading should then fall to zero.

Full reading with contacts closed indicates:

(a) Broken wire between CB terminal on coil and CB terminal on contact breaker.

(b) Break in short flexible lead between CB terminal and contact set.

(c) Contacts dirty and not making, due to moving contact being tight on its pivot.

(c) High Tension Circuit

If, after carrying out these tests, the fault has not been located, remove the high tension lead from the centre terminal of the distributor. Switch on the ignition and turn the engine until the contacts close. Flick open the contact breaker lever while the high tension lead from the coil is held about $\frac{3}{16}$" from the cylinder block. If the ignition equipment is in good order, a strong spark will be obtained. If no spark occurs, a fault in the secondary winding of the coil is indicated and the coil must be replaced.

The high tension cable must be carefully examined, and replaced if the rubber insulation is cracked or perished, using 7 mm. (p.v.c. or neoprene-covered) rubber insulated ignition cable. To fit a new cable to the ignition coil of distributor, pass the cable through the knurled moulded nut, bare about $\frac{1}{4}$" of the end of the cable, thread the wire through the brass washer (removed from the original cable) and bend back the strands. Finally screw the nut into its terminal.

The cables from the distributor to the sparking plugs must, of course, be connected in the correct firing order.

(d) Contact Breaker Mechanism

Check and adjust as described on Page G.23.

Ensure that the moving arm moves freely on its pivot, If sluggish, remove the arm and polish the pivot pin with a strip of fine emery cloth. Replace the arm and lubricate with a spot of clean engine oil.

(e) Dismantling

Before dismantling, carefully note the positions in which the various components are fitted, in order to ensure their correct replacement on re-assembly. The driving member is offset, note the relation between it and the rotating electrode, maintain this relation when re-assembling the distributor.

Spring back the securing clips and remove the moulded cap.

Lift the distributor rotor arm off the top of the spindle.

Remove the dust-excluding plate, together with the felt seal. The contact breaker base can be lifted out, together with the lever, contacts, etc., by proceeding as follows:—

(i) Remove the washer and two nuts on the low tension terminal.

(ii) Remove the insulating grommet.

(iii) Slacken and remove the three securing screws, at the edge of the plate, and lift out the complete contact breaker assembly.

(iv) Slacken the remaining nut on the low tension terminal, and lift off the contact breaker lever, its insulating washer and the condenser. Slacken the two screws, with spring and plain washers, securing the fixed contact plate, and remove the plate.

Remove the dog from the shaft.

Remove the cam, automatic timing control and shaft assembly from the distributor. Take out the screw from inside the top of the cam spindle. Lift off the cam, affording access to the automatic timing control.

(f) Bearing Replacement

(i) Bearing Bush

Remove the bearing bush at the lower end of the shank by using a hand press and mandrel of suitable diameter.

Invert the distributor body and press the new bearing bush into the lower end of the distributor shank, using a shouldered mandrel in the hand press, the mandrel being of the same diameter as the distributor shaft. Fig. 20.

Before the new bush is fitted it must be completely immersed in thin engine oil for 24 hours. On occasions of urgency, this period can be shortened by heating the oil to 100°C. for 2 hours and then allowing the oil to cool before removing the bush.

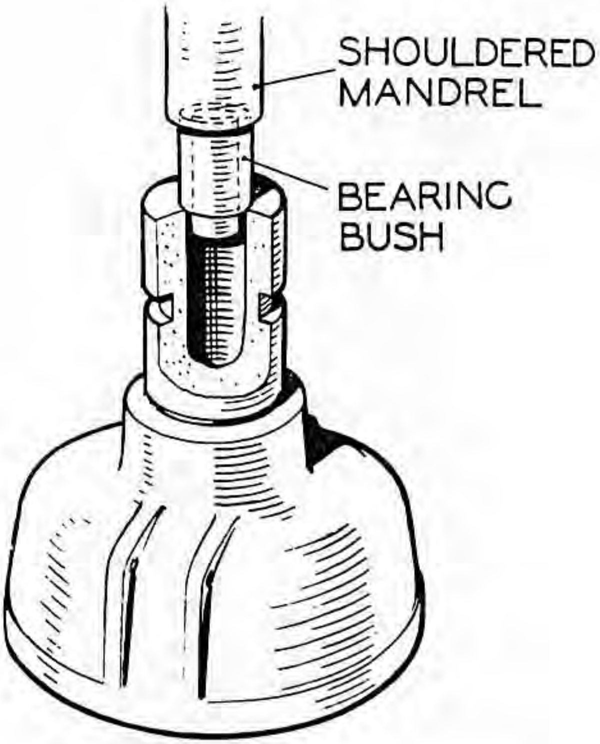


FIG. 20
FITTING REPLACEMENT BEARING BUSH

(ii) **Ball Bearing**

The ball bearing fitted to the distributor shaft can now be removed by means of an extractor. The ball bearing can be fitted by means of a sleeve which locates over the distributor shaft and bears on the inner journal of the bearing.

(g) **Re-assembly**

Before re-assembly, the automatic advance mechanism, distributor shaft and the cam spindle must be lubricated with thin engine oil. Pack the new bearing on the distributor shaft with high melting point grease. Assemble the automatic timing control, taking care that the parts are fitted in their original positions and the control springs not stretched. Two holes are provided in each toggle: the springs must be fitted to the inner hole in each case. Place the cam on the spindle and locate the two pegs on the cam foot in the holes in the toggle levers. Secure the cam by replacing the fixing screw and tightening.

Fit the shaft in its bearings and replace the driving member.

To fit a New Shaft

A shaft and action plate must be free to rotate without excessive end-play. To obviate binding on the one hand and excessive end-play on the other, a 0.002" gauge should be inserted before drilling as a temporary spacer between the dog or collar and the fibre thrust washer. Whilst drilling, the shaft and action plate must be pushed down from the cam end and the dog collar to be hard against the thrust washer and 0.002" spacer. After drilling remove the spacer. The maximum permissible end-play is 0.006".

Re-assemble the contact breaker by reversing the dismantling procedure described above. Adjust the contact breaker gap to within 0.014" to 0.016" when the contacts are fully opened. Replace the dust-excluding plate, carefully locating the felt seal.

Note.—If it is necessary to renew the contacts, a set comprising both fixed and moving contacts must be fitted.

Place the distributor rotor arm on the spindle, locating the register correctly and pushing the rotor fully home.

Fit the distributor cover moulding and secure by means of the spring clips.

IGNITION COIL

Model LA. 12. Part No. 45053.

Fitted to Carburettor Engine Tractors

1. GENERAL

An ignition coil includes primary and secondary windings wound concentrically about a laminated soft iron core—the secondary winding being next to the core. Each layer is paper-insulated from the next in both primary and secondary windings.

One end of each winding is connected to terminal "CB", (marked —), on the terminal moulding. The other ends of the primary and secondary windings are connected to the "SW", (marked +), and high tension terminals respectively. This method of connection, together with a common winding direction for both primary and secondary windings, constitutes a step-up auto-transformer.

The tractor electrical installation has a positive earth system and the ignition coil is wound to give negative polarity at the high tension terminal, and hence to produce a negative spark at the sparking plug. This arrangement increases plug life.

To provide a return path for the magnetic flux, the core and windings are placed within a soft iron sheath, and the complete assembly is housed in a sealed container. The coil is supported in an insulating fluid which impregnates the winding.

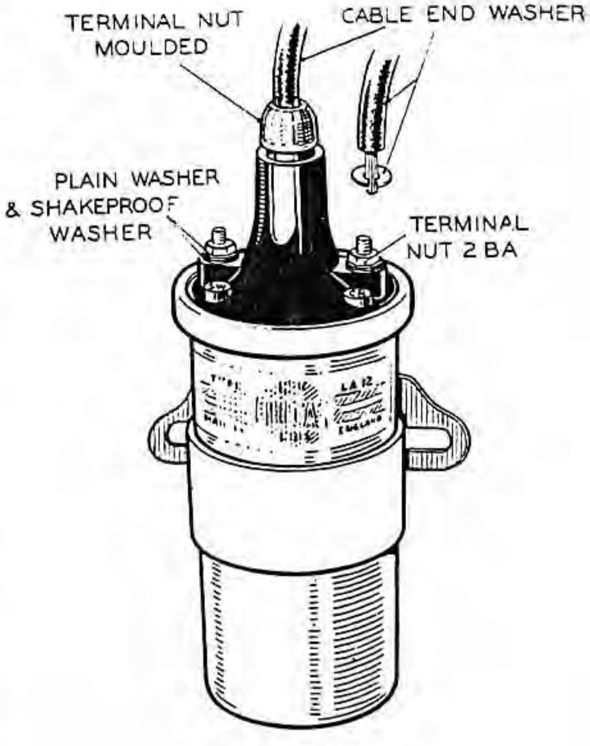


FIG. 21
IGNITION COIL

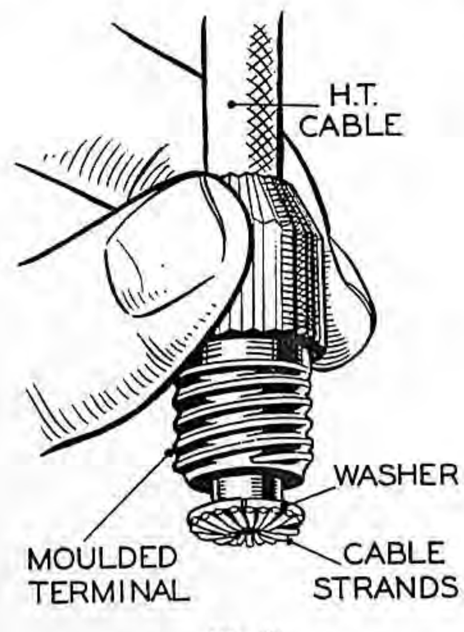


FIG. 22
FITTING NEW H.T. CABLE

2. MAINTENANCE

Occasionally, check the terminals for tightness and inspect the high tension cable for signs of wear. To fit a new high tension cable, thread the knurled terminal nut over the end of the cable and bare the end of the wire for $\frac{1}{4}''$. Thread the wire through a brass washer and bend back the strands. Finally, screw the nut into the terminal moulding.

It is essential that the exterior of the coil is kept clean and dry. If a coil develops a "tracked" moulding, and no replacement is available the following repair may temporarily suffice:

Scrape the terminal mouldings where "tracking" has occurred and remove all carbon deposit. Paint with "anti-track" varnish or, if this is not available use a good quality water-resistant varnish. Keep the varnish well stirred both before and during use.

Never attempt to remove the screw located inside the high tension terminal socket or coil.

CONTROL BOX

Model RB 108. Part 37228.

1. GENERAL

In model RB.108 control box, the regulator and cut-out contacts are positioned, for ease of access, above their respective armatures. It will be noticed that some of the internal electrical joints are resistance brazed.

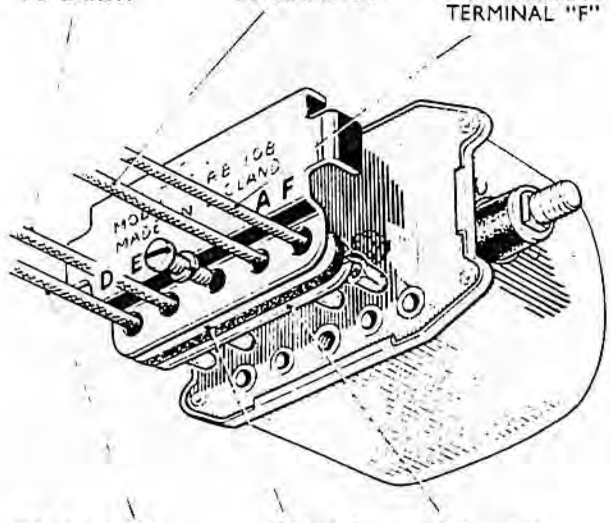


FIG. 23
CONTROL BOX TERMINALS

2. SERVICING

Before making any adjustment to the regulator, ensure that the dynamo, dynamo drive and battery are in order.

If the machine is used regularly and a sound battery does not keep in a charged condition, or if the dynamo output does not fall when the battery is fully charged, the following procedure should be adopted:—

(a) Checking the Wiring between Battery and Control Box

Remove the control box from its mountings and withdraw the cable from terminal 'A' and connect it to the negative terminal of a voltmeter.

Connect the positive terminal of the voltmeter to an earthing point on the machine.

If a voltmeter reading is given, the circuit from the battery to terminal 'A' is in order.

If there is no voltmeter reading, examine the wiring between the battery and the control box for defective cables or loose connections.

Re-connect the cable to terminal "A".

Check that the dynamo terminal "D" is connected to control box terminal "D" and that the cable is in good condition. Similarly, check the cable between terminals "F" at the dynamo and control box.

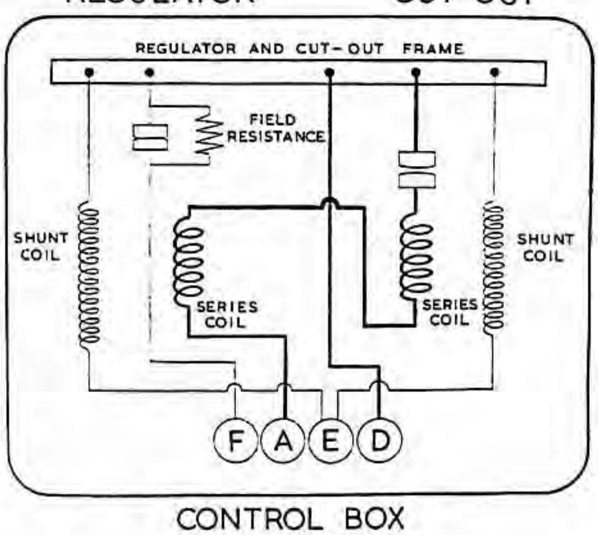


FIG. 24
RB 108 CONTROL BOX WIRING DIAGRAM

(b) Regulator Adjustment

(i) Checking the electrical setting

The regulator is carefully set during manufacture and, in general, it should not be necessary to make further adjustment If, however, the charging system is suspected it is important that only a good quality MOVING COIL VOLTMETER (0-20 volts) is used to check the system. The electrical setting of the regulator can be checked without removing the cover from the control box.

Correct voltmeter to terminal "D" (large terminal) and a good earth at dynamo.

Start engine and remove the negative terminal from the battery. Run a temporary connection from the negative terminal of the battery to the "SW" (+) terminal of the ignition coil and put ignition switch in **OFF** position.

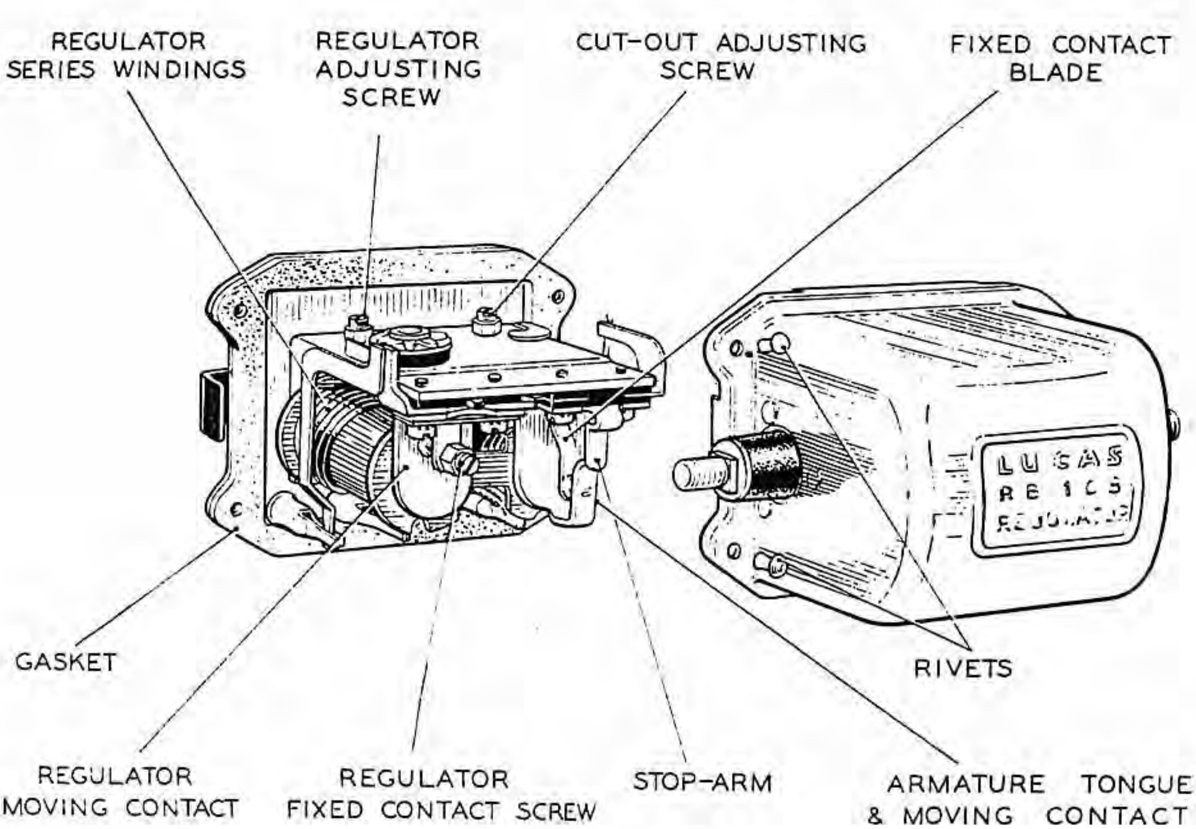


FIG. 25
RB 108 CONTROL BOX

Slowly increase the speed of the engine until dynamo is at approximately 3,000 R.P.M.

Note the reading and stop the engine.

If the voltage lies outside the limits given on Page G.3, the regulator setting must be adjusted.

If the voltage is within the limits, examine the cut-out.

(ii) **Adjusting the electrical setting**

Adjustments of the regulator require removal of the control box cover.

It is important that regulator adjustments are carried out with the control box supported in a similar position to that on the tractor.

Restart the engine.

Slacken the locknut of the regulator adjusting screw (see Fig. 25) and turn the screw, in a clockwise direction to raise the setting, or an anti-clockwise direction to lower the setting. Turn the screw only a fraction of a turn at a time and then tighten the locknut. Again run up the engine and repeat as above until the correct setting is obtained.

Adjustment of regulator open-circuit voltage should be completed within 30 seconds, otherwise heating of the shunt winding will cause false settings to be made.

Stop the engine.

Remake the original connections and replace the cover. Ensure that the cover seats correctly on the sealing washer.

(iii) **Adjusting the mechanical setting**

The mechanical or air-gap settings of the regulator, (see Fig. 25) are accurately adjusted before leaving the works and, provided that the armature carrying the moving contact is not removed, these settings should not be tampered with. If, however, the armature has been removed the regulator will have to be reset. To do this, proceed as follows:—

Slacken the locking nut on the voltage adjusting screw and unscrew the adjuster until it is well clear of the armature tension spring.

Slacken the two armature assembly securing screws.

Using a 0.015" (.38 mm.) feeler gauge, wide enough to cover completely the core face, insert the gauge between the armature and core shim, taking care not to turn up or damage the edge of the shim.

Press the armature SQUARELY down against the gauge and retighten the two armature assembly securing screws.

With the gauge still in position, screw the adjustable contact down until it just touches the armature contacts.

Retighten the locking nut.

Reset the voltage adjusting screw.

(iv) **Cleaning contacts**

After long periods of service it may be found necessary to clean the regulator contacts.

Clean the contacts using a fine carborundum stone or fine emery cloth.

Carefully wipe away all traces of dust or other foreign matter using a petrol-moistened cloth.

(c) CUT-OUT ADJUSTMENT

(i) **Checking the electrical setting**

If the regulator is correctly set but the battery is still not being charged, the cut-out may be out of adjustment.

Replace the control box in the testing position, remake the temporary connection and remove the control box cover.

Connect a voltmeter between terminals "D" and "E" at a dynamo.

Start the engine and slowly increase the speed until the cut-out contacts close. Note the voltage at which this occurs and stop the engine.

This should be 12.7-13.3 volts. If operation of the cut-out takes place outside these limits, it will be necessary to adjust.

(ii) **Adjusting the electrical setting**

Restart the engine.

Slacken the locknut securing the cut-out adjusting screw and turn the adjusting screw in a clockwise direction to raise the voltage setting or in an anti-clockwise direction to reduce the setting.

Turn the screw only a fraction of a turn at a time and then tighten the locknut. Test after each adjustment by increasing the engine speed and noting the voltmeter reading at the instant of contact closure.

Stop the engine.

Electrical setting of the cut-out, like the regulator, must be made as quickly as possible because of temperature-rise effects.

Note.—If the cut-out does not operate, there may be an open circuit in the wiring of the cut-out and regulator unit, in which case the unit should be removed for examination or replacement.

(iii) **Adjusting the mechanical setting**

If for any reason the cut-out armature has to be removed from the frame, care must be taken to obtain the correct air-gap settings on re-assembly. These can be obtained as follows:—

Slacken the adjusting screw locking nut and unscrew the cut-out adjusting screw until it is well clear of the tension spring.

Slacken the two armature securing screws.

Press the armature SQUARELY down against the copper-sprayed core face and retighten the armature securing screws.

Using a pair of suitable pliers, adjust the gap between the armature stop arm and the armature tongue by bending the stop-arm. The gap must be 0.030" (.76 mm.) when the armature is pressed squarely down against the core face.

Similarly, the fixed contact blade must be bent so that when the armature is pressed SQUARELY down against the core face there is a "follow-through", or blade deflection, of 0.010" (.25 mm.). To prevent contact chatter, the MAXIMUM "follow-through", or blade deflection must not exceed 0.020".

The contact gap, when the armature is in the free position, must be 0.010"-0.020", (.25-.51 mm.).

Reset the cut-out adjusting screw.

(iv) **Cleaning contacts**

If the cut-out contacts appear rough or burnt, place a strip of fine glass paper between the contacts—then, with the contacts closed by hand, draw the paper through. This should be done two or three times with the rough side towards each contact.

Wipe away all dust or other foreign matter, using a petrol-moistened cloth. Do not use emery cloth or a carborundum stone for cleaning cut-out contacts.

SPARK PLUGS

Champion Type

Fitted to Carburettor Engine Tractors

General

Spark plugs and their gaskets should be removed periodically for inspection and service. If the gaskets are found to have flattened excessively owing to long service or because the plugs have been pulled down too tight, they should be replaced. Wash the plugs in petrol and leave them to dry.

Clean the insulators and electrodes with a wire brush or, preferably, use one of the proprietary spark plug service units.

Remove all traces of grit or carbon from the plug threads. Examine the insulators for cracks, and the electrodes for signs of excessive burning; if damage of this nature is present, the plug should be replaced.

If it is decided that the plugs are worthy of further use, it is recommended that the gap should be dressed, on both centre and side electrodes, with a smooth file.

When resetting gap, bend the side wire only, never bend the centre electrode as this may split the insulator tip. Provided the gap has been set correctly a plug can be considered fit for further use if the spark is continuous up to 100 lbs. per square inch (7.03 kilos per sq. cm.) and there is no gas leakage at the terminal. For plug gaps, see Specification and Test Data.

When installing plugs, screw down by hand as far as possible, then use spanner for tightening only. Always use a box spanner to avoid possible fracture of the insulator. Plugs should not be screwed down too tightly on to their gaskets—just sufficiently so that a good seal can be reasonably expected.

Damage to the top half of the insulator is often responsible for poor plug performance. Inspect for paint splashes, accumulation of grime and dust, cracked insulators, especially at shoulders or terminal posts, caused by a slipping spanner or overtightening of terminal.

SWITCHES AND WIRING

Combined Ignition and Starter Switch

Model S 60. Part No. 31573A.

Fitted to Carburettor Engine Tractors

A combined ignition and starter switch is mounted on the instrument panel. The first position of the switch turns on the ignition, the second position operates the starter solenoid switch, provided that the dual range selector lever is in the 'S' position, to close the Neutral Safety Switch.

Solenoid Switch. ST 950. Part No. 76443A.

Fitted to Carburettor Engine Tractors

This switch is solenoid operated, the solenoid being energised when the combined ignition and starter switch is turned to the "Start" position; this closes the heavy duty contacts inside the unit. This completes the supply circuit from the battery to the starter motor.

To Test Switches (Wiring Diagram A refers)
If it appears that faulty operation of the starter motor is due to some cause outside the motor itself the operating switches and wiring may be checked as follows:—

(i) Connect a voltmeter with one lead to terminal (3) of the combined ignition and starter switch and the other lead to earth.

Voltmeter should read 12 volts. A lower or zero reading indicates faulty battery or faulty connections from battery to switch. If reading is 12 volts, proceed to (ii).

(ii) Connect the voltmeter between terminal (1) of the switch and earth. Turn the switch to the "Start" position.

Voltmeter should read 12 volts. Zero reading indicates faulty switch which must be replaced as a complete unit.

If reading is 12 volts, proceed to (iii).

(iii) Connect the voltmeter to the small terminal of the starter solenoid switch which is mounted just below the battery box. Turn combined ignition and starter switch to "Start" position. Voltmeter should read 12 volts. Zero reading indicates broken wire between combined ignition and starter switch and solenoid switch.

(iv) Connect the voltmeter from the large terminal on the solenoid switch marked "BAT" to earth.

Voltmeter should read 12 volts.

(v) Connect voltmeter, one lead to each of the large terminals on the solenoid switch. Voltmeter will then read 12 volts.

Turn combined ignition and starter switch to "Start" position.

Voltmeter reading should then fall to ZERO.

Note.—A maximum reading of .25 volts is permissible while the starter motor is cranking. Any reading above .25 volts indicates faulty solenoid switch which must be changed as a complete unit.

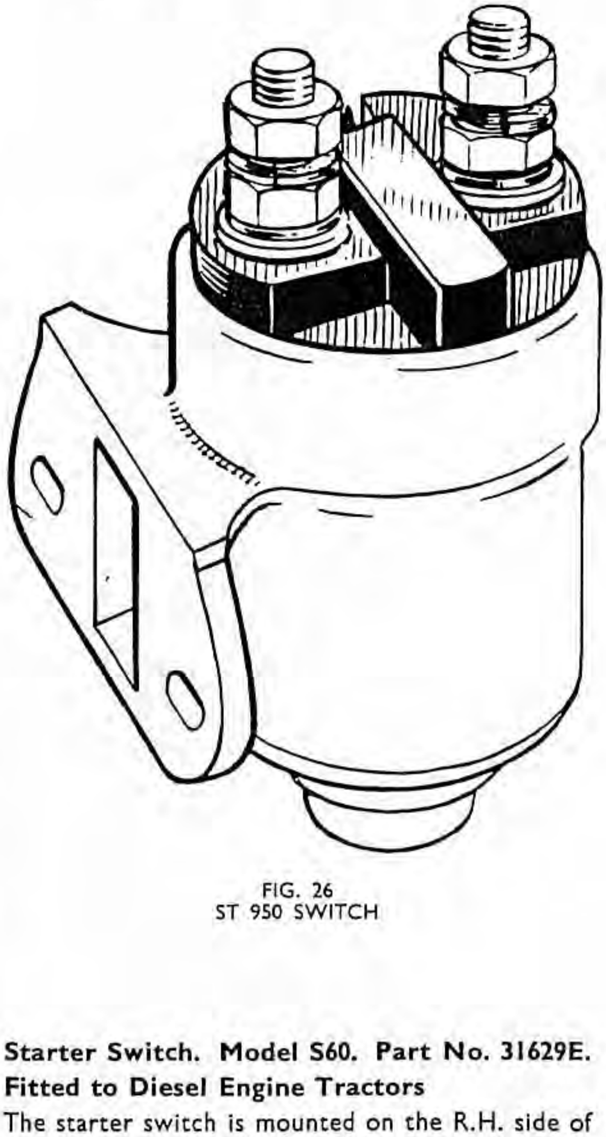


FIG. 26
ST 950 SWITCH

Starter Switch. Model S60. Part No. 31629E.

Fitted to Diesel Engine Tractors

The starter switch is mounted on the R.H. side of the instrument panel. It will operate only when the Dual Range Selector Lever is in the "S" position to close the neutral safety switch.

The first position clockwise operates starter for normal starting, first and second positions anti-clockwise operate the "Thermostart" easy starting aid and the starter motor respectively.

Thermostart. C.A.V. Type.
Fitted to Diesel Engine Tractors

The "Thermostart" consists of a combined heating and vaporising coil mounted in the inlet manifold. At the first movement anti-clockwise of the starter switch fuel flows from the reservoir tank, mounted at the rear of the main fuel tank, through the heater, wherein it is vaporised and then ignited by the heater coil. A further movement anti-clockwise of the starter switch operates the starter and the ignited fuel is drawn into the engine. For Service Instructions refer to Diesel Fuel System.

Neutral Safety Switch
Model SS10. Part No. 31601A.

The plunger type neutral safety switch is mounted on the transmission case in a position such that the plunger is compressed by the planetary shifter rail when the dual range selector lever is in the neutral or "Start" position. This closes the starter motor circuit. When the dual range selector lever is in either high or low range the switch plunger is not compressed as it protrudes either into the space beyond the end of the shifter rail (high range) or into a recess cut into the shifter rail (low range). It is therefore impossible inadvertently to start the engine with the tractor in gear.

Wiring

The wiring on the tractor is comparatively simple, but must be maintained in good condition to prevent hard starting and electrical difficulties. The battery cables are designed to carry a heavy amperage. However, if the terminal contacts are not kept clean and tight, the current carrying capacity is greatly reduced and starting trouble results. It is essential to maintain good earth connections for battery, starter and dynamo.

The high tension wiring system is of 7 mm. diameter wire with a high resistance insulating covering. If this insulation becomes cracked or broken, a current leak may occur, with the result that no spark or a reduced spark reaches the sparking plug.

The low voltage wiring system should be inspected regularly and all connections kept clean and secure. Locations where chafing has worn the covering should be repaired before a short circuit occurs. Advantage should be taken of the replacement wiring harness assembly which is made available as a service part.

COLD CLIMATE EQUIPMENT

HEATER PLUGS

(Fitted to 23C Diesel Engine)

GENERAL (Fig. 27 refers)

The 23C Diesel engine embodying Heater Plugs, is fitted to FE-35 Tractors destined for use in areas where conditions of extreme cold prevail. These plugs are fitted into, and preheat, the combustion chambers, so igniting the injected fuel during the starting sequence.

Incorporated into the tractor's electrical circuit are two 21 thin-plate batteries (which utilise the 19 plate case), a heavy duty heater/starter switch and heavy duty cables from the rear battery to the front and from the front battery to the starter motor, to accommodate the higher current required by the Heater Plug circuit.

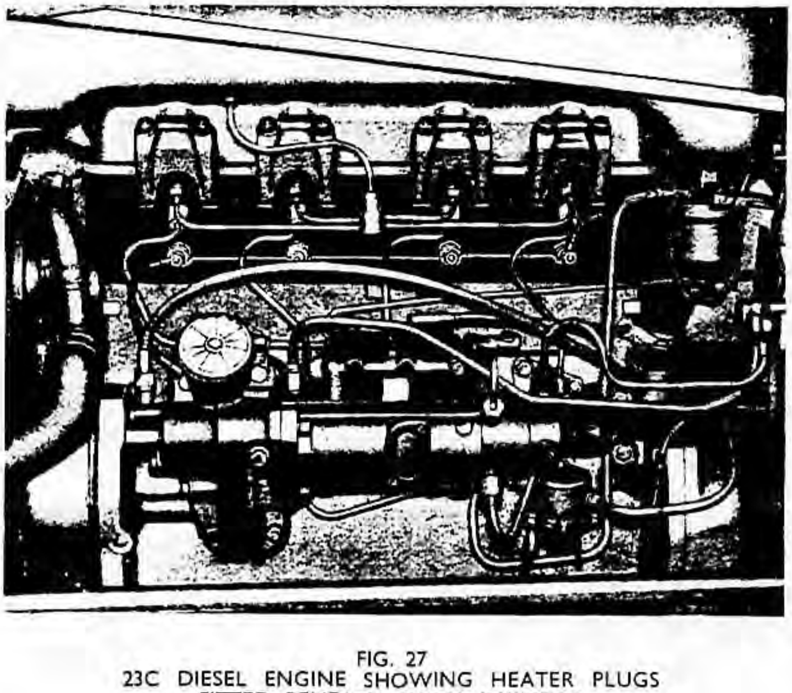


FIG. 27
23C DIESEL ENGINE SHOWING HEATER PLUGS FITTED BENEATH EACH INJECTOR

SECOND ISSUE

CABLE COLOUR CODE	
B	BLACK
U	BLUE
N	BROWN
G	.GREEN
P	PURPLE
R	RED
S	SLATE
W	WHITE
Y	YELLOW

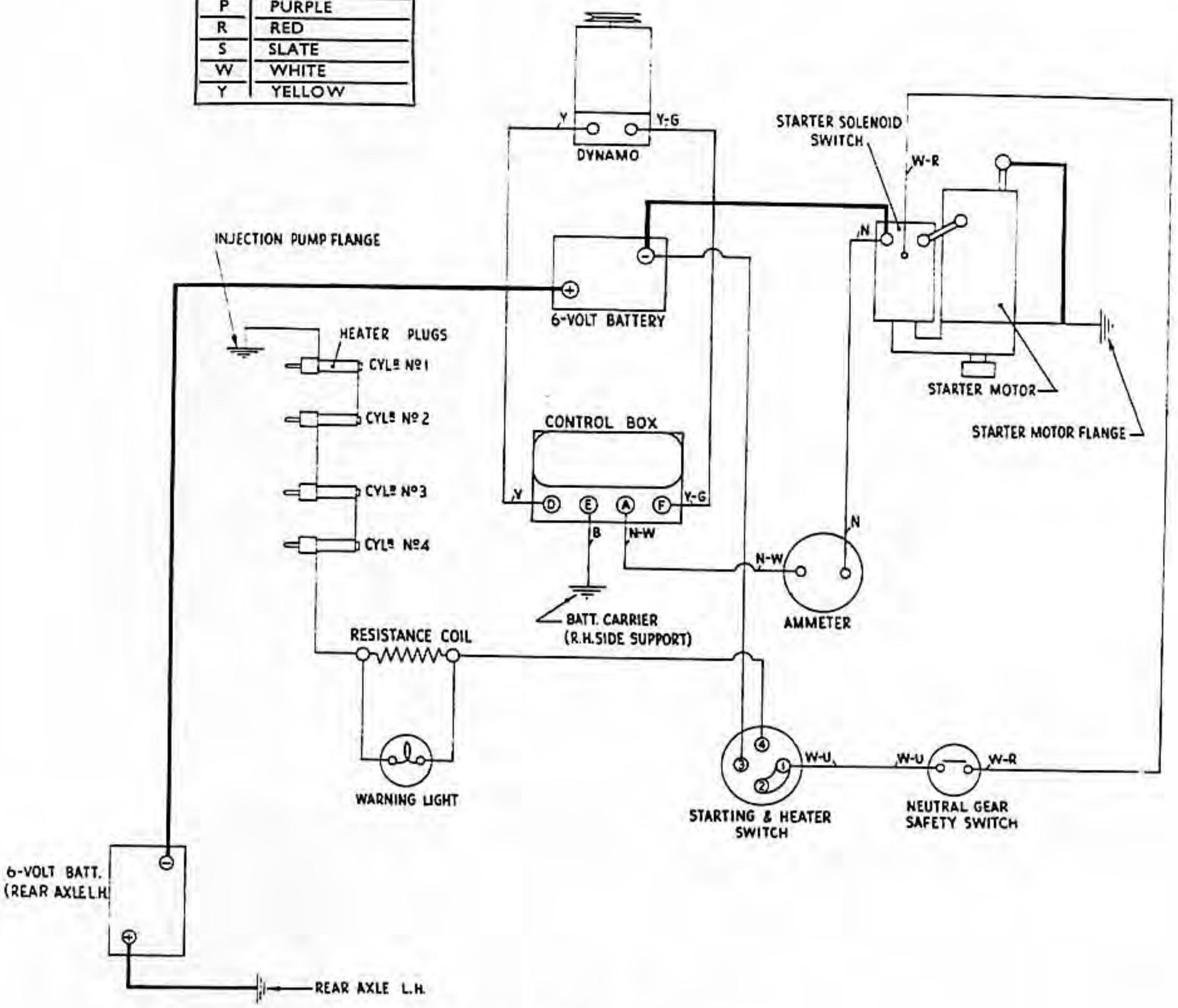


FIG. 28
HEATER PLUG WIRING DIAGRAM

A ballast resistance unit is connected in series with the Heater Plugs to prevent over-loading during the initial "Heating" period, and a Warning light assembly is fitted across this resistance to indicate when the plugs are switched on. The plugs are connected in series, and an earth lead is taken to the injection pump drive casing from No. 1 cylinder Heater Plug.

Tractors fitted with this alternative equipment have the Thermostart and Thermostart reservoir deleted; the manifold has a blanking plug in place of the Thermostart and the return pipe from the fuel filter is connected directly to the main tank.

FIRST ISSUE

DATA

Batteries

MHFK 128E Lucas No. 540283—76 (Dry)
MHFK 128E Lucas No. 540283—77 (Filled, Charged)
MHFK 128E Lucas No. 540283—78 (Dry, Charged)
(21 thin plates in 19 plate case)

One battery situated on the rear axle housing and one under the bonnet connected in series.

Battery Rating

6 Volt, 128 amp. hrs. at 10 hr. rate.
146 amp. hrs. at 20 hr. rate.

Heater Plugs

KLG. Z 161/3 ... ... (1.7V. 38 amps.)
Superseded by
Lodge D.T. 14 L-1.7V ... (1.7V. 38 amps.)
KLG. GF. 205.T ... ... (1.7V. 38 amps.)

Ballast Resistance Unit

Up to Tractor Serial No. 156502.
KLG. Z. 174/1 ... ... (3.7V. 36/40 amps.)
From Tractor Serial No. 156503.
KLG. BRQ. 1 ... ... (3.7V. 38/42 amps.)

Heater Plug Warning Light

Up to Tractor Serial No. 156502, a warning light assembly incorporating a 12V. bulb was fitted, but this was superseded at 156503 by a warning light assembly incorporating a 6V. bulb. The 6V. bulb can be used with either ballast resistance unit but the 12V. bulb can only be used with the earlier ballast resistance unit.

Heater Plug Torque Loadings

Lodge DT. 14. L-1.7V. ...
KLG. Z. 161/3 ... ...
KLG. GF. 205. T ... ...
} 15-17 lb. ft.

BATTERY SPECIFICATION

MODEL		MHFK 128 E		MHFK 128 E		MHFK 128 E	
Lucas No.		540283-76		540283-77		540283-78	
Type		Dry		Filled, Charged		Dry Charged	
Amp. Hr. Capacity	10 Hr. rate	128		128		128	
	20 Hr. rate	146		146		146	
Specific Gravity when filling cells initially		Below 90°F.	Above 90°F.	Below 90°F.	Above 90°F.	Below 90°F.	Above 90°F.
		1.270	1.210	—	—	1.270	1.210
Specific Gravity on completion of charge		Below 90°F.	Above 90°F.	Below 90°F.	Above 90°F.	Below 90°F.	Above 90°F.
		1.270 —1.290	1.210 —1.230	—	—	—	—
Maximum Temperature during Charge		Below 90°F.	Above 90°F.	Below 90°F.	Above 90°F.	Below 90°F.	Above 90°F.
		100°F.	120°F.				
Initial Charge Current		8.5 amperes		—		—	
Recharge Current		14 amperes		14 amperes		14 amperes	

FIRST ISSUE

OPERATION

Turning the starter switch key to the 'Heat' position, brings into operation the circuit from the batteries, through the switch, resistance coil and warning light, to the heater plugs and so to 'Earth' through the injection pump drive casing.

Turning the starter switch key to the 'Heat—Start' position operates the starter motor, as described on Pages G.14 and G.15, and, by cranking the engine, causes fuel to be injected into the combustion chambers, which have been pre-heated by the heater plugs.

ROUTINE MAINTENANCE

Batteries

The general instructions on Pages G.6, G.7 and G.8 under Section 2 and 3 apply but specific information on state of charge is as follows:—

The dry MHFK 128 E (540283-76) battery, when being commissioned, should be filled in two stages, as follows:—

1. Half fill and let stand for six hours.
2. Complete filling and let stand for further two hours.
3. Proceed with initial charge.

The dry charged MHFK 128 E (540283-78) battery can be filled in one operation and is capable of giving a starting discharge one hour after filling.

Specific gravity readings taken at varying electrolyte temperatures can be corrected to 60°F. by applying the following:—

For every 5°F. below 60°F. deduct .002 from actual reading.

For every 5°F. above 60°F. add .002 to actual reading.

Starter Motor

The description and maintenance of the starter motor are covered in Pages G.14-G.20.

Dynamo

The description and maintenance of the dynamo are covered in Pages G.10-G.13.

Control Box

The description and maintenance of the control box are covered in Pages G.28-G.31.

Wiring

The wiring must be kept in good condition to minimise current loss and prevent short-circuit faults developing.

All terminal and earth connections must be kept clean and bright. Maintain the correct tightness of *all* nuts.

Heater Plugs and Related Circuit

Should the warning light fail to light when the starter switch is turned to 'Heat' position, it may indicate that either the warning light is faulty, that one or more of the heater plugs are out of action, or that the earth is ineffective through being dirty or loose. Use continuity tester to locate fault.

When tightening the heater plug nuts, hold the nut under the connection with a spanner while tightening the upper nut, to minimise strain or distortion of the electrode.

Do *NOT* overtighten, as this may damage the internal plug connections or strip the thread.

480 Hour Service

This inspection can be most conveniently carried out when the injectors are serviced.

The Heater Plugs should be removed, inspected and renewed as required. The plugs should be renewed if the element shows signs of such corrosion that the wire is no longer of circular cross-section, as the resultant change in the electrical characteristics is likely to cause 'burn-out' if subjected to further use.

When removing or fitting plugs, every care must be taken to ensure that the element is not bent in the operation since it is accurately centralised during assembly. Should a bent element short through contact with the cylinder head, the failure of serviceable Heater Plugs may be caused.

Heater Plug Failure

Failure of a Heater Plug may be caused by either a short-circuit (this may be anywhere in the circuit), or a burn-out. Since the plugs are connected in series, failure of one plug will put the complete system out of action. Therefore, if the warning light does not indicate when the starter switch is turned to the 'Heat' position, proceed as follows:—

1. Check warning light assembly (by substitution).
2. Check for 'short-circuit' plug.

NOTE: For the following tests, a 12V. low wattage bulb test lamp and holder with two three foot leads (complete with probes and/or clips), will be required.

(i) Lift hood and connect lead to negative terminal of battery.

(ii) Disconnect No. 1 Heater Plug Earth lead from small terminal and check all plug connections for tightness.

(iii) Apply test probe to No. 4 plug. Lamp should *not* light.

(iv) A short-circuit is indicated if the lamp *does* light.

Remove connecting leads from all plugs and apply probe to each plug in turn. Lamp will light when connected to 'short-circuit' plug or plugs.

3. Check continuity of Heater Plug Circuit.

(i) With the plug circuit fully connected and the 'Earth' lead reconnected to small terminal of No. 1 plug, apply test lamp across negative terminal of battery and the small terminal of No. 4 plug.

Lamp should light.

If not, a broken element, or open-circuit on one or more plugs is indicated.

(ii) If only one plug is faulty, it can be located by the following method:—

With test lamp probe on No. 4 terminal, short out with screwdriver blade, the two terminals on each plug in turn. The test lamp should light when the terminals of faulty plug are shorted out.

(iii) If, however, more than one plug is at fault, it will be necessary to remove the connecting leads from all plugs. Then apply probe to small terminal of each plug and, with a screwdriver blade, short across the large terminal to the cylinder head or plug body. The test lamp will *not* light when connected across the faulty plugs.

MASSEY-FERGUSON

35 TRACTOR

WORKSHOP SERVICE MANUAL

SECTION H

LIGHTING SYSTEM

LIGHTING SYSTEM

Section H

CONTENTS

LIST OF ILLUSTRATIONS

LIGHTING SYSTEM

GENERAL

The installation of the electrical wiring and lighting system on the Massey-Ferguson 35 Tractor is straight forward and can be carried out with normal garage equipment.

Figure 1 shows a complete wiring diagram with wire colours and connection instructions.

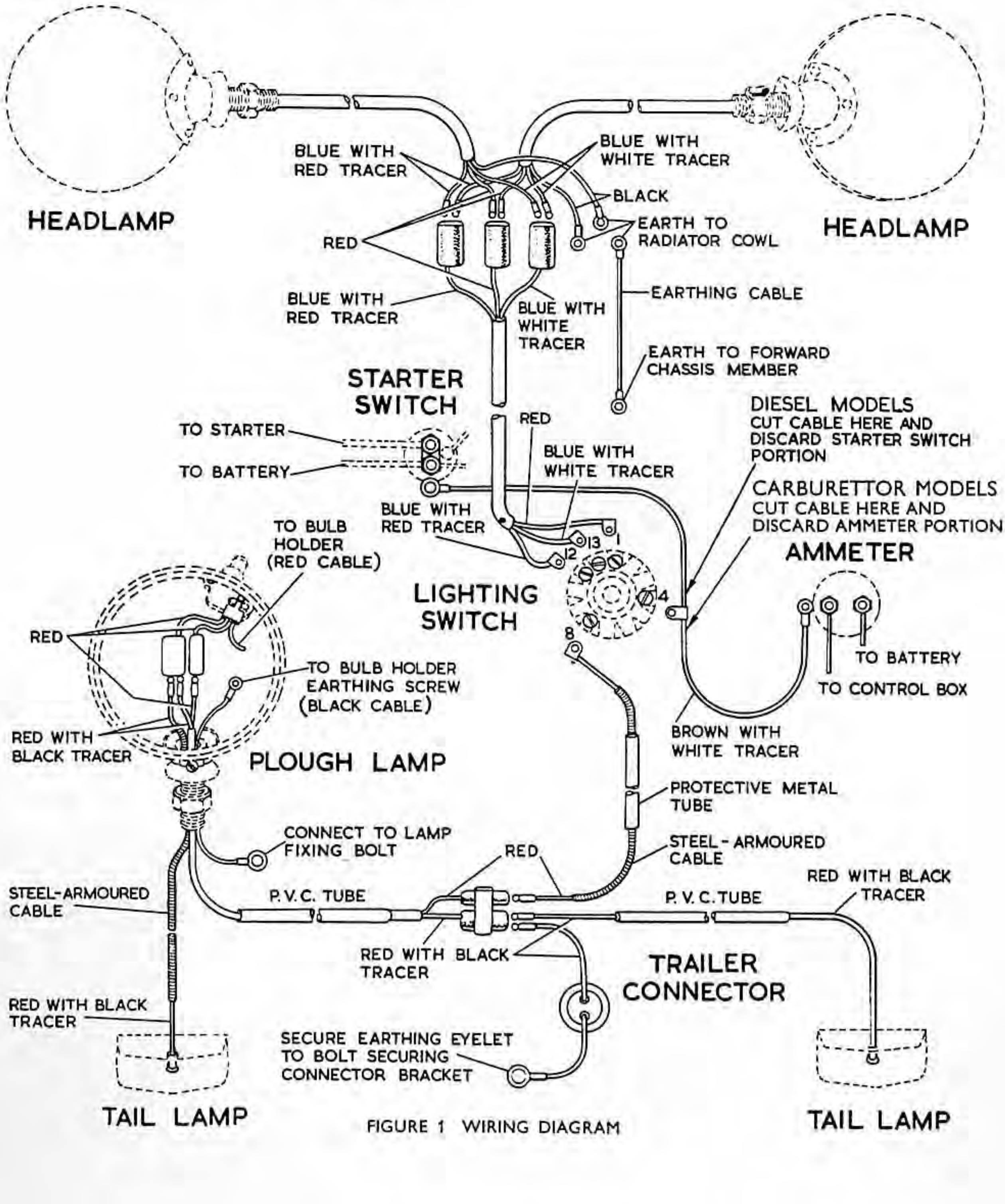


FIGURE 1 WIRING DIAGRAM

FITMENT TO TRACTOR (H-1)

The fitting instructions are given in the following paragraphs. The first four deal with preparatory work on the tractor sheet metal, the next three the fitting of the lamps and the remainder covers the fitting of the wiring harness. The second half of the section is devoted to illustrations which should be studied in conjunction with the relative descriptions.

TRACTOR MODIFICATIONS

Fenders (Figure 2)
Use the existing hole, and the bracket as a template, drill $\frac{3}{8}$" (9.52 mm.) hole at X (Figure 2). Drill other holes as shown in Figure 2.

Radiator Cowl (Figure 3)
Remove the radiator grille to give access to the cowl. Drill and pierce as indicated. Figure 3 shows the radiator of the diesel model. On the carburettor models the cowl should be drilled in a similar position on the opposite side of the tractor. Use bracket as template for lower hole.

Instrument Panel (Figure 4)
The instrument panel must be pierced, as shown in Figure 4, to receive the lighting switch.

Front Axle Support (Figure 5)
Drill the front axle support as shown in Figure 5. This illustrates a diesel model. Carburettor models must be drilled in a similar position on the opposite side.

TO ASSEMBLE LAMPS AND BRACKETS (H-2)

Rear Lamp (Figure 6)
Attach the tail lamps to their brackets. Remove the tail lamps from their holders, taking care not to lose the springs or fibre washers, and connect the tail lamp cables as shown in Figure 6. Re-assemble tail lamps.

Plough Lamp (Figure 7)
The plough lamp is assembled as shown in Figure 7 and attached by means of an angle bracket and 1" (2.54 cm.) bolt to the rear lamp angle bracket on the left fender.

Headlamps (Figure 8)
The headlamp is shown dismantled with the surplus cable coiled inside the lamp body. The headlamp is attached by its bracket to the tractor as shown in Figure 8.

TO FIT LIGHTING EQUIPMENT (H-3)

Cable Runs (Figures 9-12)
The cable run must be routed as shown in Figures 9-12. On carburettor models, the cable harness runs along the left-hand side of the engine and must be fitted on the left-hand flange of the side panel and hood assembly.

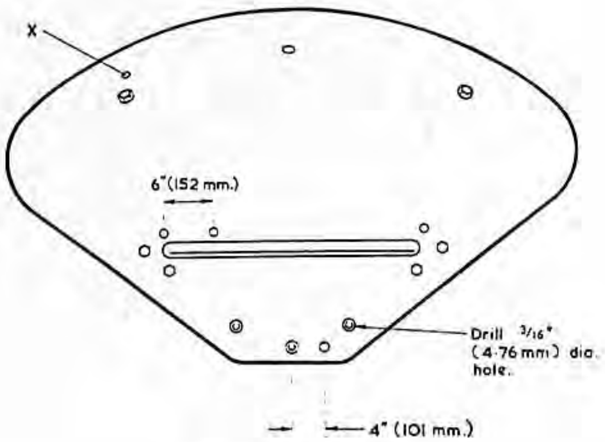


FIGURE 2 FENDERS

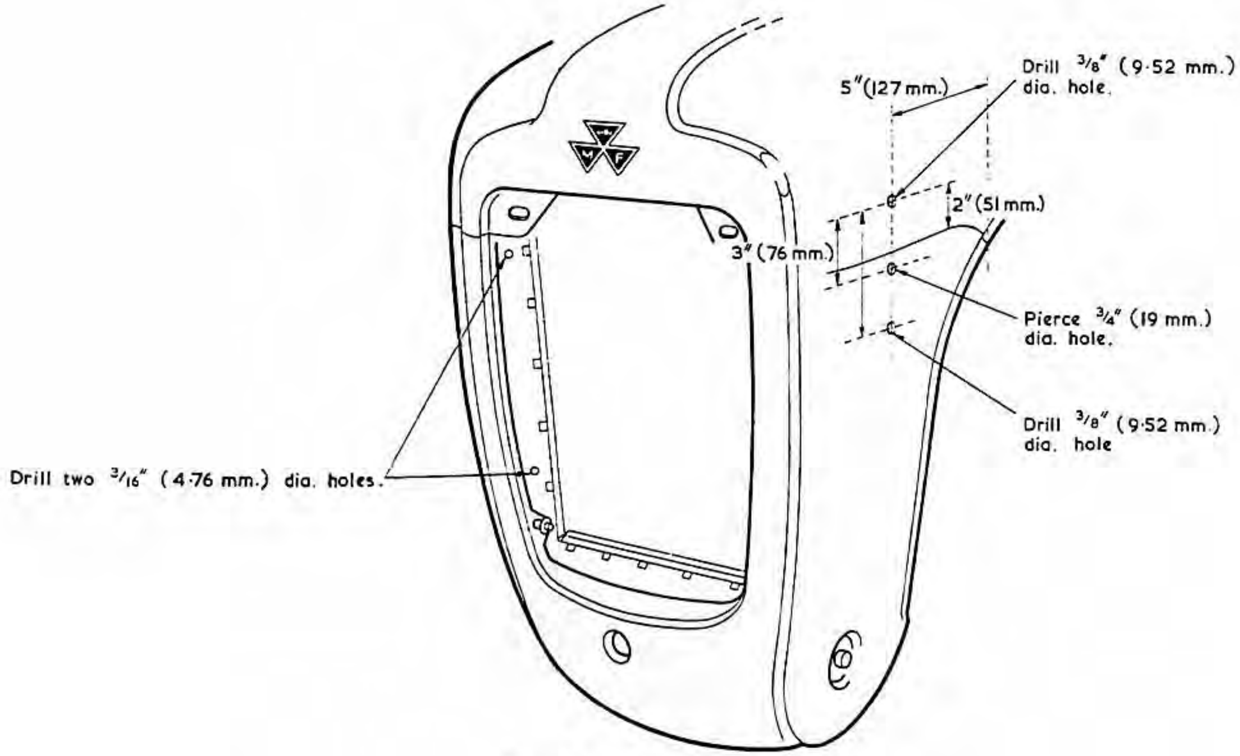


FIGURE 3 RADIATOR COWL

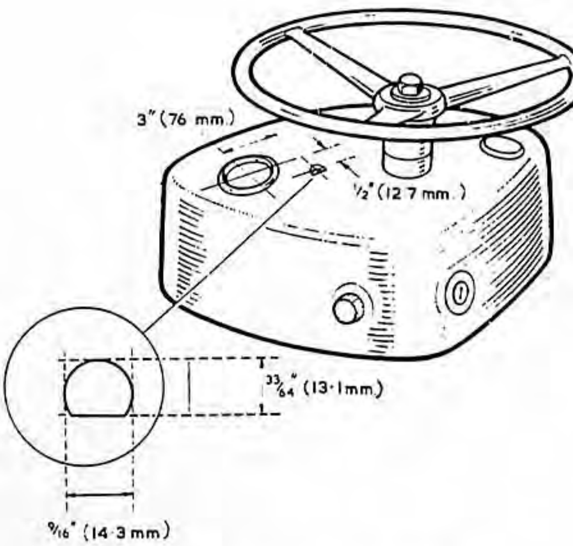


FIGURE 4 INSTRUMENT PANEL

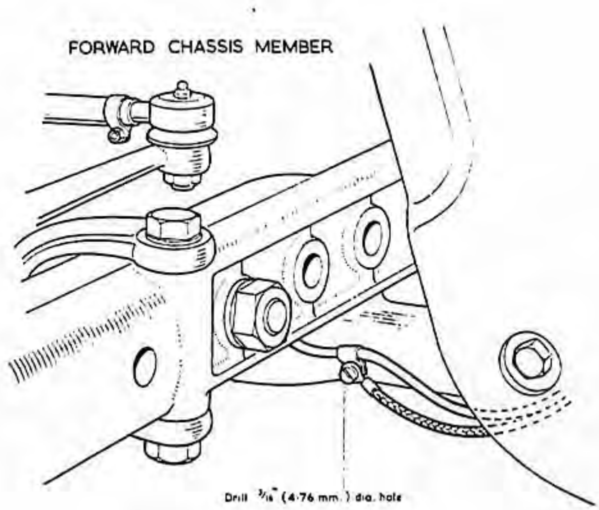


FIGURE 5 FRONT AXLE SUPPORT

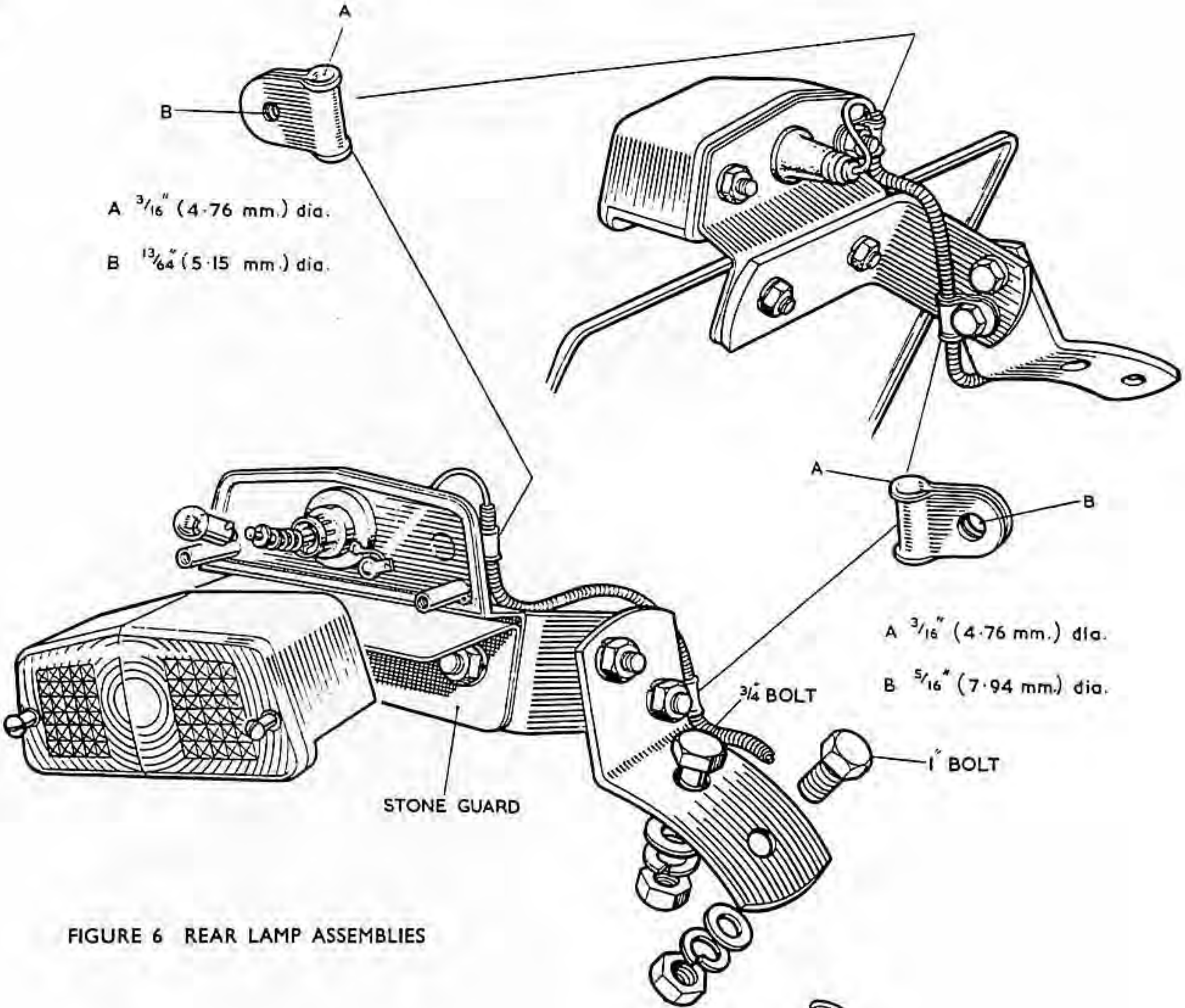


FIGURE 6 REAR LAMP ASSEMBLIES

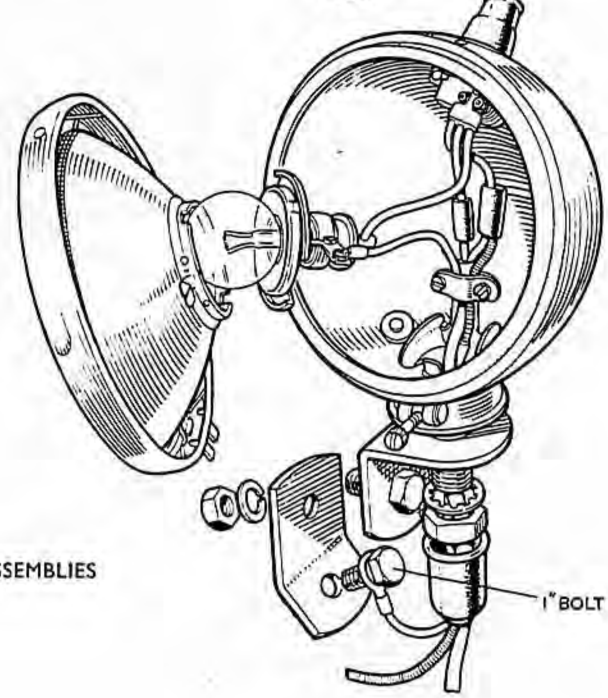


FIGURE 7 PLOUGH LAMP ASSEMBLIES

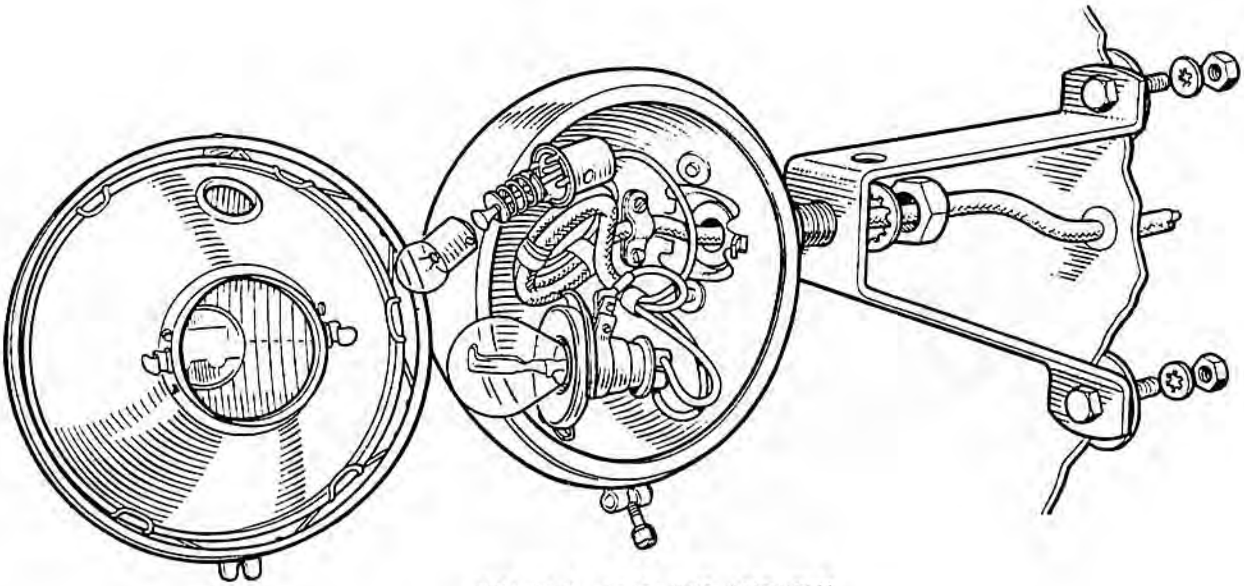
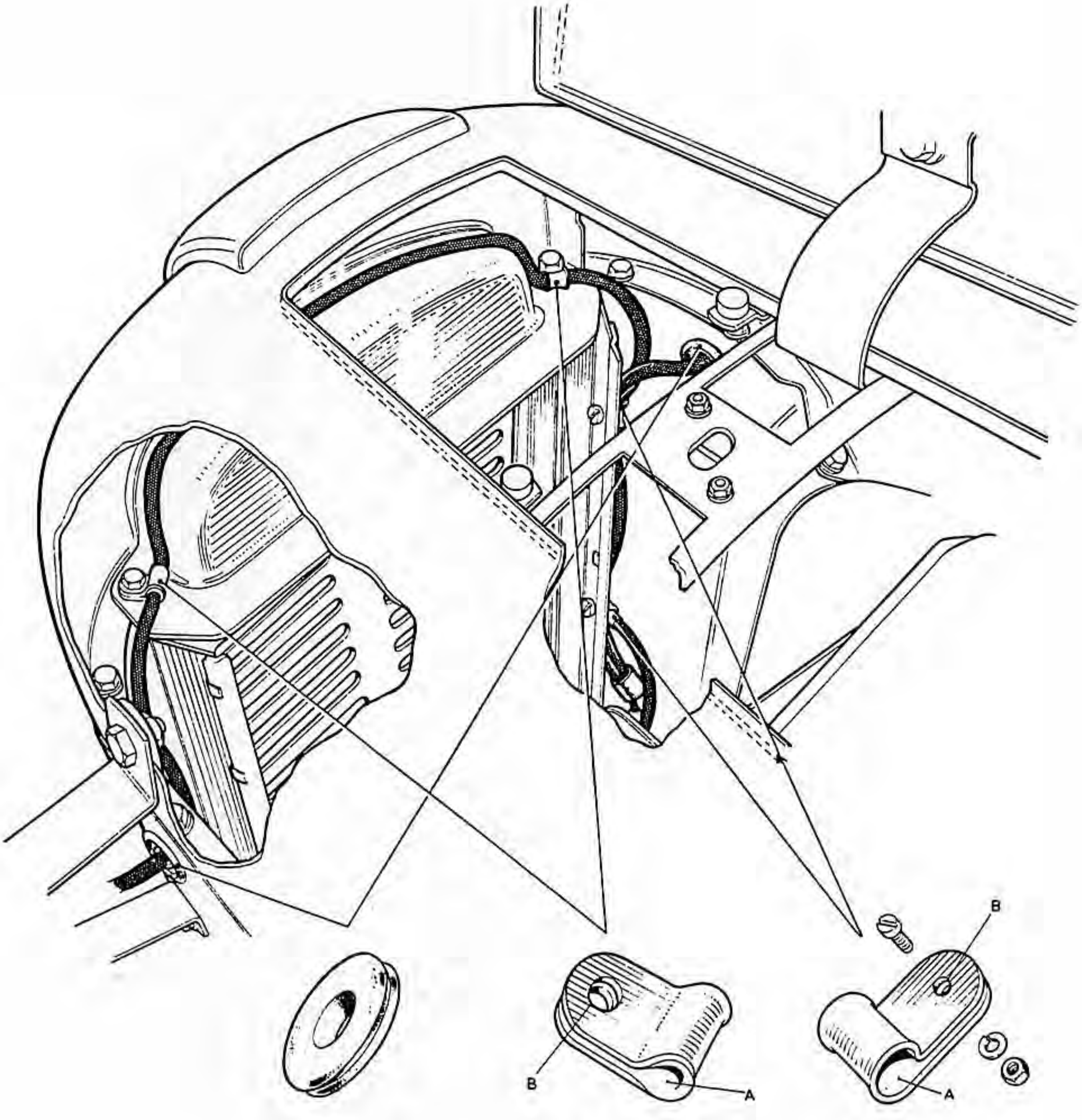


FIGURE 8 HEADLAMP ASSEMBLY



GROMMET	A 9/32" (7·14 mm.) dia.	A 7/16" (11·11 mm.) dia.
	B 19/64" (7·54 mm.) dia.	B 13/64" (5·15 mm.) dia.

