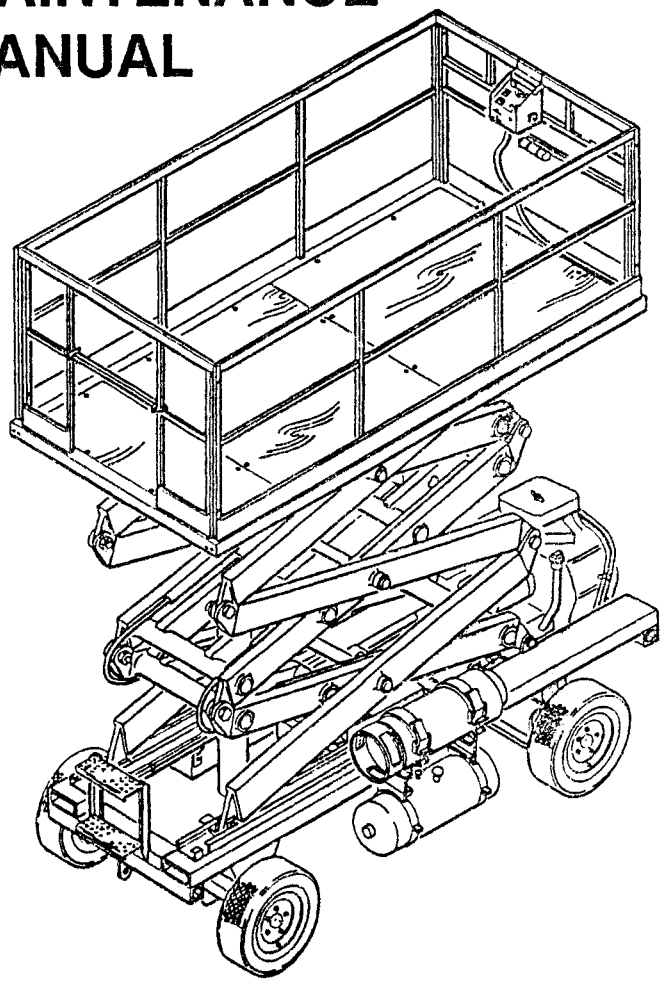
The Marklifts.®

A Product of Mark Industries

SELF-PROPELLED SCISSOR OPERATION MAINTENANCE AND PARTS MANUAL



Models:

- M20GP
- M20E
- M25E
- M20ET
- M25ET

FIRST EDITION: September 1989

Mark Industries

P.O. Box 2255
Brea, California 92622
205 South Puente Street, Brea, California 92621
(714) 879-MARK, FAX (714) 879-8884

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Mark Industries

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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 or service is needed, we urge the customer to contact his local dealer. If this is impossible, please contact the **MARK INDUSTRIES** Service Department at (714)879-6275 ext. 362.

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 frame assembly. The serial number should be used when ordering parts. This will help our parts department give prompt and accurate service.

All **MARKLIFTS** are tested and operated before shipment to assure their proper operating condition. 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 tasks are outlined in the **INSPECTION AND CHECKOUT** instructions in the operation section of this manual.

Description	Models		
	M20GP	M20E	M25E
Height –			
Working (maximum)	26'-2" (7.96m)	26'-4" (8.03m)	31'-5" (9.58m)
Platform (maximum)	20'-2" (6.15m)	20'-4" (6.20m)	25'-5" (7.75m)
Platform (minimum)	50" (1.27m)	50" (1.27m)	50" (1.27m)
Length (overall)	124.5" (3.16m)	96" (2.44m)	124.5" (3.16m)
Width (overall)	59" (1.49m)	59" (1.49m)	59" (1.49m)
Platform –			
Dimenions (inside)	57.5"X123.25" (1.46mX3.13m)	57.5"X94.5" (1.46mX2.40m)	57.5"X123.25"
Safety Rail Height	42" (1.07m)	42" (1.07m)	42" (1.07m)
Toeplate Height	6" (.15m)	6" (.15m)	6" (.15m)
Load Capacity (evenly distributed)	1000 lbs (453kg)	1000lbs (453kg)	1250lbs (566kg)
Wheel Base	77"(1.95m)	67"(1.72m)	77"(1.95m)
Wheel Track	51.75" (1.31m)	51.75" (1.31m)	51.75" (1.31m)
Turning Radius (inside)	7'-5"(2.26m)	7'-1.5" (2.17m)	9' (2.74m)
Drive speed			
Low	1.0 mph (1.61 km/hr)	1.0 mph (1.61 km/hr)	.9 mph (1.45 km/hr)
High	3.6 mph (5.80 km/hr)	3.4 mph (5.48 km/hr)	3.2 mph (5.16 km/hr)
High Speed cut-out	7' (2.13m)	7' (2.13m)	7' (2.13m)
Lift/Lower Speed (maximum load)	37/24 seconds	35/20 seconds	38/40 seconds
Power System	Onan 16 hp	24VDC	24VDC
Battery Voltage	12 VDC	4 @ 6VDC (series)	4 @ 6VDC (series)
Capacities	Gas/LPG vapor system		
Battery	Dual fuel	250 amp/hr (4)	250 amp/hr (4)
Hydraulic Tank	12 gal. (45.45L)	12 gal. (45.45L)	12 gal. (45.45L)
Battery Charger	20 amp.	40 amp.	40 amp.
Tire Size	P185/70R13 monofilled	P185/70R13 monofilled	P185/70R13 monofilled
Shipping Weight	3600lbs (1633kg)	3540lbs (1606kg)	4340lbs (1969kg)
Shipping cube	255 cu. ft. (7.23 m^3)	250 cu. ft. (7.08 m^3)	350 cu. ft. (9.91 m^3)

Description	Models	
	M20ET	M25ET
Height –		
Working (maximum)	26'-4" (8.03m)	31'5" (9.44m)
Platform (maximum)	20'-4" (6.20m)	25'5" (7.75m)
Platform (minimum)	54.75" (1.23m)	54.5" (1.39m)
Length (overall)	96" (2.44m)	124.5" (3.16m)
Width (overall)	59" (1.49m)	59" (1.49m)
Platform –		
Dimenions (inside)	57.5"x94.5" (146m x 2.40m)	57.5"x123.25"
Safety Rail Height	42" (1.07m)	42" (1.22m)
Toeplate Height	6" (.15m)	6" (.15m)
Load Capacity (evenly distributed)	750lbs (340kg)	1000lbs (453kg)
Wheel Base	67"(1.72m)	77"(1.95m)
Wheel Track	51.75" (131m)	51.75" (1.31m)
Turning Radius (inside)	7'-1.5" (2.17m)	7'5"(2.26m)
Drive speed		
Low	1.0 mph (1.61 km/hr)	1.0 mph (1.61km/hr)
High	3.4 mph (5.48km/hr)	3.6 mph (5.80km/hr)
High Speed cut-out	7' (2.13m)	7' (2.13m)
Lift/Lower Speed (maximum load)	35/20seconds	38/40seconds
Power System	24VDC	24 VDC
Battery Voltage	6VDC	6 VDC
Capacities		
Battery	250 amp/hr (4)	250 amp/hr (4)
Hydraulic Tank	12 gal. (45.45L)	12 gal. (49.45L)
Battery Charger	40 amp.	40amp.
Tire Size	P185/70R13monofilled	P185/70R13monofilled
Shipping Weight	4060lbs (1842kg)	4720lbs (2141kg)
Shipping cube	261 cu. ft. (7.39 m^3)	370 cu. ft. (10.47 m^3)

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. 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, 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.

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

Company Name

Address

Telephone

Date shipment received

Date of invoice

Date unit put into service

Unit will be used

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.

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 (Items 1, 14, 22, 27, 28, 29).

		YES	NO
1.	Platform capacity decal _____ . lbs.	☐	☐
2.	All warning, caution and emergency decals installed	☐	☐
3.	Emergency descent valve functions properly	☐	☐
4.	Operation instructions properly installed	☐	☐
5.	Operation and safety handbook received	☐	☐
6.	Electrical schematic received	☐	☐
7.	All controls (aerial & ground) are identified and operate correctly	☐	☐
8.	Stop switches operate properly (aerial & ground)	☐	☐
9.	Platform guard rails, secure and undamaged	☐	☐
10.	Platform access gate works properly	☐	☐
11.	Horn and beacon operate properly (optional)	☐	☐
12.	Brakes adjusted and operate correctly	☐	☐
13.	Circuit breakers operate properly	☐	☐
14.	Engine _____ .R.P.M	☐	☐
15.	All Hydraulic cylinders free of gas	☐	☐
16.	All hydraulic cylinder rods free of paint or scratches	☐	☐
17.	Hydraulic pump free of leaks	☐	☐
18.	Hydraulic hoses and fittings free of leaks	☐	☐
19.	Hydraulic oil level	☐	☐
20.	Hydraulic tank and fittings free of leaks	☐	☐
21.	Drive motors free of leaks	☐	☐
22.	Wheel lug nuts torqued to _____ . lbs	☐	☐
23.	Battery water level	☐	☐
24.	Engine coolant (radiator) level	☐	☐
25.	Coolant hoses and fittings free of leaks	☐	☐
26.	Electric radiator fan operates properly	☐	☐
27.	System pressure _____. PSI	☐	☐
28.	Pilot pressure _____. PSI	☐	☐
29.	Tire pressure _____. PSI	☐	☐
30.	Fuel tank and fitting free of leaks	☐	☐
31.	Manual overrides operate properly	☐	☐
32.	Muffler tight and free of leaks	☐	☐
33.	Engine oil level	☐	☐
34.	Engine oil filter free of leaks	☐	☐
35.	All electrical connections tight	☐	☐
36.	Engine alternator functions properly	☐	☐
37.	Manifold valve and fittings free of leaks	☐	☐
38.	110V generator operates properly (optional)	☐	☐

MODEL	SERIAL NUMBER
INSPECTOR	OPTIONS

The MARKLIFT conforms to applicable ANSI and OSHA requirements. Since the safety requirements made by ANSI, OSHA and the various safety boards in your area are subject to change, it is the responsibility of the owner to instruct the operators about all such current requirements.

Every operator of the MARKLIFT must read, understand and follow the safety rules set forth herein. 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.

1. Inspect the machine periodically as specified in the Inspection and Checkout, and Preventive Maintenance sections 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 the load evenly over the platform floor area.

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

7. **Do Not** change the equipment in any way.

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

9. **Do Not** store loose material in the work platform such as pipe, rope, extension cords, wire or miscellaneous boxes. If it is 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.

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

11. The **MARKLIFT** is a non-insulated personnel carrier and must not be operated within 10 feet of a 50,000 volt line. (See Division Of Industrial Safety for required clearances from overhead high voltage lines.

12. Under no circumstances should horse play be tolerated on the **MARKLIFT.**

13. **Do Not** drive on uneven, sloping or soft terrain that sets the unit in an out-of-level condition of more than 6 degrees fore and aft, or 3 degrees side to side.

14. **Do Not** drive with any part of the scissor or platform touching the ground.

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

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

17. **Do Not** use ladders or scaffolding on the platform to obtain greater height.

18. **Do Not** raise or lower scissor into objects.

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

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

21. When a machine is not in use, remove the key from the ground control panel to prevent unauthorized use.

22. When working under the elevated platform, always remember to raise the **Safety Support Arm** to prevent accidental platform descent.

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 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.

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	-	750,0000	16
over 750,000	-	1,000,000	20

(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.

(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.

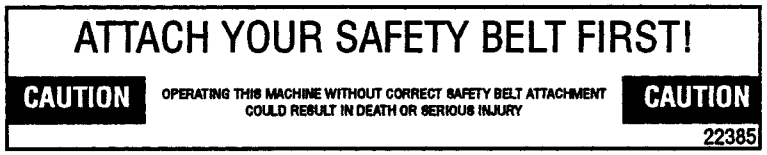
2947. **Warning Signs Required.** The owner, agent, or employer responsible for the operations of equipment shall post and maintain in plain view of the operator and driver on each crane, derrick, power shovel, drilling rig, hay loader, hay stacker, pile driver, or similar apparatus, a durable warning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

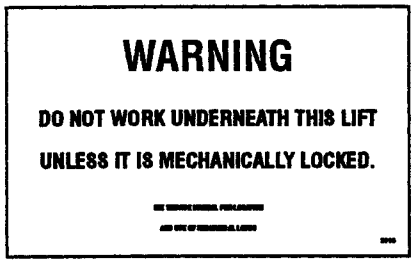
In addition to the above wording, the following statement in small lettering shall be provided on the warning sign: **"For Minimum Clearances of High-Voltage Lines in Excess of 50,000 Volts, See Article 86, Title 8, High-Voltage Electrical Safety Orders."**

OBSERVE ALL DANGER, WARNING, CAUTION AND EMERGENCY DECALS AT THE VARIOUS LOCATIONS ON THE **MARKLIFT** IN ORDER TO TAKE TIMELY PREVENTIVE AND CORRECTIVE ACTIONS.

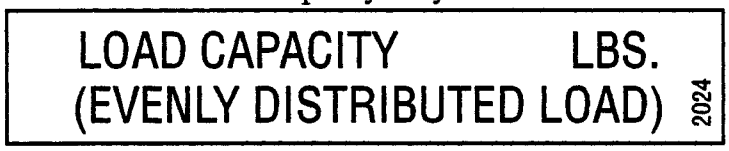
It is the primary responsibility of the user and operator to be thoroughly knowledgeable of all decal information, definition and location.

The following page illustrates a chart in which decals for the **MARKLIFT** can be replaced if the existing decal(s) is worn-out, torn, or illegible.





Fill in load capacity for your machine.



DECAL P/N	DECAL DESCRIPTION M20GP	ASSEMBLY(LOCATION)	QTY
182733	Ground control box	Ground Control Assy	1
2002	Forklift Boot	Final Assy	2
2003	Battery Water Level	Final Assy	1
2014	Caution, High Voltage	Aerial Control Panel	1
2016	Caution - Do not work Underneath	Final Assy	2
2017	Hydraulic System Fluid	Final Assy	2
2020	Gasoline or Petrol	Final Assy	1
2024	Load Capacity 1000 Lbs	Final Assy	1
2041	Do Not Lift From This End	Final Assy	1
181715	M20GP	Final Assy	1
20661	ANSI 92 Plate	Final Assy	1
31109	Caution - Guard Rails	Final Assy	2
31259	**MARKLIFT**	Final Assy	2
182732	Operation Instructions	Final Assy	1
130796	Horn & Fuel	Aerial Control Panel	1
130606	Freewheeling valve	Final Assy	1
130820	Operation & Safety Hndbk	Final Assy	1
32368	M-Series	Final Assy	1
130596	A PRODUCT OF MARK IN	Final Assy	2
130782	Drive Upper Control Box	Aerial Control Panel	1
182736	Aerial Control Box	Aerial Control Panel	1
20660	Nameplate ID	Final Assy	1
181728	Panel Strip	Final Assy	1

CAL P/N	DECAL DESCRIPTION M20E	ASSEMBLY(LOCATION)	QTY
182734	Ground control box	Ground Control Assy	1
2002	Forklift Boot	Final Assy	2
2003	Battery Water Level	Final Assy	1
2014	Caution, High Voltage	Aerial Control Panel	1
2016	Caution - Do not work Underneath	Final Assy	2
2017	Hydraulic System Fluid	Final Assy	2
2024	Load Capacity 1000 Lbs	Final Assy	1
2041	Do Not Lift From This End	Final Assy	1
11064	Attach Safety Chains Before	Final Assy	1
181716	M20E	Final Assy	1
20661	ANSI 92 Plate	Final Assy	1
31109	Caution - Guard Rails	Final Assy	2
31259	**MARKLIFT**	Final Assy	2
182732	Operation Instructions	Final Assy	1
130796	Horn & Fuel	Aerial Control Panel	1
130606	Freewheeling valve	Final Assy	1
130820	Operation & Safety HNDBK	Final Assy	1
32368	M-Series	Final Assy	1
130596	A PRODUCT OF MARK IND	Final Assy	2
130782	Drive Upper Control Box	Aerial Control Panel	1
182736	Aerial Control Box	Aerial Control Panel	1
20660	Nameplate ID	Final Assy	1
181728	Panel Strip	Final Assy	1

DECAL P/N	DECAL DESCRIPTION M25E	ASSEMBLY(LOCATION)	QTY
182734	Ground control box	Ground Control Assy	1
2002	Forklift Boot	Final Assy	2
2003	Battery Water Level	Final Assy	1
2014	Caution, High Voltage	Aerial Control Panel	1
2016	Caution - Do not work Underneath	Final Assy	2
2017	Hydraulic System Fluid	Final Assy	2
181702	Load Capacity 1250 Lbs	Final Assy	1
2041	Do Not Lift From This End	Final Assy	1
11064	Attach Safety Chains Before	Final Assy	1
181718	M25E	Final Assy	1
20661	ANSI 92 Plate	Final Assy	1
31109	Caution - Guard Rails	Final Assy	2
31259	**MARKLIFT**	Final Assy	2
182732	Operation Instructions	Final Assy	1
130796	Horn & Fuel	Aerial Control Panel	1
130606	Freewheeling valve	Final Assy	1
130820	Operation & Safety HNDBK	Final Assy	1
32368	M-Series	Final Assy	1
130596	A PRODUCT OF MARK IND	Final Assy	2
130782	Drive Upper Control Box	Aerial Control Panel	1
182736	Aerial Control Box	Aerial Control Panel	1
20660	Nameplate ID	Final Assy	1
181728	Panel Strip	Final Assy	1
22175	Caution, Monofilled Tires	Final Assy	4

DECAL P/N	DECAL DESCRIPTION M20ET	ASSEMBLY(LOCATION)	QTY
182733	Ground control box	Ground Control Assy	1
2002	Forklift Boot	Final Assy	2
2003	Battery Water Level	Final Assy	1
2014	Caution, High Voltage	Aerial Control Panel	1
2016	Caution - Do not work Underneath	Final Assy	2
2017	Hydraulic System Fluid	Final Assy	2
2023	Load Capacity 750 Lbs	Final Assy	1
2041	Do Not Lift From This End	Final Assy	1
181717	M20ET	Final Assy	1
20661	ANSI 92 Plate	Final Assy	1
31109	Caution - Guard Rails	Final Assy	2
31259	**MARKLIFT**	Final Assy	2
182732	Operation Instructions	Final Assy	1
130796	Horn & Fuel	Aerial Control Panel	1
130606	Freewheeling valve	Final Assy	1
130820	Operation & Safety HNDBK	Final Assy	1
32368	M-Series	Final Assy	1
130596	A PRODUCT OF MARK IND	Final Assy	2
130782	Drive Upper Control Box	Aerial Control Panel	1
182736	Aerial Control Box	Aerial Control Panel	1
20660	Nameplate ID	Final Assy	1
181728	Panel Strip	Final Assy	1
130802	Emergency Down Instructions	Final Assy	1

DECAL P/N	DECAL DESCRIPTION M25ET	ASSEMBLY(LOCATION)	QTY
182733	Ground control box	Ground Control Assy	1
2002	Forklift Boot	Final Assy	2
2003	Battery Water Level	Final Assy	1
2014	Caution, High Voltage	Aerial Control Panel	1
2016	Caution - Do not work Underneath	Final Assy	2
2017	Hydraulic System Fluid	Final Assy	2
2024	Load Capacity 1000 Lbs	Final Assy	1
2041	Do Not Lift From This End	Final Assy	1
181719	M25ET	Final Assy	1
20661	ANSI 92 Plate	Final Assy	1
31109	Caution - Guard Rails	Final Assy	2
31259	**MARKLIFT**	Final Assy	2
182732	Operation Instructions	Final Assy	1
130796	Horn & Fuel	Aerial Control Panel	1
130606	Freewheeling valve	Final Assy	1
130820	Operation & Safety Hndbk	Final Assy	1
32368	M-Series	Final Assy	1
130596	A PRODUCT OF MARK IND	Final Assy	2
130782	Drive Upper Control Box	Aerial Control Panel	1
182736	Aerial Control Box	Aerial Control Panel	1
20660	Nameplate ID	Final Assy	1
11064	Attach Safety Chains before..	Final Assy	1
22175	Caution, Monofilled Tires Only	Final Assy	4
181728	Panel Strip	Final Assy	1

UNLOADING

Before unloading the **MARKLIFT**, inspect it for any physical damage. Note any damage on the freight bill and report it to the carrier.

When a loading dock is unavailable and a forklift must be used, make sure that the forklift used has forks sufficiently long for the forklift boots at the front of the unit. **Do Not** attempt to lift the machine from the side.

TRANSPORTING

The **MARKLIFT** may be freewheeled for loading, unloading and towing for a very short distance (maximum of one (1) mile), at a speed no greater than five (5) mph. To transport the **MARKLIFT** over long distances, a truck or trailer must be used.

If a rollback truck with a winch is used, attach the winch cable to the tiedown brackets and pull the **MARKLIFT** onto the truck. Keep the winch cable taut at all times.

When securing the **MARKLIFT** to the truck, put the chains or straps through the tiedown brackets only. **DO NOT CHAIN OR STRAP OVER THE THE PLATFORM OR GUARD RAILS.** Severe damage to the scissor arms may result from excess pressure caused by securing the machine over the top of the platform.

After the unit is delivered and unloaded, some minor inspections must be made before putting the unit into service. The following must be checked:

For All Units:

1. Visually inspect all exposed parts of the **MARKLIFT**. Secure any loose bolts and nuts. Replace any damaged hydraulic lines or broken wires. Check for any structural damage, including cut or damaged tires.

2. Check hydraulic oil level - sight gauge shows full with unit in stowed position.

3. Check battery for 1200 ± 50 reading on the hydrometer. Charge the battery if its reading is below 1100. If batteries require water, fill to proper level AFTER charging.

4. Check the hydraulic valve manifolds for leaks, loose fittings or loose wires.

5. Position selector switch to ground then operate switches, as follows: lift; up/down, and platform; forward/reverse. Check hose for leaks.

6. Make sure that the brakes will hold the unit on an incline of up to 3 degrees.

Gasoline Units:

1. Check oil level in the engine.

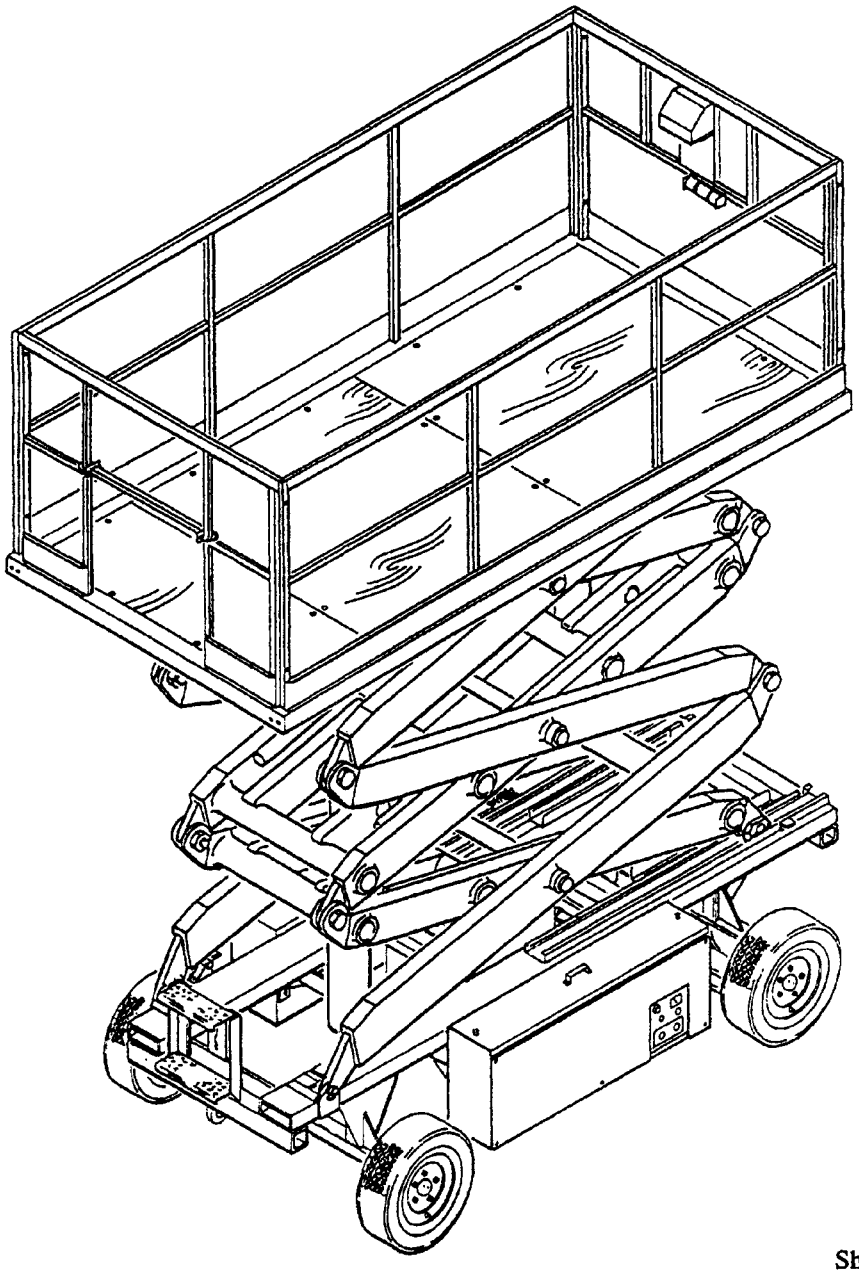
2. Fill fuel tank - use regular gasoline only or switch to propane.

3. Start engine. Allow the engine to warm up.

4. After initial warm-up of gasoline engine, press engine stop button making sure the stop circuit is operational.

It shall be the responsibility of all **MARKLIFT** operators to read and act according to the following operating instructions. The purpose of these instructions are to promote safety and a better understanding of the functions of the **MARKLIFT** self propelled scissor lift.

It is recommended that the **MARKLIFT** be moved into an area that is free of overhead obstructions and has a flat, level surface with no hazardous irregularities or accumulation of debris.



Shown: M25E

1. STARTING

A. GROUND CONTROL

The only functions that can be operated from the ground control station are: ON/OFF, LIFT:UP/DOWN, and PLATFORM:FORWARD/REVERSE. To start, turn the power switch to "ON". Position the selector switch to ground control, turn key to start position, (using manual choke button if necessary) when the engine starts, release key. The **MARKLIFT** is now ready for operation.

B. AERIAL CONTROL

Turn power switch at ground control station to "ON". Position selector switch to "AERIAL". Enter the platform, **Make sure the platform entry bar, gate, or chains are attached securely after entering the platform.** Pull open the red emergency stop switch cover located on the top right of the aerial control box. Pull down the toggle switch to the start position (using the manual choke button if necessary). When the engine starts, release the toggle switch. Electric **MARKLIFT** models are now ready to operate.

C. ANTI-RESTART MODELS

Place the key in the starter switch at the "OFF" position. Turn the key to "ON" then to "Start". When the unit starts, release the key. The anti-restart switch is spring loaded and will automatically return to the "ON" position. If the engine dies it will be necessary to turn the starter switch to "OFF" before restarting.

2. DRIVE

Forward and reverse drive is done from the aerial control box only. The **MARKLIFT** is equipped with a high and low speed for both forward and reverse drive. Rotate the drive knob forward (first position is low speed; second position is high speed). Rotate the drive knob reverse (first position is low speed; second position is high speed).

3. STEERING

A. Standard Toggle Switch

The unit may be steered from the aerial control panel only. Push the toggle switch to the left to turn the front wheels to the left. Pushing the switch to the right will cause the wheels to turn to the right. The toggle switch is a momentary switch which will automatically return to the off position when released. The wheels will remain at an angle until the toggle switch is moved in another direction.

B. Proportional Controller (Optional)

Use the thumb rocker switch on top of the drive controller. Pushing to the left causes the front wheels to turn left. Pushing the switch to the right causes the front wheels to turn to the right.

For best operation, place thumb over controller knob and wrap fingers loosely around locking stem. Apply a downward pressure with the thumb, while the index finger lifts the locking stem. Once the stem is disengaged and moved forward or reverse, the pressure on the thumb may be relaxed because the locking stem has engaged the cam and cannot drop into the locking position until the lever or handle is returned to the center position.

4. RAISE PLATFORM

To raise or lower the scissor from the ground control, set 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" toggle switch. The toggle switch is self centering. When it is released it will automatically set itself to center (the neutral position). The scissor will remain stationary.

5. WARNING LIGHT AND BUZZER

As a special safety feature, the **MARKLIFT** is equipped with an "out-of- level" sensor that will disable the scissor functions whenever the **MARKLIFT** is in an unsafe out-of-level position. An unsafe out-of-level situation is sensed by the slope sensor when the machine is tilted 3° on either side or 6 degrees front or rear.

The unsafe condition is indicated by a red warning light and buzzer, located on the top center of the aerial control box. If the platform is elevated it will automatically descend. If the platform is already in the down position, it cannot be raised. If the platform is traversed and goes into an out-of-level condition, the warning light and buzzer are activated but the platform will not automatically descend. When the signals come on, maneuver the **MARKLIFT** until it is on a safe operating surface and the lift functions will be restored.

6. **FREEWHEELING**

In order to move the machine for loading, unloading and positioning, the **MARKLIFT** may be free wheeled for very short distances at no greater than 5 mph. **WHEN PREPARING FOR FREEWHEELING, MAKE SURE THE MACHINE IS ON A LEVEL SURFACE!**

The brake is disengaged by closing the freewheeling valve and momentarily moving the rotary drive switch. Use caution when the brakes are disengaged. **ALWAYS REMEMBER TO OPEN FREEWHEELING VALVE TO RESTORE BRAKING.**

7. **WARNING HORN (OPTION)**

For some industrial applications, and to meet particular safety requirements, a warning horn may be needed. The warning horn option on the MARKLIFT can be used as an automatic movement indicator, or manually activated, as required. The horn is activated by a three-position switch on the aerial control panel. The middle position is "Off". When the switch is positioned to the right, the horn will sound when either the drive or lift function is activated (forward and reverse, up and down)

8. **TRAVERSING PLATFORM (M20ET, M25ET)**

The MARKLIFT traversing platform may be operated from either the aerial or ground control panels.

A. Aerial Control Panel

The platform traversing toggle switch is located on the left bottom of the upper control panel. Push the switch up for extension and down for retraction.

B. Ground Control Panel

The ground control panel has an extend platform switch on the left bottom side of the panel. The platform may be traversed forward or reverse by pushing the toggle switch in the desired direction.

All operators of the MARKLIFT should be instructed by trained operators. The new operators should spend at least 30 minutes practicing and becoming familiar with operating the scissor lift. He/She should begin by raising the scissor approximately 5 feet off the ground. The operator will soon find that gradual starts and stops are easy to perform.

Gradually raise the scissor higher, and drive the **MARKLIFT** again until maximum height is reached. Remember, that the proportional signal from the controller to the valve is controlled by the operator. There is approximately 3 degrees of "dead" motion on each side of the controller center position.

EMERGENCY DESCENT

If the operator has the platformtraversed and needs to descend, push down and hold the "Emergency Down" switch, then push the "Lift" switch down.

Use caution when lowering the traversed platform . Remember to **check below the platform before using the emergency down switch**, to avoid damage to anything underneath.

IMPORTANT: The aerial start switch must be set at the "ON" position in order for the emergency hydraulics to function. Emergency functions also apply to the ground control station.

The following preventive maintenance information is intended as a general guide. Please refer to the vendor section of this manual for detailed information on the engine, battery, etc.

The following preventive maintenance information is intended as a general guide. 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 perodically as stated below. Any machine not in safe operating condition must be removed from service until it is repaired by a qualified service person.

DAILY

1. Make sure that operation and safety decals are in place and easy to read.
2. Check gas & hydraulic tank levels.
3. Check the engine oil level.
4. Check the water level in the battery
5. Check for loose or worn hardware, wire connections, etc..
6. Inspect the controls for proper operations.
7. Check for and correct any hydraulic leaks.
8. Check for and correct any structural damage.

WEEKLY

1. Check the condition of the tires. Make sure they are free of serious cuts or defects.
2. Check & clean engine intake air cleaner.
3. Check that operation and safety decals are in place and are easy to read.
4. Check for proper brake operation.
5. Record hour meter reading.
6. Clean unit by removing all dirt, oil, and grease. The machine may be washed with soap and water.
7. Check overall performance.
8. Check for wear on cables and hoses.

MONTHLY (or first 50 hours)

1. Check and lubricate unit, if necessary.
2. Check battery condition.
3. Change the engine oil and filter.
4. Change the hydraulic oil return filter.
5. Grease steering linkage.
6. Check and clean engine intake air cleaner.

EVERY SIX MONTHS (or 100 hours)

1. Check and lubricate unit, if necessary.
2. Change pilot filter element.
3. Change the engine oil filter.
4. Change the hydraulic oil return filter.

EVERY YEAR

1. Re-pack all wheel bearings.
2. Change the hydraulic oil.
3. Check the torque hub oil level.
4. Change the hydraulic oil return filter.
5. Change the pilot line filter.

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

1. ELECTRICAL

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 following the 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 section for more information) and use a test light to trace 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., then even if you have a proper electrical current to the coil or relay, some items 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 relays are used to remotely switch other electrical devices.

2. HYDRAULIC

A. The various hydraulic functions are controlled by the amount of pressure in the system. When a slower drive speed is needed, a portion of the hydraulic fluid is routed to the tank by the low speed valve, reducing the pressure and speed.

B. Directional valves (outriggers, steering, and drive) have two opposed electrical coils with a moveable spool between the coils.

C. One way valves (lift, descent, and dump) are normally open and they are closed to prevent passage of fluid when electrically energized.

ENGINE

1. Will not start or run.
   - A. Check ground control box circuit breaker.
   - B. Make sure fuel shut-off valve is open.
   - C. Fuel selector should be in the "gasoline" position.
   - D. Check for low battery reading.
   - E. Check for fouled spark plugs.
   - F. Check for water in gas tank.
   - G. Check engine points.
   - H. Refer to your local service facility.
2. Can't get high speed.
   - A. Check aerial "High/Low" throttle switch.
   - B. Check throttle solenoid valve.
   - C. Refer to your local service facility.
3. No idle.
   - A. Check aerial "High/Low" throttle switch.
   - B. Check throttle solenoid valve.
   - C. Refer to your local service facility.
4. Dies under load.
   - A. Check governor setting.
   - B. Check carburetor air/fuel mixture.
   - C. Check hydraulic pressure.
   - D. Refer to your local service facility.

HYDRAULIC WHEEL DRIVE MOTOR

Turns wheel while unloaded, but slows down or stops when load is applied.

- A. Check hydraulic high pressure port with 3000 PSI gauge.
- B. Refer to your local service facility.

TRAVERSING PLATFORM

Platform will not traverse or retract

- A. Check the electrical system
- B. Refer to your local service facility.

HYDRAULIC PUMP

Pump producing excessive noise.

- A. Check suction hose from tank to pump for kinks.
- B. Check hydraulic oil level (sight gauge on tank.)
- C. Check suction line fittings for tightness.
- D. Check oil. See hydraulic fluid table.
- E. Refer to your local service facility.

LIFT

1. Functions will not operate from aerial control console.
   - A. Check "Aerial/Ground" selector switch.
   - B. Check for loose wire in aerial junction box.
   - C. Check pilot valve pressure.
   - D. Check solenoid dump valve.
2. Functions will not operate from ground control box.
   - A. Check position of "Aerial/Ground" box selector switch.
   - B. Check solenoid dump valve.
   - C. Check pilot valve pressure.
   - D. Refer to your local service facility.
3. Functions too slow or too fast.
   - A. Check pilot valve control pressure.
   - B. Check flow control valve to solenoid valves.
   - C. Refer to your local service facility.

DRIVE

- A. Make sure hydraulic system is up to recommended pressure.
- B. Check pilot valve control pressure.
- C. Refer to your local service facility.

Milestone			Hydraulic fluid			
Oil company			Chevron	Gulf	Shell	Union
Brand Name			ATF Dextron 11	ATF Dextron 11	Donaz-T6	ATF Dextron
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°

NEW EQUIPMENT MAINTENANCE RECORD

MODEL	SERIAL NUMBER
DATE	EQUIPMENT NUMBER
LOCATION	MECHANIC

ITEM	CODE	COMMENTS	ITEM	CODE	COMMENTS
Engine oil			Safety cut-outs		
Engine oil filter			Bushings		
Air filter			Rollers		
Fuel filter			Wear pad		
Tune-up			Front end assembly		
Choke			Tire pressure		
Engine RPM			Tire condition		
Charging system			Wheel nuts		
Fuel system LPG/gas			Wheel bearing		
Batteries			Nuts and bolts		
Battery terminals			Guard rails		
Motor brushes			Lubrication		
Hydraulic fluid			Warning decals		
Hydraulic oil filter			Operating inst.		
Hydraulic systems			General decals		
Hydraulic pressure			Paint		
Hydraulic hoses			All operations		
Cylinders			Lift		
Drive motors			Steering		
Brakes			Forward drive		
Aerial control box			Tilt switches		
Ground control box			Fuel level		
Relays			Literature		
Wire connections			Options		

Code	Comments
F = Filled R = Repaired C = Checked A = Adjusted X = Needs repair	

REV.

MARKLIFT SERVICE MAINTENANCE CHECKLIST

MODEL NUMBER ____________ SERIAL NUMBER ____________ DATE SOLD ____________

DATE IN SERVICE ____________ OPTIONS ____________ WARRANTY PERIOD ____________

CODE:
C – CHECKED
A – ADJUSTED
R – REPAIRED
N – NEW PART
X – NEEDS REPAIR

PREVENTIVE MAINT.	OIL CHANGE
	OIL FILTER
	AIR FILTER
	HYDRAULIC OIL CHANGE
	HYDRAULIC OIL FILTER
	WHEEL BEARING PACK
	DRIVE MOTOR ROTOR
	PUMP MOTOR ROTOR
	PUMP MOTOR BRUSHES
	ELECTRICAL CONTROLS
	TRANS/DIFF OIL CHANGE
	TUNE UP SPARK PLUGS
ELECTRICAL	GENERATOR ROTOR
	VOLTAGE REGULATOR
	BATTERY
	STARTER
	POINTS / CONDENSER
HYDRAULIC	HYDRAULIC SYSTEM
	LEV CYLINDER
	LIFT CYLINDER
	LIFT CYLINDER SEALS
	HYD CONTROL VALVE
	HYDRAULIC PUMP
	ROTARY MANIFOLD
	LIFT ROLLERS
	HYDRAULIC HOSES
	BRAKES
FUEL	FUEL SYSTEM
	CARBURATOR
	FUEL PUMP
STEER	STEERING
	STEERING HOSES
	STEER GEAR
	STEER CYLINDER
TIRE	DRIVE TIRES
	STEER TIRES
MAJ.	ENGINE OVERHAUL
	DRIVE AXEL OVERHAUL
MISC.	

DATE	REMARKS

DATE	REMARKS	AGENCY

REV.

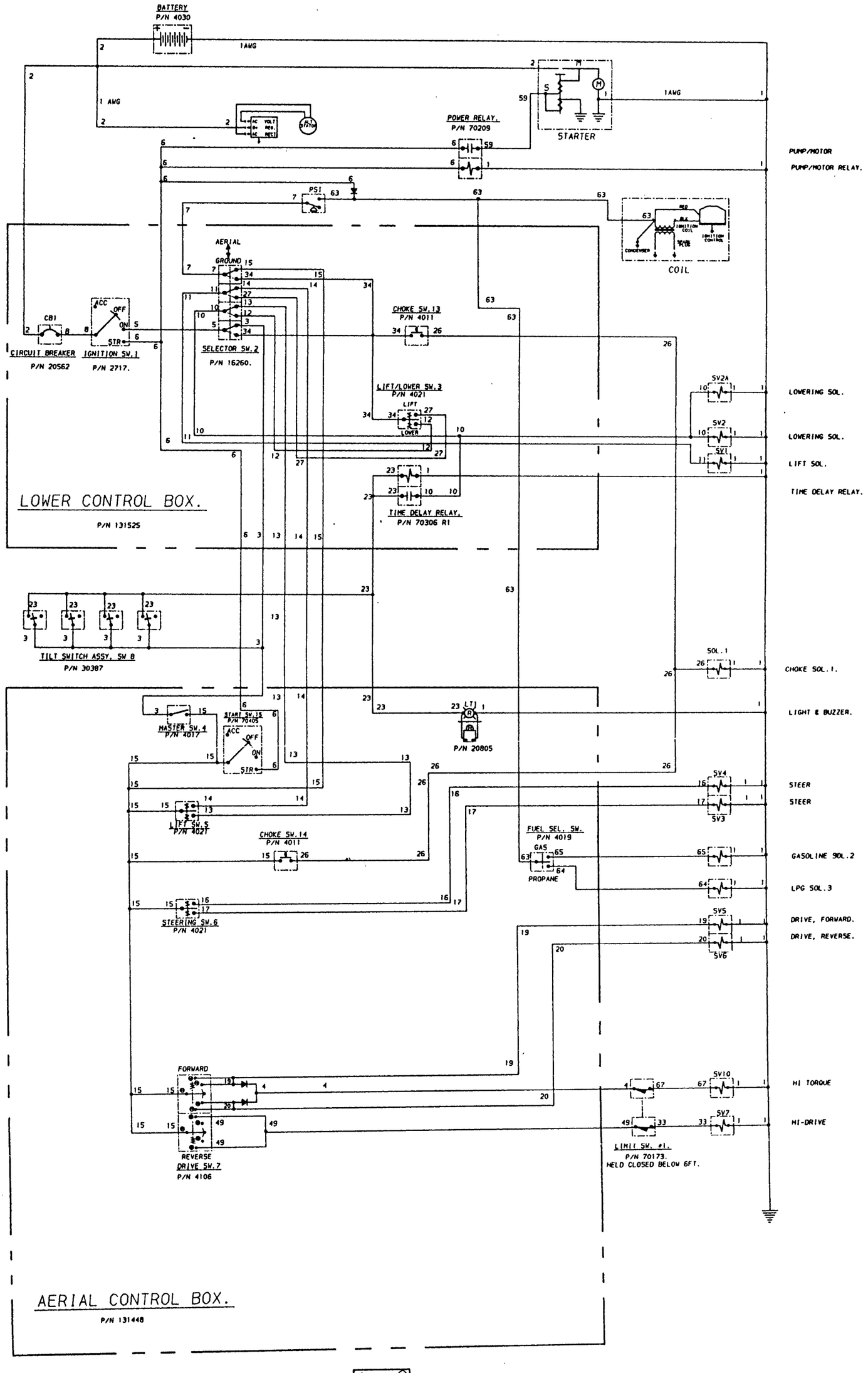
Mark Industries

DISCLAIMER

MARK INDUSTRIES strives to include in the technical manuals information and illustrations that are accurate, complete and current.

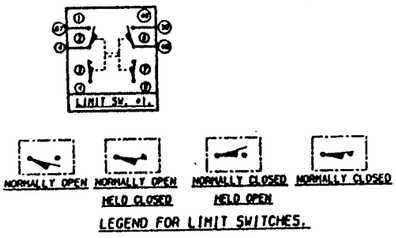
However, due to constant parts changes made by some of our many manufacturers, it is often impractical to show all variations of a given assembly.

Therefore, the information included in the technical manuals should be viewed as representative in nature.

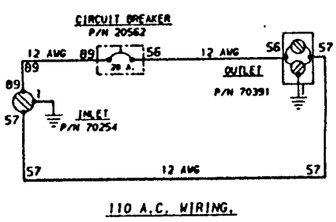


NOTES:

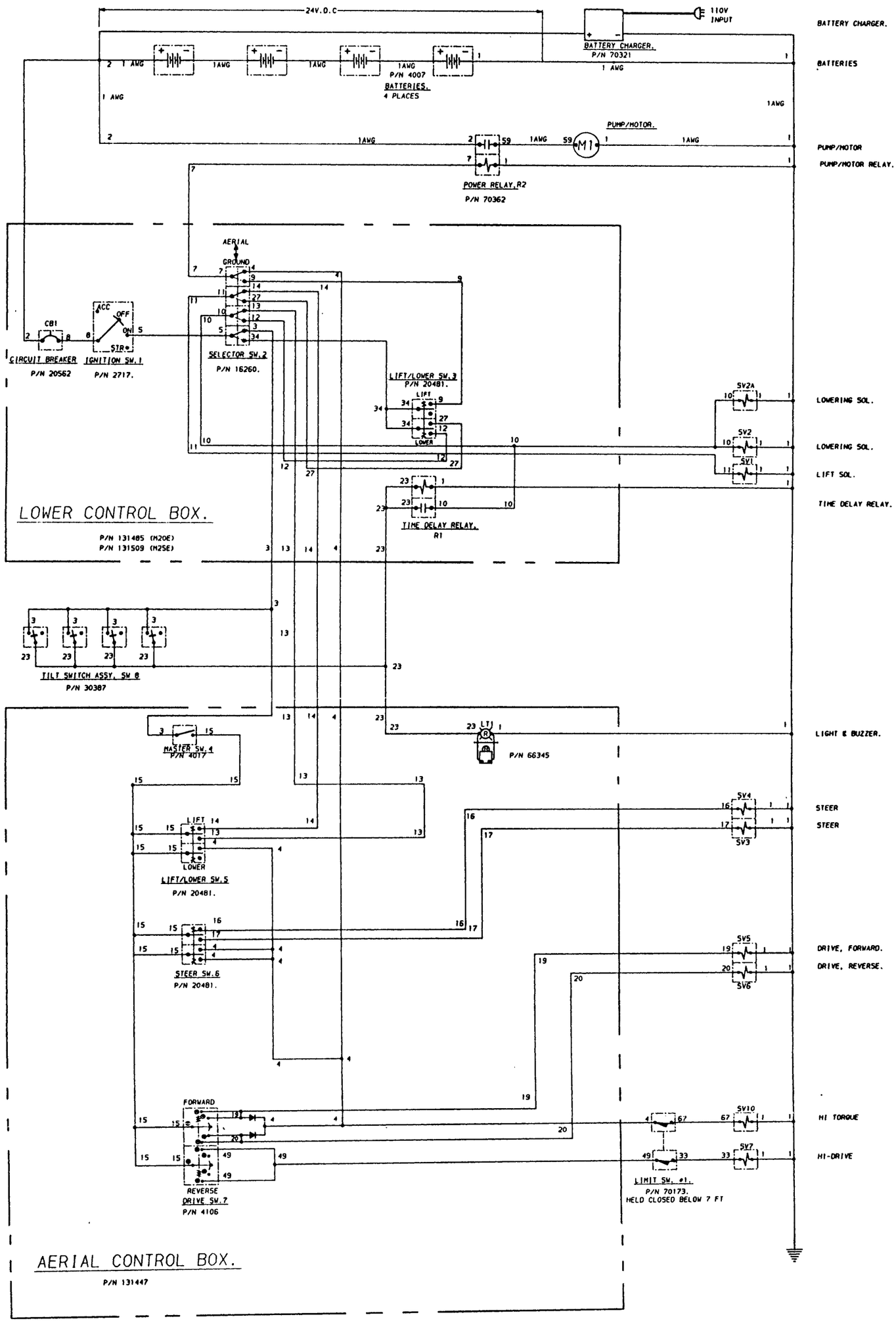
1. TO CONNECT GROUND CONTROL AND AERIAL CONTROL USE ARM CABLE P/N 130337.
2. ALL WIRES ARE 16 AWG.UNLESS OTHERWISE SPECIFIED.
3. USE 6A. 1000V. DIODE P/N 70479.
4. WIRING SHOWN IN STOWED POSITION.
5. FOR 110V A.C. GENERATOR OPTION SEE DWG 131529.
6. IDENTIFY EACH WIRE BY NUMBER FLAG AT THE ENDS WRAPPING COMPLETELY AROUND.



LEGEND FOR LIMIT SWITCHES.



110 A.C. WIRING.



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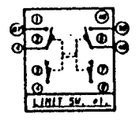

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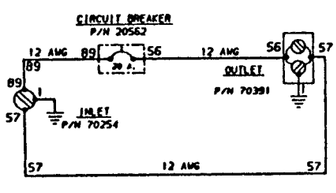
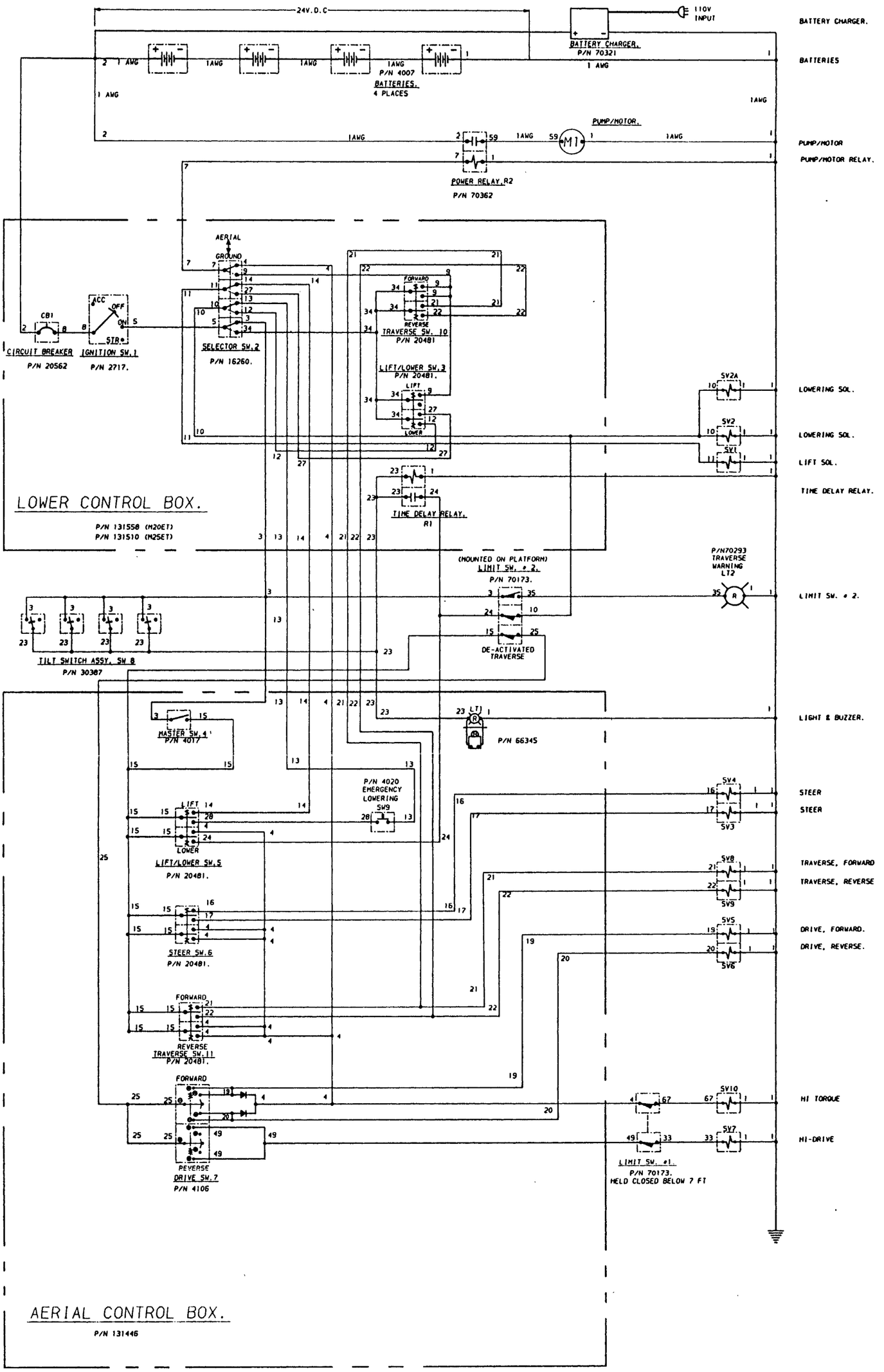


110 A.C. WIRING.



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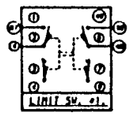

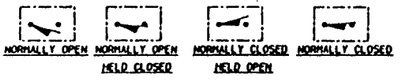

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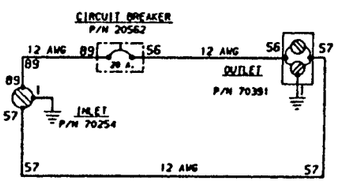

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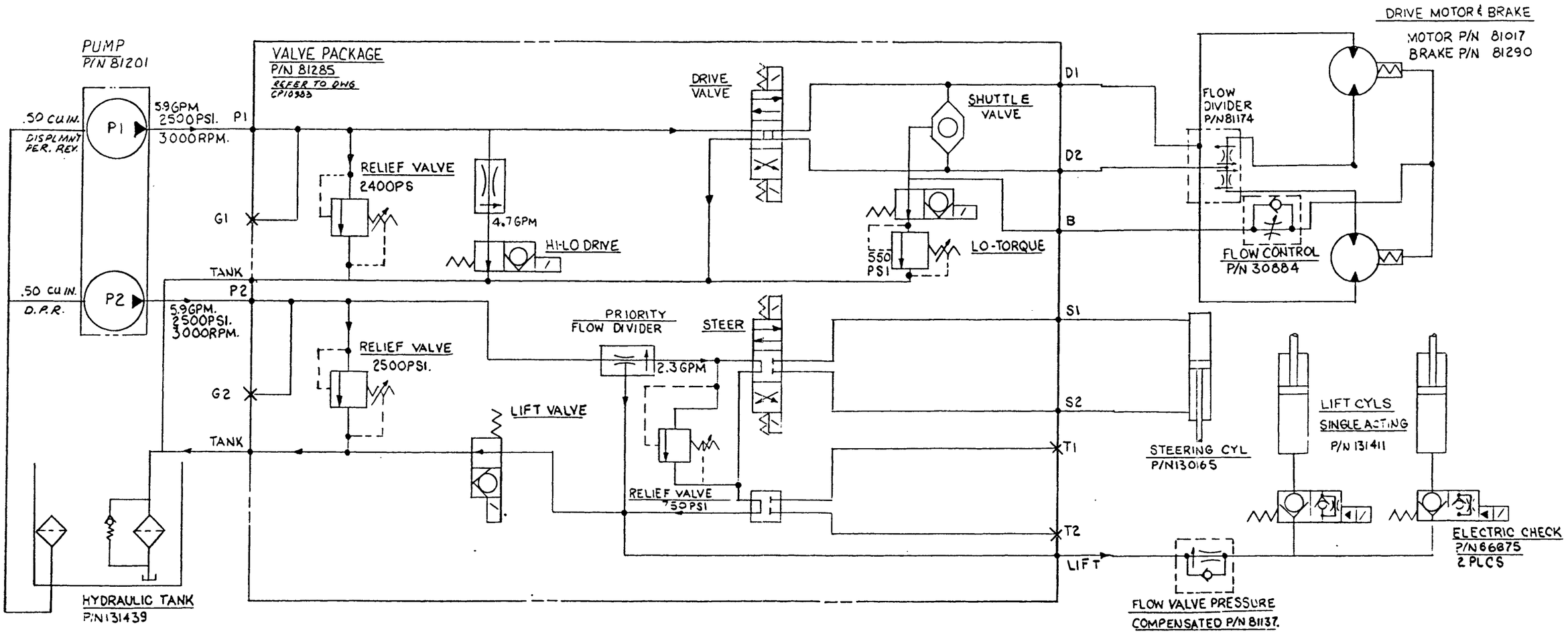

PUMP
P/N 81201
.50 CU IN.
DISPLMNT
PER. REV.
P1
5.9GPM
2500PSI.
3000RPM.
P1
VALVE PACKAGE
P/N 81285
REFER TO DWG
CP10383
DRIVE
VALVE
SHUTTLE
VALVE
D1
D2
B
DRIVE MOTOR & BRAKE
MOTOR P/N 81017
BRAKE P/N 81290
FLOW
DIVIDER
P/N81174
RELIEF VALVE
2400PSI
G1
4.7GPM
HI-LO DRIVE
LO-TORQUE
550
PSI
FLOW CONTROL
P/N 30884
TANK
.50 CU IN.
D.P.R.
P2
5.9GPM.
2500PSI.
3000RPM.
P2
PRIORITY
FLOW DIVIDER
STEER
S1
S2
RELIEF VALVE
2500PSI.
2.3GPM
G2
LIFT VALVE
TANK
T1
T2
LIFT
STEERING CYL
P/N130165
LIFT CYLS
SINGLE ACTING
P/N 131411
RELIEF VALVE
150PSI
ELECTRIC CHECK
P/N66875
2 PLCS
HYDRAULIC TANK
P/N131439
FLOW VALVE PRESSURE
COMPENSATED P/N 81137.

