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Fiat Trattori

FIAT

411 R *wheel tractor*

SERVICE MANUAL

SECOND EDITION

Service Department

Via [illegible] 3 - [illegible] Torino (Italy)

[illegible]

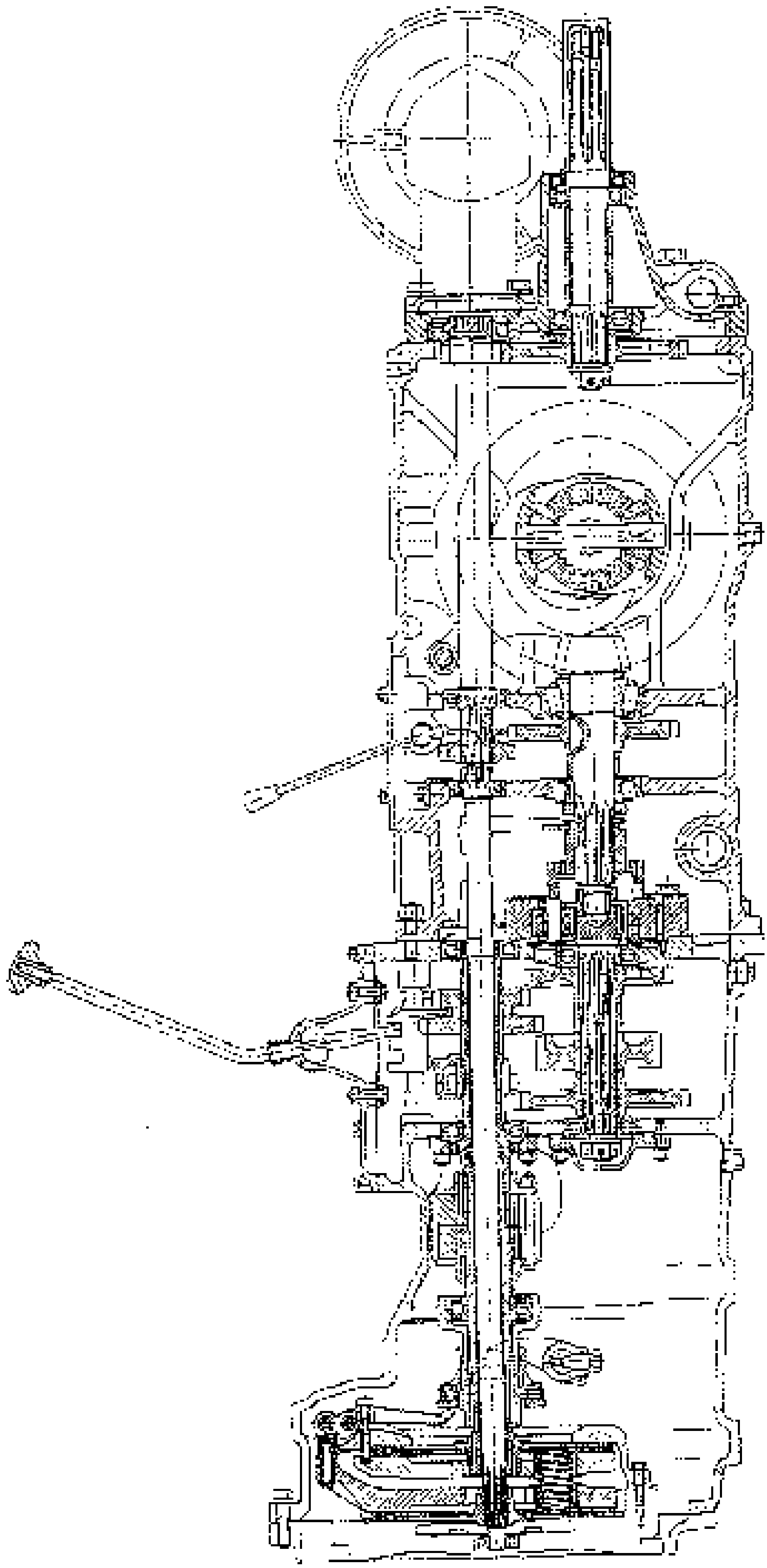


Fig. 31. Transmission longitudinal section

TRANSMISSION ASSEMBLIES

CLUTCH

The master clutch assembly is composed of two dry, single-plate clutches, one for the tractor transmission drive and the other for the power-take-off drive.
The unit is controlled by one single pedal which, during the first part of its travel, disengages the main clutch (transmission) and in the following one, the power-take-off, but only when this attachment is directly driven by the engine (independent power-take-off).
The three diagrams of Fig. 82 illustrate, respectively:
a) the clutch engaged; b) the main clutch disengaged; c) clutch completely disengaged.

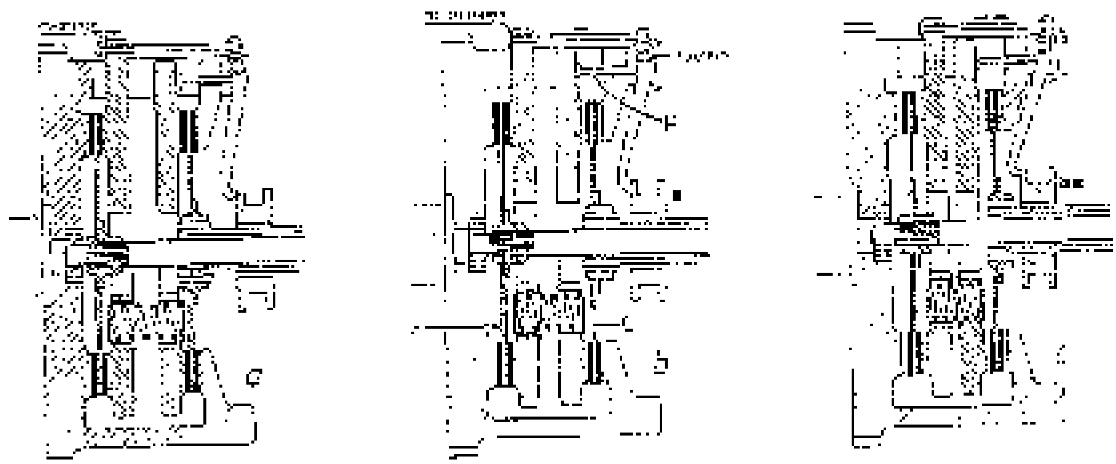


Fig. 82. - Clutch functional diagram
a - engaged clutch. b - main clutch, disengaged. c - clutch, completely disengaged.
F - Power take-off driven plate - C = Gearbox driven plate - P = Lever points

Removal and stripping of clutch.

Removing the clutch assembly from tractor:

Parts to be removed.
The batteries.
The exhaust pipe.
The engine, with the front axle (Fig. 83).

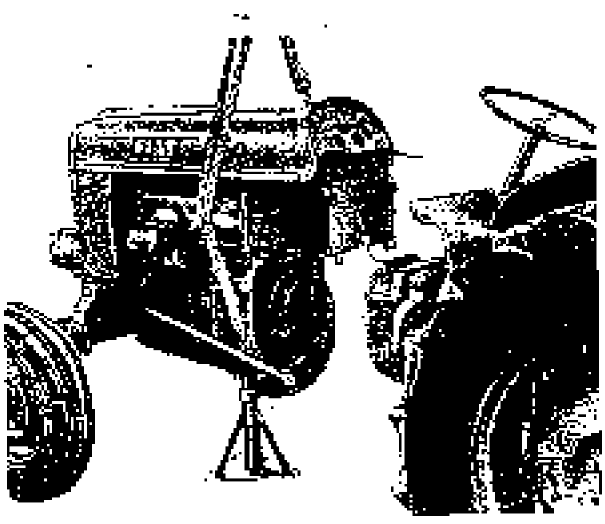


Fig. 83. - Removal of engine, with front axle.

Operations and cautions.

Disconnect the following components:

— *the hydraulic pump oil lines, the steering shaft lever longitudinal tie rod, the board from the battery support and this support from the gearbox case, the accelerator pedal linkage from the transmission shaft; the electric cables central connection;*

— *fit two wooden wedges on the front axle, attach the engine assembly to a lift and place the gearbox case on a stand;*

remove the screws assembling the engine to the gearbox and facilitate the removal by actuating the clutch pedal.

Note. - *To pull the flywheel inner pilot bearing use tool* A 619027.

B

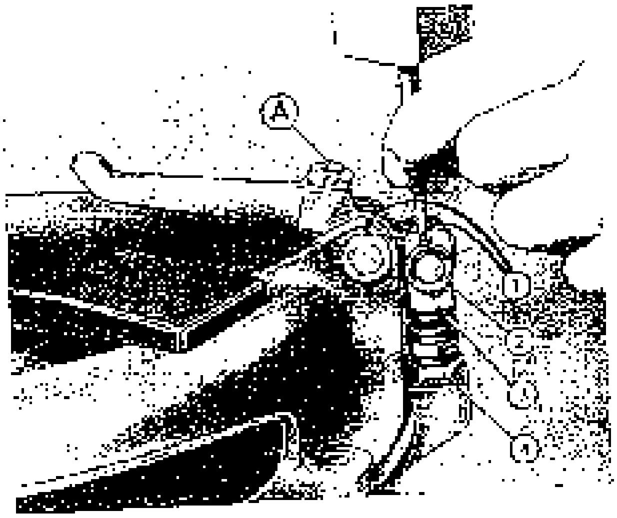


Fig. 54. - Stripping of clutch on device A 711063/A.

A. Disengagement lever adjustment nuts - 1. Elastic pins - 2. Lever pivots - 3. Yokes - 4. Fork adjusting nuts.

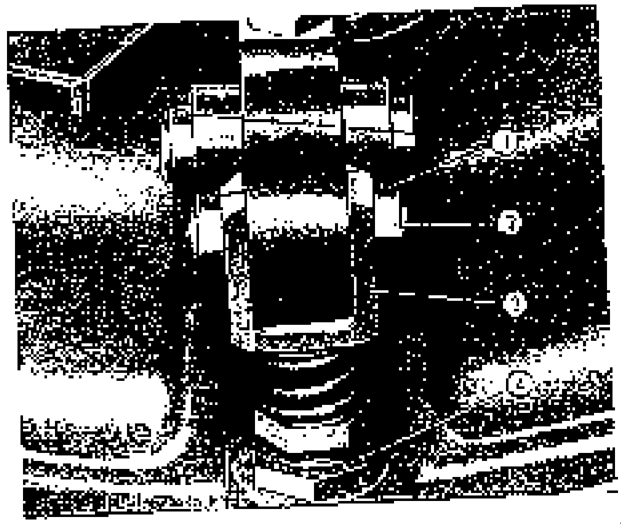


Fig. 55. - Front view of a tie-rod and orientation of elastic pins.

(See the last figure for references)

Stripping of clutch:

Mount clutch on fixture **A 711063** *or on fixture* **A 711063/A**, *remove the elastic pins (1, Fig. 54) and push out the disengagement lever pivot pins (2). By slackening the stud bolts fastening the clutch to fixture, all parts become free.*

If the clevises (3) must be removed unscrew them from the pressure plate after slackening the adjusting nuts (4).

Inspection of clutch dismantled parts.

Check the clutch components as follows, according to the data of table at page 57:

- check condition of friction linings and of metal surfaces contacting them; if necessary smooth them. If the rings are soaked with oil, replace them, as washing in gasoline and surface brushing are insufficient;
- check clearance between the clutch driven disk hub teeth and splined shafts;
- check the throw-out bearing, and the clutch shaft pilot bearing, located in the flywheel;

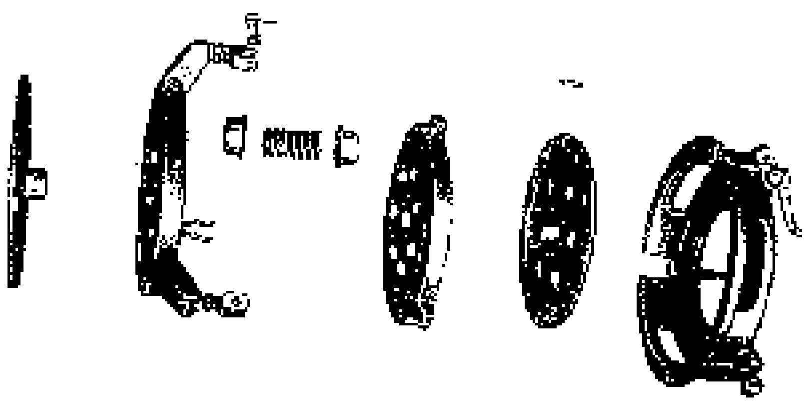


Fig. 56. - Clutch, exploded view.

- check clearance between bushes and disengagement lever pins.
- check plate spring characteristics;
- check the throw-out collar working sliding surface. If wear does not exceed the permissible limits, the shaft can be mounted again after rotating it 180°; if necessary replace the parts when grease drips due to excessive clearance.

Assembling and adjusting the clutch.

Lubrication.

Smear lightly the following components before assembling using quality chassis grease:

- *the clutch disengagement lever pivots, the clevis ends contacting the disengagement levers (3, Fig. 84), the clutch-gearbox and the clutch power take-off shaft splines, the ball ends of push levers (P, Fig. 88), the clevis lever ends where contacting the disengagement collar; in addition service the bearing housing in engine flywheel.*

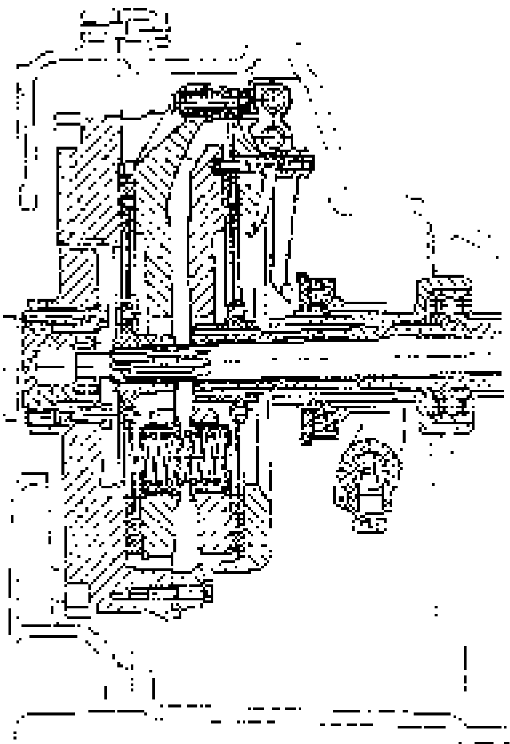


Fig. 87. - Clutch section.

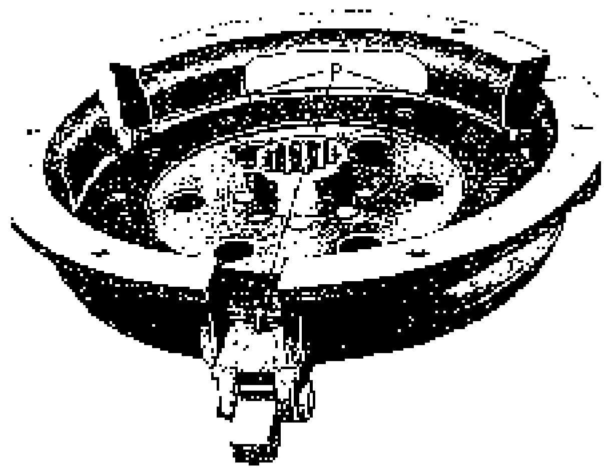


Fig. 88 - Clutch plate centering with reference to points P.

Assembling the clutch components.

It is easily performed by following Figs. 86 and 87 and noting that the clutch-gearbox plate is centered with reference to the caps and that the elastic pins are inserted as shown in Fig. 85.

Clutch assembly to be performed on fixture A 711083, using it on the side marked with the tractor number.

Clutch adjustment.

For clutch adjustment it is not necessary to place upon the fixture A 711063 the power take-off disc, which remains outside the assembly, and is substituted by a ring (Fig. 89) superposed to fixture E.

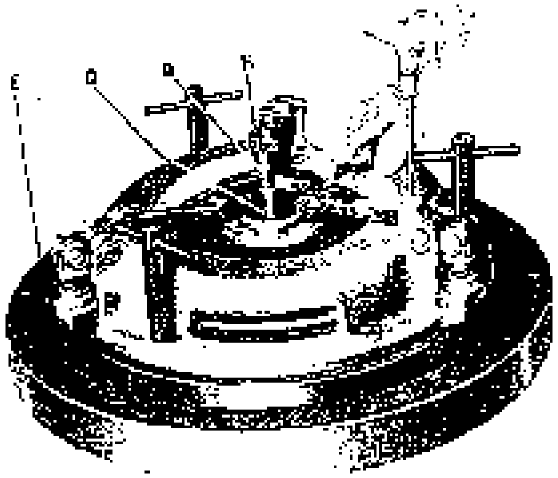


Fig. 89. - Clutch adjustment using fixture A 111063.
E, G, H Fixture components. D Spacer bearing No. 411 S. Used also for other clutch types belonging to the series 400.

Clutch adjustments should be made as follows:

a) adjustment of the complanarity of the clutch disengagement three lever ends. The adjustment to be made according the Fig. 89 i.e., by checking, using feeler gauge, that between the lever ends and the checking elements laid upon the spacer there is a max. clearance of 0,1 mm (0.0039"); a different clearance requires to unscrew the fastening nut and adjusting the proper screw.

Note. - If clutch is installed on fixture A 111063 A the adjustment may be made after the assembly on the tractor, using fixture A 117063 provided with a suitable flange (Fig. 90).

b) Adjust the clearance (B, Fig. 90) of the power take-off pressure plate clevis. Check that clearance be 1.5 to 2 mm (0.0591" to 0.0787"), and if different, unscrew the locknut and screw on or unscrew the sleeve. The clearance adjustment may also be made when the clutch is mounted on the tractor through the gearbox side cover.

Clutch control adjustment

The free travel of the clutch pedal is 25 to 35 mm (0.9843" to 1.3780"). Plate wear, however decreases the free travel. Unscrew the pedal control rod [illegible] as much as necessary to reestablish the previous value.

Assembly of clutch on engine

The centering of the assembly on the engine flywheel is facilitated by using fixture A 117063 (Fig. 91) that may also be used for the disengagement levers adjustment, when fitted with the proper plate (Fig. 90).

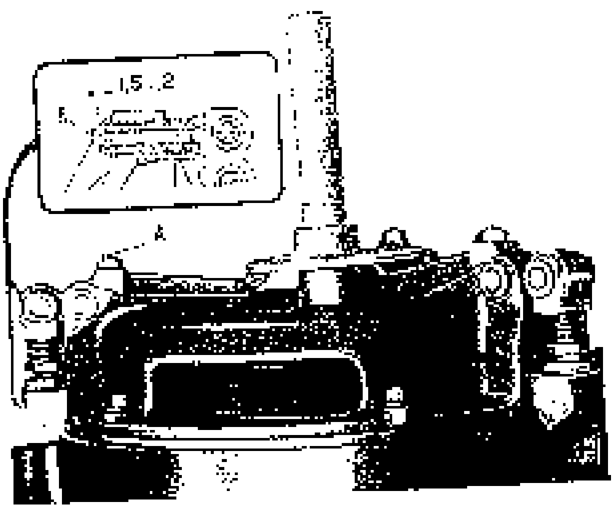


Fig. 90. - Clutch adjustment on engine, using tool A 117063, complete.

B Clearance 1,5-2 mm (0.0591-0.0787 in.)

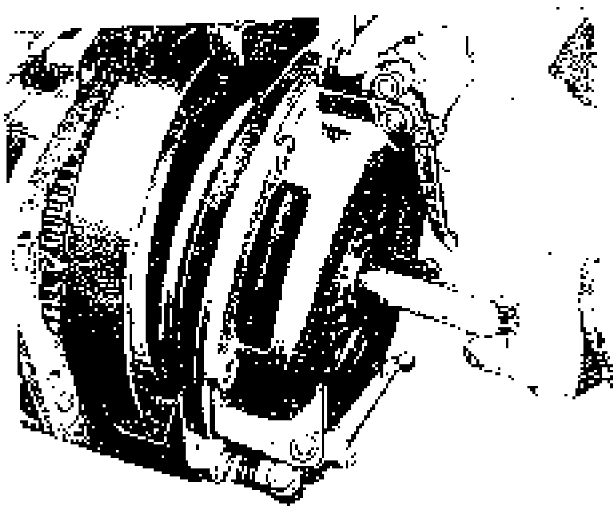


Fig. 91. - Mounting clutch on engine using tool A 117063.

FLEXIBLE COUPLING BETWEEN CLUTCH SHAFT AND GEARBOX

Noisy transmission.

Calls for the dismantling of the elastic coupling to check the rubber block efficiency: if blocks have excessive wear, replace them.

When reassembling ascertain the correct functioning by locating coupling and shaft splines correctly according the drawing of Fig. 92. In addition tighten the fastening bolts of the flanges to a torque of 2.5 kgm (18 ft.lb).

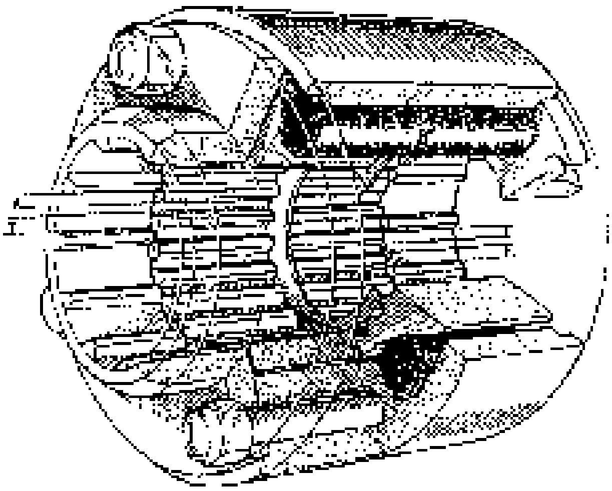


Fig. 92. - Diagram of flexible coupling for clutch-gearbox shafts.

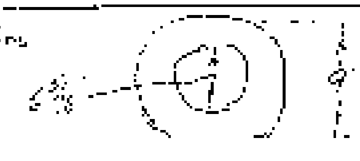
CLUTCH COMPONENTS: SPECIFICATIONS, ASSEMBLY CLEARANCES AND PERMISSIBLE WEAR

Assembly clearances	mm	in.	Wear limits mm	in.
Between wheel drive splined shaft and its disc	0.010 to 0.105	0.0004 to 0.0041	0.35	0.0138
Between power take-off clutch splined shaft and its disc	0.013 to 0.115	0.0005 to 0.0045	0.25	0.0098
Between wheel drive shaft spline banks and flexible joint collar	-0.024 to -0.072	-0.0009 to -0.0028	0.20	0.0079
Between disengagement lever bushes and their pins	0.013 to 0.064	0.0005 to 0.0025	0.03	0.0012
Between shaft and clutch throw out collar	0.030 to 0.145	0.0012 to 0.0057	0.30	0.0118
Clutch driven disc thickness (wheel drive and power take-off), complete with friction lining	8.6	0.3386	7	0.2756
Tightening torque for flexible coupling flange nuts (Fig. 92)	2.5 kgm		18 ft.lb	

Clutch spring specifications

Spring free length . . . . 66.1 mm (2.6024 in)
Spring length under check load . . . . 45.2 mm (1.7795 in)
Check load . . . . 119.0 to 124.6 kg (262.3 to 274.7 lb)

Each clutch [illegible] 64 65 [illegible]



GEARBOX AND EPICYCLIC REDUCTION GEAR

Dismantling - Stripping of components.

Remove the gearbox from tractor as follows:

Parts to be disassembled.	*Operations and cautions.*
The engine, with its front axle.	*Follow the sequence described on page 53 for the main clutch removal.*
The steering box	
The two foot-boards, the rear lamps cable and the clutch disengagement tie-rods.	*If the tractor is provided with oil lines running from the hydraulic pump to the lift, remove them.*

The stripping of gearbox components is facilitated by installing it on the rotary stand ARR 2204 (Fig. 93).

The central clutch shaft and the throw-out collar.	*Remove the two screws fastening the clutch throw-out cover support to the gearbox, and remove it together with the engine clutch shaft and the flexible coupling.*
The gearbox and the epicyclic reduction gear shifter rods.	*Remove the gearbox cover with the shift lever;* *remove the shifter forks, after pulling the fastening pins, beginning from the central rod (2, Fig. 95);* *slide out the reduction gear control sleeve with shifter forks and rods;* *take away the 3 springs (Section C-C, fig. 100) and the detent balls.*

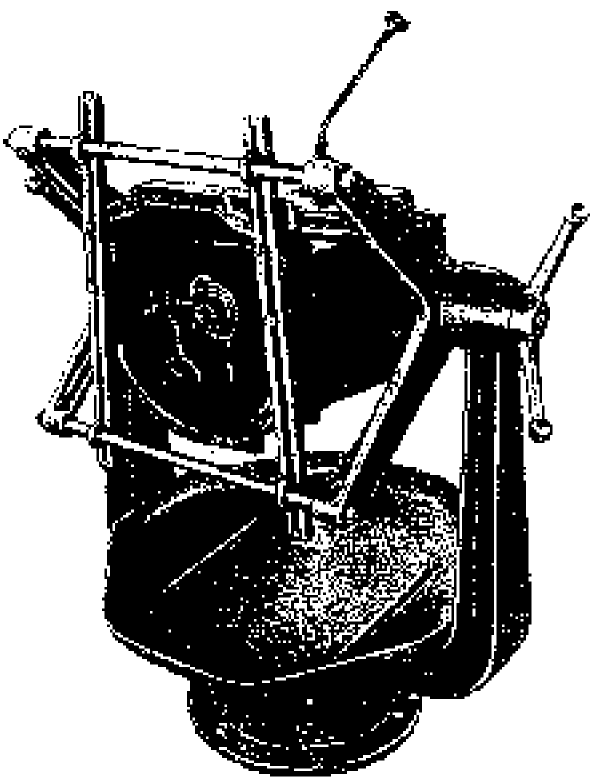


Fig. 93. - Gearbox casing mounted on rotary stand ARR 2204.

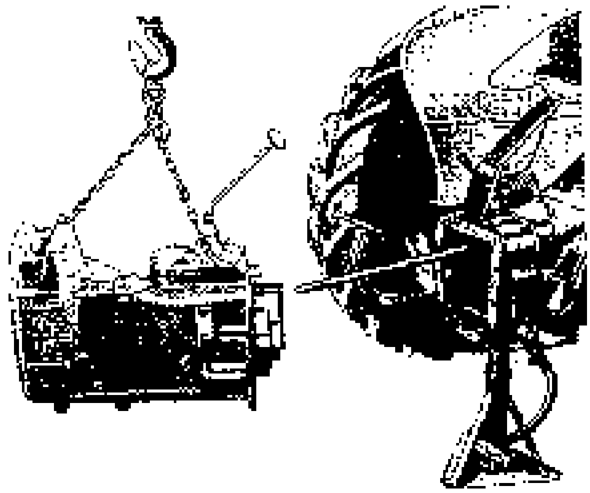


Fig. 94. - Removal of gearbox casing from tractor.

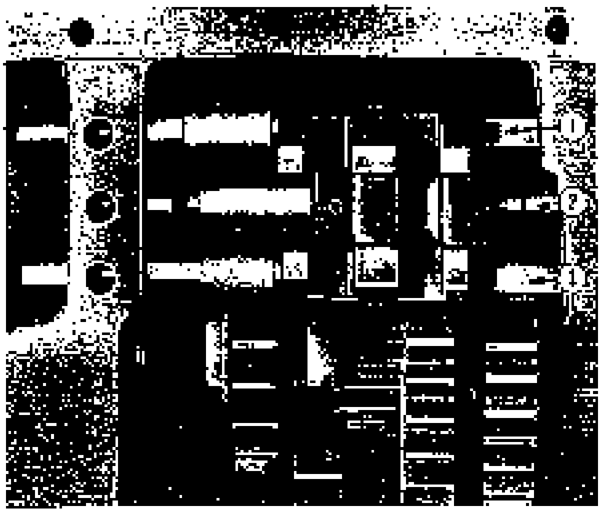


Fig. 95. - Upper view of gearbox control gears and shifter forks

1. Shifter forks for 1st, 4th gears and reverse - 2. Epicyclic reduction gear control fork - 3. Shift fork controlling 2nd and 5th, 3rd and 6th gears

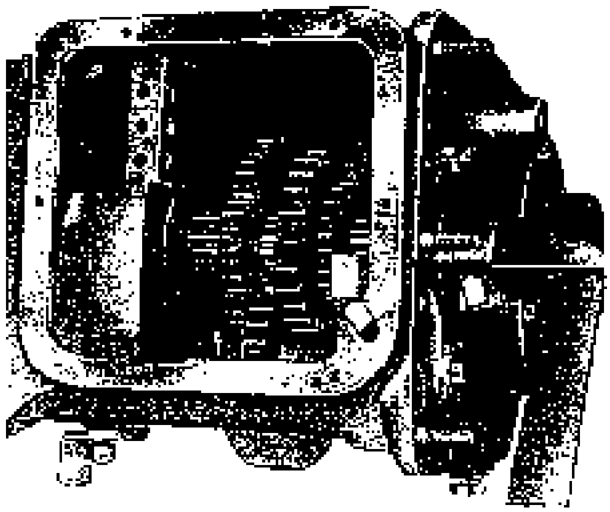


Fig. 96 - Disassembly of primary shaft

(Arrows show the wooden wedge and the punch)

Primary shaft.

Note. - *When also the secondary shaft is to be disassembled, engage two gears in order to unscrew the front end fastening nut.*

Take away the primary shaft front cover and remove the shaft by hammering on rear end.

Prevent the rear bearing from coming off together with the shaft by placing a wooden wedge as shown in Fig. 96.

If necessary pull out the bearing also using a puller **A 960703.**

Reverse gear and its shaft

Remove the stop and slide out the shaft together with the gear.

Should the shaft removal offer some difficulty, apply a screw to the threaded hole in the axle.

Remove bush from gear using the punch **A 928251**

Secondary shaft.

Remove the epicyclic reduction unit and the gearbox wall inner thrust disc;

slide out the secondary shaft with a bronze punch hammering it on its front end.

Checking the stripped out components of the gearbox and epicyclic reduction gear.

Check gearbox and epicyclic reduction gear components against specifications of page 63.

Neither gear teeth nor chamfered surfaces should be damaged.

Check if the teeth of mating gears are working on the whole face length, and if the surfaces are smooth and free from signs of scoring or hammering.

The sliding gear hub internal splines should be free from marks of wear or seizing, and all splines should have their corners without signs of hammering.

The splined primary shaft should be absolutely free from pitting or scoring, especially on gear sliding surfaces. Slide the gears on the shaft and check for clearance between the gear guide flanks and the corresponding shaft spline flanks.

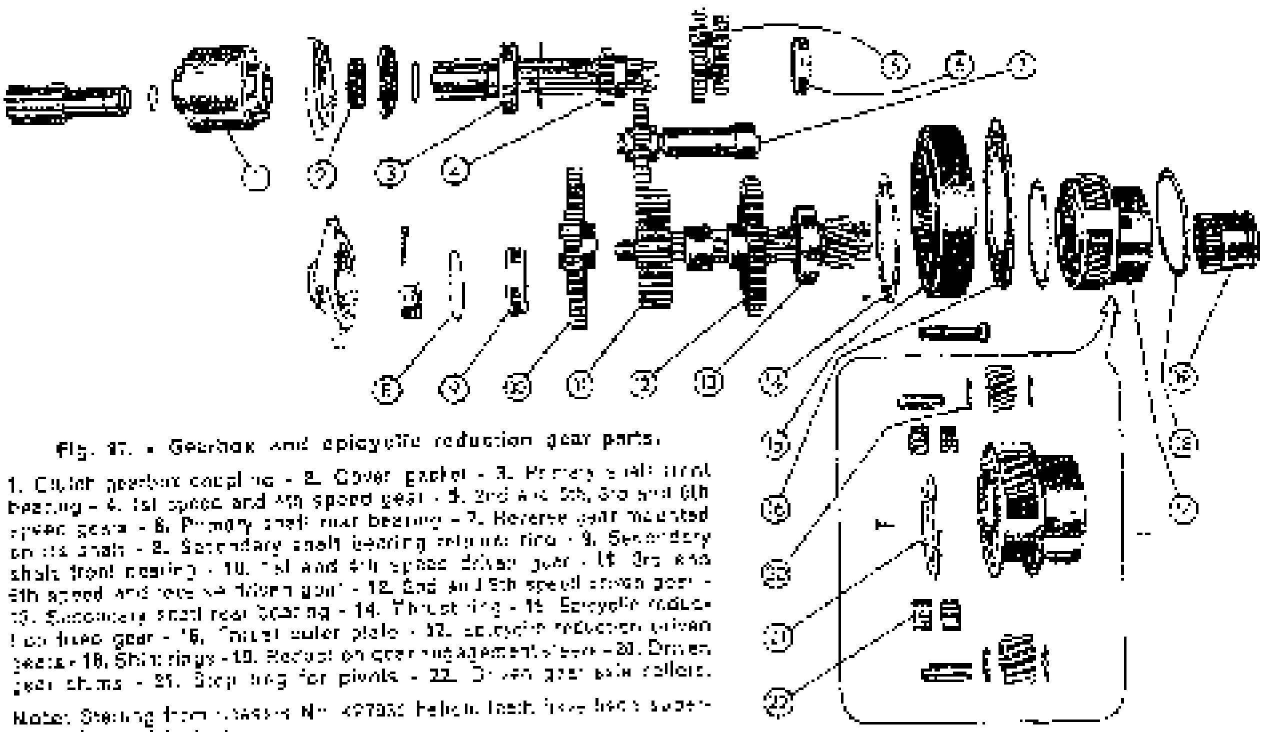


Fig. 97. - Gearbox and epicyclic reduction gear parts.

1. Clutch gearbox coupling - 2. Cover gasket - 3. Primary shaft front bearing - 4. 1st speed and 4th speed gear - 5. 2nd and 5th, 3rd and 6th speed gears - 6. Primary shaft rear bearing - 7. Reverse gear mounted on its shaft - 8. Secondary shaft bearing retaining ring - 9. Secondary shaft front bearing - 10. 1st and 4th speed driven gear - 11. 3rd and 6th speed and reverse driven gear - 12. 2nd and 5th speed driven gear - 13. Secondary shaft rear bearing - 14. Thrust ring - 15. Epicyclic reduction fixed gear - 16. Thrust outer plate - 17. Epicyclic reduction driven gears - 18. Shim rings - 19. Reduction gear engagement sleeve - 20. Driven gear shims - 21. Stop ring for pivots - 22. Driven gear axle rollers.

Note: Starting from chassis No. 427932 helical teeth have been superseded by straight teeth.

The reverse shaft should be smooth and without scoring; if the permissible clearance between the bush fitted on the gear and its shaft is in excess of the wear limits, replace both bush and shaft.

The ball bearings should be perfectly smooth in operation, without clatter. The epicyclical reduction driven gears roller bearings and those for the bevel pinion shaft should have an assembly clearance not exceeding the value listed at page 63 and the surfaces mating such components should not be damaged in any way.

The gear control forks should be checked for deformation and hardening characteristics of the working surfaces. They should slide freely with shifter rods in the box guide holes.

Replace gaskets whenever worn or damaged.

The epicyclical reduction gear thrust rings should be checked and if presenting signs of wear should be replaced.

At gearbox major overhaul, remove the control lever sector plate, located under the cover (Fig. 98), in order to check its components efficiency, especially the ratchet (3) and the control lever dowels (1), which are subject to wear.

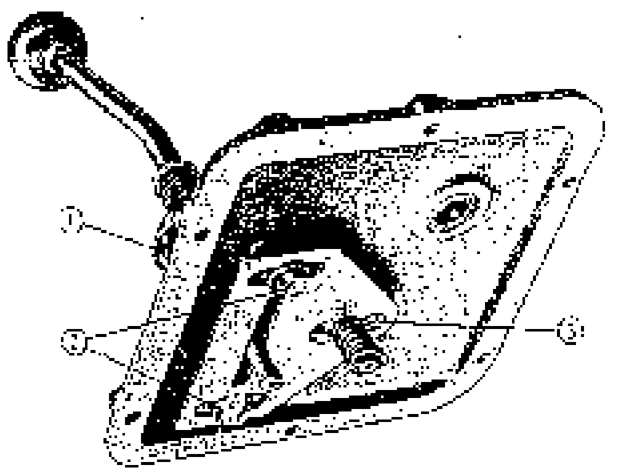


Fig. 98. - Gear shift lever.

1. Control lever dowels - 2. Sector plate fastening screws - 3. Gear selector pivot ratchet.

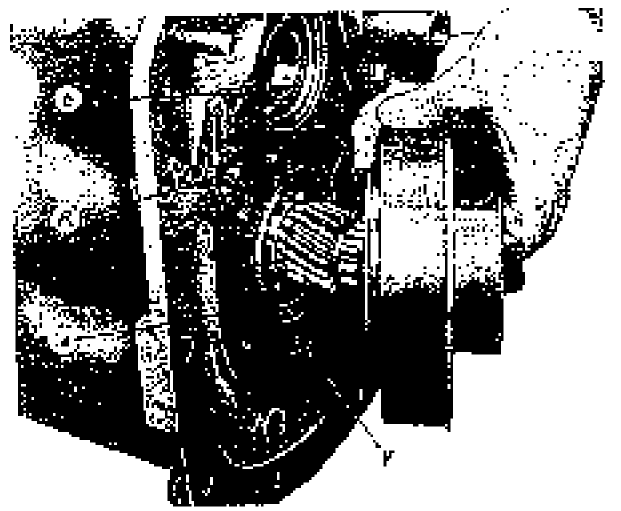


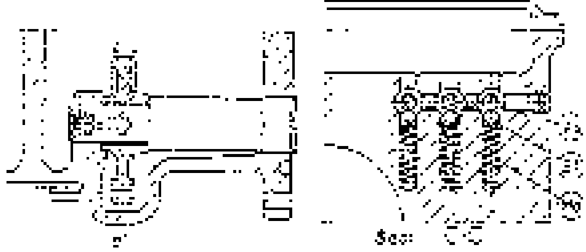
Fig. 99. - Assembling of epicyclic reduction gear on gearbox secondary shaft.

6. Primary shaft rear bearing - 14. Shim - R — Reverse gear shaft - V — Shim pin.

Gearbox and epicyclic reduction gear reassembly.

To reassembly gearbox components proceed as follows:

Parts to be assembled.	*Operations and cautions.*
Secondary shaft	*Assemble on the shaft the rear ball bearing after heating it in an oil bath to a temperature of 80° C. approx.!* *Install in the gearbox the front bearing after sliding in the shaft from the box rear end, and mount on it the gears according to Fig. 97.* **Note.** - *The shaft nut tightening should be made after the installation of the primary shaft, as it could be facilitated by meshing two gears at the same time*
Reverse.	*If the bush has been replaced, after reassembly it must be reamed using reamer* **U 0321**, *up to the dimension of page 63.* *Fasten the reverse shaft (R) as shown in Fig.* **98.**



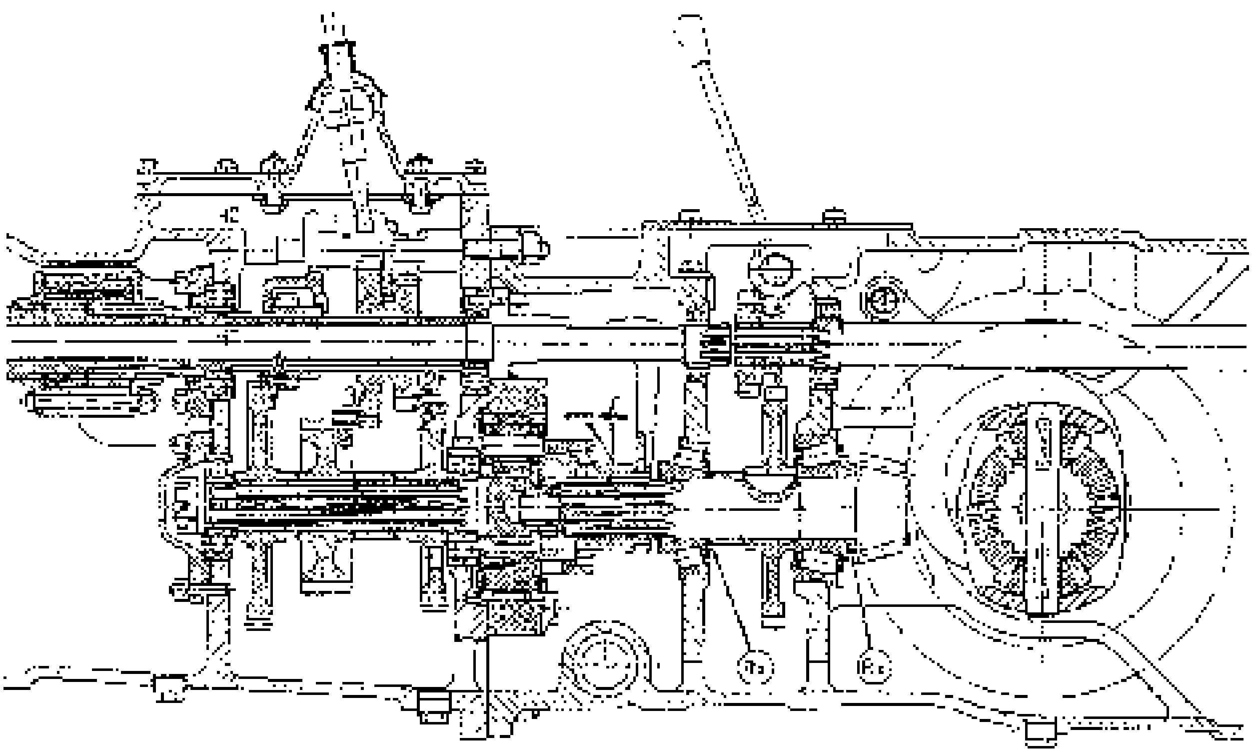


Fig. 100. - **Gearbox section.**

1-2-3-4-5-6 are indicating respectively 1st, 2nd, 3rd, 4th, 5th and 6th speed, obtained by the displacement of the epicyclic reduction gear sleeve according to the arrow direction indicated by it or opposite to it.