FIGURE 9 CUT-AWAY HOOD ASSEMBLY

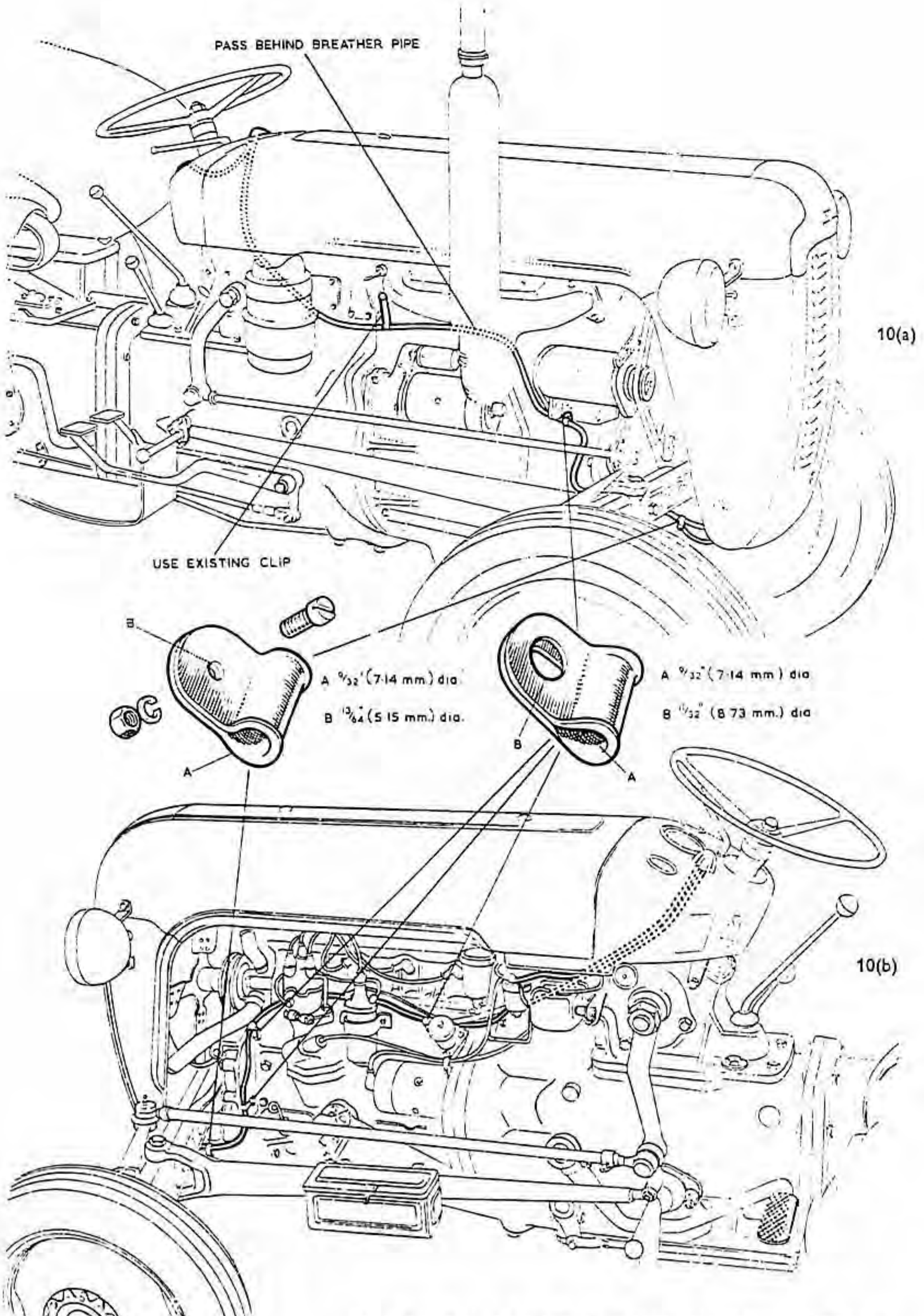


FIGURE 10(a) SIDE VIEW OF HARNESS (DIESEL MODEL)

FIGURE 10(b) SIDE VIEW OF HARNESS (CARBURETTOR MODEL)

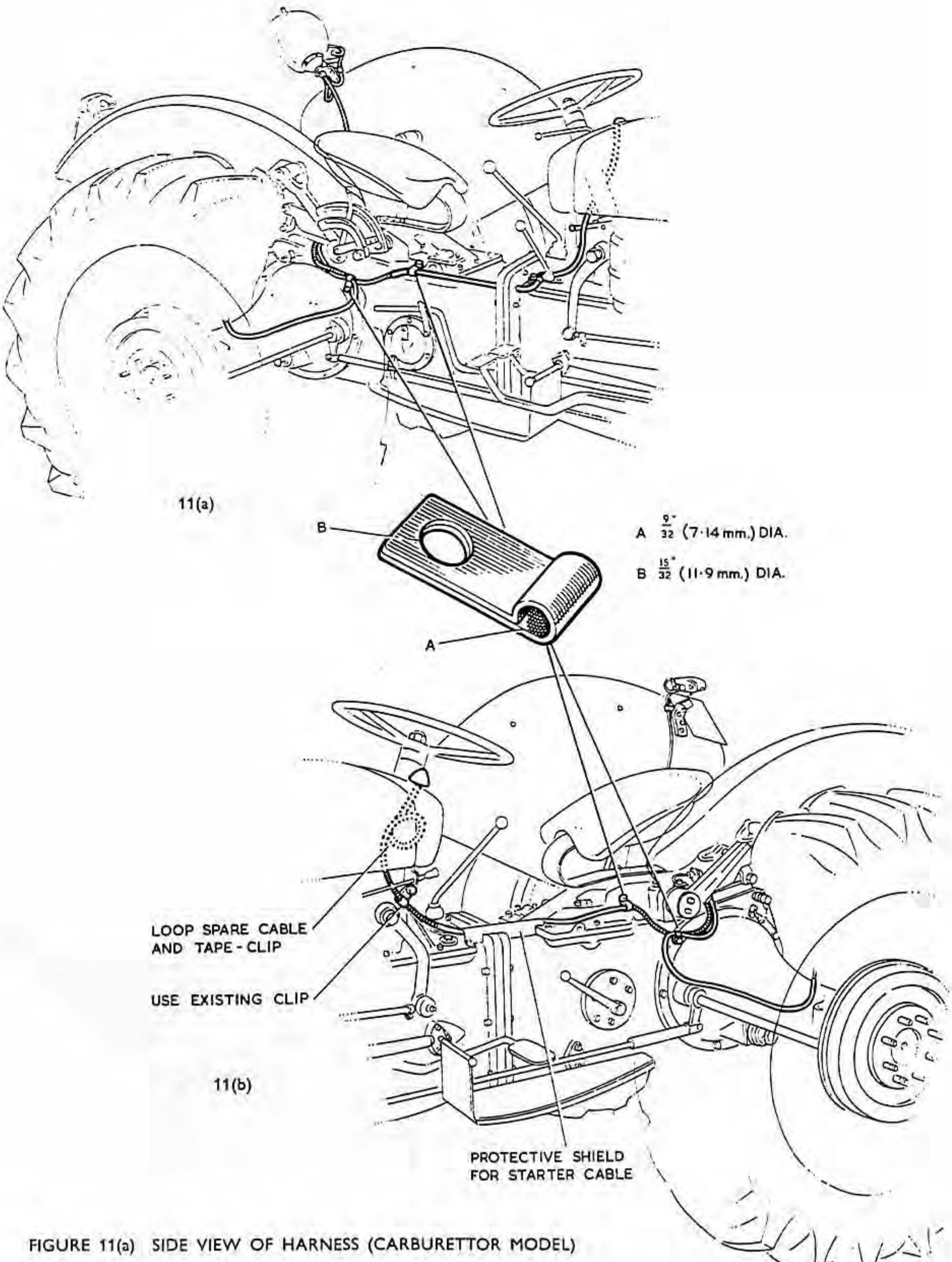
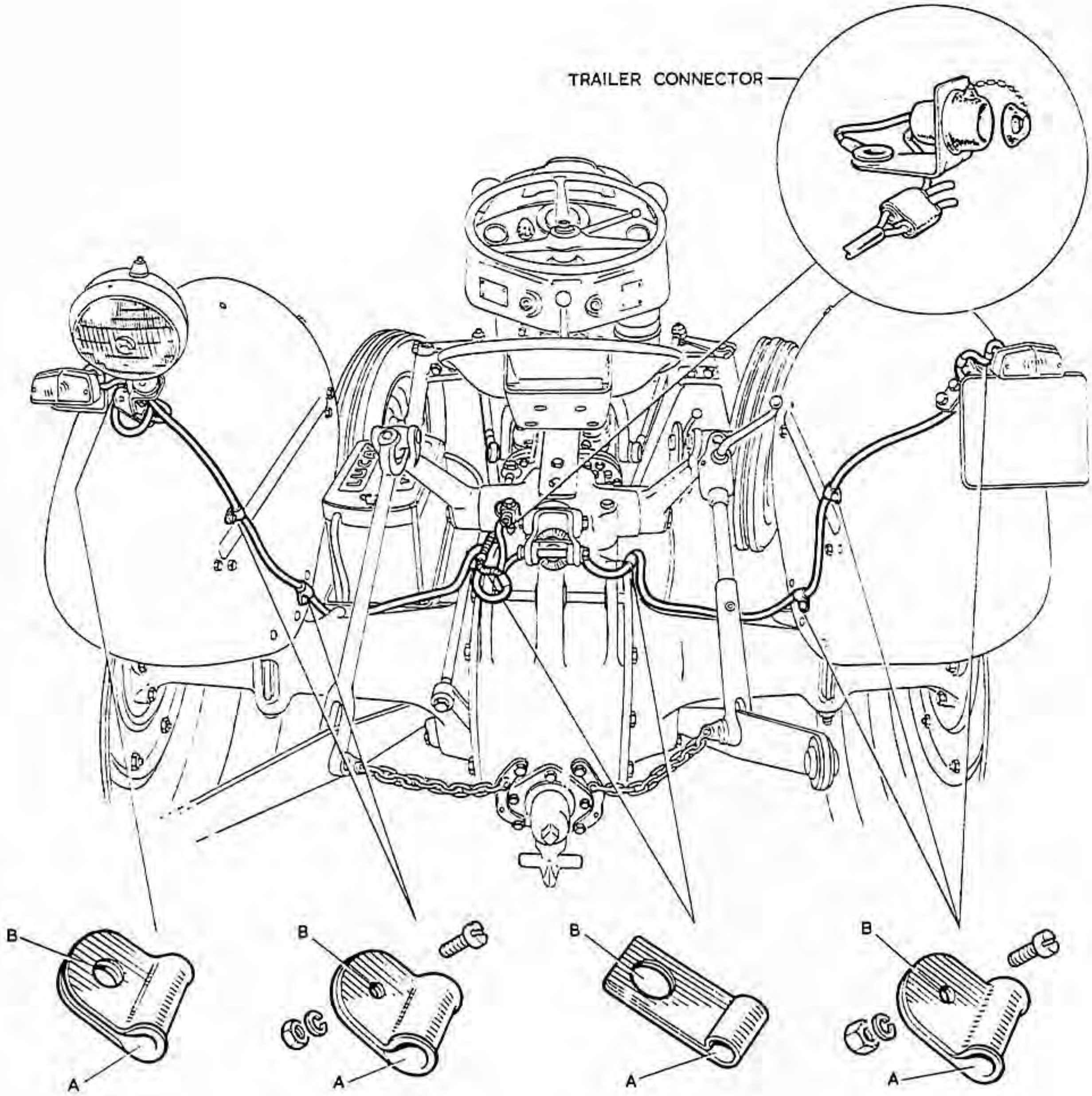


FIGURE 11(a) SIDE VIEW OF HARNESS (CARBURETTOR MODEL)

FIGURE 11(b) SIDE VIEW OF HARNESS (DIESEL MODEL)



A $\frac{3}{16}$" (4·76 mm.) DIA.
B $\frac{5}{16}$" (7·94 mm.) DIA.

A $\frac{9}{32}$" (7·14 mm.) DIA.
B $\frac{13}{64}$" (5·15 mm.) DIA.

A $\frac{9}{32}$" (7·14 mm.) DIA.
B $\frac{15}{32}$" (11·9 mm.) DIA.

A $\frac{3}{16}$" (4·76 mm.) DIA.
B $\frac{13}{64}$" (5·15 mm.) DIA.

FIGURE 12 REAR VIEW OF HARNESS (ALL MODELS)

MASSEY-FERGUSON

35 TRACTOR

WORKSHOP SERVICE MANUAL

SECTION I

SINGLE AND DUAL CLUTCH

CLUTCH

Section I

CONTENTS

CLUTCH

A choice of two different clutches is available: a single clutch of conventional design; and a dual clutch embodying two separate friction discs in tandem, one for the transmission drive through the gearbox, the second for the drive to the hydraulic pump and P.T.O. shaft.

SINGLE CLUTCH FIG. 1

Description

The "Basic" model tractor, fitted with carburettor engine, is equipped with a 9" (228.6 mm.) diameter single dry disc clutch assembly (Rigid Type) attached to the flywheel. The Diesel engine uses a 10" (254 mm.) diameter dry disc, but is otherwise similar.

A set of compression coil springs maintain pressure between the cover, disc and flywheel. The design is such that, if the engine is raced and the clutch quickly engaged, the clutch will not transmit more than twice maximum engine torque. This prevents the imposition of abnormally high shock loads on the transmission and rear axle.

Components

The components are illustrated in Fig. 1 which gives a section of the unit.

The driven plate assembly is riveted and comprises a splined hub (11) attached to a steel disc (12) fitted with nine cushion segments (10) carrying two replaceable clutch facings (13).

The cover assembly is formed by a pressed steel cover (1) and a pressure plate (2), loaded by thrust springs (3). The pressure plate carries three release levers (4) which pivot on floating pins (5) retained by eyebolts (6). Adjusting nuts (8) are screwed to the eyebolts, which pass through the clutch cover and are secured by staking. Struts (9) are interposed between lugs on the pressure plate and the outer ends of the release levers. Anti-rattle springs (7) are fitted between the release levers and the cover.

General

A noteworthy feature of FE.35 tractors is that the same transmission case is used for both the "Basic" and dual clutch model tractors, and the same clutch pedal is used to operate the different clutches.

Both clutch release mechanisms include the usual thrust type ball bearing, prepacked with grease. On the single clutch the additional space within the housing—provided to accommodate the dual clutch—is compensated for by an extension piece over the front end of the clutch release bearing.

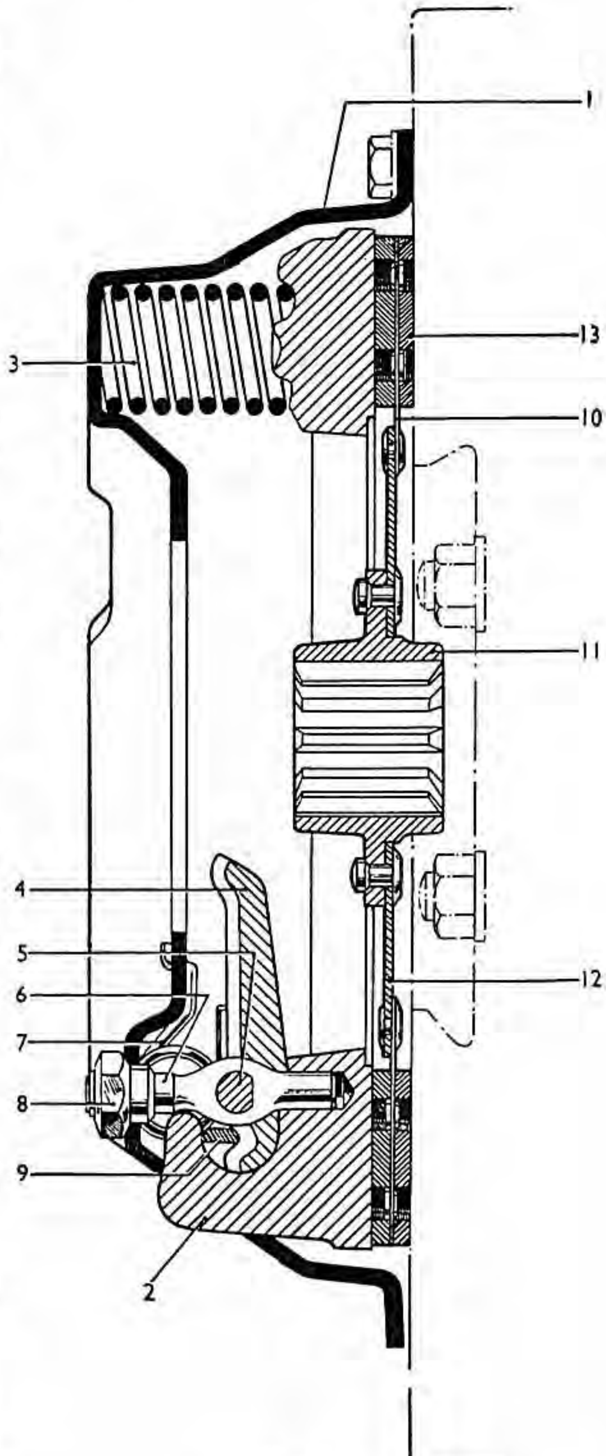


FIG. 1

SINGLE CLUTCH

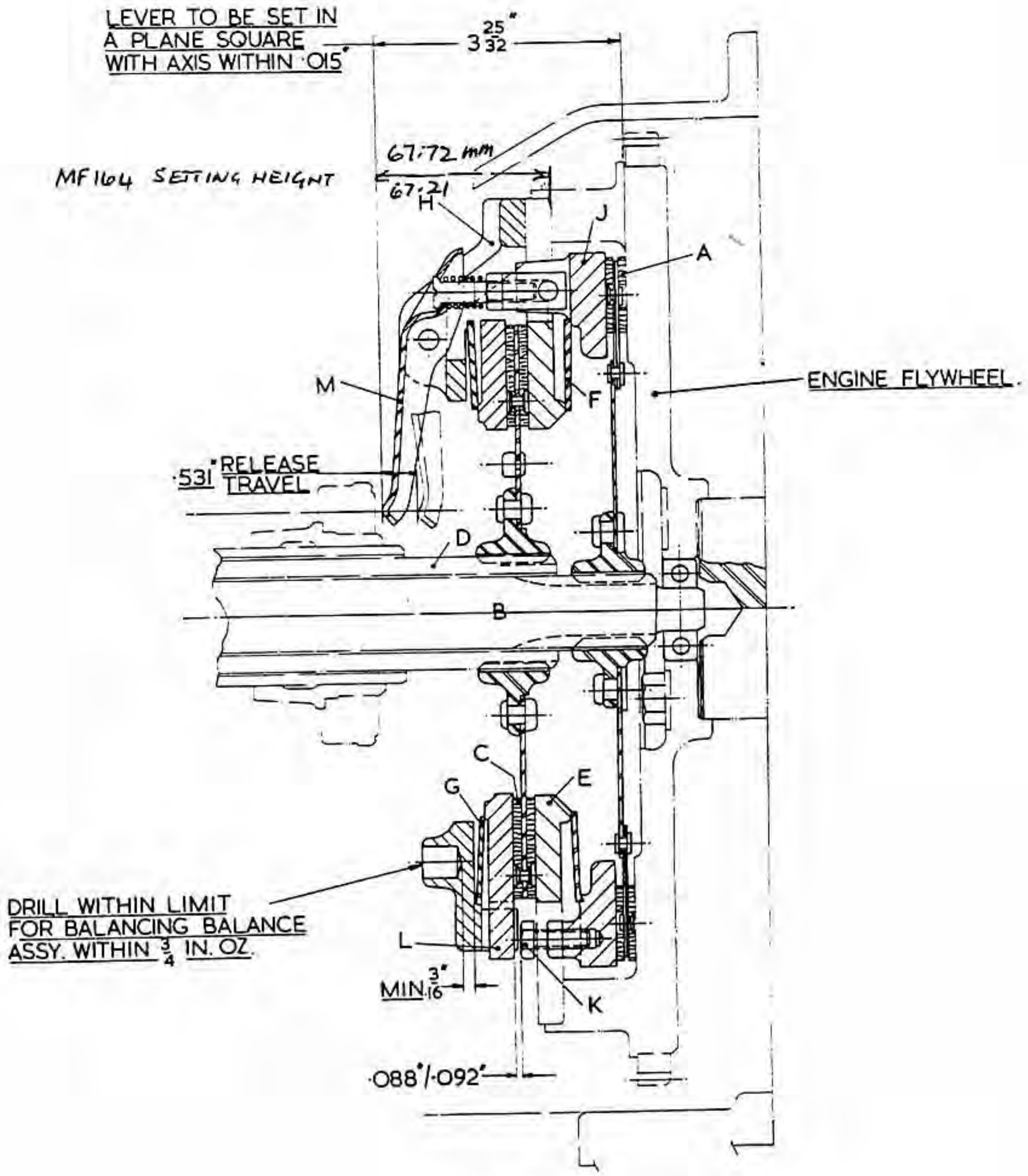


FIG. 2
DUAL CLUTCH

DUAL CLUTCH FIG. 2.

Advantages

This assembly enables the transmission drive to be disconnected—for the purpose of gear changing and stopping and starting the tractor—without interrupting the power train to the pump and P.T.O. shaft.

When the tractor is stopped in this manner, P.T.O. driven implements can still be operated and raised or lowered by means of the hydraulic system without interruption. For example, the tractor may be simply de-clutched to permit a Mower to cut a particularly heavy stand of grass or foliage or to permit a Combine to clear itself.

Components (Fig. 2)

The Dual Clutch Assembly consists of a "primary 11" disc" (A) driving the transmission input shaft (B), and a rearward "secondary 9" disc" (C) driving the hydraulic pump and P.T.O. input hollow shaft (D). The first one is operated by the "primary" pressure plate (J) against the flywheel face. the

second one is operated by a "secondary" pressure plate (L) against a "false flywheel" ring (E) secured to the flywheel by the same screws which hold the clutch cover (H). Both pressure plates (J) & (L) are interlocked with the clutch cover elements so that they rotate in unison with the flywheel, having however a possibility to be moved axially.
This axial movement is obtained through a single set of release levers (M) pivoted on the clutch housing cover (H) in such a way that the initial movement of the release levers while operating against the "Belleville" type spring (F) moves rearwards the pressure plate (J) thus releasing the "primary" disc (A). Further movement of the pressure plate (J) still actuated by the same release levers (M) abuts the set screws (K) against the "secondary" pressure plate (L) thus moving this plate against the second "Belleville" spring (G) and releasing the "secondary" disc (C).
The clutch release levers (M) are operated in the usual way by a clutch release bearing which in turn is actuated by a single clutch pedal.
The clutch discs (A) and (C) have annular friction facings bonded and riveted in a similar way as in the single clutch application.

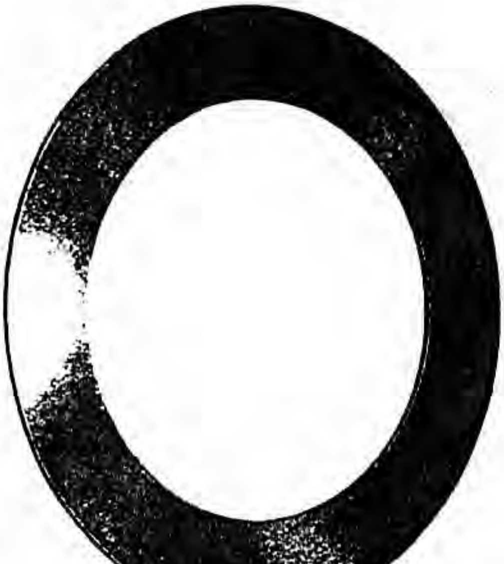


FIG. 3
BELLEVILLE SPRING

PEDAL ADJUSTMENT FIG. 4.

Single and Dual Clutch

The only normal adjustment required throughout the life of the clutch facings is periodically to restore the free movement of the clutch pedal; i.e. movement of the pedal before the release bearing comes into contact with the release levers and commences to withdraw the clutch.
When making this adjustment, measurements are taken between the upper side of the pedal and the underside of the footrest bracket, as indicated at (X) in Fig. 4. Clutch adjustment is correct when free movement, or travel before the withdrawal bearing begins to engage, is $\frac{3}{4}$" (19 mm.) single clutch and $\frac{3}{8}$" (9.5 mm.) dual clutch.

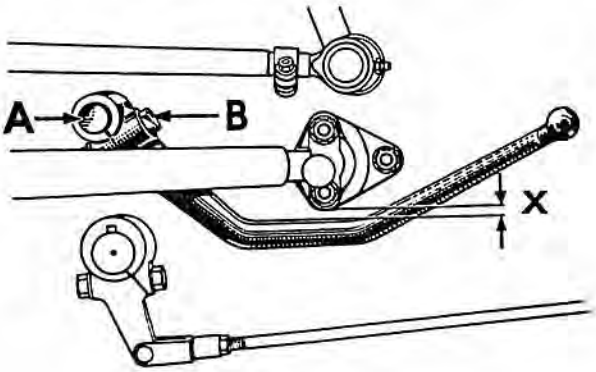


FIG. 4
CLUTCH PEDAL ADJUSTMENT

After reasonable usage, re-adjustment will be required and this is obtained by holding the end of the clutch bearing shaft (A) with a tommy bar inserted through the hole provided, releasing the pinch bolt (B) and adjusting the pedal to the correct position. After adjustment, tighten pinch bolt and re-check the measurement.
To obtain a clear release, the inner ends of the release levers (M, Fig. 2) should travel $\frac{1}{2}$ inch (12.7 mm.) towards the flywheel. If the adjustment of the pedal is correct, this movement will be obtained when the pedal reaches the pedal stop, which is not adjustable.

PRESSURE PLATE ADJUSTING SCREWS

Dual Clutch only

The clearance between the head of the three adjusting screws (K, Fig. 2) and the rear pressure plate (L) must be maintained at .088"/.092" (2.24-2.34 mm.) as indicated in Fig. 2.
An inspection cover plate is provided in the transmission case beneath the clutch assembly. Through the access hole the clearances can be checked and the screws adjusted as necessary after loosening each lock nut. It will of course be necessary to rotate the flywheel until the adjusting screws align one by one with the inspection opening.

CLUTCH DATA

SINGLE CLUTCH

	Carburettor Engine	Diesel Engine
Single Dry Disc	9″ (228.6 mm.) dia.	10″ (254 mm.) dia.

Thrust Springs

	Carburettor Engine	Diesel Engine
No. off	9	12
Colour	Black	Green
Fitted Load	150/160 lb. (68.04/72.57 kg.)	105/115 lb. (47.63/52.2 kg.)

Toggle Release Levers

Height (from flywheel face) 1.895″ 1.995″

Movement of lever ends .531″ (13.49 mm.). Variation in toggle lever height should not exceed .015″ (.381 mm.).

Clutch Pedal

Free movement of pedal should be $\frac{3}{4}$″ (19 mm.). This dimension taken between upper side of pedal and underside of footrest bracket.

DUAL CLUTCH

Transmission Disc ...... 11″ dia. (279.4 mm.)

PTO/Hydraulic Pump Disc .... 9″ dia. (228.6 mm.)

Thrust Springs .... 2 "Belleville" Type

Load—See Fig. 5 ......
at .075″ (1.905 mm.)—510/440 lb. (231.33/199.58 kg.)
at .065″ (1.651 mm.)—1080/960 lb. (489.89/435.45 kg.)

Clutch Pedal

Free movement of pedal should be $\frac{3}{8}$″ (9.5 mm.), this dimension to be taken between upper side of pedal and underside of footrest bracket.

Toggle Release Levers

Height from flywheel face $3\frac{25}{32}$″ (96 mm.).
Movement of lever ends .531″ (13.49 mm.). Variation in toggle lever height should not exceed .015″ (.381 mm.).

Adjusting Screws

Clearance between screw heads and rear pressure plate (P.T.O./hydraulic pump drive)—.088″/.092″ (2.24/2.34 mm.).

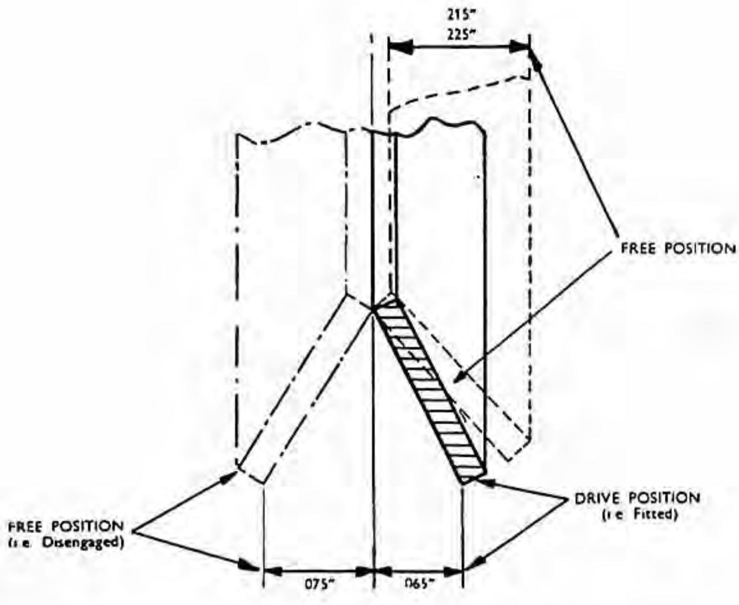


FIG. 5
PRIMARY AND SECONDARY BELLEVILLE SPRING SECTION

CLUTCH DISMANTLING INSTRUCTIONS

Separate the transmission from the engine, splitting the tractor in accordance with separate instructions.

SINGLE AND DUAL CLUTCHES

To Remove the Clutch from the Engine Flywheel

Remove the six setscrews around the outer edge of the clutch assembly, and lift the assembly off. This releases the clutch driven plate (single clutch) or the primary drive disc (dual clutch) and is all the disassembly necessary if only this part is to be replaced.

NOTE. The adjusting nuts are correctly set and locked when the unit is assembled and should not be altered unless the clutch has been dismantled. Interference with this adjustment may put the pressure plate out of position and cause clutch judder and promote failure of the clutch release bearing.

Refacing the Clutch Driven Plate

To remove the old facings, it is essential that the rivets are drilled and not punched out. Each rivet attaches one facing only. Insert a $\frac{5}{32}''$ (4 mm.) diameter drill through the clearance holes in the opposite facing. After removal, thoroughly examine the plate segments for cracks; if cracks are present, a new plate assembly must be fitted. To fit facing, place one side in position with the countersunk holes coinciding with those located on the crown or longer side of each segment.
Insert rivets and roll rivet shanks over securely against segments. If a rolling tool is not available, a blunt ended punch will be satisfactory, if used carefully.
Secure the opposite facing in a similar manner. Rivet heads should always face outwards.
Mount assembly on mandrel and spin in lathe for run-out; if more than .015" (.39 mm.) prise over as necessary.

SINGLE CLUTCH

DISMANTLING AND REASSEMBLY

Use Churchill No. 99 Clutch Assembly Fixture.

Remove from the box the gauge finger, the pillar and the actuator as shown in Fig. 6, and consult the code card to determine the reference of the adaptor and the spacers appropriate to the clutch which is being serviced.
Rest the base plate on a flat surface, wipe it clean and place the spacers upon it in the positions quoted on the code card (Fig. 7).

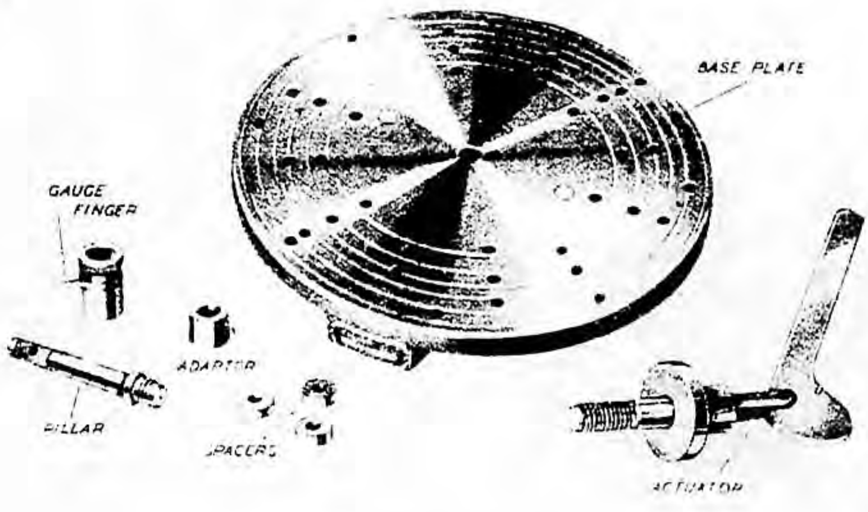


FIG. 6 99 CLUTCH ASSEMBLY FIXTURE

FIG. 7 99 CLUTCH ASSEMBLY FIXTURE.
BASE PLATE AND SPACERS

FIG. 9 99 CLUTCH ASSEMBLY FIXTURE.
REMOVING ADJUSTING NUTS

DISMANTLING FIG. 8.

1. Carefully punch mark the clutch cover, pressure plate lugs and release levers so that they can be reassembled in the same relative position, to maintain the balance of the clutch assembly.
2. Place the clutch upon the spacers, aligning it with the appropriate tapped holes in the base.
3. Screw the actuator into the centre hole in the base plate and press the handle down to clamp the clutch. Then screw the set bolts firmly into the tapped holes in the base plate and remove the actuator (Fig. 8).
4. Remove release lever plate and retainers.

FIG. 8
99 CLUTCH ASSEMBLY FIXTURE WITH ACTUATOR

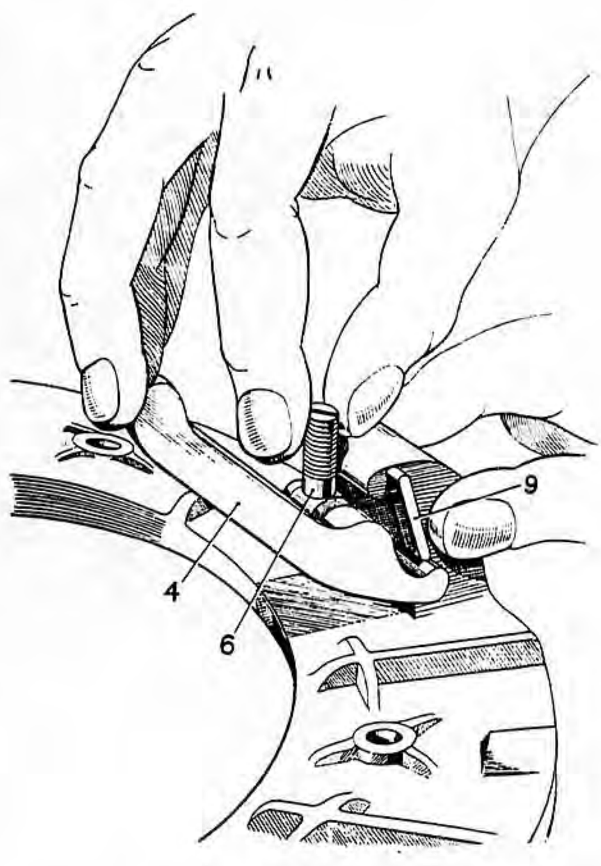


FIG. 10
REMOVING RELEASE LEVERS FROM PRESSURE PLATE

5. Remove the adjusting nuts (Fig. 9) and gradually unscrew the set bolts to relieve the load of the thrust springs. Lift the cover off the clutch.

6. Remove each release lever (4) by holding lever and eye-bolt (6) so that the inner end of the lever and the threaded end of the eye-bolt are as near together as possible, keeping the eye-bolt pin (5, Fig. 1) in position on the lever. Lift the strut (9) over the ridge on the lever and remove the eye-bolt from the pressure plate (Fig. 10).

REASSEMBLY

Before assembly, thoroughly clean all parts and renew those showing appreciable signs of wear.

A very slight smear of H.M.P. grease should be applied to the following parts during assembly. See Figs. 1 and 10.

> Lever pins (5); contact faces of struts (9); eye-bolt seats in cover; drive lug side on pressure plate (2); and plain ends of eye-bolts (6).

The clutch disc hub splines should be lubricated with "Lubriplate" 70 grease (Export Market only) or "Keenol" K.G.20 and K.G.15 grease. The latter is manufactured by Messrs. Duckham & Co. Ltd., Hammersmith, London, W.6.

If these products are not available, use a molybdenum di-sulphide grease which has been entirely satisfactory for the Clutch Splines of the TE-20 type Tractors.

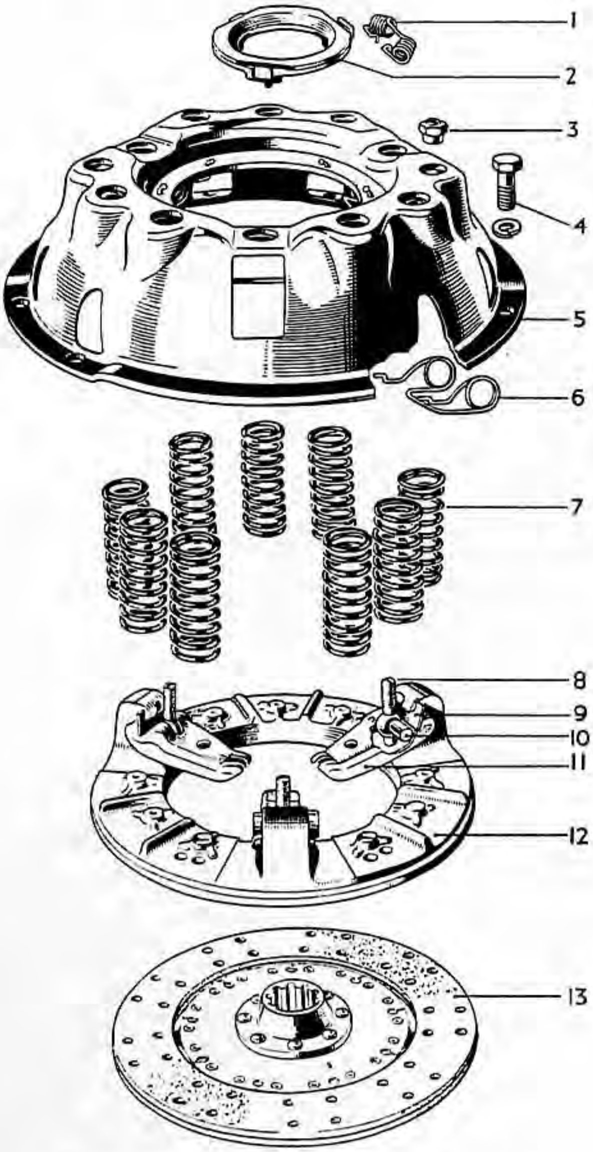


FIG. 11 EXPLODED VIEW OF SINGLE CLUTCH

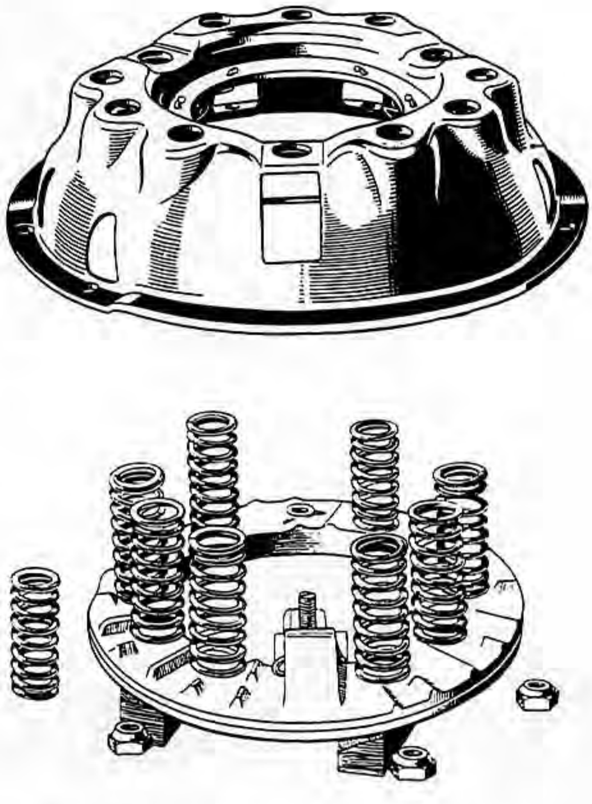


FIG. 12 THRUST SPRINGS AND BASE PLATE

Procedure:

1. Assemble release lever (4), eye-bolt (6), and eye-bolt pin (5) holding the inner end of the lever and the threaded end of the eye-bolt as close together as possible. Insert strut (9) in slot in pressure plate lug sufficiently to allow plain end of eye-bolt to be inserted in hole in pressure plate. Move strut upwards into slot in pressure plate lug and over ridge on short end of lever and drop it into groove formed into latter. Fit remaining release levers in a similar manner.

2. Arrange thrust springs (3) in vertical position on pressure plate, seating on bosses provided (Fig. 11).

   NOTE. Thrust springs must all be of the same colour, denoting that they are all of the same strength. On **no** account should springs of different colours be assembled together.

   Lay cover over assembled parts, ensuring that anti-rattle springs are in position and that tops of springs are directly under seats in cover; also that machined portions of pressure plate lugs are beneath slots provided for them. Care must be taken that parts marked before dismantling are in their correct relative positions.

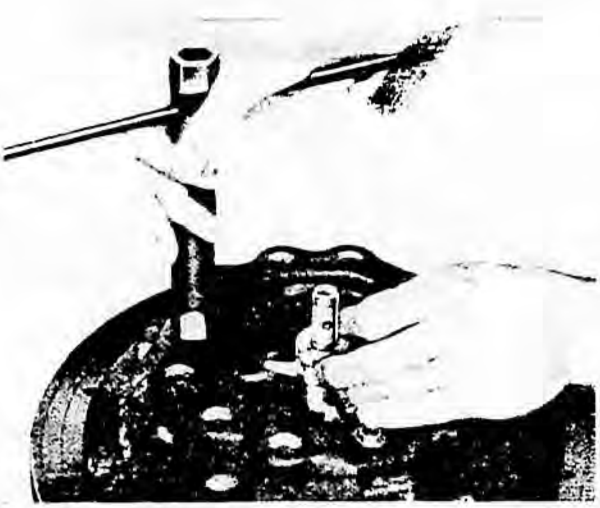


FIG. 13
99 CLUTCH ASSEMBLY FIXTURE SETTING TOGGLES

3. Transfer the assembly to the 99 base plate and screw the adjusting nuts on to the eye-bolts until flush with the tops of the latter. Screw the actuator into the base plate (Fig. 8) and pump the handle a dozen times to settle the clutch mechanism. Remove the actuator.

4. Screw the pillar firmly into the base and place upon it the appropriate adaptors—See Code Card—recessed face downwards; set the gauge finger.

   Turn the adjusting nuts until the gauge finger just touches the release levers, pressing downwards on the finger assembly to ensure that it is bearing squarely on the adaptor (Fig. 13). After adjusting the height of the toggles to suit, remove the finger, adaptor and pillar, and replace the actuator. Operate the clutch by actuating the toggles continuously until, after a series of several applications, the height of the toggles remains constant. This is most important as it will be found that the height will vary repeatedly until the assembled components are well seated.

5. Finally, lock the adjusting nuts and refit release lever plate and retainers.

   Insert retainer with open ends under toggle lever, place release lever plate in position, and, using a piece of flexible wire, pull each retainer in turn over lug on release lever plate.

To Assemble the Clutch to the Flywheel and Adjust

To install the clutch assembly on the engine flywheel, assemble the clutch assembly and the driven plate on the clutch pilot tool, FT 159 and insert the pilot tool in the pilot bearing of the flywheel. Position the assembly and install the setscrews, tightening them one turn at a time by diagonal selection until fully home.

Remove special tool when fully tightened.

DUAL CLUTCH

DISMANTLING AND REASSEMBLY

DISMANTLING

1. Carefully punch mark the clutch cover, the outer pressure plate and the two inner pressure plates, so that they can be assembled in the same relative position, to maintain the balance of the clutch assembly.
2. Place the assembly in a press with the cover assembly uppermost, place a bar or piece of wood across the centre of the cover and apply pressure downward, until the clutch release levers are just free.

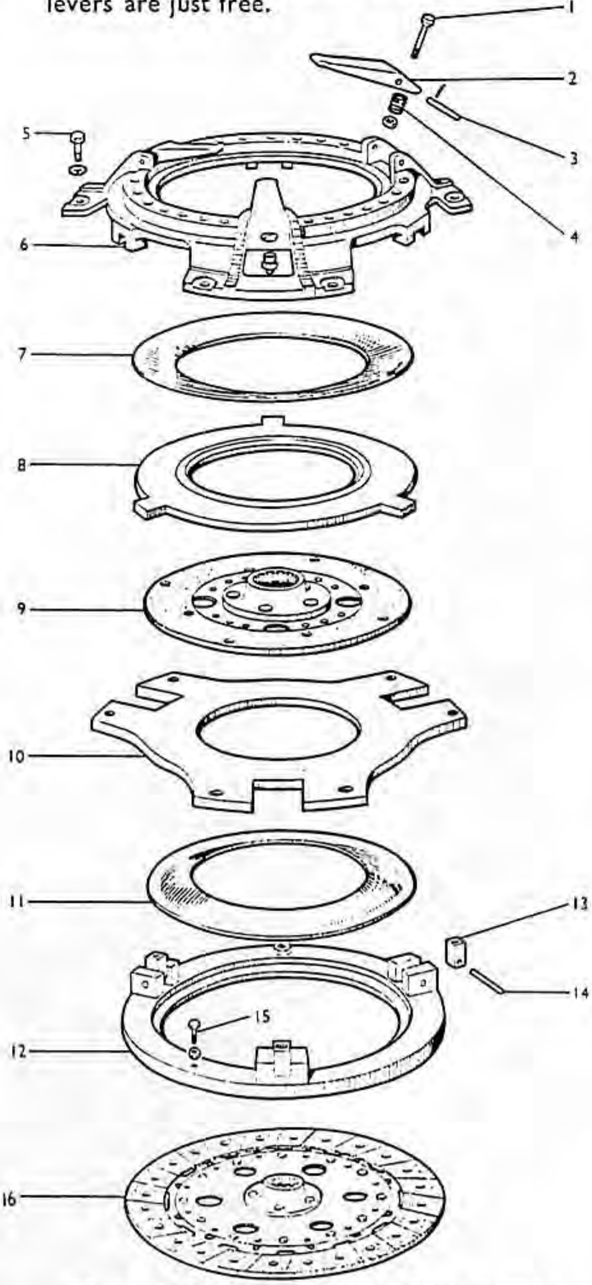


FIG. 14 EXPLODED VIEW OF DUAL CLUTCH

3. Loosen the locknuts on the adjusting screws and turn the screws completely out of the clutch rod ends. Release the pressure on the clutch and it can now be dismantled.

Note that the clutch release lever pins are secured by a small roll pin driven through the lever pin and into a hole in the clutch cover. If the release levers have been damaged, and require replacing, the lever pins can be removed by driving them out of the assembly with a small punch in the direction of the roll pin, this will pull the roll pin from the hole in the front cover. Use new roll pins when replacing the release lever pins.

REASSEMBLY

NOTE. The Belleville Springs and clutch disc hub splines should be lubricated with a light smear of "Lubriplate" 70 grease (Export Market only) or "Keenol" K.G.20 and K.G.15 grease. The latter is manufactured by Messrs. Duckham & Co. Ltd., Hammersmith, London, W.6.

If these products are not available, use a molybdenum disulphide grease which has been entirely satisfactory for the Clutch Splines of the TE-20 type Tractors.

1. Place the inner pressure plate (12) face down on the work bench. Place primary Belleville spring (*marked with a red stripe*) (11) on the pressure plate with the convex side up.

   It is most important for the edge of the spring to be accurately seated in its locating groove and not to be dislodged during subsequent assembly.
2. Place the second pressure plate (10), with the flat side up, in position on the assembly by lining up the punch marks previously made.
3. Place and centre the secondary disc assembly (9) on the pressure plate with the longer hub of the disc up. Place the outer pressure plate (8) on the assembly with the flat side against the disc. Again line up the punch marks.
4. Place the second clutch spring (*marked with a yellow stripe*) (7) on the assembly with the concave side up. Place the clutch cover (6) in position, again lining up the punch marks and carefully locating the secondary Belleville spring in its groove.

N.B.—The primary and secondary Belleville springs are identical dimensionally and in spring rates. However, the primary spring, (*marked with a red stripe on the concave side for identification purposes*) is of special material and must always be fitted in the front position.

5. Place the assembly in a press and again place a bar or piece of wood across the centre of the cover assembly. Apply just sufficient pressure with the press to get the adjusting screws started into the clutch end rods.

   Tighten the adjusting screws part way down and remove the assembly from the press.

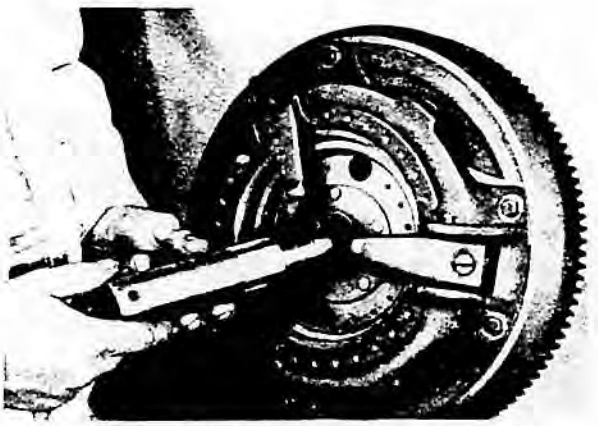


FIG. 15 REMOVING PILOT TOOL, FT 159'

To Assemble the Clutch to the Flywheel and Adjust

1. To install the clutch assembly on the engine flywheel, assemble the clutch assembly and the primary disc—short hub to the front—on the clutch pilot tool FT 159, and insert the pilot tool into the pilot bearing of the flywheel. Position the assembly and install the attaching setscrews. Unless the disc assemblies are properly aligned with the pilot tool, it will be difficult to assemble the engine to the transmission case.

67.72/67.21 MM

FIG. 16 SETTING CLUTCH RELEASE LEVERS SERVICE TOOL FT 164

2. When the clutch assembly has been attached to the flywheel, the clutch release levers should be set to the clutch release lever gauge, FT 164, with a **new** primary disc in place, as shown in Fig. 16 by loosening the locknut and turning the adjusting screw as required.

This gauge is designed to fit on the recessed shoulder of the flywheel, and the levers must be adjusted until they just contact the gauge, the levers will be positioned at the proper height.

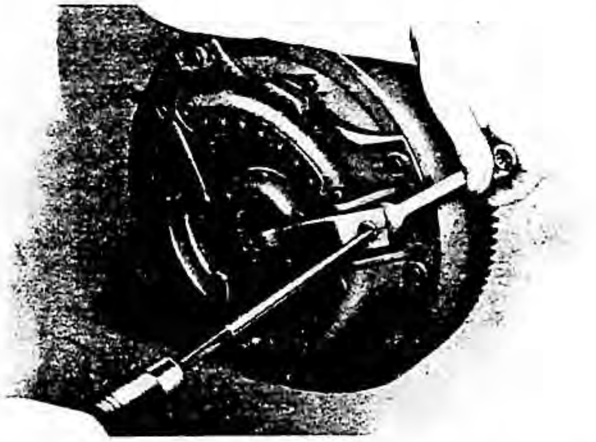


FIG. 17 SECURING CLUTCH RELEASE LEVERS IN POSITION BY TIGHTENING LOCKNUT

3. Check the secondary disc set screw clearance with the special .090″ (2.3 mm.) feeler gauge, FT 158. Adjust the clearance if necessary by loosening the locknut and turning the setscrew in or out as required. When the correct adjustment is obtained, lock the setscrew with the locknut.

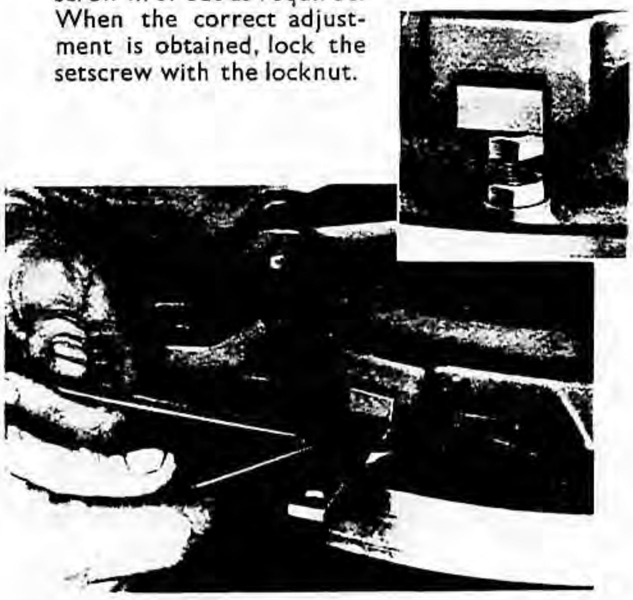


FIG. 18 ADJUSTING SECONDARY DISC SETSCREW CLEARANCE. SERVICE TOOL FT 158

This adjustment determines the point in the clutch pedal travel when the secondary pressure plate begins to release. If there is too little clearance at this point, the secondary disc will begin to release before the primary disc is fully released and the forward motion of the tractor cannot be stopped without also stopping the power take-off. Too much clearance at this point will restrict the movement of the secondary pressure plate and the result may be that the secondary disc will not be fully released at the end of the clutch pedal travel; thus it would be impossible to stop the power take-off.

CLUTCH RELEASE BEARING—SINGLE AND DUAL CLUTCHES

No attention should be required between major tractor overhauls. The bearing, which is of the self-lubricating type, is packed with H.M.P. grease on assembly.

To remove bearing proceed as for clutch removal and expose assembly. With the transmission withdrawn from the engine, the release bearing will remain in position on its hub, floating on the main drive gear bearing retainer, and retained by two release bearing springs.

By releasing the springs from the hub, the bearing and hub can be slid off the mounting and the bearing then removed.

It is recommended that the bearing should be replaced at major tractor overhauls if necessary.

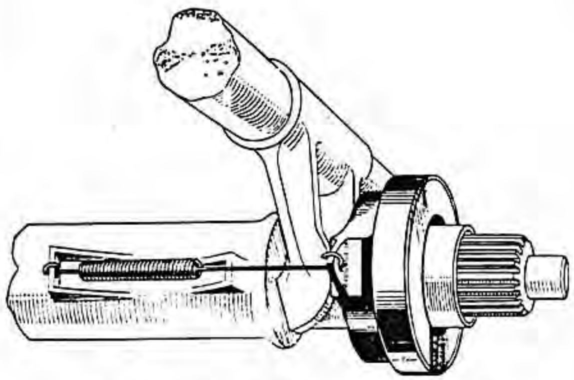


FIG. 19 CLUTCH RELEASE BEARING

Bearing adjustment is obtained by positioning the clutch pedal. See PEDAL ADJUSTMENT.

CLUTCH PILOT BEARING—SINGLE AND DUAL CLUTCHES

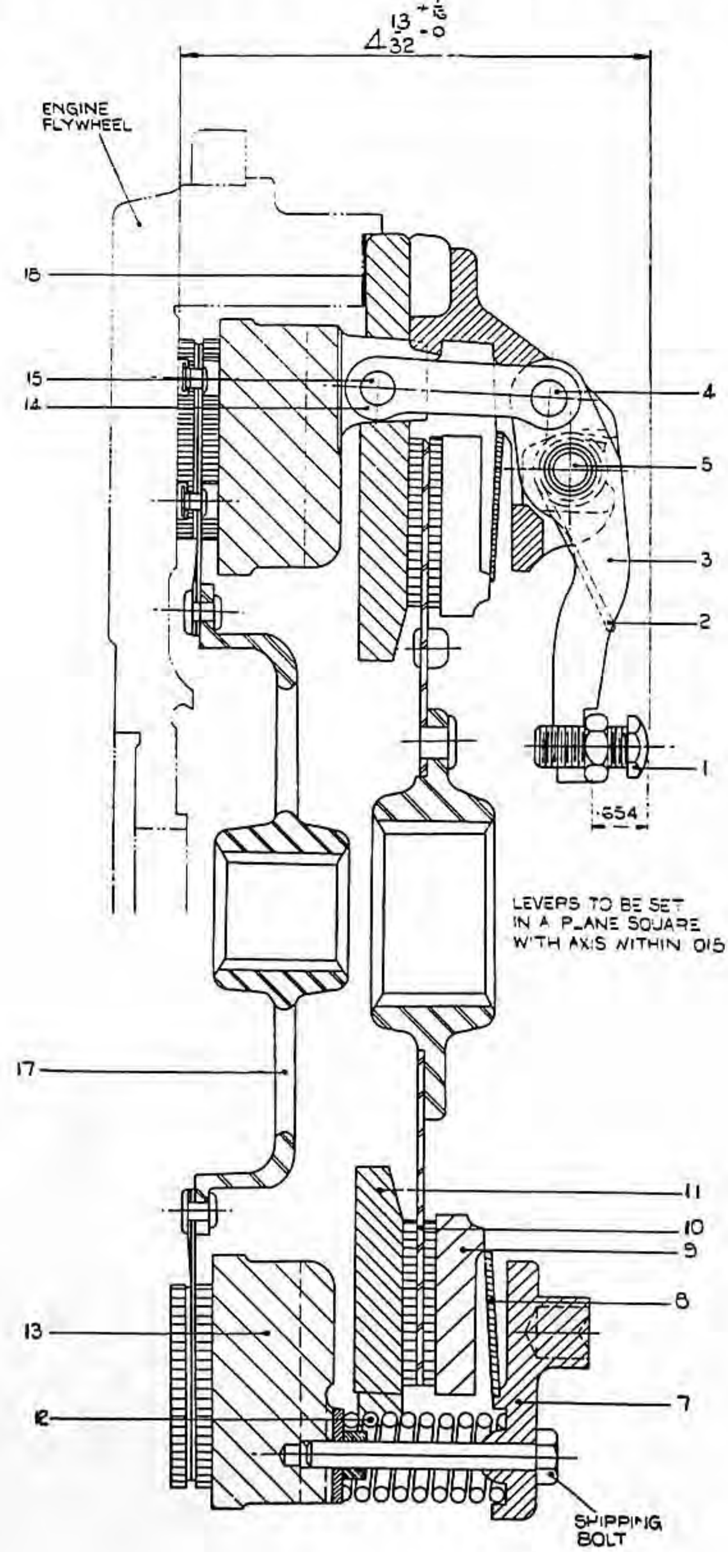
The transmission main drive shaft is supported in the engine flywheel by this self-lubricating bearing which may be examined when the clutch assembly is removed.

No service attention should be required, as this bearing is of the self-lubricating type. It should be examined for wear during major overhauls and renewed if necessary.

FAULT	POSSIBLE CAUSE	ADJUSTMENT REQUIRED
Clutch drag or spin.	Oil or grease on driven plate facings. Improper pedal adjustment not allowing free movement to release bearing. Damaged pressure plate or clutch cover. Driven plate hub binding on splined drive pinion shaft. Distorted driven plate. Broken facings of driven plate. Dirt or foreign matter in the clutch.	Fit new plate. Correct pedal adjustment. Replace defective part. Clean up splines and smear with small quantity of grease. Fit new plate. Fit new plate. Dismantle clutch from flywheel and clean with dry rag. See that all working parts are free.
Slip.	Oil or grease on driven plate facings. Weak thrust or Belleville springs. If excessive slip is allowed to occur, the heat generated will soften the springs and aggravate the trouble. Binding of clutch pedal mechanism. Improper pedal adjustment preventing full engagement.	Fit new driven plate. Fit a new set of thrust springs (single clutch), or a new Belleville spring (dual clutch). Free bearings. **Note.**—The clutch shaft bushes in the transmission case are self-lubricating. Oil or grease should ON NO ACCOUNT be applied. Correct pedal adjustment.
Fierceness or snatch.	Oil on driven faces. Binding of clutch pedal mechanism. Worn out driven plate facings.	Fit new driven plate. See above. Fit new driven plate.
Judder.	Oil, grease or foreign matter on driven plate facings. Contact area friction facings not evenly distributed. Note that 100% contact will not occur until clutch has been in use for some time, but contact area should be evenly distributed round the facings. Buckled driven plate(s).	Fit new driven plate. Adjust release levers correctly, using gauge plate. If this does not cure the trouble fit new driven plate. Fit new driven plate.
Rattle.	Anti-rattle spring(s) broken. Damaged driven plate. Worn parts in release mechanism. Excessive backlash in transmission. Wear in transmission bearings.	Fit new parts as necessary.
Abnormal facing wear.	Usually produced by over-loading and by excessive slip when starting.	In hands of the operator.
Dual Clutch only P.T.O. stops when tractor is halted.	Clearance at pressure plate adjusting screws too small.	Correct clearance.
P.T.O. cannot be stopped.	Clearance at pressure plate adjusting screws too great.	Correct clearance.

SECTION I

CLUTCH—Tractors fitted with 3-A-152 Diesel Engine



KEY

1. Clutch Adjusting Screw
2. Torsion Spring
3. Clutch Release Lever
4. Link Pin
5. Release Lever Pin
6. Clutch to Flywheel Screw
7. Clutch Cover
*8. 9" Belleville Spring
*9. 9" Pressure Plate
*10. 9" Driven Plate
11. Flywheel Plate
12. Pressure Springs
13. 11" Pressure Plate
14. Clutch End Rod
15. Rod End Pin
*16. Clutch Screw
17. 11" Driven Plate
18. Spacer Rings

FIG. 20
SECTION VIEW OF CLUTCH

GENERAL

The clutch fitted to the De Luxe FE-35 Tractor with the 3-A-152 engine is the Auburn Coil/Belleville Spring Ventilated Type Dual Clutch, and the clutch fitted to the basic version of this tractor is this same clutch with the secondary or P.T.O. clutch parts removed. (Parts marked * Fig. 20 are not fitted to the single clutch.)

In the case of the dual clutch, by depressing the clutch pedal through its first stage, the transmission drive only is disconnected, *i.e.*, for the purpose of changing gear and stopping and starting the tractor ; the power train to the pump and P.T.O. shaft is not affected. When the tractor is stopped in this manner, P.T.O. driven implements can still be operated and raised or lowered by means of the hydraulic system without interruption. The power train is disengaged by depressing the clutch through its second stage.

In the case of the single clutch, depressing the clutch through one stage will disconnect both the transmission and power train.

COMPONENTS

The components are illustrated in the sectional view of the unit (Fig. 20).

The dual clutch has a primary 11" (279.4 mm.) disc (17) driving the transmission shaft and a rearward secondary 9" (228.6 mm.) disc (10) driving the hydraulic pump and the power take-off input shaft.

The first is operated by the primary pressure plate (13) against the flywheel face, and the second is operated by a secondary pressure plate (9) against a false flywheel plate (11) secured to the engine flywheel by the clutch to flywheel screws (6).

Both pressure plates are interlocked with the clutch cover elements so that they can rotate with the flywheel and are also capable of axial movement. This movement is obtained through a single set of release levers (3) pivoted on the clutch housing cover (7) in such a way that the initial movement of the release levers operating against the pressure of 12 coil springs (12) moves the pressure plate rearwards, thus releasing the primary disc.

Further movement of the pressure plate, still actuated by the same release levers, butts three setscrews against the secondary pressure plate, thus moving this plate against the Belleville spring (8) (Fig. 3, Page I.3) and releasing the secondary disc.

The release levers are operated in the usual way by a clutch release bearing (see Page I.11 and Fig. 19) which in turn is actuated by the clutch pedal. The driven plates have bonded and riveted annular facings.

The flywheel has louvres to assist cooling and a spacer ring in three segments (18), is fitted between the flywheel and the flywheel plate to assist airflow.

CLUTCH PEDAL ADJUSTMENT

The clutch pedal free travel is periodically adjusted to $\frac{3}{8}$" (9.5 mm.) as detailed on Page I.3 and shown in Fig. 4, dimensions "X".

PRESSURE PLATE ADJUSTING SCREWS

Dual Clutch only

The clearance between the head of the three adjusting screws (see inset, Fig. 24) and the secondary pressure plate must be maintained at .090" $\pm$ .002" (2.286 mm. $\pm$ .0508 mm.) as indicated in Fig. 24.

An inspection cover plate is provided in the transmission case beneath the clutch assembly. This clearance can be checked through the access hole and the screws adjusted as necessary after loosening each lock-nut. The flywheel must be rotated to align the adjusting screws with the opening one by one.

TO REMOVE CLUTCH FROM ENGINE FLYWHEEL AND TO DISMANTLE

> **Warning.**—*The pressure of the coil springs may cause the clutch cover to fly up if the pressure is not released slowly and carefully.*

Both the single and dual clutches can be dismantled, simply, safely and quickly by adhering strictly to the following procedure. Components are shown in Fig. 21.

1. Insert three shipping bolts $\frac{1}{4}$" A.N.C. by $2\frac{1}{8}$" (54 mm.) through the clutch cover and the thrust spring at the left of each setscrew into holes which are tapped in the 11" (279.4 mm.) pressure plate.

   This will keep the clutch springs compressed, so avoiding the possibility of damage to the flywheel threads, which otherwise might be caused by the spring pressure acting against the flywheel fixing bolts as they are being released.

2. At this point it is felt advisable to mark the clutch cover outer pressure plate and the two inner pressure plates, so allowing them to be reassembled in the same relative position and the balance of the clutch assembly to be maintained.

3. Fit clutch centraliser MF.159.

4. Remove each L.H. cover plate attachment screw and replace with a $\frac{5}{16}$" U.N.C. × $3\frac{1}{4}$" (82.5 mm.) slave bolt with a $\frac{5}{16}$" U.N.C. slave nut screwed to within 1" (25.4 mm.) of the head of the bolt.
   Screw the slave bolts fully into the flywheel. Remove R.H. cover plate attachment screws.

5. Tighten the slave nuts down to the clutch cover and remove the three $\frac{1}{4}$" shipping bolts.

6. Slacken off the slave nuts approximately $\frac{1}{4}$" (6.4 mm.).

   N.B.—When slackening off these nuts, do so evenly. It is recommended that they should be slackened off in sequence, two flats at a time.

7. The roll or mills pin can now be tapped through the clutch cover against the secondary Belleville spring.

8. Sharply tap the pivot pin four or five times to shear the roll or mills pin.

9. Remove anchor clip springs and clutch release lever pivot pins.

10. Continue to slacken off the slave nuts until the spring pressure is completely released.

ASSEMBLING THE CLUTCH

Note.—The Belleville spring and clutch disc hub splines should be lubricated with a light smear of "Lubriplate" 70 grease (Export Market only) or "Keenol" K.G.20 and K.G.15 grease. The latter is manufactured by Messrs. Duckham and Co. Ltd., Hammersmith, London, W.6.

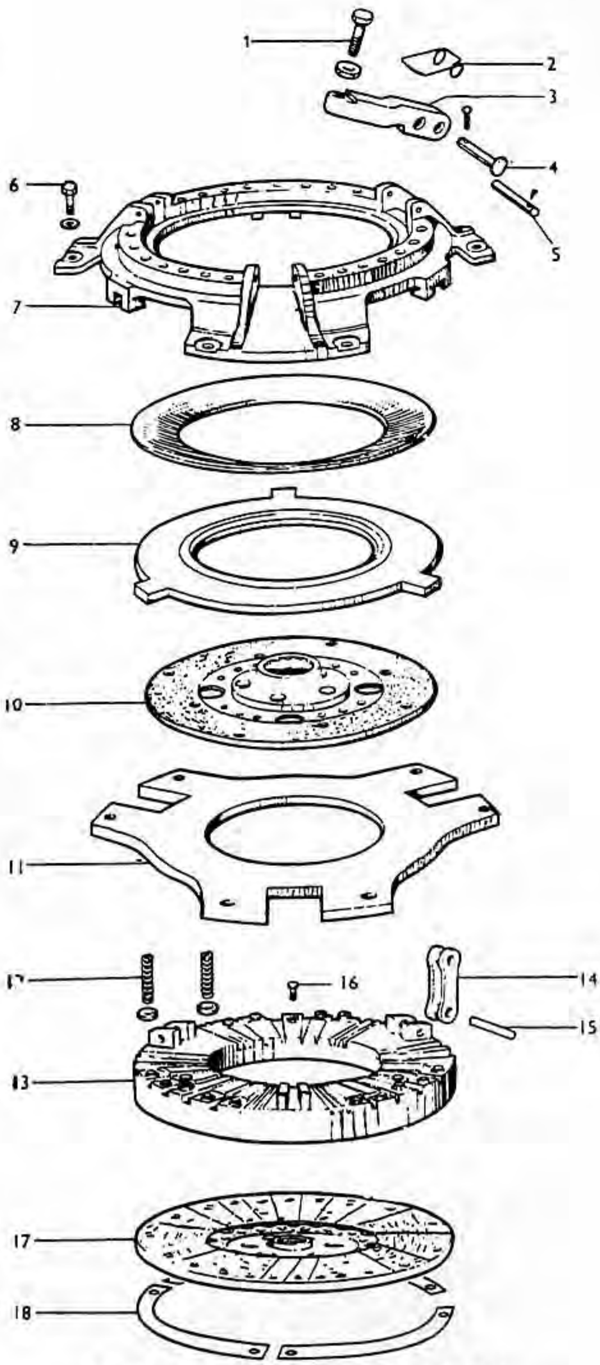


FIG. 21 EXPLODED VIEW OF CLUTCH

KEY

1.	Clutch Adjusting Screw	7.	Clutch Cover	13.	11" Pressure Plate
2.	Torsion Spring	*8.	9" Belleville Spring	14.	Clutch End Rod
3.	Clutch Release Lever	*9.	9" Pressure Plate	15.	Rod End Pin
4.	Link Pin	*10.	9" Driven Plate	*16.	Clutch Screw
5.	Release Lever Pin	11.	Flywheel Plate	17.	11" Driven Plate
6.	Clutch to Flywheel Screw	12.	Pressure Springs	18.	Spacer Rings

If these products are not available, use a Molybdenum Disulphide grease which has proved to be satisfactory for the clutch splines of other models.

1. To assemble the clutch, proceed as follows: Components are shown in Fig. 21. Place the 11" (279.4 mm.) pressure plate face down on the work bench.

2. Reassemble the coil springs, ensuring that asbestos washers are fitted beneath each.

3. Position the flywheel plate, flat side uppermost on the assembly and line up the marks previously made.

4. Place and centralise the 9" (228.6 mm.) driven plate in the pressure plate with the longer hub of the driven plate uppermost and place the 9" (228.6 mm.) pressure plate on the assembly with the flat side against the driven plate. Again align the marks.

5. Fit the Belleville spring concave upwards.

6. Fit the clutch cover and check that the coil springs and asbestos washers are correctly located.

7. Fit the anchor clip springs and clutch release lever pivot pins, substituting 'D' headed pins with retaining split pins instead of the original ones.

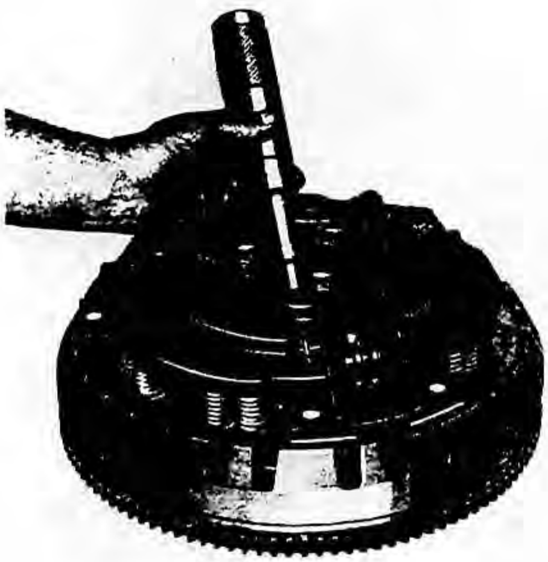


FIG. 22
CLUTCH CENTRALISER

Note.—The 'D' headed pins must be fitted so that the 'D' head is leading in the direction of rotation.

Care must be taken to ensure that the Belleville spring and the driven plate are centralised. It is recommended that MF.159 Clutch Centraliser be used (see Fig. 22).

Ensure that the rod-ends are not trapped beneath the cover, as this could easily crack it during assembly. An elastic band around the release levers will ensure correct positioning.

8. Mount the clutch assembly in a press with the clutch cover uppermost, place a bar across the centre of the cover clear of the release levers and compress the clutch assembly sufficiently to allow shipping bolts to be fitted.

TO ASSEMBLE CLUTCH TO FLYWHEEL

1. Set spacer ring segments in position on flywheel flange.

2. Assemble the clutch assembly and the primary driven plate on MF.159 clutch centraliser, and insert the centraliser into the flywheel pilot bearing.

3. Position the clutch assembly and fit the clutch cover attachment screws, tightening them one turn at a time by diagonal selection until fully home. It is strongly recommended that the clutch centraliser MF.159 be used, as difficulty may be encountered in assembling the engine to the transmission case.

4. Remove the clutch centraliser and the shipping bolts (see Fig. 22).

Alternatively:

1. Assemble the clutch components to the flywheel using the clutch centraliser MF.159.

2. Fit three $\frac{5}{16}$" U.N.C. × $3\frac{1}{4}$" (82.5 mm.) slave nuts and bolts through the clutch cover to the flywheel.

3. Tighten down the slave nuts until the shipping bolts can be fitted.

4. Remove slave bolts and fit cover plate attachment screws.

5. Remove shipping bolts.

CLUTCH ADJUSTMENTS

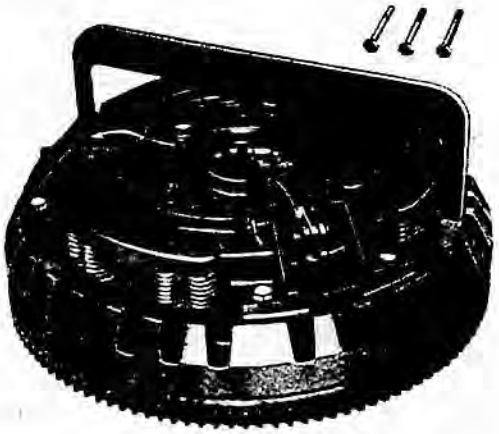


FIG. 23 RELEASE LEVER HEIGHT SETTING GAUGE

Set the clutch release levers to a height of 2.65"-2.72" (67.31 to 69.10 mm.) measured from the face of the spacer ring segments, using MF.220 Lever Fulcrum Height Setting Gauge (see Fig. 23).

Adjust on the screw at the end of the toggle lever, tightening the lock-nut when the adjustment is satisfactory.

Variation in toggle lever height must not exceed .015" (.381 mm.).

Set the secondary clutch setscrew clearance to .090" $\pm$ .002" (2.286 mm. $\pm$ .0508 mm.) and tighten the locknuts (see Fig. 24).

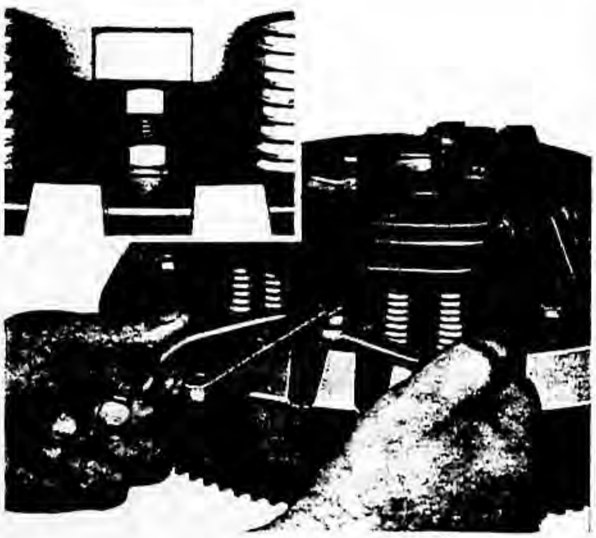


FIG. 24 CLUTCH SETSCREW CLEARANCE ADJUSTMENT

This adjustment determines the point in the clutch pedal travel when the secondary pressure plate begins to release. If there is too little clearance at this point, the secondary driven plate will begin to release before the primary driven plate is fully released and the forward motion of the tractor cannot be stopped without also stopping the power take-off. Too much clearance at this point will restrict the movement of the secondary pressure plate and the result will be that the secondary driven plate will not be fully released at the end of the clutch travel ; thus it would be impossible to stop the power take-off.

IMPORTANT

Actuate the three toggle levers together to bed-in the components, until, after a series of applications, the height of the toggle levers remain constant at the correct setting.

SERVICE TOOLS

MF.159	Clutch Centraliser.
MF.220	Lever Fulcrum Height Setting Gauge.
MF.158	Secondary Clutch Setting Gauge.

CLUTCH RELEASE BEARING

No attention should be required between major tractor overhauls. The bearing which is of the self-lubricating type is packed with H.M.P. grease on assembly.

To remove the bearing, proceed as for clutch removal and expose assembly. With the transmission withdrawn from the engine, the release bearing will remain in position on its hub, floating on the main drive gear bearing retainer and retained by two release bearing springs.

By releasing the springs from the hub, the bearing and hub can be slid off the mounting and the bearing then removed. (Fig. 19 refers).

It is recommended that the bearing should be replaced at major tractor overhauls.

Bearing adjustment is obtained by positioning the clutch pedal. SEE CLUTCH PEDAL ADJUSTMENT.

CLUTCH PILOT BEARING

The transmission main drive shaft is supported in the engine flywheel by this self-lubricating bearing which may be examined when the clutch assembly is removed.

No Service attention should be required, but it should be examined for wear during major overhauls and renewed as required.

CLUTCH DATA

Transmission Driven Plate	11″ (279.4 mm.). Lining Material (1133C Bonded and Riveted). Mintex H.19 Bonded and Riveted. (Bonding Material : Redux 64).
P.T.O./Hydraulic Pump Driven Plate	9″ (228.6 mm.). Lining Material : 1133C Riveted.
Thrust Springs (Primary Transmission) Driven Plate	12 Coil Springs.
Colour	Yellow.
Fitted Load	84 lbs. ± 5% (38.10 Kg. ± 5%).
Secondary (P.T.O./Hydraulic Pump) Driven Plate	Belleville Spring.
Load—Released Position	510-440 lb. (231.33-199.58 Kg.).
Engaged Position .065″ (1.65 mm.) Deflection	1080-960 lb. (489.82-435.45 Kg.).
Toggle Release Levers	
Height from Flywheel Face	4.13/32″ + 1/16″ — 0 (111.92 mm. + 1.587 mm. — 0).
Height from face of Spacer Ring Segment	2.65″-2.72″ (67.31 mm.-69.08 mm.).
Movement of Lever Ends	.654″ (17.611 mm.).