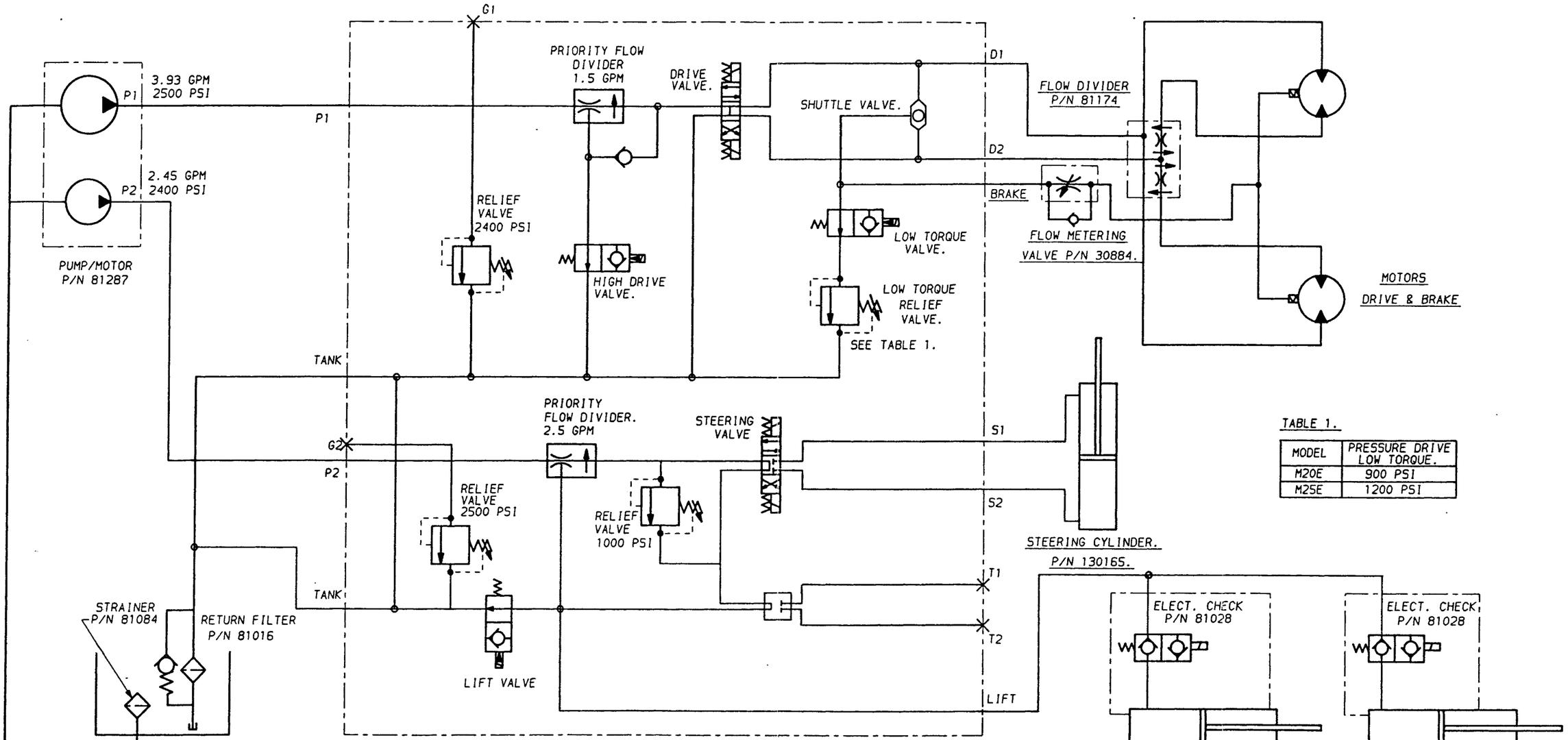


TABLE 1.

MODEL	PRESSURE DRIVE LOW TORQUE.
M20E	900 PSI
M25E	1200 PSI

MODEL	PART NO.
M20E	131411
M25E	131412

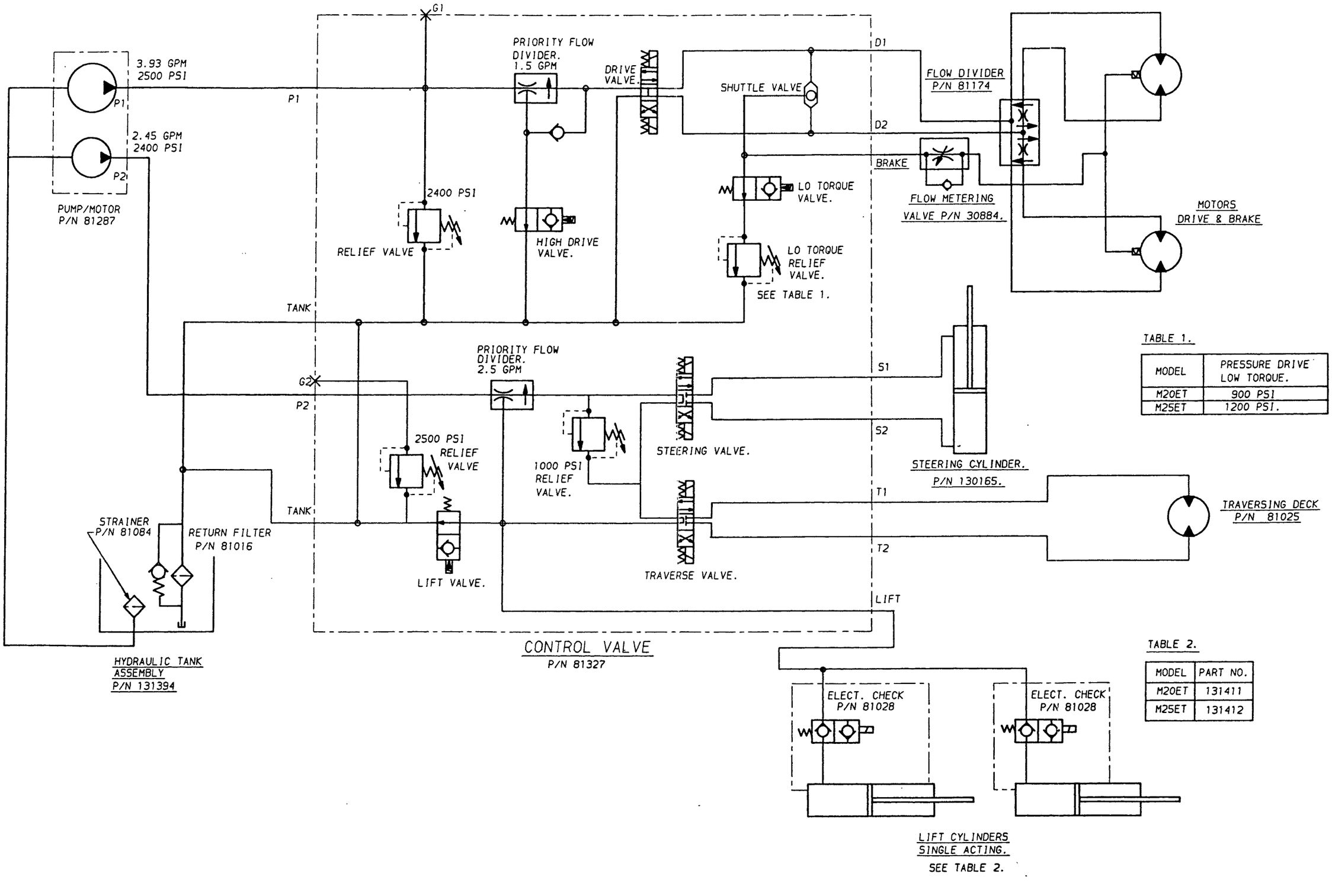
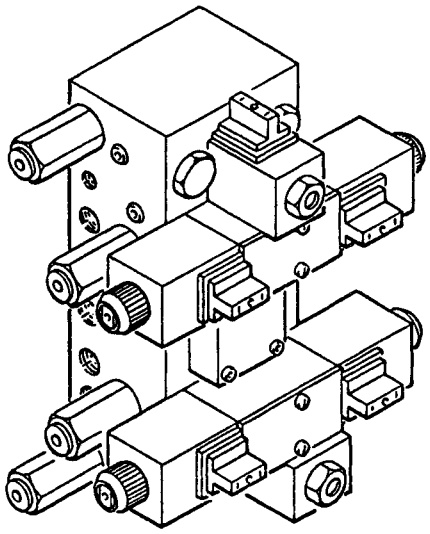


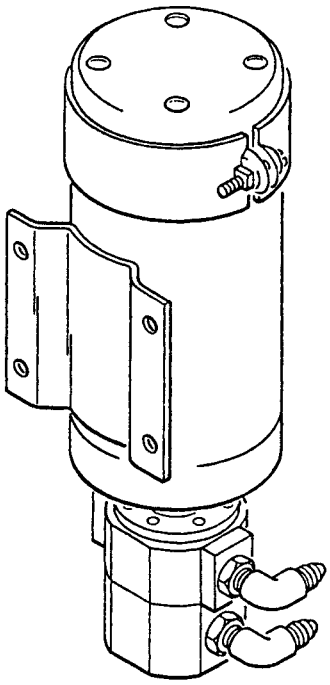
TABLE 1.

MODEL	PRESSURE DRIVE LOW TORQUE.
M20ET	900 PSI
M25ET	1200 PSI.

TABLE 2.

MODEL	PART NO.
M20ET	131411
M25ET	131412





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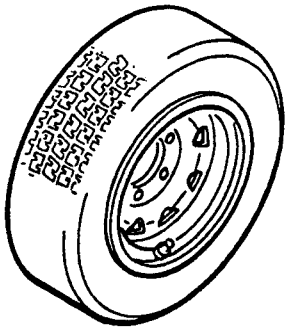
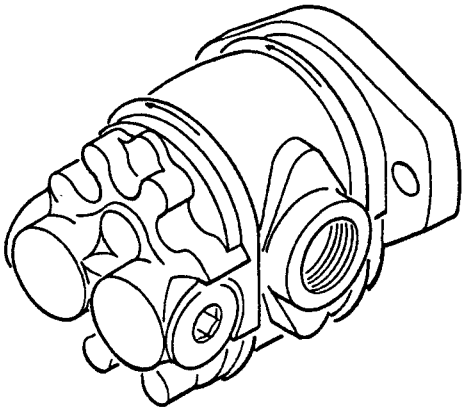
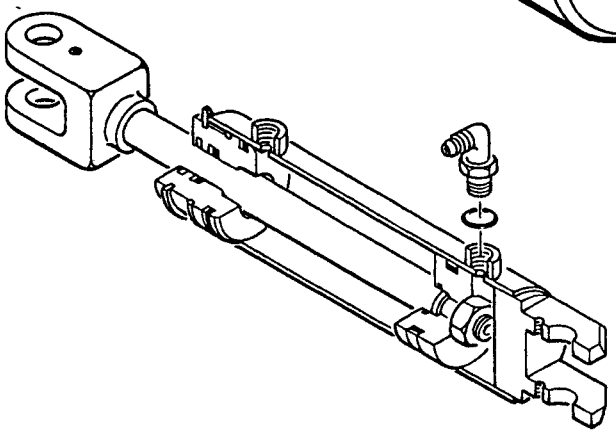






THIS PARTS CHAPTER CONTAINS:

SECTION 6	OPTIONAL ASSEMBLIES (CONT'D)
FIG. NO.	TITLE
6	PLATFORM WORK LIGHT (12V)
6A	PLATFORM WORK LIGHT (24V)
7	PROPORTIONAL DRIVE CONTROL
7A	PROPORTIONAL DRIVE CONTROL
8	SOLID STATE DELUXE CHARGER
8A	AUTOMATIC BATTERY CHARGER
9	SOLID STATE SLOPE SENSOR

1. The Parts Catalog Pagination.

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

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

   C. **PAGE** indicates the page 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 Catalog of this Technical Manual shows the relationship of one part to another.

      1 2 3 4 5

      Figure Description

      . 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.

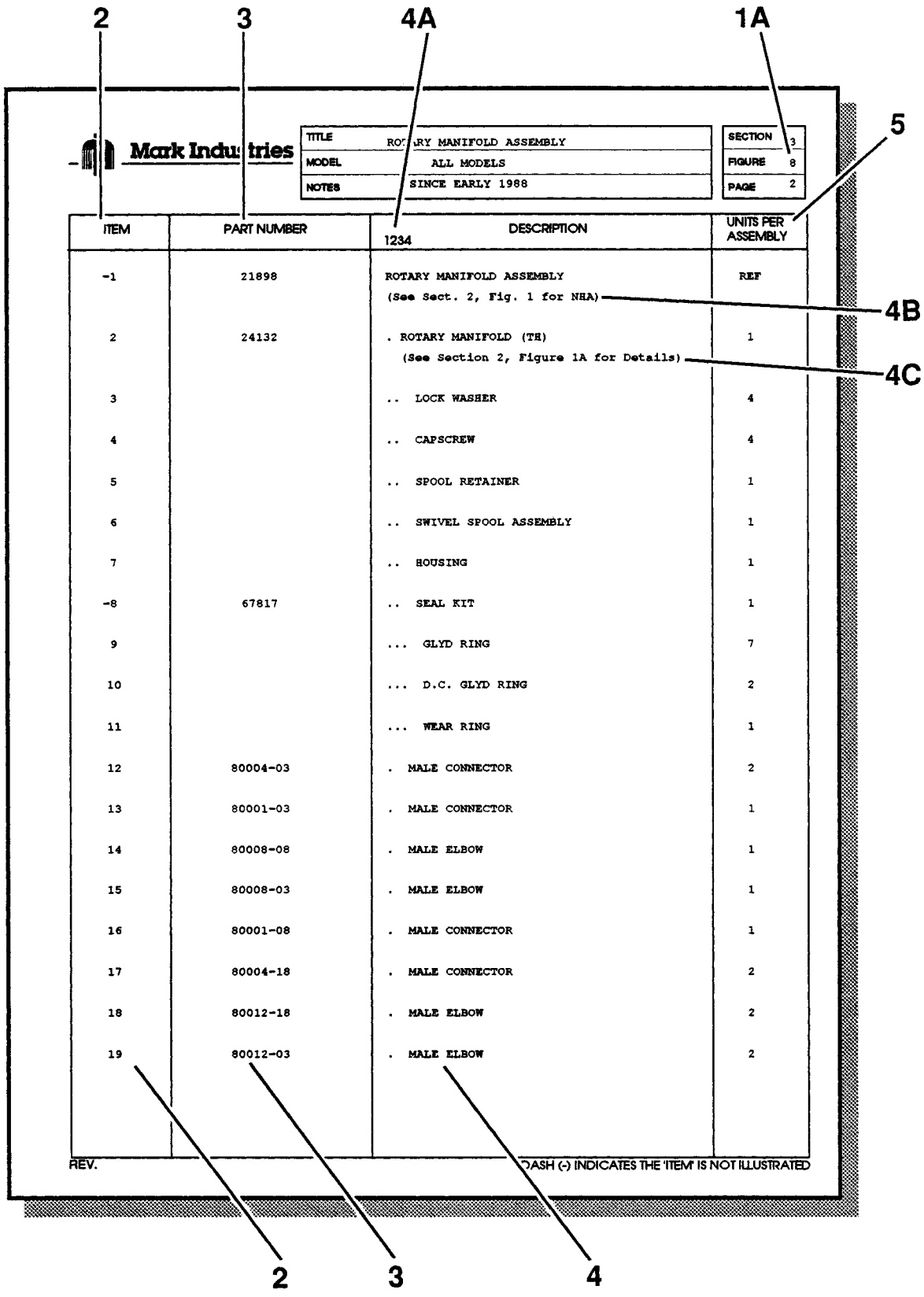
   C. **DETAILS** corresponds to the Section and Figure to be referred to for a more detailed breakdown of this item.

5. **UNIT 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.



Mark Industries

TITLE	ROTARY MANIFOLD ASSEMBLY
MODEL	ALL MODELS
NOTES	SINCE EARLY 1988

SECTION	3
FIGURE	8
PAGE	2

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

REV.

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

1. Finding the Mark Industries Part Number.

   A. Using the Table of Contents, find the Section and Figure Number. Locate the correct page 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.

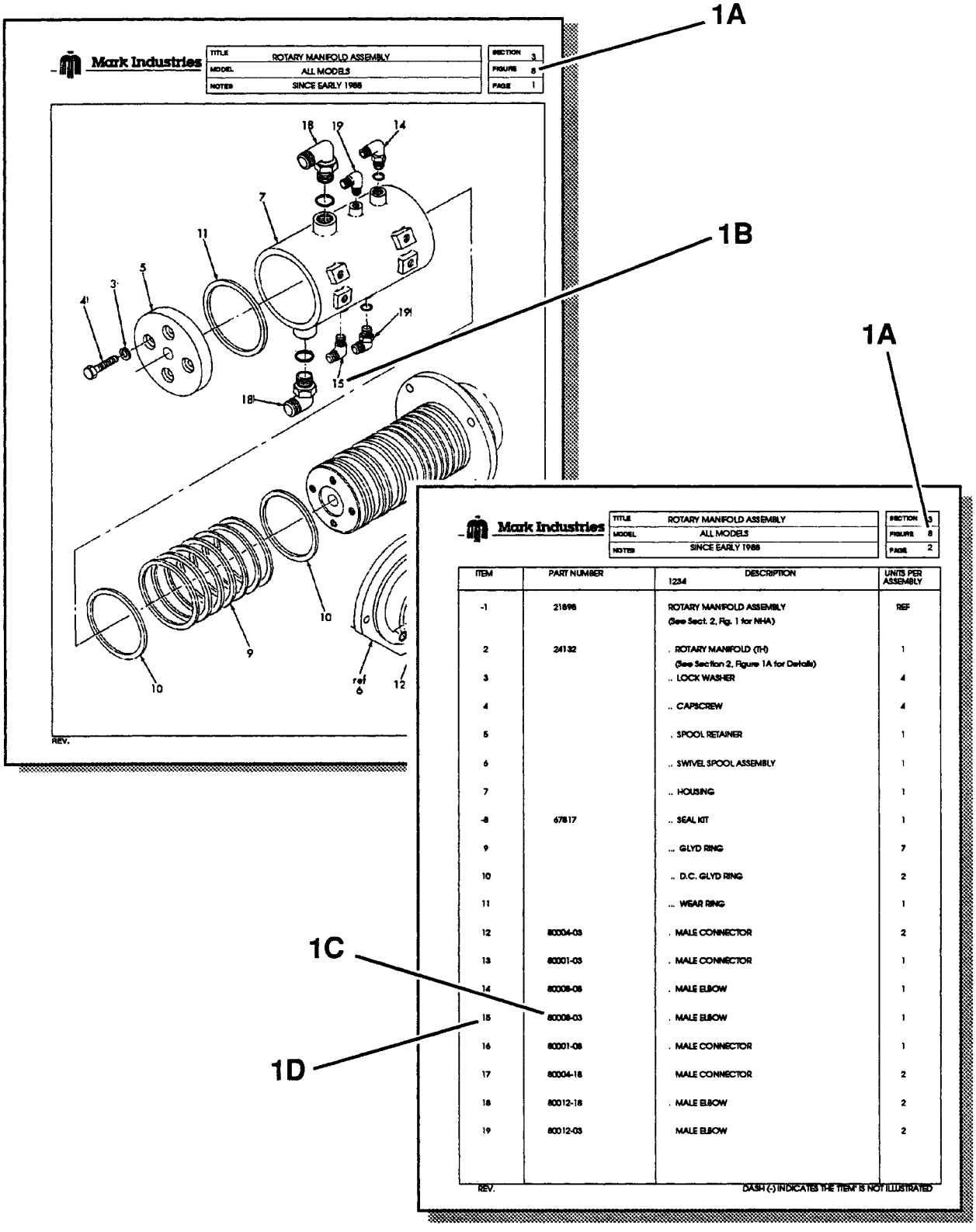
   D. Use the Mark Industries Part Number listed next to the Item Number when ordering.

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 2225
   BREA, CA. 92622



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

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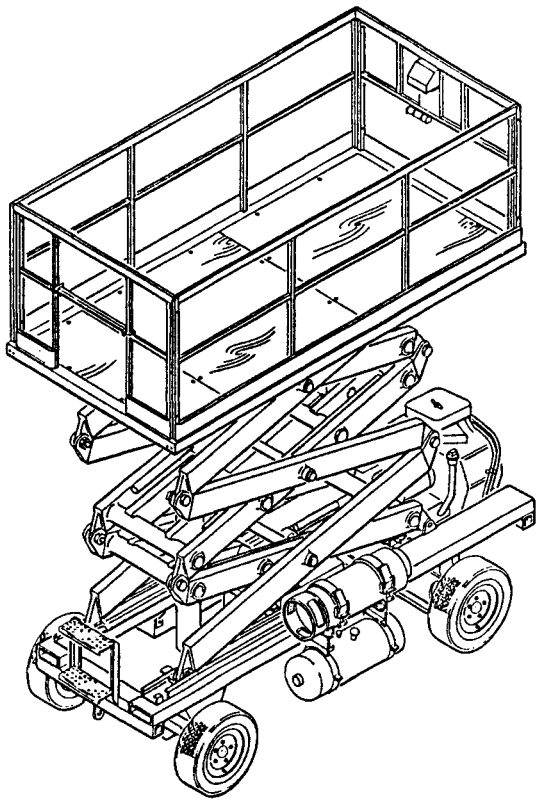
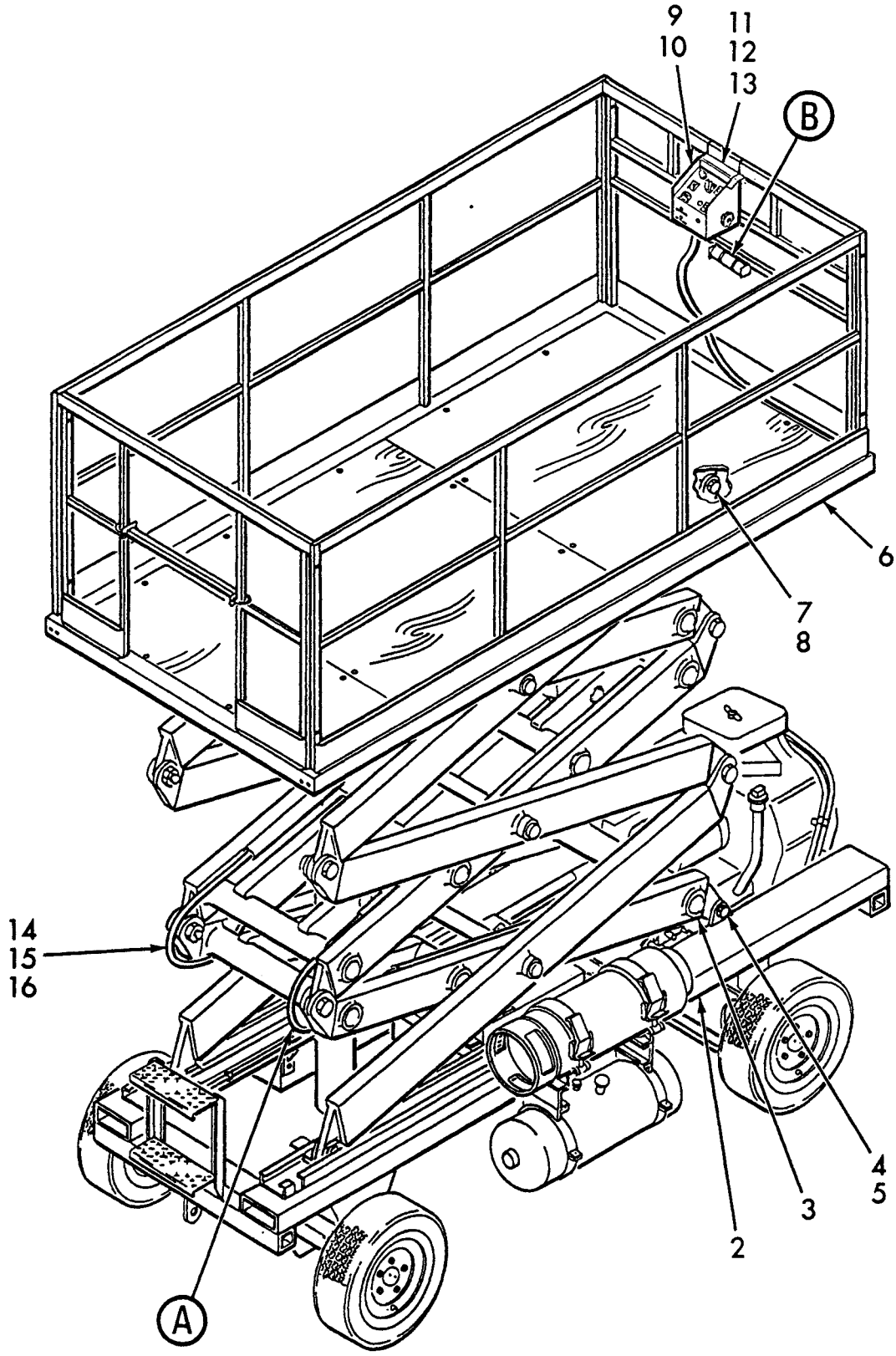
SECTION 2 CONTAINS:



FINAL ASSEMBLY (M20GP)



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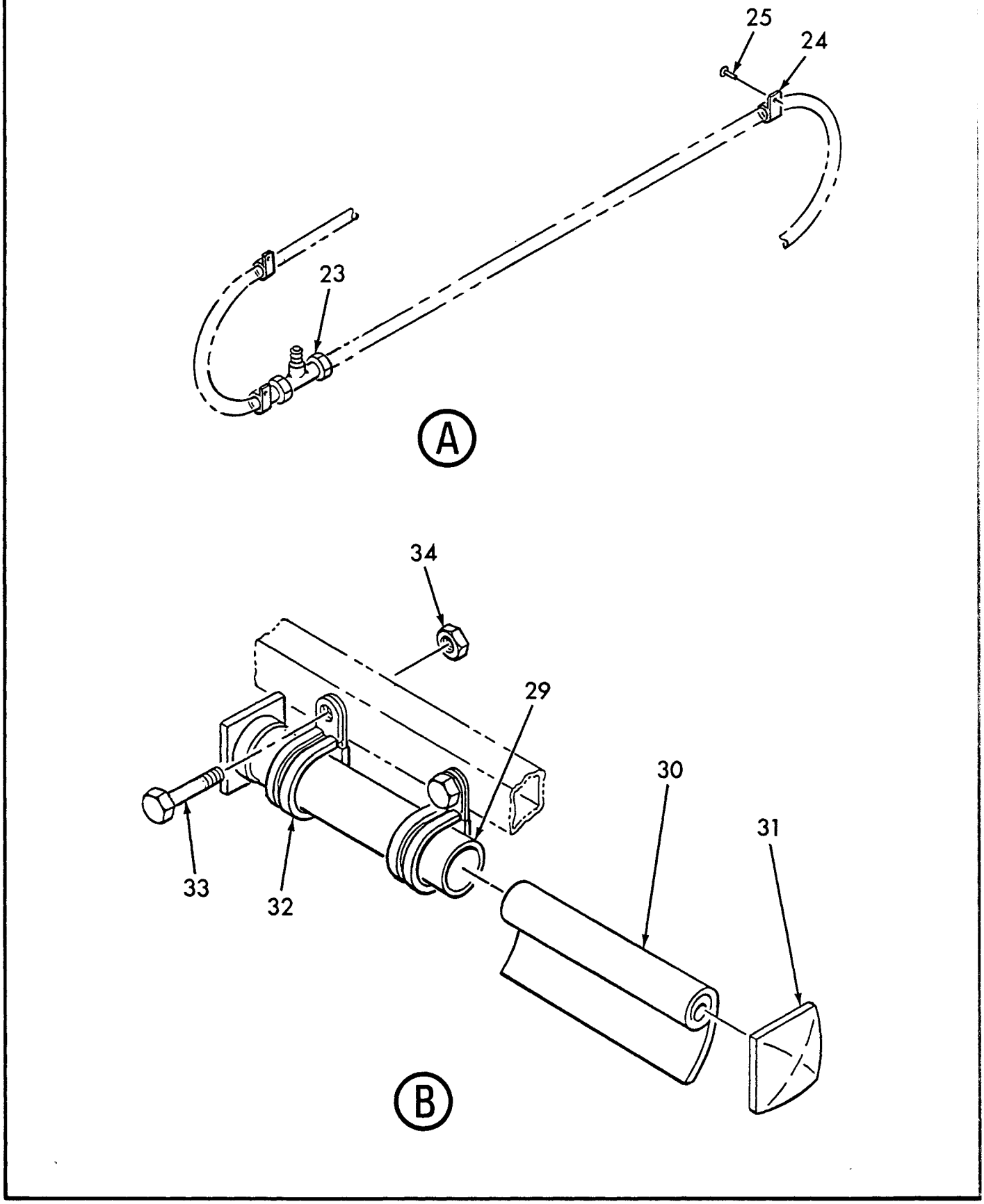
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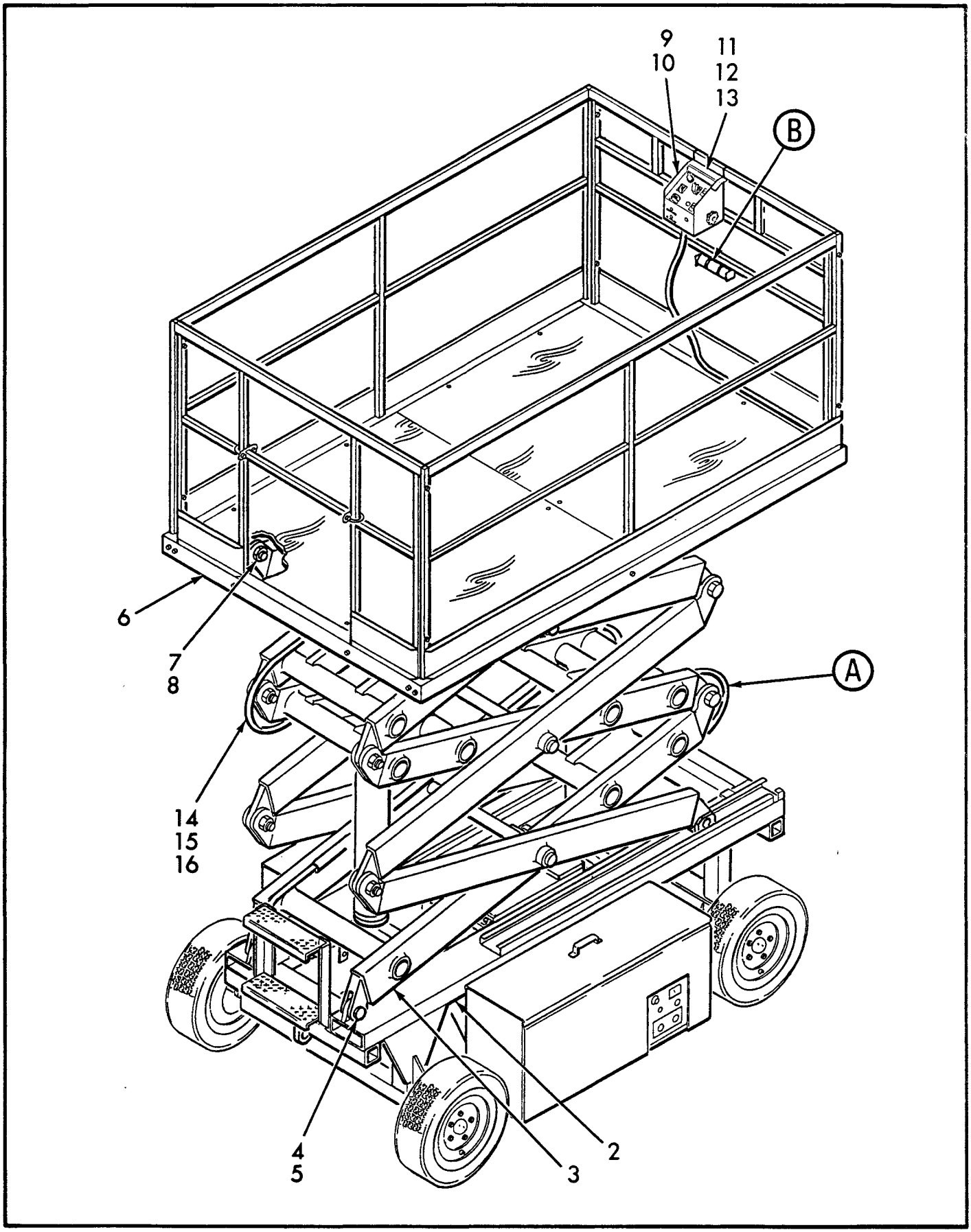
FINAL ASSEMBLY (M20GP)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	130041	ASSEMBLY, FINAL	REF
2	131388	. ASSEMBLY, FRAME (See Sect. 3, Fig. 1 for Details)	1
3	131578	. ASSEMBLY, SCISSORS (See Sect. 4, Fig. 1 for Details)	1
4	130696	. BOLT, EAR PIVOT	2
5	61249	. NUT, HEX LOCK	2
6	131450	. ASSEMBLY, PLATFORM (See Sect. 5, Fig. 1 for Details)	1
7	130696	. BOLT, EAR PIVOT	2
8	61249	. NUT, HEX LOCK	2
9	131448	. ASSEMBLY, UPPER CONTROL BOX (See Sect. 2, Fig. 2 for Details)	1
10	61711	. SCREW, SELF TAP	6
11	131576	. COVER, UPPER CONTROL BOX	1
12	130337-51	. CABLE, CONDUCTOR	51 FT
13	65655	. CLAMP, CUSHIONED	8
14	63654	. RIVET, POP	8
-15	255	. TIE, CABLE	AR
-16	256	. TIE, CABLE	AR
-17	131545	. SCHEMATIC, ELECTRICAL (See Schematic Section, page 1)	1
-18	133006	. SCHEMATIC, HYDRAULIC (See Schematic Section, page 4)	1
-19	67786	. SET, DECAL (See Sect. 2, Fig. 3 for Details)	1
-20	131521	. DIAGRAM, HYDRAULIC HOSE KIT (See Sect. 2, Fig. 4 for Details)	1
21	80031-05	. TEE, UNION	1
22	16268	. CLAMP, CUSHIONED	3

- ITEM NOT ILLUSTRATED

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
23	63654	. RIVET, POP	3
-24	765	. CLAMP, RUBBER	1
-25	65787	. CLAMP, CUSHIONED	2
-26	65116	. OIL, HYDRAULIC	13 GAL
27	130927	. CONTAINER, PLASTIC	1
28	17411	. HANDBOOK, OPERATION & SAFETY	1
29	65842	. CAP, ANTI-ROLL	2
30	65867	. CLAMP	2
31	60315	. SCREW, CAP	2
32	60711	. NUT, HEX	2
-33	65389	. PAINT, BLUE	2 GAL
-34	65368	. PAINT, BLUE	16 OZ
-35	16608	. PAINT, WHITE	5 GAL
-36	2673	. PAINT, WHITE	16 OZ
-37	2996	. OIL, MOTOR	
-38	65114	. GASOLINE	
-39	17219	. CATALOG, MARKLIFT PARTS	1

FINAL ASSEMBLY (M20E)



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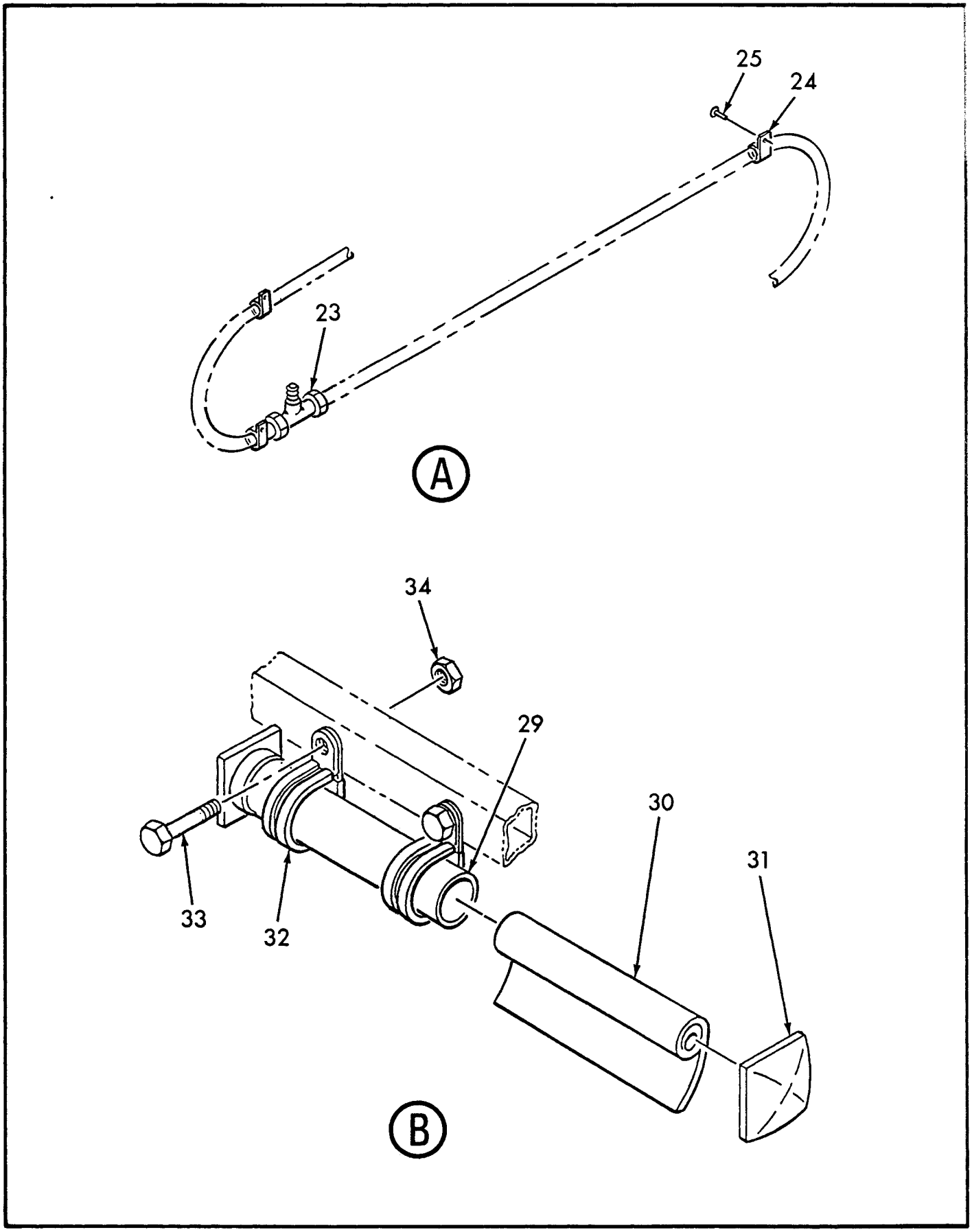
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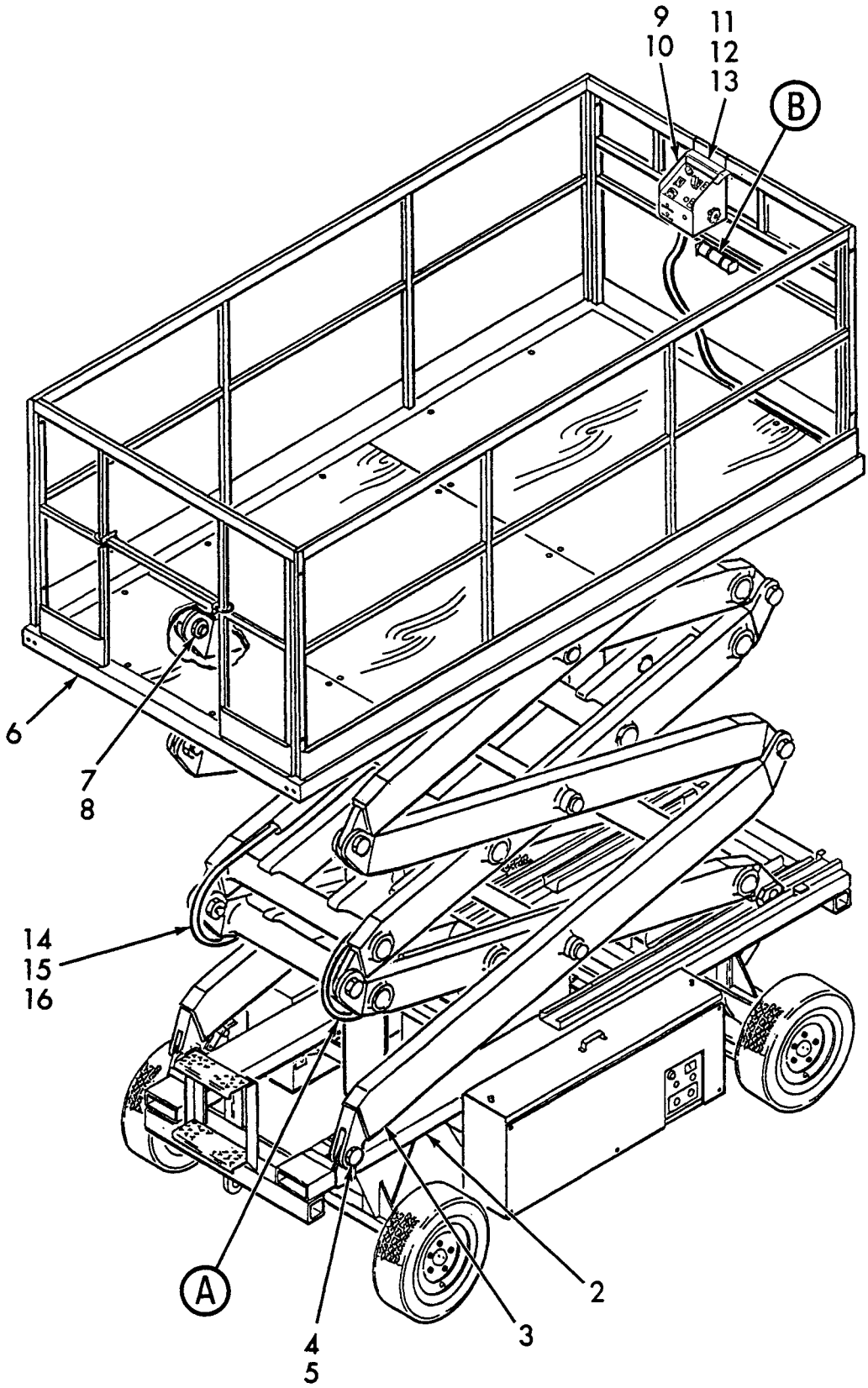
ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	130042	ASSEMBLY, FINAL	REF
2	131391	. ASSEMBLY, FRAME (See Sect. 3, Fig. 1A for Details)	1
3	131423	. ASSEMBLY, SCISSORS (See Sect. 4, Fig. 1 for Details)	1
4	130696	. BOLT, EAR PIVOT	2
5	60315	. NUT, HEX LOCK	2
6	131450	. ASSEMBLY, PLATFORM (See Sect. 5, Fig. 1A for Details)	1
7	130696	. BOLT, EAR PIVOT	2
8	60315	. NUT, HEX LOCK	2
9	131447	. ASSEMBLY, UPPER CONTROL BOX (See Sect. 2, Fig. 2A for Details)	1
10	61711	. SCREW, SELF TAP	6
11	131576	. COVER, UPPER CONTROL BOX	1
12	130337-51	. CABLE, CONDUCTOR	51 FT
13	65655	. CLAMP, CUSHIONED	9
14	63654	. RIVET, POP	9
-15	255	. TIE, CABLE	AR
-16	256	. TIE, CABLE	AR
-17	131552	. SCHEMATIC, ELECTRICAL (See Schematic Section, page 2)	1
-18	133005	. SCHEMATIC, HYDRAULIC (See Schematic Section, page 5)	1
-19	67789	. SET, DECAL (See Sect. 2, Fig. 3A for Details)	1
-20	131522	. DIAGRAM, HYDRAULIC HOSE KIT (See Sect. 2, Fig. 4A for Details)	1
21	80031-05	. TEE, UNION	1
22	16268	. CLAMP, CUSHIONED	4

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
23	63654	. RIVET, POP	4
-24	765	. CLAMP, RUBBER	2
-25	65787	. CLAMP, CUSHIONED	2
-26	65116	. OIL, HYDRAULIC	13 GAL
27	130927	. CONTAINER, PLASTIC	1
28	17411	. HANDBOOK, OPERATION & SAFETY	1
29	65842	. CAP, ANTI-ROLL	2
30	65867	. CLAMP	2
31	60315	. SCREW, CAP	2
32	61227	. NUT, HEX	2
-33	65389	. PAINT, BLUE	2 GAL
-34	65368	. PAINT, BLUE	16 OZ
-35	16608	. PAINT, WHITE	5 GAL
-36	2573	. PAINT, WHITE	16 OZ
-37	17219	. CATALOG, MARKLIFT PARTS	1

FINAL ASSEMBLY (M25E)



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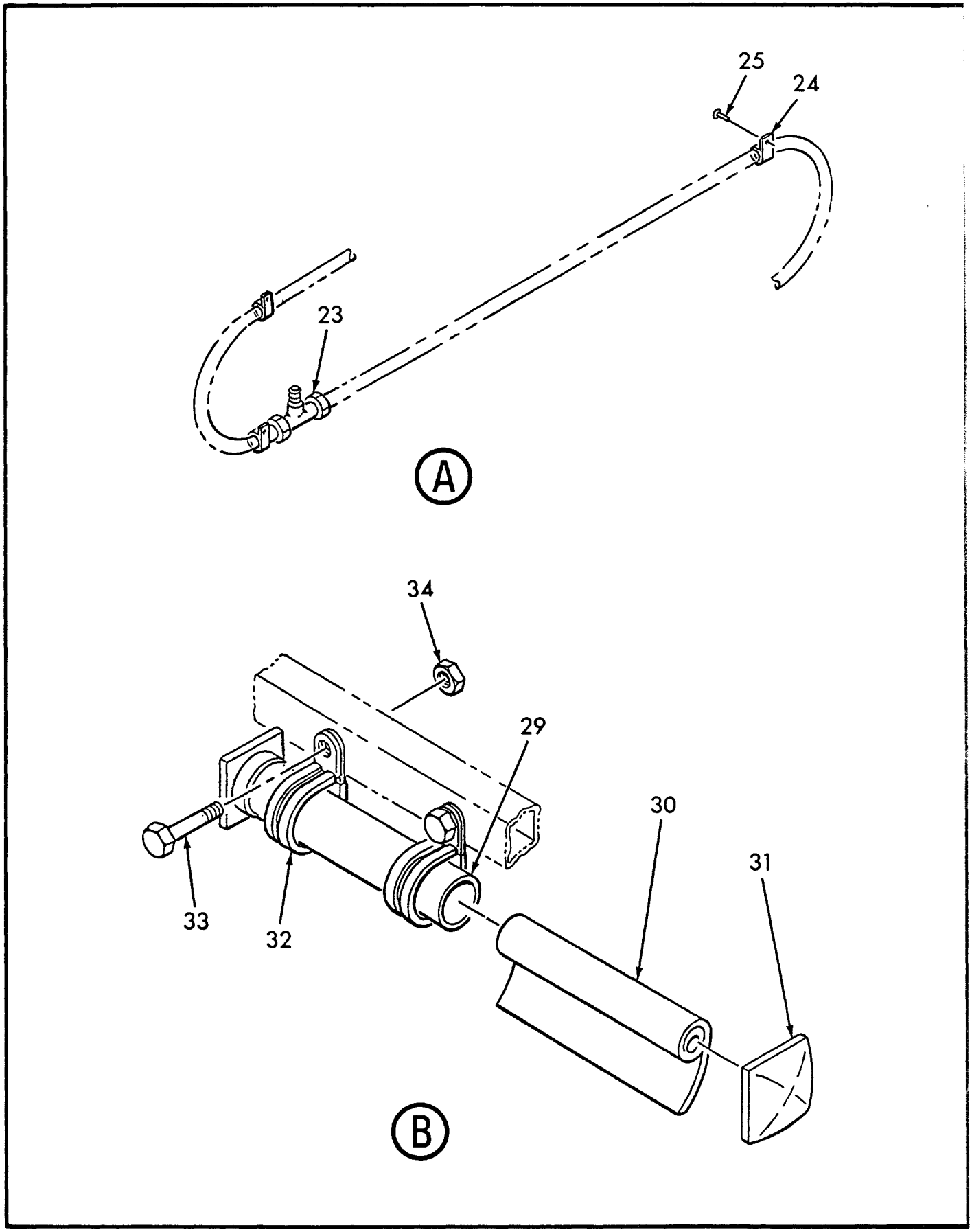
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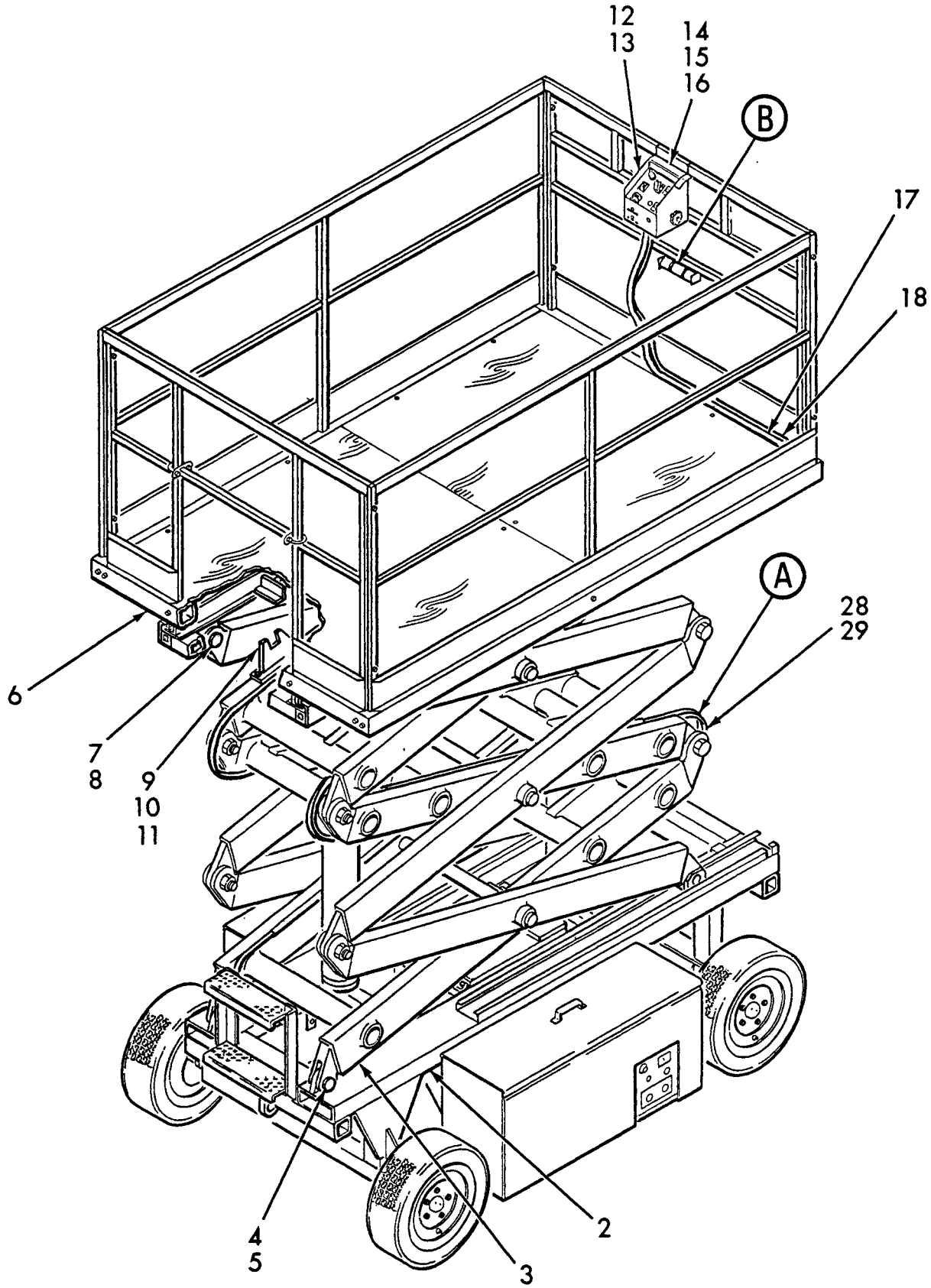
ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	130043	ASSEMBLY, FINAL	REF
2	131376	. ASSEMBLY, FRAME (See Sect. 3, Fig. 1B for Details)	1
3	131376	. ASSEMBLY, SCISSORS (See Sect. 4, Fig. 1A for Details)	1
4	130696	. BOLT, EAR PIVOT	2
5	61249	. NUT, HEX LOCK	2
6	131452	. ASSEMBLY, PLATFORM (See Sect. 5, Fig. 1B for Details)	1
7	130696	. BOLT, EAR PIVOT	2
8	61249	. NUT, HEX LOCK	2
9	131447	. ASSEMBLY, UPPER CONTROL BOX (See Sect. 2, Fig. 2A for Details)	1
10	61711	. SCREW, SELF TAP	6
11	131576	. COVER, UPPER CONTROL BOX	1
12	130337-65	. CABLE, CONDUCTOR	65 FT
13	65655	. CLAMP, CUSHIONED	8
14	63654	. RIVET, POP	8
-15	255	. TIE, CABLE	AR
-16	256	. TIE, CABLE	AR
-17	131552	. SCHEMATIC, ELECTRICAL (See Schematic Section, page 2)	1
-18	133005	. SCHEMATIC, HYDRAULIC (See Schematic Section, page 5)	1
-19	67785	. SET, DECAL (See Sect. 2, Fig. 3B for Details)	1
-20	131523	. DIAGRAM, HYDRAULIC HOSE KIT (See Sect. 2, Fig. 4B for Details)	1
21	80031-05	. TEE, UNION	1
22	65655	. CLAMP, CUSHIONED	8

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
23	63654	. RIVET, POP	8
-24	765	. CLAMP, RUBBER	1
-25	65787	. CLAMP, CUSHIONED	2
-26	65116	. OIL, HYDRAULIC	13 GAL
27	130927	. CONTAINER, PLASTIC	1
28	17411	. HANDBOOK, OPERATION & SAFETY	1
29	65842	. CAP, ANTI-ROLL	2
30	65867	. CLAMP	2
31	60315	. SCREW, CAP	2
32	61227	. NUT, HEX LOCK	2
-33	65389	. PAINT, BLUE	2 GAL
-34	65368	. PAINT, BLUE	16 OZ
-35	16608	. PAINT, WHITE	5 GAL
-36	2673	. PAINT, WHITE	16 OZ
-37	17219	. CATALOG, MARKLIFT PARTS	1

FINAL ASSEMBLY (M20ET)



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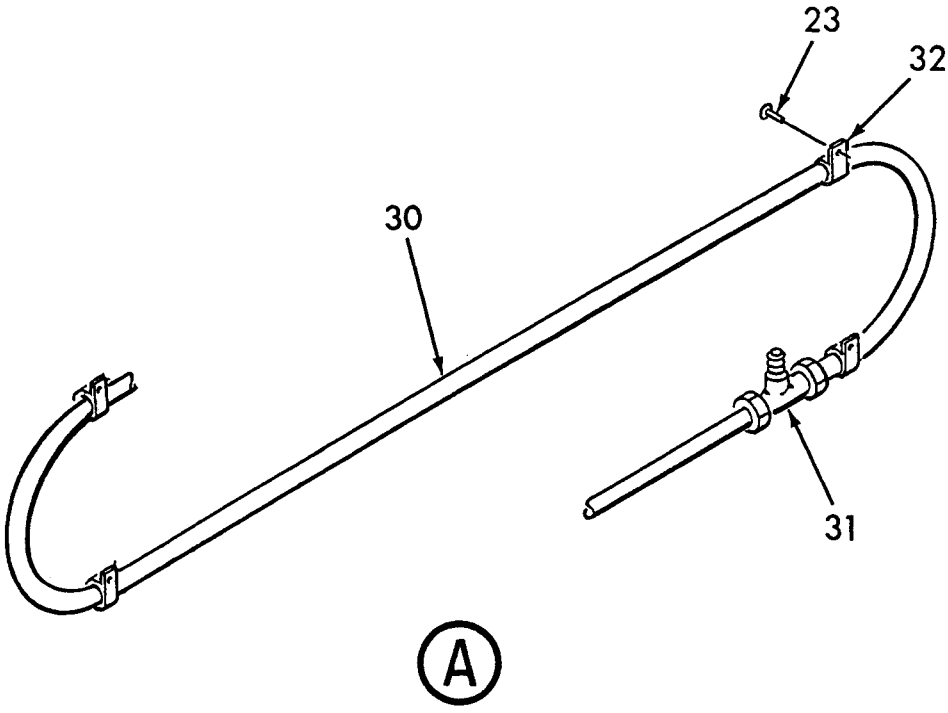
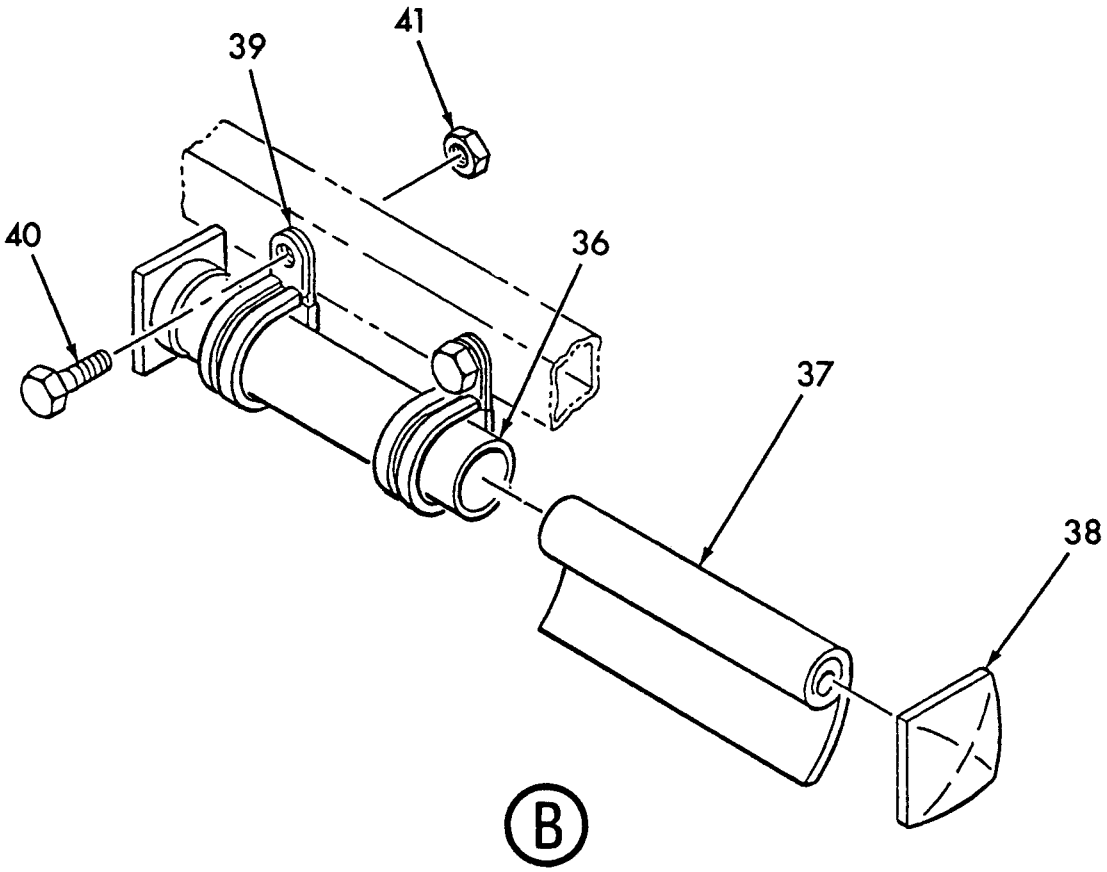




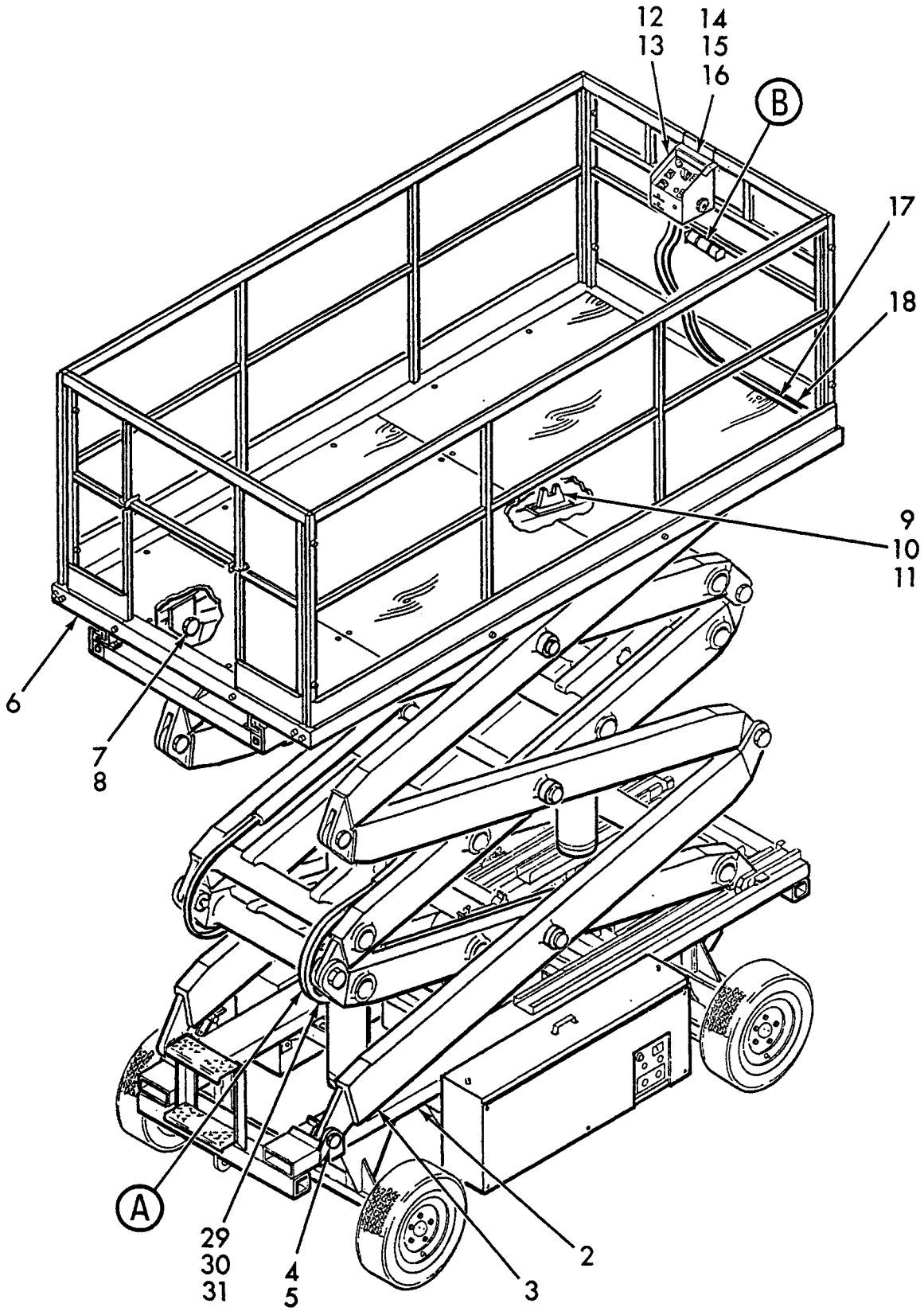
REV.

