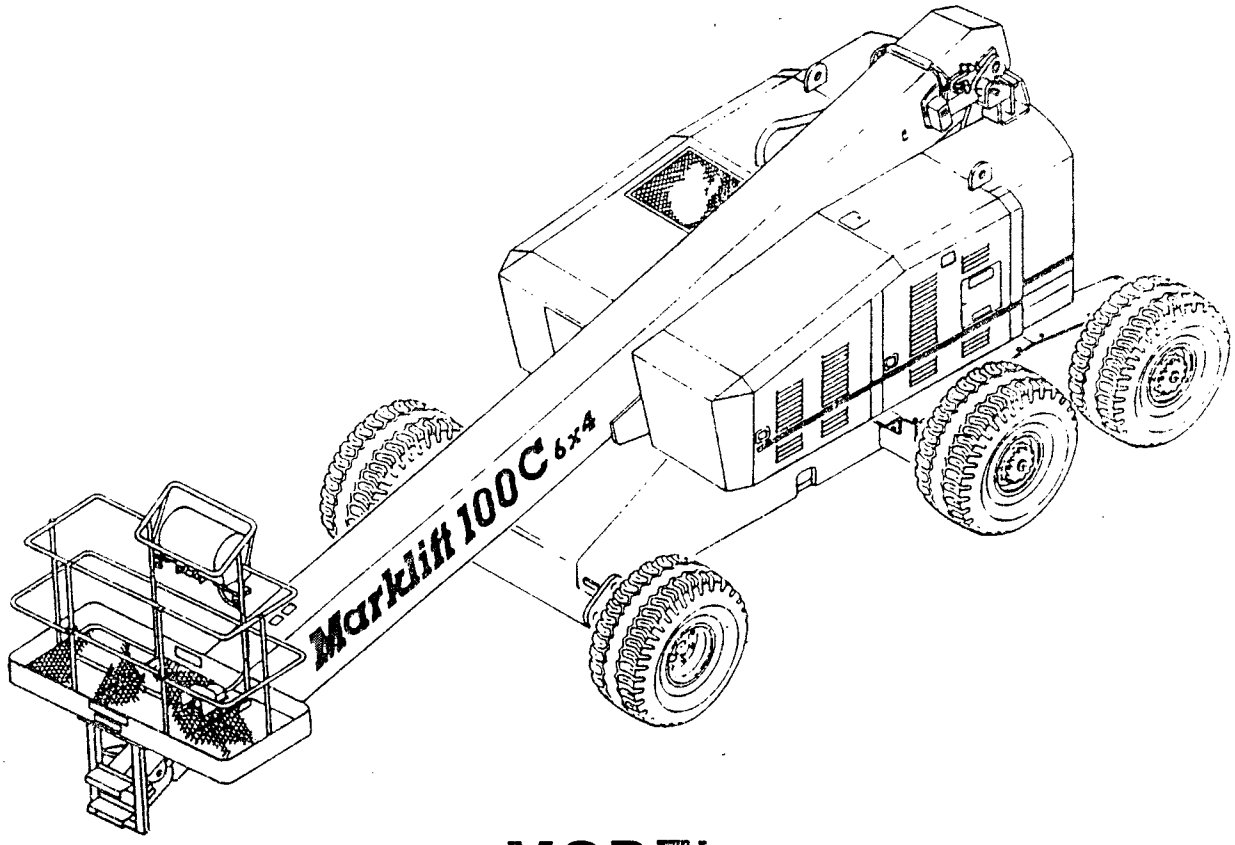
The Marklifts.®

A Product of Mark Industries

SELF-PROPELLED BOOM OPERATION MAINTENANCE AND PARTS MANUAL



MODEL 100C

FIRST EDITION: September 1989
1st. Revision: May 1991

Mark Industries

P.O. Box 2255
Brea, California 92622
205 South Puente Street, Brea, California 92621
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FOREWORD

This manual contains important information pertaining to the use and maintenance of the Marklift. A copy of the manual is provided by Mark Industries to the original purchaser * of the machine and must be made readily available to persons performing maintenance and inspection. **THIS MANUAL MUST ACCOMPANY THE MACHINE AT THE TIME OF ANY SUBSEQUENT SALE.**

Apart from the material contained in this manual, Mark Industries may send out service bulletins that pertain to this machine. These bulletins are sent to the original purchaser * of the Marklift. If you have purchased the Marklift from an authorized Marklift Dealer, you will be contacted by the dealer to perform any service that may be required per the bulletin. Since the bulletins may pertain to important safety matters, you are requested to notify your local Marklift dealer of any subsequent sale and keep him updated as to the ownership. Please provide the name of a responsible contact to whom they can direct correspondence.

If you feel you have not been provided all applicable service bulletins by the seller of the machine, copies of a volume of service bulletins for a series of years may be purchased through your local Marklift dealer. If you have trouble locating a Marklift dealer you may call Mark Industries at the phone number given below. You will be directed to the dealer closest to you.

1-800-448-MARK (Outside California)
1-800-736-MARK (California)
Ask for the Customer Service Engineering Department when calling.

It is recommended that the owner of the Marklift maintain copies of all service bulletins and maintenance records.

For your future reference write down the name, address and phone number of the Marklift dealer closest to you:

Name: _____
Address: _____
Phone: _____

* Dealer or distributor who originally purchased the machine from Mark Industries or other parties who purchased the machine from Mark Industries.

REGULATIONS PERTAINING TO YOUR MARKLIFT

There are certain OSHA, ANSI and other governmental regulations that apply to the design, manufacture, maintenance and use of this equipment. You must keep a copy of the regulations and follow their requirements. You can obtain a copy of the OSHA regulations from your local OSHA office and a copy of the ANSI regulations from the following address:

American National Standards Institute
Attention: Sales Department
1430 Broadway
New York, NY 10018

Copies of other regulations can be obtained by contacting the local office of the agency publishing the regulation.

The instructions found in this manual do not propose to be all inclusive, nor to supplement or replace other additional safety and/or precautionary measures covering usual or unusual conditions. If these instructions conflict in any way with the state, local or federal statue or regulations, said statue or regulations shall supersede these instructions, and it shall be the responsibility of each user to comply therewith, and inform Mark Industries of the variances.

NOTICE TO USERS REGARDING REPORTING OF INCIDENTS INVOLVING THE MARKLIFT

Should this Marklift be involved in an incident, please inform the nearest Marklift dealer immediately.

If you are not able to locate the dealer, you may call Mark Industries at the following telephone number: (800) 448-MARK

OPERATOR TRAINING TIPS

Following are some suggestions on how to provide proper training to all operators of the Marklift. The operators must be adequately trained in accordance with the requirements of the manufacturer, OSHA, ANSI and other agencies regulating such equipment.

1. Have the operator read the Operation & Safety Handbook.

2. Show the operator important parts and features of the machine and how to use/operate them. Some important components/features that must be pointed out and explained are:

   (1) Controls
   (2) Warnings
   (3) Decals
   (4) Maximum capacity
   (5) Safety features of the machine
   (6) Emergency Lowering
   (7) Use of stabilizers (If included)
   (8) What to do in emergencies
   (9) Hazards that must be avoided

3. Safety videos for the type of machine that will be used, if available, may be shown.
4. Give the operator a demonstration i.e. operate the machine while he watches.

5. Have the operator operate the machine while you supervise and instruct him in proper operation.

6. Have the operator acknowledge the fact that he has received training by signing a copy of the operators statement in the Operation and Safety Handbook.

NOTE:
See ANSI, OSHA and other applicable standards for operator training requirements.

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VENDOR

INTRODUCTION

The purpose of this manual is to provide the customer with operation, safety, maintenance and parts information that will enhance the reliable performance of the Marklift. Schematic and vendor information is also furnished. If additional information is needed, we urge the customer to contact the local dealer. If this is not possible, please contact the Mark Industries Customer Service Engineering Department at (714) 879-6275.

WARNING: IMPROPER USE OF THIS MACHINE WILL RESULT IN SERIOUS INJURY OR DEATH! TO PROTECT YOURSELF AND THE EQUIPMENT, STUDY THIS MANUAL BEFORE OPERATING THE MARKLIFT.

The model capacity, pressure settings and serial number can be found on the ID plate mounted on the rear of the carriage assembly. The serial number should be used when ordering parts. This will help our parts department give prompt and accurate service.

All Marklift are tested and operated to assure their proper operating condition before shipment. At this time, all necessary adjustments are made and an overall physical inspection is conducted. After the unit is delivered, some minor adjustments and inspections must be made before putting the unit into service. These are outlined in the Inspection and Checkout instructions in the General section of this manual.

MARK INDUSTRIES reserves the right to continually make product and safety improvements. Your participation in implementing such improvements will be required.

SPECIFICATIONS

Description	Model
	100 6X4
Height –	
Working (maximum)	106' (32.31m)
Platform (maximum)	100' (30.48m)
Load capacity (unrestricted)	500 lbs (226.8 kg)
Stowed height	9" (2.74m)
Width	7'11 .75 (2.43m)
Length (stowed)	34'6" (10.52m)
Wheelbase	10' (3.04m)
Wheel track	6'6" (1.98m)
Turning Radius (inside)	16'10" (5.13m)
Tires	6 (Monofilled) 18x19.5—16 ply rating
Loader lug (monofilled)	Super Single Traction Road Lug
Turret rotation	Continuous 360°
Tailswing	35" (.89m) beyond tires
Engine	Diesel / F3L912 Deutz
Drive Motors	Piston type with variable displacement and internal shifters
Four wheel drive	6x4 with walking beam
Travel speed (proportional)	0-2.5 m.p.h. (0-3.6 km/hr)
Fuel Tank capacity	70 gal. (.265 liter)
Controls	Proportional and solenoid
Hydraulic system	Load sensing and pressure compensated
Hydraulic operating pressure	2500 psi max (175.8 kg/sq cm)
Hydraulic reservoir capacity	62 gal. (234.67 liter)
Platform dimensions	72" x 36" x 42" (1.83m x .91m x 1.07m)
Horizontal reach	67'4" (20.52m)
Boom elevation	+75° (above horizontal) -15° (below horizontal)
Weight	38,670 lbs (17,541 kg)
Shipping cube	2,700 cu ft (76.46m^3)

Specifications are nominal and are subject to change without prior notice due to continuous design improvements.

Filling in the Warranty: Please refer to the applicable decals on your machine for the figures and quantities needed to fill in the blanks below.

		YES	NO	NA
1.	Platform capacity decal _____ . lbs.	☐	☐	☐
2.	All warning, caution and emergency decals installed	☐	☐	☐
3.	Operation instructions properly installed	☐	☐	☐
4.	Operation and safety handbook received	☐	☐	☐
5.	All controls (aerial & ground) are identified and operate correctly	☐	☐	☐
6.	Stop switches operate properly (aerial & ground)	☐	☐	☐
7.	Platform guard rails and other hardware, secure and undamaged	☐	☐	☐
8.	Platform access gate works properly	☐	☐	☐
9.	Horn and beacon operate properly	☐	☐	☐
10.	110V generator operates properly	☐	☐	☐
11.	Brakes adjusted and operate correctly	☐	☐	☐
12.	Circuit breakers operate properly	☐	☐	☐
13.	All hydraulic cylinders free of leaks	☐	☐	☐
14.	All hydraulic cylinder rods free of paint or scratches	☐	☐	☐
15.	Hydraulic pump free of leaks	☐	☐	☐
16.	Hydraulic hoses and fittings tight	☐	☐	☐
17.	Hydraulic oil to proper level	☐	☐	☐
18.	Hydraulic tank and fittings free of leaks	☐	☐	☐
19.	Drive motors free of leaks	☐	☐	☐
20.	Wheel lug nuts torqued to _____. Ft. lbs	☐	☐	☐
21.	Battery water level _____.	☐	☐	☐
22.	Manual overrides operate properly	☐	☐	☐
23.	All electrical connections tight	☐	☐	☐
24.	Valve manifold and fittings free of leaks	☐	☐	☐
25.	Emergency descent valve functions properly	☐	☐	☐
26.	System pressure (PSI) P1_____ P2 _____.	☐	☐	☐
27.	Stand-by pressure _____. PSI	☐	☐	☐
28.	Tire pressure _____. PSI	☐	☐	☐
29.	Drive wheel, torque hub oil level _____ .	☐	☐	☐
30.	Engine R.P.M at idle _____ at high throttle _____.	☐	☐	☐
31.	Turret rotation gear box oil level _____.	☐	☐	☐
32	Turret ring gear bolts torqued to _____ Ft. lbs	☐	☐	☐
33.	Base ring gear bolts torqued to _____ Ft. lbs	☐	☐	☐
34.	Engine coolant (radiator) to proper level	☐	☐	☐
35.	Coolant hoses and fittings free of leaks	☐	☐	☐
36.	Electric radiator fan operates properly	☐	☐	☐
37.	Fuel tank and fitting free of leaks	☐	☐	☐
38.	Muffler is tight and free of leaks	☐	☐	☐
39.	Engine oil to proper level	☐	☐	☐
40.	Engine oil filter free of leaks	☐	☐	☐
41.	Engine alternator functions properly	☐	☐	☐
42.	Retraction cable tension _____ Ft. lbs	☐	☐	☐

MODEL	
SERIAL NUMBER	
INSPECTOR	

OPTIONS _____

WARRANTY

MANUFACTURERS' LIMITED WARRANTY

Mark Industries makes no warranty, expressed or implied, on any product manufactured or sold by Mark Industries except for the following limited warranty against defect in materials and workmanship on products manufactured by Mark Industries.

> Mark Industries warrants the products manufactured by Mark Industries to be free from defects in material and workmanship under normal use and service for a period of one (1) year from the date of shipment or from date first put into service upon proper notification. This limited warranty does not extend to any product of another manufacturer or to any part, component, accessory or attachment not manufactured by Mark Industries. The warranty, if any, with respect to any product of another manufacturer or to any part, component, accessory or attachment not manufactured by Mark Industries is limited to the warranty, if any, extended to Mark Industries by the manufacturer of the other product, part, component, accessory or attachment.

This limited warranty does not extend to any product (or any part or parts on any product) which has been subject to improper use or application, misuse, abuse, operation beyond its rated capacity, repair or maintenance except in accordance with the sales and service manuals and special instructions of Mark Industries, or modification without the prior written authorization of Mark Industries (whether by the substitution of nonapproved parts or otherwise).

The sole obligation and liability of Mark Industries under this limited warranty (and the exclusive remedy for any purchaser, owner or user of Mark Industries products) is limited to the repair or replacement, at the option of Mark Industries, of any product (or any part or parts on any product) manufactured by Mark Industries which, within one (1) year from the date of shipment or date first put into service, shall have been returned to the Mark Industries facility in Brea, California (or any other location within the United States as shall be designated by Mark Industries), at no expense to Mark Industries, and demonstrated to the satisfaction of Mark Industries as being defective in material or workmanship.

To make a claim under this limited warranty, contact Mark Industries or the Mark Industries distributor from whom the product was originally purchased. A statement giving the model and serial number of the allegedly defective product, the date and a description of the alleged defect, the date of the purchase and proof of purchase and purchase date must accompany the returned product (or any part or parts of any product). Any product (or any part or parts of any product) determined by Mark Industries to be defective will be repaired or replaced, at the option of Mark Industries, free of charge, f.o.b. Brea, California. No credit will be given for any allegedly defective product (or any part or parts of any product) not returned to Mark Industries.

There are no other warranties, expressed or implied, in addition to this limited warranty. **This limited warranty is exclusive and in lieu of all other warranties, expressed or implied (in fact or by operation of law or otherwise), including the implied warranties of merchantability and fitness for a particular purpose.**

Mark Industries shall not be liable for any special, indirect or consequential damages. Further, no representation or warranty made by any person, including any representative of Mark Industries, which is inconsistent or in conflict with, or in addition to the terms of the foregoing limited warranty (or the limitations of the liability of Mark Industries as set forth above) shall be binding upon Mark Industries unless reduced to writing and approved by an officer of Mark Industries.

Tires, batteries, filter elements, electrical components are specifically excluded from this limited warranty.

Warranty effective as of 2/90

Mark Industries
P.O. Box 2255, Brea, CA 92622-2255
714-879-6275 800-448-MARK
TELEX 194402 FAX 1-714-879-8884

WARRANTY REGISTRATION

Purchaser/Dealer:

Company Name:

Address:

Telephone:

Date shipped (from invoice):

Date shipment received:

Date unit put into service:

Unit will be placed in rental fleet:

Unit will be sold:

Unit will be used for:

- ☐ Inspection
- ☐ Mining
- ☐ Welding
- ☐ Construction
- ☐ Scaffolding
- ☐ Mechanical
- ☐ General maintenance
- ☐ Heating/Air conditioning
- ☐ Carpentry
- ☐ Plumbing
- ☐ Electrical
- ☐ Sprinkler
- ☐ Painting/Sandblast
- ☐ Steel fabrication
- ☐ Rigging
- ☐ Roofing
- ☐ Glazing
- ☐ Other

Comments: _____

Inspection completed by: Title:

Warranty will be void unless this inspection report is postmarked to Mark Industries not more than fourteen (14) days from the date shipment is received.

LOADING/UNLOADING

IMPORTANT: Due to the width of the Marklifts and the overall width of the transport vehicle, **extreme caution must be taken when loading and unloading.**

When loading and unloading Marklifts, it is necessary to use a combination of winching and driving the boom in low drive speed. **The operator in the basket must wear a safety belt attached with lanyard to the safety rings provided.**

1. Make sure that the parking brake is set to start braking immediately by opening the parking brake control valve.

2. If the unit has the High/Low drive option, it must be in **LOW DRIVE** at all times when loading and unloading.

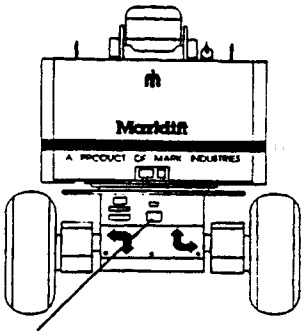


Figure 1: Parking Brake Control Valve

LOADING

1. With the transport on level ground, align the tires of the Marklift with the back end of the truck.

2. Attach the winch cable to the boom at the drive wheel end of the base through the tow or lift eyes if provided. (See Figure 2.)

3. Use great care while driving and steering the unit up the ramp. Use low drive speed and keep all slack out of the winch cable. (If the ramp is too steep for the unit to climb, the winch will pull the unit up.) It will be necessary to gradually raise the boom as the machine ascends the ramp. **You must keep the drive function engaged while winching, otherwise the brakes will prevent the machine from rolling.**

4. When the unit is on the transport vehicle and its weight has been properly distributed, tie the boom down as shown in Figure 3 of this instruction.

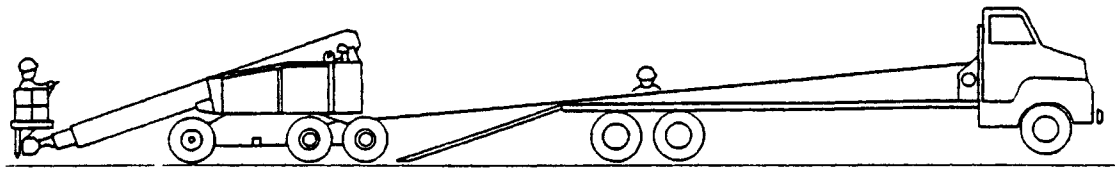


Figure 2: Loading the Marklift onto the truck

Note: Secure the platform to the carriage and tie the machine to the truck as shown.

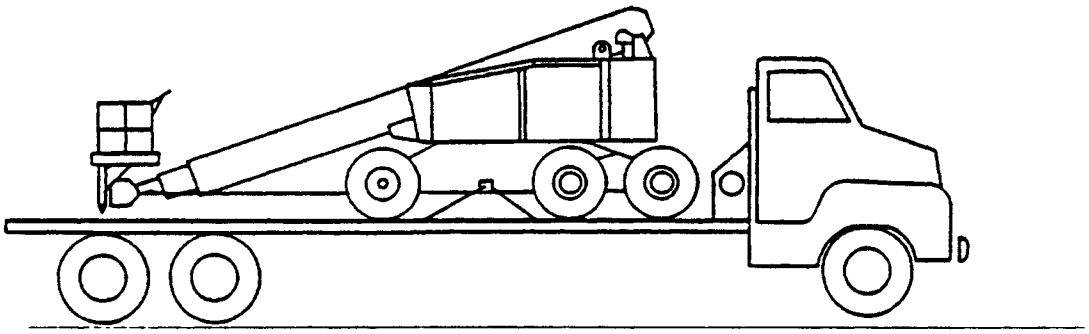


Figure 3: Securing the Marklift

UNLOADING

1. With the transport vehicle on level ground, disconnect the tie-downs from the Marklift and make sure that the winch cable is still properly attached to the boom.

2. Select the low drive speed.

3. Use great care while driving and steering the unit off the truck. Keep all slack out of the winch cable.

> **Warning:** **Do not** allow slack in the winch cable when going down the ramp, because of the possibility of snapping the cable if the unit descends too fast.

4. When all wheels are on level ground, disconnect the winch cable from the Marklift.

5. Readjust the boom parking brakes so that they start immediately after the dynamic brakes stop the unit. The procedure for re-adjusting the parking brakes is as follows: First close the needle valve completely. Open the valve 1/8

turn then place the unit on a flat surface, about 10' wide x 30' long. Position the boom slightly below horizontal and completely retract. Select "High" drive speed and "High" throttle at the platform console. Drive with the controller handle in maximum position, approximately 15 feet, letting go of the controller when the wheel is next to a visual marker on the ground. A good deceleration and braking distance would be 3 feet measured from the marker to the center line of the same wheel when the unit has completely stopped. Adjust the needle valve on the parking brakes to reach this position. Repeat this procedure, driving in both directions until the Marklift comes to a complete stop within approximately three feet.

Warning:	Do not drive on uneven sloping or soft terrain that sets the unit in an out-of-level condition.

All Marklifts are tested and operated to assure their proper operating condition before shipment. At this time all necessary adjustments are made and an overall physical inspection is conducted. **After the unit is delivered and before you put it into service**, some minor adjustments and an inspection of the unit must be made. All service must be performed by a qualified service person. Follow all safety and proper operating recommendations when inspecting the machine. The following must be checked:

1. **Check the battery.**

   A. Check the battery's water level and add water if necessary. Add only enough water to cover the top of the plates on battery powered units. Use the battery water level indicators for engine powered units. (See Battery Maintenance.)

   B. Check the battery charger for loose connections and proper operation.

   C. Check the battery cable connections to make sure that they are tight and free of corrosion.

2. **Check the electrical system by operating the unit using both the aerial and ground controls.**

   A. Check forward and reverse drive (aerial only).

   B. Steer left and right (aerial only).

   C. Extend the platform forward and reverse.

   D. Move the lift up and down.

3. **Inspect all electrical connections.**

   A. Visually inspect the wiring.

   B. Check wires for kinks and fraying.

   C. Tighten any loose connections.

4. **Check the hydraulic system.**

   A. Check the hydraulic fluid level by the sight gauge, located on the side of the hydraulic tank. The sight gauge shows full when the unit is rest.

B. Hydraulic lines must be free of cuts, kinks or leaks.

C. Make sure that the hydraulic cylinders, hoses for steering, and lift are tight and have no leaks.

D. The hydraulic pump should fit tightly and be free of leaks.

5. Check the tires and wheels.

A. Look for cuts.

B. Make sure that the cotter pins and spindle nuts are proper in place on the wheel spindles.

6. Check structural connections and fittings.

Check all nuts and bolts for tightness.

7. Check the brakes.

Make sure that the brakes will hold the unit in place on an incline.

The Marklift conforms to specified ANSI & OSHA requirements, it is the responsibility of the owner to instruct the operators about safety requirements made not only by Mark Industries, but by the various safety boards in your area, as well as requirements set forth by ANSI & OSHA.

The Marklift self-propelled aerial work platform is a personnel lifting device, and it is essential that it be properly maintained and operated to perform all functions with maximum safety and efficiency. The operation of any new and unfamiliar equipment can be hazardous in the hands of untrained operators. **Every operator of the Marklift must read, understand and follow the safety rules set forth herein.**

1. Examine the machine periodically as specified in the Preventive Maintenance section and as required by ANSI, OSHA, local safety boards and the owner. All unsafe items must be corrected by a qualified service person before use of the machine.

2. Only trained operators must be assigned to operate the Marklift.

3. It is the responsibility of the operator to read and understand this manual and to follow all recommendations made.

4. Never exceed manufacturer's recommended platform load capacity. Remember, the load capacity of the Marklift is the total combined weight of personnel and tools, fixtures, accessories, etc.

5. Always distribute load evenly over platform floor area.

6. It is recommended that head gear (hard hats) be worn by all personnel on the work platform.

7. The Marklift platform is equipped with safety belt rings. **Each operator of the Marklift must wear a body belt. The belt must be attached with lanyard to the provided anchor points.**

8. **Do Not** change, alter, or vary equipment in any way. Any alterations which effect the operation of the Marklift will void any warranty claims.

9. **Do Not** override any hydraulic, mechanical, or electrical safety devices.

THE MARKLIFT SAFETY

10. **Do Not** store loose material in the work platform such as pipe, rope, extension cords, wire or miscellaneous boxes. If necessary to store such items, they must be positioned in such a way that no one will trip over them when operating or working in the platform.

11. **Do Not** work on the platform if your physical condition is such that you feel dizzy or unsteady in any way.

12. The Marklift is a non-insulated personnel carrier and must not be operated within 10 feet of a 50,000 volt line. (See Title 8 Division Of Industrial Safety.)

13. Under no circumstances should horseplay be tolerated on the Marklift.

14. **Do Not** operate boom functions on more than 5 degree out-of-level condition.

15. **Do Not** drive the carriage or platform into objects.

16. **Do Not** lean over platform guard railings to perform work.

17. **Do Not** raise or lower the boom into objects.

19. The Marklift structure must not be used as welding ground. Disconnect both battery leads prior to performing any welding operations.

20. **Do Not** jump start other vehicles using the Marklift battery.

21. **Do Not** drive on excessively uneven, sloping or soft terrain.

TITLE 8 DIVISION OF INDUSTRIAL SAFETY 358.38.113

(Register 73, No. 30—7-28-73)

Article 86. Provisions for Preventing accidents

Article 86. Provision for Preventing Accidents Due to Proximity to Overhead Lines

2946. Provisions for Preventing Accidents Due to Proximity to Overhead Lines.

(a) **General.** No person, firm, or corporation, or agent of same, shall require or permit any employee to perform any function in proximity to energized high-voltage lines; to enter upon any land, building, or other premises and thereto engage in any excavation, demolition, construction, repair, or other operation; or to erect, install, operate, or store in or upon such premises any tools, machinery, equipment, materials, or structures (including scaffolding, house moving, well drilling, pile driving, or hoisting equipment) unless and until danger from accidental contact with said high-voltage lines has been effectively guarded against.

(b) **Clearances or Safeguards Required.** Except where electrical distribution and transmission lines have been de-energized and visibly grounded or effective barriers have been erected to prevent physical and arcing contacts with the high-voltage lines, the following provisions shall be met:

(1) **Over Lines.** The operation, erection, or handling of tools, machinery, apparatus, supplies, or materials, or any part thereof , over energized high-voltage lines shall be prohibited.

(2) **Equipment and Materials in Use.** The operation, erection, or handling of tools machinery, equipment, apparatus, materials, or supplies, or any part thereof within the minimum clearances from energized lines set forth in Table X shall be prohibited.

TABLE X

Required clearances from Overhead High-Voltage Lines

Nominal Voltage (Phase to Phase)				Minimum Required Clearance (Feet)
	750	-	50,000	10
over	50,000	-	75,000	11
over	75,000	-	125,000	13
over	125,000	-	175,000	15
over	175,000	-	250,000	17
over	250,000	-	370,000	21
over	370,000	-	550,000	27
over	550,000	-	1,000,000	42

(3) **Transportation or transit.** The transportation or transit of any tool, machinery, equipment, or apparatus, or the moving of any house or other building in proximity to overhead high-voltage lines shall be expressly prohibited if at any time during such transportation or transit of such tool, machinery, equipment, apparatus, or building, or any part thereof, can come closer to high-voltage lines than the minimum clearances set forth in Table Y.

Article 86. Provisions for Preventing Accidents

Except where the boom of boom-type equipment is lowered and no load is imposed thereon, the equipment in transit shall conform to the minimum required clearances set forth in Table X.

(4) **Storage.** The storage of tools, machinery, equipment, supplies, materials, or apparatus under, by, or near energized high-voltage lines is hereby expressly prohibited if at any time during such handling or other manipulation it is possible to bring such tools, machinery, equipment, supplies materials, or apparatus, or any part thereof, within the minimum required clearances from high-voltage lines as set forth in Table X.

TABLE Y

Required Clearances from Energized High-Voltage Conductors (While in Transit)

	Nominal Voltage (Phase to Phase)			Minimum Required Clearance (Feet)
	750	-	50,000	6
over	50,000	-	345,000	10
over	345,000	-	750,000	16
over	750,000	-	1,000,000	20

(C) The specified clearance shall not be reduced by movement due to any strains impressed (by attachments or otherwise) upon the structures supporting the high-voltage line or upon any equipment, fixtures, or attachments thereon.

(D) Insulated cage-type boom guards, boom stops, insulating links, or proximity warning devices may be used on cranes, but the use of such devices shall not alter the required clearances set forth in Table X.

(e) Any overhead conductor shall be considered to be energized unless and until the person owning or operating such line verifies that the line is not energized, and the line is visibly grounded at the work site.

2947. **Warning Signs Required.** The owner, agent, or employer responsible for the operations of equipment shall post and maintain in plain view of the operator and driver on each crane, derrick, power shovel, drilling rig, hay loader, hay stacker, pile driver, or similar apparatus, a durable warning sign legible at 12 feet reading: **"Un-lawful To Operate This Equipment Within 10 Feet of High-Voltage Lines of 50,000 Volts or Less."**

In addition to the above wording, the following statement in small lettering shall be provided on the warning sign: **"For Minimum Clearances of High-Voltage Lines in Excess of 50,000 Volts, See Article 86, Title 8, High-Voltage Electrical Safety Orders."**

DECAL INFORMATION

Observe all danger, warning, caution and emergency decals at the various locations on the Marklift in order to take timely, preventive and corrective actions.

It is the primary responsibility of the user and operator to be thoroughly knowledgeable of all decal information, definition and location.

To assist you in becoming familiar with the decals, the following page(s) illustrates instruction decals for the Marklift. See the Parts Chapter for a complete list of decals and their location on the machine. This list will enable you to replace the existing decal(s) if they become worn-out, torn, or illegible. It is essential that all decals be in a readable condition for the safe operation of the Marklift. It is therefore recommended that they be properly maintained.

Danger, Warning and Caution are used to identify levels of hazard seriousness. Given below is a definition of each term as it applies to the decals:

- Danger (Indicated in red):
  Immediate hazards which **Will** result in severe personal injury or death.

- Warning (Indicated in orange):
  Hazards or unsafe practices which **Could** result in severe personal injury or death.

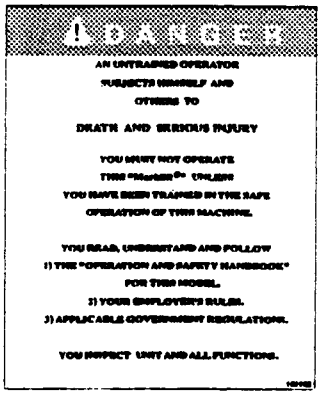
- Caution (Indicated in yellow):
  Hazards or unsafe practices which **Could** result in minor personal injury or product or property damage.

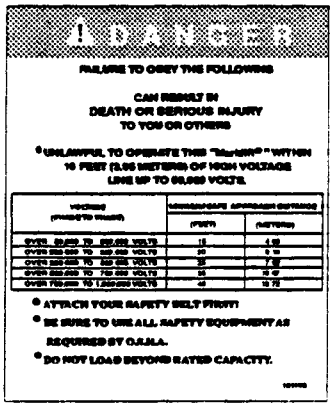
The following illustrations are of instruction decals only. See the Parts Chapter for a complete list of decals and their location on the machine.





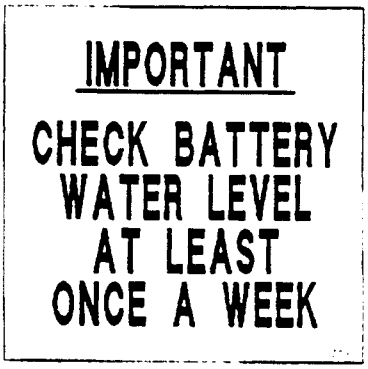


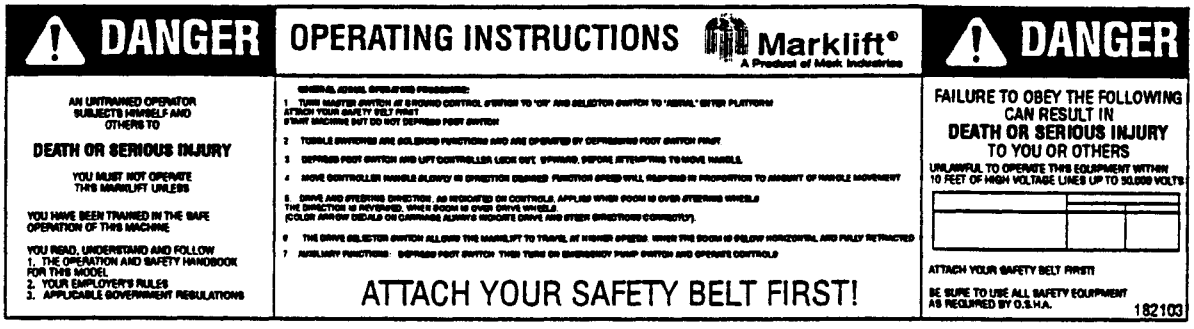




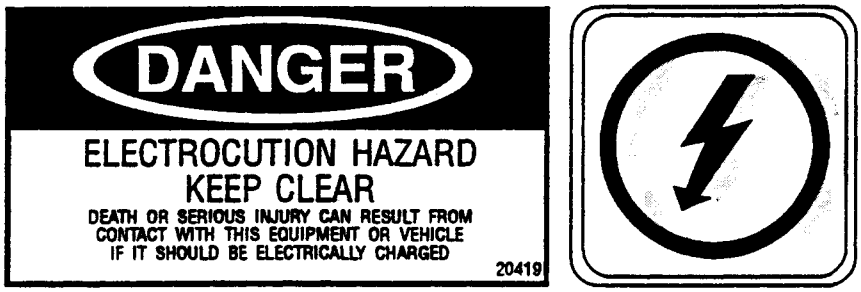


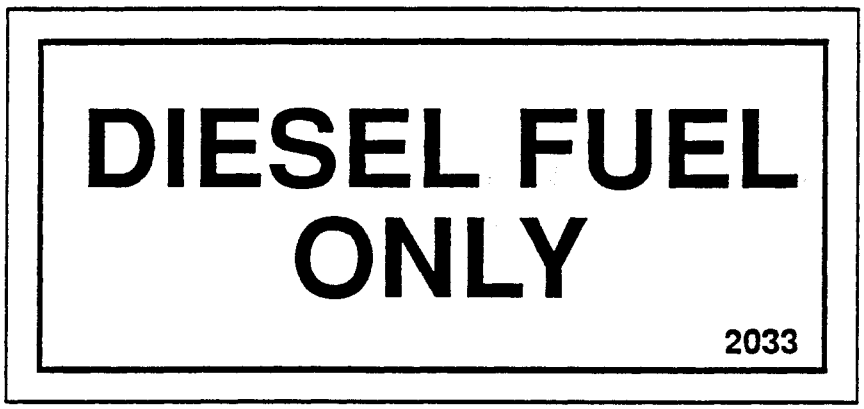




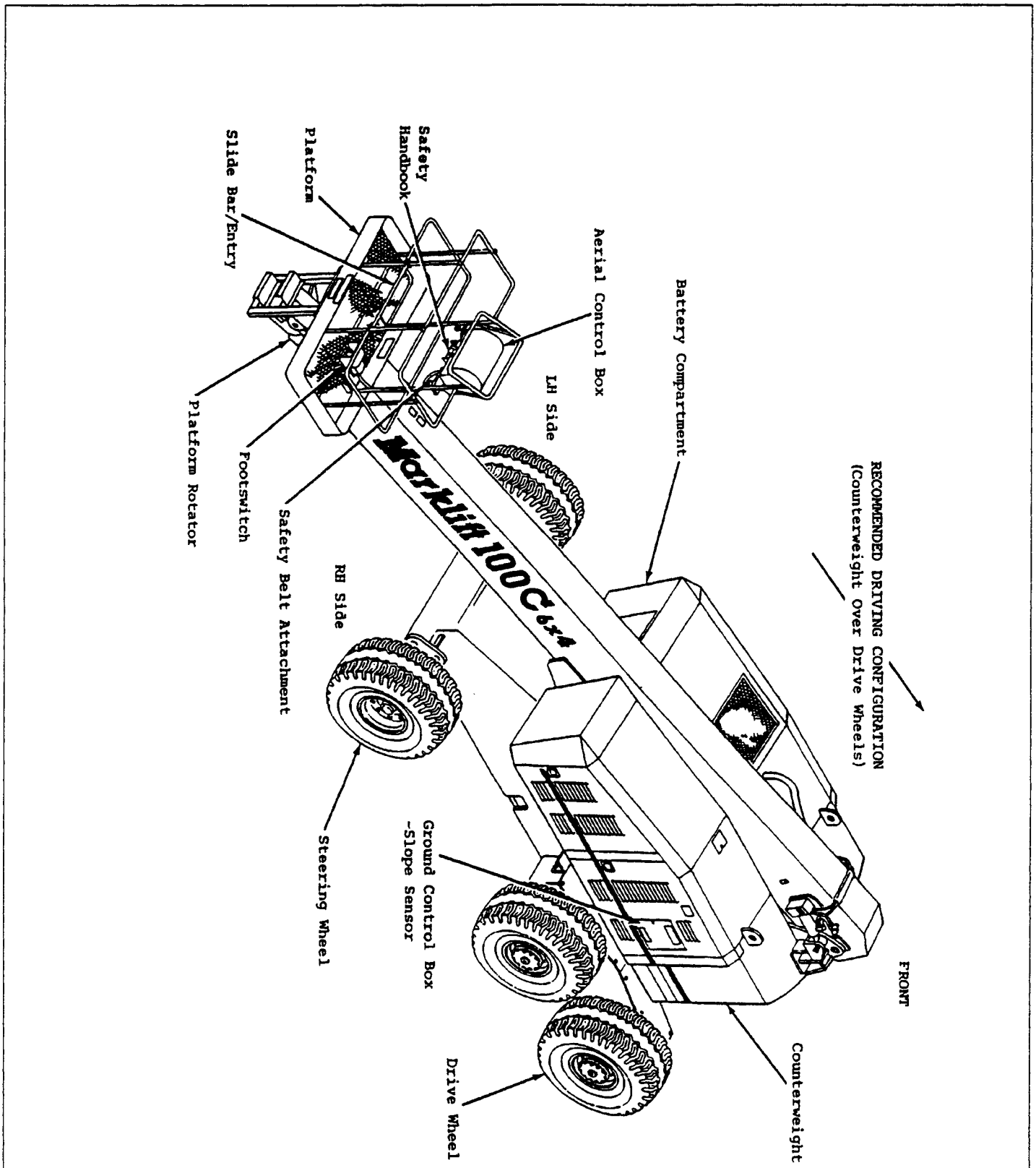


INSTRUCTION DECAL ILLUSTRATIONS





MACHINE ORIENTATION



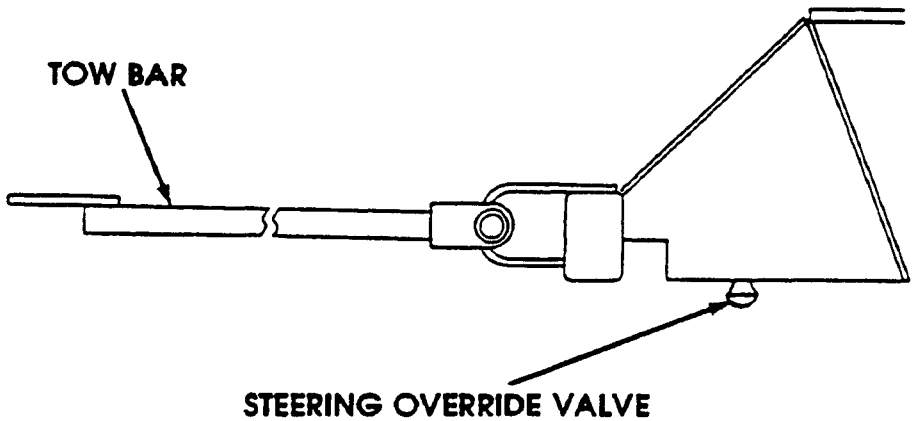
TOWING INSTRUCTIONS

These instructions are for units equipped with a towing package. The Marklift may be towed for a distance no greater than one (1) mile at a speed not to exceed 8 mph.

To tow the Marklift the following procedure must be followed:

1. Make sure machine is on level ground.
2. Fully retract the boom.
3. Rotate the turret 180° so that the boom is trailing the machine.
4. Elevate the the boom to achieve the minimum necessary ground clearance.
5. Attach the tow bar from the Marklift to the towing vehicle.
6. Disengage the torque hubs. **Block the wheels before disengaging torque hubs.**

   To disengage the torque hub, reverse the disconnect cap. The knob on the cap disengages the drive hub input shaft. **The brakes are also disengaged when the torque hubs are disengaged.**
7. Pull the steering override valve
8. Tow at a maximum speed of 8 mph for a distance no greater than one (1) mile.



Caution:

Improper towing can result in injury or property damage:

- Follow proper towing procedures.
- Do not tow faster than 8 miles per hour.
- Do not tow more than one (1) mile.

The following are applicable excerpts from the federal register, title 29, chapter XVII, O.S.H.A - 1926.556.

EXTENSIBLE AND ARTICULATING BOOM PLATFORMS

1. Lift controls shall be tested each day, prior to use, to determine that such controls are in safe and working condition.

2. Only authorized persons shall operate an aerial lift.

3. Belting off to an adjacent pole, structure, or equipment while working from an aerial lift shall not be permitted.

4. Employees shall always stand firmly on the floor of the basket, and shall not sit or climb on the edge of the basket or use planks, ladders, or other devices for a work position.

5. A body belt shall be worn and a lanyard attached to the boom or basket when working from an aerial lift.

6. Boom and basket load limits specified by the manufacturer shall not be exceeded.

7. Articulating boom and extensible boom platforms, primarily designed as personnel carriers, shall have both platform (upper) and lower controls. Upper controls shall be in or beside the platform within easy reach of the operator. Lower controls shall provide for over-riding the upper controls. Controls shall be plainly marked as to their function. Lower level controls shall not be operated unless permission has been obtained from the employee in the lift, except in case of emergency.

8. Climbers shall not be worn while performing work from aerial lift.

9. Before moving an aerial lift for travel, the boom(s) shall be inspected to see that it is properly cradled.

OPERATING INSTRUCTIONS

It shall be the responsibility of all Marklift operators to read and act according to the following operating instructions. The purpose of these instructions is to promote safety and a better understanding of the functions of the Marklift self-propelled boom.

Before use of the Marklift it must be inspected and serviced as recommended in the Preventive Maintenance section on this manual.

1. STARTING

Turn the master switch at the ground control station to "ON". Position the selector switch to "Aerial". Enter the platform and **attach safety belt**. Pull open the red emergency stop switch cover located on the top right of the aerial control station. Pull the toggle switch down to the start position, **do not** depress the footswitch. When the engine starts, release the toggle switch.

2. FOOTSWITCH OPERATION

The operation of the footswitch only completes the electrical circuit to the aerial control console and engine throttle. The footswitch is not an accelerator. The footswitch is not directly connected to the drive braking system. It completes the circuit to the controls and must be depressed before attempting to operate any functions. Operate the footswitch by placing the foot inside the footswitch cover and gradually pressing down on the pedal.

If aerial controls are being operated, remove foot from the footswitch to disengage controls in an emergency.

3. DRIVE

Forward and reverse drive is operable from the aerial control station only. For the drive to function, the operator must use both the forward/reverse controller and the footswitch. The controller has a multi-axis and may be pushed in the desired direction. If the turret is rotated 180°, the drive and steer decals read in reverse. The operator must reverse the drive and steer functions in order

to continue in the same direction. The direction decals on each end of the base will show the correct direction regardless of the turret position.

4. STEERING

To steer the Marklift, depress the footswitch and operate the steering controller. While the engine is running, depress the footswitch and push the steering controller to the left or right to turn the wheels. The wheels will remain in the last position they are set in until the controller is moved to change direction.

5. LIFT/LOWER

To raise or lower the boom from the ground control, set the selector switch to the "ground control" position, then push the toggle switch up or down.

To operate from the aerial control box, position the selector switch to the "Aerial" position. Raise or lower the platform by operating the "Lift/Lower" controller.

Warning: To avoid personal injury, do not position platform into overhead or other obstructions.

6. EXTENDING/RETRACTING

Extend or retract the boom from the ground control box by pushing the toggle switch in the direction desired.

To extend or retract the boom from the aerial control box, push the controller forward to extend or pull it back to retract.

7. TURRET ROTATION

The turret may be rotated from either the ground control or aerial control stations. Use the toggle switches at the ground control station and the controllers at aerial control station to rotate the turret in the desired direction. The turret may be rotated 360° continuously. The directional decals on each end of the base will show the correct direction regardless of the turret position. If the turret is rotated 180°, the drive and steer decals read in reverse.

8. PLATFORM TILT

The platform may be tilted forward or backward. Use the toggle switch at the aerial control station to tilt the platform.

9. PLATFORM ROTATION

The platform may be rotated to the right or left from the aerial control station. Use the toggle switch to rotate the platform.

10. WARNING LIGHT AND BUZZER

As a special safety feature, the Marklift is equipped with an "out-of-level" sensor that will disable the boom functions whenever the Marklift is in an unsafe out-of-level position. An unsafe out-of-level condition is sensed by the level sensor when the machine is tilted 5° front to rear or 5° side to side.

The unsafe condition is indicated by a red warning light and buzzer, located on the top center of the aerial control box. When the warning light and buzzer are on, Lift/Lower, Extend/Retract, and Turret Rotation will not operate but the drive and steer functions will. Should the warning signals come on, maneuver the Marklift until it is on a safe, level operating surface and all functions will be restored.

11. ENGINE STOP

Push the red "Stop" button to stop all functions and the engine. The buttons are located on the aerial and the ground control stations. The engine may also be stopped by rotating the engine start switch to the "Off" position. The engine may be restarted with the ignition switch or aerial start button.

12. EMERGENCY PROCEDURES

In case of an engine failure emergency, all boom hydraulic functions are operable with the emergency pump running. This procedure is intended only for recovering the machine and is dependent upon sufficient power supply (battery).

To operate the emergency pump from the aerial platform:

1. Set the aerial start switch to the "ON" position.

2. Position the emergency pump switch to "ON" to start the emergency pump.

3. Depress the footswitch and move the switches or controllers in the desired direction.

To operate the emergency pump from the ground:

1. Set the selector at ground control station to "Ground".

2. Turn master switch to "ON".

3. Push red emergency pump button while simultaneously operating desired function controls.

The following preventive maintenance information is intended as a general guide. In addition to the maintenance information provided below, the machine must be inspected and maintained as required by ANSI, OSHA, local safety boards and owners. Please refer to the vendor section of this manual for detailed information on the engine, battery, etc.

MARK INDUSTRIES recommends that the following items be checked according to the schedules indicated. Any machine not in safe operating condition must be removed from service until it is repaired by a qualified service person.

DAILY (Before use on Each Work Shift)

1. Make sure that operation and safety decals are in place and readable.
2. Check the water level in the battery
3. Check for loose or worn hardware.
4. Check fuel level.
5. Make sure the operating controls perform correctly.
6. Check for and correct any hydraulic leaks.
7. Check for and correct any structural damage.
8. Check for wear on cables and hoses.
9. Check the condition of the tires. Make sure they are free of serious cuts or defects.
10. Check for proper brake operation.

WEEKLY

1. Include all items indicated in daily check
2. Make sure the battery is fully charged.
3. Clean unit by removing all dirt, oil, and grease. The machine may be washed with soap and water. Stay clear of all electrical panels and enclosures.

4. Check overall performance.

5. Check the air cleaner.

6. Check for proper hydraulic and engine oil level.

MONTHLY (and first 50 hours)

1. Include all items in weekly check.

2. Check and lubricate, if necessary. (See Recommended Service Instructions.)

3. Change the hydraulic oil return filter.

4. Grease ring gear, and rotation gear box worm gear.

5. Grease steering linkage.

6. Change engine oil filter.

7. Check torque hubs. (See Torque Hub Lubrication.)

EVERY SIX MONTHS (100 hours)

1. Include all items in monthly check.

2. Check and lubricate, if necessary. (See Recommended Service Instructions)

3. Change pilot filter element. (See Recommended Service Instructions.)

EVERY YEAR

1. Include all items in bi-annual check.

2. Re-pack all wheel bearings.

3. Change the hydraulic oil.

4. Check the torque hub oil level. (See Torque Hub Lubrication.)

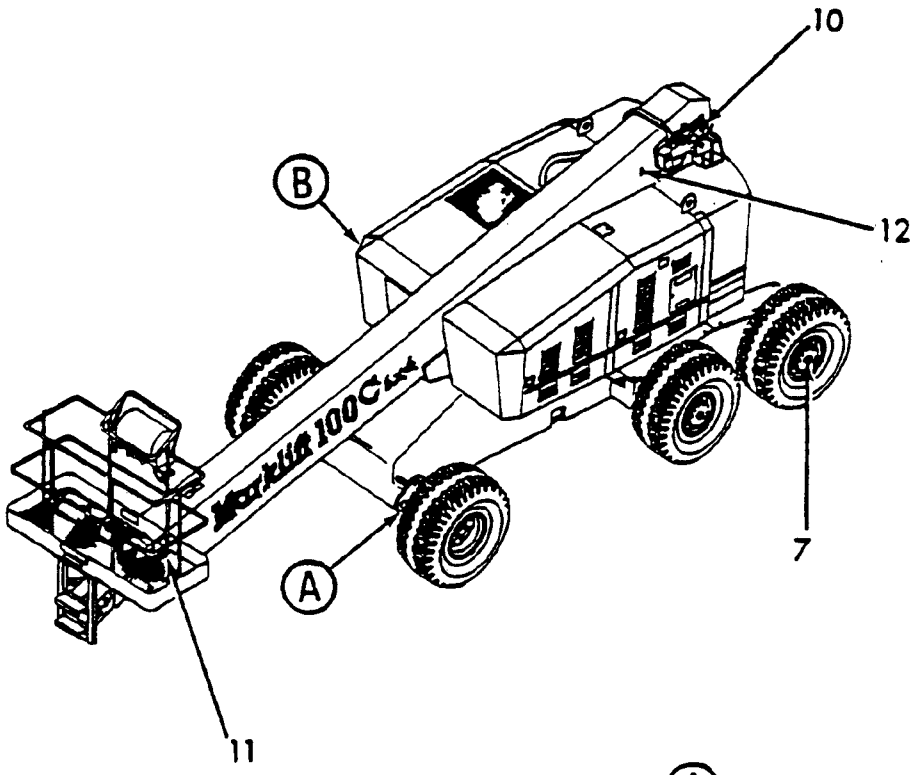
Recommended Service Instructions
80C 4x4, 80C 6x4

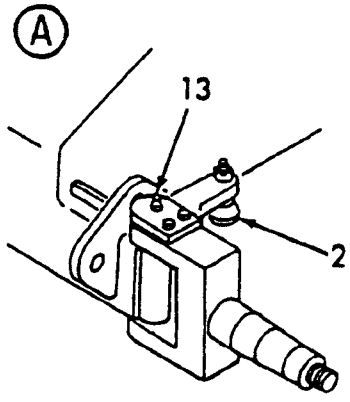
Item	Description*	Lubricant	Service/Frequency
1.	Rotation gear box	Gear oil SAE EP 90	Check/Monthly
2.	Tie Rod Pin	Mobilcote type-s	Lubricate/Monthly
3.	Ring Gear	(4) Zerks — rotate gear while greasing	Lubricate/Monthly
4.	Engine	See manufacturer's instructions	See manf. instructions
5.	Hydraulic Fluid	See Hydraulic Fluid Table	Check/Daily Replace/Yearly
6.	Hydraulic Tank Strainer	See Hydraulic Fluid Table	Clean/Yearly
7.	Torque Hubs	See Torque Hub Lubrication	Change/Yearly
8.	Hydraulic Tank Filter		Clean/Yearly
9.	Return Line Filter Pilot Strainer		Replace/100 hrs. Inspect/100 hours
10.	Main Boom Pivot Pin	Mobilcote Type-S	Lubricate/Monthly
11.	Extension Sheaves	Mobilcote Type-S Gear Grease	Lubricate/Monthly
12.	Retraction Sheaves	Mobilcote Type-S Gear Grease	Lubricate/Monthly
13.	Steering Yoke King Pins	Mobilcote Type-S Gear Grease	Lubricate/Monthly

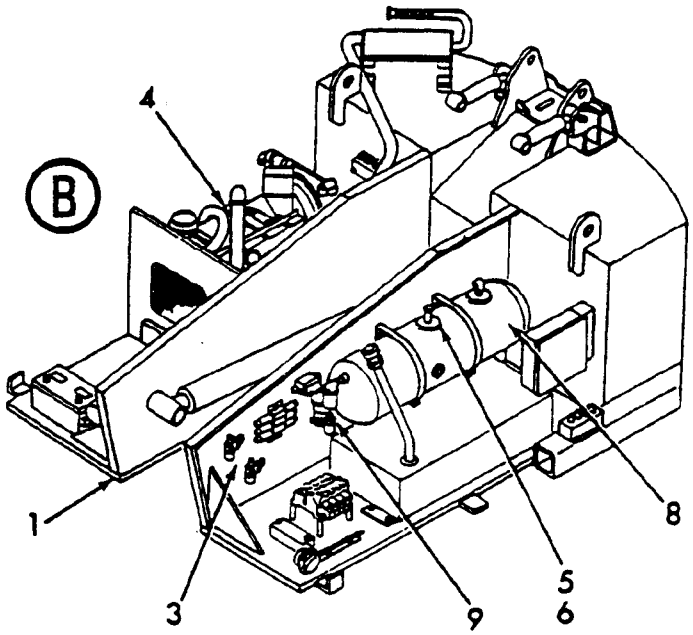
* See Following Page for Locations

PREVENTIVE MAINTENANCE

Recommended Service Instructions
100C







Battery Maintenance

Water or Acid Loss to Batteries

Water loss from the battery is mainly due to evaporation brought on by temperature rises during heavy charging cycles. A very small amount of water is lost due to hydrogen and oxygen gases formed during charging. Acid is lost if the case becomes cracked or if the battery is allowed to tip over. Therefore, acid is seldom needed.

Checking the Water Level

When checking the water level, don't allow dirt to enter into the battery cells once the caps have been removed. Take particular care to avoid setting the caps down on a dirty surface. Replace the caps immediately after checking the water level.

Materials and Equipment Required

1. Battery Filler Bottle
2. Distilled Water (if available)
3. Hydrometer

Filling the Battery

Gas and diesel powered machines have alternators that keep the batteries fully charged. For these units, add water to the level indicator.

Avoid Battery Hazards!

Batteries produce flammable and explosive gasses. Keep electric arcs, sparks, flames and lighted tobacco away from batteries.

Battery acid will damage eyes or skin on contact. Always wear a face shield during battery maintenance to avoid acid in eyes. Also wear rubber gloves and protective clothing to keep acid off skin.

Never check the battery by placing a metal object across the posts. Serious burns or an explosion can result.

Charge batteries only in a well ventilated area.

Battery Maintenance

Either excessive overcharge or moderate undercharge can shorten battery life. With proper attention to water level and charging time, compared to hydrometer readings, the batteries should give a long useful life.

TEMPERATURE/SPECIFIC GRAVITY CORRECTION TABLE FOR BATTERIES
ACTUAL HYDROMETER READING AT ACTUAL TEMPERATURE

80°F (27°C)	0°F (-18°C)	-10°F (-23°C)	-20°F (-29°C)	-30°F (-34°C)	-45°F (-43°C)	-65°F (-54°C)	Approx. State of Charge In%
1.280	1.312	1.316	1.320	1.324	1.330	1.338	100
1.250	1.282	1.286	1.290	1.294	1.300	1.308	75
1.220	1.252	1.256	1.260	1.264	1.270	1.278	50
1.190	1.222	1.226	1.230	1.234	1.240	1.248	25
1.160	1.192	1.192	1.200	1.204	1.210	1.218	0

Specific Gravity

Corrected to 80°F (17°C)	Freezing Temperature	
1.280	-90°F	-68°C
1.250	-62°F	-52°C
1.200	-16°F	-27°C
1.150	+ 5°F	-15°C
1.000	+19°F	- 7°C

Note:

Cold temperatures have a numbing effect on the electrochemical action of the battery, greatly reducing its capacity. Therefore, it is highly recommended that the battery be kept in an almost fully charged condition during cold weather.

Protecting Engines for Winter Storage

To protect the cylinders, pistons, rings and valves from rusting and sticking, a half and half mixture of kerosene and good gas engine oil should be injected into the intake manifold while the engine is warm and running at moderate speed. Use one ounce per cylinder or enough so that a heavy bluish smoke will appear at the exhaust. The ignition switch should then be shut off and the engine stopped. This fogging will give a coating of oil on the above mentioned parts protecting them from the atmosphere.

If possible, store the machine inside a building. If there is no available building, the engine should be protected from the weather by a proper covering.

TORQUE HUB LUBRICATION

Marklift Self-Propelled Boom
100C 6x4

1. Type — EP 90

   For normal application, use EP 90. For applications where the lubricant must meet special requirements, the manufacturer of the lubricant should be able to recommend a suitable substitute.

2. Oil Temperature

   Continuous — 160°F
   Intermittent — 200°F

3. Oil Change

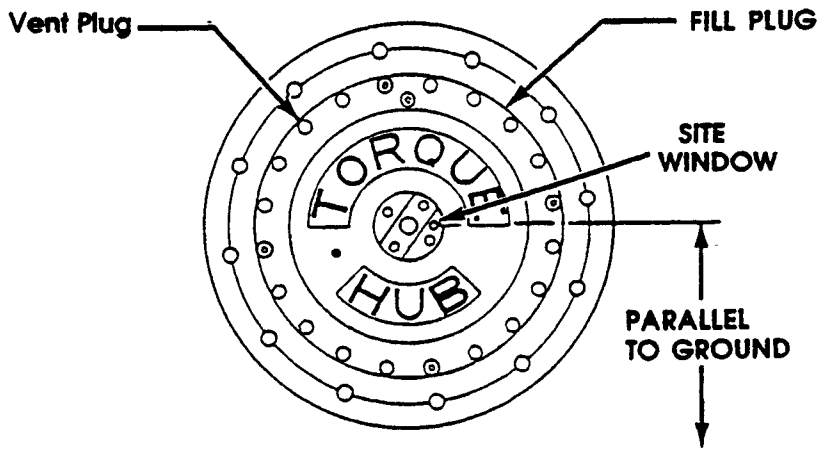
   Initial — After 50 hours or 50,000 revolutions of operation, preferable in a loaded condition.

   Subsequent — 1000 hours or (1) year whichever comes first. Higher temperatures make it necessary to change oil more frequently.

4. Oil Fill Level

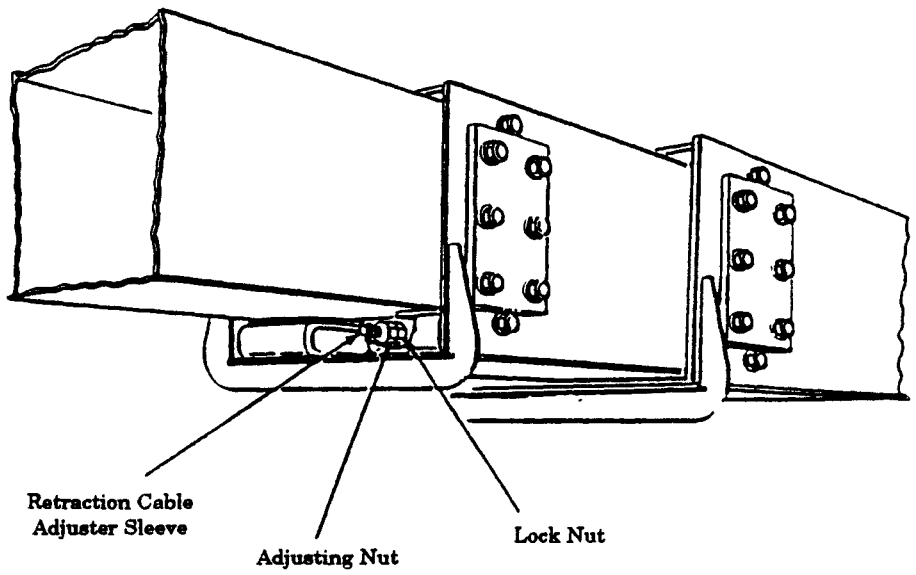
   Remove fill plug
   Remove vent plug
   Pour oil into fill plug
   Fill to half -full.

Fill at slow pace, to allow air to escape.



Marklift Self-propelled Boom
100C 6x4

1. Elevate the boom until approximately horizontal above ground.
2. Extend the boom out approximately 3 to 4 feet.
3. It is necessary to have a crow's foot wrench or a special deep well socket.
4. Set the torque wrench at 22.0 foot pounds.
5. Apply a few drops of oil or hydraulic fluid to the cable stud threads and nuts.
6. Loosen lock nut.
7. Tighten the adjusting nut until a torque of 22.0 foot pounds is registered.
8. Continue to extend the boom at one foot increments and torque the adjusting nut until the torque wrench registers ("releases") at 22.0 foot pounds. (The adjusting nut no longer turns on the adjuster sleeve.)
9. Tighten the lock nut when the cable tensioning is completed.



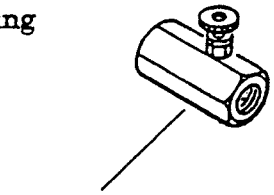
BRAKE ADJUSTMENT PROCEDURE

C and I Model Booms

All Marklift C and I model telescopic boom lifts incorporate both a "dynamic" (moving) and a "static" (stationary) braking system. This brake adjustment procedure is for models incorporating the drive/brake valve part number 22433 (100C, 80C, 62C, 42C, 60I, and 55I). This valve was employed on units manufactured from approximately 1988 to 1991. The maximum obtainable travel speed and gross vehicle weight preclude the use of a purely mechanical type brake to both stop the unit, within the minimum desirable distance, and to hold the unit stationary once stopped. Therefore, these models use a "hydrostatic" (hydraulic) braking system to generate the brake torque necessary to slow down and stop the unit and employ separate mechanical (spring applied) "parking" brakes to prevent the unit from moving of its own accord once it has stopped. The parking brakes are intended for stationary application only and ARE NOT intended to stop the unit while moving. Mis-adjustment of the braking system (either dynamic or static) could result in an unsafe condition or damage to the brake system components.

Hydrostatic braking has been adjusted at the factory and consequently adjustment of these brakes should rarely be necessary. However, it is recommended that the operation of the hydrostatic braking system be checked periodically.

To inspect the dynamic brakes, the parking brakes must first be disengaged. To accomplish this the parking brake control valve (located between the front, non-steering, drive wheels) must be closed while simultaneously operating the drive function. To ensure that the parking brakes remain disengaged while inspecting or adjusting the dynamic braking system (inadvertent application of the parking brake will affect adjustment of the dynamic braking), a pressure gauge (0-3000 psi) should be "teed" (installed parallel) into the brake supply line (in between the parking brake control valve and the parking brakes). A maintained (constant) minimum pressure reading of approximately 250 psi ensures that the parking brakes remain fully released.



Parking brake control valve

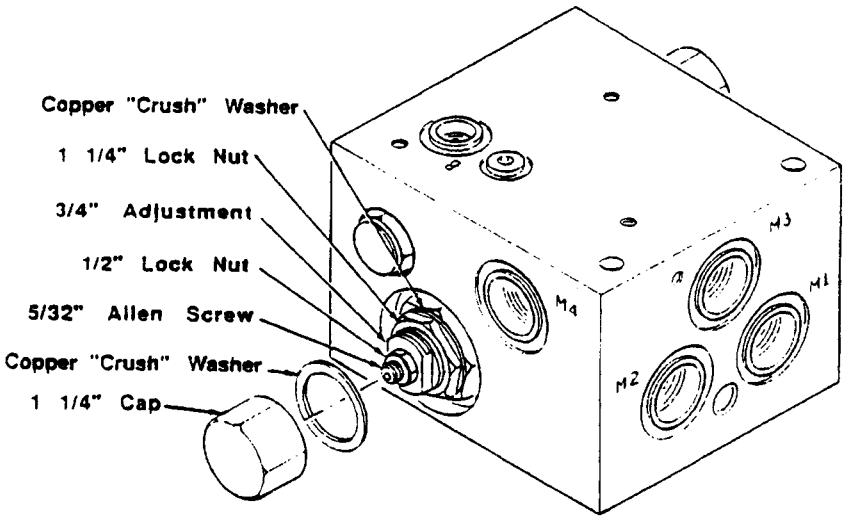
CAUTION:
Parking brakes should be disengaged ONLY while the unit is on flat level ground. When operating the unit with the parking brakes disengaged, remain clear of hazards such as obstructions, slopes, drops , or holes, etc.

To determine the maximum distance required for the unit to stop, the Marklift should be driven at high travel speed (boom below horizontal and fully retracted) and with the engine operating at "high throttle" (maximum revolutions). Place an object or chalk a line approximately 20 to 30 feet in front of the unit to serve as a reference point. Push the drive controller full "on". Drive the unit until one of the wheels (this will be called the reference wheel) passes the object or crosses the line on the ground. As the wheel crosses over the mark, release the drive controller. Simply let go of the handle. DO NOT proportion the controller back to the "off" position! After the unit has stopped, measure the distance from the center of the reference wheel back to the mark. This is the dynamic braking distance. (Make sure that the minimum parking brake release pressure is still indicated on the pressure gauge). The dynamic braking distance should fall between 2 and 4 feet.

The "dynamic braking valve" (refer to the Parts and Service Manual applicable to the unit being adjusted for the specific location of this valve) incorporates two "counterbalance" (dynamic brake adjustment) valves in the dynamic braking system, one for each direction of travel. Each counterbalance valve has two adjustments. The primary adjustment establishes the maximum brake torque, by controlling a spring operated relief valve inside the counterbalance valve. The other adjustment establishes the rate of the dynamic brake (the amount of time that the valve will remain open prior to the brake "locking down").

CAUTION: Before making any adjustments on the counterbalance valves or climbing underneath the unit to adjust the valves (this may be necessary on some models) install blocks in front of and behind the drive wheels.

To adjust the dynamic brakes (should this be necessary), you will first need to determine which counterbalance valve corresponds to a specific direction of travel. To determine this, remove the 1-1/4 inch hex head cap from one of the counterbalance valves. Be sure not to lose the copper "crush" washer between the cap and the lock nut located behind the cap. Loosen the 1 1/4 inch lock nut



Drive/brake valve (pt. no. 22433)

which secures the primary brake adjustment (large threaded shaft) Rotate the primary brake adjustment counterclockwise approximately two full turns. Lock the setting by re-tightening the jam nut. Reinstall the hex head cap and the copper "crush" washer and tighten lightly **by hand**. There are no seals inside the counterbalance valve. If the cap and sealing washer are not installed, the valve will leak whenever drive is operated. Drive the unit forward briefly. EXERCISE CAUTION!

If the unit now appears to travel a longer distance before stopping than before any adjustment was made (dynamic braking distance has increased), then the valve which was adjusted controls the dynamic braking distance in the direction of travel in which the controller was operated (forward or reverse). If no change in stopping distance was noted, then the valve which was adjusted controls the braking distance in the "opposite" direction of which the controller was operated.

To adjust the counterbalance valve to obtain the desired brake torque or stopping distance, remove the cap and loosen the 1/2 inch lock nut which secures the small threaded shaft (5/32 of an inch). The small shaft is located in the center of the primary brake adjustment. Turn the small shaft "counterclockwise" approximately three to four turns. Loosen the 1-1/4 inch jam nut which secures the primary brake adjustment and turn the valve "in" (clockwise) **by hand** until it "bottoms out". With the aid of a 3/4 inch wrench inserted on the "flats" of the valve, again adjust the valve in approximately 1/4 to 3/4 of a turn. Tighten down the jam nut to secure the valve in this position. Turn the small threaded shaft "in" (clockwise) until it **lightly** "bottoms out", and then turn the shaft "out" (counterclockwise) the primary brake adjustment counterclockwise in 1/4 turn increments until this condition is no longer noticeable. **DO NOT adjust the valve out too far as this will result in insufficient brake torque to stop the unit!** Remember, the small threaded shaft (rate adjustment screw) will need to be re-adjusted every time the primary brake relief valve (counterbalance valve) is adjusted. Assess the job site (traffic, hazards, etc.) to determine if the prevailing adjustment is safe! Tighten the lock nut securely and install the caps. **DON'T FORGET: Ensure that the copper "crush" washer is installed!**

The purpose of the dynamic braking system is to generate the brake torque necessary to slow down and stop the unit within the minimum desired distance. **Smooth (soft) controlled braking can only be accomplished by proper operation (proportioning) of the drive controller!** Adjusting the counterbalance valve to stop the unit on steep slopes, will result in a more severe braking action (reduced braking distance on level surfaces).

Once the desired dynamic braking distance has been achieved, it will be necessary to re-adjust the parking brakes. Open the parking brake control valve slightly (approximately

the primary brake adjustment counterclockwise in 1/4 turn increments until this condition is no longer noticeable. **DO NOT adjust the valve out too far as this will result in insufficient brake torque to stop the unit!** Remember, the small threaded shaft (rate adjustment screw) will need to be re-adjusted every time the primary brake relief valve (counterbalance valve) is adjusted. Assess the job site (traffic, hazards, etc.) to determine if the prevailing adjustment is safe! Tighten the lock nut securely and install the caps. **DON'T FORGET: Ensure that the copper "crush" washer is installed!**

The purpose of the dynamic braking system is to generate the brake torque necessary to slow down and stop the unit within the minimum desired distance. **Smooth (soft) controlled braking can only be accomplished by proper operation (proportioning) of the drive controller!** Adjusting the counterbalance valve to stop the unit on steep slopes, will result in a more severe braking action (reduced braking distance on level surfaces).

Once the desired dynamic braking distance has been achieved, it will be necessary to re-adjust the parking brakes. Open the parking brake control valve slightly (approximately 1/8 turn) to permit the pressure "trapped" in the parking brake circuit to dissipate. Drive the unit forward (or reverse) briefly, and observe the pressure gauge (which was previously installed in the parking brake release circuit). With the unit at a complete stop, a minimum pressure of approximately 250 (+ or - 50) psi should remain indicated on the gauge. This pressure should dissipate to "0" (zero) psi within one to two seconds of the unit stopping completely. Tighten the "jam nut" on the parking braske control valve to maintain this setting. Remove the pressure gauge from the parking brake circuit. This completes adjustment of the dynamic braking of the Marklift C and I model telescopic boom.

NOTE: The parking brake control valve may be adjusted periodically to allow for "instantaneous" braking during loading and unloading operations. Should this be performed, "fully" closing and then opening the valve approximately 1/8 turn will typically assure a sufficient time delay, in application of the parking brakes, to ensure that dynamic application does not occur. However, only the installation of a pressure gauge into the brake release circuit will ensure the accuracy of this adjustment.

Proportional Control Valve Operation

The following information will help the mechanic troubleshoot and make adjustments to the hydraulic system. It is the mechanic's responsibility to read and understand the given information.

The proportional control valve is comprised of four valve "segments" which provide individual control for each proportional function; drive (forward and reverse), boom (lift/lower and extend/retract), and turret rotation (right/left).

Flow from the hydraulic pump enters the valve at the inlet port of the inlet manifold and is introduced at the directional control spool of each valve segment across a "flow compensator valve". However, since no flow occurs across the valve spool until a function is operated, an internal passage inside the valve segment generates a pressure signal to the flow compensator causing it to be seated. Simultaneously, flow enters a parallel passage where it is directed across a 40 micron wire mesh screen or strainer, and encounters the "pilot relief valve". A proportionate amount of this flow is returned to the tank across the valve, thus generating a pilot pressure signal which is then supplied to the pilot valves.

The "pilot valves" are electromechanical valves which respond to a command signal generated by the electrical controller at the control station. Inside the pilot valve there is a plunger (which responds to the magnetic field generated by the valve coil whenever the controller is operated), a concave seat and a metering rod or needle. Operating the controller causes the plunger inside the pilot valve to lift off the concave seat which permits the seat to "snap" up off the metering rod or needle. This permits pilot flow to pass across an orifice in the valve seat (which is blocked by the metering rod when it is in contact with the seat), and through the pilot valve. This metered flow is directed through the valve segment into a "control" passage for the directional control spool. Connected to the control passage is a tank return passage, pilot flow passing through the pilot valve is returned back to tank across a flow disc installed in the passage. This disc has a small orifice which meters the flow that is returned back to tank.

The rate at which the pilot valve opens and closes (the plunger releases the concave valve seat to permit it to lift up off the metering rod) determines the rate of flow

through the pilot valve and into the control passage. As long as the valve is opened and closed at a minimum specific rate, the rate of flow into the control circuit is equal to the rate of flow which can be returned to tank across the flow disc in the tank return passage. Consequently there is no increase in pressure in the control passage. However as the controller is moved farther "on", the rate that the plunger releases the concave inlet disc increases. This permits a greater volume of oil to pass across the valve and into the pilot valve body. This increased flow generates a pressure signal in the control passage (since only a finite amount of flow can be returned to tank across the flow disc at the base of the pilot valve in the tank return passage). This pressure signal is applied against the directional control spool and causes the spool to be "shifted" opposing a spring which normally maintains the spool in its centered state.

As the directional control spool is shifted off center, inlet flow from the pump is metered across tapered "lands" on the control spool and directed out the V1 or V2 ports, to the selected function. As the directional control spool shifts, a pressure drop occurs at the supply passage of the spool and results in a pressure "differential" across the flow compensator valve, this pressure difference causes the valve to open and regulates oil passed to the directional control spool based upon the difference in pressure created by the rate of flow out to the function being operated and the rate of flow being supplied by the pump. As flow out to the desired function encounters resistance, an internal passage parallel to the supply ports (V1 and V2) directs the corresponding pressure signal against a shuttle ball (located in the valve segment), which is connected in parallel to the other valve segments. This pressure signal is diverted by the shuttle ball out to the load sense port of the proportional control valve, where it is transmitted to the pump and instructs the pump to meet the flow requirements of the function being operated.

The speed at which the function operates is controlled by the metering effect across the valve spool (amount of shift determines the rate of flow), which is controlled by the operating rate (opening and closing) of the pilot valve. The load sense circuit is configured so that the pump receives the signal from whichever function has the highest flow requirement, even when multiple functions are selected.

Additional information may be contained in the vendor chapter.

Electrical System

The Marklift electrical system is very straight forward and easy to trouble shoot because of it's simplicity. There are two major junction boxes which also serve as the ground and aerial control consoles. The source for the electrical system is a 12 volt battery with a negative ground. All electrical components typically operate directly from the source through either switches or a proportional controller.

Whenever trouble shooting any problem, begin by checking the basics. This means checking to make sure that the batteries are in good shape and have at least a three quarter charge, determined by using a hydrometer and battery maintenance instructions. A large percentage of electrical problems are often due to poorly charged or defective batteries.

A. If a problem seems to be electrical, check the schematic, (see the SCHEMATIC chapter for more information) and use a volt/OHM meter to trace the power flow (electrical current) starting at the battery and continuing through the system until the problem is located.

B. Keep in mind, if you **DO NOT** have a good ground to a valve coil, relay, etc., even if you have proper electrical current to the coil or relay, the item will not function properly.

C. Diodes can be thought of as "one way electrical check valves" they permit current flow in one direction and stop it in the opposite direction.

D. The basic purpose of a relay is to remotely switch other electrical devices.

The ground control console houses the necessary switches for starting and stopping the engine; a selector switch for isolating either the ground or aerial control console, and the required toggle switches for moving the boom. The ground control console also contains a keyed ignition/start switch, as well as an engine stop switch, ammeter, and fuel gauge. When the selector switch is placed in the aerial position, the electrical source is routed to the aerial control box. The intent of the footswitch is to provide an

additional safety interlock in the control circuit to require foot as well as hand movement by the operator, thereby requiring maximum operator attention. The function of the footswitch only completes the electrical circuit to the aerial control console and engine throttle. The footswitch is not directly connected to the drive braking system.

The aerial control console is equipped with controllers and switches to operate all of the boom functions. It also contains a start/stop and an emergency pump switch. Your Marklift is equipped with a proportional control valve. The aerial control console contains electrical controllers for these drive functions. The controller is spring-centered and is designed to produce a variable output signal to the control valve. The output signal is directly proportional to the handle movement of the controller. The valve is electrically coupled to the controller and responds only to the signal level transmitted to it by the operator.

The operator must learn how to move the controller slowly to obtain a smooth transition from start up to wide open and back to neutral.

The Marklift boom unit has additional safety systems for driving. When the unit is driven with the boom extended or raised above horizontal, the unit is automatically shifted into low speed. This is accomplished through two limit switches sensing the altitude and extension positions of the boom, wired in series to a valve which supplies a hydraulic signal to the variable displacement drive motors.

TROUBLESHOOTING CHECKLIST

Engine

1. Engine will not start or run.

A. Check ground control box circuit breaker.
B. Check for low battery reading.
C. Check for fouled spark plugs.
D. Check fuel selector to see if it is in the gas or propane position.
E. Check for closed fuel shut-off valve.
F. Check for water in gas tank.
G. Check engine points.
H. Refer to your local service facility.

2. Engine dies under load.

A. Check carburetor air/fuel mixture.
B. Check hydraulic pressure.
C. Refer to your local service facility.

3. Engine will not idle.

A. Check the carburetor.
B. Check the throttle solenoid valve.
C. Refer to your local service facility.

Hydraulic Drive Motor

Hydraulic drive motor turns wheel while unloaded, but slows down or stops when load is applied.

A. Check hydraulic pressure.
B. Refer to your local service facility.

Hydraulic Pump

Pump producing excessive noise.

A. Check hydraulic oil level (sight gauge on tank.)
B. Check suction hose from tank to pump for kinks.
C. Refer to your local service facility.

Lift

1. Lift functions will not operate from aerial control console.

A. Check position of Aerial/Ground selector switch.
B. Check footswitch continuity.
C. Check for loose wire in aerial control box.
D. Refer to your local service facility.

2. Lift functions will not operate from ground control box.

A. Check position of Aerial/Ground box selector switch.
B. Check the Aerial/Ground selector relay.
C. Refer to your local service facility.

Drive

1. Low torque drive.

A. Make sure hydraulic system is up to recommended pressure.
B. Check for extended or raised boom.
C. Refer to your local service facility.

2. Drive will not go into "HI" speed.

A. Check the aerial HI/LO speed selector switch.
B. Check the high speed solenoid valve.
C. Refer to your local service facility.

Brakes

No brakes.

A. Check the drive hub disengagement caps.
B. Check brake delay valve.
C. Refer to your local service facility.

HYDRAULIC FLUID TABLE

Milestone			Hydraulic fluid			
Oil company			Chevron	Gulf	Shell	Union
Brand Name			ATF Dexron II	ATF Dexron II	Donaz-T6	ATF Dexron
Viscosity	SUS AT 100°F (37.8°C)		187.4	195	200	200
	SUS AT 210°F (98.9°C)		49.2	50.4	50	52.3
	Index	°F	153°	155°	160°	172°
		°C	67.2°	68.3°	71.1°	77.8°
Flash point		°F	400°	405°	390°	395°
		°C	204.4°	207.2°	198.9°	201.7°
Pour point		°F	-40°	-50°	-50°	-45°
		°C	-40°	-45.6°	-45.6°	-42.8°

MODEL 100C 6X4

Part No.	Qty.	Description
67804	2	Set, decal
600377	1	Board, circuit (Multi-axis)
600378	1	Board, circuit (Single-axis)
70595	2	Switch, anti-restart
70313	4	Switch, toggle
4011	2	Switch, toggle
70291	2	Switch, toggle
20805	2	Buzzer, alarm
4021	2	Switch, toggle
20481	4	Switch, toggle
70407	2	Guard, switch
20884	5	Guard, switch
70479	10	Diode
24127	2	Assembly, terminal block
70391	2	Receptacle (GFCI)
70392	2	Cover, receptacle
70107	2	Switch, limit
70031	2	Arm, lever
70032	2	Arm, lever
2717	2	Ignition switch
20562	2	20 AMP circuit breaker
20571	2	Hourmeter
20572	2	Ammeter
20482	2	Selector switch
20573	1	Latching relay
70215	2	T-Bar relay
21250	1	Slope sensor
21219	2	Fuel gauge
70214	1	T-Bar relay base
70147	2	Capacitor
70145	2	Relay, 12vdc

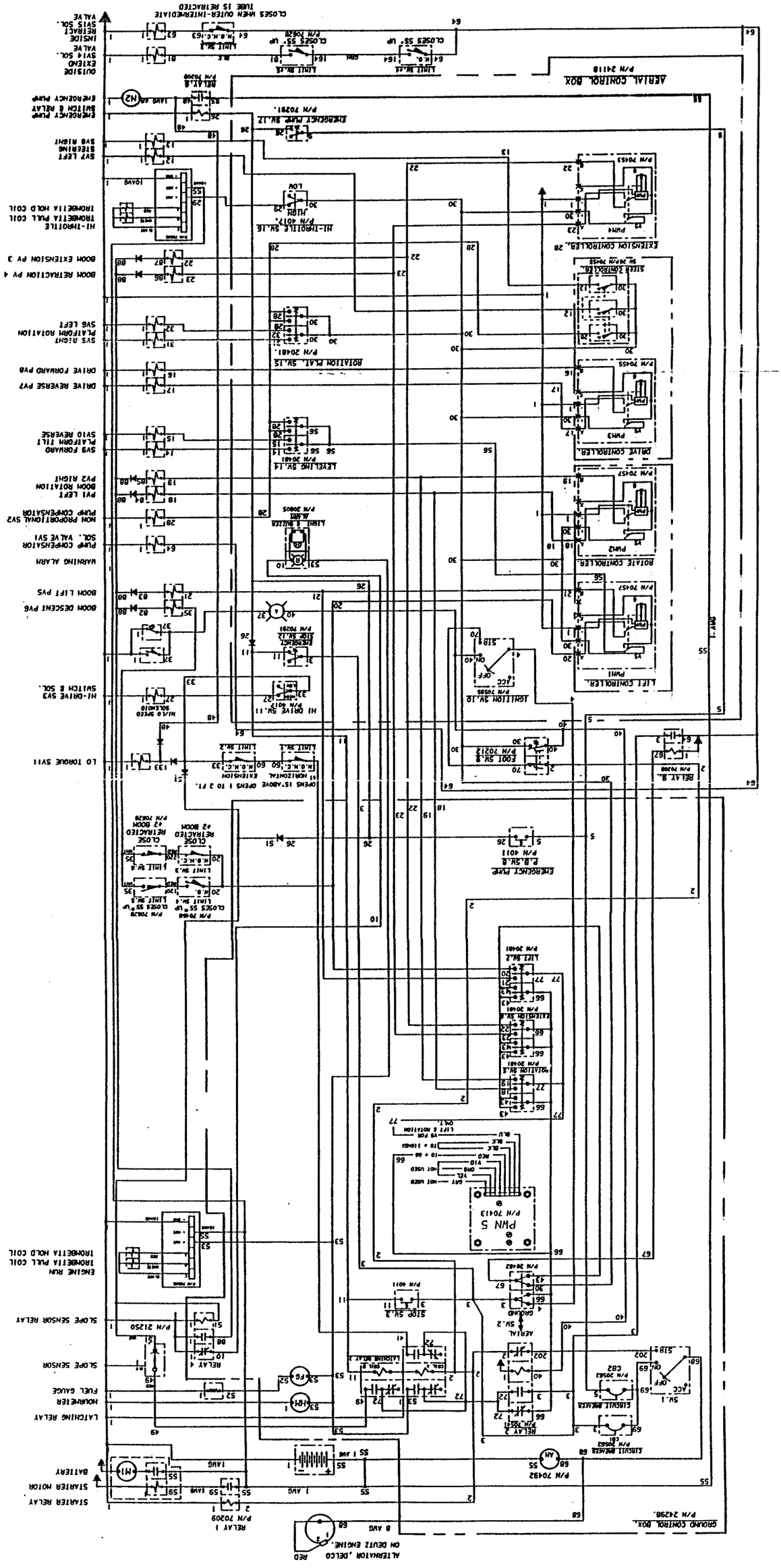
RECOMMENDED SPARE PARTS LIST

Part No.	Qty.	Description
784-A	1	Relay socket
30215	2	Clip, hold down relay
70413	1	PWM card
160	6	Fuel filter
21245	6	Return filter element
67378	2	Seal kit enerpac
67380	2	Cartridge solenoid
67382	2	pilot inlet filter
67249	2	Coil only
67248	2	Seal kit
66651	2	Seal kit master cylinder R.A.
66044	2	Seal kit master cylinder S.E.
16964	2	Seal kit engine pump
66361	2	Seal kit steering cylinder

SCHEMATIC	PAGE 1

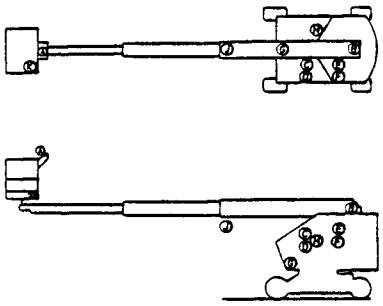
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MODEL	100C 6X4 (DEUTZ)
NOTES	P/N 24302 REV E

Mark Industries



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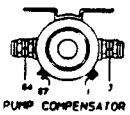
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MODEL	100C 6X4 (DEUTZ)	PAGE 1A
NOTES	P/N 24302 REV E	



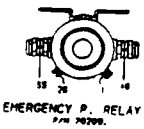
ID	DESCRIPTION.	LOCATION
A	UPPER CONTROL BOX.	PLATFORM
B	LIMIT SWITCH #1.	TURRET
C	NON-PROPORTIONAL VALVE.	TURRET
D	PROPORTIONAL VALVE.	TURRET
E	EMERGENCY PUMP/MOTOR.	TURRET
F	GROUND CONTROL PANEL.	TURRET
G	BATTERIES.	TURRET
H	ENGINE. COMPARTMENT	TURRET
J	LIMIT SWITCH #2.	BOOM
K	FOOT SWITCH #9.	PLATFORM



STARTER RELAY 1
P/N 70209.



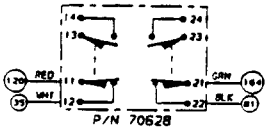
PUMP COMPENSATOR RELAY
P/N 70209.



EMERGENCY P. RELAY 6
P/N 70209.

WIRING SCHEDULE											
NO.	AWG	A	B	C	D	E	F	G	H	J	K
1	1					●		●	●		
1	12	●		●	●		●		●		
2	12	●					●		●		●
3	12	●					●				
4	12	●					●				●
5	12	●					●				
6	12	●					●	SPARE			
7	18	●					●		●		
8	18	●					●		●		
9	18	●					●		●		
10	18	●					●				
11	18	●					●				
12	18	●		●			●				
13	18	●		●			●				
14	18	●		●			●				
15	18	●		●			●				
16	18	●			●		●				
17	18	●			●		●				
18	18	●			●		●				
19	18	●			●		●				
20	18	●			●		●				
21	18	●			●		●				
22	18	●			●		●				
23	18	●			●		●				
24	18	●					●		●		
25	18	●					●	SPARE			
26	18	●				R6	●				
27	18	●		●			●				
28	18	●		●			●				
29	18	●		●			●				
30	18	●					●				●
31	18	●		●			●				
32	18	●		●			●				
33	18	●					●			●	
34	18	●					●	SPARE			
35	18	●					●	SPARE			
36	18	●					●	SPARE			
37	18	●					●		●		
38	12	●					●				
39	12	●					●				
40	12	●					●				

WIRING SCHEDULE											
NO.	AWG	A	B	C	D	E	F	G	H	J	K
43	18				●						
46	18				●		●				
48	1					●					
49	18		●				●				
51	18						●				
52	18						●				
53	12						●		●		
55	8						●		●		
55	1					R6		●	●		
56	18	●									
59	12						●		●		
60	18		●				●			●	
66	18						●				
67	18			●			●				
68	8						●		●		
69	12						●				
70	12	●									●
72	12						●				
79	12						●		●		
80	12			●			●				
82	18				●		●				
83	18				●		●				
84	18				●		●				
85	18				●		●				
86	18				●		●				
87	18				●		●				
88	18				●		●				
89	12						●				



P/N 70628
LIMIT SW.5

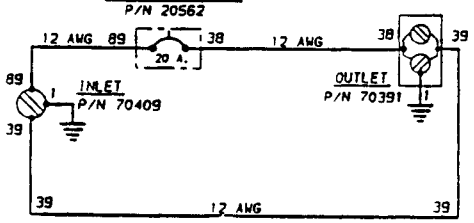


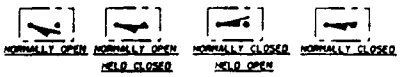
P/N 70628
LIMIT SW.6

NOTES:

1. TO CONNECT GROUND CONTROL AND AERIAL CONTROL USE ARM CABLE P/N 70528.
2. ALL WIRES ARE 18 AWG. UNLESS OTHERWISE SPECIFIED.
3. USE 6A. 1000V. DIODE P/N 70479.
4. WIRING AND SWITCHES ARE FOR A BOOM IN STOWED POSITION.
5. ALL WIRES FOR 115 VAC ARE 12 AWG.
6. IDENTIFY EACH WIRE BY NUMBER FLAG AT BOTH ENDS WRAPPING COMPLETELY AROUND.
7. WIRE NO. 34 AT CONTROL CABLE TO BE RE-NUMBERED 53.
8. FOR 115V AC GENERATOR OPTION, SEE DWG 24452.

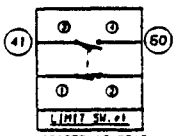
CIRCUIT BREAKER
P/N 20562



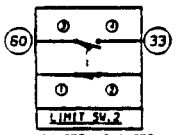


LEGEND FOR LIMIT SWITCHES.

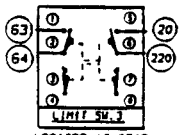
115 VAC WIRING.



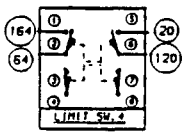
LOCATED AT REAR BOOM MOUNTING BRACKET. (BOTTOM) OPENS 15° AND ABOVE



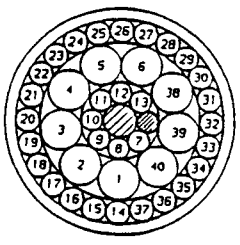
MOUNTED AT INTERMEDIATE INNER BOOM. (BOTTOM) OPEN WHEN EXTENDED MORE THAN 1 FOOT



LOCATED AT REAR BOOM MOUNTING BRACKET. (RIGHT SIDE.) CLOSES WHEN OUTER-INTERMEDIATE TUBE IS RETRACTED



LOCATED AT THE CAM. ACTUATED FROM 55° TO 75°. P/N 70468

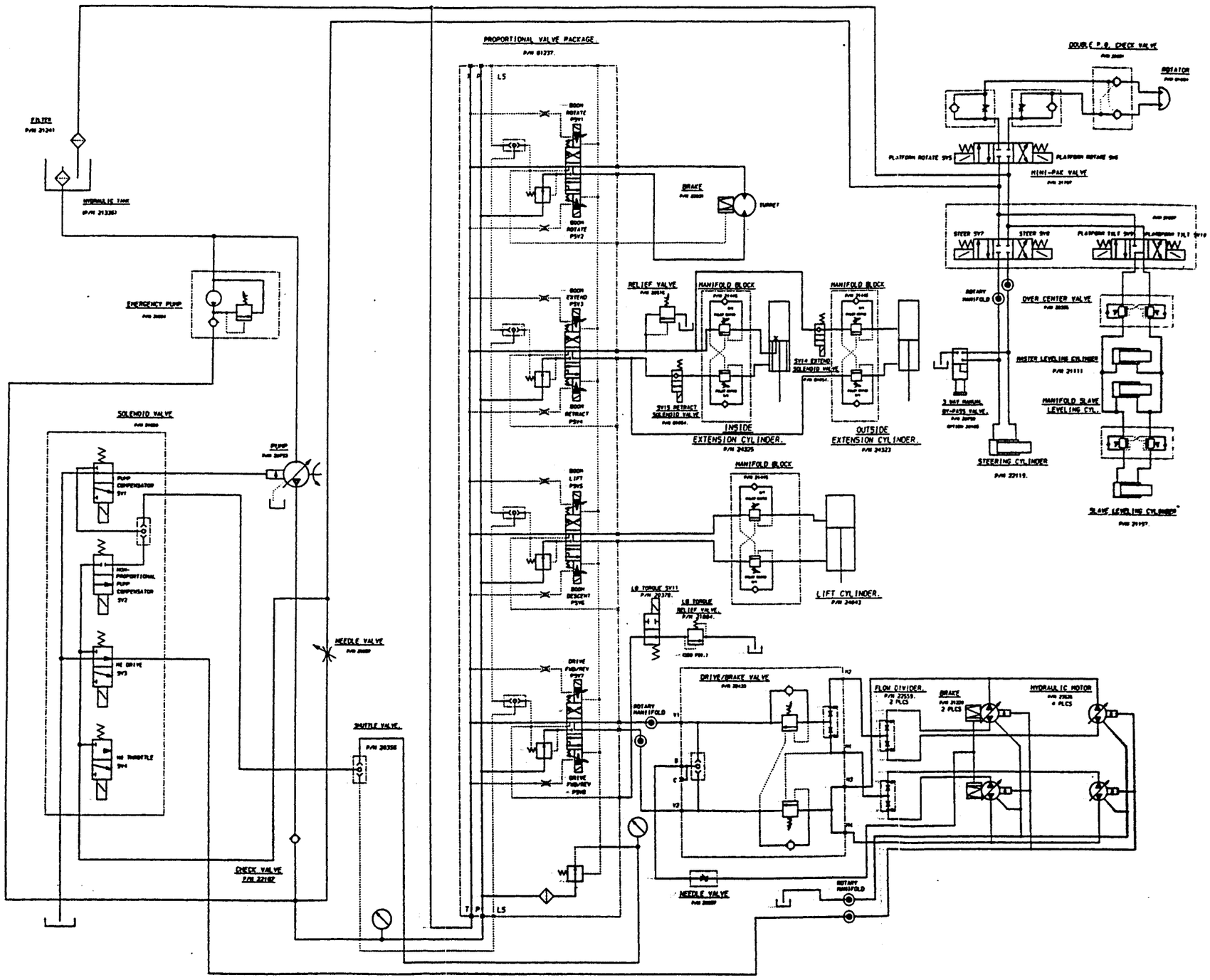

P/N 70528

REV.

Mark Industries

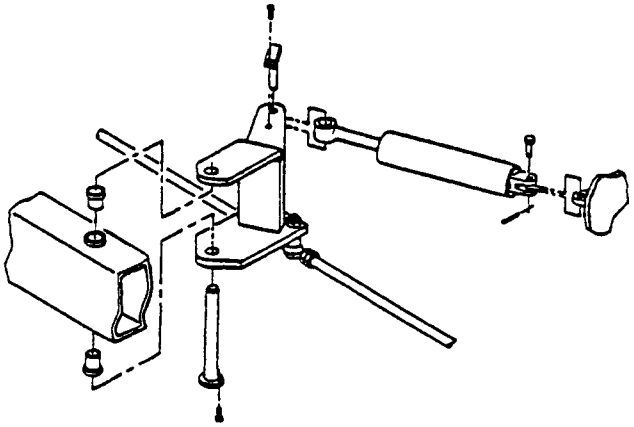
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MODEL	100C 6X4
NOTES	P/N 24301 REV NC

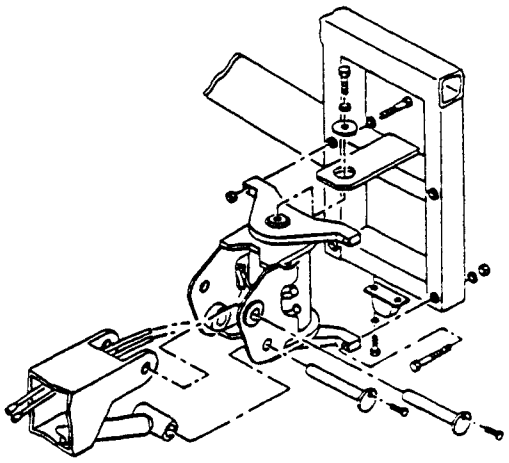
SCHEMATIC
PAGE 2

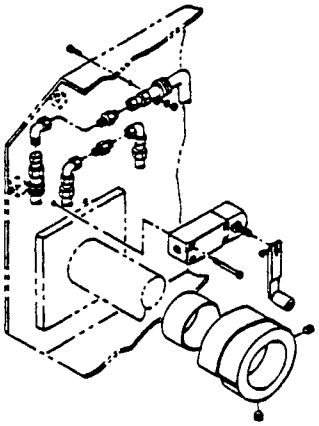


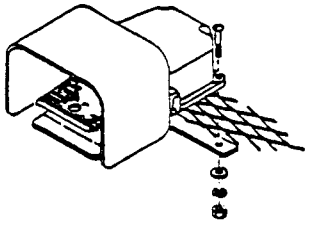
SECTION 1 CONTAINS:

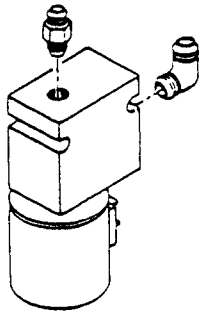
PAGE NO.	TITLE
2	NOTICE TO USERS
3	TABLE OF CONTENTS
5	HOW TO USE THE PARTS CHAPTER
7	HOW TO ORDER PARTS

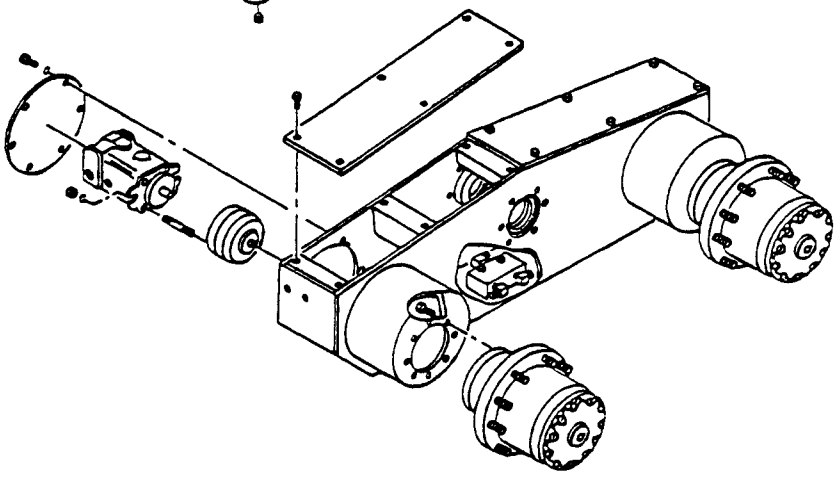


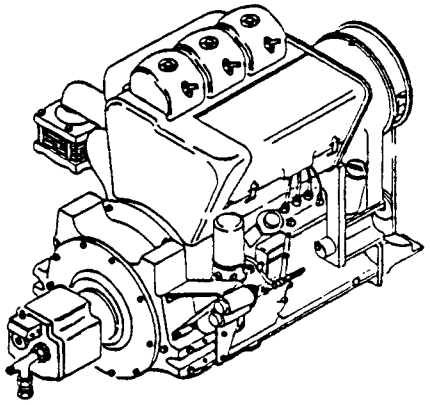












DISCLAIMER

MARK INDUSTRIES strives to include in the Parts Chapter information and illustrations that are accurate, complete, and current. Due to ongoing changes and revisions by our many suppliers, it is often impossible to show all variations of a given assembly. Therefore, this information is subject to change without notice.

Despite the care and effort taken in preparing this Parts Chapter, MARK INDUSTRIES makes **no warranties** that the information and illustrations herein are totally accurate and complete.

NOTICE

The Parts Chapter, though sometimes helpful in the process of assembly/disassembly, is **NOT** intended to be assembly/disassembly instructions.

SECTION 1	INTRODUCTION TO THE PARTS CHAPTER
PAGE NO.	TITLE
1	NOTICE TO USERS
2	TABLE OF CONTENTS
3	HOW TO USE THE PARTS CHAPTER
4	HOW TO ORDER PARTS

SECTION 2	FINAL ASSEMBLY
FIG. NO.	TITLE
1	FINAL ASSEMBLY
2	DECAL SET
3	AERIAL CONTROL BOX ASSEMBLY (UNTIL MID 1989)
3A	AERIAL CONTROL BOX ASSEMBLY (FROM MID 1989 TO LATE 1990)
3B	AERIAL CONTROL BOX ASSEMBLY (SINCE LATE 1990)
4	CONTROLLER (LIFT/ROTATE) (UNTIL MAY 1989)
4A	CONTROLLER (LIFT/ROTATE) (SINCE MAY 1989)
5	CONTROLLER (DRIVE/STEER) (UNTIL MAY 1989)
5A	CONTROLLER (DRIVE/STEER) (SINCE MAY 1989)
6	CONTROLLER (EXTENSION) (UNTIL MAY 1989)
6A	CONTROLLER (EXTENSION) (SINCE MAY 1989)
7	SHEET METAL KIT
8	HYDRAULIC HOSE DIAGRAM
9	HELAC ROTATOR ASSEMBLY

SECTION 3	CARRIAGE ASSEMBLY
FIG. NO.	TITLE
1	CARRIAGE ASSEMBLY
2	TORQUE HUB
3	STEERING CYLINDER (CONCURRENT USE) (SE)
3A	STEERING CYLINDER (CONCURRENT USE; SINCE LATE 1989) (TH)
3B	STEERING CYLINDER (CONCURRENT USE; SINCE LATE 1989) (COL)
4	DRIVE/BRAKE VALVE ASSEMBLY
5	WALKING BEAM ASSEMBLY

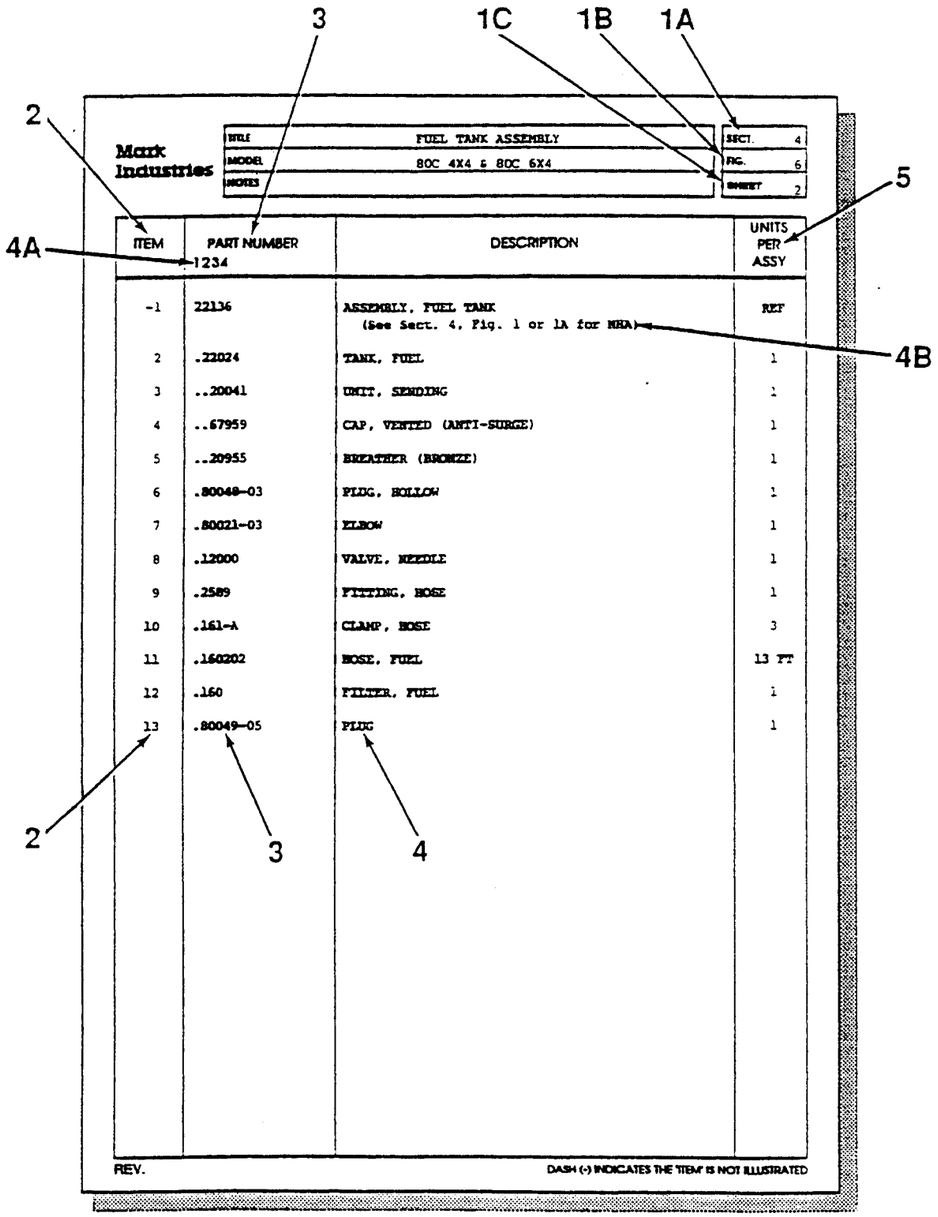
SECTION 4	TURRET ASSEMBLY
FIG. NO.	TITLE
1	TURRET ASSEMBLY
2	LIFT CYLINDER ASSEMBLY (CONCURRENT USE; SINCE EARLY 1990) (SE)
2A	LIFT CYLINDER ASSEMBLY (CONCURRENT USE; SINCE MID 1990) (GB)
3	MASTER LEVELING CYLINDER (CONCURRENT USE; SINCE EARLY 1986) (RA)
3A	MASTER LEVELING CYLINDER (CONCURRENT USE; SINCE EARLY 1986) (SE)
3B	MASTER LEVELING CYLINDER (CONCURRENT USE; SINCE LATE 1986) (TH)
3C	MASTER LEVELING CYLINDER (CONCURRENT USE; SINCE LATE 1986) (GB)
4	ENGINE/PUMP ASSEMBLY (DEUTZ F3L-912)
5	GROUND CONTROL BOX ASSEMBLY
6	FUEL TANK ASSEMBLY
7	BATTERY CABLE KIT (DEUTZ F3L-912)
8	HYDRAULIC TANK ASSEMBLY
9	ROTATION GEARBOX ASSEMBLY
9A	ROTATION GEARBOX TORQUE HUB
10	PROPORTIONAL VALVE ASSEMBLY
11	MINIPAK ASSEMBLY
12	SOLENOID VALVE ASSEMBLY
13	ROTARY MANIFOLD ASSEMBLY (UNTIL EARLY 1988)
13A	ROTARY MANIFOLD ASSEMBLY (SINCE EARLY 1988)
14	EMERGENCY PUMP/MOTOR ASSEMBLY
15	DUMP VALVE ASSEMBLY
16	SOLENOID VALVE ASSEMBLY (DEUTZ F3L-912)

SECTION 5	BOOM ASSEMBLY
FIG. NO.	TITLE
1	FINAL BOOM ASSEMBLY
2	OUTER/INTERMEDIATE BOOM SUB-ASSEMBLY
3	INNER/INTERMEDIATE BOOM SUB-ASSEMBLY
4	INNER BOOM SUB-ASSEMBLY
5	BOOM EXTENSION CYLINDER ASSEMBLY (UNTIL MID 1988; CONCURRENT USE) (SE)
5A	BOOM EXTENSION CYLINDER ASSEMBLY (SINCE MID 1988; CONCURRENT USE) (SE)
5B	BOOM EXTENSION CYLINDER ASSEBMLY (SINCE MID 1989; CONCURRENT USE) (GB)

SECTION 5	BOOM ASSEMBLY (CONT'D)
FIG. NO.	TITLE
6	OUTSIDE BOOM EXTENSION CYLINDER ASSEMBLY (CONCURRENT USE) (SE)
6A	OUTSIDE BOOM EXTENSION CYLINDER ASSEMBLY (SINCE MID 1989; CONCURRENT USE) (GB)
7	SLAVE LEVELING CYLINDER ASSEMBLY (UNTIL EARLY 1986) (RA)
7A	SLAVE LEVELING CYLINDER ASSEMBLY (UNTIL EARLY 1990) (SE)
7B	SLAVE LEVELING CYLINDER ASSEMBLY (SINCE LATE 1989; CONCURRENT USE) (GB)
7C	SLAVE LEVELING CYLINDER ASSEMBLY (SINCE EARLY 1990; CONCURRENT USE) (TH)
8	PLASTITRAK ASSEMBLY

SECTION 6	OPTIONS
FIG. NO.	TITLE
1	OPTIONS
2	ALL MOTION ALARM
3	TRAVEL WARNING HORN
4	AIRLINE TO PLATFORM
5	12 VOLT PLATFORM WORK LIGHT
6	ROTATING AMBER BEACON
7	HEADLIGHTS
8	CLEARANCE/STOP & TURNING LIGHTS
9	SPARK ARRESTOR MUFFLER (WISCONSIN V465D)
10	FRONT MOUNT PLATFORM ROTATION
11	DUAL FUEL (WISCONSIN V465D)
12	ENGINE/PUMP ASSEMBLY (SD-33)
13	SOLENOID VALVE ASSEMBLY (F3L-912) (SD-33)
14	DUAL FUEL (Z-24)
15	DUAL FUEL (FIELD KIT Z-24)
16	MINIPAK SUB-ASSEMBLY (WITH FRONT MOUNT PLATFORM ROTATION)
-	HYDRAULIC LINE TO PLATFORM
-	CATALYTIC CONVERTER
-	8' X 3' PLATFORM
-	HOSTILE ENVIRONMENT PACKAGE

- OPTION NOT PARTS LISTED OR ILLUSTRATED



1. The Parts Chapter Pagination.

   A. **SECTION** refers to the major divisions of the Parts Chapter.

   B. **FIGURE** refers to the items illustrated separately in each section.

   C. **SHEET** indicates the sheet number of the figure illustrated.

2. The **Item Number** corresponds to the item number shown for the part in the illustration. (Parts with *item numbers* preceded by a **dash** (-) are not illustrated.)

3. Items that carry a Mark Industries **part number**.

4. Elements of the **Description**.

   A. The **Indenture System** used in the Parts Chapter of this Technical Manual shows the relationship of one part to another.

      Figure Description

      1234
      . Items ***included*** as part of the **figure**.

      .. Items ***included*** as part of the **single indentured** item listed directly above it.

      ... Items ***included*** as part of the **double indentured** item listed directly above it.

      .... Items ***included*** as part of the **triple indentured** item listed directly above it.

   B. **NHA** (**N**ext **H**igher **A**ssembly) corresponds to the Section and Figure to be referred to for the major assembly that this item is part of.

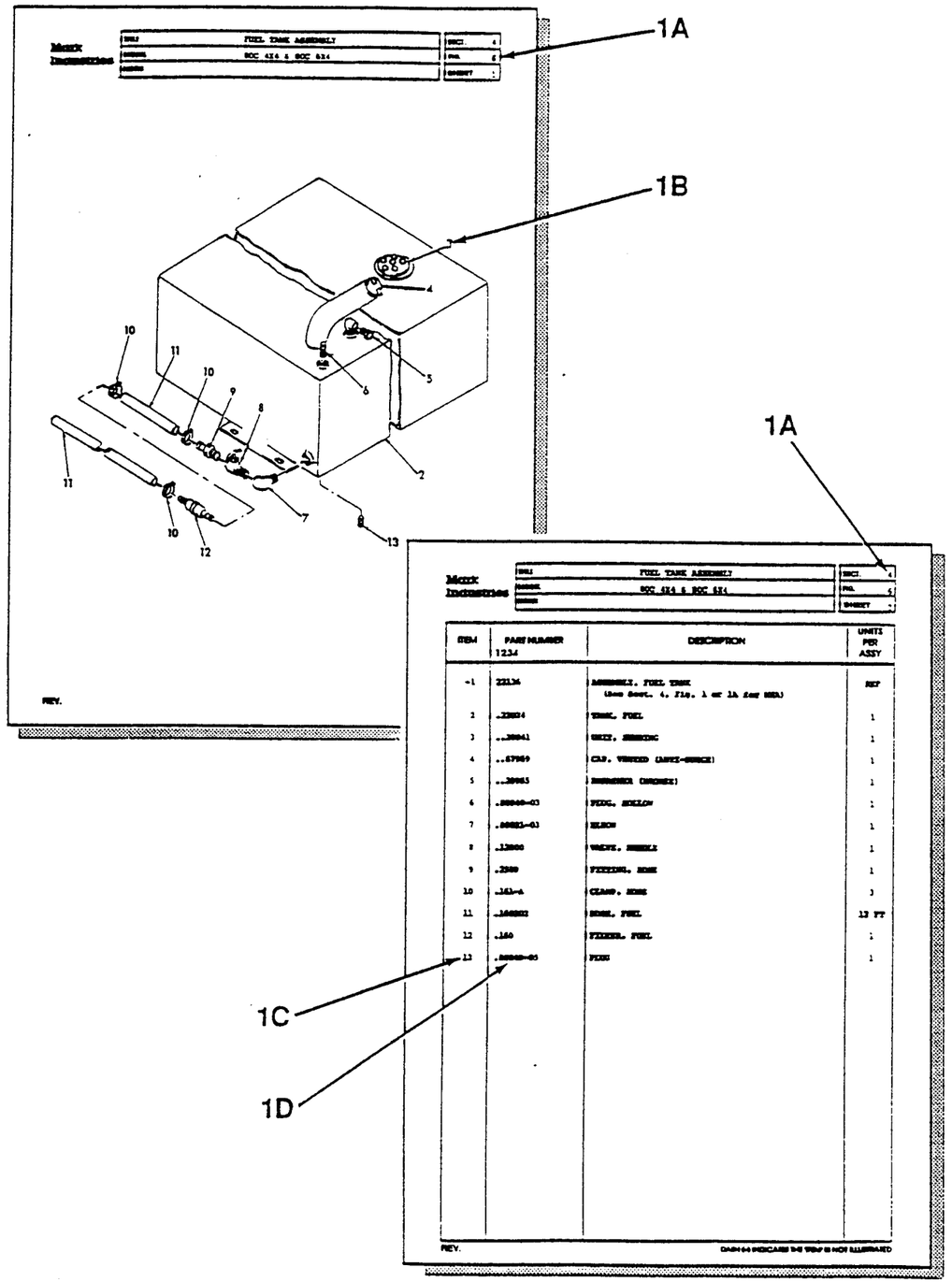
   C. **DETAILS** corresponds to the Section and Figure to be referred to for a more detailed breakdown of this item.

5. **UNITS PER ASSEMBLY** entries are as follows:

   A. **REF** indicates the item is already listed in the NHA figure.

   B. **AR** indicates the part is used in a quantity *As Required*.

   C. A **number** indicates the quantity of the part used in the next higher assembly.



1. Finding the Mark Industries Part Number.

   A. Using the Table of Contents, find the Section and Figure number. Locate the correct sheet by referencing these numbers.

   B. Match the required part to the figure illustration. Note the Item Number.

   C. Find the Item Number on the part listing that follows the figure.

   D. Use the Mark Industries Part Number listed next to the Item Number when ordering.

2. Ordering: Listed below are the methods of ordering parts. The preferred method of ordering parts is by FAX.

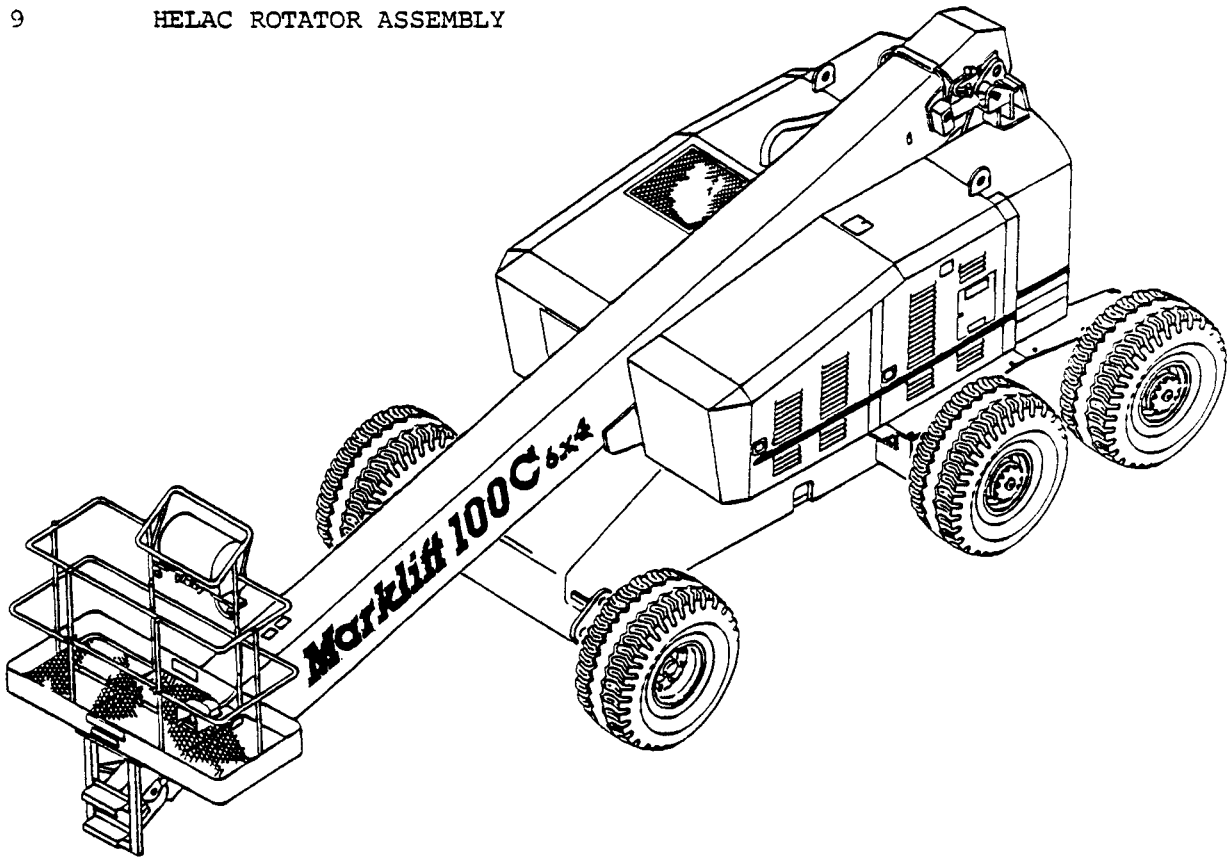
   A. By FAX: (714) 879-8884

   B. By Phone: (714) 879-MARK

   C. By Mail: MARK INDUSTRIES
   ATTENTION: PARTS DEPARTMENT
   P.O. BOX 2255
   BREA, CA 92622

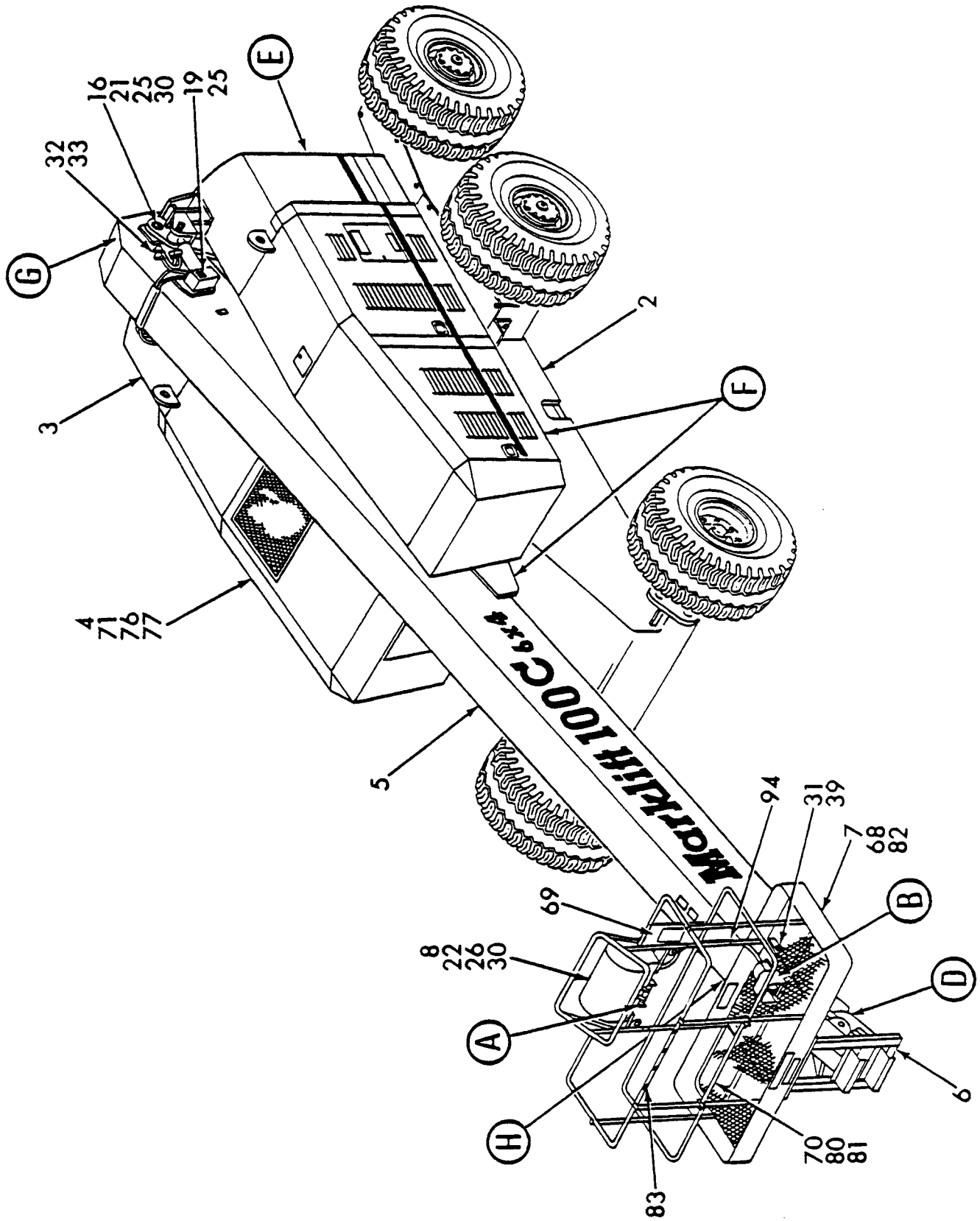
SECTION 2 CONTAINS:

FIG. NO.	TITLE
1	FINAL ASSEMBLY
2	DECAL SET
3	AERIAL CONTROL BOX ASSEMBLY (UNTIL MID 1989)
3A	AERIAL CONTROL BOX ASSEMBLY (FROM MID 1989 TO LATE 1990)
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6A	CONTROLLER (EXTENSION)(SINCE MAY 1989)
7	SHEET METAL KIT
8	HYDRAULIC HOSE DIAGRAM
9	HELAC ROTATOR ASSEMBLY



Mark Industries

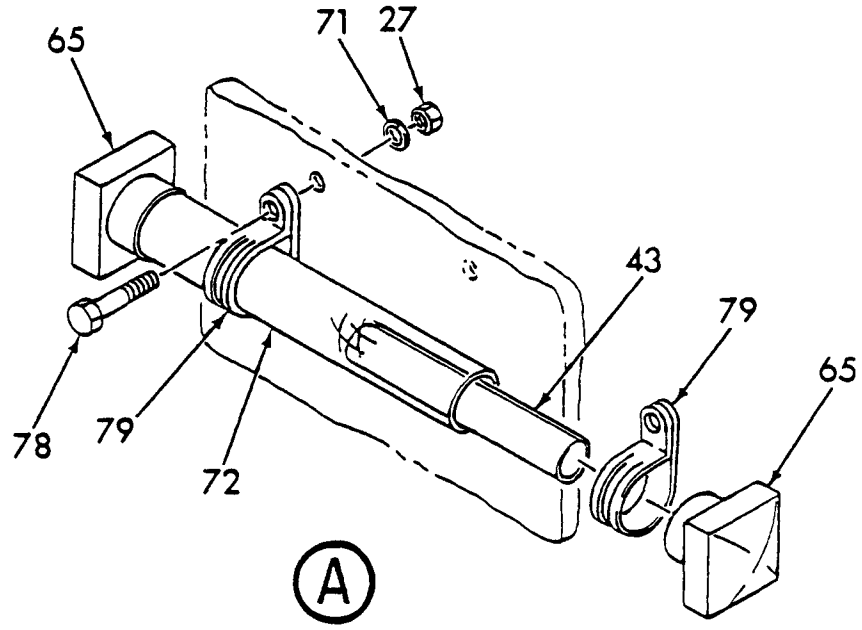
TITLE	FINAL ASSEMBLY	SECT.	2
MODEL	100C 6X4	FIG.	1
NOTES		SHEET	1

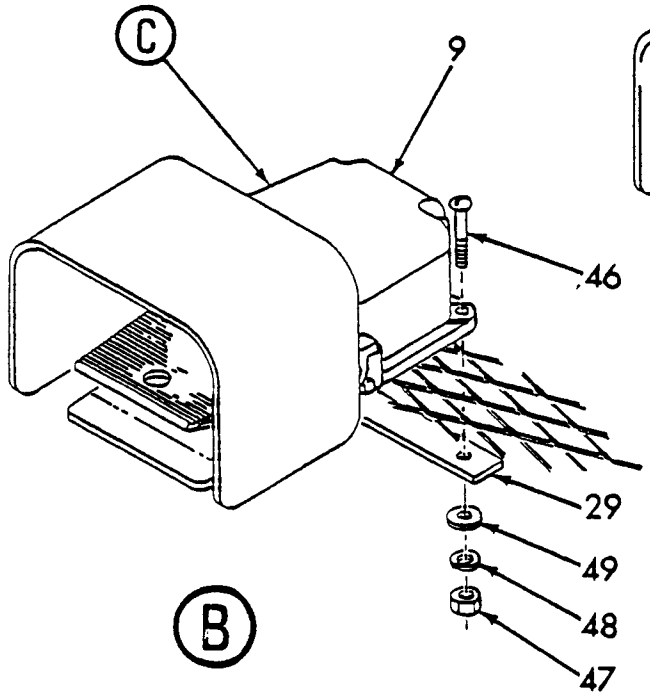


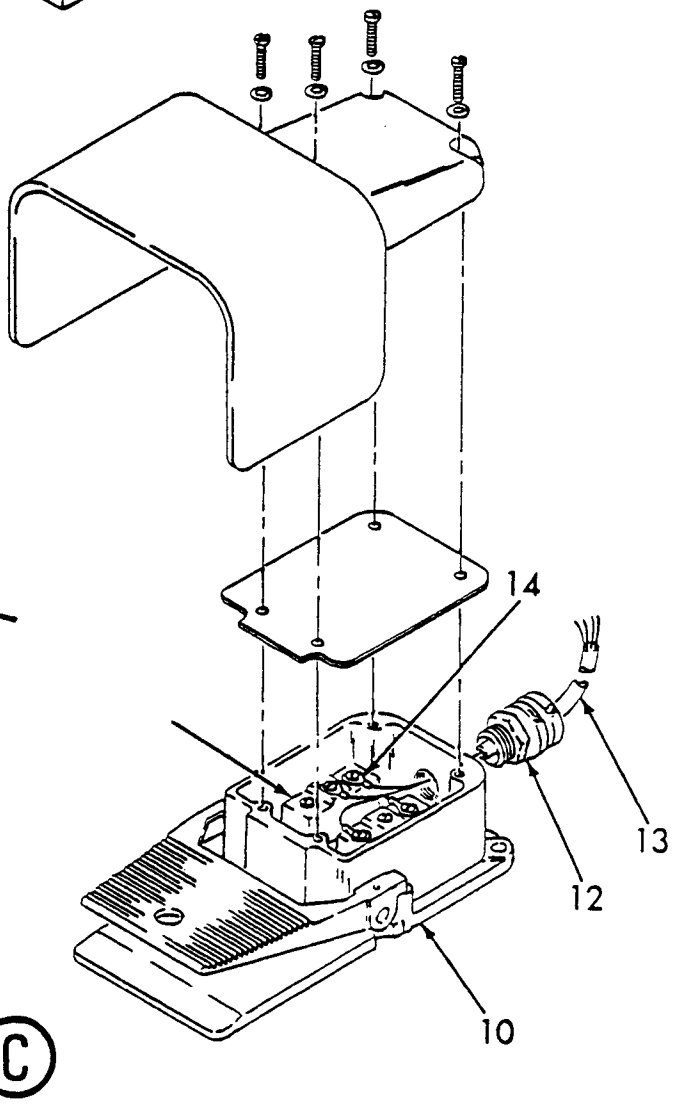
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TITLE	FINAL ASSEMBLY	SECT.	2
MODEL	100C 6X4	FIG.	1
NOTES		SHEET	2



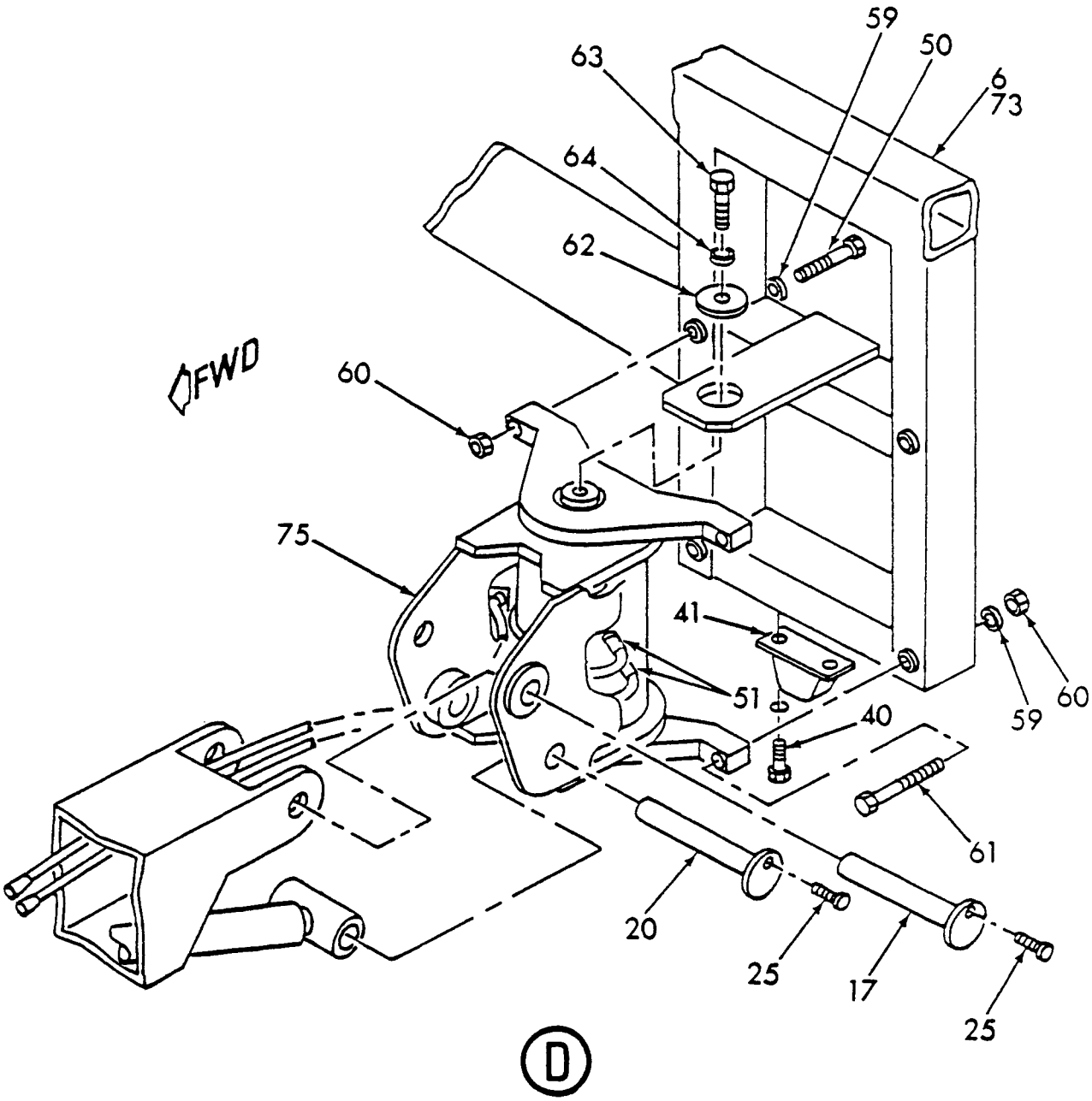




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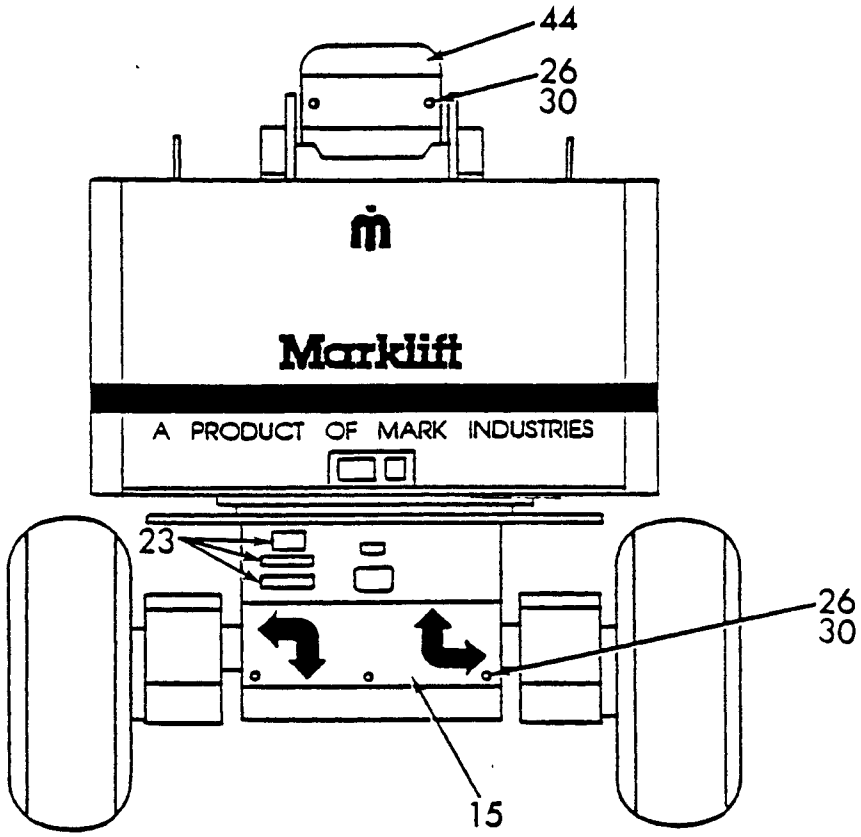
TITLE	FINAL ASSEMBLY	SECT.	2
MODEL	100C 6X4	FIG.	1
NOTES		SHEET	3



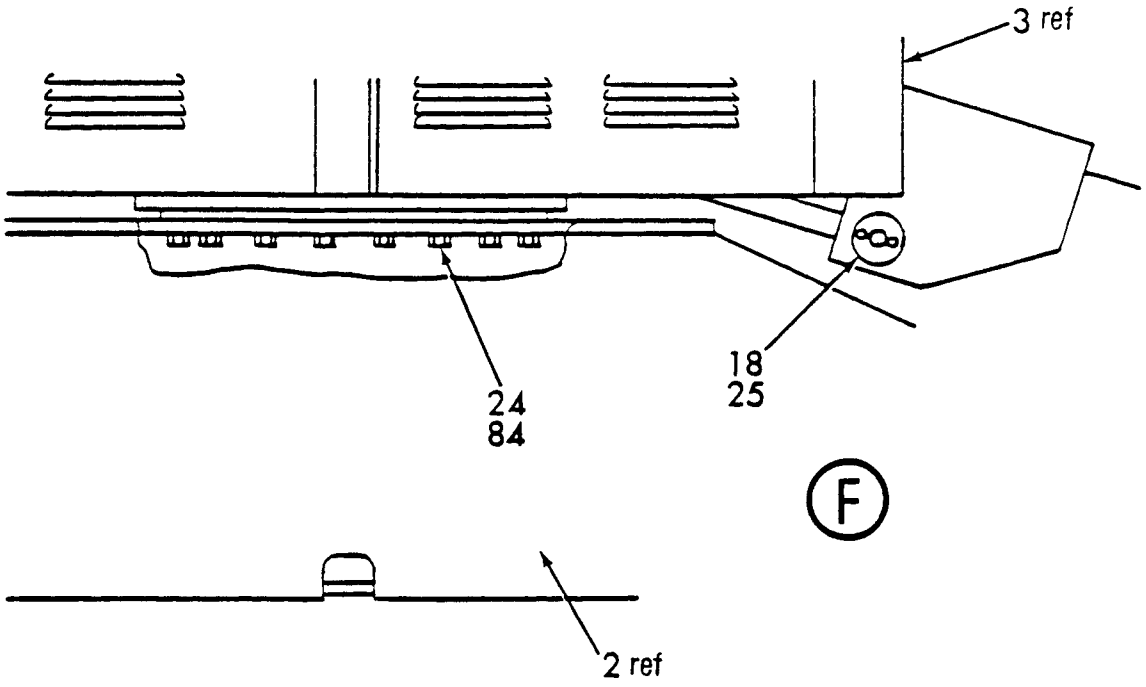
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TITLE	FINAL ASSEMBLY	SECT.	2
MODEL	100C 6X4	FIG.	1
NOTES		SHEET	4



E

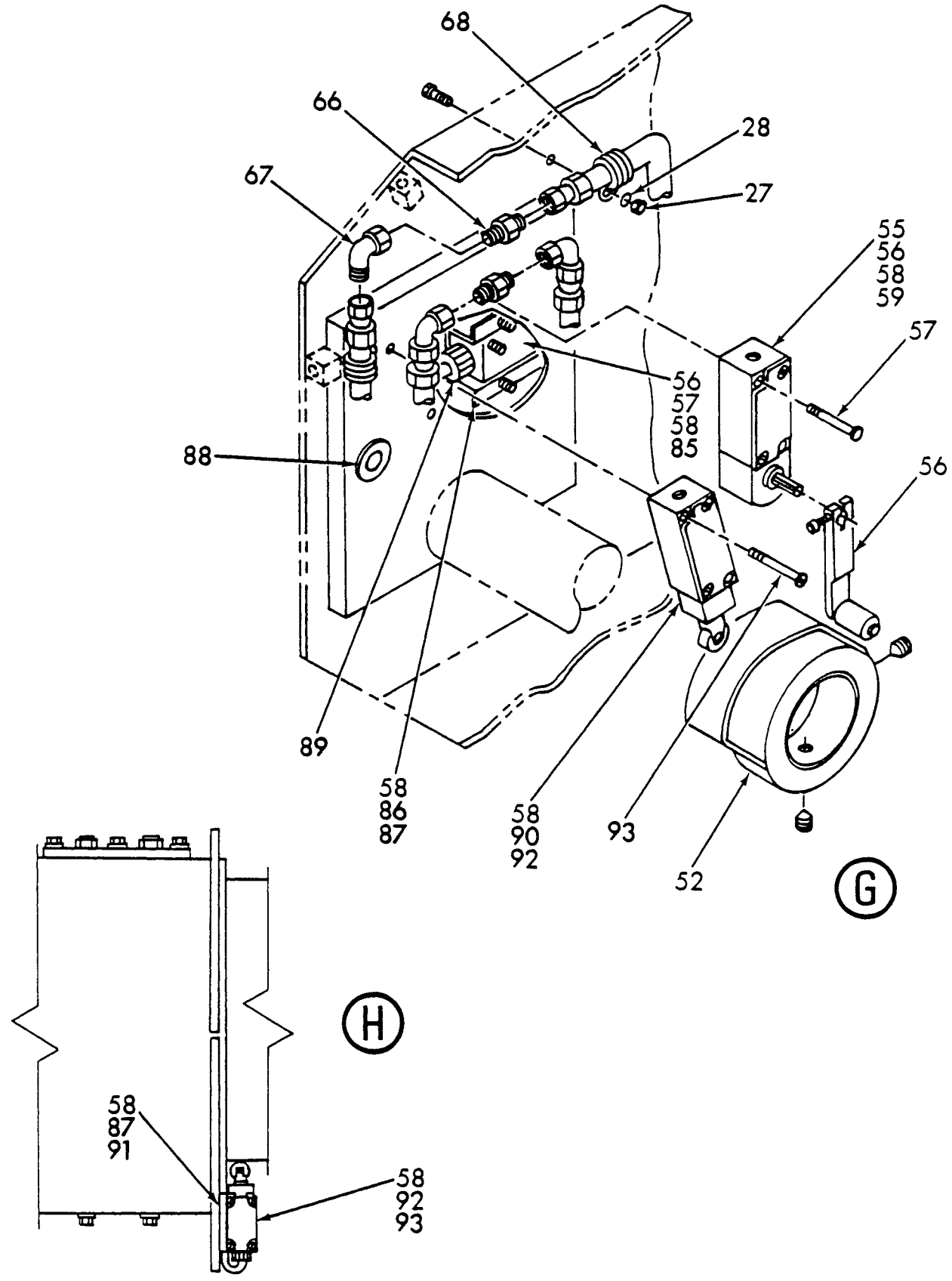


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TITLE	FINAL ASSEMBLY	SECT. 2
MODEL	100C 6X4	FIG. 1
NOTES		SHEET 5



REV.

Mark Industries

TITLE	FINAL ASSEMBLY	SECT. 2
MODEL	100C 6X4	FIG. 1
NOTES		SHEET 6

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	20062	ASSEMBLY, FINAL	REF
2	.24499	ASSEMBLY, CARRIAGE (See Sect. 3, Fig. 1 for Details)	1
3	.24485	ASSEMBLY, TURRET (DEUTZ) (See Sect. 4, Fig. 1 for Details)	1
4	.22009	KIT, SHEET METAL (See Sect. 2, Fig. 7 for Details)	1
5	.24310	ASSEMBLY, FINAL BOOM (See Sect. 5, Fig. 1 for Details)	1
6	.24171	WELDMENT, FORK PLATFORM ROTATION	1
7	.24150	WELDMENT, 6' PLATFORM (36" WIDE)	1
8	.24118	ASSEMBLY, AERIAL CONTROL BOX (See Sect. 2, Fig. 3 for Details)	1
9	.20480	ASSEMBLY, FOOTSWITCH	1
10	..70212	FOOTSWITCH	1
11	...66334	MICROSWITCH	2
12	..2531	RELIEF, STRAIN	1
13	..2912	CONDUCTOR, CABLE (18 AWG/4 COND.)	5 FT
14	..876	TERMINAL, RING (BLUE)	4
15	.22098	COVER, REAR	1
16	.23456	PIN, PIVOT	1
17	.20457	PIN, PIVOT (FORK)	1
18	.24364	PIN, LIFT CYLINDER	1
19	.21334	PIN, MASTER LEVELING CYLINDER	2
20	.20261	PIN, LEVELING CYLINDER	1
21	.28157	TUBE, ROUND	1
22	.61318	NUT, LOCK	6
23	.63653	RIVET, POP	8

Mark Industries

TITLE	FINAL ASSEMBLY	SECT. 2
MODEL	100C 6X4	FIG. 1
NOTES		SHEET 7

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
24	.60609	SCREW, CAP	36
25	.60607	SCREW, CAP	6
26	.60343	SCREW, CAP	4
27	.61239	NUT, LOCK	2
28	.63301	WASHER, SPLIT	26
29	.22742	PLATE, DEADMAN SWITCH BACKING	1
30	.63319	WASHER, SPLIT	4
31	.61302	NUT, HEX	4
32	.2617	HOSE	2 FT
33	.2594	ELBOW, SWIVEL	4
-34	.16608	PAINT, WHITE	10 GAL
-35	.65112	PAINT, WHITE	1.5 GAL
-36	.65115	FUEL, DIESEL NO. 2	5 GAL
-37	.24302	SCHEMATIC, ELECTRICAL (See Schematic Section for Details)	1
-38	.24301	SCHEMATIC, HYDRAULIC (See Schematic Section for Details)	1
39	.60515	SCREW, CAP	4
40	.60307	SCREW, CAP	2
41	.20552	BUMPER, PLATFORM	1
-42	.65116	OIL, HYDRAULIC	60 GAL
43	.17409	HANDBOOK, OPERATION & SAFETY	1
44	.24393	COVER, BOOM	1
-45	.65389	PAINT, BLUE	1 GAL
46	.60346	SCREW, CAP	2
47	.60702	NUT, HEX	2

REV.

DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

Mark Industries

TITLE	FINAL ASSEMBLY	SECT.	2
MODEL	100C 6X4	FIG.	1
NOTES		SHEET	8

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
48	.63302	WASHER, SPLIT	2
49	.63402	WASHER, FLAT	2
50	.60540	SCREW, CAP	2
51	.2562	FITTING, STRAIGHT SWIVEL	2
52	.24615	CAM	1
-53	..95029	PLATE	1
-54	..61954	SCREW, CAP	1
55	.70468	SWITCH, LIMIT	1
56	.70032	LEVER, OPERATING	2
57	.62704	SCREW, MACHINE	4
58	.63313	WASHER, SPLIT	13
59	.63415	WASHER, FLAT	4
60	.61305	NUT, LOCK	4
61	.60513	SCREW, CAP	2
62	.23565	WASHER	1
63	.60516	SCREW, CAP	1
64	.63305	WASHER, SPLIT	1
65	.65842	CAP, ANTI-ROLL	2
66	.80042-06	UNION	4
67	.80015-06	ELBOW, SWIVEL NUT	6
68	.16268	CLAMP, HOSE	6
69	.28159	SHEET	1
70	.141080	WELDMENT, SLIDE BAR	1
71	.63401	WASHER, FLAT	40
72	.130927	CONTAINER, PLASTIC	1

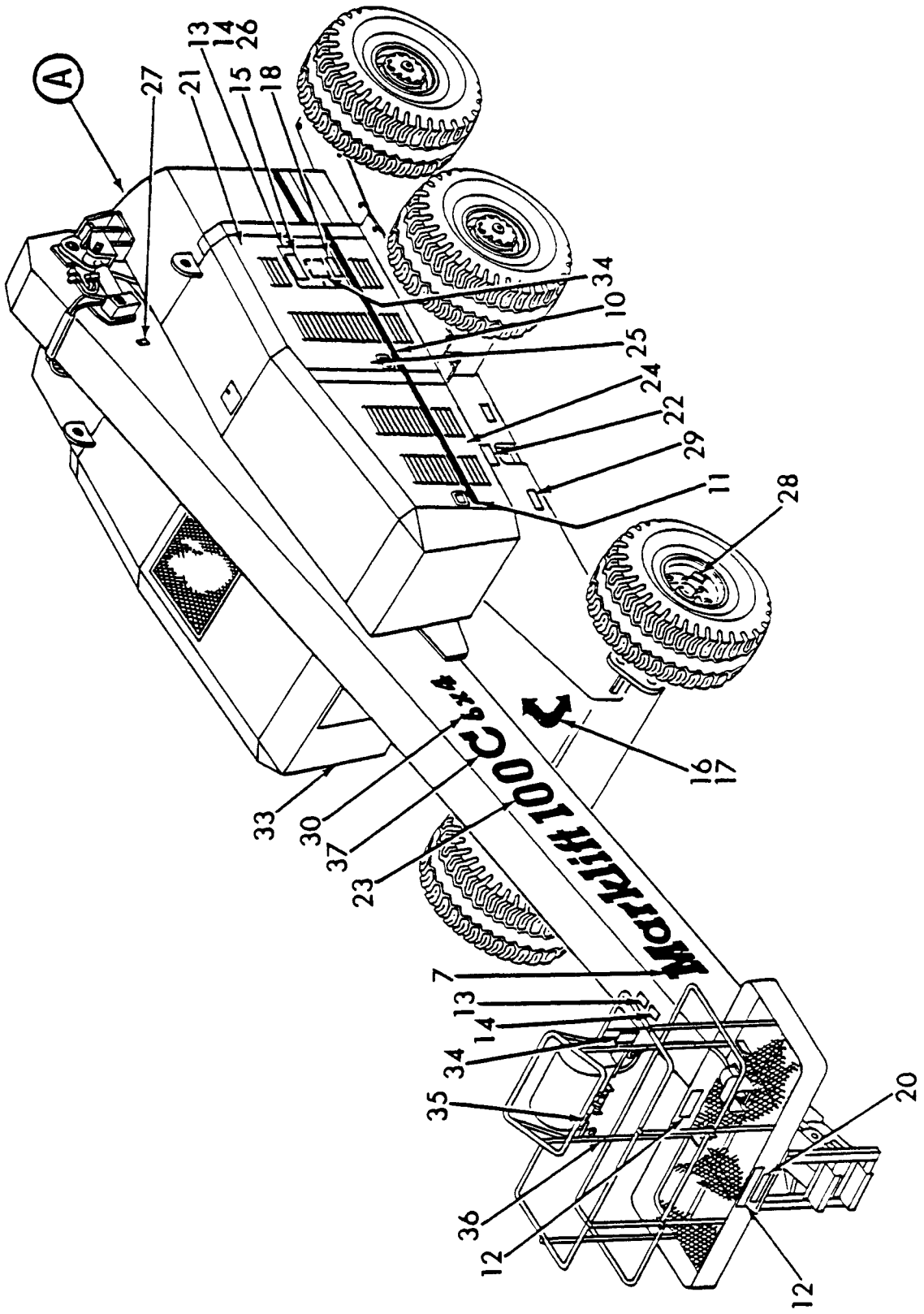
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ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
73	.65321-42	SLEEVE, PLASTIC COIL	1
74	..65321	COIL, PROTECTIVE PLASTIC	3.5 FT
75	.24444	ASSEMBLY, HELAC ROTATOR (See Sect. 2, Fig. 9 for Details)	1
76	.61902	SCREW, CAP	60
77	.60711	NUT, HEX	26
78	.60309	SCREW, CAP	2
79	.65867	CLAMP	2
80	.160212	PIN, CLEVIS	2
81	.160213	PIN, COTTER	2
82	.255	TIE, CABLE (6" X 3/16")	120
83	.160137	TAPE, WARNING (BLACK & YELLOW)	2.1 FT
-84	.63501	WASHER, FLAT	36
85	.70107	SWITCH, LIMIT	1
86	.210435	ENCLOSURE, LIMIT SWITCH	1
87	.60423	SCREW, MACHINE	5
88	.160460	GROMMET	1
89	.70627	CONNECTOR, STRAIN RELIEF	2
90	.141461	BRACKET, MOUNTING SPACER	1
91	.141462	BRACKET, MOUNTING	1
92	.70628	SWITCH, LIMIT	2
93	.160462	SCREW, CAP	4
94	.256	TIE, CABLE (3½" X 1/8")	50
-95	.62401	SCREW, CAP	2

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-96	.24616	DIAGRAM, HYDRAULIC HOSE (KIT A,B,C,E) (See Sect. 2, Fig. 8 for Details)	1
-97	.67804	SET, DECAL (See Sect. 2, Fig. 2 for Details)	1

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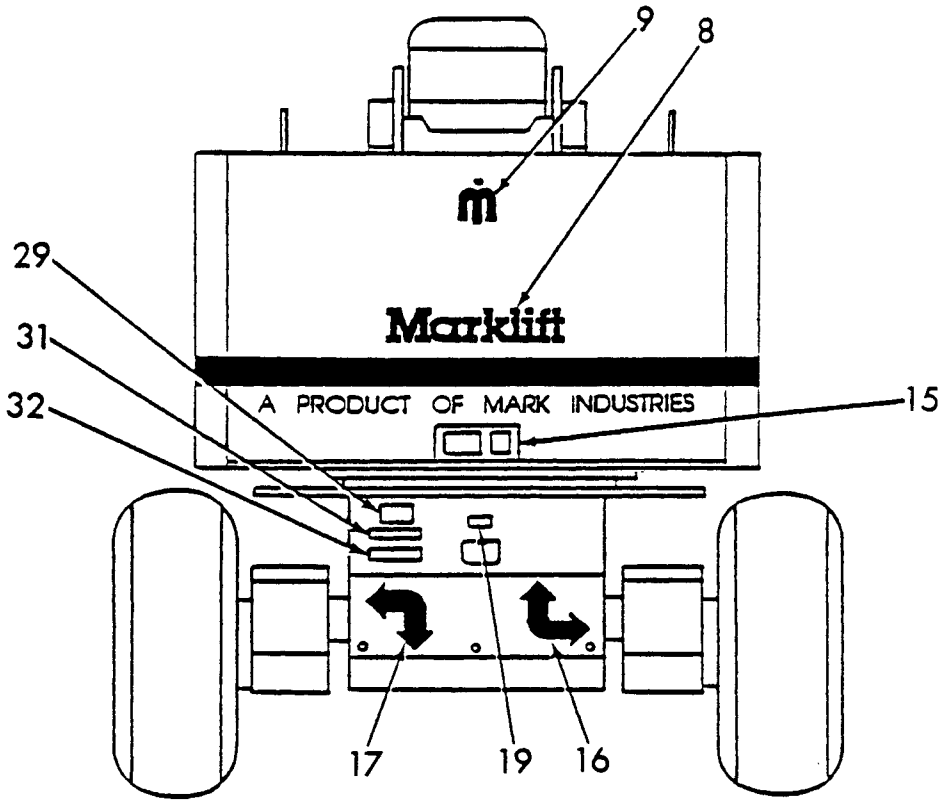
TITLE	DECAL SET	SECT.	2
MODEL	100C 6X4	FIG.	2
NOTES		SHEET	1



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TITLE	DECAL SET	SECT.	2
MODEL	100C 6X4	FIG.	2
NOTES		SHEET	2



(A)

REV.