Variations in Toggle Lever Heights must not exceed .015″ (.381 mm.).

Adjusting Screws	Clearance between screw heads and rear pressure plate (P.T.O./Hydraulic Pump Drive) .090″ ± .002″ (2.286 ± .0508 mm.).

CLUTCH FAULT/CORRECTION. See Page 1.12.

MASSEY-FERGUSON

35 TRACTOR

WORKSHOP SERVICE MANUAL

SECTION J

TRANSMISSION

TRANSMISSION

Section J

CONTENTS

CONTENTS—*continued.*

TRANSMISSION

Section J

LIST OF ILLUSTRATIONS

TRANSMISSION

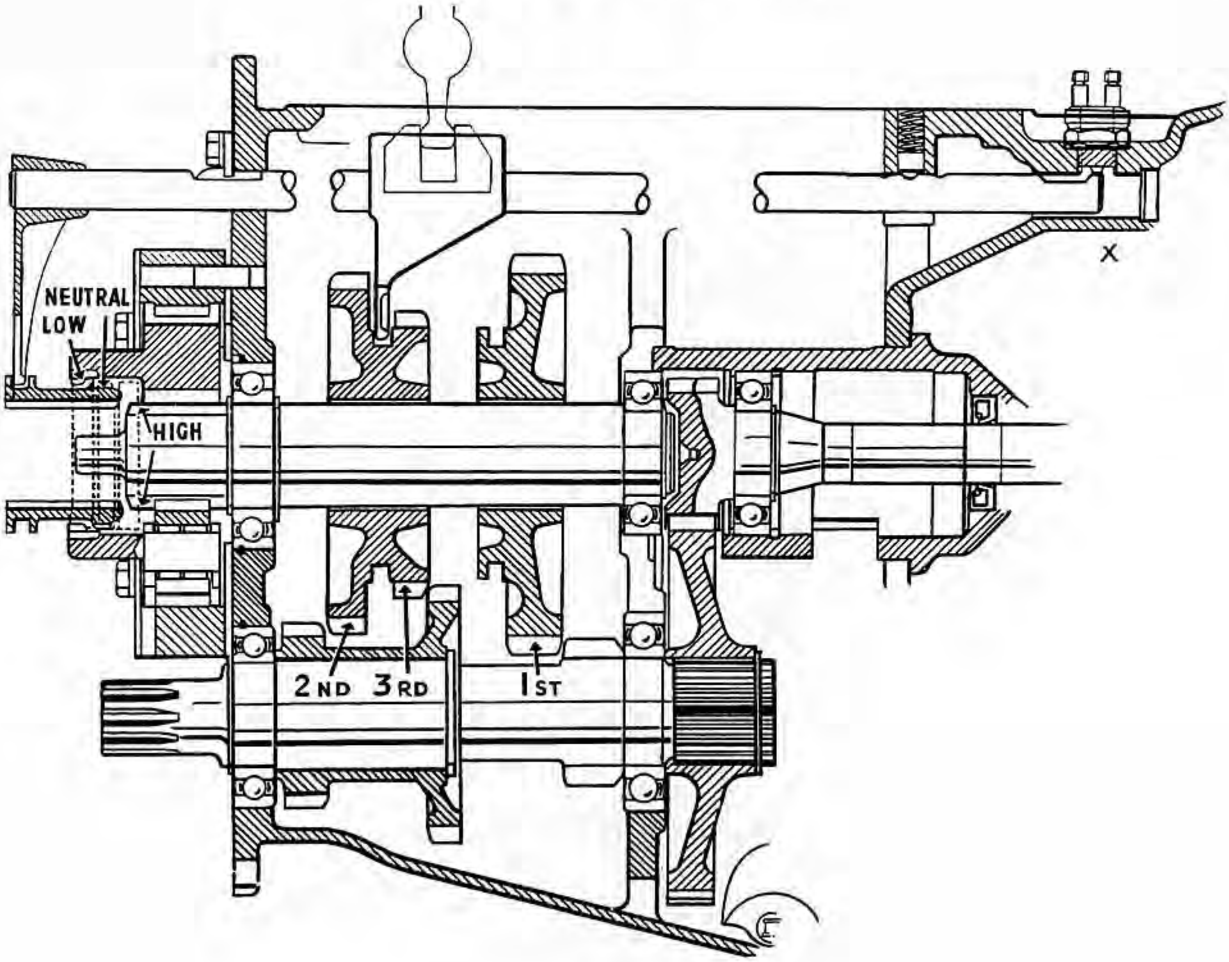


FIG. 1
SHOWING GEAR ENGAGEMENT TRANSMISSION

GENERAL DESCRIPTION

The transmission assembly is a three-speed forward and one reverse sliding spur gear transmission compounded by a planetary reduction gear set on the output end of the main shaft. This combination produces a total of six forward and two reverse speeds.

There are two gear levers : The Gear Shift Lever for the change speed gears and the Dual Range Selector Lever for the planetary unit. The three forward and one reverse gears are indicated by raised characters on the transmission housing adjacent to the Gear Shift Lever, and the high and low ranges of the Dual Range Selector Lever are shown by a raised "H" and "L"—See Fig. 2. The neutral or start position for this lever is indicated by a raised "S", and, for starting, the lever must be in this position in order to close the starter motor circuit. Low or high range must be engaged before the tractor will move off. When the lever is in the "Low" range, the planetary reduction is engaged and effects a 4 : 1 reduction of the transmission speed in all speeds.

All of the gears are case hardened, heat treated alloy steel forgings. The gears in the first reduction gear train have helical cut teeth for quietness and long life. Change speed gears have spur teeth and slide on their shafts directly into engagement for ease of shifting and simplicity of construction. The shafts are supported on ball bearings and require no shims, pre-load or adjustment.

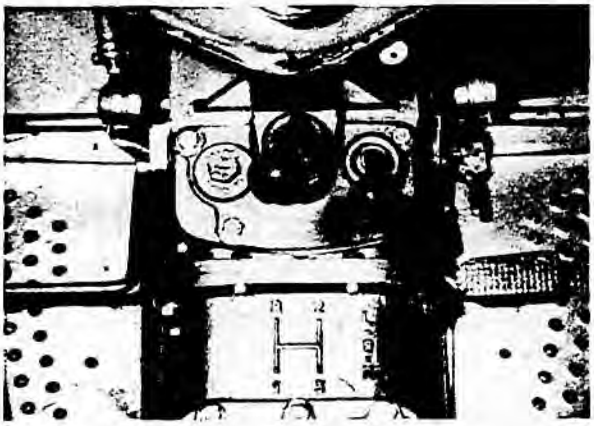


FIG. 2
GEAR LEVERS AND FILLER PLUG

The shifter forks are secured by locking pins to shifter rails which slide in holes in the end walls of the transmission casing. Chisel ended spring plungers work in notches in the rails to locate selectors for appropriate gears, while rail interlocking is by a plunger supported below the rail stop plate. The planetary reduction unit is coupled to the rear or output end of the transmission main shaft. The planet pinion carrier is the rotating member and the planetary gear ring is fixed to the transmission rear wall. With the planetary reduction unit disengaged, i.e., the Dual Range Selector Lever in "High" range, the main drive shaft is coupled directly to the gearbox main shaft. With the planetary reduction unit engaged, i.e., the Dual Range Selector Lever in "Low" range, the main drive shaft is coupled to the planet carrier and the drive is via the sun wheel and planet wheels, giving a 4 : 1 reduction in all speeds. The entire transmission assembly is enclosed in a cast iron case which forms a portion of the main structure of the tractor, and the gears run in a 6.6 Imperial gallon (30.28 litres) bath of oil. A common filler hole which serves the transmission, hydraulic system and rear axle assemblies is situated on the cover plate adjacent to the gear change lever. Two magnetic drain plugs are fitted, beneath the transmission and rear axle housings respectively.

REVERSE GEAR (See Fig. 3)

The 3rd countershaft gear splined to the countershaft is in constant mesh with the rear (larger gear) of the reverse gear cluster. The 1st mainshaft gear splined to the mainshaft is shifted into mesh with the front (small gear) of the reverse gear cluster. The drive for reverse gear is therefore from 3rd gear countershaft to reverse cluster to 1st mainshaft gear.

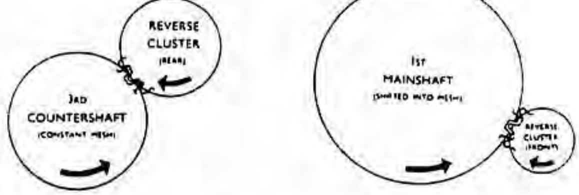


FIG. 3
REVERSE GEAR ENGAGEMENT
(viewed from front end)

STARTING SAFETY DEVICE (X Fig. 1)

The safety starter switch will operate only when its plunger is compressed by the planetary shifter rail, when the dual range selector lever is in its neutral position. This closes the starter motor circuit. When the dual range selector lever is in either high or low range the switch plunger is not compressed as it protrudes either into the space beyond the end of the shifter rail (high range) or into the recess cut in the shifter rail (low range). It is therefore impossible inadvertently to start the engine with the tractor in gear and it is necessary to engage high or low range before the tractor will move off.

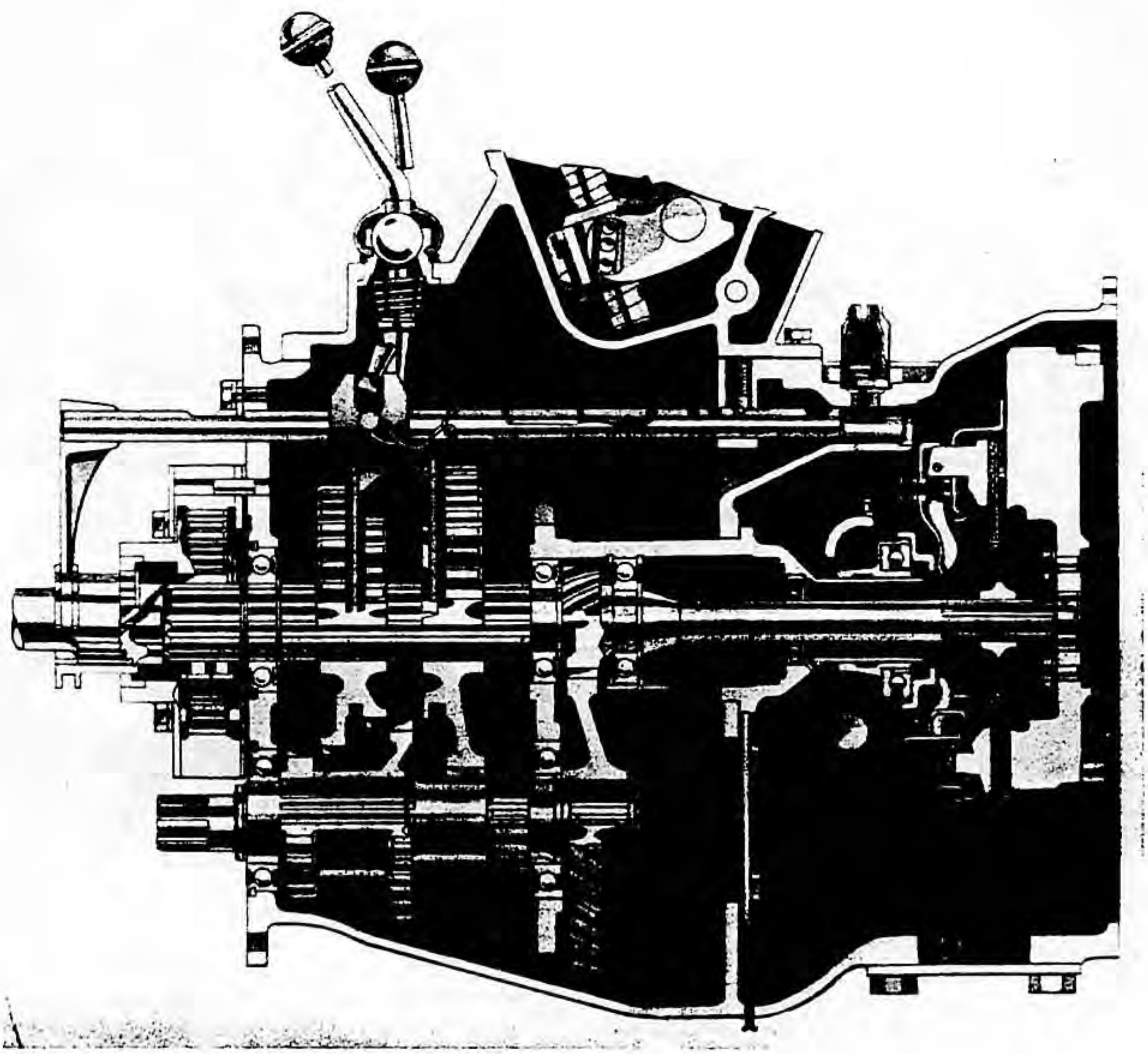


FIG. 4
SINGLE CLUTCH TRANSMISSION

"BASIC" TRACTOR—SINGLE CLUTCH TRANSMISSION (Fig. 4)

With a single clutch, the main input shaft is rotated by the clutch driven disc and the main driving pinion is forged integral with it. The main driven gear is splined to the solid countershaft, at the rear end of which the hydraulic pump and power take-off shaft is coupled.

"DE LUXE" TRACTOR—DUAL CLUTCH TRANSMISSION (Fig. 5)

On tractors fitted with the Dual Clutch, the transmission main input shaft (A) is rotated by the clutch forward primary disc and has the driving pinion forged integral with it. This pinion rotates a driven gear splined to a hollow countershaft (B), which carries the gears mating with the sliding

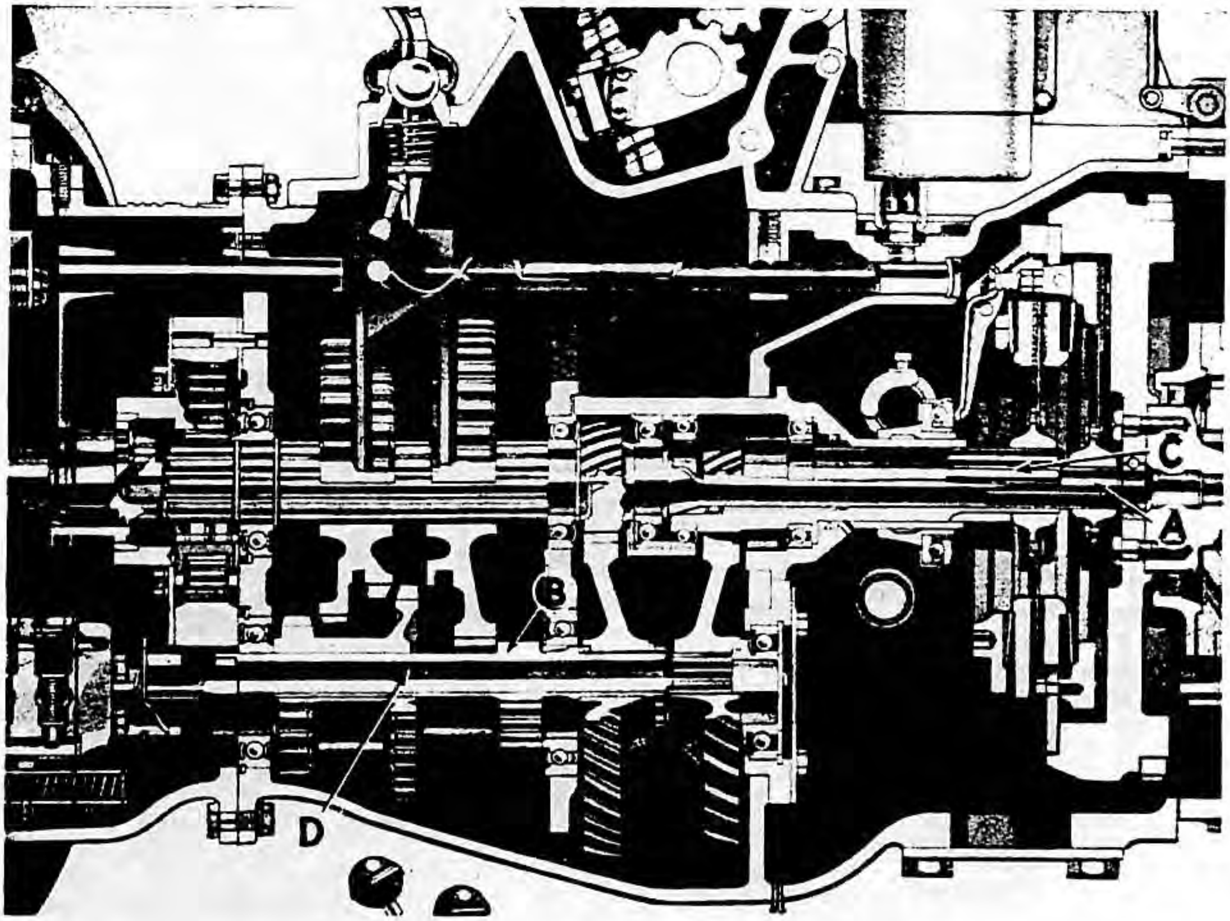


FIG. 5
DUAL CLUTCH TRANSMISSION

change speed gears on the main shaft. The drive for the hydraulic pump and P.T.O. is taken from the rear secondary clutch disc via a tubular drive shaft (C) which encloses the transmission main input shaft (A). This tubular shaft (C) is geared to a solid shaft (D) which passes through the hollow countershaft (B) to transmit the drive from the engine to the hydraulic pump and power take-off independently of the transmission.

(Refer also the Clutch and P.T.O. sections of this Manual).

DATA

Six forward speeds. Two reverse speeds. Oil Capacity : 6.6 Imperial gallons (30.28 litres).

Overall Reduction

Selected Ratio		*Road Speeds* 1500 *r.p.m.*		2000 *r.p.m.*		*Selected Ratio*		*Road Speeds* 1500 *r.p.m.*		2000 *r.p.m.*	
LOW		m.p.h.	k.p.h.	m.p.h.	k.p.h.	**HIGH**		m.p.h.	k.p.h.	m.p.h.	k.p.h.
1st	205.5 : 1	.96	1.54	1.28	2.06	4th	51.4 : 1	3.82	6.15	5.10	8.20
2nd	137 : 1	1.43	2.3	1.91	3.08	5th	34.2 : 1	5.74	9.25	7.65	12.30
3rd	74.7 : 1	2.63	4.2	3.51	5.65	6th	18.7 : 1	10.50	16.90	14.00	22.50
Rev.	153.8 : 1	1.28	2.06	1.71	2.75	Rev.	38.5 : 1	5.10	8.20	6.8	10.9

DISMANTLING

When complete dismantling of the transmission assembly is to be undertaken, it will be necessary to isolate the assembly from the rest of the tractor. This is achieved by splitting the tractor between the engine and transmission and between the transmission and the centre housing and removing the instrument panel and steering box.

Where only limited dismantling is required, instructions to this effect will be detailed under the appropriate heading.

To Remove Instrument Panel (J-1)

1. Unscrew hood retaining wingnuts, move hood forward and support in raised position.
2. Remove steering wheel nut and washer. Remove steering wheel using Service Tool MFB.8. Remove woodruff key, felt washer, grease nipple and steering column collar.
3. Disconnect batteries.
4. Remove ammeter by unseating rubber grommet. Remove heater and starter switch by unscrewing nut holding key barrel to panel. Disconnect oil pressure gauge pipe, throttle rod and tractormeter drive cable.
5. Remove fuel cut-off knob and return spring.
6. Remove setscrews and nuts and bolts holding panel to battery support and steering box and lift off instrument panel.

To Remove Steering Box (J-2)

1. Remove setscrews holding steering box to battery platform support.
2. Remove nuts securing drag links to drop arms and tap drag links free.
3. Remove cable guard by removing three setscrews holding it to steering box. Remove battery cable.
4. Remove remaining setscrews holding steering box to transmission case and lift off steering box.
5. Remove transmission shifter rail springs and plungers.

To Split Tractor between Engine and Transmission Housing (J-3)

1. Remove standard exhaust pipe and silencer (but not on vertical exhaust models).
2. Remove step assemblies and radius rods from radius rod ball caps.
3. Remove brake rods from R.H. brake pedal and combined brake arm.
4. Carry out Instructions 1, 3, 4, and 5 of J-1, disconnect neutral safety switch and remove nuts and bolts securing panel to battery platform.
5. Carry out Instructions 1, 2 and 3 of J-2 and remove setscrews securing battery platform support to steering box.
6. Remove starter motor and filter to bracket setscrews to allow fuel filter to be moved sufficiently to clear clutch housing when separating the engine from the transmission housing.

FIG. 6
MF.165, FRONT AXLE WEDGE TOOL

7. Drain transmission and centre housing assemblies and clean and replace magnetic drain plugs.
8. Fit Service Tool MF.165 between the front axle beam and the front axle support as shown in Fig. 6.

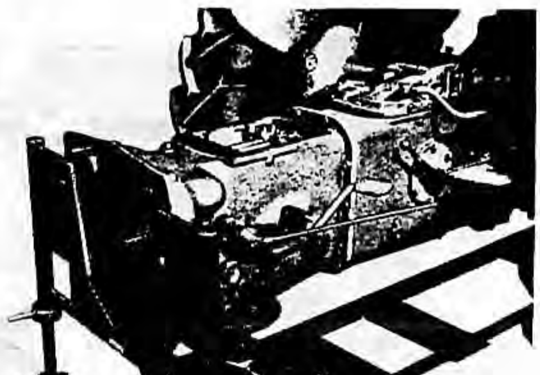


FIG. 7
TRACTOR SPLIT BETWEEN TRANSMISSION AND ENGINE

9. Position the rails of MF.27, Tractor Dismantling Stand and support the rear of engine on Engine Trolley Jack and transmission housing on Transmission Trolley Jack.

10. Remove transmission housing to engine setscrews and split the tractor. Depressing the clutch pedal will initially separate the engine and transmission housing if all attachments are free. Push the engine forwards on the rails.

11. Fit Support Stand of MF.27 to front face of transmission assembly as shown in Fig. 7.

NOTE.—Fig. 7 shows the instrument panel and steering box removed but this need not necessarily apply.

To Remove Clutch Release Fork and Bearing (J-3a)

1. Split tractor as detailed in J-3.

2. Remove two clutch release springs and clutch release bearing and carrier.

3. Remove locking wire and locking screws from clutch release fork.

4. Withdraw clutch pedal and shaft. Drive clutch release pivot shaft out through clutch shaft bore from left-hand side thus freeing clutch release fork.

To Remove Main Drive Shaft Retainer (Dual Clutch Models) (J-3b) (Fig. 8)

1. Split tractor as detailed in J-3.

2. Remove combined brake arm, which is keyed and clamped with a nut and bolt. Slide out combined brake cross-shaft from right-hand side.

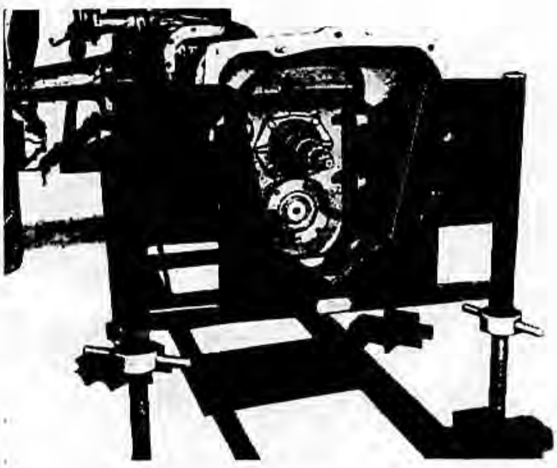


FIG. 8
REMOVAL OF FRONT P.T.O. BEARING HOUSING

3. Remove front P.T.O. cap and setscrews and gasket. Remove snap ring from solid front P.T.O. main drive shaft and using two slave setbolts ($\frac{9}{16}$" × 3" A.F.), (See Fig. 8), in tapped holes, remove bearing housing, gasket and bearing. Remove thrust washer, noting that the raised lip faces forward.

4. Remove inner snap ring from P.T.O. main drive gear and draw front P.T.O. main drive shaft forward sufficiently to allow drive gear to rest on non-splined part of shaft. This will allow sufficient clearance to allow the P.T.O. and main drive shaft pinions to be withdrawn with the main drive shaft retainer.

5. Remove setscrews holding main drive shaft retainer and remove assembly.

To Dismantle the Main Drive Shaft Retainer Assembly (J-3c)

1. Remove snap ring locating main drive shaft pinion and drive shaft complete with bearing.

2. Remove snap ring locating P.T.O. main drive shaft pinion bearing and drive out pinion complete with bearings.

3. Press off P.T.O. pinion main drive shaft pinion bearings. Remove snap ring locating main drive shaft pinion bearing and press off bearing.

4. Remove P.T.O. main drive shaft pinion and main drive shaft pinion oil seals.

To Remove and Dismantle Main Drive Shaft Retainer (Single Clutch Models) (J-3d)

1. Split tractor as detailed in J-3.

2. Remove setscrews holding main drive shaft retainer and remove assembly.

3. Remove main drive shaft pinion bearing snap ring and drive out pinion complete with bearing.

4. Remove forward bearing snap ring and press off bearing.

5. Remove oil seal.

To Split Tractor between Transmission and Centre Housing (J-4)

1. Drain transmission and centre housings of oil and clean and replace magnetic plugs.

2. Remove step assemblies and brake rods from right-hand brake pedal and combined brake arm.

3. Remove standard exhaust pipe and silencer (but not on vertical exhaust models).

4. Remove cable guard by removing three set-screws holding it to steering box and remove battery cable.
5. Position rails of MF.27, Tractor Dismantling Stand and support transmission housing on transmission trolley jack and centre housing on centre housing trolley jack.
6. Fit Service Tool MF.165 between front axle beam and front axle support (see J-3, detail 8 and Fig. 6).
7. Remove transmission to centre housing bolts. Push rear axle and centre housing rearwards.
8. Fit transmission case stand to rear face of transmission case.

To Remove and Dismantle Epicyclic Reduction Unit (J-4a)

1. Split tractor as detailed in J-4.
2. Remove planetary shifter fork and planetary shift coupling.
3. Remove plate to carrier screws and withdraw epicyclic reduction unit.
   This unit should be withdrawn rearwards to avoid damaging the dowel.
4. When the epicyclic unit is stripped down, examine two thrust washers. Signs of contact with epicyclic carrier unit pinions will be evident and thrust washers should be reversed on reassembly, but should be renewed if the thrust washers are scored.
   Scoring may indicate that the pinions are not correctly located and, in such cases, the carrier unit should be renewed.
   Fig. 9 shows the transmission case stand attached and the epicyclic reduction unit removed.

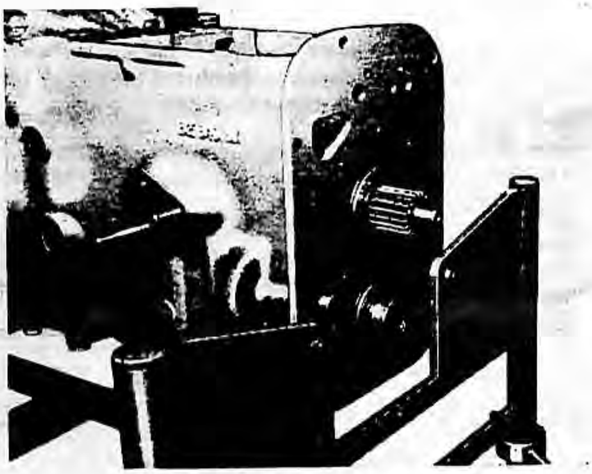


FIG. 9
REAR FACE OF TRANSMISSION CASE

To Remove and Dismantle the Gear Levers (J-5)

1. Remove steering box as detailed in J-2.
2. Press gear shift lever spring seat against spring and turn it so that it can be removed along the groove machined at the base of lower section of gear lever. Remove spring.
3. Remove gear shift lever covers.
4. Unscrew locking rings.
5. Drift out locking pins.

NOTE.—Turn planetary shift lever through 90° to drift out locking pin.

6. Draw both levers, complete with cups, downwards through cover and withdraw levers from cups.

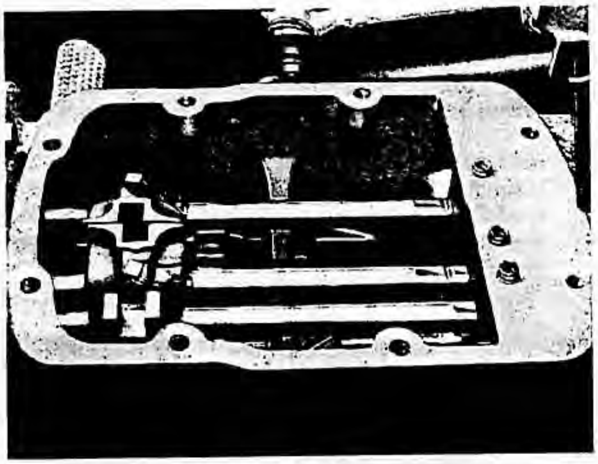


FIG. 10
TRANSMISSION CASE ASSEMBLY WITH STEERING BOX REMOVED

Complete Dismantling of Transmission Case Assembly (J-6)

1. Remove instrument panel (see J-1) and steering box (see J-2), (see Fig. 10).

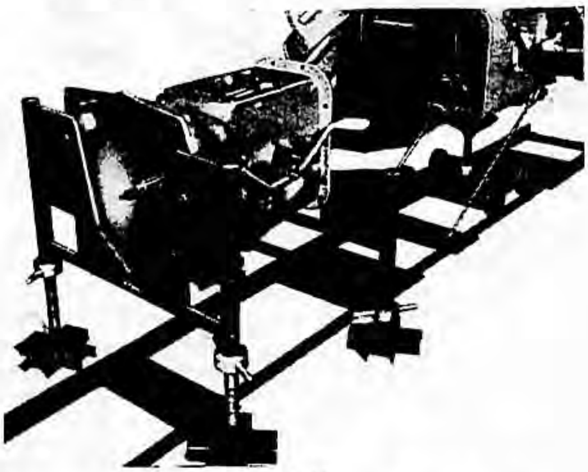


FIG. 11
TRANSMISSION CASE ASSEMBLY ISOLATED

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2. Split tractor between engine and transmission housing (see J-3) and between transmission and centre housings (see J-4).
   Fig. 11 shows transmission case assembly fitted to transmission stands and isolated from rest of tractor.

3. Remove locking wire from all fork lock screws and remove screws.
   Remove shifter rail springs and selector plungers.

4. Remove gear lever stop plate and selector lock pin.

5. Remove and dismantle epicyclic reduction unit as detailed in J-4a.

6. Withdraw planetary, reverse and low shifter, and intermediate and high shifter rails rearwards and remove interchangeable forks.

7. Remove clutch release fork and bearing as detailed in J-3a, and remove keyed combined brake arm and slide out combined brake cross-shaft, completely with pedals, from right-hand side (See Fig. 12).

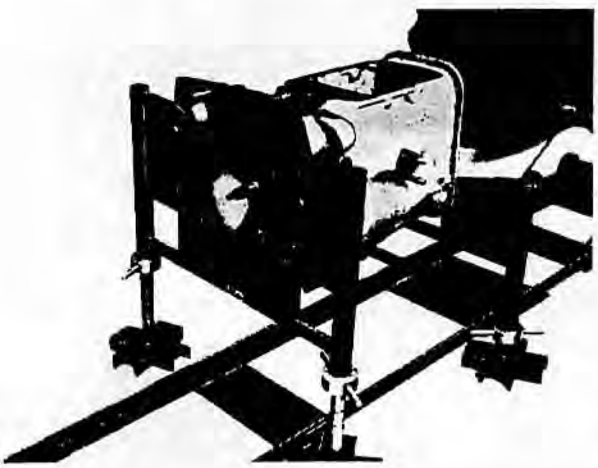

FIG. 12
SHIFTER RAILS AND PEDAL SHAFTS REMOVED

8. Remove front P.T.O. cap with setscrews and gasket. Remove snap ring from solid front P.T.O. main drive shaft and using two slave setbolts ($\frac{9}{16}''$ × 3" A.F.), (See Fig. 8) in tapped holes, remove bearing housing, gasket and bearing. Remove thrust washer, noting that the raised lip faces forward.

9. Remove inner snap ring from P.T.O. main drive gear and drive front P.T.O. main drive shaft forwards, so allowing P.T.O. main drive gear to drop to bottom of case. (See Fig. 13).

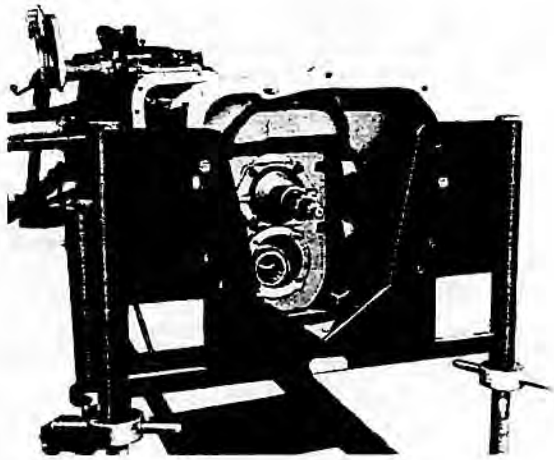

FIG. 13
P.T.O. MAIN DRIVE SHAFT REMOVED

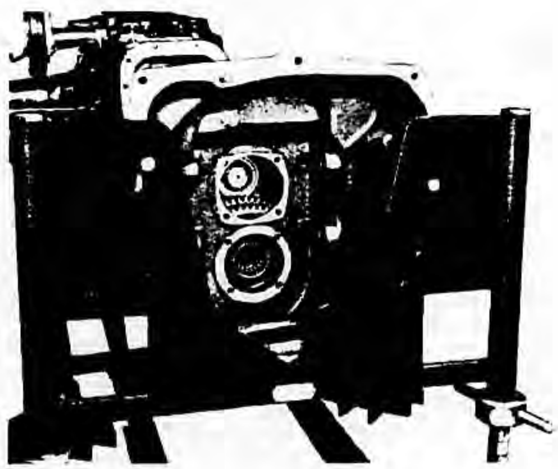

FIG. 14
MAIN DRIVE SHAFT RETAINER REMOVED

10. Remove setscrews holding main drive shaft retainer and remove assembly. (See Fig. 14). Remove P.T.O. main drive gear.

11. Remove snap ring from front end of hollow countershaft assembly and remove constant mesh gear.

12. Slide low speed gear forwards against centre flange of transmission case, and intermediate and high gear rearwards against rear flange and wedge gears apart with suitable piece of bar or tube. (See Fig. 15).

    Remove snap ring from forward end of main transmission shaft and drive shaft out rearwards. Remove low and intermediate and high gears. Remove mainshaft bearing from centre flange.

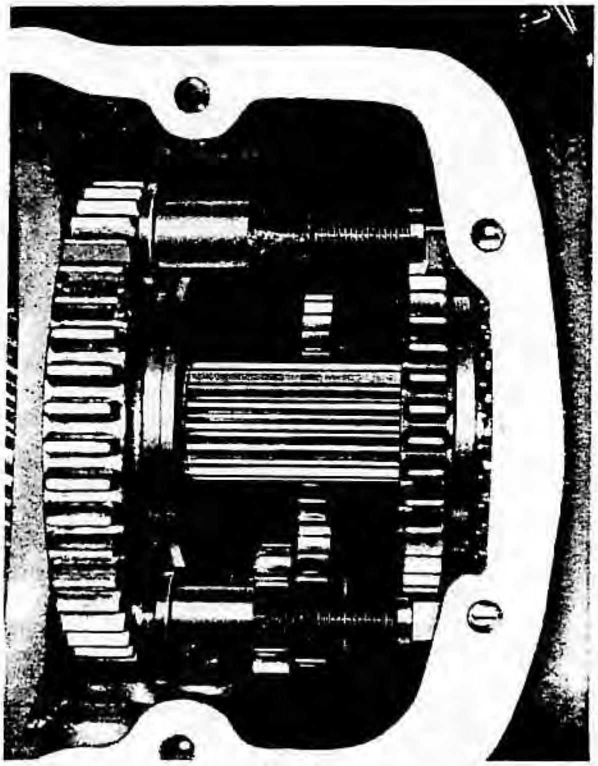

FIG. 15
LOW AND INTERMEDIATE HIGH GEARS WEDGED

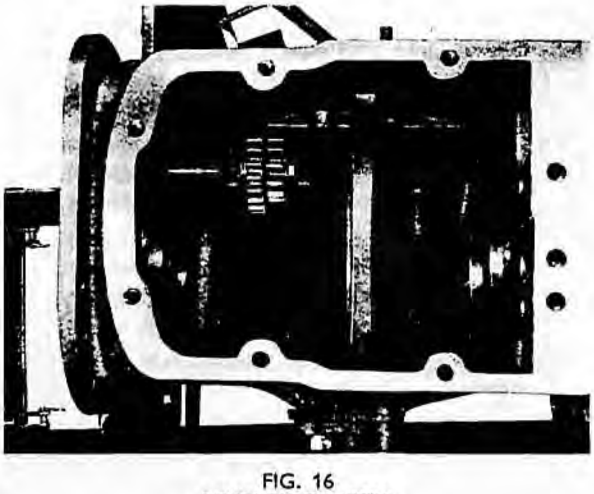

FIG. 16
REVERSE CLUSTER

13. Remove snap ring from rear of countershaft and drive shaft out forwards. Remove high speed and intermediate speed pinions. (See Fig. 16).
14. Remove reverse shaft stop and withdraw shaft slightly to rear. Insert dummy shaft (2.00″ long, 0.999″ dia. (50.8 mm. long, 25.37 mm. dia.)) into reverse shaft bore from front end and push reverse shaft out. The reverse gear cluster can then be removed with its rollers in position.

REASSEMBLY

The following sequences cover both the reassembly and replacement of individual assemblies and the transmission case assembly as a whole.

All components must be thoroughly cleaned and examined for wear or damage, since the lubricant used in the transmission is also used in the rear axle and hydraulics.

To Reassemble Main Drive Shaft Retainer (Dual Clutch Models) (J-7a)

1. Fit P.T.O. main drive shaft pinion, complete with bearings, into main drive shaft retainer and position snap ring.

   Service Tool MF.178 must be fitted over the splines of shaft during this operation to protect oil seal, as shown in Fig. 17.

FIG. 17
USE OF MF.178

2. Fit main drive shaft pinion, complete with bearing, through P.T.O. main drive shaft pinion into main drive shaft retainer.

NOTE.—Before the main drive shaft pinion is driven fully home, install snap ring between gear and bearing and then drive fully home to position snap ring in groove.

Service Tool MF.177 must be fitted over splines of shaft during this operation, to protect oil seal, as shown in Fig. 18.

To Reassemble Main Drive Shaft Retainer (Single Clutch Models) (J-7b)

1. Fit main drive shaft retainer oil seal.
2. Fit bearing to main drive shaft pinion and fit snap ring.

FIG. 18
USE OF MF.177

3. Fit forward snap ring in main drive shaft retainer.
4. Using Service Tool MF.177 fitted over splines of pinion, replace pinion in main drive shaft retainer.

NOTE.—Before main drive shaft pinion is driven fully home, install snap ring between gear and bearing and then drive fully home to position snap ring in groove.

To Refit Main Drive Shaft Retainer with Tractor Split at Engine only (Dual Clutch Models) (J-7c)

(These instructions are based upon the assumption that the tractor is in the condition achieved by instructions J-3b)

1. Using new gasket replace main drive shaft retainer and secure with four setscrews.
2. Working through bottom bore in centre flange, reposition P.T.O. main drive gear on splines of front P.T.O. main drive shaft and fit snap ring. Push shaft through hollow countershaft and through countershaft needle bearing.
3. Replace thrust washer with raised lip forwards.
4. Using Service Tool MF.218 draw on bearing housing, complete with bearing and snap ring until inner snap ring can be installed on shaft.
5. Using new gasket, fit front P.T.O. cap.

To Refit Main Drive Shaft Retainer with Tractor Split at Engine only (Single Clutch Models) (J-7d)

Using new gasket replace main drive shaft retainer and secure with four setscrews.

To Replace Clutch Release Fork and Bearing (J-8)

1. Position clutch release fork and fit clutch release pivot shaft from R.H. side and clutch pedal shaft, complete with pedal from L.H. side.
2. Fit fork locking screws through fork into shafts and lock with No. 16 S.W.G. locking wire.
3. Fit clutch release bearing carrier and bearing and fit two clutch release springs.
4. Refit brake shaft, complete with pedals, and refit combined brake arm.

Complete Reassembly of Transmission Case Assembly (J-9)

(These instructions are based upon the assumption that the transmission case assembly has been isolated from the tractor and completely dismantled).

1. Replace reverse gear cluster, small gear to front, using dummy shaft to retain needle rollers. Push reverse shaft into position, so displacing dummy shaft. Fit reverse shaft stop.
2. Replace hollow countershaft from front fitting high and intermediate speed pinions, before tapping countershaft gently through rear bearing.
3. Fit countershaft front bearing in lower bore of centre flange and fit constant mesh gear and snap ring.
4. Wedging front of countershaft against front flange with block of wood, tap rear bearing home and fit snap ring.
5. Fit rear bearing, together with circlips, onto mainshaft. Position front bearing in housing bore. Enter mainshaft from rear of housing, fitting intermediate and high gear and low speed gear, and tap shaft through front bearing until snap ring can be fitted.
6. Replace epicyclic reduction unit with oil channels in front cover plate and planetary gear shim at top.
7. Place P.T.O. main drive gear in bottom of housing in front of constant mesh gear and, using new gasket, fit main drive shaft retainer assembly, securing it with four setscrews.

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8. Replace front P.T.O. main drive shaft from front. Slide on P.T.O. main drive gear and fit snap ring and replace thrust washer with raised lip forwards.
9. Pull bearing housing into housing bore using Service Tool MF.218.
10. Tap rear of P.T.O. main drive shaft forward gently until snap ring can be fitted.
11. Fit P.T.O. front cover, with new gasket and secure with setscrews.
12. Replace shifter rails and forks, planetary shift coupling and planetary shifter fork. Replace fork lock screws and lock with No. 16 S.W.G. locking wire.
13. Fit gear lever stop plate and selector lock pin.
14. Fit selector plungers and springs.

To Reassemble and Replace Gear Levers (J-10)

1. Fit cups into steering box bores, ensuring that locking pin holes are correctly positioned. Lock with locking ring.
2. Fit gear levers and lock with locking pins.
3. Fit gear shifter spring and gear shift seat to gear shift lever.
4. Fit gear shift lever covers and gear shift lever balls.

To Fit Centre Housing to Transmission Case Assembly (J-11)

1. Position trolley jack beneath transmission case assembly and remove transmission case stand from rear face of transmission case.
2. Push centre housing forward to join transmission case assembly and tighten nuts and bolts to 47-53 lbs. ft. (6·50-7·33 kg.m.). Use new gasket.
3. Fit rear drive shaft and shear member through P.T.O. shifter-lever cover, and replace cover.

NOTE.—Care must be taken *NOT* to 'screw' rear drive shaft onto main shaft. *Instructions 4-7 are based upon the assumption that the steering box and engine housing are fitted to the transmission case assembly.*

4. Replace rear battery negative to front battery positive cable and fit cable guard.
5. Refit standard exhaust pipe and silencer.
6. Replace step assemblies and brake rods.
7. Remove Service Tool MF.165 and fill transmission case assembly to correct level with recommended lubricant (see current Instruction Book).

To Fit Transmission Case Assembly to Engine Housing (J-12)

(The following instructions are based upon the assumption that the centre housing and transmission case assembly are joined).

1. Fit trolley jack beneath transmission case and remove transmission case stand from front face.
2. Address transmission case to engine housing and align one to the other, using adjustable screws on trolley jacks beneath transmission case and engine housing. Fitting a slave bolt on each side will greatly facilitate alignment. Ensure that no component will hinder free movement of either half of the tractor during this operation, particular attention should be paid to the fuel filter bowl and related pipes and to the battery platform support to steering housing mounting.
3. Push rear of tractor forwards and at the same time turn the flywheel. This will allow the splines of the primary plate of the clutch to engage the splines of the main drive shaft pinion. Still pushing tractor forwards, engage engine speed P.T.O. and turn P.T.O. shaft to allow splines of secondary clutch plate to engage splines of P.T.O. main drive shaft pinion.
4. Fit engine housing to transmission case assembly studs and tighten to torque of 50-55 lbs. ft. (6·91-7·60 kg.m.).
5. Refit standard exhaust pipe and silencer. Fit new exhaust pipe to manifold gasket.
6. Replace radius rods, step assemblies and brake rods.
7. Fit starter motor and reconnect. Reconnect neutral safety switch.
8. Refit fuel filter to mounting bracket.
9. Refit steering box and related parts as detailed in J-13.
10. Refit instrument panel and related parts as detailed in J-14.
11. Fill transmission case to correct level with recommended lubricant (See current Instruction Book).

To Fit Steering Box (J-13)

1. Ensure shifter rail plungers and springs are correctly located and fit new gasket.
2. Fit steering box, taking care not to damage gasket during this operation. Fit battery cable and cable guard and tighten down setscrews to torque of 50-55 lbs. ft. (6·91-7·60 kg.m.).

3. Tighten steering box to battery platform support setscrews.
4. Renew outer oil seals (felt) and refit drag links to rocker shafts with rocker shaft nuts and spring washers.

To Fit Instrument Panel (J-14)

1. Position instrument panel and secure to battery platform with nuts and bolts and to steering box with setscrews.
2. Replace fuel cut-off knob and return spring. Replace ammeter and heater and starter switch. Reconnect oil pressure gauge pipe, throttle control rod and tractormeter drive cable.
3. Reconnect batteries.
4. Replace steering column cover, grease nipple felt washer and position woodruff key.
5. Replace steering wheel, steering wheel washer and steering wheel nut.

DEFECT LOCATION

Cause and Remedy

Noisy Gearbox

1. Oil level low or incorrect grade used—Refill to correct level with correct grade. (See Instruction Book).
2. Chipped, worn or burred gears—Inspect and renew as required.
3. Damaged bearings—Inspect and renew as required.
4. Gears rubbing against adjacent gears or casting —shifter fork may be bent—renew as required.

Slipping Out of High and Low Range Transmission

1. Shifter fork bent—renew as required.
2. Shifter rail plunger springs weak—renew or add shims as required.
3. Shifter rail plunger jamming in transmission case bore—renew plunger and clean up bore.

TRANSMISSION—MULTI-POWER

The following operations detail dismantling and assembly instructions for tractors fitted with Multi-power transmissions.

GENERAL DESCRIPTION

The Standard transmission — three forward and one reverse compounded by a planetary gear to give six forward and two reverse road speeds — are driven by transmission counter shaft. By driving the countershaft with either of two pairs of gears whose ratios differ, an alternative road speed for each gear becomes available, i.e., twelve forward and four reverse. Multi-power does this hydraulically and enables speed changes in any one gear to be made whilst on the move and under load.

Additions to the standard transmission for Multi-power comprise a pair of constant mesh gears, a free wheel unit and a hydraulically operated multi-plate clutch added to the constant mesh compartment; a gear pump, oil control valve and a control lever complete the assembly.

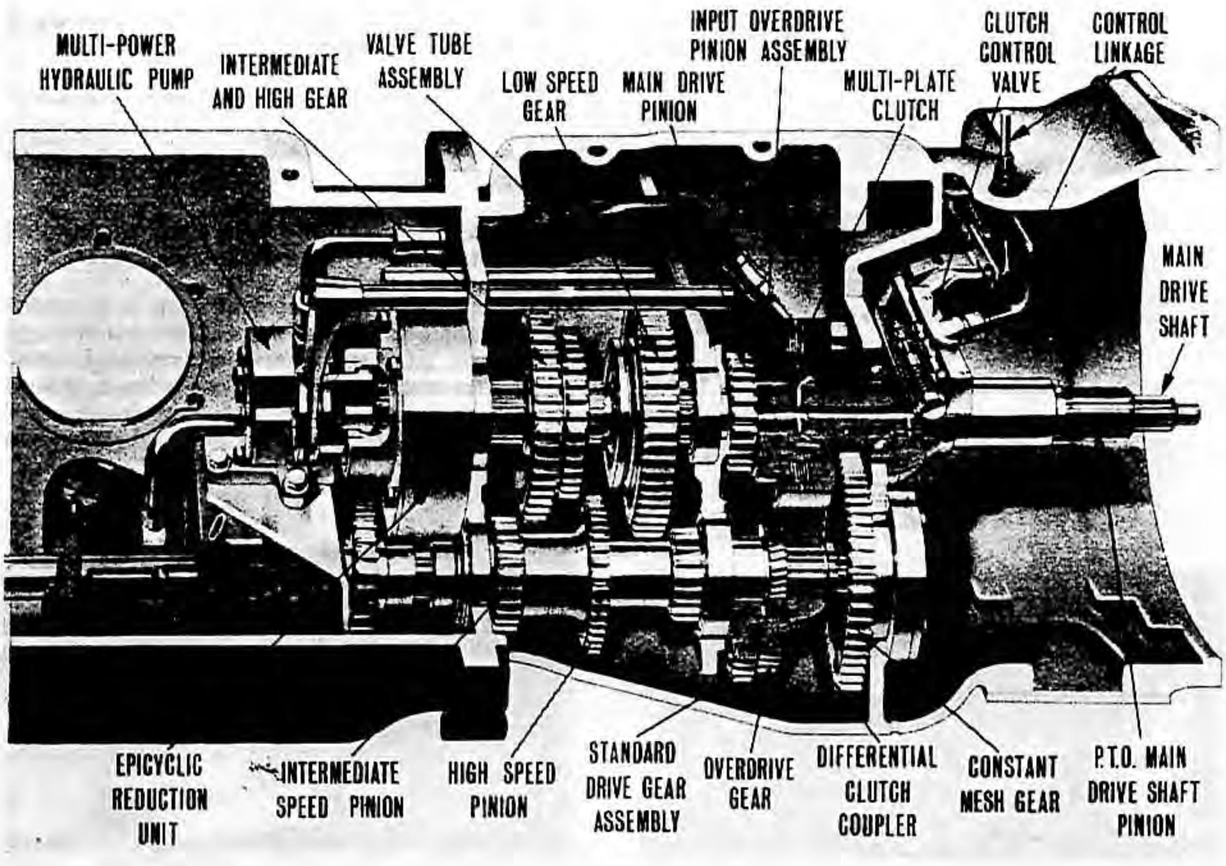

FIGURE 19.

GENERAL VIEW OF MULTI-POWER TRANSMISSION

DISMANTLING

Complete Dismantling of Transmission (J.15)

1. Split tractor between engine and transmission housing, as detailed in operation J-3.

   Note: Care should be taken to disconnect Multi-power control linkage on the transmission case.

2. Split tractor between transmission and centre housing as detailed in operation J-4.

   Note: Disconnect hose pipe between Multi-power hydraulic transmission pump and control valve.

3. Place transmission on stand MF.27 as illustrated in Figure 11.
4. Remove shifter rails and forks.
5. Remove the clutch release bearing, clutch fork and shafts.
6. Remove the brake cross shaft.
7. Remove the Multi-Power shift lever bracket by removing the top right main drive shaft setscrew A, Figure 20.
8. Remove pipe assembly B, Figure 20.
9. Remove the three remaining setscrews secu .ng the main drive shaft retainer assembly anu remove assembly from the front of the transmission, Figure 21. Care should be taken to avoid damaging the cast iron sealing ring.
10. Remove the four bolts securing the front P.T.O. cap and remove cap.
11. Remove snap ring and washer from P.T.O. drive shaft and withdraw front support bearing housing, using two slave bolts $\frac{3}{8}''$ UNC $\times$ 3" (9.525 mm. UNC $\times$ 76.2 mm.).

    Note: There are two tapped holes in the housing for this operation.

12. Withdraw P.T.O. drive shaft rearwards.
13. Remove the epicyclic reduction unit which is secured to the rear of the transmission housing by four setscrews.
14. Draw the main transmission shaft rearwards to clear the front bearing out of the casing, tilt upwards and drive out the main transmission shaft rearwards.
15. Lift out the tab located spacer from the front end of the main transmission shaft and withdraw the shaft rearwards, and lift out hydraulic clutch assembly with located thrust washer (Figure 22).
16. Remove countershaft rear bearing circlip and tap countershaft forward approximately $\frac{1}{2}''$ (12.7 mm.).
17. Remove snap ring retaining intermediate and high speed gears on countershaft.
18. Remove forward snap ring retaining free-wheel clutch gear assembly. Drive countershaft rearward until clutch assembly can be lifted out.
19. Drive countershaft forward, feeding off intermediate and high speed gears (Figure 23).
20. Remove setscrew, tab washer and retaining plate from the rear of the transmission housing flange. Insert dummy shaft through hole in reverse shaft housing from the front, and push reverse shaft out rearwards. Lift out reverse cluster, including the copper thrust washer and spacer.

FIGURE 20. MULTI-POWER SHIFT LEVER BRACKET

FIGURE 21. REMOVING MAIN DRIVE SHAFT RETAINER

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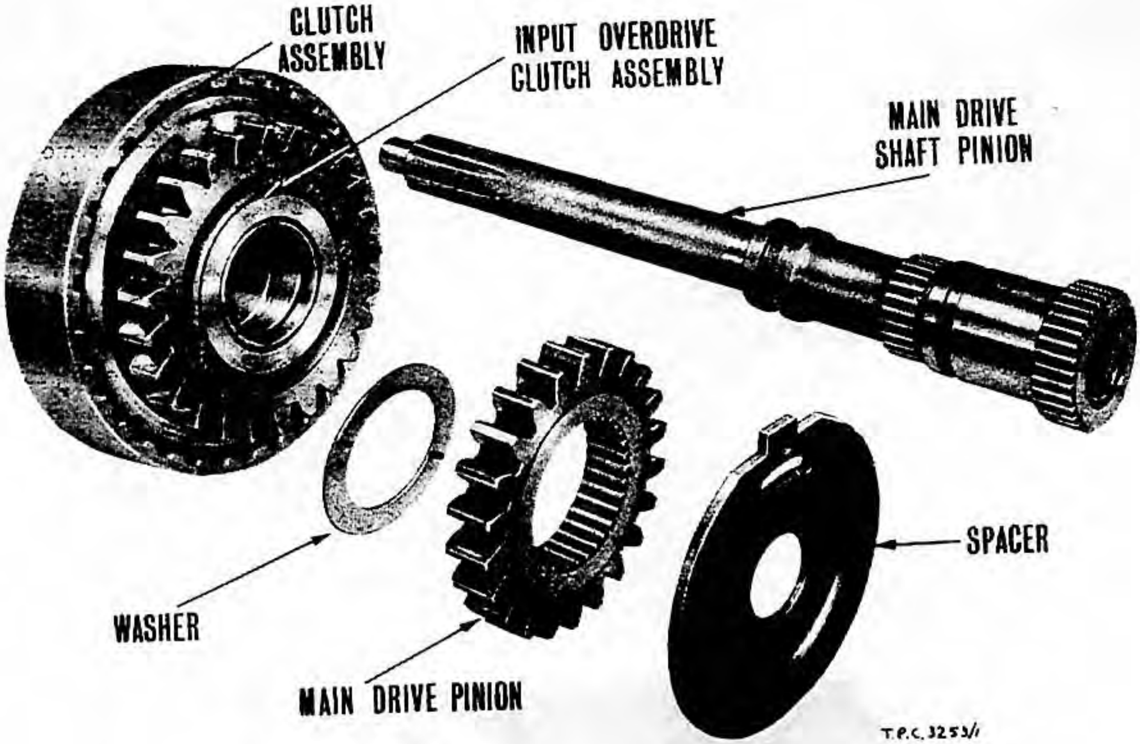


FIGURE 22. INPUT SHAFT AND CLUTCH ASSEMBLY

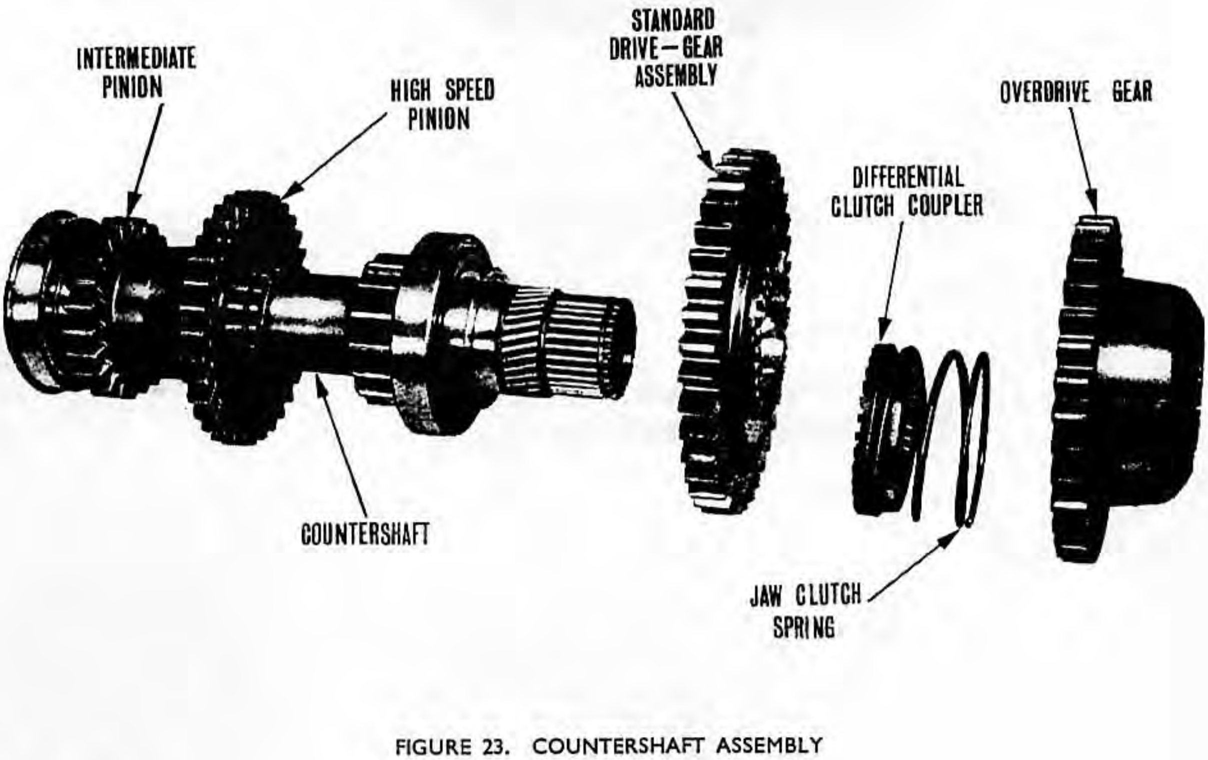
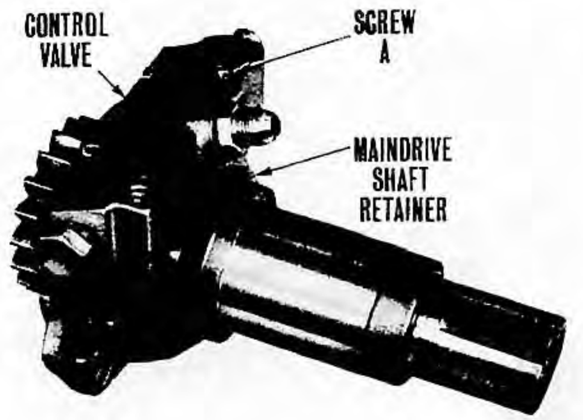


FIGURE 23. COUNTERSHAFT ASSEMBLY



To Dismantle Control Valve Assembly (J-16)

1. Remove the four socket headed setscrews which retain the valve to the main drive shaft retainer; screw A, Figure 24, retains the spool in position and is sealed by a copper washer. Care should be taken when removing the valve that the spool does not slide out of its bore, so damaging it.
2. Place control valve on clean bench, remove regulator screw, B, Figure 25, and washer, C.
3. Remove regulator spring, D, together with regulator spool, E.
4. Withdraw shift spool, F, complete with "Quad" Ring, G.

FIGURE 24. CONTROL VALVE

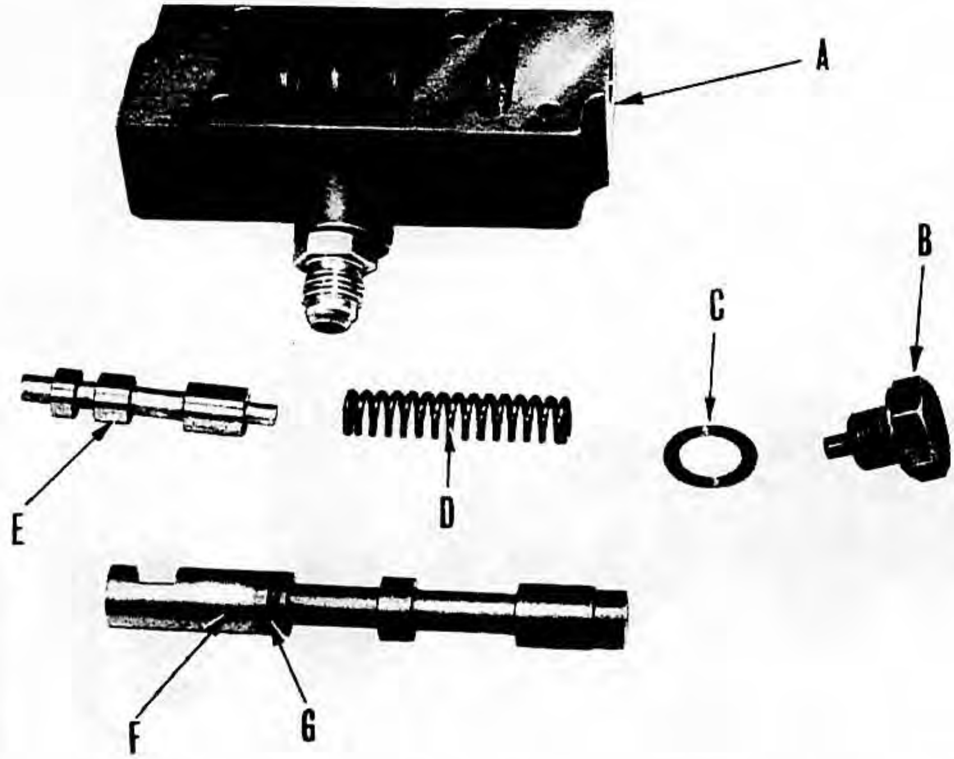


FIGURE 25. EXPLODED VIEW OF CONTROL VALVE

A. Valve Body.
B. Regulator Screw.
C. Washer.
D. Regulator Spring.
E. Regulator Spool.
F. Shift Spool.
G. "Quad" Ring.

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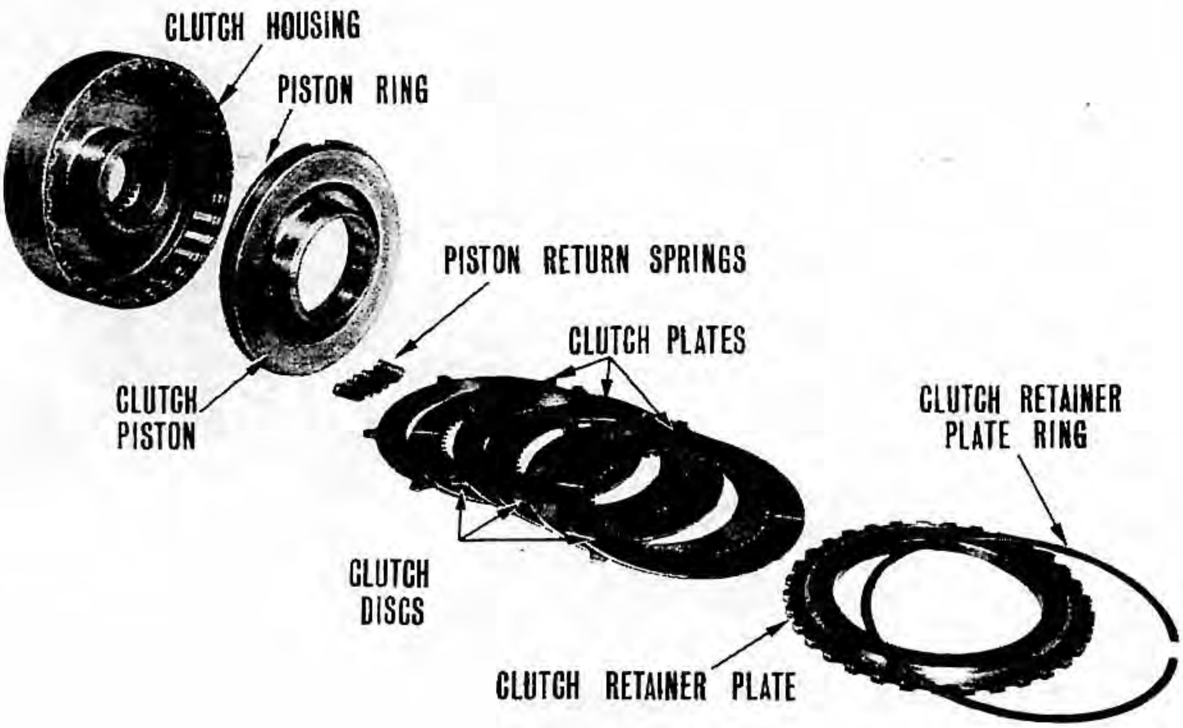

FIGURE 26. EXPLODED VIEW OF HYDRAULIC CLUTCH

To Dismantle Hydraulic Clutch Assembly (J-17)

1. Place the clutch unit on a clean bench with the high driving gear uppermost, and remove gear.
2. Depress clutch retainer plate and remove snap ring.
3. Remove retainer plate and the six piston return springs.
4. Remove the three clutch discs and the three clutch plates.
5. Invert the clutch and tap it lightly on a wooden block. This will slide the piston out of the case. Figure 26 shows the clutch dismantled.

To Remove Hydraulic Pump Assembly (J-18)

The Multi-power hydraulic pump which is positioned over the tractor hydraulic pump, can be removed without splitting the tractor, or when the tractor is split. The two removal methods are detailed overleaf :

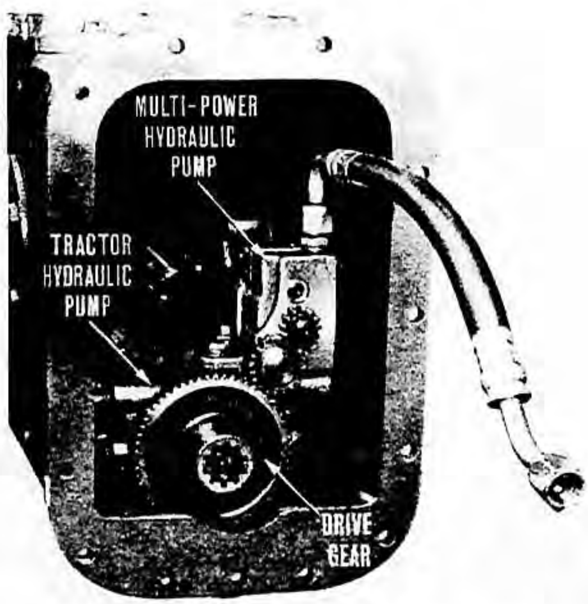

FIGURE 27. HYDRAULIC PUMP INSTALLATION

(a) To Remove Hydraulic Pump with Tractor Split

1. Disconnect hose assembly at pump (Figure 27).
2. Remove the three setscrews securing the pump to pump mounting plate and remove pump assembly.

(b) To Remove Hydraulic Pump without Splitting the Tractor

1. Disconnect levelling rods from lift fork and remove seat, hydraulic lift cover cap and stand pipe.
2. Fit Service Tool MF.226 to centre housing and lift cover.
3. Pull hydraulic lift cover over rear of centre housing and support on MF.226.
4. Disconnect hose assembly on Multi-power hydraulic pump.
5. Remove the three setscrews securing the pump to pump mounting plate and withdraw pump assembly out through top cover aperture.

Figure 28 shows pump mounted to tractor hydraulic pump.

To Dismantle Hydraulic Pump Assembly (J-19)

1. Remove the two setscrews securing the filter to the pump and remove filter.

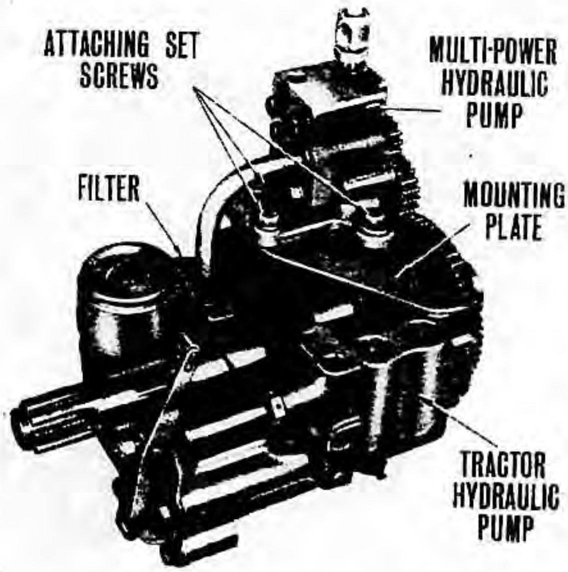

FIGURE 28. HYDRAULIC PUMP

2. Remove setscrews and socket head setscrew from the rear of the pump.
3. Remove the end cap.
4. Remove the snap ring from the drive shaft gear.
5. Remove gears and bearings.

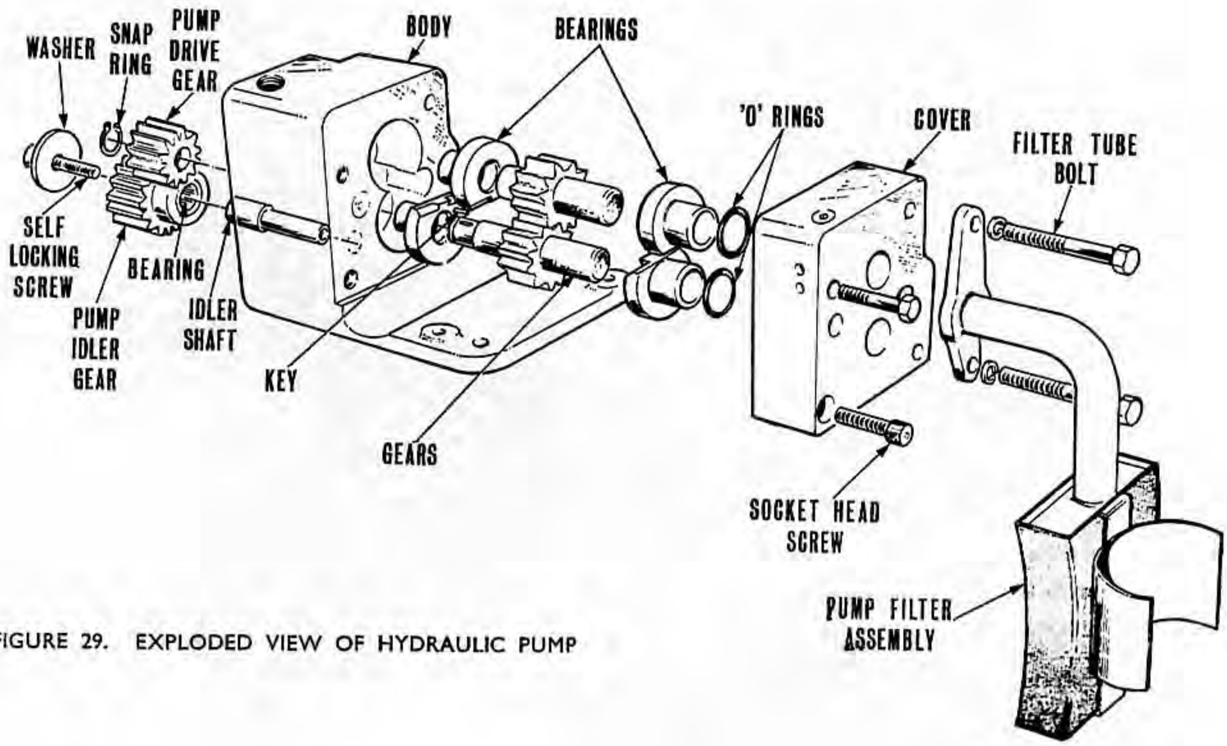

FIGURE 29. EXPLODED VIEW OF HYDRAULIC PUMP

FIRST ISSUE

ASSEMBLY

FIGURE 30. FITTING CLUTCH PISTON RING

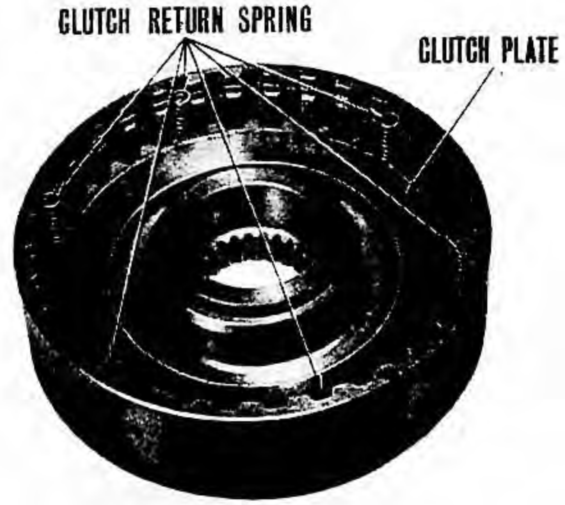

FIGURE 31. SPACING OF RETURN SPRING

To Assemble Control Valve Assembly (J-20)

1. Assembly is a direct reversal of the dismantling procedure. A new "Quad" ring G, Figure 25, should be fitted.

   Note: The regulator screw, B, Figure 25, should be tightened to a torque of 17-22 lb.ft. (2.35-2.9 kg.m.). Lubricate after assembly.