Ra. Taper roller bearing adjustment shims - **Rb.** Ring for centering the pinion on bevel ring gear - Section **C-C** through casing forward wall, and corresponding to the control rods - **As.** Rod - **Sf.** Balls - **Mo.** Ball springs - **R.** Reverse gear section.

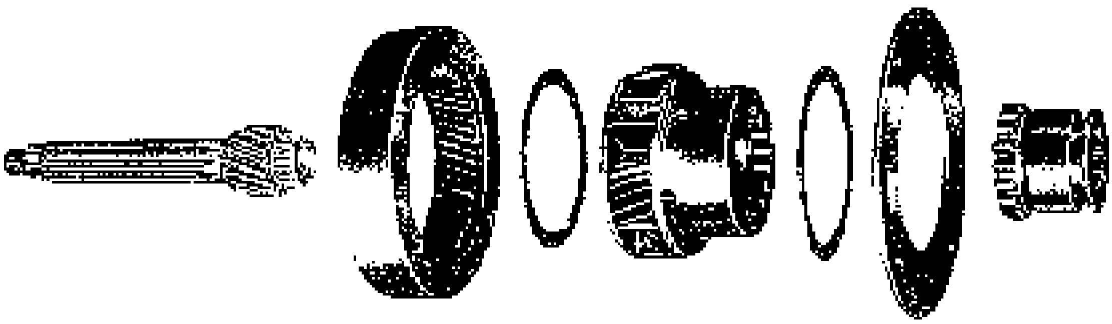


Fig. 101. - Epicyclic reduction components.

(Note: Starting from chassis No. 427935 on helical teeth have been superseded by straight teeth).

Epicyclical reduction gear (Fig. 101).

Assemble the epicyclic reduction gear components according to Fig. 101.

Mount on the gearbox the primary shaft rear bearing (6) and fasten by its pin (V), the inner thrust disc (14), having its lubrication passages located as in Fig. 99.

Primary shaft.

Mount on shaft front end the bearing, the oil baffle and the elastic rings;

slide-in the shaft from the case front side and fit on it the first, second and third speed gears;

mount the primary and secondary shafts front covers and their gaskets.

When mounting the first cover, slide it on fixture A 137003 which avoids the oil seal gasket being damaged by the primary shaft splines contact (Fig. 102).

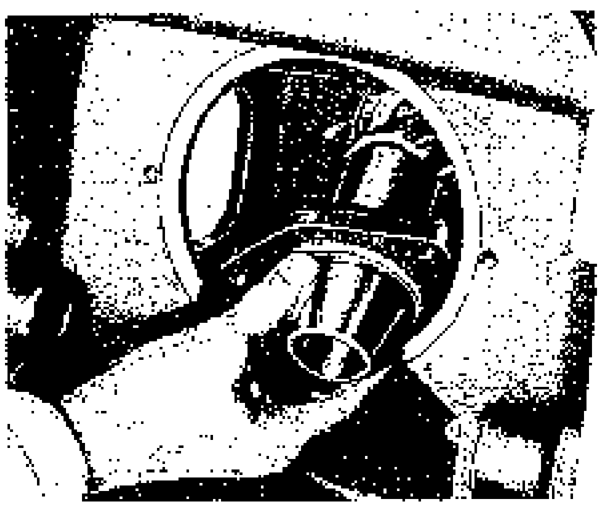


Fig. 102. - Mounting the primary shaft front cover using tool A 137003.

Rods and forks for the gear control (Fig. 95).

Introduce through the gearbox wall holes the three detent springs and mount the ball and the first gear shifter rod with its spacer and fork;

introduce through the wall middle hole the two epicyclic reduction gear control rod check balls (see diagram C-C, Fig. 100) and complete the assembly by introducing the two balls from the relevant hole and mount the rod, the spacer and fork actuating the second and the third gears.

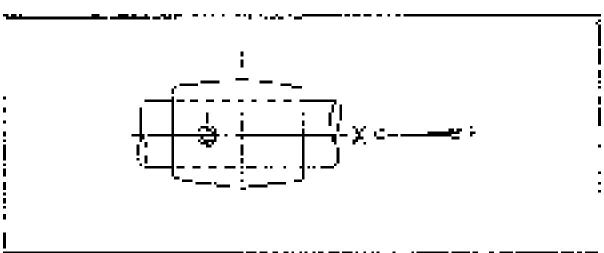


Fig. 103. - Orientation of the various spring pin cuts with reference to direction of force (F) or of rotation.

Note. - *The cuts of the pins fastening forks to rods should be oriented so that the strain expand the pins in their holes (Fig. 103).*

Gearbox cover with control lever (Fig. 98).

Mount the lever and the two dowels in the cover and add the cap and snap ring.

	mount to the cover lower section the sector plate and fasten it with the two screws (2, Fig. 98); mount also the gear selector pivot (3).
	Before mounting the cover, shift to neutral all gears.
Gearbox clutch control shaft.	*Mount on gearbox-clutch control shaft, the flexible joint, the support, the bearing, and the disengagement sleeve.*
	Before mounting all parts on the primary shaft, be sure that the seal ring is installed (Fig. 97).

NOTE: Shift the gear shift lever backwards, thus disengaging the reduction gear, in order to facilitate the operation of fastening the gearbox to the transmission casing.

GEARBOX AND EPICYCLICAL REDUCTION GEAR COMPONENTS: SPECIFICATIONS, ASSEMBLY CLEARANCES AND PERMISSIBLE WEAR

	Data mm (in)	Assembly clearances	mm (in)	Wear limits mm (in)
		Between gearbox shaft splines and their driving and driven gears	0,010 to 0,10[illegible] (0.0004 to 0.0042)	0,3[illegible] (0.0[illegible])
		Between gearbox driving and driven gear tooth flanks	0,10 to 0,20 (0.0039 to 0.0079)	0,50 (0.0197)
		Between driven gear pinion tooth flanks and the flanks of epicyclical fixed reduction gear	[illegible] to 0,13 (0.0039 to 0.0051)	0,35 (0.0138)
Epicyclical reduction driven gear needle seat diameter	20,[illegible] to 20,[illegible] (0.8[illegible] to 0.8[illegible])			
Epicyclical reduction driven gear needles diameter	2,99 to 3,00 (0.1177 to 0.1181)	Between needles and axles of epicyclical reduction driven gears	0,01 to 0,06 (0.0004 to 0.0024)	0,15 (0.0059)
Epicyclical reduction driven gears axle diameter	14,400 to 14,389 (0.5669 to 0.5665)			
Reverse shaft bush inner diameter (obtained by accurate lapping)	25,0[illegible] to 25,0[illegible] (0.9858 to 0.9861)	Between bush inner diameter and its reverse shaft	0,065 to 0,1[illegible] (0.0026 to 0.0047)	0,20 (0.0079)
Reverse shaft diameter	25,000 to 24,979 (0.9842 to 0.9834)			

Control rods release spring	Gearbox selection release springs
Spring free length . . . . . 36,5 mm (1.4370 in)	Spring free length . . . . . 21,2 mm (0.8346 in)
Spring length under check load . . . . . 31,5 mm (1.2402 in)	Spring length under check load . . . 16,5 mm (0.6496 in)
Check load . . . . . 14,7 to 15,3 kg (32,4 to 3[illegible] lb)	Check load . . . . . 18,4 to 20,4 kg (40.6 to 45 lb)

DIFFERENTIAL AND LOCK

The rear half of the tractor body is a case housing the differential assembly and its lock; it is closed at the rear by a cover through which the power take-off shaft projects, the belt pulley unit may be attached thereto.
The case upper opening allows the fitting and removal of the power take-off drive and driven gears.

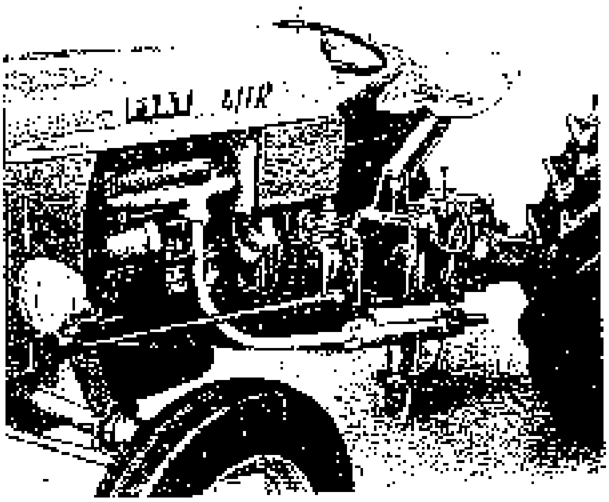


Fig. 104. - Removal of engine and gearbox from rear transmission casing.

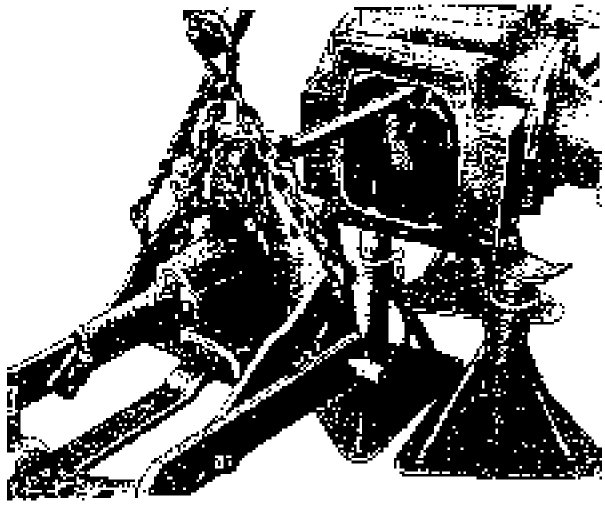


Fig. 105. - Transmission casing rear cover removal.

Disassembly.

To remove the differential case from tractor and to dismantle it, proceed as follows.

Parts to be removed.	*Operations and cautions.*
The hydraulic lift.	*Remove, if installed, the lift unit, its oil lines, and the implement hitch.*
Drain lubrication oil.	*Remove the two plugs found under the tractor body.*
The gearbox from the differential case (Fig. 104).	*Disconnect the rear light cable connection.* *Place the differential casing on a stand and lift the gearbox with a winch, remove bolts connecting such two components and disconnect them by a lever.*
The final drives (Fig. 105).	*Remove the rear wheels and their discs.* *To help the disassembly of the various units, remove the mudguards.*
The seat.	*The seat should be removed to facilitate the operations which follow.*
The transmission case rear cover (Fig. 105).	*Remove the differential case upper cover and set the power take-off control levers at the position « MOTORE » (engine).* *Unscrew the rear cover fastening screws and remove the cover by pulling and lowering it very slowly, to allow the removal of the front bearing of the power take-off shaft from its housing.*

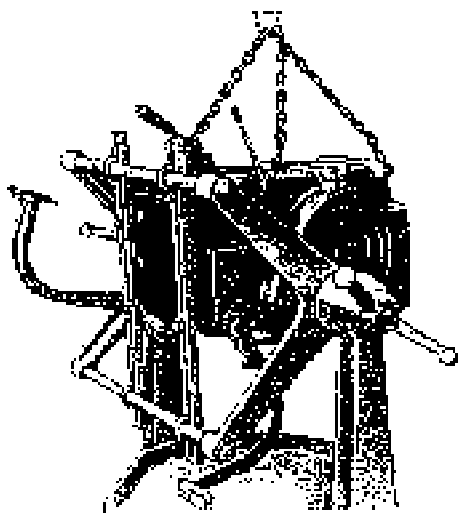


Fig. 106. - Transmission casing mounted on rotary stand ARR 2204.

At the same time, remove from the upper opening the gear which is thus free from the shaft end, to avoid damages from its falling in the box.

Note. - *To easily disengage the rear cover from the transmission casing, set the power take-off engagement lever in the «MOTORE» (engine) position.*

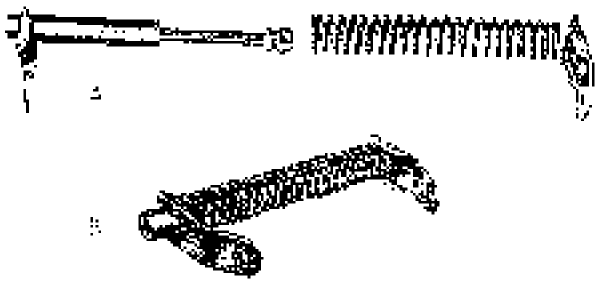
The differential lock control

To inspect or replace parts remove the rear cover, the pedal complete of attachment, the plug from the shaft left end, in order to make it possible hammering it out from the right side.

Differential gear casing supports.

Fasten the casing on support **ARR 2201**, *mounted on rotary stand* **ARR 2204** *(Fig. 106).*
Remove the gear casing supports and remove the bevel gear complete.

If the differential casing inner bearing races have to be removed, use puller **A 537105**.



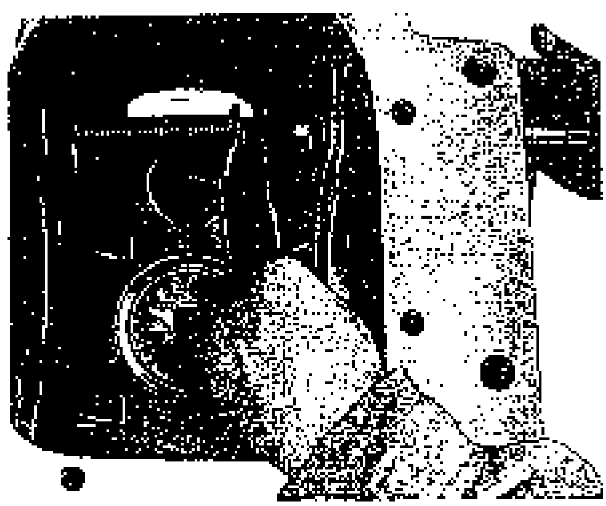


Fig. 107. - Lock control spring mounting using tool A 207033.

(On top the spring is represented before assembly (A) and after assembly (B) on the tool.

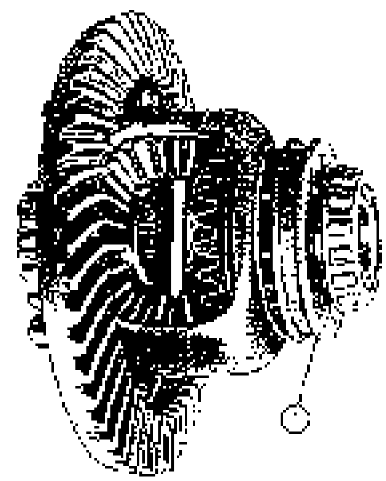


Fig. 108. - Bevel ring gear assembly with differential

1. Differential lock

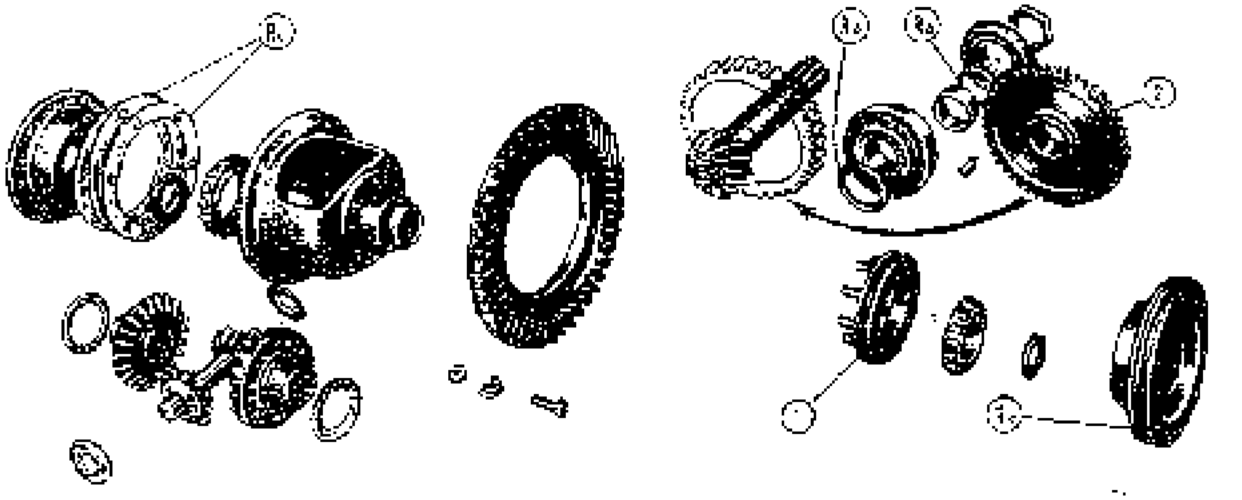


Fig. 109. - Rear transmission components.

1. Differential lock - 2. Power take-off driving gear - Ra. Bevel pinion roller-bearing adjustment shims - Rb. Ring for centering bevel pinion on ring gear - Rc. Ring gear adjustment shims

The bevel pinion.

Unscrew the bevel pinion shaft fastening nut using wrenches **A 711109** *and* **A 611100** *and stopping the rotation with the brass hammer* **A 061322**. *Remove the shaft by applying a bronze punch upon its front end and hammer it out.*
The power take-off driven gear and the spacer are removed from the casing upper opening after setting the power take off engagement lever in the position marked « CAMBIO » (gearbox).

Inspection of the stripped components of the differential casing and differential lock.

Accurately clean all stripped out components and check if the gear meshing surfaces are in good conditions

— check the differential gear thrust rings, and the pinion bushes and thrust bearings vs. the wear limits of page 69. When replacing bushes, after assembly, ream with expanding blade reamer **U 611914** to achieve the prescribed clearance;

— check the copper lining of crown wheel hubs, and replace such parts if the coating is not sufficient;

— check the taper roller bearing and the differential axles oil seals;

— check the differential lock collar working surface and the pin fastening. Check the differential lock control spring (Fig. 107) by a comparison of its characteristics with the specifications on page 69.

Differential casing assembly.

See Figs. 109 and 110 and in addition bear in mind that:

— the planetary casing is secured to the bevel gear by bolts fastened to a torque of 4.5 to 5 kgm (32 to 36 ft.lb);

— the differential pinion axle is held in place by two special head bolts, the same which secure the casing to the bevel ring gear;

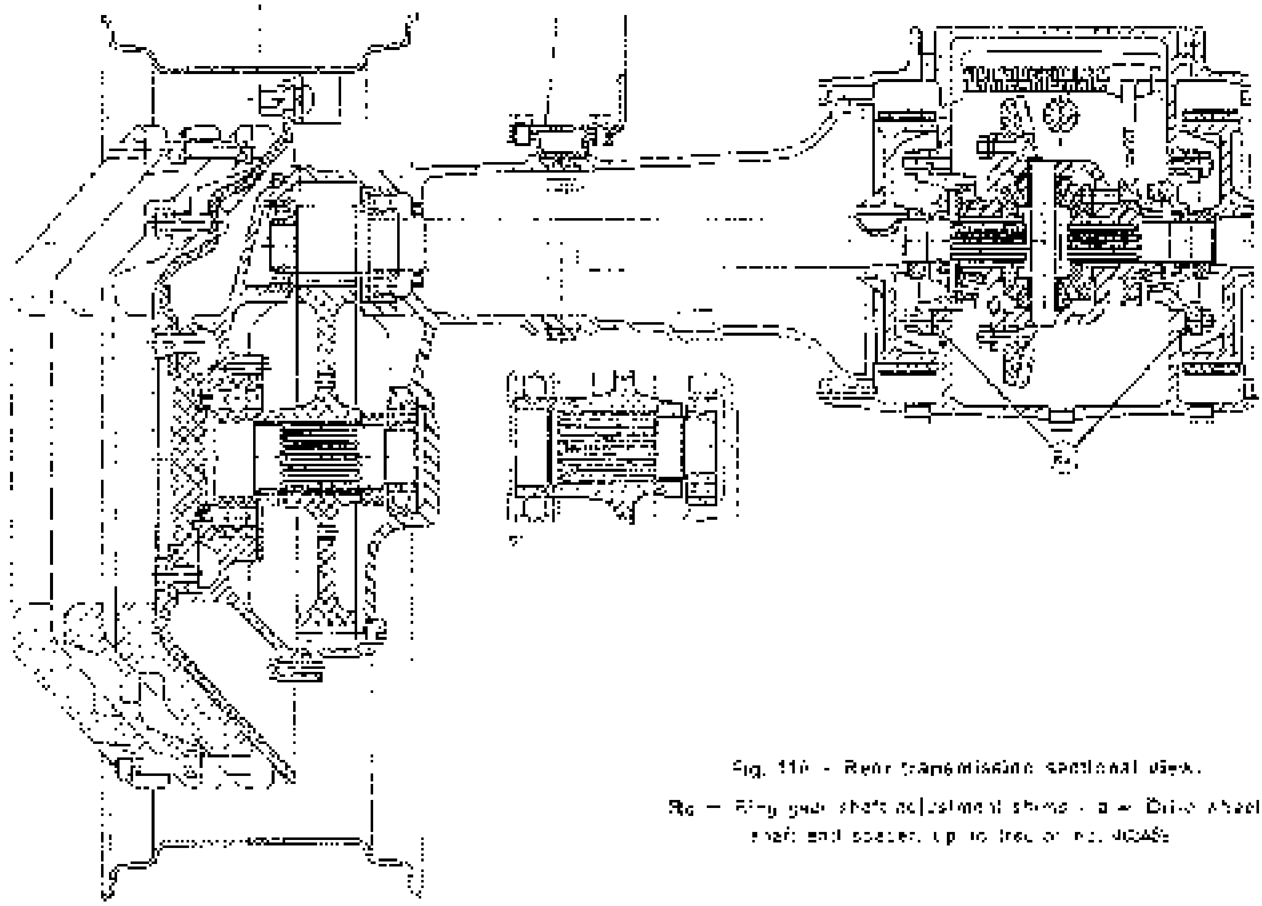


Fig. 110. - Rear transmission sectional view.

Ra — Ring gear shaft adjustment shims - a = Drive wheel shaft end spacer, up to tractor no. [illegible]

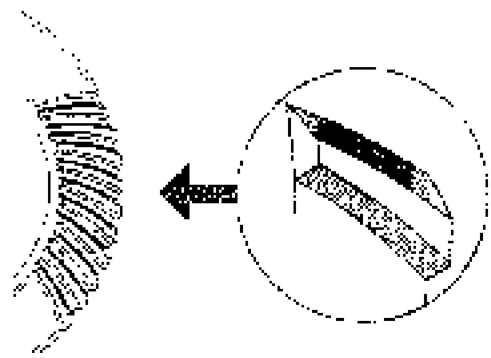


Fig. 111. - Bevel pinion and gear correct tooth bearing.

— the assembly of the taper roller bearing inner races on the casing should be made after heating the bearings in an oil bath to a temperature of 80° to 90° C; the same procedure applies to two bearings and to the power take-off driving gear on the bevel pinion shaft (2, Fig. 109).

— the differential lock control spring is installed as shown by the Fig. 107, using tool A 280033.

To facilitate the reassembling of the differential case to the gearbox we suggest placing very near to the shaft front ends — by manoeuvering the relevant levers — the power take-off driven gear and the reduction gear engagement sleeve.

Bevel pinion and ring gear adjustment.

When checking or replacing the bevel pinion and gear, the following adjustment sequence should be followed:

a) bevel pinion shaft bearing adjustment;

b) differential case bearing adjustment;

c) tooth bearing adjustment;

d) tooth backlash adjustment.

The sequence of operations is as follows:

a) install the bevel pinion shaft and its bearing, the power take-off driving gear, the spacer and the adjustment shims Ra (Fig. 100). To calculate the shim thickness, subtract from 58,5 to 58,6 mm

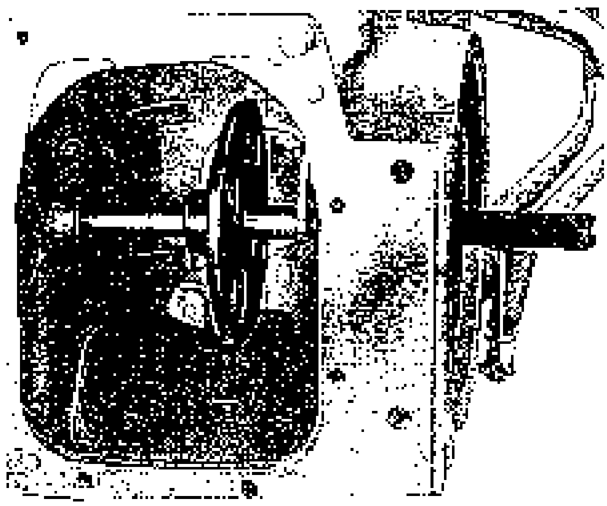


Fig. 112. - Rear view of tool A 137010 for bevel pinion and gear adjustment.

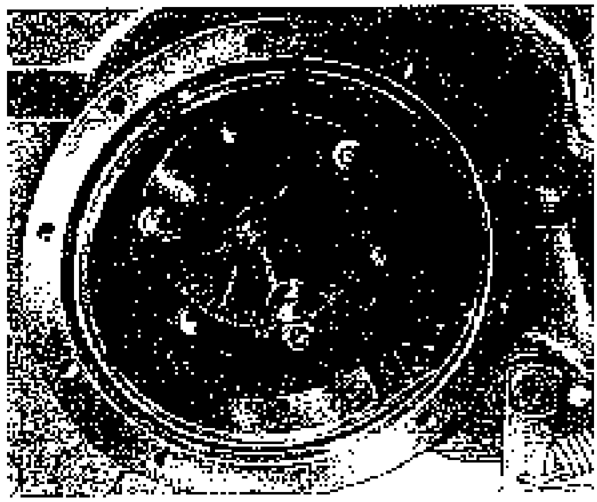


Fig. 113. - Right view of tool A 137010 for bevel pinion and gear adjustment.

(2.302" to 2.342") the sum of the gear width and the spacer width. Finally, check the shaft for free rotation and mount in place of the foregoing shims others having their total thickness minus 0.05 mm (0.002"), which will set a 50 kg/mm (110 lb) pre-load on the pinion bearings.

b) Remove the bevel pinion and mount the bevel gear complete with differential pinions and supports: tighten one of the pinions with its screw and check with a feeler gauge, at the other support, the overall thickness of the bevel roller bearing shim rings. Divide it by two placing each of the two halves Rc on the two supports and check if rotation is free but without end play.

c) For a correct tooth bearing (Fig. 111) pay attention, at pinion assembly, to the number stamped upon the smaller base and marked by + or —; this is quite necessary to determine that thickness of ring Rb, which will be most fit to avoid noises during operation.
We suggest the following sequence.

— mount the bevel pinion shaft fitted with all its parts and with a ring Rb of any thickness;

— mount on the casing the tool A 137010, according to Figs. 112 and 113;

— rotate the tool shaft clockwise so that the eccentric zone contacts the pinion base, and read on the quadrant graduated from 92 to 94 mm (3.622" to 3.700") the value at which rotation stops. If this value, indicated on the quadrant, exceeds the one calculated by adding or subtracting from the theoretical distance existing between the pinion smaller base and the bevel gear axis (93 mm - 3.661"), the number marked on the pinion (not preceeded by any letter mark), it will be necessary to replace ring Rb.
The ring to be mounted should have a thickness increased of an amount equal to the difference between the two values.
On the contrary, if the value read on quadrant results less than the one read on the pinion after adding or subtracting (according to the — or + sign) from 93 mm (3.6614"), the thickness Rb should be decreased.

Example No. 1.

Reading on the tool quadrant 93.4 mm

Measure read on the pinion + 0.2 mm

Distance between pinion and bevel gear:

93 + 0.2 = 93.2 mm (3.6614 + 0.0078 = 3.6692")

The ring Rb should be 0.2 mm thicker than the one installed, calculated by subtracting 93.4 − 93.2 = 0.2 mm in order to set the pinion at a distance of 93.2 mm according to the indication marked on it.

Example No. 2.

Reading on the tool quadrant 92.6 mm
Measure read on the pinion — 0.3 mm
Distance between pinion and bevel gear:
93 — 0,3 = 92,7 mm.
The ring **Rb** *should be 0,1 mm thinner than the one installed, calculated by subtracting 92,7 — 92,6 = 0,1 mm.*

d) Check with a dial gauge the tooth backlash which should be 0,20 mm (0.008"); the correct backlash can be obtained by shifting adjusting shims Rc from one support to the other, in order to set the bevel gear farther or nearer the pinion as required. The overhaul thickness, determined according to paragraph c) should not be altered.

SPECIFICATIONS, ASSEMBLY CLEARANCES AND PERMISSIBLE WEAR OF THE DIFFERENTIAL COMPONENTS

Assembly clearances	mm	(in)	Wear limits mm	Wear limits (in)
Between pinion and crown wheel tooth backlash	0,20	(0.008)	—	
Between splines of differential axles and their gears	0,060 to 0,106	(0.0024 to 0.0042)	0.4	(0.0157)
Differential pinion and gear tooth backlash	0,15	(0.0059)	0.5	(0.0197)
Between bushes and differential pinion axle	0,020 to 0,093	(0.0008 to 0.0037)	0.25	(0.0098)
Between casing and differential gears	0,080 to 0,159	(0.0031 to 0.0062)	0.25	(0.0098)
Between differential lock collar and casing	0,130 to 0,245	(0.0051 to 0.0097)	0.5	(0.0197)

Specifications	mm	(in)
Crown wheel adjustment ring shim thickness (Rc, fig. 110)	0,3-0,5-0,7 (toler. = 0,02)	0.0118-0.0197-0.0275 (= 0.0008)
Bevel pinion shaft adjustment shim thickness (between pinion and rear taper bearing)	3,8-3,9-4-4,1-4,2-4,3-4,4-4,5-4,6-4,7-4,8 (toler. ± 0,02)	0.1496-0.1535-0.1575-0.1614-0.1654-0.1693-0.1732-0.1772-0.1811-0.1850-0.1890 (= 0.0008)
Bevel pinion shaft bearing adjustment shim pack thickness	1,7-1,75-1,8-1,9-2-2,1-2,2-2,25-2,3 (toler. ± 0,01)	0.0669-0.0689-0.0709-0.0748-0.0787-0.0827-0.0866-0.0886-0.0906 (= 0.0004)
Differential gear thrust ring thickness (*)	1,475 to 1,525	0.0581 to 0.0600
Differential pinion round thrust washer thickness	1,4 to 1,5	0.0551 to 0.0590
Tightening torque of bolts assembling planetary gear casing to crown wheel	4,8 to 5 kgm	35 to 36 ft. lb
Differential lock control fork spring		
Spring free length	133	5.2362
Spring length under check load	126,5	4.9803
Check load	28,5 to 31,5 kg	62,8 to 69,4 lb

(*) Rings of oversized thickness of 0,1 mm (0.0039 in) are available. Wear limit of a shim: 1 mm (0.0394 in).

FINAL DRIVES

Each consists of a pair of gears having individual casings, mounted laterally to the differential and driven by it (Fig. 110).

Final drive overhaul.

The major overhaul thereof should be made as follows:

Removal from tractor (Fig. 114).

Remove the electrical cable energizing the rear lighting from connection, and take the mudguard away;
place the transmission casing on the stands and remove the wheel assembly, with disc and tire.
Remove the final drive casings from the tractor and pull outwards to slide out the differential axle from bevel gear.

Stripping out of components.

Mount the assembly on the rotary stand **ARR 2204** *with support* **ARR 2221**, *and remove the brake drum fastening nut.*
Remove the drum using a universal puller (Fig. **115**)*;*
remove both final drive casing cover and driven gears;
remove the axle inner bearing stop ring (see Fig. **110**)
and push it out the casing.

Note. - *The final driven gear removal does not necessarily require removal of the casing from tractor.*
To unscrew the driven shaft out of the final drive, mount tool **A 187014** *to stop gear rotation (Fig.* **116**)*; then use a universal puller provided with 2 screws (diameter 16 MB, pitch 1.5 mm) (Fig.* **117**)

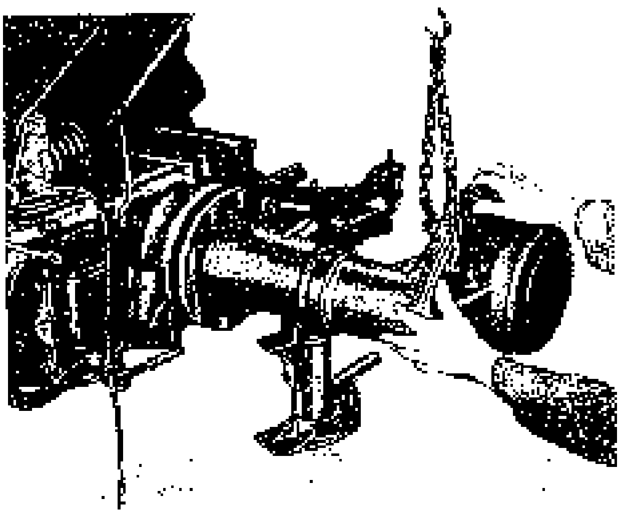


Fig. 114 - Removal of final drive casing from tractor.

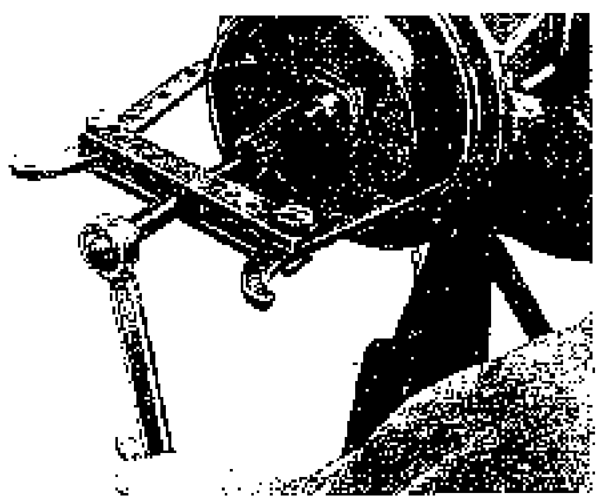


Fig. 115 - Removal of brake pulley using the universal puller.

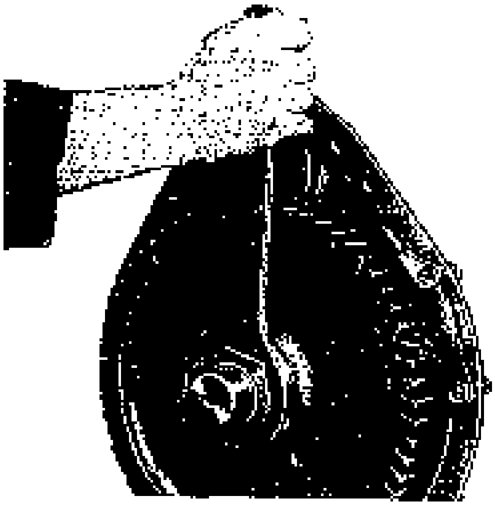


Fig. 116. - Final driven shaft nut removal.

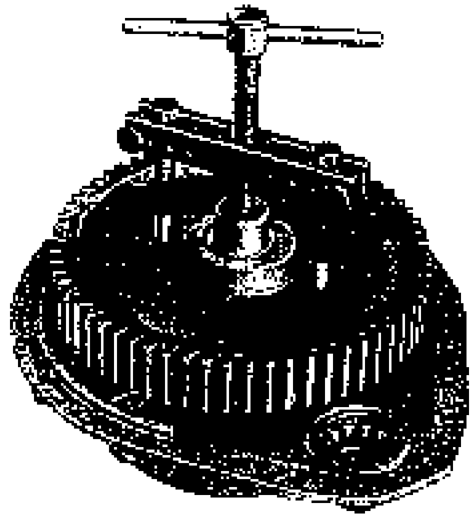


Fig. 117. - Removal of final drive driven gear using universal puller (15 MB x 1,5 mm screw - 2 required).

Inspection of components.

Check the oil seal of the differential axles and of the driving wheel shaft, to prevent oil leakage on brake bands and from the driving wheel.
Check bearings for free running and tooth backlash (see specifications on page 73).

Assembling

When reassembling avoid damaging the seal located in the differential bevel gear support.

BRAKES

The pedal and hand actuated band brakes act on the pulley keyed on the differential axles. The tractor when used on roads requires sudden and quick braking and therefore the pedals can be connected by a lock which ensures simultaneous braking action. This fact must be born in mind when setting the pedal free travel which should be equal for both.

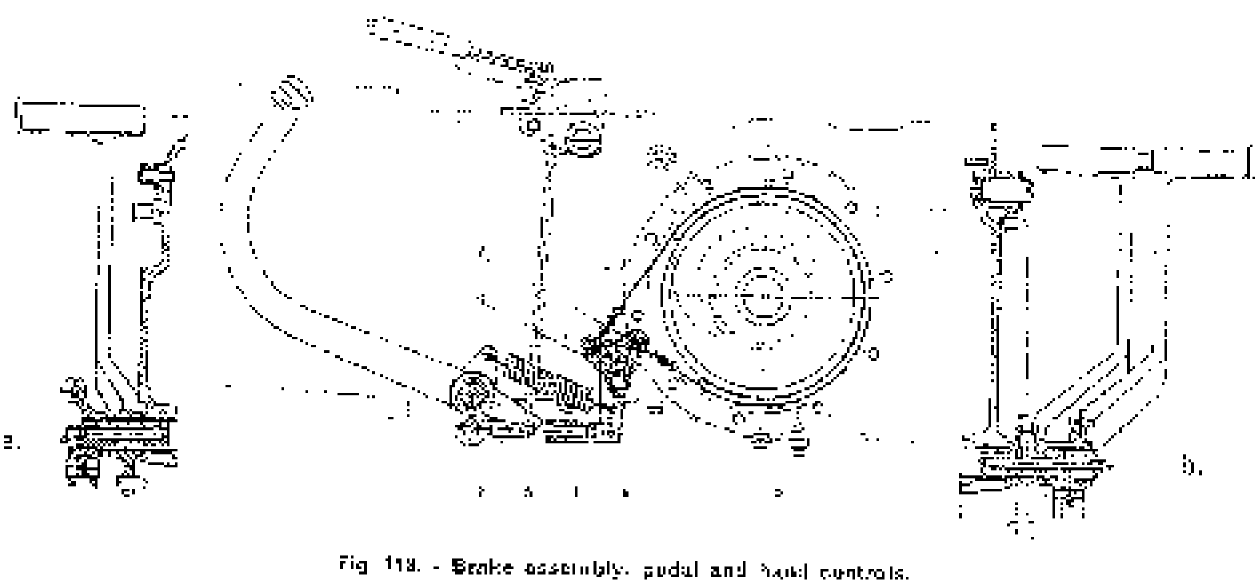


Fig. 118. - Brake assembly, pedal and hand controls.

a. Clutch control pedal assembly - b. Brake pedal assembly.
A = Clevis lock nuts - B = Cam - R = Brake band centering screws - S = Inner arm - T = Outer arm - V = Inner arm fastening screw - Z = Brake band pivot pins.

Lining area. There are 7 segments per band. Two bands per brake.
Area one segment 6 3/4" x 2" = 13.5 sq in. x 6 = 81 sq ins

Brake overhaul.

To be performed as follows:

Removal from tractor

To remove brake bands:

drain transmission casing oil and remove from the tractor the final drives, according to page 70 instructions;

— *remove the differential casing lower covers and unscrew the screws (V, Fig. 119) remove the pedal springs, remove the adjustment rod ends B from outer arm and slide it out.*

remove the braking band end pins from the inner control arm (Z, Fig. 118) and take them away

Inspection.

Check the brake pulley surface and if necessary turn it down, avoiding taking deep cuts which would impair its resistance;
check the differential axle seals for oil leakages;
correct any leakages smearing the ferodo lining,
replace bands if soaked with oil using tool A. 317007 for riveting.
In addition check the shaft and pedal bushes for wear (Fig. 118 a and b).

Assembling.