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TITLE	DECAL SET
MODEL	100C 6X4
NOTES	

SECT.	2
FIG.	2
SHEET	3

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	67804	SET, DECAL (See Sect. 2, Fig. 1 for NHA)	REF
-2	.20460	DECAL, GROUND CONTROL CONSOLE (See Ground Control Box for Details)	1
-3	.20413	DECAL, ENGINE CHOKE (See Ground Control Box for Details)	1
-4	.185702	DECAL, CIRCUIT BREAKER 110 VAC (See Ground Control Box for Details)	1
-5	.182103	DECAL, OPERATION INSTRUCTIONS & DANGER (See Aerial Control Box for Details)	1
-6	.182707	DECAL, AERIAL CONTROL BOX (See Aerial Control Box for Details)	1
7	.21236	DECAL, MARKLIFT BOOM	2
8	.20409	DECAL, STANDARD PEDESTAL	1
9	.20410	DECAL, MARK INDUSTRIES LOGO	1
10	.20411	DECAL, BLUE STRIPE (SQUARE END)(3 EACH SIDE)	6
11	.20412	DECAL, BLUE STRIPE (ROUND END)(½ EACH SIDE)	1
12	.2022	DECAL, LOAD CAPACITY 500 LBS.	2
13	.181102	DECAL, DANGER DO NOT OPERATE UNLESS...	2
14	.181103	DECAL, DANGER OBEY THE FOLLOWING...	2
15	.20419	DECAL, DANGER KEEP CLEAR	3
16	.182710	DECAL, DIRECTIONAL ARROW	2
17	.182709	DECAL, DIRECTIONAL ARROW	2
18	.20495	DECAL, EMERGENCY GROUND CONTROLS	1
19	.20896	DECAL, BRAKE	1
20	.22385	DECAL, CAUTION ATTACH YOUR SAFETY BELT	1
21	.21235	DECAL, EMERGENCY DESCENT (VALVE TYPE)	1
22	.20508	DECAL, TRANSPORTATION	2

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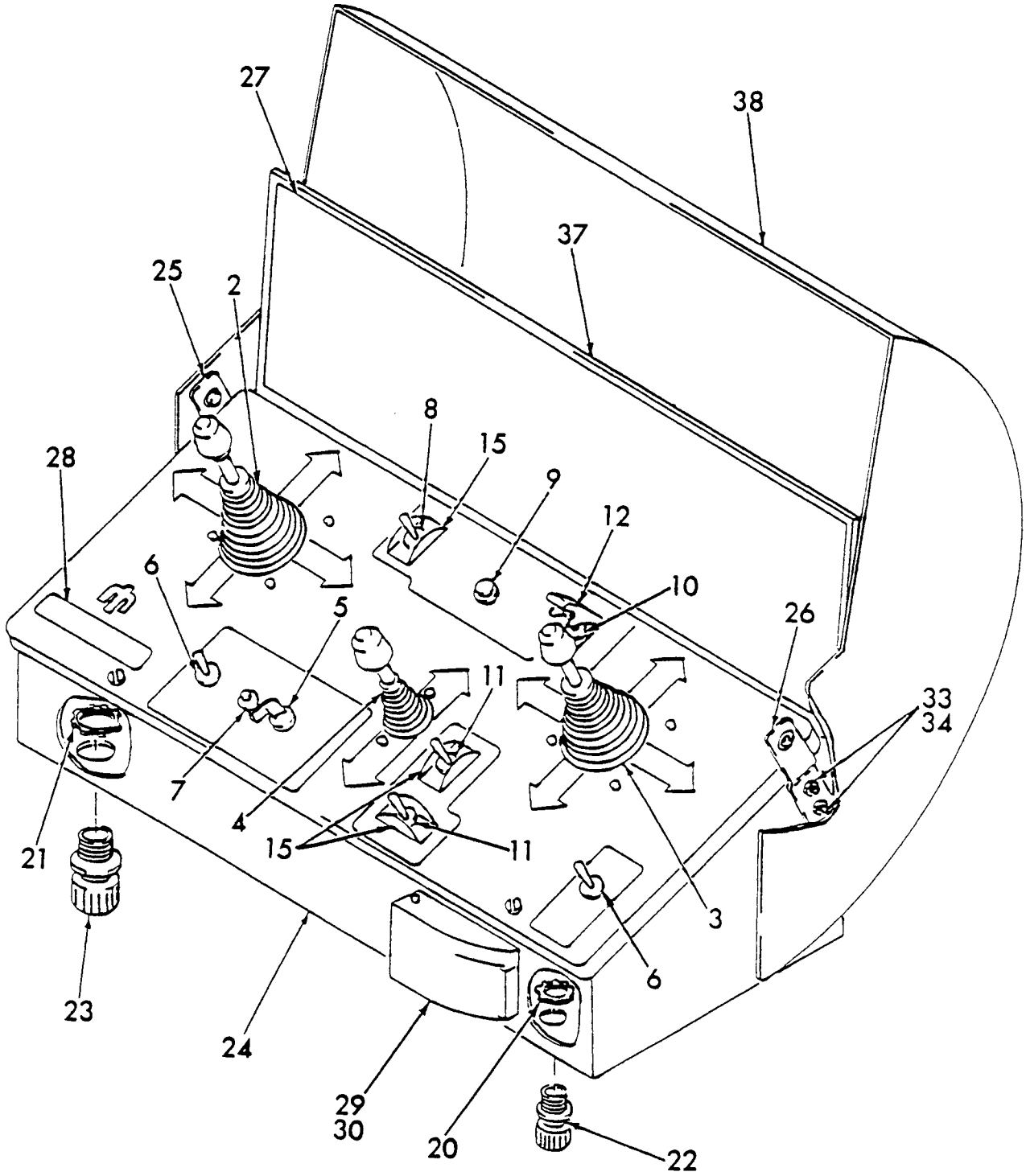
TITLE	DECAL SET
MODEL	100C 6X4
NOTES	

SECT.	2
FIG.	2
SHEET	4

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
23	.22910	DECAL, "100"	2
24	.2017	DECAL, HYDRAULIC SYSTEM FLUID (ON HYD. TANK)	1
25	.2033	DECAL, DIESEL FUEL ONLY	2
26	.20860	DECAL, GENERAL CHECKOUT & OPERATING INSTRUCTIONS	1
27	.21237	DECAL, GREASE FITTING	4
28	.22175	DECAL, CAUTION MONOFILLED TIRES ONLY	6
29	.20660	NAMEPLATE, IDENTIFICATION	1
30	.22739	DECAL, "6X4"	2
31	.20662	PLATE, PATENT NUMBER	1
32	.20661	PLATE, ANSI A92	1
33	.2003	DECAL, BATTERY WATER LEVEL	1
34	.24496	DECAL, REACH GRAPH	2
35	.130820	DECAL, OPERATION & SAFETY HANDBOOK	1
36	.22386	DECAL, "D" RING ATTACH SAFETY BELT	2
37	.181903	DECAL, "C"	2

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TITLE	AERIAL CONTROL BOX ASSEMBLY	SECT.	2
MODEL	100C 6X4	FIG.	3
NOTES	UNTIL MID 1989	SHEET	1

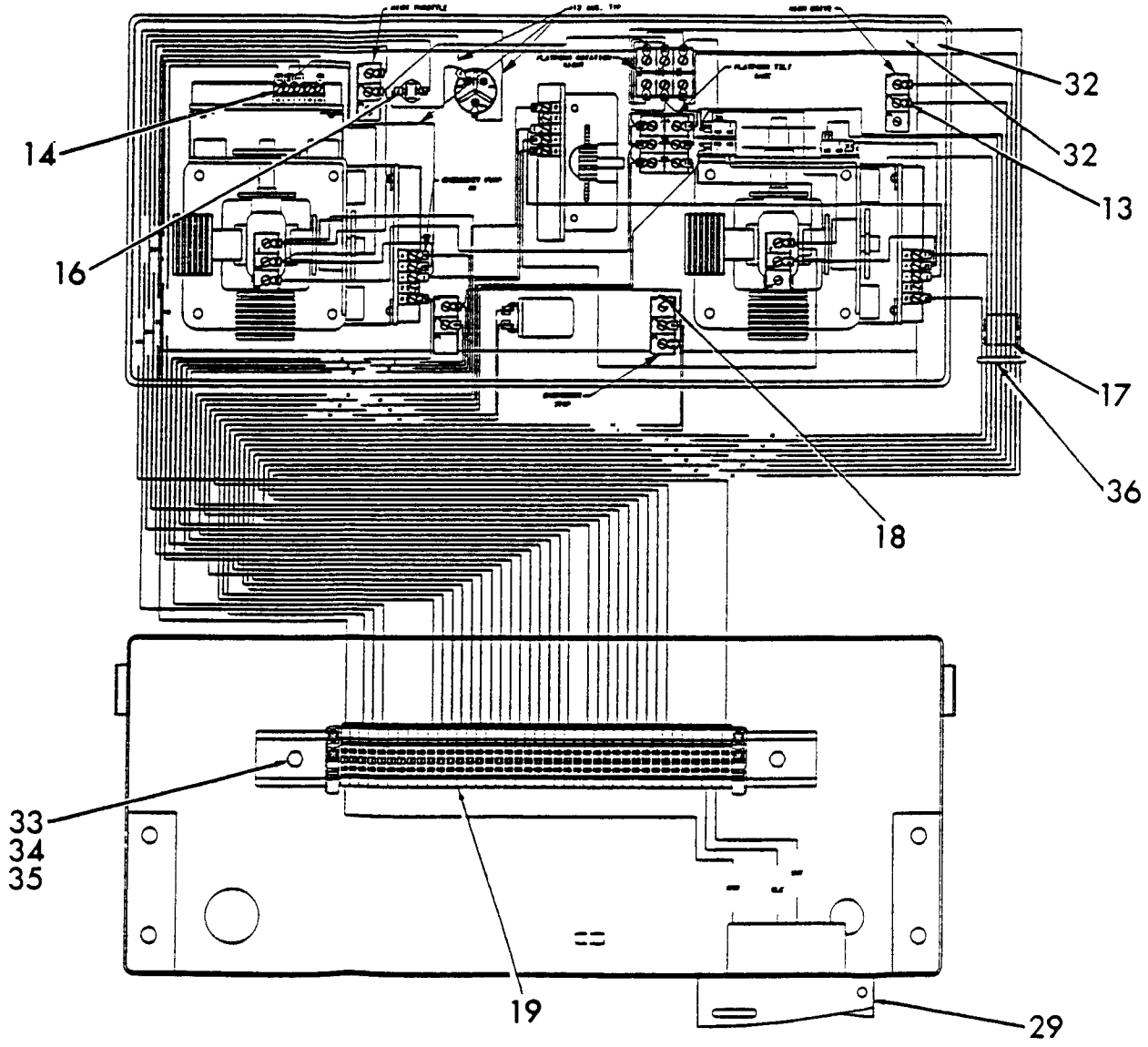


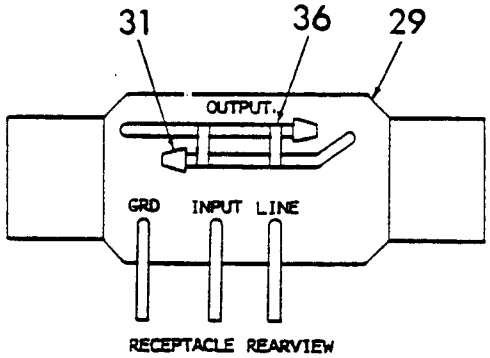
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TITLE	AERIAL CONTROL BOX ASSEMBLY
MODEL	100C 6X4
NOTES	UNTIL MID 1989

SECT.	2
FIG.	3
SHEET	2





RECEPTACLE REARVIEW

REV.

Mark Industries

TITLE	AERIAL CONTROL BOX ASSEMBLY
MODEL	100C 6X4
NOTES	UNTIL MID 1989

SECT.	2
FIG.	3
SHEET	3

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	24118	ASSEMBLY, AERIAL CONTROL BOX (See Sect. 2, Fig. 1 for NHA)	REF
2	.70398	CONTROLLER (LIFT/ROTATE) (See Sect. 2, Fig. 4 for Details)	1
3	.70399	CONTROLLER (DRIVE/STEER) (See Sect. 2, Fig. 5 for Details)	1
4	.70397	CONTROLLER (EXTENSION) (See Sect. 2, Fig. 6 for Details)	1
5	.70405	SWITCH, ANTI-RESTART IGNITION	1
6	.70313	SWITCH, TOGGLE	2
7	.4011	SWITCH, PUSH BUTTON	1
8	.70291	SWITCH, TOGGLE	1
9	.20805	ALARM, BUZZER	1
10	.4021	SWITCH, TOGGLE	1
11	.20481	SWITCH, TOGGLE	2
12	.70407	SWITCH, GUARD	1
13	.2859	CONNECTOR, RING	25
14	.70406	TERMINAL, FORK SPADE (BLUE)	17
15	.20884	GUARD, SWITCH	5
16	.117-E	TERMINAL, FEMALE DISCONNECT (RED)	2
17	.16214	MOUNTS	5
18	.4045	DIODE (6 AMP/1000V)	1
19	.24127	ASSEMBLY, TERMINAL STRIP	1
20	.2808	NUT, LOCK	1
21	.16005	NUT, LOCK	1
22	.2806	RELIEF, STRAIN	1
23	.16215	RELIEF, STRAIN	1

Mark Industries

TITLE	AERIAL CONTROL BOX ASSEMBLY
MODEL	100C 6X4
NOTES	UNTIL MID 1989

SECT.	2
FIG.	3
SHEET	4

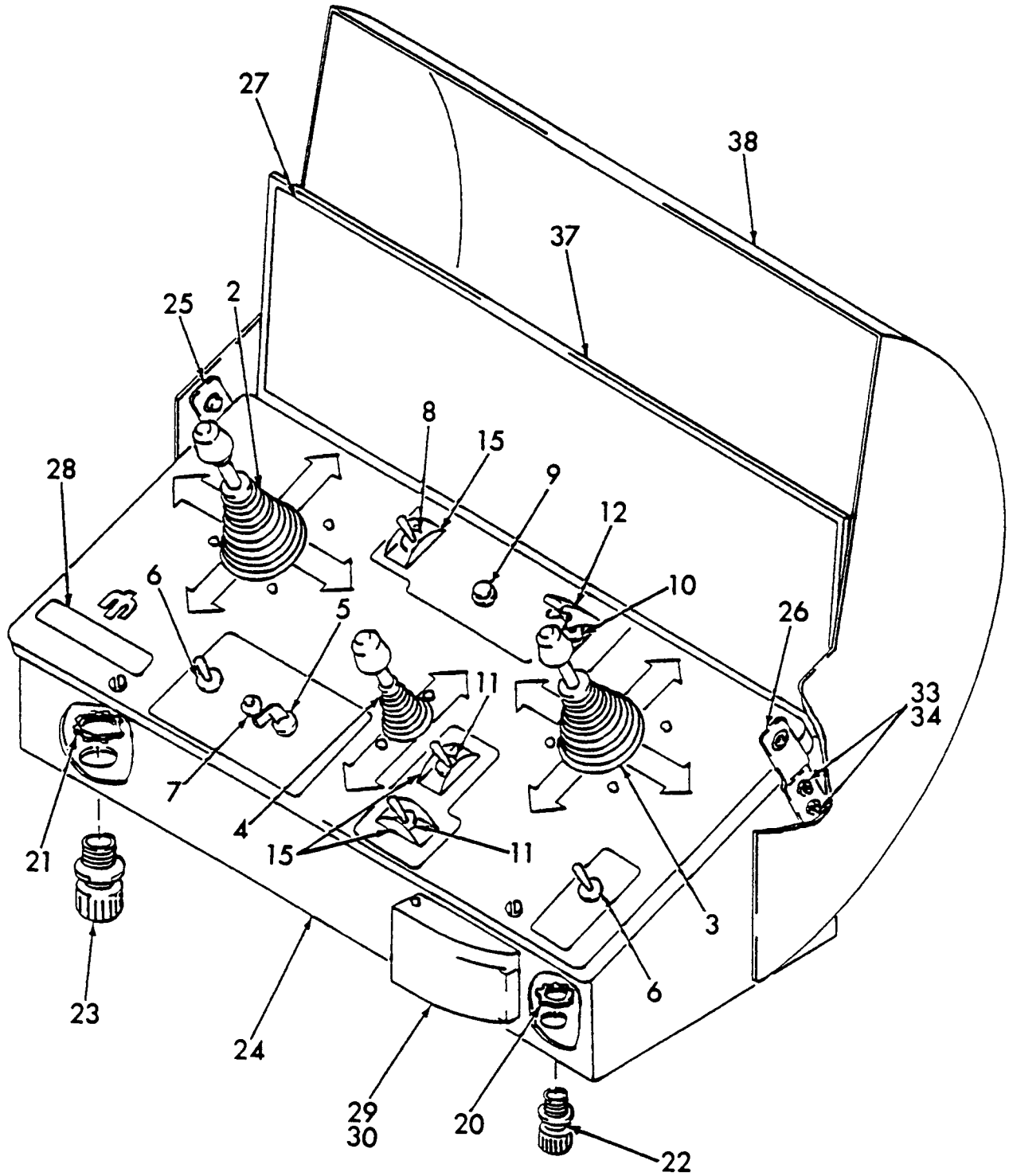
ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
24	.24119	BOX, AERIAL CONTROL	1
25	.24120	BRACKET, MOUNTING (L.H.)	1
26	.24121	BRACKET, MOUNTING (R.H.)	1
27	.182103	DECAL, OPERATION INSTRUCTIONS & DANGER	1
28	.182707	DECAL, AERIAL CONTROL BOX	1
29	.70391	RECEPTACLE, G.F.C.I.	1
30	.70392	COVER, RECEPTACLE	1
31	.70394	CONNECTOR, TWIST-ON WIRE	2
32	.160015	EXTRUSION, NEOPRENE	4 FT
33	.60701	NUT, HEX	9
34	.63301	WASHER, SPLIT	9
35	.63401	WASHER, FLAT	2
36	.256	TIE, CABLE (3½" X 1/8")	50
37	.24122	PLATE, BACK	1
38	.24123	WELDMENT, COVER	1

REV.

DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

Mark Industries

TITLE	AERIAL CONTROL BOX ASSEMBLY	SECT.	2
MODEL	100C 6X4	FIG.	3A
NOTES	FROM MID 1989 TO LATE 1990	SHEET	1

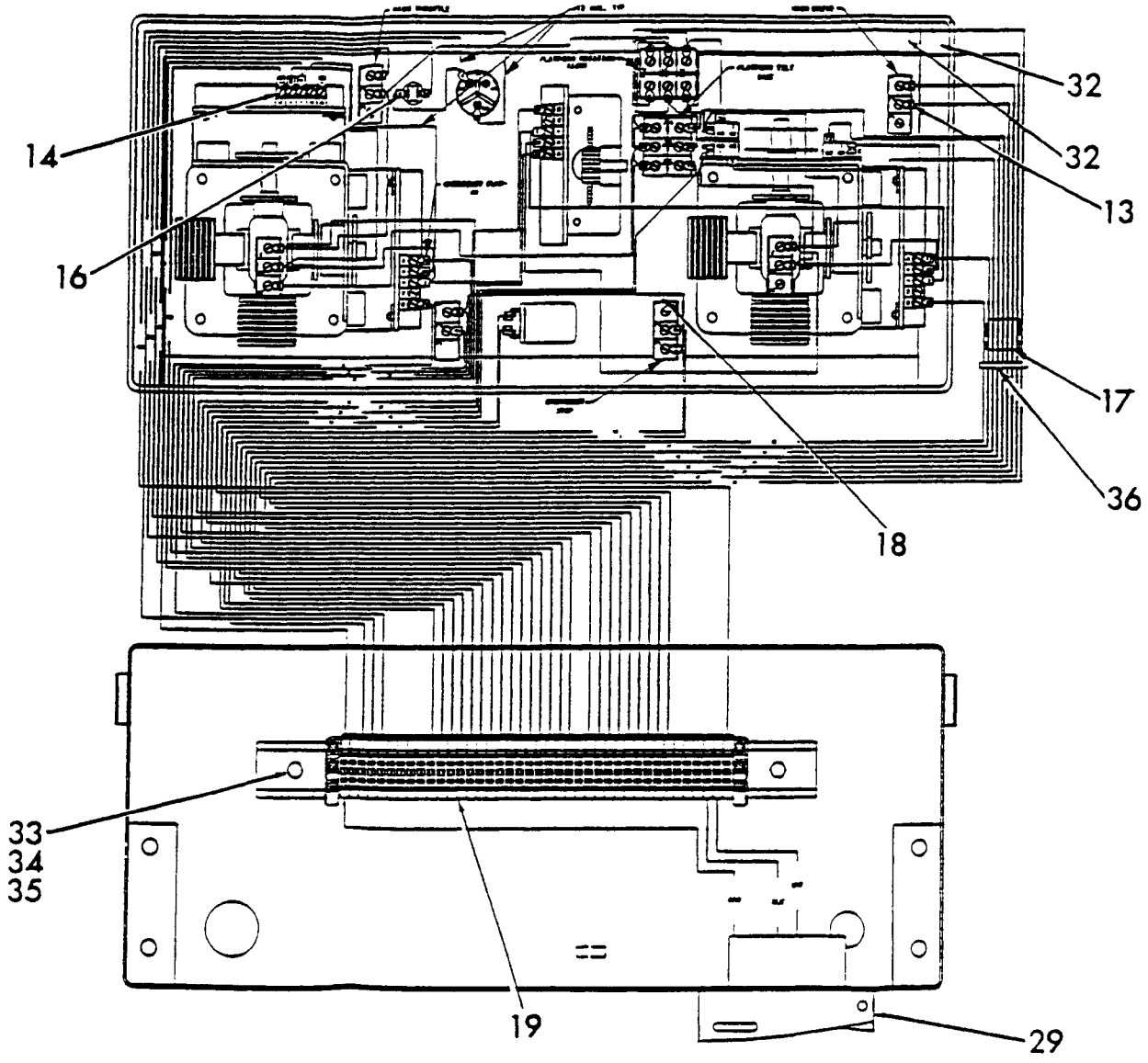


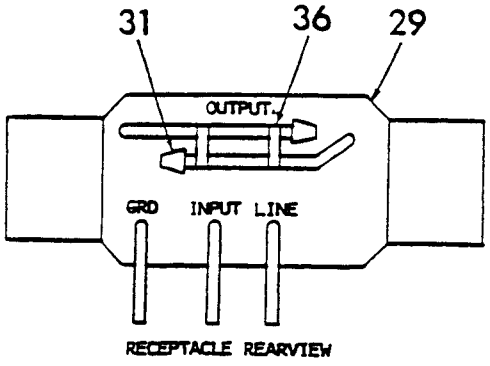
REV.

Mark Industries

TITLE	AERIAL CONTROL BOX ASSEMBLY
MODEL	100C 6X4
NOTES	FROM MID 1989 TO LATE 1990

SECT.	2
FIG.	3A
SHEET	2





REV.

Mark Industries

TITLE	AERIAL CONTROL BOX ASSEMBLY
MODEL	100C 6X4
NOTES	FROM MID 1989 TO LATE 1990

SECT.	2
FIG.	3A
SHEET	3

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	24118	ASSEMBLY, AERIAL CONTROL BOX (See Sect. 2, Fig. 1 for NHA)	REF
2	.70457	CONTROLLER (LIFT/ROTATE) (See Sect. 2, Fig. 4A for Details)	1
3	.70455	CONTROLLER (DRIVE/STEER) (See Sect. 2, Fig. 5A for Details)	1
4	.70453	CONTROLLER (EXTENSION) (See Sect. 2, Fig. 6A for Details)	1
5	.70405	SWITCH, ANTI-RESTART IGNITION	1
6	.70313	SWITCH, TOGGLE	2
7	.4011	SWITCH, PUSH BUTTON	1
8	.70291	SWITCH, TOGGLE	1
9	.20805	ALARM, BUZZER	1
10	.4021	SWITCH, TOGGLE	1
11	.20481	SWITCH, TOGGLE	2
12	.70407	SWITCH, GUARD	1
13	.2859	CONNECTOR, RING	25
14	.70406	TERMINAL, FORK SPADE (BLUE)	17
15	.20884	GUARD, SWITCH	5
16	.117-E	TERMINAL, FEMALE DISCONNECT (RED)	2
17	.16214	MOUNTS	5
18	.70479	DIODE (6 AMP/1000V)	1
19	.24127	ASSEMBLY, TERMINAL STRIP	1
20	.2808	NUT, LOCK	1
21	.16005	NUT, LOCK	1
22	.2806	RELIEF, STRAIN	1
23	.16215	RELIEF, STRAIN	1

DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

Mark Industries

TITLE	AERIAL CONTROL BOX ASSEMBLY
MODEL	100C 6X4
NOTES	FROM MID 1989 TO LATE 1990

SECT.	2
FIG.	3A
SHEET	4

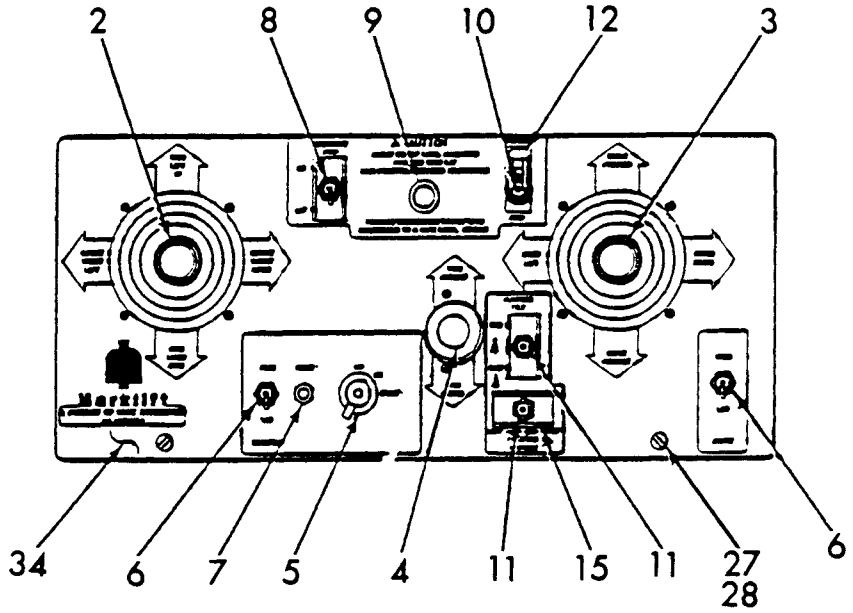
ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
24	.24119	BOX, AERIAL CONTROL	1
25	.24120	BRACKET, MOUNTING (L.H.)	1
26	.24121	BRACKET, MOUNTING (RIGHT SIDE)	1
27	.182103	DECAL, OPERATION INSTRUCTIONS & DANGER	1
28	.182707	DECAL, AERIAL CONTROL BOX	1
29	.70391	RECEPTACLE, G.F.C.I.	1
30	.70392	COVER, RECEPTACLE	1
31	.70394	CONNECTOR, TWIST-ON WIRE	2
32	.160015	EXTRUSION, NEOPRENE	4 FT
33	.60701	NUT, HEX	9
34	.63301	WASHER, SPLIT	9
35	.63401	WASHER, FLAT	2
36	.256	TIE, CABLE (3½" X 1/8")	50
37	.24122	PLATE, BACK	1
38	.24123	WELDMENT, COVER	1

REV.

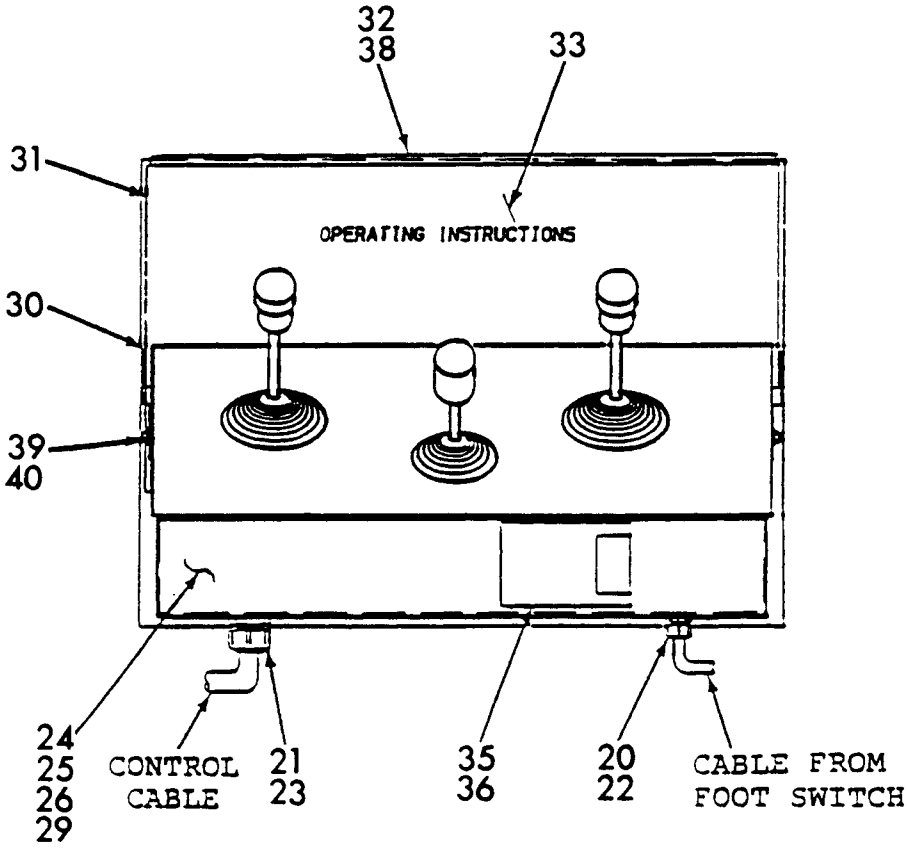
DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

Mark Industries

TITLE	AERIAL CONTROL BOX ASSEMBLY	SECT.	2
MODEL	100C 6X4	FIG.	3B
NOTES	SINCE LATE 1990	SHEET	1



TOP VIEW



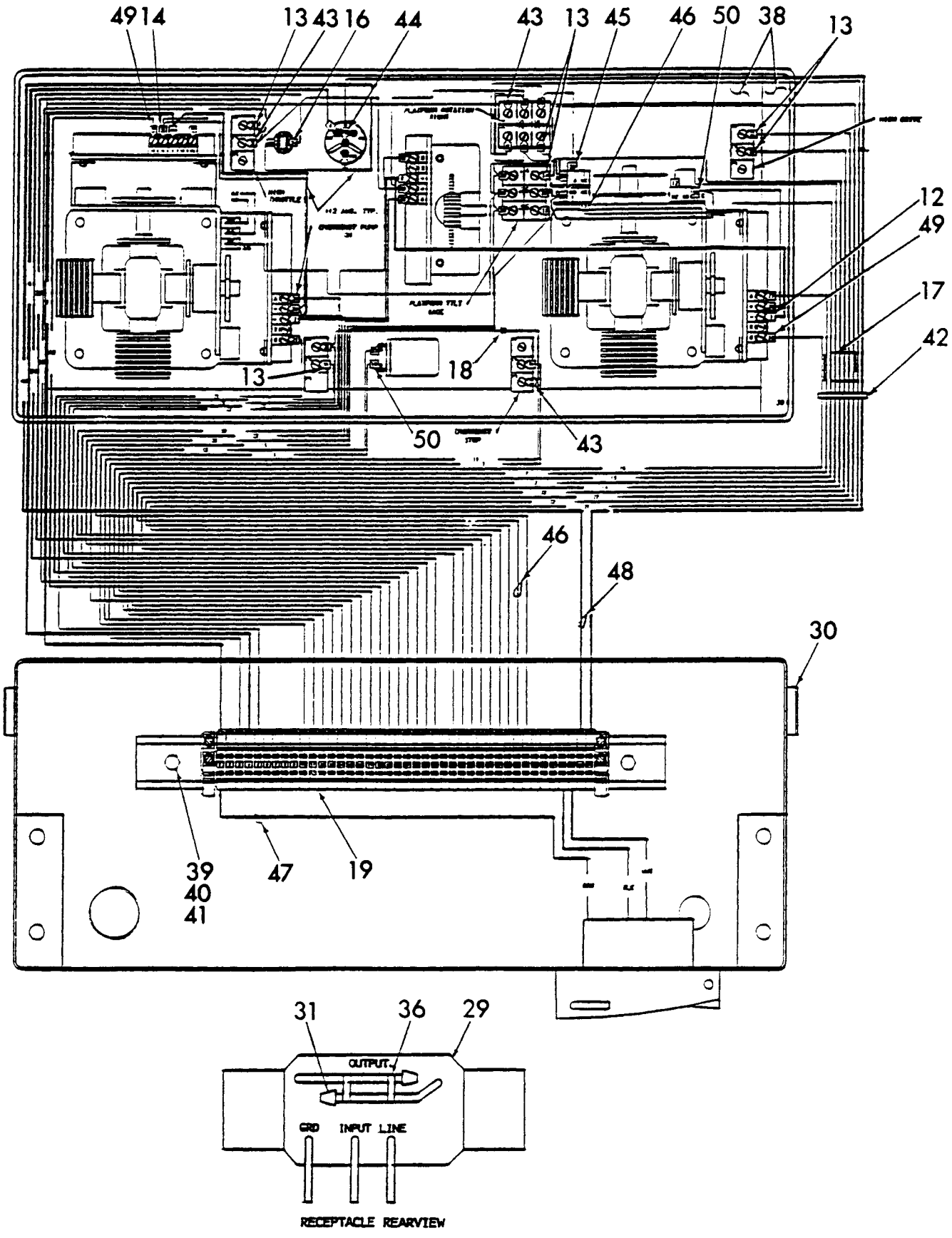
FRONT VIEW

REV.

Mark Industries

TITLE	AERIAL CONTROL BOX ASSEMBLY
MODEL	100C 6X4
NOTES	SINCE LATE 1990

SECT.	2
FIG.	3B
SHEET	2



REV.

Mark Industries

TITLE	AERIAL CONTROL BOX ASSEMBLY
MODEL	100C 6X4
NOTES	SINCE LATE 1990

SECT.	2
FIG.	3B
SHEET	3

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	24118	ASSEMBLY, AERIAL CONTROL BOX (See Sect. 2, Fig. 1 for NHA)	REF
2	.70457	CONTROLLER (LIFT/ROTATE) (See Sect. 2, Fig. 4A for Details)	1
3	.70455	CONTROLLER (DRIVE/STEER) (See Sect. 2, Fig. 5A for Details)	1
4	.70453	CONTROLLER (EXTENSION) (See Sect. 2, Fig. 6A for Details)	1
5	.70595	SWITCH, ANTI-RESTART IGNITION	1
6	.70313	SWITCH, TOGGLE	2
7	.4011	SWITCH, PUSH BUTTON	1
8	.70291	SWITCH, TOGGLE	1
9	.20805	ALARM, BUZZER	1
10	.4021	SWITCH, TOGGLE	1
11	.20481	SWITCH, TOGGLE	2
12	.70407	SWITCH, GUARD	1
13	.70149	TERMINAL, RING (RED)	14
14	.70406	TERMINAL, FORK SPADE (BLUE)	6
15	.20884	GUARD, SWITCH	3
16	.70500	TERMINAL, FEMALE DISCONNECT (RED)	2
17	.16214	MOUNTS	8
18	.70479	DIODE (6 AMP/1000V)	1
19	.24127	ASSEMBLY, TERMINAL STRIP	1
20	.2808	NUT, LOCK	1
21	.16005	NUT, LOCK	1
22	.2806	RELIEF, STRAIN	1
23	.16215	RELIEF, STRAIN	1

Mark Industries

TITLE	AERIAL CONTROL BOX ASSEMBLY
MODEL	100C 6X4
NOTES	SINCE LATE 1990

SECT.	2
FIG.	3B
SHEET	4

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
24	.210442	WELDMENT, AERIAL CONTROL BOX	1
25	..160471	RIVET, POP	2
26	..160397	CATCH, TENSION	1
27	..160473	SCREW, CAPTIVE	2
28	..160474	RECEPTACLE, CAPTIVE SCREW	2
29	..160042	GASKET	5.01 FT
30	.24120	BRACKET, COVER MOUNTING	2
31	.24122	PLATE, BACK	1
32	.24123	WELDMENT, COVER	1
33	.182103	DECAL, OPERATION INSTRUCTIONS & DANGER	1
34	.182707	DECAL, AERIAL CONTROL BOX	1
35	.70391	RECEPTACLE, G.F.C.I.	1
36	.70392	COVER, RECEPTACLE	1
37	.70394	CONNECTOR, TWIST-ON WIRE	2
38	.160015	EXTRUSION, NEOPRENE	4 FT
39	.60701	NUT, HEX	9
40	.63301	WASHER, SPLIT	9
41	.63401	WASHER, FLAT	2
42	.256	TIE, CABLE (3½" X 1/8")	50
43	.117-B	TERMINAL, RING (BLUE)	10
44	.117-C	TERMINAL, RING (BLUE)	2
45	.16325	TERMINAL, FEMALE DISCONNECT (RED)	3
46	.2990	WIRE, WHITE (18 AWG)	105 FT
47	.70098	WIRE, YELLOW WITH GREEN (12 AWG)	1 FT
48	.2991	WIRE, WHITE (12 AWG)	9 FT

REV.

DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

Mark Industries

TITLE	AERIAL CONTROL BOX ASSEMBLY
MODEL	100C 6X4
NOTES	SINCE LATE 1990

SECT.	2
FIG.	3B
SHEET	5

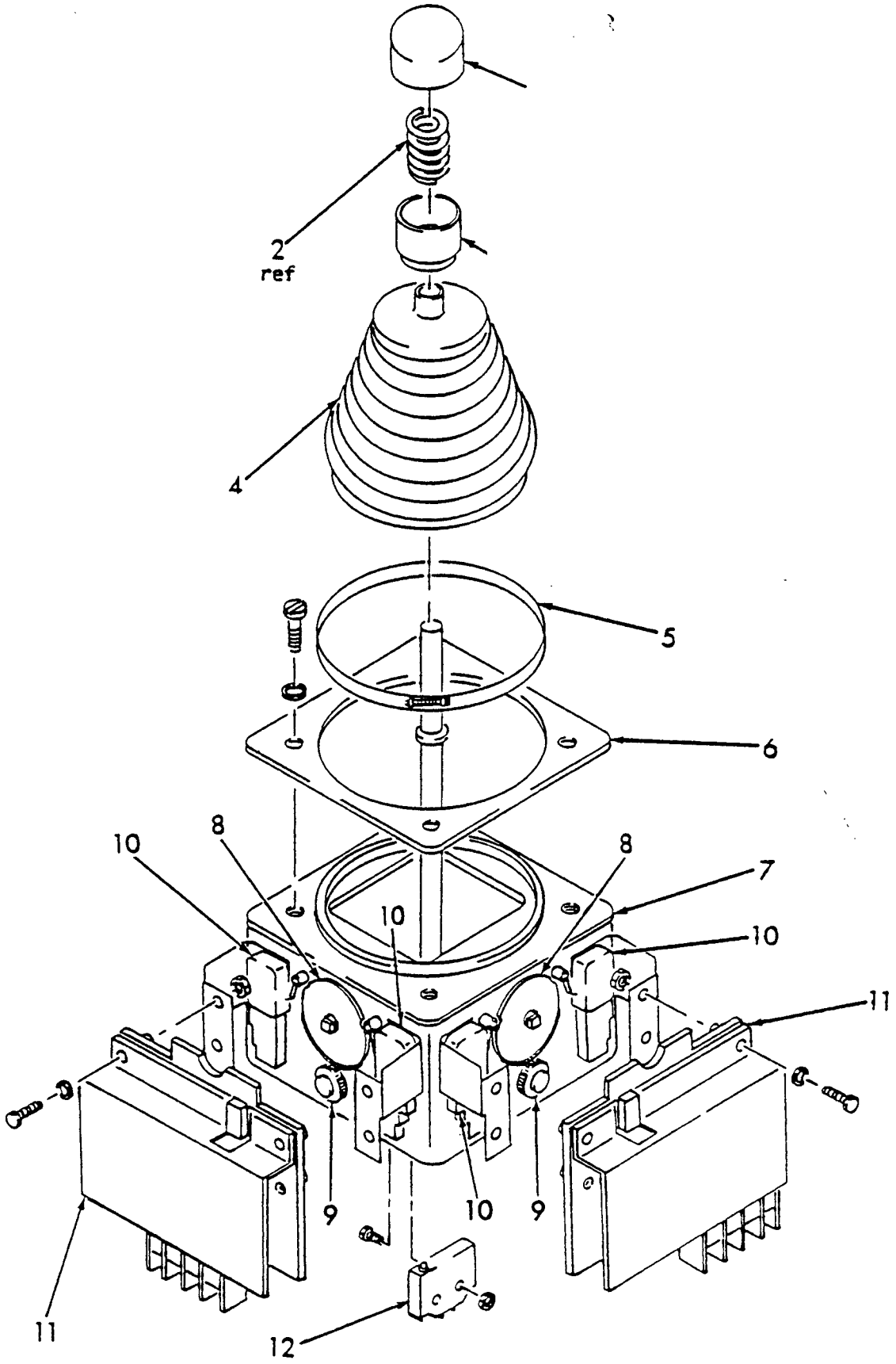
ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
49	.70566	TERMINAL, FORK SPADE (RED)	10
50	.70567	TERMINAL, RING (RED)	3
-51	.117-E	TERMINAL, FEMALE DISCONNECT (BLUE)	3

REV.

DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

Mark Industries

TITLE	CONTROLLER (LIFT/ROTATE)	SECT.	2
MODEL	100C 6X4	FIG.	4
NOTES	UNTIL MAY 1989	SHEET	1



REV.

Mark Industries

TITLE	CONTROLLER (LIFT/ROTATE)
MODEL	100C 6X4
NOTES	UNTIL MAY 1989

SECT.	2
FIG.	4
SHEET	2

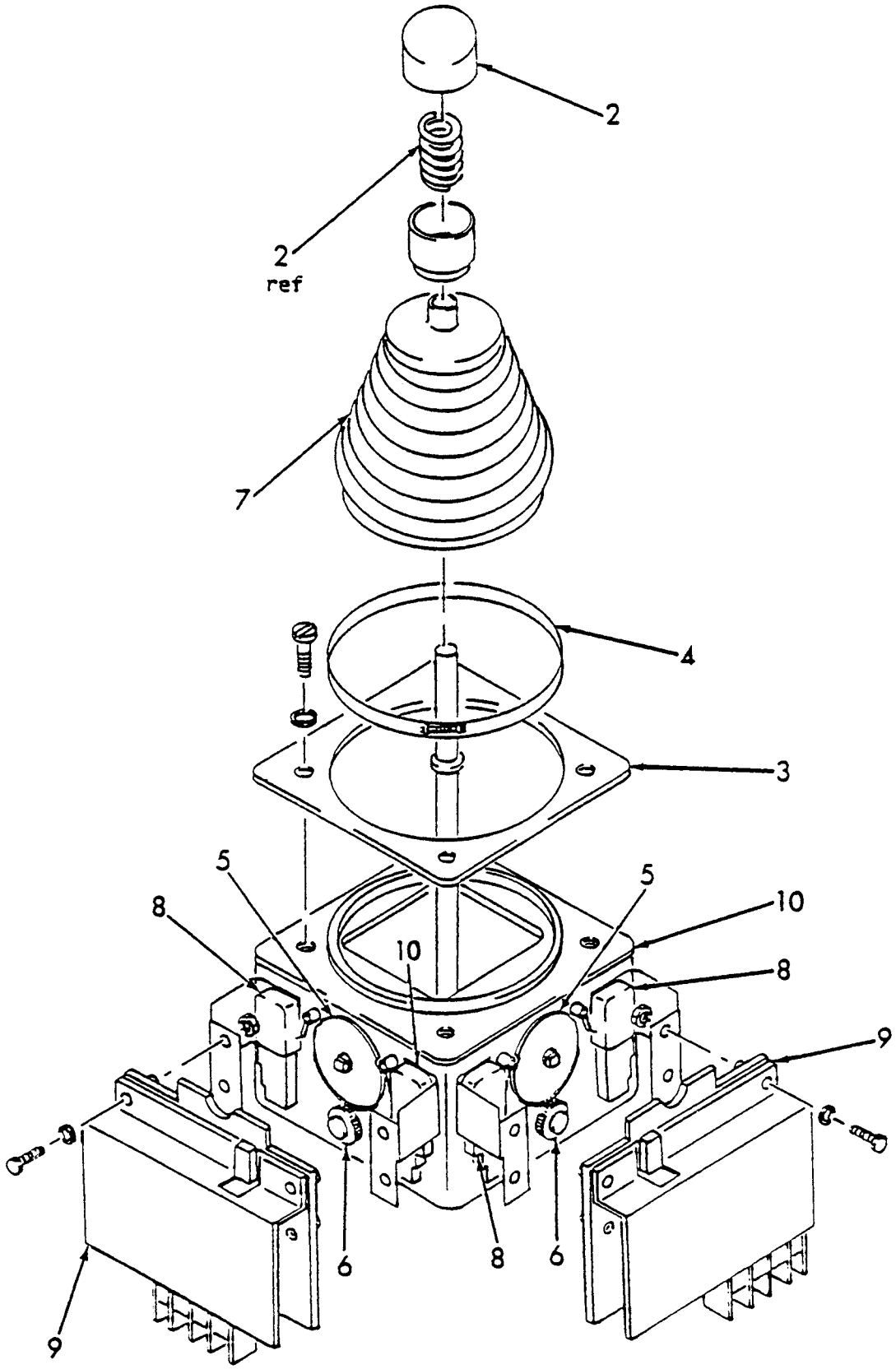
ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	70398	CONTROLLER (LIFT/ROTATE) (See Sect. 2, Fig. 3 for NHA)	REF
2	.67489	ASSEMBLY, UPPER HANDLE	1
3	.67488	HANDLE, LOWER	1
4	.67482	BOOT	1
5	.67483	CLAMP, BOOT	1
6	.67481	GASKET, MOUNTING	1
7	.67491	ASSEMBLY, POTENTIOMETER	1
8	.67484	GEAR, DRIVE	2
9	.67485	GEAR, SLAVE	2
10	.67486	MICROSWITCH	4
11	.67490	BOARD, CIRCUIT	2
12	.67487	BRACKET, AUXILIARY CONTACT	2

REV.

DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

Mark Industries

TITLE	CONTROLLER (LIFT/ROTATE)	SECT.	2
MODEL	100C 6X4	FIG.	4A
NOTES	SINCE MAY 1989	SHEET	1



REV.

Mark Industries

TITLE	CONTROLLER (LIFT/ROTATE)
MODEL	100C 6X4
NOTES	SINCE MAY 1989

SECT.	2
FIG.	4A
SHEET	2

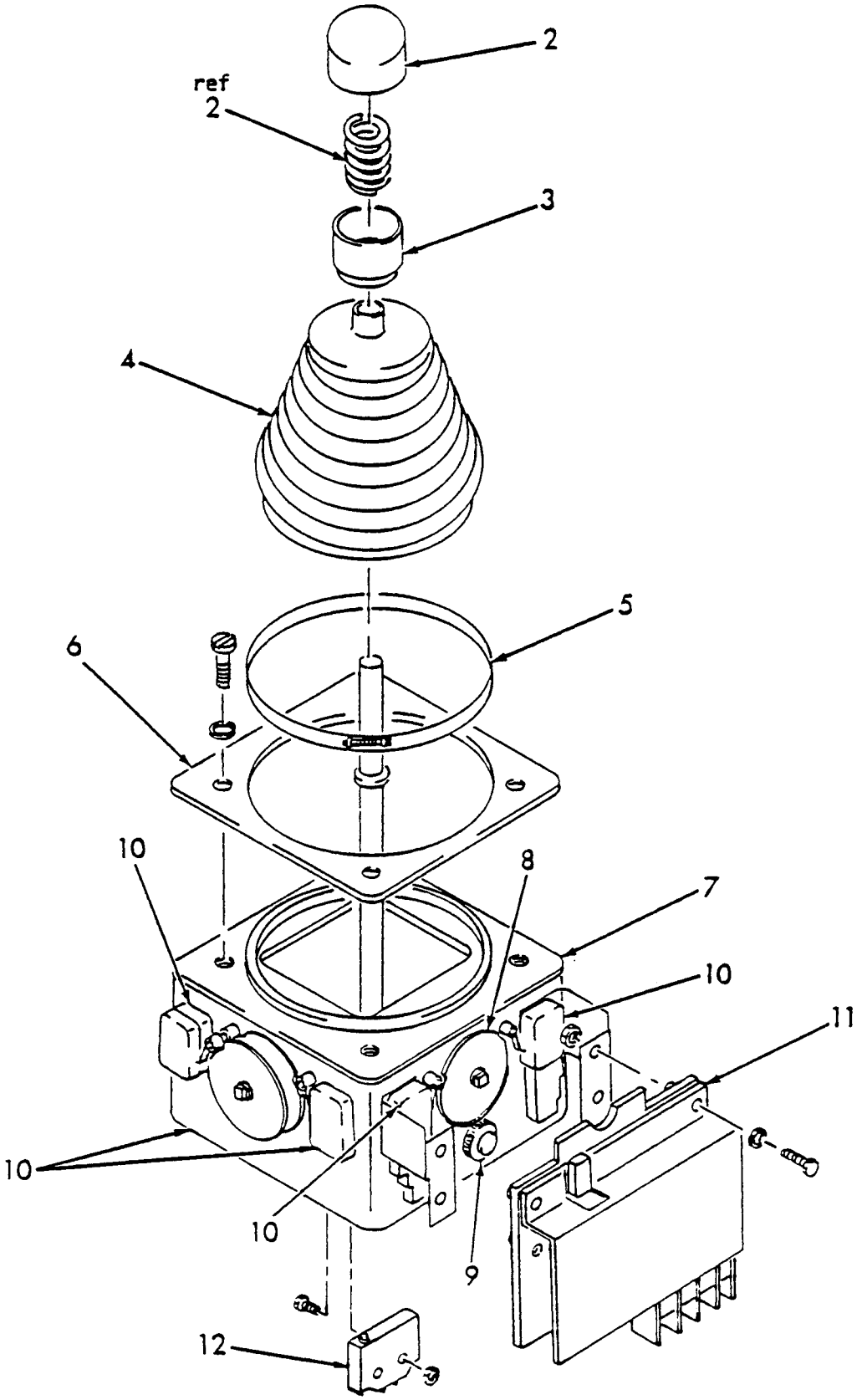
ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	70457	CONTROLLER (LIFT/ROTATE) (See Sect. 2, Fig. 3A & 3B for NHA)	REF
2	.600114	HANDLE, SOLID CAP	1
3	.67481	GASKET, MOUNTING	1
4	.67483	CLAMP, BOOT	1
5	.67484	GEAR, DRIVE	2
6	.67485	GEAR, SLAVE	2
7	.67482	BOOT	1
8	.67486	MICROSWITCH	4
9	.600377	BOARD, CIRCUIT (CURRENT LIMITED)	2
10	.67491	ASSEMBLY, POTENTIOMETER	2

REV.

DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

Mark Industries

TITLE	CONTROLLER (DRIVE/STEER)	SECT.	2
MODEL	100C 6X4	FIG.	5
NOTES	UNTIL MAY 1989	SHEET	1



REV.

Mark Industries

TITLE	CONTROLLER (DRIVE/STEER)
MODEL	100C 6X4
NOTES	UNTIL MAY 1989

SECT.	2
FIG.	5
SHEET	2

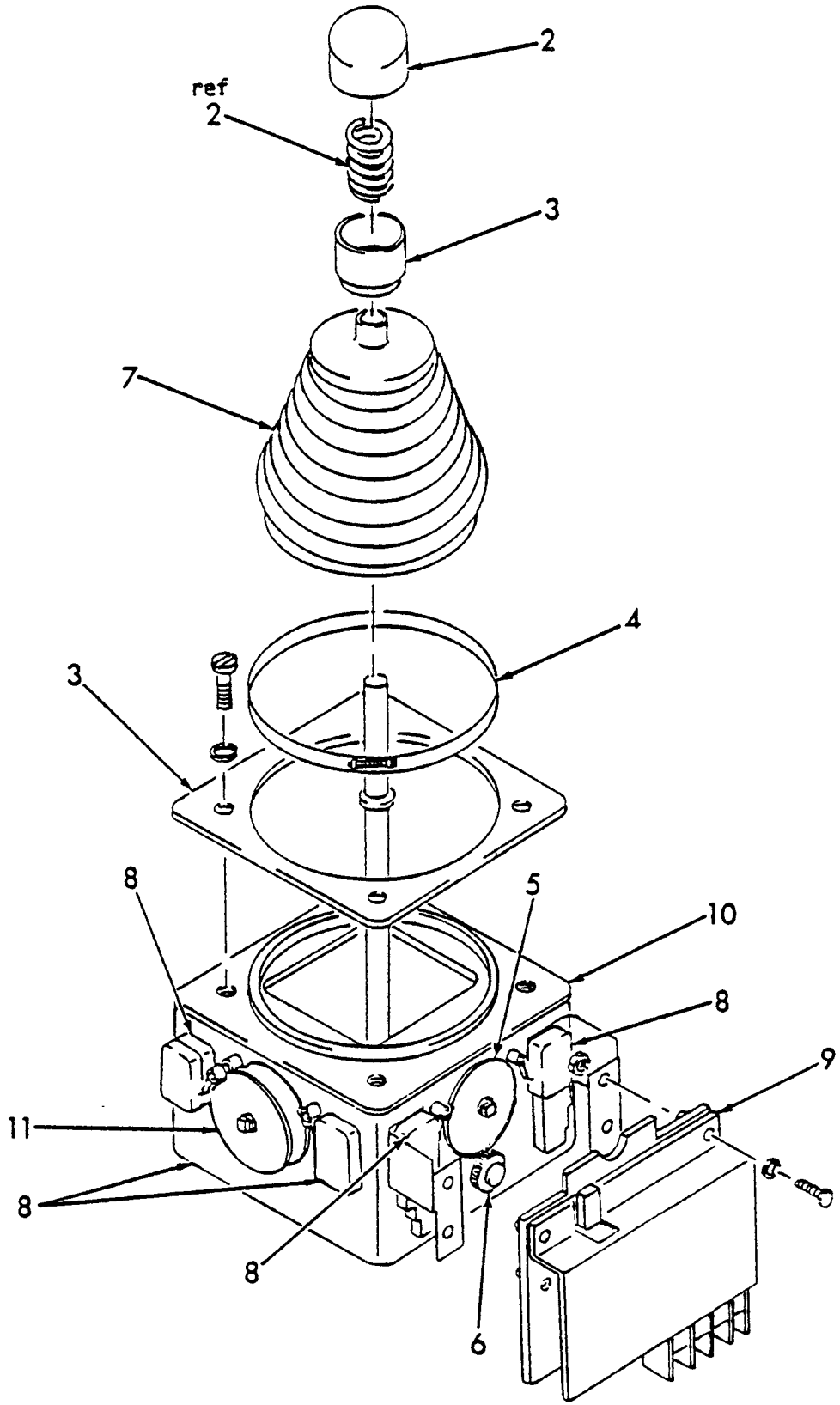
ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	70399	CONTROLLER (DRIVE/STEER) (See Sect. 2, Fig. 3 for Details)	REF
2	.67489	ASSEMBLY, UPPER HANDLE	1
3	.67488	HANDLE, LOWER	1
4	.67482	BOOT	1
5	.67483	CLAMP, BOOT	1
6	.67481	GASKET, MOUNTING	1
7	.67491	ASSEMBLY, POTENTIOMETER	1
8	.67484	GEAR, DRIVE	1
9	.67485	GEAR, SLAVE	1
10	.67486	MICROSWITCH	5
11	.67490	BOARD, CIRCUIT	1
12	.67487	BRACKET, AUXILIARY CONTACT	1

REV.

DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

Mark Industries

TITLE	CONTROLLER (DRIVE/STEER)	SECT.	2
MODEL	100C 6X4	FIG.	5A
NOTES	SINCE MAY 1989	SHEET	1



REV.

Mark Industries

TITLE	CONTROLLER (DRIVE/STEER)
MODEL	100C 6X4
NOTES	SINCE MAY 1989

SECT.	2
FIG.	5A
SHEET	2

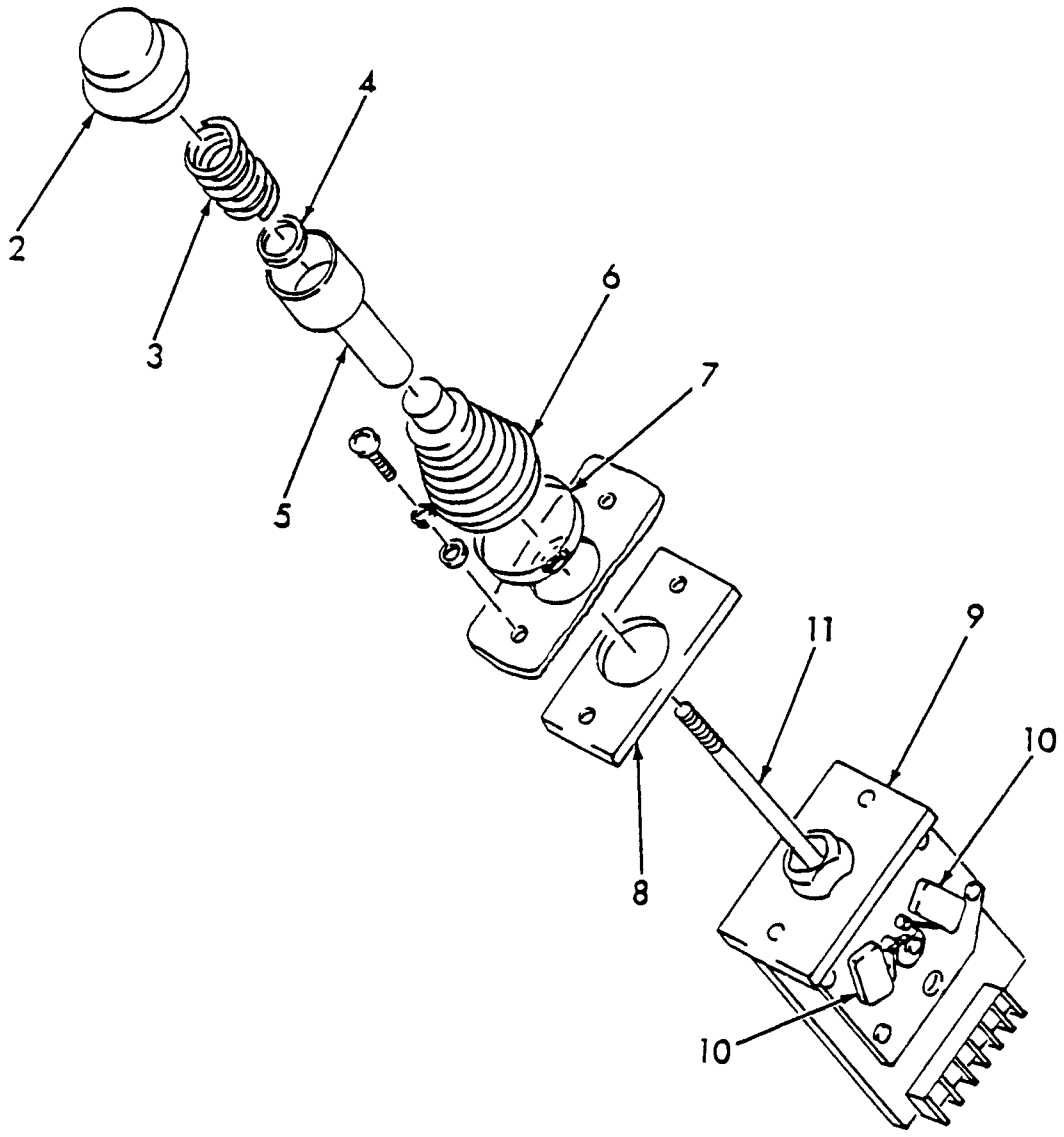
ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	70455	CONTROLLER (DRIVE/STEER) (See Sect. 2, Fig. 3A & 3B for NHA)	REF
2	.600114	HANDLE, SOLID CAP	1
3	.67481	GASKET, MOUNTING	1
4	.67483	CLAMP, BOOT	1
5	.67484	GEAR, DRIVE	1
6	.67485	GEAR, SLAVE	1
7	.67482	BOOT	1
8	.67486	MICROSWITCH	5
9	.600377	BOARD, CIRCUIT (CURRENT LIMITED)	1
10	.67491	ASSEMBLY, POTENTIOMETER	1
11	.600115	CAM, FIXED	1

REV.

DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

Mark Industries

TITLE	CONTROLLER (EXTENSION)	SECT.	2
MODEL	100C 6X4	FIG.	6
NOTES	UNTIL MAY 1989	SHEET	1



REV.

Mark Industries

TITLE	CONTROLLER (EXTENSION)
MODEL	100C 6X4
NOTES	UNTIL MAY 1989

SECT.	2
FIG.	6
SHEET	2

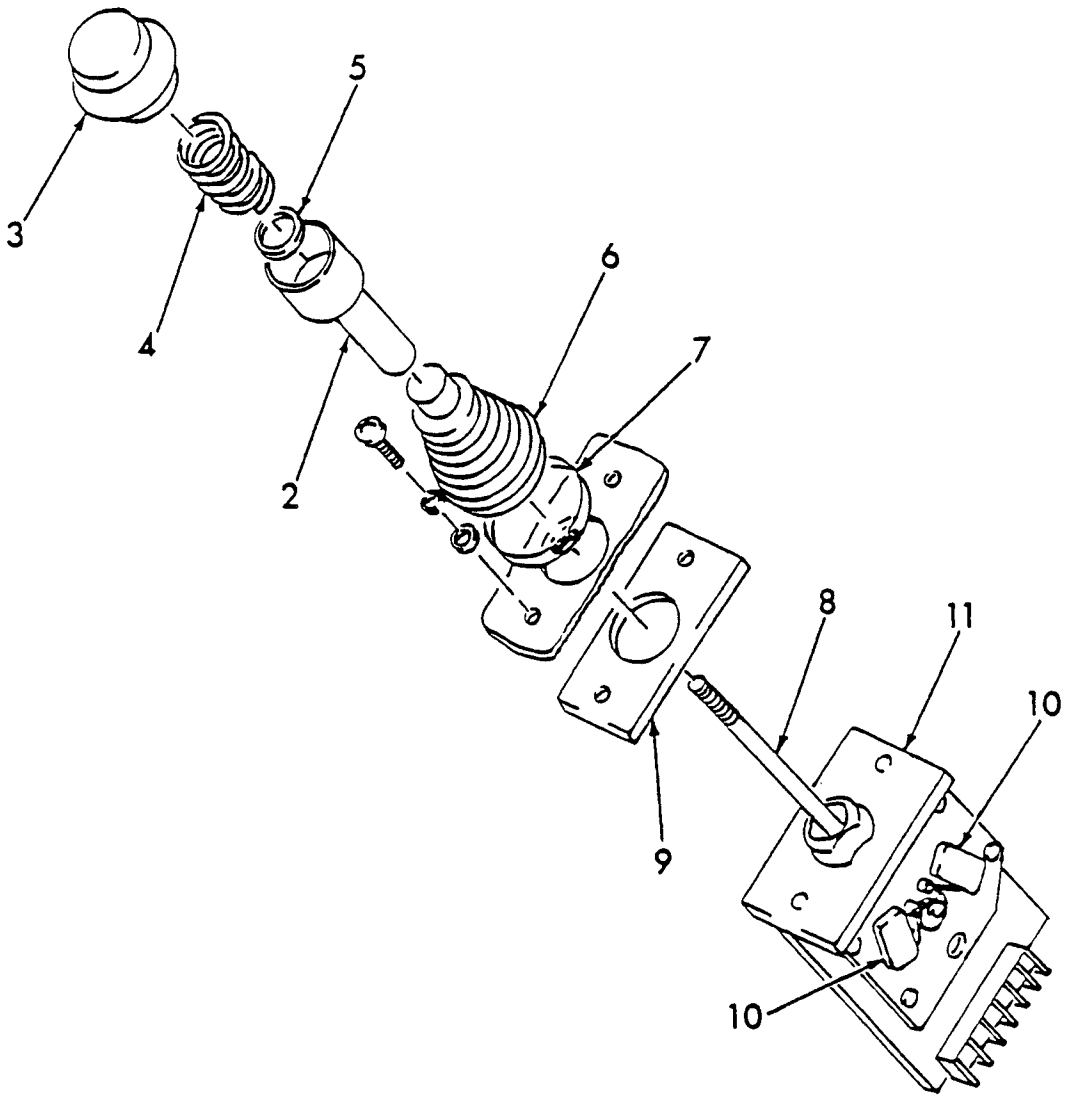
ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	70397	CONTROLLER (EXTENSION) (See Sect. 2, Fig. 3 for Details)	REF
2	.67499	CAP, UPPER (HALF)	1
3	.67498	SPRING, CAP	1
4	.67497	RING, RETAINING	1
5	.67488	HANDLE, LOWER	1
6	.67496	BOOT	1
7	.67495	CLAMP, BOOT	1
8	.67493	GASKET	1
9	.67492	BOARD, CIRCUIT (WITH POTENTIOMETER)	1
10	.67486	MICROSWITCH	2
11	.67494	TUBE, MECHANICAL INTERLOCK	1

REV.

DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

Mark Industries

TITLE	CONTROLLER (EXTENSION)	SECT.	2
MODEL	100C 6X4	FIG.	6A
NOTES	SINCE MAY 1989	SHEET	1



REV.

Mark Industries

TITLE	CONTROLLER (EXTENSION)
MODEL	100C 6X4
NOTES	SINCE MAY 1989

SECT.	2
FIG.	6A
SHEET	2

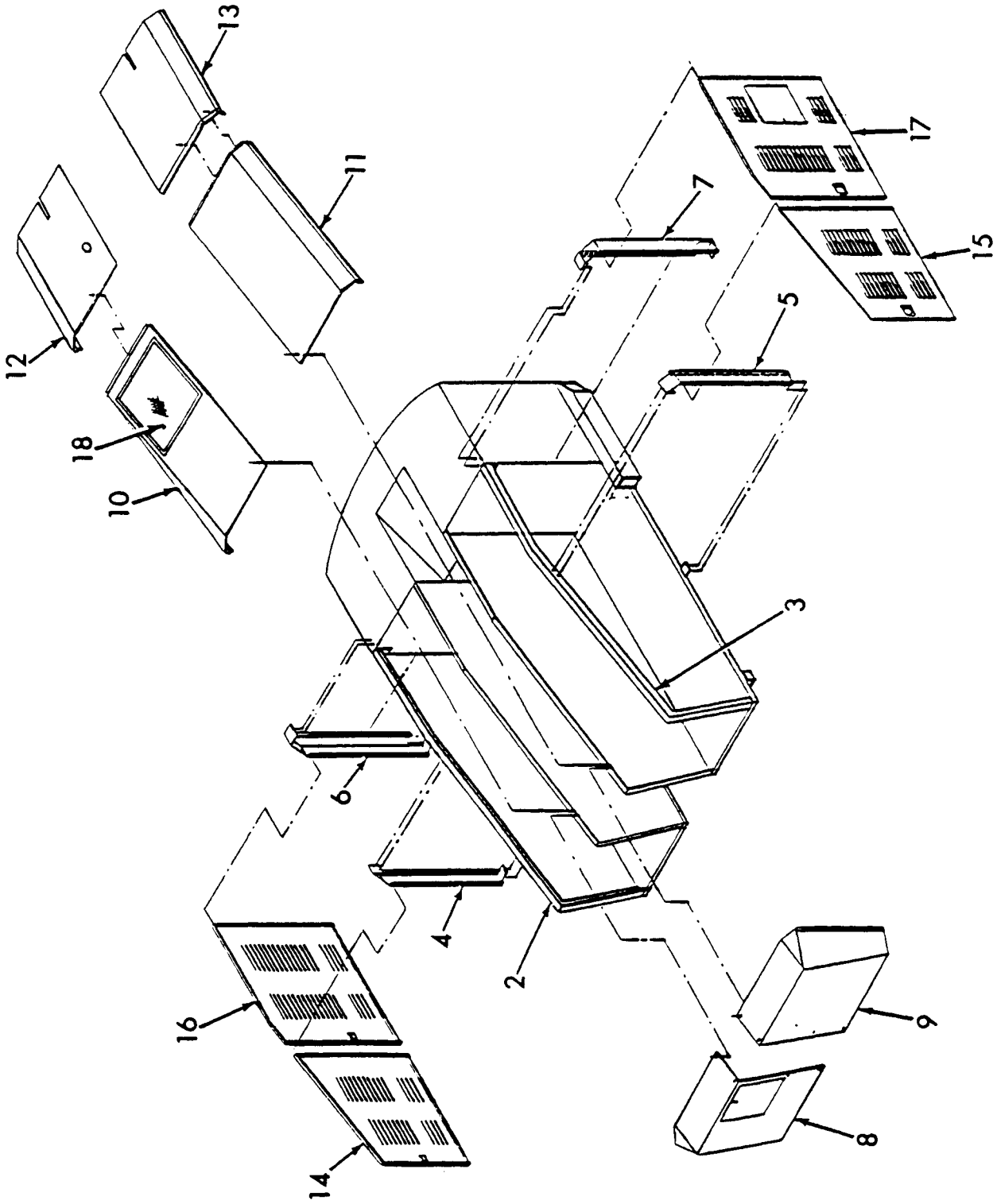
ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	70453	CONTROLLER (EXTENSION) (See Sect. 2, Fig. 3A & 3B for NHA)	REF
2	.67488	HANDLE, LOWER	1
3	.67499	CAP, UPPER (HALF)	1
4	.67498	SPRING, CAP	1
5	.67497	RING, RETAINING	1
6	.67496	BOOT	1
7	.67495	CLAMP, BOOT	1
8	.67494	TUBE, MECHANICAL INTERLOCK	1
9	.67493	GASKET	1
10	.67486	MICROSWITCH	2
11	.600378	BOARD, CIRCUIT (WITH POTENTIOMETER)	1

REV.

DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

Mark Industries

TITLE	SHEET METAL KIT	SECT.	2
MODEL	100C 6X4	FIG.	7
NOTES		SHEET	1



REV.

Mark Industries

TITLE	SHEET METAL KIT
MODEL	100C 6X4
NOTES	

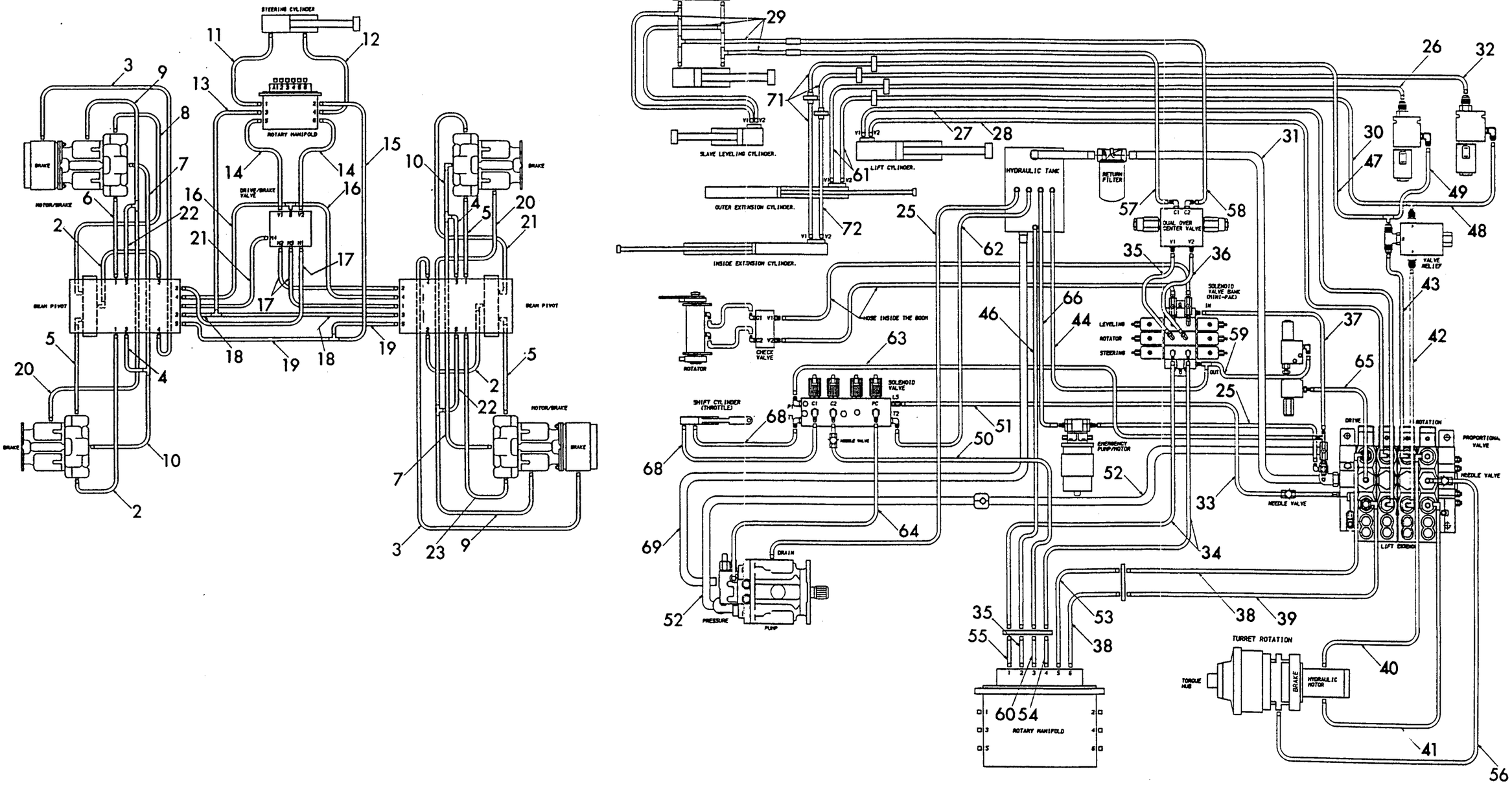
SECT.	2
FIG.	7
SHEET	2

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	22009	KIT, SHEET METAL (See Sect. 2, Fig. 1 for NHA)	REF
2	.22336	RAIL, FRAME (LEFT)	1
3	.22337	RAIL, FRAME (RIGHT)	1
4	.22338	SUPPORT, MID (LEFT)	1
5	.22339	SUPPORT, MID (RIGHT)	1
6	.22340	SUPPORT, FRONT (LEFT)	1
7	.22341	SUPPORT, FRAME (RIGHT)	1
8	.22342	COVER, NOSE (LEFT)	1
9	.22343	COVER, NOSE (RIGHT)	1
10	.22344	COVER, MID (LEFT)	1
11	.22345	COVER, MID (RIGHT)	1
12	.22346	COVER, TOP (LEFT)	1
13	.22347	COVER, TOP (RIGHT)	1
14	.22348	DOOR, REAR (LEFT)	1
15	.22349	DOOR, REAR (RIGHT)	1
16	.22350	DOOR, FRONT (LEFT)	1
17	.22351	DOOR, FRONT (RIGHT)	1
18	.22352	SCREEN, EXPANDED METAL	1

Mark Industries

TITLE	HYDRAULIC HOSE DIAGRAM
MODEL	100C 6X4
NOTES	

SECT.	2
FIG.	8
SHEET	1



Mark Industries

TITLE	HYDRAULIC HOSE DIAGRAM	SECT.	2
MODEL	100C 6X4	FIG.	8
NOTES		SHEET	2

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	24616 KIT-A	DIAGRAM, HYDRAULIC HOSE (CARRIAGE) (See Sect. 3, Fig. 1 for NHA)	REF
2	.13213-12-0270	ASSEMBLY, HOSE	3
3	.13213-04-0620	ASSEMBLY, HOSE	2
4	.13210-04-0160	ASSEMBLY, HOSE	2
5	.13210-12-0170	ASSEMBLY, HOSE	3
6	.13210-12-0160	ASSEMBLY, HOSE	1
7	.13213-04-0220	ASSEMBLY, HOSE	2
8	.13212-12-0300	ASSEMBLY, HOSE	1
9	.13213-08-0290	ASSEMBLY, HOSE	2
10	.13213-04-0380	ASSEMBLY, HOSE	1
11	.13210-04-0650	ASSEMBLY, HOSE	1
12	.13210-04-0680	ASSEMBLY, HOSE	1
13	.13210-04-0950	ASSEMBLY, HOSE	1
14	.13223-12-0800	ASSEMBLY, HOSE	2
15	.13210-08-0950	ASSEMBLY, HOSE	1
16	.13213-04-0120	ASSEMBLY, HOSE	2
17	.13214-12-0270	ASSEMBLY, HOSE	3
18	.13213-04-0154	ASSEMBLY, HOSE	2
19	.13213-08-0130	ASSEMBLY, HOSE	2
20	.13213-08-0470	ASSEMBLY, HOSE	2
21	.13213-12-0280	ASSEMBLY, HOSE	2
22	.13210-08-0190	ASSEMBLY, HOSE	2
23	.13212-12-0270	ASSEMBLY, HOSE	1
-24	24616 KIT-B	DIAGRAM, HYDRAULIC HOSE (TURRET) (See Sect. 4, Fig. 1 for NHA)	REF

Mark Industries

TITLE	HYDRAULIC HOSE DIAGRAM
MODEL	100C 6X4
NOTES	

SECT.	2
FIG.	8
SHEET	3

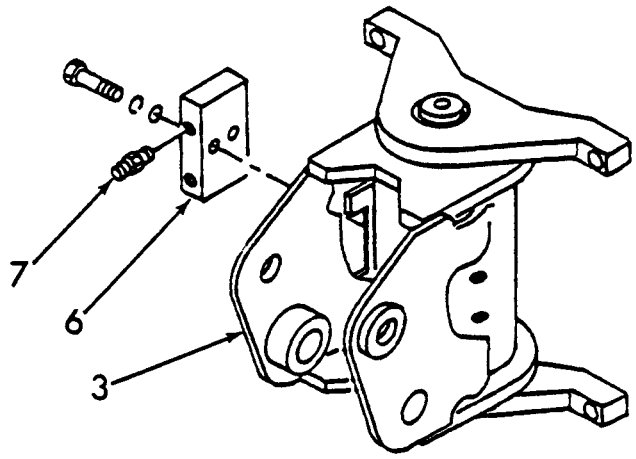
ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
25	.13210-06-0850	ASSEMBLY, HOSE	1
26	.13210-08-1540	ASSEMBLY, HOSE	1
27	.13212-08-1250	ASSEMBLY, HOSE	1
28	.13213-08-1300	ASSEMBLY, HOSE	1
29	.13211-04-0150	ASSEMBLY, HOSE	4
30	.13210-08-1180	ASSEMBLY, HOSE	1
31	.13210-16-0290	ASSEMBLY, HOSE	1
32	.13210-08-1480	ASSEMBLY, HOSE	1
33	.13213-04-1210	ASSEMBLY, HOSE	1
34	.13210-04-0190	ASSEMBLY, HOSE	1
35	.13213-04-0190	ASSEMBLY, HOSE	2
36	.13213-04-0160	ASSEMBLY, HOSE	1
37	.13213-06-0200	ASSEMBLY, HOSE	1
38	.13213-12-0230	ASSEMBLY, HOSE	2
39	.13212-12-0260	ASSEMBLY, HOSE	1
40	.13213-08-0940	ASSEMBLY, HOSE	1
41	.13212-08-0950	ASSEMBLY, HOSE	1
42	.13213-08-0270	ASSEMBLY, HOSE	1
43	.13212-08-0310	ASSEMBLY, HOSE	1
44	.13213-08-0280	ASSEMBLY, HOSE	1
45	.13213-06-1080	ASSEMBLY, HOSE	1
46	.13213-06-0320	ASSEMBLY, HOSE	1
47	.13213-08-1160	ASSEMBLY, HOSE	1
48	.13210-08-0270	ASSEMBLY, HOSE	1
49	.13210-08-0360	ASSEMBLY, HOSE	2

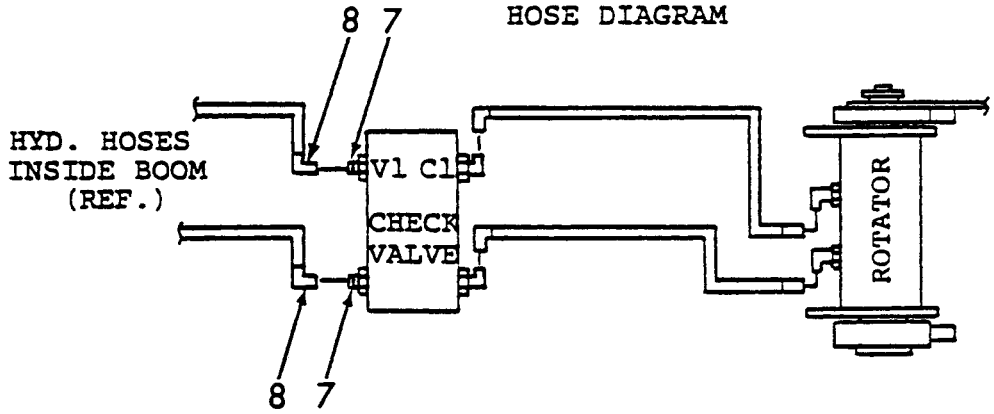
DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
50	.13213-04-1200	ASSEMBLY, HOSE	1
51	.13210-04-0100	ASSEMBLY, HOSE	1
52	.13213-16-0600	ASSEMBLY, HOSE	2
53	.13213-12-0280	ASSEMBLY, HOSE	1
54	.13213-04-0260	ASSEMBLY, HOSE	1
55	.13213-06-0210	ASSEMBLY, HOSE	1
56	.13213-04-1000	ASSEMBLY, HOSE	1
57	.13213-04-1240	ASSEMBLY, HOSE	1
58	.13213-04-1220	ASSEMBLY, HOSE	1
59	.13210-04-0110	ASSEMBLY, HOSE	1
60	.13213-04-0230	ASSEMBLY, HOSE	1
61	.13210-04-1000	ASSEMBLY, HOSE	1
62	.13210-08-0850	ASSEMBLY, HOSE	2
63	.13210-06-1200	ASSEMBLY, HOSE	1
64	.13213-06-1450	ASSEMBLY, HOSE	1
65	.13213-04-0200	ASSEMBLY, HOSE	1
66	.13213-06-1000	ASSEMBLY, HOSE	1
-67	24616 KIT-C	DIAGRAM, HYDRAULIC HOSE (TURRET) (See Sect. 4, Fig. 1 for NHA)	REF
68	.13210-04-1060	ASSEMBLY, HOSE	2
69	.13205-20-0540	ASSEMBLY, HOSE	1
-70	24616 KIT-E	DIAGRAM, HYDRAULIC HOSE (BOOM) (See Sect. 5, Fig. 1 for NHA)	REF
71	.13213-08-3120	ASSEMBLY, HOSE	3
72	.13213-08-3100	ASSEMBLY, HOSE	1

Mark Industries

TITLE	HELAC ROTATOR ASSEMBLY	SECT.	2
MODEL	100C 6X4	FIG.	9
NOTES		SHEET	1



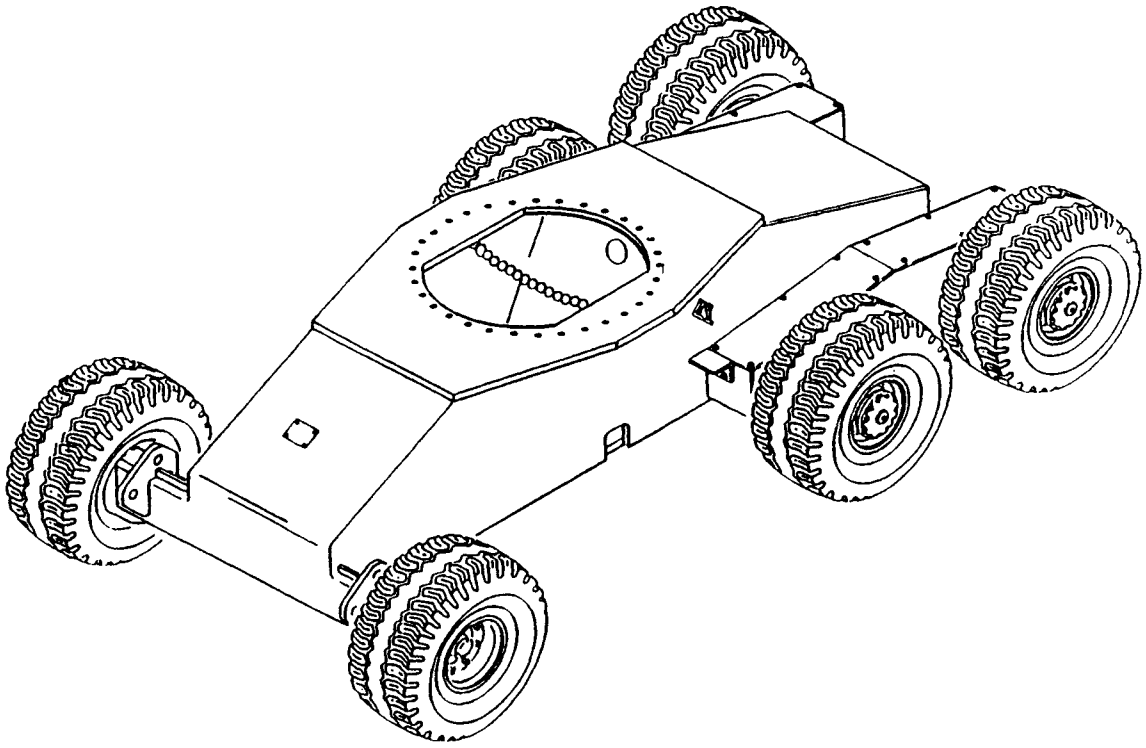


ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	24444	ASSEMBLY, HELAC ROTATOR (See Sect. 2, Fig. 1 for NHA)	REF
-2	.81372	SUB-ASSEMBLY, HELAC ROTATOR (See Vendor Chapter for Details)	1
3	..81094	ROTATOR, HELAC	1
-4	...67770	KIT, SEAL	1
-5	...67771	KIT, BEARING	1
6	..20351	VALVE, CHECK	1
7	.80004-05	CONNECTOR, STRAIGHT THREAD	2
8	.2594	ELBOW, SWIVEL	2

REV.

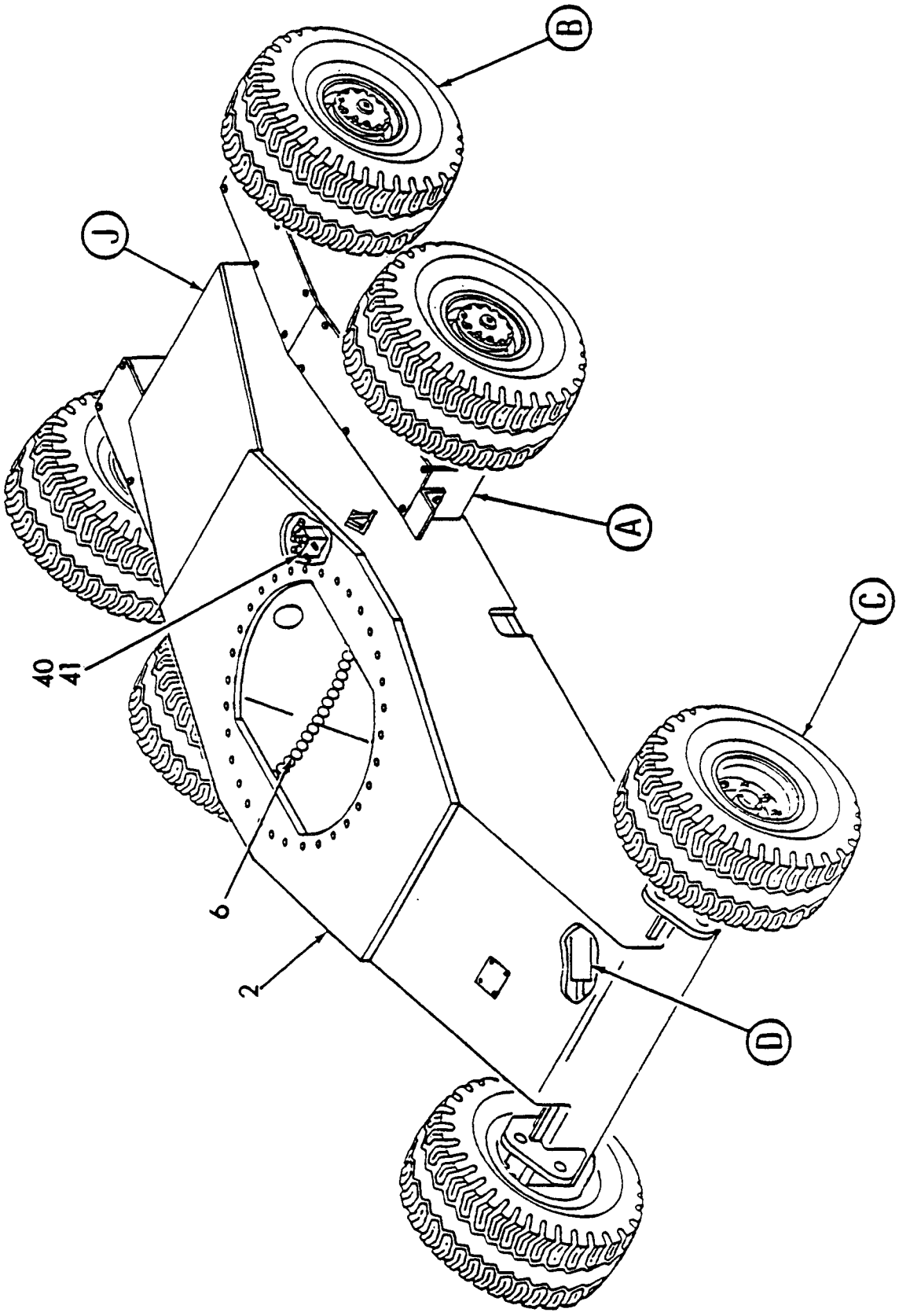
SECTION 3 CONTAINS:

FIG. NO.	TITLE
1	CARRIAGE ASSEMBLY
2	TORQUE HUB
3	STEERING CYLINDER (CONCURRENT USE)(SE)
3A	STEERING CYLINDER (CONCURRENT USE; SINCE LATE 1989)(TH)
3B	STEERING CYLINDER (CONCURRENT USE; SINCE LATE 1989)(COL)
4	DRIVE/BRAKE VALVE ASSEMBLY
5	WALKING BEAM ASSEMBLY



Mark Industries

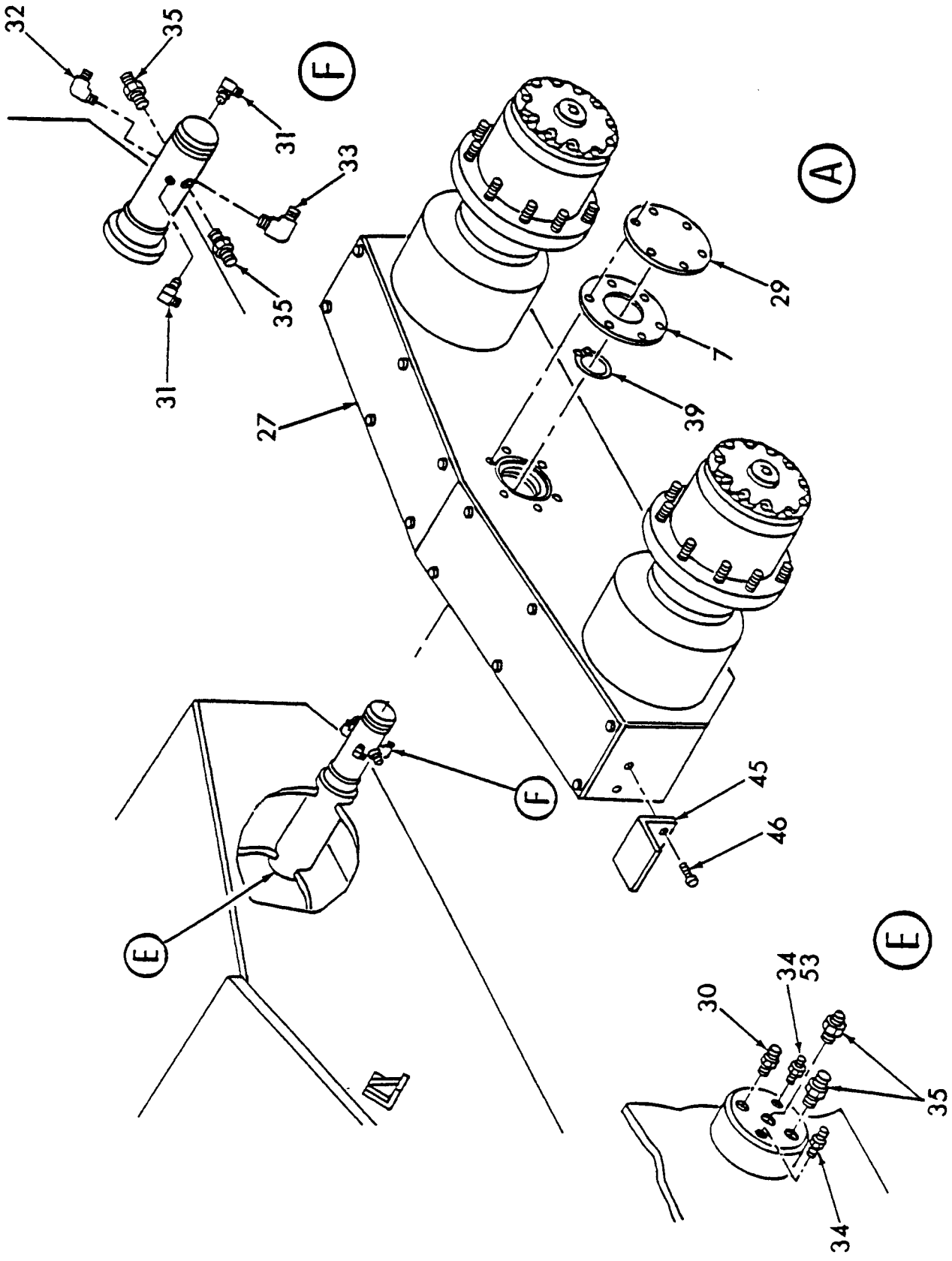
TITLE	CARRIAGE ASSEMBLY	SECT.	3
MODEL	100C 6X4	FIG.	1
NOTES		SHEET	1



REV.

Mark Industries

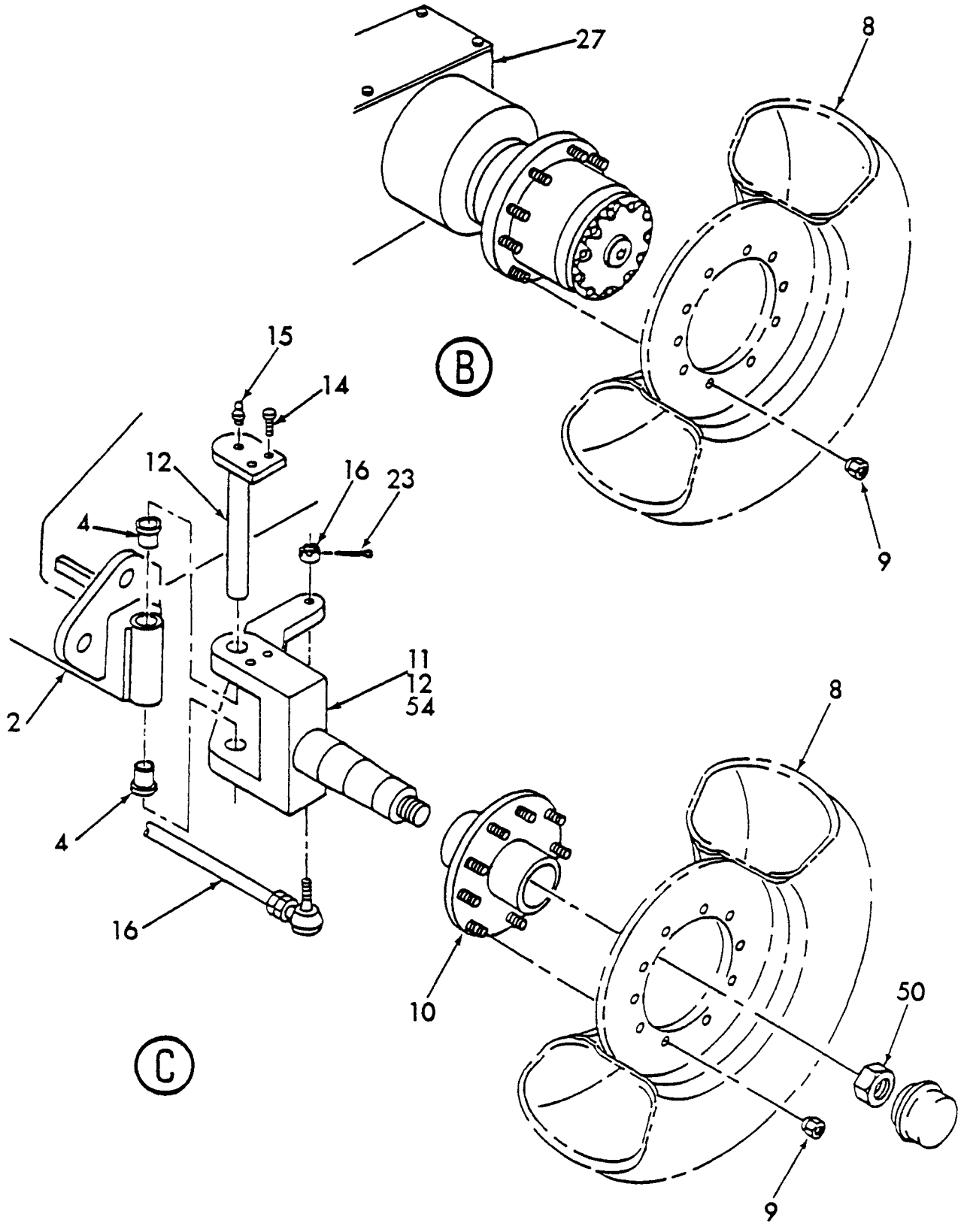
TITLE	CARRIAGE ASSEMBLY	SECT.	3
MODEL	100C 6X4	FIG.	1
NOTES		SHEET	2



REV.

Mark Industries

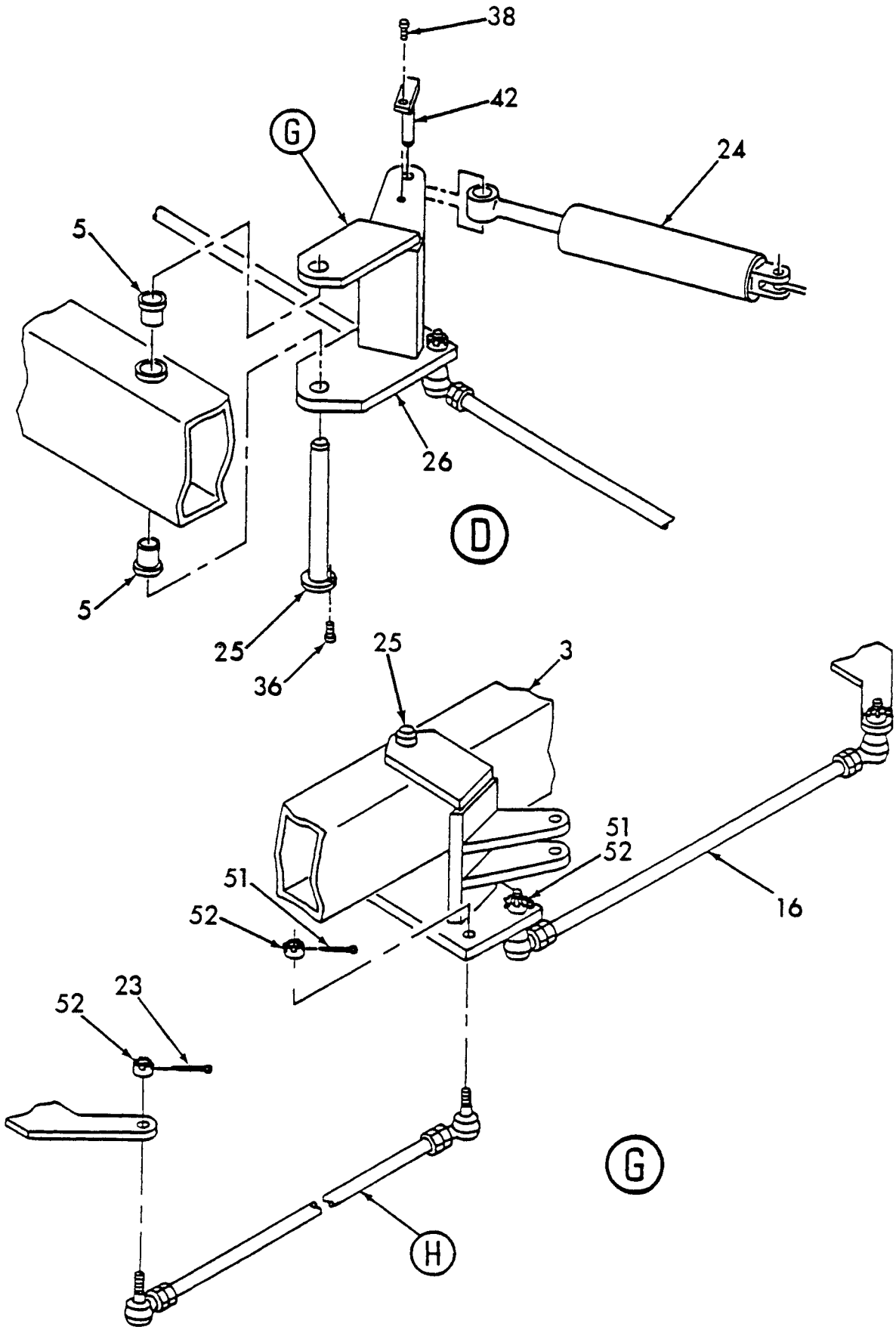
TITLE	CARRIAGE ASSEMBLY	SECT.	3
MODEL	100C 6X4	FIG.	1
NOTES		SHEET	3



REV.

Mark Industries

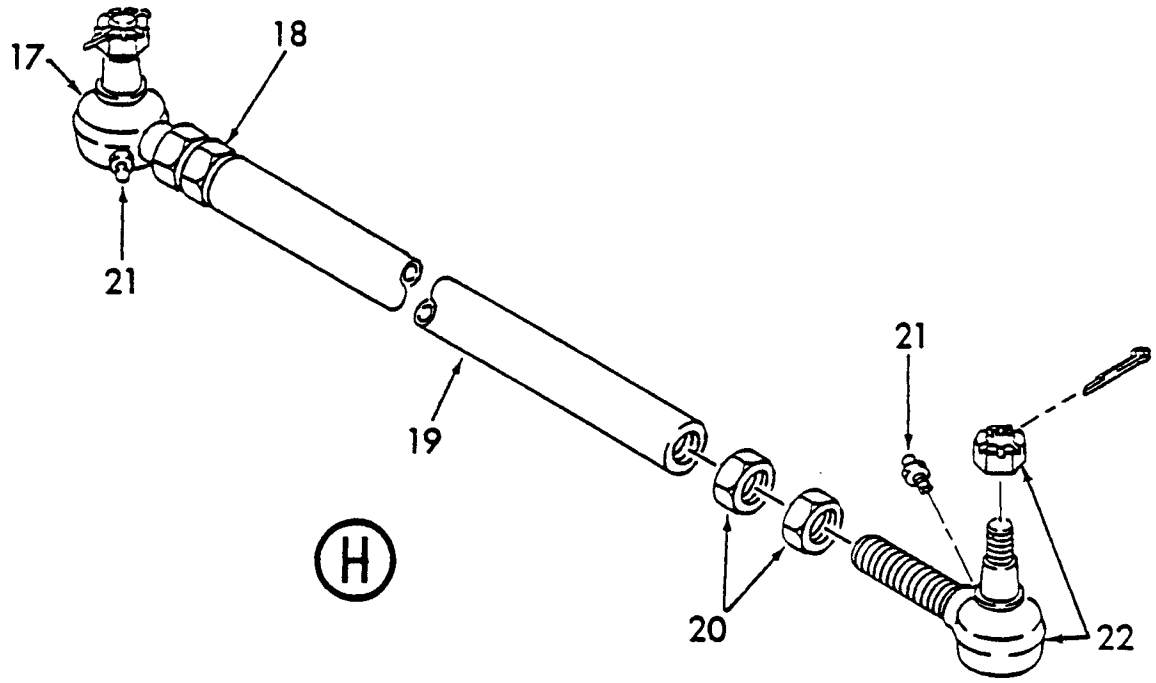
TITLE	CARRIAGE ASSEMBLY	SECT. 3
MODEL	100C 6X4	FIG. 1
NOTES		SHEET 4

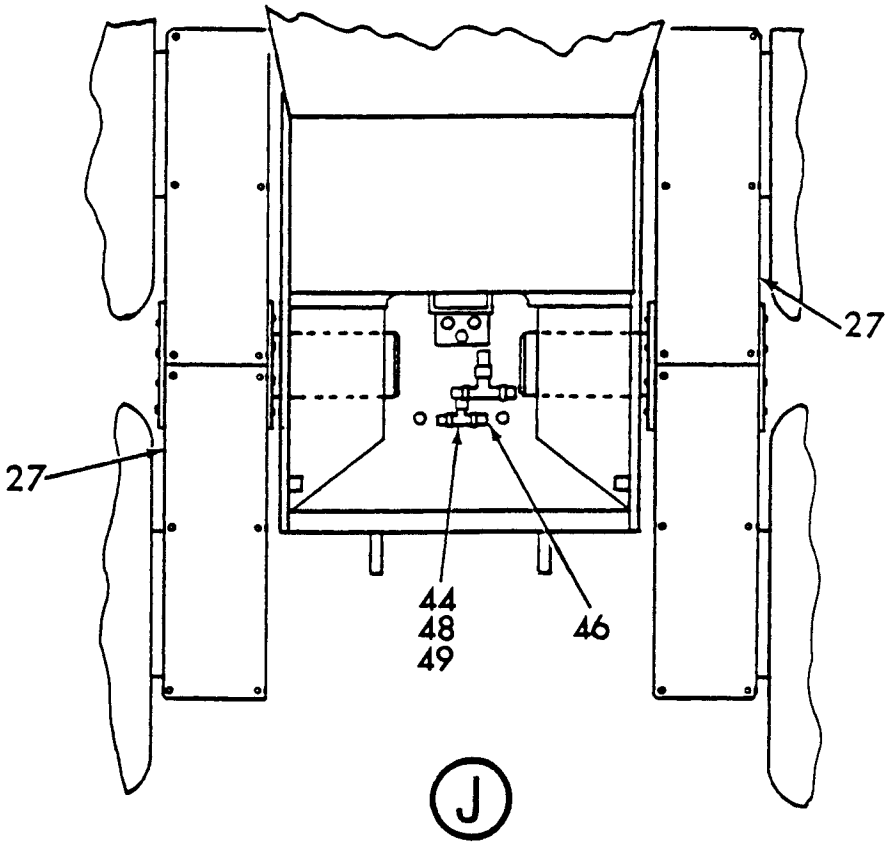


REV.

Mark Industries

TITLE	CARRIAGE ASSEMBLY	SECT.	3
MODEL	100C 6X4	FIG.	1
NOTES		SHEET	5





REV.

Mark Industries

TITLE	CARRIAGE ASSEMBLY	SECT. 3
MODEL	100C 6X4	FIG. 1
NOTES		SHEET 6

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	24499	ASSEMBLY, CARRIAGE (See Sect. 2, Fig. 1 for NHA)	REF
2	.24498	WELDMENT, CARRIAGE	1
3	..22040	WELDMENT, REAR AXLE	4
4	...21098	BUSHING	2
5	...64910	BUSHING, FLANGED	2
6	..27387	CHAIN (36 LINKS)	1
7	.21121	SEAL, BEARING	2
8	.22094	ASSEMBLY, TIRE & RIM (MONOFILLED)	6
9	.65117	NUT, BALL	60
10	.22039	HUB, STEERING	2
11	.22042	YOKE, STEERING (L.H.)	1
12	.22041	YOKE, STEERING (R.H.)	1
13	.22044	PIN, KING	1
14	.60622	SCREW, CAP	4
15	.65103	FITTING, GREASE STRAIGHT	2
-16	.24157	ASSEMBLY, TIE ROD	2
17	..20569	END, TIE ROD (L.H. THREAD)	1
18	..20567	NUT, JAM (L.H. THREAD)	2
19	..27410	ROD, TIE	1
20	..20566	NUT, JAM (R.H. THREAD)	2
21	..65103	FITTING, GREASE STRAIGHT	2
22	..20568	END, TIE ROD	1
		NOTE: DUE TO THEIR CRITICAL EFFECT ON INSURING MACHINE STABILITY, MONOFILLED TIRES CAN ONLY BE PURCHASED AS THE COMPLETE TIRE/ WHEEL ASSEMBLY.	

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
23	.64310	PIN, COTTER	4
24	.22212	ASSEMBLY, STEERING CYLINDER (See Sect. 3, Fig. 3, 3A or 3B for Details)	1
25	.22045	PIN, MAIN STEERING	1
26	.22043	WELDMENT, STEERING ARM	1
27	.21628	ASSEMBLY, WALKING BEAM (See Sect. 3, Fig. 5 for Details)	2
28	.65106	OIL, GEAR	4 GAL
29	.21632	COVER, WALKING BEAM	2
30	.80001-12	CONNECTOR, MALE	2
31	.51107	ELBOW, MALE	2
32	.80008-12	ELBOW, MALE	2
33	.80012-21	ELBOW, STRAIGHT THREAD	2
34	.80001-10	CONNECTOR, MALE	6
35	.80001-20	CONNECTOR, MALE	10
36	.60603	SCREW, CAP	2
37	.63301	WASHER, SPLIT	16
38	.60607	SCREW, CAP	1
39	.21642	RING, RETAINING	2
40	.22501	ASSEMBLY, DRIVE/BRAKE VALVE	1
41	.60356	SCREW, CAP	2
42	.22214	PIN, STEERING CYLINDER	1
-43	.60309	SCREW, CAP	8
44	.20357	VALVE, NEEDLE	1
45	.21654	STOP, WALKING BEAM	2
46	.60601	SCREW, CAP	8

Mark Industries

TITLE	CARRIAGE ASSEMBLY	SECT.	3
MODEL	100C 6X4	FIG.	1
NOTES		SHEET	8

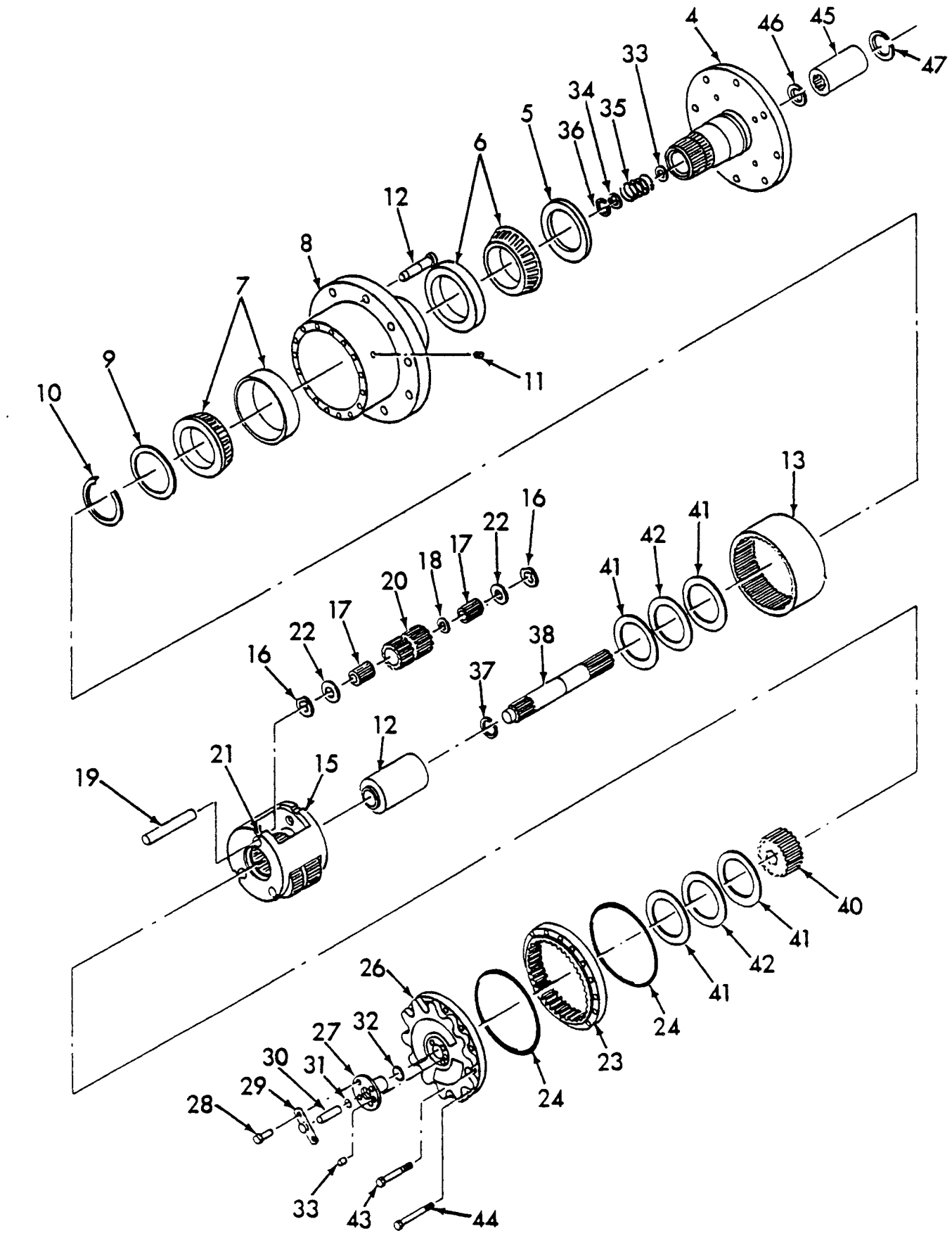
ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-47	.24616 KIT-A	DIAGRAM, HYDRAULIC HOSE (See Sect. 2, Fig. 6 or 6A for Details)	1
48	.80031-06	TEE, UNION	1
49	.80031-03	TEE, UNION	1
50	.61232	NUT, LOCK	2
51	.160056	PIN, COTTER	2
52	.65968	NUT, JAM	2
53	.80056-01	REDUCER, TUBE	6
54	.140759	SPACER, STEERING YOKE	2

REV.

DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

Mark Industries

TITLE	TORQUE HUB ASSEMBLY	SECT.	3
MODEL	100C 6X4	FIG.	2
NOTES		SHEET	1



REV.

Mark Industries

TITLE	TORQUE HUB
MODEL	100C 6X4
NOTES	

SECT.	3
FIG.	2
SHEET	2

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	21222	HUB, TORQUE (See Sect. 3, Fig. 1 for NHA) (See Vendor Chapter for Details)	REF
-2	.67870	KIT, SEAL	1
-3	.	SUB-ASSEMBLY, HUB/SPINDLE	1
4	..67875	SPINDLE	1
*5	..66399	SEAL	1
6	..600435	KIT, BEARING	1
7	..600436	KIT, BEARING	1
8	..	HUB	1
9	..67903	SPACER	1
*10	..	RING, RETAINING	1
11	..	PLUG	2
12	..67884	STUD	10
13	.	GEAR, INTERNAL	1
14	.	ASSEMBLY, CARRIER	1
15	..66429	CARRIER	1
16	..66430	WASHER	6
17	..66423	ROLLER, NEEDLE	84
18	..67904	SPACER	3
19	..66431	SHAFT, PLANET	3
20	..66432	GEAR, CLUSTER	3
21	..	PIN, ROLL	3
22	..66434	WASHER	6
23	.	GEAR, RING	1
		NOTE: ASTERISK (*) INDICATES THE ITEM IS INCLUDED IN THE SEAL KIT.	

Mark Industries

TITLE	TORQUE HUB
MODEL	100C 6X4
NOTES	

SECT.	3
FIG.	2
SHEET	3

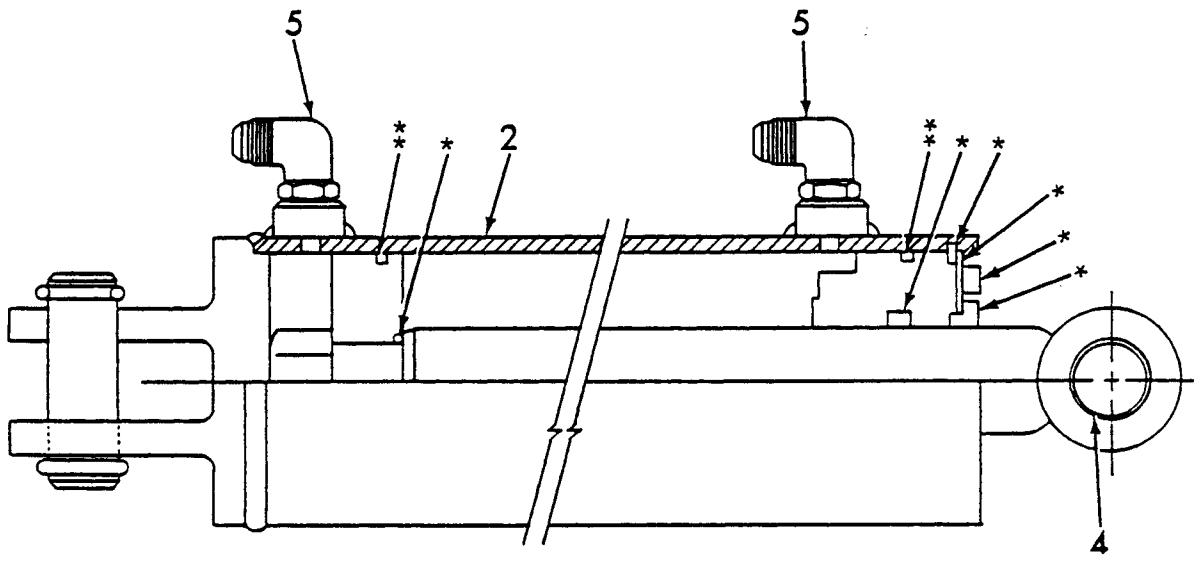
ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
*24	.	O-RING	2
25	.	ASSEMBLY, COVER	1
26	..66724	COVER	1
27	..66341	CAP, COVER	1
28	..67928	BOLT	4
29	..66115	CAP, DISCONNECT	1
30	..66230	ROD, DISCONNECT	1
*31	..	O-RING	1
*32	..	O-RING	1
33	..	PLUG, PIPE	1
34	.67892	WASHER	2
35	.	SPRING	1
36	.66524	RING, RETAINING	1
37	.67889	RING, RETAINING	1
38	.	SHAFT, INPUT	1
39	.67905	SPACER	1
40	.	GEAR, INPUT	1
*41	.	WASHER	4
*42	.	BEARING	2
43	.67929	BOLT	8
44	.67930	BOLT	4
45	.67880	COUPLING	1
46	.67890	RING, RETAINING	1
47	.67891	RING, RETAINING	1
		NOTE: ASTERISK (*) INDICATES THE ITEM IS INCLUDED IN THE SEAL KIT.	

REV.

DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

Mark Industries

TITLE	STEERING CYLINDER ASSEMBLY	SECT. 3
MODEL	100C 6X4	FIG. 3
NOTES	CONCURRENT USE (SE)	SHEET 1



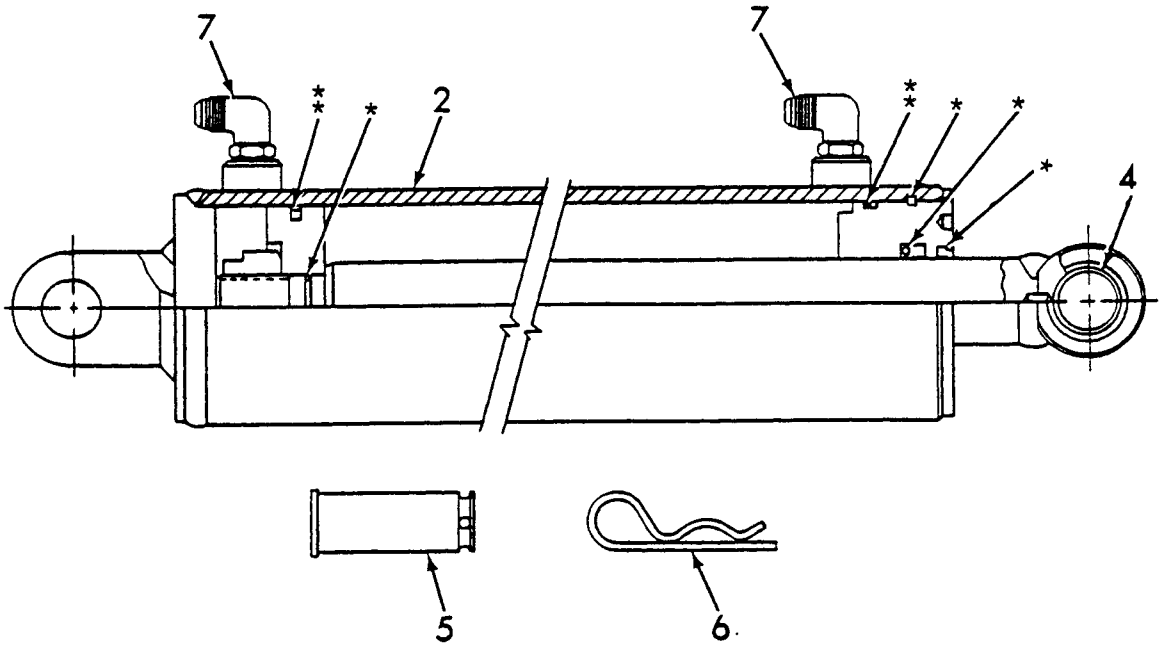
NOTE 1: DUE TO VENDOR/MFG. REVISIONS; WHEN POSSIBLE, PROVIDE ALL NUMBERS FROM THE CYLINDER I.D. TAG.

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	22212	ASSEMBLY, STEERING CYLINDER (See Sect. 3, Fig. 1 for NHA)	REF
2	.22119	CYLINDER, STEERING (SE)	1
		NOTE 2: INTERNAL SERVICE REPLACEMENT PARTS AVAILABLE ON A SPECIAL ORDER BASIS.	
-3	..66041	KIT, SEAL (SE)	1
		NOTE 3: THE SEAL KIT INCLUDES ITEMS SHOWN WITH AN ASTERISK (*).	
4	..66485	BUSHING	2
5	.80012-03	ELBOW, STRAIGHT THREAD	2

REV.

Mark Industries

TITLE	STEERING CYLINDER ASSEMBLY	SECT.	3
MODEL	100C 6X4	FIG.	3A
NOTES	CONCURRENT USE; SINCE LATE 1989 (TH)	SHEET	1



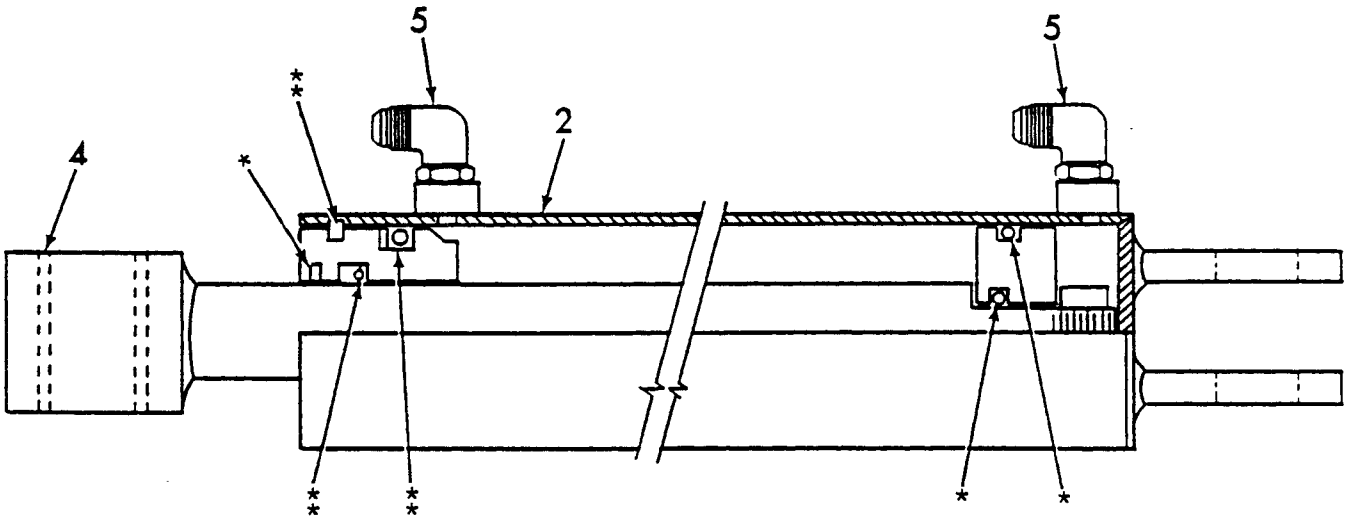
NOTE 1: DUE TO VENDOR/MFG. REVISIONS; WHEN POSSIBLE, PROVIDE ALL NUMBERS FROM THE CYLINDER I.D. TAG.

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	22212	ASSEMBLY, STEERING CYLINDER (See Sect. 3, Fig. 1 for NHA)	REF
2	.22119	CYLINDER, STEERING (TH)	1
		NOTE 2: INTERNAL SERVICE REPLACEMENT PARTS AVAILABLE ON A SPECIAL ORDER BASIS.	
-3	..600330	KIT, SEAL (TH)	1
		NOTE 3: THE SEAL KIT INCLUDES ITEMS SHOWN WITH AN ASTERISK (*).	
4	..600327	BUSHING	2
5	..600328	PIN, CLEVIS	2
6	..600329	PIN, CLIP	2
7	.80012-03	ELBOW, STRAIGHT THREAD	2

REV.

Mark Industries

TITLE	STEERING CYLINDER ASSEMBLY	SECT. 3
MODEL	100C 6X4	FIG. 3B
NOTES	CONCURRENT USE; SINCE LATE 1989 (COL)	SHEET 1



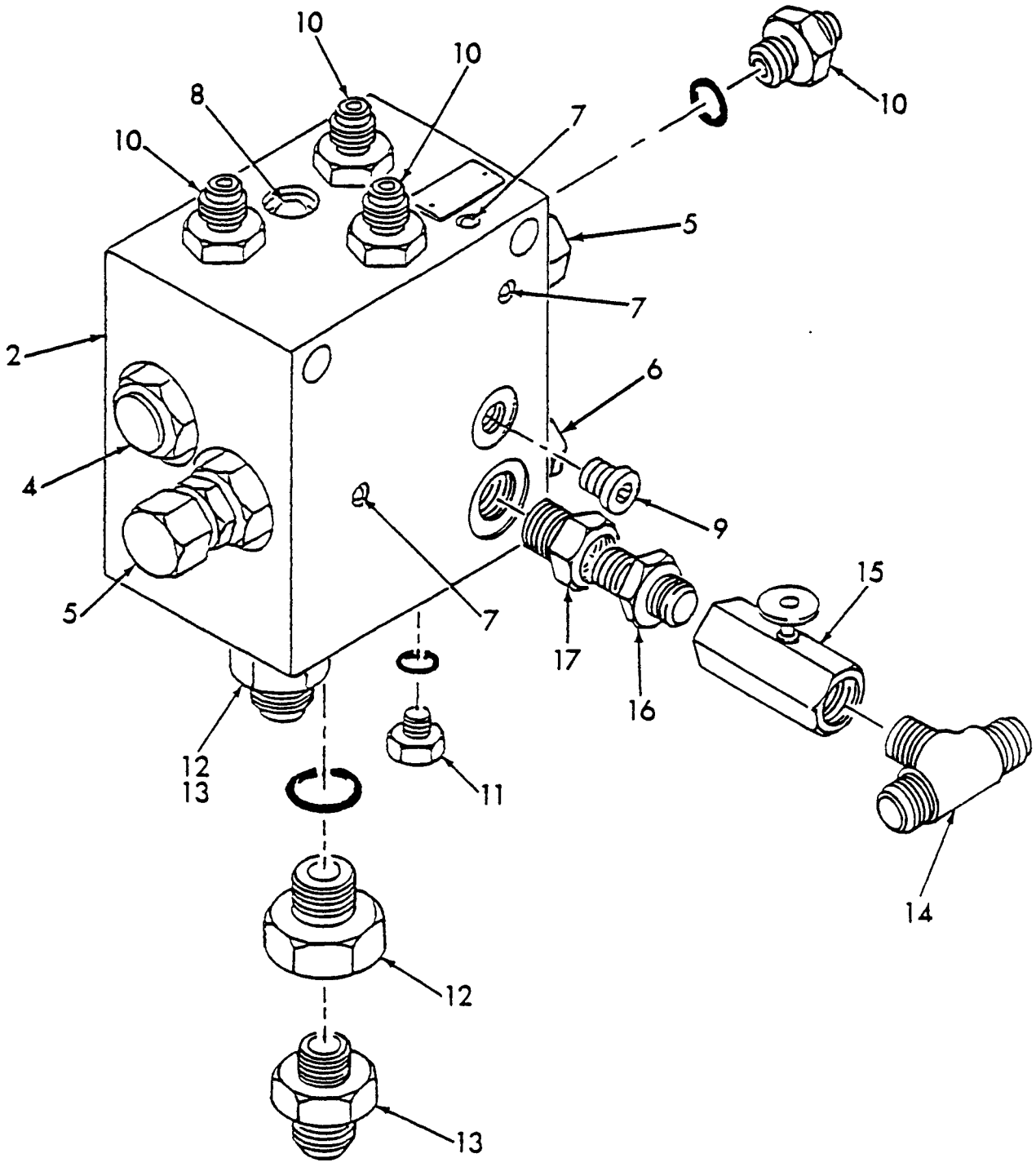
NOTE 1: DUE TO VENDOR/MFG. REVISIONS; WHEN POSSIBLE, PROVIDE ALL NUMBERS FROM THE CYLINDER I.D. TAG.

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	22212	ASSEMBLY, STEERING CYLINDER (See Sect. 3, Fig. 1 for NHA)	REF
2	.22119	CYLINDER, STEERING (COL)	1
		NOTE 2: INTERNAL SERVICE REPLACEMENT PARTS AVAILABLE ON A SPECIAL ORDER BASIS.	
-3	..600325	KIT, SEAL (COL)	1
		NOTE 3: THE SEAL KIT INCLUDES ITEMS SHOWN WITH AN ASTERISK (*).	
4	..600406	BUSHING	2
5	.80012-03	ELBOW, STRAIGHT THREAD	2

REV.

Mark Industries

TITLE	DRIVE/BRAKE VALVE ASSEMBLY	SECT.	3
MODEL	100C 6X4	FIG.	4
NOTES		SHEET	1



REV.

Mark Industries

TITLE	DRIVE/BRAKE VALVE ASSEMBLY
MODEL	100C 6X4
NOTES	

SECT.	3
FIG.	4
SHEET	2

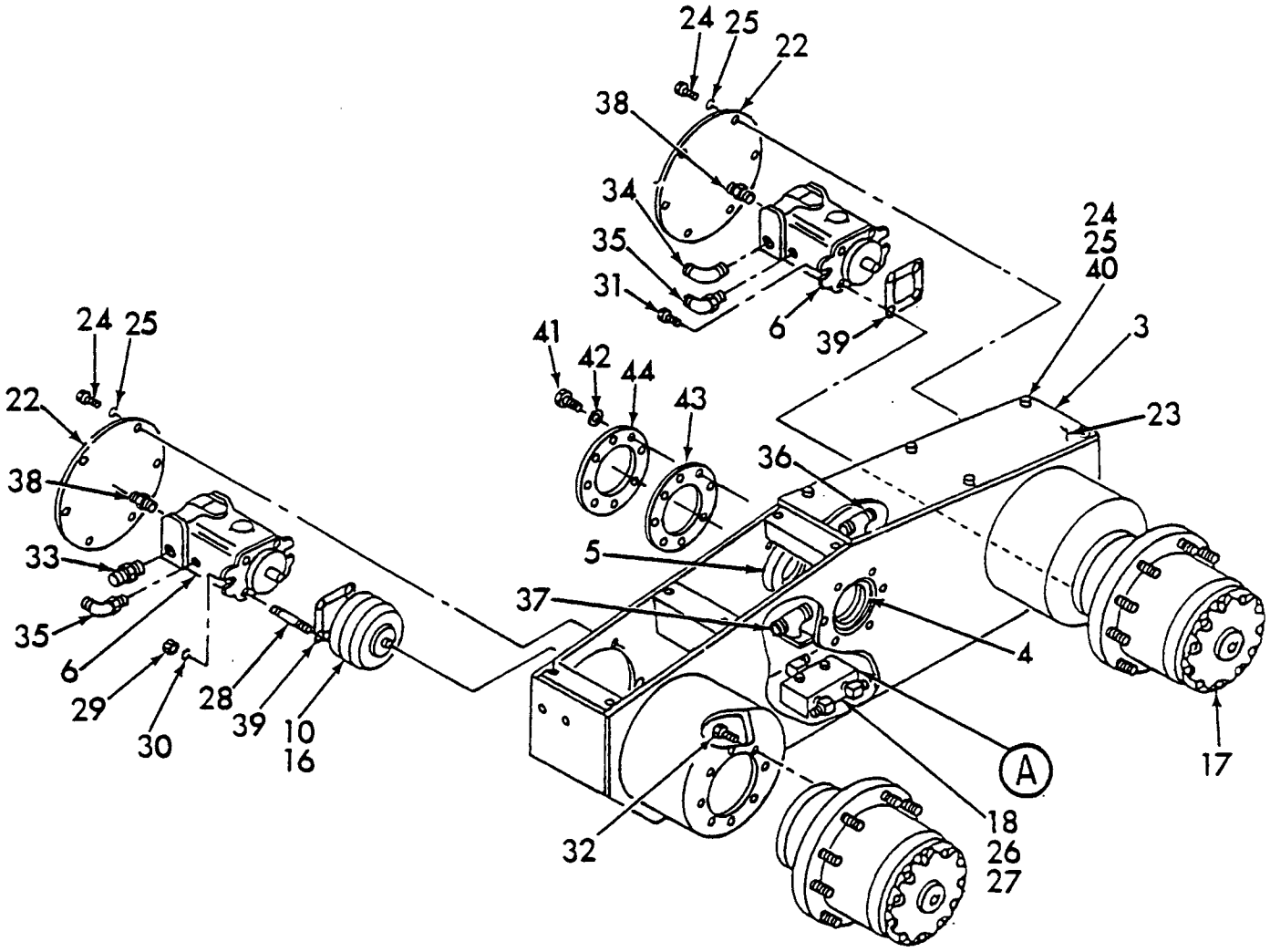
ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	22501	ASSEMBLY, DRIVE/BRAKE VALVE (See Sect. 3, Fig. 1 for NHA)	REF
2	.22433	VALVE, DRIVE/BRAKE	1
-3	..67953	KIT, SEAL	1
4	..67711	VALVE, FLOW DIVIDER/COMBINER	1
5	..600302	VALVE, COUNTERBALANCE	2
6	..67713	VALVE, SHUTTLE	1
7	..67715	PLUG, EXPANDER	4
8	..67716	PLUG, EXPANDER	1
9	..67717	PLUG, SAE	1
10	.80004-18	CONNECTOR	4
11	.80050-05	PLUG	1
12	.80063-16	ADAPTER	2
13	.80001-21	CONNECTOR	2
14	.80034-04	TEE	1
15	.20357	VALVE, NEEDLE	1
16	.80052-04	NIPPLE, PIPE	1
17	.80063-01	ADAPTER	1

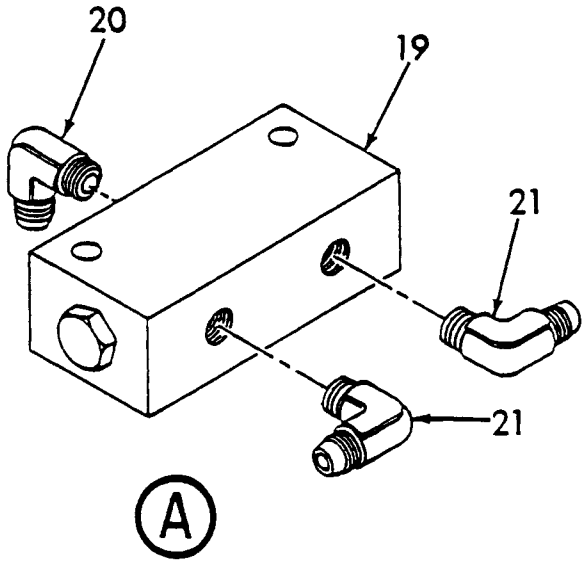
REV.

DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

Mark Industries

TITLE	WALKING BEAM ASSEMBLY	SECT. 3
MODEL	100C 6X4	FIG. 5
NOTES		SHEET 1





REV.

Mark Industries

TITLE	WALKING BEAM ASSEMBLY	SECT. 3
MODEL	100C 6X4	FIG. 5
NOTES		SHEET 2

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	21628	ASSEMBLY, WALKING BEAM (See Sect. 3, Fig. 1 for NHA)	REF
-2	.21883	SUB-ASSEMBLY, WALKING BEAM	1
3	..21627	WELDMENT, WALKING BEAM	1
4	..21641	BEARING	1
5	..21640	BEARING	1
6	.23526	MOTOR, HYDRAULIC (WITH INTERNAL SHIFT) (See Vendor Chapter for Details)	2
-7	..67632	KIT, SEAL	1
-8	...67868	SEAL, SHAFT	1
-9	.21659	ASSEMBLY, BRAKE	1
10	..21220	BRAKE (See Vendor Chapter for Details)	1
-11	...66972	KIT, SEAL	1
-12	...67643	KIT, LINING	1
-13	...67656	KIT, BEARING	1
-14	...67649	KIT, SPRING	1
-15	...67661	PISTON	1
16	..80004-03	CONNECTOR, STRAIGHT THREAD	2
17	.21222	HUB, TORQUE (See Sect. 3, Fig. 2 for Details)	2
-18	.22579	ASSEMBLY, FLOW DIVIDER	1
19	..81296	VALVE, FLOW DIVIDER	1
20	..80012-21	ELBOW, STRAIGHT THREAD	1
21	..80008-19	ELBOW, MALE	2
22	.21631	COVER, WALKING BEAM	2
23	.21639	COVER, WALKING BEAM	2

Mark Industries

TITLE	WALKING BEAM ASSEMBLY	SECT. 3
MODEL	100C 6X4	FIG. 5
NOTES		SHEET 3

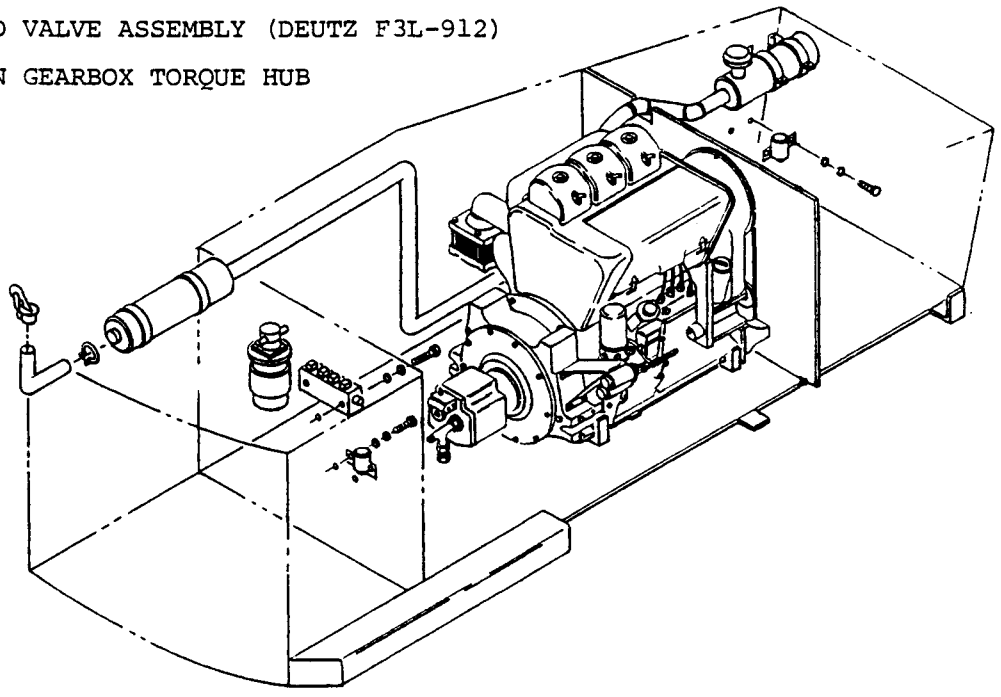
ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
24	.60322	SCREW, CAP	30
25	.63302	WASHER, SPLIT	30
26	.60317	SCREW, CAP	2
27	.63319	WASHER, SPLIT	2
28	.63633	STUD	4
29	.60705	NUT, HEX	4
30	.63305	WASHER, SPLIT	4
31	.60602	SCREW, CAP	4
32	.60604	SCREW, CAP	16
33	.80004-21	CONNECTOR, STRAIGHT THREAD	2
34	.80012-21	ELBOW, STRAIGHT THREAD	2
35	.80012-13	ELBOW, STRAIGHT THREAD	2
36	.80035-03	TEE, BULKHEAD	1
37	.80035-06	TEE, BULKHEAD	1
38	.80004-03	CONNECTOR, STRAIGHT THREAD	2
39	.66847	GASKET	2
40	.63402	WASHER, FLAT	12
41	.60309	SCREW, CAP	8
42	.63301	WASHER, SPLIT	8
43	.21645	GASKET	2
44	.21644	RETAINER, SEAL	1

REV.

DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

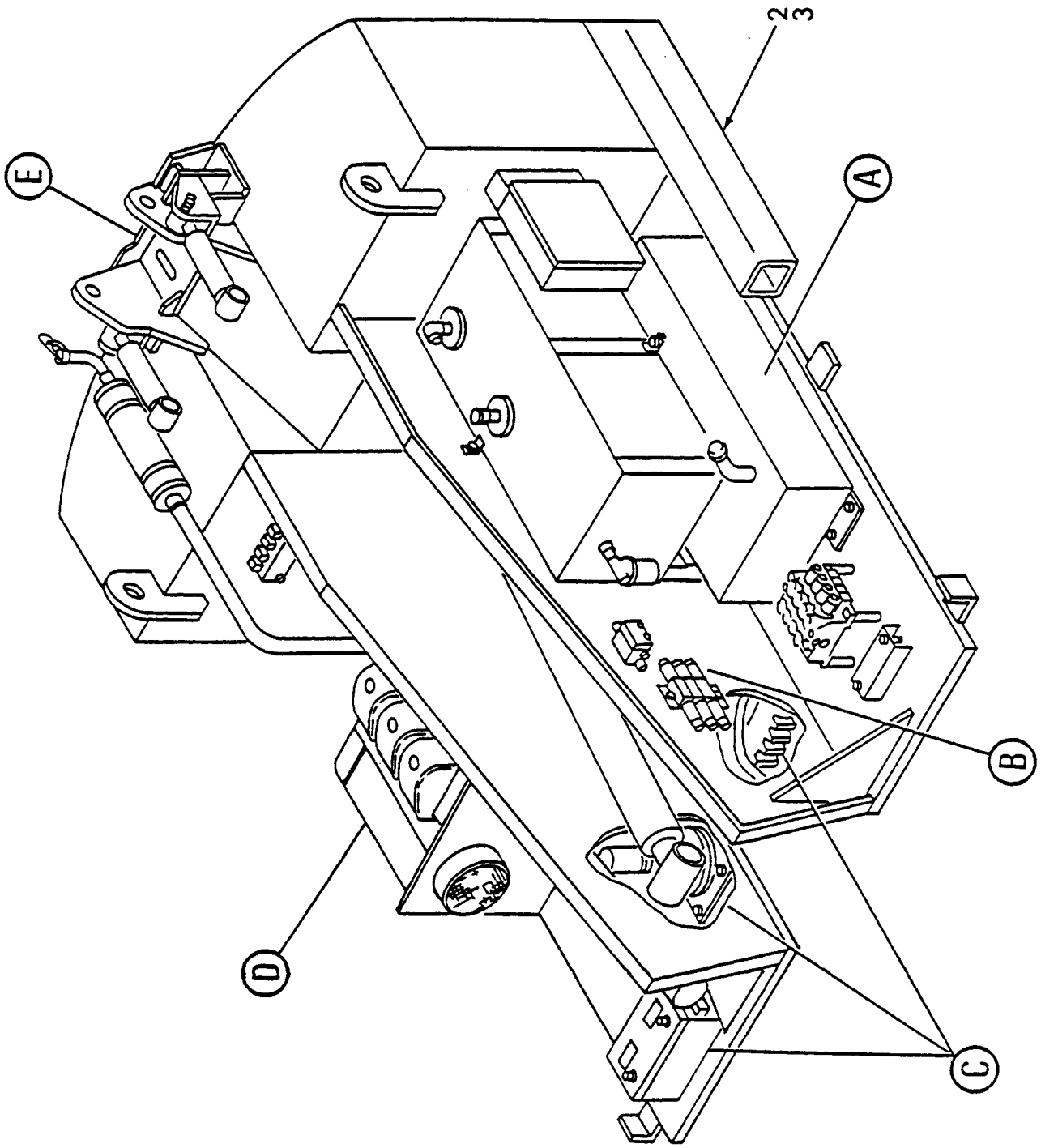
SECTION 4 CONTAINS:

FIG. NO.	TITLE
1	TURRET ASSEMBLY
2	LIFT CYLINDER ASSEMBLY (CONCURRENT USE; SINCE EARLY 1990)(SE)
2A	LIFT CYLINDER ASSEMBLY (CONCURRENT USE; SINCE MID 1990)(GB)
3	MASTER LEVELING CYLINDER (CONCURRENT USE; SINCE EARLY 1986)(RA)
3A	MASTER LEVELING CYLINDER (CONCURRENT USE; SINCE EARLY 1986)(SE)
3B	MASTER LEVELING CYLINDER (CONCURRENT USE; SINCE LATE 1986)(TH)
3C	MASTER LEVELING CYLINDER (CONCURRENT USE; SINCE LATE 1986)(GB)
4	ENGINE/PUMP ASSEMBLY (DEUTZ F3L-912)
5	GROUND CONTROL BOX ASSEMBLY
6	FUEL TANK ASSEMBLY
7	BATTERY CABLE KIT (DEUTZ F3L-912)
8	HYDRAULIC TANK ASSEMBLY
9	ROTATION GEARBOX ASSEMBLY
10	PROPORTIONAL VALVE ASSEMBLY
11	MINIPAK ASSEMBLY
12	SOLENOID VALVE ASSEMBLY
13	ROTARY MANIFOLD ASSEMBLY (UNTIL EARLY 1988)
13A	ROTARY MANIFOLD ASSEMBLY (SINCE EARLY 1988)
14	EMERGENCY PUMP/MOTOR ASSEMBLY
15	DUMP VALVE ASSEMBLY
16	SOLENOID VALVE ASSEMBLY (DEUTZ F3L-912)
17	ROTATION GEARBOX TORQUE HUB



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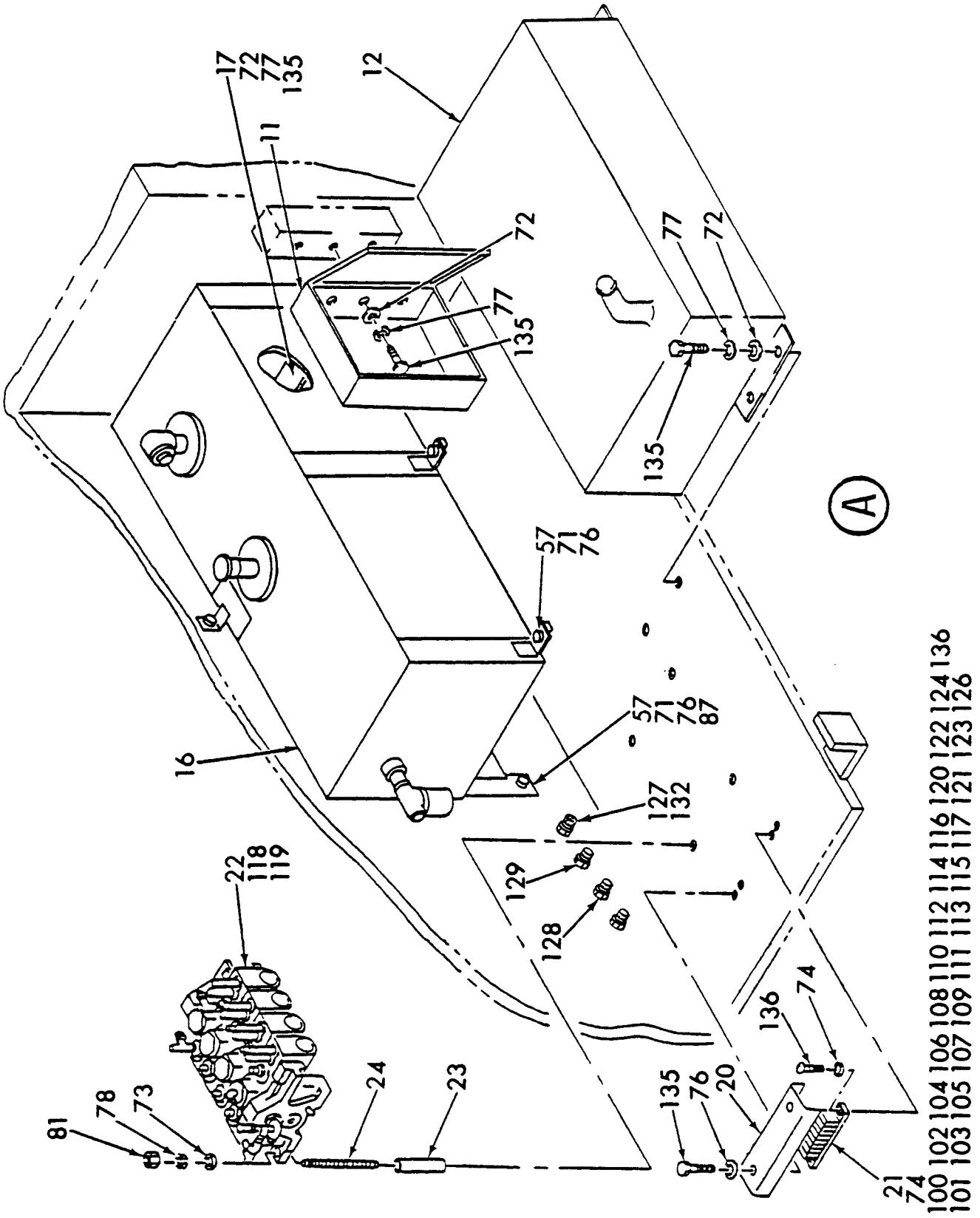
TITLE	TURRET ASSEMBLY	SECT.	4
MODEL	100C 6X4	FIG.	1
NOTES		SHEET	1



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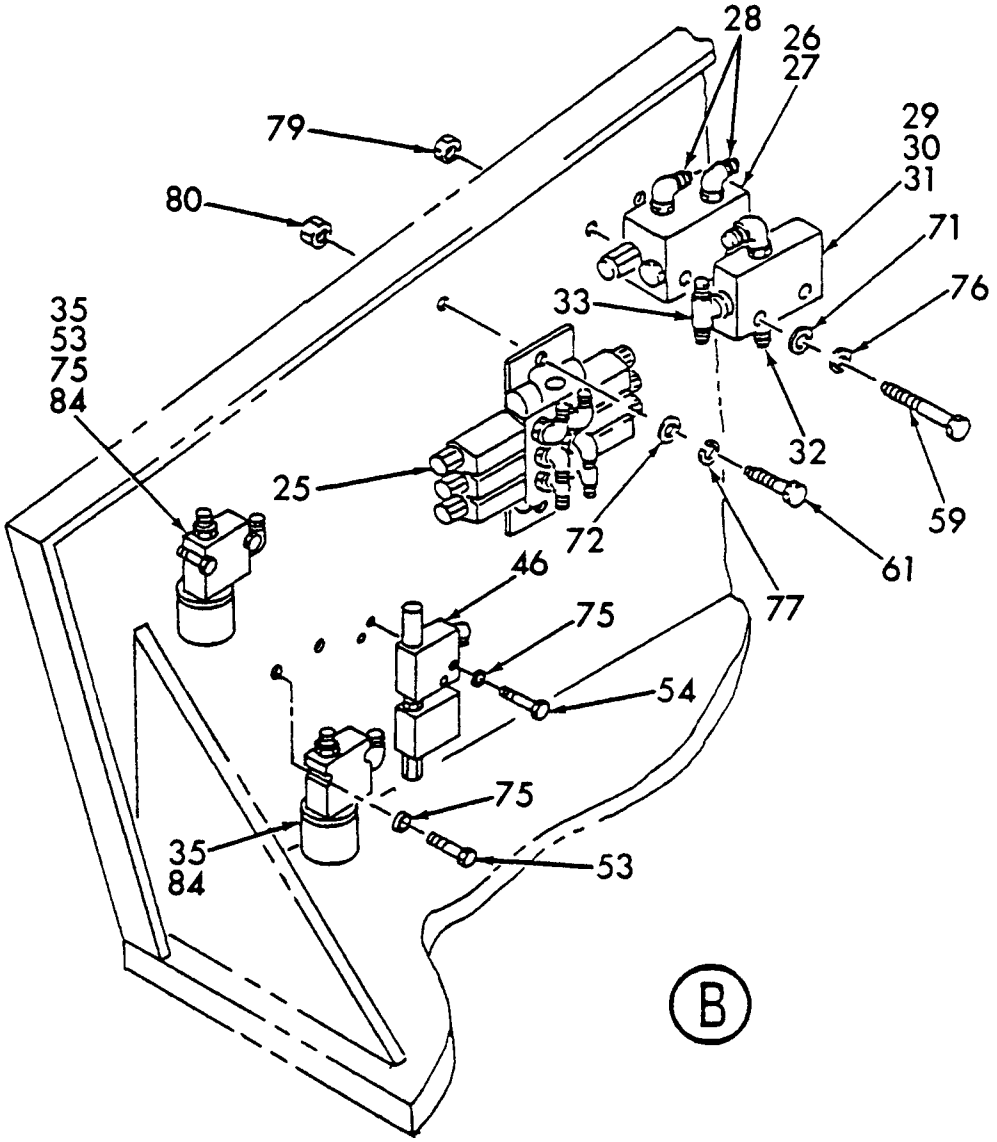
TITLE	TURRET ASSEMBLY	SECT.	4
MODEL	100C 6X4	FIG.	1
NOTES		SHEET	2



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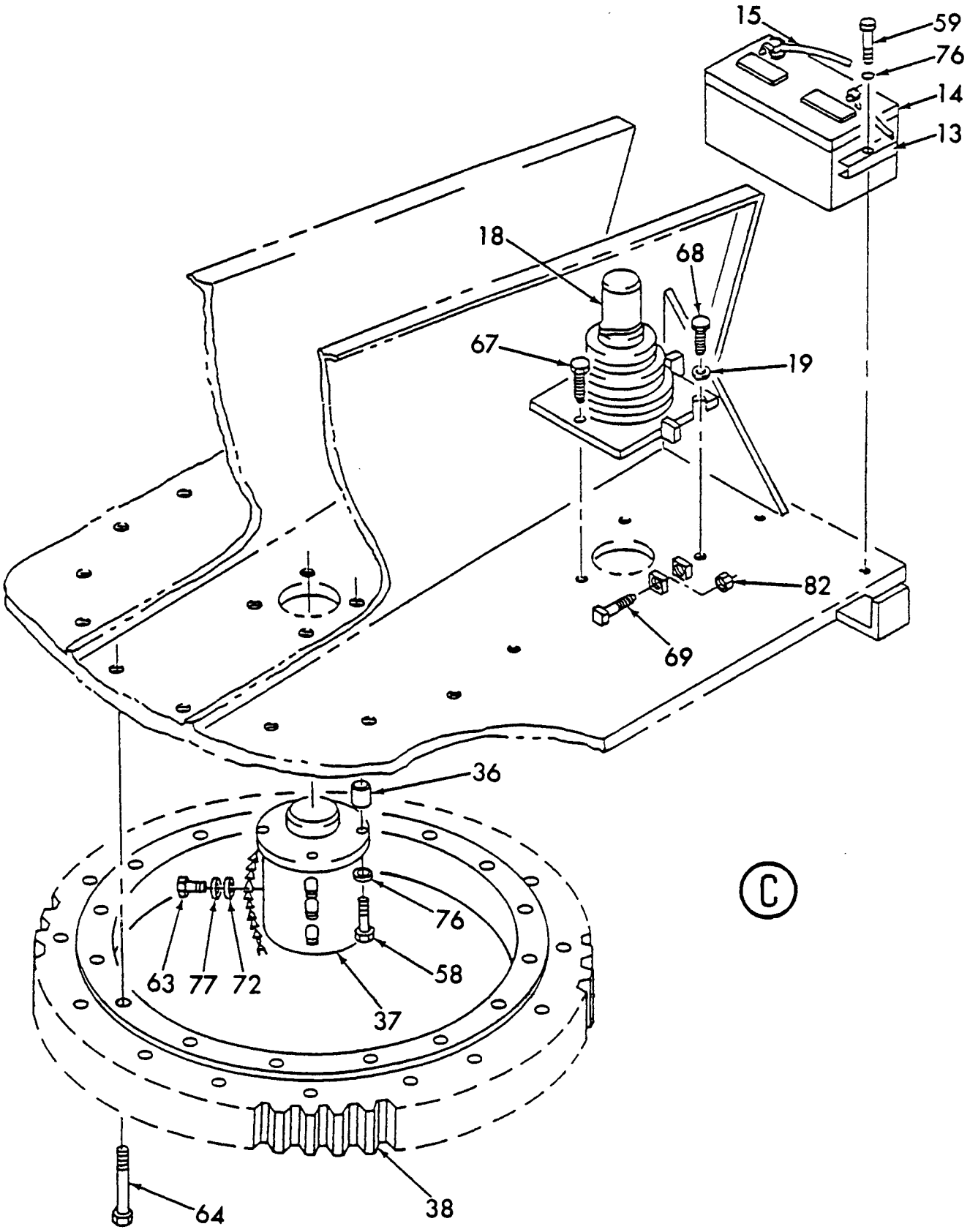
TITLE	TURRET ASSEMBLY	SECT.	4
MODEL	100C 6X4	FIG.	1
NOTES		SHEET	3



REV.

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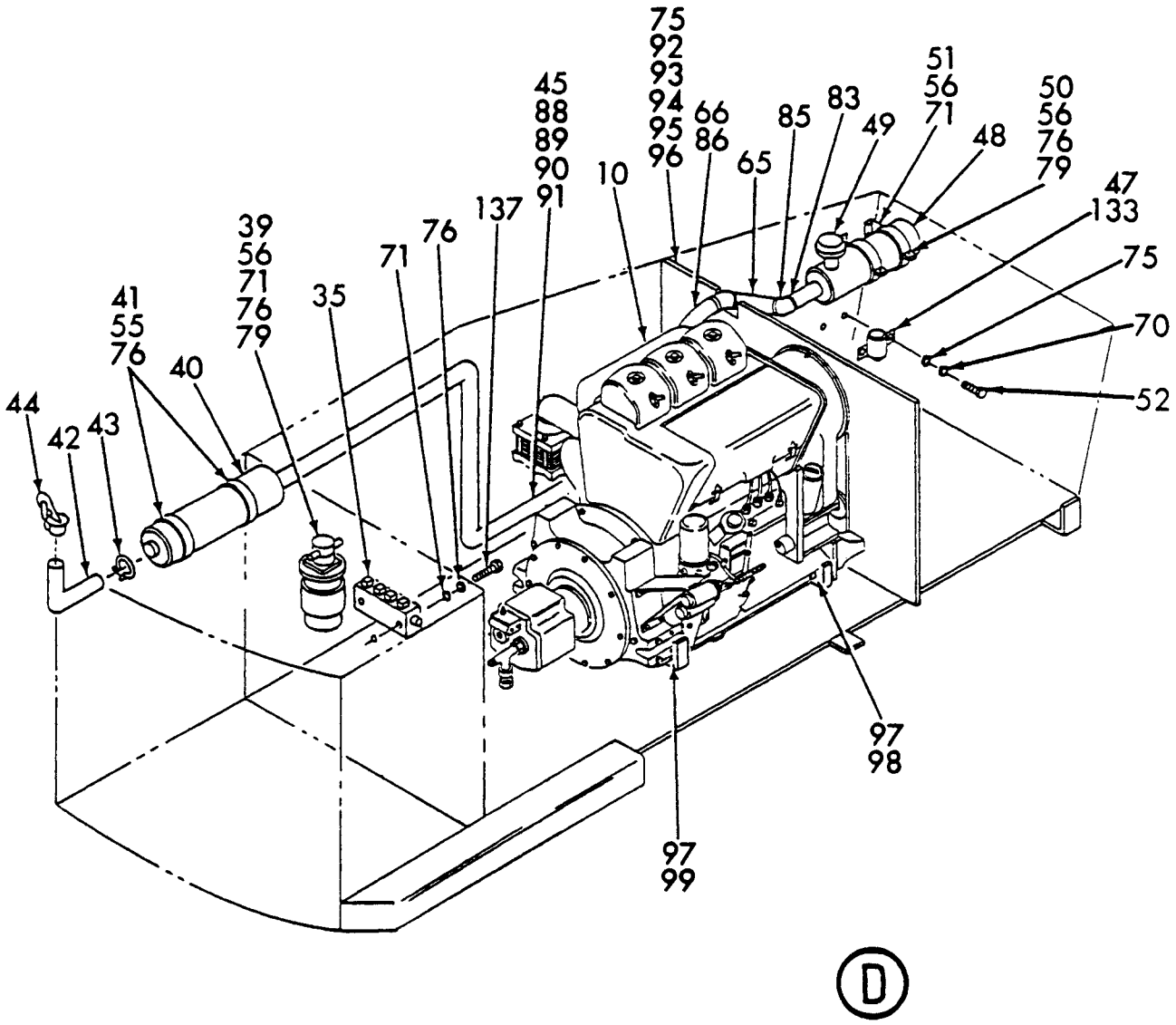
TITLE	TURRET ASSEMBLY	SECT.	4
MODEL	100C 6X4	FIG.	1
NOTES		SHEET	4



REV.

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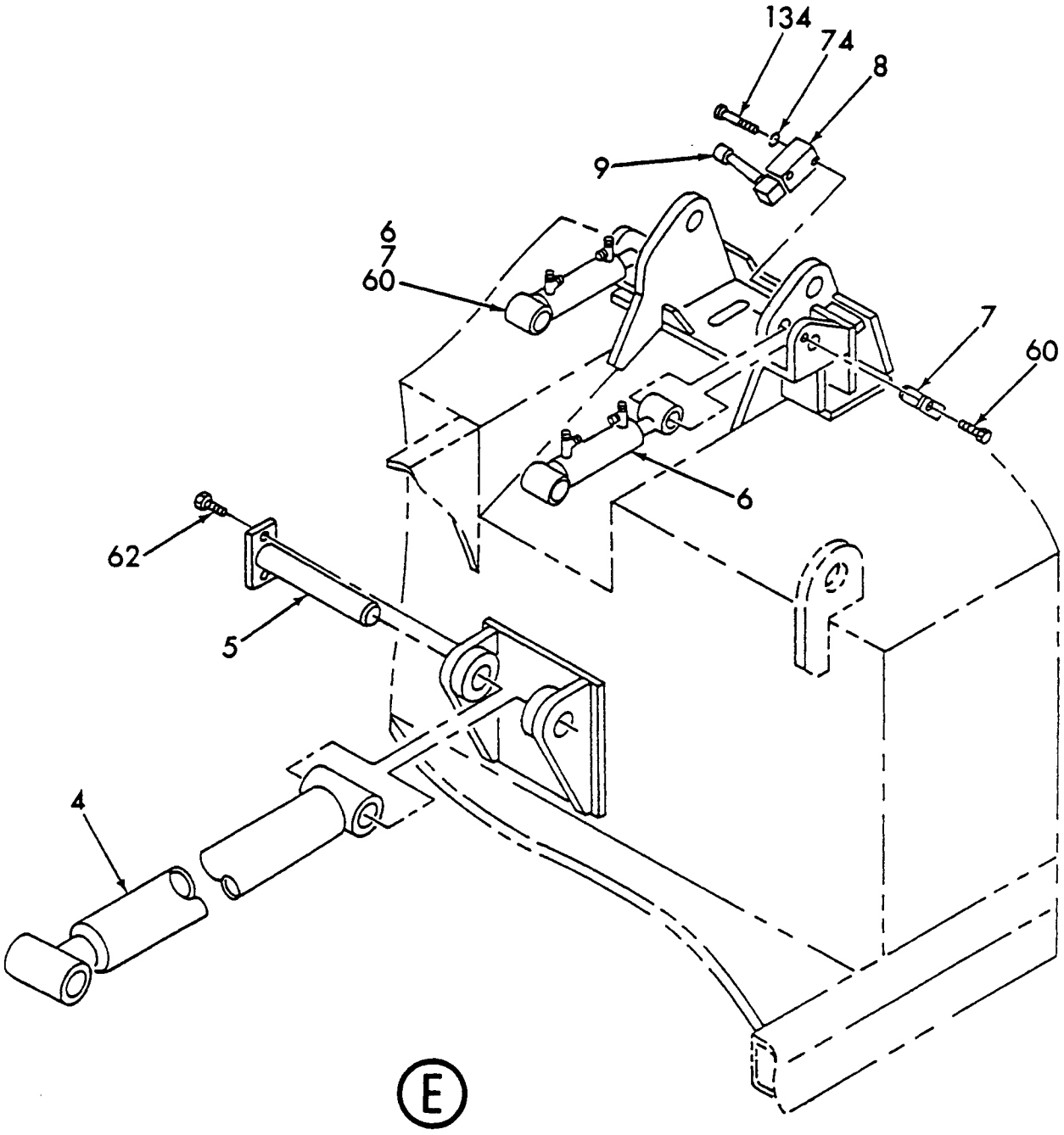
TITLE	TURRET ASSEMBLY	SECT.	4
MODEL	100C 6X4	FIG.	1
NOTES		SHEET	5



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TITLE	TURRET ASSEMBLY	SECT.	4
MODEL	100C 6X4	FIG.	1
NOTES		SHEET	6



REV.

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TITLE	TURRET ASSEMBLY
MODEL	100C 6X4
NOTES	

SECT.	4
FIG.	1
SHEET	7

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	24485	ASSEMBLY, TURRET (See Sect. 2, Fig. 1 for NHA)	REF
2	.24482	WELDMENT, TURRET	1
3	..24481	WELDMENT, PEDESTAL	1
4	.24056	ASSEMBLY, LIFT CYLINDER (See Sect. 4, Fig. 2 & 2A for Details)	1
5	.22046	PIN, LIFT CYLINDER	1
6	.21084	ASSEMBLY, MASTER LEVELING CYLINDER (See Sect. 4, Fig. 3 thru 3C for Details)	2
7	.21337	PIN, MASTER LEVELING CYLINDER	2
8	.70107	SWITCH, LIMIT	1
9	.70031	LEVER, SWITCH	1
10	.22201	ASSEMBLY, ENGINE/PUMP (DEUTZ F3L912) (See Sect. 4, Fig. 4 for Details)	1
11	.24298	ASSEMBLY, GROUND CONTROL BOX (See Sect. 4, Fig. 5 for Details)	1
12	.22136	ASSEMBLY, FUEL TANK (See Sect. 4, Fig. 6 for Details)	1
13	.21286	BRACKET, BATTERY HOLD DOWN	2
14	.21244	BATTERY	1
15	.24638	KIT, BATTERY CABLE (DEUTZ F3L912) (See Sect. 4, Fig. 7 for Details)	1
16	.24504	ASSEMBLY, HYDRAULIC TANK (62 GAL.) (See Sect. 4, Fig. 8 for Details)	1
17	.24517	SUPPORT, HYDRAULIC TANK	1
18	.22789	ASSEMBLY, ROTATION GEARBOX (See Sect. 4, Fig. 9 for Details)	1
19	.22169	WASHER	2
20	.21386	COVER, TERMINAL STRIP	2
21	.21217	STRIP, TERMINAL	2

DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
22	.24865	ASSEMBLY, PROPORTIONAL VALVE (See Sect. 4, Fig. 10 for Details)	1
23	.27527	TUBE, ROUND	3
24	.63633	STUD	3
25	.22607	ASSEMBLY, MINIPAK (See Sect. 4, Fig. 11 for Details)	1
26	.22510	ASSEMBLY, OVERCENTER VALVE	1
27	..20365	VALVE, DUAL OVERCENTER	1
28	..80012-05	ELBOW, STRAIGHT THREAD	4
29	.22144	ASSEMBLY, RELIEF VALVE	1
30	..20564	REWORK, RELIEF VALVE	1
31	...20516	VALVE, RELIEF	1
32	..80004-11	CONNECTOR, STRAIGHT THREAD	1
33	..80036-11	TEE	1
-34	..80012-11	ELBOW, STRAIGHT THREAD	1
35	.22609	ASSEMBLY, SOLENOID VALVE (See Sect. 4, Fig. 12 for Details)	1
36	.20445	SPACER, MANIFOLD	4
37	.21898	ASSEMBLY, ROTARY MANIFOLD (See Sect. 4, Fig. 13 & 13A for Details)	1
38	.22021	GEAR, RING	1
39	.22390	ASSEMBLY, EMERGENCY PUMP/MOTOR (See Sect. 4, Fig. 14 for Details)	1
40	.65328	MUFFLER	1
41	.65336	BRACKET, MUFFLER	2
42	.65337	ELBOW, MUFFLER	1
43	.16288	CLAMP, HOSE	2
44	.21288	CAP, RAIN MUFFLER	1

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
45	.22186	EXHAUST	1
46	.22204	ASSEMBLY, DUMP VALVE (DRIVE) (See Sect. 4, Fig. 15 for Details)	1
47	.70209	SOLENOID	2
48	.65324	CLEANER, AIR (DRY TYPE)	1
49	.65348	HOOD, AIR INLET	1
50	.65325	BAND, MOUNTING	2
51	.22208	BRACKET, MOUNTING AIR CLEANER	2
52	.60353	SCREW, CAP	4
53	.60319	SCREW, CAP	4
54	.60340	SCREW, CAP	2
55	.60322	SCREW, CAP	6
56	.60338	SCREW, CAP	5
57	.60346	SCREW, CAP	8
58	.60511	SCREW, CAP	4
59	.60316	SCREW, CAP	2
60	.60607	SCREW, CAP	2
61	.60343	SCREW, CAP	8
62	.60618	SCREW, CAP	2
63	.60612	SCREW, CAP	4
64	.60604	SCREW, CAP	16
65	.25377	TUBING	1
66	.25380	TUBE, ROUND	1
67	.60601	SCREW, CAP	1
68	.60637	SCREW, CAP	2
69	.62222	SCREW, CAP	2

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
70	.63401	WASHER, FLAT	8
71	.63402	WASHER, FLAT	5
72	.63403	WASHER, FLAT	13
73	.63405	WASHER, FLAT	3
74	.63313	WASHER, SPLIT	2
75	.63301	WASHER, SPLIT	6
76	.63302	WASHER, SPLIT	6
77	.63303	WASHER, SPLIT	13
78	.63305	WASHER, SPLIT	3
79	.60702	NUT, HEX	6
80	.60703	NUT, HEX	2
81	.60705	NUT, HEX	3
82	.60910	NUT, JAM	2
83	.65326	CLAMP, AIR INLET	6
84	.22909	ASSEMBLY, SOLENOID VALVE (DEUTZ F3L912) (See Sect. 4, Fig. 16 for Details)	2
85	.65344	ELBOW	2
86	.65327	HOSE	1
87	.24513	WELDMENT, BRACKET (HYDRAULIC TANK)	2
88	.65331	SCREW, CAP	3
89	.65332	NUT, HEX	3
90	.65330	GASKET, EXHAUST	1
91	.65329	FLANGE, EXHAUST	1
92	.60312	SCREW, CAP	19
93	.60701	NUT, HEX	19
94	.22179	BAFFLE, UPPER	1

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TITLE	TURRET ASSEMBLY
MODEL	100C 6X4
NOTES	

SECT.	4
FIG.	1
SHEET	11

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
95	.22211	BAFFLE, LOWER	1
96	.22287	STIFFENER	1
97	.22082	STANDOFF	4
98	.22202	SUPPORT, FRONT	1
99	.22205	SUPPORT, REAR	1
100	.6K	WIRE, BLACK	12 FT
101	.55	CLAMP, HOSE	3
102	.117-C	TERMINAL, RING (BLUE)	6
103	.117-M	TERMINAL, RING (BLUE)	3
104	.764	CLAMP, RUBBER	1
105	.2912	CONDUCTOR, CABLE	33 FT
106	.2991	WIRE, WHITE	35 FT
107	.4034	CABLE	18 FT
108	.21351	CABLE	18 FT
109	.65681	WASHER, LOCK	1
110	.66356	TERMINAL, FEMALE DISCONNECT	2
111	.66357	TERMINAL, MALE DISCONNECT	1
112	.70068	CONNECTOR, BUTT	5
113	.70036	WIRE	55 FT
114	.70069	CONNECTOR, BUTT	7
115	.70162	TERMINAL, BUTT	2
116	.70270	TERMINAL, RING	3
117	.70479	DIODE	6
118	.70500	TERMINAL, FEMALE DISCONNECT	29
119	.70501	TERMINAL, MALE DISCONNECT	21

DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

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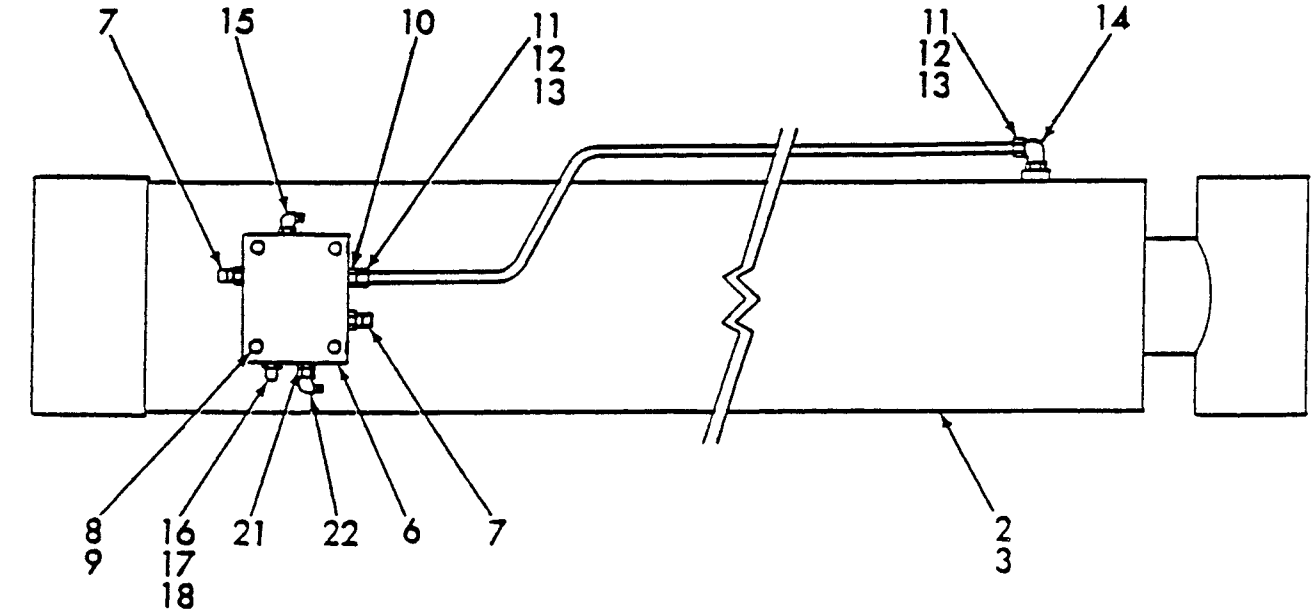
TITLE	TURRET ASSEMBLY	SECT.	4
MODEL	100C 6X4	FIG.	1
NOTES		SHEET	12

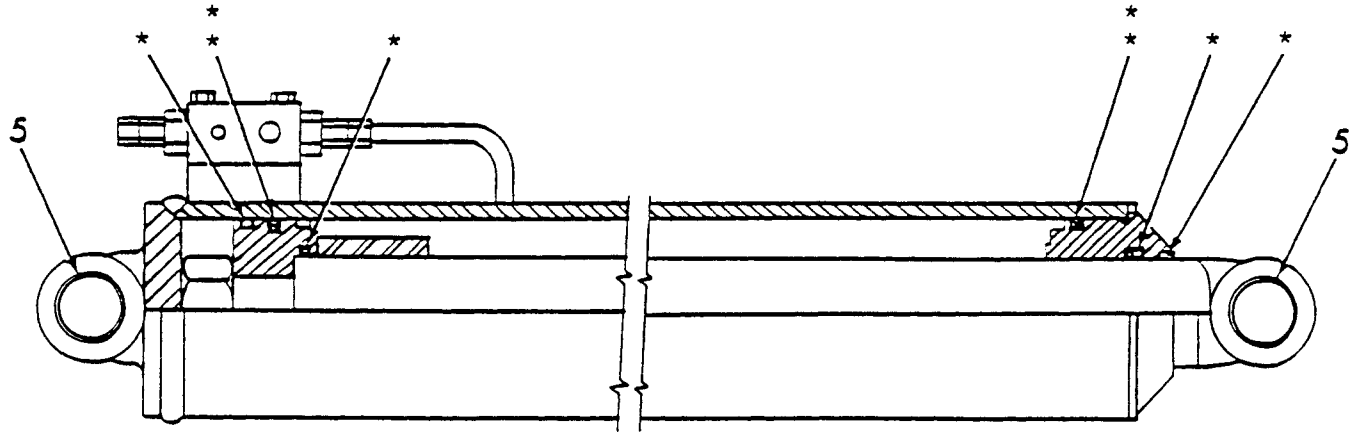
ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
120	.70566	TERMINAL, FORK SPADE (RED)	34
121	.70567	TERMINAL, RING (RED)	3
122	.70581	WASHER, LOCK	1
123	.70584	WASHER, LOCK	2
124	.70616	WASHER, STAR (INT/EXT)	2
-125	.22187	VALVE, CHECK	1
126	.255	TIE, CABLE	100
127	.80011-08	UNION, BULKHEAD ELBOW	2
128	.80017-03	UNION, BULKHEAD ELBOW	3
129	.80017-05	UNION, BULKHEAD ELBOW	1
-130	.24616 KIT-B	DIAGRAM, HYDRAULIC HOSE (See Sect. 2, Fig. 6 for Details)	1
-131	.24616 KIT-D	DIAGRAM, HYDRAULIC HOSE (See Sect. 2, Fig. 6 for Details)	1
132	.65352	WASHER, LOCK	2
133	.23808	BAR, BUSS	1
134	.62615	SCREW, CAP	2
135	.60343	SCREW, CAP	8
136	.62611	SCREW, CAP	2
137	.60346	SCREW, CAP	2

DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

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TITLE	LIFT CYLINDER ASSEMBLY	SECT.	4
MODEL	100C 6X4	FIG.	2
NOTES	CONCURRENT USE; SINCE EARLY 1988 (SE)	SHEET	1





NOTE 1: DUE TO VENDOR/MFG. REVISIONS; WHEN POSSIBLE, PROVIDE ALL NUMBERS FROM THE CYLINDER I.D. TAG.

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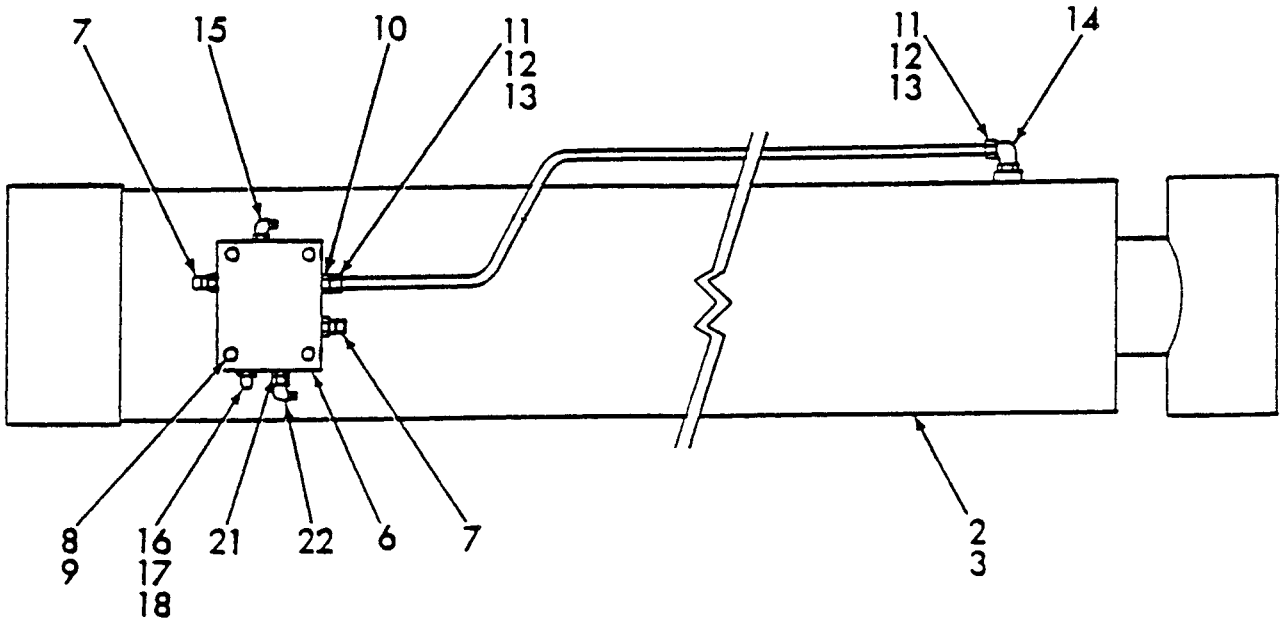
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MODEL	100C 6X4
NOTES	CONCURRENT USE; SINCE EARLY 1988 (SE)

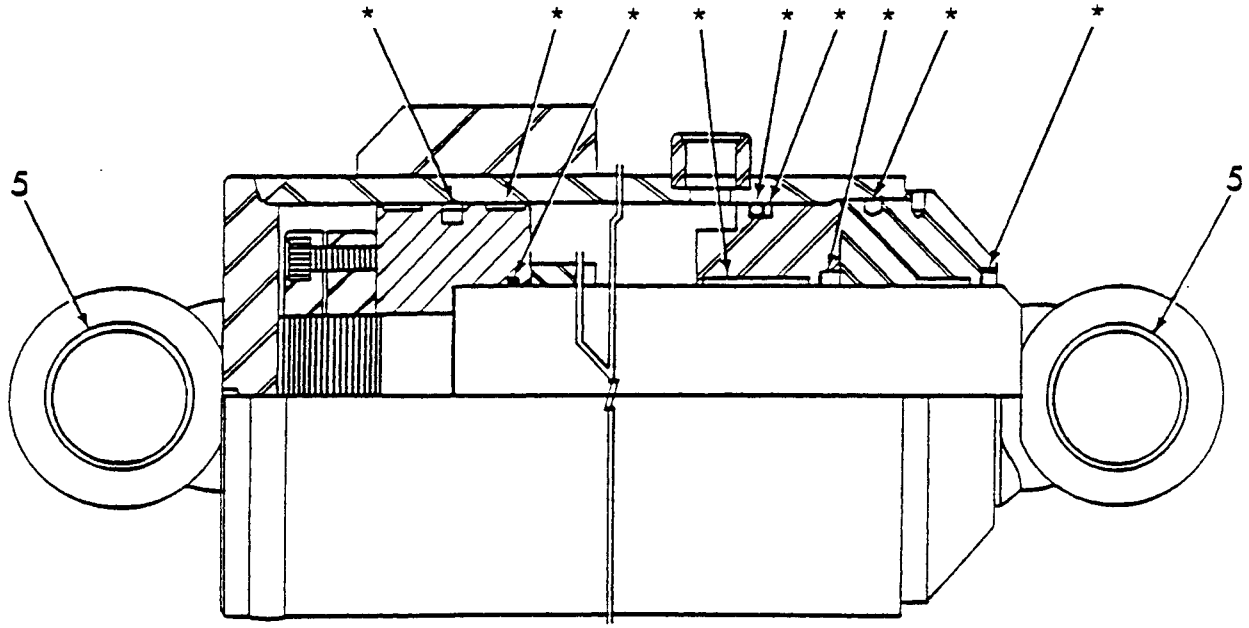
SECT.	4
FIG.	2
SHEET	2

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	24056	ASSEMBLY, LIFT CYLINDER (See Sect. 4, Fig. 1 for NHA)	REF
2	.24094	SUB-ASSEMBLY, LIFT CYLINDER (SE)	1
3	..24043	CYLINDER, LIFT	1
		NOTE 2: INTERNAL SERVICE REPLACEMENT PARTS AVAILABLE ON A SPECIAL ORDER BASIS.	
-4	...67776	KIT, SEAL (SE)	1
		NOTE 3: THE SEAL KIT INCLUDES ITEMS SHOWN WITH AN ASTERISK (*).	
5	...600170	BUSHING	4
6	..21445	VALVE, BLOCK	1
7	..81006	CARTRIDGE, OVERCENTER	2
8	..61943	SCREW	4
9	..63302	WASHER	4
10	..80004-19	CONNECTOR	1
11	..26379	TUBING, HYDRAULIC	1
12	..80062-08	SLEEVE	2
13	..80060-08	NUT	2
14	..80012-18	ELBOW	1
15	.80012-11	ELBOW	1
16	.50900	ELBOW	1
17	.80060-05	NUT	1
-18	.20348	ORIFICE	1
19	.80056-01	REDUCER	1
20	..62202	SCREW	1
21	.80004-11	CONNECTOR	1
22	.80015-06	NUT	1

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TITLE	LIFT CYLINDER ASSEMBLY	SECT.	4
MODEL	100C 6X4	FIG.	2A
NOTES	CONCURRENT USE; SINCE MID 1990 (GB)	SHEET	1





NOTE 1: DUE TO VENDOR/MFG. REVISIONS; WHEN POSSIBLE, PROVIDE ALL NUMBERS FROM THE CYLINDER I.D. TAG.

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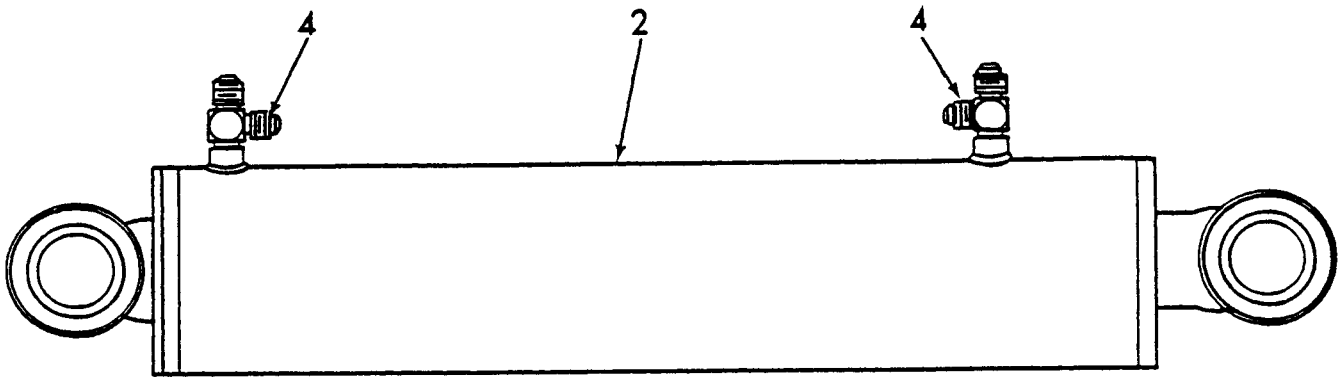
TITLE	LIFT CYLINDER ASSEMBLY
MODEL	100C 6X4
NOTES	CONCURRENT USE; SINCE MID 1990 (GB)

SECT.	4
FIG.	2A
SHEET	2

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	24056	ASSEMBLY, LIFT CYLINDER (See Sect. 4, Fig. 1 for NHA)	REF
2	.24094	SUB-ASSEMBLY, LIFT CYLINDER (GB)	1
3	..24043	CYLINDER, LIFT	1
		NOTE 2: INTERNAL SERVICE REPLACEMENT PARTS AVAILABLE ON A SPECIAL ORDER BASIS.	
-4	...600169	KIT, SEAL (GB)	1
		NOTE 3: THE SEAL KIT INCLUDES ITEMS SHOWN WITH AN ASTERISK (*).	
5	...600170	BUSHING	4
6	..21445	VALVE, BLOCK	1
7	..81006	CARTRIDGE, OVERCENTER	2
8	..61943	SCREW	4
9	..63302	WASHER	4
10	..80004-19	CONNECTOR	1
11	..26379	TUBING, HYDRAULIC	1
12	..80062-08	SLEEVE	2
13	..80060-08	NUT	2
14	..80012-18	ELBOW	1
15	.80012-11	ELBOW	1
16	.50900	ELBOW	1
17	.80060-05	NUT	1
-18	.20348	ORIFICE	1
19	..80056-01	REDUCER	1
20	..62202	SCREW	1
21	.80004-11	CONNECTOR	1
22	.80015-06	NUT	1

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TITLE	MASTER LEVELING CYLINDER ASSEMBLY	SECT.	4
MODEL	100C 6X4	FIG.	3
NOTES	CONCURRENT USE; SINCE EARLY 1986 (RA)	SHEET	1



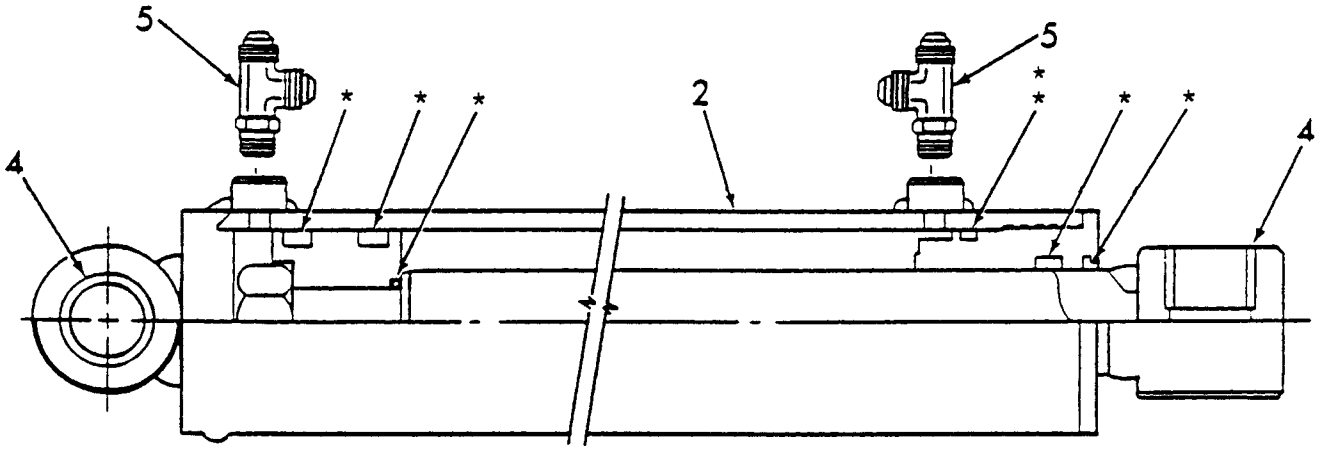
NOTE 1: DUE TO VENDOR/MFG. REVISIONS; WHEN POSSIBLE, PROVIDE ALL NUMBERS FROM THE CYLINDER I.D. TAG.

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	21084	ASSEMBLY, MASTER LEVELING CYLINDER (See Sect. 4, Fig. 1 for NHA)	REF
2	.21111	CYLINDER, MASTER LEVELING (RA)	1
		NOTE 2: INTERNAL SERVICE REPLACEMENT PARTS AVAILABLE ON A SPECIAL ORDER BASIS.	
-3	..66651	KIT, SEAL (RA)	1
4	.80033-03	TEE	2

REV.

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TITLE	MASTER LEVELING CYLINDER	SECT.	4
MODEL	100C 6X4	FIG.	3A
NOTES	CONCURRENT USE; SINCE EARLY 1986 (SE)	SHEET	1



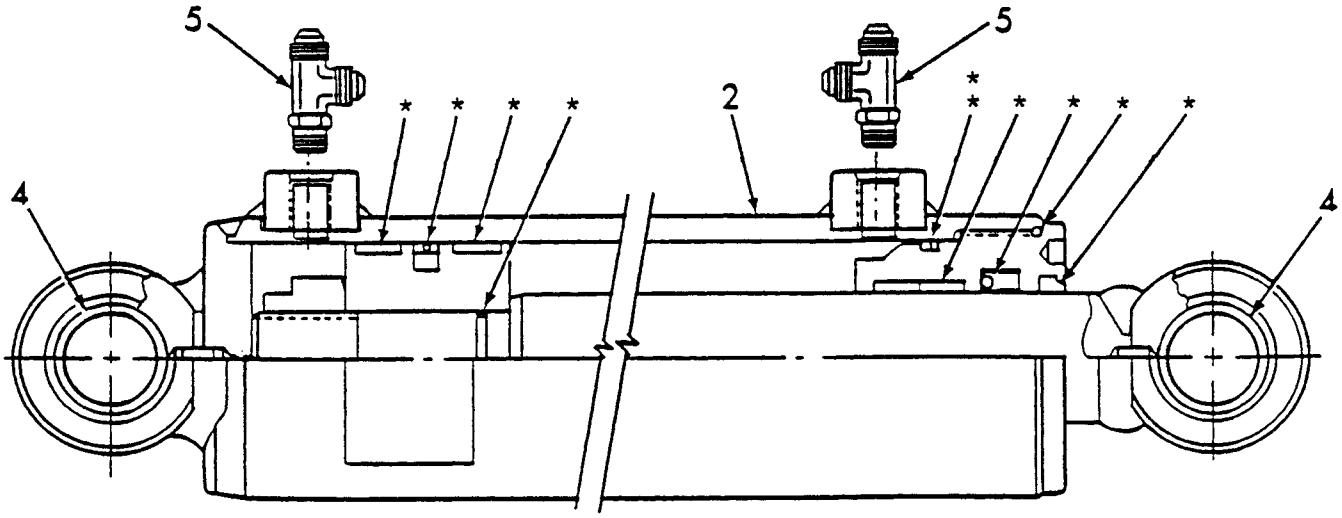
NOTE 1: DUE TO VENDOR/MFG. REVISIONS; WHEN POSSIBLE, PROVIDE ALL NUMBERS FROM THE CYLINDER I.D. TAG.

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	21084	ASSEMBLY, MASTER LEVELING CYLINDER (See Sect. 4, Fig. 1 for NHA)	REF
2	.21111	CYLINDER, MASTER LEVELING (SE)	1
		NOTE 2: INTERNAL SERVICE REPLACEMENT PARTS AVAILABLE ON A SPECIAL ORDER BASIS.	
-3	..66044	KIT, SEAL (SE)	1
		NOTE 3: THE SEAL KIT INCLUDES ITEMS SHOWN WITH AN ASTERISK (*).	
4	..67671	BUSHING	4
5	.80033-03	TEE	2

REV.

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TITLE	MASTER LEVELING CYLINDER	SECT.	4
MODEL	100C 6X4	FIG.	3B
NOTES	CONCURRENT USE; SINCE LATE 1986 (TH)	SHEET	1



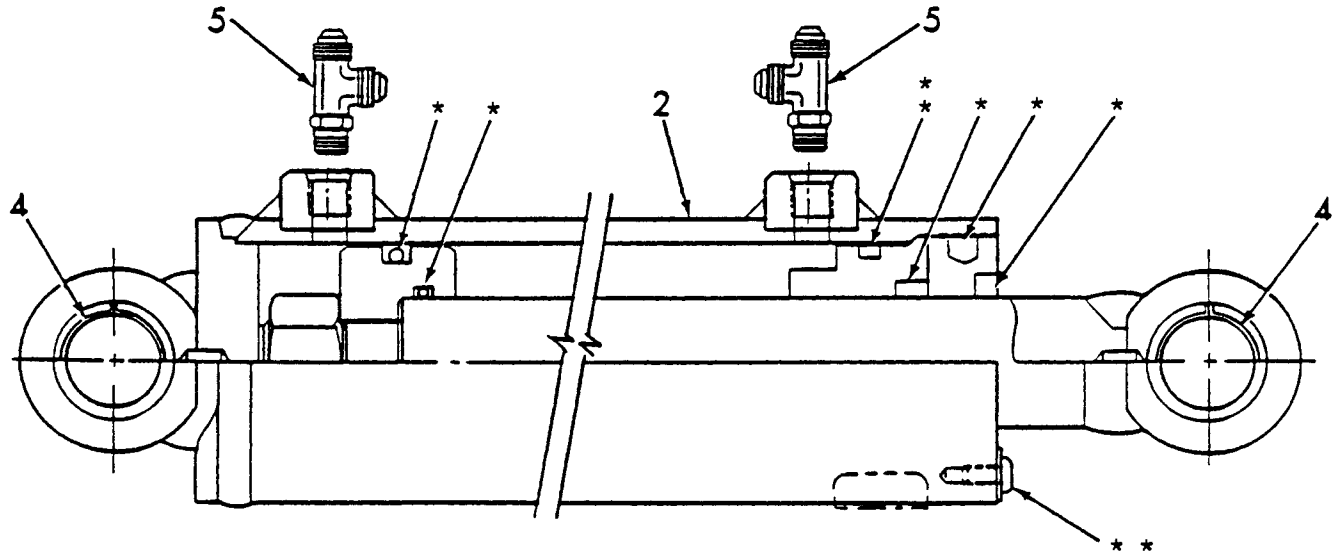
NOTE 1: DUE TO VENDOR/MFG. REVISIONS; WHEN POSSIBLE, PROVIDE ALL NUMBERS FROM THE CYLINDER I.D. TAG.

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	21084	ASSEMBLY, MASTER LEVELING CYLINDER (See Sect. 4, Fig. 1 for NHA)	REF
2	.21111	CYLINDER, MASTER LEVELING (TH)	1
		NOTE 2: INTERNAL SERVICE REPLACEMENT PARTS AVAILABLE ON A SPECIAL ORDER BASIS.	
-3	..600326	KIT, SEAL (TH)	1
		NOTE 3: THE SEAL KIT INCLUDES ITEMS SHOWN WITH AN ASTERISK (*).	
4	..600327	BUSHING	4
5	.80033-03	TEE	2

REV.

Mark Industries

TITLE	MASTER LEVELING CYLINDER	SECT.	4
MODEL	100C 6X4	FIG.	3C
NOTES	CONCURRENT USE; SINCE LATE 1986 (GB)	SHEET	1



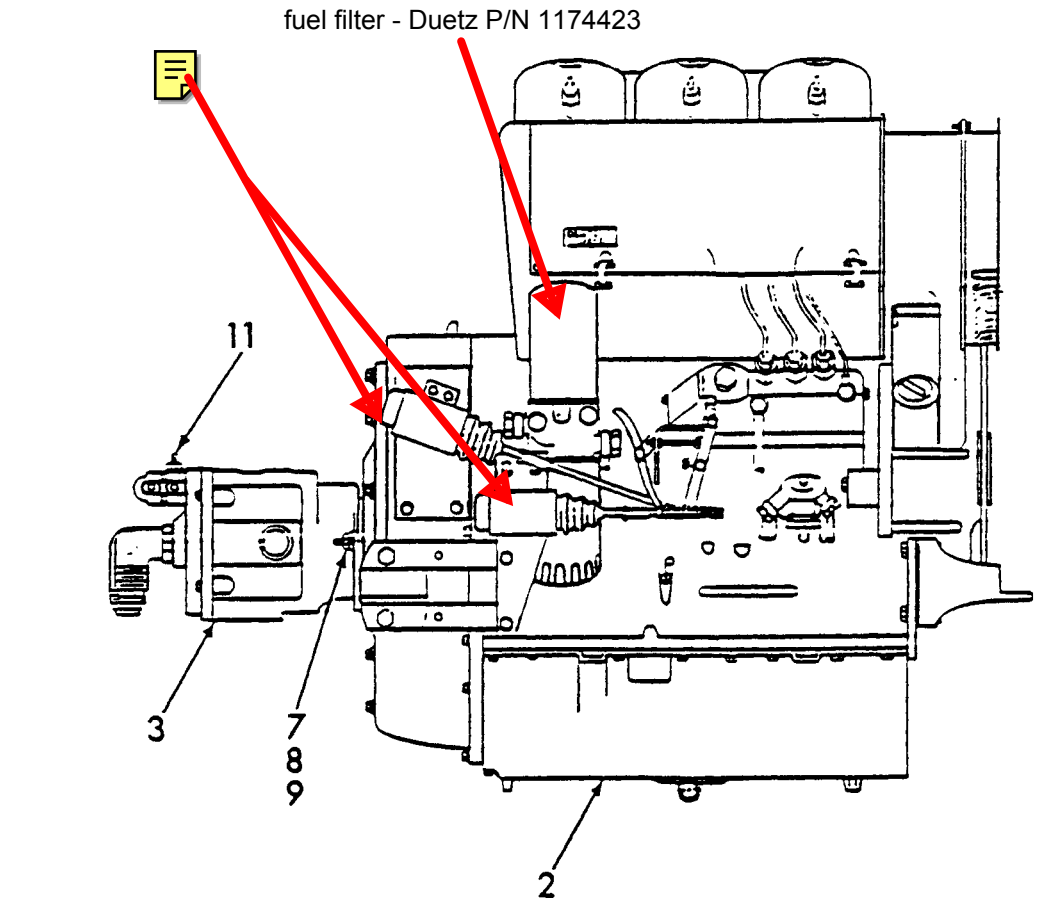
NOTE 1: DUE TO VENDOR/MFG. REVISIONS; WHEN POSSIBLE, PROVIDE ALL NUMBERS FROM THE CYLINDER I.D. TAG.

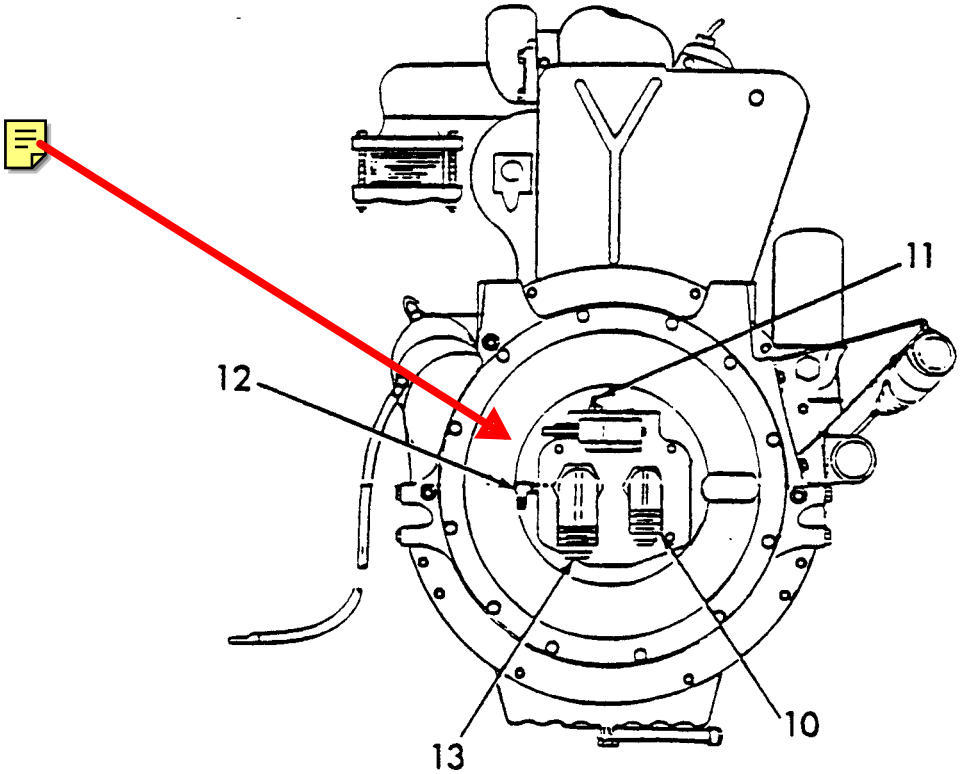
ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	21084	ASSEMBLY, MASTER LEVELING CYLINDER (See Sect. 4, Fig. 1 for NHA)	REF
2	.21111	CYLINDER, MASTER LEVELING (GB)	1
		NOTE 2: INTERNAL SERVICE REPLACEMENT PARTS AVAILABLE ON A SPECIAL ORDER BASIS.	
-3	..600081	KIT, SEAL (GB)	1
		NOTE 3: THE SEAL KIT INCLUDES ITEMS SHOWN WITH AN ASTERISK (*).	
4	..600322	BUSHING	4
5	.80033-03	TEE	2

REV.

Mark Industries

TITLE	ENGINE/PUMP ASSEMBLY	SECT.	4
MODEL	100C 6X4	FIG.	4
NOTES	DEUTZ F3L-912	SHEET	1





REV.

Mark Industries

TITLE	ENGINE/PUMP ASSEMBLY
MODEL	100C 6X4
NOTES	DEUTZ F3L-912

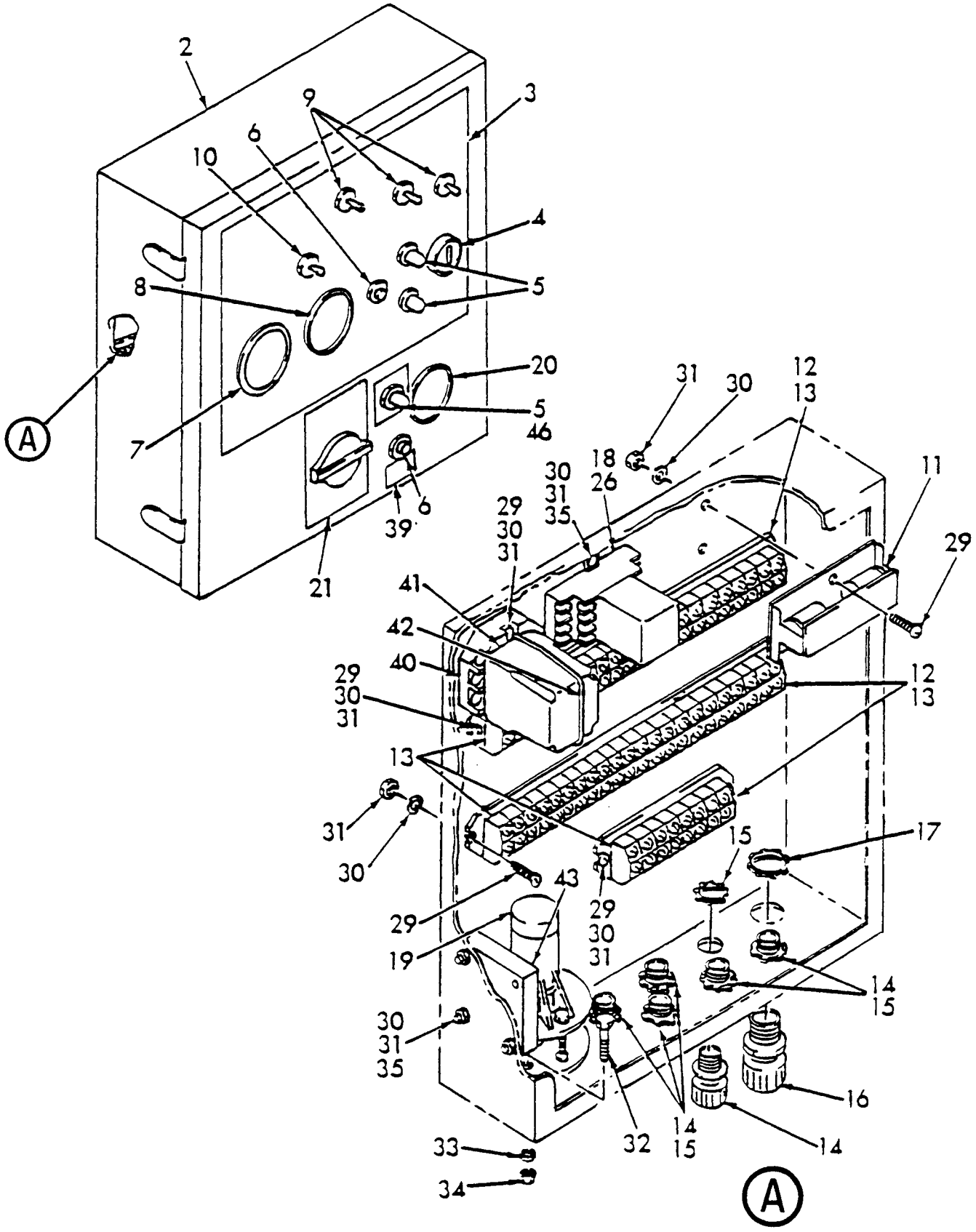
SECT.	4
FIG.	4
SHEET	2

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	22201	ASSEMBLY, ENGINE/PUMP (DEUTZ) (See Sect. 4, Fig. 1 for Details)	REF
2	.22200	ENGINE, DEUTZ DIESEL (F3L-912) (See Vendor Chapter for Details)	1
3	.21638	PUMP, HYDRAULIC (See Vendor Chapter for Details)	1
-4	..600163	KIT, SEAL	1
-5	...66741	SEAL, SHAFT	1
-6	..21757	ASSEMBLY, COMPENSATOR	1
7	.60705	NUT, HEX	2
8	.63305	WASHER, SPLIT	2
9	.63613	STUD	2
10	.80012-24	ELBOW, STRAIGHT THREAD	1
11	.80004-03	CONNECTOR, STRAIGHT THREAD	1
12	.80012-08	ELBOW, STRAIGHT THREAD	1
13	.80012-28	ELBOW, STRAIGHT THREAD	1

DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

Mark Industries

TITLE	GROUND CONTROL BOX ASSEMBLY	SECT.	4
MODEL	100C 6X4	FIG.	5
NOTES		SHEET	1

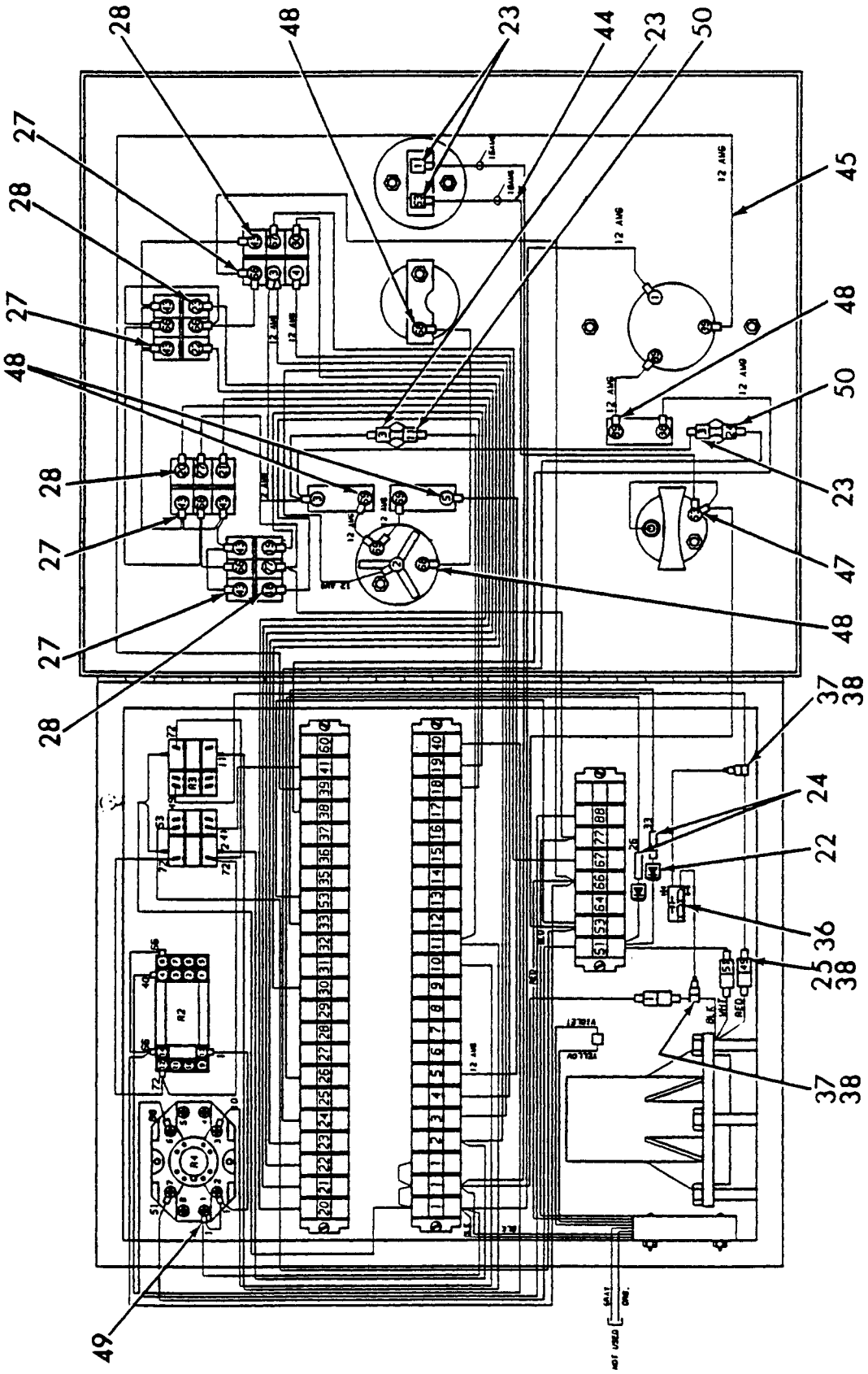


REV.

Mark Industries

TITLE	GROUND CONTROL BOX ASSEMBLY
MODEL	100C 6X4
NOTES	

SECT.	4
FIG.	5
SHEET	2



REV.

Mark Industries

TITLE	GROUND CONTROL BOX ASSEMBLY	SECT.	4
MODEL	100C 6X4	FIG.	5
NOTES		SHEET	3

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	24298	ASSEMBLY, GROUND CONTROL BOX (See Sect. 4, Fig. 1 for NHA)	REF
2	.20977	MACHINING, ELECTRICAL ENCLOSURE	1
3	.20460	DECAL, GROUND CONTROL	1
4	.2717	SWITCH, IGNITION	1
5	.20562	BREAKER, CIRCUIT	3
6	.4011	SWITCH	2
7	.20571	HOURMETER	1
8	.70492	AMPMETER	1
9	.20481	SWITCH, TOGGLE	3
10	.20482	SWITCH, TOGGLE	1
11	.20573	RELAY, LATCHING	1
12	.4027	BLOCK, TERMINAL	52
13	.117-A	BLOCK, TERMINAL	3
14	.2806	RELIEF, STRAIN	6
15	.2808	NUT	6
16	.2807	RELIEF, STRAIN	1
17	.2809	NUT	1
18	.70541	RELAY, 12 VDC	1
19	.21250	SENSOR, SLOPE	1
20	.21219	GAUGE, FUEL	1
21	.70119	RECEPTACLE, MALE	1
22	.70479	DIODE	3
23	.70500	DISCONNECT, FEMALE	4
24	.117-D	CONNECTOR, BUTT	5
25	.117-E	TERMINAL	4

Mark Industries

TITLE	GROUND CONTROL BOX ASSEMBLY
MODEL	100C 6X4
NOTES	

SECT.	4
FIG.	5
SHEET	4

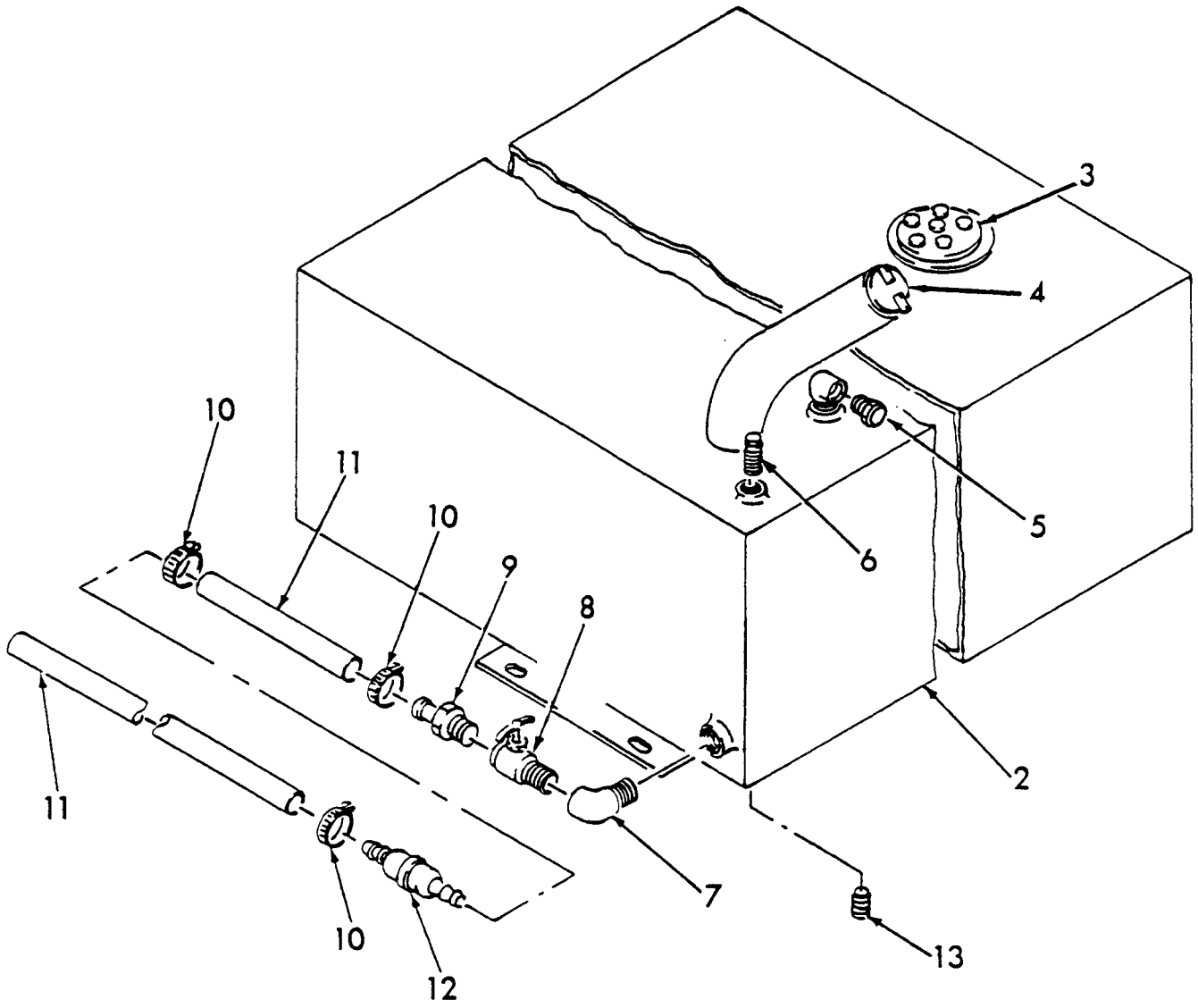
ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
26	.70214	RELAY, BASE	1
27	.117-B	CONNECTOR	14
28	.70149	CONNECTOR, RING	12
29	.62609	SCREW	14
30	.63311	WASHER	16
31	.61501	NUT	14
32	.60325	SCREW	4
33	.63303	WASHER	4
34	.60703	NUT	4
35	.62630	SCREW	4
36	.70147	CAPACITOR	1
37	.70029	CONNECTOR	2
38	.70406	SPRING, SPADE	1
39	.20413	DECAL, ENGINE CHOKE	1
40	.70145	RELAY, 12 VDC	1
41	784-A	SOCKET	1
42	.30215	CLIP, RELAY	1
43	.70413	CARD, P.W.M.	1
44	.2990	WIRE, WHITE	30 FT
45	.2991	WIRE, WHITE	5 FT
46	.185702	DECAL, CIRCUIT BREAKER 110 VAC	1
47	.16213	CONNECTOR	1
48	.117-C	CONNECTOR, RING	12
49	.70566	SPADE, SPRING (RED)	5
50	.66356	TERMINAL, FEMALE	2

REV.

DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

Mark Industries

TITLE	FUEL TANK ASSEMBLY	SECT.	4
MODEL	100C 6X4	FIG.	6
NOTES		SHEET	1



REV.

Mark Industries

TITLE	FUEL TANK ASSEMBLY	SECT.	4
MODEL	100C 6X4	FIG.	6
NOTES		SHEET	2

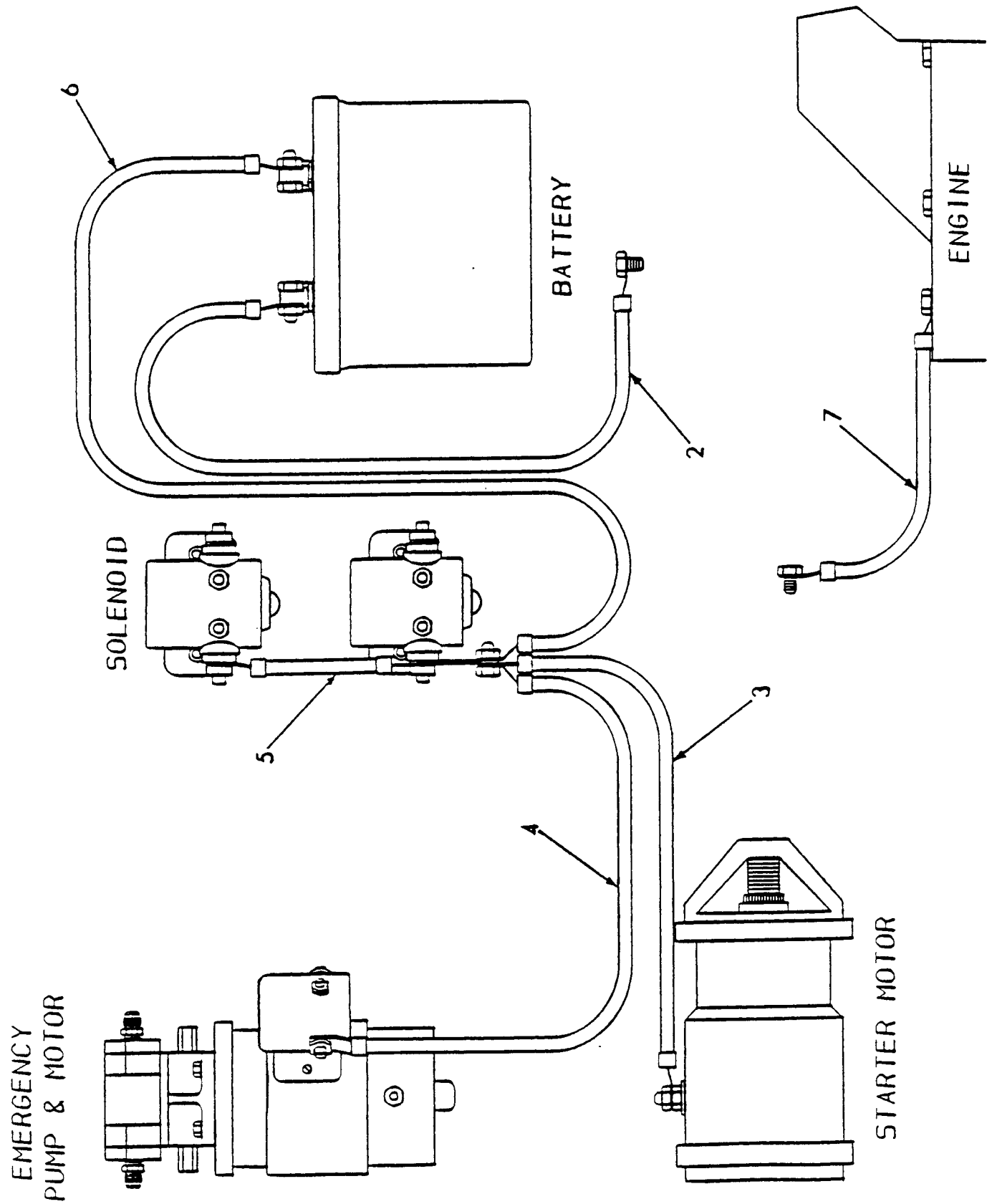
ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	22136	ASSEMBLY, FUEL TANK (See Sect. 4, Fig. 1 for NHA)	REF
2	.22024	TANK, FUEL	1
3	..20041	UNIT, SENDING	1
4	..67959	CAP, VENTED (ANTI-SURGE)	1
5	..20955	BREATHER (BRONZE)	1
6	.80048-03	PLUG, HOLLOW	1
7	.80021-03	ELBOW	1
8	.12000	VALVE, NEEDLE	1
9	.2589	FITTING, HOSE	1
10	.161-A	CLAMP, HOSE	3
11	.160202	HOSE, FUEL	13 FT
12	.160	FILTER, FUEL	1
13	.80049-05	PLUG	1

REV.

DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

Mark Industries

TITLE	BATTERY CABLE KIT	SECT.	4
MODEL	100C 6X4	FIG.	7
NOTES	DEUTZ F3L-912	SHEET	1



REV.

Mark Industries

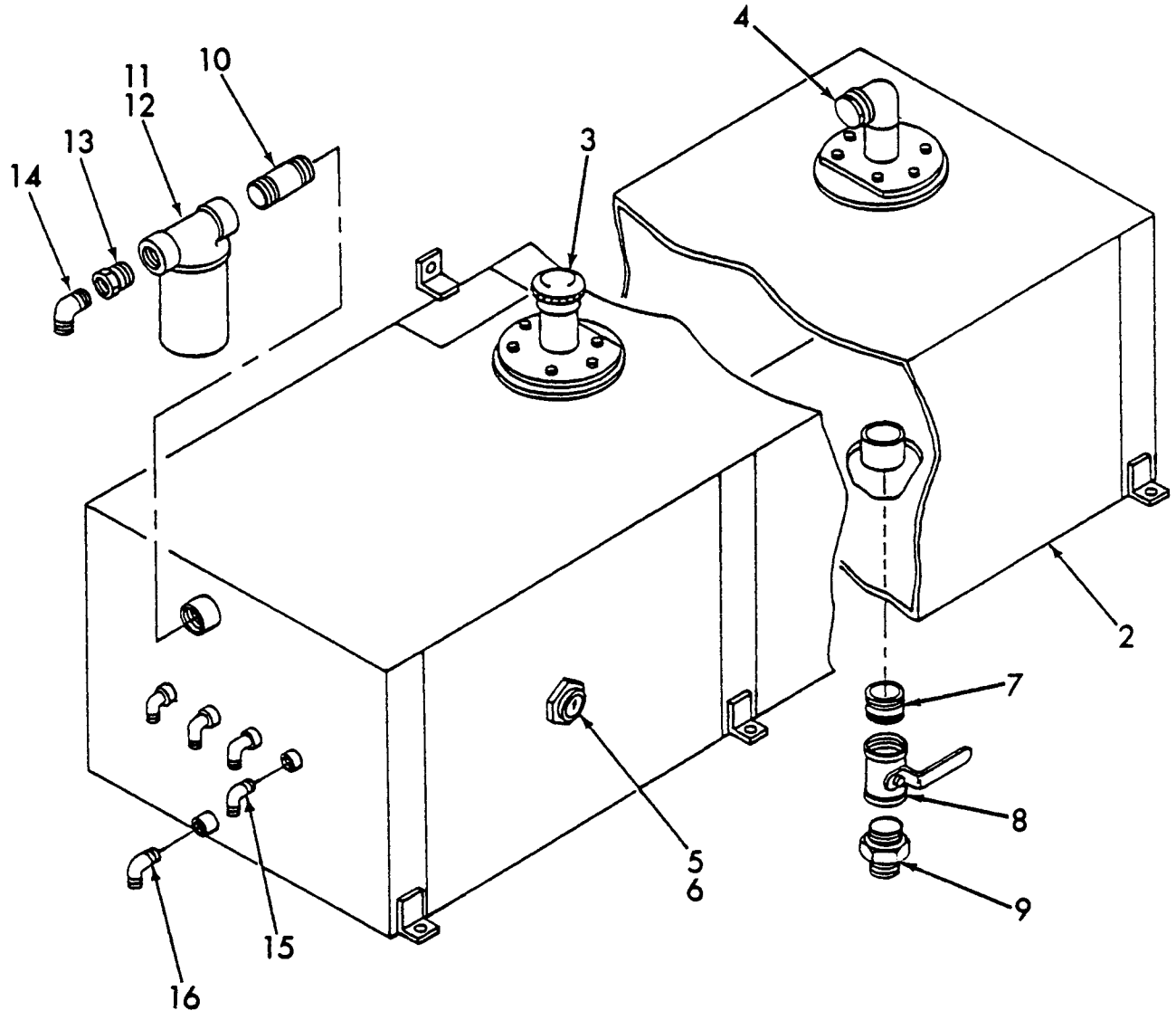
TITLE	BATTERY CABLE KIT
MODEL	100C 6X4
NOTES	DEUTZ F3L-912

SECT.	4
FIG.	7
SHEET	2

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	24638	KIT, BATTERY CABLE (See Sect. 4, Fig. 1 for NHA)	REF
2	.13226-0200	ASSEMBLY, ELECTRICAL CABLE	1
3	.13226-0660	ASSEMBLY, ELECTRICAL CABLE	1
4	.13226-0900	ASSEMBLY, ELECTRICAL CABLE	1
5	.13226-0050	ASSEMBLY, ELECTRICAL CABLE	1
6	.13226-0570	ASSEMBLY, ELECTRICAL CABLE	1
7	.13226-0090	ASSEMBLY, ELECTRICAL CABLE	1

Mark Industries

TITLE	HYDRAULIC TANK ASSEMBLY	SECT.	4
MODEL	100C 6X4	FIG.	8
NOTES		SHEET	1



REV.

Mark Industries

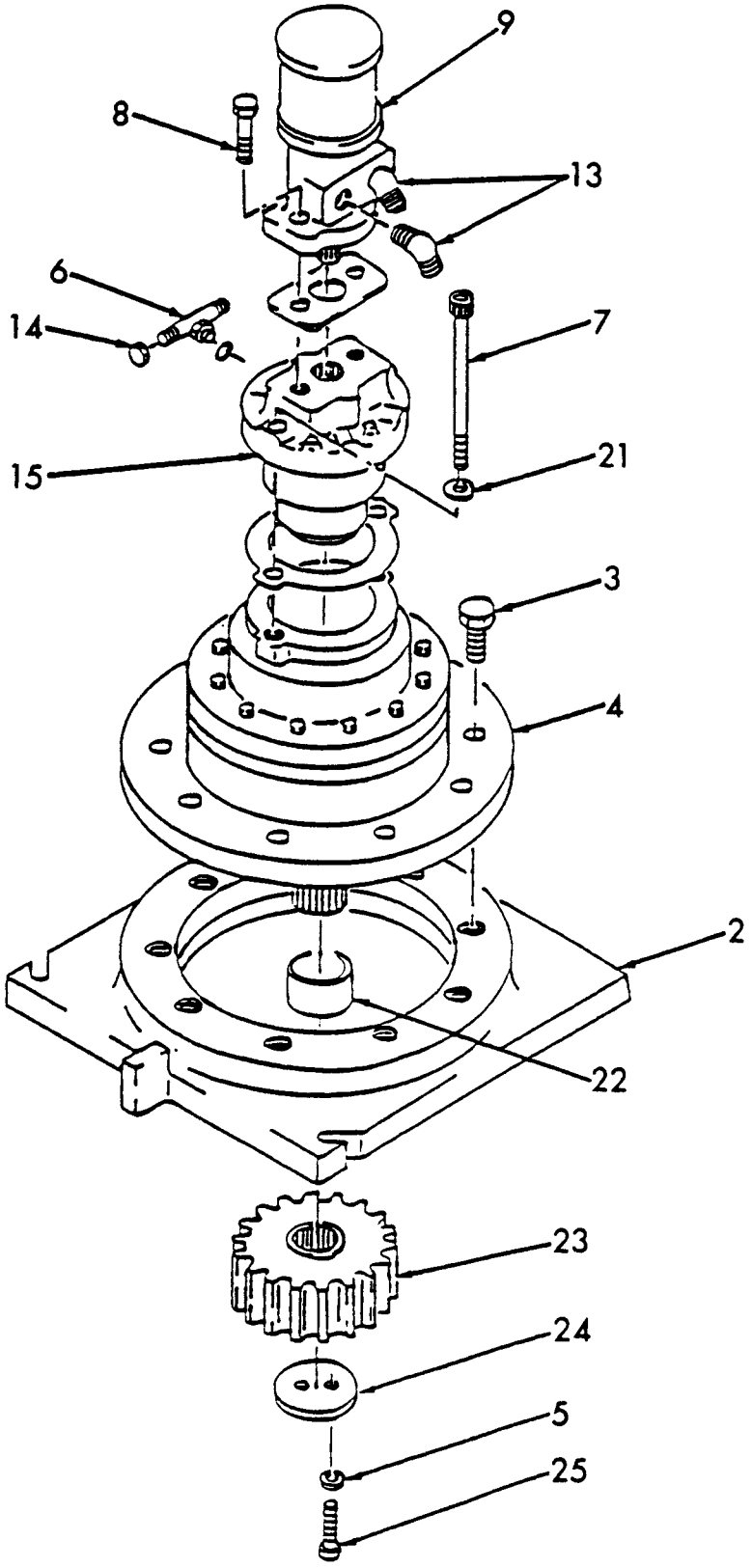
TITLE	HYDRAULIC TANK ASSEMBLY
MODEL	100C 6X4
NOTES	

SECT.	4
FIG.	8
SHEET	2

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	24504	ASSEMBLY, HYDRAULIC TANK (62 GAL.) (See Sect. 4, Fig. 1 for NHA)	REF
2	.24503	TANK, HYDRAULIC (62 GAL.)	1
3	..67959	CAP, VENTED ANTI-SURGE	1
4	..20955	BREATHER (BRONZE)	1
5	..65130	GAUGE, MECHANICAL	1
6	...65130-A	FACE, DIAL	1
7	.16553	NIPPLE	1
8	.20050	VALVE, BUTTERFLY	1
9	.2968	CONNECTOR, MALE	1
10	.16558	NIPPLE, BLACK PIPE	1
11	.21241	FILTER, RETURN LINE	1
12	..21245	ELEMENT, FILTER	1
13	.53801	REDUCER, PIPE	1
14	.80008-23	ELBOW, MALE	1
15	.80008-10	ELBOW, MALE	4
16	.80008-11	ELBOW, MALE	1

Mark Industries

TITLE	ROTATION GEARBOX ASSEMBLY	SECT.	4
MODEL	100C 6X4	FIG.	9
NOTES		SHEET	1



REV.

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	22789	ASSEMBLY, ROTATION GEARBOX (See Sect. 4, Fig. 1 for NHA)	REF
2	.22998	WELDMENT, MOUNTING PLATE	1
3	.60602	SCREW, CAP	9
4	.22830	HUB, ROTATION GEARBOX TORQUE (See Sect. 4, Fig. 17 for Details)	1
5	.63303	WASHER, SPLIT	2
6	.80036-03	TEE	1
7	.61940	SCREW, CAP	2
8	.60622	SCREW, CAP	2
*9	.81275	MOTOR, HYDRAULIC (MG SERIES)(SINCE EARLY 1989) (See Vendor Chapter for Details)	1
*-10	..67688	KIT, SEAL (TRW)	1
-11	..67691	LINK, DRIVE	1
-12	..67698	SHAFT, COUPLING	1
13	.80018-13	ELBOW, STRAIGHT THREAD	2
14	.80059-03	CAP	1
15	.22831	BRAKE (See Vendor Chapter for Details)	1
-16	..67150	KIT, SEAL	1
-17	..67644	KIT, LINING	1
-18	..67657	KIT, BEARING	1
-19	..67650	KIT, SPRING	1
-20	..67660	PISTON	1
21	.63305	WASHER, SPLIT	2
		NOTE: ASTERISK (*) INDICATES THIS ITEM SUPERSEDES HYDRAULIC MOTOR (MAG SERIES) P/N 81081 AND ITS SEAL KIT P/N 66965; USED UNTIL EARLY 1989.	

Mark Industries

TITLE	ROTATION GEARBOX ASSEMBLY
MODEL	100C 6X4
NOTES	

SECT.	4
FIG.	9
SHEET	3

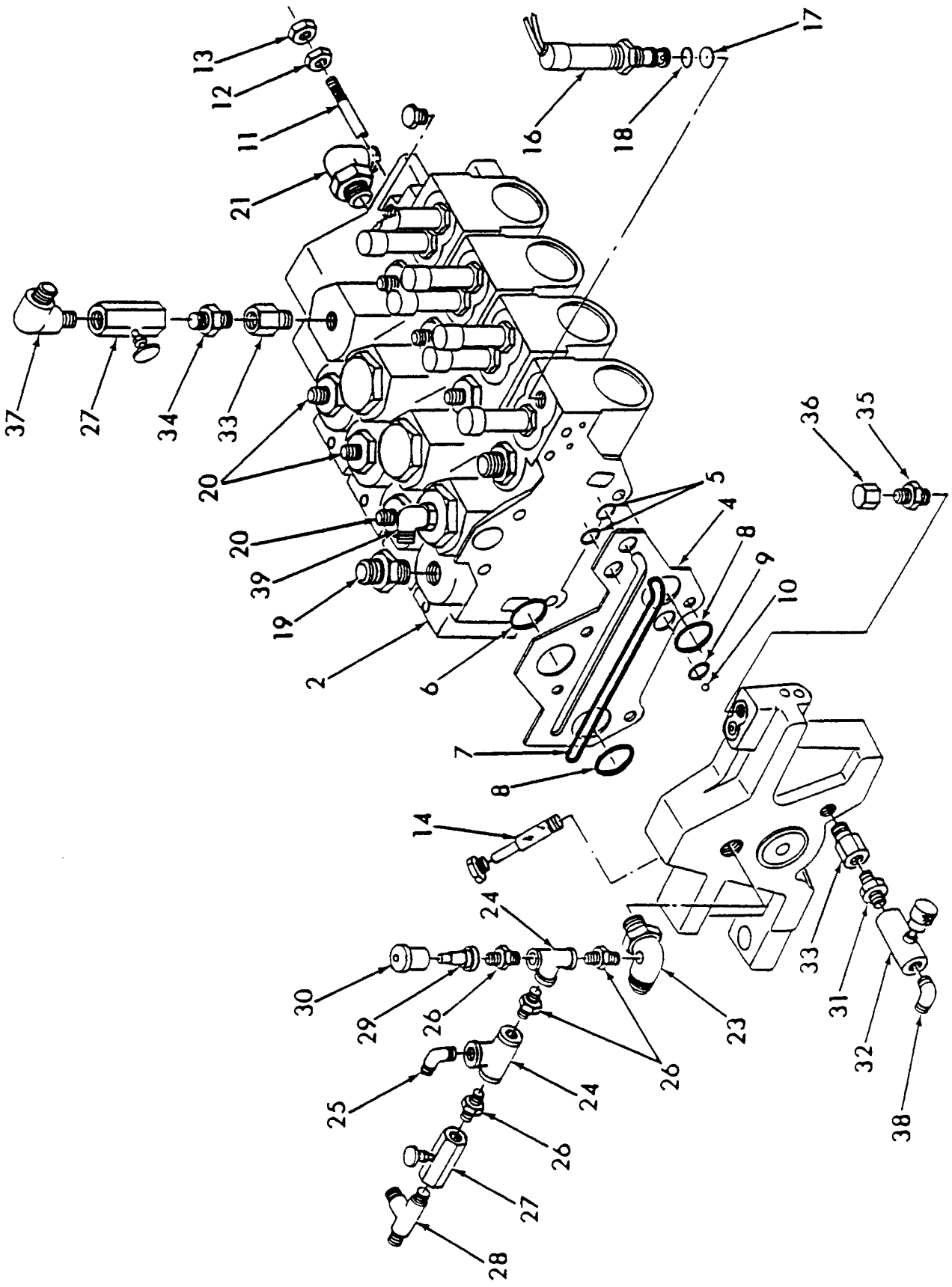
ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
22	.22099	SPACER, PINION	1
23	.22828	RETAINER, PINION	1
24	.22829	RETAINER, PINION	1
25	.61919	SCREW, CAP	2

REV.

DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

Mark Industries

TITLE	PROPORTIONAL VALVE ASSEMBLY	SECT.	4
MODEL	100C 6X4	FIG.	10
NOTES		SHEET	1



REV.

Mark Industries

TITLE	PROPORTIONAL VALVE ASSEMBLY
MODEL	100C 6X4
NOTES	

SECT.	4
FIG.	10
SHEET	2

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	24865	ASSEMBLY, PROPORTIONAL VALVE (See Sect. 4, Fig. 1 for NHA)	REF
2	.81315	VALVE, PROPORTIONAL (SINCE MID 1989)	1
2	.81237	VALVE, PROPORTIONAL (UNTIL MID 1989)	1
-3	..600180	KIT, SEAL REPAIR (4 BANKS)	1
4	...	PLATE, SEAL	5
5	...	O-RING	10
6	...	O-RING	5
7	...	O-RING	5
8	...	O-RING	10
9	...	O-RING	5
10	...	BALL	5
11	...	ROD, TIE	4
12	...	NUT, HEX	4
13	...	NUT, LOCK	4
14	..67382	FILTER, INLET	1
-15	..67380	KIT, SOLENOID CARTRIDGE (MATCHED)	8
*16	...	CARTRIDGE, SOLENOID	1
*17	...	DISK	1
18	...	O-RING	1
19	.80004-18	CONNECTOR	2
20	.80004-14	CONNECTOR	6
21	.80012-24	ELBOW	1
22	.24195	ELBOW, MODIFIED	1
		NOTE: ASTERISK (*) INDICATES THE ITEMS ARE PART OF A MATCHED SET AND CAN NOT BE REPLACED INDIVIDUALLY.	

REV.

DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

Mark Industries

TITLE	PROPORTIONAL VALVE ASSEMBLY
MODEL	100C 6X4
NOTES	

SECT.	4
FIG.	10
SHEET	3

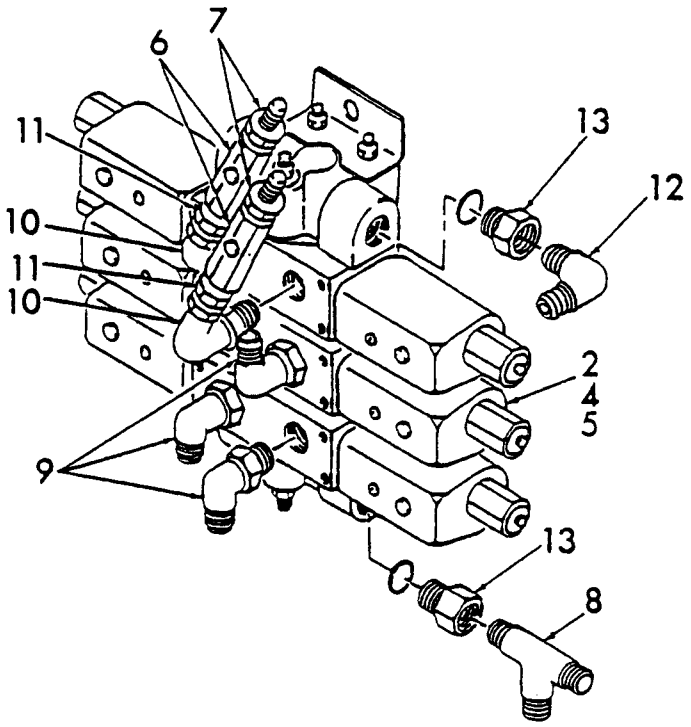
ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
23	..80012-24	ELBOW	1
24	.80039-04	TEE, FEMALE	2
25	.80008-08	ELBOW, MALE	1
26	.80052-04	NIPPLE, PIPE	4
27	.20357	VALVE, NEEDLE	2
28	.80037-08	TEE, MALE	1
29	.2527	COUPLING	1
30	.845	CAP	1
31	.80052-02	NIPPLE, PIPE	1
32	.30884	VALVE	1
33	.51903	ADAPTER, FEMALE PIPE	2
34	.80052-03	NIPPLE, PIPE	1
35	.80004-03	CONNECTOR	1
36	.80059-03	CAP	1
37	.80008-04	ELBOW, MALE	1
38	.80008-03	ELBOW, MALE	1
39	.80012-03	ELBOW	1

REV.

DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

Mark Industries

TITLE	MINIPAK ASSEMBLY	SECT. 4
MODEL	100C 6X4	FIG. 11
NOTES		SHEET 1



ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	22607	ASSEMBLY, MINIPAK (See Sect. 4, Fig. 1 for NHA)	REF
2	.21787	VALVE, MINIPAK (3 BANK) (See Vendor Chapter for Details)	1
-3	..67825	KIT, SEAL (COMPLETE VALVE PACKAGE)	1
4	..67958	CARTRIDGE (ONLY)	6
5	..16953	COIL (ONLY)	6
6	.20370	VALVE, NEEDLE	2
7	.80001-04	CONNECTOR, MALE	2
8	.80033-08	TEE	1
9	.80012-05	ELBOW	4
10	.80021-03	ELBOW	2

REV.

Mark Industries

TITLE	MINIPAK ASSEMBLY
MODEL	100C 6X4
NOTES	

SECT.	4
FIG.	11
SHEET	2

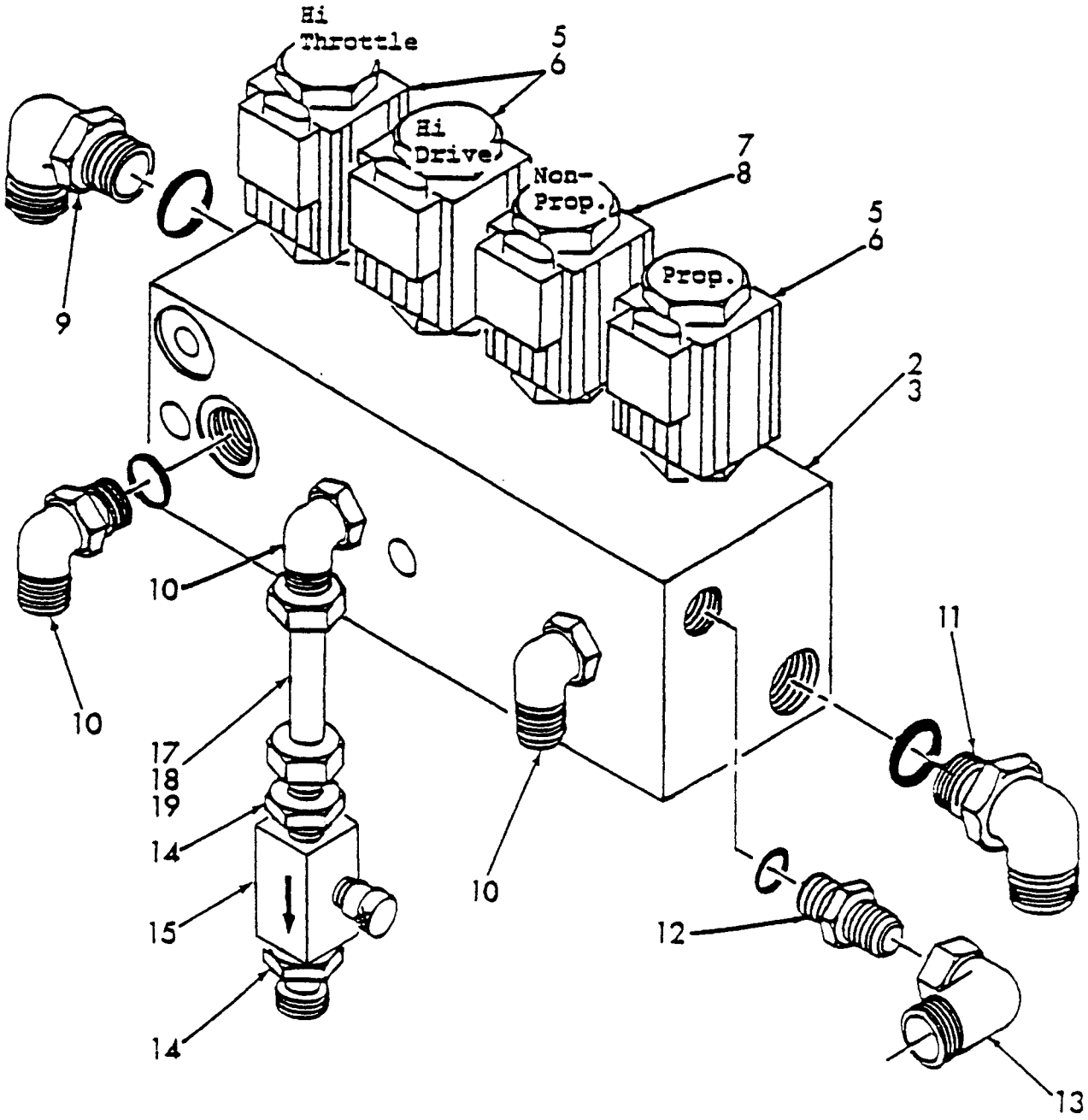
ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
11	.80052-04	NIPPLE, PIPE	2
12	.80012-08	ELBOW	1
13	.80063-01	ADAPTER, FEMALE PIPE	2

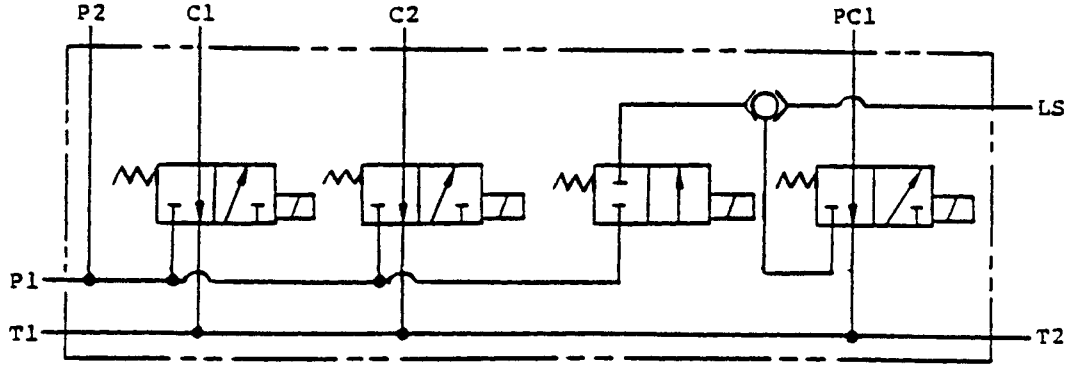
REV.

DASH-(-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

Mark Industries

TITLE	SOLENOID VALVE ASSEMBLY	SECT.	4
MODEL	100C 6X4	FIG.	12
NOTES		SHEET	1





REV.

Mark Industries

TITLE	SOLENOID VALVE ASSEMBLY
MODEL	100C 6X4
NOTES	

SECT.	4
FIG.	12
SHEET	2

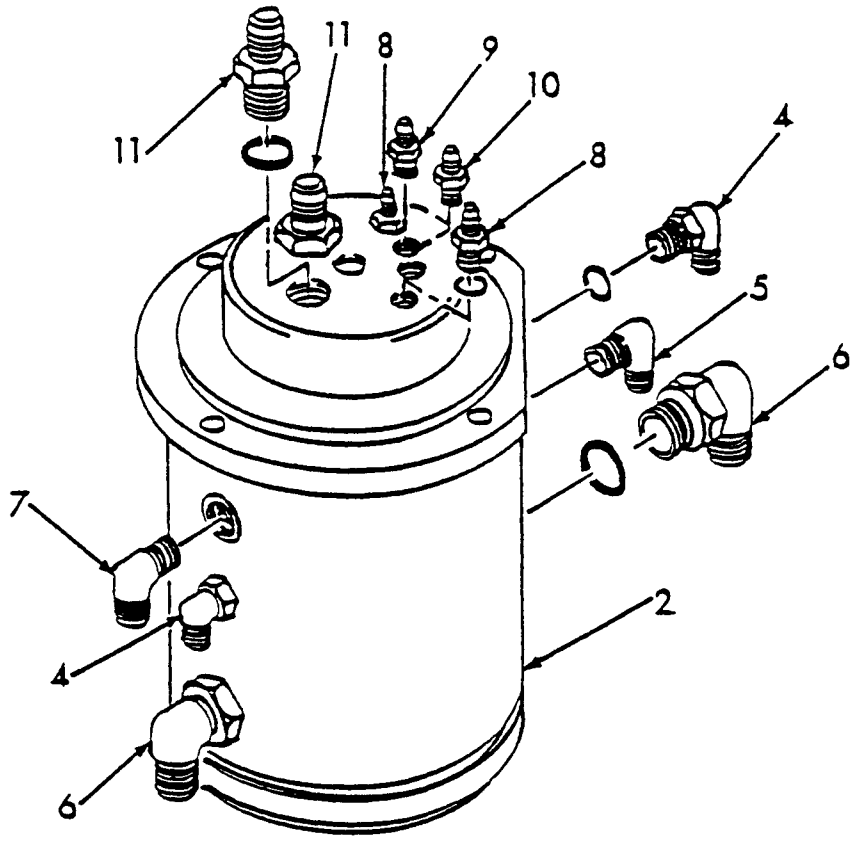
ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	22609	ASSEMBLY, SOLENOID VALVE (See Sect. 4, Fig. 1 for NHA)	REF
-2	.21860	VALVE, SOLENOID	1
3	..66885	BLOCK, MANIFOLD	1
-4	..67248	KIT, SEAL	1
5	..66884	CARTRIDGE & COIL	3
6	...67249	COIL (ONLY)	3
7	..66883	CARTRIDGE & COIL	1
8	...67249	COIL (ONLY)	1
9	.50900	ELBOW	1
10	.80012-03	ELBOW	3
11	.80012-08	ELBOW	1
12	.80004-03	CONNECTOR	1
13	.80015-03	ELBOW	1
14	.80001-03	CONNECTOR	2
15	.30884	VALVE, FLOW CONTROL	1
-16	.22609-9	ASSEMBLY, TUBE	1
17	..80062-03	SLEEVE	2
18	..80060-03	NUT	2
19	..2798	TUBE, HYDRAULIC	.38 FT

REV.

DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

Mark Industries

TITLE	ROTARY MANIFOLD ASSEMBLY	SECT. 4
MODEL	100C 6X4	FIG. 13
NOTES	UNTIL EARLY 1988	SHEET 1

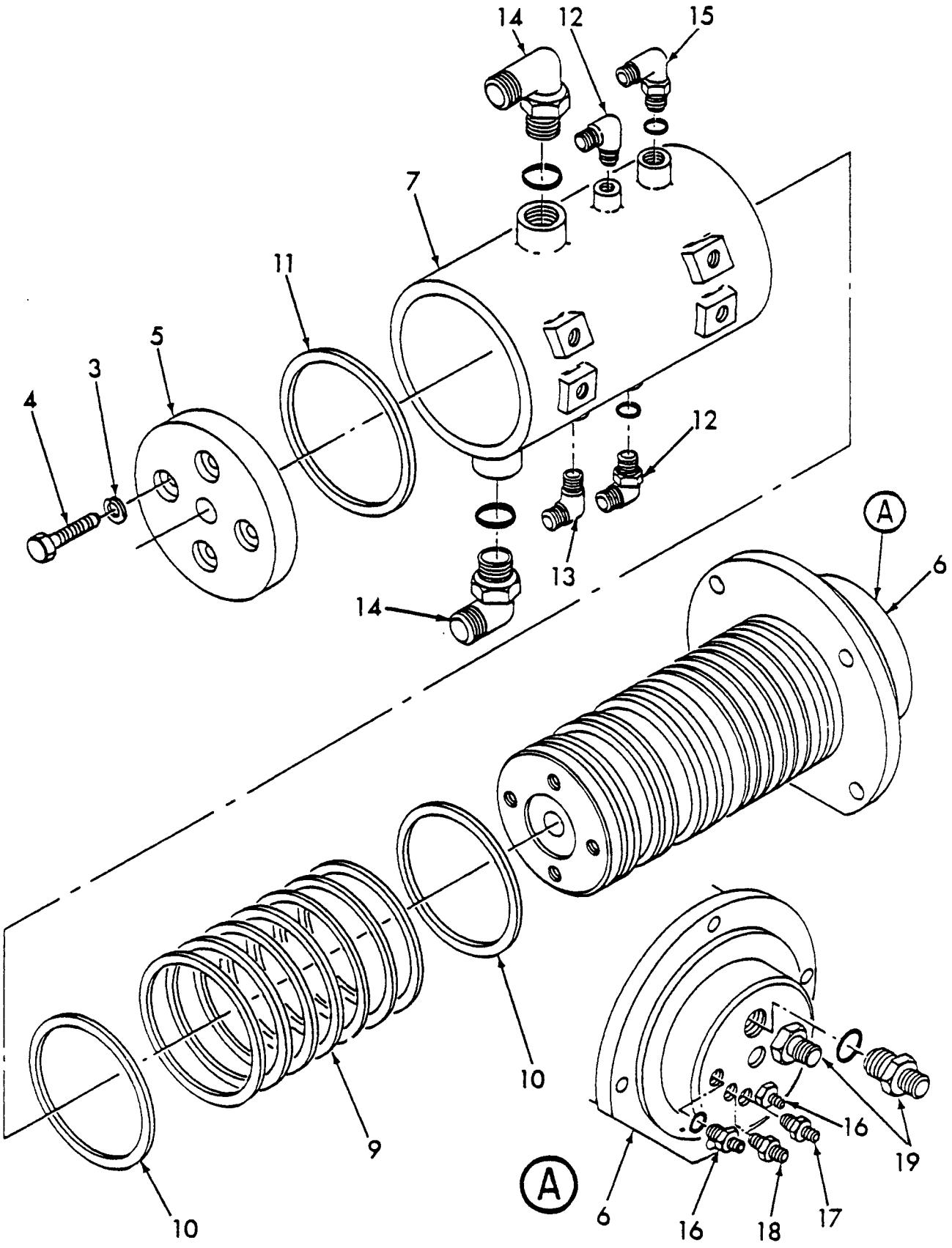


ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	21898	ASSEMBLY, ROTARY MANIFOLD (See Sect. 4, Fig. 1 for NHA)	REF
2	.21895	MANIFOLD, ROTARY (RA)	1
-3	..66561	KIT, SEAL (RA)	1
4	.80012-03	ELBOW, STRAIGHT THREAD	2
5	.80008-03	ELBOW, MALE	1
6	.80012-18	ELBOW, STRAIGHT THREAD	2
7	.80008-08	ELBOW, MALE	1
8	.80004-03	CONNECTOR, STRAIGHT THREAD	2
9	.80001-08	CONNECTOR, MALE	1
10	.80001-03	CONNECTOR, MALE	1
11	.80004-18	CONNECTOR, STRAIGHT THREAD	2

REV.

Mark Industries

TITLE	ROTARY MANIFOLD ASSEMBLY	SECT.	4
MODEL	100C 6X4	FIG.	13A
NOTES	SINCE EARLY 1988	SHEET	1



REV.

Mark Industries

TITLE	ROTARY MANIFOLD ASSEMBLY
MODEL	100C 6X4
NOTES	SINCE EARLY 1988

SECT.	4
FIG.	13A
SHEET	2

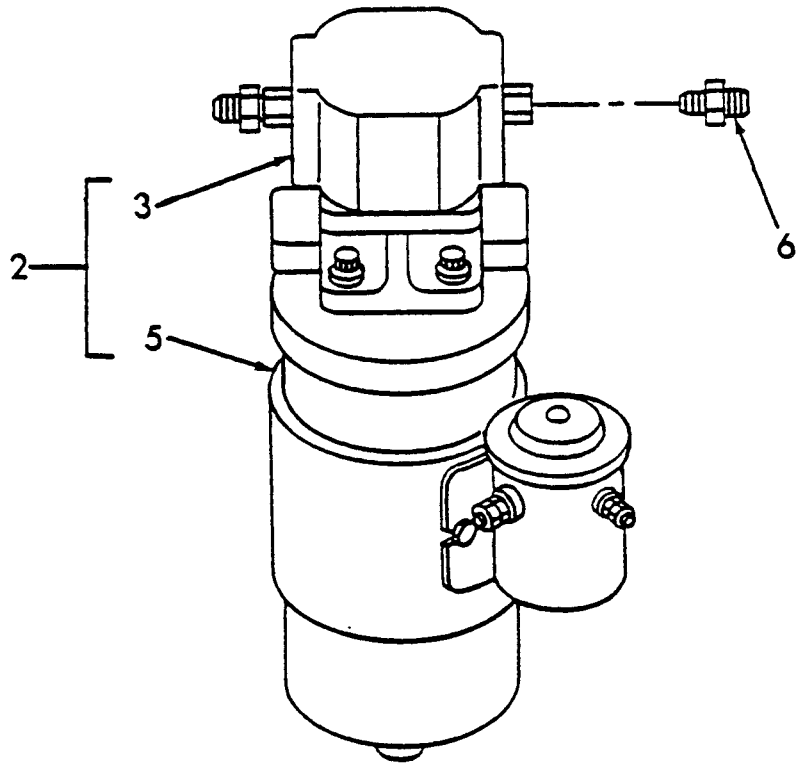
ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	21898	ASSEMBLY, ROTARY MANIFOLD (See Sect. 4, Fig. 1 for NHA)	REF
2	.24132	MANIFOLD, ROTARY	1
3	..	WASHER, LOCK	4
4	..	SCREW, CAP	4
5	..	RETAINER, SPOOL	1
6	..	ASSEMBLY, SWIVEL SPOOL	1
7	..	HOUSING	1
-8	..67817	KIT, SEAL	1
9	...	RING, GLYD	7
10	...	RING, D.C. GLYD	2
11	...	RING, WEAR	1
12	.80012-03	ELBOW	2
13	.80008-03	ELBOW	1
14	.80012-18	ELBOW	2
15	.80008-08	ELBOW	1
16	.80004-03	CONNECTOR	2
17	.80001-08	CONNECTOR	1
18	.80001-03	CONNECTOR	1
19	.80004-18	CONNECTOR	2

REV.

DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

Mark Industries

TITLE	EMERGENCY PUMP/MOTOR ASSEMBLY	SECT. 4
MODEL	100C 6X4	FIG. 14
NOTES		SHEET 1

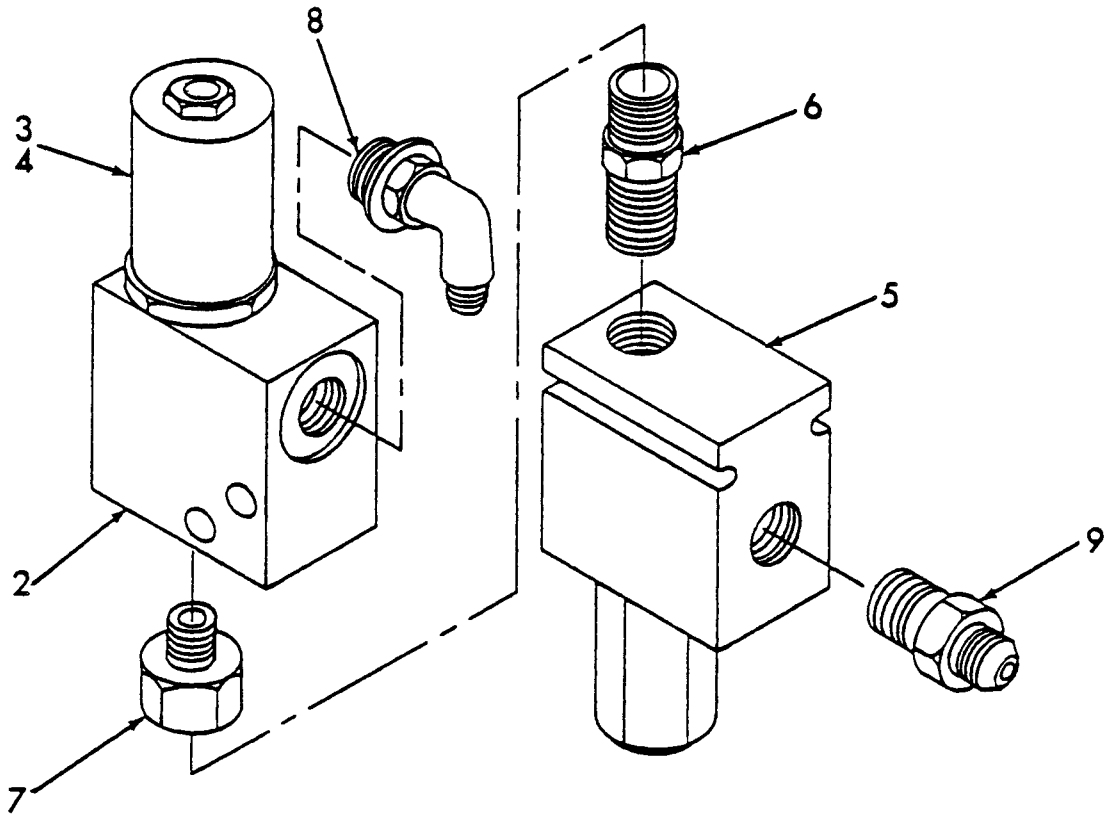


ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	22390	ASSEMBLY, EMERGENCY PUMP/MOTOR (See Sect. 4, Fig. 1 for NHA)	REF
2	.20384	PUMP, EMERGENCY RETRACTION	1
3	..66402	PUMP	1
-4	...67935	KIT, SEAL (JSB)	1
5	..67940	MOTOR	1
6	.80001-08	CONNECTOR	2

REV.

Mark Industries

TITLE	DUMP VALVE ASSEMBLY	SECT. 4
MODEL	100C 6X4	FIG. 15
NOTES		SHEET 1

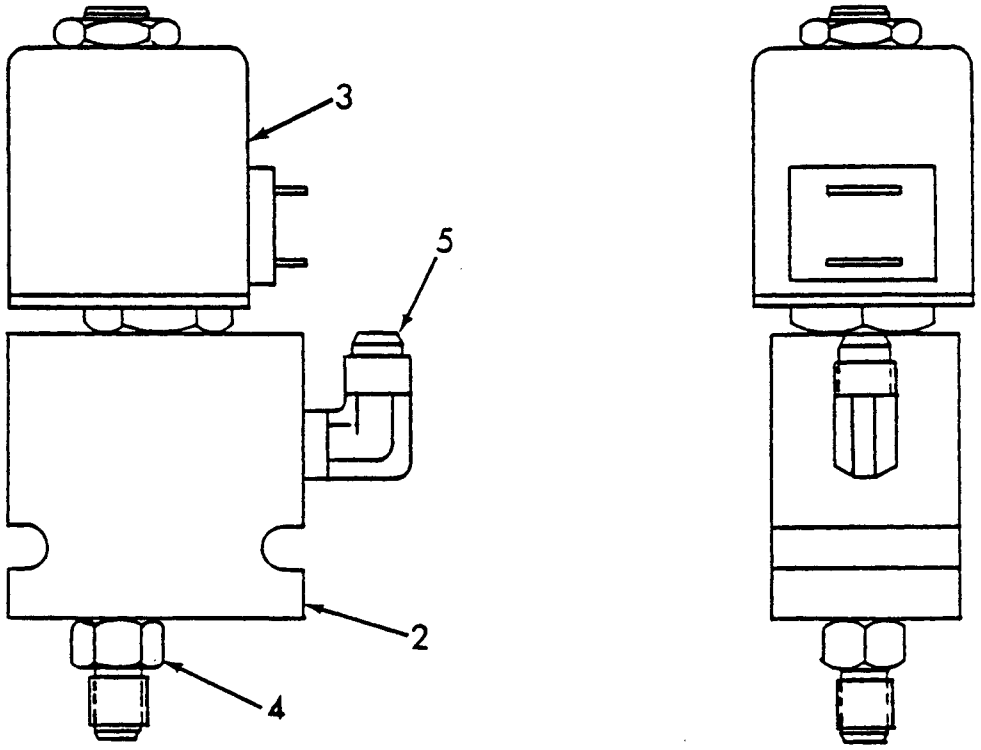


ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	22204	ASSEMBLY, DUMP VALVE (DRIVE) (See Sect. 4, Fig. 1 for NHA)	REF
2	.410	VALVE, SOLENOID (DUMP)	1
3	..600371	CARTRIDGE (WITH COIL)	1
4	...67126	COIL (ONLY)(12 VDC)	1
5	.21882	VALVE, RELIEF	1
6	.80052-04	NIPPLE, PIPE	1
7	.80063-01	ADAPTER, FEMALE PIPE	1
8	.80012-05	ELBOW	1
9	.80001-04	CONNECTOR	1

REV.

Mark Industries

TITLE	SOLENOID VALVE ASSEMBLY	SECT.	4
MODEL	100C 6X4	FIG.	16
NOTES	DEUTZ F3L-912	SHEET	1

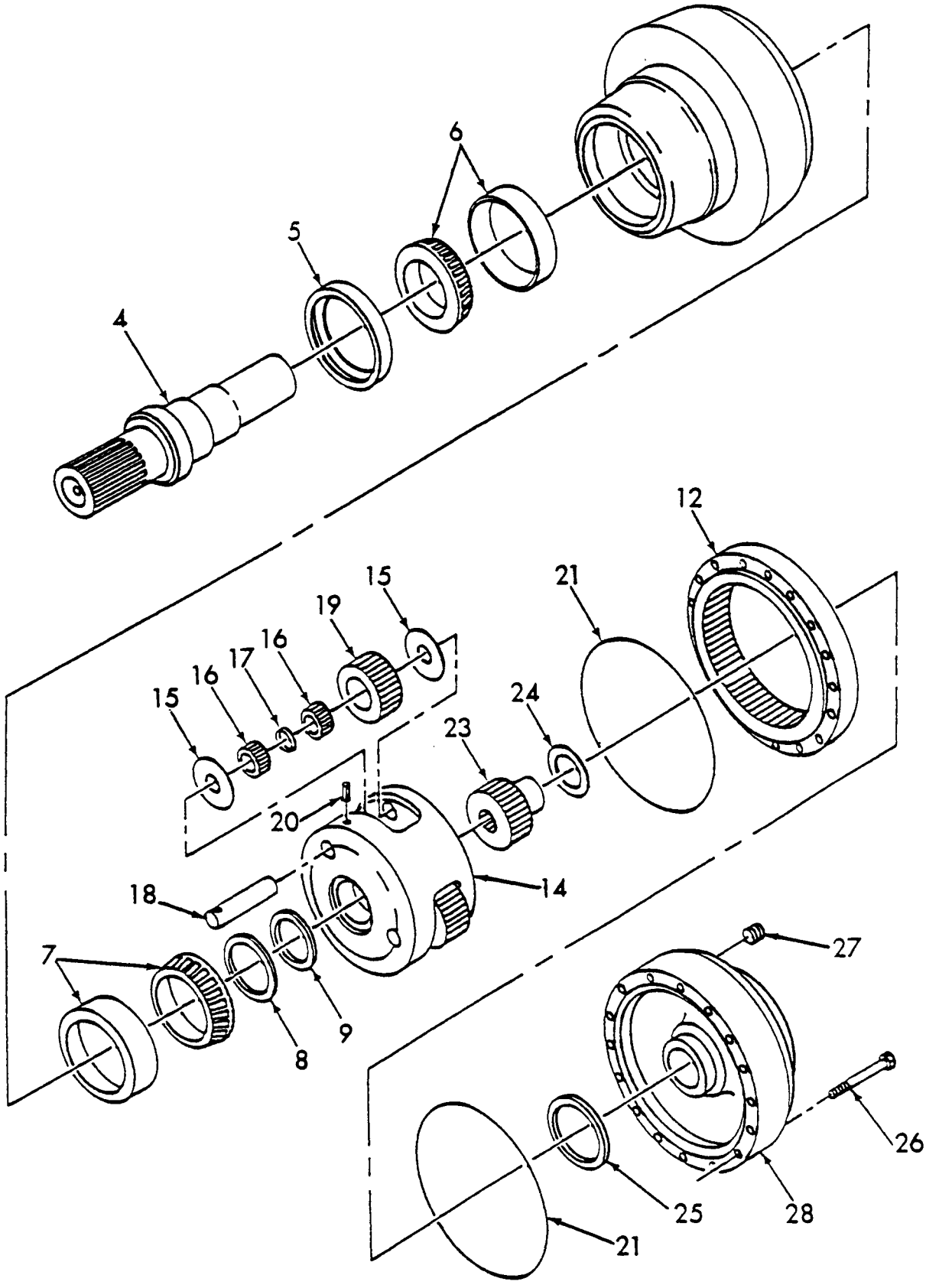


ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	22909	ASSEMBLY, SOLENOID VALVE (See Sect. 4, Fig. 1 for NHA)	REF
2	.81054	VALVE, SOLENOID	2
3	..600321	COIL (ONLY)	2
4	.80004-11	CONNECTOR, STRAIGHT THREAD	2
5	.80012-11	ELBOW, STRAIGHT THREAD	2

REV.

Mark Industries

TITLE	ROTATION GEARBOX TORQUE HUB	SECT.	4
MODEL	100C 6X4	FIG.	17
NOTES		SHEET	1



REV.

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	22830	HUB, ROTATION GEARBOX TORQUE (See Sect. 4, Fig. 9 for NHA) (See Vendor Chapter for Details)	REF
-2	.600220	KIT, SEAL	1
-3	.	SUB-ASSEMBLY, HUB/SPINDLE	1
4	..67877	SHAFT, OUTPUT	1
*5	..	SEAL	1
6	..600410	KIT, BEARING	1
7	..600436	KIT, BEARING	1
8	..67911	SPACER	1
*9	..	RING, RETAINING	1
-10	..	PLUG, PIPE	3
-11	..	PLUG, PIPE	1
12	.	GEAR, RING	1
-13	.	SUB-ASSEMBLY, CARRIER	1
14	..	CARRIER	1
15	..67898	WASHER, THRUST	6
16	..67918	ROLLER, NEEDLE	96
17	..67907	SPACER	3
18	..	SHAFT, PLANET	3
19	..	GEAR, PLANET	3
-20	..	PIN, ROLL	3
*21	.	O-RING	2
22	.	COVER	1
23	.67882	GEAR, INPUT	1
		NOTE: ASTERISK (*) INCICATES THE ITEM IS INCLUDED IN THE SEAL KIT.	

Mark Industries

TITLE	ROTATION GEARBOX TORQUE HUB
MODEL	100C 6X4
NOTES	

SECT.	4
FIG.	17
SHEET	3

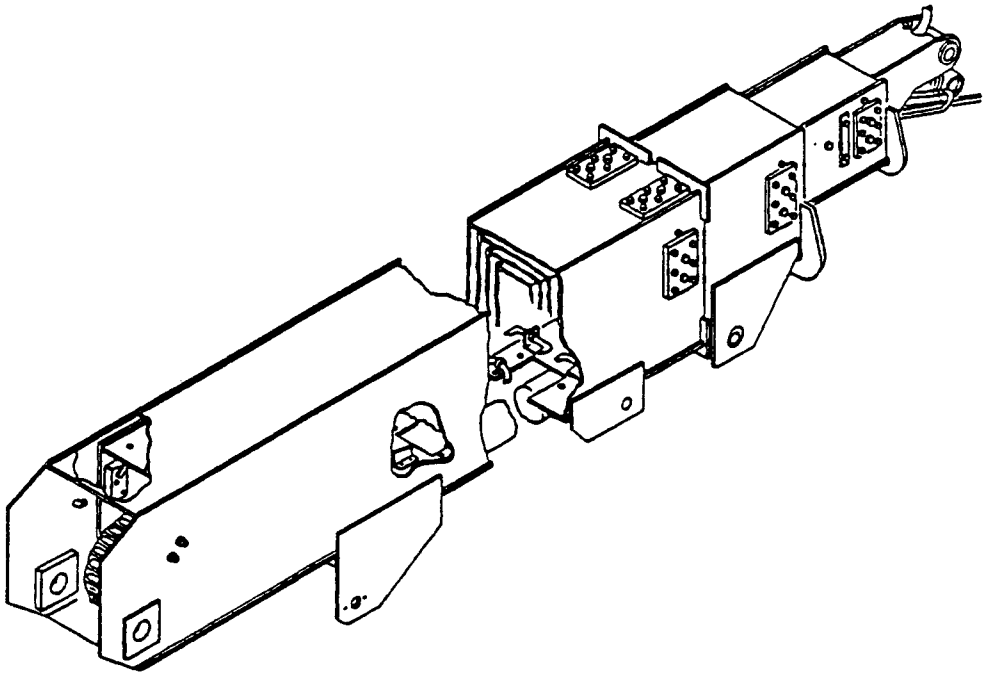
ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
24	.67899	WASHER, THRUST	1
*25	.	WASHER, THRUST	1
26	.66427	BOLT	8
27	.	PLUG, PIPE	1
28	.66426	BOLT, SHOULDER	4
		NOTE: ASTERISK (*) INDICATES THE ITEM IS INCLUDED IN THE SEAL KIT.	

REV.

DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

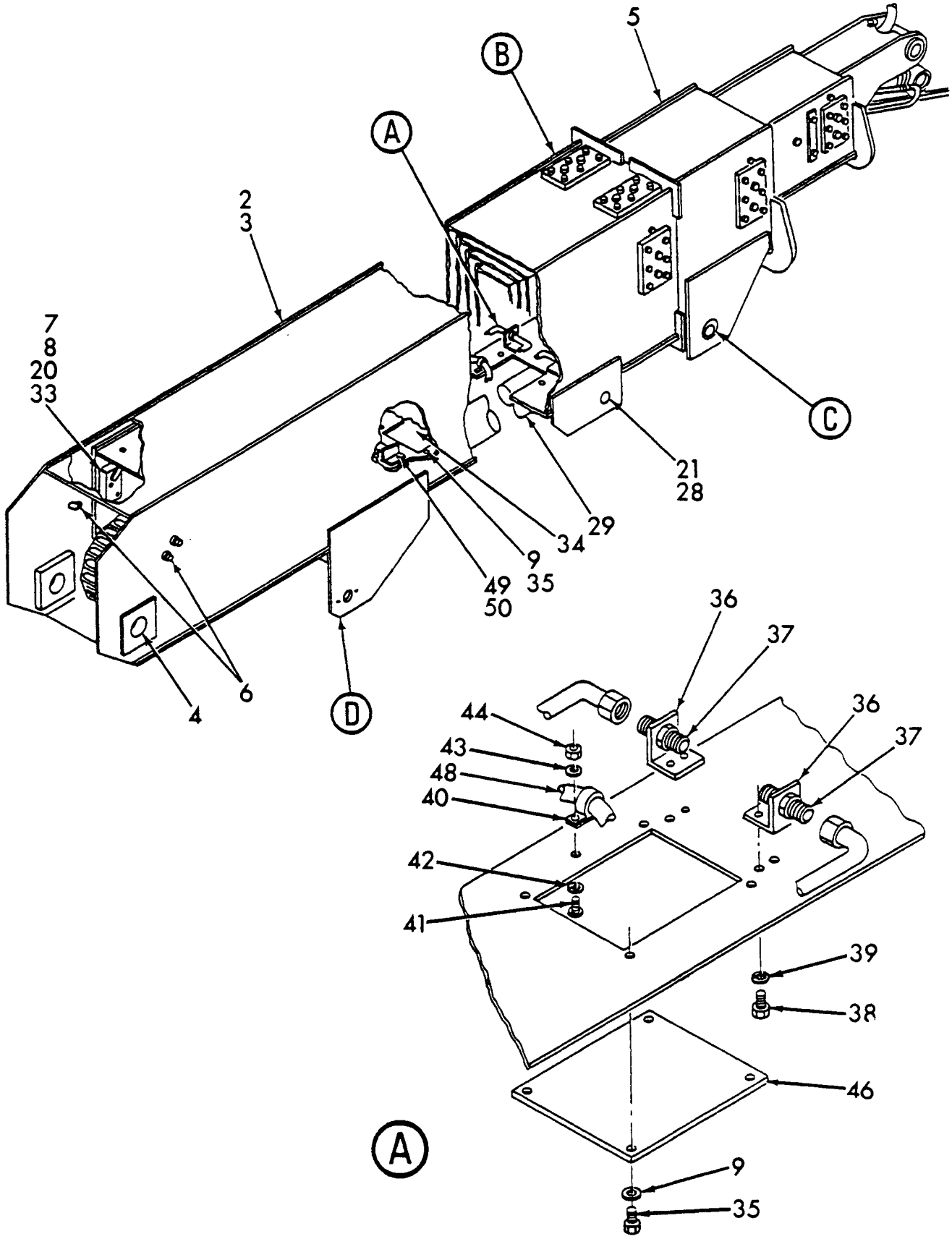
SECTION 5 CONTAINS:

FIG. NO.	TITLE
1	FINAL BOOM ASSEMBLY
2	OUTER/INTERMEDIATE BOOM SUB-ASSEMBLY
3	INNER/INTERMEDIATE BOOM SUB-ASSEMBLY
4	INNER BOOM SUB-ASSEMBLY
5	BOOM EXTENSION CYLINDER ASSEMBLY (UNTIL MID 1988 (SE)
5A	BOOM EXTENSION CYLINDER ASSEMBLY (SINCE MID 1988; CONCURRENT USE) (SE)
5B	BOOM EXTENSION CYLINDER ASSEMBLY (SINCE MID 1989; CONCURRENT USE) (GB)
6	OUTSIDE BOOM EXTENSION CYLINDER ASSEMBLY (CONCURRENT USE) (SE)
6A	OUTSIDE BOOM EXTENSION CYLINDER ASSEMBLY (SINCE MID 1989; CONCURRENT USE) (GB)
7	SLAVE LEVELING CYLINDER ASSEMBLY (UNTIL EARLY 1986) (RA)
7A	SLAVE LEVELING CYLINDER ASSEMBLY (UNTIL EARLY 1990) (SE)
7B	SLAVE LEVELING CYLINDER ASSEMBLY (SINCE LATE 1989; CONCURRENT USE) (GB)
7C	SLAVE LEVELING CYLINDER ASSEMBLY (SINCE EARLY 1990; CONCURRENT USE) (TH)
8	PLASTITRAK ASSEMBLY



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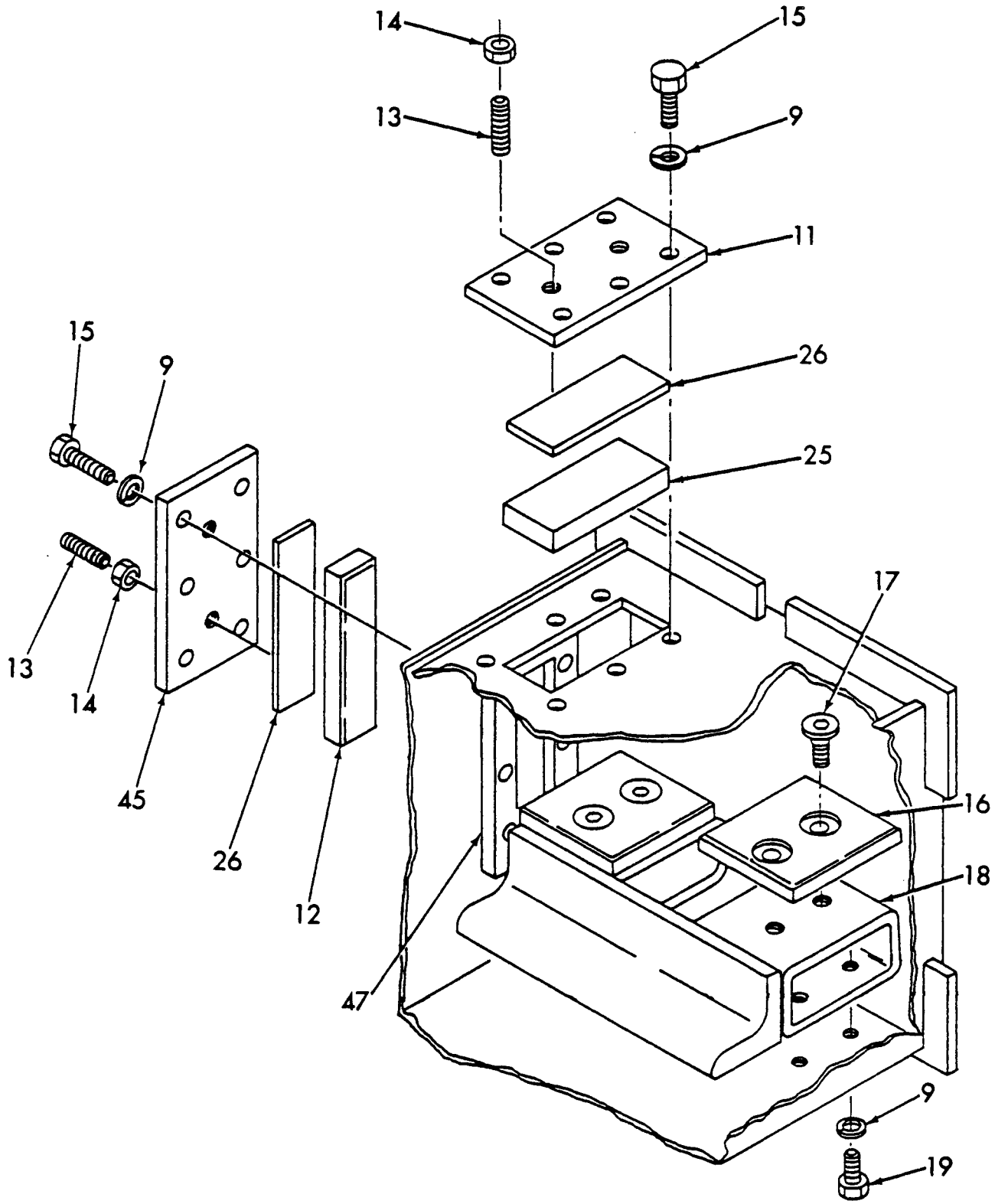
TITLE	FINAL BOOM ASSEMBLY	SECT.	5
MODEL	100C 6X4	FIG.	1
NOTES		SHEET	1



REV.

Mark Industries

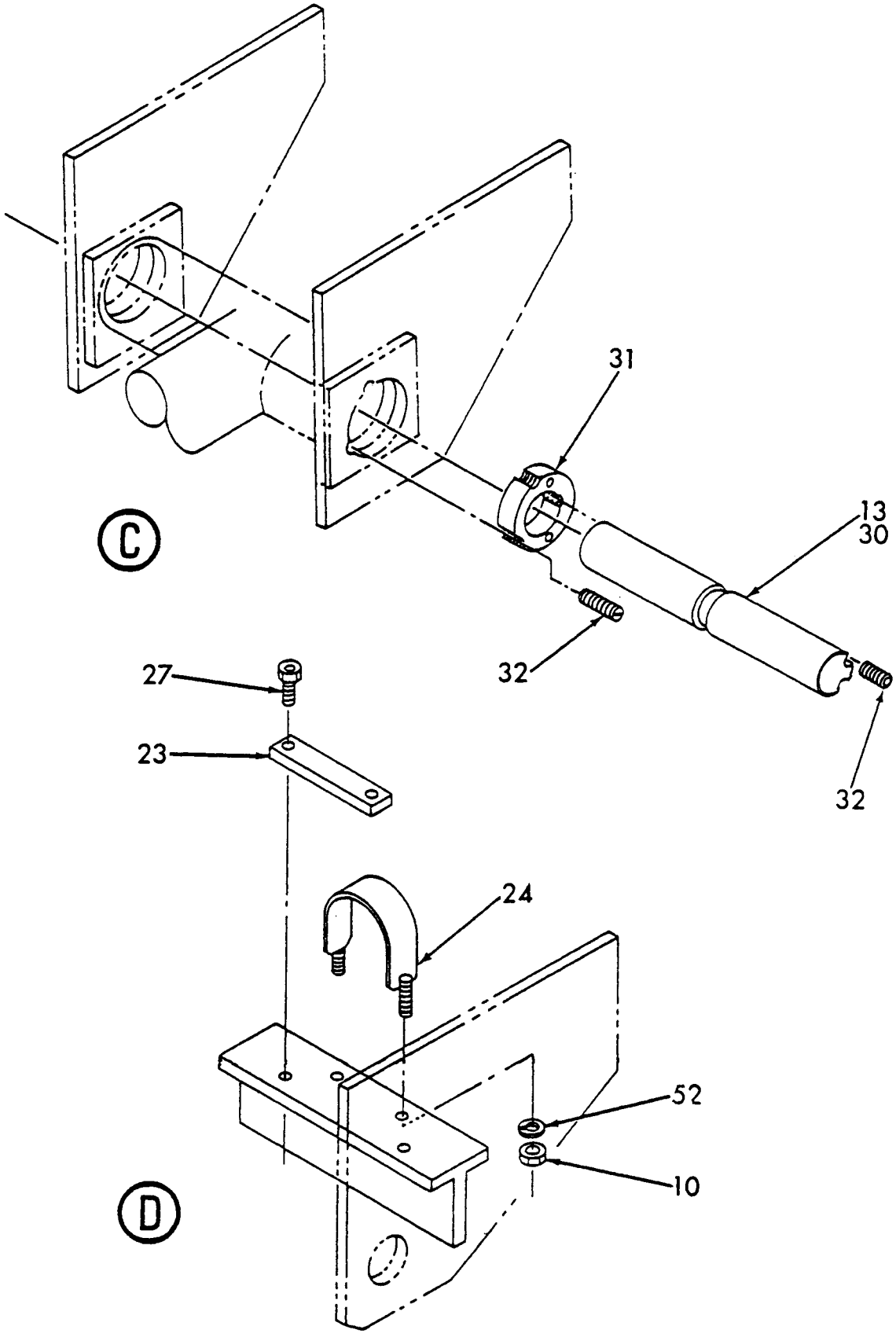
TITLE	FINAL BOOM ASSEMBLY	SECT.	5
MODEL	100C 6X4	FIG.	1
NOTES		SHEET	2



REV.

Mark Industries

TITLE	FINAL BOOM ASSEMBLY	SECT.	5
MODEL	100C 6X4	FIG.	1
NOTES		SHEET	3



REV.

Mark Industries

TITLE	FINAL BOOM ASSEMBLY
MODEL	100C 6X4
NOTES	

SECT.	5
FIG.	1
SHEET	4

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	24310	ASSEMBLY, FINAL BOOM (See Sect. 2, Fig. 1 for NHA)	REF
2	.24072	MACHINING, OUTER BOOM	1
3	..24071	WELDMENT, OUTER BOOM	1
4	..22080	BUSHING	2
5	.24311	SUB-ASSEMBLY, OUTER/INTERMEDIATE BOOM (See Sect. 5, Fig. 2 for Details)	1
6	.80011-03	UNION, ELBOW	4
7	.70107	SWITCH, LIMIT	1
8	.70032	LEVER, OPERATING	1
9	.63303	WASHER, LOCK	36
10	.60705	NUT, HEX	2
11	.22171	PLATE, WEAR PAD COVER	2
12	.23170	PAD, WEAR	2
13	.62204	SCREW, SET	9
14	.61101	NUT, JAM	8
15	.60325	SCREW, CAP	24
16	.24225	PAD, WEAR	2
17	.61805	SCREW, CAP	4
18	.24226	BRACKET, WEAR PAD	2
19	.60416	SCREW, CAP	4
20	.62704	SCREW, MACHINE	2
21	.24228	PIN, TRUNNION	2
-22	.60625	SCREW, CAP	4
23	.22125	PAD, WEAR	1
24	.24402	CLAMP	1

REV.

DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

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TITLE	FINAL BOOM ASSEMBLY
MODEL	100C 6X4
NOTES	

SECT.	5
FIG.	1
SHEET	5

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
25	.24242	PAD, WEAR	2
26	.20453	PLATE, PAD PRESSURE	4
27	.61821	SCREW, CAP	2
28	.62221	SCREW, SET	2
29	.24328	ASSEMBLY, OUTSIDE BOOM EXTENSION CYLINDER (See Sect. 5, Fig. 6 for Details)	1
30	.24227	PIN, ANCHOR	1
31	.24454	BUSHING, ECCENTRIC	2
32	.62229	SCREW, SET	2
33	.63313	WASHER, LOCK	2
34	.22121	PLATE, ACCESS COVER	1
35	.60403	SCREW, CAP	8
36	.22207	BRACKET, BULKHEAD FITTING	2
37	.80045-06	UNION, BULKHEAD	2
38	.60603	SCREW, CAP	4
39	.63302	WASHER, LOCK	4
40	.16268	CLAMP, HOSE	1
41	.60534	SCREW, CAP	1
42	.63301	WASHER, LOCK	1
43	.63401	WASHER, FLAT	1
44	.60701	NUT, HEX	1
45	.21321	PLATE, WEAR PAD COVER	2
46	.24480	PLATE, ACCESS COVER	1
47	.21358	RETAINER, WEAR PAD	2
48	.2912	CABLE, CONDUCTOR (18 AWG/4 COND.)	45 FT
49	.61919	SCREW, CAP	2

DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

Mark Industries

TITLE	FINAL BOOM ASSEMBLY
MODEL	100C 6X4
NOTES	

SECT.	5
FIG.	1
SHEET	6

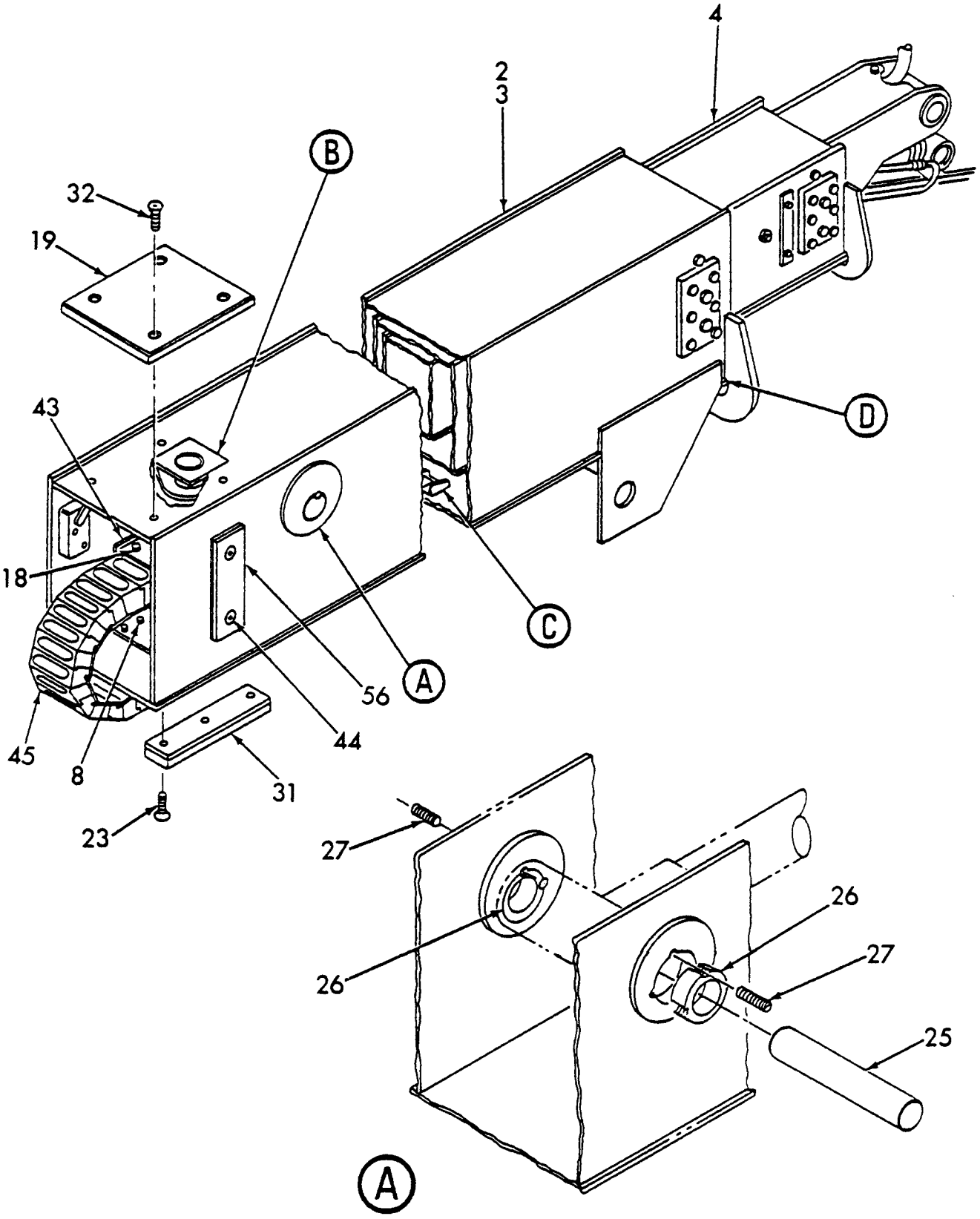
ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-50	.61245	NUT, LOCK	4
-51	.61944	SCREW, CAP	2
52	.63327	WASHER, LOCK	2
-53	.24616 KIT-E	DIAGRAM, HYDRAULIC HOSE (BOOM)	1

REV.