To Assemble Hydraulic Clutch Assembly (J-21)

1. Thoroughly clean and dry all components.
2. Install piston ring into clutch housing, compressing piston ring as shown in Figure 30.
3. Install one clutch plate into the clutch housing.
4. Space the six return springs evenly on the clutch plate (Figure 31).
5. Alternatively install the three clutch discs and two remaining clutch plates (Figure 32).

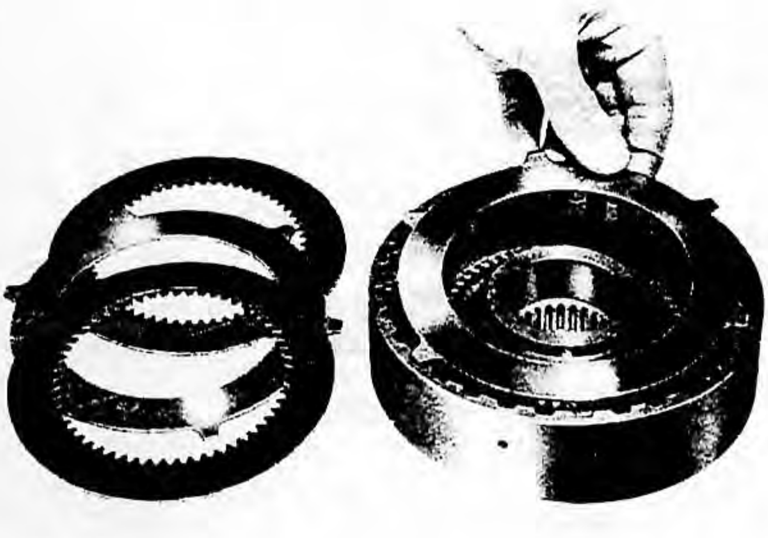

FIGURE 32.
REPLACING CLUTCH PLATE

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6. Replace retainer plate and snap ring (Figure 33). Refit input overdrive pinion to clutch assembly.

To Assemble Hydraulic Pump Asssembly (J-22)

1. Thoroughly clean all components.
2. Install the two inner bearings.
3. Install the pump gears and shaft with the marked ends to the rear.
4. Install the two outer bearings.
5. Install the drive gear and snap ring.
6. Replace end cap, securing with setscrew and socket head setscrew.
7. Refit filter assembly, using two setscrews.

To Refit Hydraulic Pump Assembly (J-23)

The refitting of the hydraulic pump in both instances, without the tractor split and with the tractor split, is a direct reversal of the removal procedure.

FIGURE 33. CLUTCH ASSEMBLY REBUILT

Complete Reassembly of Transmission (J-24)

1. Replace reverse cluster complete with washers and spacer. Note the spacer is positioned at the rear.
2. Reassemble jaw clutch to countershaft and retain front circlip.
3. Replace intermediate and high speed gears retaining circlip in its groove.
4. Drive the countershaft into rear bearing using a suitable bearing retainer plate.
5. Place the P.T.O. shaft drive gear into the casing.
6. Place the P.T.O. drive shaft into the P.T.O. drive gear from the rear.

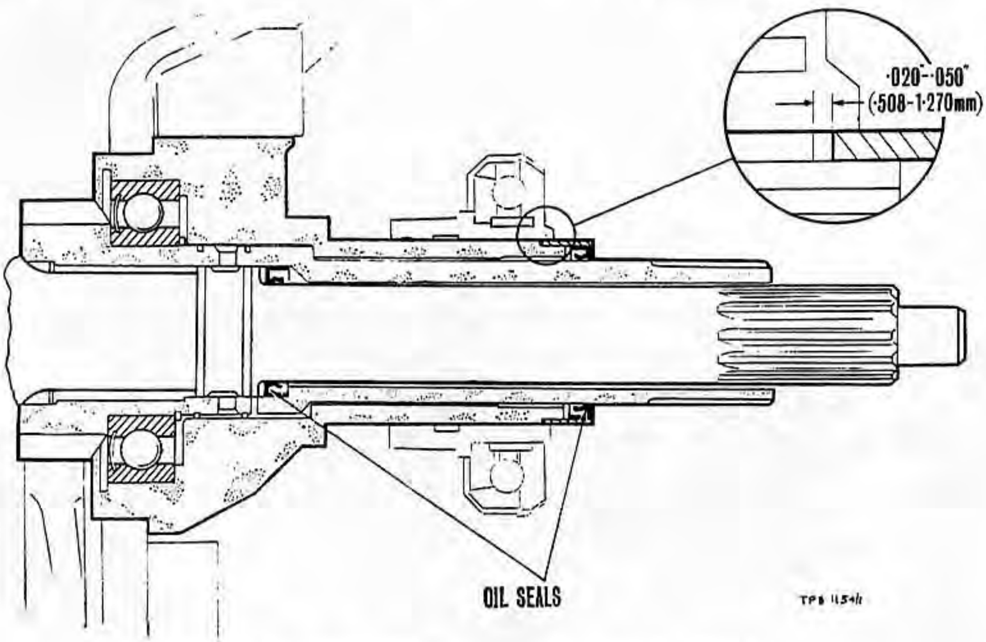

FIGURE 34. MAIN DRIVE SHAFT RETAINER OIL SEALS

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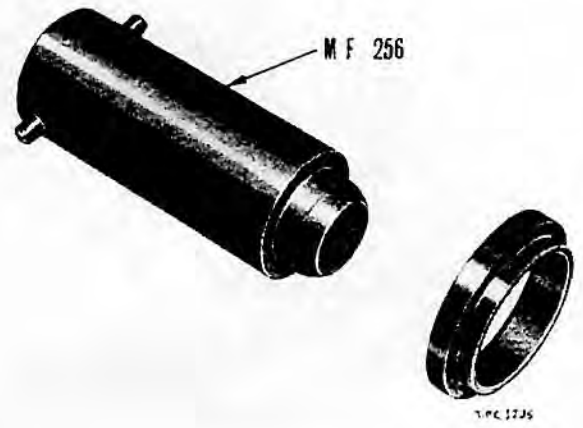

FIGURE 35. SERVICE TOOL MF.256

7. Using Service Tool MF.218, draw shaft in from the rear, this action will also draw the bearing retainer complete with gasket in from the front.

8. Replace the P.T.O. drive gear retaining circlip and washer.

9. Place the hydraulic clutch assembly into the casing and slide the main drive shaft pinion into clutch from the rear.

10. Fit the main shaft front bearing into the casing and drive the main shaft with gears, into position into the bearing. Replace circlip.

11. Place the spacer into the recess in the front of the main transmission shaft bearing.

12. Press bearing onto the P.T.O. main drive shaft and refit sealing rings. Fit P.T.O. main drive shaft into retainer ; care should be taken to avoid damaging the sealing rings and refit circlip.

FIGURE 36. FITTING MAIN DRIVE SHAFT PINION OIL SEAL

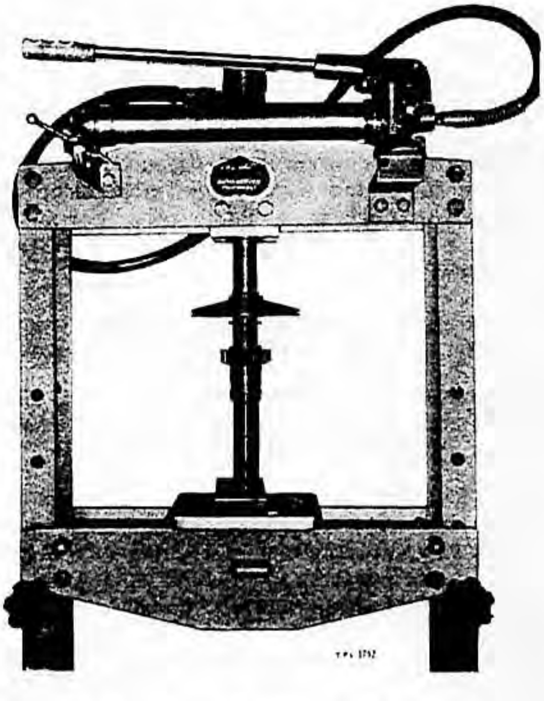

FIGURE 37. PRESSING SEAL INTO POSITION

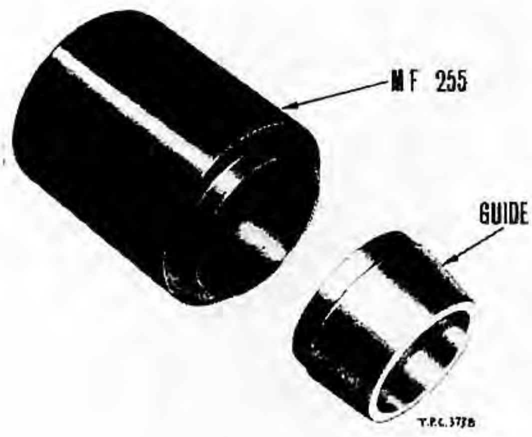

FIGURE 38. SERVICE TOOL MF.255

FIGURE 39. FITTING SEAL TO SERVICE TOOL MF.255

The following two items detail the fitment of the oil seal to the P.T.O. main drive shaft. A, Figure 34 (Smaller).

13. Place oil seal on Service Tool MF.256 (Figure 35) and enter into P.T.O. main drive shaft as shown in Figure 36.

14. Mount assembly in a suitable press and operate until oil seal is pressed into position (Figure 37). Depth is controlled by the shoulder of the Service Tool. Remove Service Tool MF.256.

The following three items detail the fitment of the oil seal to the retainer assembly. B, Figure 34.

Note :- This operation necessitates the use of an adhesive compound which requires some time to harden, therefore to avoid delay, this operation should be carried out early in the reassembly procedure.

15. Fit the seal lip first onto Service Tool MF.255 (Figure 39) and remove guide (Figure 40).

16. Coat the seating face of the main drive shaft retainer housing with an adhesive compound, e.g., ARALDITE or GASOILAR.

17. Fit Service Tool MF.255 with seal onto main drive shaft retainer housing and enter P.T.O. drive shaft pinion into housing. Mount the complete assembly on a suitable press and allow adhesive compound to harden.

    Note: Ensure that the rearward edge of the seal is located .020" - .050" (.508 - 1.27 mm.) from the spigot of the retainer body (see Figure 34).

FIGURE 40. REMOVING GUIDE

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18. Place Service Tool MF.177, oil seal protector, onto main drive shaft pinion and refit main drive shaft retainer, complete with P.T.O. main drive shaft. Care should be taken to avoid damage to cast iron rings.
19. Replace the epicyclic reduction unit.
20. Refit the Multi-power shift lever bracket and valve tube assembly.
21. Replace clutch fork release bearing and clutch shafts. Refit brake cross shaft.
22. Refit shifter rails and forks.
23. Refit centre housing to transmission (Operation J-11). Connect hose pipe between Multi-power hydraulic pump and control valve.
24. Refit transmission to engine (Operation J-12). Refit control linkage.

TO ADJUST MULTI-POWER LINKAGE
(J-25)

1. Ensure that the linkage is assembled as shown in Figure 41.
2. Loosen nut A (Figure 41) on the ball joint assembly which secures the lower linkage shift rod B (Figure 41).
3. Flip the Multi-power shift lever C (Figure 41) up into the "high" position.
4. Push the lower linkage shift lever down to its fully lowered position.
5. With the shift rod fully down, and the Multi-power shift lever in the "high" position, tighten the nut A (Figure 41) securely.

MULTI-POWER HYDRAULIC PRESSURE TESTS

The operating pressure of the Multi-power hydraulic system, and pump relief valve pressure, can be checked at one point using Service Tool MF.260, with adaptor MF.260-1. Service Tool MF.260 consists of a 500 p.s.i. (35.15 kg./sq. cm.) pressure gauge and a 6" (152.4 mm.) length of pressure hose. MF.260-1 is an adaptor for attaching to the pump outlet.

To Check Operating Pressure of Multi-power Hydraulic System (J-26)

1. Disconnect levelling rods from lift forks and remove seat, hydraulic lift cover cap and stand pipe.
2. Fit Service Tool MF.226 to centre housing.

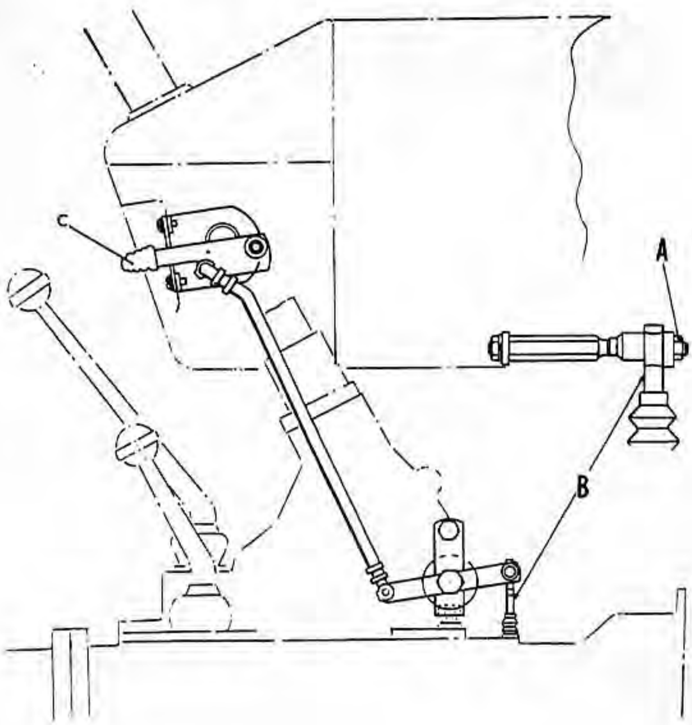

FIGURE 41. LINKAGE ADJUSTMENT

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3. Pull hydraulic lift cover over rear of centre housing and support on MF.226.
4. Disconnect valve tube assembly at Multi-power hydraulic pump, screw in adaptor MF.260-1, and refit valve tube assembly.
5. Screw pressure hose into adaptor MF.260-1. Figure 42 shows complete assembly.
6. Start engine and run at 1500 r.p.m. The control valve relief valve should maintain a delivery of oil to the Multi-power clutch of 150 p.s.i. (10.55 kg./sq. cm.).
7. Remove MF.260 and adaptor and re-connect valve tube assembly.
8. Replace hydraulic lift cover, seat, and re-connect levelling levers.

To Check Hydraulic Pump Relief Valve Pressure (J-27)

1. Carry out operation J-27, items 1 to 3.
2. Disconnect valve tube assembly at the Multi-power pump, screw adaptor MF.260-1 with blanking cap into pump.
3. Screw pressure hose into adaptor. Figure 43 shows complete assembly.
4. Start engine and run at 1500 r.p.m. Discharge pressure of pump relief valve should be 260-300 p.s.i. (18.28-21.09 kg./sq. cm.).
5. Remove MF.260 and adaptor and re-connect valve tube assembly.
6. Replace hydraulic lift cover, seat and re-connect levelling levers.

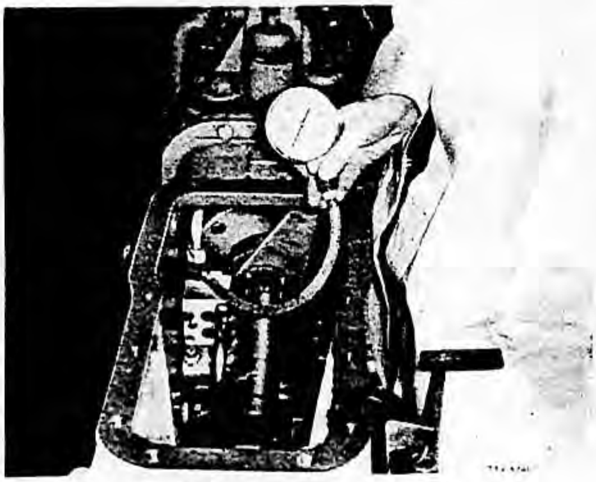

FIGURE 42. CHECKING OPERATING PRESSURE

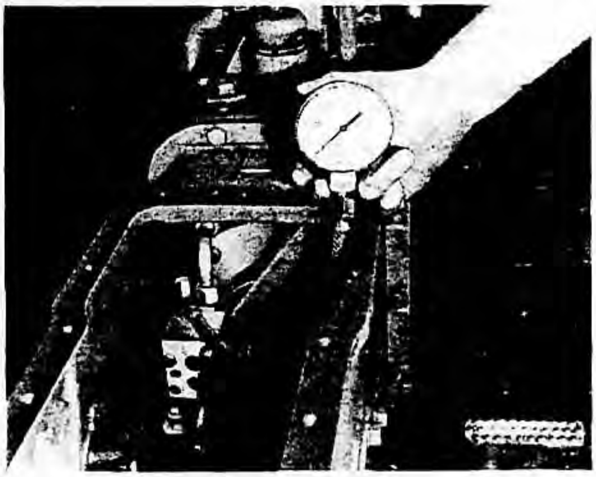

FIGURE 43. CHECKING PUMP RELIEF VALVE PRESSURE

MULTI-POWER FAULT FINDING

FAULT	POSSIBLE CAUSE	ATTENTION REQUIRED
MULTI-POWER PUMP **Low Pressure**	Worn gears or bushes.	Replace gear or bushes or complete unit.
MULTI-POWER HYDRAULIC CONTROL VALVE **Low Pressure**	Incorrectly set relief valve.	Check regulator spring length or breakage.
	P.T.O. and main drive shaft seals leaking.	Replace.
High Pressure	Incorrectly set relief valve.	Adjust pressure.
	Foreign matter in oil drain galleries.	Clean out.
	Damaged feed pipes.	Replace.
MULTI-POWER CLUTCH **Clutch Overheating**	Low oil pressure causing clutch slip.	Check and adjust pressure.

MASSEY-FERGUSON

35 TRACTOR

WORKSHOP SERVICE MANUAL

SECTION K

REAR AXLE AND HUBS

REAR AXLE AND HUBS

Section K

CONTENTS

NON DIFFERENTIAL LOCK TRACTORS

CONTENTS—*Continued*

DIFFERENTIAL LOCK TRACTORS

REAR AXLE AND HUBS

Section K

LIST OF ILLUSTRATIONS

REAR AXLE AND HUBS

GENERAL (Fig. 1 refers)

The power input from the transmission main drive shaft is transmitted through the rear drive shaft and coupling to a spiral bevel driving pinion and crown wheel of 6.166 : 1 reduction ratio. The rear drive coupling is a grooved tubular shear member, fitted to minimise consequential damage under exceptional shock loading.

DIFFERENTIAL ASSEMBLY

The case hardened driving pinion and crown wheel are machined from heat-treated alloy steel forgings which are specially treated to prevent "scuffing" during the running-in period.

The driving pinion is supported in the centre housing web by a straight roller pilot bearing and a pre-loaded sleeve assembly embodying two opposed high capacity taper roller bearings. The crown wheel is fitted to the split differential case which runs on taper roller bearings supported by cups in the outer axle housings. The overload thrust is taken up on a thrust block mounted on the left-hand axle housing. The differential gears are splined to the axle shafts while planet bevel pinions are mounted on a differential cross-joint supported between the two halves of the differential casing, and the end thrust on the gears and pinions is taken up by thrust washers.

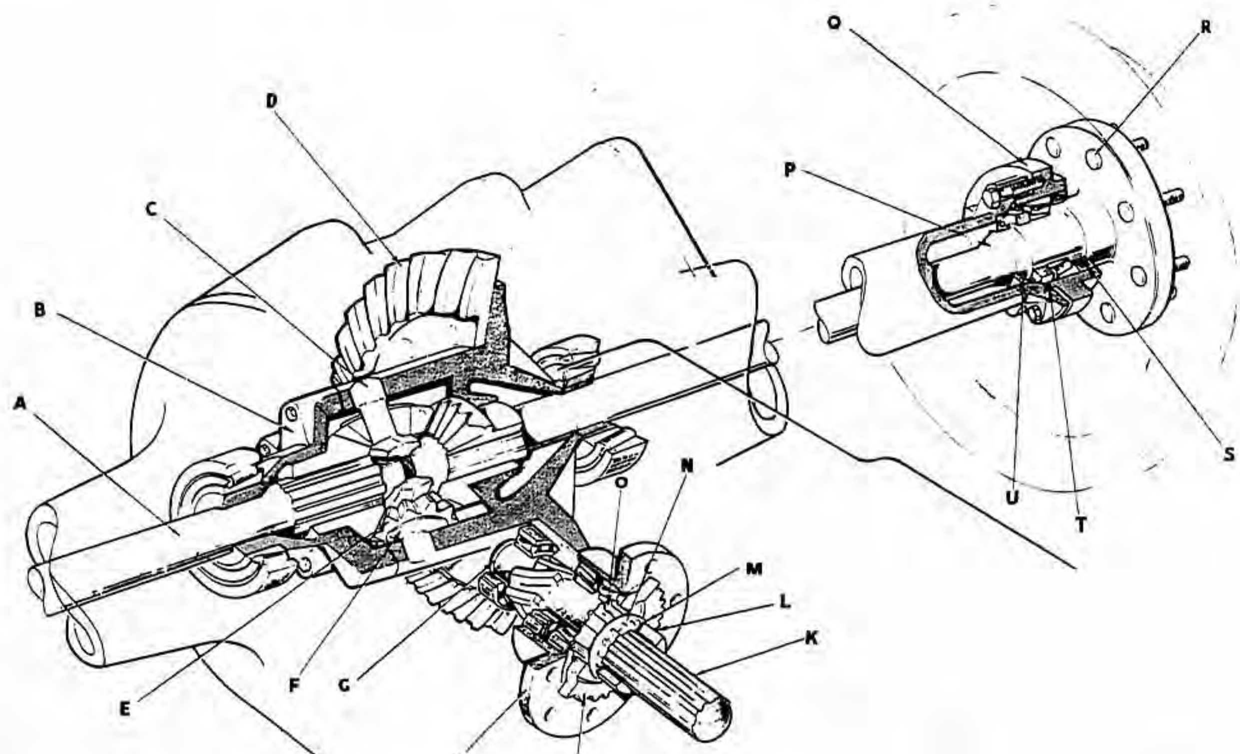

FIG. 1 CUTAWAY VIEW OF REAR AXLE

A. R.H. Rear Axle Shaft.
B. Differential Gear Housing.
C. Differential Cross Joint.
D. Driving Gear.
E. Differential Pinion.
F. Differential Pinion Thrust Washer.
G. Circlip.
H. Sleeve Assembly.
J. P.T.O. Driving Gear.
K. Driving Gear.
L. Pinion Bearing Lock Nut.
M. Pinion Housing Lock Washer.
N. Snap Ring.
O. P.T.O. Driving Gear Hub.
P. L.H. Rear Axle Shaft.
Q. L.H. Rear Axle Retainer.
R. Wheel Disc Bolt.
S. Oil Seal.
T. Collar.
U. Inner Oil Seal.

REAR AXLE SHAFTS

The semi-floating rear axle shafts are supported at the inner ends by the differential gears and are carried at the outer ends by taper roller bearings housed in rear axle bearing retainers mounted on the rear axle housings. The cones of these bearings are located on the shafts by shrunk-on collars. Oil seals are fitted in the rear axle housings and the bearing retainers. The brake backplates are fitted between the axle housings and the bearing retainers with the brake drums mounted on the flanges of the axle shafts. Axle shaft bearing endfloat of .002"-.008" (.051-.203 mm.) is obtained by shimming between the brake backplates and the axle housings.

DATA

Rear Axle Ratio—

Driving Pinion to Crown Wheel 6.166 : 1.

Torque Loadings—

Crown Wheel Bolts—110-120 lb. ft. (15.21-16.59 kg.m.).
Differential Case Setscrews—80-85 lb. ft. (11.06-11.75 kg.m.).
Backlash between Crown Wheel and Pinion—.008"-.016" (.203-.406 mm.) (ref. only—not adjustable).
Axle Shaft Bearing Endfloat—.002"-.008" (.051-.203 mm.).

DISMANTLING AND REASSEMBLY

The following sequences cover the dismantling and reassembly of both individual components and the complete rear end of the tractor.

DISMANTLING

In all cases where the stability of the tractor is endangered, such as by the removal of the wheels and axle housings or when the tractor is split, it is **imperative** that Service Tool MF.165 or suitable wedges be fitted between the front axle support and the front axle beam as shown in Fig. 2.

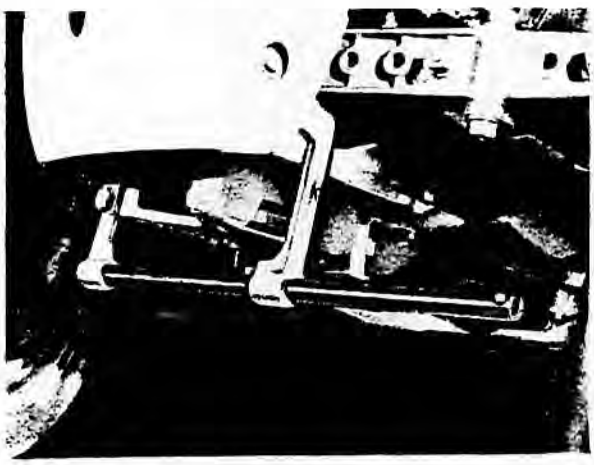

FIG. 2 USE OF MF.165

To Remove Rear Axle Shaft Assembly (K-1)

1. Jack up tractor beneath centre housing and remove wheel and brake drum.

   Note.—If the wheel is water-ballasted, it may be advisable to empty before removal, unless suitable lifting tackle is available.

2. Remove rear axle stud nuts and withdraw rear axle shaft assembly complete with rear axle bearing retainer.

   Note.—Care must be taken not to damage oil seal when removing axle shaft.

3. Remove brake backplate, camshaft and shims.

To Dismantle Rear Axle Shaft Assembly (K-2)

1. Remove rear axle shaft assembly as detailed in K-1.

2. Using Service Tool MF.26D with adaptor MF.26D-2 as shown in Fig. 3, drill axle shaft bearing collar. This should loosen collar sufficiently to allow removal, otherwise carefully split with cold chisel.

3. Fit Service Tool MF.26T with wrench MF.26A as shown in Fig. 4 to rear axle bearing retainer with rear axle studs. Apply load to tool and tap end of tool with copper faced hammer. Repeat this operation until the bearing and retainer are both free.

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FIG. 3 DRILLING AXLE SHAFT BEARING COLLAR

Note.—Having removed this bearing, it will be necessary to clean it thoroughly, since swarf generated during the removal of the collar may have been deposited in the bearing.

4. Remove oil seal and remove bearing cup from retainer using Service Tool MF.174.

To Remove and Dismantle Rear Axle Housing Assembly (K-3)

If the rear axle housing assembly is only being removed to allow another operation to be carried out, there will be no necessity to dismantle it. If adequate lifting tackle is available, it will not be necessary to remove the rear axle shaft assembly.

However, if parts are to be renewed, it will be necessary, in many cases, to check the axle shaft assembly endfloat.

1. Drain oil from centre housing and transmission case and clean and replace magnetic drain plugs.
2. Remove rear axle shaft assembly as detailed in K-1.
3. Disconnect brake rod at rear brake lever. Remove check chain and lower link.

   Note.—It will be necessary to remove the battery carrier from the left-hand rear axle housing of some diesel models.
4. Remove rear axle housing to centre housing nuts and lift off rear axle housing.

FIG. 4 WITHDRAWING REAR AXLE BEARING RETAINER

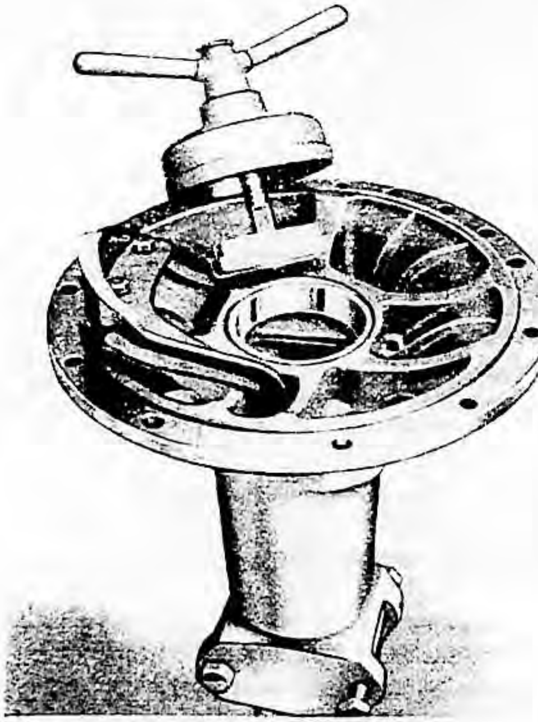

FIG. 5 USE OF MF.32A

5. Remove inner oil seal and differential bearing cup, using Service Tool MF.32A as shown in Fig. 5.

6. Remove brake camshaft expansion plug and bush.

To Remove and Dismantle Differential Case (K-4)

1. Remove left-hand rear axle housing assembly as detailed in Instructions 1, 3 and 4 of K-3.

2. Lift out differential case assembly and position on bench stand MF.9-10 utilising adaptor MF.9 or MF.9M as shown in Fig. 6.

3. Remove differential bearing cones using Service Tool MF.200 with suitable adaptors as shown in Figs. 7 and 8.

4. Remove locking wire and differential gear case setscrews. Lift off right-hand differential gear case as shown in Fig. 9.

5. The differential gears and thrust washers, cross-joint and pinions with thrust washers can now be removed.

6. Split driving gear nuts and remove driving gear from left-hand differential gear case.

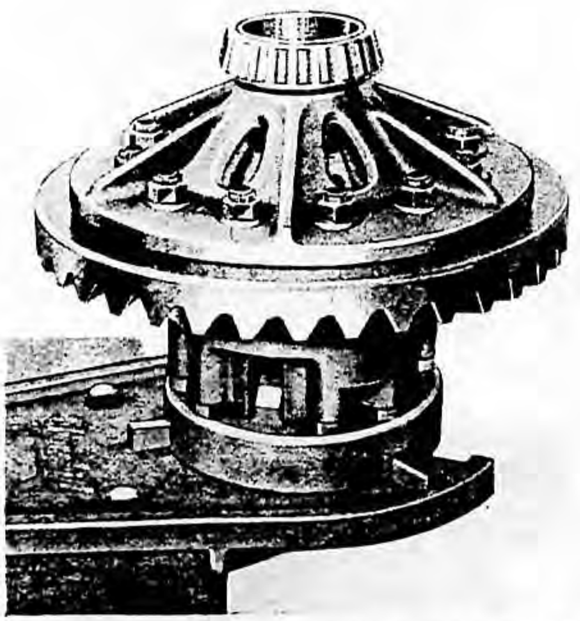

FIG. 6 DIFFERENTIAL CASE ASSEMBLY ON STAND

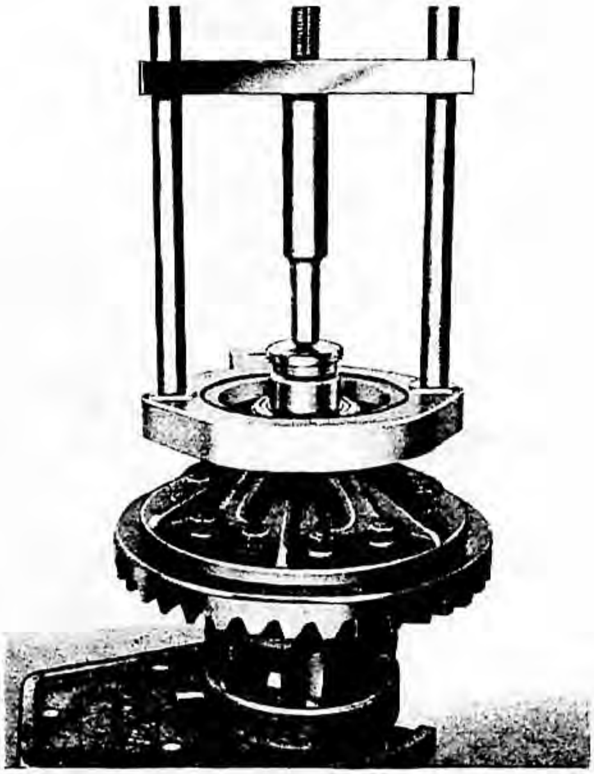

FIG. 7 REMOVING DIFFERENTIAL BEARING CONES

FIRST ISSUE

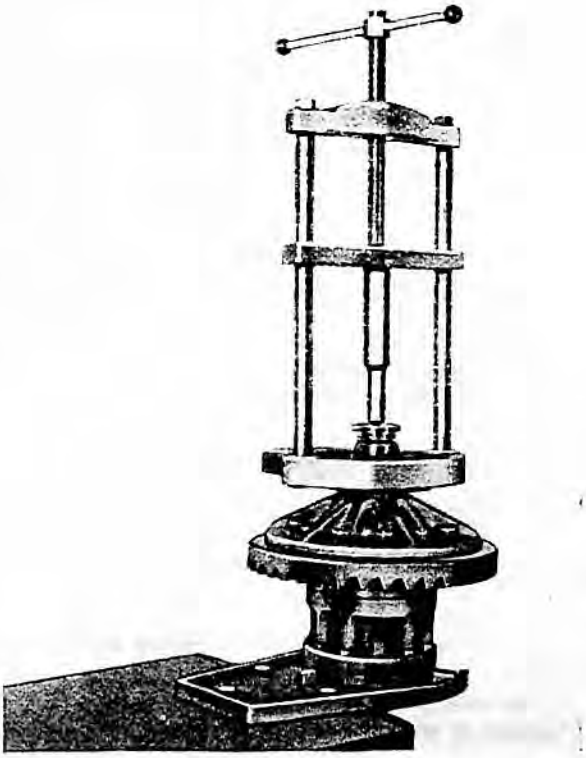

FIG. 8 REMOVING DIFFERENTIAL BEARING CONES

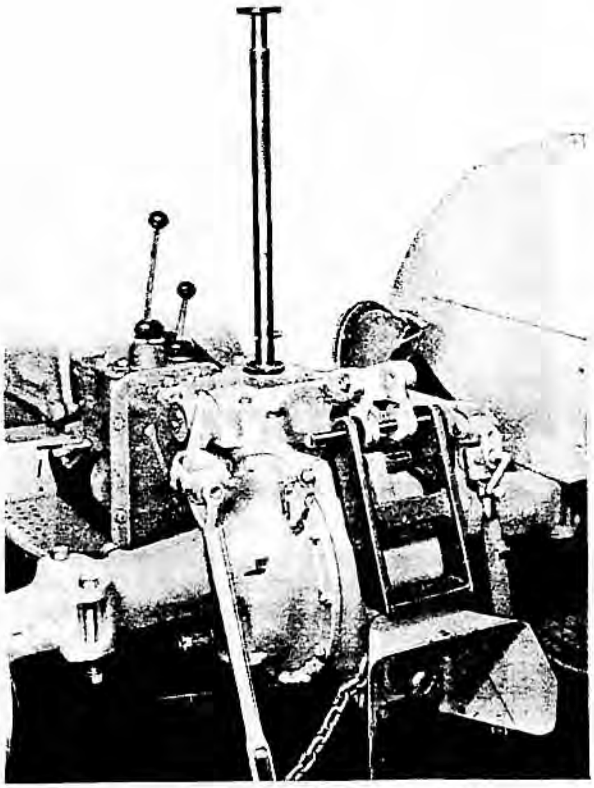

FIG. 10 MF.226 FITTED TO TRACTOR

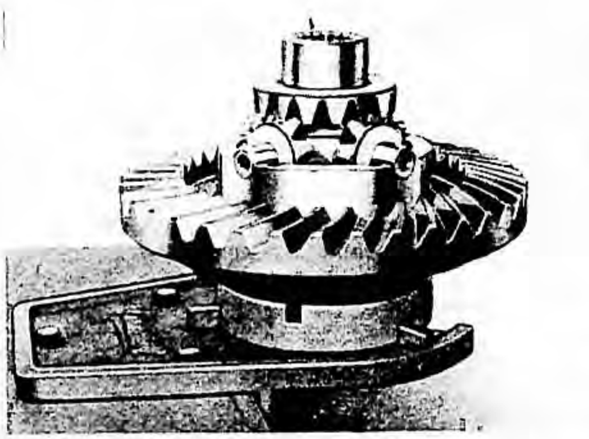

FIG. 9 DIFFERENTIAL CASE ASSEMBLY PARTIALLY DISMANTLED

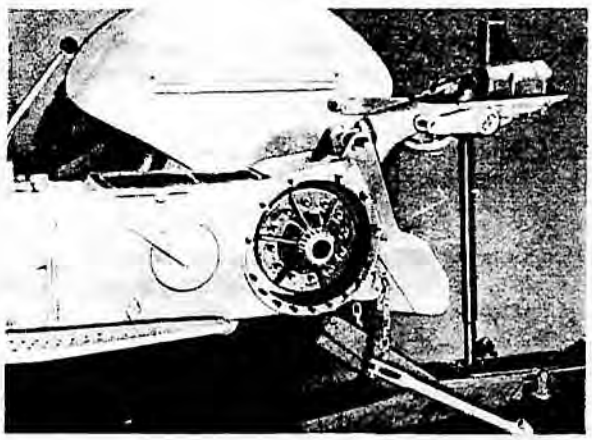

FIG. 11
HYDRAULIC LIFT COVER SUPPORTED ON MF.226

To Remove and Dismantle Driving Pinion (K-5)

1. Remove left-hand rear axle housing and differential case assembly as detailed in Instructions 1 and 2 of K-4.

2. Disconnect levelling rods from lift forks and remove seat, hydraulic lift cover cap, stand pipe and battery cable guard.

3. Fit Service Tool MF.226 to centre housing and hydraulic lift cover as shown in Fig. 10 and remove hydraulic lift cover to centre housing bolts.

4. Pull hydraulic lift cover over rear of centre housing and support on MF.226 as shown in Fig. 11.

FIG. 12 REMOVING DRIVING PINION ASSEMBLY

5. Remove cotter pin, rear drive coupling and rear drive shaft. Remove P.T.O. shaft (see Power Take-Off, Section M) and hydraulic pump.

6. Remove snap ring from drive hub and remove gear.

7. Remove sleeve to centre housing screws.

8. Insert two bolts in threaded holes and, by tightening bolts, draw off pinion and sleeve assembly as shown in Fig. 12.

9. Unlock tab washer and remove lock-nut, tab washer, drive gear and hub, outer bearing cone and sleeve assembly.

10. Remove driving pinion inner bearing cone using Service Tool MF.200 with suitable adaptors.

11. Remove driving pinion pilot bearing circlip and, using Service Tool MF.200 with suitable adaptors, remove pilot bearing.

To Split Tractor Between Centre Housing and Transmission Case (K-6)

1. Position rails of Tractor Dismantling Stand MF.27 and trolley jacks beneath centre housing and transmission case.

2. Drain oil from centre housing and transmission case and clean and replace magnetic drain plugs.

3. Remove step assemblies, and brake rods from right-hand brake pedal and combined brake arm.

4. Remove standard exhaust pipe and silencer (but not on vertical exhaust models).

5. Remove cable guard and battery cable.

6. Remove transmission case to centre housing bolts. Push rear axle and centre housing rearwards and fit centre housing stand.

To Effect Complete Dismantling of Rear Axle (K-7)

The following sequence covers the complete dismantling of the rear end of the tractor. Removal and dismantling of specific components is dealt with in K-1 to K-6.

1. Split tractor as detailed in K-6.

2. Remove lower links and levelling rods. Remove P.T.O. Shaft, P.T.O. Shifter lever cover assembly and hydraulic pump.

3. Remove P.T.O. Shaft Sleeve and bearing retainer. (See "Power Take-Off Shaft", Section M).

4. Remove rear axle housing assemblies, differential case and driving pinion assemblies.

5. Remove differential bearing trough assembly.

REASSEMBLY

The following sequences are based upon the assumption that the tractor is in the condition achieved by the corresponding dismantling instructions.

To Reassemble Rear Axle Shaft Assembly (K-8)

1. Using Service Tool MF.175, replace oil seal in bearing retainer and using Service Tool MF.174, replace bearing cup in bearing retainer.
2. Position bearing retainer and bearing cone on rear axle shaft.
3. Using Service Tool MF.26 with adaptor MF.26-1 replace axle shaft bearing cone.
4. Heat axle shaft bearing collar to red heat and fit to axle shaft.

To Replace Rear Axle Shaft Assembly and Check Endfloat (K-9)

1. Position backplate together with nominal thickness of shims and fit rear axle shaft assembly and sleeve with three equally spaced nuts tightened to a torque of 50-55 lb. ft. (6.913-7.604 kg.m.).

   Note.—It is inadvisable to fit more shims than necessary—approximately $\frac{1}{8}$" (3.175 mm.) should be sufficient.

2. Using clock gauge off wheel axle flange, check endfloat.
3. Remove shims to give .002"-.008" (.051-.203 mm.) endfloat. It will be found advantageous to allow a tightening down allowance of .002" (.051 mm.).

   Note.—It is advisable to tap the axle shaft flange to bed-in the bearing assembly.

4. Tighten down remaining nuts to a torque of 50-55 lb. ft. (6.913-7.604 kg.m.).
5. Fit brake drums and wheels and carry out running adjustments as detailed in "Brakes", Section P.
6. Remove trolley jacks and Service Tool MF.165.

To Reassemble and Replace Rear Axle Housing Assembly (K-10)

1. Refit brake camshaft bush and expansion plug.
2. Replace inner oil seal using Service Tool MF.176 as shown in Fig. 13 and differential bearing cup using Service Tool MF.32B. (See Fig. 14).
3. Replace rear axle housing assembly complete with inner axle housing gasket and tighten

FIG. 13 USE OF MF.176

FIG. 14 MF.32B

down rear axle to centre housing nuts to a torque of:

(a) $\frac{7}{16}$" and stepped studs: 50-55 lb. ft. (6.913-7.604 kg.m.) and

(b) $\frac{1}{2}$" studs: 70-75 lb. ft. (9.678-10.369 kg.m.).

4. Replace rear axle housing assembly and, if necessary, set endfloat as detailed in K-9.

To Reassemble Differential Case Assembly (K-11)

1. Replace one half of differential gear case onto Service Tool MF.9-10.

2. Assemble differential gears and thrust washers differential cross-joint, pinions and thrust washers onto gear case.

3. Fit other half of differential gear case to this assembly. (Care must be taken that the stamped numbers on each gear case are coincident).

   Tighten down differential gear case screws to a torque of 80-85 lb. ft. (11.06-11.75 kg.m.) and fit locking wire.

4. Fit driving gear and, using Service Tool MF.187, tighten down driving gear nuts and bolts to a torque of 110-120 lb. ft. (15.21-16.59 kg.m.). Stake nuts securely.

5. Replace differential bearing cones. (See Fig. 15).

To Replace Differential Case Assembly (K-12)

This operation is based upon the assumption that the right-hand rear axle housing and shaft, and driving pinion assemblies are fitted.

1. Lift differential case assembly into centre housing and fit onto right-hand axle shaft. **Note.**—Care must be taken to ensure that the differential bearing trough assembly does not foul the driving gear.

2. Fit left-hand rear axle housing assembly. Fit left-hand rear axle shaft assembly and check endfloat as detailed in K-9.

3. Fill centre housing and transmission case with correct lubricant. (See current Instruction Book).

To Set Pre-load and Reassemble Driving Pinion (K-13)

1. Fit driving pinion pilot bearing using Service Tool MF.200 with suitable adaptors.
   Refit circlip.

2. Fit driving pinion inner bearing cone using Service Tool MF.200 with suitable adaptors.

3. Fit bearing sleeve, outer bearing cone, gear hub, tab washer and locknut.

FIG. 15 REPLACING DIFFERENTIAL BEARING CONES

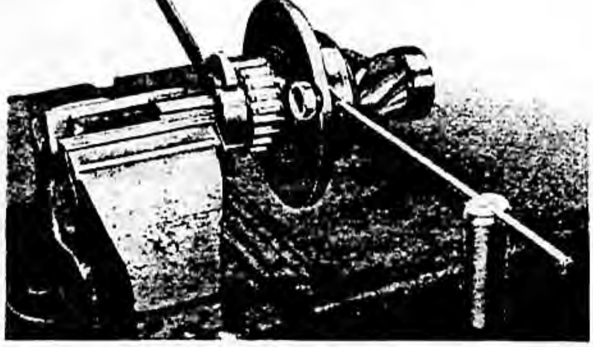

FIG. 16 SETTING DRIVING PINION BEARING PRE-LOAD

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4. With assembly mounted as shown in Fig. 16, tighten locknut until torque loading of 18-22 lb. in. (.21-.25 kg.m.) is required to turn shaft.

   Rotate shaft several times to bed-in bearing and check pre-load and reset as required. It is advisable to lubricate the bearing before setting the pre-load.

   Note.—This is not the torque loading on the shaft but is the torque loading required to turn the shaft after the locknut has been tightened.

To Replace Driving Pinion (K-14)

1. Pull driving pinion assembly into centre housing by tightening evenly, in turn, on retaining bolts.

2. Fit ground speed P.T.O. drive gear and circlip.

3. Fit ground P.T.O. driven gear, hydraulic pump and P.T.O. shaft (See Section M, "Power Take-off Shaft"). Fit rear drive shaft, coupling and cotter pin.

4. Fit hydraulic lift cover, standpipe and hydraulic lift cover cap.

   Note:

   (a) Renew standpipe "O" rings.

   (b) See Section L "Hydraulic Mechanism, and Linkage" for adjustments required when fitting hydraulic lift cover.

5. Refit levelling rods, seat, battery cable and guard.

To Effect Complete Reassembly of Rear Axle (K-15)

The following sequence covers the complete re-assembly of the rear end of the tractor. Replacement and reassembly of specific components is dealt with in K-8 to K-14.

1. Replace P.T.O. shaft sleeve and bearing retainer.

2. Fit right-hand rear axle housing and shaft assemblies as detailed in K-9 and K-10.

3. Fit driving pinion assembly as detailed in K-14.

4. Fit differential case assembly as detailed in K-12.

5. Fit left-hand rear axle housing and shaft assembly and check end-float as detailed in K-9 and K-10.

6. Fit centre housing to transmission case as detailed in K-16.

To Reassemble Centre Housing to Transmission Case (K-16)

1. With transmission case supported on transmission trolley jack and centre housing supported on centre housing trolley jack, remove centre housing stand.

2. Push centre housing forward to join transmission case assembly. Engage Engine P.T.O. and turn P.T.O. shaft by hand to engage P.T.O. drive shaft.

   Note.—Check alignment of hydraulic pump before tightening bolts.

3. Tighten nuts and bolts to a torque of 47-53 lb. ft. (6.50-7.33 kg.m.).

   Note.—When fitting new gasket, very lightly smear mating surfaces with grease. Do *not* use sealing compound.

4. Fit rear drive shaft and coupling through P.T.O. shifter lever cover and refit cover.

   Note.—Care must be taken not to "screw" rear drive shaft onto main shaft as this can tilt the needle rollers out of "fore-and-aft" alignment so impairing the efficiency of the bearing.

5. Fit standard exhaust pipe and silencer.

6. Replace step assemblies and brake rods.

7. Replace battery cable and guard.

8. Remove trolley jacks and Service Tool MF.165.

9. Refill transmission case and centre housing with recommended lubricant (see current Instruction Book).

The following operations detail dismantling and assembly instructions for tractors fitted with a differential lock.

GENERAL

On tractors fitted with a differential lock, the right-hand rear axle housing and right-hand differential gear casing have been re-designed to incorporate the differential lock operating mechanism.

When the differential lock pedal is depressed, an actuating cam brings the two halves of the coupling into mesh, thus locking the differential. To disengage, remove foot from pedal. If, however, the differential does not disengage, carry out one of the following :—

1. Deviate slightly from line of travel.
2. Momentarily declutching the tractor.
3. Lightly applying the right- or left-hand brake.

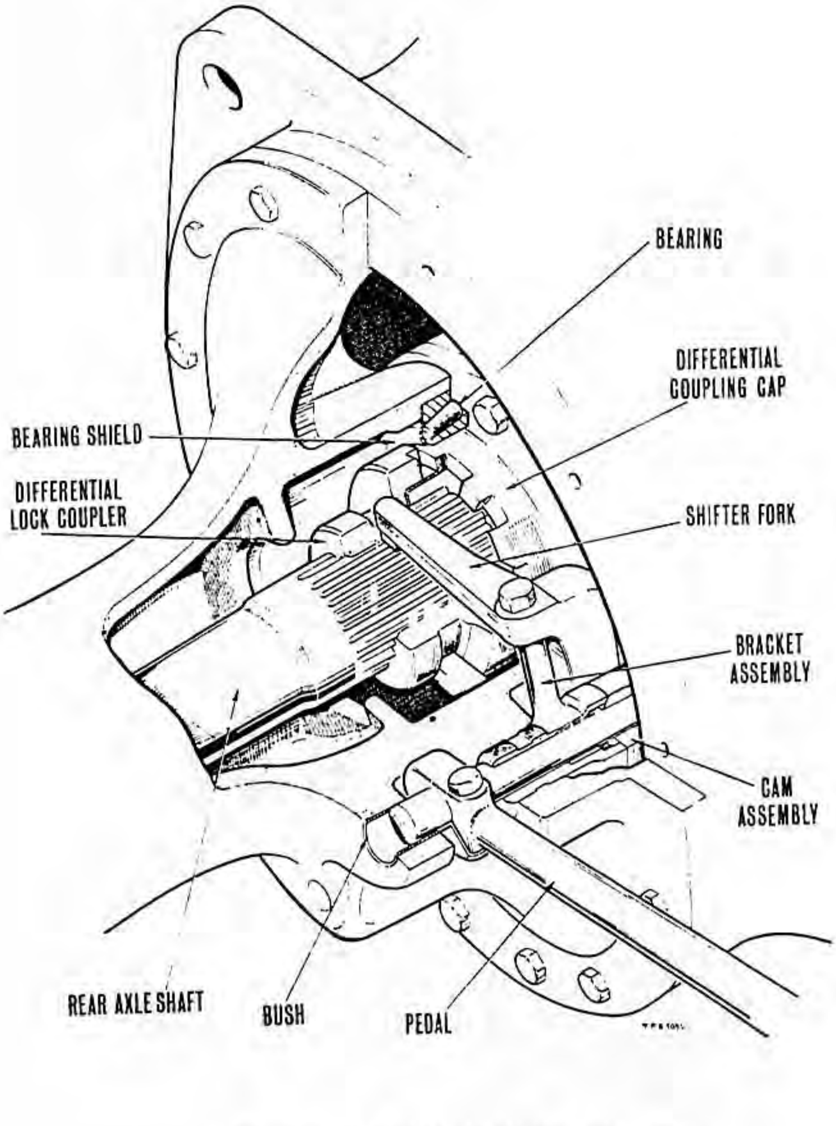

FIG. 17. CUT-AWAY VIEW OF REAR AXLE

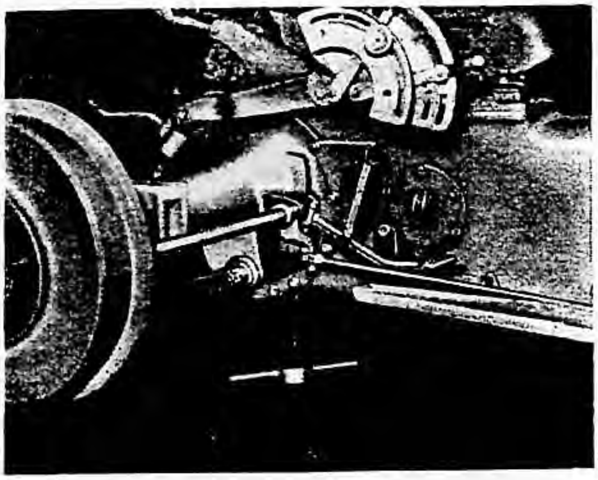

FIG. 18. DIFFERENTIAL LOCK PEDAL WEDGED IN ENGAGEMENT

DISMANTLING

To Remove Right-hand Rear Axle Shaft Assembly (K-17)

1. Jack up tractor beneath centre housing and remove wheel and brake drum.

   Note.—If the wheel is water ballasted it may be advisable to empty before removal unless suitable lifting tackle is available.
2. Remove differential lock return spring and wedge pedal in engaged, downward, position as shown in Fig. 18.
3. Disconnect brake rod at fork on rear axle.
4. Remove rear axle stud nuts and withdraw axle shaft assembly complete with rear axle bearing retainer.

   Note.—Care must be taken not to damage oil seal when removing axle shaft.
5. Remove brake backplate, camshaft and shims.

To Remove Left-hand Rear Axle Shaft Assembly (K-18)

1. Carry out instructions as detailed in operation K-1.

To Dismantle Rear Axle Shaft Assembly (K-19)

1. Carry out instructions as detailed in operation K-2.

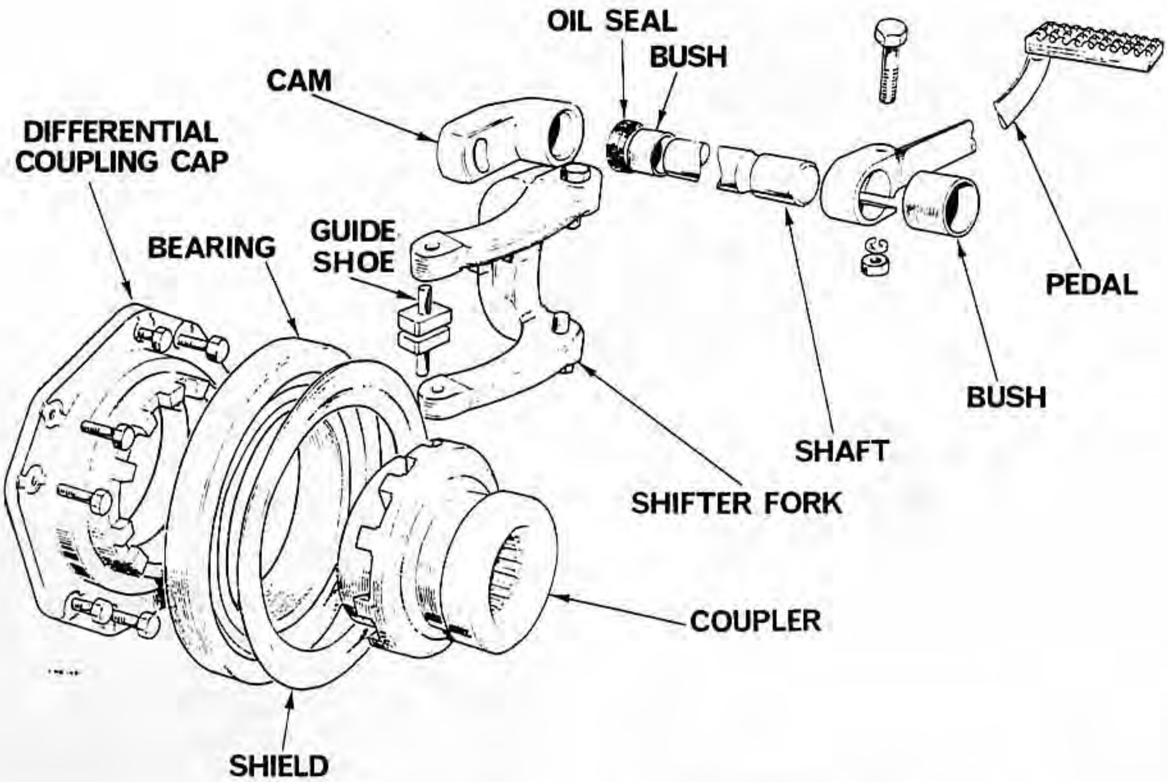

FIG. 19. EXPLODED VIEW OF DIFFERENTIAL LOCK COMPONENTS

To Remove and Dismantle Right-hand Rear Axle Housing Assembly (K-20)

If the rear axle housing assembly is only being removed to allow another operation to be carried out, there will be no necessity to dismantle it. If adequate lifting tackle is available, it will not be necessary to remove the rear axle shaft assembly. However, if parts are to be renewed, it will be necessary, in many cases, to check the axle shaft assembly end-float.

1. Drain oil from centre housing and transmission case and clean and replace magnetic drain plugs.
2. Remove wheel and fender.
3. Disconnect brake rod at rear brake lever. Remove check chain and lower link.
4. Slacken differential lock pedal pinch bolt.
5. Remove differential lock pedal return spring.
6. Remove rear axle housing to centre housing nuts and lift off rear axle housing.

To dismantle axle housing proceed as follows :—

7. Remove differential lock coupler from the half-shaft complete with guide shoes.
8. Remove rear axle stud nuts and withdraw axle shaft assembly complete with rear axle bearing retainer.
9. Remove differential lock pedal pinch bolt.
10. Drift cam assembly out of axle casing, so allowing the differential lock pedal to be removed.
11. Using a suitable tool, remove the camshaft assembly oil seal and bushes.
12. Using a suitable tool, remove bearing assembly and chip shield.

To Remove and Dismantle Left-hand Rear Axle Housing Assembly (K-21)

1. Carry out instructions detailed in operation K-3.

To Remove and Dismantle Differential Case (K-22)

1. Remove left-hand rear axle housing assembly as detailed in Instructions 1, 3 and 4 of K-3.
2. Lift out differential case assembly and, after removing differential coupling cap bearing cone, position on bench stand M-F 9-10 utilising adaptor M-F 9 or M-F 9M, as shown in Fig. 20.

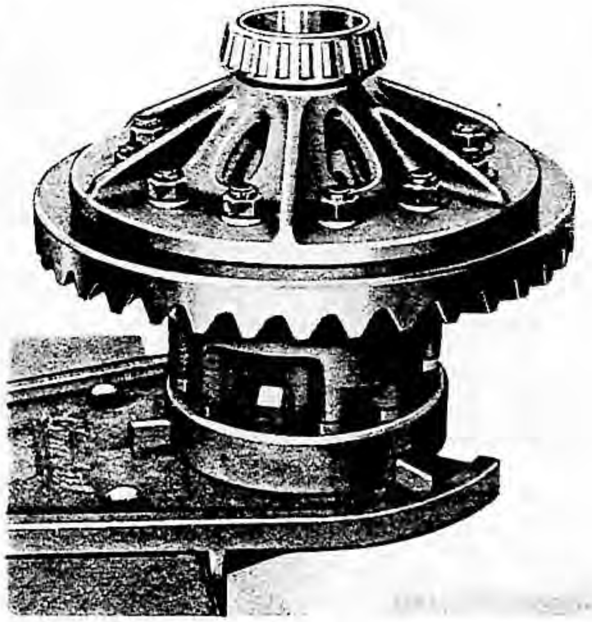

FIG. 20. DIFFERENTIAL CASE ASSEMBLY ON STAND

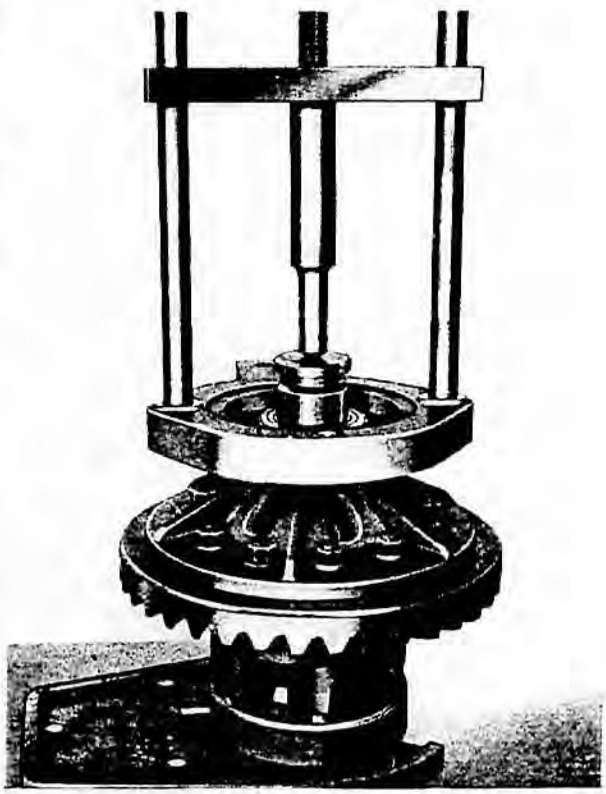

FIG. 21. REMOVING DIFFERENTIAL BEARING CONES

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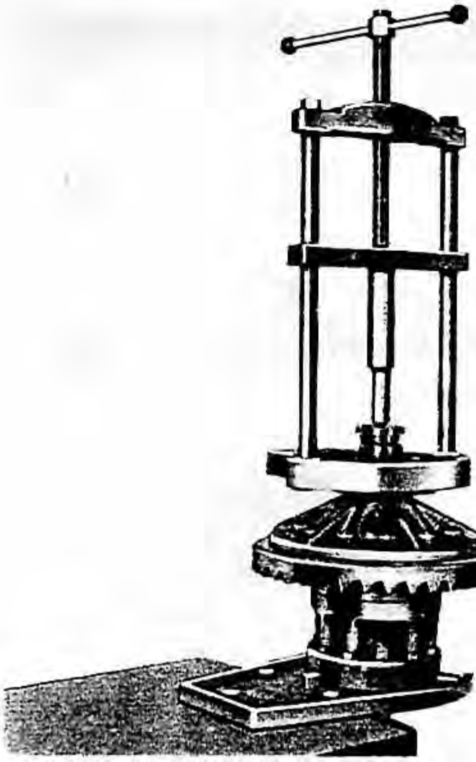


FIG. 22. REMOVING DIFFERENTIAL BEARING CONES

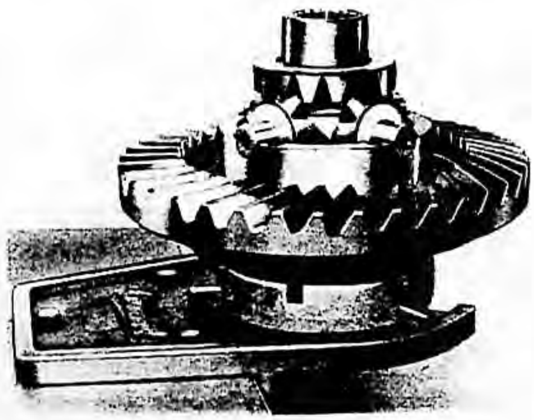


FIG. 23. DIFFERENTIAL CASE ASSEMBLY PARTIALLY DISMANTLED

3. Remove differential bearing cones using Service Tool M-F 200 with suitable adaptors, as shown in Figs. 21 and 22.
4. Remove differential gear case setscrews. Lift off right-hand differential gear case, as shown in Fig. 23.
5. The differential gears and thrust washers, cross-joint and pinions, with thrust washers, can now be removed.
6. Split driving gear nuts and remove driving gear from left-hand differential gear case.

To Remove and Dismantle Driving Pinion (K-23)

1. Carry out instructions as detailed in operation K-5.

To Split Tractor between Centre Housing and Transmission Case (K-24)

1. Carry out instructions as detailed in operation K-6.

To Effect Complete Dismantling of Rear Axle (K-25)

1. Carry out instructions as detailed in operation K-7.

RE-ASSEMBLY

The following sequences are based upon the assumption that the tractor is in the condition achieved by the corresponding dismantling instructions.

To Re-assemble Rear Axle Shaft Assembly (K-26)

1. Carry out instructions detailed in operation K-8.

To Replace Rear Axle Shaft Assembly and Check End-float (K-27)

1. Carry out instructions as detailed in operation K-9.

To Re-assemble Right-hand Rear Axle Housing Assembly (K-28)

If the axle housing assembly has been completely dismantled, it will be necessary to check the differential pre-load (operation K-30) to determine the correct size of chip shield to be fitted.

1. Replace chip shield and bearing assembly.
2. Replace differential lock camshaft bushes and oil seal.
3. Replace inner oil seal, using Service Tool M-F 176, as shown in Fig. 24.
4. Replace differential lock camshaft, pedal and pedal pinch bolt.
5. Refit axle shaft assembly.
6. Replace rear axle housing assembly complete with inner axle housing gasket, and tighten down rear axle to centre housing nuts to a torque of 70-75 lb. ft. (9.678-10.369 kg.m.).

7. If necessary, set half shaft end-float as detailed in K-9.
8. Replace differential lock pedal return spring.
9. Re-connect brake rod and replace check chain and lower link.
10. Refit wheel and fender.
11. Fill transmission to correct level with a recommended transmission oil.

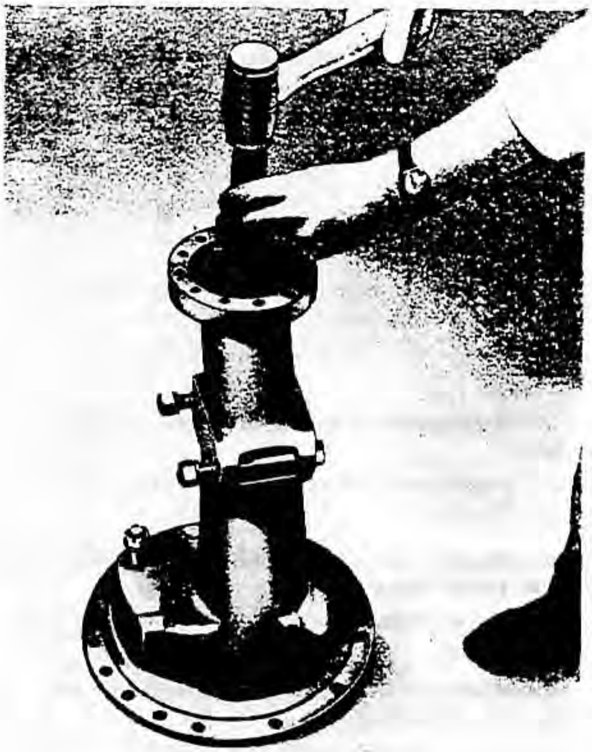


FIG. 24. USE OF M-F 176

To Re-assemble and Replace Left-hand Axle Housing Assembly (K-29)

1. Carry out instructions as detailed in operation K-10.

To Check Differential Bearing Pre-load (K-30)

This operation should be carried out whenever the differential unit is dismantled or the bearing replaced in the rear axle housing. Service Tool M-F 245 will be required to carry out this operation. Fig. 25.

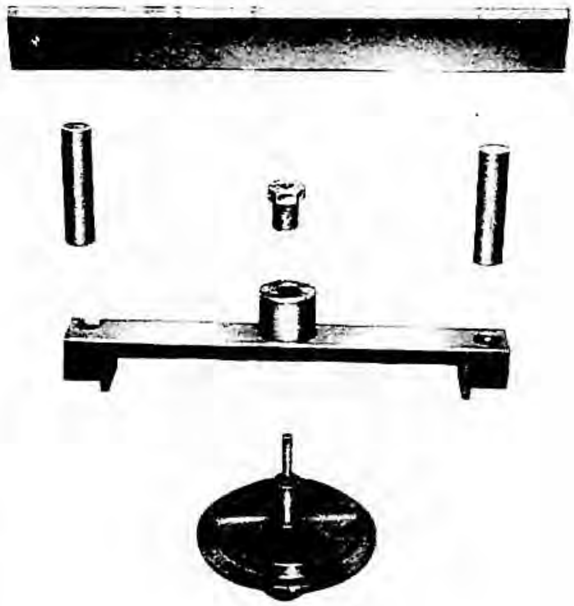


FIG. 25. SERVICE TOOL M-F 245

1. Assemble differential unit into centre housing.
2. Fit the removed bearing cap to its corresponding mating part.
3. Place the spigot end of the centraliser assembly, Service Tool M-F 245, into the splined differential gear.
4. Assemble clamp bar to centraliser, first ensuring the adjuster screw is screwed fully outwards.
5. Position ends of clamp bar over two studs on centre housing, as shown in Fig. 26.
6. Using two original nuts, secure clamp bar to centre housing.
7. Having first ensured that bearing is correctly tracking, tighten adjuster bolt to 20 lb. ft. (2.77 kg.m.). This is most important.
8. Screw the two setting blocks onto opposite studs on centre housing, Fig. 26.
9. Place straight edge across the two blocks and, with feeler gauges, measure the gap between the gauge pin on the centraliser and the underside of the straight edge. This gap is the thickness of shim required to give correct pre-load of the differential bearing, Fig. 27.

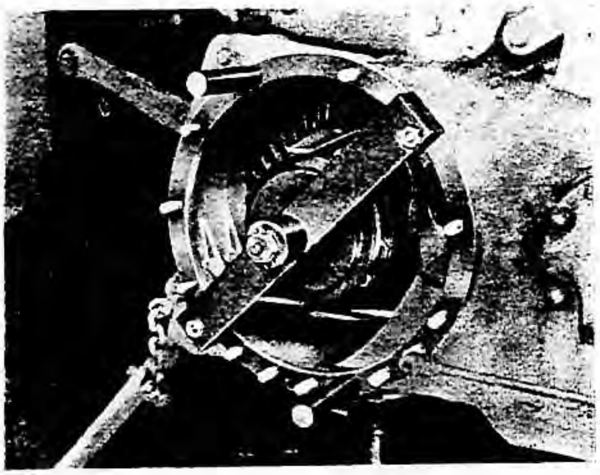


FIG. 26. USE OF M-F 245

DATA

Gap between straight edge and top of plunger	Means of Identification on Shim
.030"-.035" (.76- .89 mm.)	No Dots
.036"-.040" (.91-1.02 mm.)	One Dot
.041"-.045" (1.04-1.14 mm.)	Two Dots
.046"-.050" (1.17-1.27 mm.)	Three Dots
.051"-.055" (1.30-1.40 mm.)	Four Dots
.056"-.060" (1.42-1.52 mm.)	Five Dots

To Re-assemble Differential Case Assembly (K-31)

1. Replace one half of differential gear case onto Service Tool M-F 9-10.
2. Assemble differential gears and thrust washers, differential cross-joint, pinions and thrust washers onto gear.
3. Fit other half of differential gear case to this assembly. (Care must be taken that the stamped numbers on each gear case are co-incidental).
   Tighten down differential gear case screws to a torque of 80-85 lb. ft. (11.06-11.75 kg.m.).
4. Replace differential coupling bearing cone.
5. Fit driving gear and, after degreasing, replace driving gear bolts. Apply two drops of Loctite sealant, grade "A.V." to the threads. Replace nuts and, using Service Tool M-F 187, tighten nuts to a torque of 110-120 lb. ft. (15.21-16-59 kg.m.).
   Note.—Do not use a tractor under a heavy load for 24 hours after applying "Loctite".
6. Replace differential bearing cones (see Fig. 28).

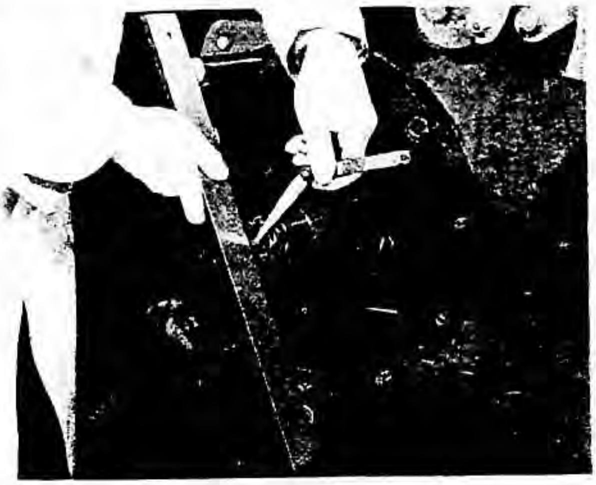


FIG. 27. USE OF M-F 245

FIG. 28. REPLACING DIFFERENTIAL BEARING CONES

To Replace Differential Case Assembly (K-32)

1. Carry out instructions detailed in operation K-12.

To Set Pre-load and Re-assemble Driving Pinion (K-33)

1. Carry out instructions detailed in operation K-13.

To Replace Driving Pinion (K-34)

1. Carry out instructions as detailed in operation K-14.

To Effect Complete Re-assembly of Rear Axle (K-35)

1. Carry out instructions as detailed in operation K-15.

To Re-assemble Centre Housing to Transmission Case (K-35)

1. Carry out instructions as detailed in operation K-16.

MASSEY-FERGUSON

35 TRACTOR

WORKSHOP SERVICE MANUAL

SECTION L

HYDRAULIC SYSTEM AND LINKAGE

HYDRAULIC SYSTEM and LINKAGE

Section L

INDEX

HYDRAULIC SYSTEM and LINKAGE

INTRODUCTION

The well known Ferguson System which combines tractor and implement into one unit, with the implement hydraulically controlled, is embodied in FE-35 tractors, and the range of control is extended to embrace:—

(*a*) **IMPLEMENT TRANSPORTING**

(*b*) **DRAFT (DRAUGHT) CONTROL**
To regulate automatically the draft and thereby the depth of soil-engaging implements.