Make sure that:

— *the screws (V, Fig. 119) are fastened by wire to the internal levers (S, Fig. 118);*
— *screws are facing the tractor rear end; if not, the external levers T have been interchanged and no braking action would be possible,*
— *when mounting final drives, avoid damaging the differential bevel gear support seal with the differential axle end.*

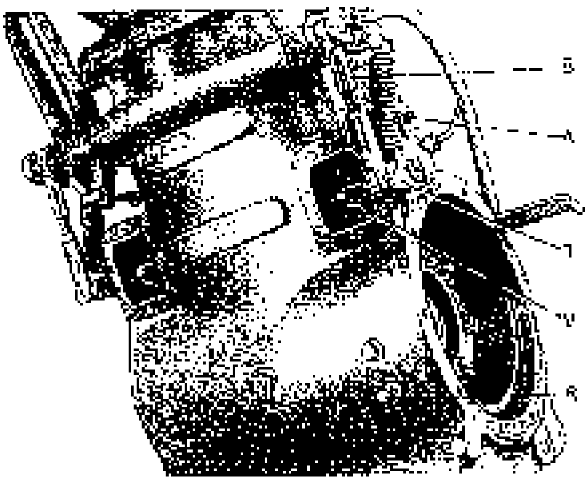


Fig. 119. - View of brake bands and controls.
A = Clevis locknuts - B = Caps - R = Brake band centering screws - T = Outer arm - V = Inner Arm Screws.

Brake adjustment.

When mounting brakes on tractor:

— *unscrew the two nuts and completely screw on the brake band centering screws (R, Fig. 119) then unscrew them through a complete turn, and retighten the nuts;*

slacken nuts A and unscrew rods (B, Fig. 119) until the free travel of each pedal is taken up, then screw them again two turns so that the brake pedal travel is about 50 mm (1.969").
Before adjustment, the brake control lever should be set all the way down with respect to the sector plate.

SPECIFICATIONS OF BRAKES AND FINAL DRIVES

	Data mm (in)	Wear limits mm (in)
Final drive pinion and bull gear tooth backlash	0.15 to 0.25 (0.0059 to 0.0098)	0,5 (0.0197)
Clearance between driven gear driver shaft splines and gear hub	0.050 to 0.043 (0.0020 to 0.00[illegible])	0,20 (0.0079)
Brake pulley diameter	1[illegible]0 ([illegible])	—
Brake band shoes thickness	6 (0.2362)	4 (0.1575)
Clearance between bushes and brake pins	0.040 to 0.144 (0.0016 to 0.0057)	0,4 (0.0157)

Brake area [illegible] (see Page 7[illegible])

STEERING AND FRONT AXLE

STEERING BOX AND LINKAGE

Removal and disassembly.

The steering box removal and disassembly should be made as follows:

Parts to be removed.	*Operations and cautions.*
The batteries.	
The dashboard.	*Remove it with its frame from the battery box and the gearbox;* *detach the rear lighting cable from central connection.*
Steering arm from drag link	
The steering box.	*Slacken the 4 screws fastening the battery box to gearbox;* *remove screws fastening the steering box to gearbox.* *remove the steering box with the dashboard (lift the battery box first).*

Clamp the steering box in a vise and remove the following components:

Steering arm.	*Use puller* **A 735009**
Shaft and roller.	*Remove the adjusting screw locknut and the roller shaft side cover (see Fig.* **121***)*

Worm gear shaft

Remove the steering wheel and the board; remove the screws fastening the steering column to the steering box and remove the steering shaft and its bearings.

Note. - *When dismantling the roller bearing outer races from the steering box, do not alter the shim pack (***S***, Fig. 120).*

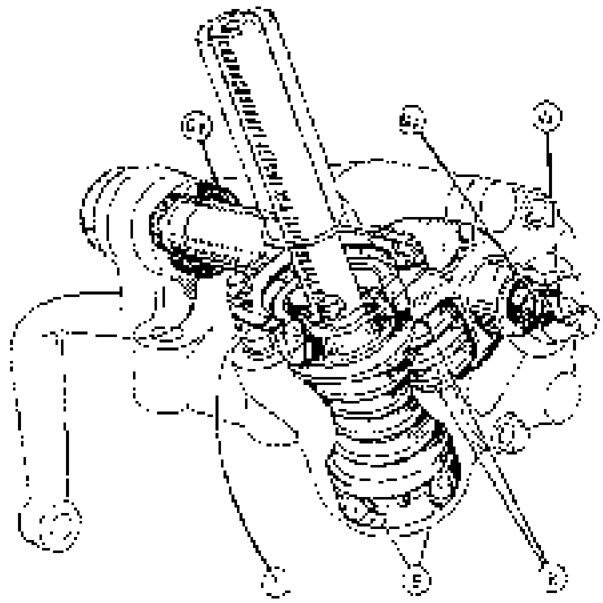


Fig. 120. - Steering box perspective view.
R — Pitch washers - S — Screw to roller tooth aligning shims - T — Taper roller bearing adjusting shims - Gg and Gp — Roller shaft seats - Vr — Adjusting screw.

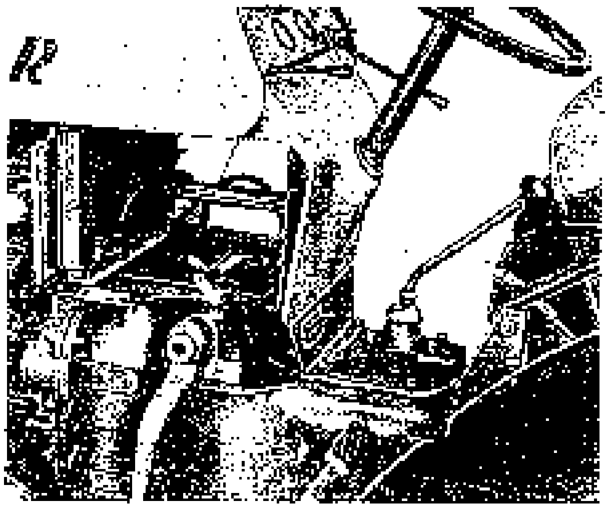


Fig. 121. - Steering box mounted on tractor.

Inspection of stripped out components of steering box and steering unit.

Check mating surfaces of roller and worm gear for notches or traces of seizing. Check alignment of roller and worm gear, this signifying that the roller and worm screw reciprocal position is correct; if otherwise the shims should be changed (S, Fig. 120).

Check for clearance between bushes and the roller shaft, according to specifications of page 76 and replace bushes when limits are exceeded, in order to maintain proper mesh between roller and worm gear.

Ream bushes after assembly, using reamer U 611916 to achieve the correct diameter.

If roller shows end play, due to wear of the two washers (R, Fig. 122), replace the shaft also, being the parts riveted together.

Check the taper roller bearing for free play and the roller shaft oil seal.

Check steering arm and drag links for straightness; if bent, straighten them and make sure that their strength is unimpaired.

Steering box assembly.

Parts to be assembled.	*Operations and cautions.*
The roller shaft bushes.	*If bushes have been replaced, after reassembly ream them using reamer* U 611916 *up to the diameter specified in page 76.*

The lower taper roller bearing outer races and shims (**S**, Fig. 122).

To avoid altering the setting of roller and worm gear, the shim pack S thickness should be varied if the worm gear, the roller or the steering box have been replaced; the shims pack should then be adjusted as follows:

a) mount the worm gear assembly, after smearing it with red lead compound, and adjust clearance of taper roller bearings;

b) mount the roller, shaft, cover and the steering arm;

c) adjust the roller and worm gear bearing according to indications following.

Note. - *Each variation of shims S, calls for a new adjustment of bearings with shims T.*

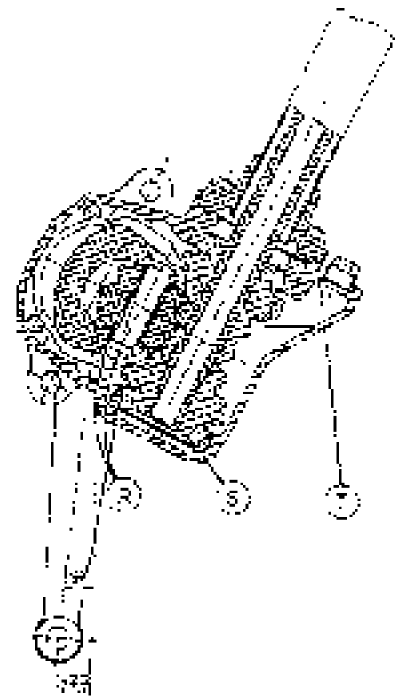


Fig. 122. - Roller tooth cross-section.
R = Roller washers - S = Shims centering screw to roller - T = Centering shims taper bearing adjusting shims.

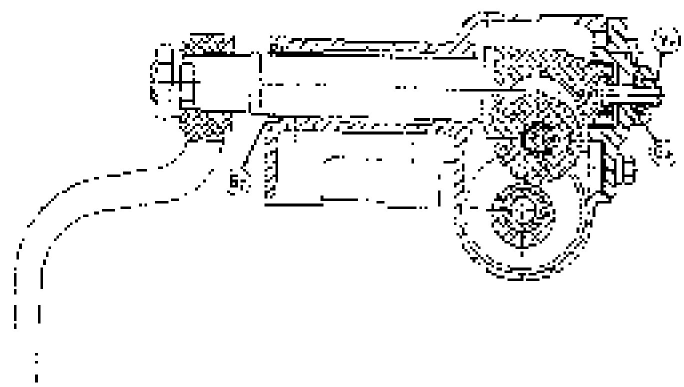


Fig. 123. - Longitudinal section of roller tooth shaft.
Gg and Gp = Seals - Vr = Adjusting screw.

The worm gear with the taper roller bearing adjusting shims (T, Fig. 122).

Mount the worm gear shaft with its bearing shims and check it for free rotation which must be accomplished without excessive effort.

The roller shaft, the cover and the steering arm.

Adjustment of roller and worm gear bearing.

The correct functioning of the mechanism requires that the distance between roller and worm gear be as small as possible and corresponding to the original specifications.
To this end, after mounting the unit and positioned the steering arm as in Fig. 122 (this corresponding to straight forward motion of the tractor) the adjusting screw (Vr, Fig. 123) should be screwed on, in order to take up the play between roller and worm screw, in addition, check that this condition remains unvaried as the steering wheel is turned 30° left and right.
After adjustment, tighten the lock nut of screw Vr.

To refit the guide box assembly to tractor reverse the dismantling procedure.

After assembly, service the guide box with **SAE** 90 oil and the drag link grease nipple with chassis grease.

Steering tests.

After adjustment check the steering wheels alignment with the tractor axis: nevertheless a toe in of about 5 mm (0.1968") and a camber of 2° are acceptable.
Check tightening of the steering lever bolts and the cross tie-rod clamps and check tie-rods and levers for straightness, to avoid early front tire wear.

SPECIFICATIONS, ASSEMBLY CLEARANCES AND PERMISSIBLE WEAR OF STEERING MECHANISM (STEERING BOX), TIE-RODS AND LEVERS

	Data mm (in)	Assembly clearances	mm (in)	Wear limits mm (in)
Steering box bush inner diameter	34,905 to 34,950 (1.3742 to 1.3760)	Between steering roller shaft and its steering box bush	0,025 to 0,075 (0.0010 to 0.0030)	0,15 (0.0059)
Steering roller shaft diameter	34,875 to 34,880 (1.3730 to 1.3732)			
Cover bush inner diameter (after press fitting)	34,912 to 34,937 (1.3745 to 1.3755)	Between steering roller shaft and its bush on steering box cover	0,012 to 0,062 (0.0005 to 0.0024)	0,15 (0.0059)
Steering control roller shaft diameter	34,875 to 34,900 (1.3730 to 1.3740)			
Upper bush inner diameter of steering transmission lever	29,020 to 29,072(*) (1.1425 to 1.1446)	Between upper bush inner diameter and the steering transmission lower lever pivot	0,020 to 0,105 (0.0008 to 0.0041)	0,25 (0.0098)
Steering transmission lever pivot diameter (Section A-A, Fig. 125)	28,967 to 29,000(*) (1.1404 to 1.1417)			
Inner diameter of lower bush of steering arm	38,025 to 38,087 (1.4970 to 1.4995)	Between lower bush inner diameter and the steering arm lower pivot	0,025 to 0,126 (0.0010 to 0.0050)	0,35 (0.0138)
Steering arm pivot diameter	37,961 to 38,000 (1.4945 to 1.4961)			
Drag-link bush inner diameter	12,000 to 12,043 (0.4724 to 0.4741)	Between drag-link end bush and its pivot	0,000 to 0,070 (0.0000 to 0.0028)	0,5 (0.0197)
Drag-link pivot diameter	11,973 to 12,000 (0.4714 to 0.4724)			

Note. The steering arm upper and lower bushes shall be mounted into their seats on the support with an interference of 0,05 to 0,23 mm (0.0020 to 0.0091 in), bushes for steering box side cover shall be mounted with an interference of 0,013 to 0,063 mm (0.0005 to 0.0025 in).
Assembling torque of steering transverse tie-rod clamp screws is of 2,5 kgm (18.1 ft·lb).

(*) The data are the pre-modification ones; the post-modification ones (from Tractor with frame No. 40[illegible]51) have been increased of 1 mm (0.0394 in).

FRONT AXLE

Checking the front axle.

Removal (Fig. 124)

Place the engine sump on a stand or hydraulic jack, drain radiator water and slacken the rubber sleeves band clamps;

disconnect the drag link from the steering arm and the radiator shutter control from its front end;

disconnect the head lamp cable connection; fasten the two ends of a rope in the radiator upper section and insert wooden two wedges to stop front axle oscillation; remove the sump screws fastening its forward end to the radiator support and move the front axle assembly forward;

remove the radiator cowling and the radiator.

Dismantling.

Apply front axle to rotary stand (see Fig. 125). To strip it out refer to fig. 126.

Checking components.

After mounting the hubs check bearings which should rotate freely without any noticeable end play; check surfaces and plays of king pins and of the axle pivot pin with their bushes;

check the bronze thrust rings thicknesses and replace them if in excess of wear limits (see table on page 79).

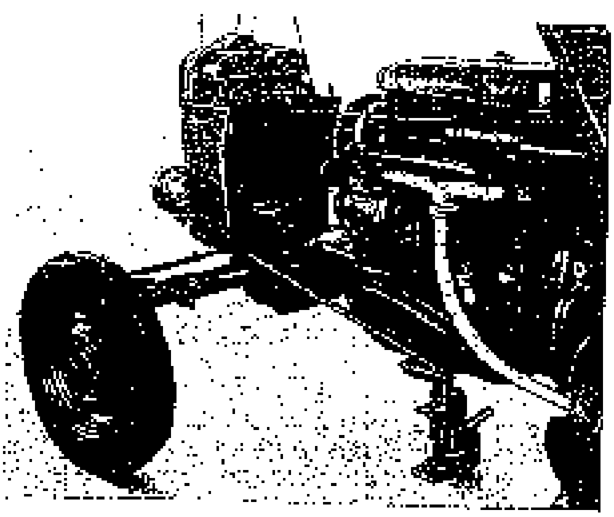


Fig. 124. - Removal of front axle and radiator from engine.

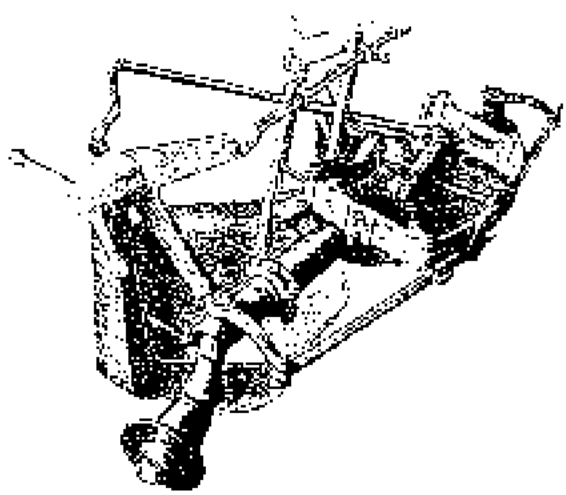


Fig. 125. - Front axle mounted on rotary stand for overhauling.

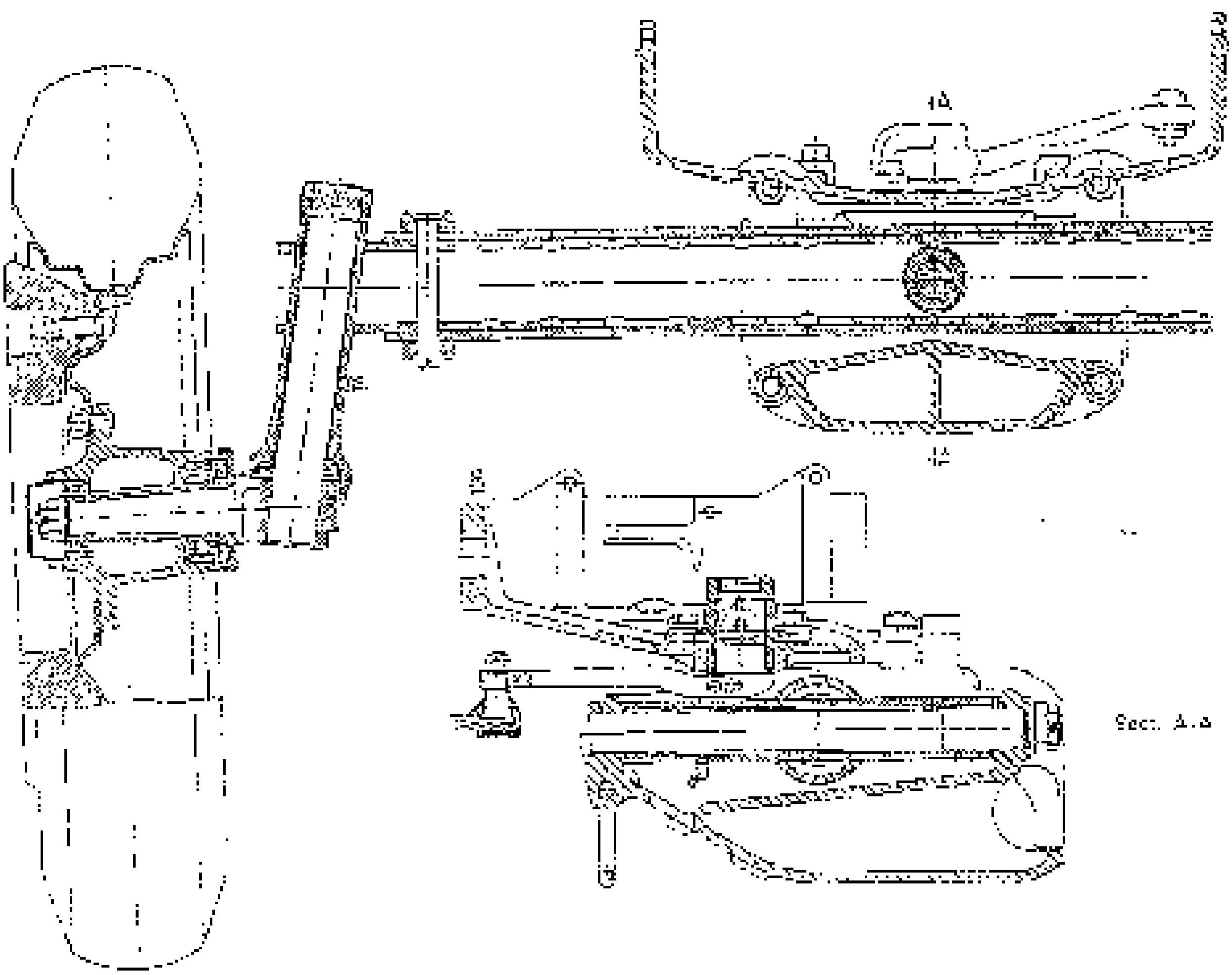


Fig. 126 - Front axle section.

Check the wheel hub cover rubber seals which must ensure protection against slush and moisture infiltration from outside into the bearing, set near to the wheel a surface gauge and rotate the wheel to check the disc and rim for deformation: this check concerns both steering wheels.

Check the camber of the steering wheels by laying a square in the vertical plane along the wheel axis, and checking if for any two opposite points on the rim, the difference between measured distances is constant:

check front tires for wear and replace them if their central steering ribs are too worn.

Assembling.

Assemble axle according to Fig. 126; no difficulty should be experienced.

Note. - *The lower bronze thrust bearing of the steering knuckle shall be installed with its lubrication passages facing one steel upper thrust bearing.*
End the assembly by greasing the hinge pivots the steering knuckles, the front wheel hub cover and the front wheel hub with chassis grease.

SPECIFICATIONS, ASSEMBLY CLEARANCES AND PERMISSIBLE WEAR FRONT AXLE COMPONENTS

	Data mm (in)	Assembly clearances	mm (in)	Wear limits mm (in)
Axle hinge pivot bush inner diameter (dimension to be obtained after bush press-fitting) (1)	32,035 to 32,087 (1.2608 to 1.2633)	Between bush and front axle hinge pivot	0,035 to 0,112 (0.0014 to 0.0044)	0,35 (0.0138)
Axle hinge pivot diameter	31,975 to 32,000 (1.2589 to 1.2598)			
Axle support thrust ring thickness	3,10 to 3,25 (0.1220 to 0.1280)			Minimum thickness 2 (0.0787)
Steering knuckle bush inner diameter (dimension to be obtained after bush press-fitting) (1)	38,025 to 38,087 (1.4970 to 1.4995)	Between bush inner diameter and king pin	0,025 to 0,112 (0.0010 to 0.0044)	0,35 (0.0138)
Steering knuckle pivot diameter	37,975 to 38,000 (1.4951 to 1.4961)			
Axle thrust bearing cup thickness	0,91 to 1,09 (0.0358 to 0.0429)	–	–	Minimum thickness 0,6 (0.0236)
Axle hinge thrust bearing thickness	3,925 to 4,000 (0.1545 to 0.1575)	–	–	Minimum thickness 3 (0.1181)

(1) Axle hinge pivot bushes and steering knuckle bushes shall be mounted into their seats with an interference of 0,06 to 0,20 mm (0.0027 to 0.0081 in).

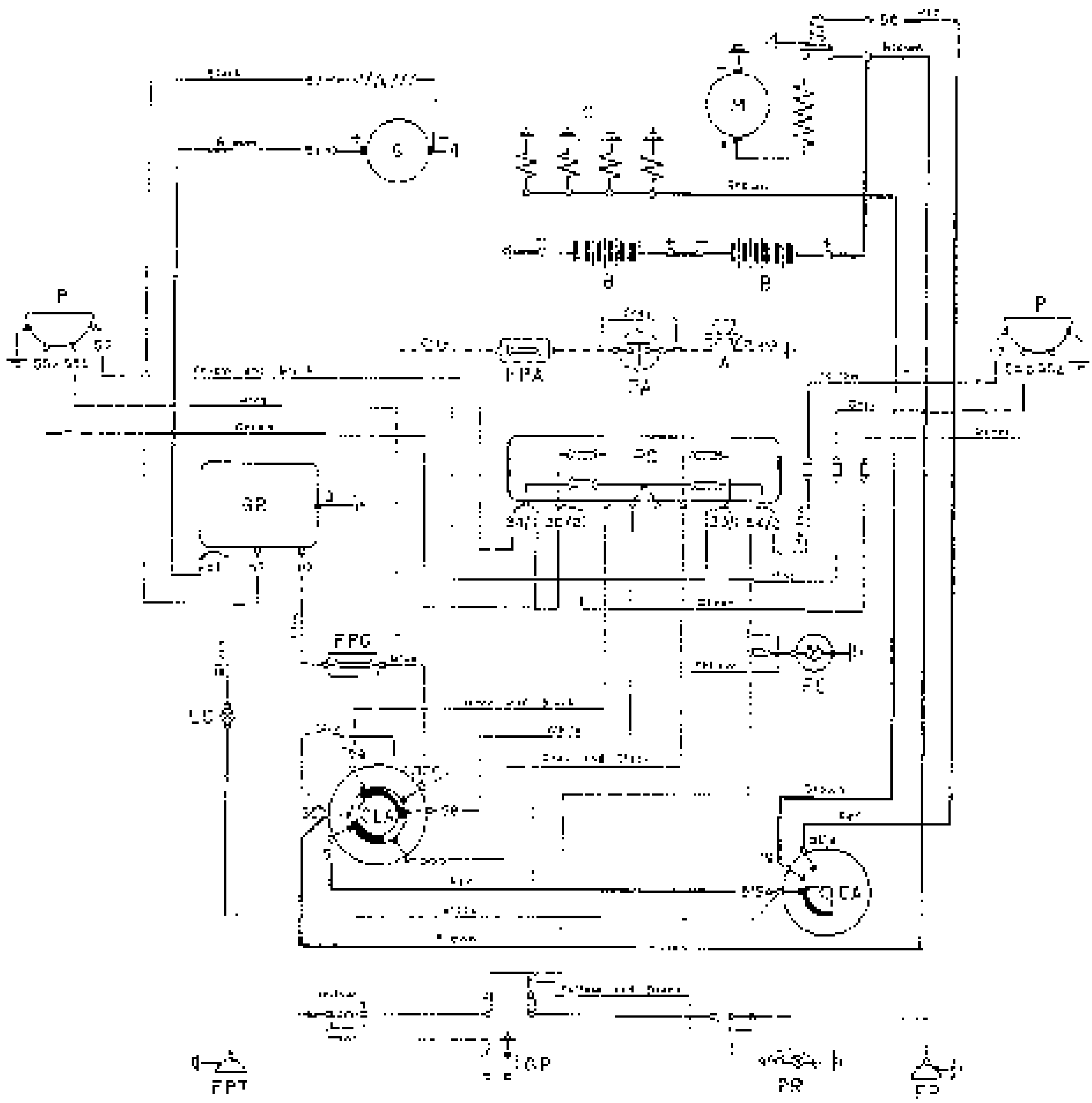


Fig. 127. - Electrical diagram of tractors series 400.

G. Generator - M. Starting motor - C. Glow plugs - B. 12 V Battery - A. Horn, optional - PA. Horn button - FPA. Horn fuse - P. Headlights, with a 50/45 W bulb - GR. Control box - PC. Fuse box - FPG. Control box fuse - LS. Battery charge warning light - PC. Dashboard lamp - CLA. Lighting and starting key switch - CA. Starting lever switch - FP. Right tail light - FPT. Combination number plate and left tail light - GP. Bipole socket - PR. Rear lamp (optional).

ELECTRICAL SYSTEM

DESCRIPTION

The tractors belonging to the **400** series are equipped with a **24 V** system, including generating, starting and lighting units. The diagram of Fig. 127 includes:

— No. 1 **Fiat** generator (type **R 115-140/24-1600 Var. 2**), **140 W**, replaced by a generator type **DC 115/24/7,3 C** starting from engine No. 005045 up.

No. 1 **Fiat** control box Mod. **A/3-140/24**, replaced by a Mod. **GP 1/24/7** unit.

CAUTION: The control box Mod. **A/3-140/24** may be used with both generator types, whilst the **GP 1/24/7** unit must be used with generator Mod. **DC 115/24/7,3 C** only. See details in the respective chapters.

No. 1 fuse (16 A) for the control box protection;

— No. 2 batteries (12 V), of 54 Ah capacity at 20 hrs. discharge, connected in series;

— No. 1 electric starter (3 Kw) equipped with a solenoid Mod. E 115-3/24;

— No. 1 five-position starting and lighting switch;

— No. 1 three-position lever type switch for starting and glow plugs;

No. 4 glow plugs (140 W);

No. 2 three-light headlamps, each with a 50/45 W bulb for driving and passing lights and a 10 W bulb for parking light;

— No. 1 dashboard lamp with 10 W bulb;

— No. 1 battery charge warning light (10 W) bulb;

— No. 1 fuse box with four 8 A fuses for equipment protection;

— No. 1 taillight with 10 W bulb;

— No. 1 combination number plate and taillight with 10 W bulb.

— No. 1 two-pole rear socket;

— No. 1 rear floodlight (optional);

No. 1 electric horn with push-button control and 8 A fuse (optional).

Lighting and starting switch.

Each position of the key on the switch corresponds to a circuit, and precisely:

position 0:	30	30/1	— All circuits off;
— position 1:	30-51	30/1	— Starting switch - battery charge warning light;
— position 2:	30-51	30/1-58	Starting switch - battery charge warning light - front parking light - dashboard light - number plate and taillights - two pole socket - 100 mm dia. floodlight with built-in switch.

C

— position 3: 30-51 30/1-58-58b — Starting switch - battery charge warning light - front parking lights - dashboard light - number plate and taillights - two-pole socket - 100 mm dia. floodlight with built in switch - passing lights.

— position 4: 30-51-50a 30/1-58 — Starting switch - battery charge warning light - front parking lights - dashboard light - number plate and taillights - two-pole socket - 100 mm dia. floodlight with built-in switch - driving lights.

The key can be removed when at position 0 only.

Starter switch.

The starting switch operation is dependent upon the position of the combination lighting and starting switch.

Each position of the lever on the switch corresponds to a circuit, and precisely:

— position 0: 15/54 — All equipment off.

— position 1: 15/54-19 — Glow plugs.

— position 2 15/54-19-50a — Glow plugs + starting.

The lever returns automatically to position 0 from levers 1 and 2.

Fuses.

The equipment belonging to the electrical system is protected by four 8 A fuses contained in a box placed near the dashboard and by two other fuses.

— Fuse 54/1 protects: L. H. side front parking light - R. H. side taillight - 100 mm dia. floodlight with built-in switch.

— Fuse 30/2 protects: Driving lights.

— Fuse 30/1 protects: Passing lights.

— Fuse 54/2 protects: R. H. side front parking light - dashboard light - L. H. taillight and number plate light - two-pole socket.

— Other fuses
- 16 A: protects the control box;
- 8 A: protects the electric horn (optional).

The generator with spy-light, the starter and the glow plug circuits are without fuse protection.

Find the cause of fuse failure prior to replacing a fuse.

GENERATOR TYPE R 115-140/24-1600 Var. 2

Specifications. PULLEY: Fiat 563730 (O.D 100 mm)

Fiat generator type **R 115 - 140/24 - 1600 Var. 2** (see fig. 128) having the following specifications, has been mounted up to engine No. 205044; it has then been replaced by generator type **DC 115/24/7.3 C.**

Maximum continuous output (24 V)	140 W
Maximum continuous current output (Ampère-limitation at 28 V)	4,75-5,25 A
Speed at maximum continuous current output, at 24 V and 20° C (68° F)	1400-1600 R.P.M.
Maximum continuous speed	4000 R.P.M.
Excitation	shunt
Direction of rotation, as viewed from driving side	clockwise
Regulator group type	A/3 - 140/24

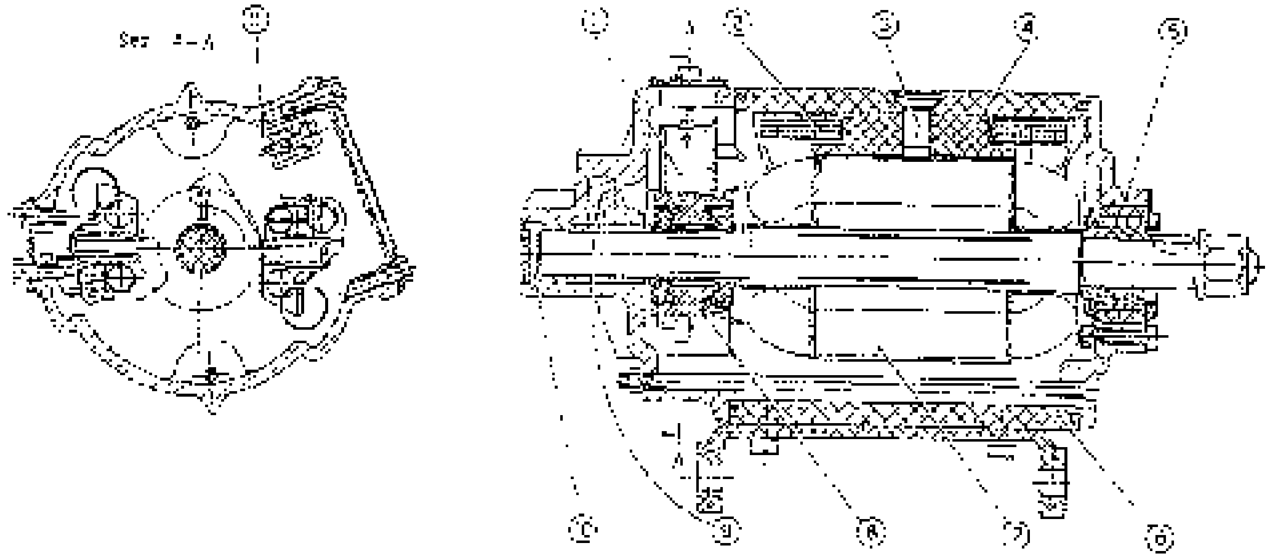


Fig. 128. - Sectional view of generator type R 115-140/24 - 1600 Var. 2.
1. Rod of brushes - 2. Field coils - 3. Pole shoe fastening screw - 4. Pole shoe - 5. Driving side support - 6. Frame - 7. Armature - 8. Commutator - 9. Lubrication wick - 10. Lubrication chamber - 11. Field coil terminal.

Bench testing the generator.

Test generator efficiency, according the checks listed hereafter.
Generator should always function coupled with regulator type **A/3 - 140/24**

Generator tested as a motor.

The arrangement consists in connecting terminals 51 and 67, short circuited, as shown in Fig. 129.

Generator shall be fed as an electrical motor at 24 V. Check that absorbed current, under such a voltage, is 3-5,5 A at 550-1150 R.P.M.

As test is finished, immediately disconnect terminals 51 and 67 (short circuited), to avoid damaging the field coils as generator speeds up.

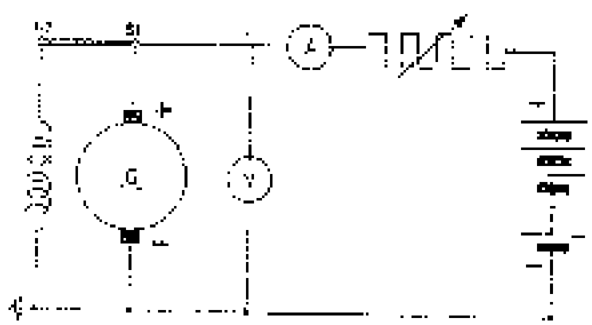


Fig. 129. - Wiring diagram for testing the generator as a motor.
G. Generator - V. Voltmeter 30 V top reading - A. Ammeter, top reading. (Battery should supply slightly more than 24 V, as current is 7 A)

Checking generator output (constant voltage).

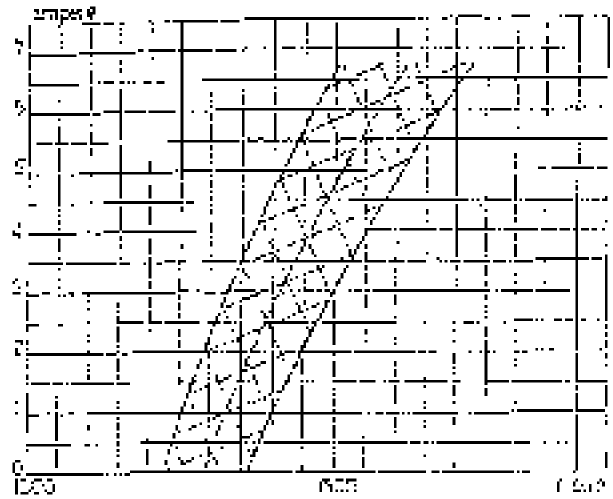


Fig. 130. - Output curve of generator type R 115 - 140/24 - 16/3 Var. 2 when warm.

(Cut-in speed at 24 V : 1250-1350 R.P.M.).

The output curve shown in Fig. 130 has been obtained with generator heated after a period of operation.

Therefore, before plotting the characteristics, mount the generator on the test bench, according to diagram of Fig. 131; run it through a motor for about 30 minutes, at 2050 R.P.M.

The current output (5-5,5 A at 28 V) should be supplied by a rheostat.

Stop generator, and disconnect load-rheostat. Rotate generator, gradually increasing its speed until the voltmeter reads 24 V, then measure the generator speed.

Such a speed represents the cut-in speed (hot conditions) and should lie between 1250 and 1350 R.P.M. (points on abscissa - diagram of Fig. 130).

Stop the generator, insert the load-rheostat, and maintaining constant the voltage, check against the various speeds the current values included in the cross-hatched area of diagram in Fig. 130.

Diagram plotting should be made rapidly when generator performance is beyond its rated output and therefore overload might damage it.

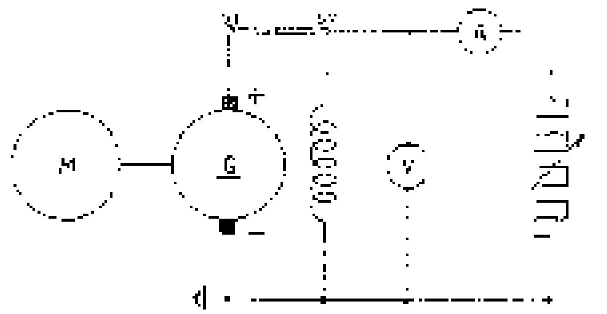


Fig. 131. - Wiring diagram for the output curve plotting (ampère versus R.P.M.) at a constant voltage of 24 V.

M. Generator actuating motor - G. Generator - V. Voltmeter, 30 V top reading - A. Ammeter, 20 A top reading.

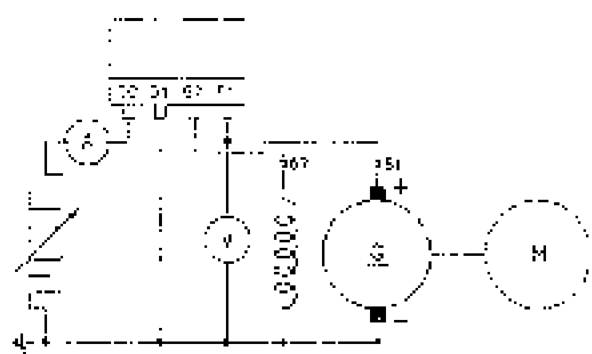


Fig. 132. - Diagram of connections to check generator heating.

M. Generator actuating motor - G. Generator - V. Voltmeter, 30 V top reading - A. Ammeter, 10 A top reading.

(The regulator group to be coupled to the generator should be of the A12 - 140/24 type)

Temperature test.

If in doubt as to the maximum temperature of the generator during operation mount it on the test bench, with pulley and regulator group, according to diagram of Fig. 132.

Run generator during 45 minutes at 2050 R.P.M. and during 15 minutes at 4000 R.P.M. supplying to a resistor a current of 4,95 to 5,55 A at 28 V.

Overheating measured by pyrometer, should be:

— on generator frame: 45° C (113° F), or less;

— on commutator: 90° C (194° F), or less.

Checking ohmic resistance.

Field-winding resistance at 20° C (68° F) should be 14.5 to 15.5 ohms, and may be measured between terminal 67 and ground, when generator is assembled.

Armature resistance at 20° C (68° F) is 0.520 to 0.545 ohm; it should be measured only exceptionally to avoid damaging the commutator bars, owing to the soldering of two pieces of wires spaced of 180°.

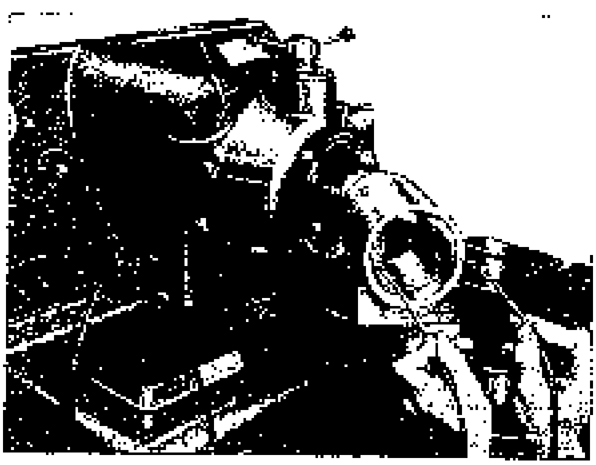


Fig. 133 - Field winding test.
(Connect the measuring instrument ends to terminal 67 and to ground)

Disassembly.

Proceed as follows:

— remove the commutator head, disconnect terminal 67, unscrew and remove the through-bolts;
— remove commutator end bracket and slide out the armature with the other bracket;
— clamp armature in a lead-jaw vise and remove the drive pulley and the remaining bracket.

Troubles - Repairs.

Battery charging faults may be due to:

— faulty generator;
— other trouble in the system.

Make sure to locate trouble first. The tell-tale lamp may furnish an indication with engine stopped or running at different speed rates.

If the generator is faulty, the cause may be sometimes found elsewhere, and particularly in the regulator group or in the circuits; therefore, the operator should take care of generator efficiency and also check the regulator group and the whole system in order to prevent repetition of the generator trouble after its reconditioning.

The battery charge spy lamp may be helpful to detect trouble. If when introducing the starting and lighting key, and setting it on position 1, the battery signal lamp remains lighted, the generator is normal; if engine is being started and accelerated to a given speed, the light should go out.

If, on the contrary, the lamp goes out only when engine has reached high speeds, the trouble may be due to faulty windings (grounded or short circuited), or to the armature.