FINAL ASSEMBLY (M20ET)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	130045	ASSEMBLY, FINAL	REF
2	131489	. ASSEMBLY, FRAME (See Sect. 3, Fig. 1C for Details)	1
3	131423	. ASSEMBLY, SCISSORS (See Sect. 4, Fig. 1 for Details)	1
4	130696	. BOLT, EAR PIVOT	2
5	61249	. NUT, LOCK	2
6	131513	. ASSEMBLY, PLATFORM (See Sect. 5, Fig. 1C for Details)	1
7	130696	. BOLT, EAR PIVOT	2
8	61249	. NUT, LOCK	2
9	130478	. BRACKET, LOCK (TRAVERSING PLATFORM)	1
10	60322	. SCREW, CAP	2
11	63302	. WASHER, LOCK	2
12	131446	. ASSEMBLY, UPPER CONTROL BOX (See Sect. 2, Fig. 2B for Details)	1
13	61711	. SCREW, SELF TAP	6
14	131576	. COVER, UPPER CONTROL BOX	1
15	130337-57	. CABLE, CONDUCTOR	57 FT
16	90547-156	. CABLE, CONTROL	13 FT
-17	255	. TIE, CABLE	AR
-18	256	. TIE, CABLE	AR
-19	65655	. CLAMP, CUSHIONED	9
-20	65787	. CLAMP, CUSHIONED	2
-21	63654	. RIVET, POP	16
-22	131555	. SCHEMATIC, ELECTRICAL (See Schematic Section, page 3)	1
-23	131560	. SCHEMATIC, HYDRAULIC (See Schematic Section, page 6)	1

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-24	67788	. SET, DECAL (See Sect. 2, Fig. 3C for Details)	1
-25	131522	. DIAGRAM, HYDRAULIC HOSE KIT (See Sect. 2, Fig. 4A for Details)	1
26	2568-40	. HOSE, HYDRAULIC	2
27	2562	. FITTING, STRAIGHT SWIVEL	4
28	31034	. HOSE, HYDRAULIC	1
29	80031-05	. TEE, UNION	1
30	16268	. CLAMP, HOSE	4
-31	65451	. CLAMP, HOSE	2
-32	765	. CLAMP, RUBBER	12
-33	65116	. OIL, HYDRAULIC	13 GAL
34	130927	. CONTAINER, PLASTIC	1
35	17411	. HANDBOOK, OPERATION & SAFETY	1
36	65842	. CAP, ANTI-ROLL	2
37	65867	. CLAMP	2
38	60315	. SCREW, CAP	2
39	61227	. NUT, LOCK	2
-40	65389	. PAINT, BLUE	2 GAL
-41	65368	. PAINT, BLUE	16 OZ
-42	16608	. PAINT, WHITE	5 GAL
-43	2673	. PAINT, WHITE	16 OZ
-44	17219	. CATALOG, MARKLIFT PARTS	1

FINAL ASSEMBLY (M25ET)



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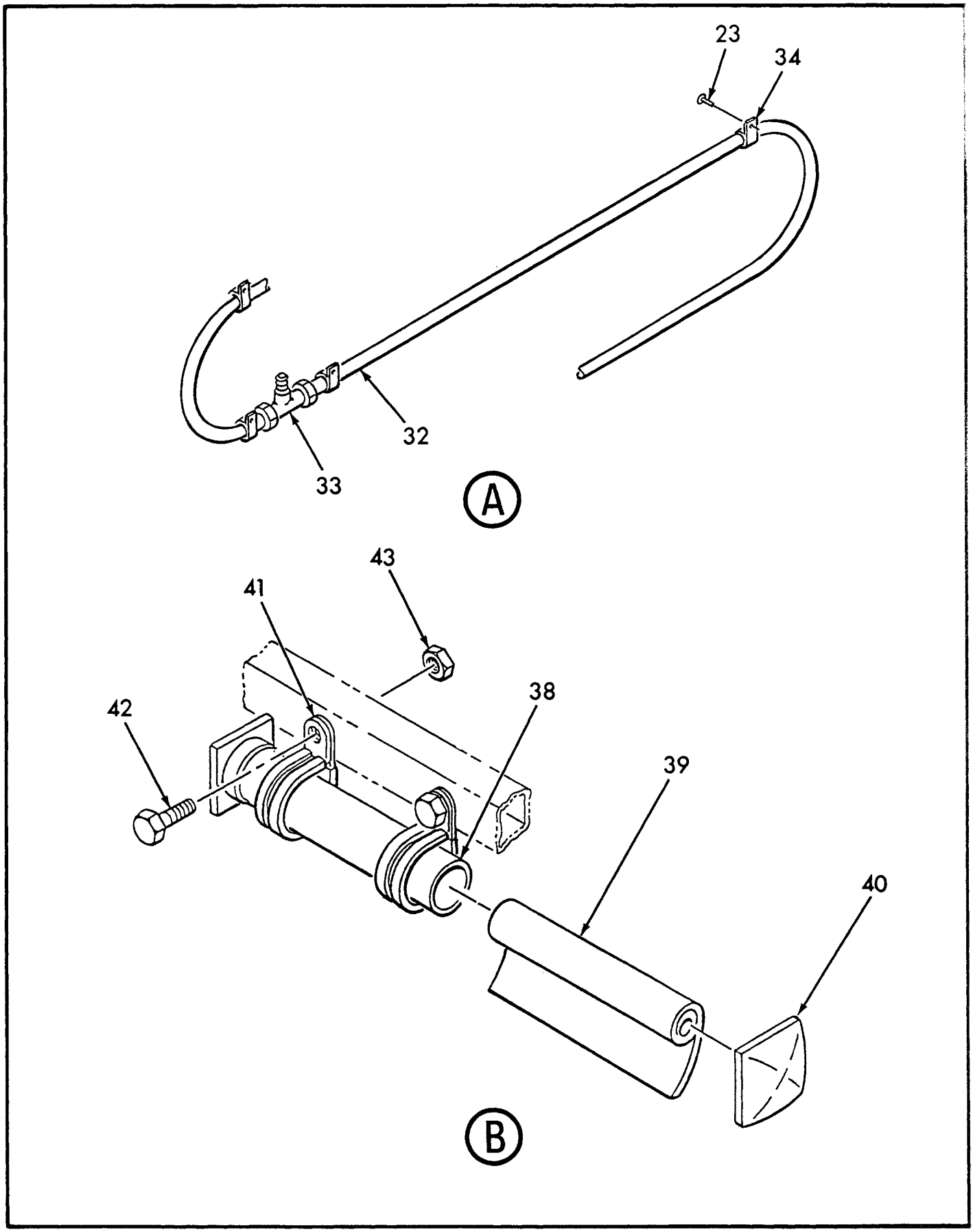


REV.

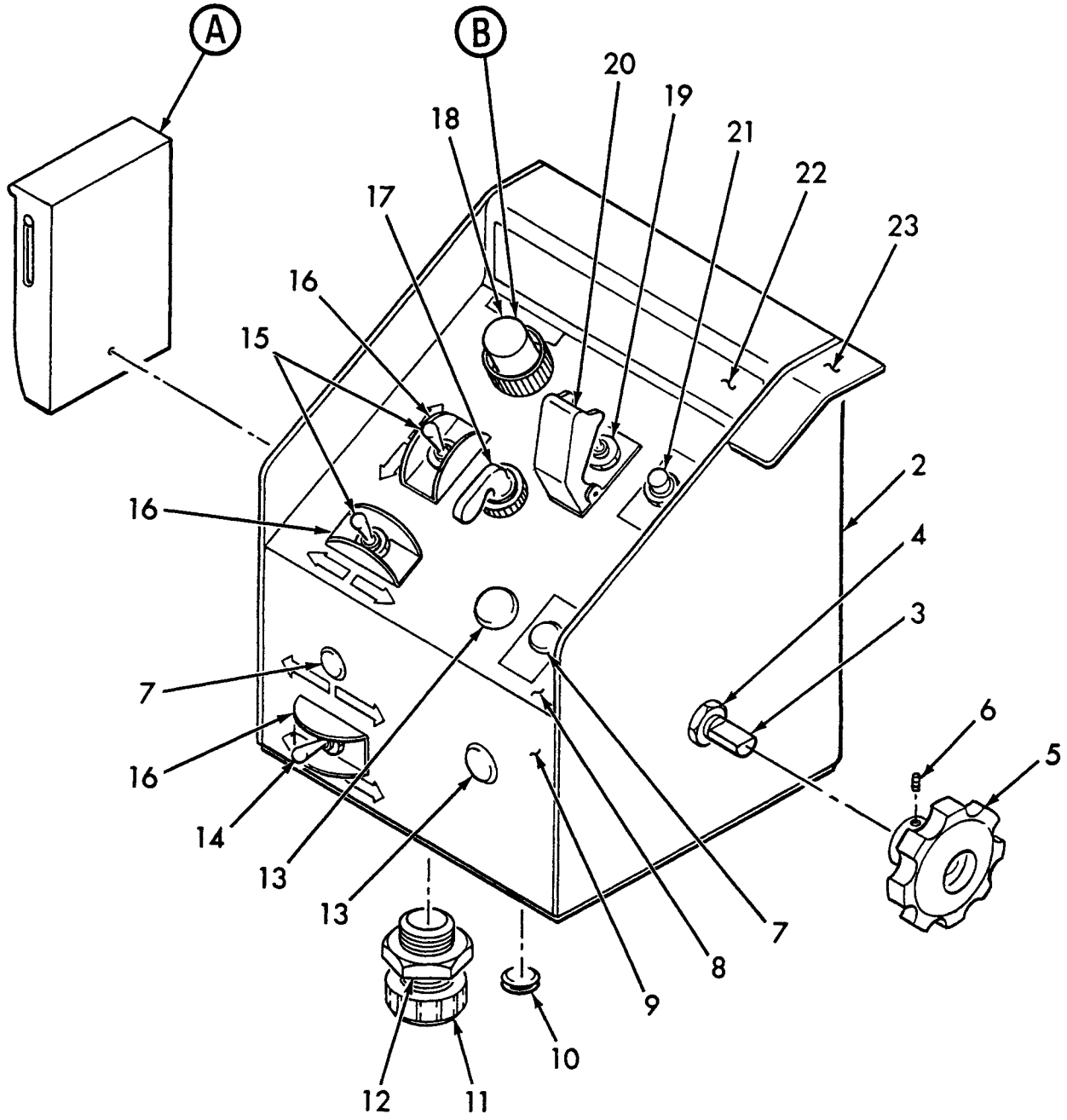
FINAL ASSEMBLY (M25ET)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	130046	ASSEMBLY, FINAL	REF
2	131490	. ASSEMBLY, FRAME (See Sect. 3, Fig. 1D for Details)	1
3	131531	. ASSEMBLY, SCISSORS (See Sect. 4, Fig. 1A for Details)	1
4	130696	. BOLT, EAR PIVOT	2
5	61249	. NUT, LOCK	2
6	131512	. ASSEMBLY, PLATFORM (See Sect. 5, Fig. 1D for Details)	1
7	130696	. BOLT, EAR PIVOT	2
8	61249	. NUT, LOCK	2
9	130478	. BRACKET, LOCK (TRAVERSING PLATFORM)	1
10	60322	. SCREW, CAP	2
11	63302	. WASHER, LOCK	2
12	131446	. ASSEMBLY, UPPER CONTROL BOX (See Sect. 2, Fig. 2B for Details)	1
13	61711	. SCREW, SELF TAP	6
14	131576	. COVER, UPPER CONTROL BOX	1
15	130337-65	. CABLE, CONDUCTOR	65 FT
16	90547-192	. CABLE, CONTROL	16 FT
-17	255	. TIE, CABLE	AR
-18	256	. TIE, CABLE	AR
-19	65655	. CLAMP, CUSHIONED	8
-20	65787	. CLAMP, CUSHIONED	2
21	63654	. RIVET, POP	12
-22	131555	. SCHEMATIC, ELECTRICAL (See Schematic Section, page 3)	1
-23	133004	. SCHEMATIC, HYDRAULIC (See Schematic Section, page 6)	1

- ITEM NOT ILLUSTRATED

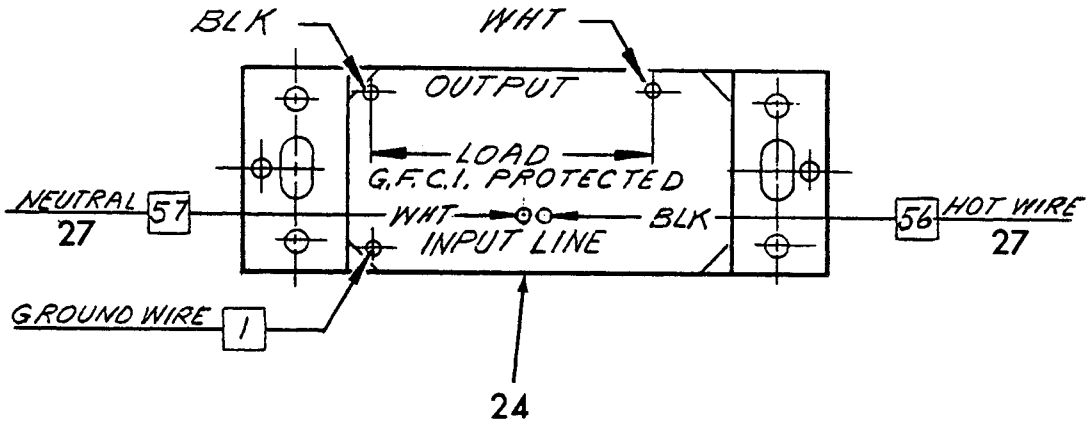
ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-24	67787	. SET, DECAL (See Sect. 2, Fig. 3D for Details)	1
-25	131523	. DIAGRAM, HYDRAULIC HOSE KIT (See Sect. 2, Fig. 4B for Details)	1
26	2568-56	. HOSE, HYDRAULIC	2
27	2562	. FITTING, STRAIGHT SWIVEL	4
28	2594	. ELBOW, SWIVEL	1
29	31034	. HOSE, HYDRAULIC	1
30	80031-05	. TEE, UNION	1
31	16268	. CLAMP, HOSE	4
-32	65451	. CLAMP, HOSE	2
-33	765	. CLAMP, RUBBER	6
-34	65116	. OIL, HYDRAULIC	13 GAL
35	130927	. CONTAINER, PLASTIC	1
36	17411	. HANDBOOK, OPERATION & SAFETY	1
37	65842	. CAP, ANTI-ROLL	2
38	65867	. CLAMP	2
39	60315	. SCREW, CAP	2
40	61227	. NUT, LOCK	2
-41	65389	. PAINT, BLUE	2 GAL
-42	65368	. PAINT, BLUE	16 OZ
-43	16608	. PAINT, WHITE	5 GAL
-44	2673	. PAINT, WHITE	16 OZ
-45	17219	. CATALOG, MARKLIFT PARTS	1

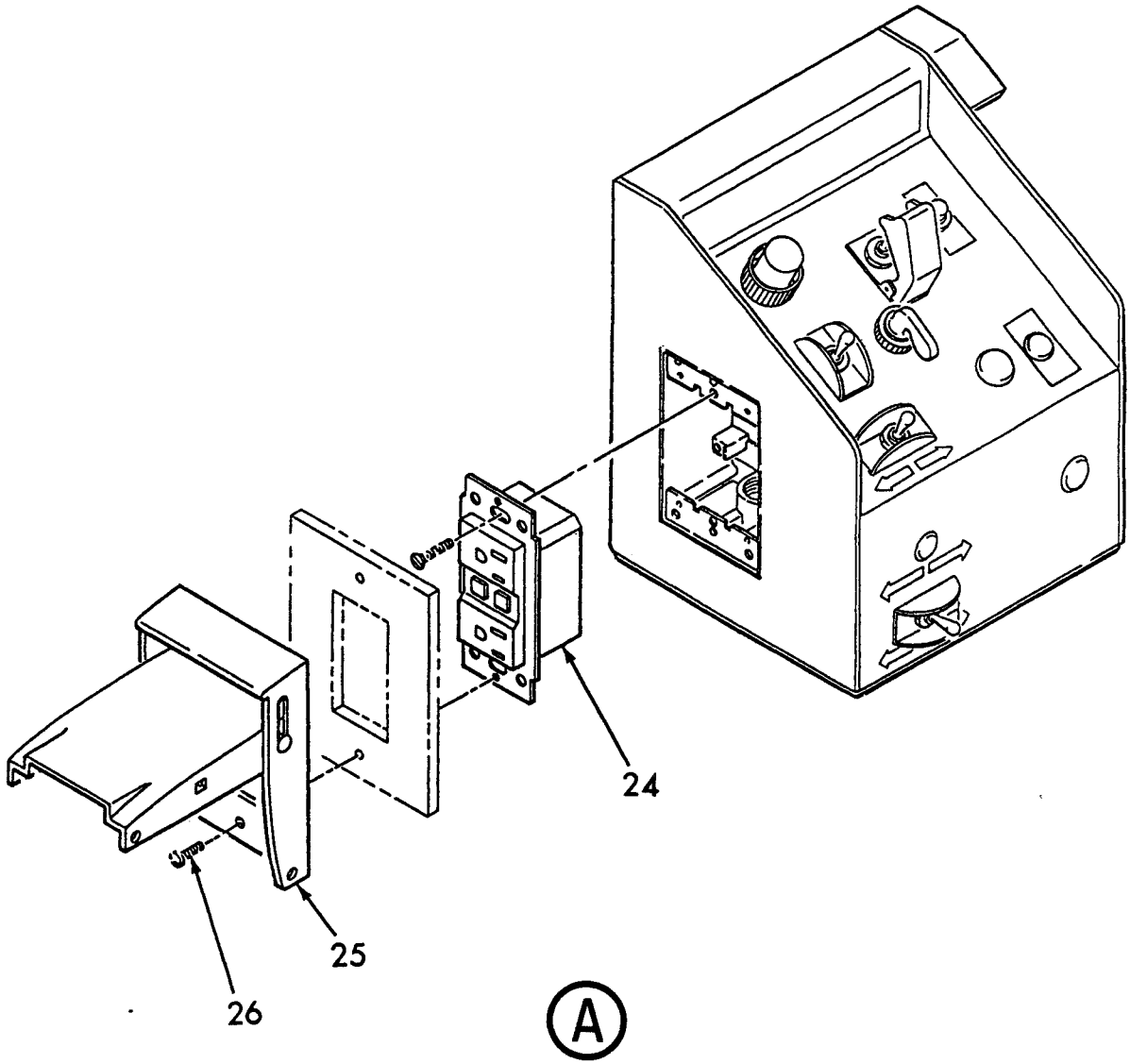
UPPER CONTROL BOX ASSEMBLY (M20GP)

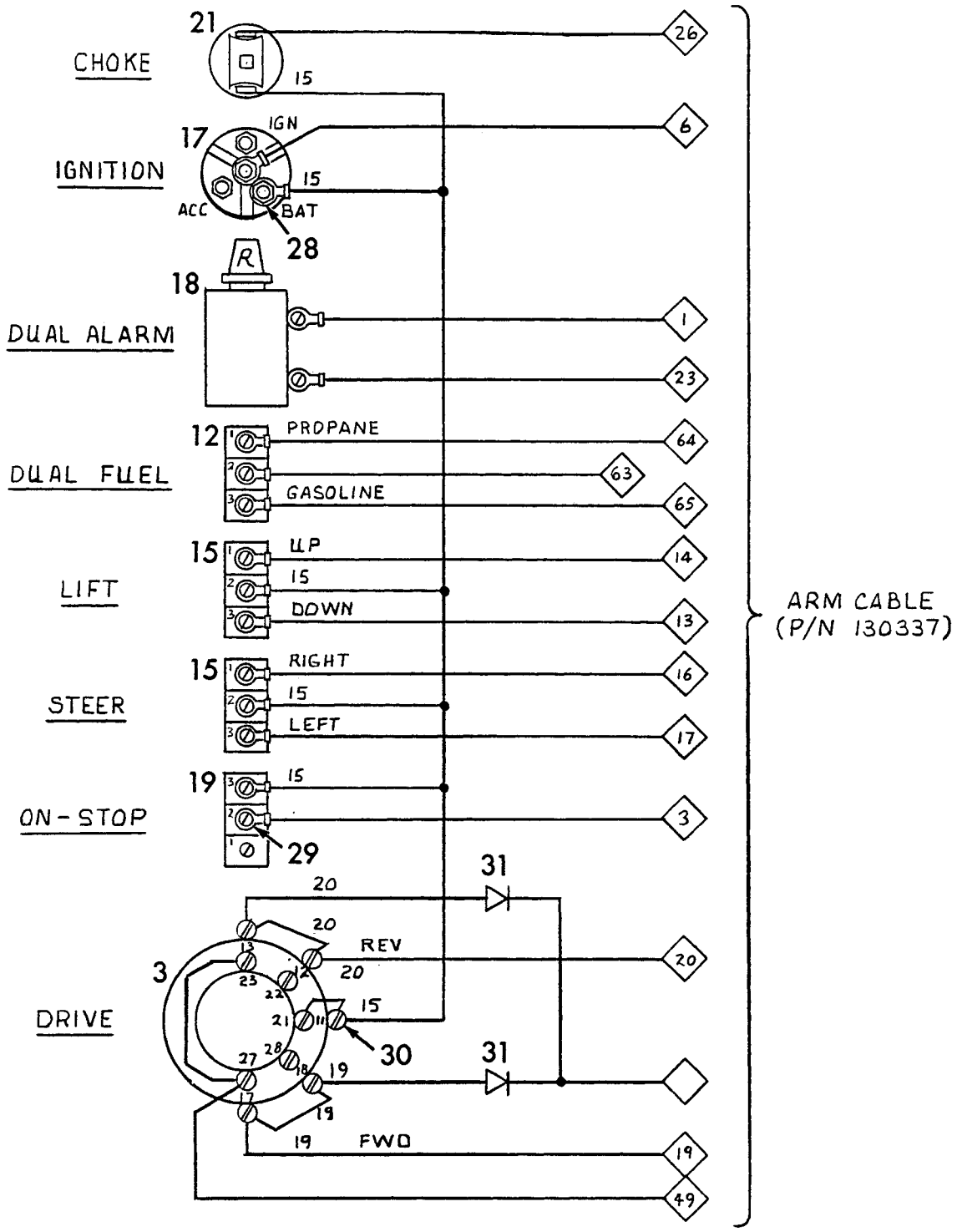


REV.

UPPER CONTROL BOX ASSEMBLY (M20GP)







ELECTRICAL DIAGRAM
UPPER CONTROL BOX

(B)

UPPER CONTROL BOX ASSEMBLY (M20GP)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	131448	ASSEMBLY, UPPER CONTROL BOX (See Sect. 2, Fig. 1 for NHA)	REF
2	131568	. WELDMENT, UPPER CONTROL BOX	1
3	67098	. SWITCH, 5 POSITION DRIVE	1
4	65131	. NUT, RUBBER COATED	1
5	65753	. KNOB, FLUTED TORQUE	1
6	62209	. SCREW, SET	1
7	771	. PLUG, WHITE	2
8	182736	. DECAL, STEER	1
9	130796	. DECAL, FUEL	1
10	65241	. PLUG, WHITE	1
11	2807	. RELIEF, STRAIN	1
12	2809	. NUT, LOCK	1
13	775	. PLUG, WHITE	2
14	4019	. SWITCH, TOGGLE	1
15	4021	. SWITCH, TOGGLE	2
16	20884	. GUARD, SWITCH	3
17	70405	. SWITCH, START, ANTI-DOUBLE	1
18	20805	. BUZZER, ALARM	1
19	4017	. SWITCH, TOGGLE	1
20	70303	. GUARD, SWITCH	1
21	4011	. SWITCH, PUSH	1
22	2014	. DECAL, UNLAWFUL TO OPERATE	1
23	130782	. DECAL, DRIVE	1
24	70391	. RECEPTACLE	1
25	70392	. COVER, RECEPTACLE	1

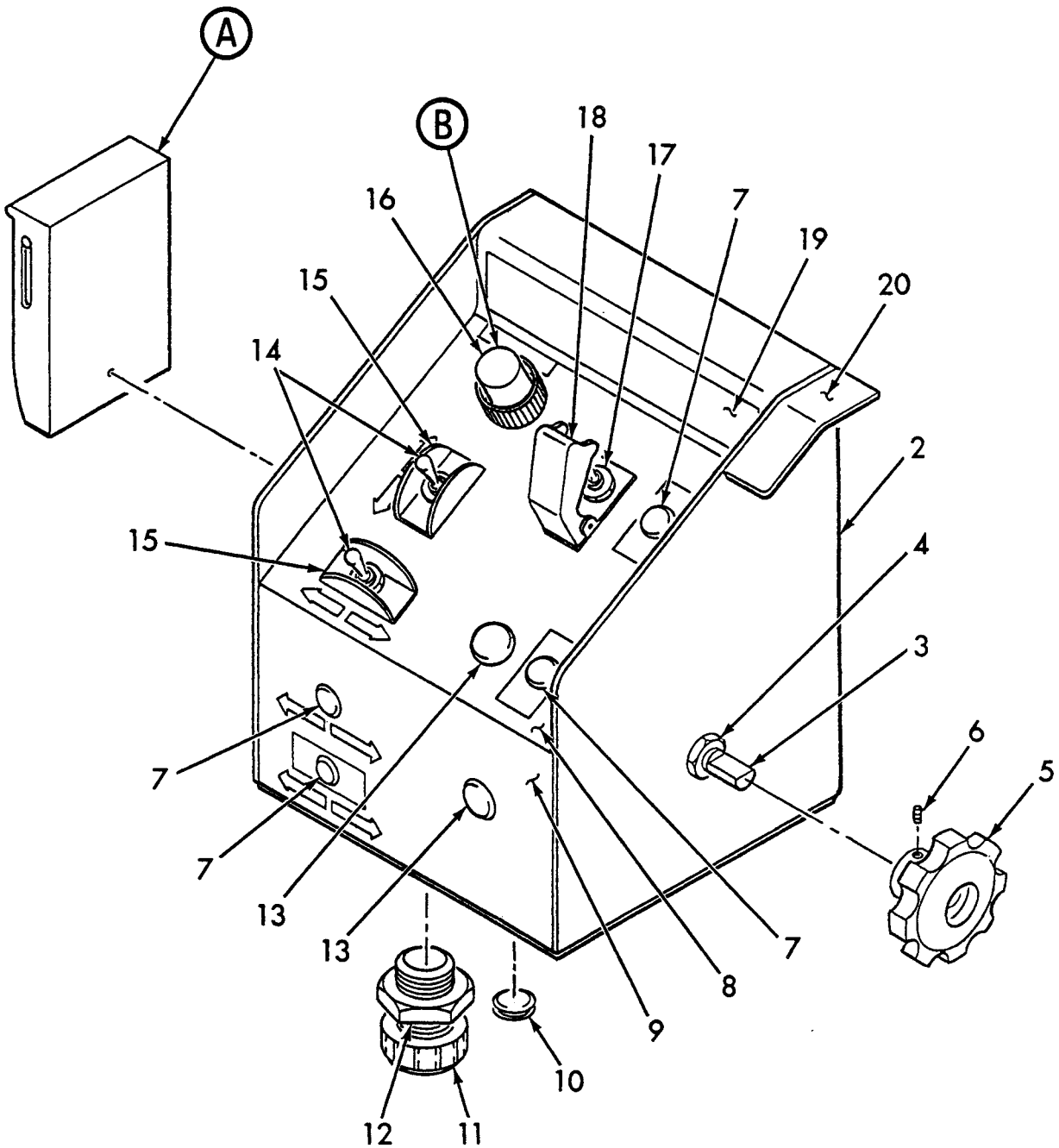
- ITEM NOT ILLUSTRATED

UPPER CONTROL BOX ASSEMBLY (M20GP)

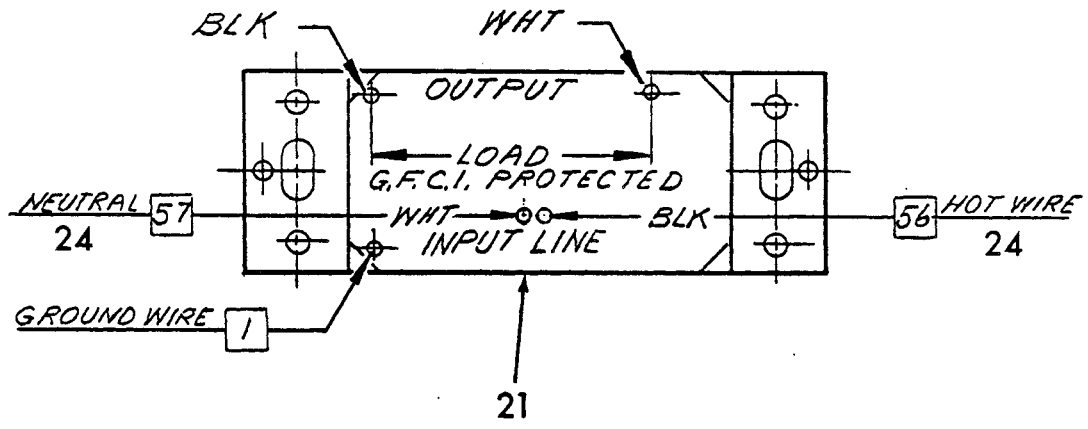
ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
26	63002	. SCREW, MACHINE	2
27	70394	. CONNECTOR, INSULATED	4
28	16228	. RING, TERMINAL	2
29	117-C	. RING, TERMINAL	15
30	16213	. RING, TERMINAL	15
31	70442	. DIODE, 3 AMP, 600V	2

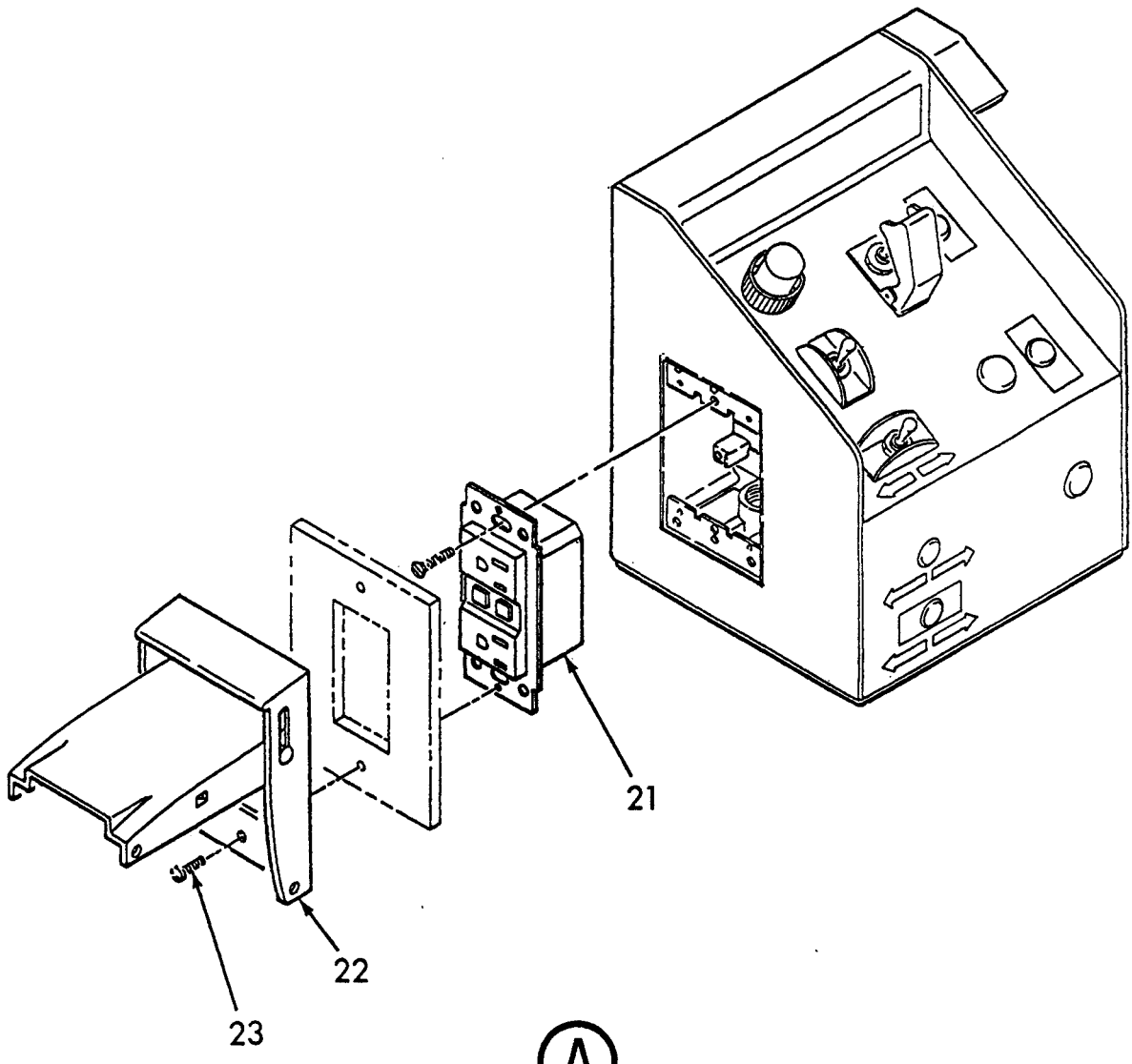
- ITEM NOT ILLUSTRATED

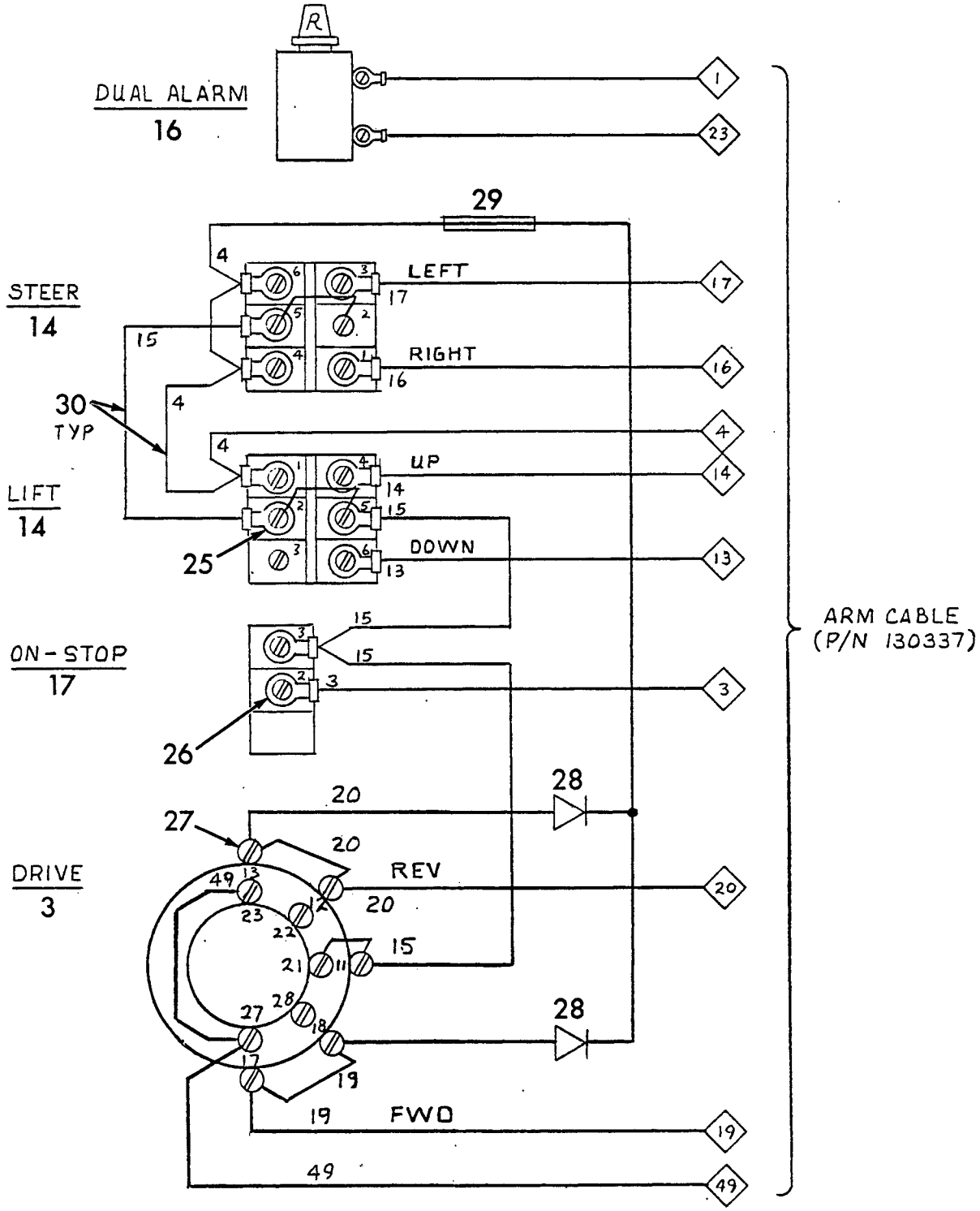
UPPER CONTROL BOX ASSEMBLY (M20E & M25E)



UPPER CONTROL BOX ASSEMBLY (M20E & M25E)







ELECTRICAL DIAGRAM
UPPER CONTROL BOX

B

UPPER CONTROL BOX ASSEMBLY (M20E & M25E)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	131447	ASSEMBLY, UPPER CONTROL BOX (See Sect. 2, Fig. 1A or 1B for NHA)	REF
2	131568	. WELDMENT, UPPER CONTROL BOX	1
3	67098	. SWITCH, 5 POSITION DRIVE	1
4	65131	. NUT, RUBBER COATED	1
5	65753	. KNOB, FLUTED TORQUE	1
6	62209	. SCREW, SET	1
7	771	. PLUG, WHITE	4
8	182718	. DECAL, STEER	1
9	130796	. DECAL	1
10	775	. PLUG, WHITE	1
11	2807	. RELIEF, STRAIN	1
12	2809	. NUT, LOCK	1
13	65241	. PLUG, WHITE	2
14	20481	. SWITCH, TOGGLE	2
15	20884	. GUARD, SWITCH	2
16	66345	. BUZZER, ALARM	1
17	4017	. SWITCH, TOGGLE	1
18	70303	. GUARD, SWITCH	1
19	2014	. DECAL, UNLAWFUL TO OPERATE	1
20	130782	. DECAL, DRIVE	1
21	70391	. RECEPTACLE	1
22	70392	. COVER, RECEPTACLE	1
23	63002	. SCREW, MACHINE	2
24	70394	. CONNECTOR, INSULATED	4
25	117-C	. RING, TERMINAL	10

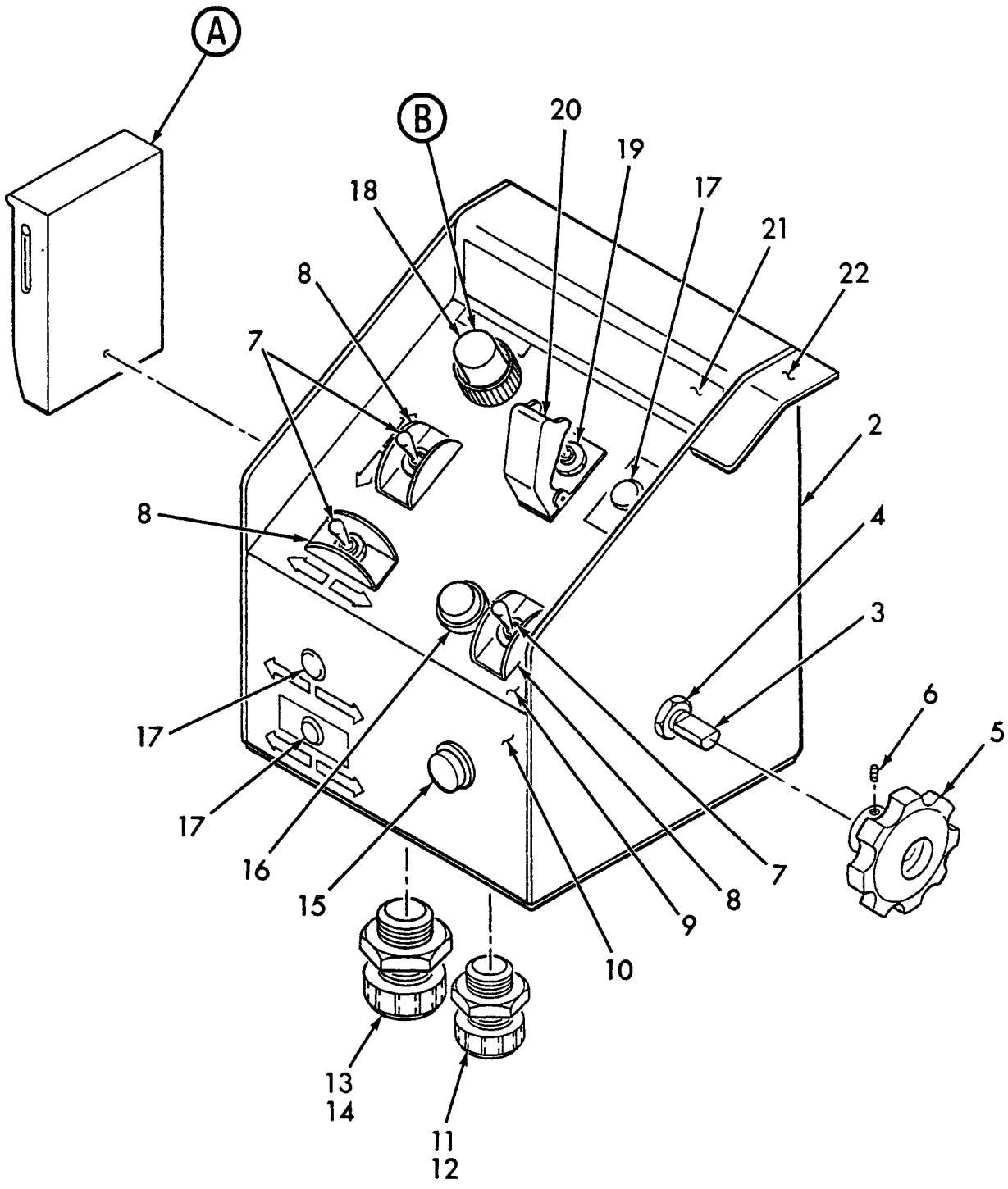
- ITEM NOT ILLUSTRATED

UPPER CONTROL BOX ASSEMBLY (M20E & M25E)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
26	16228	. RING, TERMINAL	4
27	16213	. RING, TERMINAL	15
28	70442	. DIODE, 3 AMP, 600V	2
29	70162	. CONNECTOR, BUTT	1
30	70232	. WIRE, WHITE	4 FT

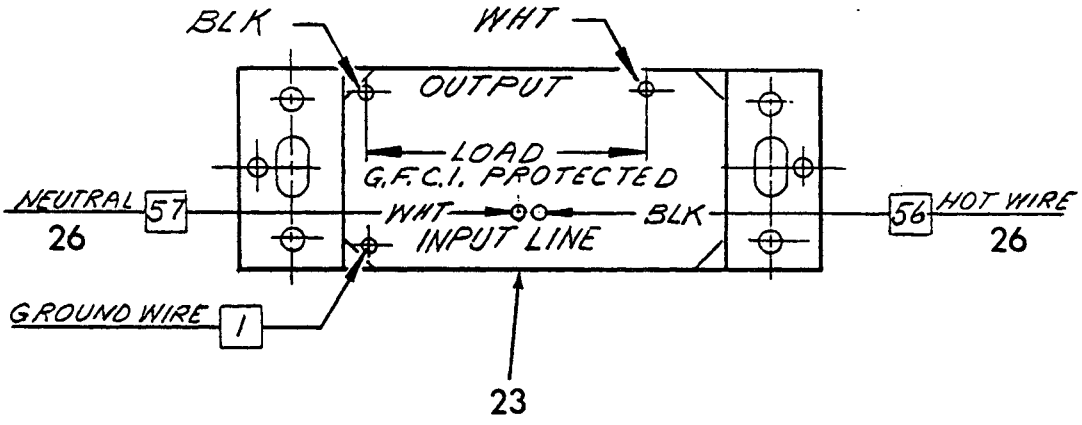
- ITEM NOT ILLUSTRATED

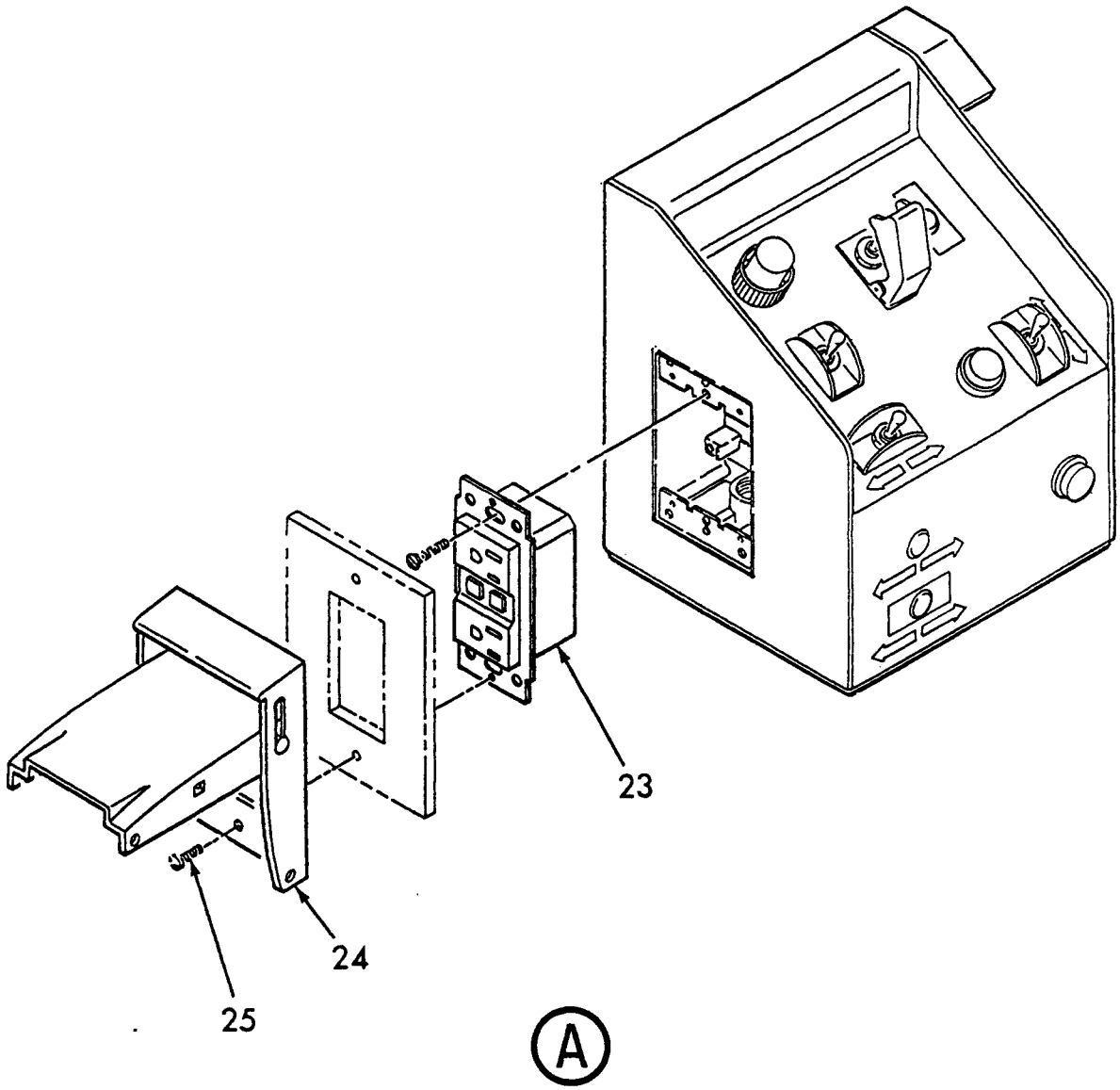
UPPER CONTROL BOX ASSEMBLY (M20ET & M25ET)



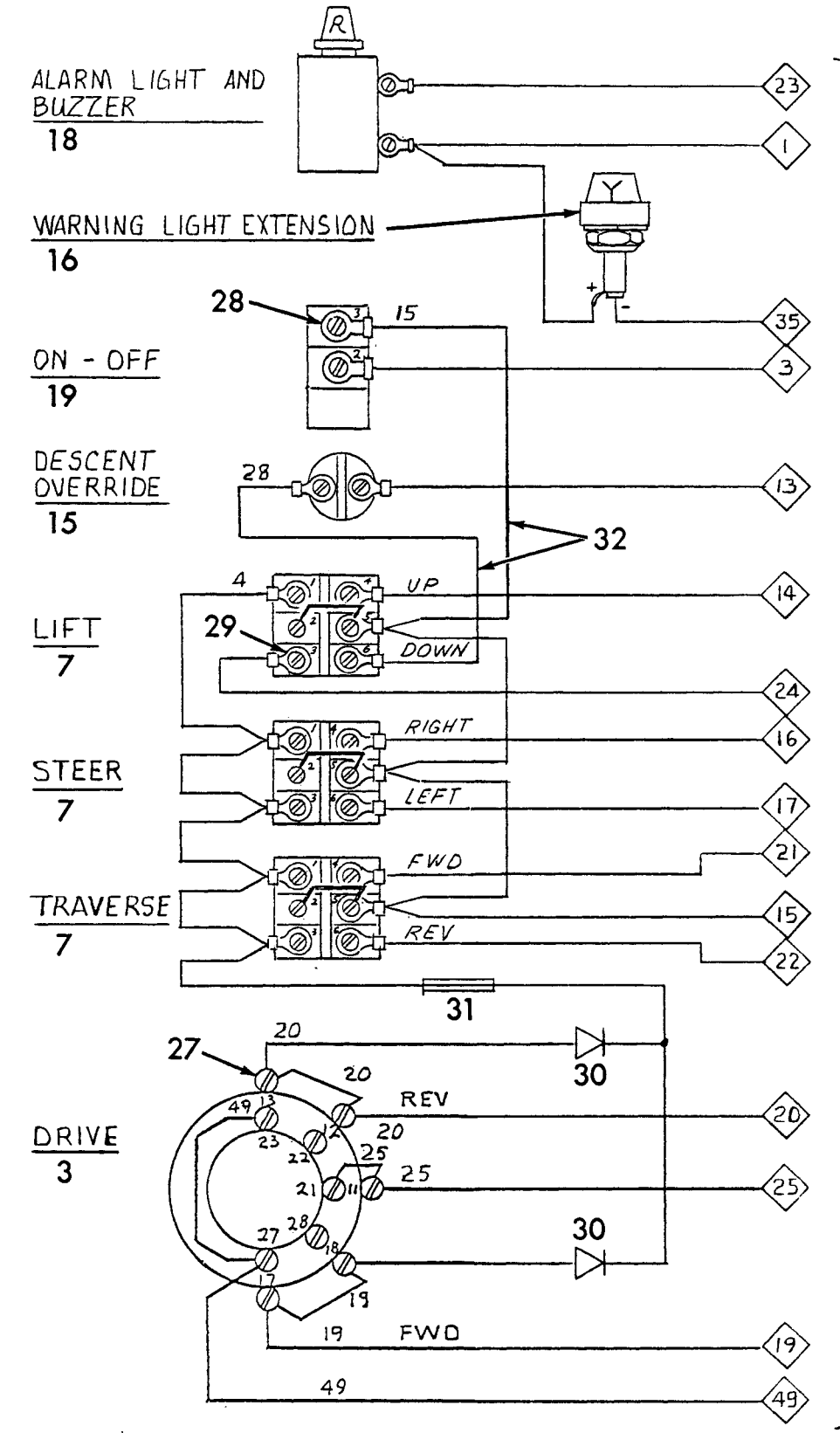
REV.