(*c*) **RESPONSE CONTROL**
To vary the rate at which the lower links fall.

(*d*) **POSITION CONTROL**
To raise or lower the links to a selected and fixed height.

(e) **OVERLOAD RELEASE**
To protect soil-engaging implements when they collide with a buried obstruction.

(*f*) **EXTERNAL OIL PRESSURE TAKE-OFF CONNECTIONS**
To supply hydraulic pressure for operating external cylinders and other ancillary equipment.

OPERATOR'S HANDLING INSTRUCTIONS

CONTROL LEVERS (Fig. 1)

Located on the right of the driver's seat within easy reach of the operator the two levers provide manual control of the Hydraulic System. With the lever on the outer quadrant (draft control lever), the desired working depth of the implement is selected. The lever on the inner quadrant (operational lever) in its upper range provides position control of the lower link height and in the lower range adjusts the rate at which the working implement drops, i.e. the speed of response. The quadrants are marked accordingly as shown in Fig. 1.

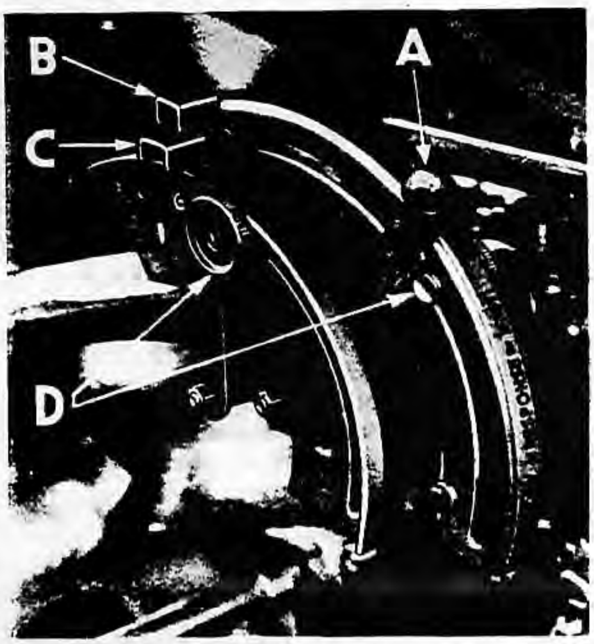


FIG. 1
HAND CONTROL LEVERS AND QUADRANTS

A. Operational Lever.
B. Draft Control Lever.
C. Adjustable Sector Fingergrip.
D. Knurled fixing nuts for adjustable marker stops.

DRAFT CONTROL

A soil-engaging implement fitted and raised to the transport position is lowered to the working position by moving the **operational lever** downwards through the position control range. See Fig. 1.

The depth at which the implement is required to operate is then selected, as the tractor moves forward, by the **draft control lever** situated in the outer quadrant and the lower the lever is set down the quadrant, the deeper will the implement be allowed to penetrate under the influence of its weight and the "suck" designed into the soil engaging parts. Once the selected depth is reached it will be maintained, uninfluenced by the rise or fall of the ground contour and the pitching of the tractor.

When the **draft control lever** position has been established, the finger grip of the small adjustable sector on the quadrant must then be positioned in line with the lever setting and locked in this position by the knurled nut. The finger grip marks for the operator his selected position and the small sector defines a working range on each side within which field adjustments may have to be made when changes in soil texture alter the draft and, therefore, the depth of the implement.

FIG. 2
HAND CONTROL LEVERS
Securing small adjustable sector in line with the draft control lever setting. Operational lever in the Response Sector.

Raising and Lowering the Implement at the end of a Furrow

The **draft control lever** must **not** be used for this purpose, but should be left at the chosen setting and the **operational lever** used to override "draft control" and raise the implement to the transport position.

If the draft control lever is fully raised, and the tension load on the top link is less than 1,000 lbs. (453.6 Kg.), the implement will be lifted beyond the transport shut-off position and the safety relief valve will discharge. The small adjustable sector, when locked in position, therefore serves also to prevent the operator from using the draft control lever inadvertently.

RESPONSE SELECTION

Assuming the selected depth has been obtained by use of the **draft control lever,** the rate at which certain implements drop when responding to the depth adjustments dictated by the hydraulic system is often too fast, while with other implements the drop is too slow for optimum control. The speed of response is therefore made variable to suit the implement, and the rate is etablished by the position of the **operational lever** in its lower range, which is suitably marked as shown in Fig. 1.

If "bobbing" or "bouncing" of the implement is apparent it can be smoothed by moving the **operational lever** closer to slow response. In general the response selection should be as slow as possible consistent with satisfactory depth control.

Implement Weight Transfer

In heavy going with a soil-engaging implement, when maximum weight transference from the implement on to the rear wheels is required so that traction is maintained, the **operational lever** should be moved towards slow response position until the implement takes about three seconds to drop to ground level from the fully raised position, when the oil is warm.

The speed of drop can be checked by setting the **operational lever** in the response range and fully lifting and lowering the implement by means of the **draft lever.**

Generally the lower the response setting, the smoother will be the ride, also a more level furrow bottom will be obtained. Care should be taken with this setting so that the implement does not pitch with the tractor, however, the closer the lever can be set to the pitch setting, the better will be the results obtained.

The final selection is dependent upon the operator's feel of the tractor or implement and the operational lever stop, which is provided with a knurled nut, should afterwards be locked in position to mark the setting, as the **operational lever** is used to raise the implement at the end of the furrow.

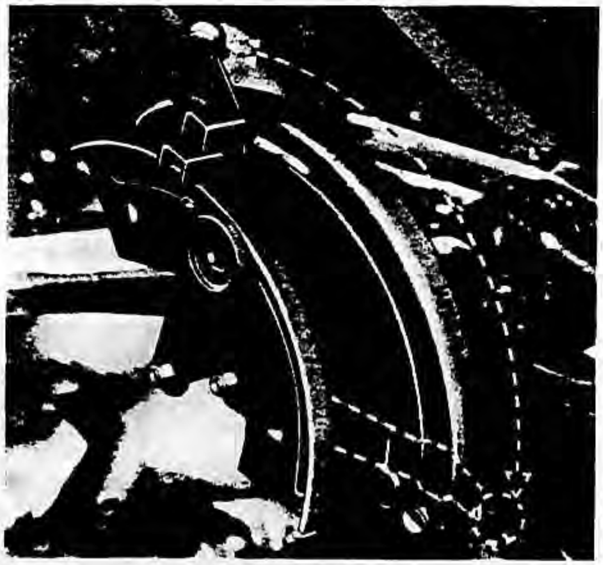


FIG. 3
HAND CONTROL LEVERS
Raising operational lever to transport position. Draft control lever remains at chosen setting (at end of furrow).

POSITION CONTROL (Fig. 4)

As previously noted, the **operational lever** at the lower end of its quadrant varies the speed of response.

At the upper end of its quadrant the **operational lever** raises and lowers the implement and also provides an infinite number of positions for the lower link height, which correspond approximately to the lever position. The operator may thereby select and automatically maintain a fixed height or depth of an implement.

The adjustable stop is provided on the quadrant so that the implement, after being raised, may always be returned to its previously selected position.

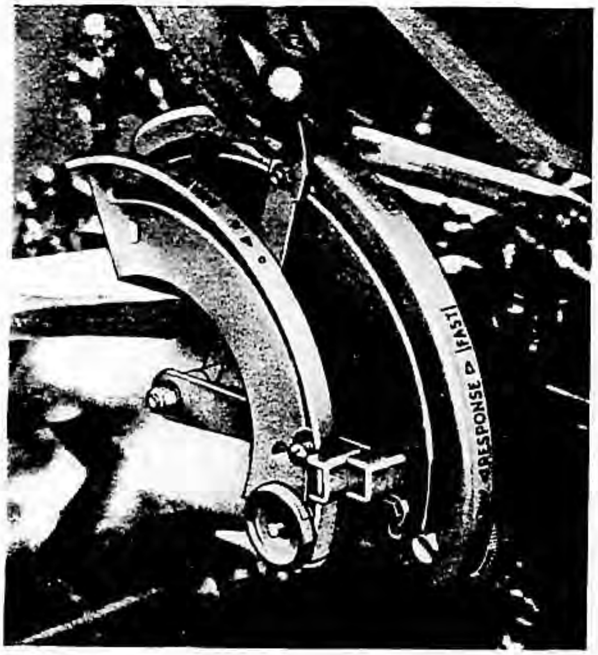


FIG. 4
HAND CONTROL LEVERS
Selecting operational lever setting for a fixed implement position. Draft control lever at maximum draft position.

Advantages

"Position Control" is useful for earth moving implements with steep entry angles which are coupled closely enough to be unaffected by the pitching of the tractor. It is of assistance when hitching an implement and is definitely advantageous for devices that are not soil engaging, such as the crane, or partly so, such as the scraper blade or soil scoop.

WARNING

Do not move the operational lever from Position Control to "Fast" Response when the tractor is standing on a hard surface, e.g. a concrete floor, as the implement will crash down and may be damaged.

OVERLOAD RELEASE

If the implement strikes a hidden obstruction, an excessive forward thrust occurs against the control spring (see Fig. 14) and the hydraulic system control valve is moved to jettison the oil from the hydraulic lift cylinder. This immediately releases the implement weight from the rear of the tractor. As this weight, plus the soil suck of the implement and the weight of the soil have been providing draft weight at the rear wheels to give traction, the tractor stops with the rear wheels spinning without damage to the implement. At the same time a very powerful force is directed forward and down on the front end of the tractor and prevents it from rearing. The tractor can then be reversed, the implement raised and the tractor moved forward before lowering the implement at a point beyond the obstruction.

EXTERNAL HYDRAULIC EQUIPMENT

There are three external oil pressure points in the hydraulic lift cover as indicated in Fig. 5, for use with the implements which incorporate remote pressure operated hydraulic systems, such as the Ferguson High Lift Loader. Oil can be supplied to and drained from auxiliary cylinders without holding the lower links down, by using the **draft control lever,** when there is little or no tension load on the control spring and the **operational lever** is at the bottom of its quadrant in the Response Sector, i.e. situated according to the speed of response required.

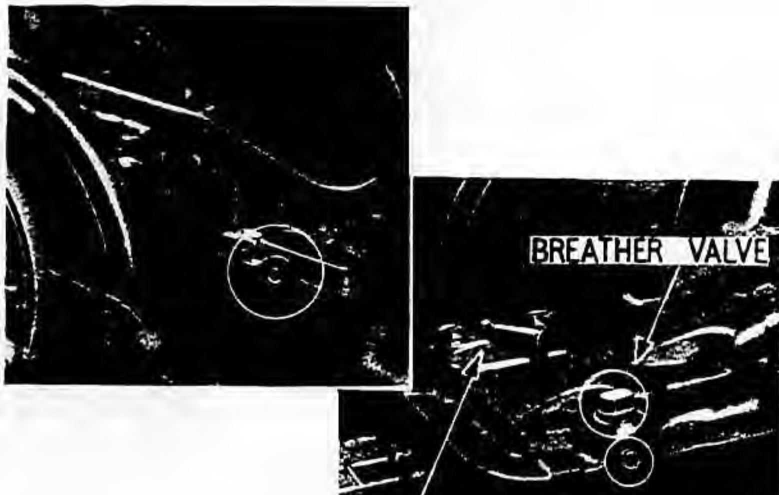


FIG. 5
OIL PRESSURE TAKE-OFF CONNECTIONS

The pump is connected to the internal lift cylinder through the external cap, Figs. 5 and 7, which can be removed for the installation of external valves.

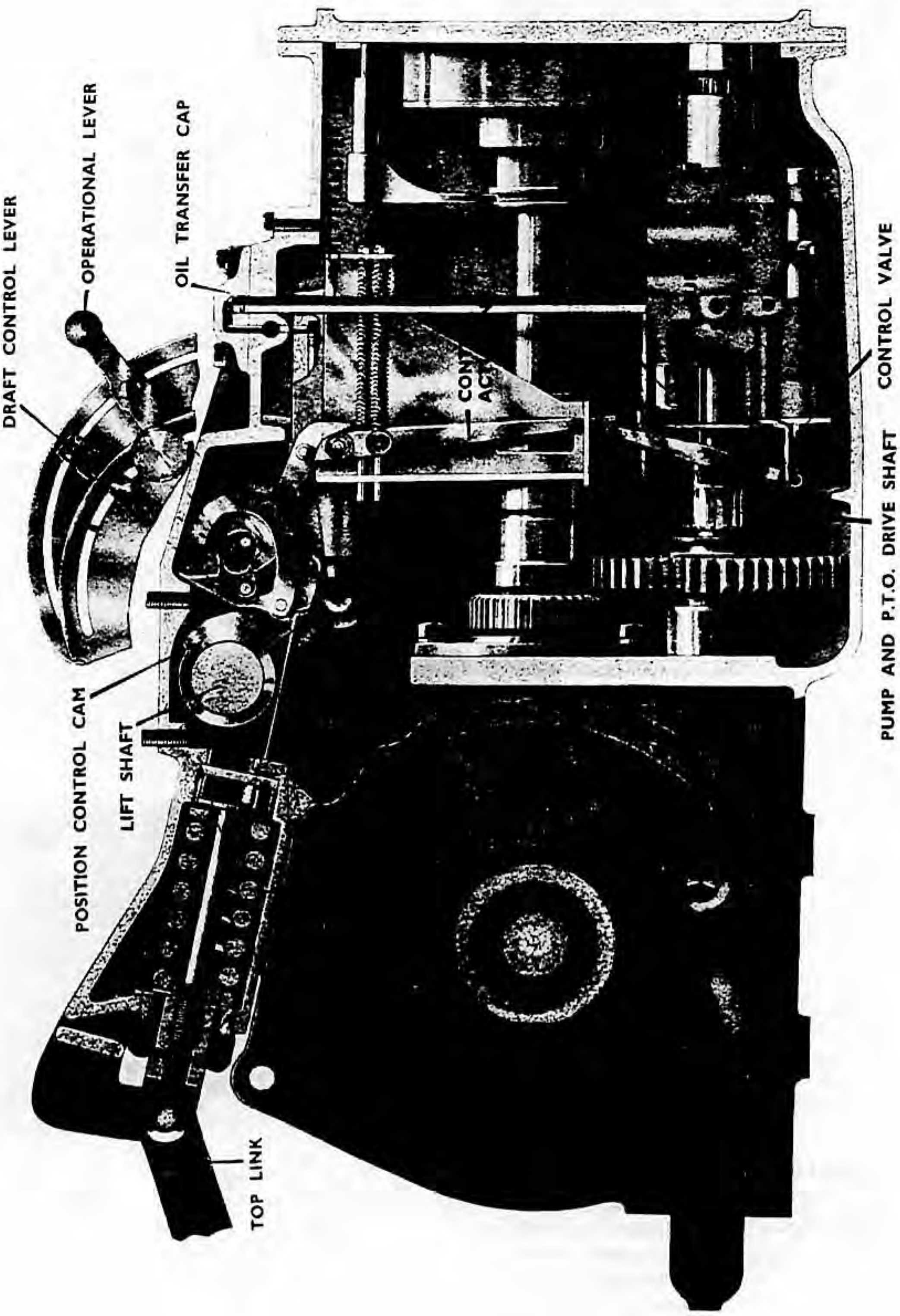


FIG. 6(*b*)
INTERNAL LAY-OUT OF THE HYDRAULIC SYSTEM

COMPONENTS

The Hydraulic System which provides these controls is located within and about the tractor centre housing.

FIG. 6(*a*)

EXTERNAL VIEW OF THE HYDRAULIC SYSTEM

1. End of lift shaft.
2. Lift arms.
3. Lift rods.
4. Lower links.
5. Levelling lever.
6. Forward ball mounting.
7. Hydraulic system control levers.
8. Top link connection.
9. Control spring (internal).
10. Check chains.

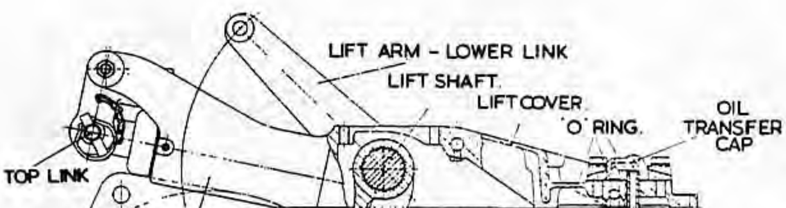


FIG. 7
ARRANGEMENT OF THE HYDRAULIC RAM CYLINDER

As shown in Figs. 6(*a*) and 6(*b*) the system comprises a four cylinder pump which supplies oil through a vertical pipe to the hydraulic cylinder. A connecting rod from the cylinder engages the ram arm of the lift shaft, the ends of which project from the top of the casing. Splined to each end of the shaft (1) is an arm (2) to which is attached, through a universal joint, a lift rod (3) which is in turn connected to the mid-point of each lower link (4). The right hand rod is adjustable for length by means of a levelling lever (5). The implement is attached on rear ball mountings (4) to the lower links, which can pivot on their forward ball mountings (6) at the base of the rear axle casing.

The arrangement is such that, when oil under pressure from the pump is supplied to the closed end of the hydraulic lift cylinder, the piston is forced rearwards, rocking the lift arm and thereby rotating the lift shaft to raise the lower links. See Fig. 7.

Similarly, when oil is allowed to drain back from the system the piston retreats back into the cylinder under the load on the links.

HYDRAULIC PUMP

The constant running, positive displacement, four cylinder pump is located in the oil sump between the transmission and final drive, as shown in Fig. 6(*b*).

The pump is driven in the Basic Model Tractor by an extension of the transmission countershaft and in the De Luxe Model by a separate shaft, which extends through a hollow countershaft to connect the pump, and P.T.O. to the engine independently of the transmission drive. The pump shaft, supported at the front in a pinned coupling collar and at the rear on the P.T.O. shaft by needle roller bearings is, in effect, the linking shaft between the drive from the engine and the P.T.O. at the rear.

The pump body is carried on its shaft by bronze bushes, it is made "fully floating" to facilitate alignment and restrained from rotating by dowel pins inserted through the side walls of the rear axle centre housing.

The discharge pressure is adjusted by the spring cap which is screwed inwards to increase and outwards to decrease the operating pressure.

FIG. 8

COMPONENTS OF THE HYDRAULIC PUMP

1. Piston yokes.
2. Cam blocks.
3. Pump drive shaft.
5. Valve chambers.
6. Front casting.
7. Rear casting.
8 & 9. Valve oscillator rocker and follower.

The construction, as shown in Figs. 8 and 13, consists of two piston yokes which ride on cam blocks over eccentrics on the pump drive shaft. The pistons reciprocate in two opposed valve chambers, each embodying a pair of inlet and outlet valves and springs. A sealing plug, complete with "O" ring and held in place by a circlip, closes the valve chamber above each assembly.

The pump assembly is sandwiched between front and rear castings, which incorporate the oil galleries joining the two valve chambers and house the control valve at the rear and support the valve oscillator body—see Fig. 12.

Relief Valve

There is no check valve in the system, but a pressure relief valve in the pump outlet gallery, situated as shown inset Fig. 12, operates when a nominal pressure of 2,500 lb/sq. in. (175.9 Kg/sq. cm.) is exceeded. This could be caused by attempting to lift too heavy a load on the lower links or by trying to lift an implement caught beneath an obstruction.

ACTION OF THE PUMP (Fig. 9)

The lower portion of the pump is immersed in the transmission oil which also supplies the hydraulic system.

As each of the pump pistons moves down its cylinder it creates suction which lifts the inlet valve from its seat and draws in oil past the control valve—if open—along the intake gallery into the cylinder.

During this inlet stroke the outlet valve is held closed by the spring acting upon it. When the piston reaches the end of its inlet stroke the inlet valve is closed by the inlet valve spring.

As the piston returns into the cylinder, the resultant pressure on the oil keeps the inlet valve closed and lifts the outlet valve. This pressure forces the oil past the outlet valve into the discharge passage.

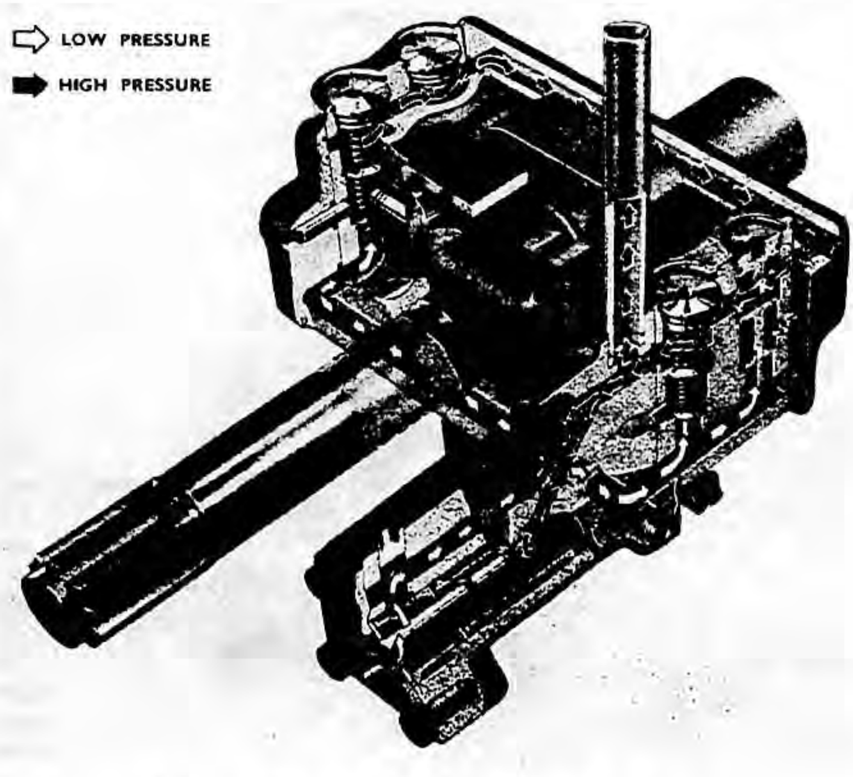


FIG. 9 HYDRAULIC PUMP SHOWING OIL FLOW

The foregoing action, as described for one cylinder only is completed for that cylinder each time the P.T.O. shaft makes one revolution. The other three cylinders are working in the same manner so that there are four uniformly spaced impulses of oil, for each revolution of the P.T.O. shaft, being delivered into a common outlet gallery leading to the lift cylinder, as shown in Fig. 9.

CONTROL VALVE ASSEMBLY

Flow of oil through the pump is governed by a sliding control valve, which regulates the supply to and from the lift cylinder according to the height prescribed for the lower links by the manual control levers beside the driver's seat. The automatic features of the system which follow pre-selection by the hand levers will be explained, together with details of "Overload Release" and the use of the system to operate external ancillaries.

FIG. 10
CONTROL VALVE

Construction

The control valve—a sleeve type of tubular construction—slides inside the lower portion of the pump rear casting on three hardened steel washers which are separated by spacing sleeves, thereby dividing the bore inside the casting into two compartments.

These two compartments provide inlet and outlet chambers for the pump which are opened and closed by the inlet and outlet slots at opposite ends of the control valve. The suction side of the pump or intake passage connects with the rear or outer compartment and similarly the inner compartment lies at the bottom of the high pressure side of the system. The outer ends of the high pressure chamber are sealed by "O" rings and the assembly is held in place by a cover plate bolted to the rear casting.

Operation

When the valve slides forward, Fig. 11(*a*), its inlet slots pass within the suction chamber so that the

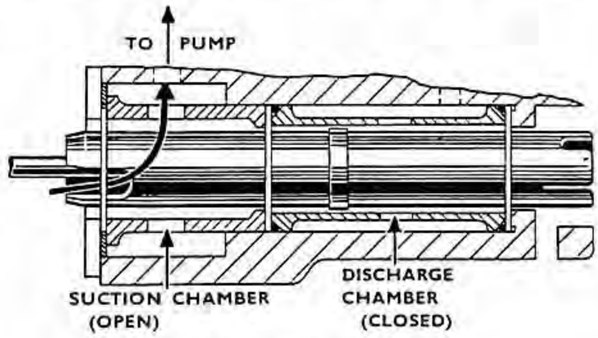


FIG. 11(*a*) 'LIFT' POSITION

constant running pump may draw on the oil supply and deliver it to the lift cylinder to raise the lower links. In this position the valve keeps the discharge chamber closed so that oil cannot escape back to the sump.

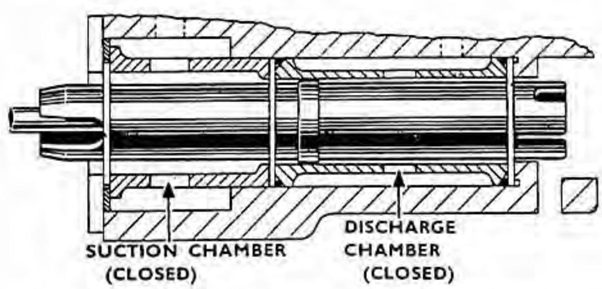


FIG. 11(*b*) 'NEUTRAL' OR 'CUT-OFF' POSITION

With the valve positioned centrally, Fig. 11(*b*), both the inlet and outlet slots are outside their respective chambers, the oil is therefore locked in the system and the lift piston and lower links remain stationary.

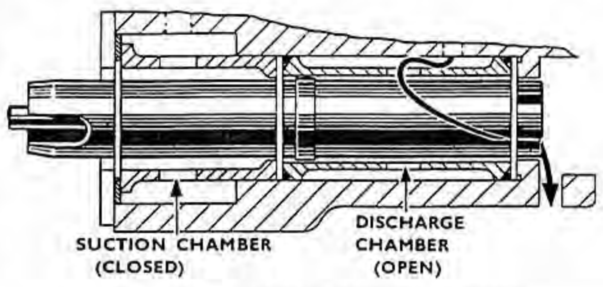


FIG. 11(*c*) 'DROP' POSITION—'SLOW'

When the valve slides rearwards, Fig. 11(*c*), the suction chamber remains closed, but the outlet slots are brought within the discharge chamber, permitting oil thereby to drain into the sump from the lift cylinder and the lower links fall.

The rate at which the oil drains away is, of course, proportional to the area of the slot within the chamber, which is dependent on the amount the valve is withdrawn. Added to this the second and larger pair of slots, see Fig. 11(*d*), begin to be

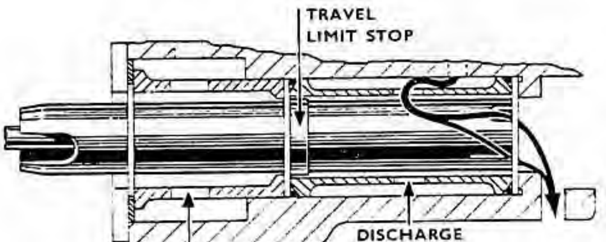


FIG. 11(*d*) 'DROP' POSITION—'FAST'

exposed as the valve moves progressively rearward, the rate of drop therefore accelerates abruptly when these two also pass within the discharge chamber. The fast rate of dumping thus provided is a distinct advantage with various implements as will be apparent, but this arrangement is *not* connected with "Overload Release" which is obtained when the valve is thrown right forwards until the even larger inlet slots of the valve just enter the discharge chamber to jettison the oil from the system—Fig. 11(e).

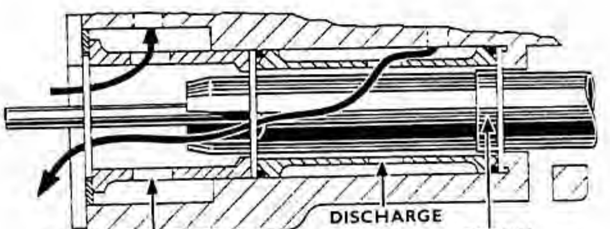


FIG. 11(e) 'OVERLOAD RELEASE' POSITION

The travel of the valve is limited by a collar which butts against the front sealing washer in the one direction and the centre sealing washer in the other, as shown in Figs. 11(*d*) and (e).

As shown in Fig. 12, **the valve is always biased towards the drop position by a compression spring** which operates against a square head on the end of the valve push rod. A tapered square on the other end of the push rod wedges into a squared portion of the control valve bore.

Four grooves in the bore of the oscillator body receive the corners of the square head of the push rod, which is free to slide within the cylinder against the spring pressure. The assembly is immersed in the transmission oil and the front of the cylinder is closed, the clearance between the square and the round bore in the oscillator body therefore provides dash-pot action or dampening effect on the movement of the valve.

Further, the head of the push-rod in the grooves of the oscillator body transmits directly to the valve the oscillating movement imparted to the body as described hereafter.

CONTROL VALVE OSCILLATING MECHANISM (Fig. 13)

To keep the control valve responsive and free from sticking a valve oscillating mechanism is incorporated as shown in Fig. 13 and functions as follows:—

The oscillator body, supported at each end in the pump front and rear castings, is free to rotate and has a rocker arm encircling its centre secured by a set screw.

The arm of the rocker is joined to a cam follower, which rides one of the pump eccentrics as the drive shaft rotates, and, thereby driven, imparts oscillating motion to the rocker arm and through the oscillator body and push rod to the control valve.

Cleanliness

Even so, it must be realised that the finest of working tolerances are used to ensure extreme accuracy in the fit of the control valve in the bore of the sealing washers, the importance of using only clean oil in the tractor transmission will therefore be appreciated. Additionally, magnetic type drain plugs for the transmission oil provide a measure of protection.

CONTROL VALVE OPERATING LINKAGE AND MECHANISM

As shown in Fig. 12, the connection between the valve and its operating linkage is made by a hemispherical ended push rod which is attached at the rear to the control valve actuating lever pivoting at its centre on a rod protruding from the rear of the pump.

From the top end of the valve actuating lever the mechanism divides into two separate and independent series of linkages which terminate at two levers working side by side against a common roller on the end of the valve actuating lever as shown inset. (Fig. 12).

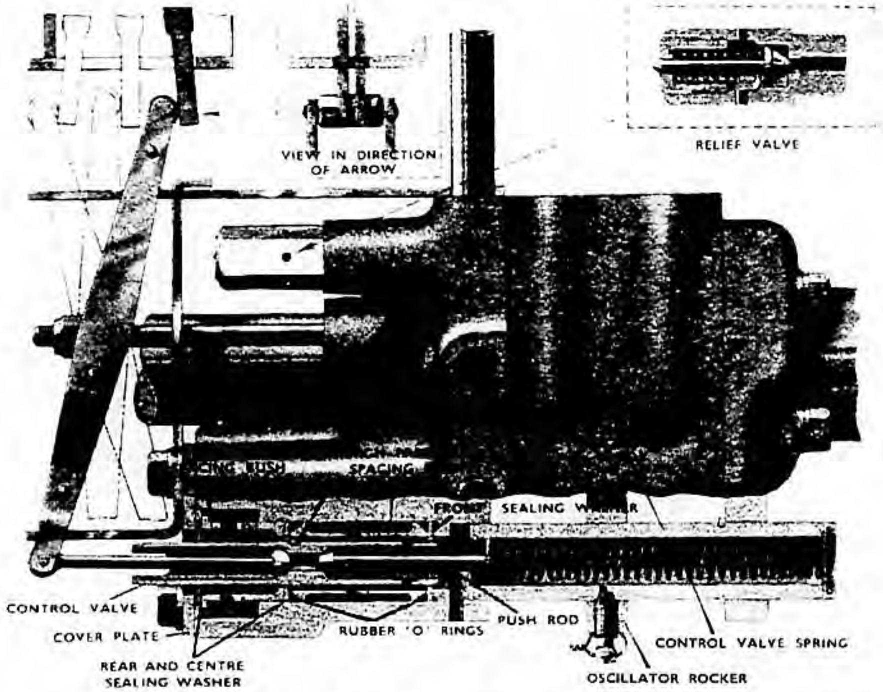


FIG. 12 HYDRAULIC PUMP CUT AWAY TO SHOW THE CONTROL VALVE ASSEMBLY

Note Insets: The section through the relief valve and that two levers operate side by side against the valve actuating lever

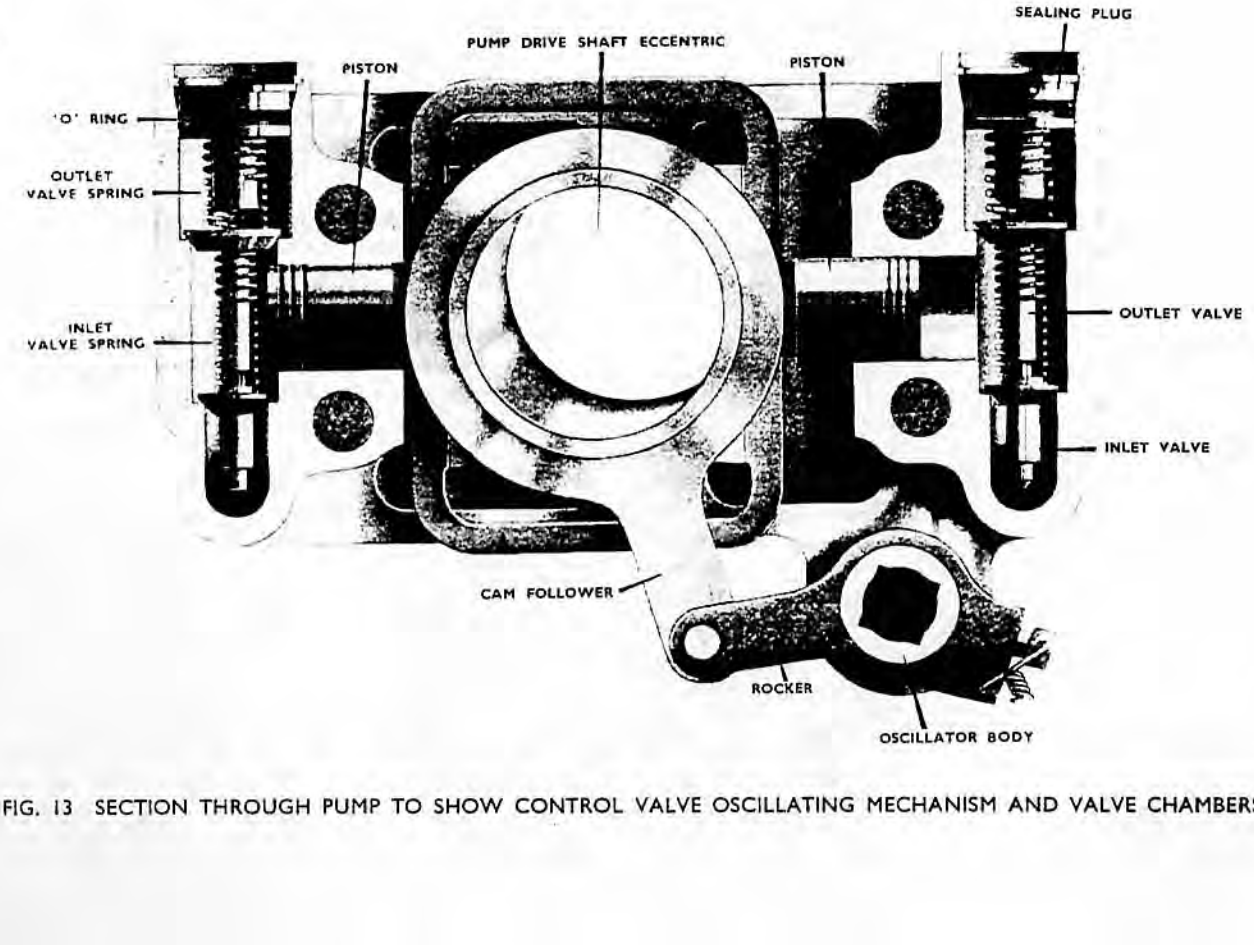


FIG. 13 SECTION THROUGH PUMP TO SHOW CONTROL VALVE OSCILLATING MECHANISM AND VALVE CHAMBERS

The control valve can therefore be operated through its three positions—"lift", "cut-off" and "drop" by means of two separate systems each of which is controlled both manually and automatically.

Manual operation is effected by the separate hand levers as explained on page L.1; the **Automatic** source of control is provided for one system by a cam which rotates with the lift shaft as the lower links rise or fall; and for the other system by the draft reaction of the implement through the top link measured by a control spring—refer to Fig. 14.

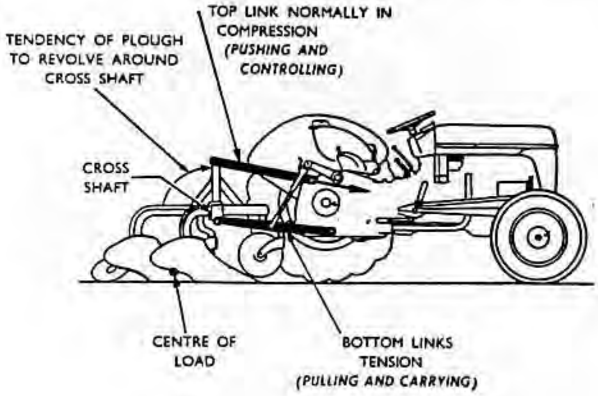


FIG. 14
SOIL REACTION ON TRACTOR LINKAGE

Before continuing with the description of the control valve actuating linkage it may perhaps be advisable first to examine the purpose and operation of the control spring as explained on page L.17.

VALVE LINKAGE

This section explains in detail the operation of the two valve linkages.

SYSTEM A

LIFT AND DROP—POSITION AND RESPONSE CONTROL—Figs. 15 and 16.

Components

The main components of this system include an elliptical position control link (A) pivoting at the top and having at the bottom two rollers—one (B) in contact with a cam on the ram arm, the other (C) in contact with a position control differential cam (D). This cam is jaw shaped at one end to accommodate a roller (U) on the shaft of the operational lever and pivots at the other end on a vertical lever (E), which, in turn, pivots on a spring loaded guide rod (F). The lower end of the lever moves in a slot in a support bracket and is in contact with the roller at the top end of the valve lever (G).

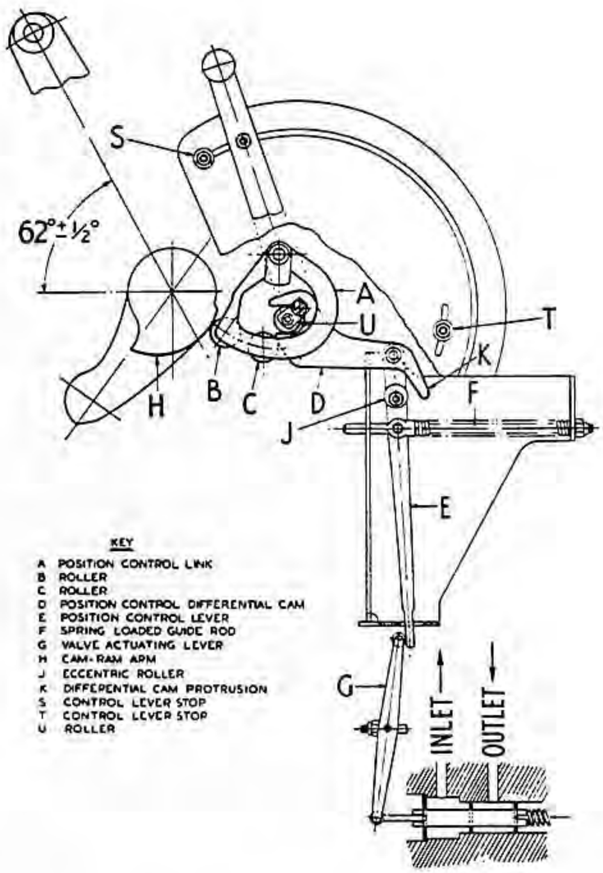


FIG. 15
RESPONSE AND POSITION CONTROL
'TRANSPORT SHUT OFF'

With the operational lever at the top of its quadrant, the control valve is maintained in the mid or neutral position by the vertical lever (E) holding back the valve lever (G) against the force of the spring loaded valve. This same force always tends to pivot vertical lever (E) about the guide rod and thus move cam (D) back against the roller (C) on control link (A).

To Lower the Links (Fig. 16)

If the operational lever is moved forward within the position control range, the roller (U) on the operational lever shaft lifts cam (D) and allows it to ride up the roller (C) on link (A) under the action of the control valve compression spring. In doing so the cam (D) moves rearwards and enables the lower end of the vertical lever (E) to pivot forward about the guide rod (F) and the control valve to move into the drop position. As the oil drains from the lift cylinder the ram arm moves forwards rotating with the lift shaft and

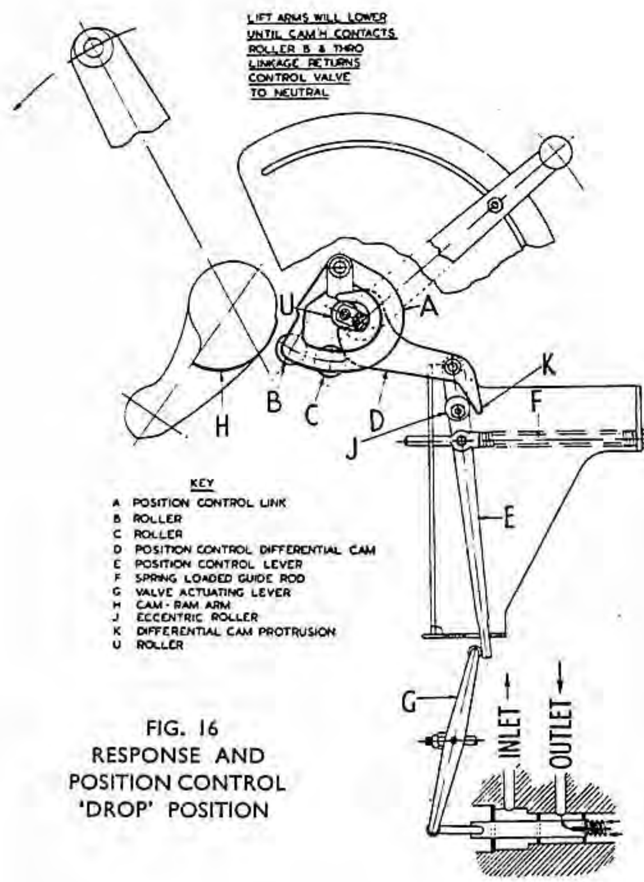


FIG. 16
RESPONSE AND
POSITION CONTROL
'DROP' POSITION

cam (H) is pushed against roller (B) on link (A) and moves it forward against cam (D). The latter moves in the same direction since it is in contact with the roller (C) on the link (A) and, in so doing, pivots the end of the vertical lever (E) to move the valve to neutral. This sequence of action occurs when the operational lever is moved forwards and stopped in the position control range.

The lower links follow at all times the position of the lever in its quadrant and the speed with which it is moved.

Response Control

When the operational lever is moved out of Position Control into Response Control (Fast), cam (D) continues to move rearwards and up the roller (C) and allows the control valve to assume the full discharge or drop position. Continued movement of the operational lever towards the slow response setting lifts cam (D) to bring protrusion (K) on its forward end in contact with an eccentric roller (J) on vertical lever (E). Thereafter, cam (D) and vertical lever (E) work as a solid bell crank lever free to pivot on the guide rod, cam (D) being lifted out of effective contact with roller (C). Once this stage is reached further movement of the operational lever effects a reverse action of the valve lever (G) to move the valve inwards and brings about a progressive decrease in the area of the control valve outlet slots within the discharge chamber of the pump. Vertical lever (E) thus becomes an adjustable stop or abutment regulating how far actuating lever (G) can move the control valve into the drop position, thereby establishing the rate at which the oil can drain from the system.

To Raise the Lower Links (Fig. 17)

Understanding of the foregoing should make it obvious that return or upward movement of the operational control lever from "Slow" to "Fast Response" moves the control valve outwards to full discharge. When the operational lever reaches the lower end of the position control range it forces cam (D) downwards and rearwards against roller (C), reverses the movement of vertical lever (E) and moves the valve to "lift". If the operational lever is now left in a fixed position, rotation of cam (H) on the ram arm, as the lower links rise, allows link (A) and cam (D) to move rearwards due to the force of

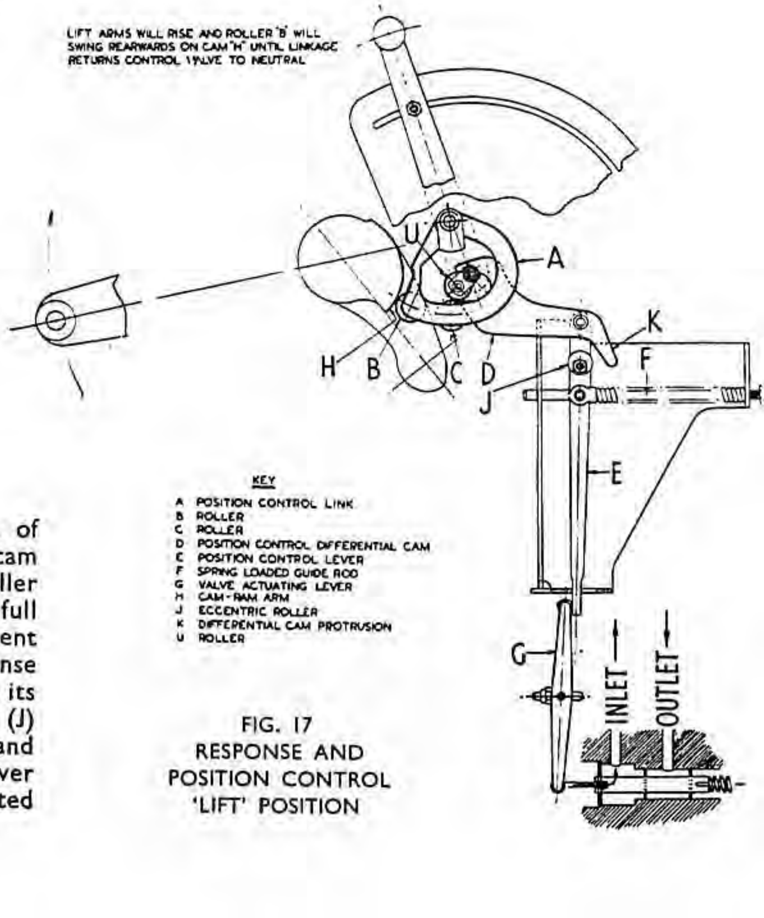


FIG. 17
RESPONSE AND
POSITION CONTROL
'LIFT' POSITION

the control valve spring and the valve itself to shift into neutral. Thus a position control setting for a given position of the operational lever is established.

Movement of the operational lever to the top of its quadrant moves the valve into intake and when maximum rise of the lower links is approached rotation of cam (H) and consequent rearward movement of cam (D) returns the control valve to neutral to effect pump "cut-off".

General
To ensure a quick reaction of the hydraulic system, to changes in the position of the operational lever the various components are so arranged that full travel of lever (E) and hence that of the control valve is effected by a comparatively small movement of the operational lever. The purpose of the compression spring on guide rod (F) is to absorb movement of the operational lever in excess of that necessary to produce full travel of the control valve. When the tractor linkage is raised by fairly **slow** upward movement of the operational lever through the position control range, the resulting forward movement of cam (D) is just sufficient to maintain the control valve in intake since it (cam D) is subject at the same time to the rearward motion of link (A) due to the changing position of cam (H) on the ram arm as the linkage rises. Thus, the position of the control valve is maintained by the combined movements of the operational lever and cam (H) acting in unison. If the operational lever is moved upwards fast enough to over-ride the rate at which cam (H) turns, the lower end of vertical lever (E) comes into contact with the end of the slot in the lever support bracket. In these circumstances further forward movement of cam (D) is absorbed by the compression spring on rod (F), lever (E) pivoting about its lower end until such time as cam (H) rotates sufficiently to allow link (A) and cam (D) to shift rearwards and return the guide rod pivot to its normal position, lever (E) will then return control valve to neutral in the usual manner.

SYSTEM B

DRAFT CONTROL AND OVERLOAD RELEASE

The chief components of this second system are arranged side by side with those of System A and comprise, as shown in Fig. 18, a draft control differential cam (L) secured to a vertical lever (M) free to pivot about guide rod (N) and able at its bottom end to come into contact with the valve lever (G). The rear end of cam (L) is jaw shaped and rests on a small roller (V) secured to the shaft of the draft control lever. A second roller (P) on the forward end of the draft control rod (O) is in contact with the lower inner surface of the jaws. A supporting linkage prevents vertical movement of roller (P) by the force of the spring-loaded control valve acting through the levers (G) and (M).

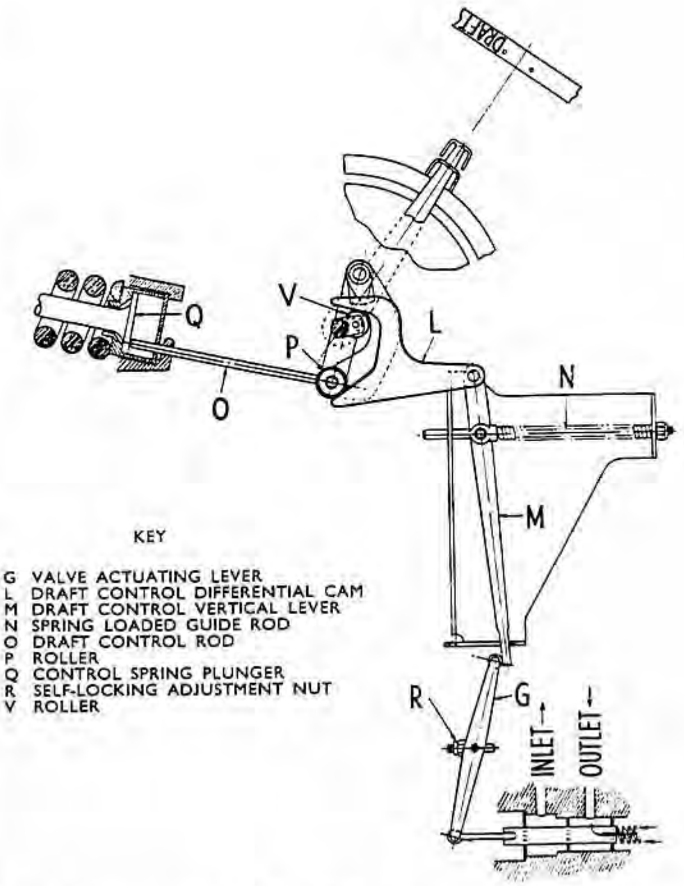


FIG. 18 DRAFT CONTROL
'ZERO' DRAFT POSITION—LEVER ON SECTOR MARKS

Let it be assumed that a suitable implement is attached to the tractor and that the operational lever has been moved forward into the "Response" range, thus lowering the implement to the ground. The control valve will be in the discharge position. If the tractor is driven forwards the implement will gain depth and automatic draft control will come into operation in the following manner:

Implement draft pressure (see Fig. 14) against control spring plunger (Q) moves control rod (O) forward and pivots cam (L) forwards about roller (V) on the draft control lever shaft. This action pivots lever (M) about guide rod (N) and operates valve lever (G) to move the control valve to neutral. Once the valve attains the neutral position further penetration of the implement is prevented—the implement draft balancing the degree of control spring compression necessary to centralise the valve. Should, for instance, surface undulations cause a temporary increase or decrease in working depth and therefore in the compression force against the control spring, the position of cam (L) will alter to move the control valve into intake or discharge to re-establish the original draft setting.

To make the implement work deeper the draft control lever is moved forwards to lower the position of the roller (V) secured to its shaft. This causes cam (L) to drop and move rearwards, the roller (P) to assume a new position further up cam (L), the control valve to go into discharge and the implement to lower. The effect of this action is to increase the forward travel of control spring plunger (Q) necessary to move cam (L) sufficiently to return the control valve to neutral. The implement will continue to gain depth until enough draft is produced to provide the necessary extra compression of the control spring to move the rod (O) the required amount. When this occurs a state of balance is once again established. The action is repeated each time the draft control lever is moved further down its quadrant.

A reverse action takes place when the draft control lever is pulled back slightly to effect a decrease in implement depth. Cam (L) is lifted by the roller (V) on the draft lever shaft and, owing to the position of roller (P), moves simultaneously forwards to pivot lever (M) and moves the control valve to intake. Implement working depth is immediately reduced and likewise the compression of the control spring. The draft control rod (O) and roller (P) move to the rear as does cam (L) and the control valve returns, once more, to neutral.

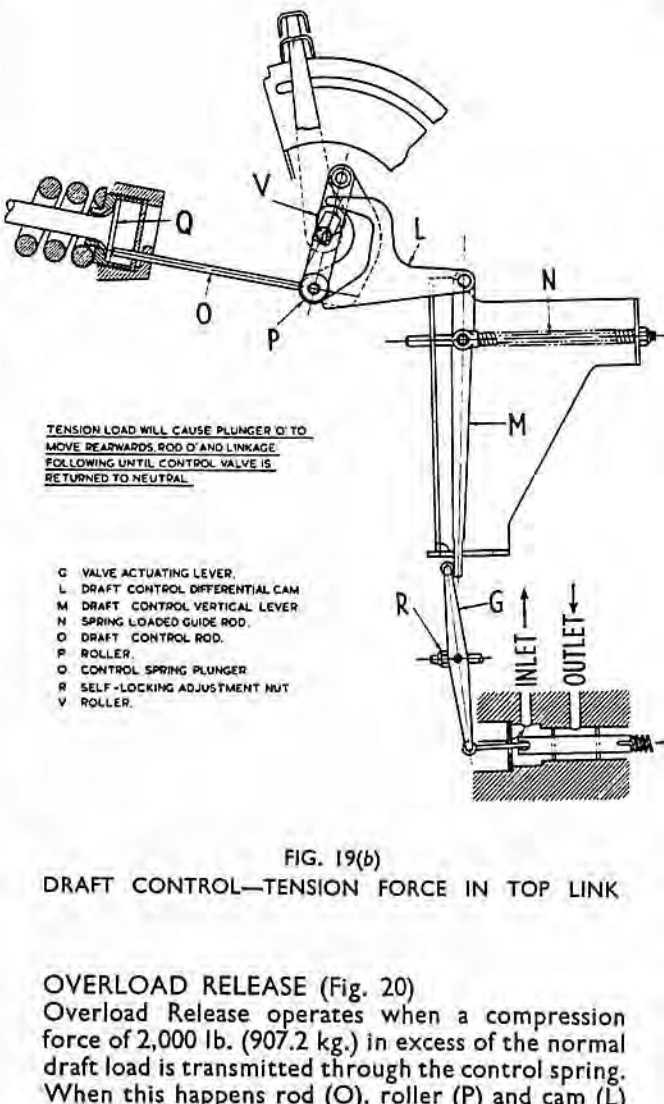


FIG. 19(*b*)
DRAFT CONTROL—TENSION FORCE IN TOP LINK

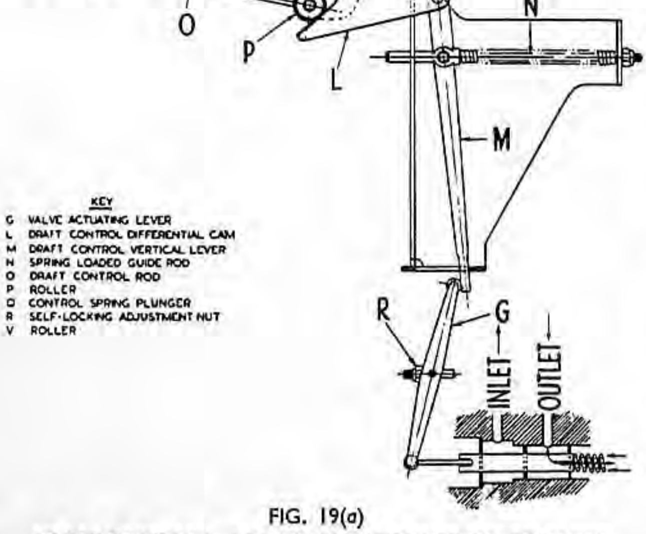


FIG. 19(*a*)
DRAFT CONTROL—COMPRESSIVE FORCE ON TOP LINK

OVERLOAD RELEASE (Fig. 20)

Overload Release operates when a compression force of 2,000 lb. (907.2 kg.) in excess of the normal draft load is transmitted through the control spring. When this happens rod (O), roller (P) and cam (L) move forwards sufficiently to move the control valve through the lift position until the inlet slots enter the discharge compartments, Fig. 11(e). The larger inlet slots ensure an immediate and rapid discharge of oil from the ram cylinder.

The fact that overload release always operates for a force of 2,000 lb. (907.2 kg.) in excess of the prevailing draft load against the control spring ensures equal protection for implements developing light or heavy draft. With a light draft implement producing a compression load of 500 lb. (226.8 kg.) through the control spring, overload release is actuated for a total load of 2,500 lb. (1134 kg.), the corresponding figures for an implement of heavy draft could be 3,000 lb. (1360.8 kg.) and 5,000 lb. (2268 kg.). For an implement developing a tension load of 1,000 lb. (453.6 kg.) against the control spring, overload release takes place when the load is reversed into a compression one of 1,000 lb. (453.6 kg.).

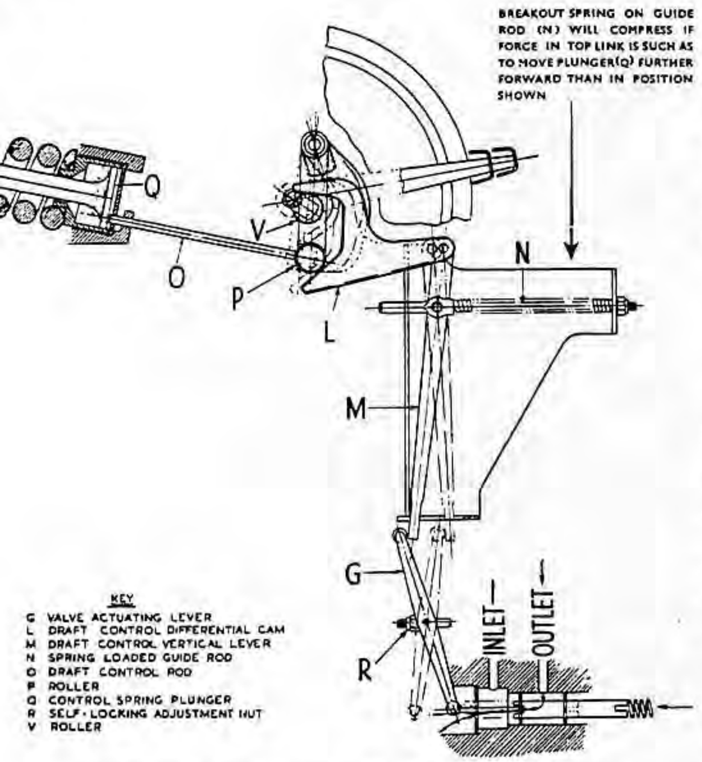


FIG. 20 DRAFT CONTROL 'OVERLOAD RELEASE'

The foregoing characteristics of the overload release system are due to the respective positions assumed by cam (L) and roller (P), (see Fig. 20). With an implement operating under draft control the position of roller (P) is governed by the degree of control spring compression in turn dependent upon the amount of draft. Independent of the location of roller (P), by a combination of the position of the draft control lever and the natural bias of the cam (L) rearwards, the necessary degree of forward travel of roller (P) to move the valve from neutral into overload release never varies. In practice, cam (L) functions as a link of variable length that automatically adjusts itself to alterations in the distance between roller (P) and the top of lever (M) when the valve is in neutral and thus establishes a constant value for the amount of control spring deflection to achieve overload release.

The compression spring fitted about guide rod (N) absorbs movement of lever (M) under overload shock forces in excess of those necessary to move the control valve into overload release to the full extent of its available travel. Under these conditions damage to the valve and control members is prevented by a forward pivoting action of lever (M) about rear end of slot in support bracket and resulting compression of the spring.

CO-ORDINATION OF SYSTEMS A & B

It will now be realised that the positioning of the two hand levers must be co-ordinated to ensure that the two systems work in harmony without the functioning of the system operative being adversely affected by the other.

Consider therefore the correct positioning of the control levers for the following.

(i) Draft Control.
(ii) Transporting an implement.
(iii) Position Control.
(iv) To operate external hydraulic equipment.

NOTE

The differential cam and roller elements operated by the hand levers as described, simply constitute links of variable length which are adjustable to suit the changing distances between the internal linkages and the control spring plunger on the one hand and the position control cam on the other. For the purposes of simplifying the following explanations and illustrations, these elements are treated as straight forward link rods.

(i) DRAFT CONTROL (Fig. 21)

Requirements

The control valve must be responsive to fluctuating draft forces acting against the top link and be uninfluenced by the rotation of the position control cam on the lift shaft.

Procedure

SYSTEM A. The **Operational Lever** must be out of the position control range so that the cam on the lift shaft has no influence on the position of the control valve. The **Operational Lever** will, therefore, be in the "Response" sector of its quadrant as required, and then System A Lever (Fig. 21), as already explained, becomes an adjustable stop regulating how far the valve actuating lever can move the control valve into the drop position, thereby establishing the rate of fall. See 'Rate of Response' opposite.

SYSTEM B. **Draught Control Lever Position**

(*a*) **For a Compression Load against the Top Link,** *e.g. Normal ploughing and cultivating.*
When the draft control lever is at the Sector Marks on its quadrant, System B lever is at "Full Drop" (see 'Rate of Response' opposite) but the draft force against the top link would simply have to be sufficient to move the control valve from "Full Drop" to "Cut-off": which would be effected as soon as the implement started to penetrate.

The **Draft Control Lever** must therefore be moved forwards from the Sector Marks setting to move the control rod away from the control spring plunger, refer to (Fig. 21). The gap

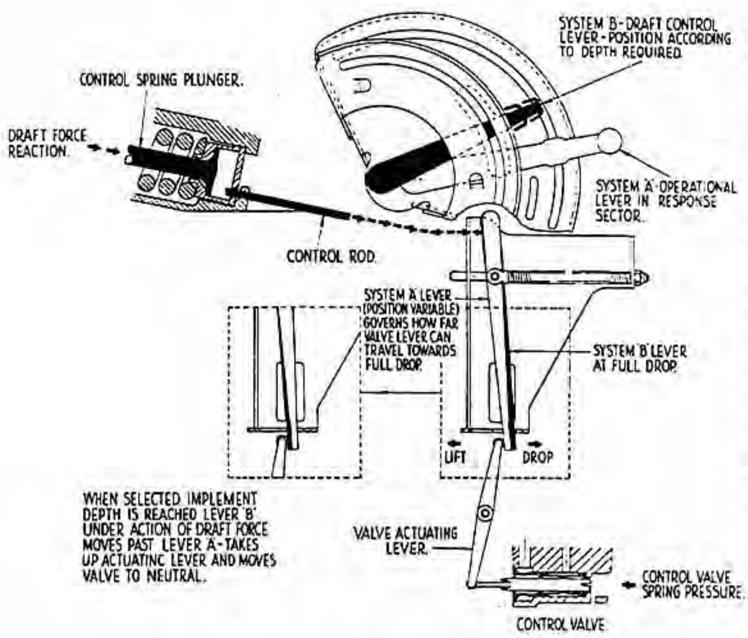


FIG. 21
DRAFT CONTROL

created between the two must then first be closed before the forward thrust of the plunger can reach the control rod to alter the position of the control valve. Meanwhile the implement is penetrating. The amount the draft control lever must be moved and therefore the width of the gap is, of course, proportional to the draft or depth to which the implement is required to penetrate, before penetration is arrested by the valve being moved to "cut-off".

(*b*) **For a Tension Load on the Top Link** *i.e. Light Draft with a Heavy Implement.*

A tension load on the top link draws the control spring plunger **rearwards** away from the control rod—see Fig. 25 (*c*)—separating the two so that if operated under these conditions, the implement would penetrate until the draft force against the top link was sufficient to take up or balance the implement weight, closing the gap between the control rod and plunger, and then move the control valve to "cut-off". Meanwhile the heavy implement would have penetrated beyond the light draft or depth required.

For a tension load therefore the **Draft Control Lever** must be moved rearwards from the Sector Marks to reduce the gap between the control rod and control spring plunger to an amount proportional to the depth at which the implement is required to operate.

Rate of Response

Although System B lever is at **full** drop, the roller on the control valve actuating lever (except when "Fast" response is operative) is resting against System A lever, which may be restricting the travel of the control valve so that only a portion of the control valve narrow outlet slots are exposed. This should be the case if the depth of a **heavy** implement is being corrected, otherwise a heavy implement would tend to penetrate too quickly and deeply before penetration could be arrested.

Conversely with a **light** implement greater travel into the "drop" position must be allowed so that a larger control valve slot area may be uncovered. The rate of fall of a light implement can thereby be made to equal that of a heavier implement according to requirements—the slot area exposed compensating for the weight.

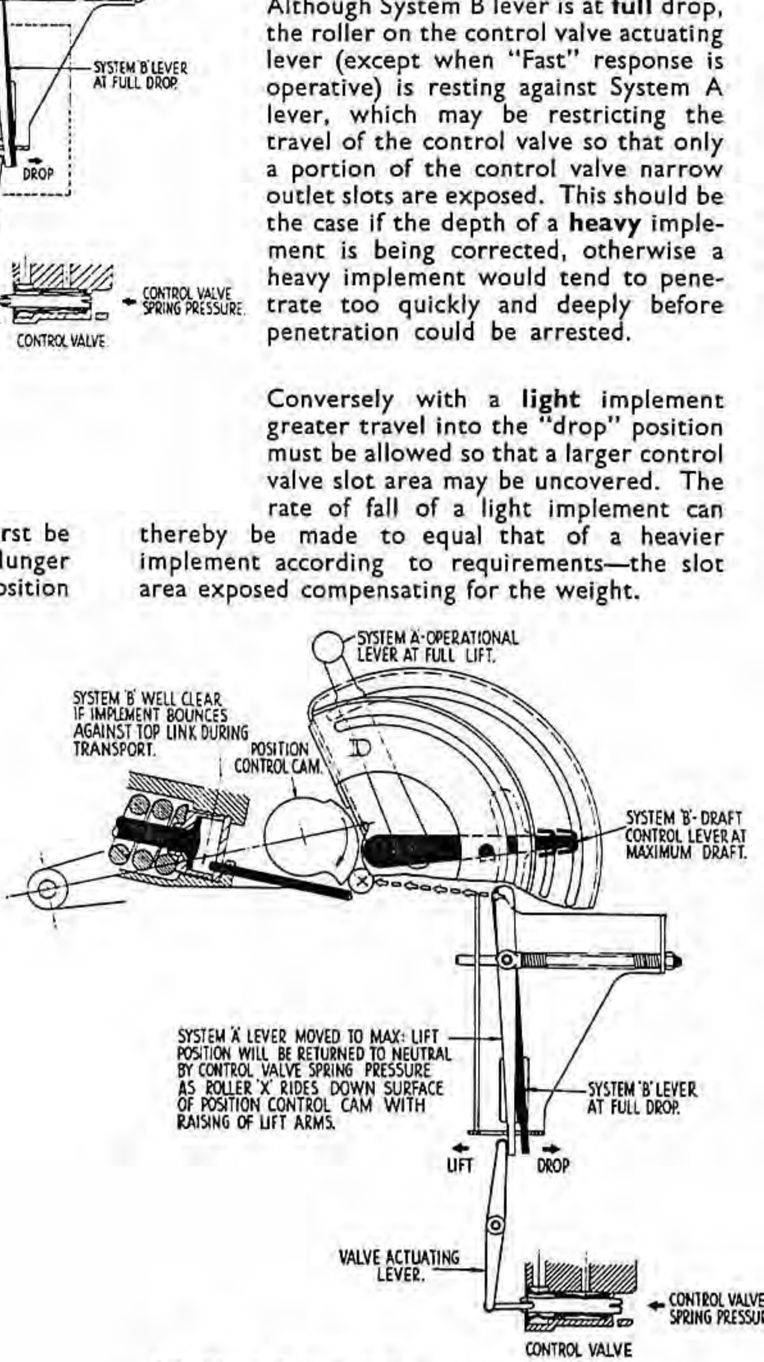


FIG. 22 IMPLEMENT TRANSPORT POSITION

When the implement is raised the rate of lift is less dependent upon the weight since the pump delivery rate for a given intake is substantially unaffected by changes in oil pressure occasioned by differences in implement weight. Hence, there is no need for adjustable limiting of the valve travel in the "lift" direction.

(ii) TRANSPORTING AN IMPLEMENT (Fig. 22)

Requirements

The control valve must be moved to "lift" to raise the implement and then, when maximum height is reached, be returned automatically to "cut-off".

Procedure

SYSTEM A. The **Operational Lever** must be pulled to the top of its quadrant to move the control valve to "lift". As the lower links reach maximum height the valve is returned automatically to "cut-off" by the action of the position control cam rotating with the lift shaft.

SYSTEM B. The **Draft Control Lever** should, ideally, be at the bottom of its quadrant so that the control valve actuating mechanism of this system is well out of range should the implement weight bounce against the top link during transport over rough ground.

(iii) POSITION CONTROL (Fig. 23)

Requirements

The implement must rise or fall to a selected position according to the height or depth at which it is required to operate.

Procedure

SYSTEM A. The **Operational Lever** must be situated in the Position Control range, selecting the interval between the roller (shown "X", Fig. 23) and the position control cam. The lower links will faithfully follow the position of the lever in its quadrant—when the selected height or depth is reached, the return of the control valve to "cut-off" will be effected by the action of the cam rotating with the lift shaft.

SYSTEM B.

(a) Soil-engaging Implements

The **Draft Control Lever** will normally have to be situated at the bottom of its quadrant, i.e. at the limit of the draft control range. This will ensure that the draft control system cannot interfere with the established position of the lower links unless the draft force against the top link reaches a thrust equivalent to "Maximum Draft". If this happens, "Position Control" will be overriden and the control valve moved to lift by the draft control system.

(b) Non-Soil-engaging Implements

If there are no draft forces to be considered the **Draft Control Lever** may be situated at or anywhere below the "Sector Marks".

(iv) TO OPERATE EXTERNAL HYDRAULIC EQUIPMENT, OR TO DISCHARGE THE HYDRAULIC SYSTEM SAFETY RELIEF VALVE (WITHOUT HOLDING DOWN THE LOWER LINKS) Fig. 24.

Requirements

When the lower links have reached maximum height the control valve must still remain in the "lift" position.

Procedure

SYSTEM A. **The Operational Lever** should in most cases be out of the position control range—so that the control valve is not influenced by the position control cam rotating with the lift shaft.

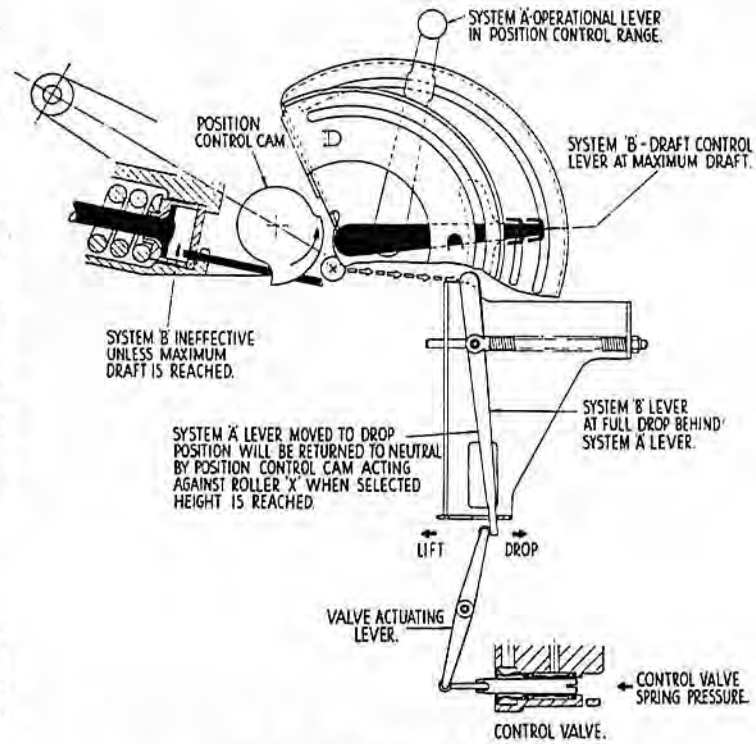


FIG. 23 POSITION CONTROL

(The action will be reversed as indicated in Fig. 22, when position selected is above existing lower link height).