Generally, the higher the R.M.P. rate at which the charging begins, the higher the potential damage.

If the lamp remains lighted, this indicates an interruption between the generator cables and the regulator group; or shows that the group contacts are oxidized, and internal connections dissoldered; or that some generator coil is interrupted, or completely grounded.

If the above procedure leaves the light out and the trouble persists also after replacing the bulb this signifies that the trouble is to be found between bulb holder and switch, or between switch and the connections of the components branched upon it.

When the battery indicator light goes out to go on again the engine speed being steady the fault is probably due to the regulator group or lines or to the electric connections (the jacks).

Generator repairs are to be carried out as follows:

a) *Brushes.*

If broken, chipped, or worn out, replace them with spare parts furnished by the FIAT Company - Sezione Ricambi. Be sure to avoid the installation of other brush makes, as FIAT spares only can ensure a regular and long lasting operation of both commutator and generator.

b) *Field-winding*

Check field coils by circulating test bench current through them (Fig. 133) and measuring the voltage and the current with the bench instruments, then calculating the coil's resistance.

If connections alone are interrupted, repair them carefully; but if the winding is damaged replace the assembly with a new FIAT spare. We do not suggest making field coils, as a special procedure is required.

Pole-shoe screws should then be fully tightened to set the air gap at its previous value. Reboring of pole-shoes must never be resorted to. If the air gap (see table on page 87) is not obtained, we advise warming up somewhat the coils, which are already shaped, to facilitate their installation.

c) *Armature*

Commutator. — If commutator bar surface contacting the brushes is worn or out-of-round, turn down the commutator. Be careful when fixing the armature in a lathe and centering it, as the installation of armature assembly between centers is not possible. Commutator centering should be most accurate, as commutator out-of-round, measured on brush ways should not exceed 0.01 mm (0.0004"). After commutator turning, undercut the mica between bars using a saw blade to a depth of 1 mm (0.0394").

Armature winding. — If damage is in the armature winding, replace the whole assembly. It is not advisable to attempt making a new coil, as a special procedure would be required. Armature checks are to be made with the instruments illustrated in Figs. 134 and 135.

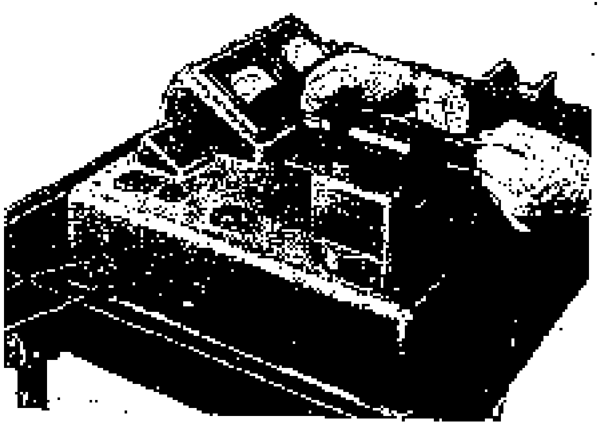


Fig. 134. - Checking the armature with twin-contact tool.

(The interruption is located by the no indication of the ammeter)

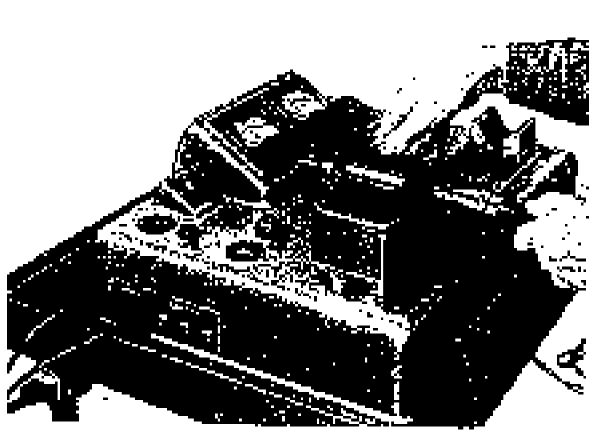


Fig. 135. - Checking the armature on the testing apparatus using a blade.

(Blade vibrates at short circuits).

Reassembly of generator.

After any repair or replacement and before reassembling the generator proceed as follows.

a) blow away all dust — chiefly carbon dust — from all components, using an air jet;

b) clean brush holders and the commutator end bracket from grease and carbon dust deposits, using a dry cloth;

c) clean commutator surface, removing carbon dust between bars. Avoid using emery paper or cloth soaked with gasoline or solvents.

d) check brushes for play inside brush-holders, against the values listed below:

— cross clearance . . . . 0,1 to 0,3 mm (0.0039" to 0.0118")

— end clearance . . . . 0,2 to 0,5 mm (0.0078" to 0.0197")

e) check brush spring pressure which should be 69 to 76 kg (1.521 to 1.675 lb.);

f) service with high melting point grease the ball bearing, the commutator end bracket bush and the recess at the end of the bushes (10, Fig. 128) and replenish with oil **SAE 50 HD** the wick of the same bracket.

The sequence shown in the chapter « Covering disassembly » should be reversed to reassemble the generator. Mind that when assembling the drive end bracket its introduction may be facilitated by holding laterally both brushes and springs.

After reassembling, repeat the functional checks as shown in paragraph « Bench testing the generator ».

FIAT GENERATOR R 115-140/24 - 1600 Var. 2 - SPECIFICATIONS

Items	Values
Operational test as motor	Speed . . . r.p.m. 950-1150 Voltage . . . 24 V Current . . . 4-5,5 A
Running generator before plotting of the curve (hot conditions — duration: 20 minutes): amp. versus revs . . .	Speed . . . r.p.m. 2000 Voltage . . . 28 V Current . . . 5-5,5 A
Heating test	Running . . . . at 45 min. at 2000 r.p.m. — for 15 min. at 4500 r.p.m. Output current . . . 5,83 ± 0,3 A Voltage . . . 28 V Commutator temperature increment . . . not more than 90° C (194° F) Casing temperature increment . . . not more than 45° C (113° F)
Resistance, at 20° C:	
— field-coils	14,8-15,5 ohm.
armature	0,539-0,546 ohm.
Commutator bar maximum allowed out-of-round . . .	0,01 mm (0.0003")
Brush duration	1500-2000 hours
Pressure by springs on brushes (new)	0,69-0,76 kg (1.521-1.675 lb.)
Brush cross clearance inside brush-holders . . .	0,1-0,3 mm (0.0039"-0.0118")
Brush end clearance	0,2-0,5 mm (0.0078"-0.0197")
Diameter between pole shoes middle line . . .	70,6-70,9 mm (2.779"-2.791")
Air gap	0,28-0,407 mm (0.0110"-0.0160")
Tightening torque of drive pulley nut . . .	7 kgm (50.63 ft.-lb.)

GENERATOR TYPE DC 115/24/7/3 C

PULLEY: N° 272725 (Ø 88 mm)

Specifications.

The generator type **DC 115/24/7/3 C**, illustrated in Fig. 136, has been mounted beginning from engine No. 005049; its specifications are:

Voltage	24 V
Maximum continuous current (ampère - limited)	7 A
Maximum current	8,5 A
Maximum continuous power	196 W
Maximum power	238 W
Cut-in speed, 24 V, 20° C (68° F)	1550 to 1650 R.P.M.
Speed of maximum continuous current, 7 A, 20° C (68° F)	1725 to 1875 R.P.M.
Speed of maximum current, 8.5 A at 20° C (68° F)	1770 to 1930 R.P.M.
Maximum continuous speed	5600 R.P.M.
Rotation (from drive side)	clockwise
Excitation	shunt
Regulator group type:	A.3-140/24 GP 1/24/7

Main features of this generator compared with the preceding one are: completely enclosed, more power, reaction type brushes.

Reaction brushes are advantageous, as vibrations against the brush-holders are reduced, compared to the radial type.

For equal brush sections, they allow a larger contact surface on the commutator, thus reducing both sparkling and temperature; the excitation current, also, is reduced, and the regulator group contacts, voltage and current regulators, have longer life.

When the generator is coupled to regulator group **GP 1/24/7**, starting (cold), it may generate a current greater than the maximum one; but it is reduced when the internal continuous running temperature has reached appropriate levels (thermal equilibrium), without any damages to the components.

The feature is due to the current regulator, which, as explained when describing the regulator group, is thermostabilized.

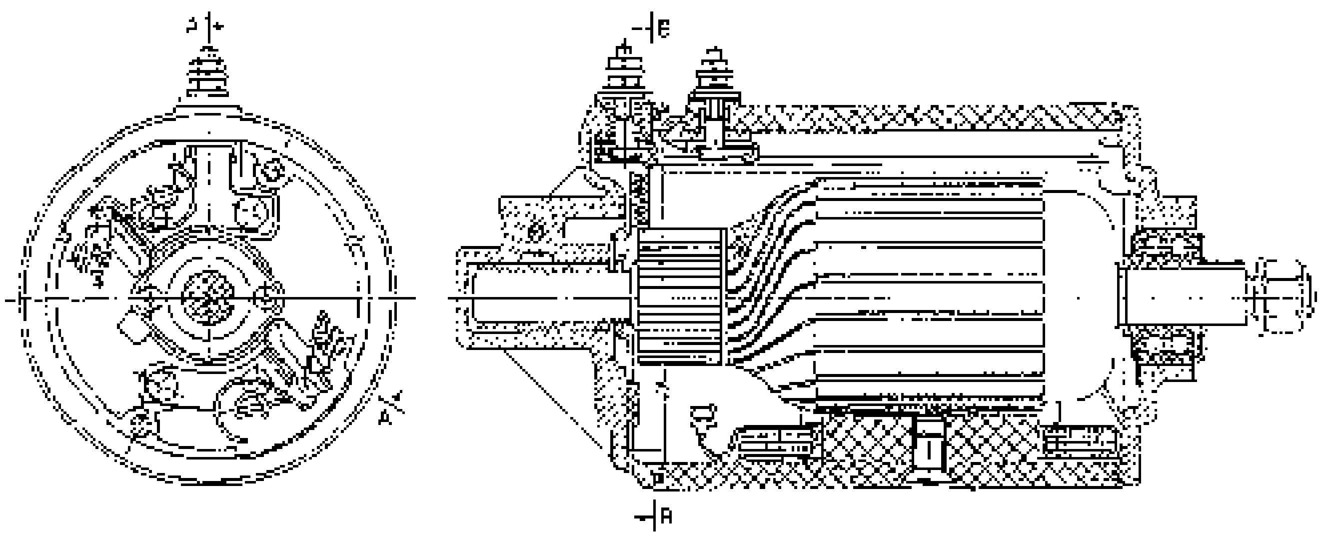


Fig. 136. - Longitudinal and cross section of generator type DC 115/24/7/3 C.

Note: A bracket is fastened by screws (not represented in the figure) to the generator frame. Bracket must be required separately.

Therefore if required by the equipment inserted in the system, the generator may be overcharged without any damage to windings: in fact, they are at ambient temperature at the start of operation and therefore are not yet thermally stabilized.

When, after 20-30 minutes of functioning, due to ohmic resistance, the group and generator become stabilized, the current regulator reduces the current to a value continuously possible.

The temporary overcharged operation of the generator allows a quicker battery recharge, especially if its charge level is low, due to repeated and cold startings.

The limiting current is a function of the surrounding temperature; and therefore during the summer the limiting current will be less than during the Winter, and the generator temperatures during the various seasons are more uniform.

Checking the generator: troubles and remedies.

Consult diagrams of Figs. 129-131-132 for the generator checks, and for the coil check the Figs. 133-134-135.

Tests to be carried out as for generator type R 115-140/24-1600 Var. 2. For specifications, see table on page 89.

Plotting the output curve (Fig. 137), requires the previous inspection of the brushes, that should be completely seated upon the commutator, which takes place after ten hours of operation, with a current output of 7 A at 2300 R.P.M.

See page 85 for the generator trouble - shooting and repairs.

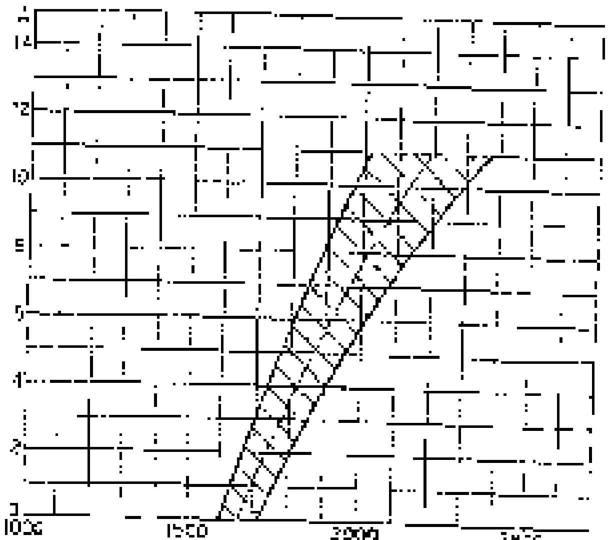


Fig. 137. - Output curve of generator type DC 115/24/7/3 C. (Beginning of battery charging, at 24 V, 1350-1550 R.P.M.)

GENERATOR FIAT DC 115/24/7/3 C - SPECIFICATIONS

Items	Values
Operational test as motor	Speed . . . 1100-1250 r.p.m. Voltage . . . 24 V Current . . . 4.5-6.5 A
Running generator before plotting of Amp. output curve (for conditioning, duration 30 minutes)	Speed . . . 2300 r.p.m. Voltage . . . 28 V Current . . . 6.75-7.25 A
Heating test	Running { of 45 min. at 2300 r.p.m. / of 15 min. at 5000 r.p.m. Output current . . . 6.75-7.25 A Voltage . . . 28 V Commutator temperature, not more than . . . 90° C (194° F) Casing temperature, not more than . . . 60° C (140° F)
Resistance at 20° C (68° F) ohm:	
— Field-coils (between terminal 67 and ground)	15.5-15.9 Ohm
— Armature	0.30-0.32 Ohm
Commutator bar maximum allowed out-of-round	0.01 mm (0.0004")
Brush end play with respect to holders	0.1-0.4 mm (0.0039"-0.0157")
Pressure by springs on brushes (new)	0.60-0.75 kg (1.32-1.65 lb.)
Diameter between pole shoes middle line	70.5-70.75 mm (2.775"-2.785")
Air gap	0.3-0.45 mm (0.0118"-0.0177")
Tightening torque of drive pulley nut	7 kgm (50.5 ft lb.)

CONTROL BOX MOD. A/3 - 140/24

Description.

The Fiat **A/3-140/24** regulator unit contains three elements: voltage regulator, current limiting regulator and circuit-breaker. These three elements (Fig. **138**), fastened to the block, are enclosed in a sealing cover, equipped with gasket, which prevents shocks, dust and dampness.

Note. - A distinction will be made in the text between modifications made on regulator units with numbers up to 098917 and on those with numbers starting 098918 up: the numbers are marked on the cover.

Figs. **139** and **140** represent voltage regulator and circuit breaker: the current limiting regulator looks quite similar to the voltage regulator.

Fig. **141** represents the wiring diagrams of the regulator units mounted on tractors series 400 and bearing the production number up to 098917 and from number 098918 up. The diagrams have thick lines to represent the coils in series on the generator recharge circuit, to differentiate them from the shunted ones on the same circuit.

All armature stops are of the spring blade type, and adjust their load according to the calibration value, through the screw located at each regulator unit element side.

The temperature increment due to the shunted circuit currents and deriving thermal expansion, might influence the calibration values of the voltage regulator and of the circuit breaker. This is prevented by the contact hinges, which, being bimetallic, are thermally compensated.

The group bears the following terminal numbers:

— **51** - connected to positive generator terminal;

— **67** - connected to generator field coils;

— **31** - grounded;

— **30** - connected to the battery positive terminal and to electric system.

The wiring diagram of Fig. **127**, points out the valve (FPG) protecting the regulator group.

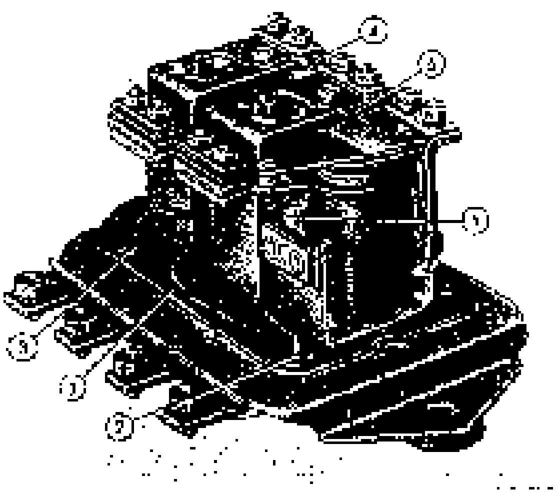


Fig. 138. - **Regulator unit (from no. 098918 up) as seen from the circuit breaker side.**

1. Terminal 31 - 2. Terminal 51 - 3. Terminal 30 - 4. Voltage regulator to current regulator connection - 5. Current regulator series winding terminal soldered to circuit breaker - 6. Current regulator fixed contact connection with the regulating resistance.

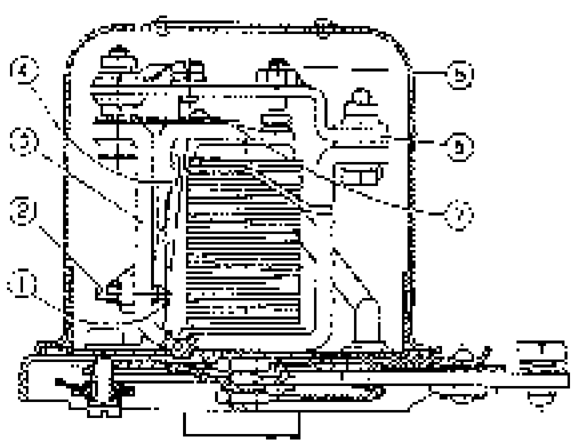


Fig. 139. - **Cross section of regulator unit (section shows voltage regulator).**

1. Armature adjustment spring - 2. Calibration screw - 3. Voltage regulator body - 4. Armature - 5. Fixed contact holder screw - 6. Fixed contact bridge - 7. Hinge spring (the bimetallic blade is located on top).

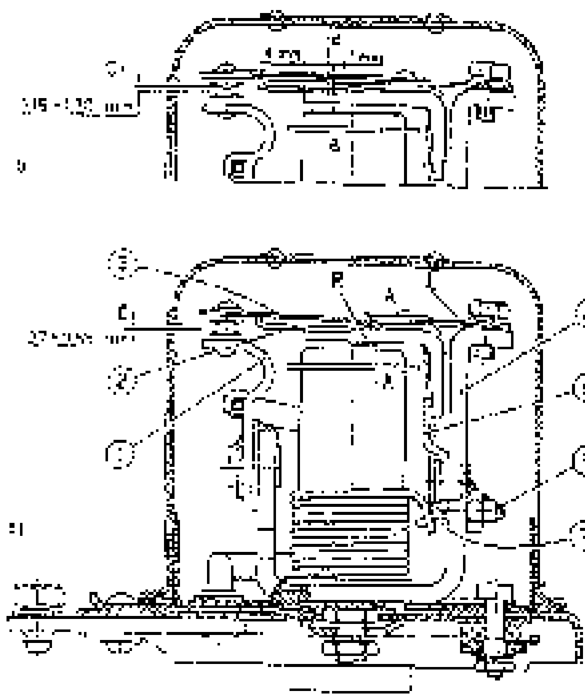


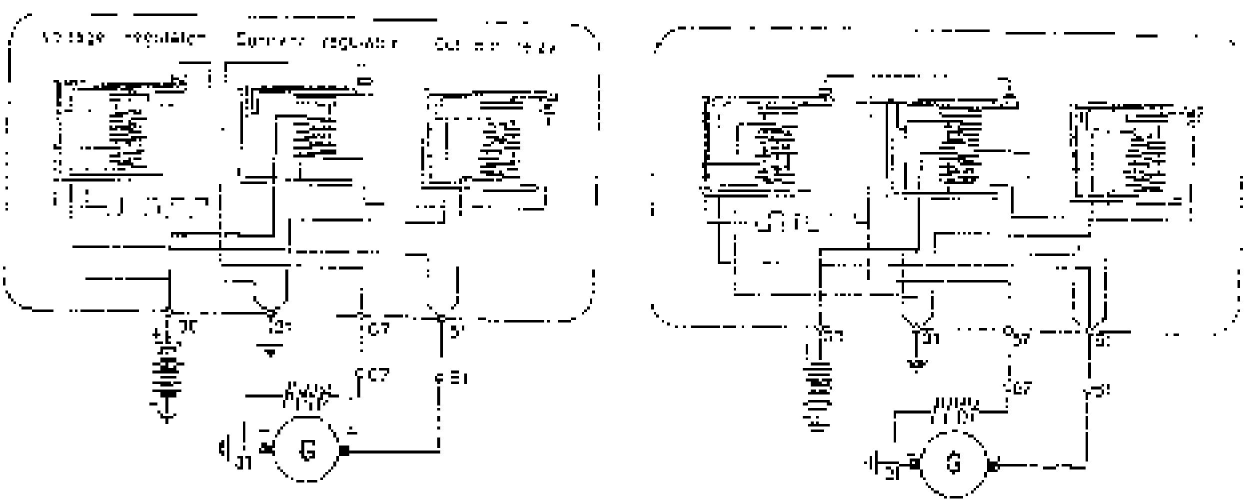
Fig. 140. - Cross section of regulator group. (Across circuit breaker)

1. Fixed contact bracket - 2. Pre load shim - 3. Hinge spring (steel) bearing mobile contact - 4. Body - 5. Armature stop - 6. Calibration screw - 7. Adjustment spring - L. Thermal compensation bi-metallic blade - (a). Up to No. 038917 - b. From No. 038918 up). - R. Armature rivet - C. Contact gap 0.7-0.85 mm (.00275-.0334") for armature, fitted with rivet R for rivetless armature, the clearance between contacts is 1.15-1.20 mm (0.0452-0.0472")

The wiring diagram of Fig. 127 shows the regulator group fuse.
The diagram of Fig. 142 represent the characteristics of the post-modification and the pre-modification groups. The junction zones between the two hatched strips, represents the functional limit between voltage regulator and current regulator.

Important.

1. The regulation group type A/3-140/24, should function only with generator type R 115-140/24-1800 and type DC 115/24/7/3 and derived.
   The group shall never be used with a third brush generator even if of size corresponding to the generator prescribed above; the elimination of the third brush would not change things; even worse it would be to connect a third brush generator as if it were controlled by a regulation unit.
   The reason is that both groups and generator circuits, mainly the field coils of the generator, that are so reciprocally arranged as to get the best performance for the whole combination.

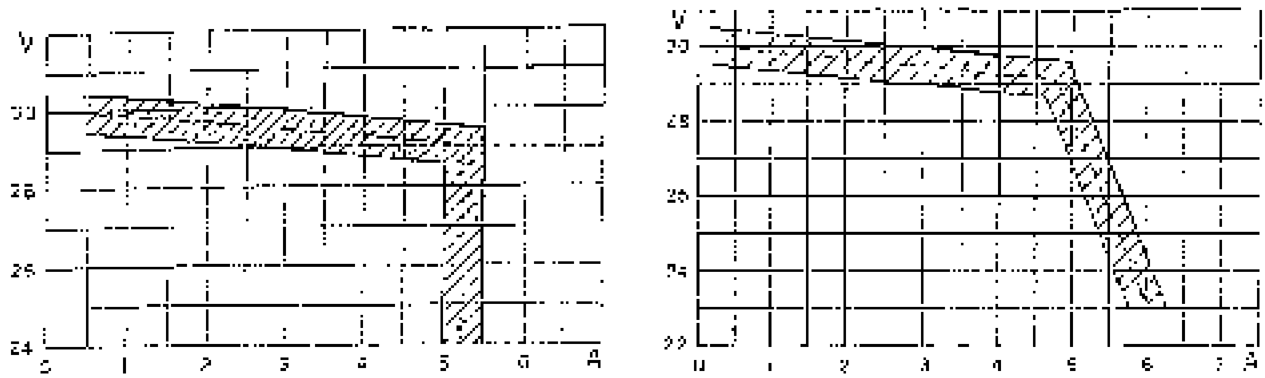


a) up to group No. 038917

b) from group No. 038918

Fig. 141. - Regulation unit type A/3 - 140/24 electric diagram.

(As group is at rest with generator running at low speed the voltage regulator and current regulator contacts are closed - also those of the circuit breaker are open.)



a) Characteristic obtained as generator runs at 2000 R.P.M., for regulation group up to No. [illegible]

b) Characteristic obtained as generator runs at 2000 R.P.M. for regulation group from No. 089418 up

Fig. 142. - Output characteristic on battery, with group at 50 ± 3° C (122 ; 37.4° F).

2. Avoid connecting group terminal 67 to generator terminal 51, even momentarily, because heavy sparkling and group contact oxidation would follow and contact welding would also eventually follow. It is thus indispensable to connect terminals having the same number; as even if wrong connections are eventually corrected and the group functions regularly, it's usefulness would be nonetheless shortened.

3. Shocks to regulator unit should be avoided, especially to its lower part containing the adjustment resistance (Fig. 146). During the bench-testing the group shall be mounted with its terminals placed downwards, and an insulating sheet shall be interposed between the fastening support and the base.

4. Connection between group terminal 31 and tractor grounding shall be well secured, otherwise the regulation effect would fail as both the current and the shunt coils are lacking. This case allows the generator to increase its voltage as speed increases and windings are burned and voltage regulator and cut-out contacts are damaged, owing to excess of current excitation of the generator.

Regulator group bench testing.

To avoid miscalculations, the regulator group performance data must be measured by instruments periodically calibrated and according to the prescribed rules and methods.
No removal of group seals is allowed for taking such measurements.

Checks.	*Operations and cautions.*
	Test efficiency of regulator group as follows:
	a) a test bench will be provided with a FIAT P 115-140/24-1600 Var. 3 or FIAT DC 115-24/7/3 C generator, coupled to a motor whose speed may be gradually stopped;
	b) installation should have the measuring devices and instruments, concerning the testing of cut-out relay, current and voltage regulators according to instructions and rules hereafter.
Cut-out relay.	*c) Closing voltage.*
	Wiring should be as shown in Fig. 143:
	— generator speed should be gradually increased:

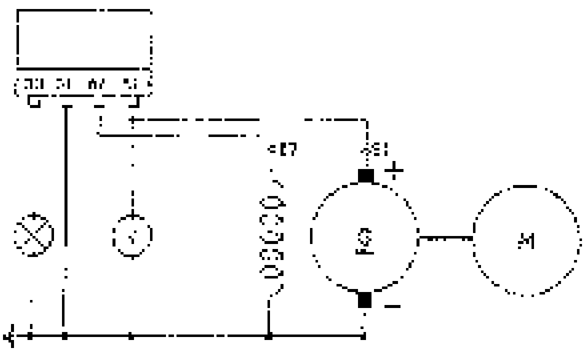


Fig. 143. - Electrical diagram for testing the cut-out relay closing voltage.
M. Motor of test bench - G. Generator - V. Voltmeter.

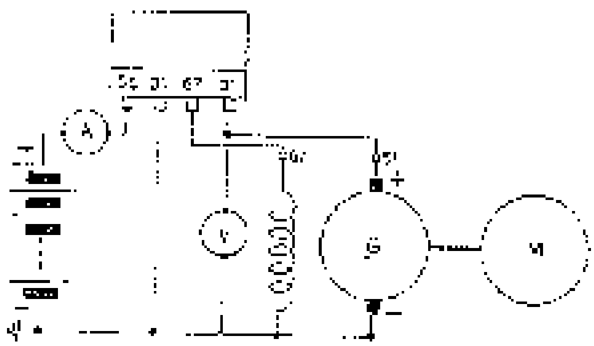


Fig. 144. - Electrical diagram for testing the inversion current.
M. Motor of test bench - G. Generator - A. Ammeter - V. Voltmeter.
(Batteries are connected in series and must be fully charged, at a capacity of 60 Ah).

— *check the voltmeter value when cut-out relay closes; it must be read at the moment the lamp of 24 V, 5 W, lights: insert lamp between terminal 30 and ground.*

Closing value must be 25,1 to 26,9 V, for both pre-modification and post-modification groups. Checks should be made when cold, before coil temperature increases.

2) Back current at 25 ± 10° C (77 ± 50° F).
Wiring should be made according to Fig. **144** *and generator run to 2050 R.P.M. during about 5 minutes, making sure that voltmeter reads at least 30 V, then decrease the generator speed.*

The ammeter pointer which was indicating a certain charging current will decrease and approach to zero and begin to show the inverted current value.

As the generator progressively slows down the ammeter dial will show increased values, up to a certain limit, after that a sudden fall to zero will be observed, due to the opening of the cut-out relay points. Such a current value will be not larger than 3 A for groups having production number up to 683917 and within 5 to 10 A for groups from number 683918 up.

Note. - *Such a test should be carried out quickly to avoid battery discharge. When repeated start from a stopped generator.*

Voltage regulator.

Regulation voltage at half load on batteries, at 50° ± 3° C (122 ± 37.4° F).

Close the cover and connect it according to the diagram of Fig. **145** *and operate the group until the coil temperature reaches 47 to 53° C (117 to 127° F).*

Start the generator and slowly run it up to the speed rate of 3000 R.P.M.;
adjust rheostat so that generator delivers a current of 4 A (half-load current);

Check that at such current value, the voltage is about 26,7 to 28,7 V.

Current regulator

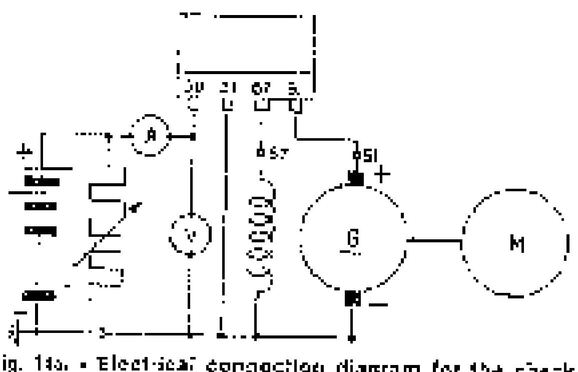


Fig. 145. - Electrical connection diagram for the checking of the voltage regulator and of the current regulator.
M. Motor of the test bench - G. Generator - V. Voltmeter - A. Ammeter.

Limitation current on batteries.
Connect group according to wiring of Fig. **145**, *and check the limitation current on batteries immediately after the foregoing test, using the same instruments: proceed as follows:*

— *rheostat should be set at its maximum resistance value;*

— *resistance shall then be reduced until the current limitation value of 5 to 5,5 A has been reached, for groups up to No. 683917, and of 4,75 to 5,25 A for groups from No. 683918 up (corresponding voltage: 28 V);*

— *said currents should not decrease when resistance is reduced, and on the contrary, voltage should go down nearly to 24 V (for groups up to No. 683917).*

For those groups with numbers from 628916 up, the resistance being decreased, the current shall increase up to 6 A, approximately, and the voltage decrease down to 24 V.

Regulator group repairs.

In most cases when the unit does not perform correctly, it is advisable to substitute it instead of attempting to repair and calibrate it.

Exceptionally, if in need of repair, follow the bench checks already described; successively, according to the data, obtained replace the resistance, Fig. 146, and faulty elements. Always replace complete units.

Components elements as well as resistances should be kept into suitable containers, which prevent their being damaged deformed, smeared by grease or foreign matter, etc.

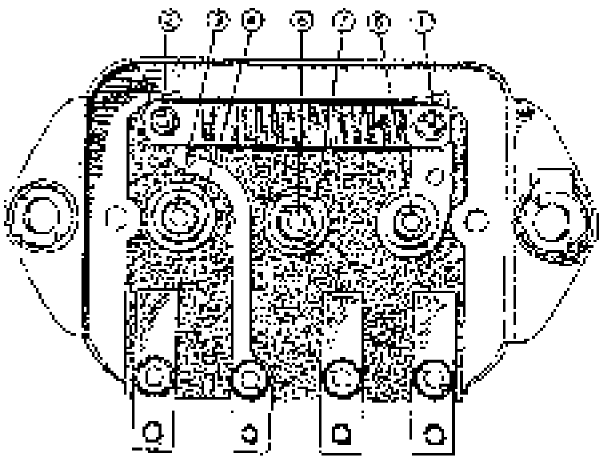


Fig. 146. - Regulator group bottom view.

1-2. Screw and nut, fastening the resistance - 3-4. Nut and cup fastening the cut out relay - 5. Nut fastening the voltage regulator - 6-7. Nut and cup fastening the current regulator

Note. - Most failures, especially the important ones, such as:

- — excessive wear, or cut-out relay contact sticking;
- oxidation of voltage and current regulator points;
- — burnt or fitted points;
- — short-circuited coils;
- — coil burning;

may be due to causes originating outside the regulator group and chiefly to generator misfunction, as, for example, to field winding resistance alteration, impaired circuits (cables, etc.).

Therefore the operator should make the group operate correctly, but in addition extend his checking to the generator and to the charging system.

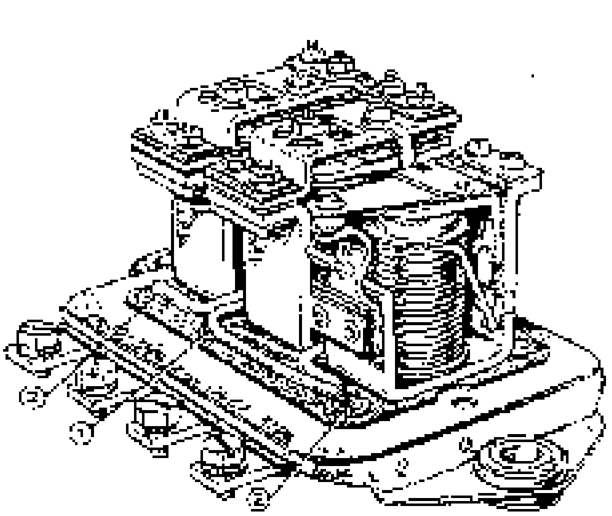


Fig. 147. - Regulator group (up to No. 628917) as seen from cut-out relay.

1. Terminal tube 31 for shunt winding end - 2. Terminal tube 51 - 3. Terminal tube 30

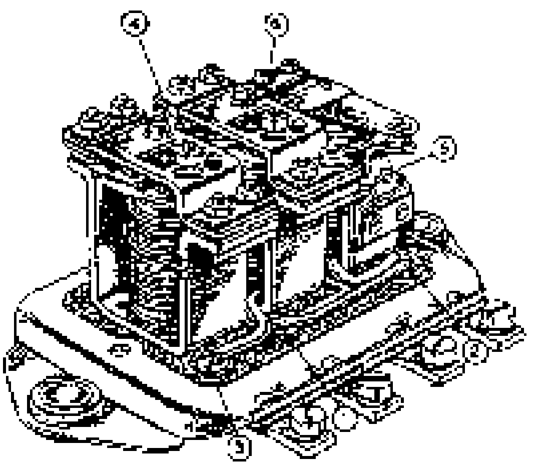


Fig. 148. - Regulator group (up to No. 628917) as seen from voltage regulator side.

1. Terminal tube 31 - 2. Terminal tube 51 - 3. Terminal tube 30 - 4. Connection from current regulator to voltage regulator - 5. Current regulator series winding end - 6. Connection of regulator to the adjustment resistance

Dismantling and reassembling of group.

Remove lead seals, unscrew the nuts fastening the cover to base, remove both cover and gasket and dismantle according to needs.

Unweld the coil terminals connected to other elements, and unscrew the nut fastening it to the base. When checking or reassembling such elements, make sure that the setting screws are not being tampered with, as during manufacturing they have been sealed with varnish.

For coil terminal soldering use exclusively a neutral flux, avoiding acids.

Carefully watch the insulating washer assembling.

Before reinstalling the group cover, make sure that:

— the open contacts distance of the cut-out relay, when at rest, is 0,70 to 0,85 mm (0.0275" to 0.0334") for riveted-type groups (R, Fig. 140), and 1,15 to 1,30 mm (0.0452" to 0.0512") for non-riveted groups;

— check the group insulation by applying 500 V at 50 cycles between the magnetic coils and the base and between terminal 30 and the base.

Mount cover when group is hot to avoid moisture condensation after closing.

CHECKING AND CALIBRATION VALUES OF REGULATOR GROUP A 3-140/24

Group	Cut-out relay (when cold)		Voltage regulation (when heated to 50°C = 122°F on battery)		Cut-out relay (when hot on battery)
	Closing voltage V	Reverse current A	Battery Ah	Regulation voltage at half load on battery V	Limitation current A
Up to No. 038917	25,1-25,9	not more than 5	60 (No. 2 batteries in series)	28,0-29,7 (with 4 A)	5-5,5
From No. 038918 up	25,1-25,9	5 to 10 (with wiring of Fig. 144)	50 (No. 2 batteries in series)	28,7-29,7 (with 4 A)	4,75-5,25

Adjustment resistance of group (Fig. 146) at 20°C (68°F) is 138-142 ohm.

CONTROL BOX MOD. GP 1/24/7 (Part No. ~~4053889~~ 4055883)

Description.

The Control Box Mod. **GP 1/24/7** is composed by three units: cut-out relay, current regulator and voltage regulator.

Both the voltage and the current regulators (Fig. 149) consist of a J-shaped body with a bend on the end of one arm and a tongue (5) on the other. An armature (2) supported by a tension spring (1) is fastened to the body (9). The spring is made of two blades lying flat on each other, one of steel and the other bi-metallic.

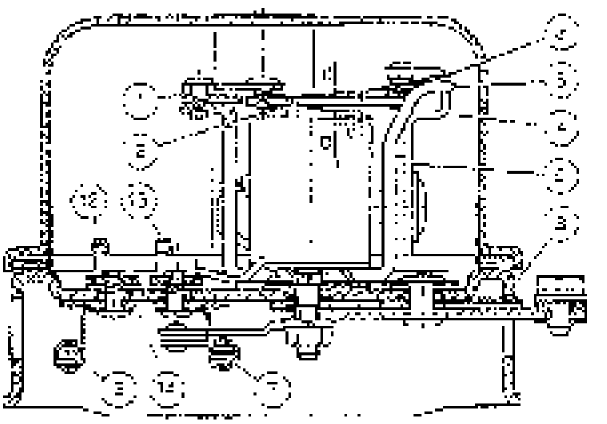


Fig. 149. - Sectional view of the voltage regulator.

e. Air gap between core extension and armature (to be measured at the position indicated by the axis 0-0 = 0,99 to 1,1 mm or 0.039 to 0.044 in).

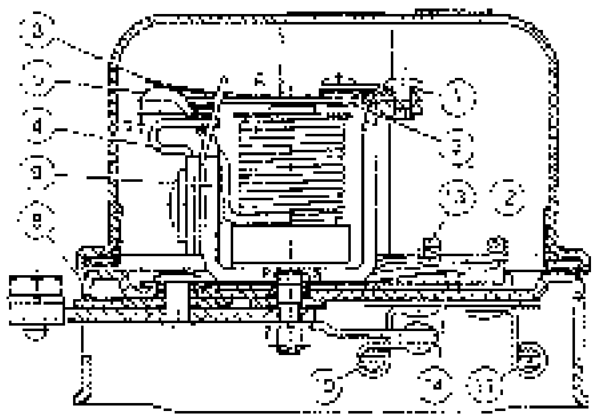


Fig. 150. - Sectional view of the cut-out relay.

d. Air gap 0,64 to 0,76 mm = 0.025 to 0.030 in.

1. Hinge spring (steel and bi-metallic). - 2. Armature. - 3. Adjusting spring. - 4. Fixed contact supporting tip. - 5. Adjusting spring supporting tip. - 6. Regulation resistance. - 7. Additional resistance in series with the shunted winding of the voltage regulator. - 8. Base. - 9. Body. - 10. Damping resistance. - 11. Additional resistance in series across the shunted windings of the current regulator and cut-out relay. - 12-13. Plates clamping the leads of the windings to the additional (7) and regulation (6) resistances. - 14. Resistance terminals insulators.

The contacts points of the elements are fixed to the armatures (2) and to a support applied to the elements. Point resetting is carried out by using a special tool on the tongues which carry the fixed contact points. The cut-out relay is similar to the other two elements and is also equipped with a hinge (1) made of one steel and one bi-metallic leaves.

The armatures of the three units are equipped with adjusting springs (3). Adjusting is done by loading the tongues (5) of the springs. The three units are fastened to the base by the threaded ends on their cores and sealed by a cover with a rubber gasket. The base is provided with three terminals, the numbers of wich are marked on the cover connected to the cables as follows:

— 51, connected to the generator positive terminal;

— 67, connected to the generator field coils;

— 30, connected to the electric system.

The following resistances are riveted under the base (Fig. 150):

— the additional resistance for the shunt winding of the voltage regulator (7) and additional resistance for the shunt winding to the current regulator and cut-out (11);

— the regulator resistance (6) connected in series to the acceleration winding (a); damping resistance (10) shunted to the generator field-winding (between the current regulator body and ground).

Operation.