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Mark Industries

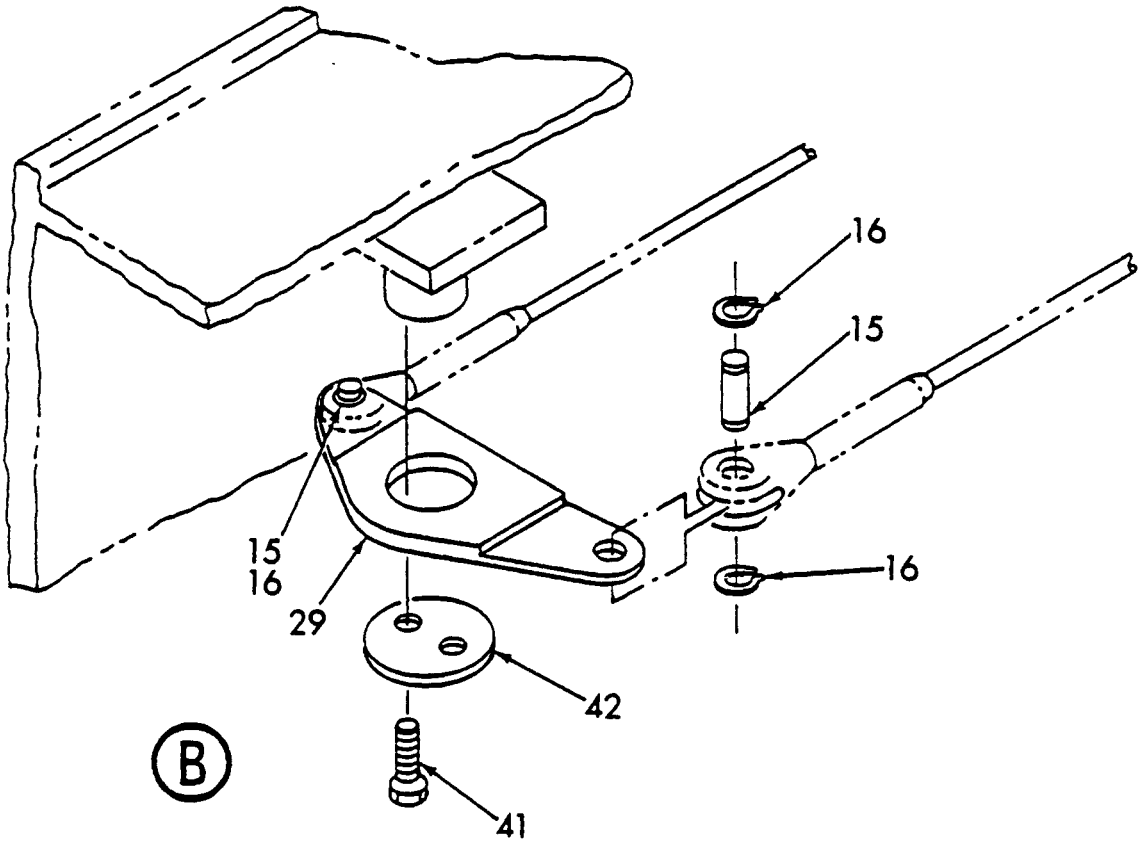
TITLE	OUTER/INTERMEDIATE BOOM SUB-ASSEMBLY	SECT.	5
MODEL	100C 6X4	FIG.	2
NOTES		SHEET	1

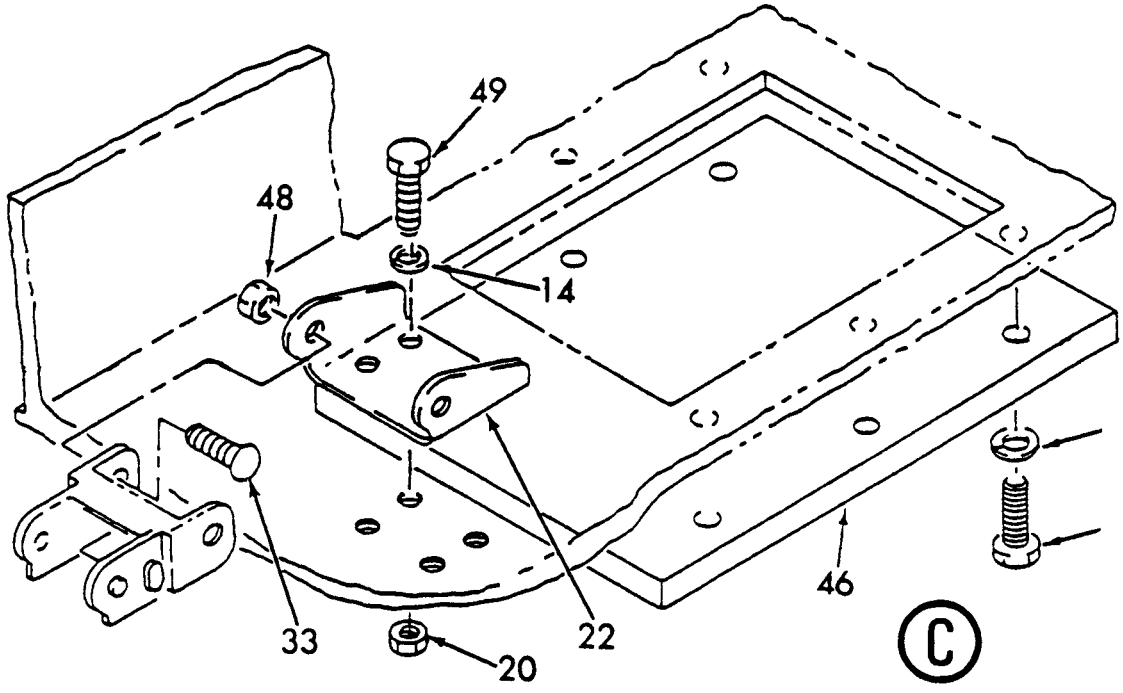


REV.

Mark Industries

TITLE	OUTER/INTERMEDIATE BOOM SUB-ASSEMBLY	SECT.	5
MODEL	100C 6X4	FIG.	2
NOTES		SHEET	2

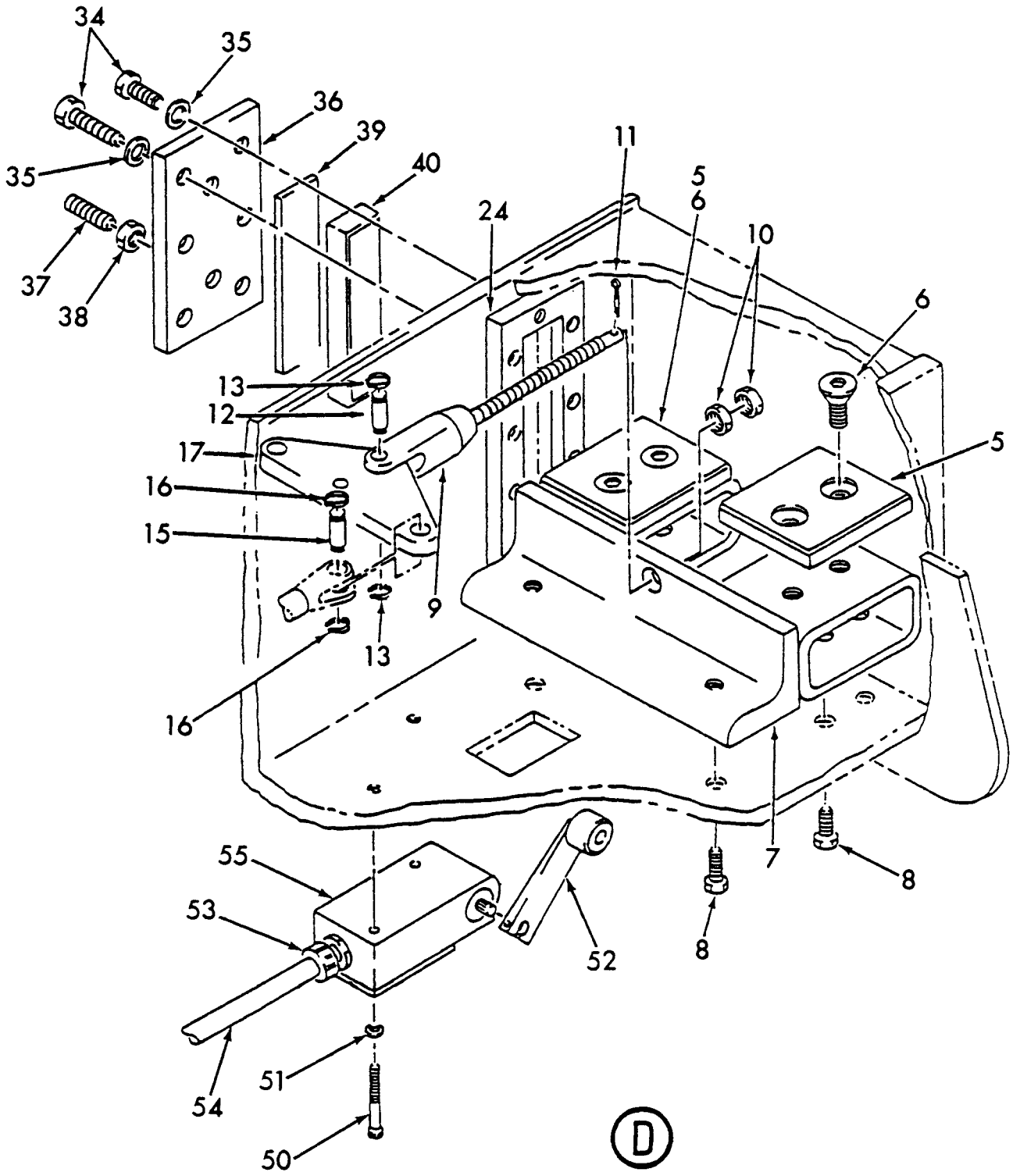




REV.

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TITLE	OUTER/INTERMEDIATE BOOM SUB-ASSEMBLY	SECT.	5
MODEL	100C 6X4	FIG.	2
NOTES		SHEET	3



REV.

Mark Industries

TITLE	OUTER/INTERMEDIATE BOOM SUB-ASSEMBLY
MODEL	100C 6X4
NOTES	

SECT.	5
FIG.	2
SHEET	4

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	24311	SUB-ASSEMBLY, OUTER/INTERMEDIATE BOOM (See Sect. 5, Fig. 1 for NHA)	REF
2	.24074	MACHINING, OUTER/INTERMEDIATE BOOM	1
3	..24073	WELDMENT, OUTER/INTERMEDIATE BOOM	1
4	.24312	SUB-ASSEMBLY, INNER/INTERMEDIATE BOOM (See Sect. 5, Fig. 3 for Details)	1
5	.24392	PAD, WEAR	2
6	.61806	SCREW, CAP	4
7	.24224	BRACKET, BOOM END	1
8	.60607	SCREW, CAP	10
9	.22710	CLEVIS	1
10	.60910	NUT, JAM	2
11	.64301	PIN, COTTER	1
12	.22708	PIN	1
13	.65076	RING, SNAP	2
14	.63301	WASHER, SPLIT	4
15	.22703	PIN	4
16	.65082	RING, SNAP	8
17	.24238	LEVER, RETRACTION CABLE	1
18	.60625	SCREW, CAP	4
19	.24239	PAD, WEAR	1
20	.60701	NUT, HEX	8
-21	.60617	SCREW, CAP	4
22	.23894	BRACKET, STATIONARY	1
23	.61805	SCREW, CAP	6
24	.21358	RETAINER, WEAR PAD	2

REV.

DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

Mark Industries

TITLE	OUTER/INTERMEDIATE BOOM SUB-ASSEMBLY
MODEL	100C 6X4
NOTES	

SECT.	5
FIG.	2
SHEET	5

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
25	.23213	PIN, BOOM EXTENSION CYLINDER	1
26	.21353	BUSHING, ECCENTRIC	2
27	.62229	SCREW, SET	2
28	.63302	WASHER, SPLIT	4
29	.24229	LEVER, EXTENSION CABLE	1
30	..64915	BUSHING	1
31	.24240	PAD, WEAR	2
32	.61827	SCREW, CAP	4
33	.61931	SCREW, CAP	2
34	.60325	SCREW, CAP	16
35	.63303	WASHER, SPLIT	16
36	.21321	PLATE, WEAR PAD COVER	2
37	.62204	SCREW, SET	4
38	.61101	NUT, JAM	4
39	.20453	PLATE, PAD PRESSURE	2
40	.23170	PAD, WEAR	2
41	.60603	SCREW, CAP	2
42	.22593	RETAINER	1
43	.22031	BRACKET, PLASTITRAK	1
44	.61801	SCREW, CAP	4
45	.24401	ASSEMBLY, PLASTITRAK (See Sect. 5, Fig. 8 for Details)	1
46	.24230	PLATE, COVER	1
47	.60367	SCREW, CAP	4
48	.61322	NUT, LOCK	2
49	.60644	SCREW, CAP	4

DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

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TITLE	OUTER/INTERMEDIATE BOOM SUB-ASSEMBLY
MODEL	100C 6X4
NOTES	

SECT.	5
FIG.	2
SHEET	6

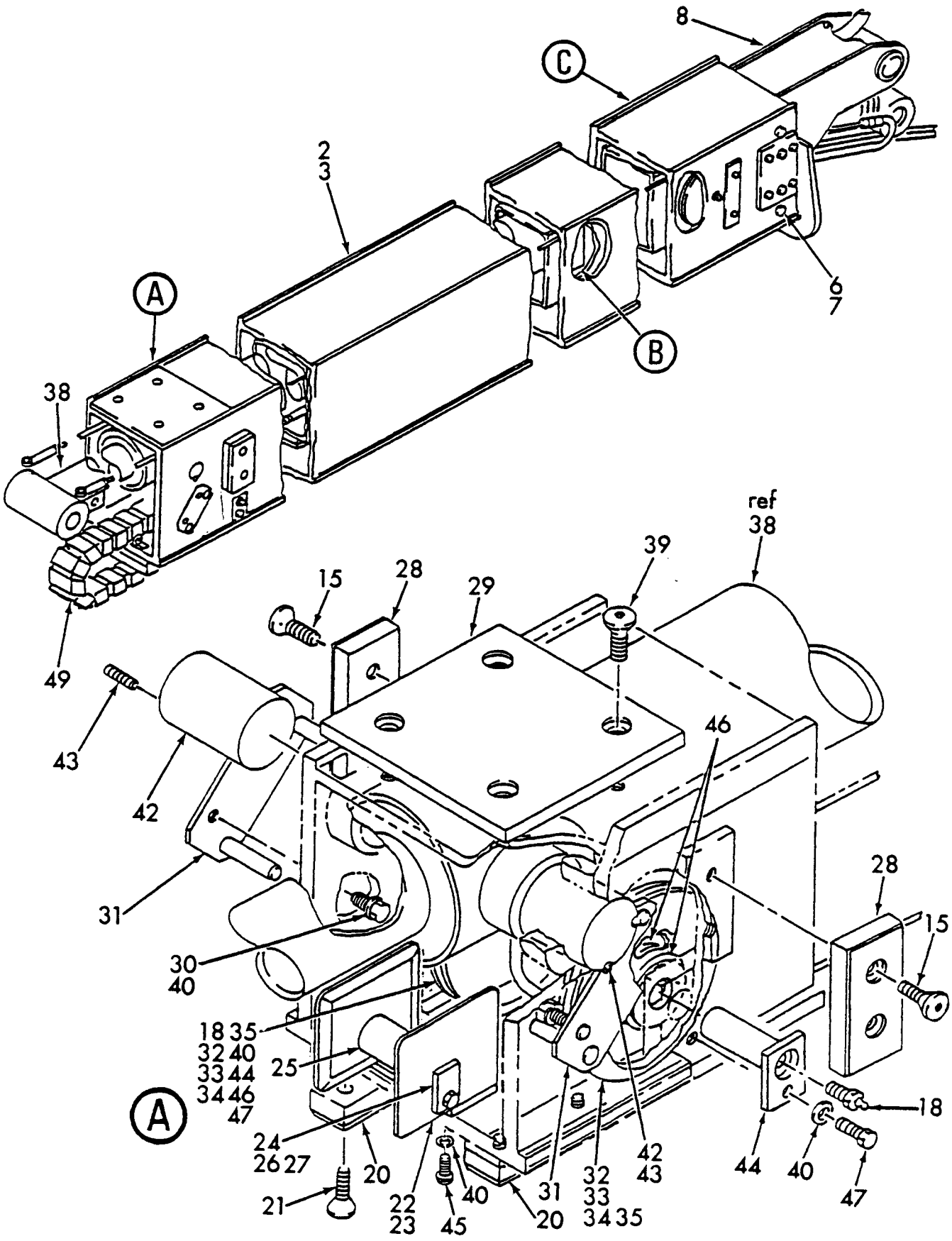
ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
50	.62704	SCREW, MACHINE	2
51	.63313	WASHER, SPLIT	2
52	.70148	ARM, SWITCH LEVER	1
53	.70627	CONNECTOR, STRAIN RELIEF	1
54	.2768	CABLE, ELECTRICAL	75 FT
55	.70107	SWITCH, LIMIT	1
56	.24241	PAD, WEAR	2

REV.

DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

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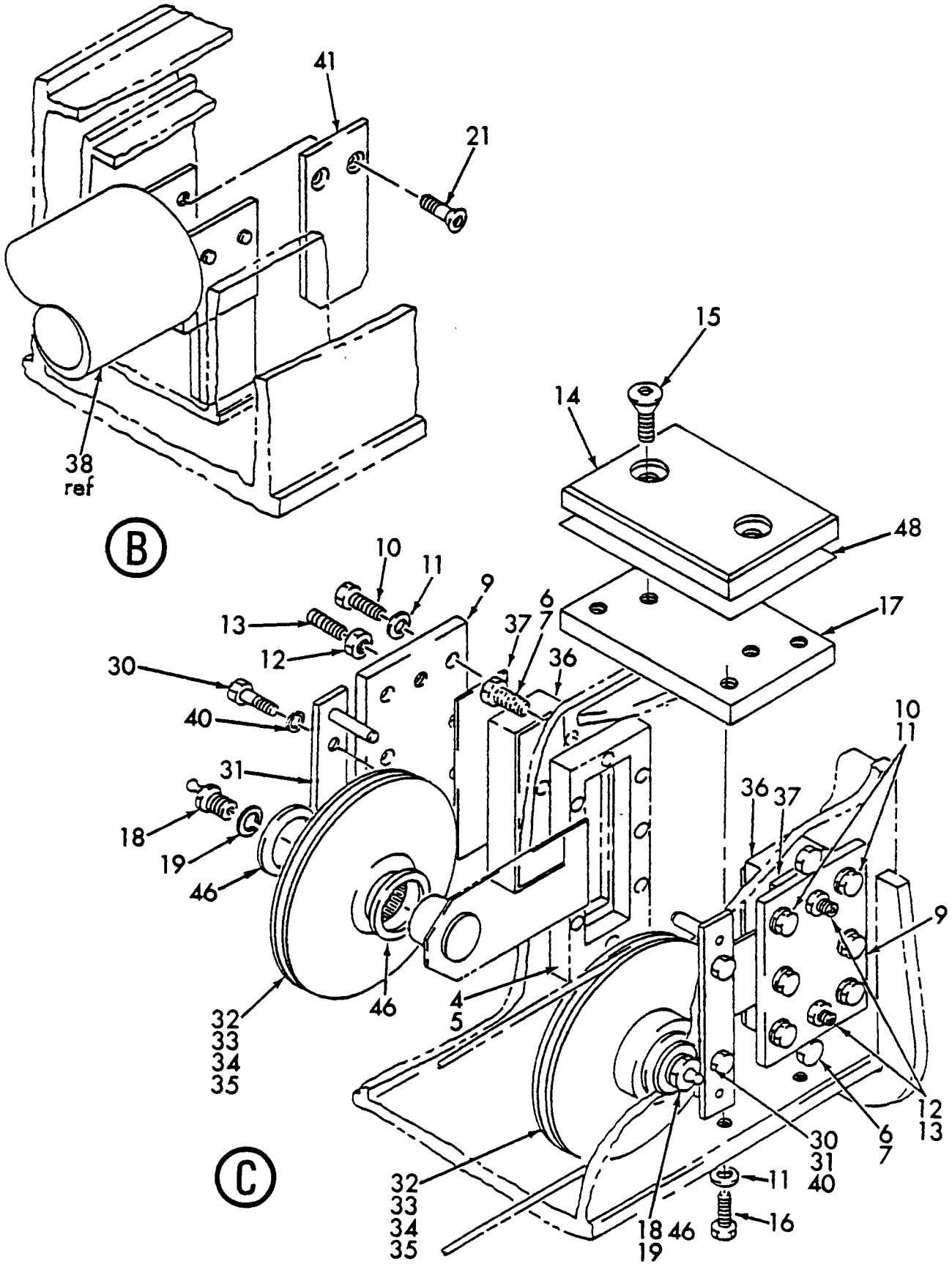
TITLE	INNER/INTERMEDIATE BOOM SUB-ASSEMBLY	SECT.	5
MODEL	100C 6X4	FIG.	3
NOTES		SHEET	1



REV.

Mark Industries

TITLE	INNER/INTERMEDIATE BOOM SUB-ASSEMBLY	SECT.	5
MODEL	100C 6X4	FIG.	3
NOTES		SHEET	2



REV.

Mark Industries

TITLE	INNER/INTERMEDIATE BOOM SUB-ASSEMBLY
MODEL	100C 6X4
NOTES	

SECT.	5
FIG.	3
SHEET	3

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	24312	SUB-ASSEMBLY, INNER/INTERMEDIATE BOOM (See Sect. 5, Fig. 2 for NHA)	REF
2	.24076	MACHINING, INNER/INTERMEDIATE BOOM	1
3	..24075	WELDMENT, INNER/INTERMEDIATE BOOM	1
4	..24205	BRACKET, SIDE WEAR PAD (L.H.)	1
5	..24206	BRACKET, SIDE WEAR PAD (R.H.)	1
6	..60539	SCREW, CAP	4
7	..65303	WASHER, LOCK	4
8	.24313	SUB-ASSEMBLY, INNER BOOM (See Sect. 5, Fig. 4 for Details)	1
9	.21321	PLATE, WEAR PAD COVER	2
10	.60541	SCREW, CAP	12
11	.63303	WASHER, LOCK	16
12	.61101	NUT, JAM	4
13	.62204	SCREW, SET	4
14	.23206	PAD, WEAR	1
15	.61801	SCREW, CAP	8
16	.60325	SCREW, CAP	4
17	.23207	SUPPORT, WEAR PAD	1
18	.65103	FITTING, GREASE	4
19	.65076	RING, SNAP	4
20	.24223	PAD, WEAR	2
21	.61804	SCREW, CAP	4
22	.24510	ASSEMBLY, SUPPORT ROLLER	1
23	..24509	WELDMENT, ROLLER BRACKET	1
24	..22716	PIN, ROLLER	1

Mark Industries

TITLE	INNER/INTERMEDIATE BOOM SUB-ASSEMBLY	SECT.	5
MODEL	100C 6X4	FIG.	3
NOTES		SHEET	4

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
25	..24508	ROLLER, PLASTITRAK	1
26	..60324	SCREW, CAP	1
27	..63302	WASHER, LOCK	1
28	.22567	PAD, WEAR	2
29	.23204	PAD, WEAR	1
30	.60527	SCREW, CAP	8
31	.24474	WELDMENT, CABLE KEEPER	2
32	.24222	ASSEMBLY, CABLE SHEAVE	4
33	..27639	PLATE	1
34	..65064	ASSEMBLY, OUTER RING & ROLLER	1
35	..65063	RING, INNER	1
36	.23200	PAD, WEAR	2
37	.20453	PLATE, PAD PRESSURE	2
38	.24329	ASSEMBLY, BOOM EXTENSION CYLINDER (See Sect. 5, Fig. 5 for Details)	1
39	.61822	SCREW, CAP	4
40	.63302	WASHER, LOCK	8
41	.24400	PAD, WEAR	2
42	.24231	PIN, TRUNNION	2
43	.62229	SCREW, SET	2
44	.24221	PIN, CABLE SHEAVE	2
45	.61931	SCREW, CAP	4
46	.65534	WASHER, THRUST	8
47	.60553	SCREW, CAP	2

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TITLE	INNER/INTERMEDIATE BOOM SUB-ASSEMBLY
MODEL	100C 6X4
NOTES	

SECT.	5
FIG.	3
SHEET	5

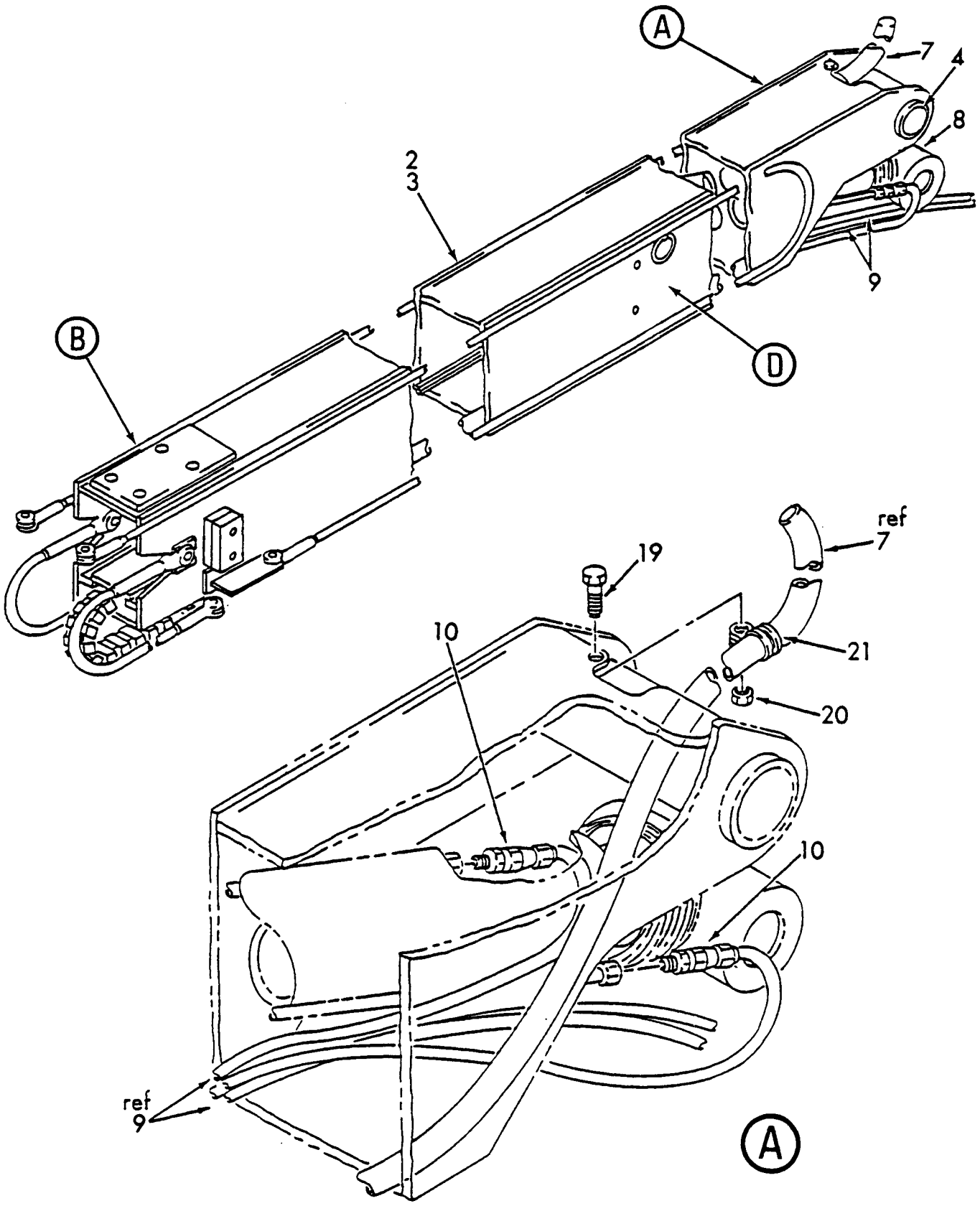
ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
48	.23620	SHIM	1
49	.24401	ASSEMBLY, PLASTITRAK (See Sect. 5, Fig. 7 for Details)	1

REV.

DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

Mark Industries

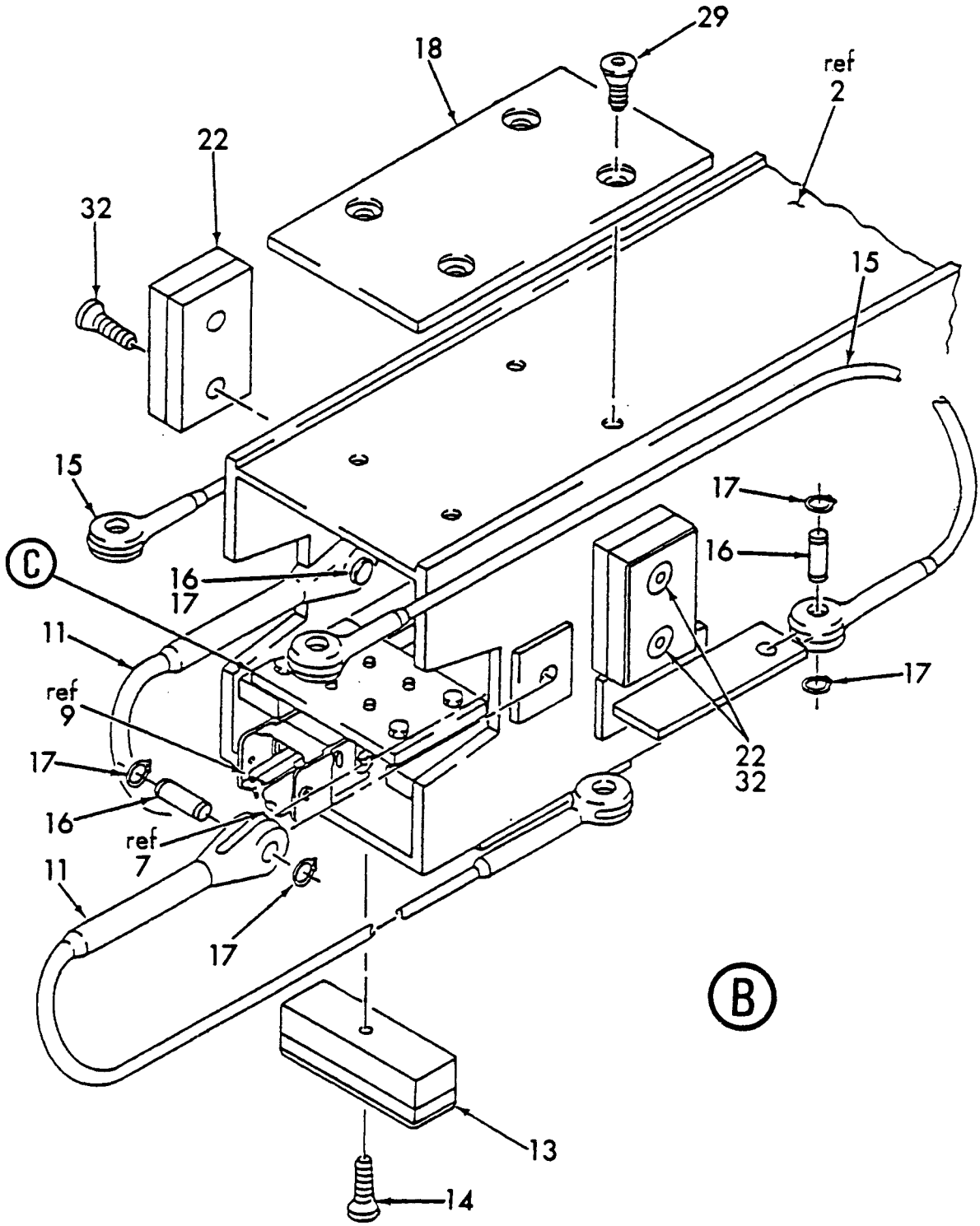
TITLE	INNER BOOM SUB-ASSEMBLY	SECT.	5
MODEL	100C 6X4	FIG.	4
NOTES		SHEET	1



REV.

Mark Industries

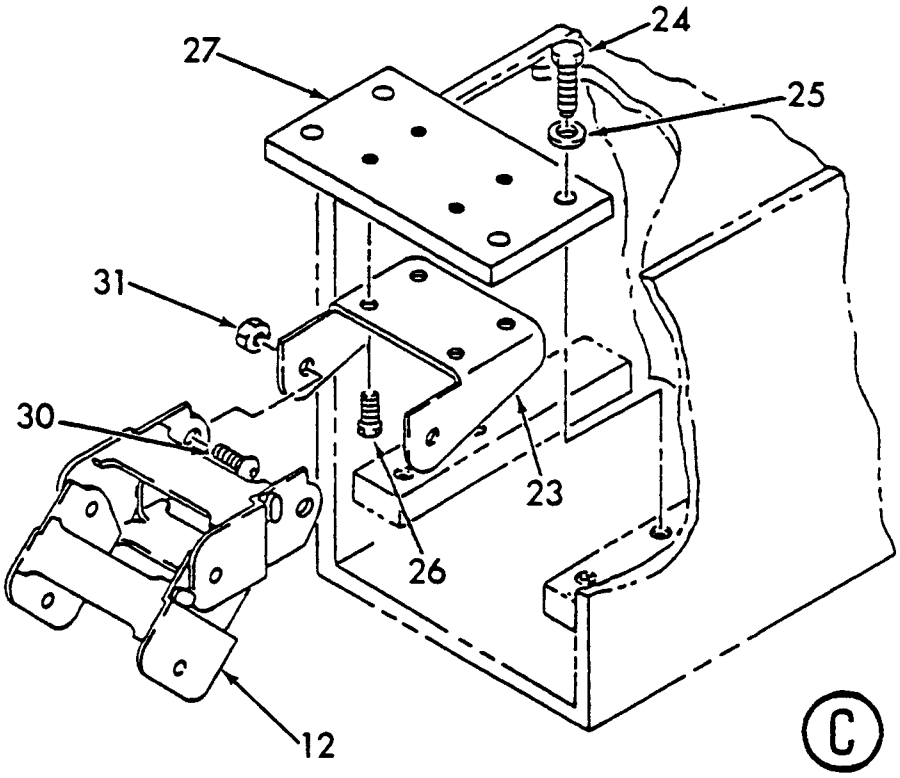
TITLE	INNER BOOM SUB-ASSEMBLY	SECT.	5
MODEL	100C 6X4	FIG.	4
NOTES		SHEET	2

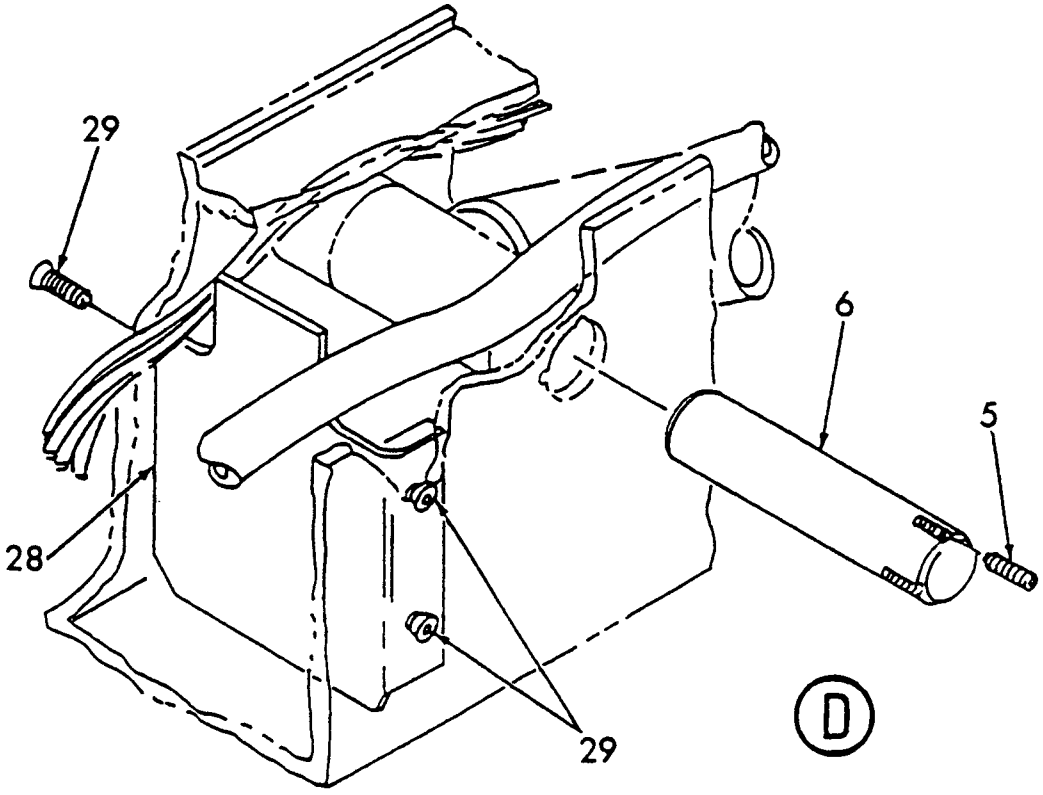


REV.

Mark Industries

TITLE	INNER BOOM SUB-ASSEMBLY	SECT.	5
MODEL	100C 6X4	FIG.	4
NOTES		SHEET	3





REV.

Mark Industries

TITLE	INNER BOOM SUB-ASSEMBLY	SECT.	5
MODEL	100C 6X4	FIG.	4
NOTES		SHEET	4

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	24313	SUB-ASSEMBLY, INNER BOOM (See Sect. 5, Fig. 3 for NHA)	REF
2	.24078	MACHINING, INNER BOOM	1
3	..24077	WELDMENT, INNER BOOM	1
4	..20582	BUSHING	2
5	.62229	SCREW, SET	2
6	.23218	PIN, SLAVE LEVELING CYLINDER	1
7	.70528	CABLE, 40 CONDUCTOR W/BRAIDING	155 FT
8	.21094	ASSEMBLY, SLAVE LEVELING CYLINDER (See Sect. 5, Fig. 7 for Details)	1
9	.2568	HOSE	150 FT
10	.2562	FITTING, STRAIGHT SWIVEL	2
11	.24398	CABLE, RETRACTION	2
12	.23824	TRACK, POWER (BLUE)	159
13	.23083	PAD, WEAR	1
14	.60403	SCREW, CAP	6
15	.24399	CABLE, EXTENSION	2
16	.22703	PIN	4
17	.65082	RING, SNAP	8
18	.23203	PAD, WEAR	1
19	.60309	SCREW, CAP	1
20	.60711	NUT, HEX	1
21	.16268	CLAMP, HOSE	1
22	.22569	PAD, WEAR	2
23	.23895	BRACKET, MOVABLE	1
24	.60322	SCREW, CAP	4

REV.

DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

Mark Industries

TITLE	INNER BOOM SUB-ASSEMBLY
MODEL	100C 6X4
NOTES	

SECT.	5
FIG.	4
SHEET	5

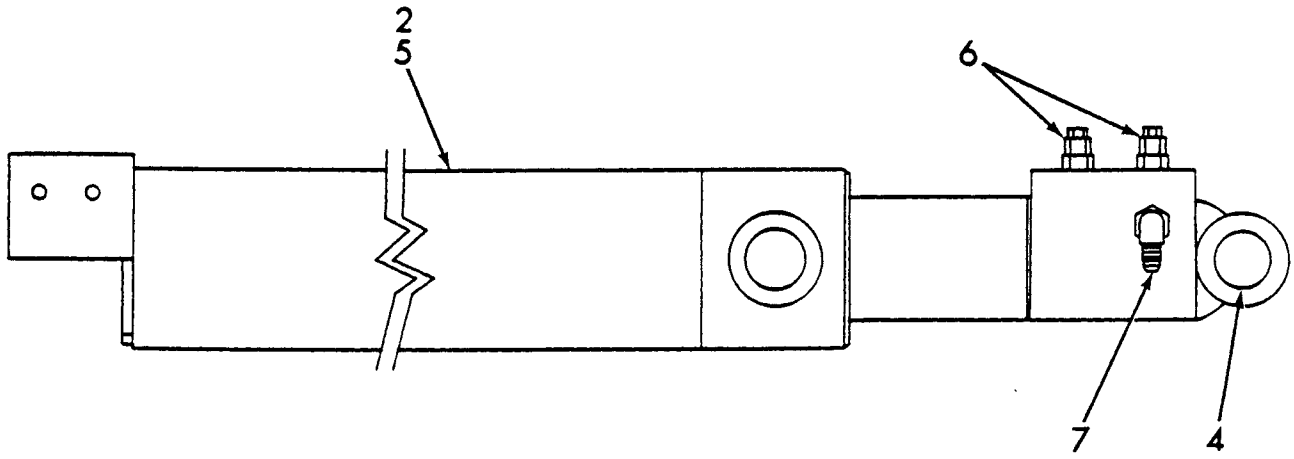
ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
25	.63302	WASHER, SPLIT	4
26	.60543	SCREW, CAP	4
27	.22730	PLATE, MOUNTING	1
28	.23214	PLATE, BULKHEAD	1
29	.61822	SCREW, CAP	8
30	.61931	SCREW, CAP	2
31	.61322	NUT, LOCK	2
32	.61805	SCREW, CAP	8

REV.

DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

Mark Industries

TITLE	BOOM EXTENSION CYLINDER ASSEMBLY	SECT.	5
MODEL	100C 6X4	FIG.	5
NOTES	UNTIL MID 1988 (SE)	SHEET	1



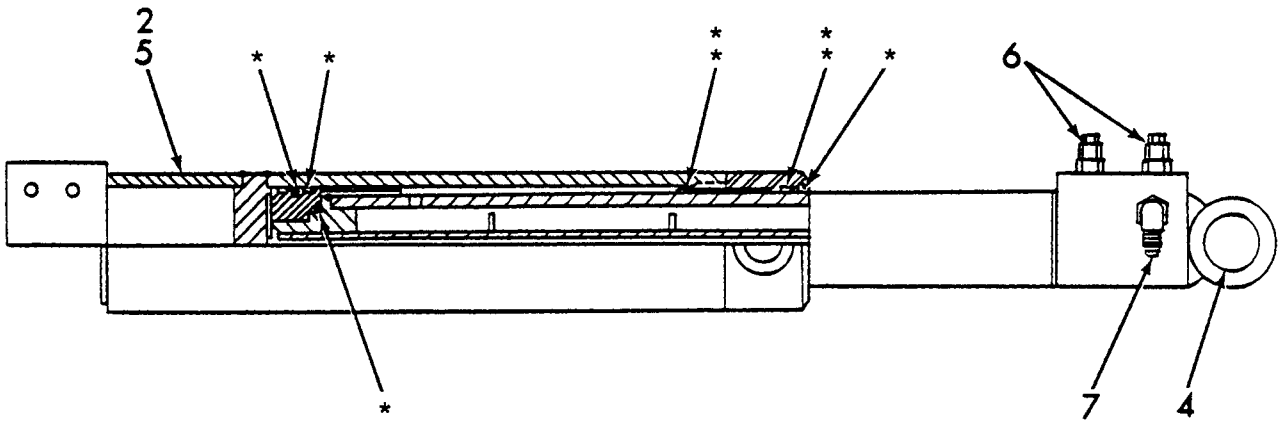
NOTE 1: DUE TO VENDOR/MFG. REVISIONS; WHEN POSSIBLE, PROVIDE ALL NUMBERS FROM THE CYLINDER ID TAG.

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	24329	ASSEMBLY, BOOM EXTENSION CYLINDER (See Sect. 5, Fig. 3 for NHA)	REF
2	.24326	SUB-ASSEMBLY, BOOM EXTENSION CYLINDER	1
-3	..67131	KIT, SEAL (SE)	1
		NOTE 3: THE SEAL KIT INCLUDES ITEMS SHOWN WITH AN ASTERISK (*).	
4	..	BEARING, DU (SE)	2
5	..24325	CYLINDER, BOOM EXTENSION (SE)	1
		NOTE 2: INTERNAL SERVICE REPLACEMENT PARTS AVAILABLE ON A SPECIAL ORDER BASIS.	
6	..81006	CARTRIDGE, OVERCENTER	2
7	.80012-11	ELBOW, STRAIGHT THREAD	2

REV.

Mark Industries

TITLE	BOOM EXTENSION CYLINDER ASSEMBLY	SECT.	5
MODEL	100C 6X4	FIG.	5A
NOTES	SINCE MID 1988; CONCURRENT USE (SE)	SHEET	1



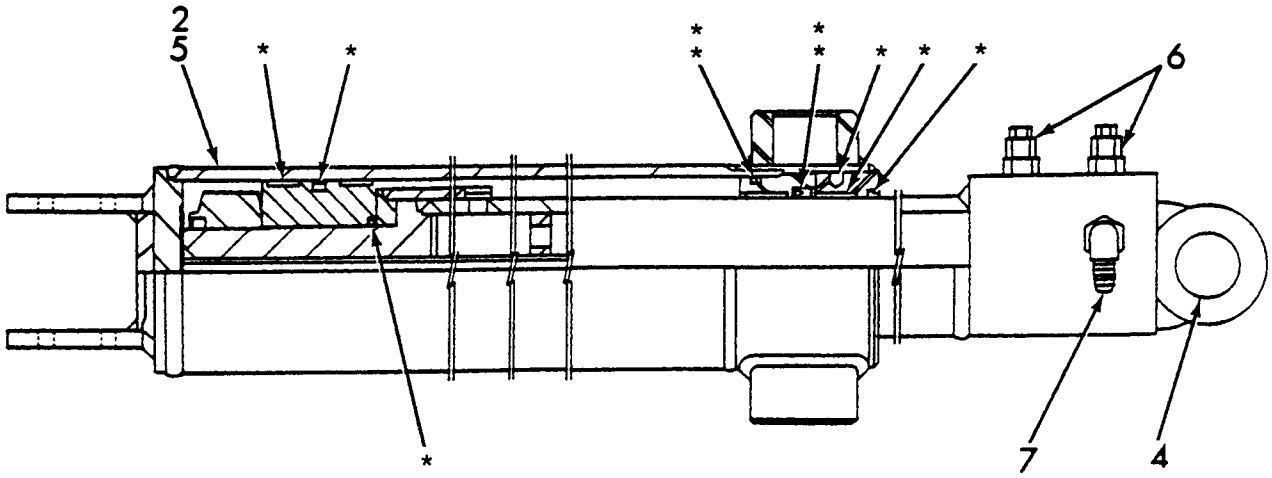
NOTE 1: DUE TO VENDOR/MFG. REVISIONS; WHEN POSSIBLE, PROVIDE ALL NUMBERS FROM THE CYLINDER ID TAG.

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	24329	ASSEMBLY, BOOM EXTENSION CYLINDER (See Sect. 5, Fig. 3 for NHA)	REF
2	.24326	SUB-ASSEMBLY, BOOM EXTENSION CYLINDER	1
-3	..600432	KIT, SEAL (SE)	1
		NOTE 3: THE SEAL KIT INCLUDES ITEMS SHOWN WITH AN ASTERISK (*).	
4	..67948	BEARING, DU (SE)	2
5	..24325	CYLINDER, BOOM EXTENSION (SE)	1
		NOTE 2: INTERNAL SERVICE REPLACEMENT PARTS AVAILABLE ON A SPECIAL ORDER BASIS.	
6	..81006	CARTRIDGE, OVERCENTER	2
7	.80012-11	ELBOW, STRAIGHT THREAD	2

REV.

Mark Industries

TITLE	BOOM EXTENSION CYLINDER ASSEMBLY	SECT.	5
MODEL	100C 6X4	FIG.	5B
NOTES	SINCE MID 1989; CONCURRENT USE (GB)	SHEET	1



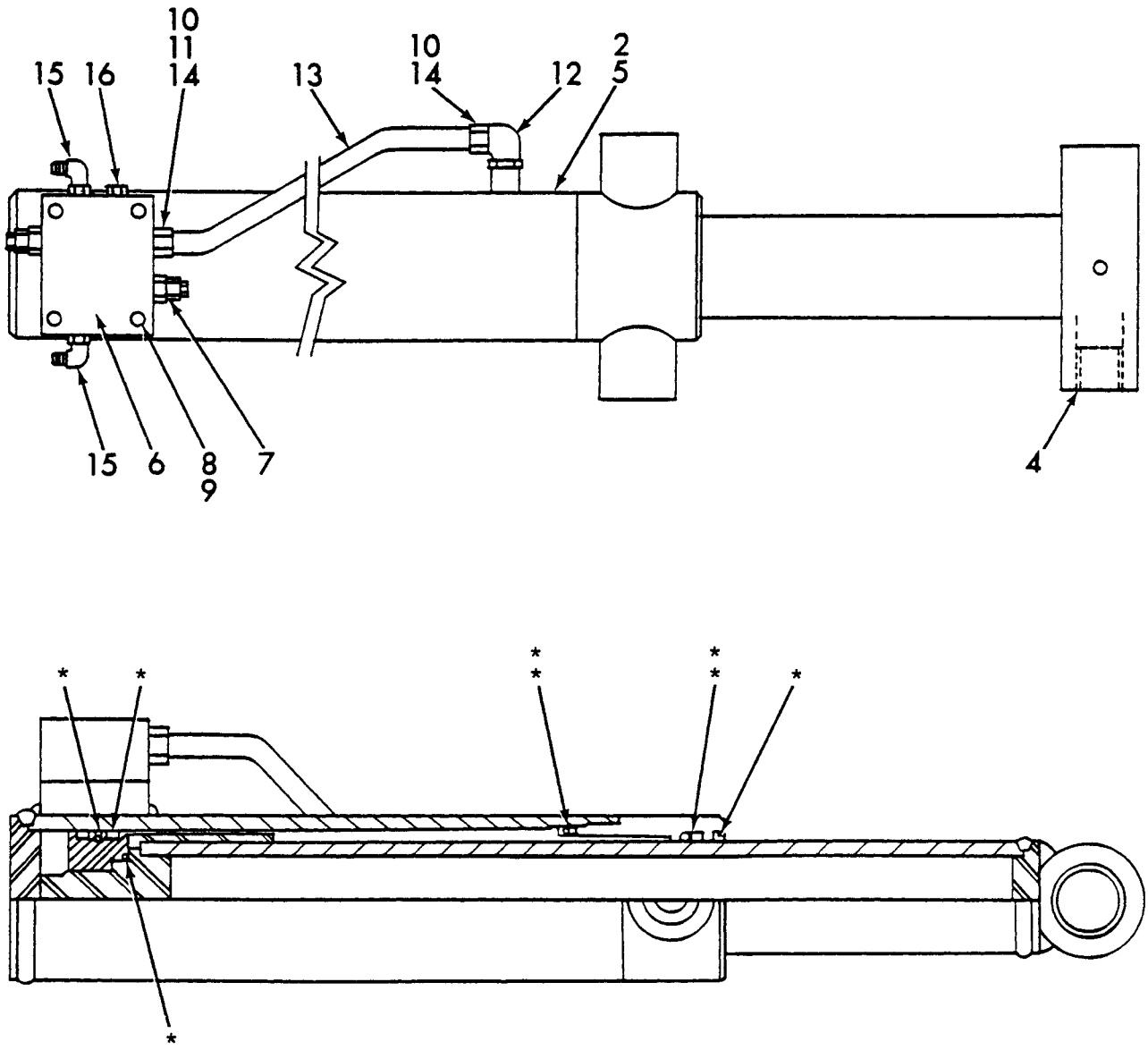
NOTE 1: DUE TO VENDOR/MFG. REVISIONS; WHEN POSSIBLE, PROVIDE ALL NUMBERS FROM THE CYLINDER ID TAG.

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	24329	ASSEMBLY, BOOM EXTENSION CYLINDER (See Sect. 5, Fig. 3 for NHA)	REF
2	.24326	SUB-ASSEMBLY, BOOM EXTENSION CYLINDER	1
-3	..600088	KIT, SEAL (GB)	1
		NOTE 3: THE SEAL KIT INCLUDES ITEMS SHOWN WITH AN ASTERISK (*).	
4	..67948	BEARING, DU (GB)	2
5	..24325	CYLINDER, BOOM EXTENSION (GB)	1
		NOTE 2: INTERNAL SERVICE REPLACEMENT PARTS AVAILABLE ON A SPECIAL ORDER BASIS.	
6	..81006	CARTRIDGE, OVERCENTER	2
7	.80012-11	ELBOW, STRAIGHT THREAD	2

REV.

Mark Industries

TITLE	OUTSIDE BOOM EXTENSION CYLINDER ASSEMBLY	SECT.	5
MODEL	100C 6X4	FIG.	6
NOTES	CONCURRENT USE (SE)	SHEET	1



NOTE 1: DUE TO VENDOR/MFG. REVISIONS; WHEN POSSIBLE, PROVIDE ALL NUMBERS FROM THE CYLINDER ID TAG.

REV.

Mark Industries

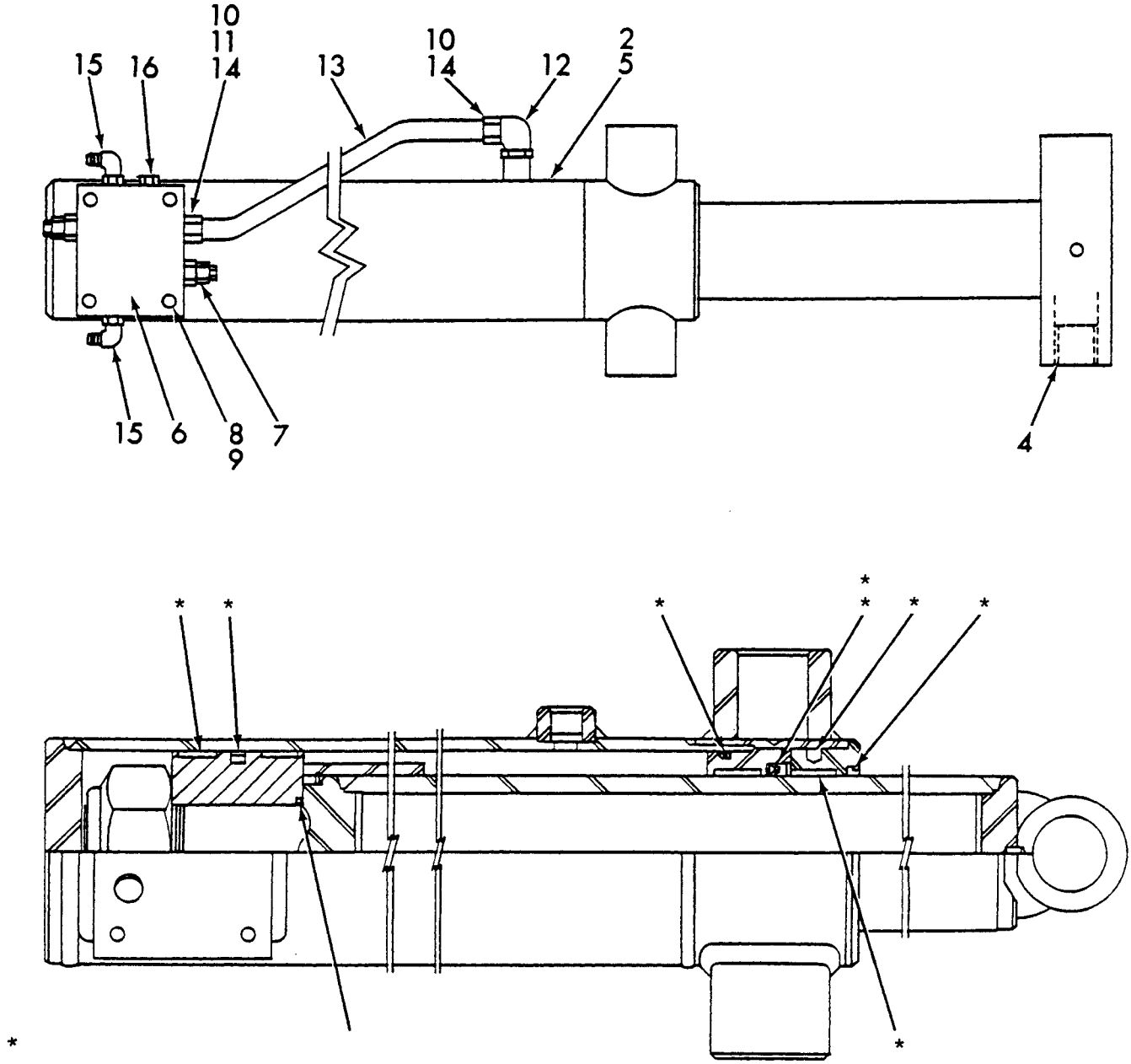
TITLE	OUTSIDE BOOM EXTENSION CYLINDER ASSEMBLY
MODEL	100C 6X4
NOTES	CONCURRENT USE(SE)

SECT.	5
FIG.	6
SHEET	2

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	24328	ASSEMBLY, OUTSIDE EXTENSION CYLINDER (See Sect. 5, Fig. 1 for NHA)	REF
2	.24327	SUB-ASSEMBLY, OUTSIDE EXTENSION CYLINDER (SE)	1
-3	..600432	KIT, SEAL (SE)(AFTER MID 1988)(SHOWN)	1
-3	..67243	KIT, SEAL (SE)(BEFORE MID 1988)(NOT SHOWN)	1
		NOTE 3: THE SEAL KIT INCLUDES ITEMS SHOWN WITH AN ASTERISK (*).	
4	..67948	BUSHING, DU	2
5	..24323	CYLINDER, OUTSIDE EXTENSION	1
		NOTE 2: INTERNAL SERVICE REPLACEMENT PARTS AVAILABLE ON A SPECIAL ORDER BASIS.	
6	..21445	VALVE, BLOCK	1
7	..81006	CARTRIDGE, OVERCENTER	2
8	..63302	WASHER, SPLIT	4
9	..61820	SCREW, CAP	4
10	..80060-06	NUT	2
11	..80004-19	CONNECTOR, STRAIGHT THREAD	1
12	..80012-19	ELBOW, STRAIGHT THREAD	1
13	..27735	TUBING, HYDRAULIC	1
14	..80062-08	SLEEVE	2
15	.80012-11	ELBOW, STRAIGHT THREAD	2
16	.80050-03	PLUG, STRAIGHT THREAD	1

Mark Industries

TITLE	OUTSIDE BOOM EXTENSION CYLINDER ASSEMBLY	SECT.	5
MODEL	100C 6X4	FIG.	6A
NOTES	SINCE MID 1989; CONCURRENT USE (GB)	SHEET	1



NOTE 1: DUE TO VENDOR/MFG. REVISIONS; WHEN POSSIBLE, PROVIDE ALL NUMBERS FROM THE CYLINDER ID TAG.

REV.

Mark Industries

TITLE	OUTSIDE BOOM EXTENSION CYLINDER ASSEMBLY
MODEL	100C 6X4
NOTES	SINCE MID 1989; CONCURRENT USE (GB)

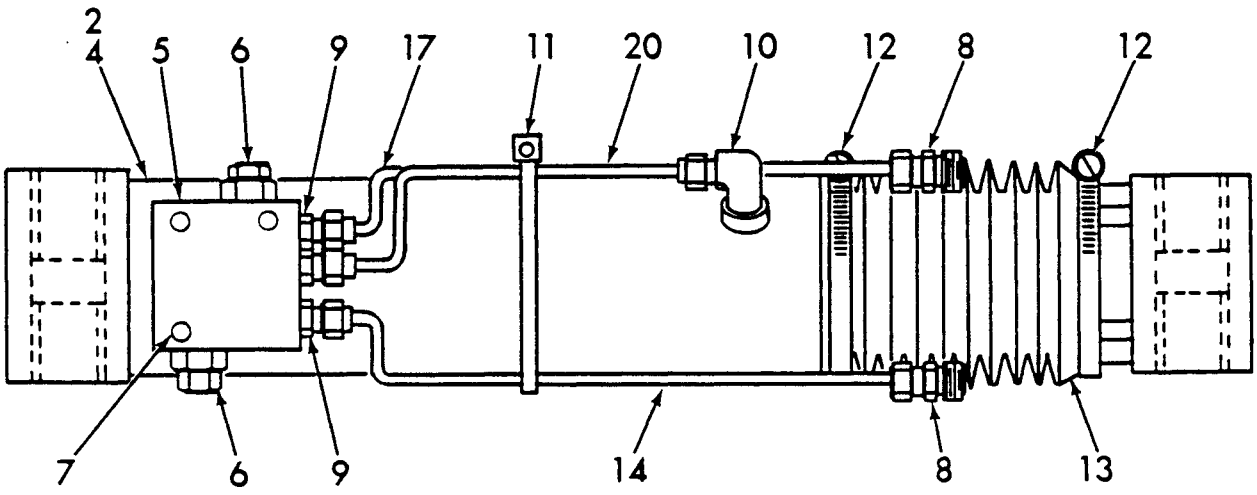
SECT.	5
FIG.	6A
SHEET	2

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	24328	ASSEMBLY, OUTSIDE EXTENSION CYLINDER (See Sect. 5, Fig. 1 for NHA)	REF
2	.24327	SUB-ASSEMBLY, OUTSIDE EXTENSION CYLINDER (GB)	1
-3	..600088	KIT, SEAL (GB)	1
		NOTE 3: THE SEAL KIT INCLUDES ITEMS SHOWN WITH AN ASTERISK (*).	
4	..67948	BUSHING, DU	2
5	..24323	CYLINDER, OUTSIDE EXTENSION	1
		NOTE 2: INTERNAL SERVICE REPLACEMENT PARTS AVAILABLE ON A SPECIAL ORDER BASIS.	
6	..21445	BLOCK, VALVE	1
7	..81006	CARTRIDGE, OVERCENTER	2
8	..63302	WASHER, SPLIT	4
9	..61820	SCREW, CAP	4
10	..80060-06	NUT	2
11	..80004-19	CONNECTOR, STRAIGHT THREAD	1
12	..80012-19	ELBOW, STRAIGHT THREAD	1
13	..27735	TUBING, HYDRAULIC	1
14	..80062-08	SLEEVE	2
15	.80012-11	ELBOW, STRAIGHT THREAD	2
16	.80050-03	PLUG, STRAIGHT THREAD	1

DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

Mark Industries

TITLE	SLAVE LEVELING CYLINDER ASSEMBLY	SECT. 5
MODEL	100C 6X4	FIG. 7
NOTES	UNTIL EARLY 1986 (RA)	SHEET 1



NOTE 1: DUE TO VENDOR/MFG. REVISIONS; WHEN POSSIBLE, PROVIDE ALL NUMBERS FROM THE CYLINDER I.D. TAG.

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	21094	ASSEMBLY, SLAVE LEVELING CYLINDER (See Sect. 5, Fig. 4 for NHA)	REF
2	.21263	SUB-ASSEMBLY, SLAVE LEVELING CYLINDER	1
-3	..66563	KIT, SEAL (RA)	1
4	..21197	CYLINDER, SLAVE LEVELING (RA)	1
		NOTE 2: INTERNAL SERVICE REPLACEMENT PARTS AVAILABLE ON A SPECIAL ORDER BASIS.	
5	..21447	MANIFOLD, SLAVE LEVELING CYLINDER	1
6	..21267	CARTRIDGE, OVERCENTER	2
7	..61903	SCREW, CAP	3

REV.

Mark Industries

TITLE	SLAVE LEVELING CYLINDER ASSEMBLY
MODEL	100C 6X4
NOTES	SINCE EARLY 1986 (RA)

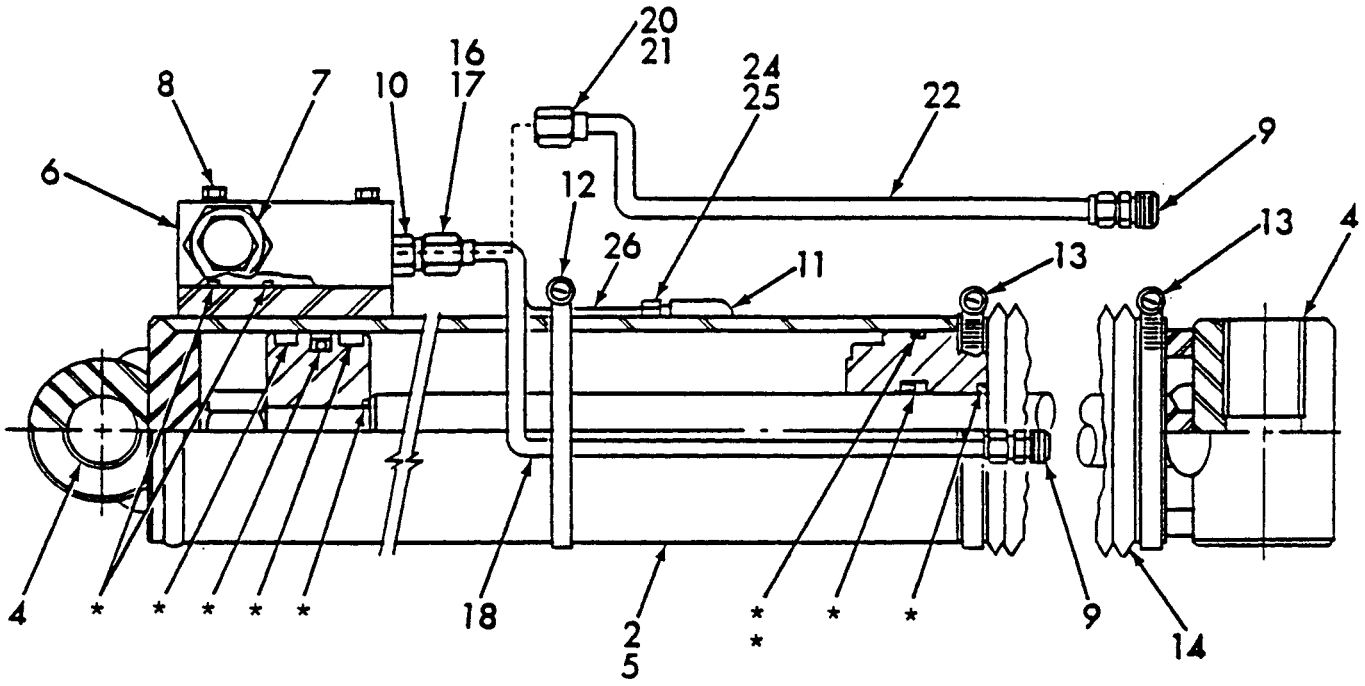
SECT.	5
FIG.	7
SHEET	2

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
8	.80042-03	CONNECTOR, UNION	2
9	.80004-03	CONNECTOR, STRAIGHT THREAD	3
10	.80012-03	ELBOW, STRAIGHT THREAD	1
11	.65111	STRAP	1
12	.16318	CLAMP	2
13	.21388	TUBING, CONVOLUTED	1
-14	.21094-8	ASSEMBLY, TUBE	1
15	..80062-03	SLEEVE	2
16	..80060-03	NUT	2
-17	.21094-9	ASSEMBLY, TUBE	1
18	..80062-03	SLEEVE	2
19	..80060-03	NUT	2
-20	.21094-10	ASSEMBLY, TUBE	1
21	..80062-03	SLEEVE	2
22	..80060-03	NUT	2

DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

Mark Industries

TITLE	SLAVE LEVELING CYLINDER ASSEMBLY	SECT. 5
MODEL	100C 6X4	FIG. 7A
NOTES	UNTIL EARLY 1990 (SE)	SHEET 1



NOTE 1: DUE TO VENDOR/MFG. REVISIONS; WHEN POSSIBLE, PROVIDE ALL NUMBERS FROM THE CYLINDER I.D. TAG.

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	21094	ASSEMBLY, SLAVE LEVELING CYLINDER (See Sect. 5, Fig. 4 for NHA)	REF
2	.21263	SUB-ASSEMBLY, SLAVE LEVELING CYLINDER	1
-3	..67040	KIT, SEAL (SE)	1
		NOTE 3: THE SEAL KIT INCLUDES ITEMS SHOWN WITH AN ASTERISK (*).	
4	..66468	BUSHING, DU (SE)	4
5	..21197	CYLINDER, SLAVE LEVELING (SE)	1
		NOTE 2: INTERNAL SERVICE REPLACEMENT PARTS AVAILABLE ON A SPECIAL ORDER BASIS.	
6	..21447	MANIFOLD, SLAVE LEVELING CYLINDER	1
7	..21267	CARTRIDGE, OVERCENTER	2

REV.

Mark Industries

TITLE	SLAVE LEVELING CYLINDER ASSEMBLY
MODEL	100C 6X4
NOTES	UNTIL EARLY 1990 (SE)

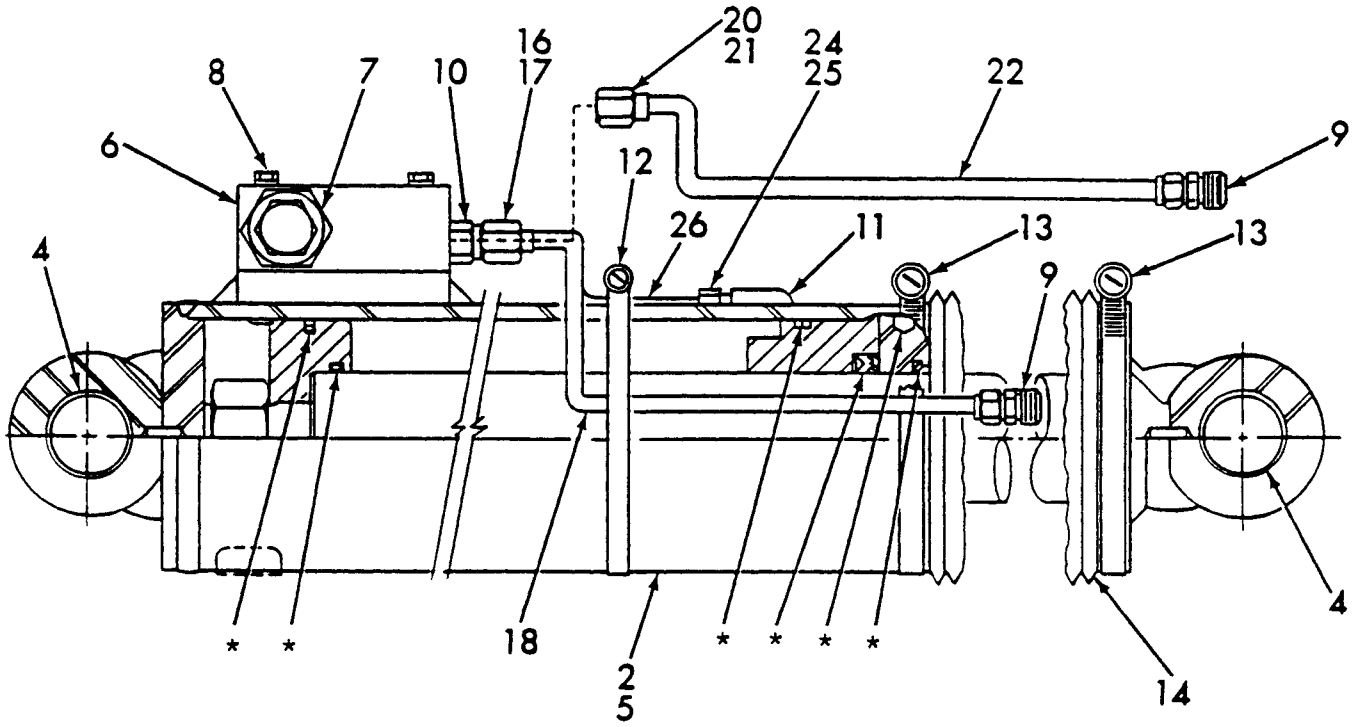
SECT.	5
FIG.	7A
SHEET	2

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
8	..61903	SCREW, CAP	3
9	.80042-03	CONNECTOR, UNION	2
10	.80004-03	CONNECTOR, STRAIGHT THREAD	3
11	.80012-03	ELBOW, STRAIGHT THREAD	1
12	.65111	STRAP	1
13	.16318	CLAMP	2
14	.21388	TUBING, CONVOLUTED	1
-15	.21094-8	ASSEMBLY, TUBE	1
16	..80062-03	SLEEVE	2
17	..80060-03	NUT	2
-18	.21094-9	ASSEMBLY, TUBE	1
19	..80062-03	SLEEVE	2
20	..80060-03	NUT	2
-21	.21094-10	ASSEMBLY, TUBE	1
22	..80062-03	SLEEVE	2
23	..80060-03	NUT	2

DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

Mark Industries

TITLE	SLAVE LEVELING CYLINDER ASSEMBLY	SECT.	5
MODEL	100C 6X4	FIG.	7B
NOTES	SINCE LATE 1989; CONCURRENT USE (GB)	SHEET	1



NOTE 1: DUE TO VENDOR/MFG. REVISIONS; WHEN POSSIBLE, PROVIDE ALL NUMBERS FROM THE CYLINDER I.D. TAG.

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	21094	ASSEMBLY, SLAVE LEVELING CYLINDER (See Sect. 5, Fig. 4 for NHA)	REF
2	.21263	SUB-ASSEMBLY, SLAVE LEVELING CYLINDER (GB)	1
-3	..600074	KIT, SEAL (GB)	1
		NOTE 3: THE SEAL KIT INCLUDES ITEMS SHOWN WITH AN ASTERISK (*).	
4	..66468	BUSHING, DU (GB)	4
5	..21197	CYLINDER, SLAVE LEVELING (GB)	1
		NOTE 2: INTERNAL SERVICE REPLACEMENT PARTS AVAILABLE ON A SPECIAL ORDER BASIS.	
6	..21447	MANIFOLD, SLAVE LEVELING CYLINDER	1
7	..21267	CARTRIDGE, OVERCENTER	2

REV.

Mark Industries

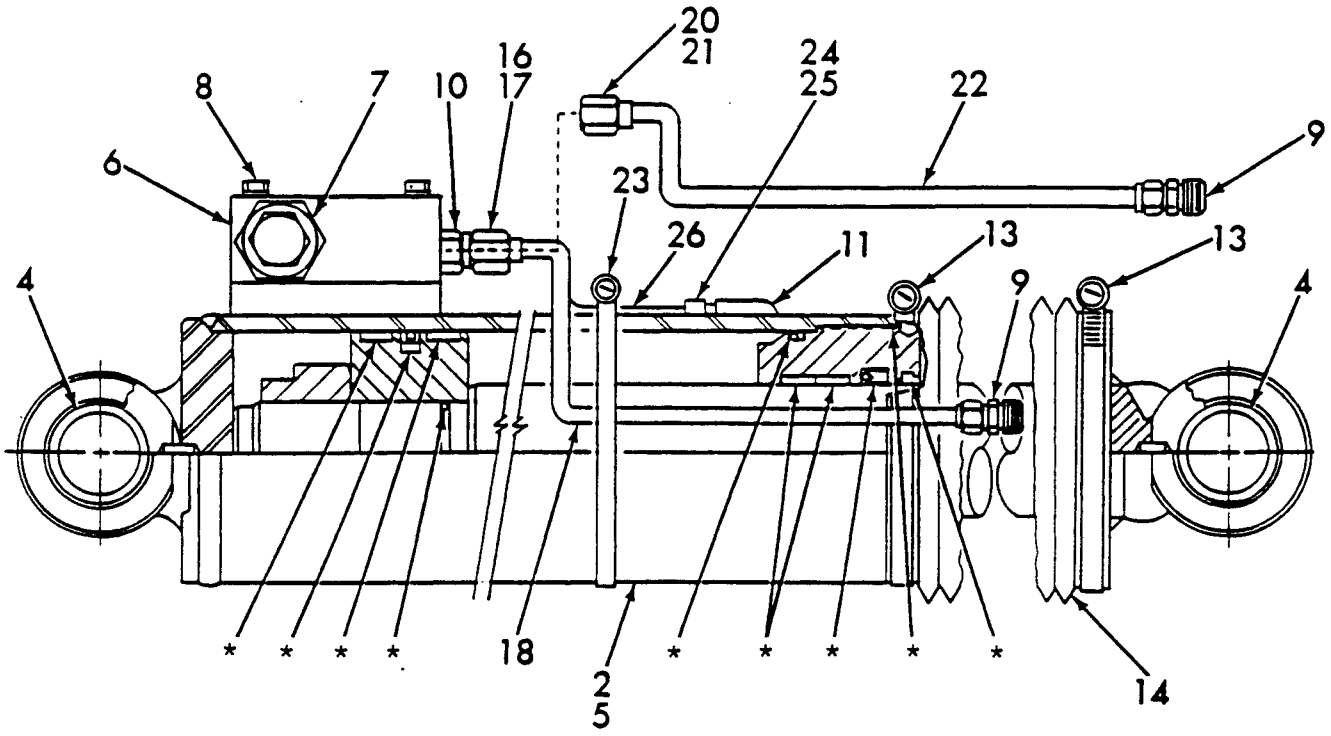
TITLE	SLAVE LEVELING CYLINDER ASSEMBLY
MODEL	100C 6X4
NOTES	SINCE LATE 1989; CONCURRENT USE (GB)

SECT.	5
FIG.	7B
SHEET	2

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
8	..61903	SCREW, CAP	3
9	.80042-03	CONNECTOR, UNION	2
10	.80004-03	CONNECTOR, STRAIGHT THREAD	3
11	.80012-03	ELBOW, STRAIGHT THREAD	1
12	.65111	STRAP	1
13	.16318	CLAMP	2
14	.21388	TUBING, CONVOLUTED	1
-15	.21094-8	ASSEMBLY, TUBE	1
16	..80062-03	SLEEVE	2
17	..80060-03	NUT	2
-18	.21094-9	ASSEMBLY, TUBE	1
19	..80062-03	SLEEVE	2
20	..80060-03	NUT	2
-21	.21094-10	ASSEMBLY, TUBE	1
22	..80062-03	SLEEVE	2
23	..80060-03	NUT	2

Mark Industries

TITLE	SLAVE LEVELING CYLINDER ASSEMBLY	SECT.	5
MODEL	100C 6X4	FIG.	7C
NOTES	SINCE EARLY 1990; CONCURRENT USE (TH)	SHEET	1



NOTE 1: DUE TO VENDOR/MFG. REVISIONS; WHEN POSSIBLE, PROVIDE ALL NUMBERS FROM THE CYLINDER I.D. TAG.

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	21094	ASSEMBLY, SLAVE LEVELING CYLINDER (See Sect. 5, Fig. 4 for NHA)	REF
2	.21263	SUB-ASSEMBLY, SLAVE LEVELING CYLINDER	1
-3	..600374	KIT, SEAL (TH)	1
		NOTE 3: THE SEAL KIT INCLUDES ITEMS SHOWN WITH AN ASTERISK (*).	
4	..600375	BUSHING (TH)	4
5	..21197	CYLINDER, SLAVE LEVELING (TH)	1
		NOTE 2: INTERNAL SERVICE REPLACEMENT PARTS AVAILABLE ON A SPECIAL ORDER BASIS.	
6	..21447	MANIFOLD, SLAVE LEVELING CYLINDER	1
7	..21267	CARTRIDGE, OVERCENTER	2

REV.

Mark Industries

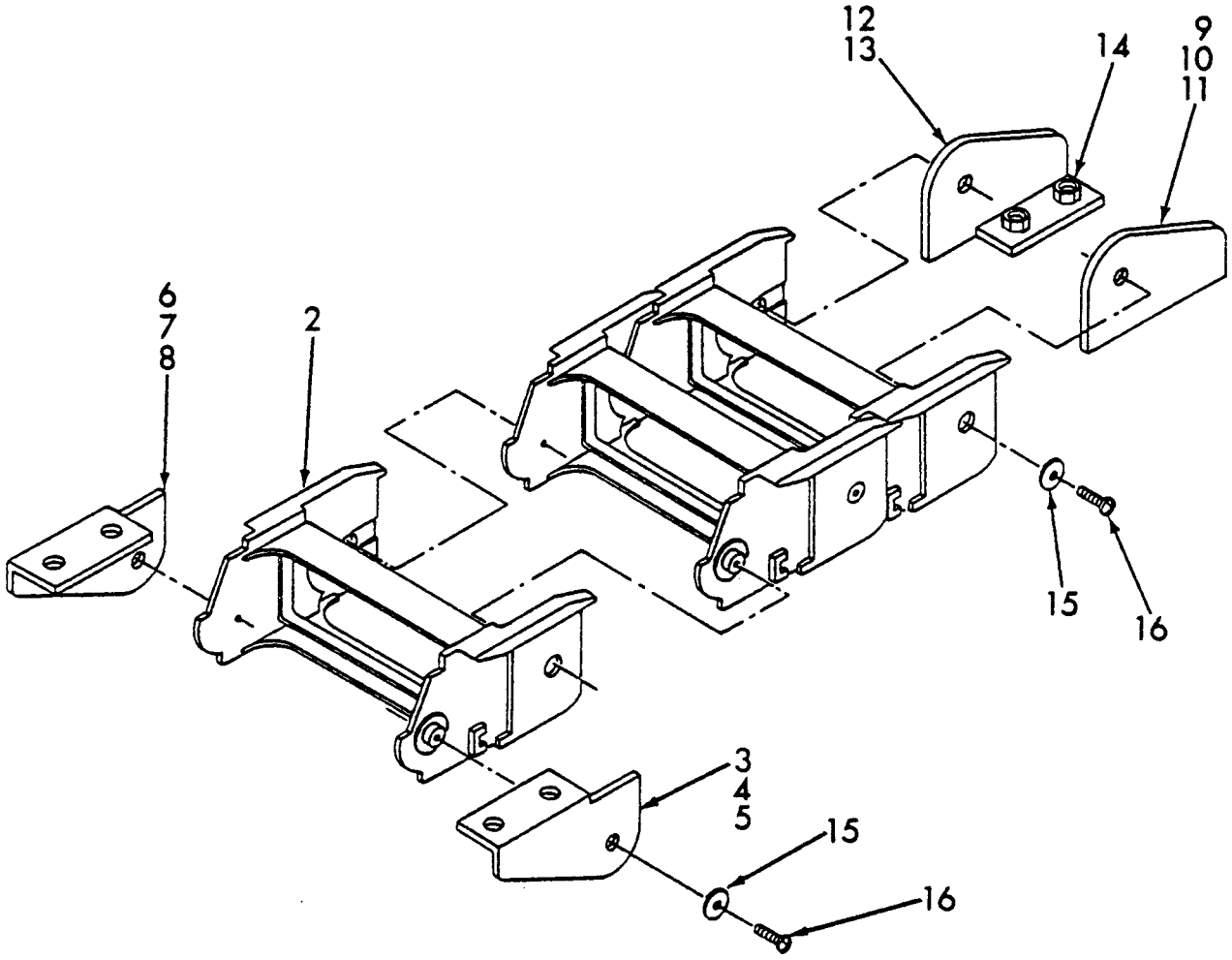
TITLE	SLAVE LEVELING CYLINDER ASSEMBLY
MODEL	100C 6X4
NOTES	SINCE EARLY 1990; CONCURRENT USE (TH)

SECT.	5
FIG.	7C
SHEET	2

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
8	..61903	SCREW, CAP	3
9	.80042-03	CONNECTOR, UNION	2
10	.80004-03	CONNECTOR, STRAIGHT THREAD	3
11	.80012-03	ELBOW, STRAIGHT THREAD	1
12	.65111	STRAP	1
13	.16318	CLAMP	2
14	.21388	TUBING, CONVOLUTED	1
-15	.21094-8	ASSEMBLY, TUBE	1
16	..80062-03	SLEEVE	2
17	..80060-03	NUT	2
-18	.21094-9	ASSEMBLY, TUBE	1
19	..80062-03	SLEEVE	2
20	..80060-03	NUT	2
-21	.21094-10	ASSEMBLY, TUBE	1
22	..80062-03	SLEEVE	2
23	..80060-03	NUT	2

Mark Industries

TITLE	PLASTITRAK ASSEMBLY	SECT. 5
MODEL	100C 6X4	FIG. 8
NOTES		SHEET 1



ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	24401	ASSEMBLY, PLASTITRAK (See Sect. 5, Fig. 2 for NHA)	REF
2	.24403	PLASTITRAK (12.5 FT)	1
3	.22129	BRACKET, MOVABLE PLASTITRAK	1
4	..22162	BRACKET, MOVABLE (R.H.)	1
5	.60702	NUT, HEX	2
6	.22093	BRACKET, MOVABLE PLASTITRAK	1
7	..22163	BRACKET, MOVABLE (L.H.)	1

REV.

Mark Industries

TITLE	PLASTITRAK ASSEMBLY
MODEL	100C 6X4
NOTES	

SECT.	5
FIG.	8
SHEET	2

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
8	..60702	NUT, HEX	2
9	.22128	BRACKET, STATIONARY PLASTITRAK	1
10	..22160	BRACKET, STATIONARY (R.H.)	1
11	..60702	NUT, HEX	2
12	.22126	BRACKET, STATIONARY PLASTITRAK	1
13	..22161	BRACKET, STATIONARY (L.H.)	1
14	..60702	NUT, HEX	2
15	.22164	WASHER, PLASTIC	4
16	.22165	SCREW	4

REV.

DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

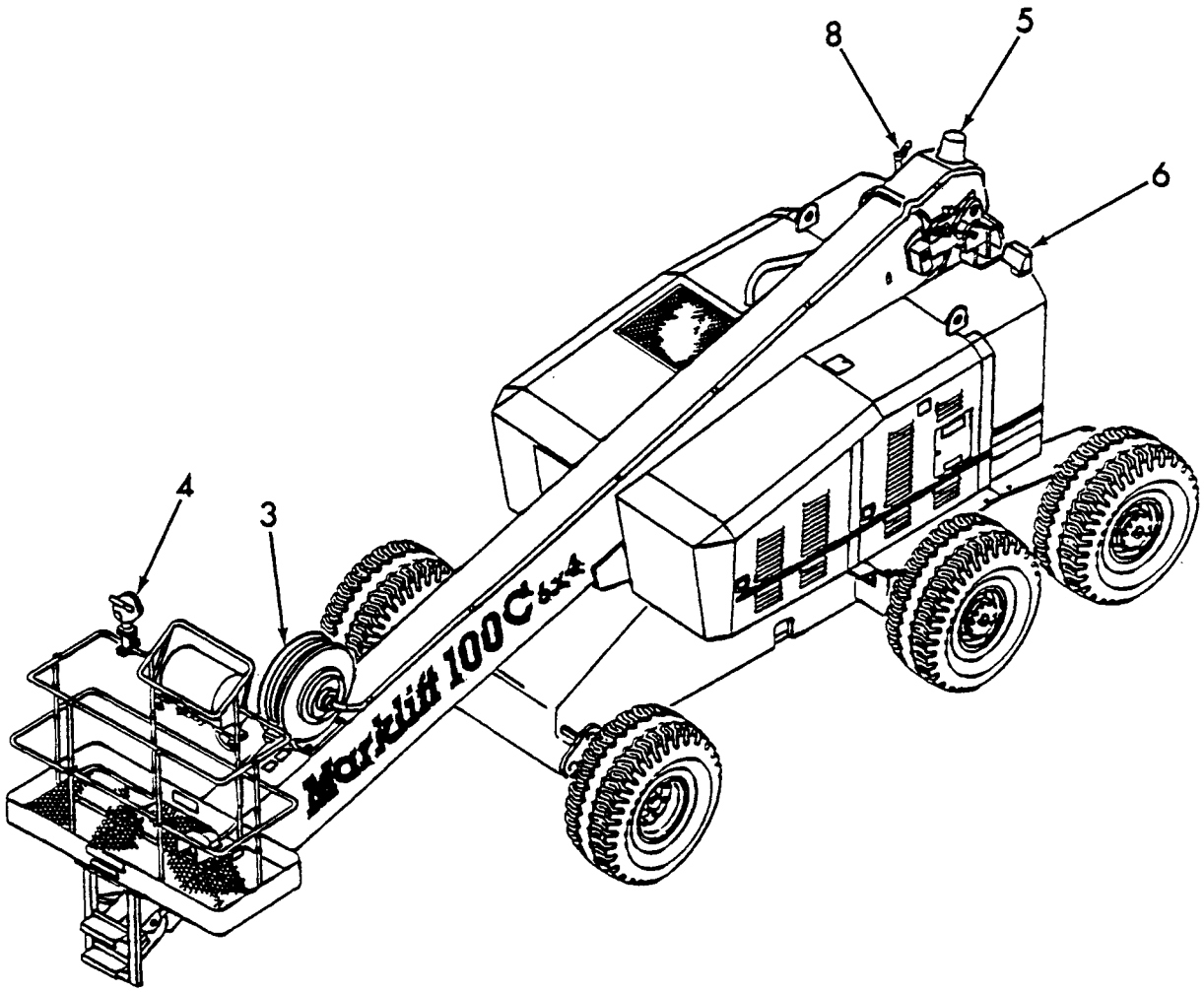
SECTION 6 CONTAINS:

FIG. NO.	TITLE
1	OPTIONS
2	ALL MOTION ALARM
3	TRAVEL WARNING HORN
4	AIRLINE TO PLATFORM
5	12 VOLT PLATFORM WORK LIGHT
6	ROTATING AMBER BEACON
7	HEADLIGHTS
8	CLEARANCE/STOP & TURNING LIGHTS
9	SPARK ARRESTOR MUFFLER (WISCONSIN V465D)
10	FRONT MOUNT PLATFORM ROTATION
11	DUAL FUEL (WISCONSIN V465D)
12	ENGINE/PUMP ASSEMBLY (SD-33)
13	DUAL FUEL (Z-24)
14	DUAL FUEL (FIELD KIT Z-24)
15	MINIPAK SUB-ASSEMBLY (WITH FRONT MOUNT PLATFORM ROTATION)
-	HYDRAULIC LINE TO PLATFORM
-	CATALYTIC CONVERTER
-	8' X 3' PLATFORM
-	HOSTILE ENVIRONMENT PACKAGE

- OPTION NOT PARTS LISTED OR ILLUSTRATED

Mark Industries

TITLE	OPTIONS	SECT. 6
MODEL	100C 6X4	FIG. 1
NOTES		SHEET 1



REV.

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	23392	ALARM, ALL MOTION (See Sect. 6, Fig. 2 for Details)	REF
-2	20108	HORN, TRAVEL WARNING (See Sect. 6, Fig. 3 for Details)	REF
3	23381	PLATFORM, AIRLINE TO (See Sect. 6, Fig. 4 for Details)	REF
4	20139	LIGHT, 12 VOLT PLATFORM WORK (See Sect. 6, Fig. 5 for Details)	REF
5	20107	BEACON, ROTATING AMBER (See Sect. 6, Fig. 6 for Details)	REF
6	20078	HEADLIGHTS (See Sect. 6, Fig. 7 for Details)	REF
-7	20106	LIGHTS, CLEARANCE/STOP & TURNING (See Sect. 6, Fig. 8 for Details)	REF
8	22253	MUFFLER, SPARK ARRESTOR (WISCONSIN V465D) (See Sect. 6, Fig. 9 for Details)	REF
-9	23304	ROTATION, FRONT MOUNT PLATFORM (See Sect. 6, Fig. 10 for Details)	REF
-10	23391	FUEL, DUAL (WISCONSIN V465D) (See Sect. 6, Fig. 11 for Details)	REF
-11	210173	ASSEMBLY, ENGINE/PUMP (SD-33) (See Sect. 6, Fig. 12 for Details)	REF
-12	200051	FUEL, DUAL (Z-24) (See Sect. 6, Fig. 13 for Details)	REF
-13	600423	FUEL, DUAL (FIELD KIT Z-24) (See Sect. 6, Fig. 14 for Details)	REF
-14	21713	SUB-ASSEMBLY, MINIPAK (WITH FRONT MOUNT PLATFORM ROTATION) (See Sect. 6, Fig. 15 for Details)	REF
-15	23382	PLATFORM, HYDRAULIC LINE	REF
-16	23335	CONVERTER, CATALYTIC	REF

DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-17	23359	PLATFORM, 8' X 36"	REF
-18	23397	PACKAGE, HOSTILE ENVIRONMENT	REF

Mark Industries

TITLE	ALL MOTION ALARM
MODEL	100C 6X4
NOTES	

SECT.	6
FIG.	2
SHEET	1

ILLUSTRATION NOT AVAILABLE

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	23392	ALARM, ALL MOTION	REF
-2	.70053	HORN, WARNING	1
-3	.2990	WIRE, WHITE (18 AWG)	4 FT
-4	.60353	SCREW, CAP	2
-5	.63401	WASHER	
-6	.61239	NUT, LOCK	2
-7	.729	BUSHING	1
-8	.70149	TERMINAL, RING (RED)	2
-9	.70566	TERMINAL, FORK SPADE (RED)	1
-10	.70036	WIRE (18 AWG/2 COND.)	2 FT

REV.

Mark Industries

TITLE	TRAVEL WARNING HORN	SECT. 6
MODEL	100C 6X4	FIG. 3
NOTES		SHEET 1

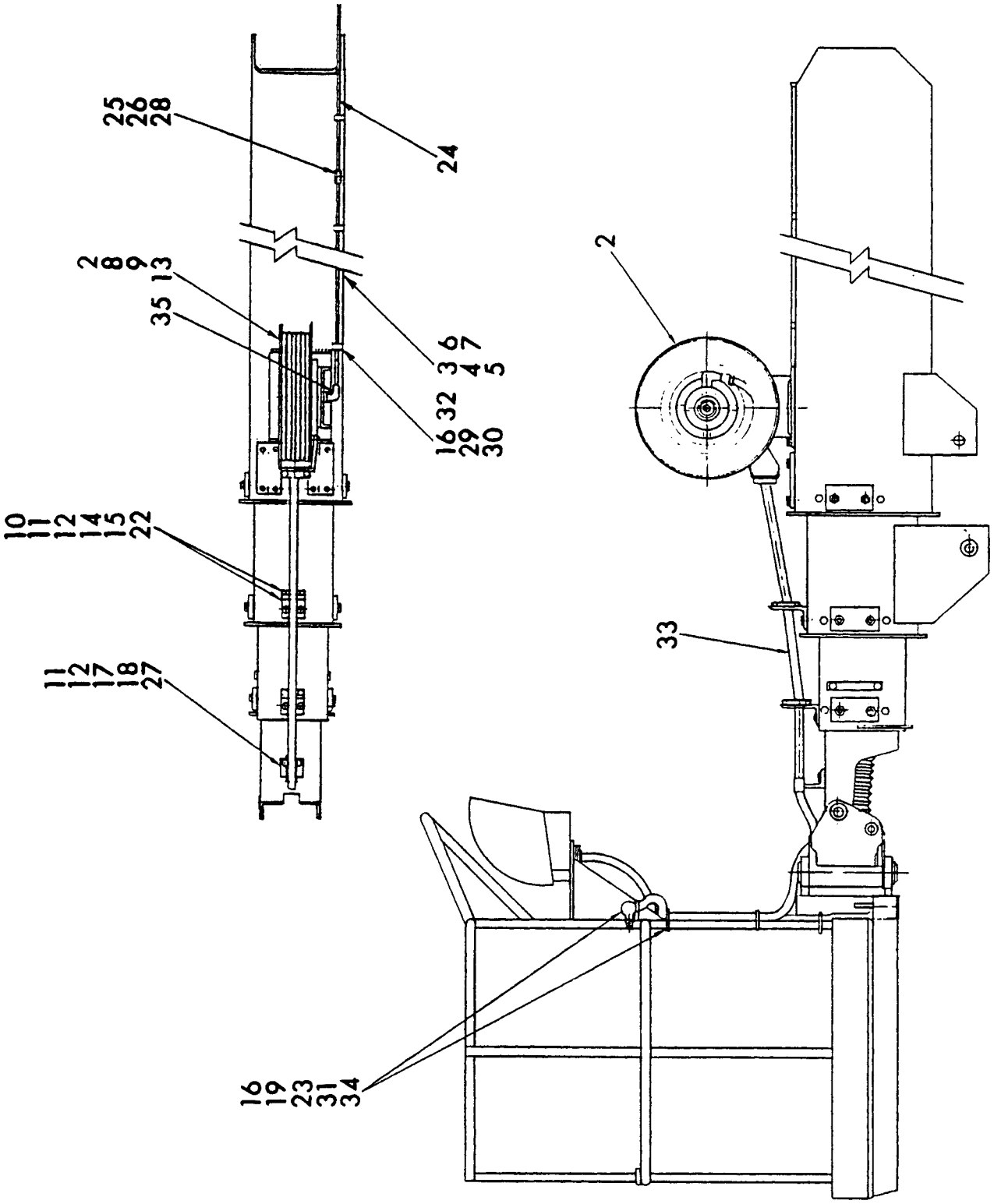
ILLUSTRATION NOT AVAILABLE

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	20108	HORN, TRAVEL WARNING	REF
-2	.70053	HORN, WARNING	1
-3	.2990	WIRE, WHITE (18 AWG)	4 FT
-4	.60353	SCREW, CAP	2
-5	.63401	WASHER, FLAT	2
-6	.61239	NUT, LOCK	2
-7	.729	BUSHING	2
-8	.70149	TERMINAL, RING (RED)	2
-9	.70566	TERMINAL, FORK SPADE (RED)	1
-10	.70036	WIRE (18 AWG/2 COND.)	2 FT

REV.

Mark Industries

TITLE	AIRLINE TO PLATFORM	SECT.	6
MODEL	100C 6X4	FIG.	4
NOTES		SHEET	1



REV.

Mark Industries

TITLE	AIRLINE TO PLATFORM
MODEL	100C 6X4
NOTES	

SECT.	6
FIG.	4
SHEET	2

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	23381	PLATFORM, AIRLINE TO	REF
2	.210560	REEL, HOSE	1
3	.210658	REWORK, OUTER BOOM	1
4	..24072	MACHINING, OUTER BOOM	1
5	...24071	WELDMENT, OUTER BOOM	1
6	...22080	BUSHING	2
7	..210559	PLATE, HOSE REEL MOUNTING	1
8	.60383	SCREW, CAP	4
9	.63305	WASHER, SPLIT	4
10	.20921	MOUNTING, HOSE GUIDE	2
11	.60367	SCREW, CAP	6
12	.63302	WASHER, SPLIT	4
13	.63405	WASHER, FLAT	4
14	.20924	GUIDE, ROLLER HOSE	2
15	.60312	SCREW, CAP	8
16	.63301	WASHER, SPLIT	10
17	.21927	BRACKET, HOSE END	1
18	..54805	COUPLING	1
19	.210255	BRACKET, AIRLINE HOSE	1
20	..28971	PLATE	1
21	..80020-10	ELBOW, FEMALE	1
22	.160057	NUT, LOCK	8
23	.53904	PLUG, PIPE	1
24	.235	TUBING, HYDRAULIC	30 FT
25	.80042-06	UNION	3

REV.

DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

Mark Industries

TITLE	AIRLINE TO PLATFORM
MODEL	100C 6X4
NOTES	

SECT.	6
FIG.	4
SHEET	3

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
26	.80060-06	NUT	6
27	.21926	ASSEMBLY, HOSE	1
28	.80062-06	SLEEVE	6
29	.764	CLAMP, RUBBER	8
30	.60353	SCREW, CAP	8
31	.255	TIE, CABLE (6" X 3/16")	10
32	.61921	SCREW, CAP	8
33	.210558	ASSEMBLY, HOSE	1
34	.60309	SCREW, CAP	2
35	.80001-14	CONNECTOR, MALE	1

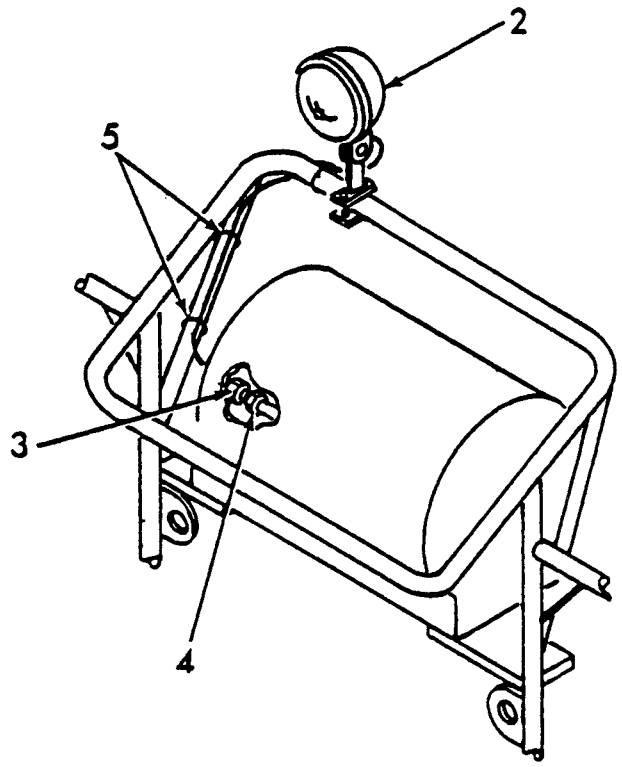
REV.

DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

Mark Industries

TITLE	12 VOLT PLATFORM WORK LIGHT
MODEL	100C 6X4
NOTES	

SECT.	6
FIG.	5
SHEET	1

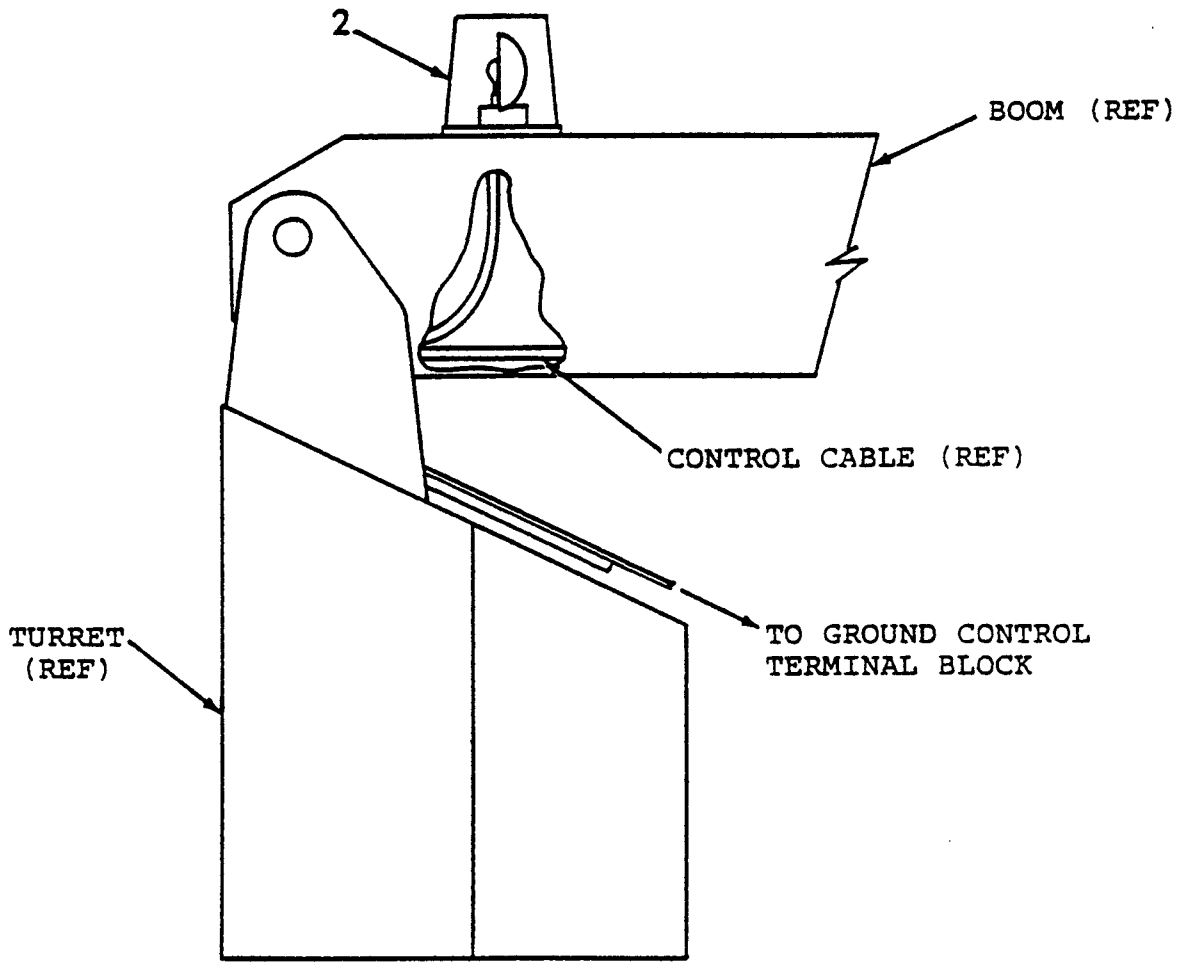


ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	20139	LIGHT, 12 VOLT PLATFORM WORK	REF
2	.20862	LIGHT	1
3	.2806	RELIEF, STRAIN	1
4	.2808	NUT, LOCK	1
5	.255	TIE, CABLE	AR

REV.

Mark Industries

TITLE	ROTATING AMBER BEACON	SECT.	6
MODEL	100C 6X4	FIG.	6
NOTES		SHEET	1

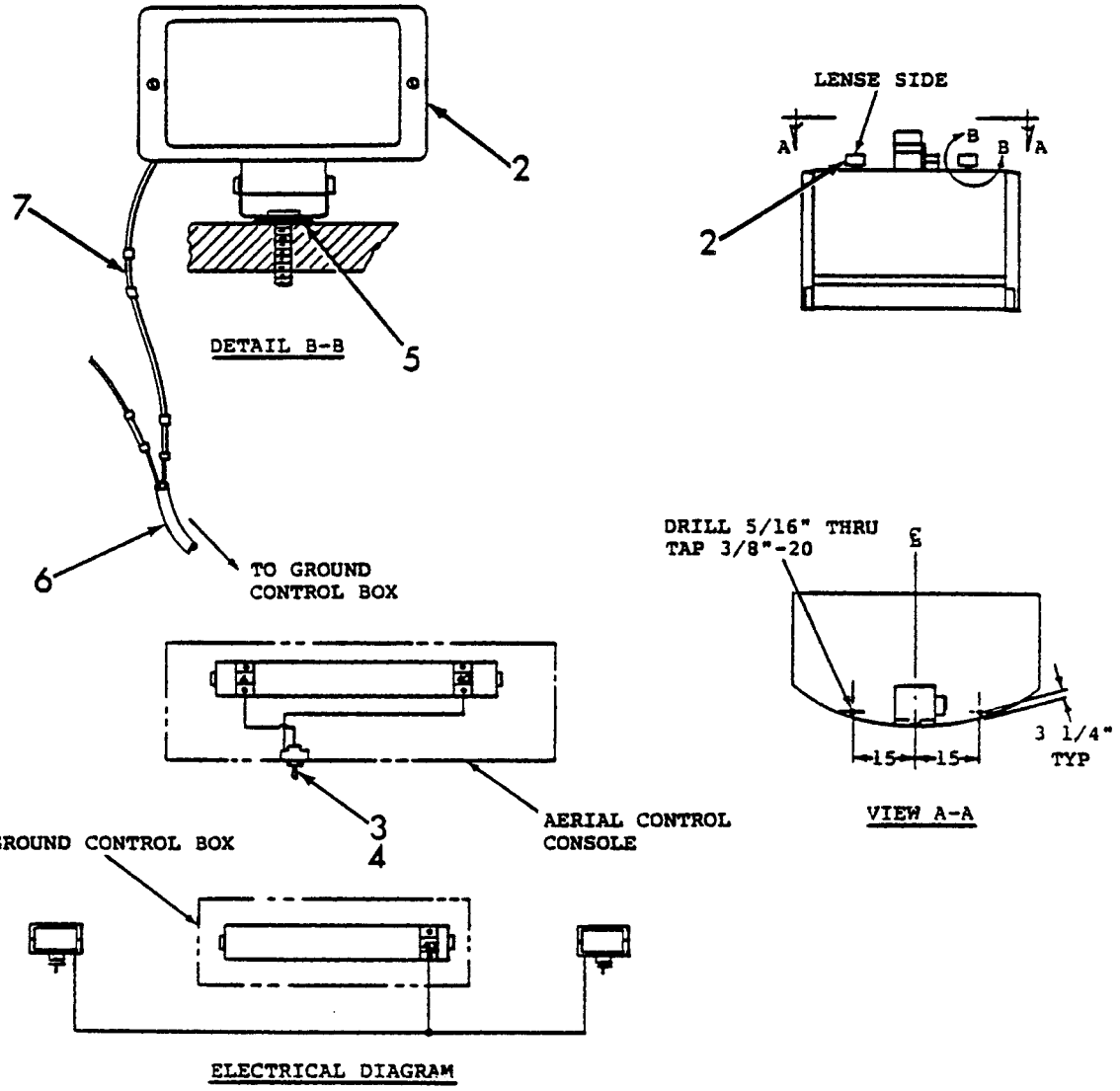


ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	20107	BEACON, ROTATING AMBER	REF
2	.20863	BEACON (W/SWITCH)	1

REV.

Mark Industries

TITLE	HEADLIGHTS	SECT.	6
MODEL	100C 6X4	FIG.	7
NOTES		SHEET	1

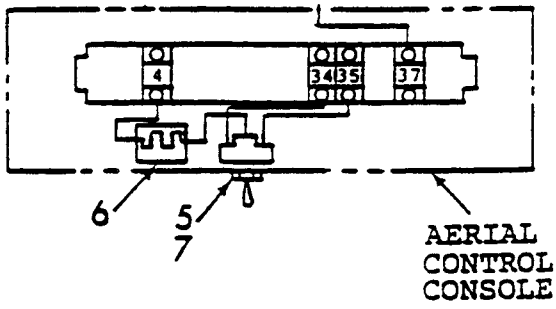


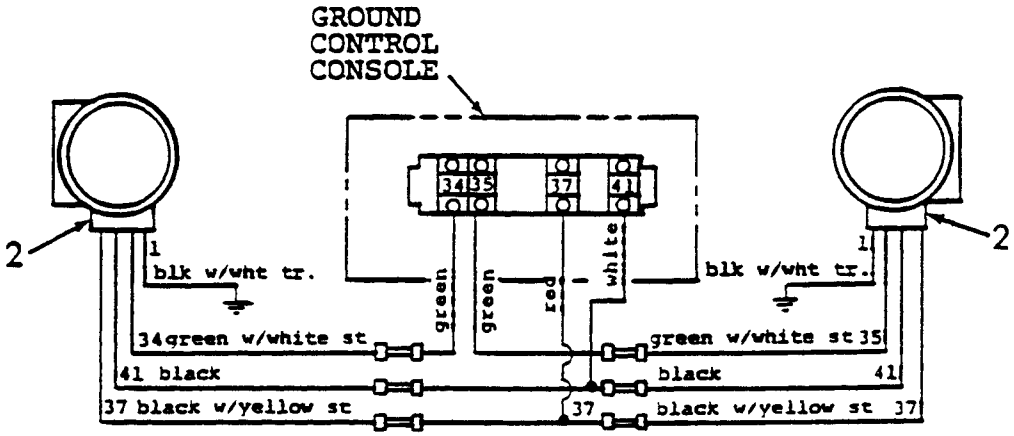
ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	20078	HEADLIGHTS	REF
2	.20971	HEADLIGHT	2
3	.4017	HEADLIGHT	2
4	.20509	DECAL, LIGHTS	1
5	.63403	WASHER, FLAT	1
6	.2991	WIRE, WHITE	6 FT
7	.117-D	CONNECTOR, BUTT	4

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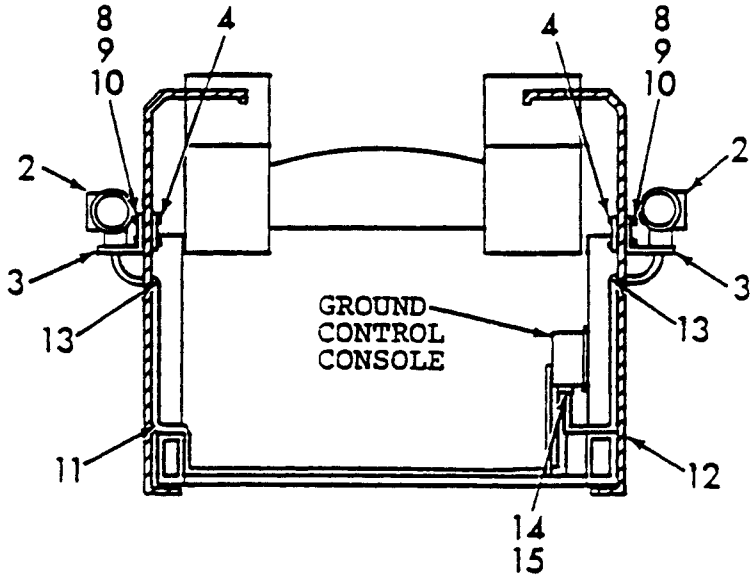
Mark Industries

TITLE	CLEARANCE/STOP & TURNING LIGHTS	SECT.	6
MODEL	100C 6X4	FIG.	8
NOTES		SHEET	1





ELECTRIC DIAGRAM



REV.

Mark Industries

TITLE	CLEARANCE/STOP & TURNING LIGHTS
MODEL	100C 6X4
NOTES	

SECT.	6
FIG.	8
SHEET	2

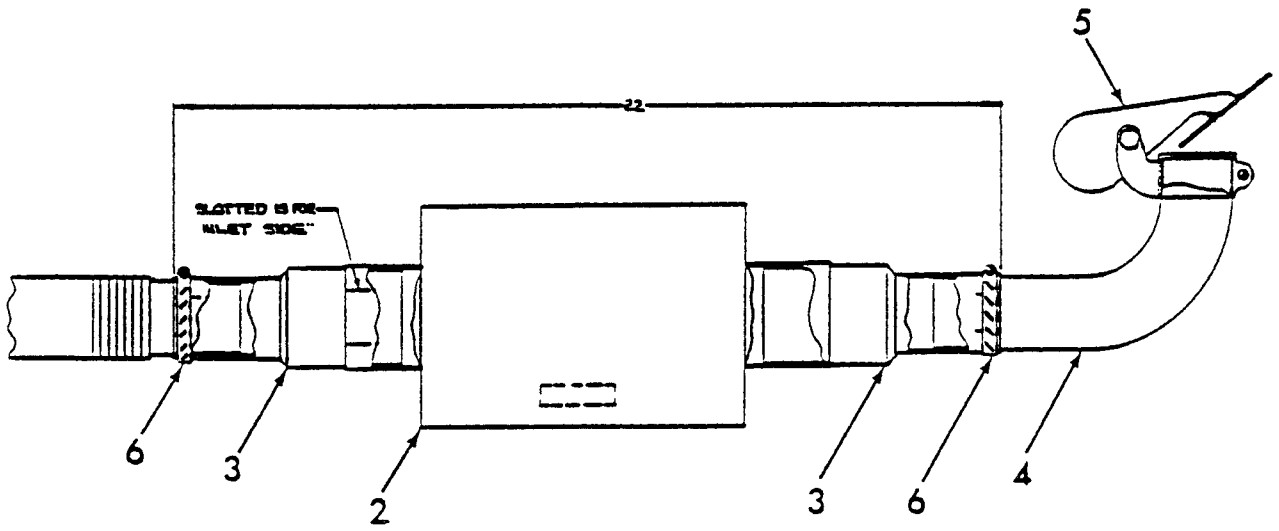
ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	20106	LIGHTS, CLEARANCE/STOP & TURNING	REF
2	.20838	LIGHT, CLEARANCE	2
3	.20864	BRACKET, MOUNTING	2
4	.20865	PLATE, BACK-UP	2
5	.4019	SWITCH, TOGGLE	1
6	.448-A	FLASHER	2
7	.20866	DECAL, TURN INDICATOR	1
8	.60331	SCREW, CAP	4
9	.60703	NUT, HEX	4
10	.63303	WASHER, SPLIT	4
11	.2912	CABLE (18 AWG/4 COND.)	16 FT
12	.117-D	CONNECTOR, BUTT	8
13	.2806	RELIEF, STRAIN	2
14	.2808	NUT, LOCK	2

REV.

DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

Mark Industries

TITLE	SPARK ARRESTOR MUFFLER	SECT.	6
MODEL	100C 6X4	FIG.	9
NOTES	WISCONSIN V465D	SHEET	1

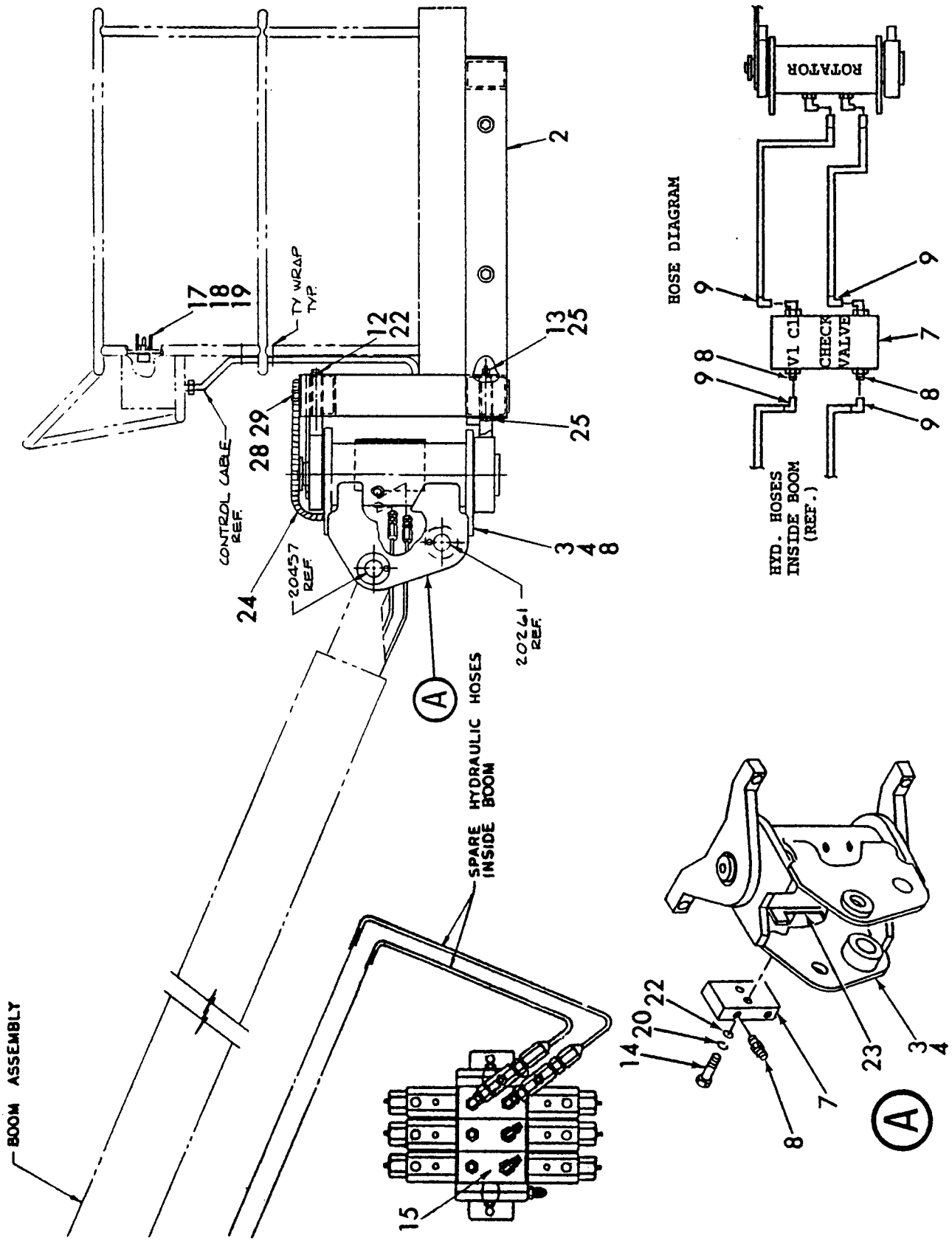


ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	22253	MUFFLER, SPARK ARRESTOR (WISCONSIN V465D)	REF
2	.65520	ARRESTOR, SPARK	1
3	.65521	REDUCER	2
4	.65337	ELBOW, MUFFLER	1
5	.21228	CAP, RAIN	1
6	.16288	CLAMP, HOSE	1

REV.

Mark Industries

TITLE	FRONT MOUNT PLATFORM ROTATION	SECT.	6
MODEL	100C 6X4	FIG.	10
NOTES		SHEET	1



REV.

Mark Industries

TITLE	FRONT MOUNT PLATFORM ROTATION
MODEL	100C 6X4
NOTES	

SECT.	6
FIG.	10
PAGE	2

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	23304	ROTATION, FRONT MOUNT PLATFORM	REF
2	.23564	WELDMENT, FORK	1
3	.81372	SUB-ASSEMBLY, HELAC ROTATOR	1
4	..81094	ROTATOR, HELAC (See Vendor Chapter for Details)	1
-5	...67770	KIT, SEAL	1
-6	...67771	KIT, BEARING	1
7	..20351	VALVE, CHECK	1
8	.80004-05	CONNECTOR, STRAIGHT THREAD	2
9	.2594	ELBOW, SWIVEL	4
12	.60540	SCREW, CAP	2
13	.61305	NUT, LOCK	4
14	.60360	SCREW, CAP	2
15	.21713	SUB-ASSEMBLY, MINIPAK (See Sect. 6, Fig. 15 for Details)	1
16	.63305	WASHER, LOCK	1
17	.4021	SWITCH, TOGGLE	1
18	.20884	GUARD, SWITCH	1
19	.22571	DECAL, AERIAL CONTROL BOX	1
20	.63302	WASHER, LOCK	2
21	.63402	WASHER, FLAT	2
-22	.63415	WASHER, FLAT	4
23	.23197	BRACKET, CHECK VALVE	1
24	.65321	SLEEVE, PLASTIC COIL	3.5 FT
25	.60513	SCREW, CAP	2
26	.23565	WASHER	1

Mark Industries

TITLE	FRONT MOUNT PLATFORM ROTATION
MODEL	100C 6X4
NOTES	

SECT.	6
FIG.	10
SHEET	3

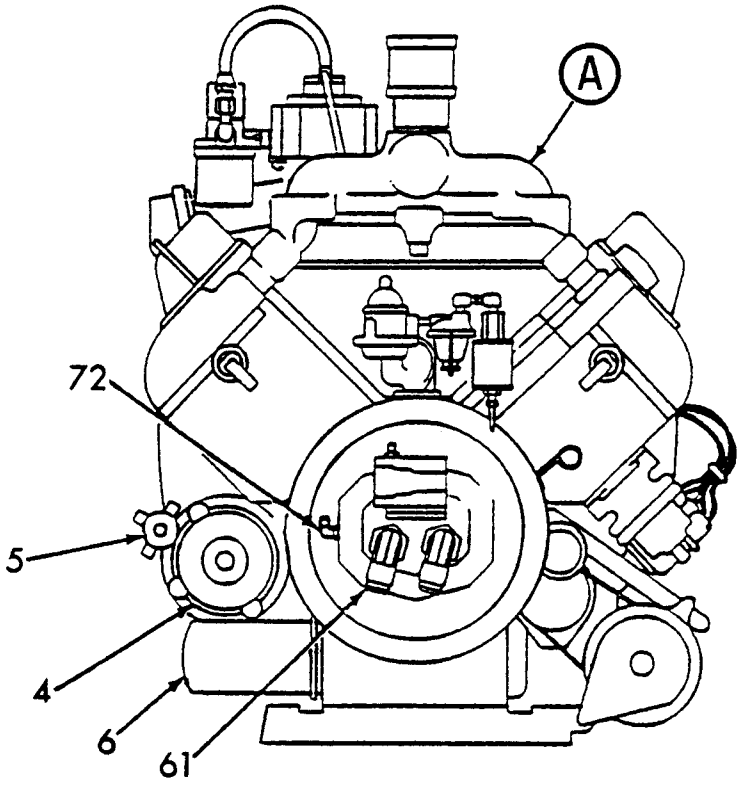
ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
27	.60516	SCREW, CAP	1
28	.16268	CLAMP, HOSE	5
29	.61902	SCREW, CAP	5

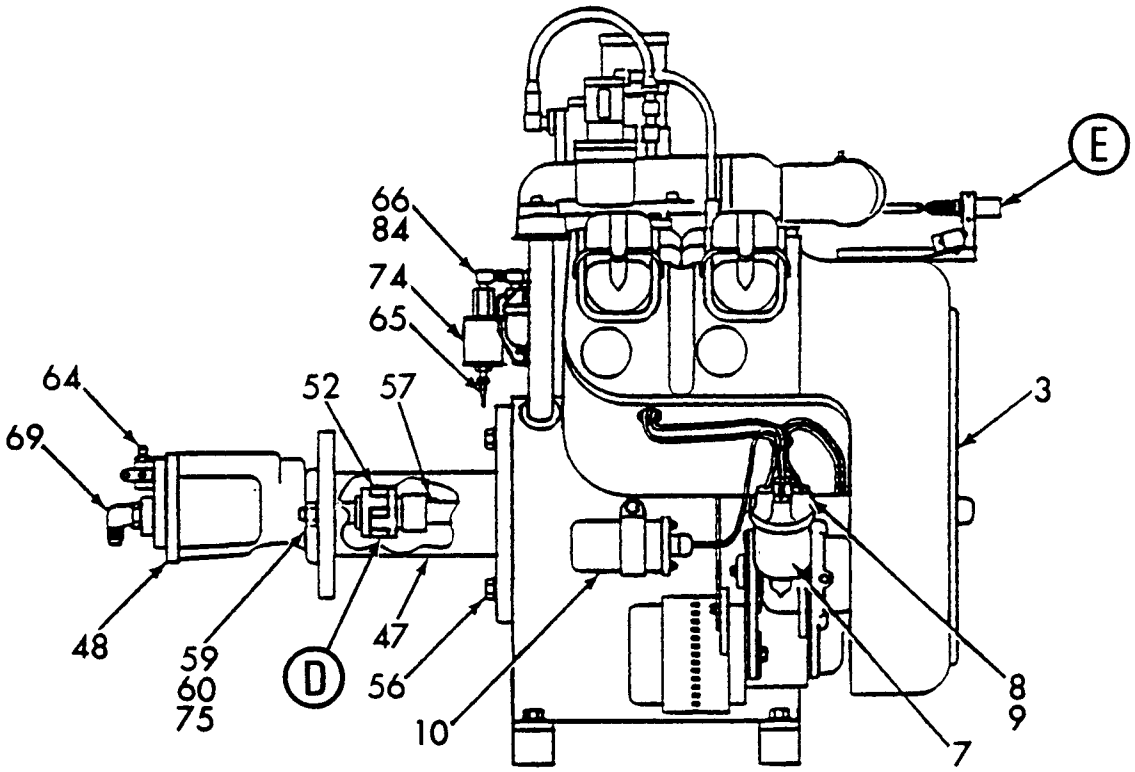
REV.

DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

Mark Industries

TITLE	DUAL FUEL	SECT.	6
MODEL	100C 6X4	FIG.	11
NOTES	WISCONSIN V465D	SHEET	1

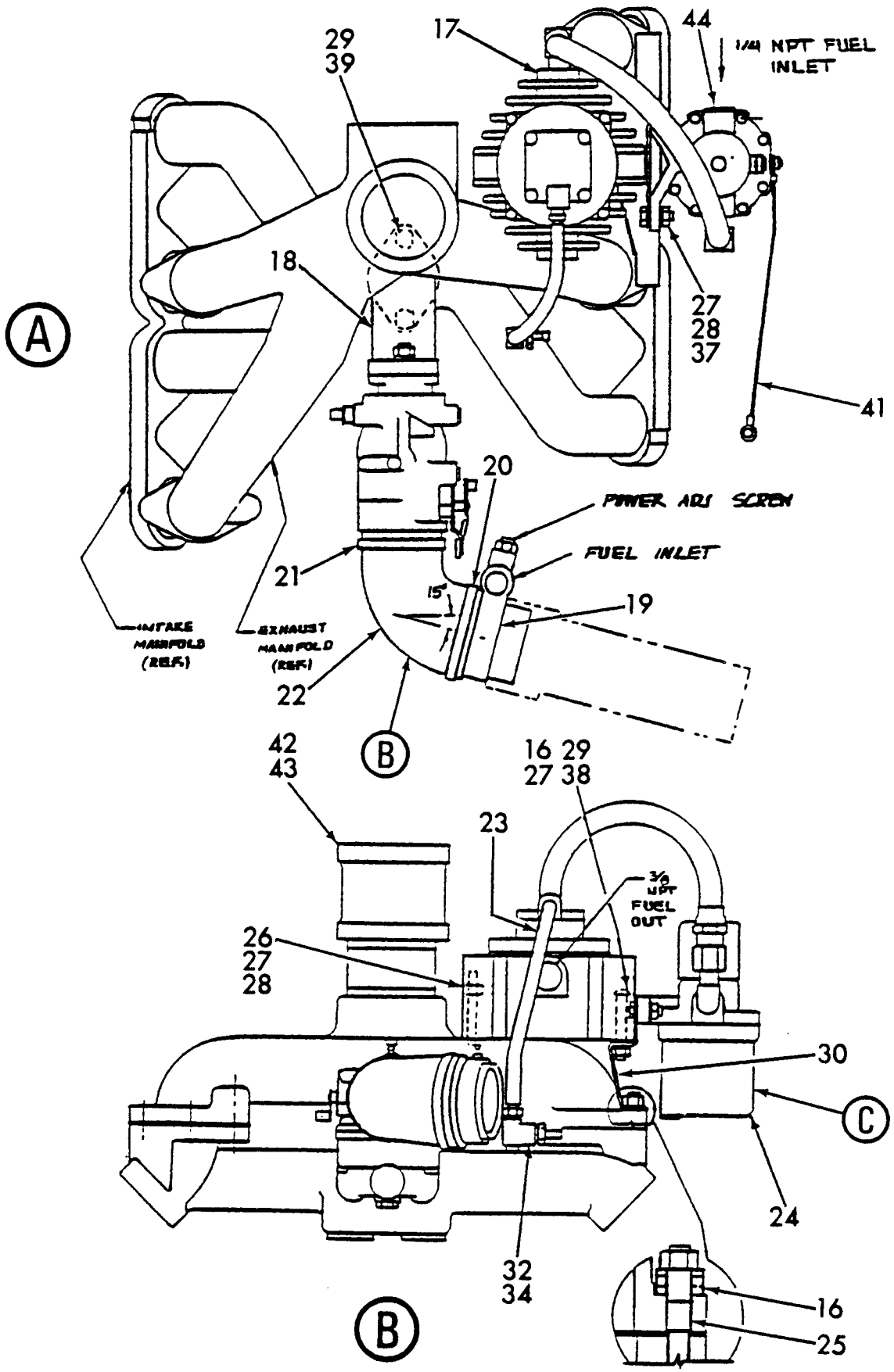




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Mark Industries

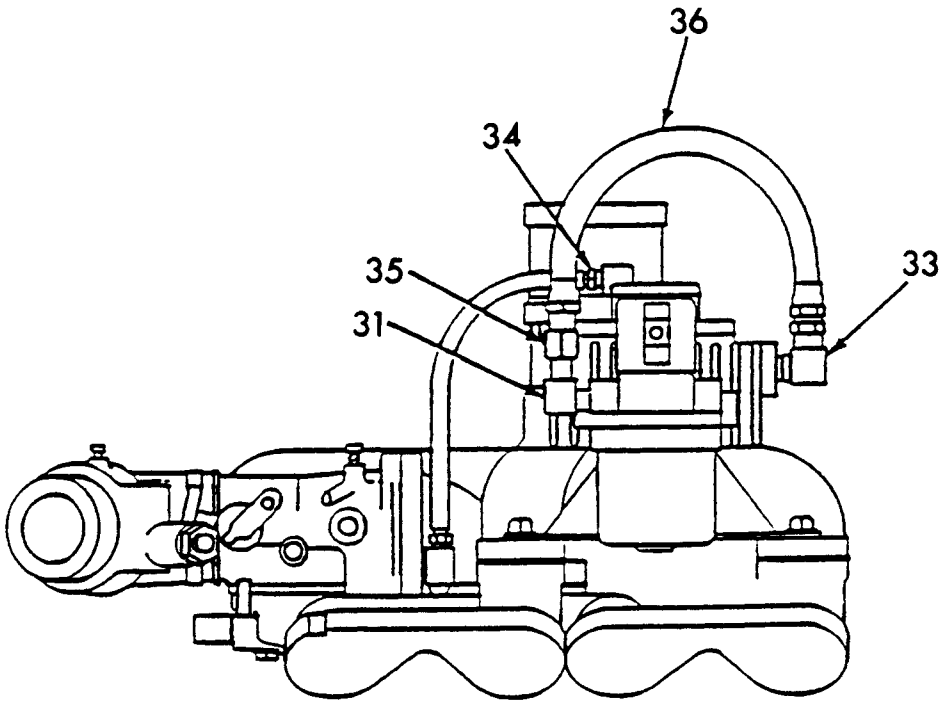
TITLE	DUAL FUEL	SECT.	6
MODEL	100C 6X4	FIG.	11
NOTES	WISCONSIN V465D	SHEET	2



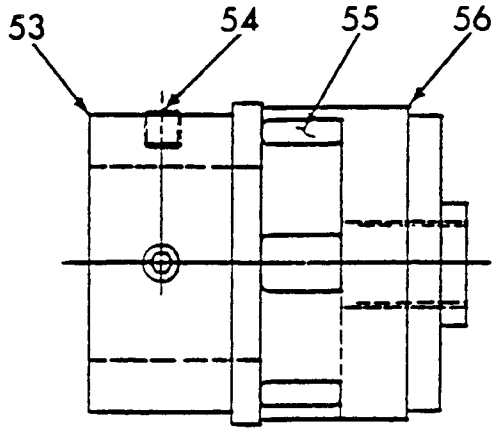
REV.

Mark Industries

TITLE	DUAL FUEL	SECT.	6
MODEL	100C 6X4	FIG.	11
NOTES	WISCONSIN V465D	SHEET	3



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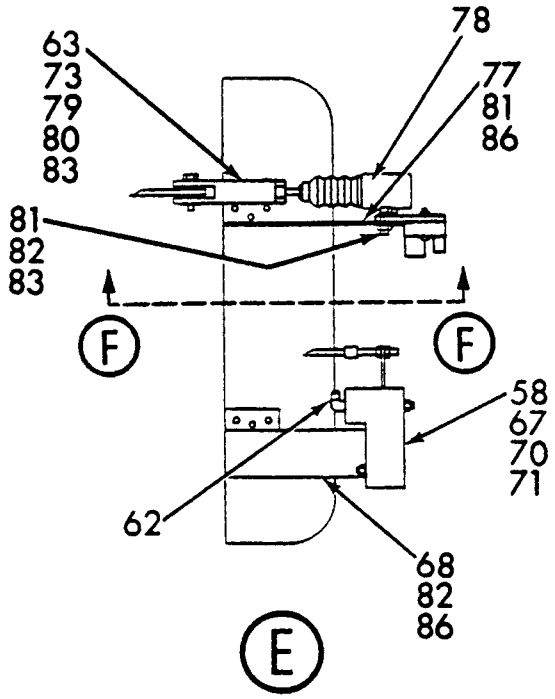


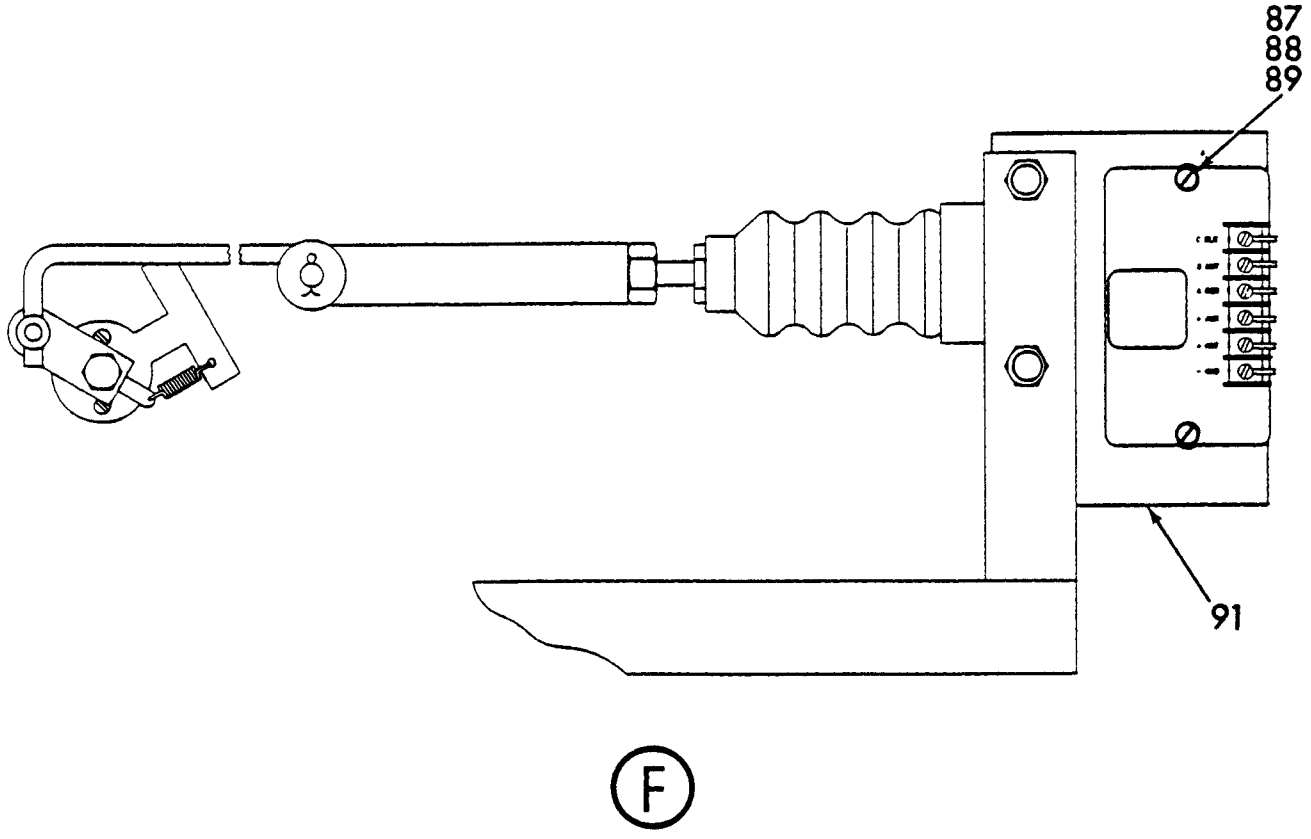
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REV.

Mark Industries

TITLE	DUAL FUEL	SECT.	6
MODEL	100C 6X4	FIG.	11
NOTES	WISCONSIN V465D	SHEET	4





REV.

Mark Industries

TITLE	DUAL FUEL	SECT.	6
MODEL	100C 6X4	FIG.	11
NOTES	WISCONSIN V465D	SHEET	5

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	23391	FUEL, DUAL (V465D)	REF
-2	.24441	ASSEMBLY, ENGINE/PUMP (V465D)	1
3	..24440	ENGINE, DUAL FUEL (V465D) (See Vendor Chapter for Details)	1
4	...600339	STARTER (YA53B)	1
5	600340	SOLENOID, STARTER	1
6	...600334	FILTER, OIL	1
7	...600341	DISTRIBUTOR, ELECTRONIC (YF50S1)	1
8	600131	CAP, DISTRIBUTOR	1
9	600342	CAP, ROTOR	1
10	...67268	COIL, IGNITION	1
-11	...67295	PLUG, SPARK	4
-12	...67302	GUAGE, OIL PRESSURE	1
-13	...67762	ASSEMBLY, GOVERNOR	1
-14	...67763	ASSEMBLY, GOVERNOR CONTROL	1
-15	...24438	ASSEMBLY, DUAL FUEL (LIQUID WITHDRAWAL)	1
16	67738	SPACER, CONVERTER BRACKET	3
17	67739	CONVERTER, LPG (L90)	1
18	67740	ELBOW, CARBURETOR	1
19	67741	ADAPTER, LPG	1
20	67742	CLAMP, HOSE	1
21	67743	CLAMP, HOSE	1
22	67744	ELBOW, AIR INLET	1
23	67745	LINE, VACUUM	1
24	67746	LOCK, FILTER	1
25	....	STUD	2

REV.

DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
26	....	STUD	1
27	....	NUT, HEX	4
28	....	WASHER, LOCK	4
29	....	WASHER, LOCK	2
30	67747	BRACKET, CONVERTER	1
31	67748	ELBOW, PIPE	1
32	67749	TEE	1
33	67750	ELBOW	1
34	67751	CONNECTOR, HOSE	3
35	67752	ADAPTER, PIPE	1
36	67753	ASSEMBLY, FUEL LINE	1
37	....	SCREW, CAP	2
38	....	SCREW	1
39	....	SCREW, CAP	2
40	67754	ROD, CONTROL	1
41	67755	WIRE	1
42	67756	COUPLING, PIPE	1
43	67757	NIPPLE, PIPE	1
44	600161	KIT, REGULATOR REPAIR (FOR 160087 REGULATOR)	1
-45	16923	SWITCH, VACUUM SAFETY	1
-46	16919	KIT, VACUUM SWITCH REPAIR	1
47	..22101	ADAPTER, PUMP MACHINING	1
48	..21638	PUMP, HYDRAULIC (See Vendor Chapter for Details)	1
-49	...600163	KIT, SEAL	1
-50	66741	SEAL, SHAFT	1

Mark Industries

TITLE	DUAL FUEL	SECT.	6
MODEL	100C 6X4	FIG.	11
NOTES	WISCONSIN V465D	SHEET	7

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-51	...21757	ASSEMBLY, COMPENSATOR	1
52	..22137	ASSEMBLY, COUPLING	1
53	...22102	COUPLING (ENGINE END)	1
54	...62203	SCREW, SET	2
55	...20930	INSERT, RUBBER SPIDER	1
56	...20925	COUPLING (PUMP END)	1
57	..25253	KEY	1
58	..63402	WASHER, FLAT	2
59	..63613	STUD	2
60	..63305	WASHER, LOCK	2
61	..80012-28	ELBOW, STRAIGHT THREAD	1
62	..80008-04	ELBOW, MALE	1
63	..60805	NUT, HEX	2
64	..80004-03	CONNECTOR, STRAIGHT THREAD	1
65	..240	HOSE, BARB	1
66	..66196	ELBOW, STREET	1
67	..20364	THROTTLE, HYDRAULIC	1
68	..22209	BRACKET, THROTTLE MOUNTING	1
69	..80012-24	ELBOW, STRAIGHT THREAD	1
70	..60404	SCREW, CAP	2
71	..63302	WASHER, LOCK	2
72	..80012-08	ELBOW, STRAIGHT THREAD	1
73	..64313	PIN, COTTER	2
74	..20832	VALVE, FUEL SHUT-OFF	1
75	..60705	NUT, HEX	2

REV.

DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

Mark Industries

TITLE	DUAL FUEL
MODEL	100C 6X4
NOTES	WISCONSIN V465D

SECT.	6
FIG.	11
SHEET	8

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
76	..60604	SCREW, CAP	4
77	..22194	BRACKET, SOLENOID	1
78	..70504	SOLENOID, 12 VDC	1
79	..67432	YOKE, HI SPEED	1
80	..67793	PIN, YOKE	1
81	..60312	SCREW, CAP	2
82	..63301	WASHER, LOCK	2
83	..60701	NUT, HEX	2
84	..16550	NIPPLE, PIPE	1
85	..24609	LINKAGE, CHOKE	1
86	.60353	SCREW, CAP	6
87	.62726	SCREW, MACHINE	2
88	.63313	WASHER, SPLIT	1
89	.60802	NUT, HEX	1
-90	.70505	MODULE, RELAY	1
91	.134215	BAR, THROTTLE	1
-92	.65937	TANK, LIQUID PROPANE	1
-93	.486-A	BRACKET, TANK	2
-94	.4019	SWITCH, MICRO	1
-95	.20884	SWITCH, GUARD	1
-96	.182706	DECAL, DUAL FUEL SELECTOR	1
-97	.23558	DECAL, LIQUID TANK ONLY	2
-98	.65142	SOCKET, QUICK DISCONNECT	2
-99	.2616	HOSE	16
-100	.16452	FITTING	2

Mark Industries

TITLE	DUAL FUEL
MODEL	100C 6X4
NOTES	WISCONSIN V465D

SECT.	6
FIG.	11
SHEET	9

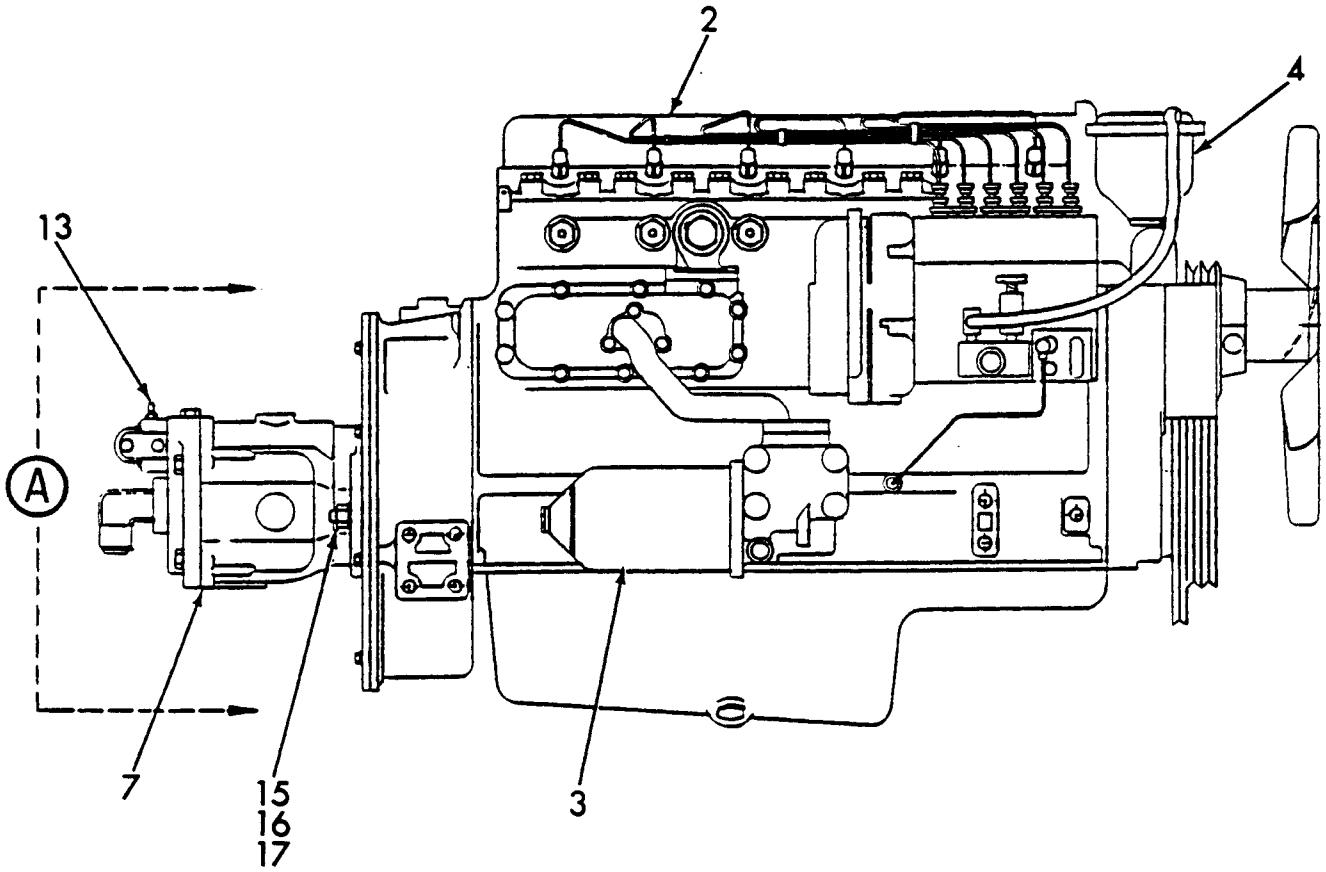
ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-101	.16451	FITTING	2
-102	.65141	NIPPLE, QUICK DISCONNECT	2
-103	.21897	ASSEMBLY, LPG LINE SWIVEL JOINT	1
-104	.60343	SCREW, CAP	2
-105	.63403	WASHER, FLAT	2
-106	.60333	WASHER, SPLIT	2

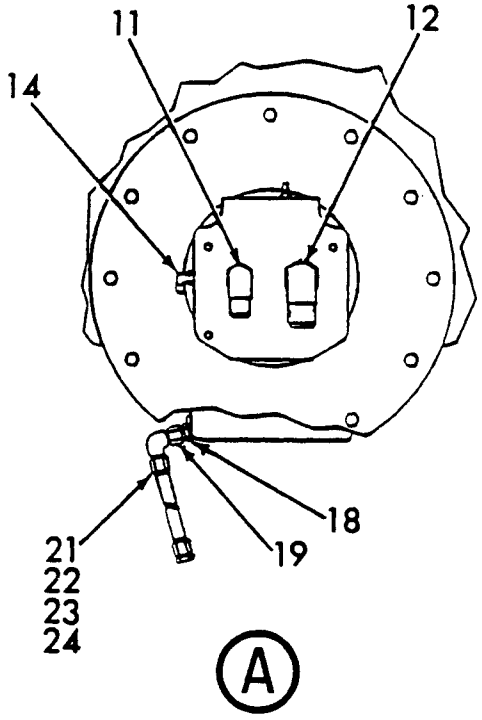
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DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

Mark Industries

TITLE	ENGINE/PUMP ASSEMBLY	SECT.	6
MODEL	100C 6X4	FIG.	12
NOTES	SD-33	SHEET	1





REV.