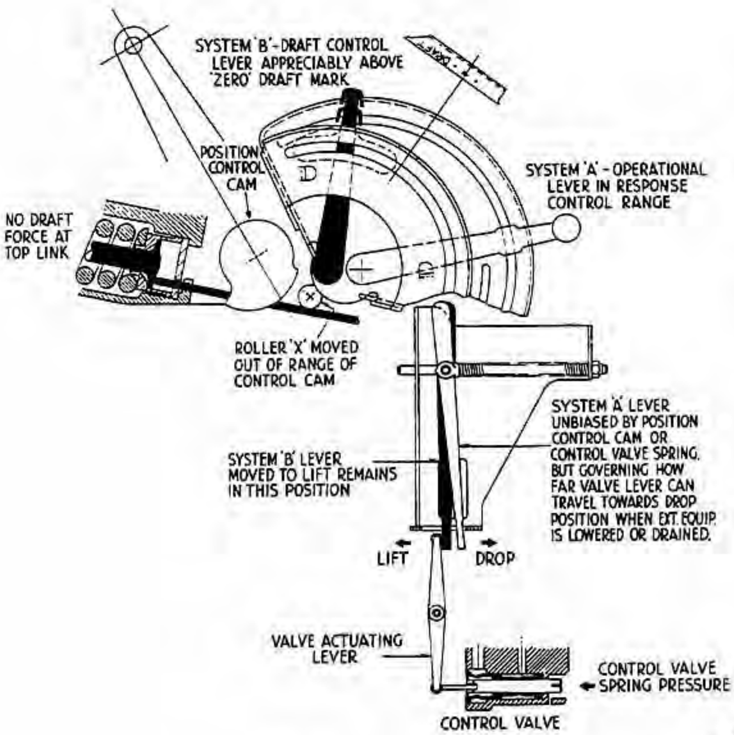


FIG. 24

TO OPERATE EXTERNAL HYDRAULIC EQUIPMENT OR DISCHARGE RELIEF VALVE (WITHOUT HOLDING DOWN THE LOWER LINKS)

SYSTEM B. **The Draught Control Lever** must be moved appreciably above the Sector Marks on its quadrant, sufficiently in fact to shift the control valve from the "drop" to the "lift" position.

There are no draft forces active at the top link to affect the control valve and no automatic return to "cut-off" by the position control cam, the control valve therefore remains in the "lift" position. When the lower links reach maximum height the oil pressure operates the external auxiliary—if connected—or otherwise discharges the relief valve. When the draft control hand lever is lowered the control valve will be moved to "drop" and oil will drain from the auxiliary equipment at a rate established by the position of the operational lever in the "Response Sector" of its quadrant.

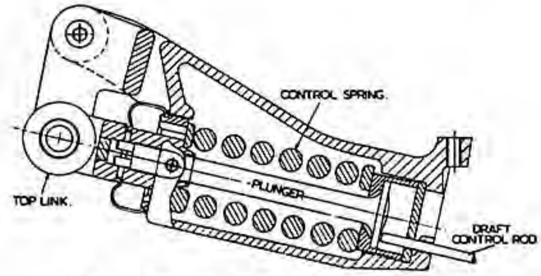
Compare—**"Raising and Lowering the Implement at the end of a Furrow".** Page L.2.

Outlets are provided on the lift cover as shown in Fig. 5, for connecting auxiliary hydraulic systems to be operated in this manner.

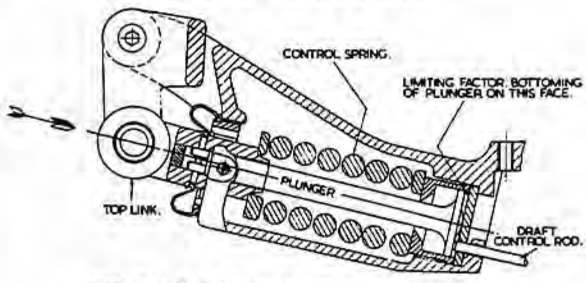
CONTROL SPRING

The control spring measures the draft reaction on the implement through the top link and the expansion or contraction of this spring translates the changes to the hydraulic system for appropriate adjustment to maintain the selected depth as described.

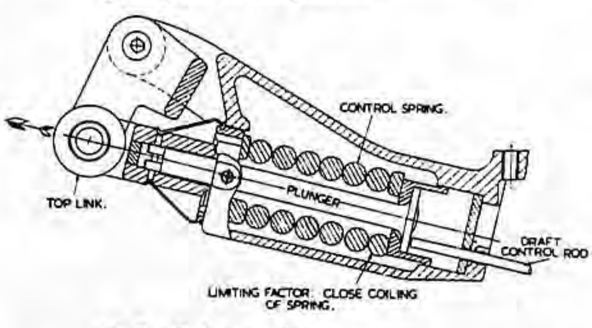
The control spring is enclosed in the hydraulic lift cover as indicated in Fig. 6(*a*) and is double acting, this meaning that it reacts when subjected to the tension loads as well as the compression loads against the top link. See Figs. 25(*a*), (*b*) and (*c*). The advantage of this important feature is that heavy implements, which weigh excessively on the



(*a*) Initial setting—Zero end float.



(*b*) Top link in compression.



(*c*) Top link in tension.

FIG. 25 DOUBLE ACTING CONTROL SPRING

top link still remain within the range of influence of the hydraulic system even when operated under light draft at shallow depth. Without this arrangement a balance spring would have to be fitted between the implement and tractor to balance the overhung weight of the implement and so provide, under all operating conditions, a compressive force in the control spring.

Furthermore, in the transport position, the overhung weight of any implement floats on the control spring, which cushions shock loads over rough ground.

Note. It should be realised that exceptionally heavy overhung implements, which under working conditions produce a tension load on the top link greater than 1000 lb. (453.6 kg.), would require a balance spring.

UPPER LINK (Fig. 26)

The upper link assembly mounts between the implement struts and the control spring rocker above the rear axle casing. It transmits to the hydraulic system a forward thrust developed by soil resistance at the implement point. Its function is, therefore, of the highest importance.

DRAWBAR (Fig. 27)

Figure 27 shows the adjustable drawbar mounted to the tractor in the correct manner, with the stay assemblies attached to the long hitch pin on the rear axle casing.

With the stay assemblies fitted, it is essential that the hydraulic lift is not operated.

The higher the implement attachment point from the ground, the greater the amount of weight transferred from the tractor front wheels to the rear wheels, thus increasing traction.

It is recommended that the attachment point of any towed implement is so adjusted that this weight transference provides the maximum traction at the rear wheels while still retaining sufficient weight on the front wheels for efficient steering.

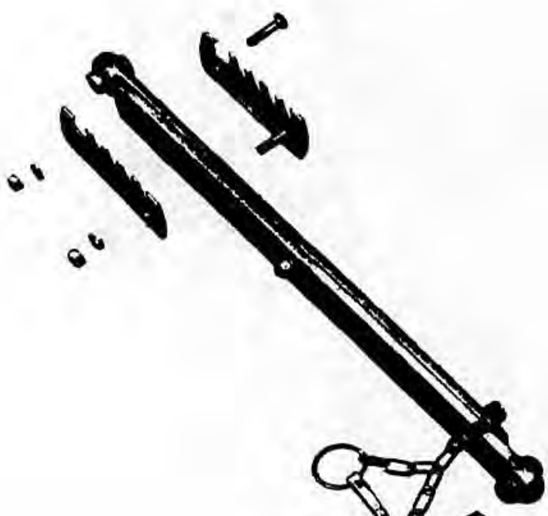


FIG. 26
UPPER LINK

FIG. 27
DRAWBAR

LUBRICATION

Lubrication points are provided for the lift rod thread and the levelling lever gear assembly and require daily attention.

It is important that no grease or oil is applied to linkage ball joints.

HYDRAULIC SYSTEM AND LINKAGE

DATA

Hydraulic Pump

Constant running, positive displacement four cylinder, scotch-yoke piston type pump "floating" in the tractor centre housing.
Speed—.36 × engine speed.
Delivery—2.8 Imp. gallons/min. (12.72 litres) at zero lb/sq. in. at 2000 engine r.p.m. (720 pump r.p.m.)
Oscillating Control Valve.

Hydraulic System Safety Relief Valve

Nominal setting 2500 lb/sq. in. (175.8 kg/sq. cm.).

Test Data:

The valve must begin to open at a minimum static pressure of 2300 lb/sq. in. (161.7 kg/sq. cm.). The maximum pressure must not exceed 2800 lb/sq. in. (196.9 kg/sq. cm.) when by-passing 2 Imp. gallons (9.1 litres) per minute. S.A.E. 50 oil at 110°-140°F. (43.3°-60°C.)

Hitch Points

In accordance with British Standard—"Attachment of Mounted Implements to Agricultural Wheeled Tractors"—1841 Category 1.

Lower Links

Maximum Recommended Lift Load — 1250 lb. (567.5 kg.).
Height range 8½" (216 mm.) to 34½" (876 mm.) above ground level.

Upper Link

Nominal length 25" (635 mm.) adjustable between 24½" (622 mm.) and 26½" (672 mm.) in ¼" (6.35 mm.) steps.

Drawbar Adjustable

Height range 11" (279.4 mm.) and 24" (609 mm.) above ground level.
Normal height 19¾" (502 mm.) above ground level.
Nine $\frac{25}{32}$" (19.84 mm.) holes provided to permit lateral adjustment of 17" (431.8 mm.).

Hydraulic Tapping Points

Three Pick-up points in lift cover—
Thread sizes—Top: ⅜" N.P.S.M.
Laterals: ⅜" N.P.T.F.

Oil Capacity

(Supplying Hydraulic System, Transmission and Rear Axle)—6.6 Imp. Gallons (30.28 litres).
Maximum of 1½ gallons (6.81 litres) may be withdrawn for operating external services.

ADJUSTMENTS

It is strongly recommended that, whenever the hydraulic system functions unsatisfactorily and the cause is not readily apparent, the system adjustments are checked carefully and systematically, in order, proceeding as follows:—

1. Detach the implement from the tractor, place the lower links fully down and the quadrant levers at their respective sector marks on the quadrant, i.e. the operational lever at "FAST" and the draft control lever between the two dots—see Fig. 28.

2. CONTROL SPRING SETTING (Fig. 29)

Check the control spring (91) for end play and, if there is any end play, remove the two special cap screws (90) from the hydraulic lift rocker link, loosen the socket screw in the side of the housing (shown "Y" in Fig. 30) and turn the retainer nut (92) in or out as required to eliminate all play. Remember that having the nut either too loose or too tight will cause end play.

If the play cannot be eliminated by adjusting the retainer nut, it will be necessary first to remove the retainer nut (92) and to slide the control spring assembly out of the housing. Then check for play and if necessary tap out retainer pin (95) and turn the top link yoke (96) on the plunger (97) until the assembly is snug, but the spring can still be rotated by finger pressure.

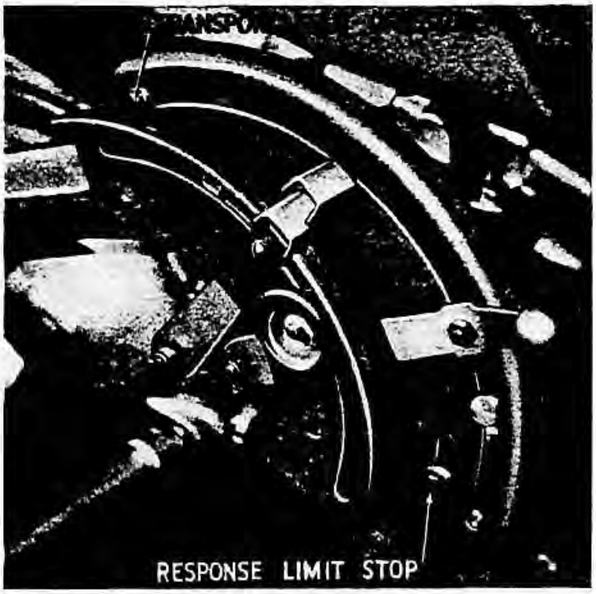


FIG. 28 CONTROL LEVERS AT SECTOR MARKS

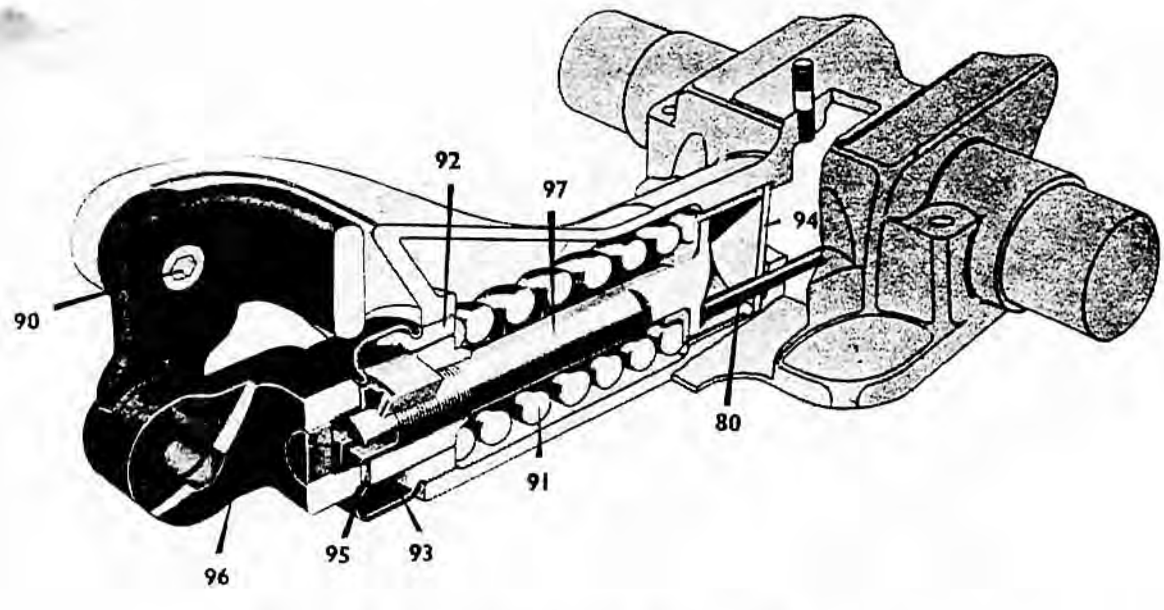


FIG. 29 SECTION THROUGH THE CONTROL SPRING

90. Special Socket Screws.
91. Control Spring.
92. Retainer Nut.
93. Rubber Boot.
94. Overload Disc Stop.
95. Retainer Pin.
96. Top Link Yoke.
97. Plunger.
80. Draft Control Rod.

Install retainer pin (95) and replace spring assembly after making sure that the overload disc (94) is correctly positioned at the front end of the cylinder. Screw in retainer nut (92) until there is no end play—remember that having the nut too tight or too loose will cause end play—tighten socket screw ("Y", Fig. 30) and refit rubber boot (93).
Do not tighten socket screw (Y) above 5-6 lb. ft. (.69/.83 kg.) ; if overtightened the internal lead ball will spread around the thread of the retainer nut and subsequent removal of the nut will be difficult.

3. Remove right-hand inspection cover and check that the movement of the control valve and its actuating linkage is satisfactory. Any binding or restriction must first be rectified before the following adjustments are made.

4. ADJUSTMENT OF POSITION AND DRAFT CONTROL LEVERS E. & M. (Fig. 30)

Use a punch or chisel to wedge the control valve actuating lever to the rear away from the vertical levers (E. & M.). Remove lift cover assembly, see separate instructions. Loosen the retainer nut of the small eccentric cam (J) on the vertical lever (E) and move the cam out of contact with the cam arm (D).

Place the quadrant levers at their sector marks (Fig. 28) and the lift arms in the fully lowered position and then check the adjustment of the two vertical levers (E. & M.) individually by means of a spring balance as shown in Fig. 30. The adjustment is correct when 3 lb. *(1361 grms.) is required on the end of the lever to spring it just into contact with the front of the slot in the lever support bracket. Any adjustment necessary is made by the appropriate self-locking nut on guide rods (F and N). If the lever can be pulled against the end of the slot without any pressure, the nut on the guide rod affected (F or N) should be loosened. If the nut is too loose, more pressure than specified will be required to force the lever against the slot and the nut should be tightened to the proper adjustment. Do not be confused by the fact that adjusting the nut brings the lever nearer or further away from the slot end.

* Note. 3 lb. (1361 grms.) equals the force applied by the control valve spring when the assembly is in the tractor.

5. ADJUSTMENT OF ECCENTRIC CAM (J) (Fig. 30)

With the quadrant levers still at their sector marks (Fig. 28) and the lift arms in the fully lowered position, rotate the small eccentric cam (J) into firm contact with the cam arm (D) and tighten the lock nut to the 5-6 lb. ft. (.691/.83 kg.), taking care not to rotate the cam at the same time. Check this adjustment by moving the operational lever down from its sector mark into the response range, as the lever leaves the "FAST" position, the bottom of the vertical lever (E) should begin to move to the rear.

6. Remount lift cover assembly, see separate instructions, and remove the wedge to release the valve actuating lever.

7. ADJUSTMENT OF CONTROL VALVE ACTUATING LEVER

With the quadrant levers at their sector marks (Fig. 28), check the adjustment of the valve actuating lever. The self-locking nut on the end of the rod from the pump carrying the lever should be adjusted so that there is light contact between the

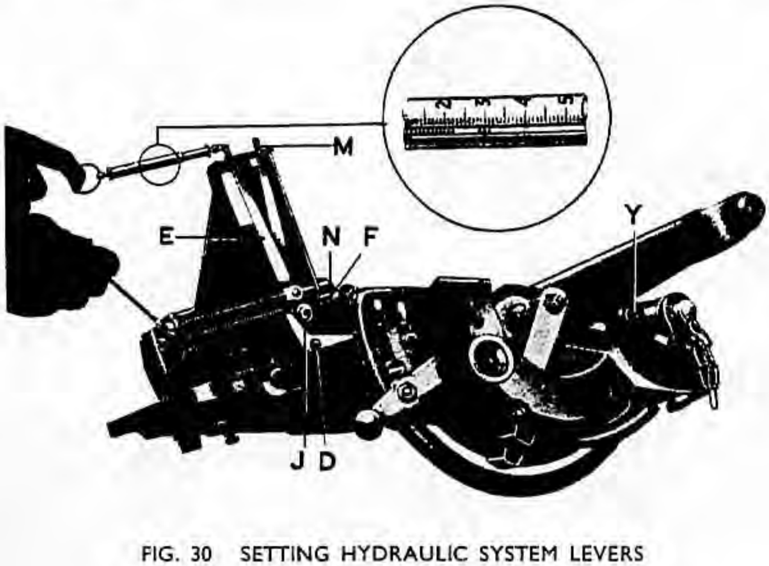


FIG. 30 SETTING HYDRAULIC SYSTEM LEVERS

ends of the vertical levers and the roller on top of the valve actuating lever.
Replace the inspection cover as this completes the internal adjustments.

8. TRANSPORT SHUT-OFF AND RESPONSE LIMIT STOP ADJUSTMENT

Before making these adjustments observe the following:—

(a) Transmission must be filled with oil.

(b) A load of 600 lbs. (272.2 kg.)—or a Ferguson 2 furrow 12" plough—must be attached to end of lower links.

(c) Pump must be running.

(d) Draft control lever to be at or below sector marks.

(e) Make sure that the lower links and check chains are fitted correctly.

(f) Raise and lower linkage several times to expel air from system.

(i) Transport Shut-Off Adjustment (Fig. 31)
Remove long hitch pin from centre housing and insert a length of $\frac{3}{4}$" (19 mm.) rod. Start the tractor and raise the operational lever until a distance of 11.8" (300 mm.) is obtained between the centre of the rod and the centre pin in the lift arm. Make this measurement accurately and if desired a chisel mark may be made on the lift arm and the lift cover housing to be used as an index mark for possible future re-adjustment. Tighten the Transport Shut-Off Stop (Fig. 28) in contact with the rear edge of the lever at this position.

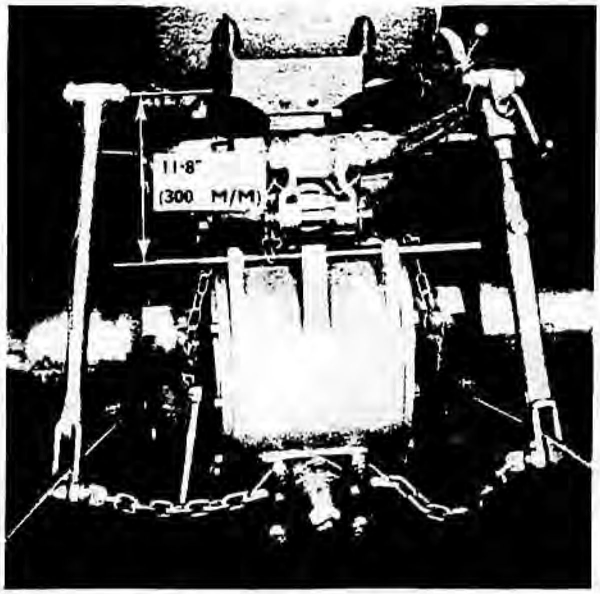


FIG. 31 TRANSPORT SHUT-OFF SETTING

(ii) Response Limit Stop Adjustment
Loosen the Response Limit Stop (Fig. 28) and move the operational lever carefully forwards through the response range until the lower links begin to rise. Next, bring the operational lever rearwards until the lower links begin to fall very slowly and lock the lower stop in contact with the lower edge of the lever at this position.

9. CONTROL LEVER FRICTION WASHERS

The quadrant friction washers should be adjusted so that the quadrant levers work smoothly and easily and will still hold their position on the quadrant. These friction washers should not be lubricated with any type of oil or grease. If excessive binding occurs the quadrant and washers can be coated with dry or colloidal graphite to prevent them from binding on the quadrant. They should then be adjusted so that the quadrant levers work smoothly when a pressure of 3 lb. $\pm \frac{1}{4}$ lb. (1361 grms. $\pm$ 113.4 grms.) is applied to the lever.

10. LIFT ARM SHAFT

The cap screws in the ends of the lift arm shaft should be tightened until the lower links will just fall under their own weight when lifted by hand. If the cap screws are tightened too tight this will cause the lift arms to bind which will cause erratic action of the hydraulic system. After adjustment bend the clips over the heads of the cap screws to lock them in position.

11. UPPER LINK (Fig. 26)

For normal setting the length of this assembly should be 25" (63.5 cms.) from ball centre to ball centre, but it may be necessary on occasion to lengthen or shorten this slightly when certain implements are operating in difficult conditions. The adjustment is effected by locating the centre bolt in different pairs of holes in the two members, by this means adjustment between $24\frac{1}{2}$" and $26\frac{1}{2}$" (62.2 and 67.2 cms.) is obtained. The shortest adjustment must only be used with certain implements and in such cases a precise recommendation will be made.
It is essential that this assembly is perfectly rigid and that the bolts securing the two halves are dead tight.
The marks provided on the sections are in line when the link is at the normal setting for length.

12. DRAWBAR (Fig. 27)

The height of the drawbar is governed by the length of the stay assemblies, and the normal setting of $19\frac{3}{4}$"(50.2 cms.) above the ground is obtained when the notches marked on the two sections of each stay assembly are in line. Various heights may be particularly suited to different pull-type implements.

HYDRAULIC SYSTEM AND LINKAGE FAULT TABLE

(File at end of Section L)

FAULT	POSSIBLE CAUSE	ATTENTION REQUIRED
1. Implement will not raise.	a. Lift cover installed so that the ends of the vertical levers are behind the roller on the valve lever.	Install lift cover correctly.
	b. Sticking control valve.	Remove inspection cover and check valve. Remove pump, determine cause and correct.
	c. Leak in system.	Remove inspection cover and check system while operating. Check for leaks at the ram cylinder, stand pipe, control valve, and pump side chambers. Renew seals when necessary to correct.
	d. Broken, bent or damaged control linkage.	Remove inspection cover and determine if linkage is moving control valve to intake when operation lever is raised. If not, remove lift cover and determine cause.
	e. Faulty relief valve.	Check valve while operating system, renew or adjust valve as necessary.
	f. Broken or damaged internal pump parts.	Will probably be indicated by a noisy pump.
	g. Seized ram cylinder.	Remove inspection cover and check to see if relief valve is blowing.
	h. Lift arms binding.	Adjust screws at each end of shaft so that lower links will fall under their own weight.
	i. Implement weight too great for the system.	
2. Implement lifts but will not lower.	a. Sticking control valve.	Remove inspection cover, and check valve. Remove pump, determine cause and correct.
	b. Damaged control valve spring.	Remove inspection cover, check valve to determine if spring will put valve to discharge. Remove pump, determine cause and correct.
	c. Lift arms binding.	Adjust screws at each end of shaft so that lower links will fall under their own weight.
3. Jerky or uneven lift when the operational lever is raised.	a. One or more inoperative side chamber valves.	Remove pump and examine outlet valve seats and check for dirt or foreign material.

FAULT	POSSIBLE CAUSE	ATTENTION REQUIRED
4. Relief valve blows when operational lever is raised to the transport position.	a. Quadrant stop not properly positioned.	Check and adjust stop to the 11.8" (300 mm.) measurement. See Fig. 31.
	b. Check chains twisted.	Correct.
	c. Check chains installed in the lower holes of the anchor brackets.	Correct.
	d. Lower links reversed.	Correct.
5. Implement will not lower or will raise when the operational lever is moved to the lower stop.	a. Stop incorrectly located.	Adjust Response Limit Stop. See page L.22.
	b. Valve lever adjusting nut too tight.	Adjust valve lever, see page L.21, then check adjustment of operational lever Response Limit Stop—see page L.22.
	c. The self-locking adjusting nut on the horizontal spring guide for the position control linkage too loose.	Adjust in accordance with Instructions on page L.21.
6. Unable to obtain slow drop when operational lever is moved into the response sector of the quadrant.	a. Eccentric cam on vertical position control lever not properly positioned with respect to the position control cam arm.	Adjust eccentric cam, see page L.21.
	b. Self-locking nut on horizontal spring guide adjusted too tight **after** adjusting eccentric cam.	Adjust horizontal spring self-locking nut first, then adjust eccentric cam, see Instructions on page L.21.
7. Erratic action or poor control when operating in draft control with light pressure or tension on the top link.	a. End play in control spring.	Check and adjust.
	b. Self-locking nut on horizontal spring guide for draft control linkage too tight.	Adjust as outlined on page L.21.
	c. Damaged control linkage.	Locate trouble and correct.
8. Draft control will not allow implement to obtain sufficient depth.	a. Self-locking nut on horizontal spring guide for draft control too loose.	Adjust as outlined on page L.21.
9. When operating in position control with knurled nut set on quadrant, implement does not return to the same position when the operational lever is raised and lowered again to the stop.	a. Rollers on position control link assembly eccentric.	Renew assembly.
	b. Roller on position control shaft eccentric or binding in the cam jaw position control.	Renew assembly as necessary.

The aforementioned suggested problems and corrections are concerned primarily with adjustments and indications of maladjustments which are peculiar to the system. We have purposely omitted such problems as leaks, noisy pumps and other problems, which are of a more conventional nature, with the idea of placing more emphasis on the adjustments and their relationship to the proper operation of the system. It should be realised that some problems which, at first might appear to be the result of some malfunction of the hydraulic system, can be the direct result of at least two other causes: First, incorrect handling by the operator; Second, maladjusted implements or implements having severely worn or damaged parts.

DISMANTLING AND RE-ASSEMBLY PROCEDURES— (FIGS. 32, 33 and 34).

LIFT COVER AND HYDRAULIC PUMP (Fig. 33)

To Remove

1. Drain transmission oil. (6.6 Imp. gallons-30.3 litres).
2. Remove the tractor seat, oil transfer cap (51) and stand pipe (52). Note the "O" ring (53) at each end of the stand pipe which seals it at the pump and at the transfer cap.
3. Remove the screws from around the lift cover flange. Remove right-hand inspection cover and wedge the control valve actuating lever to the rear away from the vertical levers. Disconnect the lift arms and remove the lift cover (54) and carefully place the assembly upside down on a bench.
4. After removing split pin, slide transmission coupler sleeve forward and lift out the rear drive shaft and coupler. Remove the three screws securing the P.T.O. bearing retainer to the rear of the centre housing and withdraw the P.T.O. shaft about 1" (25.4 mm.). The shaft may resist slightly since the bearing is removed with the shaft.
5. From each side of the centre housing remove the dowel assemblies, which prevent the pump from rotating, and lift out the pump.

TO DISMANTLE THE PUMP (Fig. 32)

1. Remove split pin (4) and withdraw front coupling collar (5).
2. Remove the lever assembly adjusting nut (6) and remove the lever assembly (7). Remove upper guide (8) held by screw on lock washer, remove four screws (9) on lock washers securing control valve lever guide bracket (10) and end plate (11). Extract control valve (12) with rear sealing washer (13) and outer washer (14), low pressure spacing bush (15) and centre sealing washer (16). Keep washers in order of removal as it is desirable for each to be replaced in its original position.
3. Remove the locking wire, set screw (17) and snap ring (18) and withdraw the oscillator body assembly (40) towards the front of the pump; then remove the high pressure spacing bush (19) with two "O" rings (20) and (39) and rear sealing washer (21). To dismantle oscillator body assembly (40), carefully extract circlip (41) and allow push rod (42) and spring (43) to emerge followed by retainer disc (44). Extract circlip (45) from the front end of the bore.
4. Punch mark both valve chamber assemblies (22) and the adjacent portion of the pump front or rear casting (23) or (24) to identify their correct positions on re-assembly.
5. Remove the four retainer screws (25) and separate the pump assembly comprising front and rear castings (23) and (24), piston units (26), cam blocks (27) and (28), valve chambers (22), oscillator rocker (29) with follower (30) and pump drive shaft (31).
   Note that the cam blocks (27) and (28) are not interchangeable, the front cam block (28) has a shoulder whereon the oscillator follower (30) rides.
   To remove the valve assemblies from the valve chambers:—
   After removing the circlip (32) thread a small screw into the tapped hole in the valve chamber plug (33) and pull on the screw. Note the following about the valve chambers, the valve chamber plug is sealed in the bore with an "O" ring (34); the valves (35) and (36) are self-centring on the valve seats with no centre valve guide, however, the inlet valve (36) is supported on an extension of the outlet valve stem (35).
   Note also the "O" rings which seal the oil passages.

TO RE-ASSEMBLE THE PUMP (Fig. 32)

1. Re-assemble the valve chambers and replace sealing plugs (33) with "O" ring (34) and snap rings (32).
2. Place the cam block with the shoulder (28) and cam follower (30) on the front eccentric of the drive shaft (31) so that the follower is between the cam blocks with the arm extending towards the bottom of the pump. Place the remaining cam block on the other eccentric.

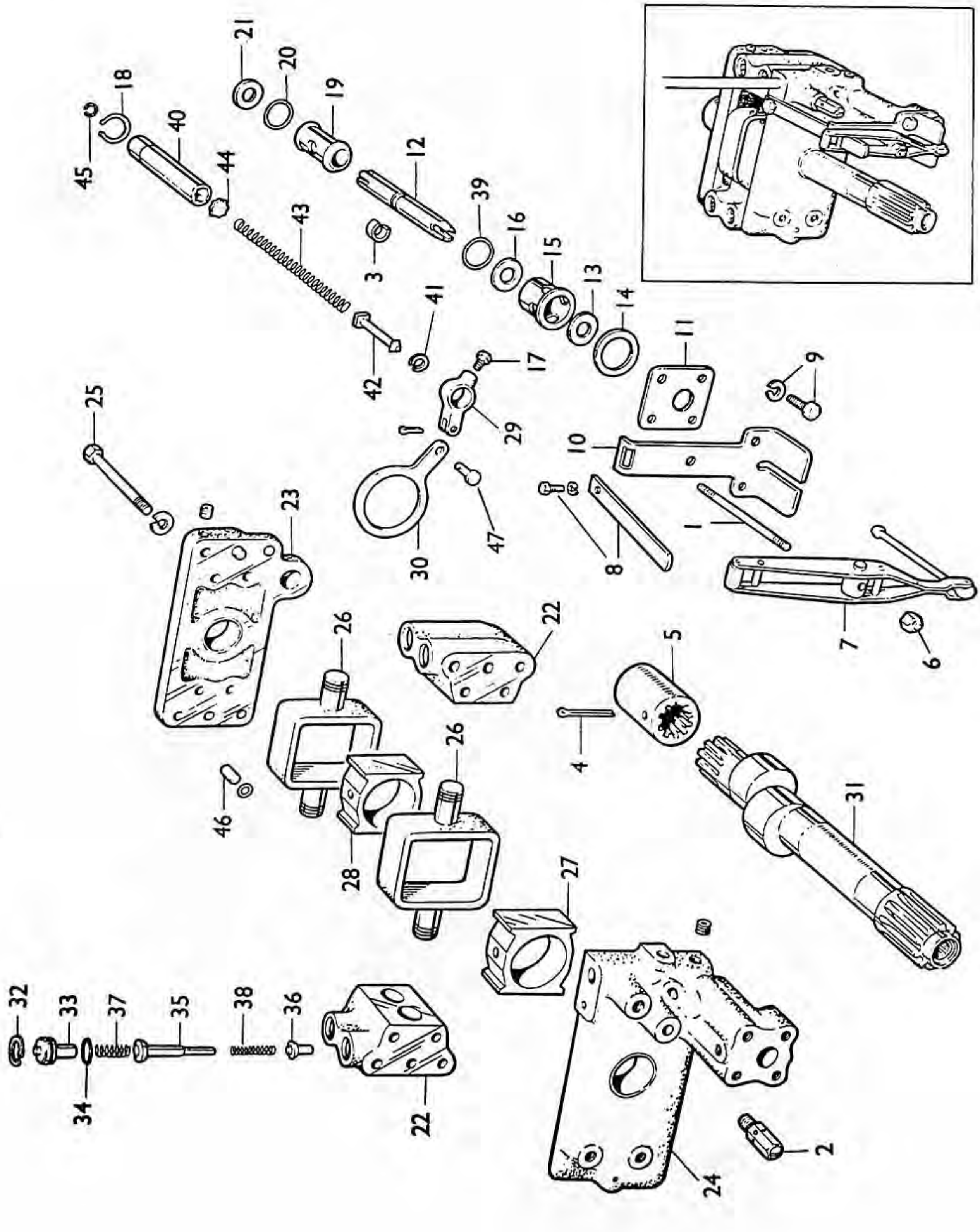


FIG. 32
EXPLODED VIEW OF HYDRAULIC PUMP

3. Place piston units (26) on the cam blocks with the bevelled edges outwards.
If the drive shaft bronze bearing is removed from the front or rear casting (23) or (24) the new bearing must be inserted with the chamfered end of the bore inwards without any protrusion, and with the oil slots on the vertical axis. The two bearings are identical.

4. With the front and rear castings correctly situated and all "O" rings in position, mount the valve chamber assemblies, with punch marks aligning, over the piston assemblies, and press on the end castings located by dowels (46).

5. Insert four retaining screws (25) and tighten evenly by diagonal selection to 50/55 lb. ft. (6.9/7.6 kg.m.) torque, checking to ensure that pistons move freely in their bores.

Important

Before inserting the control valve assembly make sure that the bore in the pump and all related parts are perfectly clean. The fit of the valve in the sealing washers is such that any discrepancies in assembling which result in any of the washers being tilted will cause the valve to stick.
The sealing washers should be replaced in their original positions and, furthermore, should never be serviced separately without the control valve itself being renewed. The valve and washers are supplied as a matched set only with a working clearance of .0004" (.0102 mm.) and a lapped finish of 4 micro inches.

6. Insert the control valve front sealing washer (21), front "O" ring (20) and pressure-side spacing bush (19) followed by the second "O" ring (39) in the control valve bore of the pump. Position rear sealing washer (13), inlet spacing bush (15) and centre sealing washer (16) on the end of the control valve (12) and carefully slide the assembly into position making sure that the inlet slots of the valve are in the horizontal plane to prevent the edges of the inlet slots from catching on the rear sealing washer (13) which is floating when the valve is returning from "overload release".

7. Insert the control valve outer washer (14) around the rear sealing washer (13) followed by end cover plate (11) and lever guide bracket (10), attach upper guide (8) and tighten all fixing screws on lock washers.

8. Re-assemble the oscillator body unit (40) with circlip (45) retainer disc (44) followed by spring (43) and push rod (42) held in place by the rear circlip (41). Install the assembly through the base of the front casting (23), the snap ring (18) and the oscillator rocker (29), locating the coned end of the push rod (42) accurately against its shoulder in the control valve bore.
Secure rocker (29) with grub screw (17) inserted into hole in oscillator body (40), tighten down and lock with wire. Locate snap ring (18) in its groove around the oscillator body.

9. Position the control valve lever assembly (7) and turn the self-locking nut on several turns, final adjustment of this nut, see page L.21, will have to be made when the assembly is in the centre housing.

10. Replace the front coupling collar (5) over the end of the pump drive shaft (31) and insert split pin (4).

TO REPLACE THE PUMP

1. Lower the pump assembly into place. Locate the front coupling collar over the splined end of the shaft at the gearbox and insert the P.T.O. shaft from the rear, through the ground speed P.T.O. driven gear, into the end of the pump drive shaft and secure shaft in position.

2. Locate the pump by means of the two dowels inserted from each side of the centre housing. Fit the right dowel before the left and secure with nuts on studs as, to facilitate alignment, the hole in the casing for the left dowel is larger.

3. Refit transmission rear drive shaft and coupler located by split pin at this stage although it should be realised that removal and replacement of the shaft and coupler can be effected through the inspection window in the centre housing.

CONTROL SPRING ASSEMBLY

(Figs. 29 and 33)

To Dismantle

1. Unscrew nuts and remove the special cap screws (90) from the hydraulic lift rocker link. Loosen the small socket screw (89), lever aside the rubber boot (93) and unscrew control spring retainer nut (92). Remove the control spring assembly and extract the overload stop disc (94) from the front end of the cylinder. Knock out retainer pin (95) and unscrew the yoke (96).

To Re-assemble and Adjust

1. Install the overload stop disc (94) with the hole in line with the hole in the casing for the control rod (80).

2. Adjust the master control spring to the plunger (97), by turning the clevis on the plunger until the plunger is snug, but so that the spring can still be rotated by finger pressure. Tap in lock pin (95) through suitable hole in clevis into the adjacent slot in the end of the plunger stem.

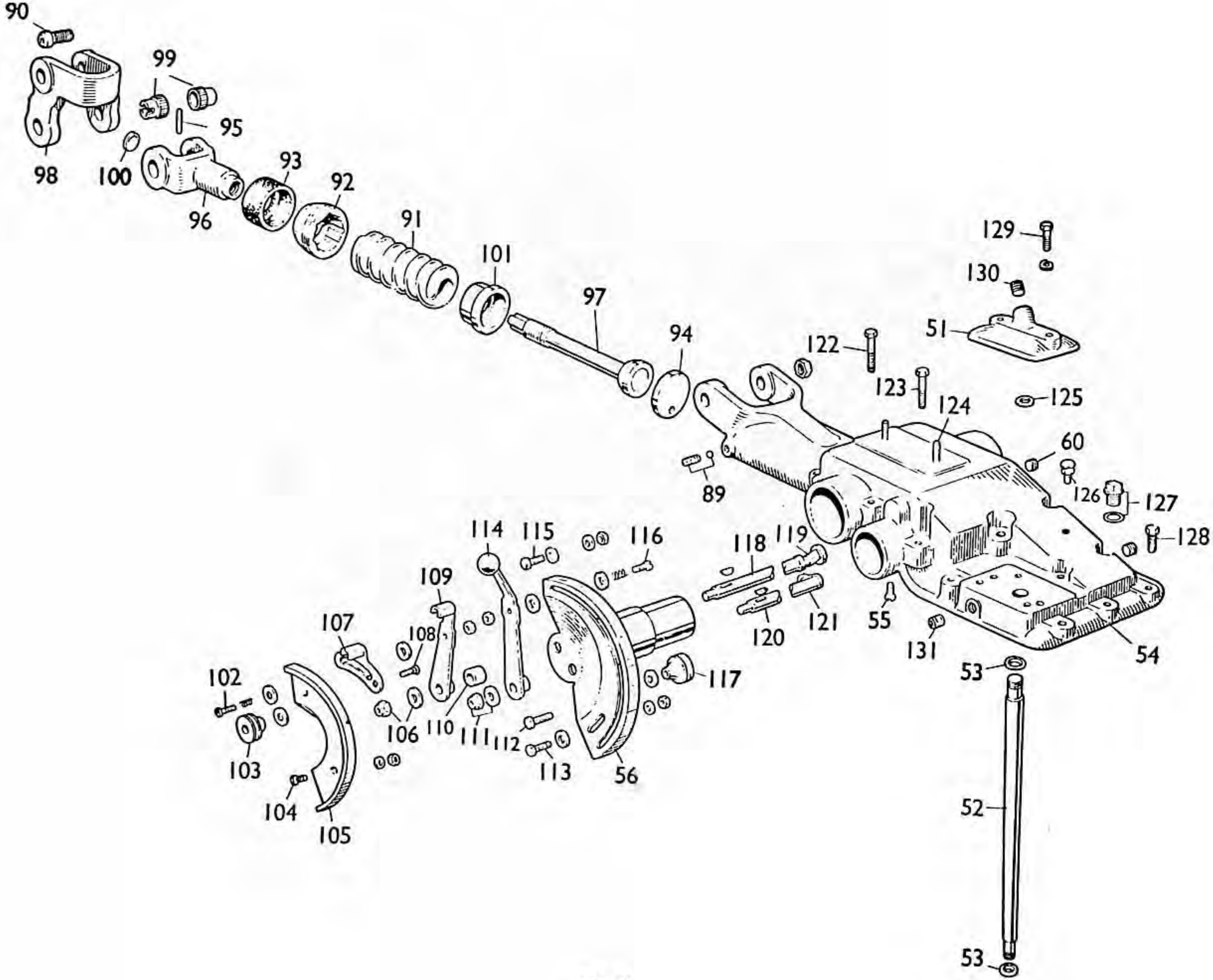


FIG. 33
EXPLODED VIEW OF LIFT COVER ASSEMBLY
—Control Spring and Quadrants

3. Install the control spring assembly in the housing, and tighten the retainer nut (92) until the end play is completely removed. Make certain that the hole in the overload stop disc is properly aligned to accept the control rod. Install the two special cap screws (90) in the rocker link, tighten the socket set screw (89) and replace the rubber boot (93).
   Do not tighten socket screw (89) above 5-6 lb. ft. (.69/.83 kg.); if overtightened the internal lead ball will spread around the thread of the retainer nut and subsequent removal of the nut will be difficult.

RAM CYLINDER AND RELATED PARTS
(Fig. 34)

To Remove

The ram cylinder (66) can be removed and replaced without dismantling any of the hydraulic control linkage by removing two screws (67), which attach the support bracket (59) to the ram cylinder and four nuts (83) and bolts (88) securing it to the lift cover, then removing the ram cylinder and piston assembly (68). Note the rubber "O" ring (82) sealing the inlet port in the lift cover (54).

The piston may be removed from the cylinder by carefully striking the open end of the cylinder on a piece of softwood, or by holding a pressure air-line against the oil inlet hole in the cylinder casing. If air is used, hold the assembly so that the piston points downwards, and increase the pressure gradually.

Remove roll pin (69) to disconnect the connecting rod (70) from the ram arm (71).

Clearance between cylinder and piston should be .004"-.0015" (.101-.038 mm.) new.

Piston ring gap, .0025"-.0075" (.064-.190 mm.) when ring is inserted in 2.500" dia. gauge.

To Replace

Proceed in reverse order to the removal instructions, but remember that the linkage support bracket (59) is attached to the cylinder, a check must therefore be made during re-assembly on earlier tractors to ensure that the hydraulic linkage is accurately aligned and not offset to the control valve actuating lever. To reduce the amount of misalignment obtainable on later tractors, two of the ram cylinder securing bolts—located diagonally opposite—are "fitted" bolts, and these two should be inserted first during assembly.

Tighten nuts securing ram cylinder to a torque reading of 45-50 lb. ft. (6.2-6.9 kg.m.)

LIFT SHAFT ASSEMBLY (Fig. 34)

To Remove

Remove two screws (72) from one end of lift shaft (73) and withdraw lock washer (74) and washer (75). Holding remaining lift arm (76) the shaft can be drawn out, disengaging the ram arm (71).

Remove inner and outer bushes (77 and 78), separated by rubber "O" rings (79).

Disengage rear of draft control rod (80) from end of control spring cylinder by pressing the draft control link (81) forwards and lift out ram arm (71).

To Replace

Proceeding in the reverse order to the dismantling instructions, insert the lift shaft so that the centre splines are in line with the arm of the ram arm and ram cylinder.

Note that master splines ensure correct location of both lift arms and ram arm.

Finally tighten the screws at each end of the shaft when the lift cover is in position in accordance with the Adjustment Instructions on page L.22 under **"Lift Arm Shaft".**

HYDRAULIC CONTROL LINKAGE
(Figs. 33 and 34)

To Dismantle

Remove the quadrant assembly countersunk screw (55) from the lift cover joint face and, with both hand control levers in line with the sector marks on the **outer quadrant,** by careful manipulation withdraw quadrant assembly (56) from the lift cover.

Remove the self-locking nut on the spring guide (57) for the position control lever assembly (58) and pull the spring guide rearward out of the support bracket (59) and, at the same time, remove the spring guide from the position control lever dowel. Carefully remove spring guide, spring and position control lever assembly (58). Similarly remove the draft control lever assembly (63), spring guide (64) and spring (65).

Remove the allen pipe plug (60) from the left side of the lift cover, and remove the socket screw (61) from link shaft (62) and remove the shaft. Remove the remainder of the control linkage from the cover.

To Re-assemble
(Refer to Figs. on pages L.11 and L.12)

Install the draft control and position control link and roller assemblies (81 and 85) and insert the link shaft (62). Install the draft control and position control lever assemblies (63 and 58). Install the springs (65 and 132) and spring guides (64 and 57) by compressing the spring, and inserting the spring guide through the forward hole in the support bracket (59) and turning on the self-locking nut

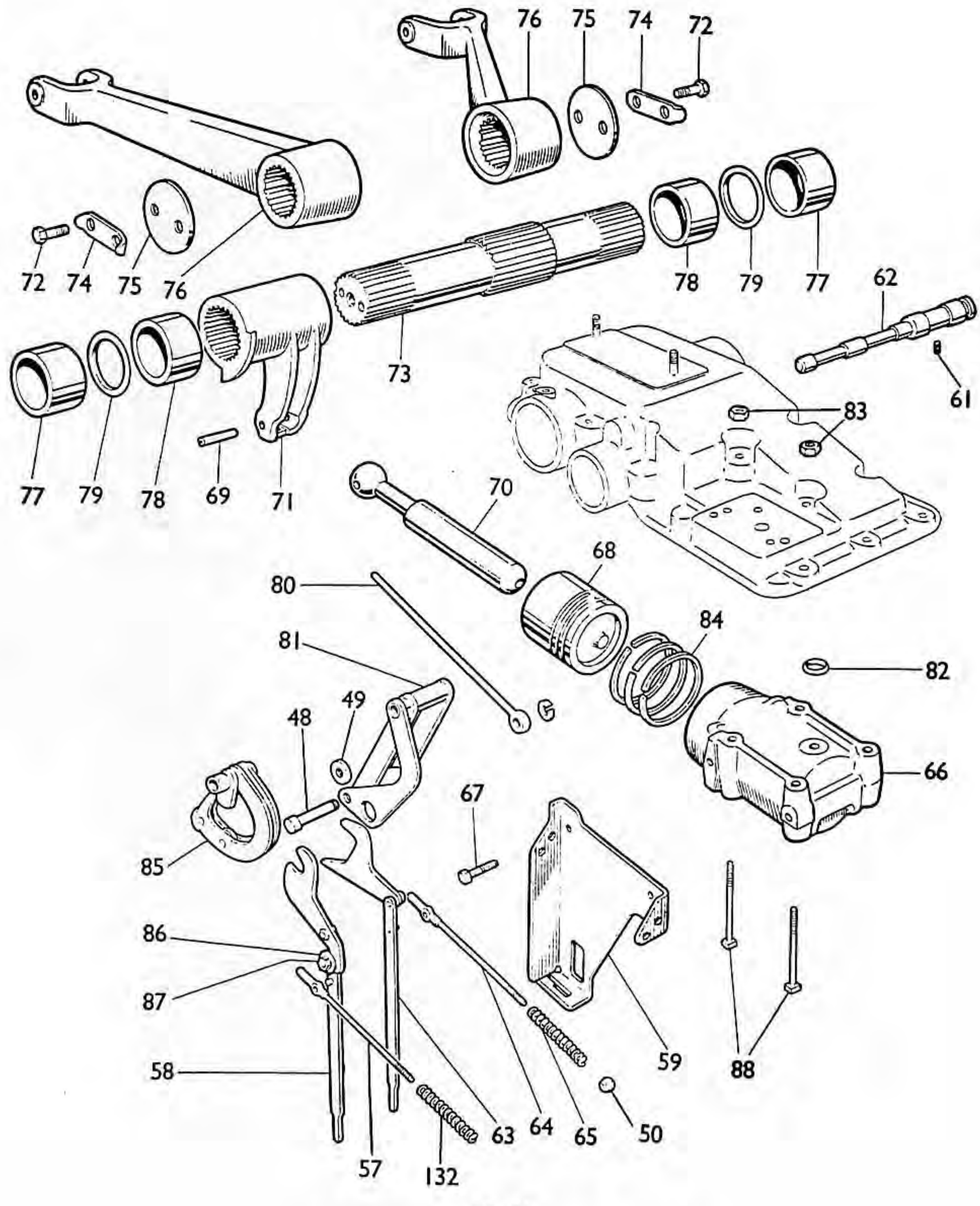


FIG. 34
EXPLODED VIEW OF LIFT COVER ASSEMBLY
—Ram Cylinder, Hydraulic Linkage and Lift Shaft.

several turns. Grasp the self-locking nut with a pair of vice grips and pull it back until the spring guide can be inserted in the rear hole and, at the same time, be guided over the dowel on the vertical lever.

With both hand control levers in line with the sector marks on the **outer quadrant,** install the quadrant assembly (56) and tighten the countersunk screw (55). After aligning the cams and rollers refit and tighten the socket screw (61) which positions the link shaft (62). Refit the pipe plug (60) in the left side of the cover (54).

Adjust the position and draft control levers and the eccentric cam in accordance with instructions on page L.21.

TO REPLACE LIFT COVER ASSEMBLY

(Fig. 33)

Before remounting the lift cover make sure that the adjustments are correct. See page L.21.

1. Position gasket on centre housing. Wedge the control valve actuating lever to the rear out of the way of the vertical levers on the lift cover, and mount the lift cover assembly—tighten fixing screws to 45-50 lb. ft. (6.2-6.9 kg.m.) torque. Install the stand-pipe (52) with "O" rings in position at each end. Fit transfer cap (51), and tighten screws to 45-50 lb. ft. (6.2-6.9 kg.m.) torque.

2. Fit tractor seat and connect the lift arms and rods. Adjust tightness of the screws in the ends of the lift shaft in accordance with instructions on page L.22 under **"Lift Arm Shaft".**

3. Remove wedge from the control valve lever, and adjust the lever nut, see page L.21, with the quadrant levers at their sector marks, **(Fig. 28).**

4. Replace the inspection cover and drain plugs and refill the system with oil (6½ gallons-30.3 litres).

5. Attach an implement, preferably a 2 furrow plough and raise and lower the linkage several times to expel air from the system.

6. Check and reset if necessary the adjustment of the operational lever stops, the control lever friction washers and the lift arm shaft, see page L.22.

MASSEY-FERGUSON

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WORKSHOP SERVICE MANUAL

SECTION M

POWER TAKE-OFF

POWER TAKE-OFF

Section M

CONTENTS

POWER TAKE-OFF

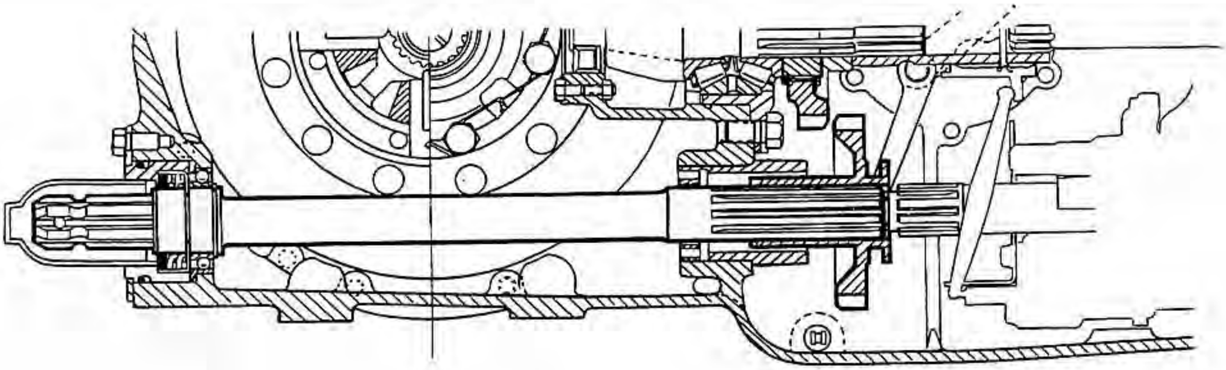

FIG. 1
SECTIONAL VIEW OF P.T.O. SHAFT

DESCRIPTION

The power take-off shaft projects from the rear of the tractor centre housing, it has a $1\frac{3}{8}''$ (British Standard) (34 mm.) spline with an annular groove for positive fixing of implement couplings.

A removable cap protects the splines when the shaft is not in use. The shaft itself is supported at the rear by a ball bearing and at the front by a needle roller bearing. Double seals exclude dirt from the bearing and retain lubricant in the housing. The power take-off is engaged by a lever, located on the left side of the tractor centre housing, which selects either proportional engine speed or proportional ground speed. Alternatively, placing the lever in the neutral position disconnects the drive.

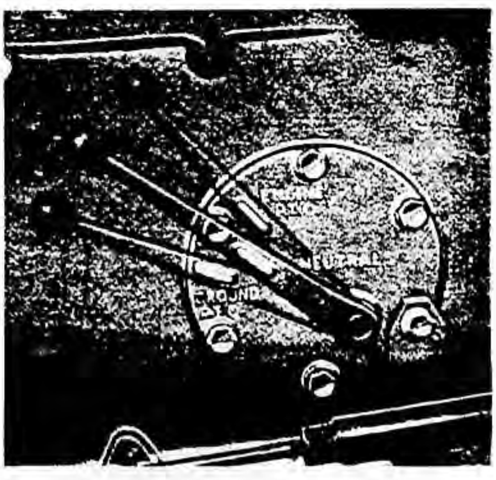

FIG. 2
P.T.O. LEVER

FIG. 3
P.T.O. SHAFT

PROPORTIONAL ENGINE SPEED

This drive is selected by pulling the lever upwards (see Fig. 2) to engage the internal splines of the ground P.T.O. driven gear with the splines on the rear end of the hydraulic pump drive shaft. The

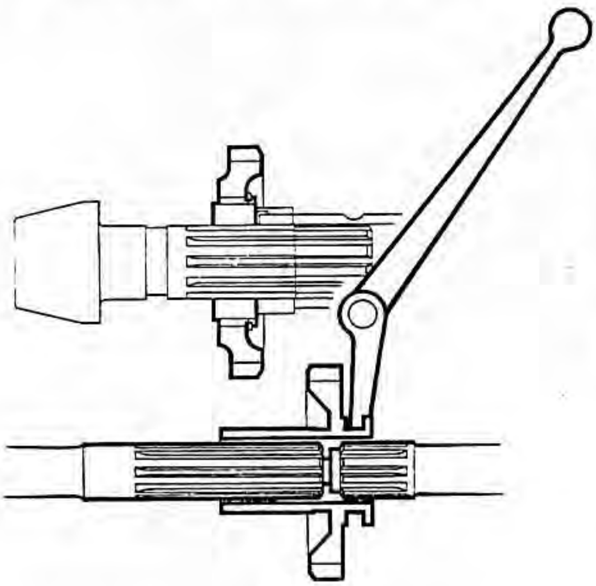

FIG. 4
PROPORTIONAL ENGINE SPEED

P.T.O. shaft is then driven at 18/50 of the engine r.p.m., a speed at which most P.T.O. driven equipment is designed to operate. It should be noted that the P.T.O. shaft is coupled behind the hydraulic

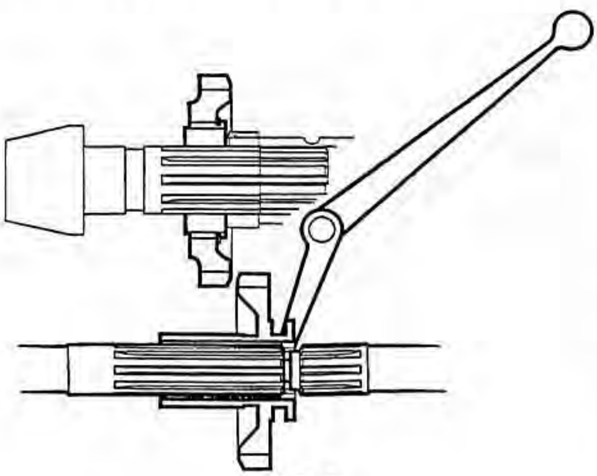

FIG. 5
NEUTRAL

pump shaft, the pump is therefore constant running and continues to operate even when the P.T.O. is disengaged.

PROPORTIONAL GROUND SPEED

This is engaged by pushing the P.T.O. lever downwards towards the ground—thereby shifting the ground P.T.O. driven gear into mesh with the gear splined on to the rear axle driving pinion. The P.T.O. shaft speed is then intimately related to the ground speed of the tractor and the shaft revolves once for approx. every 20" (508 mm.) of travel by the rear wheels. If the tractor is reversed the direction of rotation will also be reversed and this characteristic must be remembered as the implement mechanism may be damaged if driven in reverse.

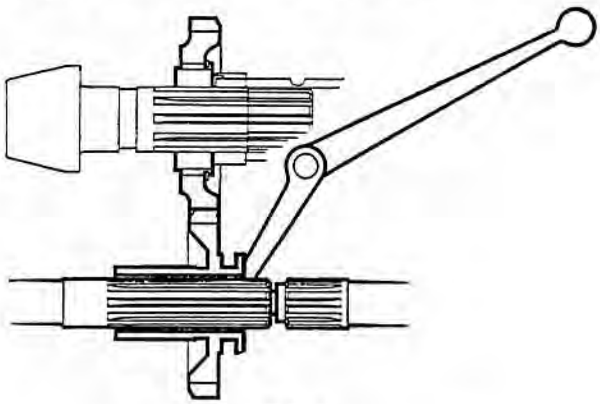

FIG. 6
PROPORTIONAL GROUND SPEED

LIVE P.T.O.

The De Luxe Tractor is fitted with Dual Clutch and Live P.T.O. The P.T.O. drive from the engine is controlled by the clutch pedal in the bottom half of its range. The initial movement of the clutch disengages the transmission only ; additional downward movement disconnects the hydraulic pump and P.T.O. shaft and transmission. On the Basic tractor the hydraulic pump and P.T.O. shaft and transmission are driven directly by the transmission countershaft, and on the De Luxe tractor by a drive shaft which passes through hollow countershaft assembly, and is therefore independent of the gearbox. (See also Clutch and Transmission Sections of this Service Manual).

Advantages of the live P.T.O.

This allows such machines as the Baler or Mower to operate continuously without being affected by the tractor stopping and starting. This enables the operator to halt the tractor's forward motion, permitting the mower or baler to clear a particularly heavy stand of grain or foliage. Moreover, since the P.T.O. drive shaft rotates the hydraulic pump, the operator, when using a manure loader, will be able to have continuous control over the fork height without having to select neutral gear to maintain the drive to the pump.

DATA

SHAFT DIMENSIONS

No. of Splines : 6
Major Diameter : 1.371"/1.373" (34.82/34.87 mm.)
Minor Diameter : 1.098"/1.108" (27.89/28.14 mm.)
Width of Splines : .338"/.340" (8.58/8.63 mm.)
Length suitable for drive attachment : 2.78" (70.6 mm.)
Diameter of hole : 21/64" (8.33 mm.)
Distance of hole from shaft end : .625" (15.88 mm.)
Dimensions of groove—
Bottom dia. : 1.160"/1.155" (29.46/29.34 mm.)
Radius : .265" (6.53 mm.)
Distance of groove from shaft end : $1\frac{1}{8}$" (28.6 mm.)

PROPORTIONAL ENGINE SPEED

Shaft Speeds :

Engine Speed	*P.T.O. Shaft*	*Pulley Speed r.p.m.*	*Belt Speed ft./min.*
1500	540	985	2320
2000	720	1313	3083

PROPORTIONAL GROUND SPEED

1 revolution for approximately 20" (508 mm.) of travel by the rear wheels.

DISMANTLING THE P.T.O. SHAFT

The following sequence covers the removal and dismantling of the Power Take-off Shaft and related parts.

DISMANTLING PROCEDURE

Before undertaking any removal of the Power Take-off Shaft or any related part, drain all oil from the transmission, hydraulic system and rear axle by removing the two magnetic drain plugs situated in the lower left-hand sides of the transmission and centre housing assemblies. To ensure that the ram cylinder is completely drained, the draft and position control levers should be in the "lower" position.

TO REMOVE P.T.O. SHAFT (Figure 7 refers)

1. Remove nuts retaining P.T.O. shield. Remove shield.
2. Remove retainer to centre housing screws and remove P.T.O. bearing retainer and P.T.O. seal retainer.
3. Withdraw P.T.O. shaft.

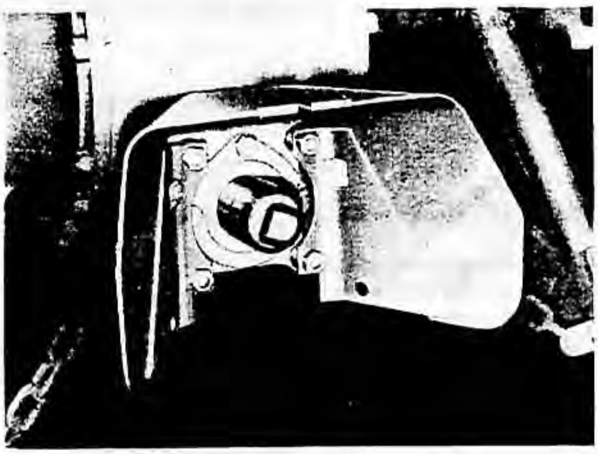

FIGURE 7.
VIEW SHOWING P.T.O. SHIELD BEARING RETAINER

TO REMOVE BALL BEARING (Figure 8 refers)

1. Remove both circlips.
2. Using Main Tool MF.200 with suitable adaptors, press off bearing.

SECOND ISSUE

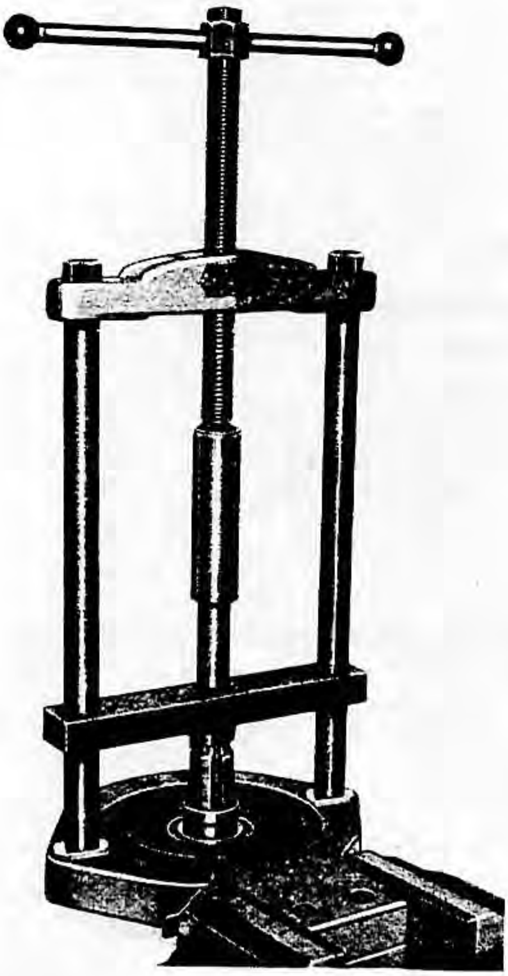

FIGURE 8.
REMOVAL AND REPLACEMENT OF P.T.O. BALL-BEARING

TO REPLACE BALL BEARING

1. Using suitable adaptors with Main Tool MF.200, set bearing in split ring. The bearing locating ring must be uppermost in the adaptors so that it will be nearest to the spline when assembled to the shaft.

2. Fit outer circlip to shaft and press shaft through bearing until bearing is in position against circlip as shown in Fig. 8.

3. Remove assembly from tool and fit inner circlip.

NOTE.—Fig. 8, if the circlip is removed, illustrates the position of the shaft and bearing for removal of the bearing.

TO REMOVE AND REPLACE P.T.O. OIL SEAL IN SEAL RETAINER

(Figure 9 refers)

Removal

Use suitable drift.

Replacement

Fit new oil seal in retainer, using adaptor MF.168 with 550 Handle, as shown in Fig. 9.

FIGURE 9.
REPLACING P.T.O. OIL SEAL IN OIL SEAL RETAINER

TO FIT P.T.O. SHAFT INTO CENTRE HOUSING (Figure 10 refers)

1. Insert P.T.O. shaft until locating circlip is against centre housing.

2. Fit Service Tool MF.167 over splines of P.T.O. shaft.

3. Mount oil seal retainer, with flats to sides, and tap into position in housing as shown in Fig. 10.

4. Remove Service Tool MF.167 and fit P.T.O. retainer seal "O" ring and P.T.O. bearing retainer, and secure with retainer to centre housing screws.

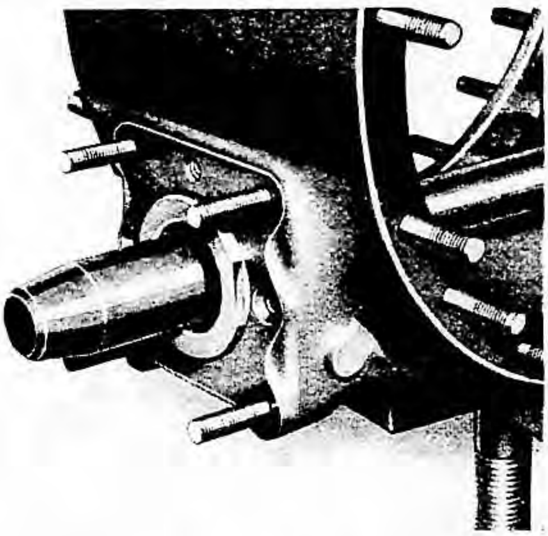

FIGURE 10.
USE OF SERVICE TOOL MF.167

TO REMOVE AND REPLACE NEEDLE BEARING AND RETAINER IN CENTRE HOUSING

Before inspection or removal of the P.T.O. Shaft Bearing Retainer or P.T.O. shaft sleeve be considered, it can be assumed that the crown wheel will have been removed.

Further dismantling will be required to provide access. This is as follows :—

1. Remove P.T.O. Shaft.
2. Remove Coupler Shifter Cover Assembly.
3. Remove Hydraulic Lift Cover.
4. Remove Hydraulic Pump and P.T.O. gear.

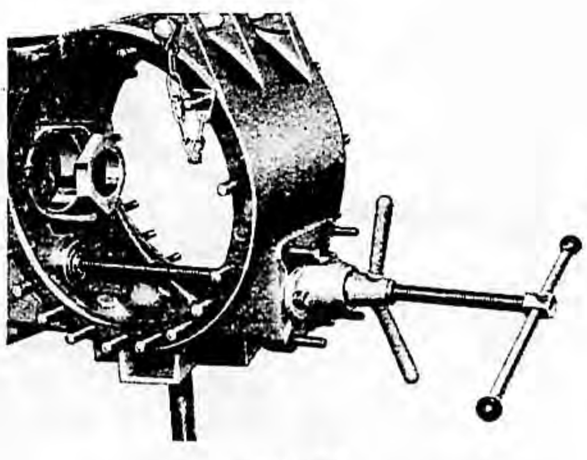

FIGURE 11.
REMOVING P.T.O. SHAFT BEARING RETAINER

TO REMOVE P.T.O. SHAFT BEARING RETAINER (Figure 11 refers)

Use Service Tool MF.195 with Adaptor MF.195-1. Details 6, 10 and 1, as shown in Fig. 11, and withdraw retainer rearwards.

TO REMOVE NEEDLE BEARING FROM RETAINER (Figure 12 refers)

Use Service Tool MF.195 with Adaptors MF.195-1, Details 5, 7 and 9, as shown in Fig. 12.

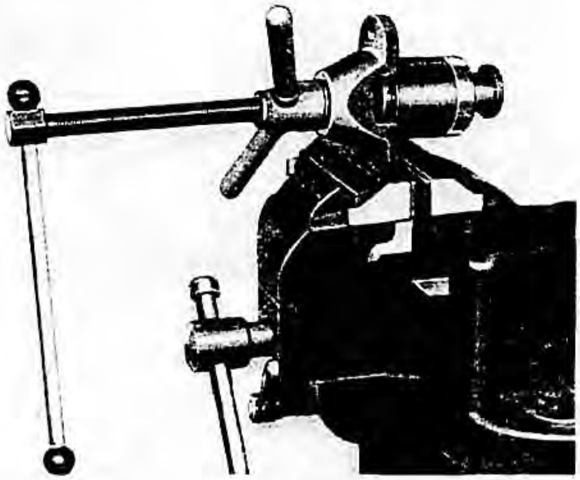

FIGURE 12.
REMOVING NEEDLE BEARING FROM RETAINER

TO REPLACE NEEDLE BEARING IN RETAINER (Figure 13 refers)

Use Service Tool MF.195 with Adaptor MF.195-1, Details 5, 6 and 7, as shown in Fig. 13.

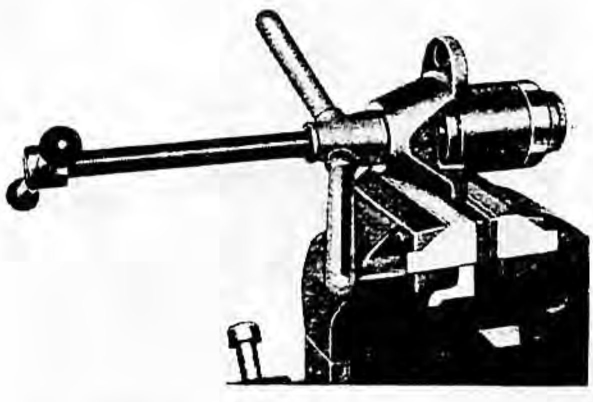

FIGURE 13.
REPLACING NEEDLE BEARING IN RETAINER

TO REPLACE P.T.O. SHAFT BEARING RETAINER (Figure 14 refers)

Use Service Tool MF.195 with Adaptor MF.195-1, as shown in Fig. 14, to push retainer forwards into centre housing bore.

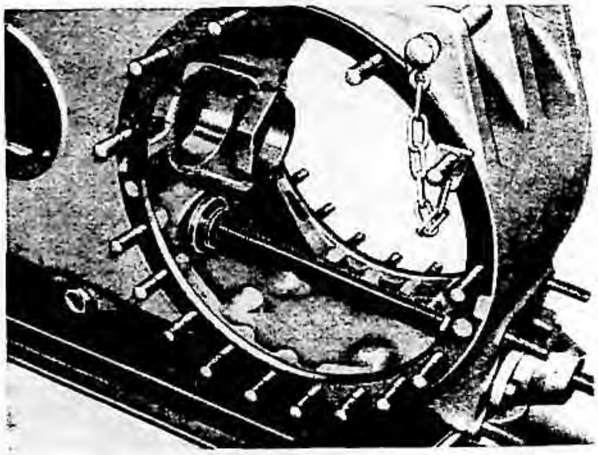

FIGURE 14.
REPLACING P.T.O. SHAFT BEARING RETAINER

TO REMOVE AND REPLACE P.T.O. SHAFT SLEEVE IN CENTRE HOUSING

To Remove Sleeve (Figure 15 refers)

Remove P.T.O. Shaft Bearing Retainer.

Use Service Tool MF.195 with Adaptor MF.195-1, as shown in Fig. 15, to push sleeve through centre housing bore.

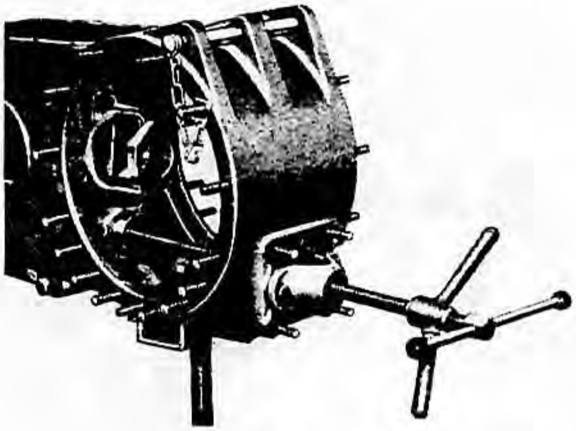

FIGURE 15.
REMOVING P.T.O. SHAFT SLEEVE

TO REMOVE P.T.O. SLEEVE BUSHING

(Figure 16 refers)

Use Service Tool MF.195 with Adaptors MF.195-1, as shown in Fig. 16, to pull sleeve into body of adaptor.