At low speeds the generator voltage is not sufficiently strong to induce in the shunted windings of the control box units a magnetic flux apt to attract the armature to the cores. All armatures are therefore at rest and the cut-out contacts are open, whilst the current and voltage regulators ones are closed.

As the generator speed increases the voltage and the current output increase creating a stronger magnetic flux, when the generator reaches predetermined values of speed and voltage the magnetic flux becomes sufficiently strong to win the resistance of the tension springs and so attract the armature to the cut-out core to close the contacts. A current is then circulated from the generator positive terminal through the series windings of the units (Fig. 151) to the electric system equipped and positive terminal of the battery and returning to the negative brush of the generator.

The magnetic flux induced in the series windings is added to the one induced in the shunted windings to hold the cut-out contacts more securely closed. As a rule, after the cut-out is closed and the generator voltage keeps on raising, the contacts of the voltage reach the predetermined setting value. As the contacts open due to the magnetic flux induced by the shunt winding and acting on the armature, an acceleration winding (a) and the regulation resistance (6) are inserted in the field winding circuit of the generator. The regulation resistance lowers the current through the generator field winding and consequently the generator voltage until the voltage regulator contacts close again.

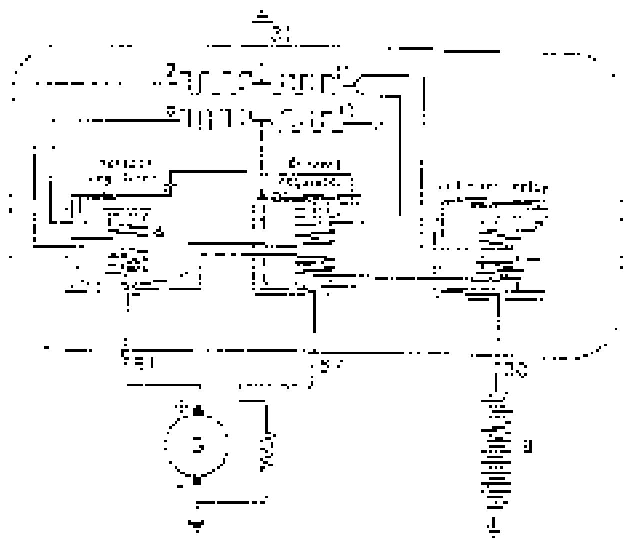


Fig. 151. - Electrical diagram of the control unit GF (24/).

6. Regulation resistance - 7. Additional resistance in series across the shunted winding of the voltage regulator - 10. Damping resistance - 11. Additional resistance in series across the shunted windings of the current regulator and cut-out relay - a. Accelerator resistance in series with the regulation resistance (6) - B. 12 v batteries connected in series - G. Generator model DC 115/24/7/3 and its modified versions - 28. Electrical equipment terminal - 31. Ground - 51. Generator positive terminal - 67. Generator field winding terminal.

(Note. The windings of the three elements of the control box drawn with light lines are shunted across the generator circuit, those drawn with black lines are connected in series)

Then the field winding current and consequently the generator voltage increase resulting in the re-opening of the contacts. This cycle repeats itself and an oscillation of the armatures is maintained to keep the voltage within the setting limits.

The function of the acceleration resistance (a) is to increase the oscillation frequency of the voltage regulator which reduces its pull on the armature (2). In fact, as the contacts open the field winding current going through the acceleration coil creates a magnetic field which is subtracted from the one created by the regulator shunt winding and therefore reduces the magnetic pull on the armature, favouring its release.

Should current consumption exceed a certain limit or the battery be discharged, a great current output will be required from the generator: this current induces a magnetic pull on the current regulator armature sufficient to close it against the action of the springs. The contacts open and insert through the generator field winding circuit the regulation resistance and the acceleration coil with the same results described above in the case of the voltage regulator. In this case it is the current which is contained within set limits. If the current output requirements remain above said limit, the current regulator armature keeps on oscillating substituting the voltage regulator one, which remains at rest.

To conclude, the current regulator limits the maximum current output of the generator, whilst the voltage regulator ensures through the system a voltage ranging within pre-determined limits (calibration limits) not harmful to the battery, for all the charging range which requires an output below the maximum values from the generator, equipment and battery.

The maximum power is reached at the operational limit between the two units (current and voltage regulators) and is also known as peak-load.

The damper resistance coil (10) protects the voltage and current regulator contacts from the sparking deriving from the electromagnetic energy of the field coils during the opening cycles by grounding part of the energy.

When the generator slows down to a point where its voltage is lower than the battery voltage, a reverse current is produced from battery to generator. This reverse current will go through the series windings of the current regulator and cut-out in the opposite direction. No consequences will derive to the current regulator, as the current is not strong enough to pull the armature, but it will demagnetize somewhat the cut-out relay which has the contacts closed, so that as soon as the reverse current will reach a certain value the armature will be released causing the contacts to open and consequently discharging from battery to generator will be prevented.

Finally note the functional importance of the bi-metallic blades which together with the steel ones make up the fastening hinges of the armatures (1, Figs. 149 and 150).

The passage of current across the shunted windings of the control box units causes a temperature rise, which produces an increment of the ohmic resistance, and consequently the quantity of current going through them is reduced. As for the armatures, the current reduction results in less magnetic pull, therefore a voltage higher than the set values would be needed in summertime to open the voltage regulator contacts and close the cut-out contacts.

To compensate the reduction of the magnetic pull on the armatures, the bi-metallic blade which makes up the hinges is so disposed as to gradually reduce the tension in the spring as the temperature rises.

In the case of the voltage regulator the action of the bi-metallic blade is more than sufficient to maintain the set voltage against the variations of ambient temperature (thermal overcompensation), therefore the setting is slightly lower in the summer and slightly higher in the winter. This setting value of the voltage which varies slightly according to the temperature favours long life of the batteries the voltage of which, when current passes through, decreases as the electrolyte temperature increases, and on its part electrolyte also is sensitive to the surrounding temperature.

Therefore, should the voltage setting of the voltage regulator not follow the requirements of the battery temperature conditions, the following trouble would develop:

— when room temperature is high, the voltage would exceed the set limits and the battery would be compelled to absorb a very strong current resulting in excessive electrolysis and consequently wear of plates, insulators, etc.;
— when room temperature is low, the voltage would be scarce and could not ensure a correct recharging rate.

Also in the current regulator, the bi-metallic blade (1, Fig. 152) which is part of the spring hinge of the armature is so disposed as to gradually reduce the tension as temperature rises.

But, as explained above regarding the other two units (voltage regulator and cut-out), as the shunt winding temperature rises the current put across it decreases and consequently also decreases the magnetic pull on the armature. When the unit is cold this results in a higher regulated current and when it is hot a lower current because of the bi-metallic blade.

The bi-metallic spring of the current regulator works as thermal compensation of the current going through it and determines the following advantages:

— at the start or after an interval of about 2 hours from the last period of operation, the control box is at room temperature (that is, not thermally stabilized) and therefore, as explained before, the regulated current is higher than the maximum continuous permissible one for the generator, and should the system require it, the generator **DC 115/24/7.3 E** can be overloaded.

  When the control box and generator temperatures rise, the bi-metallic blade reduces (in about 20 to 30 minutes) the regulated current to a value which the generator can tolerate, therefore the temporary overload of the generator not only does not damage the windings but is good for the battery particularly when the charge is low, which may happen after difficult or repeated cold starting or after the kind of work which requires repeated startings for short hauls;

— the regulated current is dependent upon the temperature of the surroundings and will be higher or lower depending upon a low (Winter) or high (Summer) temperature, which for the generator means more uniformity of temperature through the seasons.

The curve of a hot control box is plotted in Fig. 153 and as one can notice it starts with an almost horizontal line which shows that the current is maintained constant up to a certain voltage then drops quickly.

The junction area between the two strips shows the operating limit between the voltage and current regulators.

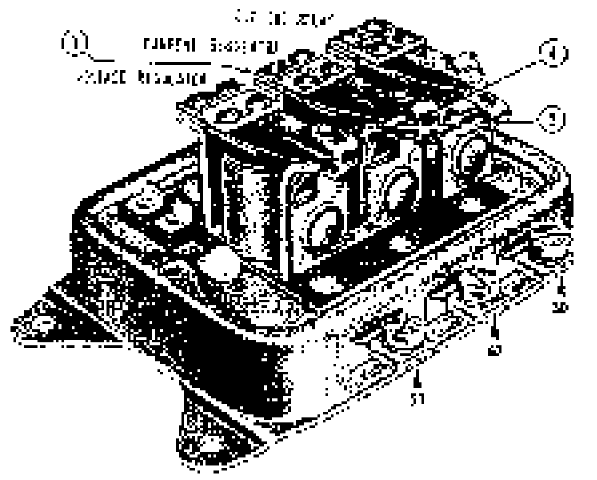


Fig. 152. - Front view of the control box.
1. Current regulator armature hinge - 4. Fixed contact support pin - 5. Adjusting spring support pin - 51-67-30. Terminals.

This regulation system takes full advantage of the generator output and maintains the battery at a good level of charging even after difficult or often repeated starts. Should the battery be discharged, it will be recharged with the maximum output current up to a high charge (28 V) and when the latter is exceeded (28.5 V) the voltage regulator intervenes to reduce the generator charge (all electrical equipment off). When the battery is charged, the delivery current is reduced to a few amperes to prevent excessive electrolysis, overheating, insulator damage.

IMPORTANT

1. - The control box mod. **GP 1/24/7** must only operate together with the generator mod. **DC 115/24-7/3**; this limitation is necessary for two reasons:

a) only the generators specified above can be overloaded at cold starting;

b) the control box has been designed to suit these generators and the field windings have been designed to suit the control box. Should the latter be connected to a different generator, the operation would be incorrect, the settings would change, the useful life of the contacts would be practically shortened and the generator would soon be put out of use.

2. - An incorrect connection of the control box terminal No. 67 with the generator terminal No. 51 produces immediately a strong sparking effect which oxidizes the contacts of the elements of the control unit, if protracted longer it consequently

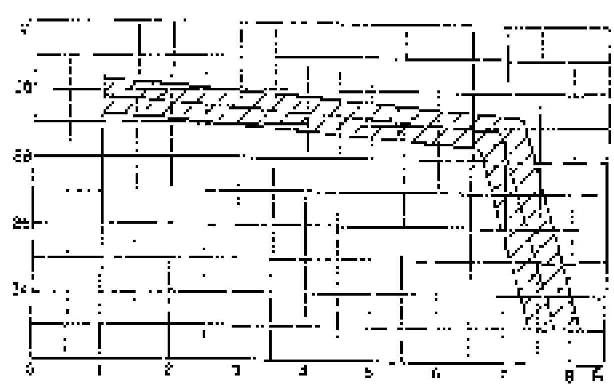


Fig. 153. - Regulation characteristics (volt-ampere) of the control box model GP 1/24/7 on the battery (curve plotted with data obtained at an ambient temperature of 50° [illegible] °C - 122° [illegible] °F and generator speed of [illegible] r.p.m.).

cause spark welding of the contacts. It is therefore absolutely necessary to connect terminals bearing the same number, keeping in mind that even if the wrong connections are corrected and the operation becomes normal again, the useful life has been nonetheless shortened.

3. – The control box should never undergo shocks of any kind, particularly the lower side which houses the resistances (Fig. 158).
During bench testing the box must be positioned with the terminals downwards, and with an insulator lining between the bench mounting and the base.

4. – The grounding connection between the control box and the tractor must be secure, otherwise there will be no regulation there being no current going across the shunt windings. In this case the generator voltage output which increases with speed (as it is not regulated) will burn the winding ends and deteriorate the voltage and current regulator contacts due to the excess of current across the field winding of the generator.

Bench testing - Instructions.

To check the performance of the control box mod. GP 1/24/7 start with the following operations without unsealing the unit:

— place on the bench a generator model DC 115/24/7.3 (regardless of modification A, B, etc.):

connect the generator to an electric motor the speed of which can undergo fine variations over a wide range and provide a 30 V battery;

— make ready the instruments and gauges necessary to the elements of the control box keeping in mind that dependable results are dependent upon the observance of the rules and procedure which will be given below.

Caution: The test must absolutely be performed at the temperature specified for each control and after at least 30 minute operation i. e., when the temperature condition specified has been reached. This requires a special oven suitable for the thermal stabilization of the control boxes. Tests performed otherwise will not give dependable results.

Cut-out relay check.

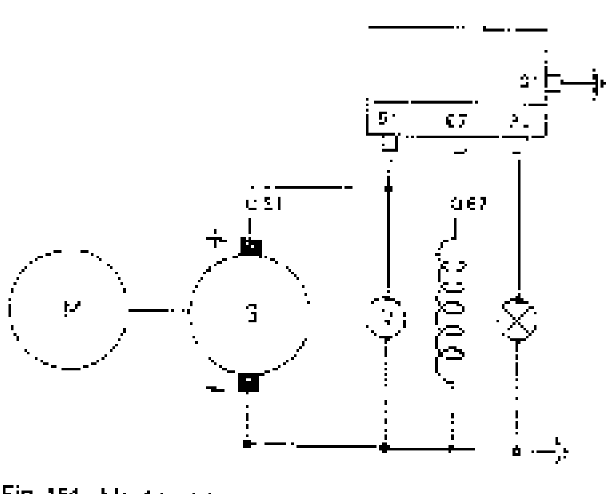


Fig. 154. - Electrical diagram of the arrangement for testing the cut-out relay contact closing temperature.

M. Test bench electric motor - G. Generator DC 115/24/7.3 and its modified versions - V. Voltmeter, 30 V for reading.

a) Contact closing voltage at 25° ± 10° C (77° ± ± 50° F) ambient temperature.

In surroundings with the temperature specified above connect the control box according to the wiring diagram of Fig. 154 and run it idle at 30 V for 15 to 18 minutes.

This preliminary operation allows the unit to reach the thermal level allowing the cut-out shunt winding and the bimetallic spring blade to reach thermal stability after an initial period during which the voltage oscillates considerably.

Immediately after obtaining thermal stability, starting from an inactive generator, gradually increase the speed to check the voltmeter for the value of the cut-out contact closing voltage, which should read 25.1 to 25.5 V when the light goes on.

b) Reverse current (in ambient temperature of 25° ± 10° C = 77° ± 50° F).

This test should be performed immediately after the contact closing voltage test, in order to keep the thermal stability reached in the preceding test.

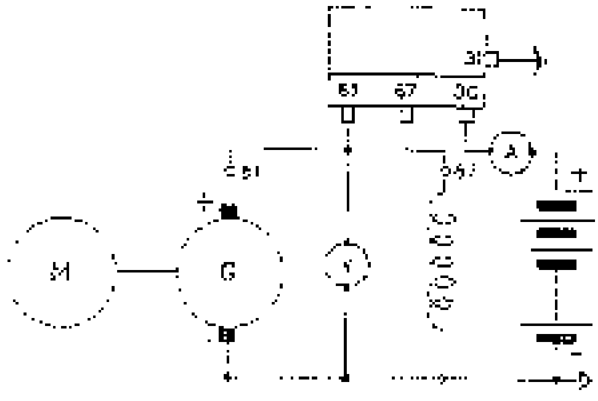


Fig. 155. Electrical diagram of the arrangement for testing the cut-out relay return current.

M. Test bench electric motor - G. Generator DC 115/24/7/3 and its modified versions - A. Ammeter - V. Voltmeter, 30 V too reading.

Hook up according to the wiring diagram of Fig. 157 and run the generator up to 3500 R.P.M., holding it at this speed for 5 minutes.

See that the voltmeter reads at least 22 V, then gradually decrease the generator speed. The amperometer indicator which had shown at first a certain amount of charging current, will gradually go to zero, then will show the reverse current on the opposite scale. As the generator speed gradually decreases, the reverse current will increase up to a given limit at which it will drop to zero (cut-out contacts open). Said limit represents the maximum reverse current value which should be 5 to 14 A.

Note. - *To repeat the test, if necessary, begin from a stopped generator to avoid incorrect readings due to residual magnetism in the magnetic material of the cut-out.*

Voltage regulator check

Regulation voltage on half-charged battery (ambient temperature of 50° ± 3° C or 122° ± 37.4° F):

Connect the group according to the diagram of Fig. 156 and operate it at 50° ± 3° C temperature for about 30 minutes, with a half-charge current output corresponding to 5 A.

Immediately afterwards, maintaining the box at an ambient temperature of 50° ± 3° C stop the generator and run it again at a gradually increasing speed up to 3500 rpm; adjust the rheostat so to set the generator half charging with a current of 5 A at 27.7 to 28.7 V.

Current regulator check.

Regulation current on battery: this check must immediately follow the preceding one.

Connect the unit according to the diagram of Fig. 156 and connect the rheostat maximum resistance, operate the unit at 50° ± 3° C ambient temperature for 30 minutes, at regulation current speed (to this end decrease the resistance of rheostat until the current remains about constant and the voltage drops) and at the specified 26 V. At the end check that the output current has become stable (i. e., thermal stability has been reached); stop the generator and connect the rheostat maximum resistance, start it again and run it up to 3500 R.P.M.;

decrease the resistance gradually until the voltmeter indicates 28 V and the ammeter a regulation current of 6.6 to 7.4 A.

As the resistance continues to decrease the current should slowly rise, and the voltage drop sharply almost to 24 V.

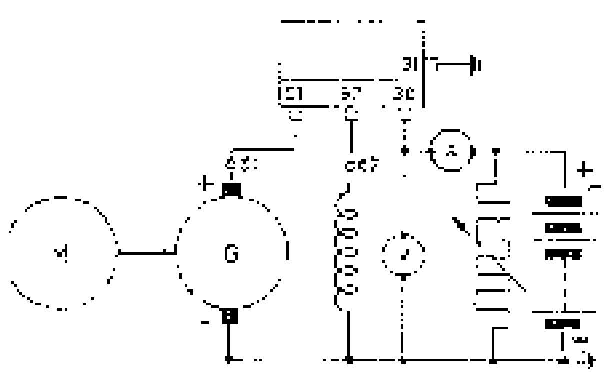


Fig. 156. - Electrical diagram of the arrangement for testing the voltage and current regulators.

M. Test bench electric motor - G. Generator DC 115/24/7/3 and its modified versions - V. Voltmeter, 30 V too reading - A. Ammeter, 10 A too reading.

Trouble-shooting.

The various cases which may occur during the operation of the control box are the following:

A - Low charging rate with a fully charged battery

This is the condition of a generator-control box system working correctly.

B - High charging rate with a fully charged battery.

This condition indicates that the voltage regulator does not limit the output as it should because a high charging rate not only damages the already fully-charged batteries, but also the equipment of the system. The causes are the following:

a) high voltage regulator setting;

b) defective voltage regulator windings or additional resistance (7, Fig. 159);

c) short circuit across the generator positive terminal and field winding which prevents the current from passing through the regulation resistance at voltage regulator contacts opening;

d) insufficient connection between control box and generator through mass.

e) high temperature which reduces the battery electromotive force reacting to the charge, so that the battery absorbs a high charging current even if the regulator set voltage is normal;

f) self-welding of the voltage and current regulator contacts.

In all the above cases, excluding case e), one of the two following conditions will occur on disconnecting the cable 67 from generator to control box:

1) Output remains high (trouble covered by point c).

2) The output stops completely (the trouble lies in the control box which should be checked as to points a), b), d) and f).

Note - If the generator output remains high even after a long period of charging but neither trouble nor high temperature show up in the control box, the battery is old or maintenance wrong. It does not absorb any more current, the voltage does not rise above a certain value and the generator current does not decrease.

C - Discharged battery and high charge.

Condition of correct operation of the generator and control box unit.

D - Discharged battery and low or no charging rate

This condition is due to the following:

a) burnt control box fuse - b) interruption of the additional resistance of the cut-out relay shunt winding (11, Fig. 159) - c) loose connections, defective cables - d) defective battery - e) charging system high resistance - f) voltage or current regulator low voltage setting - g) voltage or current regulator oxidized contacts - h) generator trouble.

Should the above condition be caused by the failure of the additional resistance (11, Fig. 159) replace it.

If, on the other hand, it is caused by fuse failure, search for the cause of fuse burning before replacing it. The reason may be found among the following:

— the cut-out relay contacts do not open as the engine stops;

— short circuit;

— reversed generator polarity.

Finally, if the trouble is not due to one of the causes described at paragraphs a), b) and c), look for it in the battery, control box, or generator. To find out whether the trouble is due to the battery replace the existing one with a new one discharged so that if the output still goes to the maximum evidently the fault is in the battery. If not, look for it either in the control box or generator by shorting momentarily the terminal 67 with the 51 and increasing the generator speed. Should the output, previously absent or very low, either reach a set value or increase, the trouble is due to one of the following:

— low current or voltage regulator setting;

— current or voltage regulator contacts oxidized;

— undue resistance, interruption of the generator field winding or inside the unit.

Otherwise, look for trouble in the generator.

REPAIR INSTRUCTIONS

As a rule it is preferable to replace the control box rather than repairing or adjusting it, therefore only exceptional cases may justify handling it. The repairs which can be done, provided that it has been found for sure that it is the cause of trouble, are: replacing the cover, the additional resistances (7, 11, Fig. 159), the damping resistance (10), and the regulation resistance (6).

The spares are furnished in special containers to avoid contacts with foreign material.

Most of the faults of the trouble, particularly the more serious ones such as excessive consumption or welded cut-out relay contacts, oxidized or pitted voltage or current regular contacts, coil shorts and winding overheating, are due to faults outside the unit and particularly to the same faults of generator components (field winding resistance altered, wrong brushes, faulty cables, etc.).

Therefore, the repair man should not content himself by replacing the control box, which has anyhow a high factor of safety in operation, but rather check the generator and the whole charging system.

Cover replacement.

Should the replacement be due to bruises or warping we suggest to check the control box prior to replacement, according to the testing procedure of page 100 and following.

When replacing the cover check the seal gasket and plate spring washers under the screw heads of the base, then tighten the screws until the two ends of the washers come in contact. Finally, apply a paint seal on the head of one screw.

Replacing the regulation and damping resistances (6, 10, Fig. 159).

Here follow the causes and their respective consequences in case of wire interruption or shorts of the resistances (6, 10, Fig. 159):

a) control voltage low or very low;	a) oxidized voltage and current regulator contacts;
b) control voltage rising because out of control;	b) voltage regulator contacts stuck because of self-welding;
c) control current rising because out of control;	c) current regulator contacts stuck because of self-welding;
d) control voltage very unstable particularly at high generator speeds	d) temporary sticking of the voltage regulator contacts.

Paragraphs a), b), c) concern the control resistance, paragraph d) the damper resistance.

If still in doubt, replace these resistances which are fixed to the base by rivets. Drill the rivet head first, then drive the rivets out with a punch paying attention not to damage the wires soldered to the plates (12 and 13, Fig. 149). To prevent the current regulator core from rotating while removing and refitting the resistances use tool A 127050 as shown in Fig. 157. The new resistances shall be fastened down with the screws, spring washers, and nuts specified for the replacement.

The value of the control resistance (8) is 135 to 144 ohm, that of the damping resistance (10) is 60 ohm.

Check that the air gap between the armature and the expansion edge of the current regulator core (at position C-C of Fig. 149) is 0,99 to 1,11 mm (0.039" to 0.044"). To correct the air gap use tool A 127051 on the fixed contact support (4, fig. 152) and check with a magnifying lens if the contacts are aligned correctly. The gap between contacts of the cut-out relay should be 0,64 to 0,75 mm (0.025 to 0.030") and the air gap measured on the expansion edge of the core facing the contacts (Axis A-A, Fig. 150) and with contacts closed should be 0,25 mm (0.010").

Then follow test bench checks, reported on page 100, to ensure that the trouble has been completely eliminated and reassembly has not altered in any way the operation of the various parts.

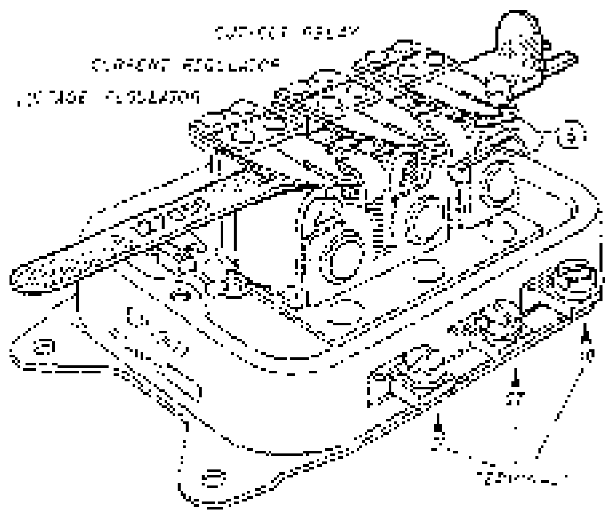


Fig. 157. - Control box GP 1/24/? with tool A 127050 installed to replace resistances 8 and 10, Fig. 155.

5. Setting spring, support tang.

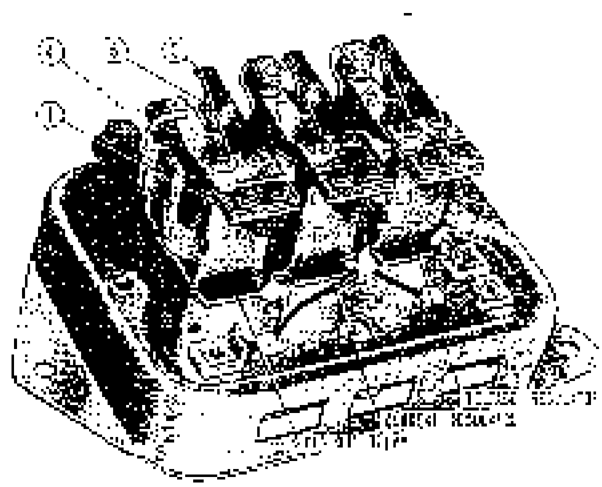


Fig. 158. - Rear view of the control box.

1. Cut-out relay armature hinge - 3. Setting spring - 4. Fixed contact support tang - 5. Setting spring, support tang - 30. Ground.

Replacing the resistance on the voltage regulator shunt winding and the resistance of the current regulator and cut-out relay shunt windings (7, 11, Fig. 159).

If the voltage setting of the regulator has changed, that is:

— regulating voltage is low;
— regulating voltage rises to high values because out of control;

the cause can be attributed to the resistance of the voltage regulator shunt winding (7, Fig. 159) which can be altered (short) or interrupted.

A coil short increases the absorption on the part of the voltage regulator shunt winding (because the resistance is connected in series to said winding) and increases the pull on the armature resulting in a lower regulating voltage. Should the resistance be interrupted, the voltage regulator shunt winding does no longer get across to the generator but remains insulated.

Therefore, as the flow of current is interrupted the core cannot pull the armature, contacts do not open and the voltage, out of control, rises.

The resistance value is 73 to 77 ohms at 20° C (58° F). If the cut-out contact closing voltage is found to be low, or the contacts remain open even at high generator speed, check the resistance (11, Fig. 159) to ascertain whether the cause must be attributed to altered value or to an interruption of the wire.

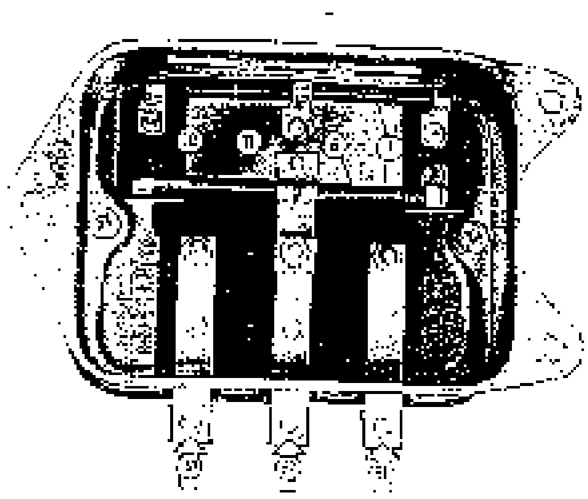


Fig. 159. - Bottom view of the control box GP 1/24/1.

6. Regulation resistance - 7. Additional resistance connected to the voltage regulator winding - 10. Damping resistance shunted across the generator between current regulator and ground - 11. Additional resistance for current regulator and cut-out relay shunt windings - 30. Electrical equipment terminal - 51. Terminal connected to the positive pole of the generator - 67. Terminal connected to the generator field winding.

In case of a coil short, the value of the resistance decreases while the current regulator and cut-out relay shunt winding absorbs more (as the resistance is connected in series to these windings and closes the circuit to ground); that is, it creates a greater pull on the armatures, particularly on the cut-out one, where the magnetic effect is greater and therefore the contacts close at a lower voltage.

Should the resistance wire be interrupted, the cut-out and current regulator shunt windings have no current flowing through them as the circuit is not closed across the generator casing; therefore the cut-out contacts remain open, which is signaled on the dashboard by the battery charge warning lamp which remains lighted. Resistance trouble has no effect on the current regulator.

The resistance value is 73 to 77 ohms at 20° C (68° F). Replacing one resistance calls for replacement of the other one, too. To replace them proceed as for resistances 6 and 10.

Control box setting.

The setting of the control box on the test bench should be performed without the cover, placing the box vertically with the terminals facing downwards.

Cautions: If the control box has remained for a certain length of time at ambient temperature below 15° C (59° F) or above 35° C (95° F), place it for about one hour at a temperature of 25° ± 10° C (77° ± 50° F).

Cut-out relay setting.

Wire the control box according to the diagram of Fig. 160 and place the instruments as follows:

- *potentiometer P at minimum (voltmeter at zero);* *switch T open;*
- *rheostat R all on (max. resistance);*
- *switch T' open.*

1) *Contact points closing voltage (at a temperature of 25° ± 10° C — 77° ± 50° F).*

Close switch T. Stabilize the temperature of the unit, equipped with its own cover, by feeding it for about 15 to 18 minutes at a voltage of 13 V, through potentiometer P;

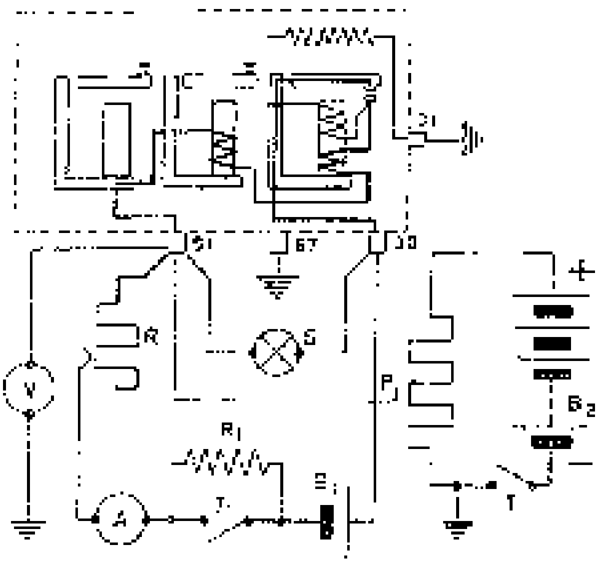


Fig. 160. - Electrical diagram of the arrangement for setting the cut-out relay.

B_1. 2 V battery - B_2. 40 V battery - A. Ammeter, 30 A top reading (1% accuracy) - V. Voltmeter, 30 V top reading (0.5% accuracy class) connected across terminals 51 and 31 - P. Potentiometer, voltage adjusting; capacity must be such that the cut-out relay shunt winding coil consumption does not create notable variations of the supplied voltage measured by the voltmeter - S. Warning light indicating opening and closing of contacts (2 V-3 W bulb) - R. Rheostat 1 ohm - 20 A - R_1. Drop resistance sufficient to allow lighting up of the warning light S by switch T_1 with the cut-out relay contacts open.

once thermally stabilized, bring the voltage to 25.1 to 25.9 V through potentiometer P;

adjust the load on the calibration spring (3, Fig. 158) by bending its metal tongue (5) until the light S goes out;

bring potentiometer P setting back to the minimum, increase the voltage again acting once more on the potentiometer and check that the light S goes out at the specified setting.

The contact points entire closing stroke should occur at a voltage variation lower than 0.2 V.

2) Reverse current (at a temperature of 25° ± 10° C = 77° ± 50° F).

This test must immediately follow the preceding one in order to take advantage of the thermal stability achieved by the unit.

With switch T closed, bring the voltage to 27 V by acting on the potentiometer P (the cut-out relay contact points are closed and light S off); close switch T¹, increase the reverse current through the rheostat R and check that the light S goes on when the contact points open. The opening may result to be unstable evidenced only by a ringing noise;

check the ammeter reading of the reverse current which starts the contacts opening (5 to 14 A). Should the reading be uncertain or should the light go on the tolerance limit, bring the reverse current back to minimum and increase it again working on the rheostat R, as instructed before;

open switches T and T¹ and bring the sliders of the potentiometer P and rheostat R back to minimum.

Voltage regulator setting.

Provide the conditions suitable to maintain the unit at a temperature of 50° ± 3° C (122 ± 27° F).

After wiring the unit according to the diagram of Fig. 161, shorten the adjusting spring of the current regulator by shaping the adjusting tongue (5, Fig. 152);

close switch I, start the generator and stabilize the temperature of the unit, for 30 minutes, at 28 V, by varying the generator speed;

open the switch I and bring the generator speed up to 3500 R.P.M.; adjust the load of the adjusting spring of the voltage regulator by bending the tongue, and the rheostat R, so to obtain a regulating voltage and a medium charge current of 28.7 to 29.7 V and 5 A, respectively,

check stability and accuracy of the regulation voltage by stopping the generator and running it again up to the speed of 3500 R.P.M.

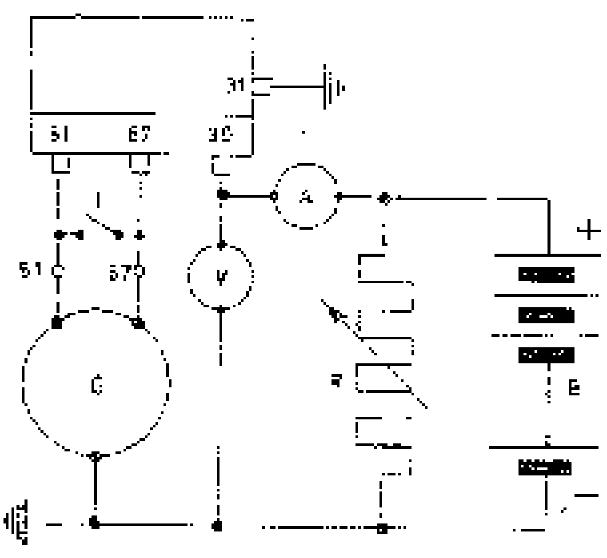


Fig. 161. - Electrical diagram for setting the voltage and current regulators.

G. Generator DC 115/24/7/3 and its versions - V. Voltmeter, 30 V top reading (0.5% accuracy class) - A. Ammeter, 10 A top reading - R. Rheostat, 3 ohms-20 A - B. 12 V - [illegible] Ah batteries connected in series, fully charged - I. Switch.

Current regulator setting.

This test must immediately follow the preceding one, holding the test temperature at 50° ± 3° C (122° ± 37° F), and using the same instruments and the same wiring diagram (Fig. 161);

close the switch I, start the generator, adjust its speed and rheostat R to obtain a voltage and a current of 26 V and 6.5 to 7.4 A, respectively;

after 30 minutes of operation at the above conditions stop the generator and open the switch I. Bring the generator back to a speed of 3500 R.P.M., adjust the load of the adjusting spring by acting on the tongue (5, Fig. 152), and the rheostat R to obtain a regulating current and voltage of 6.5 to 7.4 A and 28 V, check the stability and the accuracy of the regulating current by stopping the generator and running it again as to a speed of 3500 R.P.M.

Performance check and sealing of the unit.

Once set, close the hot control unit with cover and gasket before it undergoes the bench test as from instructions of page 100 and following. Than put the paint seal on one of the cover fastening screw heads before returning it to the owner.
Overhauling or repairs must be entrusted to FIAT Service Shops only.
Whenever a control box is opened for overhaul or repair, operate it for a certain length of time without the cover on so that it will warm up and eliminate any residual dampness on its elements, if any.

CONTROL BOX GP 1/24/7 SPECIFICATIONS (*)

Description	Data
Cut-out relay:	
— Test current for thermal stabilization	≥ 30 V
Cut-in voltage	25,1 to 25,9 V
— Voltage variation for contact closing stroke	≥ 0,2 V
— Reverse current	6 to 14 A
— Air gap, contacts closed (axis A-A, Fig. 157)	0,28 mm ([illegible] in)
— Gap between contacts (d, Fig. 150)	0,64 to 0,76 mm (0.025 to 0.030 in)
Voltage regulator:	
Batteries capacity at 20 h	100 Ah
— Average load current	8 A
Rated voltage after thermal stabilization at a room temperature of 50° ± 3° C (122 ± 37.4 F) for 30 minutes	28,7 to 29,7 V
— Test voltage for thermal stabilization	≥ 30 V
— Air gap (C, Fig. 149)	0,89 to 1,11 mm (0.035 to 0.044 in)
Current regulator:	
— Rated current on battery at 50° ± 3° C (122 ± 37.4 F) room temperature after thermal stabilization	6,5 to 7,4 A
— Rated current check voltage	28 V
Air gap (C, Fig. 149)	0,89 to 1,11 mm (0.035 to 0.044 in)
Resistances, Fig. 159	
— regulation resistance (6)	136 to 144 ohm
— damping resistance (10)	90 ohm
— additional resistance for voltage regulator (7)	73 to 77 ohm*
— additional resistance for cut-out relay and current regulator (11)	73 to 77 ohm*

Note: The generator check and adjustment speed is 3500 r.p.m.
(*) See data for modified groups under the following heading.

CONTROL BOX TYPE GP 1/24/7, MODIFIED (Dwg. no 4085433).

The modified control box 4085433 differs from the previous type (4055983) as follows:
- the series and parallel windings of the cut-out relay are mounted in succession instead of being superimposed;
- the value of supplementary resistances for the voltage regulator (7, Fig. 151), cut-out relay and current regulator (11, Fig. 151) have been lowered from 73-77 ohms. to 55,5 to 65,5 ohms. These resistances, together with those placed under the base of the control box, are not furnished as spare parts.

BATTERIES

Specifications and dimensions.

Tractors are equipped with two 12V batteries, capacity 56 Ah (measured at 20 hours discharge) connected in series, to reach the generator voltage of 24 V. The main battery characteristics are:

1. *Connections, covered with plastic insulating material to prevent current dispersions and protect against corrosion the connections and the pole terminals.*

2. *Separators, for protection of battery lead plates from vibrations, made of extremely thin porous rubber, or of polyvinyl plastics.*

3. *Self-levelling and splash-proof plugs, allowing electrolyte self-levelling, and preventing its splashing from the vent holes, when tractor jolts in operation.*

Sizes:

- *length . . . 368 to 372 mm (14.4882" to 14.6456")*
- *width . . . 173 to 177 mm (6.8110" to 6.9685")*
- *height . . . 197 to 200 mm (7.7559" to 7.8740")*

Battery makes:

- *Marelli 6 TF 9;*
- *Tudor 6 CR 4 F.*

Weight (with electrolyte) approx. 24 kg (52.910 lb).

Cleaning.

Keep batteries clean and dry, particularly the upper parts, thus avoiding, especially after the recharge, the corrosion of the element sealing compound; smear terminals with pure vaseline, avoiding the use of lubricating grease as it reacts with sulphuric acid of the electrolyte (vapour or liquid).

Electrolyte level checking and top up.

*Electrolyte should completely cover the element plates, and top-up them of about 5 mm (0.1969"). Distilled water only should be used for topping-up then make sure the plugs (**A**, Fig. 162) are fully tightened.*
For longer battery life, avoid any contact between water and metallic containers.

Battery charge check.

Unscrew the plug, and introduce the hydrometer in each element: the specific gravity represents the battery charge conditions, as follows:

Electrolyte gravity	Condition of battery charge
1,25	100%
1,2[illegible]	75%
1,22	50%
1,1[illegible]	25%
1,15	nearly discharged
1,1[illegible]	completely discharged

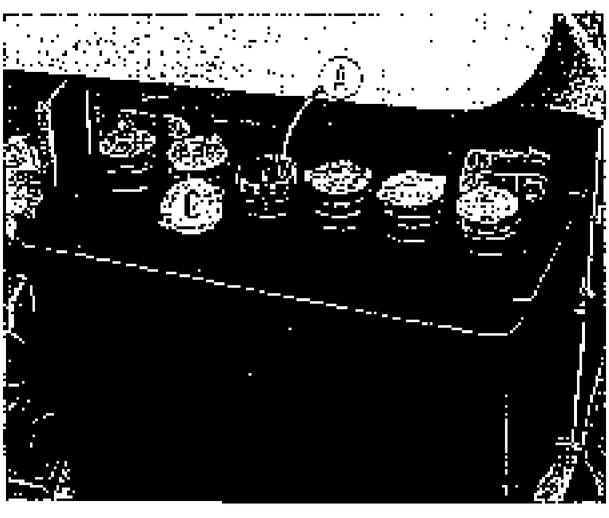


Fig. 162. - Batteries mounted on tractor.