UPPER CONTROL BOX ASSEMBLY (M20ET & M25ET)





REV.



ELECTRICAL DIAGRAM
UPPER CONTROL BOX

(B)

REV.

UPPER CONTROL BOX ASSEMBLY (M20ET & M25ET)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	131446	ASSEMBLY, UPPER CONTROL BOX (See Sect. 2, Fig. 1C or 1D for NHA)	REF
2	131568	. WELDMENT, UPPER CONTROL BOX	1
3	67098	. SWITCH, 5 POSITION	1
4	65131	. NUT, RUBBER COATED	1
5	65753	. KNOB, FLUTED TORQUE	1
6	62209	. SCREW, SET	1
7	20481	. SWITCH, TOGGLE	3
8	20884	. GUARD, SWITCH	3
9	182718	. DECAL, STEER	1
10	130796	. DECAL	1
11	2806	. RELIEF, STRAIN	1
12	2808	. NUT, LOCK	1
13	2807	. RELIEF, STRAIN	1
14	2809	. NUT, LOCK	1
15	4011	. BUTTON, PUSH	1
16	70293	. LIGHT, WARNING	1
17	771	. PLUG, WHITE	3
18	66345	. BUZZER, ALARM	1
19	4017	. SWITCH, TOGGLE	1
20	70303	. GUARD, SWITCH	1
21	2014	. DECAL, CAUTION	1
22	130782	. DECAL, DRIVE	1
23	70391	. RECEPTACLE	1
24	70392	. COVER, RECEPTACLE	1
25	63002	. SCREW, MACHINE	2

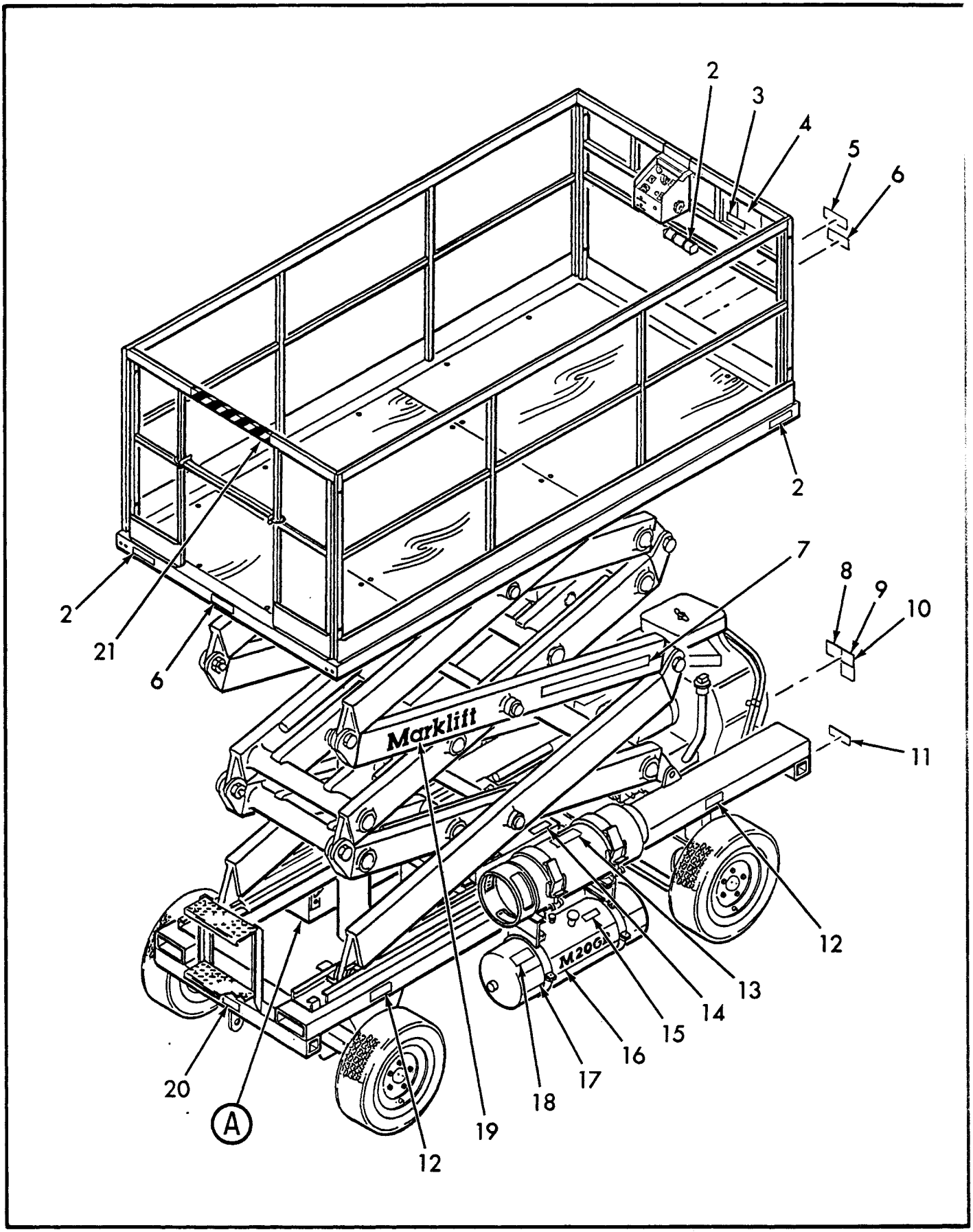
- ITEM NOT ILLUSTRATED

UPPER CONTROL BOX ASSEMBLY (M20ET & M25ET)

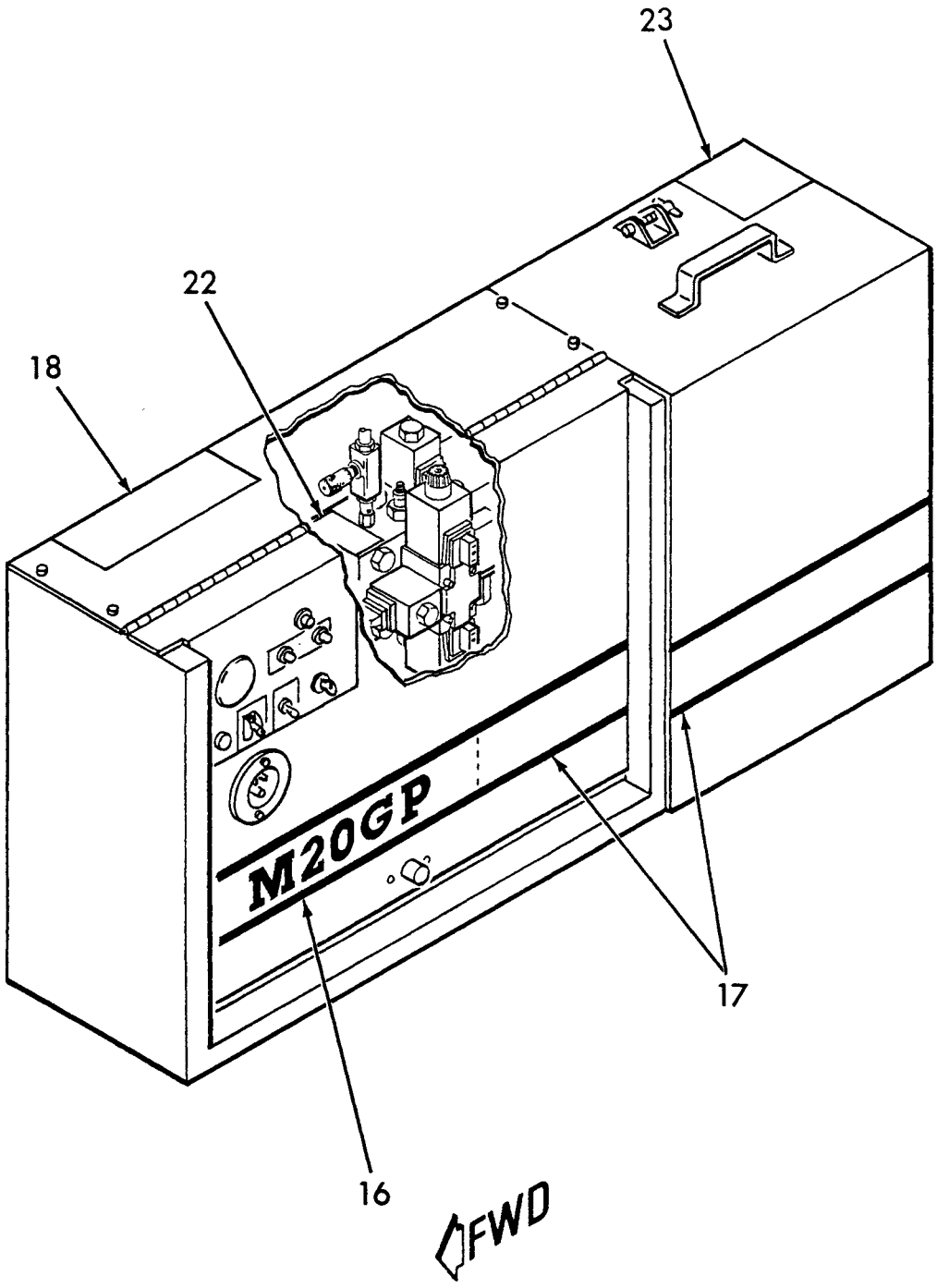
ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
26	70394	. CONNECTOR, INSULATED	4
27	117-C	. RING, TERMINAL	10
28	16228	. RING, TERMINAL	4
29	16213	. RING, TERMINAL	15
30	70442	. DIODE, 3 AMP, 600V	2
31	70162	. CONNECTOR, BUTT	1
32	70232	. WIRE, WHITE	4 FT

- ITEM NOT ILLUSTRATED

DECAL SET (M20GP)



DECAL SET (M20GP)



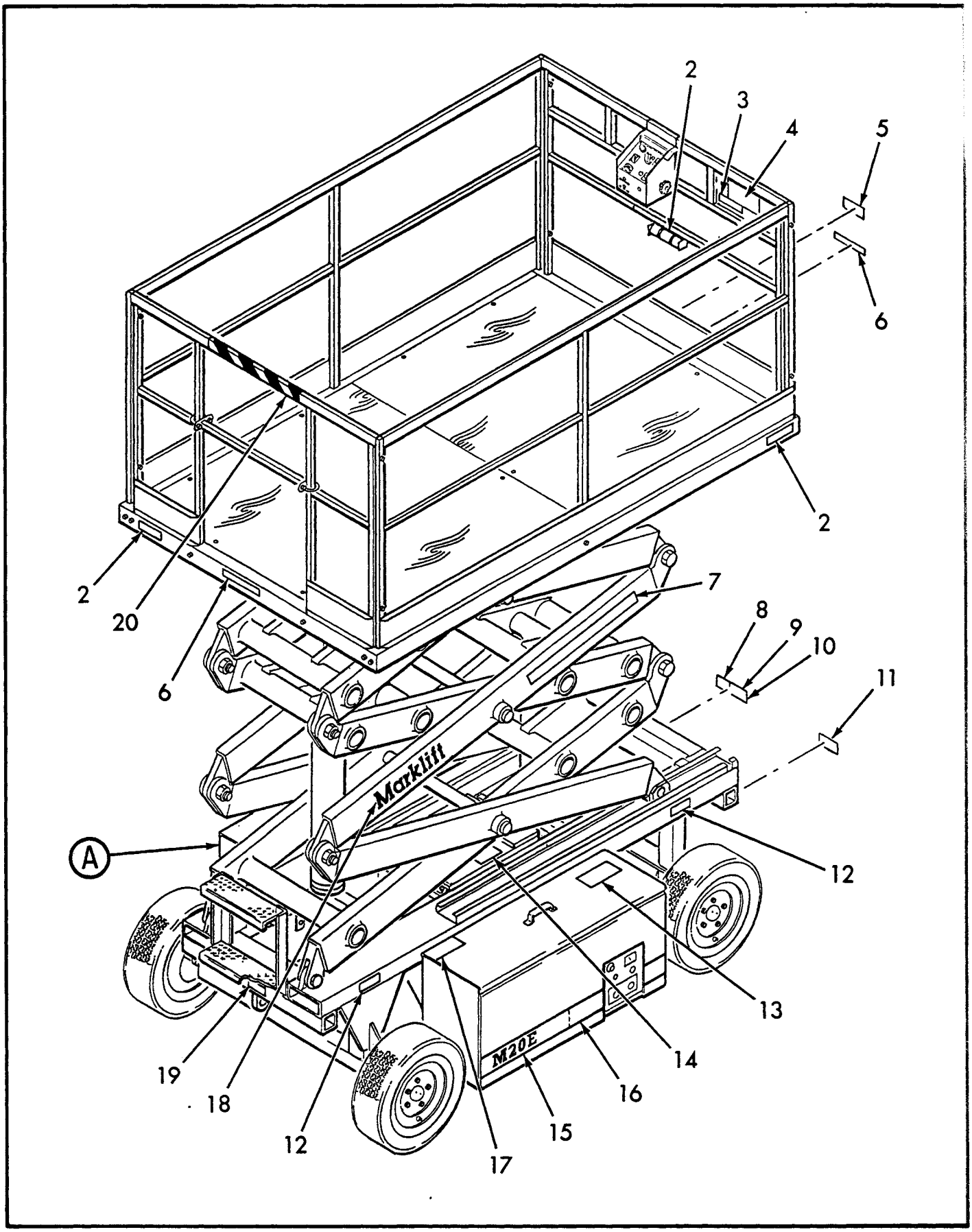
A

DECAL SET (M20GP)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	67786	SET, DECAL (See Sect. 2, Fig. 1 for NHA)	REF
2	130820	. DECAL, OPERATION & SAFETY HANDBOOK	1
3	2024	. DECAL, LOAD CAPACITY 1000 LBS.	5
4	182732	. DECAL, OPERATION INSTRUCTION	1
5	32368	. DECAL, M-SERIES	1
6	31109	. DECAL, CAUTION SCISSOR GUARD RAILS	2
7	130596	. DECAL, A PRODUCT OF MARK INDUSTRIES	2
8	20660	. PLATE, IDENTIFICATION	1
9	20661	. PLATE, ANSI A92	1
10	63653	. RIVET, POP	8
11	2002	. DECAL, FORKLIFT BOOT	2
12	22175	. DECAL, MONOFILLED TIRES	4
13	2004	. DECAL, USE VAPOR TANK ONLY	1
14	2017	. DECAL, HYDRAULIC SYSTEM FLUID	1
15	2020	. DECAL, GASOLINE OR PETROL	1
16	181715	. DECAL, M20GP	2
17	181728	. DECAL, PANEL STRIP	3
18	2016	. DECAL, DO NOT WORK UNDER	2
19	31259	. DECAL, MARKLIFT	2
20	2041	. DECAL, DO NOT LIFT THIS END	1
21	160137	. TAPE, WARNING (BLACK & YELLOW)	2
22	130606	. DECAL, FREE WHEELING VALVE	1
23	2003	. DECAL, BATTERY LEVEL	1

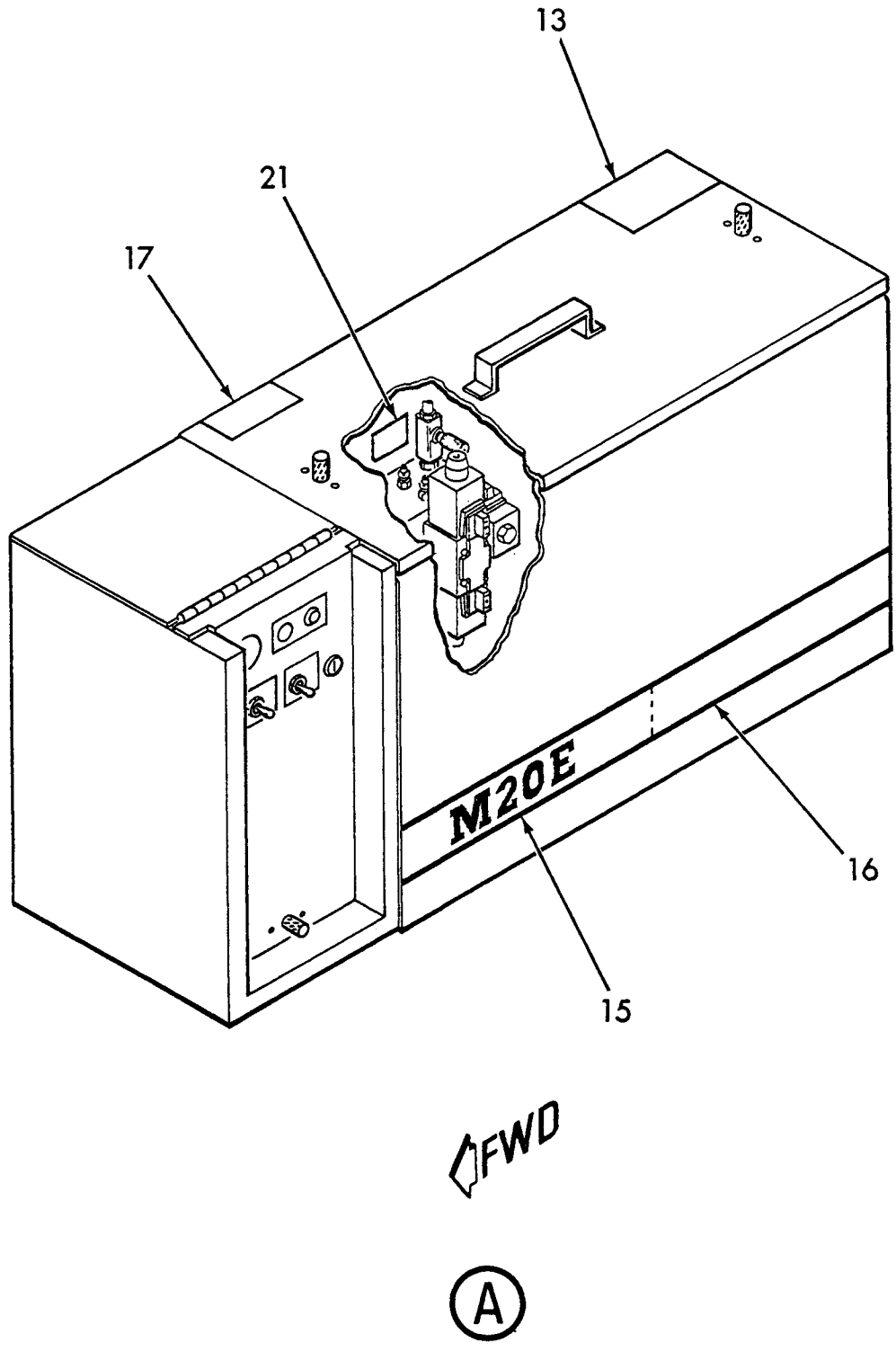
- ITEM NOT ILLUSTRATED

DECAL SET (M20E)



REV.

DECAL SET (M20E)



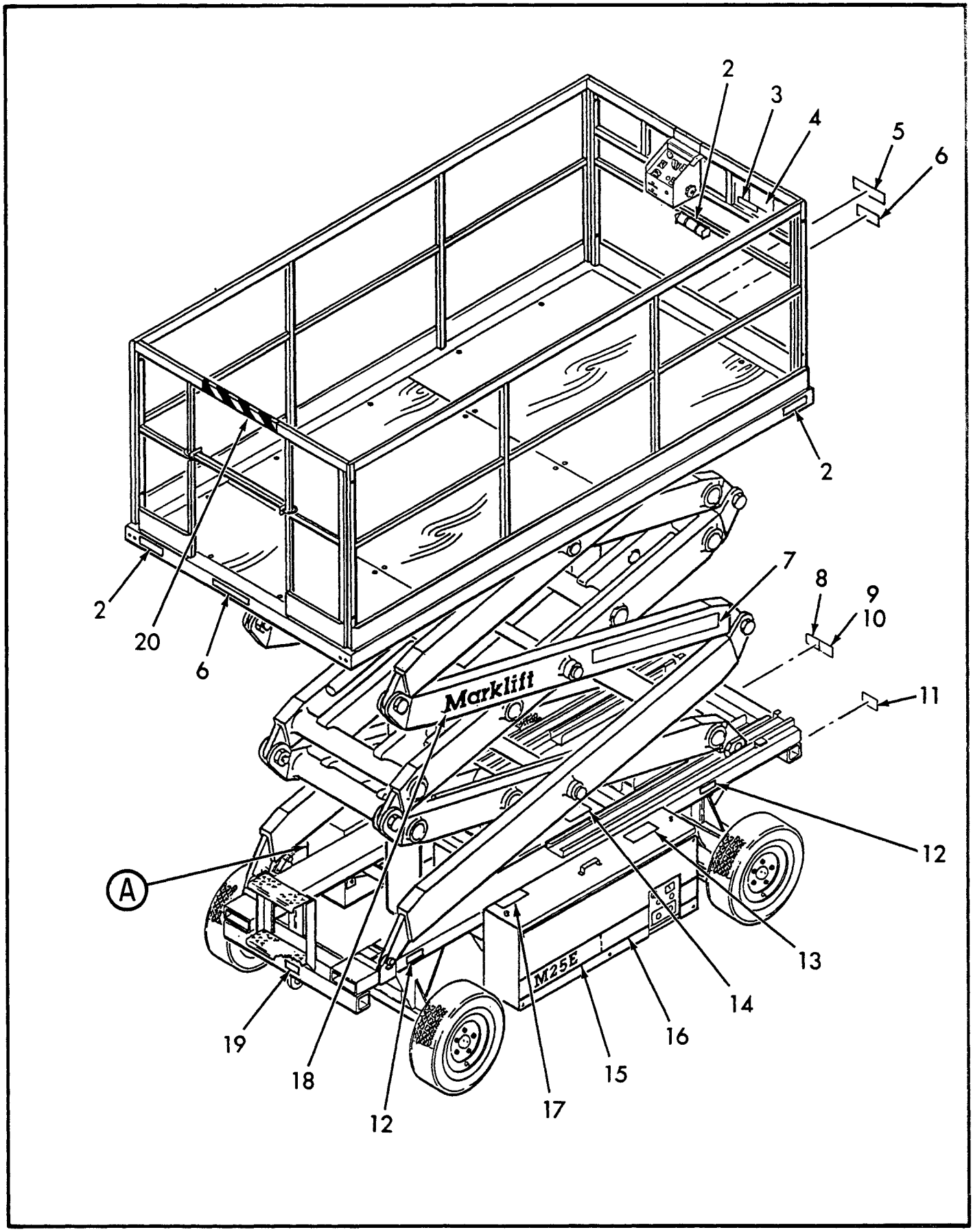
REV.

DECAL SET (M20E)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	67789	SET, DECAL (See Sect. 2, Fig. 1A for NHA)	REF
2	130820	. DECAL, OPERATION & SAFETY HANDBOOK	1
3	2024	. DECAL, LOAD CAPACITY 1000 LBS.	5
4	182732	. DECAL, OPERATION INSTRUCTION	1
5	32368	. DECAL, M-SERIES	1
6	31109	. DECAL, CAUTION SCISSOR GUARD RAILS	2
7	130596	. DECAL, A PRODUCT OF MARK INDUSTRIES	2
8	20660	. PLATE, IDENTIFICATION	1
9	20661	. PLATE, ANSI A92	1
10	63653	. RIVET, POP	8
11	2002	. DECAL, FORKLIFT BOOT	2
12	22175	. DECAL, MONOFILLED TIRES	4
13	2003	. DECAL, BATTERY WATER LEVEL	2
14	2017	. DECAL, HYDRAULIC SYSTEM FLUID	1
15	181716	. DECAL, M20E	2
16	181728	. DECAL, PANEL STRIP	2
17	2016	. DECAL, DO NOT WORK UNDER	2
18	31259	. DECAL, MARKLIFT	2
19	2041	. DECAL, DO NOT LIFT THIS END	1
20	160137	. TAPE, WARNING (BLACK & YELLOW)	2
21	130606	. DECAL, FREE WHEELING VALVE	1

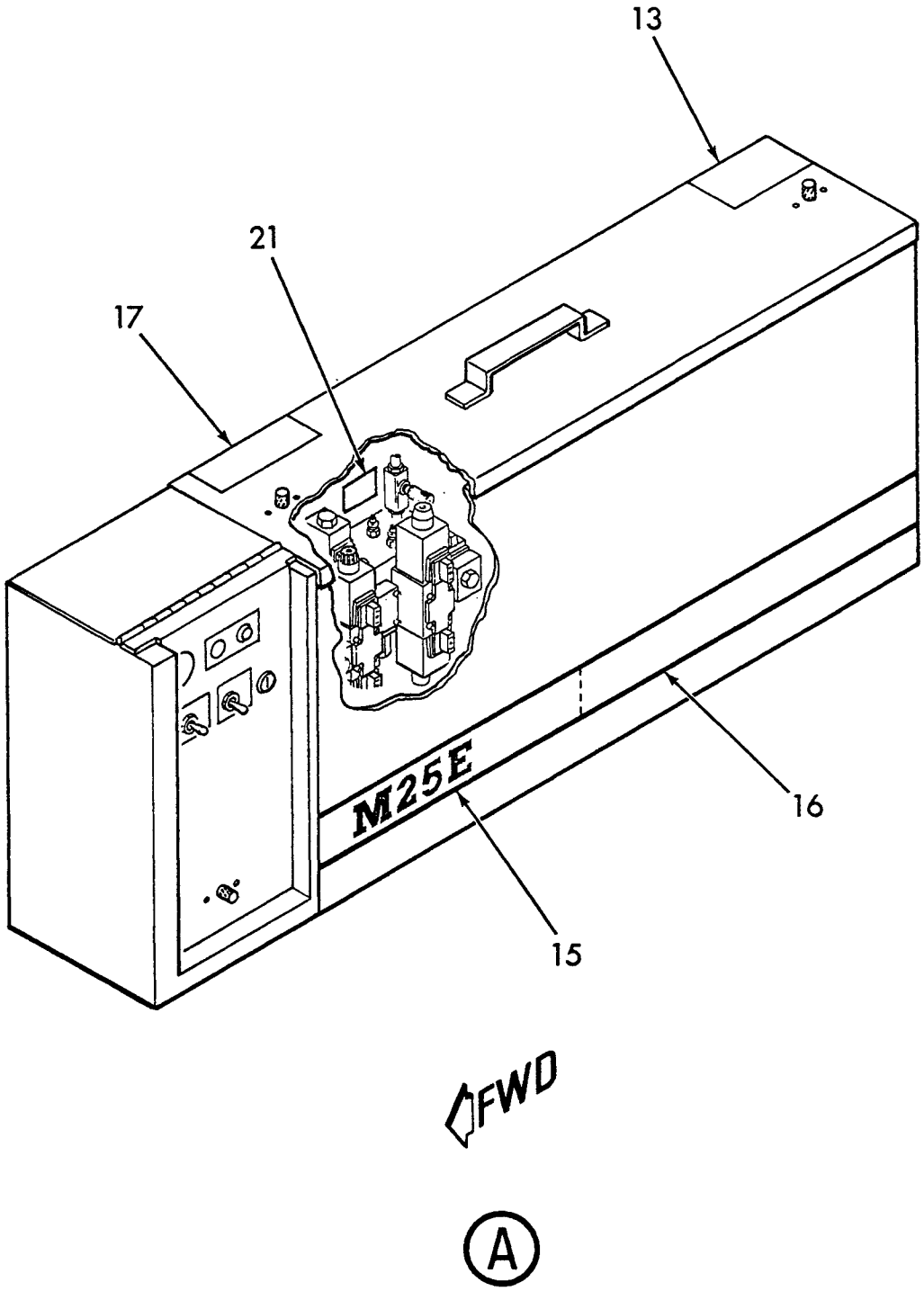
- ITEM NOT ILLUSTRATED

DECAL SET (M25E)



REV.

DECAL SET (M25E)

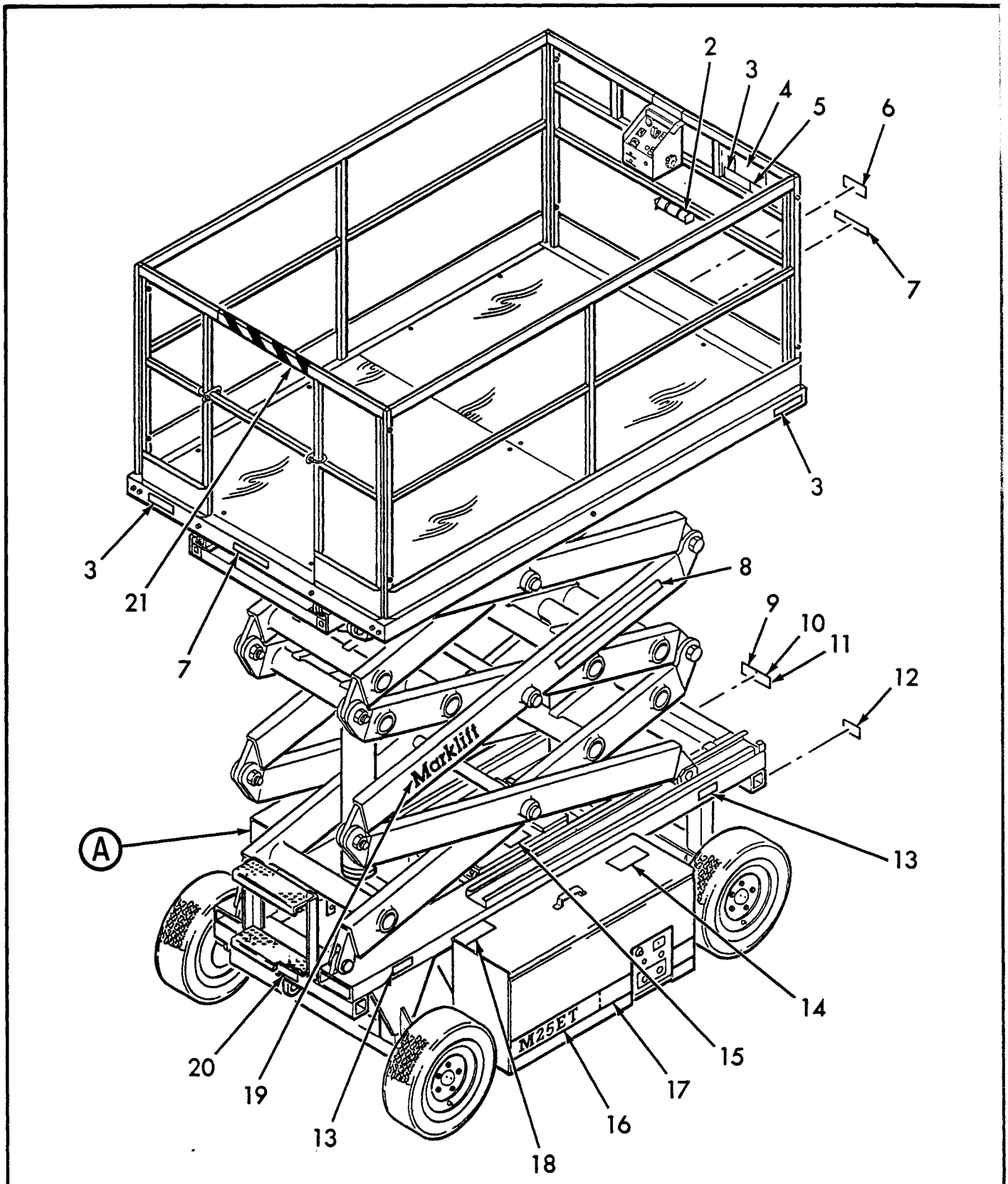


DECAL SET (M25E)

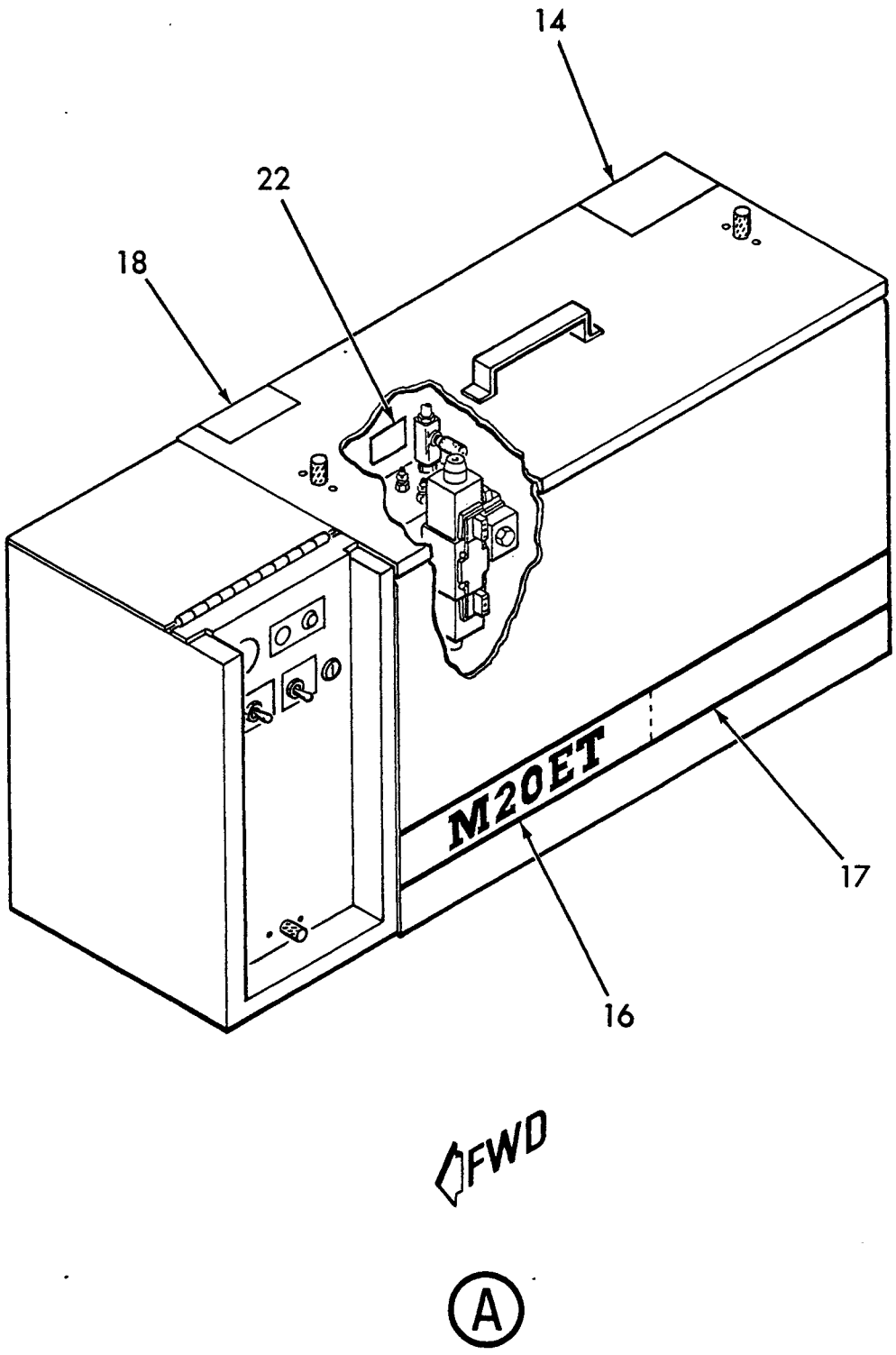
ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	67785	SET, DECAL (See Sect. 2, Fig. 1B for NHA)	REF
2	130820	. DECAL, OPERATION & SAFETY HANDBOOK	1
3	18702	. DECAL, LOAD CAPACITY 1250 LBS.	5
4	182732	. DECAL, OPERATION INSTRUCTION	1
5	32368	. DECAL, M-SERIES	1
6	31109	. DECAL, CAUTION SCISSOR GUARD RAILS	2
7	130596	. DECAL, A PRODUCT OF MARK INDUSTRIES	2
8	20660	. PLATE, IDENTIFICATION	1
9	20661	. PLATE, ANSI A92	1
10	63653	. RIVET, POP	8
11	2002	. DECAL, FORKLIFT BOOT	2
12	22175	. DECAL, MONOFILLED TIRES	4
13	2003	. DECAL, BATTERY WATER LEVEL	2
14	2017	. DECAL, HYDRAULIC SYSTEM FLUID	1
15	181718	. DECAL, M25E	2
16	181728	. DECAL, PANEL STRIP	2
17	2016	. DECAL, DO NOT WORK UNDER	2
18	31259	. DECAL, MARKLIFT	2
19	2041	. DECAL, DO NOT LIFT THIS END	1
20	160137	. TAPE, WARNING (BLACK & YELLOW)	2
21	130606	. DECAL, FREE WHEELING VALVE	1

- ITEM NOT ILLUSTRATED

DECAL SET (M20ET)



DECAL SET (M20ET)

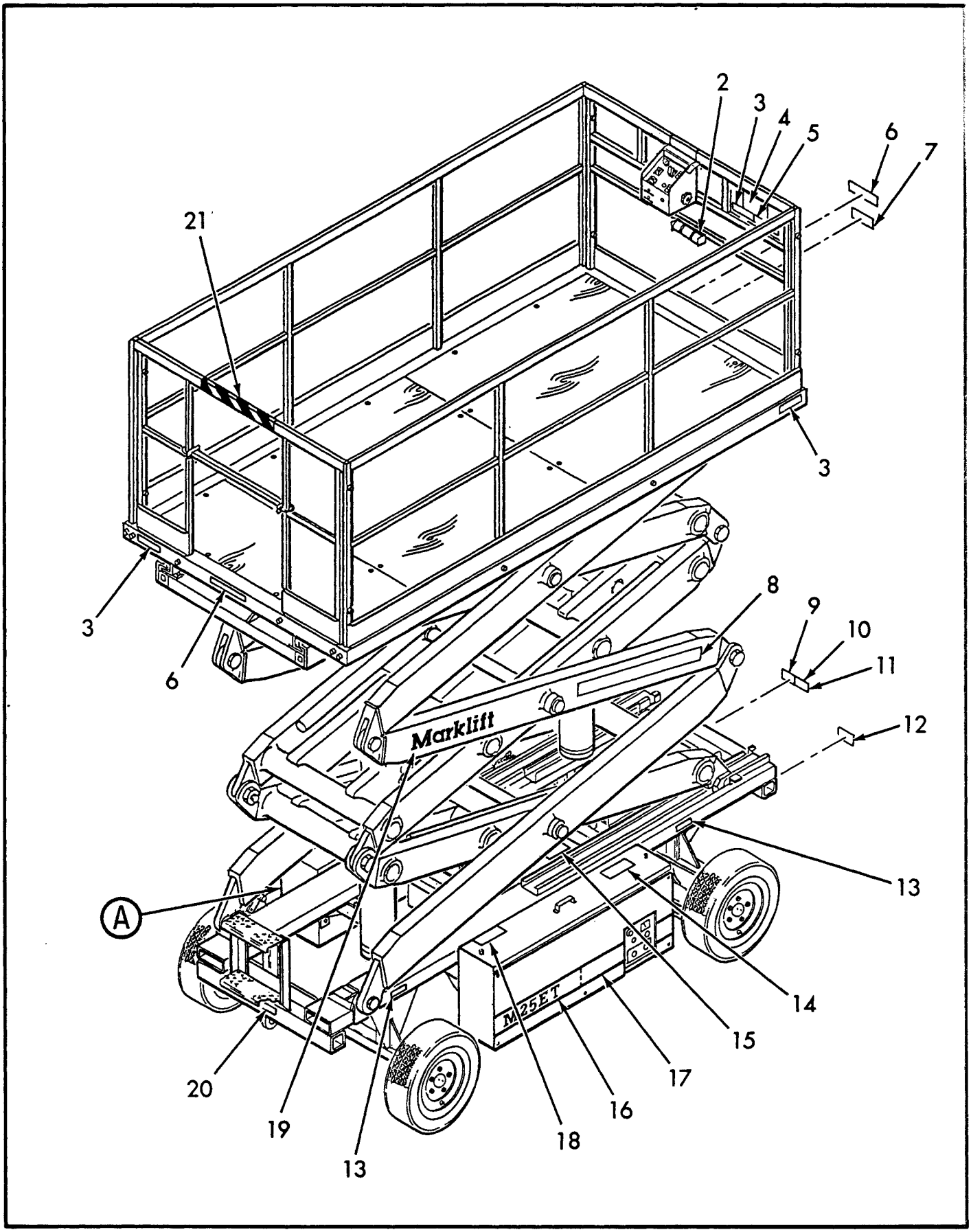


DECAL SET (M20ET)

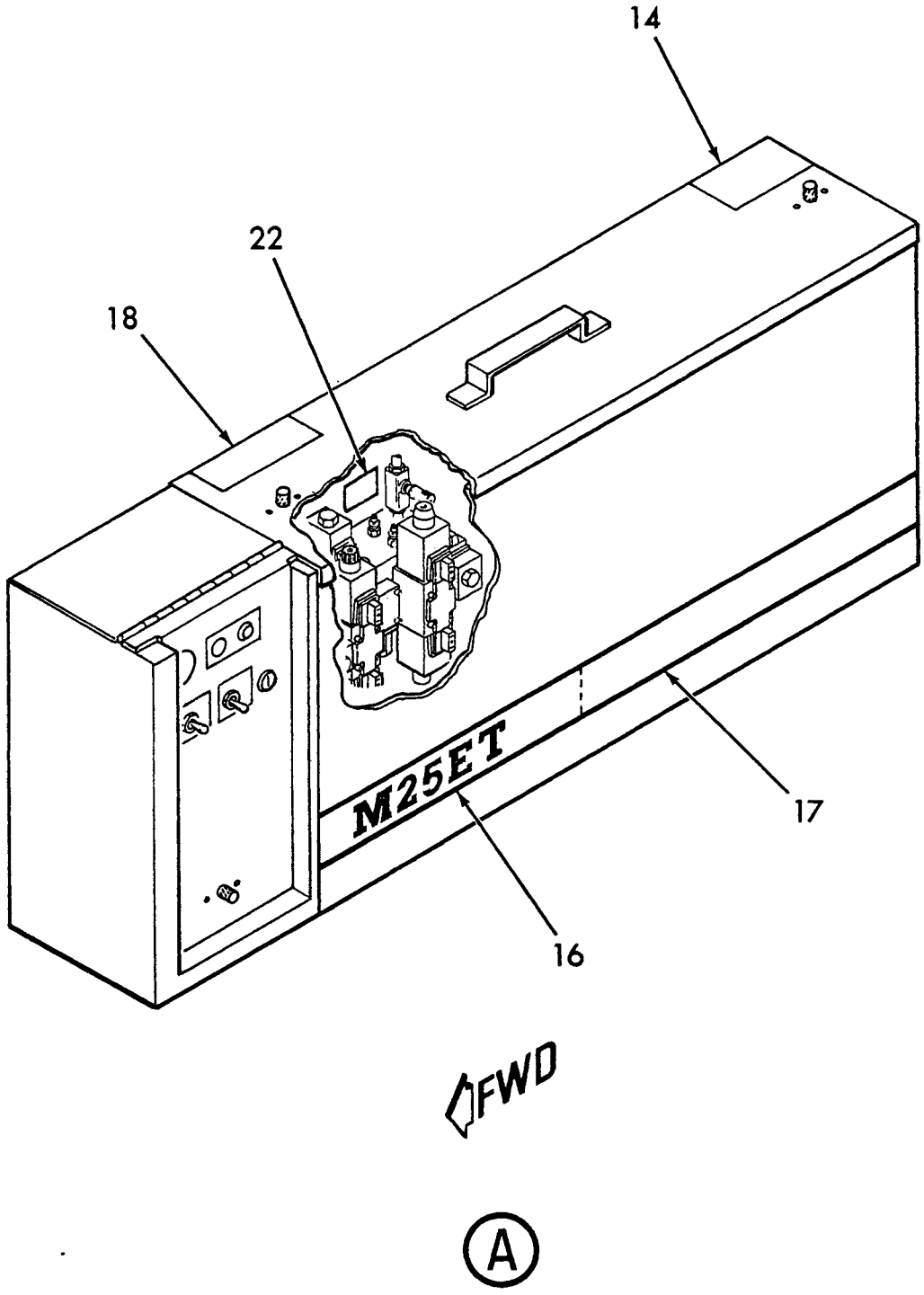
ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	67788	SET, DECAL (See Sect. 2, Fig. 1C for NHA)	REF
2	130820	. DECAL, OPERATION & SAFETY HANDBOOK	1
3	2023	. DECAL, LOAD CAPACITY 750 LBS.	5
4	182732	. DECAL, OPERATION INSTRUCTION	1
5	130802	. DECAL, EMERGENCY DOWN INSTRUCTIONS	1
6	32368	. DECAL, M-SERIES	1
7	31109	. DECAL, CAUTION SCISSOR GUARD RAILS	2
8	130596	. DECAL, A PRODUCT OF MARK INDUSTRIES	2
9	20660	. PLATE, IDENTIFICATION	1
10	20661	. PLATE, ANSI A92	1
11	63653	. RIVET, POP	8
12	2002	. DECAL, FORKLIFT BOOT	2
13	22175	. DECAL, MONOFILLED TIRES	4
14	2003	. DECAL, BATTERY WATER LEVEL	2
15	2017	. DECAL, HYDRAULIC SYSTEM FLUID	1
16	181717	. DECAL, M20ET	2
17	181728	. DECAL, PANEL STRIP	2
18	2016	. DECAL, DO NOT WORK UNDER	2
19	31259	. DECAL, MARKLIFT	2
20	2041	. DECAL, DO NOT LIFT THIS END	1
21	160137	. TAPE, WARNING (BLACK & YELLOW)	2
22	130606	. DECAL, FREE WHEELING VALVE	1

- ITEM NOT ILLUSTRATED

DECAL SET (M25ET)



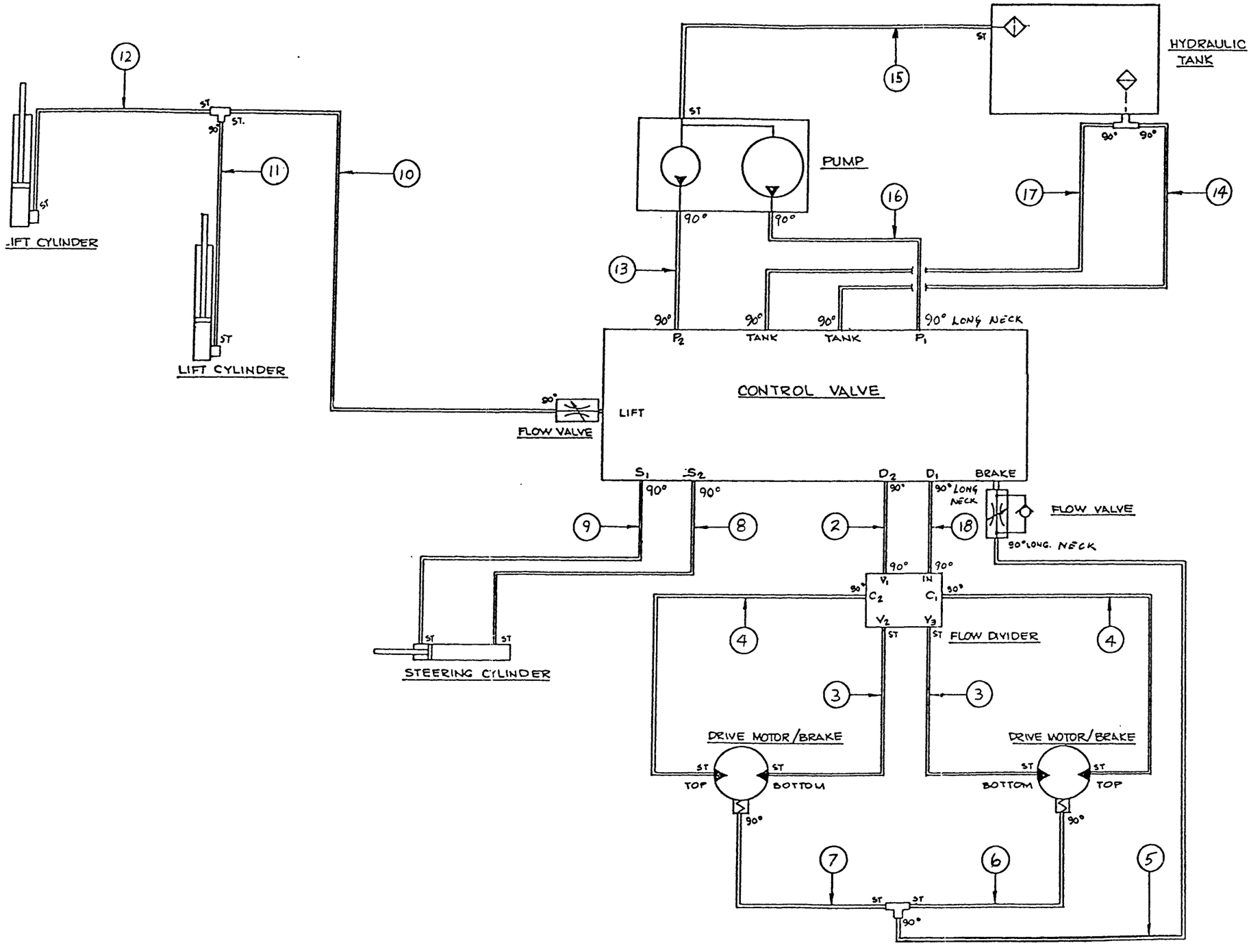
DECAL SET (M25ET)



DECAL SET (M25ET)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	67787	SET, DECAL (See Sect. 2, Fig. 1D for NHA)	REF
2	130820	. DECAL, OPERATION & SAFETY HANDBOOK	1
3	2024	. DECAL, LOAD CAPACITY 1000 LBS.	5
4	182732	. DECAL, OPERATION INSTRUCTION	1
5	130802	. DECAL, EMERGENCY DOWN INSTRUCTIONS	1
6	32368	. DECAL, M-SERIES	1
7	31109	. DECAL, CAUTION SCISSOR GUARD RAILS	2
8	130596	. DECAL, A PRODUCT OF MARK INDUSTRIES	2
9	20660	. PLATE, IDENTIFICATION	1
10	20661	. PLATE, ANSI A92	1
11	63653	. RIVET, POP	8
12	2002	. DECAL, FORKLIFT BOOT	2
13	22175	. DECAL, MONOFILLED TIRES	4
14	2003	. DECAL, BATTERY WATER LEVEL	2
15	2017	. DECAL, HYDRAULIC SYSTEM FLUID	1
16	181719	. DECAL, M25ET	2
17	181728	. DECAL, PANEL STRIP	2
18	2016	. DECAL, DO NOT WORK UNDER	2
19	31259	. DECAL, MARKLIFT	2
20	2041	. DECAL, DO NOT LIFT THIS END	1
21	160137	. TAPE, WARNING (BLACK & YELLOW)	2
22	130606	. DECAL, FREE WHEELING VALVE	1

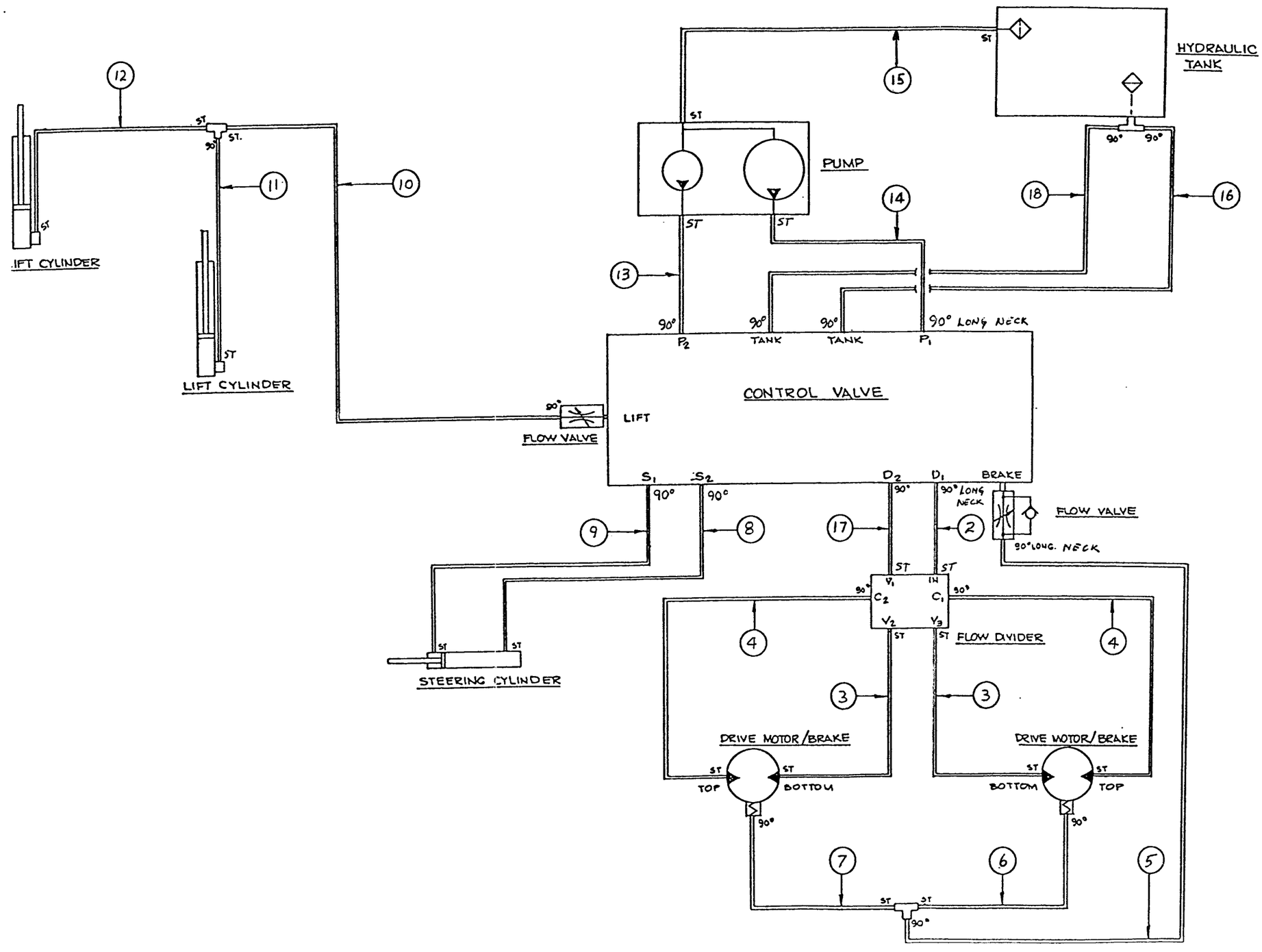
- ITEM NOT ILLUSTRATED


12
ST
90°
ST.
11
10
ST
LIFT CYLINDER
ST
LIFT CYLINDER
90°
FLOW VALVE
ST
ST
STEERING CYLINDER
15
ST
HYDRAULIC TANK
ST
PUMP
90°
90°
90°
90°
16
17
14
13
90°
90°
90°
90° LONG NECK
P2
TANK
TANK
P1
CONTROL VALVE
LIFT
S1
S2
D2
D1
BRAKE
90°
90°
90°
90° LONG NECK
9
8
2
18
FLOW VALVE
90° LONG. NECK
90°
90°
V1
IN
C2
C1
V2
V3
ST
ST
FLOW DIVIDER
4
4
3
3
DRIVE MOTOR/BRAKE
DRIVE MOTOR/BRAKE
ST
ST
TOP
BOTTOM
ST
ST
BOTTOM
TOP
90°
90°
7
6
5
ST
ST
90°