Mark Industries

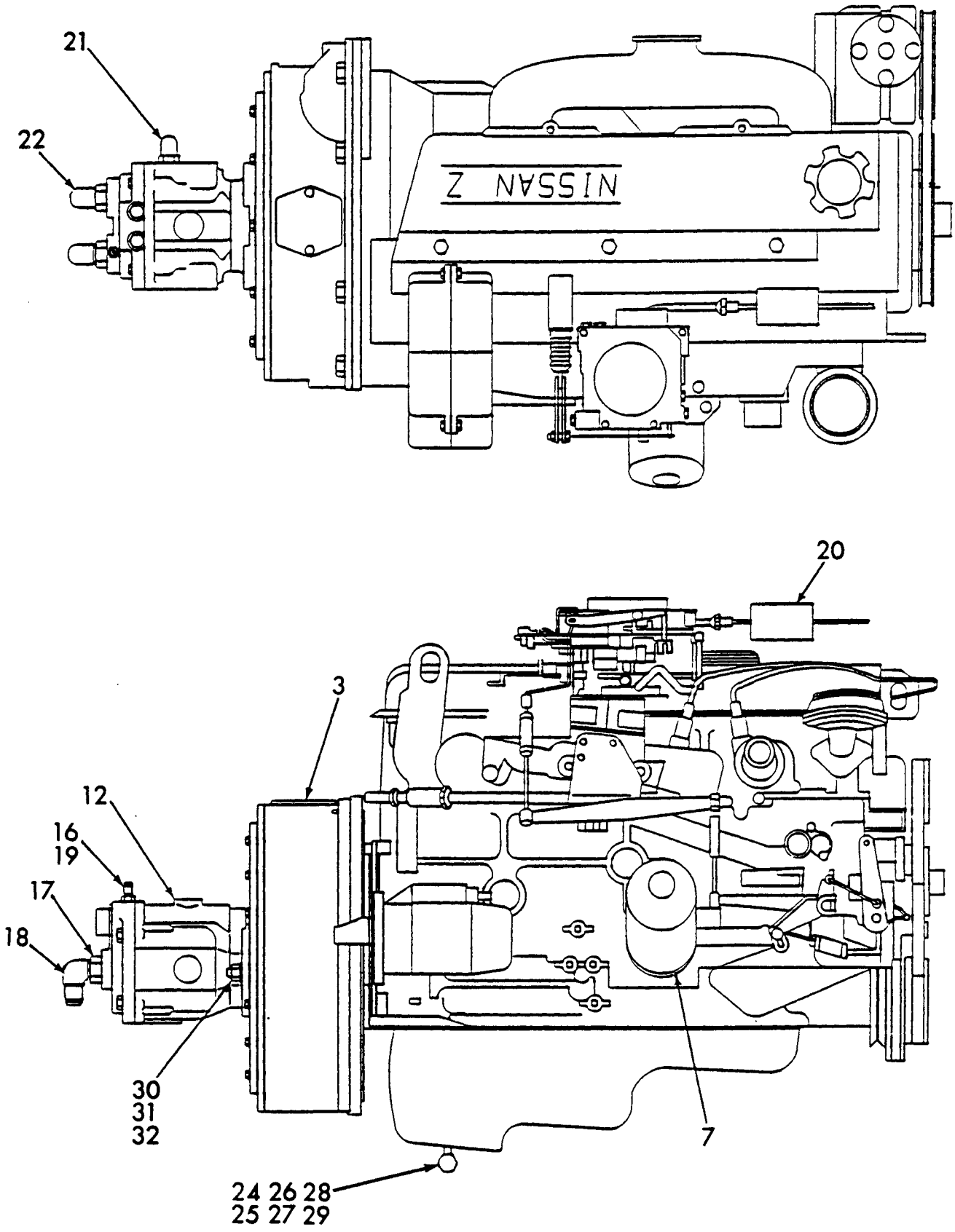
TITLE	ENGINE/PUMP ASSEMBLY	SECT. 6
MODEL	100C 6X4	FIG. 12
NOTES	SD-33	SHEET 2

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	210173	ASSEMBLY, ENGINE/PUMP	REF
2	.24384	ENGINE, NISSAN (SD-33) (See Vendor Chapter for Details)	1
3	..600445	FILTER, OIL	1
4	..600446	FILTER, FUEL	1
-5	..600231	SENDER, OIL	1
-6	..66942	SENDER, TEMPERATURE	1
7	.21638	PUMP, HYDRAULIC (See Vendor Chapter for Details)	1
-8	..600163	KIT, SEAL	1
-9	...66741	SEAL, SHAFT	1
-10	..21757	ASSEMBLY, COMPENSATOR	1
11	.80012-24	ELBOW, STRAIGHT THREAD	1
12	.80012-28	ELBOW, STRAIGHT THREAD	1
13	.80004-03	CONNECTOR, STRAIGHT THREAD	1
14	.80012-08	ELBOW, STRAIGHT THREAD	1
15	.63613	STUD	2
16	.60705	NUT, HEX	2
17	.63305	WASHER, SPLIT	2
18	.81152	FITTING	1
19	.80015-06	ELBOW, SWIVEL	1
-20	.23501	ASSEMBLY, DRAIN TUBE	1
21	..26449	TUBE, HYDRAULIC	1
22	..80062-06	SLEEVE	2
23	..80060-06	NUT	2
24	..80046-06	PLUG	1

Mark Industries

TITLE	DUAL FUEL
MODEL	100C 6X4
NOTES	Z-24

SECT.	6
FIG.	13
SHEET	1



REV.

Mark Industries

TITLE	DUAL FUEL	SECT.	6
MODEL	100C 6X4	FIG.	13
NOTES	Z-24	SHEET	2

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	200051	FUEL, DUAL	REF
-2	.210174	ASSEMBLY, ENGINE/PUMP	1
3	..24381	ENGINE, DUAL FUEL	1
-4	...67520	GOVERNOR, MECHANICAL	1
-4	...600361	CONTROLLER, ELECTRONIC GOVERNOR (USE WITH P/N 600373)	1
-4	...600373	ACTUATOR, ELECTRONIC GOVERNOR (USE WITH P/N 600361)	1
-5	...67525	FLYWHEEL	1
-6	600365	GEAR, RING	1
7	...67607	FILTER, OIL	4
8	...67468	THERMOSTAT	1
9	...66941	SWITCH, OIL	1
10	...66942	SWITCH, TEMPERATURE	1
11	...67620	KIT, DUAL FUEL	1
12	..21638	PUMP, HYDRAULIC (C/E) (See Vendor Chapter for Details)	1
-13	...600163	KIT, SEAL (C/E)	1
-14	66741	SEAL, SHAFT (C/E)	1
-15	...21757	ASSEMBLY, COMPENSATOR (C/E)	1
16	..80004-03	CONNECTOR, STRAIGHT THREAD	1
17	..80063-15	ADAPTER, FEMALE PIPE	1
18	..80008-23	ELBOW, MALE	1
19	..160223	CAP, PLUG	1
20	..20832	VALVE, FUEL SHUT-OFF	1
21	..80012-08	ELBOW, STRAIGHT THREAD	1
22	..80012-28	ELBOW, STRAIGHT THREAD	1

Mark Industries

TITLE	DUAL FUEL
MODEL	100C 6X4
NOTES	Z-24

SECT.	6
FIG.	13
SHEET	3

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-23	..210375	ASSEMBLY, ENGINE DRAIN TUBE	1
24	...80060-06	NUT	2
25	...80062-06	SLEEVE	2
26	...235	TUBING, HYDRAULIC	1.5 FT
27	...80042-06	UNION	1
28	...80059-06	CAP	1
29	...81319	FITTING, METRIC	1
30	..63613	STUD	2
31	..63305	WASHER, SPLIT	2
32	..60705	NUT, HEX	2
-33	.65937	TANK, LIQUID PROPANE	2
-34	.486-A	BRACKET, TANK	4
-35	.4019	SWITCH, TOGGLE	1
-36	.20884	GUARD, SWITCH	1
-37	.182706	DECAL, DUAL FUEL SELECTOR	1
-38	.23558	DECAL, LIQUID TANK ONLY	2
-39	.65142	SOCKET, QUICK DISCONNECT	2
-40	.2616	HOSE	16 FT
-41	.16452	FITTING	2
-42	.16451	FITTING	2
-43	.65141	NIPPLE, QUICK DISCONNECT	2
-44	.21897	ASSEMBLY, LPG LINE SWIVEL JOINT	1
-45	.60343	SCREW, CAP	2
-46	.63403	WASHER, FLAT	2
-47	.60333	WASHER, SPLIT	2

REV.

DASH (-) INDICATES THE 'ITEM' IS NOT ILLUSTRATED

Mark Industries

TITLE	DUAL FUEL (FIELD KIT)	SECT. 6
MODEL	100C 6X4	FIG. 14
NOTES	Z-24	SHEET 1

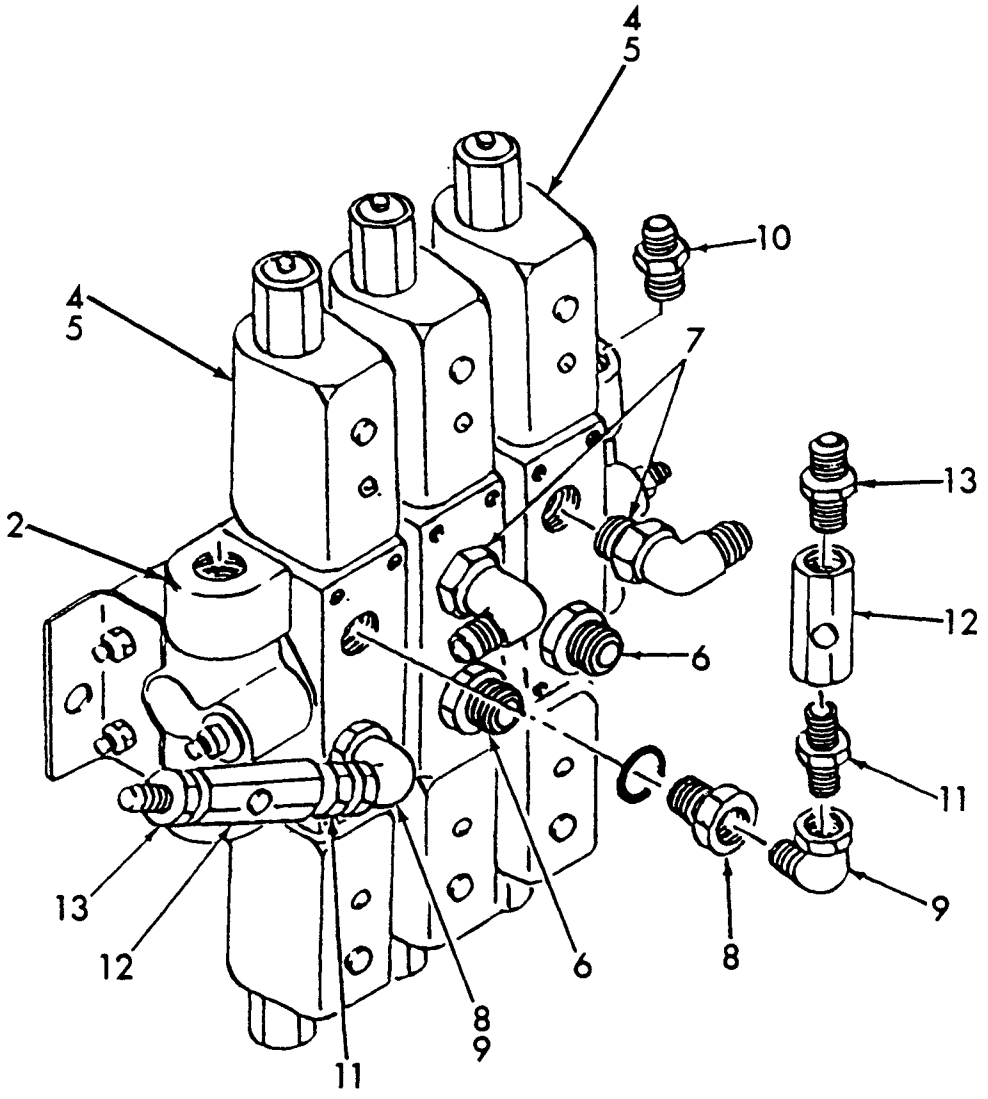
ILLUSTRATION NOT AVAILABLE

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	600324	FUEL, DUAL (FIELD KIT)	REF
2	.16451	FITTING	2
3	.16452	FITTING	2
4	.16975	KIT, MICROVAC	1
5	..16919	KIT, VACUUM SWITCH REPAIR	1
6	.182706	DECAL, DUAL FUEL SELECTOR	1
7	.20884	GUARD, SWITCH	1
8	.21897	ASSEMBLY, L.P.G. LINE	1
9	.23558	DECAL, LIQUID TANK ONLY	2
10	.2616	HOSE	16 FT
11	.4019	SWITCH	1
12	.486-A	BRACKET, TANK	4
13	.60333	WASHER, SPLIT	2
14	.60343	SCREW, CAP	2
15	.63403	WASHER, FLAT	2
16	.65141	NIPPLE, QUICK DISCONNECT	2
17	.65142	SOCKET, QUICK DISCONNECT	2
18	.65937	TANK, LIQUID PROPANE	2
19	.66143	ELBOW	3 FT
20	.66146	HOSE	2
21	.66147	CLAMP, HOSE	2
22	.67620	KIT, DUAL FUEL (Z-24)	1

REV.

Mark Industries

TITLE	MINIPAK SUB-ASSEMBLY	SECT.	6
MODEL	100C 6X4	FIG.	15
NOTES	WITH FRONT MOUNT PLATFORM ROTATION	SHEET	1



REV.

Mark Industries

TITLE	MINIPAK SUB-ASSEMBLY
MODEL	100C 6X4
NOTES	WITH FRONT MOUNT PLATFORM ROTATION

SECT.	6
FIG.	15
SHEET	2

ITEM	PART NUMBER 1234	DESCRIPTION	UNITS PER ASSY
-1	21713	SUB-ASSEMBLY, MINIPAK (See Sect. 6, Fig. 9 for NHA)	REF
2	.21787	VALVE, MINIPAK (See Vendor Chapter for Details)	1
-3	..67825	KIT, SEAL (COMPLETE VALVE PACKAGE)	1
4	..67958	CARTRIDGE (ONLY)	6
5	..16953	COIL (ONLY)	6
6	.2608	CONNECTOR	2
7	.2572	ELBOW	2
8	.80063-01	ADAPTER, FEMALE PIPE	2
9	.2450	ELBOW, STREET	2
10	.2474	CONNECTOR, STRAIGHT THREAD	2
11	.2475	NIPPLE, PIPE	2
12	.20370	VALVE, NEEDLE	2
13	.2415	CONNECTOR, MALE	2

REV.

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Mark Industries

TITLE	VENDOR CHAPTER
MODEL	100C 6x4
NOTES	

VENDOR CHAPTER CONTAINS:

SECTION	DESCRIPTION	PART NO.
1	MICO BRAKE	21220
2	EATON HYDRAULIC MOTOR	23526
3	FAIRFIELD TORQUE HUB	21222
4	WISCONSIN ENGINE	24309, 24440
5	EATON PUMP	21638
6	PAUL MONROE VALVE (MINIPAK)	21787
7	HELAC ROTATOR	81372
8	DEUTZ ENGINE (F3L-912)	22200
9	NISSAN ENGINE (SD-33)	24384
10	DEUTZ ENGINE (F4L1011)	200057
11	MICO BRAKE	22831
12	FAIRFIELD TORQUE HUB	22830
13	TRW MOTOR	81275

















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VENDOR CHAPTER DISCLAIMER

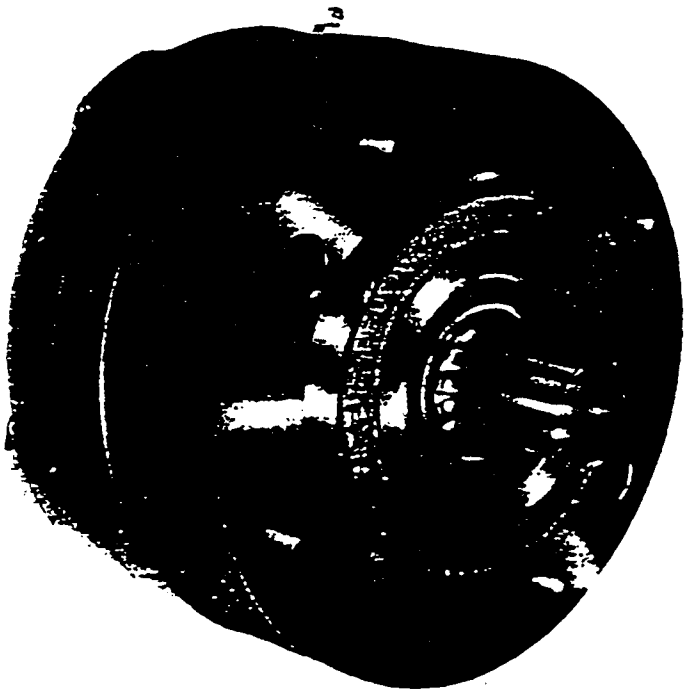
INFORMATION PROVIDED IN THIS VENDOR CHAPTER IS BEING FORWARDED AS A COURTESY. ***MARK INDUSTRIES*** IS NOT RESPONSIBLE FOR THE ACCURACY OF THE INFOMATION PROVIDED HEREIN.

SY·TEC SERIES

MULTIPLE DISC BRAKE

(dry design - SAE C size)

SERVICE MANUAL



REV.

TYPICAL BRAKE

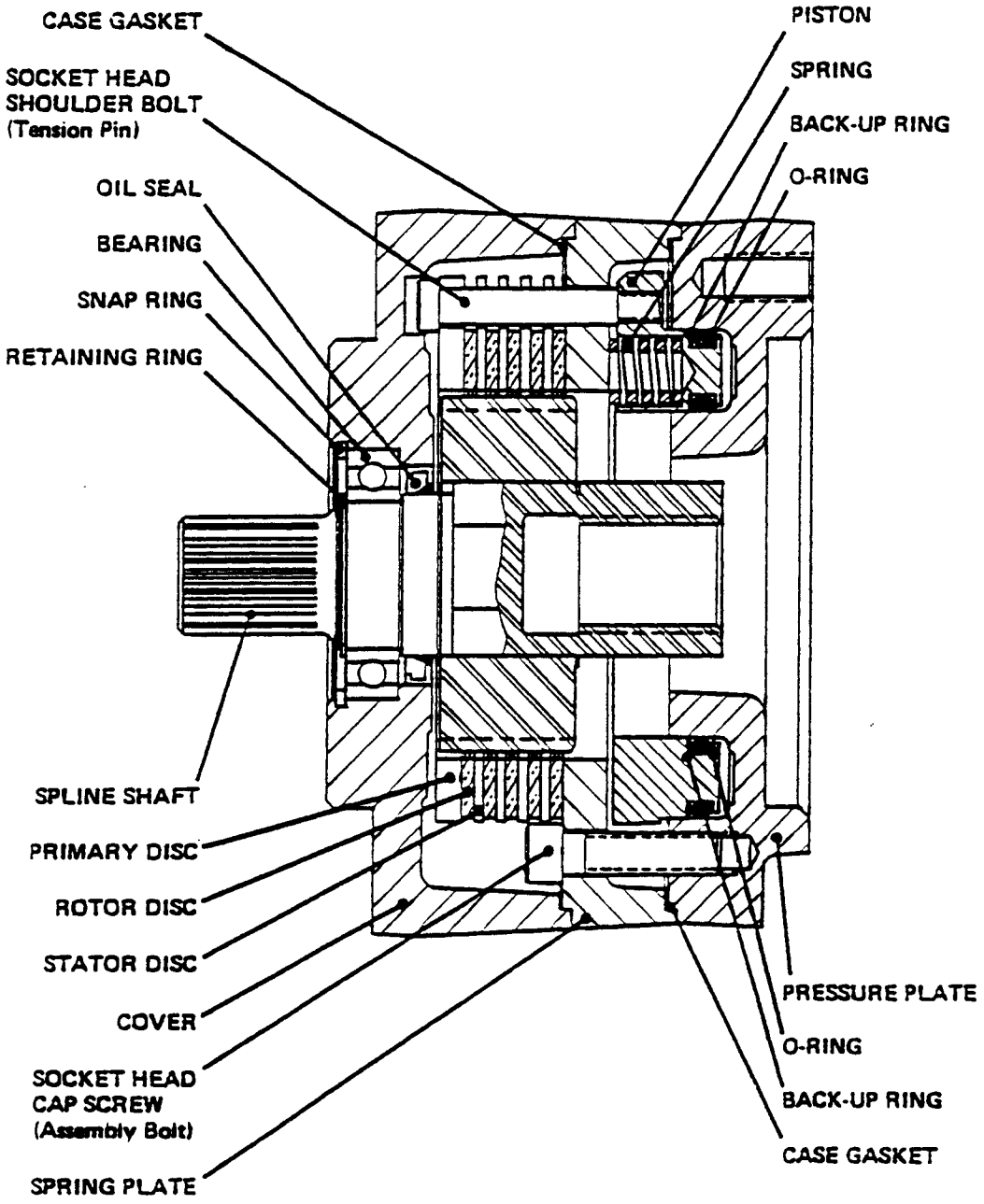


FIGURE 1

PRINCIPLES OF OPERATION

These brakes are spring-set, hydraulically released, multi-disc brakes. They are used primarily for holding loads, vehicles, conveyors, etc. in place when the hydraulic drive system is shut down or fails. Although the brakes are rated at 3,000 psi, they only require from 100 psi to 220 psi to make them function normally. The exact pressure required for operation is dependent upon the number of springs used to generate the torque necessary to hold the designed load. Thus, a brake with a full compliment of springs, will generate the highest level of torque and require approximately 220 psi to fully release the brake and provide adequate running clearance for the individual discs. A brake with 1/2 of the full spring compliment will have 1/2 as much torque and will require only 100 psi to fully release the brake. Consult catalog to choose the torque which best suits your design parameters.

It is very important to remember that any pressure on the brake's release piston will directly effect the level of torque.

Two application examples.

1. The brake has a release pressure of 200 psi. The actuation pressure is provided by a charge pump. During certain phases of the machine's operation, the charge pump pressure dips from 200 psi to 100 psi. At 200 psi, the brake runs free (zero torque) but at 100 psi the brake will generate slightly less than half of its rated torque. The brake will drag – failure may occur. In this case, a brake should be selected which has a lower release pressure.
2. A brake has a release pressure of 200 psi. The system is set up to hold a load when a variable pump is shifted into neutral. Everything is running fine until the filter clogs, causing a build-up of back pressure in the return line to the tank. At a pressure of 60 psi, the brake will lose 25% of its holding torque; thus the load may slip. The situation can be corrected by replacing the filter or adding an extra margin of safety to your required brake torque in the initial design.

These brakes are designed to give thousands of trouble-free hours of service when set up correctly in the hydraulic circuit.

DESCRIPTION OF MODEL NUMBERS



SERIES
S – Sy-Tec

OUTPUT FACE
C – SAE C-Mount 4-Bolt

OUTPUT SPLINE
04 – 14T 12/24 (internal)
14 – 14T 12/24 (external)
17 – 17T 12/24
25 – 1.25 Dia. Keyed
10 – 1.0 Dia. Keyed

INPUT SPLINE
14 – 14T 12/24
17 – 17T 12/24
06 – 1.0 Dia. 6B
25 – 1.25 Dia. Keyed
10 – 1.0 Dia. Keyed
21 – 21T 16/32
12 – 12T 12/24
13 – 13T 16/32

INPUT FACE
C – SAE C-Mount 4-Bolt
A – MAB 4-Bolt and SAE A 2-Bolt
R – Closed
B – SAE B-Mount 2-Bolt
A4 – Char-lynn Standard 4000
L – Char-lynn 4000 Beamgless

OPTIONS *
S – Speed Sensor
Z – Oil Cooled
D – Double Bearing
2 – SAE C-Mount 2-Bolt Thru
24 – 2-Bolt Offset C-Mount

* (Available separately or in combination)

TORQUE 1 psi = .06895 bar

Code	Standard (In. lbs.)	High (In. lbs.)	Release Pressure (psi)	Full Release Pressure (psi)
12		12,000	200	230
98	9800		200	230
10		10,000	170	200
80	8000		170	200
85		8500	150	180
70	7000		150	180
66		6600	125	155
55	5500		125	155
54		5400	105	135
45	4500		105	135

Lower torques available on request.

DISASSEMBLY

1. Remove 2 flat head assembly bolts (items 1). A suitable holding fixture is useful to keep brake in position.
2. Tap female end of spline shaft assembly (item 8) and spring plate (item 14) with soft mallet to separate cover. If sections will not separate, use a screwdriver to carefully pry sections apart.
3. Remove case gasket (item 7) from cover (item 6).
4. Remove retaining ring (item 2) from spline shaft assembly (item 8).
5. Remove spline shaft assembly (item 8) from cover (item 6) by tapping male end of spline shaft assembly with soft mallet.
6. Remove snap ring (item 3) from cover (item 6) and press out oil seal (item 5) and bearing (item 4) if required.
7. Remove four socket head shoulder bolts (items 10). A suitable holding fixture is useful to hold brake in position.

   CAUTION: Do not remove shoulder bolts without pressurization of brake (approx. 200 psi) or damage may result.

8. Remove primary disc (item 11), five rotor discs (items 12) and four stator discs (items 13).
9. Remove 2 socket head cap screws (items 9).
10. Remove spring plate (item 14).
11. Remove case gasket (item 7) from spring plate (item 14).
12. Before removing springs (items 15), note pattern for reassembly purposes.
13. Remove piston (item 16) by carefully exerting hydraulic pressure through brake release port on pressure plate (item 21).
14. Remove outside and inside o-rings (items 18 & 20) and outside and inside back-up rings (items 17 & 19) from piston (item 16).

    CAUTION: Care must be taken so as not to scratch or mar piston.

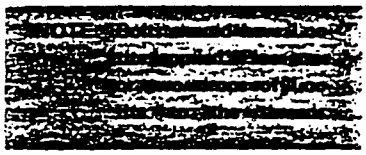
ASSEMBLY

LUBRICATE ALL RUBBER COMPONENTS FROM REPAIR KIT WITH CLEAN TYPE FLUID USED IN THE SYSTEM.

1. Clean all parts thoroughly before assembling.
2. Press oil seal (item 5) into bore until it is flush with bearing shoulder. Open side of oil seal must face toward the front side of cover (item 6).
3. Press bearing (item 4) into position until it bottoms out on oil seal borestep.
4. Install snap ring (item 3) into cover (item 6).
5. Press spline shaft assembly (item 8) into bearing (item 4) until shaft bottoms on shaft shoulder. Bearing inner race must be supported during this operation.
6. Install retaining ring (item 2) on spline shaft assembly (item 8).
7. Install back-up rings (items 17 & 19) on piston (item 16) toward spring pockets.
8. Install o-rings (items 18 & 20) on piston (item 16). Be sure o-rings are flat and all twists removed.

   CAUTION: Care must be taken so as not to scratch or mar piston.

9. Lubricate piston (item 16) with type fluid used in the system. Carefully press piston into pressure plate (item 21). Be sure piston is aligned correctly at all times and that there are no extrusions. Press piston until it bottoms on pressure plate (item 21).
10. Install eight springs (item 15) according to pattern noted during disassembly. Different colored springs must be alternated.
11. Apply a bead of 3M-08001 adhesive on the spring plate (item 14), pressure plate (item 21) and cover (item 6) sealing surfaces. Affix case gaskets (item 7) to cover (item 6) and spring plate (item 14).
12. Place unit on a press. Using fixture, depress and install two socket head assembly bolts (item 9). SEE NOTE BELOW. Torque bolts to 40 ft. lbs. A suitable holding fixture is useful to hold brake in position.
13. Install stator discs (item 13) and rotor discs (item 12). Begin with a rotor disc (item 12) and alternate with stator discs (item 13).
14. Install primary disc (item 11).
15. Align discs and partially screw in four socket head shoulder bolts (item 10). SEE NOTE BELOW. Inspect for free movement of stack. Pressurize brake release port (approx. 200 psi) to release discs. Torque shoulder bolts to 20 ft. lbs. and release pressure. A suitable holding fixture is useful to hold brake in position.
16. Install cover (item 6) using flat head assembly bolts (item 1). SEE NOTE BELOW. Torque bolts to 45 ft. lbs.



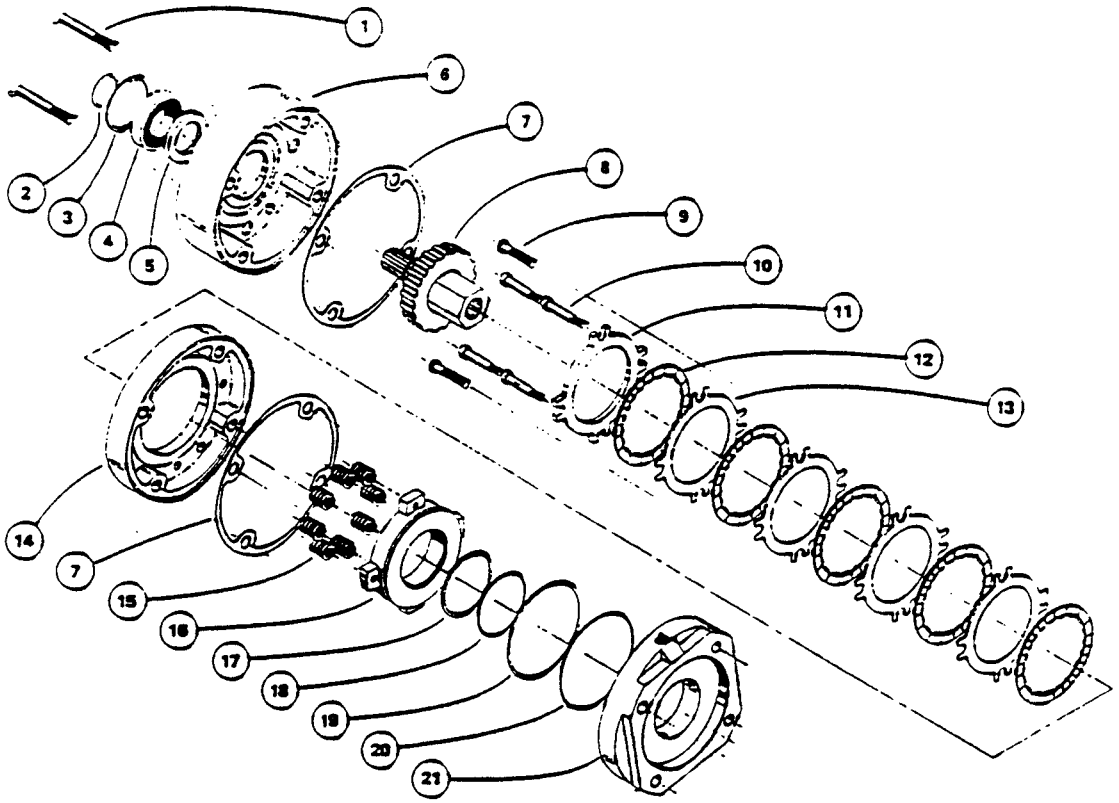


FIGURE 2

PARTS LIST

ITEM	DESCRIPTION	ITEM	DESCRIPTION
1	FLAT HEAD ASSEMBLY BOLTS (2)	11	PRIMARY DISC
2	RETAINING RING	12	ROTOR DISCS (5)
3	SNAP RING	13	STATOR DISCS (4)
4	BEARING	14	SPRING PLATE
5	OIL SEAL	15	SPRINGS (8)
6	COVER	16	PISTON
7	CASE GASKETS (2)	17	BACK-UP RING
8	SPLINE SHAFT ASSEMBLY	18	O-RING
9	SOCKET HEAD CAP SCREWS (2) (Assembly Bolts)	19	BACK-UP RING
10	SOCKET HEAD SHOULDER BOLTS (4) (Tension Pins)	20	O-RING
		21	PRESSURE PLATE

BLEEDING

1. Install brake in system and connect pressure lines.
2. Bleed pressure release section of brake by pressurizing side inlet port and allowing air to escape from top port. Pressure should not exceed 100 psi during bleeding.
3. Apply sufficient pressure to release brake and check for proper operation in system.

SERVICE DIAGNOSIS

(Numbers shown refer to Figure 2)

PROBLEM	CAUSE	EXPLANATION	ACTION
Brake slips	A. Excessive pressure in hydraulic system	If there is back pressure in the brakes actuation line, the holding torque of the brakes is reduced.	Check filters, hose size, restrictions in other hydraulic components.
	B. Oil in brake if designed for dry use	Dry linings generate 66% more torque than linings saturated with oil. If the brake has oil in it, check the type of oil hydraulic or gearbox. 1. Gearbox oil 2. Hydraulic oil	Replace oil seal in brake Check motor seal Check piston seals Note: Internal components will need to be inspected, cleaned and replaced as required.
	C. Disc plates worn	The thickness of the disc stack sets the torque level. A thin stack reduces torque.	Check disc thickness
	D. Springs broken or have taken a permanent set	Broken or set springs can cause reduced torque - a rare occurrence	Check release pressure
Brake drags or runs hot	A. Low actuation pressure	The brake should be pressurized to minimum of 20 psi over the specified release pressure under normal operating conditions. Lower pressures will cause the brake to drag thus generating heat.	Place pressure gauge in bleed port & check pressure with system on
	B. Bearing failure	If the bearing should fail, a large amount of drag can be generated	Replace bearing
	C. Oil in brake	Excess fill of oil in sump condition thru wet brakes can cause the unit to run hot. Also excessive rpm in sump condition.	Drain oil and refill as specified for brakes Switch to flow thru cooling.
Brake will not release	A. Stuck valve or clogged	Brakes are designed to come on when system pressure drops below stated release pressure. If pressure cannot get to brake, the brake will not release.	Place pressure gauge in bleed port - check for adequate pressure - Replace defective line or component
	B. Bad o-rings	If release piston will not hold pressure, brake will not release.	Replace o-rings
	C. Discs frozen	Sy-Tec brakes are designed for only limited dynamic braking. A severe emergency stop or prolonged reduced release pressure operation may result in this type of damage.	Replace disc stack

REPAIR KITS

NUMBER	DESCRIPTION	INCLUDES
66972	O-ring and Back-up Ring Kit	Case Gaskets (item 7) Face Gasket (not shown) Oil Seal (item 5) O-rings (items 18 & 20) Back-up Rings (items 17 & 19) Loc-tite
67643	Lining Kit	Case Gaskets (item 7) Face Gasket (not shown) Primary Disc (item 11) Stator Discs (item 13) Rotor Discs (item 12) Loc-tite
67656	Bearing Kit	Case Gaskets (item 7) Face Gasket (not shown) Bearing (item 4) Loc-tite
67649	Spring Kit	Case Gaskets (item 7) Face Gasket (not shown) Springs - red (item 15) Springs - blue (item 15) Loc-tite
N/A	High Torque Lining Kit	Case Gaskets (item 7) Face Gasket (not shown) Primary Disc (item 11) Stator Discs (item 13) Rotor Discs - thick (item 12) Rotor Discs - thin (item 12) Loc-tite

SERVICE INSTRUCTIONS
FOR THE
71593-DAA

DISASSEMBLY

1. Disconnect all hydraulic lines and remove motor assembly from vehicle.

2. Plug all ports and thoroughly clean outside of motor.

3. Clamp the end of the drive shaft in a protected jaw vise with body of the motor up.

4. Remove the six capscrews (33) and (34) from the back plate of the motor.

5. Use a plastic mallet and tap the back plate (32) to loosen it, then pull the back plate. Remove the gasket (28) and control piston (29).

6. Remove the motor from the vise and lay on bench to remove rotating assembly (22A) from motor housing.

7. Remove pistons (19), spider (20) and spider pivot (21) from piston block.

8. The piston block assembly need not be disassembled unless the internal pins (24) or spring (26) are damaged.

CAUTION:

The following procedure should be used in the disassembly of the piston block assembly.

Spring (26) is highly compressed and snap ring (27) should not be removed without first compressing spring (26).

The following parts are used to disassemble the piston block assembly.

2 each 1/2 flat washers with 1-3/8 OD
1 each 5/8 flat washer with 1-3/4 OD
1 each 1/2 X 4-1/2 NC capscrew
1 each 1/2 NC nut

Place one of the 1/2 flat washers over the 1/2 X 4-1/2 capscrew and place this through the center of the piston block. Place the 5/8 flat washer over the capscrew and let it rest on the three pins. Place the other 1/2 flat washer on the capscrew and screw nut on and compress the spring inside the piston block. Use a pair of snap ring pliers and remove the internal snap ring (27).

Remove the nut, bolt and three washers. Remove spring (26), washer (25), three pins (24) and the internal pin keeper (23).

9. Remove the snap ring (1), shaft seal (2) and washer (3) from front of housing (9).

10. Remove shaft (7) from housing.

11. Remove the two snap rings (4), bearing (6) and two thrust washers (5) from drive shaft.

12. To remove the camplate (18) from the housing, remove the two internal snap rings (1) from the sides of the housing. Remove the two covers (13), the two o-rings (12), the two inner races (11) and the bearings (10). The camplate can now be slid over to one side and removed. The two camplate pivot bearings are a loose slip fit into the housing - do not be concerned if they are not tight.

13. Remove the spring guide (15) and spring (14). Do not remove the button (16) and roll pin (17) unless they are worn or loose.

INSPECTION

1. Inspect the flat surface of the back plate (32), the finish on the piston block side should be smooth and free of grooves or metal build up. The back plate should be replaced if it shows any of the wear characteristics outlined above. The piston guide should be tight in the housing.

2. Inspect the piston block (22). The surface that contacts the back plate should be smooth and free of grooves or metal build up.

3. The pistons (19) should move freely in the piston block bore. If they are sticky in the bore, examine the bore for scoring or contamination.

4. Examine the OD of the pistons for finish condition. They should not show wear or deep scratches. The shoes should be snug fit on the ball end of the pistons. The flat surface of the shoes should be flat, smooth, and show no signs of metal build up. Do not lap piston shoes.

5. Examine the spider (20). It should be flat, no cracks and no signs of wear in the pivot area.

6. Examine the pivot (21). It should be smooth and show no signs of wear.

7. The camplate (18) should be inspected for the condition of the finish of the polished shoe surface. It should show no signs of scoring.

8. Inspect the shaft for fretting in the bearing and spline areas.

9. Inspect thrust bearing (6) and washers (5) for wear.

10. Inspect the needle bearing (8) in the housing assembly. If the needles are free of excessive play and remain in the bearing cage, there is no need to replace the bearing.

11. It is not necessary to inspect the o-rings, snap rings, gaskets, or shaft seal as they should be replaced as new items and are included in the seal repair kit available for this assembly.

REASSEMBLY

1. Clean all parts in suitable solvent, and lubricate all critical moving parts before reassembly. If necessary, install new needle bearings in the housing. The camplate pivot bearings (10) are slip fit, the shaft bearing (8) press fit. The shaft bearing should be installed with numbered end of the bearing outward.

2. Install spring (14), spring guide (15) in housing (9).

3. Insert camplate into housing (9). Insert the needle bearing (10) with numbered end inward and bearing inner race (11) over the camplate journals and slide into the housing. The numbered end of the race should face outward and the chamferred should be inward.

4. Install new o-ring (12) around OD of cam pivot bearings. Install trunnion covers (13) and secure with snap rings (1).

5. Install snap ring (4) on shaft (7). Install thrust washer (5), thrust bearing (6), and second thrust washer (5), secure with second snap ring.

6. Install shaft in housing and install washer (3), shaft seal (2) and retain with snap ring (1).

7. Compress the pin keeper (23) and install in the spline. Install the three pins (24) with head end to the inside of the block and install in the special grooves of the piston block spline.

8. Install the washer (25) and spring (26) in the piston block. Use the 11/2 X 4-1/2 NC capscrew with the three flat washers to compress the spring and retain with snap ring (27). Remove the 1/2 X 4-1/2 capscrew and the three washers.

9. Install the pivot (21), spider (20) and the piston assemblies (19) in the piston block. Install this assembly in the housing assembly, the piston shoes must be in contact with the camplate. Be sure all the parts are in their proper position.

10. Clamp spline end of drive shaft in a protected jaw vise with the open end of the housing up.

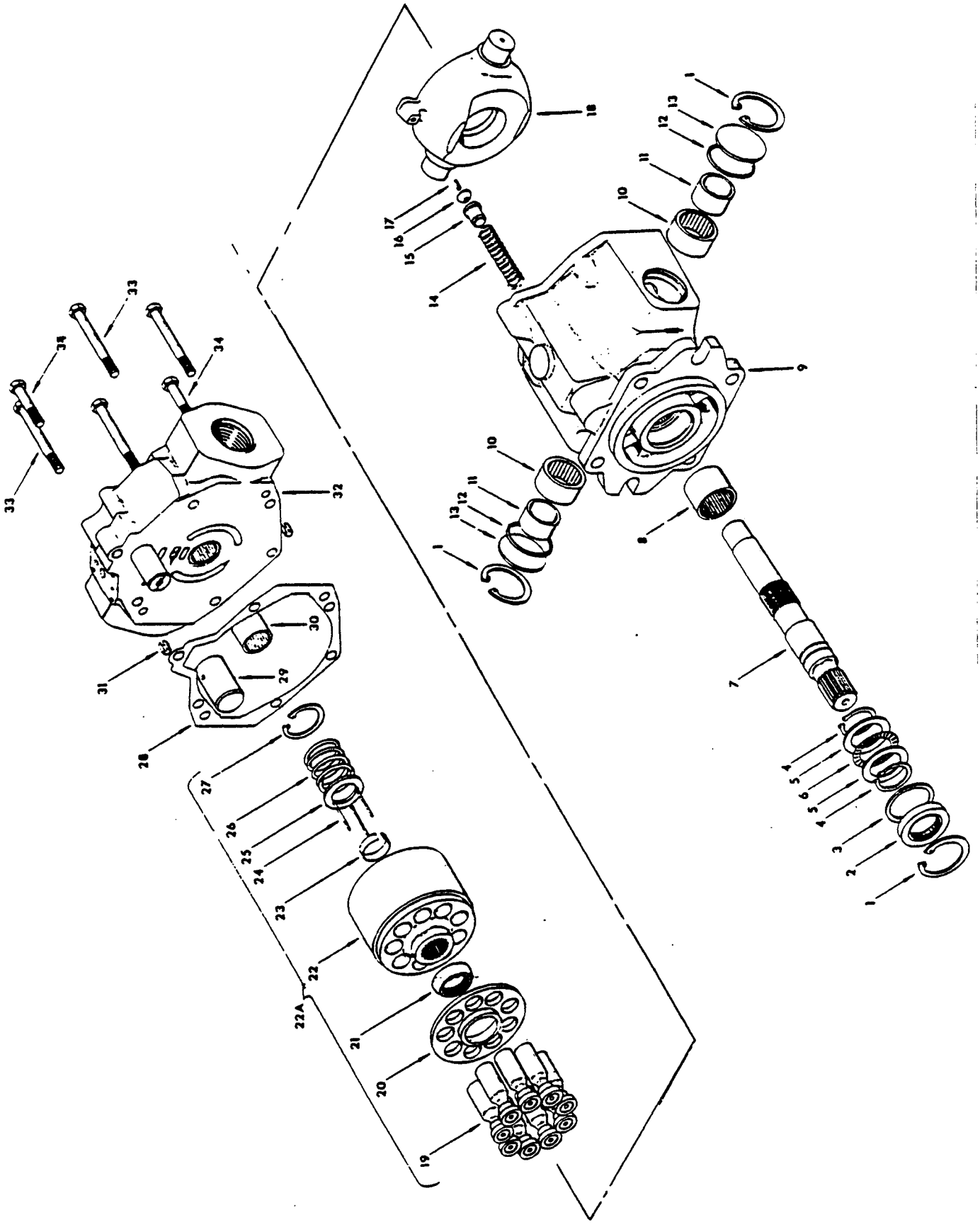
11. Install new gasket (28).

12. Install control piston (29) on back plate.

13. Install back plate (32). Install capscrews (33), (34) and torque to 35/40 ft. lbs.

PARTS LIST
FOR THE
71593-DAA

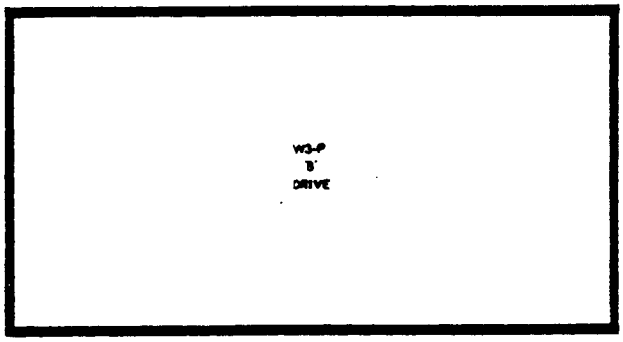
REF. NO.	DESCRIPTION
1.	Snap ring
2.	Shaft seal
3.	Washer
4.	Snap ring
5.	Thrust race
6.	Thrust bearing
7.	Drive shaft
8.	Needle bearing
9.	Housing assembly
10.	Needle bearing
11.	Inner race
12.	O-ring
13.	Cover
14.	Spring
15.	Spring guide
16.	Spring button
17.	Roll pin
18.	Camplate
19.	Piston assembly
20.	Spider
21.	Spider pivot
22.	Piston block
22A.	Rotating assembly
23.	Pin keeper
24.	Pin
25.	Washer
26.	Spring
27.	Snap ring
28.	Gasket
29.	Control piston
30.	Needle bearing
31.	Roll pin
32.	Back plate assembly
33.	Capscrew
34.	Capscrew


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REV.

Torque-Hub® Final Drives

Service Manual



Fairfield

THE DRIVE PEOPLE

REV.

Introduction

This Service Manual is a step-by-step guide designed for the customer or shop mechanic who is servicing or repairing a particular model of Torque-Hub Final Drive. (The model covered by this copy of the Manual is specified on the Manual cover.)

Included are —

1. assembly and exploded view drawings
2. disassembly procedure
3. main assembly procedure (assuming all sub-assemblies to be intact)
4. sub-assembly procedures.

At the time of printing, this Manual was complete for the specific Torque-Hub model designated. However, Fairfield Manufacturing Co., Inc., reserves the right to update and improve its products at any time. All specifications and procedures are therefore subject to change without notice.

Safety

Standard safety practices should be followed during the disassembly and assembly procedures described. Safety glasses and safety shoes should be worn; heavy, heat resistant gloves should be used when heated components are handled. Be especially alert when you see a caution symbol (⚠). This symbol indicates that a particular operation could cause personal injury if not performed properly or if certain safety procedures are not followed.

W3-P "B" Drive Disassembly Procedure

1. Loosen all 12 Cover Bolts and drain the oil from the unit.

2. Remove the 12 Cover Bolts and lift off the Cover Sub-Assembly. Discard the 'O' ring Seal from the Cover counterbore.

3. Lift out the Carrier Sub-Assembly and Thrust Bearing Set. A Thrust Washer may stick inside the Cover

4. Pry the Ring Gear loose and remove it. Discard the 'O' ring Seal from the Hub counterbore.

5. Remove the Input Shaft, Input Gear, and the Thrust Spacers that are on the Input Shaft.

6. Lift out the Internal Gear and Thrust Bearing Set. A Thrust Washer may stick to the bottom of the Carrier.

7. Remove the Retaining Ring from the Spindle and discard; then lift the hub off the Spindle.
   Eye protection should be worn during Retaining Ring removal.

8. The inside Bearing Cone and the Bearing Shim can now be removed.

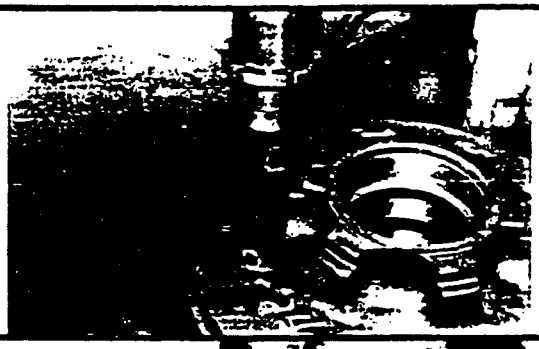
9. The Seal can be pried out of the Hub with a screw driver or pry bar. This will also allow the outside Bearing to be removed.

   Note: If bearing replacement is necessary, the Bearing Cups can be removed with a "slide hammer puller" or driven out with a punch

10. To remove the Cluster Gears from the Carrier, drive the anti-roll pin into the Planet Shaft of the Cluster Gear. After the Planet Shaft is removed the roll pin should be driven out of the Planet Shaft.

WARNING: When rebuilding the unit, the 'O' rings and Retaining Rings should always be replaced.

Main Assembly Procedure

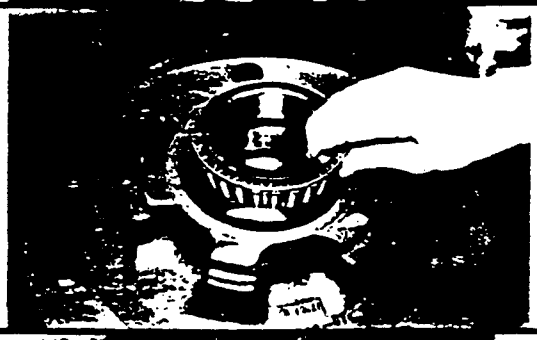


1 Using an arbor type press if available. (If not, a hammer may be used), install the wheel studs. The hub flange should be supported from the underside during this operation

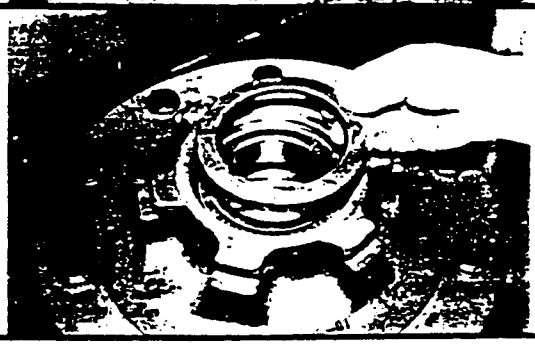
Note: Wheel studs are optional.



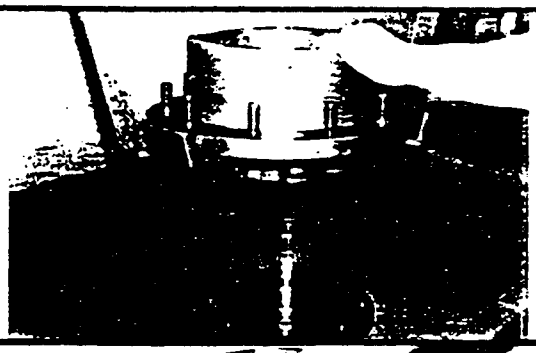
2. Using an arbor type press if available, press Bearing Cups with large inside diameters facing out, into Hub counterbores. Cup #JM716610 will go into small end of Hub, and Cup #JM515610 will go into large end of Hub.



3. Place Bearing cone #JM716649 into Bearing Cup in small end of Hub.



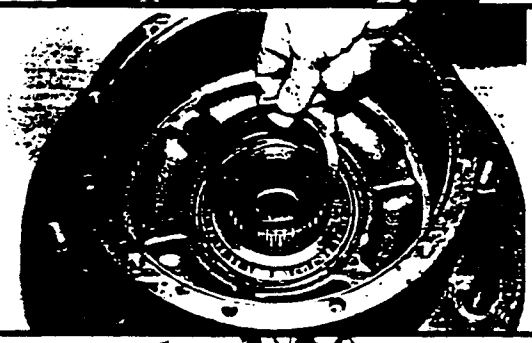
4 Press Seal into Hub counterbore with flat metal side facing in. Use a flat object to assure that Seal is pressed evenly and is flush with Hub face



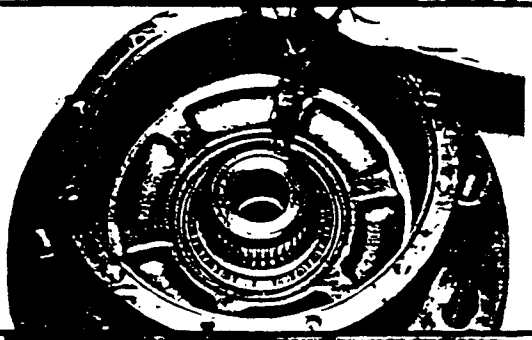
5 Lower Hub onto Spindle with large open end up



6. Place Bearing cone #JM515649 over end of Spindle and into Bearing Cone.

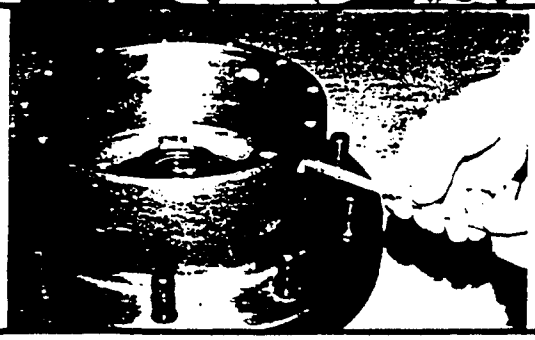


7 Place Bearing Shim over end of Spindle and against Bearing Cone.

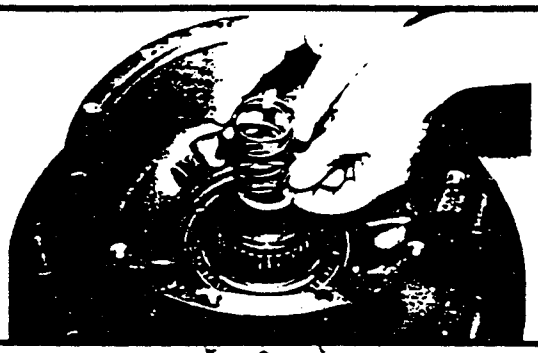


8 Secure Retaining Ring completely into Spindle groove and against Bearing Shim Be sure that Retaining Ring is entirely in groove.

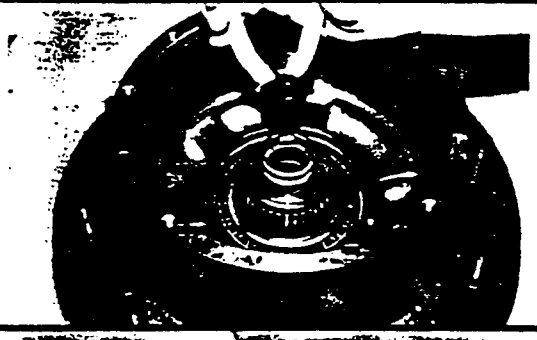
⚠ Eye protection should be worn during Retaining Ring installation



9 The pipe plugs are installed in the Hub. The use of lub-seal is recommended on the pipe plug

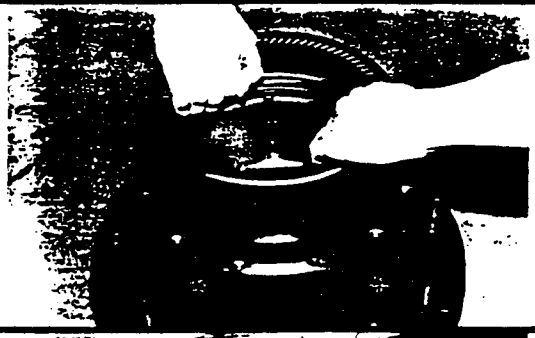


10 The disengage spacer and spring are installed into the co bore of the Spindle.

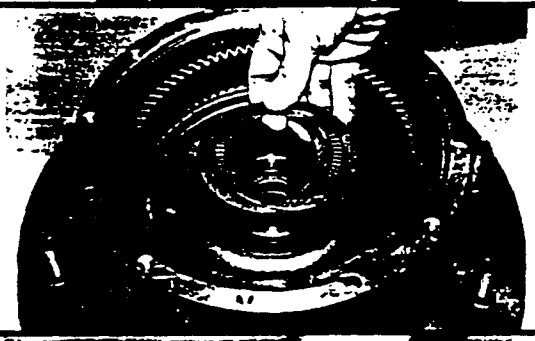


11. Another spacer and the correct Retaining Ring are installed into the Spindle co'bore and Retaining Ring groove provided.

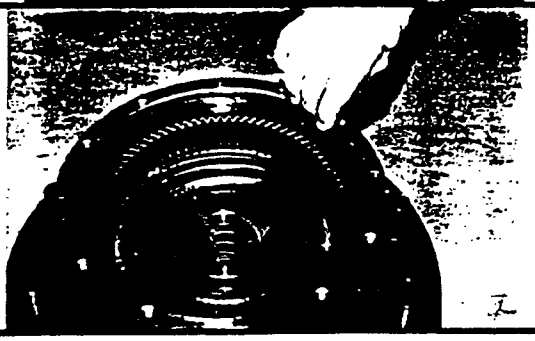
⚠ Eye protection should be worn during Retaining Ring installation.



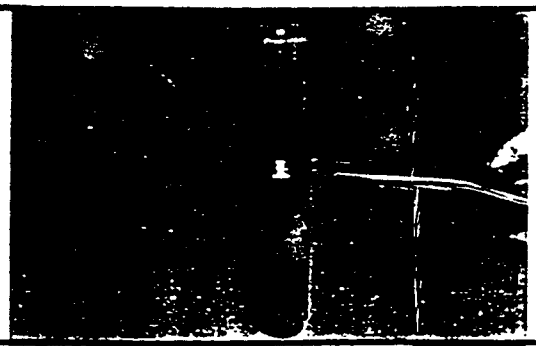
12. The internal gear is installed matching the Bore Spline the Spindle Spline.



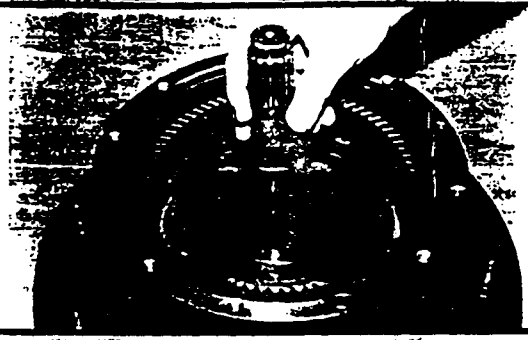
13. The thrust washer/thrust bearing set is installed on the portion of the Spindle which extends into the internal gear.



14. The O'Ring is placed into the counterbore provided in the Hub. Slight stretching may be necessary. Use sufficient grease or petroleum jelly to hold in place.

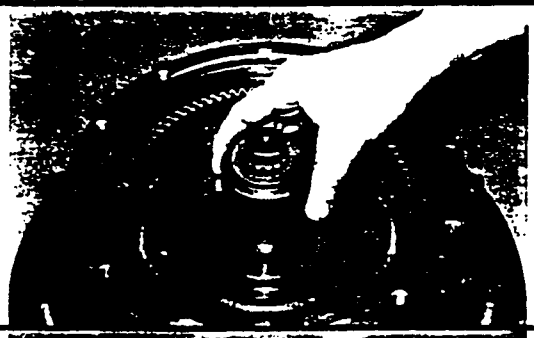


15. Install retaining ring into input shaft retaining ring groove

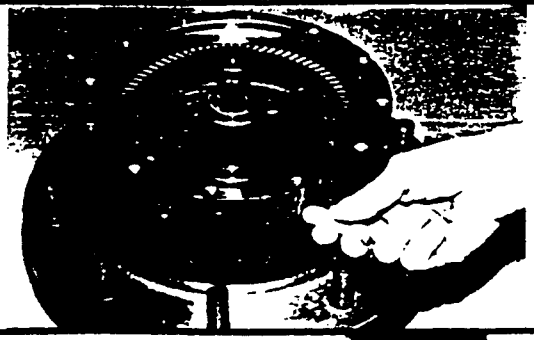


16. The input shaft is installed into the spindle.

    The action of the spring should be checked at this point.

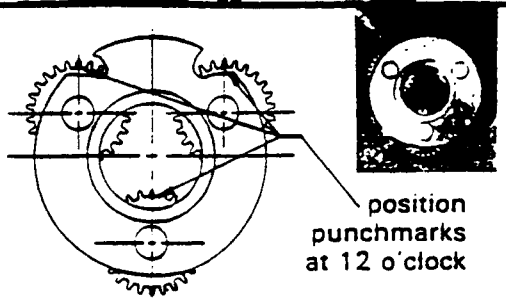


17. The thrust spacer is installed on the input shaft.

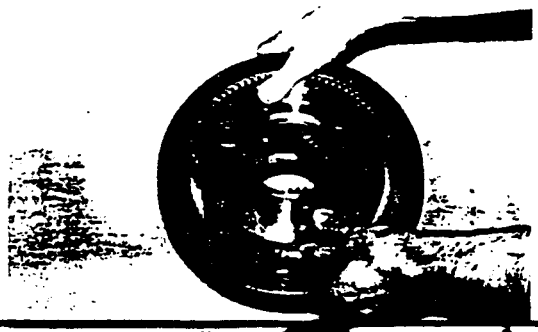


18 Locating the four counter reamed holes in the face of the hub, mark them for later identification.

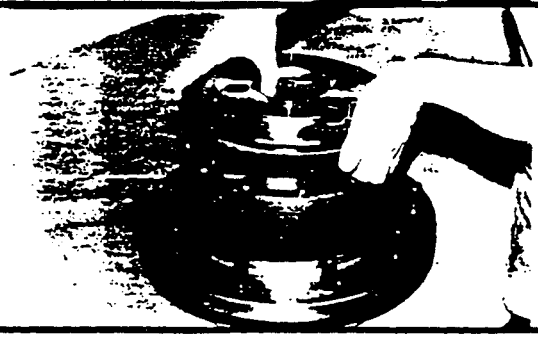
    These holes are reamed to accept the shoulder bolts.



19. Place Carrier Assembly on a flat surface with the large gears up and positioned as shown Find the punch marked tooth on each large gear and locate at 12 o clock (straight-up) from each planet pin. Marked tooth will be located just under the Carrier on upper two gears.

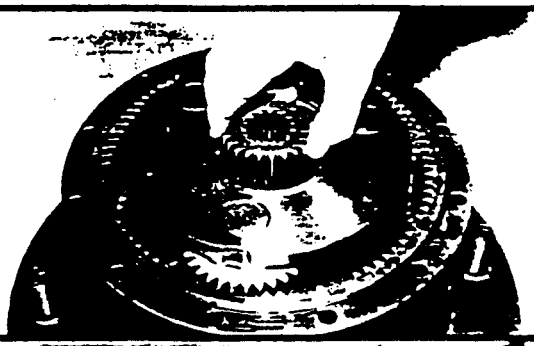


20. With shoulder side of Ring Gear facing down, place Ring Gear over (into mesh with) large gears. Be sure that punch marks remain in correct location during Ring Gear installation. The side of the Ring Gear with an "X" stamped on it should be up.



21. While holding Ring Gear and Cluster Gears in mesh, place small side of Cluster Gear into mesh with the Internal Gear. On the Ring Gear locate the hole marked "X" over one of the marked counterbored holes in Hub.

Note: If gears do not mesh easily or Carrier Assembly does not rotate freely, then remove the Carrier and Ring Gear and check the Cluster Gear timing.



22. The Input Gear is installed into this assembly meshing with the larger diameter Cluster Gear. The counterbored side of the Input Gear is installed down or to the inside of the unit.



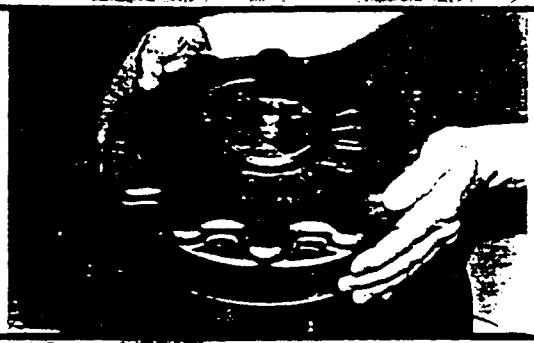
23. After inserting at least one shoulder bolt in the proper location, rotate the carrier. This is to check freedom of rotation and recheck timing.



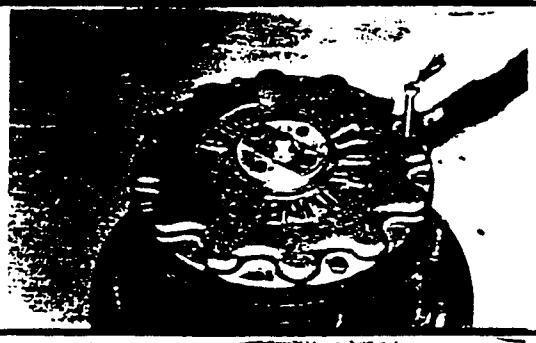
24 Another thrust washer thrust bearing set is now installed into the counterbore in the face of the carrier



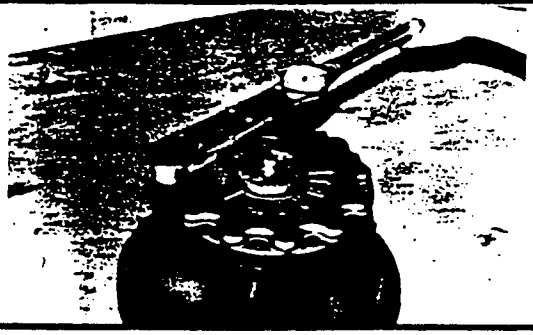
25. Place O'Ring into cover assembly counterbore Slight stretching may be necessary Use sufficient grease or petroleum jelly to hold in place



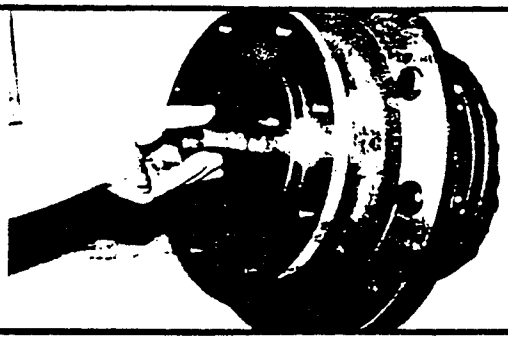
26. Place cover assembly on Ring Gear with oil level. check plug in cover located approximately 90° from oil fill plug in Hub.



27 Locate four shoulder bolts 90° apart into counterbored hole in Hub which were marked in step 17 Torque each bolt to 47 ft. lbs.



28. Install grade eight bolts into the remaining eight holes and torque all bolts to 47ft. lbs. Use the 180° to 90° method in torqueing all bolts.

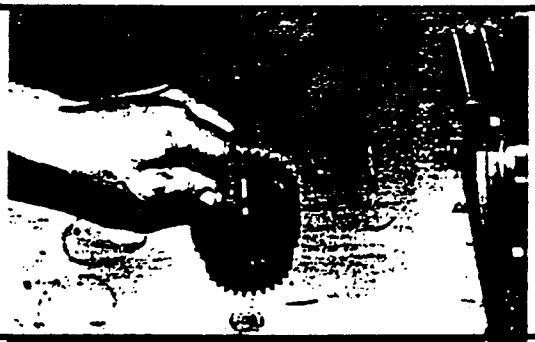


29. Place Coupling into the Spindle and onto the Input Shaft.

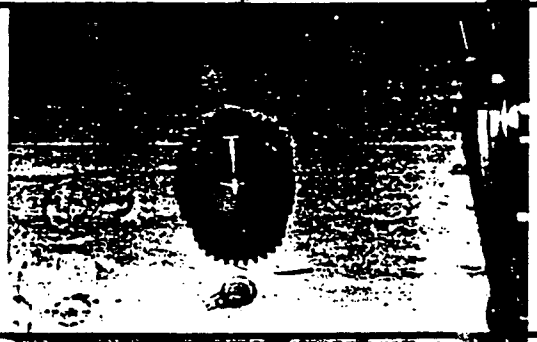
    Note: W3C units must have one external and one internal Snap Ring installed. All units with a "X" on the end of the model number must have two internal Snap Rings with a spacer between them installed in the Coupling.

This completes the assembly. The unit must be filled one-half full of EP 90 lubricant before operation.

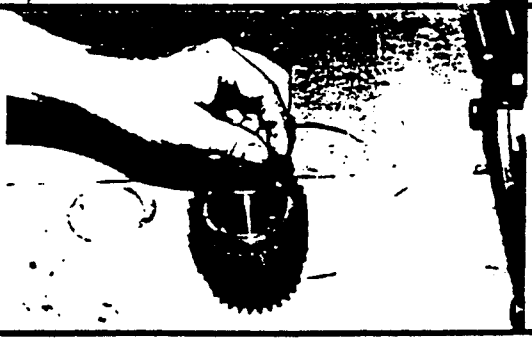
Carrier Sub-Assembly (Bronze Washers)



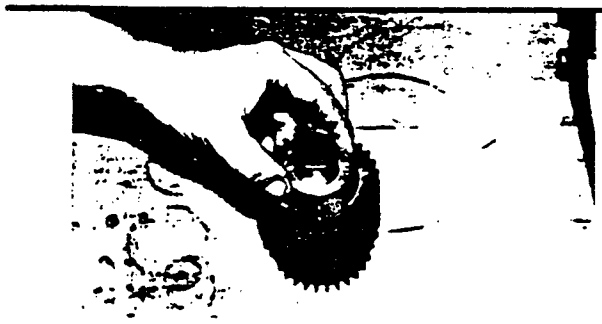
1. To aid in centering Planet Pin (3E) use an extra Spacer (3D) inserted into the bore of Cluster Gear (3F) which has been positioned on a flat surface, small diameter Cluster Gear down.



2. Position Planet Pin (3E) in the bore of Cluster Gear (3F) locating in Spacer (3D).



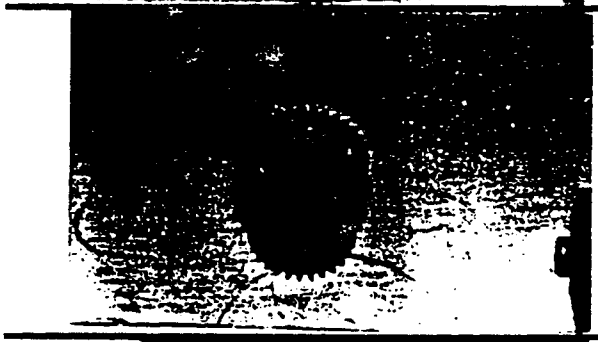
3. Install 14 Needle Rollers (3C) into lower half of Cluster Gear (3F) using sufficient grease or petroleum jelly to assist in holding Needle Rollers (3C).



4. Install Spacer (3D) onto Planet Pin (3E) locating on inboard end of Needle Rollers (3C).



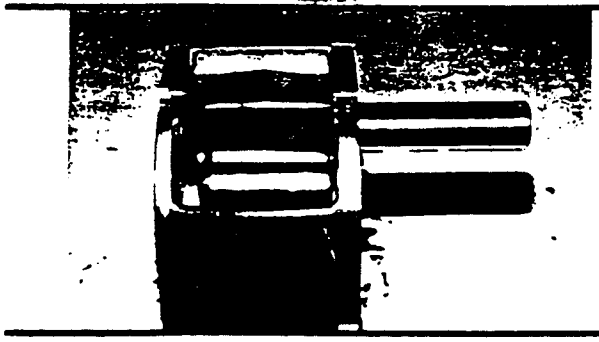
5. Install another 14 Needle Rollers (3C) into the remaining half of Cluster Gear (3F) using sufficient grease or petroleum jelly to assist in holding Needle Rollers (3C) in place once Planet Pin (3E) is removed.



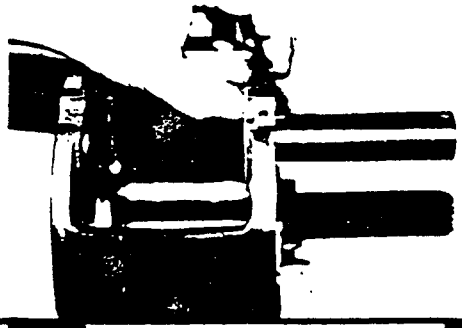
6. Planet Pin (3E) may be removed from the bore of Cluster Gear (3F).



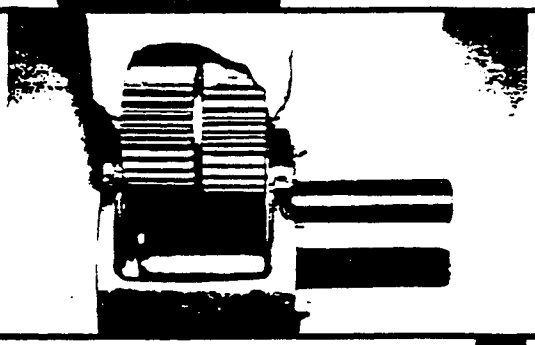
7. Thrust Washers (3H) are installed into the counterbores of each end of the Cluster Gear (3F). Care is to be taken to install the smooth side of Thrust Washer (3H) into the counterbore of Cluster Gear (3F).



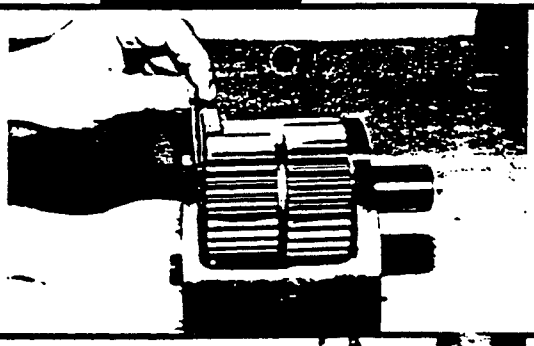
8. Insert Planet Pin (3E) into the Planet Pin hole of Carrier (3A) from the Roll Pin hole side. Care is to be taken to align Planet Pin (3E) with the chamfered end of the Roll Pin hole up. This chamfered hole is to assist in aligning the Roll Pin holes in the Carrier (3A) and Planet Pin (3E) as Roll Pin (3G) is tapped into location.



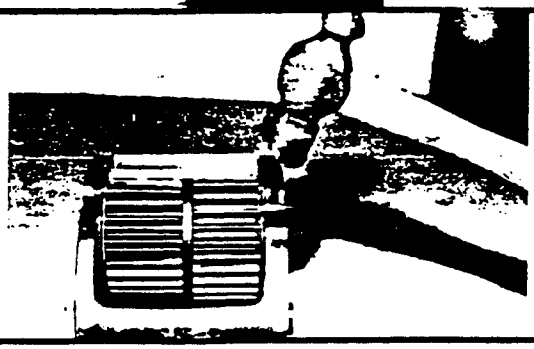
9. Using sufficient grease or petroleum jelly to assist in holding in position. Thrust Washer (3B) is installed onto Planet Pin (3E). Care is to be taken to install Thrust Washer (3B) with the tang positioned in the slot provided.



10. Cluster Gear (3F) with Thrust Washers (3H), Needle Rollers (3C) and Spacer (3D) installed is positioned into Carrier (3A) and aligned with Planet Pin (3E). Care is to be taken to insure Cluster Gear (3F) is installed with the large diameter end to the Roll Pin (3G) side of Carrier (3A).

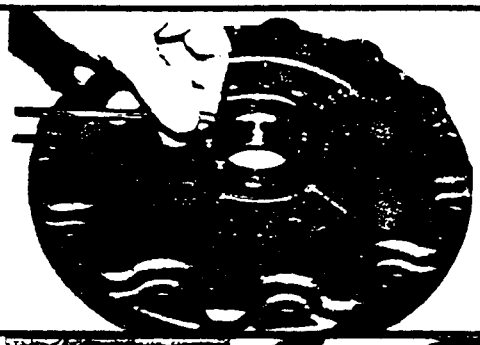


11. A second Thrust Washer (3B) is installed on the small diameter end of Cluster Gear (3F) using sufficient grease or petroleum jelly to assist in holding position as Planet Pin (3E) is fully extended through Carrie (3A).



12. Upon checking alignment of the Roll Pin holes in Carrier (3A) and Planet Pin (3E), Roll Pin (3G) is tapped into location. Care is to be taken to insure that the external end of Roll Pin (3G) is below the outer diameter of Carrier (3A).

Cover Sub-Assembly



1. Screw Pipe Plug into Cover.



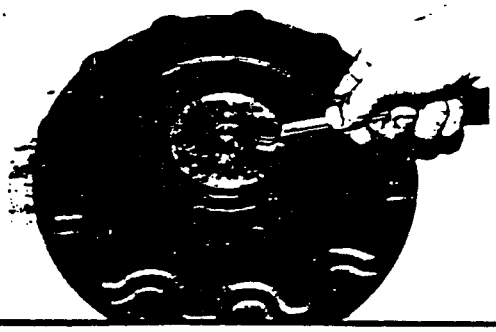
2. Place 'O' Ring into Cover Cap internal groove. The Disconnect Rd may be used to push 'O' Ring into groove. Rod will be held in place by friction from the 'O' Ring.



3. Slip 'O' Ring over Cover Cap and against face.



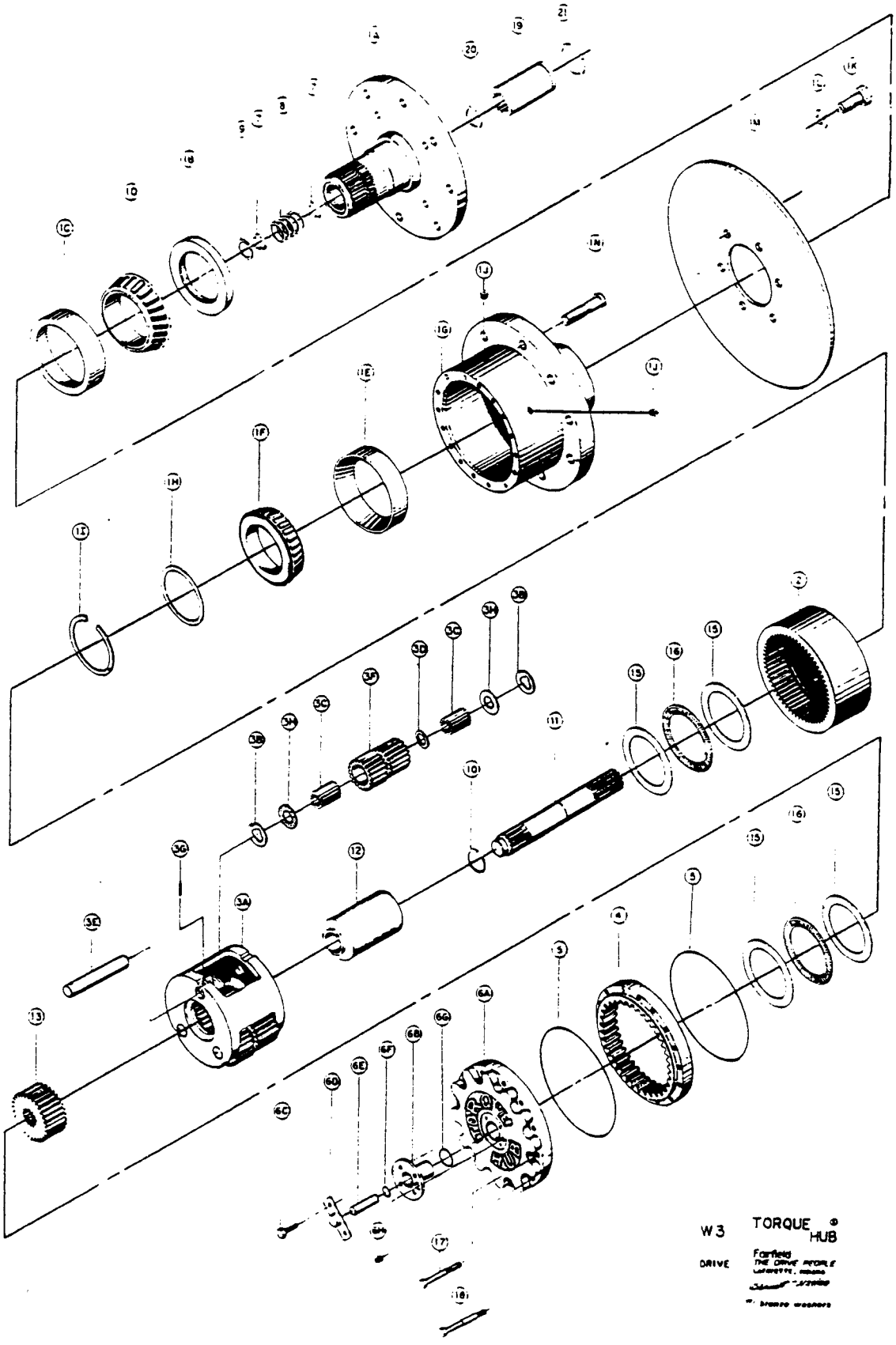
4. Place Cover Cap into Cover with large hole located over Pipe Plug.



5. Install two 1/4 × 20 × 3/4 bolts 180° apart and torque to 70 - 80 in. lbs.



6. Place disconnect cap over cover cap with nipple facing out and align with two open holes. Secure disconnect cap to cover with two 1/4 × 20 × 3/4 and 70 - 80 in. lbs.



REV.

STARTING and OPERATING INSTRUCTIONS

ISSUE MM-357

WISCONSIN

Air-Cooled Engines

Four Cylinder Engine Models

VH4D • VG4D • V-465D

TELEDYNE WISCONSIN MOTOR

WORLD'S FOREMOST SOURCE FOR HEAVY DUTY AIR COOLED ENGINES

REV.

INTRODUCTION

WISCONSIN heavy duty air cooled engines are of the most advanced design and are built in a modern factory, equipped with the latest machinery available. Only the best materials, most suitable for the particular part, are used. During production, every part is subjected to rigid inspection, as are also the completely assembled engines. After assembly, every engine is operated on its own power and all adjustments are carefully made so that each engine will be in perfect operating condition when it leaves the factory.

Teledyne Wisconsin Motor is backed by over 65 years of engineering experience in the design of internal-combustion engines for every conceivable type of service. The performance of these engines is proof of the long satisfactory service you too can expect from your engine.

Like all fine machinery, the engine must be given regular care and be operated in accordance with the instructions.

SPECIFICATIONS

MODEL VH4D

Bore	3¼"
Stroke	3¼"
Piston Displacement — cu. in.	107.7
Horsepower — 1400 R.P.M.	17.2
1600 R.P.M.	20.0
1800 R.P.M.	22.5
2000 R.P.M.	24.7
2200 R.P.M.	26.5
2400 R.P.M.	28.0
2600 R.P.M.	29.2
2800 R.P.M.	30.0

MODEL VG4D

Bore	3½"
Stroke	4 "
Piston Displacement — cu. in.	154
Horsepower — 1400 R.P.M.	25
1600 R.P.M.	29
1800 R.P.M.	32
2000 R.P.M.	34
2200 R.P.M.	36
2400 R.P.M.	37

MODEL V-465D

Bore	3¾"
Stroke	4 "
Piston Displacement — cu. in.	177
Horsepower — 1600 R.P.M.	41.6
1800 R.P.M.	47.5
2000 R.P.M.	52.4
2200 R.P.M.	56.7
2400 R.P.M.	60.0
2600 R.P.M.	63.0
2800 R.P.M.	64.5
3000 R.P.M.	65.9

Note: For continuous operation, allow 20% of horsepower shown, as a safety factor.

SAFETY PRECAUTIONS

- Never fill fuel tank while engine is running or hot; avoid the possibility of spilled fuel causing a fire.
- Always refuel slowly to avoid spillage.
- When starting engine, maintain a safe distance from moving parts of equipment.
- Do not start engine with clutch engaged.
- Do not spin hand crank when starting. Keep cranking components clean and free from conditions which might cause the crank jaw to bind and not release properly. Oil periodically to prevent rust.
- Never run engine with governor disconnected, or operate at load speeds in excess of: 2800 R.P.M. for model VH4D, 2400 R.P.M. for model VG4D and 3000 R.P.M. for model V-465D.
- Do not operate engine in a closed building unless the exhaust is piped outside. This exhaust contains carbon monoxide, a poisonous, odorless and invisible gas, which if breathed causes serious illness and possible death.
- Never make adjustments on machinery while it is connected to the engine without first removing the ignition cables from the spark plugs. Turning the machinery over by hand during adjusting or cleaning might start the engine and machinery with it, causing serious injury to the operator.
- Precaution is the best insurance against accidents.

NEW ENGINE Instructions

• LUBRICATION

Operating without oil will ruin engine.

IMPORTANT

There is **NO OIL** in this unit.
Fill crankcase to proper oil level, also clutch or gear box if furnished, and oil bath air cleaner.

Refer to *GRADE OF OIL* chart (page 2) and fill with proper oil *before* starting engine.

• AIR CLEANER

Oil bath type — Add same grade oil as used in crankcase to the level line indicated on cleaner bowl. Maintain oil level or dirt will be drawn in and damage engine.

Dry element type, optional equipment – DO NOT OIL – Follow instructions on cleaner body.

• FUEL

Use 'REGULAR' grade gasoline. Engines built to operate on FUEL OIL, KEROSENE, L.P.G. or NATURAL GAS are so identified in the model designation. Refer to *'FUEL'* paragraphs of instructions. Buy fresh fuel. Do not use *out-of-season* gasoline.

• NEGATIVE GROUND CIRCUIT

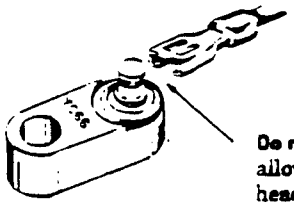
, if engine is equipped with STARTING MOTOR, DISTRIBUTOR IGNITION and FLYWHEEL ALTERNATOR, or GENERATOR.



GROUND ENGINE TO NEGATIVE TERMINAL ON BATTERY.

CAUTION: Be absolutely sure of proper connection or damage to the Alternator or Generator circuits will result.

• PREVENT OVERHEATING



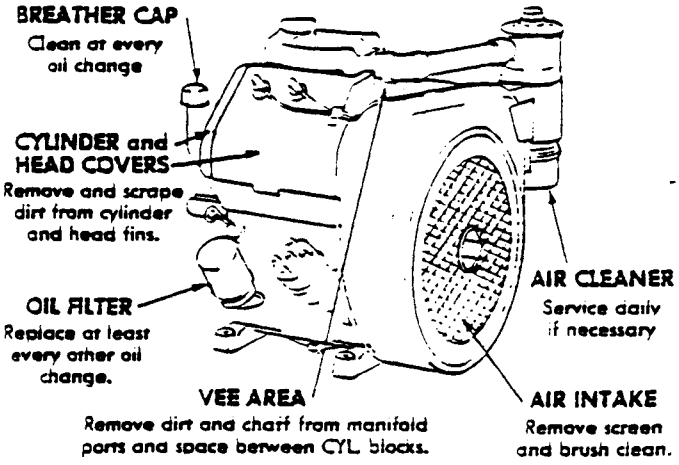
Temperature Safety Switch

Do not disconnect wire or allow terminal to touch head fins or shrouding.

Optional accessory mounted to cylinder head bolt near spark plug — *TO PROTECT ENGINE AGAINST OVERHEATING.* If engine stops, check first to see if engine is overheated. Other conditions may have caused the engine to stop. Clean air cleaner, air intake screen, fins, and check oil level, spark plugs and wiring. Let engine cool at least 10 minutes before restarting.

Keep Engine Clean

External dirt restricts cooling and internal dirt causes wear.



• NEW ENGINE BREAK-IN

Proper *break-in* will lead to trouble-free operation and increased engine life. The factory test given to a new engine is not sufficient to establish the polished bearing surfaces which are so necessary for good performance and long engine life. There is no quick way to force the establishment of good bearing surfaces, and these can only be obtained by running a new engine carefully and under reduced speeds and loads for a short period of time. Run the engine for a half hour without load at low idle speed (1000 to 1200 R.P.M.). The speed should then be increased gradually, to engine operating r.p.m. still without load, for an additional two hours. If at all possible, operate the engine at light loads for a period totaling about eight hours, before maximum load is applied.

STARTING AND OPERATING INSTRUCTIONS

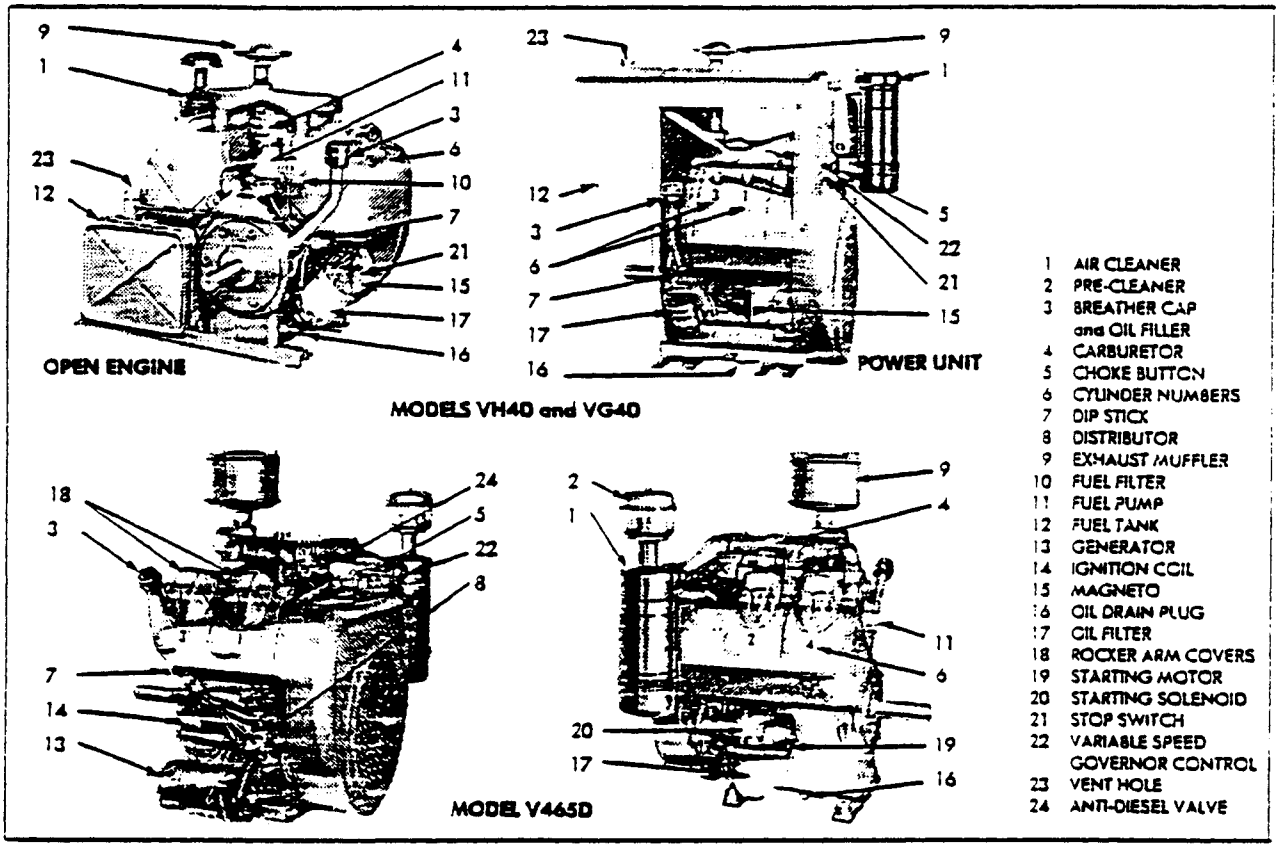


Fig. 1, REFERENCE VIEWS

GENERAL INFORMATION

These engines are of the four cycle type, in which each of the four operations of suction, compression, expansion and exhaust constitutes a complete stroke. This gives one power stroke per cylinder for each two revolutions of the crankshaft.

COOLING

Cooling is accomplished by a flow of air circulated over the cylinders and heads of the engine from a combination fan-flywheel encased in a sheet metal shroud. The air is divided and directed by ducts and baffles to insure uniform cooling of all parts.

NEVER OPERATE AN ENGINE WITH ANY PART OF THE SHROUDING REMOVED — this will retard air cooling.

IGNITION

The spark for ignition of the fuel mixture is furnished by a high tension magneto driven by the timing gears at crankshaft speed (models VH4D and VG4D).

Battery ignition (12 volt) distributor, is furnished in place of magneto on engines equipped with flywheel alternator, or as optional ignition (Std. on model V-465D).

ROTATION

The rotation of the crankshaft is clockwise when viewing from the flywheel or front end of the engine, and counterclockwise rotation of the power takeoff or rear end of the engine.

BEFORE STARTING NEW ENGINE

1. Fill tank with Regular grade gasoline.

   OIL BURNING engine has letter 'O' suffixed to model designation — use 35 minimum octane fuel oil.

   L.P.G. BURNING engine has letter 'G' added to model designation — use propane HD5.

   NATURAL GAS burning engines require a B.T.U. content of at least 1000.

2. Fill crankcase base with the proper grade of engine oil as specified in "GRADE OF OIL" chart. Fill through the breather tube opening to the level indicated by the FULL mark on DIPSTICK.

   For run-in of new engines, use same oil as recommended in GRADE OF OIL chart.

   Check crankcase oil level every 8 hours, change oil every 50 hours of operation.

   To change oil, remove drain plug from oil pan. Oil should be drained while engine is hot; it will flow more freely.

3. Clutch and gear reduction unit lubrication differs between the various engine models. All units operating in oil are furnished with oil filler, level and drain plugs, suitable for any take-off shaft position.

GRADE OF OIL

SEASON OR TEMPERATURE	GRADE OF OIL
Spring, Summer or Autumn +120°F to +40°F	SAE 30
Winter +40°F to +15°F	SAE 20-20W
+15°F to 0°F	SAE 10W
Below 0°F	SAE 5W-20
Use oils classified as Service MS, SD or SE	

Crankcase Capacity	VH4D	VG4D	V-465D
New Engine	3½ qts.	4½ qts.	6 qts.
Oil and filter change	4 qts.	5 qts.	7 qts.
Less — oil filter or filter change	3½ qts.	4½ qts.	6 qts.

Model VH4D, Fig 2 and Fig. 3:

Fill clutch and gear reduction units to the height of the oil level plug opening. Use same grade oil as used in engine crankcase. Add sufficient oil between changes to keep oil up to the level plug opening.

Change oil in clutch and reduction units at least every 500 hours of operation.

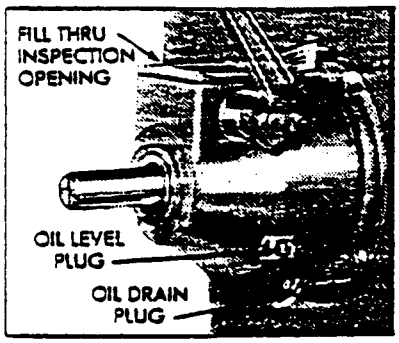


Fig. 2, VH4D
CLUTCH LUBRICATION

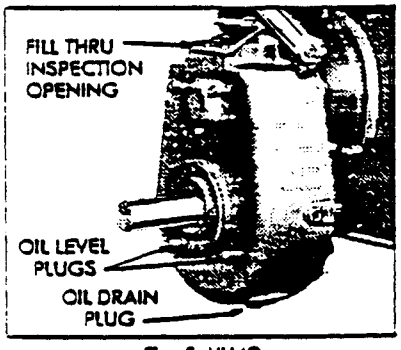


Fig. 3, VH4D
CLUTCH REDUCTION LUBRICATION

Models VG4D and V465, Fig. 4 and Fig. 5:

The clutch in both the power take-off and clutch reduction units is of the dry disc type, therefore NO OIL should be put into the clutch housing. Grease fittings are provided for periodic lubrication of the bearings. The HOUSING BEARING should be greased every 50 hours of operation, and the THROWOUT BEARING every day before starting. use Mobil Gargoyle grease BRB No.3, Sinclair AF-1 grease, or equal.

The PILOT BEARING is sealed and requires no external lubrication.

The SHIFTER SHAFT should be lubricated periodically if external oil fittings are provided.

THE REDUCTION UNIT IS OPERATED IN OIL and the gear case oil level must be maintained to the oil DIPSTICK mark or PLUG opening, which ever is applicable. In ROCKFORD units use No. 30 S.A.E. crankcase oil, for TWIN DISC units use

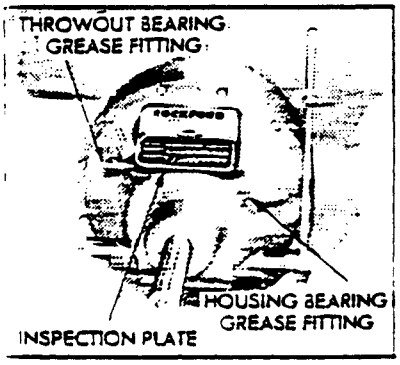


Fig. 4, VG4D, V465D
CLUTCH LUBRICATION

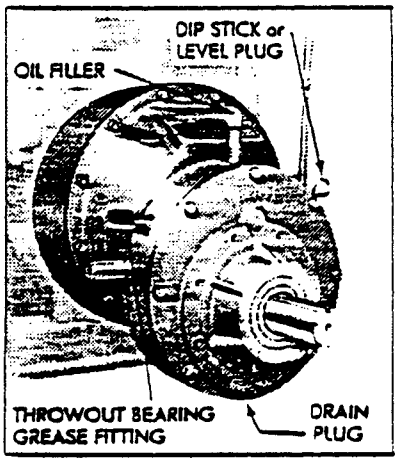


Fig. 5, VG4D, V465D
CLUTCH REDUCTION LUBRICATION

high grade transmission oil, S.A.E. No. 90 to No. 110 viscosity. Change oil every 500 hours of service, while unit is warm.

STARTING

With reference to Fig. 1: Engines enclosed in a sheet metal house are referred to as Power Units, whereas those without a house are called Open Engines.

Power Unit side doors should always be removed when operating.

STARTING PROCEDURE Fig.'s 6,7,8

1. Check crankcase oil level and gasoline supply. Open shut-off valve in fuel strainer.

   OIL BURNING engines must be started on gasoline and run for 2 or 3 minutes before switching to oil. Special instructions are available for starting L.P.G. and NATURAL GAS burning engines.

2. Disengage clutch, if furnished.

3. Prime new engine — if necessary, see Fig. 6. Hand primer lever at fuel pump (available option), should be worked back and forth until strainer bowl is full — then an additional 5 or 10 strokes to fill carburetor bowl. If primer does not function — turn crankshaft one complete revolution.

   Gravity feed (power units), and electric start engines do not require priming.

4. Set throttle about 1/2 open if variable speed governor control is furnished. With a two speed control, start in full load position — idle after engine starts.

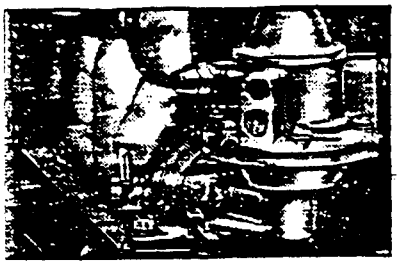


Fig. 6, FUEL PUMP PRIMER

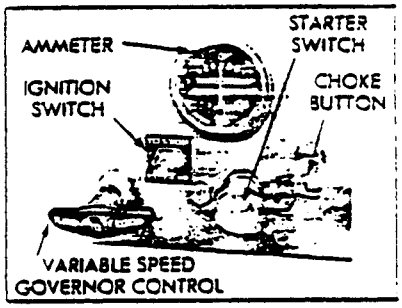


Fig. 7, VH4D, VG4D
CONTROL PANEL

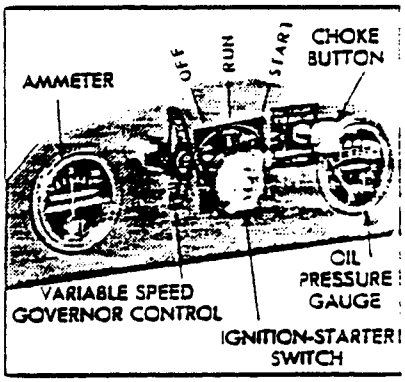


Fig. 8, V465D
CONTROL PANEL

Models VH4D and VG4D only, Fig. 7

5. Pull out ignition switch, if applicable (tag reads "TO STOP PUSH IN").

   Magneto ignition engines (less ignition switch), have a lever type ground switch on side of magneto which is always in the ON or running position, except when depressed for stopping.

5a. Close choke by pulling choke button to extreme out position.

5b. Turn engine over slowly one or two revolutions. CAUTION: Be sure that crank does not bind — apply oil to the crank jaw and crank nut extension for ease of engagement and release.

   Push choke control button in about halfway and then pull up rapidly on the starting crank. Do not attempt to spin the engine with the starting crank. If engine does not start on the first pull up of the crank, re-engage the crank and repeat the operation.

   With electric starting motor: depress starter switch button in place of hand cranking. See Fig. 7.

5c. After engine starts, push choke button in as required for smooth running. Choke should be completely open (button in), when engine is warmed up.

Less choking is necessary in warm weather or when engine is warm, than when cold. Should flooding occur, open choke fully and continue cranking.

Model V465D only, Fig. 8

6. After setting throttle as per paragraph 4.
   Turn IGNITION-STARTING SWITCH to 'Start' position and at the same time pull out choke button only sufficient to start the engine.

6a. Release choke button to open position after engine starts, but rechoke if it tends to stop. EVEN A HOT ENGINE REQUIRES MOMENTARY CHOKING WHEN STARTING. When engine starts release switch to 'RUN' position.

If flooding should occur, continue cranking with the starting motor, but with the choke open (choke button in).

WARM-UP

If all conditions are right, engine will start promptly in one or two attempts. After engine starts, allow it to warm up a few minutes before applying load. Do not race or gun engine to hurry WARM-UP. The proper oil film on various surfaces of the pistons, cylinders, bearings, etc., cannot be established until the oil has warmed up and become sufficiently fluid. Break-in new engine per instructions on page 1.

TO STOP ENGINE

Magneto ignition (open engines) have a lever type ground switch on the side of the magneto. DEPRESS AND HOLD DOWN UNTIL ENGINE STOPS. See Fig. 1, Ref. 21.

Power units and battery ignition, Fig. 7, are furnished with an ignition switch, "TO STOP PUSH IN".

Model V465D: turn IGNITION-STARTING SWITCH to OFF position. See Fig. 8.

If engine has been running hard and is hot, do not stop it abruptly from full load. Remove the load and allow the engine to run idle (1000 to 1200 R.P.M.), for 3 to 5 minutes. Air circulation from the flywheel will reduce the temperature of the engine much faster and minimize valve warping.

MAINTENANCE

AIR CLEANERS

The air cleaner is an essential accessory, filtering the air entering the carburetor and preventing abrasive dirt from entering the engine and wearing out valves and piston rings in a very short time.

The air cleaner must be serviced frequently, depending on the dust conditions in which the engine is operated. Check hose connections for leaks or breaks and replace all broken or damaged hose clamps.

Excessive smoke or loss of power are good indications that the air cleaner requires attention.

OIL BATH AIR CLEANER, Fig. 9

Service daily; or twice a day if engine is operating in very dusty conditions. Once each week: in comparatively clean conditions.

Remove oil cup from bottom of air cleaner and clean thoroughly. Add the same grade of oil, as used in the engine crankcase, to the LEVEL LINE indicated on the oil cup.

Operating the engine under dusty conditions without oil in the air cleaner or with dirty oil, may wear out cylinders, pistons, rings and bearings in just a few days time.

Once a year; or oftener if conditions are severe, the air cleaner should be removed from the engine and the element, which is not removable, should be washed in a solvent to clean out accumulated dust and dirt.

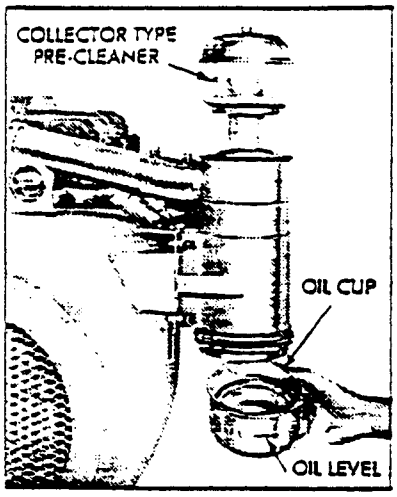


Fig. 9 OIL BATH AIR CLEANER

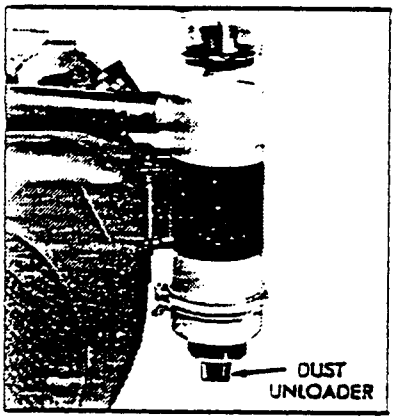


Fig. 10, DRY TYPE AIR CLEANER

DRY TYPE AIR CLEANER, Fig. 10

Service daily; squeeze rubber dust unloader once or twice a day to check for possible obstruction. If engine is operating in very dusty conditions, remove cartridge and shake out the accumulated dirt (do not tap or strike element — it may become damaged). Wipe out dirt from inside cover and bowl, after removing baffle and dumping out dust.

Once each week: the filtering cartridge should be taken out and rinsed under a faucet with cold water, then wash by repeated dippings for several minutes in a solution of lukewarm water and a mild, NON-SUDSING detergent. Rinse in cold water from the inside out, and allow to dry overnight before re-installing. In cold weather, protect element from freezing until dry.

DO NOT USE GASOLINE, KEROSENE OR SOLVENT — DO NOT OIL ELEMENT.

After ten washings or one year of service, replace cartridge. New cartridges are available at your TELEDYNE WISCONSIN MOTOR Service Center.

PRE-CLEANER

The collector type pre-cleaner, mounted to the top of the air cleaner as illustrated in Fig. 9, removes the larger dirt and dust particles before the air reaches the main air cleaner.

Clean bowl regularly of accumulated dust and dirt. Do not put oil or water in pre-cleaner, this must be kept dry.

BREATHER CAP, Fig. 1, Ref. 3

The crankcase is ventilated thru a breather cap mounted on the top of the oil filler tube. At every oil change, it is recommended that the cap be cleaned by washing in kerosene.

DISTRIBUTOR, Fig. 1, Ref. 8

If engine is equipped with battery ignition distributor:

Every 250 hours of operation; add 3 to 5 drops of medium engine oil to the oiler on side of distributor base.

Every 250 hours, apply 3 to 5 drops of light engine oil (10W), to the felt in the top of the cam sleeve, and 1 or 2 drops to the breaker arm pivot.

Every 250 hours, add a small amount of high melting point grease to the breaker arm rubbing block.

Avoid excessive lubrication. Oil on the contact points will cause them to burn.

GENERATOR - Belt Driver, Fig. 1, Ref 13

Every 50 hours of operation; add 3 to 5 drops of medium engine oil into the oil cups at both ends of the generator.

FUEL FILTER, Fig. 11

It is very important that the fuel be filtered to prevent sediment, dirt and water from entering the carburetor and causing trouble or even complete stoppage of the engine. The glass filter bowl should be inspected frequently, and cleaned if dirt or water are present.

To remove sediment bowl, loosen nut below bowl, swing bail to one side and twist bowl as it is being removed. Clean screen and bowl thoroughly — replace gasket if it is damaged or hardened.

OIL FILTER, Fig. 1, Ref. 17

A BY-PASS type oil filter is furnished on all Model VH4D and VG4D engines, except where the use of other accessories prevent mounting an oil filter.

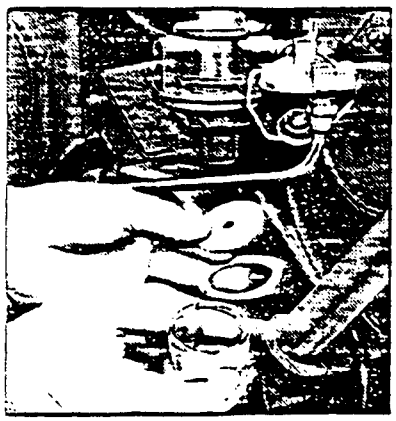


Fig. 11, FUEL FILTER

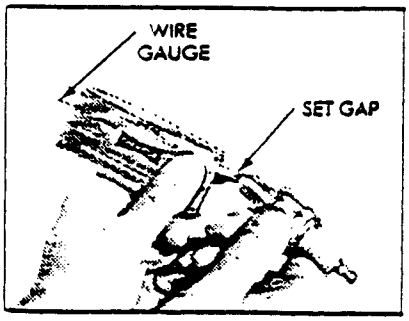


Fig. 12

A FULL-FLOW oil filter is furnished on model V465D engines as standard equipment. Since all of the circulated oil passes thru the filter, it is very important that it be serviced regularly.

The oil filtering cartridge should be replaced after EVERY OTHER OIL CHANGE. If operating conditions are extremely dusty, replace cartridge after every oil change. Use only Wisconsin Micro-Fine or Full-Flo oil filter cartridges from your nearby Teledyne Wisconsin Motor Service Center.

SPARK PLUGS, Fig. 12

Incorrect gap, fouled or worn spark plug electrodes, will have an adverse affect on engine operation. Remove spark plugs periodically — clean, regap or replace if necessary.

Spark plug gap - .030 inch.

Use new spark plugs at the beginning of a new season. Replacement plug must be of the correct heat range, equal to:

Model	Thread Size	Make
VH4D VG4D	18mm	Champion D-16J (Wisconsin YD-6)
V465D	14mm	Champion N-12Y Wisconsin YD-301

Torque spark plugs 25 to 30 foot pounds for Models VH4D, VG4D, and to 22 foot pounds for Model V465D.

STARTING MOTOR, Fig. 1, Ref. 19

No maintenance is required other than keeping the outside of the starting motor clean, and periodic inspection for unsecure mounting and loose or corroded cable connections.

In extreme dust and dirt conditions it may be necessary to occasionally remove the starter from the engine and clean the Bendix by brushing with Kerosene. Do not oil Bendix.

ADJUSTMENTS

CARBURETOR

The carburetor MAIN METERING JET is of the fixed type and therefore no adjustment is necessary.

The correct amount of throttle plate opening for the proper low idle speed is obtained by means of the THROTTLE STOP SCREW. However, this is set at the factory

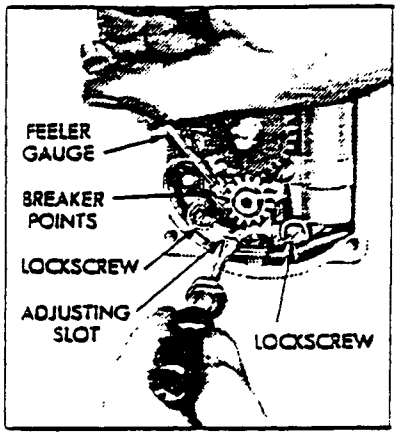


Fig. 13

so that no immediate adjustment is necessary. The IDLE ADJUSTMENT is for smooth low speed operation and this adjustment, if necessary, must be made with the carburetor throttle lever closed. Initial setting is approximately 1½ turns open.

MAGNETO BREAKER POINTS, Fig. 13

At least once each season or when ignition spark becomes weak, remove magneto end cover, inspect points and check gap opening. If there is evidence of pitting or pyramiding and it becomes necessary to resurface or replace points, it will also be necessary to readjust the gap clearance. The BREAKER POINT GAP should be:

.015 inch at full separation.

Turn engine crankshaft over until breaker points are at their maximum opening. Loosen the two lockscrews on breaker plate just enough so that plate can be moved. Place a 0.015 inch feeler gauge between points. Insert end of small screw driver into adjusting slot at bottom of breaker plate and open or close the contacts by moving plate until a slight drag is felt when sliding the feeler gauge from between the points. Tighten lockscrews and recheck point gap.

Before placing end cover on frame, clean contact surfaces, coat with gasket cement and mount new gasket. Assemble cover, rotor and end cap.

DISTRIBUTOR (Battery Ignition), Fig. 14

The breaker point gap should be:

.020 inch at full separation.

To readjust point gap, turn engine over by means of the hand crank until the distributor breaker arm RUBBING BLOCK is on a high point of the CAM. Loosen the stationary contact LOCKSCREW slightly and insert a feeler gauge between the points. By means of a screw driver, turn ADJUSTING SCREW until correct gap is obtained. Tighten lockscrew and recheck gap.

Points that are badly pitted or worn should be replaced.

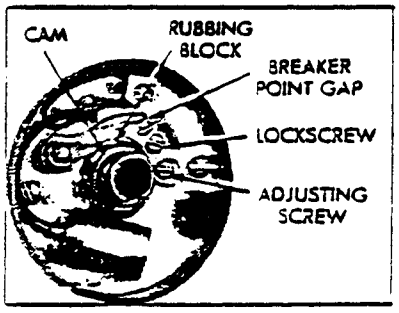


Fig. 14

VALVE TAPPET ADJUSTMENT

Models VH4D, VG4D, Fig. 15

With the tappets in their lowest position (valves completely closed) and engine cold, the clearance between valve stem and tappet adjusting screw should be:

Inlet - .008" Exhaust - .016"

The inlet valves are to the inside of the cylinder block, the exhaust valves are toward the outside. Place feeler gauge between valve stem and tappet screw, and adjust clearance by means of two wrenches.

Model V465D, Fig. 16

The clearance between the valve and rocker arm, with the tappet in its lowest position (valve completely closed) and the engine cold.

Inlet - .008" Exhaust - .014"

The rocker arms can be identified as follows: When facing toward the sideof the engine, the Exhaust Rocker Arm is to the right in the cylinder head and the inlet rocker arm to the left.

Measure clearance between the top of the valve and nose of rocker arm with a feeler

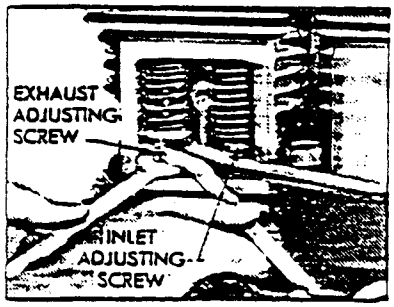


Fig. 15, VH4D, VG4D
VALVE TAPPET ADJUSTMENT

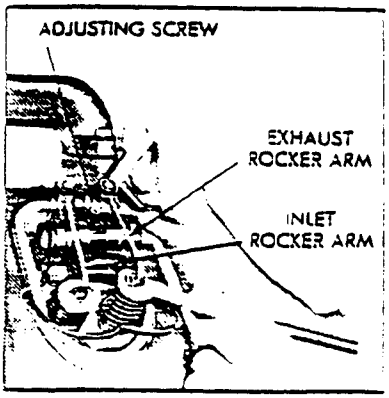


Fig. 16, V465D
VALVE TAPPET ADJUSTMENT

gauge as shown. By means of a ½ inch tappet wrench, turn the adjusting screw clockwise to decrease valve clearance and counter-clockwise to increase the clearance.

The sequence in which the tappets are adjusted is determined by the 1-3-4-2 firing order. Start by adjusting No. 1 inlet valve clearance first, then by just a short turn of the crank, No. 3 inlet can be adjusted. Return to No. 1 cylinder and adjust the exhaust clearance, then adjust the No. 3 exhaust.

The same procedure applies to the No. 2 and No. 4 bank of cylinders, starting with No. 4 inlet valve. Mark each rocker arm with chalk as adjustment is completed, to prevent repetition.

TIMING

FIRING ORDER

The firing order of the cylinders is 1-3-4-2, and the magneto or distributor rotor turns at one-half engine speed, as is the case with conventional 'In Line' engines.

The intervals between the firing of the cylinders is 180°. No. 1 cylinder is the one nearest to the flywheel in the left bank of cylinders, when viewed from the flywheel end of the engine. No. 3 cylinder is the other cylinder in this bank. No. 2 cylinder is the one nearest to the flywheel in the right bank of cylinders and No. 4 is the other cylinder in this bank. The cylinders are numbered on the head covers.

Note: When disconnecting ignition wires, mark cap, and tag wires for correct re-assembly.

TIMING CHECK, Fig. 17

The running spark advance for both magneto and battery ignition, is 23°, and timing must be checked with the engine running at 2000 R.P.M. or over.

Insert a small screw driver into the No. 1 terminal tower on the distributor cap, making contact with the ignition wire terminal. Connect the red terminal clip, from an automotive timing light to the metal part of the screw driver. Connect the other two wires of the timing light one to the positive side of the battery, the other to ground. Chalk or paint the end of the 'X' marked vane of the flywheel, white. Then, with the engine operating at 2000 r.p.m. or over, allow the flash from the timing light to illuminate the white vane. At the time of the flash the leading edge of the vane should line up with the running spark advance timing hole in the front face of the flywheel shroud.

Note: Timing can be checked without removing flywheel shroud screen (Fig. 17 shows screen removed), by illuminating leading edge of white vane with timing light thru the ¼" diameter hole in rim face of flywheel screen.

Timing Adjustment for either battery or magneto ignition: Refer to the INSTRUCTION and PARTS MANUAL of the specific engine model for adjustment procedure.

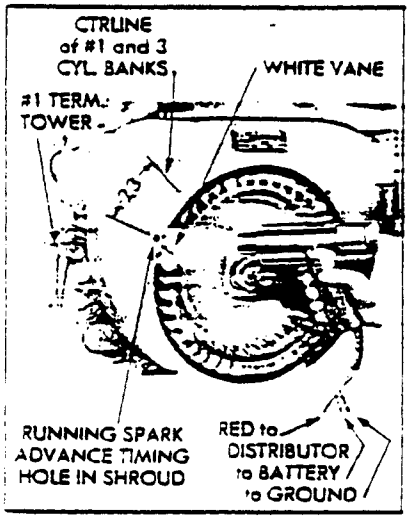


Fig. 17

CLUTCH ADJUSTMENT

If the clutch begins to slip, it should be readjusted to prevent it from becoming overheated and damaged. First, remove inspection plate to expose the adjusting ring. Release clutch by pushing shifter lever forward (toward engine).

VH4D Clutch, Fig. 18

Turn engine over by means of the starting crank until clutch adjustment lock is visible thru the inspection opening. Loosen adjustment lockscrew one full turn. Keep clutch from turning by securing the crankshaft at cranking end. Then, by means of a screw driver, turn adjusting ring one notch at a time in a clockwise direction, until a very firm pressure is required when engaging the clutch shifter lever, and as the clutch snaps into engaged position. Securely tighten adjustment lockscrew.

VH4D CLUTCH REDUCTION, Fig. 19

The clutch in the clutch reduction unit is the same as used in the power take-off unit and is adjusted thru two pipe tap openings: one for the adjustment lockscrew and the other for turning the adjusting ring. If one of the taps is inaccessible, adjustment can be made thru just one opening by rotating clutch slightly after adjustment lockscrew is loosened. Follow adjustment procedures as outlined in preceding paragraph.

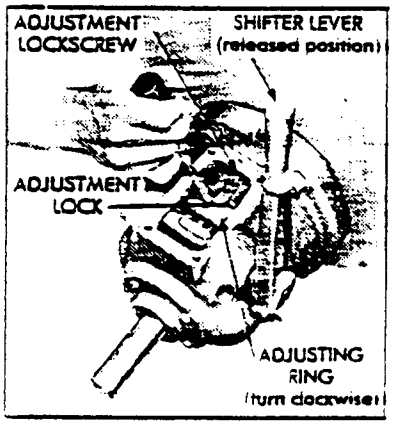


Fig. 18, VH4D
CLUTCH ADJUSTMENT

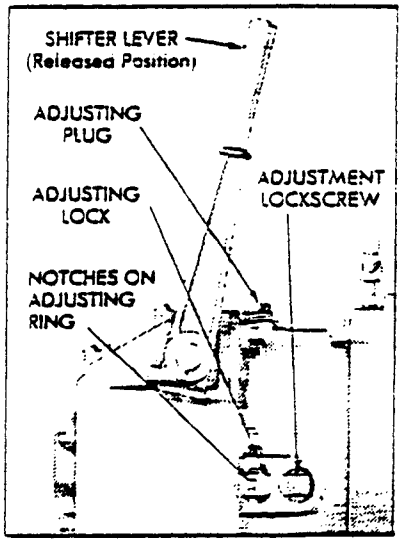


Fig. 19, VH4D
CLUTCH REDUCTION ADJUSTMENT

VG4D, V465D CLUTCH ADJUSTMENT

Rockford Clutch Fig. 20: After removing the inspection cover and disengaging clutch with the shifter lever, turn engine over by means of the hand crank, until the clutch adjustment lock is visible thru the inspection opening in the clutch housing. Prevent take-off shaft from turning by means of a drift punch wedged in place as shown. Then, loosen the lockscrew holding the adjustment lock in place. Insert a screwdriver in one of the notches and turn the adjusting ring, in a counter-clockwise direction, one notch at a time, until a very firm pressure is required to engage the clutch with the shifter lever. Tighten adjusting lockscrew and mount inspection cover.

TWIN DISC CLUTCH, Fig. 21: Pull adjusting lockpin out and insert a piece of 1/16" diameter wire into the hole on the side of the lockpin to keep pin in outer position. Turn the adjusting yoke in a clockwise direction

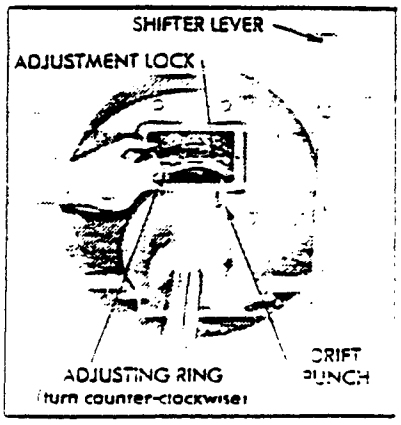


Fig. 20, VG4D, V465D
ROCKFORD CLUTCH ADJUSTMENT

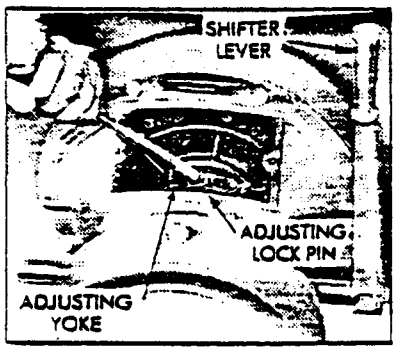


Fig. 21, VG4D, V465D
TWIN DISC CLUTCH ADJUSTMENT

as shown, or wedge a screw driver into the adjusting yoke and against the side of the inspection hole openings to keep the yoke from turning, then turn the take-off shaft counter-clockwise to adjust yoke enough so that the shifter lever requires a distinct pressure to engage. Remove wire from lockpin and turn adjusting yoke slightly, to allow lockpin to snap into hole in floating plate.

A new clutch generally requires several adjustments until the friction surfaces are worn in. Do Not let a new clutch slip, this will ruin the friction surfaces.

FLYWHEEL ALTERNATOR

Fig. 22 and Fig. 23

12 Volt - 10 Amp or 25 Amp Flywheel Alternator, consisting of a flywheel with Magnetic Rotor, Stator and Rectifier-Regulator modules, is optional equipment on models VH4D and VG4D-furnished when battery ignition is required. There are no brushes, commutator or belts to contend with and no adjustments are necessary.

Since the physical appearance of both 10 amp and 25 amp alternator systems are very similar, they can be distinguished from each other by the ammeter calibrations: 0 to 15 amps for the 10 amp circuit and 0 to 30 amps for the 25 amp circuit.

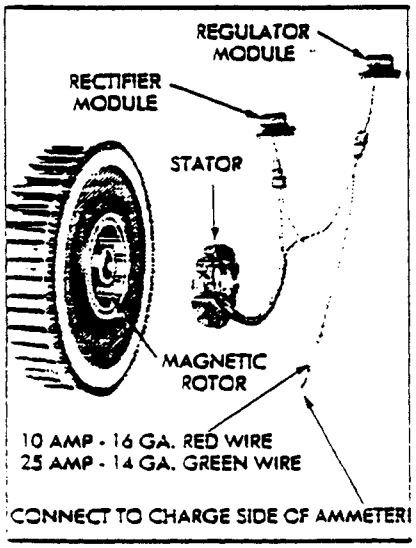


Fig. 22. FLYWHEEL ALTERNATOR

PRECAUTIONS to be exercised in the use of this flywheel alternator:

1. Do not reverse battery connections. This is a negative ground system only.
2. Connect booster batteries — positive to positive and negative to negative.
3. Do not polarize the alternator.
4. Do not ground any wires from stator or modules which terminate at connectors.
5. Do not operate engine with battery disconnected from system.
6. Disconnect at least one battery lead if a battery charger is used.

GENERATOR — WIRING CIRCUIT, Fig. 24

The model V465D engine is equipped with a 12 volt-17 amp generator in a negative ground electrical system. Do not reverse polarity-damage to both generator and regulator will occur. Engine will not operate with carburetor anti-diesel solenoid wire disconnected.

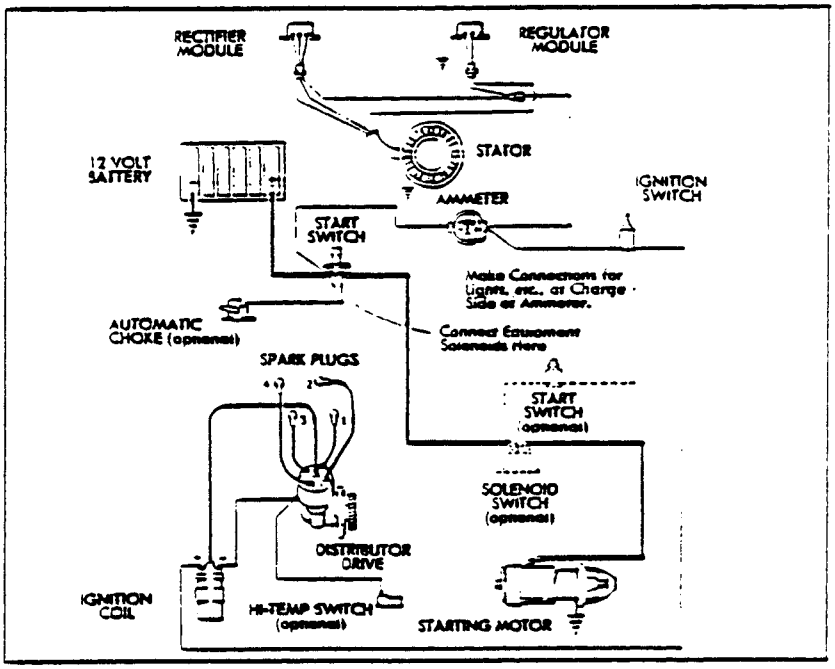


Fig. 23. WIRING DIAGRAM, Flywheel Alternator and Battery Ignition, Models VH4D, VG4D

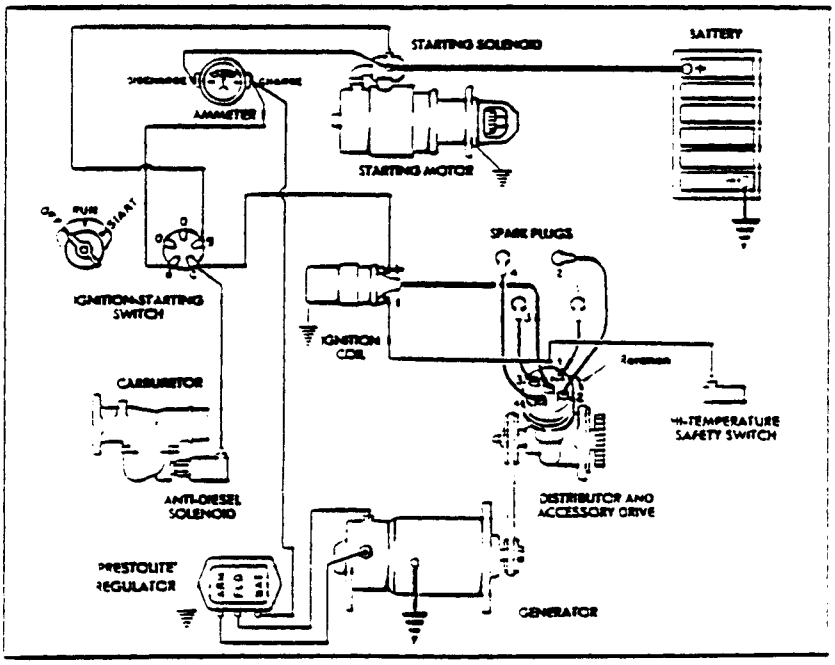


Fig. 24. WIRING DIAGRAM, Generator and Battery Ignition, Model V465D

TROUBLE SHOOTING

The three prime requisites essential to starting and maintaining satisfactory operation of internal combustion engines are:

1. A proper fuel mixture in the cylinder.
2. Good compression in the cylinder.
3. Good spark, properly timed, to ignite the mixture.

If all three of these conditions do not exist the engine cannot be started.

As a guide to locating some of the difficulties in starting, causes are listed under the three main headings of: Fuel Mixture, Compression, and Ignition.

FUEL MIXTURE

No fuel in tank or fuel valve closed.

Plugged vent hole in fuel tank cap.

Fuel line clogged.

Fuel pump diaphragm worn or punctured.

Anti-diesel solenoid valve at carburetor inoperative (model V465D).
Check for disconnected, loose or broken wire.

Carburetor not choked sufficiently, especially if engine is cold.

Water, dirt, or gum in gasoline interfering with free flow of fuel to carburetor.

Poor grade, stale or out-of-season gasoline.

Carburetor flooded, caused by too much choking especially if engine is hot.

Carburetor float needle valve stuck open. This condition would be indicated if fuel continues to drip from carburetor with engine standing idle.

COMPRESSION

Cylinders dry due to engine having been out of use. Pour one fluid ounce of crankcase oil through spark plug holes.

Loose or broken spark plug. A hissing noise will be heard in cranking due to escaping gas mixture on compression stroke.

Damaged cylinder head gasket or loose cylinder head. This will likewise cause hissing noise on compression stroke.

Valve stuck open. Piston rings stuck or worn.

Valves adjusted with insufficient clearance.

IGNITION

Test for spark by removing spark plugs and observe spark at plug gap while turning engine over. No spark or weak spark may be attributed to the following:

Ignition wires loose or disconnected at magneto, spark plug, distributor or coil.

Broken or frayed ignition wires.

Spark plug insulator broken.

Spark plugs wet or dirty.

Spark plug gap incorrect.

Condensation on spark plug electrodes.

Breaker point gap incorrect.

Breaker points pitted or fused.

Breaker arm sticking.

Condenser leaking or grounded.

Spark timing wrong.

Weak battery. Faulty ignition coil.

ENGINE MISSES

Spark plug gap incorrect.

Worn, leaking or loose ignition cables.

Weak spark. See 'Ignition' test for spark.

Breaker points pitted or worn.

Water in gasoline.

Poor compression. See 'Compression'.

Sticky valves.

ENGINE STOPS

Fuel tank empty.

Water, dirt or gum in gasoline.

Gasoline vaporized in fuel lines, due to excessive heat around engine (Vapor Lock). See 'Stopping Engine'.

Vapor lock in fuel lines due to using winter gas (too volatile) in hot weather.

Air vent hole in fuel tank cap plugged.

Ignition troubles. See 'Ignition'.

OVERHEATING

Crankcase oil supply low.

Ignition timing wrong.

Low grade of gasoline.

Engine overloaded.

Restricted cooling air circulation.

Part of air shroud removed from engine.

Dirt between cooling fins.

Intake or rotating screen clogged with dirt.

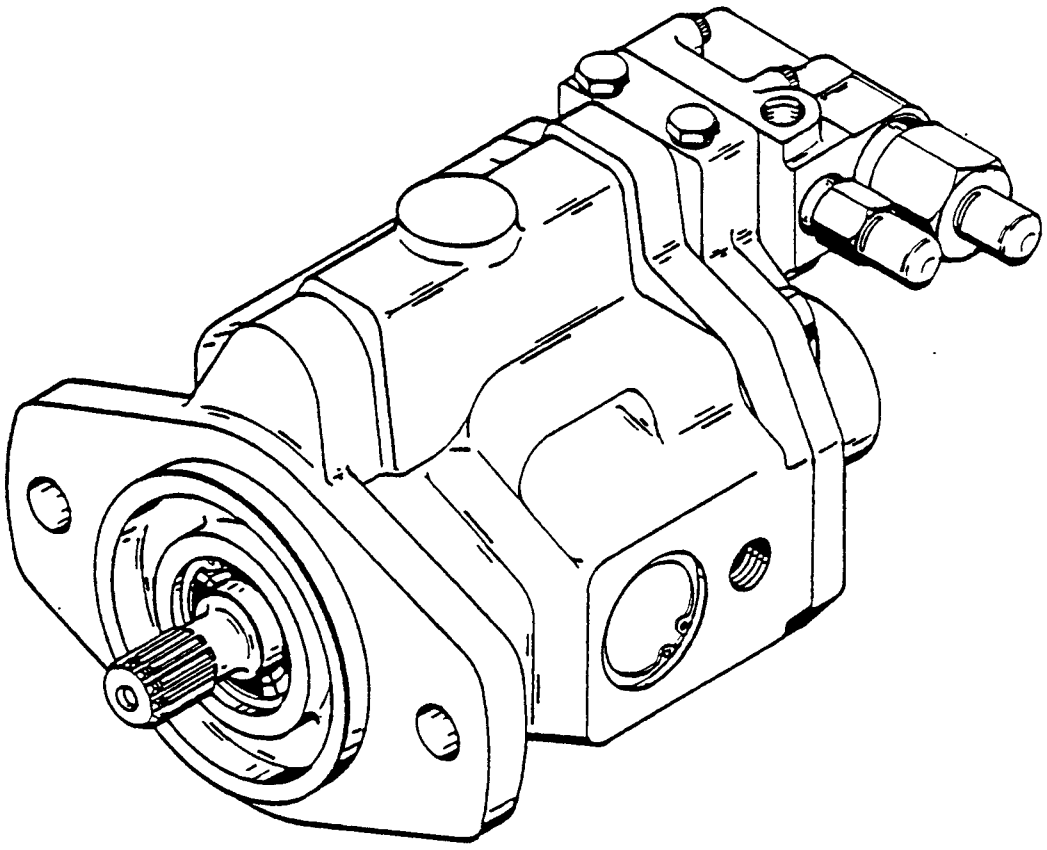
Restricted exhaust.

ENGINE MAINTENANCE SCHEDULE	Page Ref.	Daily	Weekly or 50 hrs.	100 hrs.	250 hrs.	Seasonally or 500 hrs.
CHECK OIL LEVEL. Add to full mark - Do not overfill.	2	●				
CHECK AIR CLEANER. Shake out accumulated dirt from dry element cleaner - Maintain oil level in oil bath type cleaner.	4	●				
CLEAN AIR INTAKE SCREEN. Clean cooling fins if necessary.	1	●				
GREASE CLUTCH THROWOUT BEARING (VG4D, V465D).	3	●				
CHANGE CRANKCASE OIL	2		●			
CLEAN AIR FILTER ELEMENT. DRY Element and Oil Bath types.	4		●			
CLEAN CRANKCASE BREATHER CAP.	4		●			
GREASE CLUTCH HOUSING BEARING (VG4D, V465D).	3		●			
REPLACE OIL FILTER. In adverse conditions replace every oil change.	4			●		
LUBRICATE DISTRIBUTOR SHAFT.	4				●	
CHECK COMPRESSION. Pressure should not vary more than 10 p.s.i. between cylinders. Remove head - clean out carbon deposits. Reseat valves if necessary.	-				●	
INSPECT SPARK PLUGS and BREAKER POINTS. Replace if necessary and regap to specification.	5				●	
INSPECT FUEL FILTER. Clean filter screen and glass bowl.	4				●	
LUBRICATE DISTRIBUTOR CAM and breaker arm pivot.	4				●	
INSPECT COOLING SYSTEM. Remove shrouding and scrape off dirt from between fins, around cylinders and from shrouding.	1				●	
INSPECT STARTING MOTOR. Check for loose mounting and cable connections.	5				●	
CHANGE OIL IN CLUTCH and REDUCTION GEAR HOUSINGS.	2					●

Eaton
Hydraulics
Division

Repair Information

Model 70422 and 70423
Pressure, Pressure-Flow Compensated Piston Pump



EATON

REV.

PARTS LIST

Item No.	Description	Quantity
1	Retaining ring	1
2	Shaft seal	1
3	Washer	1
4	Retaining ring	2
5	Thrust washer	2
6	Thrust bearing	1
7	Key	1
8	Drive shaft	1
9	Housing assembly	1
10	Needle bearing	2
11	Inner race	2
12	O-ring, 3/32 x 1-7/16 I.D.	2
13	Trunnion cover	2
14	Retaining ring	2
15	Camplate control spring	1
16	Spring collar	1
17	Pivot button	1
18	Roll pin	1
19	Camplate	1
20	Piston assembly	9
21	Spider	1
22	Spider pivot	1
23	Piston block	1
24	Pin keeper	1
25	Pin	3
26	Washer	2
27	Spring	1
28	Retaining ring	1
29	Rotating kit assembly	1
30	Control piston	1
31	Gasket	1
32	Roll pin	2
33	Backplate assembly	1
34	Cap screw	4
35	Gasket, compensator	1
36	O-ring, 1/16 x 1/4 I.D.	1
37	Compensator assy., pressure-flow	1
38	Allen head cap screw	4
39	Compensator assembly, pressure	1
40	Plug	4
41	O-ring, 1/16 x 19/64 I.D.	4
42	Compensator housing, pressure-flow	1
43	Spool, pressure compensator	1
44	Spring pivot cap	1
45	Spring, pressure compensator	1
46	O-ring, 3/32 x 9/16 I.D.	1
47	Spring follower, pressure	1
48	O-ring, 3/32 x 7/8 I.D.	1
49	Adjustment cap, pressure	1
50	Spool, flow compensator	1
51	Spring pivot	1
52	Spring, flow compensator	1
53	O-ring, 1/16 x 7/32 I.D.	1
54	Spring follower, flow	1
55	O-ring, 5/64 x 15/32 I.D.	1
56	Adjustment cap, flow	1
57	Compensator housing, pressure	1

Tools Required For Disassembly And Reassembly

- 3/16 Allen wrench
- 9/16 Socket
- 1-1/8 Open end wrench
- 11/16 Open end wrench
- O-ring pick
- Plastic or wooden mallet
- Internal and External Retaining Pliers (Straight, .070" tip)
- 3/8 I.D. x 1-1/8 O.D. Flat washer (2 ea.)
- 3/8 x 3-1/4 N.C. Cap screw (1 ea.)
- 3/8 N.C. Nut
- Screw driver (1/4 in. blade)
- Torque wrench (40 lb-ft [54 N-m] capacity)

REPAIR INFORMATION - Model 70422 and 70423

Cleanliness is extremely important when repairing these pumps. Work in a clean area. Before disconnecting the lines clean port area of pump. Disconnect hydraulic lines and remove pump assembly from vehicle and plug ports. Thoroughly clean the outside of pump. After cleaning, remove port plugs and drain oil.

DISASSEMBLY

ATTENTION: Removal of the adjusting screw covers from cap may void the warranty on this assembly.

1 Clamp the end of the drive shaft in a protected jaw vise with the body of the pump up and remove the four allen head screws (38) holding compensator (37).

2 Remove the compensator assembly (37 or 39), o-ring (36), and gasket (35).

3 Remove the four cap screws (34) from the backplate of the pump.

4 Place a screw driver in slots provided between housing and loosen backplate. Remove backplate (33) and gasket (31) from housing.

5 Remove the control piston (30) remaining on the backplate or in housing. Also remove plug (40) from backplate (33).

6 To remove rotating assembly (29) from housing, remove pump from vise and slide rotating assembly off shaft. Caution: pistons may not come out with piston block.

7 Remove pistons (20), spider (21), and spider pivot (22) from piston block (23).

8 The piston block assembly (23) need not be disassembled unless the internal pins (25) or spring (27) are damaged.

CAUTION: Use the following procedure if the spring is to be removed from the piston block. The spring (27) is highly compressed and the snap ring (28) should not be removed without compressing the spring (27).

The following parts will be needed to disassemble the piston block:
2 ea. 3/8 I.D. x 1-1/8 O.D. flat washer.
1 ea. 3/8 x 3-1/4 N.C. cap screw, and
1 ea. 3/8 N.C. nut.

Place one of the flat washers over the 3/8 x 3-1/4 cap screw and place this through the center of the piston block (23). Place the other washer over the cap screw and let it rest on the three pins. Screw the nut on and compress the spring inside the piston block. Use a pair of snap ring pliers and remove the internal snap ring (28). Remove the bolt and the two washers (26), three pins (25), and the internal pin keeper (24).

9 To free shaft seal and shaft, remove retaining ring (1).

10 Remove shaft (8) from housing (9) by tapping backplate end of shaft with a wooden or plastic mallet.

11 Remove shaft seal (2), washer (3), the two retaining rings (4), the two thrust washers (5), and bearing (6) from shaft.

12 To remove the camplate (19) from the housing, remove the two internal retaining rings (14) from the sides of the housing. Remove the two covers (13), the two o-rings (12), the two inner races (11), and the bearings (10). The camplate can now be moved over to one side and removed. The two camplate pivot bearings are a loose slip fit into the housing. Do not be concerned if they are not tight.

13 Remove the spring collar (16) and spring (15). Do not remove the button (17) and roll pin (18) unless they are worn or loose.

14 The pressure-flow compensator assembly (37) may be disassembled for cleaning and inspection.

ATTENTION: Removal of the adjusting screw covers from cap may void the warranty on this assembly.

15 Remove pressure adjustment cap (49) from compensator housing (37). Pressure spring follower (47) will remain in cap (49), pull follower from cap.

16 Remove flow adjustment cap (56) from compensator housing (37). Flow spring follower (54) will remain in cap (56). Pull follower from cap.

17 Remove springs (45 and 52) and spring pivots (44 and 51) from compensator housing.

18 Remove plugs (40), pressure compensator spool (43), and flow compensator spool (50) from compensator housing (37).

19 The shaft seal, all o-rings, and all gaskets should be removed and replaced with new items upon reassembly.

INSPECT PARTS FOR WEAR

1 Inspect the flat surface of the backplate (33), the finish on the piston block side should be smooth and free of grooves. The piston guide should be tight in the backplate. The needle bearing in the backplate should be free of excessive play and remain in the bearing cage. If the backplate has any of the wear characteristics outlined above, replace complete backplate assembly.

2 Inspect the piston block (23). The surface that contacts the backplate should be smooth and free of grooves.

3 The pistons (20) should move freely in the piston block bore. If they stick in the bore, examine the bore for scoring or contamination.

4 Examine the O.D. of the piston (20) for finish condition. They should not show wear or deep scratches. The shoes should be a snug fit on the ball end of the piston. The flat surface of the shoes should be flat, and smooth. Do not lap piston shoes.

5 Examine the spider (21). It should be flat, no cracks, and no signs of wear in the pivot area.

6 Examine the pivot (22). It should be smooth and show no signs of wear.

7 Inspect the camplate (19) for the condition of finish of the polished shoe surface. It should show no signs of scoring.

8 Inspect shaft (8) for wear in bearing and spline areas.

9 Inspect thrust bearing (6) and thrust washers (5) for wear.

10 Inspect the needle bearing in the housing assembly (9). If the needles are free of excessive play and remain in the bearing cage, there is no need to replace the housing.

11 Inspect the compensator springs (45 and 52) for breakage or weakness.

12 Inspect the spools (43 and 50) for scoring.

13 It is not necessary to inspect the o-rings, retaining rings, gaskets, or shaft seal as they should be replaced as new items and are included in the seal repair kit available for this assembly.

REASSEMBLY

1 Clean all parts in suitable solvent; lubricate all critical moving parts before reassembly.

2 Install camplate control spring (15) and spring collar (16) in housing (9).

3 Insert camplate (19) into housing (9). Insert needle bearings (10) and bearing inner race (11) over the camplate arms and slide into housing (9). The numbered end of the bearing should face outward and the chamfered I.D. of the race should face inward.

4 Install new o-ring (12) around O.D. of camplate pivot bearing (10). Install trunnion covers (13) and secure with retaining rings (14).

5 Install retaining ring (4) on shaft (8). Install thrust washer (5), thrust bearing (6), and second thrust washer (5). Secure with second retaining ring (4).

6 Install shaft (8) in housing (9) and install washer (3), shaft seal (2), and retain with retaining ring (1). Make sure retaining ring is seated in the groove.

7 If piston block assembly was disassembled, compress the pin keeper (24), and install in the spline area of piston block. Install the three pins (25) with the head end to the inside of the block and install in the special grooves of the piston block spline.

8 Install the washer (26), spring (27), and second washer (26) in the piston block. Use the two 3/8 I.D. washers and the 3/8 x 3-1/4 cap screw to compress the spring and retain with retaining ring (28). Remove the 3/8 x 3-1/4 cap screw and the two washer.

9 Install the pivot (22), spider (21), and piston assemblies (20) in the piston block. Install this assembly in the housing assembly, the piston shoes must be in contact with the camplate. Be sure all the parts are in their proper position.

10 Clamp this assembly in a protected jaw vise with the open end of the housing (9) up.

11 Install new gasket (31).

12 Install control piston (30), and plug (40) with new o-ring onto backplate. Note roll pin (32) locations.

13 Install backplate (33) and retain with cap screws (34). Torque to 27 to 31 lb-ft [37 to 42 N-m].

14 Place new o-ring (41) on plug (40). Install plug assembly (40),flow compensator spool (50), spring pivot (51), spring (52), flow spring follower (54) with new o-ring (53), and flow adjustment cap (56) with new o-ring (55) into compensator housing (42). Torque plug (40) 6 to 8 lb-ft [8 to 11 N-m] and torque flow adjustment cap (56) 10 to 12 lb-ft [14 to 16 N-m].

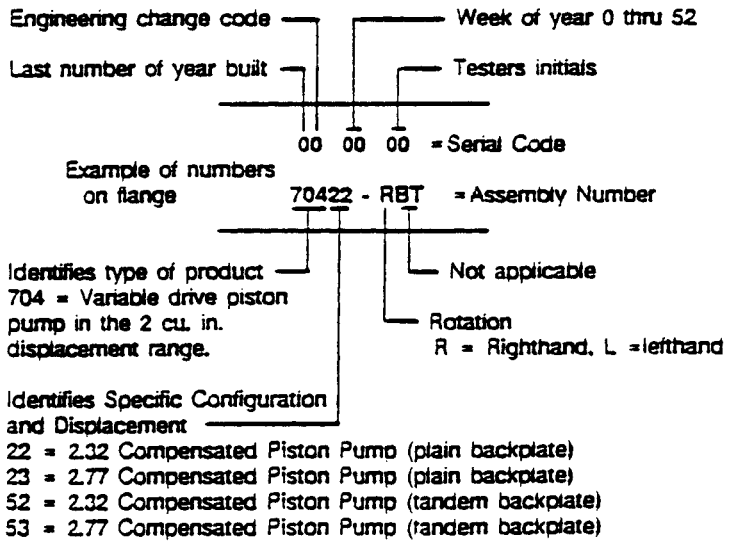
15 Place new o-ring (41) on plug (40). Install plug assembly (40), pressure compensator spool (43), spring pivot (44), spring (45), pressure spring follower (47) with new o-ring (46), and pressure adjustment cap (49) with new o-ring (48) into compensator housing (42). Torque plug (40) 6 to 8 lb-ft [8 to 10 N-m] and torque pressure adjustment cap (49) 35 to 40 lb-ft [47 to 54 N-m].

16 Install new gasket (35) and new o-ring (36), then install compensator assembly (37 or 39),and retain with four allen head cap screws (38) and torque to 10 to 12 lb-ft [14 to 16 N-m].

17 Plug ports to preserve cleanliness until installation on vehicle. (Refer to start up procedures.)

EACH ORDER MUST INCLUDE
THE FOLLOWING INFORMATION
1. Product Number
2. Date Code
3. Part Name
4. Part Number
5. Quantity of Parts

Identification Numbers



Start-Up Procedure

When initially starting a rebuilt load sensing system, it is extremely important that the start-up procedure be followed. It prevents the chance of damaging the pump which might occur if the system was not properly purged with oil before start-up.

1 After the pump has been properly installed onto the machine and all hydraulic connections have been made, check all fittings to make sure that they are tight.

2 Fill the pump housing at least 1/2 full with system oil that has been filtered through a 10 micron filter.

3 Fill the reservoir with an approved oil that has been filtered through a 10 micron filter. Leave the filler cap loose as a means of air that is trapped in the system.

4 Note on gasoline or L.P. engines: remove the coil wire and turn the engine over for 15 seconds. Diesel engines: shut off the fuel flow to the injectors and turn the engine over for 15 seconds. This procedure enables the pump to pick-up the oil before start-up. At this time disconnect the sensor line from the pump compensator and pull one of the valve spools while the engine is being turned over. This allows oil to flow through the sensor line, thus, removing any air in the sensor line. Reconnect the sensor line after a steady flow of oil is coming from the line.

5 Replace the coil wire or return the fuel flow to the injectors and start the engine. Run at low idle speed for one minute. The pump should immediately pick up oil and go into low pressure standby. If there is no indication of fill in 30 seconds, stop engine and determine the cause.

6 After the pump has stabilized in low pressure standby, operate the control valve and steering, if the system is equipped with one, to purge the system of air and to fill the cylinders with oil. Continue operating the system slowly with no load until it responds fully.

7 Check fluid level at the reservoir and refill if necessary to the proper level at the reservoir and refill if necessary to the proper level with an approved filtered oil.

8 Check all line connections for leaks tighten if necessary.

9 The machine is now ready to be put into operation.

10 Short hour filter changes are recommended for the first two changes after placing the machine back into operation. The first filter would be changed in 3-5 hours and the second at approximately 50 hours. Routine scheduled filter changes are recommended for maximum life of hydraulic system.

EATON
REPAIR INFORMATION
PRESSURE OR PRESSURE-FLOW
COMPENSATED PISTON PUMP
MODEL 70422 AND 70423
NO. 7-602

Trouble Shooting

Problem	Possible Cause	Correction
1 Noisy pump caused by cavitation.	A Oil too heavy. B Suction strainer or filter plugged. C Suction line plugged, too small, or too long.	A Change to proper viscosity. B Clean or replace. C Clean line and check for proper size and length.
2 Noisy pump caused by aeration.	A Oil supply low. B Air leaking into suction line. C Foaming oil.	A Fill reservoir. B Tighten fittings. C Drain reservoir and fill with non-foaming type oil.
3 Hydraulic system overheating.	A Oil supply low. B Oil in system too light. C Excessive internal leakage. D Aeration of oil.	A Fill reservoir. B Drain reservoir and refill with proper viscosity oil. C Disconnect case, drain line, measure leakage volume while pressurizing hydraulic system. Case drain flow should not exceed 3 G.P.M. If excessive, remove pump, disassemble and repair. D Tighten fittings.
4 System not developing adequate pressure.	A Excessive internal leakage. B Either compensator spool stuck open. C Either compensator spring weak or broken. D Loss of flow compensator signal.	A Refer to 3-c. B Disassemble compensator, inspect for stuck spool, clean or replace compensator assembly. C Disassemble compensator, inspect for weak or broken spring. Replace spring if necessary. D Check signal line connections, check for line obstruction, line damage and line size and length.
5 System not developing adequate flow.	A Excessive internal leakage. B Either compensator spool stuck open. C Either compensator spring weak or broken. D Pump cavitation. E Loss of flow compensation signal.	A Refer to 3-c. B Refer to 4-b. C Refer to 4-c. D Refer to 1-a,1-b,1-c. C Refer to 4-d.

MINIPAK DISASSEMBLY/ASSEMBLY INSTRUCTIONS

DISASSEMBLY: (See Figure)

NOTE: Before attempting to disassemble this or any other hydraulic component, prepare a **CLEAN** work area.

1. Remove coil nut (1) and slide coil (3) off tube (4).
2. Remove nuts (18), mounting bracket (17) and washer (16) from the inlet end of the valve bank.
3. Remove inlet (15), attachments (20) as necessary, and O-Rings.
4. Remove valve sections (14), one at a time, removing O-Rings (12) or (13) between each section. Remove only those sections to be repaired or replaced.
5. Use a 1 1/4" wrench to loosen tubes (4) from body.

CAUTION: Use proper tools to avoid damaging tube sub-assembly.

6. Remove tube sub-assembly by hand. Spring (8) and spring retainer (9) may fall from valve body.
7. Slide pin, plug, and plunger out of tube.

NOTE: Pin, plug, and plunger are a matched set. Do **NOT** mix parts.

8. Use a small punch to gently push manual override pin into tube until it is free and falls out.
9. If valve has manual override option "JJ", use a screwdriver inside the tube to hold pin (5) from turning while removing the palm button.
10. Repeat steps 5 through 8 to remove tubes on the opposite side of the valve.
11. Gently slide spool (14) from valve body. Make a note of its position in the valve body. Spool cannot be turned around. It must slide into the body in the same position it came out.