A. Funnel of level control plug for water filling - **C.** Cover for level control plug.

Therefore a battery may be considered charged if the electrolyte gravity reads between 1,28-1,31 at 25° C (77° F). Avoid letting the battery to discharge completely; recharging should be made when gravity is not less than 1,15 (20° Bé). The recharging current rate should never exceed 5 A.

In order to maintain the battery charging within actual conditions the checks should not be made when:

1. *the electrolyte is different from the prescribed one. If distilled water is being poured in, take time to get a uniform distribution;*

2. *battery is hot, or immediately after repeated startings, or when electrolyte is cold. The most suitable temperature is between 15° and 25° C (59-77° F).*

If the battery cells have a specific gravity with differences exceeding 0.02 or high or low gravities, accompanied by excess of heat (more than 10° C - 50° F, above the ambient temperature), call the Service Organization of the battery supplier.

Discharge of battery during operation.

During operation, the batteries are not to be periodically recharged, as the tractor charging plant can maintain their efficiency.

When discharged (excluding after long tractor stops which cause battery self-discharge), the batteries indicate abnormal functional conditions.

These may be traced to:

1. *Faulty recharging system (generator - regulator group): see service instructions.*

2. *Current dispersion, due to insulation defects in the electric system. This may take place after heavy current draw due to the insertion of extra accessories. A rapid check is made by inserting a milliammeter between battery positive terminal and its disconnected clamp, after having stopped the engine and excluded all equipment. The current rate should not exceed 1 milliampere.*

3. *Extra accessories in addition to the standard ones installed by the manufacturer are dependent upon the electric system capacity.*

4. *Tractor short hauls, using high gears at low speeds and with frequent stops.*
   To maintain the generator at its normal recharging speed rate, use low gears when running at low speeds.

5. *Sulphated battery; short circuited elements or interrupted.*

Refitting and removing from tractor.

No difficulty should be met in installing or removing the battery from tractor; to avoid heavy discharges, be sure to disconnect the grounding cable before working. In addition use proper wrenches, and never use pliers to screw or to unscrew the terminals.

STARTING MOTOR

Specifications.

Type	FIAT E 115-3/24 Var. 2
Rated voltage	24 V
Rated output	3 KW
Excitation	compound
Direction of rotation (pinion side)	clockwise

The starting motor mounted on tractors of series 400 is a direct current 4-pole motor with solenoid and free-wheel engagement pinion drive (Fig. 163).

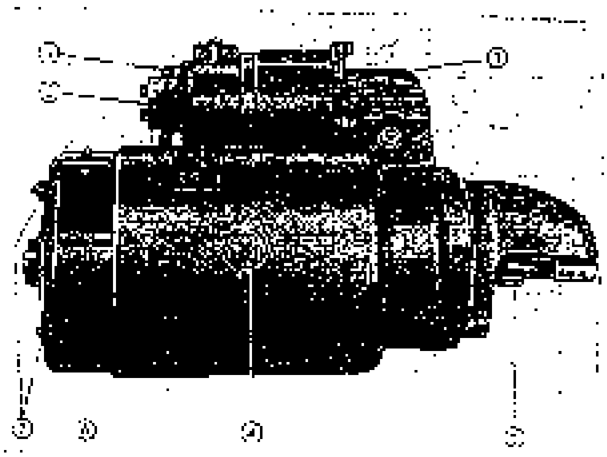


Fig. 163. - Starting motor.

1. Remote-control switch terminal - 2. Terminal for motor field coil - 3. Remote control switch - 4. Pole piece fastening screw - 5. Starting pinion - 6. Belt for brush protection - 7. Through bolt nuts.

Test bench checks.

As voltage, during tests, should be approximately constant, the starting motor shall be energized by large capacity batteries.

The specified voltages, applied to the motor terminals, shall determine the prescribed current drains through the setting of a rheostat. No result would be reliable if such conditions were disregarded, with the exception of the torque reading, and only approximately.

To verify the motor performance check the electrical and mechanical specifications as follows:

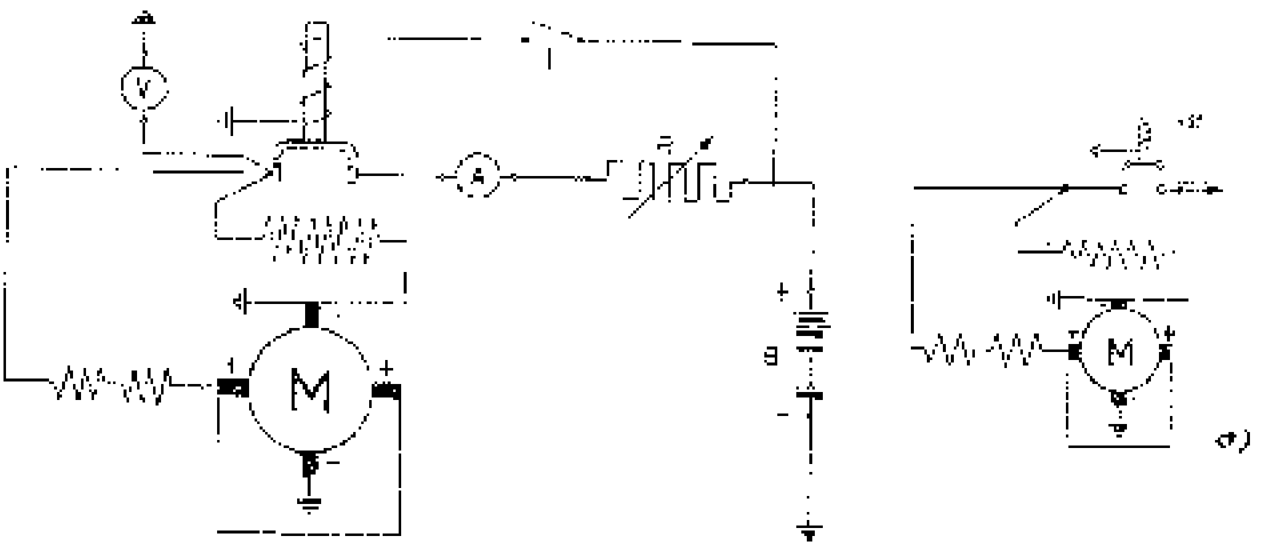


Fig. 164. - Electric diagram for bench test of starting motor.

M. Starting motor - V. Voltmeter, 30 V top reading - A. Ammeter, 1000 A, top reading - B. Batteries, 12 V 100 Ah, connected in series, fully charged - R. Rheostat, carbon plate type, 1000 A, top reading - I. Switch.
a) Starting motor electrical diagram.

Checks.	*Operations.*
Operational test (under load).	*Wire up according to Fig.* **164.** *Use a test bench fitted with a ring-gear having a ratio between pinion and gear of about 1 to 10; make some startings of short duration, and check, by braking the motor until a current of 285 A is reached, that its torque is about 1,85 to 2,15 kgm (13.4 to 15.7 ft.lb) at 1510 to 1610 R.P.M., the voltage being 19 V.*
Checking motor torque when stopped.	*Stop the test bench ring gear; switch on, and adjust voltage to motor terminals, so that it will absorb a current of 685 A at 12.7-13 V. The starting motor should then deliver a torque of 4.62 to 4.75 kgm (33.4 to 34.3 ft.lb).*
Idling test of motor.	*Clear away the ring-gear, to prevent its meshing with the pinion.* *Shut the starting switch and adjust the terminal voltage at 24 V.* *Motor should then absorb a current not exceeding 30 A at 4000 to 5000 R.P.M.*
Electromagnet run.	*The mobile contact of electromagnet should perform a run of 6,4 to 6,45 mm (0.252" to 0.332"); the core being of 9.5 to 10.1 mm (0.374" to 0.397").*
Motor internal total resistance.	*The test data of the motor when stopped allow calculating the motor total resistance, by the ratio between the voltage applied and the current. At 40° C (104° F) the resistance should be of 0,0205 to 0,0213 Ohm.*
Field coil resistance.	*1) The main field coil resistance (in series), at 20° C (68° F) should be of 0,0055 to 0,0070 Ohm.* *2) The secondary field coil resistance (shunted), at 20° C (68° F) should be of 1 to 1,14 Ohm.*
Electromagnet coil resistance.	*The electromagnet coil resistance, at 20° C (68° F) should be of 1,36 to 1,45 Ohm.*
Mechanical characteristics.	*See data on page* **115**

Guide for finding starting motor troubles.

Faults in the starting system may be localized either in the electric motor or somewhere else in the system. It is therefore necessary to localize trouble first in order to avoid a waste of time by looking for faults in the electric motor not being there or due to outside causes, so that repairs would be useless as trouble would repeat itself.

Therefore, if cranking is very slow or absent, the defect must be localized. To this end, as engine is stopped, the headlights can be used.

Comparatively scarce illumination can be traced to low battery charge, damaged cables, or terminals not tightened. Naturally, the check is made taking for granted that the headlight circuit and its components are efficient and without tension losses for poor contacts at the switches, bulb-sockets, etc.

It happens less often that the recharge plant is defective, and this may be ascertained through the regulator checks. Anyway, the battery recharge, without having found out the causes, will not eliminate the trouble that will repeat.

The battery being normally charged, and the starting motor operated, causes the following headlight behaviour:

1) No light: traced to poor connections between battery and motor, or corroded battery terminals.

2) Considerable dimming as engine is started, and the latter runs slowly or stops:

   a) excess of oil crankcase density;

   b) armature spindle bent, bushes and support worn, and polar shoe screws loose;

   c) commutator damaged, series field coil or armature coils grounded or short-circuited.

3) Bright headlights, and starting motor cranking slowly or stopping:

   a) loose terminals of the motor solenoid contacts oxidized or insulated by foreign matter intrusion, or damage of the excitation circuit and commutators circuits;

   b) poor or faulty brush contact on commutator.

Trouble-shooting instructions.

Item 1) of the preceding chapter increases the ohmic resistance between batteries and motor and may be measured by a voltmeter when motor is running.

The voltage drop measurements to be taken are as follows: between tractor body and battery negative pole; between tractor body and the electric motor frame; between battery positive pole and the solenoid terminal, where the battery feeding cable ends.

Each measurement should not give more than 0,1 V, when the starting motor is running.

However, if the voltage drop is excessive, disconnect the cables, clean the battery terminals and smear them with vaseline, to prevent corrosion.

Items 2) and 3) of the preceding chapter call for a commutator check for efficiency and the removal of the starting motor to perform its test with no load and when stopped (torque test).

The following cases may occur when such tests are being performed.

I - Torque current and speed up to specifications.

II - Low speed and torques with no-load; high current drain: trouble to be traced to armature winding partly short circuited or grounded; or to mechanical defects, such as worn out bushes, armature shaft bent, loose polar shoe screws.

A simple inspection may indicate that some armature turns are grounded, as the corresponding commutator blades would be deteriorated by heavy current passage that would take place through the brushes.

III - Motor does not start and high current drain might be caused by the armature or the field coil completely grounded.

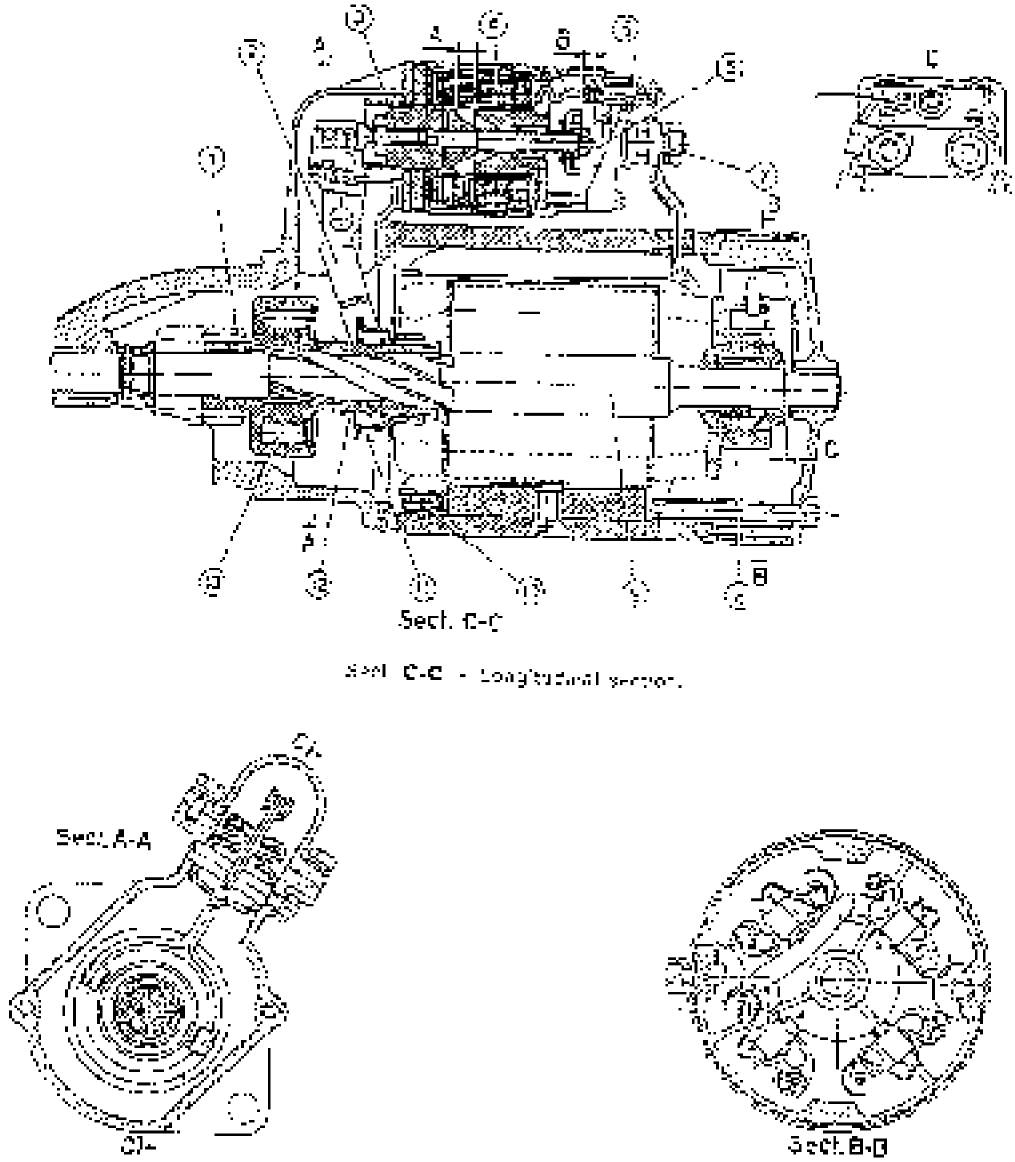
IV - Motor does not start and no current drain or less than 24 A: low current drain requires checking the solenoid contacts on the commutator, and of the brush spring performance.

Very low current drain signifies that the field series winding is interrupted.

The solenoid winding interruption may be checked with a test lamp.

V - Low speed, with no load low current and torque, the fault may be traced to the internal resistance of the motor, or to commutator expanded bars due to centrifugal force.

The first trouble is readily detected when the motor is dismantled, the second one may be caused by the free-wheel too hard to turn or by field coil connections unsoldered from the commutator bars.



Sect. C-C - Longitudinal section.

Sect. A-A. - Cross section on fork lever.

Sect. B-B - Cross section on commutator.

Fig. 155. - Sectional views on starting motor type E 115-0,8-12 Var. 2

1. Starting drive pinion - 2. Fork lever - 3. Solenoid core - 4. Solenoid coil - 5. Solenoid terminal - 6. Fixed contacts - 7. Clamp for field coil lead - 8. Commutator - 9. Armature - 10. Field coil - 11. Sleeve - 12. Overrunning clutch hub - 13. Overrunning clutch - A. Solenoid core travel (9.5-10 mm = 0.374"-0.394") - B. Solenoid mobile contact travel (6.4-6.95 mm = 0.252"-0.273") - C. Armature shaft end play (0.35-0.75 mm = 0.0138"-0.0295") - D. Solenoid terminals.

Motor disassembly.

The starting motor can be dismantled into the following subassemblies: solenoid unit, commutator end bracket assembly, armature assembly, clutch assembly, pinion end bracket assembly, motor frame assembly.

Parts to be removed.	*Operations and cautions.*
The solenoid.	*Remove the screws fastening it to the support, also the field coil end from terminal (2, Fig. 163). Lift the solenoid assembly and take it away.* *To dismantle it remove the upper cover (in order to disengage the coil end) and make free the central part of the solenoid body (3) from the screws fastening it to the support, and from the terminal rods.* *To remove the solenoid coil core, remove the split pin and the mobile contact nut.*

Commutator end head. *Remove the nuts and the tie-rods fastening the head to the frame (7) and the protection strip (6), free the field coil leads connected to the brushes, and remove the complete head.*

Pinion and bracket. *Slide it out from the frame with the armature; remove the pinion engagement control fork pivot and pull upwards the fork to disengage the pinion.*

Free-wheel. *Remove split pin, unscrew the nut, remove the pinion stop ring, and slide the free-wheel out.*

To strip the free-wheel, remove the spring cup stop ring, and slide out components; remove the ring fastening the wheel to the bell and carefully slide out the spindle, to prevent rollers and springs from jumping out.

Starting motor trouble-shooting and component checks.

Brush replacement in the commutator is comparatively simple: raise the springs and slide out broken or worn brushes. Use only original brushes supplied by FIAT - Sezione Ricambi, which ensure a long service.

Check the solenoid contact which, if oxidized or burnt, should be cleaned using emery cloth, then remove all metal and emery dust before reassembly.

If necessary, replace the solenoid and the starting motor field coils using original spares, without attempting to repair them or to wind a new coil, as good performance cannot be obtained by such means. After having tightened the coils under the pole shoes, check that the air gap corresponds to specifications: to facilitate the assembly warm up the windings to about 50° C (122° F).

Check commutator for out-of-round which should not exceed 0.02 mm (0.00078"): if necessary, and if the commutator bars have not been thrown out-of-round by centrifugal force, turn them down, then undercut the mica of 1 mm (0.039") using a saw blade.

Check armature conditions with the same device used for the generator and if grounded renew it.

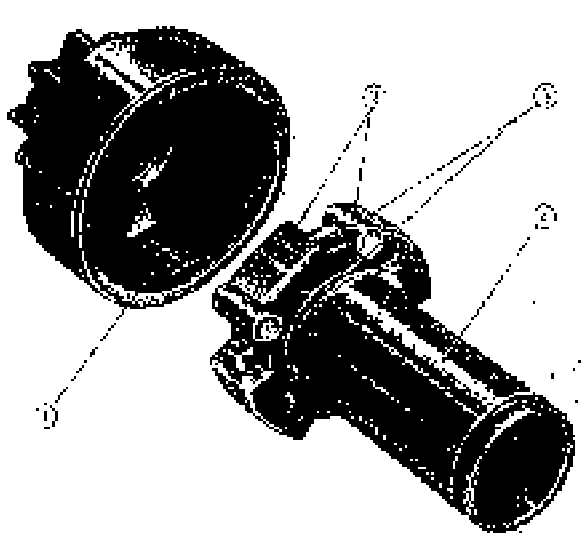


Fig. 166. - Parts of starting motor clutch.

1. Clutch rollers way - 2. Clutch rollers - 3. Push rod for clutch rollers - 4. Clutch hub.

Reassembly instructions.

To reassemble the starting motor reverse the sequence used for dismantling.

Before assembling, clean armature and brackets with a strong air jet, and clean the commutator using a dry cloth.

Refill the free-wheel, and the starting pinion fork guides with high melting point grease; when assembled, before the test-bench checks, see that end clearance (C, Fig. 165) is 0.35 to 0,75 mm (0.0138" to 0.0295").

STARTING MOTOR PERFORMANCE DATA

Specifications		Values
Operational test (under load)	current	255 A
	torque	1,52 to 2,15 kgm ([illegible] to 15.5 ft lb)
	speed rate	1510 to 1810 r.p.m.
	voltage	19 V
Checking motor torque when stopped	current	620 A
	voltage	12.7 to 15 V
	torque	4,62 to 4,75 kgm (33.4 to 34.3 ft.lb.)
Idling test of motor (under no load)	current	80 A
	voltage	24 V
	speed rate	4000 to 5300 r.p.m.
Commutator out-of-round		0,02 mm (0.00079")
Pole shoes inner diameter		75.83 to 76 mm (2.9854 to 2.992")
Armature outer diameter		74.95 to 75 mm (2.9508 to 2.9528")
Internal total resistance of motor when stopped (at 40° C - 104° F)		0.0206 to 0.0215 ohm
Resistance of main field coil (in series), at 20° C (68° F)		0.0060 to 0.0070 ohm
Resistance of secondary field coil (shunted), at 20° C (68° F)		1 to 1.14 ohm
Solenoid	energizing current at 24 V, (20° C - 68° F)	17 A
	solenoid internal coil resistance when heated	1.35 to 1.46 ohm
	solenoid lift force, with a current of 9 A and an air gap of 5 mm (0.19")	not less than 11 kg (24.2 lb.)
Solenoid mobile contact travel		6,4 to 8,45 mm (0.252 to 0.332")
Solenoid core travel		8,5 to 10,5 mm (0.334 to 0.413")
Brush spring pressure (new brushes)		1,15 to 1,30 kg ([illegible] to [illegible] lb.)
Armature axial play (C, Fig. 165)		0,35 to 0,75 mm (0.0138 to 0.0295")

GLOW PLUGS

The glow plug consists of a thin wire helix, contained in an insulator and surrounded by a metallic shell, which is heated by the incandescent coil to 850° C (1562° F) through the insulator when energized by a 24 V current.

The glow plugs are shunt connected (nominal voltage 24 V, 140 W each).

Removal and cleaning.

Before unscrewing the plugs, free their terminals. Clean them with a metallic brush, wash in gasoline and blow them dry.

Checks on the test bench.

a) Check the plug current absorption at 24 V (5.83 ± 0.2 A);

b) Sealing. The plug is screwed in a seat similar to the one existing on the engine in a vessel the pressure of which can be raised to 30 kg/cm² (426.73 p.s.i.).

Air leaks, against the atmospheric pressure of 760 mm (29.9213") of mercury, shall not exceed 2 cm³ (0.1220 cu.in) of air.

ATTACHMENTS

POWER TAKE-OFF

The power take-off assembly is located inside the transmission casing rear cover and may be actuated by a lever directly from the crankshaft or from the gearbox (through a gear installed on the bevel pinion shaft, Fig. 81).
In the first case, the power take-off shaft runs at a speed proportional to the engine (575 r.p.m., engine running at 2300 r.p.m.), and in the other case the speed is proportional to the tractor forward travel (3.75 revolutions per meter of forward travel).

Major overhaul.

Removal.

Drain differential and gearbox oil.

Set the control lever for engine drive and remove the screws fastening the rear cover to the transmission casing (Fig. 108).

Note. - *If tractor is fitted with hydraulic lift, there is no need to remove it, we suggest, instead, to remove the belt pulley transmission cover, if mounted, to simplify the assembly.*

Mount the assembly on rotary stand **ARR 2204** *(see Fig. 167).*

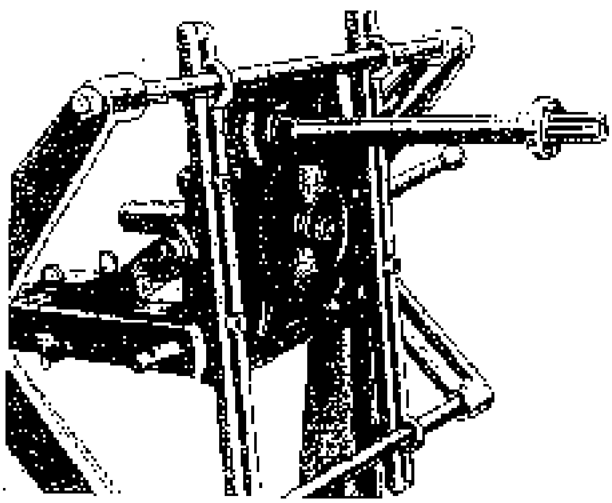


Fig. 167. - Cover-rear transmission, with power take-off, mounted on rotary stand ARR 2204.

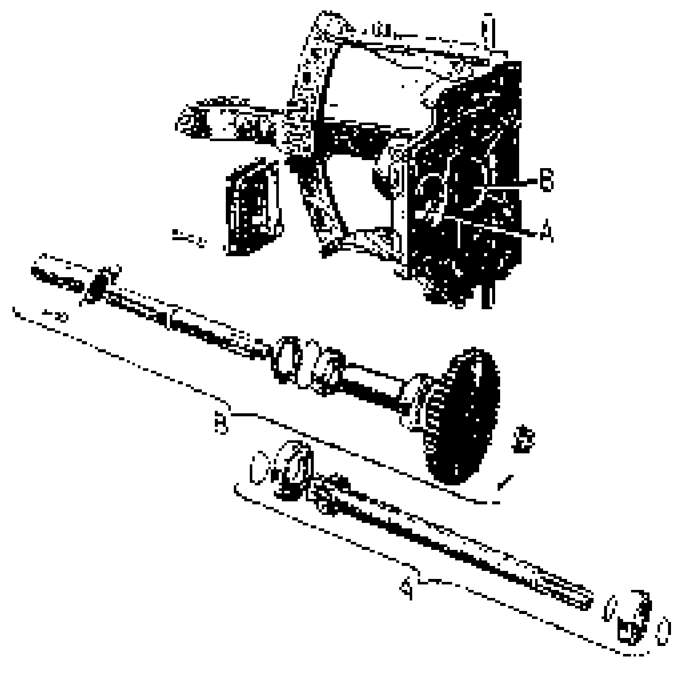


Fig. 168. - Power take-off assembly, stripped.

A. Driving shaft components.

B. Driven shaft components.

Dismantling.

See **A, B**, *Fig. 168 representing the disassembling sequence of the various components from their seats.*

Inspection of components.

Check gear teeth and shaft and hub splines conditions.
The power take-off driving shaft sliding gear can be checked and also disassembled by removing the transmission casing upper cover.
Check the bearings for smooth running and the power take-off driven shaft oil seal conditions.

See page 113 for main assembling clearances and permissible wear limits.

Assembly.

Reverse the dismantling sequence.

Note. - *To fit the power take-off driving shaft into the sliding gear hub, turn the power take-off driven gear by hand.*

BELT PULLEY

The belt pulley assembly is mounted in place of the power take-off cover (Fig. 31) and may be set with the pulley either on the right or left side according to the required direction of rotation. In both cases the vent should be mounted on top and the drain plug at bottom (Fig. 169). If necessary, interchange the position of the parts.
The unit is controlled by the power take-off lever shifted into « MOTORE » (engine).

Major overhaul.

Dismantling.

Drain lubrication oil, remove the pulley from drive shaft end, and take away the opposite end cover,

remove the snap ring from the driving shaft support, and hammering on a bronze punch from the inside, remove the shaft and all its parts.

The roller bearing outer race, if necessary, is removed from its seat after taking away the snap ring;
from the pulley driven shaft remove the nut and its split pin and, using a bronze punch, push out the driven shaft.

The roller bearing outer race and the ball bearing remain in their seats, and may be removed after taking away the snap rings.

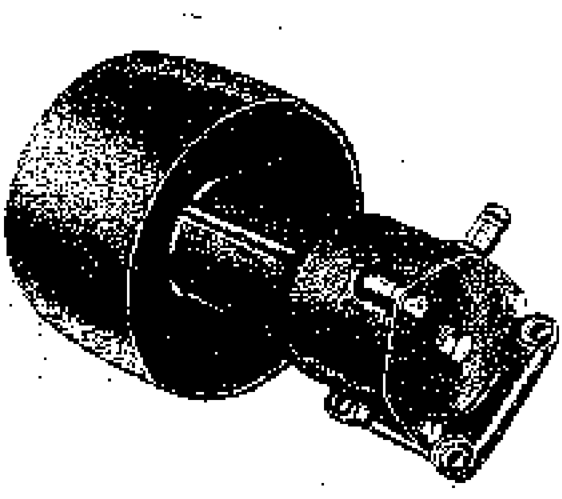


Fig. 169. - Belt pulley unit

D

Checking all components.

Check bevel gears and shaft splines according to data of page 118.
Check bearings for correct functioning and shaft seal for oil leaks.

Reassembling and adjusting the pulley assembly.

Refer to Fig. 170 and reverse the sequence followed for dismantling.

Bevel pinion and wheel adjustment made by varying the shim ring P of driving pinion and shim ring L of bevel crown gear.

The suggested clearance for bevel pinion and wheel is of 0.15 mm (0.0059"), and should be obtained by varying the L and P shim ring thicknesses.

Service with SAE 140 oil the belt pulley assembly until level reaches the plug located on the cover opposite to the same.

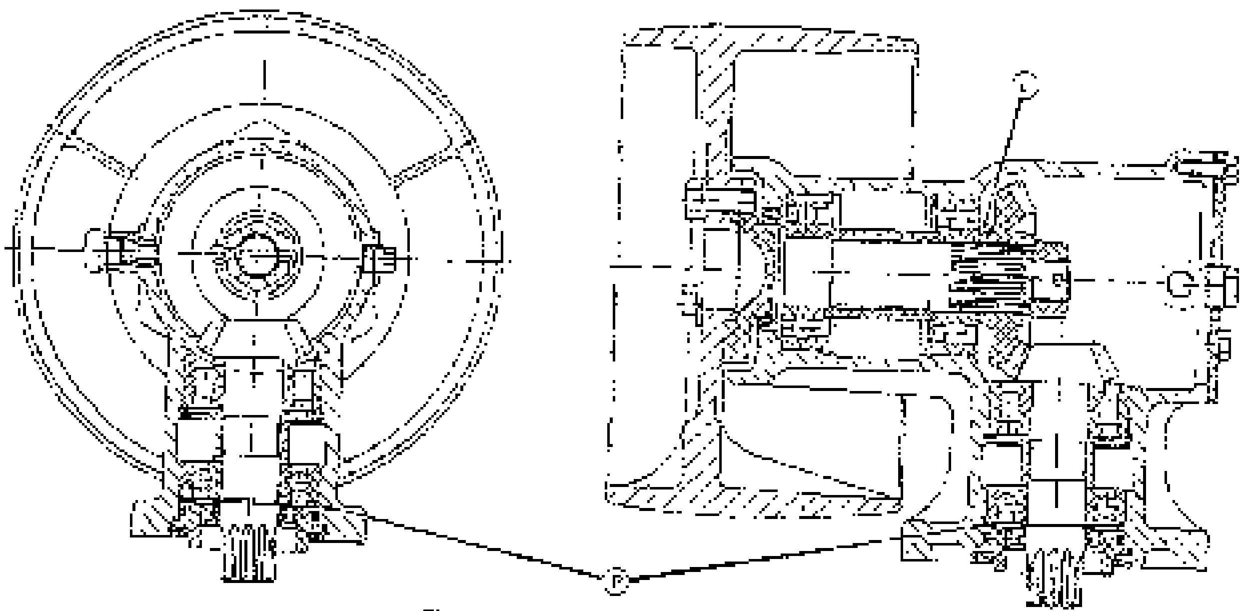


Fig. 170. - Belt pulley unit section.
L. Bevel gear adjustment shim. P. Bevel pinion adjustment shim.

SPECIFICATIONS, ASSEMBLY CLEARANCES AND PERMISSIBLE WEAR OF POWER TAKE-OFF AND BELT PULLEY COMPONENTS

Assembly clearances	Data		Wear limits	
	mm	in.	mm	in.
Take off gear backlash	0.15 to 0.50	0.0059 to 0.0195	0.4	0.0157
Between driving gear splines and power take-off control shaft	0.010 to 0.105	0.0004 to 0.0041	0.25	0.0098
Between gear splines and power take-off driven shaft	–0.020 to 0.072	–0.0008 to 0.0028	—	—
Belt pulley pinion backlash	0.15	0.0059	0.4	0.0157
Between driver gear splines and pulley shaft	0.024 to 0.072	+0.0009 to 0.0028	—	
Belt pulley gear adjustment shims	1.8-1.9-2-2.2-2.4	0.0689-0.0709-0.0787-0.0866-0.0945		

HYDRAULIC LIFT

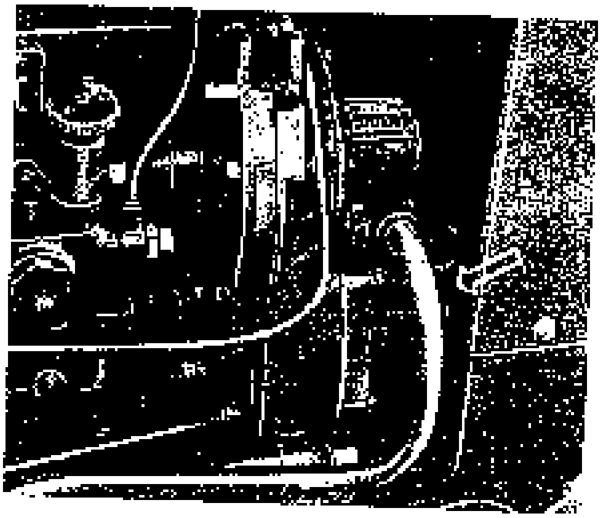


Fig. 171. - Hydraulic pump mounted on tractor.

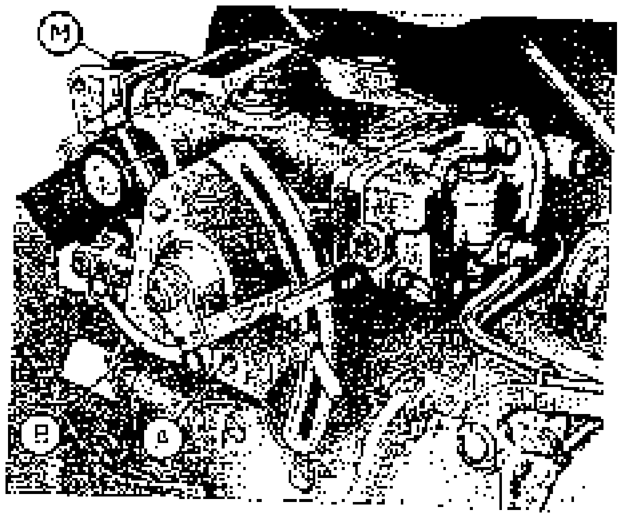


Fig. 172. - Hydraulic lift mounted on tractor.
A. Lift control lever - B. Selection lever (position control requires the lever to be shifted down) - M. Spring for reaction stud.

Hereafter are the main components of the lift mounted on 411 R tractors:

— A gear hydraulic pump, driven by engine timing gears (Fig. 171);

— a lift with integral oil tank composed of a ram (simply effect) acting through a bull-headed link on a lever keyed on the lifting arm shaft;

— a three point implement hitch, adjustable with a screw controlled by a hand wheel on the right link, allowing the cross adjustment of the implement position (Fig. 187);

— a control valve, optional, to be applied in place of the control valve cover for supplementary attachment control (Fig. 193).

HYDRAULIC PUMP

The hydraulic pump needs no maintenance, checking or adjustment even after long operation. This is due to the fact that clearance between the gears and bushes is taken up automatically by the oil pressure in the pressure side.

The bushes have their side facing the delivery fitted with a fillet (f, Fig. 173), which the oil crosses through to act upon a surface recessed on the two covers and defined by two rubber gaskets shaped as a heart, and laid eccentrically (2).

Pump general overhaul.

See Fig. 173 for the disassembling and assembling sequence of the hydraulic pump components. The explanations of the preceding paragraph should facilitate a correct assembly and disassembling; sense of rotation of the drive shaft is indicated on the pump cover.

In addition, notice that assembly and disassembly require no special tooling, as the high finish of machined surfaces would be damaged by a careless assembly.

Never disassemble a hydraulic pump if original spare parts are not available; if repairs are necessary entrust them to FIAT Service Organization.

We give hereafter the specifications of the hydraulic pump, to check its performance:

— ratio between engine and pump R.P.M. 1.162

— pump speed (with engine at rated speed, 2300 R.P.M.) . . . . 2,000 R.P.M.

— pump rotation, as viewed from driving shaft end . . . . clockwise

— suction head . . . . ± 300 mm (± 11.811")

— deliveries (oil at temperature of 60° C - 140° F) { at 0 kg/sq.cm (0 p.s.i.) . . . . 17 liters/min (3.75 Imp.gal.) / at 150 kg/sq.cm (2133.5 p.s.i.) . . . . 16.5 liters/min (3.65 Imp.gal.)

— pressure valve opening pressure (marked C or E) . . . . 145-155 kg/sq.cm (2062-2205 p.s.i.)

To secure a good performance of the lift hydraulic pump, use exclusively SAE 20 hydraulic oil avoiding all mixtures.

The customer shall be warned that periodical checks and cleaning of the hydraulic lift oil filter is absolutely necessary. After the first 20 hours from any oil change clean accurately to remove dirt from the filter.

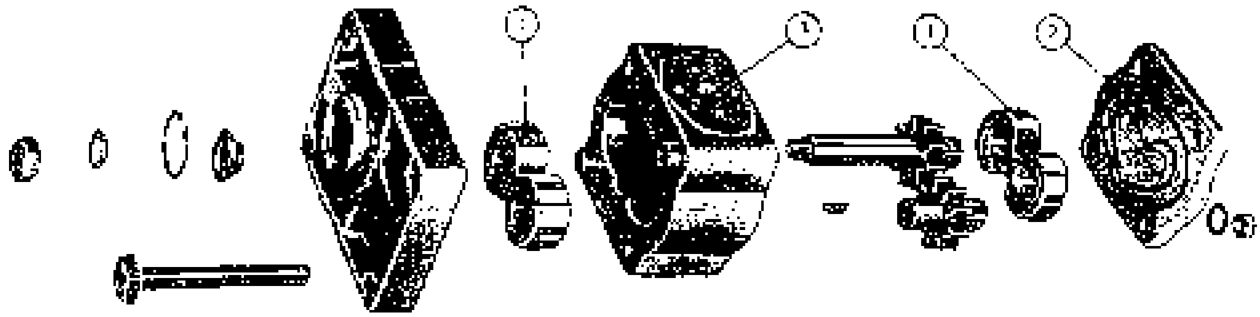


Fig. 173. - Hydraulic lift pump components.
1. Shaft bushes - 2. Forward cover - 3. Delivery port.

HYDRAULIC POWER LIFT OPERATION

The power lift consents performing two different operations, position control and draft control. To choose either one just move lever B (Fig. 172) downwards in the former case and upwards in the latter.

The lever can be actuated only when the lift arms are raised.

The lift arm raising or lowering control is performed by lever A. In the position control operation, at every position of lever A corresponds a different height of the lift arms, and consequently of the implement. In the draft control operation most of the excursion in the quadrant is used to determine the draft of the implement during work.

Whenever lever A is moved, the control valve spool rotates and according to its sense of rotation lets oil pass in different conditions through the valves of the hydraulic circuit which control the raising or the lowering of the arms. In the position control operation, the height of the arms can be controlled through lever A only, while in draft control also intervenes the reacting force which the implement passes on to the spring M, Fig. 175. The deformation of the latter consents the rotation of the control valve spool, (the strain of the spring being transformed by a lever mechanism) and consequently a movement of the arms which brings the resistance encountered by the implement in the ground back within the limits established by the position of the lever A in its sector.

In position control operation the selector lever B, acting on the relative position of levers and rockers of the linkage cuts off the control valve spool from the effects of the strain set by the implement on spring M.

Fig. 176 illustrates the hydraulic diagram of the system. For further details on the power lift operation see the Technical Information Bulletin, Form No. 324/92.