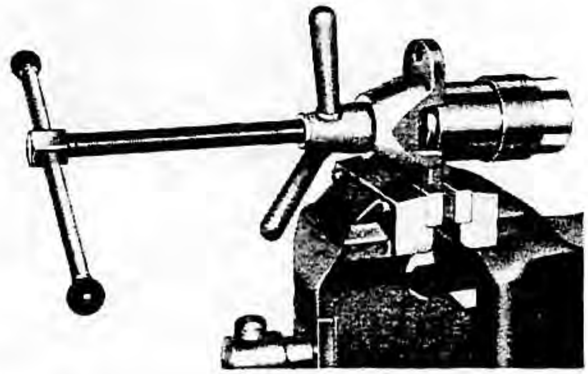

FIGURE 16.
REMOVING P.T.O. SLEEVE BUSHING

TO REPLACE P.T.O. SLEEVE BUSHING

(Figure 17 refers)

Use Service Tool MF.195 with Adaptor MF.195-1, as shown in Fig. 17, to draw bushing into sleeve. Care must be taken to ensure that the bushing is located correctly, *i.e.*, the "dimple" on the bushing must coincide with the recess in the sleeve.

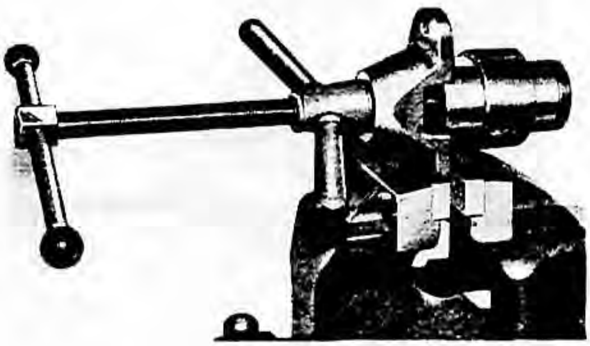

FIGURE 17.
REPLACING P.T.O. SLEEVE BUSHING

TO REPLACE SLEEVE (Figure 18 refers)

Use Service Tool MF.195 with Adaptor MF.195-1, as shown in Fig. 18, to draw sleeve into centre housing bore from front of housing.

Replace P.T.O. Shaft Bearing Retainer.

NOTE.—Fully detailed instructions for the use of Service Tool MF.195 with the Adaptor MF.195-1 are contained with each set of adaptors.

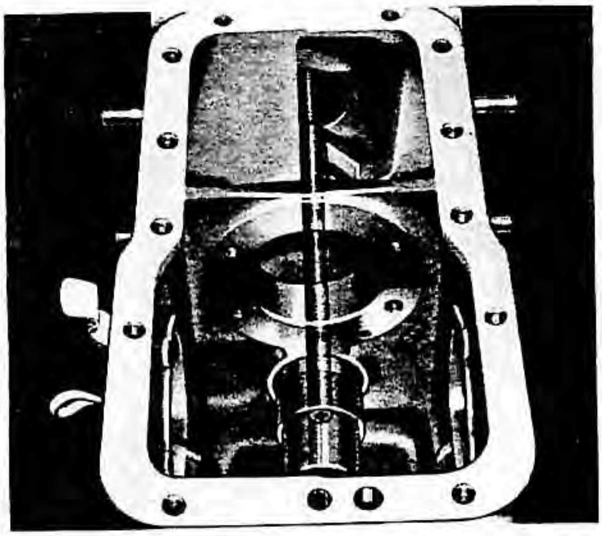

FIGURE 18.
REPLACING P.T.O. SHAFT SLEEVE

TO RE-ASSEMBLE TRACTOR

1. Replace differential assembly and axle housing(s).
2. Position hydraulic pump and locate, but do not tighten pump support pins.
   Slide in P.T.O. shaft, with P.T.O. driven gear and push driven gear forward to engage pump shaft, so centralising pump.
   Secure pump support pin locknuts, tightening right-hand ones first, as left-hand support pin hole in pump casing is made larger to facilitate alignment.
3. Fit P.T.O. shaft oil seal and bearing retainers and secure with retainer to centre housing screws. (Use MF.167 to protect oil seal).
4. Replace Coupler Shifter Cover Assembly.
5. Replace Hydraulic Lift Cover with new gasket.
6. Renew Standpipe "O" Rings and replace Standpipe.
7. Fit linkage, seat, stepboards and all related equipment.
8. Clean magnetic drain plugs and fit to centre and transmission housings.
9. Refill through oil filler located by gear change lever with 6.6 galls. (30.28 litres) of recommended lubricant as detailed in the Instruction Book.

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WORKSHOP SERVICE MANUAL

SECTION N

STEERING

STEERING

Section N

CONTENTS

LIST OF ILLUSTRATIONS

SECTION N

STEERING

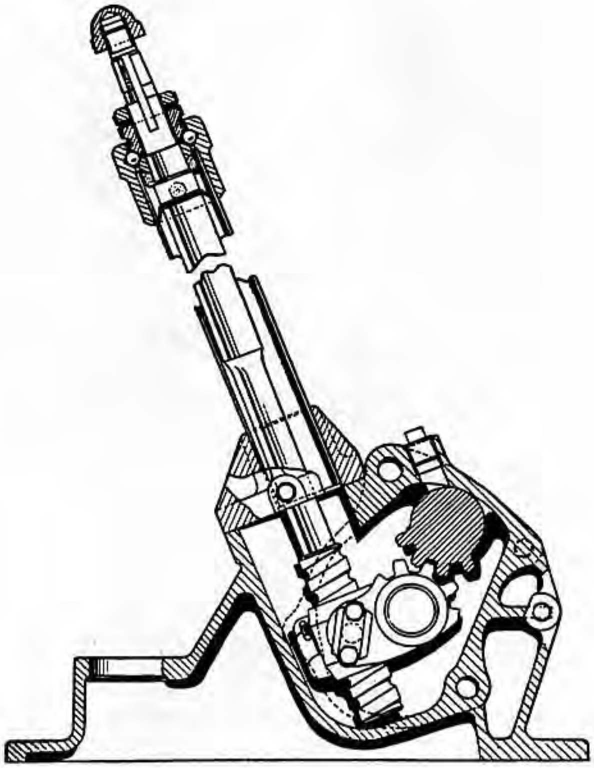

FIG. 1

SECTIONAL VIEW OF STEERING BOX

The steering gear is a screw and recirculating ball nut unit, with the nut supported on the threaded lower end of the steering shaft, and with recirculating balls interposed between the working threads to provide the utmost efficiency and smoothness of action.

The primary (L.H.) rocker shaft which is attached to this nut, has rack teeth cut on the upper side which engage with teeth cut in the lower side of the secondary (R.H.) rocker shaft.

As the steering column is turned by the steering wheel, the nut is moved vertically, rotating the rocker shafts.

The steering drop arms are splined to the outer ends of the rocker shafts, which thereby control the front wheels by means of the drag links.

The centres of the rocker shafts and the length of the drop arms are so arranged as to ensure correct steering geometry and to permit change of track without adjusting the length of the steering drag links.

The top only of the steering column is supported in a ball race, permitting a degree of freedom to the unsupported bottom end of the column.

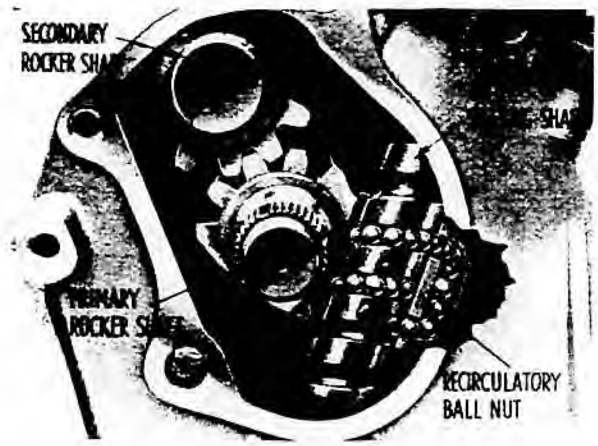

FIG. 2
STEERING ASSEMBLY

MAINTENANCE

The lubricating oil capacity of the steering assembly is 1.8 pints, it is factory filled with non-fluid oil and should be topped up with transmission oil, when necessary, to the level of the filler plug (See Fig. 3). A grease nipple is provided for greasing the ball race at intervals of 120 working hours.

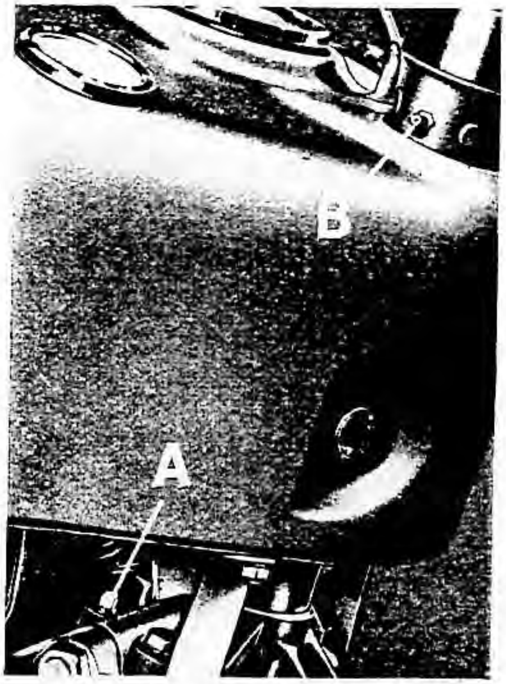

FIG. 3
STEERING FILLER PLUG AND GREASE NIPPLE

DISMANTLING AND REASSEMBLY

The following sequences cover the dismantling and reassembly of the steering box assembly, both in part and as a complete unit. Where only limited dismantling is required, a note to this effect will be included in the relevant instructions.

On tractors built before February 1959, it was necessary to remove the steering box to gain access to the cover plate. Tractors built after this date incorporated a modified left-hand battery platform support, which allowed the plate to be removed and the steering box to be serviced without removal from the tractor.

The following instructions apply to the currently produced tractor, which incorporates this modification.

To Remove and Dismantle Cover Plate (N-1)

1. Remove drag link to drop arm nuts and tap links free.

   Remove rocker shaft nuts and spring washers and tap off drop arms.

   Remove felt outer oil seals.

2. Fit Service Tool MF.173 over splines of primary rocker shaft to protect inner oil seal. Remove setscrews and nuts and bolts securing cover plate to steering box. Remove cover plate and gasket. (See Fig. 4).

3. Remove inner oil seal.

4. Tap out welch washer.

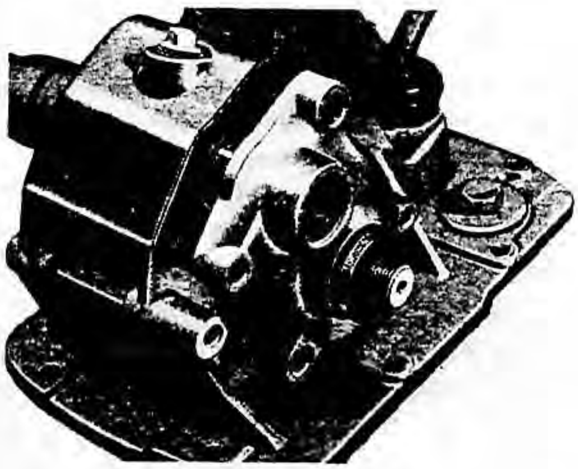

FIG. 4
USE OF MF.173

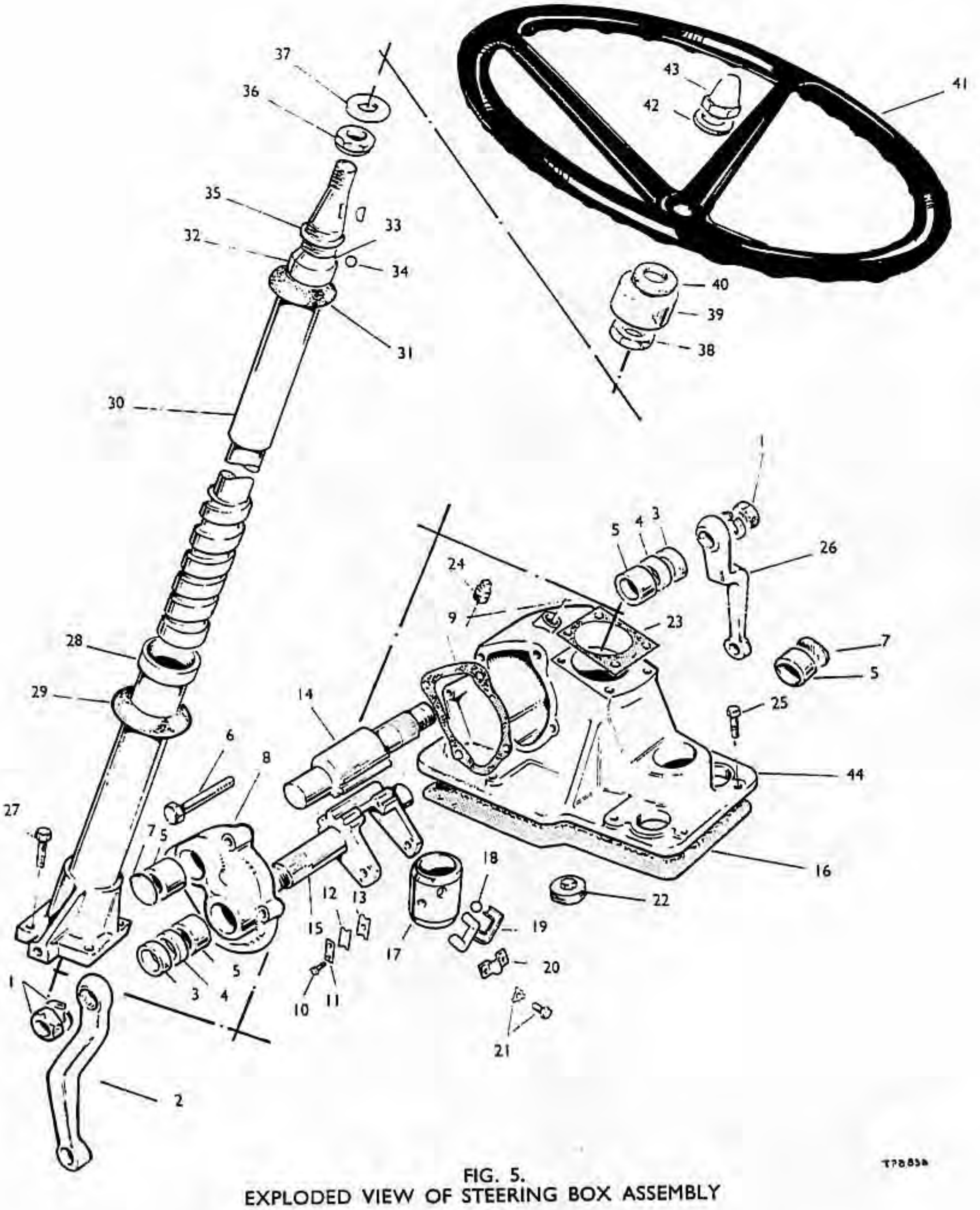

FIG. 5.
EXPLODED VIEW OF STEERING BOX ASSEMBLY

KEY TO FIG. 5

1 Rocker Shaft Nut and Spring Washer.
2 Primary Drop Arm.
3 Outer Oil Seal.
4 Inner Oil Seal.
5 Rocker Shaft Bush.
6 Cover Plate Dowel Bolt.
7 Welch Washer.
8 Cover Plate.
9 Cover Plate Washer.
10 Ball Peg Bolt.
11 Tab Washer.
12 Ball Peg.
13 Ball Peg Shim.
14 Secondary Rocker Shaft.
15 Primary Rocker Shaft.
16 Steering Box Gasket.
17 Main Nut.
18 Main Nut Steel Balls.
19 Transfer Tube.
20 Transfer Tube Retainer.
21 Transfer Tube Bolt and Tab Washer.
22 Filler Plug.
23 Tube Housing Washer.
24 Oil Plug.
25 Setscrew.
26 Secondary Drop Arm.
27 Tube Housing Bolt and Spring Washer.
28 Outer Tube Assembly.
29 Steering Column Collar.
30 Inner Column.
31 Inner Column Oil Seal.
32 Ballrace ring.
33 Spherical Ballrace.
34 Ballrace Steel Ball.
35 Oil Seal.
36 Adjustable Ballrace.
37 Tab Washer Assembly.
38 Adjustable Ballrace Nut.
39 Steering Column Cover.
40 Felt Washer.
41 Steering Wheel.
42 Steering Wheel Washer.
43 Steering Wheel Nut.
44 Steering Box.

FIRST ISSUE

NOTE.—Further dismantling is only carried out in the event of the complete breakdown of the steering box assembly and this is usually undertaken only when the steering box has been removed from the tractor.

To Remove Instrument Panel (N-2)

1. Unscrew hood retaining wing-nuts, move hood forward and support it in raised position.

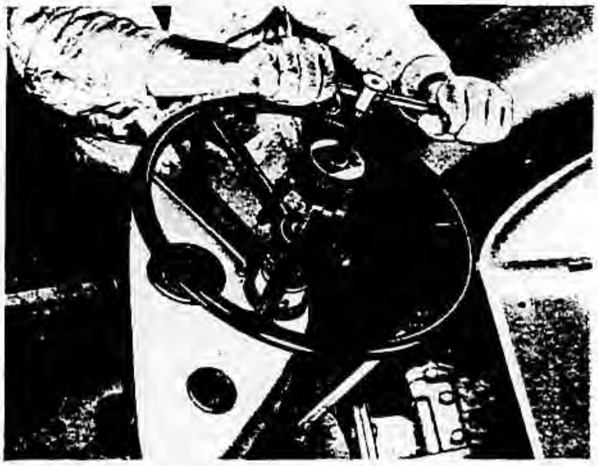

FIG. 6
REMOVING STEERING WHEEL

2. Remove steering wheel nut and washer. Using Service Tool, MFB.8, or a similar tool, as shown in Fig. 6, remove steering wheel. Remove woodruff key, felt washer, steering column cover and grease nipple.
3. Disconnect batteries.

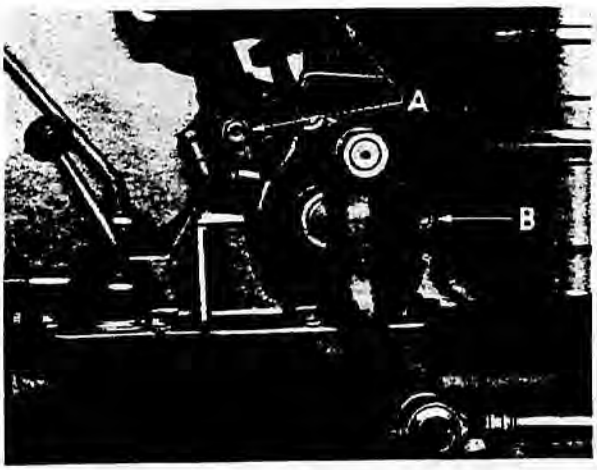

FIG. 7
GENERAL VIEW OF R.H. SIDE OF STEERING BOX

4. Remove ammeter, heater/starter switch, fuel cut-off knob and return spring.
   Disconnect oil pressure gauge pipe, throttle rod and tractormeter cable.
5. Remove setscrew and bolts securing instrument panel to steering box and battery platform support. (See A, Fig. 7).
6. Lift off instrument panel.

To Remove Steering Box (N-3)

(This is only necessary on earlier tractors).

1. Remove instrument panel as detailed in N-2.
2. Remove setscrews holding steering box to battery platform support. (See B, Fig. 7).
3. Remove drag link to drop arm nuts and tap drag links free. Remove rocker shaft nuts and spring washers and tap off drop arms.
4. Remove three setscrews holding battery cable guard to steering box and remove guard and cable.
5. Remove remaining setscrews holding steering box to transmission case and lift off box.

To Dismantle Steering Box (N-4)

1. Remove steering box from tractor as detailed in N-3 and remove and dismantle cover plate as detailed in N-1.
2. Fit Service Tool MF.173 over splines of secondary rocker shaft to protect inner oil seal and slide out rocker shaft.
3. Straighten ball peg bolt tab washers and remove ball peg bolts, ball peg and shims.
4. Remove tube housing bolts and withdraw inner column and outer tube assembly complete with main nut.
5. Remove primary rocker shaft.
6. Remove inner oil seal.

To Dismantle Inner Column and Outer Tube Assembly (N-5)

1. Remove inner column and outer tube assembly from steering box as detailed in N-4.
2. Allow main nut to run off inner column and collect twenty-eight steel balls.
3. Straighten tab washer assembly and remove adjustable ball-race nut and adjustable ball-race.
4. Withdraw inner column from outer tube assembly. Remove twelve steel balls, spherical ball-race, ball-race ring and inner column oil seal.

FIRST ISSUE

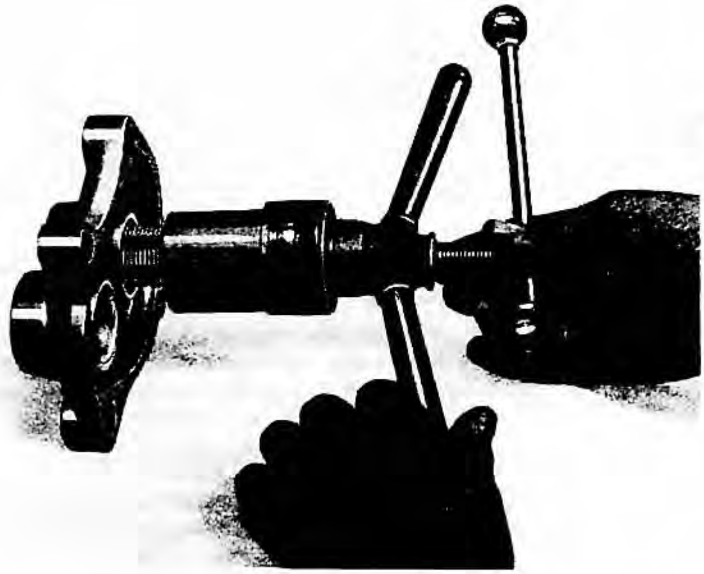

FIG. 8 (a)
USE OF MF.17

FIG. 8 (b)
USE OF MF.17

To Remove and Replace Rocker Shaft Bushes (N-6)

The following instructions apply both when the steering box is removed or when it is in position on the tractor.

1. Tap out welch washers from steering box and cover plate.
2. Using Service Tool MF.17 as shown in Figs. 8(a) and (b), remove four rocker shaft bushes from cover plate and steering box.
3. Using Service Tool MF.18 as shown in Fig. 9, replace rocker shaft bushes.
4. Expand bushes by using Service Tool MF.19 as shown in Fig. 10.
5. Fit cover plate to steering box and ream through each pair of bushes using reamer of Service Tool MF.19.
6. Separate cover plate and steering box and clean away excess swarf.

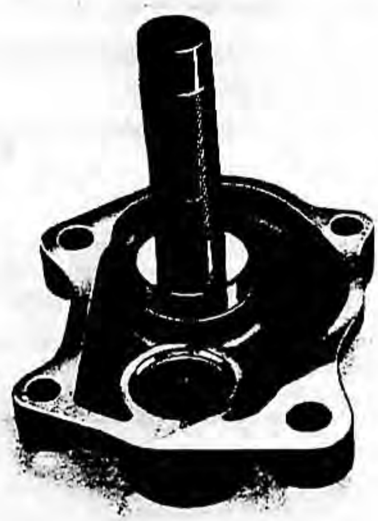

FIG. 9.
USE OF MF.18

FIG. 10
EXPANDING BUSH USING MF.19

7. Fit primary and secondary rocker shafts in position and fit cover plate with washer.
   Check movement of rocker shafts. If movement is stiff repeat reaming operation. Separate cover and box and remove rocker shafts.

8. Using suitable sealing compound around periphery, position welch washers in position in upper bore in cover plate and lower bore in steering box.
   Tap convex centres of welch washers to spread into position.

To Reassemble Inner Column and Outer Tube Assembly (N-7)

1. Position ball-race ring and inner column oil seal on inner column, and enter inner column into outer tube from lower end.

2. Place spherical ball-race on inner column and using grease, place steel balls on spherical ball-race.

3. Fit new outer tube oil seal in groove on adjustable ball-race.
   Screw adjustable ball-race down until endfloat is eliminated with inner column still able to rotate freely.

4. Place tab washer assembly adjustable ball-race and fit and tighten down adjustable ball-race nut. Bend tab washer assembly to lock both adjustable ball-race and nut.

To Refit Main Nut to Inner Column (N-8)

1. Fit inner column into outer tube as detailed in N-7.

2. Temporarily fit steering wheel and invert assembly onto bench.

3. Place main nut over lower threaded end of inner column and feed twenty-eight steel balls into main nut channel one by one. Turn main nut to accommodate them as balls are fed in.

4. Support main nut and invert assembly.

To Reassemble Steering Box Assembly (N-9)

1. Fit inner oil seals and welch washers in cover and box.

2. Slide primary rocker shaft into lower bore in steering box.

3. Run main nut to top of lower threaded portion of inner column and, positioning tube housing washer, enter column into steering box with machined chamfer on base of tube to front. Maintain main nut at top of thread during this operation with transfer tube to rear.

4. As column is lowered, turn primary rocker shaft until ball peg locates in hole in main nut. Hold assembly in this position until outer tube has been bolted to steering box. Fit L.H. ball peg.

5. Turn inner column until main nut is approximately half-way along threaded portion of column. All end-play must be eliminated while still allowing the main nut to rotate freely. Shims should be of even thickness beneath each ball peg.

6. Fit secondary rocker shaft so that two centre teeth mesh with two centre teeth of primary rocker shaft and tighten down ball peg bolts, and lock with tab washers.

7. Tighten down tube housing bolts.

8. Using suitable non-hardening sealing compound with new gasket, replace cover plate.

9. Fill to level of filler plug with recommended lubricant (see current Instruction Book) and turn steering wheel several times to lubricate all parts.

10. Positioning steering wheel in 'straight-ahead' position, replace felt outer oil seals and drop arms so that drag link attaching holes are directly above radius rod ball joints. Replace drop arm spring washers and nuts and tighten.

To Replace Steering Box (N-10)

1. Ensure correct positioning of shifter rail plunger springs and fit steering box gasket. Position selector forks in 'neutral' and ensure that gear levers engage correctly with selector forks.
   Fit steering box assembly.

2. Position battery cable, battery cable guard and tighten down setscrews.

3. Fit battery platform support to steering box setscrews.

To Replace Instrument Panel (N-11)

1. Position instrument panel over steering column and secure with setscrews and nuts and bolts to steering box and battery platform support.

2. Reconnect oil pressure gauge pipe, throttle rod and tractormeter cable.
   Replace ammeter, heater/starter switch, fuel cut-off knob and return spring and reconnect batteries.

3. Refit grease nipple, steering column cover, felt washer and woodruff key. Position steering wheel, fit washer and nut and tighten down.

4. Lower hood and secure with hood retaining wingnuts.

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WORKSHOP SERVICE MANUAL

SECTION O

FRONT AXLE

FRONT AXLE

Section O

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LIST OF ILLUSTRATIONS

FRONT AXLE

INTRODUCTION (Refer Figure 1)

The front axle assembly comprises a robust support bracket, a central articulated axle beam, and two outer axle assemblies which can be fitted in alternative positions to provide adjustment for the front wheel track. The centre axle member is swept rearwards; the geometry of the sweep accommodating the adjustable axle ends and enabling the wheel track to be altered without affecting front wheel toe-in adjustment.

Two non-adjustable radius rods connect the axle beam outer members, or axle assemblies, to the transmission casing. These radius rods are fitted to provide rigidity to the axle beam and to prevent longitudinal axle movement.

The dismantling instructions contained within this section follow through from the removal of the complete front axle assembly. For the removal of sub units, where it is not intended to remove the front axle, the relevant information may readily be extracted. Figure 1 illustrates the relationship of the various components.

ADJUSTING FRONT WHEEL TRACK
(Refer Figure 2)

The front wheel track can be adjusted in 4" (101.6 mm.) steps from 48" (1219 mm.) to 80" (2032 mm.) To adjust wheel track between 48"—72" (1219-1828 mm.) proceed as follows.

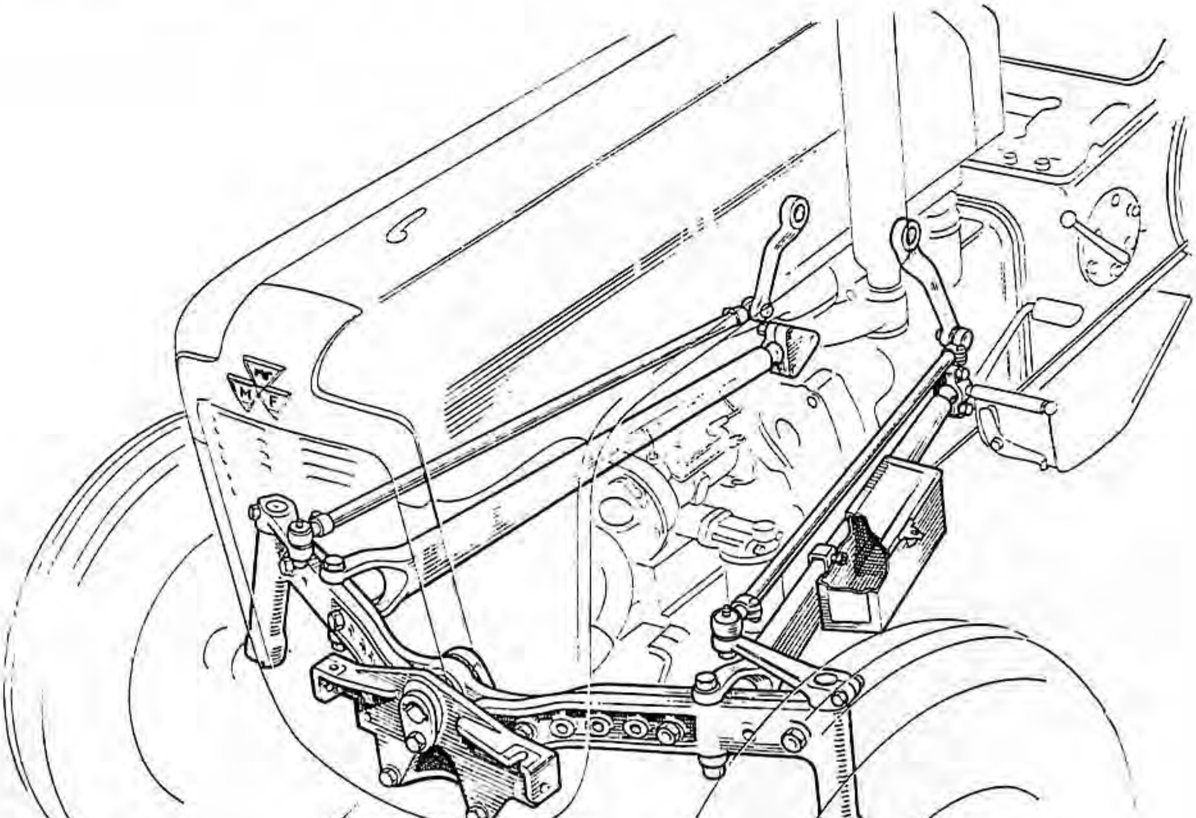
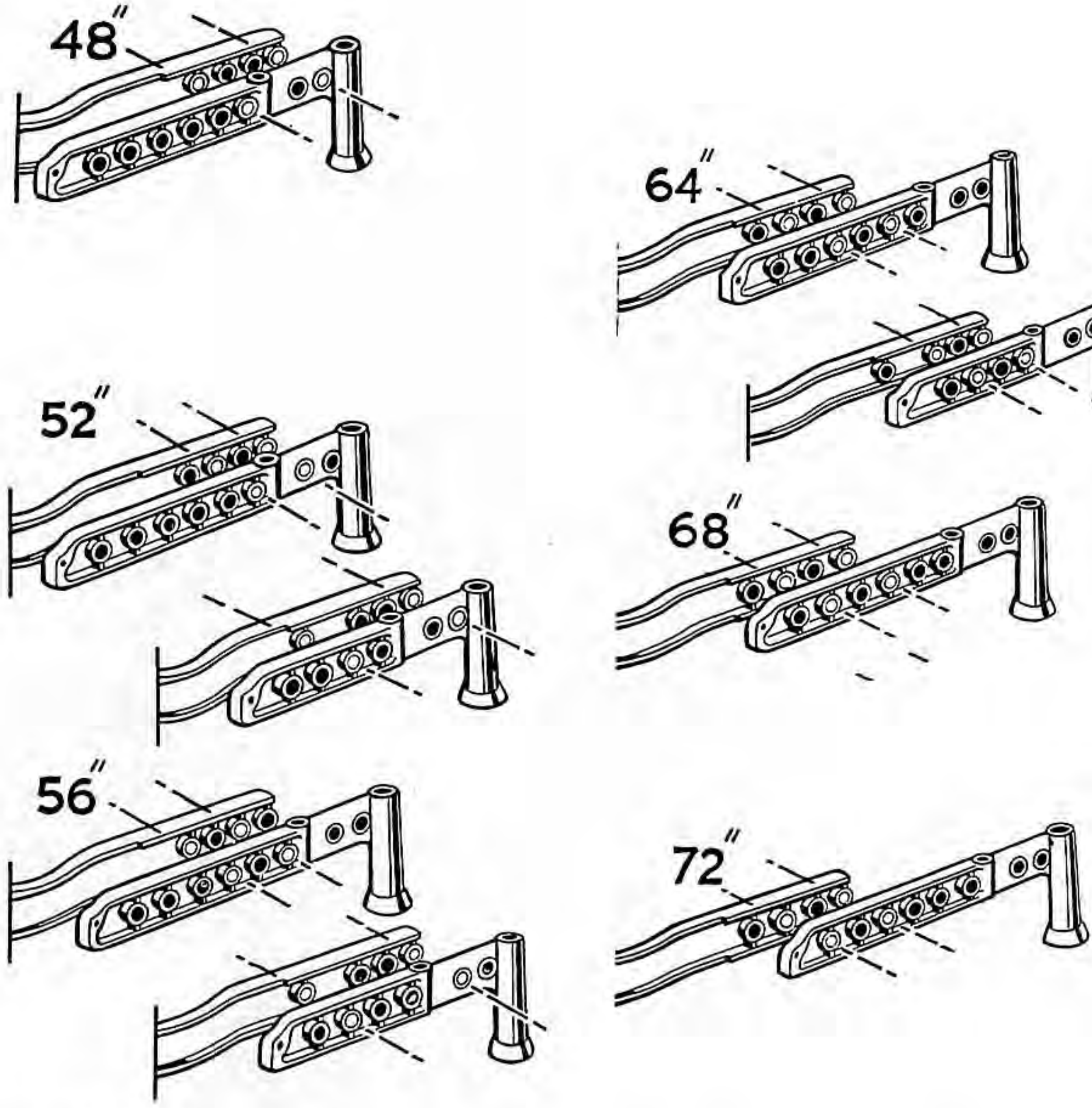
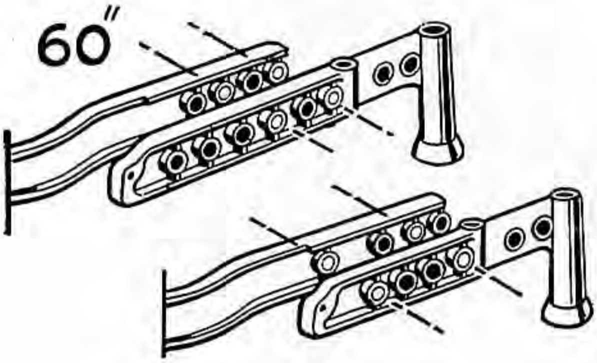


FIGURE 1
GENERAL ARRANGEMENT OF FRONT AXLE ASSEMBLY





The front axle assembled to 72" but with wheels reversed will give a wheel track setting of 80". Similarly, the wheels still reversed but with 68" axle assembly give a track setting of 76".

FIGURE 2
FRONT WHEEL TRACK ADJUSTMENT

Jack up and securely support front end of tractor. Remove the bolts which attach each outer axle assembly to the central axle member.

Locate outer axle assemblies in desired positions. Replace and tighten securing bolts.

Note that the two bolts securing each outer axle assembly must never be located in adjacent holes. The 80″ (2032 mm.) track width dimension is obtained by reversing the front wheels.

Figure 2 illustrates the location of the outer axle assemblies and track widths.

No adjustment to steering drag links is necessary when altering wheel track. Toe-in will not be affected.

ADJUSTING FRONT WHEEL TOE-IN

Front wheel toe-in should be ⅛″ (3.18 mm.)

To adjust toe-in proceed as follows:-

Locate tractor on firm level ground.

Place front wheels in straight ahead position.

Using a suitable track gauge, check toe-in.

If adjustment is required the pinch bolts clamping the drag link ends to the drag links should be slackened off and the drag links rotated clockwise or anti-clockwise to increase or decrease toe-in as required. Adjustment should be made equally to both drag links. This may be checked by noting the relationship of the rear drag link ends to the footrests. When the front wheels are in the straight ahead position the distance between the rear end of each drag link and the adjacent footrest should be equal.

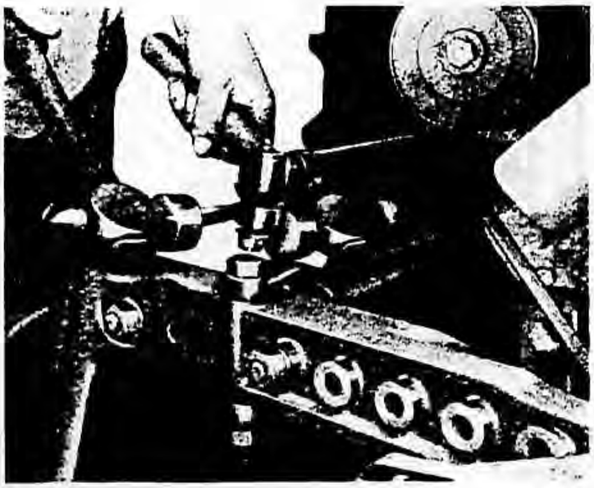


FIGURE 3 REMOVING DRAG LINK END FROM TRACTOR

Tighten drag link pinch bolts when adjustment has been completed.

Remove track gauge.

Move tractor until front wheels have rotated 180°. Re-check toe-in.

REMOVING DRAG LINKS (Refer Figure 3)

Remove split pins and castellated nuts securing drag link ends to steering box drop arms and spindle arms.

The method of removal is illustrated in Figure 3.

The use of two hammers, or alternatively a small block of metal and one hammer is advised.

The effect of a crisp impact, with the drop arm or spindle suitably supported, will cause the tapered faces of the drag link ball joint to be sprung clear of the arm to which it was attached. Care must be taken when performing this operation to ensure that the drop arm and spindle arm are not damaged in the process of removal and that the hammer correctly strikes the **end** of the appropriate arms.

REMOVING AND REPLACING DRAG LINK ENDS (Refer Figures 1 and 2)

Slacken-off pinch bolts on drag link end clamps. Unscrew drag link ends from drag link.

Note that drag link ends are not interchangeable, one being left-handed and the other right-handed.

The grease nipples are positioned to facilitate accessibility in position.

Drag link ends, must be discarded if worn. No attempt at reclamation is permissible.

REMOVING FRONT AXLE ASSEMBLY (Refer Figure 1)

The front axle, wheels, drag links, and centre axle support bracket, may, if required, be removed as a complete unit. This can be carried out as follows:-

Remove hood and cowl assembly.

Drain off water from cooling system.

Remove radiator.

Release drag link ends from track, or spindle arms. (This is described fully under 'Removing drag links').

Brake or chock rear wheels.

Jack up front end of tractor.

Support transmission housing securely.

Remove foot rest and outer bearing cap of radius rod ball joints.

Slacken off and remove nuts and bolts securing centre axle support bracket to engine.

Withdraw front axle assembly complete with wheels and radius rods from tractor. This may be facilitated by judicious use of the axle and transmission housing support jacks permitting the front axle assembly to be wheeled away from the tractor.

Assemble in reverse order.

REMOVING RADIUS RODS (Refer Figure 1)

The radius rods are secured to the outer axle assemblies by a single bolt, the removal of which will release the radius rod from the axle. The ball socket seats for the rear of the radius rods are located and held by three studs and three nuts.

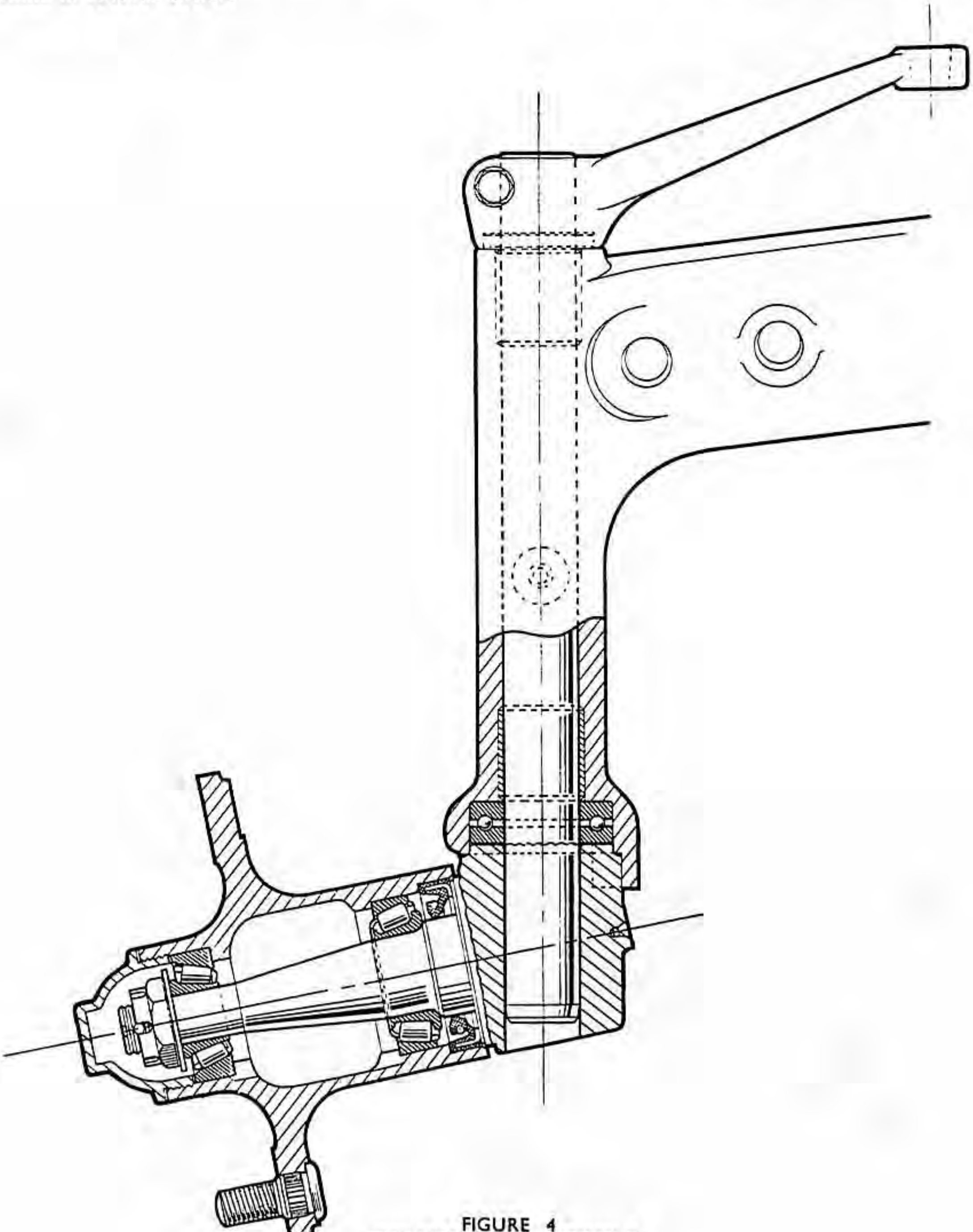


FIGURE 4
THE FRONT HUB ASSEMBLY

DISMANTLING AND ASSEMBLING FRONT HUBS (Refer Figure 4)

Remove road wheel.
Remove hub cap.
Straighten out and remove split pin locking castellated nut.
Slacken off and remove castellated nut and washer.
Withdraw front hub from spindle assembly complete with bearings and oil seal.
Thoroughly clean all components and examine.
Bearing outer tracks should not be removed unless renewal is required.
Place inner bearing in position and fit new oil seal.
Pack hub $\frac{1}{3}$ full with grease.
Mount hub on spindle assembly.
Fit outer race, washer and castellated nut.
Tighten castellated nut to 60 lbs/ft. Slacken off not less than two and up to three flats when float of hub should be zero — 0.010" (0.0—0.254 mm.)
Fit new split pin.
Correctly adjusted, the hub bearings should have a running clearance of 0.004—0.008" (0.1016—0.2032 mm.)
In this condition there should be neither load nor pre-load on the bearings.
Half fill hub cap with grease and replace.
Fit road wheel.

REMOVING AND DISMANTLING OUTER AXLE ASSEMBLY (Refer Figure 1)

Remove front wheel.
Remove front hub cap.
Wipe off grease concealing castellated nut and split pin.
Remove split pin and castellated nut.
Remove front hub complete with bearings.
Ensure drag link is disconnected at spindle arm.
Remove the two bolts securing outer axle assembly to centre axle beam.
Withdraw outer axle assembly.
Remove pinch bolts clamping spindle arm to spindle.
Remove spindle arm.
Withdraw woodruff key and seal.
Withdraw spindle complete with thrust race from outer axle.
Thoroughly clean and examine all components.

FITTING NEW BUSHES TO OUTER AXLES (Refer Figures 5 and 8)

Treating upper and lower bushes in turn mount bush remover MF.17 as shown in Figure 5.

FIGURE 5
REMOVING OUTER AXLE SPINDLE BUSHES

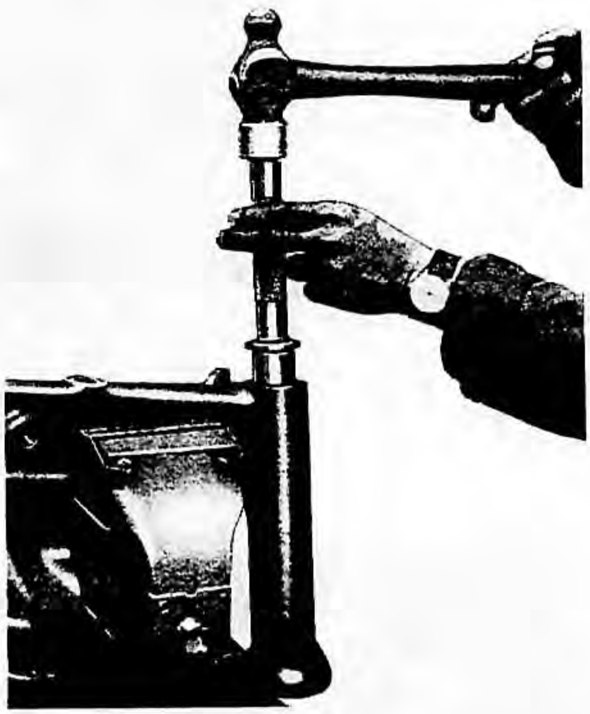


FIGURE 6
FITTING NEW SPINDLE BUSHES

FIGURE 7 EXPANDING THE SPINDLE BUSHES

Enter tap in bush as normal hole tapping procedure until tap is properly engaged. Rotate the larger wing nut of Tool MF.17 when the bush will be withdrawn. Remove remaining bush in similar fashion.
Remove grease nipple and thoroughly clean outer axle. Mount new bush on boss of replacing Tool MF.18 and tap into position as shown in Figure 6.

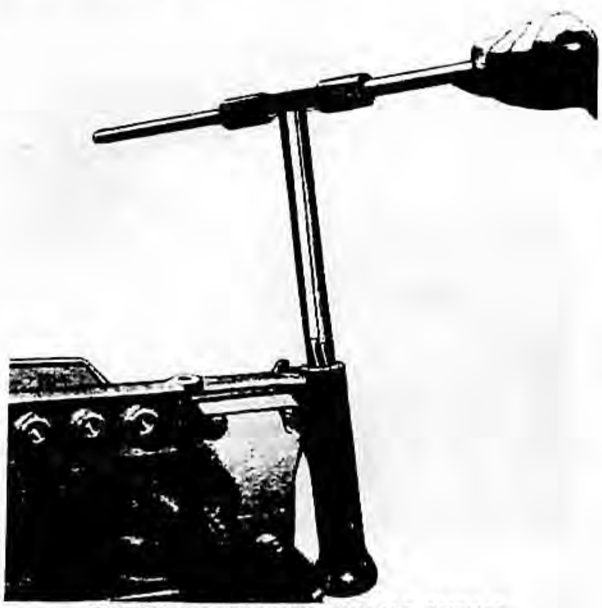


FIGURE 8 REAMING SPINDLE BUSHES

To ensure correct fitting, bushes should be expanded and reamed after installation.
Use reaming and expanding Kit MF.19 as outlined below. Place split boss of expanding tool in position illustrated in Figure 7 and tap through ball-ended rod. This corrects any compressive distortion which may have resulted when the bush was fitted. Ream bushes as shown in Figure 8.
Clean outer axle assembly and ensure that all metal cuttings are removed and that grease nipple drilling is clear.

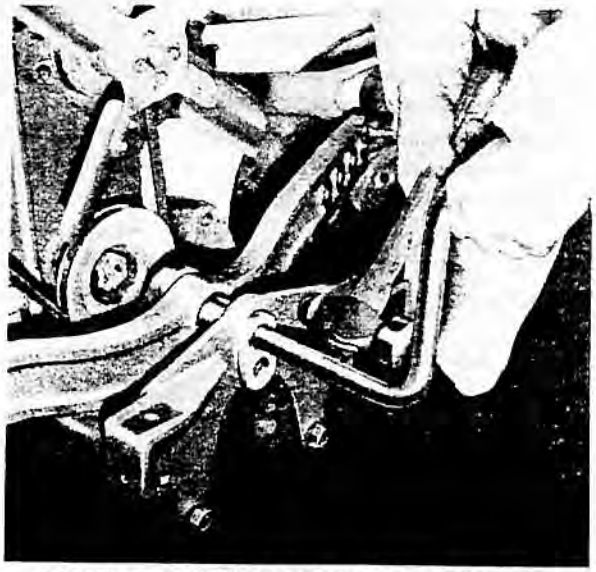


FIGURE 9 REMOVING CENTRE AXLE PIVOT PIN

REMOVING CENTRE AXLE MEMBER

(Refer Figures 1 and 9)
Support weight of tractor on transmission housing or front axle bracket removing all load from centre axle pivot.
Remove bolt securing centre axle pin assembly. Remove pin assembly. The engine cranking handle may be employed for this purpose as illustrated in Figure 9.
Remove centre axle member.
The pivot bush is a press fit in the centre axle beam, and its removal and replacement may be carried out with the aid of a press.
Assemble in reverse order.

DATA

CASTOR 5°
SPINDLE INCLINATION 9°
CAMBER 2°
TOE-IN 0—⅛″ (0—3.175 mm.)

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SECTION P

BRAKES

BRAKES

Section P

CONTENTS

DUAL BRAKES — HYDRAULIC

CONTENTS—*continued*

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DUAL BRAKES — MECHANICAL

LIST OF ILLUSTRATIONS

BRAKES

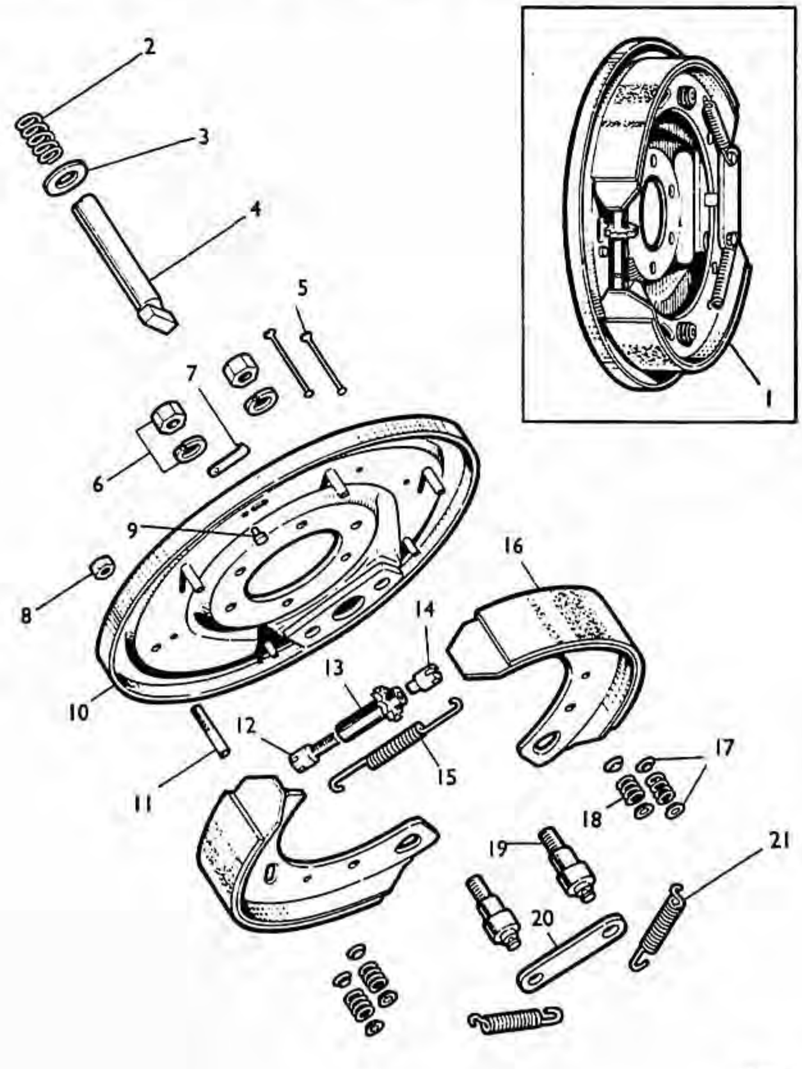
GENERAL

The brakes fitted to the agricultural model of the Massey-Ferguson 35 Tractor are Girling Double Anchor Floating Cam type and are fitted to the rear wheels only. They are internally expanding 14″ × 2″ drum brakes and can be operated either independently for field work or simultaneously for roadwork.

The shoes are fitted with bonded linings in production but are drilled to receive riveted linings in service if required.

The brake consists of a backplate on which is mounted the double anchor pin assembly securing one end of each shoe and between the free end of each shoe is located the adjuster assembly. Between the shoe webs at the anchor pin end is the operating camshaft to which the foot pedal lever is directly connected. A shoe to anchor pin spring is connected between the anchor pin and shoe web of each shoe, and an adjuster end spring controls the free end of the shoes. The shoes are kept square in relation to the backplate by steady posts and shoe hold-down pins. The backplate is secured to the rear axle housing assembly and is enclosed within a drum which is fitted to the rear axle shaft assembly.

The brakes are operated by two independent brake pedals situated on the right-hand side of the transmission housing. Either pedal can be depressed



KEY TO FIG. 1

1. Brake Assembly.
2. Cover Plate Spring.
3. Camshaft Cover Plate.
4. Camshaft.
5. Shoe Hold-down Pin.
6. Spring Washer and Anchor Pin Nut.
7. Cover Plate.
8. Steady Post Nut.
9. Cover Plate Pivot.
10. Backplate Assembly.
11. Adjustable Steady Post.
12. Adjustable Tappet.
13. Barrel Assembly.
14. Plain Tappet.
15. Adjuster End Spring.
16. Shoe Assembly.
17. Shoe Hold-down Cup.
18. Shoe Hold-down Spring.
19. Spacer Washer and Anchor Pin.
20. Anchor Pin Plate.
21. Shoe to Anchor Pin Spring.

FIG. 1.

T.P.C.974 EXPLODED VIEW OF BRAKES

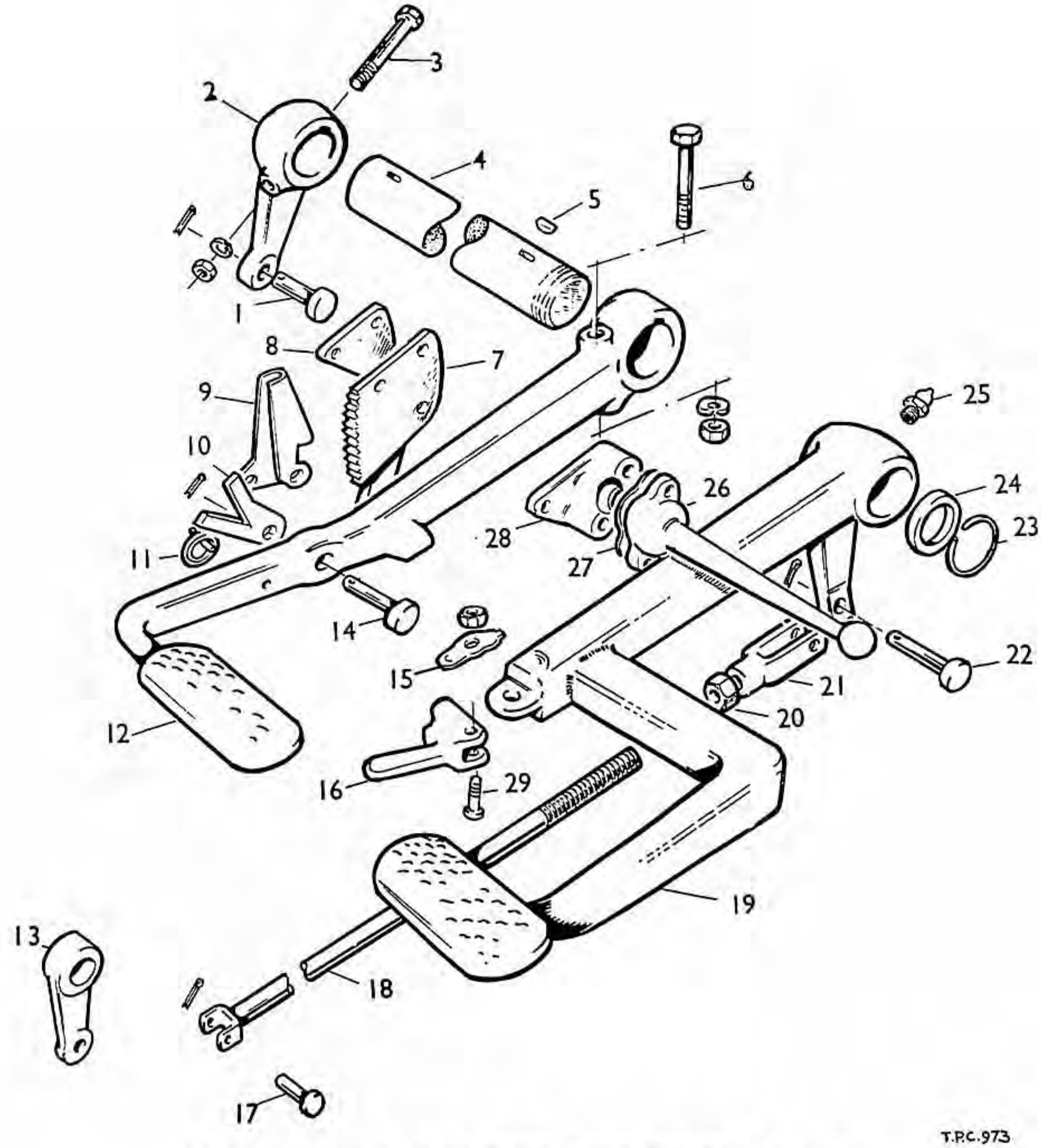


FIG. 2. EXPLODED VIEW OF BRAKE PEDALS AND RELATED PARTS.

KEY TO FIG. 2

1. Clevis and Cotter Pins.
2. Combined Brake Arm.
3. Combined Brake Arm Bolt.
4. Combined Brake Cross Shaft.
5. Woodruff Key.
6. Brake Pedal Bolt.
7. Parking Brake Sector.
8. Plate.
9. Parking Brake Latch Actuator.
10. Parking Brake Latch.
11. Parking Brake Latch Spring.
12. Left Wheel Brake Pedal.
13. Rear Brake Lever.
14. Clevis and Cotter Pins.
15. Combined Brake Lock Spring.
16. Combined Brake Lock.
17. Clevis and Cotter Pins.
18. Rod and Yoke Assembly.
19. Right Wheel Brake Pedal.
20. Hexagon Jam Nut.
21. Adjustable Yoke.
22. Clevis and Cotter Pins.
23. Snap Ring.
24. Brake Cross Shaft Washer.
25. Lubricator.
26. Radius Rod Ball Cap.
27. Radius Rod Ball Cap Shim.
28. Radius Rod Ball Cap Spacer.
29. Flat Head Screw and Nyloc Nut.

for independent operation of the brakes to assist in turning the tractor during field work. For normal braking, both brakes can be applied simultaneously by engaging the combined brake lock pivoted on the right-hand pedal. For locking the brakes 'ON' whilst parking, a parking brake latch and actuator pivoted on the left-hand brake pedal engage a parking brake sector secured beneath the radius rod ball cap spacer.

SERVICING

To Adjust Brakes (P-1)

This operation must be carried out whenever any component within the brake is replaced. However, this operation will be carried out by the Owner or Operator as the working efficiency of the brake decreases. This deterioration in braking power is indicated by an increase in pedal travel, by the brakes pulling to one side or by any obvious decrease in braking efficiency.

1. Jack rear wheels clear of ground.
2. Ensure that all shafts and pins work freely and that when the brakes are 'OFF' the brake pedals are against their stops.
3. Expand shoes fully in drum by means of adjuster assembly (turn clockwise to expand) until wheel is fully locked. Tap drum lightly with hide or copper faced hammer and again attempt to tighten adjuster.
   Tighten brakes by moving cover plate and rotating barrel assembly clockwise with a screwdriver through the aperture, as shown in Fig. 4.
4. Slacken off barrel assembly six to eight "clicks" when the wheel should be free to rotate.
5. To test brakes, engage fourth gear and whilst driving slowly and with pedals locked together apply brake firmly. Any tendency to veer off course should be counteracted by slackening off the barrel assembly on the side to which the tractor veers.
   Note.—The brakes **must not** be adjusted by altering the length of the brake rods.

To Fit Replacement Shoes (P-2)

Sponginess and lack of braking power, even after carrying out the adjustments detailed in P-1, may indicate that the brake linings are excessively or unevenly worn or perhaps contaminated by oil or grease. Brake squeal may indicate that the linings are unevenly worn or that the rivet heads are protruding above the lining face. The brake shoes and linings should be examined when these symptoms become evident, and should be changed if the lining is worn to less than one-third of its original thickness at any one point (less than $\frac{3}{32}$") (2.38 mm.) or if the rivet heads are less than $\frac{1}{16}$" (1.5 mm.) below the lining face.

It is important that, when fitting replacement shoes, **genuine** spares of approved quality be used.

Should varied lining materials be used it will be found difficult, if not impossible, to achieve satisfactory braking power or balance.

1. Jack rear wheels clear of ground and remove wheels and drums. Detach brake rods from combined brake arm and right-hand pedal.
2. Remove shoe to anchor pin springs and anchor pin plate. Remove shoe hold-down cups and springs.
3. Lift off and dismantle shoes and adjuster assembly.
4. Very lightly smear steady posts, cam, adjuster assembly and shoe webs around shoe hold-down pin holes with Girling Brake Grease. NEVER USE ORDINARY GREASE.
5. Fit flat washers to anchor pins.
6. Refit replacement shoes to adjuster assembly and fit to anchor pins. Fit anchor pin plate and shoe hold-down pins. Fit adjuster end and shoe to anchor pin springs.
7. Slacken steady post nuts and screw steady posts well back into the backplate.

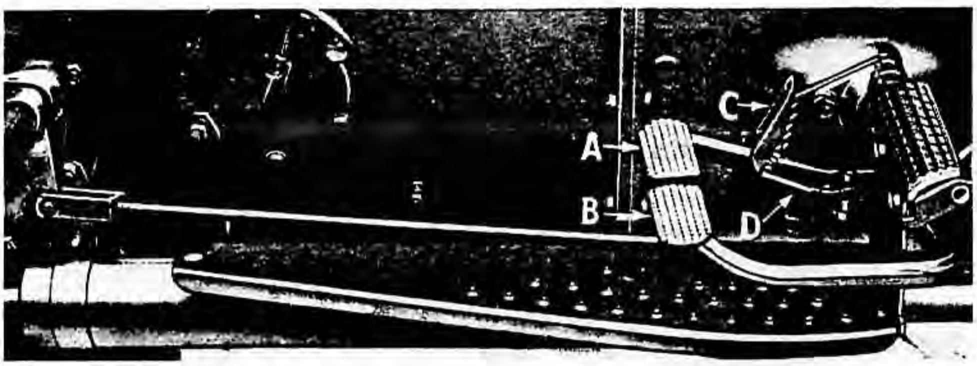


FIG. 3.
BRAKE ASSEMBLY

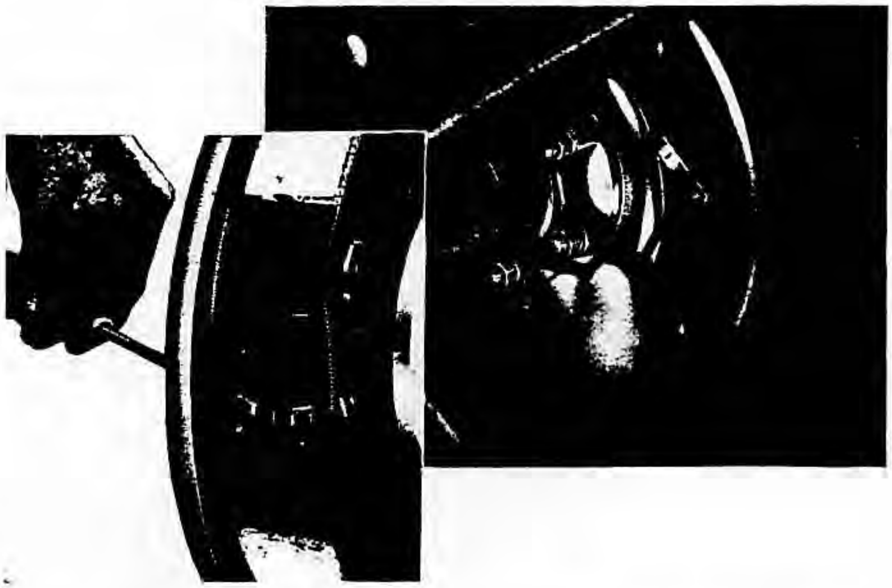


FIG. 4.
ADJUSTING BRAKES

8. Turn adjuster to fully 'OFF' position and replace drums.

9. Slacken anchor pin nuts.

10. Using adjuster, expand shoes in drums and with hide or copper faced hammer tap anchor pin nuts to ensure that they settle in their correct positions.
Check that shoes are still fully expanded but if adjuster assembly can be tightened, repeat 'tapping and tightening' procedure until adjuster assembly can be tightened no further.

11. Tighten anchor pin nuts to a torque of 135-170 lb. ft. (18.7-23.5 Kg.m.).

12. Screw in steady posts until they are in **light** contact with shoe webs. Check squareness of drums to shoe faces, using suitable straight edge and set-square. It will be necessary to remove the drums to check this.
Tighten steady post locknuts.
Instruction 13 should only be carried out if the brake rods or yokes have to be renewed.

13. With brake rod and yoke assemblies detached from combined brake arm and right-hand pedal and with shoes **fully** expanded in drums, adjust yoke assemblies to obtain a depression on the pedals corresponding to three or four teeth on the parking brake sector.

14. Connect brake rod and yoke assemblies to combined brake arm and right-hand pedal, having eliminated all backlash. Fit rear wheels.

15. Carry out instructions detailed in P-1.

DISMANTLING

Further dismantling is only required if the backplate is damaged and is to be replaced.

To Dismantle Brake (P-3)

1. Jack up rear of tractor and remove wheel and drum.
2. Detach brake rods from combined brake arm and right-hand pedal.
3. Remove shoe to anchor pin springs and anchor pin plate. Remove shoe hold-down cups and springs.
4. Lift off and dismantle shoe and adjuster assembly.
5. Remove adjustable steady posts, anchor pin plate washers, anchor pins and camshaft.
6. Remove backplate by removing rear axle stud nuts and withdrawing rear axle assembly complete with rear axle bearing retainer.

To Dismantle Brake Linkage (P-4)

1. Remove brake rod and yoke assemblies from rear brake levers and brake arms.
2. Remove circlip and washer and right-hand brake pedal. Remove left-hand brake pedal bolt and combined brake arm bolt and remove brake arm and pedal.
3. Remove Woodruff keys and combined brake cross shaft.
4. Remove parking brake sector from beneath radius rod ball cap spacer, parking brake latch and actuator from left-hand brake pedal and combined brake lock and spring from right-hand pedal.

INSPECTION

Clean and inspect all components and renew as required.

Brake shoes should be of the standard demanded under P-2.

Brake springs should be replaced if they show signs of weakness or have damaged ends.

Anchor pins should be carefully examined for wear and if this is excessive they should be turned through an angle to equalise wear.

The self-lubricating bushes in the axle housing and the right-hand brake pedal should be examined and renewed as required.

RE-ASSEMBLY

To Replace Backplate and Check Rear Axle Endfloat (P-5)

1. Position backplate together with nominal thickness of shims and fit rear axle shaft and bearing retainer and secure with three equally spaced nuts tightened to a torque of 50-55 lb. ft. (6.913-7.604 Kg.m.).

2. Using clock gauge off wheel axle flange, check endfloat.

3. Add or remove shims to give .002"-.008" (.051-.203 mm.) endfloat.

   Note.—It may be found advantageous to make a tightening down allowance of .002" (.051 mm.)

4. Tighten down remaining nuts to torque of 50-55 lb. ft. (6.913-7.604 Kg.m.).

To Re-assemble Brake Assembly (P-6)

1. Fit backplate as detailed in P-5.

2. Fit anchor pins but do not, at this stage, tighten nuts. Lightly fit steady posts but do not tighten.

3. Refit shoes to adjuster assembly and carry out Instructions 4-15 of P-2.

To Re-assemble Brake Linkage (P-7)

1. Fit combined brake cross shaft through transmission housing and replace Woodruff keys.

2. Refit parking brake sector beneath radius rod ball cap spacer, parking brake latch and actuator to left-hand pedal and combined brake lock and spring to right-hand brake pedal.

3. Replace combined brake arm and left-hand pedal and secure with pinch-bolts.
   Fit right-hand pedal and secure with washer and circlip.

4. Fit brake rod and yoke assemblies.

5. Carry out Instructions 14 and 15 of P-2. (If the brake rods or yokes have been changed, carry out Instruction 13 of P-2).

To Re-line Brake Shoes (P-8)

In territories where reconditioned shoes are not available it is permissible to re-line the shoes.

However, it must be stressed that it is advisable to fit genuine reconditioned shoes in preference to re-lining.

1. Place shoe assembly in oven and heat to 700°C.

2. When lining material turns white, remove assembly and lining will peel off platform.
   Note.—Should there be no oven available, immerse shoe assembly in boiling water until lining can be peeled off.

3. Place clamps close to centre holes of shoe and lining and securely rivet.

4. Working outwards in both directions from centre holes, position clamp between last riveted holes and holes next to be riveted and securely rivet.
   Use punch to swell rivet in hole.
   Peening alone is not effective and could be dangerous.

5. Gap between shoe and lining must not exceed .004" (.1016 mm.).

DUAL BRAKES

INTRODUCTION (Refer Figure 5)

The dual brakes operate on the rear wheels only. Briefly, the brake assemblies comprise two pairs of brake shoes housed within a common brake drum. The inner and narrower set of shoes is operated mechanically, the outer set is operated hydraulically. Each set of mechanical shoes is linked to its individual foot pedal and is connected also through a handbrake lever to its opposite counterpart. The hydraulic brake assemblies are fitted to the outside of a torque plate interposed between the hydraulic and mechanical shoes. The mechanical brake shoes, save for a reduction in shoe width from 2" to 1½" (50·8-38·1 mm.) are identical to those fitted to machines equipped with mechanical brakes only. Prior to March, 1961, two leading shoe hydraulic brakes were employed, each brake shoe being operated by individual wheel cylinders. Current machines employ the same mechanical brake arrangement as previous models, but there are decided differences in the hydraulic arrangement. The individual brake shoe cylinders are replaced by a single, double-acting cylinder and a floating adjuster is employed. The result is a high efficiency duo-servo brake.

FIGURE 5. THE DUAL BRAKE ARRANGEMENT.

MAINTENANCE

Maintenance on the brakes is confined to the following requirements:

(1) Lubrication

Lubrication within the brake drum is carried out on assembly and will not normally require attention between brake overhaul periods. It is important, however, to ensure that the pedal linkages and connecting rods are kept clean, lubricated and free from "binding" and restriction.