HYDRAULIC HOSE DIAGRAM (M20GP)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	131879	DIAGRAM, HYDRAULIC HOSE	REF
2	13214-08-0420-90°	. HOSE ASSEMBLY	1
3	13210-08-0290	.	2
4	13213-08-0290	.	2
5	13215-04-0450	.	1
6	13213-04-0280	.	1
7	13213-04-0340	.	1
8	13213-04-0510	.	1
9	13213-04-0550	.	1
10	13210-06-1600	.	1
11	13213-06-0310	.	1
12	13210-06-1100	.	1
13	13214-08-0520	.	1
14	13214-10-0320-180°	.	1
15	13205-16-0330	.	1
16	13215-08-0520	.	1
17	13214-10-0340-180°	.	1
18	13215-08-0470-90°	. HOSE ASSEMBLY	1

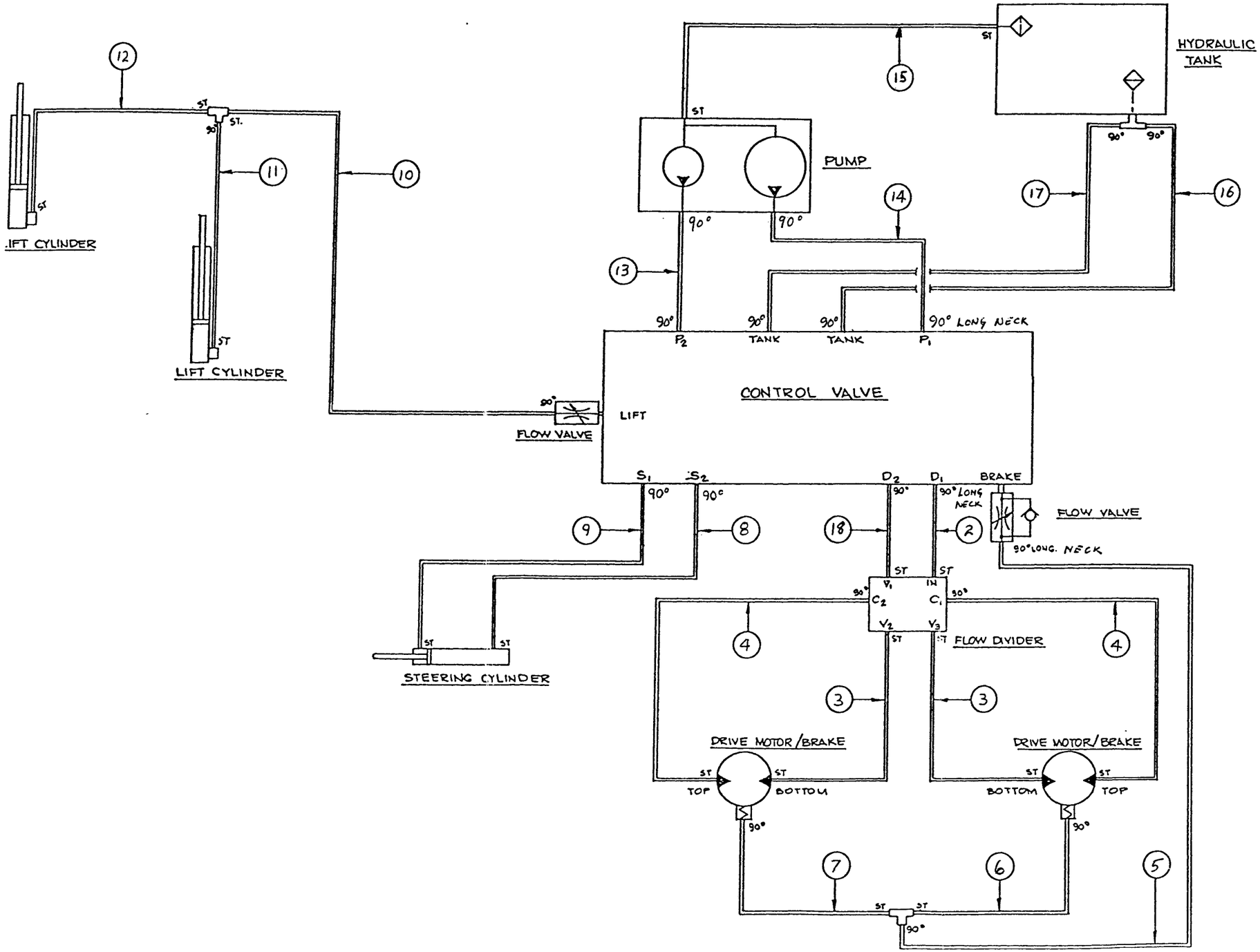
- ITEM NOT ILLUSTRATED


12
ST
ST.
90°
11
10
ST
LIFT CYLINDER
ST
LIFT CYLINDER
90°
FLOW VALVE
15
ST
HYDRAULIC TANK
ST
PUMP
90°
90°
18
16
14
ST
ST
13
90°
90°
90°
90° LONG NECK
P2
TANK
TANK
P1
CONTROL VALVE
LIFT
S1
S2
D2
D1
BRAKE
90°
90°
90°
90° LONG NECK
9
8
17
2
FLOW VALVE
90° LONG. NECK
ST
ST
ST
ST
V1
IN
C2
C1
V2
V3
ST
ST
FLOW DIVIDER
4
4
3
3
STEERING CYLINDER
DRIVE MOTOR/BRAKE
DRIVE MOTOR/BRAKE
ST
ST
TOP
BOTTOM
BOTTOM
TOP
90°
90°
7
6
5
ST
ST
90°

HYDRAULIC HOSE DIAGRAM (M20E & M20ET)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	131882	DIAGRAM, HYDRAULIC HOSE	REF
2	13215-08-0330-90°	. HOSE ASSEMBLY	1
3	13210-08-0290	.	2
4	13213-08-0300	.	2
5	13215-04-0330	.	1
6	13213-04-0340	.	1
7	13213-04-0310	.	1
8	13213-04-0440	.	1
9	13213-04-0470	.	1
10	13210-06-1640	.	1
11	13213-06-0310	.	1
12	13210-06-1100	.	1
13	13213-08-0550	.	1
14	13212-08-0550	.	1
15	13203-12-0240	.	1
16	13214-10-0450-180°	.	2
17	13214-08-0300-90°	.	1
18	13214-10-0520-180°	. HOSE ASSEMBLY	1

- ITEM NOT ILLUSTRATED

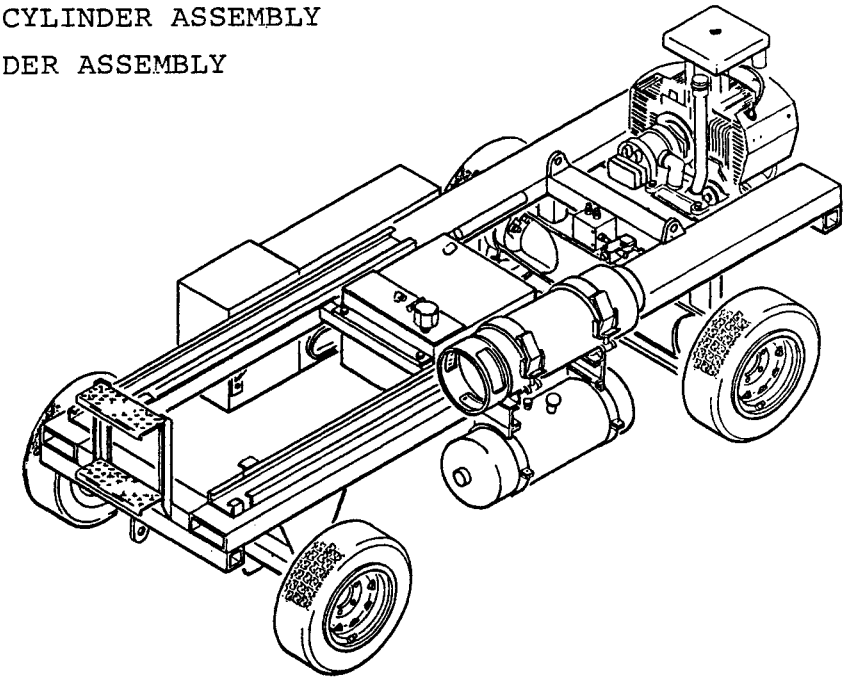

12
ST
90°
ST.
11
10
ST
LIFT CYLINDER
ST
LIFT CYLINDER
HYDRAULIC TANK
ST
15
ST
PUMP
90°
90°
14
17
16
13
90°
90°
90°
90°
90° LONG NECK
P2
TANK
TANK
P1
CONTROL VALVE
LIFT
90°
FLOW VALVE
S1
S2
D2
D1
BRAKE
90°
90°
90° LONG NECK
9
8
18
2
FLOW VALVE
90° LONG. NECK
ST
ST
V1
IN
90°
C2
C1
90°
V2
V3
ST
ST
FLOW DIVIDER
ST
ST
4
4
3
3
STEERING CYLINDER
DRIVE MOTOR/BRAKE
DRIVE MOTOR/BRAKE
ST
ST
TOP
BOTTOM
ST
ST
BOTTOM
TOP
90°
90°
7
6
5
ST
ST
90°

HYDRAULIC HOSE DIAGRAM (M25E & M25ET)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	131878	DIAGRAM, HYDRAULIC HOSE	REF
2	13215-08-0360-90°	. HOSE ASSEMBLY	1
3	13210-08-0330	.	2
4	13213-08-0340	.	2
5	13215-04-0360	.	1
6	13213-04-0350	.	1
7	13213-04-0330	.	1
8	13213-04-0500	.	1
9	13213-04-0520	.	1
10	13210-06-1930	.	1
11	13210-06-0280	.	1
12	13210-06-1320	.	1
13	13213-08-0630	.	1
14	13212-08-0660	.	1
15	13203-12-0240	.	1
16	13214-10-0420-180°	.	1
17	13214-10-0380-180°	.	1
18	13214-08-0330-90°	. HOSE ASSEMBLY	1

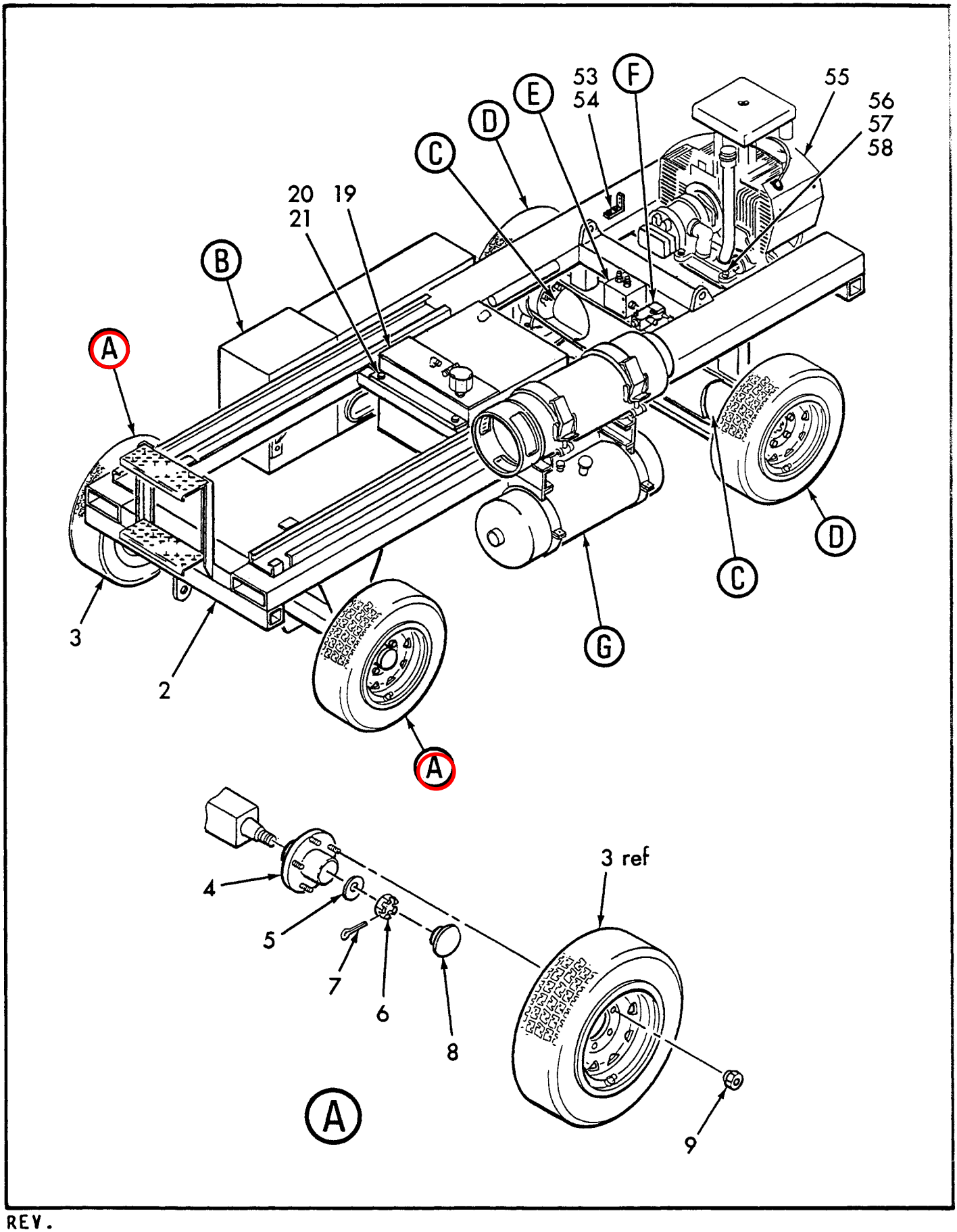
- ITEM NOT ILLUSTRATED

SECTION 3 CONTAINS:



SECTION 3 (CONT'D)

FRAME ASSEMBLY (M20GP)



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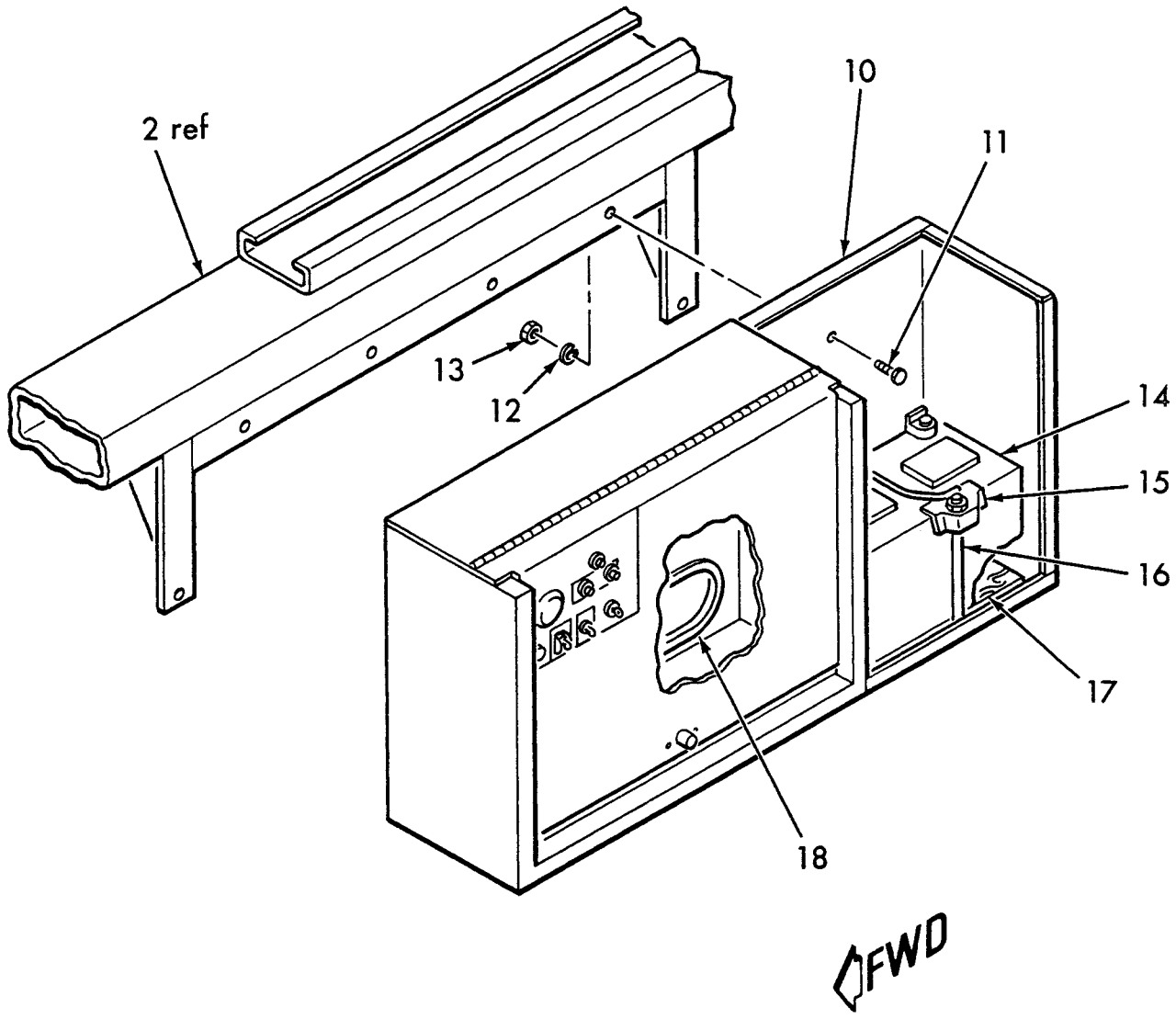

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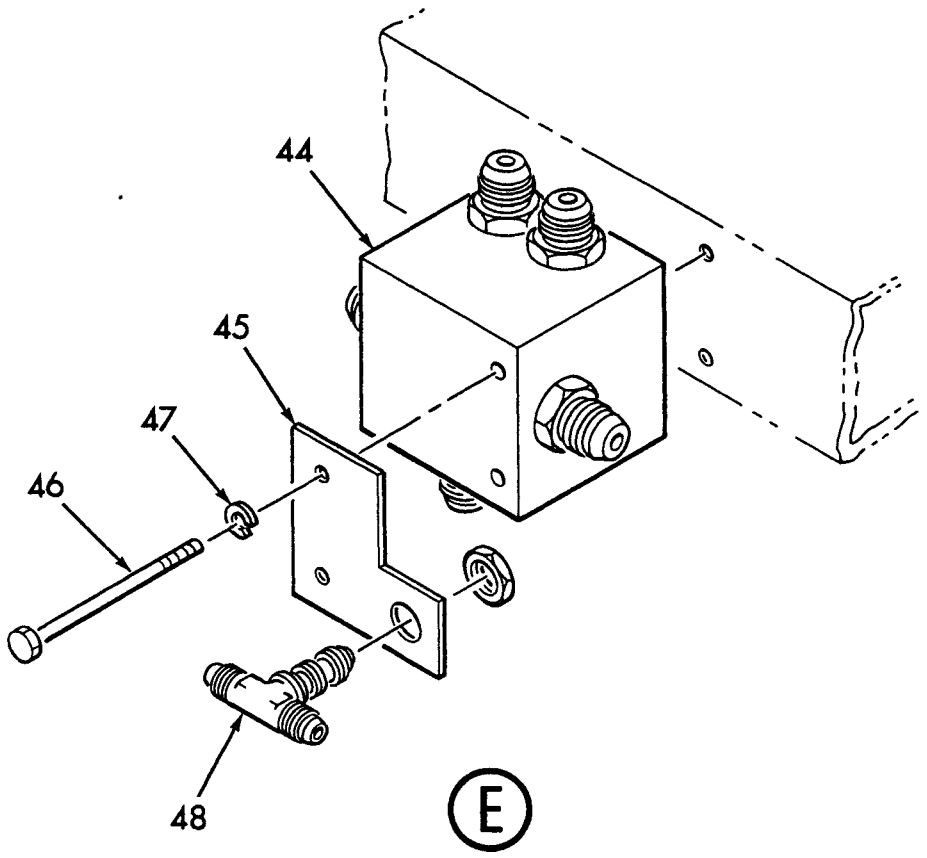
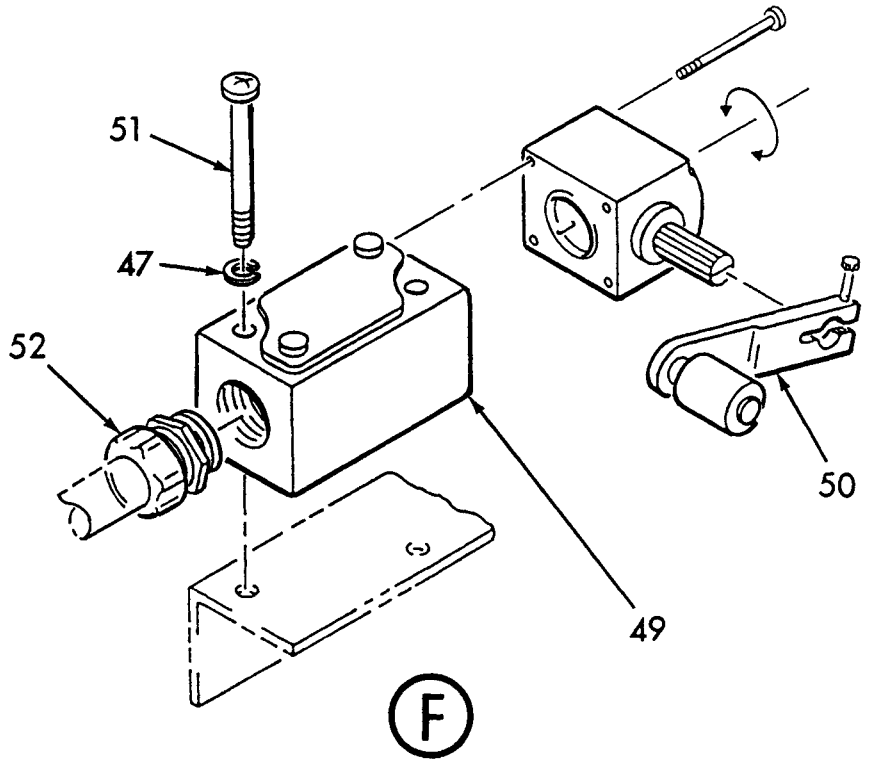
FRAME ASSEMBLY (M20GP)





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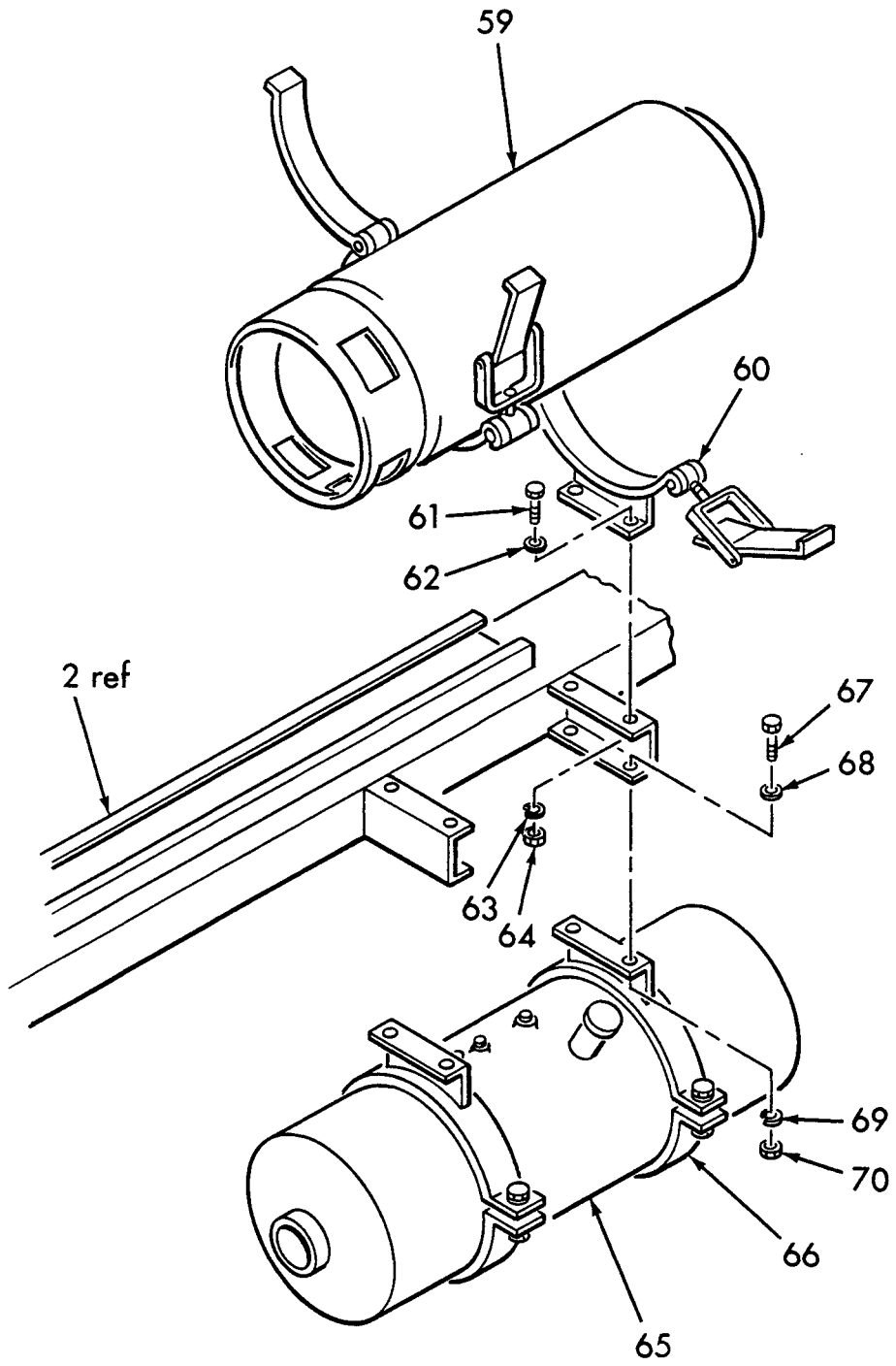

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REV.

FRAME ASSEMBLY (M20GP)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	131388	ASSEMBLY, FRAME (See Sect. 2, Fig. 1 for NHA)	REF
2	131389	. WELDMENT, FRAME	1
3	130661	. ASSEMBLY, TIRE & WHEEL (See Sect. 3, Fig. 2 for Details)	4
4	134-1	. ASSEMBLY, HUB (See Sect. 3, Fig. 3 for Details)	2
5	63409	. WASHER, FLAT	2
6	60811	. NUT, SLOTTED HEX	2
7	64306	. PIN, COTTER	2
8	137	. CAP, DUST	2
9	61316	. NUT, WHEEL	10
10	131844	. ASSEMBLY, CONTROL/COMPONENT BOX (See Sect. 3, Fig. 4 for Details)	1
11	60383	. SCREW, CAP	6
12	63305	. WASHER, LOCK	6
13	61242	. NUT, HEX	6
14	4030	. BATTERY	1
15	20375	. CLAMP, BATTERY	1
16	65108	. BOLT, HOLD DOWN	2
17	131570	. PLYWOOD, BATTERY	1
18	411-26.6	. EXTENSION, RUBBER MOLDING	26.6"
19	131439	. ASSEMBLY, HYDRAULIC TANK (See Sect. 3, Fig. 5 for Details)	1
20	60343	. SCREW, CAP	4
21	63319	. WASHER, LOCK	4
22	131527	. ASSEMBLY, DRIVE MOTOR/BRAKE (L.H.) (See Sect. 3, Fig. 6 for Details)	1
23	130395	. MACHINING, STEERING LEVER ARM (L.H.)	1

- ITEM NOT ILLUSTRATED

FRAME ASSEMBLY (M20GP)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
24	60622	. SCREW, CAP	3
25	131528	. ASSEMBLY, DRIVE MOTOR/BRAKE (R.H.) (See Sect. 3, Fig. 7 for Details)	1
26	130396	. MACHINING, STEERING LEVER ARM (R.H.)	1
27	60622	. SCREW, CAP	2
28	130469	. ASSEMBLY, TIE ROD (See Sect. 3, Fig. 8 for Details)	1
29	60393	. SCREW, CAP	2
30	61242	. NUT, LOCK	2
31	130237	. ASSEMBLY, STEERING CYLINDER (See Sect. 3, Fig. 9 for Details)	1
32	20252	. PIN, STEERING CYLINDER ANCHOR	2
33	60353	. SCREW, CAP	2
34	63301	. WASHER, LOCK	2
35	65658	. BEARING, THRUST	2
36	131467	. PIN, STEERING	4
37	65103	. FITTING, GREASE	4
38	60338	. SCREW, CAP	8
39	63302	. WASHER, LOCK	8
40	131372	. HUB, DRIVE	2
41	65174	. NUT, SLOTTED JAM	2
42	64306	. PIN, COTTER	2
43	61316	. NUT, WHEEL	10
44	131526	. ASSEMBLY, FLOW DIVIDER (See Sect. 3, Fig. 10 for Details)	1
45	131546	. BRACKET, BULKHEAD	1
46	60377	. SCREW, CAP	2
47	63313	. WASHER, LOCK	4

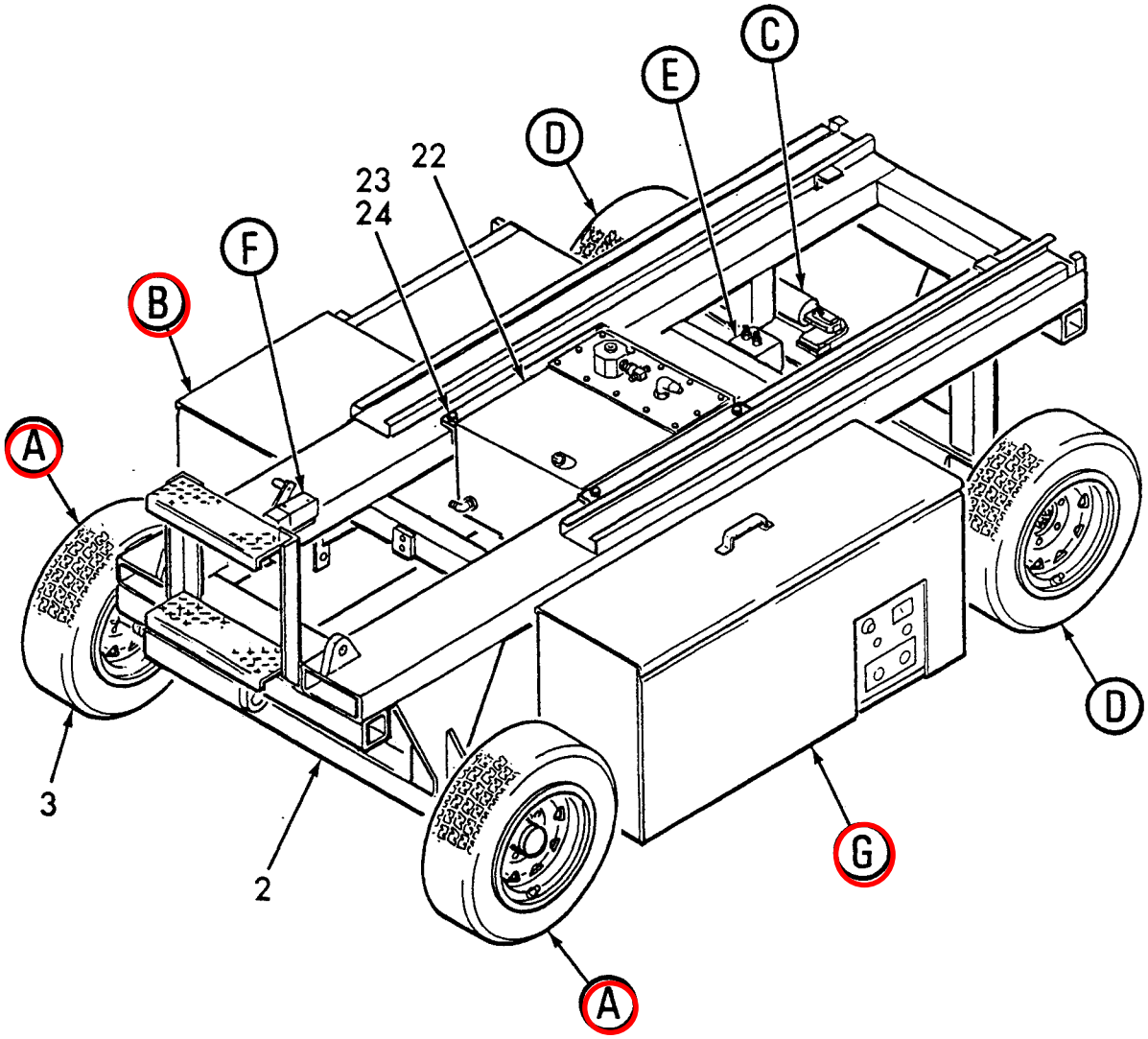
- ITEM NOT ILLUSTRATED

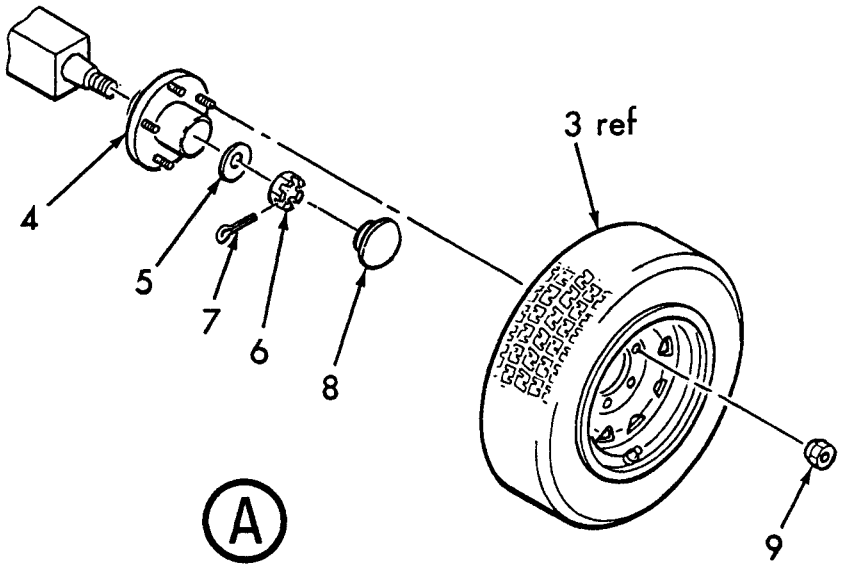
FRAME ASSEMBLY (M20GP)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
48	80035-03	. TEE, BULKHEAD BRANCH	1
49	70173	. SWITCH, LIMIT	1
50	70032	. LEVER, OPERATING	1
51	62615	. SCREW, MACHINE	2
52	70288	. RELIEF, STRAIN	1
53	131559	. BRACKET, LPG REGULATOR	1
54	60353	. SCREW, CAP	4
55	131374	. ASSEMBLY, ENGINE/PUMP (See Sect. 3, Fig. 11 for Details)	1
56	60368	. SCREW, CAP	4
57	63506	. WASHER, FLAT	8
58	63304	. WASHER, LOCK	4
59	486-C	. TANK, LPG	1
60	486-A	. BRACKET, LPG TANK	2
61	60343	. SCREW, CAP	4
62	63403	. WASHER, FLAT	4
63	63319	. WASHER, LOCK	4
64	60703	. NUT, HEX	4
65	131371	. TANK, GAS	1
66	131449	. BRACKET, GAS TANK	2
67	60343	. SCREW, CAP	4
68	63403	. WASHER, FLAT	4
69	63319	. WASHER, LOCK	4
70	60703	. NUT, HEX	4

- ITEM NOT ILLUSTRATED

FRAME ASSEMBLY (M20E)





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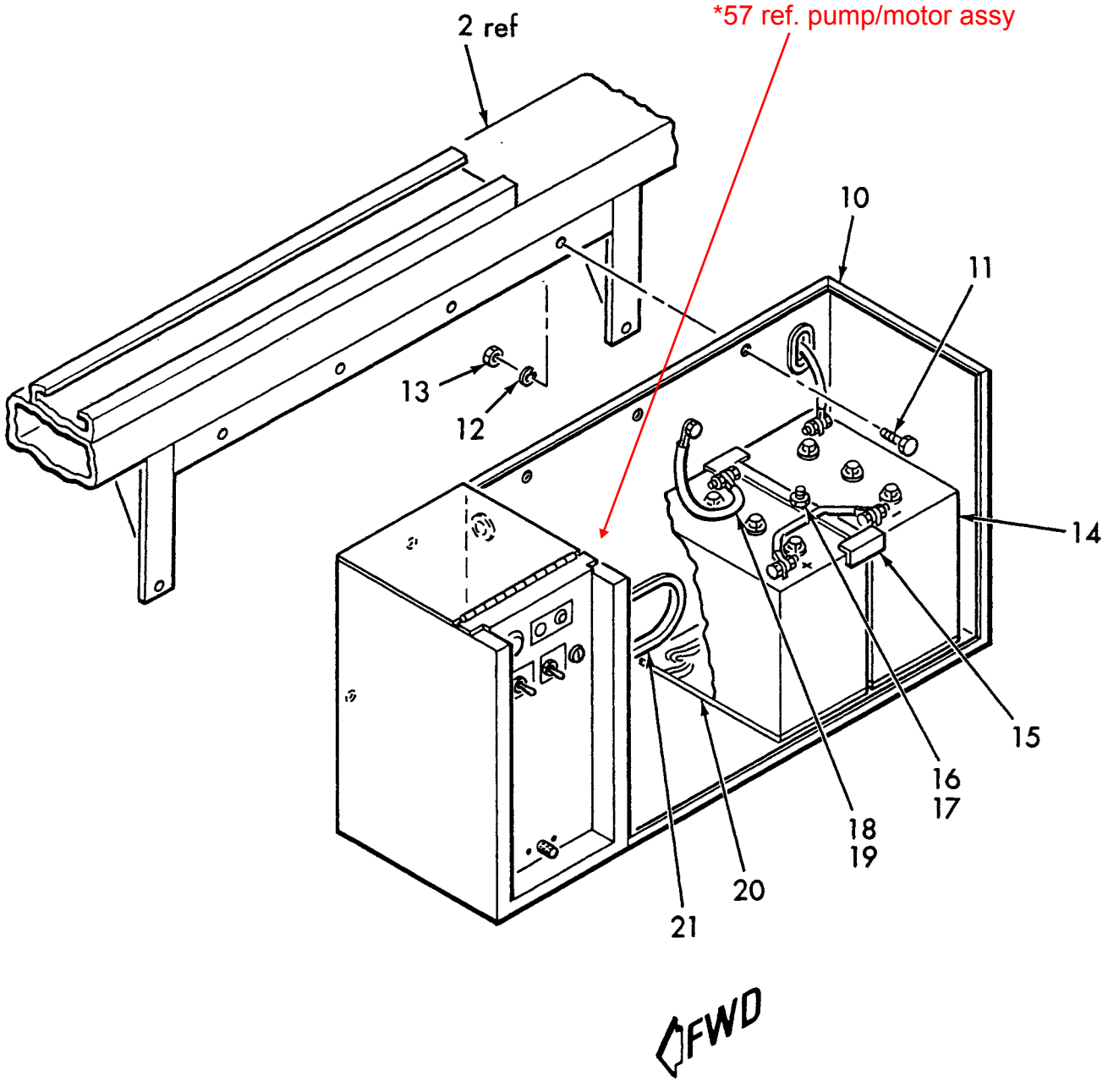

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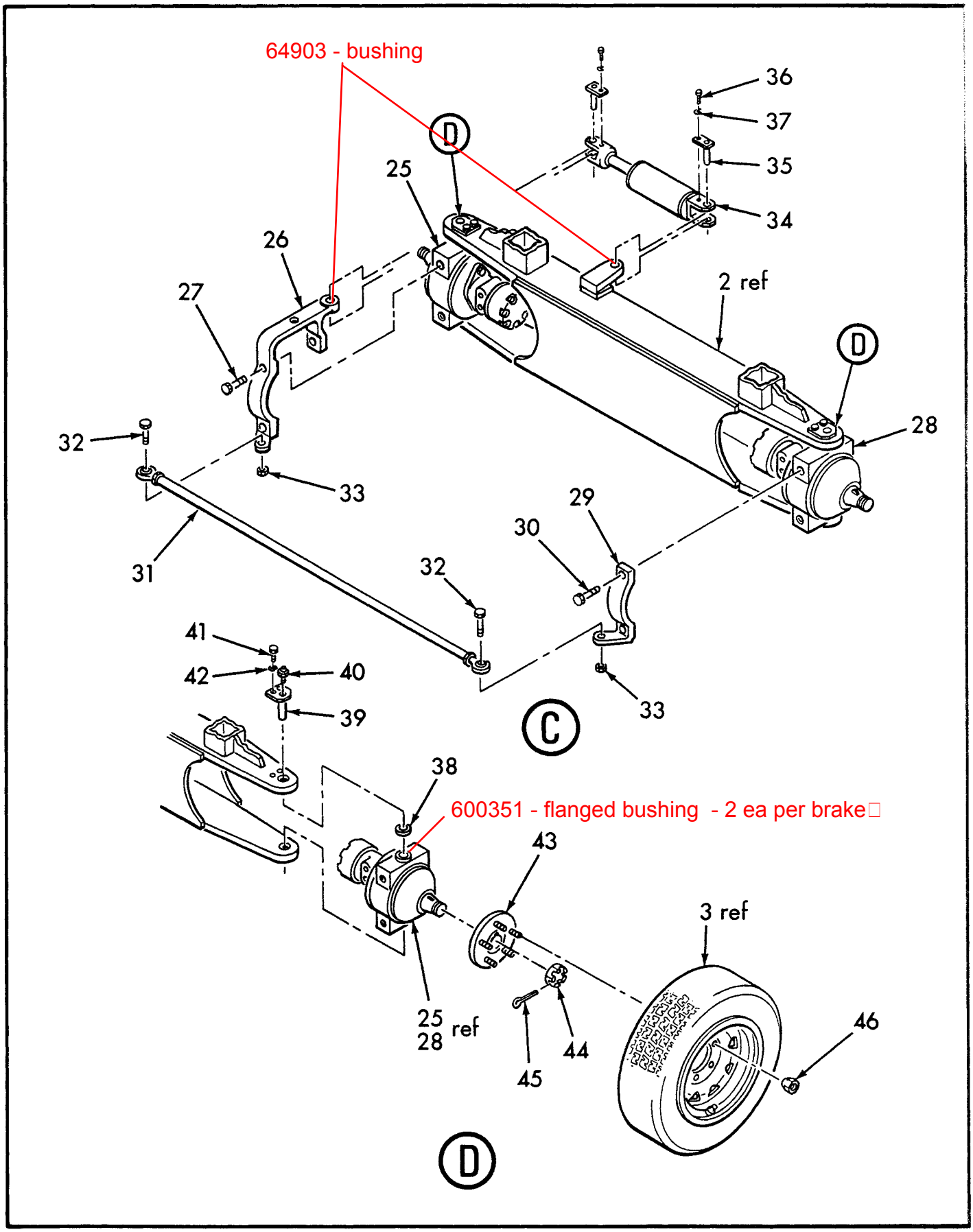
64903 - bushing
36
37
35
34
25
26
27
2 ref
28
32
33
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30
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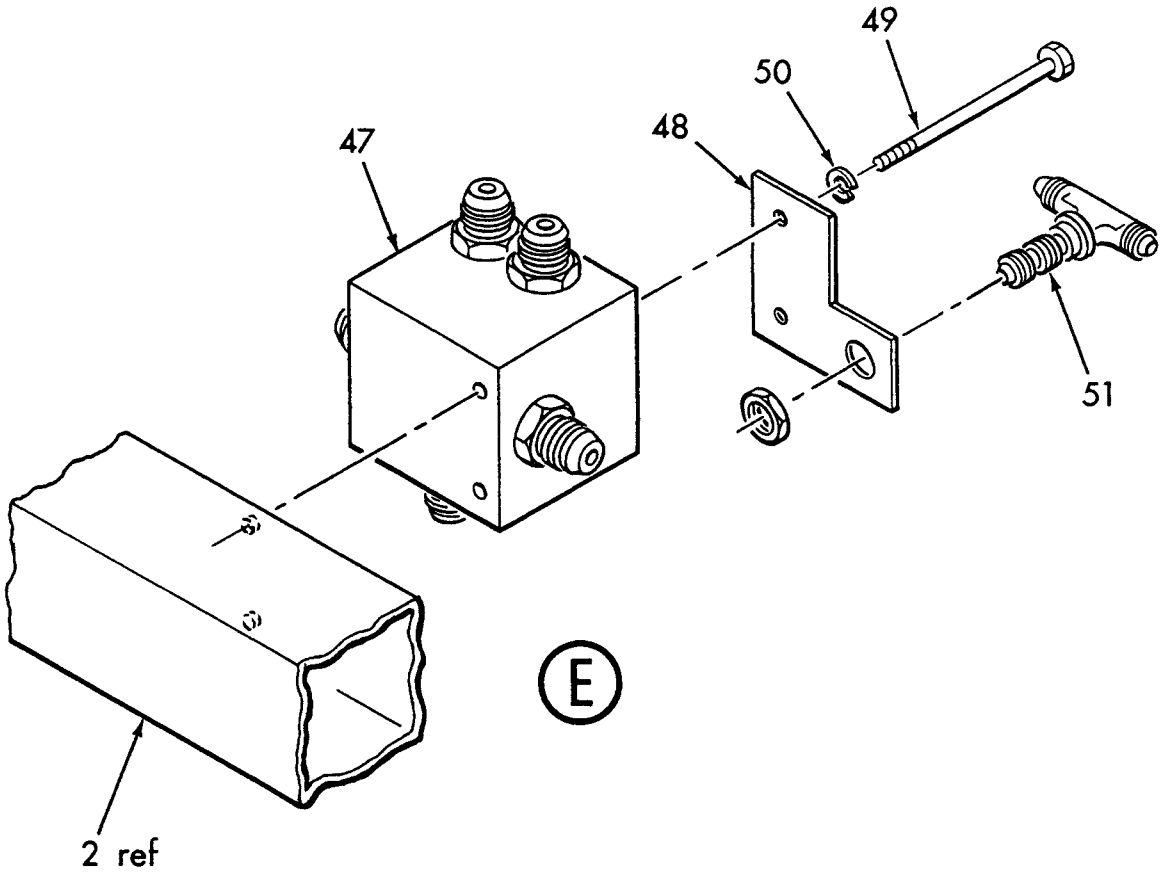
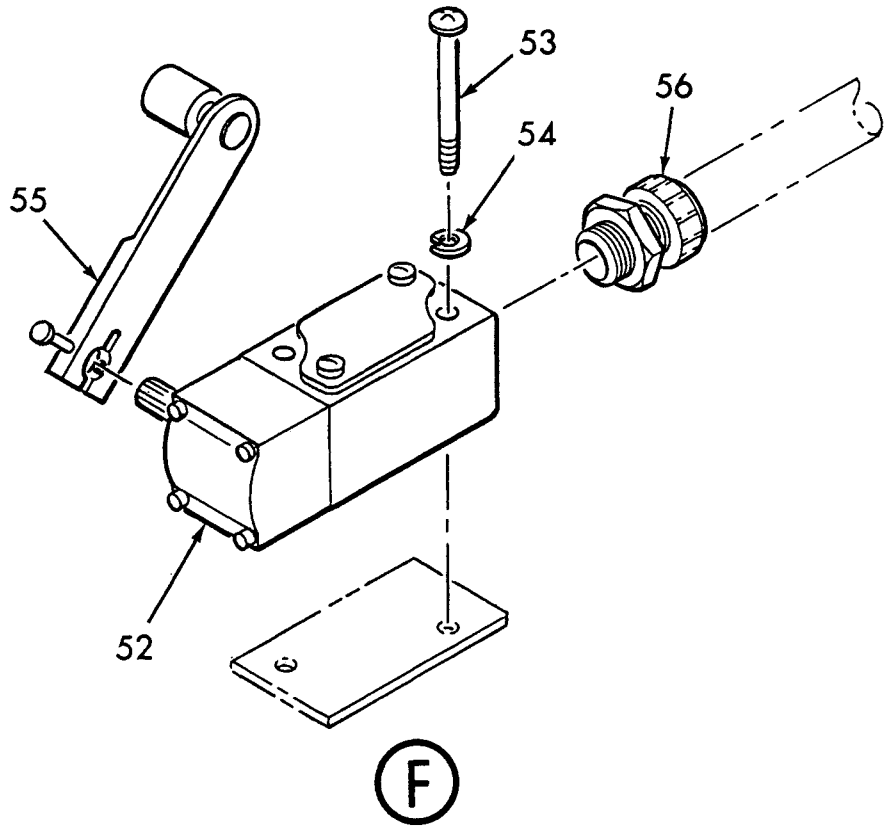
41
42
40
39
33
38
600351 - flanged bushing - 2 ea per brake
43
3 ref
25
28 ref
44
45
46
D
C
D

FRAME ASSEMBLY (M20E)





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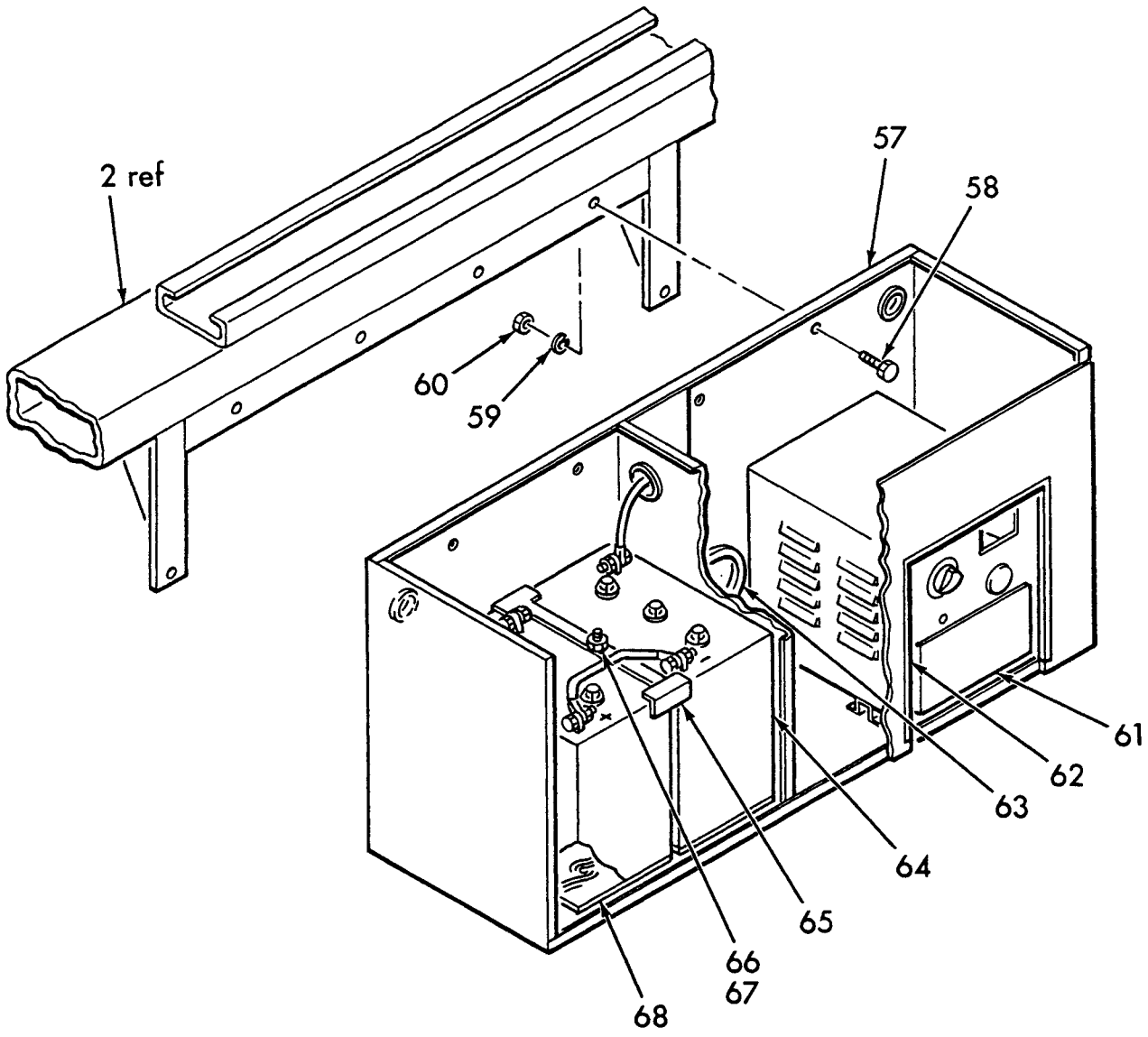
FRAME ASSEMBLY (M20E)



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REV.