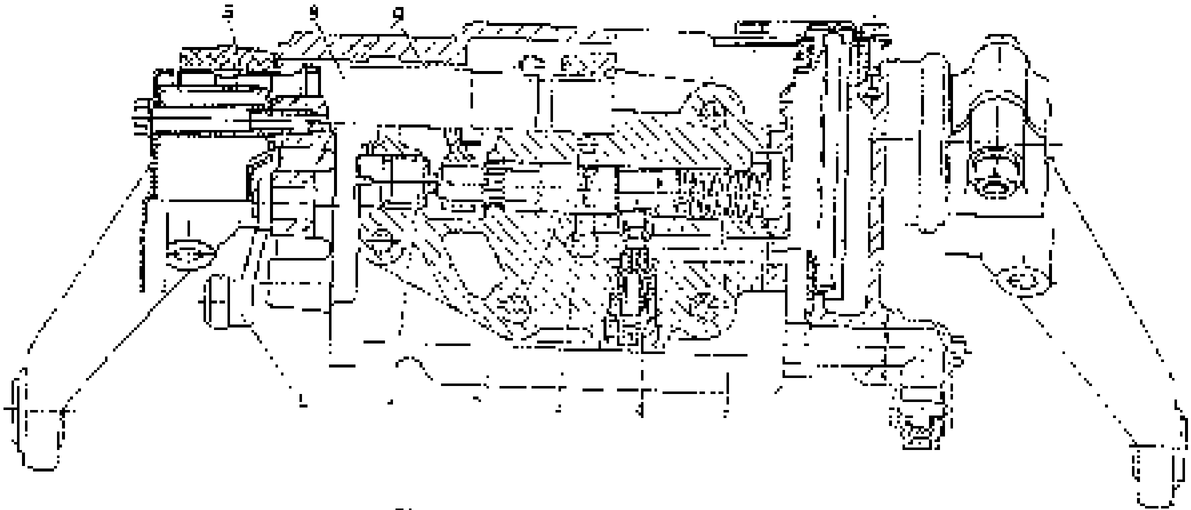
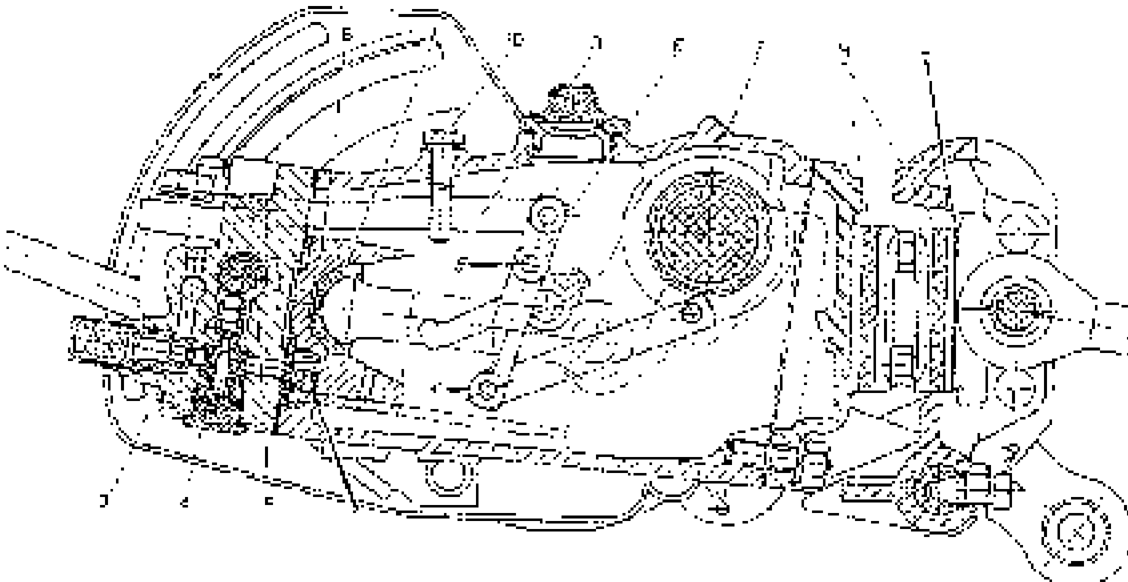
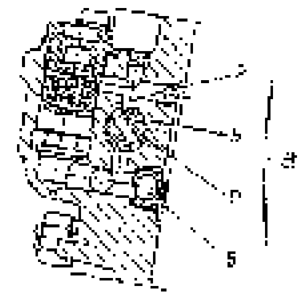


Fig. 174. - Arm control shaft section.

4. Cylinder discharge valve - 8. Lift arms control shaft - 9. Shaft bushings - L. [illegible] part in the control spool - P. Control spool - R. Tension spring - S. Lift arms - [illegible] control spool adjusting [illegible] - L. Linkage control lever.





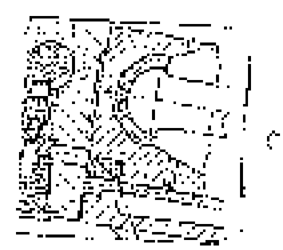


Fig. 175. - Sectional view of the hydraulic lift unit.

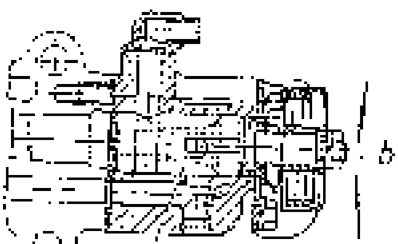
3. Cylinder pressure safety valve - 4. Discharge valve - 6. Piston - 7. Item seal on piston - 10. Arms max. lift adjusting screw - H. Spring adjusting screws - M. Spring - D. E. P. F. a. c. See Fig. 176.

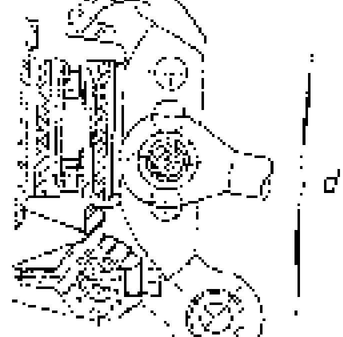
(The arrow indicates the leather washer placed between the piston and the rubber one on lift units up to No. 05502).

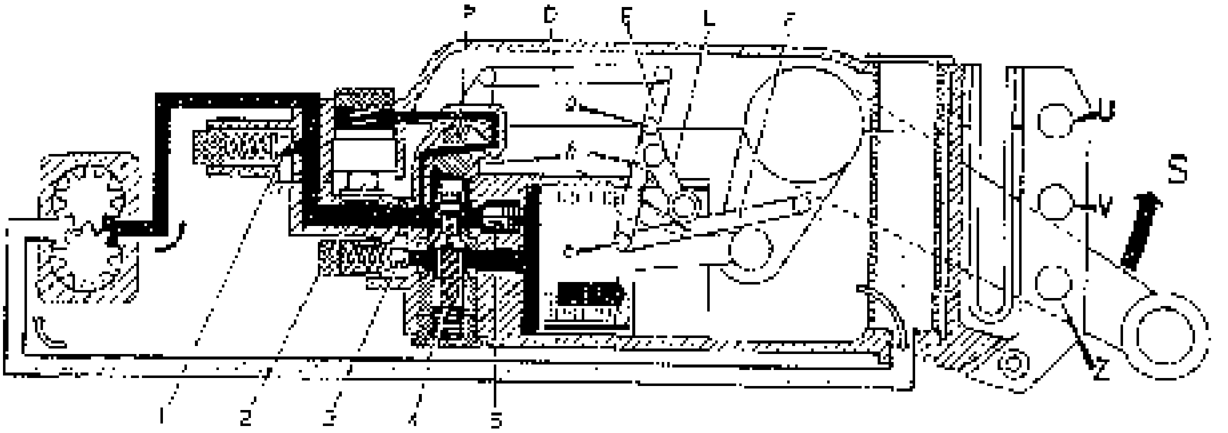
a) Sectional view of the cylinder intake valve.

2. Lift control valve - 5. Cylinder intake valve - N. Groove machined along the control spool axis to discharge the oil, the pressure of which keeps valve (2) closed by acting on the [illegible] of [illegible] - P. Control spool.

b) Detail of section through the control spool - P. Control spool. - c) Sectional view of the piston of the hydraulic lift No. [illegible] and up. - d) Starting from lift No. 57100 up (April 1962) the number of the unit mounting holes has been increased from 3 to 4.

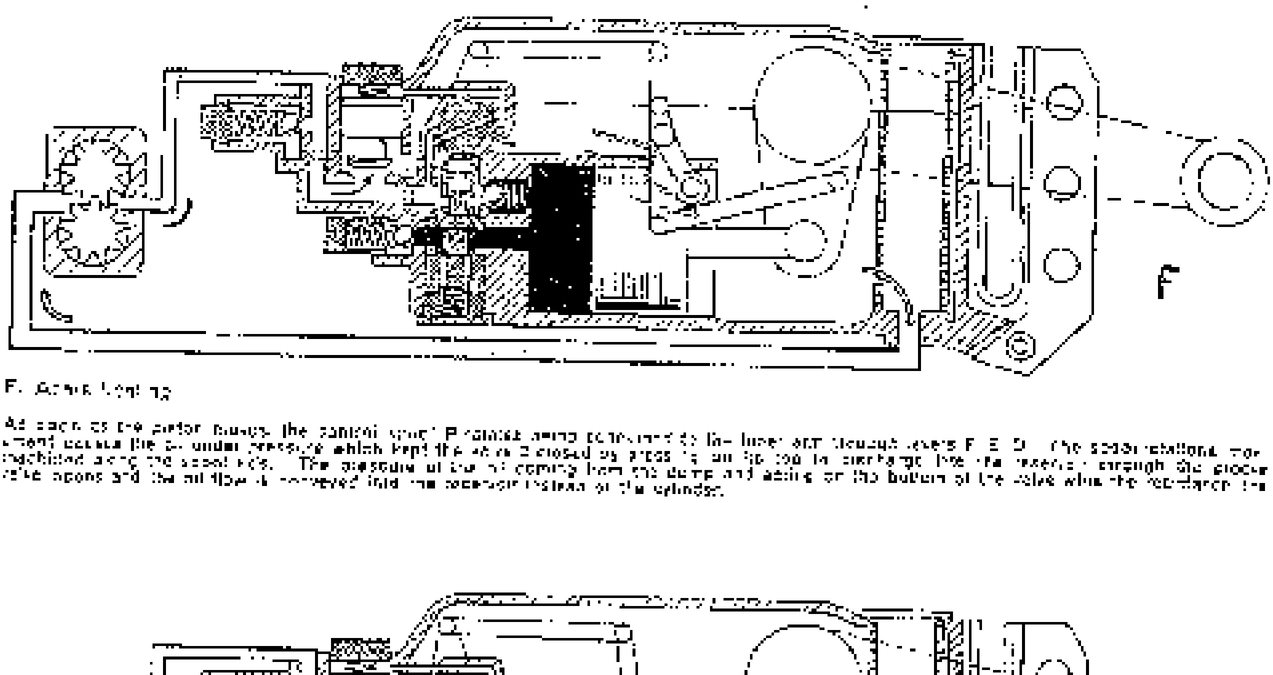






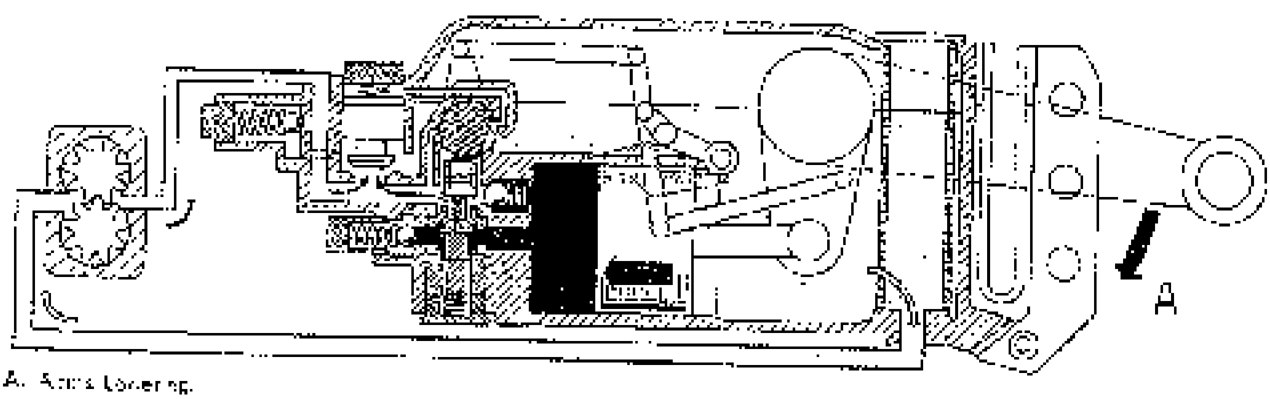
S. Arms lifting.

The control spool P is rotated so as to let oil pass from the pump onto the top of the [illegible] control valve plunger 2, enabling its closure. The [illegible] [illegible] oil can then flow in the cylinder through valve 5 and displace the piston to lift the arms.



F. Arms floating.

As soon as the piston moves, the control spool P rotates, being connected to the lower arm through levers F, E, D. The spool rotational movement causes the oil under pressure which kept the valve 2 closed by pressing on its top to discharge into the reservoir through the groove machined along the spool axis. The pressure of the oil coming from the pump and acting on the bottom of the valve wins the resistance, the valve opens and the oil flow is conveyed into the reservoir instead of the cylinder.



A. Arms lowering.

To lower the arms, the valve spool opens by cam action the discharge valve (4), which allows the oil to outflow towards the tank under the pressure on the piston.

Fig. 176. - Working diagrams of the hydraulic system for different arm positions

(Note: The oil flow pattern in the circuit is identical both for position and draft control operation) - 1. Pressure relief valve - 2. Control valve - 3. Cylinder safety valve - 4. Cylinder discharge valve - 5. Cylinder intake valve - **D.** Link - **E.** Rocker - **F.** Yoke link - **P.** Control spool - g, e. Pivot points - h. Groove along the control spool axis for oil discharge when valve (2) opens - L. Linkage control lever - U.V.Z. Top link mounting holes. (Starting from [illegible] the number of holes has been increased from 3 to 4, see Fig. 175).

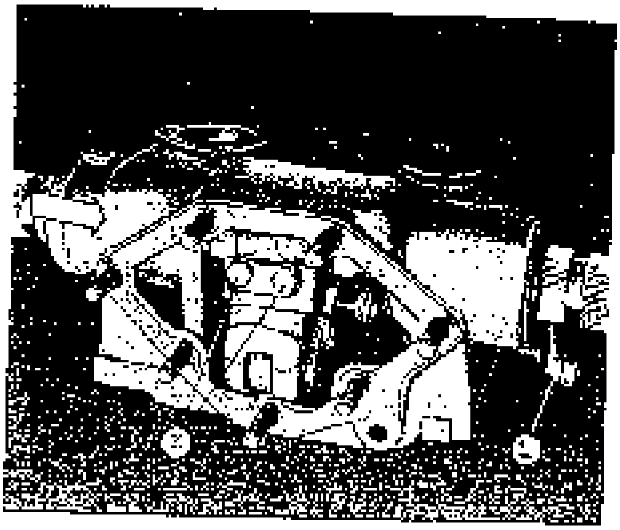


Fig. 177. - Removing the arms lifting shaft (the arrow shows the direction of extraction).

21. Screws which fasten the levers to the inside arm - L. Linkage control lever.

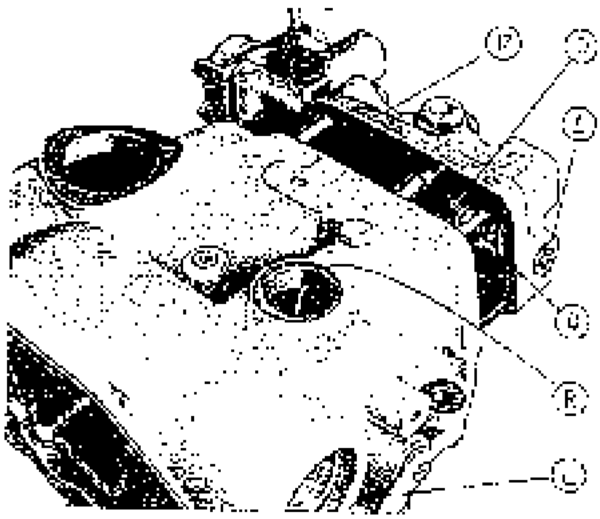


Fig. 178. - Removing the valve block.

17. Valve block - L. Linkage control lever - D. Cotter pin connecting the link to the control spool lever - Q. Set screw connecting the control lever to the control spool - R. Access port for removing screw R (see Fig. 132) - S. Control spool [illegible] pin.

Dismantling the power lift.

To remove the unit from the tractor separate the arms from the implement hitch first, then disconnect the two oil lines and remove the screws which fasten the unit to the transmission housing. To dismantle the power lift proceed according to the following sequence.

Components to be removed.	*Operations and cautions.*
Filter (11, Fig. 133).	*Pull the parts out the lift box.*
Outside linkage (12).	*Remove the complete assembly freeing it from the lift box and spring support.*
Cover (13).	*Can be removed together with the spring support.*

Fig. 179. - Cylinder discharge valve parts.

1. Plunger.

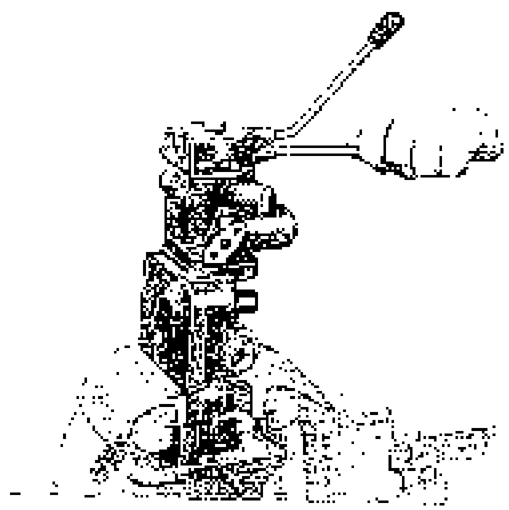


Fig. 180. - Unlocking the auxiliary equipment control block screws.

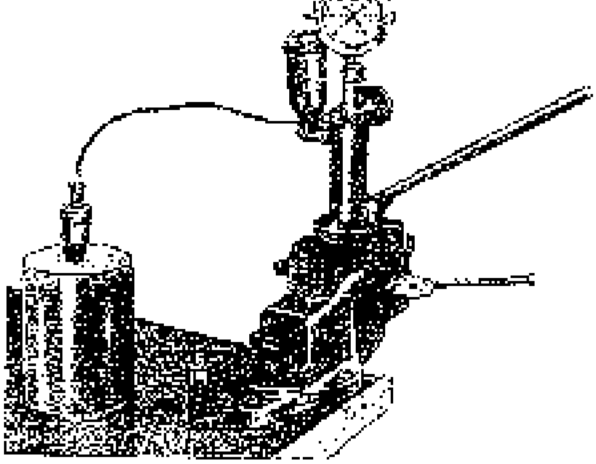


Fig. 181. - Testing apparatus for safety and pressure relief valves, using valve holder A. 197032/A/B.

Arms control shaft.

Remove the lift outer arms, the screws which fasten the levers to the inner arm (21, Fig. 177) and slide the shaft in the direction shown by the arrow.

Note. - *To prevent damaging the seal ring located on the left end of the arms control shaft move the shaft about 2 cm (25/32") in the sense opposite to the arrow and remove the ring (Fig. 177).*

The inner arm with its piston driving strut remains inside the power lift.

Control valve (Fig. 178).

Remove pin (Q) which fixes the valve spool control lever to its link prior to sliding the whole unit off the studs.

Note. - *The following components remain free inside the power lift:*

— *the lever mechanism which is removed by unscrewing the screw (R) first and sliding off the outer lever (L) in a second time;*

— *the piston and barrel. The latter can be slid out the front by applying a slight force.*

The valves can all be disassembled easily enough as they all are accessible from the outside, with the exception of the oil inlet into the power cylinder valve (8) which requires removing the control valve group. To disassemble the control valve slacken the screw which fixes the control lever (Q), remove the adjusting plug (t) and the side cover of the control valve for auxiliary equipment (Fig. 180).

Fig. 183 shows the power lift subassemblies in the dismantling sequence and Fig. 182 the outside lever mechanism (above), and the inside lever mechanism connected as they are during operation (below).

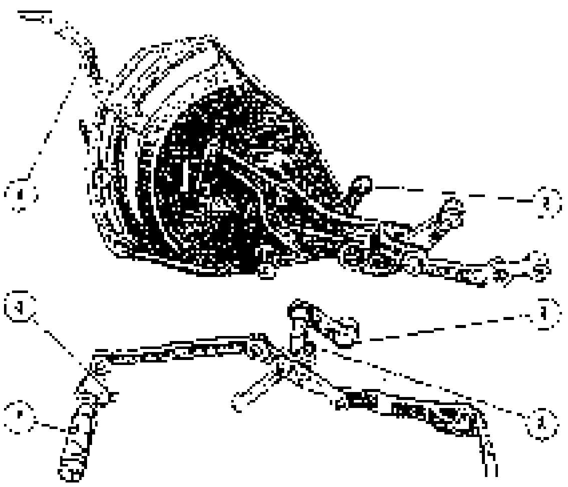


Fig. 182. - Lift outside and inside control linkage

The illustration shows on top, the outer linkage removed from the lift; below, the inside linkage pinned as during work. A. Lift control lever - B. Selector lever - L. Linkage [illegible] lever - P. Control spool - Q. Screw securing the control lever to the spool - R. Screw securing the lever L to the rocker.

Inspection of components disassembled from the hydraulic lift.

After dismantling the power lift unit check the following:

— check conditions of the gasket between barrel and housing and between piston and barrel;

— check the play between the arm control shaft journals and the bushings; if found exceeding the values specified on the table of page 130 replace the bushings.

— check that the play between the control valve spool and its bore lies within the specified limits. Note that the valve spool is not furnished singly as a spare, but always together with the valve block being fitted to the bore;

— wash and replace the oil filter cartridge, if found defective, and make sure that the filter inlet plug is well welded to the plate for cartridge protection to prevent air suction on the part of the hydraulic pump;

— replace the oil seals for the lift arms shaft and the gaskets of covers, plugs and valve seats if they are not dependable;

— check sealing characteristics of the discharge valve and of the lift control valve (4, 2, Fig. 196), grind the seats if necessary and check spring performance;

— check the setting of the pressure limiting and safety valves by means of a hand pump equipped with valve carrier A 197032/A/B, Fig. 181. If data do not correspond, replace the valves, as component parts are not furnished separately as spares.

Relief valve : 2133 ± 70 p.s.i.

" " cyl : 2772 to 2917 p.s.i.

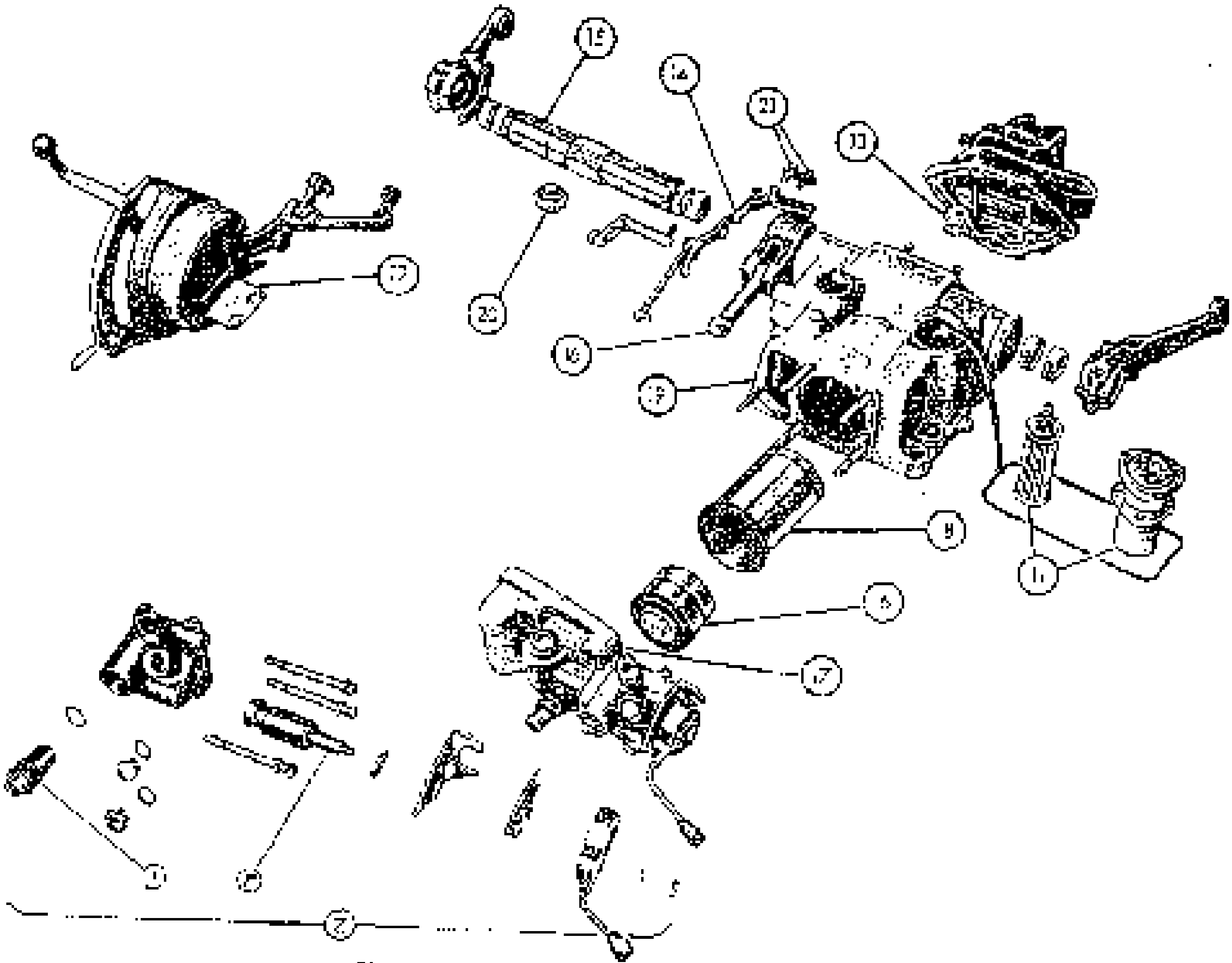


Fig. 183. - Exploded view of the hydraulic lift.

6. Piston - 11. Oil filter components - 12. Outside linkage - 13. Rear cover with [illegible] mounting - 14. Inside linkage - 15. Arms lifting control shaft - 16. Inside arm with [illegible] - 17. Control unit - 18. Screw - 19. Lift body - 20. Breather plug - 21. Screws fixing linkage to inside arm.
2) Exploded view of the auxiliary control block - 1. Pressure relief valve - 5. Control [illegible].

Power lift assembly.

Reverse the order of dismantling and follow closely the instructions given below:

— when placing the inside and outside arms on the control shaft make their respective stamped marks to register (see Fig. 184),

— the installation of the seal rings on the arms requires using the protection A 197003/A first, in order to prevent contact with the teeth of the shaft and, then the use of the punch A 197003/B (Fig. 185);

— the screw which fastens the control lever to the control valve spool (Q, Fig. 182) should be mounted on the piston side.

Power lift adjustment.

The adjustment of the power lift should be carried out by placing the unit on the tractor or on the bench I 495005 which is equipped with the necessary weights.

a) *Control valve spool adjustment* — Run the engine to high idle speed, then raise the lift arms, and place the selector lever on position control (downwards). Remove the cotter pin and slowly screw in the adjustment plug (1, Fig. 186) until the load starts oscillating (vertical oscillations): unscrew the plug half a turn and fit the cotter pin.

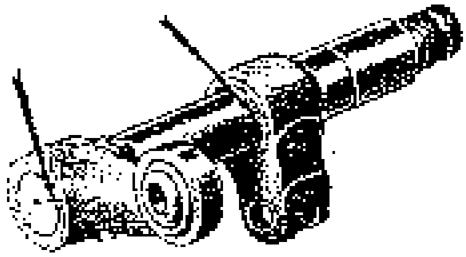


Fig. 184. - Register marks for fitting the inside and outside arms onto the control shaft.

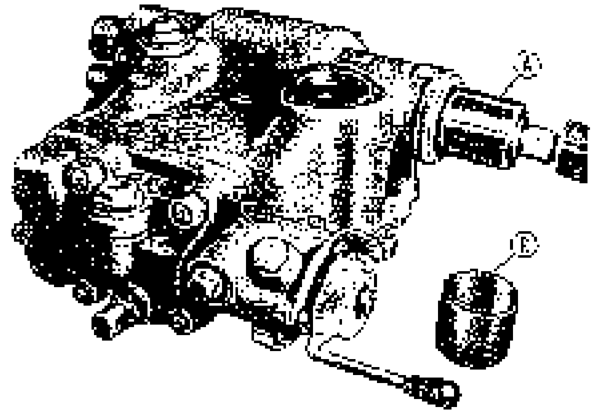


Fig. 185. - Lift arms control shaft seals fitting.

A — A 157003 A Punch - B — A 157003 B Protector

b) *Arms stroke adjustment.* — Start the engine and check that the stroke of arm ends of the implement hitching device (with the links connected in the holes as shown in Fig. 187 is from 580 to 600 mm (22-27/32" to 23-5/8"). If the stroke length does not lie within the above tolerance, act on screw (10, Fig. 186) by means of spacers.

Note that when the implement hitching device arms are at their highest position there must be a margin left, which is controlled by raising by hand the lift arms.

c) *Adjustment of the distance between the lift cover and strut support.* — Whenever parts have been replaced (spring, strut support or lift cover) or after a major overhaul check the following:

1) Remove the strut and check that distance I (1, Fig. 190a) is 15 ± 0.5 mm (0.590" ± 0.02"). If otherwise change one or two spacers H between spring and support. Note that it would not be convenient to use a large number of shims H to decrease the clearance I because that would vary the load and conditions of the spring M.

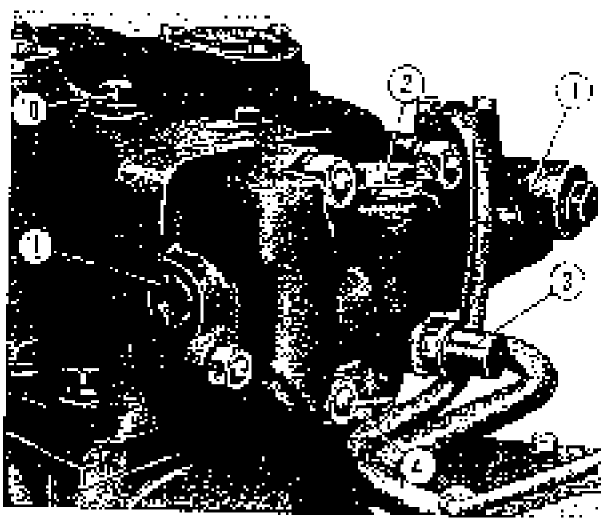


Fig. 186. - Valve block.

1. Pressure relief valve - 2. Lift control valve - 3. Cylinder pressure safety valve - 4. Discharge valve - 10. Lift arms stroke adjusting screw - 11. Control spool adjustment plug.

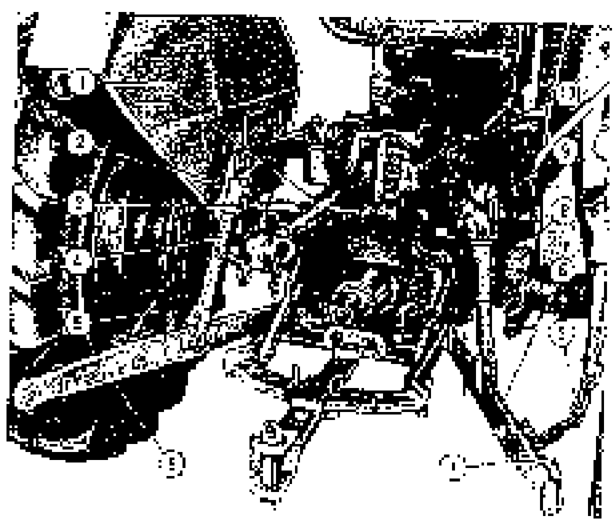


Fig. 187. - Hydraulic lift linkage installed on the tractor.

1. Top link, adjustable - 2. Removable pin - 3. Fixed pin - 4. Left lifting rod - 5. Check chains - 6. Left lower link - 7. Snap pins - 8. Right lower link - 9. Levelling lever - 10. Top link mounting pin.

(See new, improved drawbar assembly on page [illegible])

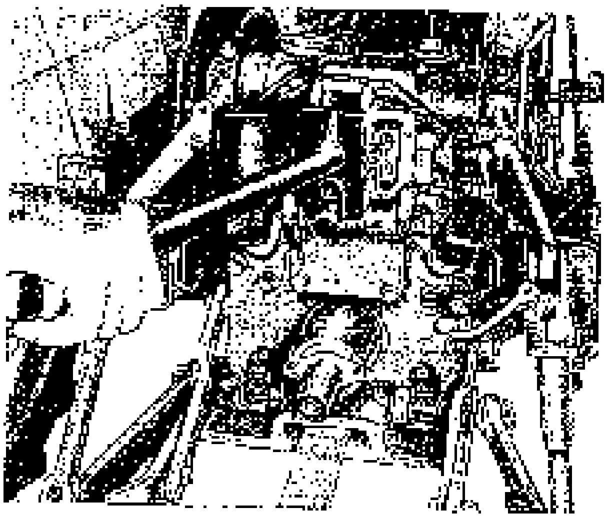


Fig. 188. - Adjusting the top link supporting spring tension using tool A 197016.

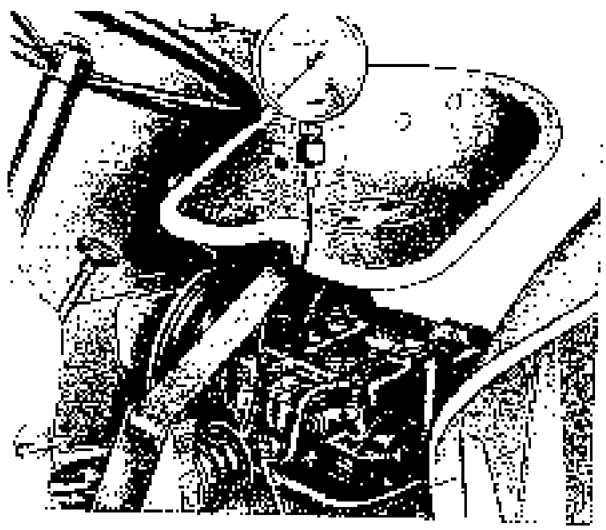


Fig. 189. - Hydraulic system pressure reading using a pressure gauge with fitting A 197035 mounted in place of the safety valve.

5) Install the lever A 197016 in the mounting holes (Fig. 188) and by pressing downwards take up completely the clearance existing between cover and support at the lower stop shown with an arrow (2 Fig. 190 a). In these conditions, the distance I should measure 22,5 ± 0,5 mm (0,885 ± 0,02"); a greater distance means that the surfaces of the lower stop are worn and need added material. The distance I in cases 1) and 2) of Fig. 190 a can be checked using the two ends of the « Go - No - Go » gauge C 197015.

6) *Adjusting the play between roller and sector* (Fig. 190 b). - Move the lift control lever to the highest position in the sector slot to get full raising of the arms, and place the selector lever in draft control (upwards); apply the lever A 197016 to the mounting holes of the strut to its support so as to completely take up the play existing between cover and support at the lower stop: in these conditions the distance between cam and follower should measure 1,5 to 2 mm (1/16 to 5/64"). If necessary, the distance can be corrected by rotating the eccentric on which the follower is mounted.

Note. - Should the working pressure of the lift hydraulic system need checking, place a pressure gauge with fitting A 197035 in place of the safety valve as shown in Fig. 189.

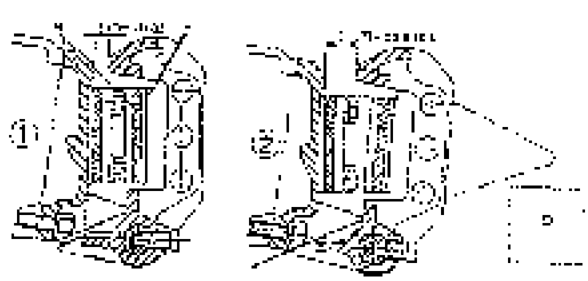


Fig. 190 a. - Setting the clearance between lift cover and top link mounting bracket.

1) Setting the clearance I (14,5 to 15,8 mm = 0,571 to 0,610 in) between cover and top link support bracket, spring M being free.

2) Setting the clearance I (23 to 23 mm — 0,905 to 0,905 in) between cover and top link support bracket, spring M being loaded.

H. Adjusting shims - M. Top link support bracket spring. Clearance I indicated in sketches 1 and 2 of Fig. 190 must be considered as a practical working dimension; for new lift units the clearance is 14,8 to 15,1 mm (0,580 to 0,594 in) and 22 to 22,5 mm (0,874 to 0,886 in) respectively.

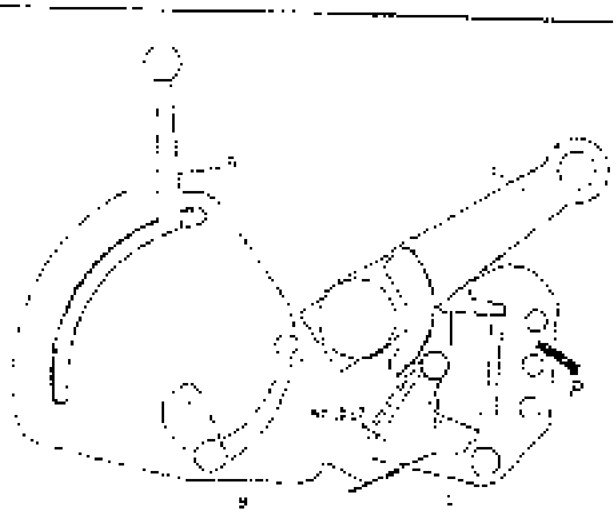


Fig. 190 b. - Adjusting the clearance between cam and roller.

A. Lift control lever - B. Selector lever - R. Reaction roller - S. Lift arms - P. Load to apply to the support bracket to take up the play existing between the parts indicated by the arrow.

Important

To be sure to make the best use of the power lift in every circumstance, read the following instructions.

Position control operation.

Move lever **B** (Fig. **190 b**) downwards and insert the strut support wedge as shown in Fig. **192**. In these conditions the holes of the support shown in Fig. **176** can be used to mount the top link.

Draft control operation.

Move lever **B** upwards (Fig. **190 b**) and take the wedge away from the strut support (Fig. **192**). For a more sensitive operation use the intermediate holes but not for implements which determine heavy loads on the strut (rippers, disc plows etc.) which require the use of the lower holes. Exceptionally, and only for very light work requiring high sensitivity, use the top holes. Never mount the top link in the top hole for all other cases in order to avoid excessive stresses on the spring.

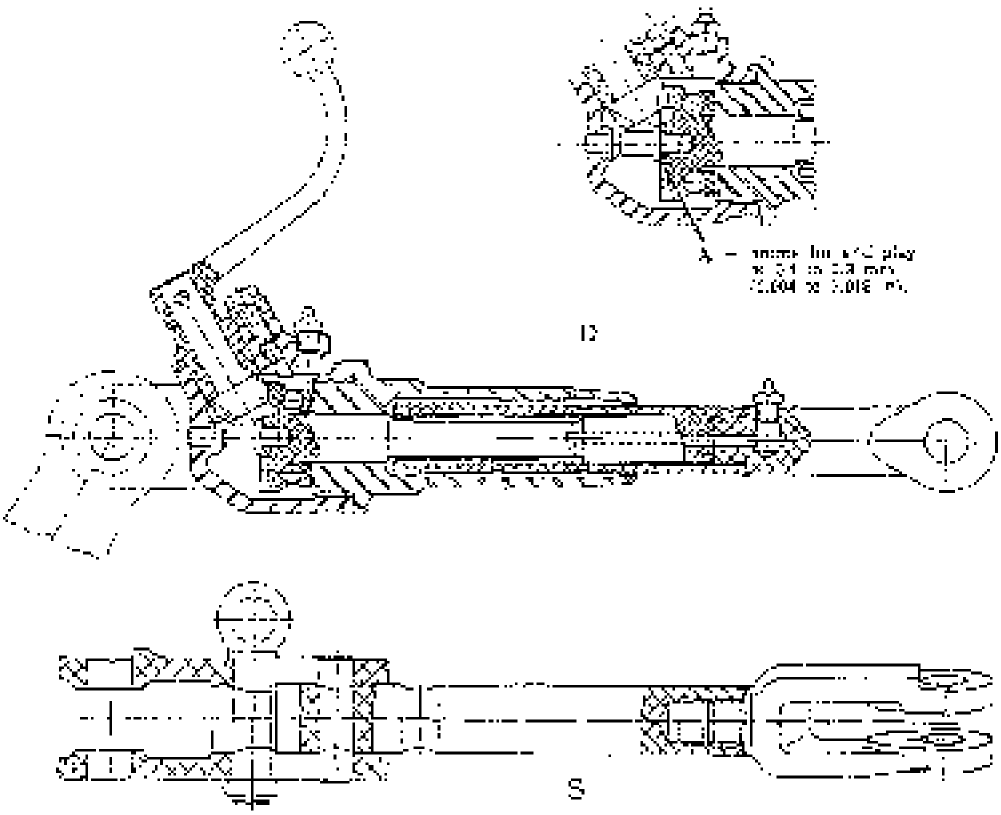


Fig. 191. - Sectional view of the hydraulic lift linkage rods
D. Right lifting rod - S. Left lifting rod.

AUXILIARY COCK

The hydraulic power lift can be equipped with a control cock unit in place of the control valve cover in order to actuate attachments controlled by hydraulic power cylinders, both single and double acting.