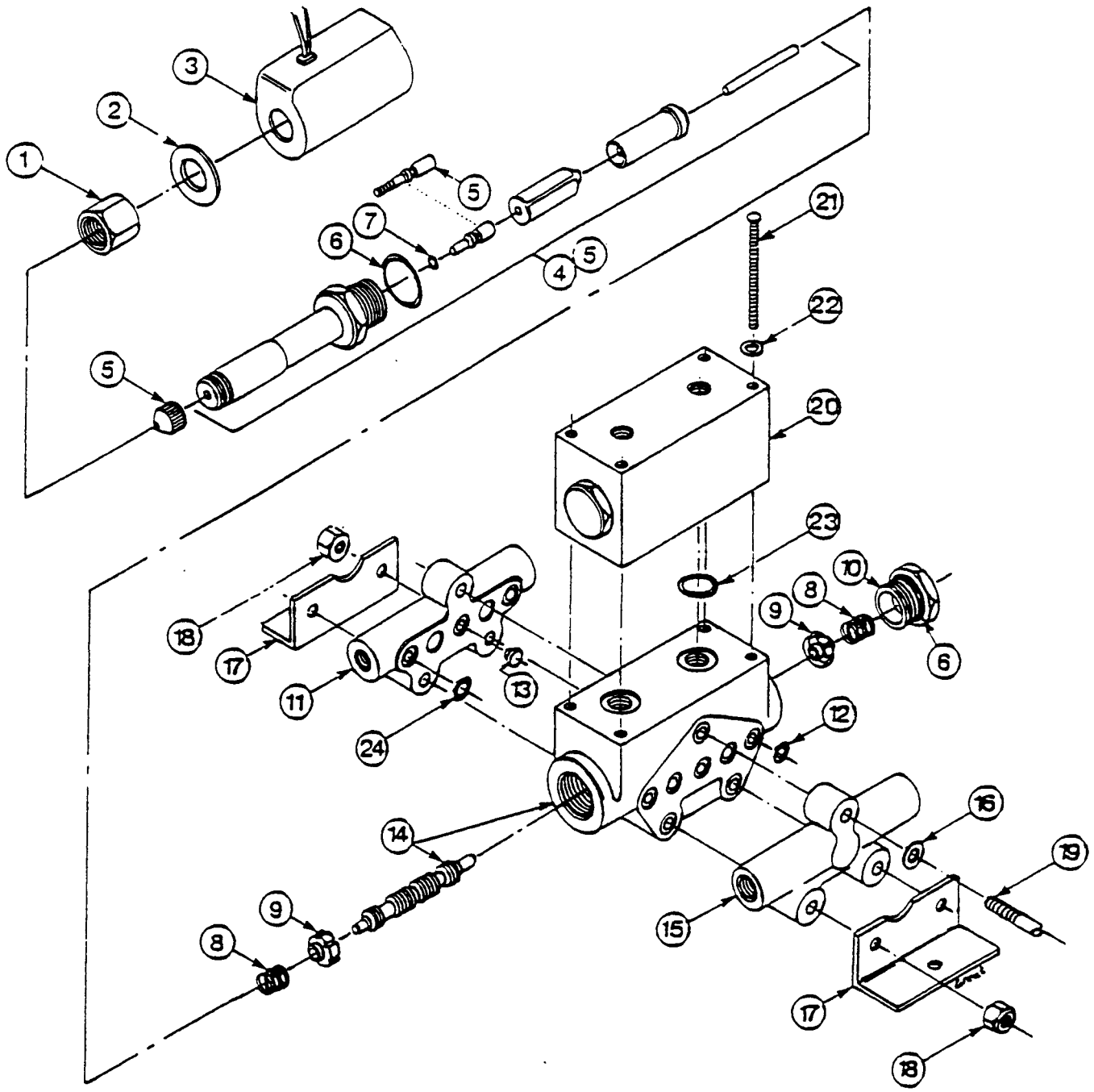
CAUTION: **BODY AND SPOOL ARE A MATCHED SET.** If either one is damaged, **BOTH** must be replaced.

12. Wash all parts in cleaning solvent and dry with air gun. Be sure to remove all traces of solvent.

ASSEMBLY:

NOTE: Before re-assembly, discard all used O-Rings.

1. All parts should be individually inspected to verify they are free from wear, burrs, nicks, scratches or any other defect that could cause poor performance.
2. Lubricate all system parts and O-Rings with clean system oil before assembly.
3. Lubricate spool (14) and valve body and carefully slide spool into body, making sure it is in the same position as when it was removed. Spool should slide freely in plug.
4. Install O-Ring (7) on manual override pin. Lubricate inside of tube where pin is installed. Carefully push pin into place. Install O-ring (6) on tube. Install plunger, plug and pin. Make sure that these parts are lubricated with oil. Pin should slide freely in plug.
5. Place spring retainer (9) onto spool with prongs towards spool. Place spring (8) over retainer and install tube subassembly into valve body by hand.
6. Repeat steps 4 and 5 for the opposite side of the valve.
7. For single solenoid sections, place O-ring (6) on plug (10), retainer (9) on spool with prongs towards spool and spring (8) over retainer. Tighten plug and/or tube subassembly to 100 in./lbs.
8. Install one nut (18) on each tie rod (19). Place two tie rods through the mounting bracket (17). Place one flat washer (16) on the third tie rod. Place outlet section (11) over the tie rods. An aid in banking sections is to place the mounting bracket in a vice or on the edge of a flat surface with the tie rods in a vertical positions. Place five O-rings (24). Install a valve section over the tie rods. Place the O-rings (12) on this section. Replace remaining sections as above.
9. Install inlet section (15). Place mounting bracket (17) over lower tie rods and install two nuts (18). Place a flat washer (16) over top tie rod only.
10. Torque tie rods in three steps of 50 in./lbs., 90 in/lbs. and finally 115 in./lbs.
    THIS IS VERY IMPORTANT! OVERTORQUEING WILL CAUSE BORE DISTORTION & MAY CAUSE SPOOL BINDING OR INCREASED LEAKAGE.
11. In order to set the relief, if installed, the complete valve must be placed on a test stand capable of flow from 1 to 5 GPM. Remove the cap over the adjustment screw and loosen the lock nut (see below). Set incoming pressure on test stand to desired valve setting and adjust screw in to increase relief setting or out to decrease relief setting. Setting is correct when .25 GPM flows out of valve at desired pressure.
12. If painting is required make sure all ports are plugged and electrical connections are masked.



Parts List

Item	Description
1.	Nut
2.	Nameplate
3.	Solenoid coil
4.	Tube S/A (standard)
5.	Tube S/A (palm button)
6.	O-ring
7.	O-ring
9.	Spring retainer
10.	Plug
11.	Outlet section
12.	O-ring (5)
13.	Closed center plug
14.	Body & spool
15.	Inlet section
16.	Washer
18.	Nut
19.	Tie rod
20.	Attachment (optional)
21.	Bolt
22.	Washer
23.	O-ring
24.	O-ring (5)

HELAC

MAINTENANCE MANUAL

FOR

"HELAC" PIVOT

ROTARY ACTUATORS

HP-SERIES

TABLE OF CONTENTS

I. THEORY OF OPERATION
II. HYDRAULIC LINE ATTACHMENT
III. DISASSEMBLY AND INSPECTION
IV. ASSEMBLY AND TESTING

HP-286

I. THEORY OF OPERATION

In reference to Fig. I, fluid entering Port E2 under pressure will bear on piston (4) and force piston sleeve (3) upwards. The left-handed spline of piston sleeve (3) will combine with the right-handed spline of shaft (2) and cause rapid CW rotation of shaft and flange (2) (looking down). Fluid entering Port E1 will reverse this rotation.

Displacement and torque are identical for CW and CCW rotation.

Shaft (2A) is integral with shaft flange (2B) and bearing tube (2C). The shaft is supported radially by the large upper radial bearing (19) and the lower radial bearing (18). Axially, the shaft is separated from the housing by upper and lower thrust rings (20). End cap (5) is adjusted for axial clearance and locked in position by cap screw (7).

II. HYDRAULIC LINE ATTACHMENT

Ports E1 and E2 are provided with either NPT or SAE threads. The hydraulic lines from the control valve to the actuator should be as short as possible. If the lines are too long, the actuator cycles the fluid back and forth, not allowing sufficient fluid to reach the continuous flow circuit for filtering.

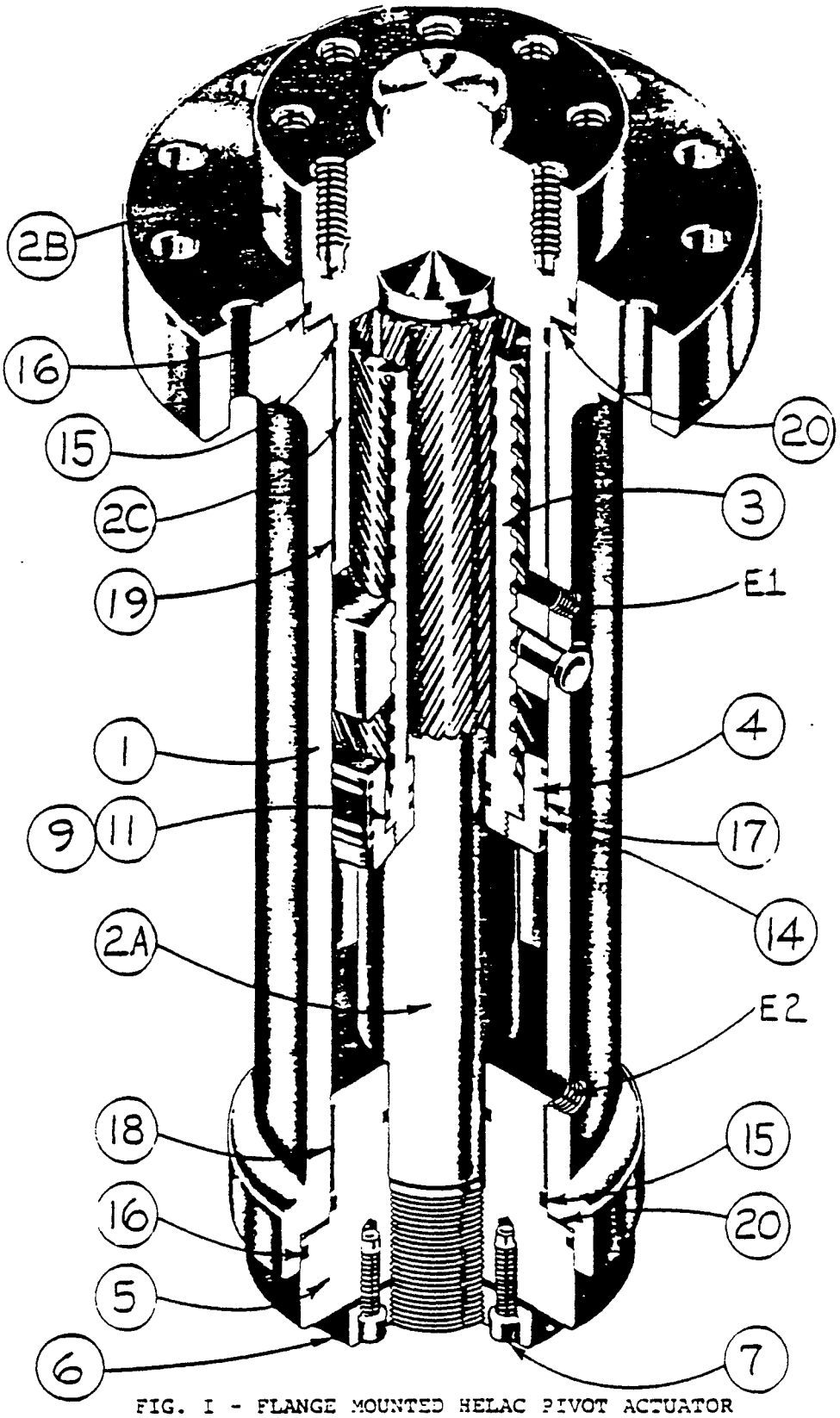


FIG. I - FLANGE MOUNTED HELAC PIVOT ACTUATOR

III. DISASSEMBLY AND INSPECTION

Place on clean work bench with room to place the internal parts as they are removed. Remove all hydraulic fittings. Loosen cap screws (7) and unscrew locknut (6) and end cap (5). The shaft is now free to slide up and out of engagement with the piston sleeve (3). Note the orientation (see Fig. II) between the spline teeth, as this will greatly simplify actuator timing upon reassembly.

After removing the shaft, the piston sleeve and the piston assembly can now be moved down and out of the housing. Remove all seals and wear strips from their grooves, except static piston seals (9) and (11). These seals generally do not require replacement. Clean all parts thoroughly and inspect for wear. A small amount of wear in the spline teeth will have little effect on the actuator strength. New spline sets are manufactured with a backlash of about .005 per mating set. After long service, a backlash of about .015 per set may still be acceptable in most cases, depending on the required accuracy of the application.

Item (1) is the integral housing and ring. Check the ring gear for wear and weld damage to the pins. Inspect the cylinder bore for wear and scratches. The surface finish should be 32 RMS or better, rehone if necessary. The radial bearing (18) and (19) and the piston wear strip (17) should have maximum radial clearance of

III. DISASSEMBLY AND INSPECTION (CONT'D)

.006. A clearance in excess of .008 calls for replacement of the bearings. Rough and grooved shaft journals require shaft replacement.

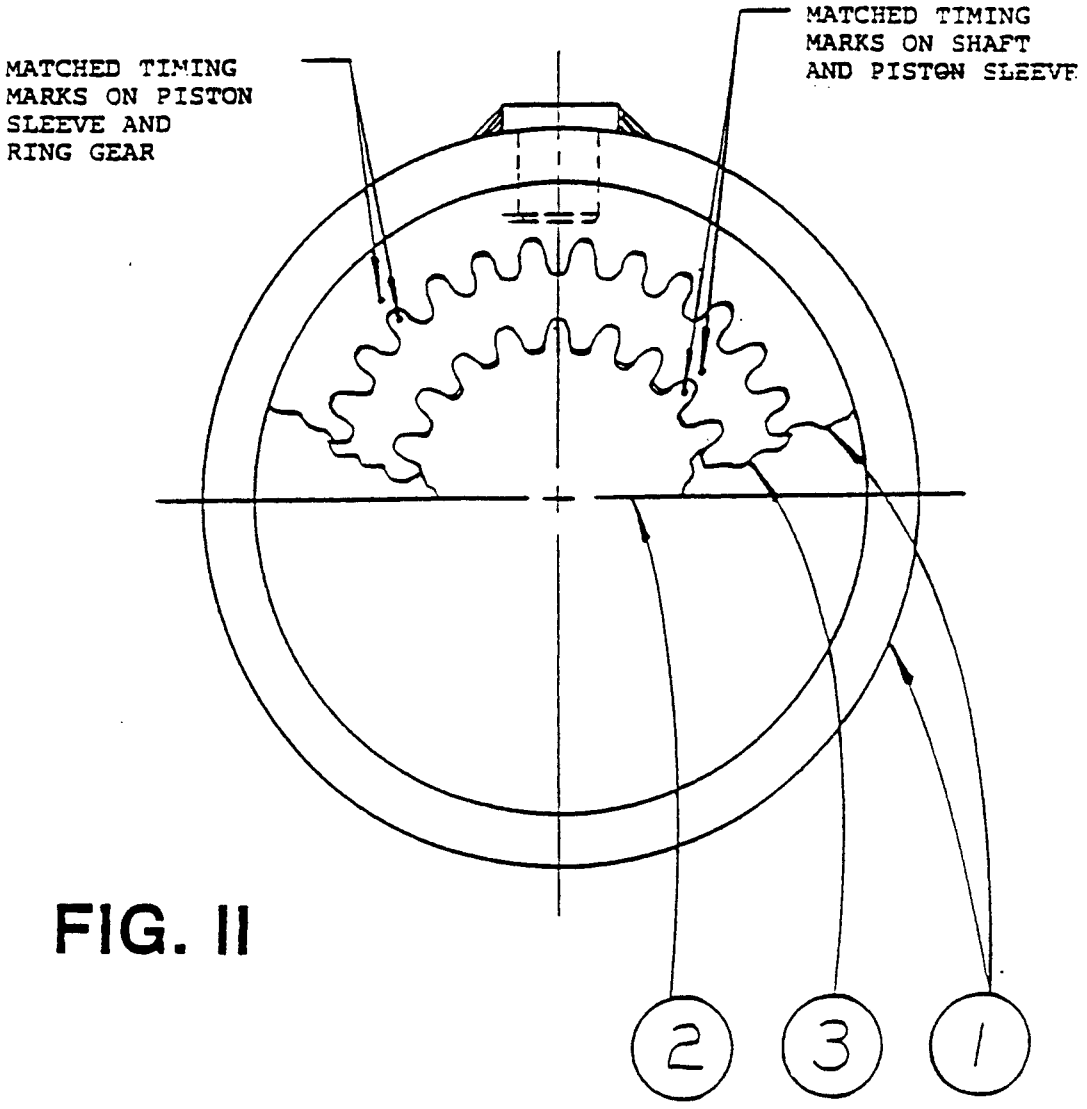


FIG. II

IV. ASSEMBLY AND TESTING

Wash all parts thoroughly in cleaning solvent and blow dry. Coat all sealing and working surfaces with a good grade hydraulic oil. Install seals in piston sleeve, piston and end caps. The lips of exclusion seals (16) face outward, and the lips of high pressure seals (15) face inwards.

Place the actuator in a vertical position, install the piston sleeve (3) in timed relation to the housing, applying firm pressure as the new seals and wear strip enter the housing and become compressed by the housing chamber. (CAUTION: Do not cock the sleeve too much any one way, for it will mar the cylinder bore). The timing marks (small punch marks on the face of each gear), must be lined up for proper shaft orientation. (Fig. II).

Thrust rings (20) are coated with good grease before sliding on the shaft and end cap. The shaft is installed by again aligning the proper punched timing marks (Fig. II). Temporary taping (masking tape works well) of threaded portion of shaft will help installation past the shaft seals. Apply antiseize to threaded and surrounding areas of end caps. Also depending on the size of the actuator (some 60K's& up), the end cap may need to be installed with the actuator in a vertical position.

IV. ASSEMBLY AND TESTING (CONT'D)

End cap (5) is torque to 40-80 ft-lb depending on the actuator size, such that the actuator begins rotation at approximately 100 PSI pressure. The torque flange cannot be rotated by hand. The combined back-drive efficiency and friction prevent manual rotation. If the end cap is torqued too high, the actuator may take as much as 300 PSI to rotate. If end cap is not torqued high enough, shaft axial motion in excess of .015 will occur and damage the ring gear, piston, sleeve and/or shaft can result. The end cap must be secured against the shaft by tightening cap screws (7). Apply hydraulic pressure and check for shaft axial motion.

To test for leakage, pressurize port E2 to 3000 PSI. No oil should seep from port E1 or from around end cap (5). Repeat test for pressurizing port E1 and check for leakage out of port E2 and around shaft flange (2B).

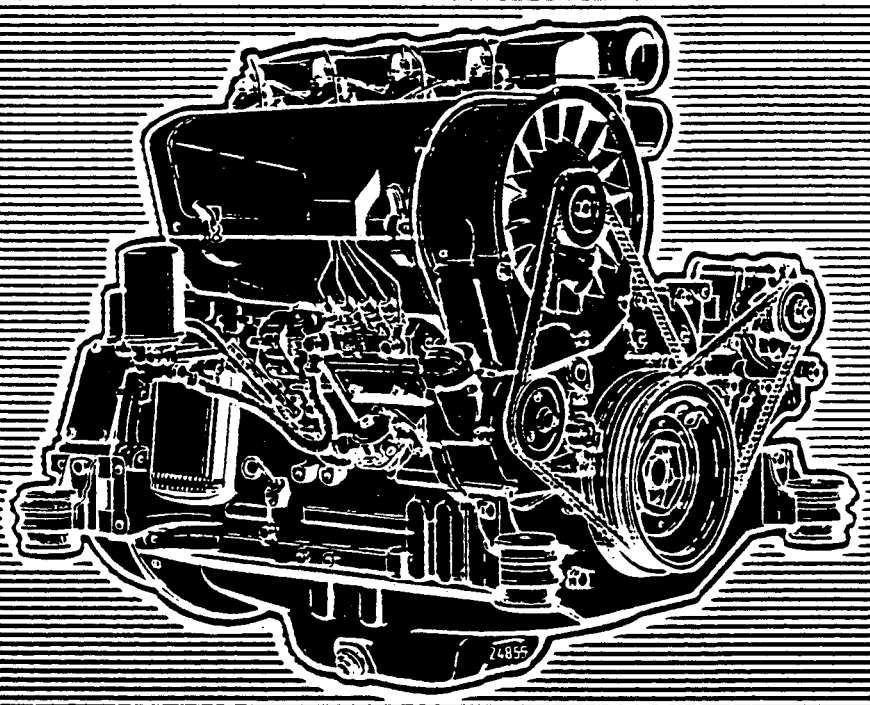
Note: End cap torque should be checked at least every 800 hours or once a year. If end play is observed, (the torque flange moving out of the housing), tighten end cap.

Betriebsanleitung
Operation Manual

KHD DEUTZ

297 4078 D/E

F 3-6 L 912/W



REV.

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Foreword

Before Commissioning Your New Engine:
Surely you expect top service from your DEUTZ engine ... So please give this manual your top attention!

All necessary safety precautions and regulations have been observed in the design, choice of material and manufacture of your engine, and before the engine left our factory, it stood up satisfactorily to the severest tests and trials.

Maximum engine performance is however not possible without a minimum of upkeep. Remember that even simple household appliances need some care and attention once in a while. So be sure to maintain your engine as scheduled herein and to use the fuels and lube oils recommended. **You will get a lot in return: a long lifespan of your DEUTZ engine, high power output and reliability, plus low consumption rates and exhaust emissions.**

Should, on the other hand, any trouble arise on engine calling for overhaul or repair, **do not tamper with it but entrust the job to a workshop of the worldwide DEUTZ organization,** where you will find a staff of DEUTZ-trained mechanics, the latest special tools and facilities, and a full stock of

KHD DEUTZ

Genuine Spare Parts

For ordering such spares, please always refer to the relevant Parts Catalogue. Otherwise ask your local DEUTZ distributor.

By the way, you will agree with us that "Safety first" is a good slogan. **So please be sure to refit any guards and protective devices that should have been removed for carrying out work on the engine.**

To prevent pollution of the environment, please let old fuel and oil run into a special receptacle.

Note: In view of the constant improvements to our engines, the specification data as well as other information included in this manual are subject to change without notice.

Safety and dependability result from superior technology, correct operation, plus proper care and maintenance



When reading through this manual, you will find the above symbol marking all important safety instructions. Give particular heed to these instructions and proceed with special care. Pass on these safety instructions to your operating personnel.

General Safety Rules

Apart from the safety instructions given in this manual, it is also necessary to observe the official safety rules, which may vary from country to country.

The Right Work Clothing

Work clothing should be closely fitting, so that it cannot be caught by rotating or projecting parts.

Beware of Running Engine

Always stop the engine before refuelling.

Always stop the engine before carrying out maintenance or repair work.

Care and Maintenance

Reliability of the engine largely depends on close observance of the Maintenance Schedule (page 95).

Never attempt to rectify faults or carry out repairs for which you do not have the necessary experience and special tools. Entrust the job to your DEUTZ Service Station, where DEUTZ-trained personnel will give your engine expert attention.

Foreword

Important for your Engine's Power Output

Power output, temperature level and exhaust gas quality of any diesel engine are governed by careful matching of combustion air and fuel injection volumes, and since the density of the combustion air taken in varies with the atmospheric pressure and the ambient temperature, full rated power is obtained only at standard reference conditions in respect of atmospheric pressure (altitude of engine site) and ambient temperature.

Standard reference conditions are as follows:

(a) 101.3 kPa = 1013 mbar (sea level) and 20° C.
for automotive engines to DIN 70020

(b) 100 kPa = 1000 mbar (100 m above sea level) and 27° C
for industrial and marine engines to DIN 6271.

Where engines are operated at greater altitudes and/or higher ambient temperatures, they must be de-rated (reduced fuel injection and hence engine loading) in accordance with special Tables available.

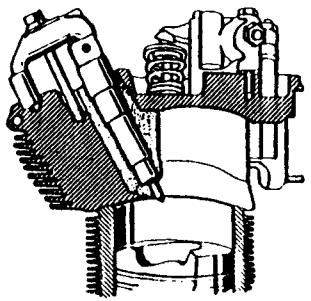
Note:

Therefore, never run your DEUTZ diesel in "thin air" under heavy-duty conditions unless your engine has been de-rated accordingly, otherwise the engine's lifespan, reliability and exhaust emissions may be affected, especially at altitudes above 1000 m and/or temperatures above 30 °C. Be sure to contact us or your equipment supplier in good time!

Description of Engine

Combustion Method

FL 912
Direct Injection



FL 912 W
Two-stage Combustion

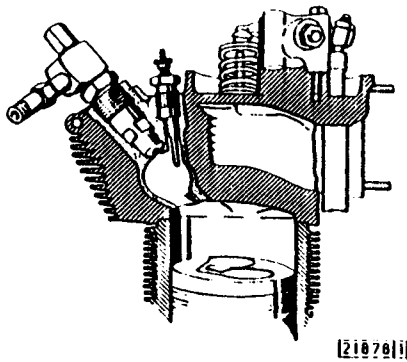


Fig. 1

[21070|1]

Note:

This Instruction Manual applies both to FL 912 engines using direct injection and to FL 912 W engines using two-stage combustion.

The difference in the two systems is dealt with in the sections «Specification Data», «Starting» and «Operation in Winter».

Direct-injection engines are used where high power output and compact construction are more important than high exhaust-gas quality, while two-stage combustion engines are designed for applications where low exhaust emissions are of prime importance.

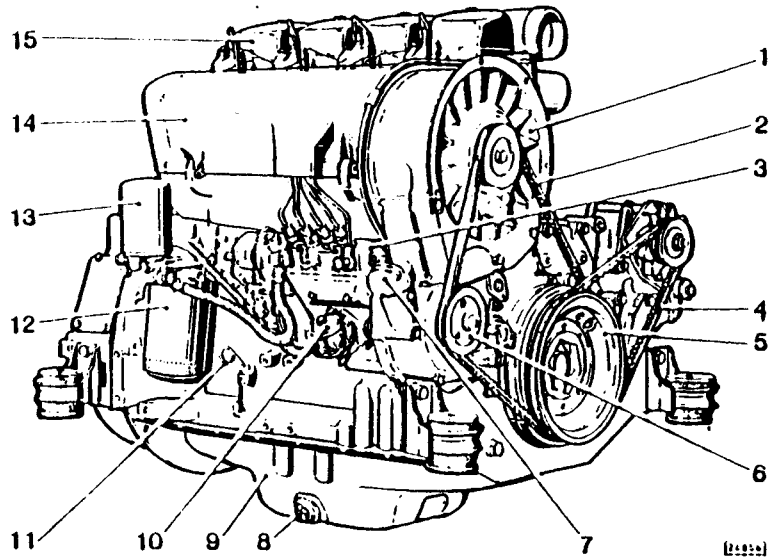


Fig. 2

Description of Engine (service side) F4L 912

1 Cooling air blower
2 V-belt (blower)
3 Injection pump
4 V-belt (alternator)
5 V-belt pulley
6 Idler pulley
7 Oil filler neck
8 Oil drain plug
9 Oil sump
10 Fuel feed pump
11 Oil dipstick
12 Oil filter
13 Fuel filter
14 Air cowling
15 Rocker chamber cover

Description of Engine

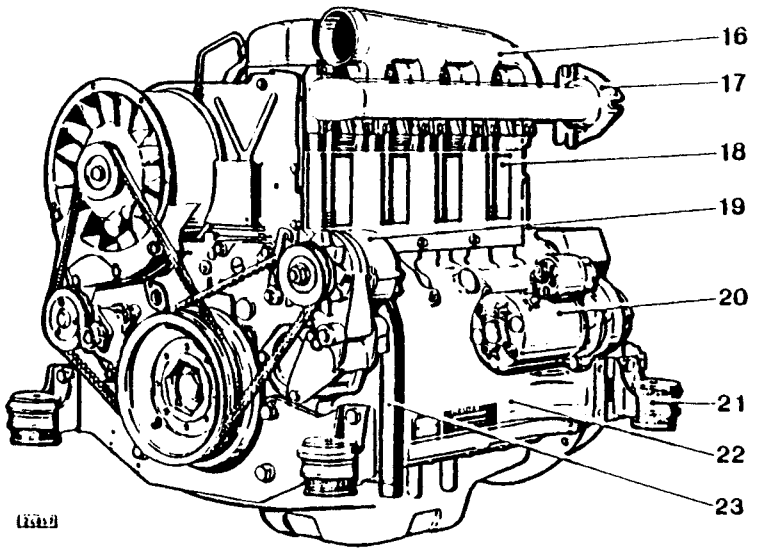


Fig. 3

Description of Engine (exhaust-air side) F4L 912

16 Air intake manifold
17 Exhaust manifold
18 Air outlet frame
19 Alternator
20 Starter motor
21 Engine mounting
22 Crankcase
23 Crankcase breather

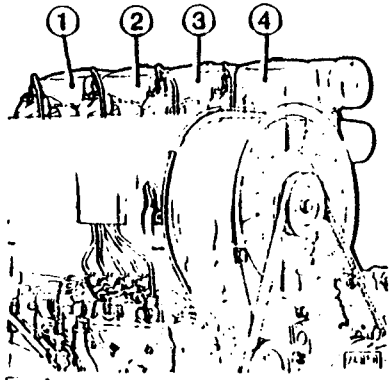


Fig. 4

Cylinder Numbers (Fig. 4)

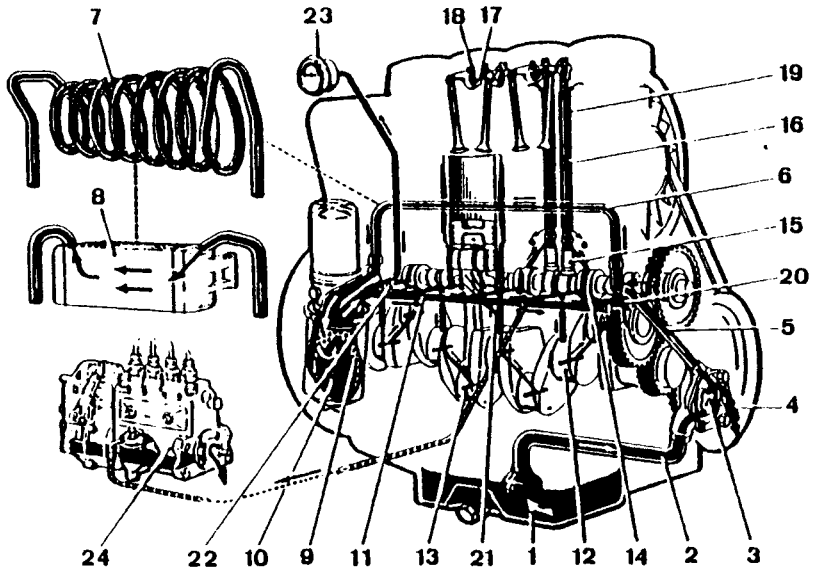


Fig 5

Lube Oil Circuit (not for space heating)

1 Oil sump
2 Suction pipe
3 Oil pump
4 Pressurestat
5 Delivery pipe
6 Bypass pipe or, at option ...
7 Cooling coil or, at option ...
8 Integral oil cooler
9 Oil filter
10 Safety valve
11 Oil gallery
12 Main bearing
13 Big-end bearing
14 Camshaft bearing
15 Tappet (with groove for pulse-fed rocker arm lubrication)
16 Pushrod (hollow, supplying oil to rocker arms)
17 Rocker arm bearing
18 Metering plug (for valve lubrication)
19 Pushrod cover tube (surplus oil returning from rocker arm chamber to sump)
20 Restrictor (for lubrication of gears)
21 Spray nozzle for piston cooling
22 Connection for oil pressure gauge
23 Oil pressure gauge
24 Injection pump (connected to engine lubrication oil circuit)

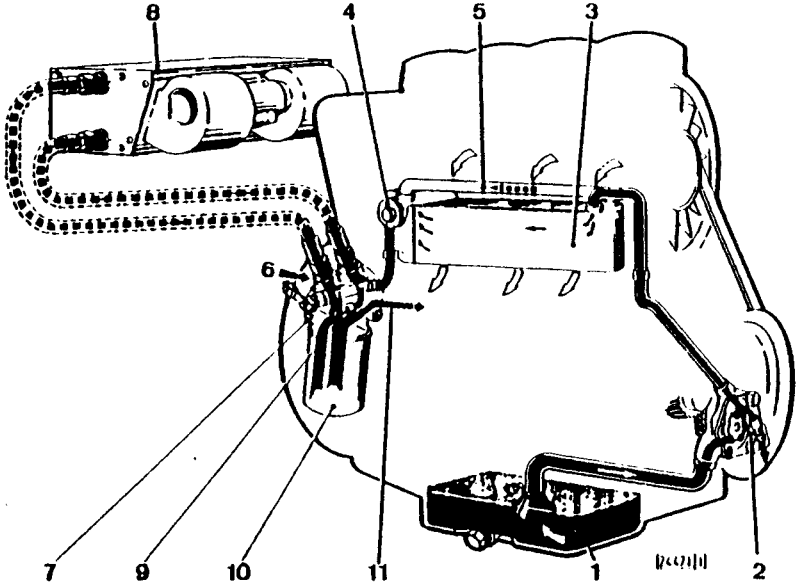


Fig. 6

Lube Oil Circuit (incorporating space heating)

1 Oil sump
2 Oil pump
3 Oil cooler
4 Thermostatic valve
5 Bypass pipe
6 Connection for oil temperature indicator
7 Heating control valve
8 Heat exchanger with fan
9 Bypass valve
10 Oil filter
11 Connection to oil circuit

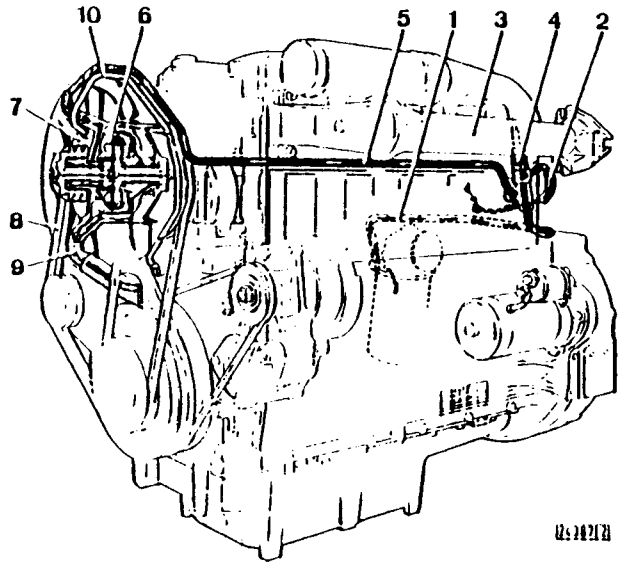


Fig 7

Control of Cooling Air Flow by Exhaust Gas Thermostat
(with Oil-Controlled Blower)

1 Pressure oil line from engine to thermostat
2 Air line to exhaust gas thermostat
3 Exhaust manifold
4 Exhaust thermostat
5 Control oil blower coupling
6 Blower coupling
7 Cooling blower
8 Blower drive
9 Oil return line to sump
10 Breather line

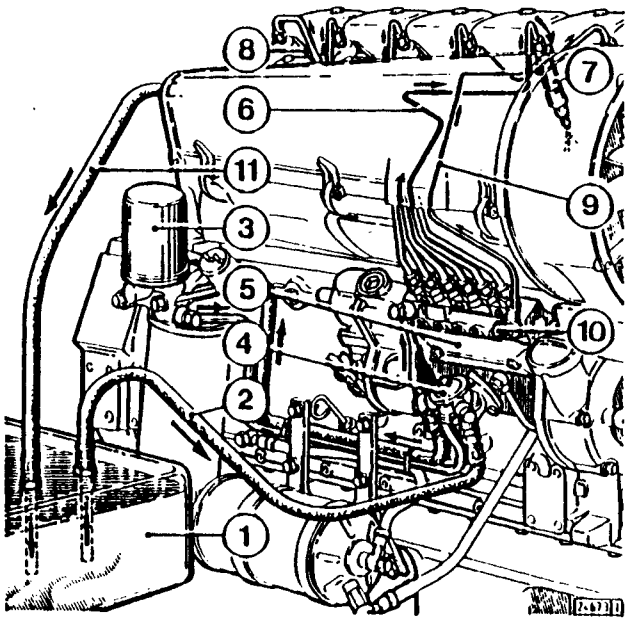


Fig. 8

Layout of Fuel Sytem (Direct Injection) F6L 912

1 Fuel tank
2 Fuel supply line
3 Fuel filter
4 Fuel feed pump
5 Injection pump
6 Injection lines
7 Injector
8 Backleakage line
9 Overflow line
10 Overflow valve
11 Fuel return line

Description of Engine

Engine Model and Engine Serial No.

The model designation A and the engine serial No. B are given on the rating plate (Fig. 9).

The rating plate is attached to the crankcase below the starter motor (Fig. 10).

The serial No. is also stamped into the crankcase near the oil filler neck (Fig. 11).

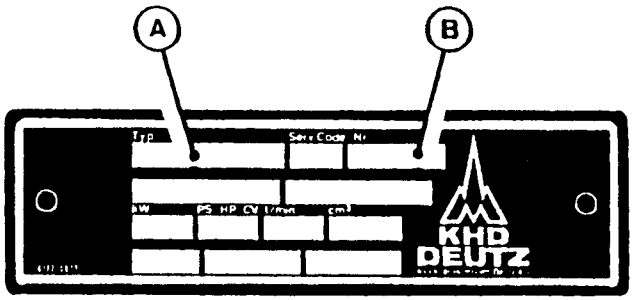


Fig 9

25611

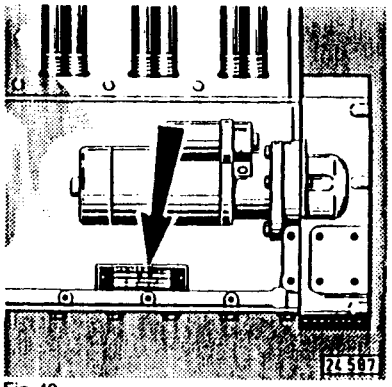


Fig 10

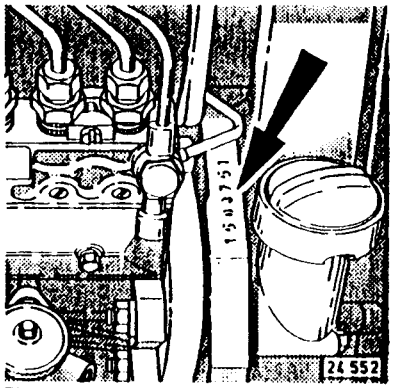
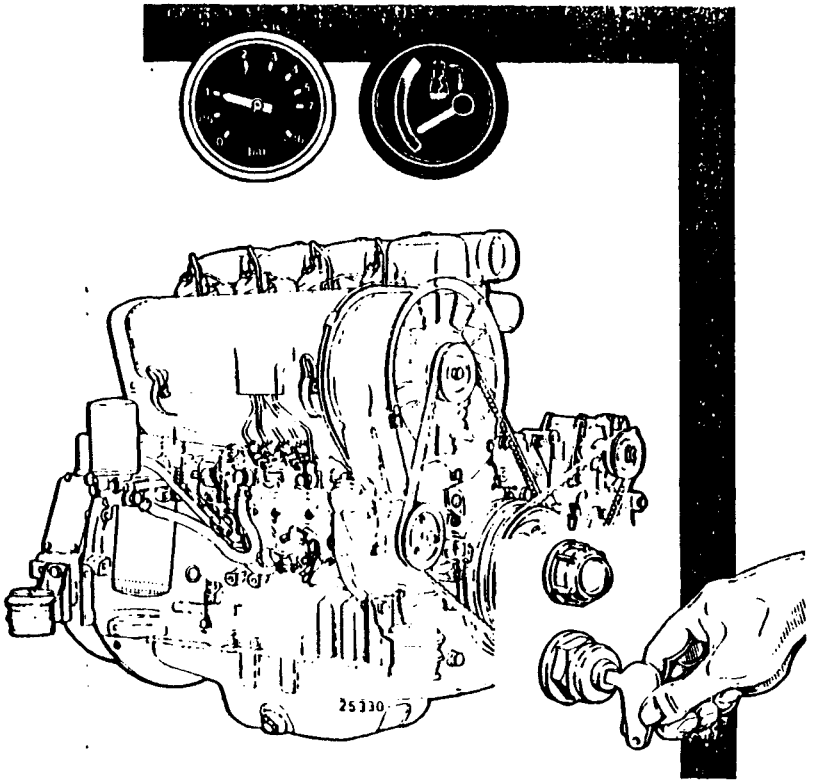


Fig. 11

Starting up a new engine for the first time involves a number of preparatory jobs, some of which must also be carried out later on in the course of routine maintenance (see Maintenance Schedule on page 95).



Engine Operation

1. Fuel

1.1 Grade

Always use a reputable branded grade of diesel fuel, the sulphur content of which should be below 0.5 %, and observe strict cleanliness when filling in. Higher sulphur contents affect the oil-change intervals (page 104). At low ambient temperatures use winter-grade fuel only (see hints on page 89). The fuel must be replenished promptly to prevent the tank from running dry, otherwise fuel filter and injection lines will need air-bleeding.

The following fuel specifications are approved: DIN 51601; NATO Codes F 54, F 75, F 76; BS 2869: A 1 and A 2*; ASTM D 975-78: 1-D and 2-D; VV-F-800a: DF-A, DF-1 and DF-2.

1.2 Air-bleeding

Never let the tank run dry!

Any air which has found its way into the fuel system can cause irregular running of the engine and decrease its performance, even leading to stopping of the engine and preventing its restarting.

Not only when the fuel tank has been run dry, but also after changing the fuel filter or working on the fuel line system, is it therefore necessary to air-bleed the system by:

Pierburg fuel feed pump:

- undoing the overflow valve 1 (Fig. 12) at the lower (larger) hexagon by 2 – 3 turns,
- actuating the priming lever 2 by pressing repeatedly downwards against spring force until fuel emerges free of air bubbles at the loosened overflow valve 1,
- and then tightening the overflow valve securely, while still pumping.

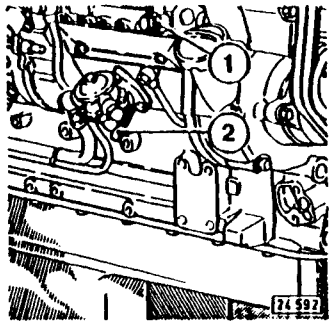


Fig. 12

Bosch fuel feed pump:

- undoing the overflow valve 1 (Fig. 13) at the lower (larger) hexagon by 2 – 3 turns,
- releasing the knurled knob 3 of hand pump 2 by turning anticlockwise a few times,
- actuating the hand pump until fuel emerges free of air bubbles at the loosened overflow valve 1,
- and then tightening the overflow valve securely, while still pumping.
- Finally, screw in knob 3.

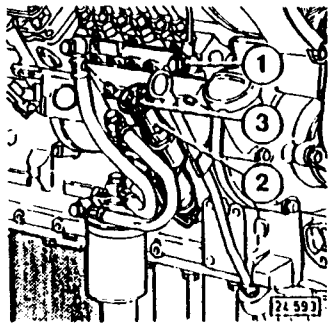


Fig. 13

Note:

Catch leakage fuel in suitable receptacle to prevent pollution of the environment!

* Observe sulphur content!

Caution:

Stop engine before filling fuel tank!
Observe strict cleanliness!
Do not spill any fuel!

2. Motor Oil

2.1 Filling in Oil (Fig. 14)

2.2 Checking Oil Level (Fig. 15)

- see page 99 -

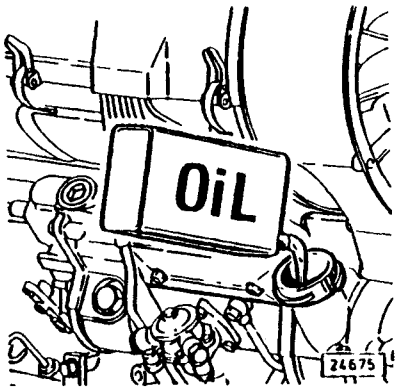


Fig. 14

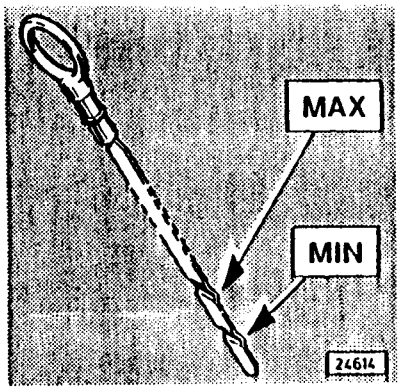


Fig. 15

2.3 Oil Quality

By preference, use oils of the API quality grade **CD/SE** or **CD/SF**. You will thus attain the longest possible oil change intervals.

Oils of the API quality grade **CC/SE** and **CC/SF** can be used when halving the length of oil intervals (see page 104).

Note:

During operation of the engine, not only part of the oil lubricating the pistons is burnt but the thermal stress and the combustion residues mixing with the oil also entail a deterioration of the oil and in particular of its chemical additives. Therefore, a complete change of the oil should be carried out at the recommended intervals.

As this deterioration is greatly influenced by the operating conditions as well as by the quality of the fuel and oil used, the oil change intervals differ accordingly. Be sure, therefore, strictly to observe the specifications given on page 104.

Mixing of different oil grades can reduce the output power and should be avoided where possible

Engine Operation

2.4 Oil Viscosity

The viscosity of the oil being greatly influenced by the ambient temperature, the choice of the SAE-grade should be governed by the ambient temperature at engine site (see diagram). If temperatures temporarily fall below the limit of the SAE-grade selected, this will merely affect the starting performance but cause no engine damage.

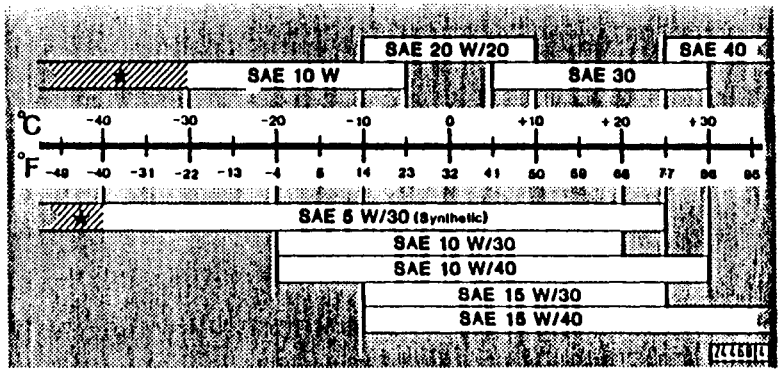


Fig. 16

★ Only with engine oil preheating.

Since a too viscous oil causes starting difficulties, the choice of the viscosity grade during winter operation should be governed by the ambient temperature prevailing at the time of starting the engine. Oil changes as a function of ambient temperatures can be avoided by using multigrade oils, which are again subject to the oil change intervals recommended on page 104. The required oil capacities are given under "Specification Data" on pages 72 and 73.

Engine Operation

3. Oil Bath Air Cleaner (if mounted)

The air cleaner bowl 1, Fig. 17, must be filled with oil before starting up (use the same grade of motor oil as for the engine). Be sure not to fill dust trap 2 of precleaner 3, if provided, with oil as it is exclusively meant for collecting dust.

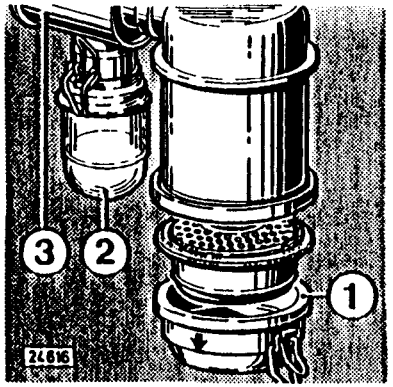


Fig. 17

4. Starting of Engines with Direct Injection (F 3-6 L 912)

- Disengage the clutch.
- Move speed control lever 1 (Fig. 18) to about quarter speed by hand or foot.
- Insert starter key 1 (Fig. 19), turn clockwise to detent and check that charging pilot lamp 2 lights up. Push key in deeper and turn farther clockwise against spring pressure; release key as engine starts firing.

  Design with heater plug/starter switch 3: Insert key 4 as far as it will go and turn switch 3 via position 1 to position 2; release switch as engine starts firing.
- Cut the speed back as soon as the engine is firing smoothly. The charging pilot lamp 2 should by now have gone out. A few minutes' running at moderate load and varying speed will bring the engine up to its normal working temperature.

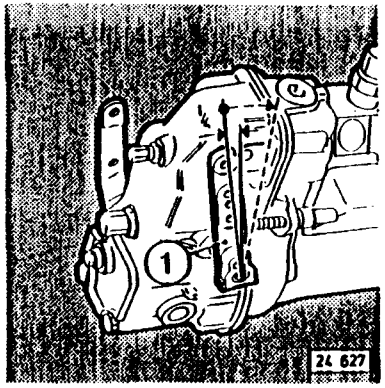


Fig. 18

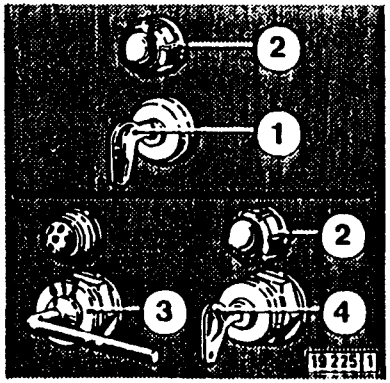


Fig. 19

4.1 Starting at Low Ambient Temperatures

See "Operation in Winter", page 91.

Note:

Do not actuate the starter for more than 20 seconds at a time. You will protect your battery if you wait for 1 minute between each starting attempt. Then begin again with preheating, if necessary.

If the engine fails to start after two attempts, find out the cause with the aid of the Trouble Chart on pages 124 and 125.

Caution!

Before starting, make sure that no one is standing in the close vicinity of the engine or driven machine.

After carrying out repairs: Check that all safety guards have been refitted and all tools have been removed from the engine.

4.2 Starting of Engines with Two-stage Combustion (F 3-6 L 912 W)

- Disengage the clutch.
- Set speed control lever 1 (Fig. 20) to about quarter speed by hand or foot.
- Insert switch key 4 (Fig. 21), turn clockwise to indent, whereupon charging control lamp 2 should light up.
- Turn heater plug/starter switch 3 to position I and hold for about 1 minute (preheating). The heater plug indicator 5 should light up brightly.
- Turn heater plug/starter switch 3 to starting position II.
- Once the engine fires smoothly, release switch, which will then return to zero position.
- Should the engine not fire smoothly or expel grey-white smoke, do not attempt to accelerate with the speed control lever 1 (Fig. 20), but
- Afterheat in position I for not more than 3 minutes.
- Cut the speed back as soon as the engine is firing smoothly. The charging pilot lamp 2 should by now have gone out. A few minutes' running at moderate load and varying speed will bring the engine up to its normal working temperature.

Note:

Do not actuate the starter for more than 20 seconds at a time. You will protect your battery if you wait for 1 minute between each starting attempt. Then begin again with preheating, if necessary.

If the engine fails to start after two attempts, find out the cause with the aid of the Trouble Chart on pages 124 and 125.

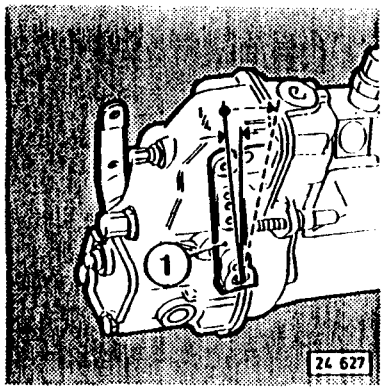


Fig. 20

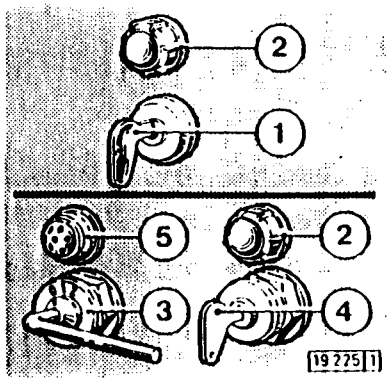


Fig. 21

4.3 Starting at Low Ambient Temperatures

See "Operation in Winter", page 91.

Caution!

Before starting, make sure that no one is standing in the close vicinity of the engine or driven machine. After carrying out repairs: check that all safety guards have been refitted and all tools have been removed from engine.

5. Attendance In Service

5.1 Motor Oil Pressure

Check that, at low idling speed,

- the green oil pressure pilot lamp (if provided) has gone out, or
- the pointer of the oil pressure indicator (if provided) is in the green sector, or
- the pointer of the oil pressure gauge (if provided) shows a pressure of at least 1.0 bar.

5.2 Engine Temperature

The pointer of the temperature indicator* should always be in the green sector, and in the yellowish-green sector in exceptional cases only. **If the pointer moves into the orange sector, this means that the engine is overheated and must be shut down immediately.** In this case, the cause of the overheating must be traced with the aid of the Trouble Chart on pages 124 and 125.

5.3 Fan Drive

Should the fan belt fail, switch 1* (Fig. 22) will release an audible or visual signal. **Stop engine immediately, to prevent overheating!**

* Devices not mounted on all engine versions.

6. Stopping

- Set speed control lever 1 (Fig. 23) to idling position.
- Operate stopping lever 2 (Fig. 23) on the injection pump until the engine stops, whereupon the pilot lamp 2 (Fig. 21) should light up again.
- Turn switchkey 1 or 4 (Fig. 21) fully anticlockwise and pull out; this will cause the pilot lamp to go out.

Note:

Like all internal combustion engines, the air-cooled DEUTZ diesel engine should not be shut down suddenly from full-load running. It is better to let the engine idle for 1 – 2 minutes to allow for temperature balance.

Note:

The minimum oil pressure is 1.0 bar at low idling speed of 650 + 50/min.

Lighting up of the warning lamp at low idling speed (engine warm) or movement of the pointer into the red sector is admissible, provided that, when speed is increased, the lamp goes out again or the pointer moves into the green sector.

Where a continuous monitoring of the oil pressure is desired also within the engine's working speed range, this will require optional extra equipment.

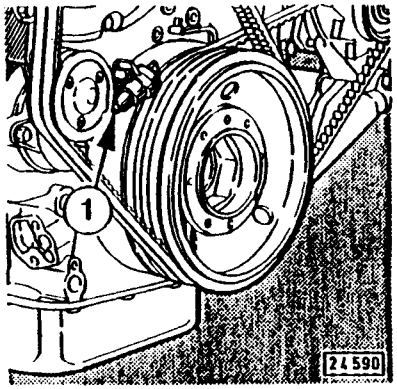


Fig. 22

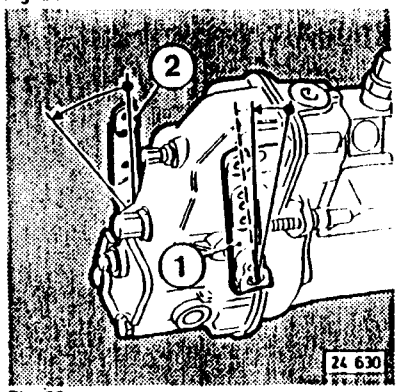


Fig. 23

7. Operation In Winter

7.1 Use winter-grade motor oil

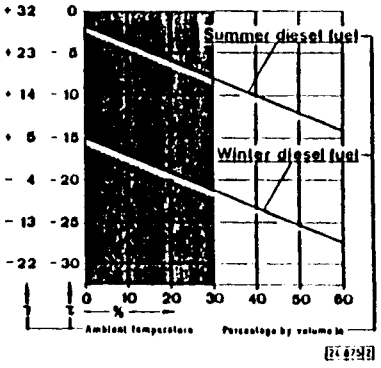
To ensure satisfactory cold starting, the choice of the viscosity grade (SAE-grades page 84) should be governed by the ambient temperature prevailing at the time of starting.

As to the oil change intervals, it should be borne in mind that operation below – 10 °C requires shorter oil change intervals (see page 104, "Changing Motor Oil").

7.2 Fuel

Use winter-grade fuel in winter because with ordinary fuel, waxing may occur at low temperatures and clog the fuel filter. At excessively low temperatures, even winter-grade fuel may tend to wax.

Therefore, if only summer-grade fuel is available, or if winter-grade fuel is used at excessively low temperatures, we recommend the following percentages (see diagram) for mixtures of diesel fuel and kerosene or regular-grade gasoline*. Admixture of the latter is however permissible for a short period only – on no account for permanent operation.



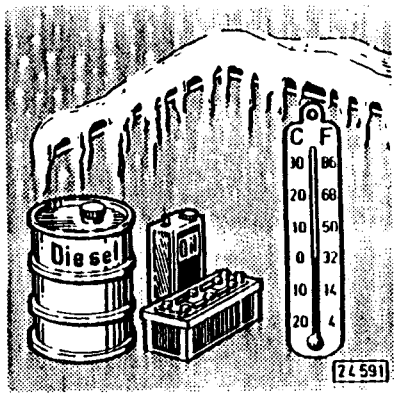


Fig. 24

Caution!

Prepare the blend in the tank itself: fill in the regular-grade gasoline first, then add diesel fuel. The blend is as easily inflammable as pure gasoline.*

Maximum admixture of regular-grade gasoline* 30 %; when admixing **more than 30 %, use kerosene only.**

For using a commercial additive, please consult your DEUTZ Service Station

* **Never** use premium fuel.

7.3 Additional Maintenance Jobs

- **Drain off the thick sludge from the fuel tank once a week.** Do this by taking out the sludge drain plug.
- **The grade of oil in the oil bath air cleaner** – if fitted – should preferably suit the ambient temperature just like the engine oil.
- **The flywheel ring gear**
should be lubricated, at temperatures below – 20 °C (– 4 °F), with low temperature grease, e.g. Bosch FT 1 V 31, from time to time through the pinion hole (if necessary remove starter). This will ensure full engagement of the pinion.

7.4 Cold Starting Aids

7.4.1 Flame-type Heater Plug

The flame-type heater plug should always be used over a prolonged preheating period in the case of ambient temperatures near or below freezing point. It not only lowers the starting limit temperature, but proves also useful at temperatures normally not requiring a starting aid. This plug can also be used for afterburning for the purpose of preventing starting smoke if it is employed right from the beginning of the starting operation (preheating).

Located at the inlet of the air intake pipe, the flame-type heater plug heats up the combustion air by burning small amounts of fuel from the injection pump as metered by a solenoid valve.

Note:

Cold starting of a Diesel engine depends, among other things, on the capacity of the starter motor and that of the battery, as well as the turning resistance offered by the transmission and driven machine. Since the starting equipment of the engine may differ according to its application, no data on limit temperatures for cold starting are given in this Manual. Any DEUTZ distributor, however, will furnish you with the desired information on this subject.

The viscosity specification for lube oils should by all means be observed.

Cold starting requires satisfactory condition of the battery.
Lowering the limit temperatures by 4 – 5 °C is possible by raising the battery temperature to about + 20 °C. This is done by removing the battery with the engine stopped and storing it in a warm room.

When installing the battery, ensure satisfactory terminal contact by keeping contact surfaces clean and bright. To avoid distortion of terminal cones, be sure to tighten screws only moderately.

At very low temperatures (below – 30 °C)
In the case of extremely low temperatures, the engine is to be warmed up to ensure satisfactory starting and lube oil supply. Parts for connecting preheating units, however, are provided only on engines intended for operation in very cold regions.

Starting Operation

- Disengage the clutch.
- Set speed control lever 1 (Fig. 25) to about quarter speed by hand or foot.
- Insert switch key 4 (Fig. 26), turn clockwise to indent, whereupon charging control lamp 2 should light up.
- Turn heater plug/starter switch 3 to position I and hold for about 1 minute (preheating). The heater plug indicator 5 should light up brightly.
- Turn heater plug/starter switch 3 to starting position II.
- Once the engine fires smoothly, release switch, which will then return to neutral position.
- Should the engine not fire smoothly or expel grey-white smoke, do not attempt to accelerate with the speed control lever 1 (Fig. 25), but
- Afterheat in position I for not more than 3 minutes.

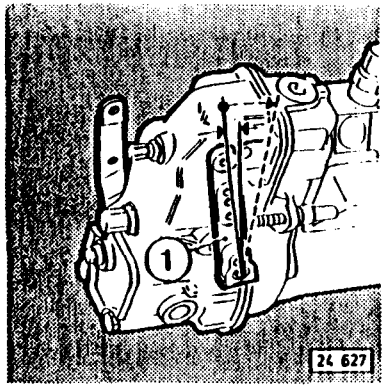


Fig. 25

Note:

Do not actuate the starter for more than 20 seconds at a time. You will protect your battery if you wait for 1 minute between each starting attempt. Then begin again with preheating, if necessary.

If the engine fails to start after two attempts, find out the cause with the aid of the Trouble Chart on pages 124 and 125.

For testing the heater plug, see page 118.

When starting with **start pilot**, fuel of very high ignition quality is sprayed into the intake pipe.

- **Assist starting operation by actuating the pump until the engine fires smoothly. Closely observe special instructions for start pilot VISO F 27 (Order No. 297 3654).**

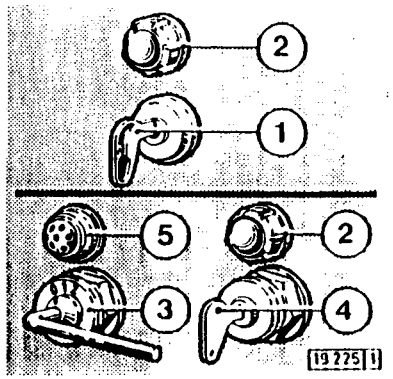


Fig. 26

Caution!

Do not inject an excessive amount of fuel. Never use the start pilot together with the flame plug preheating system.



Stop engine before carrying out any maintenance work.

Maintenance Chart*

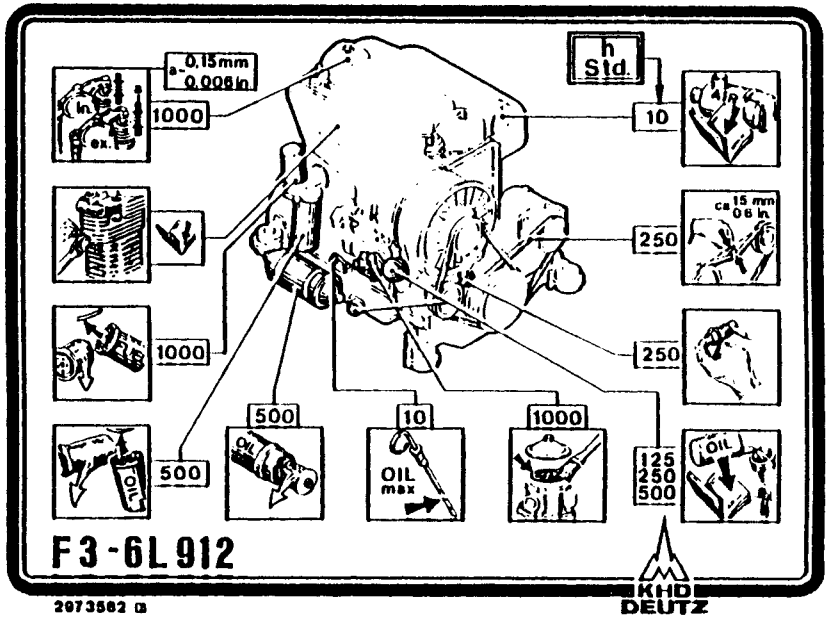
IMPORTANT!

The Maintenance Chart displayed below is supplied as a self-adhesive label along with each engine.

Check that this label is stuck at a convenient location on the engine or driven equipment.

If necessary, ask for a fresh supply of labels.

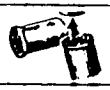
* **Note:**
Valid for routine maintenance work is the Maintenance Schedule on page 95.



Maintenance

Engine Maintenance

The maintenance jobs described on the following pages ensure ready engine availability at all times and long life span.

Improvement of → / by servicing ↓	Engine power	Specific fuel consumption	Specific oil consumption	Bearing clearances	Exhaust emissions	Engine noise	Starting performance	Engine reliability	Long life
			O	O			O	O	O
OIL 				O				O	O
AIR 	O	O	O	O	O			O	O
FUEL 	O			O			O	O	O
				O				O	O
							O	O	
	O	O		O	O	O	O	O	O
	O	O			O	O	O	O	O

Maintenance Schedule

● Check ■ Clean ▲ Change — See Note

Every 10 hours	● 	● ■ 	● 		Job
	99	100-102	103		Maintenance point
					See page
Every 125 hours	▲ 	● ■ 	● 		Job
	104/105	106	108		Maintenance point
					See page
Every 250 hours	▲ 	● 	● 		Job
	104/105	108	109/110		Maintenance point
					See page
Every 500 hours	▲ 	▲ 	● FL 912 W 		Job
	104/105	111	112/113		Maintenance point
					See page
Every 1000 hours	● FL 912 	■ 	▲ 		Job
	112/113	114	115-117		Maintenance point
					See page

Workshop Maintenance

Every 1000 hours	●	Air intake and exhaust manifolds	119
	●	Cylinder-head temperature indicator	119
Every 1500 hours	●	Alternator	120
	●	Starter motor	120
Every 3000 hours	●	Injectors	121

Maintenance

The maintenance jobs duly completed can be recorded and certified in the schedule below.

Completed Maintenance Jobs

Hours	Date	Signature	Hours	Date	Signature
–			–		
* 50			–		
125			250		
375			500		
625			750		
875			1000		
1125			1250		
1375			1500		
1625			1750		
1875			2000		
2125			2250		
2375			2500		
2625			2750		
2875			3000		
3125			3250		
3375			3500		
3625			3750		
3875			4000		
4125			4250		
4375			4500		
4625			4750		
4875			5000		
5125			5250		
5375			5500		
5625			5750		
5875			6000		

* See instructions on page 98

Maintenance

The maintenance jobs duly completed can be recorded and certified in the schedule below.

Completed Maintenance Jobs

Hours	Date	Signature	Hours	Date	Signature
6125			6250		
6375			6500		
6625			6750		
6875			7000		
7125			7250		
7375			7500		
7625			7750		
7875			8000		
8125			8250		
8375			8500		
8625			8750		
8875			9000		
9125			9250		
9375			9500		
9625			9750		
9875			10000		
10125			10250		
10375			10500		
10625			10750		
10875			11000		
11125			11250		
11375			11500		
11625			11750		
11875			12000		
12125			12250		
12375			12500		

Important: Commissioning New or Overhauled Engines

At the end of 15 minutes' running:

- **Retension V-belts (Fig. 27).**
  See page 109.

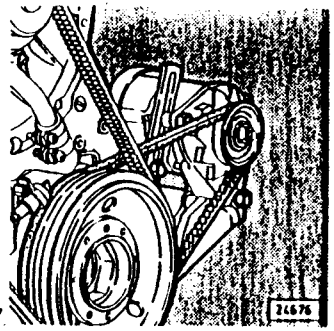


Fig. 27

At the end of 50 hours' running:

- **Change oil.**
  See pages 104/105.
- **Renew lube oil filter cartridge (item 1, Fig. 28). See page 111.**
- **Oil sump:**
  Retighten bolts (2).
- **Retighten engine mounting bolts.**
- **Retighten bolts securing air intake and exhaust manifolds to the cylinder heads (item 3, Fig. 29). See page 119.**
- **Check valve clearance (item 4, Fig. 29), readjusting if necessary.**
  See pages 112/113.

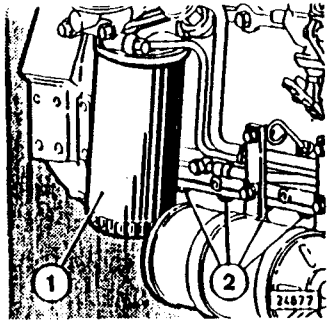


Fig. 28

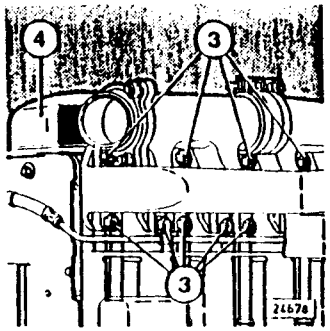


Fig. 29

Routine Maintenance



Check Oil Level In Engine

- Engine must be in horizontal position and shut down.
- Pull out dipstick 1 (Fig. 30),
- wipe with clean, non-fraying rag,
- reinsert as far as it will go, and then
- withdraw again.

  The oil level should be between the marks 2 and 3. If the level is only up to or even below the lower mark, top up with oil immediately, preferably up to the upper mark 2, in order to prevent serious damage being caused to engine.

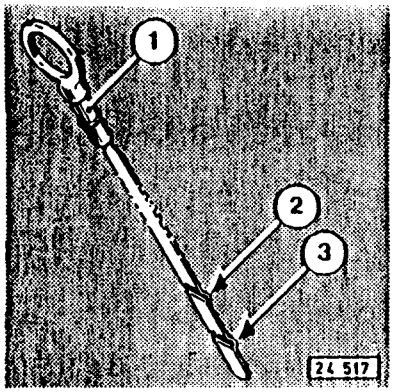


Fig. 30

Note:

Checking the oil level prior to starting the engine ensures a sufficient engine oil level for the start.

To check the oil level accurately, it is necessary to shut down the engine after about one minute of operation. The entire oil system will then be filled. The immediate oil level check will then show the oil sump filling volume actually available during operation of the engine.

On engines with engine oil operated driver's cab heater system, the heater actuating lever must be set to the position "maximum heating capacity" during subject operating time of about one minute.

We strongly recommend to carry out this double check of the oil level before any prolonged engine operation, particularly if the check prior to the engine start discloses an oil level in the vicinity of the lower or minimum mark on the dipstick.

Normally, new engines have a higher oil consumption. During the running-in period (about 200 running hours) it is therefore essential to check the oil level twice a day. After the running-in period, one check per day is sufficient.

Where engines are inclined, oil level should reach top mark of dipstick.

Checking and Cleaning Air Cleaners

Dust in the combustion air can cause premature wear of the engine. Maintenance of the air cleaners is therefore essential to ensure long life. **It is also necesary to check unions and connections of the intake manifold regularly.**

The maintenance intervals for air cleaners depend on the amount of dust fall-out. No fixed intervals can therefore be given.

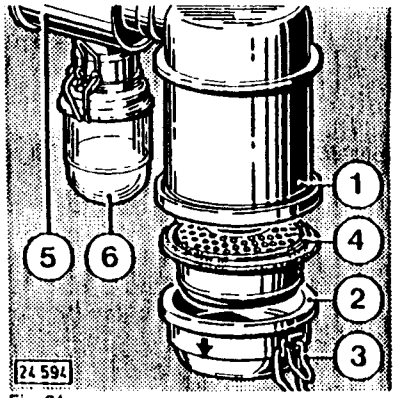


Fig. 31

1. Oil Bath Air Cleaner (if mounted, otherwise see page 101)

- Before checking, wait at least one hour after stopping the engine, so that the oil has had time to drip down from the cleaner element.
- Release the snap clips 3 (Fig. 31) and remove oil bowl 2.
- Remove element 4 by sidewise tapping with the hand or by inserting a screwdriver. Do not damage rubber gasket!
- Renew oil in bowl 2 (for motor oil viscosity, see page 84). Note oil level mark (arrow).
- Rinse filter element 4 in diesel fuel (never in gasoline!) and allow to drip-dry thoroughly.
- Once or twice a year (depending on amount of dust), remove also the filter upper part 1 and likewise rinse in diesel fuel. Allow to drip-dry thoroughly.
- Following reassembly, check all connections for leaks.

1.1 Cyclone-type Pre-cleaner 5 (Fig. 31) (if mounted)

- Empty dust trap 6 when it is half full (see mark).
- Never fill the dust trap with oil.

2. Dry-type Air Cleaner (if mounted)

The life of the expendable paper cartridges in dry-type air cleaners depends on dust collector 2 (Fig. 32) being emptied in good time. Failing this, the cartridge will clog up fast. **Be sure, therefore, to empty the collector not later than when filled half-way. Where the air is very dust-laden, this may require daily servicing.**

If a special dust ejector 8 is provided, it is only necessary to clear the discharge slot from time to time.

2.1 Emptying the Dust Collector

- Stop engine.
- Release clip 1 (Fig. 32) and remove dust collector 2 along with cover 3.
- Take off cover 3 and empty collector.

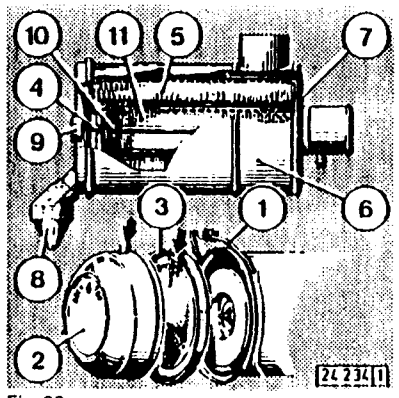


Fig. 32

- Refit assembly, making sure that recess on cover mates with lug on collector (see arrows, Fig. 32).
- When cleaner is installed in horizontal position, check that the "Top" mark is actually at top.

2.2 Servicing the Cartridge

Where a service gauge (Fig. 33) is fitted and keeps displaying the red warning signal 1 when the engine is stopped, or where a yellow warning light goes on with the engine running, the cartridge is due for servicing. (Also indicated by smoking exhaust and decreasing engine output.) It is not advisable to service the cartridge more frequently, as this may affect seal 7 (Fig. 32) between cartridge 5 and housing 6.

Replace cartridge not later than at the end of 12 months or when soiled by soot. If no new cartridge is to hand for replacement, the existing cartridge can also be cleaned for reuse (see Section 2.2.1), but should then be replaced at the earliest opportunity.

- Proceed by taking down dust collector 2 (Fig. 32) as described under 2.1.

  (Where a dust ejector 8 is provided, unscrew wing nut 9 and remove cover.)

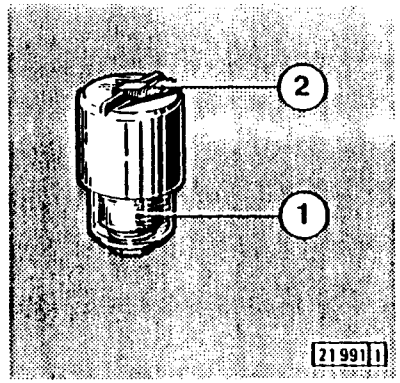


Fig. 33

- Unscrew hex. nut 4 and remove soiled cartridge 5.
- Renew or clean cartridge.
- After having serviced cartridge 5 five times, or after two years at the latest, renew together with safety cartridge 11 (secured to body 6 by nut 10). Enter the number of servicings of cartridge 5 in the spaces provided on safety cartridge 11.
- **Safety cartridge 11 may not be cleaned and reused.**
- Renewal of cartridge 11 is also required when cartridge 5 is renewed because of defects, etc., or when warning signal reappears although cartridge 5 has been serviced.
- **Make sure that only genuine cartridges are used as supplied by the air cleaner manufacturer. Cartridges of other make usually do not fit and are a hazard to the engine.**

2.2.1 Cleaning the cartridge:

a) by tapping (provisional): Tap cartridge 5 with its front end gently against the palm of your hand or on a soft surface, to shake off the dust. Take care not to damage the front end of the cartridge.

b) with air: Apply air blast of max. 5 bar from inside to outside until no more dust is coming out. **Do not blow out housing 6.**

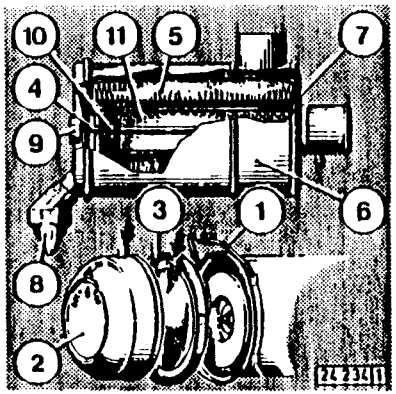


Fig. 32

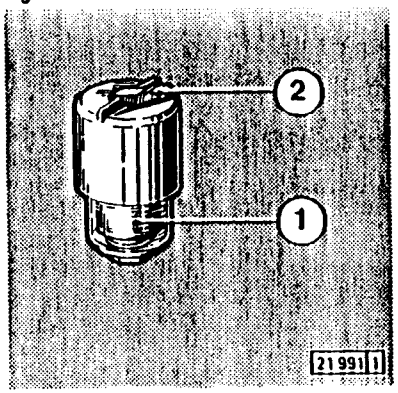


Fig. 33

Caution:

In no event use gasoline or hot liquids for cleaning the cartridge!

3. Checking:

Prior to reassembly, introduce a lighted bulb into filter cartridge 5 to see whether it suffered damage (damaged cartridges must definitely be renewed). Also make sure that gasket 7 is not defective. If a service gauge with visual signal is fitted (Fig. 33), press push button 2; this causes the red signal to disappear from the window.



Checking Water Separator on Two-stage Fuel Filter

(if mounted)

Some engine versions use a two-stage fuel filter with water separator for protection of the injection system. The water collects in bowls 2 and 3 (Fig. 34). In the transparent bowl 2, the water is distinguished from the fuel above by its lighter shade. Make sure that water level will not exceed the lower rim of bead 4.

The maintenance intervals for the water separator depend on the amount of water contained in the fuel and cannot be stated definitely. Initially, therefore, check daily whether there are indications of water in the transparent bowl 2.

Draining off the water:

- Loosen knurled screws 5 at bowls 2 and 3 through one or two turns.
- Observe the flow of draining liquid and the transition from water to diesel fuel.
- Gently retighten knurled screws 5.

Note:

Catch fuel in special receptacle to prevent pollution of the environment.

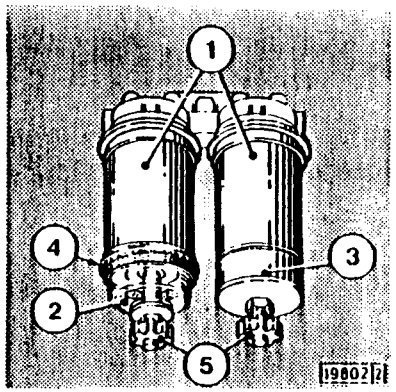


Fig. 34



Changing the Motor Oil

Important:

Should the engine run less than the hours stated in the following Table, the oil must be changed in any case once a year.

Oil Change Periods

Engine Application	Category of Oil Stressing	Oil Change Intervals (running hours)	
		Oil Grade API: CC/SE or CC/SE	Oil Grade API: CD/SE or CD/SE
Tractors, Lift trucks, Cranes, Construction machinery, Rail traction units, Ships, Base-load gensets, Pumps	A	250	500
Farm equipment (seasonal) Underground mining, Road sweepers, Winter service, Emergency gensets, Emergency pumps Engines with two-stage combustion (FL 912 W)	B	125	250

Important:

The above intervals are based on the use of a diesel fuel containing max. 0.5 % b.w. of sulphur and ambient temperatures above – 10 °C.

Periods between oil changes should be cut by half

- when using fuels containing more than 0.5 % up to 1 % sulphur or
- if the ambient temperatures are permanently below – 10 °C.
  In the case of fuels containing more than 1 % up to 1.5 % sulphur, the motor oil should have a TBN* of about 12 × % S-content, with the periods between oil changes being halved.

Typical examples:

1) Tropical climate, oil stressing category A, fuel containing 0.8 % sulphur, lube oil grade CD/SE: Change oil every 250 hours.

2) Tropical climate, oil stressing category A, fuel containing 1.2 % sulphur: Change oil every 250 hours, using CD/SE or CD/SF oil having a TBN* of about 14 mg KOH/g.

Oil Grades

The responsibility for the grading of his particular oil product to API Specification is borne by the supplier.

Note

Upon changing over to a higher grade of oil following a prolonged period of operation, change oil at the end of 20 hours and renew oil filter.

* TBN = "Total Base Number", expresses the neutralising capacity of the oil. Ask your supplier to quote TBN.

Change Oil

while the engine is still hot, since the old oil will run more easily in this condition.

- Shut down engine.
- Unscrew drain plug 1 (Fig. 35), after placing suitable receptacle underneath.
- When all old oil has run off, refit drain plug 1 complete with new sealing ring 2.
- Fill in fresh oil through filler neck 3 (Fig. 35) up to the upper dipstick mark (Max., Fig. 36).
- Following a short trial run, check oil level again, topping up to the upper mark (Max.) if necessary.

Oil capacity at refill
(without filter replacement)

3-cyl. engine: approx. 8 litres
4-cyl. engine: approx. 9.5 litres
5-cyl. engine: approx. 12 litres
6-cyl. engine: approx. 12 litres

These approximate values refer to the standard oil sump (observe the dipstick marks!).

Note:

In the case of engines with engine oil operated driver's cab heater system, the heater actuating lever must be set to the position "maximum heating capacity" before undoing the plug for draining off the engine oil, so that the oil in the heater circuit is also drained.

The heater actuating lever should also be set to the position "maximum heating capacity" during the short trial run before final checking of the oil level after refilling with fresh oil.

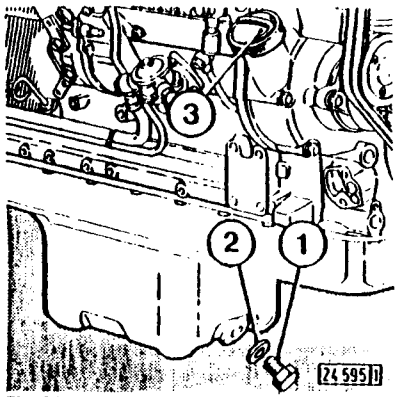


Fig. 35

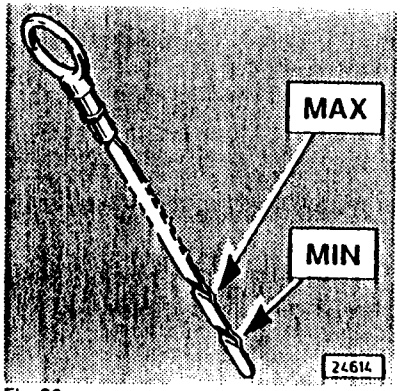


Fig. 36

Caution:

Danger of scalding when draining off the hot oil!

Catch old oil in suitable receptacle to prevent pollution of the environment!

Inspecting/Cleaning the Cooling System

Cleaning the cooling system is most important since accumulation of dust on the inside of the cooling air blower, on the cooling fins 1 (Fig. 37), as well as on oil cooler 2 is liable to reduce cooling efficiency substantially, especially where the dust is retained by a film of fuel or oil.

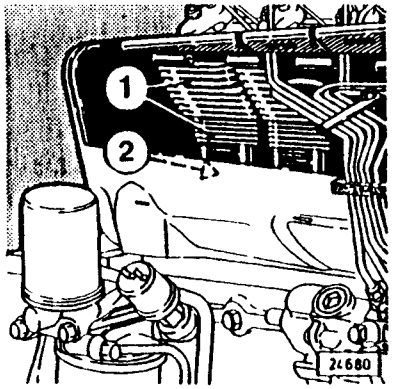


Fig. 37

Check the cooling system regularly for contamination in accordance with the following table, and clean if necessary. Please note that the inspection intervals can only be given as guide figures based on normal operating conditions, and that in the case of abnormally contaminated cooling air – check mounted cooling air sleve boxes for correct seating and good condition – the inspection and cleaning intervals may have to be shortened accordingly.

Inspection Interval (guide figures only) Running Hours	Engine Application
2000	Ships, Gen-sets in closed rooms, Pumps
1000	Vehicles on paved roads
500	Tractors, Lift trucks, Mobile gen-sets
250	Vehicles on building sites and unpaved roads, Construction machinery, Compressors, Underground mine units
125	Farm equipment, Tractors doing harvesting work

For inspecting and cleaning, proceed by releasing the fasteners 2 (Fig. 38) securing the air cowling hood 1 on the injection pump side, and removing the hood.

Cleaning methods:

- **Dry cleaning** by means of compressed air. Start blowing through from the exhaust-air side (Fig. 39). Any dirt blown into the air cowling space must be removed afterwards, of course.
- **Use of cold cleansing agent** (e.g. P3 or Nalfleet). After allowing an adequate soaking-in period, wash the engine with a powerful water jet.
- **If a high-pressure jet** is available, this method of cleaning is preferable to any other.

Note:

When cleaning the vehicle or engine by means of cold cleansing agent or steam, cover up the injection pump, alternator, voltage regulator and starter motor as protection against direct application of the jet.

After wet-cleaning, let the engine run until warm so that any water left behind will be evaporated before rust can form.

Caution:

Always stop the engine before cleaning!

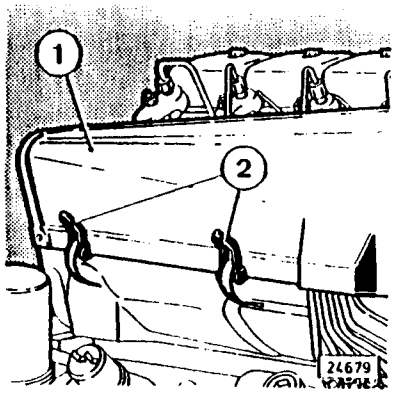


Fig. 38

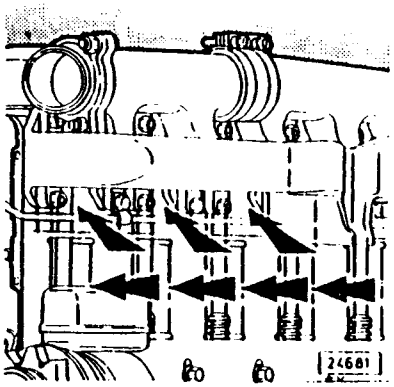


Fig. 39



Checking Electrolyte in Battery

- Remove cell caps 1 (Fig. 40).
- In some cases, electrolyte level testers 2 are provided: the level should be high enough to wet the bottom of these.
- An alternative method is to insert a clean wooden stick 3 into the cell until it touches the top of the plates. The electrolyte should wet the stick over a length of about 10 – 15 mm.
- If the electrolyte level is low, top up with **distilled water** only.
- Replace cell caps.
- For hints on battery care in winter, see page 90.

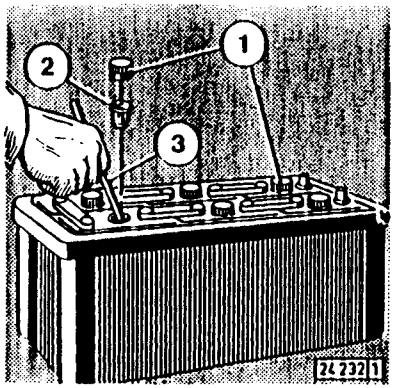


Fig. 40

Caution:

When working on the battery, keep naked lights away, do not smoke! Do not allow acid to come into contact with the skin or clothing! Wear protective goggles! Do not place tools on battery!



Checking the Warning Device*

In the event of V-belt failure, the idler pulley will operate the electric switch 1 (Fig. 41), thus causing an audible or visual warning to be given.

- Shut down engine.
- Switch on electric power supply to engine.
- Press in the pin 1 (Fig. 41) with finger to check function.

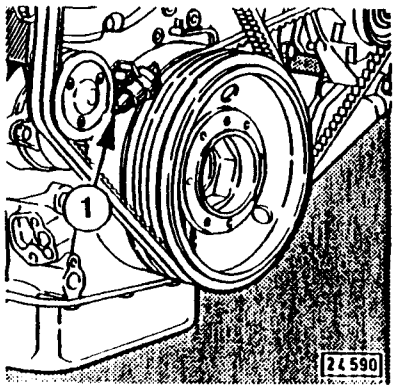


Fig. 41

Caution:

As safety precaution, always stop engine before checking function!

* Only fitted to order and on special models.



Checking V-belt/ V-belt Tension

- Inspect V-belt over whole length for damage or cracks. Renew damaged or cracked V-belts.
- Check by pressing with the thumb (Fig. 42) midway between the pulleys to see whether the V-belt deflects inwards by max. 10 – 15 mm (0.4 – 0.6 in.).

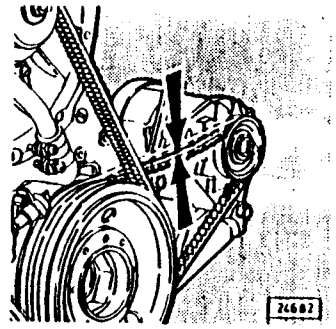


Fig. 42

Retensioning the V-belt:

- Slacken hex. bolts 1, 2 and 3 (Fig. 43).
- Pull generator 4 in direction A until the correct belt tension is obtained.
- Then securely retighten hex. bolts 1, 2 and 3.

Renewing the V-belt:

Blower V-belt

- Push idler pulley 1 (Fig. 44) vigorously inwards.
- Place on new belt.

Alternator V-belt

- Take off blower V-belt.
- Slacken hex. bolts 1, 2 and 3 (Fig. 43).
- Press alternator 4 in direction B against engine. In this position, it is easy to fit the new V-belt.
- Tension V-belt as described above.
- Refit blower V-belt.

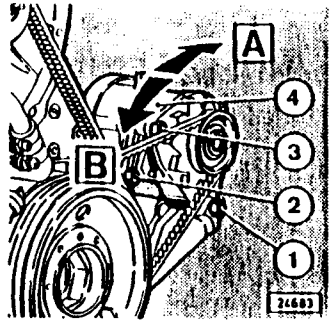


Fig. 43

Note:

Retension new V-belts after running for 15 minutes.

Not applicable to cooling blower drive with automatic tensioning pulley 1 (Fig. 44).

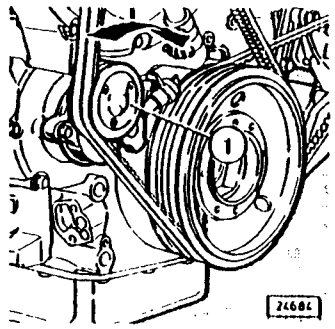


Fig. 44

Caution!

Stop engine before retensioning V-belts! Remount guards if fitted!

Mark Industries

TITLE	VENDOR CHAPTER
MODEL	100C 6X4
NOTES	P/N 22200

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Retensioning Single-type V-belt on Compressor

- Unscrew hex. bolts 1 (Fig. 45).
- Take down outer half-pulley 2.
- Remove one or more shims 3 (Fig. 46) – as may be required – from inside and place removed shim(s) outside on half-pulley 2.
- Retighten bolts 1 (Fig. 45) while turning over the engine with the turning device to prevent the belt being squeezed.

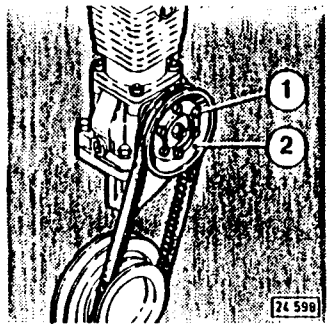


Fig. 45

Retensioning Twin-type V-belts on Compressor

- Unscrew hex. nuts 1 (Fig. 47).
- Take down half-pulleys 2 and 5 together with shim packs 6 and 7, as well as intermediate piece 4.
- For the purpose of retensioning the belts, take one or more shims – as may be required – from packs 6 and 7 and place them before or behind the half-pulleys (Fig. 47) to ensure alignment of the belts. The number of shims taken from each pack at a time must always be the same.
- Retighten hex. nuts 1 while turning over the engine with the turning device to prevent the belts being squeezed.

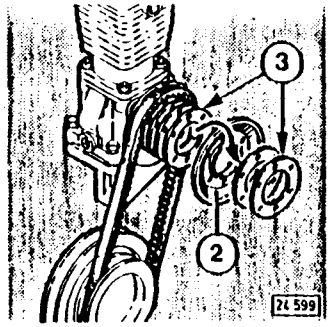


Fig. 46

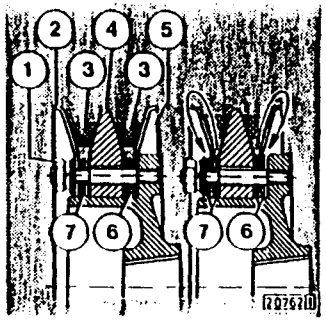


Fig. 47

Note:

When two V-belts are provided, always renew both belts when only one is worn or damaged. The difference in length of the new V-belts may not exceed 0.15 %.

Renewing the Oil Filter Cartridge or Filter Element

1. Main Cartridge

- Release cartridge 1 (Fig. 48) by wrench and screw off by hand.
- Clean sealing surface 2.
- After slightly oiling the rubber gasket 3, screw new cartridge in place by hand until gasket is evenly seated and give the cartridge a final half turn.

Note:

During test-run following assembly, check oil pressure and filter tightness.

2. Bypass Microfilter Element*

- Drain oil after removing plug 1 (Fig. 49)
- Unscrew bolt 2 and remove filter top.
- Remove element and clean body.
- Renew top gasket if defective.
- Refit drain plug, install new element and resecure top.
- On restarting engine, make sure there are no leaks and oil pressure is correct.

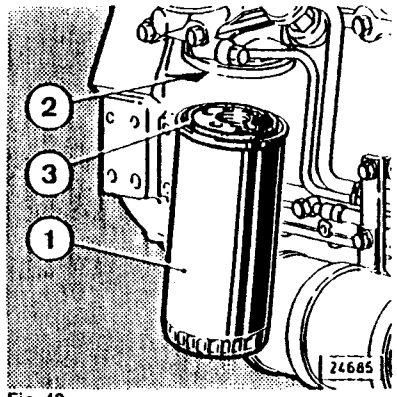


Fig. 48

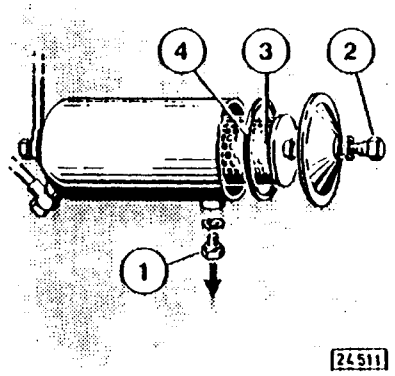


Fig. 49

Caution!

A small amount of oil runs out when screwing off the oil filter or removing the microfilter element.

Danger of scalding in case of hot oil!

Catch old oil in suitable receptacle to prevent pollution of the environment!

* If mounted.



Checking Valve Clearance

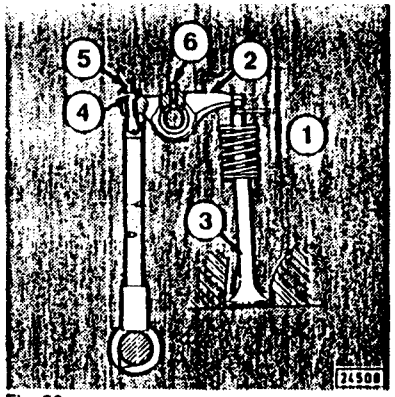


Fig. 50

- Valve clearance to be checked with engine cold.

Note:

The valve clearance is the requisite gap 1 between the pads of rocker arms 2 and valves 3 (Fig. 50). Good engine performance and power output depend on its correct setting which may be carried out by a skilled mechanic according to the following instructions, but preferably by a specialist.

- First remove rocker chamber covers.
- Turn crankshaft at front end by means of 36 mm socket wrench until the valves of the cylinder in question are "overlapping" (exhaust valve about to close, inlet valve about to open).
- Then continue turning the crankshaft through 360°.
- Check valve clearance:
  Valve clearance 1 is correct when a **0.15 mm feeler gauge** can be inserted with a slight drag between pad of rocker arm 2 and valve 3.
- Failing this, the valve clearance must be readjusted.
- Readjust as follows:
  Loosen locknut 4 by two to three turns.
  Adjust setscrew 5 with screwdriver so that, when locknut is retightened, the feeler gauge can be inserted and withdrawn with slight drag.
- Check the valve clearances of each of the remaining cylinders and readjust if necessary.
- Do not change the setting of oil nozzle 6 unless required. With hot engine running at idling, an oil flow to pad of rocker arm 2 must be just noticeable. An excessive oil flow can lead to higher oil consumption.

Note:

Checking or resetting of the valve clearances at only two positions of the crankshaft is possible by means of the following method (see page 113).

Positioning the Crankshaft for Setting the Valve Clearances

Crankshaft Position 1

Turn the crankshaft until both valves at cylinder 1 are "overlapping" (exhaust valve about to close, inlet valve about to open). Fig. 51 shows under "Crankshaft Position 1" which valves can now be set.

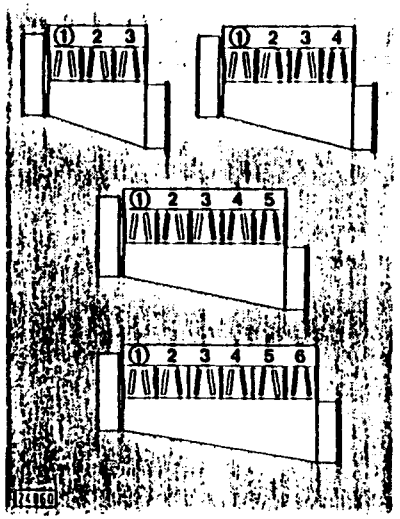


Fig. 51

Crankshaft Position 2

Having done this, turn the crankshaft further by **one rotation (360°)** (as guide, put a chalk mark on flywheel or V-belt pulley) – see Fig. 52, "Crankshaft Position 2".

Now the other valves can be set.

Not ready for setting



Ready for setting

Note:

After setting a valve, put a chalk mark to serve as a reminder that it has been done.

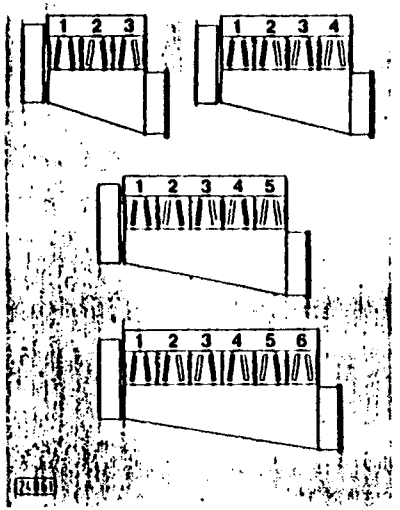


Fig. 52



Cleaning Strainer of Fuel Feed Pump

Design 1:

Pierburg fuel feed pump

- In case of high-level tank, close fuel cock.
- Remove hex. bolt 1 (Fig. 53).
- Take off cover 2.
- Take out gasket 3 and strainer 4.
- Clean strainer in diesel fuel.
- Following reassembly, check unit for tightness.

Design 2:

Bosch fuel feed pump

- In case of high-level tank, close fuel cock.
- Loosen clamping nut 2 (Fig. 54).
- Swing aside wire yoke 1.
- Remove filter bell 5 together with filter strainer 4, and clean in fuel.
- Following reassembly, check for leaks.

Note:

Falling-off engine performance can be due to contamination of these strainers.



Caution:

When working on the fuel system, keep naked lights away, do not smoke!
Do not spill any fuel!

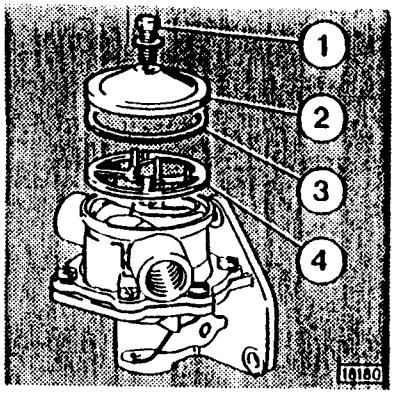


Fig. 53

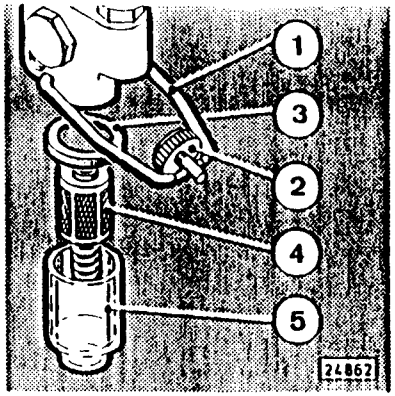


Fig. 54



Renewing the Fuel Filter Cartridge

- In case of high-level tank, close fuel cock.
- Place receptacle in position to catch escaping fuel.
- Screw off fuel filter cartridge 1 (Fig. 55), using special tool if necessary.
- Clean sealing surface.
- Apply a light film of oil to rubber gasket 2 of the new filter cartridge.
- Screw new cartridge in place by hand until gasket is evenly seated.
- Give cartridge a final half turn.
- Air-bleed fuel system (see page 82).

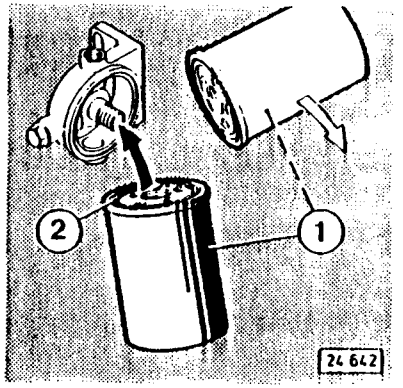


Fig. 55

Note:

Falling-off engine performance can be due to clogged filter cartridge. If the filter cartridge clogs up too quickly, check fuel for contamination, clean tank, check sealing of filler cap.



Caution:

When working on the fuel system, keep naked lights away, do not smoke!
Do not spill any fuel!



Renewing the Two-stage Fuel Filter Cartridge (1st stage)

- In case of high-level tank, close fuel cock.
- Place receptacle in position to catch draining-off fuel.
- Unscrew drain plug 2 (Fig. 56).
- Release clamping pin 3.
- Remove water bowl 5 and the two seals 4 and 6.
- Unscrew cartridge 1 from bracket and replace by new cartridge.
- Refit water bowl in reverse sequence, taking care that seals 4 and 6 are properly seated.
- Air-bleed fuel system (see page 82).

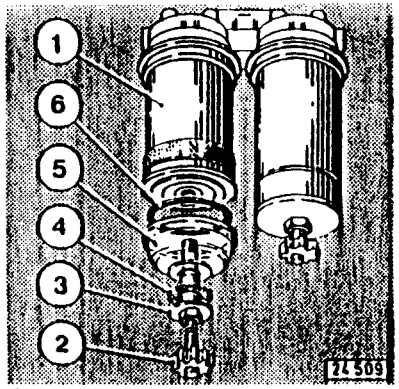


Fig. 56



Renewing the Two-stage Fuel Filter Cartridge (2nd stage)

- In case of high-level tank, close fuel cock.
- Place receptacle in position to catch escaping fuel.
- Unscrew filter cartridge 1 (Fig. 57) complete with drain plug by means of hexagon 2 at the bottom.
- Clean sealing surface.
- Apply a light film of oil to the rubber gasket of the new filter cartridge and screw new cartridge in place by hand until gasket is evenly seated, then give cartridge a final half-turn.
- Air-bleed fuel system (see page 82).

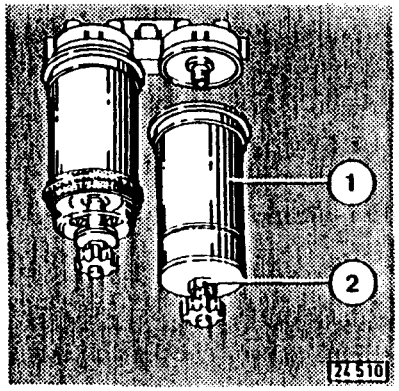


Fig. 57

Note:

Falling-off engine performance can be due to clogged filter cartridges. If the filter cartridges clog up too quickly, check fuel for contamination, clean tank, check sealing of filler cap.

Caution:

When working on the fuel system, keep naked lights away, do not smoke!
Do not spill any fuel!

Testing the Flame-type Heater Plug before the Cold Season begins or in Case of Starting Difficulties

Note:

When the heater plug functions properly, the intake pipe 4 (Fig. 58) should become fairly warm in the zone of the plug during the starting process with preheating (page 91). If not, check in stages as follows:

Test Stage 1

- Place speed control/stop lever in position "Stop"
- Insert switch key 4 (Fig. 59). Battery charging indicator lamp should then light up.
- Preheat for 1 minute in preheating position I of heater plug/starter switch 3 (Fig. 59). Heater plug indicator 5 should then light up brightly. If not, the plug is faulty or connection is interrupted.

Test Stage 2

- Loosen pipe coupling 1 (Fig. 58) by a few turns.
- Turn heater plug/starter switch at once to position 2 to turn engine by starter.
- Fuel should emerge at the slackened pipe connection. If not, have the system (solenoid valve) checked by a specialist!

Test Stage 3

- Remove flame-type heater plug and reconnect fuel line to plug.

  Turn engine with starter.

  Fuel should now emerge at plug.

  If not, plug is blocked and must be renewed.

Caution:

Keep away from rotating parts!

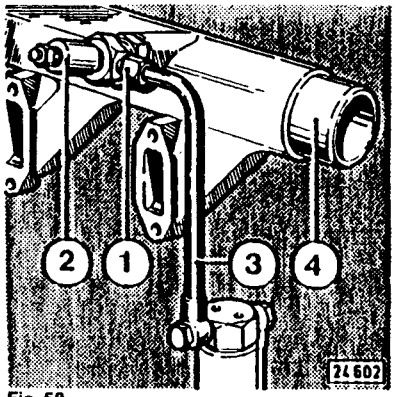


Fig. 58

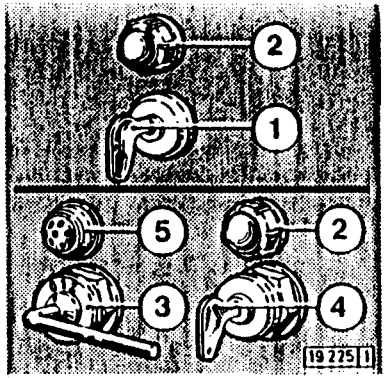


Fig. 59

Inspecting Air Intake and Exhaust Manifolds

Check the connections of air intake manifold 1 (Fig. 60) and exhaust manifold 2 to the cylinder heads for tightness and retighten if necessary.

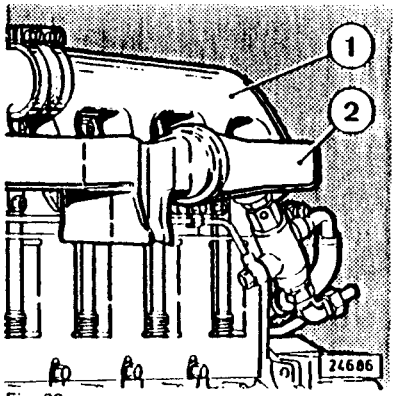


Fig 60

Testing Temperature Indicator/Pilot Light

Unscrew sensor or switch 1, as provided (Fig. 61), from cylinder head 2 and immerse in SAE 30 or SAE 40 oil heated to 150 – 155 °C (302 – 311 °F). This should cause the red sector to appear in the window of the indicator or the lamp, if provided, to light up.

Caution:

Heat the oil in a container on a hot-plate (not with welding torch). Do not exceed the specified temperature range. Danger of burns.

Note:

The temperature elements 1 (sensor or switch) are always screwed into the head of the No. 1 cylinder.

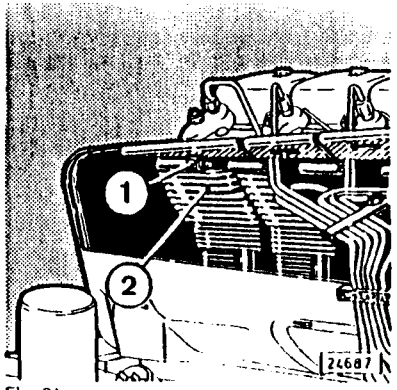


Fig 61

Testing Alternator

It is advisable to have the alternator 1 (Fig. 62) tested in a specialized workshop.

Notes on three-phase system:

- When the engine is running, never disconnect the leads between battery, alternator and regulator. Where it is however necessary to operate the engine without battery, disconnect, before starting, the alternator from the regulator.
- Never interchange the battery leads.
- Renew a defective charging pilot light bulb immediately.
- Before washing the engine, fit covers to protect the alternator and regulator.
- The common practice on a DC-system of touching a lead against earth for checking whether the lead is live must under no circumstances be adopted on a three-phase current system.
- In case of electric welding, connect the earth terminal of the welding unit direct to the piece to be welded.

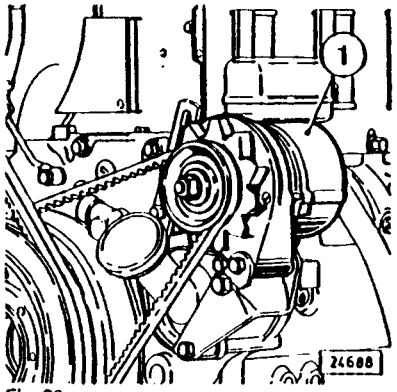


Fig. 62

Testing Starter Motor

It is advisable to have the starter motor 1 (Fig. 63) tested in a specialized workshop.

Note:

Cover up starter motor before washing engine.

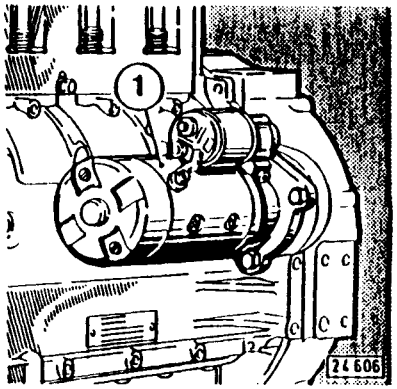


Fig. 63

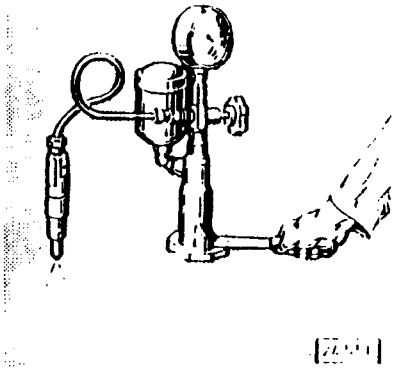
Workshop Maintenance

Testing Injectors

- Remove injectors.
- Have the injectors tested in a specialized workshop. For specified injection pressure, see Specification Data, pages 72 and 73.
- When refitting the injectors, observe tightening torque (see page 127)!

Note:

Inspection of the injectors between the times stated on page 95 is unnecessary unless the engine displays unusual symptoms (e.g. black exhaust smoke, harsh combustion noises).


Fig. 64

Caution:

To prevent personal injury, do not allow the pressurized spray-jet to come into contact with the skin!

Engine Preservation

If your engine is to be shut down for a major period (e. g. over the winter), we recommend the following preservation measures against rust formation.

1. Clean the engine, including the cooling system, with commercial detergent and a water-jet or, better, a high-pressure jet (see page 107).
2. Run engine up to working temperature and then shut down.
3. Drain the motor oil from the sump when still hot and fill in anti-corrosive oil.
4. Pour the oil out of the bowl of the oil bath air cleaner, clean bowl and fill up with anti-corrosive oil.
5. Drain fuel from tank, mix well with 10 % anti-corrosive and fill back into tank. Instead of adding anti-corrosive oil to the fuel, the tank can be filled up with injection pump testing oil having corrosion inhibiting properties (e. g. Calibration Fluid B).
6. Run engine for about 10 minutes, so that pipes, filter, pump and nozzles are filled with the preservative mixture and the mixture is distributed to all parts.
7. After this run, detach the rocker chamber covers and spray the rocker chambers with a mixture of diesel fuel and 10 % anti-corrosive or with injection pump testing oil. After this, refit the covers.
8. Now turn the engine over several times without firing in order to spray the mixture into the combustion chambers.
9. Remove V-belts and spray the grooves of the V-belt pulleys with anti-corrosive. Before reusing the engine, wipe off the anti-corrosive.
10. Close intake opening of air cleaner and exhaust opening tightly.

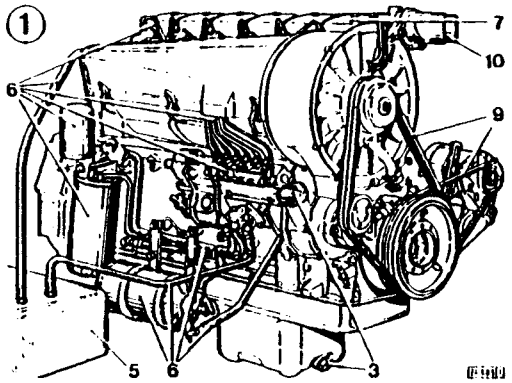


Fig. 65

Note:

These preservative measures will give the engine a protection of 6 to 12 months, depending on weather effects.

Before reusing the engine, replace the preserving mixture by regular motor oil to API Specifications.*

The anti-corrosive oils used should conform to MIL-L-21260 B or TL 9150-037/2 specifications or NATO Code C 640/642.

* See page 104

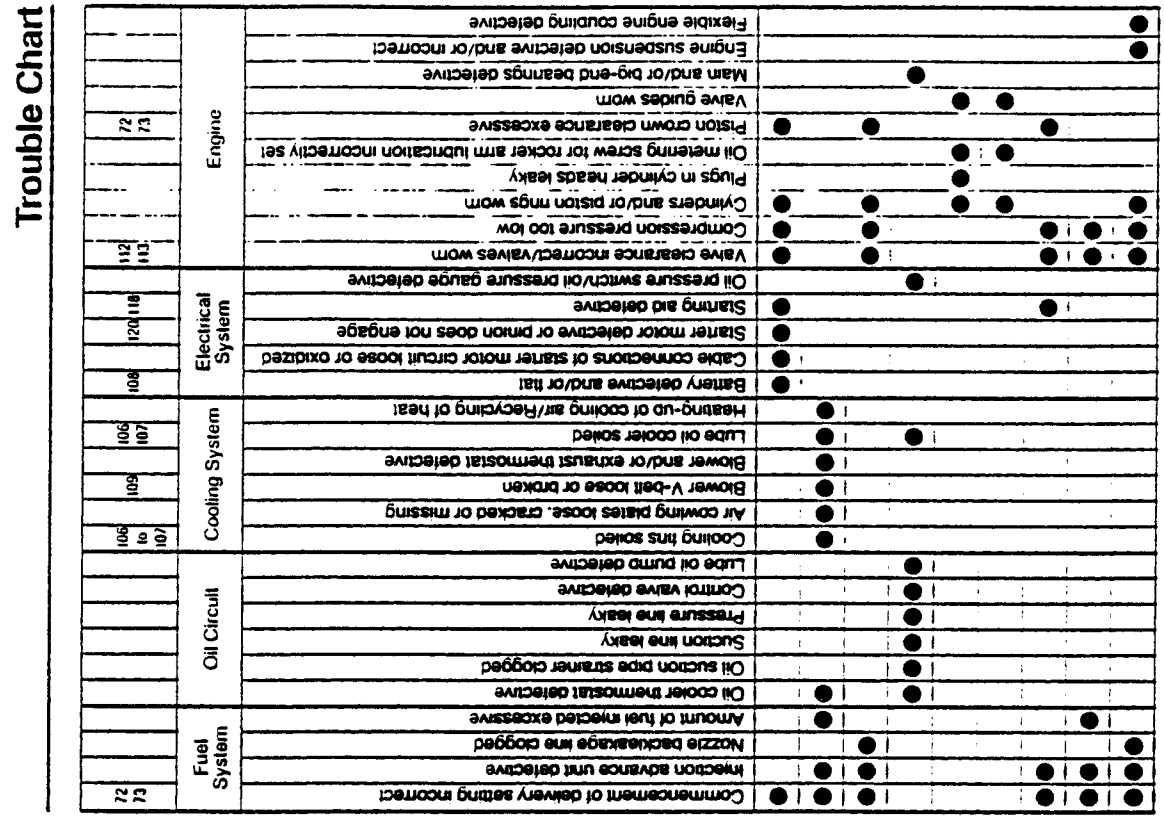
Trouble Shooting

If troubles should occur, these will be frequently due to incorrect operation, lubrication or maintenance of the engine. In such a case, therefore, make a point of thoroughly re-reading the Sections on pages 82 to 121.

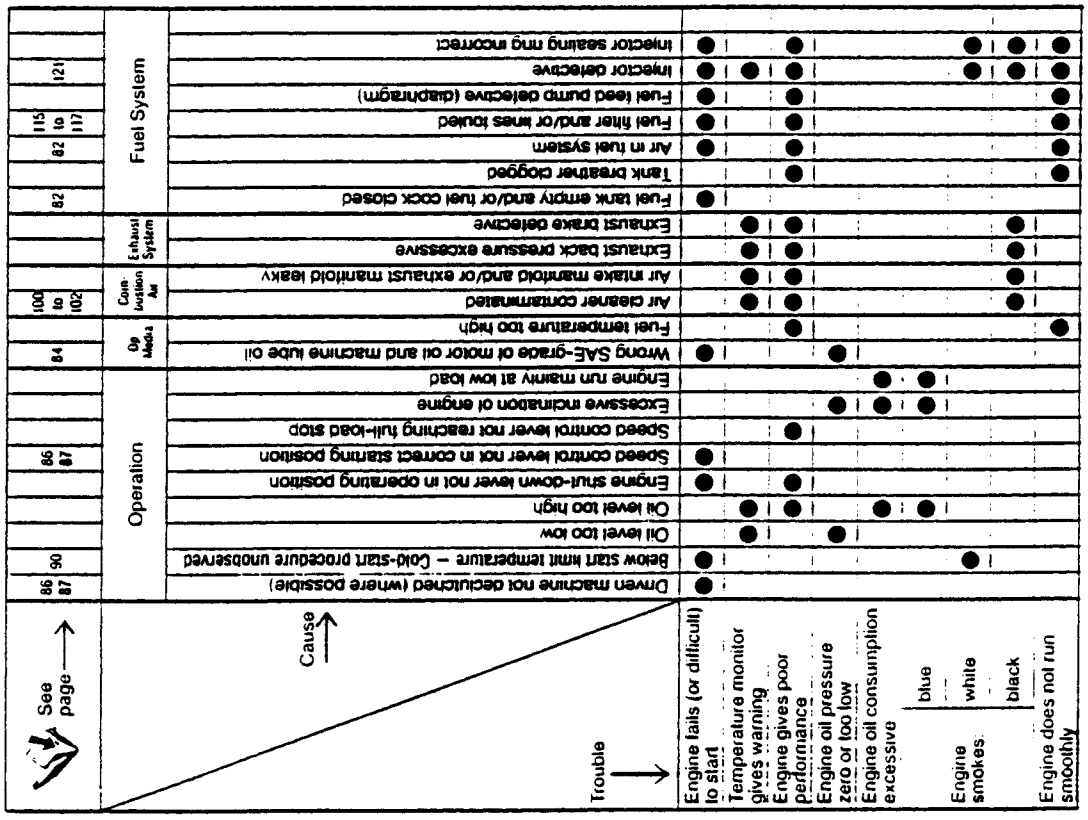
If you cannot identify the cause of the trouble or are unable to put it right yourself, the best plan is to contact your local DEUTZ distributor.

See Trouble Charts on pages 124 and 125.

Trouble Chart



Trouble Chart



REV.

Workshop Information

The Workshop Manual dealing with the engines described in this Instruction Manual bears the number 291 1842 and can be ordered from our headquarters in Cologne, Department MZA.

Tightening Heavy-duty Bolts and Nuts

To prevent faulty assembly, the following information includes instructions on the tightening of heavy-duty bolts, because the procedure differs from that normally employed. The tightening angle is particularly important and, for this reason, Fig. 66 indicates how various angles can be readily obtained by comparison with a clock face.

1. **Wet threads and seatings with motor oil before fitting.**
2. **Screw the bolts in until they are uniformly positioned ready for pre-loading.**
3. **Pre-load the bolts to the value stated in the "Tightening Table for Bolts and Nuts" on page 127.**
4. **Tighten the bolts according to the Table, if necessary in stages, in conformity with the tightening angles specified.**

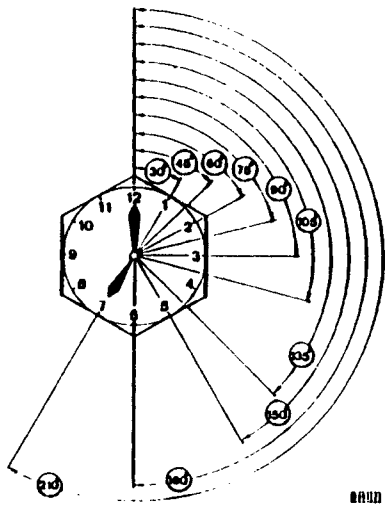


Fig. 66

Tightening Table for Bolts and Nuts

Designation		Pre-loading Nm	Tightening 1st stage	2nd stage	3rd stage	Total	Note
Cylinder head	210 1681	30	45°	45°	45°	135°	
Connecting rod	213 3871	30	30°	60°	–	90	
Bearing cap	BM 14 x 110	30	40°	65°	–	105°	
Idler gear	M 10 x 60	30	60°	–	–	60	
Balance weight	M 12 x 60	30	30°	30°	–	60	
Flywheel	M 10 x 1 x 35	30 30	30° 30°	60° 30°	– –	90 60	Waisted bolt H 803 Bolt DIN 961
Flywheel	M 10 x 1 x 40	30 30	30° 30°	60° 30°	– –	90 60	Waisted bolt H 803 Bolt DIN 961
Flywheel	M 10 x 1 x 45	30 30	30° 30°	60° 30°	– –	90 60	Waisted bolt H 803 Bolt DIN 961
Flywheel	M 10 x 1 x 50	30 30	30° 30°	60° 30°	– –	90 60	Waisted bolt H 803 Bolt DIN 961
Injectors	M 10 DIN 934-8 B 4 C	–	–	–	–	–	Tightening torque 25 Nm
V-belt pulley	M 24 x 2 x 110	50	210°	–	–	210	Left-hand thread
Cooling blower	M 12 x 140	30	–	–	–	90°	
Cooling blower	M 12 x 180	30	–	–	–	90°	
Filter carrier	M 10 x 160	30	30°	60°	60°	150	
Alternator	M 10 x 180 M 14 x 230	30 30	180° 150°	– –	– –	180° 150°	
Idler pulley	213 6384	30	45°	–	–	45	
Engine suspension	M 14 x 100	30	15°	60°	–	75°	
Engine suspension	M 14 x 110	30	45°	60°	–	105°	
Engine suspension	M 14 x 125	30	45°	60°	–	105°	
Advance/retard unit	M 12 M 14 x 1.5	–		–	–		60 ± 10 Nm 80 ± 10 Nm

Note:

When renewing main and big-end bearings or after piston seizures, be sure to renew the bearing bolts as well.

Workshop Information

Fitting Valve Springs

Be sure the close-coil end is at the bottom (Fig. 67).

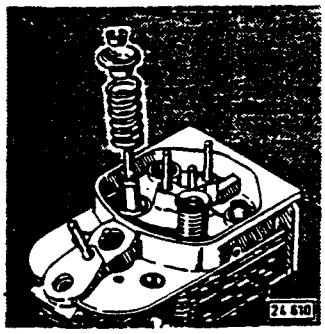


Fig. 67

FL 912 (Direct Injection)

When fitting a new piston, make sure that the stamped-in arrow points to the exhaust-air side of the engine (Fig. 68).

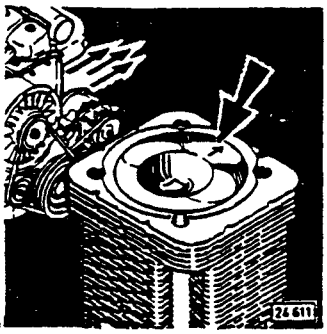


Fig. 68

FL 912 W (Two-stage Combustion)

When fitting a new piston, make sure that the stamped-in arrow points to the exhaust-air side of the engine (Fig. 69).

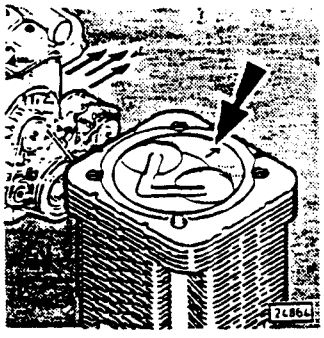


Fig. 69

FOREWORD

This manual has been prepared to provide the necessary information for the operation, inspection and maintenance of the Nissan Diesel engine.

We strongly recommend that you read this manual throughly and familiarize yourself with the information and procedures contained herein. Only in this way is it possible to ensure proper operation and maintenance, with a minimum of difficulty and with the utmost safety.

This manual is based upon information which is applicable to the standard engine. Should you have any problem understanding the information, please contact the nearest Nissan Diesel Service Station for assistance.

ENGINE SERIAL NUMBER 1
NAMES OF PARTS 1
HANDLING OF VARIOUS DEVICES 5
OPERATION 7
HANDLING UNDER SPECIAL CONDITIONS 10
PRELIMINARY INSPECTION 14
INSPECTION AND MAINTENANCE 16
TROUBLE-SHOOTING 26
TABLE OF PERIODIC INSPECTION ITEMS 30
RECOMMENDED LUBRICANTS, FUEL AND ANTI-FREEZE 33
SYSTEM DIAGRAMS 36

Metric units are used as the unit of measure throughout this manual. When conversion to the corresponding U.S. system is necessary, use the following table:

1 mm	0.0394 in.
1 m	3.2808 ft.
1 km	0.6214 mile

$t\,(°F) = 32 + \frac{9}{5} T\,(°C)$

1 kg	2.205 lb
1 liter	0.22 Imp. gal.
1 liter	0.264 U.S. gal.
1 kgm	7.23 lb. ft.
1 kg/cm^2	14.223 psi
1 km/h	0.6214 mph.

Nissan Diesel reserves the right to make changes for improvement at any time without notice.
Accordingly, some of the descriptions contained in this manual may not be applicable to your particular vehicle.

Automotive Use	Automotive engine. SD22, SD25, SD33, SD33T
Industrial Use	Engines for construction machinery, and engines as general power units. SD16, SD22, SD25, SD33

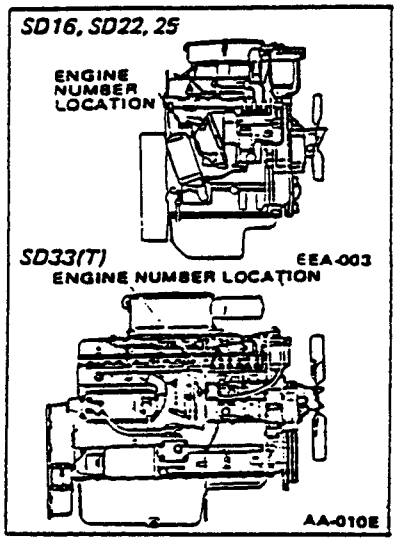
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Issued: June 1983 8306161-56-1,000-S(M)

ENGINE SERIAL NUMBER

The engine serial number given to each engine indicates the type of engine and its manufactured sequence. When ordering parts at the Service Station or asking for repair, this engine serial number should also be given to ensure smooth and quick service.

LOCATION OF ENGINE SERIAL NUMBER

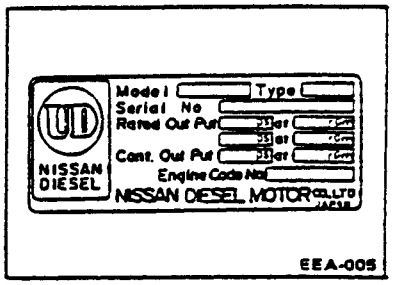


FORMAT OF ENGINE SERIAL NUMBER

SD16 – XXXXXX
SD22 – XXXXXX
SD25 – XXXXXX
SD33 – XXXXXX
SD33 – XXXXXXT

- XXXXXX: Engine serial number
- T: Engine model designation

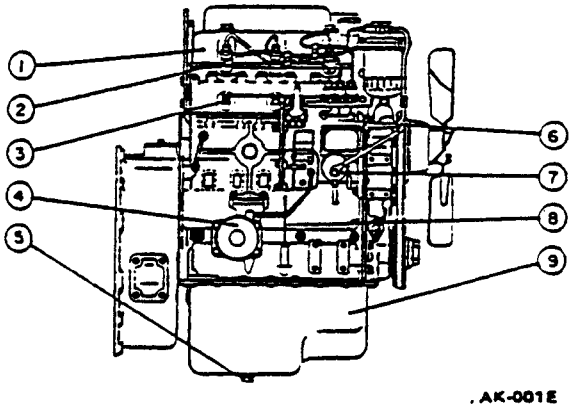
ENGINE NAME PLATE



The engine name plate is attached to the rocker cover, and the engine serial number, engine model and engine performance data are stamped on the plate.

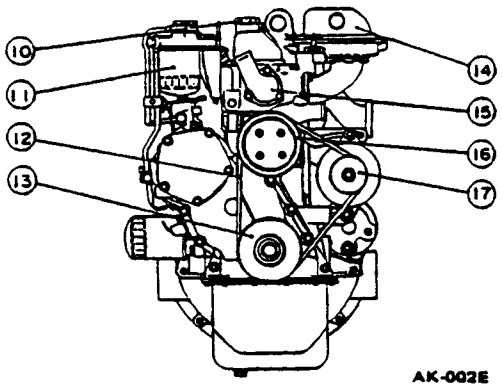
NAMES OF PARTS

MODEL SD16 ENGINE



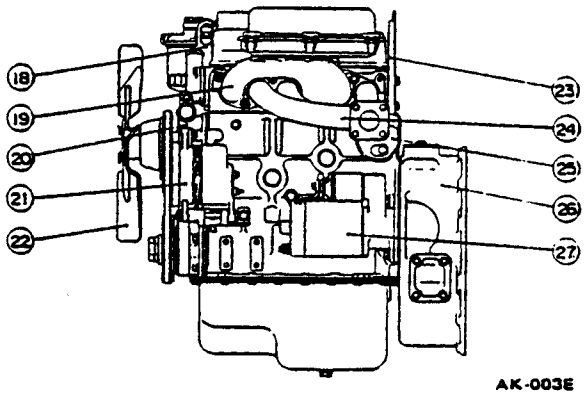
Right-hand side view

1	Rocker cover	6	Fuel injection pump
2	Injection nozzle	7	Feed pump
3	Glow plug	8	Oil level gauge
4	Oil filter	9	Oil pan
5	Drain plug		



Front side view

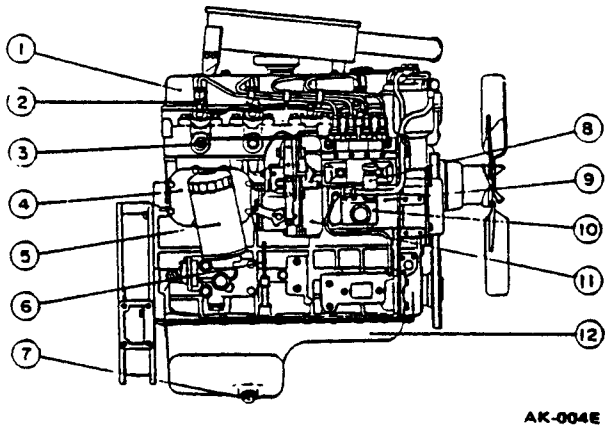
10	Oil filler	14	Air cleaner
11	Fuel filter	15	Water outlet
12	V-belt	16	Fan pulley
13	Crank pulley	17	Generator pulley



Left-hand side view

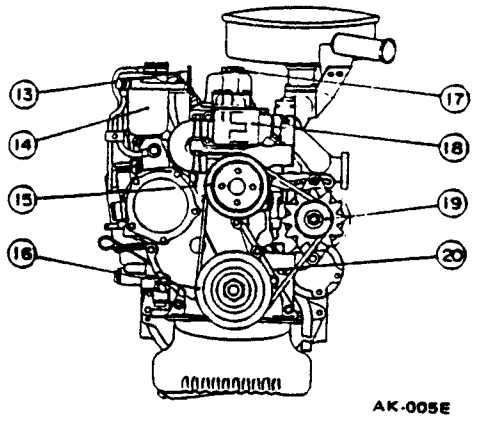
18	Front engine lifter	23	Rear engine lifter
19	Air intake manifold	24	Exhaust manifold
20	Water pump	25	Air breather
21	Generator	26	Flywheel housing
22	Cooling fan	27	Starting motor

MODEL SD22 and 25 ENGINE



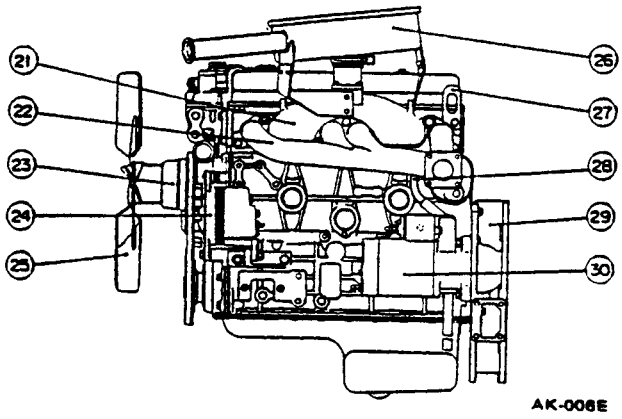
Right-hand side view

1	Rocker cover	7	Drain plug
2	Injection nozzle	8	Priming pump
3	Glow plug	9	Fuel injection pump
4	Oil cooler	10	Feed pump
5	Oil filter	11	Governor
6	Oil level gauge	12	Oil pan



Front side view

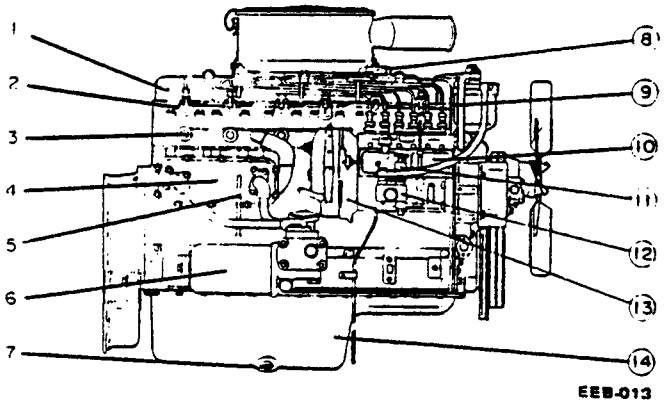
13	Front engine lifter	17	Oil filler
14	Fuel filter	18	Thermostat housing
15	Fan pulley	19	Generator pulley
16	Crank pulley	20	V-belt



Left-hand side view

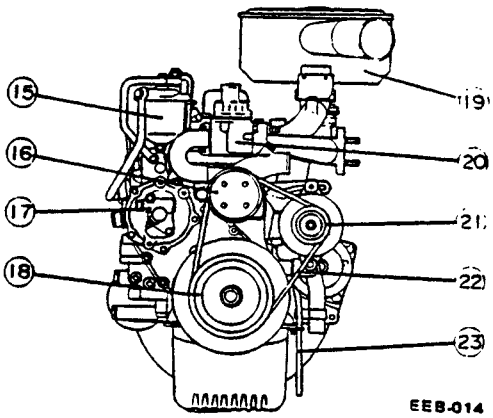
21	Air intake manifold	26	Air cleaner
22	Exhaust manifold	27	Rear engine lifter
23	Water pump	28	Air breather pipe
24	Generator	29	Flywheel housing
25	Cooling fan	30	Starting motor

MODEL SD33 ENGINE



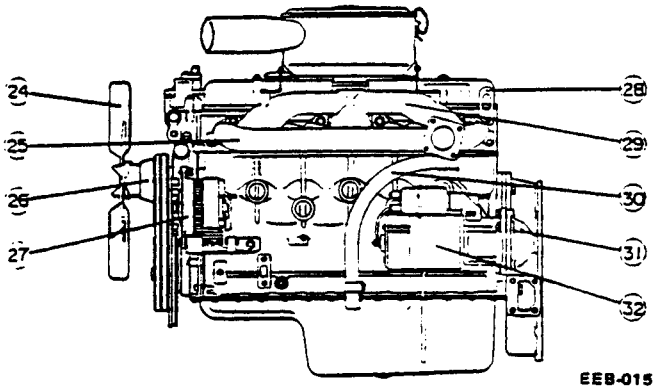
Right-hand side view

1	Rocker cover	8	Oil filler
2	Injection nozzle	9	Front engine lifter
3	Glow plug	10	Fuel injection pump
4	Oil cooler	11	Priming pump
5	Oil level gauge	12	Feed pump
6	Oil filter	13	Governor
7	Drain plug	14	Oil pan



Front side view

15	Fuel filter	20	Thermostat housing
16	Fan pulley	21	Generator pulley
17	Hour meter driver	22	V-belt
18	Crank pulley	23	Water drain hose
19	Air cleaner		



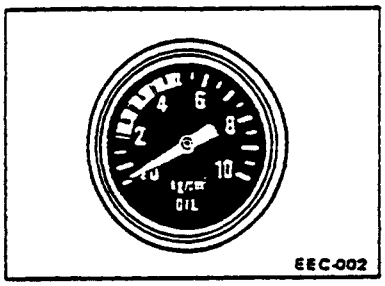
Left-hand side view

24	Cooling fan	29	Air intake manifold
25	Exhaust manifold	30	Air breather pipe
26	Water pump	31	Flywheel housing
27	Generator	32	Starting motor
28	Rear engine lifter		

HANDLING OF VARIOUS DEVICES

Meters and Gauges (Reference)

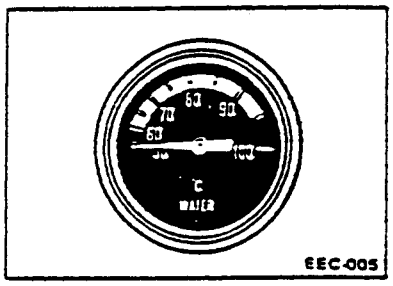
OIL PRESSURE GAUGE



EEC-002

The needle pointer indicates the pressure of engine lubricating oil. Normal pressure during engine operation is 2.0 to 5.0 kg/cm^2.

WATER TEMPERATURE GAUGE

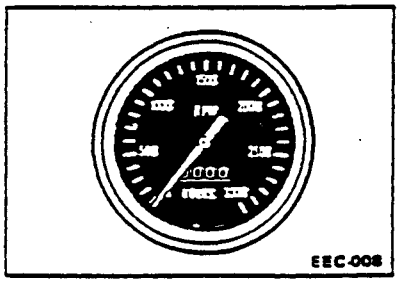


EEC-005

The needle pointer indicates the temperature of engine cooling water. Normal temperature during normal engine operation is around 80°C.

Meters and gauges (Reference) 5
Switches and controls (Reference) 6
Alarm devices (Reference) 6

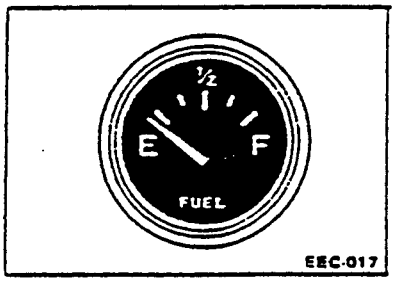
HOUR METER AND ENGINE TACHOMETER



EEC-008

The needle pointer indicates the engine rpm. The engine speed should never exceed the rated rpm.
The hour meter registers the total operating hours of the engine (equivalent to operation at 1,600 rpm).

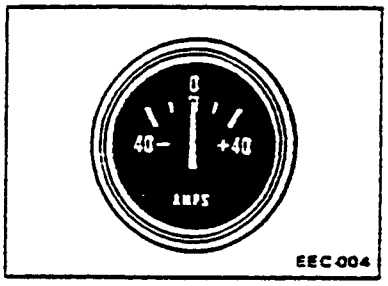
FUEL GAUGE



EEC-017

The needle pointer indicates the amount of fuel in the fuel tank. Fuel should be added to the tank when the needle approaches the "E" position.

AMMETER

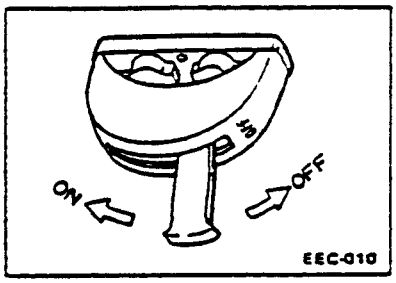


EEC-004

The needle pointer indicates the charge level of the battery. During engine operation, the needle should be on the "0" or to the "+" side of the meter scale.

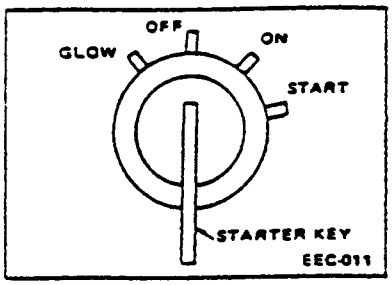
Switches and Controls (Reference)

MAIN SWITCH



The main switch is used to connect and disconnect the circuit between the engine and the battery. Before starting the engine, set this switch at the "ON" position.
During engine operation, never move the switch from the "ON" position; otherwise, electrical units may be damaged.

KEY SWITCH

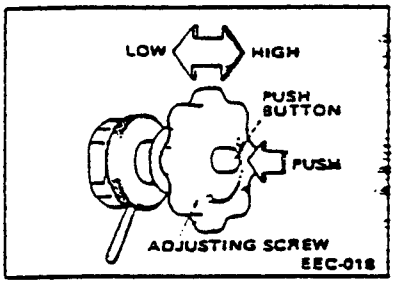


OFF: Engine stop position
After the engine has stopped, return the key to this "OFF" position. The key can be either inserted or taken out at this position.
ON: Engine operation position
During engine operation, never move the key switch from this "ON" position; otherwise, electrical units may be damaged.
START: Engine starting position
Do not leave the key switch at the "START" position for more than 15 seconds at a time. Wait about 20 seconds before trying to start the engine again.
GLOW: Preheating position
Use this position for starting the engine easily. However, do not use this position for more than 40 seconds at a time, and be sure to wait about 20 seconds, before using it again.

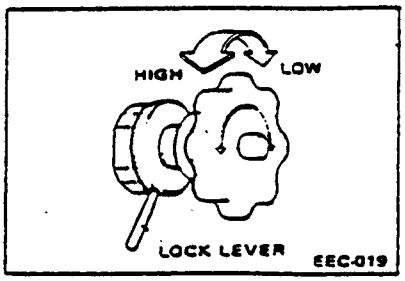
ENGINE CONTROL BUTTON

The engine control button is used to adjust engine rpm and to stop the engine.

Engine rpm adjustment



Approximate adjustment



Precise adjustment

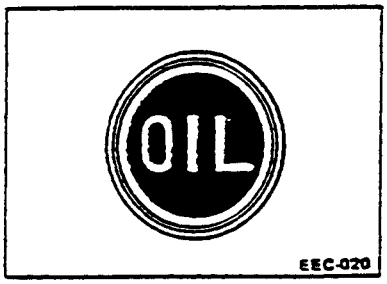
To adjust engine rpm approximately, depress the push button, and then operate the adjusting screw. The adjusting screw will be fixed upon release of the push button.
To adjust engine rpm precisely, simply turn the adjusting screw, without depressing the push button.
The engine control button is fixed when the lock lever is tightened by turning it fully clockwise.

Stopping engine

Release the lock lever by turning it fully counterclockwise, and fully depress the adjusting screw while pushing the push button. This will stop the engine operation.

Alarm Devices (Reference)

OIL PRESSURE WARNING LIGHT



If the lubricating oil pressure drops below the specified level during engine operation, this light lights up to warn the driver of low oil pressure. Do not operate the engine when the lubricating oil pressure is low; otherwise, engine trouble may result.

CHARGE WARNING LIGHT



If any failure occurs in the charging circuit during engine operation, this light lights up as a warning to the driver. If this warning light lights up occasionally or steadily during engine operation, check the charging circuit and make the necessary correction.

OPERATION

Check prior to engine operation (Preliminary inspection) 7
Handling of new engine 7
Engine handling precautions 7
Starting and operating the engine 8
Cautions during operation 8
Stopping the engine and completion of the day's operation 9

ENGINE OIL

Change the engine oil after the first 25 hours of operation or 1,000 km of driving.

Check Prior to Engine Operation (Preliminary Inspection)

In order to prevent engine trouble, the driver must always be aware of the condition of the engine. To this end the driver is required to inspect the engine himself before starting the day's operation. This is called the "Daily inspection".

Engine Handling Precautions

When handling the engine, be sure to observe the following precautions:

WHEN STARTING THE ENGINE

1. After starting up, make sure that the lubricating oil pressure is higher than 0.5 kg/cm^2, or that the "OIL" warning light is OFF.
2. Warm up the engine until it runs smoothly, emitting normal exhaust gases (colorless or light bluish).
3. During this warming up operation, or when the cooling water temperature is still low, never attempt to race the engine.

DURING ENGINE OPERATION

1. During operation, always make sure that the cooling water temperature and lubricating oil pressure are both normal. Normal cooling water temperature is 75 to 80°C.
   Normal oil pressure is over 0.5 kg/cm^2 during idling, and is 2.0 to 5.0 kg/cm^2 during normal operation. Oil pressure is normal if the "OIL" warning light remains OFF during engine operation.

Handling of New Engine

The life and performance of an engine are greatly influenced by how it is handled and serviced during the initial period.
Operate the engine by observing the following the precautions during the initial 100 hours of operation, or initial 4,000 km of driving.

CAUTIONS IN OPERATION

1. After starting, warm the engine throughly by means of warming-up operation until the cooling water temperature rises above 50°C.
2. Never attempt to race the engine under non-loaded conditions.
3. Avoid sudden starts and sudden stops. (Automotive engine only)
4. Never overload the engine. (Automotive engine only)
   Note that overloading will shorten the service life of an engine.
5. Always maintain the operating speed of the engine below 70% of the maximum engine rpm.
6. Avoid overloading. (Engines for construction machinery, and engines as general power units)

2. Always be aware of the condition of the engine, paying attention to any abnormal vibration, noise or other unusual circumstances. If any abnormality is found, immediately stop the operation, examine the cause, and make the necessary correction.

WHEN STOPPING THE ENGINE

Upon completion of operation, idle the engine for some time to lower its temperature before stopping. This procedure will help to extend the engine life.
Note that stopping the engine immediately after high speed driving or heavily loaded operation will deteriorate the engine because it is still in an overheated state.

OTHERS

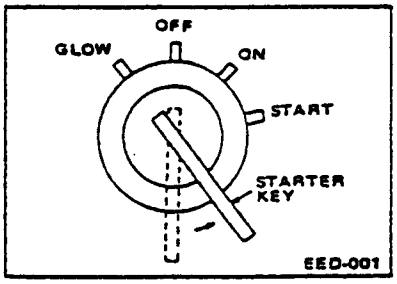
Perform periodical inspection and replacement of the following items:
Engine oil, oil filter element, air cleaner element, fuel filter element.
Use the recommended API service class CD engine oil. Use genuine Nissan Diesel parts for the cleaner and filter element.

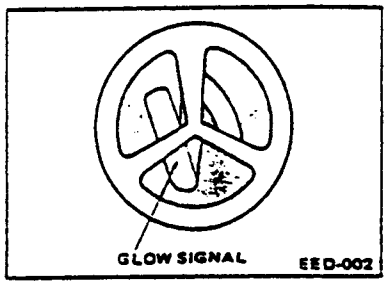
Starting and Operating the Engine

STARTING PROCEDURE

1. Insert the engine key into the key switch.
2. Set the main switch at the "ON" position.
3. Turn the key switch to the "GLOW" position to preheat the glow plug.

The glow plug indicator will turn red in 10 to 15 seconds indicating that the glow plug is already heated.
Note that prolonged use of the glow plug for more than 40 seconds may burn out the heater wire in the plug.





4. During this preheating operation, pull the adjusting screw of the engine control button all the way out while pushing the button.
5. When the glow plug indicator has turned red, set the engine key at the "START" position.

1. **Do not hold the engine key in the "START" position for more than 15 seconds at a time. Holding this position too long may shorten the life of the battery, or damage the starting motor.**
2. **Be sure to wait about 20 seconds before trying again.**

6. When starting, release the engine key, and return the adjusting screw to its original position.
7. Turn the adjusting screw to adjust engine idling speed, and to perform warming-up operation.
   In this case set the engine speed slightly higher, and readjust the speed after the warming-up operation is over. Never race the engine during this warming-up period.

Cautions During Operation

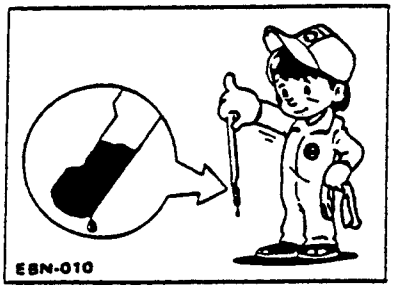
During engine operation, the warning light should remain OFF. If it comes ON, immediately stop operation, and take the actions that are described below.
If any other abnormalities such as unusual noise, vibration, or shocks are observed, again, stop the operation, and make the necessary inspection and repair.

LOW ENGINE OIL PRESSURE

Oil pressure warning light is ON, or oil pressure gauge indication is below 0.5 kg/cm^2.

Trouble
The oil pressure is low due to failure in the engine lubricating system. If operation is continued, the engine's moving parts may be seized, resulting in a disabled engine.

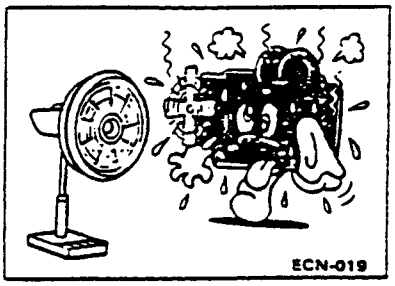
Corrective action
1. Immediately stop the engine operation.
2. Check each portion of the engine for any sign of an oil leak. If any oil leak is found, examine the cause and make the necessary correction.
3. Check the engine oil level after the engine has been stopped for at least 30 minutes.
   If the oil level is below the "L" mark on the oil level gauge, add engine oil up to the "H" mark.



4. If no oil leak is detected and the oil level is normal, something else is causing the trouble. Have the engine checked and repaired by the Service Station.

ENGINE OVERHEATING

Water temperature gauge is pointing to around 100°C, and the temperature not lower quickly.



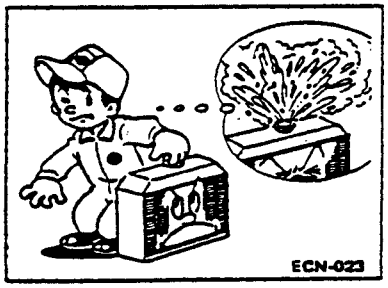
Trouble
The engine is overheated due to failure of the cooling system. Continued engine operation will lead to seizure in each portion of the engine, finally disabling the engine.

Corrective action
1. Immediately stop whatever operation is being performed. In this case do not stop the engine; run the engine at high idle until the water temperature comes down.

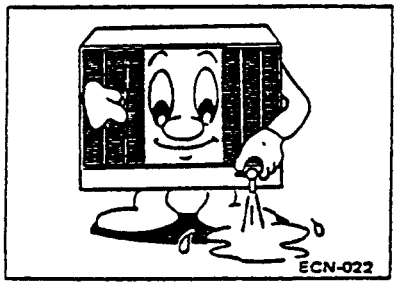
2. Check each portion of the engine and the radiator for any sign of a water leak.
3. Using a cloth to avoid the danger of being burned by hot steam, slightly loosen the radiator cap to release pressure in the radiator. After the pressure has been released and a hissing sound can no longer be heard, remove the cap.