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	131391	ASSEMBLY, FRAME (See Sect. 2, Fig. 1A for NHA)	REF
2	131390	. WELDMENT, FRAME	1
3	130661	. ASSEMBLY, TIRE & WHEEL (See Sect. 3, Fig. 2 for Details)	4
4	134-1	. ASSEMBLY, HUB (See Sect. 3, Fig. 3 for Details)	2
5	63409	. WASHER, FLAT	2
6	60811	. NUT, SLOTTED HEX	2
7	64306	. PIN, COTTER	2
8	137	. CAP, DUST	2
9	61316	. NUT, WHEEL	10
10	131843	. ASSEMBLY, CONTROL/COMPONENT BOX (See Sect. 3, Fig. 4A for Details)	1
11	60383	. SCREW, CAP	6
12	63305	. WASHER, LOCK	6
13	61242	. NUT, HEX	6
14	4007	. BATTERY	2
15	131543	. RETAINER, BATTERY	1
16	160155	. ROD, THREADED	1
17	61239	. NUT, LOCK	3
18	131566	. KIT, BATTERY CABLE (See Sect. 3, Fig. 17 for Details)	1
19	60312	. SCREW, CAP	1
20	131570	. PLYWOOD, BATTERY	2
21	411-26.6	. EXTENSION, RUBBER MOLDING	26.6"
22	131394	. ASSEMBLY, HYDRAULIC TANK (See Sect. 3, Fig. 5A for Details)	1
23	60343	. SCREW, CAP	4

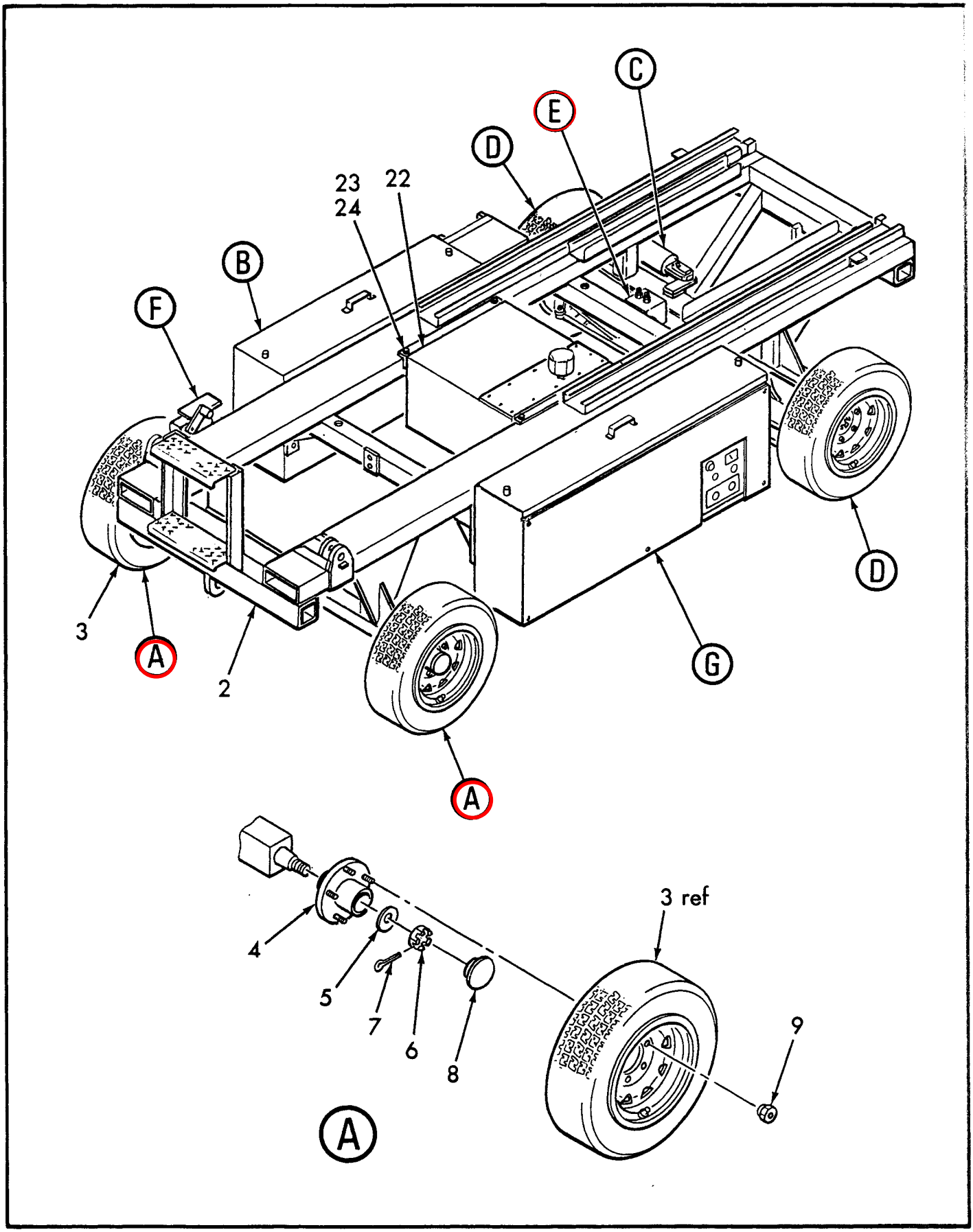
ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
24	63319	. WASHER, LOCK	4
25	131527	. ASSEMBLY, DRIVE MOTOR/BRAKE (L.H.) (See Sect. 3, Fig. 6 for Details)	1
26	130395	. MACHINING, STEERING LEVER ARM (L.H.)	1
27	60622	. SCREW, CAP	3
28	131528	. ASSEMBLY, DRIVE MOTOR/BRAKE (R.H.) (See Sect. 3, Fig. 7 for Details)	1
29	130396	. MACHINING, STEERING LEVER ARM (R.H.)	1
30	60622	. SCREW, CAP	2
31	130469	. ASSEMBLY, TIE ROD (See Sect. 3, Fig. 8 for Details)	1
32	60393	. SCREW, CAP	2
33	61242	. NUT, LOCK	2
34	130237	. ASSEMBLY, STEERING CYLINDER (See Sect. 3, Fig. 9 for Details)	1
35	20252	. PIN, STEERING CYLINDER ANCHOR	2
36	60353	. SCREW, CAP	2
37	63301	. WASHER, LOCK	2
38	65658	. BEARING, THRUST	2
39	131467	. PIN, STEERING	4
40	65103	. FITTING, GREASE	4
41	60338	. SCREW, CAP	8
42	63302	. WASHER, LOCK	8
43	131372	. HUB, DRIVE	2
44	65174	. NUT, SLOTTED JAM	2
45	64306	. PIN, COTTER	2
46	61316	. NUT, WHEEL	10

FRAME ASSEMBLY (M20E)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
47	131526	. ASSEMBLY, FLOW DIVIDER (See Sect. 3, Fig. 10 for Details)	1
48	131546	. BRACKET, BULKHEAD	1
49	60377	. SCREW, CAP	2
50	63313	. WASHER, LOCK	4
51	80035-03	. TEE, BULKHEAD BRANCH	1
52	70173	. SWITCH, LIMIT	1
53	62615	. SCREW, MACHINE	2
54	63313	. WASHER, LOCK	2
55	70032	. LEVER, OPERATING	1
56	70288	. RELIEF, STRAIN	1
57	131557	. ASSEMBLY, COMPONENT BOX (See Sect. 3, Fig. 14A for Details)	1
*57			
58	60383	. SCREW, CAP	6
59	63305	. WASHER, LOCK	6
60	61242	. NUT, HEX	6
61	70478	. CHARGER, BATTERY (See Sect. 3, Fig. 19 for Details)	1
62	411-31	. EXTRUSION, RUBBER	31"
63	411-13.4	. EXTRUSION, RUBBER	13.4"
64	4007	. BATTERY	2
65	131543	. RETAINER, BATTERY	1
66	160155	. ROD, THREADED	1
67	61239	. NUT, LOCK	3
68	131570	. PLYWOOD, BATTERY	2

- ITEM NOT ILLUSTRATED

FRAME ASSEMBLY (M25E)



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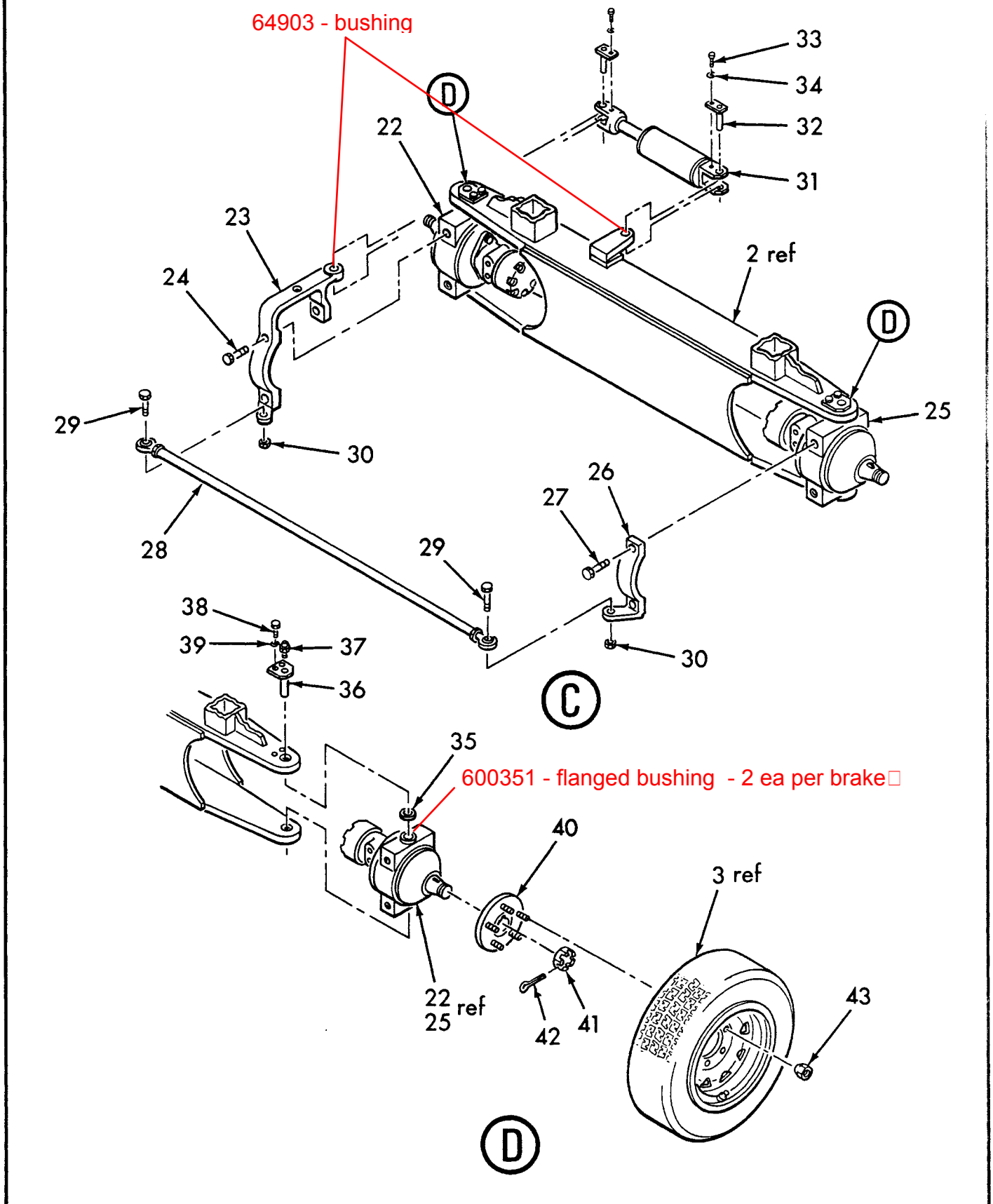
64903 - bushing
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35
600351 - flanged bushing - 2 ea per brake
40
3 ref
22 ref
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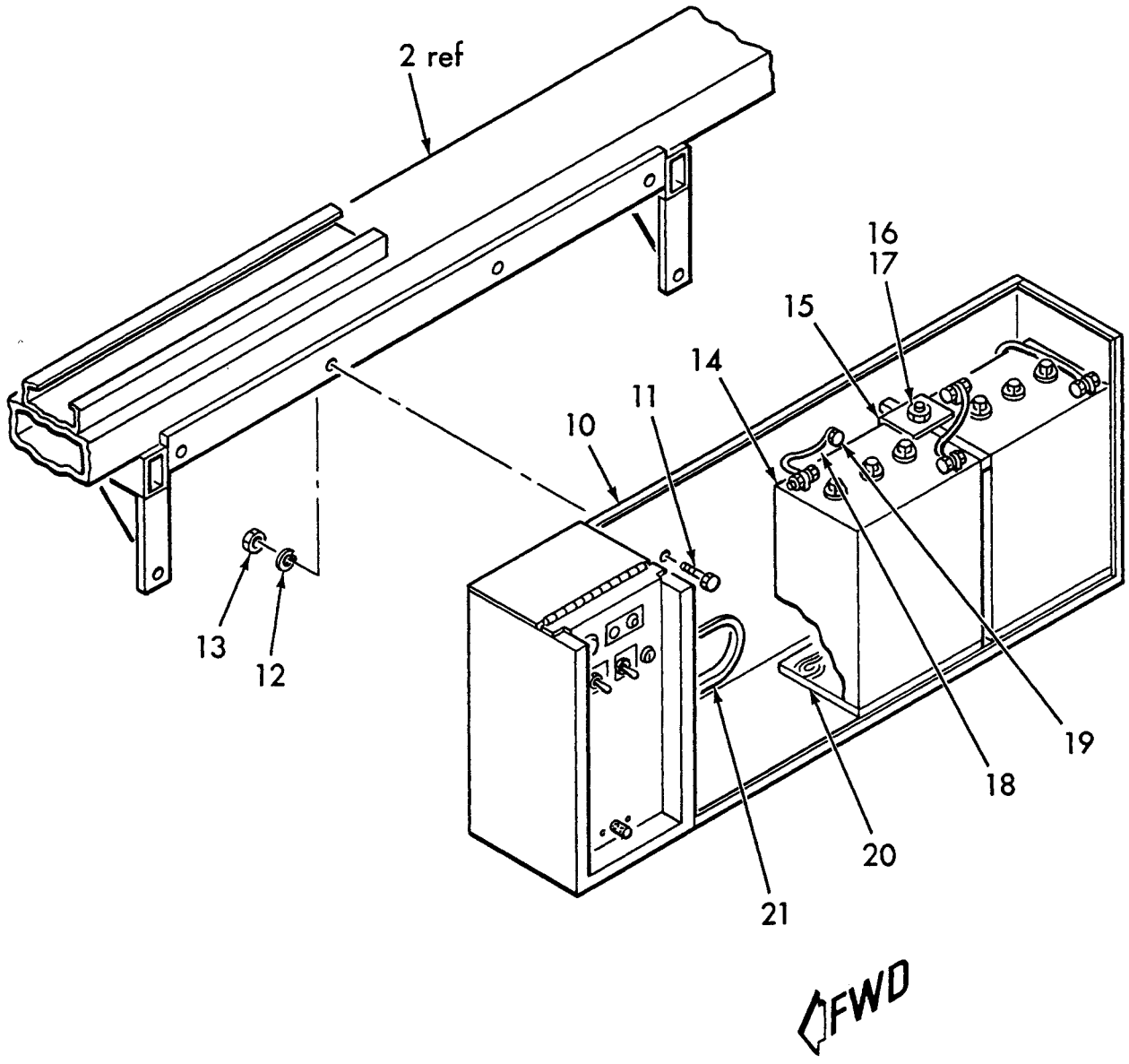
D

FRAME ASSEMBLY (M25E)



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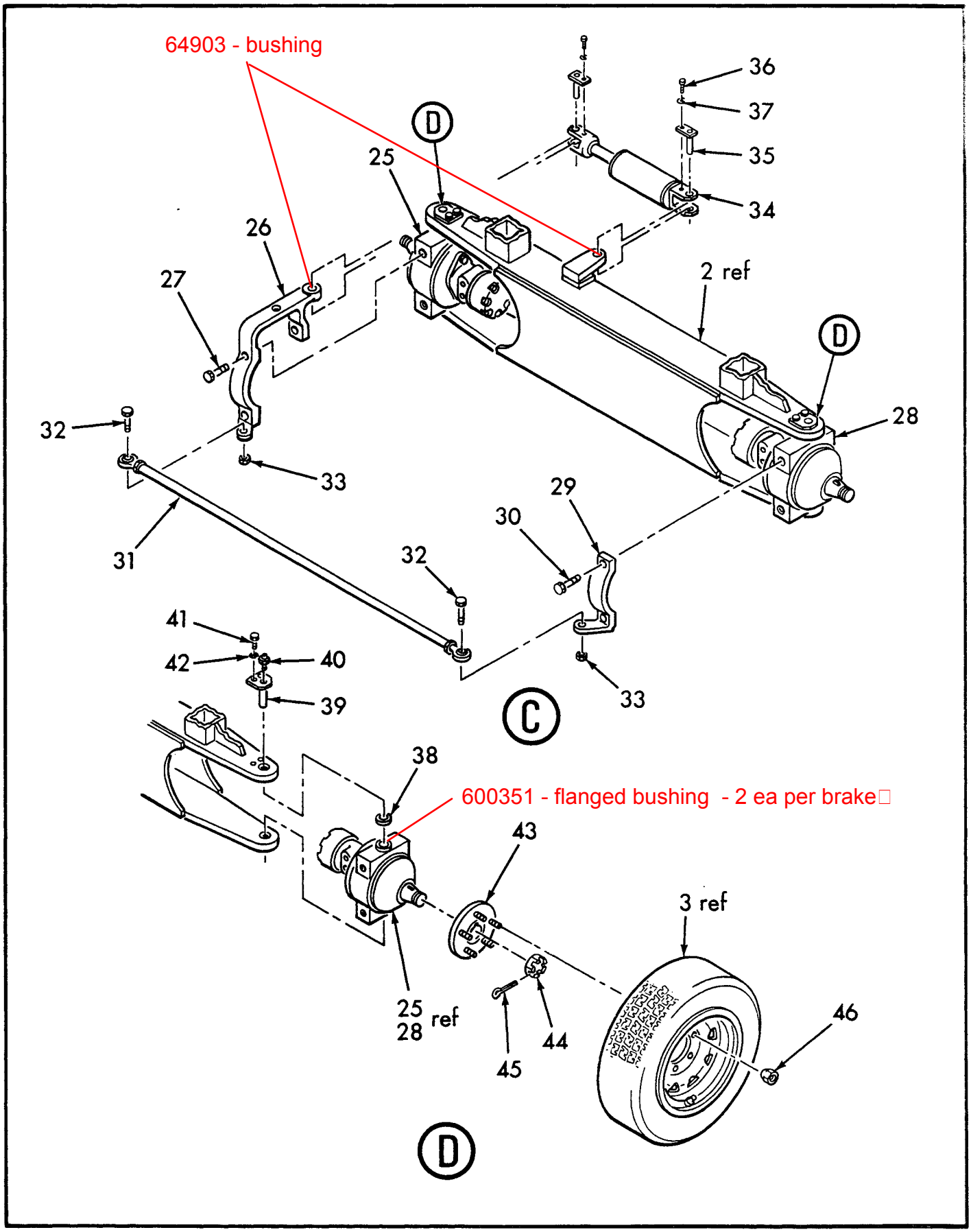
REV.


64903 - bushing
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600351 - flanged bushing - 2 ea per brake
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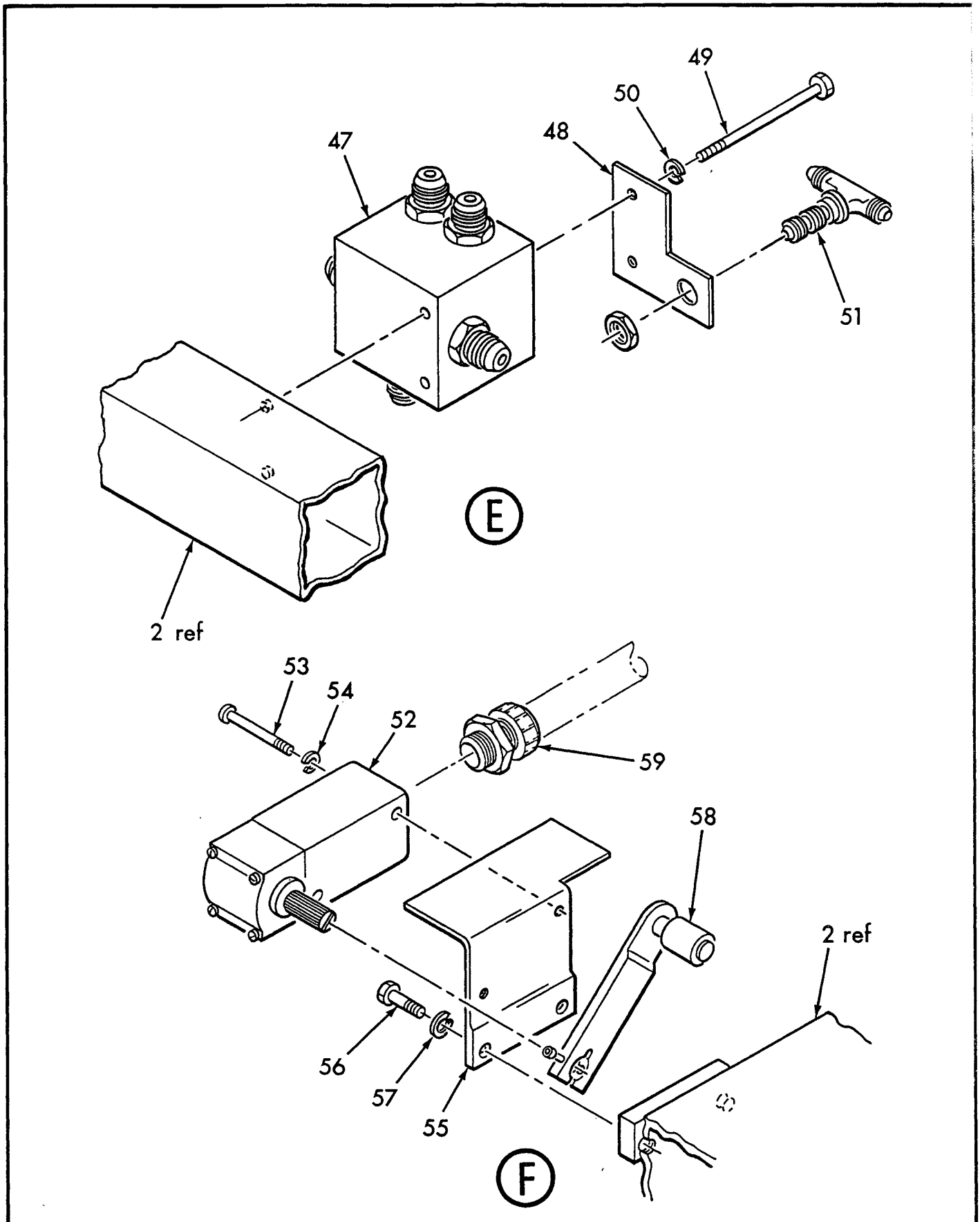
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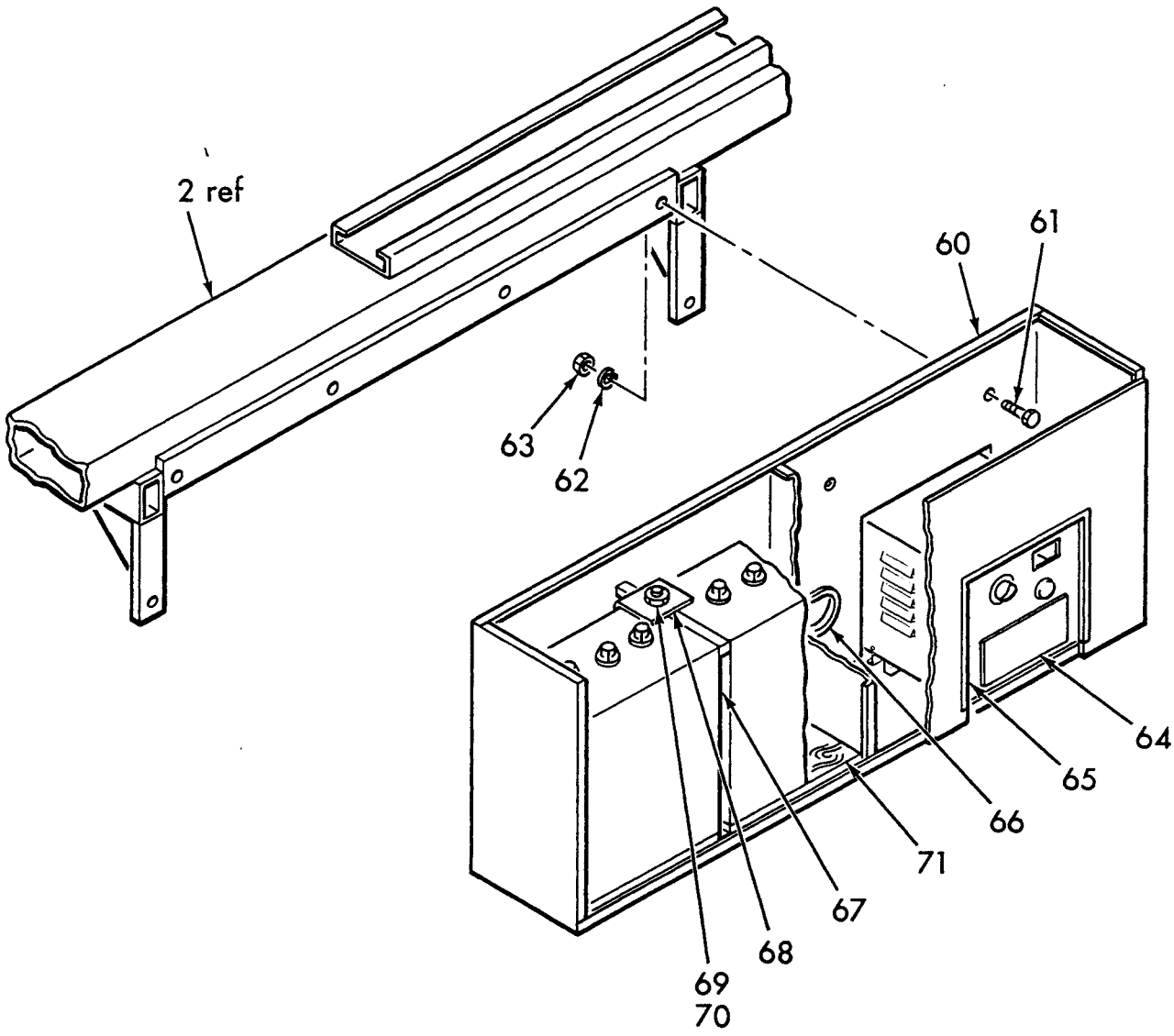
FRAME ASSEMBLY (M25E)



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FRAME ASSEMBLY (M25E)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	131376	ASSEMBLY, FRAME (See Sect. 2, Fig. 1B for NHA)	REF
2	131377	. WELDMENT, FRAME	1
3	130661	. ASSEMBLY, TIRE & WHEEL (See Sect. 3, Fig. 2 for Details)	4
4	134-1	. ASSEMBLY, HUB (See Sect. 3, Fig. 3 for Details)	2
5	63409	. WASHER, FLAT	2
6	60811	. NUT, SLOTTED HEX	2
7	64306	. PIN, COTTER	2
8	137	. CAP, DUST	2
9	61316	. NUT, WHEEL	10
10	131840	. ASSEMBLY, CONTROL/COMPONENT BOX (See Sect. 3, Fig. 4B for Details)	1
11	60383	. SCREW, CAP	6
12	63305	. WASHER, LOCK	6
13	61242	. NUT, HEX	6
14	4007	. BATTERY	2
15	131541	. RETAINER, BATTERY	1
16	160155	. ROD, THREADED	1
17	61239	. NUT, LOCK	3
18	131566	. KIT, BATTERY CABLE (See Sect. 3, Fig. 17 for Details)	1
19	60312	. SCREW, CAP	1
20	131570	. PLYWOOD, BATTERY	2
21	411-24.5	. EXTRUSION, RUBBER	24.5"
22	131394	. ASSEMBLY, HYDRAULIC TANK (See Sect. 3, Fig. 5B for Details)	1
23	60343	. SCREW, CAP	4

- ITEM NOT ILLUSTRATED

FRAME ASSEMBLY (M25E)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
24	63319	. WASHER, LOCK	4
25	131527	. ASSEMBLY, DRIVE MOTOR/BRAKE (L.H.) (See Sect. 3, Fig. 6 for Details)	1
26	130395	. MACHINING, STEERING LEVER ARM (L.H.)	1
27	60622	. SCREW, CAP	3
28	131528	. ASSEMBLY, DRIVE MOTOR/BRAKE (R.H.) (See Sect. 3, Fig. 7 for Details)	1
29	130396	. MACHINING, STEERING LEVER ARM (R.H.)	1
30	60622	. SCREW, CAP	2
31	130469	. ASSEMBLY, TIE ROD (See Sect. 3, Fig. 8 for Details)	1
32	60393	. SCREW, CAP	2
33	61242	. NUT, LOCK	2
34	130237	. ASSEMBLY, STEERING CYLINDER (See Sect. 3, Fig. 9 for Details)	1
35	20252	. PIN, STEERING CYLINDER ANCHOR	2
36	60353	. SCREW, CAP	2
37	63301	. WASHER, LOCK	2
38	65658	. BEARING, THRUST	2
39	131467	. PIN, STEERING	4
40	65103	. FITTING, GREASE	4
41	60338	. SCREW, CAP	8
42	63302	. WASHER, LOCK	8
43	131372	. HUB, DRIVE	2
44	65174	. NUT, SLOTTED JAM	2
45	64306	. PIN, COTTER	2
46	61316	. NUT, WHEEL	10
47	131526	. ASSEMBLY, FLOW DIVIDER (See Sect. 3, Fig. 10 for Details)	1

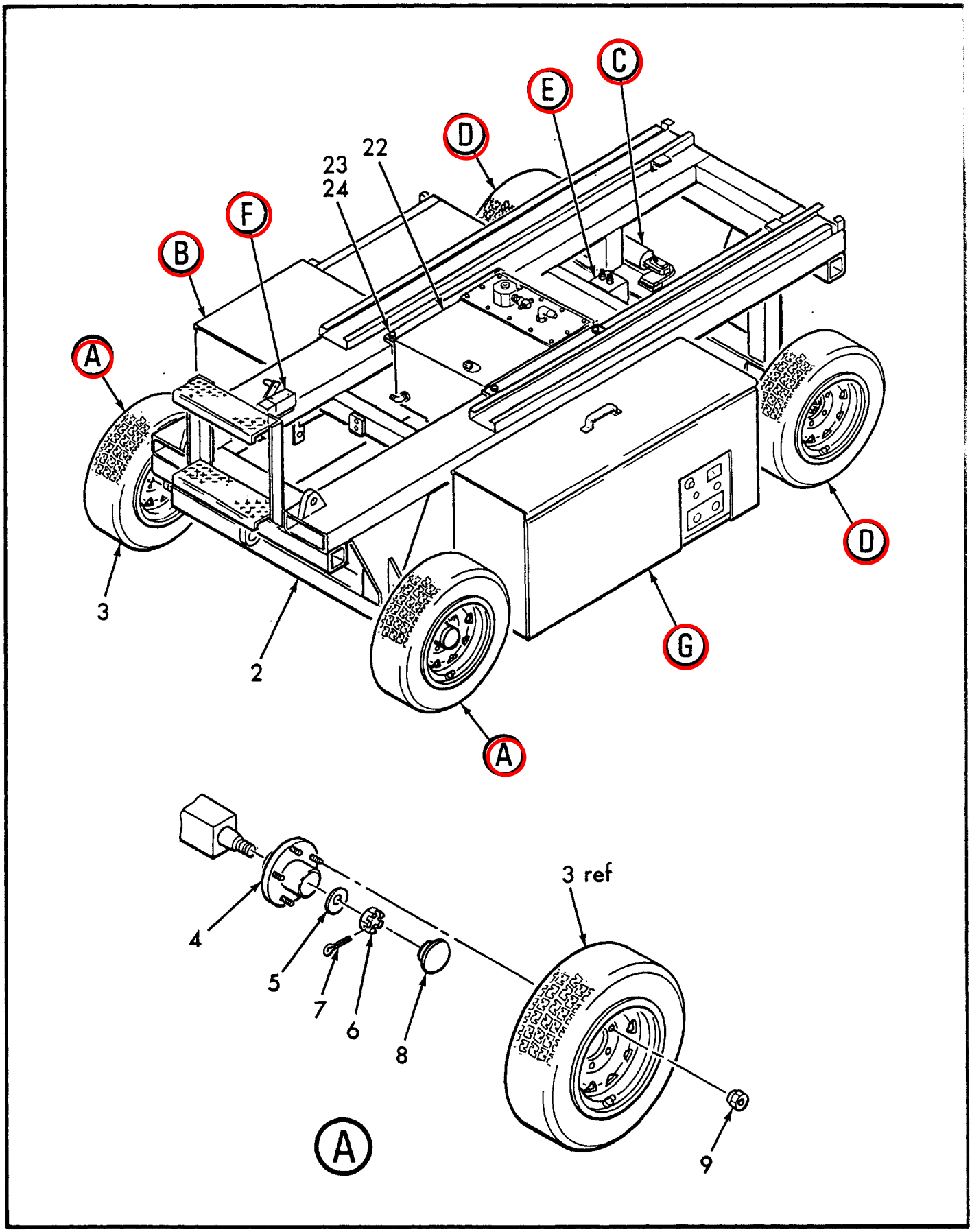
- ITEM NOT ILLUSTRATED

FRAME ASSEMBLY (M25E)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
48	131546	. BRACKET, BULKHEAD	1
49	60377	. SCREW, CAP	2
50	63313	. WASHER, LOCK	4
51	80035-03	. TEE, BULKHEAD BRANCH	1
52	70173	. SWITCH, LIMIT	1
53	62615	. SCREW, MACHINE	2
54	63313	. WASHER, LOCK	2
55	130514	. BRACKET, LIMIT SWITCH MOUNTING	1
56	60314	. SCREW, CAP	2
57	63301	. WASHER, LOCK	2
58	70032	. LEVER, OPERATING	1
59	70288	. RELIEF, STRAIN	1
60	131499	. ASSEMBLY, COMPONENT BOX (See Sect. 3, Fig. 14B for Details)	1
61	60383	. SCREW, CAP	6
62	63305	. WASHER, LOCK	6
63	61242	. NUT, HEX	6
64	70478	. CHARGER, BATTERY (See Sect. 3, Fig. 19 for Details)	1
65	411-31	. EXTRUSION, RUBBER	31"
66	411-13.5	. EXTRUSION, RUBBER	13.5"
67	4007	. BATTERY	2
68	131541	. RETAINER, BATTERY	1
69	160155	. ROD, THREADED	1
70	61239	. NUT, LOCK	3
71	131570	. PLYWOOD, BATTERY	2

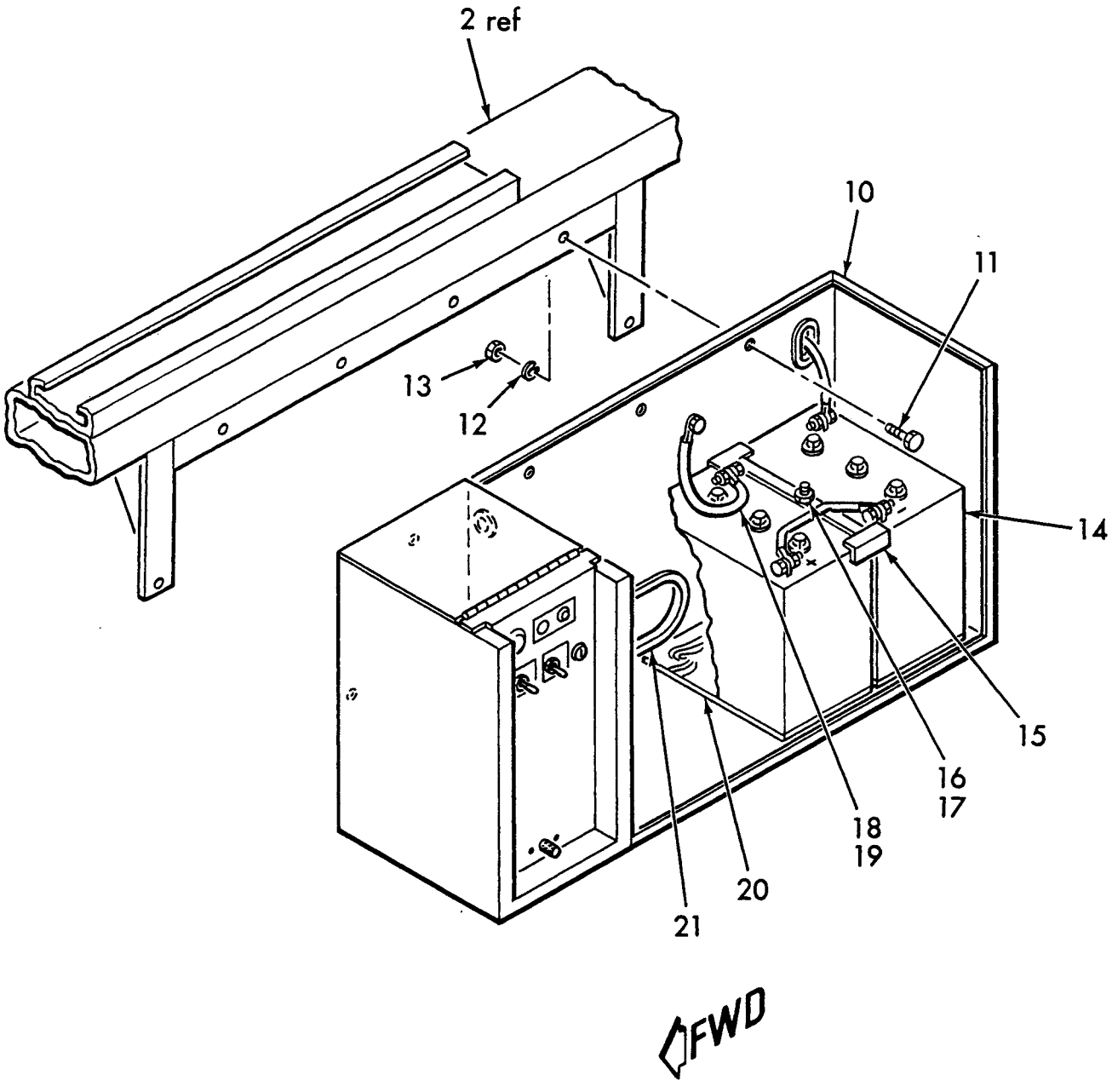
- ITEM NOT ILLUSTRATED

FRAME ASSEMBLY (M20ET)



REV.

FRAME ASSEMBLY (M20ET)



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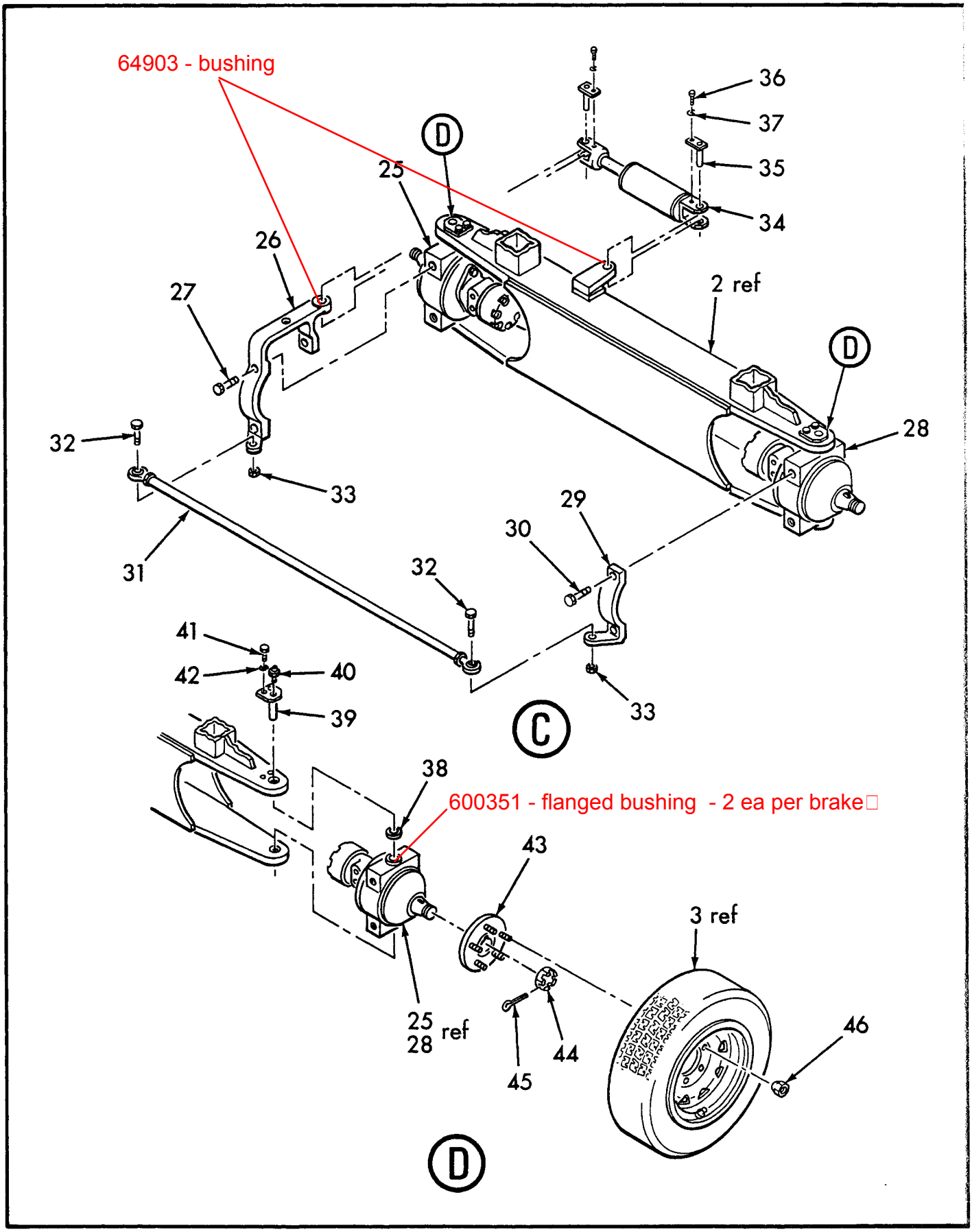
REV.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600351 - flanged bushing - 2 ea per brake
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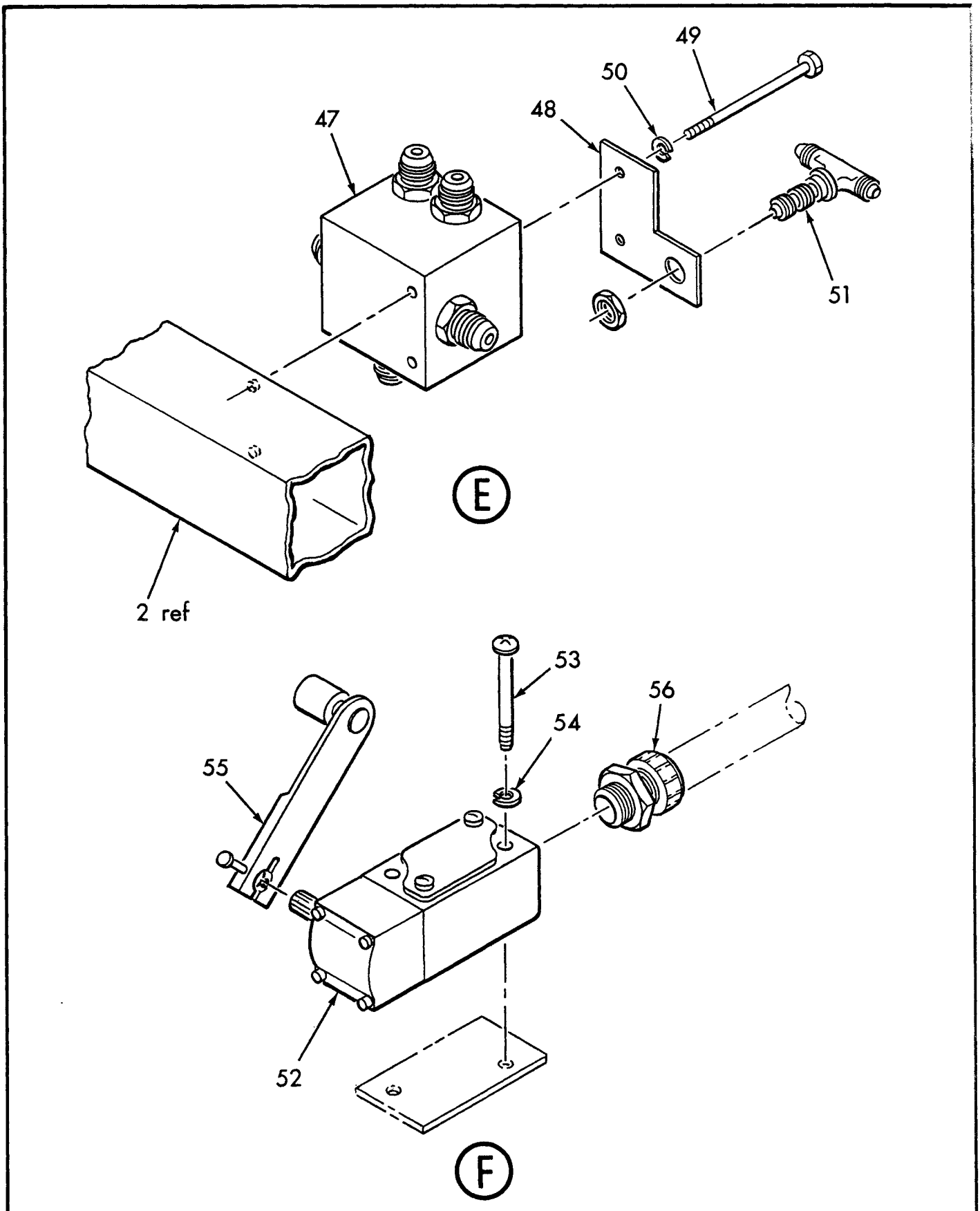
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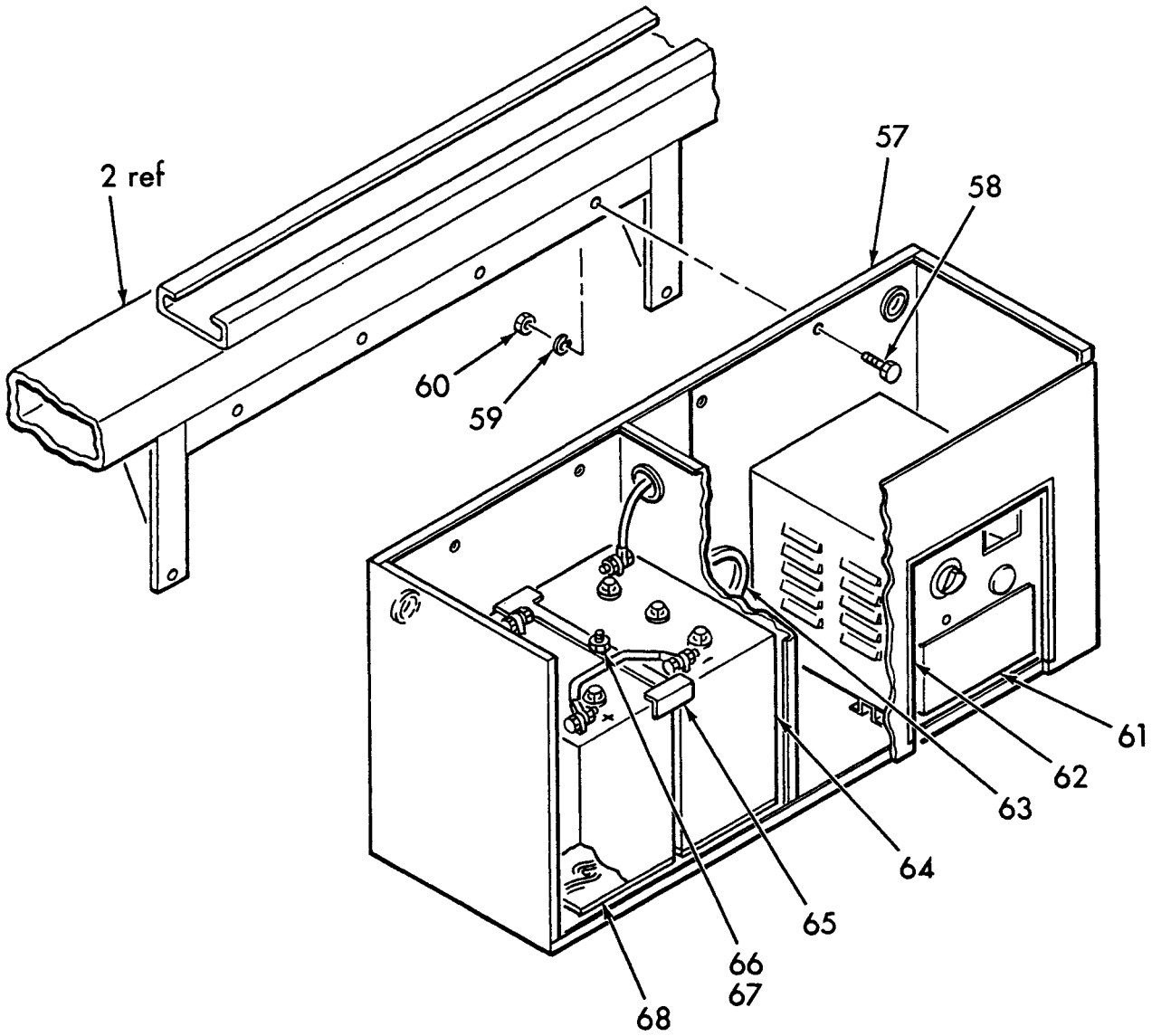
FRAME ASSEMBLY (M20ET)



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REV.

FRAME ASSEMBLY (M20ET)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	131489	ASSEMBLY, FRAME (See Sect. 2, Fig. 1C for NHA)	REF
2	131390	. WELDMENT, FRAME	1
3	130661	. ASSEMBLY, TIRE & WHEEL (See Sect. 3, Fig. 2 for Details)	4
4	134-1	. ASSEMBLY, HUB (See Sect. 3, Fig. 3 for Details)	2
5	63409	. WASHER, FLAT	2
6	60811	. NUT, SLOTTED HEX	2
7	64306	. PIN, COTTER	2
8	137	. CAP, DUST	2
9	61316	. NUT, WHEEL	10
10	131841	. ASSEMBLY, CONTROL/COMPONENT BOX (See Sect. 3, Fig. 4 for Details)	1
11	60383	. SCREW, CAP	6
12	63305	. WASHER, LOCK	6
13	61242	. NUT, HEX	6
14	4007	. BATTERY	2
15	131543	. RETAINER, BATTERY	1
16	160155	. ROD, THREADED	1
17	61239	. NUT, LOCK	3
18	131566	. KIT, BATTERY CABLE (See Sect. 3, Fig. 17 for Details)	1
19	60312	. SCREW, CAP	1
20	131570	. PLYWOOD, BATTERY	2
21	411-24.6	. EXTRUSION, RUBBER	24.6"
22	131394	. ASSEMBLY, HYDRAULIC TANK (See Sect. 3, Fig. 5A for Details)	1
23	60343	. SCREW, CAP	4

- ITEM NOT ILLUSTRATED

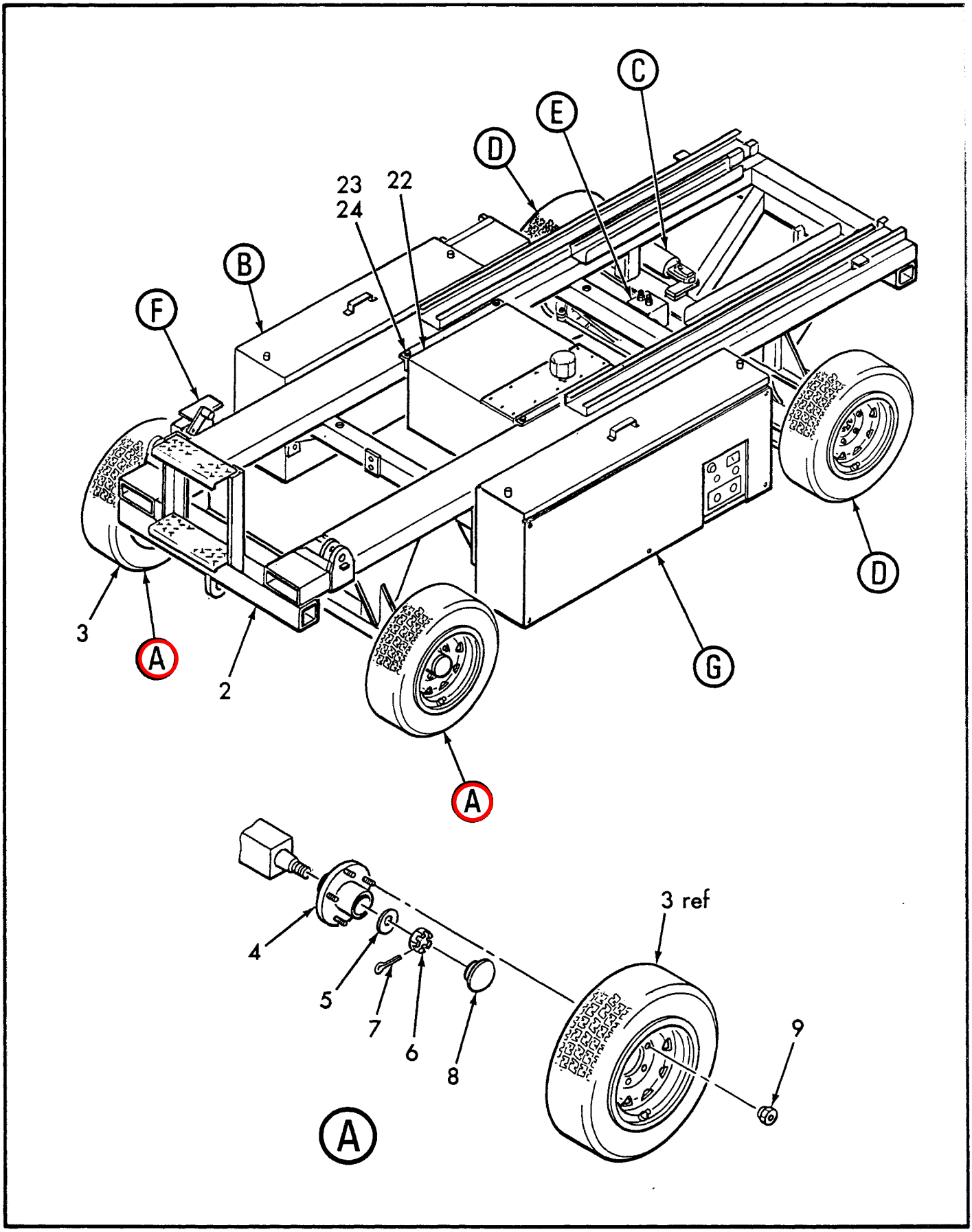
ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
24	63319	. WASHER, LOCK	4
25	131527	. ASSEMBLY, DRIVE MOTOR/BRAKE (L.H.) (See Sect. 3, Fig. 6 for Details)	1
26	130395	. MACHINING, STEERING LEVER ARM (L.H.)	1
27	60622	. SCREW, CAP	3
28	131528	. ASSEMBLY, DRIVE MOTOR/BRAKE (R.H.) (See Sect. 3, Fig. 7 for Details)	1
29	130396	. MACHINING, STEERING LEVER ARM (R.H.)	1
30	60622	. SCREW, CAP	2
31	130469	. ASSEMBLY, TIE ROD (See Sect. 3, Fig. 8 for Details)	1
32	60393	. SCREW, CAP	2
33	61242	. NUT, LOCK	2
34	130237	. ASSEMBLY, STEERING CYLINDER (See Sect. 3, Fig. 9 for Details)	1
35	20252	. PIN, STEERING CYLINDER ANCHOR	2
36	60353	. SCREW, CAP	2
37	63301	. WASHER, LOCK	2
38	65658	. BEARING, THRUST	2
39	131467	. PIN, STEERING	4
40	65103	. FITTING, GREASE	4
41	60338	. SCREW, CAP	8
42	63302	. WASHER, LOCK	8
43	131372	. HUB, DRIVE	2
44	65174	. NUT, SLOTTED JAM	2
45	64306	. PIN, COTTER	2
46	61316	. NUT, WHEEL	10

FRAME ASSEMBLY (M20ET)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
47	131526	. ASSEMBLY, FLOW DIVIDER (See Sect. 3, Fig. 10 for Details)	1
48	131546	. BRACKET, BULKHEAD	1
49	60377	. SCREW, CAP	2
50	63313	. WASHER, LOCK	4
51	80035-03	. TEE, BULKHEAD BRANCH	1
52	70173	. SWITCH, LIMIT	1
53	62615	. SCREW, MACHINE	2
54	63313	. WASHER, LOCK	2
55	70032	. LEVER, OPERATING	1
56	70288	. RELIEF, STRAIN	1
57	131557	. ASSEMBLY, COMPONENT BOX (See Sect. 3, Fig. 14A for Details)	1
58	60383	. SCREW, CAP	6
59	63305	. WASHER, LOCK	6
60	61242	. NUT, HEX	6
61	70478	. CHARGER, BATTERY (See Sect. 3, Fig. 19 for Details)	1
62	411-31	. EXTRUSION, RUBBER	31"
63	411-13.4	. EXTRUSION, RUBBER	13.4"
64	4007	. BATTERY	2
65	131543	. RETAINER, BATTERY	1
66	160155	. ROD, THREADED	1
67	61239	. NUT, LOCK	3
68	131570	. PLYWOOD, BATTERY	2

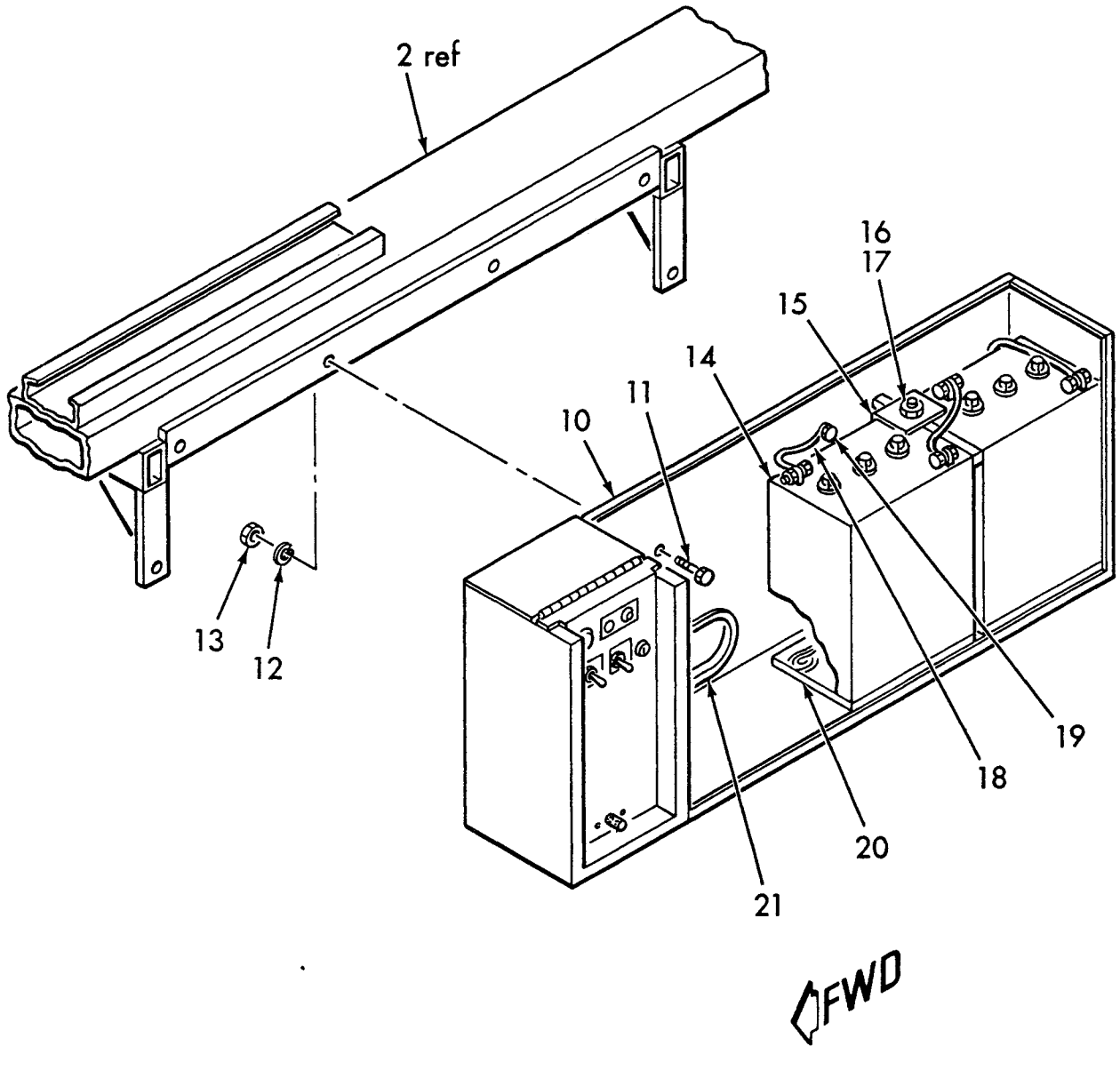
- ITEM NOT ILLUSTRATED

FRAME ASSEMBLY (M25ET)



REV.