This attachment is not controlled by the lever which determines the raising and lowering of the arms, but rather by a lever which is part of the control cock lever. This makes the two operations independent

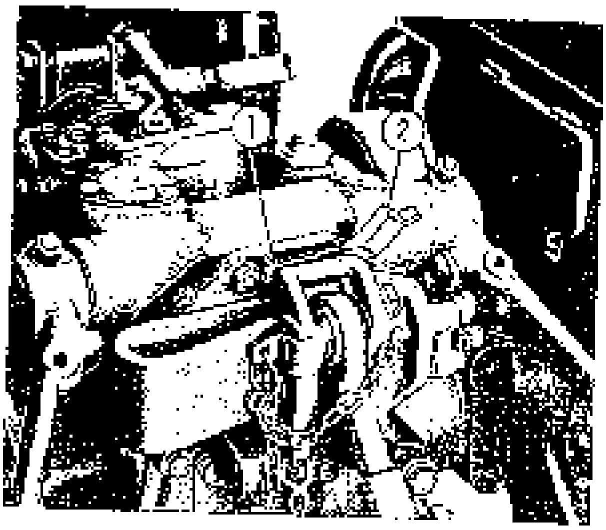


Fig. 192. - Top link support bracket wedge. 1. In - 2. Out

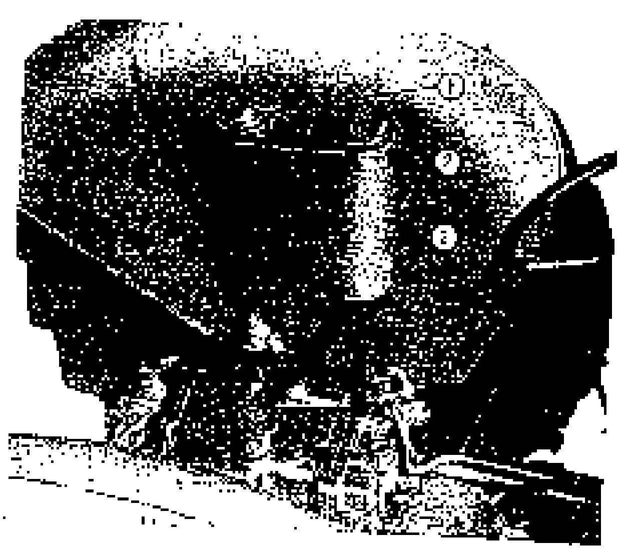
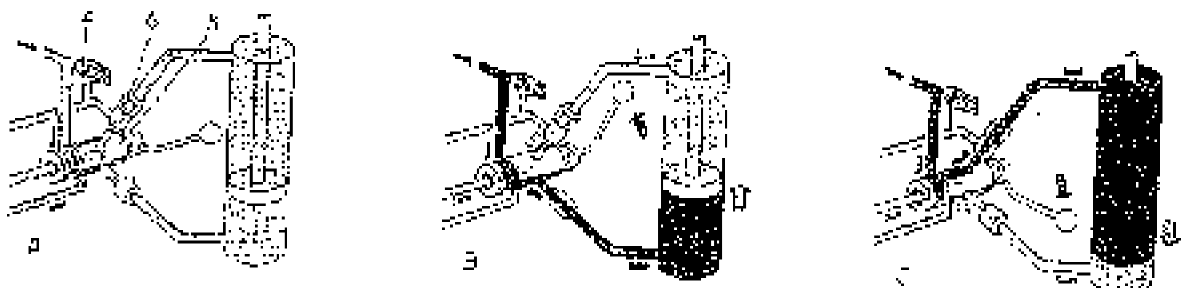
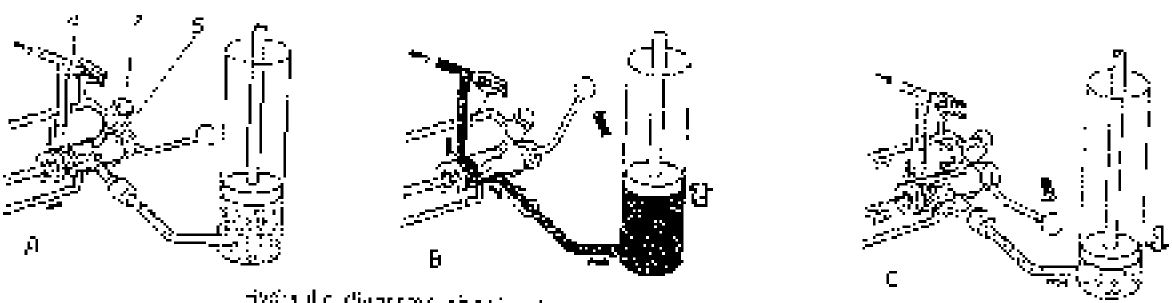


Fig. 193. - Auxiliary oil reservoir installed on the left fender and supplying a single-acting cylinder.
1. Breather - 2. Filler plug - 3. Dipstick - 4. Control cock

from each other and allows using the same oil contained in the lift unit. The two different types of operation control function at the same time. Should the application require more than 2 to 2,5 liters (1-3,4 to 2-1,4 Imp. quarts) of oil, an auxiliary oil reservoir must be added. Fig. 193 shows the installation of an auxiliary oil reservoir with a capacity of 9 liters (5 Imp. quarts) for actuating a power cylinder with a max. capacity of 11 liters (3.8 Imp. quarts).
The auxiliary oil reservoir is connected to the hydraulic power lift unit through a tube fixed to the breather plug by means of a fitting. The plug is then installed on the auxiliary reservoir. Check all the seals before installing the reservoir to prevent leakages due to the higher pressure head.
The control cock unit shown on Fig. 190 and 193 is installed on the power lift unit in place of the control valve block cover. From the latter it is possible to recover the gasket and the complete pressure valve which can be installed in the new unit.
The operational diagrams for single and double acting cylinders are shown on Fig. 194.



Hydraulic diagrams showing the operation of one double acting cylinder



Hydraulic diagrams showing the operation of single acting cylinder

Fig. 194. - Diagram showing the operation of the control cock connected to single and double-acting cylinders.
4. Pressure relief valve - 5. Control cock pin - 6. Double acting cylinder pipe fitting - 7. Plug 16 MB x 1.5 to be used after installing single acting cylinders. - A. Stop position - B. Lifting position - C. Lowering position

HYDRAULIC LIFT ASSEMBLY DATA

Description	Data mm (in)	Assembly clearances	mm (in)	Wear limits mm (in)
Inside diameter of cylinder sleeve	85,035 to 85,071 (3.3478 to 3.3492)	Inside diameter of cylinder sleeve and piston	0,035 to 0,105 (0.0014 to 0.0041)	0.25 (0.010)
Diameter of piston	84,966 to 85,000 (3.3451 to 3.3465)			
Inside diameter of bushings on arm control shaft (1): right end	55,100 to 55,170 (2.1693 to 2.1721)	Arm shaft and bushings: right end	0,100 to 0,200 (0.0039 to 0.0079)	[illegible] (0.016)
left end	47,100 to 47,170 (1.8543 to 1.8571)	left end	0,100 to 0,195 (0.0039 to 0.0076)	
Diameter of arm control shaft at bushings: right end	54,970 to 55,000 (2.1642 to 2.1654)			
left end	46,975 to 47,000 (1.8495 to 1.8504)			
Inside diameter of bushings for upper support lever (press-fitted bushings)	12,016 to 12,059 (0.4730 to 0.4748)	Inside diameter of bushings and the diameter of the lever pin	0,016 to 0,086 (0.0006 to 0.0034)	0.15 (0.006)
Diameter of draft control lever pin	11,973 to 12,000 (0.4714 to 0.4724)			
Inside diameter of roller and lift control lever bushings (press-fitted)	12,032 to 12,075 (0.4737 to 0.4754)	Inside diameter of press-fitted bushing and their pins	0,032 to 0,102 (0.0013 to 0.0040)	0,5 (0.020)
Diameter of roller ([illegible], Fig. 190) and lift control lever ([illegible], Fig. 192) pins	11,973 to 12,000 (0.4714 to 0.4724)			
Thickness of friction discs for lift control lever	2 (0.079)			
Thickness of spacer for lift arm and adjusting screw (10, Fig. 186)	0,45 to 0,55 (0.018 to 0.022)	—	—	—
Inside diameter of bushings press-fitted into the upper link bracket (2)	25,0[illegible] to 25,0[illegible] ([illegible])	Bushings and upper link bracket hinge axis	0,020 to 0,130 (0.0008 to 0.0051)	0,5 (0.020)
Diameter of upper link bracket hinge axis	25,000 to 24,942 (0.9843 to 0.9820)			

Valve spring specifications		Safety (cylinder)	Control (lift)	Discharge
Free length	mm (in)	36 (1.42)	46 ([illegible])	23 (0.91)
Compressed length	mm (in)	27 (1.06)	20 (0.79)	10 (0.40)
Test load	kg (lb)	25 to 29 (55 to 64)	[illegible] to 2,2 ([illegible] to 4.8)	2,3 to 2,6 (5 to 5.7)

Opening pressure of relief valve (1, Fig. 186) (marked with letter [illegible]): 165 to 185 kg/cm² (2350 to 2635 p.s.i.)
Opening pressure of cylinder safety valve (3, Fig. 186): 195 to 205 kg/cm² (2774 to 2916 p.s.i.)

Discharge valve (4, Fig. 186) to control valve body wrench torque: 9 to 10 kgm (65 to 72 ft-lb)
Cylinder safety valve ([illegible], Fig. 186) wrench torque: 4 to 5 kgm (29 to 36 ft-lb)

(1) Bushings are fitted into their housings in the lift casing with an interference of 0,070 to 0,132 mm (0.0028 to 0.0052 in).
(2) Bushings are fitted into their housings with an interference of 0,05 to 0,23 mm (0.0020 to 0.0091 in).

Tightening torque on valve bodies
Relief valve cylinder (3 Fig 186) 4 to 5 kgm (29 to 36 ft lb)
Relief valve (1 Fig 186) 9 to 10 kgm (65 to 72 ft lb)

HYDRAULIC LIFT SYSTEM FAULT TABLE

FAULT	POSSIBLE CAUSE	ATTENTIONS REQUIRED
Lift fails to operate.	1) No oil.	Top up.
	2) Control valve sticking.	Dismantle and clean it.
	3) Hydraulic pump does not work.	Overhaul the pump.
Lift jolts.	1) Oil level very low.	Top up.
	2) Oil filter clogged up.	Clean it.
	3) Air bubbles in suction ducts.	Check fittings and seals.
Lift does not hold the load in raised position (when the engine is running, the load keeps on oscillating up and down; when the engine is stopped, the load drops).	1) Faulty adjustment of valve spool.	Readjust the valve spool as specified on page 128.
	2) Faulty sealing or sticking of discharge valve.	Dismantle and check the parts involved; assemble the valve tightening the plug with a torque wrench set at 9 to 10 kgm (65 to 72 lb.ft) in order to avoid possible distortions.
	3) Oil inlet valve of hydraulic cylinder leaks.	Dismantle and check the parts involved.
	4) Oil leaks past lift piston seal or cylinder seal.	Replace them.
	5) Cylinder pressure relief valve leaks.	Replace it.
	6) Discharge valve seats damaged.	Replace them.
Not sufficient pressure to raise lift ~~Scarce lifting force.~~	1) Pressure relief valve out-of-adjustment.	Check setting.
	2) Cylinder pressure relief valve out-of-adjustment.	Replace it (torque loading spring setting)
	3) Low pump efficiency (*).	Test pump performance and overhaul it, if necessary.
Pressure relief valve cuts in when lift arms are ~~all~~ fully raised ~~up~~.	1) Lift arm stroke adjustment screw out-of-adjustment.	Take a few shims from underneath the screw head (see paragraph e b x of lift adjustment on page 125).
Traces of engine oil in the hydraulic fluid	1) Oil leaking through between hydraulic pump and seal.	Check the parts involved and replace the damaged ones.

(*) Usually accompanied by a considerable increment of the force required to raise the load.

TOOL LIST

Tool No.	Description	Page No.	Fig. No.
A 001322	Hammer, brass	50	
A 5717	Swivel stand, pump overhaul	39	
A 11401	Grinder, engine valves	13	
A 12731	Hand pump	39	
A 48701	Adaptor	35	
A 18177	Dial gauge	40	
A 117019	Wrench, injection pump timing	45	50
A 117052	Wrench, engine timing	46	
A 117063	Pilot rod	56	85-91
A 117066	Bushing	47	
A 127050	Gauge, control box setting	101	157
A 127051	Gauge, control box setting	104	
A 137003	Adapter, gearbox primary shaft	67	132
A 137016	Gauge, bevel pinion setting	63	112-113
A 137014	Lock, final drive gear	76	
A 197003 A/B	Driver and protector	125	158
A 197015	Lever	127	65
A 197032 A/B	Valve holder, for recess check	124	161
A 197035	Fitting	127	163
A 217028	Valve spring compressor	13	21
A 217030 A/B/C/D/E/F/G	Cutters and spindle set, for valve seat grinding	12	
A 217072 A/B	Driver, cylinder liner removal and installing	11	17
A 227004	Puller, injection pump drive	36	
A 267013	Adapter set, differential lock installing	57	137
A 313030	Driver, valve guide removal and installing	19	
A 323005	Puller, injection pump plungers	34-38	54
A 323010	Wrench set, injection pump adjustment	40	
A 323023	Support, injectors	44	67
A 323025	Puller, injection pump shaft bearing	35	57
A 323028	Puller, pump bearing outer race	37	
A 323032	Retainer forks, injection pump followers	35-36-38	
A 323033	Tool, injection pump tappet removal and installing	35-38	
A 323044	Screw driver	35	
A 423572	Measuring set for control rack travel	41	
A 517007	Riveting set	12	
A 527031	Wire brush	12	
A 527002	Connection, injection pump plunger stroke check	40	51
A 527005	Puller, injection pump delivery valves	38	
A 527015	Connection set with pressure gauge, injectors and pump elements check	33	
A 527103	Puller	65	
A 711196	Wrench	68	
A 619018	Clamp piston rings	18-20-45	27
A 619022	Pliers, piston rings	18	29
A 619027	Puller, pilot bearing in flywheel	53	
A 711033 A	Fixtures, main clutch dismantling and reassembling	54-55-56	52-59
A 711109	Wrench	66	
A 711250	Spring tester	12	
A 735108	Puller, steering arm	13	
A 823154	Driver, gearbox	59	
A 860763	Driver, gearbox	58	
ARR 2204	Rotary stand, medium size	59-65-70-119	96-105
ARR 2216	Rotary stand, large size	45	
ARR 2228	Stirrup set, for rotary stand ARR 2204	65-70	
ARR 117004	Stirrup set, for engine installation	6-45	
ARR 117035	Engine lifting hook	5-6	3
C 680	Dial gauge, with stand	30	
C 687	Dial gauge set	11	
C 731	Gauge block	39	
C 197219	Go-no-go gauge	127	
C 517021	Fixture, connecting rod alignment check	20	
C 619012	Ring gauge, for setting dial gauge C 687	11-16	
J 495005	Bench, hydraulic lift	115	
U 0321	Reamer, reverse shaft bush	61	
U 0337/A/B	Reamers set, engine	14	
U 217017	Expansion reamer	17-19	
U 350030	Reamer, valve guides	14	
U 323034	Reamer, pump rack bushing	57	
U 616914	Expansion reamer	66	
U 616915	Expansion reamer	74	

E

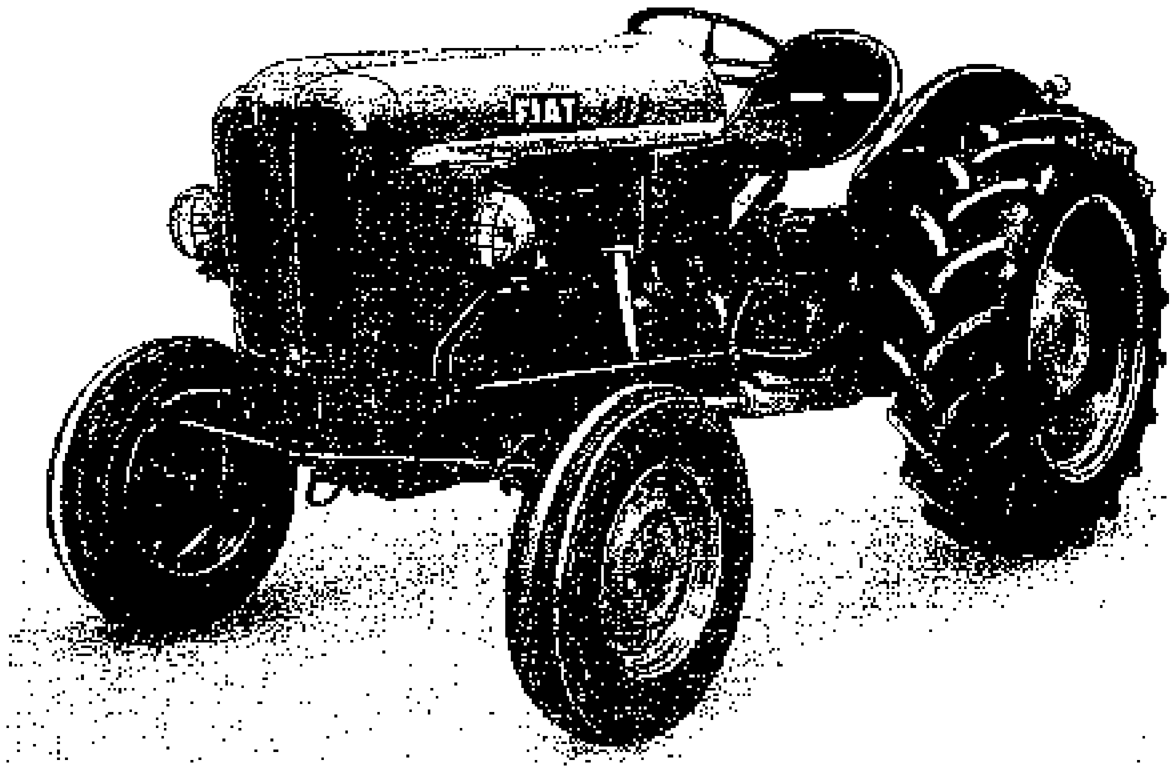


Fig. 135 - Front and side view of tractor 411 R.

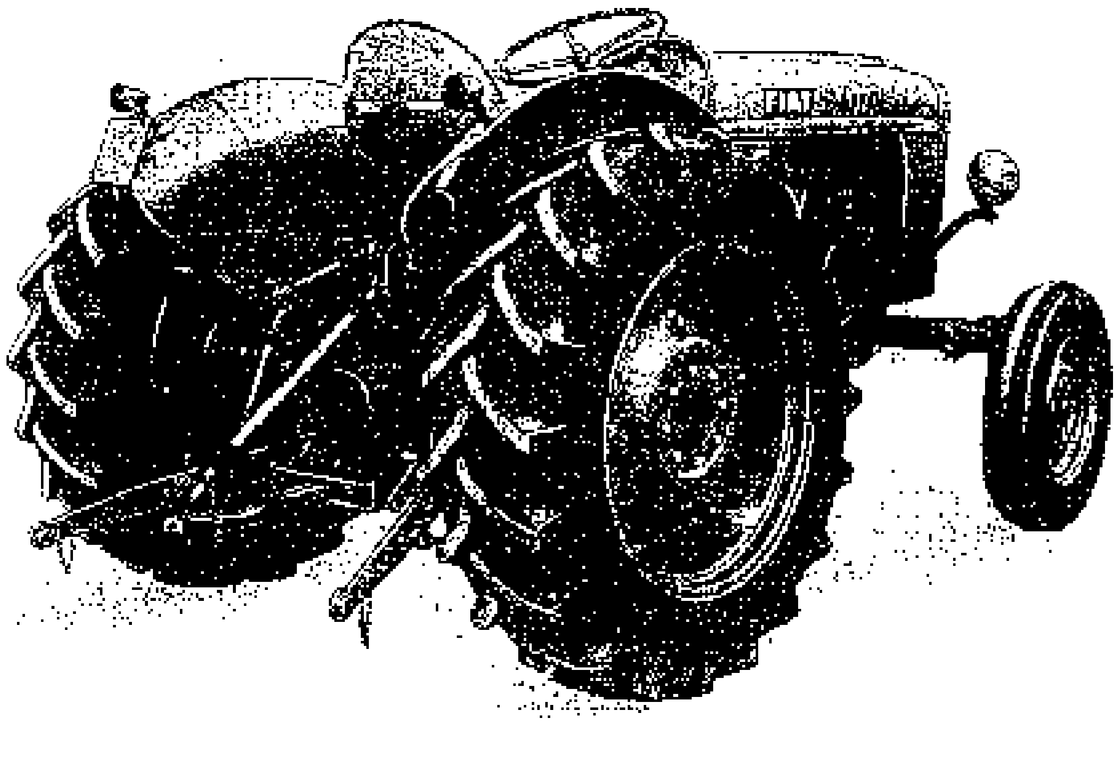


Fig. 136 - Rear and side view of tractor 411 R.

SPECIFICATIONS

ENGINE

Type	
Diesel 4 stroke with turbulence chambers	615.000 (*)
Numbers of cylinders	4
Bore and stroke	85 x 100 mm (3.346" x 3.937")
Piston displacement	2270 cm³ (138.5 cu.in.)
Compression ratio approx.	21.5 : 1
Maximum rated horse power (with air cleaner, without fan and exhaust muffler)	40 H.P. (¹)
Maximum H.P. developed at	2300 R.P.M.
Maximum torque	14.3 kgm (101 ft.lb)
Maximum torque developed at	1600 R.P.M.
Engine weight (with air cleaner, without lubricating oil)	275 kg (600 lb)
Lubricating oil quantity (in sump and pipes)	7 kg (15.4 lb)

Timing

Inlet	opens	2° before T.D.C.
	closes	33° after B.D.C.
Exhaust	opens	33° before B.D.C.
	closes	3° after T.D.C.
Clearance between valve stem and rocker arm for check of timing engine cold		0.375 mm (0.0147 in)
Normal running clearance between valve stem and rocker arm engine cold (inlet and exhaust)		0.20 mm (0.008 in)

Fuel supply

Plunger-type fuel pump	without sediment bowl type	FIAT FP/KE 22A/L4/1
	with sediment bowl type	FIAT FP/KE 22A 40
Operating pressure		1.2 to 1.5 kg/cm² (17 to 21 p.s.i.)
Injection pump (Bosch licence) with 4 plungers	for fuel pump without sediment bowl type	PES 4A 60B 410/L4/1
	for fuel pump with sediment bowl type	PES 4A 60B 410/L4/16
Direction of rotation of pump shaft (looking on drive side)		clockwise
Injection order		1-3-4-2
Setting of injection assembly on engine. The pump assembly with plunger No. 1 at the beginning of delivery, is mounted on engine having piston No. 1 in the compression stroke		20° ± 1° before T.D.C.
Nozzle holders type		KC 55 S 8 F
Nozzles type		DN 12 SD 12
Injectors calibrated at		120 ± 5 kg/cm² (1700 ± 70 p.s.i.)

Governor

Vacuum governor (embodied with the injection pump) type:	EP/M 63 A/L4 5
Max. engine speed (no load), not less than	2600 R.P.M.
Min. engine speed (no load) from	420 to 480 R.P.M.

Lubrication

Lubrication oil pressure (automatically adjusted by a valve) with hot engine at normal R.P.M. rate	3 kg/cm² (43 p.s.i.)

(*) For tractors 415 R and 420 R.

(¹) Engines with 5% less power should be accepted.

Starting

Electric motor with engagement controlled by electro-magnet type FIAT E 115-3/24 ... 3 Kw

Glow plugs for cold starting ... 140 W

TRANSMISSION

	Gearbox ratios	Overall reduction ratios
1st gear	10.668 : 1	215.449 : 1
2nd gear	5.901 : 1	130.270 : 1
3rd gear	3.749 : 1	92.755 : 1
4th gear	2.938 : 1	64.847 : 1
5th gear	1.605 : 1	35.873 : 1
6th gear	1.037 : 1	22.788 : 1
1st reverse	7.253 : 1	160.340 : 1
2nd reverse	2 : 1	44.151 : 1

Rear reduction train

Bevel gears ratio	3.917 : 1
Final drives ratio	5.638 : 1
Total reduction ratio (bevel gears and final drives)	22.076 : 1

TIRES

Tractor type		615.100 (411 R)	615.103 (421 R)
Size of front tires		6.00-16	5.50-16
Max. inflating pressure of front tires		2,5 kg/cm² (35 p.s.i.)	2,5 kg/cm² (35 p.s.i.)
Size of rear tires		13-28	11.2-28
Max. inflating pressure of rear tires	field work	0.8 kg/cm² (11 p.s.i.)	0,8 kg/cm² 11 (p.s.i.)
	road work	1,2 to 1,5 kg/cm² (17 to 21 p.s.i.)	1,2 to 1,5 kg/cm² (17 to 21 p.s.i.)

STEERING SYSTEM

Turning radius	3 m (9 ft. 10 in)	2.8 m (9 ft. 2 in)

BRAKES

Outer diameter of drums	2100 mm (82⅝")	2100 mm (82⅝")
Width of brake lining	50 mm (2")	50 mm (2")

DRAWBAR (*)

Horizontal swing of drawbar clevis		665 mm (26")	660 mm (26")
Height of drawbar clevis above ground	minimum	270 mm (10⅝")	200 mm (7⅞")
	maximum	550 mm (21⅝")	470 mm (18½")

DIMENSIONS AND WEIGHTS

Wheelbase	1825 mm (71⅞")	1810 mm (71¼")
Front track	1280-1380-1480-1580-1680-1780-1880-1980 mm 50⅜-54⅜-58¼-62¼-66⅛-70⅛-74¹-78"	1260-1360-1460-1560-1660-1760-1860-1960 mm 49⅝-53½-57½-61⅜-65⅜-69¼-73¼-77⅛"

(*) See new drawbar specifications on page 104 for tractors with chassis No. [illegible] up.

Tractor type		615.100	615.103
Rear tread		1200-1300-1400-1500-1600-1700-1800-1900 mm 47¼-51⅛-55⅛-59…-63-67-70…-74…"	the same as for type 615.100
Overall length of tractor	with drawbar	2900 mm (114")	2880 mm (113⅜")
	without drawbar	2820 mm (111")	2755 mm (108½")
Overall width	with min. tread	1500 mm (59")	1490 mm (58⅝")
	with max. tread	2200 mm (86⅝")	2150 mm (83¾")
Max. height	to the top of steering wheel	1410 mm (55½")	1335 mm (52½")
	to the top of bonnet	1370 mm (54")	1300 mm (51¼")
Ground clearance under front axle		400 mm (15¾")	400 mm (15¾")
Ground clearance under rear axle			—
Operating weight of tractor		1420 kg (3130 lb)	1400 kg (3090 lb)
Weight of the two front wheel weights, approx.		70 kg (150 lb)	70 kg (150 lb)
Weight of the four rear wheel weights, approx.		220 kg (480 lb)	220 kg (480 lb)

PERFORMANCE AND FUEL CONSUMPTION

Speeds (with engine at rated speed for concrete course):	k.p.h.	m.p.h.	k.p.h.	m.p.h.
1st gear	2.2	1.4	2.1	1.3
2nd gear	4.2	2.6	3.9	2.4
3rd gear	6.3	3.9	6.1	3.8
4th gear	8.0	5.0	7.7	4.8
5th gear	14.5	9.0	14.0	8.7
6th gear	26.0	16.2	22.1	13.7
1st reverse	3.3	2.0	3.2	2.0
2nd reverse	11.8	7.3	11.4	7.1
Diesel fuel consumption	3.5-4 kg (7.7-8.8 lb)		3.5-4 kg (7.7-8.8 lb)	

Maximum drawbar pulls on concrete course, with tractor fully ballasted (iron discs and 75% water ballasted tires):	615.100	615.103
1st gear	1500 kg (3,300 lb)(*)	the same as for type 615.100
2nd gear	1500 kg (3,300 lb)(*)	
3rd gear	1500 kg (3,300 lb)(*)	
4th gear	1350 kg (3,000 lb)	
5th gear	750 kg (1,650 lb)	
6th gear	450 kg (1,000 lb)	

(*) Wheels slip during tests.

ELECTRIC SYSTEM

Running at 24 V.
See page 81 for instructions on its components.

ACCESSORIES

The performances of the accessories (power take-off, belt pulley, hydraulic lift) are the same for the several types of tractors.

Power take-off

Diameter of shaft . . . . . 1⅜"
Speed of live power take-off (at rated engine speed) . . . . . 575 R.P.M.
Revolutions to ground speed . . . . . 1 revolution for approx. 10⅝" of forward travel (27 cm)

Belt pulley

Pulley speed at rated engine speed	1195 R.P.M.
Belt speed	15.6 m/s (3,070 f.p.m.)
Diameter of pulley	250 mm (9$^{13}/_{16}$")
Width of band	150 mm (6")
Weight of pulley (without lubricating oil)	26.5 kg (58 lb)

Hydraulic lift

Hydraulic gear pump, type	Plessey C 10 X
Reduction ratio between engine shaft and hydraulic pump drive shaft speed	1.162 : 1
Pump speed (with engine at rated speed)	2000 R.P.M.
Delivery (oil at approx. 60° C - 140° F) at 0 kg/sq.cm (0 p.s.i.)	17 litres (3.75 Imp.gal.)
Delivery (oil at approx. 60° C - 140° F) at 150 kg/sq.cm (2133 p.s.i.)	16.5 litres (3.65 Imp.gal.)
Relief valve opening pressure (Marked with letters C or E)	150 kg/sq.cm (2100 p.s.i.)
Bore of hydraulic lift cylinder	85 mm (3.34")
Displacement	500 cu.cm. (31.5 cu.in)
Maximum travel of lift lower links	580 to 600 mm ([1]) (22$^{7}/_{8}$" to 23$^{5}/_{8}$")
Maximum weight raised at the end of the lower links	900 to 1200 kg ([1]) (1985 to 2645 lbs)
Indicated lifting capacity	approx. 750 kgm (5425 ft.lb)
Lifting time (with engine at 2300 R.P.M.)	3 sec.
Weight of draft-and-position-control hydraulic lift, including pipes and pump (without oil)	82 kg (180 lb)

([1]) Starting from chassis No. 424974 up, specifications are as follows:

Max. travel of lift lower link	580 and 592 mm (22$^{7}/_{8}$" and 23$^{5}/_{16}$")
Max. weight raised on lower link ends	900 and 1200 kg (1985 and 2645 lbs)

CAPACITIES

Part to be filled	Quantity		Material
Cooling system	12 l.	2$^{5}/_{8}$ Imp.gal.	Water
Fuel tank	39 l.	8$^{1}/_{2}$ Imp.gal.	Diesel fuel
Engine crankcase (filters and pipes included)	2 kg	7$^{3}/_{4}$ Qts.	SAE 30 HD oil for temperature from 0° C (32° F); SAE 10 W oil for temperature below 0° C (32° F); SAE 50 HD oil for temperature above 25° C (77° F)
Injection pump and governor	—	—	Same oil as used for the engine sump
Air cleaner	0.8 »	$^{7}/_{8}$ »	SAE 30 HD oil
Transmission	12 »	11 $^{1}/_{2}$ »	SAE 90 oil
Final drives (each)	2 »	1 $^{3}/_{4}$ »	SAE 140 oil for temperature above −10° C (14° F); SAE 90 oil for temperature below −10° C (14° F)
Steering system	—	—	SAE 90 oil
Front wheels			Chassis grease
Grease nipples	—	—	Chassis grease
Belt pulley	0.4 »	$^{3}/_{8}$ »	SAE 140 oil for temperature above −10° C (14° F); SAE 90 oil for temperature below −10° C (14° F)
Hydraulic lift	3.7 »	3 $^{7}/_{8}$ »	SAE 20 hydraulic oil
Generator supports	—	—	High melting point grease
Generator wick	—	—	SAE 30 HD oil
Starting motor overrunning clutch	—	—	High melting point grease

MODIFICATIONS

Starting from the tractor with engine No. 070425 and chassis No. 41730 up, the fuel filter and feed pump have been modified as follows.

DOUBLE FUEL FILTER

In addition to the single paper element a cloth element has been added.
Inspect each 300 hours the filtering elements to check their efficiency and to wash with kerosene the cloth one, and replace, if necessary, the paper element which must not be washed.

Fig. 197. - Two element fuel filter.

1. Filter air bleed screws - a. Filtering cloth element - b. Paper filtering element.

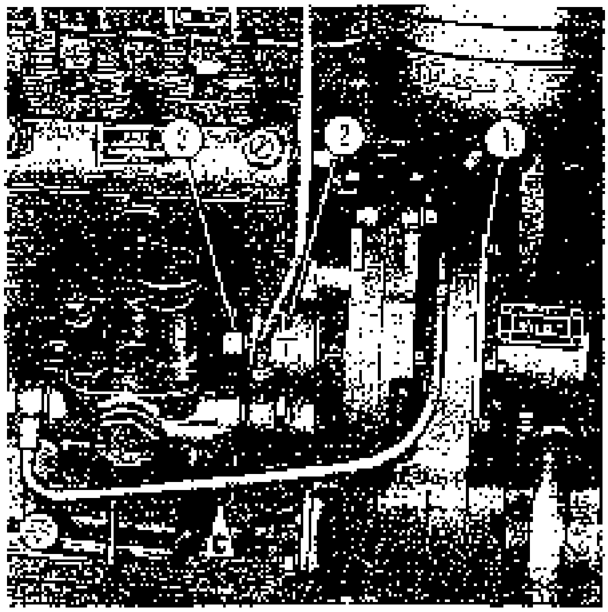


Fig. 198. - Injection pump type PES 4 A 60 B 410:L4/16.

1. Cover protecting the pump control sleeve - 2. Reference marks - 3. Pump fastening nuts - c. Feed pump fuel filter.

After the filter elements assembly, bleed air as follows:

- screw back of two turns the screws (1, fig. 198);
- unscrew the knob of the priming pump of the feed pump and pump till the fuel that flows from the holes located under said screws is free from air bubbles. Retighten said screws.

FEED PUMP WITH BOWL-TYPE FILTER

The injection pump type PES 4 A 60 B 410:L4/16 features a feed pump fitted with bowl filter mounted outside the pump body (figs. 198 and 199).

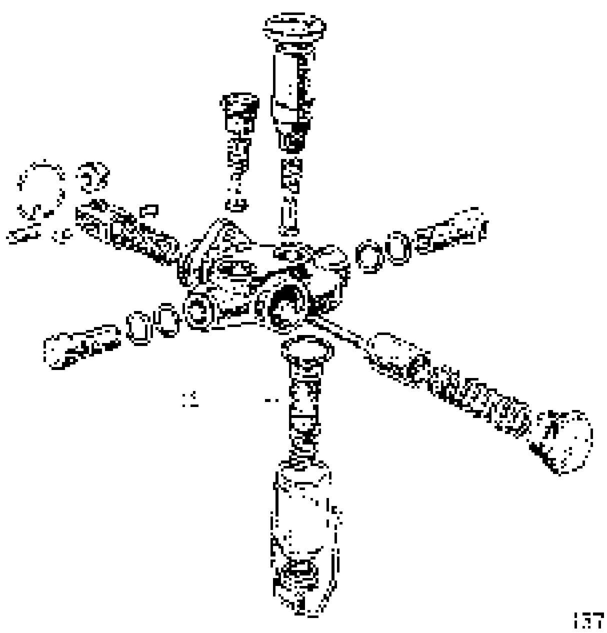


Fig. 199. - Feed pump components.
15. Fuel filter.

The calibration with respect to previous pump type PES 4 A 60 B 410 L4/1 is the same and the sole difference concerns the fuel feeding.

Fuel filter cleaning should be done with petrol every 120 working hours and before reinstalling it, it is advisable to check and to replace it if necessary.

After assembly, bleed air bubbles from the system by slackening the relevant screw located on the injection pump body and by actuating the priming hand pump.

U-FLEX TYPE OIL RING

A U-Flex type oil ring has been installed on engines No. 016735 and above. This type ring is higher than standard ones, therefore the piston groove has been modified accordingly.

Said changes have also been made on engines from No. 016266 to 015513.

Modified dimensions are shown in Fig. 200.

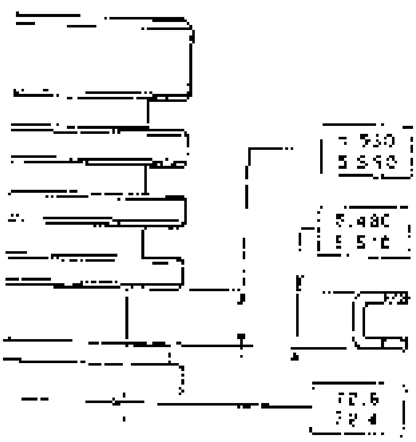


Fig. 200. - Dimensions of piston ring and its groove
5.530-5.550 mm (0.2177-0.2184 in.) 5.480-5.510 mm (0.2157-0.2169 in.) 72.6-72.4 mm (2.8583-2.8504 in.)

NEW DRAWBAR AND HITCH

Starting from chassis No. 420451 up the drawbar and hitch device of the series 400 tractors (except mod. 480 R) have been modified in order to bring location of the various parts within the requirements of international standards. Changes are as follows:

- stronger and simpler frame;
- more adjustment possibilities, in fact:
  - the drawbar plate can be fixed to the tractor at two different heights, and for each one it is furthermore possible to adjust the height by turning the drawbar plate upward or downward. More vertical settings are possible by turning over the drawbar;
  - the drawbar can be set on 3 longitudinal and on 3 traverse positions.
- Besides, the lower links are made 4 mm longer and the PTO shaft 1 mm longer.

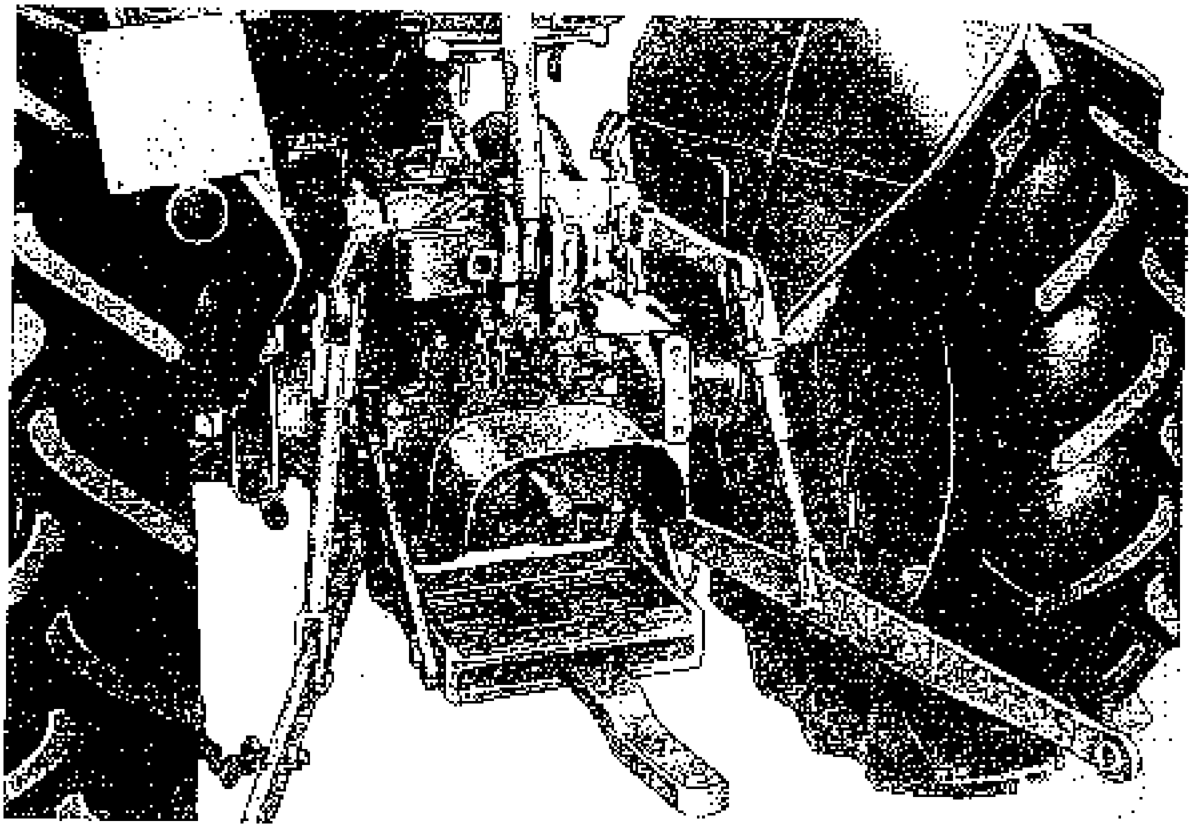


Fig. 201 - New drawbar and hitch assembly

Specifications.

Vertical distance from ground line to top of drawbar at hitch point, adjustable as follows . . . . 313 - 378 - 438 mm (12 5/16" - 14 7/8" - 17 1/4")

Horizontal swing distance at hitch point . . . . 510 mm (20")

Horizontal distance between hitch point and rearmost point of 12.4-28 tyres, adjustable as follows . . . . 10 - 55 - 100 mm (3/8" - 2 1/8" - 4")

Horizontal distance between hitch point and end of PTO shaft, adjustable . . . . 354 - 399 - 444 mm (14" - 15 23/32" - 17 15/32")

Vertical distance between top of drawbar at hitch point and centerline of PTO shaft, adjustable as follows . . . . 220 - 160 - 100 - 40 mm (8 21/32" - 6 5/16" - 4" - 1 9/16")

Vertical distance from ground line to centerline of PTO shaft . 530 mm (21 1/8")

Diameter of hitch hole (plus one 17.5 mm = 11/16" hole at 102 mm = 4" ahead of hitch hole) . . . . 29 mm (1 1/8")

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