1. Do not remove the radiator cap without first releasing the pressure inside the radiator, because scalding water and steam will spout out, possibly causing serious injury.

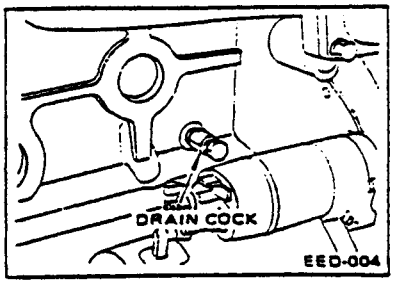
2. If the cap is provided with a pressure releasing push button, be sure to depress it and release the pressure before removing the cap.



4. If the cooling water level is up to the filler neck of the radiator and no water leak is detected, have the engine checked and repaired by the Service Station.
   If the cooling water level is too low, slightly open the drain valve of the radiator or engine while carefully adding new cooling water so that the change in cooling water will be gradual. By using this method, gradually lower the engine temperature.



Radiator



Left side view of cylinder block

Be sure to continue the idling operation of the engine when adding new cooling water, because sudden addition of cold water into an overheated engine when it is stopped will cause great stress in the engine, leading to a cracked cylinder block.

5. After the temperature has lowered, checked for faulty parts. If the cause is not found or if repair is impossible, have the engine checked and repaired by the Service Station.

Stopping the Engine and Completion of the Day's Operation

STOPPING THE ENGINE

When operation of the engine is over, run the engine at idling speed to lower the engine temperature before stopping.

1. Using the engine control button, stop the engine.
2. Return the key switch to the "OFF" position.
3. Return the main switch to the "OFF" position.

AT COMPLETION OF THE DAY'S OPERATIONS

1. Make sure that there is no oil leak, water leak, or any other defects.
2. Clean the exterior of the engine so that any oil leak, water leak, fuel leak or other defect may be easily detected.
3. If antifreeze is not used in the cooling system in cold weather, be sure to discharge the cooling water to prevent freezing.
4. Repair any faulty parts detected during operation.

HANDLING UNDER SPECIAL CONDITIONS

Care in hot weather 10
Care in cold weather 10
Flushing of cooling system 11
Operating under adverse conditions 12
Precedures for preparing the engine when it will be out of operation for an extended time 12

LUBRICATING OIL

The viscosity of engine oil lowers when atmospheric temperature increases and this decreases the lubricating effect. Use engine oil which has higher viscosity and suits the atmospheric temperature condition.

BATTERY

Insufficienty battery electrolyte will result in damaged plates. Keep the electrolyte at the specified level (10 to 15 mm above the plate), and maintain the specific gravity of electrolyte within the specified range (1.250 to 1.270 at electrolyte temperature 20°C).

V-BELT

Always maintain the proper tension on the V-belt.

OTHERS

Check each portion of the engine, and take the necessary precautions to protect it against high temperatures.

Care in Hot Weather

In hot weather engine overheating may occur easily due to fast evaporation of water. Take the following precaution's to prevent engine overheating:

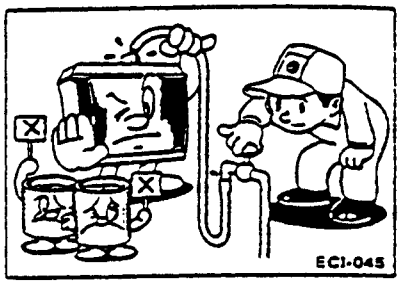
COOLING WATER

Make sure that the cooling system is filled with clean water. Insufficient water and formation of scale can cause overheating.

Scale and rust may be easily formed in the cooling water passage of the radiator and engine when the atmospheric temperature is high. To prevent clogging, change the cooling water from time to time so that clean water flows through the passage. Accumulation of dirt, dust, or mud on the front portion of the radiator and core obstructs the normal flow of air, causing a reduction in cooling efficiency. Always keep the radiator and core clean.

Be sure to use clean, soft water such as processed city water when adding cooling water to the radiator. Do not use hard water such as well water or river water because such water can easily form scale.

If cooling water is contaminated due to formation of scale or rust, flush out the cooling water passage.



Care in Cold Weather

Low temperatures may cause a loss of engine power when starting and difficulty in starting the engine due to decreased battery capacity, as well as other problems. When the temperature falls below 0°C, the engine and radiator may suffer damage resulting from frozen cooling water, and the battery case may be damaged by frozen electrolyte. To avoid such troubles, be sure to take the following precautions:

COOLING WATER

When antifreeze is not used

After completion of the day's operations, open the drain valve and throughly drain the cooling water. This will prevent frozen water in the cooling system from obstructing normal feeding of water, which in extreme situations can cause damage to the engine and radiator. Before beginning the next day's operations, fill the water and run the engine until the cooling water level stabilizes at the specified level. After the level is stablized, bleed air from the cooling system.

When using antifreeze

The above described procedure will be unnecessary if antifreeze is used in the cooling system.

Flush the cooling system, and pour in the amount of antifreeze recommended by Nissan Diesel.

Precautions for handling antifreeze solution

General precautions on the use of antifreeze are set forth below: When using a recommended brand of antifreeze, always follow the manufacturer's instructions.

1. Limit the use of antifreeze to the winter only. After winter is over, drain the coolant from the cooling system, and flush it thoroughly before adding fresh water and an anti-rust agent.
2. If the coolant level is lowered naturally while antifreeze is being used, add undiluted antifreeze or 50% diluted solution of antifreeze.
3. The antifreeze mixture ratio must be 45 to 60%. Excessively thin or thick mixture will reduce the antifreeze's effect and also reduce its rust and

corrosion prevention powers.

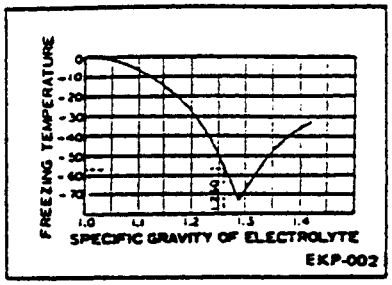
4. Always use city water or other soft water to mix the antifreeze solution.
5. Do not mix different brands of antifreeze because they each contain special additives. Careless mixing often diminishes the effect of these additives.
6. Be sure to flush the interior of the cooling system thoroughly before and after antifreeze is used.
7. Before using any antifreeze, carefully check the engine, radiator and hoses for any sign of water leakage.
8. Do not use antifreeze that has already been used once.

LUBRICATING OIL

The viscosity of engine oil increases as the atmospheric temperature lowers, causing low engine speed when the engine is started. To prevent such trouble, use engine oil which has lower viscosity relative to atmospheric temperature.

BATTERY

Main tain the specific gravity of battery electrolyte within the specified range (1.250 to 1.270 at electrolyte temperature of 20°C). Since a low electrolyte temperature may cause difficut starting due to reducted charge or damage the battery as a result of frozen electrolyte, keep the battery warm in very cold weather.



Relation between specific gravity of electrolyte and freezing temperature

FUEL TANK

To minimize water in the air inside the tank, when adding fuel, it is recommended that the fuel tank be completely filled. This practice will prevent freezing and formation of rust in the fuel system which is caused by the condensation of water. Securely tighten the fuel tank cap to prevent a rainwater and snow from entering the tank.

OTHERS

When the engine is extremely cold, it takes a considerable time to raise the cooling water to the proper temperature (75 to 85°C). In such event, to more effectively raise the temperature of the cooling water, place a cover on the front face of the radiator. While operating the engine with the radiator cover attached, observe the water temperature gauge, and remove the cover when the proper temperature is attained.

If it is necessary to leave the engine exposed to the open air, place it in a sheltered location out of the rain and snow, and cover it with a suitable sheet or similar covering.

Flushing of Cooling System

Flush the interior of the cooling system before and after antifreeze is used or whenever any heavy contamination in the coolant is noticed. In addition, flush the system every six months. Flushing removes water scale and fat from the cooling system, and restores its original cooling efficiency, which greatly reduces the possibility of the engine overheating.

FLUSHING PROCEDURE

The cooling system must be flushed when the coolant temperature is higher than 80°C and the engine is run at high idle. If the water temperature is too low, the thermostat will remain closed, and the flushing agent will not circulate in the radiator, so no flushing effect will occur. It is also necessary to keep the heater inlet valves (both on the engine and the heater proper) open.

1. Drain the cooling water from each water drain cock completely.
2. Close the drain cock, and pour city water and flushing agent into the radiator.
3. Run the engine at high idling speed (refer to the flushing agent manufacturer's instructions). Cover the front end of the radiator to prevent the temperature of the fluid in the cooling system from dropping. Observe the fluid level carefully for five minutes after starting the engine. If it lowers, add city water.
4. After flushing, stop the engine, and thoroughly drain the fluid from each drain cock.
5. Close the drain cocks, and add fresh city water. Start the engine and run it at high idle until the water temperature goes above 80°C. Then stop the engine, and drain the water from the drain cocks once again.

   Repeat this operation two or more times, until only clean water is discharged from the drain cocks. Dirty or colored water from the drain cocks means that fat or scale is still in the cooling system.
6. After completing the flushing operation, close each drain cock securely, and add fresh city water up to the

specified level. Then start the engine, and purge the air from the system until the coolant level is stabilized at the specified position. If the coolant level lowers during this operation, add fresh city water.

Operating Under Adverse Conditions

WHEN USING THE ENGINE EITHER IN MUDDY AREAS, RAIN OR SNOW

Upon completion of preliminary inspection, insure that all the drain plugs and drain valves are tightened securely. After completing the day's operation, check the engine oil and fuel for water; if they contain any amount of water, change the oil or fuel.

WHEN USING IN DUSTY AREAS

Use special care to prevent dust from entering either the lubrictating oil or any portion of the engine. (Dust is particularly harmful to electrical units such as the generator and starting motor).
To extend the service life of the engine, observe the following procedures:

1. Check the air cleaner every 180 hours or every 4,000 km. Since contamination is heavier, reduce the replacement interval.
2. Also reduce the checking and replacing interval for the fuel filter and oil filter elements.
3. Cover or plug all the oil filter holes and grease fittings. Also clean the breather pipe on a regular basis.
4. Securely attach the covers of the starting motor and generator.
   Please note that the accumulation of dust on the brush may lead to low engine output, or other troubles.
5. To prevent a reduction in cooling efficiency, occasionally clean the radiator core and remove dirt and dust.

Procedures for Preparing the Engine When It Will Be Out of Operation for an Extended Time

WHEN USING THE ENGINE ONLY DURING A PARTICULAR PERIOD OF THE YEAR

When the engine is to be used only in a particular period of the year, such as summer or winter, the service life of the engine will be determined by how it is maintained during the out-of-use period. Follow the procedures below when preparing the engine.

During in-use period

Follow the normal handling procedures during this period. However, it will be necessary to shorten the oil replacement internal and other service intervals, because the engine will often be operated for a longer than normal period of time during a single day and the load applied will often be greater than usual.

During out-of-use period

During the out-of-use period, perform the following maintenance procedures for the engine. If it is impossible to perform these operations, refer to "Long Term Storage".

1. Perform non-loaded engine operation once a week.
   - Conduct checks prescribed in the "daily inspection" before starting the engine.
   - Start the engine, and idle it for about 30 seconds. Make sure that the lubricating oil pressure is over 0.5 kg/cm^2.
   - Slowly raise the engine rpm to the rated rpm, and run the engine at this speed for about 10 minutes. Make sure that no abnormal noise or vibration is produced, and that the lubricating oil pressure remains at the specified level (2.0 to 5.0 kg/cm^2).
   - Operate the engine at idling speed for some time before stopping it.
2. Perform loaded operation once a month.
   - Run the engine and perform checks set forth in item 1 above.
   - Apply a load in excess of 50% of the rated load to the engine, and operate it for more than 10 minutes. Make sure that no abnormal noise or vibration is produced, and that the lubricating oil pressure and cooling water temperature are all normal.

   Oil pressure gauge:
   2.0 to 5.0 kg/cm^2
   Water temperature gauge:
   50 to 80°C
   Ammeter:
   Pointer on charge (+) side
3. Perform the following inspection and adjustment before placing the engine into operation.
   - Drain sediment from the fuel system (fuel filter and fuel tank).
   - Change engine oil and oil filter element.
   - Check and adjust valve clearance.
   - Check and adjust fan belt tension.
   - Check battery electrolyte level and specific gravity.
   - Change air cleaner element.

PROCEDURES FOR PLACING THE ENGINE IN LONG-TERM STORAGE

Before storing the engine for a long period of time (more than 3 months), perform the following procedures to prevent formation of rust. If the storage period is short, follow the maintenance procedures for the engine as described in the previous paragraph.

Lubricating system
Drain the engine oil, pour the specified amount of rust preventive oil equivalent to P-10 into the oil pan, and then run the engine under no load at approximately 1,500 rpm for about 10 minutes. Stop the engine, and seal all the openings of the lubricating system (such as oil filler, level gauge, breather, etc.) with sealing tape.
For a greater rust preventing effect, perform this operation in combination with the rust preventing procedure for the fuel system and cooling system.

Fuel system
Drain fuel from the fuel system, and pour the mixed fuel (the ratio of fuel to rust preventing oil equivalent to P-9 should be 1 : 1) into the fuel tank. Operate the engine under no load at 1,500 rpm for about 10 minutes. Stop the engine, drain the mixed fuel, and then seal all of the openings in the fuel system (such as the breather of the fuel tank) with sealing tape.

Cooling system
Flush the cooling system, and pour antifreeze or an anti-rust agent into the cooling water. Run the engine under no load at 1,500 rpm for about 10 minutes. Stop the egine, and seal all of the openings in the cooling system (such as radiator cap, overflow pipe, etc.) with sealing tape. If antifreeze is used, keep the cooling water in the system. If an anti-rust agent is used, thoroughly drain the cooling water before sealing.
When using antifreeze, pay attention to the freezing point of coolant and choose a mixing ratio of at least 30%, a mixing ratio of less than 30% provides only a limited rust preventing effect. Note that the anti-rust agent will freeze when the temperature falls below 0°C. In such event, either thoroughly drain the cooling water or use antifreeze.

Combustion chamber
After completing the rust preventive procedure, allow the engine temperature to drop to room temperature. Then disconnect the air cleaner from the intake manifold, and spray or pour rust preventing oil P-10 or its equivalent into the combustion chamber. Next, turn the engine control button to the "STOP" position, and crank the engine five to ten times.

Engine exterior
Using a petroleum solvent, remove dirt and oil from the uncoated metal surfaces of the engine (injection pump, fuel tube, oil cooler, intake manifold, exhaust manifold, rocker cover, V-belt groove of pulleys, etc.). Spray or apply anti-rust agent P-1, P-19 or their equivalent to the cleaned surfaced. Do not apply any type mineral or vegetable oil to the V-belt groove of the pulley.

Others
1. Remove the V-belt or keep it loosened.
2. Seal the air intake hole of the air cleaner and air outlet hole of the exhaust tube with adhesive tape.
3. Wrap the open type generator with a porous bag, and fasten the bag with a rubber band or similar item.
4. If the engine is equipped with a clutch, spray an evaporative anti-rust agent into the clutch housing, and seal the opening with adhesive tape.
5. When storing the engine as a completement outdoors, cover it fully with a porous water-proof sheet.
   Do not use a vinyl sheet, because it lacks porosity and retains water inside.

Preparations for operation after long-term storage
1. Remove all adhesive sealing tapes from the openings of the engine.
2. Drain the rust preventing oil and anti-rust agent by using the following procedure, and replace it with the specified amont of engine oil, fuel and cooling water.

Lubricating system:
Drain oil through the drain plug of oil pan and oil filter.

Fuel system:
First operate the engine with the mixed fuel that is used in the rust preventing operation, and then drain the fuel.

Cooling system:
If antifreeze is used, drain cooling water from the drain valves on each of the radiator and cylinder block, and flush the cooling system.
If an anti-rust agent is used, flush the cooling system.

Exterior of engine:
Clean the exterior surfaces of the engine with a petroleum solvent (Trichlene).

3. Replace the elements of the oil filter, the air cleaner and the fuel filter with new ones.
4. Adjust the V-belt for proper tension.
5. Check and adjust valve clearance. Apply engine oil to the rocker arm and other valve mechanism.
6. Set the engine control button at the "STOP" position, and crank the engine for about 10 seconds. Repeat this cranking operation two or three times in order to disperse engine oil to every portion of the engine.
7. Start the engine, and let it idle for about 5 minutes. Make sure that the lubricating oil pressure is above 0.5 kg/cm^2.
8. Gradually increase the engine speed to the rated rpm, and run the engine for about 10 minutes under no load. Make sure that the lubricating oil pressure and cooling water temperature are normal, and that the engine does not produced any abnormal vibration or noise.

PRELIMINARY INSPECTION

In order to prevent trouble in daily operation, it is necessary that the operator be constantly aware of the condition of the engine. To achieve this awareness, the operator must personally inspect the engine before starting the day's activities. This inspection is called "Daily inspection".
Take the following precautions before commencing the daily inspection. (These precautions should also be confirmed before starting operation.)

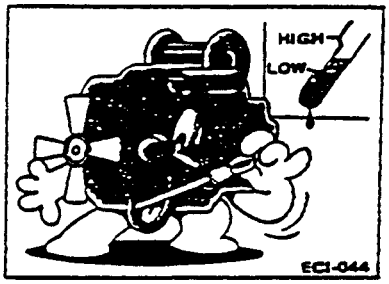
1. Insure that the vehicle or engine is placed on a level surface.
2. Be sure that the key switch is at the "OFF" position.
3. Make sure that the main switch is also set at "OFF".
4. Insure that the parking brake lever is applied.
5. Make sure that the transmission gear selector lever is set at "NEUTRAL".

Inspection items prior to engine start..... 14
Inspection items after engine start..... 15

Inspection Items Prior to Engine Start

CHECK ENGINE OIL LEVEL

1. Pull out the oil level gauge, wipe oil from the gauge surface, and insert the gauge into its original position. After several seconds, carefully pull it out, and read the oil level on the gauge.
   The oil level is correct if it is found to be between the "H" mark and the "L" mark on the gauge. If the oil level is lower than the "L" mark position, add the specified quality of engine oil in an amount sufficient to raise the level to the "H" level.

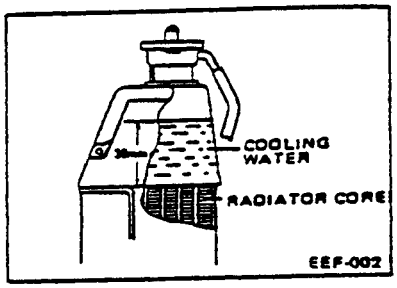


2. Inspect the oil adhering to the level gauge and examine it to see whether the oil is contaminated or if it contains foreign matter such as fuel or water. If it is determined to be faulty, replace the engine oil.

1. Always check the oil level before starting the engine.
2. Use the engine oil recommended by Nissan Diesel.
3. Do not add engine oil to exceed the "H" mark position.

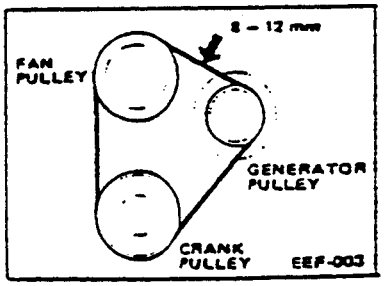
CHECK COOLING WATER LEVEL

Remove the radiator cap, and check the cooling water level. Also check the cap and determine if it functions correctly.
The cooling water level is correct if it is near to the filler neck of radiator. Insufficient water level may be caused by leakage from the engine or radiator. Check carefully for any sign of leakage; if no leaks are discovered, add water to the filler neck portion.
If cooling water is dirty, flush the cooling system.
When replacing the radiator cap, be sure to fit it securely. If replaced loosely or improperly, the cooling water will quickly evaporate, causing the engine to overheat.



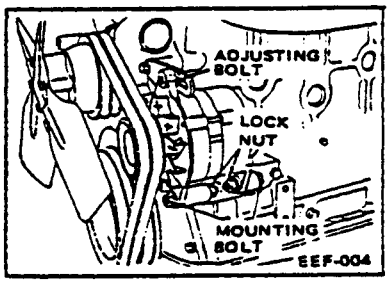
CHECK V-BELT TENSION

1. To check the V-belt tension, push the V-belt at a point located midway between the fan pulley and generator pulley, applying a force of approximately 10 kg.



If the belt tension is insufficient, the cooling fan, water pump and generator cannot be driven with enough power. Engine overheating and insufficient charging of the battery will result. On the other hand, too much belt tension can cause damage to the pulleys as well as the belt.

2. If the belt tension is incorrect, adjust it using the following procedure. Remember to recheck the tension after completing the adjustment.
   Loosen the generator upper adjusting bolt and the lock nut on the lower mounting bolt. Then move the generator either toward or away from the engine, until the belt can be depressed about 8 to 12 mm when it is pushed at the midway point using a force of 10 kg. Then, tighten the adjusting bolt.
   Finally, tighten the lock nut.



CHECKING METERS, GAUGES AND THE WARNING DEVICE

With the main switch and key switch set at "ON", perform the following checks:

1. The fuel gauge reads normal if the pointer indicates somewhere between "E" and "F" on the scale.
2. The oil pressure warning device indicates normal if the warning light is ON.

CHECKING AMOUNT OF FUEL

By looking at the fuel gauge, determine whether or not the fuel tank is filled.

Inspection Items after Engine Start

After the engine has been started, perform the folloing checks:

CHECKING METERS, GAUGES AND WARNING DEVICE

1. The lubrication system and alarm device are functioning normally if the needle pointer of the oil pressure gauge indicates over 0.5 kg/cm^2, and the oil pressure warning light is "OFF".
2. The charging circuit is functioning normally if the needle pointer of the ammeter points either at "0" or to the (+) side, and deflects toward the (+) side when the engine rpm is gradually increased.
   The charge light (charge warning light), if the engine is so equipped, sould remain OFF when the charging circuit is functioning normally.
3. The water temperature gauge reads normal if the pointer indicates around 50°C.

CHECKING THE ENGINE FOR LEAKAGE

1. Insert around the engine, and insure that the engine, radiator and hoses are not leaking.
2. Check each portion of the engine, and make sure that there is no sign of an oil leak.
3. Check the fuel system to make sure that the fuel pipe and hose are not leaking.

CHECKING ENGINE EXHAUST SMOKE

After completing the warming up procedures for the engine, observe the color of exhaust smoke, and check its state of combustion.

- Colorless or light bluish smoke:
  Normal:
  Complete combustion
- Black smoke:
  Abnormal:
  Incomplete combustion
- Whitish smoke
  Abnormal:
  Engine is also burning.

Also check the engine for abnormal noise or vibration.

CHECKING THE ENGINE OPERATION DURING BOTH IDLING AND ACCELERATION

Make sure that the engine runs normally at idling speed, and that engine rpm increases smoothly as it is accelerated.

OTHERS

Correct all of the faults and problems that were observed during the previous day's operation.

If any faults are discovered during the daily inspection, contact the Service Station for additional inspection, adjustment or repair. Always maintain the engine in its top condition.

INSPECTION AND MAINTENANCE

Periodic inspection and service will extend the life of an engine, and assure the maximum efficiency of its opeation.
After completing inspection and adjustment work, make sure that waste cloth, tools or any other foreign materials are not left on or near the engine. Remember that any flammable matter left on the engine (particularly near the exhaust manifold) can cause a fire.

Engine proper ____ 16
Fuel system ____ 17
Air cleaner ____ 19
Lubricating system ____ 21
Cooling system ____ 22
Electrical system ____ 23
Others ____ 25

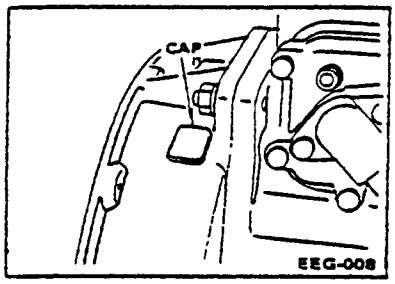
Engine Proper

VALVE CLEARANCE

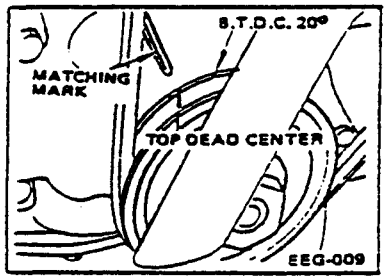
Inspection Interval
Initial inspection:
25 hours or 1,000 km
Subsequent inspections:
Every 300 hours or 12,000 km

Standard clearance
0.3 mm or over; GO
0.4 mm; NO GO

Inspection procedure
1. Remove the air cleaner and rocker cover.
2. Remove the cover from the top of the flywheel housing.

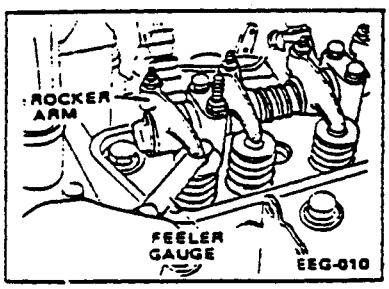


3. Using a bar, turn the flywheel in the normal direction (counterclockwise as viewed from the flywheel side), and align the TDC mark of the torsional damper (crank pulley for SD16 type) with the mark line provided on the gear case. If the TDC mark is mistakenly moved beyond the mark line, return the flywheel, and try again to obtain the correct alignment. This position indicates that the piston in the No. 1 cylinder is at the TDC position.
Note that the TDC position occurs twise in one cycle of piston operation, once during the compression stroke and once during the exhaust stroke. Inspection and adjustment of valve clearance should be performed when both the intake and exhaust valves are closed, that is, when play can be felt on both push rods.



4. Check the clearance between the valve stem and rocker arm using a feeler gauge. The valve clearance is correct if the 0.3 mm gauge fits and the 0.4 mm gauge does not fit. When the No. 1 cylinder is in the TDC position in compression stroke, the valves with the "○" mark as indicated in the following table, can be checked for clearance.
When the No. 1 cylinder is in the TDC position during exhaust stroke, the valves with the "●" mark, as indicated in the table, can be checked.

The cylinders and valves are numbered 1, 2, 3, . . starting from the one on the end nearest the cooling fan.



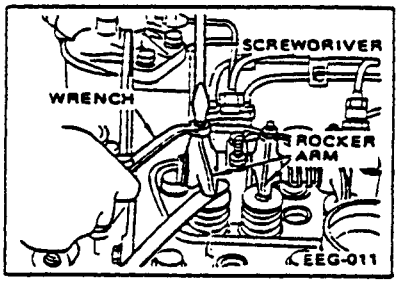
5. If the valve clearance is incorrect, adjust it to the standard clearance by referring to the "Adjustment procedure", below.

Engine Type	Cylinder No.	1		2		3		4		5		6	
	Valve No.	1	2	3	4	5	6	7	8	9	10	11	12
		Ex	In	In	Ex	Ex	In	In	Ex	Ex	In	In	Ex
SD33, SD33T	No. 1 compression TDC	o	o		o		o		o		o		
	No. 1 exhaust TDC			•		•		•		•		•	•
SD22, SD25	No. 1 compression TDC	o	o	o		o							
	No. 1 exhaust TDC				•		•	•	•				

Engine Type	Cylinder No.	1		2		3	
	Valve No.	1	2	3	4	5	6
		In	Ex	Ex	In	In	Ex
SD16	No. 1 compression TDC	o	o		o		o
	No. 1 exhaust TDC			•		•	

Adjustment procedure

1. Loosen the lock nut on the adjusting screw.
2. Insert the 0.3 mm gauge into the clearance between the valve stem and rocker arm.
3. Rotate the adjusting screw until some resistance is felt when you slide the feeler gauge; then tighten the lock nut. In this procedure, hold the adjusting screw at the adjusted position with a screwdriver so that it will not rotate along with the lock nut.



4. Upon completing the adjustment, turn the flywheel two or three turns in the normal direction of the engine, and check the valve clearance again to insure that the standard clearance has been attained.

CRANKSHAFT DAMPER (Model SD33 and 33T)

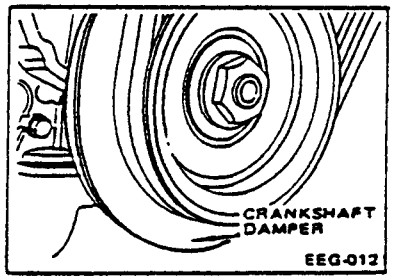
Inspection interval

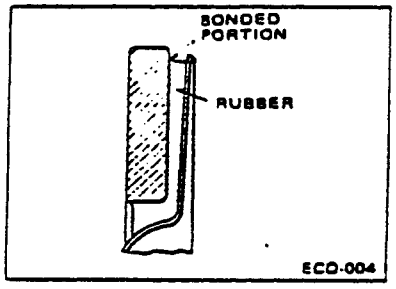
Periodic inspection:

Every 1,200 hours or 48,000 km

Inspection procedure

Inspect the rubber adhering to the crankshaft damper for cracking or separation from the damper. If either adhesion is poor or there is any crack in the circumferential direction, replace the damper. Be careful not to mistake peeling paint for a crack. If the V-belt frequently comes off during operation, suspect a problem with the damper.

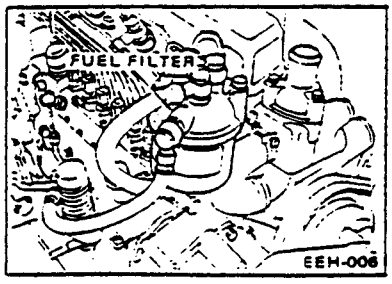




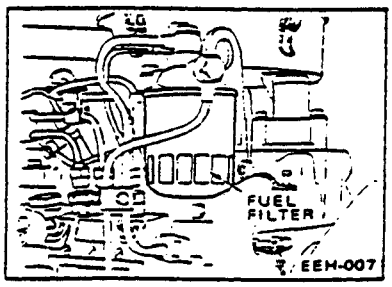
Fuel System

FUEL FILTER

The fuel filter, located on the right side of engine, uses a paper type filteer element. Periodically clean and replace the element.



Center bolt type filter



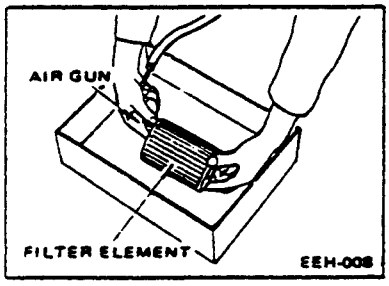
Cartridge type filter

Inspection and replacement intervals
Inspection:
Every 300 hours or 12,000 km
Replacement:
Every 600 hours or 24,000 km

Inspection is not required on the models SD16, 22 and 25.

Inspection and replacement procedure:
Models SD33 and SD33T

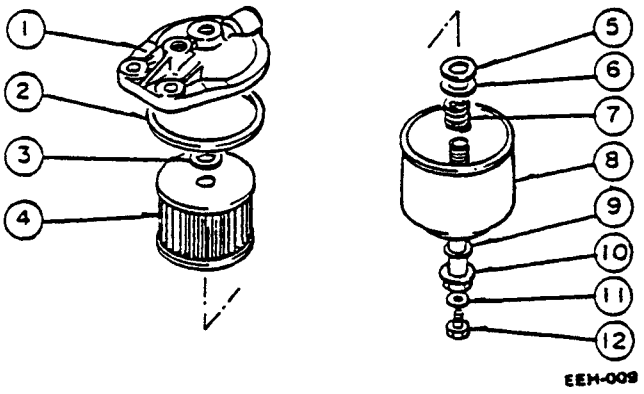
1. Place a receptacle to receive fuel under the filter, remove the drain plug, and drain fuel and sediment. If water or dirt are frequently found in the filter, clean the tank and take action to discover the cause.
2. Loosen the center bolt located at the bottom of filter case. Remove the elements, packings, springs, and case from the body.
3. Check the element for clogging and contamination. If the element is clogged or heavily contaminated, replace the element immediately, even if it is before the normal replacement period.
4. Clean each part of the filter using a clean light oil.
5. Clean the element by closing one hole of the element with a finger, and applying compressed air of 1.5 to 2.0 kg/cm^2 to the other hole, blowing off dirt which has become attached to the outside of the element. Change holes and repeat the cleaning process.
   Next, close both holes with fingers so as to prevent entrance of dirt into the inside of element, and wash the element in light oil by shaking it.



6. Reassemble the parts, being careful not to incorrectly install the packings.

Replace the gasket each time it is removed.

7. After completing assembly, be sure to bleed the air from the fuel system.



1	Filter cover	7	Set spring
2	Packing	8	Filter case
3	Packing	9	Packing
4	Element	10	Center bolt
5	Packing	11	Packing
6	Spring seat	12	Drain plug

Replacement procedure:
Models SD16, 22 and 25

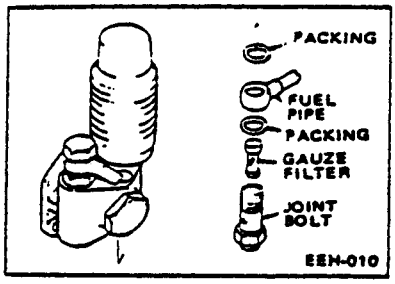
1. Remove the filter case and cartridge element together, and replace the element with a new one.
2. When installing the filter, apply a thin coat of light oil to the "O" ring fitting portion of the filter.
3. Tighten the filter by hand only. After the "O" ring contacts the filter bracket, tighten it another 2/3 turn.
4. Upon completing the installation, bleed air from the fuel system.

FUEL FEED PUMP

The gauze filter is attached to the fuel suction side of the feed pump. Clean the filter periodically.

Cleaning interval
Cleaning of filter:
Every 600 hours or 24,000 km

Cleaning procedure

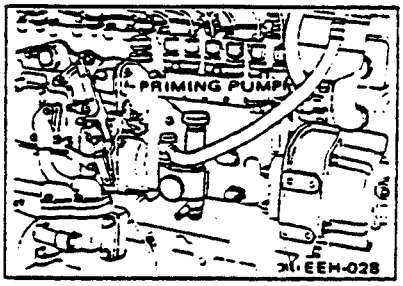


1. Place a receptacle under the feed pump, and drain the fuel by loosening the joint bolt. Remove the bolt being careful not to lose the gasket.
2. Remove the gauze filter from the joint bolt, and wash it with clean light oil.
3. To reassemble, reverse the disassembly procedure.
   Be sure to fit a packing on both the upper and the lower side of the fuel pipe.
4. After reassembling, bleed air from the fuel system.

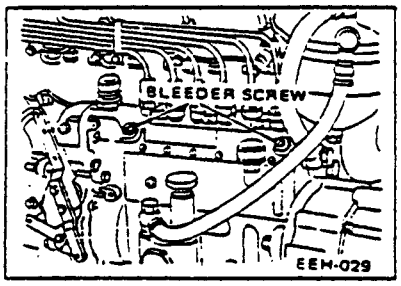
AIR BLEEDING PROCEDURE

Air in the fuel line will result in poor fuel injection, and difficult starting, insufficient engine output or the engine stopping entirely. To prevent such difficulties, be sure to bleed air from the fuel line after the filter element has been checked or replaced, or when the fuel pipe has been reconnected.

1. Remove the priming pump cover of the injection pump, and turn the knob counterclockwise. This will automatically cause the knob to lift up.



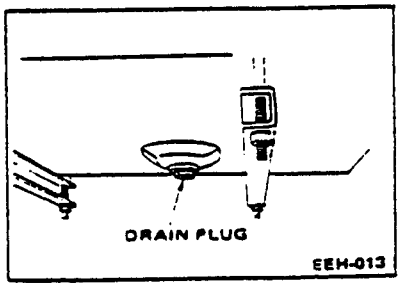
2. Move the knob up and down. Fuel will be sucked up from the tank and retained in the filter.
   Slightly loosen the injection pump bleeder screw, and continue operation of the priming pump until no bubbles are contained in the fuel coming out of the bleeder.
   There are two bleeders, and bleeding operation must be conducted using each of them, separately.



3. After conducting air bleeding operation, sequre the priming pump knob to its original position and put the cover on.

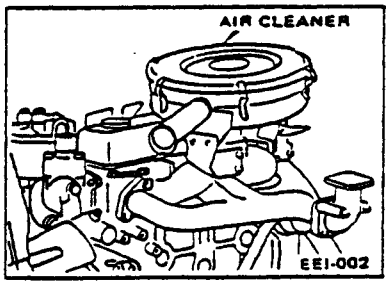
FUEL TANK

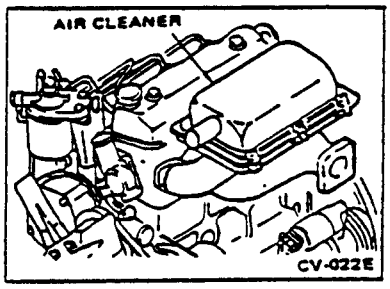
Drain sediment in the fuel tank every 600 hours or 24,000 km. However if water, dirt or other foreign matter is found in the fuel filter, perform this draining operation. To drain sediment, remove the drain plug which is located at the bottom of the fuel tank.



Air Cleaner

The air cleaner uses a paper type filter element.





Inspection and replacement intervals

Inspection and cleaning:

Every 200 hours or 8,000 km (In dusty area, every 100 hours or 4,000 km)

Every 2,500 hours or 10,000 km (Model SD16)

Replacement interval:

Every 1,200 hours or 48,000 km

Every 10,000 hours or 40,000 km (Model SD16)

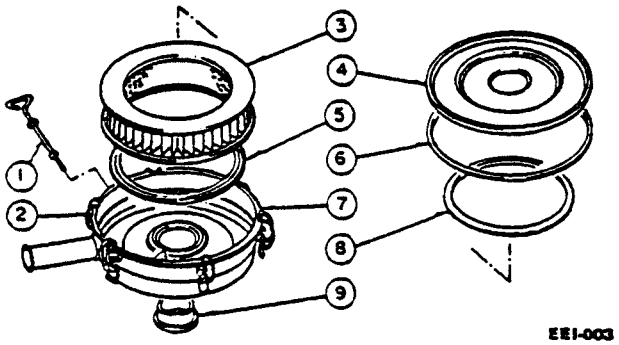
Cleaning is not required on the model SD16.

AIR CLEANER HANDLING PRECAUTIONS

1. Install the cleaner cover and element securely. Loose or improper installation may cause dust to be sucked into the air cleaner, preventing its normal functioning.
2. Do not touch the filter paper portion of the element with hands or other objects. Particularly, use care to prevent oils from adhering to it.

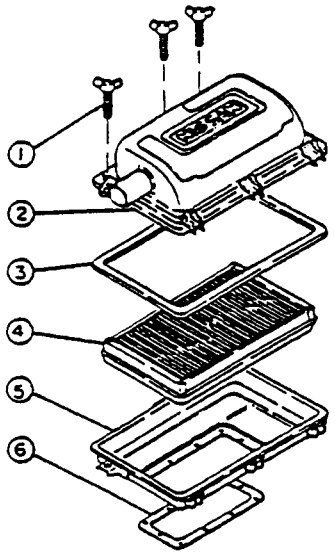
ELEMENT REMOVAL

1. Remove the clip which secures the cleaner cover (or wing bolt), and take off the cleaner cover.
2. Remove the element.



EEI-003

1	Band bolt	6	Packing
2	Clip	7	Cleaner case
3	Element	8	Packing
4	Cleaner cover	9	Insulator
5	Packing		



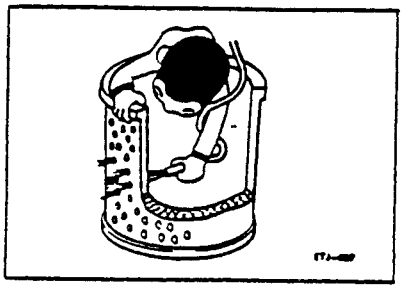
CV-023E

1	Wing bolt
2	Cleaner cover
3	Packing
4	Element
5	Cleaner case
6	Gasket

ELEMENT CLEANING

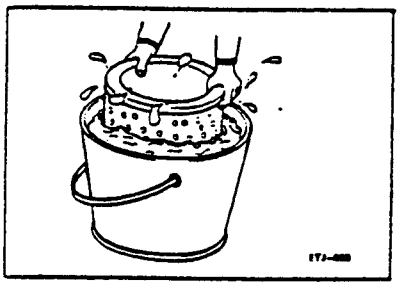
Clean the element by using one of the following two methods depending upon the nature of its contamination.

Element contaminated with dry dust:
Apply compressed air of 2 to 3 kg/cm^2 for cleaning. First, direct the air in the circumferential direction towards the inside of element, then direct air towards the outside in a lengthwise, direction to blow off the dirt.



Element contaminated with carbon and oils:
Wash the element in a cleaning fluid prepared using the cleaning agent ND-1500 or D-1400 (manufactured by Donaldson C.).

1. Dissolve the cleaning agent (300g) in 5 liters of water, and dilute it with 20 liters of water to prepare the cleaning fluid.
2. Place the dirty element in the fluid for about 20 to 30 minutes, and then wash it by shaking it 4 to 5 times.
   For a more thorough cleaning, warm the cleaning fluid to 40 to 50°C.



3. Remove the element and rinse it thoroughly with clean water.

The pressure of water should be less than 2.8 kg/cm^2.

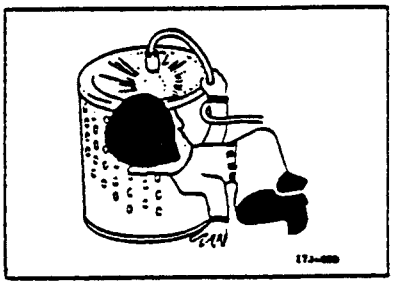
4. Thoroughly shake water from the element, and place it in a well ventilated location for drying but avoid direct sunlight. Use an electric fan or a drying furnace for quick drying.
   Since natural drying of the element will take two or three days, it is recommended that a spare element be available.

1. When using a drying furnace, keep the temperature below 80°C.
2. Do not dry the element by direct sunlight, by placing it near a fire, or by applying compressed air.
3. Never use an incompletely dried element.

Lubricating System

ELEMENT INSPECTION

After thoroughly drying the element, check the element for any damage, pin hole, or thinned portion by shining light through it from the inside. If any faults are found, or if the packing is damaged or deformed, replace the element with a new one.



ENGINE OIL

Replacement interval

Initial replacement:
- Automotive use
  - Initial 1,000 km
- Industrial use
  - Initial 25 hours

Subsequent replacement:
- Automotive use
  - Every 3,000 km
- Industrial use
  - Every 100 hours

Quantity of oil

Engine model	SD16	SD22	SD33	SD33T
Oil pan capacity	5.5 ℓ	5.5 ℓ	7.5 ℓ	9.5 ℓ
Total capacity	7.0 ℓ	7.0 ℓ	10.5 ℓ	11.5 ℓ

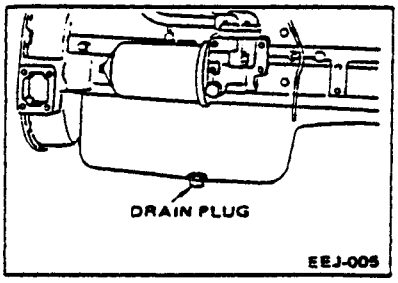
The oil quantity may vary according to specifications.

Do not add amounts of oil which will exceed the "H" level.

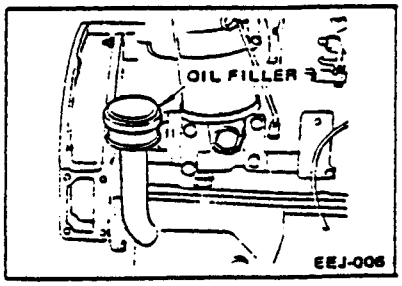
Replacement method

Change engine oil while it is still warm, following the below described procedure.

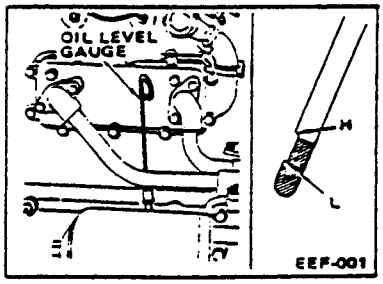
1. Remove the drain plug located at the bottom of the oil pan, and drain the oil.
2. Pour new engine oil through the oil filler. Check the oil level after the oil has stabilized in the pan, and make sure that the level approaches, the "H" mark position of the level gauge.



Drain plug



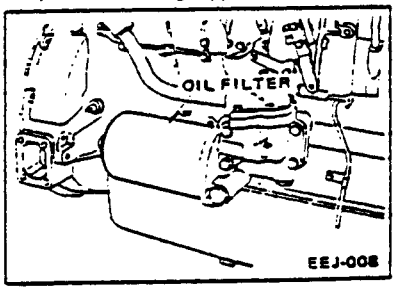
Oil filler (oil pan)



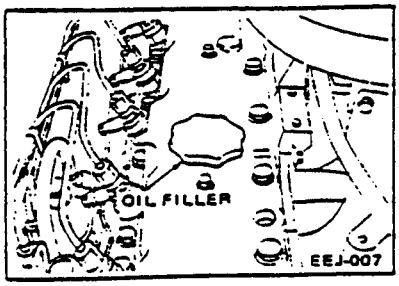
Level gauge

OIL FILTER

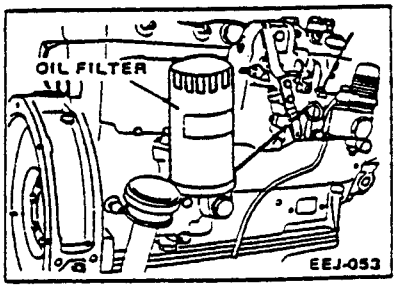
The oil filter is a full-flow type, and is mounted on the right side of the engine. The models SD16, 22 and 25 engine adopts the cartridge type oil filter.



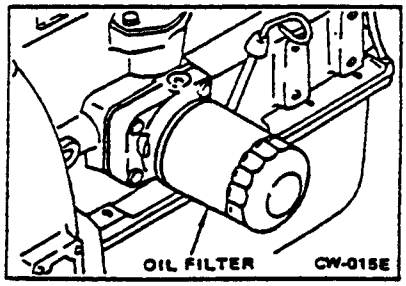
SD33 and SD33T



Oil filler (rocker cover)



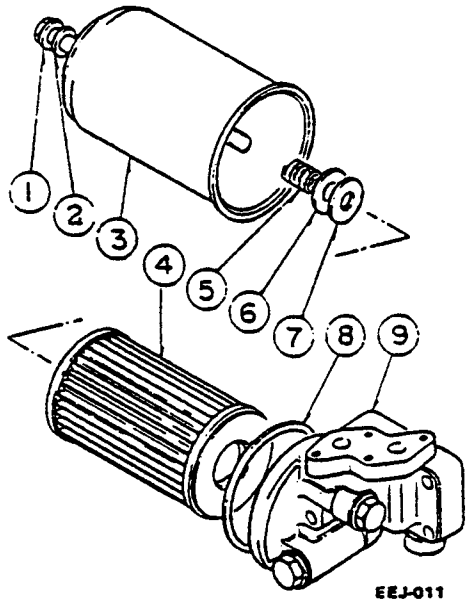
SD22 and SD25



SD16

Replacement intervals:
Element replacement:
Automotive use
Every 3,000 km
Industrial use
Every 200 hours

SD33 and SD33T



1	Center bolt	6	Spring retainer
2	Packing	7	Packing
3	Filter case	8	Packing
4	Element	9	Filter bracket
5	Set spring		

Cooling System

Element replacement procedure:
Models SD33 and SD33T

1. Place a receptacle under the filter.
2. Drain the oil by loosening the center bolt, and remove the element, gasket, case, spring and other parts from the body.
3. Replace the element with a new one.
4. Clean all the parts except the element with light oil.
5. Assemble each part correctly, being careful not to incorrectly install the gasket.

Replace the packing with a new one whenever disassembling.

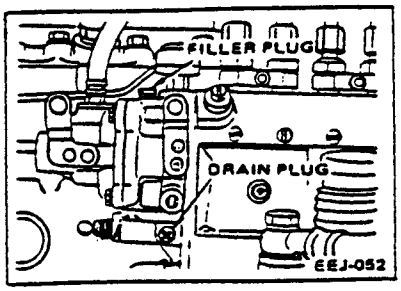
6. After reassembling, start the engine, and make sure that oil does not leak from the oil filter.

Replacement procedure:
Models SD16, 22 and 25

1. Remove the filter case togetehr with the element, and replace the whole unit with a new one.
2. Apply a thin coat of the engine oil to the "O" ring of the filter before installing.
3. Tighten the filter by hand until the "O" ring touches the filter bracket. From this position, tighten the filter another 2/3 turn.
4. After installing the filter, start the engine and make sure that no oil leaks from the mounting portion.

When pneumatic governor is used
Check the oil level and change the oil in the camshaft camber in the same manner as described above. Remove the filler plug of the governor chamber, and add the specified quantity (4 to 5cc) of diaphragm oil.

Use diaphragm oil recommended by Nissan Diesel.



FLUSHING OF COOLING SYSTEM

Flush the interior of the cooling system before and after antifreeze is used or whenever any heavy contamination in the coolant is noticed. In addition, flush the system every six months. Flushing removes water scale and fat from the cooling system, and restores its original cooling efficiency, which greatly reduces the possibility of the engine overheating.

FLUSHING PROCEDURE

The cooling system must be flushed when the coolant temperature is higher than 80°C and the engine is run at high idle. If the water temperature is too low, the thermostat will remain closed, and the flushing agent will not circulate in the radiator, so no flushing effect will occur. It is also necessary to keep the heater inlet valves (both on the engine and the heater proper) open.

1. Drain the cooling water from each water drain cock completely.
2. Close the drain cock, and pour city water and flushing agent into the radiator.

3. Run the engine at high idling speed (refer to the flushing agent manufacturer's instructions). Cover the front end of the radiator to prevent the temperature of the fluid in the cooling system from dropping. Observe the fluid level carefully for five minutes after starting the engine. If it lowers, add city water.
4. After flushing, stop the engine, and thoroughly drain the fluid from each drain cock.
5. Close the drain cocks, and add fresh city water. Start the engine and run it at high idle until the water temperature goes above 80°C. Then stop the engine, and drain the water from the drain cocks once again.
   Repeat this operation two or more times, until only clean water is discharged from the drain cocks. Dirty or colored water from the drain cocks means that fat or scale is still in the cooling system.
6. After completing the flushing operation, close each drain cock securely, and add fresh city water up to the specified level. Then start the engine, and purge the air from the system until the coolant level is stabilized at the specified position. If the coolant level lowers during this operation, add fresh city water.

ANTIFREEZE

Precautions for handling antifreeze solution

General precautions on the use of antifreeze are set forth below: When using a recommended brand of antifreeze, always follow the manufacturer's instructions.

1. Limit the use of antifreeze to the winter only. After winter is over, drain the coolant from the cooling system, and flush it thoroughly before adding fresh water and an antirust agent.
2. If the coolant level is lowered naturally while antifreeze is being used, add undiluted antifreeze or 50% diluted solution of antifreeze.
3. The antifreeze mixture ratio must be 45 to 60%. Excessively thin or thick mixture will reduce the antifreeze's effect and also reduce its rust and corrosion prevention powers.
4. Always use city water or other soft water to mix the antifreeze solution.
5. Do not mix different brands of antifreeze because they each contain special additives. Careless mixing often diminishes the effect of these additives.
6. Be sure to flush the interior of the cooling system thoroughly before and after antifreeze is used.
7. Before using any antifreeze, carefully check the engine, radiator and hoses for any sign of water leakage.
8. Do not use antifreeze that has already been used once.

Electrical System

Before performing any service for the electrical system, be sure to disconnect the battery minus side cable from the battery to assure safety in operation.

BATTERY

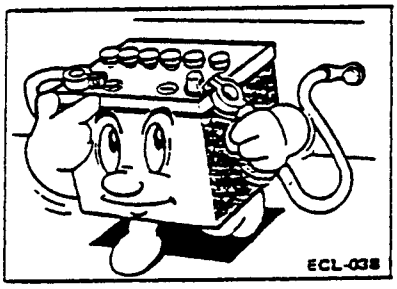
Always keep the battery in good condition.

Inspection interval

Electrolyte level:
Every 100 hours or 4,000 km
Specific gravity:
Initial check:
After 100 hours or 4,000 km
Subsequent check:
Every 300 hours or 12,000 km

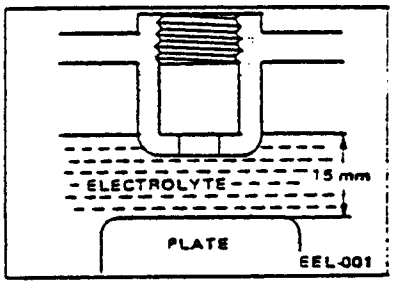
Checking electrolyte level

1. When the electrolyte level can be seen from the side of the battery case:



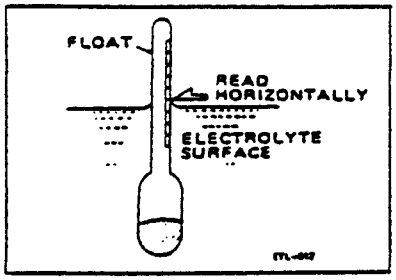
Check the level using the level mark provided on the side of the case. The electrolyte level should be anywhere between the "UPPER LEVEL" and "LOWER LEVEL" marks. If the level is below the "LOWER LEVEL" mark, add distilled water up to the "UPPER LEVEL" mark, and charge the battery for more than 30 minutes so that the fluid will be thoroughly mixed.

2. When the electrolyte level cannot be seen from the side of the battery case:

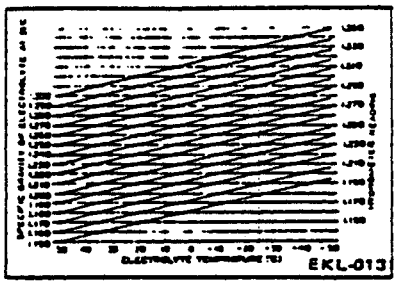


Remove the cap on the top of the battery, and check the electrolyte level. The leve is correct if it is 10 to 15 mm above the plates. If the level is lower than this, add distilled water until the correct level is attained, and charge the battery for more than 30 minutes to thoroughly mix the fluid.

Checking specific gravity



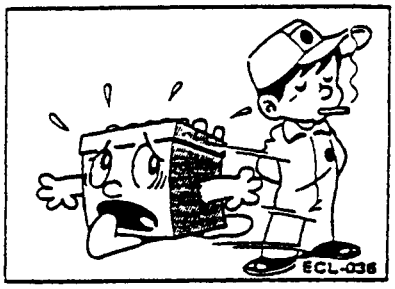
The specific gravity of the electrolyte lowers as the battery is discharged, and rises as it is recharged. Therefore, the charge condition of a battery can be determined by measuring the specific gravity of the electrolyte.
The specific gravity of the electrolyte of a fully charged battery is 1.250 to 1.270 when the electrolyte temperature is 20°C. If the specific gravity is lower than 1.200, the battery must be recharged.



Relation between atmospheric temperature and specific gravity of the electrolyte

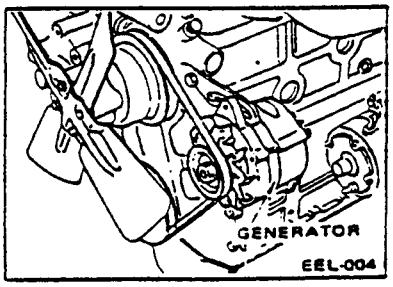
Handling precautions

1. Do not permit a fire to occur in the vicinity of the battery. Note that explosive gas (hydrogen and oxygen) is produced in the battery due to charging and discharging actions, and this can cause an explosion if it comes in contact with fire.



2. Improper or loose mounting of the battery may cause damage to the battery case or plates due to vibration during operation, resulting in a reduced battery life. To avoid this, be sure to install the battery securely. After connecting the battery cable, apply a thin coat of vaseline or grease to the portion which joints with the terminal to prevent corrosion.
3. Always keep the battery clean.
   Note that accumulation of dirt on the battery may cause damage to the plate due to the entrance of impurities into electrolyte, or cause an electrical leak over the cover.
   To clean, wash the battery, with the caps attached, with lukewarm water, and dry it by wiping with a dry cloth; or, remove the battery, and with the caps attached, wash it with water using a brush, and then reinstall the battery.
4. Be sure to add distilled water before recharging.
   After adding the distilled water, run the engine for more than 30 minutes, or take out the battery and charge it with a battery charge so that the eletrolyte and distilled water will be thoroughly mixed.
   Note that a thorough agitation of trolyte by charging should especially be performed in cold season; otherwise, the distilled water may freeze in the battery, resulting in a damaged battery.
5. During the recharging operation, pay attention to the temperature of the battery.
   If the electrolyte temperature rises above 45°C during the charging operation, suspend the charging, or reduce the charge current by one-half, or pour water on the battery from the outside to prevent a temperature rise in the electrolyte.

GENERATOR



This generator is of the AC type, and special attention should be paid to the following points:

1. When installing the battery, be careful not to make a mistake in connecting it.
2. Do not try to disconnect wires in the charging circuit and take care not to cause a shortcircuit while the engine is running.
3. Do not change the main switch and key switch from the "ON" position or "OPERATE" position during engine operation.
4. Do not splash any water or oils onto the generator.
5. Whenever servicing the generator, also change the bearing grease. It is recommended to have this grease changing operation done by the Service Shop.

STARTING MOTOR

When the starting motor has been removed from the engine and inspection and maintenance completed, apply grease to the sliding portion of the pinion.

Others

GREASING

Periodically apply grease to the hour meter driver. Also apply grease the hour meter cable.

Greasing interval

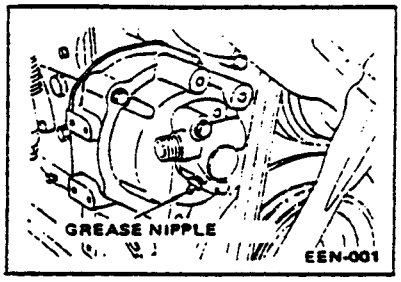
Hour meter driver:

Every 300 hours or 12,000 km

Hour meter cabel:

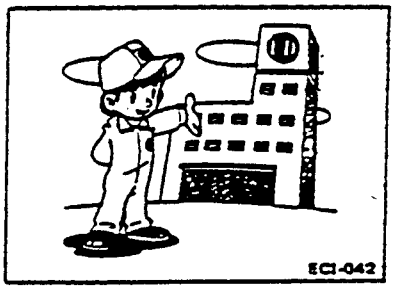
Every 600 hours or 24,000 km

Greasing points



TROUBLE-SHOOTING

It is necessary to detect any faults or abnormalities early and to correct them before they become greater and cause dry damage. If any of the difficulties listed herein occur, take proper corrective action without delay.
Troubles and their possible causes are listed in this capter. In order to prevent the expansion of trouble into other areas or the creation of new trouble due to the wrong diagnosis, be sure to disclose the nature of the trouble to the Service Station before repair work is begun.



When starting engine 27
When warming-up engine 27
During operation of engine 28
Others 29

When Starting Engine

Difficulty			Possible Cause	
Engine will not start	Engine will not rotate		Starting system	Insufficient battery charge
				Loose battery terminal
				Faulty starting motor
				Faulty ring gear
				Faulty wiring or switch
				Blown fuse
			Engine proper	Improper viscosity of engine oil
				Seizure in rotating parts
				Frozen cooling water
	Engine rotates	Large amount of exhaust smoke	Incorrect injection timing	
			Faulty injection nozzle	
			Insufficient compression pressure in combustion chamber	Incorrect valve clearance
				Worn cylinder liner and piston rings
				Seized piston rings
			Poor fuel	Improper quality of fuel
				Dirt, water, or air in fuel
			Low compression air temperature in combustion chamber	Faulty glow plug
				Slow starting motor speed
		Small amount of exhaust smoke	Poor returning of stop wire	
			Air in fuel system	
			Clogged fuel system (element, etc.)	
			Faulty injection pump	
			Insufficient injection quantity (faulty injection nozzle)	

Difficulty			Possible Cause
Engine will not start	Engine rotates	No exhaust smoke	Lack of fuel
			Faulty feed pump
			Faulty injection pump
			Clogged fuel system (element)
			Clogged injection nozzle

When Warming-up Engine

Difficulty		Possible Cause	
Abnormal noise		Engine	Incorrect injection timing
			Poor spraying of injection nozzle
			Faulty fan pulley bearing
			Deformed or damaged fan or fan shroud
			Loose V-belt
			Faulty gear train
			Faulty pumps
			Faulty valve mechanism
			Faulty generator
			Wear on main bearing shell
			Poor fuel
			Cold engine (lack of warming-up)
			Loose tightening
		Damaged muffler or improper mounting	
Unstable idling	Hunting occurs	Low injection pressure of nozzle	
		Fuel leak from nozzle pipe	
		Faulty engine control linkage	
		Faulty governor	
		Faulty injection pump	
		Wear or deterioration in quality of engine mounting rubber	
		Water or air in fuel	

Difficulty		Possible Cause
Unstable idling	Engine stops immediately after starting	Faulty injection pump
		Clogged fuel system (element)
		Cold engine (lack of warming-up)
		Lack of fuel
Low oil pressure	Oil pressure warning lamp will not go out	Improper viscosity of engine oil
		Lack of engine oil
		Faulty oil pump or pump drive
		Faulty oil pressure switch

During Operation of Engine

Difficulty		Possible Cause		
Abnormal noise	Engine knocks	Faulty injection nozzle		
		Faulty injection pump		
		Insufficient or uneven compression pressure		
		Abnormal wear in cylinder		
		Incorrect injection timing		
		Incorrect valve clearance		
		Poor fuel (Low cetane number)		
		Cold engine (lack of warming-up)		
	Others	Loose tightening		
Poor acceleration	Engine rpm will not go up to the specified max. rpm	Incorrect adjustment of governor		
		Faulty injection pump (worn plunger)		
		Faulty injection nozzle		
		Faulty engine control linkage		
		Lack of fuel	Water or air in fuel	
			Clogged fuel system (element)	
			Faulty feed pump	
			Insufficient injection quantity in injection pump	
		Insufficient compression pressure in combustion chamber		
Unusual engine exhaust	Engine emits too much whitish smoke	Delay in injection timing		
		Faulty injection nozzle		
		Oil is burning	Oil comes down	Worn piston rings
			Oil comes up	Worn valve guide

Difficulty		Possible Cause	
Unusual engine exhaust	Engine emits too much whitish smoke	Cold engine	Lack of warming-up
			Faulty cooling system
	Engine emits too much black smoke	Clogged air cleaner element	
		Insufficient compression pressure in combustion chamber	Incorrect valve clearance
			Worn cylinder liner and piston rings
			Seized piston rings
		Advanced injection timing	
		Incorrect valve timing	
		Incorrect timer advance	
		Faulty injection nozzle	
		Faulty injection pump	Excessively large injection quantity (faulty governor)
			Uneven injection quantity
		Faulty turbo-charger	
	Small amount of exhaust smoke	Clogged fuel filter element	
		Clogged fuel pipe	
		Faulty injection pump	Excessively small injection quantity
			Faulty feed pump
			Faulty overflow valve
Oil pressure drops	Oil pressure warning lamp is ON	Insufficient engine oil	
		Oil leak from engine	
		Worn main bearing	
		Faulty oil pump or pump drive	
		Faulty oil pressure switch	

Difficulty		Possible Cause	
Excessive oil consumption		Oil leak from engine	
		Oil comes up into combustion chamber	Worn piston rings
		Oil comes down into combustion chamber	Worn valve guide
Engine overheats		Cooling system	Faulty water pump or pump drive
			Lack of cooling water due to water leak
			Faulty thermostat
			Dirty cooling water
			Clogged radiator core
		Fuel system	Faulty injection nozzle
			Delay in injection timing
			Excessive injection quantity
		Engine proper	Seized piston
			Seized piston rings
		Rough handling	Forced operation on uphill
			Operation carrying too much load
			Operation under over-loaded condition
		Clogged muffler (carbon accumulation)	
Unstable engine speed	Irregular engine rpm	Dirt, water, or air in fuel	
		Faulty governor	
		Faulty injection pump (Non-uniform injection quantity, irregular injection interval, etc.)	

Difficulty		Possible Cause
Unstable engine speed	Irregular engine rpm	Faulty fed pump
		Clogged fuel system (element)
		Fuel leak from fuel system
		Faulty engine control linkage
	Engine stops suddenly	Lack of fuel in tank
		Dirt, water, or air in fuel
		Clogged fuel system (filter, pipe, etc.)
		Seizure in injection pump drive
		Faulty governor
		Seized parts in engine proper
Failure in charging system	Needle of ammeter will not deflect	Faulty ammeter
		Faulty charging circuit or poor connection
	Needle of ammeter remains on minus (−) side	Faulty generator
		Faulty regulator
		Faulty charging circuit or poor connection
		Too much electric current is being used
		Blown fuse
	Needle of ammeter remains on plus (+) side	Faulty regulator
		Faulty battery
	Needle of ammeter remains in deflected position	Faulty ammeter
		Faulty generator
		Faulty regulator
		Faulty charging circuit or poor connection

Others

Difficulty		Possible Cause	
Oil leak from engine		Loose tightening	
		Clogged breather	
		Faulty gasket, packing, oil seal, etc.	
		Oil level too high	
Engine oil in cooling water		Faulty oil cooler	Cracks in oil cooler core
			Faulty rubber ring (cracks, etc.)
		Engine proper	Cracks in cylinder block
			Cracks in cylinder head
			Faulty cylinder head gasket rubber ring
Cloudy engine oil due to mixing of cooling water		Faulty cylinder head rubber ring	
		Faulty cylinder liner rubber ring	
High oil level due to mixing of fuel		Faulty injection pump (plunger portion)	
Cooling water runs short too quickly	Water leak	Faulty water hose or loose connection	
		Loose drain valve	
		Faulty radiator	Crack or damage in core
			Crack or damage in upper or lower tank
		Faulty water pump	
		Faulty radiator cap	
		Blow-back due to entrance of burnt gases	

Difficulty		Possible Cause	
Too much fuel consumption	Engine emits large quantity of black smoke	Refer to "Unusual Engine Exhaust".	
	Engine exhaust is normal	Fuel leak from fuel system	
		Operating conditions	Condition of road (type of surface, uphill, etc.)
			Carried load
			Operating method (sudden start-up, sudden braking, etc.)
			Route (geography, distance, etc.)
			Others (running resistance) resistance)
			Load condition (overload)

TABLE OF PERIODIC INSPECTION ITEMS

In order to keep the engine in top condition as well as to prevent unexpected trouble, it is necessary to periodically perform inspection and maintenance.
This chapter provides the table of daily inspection items and periodic inspection items that must be done at the specified intervals according to the operating hours or running distance.
The periodic inspection should be performed by the Service Shop.

Inspection interval

1. The "●" mark in the table indicates the interval of periodic inspection or adjustment.
2. The "●" mark in column "D" indicates that the item should be checked before beginning the day's operation by referring to "PRELIMINARY INSPECTION".
3. The "●" mark in the table indicates the time of initial inspection, adjustment and replacement on a new engine.
4. The "☆" mark in the table indicates the replacement interval of the parts that must be replaced periodically.
5. "D, 1, 2, 3, 6, 12" in the "Inspection interval" column indicate:
   - D: Daily inspection
   - 1: Every 100 operating hours or every 4,000 km
   - 2: Every 200 operating hours or every 8,000 km
   - 3: Every 300 operating hours or every 12,000 km
   - 6: Every 600 operating hours or every 24,000 km
   - 12: Every 1,200 operating hours or every 48,000 km

Oils and fluids

Oils and fluids should be replaced periodically according to the operating hours of the engine or the driving distance of the vehicle. However, the quality of the oils and fluids will deteriorate in time even if the engine is not operated. If the operating hours are small, replacement should be made according to the number of months. In this case "1, 2, 3, 6, 12" in the inspection interval column may be regarded as "Every month, Every 2 months, Every 3 months, Every 6 months, and Every 12 months".
When adding or replacing oils and fluids, be sure to use the brands recommended by Nissan Diesel.

Periodic replacement parts

Some component parts of the engine may experience change or deterioration in material, or may wear in time, and it is difficult to determine the degree of such deterioration by periodic inspection. Such parts are classified as periodic replacement parts, and must be periodically replaced with new ones even if no particular abnormality is observed. For the Nissan Diesel engine, be sure to use the Nissan Diesel genuine replacement parts.

Inspection item		Inspection interval						Remarks
		D	1	2	3	6	12	
Engine proper	Check for normal starting, or for noise	●	●					
	Check low speed operation, and acceleration	●	●					
	Check the condition of exhaust	●	●					
	Check condition of air cleaner element			●				In dusty area, every 100 hours or 4,000 km
	Check cylinder head and manifold for looseness						●	*25 hours or 1,000 km Tightening torque: Cylinder head Main bolt 13 kgm Sub bolt 5 kgm Manifold Intake 1.5 to 1.8 kgm Exhaust 1.5 to 1.8 kgm
	Check compression pressure						●	Limit of compression pressure: 19 kg/cm² — 180 to 220 rpm Difference among cylinders: Within 4 kg/cm²
	Check valve clearance				●			*25 hours or 1,000 km Intake and exhaust valves: 0.3 to 0.4mm (both for cold and hot engines)
	Check condition of crankshaft damper						●	
	Replace air cleaner element							* Every 1,200 hours or 48,000 km * Every 10,000 hours or 40,000 km (Model SD16)
Lubricating system	Check for oil leak	●	●					
	Check for contamination	●	●					

Inspection item		Inspection interval						Remarks
		D	1	2	3	6	12	
Lubricating system	Check oil level	●	●					
	Replace engine oil		●					*25 hours or 1,000 km Automotive use: Every 3,000 km
	Replace oil filter element			●				Automotive use: Every 3,000 km
Fuel system	Check for fuel leak	●	●					
	Check fuel filter for clogging						●	
	Check injection pressure and spray condition of injection nozzle						●	Injection pressure ..... 100 kg/cm²
	Check injection timing						●	Injection timing (B.T.D.C.) ..... 20.0°
	Check injection quantity of injection pump				●			
	Clean gauze filter of feed pump					●		
	Drain sediment in fuel tank					●		
	Add diaphragm oil				●			Pneumatic governor equipped models only
	Replace fuel filter element					●		
	Check fuel level	●						
	Check function of feed pump						●	
	Replace fuel hose							* Every two years

	Inspection item	Inspection interval						Remarks
		D	1	2	3	6	12	
Cooling system	Check for water leak	●	●					
	Check water level	●	●					
	Check installation of radiator cap	●						
	Check function of radiator cap						●	
	Check V-belt for looseness, or damge	●	●					
	Change cooling water and flush the inside of system					●		
	Check function of thermostat						●	
Electrical system	Check battery electrolyte level		●					Between "H" and "L", or 10 to 15 mm above plates
	Check specific gravity of electrolyte		●		●			1.250 to 1.270 at fluid temperature of 20°C If less than 1.200 recharge
	Check function of generator and regulator		●					
	Check connections of electrical wires for looseness or damage		●					
	Check switch operation	●	●			●		
	Apply grease to pinion sliding surface of starting motor						●	In Service Station upon disassembly and check
	Replace grease of generator bearing						●	In Service Station upon disassembly and check

	Inspection item	Inspection interval						Remarks
		D	1	2	3	6	12	
Meter	Check operation of each meter	●	●					
	Add grease to hour meter driver				●			
	Apply grease to hour meter cable					●		
Other	Check engine mounting bolts for looseness						●	
	Check for play of turbocharger turbine rotor and rotation						●	Turbocharger equipped models only

RECOMMENDED LUBRICANTS, FUEL AND ANTI-FREEZE

Engine oil 33
Bearing grease 33
Antifreeze 34
Fuel 34
Diaphragm oil 35
Cooling water 35
Anti-rust agent 35

In order to maintain the original high performance of the Nissan Diesel engine and to extend its service life as much as possible, it is strongly recommended to use those oils and fluids recommended by Nissan Diesel Co., Ltd, and to replace them periodically.

Engine Oil

The Nissan Diesel engine requires high performance, high quality engine oil capable of withstanding high speed and heavily loaded operations. Be sure to use API service class CD or CC engine oil.

The engine oil will not exhibit its original performance if used under improper temperature conditions. It is therefore important to use engine oil having proper viscosity corresponding to the atmospheric temperature conditions under which the engine is to be operated.

Specifications and Viscosity

Recommended A.P.I. Service Classification
CD class (MIL-L-2104C) or CC class (MIL-L21048 or MIL-L-46152)

In SD33T engines, be sure to use CD class (MIL-L-2104C) engine oil.

Atmospheric temperature	Recommended SAE viscosity	
−18 to +10°C	10W	10W/30
−7 to +25°C	20W/20	
−12 to +40°C	15W/40, 20W/40	
+5 to +40°C	30	
Over +30°C	40	

A.P.I.: American Petroleum Institute
S.A.E.: Society of Automotive Engineers

Recommended class-CD engine oils (MIL-L-2104C)

Petroleum Maker	Brand	SAE Viscosity
CALTEX	CALTEX RPM DELO 300 OIL	10W, 20W/20, 30, 40
	CALTEX RPM DELO 400 OIL	15W/40, 20W/20, 10W, 30, 40
TEXACO	URSA OIL LA-3	10W, 20W/20, 30, 40
	TEXACO URSA SUPER PLUS	10W, 15W/40, 20W/20, 30, 40
	TEXACO URSA OIL SUPER 3	10W, 20W/20, 30, 40
ESSO	ESSOLUBE D-3 SERIES	10W, 20W, 30, 40
	ESSOLUBE XD-3	10W, 10W/30, 15W/40, 20W/20, 30, 40
	ESSOLUBE XD-3 EXTRA	10W, 10W/30, 15W/40, 20W/20, 30, 40
MOBIL	MOBIL DELVAC 1300 SERIES	30, 40
GULF	GULF SUPER DUTY MOTOR OIL	10W, 15W/40, 20W/20, 30, 40
SHELL	SHELL RIMULA CT OIL or SHELL RIMULA X OIL	10W, 20W/20, 30, 40
	SHELL MYRINA OIL	15W/40, 20W/20, 30, 40
BP	BP VANELLUS C3	10W, 20W, 30, 40

Petroleum Maker	Brand
CASTROL	CASTROL LM GREASE
AGIP	AGIP F.1 GREASE 1530
VALVO-LINE	VAL-LITH NO. 2 EP GREASE
	GLO GREASE
CHEV-RON	CHEVRON MULTI-MOTIVE GREASE NO. 2
	CHEVRON POLYUREA EP GREASE NO. 2
VEEDOL	VEEDOL MULTIPURPOSE or ALL PURPOSE GREASE NO. 2

Antifreeze

Use high quality, ethylene glycol base antifreeze which prevents, both corrosion in the cooling system and attachment of scale. Note that low quality antifreeze can reduce the cooling effect and cause engine trouble due to corrosion.

Recommended antifreeze

Petroleum Maker	Brand	Remarks
CALTEX	CALTEX AF ENGINE COOLANT	Ethylene glycol base
TEXACO	TEXACO ANTIFREEZE COOLANT AND SUMMER COOLANT	
	TEXACO STARTEX ANTI-FREEZE AND SUMMER COOLANT	
ESSO	ESSO ANTIFREEZE	
MOBIL	MOBIL PERMAZONE	
GULF	GULF ANTIFREEZE AND SUMMER COOLANT	
SHELL	SHELL ANTIFREEZE	
BP	BP ANTIFROST	
CASTROL	CASTROL ANTIFREEZE	
AGIP	AGIP F.1 ANTIFREEZE	

Petroleum Maker	Brand	Remarks
VALVO-LINE	VALVOLINE ANTIFREEZE & COOLANT	Ethylene glycol base
CHEV-RON	CHEVRON ATLAS PERMA GUARD ANTIFREEZE AND COOLANT	
VEEDOL	VEEDOL ANTIFREEZE	

Fuel

The Nissan Diesel engine is designed to produce power by using light oil as fuel. Do not use any fuel except light oil; otherwise, engine trouble will result.
The light oil should have a cetane number greater than 45, specific gravity of 0.81 to 0.85, boiling point ranging from 180 to 350°C, sulfer content of less than 0.5%, and should prove neutral in a chemical reaction test. It should be clean, posses the proper viscosity, and contain no water or sediment.

Diaphragm Oil

How the diaphragm of the pneumatic governor is lubricated can influence the engine performance. To obtain top engine performance, be sure to use the recommended diaphragm oil.
Recommended oil: Diesel Kiki Diaphragm Oil (Part No. 55413-132)

Cooling Water

Be sure to use clean, soft water such as city water in the cooling system. Do not use hard water such as well water or river water, because such water can easily form scale in the system. Note that scale attached to the water passage in the cooling system (particularly in the radiator) can cause engine overheating.

Anti-rust Agent

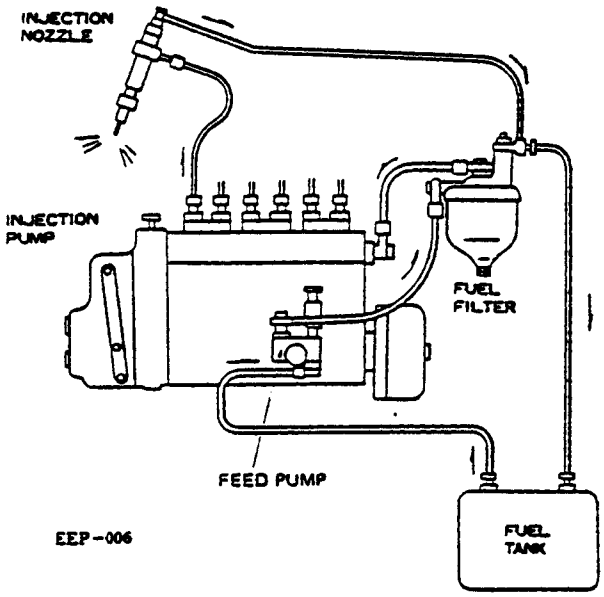
Recommended anti-rust agents for long term storage

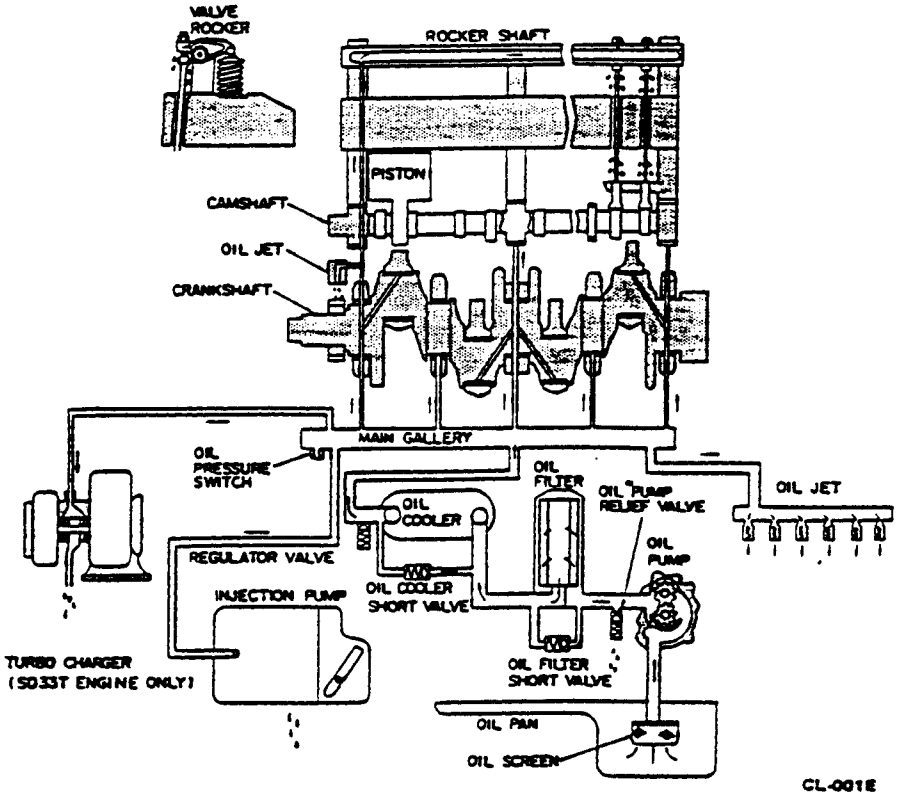
Maker	Brand Name	Specifications
CALTEX	CALTEX PRESERVATIVE OIL 30	P-10
ESSO	RUST-BAN 339	MIL-L-21260 Grade II,
MOBIL	MOBIL KOTE 503	MIL-L-21260B Type II
	MOBIL ARMA 524	Grade 30
GULF	GULF NO RUST ENGINE OIL Grade II	Use for lubricating system
SHELL	SHELL ENSSIS ENGINE OIL 30	
CALTEX	CALTEX 564 RUST PROOF OIL	
ESSO	RUST-BAN 334	P-9
MOBIL	MOBIL ARMA 777	MIL-L-6448
GULF	GULF OIL COAT R	Use for fuel system
SHELL	SHELL ENSSIS OIL 152	
CALTEX	CALTEX TEXACOAT	P-1
MOBIL	MOBIL KOTE 601	MIL-L-16173B Grade I
GULF	GULF NO-RUST A	Apply to metal surface
SHELL	SHELL ENSSIS FLUID 264	

Maker	Brand Name	Specifications
ESSO	ELOMA AK50F	P-19 MIL-C-16173C Grade 4 Apply to metal surface
	ELOMA PH32S	
CALTEX	SOLUBLE OIL C	EMULSION TYPE MIL-C-40084A, MIL-C-22572 Type I Use for cooling system
ESSO	KUTWELL 40	
	RUST-BAN 310	
MOBIL	SOLVAC 1535G	
	PROSOL 35	
GULF	GULF CUT SOLUBLE OIL	
SHELL	SHELL DROMUS OIL B	

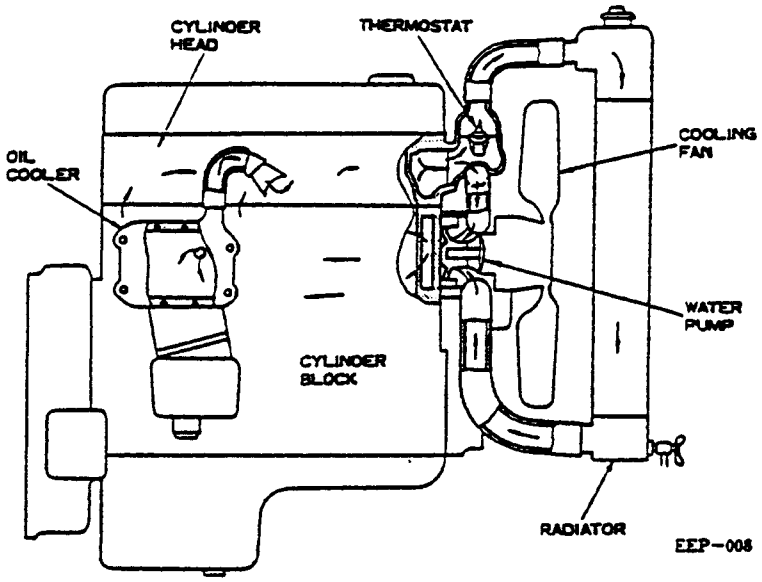
SYSTEM DIAGRAMS

FUEL SYSTEM DIAGRAM

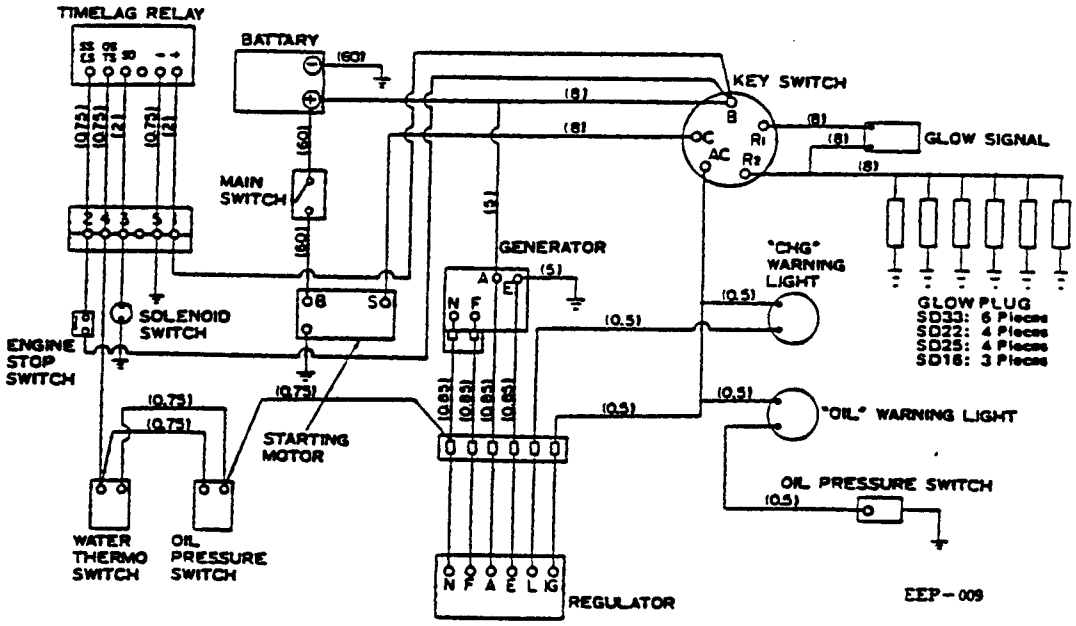




COOLING SYSTEM DIAGRAM



ELECTRICAL SYSTEM DIAGRAM

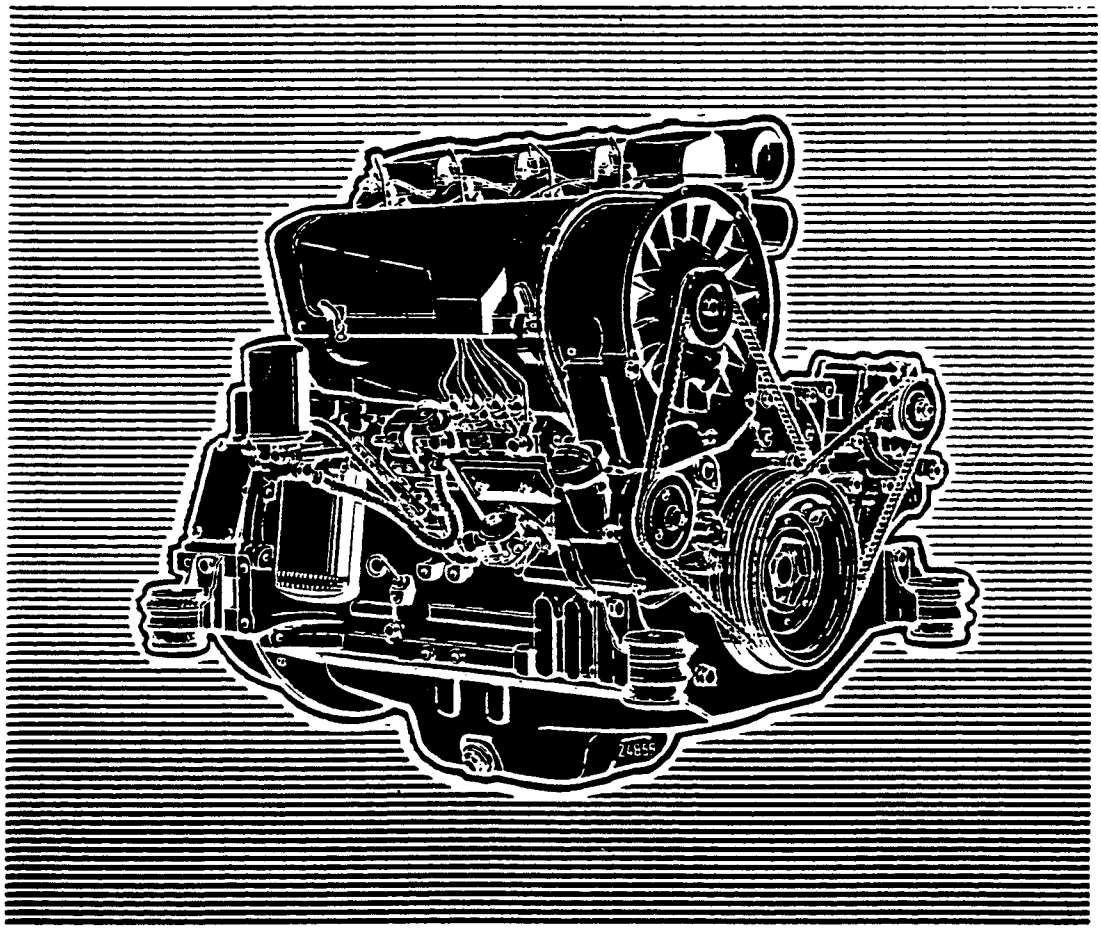


REV.

Operation Manual

KHD DEUTZ

FL 1011



REV.

DEUTZ Diesel Engines

are the product of research and development ranging over many years. The know-how thereby gained, coupled with high demands with regard to quality, forms the guarantee for the manufacture of engines featuring long service-life, high reliability, and low fuel consumption.
It goes without saying that the high demands regarding protection of the environment are also fulfilled.

Service and Maintenance

will also play a decisive role as to whether the engine fulfills to your satisfaction the demands you make on it. Observance of the prescribed maintenance intervals and careful carrying out of the service and maintenance jobs are therefore essential.
Particular attention must be given with regard to applications involving differing and harder operating conditions as compared with normal operation.

DEUTZ SERVICE

In case of operational troubles and queries concerning spare parts, please contact your DEUTZ agent. Where necessary, our trained specialists will ensure a quick and professional repair, using DEUTZ spare parts. Genuine DEUTZ spare parts are always manufactured to the latest technical standards. More information on DEUTZ SERVICE is to be found at the end of this Operation Manual.

Beware of Running Engine

Always stop the engine before carrying out maintenance or repair work. After completing the work, refit any guards which had to be removed.
Closely-fitting work clothing should be worn when working on the running engine.
Always stop the engine before refuelling.
Never run the engine in an enclosed space – danger due to poisonous vapours.

Safety

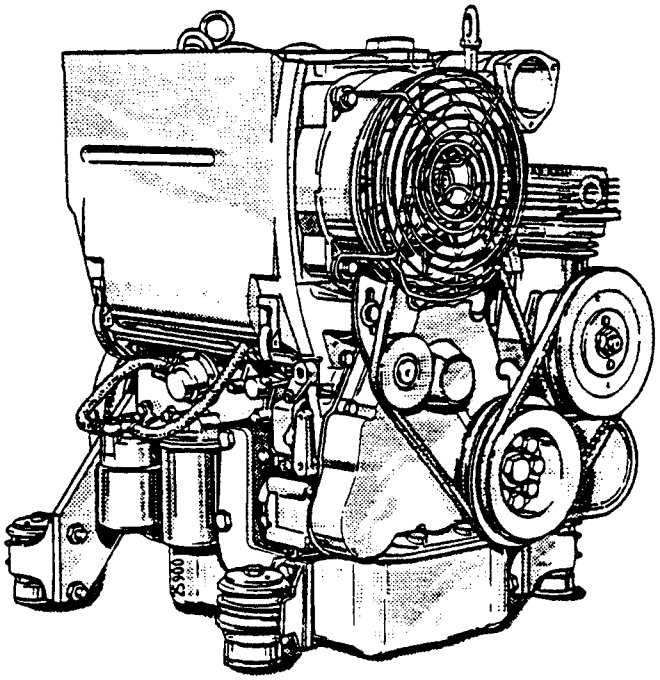


When reading through this Manual, you will find this symbol marking all safety instructions and proceed with special care. Pass on these safety instructions to your operating personnel.
In addition, it is also necessary to observe the official safety and accident prevention rules.

Asbestos

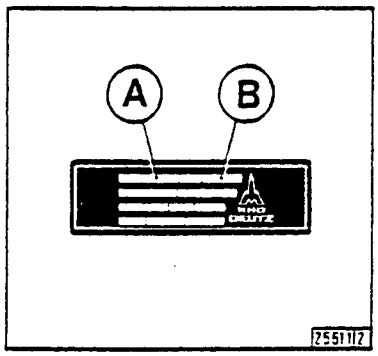


Gaskets used in this engine may contain asbestos.
When carrying out repair work, pay special attention to spare parts which are marked „a".



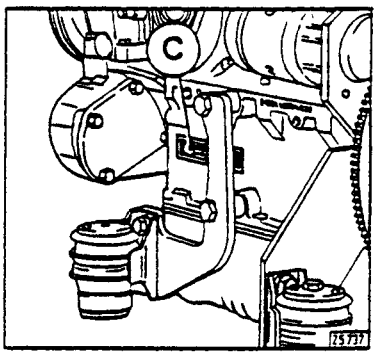
2.1 Model Designation
2.2 Engine Illustrations
2.3 Lube Oil Circuit
2.4 Layout of Fuel System

2.1.1 Rating Plate



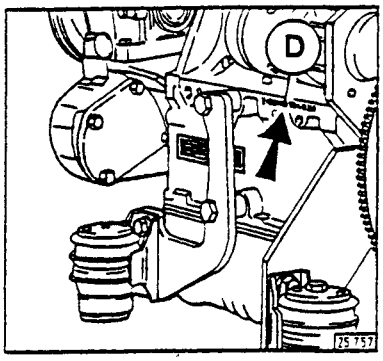
The model designation A, the engine serial number B and the performance data are stamped on the rating plate. When ordering spare parts, it is essential to quote the model designation and engine serial number.

2.1.2 Location of Rating Plate



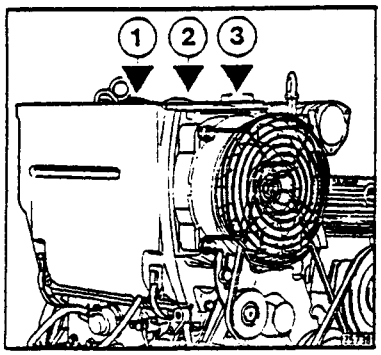
The rating plate C is attached to the crankcase; depending on the version, an additional rating plate may be attached to the air cowling.

2.1.3 Engine Serial Number



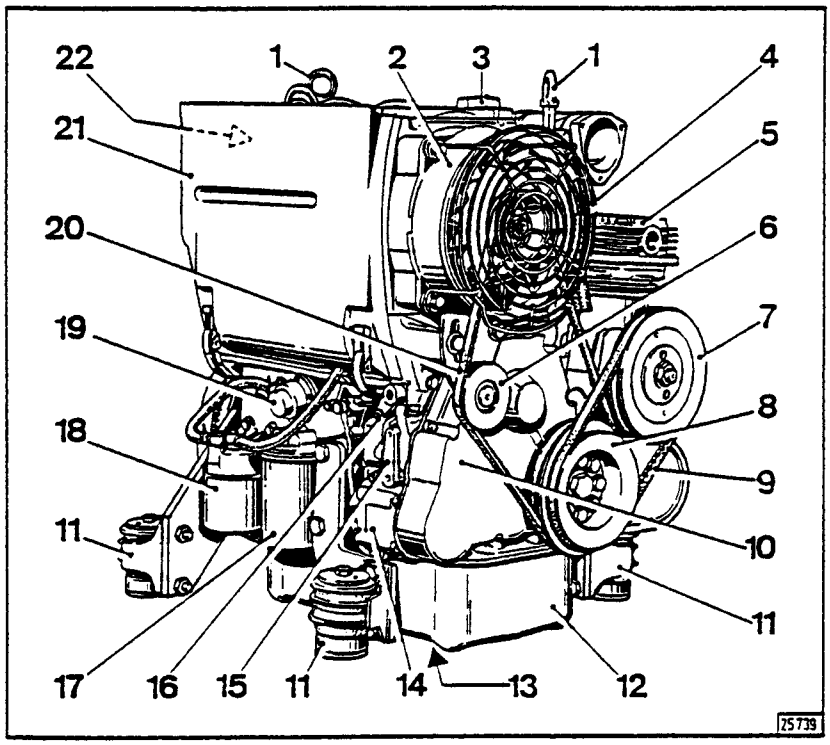
The engine serial number D is stamped into the crankcase as well as on the rating plate(s).

2.1.4 Numbering of Cylinders



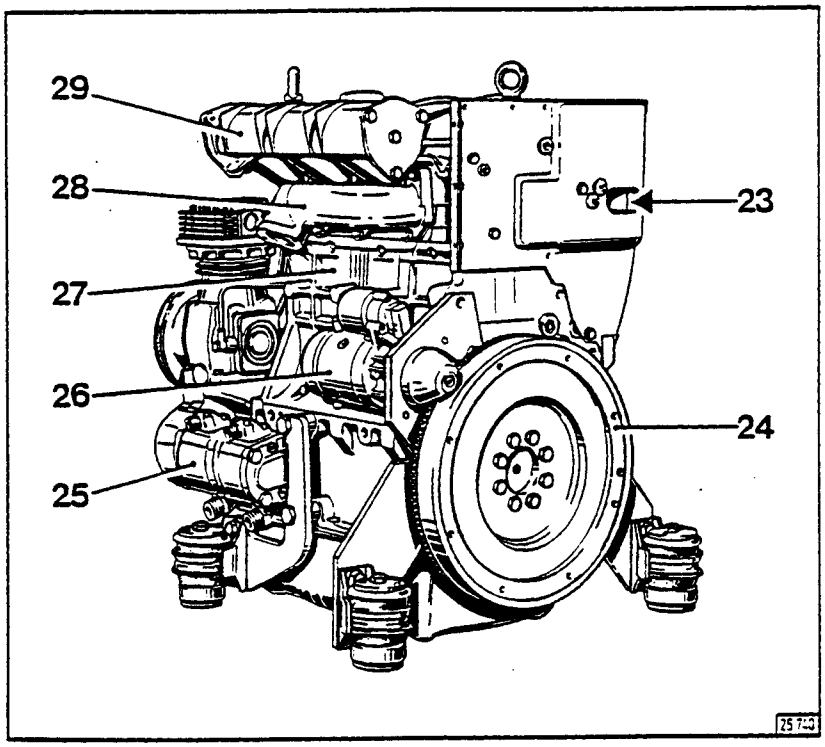
The cylinders are numbered consecutively, beginning at the flywheel end.

2.2.1 Service Side

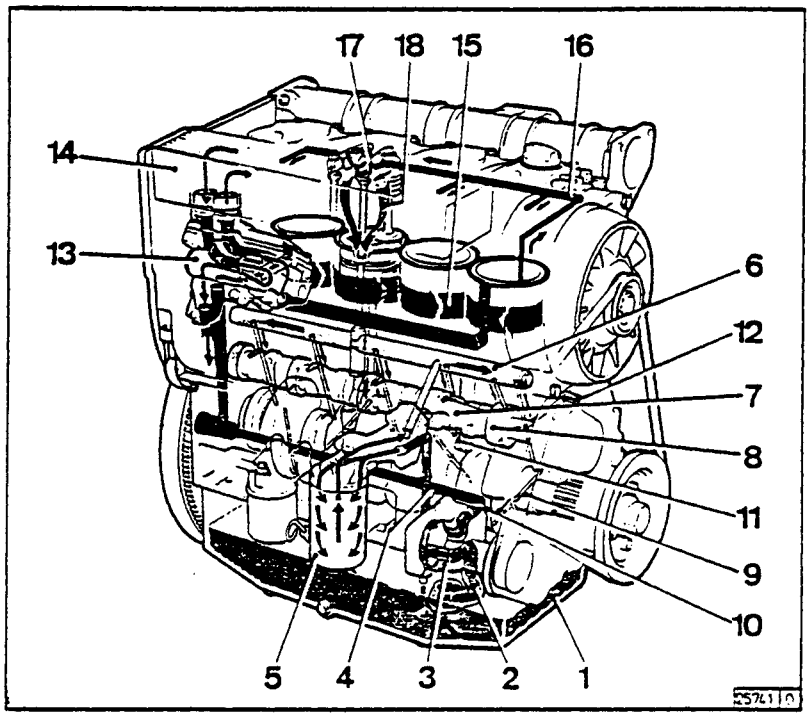


1 Lifting eyebolts
2 Cooling blower (with integrated alternator)
3 Oil filler neck
4 Guard
5 Air compressor
6 V-belt idler pulley
7 V-belt pulley (air compressor)
8 V-belt pulley (crankshaft)
9 Air compressor V-belt
10 Hood of toothed belt drive
11 Flexible engine mountings
12 Oil pan
13 Oil drain plug
14 Oil pump
15 Speed control lever
16 Shut-down lever
17 Oil filter
18 Fuel filter
19 Fuel pump
20 Cooling blower V-belt
21 Removable air cowling
22 Oil cooler

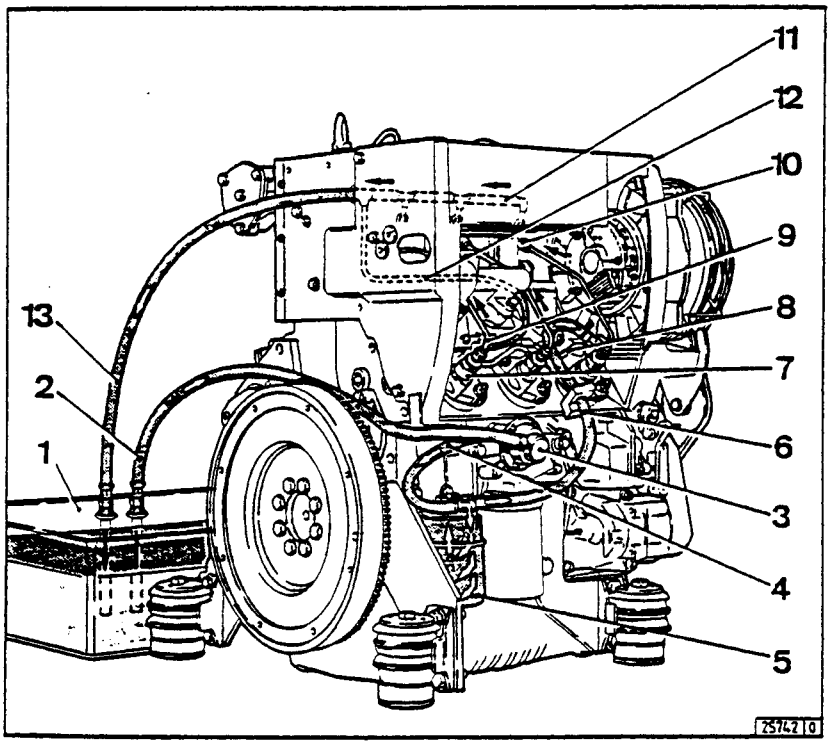
2.2.2 Exhaust-Air Side



23 Cut-out for passage of lines (in case of engine-oil can heating system)
24 Flywheel
25 Hydraulic pump
26 Starter motor
27 Cylinder crankcase
28 Exhaust manifold
29 Air intake manifold



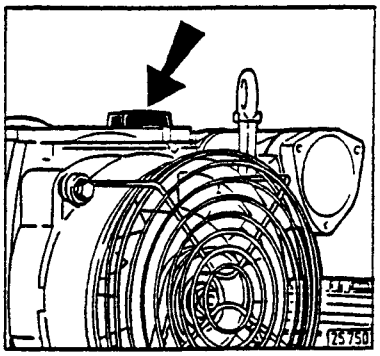
1 Oil pan
2 Suction pipe
3 Oil pump
4 Oil duct to oil filter and thermostat housing
5 Oil filter
6 Oil gallery
7 Oil bores to camshaft and main bearings
8 Camshaft bearing
9 Main bearing
10 Big-end bearing
11 Spray nozzle for piston cooling
12 Connection for air compressor lubrication
13 Thermostat housing
14 Oil cooler
15 Oil-cooled cylinder
16 Oil duct for lubrication of rocker arms
17 Rocker arm lubrication
18 Oil return via crankcase to oil pan



1 Fuel tank
2 Fuel line from tank to fuel feed pump
3 Fuel feed pump
4 Fuel line from feed pump to fuel filter
5 Fuel filter
6 Fuel line from filter to plug-in injection pump
7 Plug-in injection pumps
8 Fuel distribution line
9 Injection lines
10 Injectors
11 Fuel backleakage line
12 Fuel overflow line
13 Fuel return line to tank

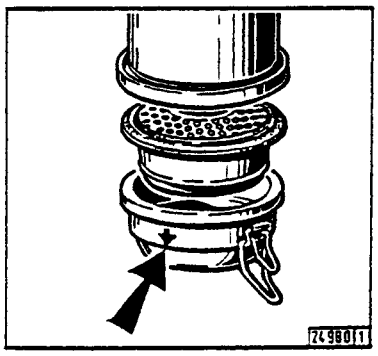
3.1 Commissioning
3.2 Starting
3.3 Monitoring Systems
3.4 Stopping
3.5 Operating Conditions

3.1.1 Filling in Engine Oil



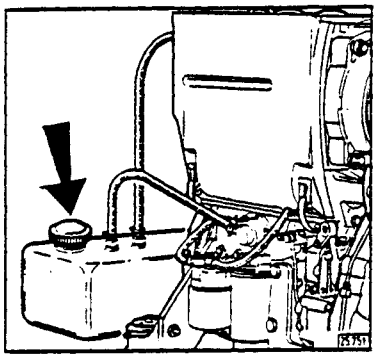
As a rule, the engines are delivered without oil filling.
Fill the engine with lube oil through the oil filler neck (arrow).
For oil filling volume, see 9.1
For oil quality grade and oil viscosity, see 4.1

3.1.2 Filling Oil Bath Air Cleaner with Engine Oil



Fill oil bath air cleaner (if mounted) with engine oil up to the arrow mark.

3.1.3 Filling the Fuel Tank



Use only commercial-grade diesel fuel. See 4.2 for fuel quality grade.
In accordance with ambient temperatures, summer or winter diesel fuel should be used.



Stop engine before filling fuel tank!
Observe strict cleanliness!
Do not spill any fuel!

3.1.4 Other Preparations

- Check battery and lead connections: see 6.7.1
- Remove lifting eyebolts, if mounted: see 6.7.2
- Trial Run
  Upon completing the preparations, run the engine for a short trial period of about 10 minutes without load.

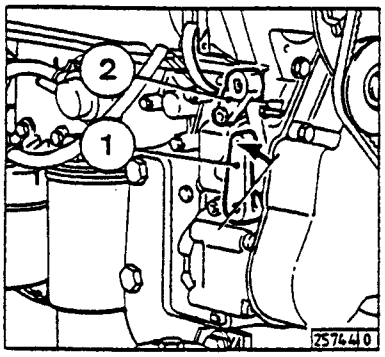
  Steps to be taken during and after trial run:
  – Check engine for leakages.
  – Check oil level, top up with oil if necessary: see 3.1.1 and 6.1.2
  – Retension V-belts: see 6.5
- Running in
  Normally, new engines have a higher oil consumption. During the running-in phase, approx. 200 running hours, it is recommended to check the oil level twice daily. After the running-in phase, checking once a day will be sufficient.

3.1.5 Additional Maintenance Jobs

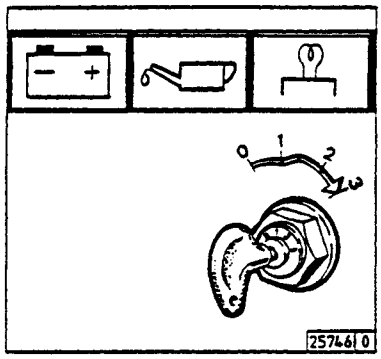
After 50 running hours, the following maintenance jobs are to be carried out:

- Change lube oil: see 6.1.2
- Renew oil filter cartridge: see 6.1.3
- Renew fuel filter cartridge: see 6.2.1
- Check V-belt tension, retension if necessary: see 6.5
- Check valve clearances, readjust if necessary: see 6.6.1
- Check engine for leakages
- Check engine mountings, retighten if necessary: see 9.2

3.2.1 Electric Starting



- Disengage the clutch – where possible – to separate engine from driven equipment.
- Set speed control lever 1 to idling speed position.
- Set shut-down lever 2 to operating position.
- Insert key:
  – Position 0 = No operating voltage.
- Turn key clockwise:
  – Position 1 = Operating voltage.
  – Charging pilot lamp 3 lights up.
  – Oil pressure pilot lamp 4 lights up.



without Cold-Starting Aid

- Push key in deeper and turn further clockwise against spring pressure as far as detent.
  – Position 2 = No function.
  – Position 3 = Start.
- Release key as soon as engine starts firing.
  – Pilot lamps go out.

with Cold-Starting Aid (Heating Plug)

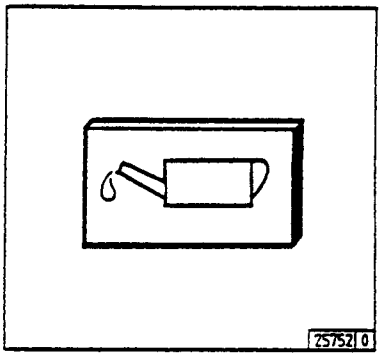
- Push key in deeper and turn further clockwise against spring pressure.
  – Position 2 = Preheating.
  Hold in position 2 for about 1 minute for preheating.
- Turn key further as far as detent.
  – Position 3 = Start.
- Release key as soon as engine starts firing.
  – Pilot lamps go out.

Do not actuate starter for more than 20 seconds at a time. If engine does not start, wait 1 minute before repeating attempt.
If engine does not start after two attempts, trace the cause with aid of Diagnosis Chart (see 7.1).

Before starting , make sure that no-one is standing in the close vicinity of the engine or driven machine.
After carrying out repairs: Check that all safety guards have been refitted and all tools have been removed from the engine.
When starting with heating plug, do not use any additional starting aids (e.g. spraying of start pilot). Danger of accident!

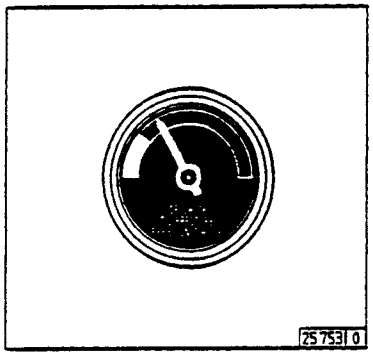
3.3.1 Engine Oil Pressure

Oil Pressure Pilot Lamp



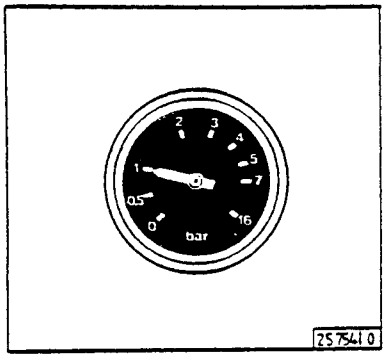
- The oil pressure pilot lamp lights up with operating voltage switched on but engine stopped.
- When the engine is running, the oil pressure pilot lamp must be out.

Oil Pressure Indicator



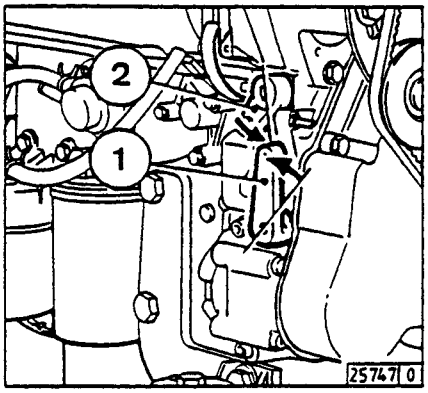
- The pointer of the oil pressure indicator must remain in the green sector over the entire operating range.

Oil Pressure Gauge



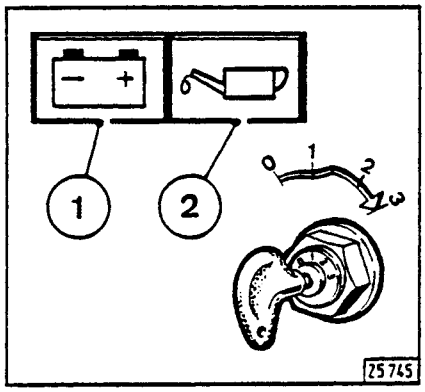
- The pointer of the oil pressure gauge must show the minimum oil pressure (see 9.1).

3.4.1 Mechanical Shut-Down



- Set speed control lever 1 to low speed position.
- Actuate shut-down lever 2 until engine stops, whereupon charging pilot lamp and oil pressure pilot lamp light up.
- Turn key counter-clockwise (to postition 0) and withdraw. Pilot lamps go out.

3.4.2 Electrical Shut-Down (Ignition Key)

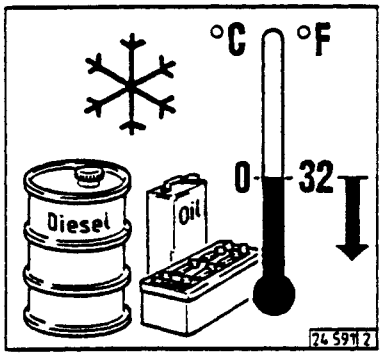


- Turn key counter-clockwise (to position 0) and withdraw. Pilot lamps 1 and 2 go out.

Do not shut engine down suddenly from full-load running.

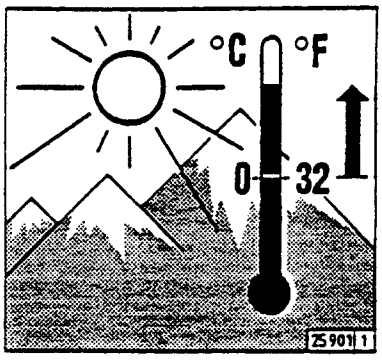
3.5.1 Operation in Winter

- Lube Oil Viscosity
  - Select viscosity (SAE-grade) as governed by the ambient temperature prevailing at the time of starting the engine: see 4.1.2.
    Note shorter periods between oil changes when operating below – 10 °C (+ 14 °F): see 6.6.1.
- Diesel Fuel
  - Use winter-grade fuel for operation below 0 °C (+ 32 °F): see 4.4.2.
- Additional Maintenance Jobs
  - Drain the thick sludge from fuel tank once a week (by undoing the sludge drain plug).
  - Match the oil filling in oil bath air cleaner (if fitted) to ambient temperature, as in case of engine oil.
  - At temperatures below – 20 °C (– 4 °F), lubricate the flywheel ring gear with low-temperature grease, e.g. Bosch FT 1 V 31, from time to time through the pinion hole (if necessary, remove starter).
- Cold-Starting Aids
  - At temperatures near or below freezing point, start if necessary with heating plug: see 3.2.1.
    This not only lowers the starting limit temperature, but proves also useful at temperatures normally not requiring a starting aid.
- Battery
  - Cold starting requires a good state of charge of the battery: see 6.7.1.
  - Lowering the limit temperatures by 4 – 5 ° (39 – 41 °F) is possible by raising the battery temperature to about + 20 °C (+ 68 °F). This is achieved by removing the battery and storing it in a warm room.



3.5.2 High Ambient Temperature, High Altitude

- With increasing altitude and increasing ambient temperature, the density of the air tends to decrease. This has an effect on the maximum power output of the engine, the exhaust gas quality, the temperature level and, in the extreme case, the starting behaviour. For non-stationary engines, operation at altitudes up to 1000 metres is admissible (up to 30 °C [86 °F]). When operating under unfavourable conditions (higher altitude or higher temperature), a reduction in the amount of injected fuel, and therefore in the engine's power output, is necessary.
- In case of doubt concerning such engine applications, ask your engine or equipment supplier whether, in the interests of operational safety, service life and exhaust gas quality (smoke!), an engine derating had been considered necessary, or simply contact the DEUTZ SERVICE.



4.1 Lube Oil
4.2 Fuel

4.1.1 Quality Grade

Lube oils are differentiated according to their efficiency and quality grade. Commonly used are the API-Specifications, named after the „American Petroleum Institute".

Approved Oils:

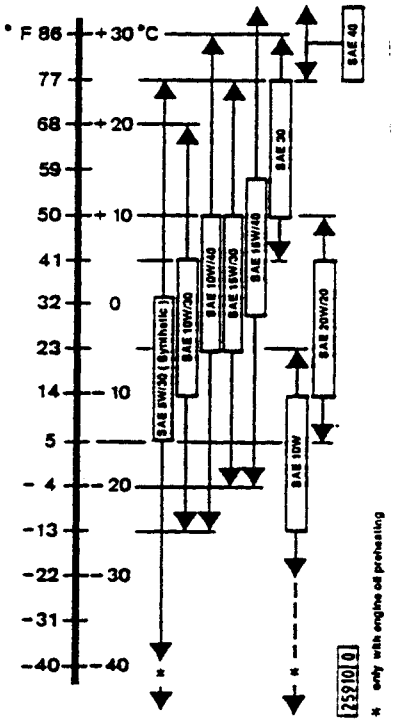
Unturbocharged Engines	API-Specific.	
	CC/SE	CC/SF
	CD/SE	CD/SF
Turbocharged Engines	API-Specific.	
	CD/SE	CD/SF
	SHPD*	

* SHPD (Super High Performance Diesel) oils are approved by KHD by name only, since a valid Specification has not yet been laid down. Should you have any doubt, ask the DEUTZ SERVICE.

Oil change intervals: see 6.1.1
Oil filling volumes: see 9.1.

4.1.2 Viscosity

As the viscosity of lube oil is greatly influenced by the temperature, the choice of SAE-grade should be governed by the ambient temperature at engine site. Optimum operating behaviour will be attained if you take as guide the oil viscosity diagram appearing alongside.
Should temperatures temporarily fall below the limits of the SAE-grade selected, this will merely affect the starting performance but cause no damage to the engine. Exceeding the application limits should not be over a prolonged period, in order to keep wear down to a minimum.
Oil changes dictated by the time of year can be avoided by using multi-grade oils. Multi-grade oils – particularly light-flowing oils – also tend to reduce fuel consumption.



4.2.1 Quality Grade

Always use branded grades of diesel fuel having a sulphur content of below 0.5 %. In the case of a higher sulphur content, the periods between oil changes must be shortened: see 6.1.1.

The following fuel specifications are approved:

- DIN 51 601
- NATO Codes F 54, F 75 and F 76
- BS 2869: A 1 and A 2 (in case of A 2, note sulphur content)
- ASTM D 975-81: 1-D and 2-D
- VV-F-800a: DF-A, DF-1 and DF-2.

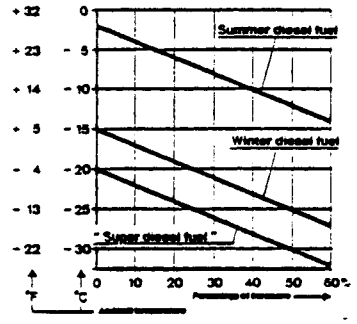
4.2.2 Winter-Grade Fuel

At low temperatures, waxing may occur and clog the fuel system, thus causing operational troubles. In the case of ambient temperatures below 0 °C (+ 32° F), use winter-grade diesel fuel (down to – 15 °C [+ 5 °F]). Normally, this is offered at filling stations in good time before the cold season starts. Diesel fuel with additives („Super diesel") is frequently also on sale for use at temperatures down to – 20 °C (– 4 °F).

- At temperatures as low as – 15 °C (+ 5 °F) to – 20 °C (– 4 °F), kerosene should be mixed with the diesel fuel.
  The necessary percentages for admixing are to be seen in the diagram at right.

If summer diesel fuel has to be used at temperatures below 0 °C (+ 32 °F), up to 60 % kerosene can be admixed (see diagram).

In most cases, adequate resistance to cold is also attained by adding a flow improver (fuel additive). Ask your DEUTZ SERVICE about this.



Prepare the blend in the tank itself!
Fill in the necessary amount of kerosene first, then add diesel fuel.

5.1 Maintenance Schedule
5.2 Maintenance Chart
5.3 Completed Maintenance Jobs

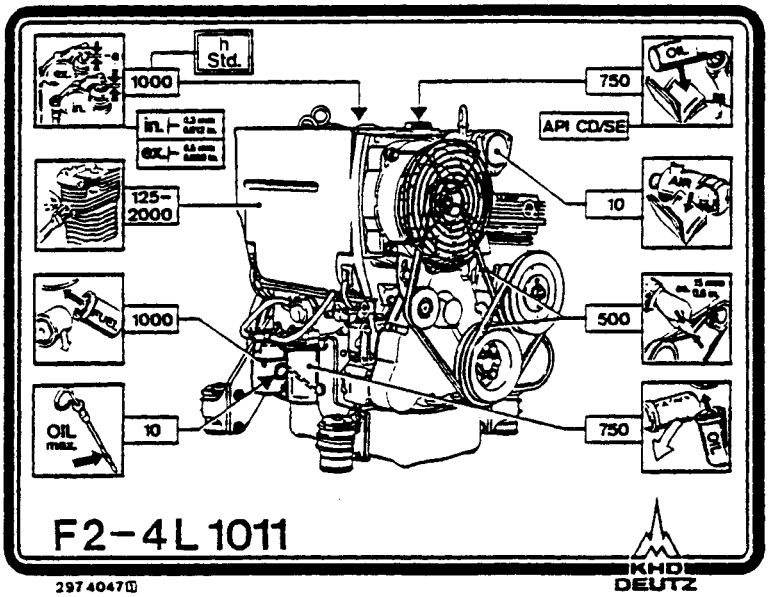
In running hours (h) [1]									Check				See Section
Every 10 h resp. daily	Every									Clean			
	50[2]	125	250	500	750	1000	2000	3000			Renew	Job	
•									•			Oil level in engine/separate tank	6.1.2
	•								•			Engine for leakages	
•									•			Oil bath- and dry-type air cleaners [3] [6]	6.4
		•							•			Battery and lead connections	6.7.1
		•	•	•		•	•		•			Cooling system (dep. on engine use) [3]	6.3
	•			• [4]	• [5]						•	Engine oil (dep. on engine use)	6.1.2
	•			•	•						•	Oil filter (dep. on oil change interval)	6.1.3
	•				•						•	Fuel filter	6.2.1
	•					•			•			Valve clearances (readjust if necessary)	6.6.1
	•								•			Engine mountings (retighten if necessary)	9.2
	•			•					•			V-belts (retension if necessary)	6.5
						•			•			Toothed belt	6.5.5
								•	•			Injectors	

[1] Max. permissible guide-times
[2] Commissioning new and overhauled engines
[3] Clean if necessary
[4] Oil quality grade API: CC/SE
[5] Oil quality grade API: CD/SE
[6] Renew if necessary

The Maintenance Chart displayed here is supplied as self-adhesive label along with each engine. Check that this label is stuck at a convenient location on the engine or driven equipment.

If necessary, ask for a fresh supply of labels.

Valid for routine maintenance work is the Maintenance Schedule: see 5.1



2974047①

Stop engine before carrying out any maintenance work

REV.

Hours	Date	Signature/Stamp	Hours	Date	Signature/Stamp
*50			–		
125			250		
375			500		
625			750		
875			1000		
1125			1250		
1375			1500		
1625			1750		
1875			2000		
2125			2250		
2375			2500		
2625			2750		

The maintenance jobs duly completed can be recorded in the above table.
* Commissioning new and overhauled engines.

Hours	Date	Signature/Stamp	Hours	Date	Signature/Stamp
2875			3000		
3125			3250		
3375			3500		
3625			3750		
3875			4000		
4125			4250		
4375			4500		
4625			4750		
4875			5000		
5125			5250		
5375			5500		
5625			5750		

The maintenance jobs duly completed can be recorded in the above table.

6.1 Lubrication System
6.2 Fuel System
6.3 Cooling System
6.4 Combustion Air Cleaner
6.5 Belt Drives
6.6 Adjustments
6.7 Accessories

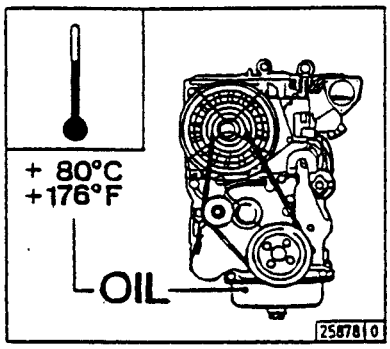
6.1.1 Oil Change Interval

- The oil change intervals are dependent on the engine application and on the quality of the lubrication oil.
- Should, within one year, the engine run less than the hours stated in the table, the oil must be changed at least once a year.
- The table is subject to the following conditions:
  - For diesel fuel, sulphur content max. 0.5 % b. w.
  - Prevailing ambient temperature above − 10 °C (+ 14 °F).
- In the case of sulphur content > 0.5 up to 1 %, or prevailing ambient temperatures being below − 10 °C (+ 14 °F), the intervals between oil changes are to be halved.
- In the case of fuels containing more than 1 up to 1.5 % sulphur, a lube oil with a TBN of 12 x % sulphur content must be used.

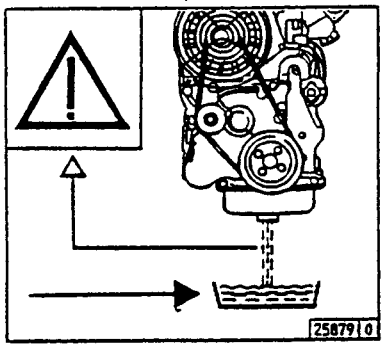
	Naturally Aspirated Engines	
Oil Grade	CC/SE CC/SF	CD/SE CD/SF
Equipment engines	Oil Change (running hours)	
Light duties, e.g.: Road vehicles, Tractors, Lift trucks, Cranes, Construction machinery, Rail traction units, Ships, Generating sets, Pumps	500	750
Heavy duties, e.g.: Combine harvesters, Underground mining, Road sweepers, Winter service, Emergency gensets, Emergency pumps	250	375

TBN = „Total Base Number": expresses the neutralising capacity of the oil. Ask your supplier to quote TBN.

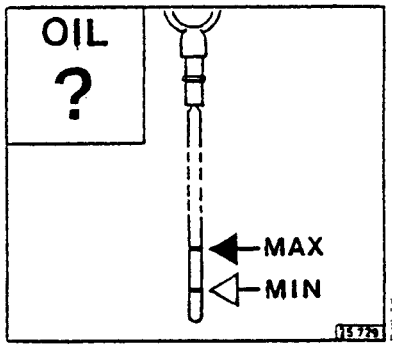
6.1.2 Changing Engine Oil Checking Oil Level



- Position engine or vehicle on level surface.
- Set cab heater actuating lever to maximum heating capacity (only in the case of vehicles with engine oil-operated cab heater system).
- Warm up engine
  - lube oil temperature approx. 80°C (+ 176°F).
- Stop engine.



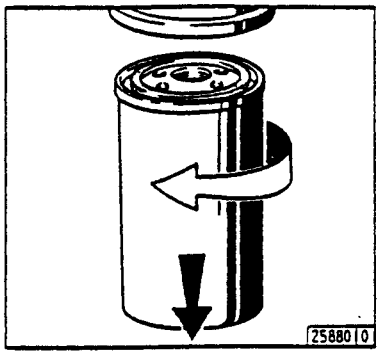
- Place oil tray under engine.
- Screw out oil drain plug.
- Drain oil.
- Refit oil drain plug complete with new sealing ring and tighten firmly. (For tightening torque, see 9.2)
- Fill in fresh lube oil.
  - Oil grade/viscosity: see 4.1
  - Filling volumes: see 9.1
- Start engine and run at low idling speed (for about 2 min. in case of oil-operated heater system).



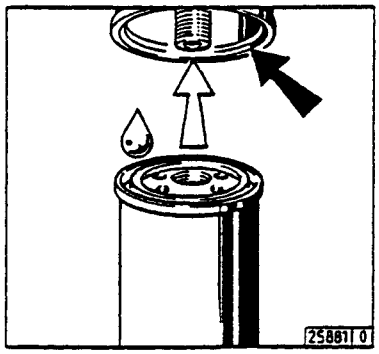
- Stop engine.
- Check oil level.
  - In case of oil dipsticks with double marking (● and −), the dash mark is applicable.
  - If necessary, top up with oil as far as the upper dash mark.

Take care when draining off hot oil: Danger of scalding!
Catch old oil in suitable receptacle ready for proper disposal to prevent environmental pollution!

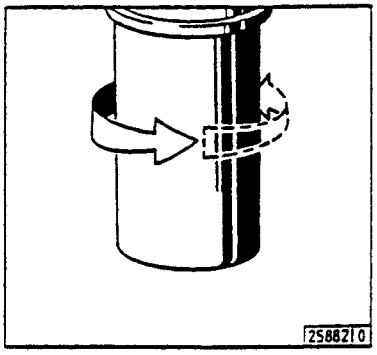
6.1.3 Renewing Oil Filter



- Release lube oil filter cartridge with normal commercial tool and spin off.
- Catch any escaping oil in receptacle.



- Clean sealing surface of filter carrier.
- Apply light film of oil to rubber gasket of new lube oil filter cartridge.
- Screw cartridge into place by hand until gasket is evenly seated.

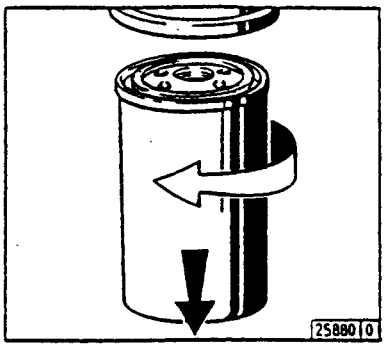


- Tighten lube oil filter cartridge firmly by giving a final half turn.
- Check oil level: see 6.1.2
- Check oil pressure: see 3.3.1
- Check sealing of lube oil filter cartridge for leaks.

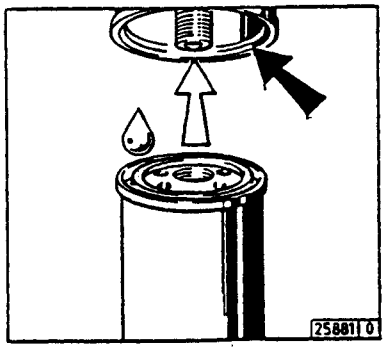


Beware of hot oil:
Danger of scalding!

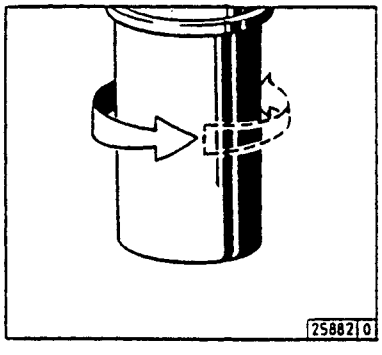
6.2.1 Renewing Fuel Filter



- Close fuel stopcock.
- Release fuel filter cartridge with normal commercial tool and spin off.
- Catch escaping fuel in receptacle.



- Clean sealing surface of filter carrier.
- Apply light film of oil or diesel fuel to rubber gasket of new fuel filter cartridge.
- Screw cartridge into place by hand until gasket is evenly seated.



- Tighten fuel filter cartridge firmly by giving a final half turn.
- Open fuel stopcock.
- Check sealing for leaks.



When working on the fuel system, keep naked lights away! Do not smoke!

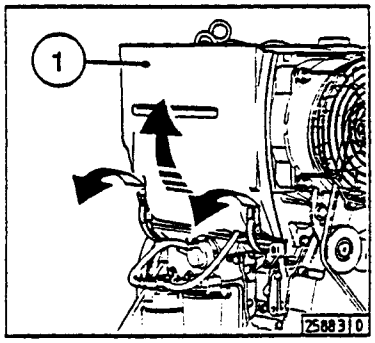
Bleeding of the fuel system is not necessary.

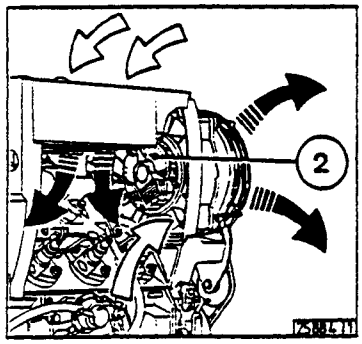
6.3.1 Cleaning Intervals

- The degree of soiling of the cooling system is dependent on the type of engine application.
- More severe contamination can occur, e.g. in case of:
  - Construction site application, due to heavily dust-laden air.
  - Harvesting work, due to the high proportion of chaff and chopped straw, for example, in the vicinity of the implement.
- The danger of contamination is increased due to residues of oil and fuel on the engine. Check extra carefully, therefore, for leakages when applications involve high dust fall-out.
- In view of the varying conditions of application, the cleaning intervals must be determined from case to case. The cleaning intervals stated in the table can be taken as guide values.

Checking or Cleaning intervals Guide Values (running hours)	Engine Application
2000	Ships, Generating sets in closed rooms, Pumps
1000	Vehicles on paved roads
500	Tractors, Lift trucks, Mobile gensets
250	Vehicles on construction sites and unpaved roads, Construction machinery, Compressors, Underground mine units
125	Farm equipment, Tractors doing harvesting work

6.3.2 Cleaning the Cooling System





With Compressed Air

- Remove cooling-air cowling 1.
- Start blowing through the engine with compressed air from the exhaust-air side, paying particular attention to the cooling fins and oil cooler. Remove any dirt blown into the air cowling space.
- Remount cooling-air cowling 1.

Engine must be stopped and cooled down prior to cleaning!

With Cold Cleansing Agent

- Remove cooling-air cowling 1.
- Spray engine with a commercial cold cleansing agent and allow a soaking-in period of about 10 minutes.
- Wash engine clean with a powerful water jet (taking care to avoid direct contact of the water jet with sensitive engine components, e.g. alternator 2).
- Repeat procedure, if necessary.
- Remount cooling-air cowling 1.
- Run engine until warm, in order to prevent rust formation.

With High-Pressure Steam Jet

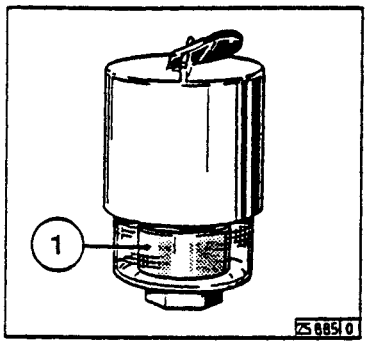
- Remove cooling-air cowling 1.
- Clean engine with steam jet (taking care to avoid direct contact of the steam jet with sensitive engine components, e.g. alternator 2).
- Remount cooling-air cowling 1.
- Run engine until warm, in order to prevent rust formation.

6.4.1 Cleaning Intervals

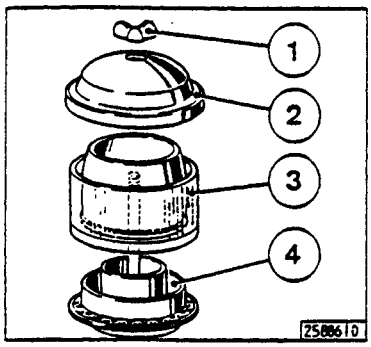
- The degree of soiling of the combustion air cleaner depends on the amount of dust in the air and the size of filter used. If very dusty air is to be expected, the combustion air cleaner can be preceded by a cyclone-type pre-cleaner.
- Consequently, the cleaning intervals cannot be laid down generally, but have to be determined from case to case.
- If dry-type air cleaners are used, cleaning should be carried out only when the service gauge indicates that servicing is due.
- Too frequent dismantling and refitting may damage the seal between filter cartridge and housing.

Servicing of the air cleaner becomes necessary if:

- with contamination indicator
  – the red flag 1 is fully visible with engine stopped.
- with filter service trip
  – the yellow warning lamp lights up with engine running.



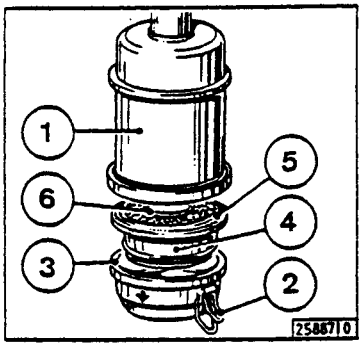
6.4.2 Emptying the Cyclone-Type Pre-Cleaner



- Undo wing nut 1 and take off housing cap. 2.
- Lift dust collector 3 off cyclone base 4 and empty. Clean cyclone base by removing leaves, straw, etc.
- Reposition dust collector 3 onto base 4 and fasten housing cap 2 in place by tightening wing nut 1.

Never fill dust collector with oil!
Renew dust collector if damaged!

6.4.3 Cleaning the Oil Bath Air Cleaner

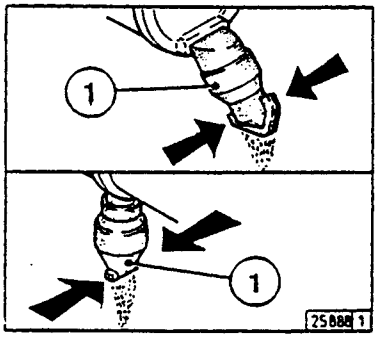


- Stop engine and wait about 10 minutes until the oil has run out of filter upper part 1.
- Release snap clips 2 and remove oil bowl 3 together with filter lower part 4, loosening filter element at joint by means of a screwdriver, if necessary. Do not damage rubber seal 5!
- After removing dirty oil and sludge, clean oil bowl.
- Rinse filter lower part 4 in diesel fuel and allow to drip-dry thoroughly.
- Clean filter upper part 1, if necessary.
- Inspect rubber seals 5 and 6, renewing if necessary.
- Fill oil bowl with engine oil up to oil level mark (arrow). For oil viscosity, see 4.1.2.
- Refit oil bowl and filter element to filter upper part and fasten snap clips.

Never rinse filter in petrol (gasoline)!
Dispose of used oil in compliance with statutory provisions.

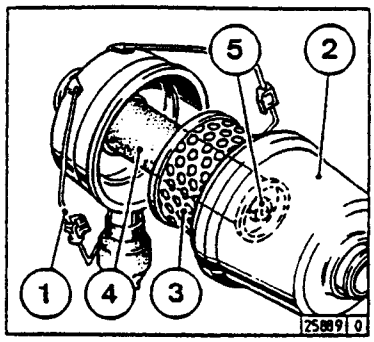
6.4.4 Dry-Type Air Cleaner

Dust Ejector Valve



- Discharge the dust ejector valve 1 by pressing apart the lips of the ejection slot, applying pressure as indicated by the arrows.
- Clean the ejection slot from time to time.
- Remove any cakes of dust by pressing together the upper part of the valve.

Filter Cartridges

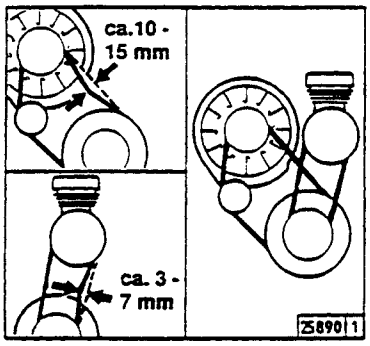


- Release fastening clamps 1.
- Take off filter hood 2 and pull out filter cartridge 3.
- Clean filter cartridge or renew after 1 year at latest.
- Clean filter cartridge 3:
  - With dry compressed air (max. 5 bar), applied from inside to outside, or
  - Tap out (emergency measure only), taking care not to damage cartridge, or
  - Wash out as per maker's instructions.
- Check cartridge for damage to filter paper (by introducing lighted lamp), and check seals. Renew, if necessary.
- After having serviced the filter cartridge five times, or after 2 years at the latest, renew safety cartridge 4 (never clean!).
  Proceed as follows:
  - Undo hex. nut 5 and pull out cartridge 4.
  - Insert new cartridge and secure with hex. nut.
- Insert filter cartridge 3, place on hood 2 and fasten with clamps 1.



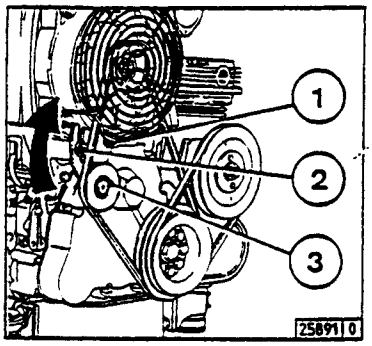
In no event use petrol (gasoline) or hot liquids for washing the filter cartridge!

6.5.1 Checking V-Belts



- Inspect V-belt over whole length for damage or cracks. Renew damaged or cracked V-belts.
- Check by pressing with the thumb midway between the pulleys to see whether the V-belt deflects inwards by not more than approx.
  10-15 mm - cooling blower or 3-7 mm-air compressor.
- If necessary, retension V-belt: see 6.5.2 and 6.5.4.

6.5.2 Retensioning Blower V-Belt

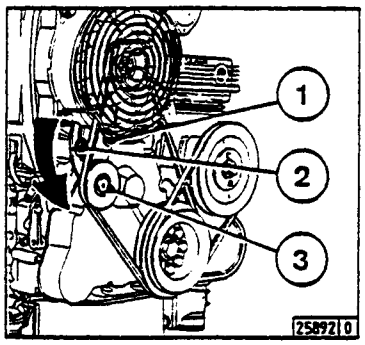


- Slacken hex. bolts 1 and 2.
- Push idler pulley 3 outwards until correct V-belt tension is attained.
- Retighten hex. bolts 1 and 2.



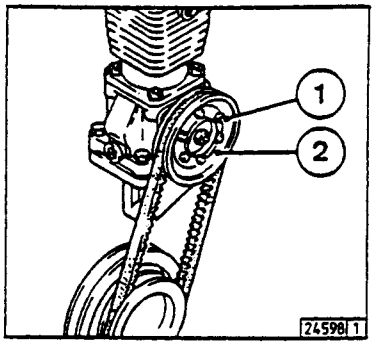
Stop engine before retensioning V-belts! If applicable, refit V-belt guard.

6.5.3 Renewing Blower V-Belt

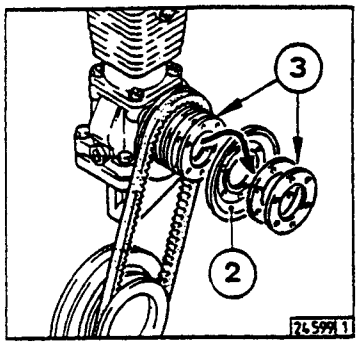


- If air compressor is mounted: First, remove compressor V-belt: see 6.5.4.
- Slacken hex. bolts 1 and 2.
- Push idler pulley 3 inwards.
- Remove V-belt and place on new belt.
- Push idler pulley 3 outwards until correct V-belt tension is attained.
- Retighten hex. bolts 1 and 2.
- If applicable, refit air compressor V-belt: see 6.5.4.

6.5.4 Retensioning or Renewing Air Compressor V-Belt



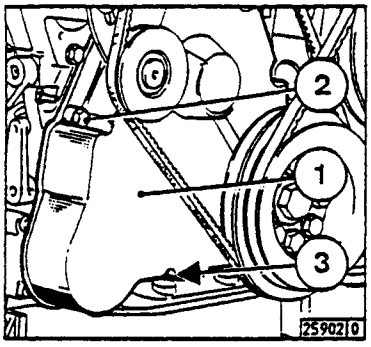
- Unscrew hex. bolts 1.
- Take off outer half-pulley 2.
- Renew V-belt if necessary
- To retension, remove one or more shims 3 – as may be required – from inside. Place removed shim(s) outside on removed half-pulley 2.



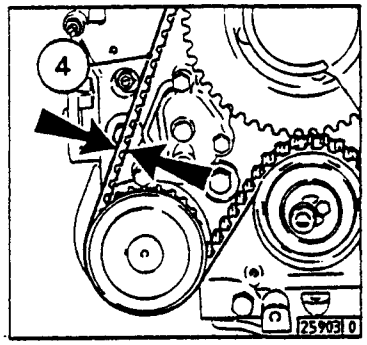
- Retighten bolts 1, while turning engine with turning tool to prevent the V-belt being squeezed.

In the case of new V-belts, recheck belt tension after running for 15 minutes.

6.5.5 Checking Toothed Belt

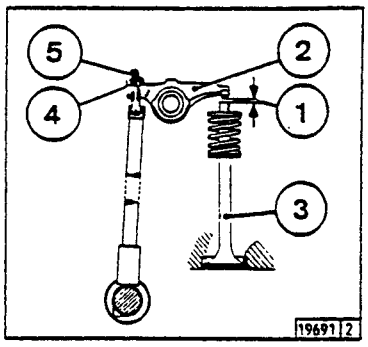


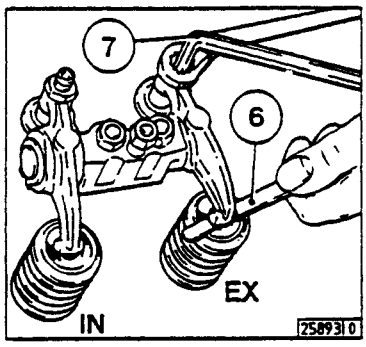
- Take off left-hand covering hood 1 of the toothed belt drive, after undoing hex. bolts 2 and 3.
- Check toothed belt 4 over whole length at tooth roots and tooth backs for cracks (see arrows).
- To do this, turn engine four revolutions with turning tool.



- If cracks are found, renew toothed belt (see Workshop Manual).
- Replace hood 1 and secure with hex. bolts 2 and 3.

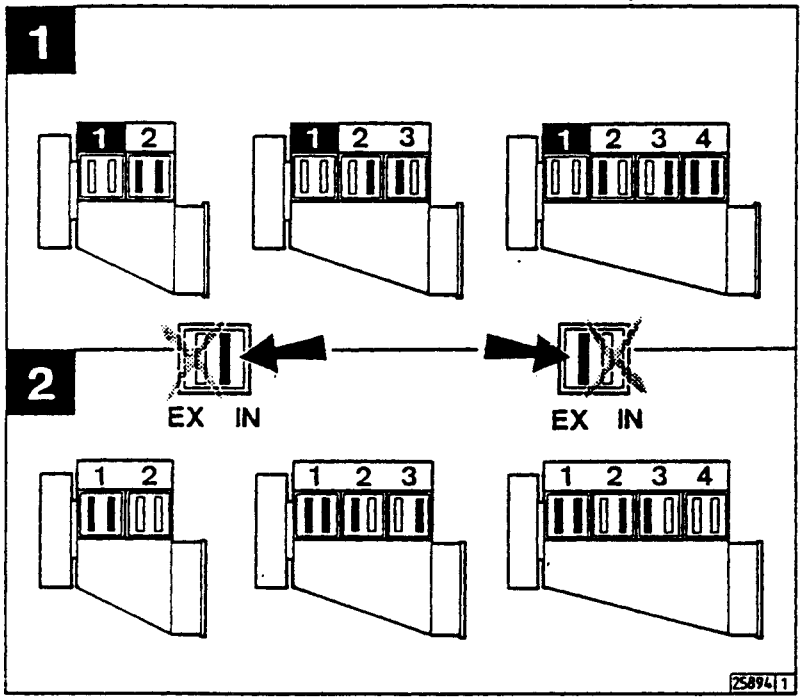
6.6.1 Checking/ Adjusting Valve Clearances





- Remove rocker cover.
- Position crankshaft as per setting schematic: see 6.6.1.1.
- Before adjusting valve clearance: Allow engine to cool down for at least 30 minutes (oil temperature below 80 °C (176 °F).
- Check valve clearance 1 between pad of rocker arm 2 and valve 3 with feeler blade 6 (clearance is correct if feeler blade can be inserted in gap with a slight drag).
  For permissible valve clearance, see 9.1.
- If necessary, adjust valve clearance as follows:
  – Loosen locknut 4 by 2 - 3 turns.
  – With Allen key 7 adjust setscrew 5 so that, when locknut 4 is retightened, the correct valve clearance is attained.
- Check the valve clearances at each of the remaining cylinders and adjust if necessary.
- Refit rocker cover with new seal.

6.6.1.1 Setting Schematic for Adjusting Valve Clearances

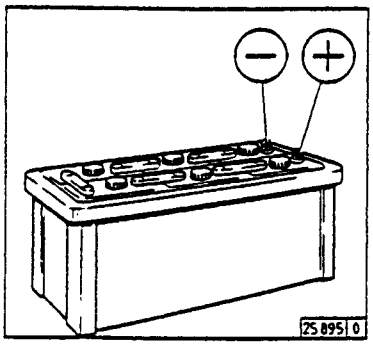


- Crankshaft Position 1:
  Turn the crankshaft until both valves at cylinder 1 are on „overlap" (i.e. exhaust valve about to close, inlet valve about to open).
  The valves marked black can now be adjusted.
  Mark each adjusted valve with chalk to show that it has been done.

- Crankshaft Position 2:
  Turn the crankshaft further by one rotation (360°). The valves marked black can now be adjusted.

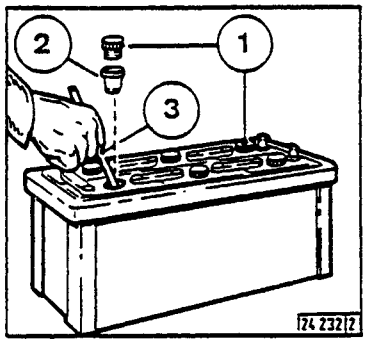
6.7.1 Battery

6.7.1.1 Checking Battery and Lead Connections



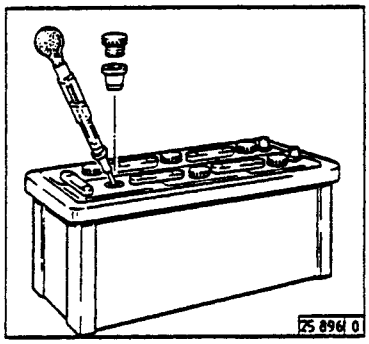
- Keep battery clean and dry.
- Undo soiled terminal clamps.
- Clean battery terminal posts (+ and −) and clamps, and treat with an acid-free and acid-resistant grease.
- When reconnecting, ensure good contact of the terminal clamps. Tighten clamping bolts firmly.

6.7.1.2 Checking Electrolyte Level



- Remove cell caps 1.
- If electrolyte level testers 2 are provided: the level should be high enough to wet the bottom of these.
- An alternative method is to insert a wooden stick 3 into the cell until it touches the top of the plates. The electrolyte should wet the stick over a length of about 10 - 15 mm.
- If the electrolyte level is low, top up with distilled water.
- Replace cell caps.

6.7.1.3 Checking Specific Gravity of Electrolyte



- Measure the specific gravity of the individual cells with a hydrometer.

The measured values (see table alongside) indicate the state of charge of the battery.
During the measurement, the temperature of the electrolyte should preferably read 20 °C (68 °F).

Specific Gravity				
in kg/l		in °Bé (°Baumé)*		State of Charge
Normal	Tropics	Normal	Tropics	
1,28	1,23	32°	27°	Fully charged
1,20	1,12	24°	16°	Half charged: Recharge
1,12	1,08	16°	11°	Discharged: Charge up immediately

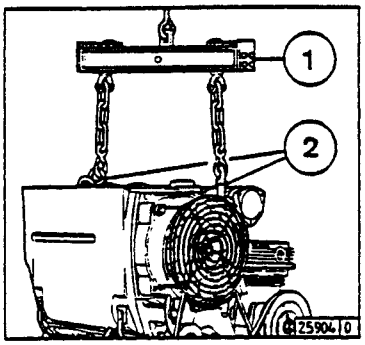
* Measurement of the specific gravity in °Bé (°Baumé) is obsolete and rarely used today.

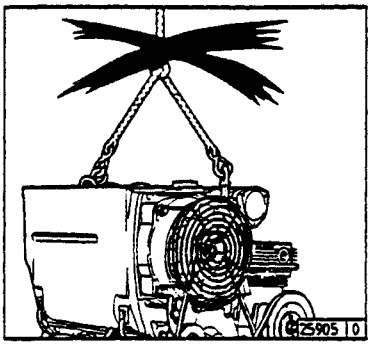
The gases emitted by the battery are explosive! Avoid formation of sparks in vicinity of battery, keep naked lights away!
Do not allow acid to come into contact with the skin or clothing! Wear protective goggles!
Do not place tools on battery!