FRAME ASSEMBLY (M25ET)



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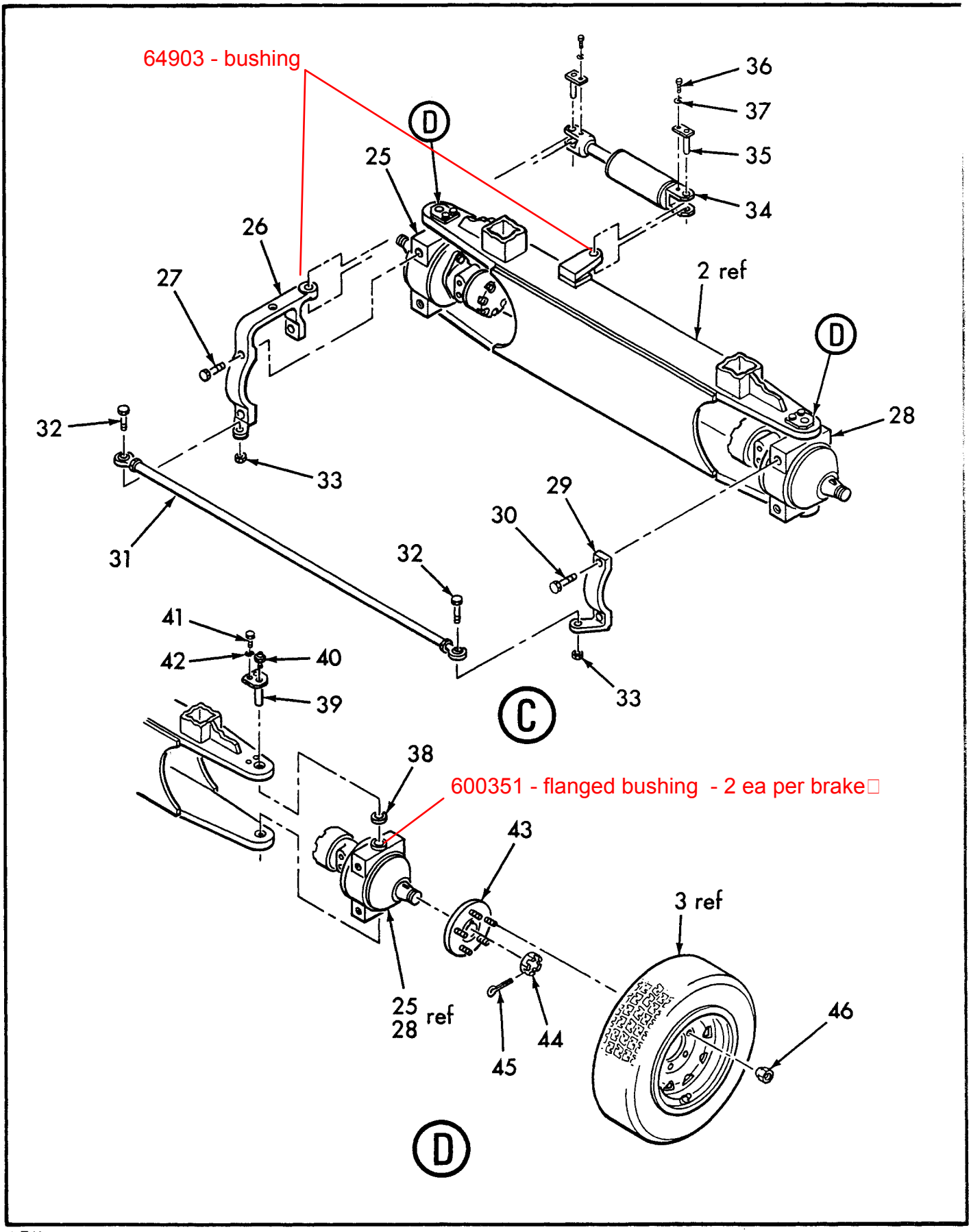
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600351 - flanged bushing - 2 ea per brake
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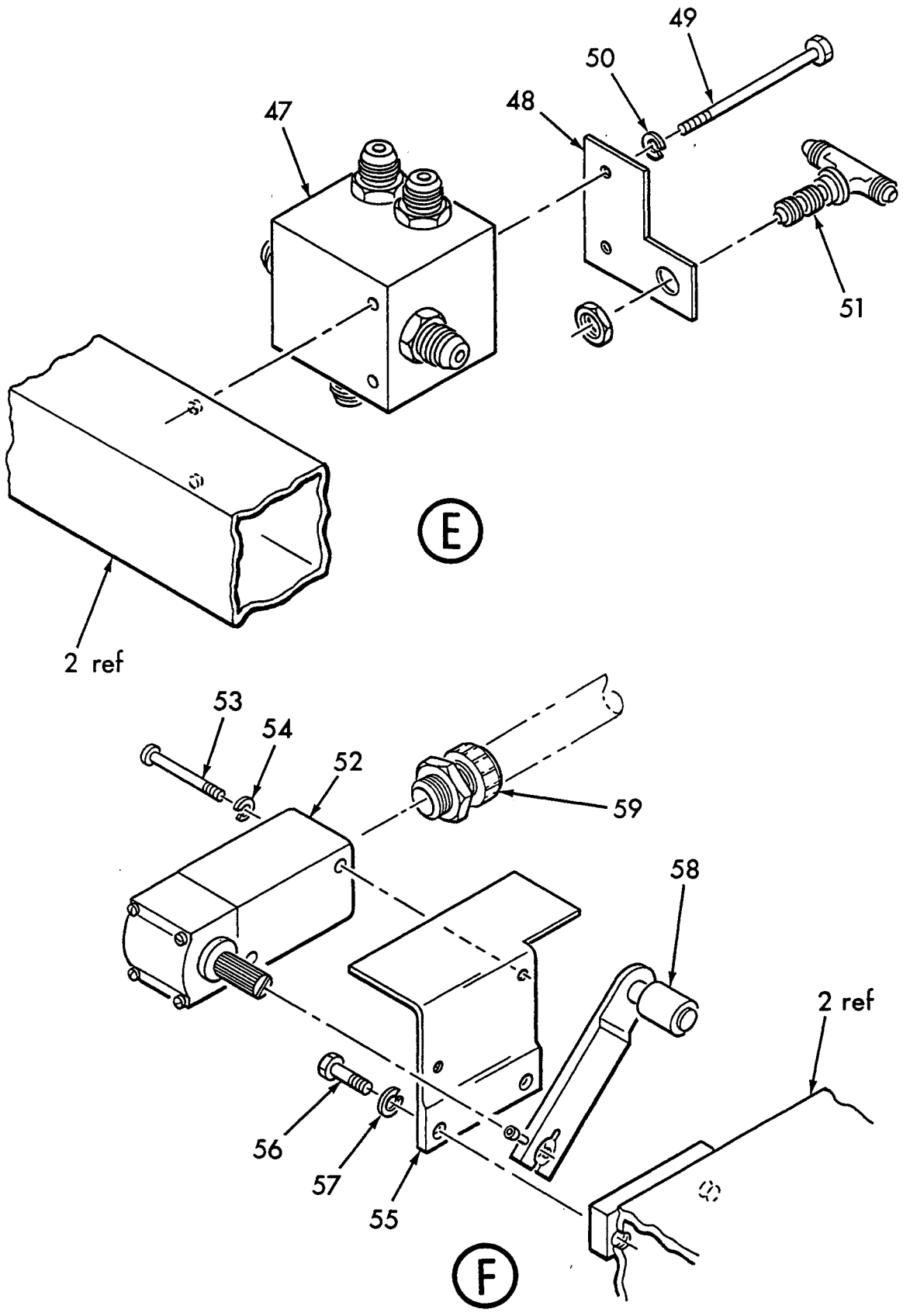
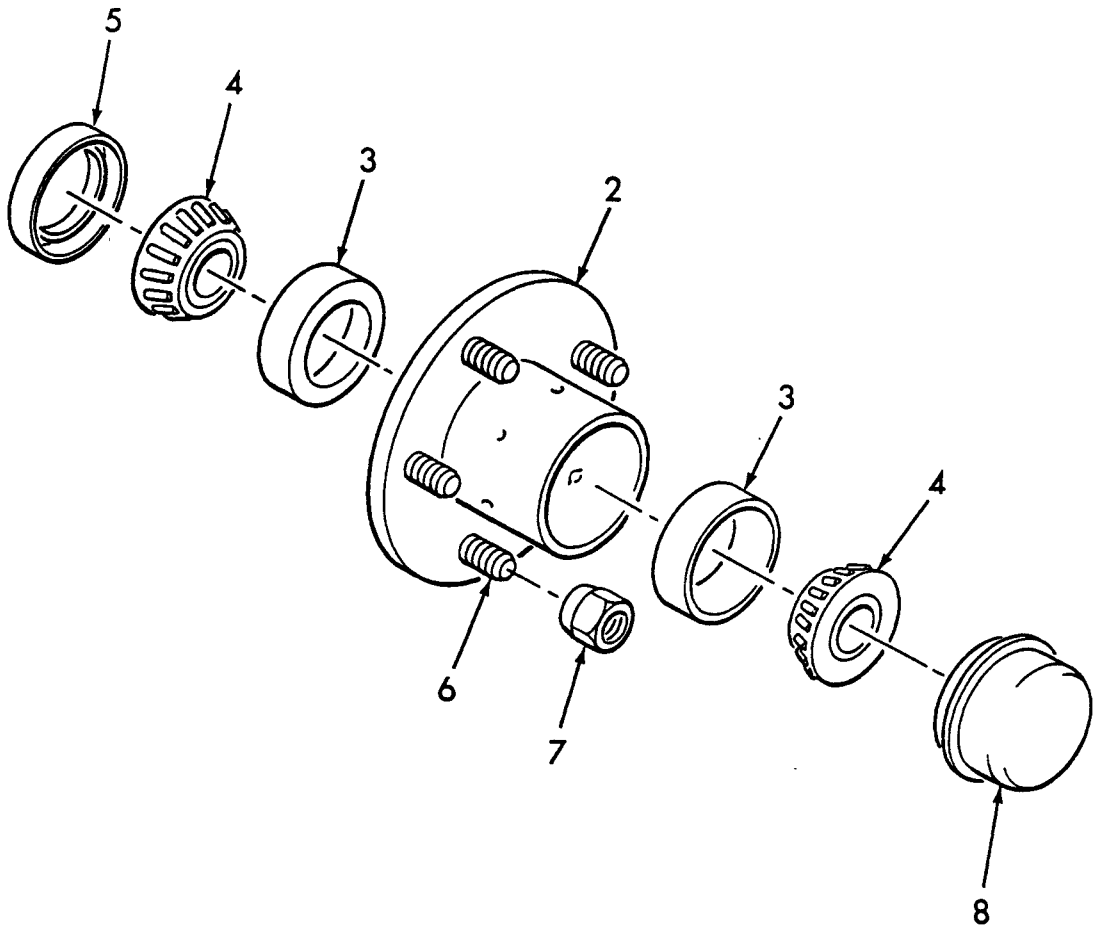
FRAME ASSEMBLY (M25ET)



REV.

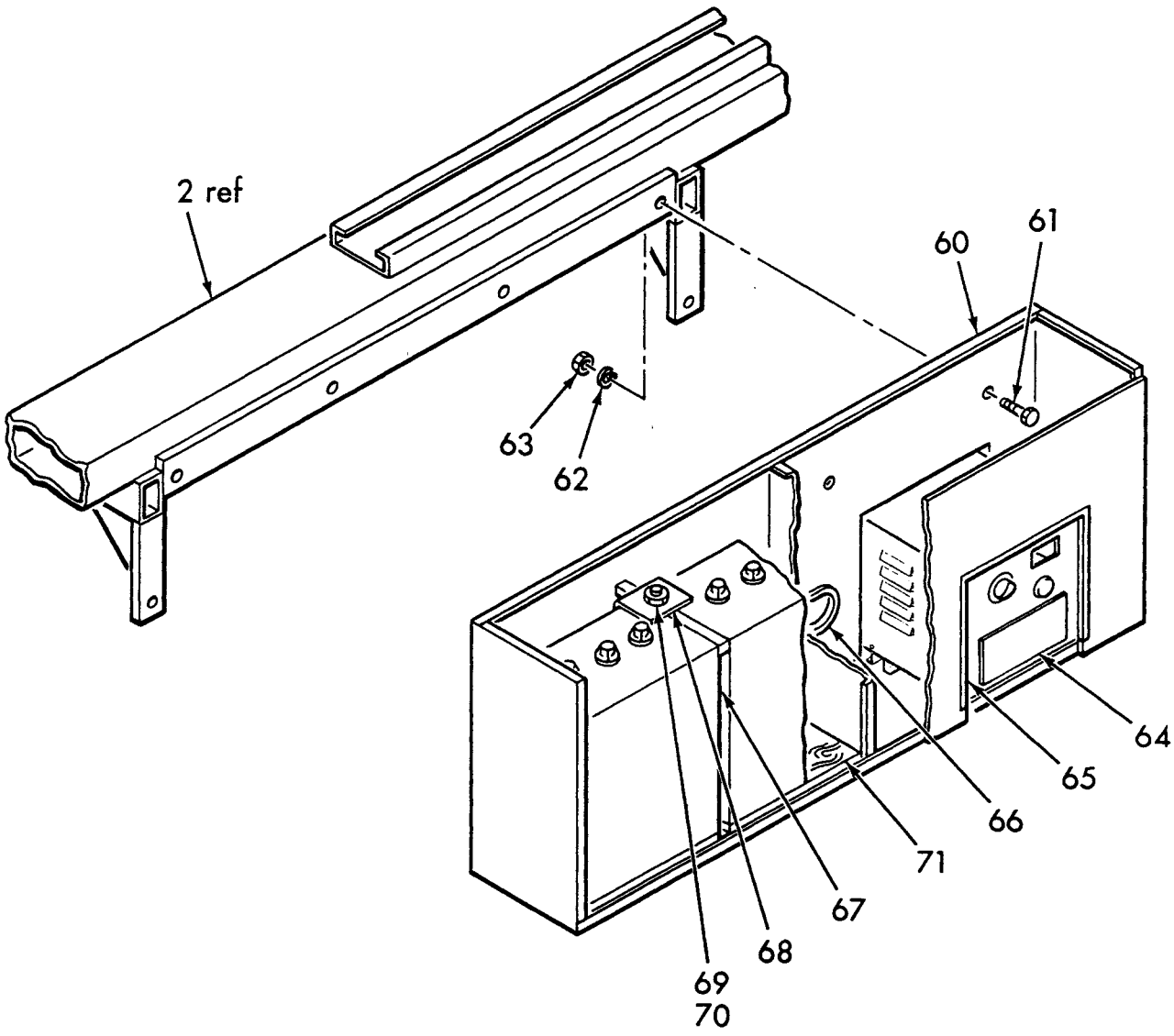
HUB ASSEMBLY (ALL MODELS)



ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	134-1	ASSEMBLY, HUB (See Sect. 3, Fig. 1 thru 1D for NHA)	REF
2	65684	. HUB	1
3	65686	. RACE, BEARING	2
4	65059	. BEARING	2
5	66113	. SEAL, GREASE	1
6	65685	. BOLT, LUG	5
7	61316	. NUT, LUG	5
8	137	. CAP, DUST	1

REV.

FRAME ASSEMBLY (M25ET)



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REV.

FRAME ASSEMBLY (M25ET)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	131490	ASSEMBLY, FRAME (See Sect. 2, Fig. 1B for NHA)	REF
2	131377	. WELDMENT, FRAME	1
3	130661	. ASSEMBLY, TIRE & WHEEL (See Sect. 3, Fig. 2 for Details)	4
4	134-1	. ASSEMBLY, HUB (See Sect. 3, Fig. 3 for Details)	2
5	63409	. WASHER, FLAT	2
6	60811	. NUT, SLOTTED HEX	2
7	64306	. PIN, COTTER	2
8	137	. CAP, DUST	2
9	61316	. NUT, WHEEL	10
10	131842	. ASSEMBLY, CONTROL/COMPONENT BOX (See Sect. 3, Fig. 4D for Details)	1
11	60383	. SCREW, CAP	6
12	63305	. WASHER, LOCK	6
13	61242	. NUT, HEX	6
14	4007	. BATTERY	2
15	131541	. RETAINER, BATTERY	1
16	160155	. ROD, THREADED	1
17	61239	. NUT, LOCK	3
18	131566	. KIT, BATTERY CABLE (See Sect. 3, Fig. 17 for Details)	1
19	60312	. SCREW, CAP	1
20	131570	. PLYWOOD, BATTERY	2
21	411-24.5	. EXTRUSION, RUBBER	24.5"
22	131394	. ASSEMBLY, HYDRAULIC TANK (See Sect. 3, Fig. 5B for Details)	1
23	60343	. SCREW, CAP	4

- ITEM NOT ILLUSTRATED

FRAME ASSEMBLY (M25ET)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
24	63319	. WASHER, LOCK	4
25	131527	. ASSEMBLY, DRIVE MOTOR/BRAKE (L.H.) (See Sect. 3, Fig. 6 for Details)	1
26	130395	. MACHINING, STEERING LEVER ARM (L.H.)	1
27	60622	. SCREW, CAP	3
28	131528	. ASSEMBLY, DRIVE MOTOR/BRAKE (R.H.) (See Sect. 3, Fig. 7 for Details)	1
29	130396	. MACHINING, STEERING LEVER ARM (R.H.)	1
30	60622	. SCREW, CAP	2
31	130469	. ASSEMBLY, TIE ROD (See Sect. 3, Fig. 8 for Details)	1
32	60393	. SCREW, CAP	2
33	61242	. NUT, LOCK	2
34	130237	. ASSEMBLY, STEERING CYLINDER (See Sect. 3, Fig. 9 for Details)	1
35	20252	. PIN, STEERING CYLINDER ANCHOR	2
36	60353	. SCREW, CAP	2
37	63301	. WASHER, LOCK	2
38	65658	. BEARING, THRUST	2
39	131467	. PIN, STEERING	4
40	65103	. FITTING, GREASE	4
41	60338	. SCREW, CAP	8
42	63302	. WASHER, LOCK	8
43	131372	. HUB, DRIVE	2
44	65174	. NUT, SLOTTED JAM	2
45	64306	. PIN, COTTER	2
46	61316	. NUT, WHEEL	10
47	131526	. ASSEMBLY, FLOW DIVIDER (See Sect. 3, Fig. 10 for Details)	1

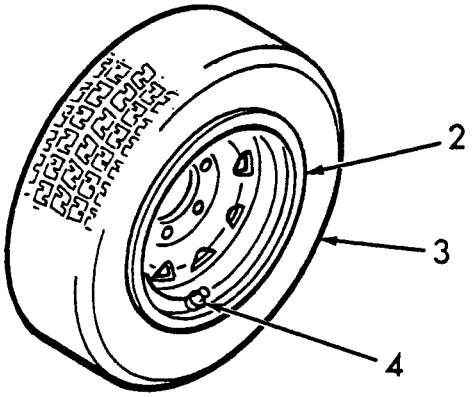
- ITEM NOT ILLUSTRATED

FRAME ASSEMBLY (M25ET)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
48	131546	. BRACKET, BULKHEAD	1
49	60377	. SCREW, CAP	2
50	63313	. WASHER, LOCK	4
51	80035-03	. TEE, BULKHEAD BRANCH	1
52	70173	. SWITCH, LIMIT	1
53	62615	. SCREW, MACHINE	2
54	63313	. WASHER, LOCK	2
55	130514	. BRACKET, LIMIT SWITCH MOUNTING	1
56	60314	. SCREW, CAP	2
57	63301	. WASHER, LOCK	2
58	70032	. LEVER, OPERATING	1
59	70288	. RELIEF, STRAIN	1
60	131499	. ASSEMBLY, COMPONENT BOX (See Sect. 3, Fig. 14B for Details)	1
61	60383	. SCREW, CAP	6
62	63305	. WASHER, LOCK	6
63	61242	. NUT, HEX	6
64	70478	. CHARGER, BATTERY (See Sect. 3, Fig. 19 for Details)	1
65	411-31	. EXTRUSION, RUBBER	31"
66	411-13.5	. EXTRUSION, RUBBER	13.5"
67	4007	. BATTERY	2
68	131541	. RETAINER, BATTERY	1
69	160155	. ROD, THREADED	1
70	61239	. NUT, LOCK	3
71	131570	. PLYWOOD, BATTERY	2

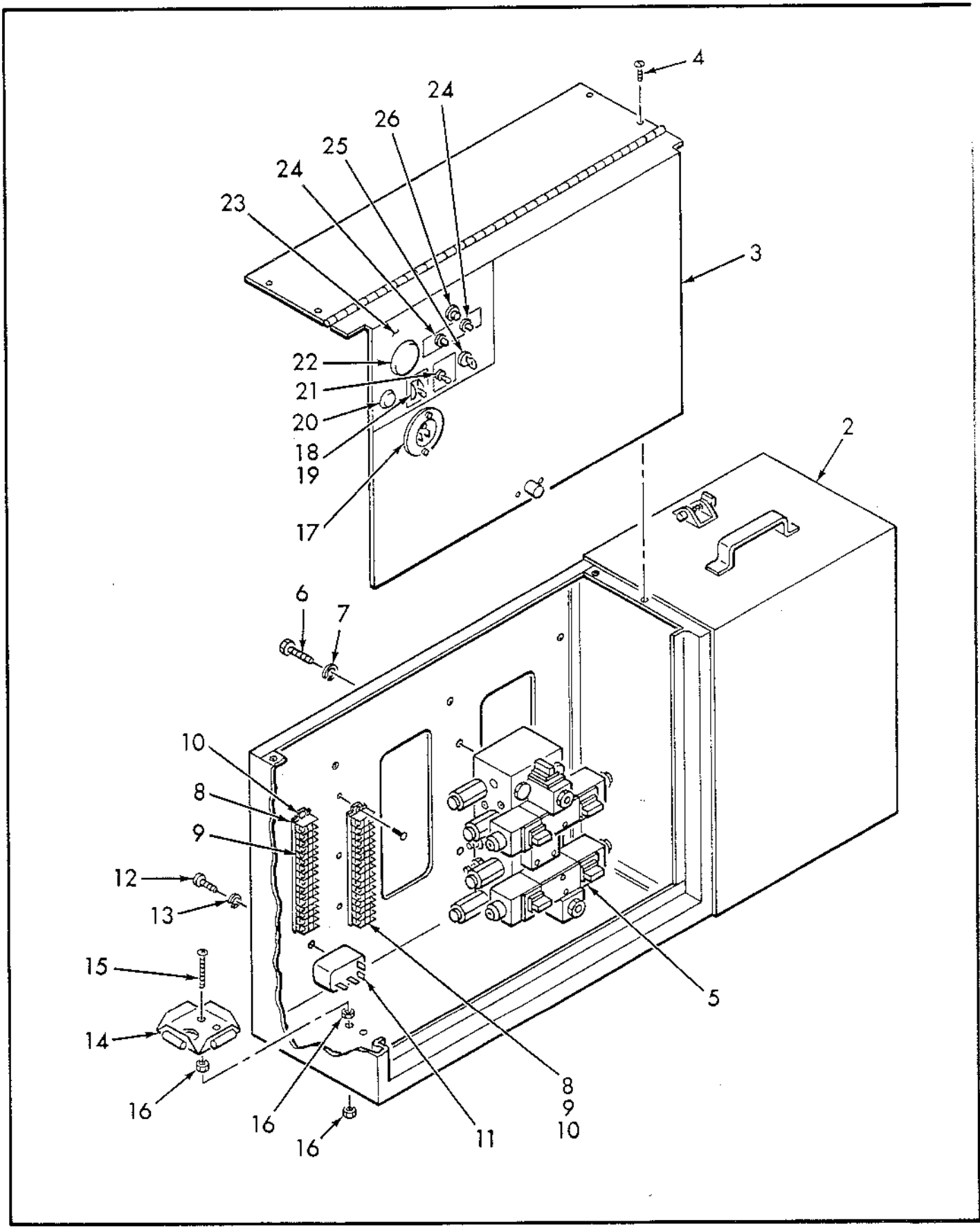
- ITEM NOT ILLUSTRATED

TIRE AND WHEEL ASSEMBLY (ALL MODELS)

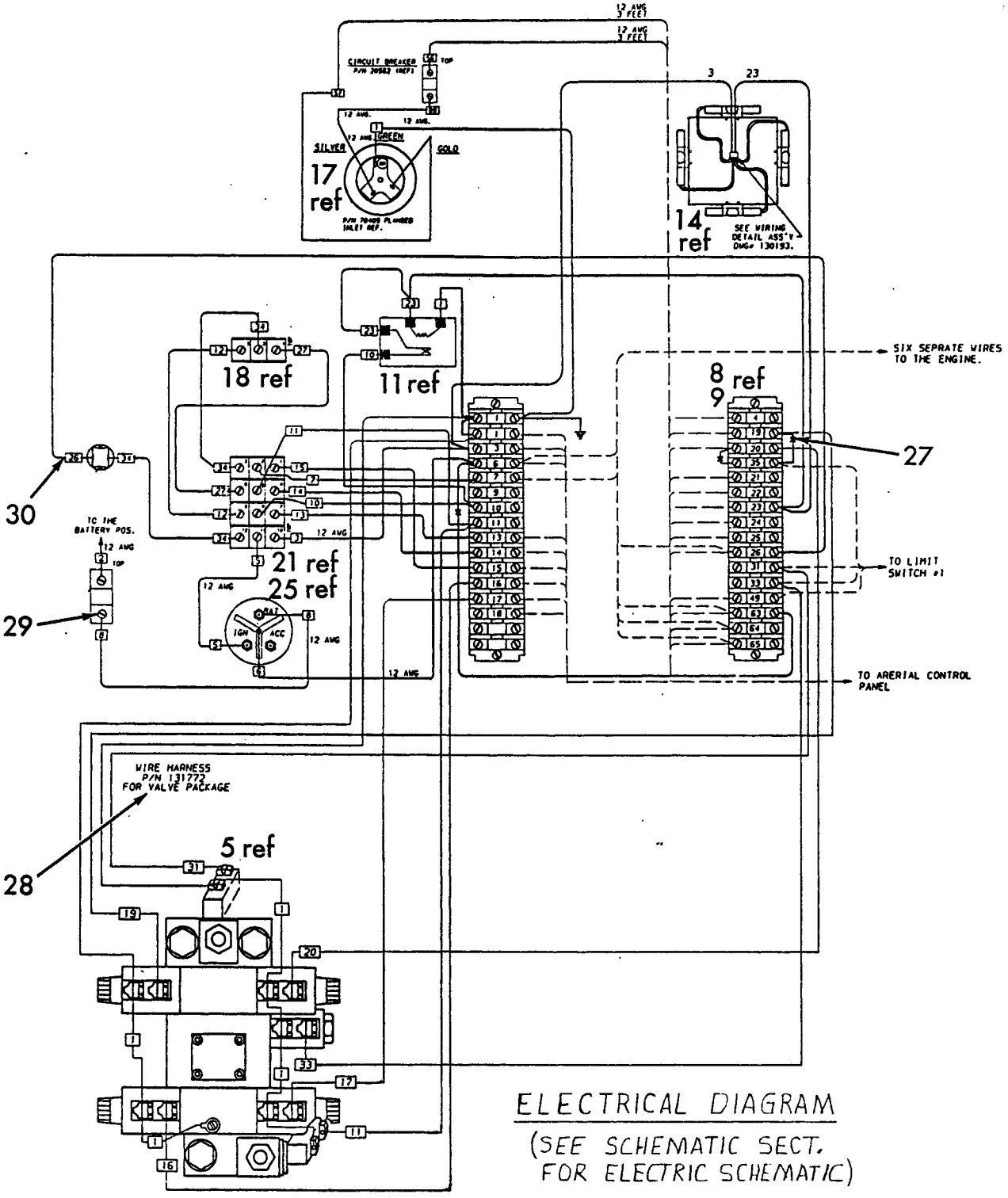


ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	130661	ASSEMBLY, TIRE AND WHEEL (See Sect. 3, Fig. 1 thru 1D for NHA)	REF
2	130662	. WHEEL, 13 INCH	1
3	30480	. TIRE, RADIAL (MONOFILLED)	1
4	2252	. STEM, VALVE	1

CONTROL/COMPONENT BOX ASSEMBLY (M20GP)



REV.



ELECTRICAL DIAGRAM

(SEE SCHEMATIC SECT. FOR ELECTRIC SCHEMATIC)

REV.

CONTROL/COMPONENT BOX ASSEMBLY (M20GP)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	131844	ASSEMBLY, CONTROL/COMPONENT BOX (See Sect. 3, Fig. 1 for NHA)	REF
2	131833	. SUB-ASSEMBLY, CONTROL/COMPONENT BOX	1
3	131462	.. COVER, GROUND CONTROL	1
4	61921	.. SCREW, CAP SOCKET	4
5	131847	. ASSEMBLY, VALVE CONTROL (See Sect. 3, Fig. 15 for Details)	1
6	60613	. SCREW, SOCKET	2
7	63303	. WASHER, LOCK	2
8	117-A	. BLOCK, TERMINAL END	2
9	4027	. BLOCK, TERMINAL	32
10	62612	. SCREW, SLOT	6
11	70306	. RELAY, TIME DELAY	1
12	61730	. SCREW, PAN	1
13	63322	. WASHER, LOCK	1
14	130193	. ASSEMBLY, TILT SWITCH (See Sect. 3, Fig. 16 for Details)	1
15	60340	. SCREW, HEX	2
16	63701	. NUT, HEX	6
17	70409	. INLET, FLANGED 110V	1
18	4021	. SWITCH, TOGGLE	1
19	20884	. GUARD, SWITCH	1
20	771	. PLUG, WHITE	1
21	16260	. SWITCH, TOGGLE	1
22	65244	. PLUG, WHITE	1
23	182733	. DECAL	1
24	20562	. BREAKER, CIRCUIT	2

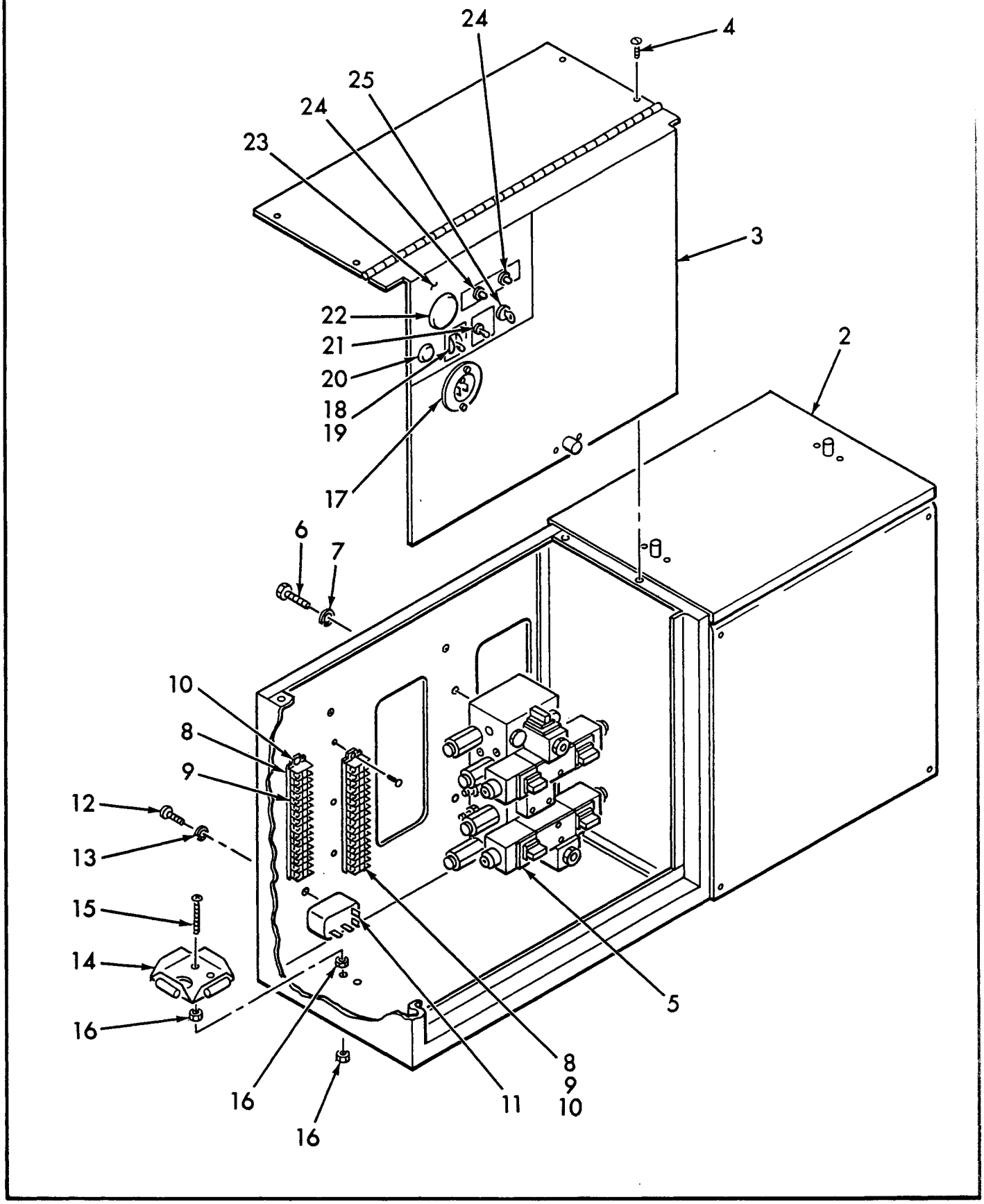
- ITEM NOT ILLUSTRATED

CONTROL/COMPONENT BOX ASSEMBLY (M20GP)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
25	2717	. SWITCH, IGNITION	1
26	4011	. SWITCH, PUSH BUTTON	1
27	70479	. DIODE (6 AMP, 1000V)	3
28	131772	. HARNESS, WIRE	1
29	117-C	. CONNECTOR, RING	31
30	16213	. CONNECTOR	2
31	70232	. WIRE, WHITE (16 AWG)	15 FT
32	2991	. WIRE, WHITE (12 AWG)	10

- ITEM NOT ILLUSTRATED

CONTROL/COMPONENT BOX ASSEMBLY (M20E)



REV.

CONTROL/COMPONENT BOX ASSEMBLY (M20E)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	131843	ASSEMBLY, CONTROL/COMPONENT BOX (See Sect. 3, Fig. 1A for NHA)	REF
2	131827	. SUB-ASSEMBLY, CONTROL/COMPONENT BOX	1
3	131745	.. COVER, GROUND CONTROL	1
4	61921	.. SCREW, CAP SOCKET	4
5	131845	. ASSEMBLY, VALVE CONTROL (See Sect. 3, Fig. 15A for Details)	1
6	60613	. SCREW, SOCKET	2
7	63303	. WASHER, LOCK	2
8	117-A	. BLOCK, TERMINAL END	2
9	4027	. BLOCK, TERMINAL	32
10	62612	. SCREW, SLOT	6
11	70337	. RELAY, TIME DELAY	1
12	61730	. SCREW, PAN	1
13	63322	. WASHER, LOCK	1
14	130193	. ASSEMBLY, TILT SWITCH (See Sect. 3, Fig. 16 for Details)	1
15	60340	. SCREW, HEX	2
16	63701	. NUT, HEX	6
17	70409	. INLET, FLANGED 110V	1
18	20481	. SWITCH, TOGGLE	1
19	20884	. GUARD, SWITCH	1
20	771	. PLUG, WHITE	1
21	16260	. SWITCH, TOGGLE	1
22	65244	. PLUG, WHITE	1
23	182734	. DECAL	1
24	20562	. BREAKER, CIRCUIT	2

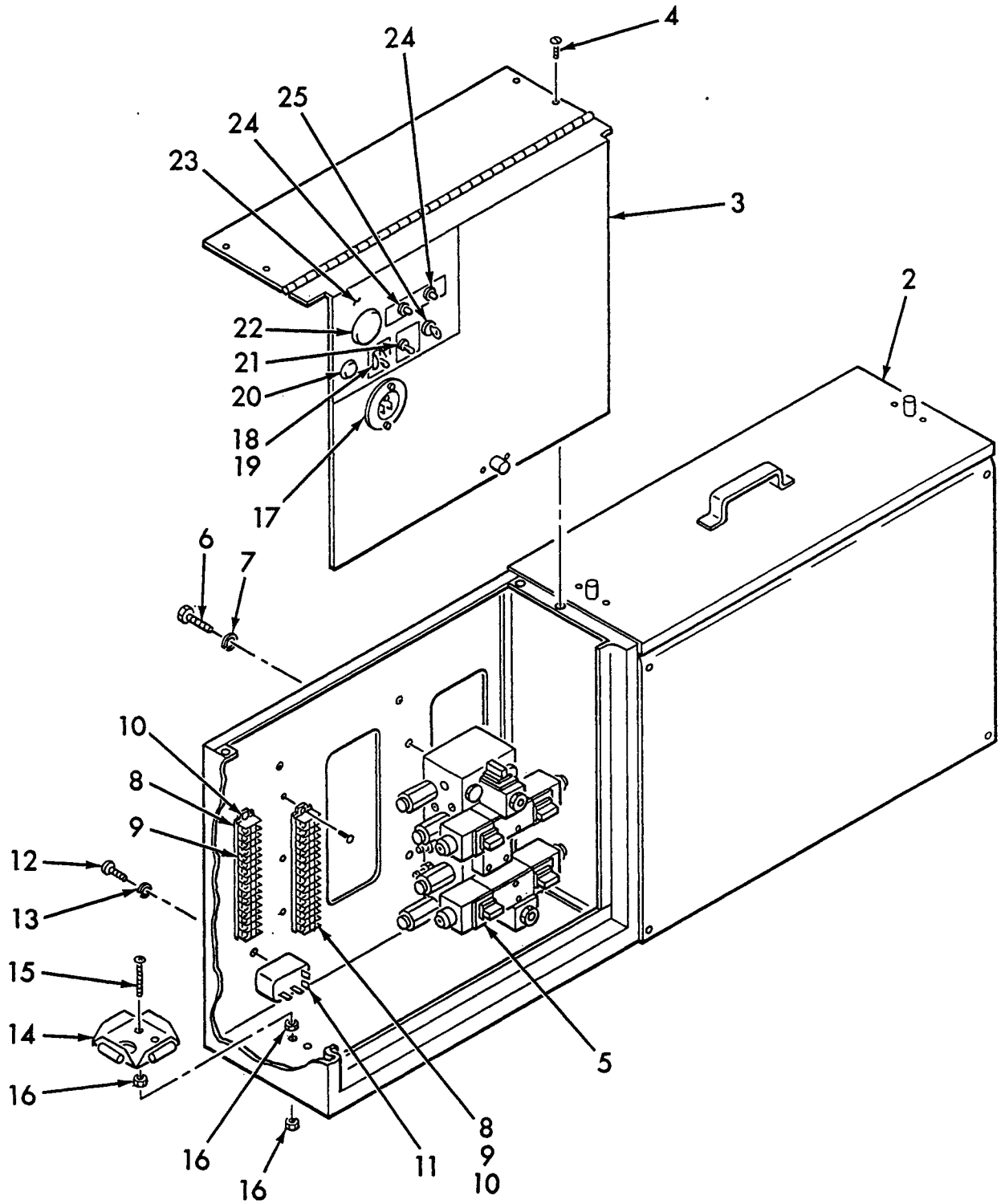
- ITEM NOT ILLUSTRATED

CONTROL/COMPONENT BOX ASSEMBLY (M20E)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
25	2717	. SWITCH, IGNITION	1
-26	70479	. DIODE (6 AMP, 1000V)	4
-27	131772	. HARNESS, WIRE	1
-28	70232	. WIRE, WHITE (16 AWG)	15 FT
-29	2991	. WIRE, WHITE	4 FT
-30	70008	. WIRE, YELLOW (12 AWG)	3

- ITEM NOT ILLUSTRATED

CONTROL/COMPONENT BOX (M25E)



CONTROL/COMPONENT BOX ASSEMBLY (M25E)

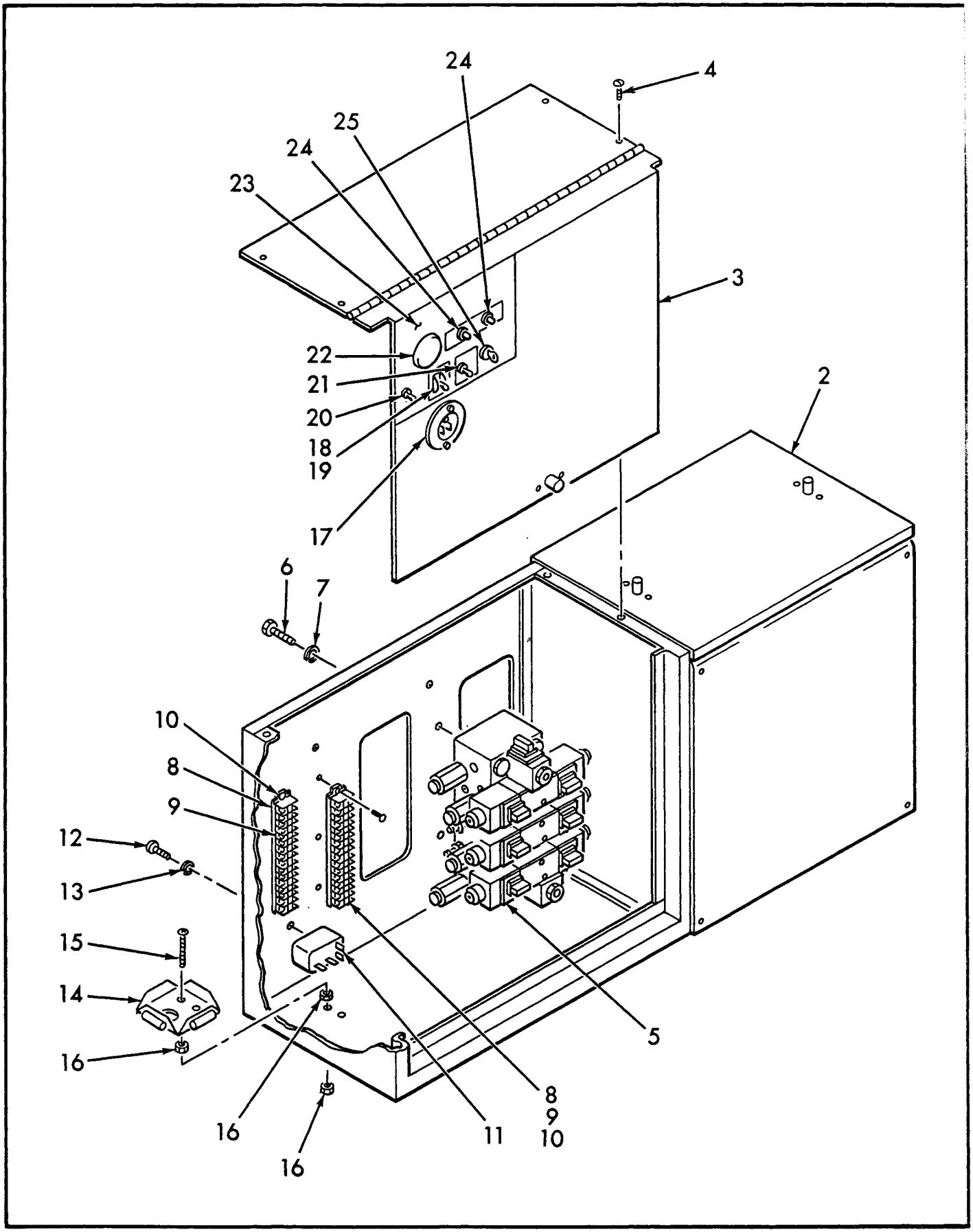
ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	131840	ASSEMBLY, CONTROL/COMPONENT BOX (See Sect. 3, Fig. 1B for NHA)	REF
2	131830	. SUB-ASSEMBLY, CONTROL/COMPONENT BOX	1
3	131753	.. COVER, GROUND CONTROL	1
4	61921	.. SCREW, CAP SOCKET	4
5	131845	. ASSEMBLY, VALVE CONTROL (See Sect. 3, Fig. 15A for Details)	1
6	60613	. SCREW, SOCKET	2
7	63303	. WASHER, LOCK	2
8	117-A	. BLOCK, TERMINAL END	2
9	4027	. BLOCK, TERMINAL	32
10	62612	. SCREW, SLOT	6
11	70337	. RELAY, TIME DELAY	1
12	61730	. SCREW, PAN	1
13	63322	. WASHER, LOCK	1
14	130193	. ASSEMBLY, TILT SWITCH (See Sect. 3, Fig. 16 for Details)	1
15	60340	. SCREW, HEX	2
16	63701	. NUT, HEX	6
17	70409	. INLET, FLANGED 110V	1
18	20481	. SWITCH, TOGGLE	1
19	20884	. GUARD, SWITCH	1
20	771	. PLUG, WHITE	1
21	16260	. SWITCH, TOGGLE	1
22	65244	. PLUG, WHITE	1
23	182734	. DECAL	1
24	20562	. BREAKER, CIRCUIT	2

- ITEM NOT ILLUSTRATED

CONTROL/COMPONENT BOX ASSEMBLY (M25E)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
25	2717	. SWITCH, IGNITION	1
-26	70479	. DIODE (6 AMP, 1000V)	4
-27	131772	. HARNESS, WIRE	1
-28	70232	. WIRE, WHITE (16 AWG)	15 FT
-29	2991	. WIRE, WHITE	4 FT
-30	70008	. WIRE, YELLOW (12 AWG)	3

CONTROL/COMPONENT BOX ASSEMBLY (M20ET)



REV.

CONTROL/COMPONENT BOX ASSEMBLY (M20ET)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	131842	ASSEMBLY, CONTROL/COMPONENT BOX (See Sect. 3, Fig. 1C for NHA)	REF
2	131827	. SUB-ASSEMBLY, CONTROL/COMPONENT BOX	1
3	131745	.. COVER, GROUND CONTROL	1
4	61921	.. SCREW, CAP SOCKET	4
5	131846	. ASSEMBLY, VALVE CONTROL (See Sect. 3, Fig. 15B for Details)	1
6	60613	. SCREW, SOCKET	2
7	63303	. WASHER, LOCK	2
8	117-A	. BLOCK, TERMINAL END	2
9	4027	. BLOCK, TERMINAL	32
10	62612	. SCREW, SLOT	6
11	70337	. RELAY, TIME DELAY	1
12	61730	. SCREW, PAN	1
13	63322	. WASHER, LOCK	1
14	130193	. ASSEMBLY, TILT SWITCH (See Sect. 3, Fig. 16 for Details)	1
15	60340	. SCREW, HEX	2
16	63701	. NUT, HEX	6
17	70409	. INLET, FLANGED 110V	1
18	20481	. SWITCH, TOGGLE	1
19	20884	. GUARD, SWITCH	1
20	20481	. SWITCH, TOGGLE	1
21	16260	. SWITCH, TOGGLE	1
22	65244	. PLUG, WHITE	1
23	182734	. DECAL	1
24	20562	. BREAKER, CIRCUIT	2

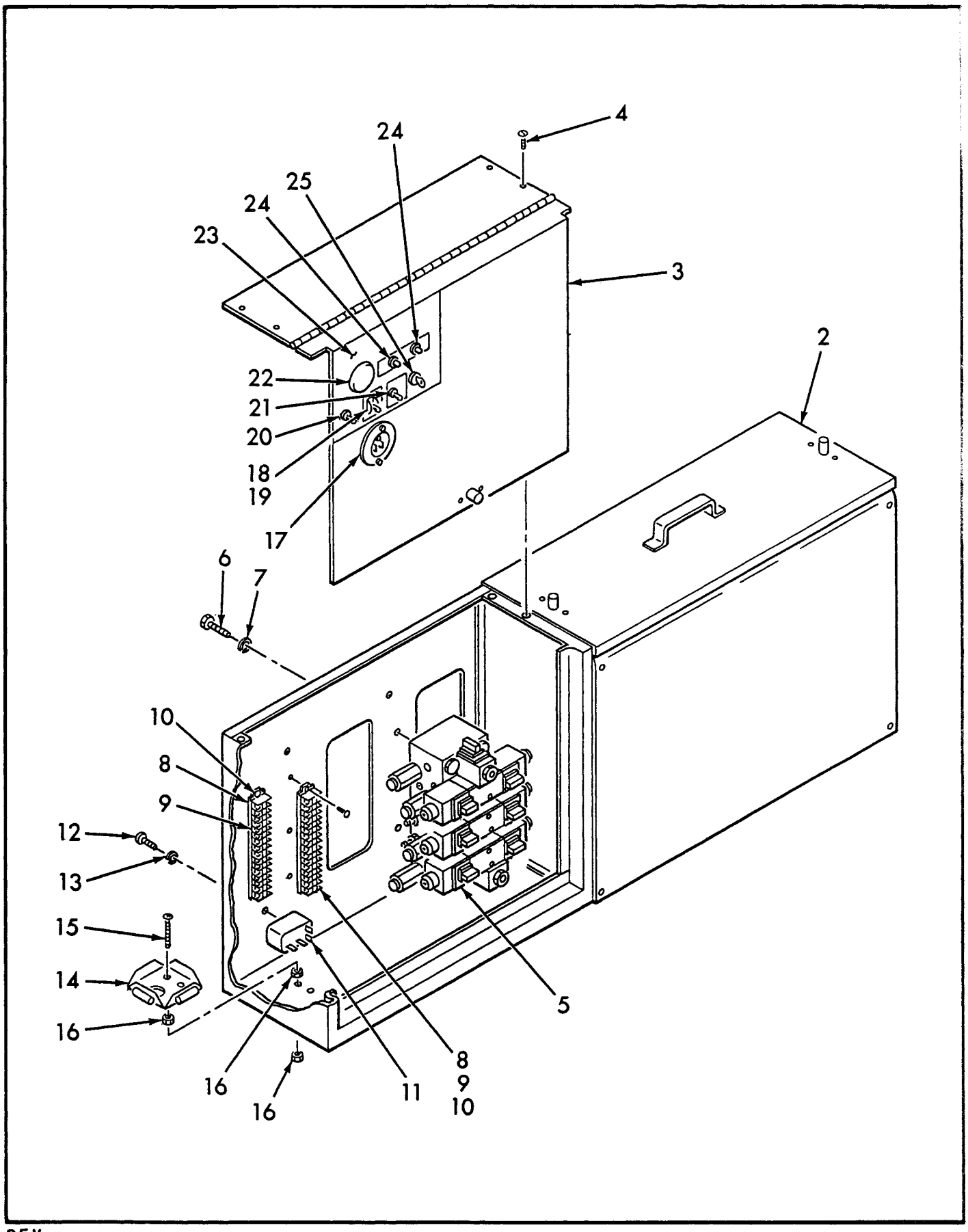
- ITEM NOT ILLUSTRATED

CONTROL/COMPONENT BOX ASSEMBLY (M20ET)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
25	2717	. SWITCH, IGNITION	1
-26	70479	. DIODE (6 AMP, 1000V)	4
-27	131772	. HARNESS, WIRE	1
-28	70232	. WIRE, WHITE (16 AWG)	15 FT
-29	2991	. WIRE, WHITE	4 FT
-30	70008	. WIRE, YELLOW (12 AWG)	3

- ITEM NOT ILLUSTRATED

CONTROL/COMPONENT BOX ASSEMBLY (M25ET)



REV.

CONTROL/COMPONENT BOX ASSEMBLY (M25ET)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	131841	ASSEMBLY, CONTROL/COMPONENT BOX (See Sect. 3, Fig. 1D for NHA)	REF
2	131830	. SUB-ASSEMBLY, CONTROL/COMPONENT BOX	1
3	131753	.. COVER, GROUND CONTROL	1
4	61921	.. SCREW, CAP SOCKET	4
5	131846	. ASSEMBLY, VALVE CONTROL (See Sect. 3, Fig. 15B for Details)	1
6	60613	. SCREW, SOCKET	2
7	63303	. WASHER, LOCK	2
8	117-A	. BLOCK, TERMINAL END	2
9	4027	. BLOCK, TERMINAL	32
10	62612	. SCREW, SLOT	6
11	70337	. RELAY, TIME DELAY	1
12	61730	. SCREW, PAN	1
13	63322	. WASHER, LOCK	1
14	130193	. ASSEMBLY, TILT SWITCH (See Sect. 3, Fig. 16 for Details)	1
15	60340	. SCREW, HEX	2
16	63701	. NUT, HEX	6
17	70409	. INLET, FLANGED 110V	1
18	20481	. SWITCH, TOGGLE	1
19	20884	. GUARD, SWITCH	1
20	20481	. SWITCH, TOGGLE	1
21	16260	. SWITCH, TOGGLE	1
22	65244	. PLUG, WHITE	1
23	182734	. DECAL	1
24	20562	. BREAKER, CIRCUIT	2

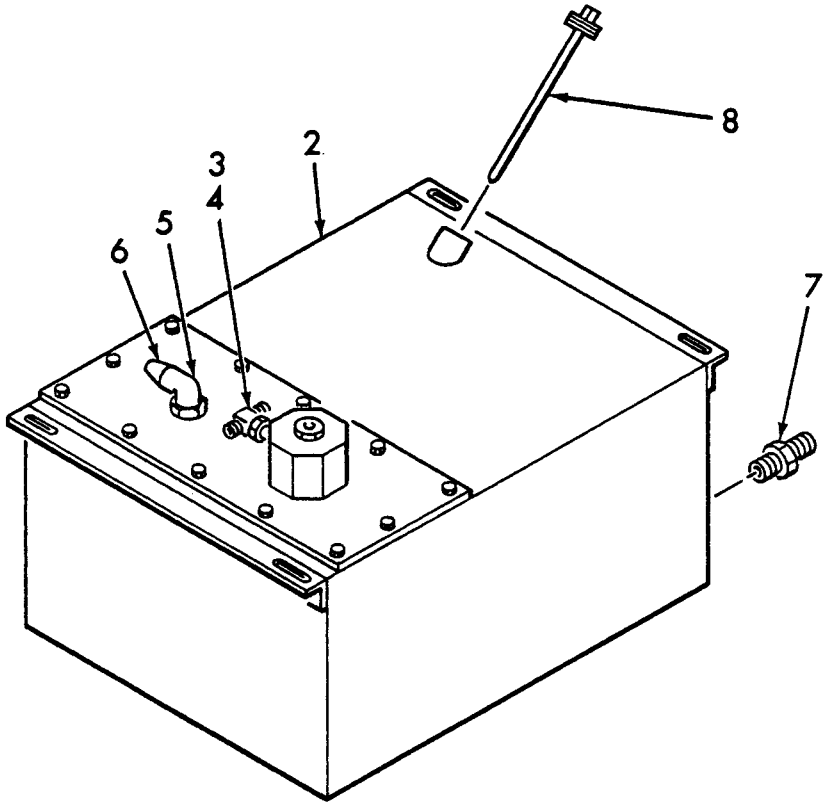
- ITEM NOT ILLUSTRATED

CONTROL/COMPONENT BOX ASSEMBLY (M25ET)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
25	2717	. SWITCH, IGNITION	1
-26	70479	. DIODE (6 AMP, 1000V)	4
-27	131772	. HARNESS, WIRE	1
-28	70232	. WIRE, WHITE (16 AWG)	15 FT
-29	2991	. WIRE, WHITE	4 FT
-30	70008	. WIRE, YELLOW (12 AWG)	3

- ITEM NOT ILLUSTRATED

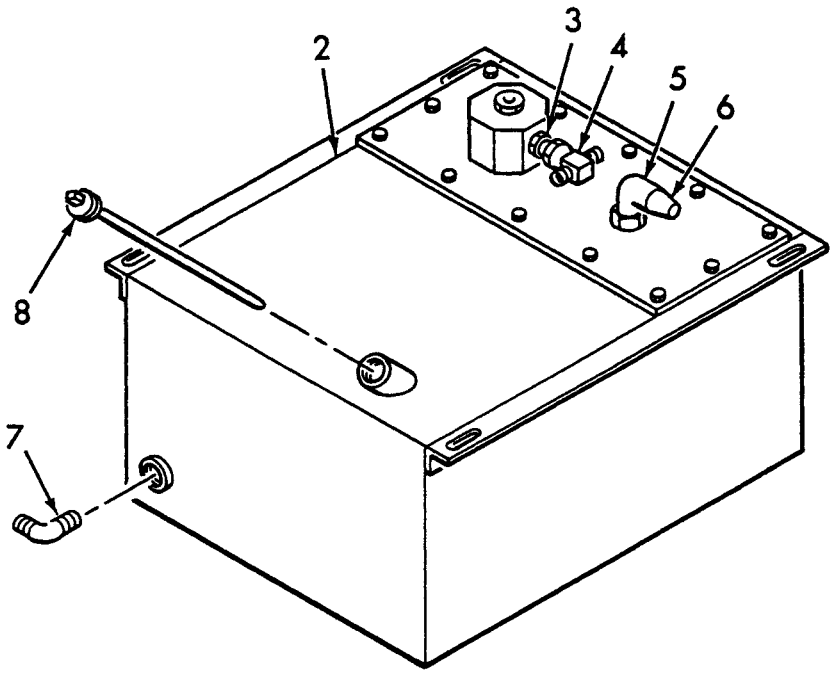
HYDRAULIC TANK ASSEMBLY (M20GP)



ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	131439	ASSEMBLY, HYDRAULIC TANK (See Sect. 3, Fig. 1 for NHA)	REF
2	131561	. SUB-ASSEMBLY, HYDRAULIC TANK	1
3	80001-16	. CONNECTOR, MALE	1
4	80030-07	. TEE, BRANCH SWIVEL NUT	1
5	80021-03	. ELBOW, STREET	1
6	65213	. CAP, BREATHER	1
7	80001-23	. CONNECTOR, MALE	1
8	130230	. WELDMENT, DIPSTICK	1

REV.