(2) Adjustment

Adjustment should be carried out as and when required and in the manner described elsewhere in this Section.

(3) The hydraulic reservoir

The level of brake fluid in the hydraulic reservoir should be examined weekly and topped up as required, to not less than ½" (12·7 mm.) below the filler cap. It is important to ensure that the small air vent hole in the filler plug is not permitted to become choked. Extreme cleanliness must be observed when removing the filler cap and topping up the reservoir.

(4) Bleeding the hydraulic brakes

Hydraulic brakes cannot operate efficiently if air is present in the wheel cylinders or fluid lines, bleeding must therefore be carried out subsequent to the removal or renewal of wheel cylinders, cups, fluid line unions, or if the level of the hydraulic reservoir has been permitted to fall so low that air is admitted to the master cylinder.

BLEEDING THE BRAKES (Refer Figure 6)

There are two ways by which the brakes may be bled.

One is with the aid of proprietary priming equipment which is connected to the reservoir, and the system pressurised and bled.

When employing this equipment it may be found necessary to pump the brake pedal in order to rid the master cylinder of pockets of air which would not otherwise be exhausted from the system.

When removed from workshop facilities, bleeding may be carried out as follows :

Obtain a clean transparent jar, preferably one fitted with a lid and with a length of copper tube penetrating the lid and reaching almost to the bottom of the jar.

Thoroughly clean hydraulic reservoir and remove all grit, mud, etc., from the vicinity of the brake bleed nipples.

Ensure hydraulic reservoir is topped up.

Remove protective rubber caps from brake wheel cylinder bleed nipples.

Connect a suitable length of small bore rubber tube to bleed nipple.

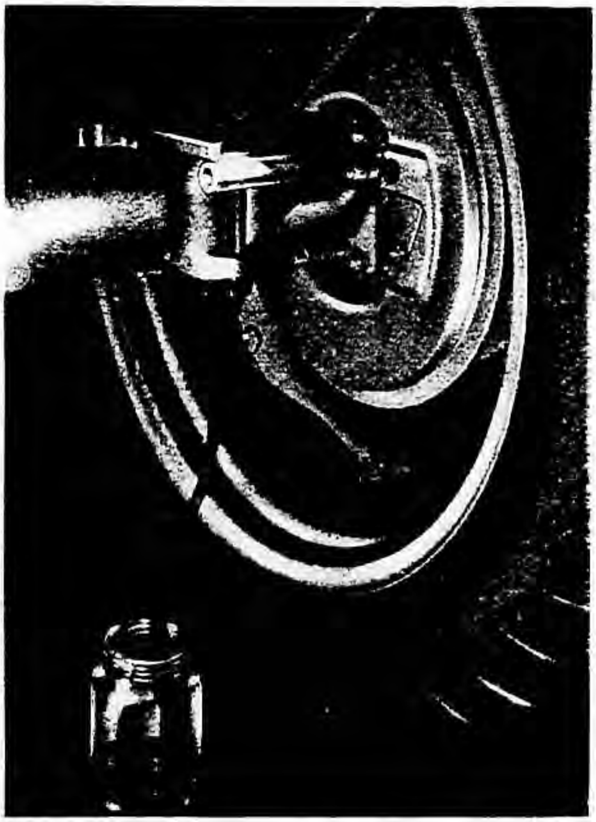


FIGURE 6. BLEEDING THE BRAKES.

Pour sufficient clean brake fluid into jar to submerge end of bleed tube.

The system is now ready for bleeding.

Slacken off bleed nipple to which rubber tube is attached.

Operate brake pedal, pausing at the end of the downward stroke until air ceases to bubble from the bottom of the glass jar.

Allow pedal to return to "at rest" position and repeat above procedure until brake fluid free of air bubbles enters glass jar.

Care must be taken when performing this operation to ensure that the level of hydraulic fluid in the reservoir is not permitted to drop too far and thus enable the master cylinder to draw air.

When satisfied that air has been exhausted from wheel cylinder, depress brake pedal and close bleed nipple.

Release brake pedal and, using fresh hydraulic fluid, top up master cylinder as required.

Repeat "bleeding" procedure on remaining wheel.

Top up hydraulic reservoir, replace filler cap and protective caps on wheel cylinder bleed nipples.

A "spongy" brake pedal, after bleeding, would suggest that bleeding has been incorrectly carried out or that there is a defect in the wheel cylinder, master cylinder or hydraulic connections. It may in certain cases be found advisable to disconnect the pedal linkage from the master cylinder and to bleed the brake by operating the master cylinder directly by hand. This method ensures full travel of the master cylinder piston and minimises the possibility of air retention in the master cylinder. Note that there must always be $\frac{1}{8}$" (3·18 mm.) clearance between the master cylinder piston and the operating linkage.

ADJUSTING THE BRAKES

The power and ability to stop is a safety factor beyond dispute and the operation of a machine with brakes that are other than effective must be deplored. Brake adjustment, when required, should be made by adjusting the "at rest" position of the brake shoes. It should not be necessary to alter the brake rods or linkage.

ADJUSTING THE BRAKES (MECHANICAL) (Refer to Figures 4 and 7)

Jack up the tractor and support on stands with rear wheels clear of ground contact.

Place all controls in neutral.

Spin the road wheels by hand to ensure they are free to rotate.

Move cover plate on backplate to expose adjuster.

On later machines access to the adjuster is obtained by removing the single large washer at the rear of the backplate.

Slacken off brake shoe adjuster centraliser nut.

Expand shoes in drum by means of brake adjuster until wheel is locked. It will assist the shoes to centralise if the wheel is rotated as adjustment is made.

Tighten adjuster centraliser nut.

Slacken off brake adjuster until wheel spins freely.

Repeat above operation on the opposite wheel.

Lower tractor to ground.

Subsequent adjustment, resulting from a road test, if a degree of unbalance is found, should be made by slackening off the brake adjuster on the side to which "pull" or "snatch" is evident.

ADJUSTING THE HYDRAULIC BRAKE (TWO LEADING SHOE TYPE)

(Refer Figure 7)

Jack up tractor and support on stands with rear wheels clear of ground.

Place all controls in neutral.

Spin road wheels by hand to ensure that they are free to rotate.

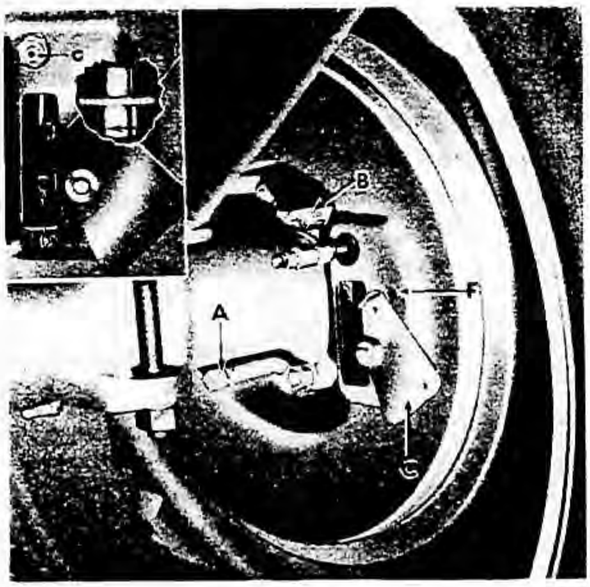


FIGURE 7. BRAKE ADJUSTMENT
(MECHANICAL AND TWO LEADING SHOE HYDRAULIC).

A. Bottom Shoe Adjuster—Hydraulic Brake.
B. Top Shoe Adjuster—Hydraulic Brake.
C. Cover Plate.
D. Centraliser Nut—Mechanical Brake.
E. Clicker Adjuster—Mechanical Brake.
F. Hole for Clicker Adjuster.
G. Bleed Screw.

Turn the two square-headed spindles until the cams to which the spindles are engaged press the brake shoes into hard contact with the brake drum.

Ease off brake cams until wheel is free.

Repeat above operation on opposite wheel.

Lower tractor to ground.

Hydraulic brakes are self balancing and since equal effort is applied to each brake shoe there should be no tendency to "pull" to one side. "Veering", if evident, may suggest seized or partially seized wheel cylinder pistons, or a leaking oil seal.

ADJUSTING THE HYDRAULIC BRAKE (DUO-SERVO TYPE) (Refer Figures 5 and 9)

Jack up tractor and support on stands with rear wheels clear of ground.

Place all controls in neutral.

Spin road wheels by hand to ensure they are free to rotate.

Remove the large plain washer secured by a single bolt to the backplate.

Slacken off hydraulic adjuster centraliser bolt.

Expand hydraulic adjuster until wheel is locked. It will assist the shoes to centralise if the wheel is turned as adjustment is made. A sharp stab on the brake pedal will also assist centralisation.

Tighten centraliser bolt.

Slacken off brake adjuster until wheel rotates freely.

Replace large plain washer, ensuring that washer joint is undamaged.

Repeat procedure on opposite wheel.

Lower tractor to ground.

Hydraulic brakes are self balancing, and since equal effort is applied to both sets of brake shoes there should be no tendency to "pull" to one side. "Veering", if evident on road test, may suggest a scored brake drum, a seized or partially seized wheel cylinder piston, or a leaking oil seal.

OVERHAULING THE BRAKES

A specific time recommendation for brake examination and overhaul cannot reasonably be given. Individual consideration must be given each machine in relation to the type of work on which it is employed and the particular operator concerned. The need for a brake overhaul will generally be evident by the need for heavier pedal application and deterioration in braking efficiency.

REMOVING BRAKE ASSEMBLY

(Refer Figure 5)

Jack up rear of tractor and support securely on stands.

Remove rear wheel.

Remove the two countersunk screws securing brake drum and withdraw brake drum. It may be found advantageous if the brakes are first slackened off.

Disconnect hydraulic supply unions at backplate. Tape or plug the disconnected union to prevent the admission of grit or dust.

Detach brake rod at mechanical brake actuating shaft.

Remove the nuts and locking washers securing bearing housing and torque plate to axle casing flange.

Withdraw half shaft and bearing housing from axle casing.

Remove brake assembly complete with mechanical brake actuating shaft and pedal.

Note.—Care must be taken to ensure that the shim pack fitted between the hub axle casing is not damaged and is refitted on re-assembly.

The nuts securing the bearing housing and torque plate to the axle casing flange must be tightened to a torque of 50-55 lbs./ft.

Correctly adjusted, the half shaft should have an end float between 0·002"-0·008" (0·051-0·203 mm.). Adjustment is made by adding or removing shims as required.

Assemble in reverse order.

If it is found necessary to reset the shoe steady pins to obtain proper shoe location, it is suggested the hydraulic shoes should be first set and subsequently employed as a jig for the setting of the mechanical shoe steady pins.

Adjust and bleed brakes after assembly.

DISMANTLING THE BRAKE ASSEMBLY

Removing backplate (Refer Figure 5)

Remove bleed screw adaptor from bleed pipe.

Disconnect hydraulic feed pipe at union.

Tape or seal disconnected unions.

Remove rubber grommet from hydraulic pipes and backplate.

Remove the four bolts and washers securing backplate to torque plate.

Remove spring and washer from actuating shaft.

Withdraw backplate from brake assembly.

Assemble in reverse order.

Adjust and bleed brakes.

To remove actuating shaft (Refer Figure 5)

Remove backplate.

Slacken off and remove the two nuts and lock washers securing actuating shaft bridge piece.

Remove bridge piece.

Withdraw actuating shaft.

Assemble in reverse order using new lock washers.

REMOVING BRAKE SHOES (MECHANICAL) (Refer Figures 1 and 5)

Remove backplate and actuating shaft.

Remove self locking nuts and washers from spacer pins (one each shoe).

On later machines a hold down spring assembly is fitted. This is released by compressing the spring and turning the spring cap to align slot in cap with head of retaining pin.

Unhook shoe steady springs.

Release and remove adjuster.

Remove brake shoe return spring at adjuster end of shoes.

Release adjuster end of shoes and shoe return springs.

Remove brake shoes.

Assemble in reverse order.

Note.—Bent, stretched or weak springs must be renewed.

It is important to ensure that the **red** spring is fitted to the secondary shoe.

On machines fitted with the duo-servo type hydraulic brake the return springs fitted to the mechanical shoes are identical.

Adjust and bleed brakes after assembly.

Removing brake shoes in situ (Mechanical) (Refer Figures 1 and 5)

Remove road wheel and brake drum.

Remove bleed screw adaptor from bleed pipe.

Disconnect hydraulic feed pipe at union.

Tape or seal disconnected unions.

Remove rubber grommet from hydraulic pipes and backplate.

Remove the four nuts and washers securing backplate to torque plate. Slide spring and plain washer, located behind backplate, on actuating shaft along actuating shaft.

Slide backplate clear of brake assembly.

Remove nuts and spring washers securing bridge piece.

Slide bridge piece along actuating shaft.

Accessibility will be improved if the appropriate rear fender is removed.

Remove and replace brake shoes as previously described.

Assemble in reverse order.

Adjust and bleed brakes.

Removing brake shoes (Hydraulic, two leading shoe type) (Refer Figure 8)

Unhook shoe steady springs.

Remove the nut and washer securing each shoe anchor to rear of wheel cylinder.

Release leading ends of brake shoes from wheel cylinders.

Release trailing ends of brake shoes from anchor.

Unhook brake shoe return springs and remove brake shoes.

It is advisable, when the brake shoes are removed, to encircle the wheel cylinders with stout elastic bands to prevent the pistons and cups becoming displaced.

The above operation can be carried out with the brake assembly in position or removed from the tractor.

Assemble in reverse order.

Adjust brakes.

Removing brake shoes (Hydraulic, duo-servo type) (Refer Figure 5)

Unhook shoe steady springs.

Release brake shoes from adjuster.

Remove adjuster and adjacent shoe return spring.

Release brake shoes from wheel cylinders.

Unhook shoe return spring and lift off brake shoes.

It is advisable, when the brake shoes are removed, to encircle the wheel cylinder with a stout elastic band to prevent the pistons and cups becoming displaced.

Assemble in reverse order. Adjust brakes.

BRAKE SHOE LININGS

It will be necessary, after a period of service, to restore brake efficiency lost due to worn linings. Restoration must be undertaken before the linings are reduced below normal limits.

Replacement shoes are available and their employment is strongly advised.

The re-lining of brake shoes with friction material other than that fitted as original equipment cannot be advised.

Bonded brake linings are fitted to drilled shoes, thus permitting the fitting of riveted linings on the removal of the bonded material.

FITTING DRILLED LININGS

Place worn, bonded brake shoes in oven and heat to 500°C.-700°C. until lining material turns white.

Remove brake shoes from oven and peel off old lining.

Thoroughly clean brake shoes, paying particular attention to the lining contact surface. Ensure all drillings are clear.

Offer up lining to brake shoe and align holes.

Locate lining to shoe by inserting two rivets at centre of lining.

Place clamps in position and tighten securely.

Using brake riveting anvil and the appropriate punch or brake re-lining equipment, secure centre rivets in position.

Working alternately from the centre of the brake shoe, move clamps, insert rivets and secure in position. If a gap exists between lining and shoe platform it must not exceed 0·004" (0·102 mm.). New linings fitted to worn or scored brake drums can never be satisfactory.

REMOVING WHEEL CYLINDERS (TWO LEADING SHOE TYPE)

(Refer Figure 8)

Remove mechanical and hydraulic brake shoes.

Disconnect and remove wheel cylinder interconnecting feed pipe.

Remove nut and washer securing blind end of wheel cylinder to torque plate.

Remove the two setpins securing wheel cylinder to torque plate.

Remove wheel cylinder.

Replace in reverse order.

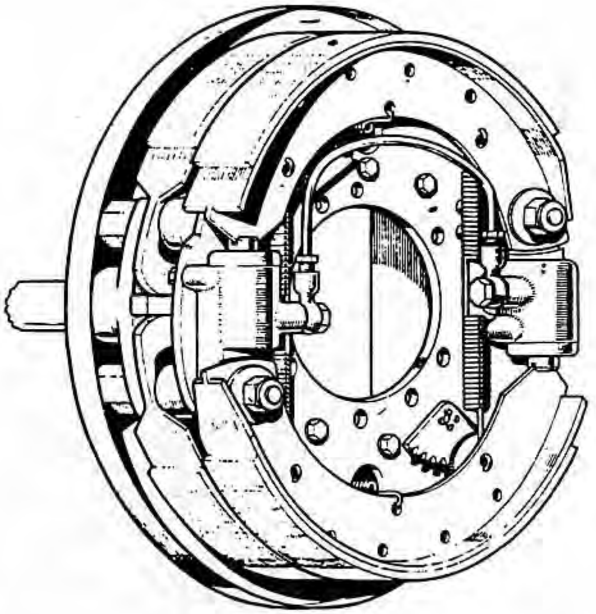


FIGURE 8
THE TWO LEADING SHOE BRAKE (HYDRAULIC)

DISMANTLING WHEEL CYLINDER

Dismantling may be carried out with or withou the wheel cylinder removed from the torque plate

Remove rubber boot.

Withdraw piston and seal.

Remove spring end cover and spring.

Withdraw air excluder.

Thoroughly wash all components in clean Girling brake fluid.

Examine units, and renew all worn, damaged or doubtful components.

Assemble in reverse order, ensuring that the cylinder piston is liberally coated with Castrol Girling rubber grease. Other lubricants must not be employed.

REMOVING WHEEL CYLINDER (DUO-SERVO BRAKE) (Refer Figure 9)

Remove brake shoes (hydraulic).

Disconnect hydraulic feed pipe at backplate.

Remove bleed pipe bleed adaptor.

Tape or seal disconnected unions to prevent ingress of grit and dust.

Remove rubber grommet.

Remove the four nuts and washers securing backplate to torque plate.

Slide backplate, cover plate and spring along mechanical brake actuating shaft.

Slide backplate along actuating shaft clear of brake assembly.

Disconnect hydraulic feed and bleed pipes from wheel cylinder.

Slacken off and remove the two nuts and spring washers from the two bolts securing wheel cylinder to torque plate.

Remove the two set pins securing wheel cylinder to torque plate.

Remove wheel cylinder.

Assemble in reverse order.

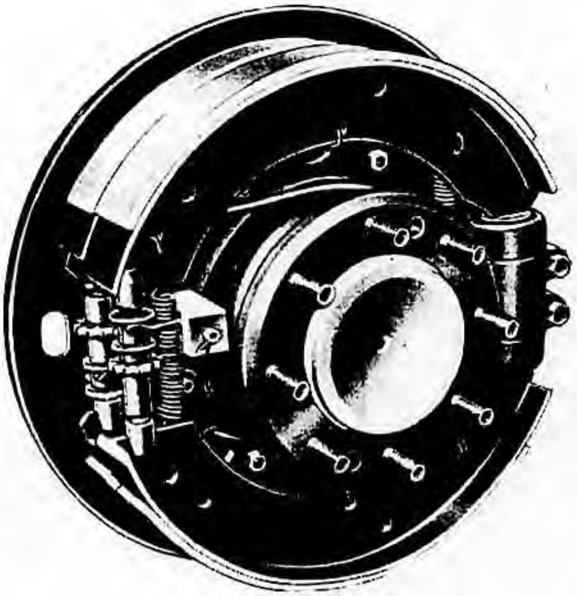


FIGURE 9. THE DUO-SERVO BRAKE (HYDRAULIC).

DISMANTLE THE WHEEL CYLINDER (DUO-SERVO BRAKE)

Dismantling can be carried out with the wheel cylinder in position on the machine.

Remove rubber boots.

Withdraw pistons, cups and spring.

Thoroughly clean all components with Girling brake fluid and examine.

Damaged, scored or doubtful components must be renewed.

Assemble in reverse order, ensuring pistons are liberally coated with Castrol Girling rubber grease. Normal lubricants must not be employed.

THE MASTER CYLINDER

(Refer Figures 5 and 10)

The Girling compression type master cylinder and reservoir assembly is bolted to the left-hand side of the transmission casing adjacent to the battery carrier, and is linked to a brake pedal on the right-hand side of the machine. A single outlet pipe connects through a branch union to the rear wheel cylinders. This assembly demands observance of scrupulous cleanliness when checking or topping up the fluid level. Dirty or aerated fluid must not be employed for this purpose.

A master cylinder with improved bleeding and recuperating characteristics was incorporated from Tractor Serial No. 189429.

REMOVING THE MASTER CYLINDER

Disconnect battery terminals and remove battery.

Remove battery carrier.

Disconnect discharge pipe at master cylinder and tape or plug unions to prevent the entry of grit.

Disconnect master cylinder push rod at operating linkage.

Remove master cylinder securing bolts, disconnect return spring and remove master cylinder.

Assemble in reverse order, ensuring $\frac{1}{8}$" (3·18 mm.) clearance exists between master cylinder piston and connecting linkage.

Top up reservoir and bleed brakes.

DISMANTLING THE MASTER CYLINDER

(Refer Figure 10)

Remove reservoir filler cap and drain off fluid.

If required, the reservoir may be removed by removing the inlet union and set pin, accessible through the filler cap.

Unscrew and remove end cap complete with gasket, and remove plunger return spring.

Slide rubber boot along push rod and release circlip.

Withdraw push rod complete with rubber boot, circlip and retaining washer.

Withdraw plunger complete with seal retainer and end seal from push rod end of cylinder.

Remove recuperating seal and shim from body.

Wash all components in clean Girling brake fluid and thoroughly examine.

Renew worn, damaged or doubtful components.

Rubber cups, once disturbed, should be renewed in all cases.

ASSEMBLING THE MASTER CYLINDER

(Refer Figure 10)

Ensure master cylinder and components are scrupulously clean.

Smear cylinder bore and components with clean Girling brake fluid.

Insert shim into pressure end of cylinder.

Insert recuperating seal, ensuring that back of seal is in contact with shim.

Fit end seal to plunger, ensuring that lips of seal will face towards master cylinder end cap.

Insert plunger, open end first, into cylinder from push rod end, carefully easing seal lips into bore.

The lips of both seals should now be facing the end cap.

Insert push rod assembly into bore and secure with circlip.

Pack the boot with Wakefield Girling Rubber Grease No. 3 (Red) and slide boot into position.

Insert plunger return spring.

Replace end cap complete with recuperating seal support and gasket.

Tighten end cap.

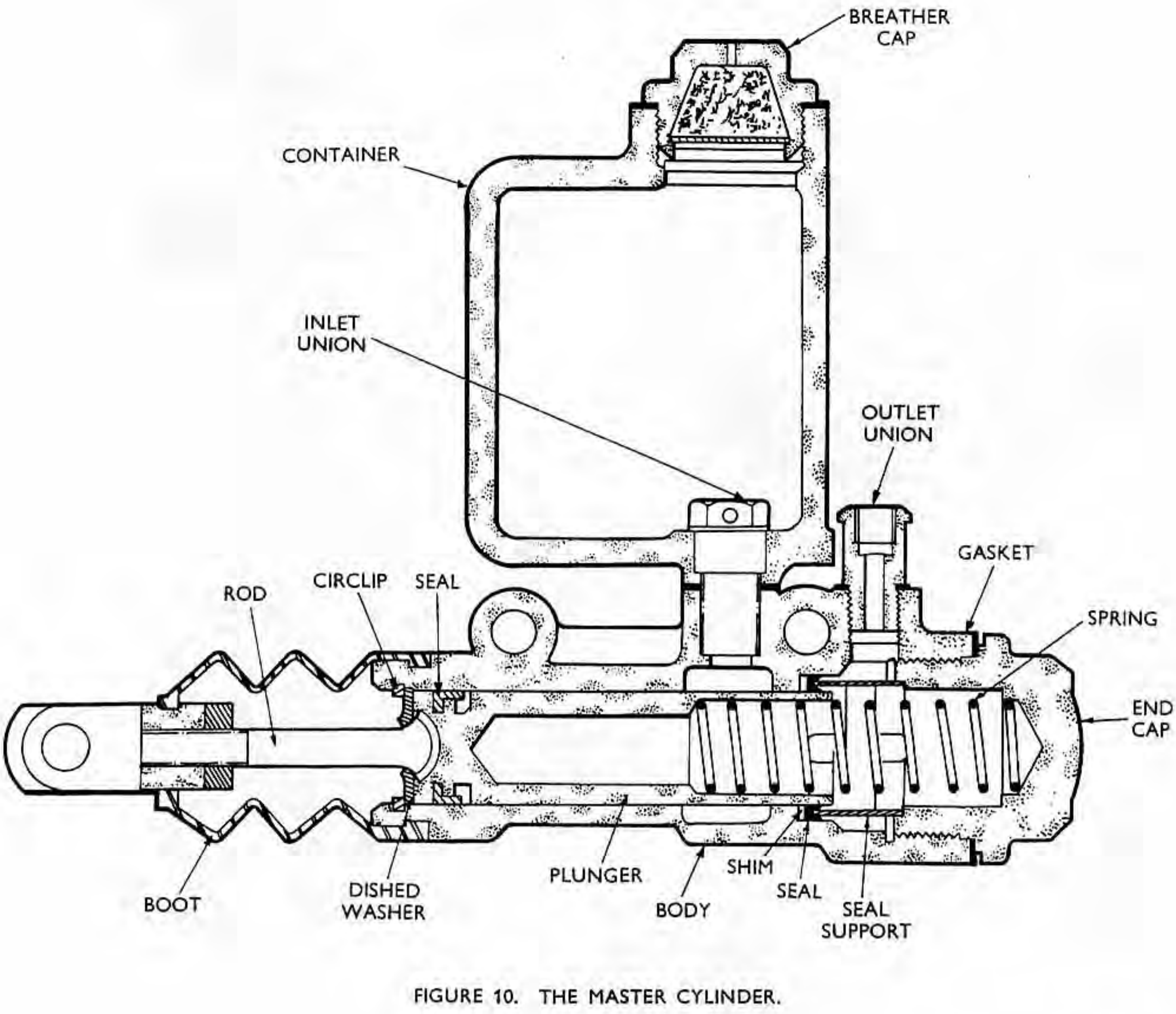


FIGURE 10. THE MASTER CYLINDER.

FIRST ISSUE

DUAL BRAKES—MECHANICAL

INTRODUCTION

A dual mechanical brake unit consists of two separate brakes, each with separate means of operation, mounted on a common torque plate and housed within one drum. One brake is actuated by the foot pedals, through a shaft and cam, and operates the outer pair of shoes. The other by handbrake and cable and operates the inner pair of shoes. Fig. 50 shows the layout of braking system. Both brakes are self-servo in action, by which the input force is increased considerably by the rotating drum, and provides a powerful brake action. The inner adjuster adjusts the handbrake, and the outer the footbrake.

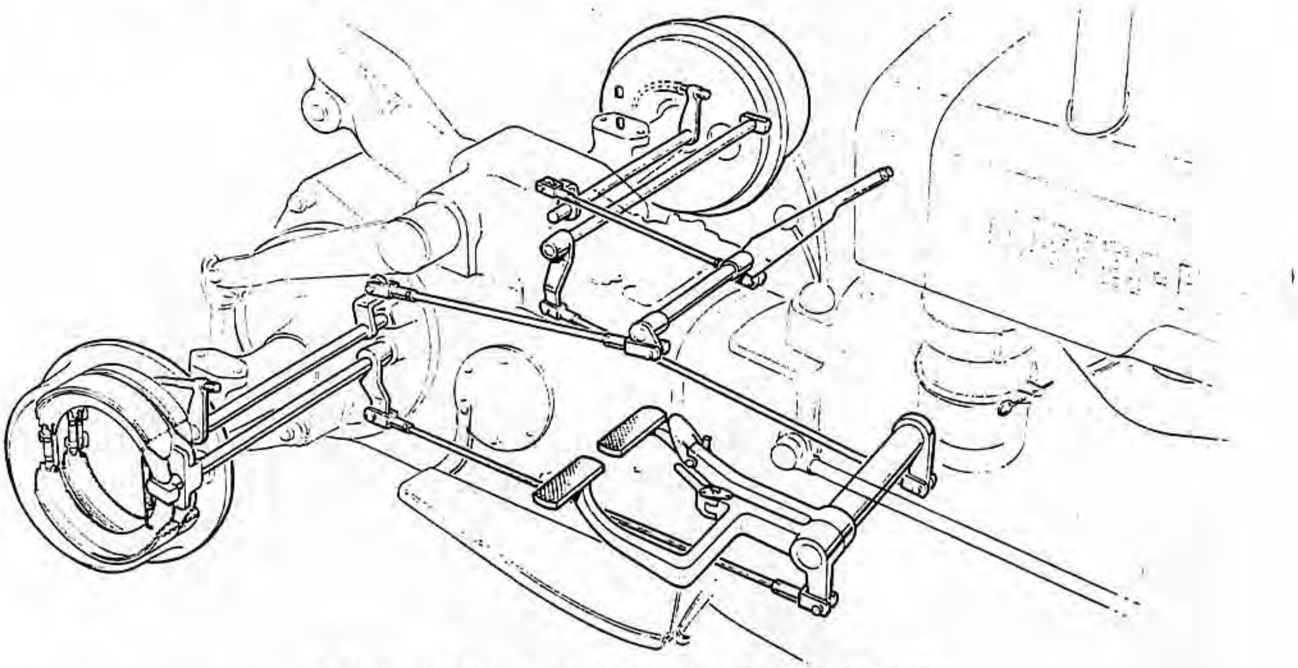


FIGURE 50 DUAL MECHANICAL BRAKE ARRANGEMENT

SPECIFICATION

FOOTBRAKE

Girling 14" x 2", two shoe internal expanding, full servo-brakes, individual adjustment, operated together, or independently to assist turning.

HANDBRAKE

Girling 14" x $1\frac{1}{2}$", two shoe, internal expanding full servo brake, individual adjustment.

ADJUSTMENTS

GENERAL

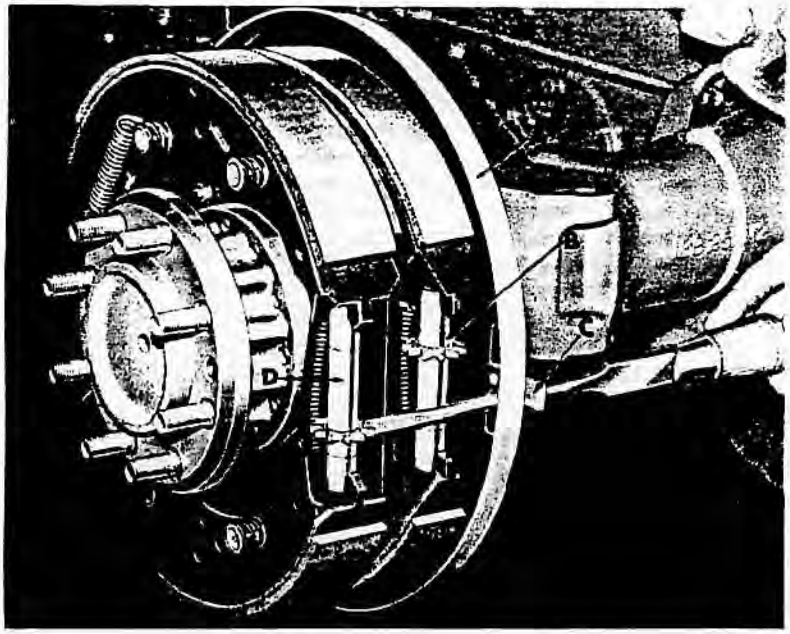
Ensure that all shafts and pins work freely, and that when the brakes are "off" the brake pedals are against their stops.

THE BRAKES **CANNOT** BE ADJUSTED BY ALTERING THE LENGTH OF THE OPERATING RODS. THE BRAKES MUST BE ADJUSTED IN THE BRAKE DRUM.

FOOTBRAKE (P-50)

Jack the tractor rear wheels clear of the ground, and push the rectangular cover plate, situated on the dust cover, to one side. Insert a screwdriver into the top aperture, for the right-hand brake, and bottom aperture for left-hand brake, and lever the star wheel round to expand the shoes. (Lever screwdriver handle towards centre of brake for left-hand wheel, and away from centre of brake for right-hand wheel). Adjusters should be expanded until wheel is just locked and then the star wheel is turned back four (4) "clicks", the wheel should then just rotate freely.

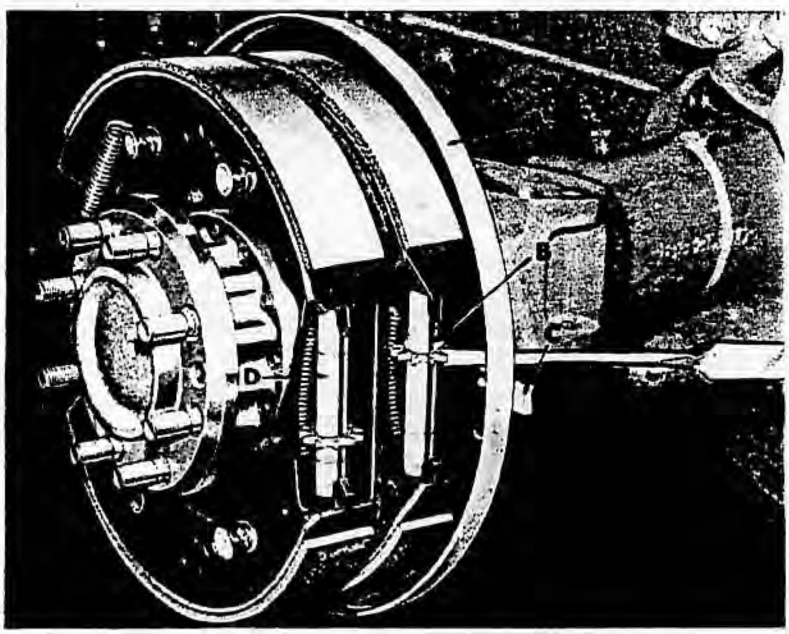
FIRST ISSUE



KEY TO FIGURE 51

A. Dust Cover
B. Handbrake Shoe Adjuster
C. Cover Plate
D. Footbrake Shoe Adjuster

FIGURE 51
FOOTBRAKE ADJUSTMENT



KEY TO FIGURE 52

A. Dust Cover
B. Handbrake Shoe Adjuster
C. Cover Plate
D. Footbrake Shoe Adjuster

FIGURE 52
HANDBRAKE ADJUSTMENT

HANDBRAKE (P-51)

Jack the rear wheels clear of the ground, and push the rectangular cover plate situated on the dust cover to one side. Insert a screwdriver into the bottom aperture, for the right-hand brake, and top aperture for the left-hand brake and lever the star wheel round to expand the shoes. (Lever screwdriver handle away from centre of brake for left-hand wheel, and towards centre of brake for right hand wheel). Adjusters should be expanded until the wheel is just locked, and then the star wheel is turned back four (4) "clicks", the wheel should then just rotate freely.

Testing

To test brakes for even balance, engage fourth gear and driving at slow speed apply brakes firmly. Any tendency to veer off course should be counteracted by slackening off the clicker adjuster on the side towards which veering took place.

FIRST ISSUE

OVERHAULING THE BRAKES

General

The overhaul instructions contain two main operations, (a) Replacement of footbrake shoes which can be replaced in situ, (b) Replacement of handbrake shoes, which necessitate the removal of the brake unit from the tractor, and therefore constitute the complete overhaul of the brake unit. Instructions are also given for the replacement of the bonded linings fitted during manufacture, with riveted linings, this being applicable to both foot and handbrake shoes.

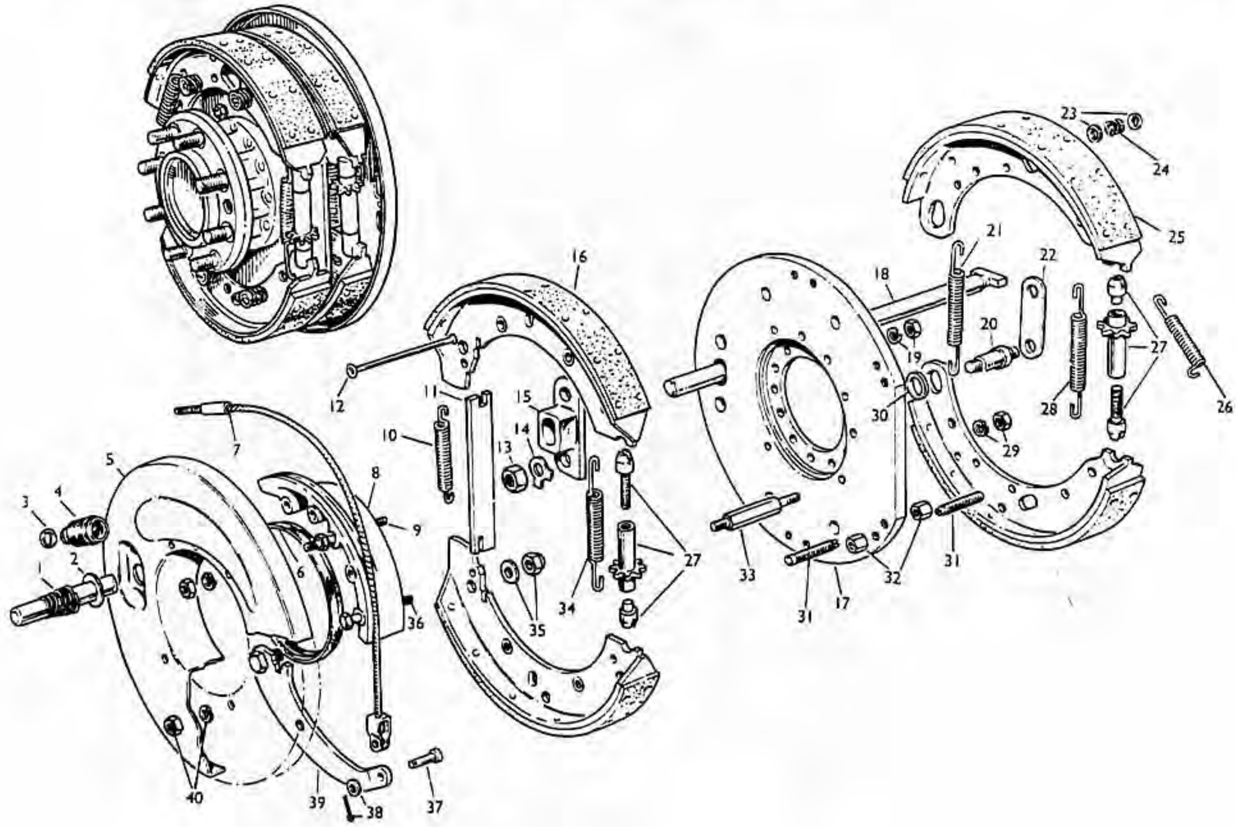


FIGURE 53 EXPLODED VIEW OF BRAKE UNIT

KEY TO FIGURE 53

1. Cover Plate Spring
2. Cover Plate
3. Crimping Sleeve
4. Rubber Dirt Excluder
5. Dirt Excluder
6. Dirt Excluder Seal
7. Cable Assembly
8. Cable Guide
9. Cable Guide Stud
10. Cam End Spring
11. Push Rod
12. Pin
13. Nut
14. Tab Washer
15. Abutment Block
16. Handbrake Shoe Assembly
17. Backplate Assembly
18. Operating Shaft
19. Nut and Washer
20. Anchor
21. Shoe Return Spring
22. Anchor Pin Plate
23. Cup Washer
24. Shoe hold down Spring
25. Footbrake Shoe Assembly
26. Shoe to Anchor Spring
27. Adjuster Assembly
28. Adjuster End Spring
29. Nut and Washer
30. Spacer Washer
31. Steady Post
32. Lock nut
33. Stud
34. Adjuster End Spring
35. Locknut and Washer
36. Bolt
37. Pin
38. Split pin and Washer
39. Operating Lever Assembly
40. Nut and Washer

To Remove and Replace Footbrake Shoes (P-52)

1. Jack up rear of tractor, and remove wheel and brake drum.
2. Remove the shoe hold down springs by gripping each pin in turn with pliers and pressing and turning the dished washer until it springs off.
3. Remove washer and springs, leaving the pin in place.
4. Force apart the shoes at the adjuster end to allow the adjuster to drop out of position, and the adjacent spring (Black) can then be unhooked.
5. The removal of the adjuster also relaxes the two heavy springs (Red) at the cam end and they can be removed by levering with a screwdriver between the spring and the bridge piece.
6. Remove bridge piece, shoe return spring (Green) and lift off brake shoes and spacer washers.
7. Smear both ends of new shoes and flat end of operating shaft with Girling brake grease, replace spacer washer and fit new shoes over the anchor pins and hold down pins.
8. Replace bridge piece, and insert the shoe to anchor springs (Red) into the shoes and pull the hooks (with a spring hook) onto the anchor pins.
9. Hook shoe return spring (Green) on to shoes, then hook on spring (Black) at adjuster end of shoes.
10. Pull shoes apart and insert the adjuster. Ensure that the adjuster is inserted so that the star wheel is at the opposite end to the handbrake adjuster, so that it can be reached from the hole in the dust cover.
11. Replace hold down pin washer and springs.
12. Replace brake and wheel.
13. Adjust brakes as previously described.

To Remove and Dismantle Complete Brake Unit (P-53) (Refer to Figure 53)

1. Jack up rear of tractor and remove wheel and brake drum.
2. Disconnect the footbrake connection from the brake operating shaft.
3. Disconnect handbrake by removing the two nuts on cable at rear of dirt excluder.
4. Remove the 12 nuts securing half shaft assembly to rear axle housing, and withdraw half shaft together with brake unit.

   Note: Care should be taken when removing half shaft to avoid damaging the axle housing oil seal, and that the shims are retained, and the same number replaced on re-assembly.
5. Lift brake unit assembly from half shaft.
6. Remove the spring (1) and cover plate (2) retaining operating shaft (18) to dirt excluder (5).

FIGURE 54 REMOVING HOLD DOWN SPRINGS

7. Reverse the brake on the bench so that the footbrake side is uppermost.
8. Remove the shoe hold down spring (24) by gripping each pin in turn with pliers (Fig. 54) and pressing and turning the dished washer (23) until it springs off. Remove the washers and springs. The pin will fall away far enough to proceed with the removal of the shoes.
9. Force apart the shoes at the adjuster end to allow the adjuster (27) to drop out of position, and the adjacent spring (28) can then be unhooked.
10. The removal of the adjuster also relaxes the two heavy springs (26) at the cam end, and they can be removed by levering with a screwdriver (Fig. 55) between the spring and the bridge piece.
11. Remove footbrake shoes (25), anchor pin plate (22), spacer washers (30) and withdraw the operating shaft (18).
12. Dismantle the adjuster, clean, grease with Girling White Brake Grease and re-assemble. Ensure that the threaded end of the adjuster is screwed right home.
13. Turn the brake over and remove the five nuts (40) securing dirt excluder (5) to torque plate and remove dirt excluder.
14. Reverse brake and remove the three nuts (19) securing cable guide to torque plate.

FIRST ISSUE

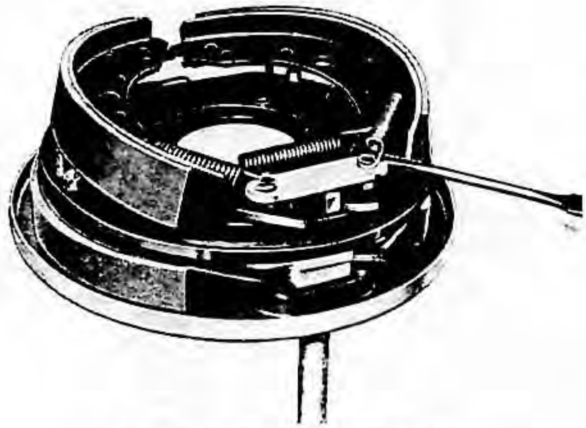


FIGURE 55 REMOVING SPRING

15. Remove the two remaining bolts (36) to enable the cable guide to be removed and cleaned.
16. Remove the four loose hold down pins (12) from shoes.
17. Force apart the shoes at the adjuster end allowing the adjuster (27) to drop away and remove spring (34).
18. Pull apart the shoes and release the handbrake strut (11), and the shoes (16), with the spring (10), lever cable and pin (7), can be lifted from the torque plate.
19. Unhook the shoes from the spring and detach the lever with cable from the shoe, by removing locknut and washer (35) and withdrawing pivot pin. Clean the lever and cable.
20. Dismantle the adjuster, clean, grease with Girling White Brake grease and re-assemble, screwing in the threaded end right home.
21. Both adjusters are the same and can be fitted to either brake. Clean down the torque plate and check that the brake anchor block is tight.

To Re-assemble and Replace Complete Brake Unit (P-54) (Refer to Figure 53)

1. Take a new pair of handbrake shoes and fit the handbrake lever (39) to one of them. Replace washer and lock nut (35). Apply a smear of Girling White Brake Grease to the pivot and bearing faces of the shoes.
2. Hook the strong black spring (10) onto the operating end of the shoes, and press the shoes over the anchor block so that the lever is on the bottom shoe when the brake is fitted to the tractor.
3. Pull apart the ends of the shoes so that the handbrake strut (11) can be inserted in the slot in the lever and in the opposite shoe. The strut must be fitted the correct way around (see Fig. 56).

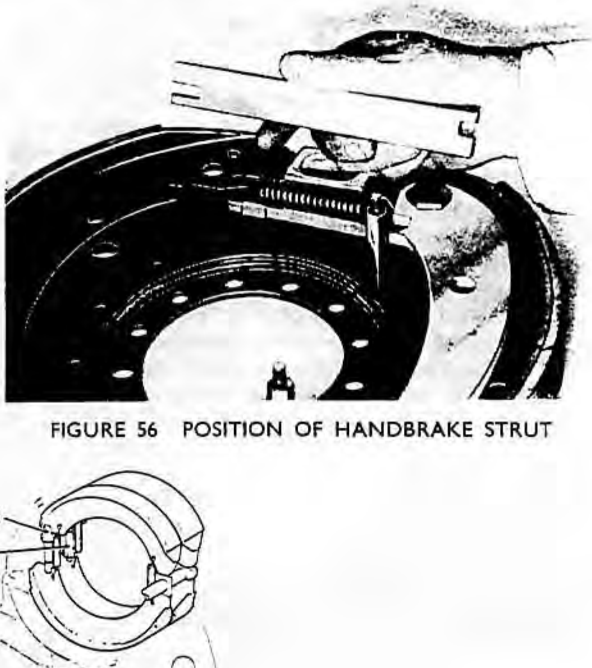


FIGURE 56 POSITION OF HANDBRAKE STRUT

FIGURE 57
POSITION OF ADJUSTERS

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4. Work spring (34) into the holes at the adjuster end of the shoes (from the underside) and pull the shoes apart to insert the adjuster (27). Correct position for adjusters is shown in Fig. 57.
5. Do not at this stage fit the cable guide, but turn the assembly over to work on the foot-brake side.
6. Insert the operating shaft (18) between the anchor pins (20), place the distance pieces on the anchor pins.
7. Smear both ends of the new shoes, and the flat end of the operating shaft with Girling White Brake Grease. Fit green spring (21) to shoes, place washer (30) over anchor pins and fit shoes to anchor pins.
8. Replace bridge piece (22) and fit red springs (26) to shoes and anchor pins.
9. Replace adjuster end spring, black (28) pull shoe apart and insert adjuster (27). Ensure that the adjuster is correctly positioned (see Fig. 57).
10. Thread the four hold down pins (12) through the shoes from the handbrake side. Place over each pin a cup washer (23) and spring (24). Grip each pin in turn beneath the shoe web with pliers and on to the end of the pin fit a cup washer. When the spring is compressed turn the washer to lock it under the flattened end of the pin.
11. The setting of the steady posts should be checked, although it is unlikely that any alteration will be needed. Expand the shoes until a straight edge placed across the lining of the shoes (parallel to the axle) indicates that the shoes are expanded to the same diameter. Both shoes should have a slight gap (not more than .010" (.254 mm.) (see Fig. 58) at the edge of the lining near the torque plate.

If this condition is not satisfied the steady posts near the centre of the shoes needs adjusting. The steady posts near the end of the shoes need not be touched. The squareness of the foot-brake shoes is adjusted from the handbrake side and vice versa. Loosen the locknut, (32) under the shoe web, screw in or out the steady post (31) as required with a screwdriver through the shoe web, and when the correct position is reached tighten the locknut to a torque of 8-10 lb.ft. (1.1-1.38 Kg.m.).

12. Fit cable guide (8), tighten bolts and nuts to a torque of 4-6 lb.ft. (.55-.83 Kg.m.) and apply a smear of brake grease to the groove. Grease the cable and place in position.
13. Clean dirt excluder and remove cable fork end (5), fit a new rubber seal (6) onto centre rim (Fig. 59) and place dirt excluder into position on the brake over the operating shaft.
14. Lead the cable end through the hole in the dirt excluder, fit new rubber dirt excluder (4) and crimping sleeve to cable. Replace the five washers and nuts (40) securing dirt excluder to torque plate and tighten to a torque of 4-6 lb.ft. (.55-.83 Kg.m.).
15. Drop the large washer (2) over the operating shaft and press down the retaining spring (1) large diameter first. Screw the fork end onto the cable end.
16. Fit brake unit onto half shaft, ensuring that the centre long stud is in line with the operating shaft and half shaft (Fig. 60).
17. Replace shims and refit complete assembly to axle, taking care not to damage oil seal in axle housing. Tighten nuts to a torque of 50-55 lb.ft. (6.913-7.604 Kg.m.).
18. Connect up handbrake and footbrake.
19. Refit brake drum and wheel.
20. Adjust brakes as previously described.

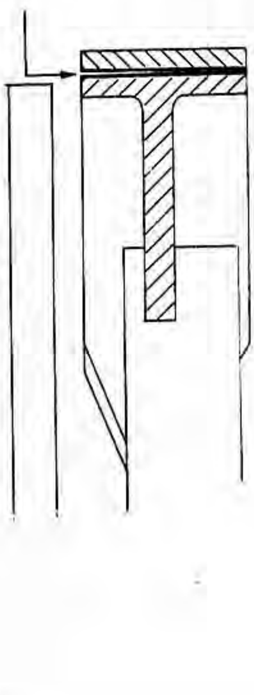

FIGURE 58 CHECKING BRAKE SHOE GAP

FIRST ISSUE

FIGURE 59 FITTING NEW SEAL TO DIRT EXCLUDER

FIGURE 60 REPLACING HALF SHAFT

BRAKE SHOE LININGS

After a period of service it will be necessary to restore brake efficiency lost due to worn linings. Restoration must be undertaken before the linings are reduced below normal limits.

Replacement shoes are available and their employment is strongly advised.

The re-lining of brake shoes with friction material other than that fitted as original equipment cannot be advised.

Bonded brake linings are fitted to drilled shoes, thus permitting the fitting of riveted linings on the removal of the bonded material.

FITTING DRILLED LININGS (P-55)

1. Place worn, bonded brake shoes in oven and heat to 500°C-700°C until lining material turns white.
2. Remove brake shoes from oven and peel off old lining.
3. Thoroughly clean brake shoes paying particular attention to the lining contact surface. Ensure all drillings are clear.
4. Offer up lining to brake shoe and align holes.
5. Locate lining to shoe by inserting two rivets at centre of lining.
6. Place clamps in position and tighten securely.
7. Using brake riveting anvil and the appropriate punch or brake re-lining equipment, secure centre rivets in position.
8. Working alternately from the centre of the brake shoe, move clamps, insert rivets and secure in position. If a gap exists between lining and shoe platform it must not exceed 0.004" (0.102 mm.). New linings fitted to worn or scored drums can never be satisfactory.

BRAKE LINKAGE

TO DISMANTLE FOOTBRAKE LINKAGE

(P-56) Fig. 61

1. Remove brake rod (63) and yoke assemblies (71) from rear brake levers (57) and brake arms (4).
2. Remove snap ring (13), washer (12) and right-hand brake pedal (24).
3. Remove brake pedal nut (18), bolt (9) and washer (17) and remove left-hand pedal (10).
4. Remove bolt (5), nut (2) and washer (3) from combined brake arm (4) and remove brake arm.
5. Remove Woodruff keys (6 and 8) and withdraw combined brake cross shaft (7).
6. Remove parking brake sector (62) from beneath radius rod ball cap spacer, parking brake latch (68) and actuator (69) from left-hand brake pedal, and combined brake lock (22) and spring (20) from right-hand pedal.

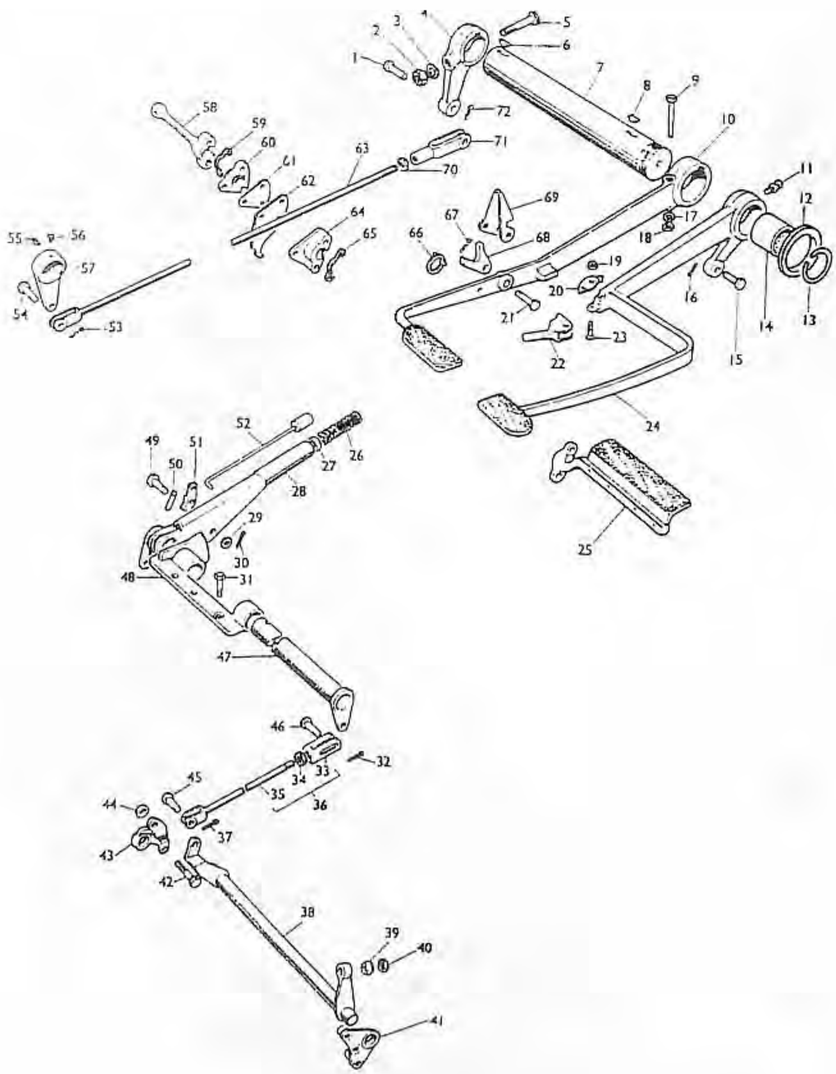

FIGURE 61 EXPLODED VIEW OF BRAKE LINKAGE

KEY TO FIGURE 61

1. Clevis Pin
2. Hex. Nut
3. Lock Washer
4. Combined Brake Arm
5. Hex. Bolt
6. Woodruff Key
7. Cross Shaft
8. Woodruff Key
9. Hex. Bolt
10. Brake Pedal
11. Greaser
12. Washer
13. Snap Ring
14. Bush
15. Clevis Pin
16. Cotter Pin
17. Lock Washer
18. Hex. Nut
19. Nyloc Nut
20. Combined Brake Lock Spring
21. Clevis Pin
22. Combined Brake Lock
23. Screw
24. Brake Pedal
25. Radius Rod Ball Cap
26. Spring
27. Spring Stop
28. Handbrake
29. Flat Washer
30. Cotter Pin
31. Hex. Bolt
32. Cotter Pin
33. Adjustable Yoke
34. Jam Nut
35. Rod
36. Rod and End Assembly
37. Cotter Pin
38. Cross Shaft and Lever Assembly
39. Spherical Spacer
40. Jam Nut
41. Outer Bracket
42. Hex. Bolt
43. Inner Bracket
44. Packing Washer
45. Clevis Pin
46. Clevis Pin
47. Cross Shaft
48. Bracket Assembly
49. Clevis Pin
50. Taper Pin
51. Pawl
52. Push Rod Assembly
53. Cotter Pin
54. Clevis Pin
55. Woodruff Key
56. Set Screw
57. Brake Lever
58. Radius Rod Ball Cap
59. Shim
60. Spacer
61. Plate
62. Parking Brake Sector
63. Rod
64. Radius Rod Ball Cap Spacer
65. Shim
66. Parking Brake Latch Spring
67. Cotter Pin
68. Parking Brake Latch
69. Parking Brake Actuator Latch
70. Jam Nut
71. Adjustable Yoke
72. Cotter Pin

FIRST ISSUE

TO RE-ASSEMBLE FOOTBRAKE LINKAGE

(P-57) (Fig.61)

1. Fit combined brake cross shaft (7) through transmission housing, and replace Woodruff keys (6 and 8).
2. Refit parking brake sector (62) beneath radius rod ball cap spacer, parking brake latch (68) and actuator (69) to left-hand pedal, and combined brake lock (22) and spring (20) to right-hand brake pedal.
3. Replace combined brake arm (4) and left-hand pedal (10) and secure with nut, bolt and washer.
4. Fit right-hand pedal (24) and secure with washer (12) and snap ring (13).
5. Fit brake rod and yoke assemblies to brake levers.
6. Connect brake rod and yoke assemblies to combined brake arm and right-hand pedal, having eliminated all backlash.

   Note: If the brake rods or yokes have been changed, detach rod and yoke assemblies from combined brake arm and right-hand pedal and with the shoes fully expanded in the drums, adjust yoke assemblies to obtain a depression on the pedals corresponding to three or fourth teeth on the parking brake sector.
7. Adjust brakes as described in operation P-50.

TO DISMANTLE HANDBRAKE LINKAGE

(P-58) (Refer to Fig. 61)

1. Disconnect and remove brake rods (35).
2. Disconnect handbrake cable at cross shaft (38) by removing nut (40) and spacer (39).
3. Remove bolts (42) inner bracket (43) and cross shaft (38).
4. Remove the three bolts (31) securing the handbrake bracket assembly (48) to the transmission housing.

   Note: If lights are fitted to the tractor, it will be necessary to remove the cable guard which is positioned over the bracket assembly.
5. Hold bracket assembly in vice, drift out taper pin (50) and remove cross shaft (47) and handbrake (28) from bracket assembly (48).
6. To further dismantle the handbrake remove cotter pin (30), washer (29) and clevis pin (49), the pawl (51), push rod assembly (52), spring stop (27) and spring (26) can then be removed.

TO RE-ASSEMBLE HANDBRAKE LINKAGE

(P-59) (Refer to Fig. 61)

1. Fit spring (26), spring stop (27) to push rod assembly (52), and enter into handbrake assembly (28).
2. Fit pawl (51) to push rod and secure with clevis pin (49) washer (29) and cotter pin (30).
3. Refit cross shaft (47) to bracket assembly (48) and handbrake assembly. Replace taper pin (50).
4. Fit complete handbrake assembly to transmission housing, and replace the three Hex. bolts (31).

   Note: Replace cable guard if lights are fitted.
5. Replace cross shaft and lever assembly (38), inner bracket (43) and bolts (42).
6. Replace the handbrake cable spherical spacers (39) and jam nut (40).
7. Refit brake rods (35).

   Note: If any components of the brake rod have been replaced with new items, the following procedure for adjusting the linkage will have to be carried out.
8. Set the handbrake in the fully relaxed position, then adjust each brake rod length to $18\frac{3}{4}''$ (476.25 mm.) centres. With the cable and spherical end completely free, the handbrake shoes are then to be tightened hard on to the drums, all the free play in brake cable is then to be just taken up by adjustment of the spherical end. The handbrake is to be applied hard and released, brake cable is then to be re-checked for free play and necessary further adjustments made and the spherical end locked. The brake shoes are then adjusted as detailed in operation P-51.

MASSEY-FERGUSON

35 TRACTOR

WORKSHOP SERVICE MANUAL

SECTION R

SEAT, HOOD AND FENDERS

SEAT, HOOD AND FENDERS

Section R

CONTENTS

ILLUSTRATIONS

SEAT, HOOD AND FENDERS

SEAT

There are two types of seat fitted to the Massey-Ferguson 35 Tractor :

(a) On the basic tractor, a pan type seat is mounted by a double hinge on a spring support.

(b) On the de-luxe tractor, a bucket type seat, with a foam rubber cushion and a back rest, is mounted by a double hinge on a support bracket.

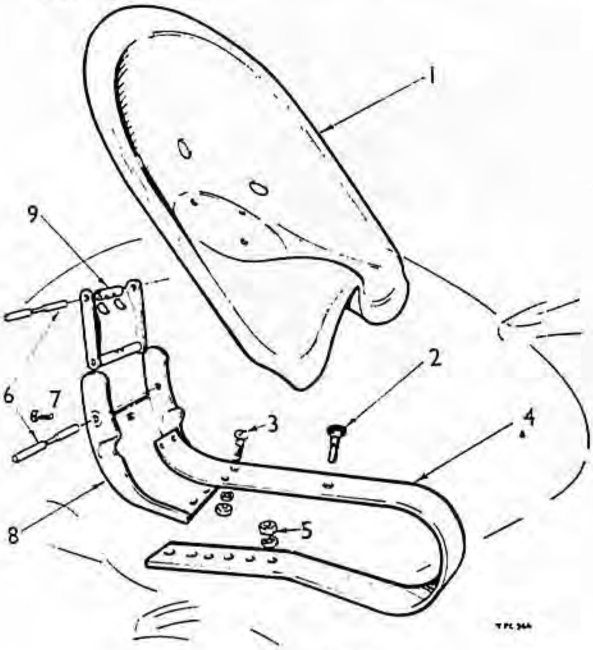

FIGURE ONE

Key to Fig. 1

1. Hinged Seat Assembly.
2. Driver's Seat Bumper.
3. Screw, Washer and Nut.
4. Driver's Seat Spring.
5. Nut and Lock Washer.
6. Driver's Seat Hinge Pins.
7. Nut, Bolt and Washer.
8. Seat Hinge Assembly.
9. Hinge Link.

The double hinge allows the seat to be lifted up and back to give more leg room to the driver when standing up to drive and also to protect the seat cushion in inclement weather when the tractor is not in use. Both the spring support on basic models and the support bracket on de-luxe models are secured to two studs on the hydraulic lift cover. The seat on both models can be adjusted longitudinally in any of three positions.

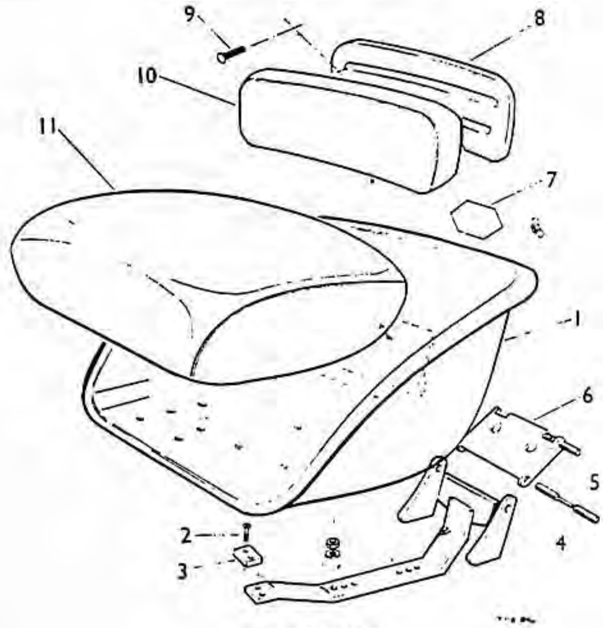

FIGURE TWO

Key to Fig. 2

1. Seat Pan Assembly.
2. Flat Head Screw.
3. Driver's Seat Bumper.
4. Seat Mounting Bracket Assembly.
5. Driver's Seat Hinge Pin.
6. Hinge Link.
7. M-F Trademark.
8. Seat Back Rest Support.
9. Carriage Bolts and Wing Nut.
10. Back Rest Inlay and Cover Assembly.
11. Seat Inlay and Cover Assembly.

HOOD

The hood and service panel assembly fitted to currently produced tractors was introduced on Tractor Serial Nos. 140982 to 141078 to 141120 and 141141 and future. It is secured with Dzus type quick action fasteners and it pivots open on robust hinges which allow it to remain open without a locking device.

An exploded view of this arrangement is shown in Fig. 3.

The hood and service panel assembly fitted previously incorporated a spring panel and push-button type catches, shown in inset Fig. 3.

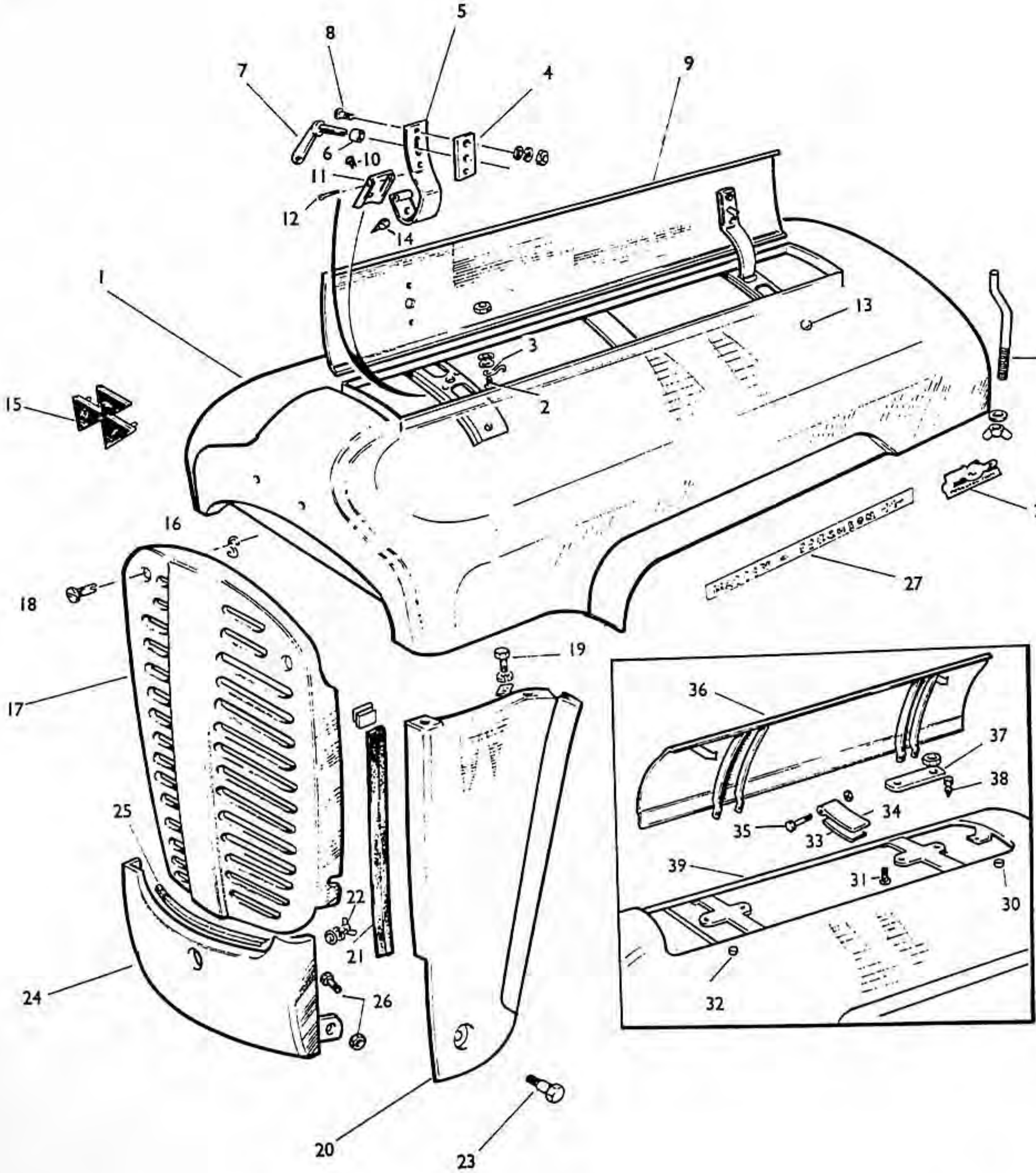

FIGURE THREE

T.P.S.855

Key to Fig. 3

1. Hood Assembly.
2. Setscrew and Washer.
3. Fastener Spring.
4. Bracket.
5. Service Panel Hinge.
6. Fastener Grommet.
7. Fastener Assembly.
8. Nut, Bolt and Washer.
9. Hood Service Panel Assembly.
10. Nut, Bolt and Washer.
11. Hinge Bracket.
12. Cotter Pin.
13. Stiffening Bolt.
14. Rubber Bumper.

Key to Fig. 3—*continued*

15.	Hood Front Name Plate.	27.	M-F 35 Emblem.
16.	Dzus Fastener Spring.	28.	Ferguson System Emblem.
17.	Grille Assembly.	29.	Hood Catch Rod and Wing Nut.
18.	Dzus Fastener.	30.	Push-button Assembly.
19.	Acme Screw and Nut.	31.	Spring to Plate Nut and Bolt.
20.	Side Panel Assembly.	32.	Push-button Assembly.
21.	Panel Seal Rubber and Clip.	33.	Hinge Helper Spring.
22.	Wing Nut.	34.	Hinge Spring and Cotter Pin.
23.	Hood Pivot Bolt.	35.	Hinge Pin and Flat Washer.
24.	Front Lower Panel Assembly.	36.	Hood Service Panel Assembly.
25.	Panel Seal Rubber and Clip.	37.	Hinge Spring Lock Plate.
26.	Setscrew and Lock Washer.	38.	Rubber Bumper.
39.	Hood Assembly.		

FENDERS

The fenders are each secured with two nuts and bolts to the fender mounting pads of the rear axle housing.

GENERAL

The Seat, Hood and Fenders are both robust and efficient and yet enhance the general appearance of the tractor. All sheet metal work is painted in 'Massey-Ferguson' red. All paintwork should be kept clean and free from rust, and any persistent rattle should be located and remedied.

DISMANTLING AND RE-ASSEMBLY

The following sequences cover the complete dismantling and re-assembly of the Seat, Hood and Fenders. Where differences in procedure occur, both are covered.

To Remove and Dismantle Seat (R-1)

1. Remove nuts securing driver's seat spring/seat mounting bracket assembly to hydraulic lift cover and lift off spring.
2. Bend back lips holding waisted hinge pins and knock out pins.
3. (a) Standard Tractors :
   Remove truss-headed screws and carriage bolts and remove seat hinge assembly.
   (b) De-luxe Tractors :
   Remove inlay and seat cover assembly. Remove wing nut and bolt securing seat back rest support to seat and remove support, inlay and back rest cover assembly.

To Re-assemble and Replace Seat (R-2)

1. (a) Standard Tractors :
   Replace seat hinge assembly with truss-headed screws and carriage bolts.
   (b) De-luxe Tractors :
   Replace inlay and back rest cover assembly on back rest. Replace support and secure with wing nuts and bolts. Replace inlay and seat cover assembly.
2. Position hinge pins. Lock in position by bending down lips.
3. Replace seat assembly on studs on hydraulic lift cover and secure with two nuts.

To Remove and Dismantle Hood Assembly (R-3)

1. Unscrew wing nuts to release hood catch rods. Remove hood pivot bolts and remove hood assembly.
2. Remove radiator grille Dzus fasteners and remove grille.
3. Remove lower to side panel wing nuts and setscrews and remove front lower panel assembly.
4. Remove eight side panel to hood Acme screws and remove side panel assemblies.
5. Remove name plate speed nuts and name plate.
6. (a) On tractors not incorporating the later type of service panel assembly, remove hinge pins at each hinge and lift off assembly.
   (b) On tractors fitted with the later type of service panel assembly, remove bracket to hood nuts and bolts and lift off service panel assembly.
7. (a) On the earlier tractor, drill out rivet securing the push-button catch.
   (b) On the later tractor, remove Dzus fastener by removing hinge to service panel nuts and bolts.

To Re-assemble and Replace Hood Assembly (R-4)

1. (a) Fit new push-button catch and rivets on tractors not incorporating later type of hood and service panel. Refit hinge spring helper and hinge spring with hinge pin and refit service panel.

   (b) On tractors incorporating this modification, refit Dzus fasteners and hinge to service panel nuts and bolts. Refit service panel securing bracket to hood nuts and bolts.

2. Refit name plate with speed nuts.

3. Replace side panel assemblies, securing with Acme screws and fit panel seal rubber with spring clips.

4. Replace front lower panel assembly securing with lower to side panel wing nuts and setscrews, and fit panel seal rubber with spring clips.

5. Refit grille and secure with two Dzus fasteners.

6. Position hood assembly and fit hood pivot bolts. Engage hood catch rods and secure with wing nuts.

FENDERS

The fenders are removed or replaced by removing or replacing the fender mounting nuts and bolts.