6.7.2 Notes on three-phase system:

- When the engine is running, never disconnect the leads between battery, alternator and regulator. Where it is however necessary to operate the engine without battery, disconnect, before starting, the regulator from the alternator.
- Be sure not to confuse the battery terminals.
- Renew a defective charging pilot light bulb immediately.
- Before washing the engine, fit covers to protect the alternator and regulator.
- The common practice on a DC-system of touching a lead against frame for checking whether the lead is live must under no circumstances be adopted on a three-phase current system.
- In case of electric welding, connect the earth terminal of the welding unit direct to the part to be welded.

6.7.3 Lifting Tackle





- For transporting the engine, always use the correct lifting tackle 1.
- Upon completion of transporting manoeuvres, prior to recommissioning the engine: Remove lifting eyebolts 2.



Always use the correct lifting tackle!

7.1 Diagnosis Chart

- If engine problems occur, they will frequently be caused by improper operation or maintenance of the engine.
- In case of any trouble, always check whether the operating and maintenance instructions have been observed.
- An appropriate Diagnosis Chart appears on the page opposite.
- If you cannot identify the cause of the trouble or are unable to put it right yourself, contact your DEUTZ SERVICE.

Trouble: Engine fails (or difficult) to start	Engine starts, but runs unevenly or stalls	Engine becomes too hot, temperature monitor gives warning	Engine gives poor performance	Engine not working on all cylinders	Engine has little or no oil pressure	Engine oil consumption excessive	Engine smokes - blue	Engine smokes - white	Engine smokes - black	Cause	Section	Remedial Measure
												Check CH
												Adjust A
												Renew R
												Clean CL
												Top up TU
												Lower level LL
•										Not declutched (where possible)	Operation	CH
•								•		Below start limit temperature		CH
		•		•						Oil level too low		TU
		•	•		•	•				Oil level too high		LL
				•	•	•				Excessive inclination of engine		CH
•				•						Wrong SAE-grade of engine oil and oil quality	Op. Media	R
•	•		•					•		Fuel quality not as quoted in Op. Manual		R
		•	•						•	Air cleaner: Filter soiled	Combustion Air	R
		•	•						•	Air cleaner: Contamination indicator/Filter service trip defective		R
		•	•							Cooling fins soiled	Cooling System	CL
		•								Cooling blower faulty, V-belt broken/loose		CH/R
		•								Heating-up of cooling air/Recycling of heat		CH
•										Battery defective or flat	Electrics	CH
•										Connections of starter circuit loose/oxidized		CH
•										Starter faulty or pinion does not engage		CH
•	•		•						•	Valve clearances incorrect	Engine	A
	•		•	•						Injection line leaky		CH
•	•	•	•	•				•	•	Injector defective		CH/R

8.1 Preservation

8.1 Preservation

If the engine is to be shut down for a major period, it is necessary to take preservative measures to prevent rust formation. The preservative measures described here will protect the shut-down engine for a period of up to about 6 months. Before re-using the engine, the preservatives must be removed, except from the oil and fuel.

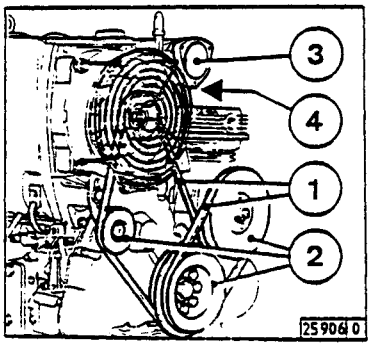
- Anti -corrosive oils to Specification:
  - MIL-L-21260B
  - TL 9150-037/2
  - NATO Code C 640 / 642
- Anti-corrosive agent to Specification:
  - NATO Code C 632
- Recommended cleansing agent for removing preservatives:
  - Benzine
    (dangerous materials class A 3)

Preserving Engine:

- Clean engine with high-pressure steam jet (in case of need, cold cleansing agent): see 6.3.2.
- Warm up engine and stop.
- Drain engine oil: see Chapter 6, and fill in anti-corrosive oil.
- Clean oil bath air cleaner (if provided): see 6.4.3, and fill in anti-corrosive oil.
- Drain fuel out of tank.
- Prepare fuel mixture of 90 % diesel fuel and 10 % anti-corrosive oil and fill up tank.
- Run engine for about 10 minutes.
- Stop engine.
- Turn engine over several times by hand.
- Remove V-belts 1 and store in wrapped condition.
- Spray grooves of V-belt pulleys 2 with anti-corrosive agent, which must be wiped off before re-using engine.
- Close intake opening 3 and exhaust opening 4.

Removing Engine Preservatives:

- Remove anti-corrosive agent from the grooves of the V-belt pulleys 2.
- Fit V-belts 1. Retension later, if necessary, after short period of operation: see 6.5.
- Remove closures of intake opening 3 and exhaust opening 4.
- Engine now ready for operation.



9.1 Engine Specifications and Settings
9.2 Torque Wrench Settings

Model		F2L 1011	F3L 1011	F4L 1011
Number of cylinders		2	3	4
Cylinder arrangement			vertical, in-line	
Bore	mm	91	91	91
Stroke	mm	105	105	105
Piston displacement	cm^3	1366	2049	2732
Compression ratio		18.5	18.5	18.5
Working principle			4-stroke diesel	
Combustion system			direct injection	
Direction of rotation (facing flywheel)			counter-clockwise	
Weight incl. integrated cooling system				
(excl. starter, incl. alternator), approx.	kg	162	202	242
Power	kW (HP)	[1]	[1]	[1]
Speed	rpm	[1]	[1]	[1]
Lubrication system			forced-feed lubrication	
Min. oil pressure (engine warm, oil temp. ~ 100 °C [212 °F]),				
at: 900 rpm (low idling speed)	bar	1.8	1.8	1.8
1800 rpm	bar	2.6	2.6	2.6
3600 rpm	bar	4.3	4.3	4.3
Oil capacity (initial filling), approx.	ltr. [2]	8.0	8.0	13.0
Oil capacity with filter renewal (standard 0.5 ltr.), approx.	ltr. [2]	6.5	6.0	10.5
Valve clearance	mm (in.)		inlet valve 0.3 (0.012)	
(engine left to cool down for at least 30 min.: oil temperature below 80 °C/176 °F)	mm (in.)		exhaust valve 0.5 (0.020)	
Injector working pressure	bar	250 +6	250 +6	250 +6
Commencement of delivery	crank angle bTDC	[1]	[1]	[1]
Firing order		1-2	1-2-3	1-3-4-2

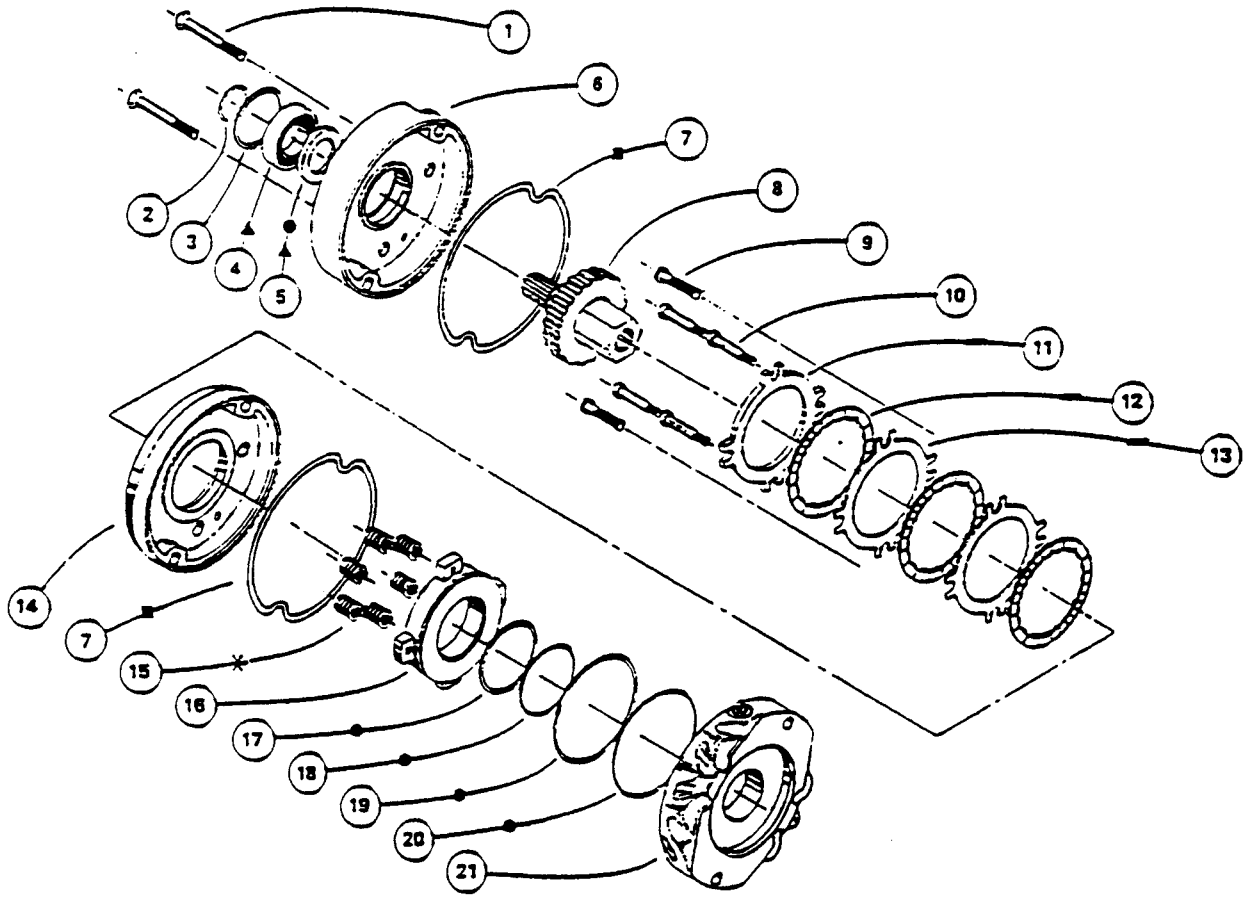
[1]) Engine power, speed and commencement of delivery are stamped on the rating plate (see also 2.1).
[2]) Approximate values, can vary depending on design. Decisive is always the upper oil dipstick mark. For engines with heating system, add about 1 ltr.

Location	Preloading (Nm)	Tightening Nm 1st Stage	2nd Stage	3rd Stage	4th Stage	Total (Nm)	Note
Idler pulley/V-belt pulley	–	–	–	–	–	40 ± 4	
Rocker cover	–	–	–	–	–	9 ± 1	
Rocker arm setscrew	–	–	–	–	–	20 ± 2	
Mounting foot, rear (flywheel end)	–	–	–	–	–	106	
Mounting foot, front (blower end)	–	–	–	–	–	168	
Intake manifold	–	–	–	–	–	22 ± 2	TORX
Exhaust manifold	–	–	–	–	–	40 ± 4	TORX + Never Seize
Oil drain plug	–	–	–	–	–	55 ± 5	
Injector fastening	–	–	–	–	–	20 ± 2	TORX
Injector unio nut	–	–	–	–	–	45 ± 5	

Mark Industries

TITLE	VENDOR CHAPTER	VENDOR
MODEL	100C 6X4	SECT. 11
NOTES	P/N 22831	PAGE 1

- • Items included in O-ring and Back-up Ring Kit
- – Items included in Lining Kit
- ▲ Items included in Bearing Kit
- * Items included in Spring Kit
- ■ Items included in all Repair Kits listed above



PARTS LIST

ITEM	QTY.	DESCRIPTION
1	2	Flat Head Socket Cap Screws
2	1	Retaining Ring
3	1	Snap Ring
4	1	▲ Bearing
5	1	● ▲ Oil Seal
6	1	Cover Plate
7	2	■ Case Seals
8	1	Spline Shaft Assembly
	1	Shaft
	1	Outer Spline
	1	Retaining Ring
9	2	Socket Head Cap Screws (Assembly Bolt)
10	4	Socket Head Shoulder Bolts (Tension Pin)

ITEM	QTY.	DESCRIPTION
11	1	– Primary Disc
12	3	– Rotor Discs
13	2	– Stator Discs
14	1	Spring Plate
15	4	* Springs - Red
	2	* Springs - Blue
16	1	Piston
17	1	● Back-up Ring (I.D.)
18	1	● O-ring (I.D.)
19	1	● Back-up Ring (O.D.)
20	1	● O-ring (O.D.)
21	1	Pressure Plate

REV.

TORQUE-HUB®

Final Drives

ASSEMBLY-DISASSEMBLY MANUAL

FOR THE

S1C

UNIT

REV.

INTRODUCTION

This manual is a step-by-step guide to assembly and disassembly of torque-hub units. It is designed for the customer or shop mechanic who is repairing a particular model of torque-hub final drive.

Users of this manual should note that each part mentioned is followed by an identification number enclosed in parentheses. These part numbers may be referred to in the Parts List section of this manual and on the cross-sectional view of this unit.

Any specialized tools normally used to assemble this unit are noted in the assembly procedures and diagrammed in the tooling section. However, it is not mandatory that these tools be used in this unit's assembly. Bearing cups and cones can be pressed using a punch and hammer along their top edges. Seals can be pressed by laying a board flat on top of the seal and then hammering the board down until it meets the hub. Studs can be hammered into stud holes. Should you use these methods, be very careful not to damage parts when using a punch and/or hammer.

Users should familiarize themselves with the procedures for roll and leak testing and bolt tightening and torquing found on the following pages before getting started.

SAFETY

Standard safety practices should be followed during the disassembly and assembly procedures described. Safety glasses and safety shoes should be worn. Heavy, heat resistant gloves should be used when heated components are handled. Be especially alert when you see the word CAUTION. This indicates that a particular operation could cause personal injury if not performed properly or if certain safety procedures are not followed.

ROLL and LEAK TESTING

Torque-hub units should always be roll and leak tested before disassembly and after assembly to make sure that the unit's gears and sealants are working properly. The following information briefly outlines what to look for when performing these tests.

The Roll Test

The purpose of a roll test is to determine if the unit's gears are rotating freely and properly. You should be able to rotate the gears in your unit by applying a constant force to the roll checker. If you feel more drag in the gears only at certain points, then the gears are not rolling freely and should be examined for improper installation or defects. Some gear packages roll with more difficulty than others. Do not be concerned if the gears in your unit seem to roll hard as long as they roll with consistency.

The Leak Test

The purpose of a leak test is to make sure the unit is air tight. You can tell if your unit has a leak if the pressure gauge reading on your air checker starts to fall once the unit has been pressurized. Leaks will most likely occur at the main seal or wherever "O" rings or gaskets are located. The exact location of a leak can usually be detected by brushing a soap and water solution around the main seal and where "O" rings or gaskets meet the exterior of the unit, then checking for air bubbles. If a leak is detected in a seal, "O" ring, or gasket, the part must be replaced.

TIGHTENING and TORQUING BOLTS

If an air impact wrench is used to tighten bolts, extreme care should be taken to insure that the bolts are not tightened beyond their specified torque. Never use an impact wrench to tighten shoulder bolts. All shoulder bolts should be tightened by hand.

The following steps describe how to tighten and torque bolts or socket head cap screws in a bolt circle.

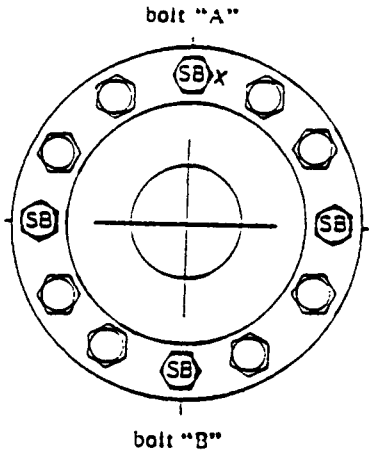
1. Tighten (but do not torque) bolt "A" until snug.

2. Go to the opposite side of the bolt circle and tighten bolt "B" until equally snug.

3. Continue around the bolt circle and tighten the remaining bolts.

4. Now use a torque wrench to apply the specified torque to bolt "A".

5. Continue around the bolt circle and apply an equal torque to the remaining bolts.



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MAIN DISASSEMBLY

1. Remove the two pipe plugs (13) in cover (6) and drain the oil from the unit.

2. Loosen and remove the four shoulder bolts (14) and eight grade 8 bolts (12) from cover (6).

3. Remove cover (6) from hub (1G).

4. Remove "O" ring (5) from the counterbore in cover (6) and discard.

5. Remove thrust washer (11) from the counterbore in carrier housing (3A).

6. Remove input gear (9) from mesh with planet gears (3F).

CAUTION: Safety glasses should be worn during this step:
7. Using a punch, remove retaining ring (20) from the groove around the inside of input gear (9) and discard.

8. Lift carrier sub-assembly (3) out of hub (1G).

9. Lift ring gear (2) off of hub (1G).

10. Remove "O" ring (5) from the counterbore in hub (1G) and discard.

11. Remove the three pipe plugs (1J) from side of hub (1G).

12. Apply a preload to output shaft(1A) in order to remove retaining ring(11). To do this, follow steps a-b:

a. Place bearing cone pressing tool (T-116407) on top of retaining ring (11).

b. Apply pressure to the fixture using a hydraulic ram or by striking the fixture with a soft face hammer. Pressure should be applied until the hub rotates with difficulty.

CAUTION: Safety glasses should be worn during this step:
13. Using retaining ring pliers, remove retaining ring (11) and discard.

14. Remove spacer (1H) from output shaft (1A).

15. Raise hub (1G) above your work surface and place a support underneath it in such a manner that output shaft (1A) will be able to fall through the bottom when pressed in next step.

16. Press output shaft (1A) out of hub (1G). The output shaft may come out with bearing cone (1D) and seal (1B) attached. If so, remove seal (1B) from output shaft and discard. Use a soft punch and hammer to remove bearing cone (1D) from the shaft. Be very careful not to strike the shaft when using the punch.

17. If **seal (1B)** and **bearing cone (1D)** remain in the hub, press the seal and bearing cone out using a bearing cone pressing tool (T-116407). Discard the seal.

18. Lift **bearing cone (1F)** out of **hub (1G)**.

19. Stand **hub(1G)** on its small diameter end. Using a soft punch and hammer, remove **bearing cup (1C)** from the counterbore of **hub (1G)**. Be very careful not to strike the counterbore when using the punch.

20. Turn **hub (1G)** over so that it rests on its large end. Using a soft punch and hammer, remove **bearing cup (1E)** from the counterbore of **hub (1G)**. Be very careful not to strike the counterbore when using the punch.

21. At this point the main disassembly is complete.

CARRIER DISASSEMBLY

1. Locate **roll pin (3G)** which holds **planet shaft (3E)** in the **carrier housing (3A)**.

2. Drive the **roll pin (3G)** down into **planet shaft (3E)** until it bottoms against the carrier housing. If the roll pin is not completely driven into the planet shaft, damage to the carrier could occur when the shaft is removed.

3. Remove **planet shaft (3E)** from **carrier housing (3A)**. The two **thrust washers (3B)** and **planet gear (3F)** will slide off.

4. Place **planet shaft (3E)** in a vise and drive **roll pin (3G)** out through the roll pin hole.

5. Remove the **needle rollers (3C)** and **spacer (3D)** from inside **planet gear (3F)**.

6. Repeat steps 1-5 to remove and disassemble the two remaining planet gears.

7. At this point the carrier disassembly is complete.

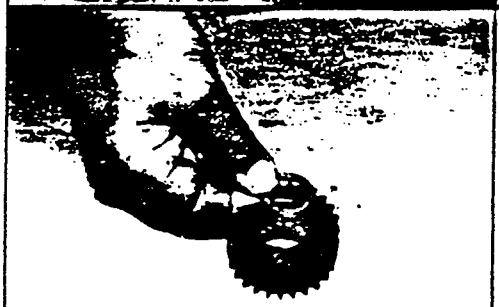
CARRIER SUB-ASSEMBLY



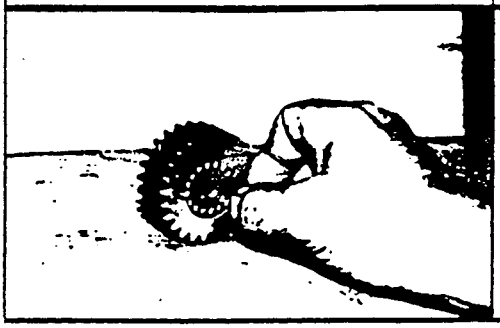
1. Apply grease to the inside of one **planet gear (3F).**



2. Line one half of **planet gear (2F)** with **16 needle rollers (3C).**

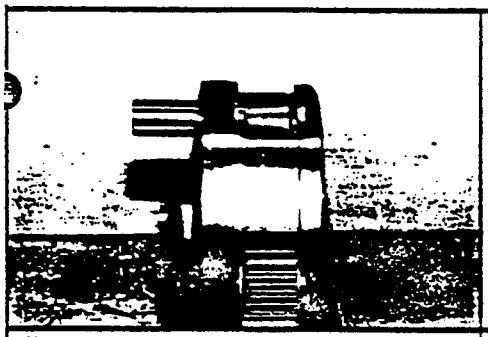


3. Place one **spacer (3D)** inside **planet gear (3F)** so that it rests on top of the **needle rollers (3C).**



4. Line the remaining half of **planet gear (3F)** with 16 **needle rollers (3C).**

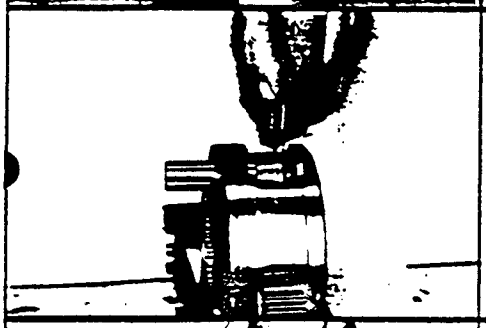
Carrier Sub-Assembly



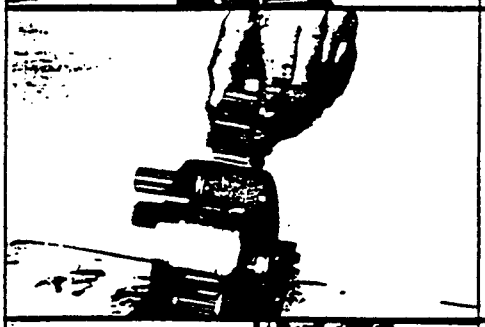
5. Stand carrier housing (3A) in an upright position.



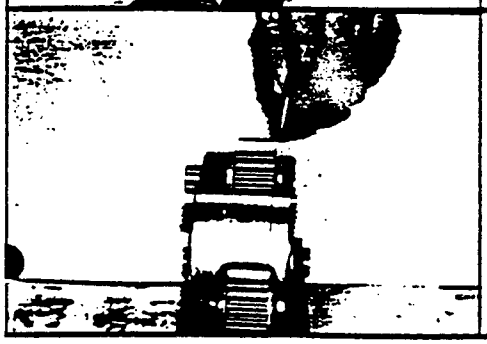
6. Insert a planet shaft (3E) into one of the planet shaft holes which also has a roll pin hole on carrier housing (3A). The end of the planet shaft that does not have the roll pin hole should be inserted into the carrier housing first.



7. Place one thrust washer (3B) onto the end of planet shaft (3E) which has been inserted through the planet shaft hole. Notice that the thrust washer has a tang on it: the tang should point straight down so as to fit within the space in the raised inside edge of the planet shaft hole.

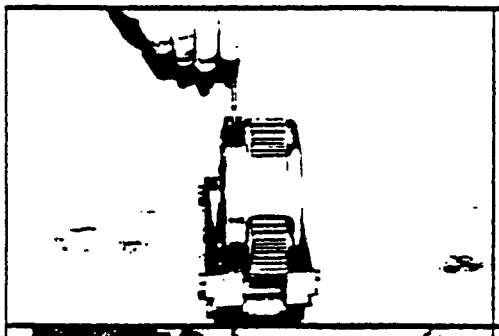


8. Following the thrust washer, place assembled planet gear (3F) onto planet shaft (3E).

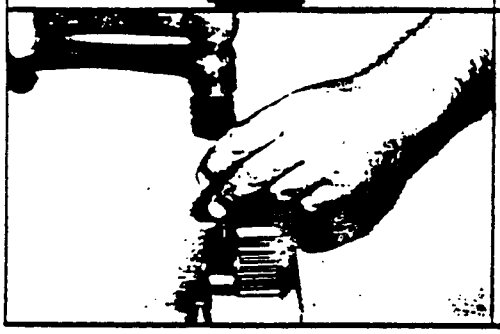


9. Following the planet gear, place one more thrust washer (3B) onto planet shaft (3E). Now insert planet shaft (3E) through the opposite planet shaft hole on carrier housing (3A).

Carrier Sub-Assembly



10. Use an alignment punch or similar tool to align the roll pin holes on the carrier housing (3A) and planet shaft (3E).



11. Drive roll pin (3G) down into the aligned roll pin holes.

12. Repeat steps 1-11 to assemble and install the two remaining planet gears.

13. At this point the carrier sub-assembly is complete.

SCRAPER CUTTING EDGE APPLICATIONS

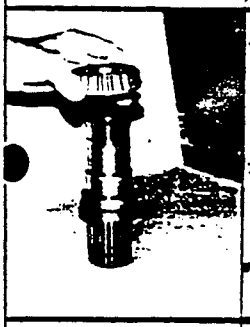
TEREX

Unit — Model			ALL-PURPOSE" (Hard Face) 1" Byloy Steel Use in Rock Abrasives & Shock Loading							TUFF-STEEL (Hardened) Hardened-Use in High Abrasives&Aver. Rock										STANDARD UTILITY										SIDE BLADE									
										1"								1.250"														Heavy Duty						Standard Inter-Change-able			
			9189500	9194419	9194639	9213952	9224484			9030088	9197452	9204511	9213591	9030877	9252041	9252042		9210029	9210030	9210031	9038716	9186286		9186289	9051236	9051245		9037392	9037391	9036603	9036630	9039426	9039463	9197711LH	9197712RH	9204661LH	9204662RH	9012587LH	9012588RH	9186325	9186326	9037784	9036627	9039444	9051235
S-7	3 & 4UOT	26SH																				4																		2					
TS-18	29LOT	27SH		4							4																													2					
S-18	27LOT	28SH	4	4						4	4	4			4	4								4																	2					
S-12	78FOT	29SH										4			4																									2					
S-18	30LOT	31SH	4	4						4	4	4			4	4								4																	2					
SS-24	34LDT	32SH	4	4						4	4				4									4											1	1					2					
TS-24	31LOT	33SH	4	4						4	4				4									4											1						2					
SS-18	23 & 28TDT	36SH	4	4						4	4				4									4																	2					
TSS-24	37LDT	37SH	4							4					4																									2					
TS-14	6UOT	38SH									4				4																				1	1					2					
SS-12	76 & 77FDT	40SH									4				4																									2					
SS-33	34LDT	42SH			4																													1	1											
S-24	39LOT	46SH		4						4								4																	1	1										
SS-40	43LDT	47SH			4	4							4						4																1	1										
S-28	38LOT	50SH				4						4								4															1	1										
SS-40	34LDT	51SH			4																														1	1										
SS-40	36 & 49LDT	52SH			4															4															1	1										
SS-28	36 & 49LDT	53SH				4																													1	1										
S-24	39LOT	55SH		4						4								4																	1	1					2					
TS-24	31 & 39LOT	56SH		4						4								4																	1	1					2					
SS-24	49LDT	59SH		4						4								4																	1	1					2					
TTS-14	7UOT	60SH									4				4					4																1	1				2					
TS-14	7UOT	61SH									4				4					4																1	1				2					
TTS-14	7UOT	62SH									4				4					4																1	1				2					
TTS-14	7UOT	63SH									4				4					4																1	1				2					
TTSS-40	53LDT	65SH					4																												1	1										
TTSS-40	53LDT	66SH					4																												1	1										
S-24	39LOT	76SH		4						4								4																	1	1					2					
S-24	49LOT	76SH		4						4								4																	1	1					2					
SS-24	49LDT	77SH		4						4								4																	1	1					2					
TS-24	43LOT	78SH		4						4								4																	1	1					2					
S-32	47LOT	79SH				4														4															1	1										
TS-32	47LOT	80SH				4														4															1	1										
TS-14	13UOT	81SH									4				4					4																1	1				2					
TTS-14	13UOT	82SH									4				4					4																1	1				2					
TTS-14	13UOT	83SH									4				4					4																1	1				2					
TTS-14	13UOT	84SH									4				4					4																1	1					2					
S-35E	47LOT-H	90SH																											1	2											2				
TS-18	33TOT	92SH	4												4																											2				
S-23E	33TOT-H	93SH																													2	2										2			
S-11E	16UOT	94SH																															1	2								2			
979	50LOT	95SH		4						4																																	2			
TS-14B	17UOT	97SH									4				4					4																1	1									2	
S-11EB	18UOT	101SH																						2	2																					

HUB-SHAFT SUB-ASSEMBLY



1. Oil **output shaft (1A)** and **bearing cone (1D)**.

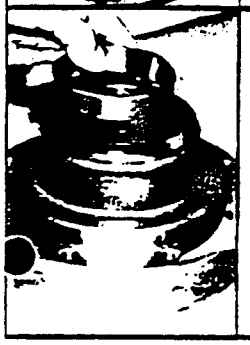


2. Using bearing cone pressing tool (T-116407), press **bearing cone (1D)** onto the end of **output shaft (1A)** that has the retaining ring groove.



3. Stand **hub (1G)** on its small end. Using bearing cup pressing tool (T-116412), press **bearing cup (1E)** down into **hub (1G)**.

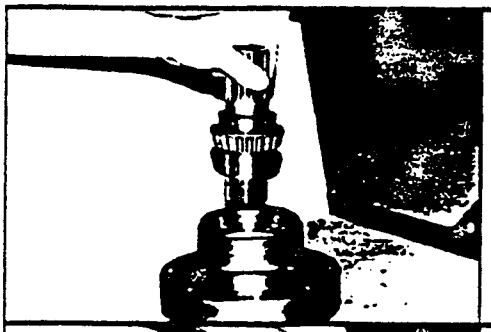
NOTE: Make sure that the cup sits square with the counterbore before pressing.



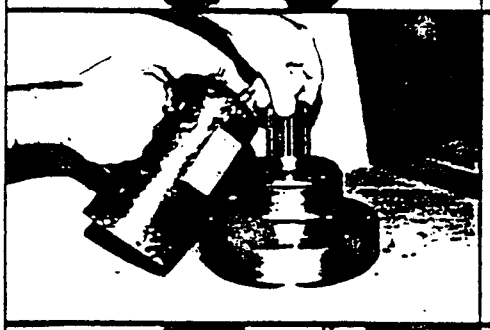
4. Turn **hub (1G)** over so that it rests on its large diameter end. Using bearing cup pressing tool (T-116412), press **bearing cup (1C)** into the small end of **hub (1G)**.

NOTE: Make sure that the cup sits square with the counterbore before pressing.

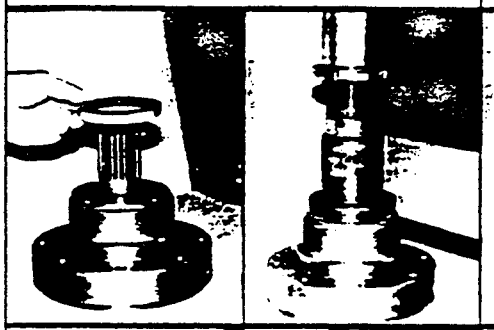
Hub-Shaft Sub-Assembly



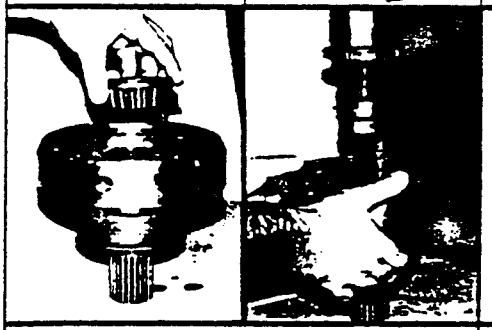
5. With hub (1G) still standing on its large end, place output shaft (1A) into hub (1G) so that the end of the shaft with the retaining ring groove points down.



6. Oil output shaft (1A).



7. Using seal pressing tool (T-116402), press seal (1B) into the counterbore in the small end of hub (1G). The closed face of the seal should be up.

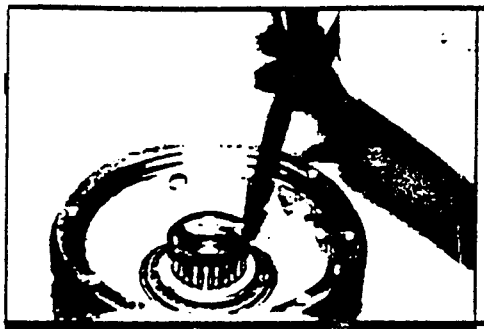


8. Turn hub(1G) over so that its small end points down. Using bearing cone pressing tool (T-116407), press bearing cone (1F) onto output shaft (1A). Rotate the hub while pressing the bearing. Stop pressing when the hub starts to resist rotating.



9. Place spacer (1H) onto output shaft (1A) so that it rests on top of bearing cone (1F).

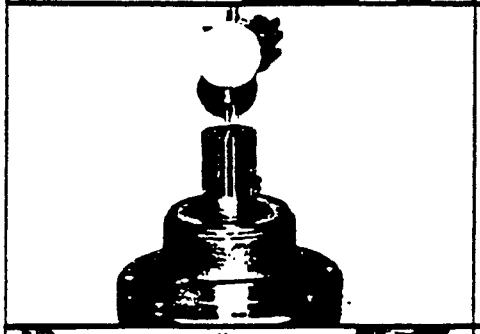
Hub-Shaft Sub-Assembly



CAUTION: Safety glasses should be worn during this step:
10. Using retaining ring pliers, place **retaining ring (1I)** into the groove on **output shaft (1A)**. Use a soft punch against the retaining ring to make sure that it is seated.

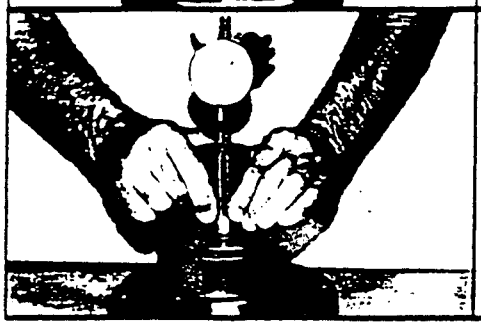


11. Hit the end of **output shaft (1A)** once or twice with a soft face hammer. Turn the shaft in both clockwise and counter clockwise directions while hitting. This will seat the bearing cone against the spacer and retaining ring, allowing necessary endplay in the hub-shaft sub-assembly.



12. Turn **hub (1G)** over so that it rests on its large end. Measure the endplay in the hub-shaft sub-assembly. To do this, follow steps a-c:

a. Mount a dial indicator on **hub (1G)**.Locate the dial rod on top of **output shaft (1A)**.

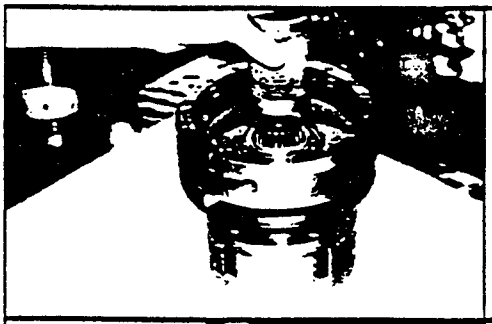


b. Lift up on the output shaft until the needle on the dial stops moving.

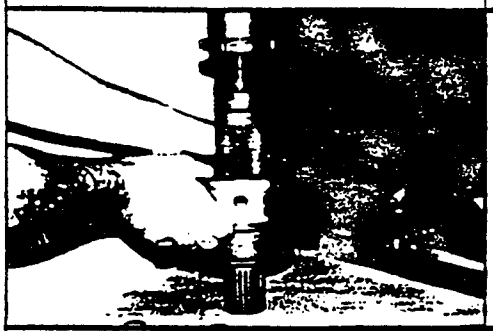
NOTE: Before doing step c, be aware that some applications of this unit may require an endplay of 0.000 in. to 0.003 in. If this is the case, installation of shims on **bearing cone (1F)** may be necessary to achieve this endplay. Contact your original equipment manufacturer (OEM) for the endplay information on your unit.

c. Read the dial. The reading on the dial should be no greater than 0.008 in.
- If the reading is less than 0.008 in., go to step 13.
- If the reading is above 0.008 in., continue to do steps d-h.

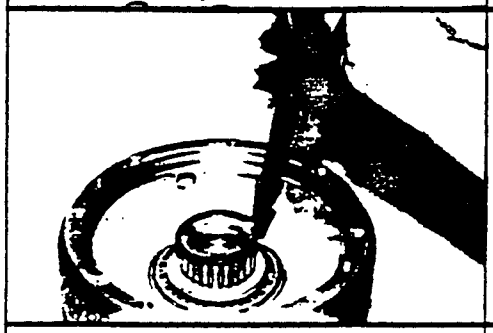
Hub-Shaft Sub-Assembly



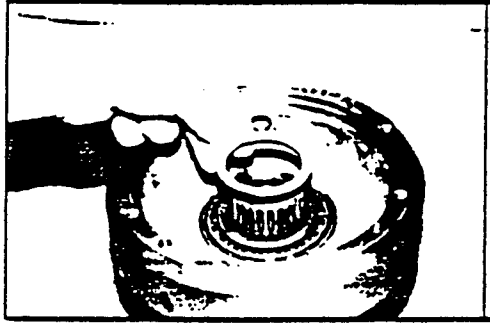
d. Place a bearing cone pressing tool (T-116407) on top of retaining ring (11).



e. Press the fixture with a hydraulic ram or by striking it with a soft face hammer. Pressure should be applied until the hub rotates with difficulty. This step is necessary in order to remove the preload against the retaining ring.



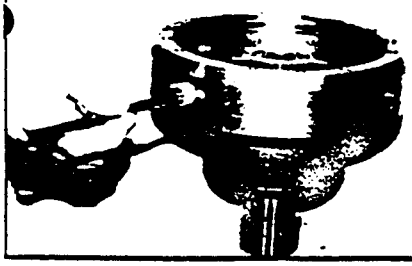
CAUTION: Safety glasses should be worn during this procedure.
f. Using retaining ring pliers, remove retaining ring (11) and discard.
NOTE: Do not reuse the retaining ring.



g. Remove spacer (1H) and replace it on the output shaft with an SK91 spacer. This spacer is thicker and will reduce the endplay.

h. Repeat steps 8-12 to reassemble the shaft and remeasure the endplay.

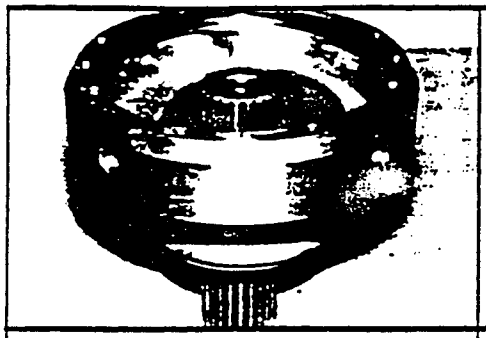
Hub-Shaft Sub-Assembly



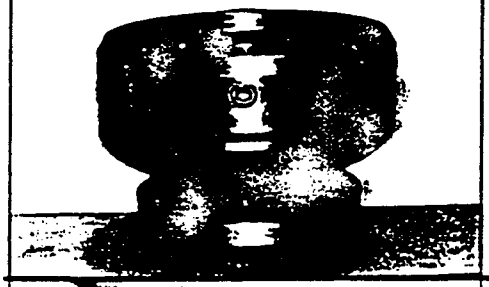
13. Apply a light coat of "Never-Seize" to the three pipe plugs (1J). Tighten pipe plugs (1J) into the three pipe plug holes on hub (1G).

14. At this point the hub-shaft sub-assembly is complete.

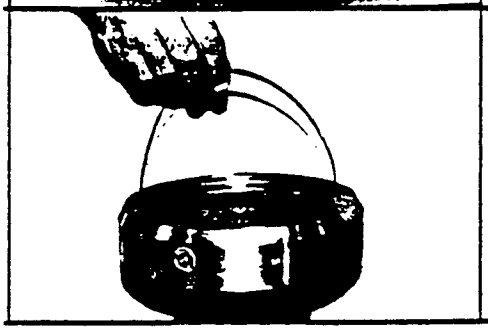
MAIN ASSEMBLY



1. Position hub (1G) on its output shaft (1A) so that the hub's small diameter end points down.



2. Mark the four shoulder bolt holes in hub (1G) with chalk or marker so that they can be aligned with the shoulder bolt holes in the ring gear (2) in a later step.

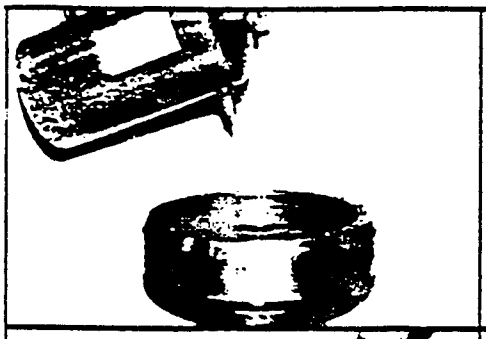


3. Grease "O" ring (5). Place "O" ring (5) into the counterbore of hub (1G).

CAUTION: Beware of sharp edges and burrs around the counterbore when installing the "O" ring.

NOTE: "O" rings may be stretched to fit the counterbore. If an "O" ring has been stretched too much, simply squeeze the "O" ring together bit by bit as you place it around the counterbore. It can be made to fit exactly.

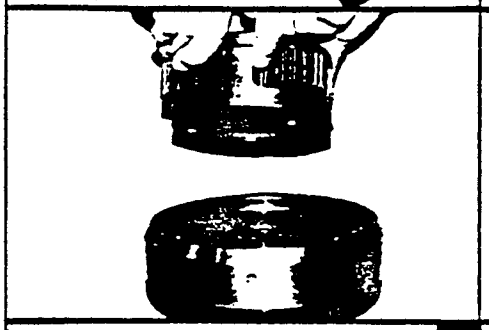
Main Assembly



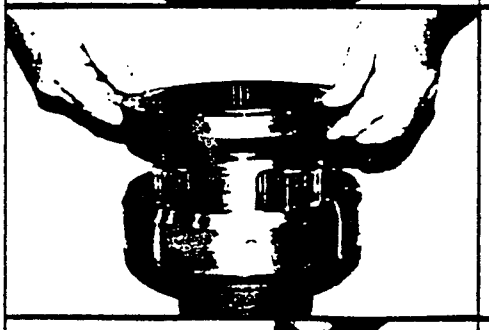
4. Oil all exposed surfaces inside hub (1G).



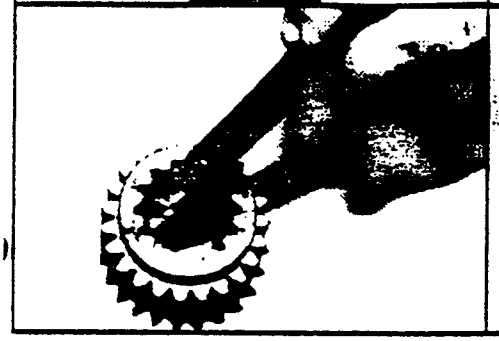
5. Oil carrier sub-assembly (3).



6. Place carrier sub-assembly (3), with spline connections down, into mesh with output shaft (1A).

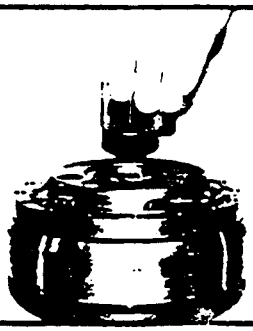


7. Place ring gear (2), with squared shoulder side down, into mesh with the planet gears (3F) of the carrier sub-assembly. Make sure that the shoulder bolt hole that is marked with an "X" on the ring gear aligns with any one of the marked shoulder bolt holes on the hub. The "X" should be on the cover side the ring gear.

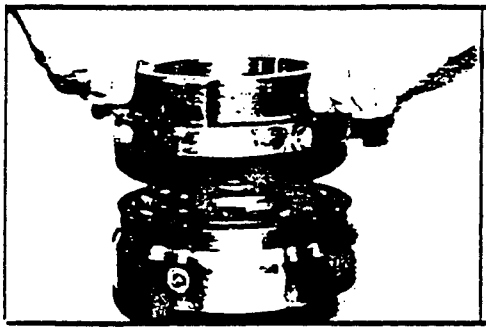


8. Start one half of retaining ring (20) into the groove inside input gear (9). Use a soft punch to press the remaining half of the retaining ring into the groove.

Main Assembly

	9. Insert input gear (9), with large diameter end down, into mesh with planet gears (3F).
	10. Place large thrust washer (11) over input gear (9) so that it rests on carrier housing (3A).
	11. Oil all exposed surfaces inside hub (1G).
	12. Grease "O" ring (5). Place "O" ring (5) into the counterbore of cover (6). CAUTION: Beware of sharp edges and burrs around the counterbore when installing "O" ring.

NOTE: "O" rings may be stretched to fit counterbore. If an "O" ring has been stretched too much, simply squeeze the "O" ring together bit by bit as you place it around the counterbore. It can be made to fit exactly.



14. Place cover (6) on top of ring gear (2) so that the two pipe plug holes in the cover line up between the pipe plug holes in the hub as shown in Diagram 1: pipe plug timing.

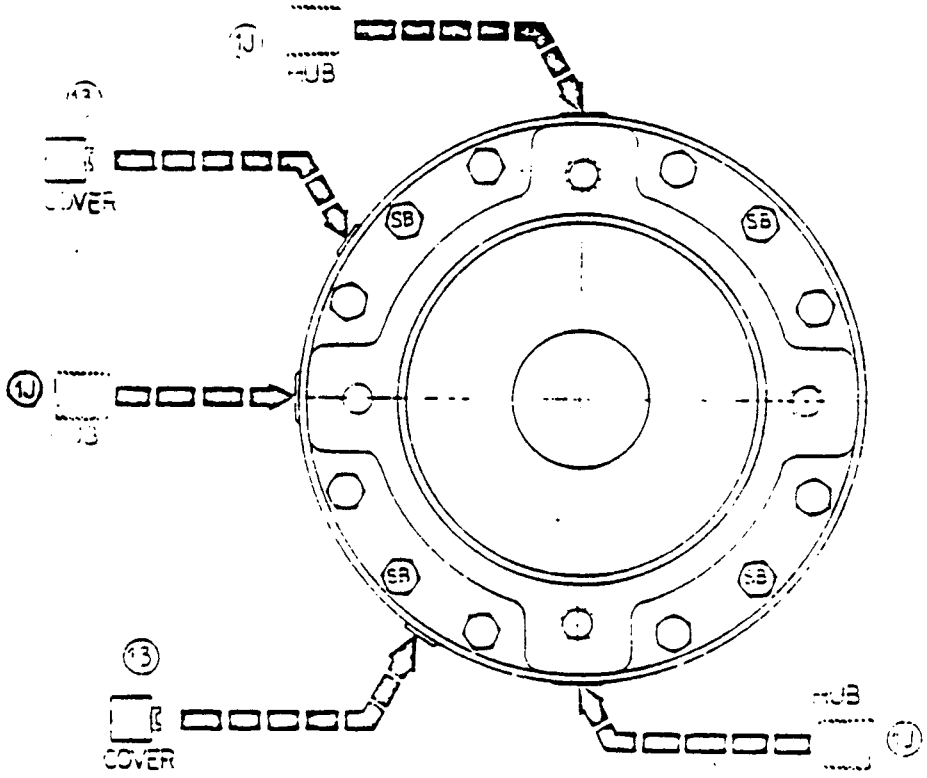
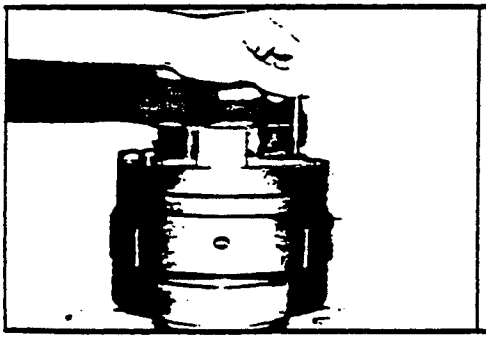
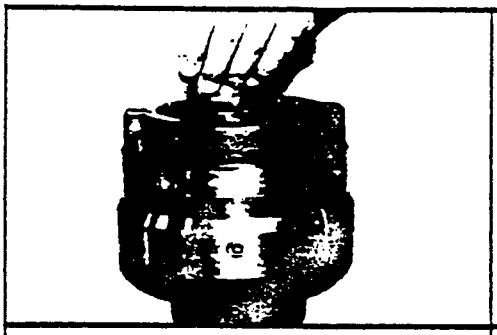
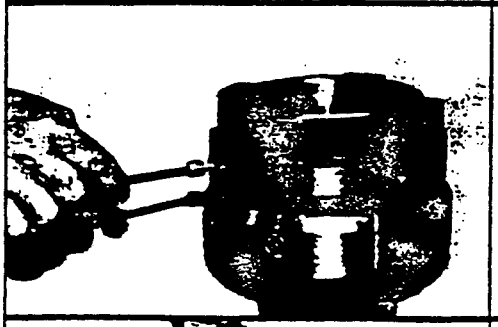
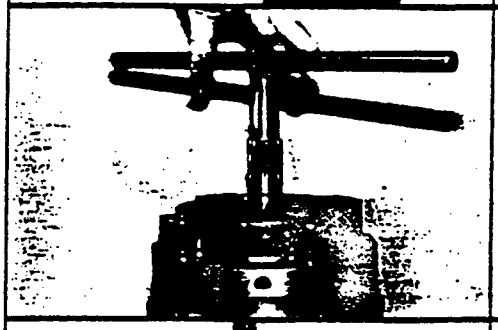
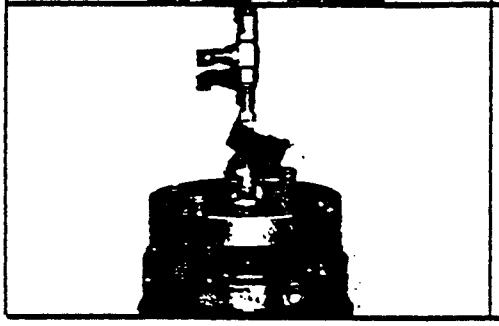


DIAGRAM 1: Pipe plug timing.



15. Place the four shoulder bolts (14) into the shoulder bolt holes marked on the hub and tighten.

Main Assembly

	16. Place the eight grade 8 bolts (12) into the remaining bolt holes and tighten.
	17. Apply 23-27 ft.-lbs. of torque to all bolts.
	18. Apply a light coat of "Never-Seize" to both pipe plugs (13). Tighten pipe plugs (13) into the two pipe plug holes on cover (6).
	19. Roll test the unit in both clockwise and counterclockwise directions. Perform the same number of turns as the ratio of the unit. The ratio is the last two digits of the model number found on the unit's ID tag. For example, unit S1C544S4 should be rolled 4 times in each direction.
	20. Leak test the unit at a pressure of 5 psi for 2-3 minutes. 21. At this point the main assembly is complete.

TOOLING

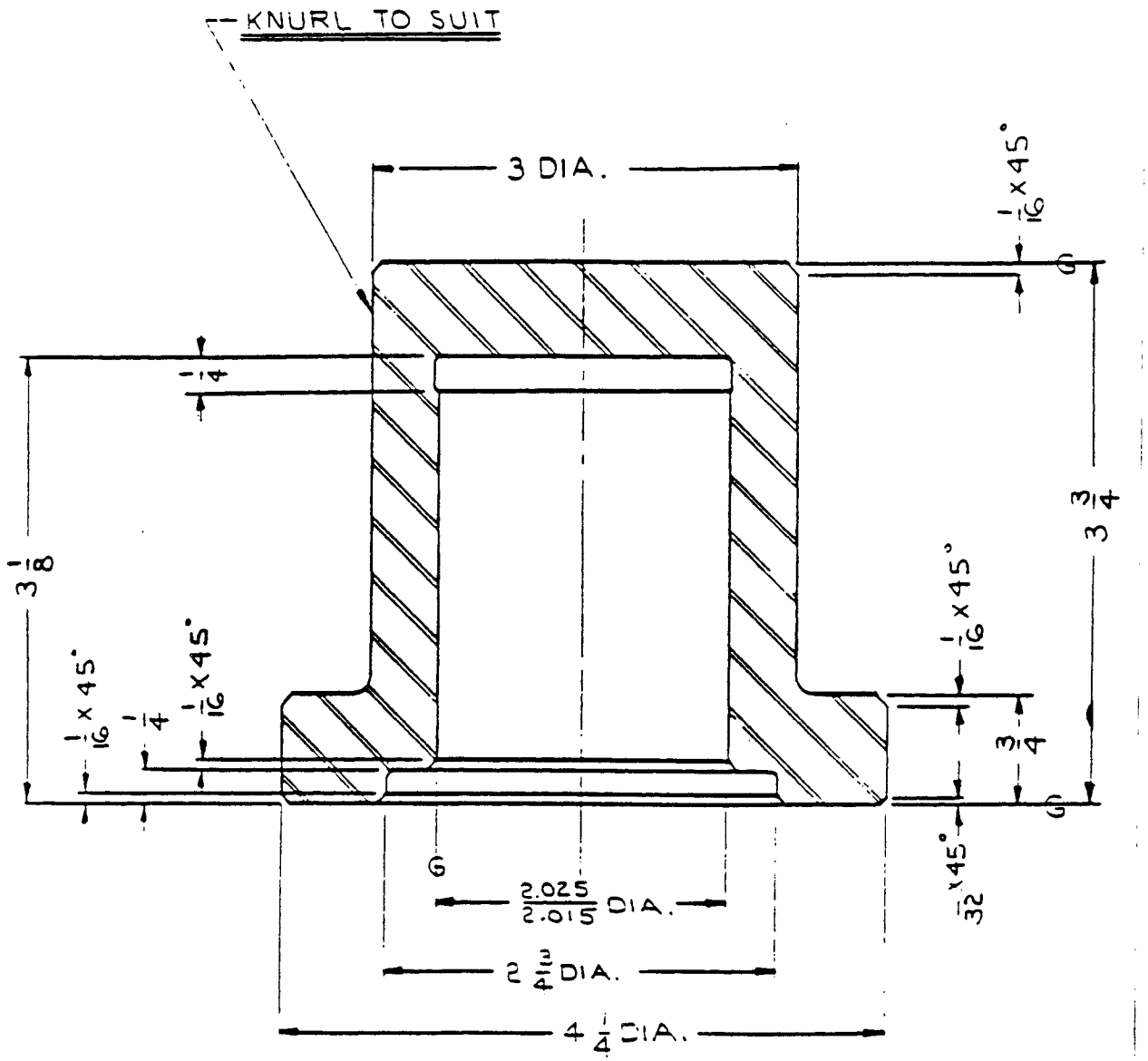
The following specialized tools are used in the assembly of this unit. The tool diagrams included in this manual are intended for the customer who may wish to have a tool made. All tools exist as one piece and must be made from mild steel. All dimensions are given in inches.

OPTIONAL: In order to improve tool life, tools may be carburized and hardened. If this is done, however, the tools must be ground on all surfaces labeled with a "G" on the tool diagram.

1.) T-116402
SEAL PRESSING FIXTURE for SEAL (1B)

2.) T-116407
ASSEMBLY PRESSING TOOL for BEARING CONES (1D) and (1F)

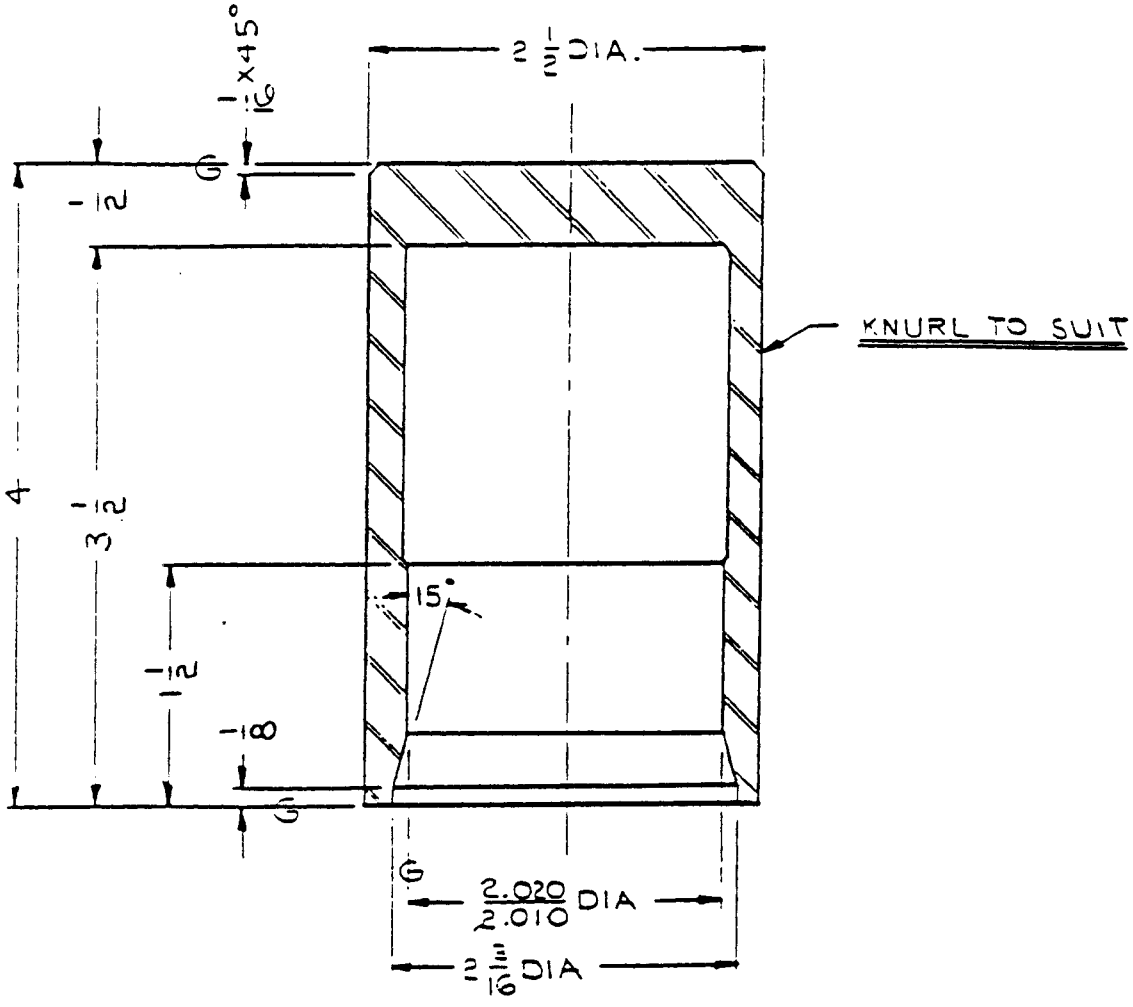
3.) T-116412
ASSEMBLY PRESSING TOOL for BEARING CUPS (1C) and (1E)



TOOL NO. T-116402

SEAL PRESSING FIXTURE
Used with seal(1B)

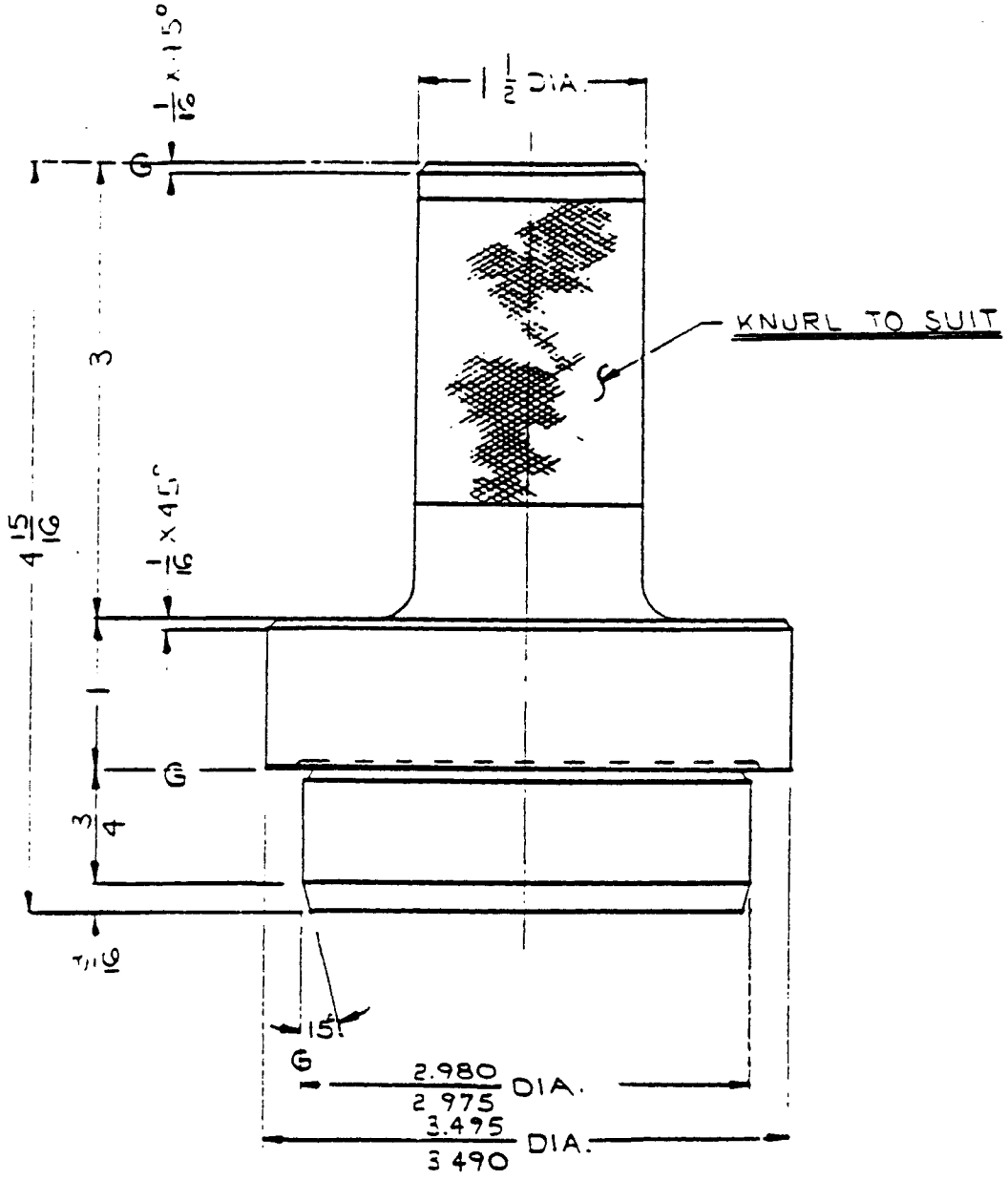
REV.



TOOL NO. T-116407

BEARING CONE PRESSING FIXTURE
Used with bearing cones(1D) and (1F)

REV.



TOOL NO. T-116412

BEARING CUP PRESSING FIXTURE
Used with bearing cups(1C) and (1E)

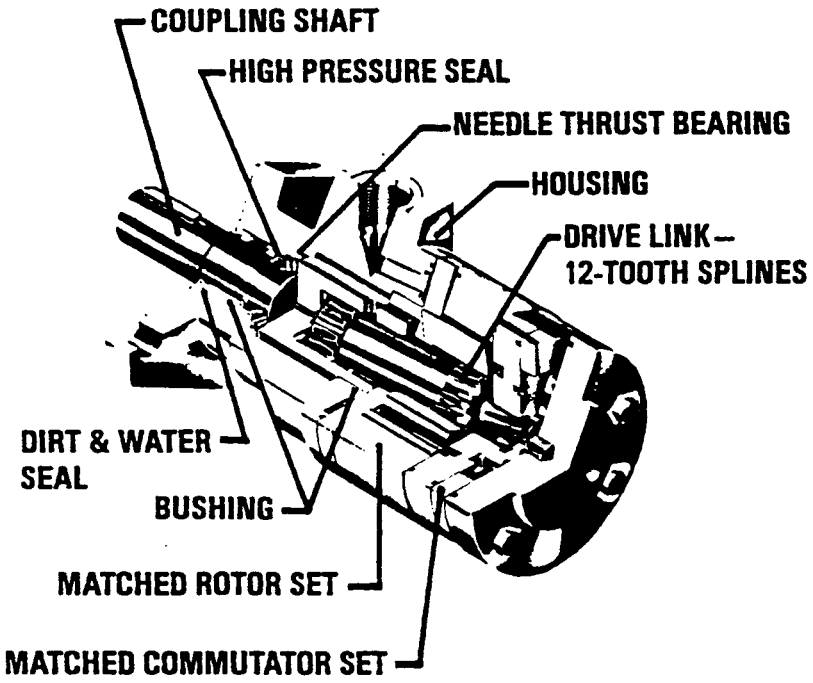
Torqmotor™

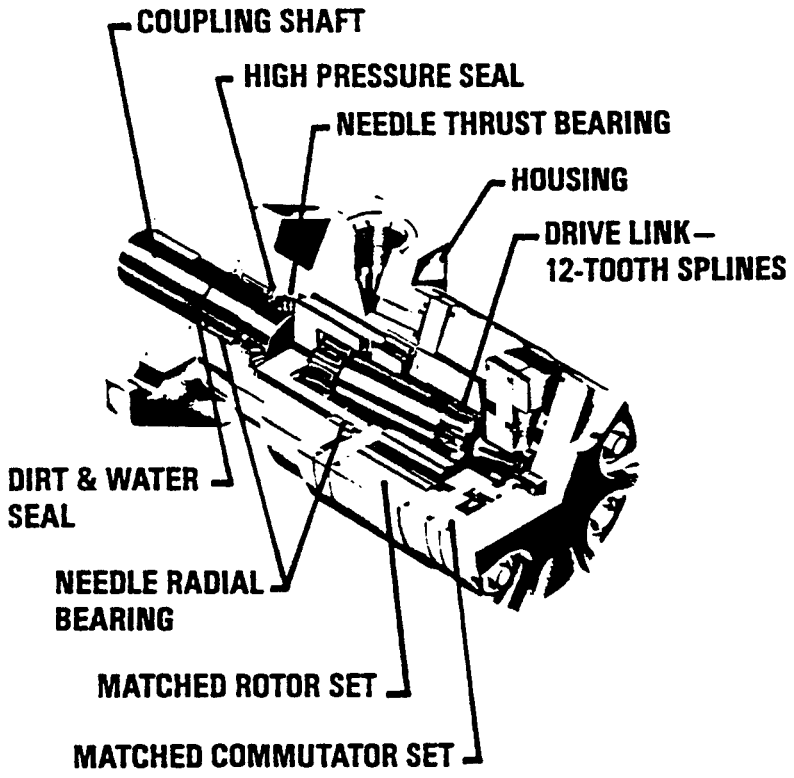
Service Procedure

MG, MF, MB, ME Series

REV.

Torqmotor™ Design Features





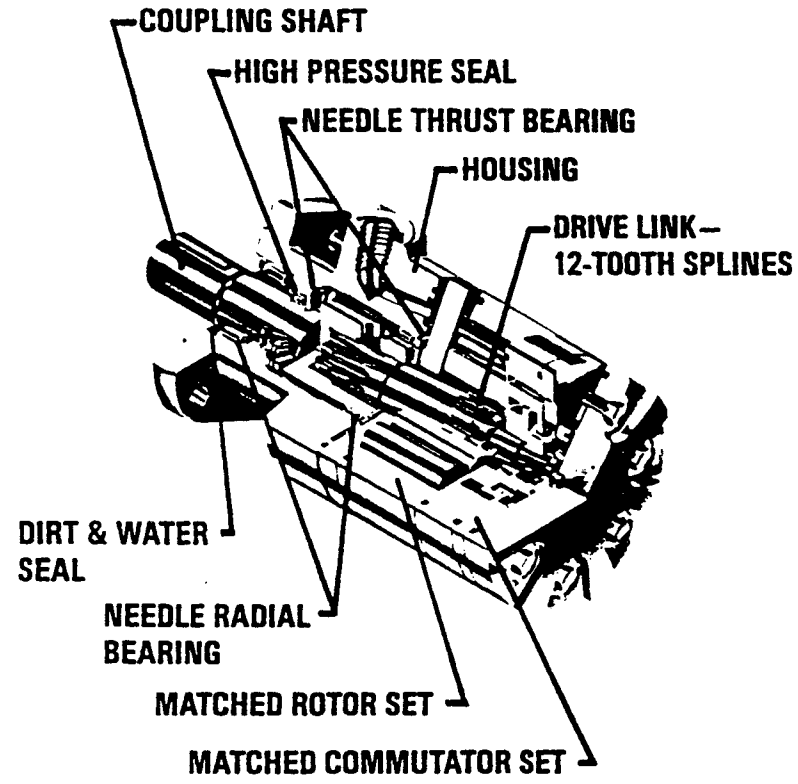
Torqmotor™ MG Series features include:

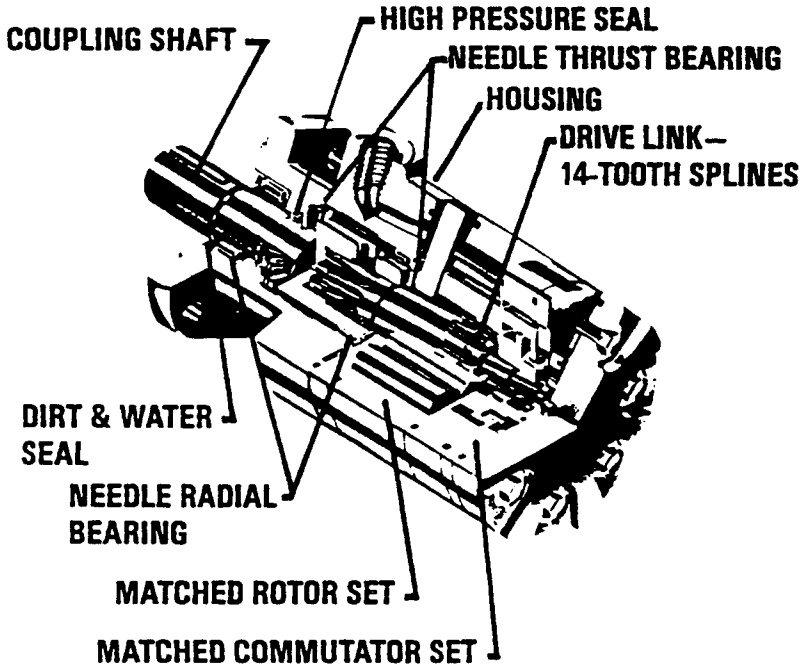
- The roller vane rotor set design offers a low-friction, wear compensation which maximizes the useful performance life of the motor.
- **Zero leak** commutation valve provides greater, more consistent volumetric efficiency.
- Design flexibility - MG offers the widest selection of shaft options, displacements and mounting flanges in the industry.
- Patented 60-40 spline member arrangement transmits more torque with less weight.
- Full flow lubrication maximizes cooling and may provide up to 50% longer life than motors not having this feature.
- Higher pressure ratings provide greater torque than competitive brands.
- Full interchangeability with other motors which are designed according to industry standards.
- Compatible with most hydraulic systems with regard to pressure, torque and speed.
- A unique high-pressure shaft seal that eliminates the need for case drains.
- Up to 13 horse power output.

Torqmotor™ MF Series features include:

- Roller vanes to reduce friction and internal leakage and to maintain efficiency.
- **Zero leak** commutation valve provides greater, more consistent volumetric efficiency.
- Wheel mount version available.
- More starting torque than competitive motors in applications where the shaft is side loaded. (Competitive brands require more pressure to start the motor.)
- A needle-roller mounted coupling shaft and steel-caged thrust bearing which can withstand 1000-pound thrust loads.
- Side load capacity is 1600 lbs (727.3 kg) maximum at center of output shaft.
- A unique high-pressure shaft seal that eliminates the need for case drains, check valves and extra plumbing.
- Up to 17 horsepower output.
- Greater durability due to superior lubrication and minimum drive spline wear.
- Patented 60-40 spline member arrangement transmits more torque with less weight.

Torqmotor™ Design Features





Torqmotor™ MB Series features include:

- Heavy-duty thrust and roller bearings for up to twice side-load capacity to the previous motor.
- Roller vanes to reduce friction and internal leakage, and to maintain efficiency.
- A patented orbiting commutation system for less wear and longer life.
- A patented 60:40 arrangement of internal and external spline members to transmit more torque with less weight.
- A unique high-pressure shaft seal that eliminates the need for case drains, check valves and extra plumbing.
- A unique manifold designed to improve operating efficiency.
- Up to 1000 lbs (453.6 kg) end-thrust capacity in either direction.
- A design that is less sensitive to contamination than competitive motors.
- Up to 36 horsepower output.
- Greater durability because of superior lubrication and minimum drive spline wear.
- Superior low speed performance.
- **Zero leak** commutation valve provides greater, more consistent volumetric efficiency.

Torqmotor™ ME Series features include:

- Roller vanes to reduce friction and internal leakage and to maintain efficiency.
- A patented orbiting commutation system for less wear and longer life.
- A patented 60:40 arrangement of internal and external spline members to transmit more torque with less weight.
- A unique high-pressure shaft seal that eliminates the need for case drains, check valves and extra plumbing.
- A manifold designed to improve operating efficiency.
- Heavy-duty thrust and roller bearings for up to twice the side-load capacity to the previous motor.
- Up to 1000 lbs (453.6 kg) end-thrust capacity in either direction.
- A design that is less sensitive to contamination than competitive motors.
- Up to 49 horsepower output.
- Greater durability because of superior lubrication and minimum drive spline wear.
- **Zero leak** commutation valve provides greater, more consistent volumetric efficiency.

Definitions

NOTE: A NOTE provides key information to make a procedure easier or quicker to complete.

CAUTION: A CAUTION refers to procedure that must be followed to avoid damaging the Torqmotor™ or other system components.

WARNING: A WARNING REFERS TO PROCEDURES THAT MUST BE FOLLOWED FOR THE SAFETY OF THE EQUIPMENT OPERATOR AND THE PERSON INSPECTING OR REPAIRING THE TORQMOTOR™

Disclaimer

This Service Manual has been prepared by TRW Ross Gear Division for reference and use by mechanics who have been trained to repair and service hydraulic motors and systems on commercial and non-commercial equipment applications. TRW Ross Gear Division has exercised reasonable care and diligence to present accurate, clear and complete information and instructions regarding the techniques and tools required for maintaining, repairing and servicing the complete line of TRW Ross Gear MG, MF, MB & ME Torqmotor Units. However, despite the care and effort taken in preparing this general Service Manual, TRW **makes no warranties** that (a) the Service Manual or any explanations, illustrations, information, techniques or tools described herein are either accurate, complete or correct as applied to a specific Torqmotor unit, or (b) any repairs or service of a particular Torqmotor unit will result in a properly functioning Torqmotor unit.

If inspection or testing reveals evidence of abnormal wear or damage to the Torqmotor unit or if you encounter circumstances not covered in the Manual, STOP — CONSULT THE EQUIPMENT MANUFACTURER'S SERVICE MANUAL AND WARRANTY. DO NOT TRY TO REPAIR OR SERVICE A TORQMOTOR UNIT WHICH HAS BEEN DAMAGED OR INCLUDES ANY PART THAT SHOWS EXCESSIVE WEAR UNLESS THE DAMAGED AND WORN PARTS ARE REPLACED WITH ORIGINAL TRW REPLACEMENT AND SERVICE PARTS AND THE UNIT IS RESTORED TO TRW'S SPECIFICATIONS FOR THE TORQMOTOR UNIT.

It is the responsibility of the mechanic performing the maintenance, repairs or service on a particular Torqmotor unit to (a) inspect the unit for abnormal wear and damage, (b) choose a repair procedure which will not endanger his/her safety, the safety of others, the equipment, or the safe operation of the Torqmotor, and (c) fully inspect and test the Torqmotor unit and the hydraulic system to insure that the repair or service of the Torqmotor unit has been properly performed and that the Torqmotor and hydraulic system will function properly.

Patents

Ross Gear Division products and systems described in this manual are protected by one or more of the following United States patents: 3,606,601. In addition, foreign patents have been issued in Canada, the United Kingdom, and West Germany.

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Introduction

Service Manual for Series MG, MF, MB, ME

This service manual has one purpose: to guide you in maintaining, troubleshooting, and servicing the MG, MF, MB & ME Torqmotor (low-speed, high-torque hydraulic motor).

Material in this manual is organized so you can work on the Torqmotor and get results without wasting time or being confused. To get these results, you should read this entire manual before you begin any work on the Torqmotor.

This manual also contains troubleshooting information and checklist. If you must service the Torqmotor, the checklist will help you to determine where the problem may be.

The three-column format of the Disassembly and Inspection, and Assembly sections will make it easier for you to conduct major work on the Torqmotor. Column 1 gives a brief key for each procedure. Column 2 explains in detail the procedure you should follow. Column 3 illustrates this procedure with photographs. Read all material carefully and pay special attention to the notes, cautions, and warnings.

A foldout page with the same Torqmotor exploded assembly view on both sides is provided in this manual. The component part names and item numbers assigned on this exploded assembly view correspond with names and item numbers (in parentheses) used in the disassembly and assembly procedures set forth in this manual. When this exploded assembly view page is folded out, you can easily identify components and locate their relative position on the exploded assembly view as you follow the disassembly and assembly procedures.

Service part list charts are also provided in this manual with the part names and exploded view item numbers cross referenced to Ross Gear service part numbers.

Service parts are available through the Original Equipment Manufacturer or Ross approved MG, MF, MB & ME Distributors.

As you gain experience in servicing the Torqmotor, you may find that some information in this manual could be clearer or more complete. If so, let us know about it. Do not try to second guess the manual. If you are stuck, contact us. Servicing the Torqmotor should be a safe and productive procedure, in order for the unit to deliver the reliable, long-life operation engineered into it.

Troubleshooting Guide

NOTE: Before troubleshooting any system problem, check service literature published by the equipment and/or component manufacturers. Follow their instructions, if given, for checking any component other than the Torqmotor™ unit.

Preparation

Make your troubleshooting easier by preparing as follows:

- work in a clean, well-lighted place;
- have proper tools and materials nearby;
- have an adequate supply of clean petroleum-based solvent.

WARNING: SINCE SOLVENTS ARE FLAMMABLE, BE EXTREMELY CAREFUL WHEN USING ANY SOLVENT, EVEN A SMALL EXPLOSION OR FIRE COULD CAUSE INJURY OR DEATH.

WARNING: WEAR EYE PROTECTION AND BE SURE TO COMPLY WITH OSHA AND OTHER MAXIMUM AIR PRESSURE REQUIREMENTS.

Preliminary Checks

Hydraulic systems are often trouble-free. Hence, the problem an operator complains of could be caused by something other than the hydraulic components.

Thus, once you have determined that a problem exists, start with the easy-to-check items, such as:

- parts damaged from impact that were not properly repaired, or that should have been replaced; and
- improper replacement parts used in previous servicing
- mechanical linkage problems such as binding, broken, or loose parts or slipping belts.

Hydraulic Components

If you think the problem is caused by a hydraulic component, start by checking the easy-to-reach items.

Check all hoses and lines for cracks, hardening, or other signs of wear. Reroute any useable hoses that are kinked, severely bent, or that rest against hot engine parts. Look for leaks, especially at couplings and fittings. Replace any hoses or lines that don't meet system flow and pressure ratings.

Next, go to the reservoir and filter or filters. Check fluid level and look for air bubbles. Check the filter(s). A filter with a maximum 50 micron filtration is recommended for the Torqmotor system.

Visually check other components to see if they are loosely mounted, show signs of leaks, or other damage or wear.

Excessive heat in a hydraulic system can create problems that can easily be overlooked. Every system has its limitation for the maximum amount of temperature. After the temperature is attained and passed, the following can occur:

- oil seal leaks
- loss of efficiency such as speed and torque
- pump loss of efficiency
- pump failure
- hoses become hard and brittle
- hose failure

A normal temperature range means an efficient hydraulic system. Consult the manuals published by equipment and/or component manufacturers for maximum allowable temperatures and hydraulic tests that may be necessary to run on the performance of the hydraulic components. The Torqmotor™ is not recommended for hydraulic systems with maximum temperatures above 200°F (93.3°C).

Troubleshooting Checklist

Trouble	Cause	Remedy
Oil Leakage	1. Hose fittings loose, worn or damaged	Check & replace damaged fittings or "O" Rings. Torque to manufacturers specifications.
	2. Oil seal rings (4) deteriorated by excess heat	Replace oil seal rings by disassembling Torqmotor™ unit.
	3. Special bolt (1, 1A, 1B or 1C) loose or its sealing area deteriorated by corrosion	(a) Loosen then tighten single bolt to torque specification. (b) Replace bolt.
	4. Internal shaft seal (16) worn or damaged	Replace seal. Disassembly of Torqmotor™ unit necessary.
	5. Worn coupling shaft (12) and internal seal (16)	Replace coupling shaft and seal by disassembling Torqmotor™ unit.
Significant loss of speed under load	1. Lack of sufficient oil supply	(a) Check for faulty relief valve and adjust or replace as required. (b) Check for and repair worn pump. (c) Check for and use correct oil for temperature of operation.
	2. High internal motor leakage	(a) Replace worn rotor set by disassembling Torqmotor™ unit.
	3. Severely worn or damaged internal splines	Replace rotor set, drive link and coupling shaft by disassembling Torqmotor™ unit.
	4. Excessive heat	Locate excessive heat source (usually a restriction) in the system and correct the condition.
Low mechanical efficiency or undue high pressure required to operate Torqmotor™ unit	1. Line blockage	Locate blockage source and repair or replace.
	2. Internal interference	Disassemble Torqmotor™ unit, identify and remedy cause and repair, replacing parts as necessary.
	3. Lack of pumping pressure	Check for and repair worn pump.
	4. Excessive binding or loading in system external to Torqmotor™ unit.	Locate source and eliminate cause.

CAUTION: If the hydraulic system fluid becomes overheated [in excess of 200°F (93.3°C)], seals in the system can shrink, harden or crack, thus losing their sealing ability.

Tools and Materials Required for Servicing

MG, MF, MB, ME Series Service Manual

Clean, petroleum-based solvent

Emery paper

Vise with soft jaws

Air pressure source

Arbor press

Screw driver

Masking tape

Breaker bar

Torque wrench—ft. lbs. (N m)

Sockets: 1/2 or 9/16 inch thin wall, 1 inch

Allen Sockets: 3/16, 3/8 inch

Adjustable crescent wrench or hose fitting wrenches

SAE 10W40 SE or SF oil

Special bearing mandrel for MG & MF Torqmotors (SEE FIGURE 1)

Special bearing mandrel for MB & ME Torqmotors (SEE FIGURE 2)

Feeler gage .005 inch (.13 mm)

MG & MF Torqmotors require blind hole bearing puller for 1.06 inch (26.9 mm) and 1.62 inch (41.1 mm) diameter bearing/bushing.

MB & ME Torqmotors require blind hole bearing puller for 1.40 inch dia. (35.6 mm) and 2.130 inch dia. (54.1 mm) bearing.

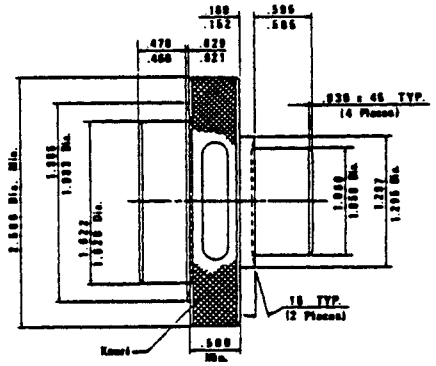
Clean corrosion resistant grease. Recommended grease is E/M Lubricant #K-70M, Ross Gear Specification #045236

NOTE: The available service seal kits include the recommended grease as a grease pack #406018

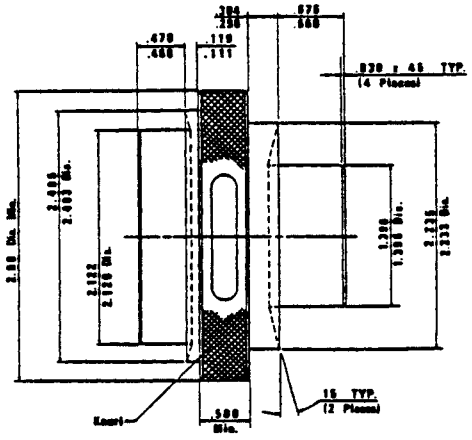
CAUTION: Mixing greases that have different bases can be detrimental to bearing life.

CONVERSIONS

INCHES	mm	INCHES	mm
.020	.51	1.060	26.92
.021	.53	1.295	32.89
.029	.74	1.297	32.94
.030	.76	1.396	35.46
.111	2.81	1.398	35.51
.119	3.02	1.620	41.15
.152	3.86	1.622	41.20
.160	4.06	1.983	50.37
.296	7.52	1.985	50.42
.304	7.72	2.120	53.85
.460	11.68	2.122	53.90
.470	11.94	2.233	56.72
.500	12.70	2.235	56.77
.585	14.86	2.483	63.07
.595	15.11	2.485	63.12
.660	16.76	2.500	63.5
.675	17.15	2.88	73.2
1.058	26.87		



(Fabricate if considered necessary)
FIGURE 1—MG & MF

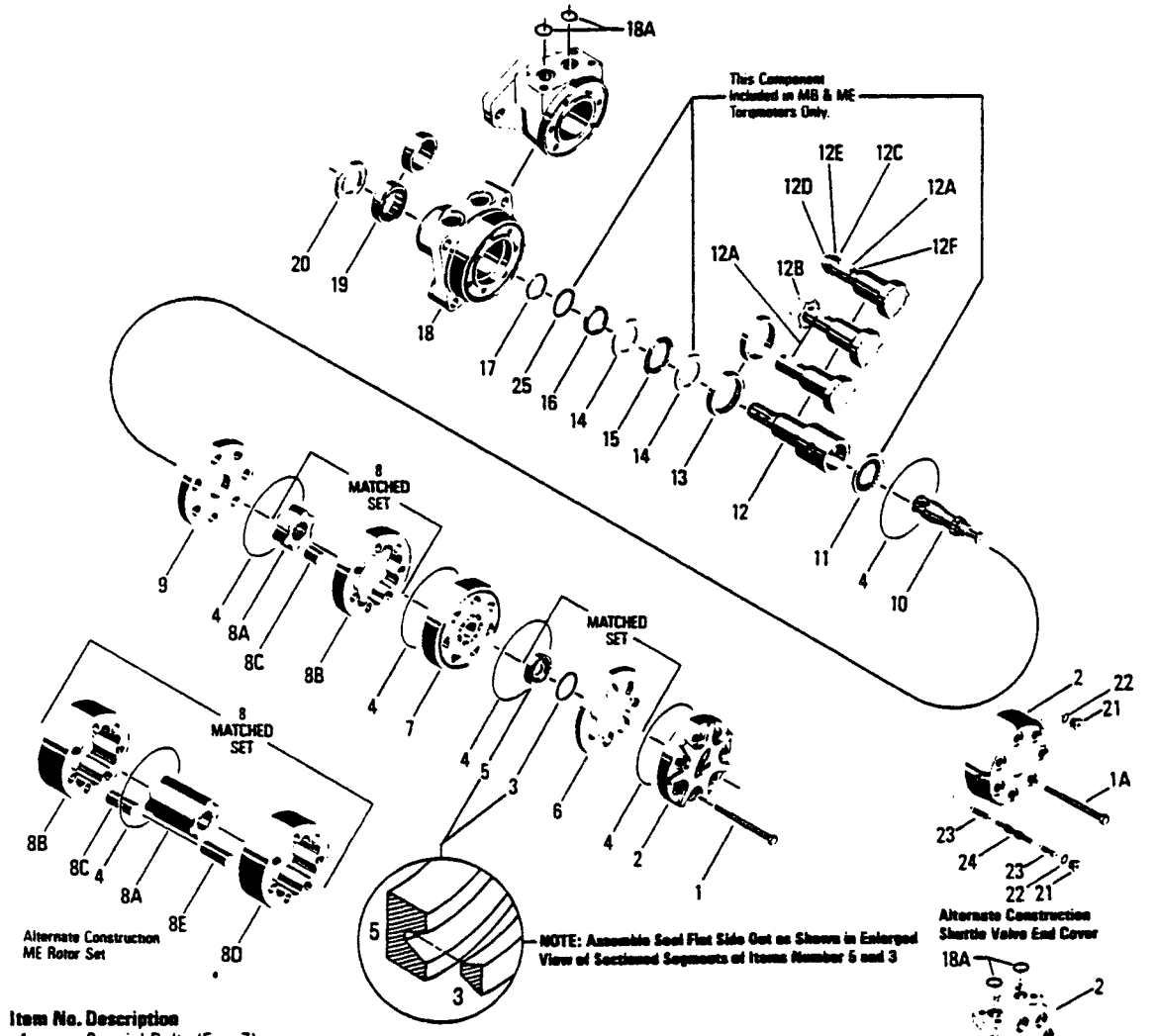


(Fabricate if considered necessary)
FIGURE 2—MB & ME

Torque Chart

Part Name	Item Number	Torque
bolt 5/16 24 UNF 2A	1, 1A, 1B or 1C	22-26 ft. lbs. (30-35 N m)
bolt 3/8 24 UNF 2A	1, 1A, 1B or 1C	45-55 ft. lbs. (60-76 N m)
bolt 5/8 18 UNF 2A	12D	140-180 ft. lbs. (190-244 N m)
nut 3/4 16 UNF 2B	12B (MG, MF)	175-255 ft. lbs. (237-305 N m)
nut 1 20 UNEF 2B	12B (MB, ME)	300-400 ft. lbs. (407-542 N m)
nut 1-1/8 18 UNEF 2B	12B (ME)	300-400 ft. lbs. (407-542 N m)

Torqmotor™ Exploded Assembly View—Typical



Item No.	Description				
1.	Special Bolts (5 or 7)				
1A.	Special Bolts (7)				
1B.	Special Bolts (7)	11.	Thrust Bearing	20.	Dirt & Water Seal
1C.	Special Bolts (7)	12.	Coupling Shaft	21.	Plug (2)
2.	End Cover	12A.	Key	22.	O-Ring (2)
3.	Seal Ring-Commutator	12B.	Nut	23.	Spring
4.	Seal Ring (5)	12C.	Washer	24.	Valve (Shuttle or Relief)
5.	Commutator	12D.	Bolt	25.	Backup Washer
6.	Commutator Ring	12E.	Lockwasher		
7.	Manifold	12F.	Retaining Ring		
8.	Rotor Set	13.	Bearing/Bushing, Inner		
8A.	Rotor	14.	Thrust Washer		
8B.	Stator or Stator Half	15	Thrust Bearing		
8C.	Vane (7)	16.	Seal		
8D.	Stator Half	17.	Backup Washer		
8E.	Vane (7)	18	Housing		
9.	Wear Plate	18A.	O-Ring (2)		
10.	Drive Link	19.	Bearing/Bushing, Outer		

Disassembly and Inspection

(Preparation Before Disassembly)

- Before you disassemble the Torqmotor unit or any of its components read this entire manual. It provides important information on parts and procedures you will need to know to service the Torqmotor.
- Determine whether the Torqmotor you are about to disassemble is the Small Frame Series MG or MF or the Large Frame Series MB or ME so you can follow those procedures that pertain to that Series Torqmotor. The first two letters of the "spec" number on the Torqmotor identification tag is the Series designation. Also determine the type of end cover construction from the alternate views shown on page 7A and 7B.
- The Small Frame Series MG & MF Torqmotors will have a 3.66 inch (92.9 mm) main body outside diameter and five 5/16-24 UNF 2A cover bolts. The Large Frame Series MB & ME Torqmotors will have a 5 inch (127.0 mm) main body outside diameter and seven 3/8 24 UNF 2A cover bolts.
- Refer to page 7 for tools and other items required to service the Torqmotor and have them available.
- Thoroughly clean off all outside dirt, especially from around fittings and hose connections, before disconnecting and removing the Torqmotor. Remove rust or corrosion from coupling shaft.
- Remove coupling shaft connections and hose fittings and immediately plug port holes and fluid lines.
- Remove the Torqmotor from system, drain it of fluid and take it to a clean work surface. (A piece of wrapping paper makes an excellent disposable top.)
- Clean and dry the Torqmotor before you start to disassemble the unit.
- As you disassemble the Torqmotor clean all parts, except seals, in clean petroleum-based solvent, and blow them dry.

WARNING: SINCE THEY ARE FLAMMABLE, BE EXTREMELY CAREFUL WHEN USING ANY SOLVENT. EVEN A SMALL EXPLOSION OR FIRE COULD CAUSE INJURY OR DEATH.

WARNING: WEAR EYE PROTECTION AND BE SURE TO COMPLY WITH OSHA OR OTHER MAXIMUM AIR PRESSURE REQUIREMENTS.

CAUTION: Never steam or high pressure wash hydraulic components. Do not force or abuse closely fitted parts.

- Keep parts separate to avoid nicks and burrs.
- Discard all seals and seal rings as they are removed from the Torqmotor. Replace all seals, seal rings and any damaged or worn parts with genuine Ross or OEM approved service parts.

Disassembly and Inspection

(Reference Exploded Assembly View)

place Torqmotor in a vise

1. Place the Torqmotor in a soft jawed vice, with coupling shaft (12) pointed down and the vise jaws clamping firmly on the sides of the housing (18) mounting flange or port bosses. Remove manifold port O-Rings (18A) if applicable.

WARNING

WARNING: IF THE TORQMOTOR IS NOT FIRMLY HELD IN THE VISE, IT COULD BE DISLODGED DURING THE SERVICE PROCEDURES, CAUSING INJURY.

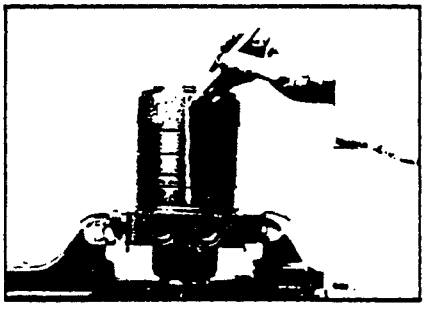


Figure 3

scribe alignment mark & loosen valve plugs

2. Scribe an alignment mark down and across the Torqmotor components from end cover (2) to housing (18) to facilitate reassembly orientation where required. Loosen two shuttle or relief valve plugs (21) for disassembly later if included in end cover. 3/16 or 3/8 inch allen wrench or 1 inch hex socket required. SEE FIGURE 3 & 4.

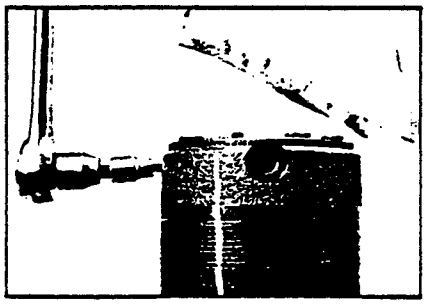


Figure 4

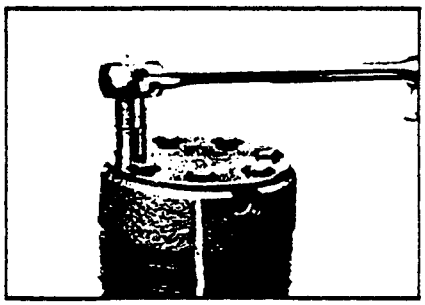


Figure 5

remove special bolts & inspect bolts

3. Remove the five or seven special ring head bolts (1, 1A, 1B, or 1C) using an appropriate 1/2 or 9/16 inch size socket. SEE FIGURE 5. Inspect bolts for damaged threads, or sealing rings, under the bolt head. Replace damaged bolts. SEE FIGURE 6.

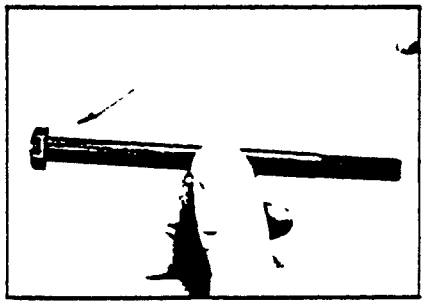


Figure 6

remove end cover & inspect bolts

4. Remove end cover assembly (2) and seal ring (4). Discard seal ring. SEE FIGURE 7.

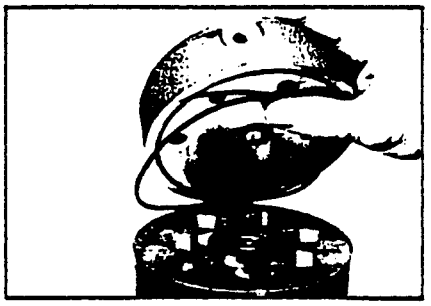


Figure 7

NOTE

NOTE: Refer to the appropriate "alternate cover construction" on page 7A or 7B to determine the end cover construction being serviced.

remove plugs and valves

5. If the end cover (2) is equipped with shuttle valve or relief valve (24) components, remove the two previously loosened plugs (21) and o-rings (22). SEE FIGURE 8.

CAUTION

CAUTION: Be ready to catch the shuttle valve or relief valve components that will fall out of the end cover valve cavity when the plugs are removed.

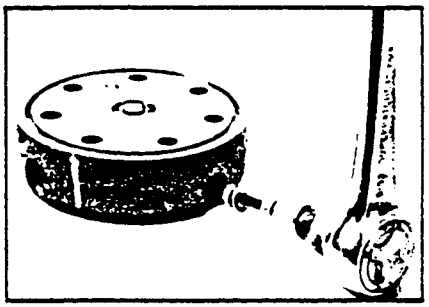


Figure 8

NOTE

NOTE: O-ring (22) is not included in seal kits but serviced separately if required.

NOTE

NOTE: The insert and if included the orifice plug in the end cover (2) must not be removed as they are serviced as an integral part of the end cover.

wash & inspect end cover

6. Thoroughly wash end cover (2) in proper solvent and blow dry. Be sure the end cover valve apertures, including the internal orifice plug, are free of contamination. Inspect end cover for cracks and the bolt head recesses for good bolt head sealing surfaces. Replace end cover as necessary. SEE FIGURE 9.

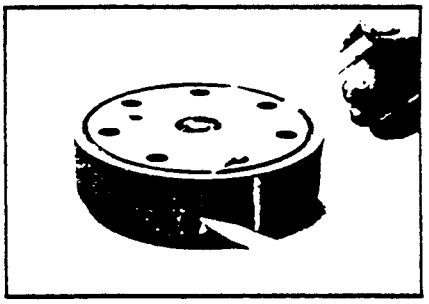


Figure 9

NOTE

NOTE: A polished pattern (not scratches) on the cover from rotation of the commutator (5) is normal. Discoloration would indicate excess fluid temperature, thermal shock, or excess speed and require system investigation for cause and close inspection of end cover, commutator, manifold, and rotor set.

remove & inspect commutator ring

7. Remove commutator ring (6). SEE FIGURE 10. Inspect commutator ring for cracks, or burrs.



Figure 10

remove & inspect commutator

8. Remove commutator (5) and seal ring (3). Remove seal ring from commutator, using an air hose to blow air into ring groove until seal ring is lifted out and discard seal ring. Inspect commutator for cracks or burrs, wear, scoring, spalling or brinelling. If any of these conditions exist, replace commutator and commutator ring as a matched set. SEE FIGURE 11 & 12.

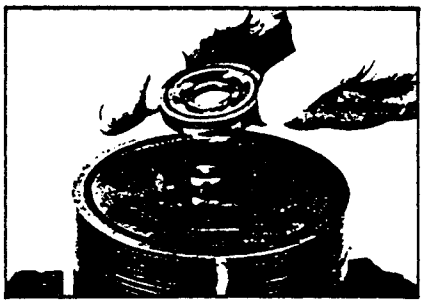


Figure 11

remove manifold

9. Remove manifold (7) and inspect for cracks surface scoring, brinelling or spalling. Replace manifold if any of these conditions exist. SEE FIGURE 13. A polished pattern on the ground surfaces from commutator or rotor rotation is normal. Remove and discard the seal rings (4) that are on both sides of the manifold.

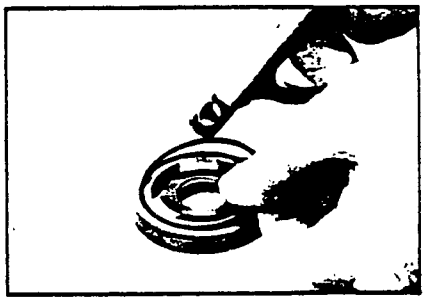


Figure 12

NOTE

NOTE: The manifold is constructed of plates bonded together to form an integral component not subject to further disassembly for service. Compare configuration of both sides of the manifold to ensure that same surface is reassembled against the rotor set.

remove & inspect rotor set & wearplate

10. Remove rotor set (8) and wearplate (9) together to retain the rotor set in its assembled form, maintaining the same rotor vane (8C) to stator (8B) contact surfaces. SEE FIGURE 14. The drive link (10) may come away from the coupling shaft (12) with the rotor set, and wearplate. You may have to shift the rotor set on the wearplate to work the drive link out of the rotor (8A) and wearplate. SEE FIGURE 15, Page 15. Inspect the rotor set in its assembled form for nicks, scoring, or spalling on any surface and for broken or worn splines. If the rotor set component requires replacement, the complete rotor set must be replaced as it is a matched set. Inspect the wearplate for cracks, brinelling, or scoring. Discard seal ring (4) that is between the rotor set and wearplate.



Figure 13

NOTE

NOTE: The rotor set (8) components may become disassembled during service procedures. Marking the surface of the rotor and stator that is facing UP, with etching ink or grease pencil before removal from Torqmotor will ensure correct reassembly of rotor into stator and rotor set into Torqmotor. Marking all rotor components and mating spline components for exact repositioning at assembly will ensure maximum wear life and performance of rotor set and Torqmotor.

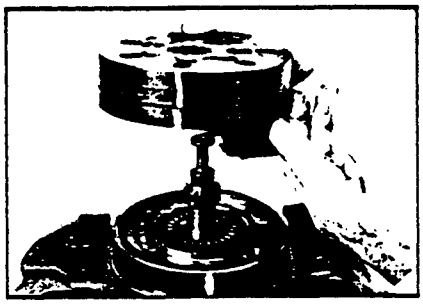


Figure 14

NOTE

NOTE: Series ME Torqmotors may have a rotor set with two stator halfs (8B & 8D) with a seal ring (4) between them and two sets of seven vanes (8C & 8E). Discard seal ring only if stator halfs become disassembled during the service procedures.

NOTE

NOTE: A polished pattern on the wear plate from rotor rotation is normal.

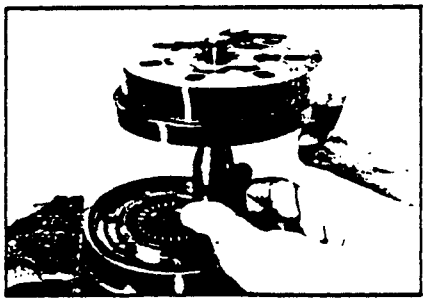


Figure 15

check rotor, vane clearance

11. Place rotor set (8) and wear plate (9) on a flat surface and center rotor (8A) in stator (8B) such that two rotor lobes (180 degrees apart) and a roller vane (8C) centerline are on the same stator centerline. Check the rotor lobe to roller vane clearance with a feeler gage at this common centerline. If there is more than .005 inches (0.13 mm) of clearance, replace rotor set. SEE FIGURE 16.

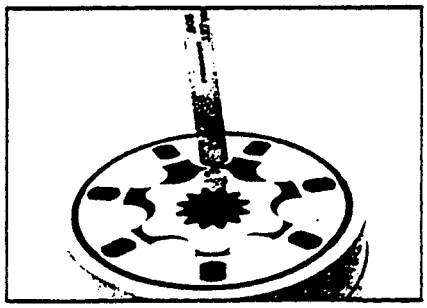


Figure 16

NOTE

NOTE: If rotor set (8) has two stator halfs (8B & 8D) and two sets of seven vanes (8C & 8E) as shown in the alternate construction ME rotor set assembly view, check the rotor lobe to roller vane clearance at both ends of rotor.

remove & inspect drive link

12. Remove drive link (10) from coupling shaft (12) if it was not removed with rotor set and wear plate. Inspect drive link for cracks and worn or damaged splines. No perceptible lash (play) should be noted between mating spline parts. SEE FIGURE 17. Remove and discard seal ring (4) from housing (18).

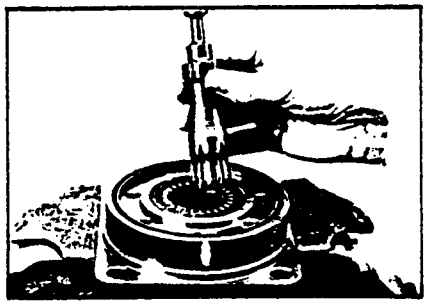


Figure 17

remove thrust bearing

13. Remove thrust bearing (11) from top of coupling shaft (12) if Torqmotor is a Series MB or ME. Inspect for wear, brinelling, corrosion and a full complement of retained rollers. SEE FIGURE 18.



Figure 18

check coupling shaft for rust or corrosion

14. Check exposed portion of coupling shaft (12) to be sure you have removed all signs of rust and corrosion which might prevent its withdrawal through the seal and bearing. Crocus cloth or fine emery paper may be used. SEE FIGURE 19. Remove any key (12A), nut (12B), washer (12C), bolt (12D), lock washer (12E), or retaining ring (12F).

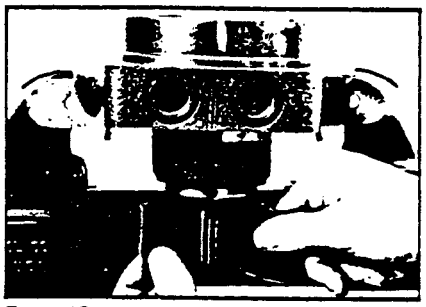


Figure 19

remove & inspect coupling shaft

15. Remove coupling shaft (12), by pushing on the output end of shaft. SEE FIGURE 20. Inspect coupling shaft bearing and seal surfaces for spalling, nicks, grooves, severe wear or corrosion and discoloration. Inspect for damaged or worn internal and external splines or keyway. SEE FIGURE 21. Replace coupling shaft if any of these conditions exist.

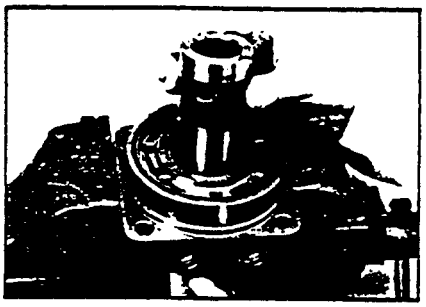


Figure 20

NOTE

NOTE: Minor shaft wear in seal area is permissible. If wear exceeds .020 inches (0.51 mm) diametrically, replace coupling shaft.

NOTE

NOTE: A slight "polish" is permissible in the shaft bearing areas. Anything more would require coupling shaft replacement.

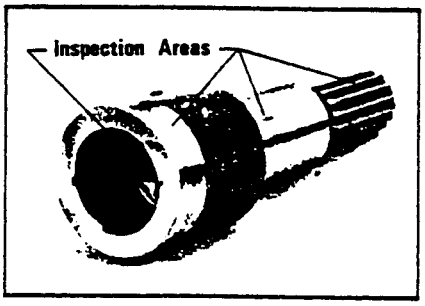


Figure 21

remove seal ring from housing

16. Remove and discard seal ring (4) from housing (18).

remove & inspect thrust washer & thrust bearing

17. Remove thrust bearing (15) and thrust washer (14) if the unit is a Series MG or MF. Inspect for wear, brinelling, corrosion and a full complement of retained rollers. SEE FIGURE 22.

NOTE

NOTE: Large Frame Series MB & ME Torqmotors have a thrust bearing (15) sandwiched between two thrust washers (14) that cannot be removed from housing (18) unless bearing (13) is removed for replacement.

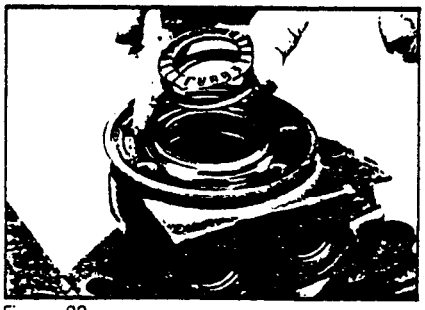


Figure 22

remove seal & washer or washers

18. Remove seal (16) and back up washer (17) from Small Frame, MG & MF housing (18). Discard both. SEE FIGURE 23.

Remove seal (16), backup washer (17), and backup washer (25) from Large Frame, Series MB & ME Torqmotor housing by working them around unseated thrust washers (14) and thrust bearing (15) and out of the housing. Discard seal and washers. SEE FIGURE 24.

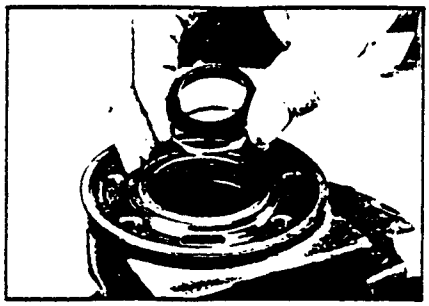


Figure 23

NOTE

NOTE: The original design units of Large Frame, Series MB & ME Torqmotors did not include backup washer (25), but must include backup washer (25) when reassembled for service.



Figure 24

remove seal

19. Remove housing (18) from vise, invert it and remove and discard seal (20). A blind hole bearing or seal puller required. SEE FIGURE 25.

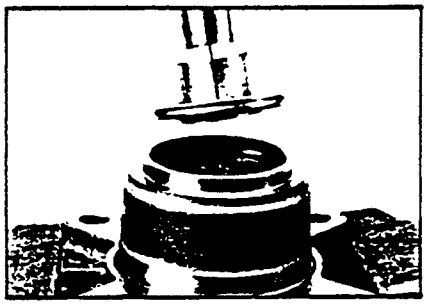


Figure 25

inspect housing assembly

20. Inspect housing (18) assembly for cracks, the machined surfaces for nicks, burrs, brinelling or corrosion. Remove burrs that can be removed without changing dimensional characteristics. Inspect tapped holes for thread damage. SEE FIGURE 26. If the housing is defective in these areas, discard the housing assembly.

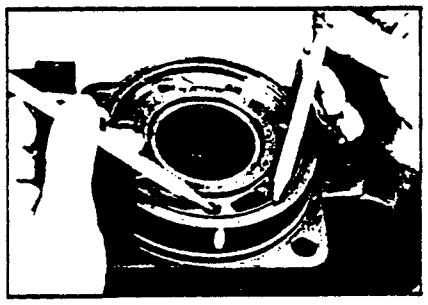


Figure 26

inspect housing bearing/bushing

21. If the housing (18) assembly has passed inspection to this point, inspect the housing bearings/bushings (19) and (13) and if they are captured in the housing cavity the two thrust washers (14) and thrust bearing (15). The bearing rollers must be firmly retained in the bearing cages, but must rotate and orbit freely. All rollers and thrust washers must be free of brinelling and corrosion. SEE FIGURE 27. The MG Series bushing (19) or (13) to coupling shaft diametral clearance must not exceed .010 inch (.025 mm). A bearing, bushing, or thrust washer that does not pass inspection must be replaced. SEE FIGURE 28. If the housing has passed this inspection the disassembly of the Torqmotor is completed.

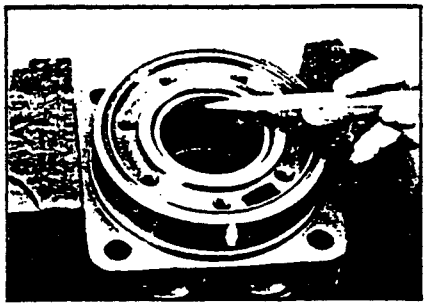


Figure 27

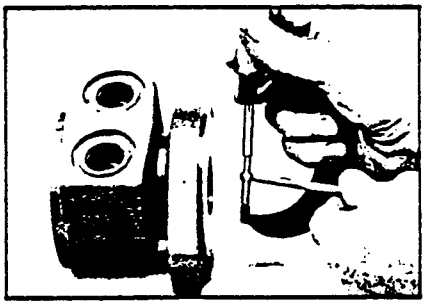


Figure 28

NOTE

NOTE: The depth or location of bearing/bushing (13) in relation to the housing wear plate surface and the depth or location of bearing/bushing (19) in relation to the beginning of bearing/bushing counter bore should be measured and noted before removing the bearings/bushings. This will facilitate the correct reassembly of new bearings/bushings. SEE FIGURE 29.

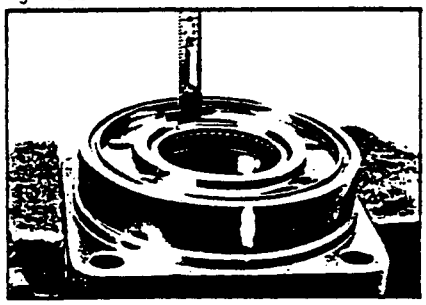


Figure 29

remove bearings or bushings & thrust washers

22. If the bearings, bushing or thrust washers must be replaced use a suitable size bearing puller to remove bearing/bushings (19) and (13) from housing (18) without damaging the housing. Remove thrust washers (14) and thrust bearing (15) if they were previously retained in the housing by bearing (13). SEE FIGURES 30 & 31.

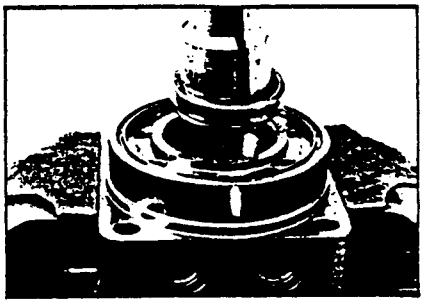


Figure 30

THE DISASSEMBLY OF TORQMOTOR IS COMPLETED.

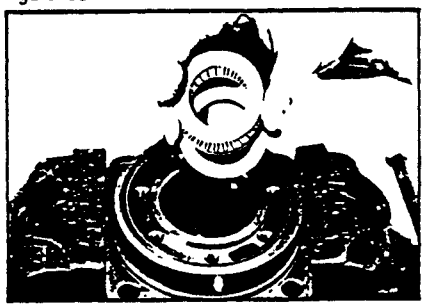


Figure 31

Torqmotor™ Assembly

- Replace all seals and seal rings with new ones each time you reassemble the Torqmotor unit. Lubricate all seals and seal rings with SAE 10W40 oil or clean grease before assembly.
- **NOTE: Individual seals and seal rings as well as a complete seal kit are available. SEE FIGURE 32. The parts should be available through most OEM parts distributors or Ross approved Torqmotor™ distributors. (Contact your local dealer for availability).**
- **NOTE: Unless otherwise indicated, do not oil or grease parts before assembly.**
- Wash all parts in clean petroleum-based solvents before assembly. Blow them dry with compressed air. Remove any paint chips from mating surfaces of the end cover, commutator set, manifold rotor set, wear plate and housing and from port and sealing areas.

WARNING

WARNING: SINCE THEY ARE FLAMMABLE, BE EXTREMELY CAREFUL WHEN USING ANY SOLVENT. EVEN A SMALL EXPLOSION OR FIRE COULD CAUSE INJURY OR DEATH.

WARNING

WARNING: WEAR EYE PROTECTION AND BE SURE TO COMPLY WITH OSHA OR OTHER MAXIMUM AIR PRESSURE REQUIREMENTS.

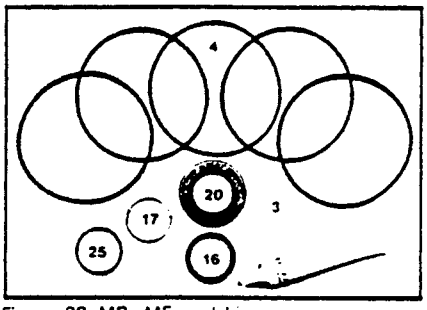
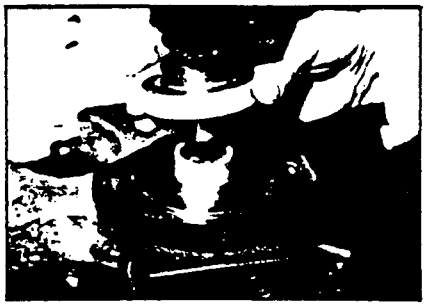


Figure 32 MB, ME seal kit

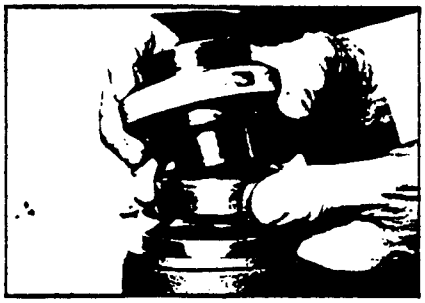
press in outer bearing/bushing

1. If the housing (18) bearing components were removed for replacement, thoroughly coat and pack a **new** outer bearing/bushing (19) with clean corrosion resistant grease recommended in the material section on page 7. Press the new bearing/bushing into the counterbore at the mounting flange end of the housing, using the appropriate sized bearing mandrel such as described in figure 1 or figure 2 on page 7 which will control the bearing/bushing depth.

   Small Frame Series MG and MF Torqmotor housings require the use of bearing mandrel shown in figure 1 on page 7 to press bearing/bushing (19) into the housing to a required depth of .151/.161 inches (3.84/4.09 mm) from the end of the bearing counterbore. SEE FIGURE 33.


Figure 33

   Large Frame Series MB and ME Torqmotor housings require the use of the bearing mandrel shown in figure 2 on page 7 to press bearing (19) into the housing to a required depth of .290/.310 inches (7.37/7.87 mm) from the outside end of the bearing counterbore. SEE FIGURE 34.


Figure 34

NOTE

NOTE: Bearing mandrel must be pressed against the lettered end of bearing shell. Take care that the housing bore is square with the press base and the bearing/bushing is not cocked when pressing a bearing/bushing into the housing.

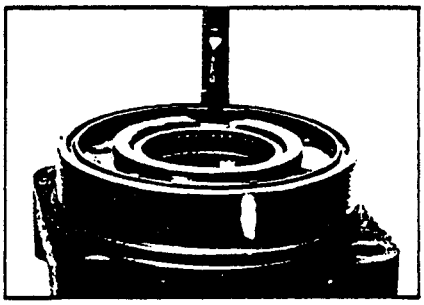


Figure 35

CAUTION

CAUTION: If the bearing mandrel specified on page 7 is not available and alternate methods are used to press in bearing/bushing (13) and (19) the bearing/bushing depths specified must be achieved to insure adequate bearing support and correct relationship to adjacent components when assembled. SEE FIGURE 35.

CAUTION

CAUTION: Because the bearing/bushings (13) and (19) have a press fit into the housing they must be discarded when removed. They must not be reused.

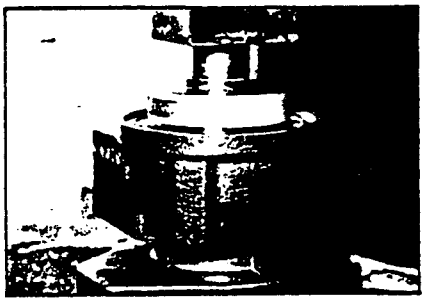


Figure 36

press in inner bearing/bushing

2. The Small Frame Series MG and MF Torqmotor inner housing bearing/bushing (13) can now be pressed into its counterbore in housing (18) flush to .03 inch (.76 mm) below the housing wear plate contact face. Use the opposite end of the bearing mandrel that was used to press in the outer bearing/bushing (19). Reference figure 1, page 7. SEE FIGURE 36.



Figure 37

The Large Frame Series MB and ME Torqmotor housing (18) requires that you assemble a **new** backup washer (17), **new** backup washer (25), **new** seal (16), with the lip facing out, **new** thrust washer (14), **new** thrust bearing (15) and a **new** second thrust washer (14) in that order before pressing in the inner housing bearing (13). SEE FIGURE 37 & 38. When these components are in place, press **new** bearing (13) into the housing (18) to a depth of .105/.125 inches (2.67/3.18) below the housing wear plate contact face. Use the opposite end of the bearing mandrel used to press in outer bearing (19). Reference figure 2, page 7. SEE FIGURE 39.

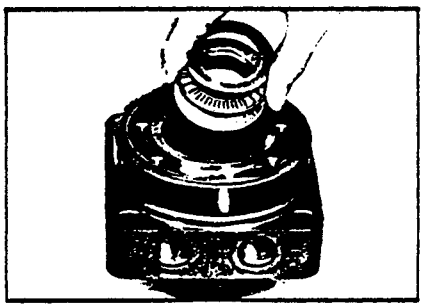


Figure 38

press in dirt & water seal

3. Apply a small amount of clean grease to a new dirt and water seal (20) and press it into the housing (18) outer bearing counterbore.

   The Small Frame Series MG and MF Torqmotor dirt and water seal (20) must be pressed in until its' flange is flush against the housing. SEE FIGURE 40.

   The Large Frame Series MB and ME Torqmotor dirt and water seal (20) must be pressed in with the lip facing out and until the seal is flush to .020 inches (.51 mm) below the end of housing. SEE FIGURE 41.



Figure 39



Figure 40

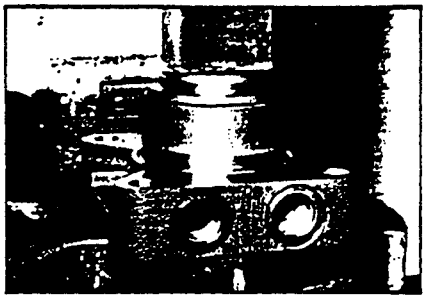


Figure 41

place housing assembly into vise

4. Place housing (18) assembly into a soft jawed vise with the coupling shaft bore down, clamping against the mounting flange. SEE FIGURE 42.

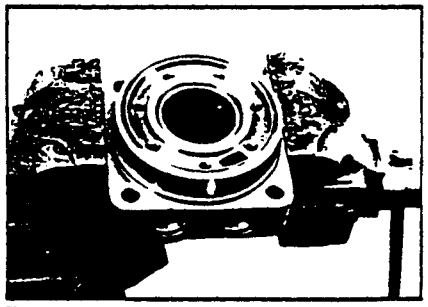


Figure 42

assemble backup washer & seal

5. On Small Frame, Series MG & MF Torqmotors assemble a new backup washer (17) and new seal (16) with the seal lip facing out, into their respective counterbores in housing (18) if they were not assembled in procedure 2.

   Large Frame, Series MB and ME Torqmotor housing (18) that did not require replacement of the bearing package will require that the two "captured" thrust washers (14) and thrust bearing (15) be unseated and vertical to the counterbore and the new backup washer (17), new backup washer (25), and new seal (16) be worked around the thrust bearing package and placed into their respective counterbores. The seal lip must face out of the seal counterbore. Be sure the thrust bearing package is reseated correctly after assembly of the seal and backup washer. SEE FIGURE 43 & 44.

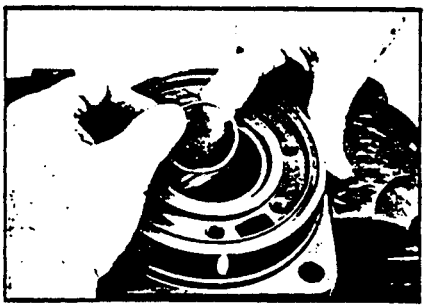


Figure 43

CAUTION

CAUTION: Original design Large Frame, MB & ME Torqmotors that do not have backup washer (25) when disassembled must be assembled with a new backup washer (17), new backup washer (25), and new seal (16).

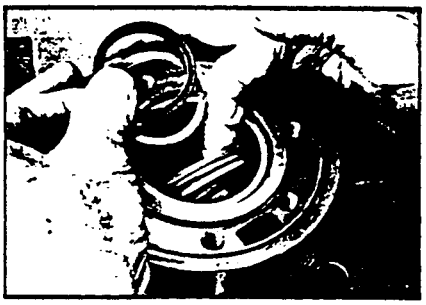


Figure 44

assemble thrust washer & bearing

6. Assemble thrust washer (14) then thrust bearing (15) that was removed from the Series MG or MF Torqmotor. SEE FIGURE 45.

NOTE

NOTE: Small Frame Series MG and MF Torqmotors require one thrust washer (14) with thrust bearing (15). The coupling shaft will be seated directly against the thrust bearing.

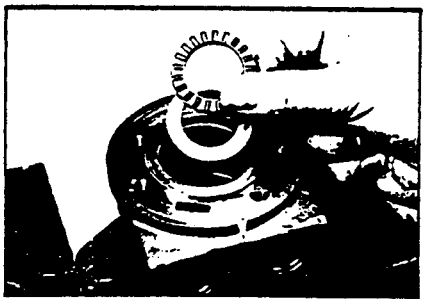


Figure 45

apply masking tape to shaft

7. Apply masking tape around splines or keyway on shaft (12) to prevent damage to seal. SEE FIGURE 46.



Figure 46

install coupling shaft

8. Be sure that a generous amount of clean corrosion resistant grease has been applied to the lower (outer) housing bearing/bushing (19). Install the coupling shaft (12) into housing (18), seating it against the thrust bearing (15) in MG and MF Series housings and against the second thrust washer (14) in MB and ME Series housings. SEE FIGURE 47.

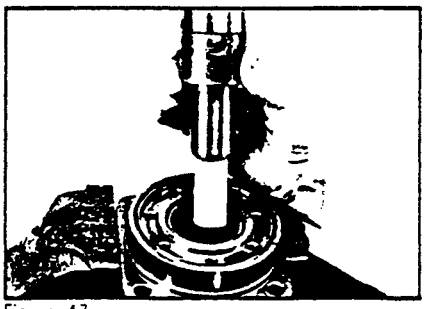


Figure 47

CAUTION

CAUTION: The outer bearing (19) is not lubricated by the system's hydraulic fluid. Be sure it is thoroughly packed with the recommended grease, Ross Gear grease specification #045236, E/M Lubricant #K-70M.

NOTE

NOTE: The coupling shaft (12) will be flush or just below the housing wear plate surface on Small Frame, Series MG and MF Torqmotors when properly seated while the coupling shaft (12) on Large Frame, Series MB and ME Torqmotors will be approximately .10 inch (2.54 mm) below the housing wear plate surface to allow the assembly of thrust bearing (11). The coupling shaft must rotate smoothly on the thrust bearing package. SEE FIGURE 48.

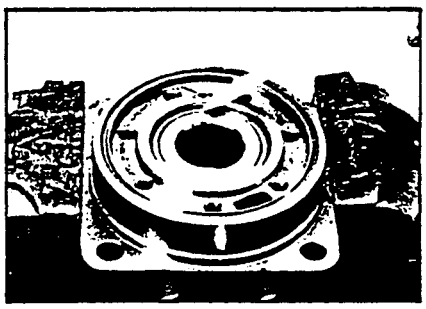


Figure 48

install thrust bearing

9. Install thrust bearing (11) onto the end of coupling shaft (12) only if you are servicing an MB or ME Series Torqmotor. SEE FIGURE 49.



Figure 49

insert seal ring

10. Apply a small amount of clean grease to a **new** seal ring (4) and insert it into the housing (18) seal ring groove. SEE FIGURE 50.

NOTE

NOTE: One or two alignment studs screwed finger tight into housing (18) bolt holes, approximately 180 degrees apart, will facilitate the assembly and alignment of components as required in the following procedures. The studs can be made by cutting off the heads of either 3/8-24 UNF 2A or 5/16-24 UNF 2A bolts as required that are over .5 inch (12.7 mm) longer than the bolts (1, 1A, 1B or 1C) used in the Torqmotor.

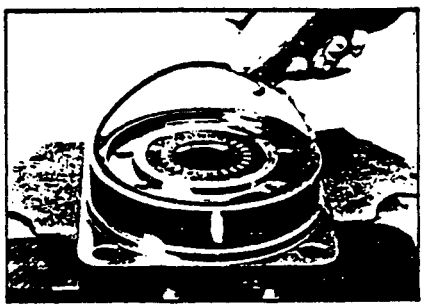


Figure 50

install drive link

11. Install drive link (10) the long splined end down into the coupling shaft (12) and engage the drive link splines into mesh with the coupling shaft splines. SEE FIGURE 51.

NOTE

NOTE: Use any alignment marks put on the coupling shaft and drive link before disassembly to assemble the drive link splines in their original position in the mating coupling shaft splines.

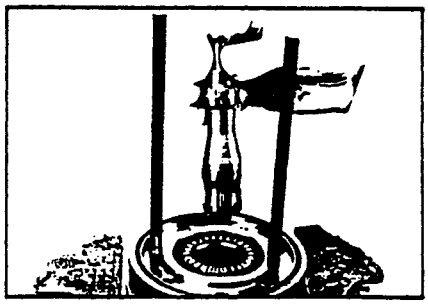


Figure 51

assemble wear plate

12. Assemble wear plate (9) over the drive link (10) and alignment studs onto the housing (18). SEE FIGURE 52.

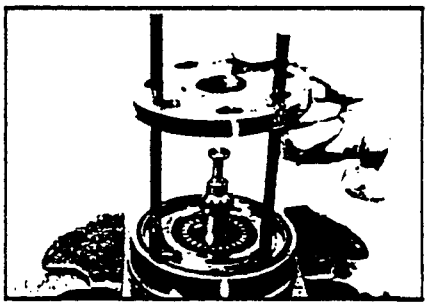


Figure 52

assemble seal ring

13. Apply a small amount of clean grease to a new seal ring (4) and assemble it into the seal ring groove on the wear plate side of the rotor set stator (8B). SEE FIGURE 53.

install the assembled rotor set

14. Install the assembled rotor set (8) onto wear plate (9) with rotor (8A) counterbore and seal ring side down and the splines into mesh with the drive link splines. SEE FIGURE 54.

NOTE

NOTE: It may be necessary to turn one alignment stud out of the housing (18) temporarily to assemble rotor set (8) or manifold (7) over the drive link.

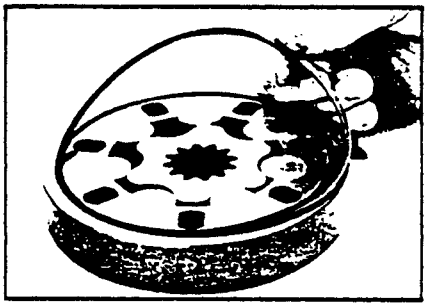


Figure 53

NOTE

NOTE: If necessary, go to the appropriate, "Rotor Set Component Assembly Procedure," on page 30 or 31.

NOTE

NOTE: The rotor set rotor counterbore side must be down against wear plate for drive link clearance and to maintain the original rotor-drive link spline contact. A rotor set without a counterbore and that was not etched before disassembly can be reinstalled using the drive link spline pattern on the rotor splines if apparent, to determine which side was down. The rotor set has a seal ring groove on the wear plate contact side of the stator (8B).

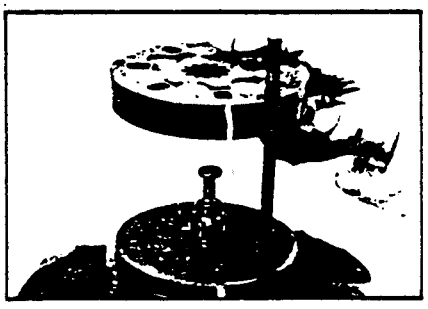


Figure 54

assemble seal ring in manifold

15. Apply clean grease to a **new** seal ring (4) and assemble it in the seal ring groove in the rotor set contact side of manifold (7). SEE FIGURE 55.

NOTE

NOTE: The manifold (7) is made up of several plates bonded together permanently to form an integral component. The manifold surface that must contact the rotor set has it's series of irregular shaped cavities on the largest circumference or circle around the inside diameter. The polished impression left on the manifold by the rotor set is another indication of which surface must contact the rotor set.

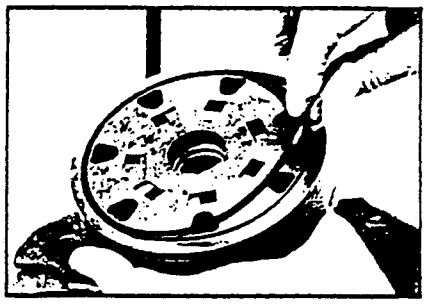


Figure 55

assemble manifold

16. Assemble the manifold (7) over the alignment studs and drive link (10) and onto the rotor set. Be sure the correct manifold surface is against the rotor set. SEE FIGURE 56.

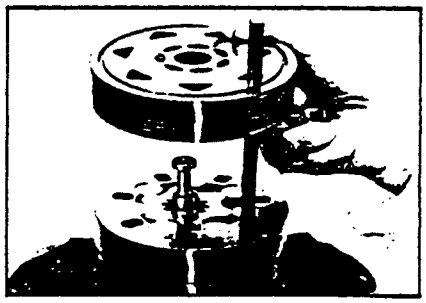


Figure 56

insert a seal in manifold

17. Apply grease to a **new** seal ring (4) and insert it in the seal ring groove exposed on the manifold. SEE FIGURE 57.

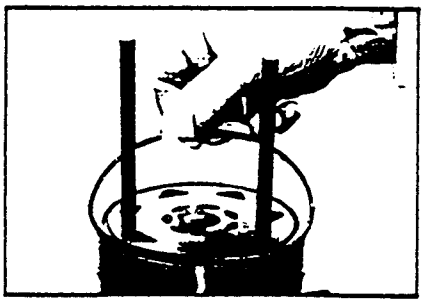


Figure 57

assemble commutator ring

18. Assemble the commutator ring (6) over alignment studs onto the manifold. SEE FIGURE 58.

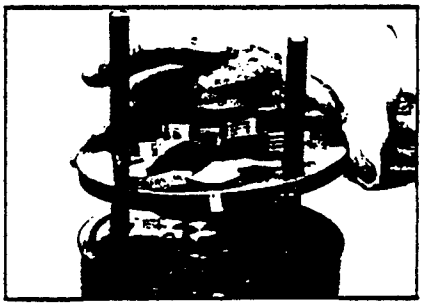


Figure 58

assemble seal & commutator

19. Assemble a **new** seal ring (3) flat side up, into commutator (5) and assemble commutator over the end of drive link (10) onto manifold (7) with seal ring side up. SEE FIGURE 59, 60.

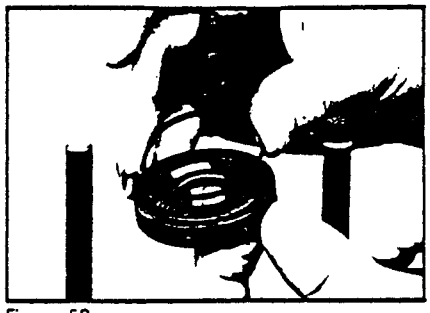


Figure 59

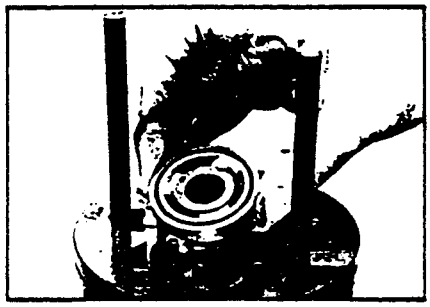


Figure 60

assemble shuttle valve parts into end cover

20. If shuttle valve components items #21, #22, #23, #24 were removed from the end cover (2) turn a plug (21) with a **new** o-ring (22), loosely into one end of the valve cavity in the end cover. Insert a spring (23) the valve (24) and the second spring (23) into the other end of the valve cavity. Turn the second plug (21) with a **new** o-ring (22) loosely into the end cover valve cavity. 3/16 inch Allen wrench required. SEE FIGURE 61.

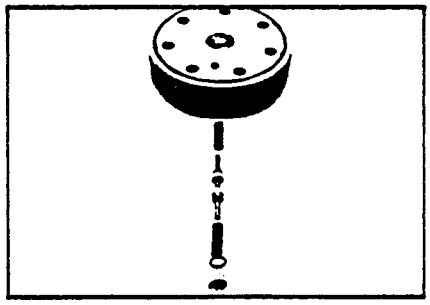


Figure 61

assemble relief valve parts in end cover

21. If relief valve components items #21, #22, #24 were removed from the end cover (2) assemble a **new** o-ring (22) on the two plugs (21). Assemble a two piece relief valve (24) in each of the plugs, with the large end of the conical spring into the plug first and the small nut of the other valve piece in the small end of the conical spring. Turn each of the plug and relief valve assemblies into the end cover loosely to be torqued later. 3/8 inch Allen or 1 inch Hex socket required. SEE FIGURE 62.

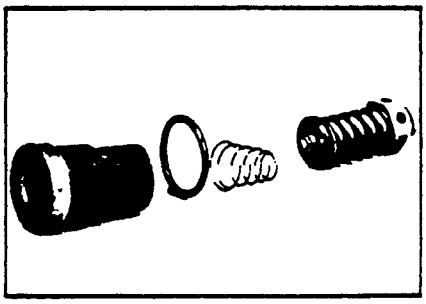


Figure 62

assemble seal ring & end cover

22. Assemble a new seal ring (4) into end cover (2) and assemble end cover over the alignment studs and onto the commutator set. SEE FIGURE 63, 64. If the end cover has only 5 bolt holes be sure the cover holes are aligned with the 5 threaded holes in housing (18). The correct 5 bolt end cover bolt hole relationship to housing port bosses is shown in FIGURE 65.

NOTE

NOTE: If the end cover has a valve (24) or has five bolt holes, use the line you previously scribed on the cover to radially align the end cover into its original position.

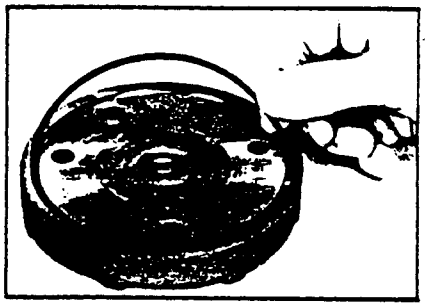


Figure 63

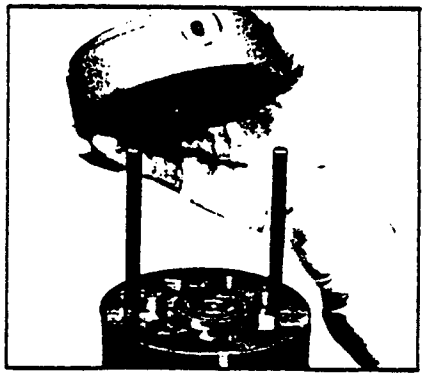


Figure 64

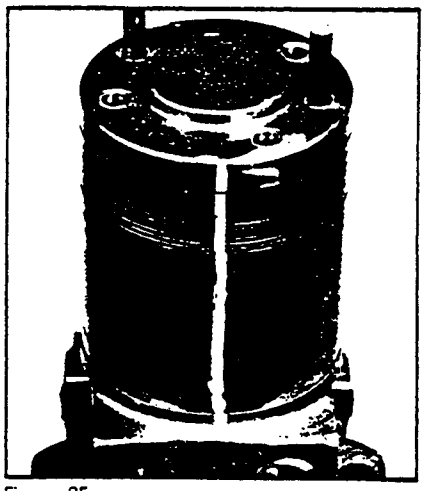


Figure 65

assemble cover bolts

23. Assemble the 5 or 7 special bolts (1, 1A, 1B or 1C) and screw in finger tight. Remove and replace the two alignment studs with bolts after the other bolts are in place. Alternately and progressively tighten the bolts to pull the end cover and other components into place with a final torque of 22-26 ft. lbs. (30-35 N m) for the five MG & MF Series 5/16 24 threaded bolts or 45-55 ft. lbs. (61-75 N m) for the seven MB & ME Series 3/8-24 threaded bolts. SEE FIGURE 66, 67, 68.

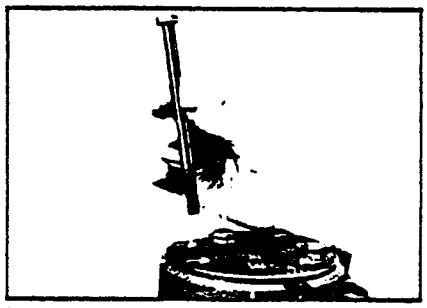


Figure 66

NOTE

NOTE: The special bolts required for use with the relief or shuttle valve (24) end cover assembly (2) are longer than the bolts required with standard end cover assembly. Refer to the individual service parts lists or parts list charts for correct service part number if replacement is required.

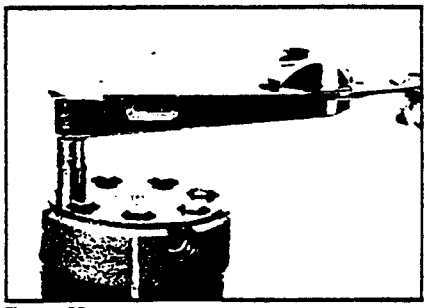


Figure 67

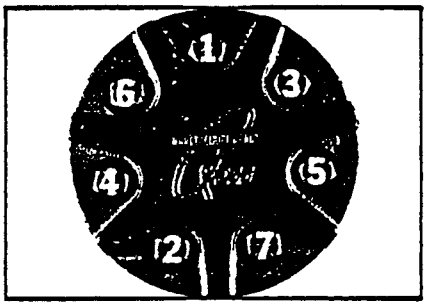


Figure 68

torque the valve plugs

24. Torque the two shuttle valve plug assemblies (21) in end cover assembly to 9-12 ft. lbs. (12-16 N m) if cover is so equipped. SEE FIGURE 69.

Torque the two relief valve plug assemblies (21) in end cover assembly to 45-55 ft. lbs. (61-75 N m) if cover is so equipped.

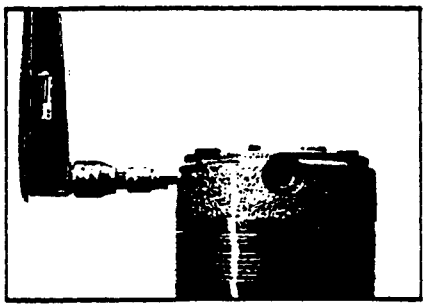


Figure 69

THE ASSEMBLY OF THE TOROMOTOR IS NOW COMPLETE EXCEPT FOR WOODRUFF KEY (12A), NUT (12B), WASHER (12C), BOLT (12D), LOCKWASHER (12E), RETAINER RING (12F) or PORT O-RINGS (18A) AT INSTALLATION IF APPLICABLE. SEE PAGE 32 FOR FINAL CHECKS.

Rotor Set Component Assembly Procedure

One Piece Stator Construction

A disassembled rotor (8A) stator (8B) and vanes (8C) that cannot be readily assembled by hand can be assembled by the following procedures.

assemble stator

1. Place stator (8B) onto wear plate (9) with seal ring (4) side down, after following Torqmotor assembly procedures 1 through 13. Be sure the seal ring is in place. SEE FIGURE 70.

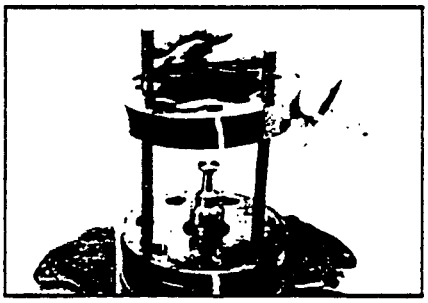


Figure 70

insert two bolts

2. If assembly alignment studs are not being utilized, align stator bolt holes with wear plate and housing bolt holes and turn two bolts (1) finger tight into bolt holes approximately 180 degrees apart to retain stator and wear plate stationary.

assemble rotor

3. Assemble the rotor (8A), counterbore down if applicable, into stator (8B), and onto wear plate (9) with rotor splines into mesh with drive link (10) splines. SEE FIGURE 71.



Figure 71

NOTE

NOTE: If the manifold side of the rotor was etched during Torqmotor disassembly, this side should be up. If the rotor is not etched and does not have a counterbore, use the drive link spline contact pattern apparent on the rotor splines to determine the rotor side that must be against the wear plate.

assemble vanes

4. Assemble six vanes (8C), or as many vanes that will readily assemble into the stator vane pockets. SEE FIGURE 72.



Figure 72

CAUTION

CAUTION: Excessive force used to push the rotor vanes into place could shear off the coating applied to the stator vane pockets.

assemble full complement of vanes

5. Grasp the output end of coupling shaft (12) with locking pliers or other appropriate turning device and rotate coupling shaft, drive link and rotor to seat the rotor and the assembled vanes (8C) into stator (8B), creating the necessary clearance to assemble the seventh or full complement of seven vanes. Assemble the seven vanes using minimum force. SEE FIGURE 73.

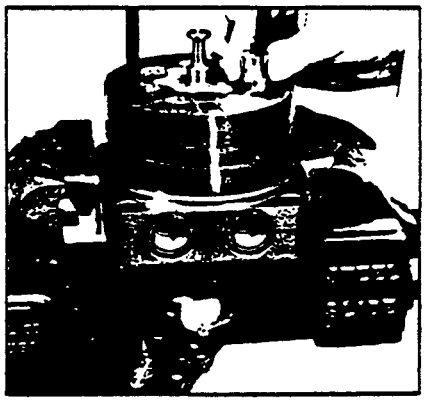


Figure 73

remove two assembled bolts

6. Remove the two assembled bolts (1) if used to retain stator and wear plate.

Go to Torqmotor assembly procedure #15, page 25 to continue Torqmotor assembly.

Rotor Set Component Assembly Procedure

Two Piece Stator Construction

A disassembled rotor set (8) that cannot be readily assembled by hand and has a two piece stator can be assembled by the following procedures.

assemble stator halfs

1. Place stator half (8B) onto wear plate (9) with seal ring (4) side down, after following Torqmotor assembly procedures 1 through 13. Be sure the seal ring is in place.

insert two alignment studs

2. Align stator bolt holes with wear plate and housing bolt holes and turn two alignment studs finger tight into bolt holes approximately 180 degrees apart to retain stator half and wear plate stationary.

assemble rotor

3. Assemble rotor (8A), counterbore down if applicable, into stator half (8B), and onto wear plate (9) with rotor splines into mesh with drive link (10) splines.

NOTE

NOTE: Use any marking you applied to rotor set components to reassemble the components in their original relationship to ensure ultimate wear life and performance.

assemble vanes

4. Assemble six vanes (8C), or as many vanes that will readily assemble into the stator vane pockets.

CAUTION

CAUTION: Excessive force used to push the rotor vanes into place could shear off the coating applied to the stator vane pockets.

assemble full complement of vanes

5. Grasp the output end of coupling shaft (12) with locking pliers or other appropriate turning device and rotate coupling shaft, drive link and rotor to seat the rotor and the assembled vanes (8C) into stator half (8B), creating the necessary clearance to assemble the seventh or full complement of seven vanes. Assemble the seven vanes using minimum force.

assemble seal ring in stator half

6. Place second stator half (8D) on a flat surface with seal ring groove up. Apply a small amount of grease to a **new** seal ring (4) and assemble it into stator half ring groove.

assemble second stator half

7. Assemble the second stator half (8D) over the two alignment studs and rotor (8A) with seal ring side down onto the first stator half (8B) aligning any timing marks applied for this purpose.

CAUTION

CAUTION: If the stator half (8B) is a different height (thickness) than stator half (8D) the stator vanes (8C) or (8E) of the same length (height) as the stator half must be reassembled in their respective stator half for the rotor set to function properly.

assemble vanes

8. Assemble six vanes (8E), or as many vanes that will readily assemble into the stator vane pockets.

assemble full complement of vanes

9. Grasp the output end of coupling shaft (12) with locking pliers or other appropriate turning device and rotate coupling shaft, drive link and rotor to seat the rotor and the assembled vanes (8E) into stator (8D), creating the necessary clearance to assemble the seventh or full complement of seven vanes. Assemble the seven vanes using minimum force.

Go to Torqmotor assembly procedure #15, page 25 to continue Torqmotor assembly.

Final Checks

Final Checks

- Pressurize the Torqmotor™ with 100 p.s.i. dry air or nitrogen and submerge in solvent to check for external leaks.
- Check Torqmotor™ for rotation. Torque required to rotate coupling shaft should not be more than 50 ft. lbs. (68 N m)
- On MG & MF Series Torqmotors, pressure port with "A" cast under it on housing (18) is for clockwise coupling shaft rotation as viewed from the output end of coupling shaft. Pressure port with "B" cast under it is for counter clockwise coupling shaft rotation.
- On MB & ME Series Torqmotors, pressure port with "B" cast under it on housing (18) is for clockwise coupling shaft rotation as viewed from the output end of coupling shaft. Pressure port with "A" case under it is for counter clockwise coupling shaft rotation.
- Use test stand if available, to check operation of the Torqmotor™.

Hydraulic Fluid

Keep the hydraulic system filled with one of the following:

- 10W40 SE or SF manufacturers suggested oil.
- Hydraulic fluid as recommended by equipment manufacturer, but the viscosity should not drop below 50 SSU or contain less than .125% zinc anti-wear additives.

  CAUTION: Do not mix oil types. Any mixture, or an unapproved oil, could deteriorate the seals. Maintain the proper fluid level in the reservoir. When changing fluid, completely drain old oil from the system. It is suggested also that you flush the system with clean oil.

Filtration

Recommended filtration 20-50 micron.

Oil Temperature

Maximum operating temperature 200°F (93.3°C).

Tips for Maintaining the Torqmotor™ Hydraulic System

- Adjust fluid level in reservoir as necessary.
- Encourage all operators to report any malfunction or accident that may have damaged the hydraulic system or component.
- Do not attempt to weld any broken Torqmotor™ component. Replace the component with original equipment only.
- Do not cold straighten, hot straighten, or bend any Torqmotor™ part.
- Prevent dirt or other foreign matter from entering the hydraulic system. Clean the area around and the filler caps before checking oil level.
- Investigate and correct any external leak in the hydraulic system, no matter how minor the leak.
- Comply with manufacturer's specifications for cleaning or replacing the filter.

CAUTION: Do not weld, braze, solder or any way alter any Torqmotor™ component.

CAUTION: Maximum operating pressure must not exceed recommended Torqmotor™ pressure capacity.

CAUTION: Always carefully inspect any system component that may have been struck or damaged during operation or in an accident. Replace any component that is damaged or that is questionable.

CAUTION: Do not force any coupling onto the Torqmotor™ coupling shaft as this could damage the unit internally.

Ross Gear extends close technical cooperation and assistance. If problems occur which you cannot solve, please contact our Ross Service Department or local Ross approved Distributor. Our phone number and telex number and address are on the back cover of this manual.

SERVICE BULLETINS

As we make improvements to the **MARKLIFTS**, we like to supply you, the customer, with updated information which applies to your machine.

This section is provided as a place to store Service Bulletins as you receive them from MARK INDUSTRIES.