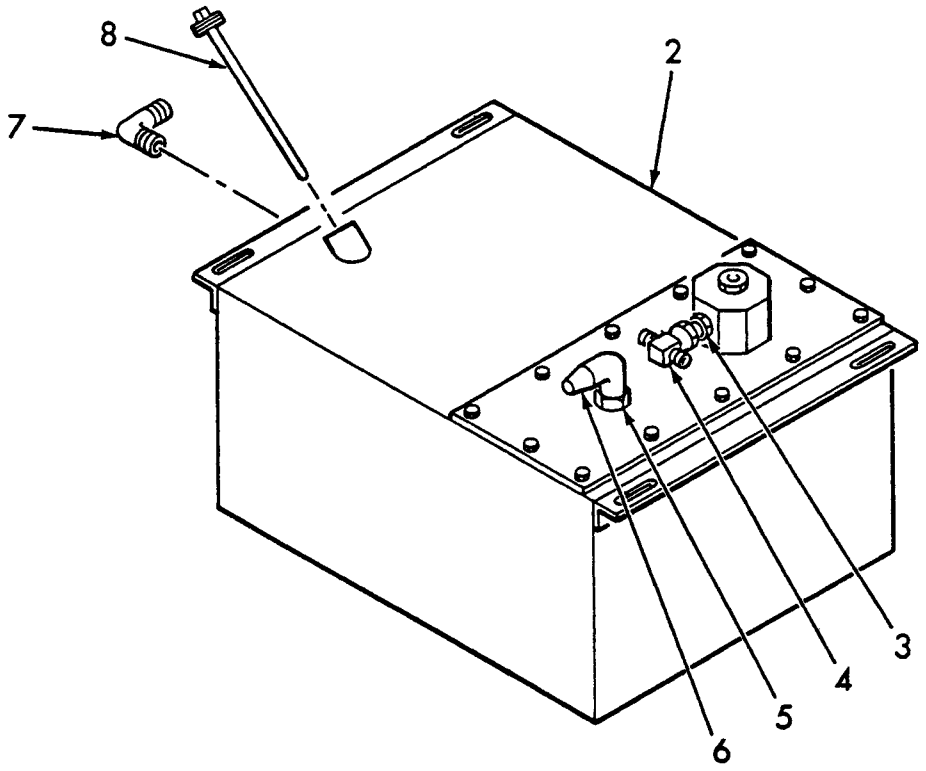
HYDRAULIC TANK ASSEMBLY (M20E & M20ET)



ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	131394	ASSEMBLY, HYDRAULIC TANK (See Sect. 3, Fig. 1A or 1C for NHA)	REF
2	131413	. SUB-ASSEMBLY, HYDRAULIC TANK	1
3	80001-16	. CONNECTOR, MALE	1
4	80030-07	. TEE, BRANCH SWIVEL NUT	1
5	80021-03	. ELBOW, STREET	1
6	65213	. CAP, BREATHER	1
7	80008-21	. ELBOW, MALE	1
8	130230	. WELDMENT, DIPSTICK	1

REV.

HYDRAULIC TANK ASSEMBLY (M25E & M25ET)

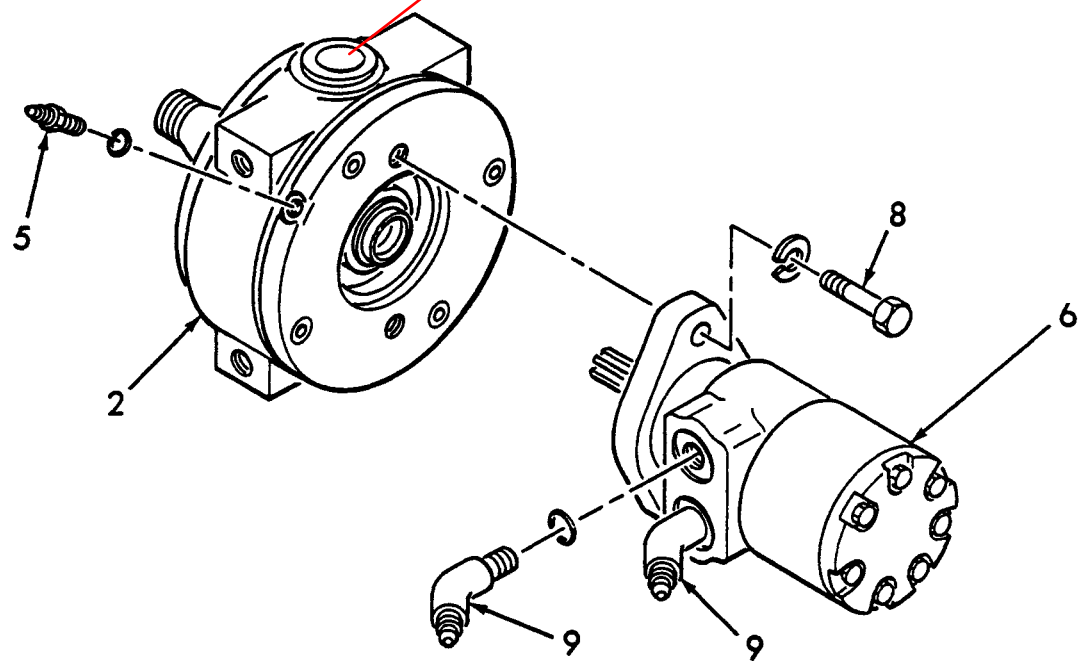


ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	131394	ASSEMBLY, HYDRAULIC TANK (See Sect. 3, Fig. 1B or 1D for NHA)	REF
2	131413	. SUB-ASSEMBLY, HYDRAULIC TANK	1
3	80001-16	. CONNECTOR, MALE	1
4	80030-07	. TEE, BRANCH SWIVEL NUT	1
5	80021-03	. ELBOW, STREET	1
6	65213	. CAP, BREATHER	1
7	80008-21	. ELBOW, MALE	1
8	130230	. WELDMENT, DIPSTICK	1

REV.

DRIVE MOTOR & BRAKE ASSEMBLY (L.H.)
(ALL MODELS)

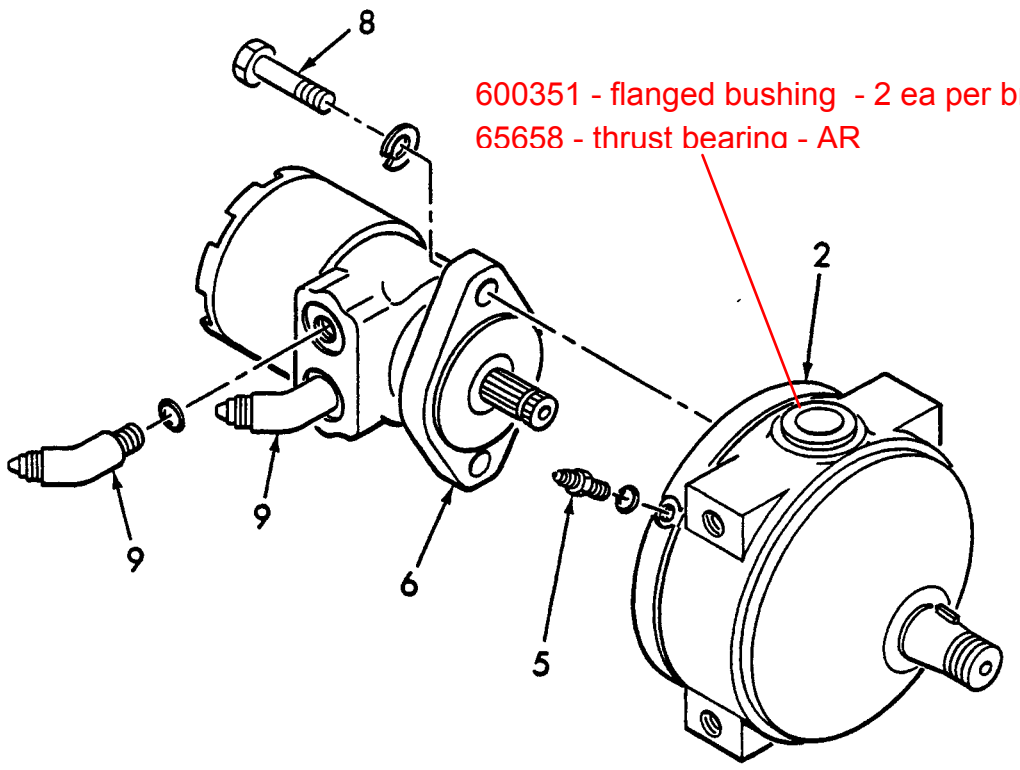
600351 - flanged bushing - 2 ea per brake
65658 - thrust bearing - AR



ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	131527	ASSEMBLY, DRIVE MOTOR & BRAKE (L.H.) (See Sect. 3, Fig. 1 thru 1D for NHA)	REF
2	81290	. BRAKE, MULTIPLE DISC (See Vendor Section)	1
-3	66806	.. KIT, SEAL	1
-4	67648	.. KIT, LINING	1
5	80004-03	. CONNECTOR, STRAIGHT THREAD	1
6	81017	. MOTOR, HYDRAULIC DRIVE (See Vendor Section)	1
-7	66896	.. KIT, SEAL	1
8	60610	. SCREW, CAP	2
9	80018-13	. ELBOW, STRAIGHT THREAD	2

REV.

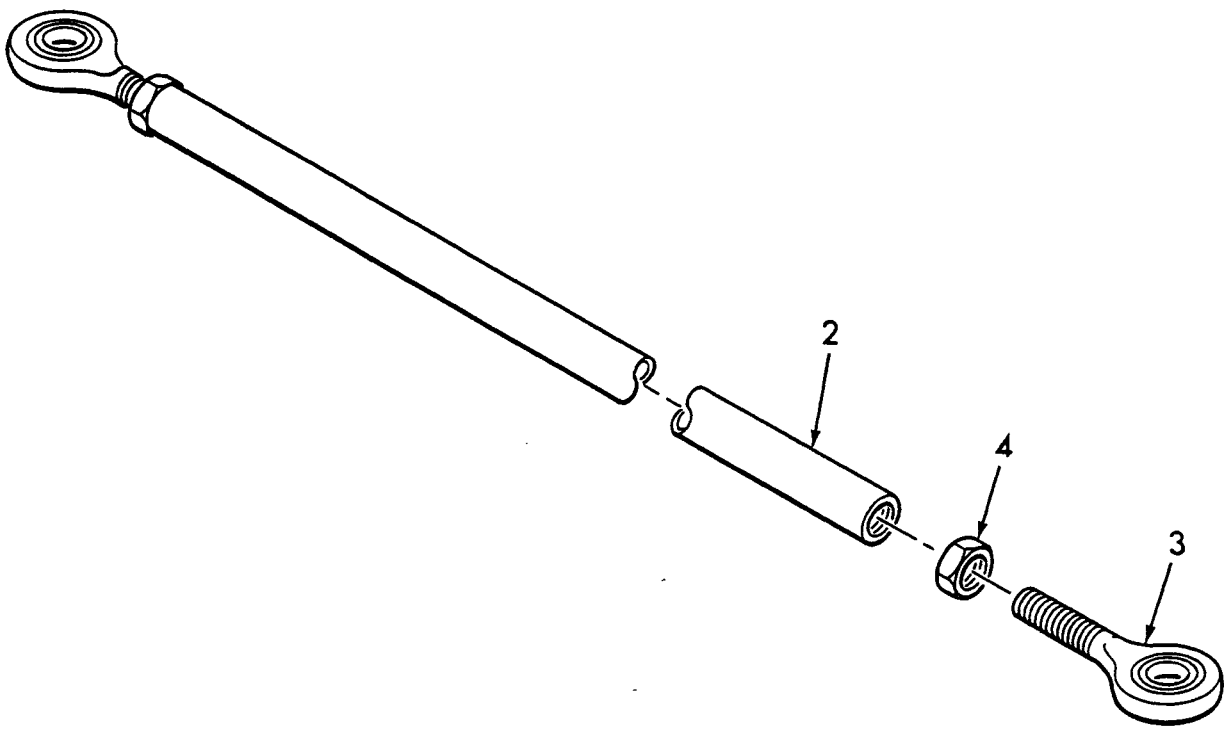
DRIVE MOTOR & BRAKE ASSEMBLY (R.H.)
(ALL MODELS)



ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	131528	ASSEMBLY, DRIVE MOTOR & BRAKE (R.H.) (See Sect. 3, Fig. 1 thru 1D for NHA)	REF
2	81290	. BRAKE, MULTIPLE DISC (See Vendor Section)	1
-3	66806	.. KIT, SEAL	1
-4	67648	.. KIT, LINING	1
5	80004-03	. CONNECTOR, STRAIGHT THREAD	1
6	81017	. MOTOR, HYDRAULIC DRIVE (See Vendor Section)	1
-7	66896	.. KIT, SEAL	1
8	60610	. SCREW, CAP	2
9	80018-13	. ELBOW, STRAIGHT THREAD	2

REV.

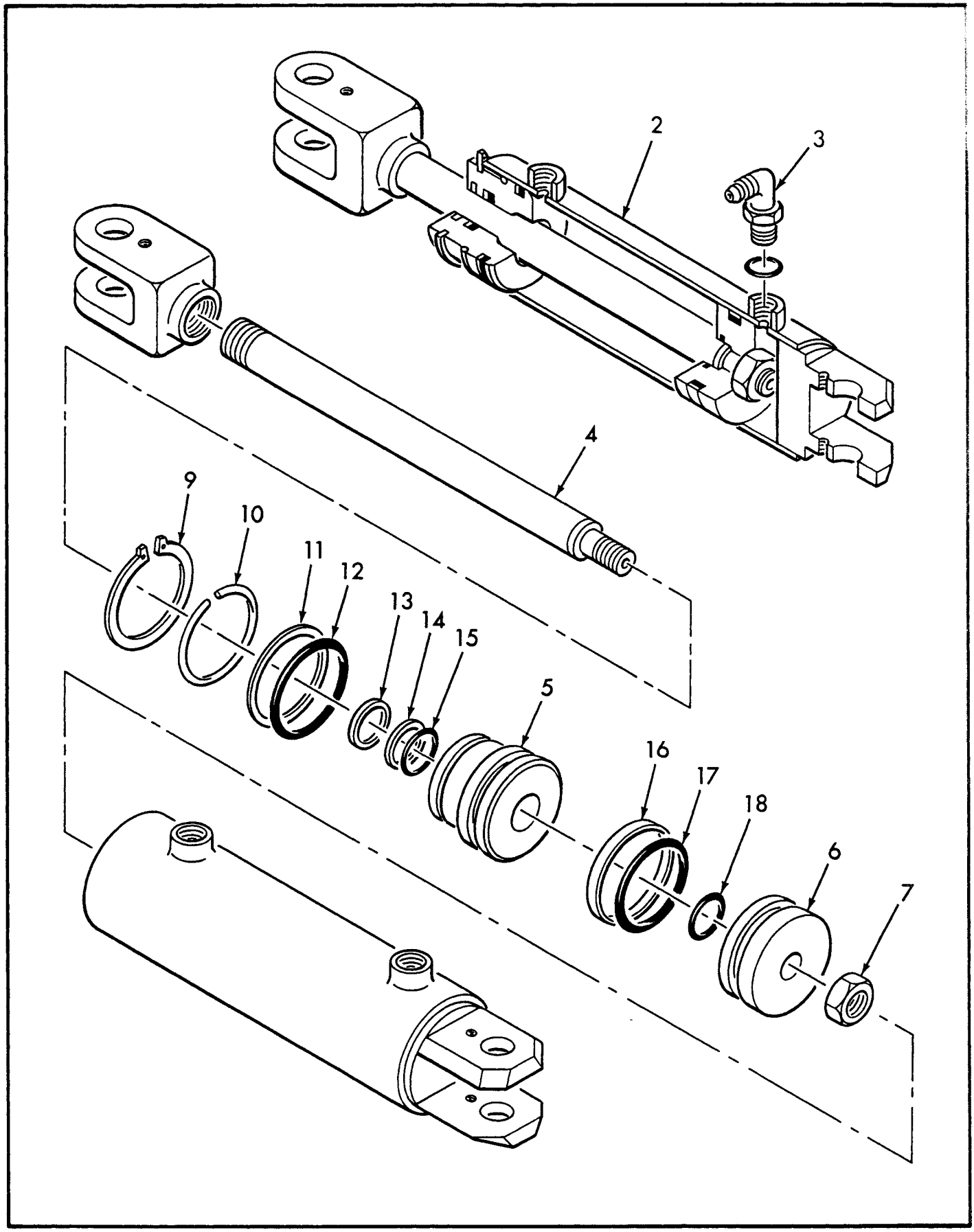
TIE ROD ASSEMBLY (ALL MODELS)



ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	130469	ASSEMBLY, TIE ROD (See Sect. 3, Fig. 1 thru 1D for NHA)	REF
2	130470	. ROD, TIE	1
3	2274	. END, TIE ROD	2
4	60901	. NUT, JAM	2

REV.

STEERING CYLINDER ASSEMBLY (ALL MODELS)



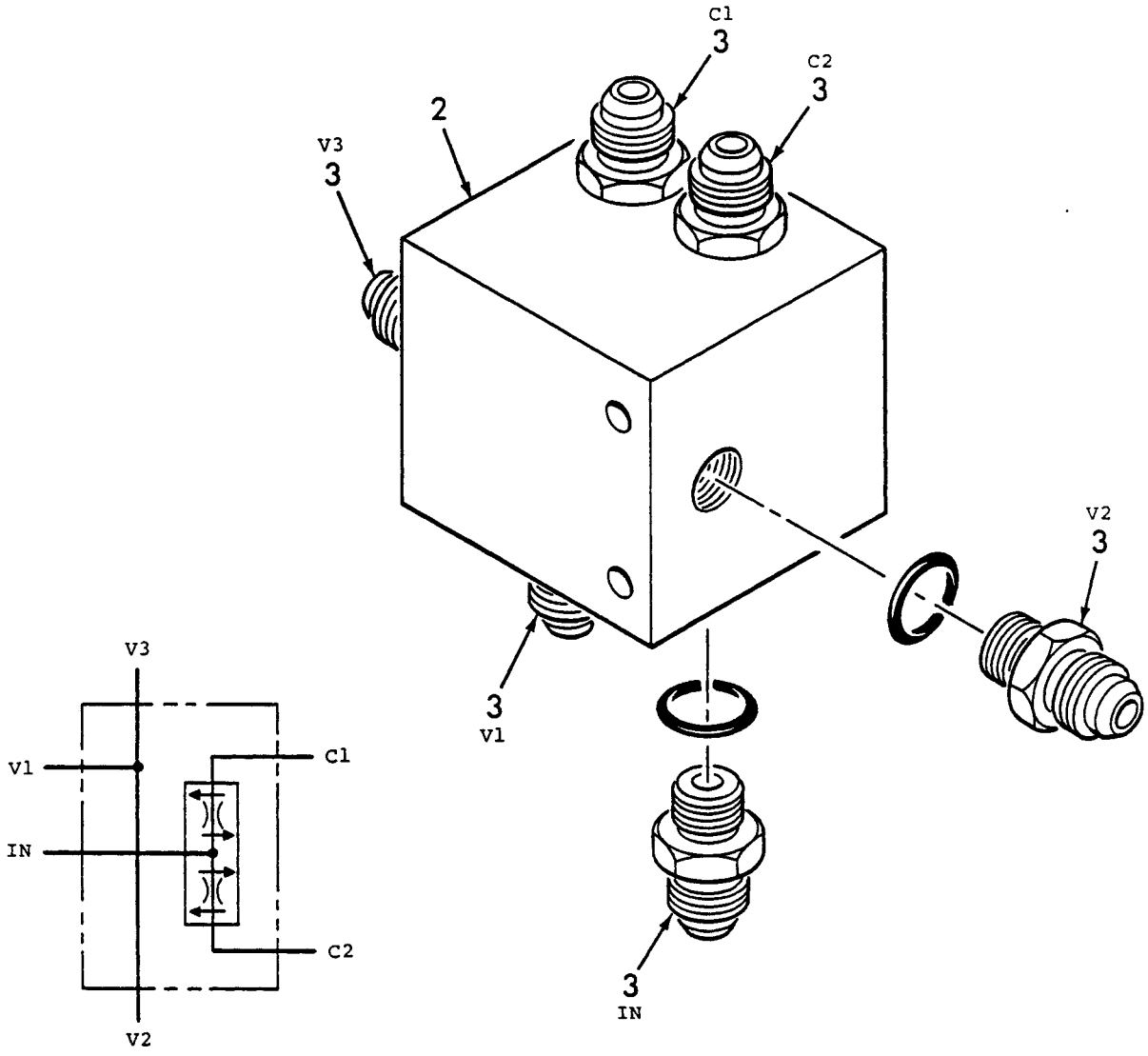
REV.

STEERING CYLINDER ASSEMBLY (ALL MODELS)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	130237	ASSEMBLY, STEERING CYLINDER (See Sect. 3, Fig. 1 thru 1D for NHA)	REF
2	130165	. CYLINDER, STEERING	1
3	80004-03	. ELBOW, STRAIGHT THREAD	2
4	67950	.. ROD, CHROME PLATED	1
5		.. BEARING	1
6	67951	.. PISTON	1
7		.. NUT, LOCK	1
-8	66640	.. KIT, SEAL	1
9		... RING, RETAINING	1
10		... RING, LOCK	1
11		... WASHER, BACKUP	1
12		... O-RING	1
13		... SEAL, WIPER	1
14		... WASHER, BACKUP	1
15		... O-RING	1
16		... RING, SLIPPER	1
17		... O-RING	1
18		... O-RING	1

- ITEM NOT ILLUSTRATED

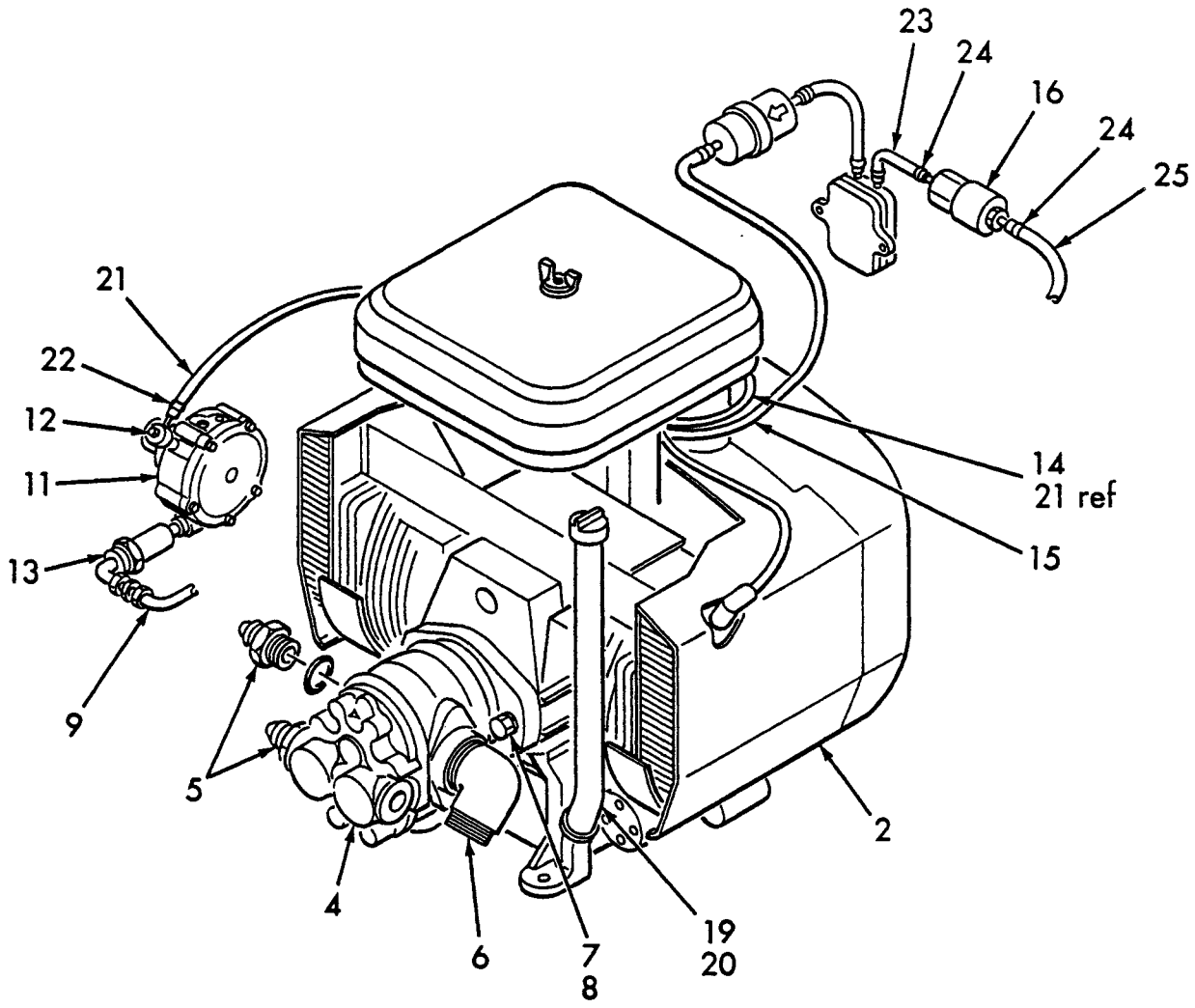
FLOW DIVIDER ASSEMBLY (ALL MODELS)



ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	131526	ASSEMBLY, FLOW DIVIDER (See Sect. 3, Fig. 1 thru 1D for NHA)	REF
2	81174	. VALVE, FLOW DIVIDER	1
3	80004-11	. CONNECTOR, STRAIGHT THREAD	6

REV.

ENGINE & PUMP ASSEMBLY (M20GP)



ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	131374	ASSEMBLY, ENGINE & PUMP (See Sect. 3, Fig. 1 for NHA)	REF
2	131375	. ENGINE, ONAN P216	1
-3	131551	. ASSEMBLY, PUMP	1
4	81284	.. ASSEMBLY, DOUBLE GEAR PUMP (See Sect. 3, Fig. 12 for Details)	1
5	80004-12	.. CONNECTOR, STRAIGHT THREAD	2
6	80012-27	.. ELBOW, STRAIGHT THREAD	1

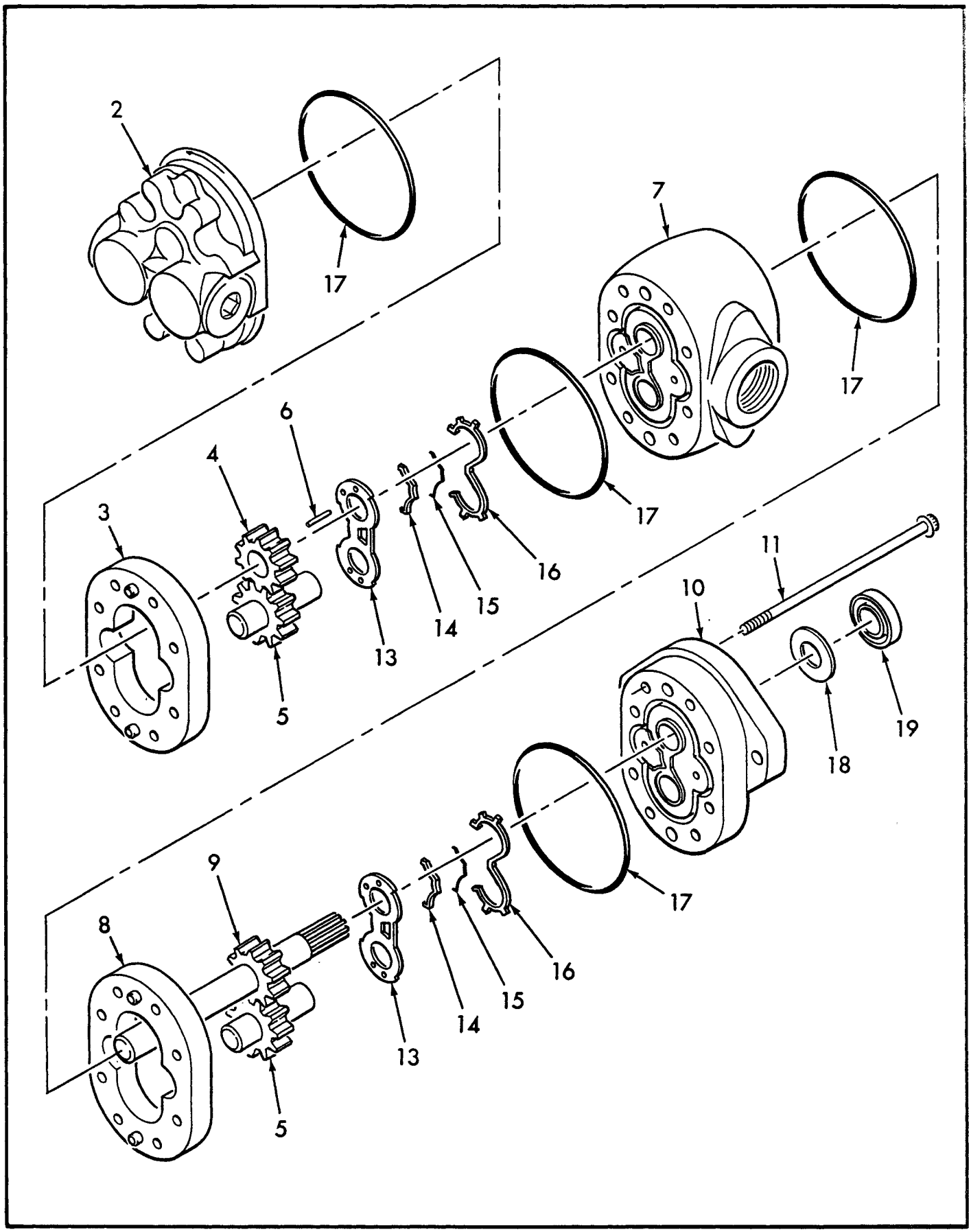
REV.

ENGINE & PUMP ASSEMBLY (M20GP)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
7	60351	. SCREW, CAP	2
8	63303	. WASHER, LOCK	2
9	131575	. ASSEMBLY, PROPANE HOSE (See Sect. 3, Fig. 13 for Details)	1
-10	131511	. KIT, DUAL FUEL	1
11	67778	.. REGULATOR, DRY-GAS	1
12	67782	.. ELBOW, POWER ADJUSTMENT	1
13	67780	.. VALVE, GASOLINE	1
14	67781	.. ADAPTER, CARBURETOR	1
15	67783	.. FITTING, HOSE	1
16	67779	.. LOCK, FILTER	1
17	67837	.. CLAMP, HOSE (DRY-GAS)	2
18	67840	.. HOSE, COOL AIR	8
19	67838	.. SPACER, CRANK-CASE VENT	1
20	67839	.. CLAMP, CRANK-CASE VENT	2
21	66146	. HOSE	1.5 FT
22	2713	. CLAMP, HOSE	2
23	160-B-0050	. HOSE, FUEL	1
24	161-A	. CLAMP, HOSE	4
25	160-B-0880	. HOSE, FUEL	1

- ITEM NOT ILLUSTRATED

DOUBLE GEAR PUMP ASSEMBLY (M20GP)



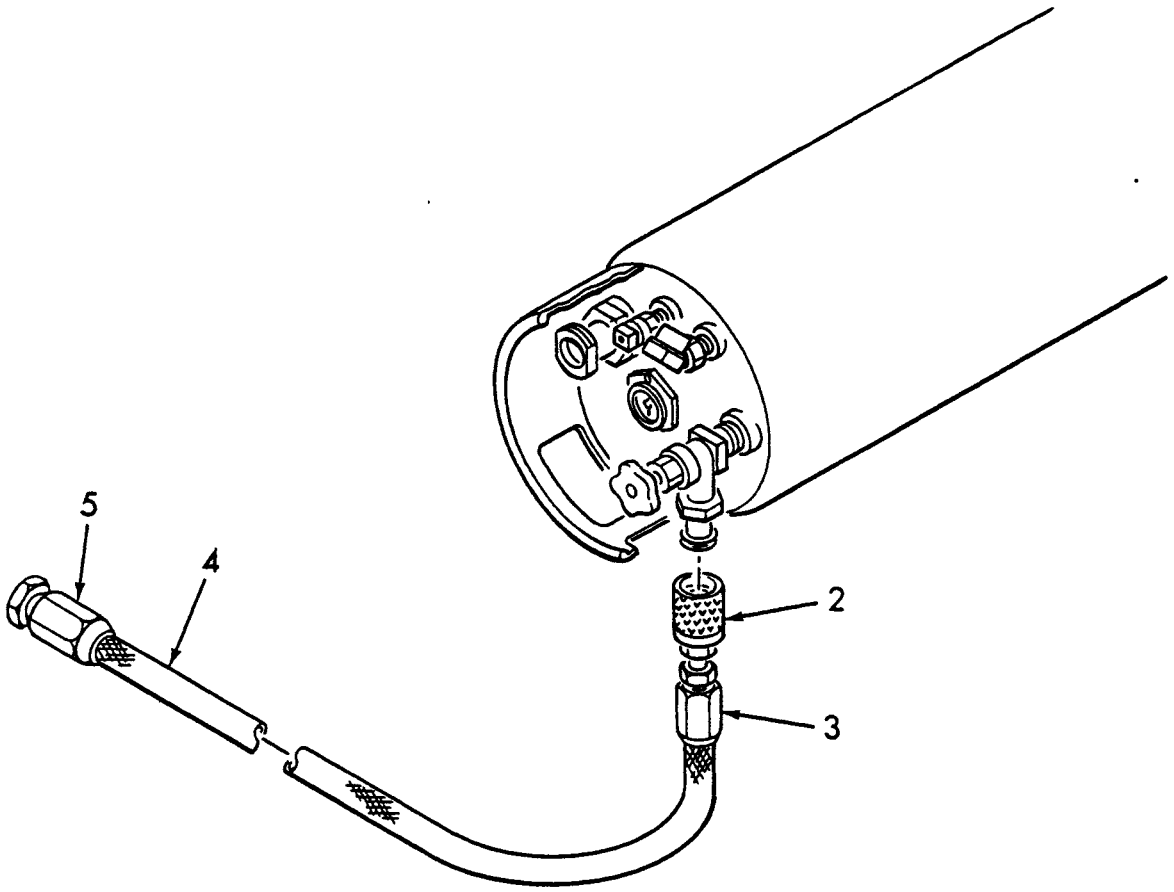
REV.

DOUBLE GEAR PUMP ASSEMBLY (M20GP)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	81284	ASSEMBLY, DOUBLE GEAR PUMP (See Sect. 3, Fig. 11 for NHA)	REF
2	67501	. ASSEMBLY, BACK PLATE	1
3		. BODY, REAR	1
4		. GEAR, SLIP FIT	1
5		. GEAR, IDLER	2
6		. KEY, ROUND	1
7	67504	. PLATE, ADAPTER	1
8		. BODY, FRONT	1
9		. ASSEMBLY, SPLINE DRIVE GEAR	1
10	67502	. ASSEMBLY, FRONT PLATE	1
11		. SCREW, CAP	8
-12	66869	. KIT, SEAL	1
13		.. PLATE, WEAR	2
14		.. SEAL, BEARING	2
15		.. O-RING, MOLDED	2
16		.. GASKET, BACK-UP	2
17		.. O-RING	4
18		.. WASHER	1
19		.. SEAL, SHAFT	1

- ITEM NOT ILLUSTRATED

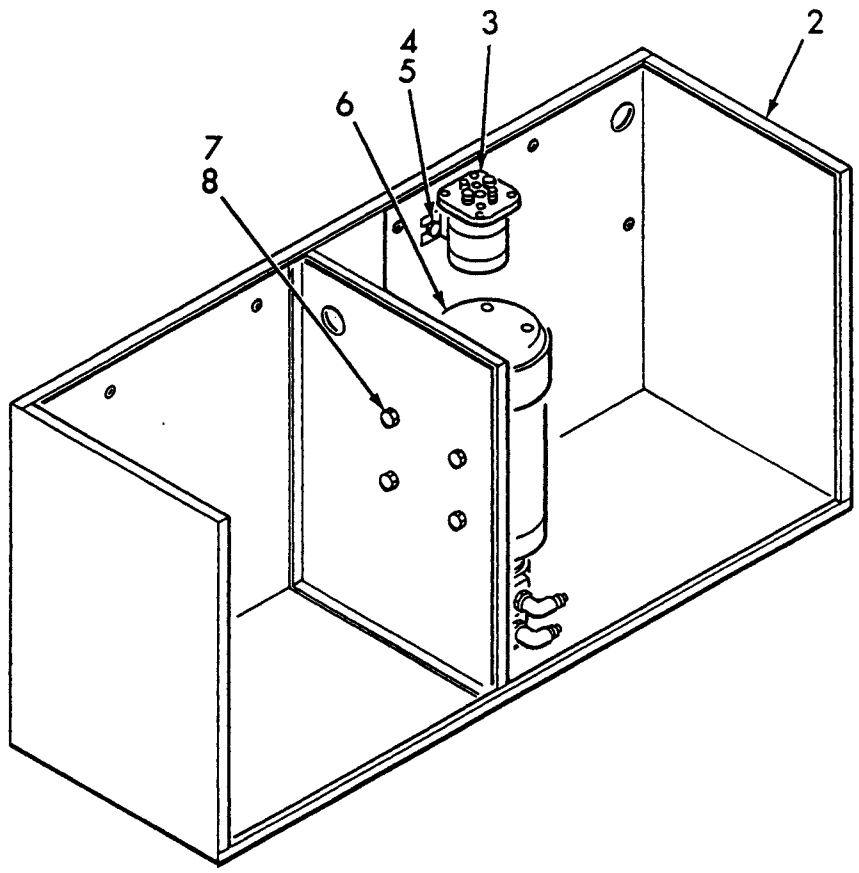
PROPANE HOSE ASSEMBLY (M20GP)



ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	131575	ASSEMBLY, PROPANE HOSE (See Sect. 3, Fig. 11 for NHA)	REF
2	65142	. SOCKET, QUICK DISCONNECT	1
3	16452	. FITTING, HOSE (MALE)	1
4	2616	. HOSE	12 FT
5	16451	. FITTING, HOSE (MALE)	1

REV.

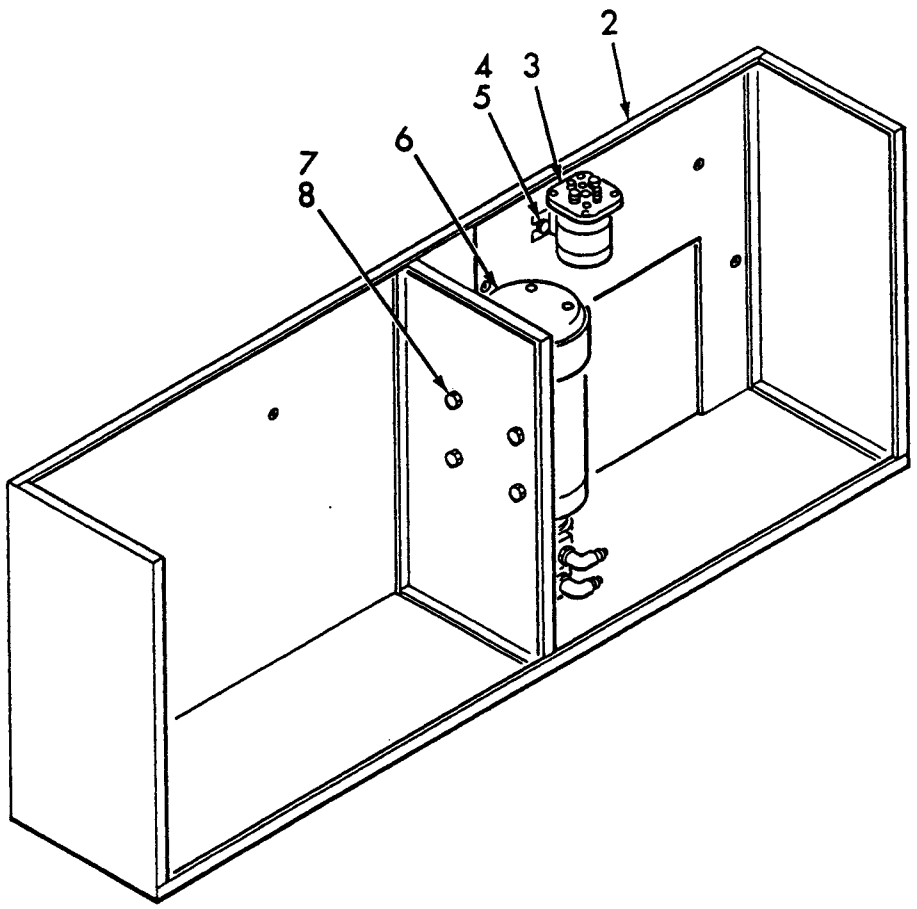
COMPONENT BOX ASSEMBLY (M20E & M20ET)



ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	131557	ASSEMBLY, COMPONENT BOX (See Sect. 3, Fig. 1A or 1C for NHA)	REF
2	131474	. SUB-ASSEMBLY, COMPONENT BOX	1
3	70362	. RELAY, POWER	1
4	63359	. SCREW, CAP	2
5	61312	. NUT, SELF LOCKING	2
6	131562	. ASSEMBLY, PUMP/MOTOR (See Sect. 3, Fig. 18 for Details)	1
7	60343	. SCREW, CAP	4
8	61318	. NUT, SELF LOCKING	4

REV.

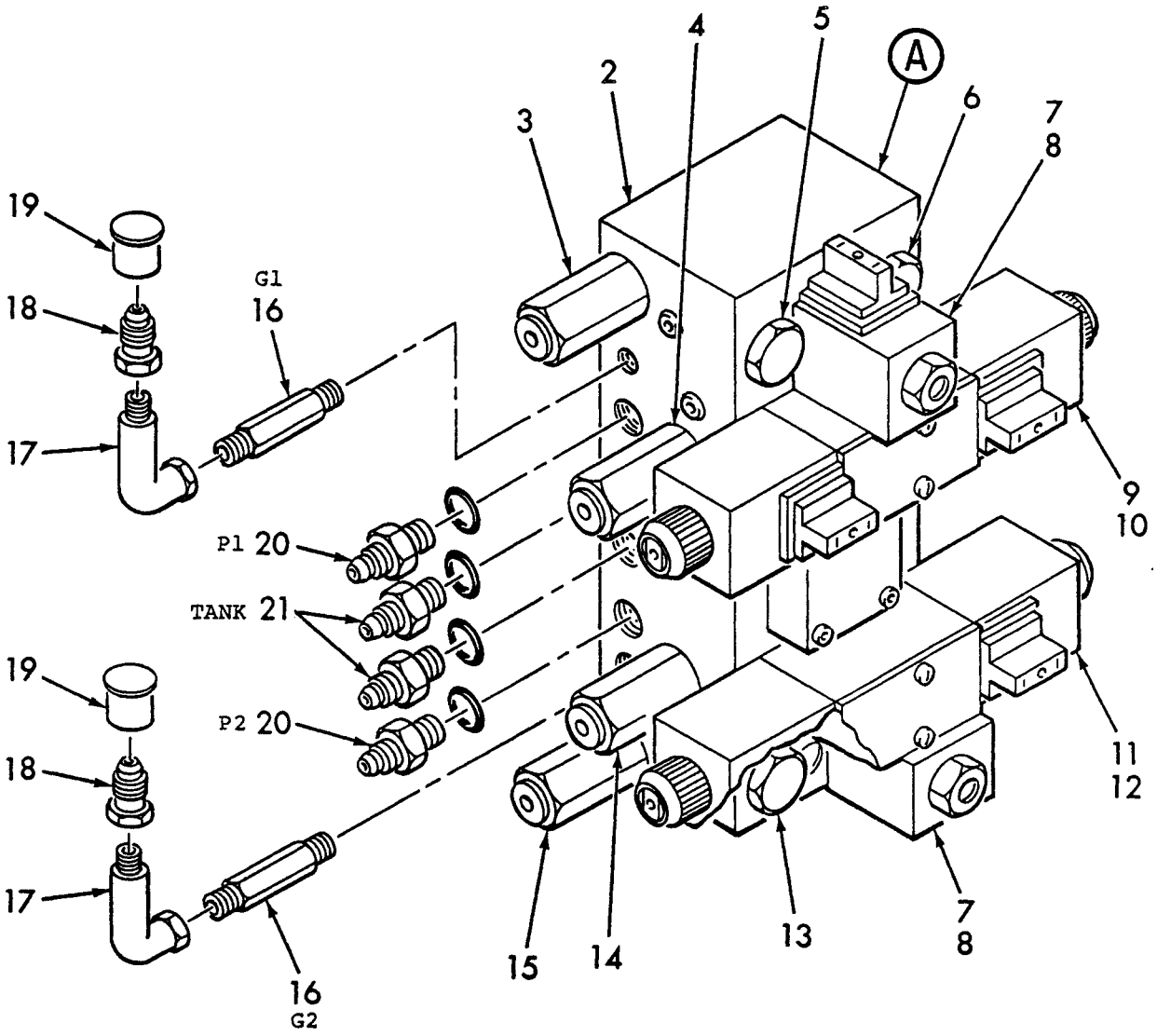
COMPONENT BOX ASSEMBLY (M25E & M25ET)



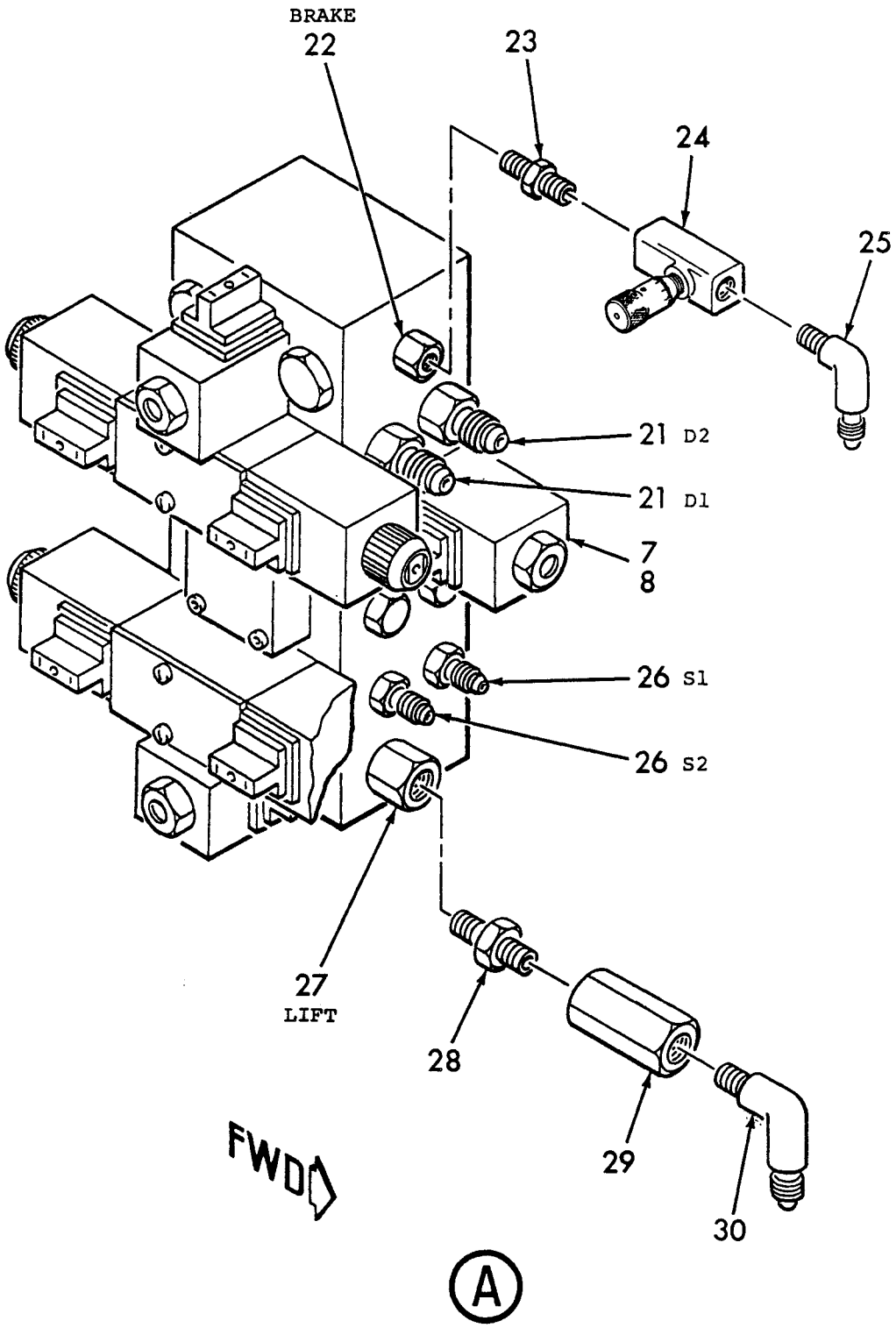
ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	131499	ASSEMBLY, COMPONENT BOX (See Sect. 3, Fig. 1B or 1D for NHA)	REF
2	131491	. SUB-ASSEMBLY, COMPONENT BOX	1
3	70362	. RELAY, POWER	1
4	63359	. SCREW, CAP	2
5	61312	. NUT, SELF LOCKING	2
6	131562	. ASSEMBLY, PUMP/MOTOR (See Sect. 3, Fig. 18 for Details)	1
7	60343	. SCREW, CAP	4
8	61318	. NUT, SELF LOCKING	4

REV.

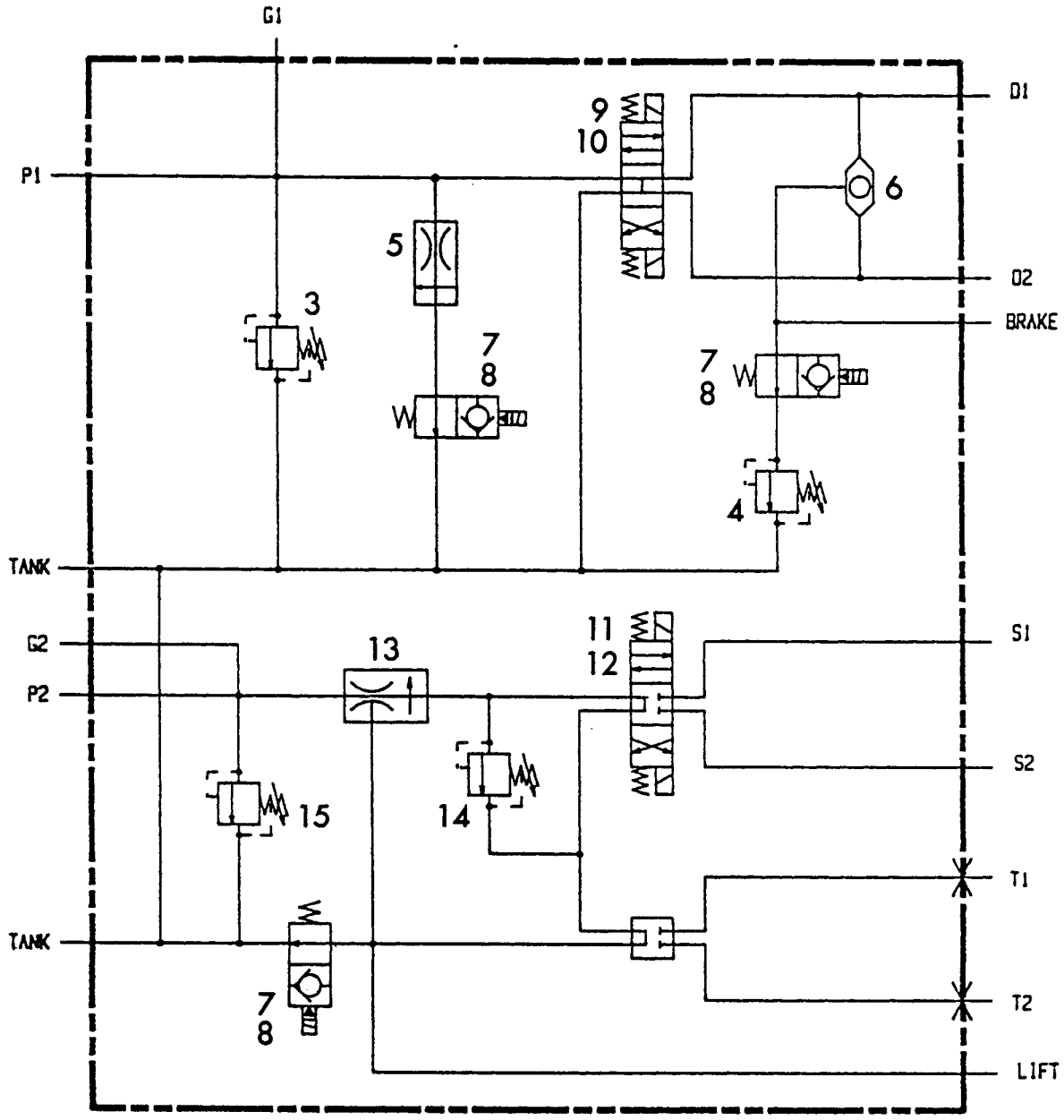
VALVE CONTROL ASSEMBLY (M20GP) (BEFORE LATE 1989)



VALVE CONTROL ASSEMBLY (M20GP) (BEFORE LATE 1989)



VALVE CONTROL ASSEMBLY (M20GP)
(BEFORE LATE 1989)



REV.

VALVE CONTROL ASSEMBLY (M20GP)
(BEFORE LATE 1989)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	131548	ASSEMBLY, VALVE CONTROL (See Sect. 3, Fig. 4 for NHA)	REF
2	81285	. VALVE, CONTROL	1
3	68060	.. VALVE, RELIEF*	1
4	68057	.. VALVE, RELIEF*	1
5	600000	.. REGULATOR, FLOW	1
6	66924	.. VALVE, SHUTTLE	1
7	66920	.. SOLENOID, N.O. POPPET	3
8	66914	... COIL (12 VOLT)	3
9	600001	.. VALVE, D01	1
10	66913	... COIL, D01 (12 VOLT)	2
11	66668	.. VALVE, D01	1
12	66913	... COIL, D01 (12 VOLT)	2
13	67004	.. REGULATOR, FLOW	1
14	68057	.. VALVE, RELIEF*	1
15	68060	.. VALVE, RELIEF*	1
16	160153	. NIPPLE	2
17	80009-04	. ELBOW, MALE	2
18	2527	. COUPLING	2
19	845	. CAP, QUICK DISCONNECT	2
20	80004-12	. CONNECTOR, STRAIGHT THREAD	2
21	80004-11	. CONNECTOR, STRAIGHT THREAD	4

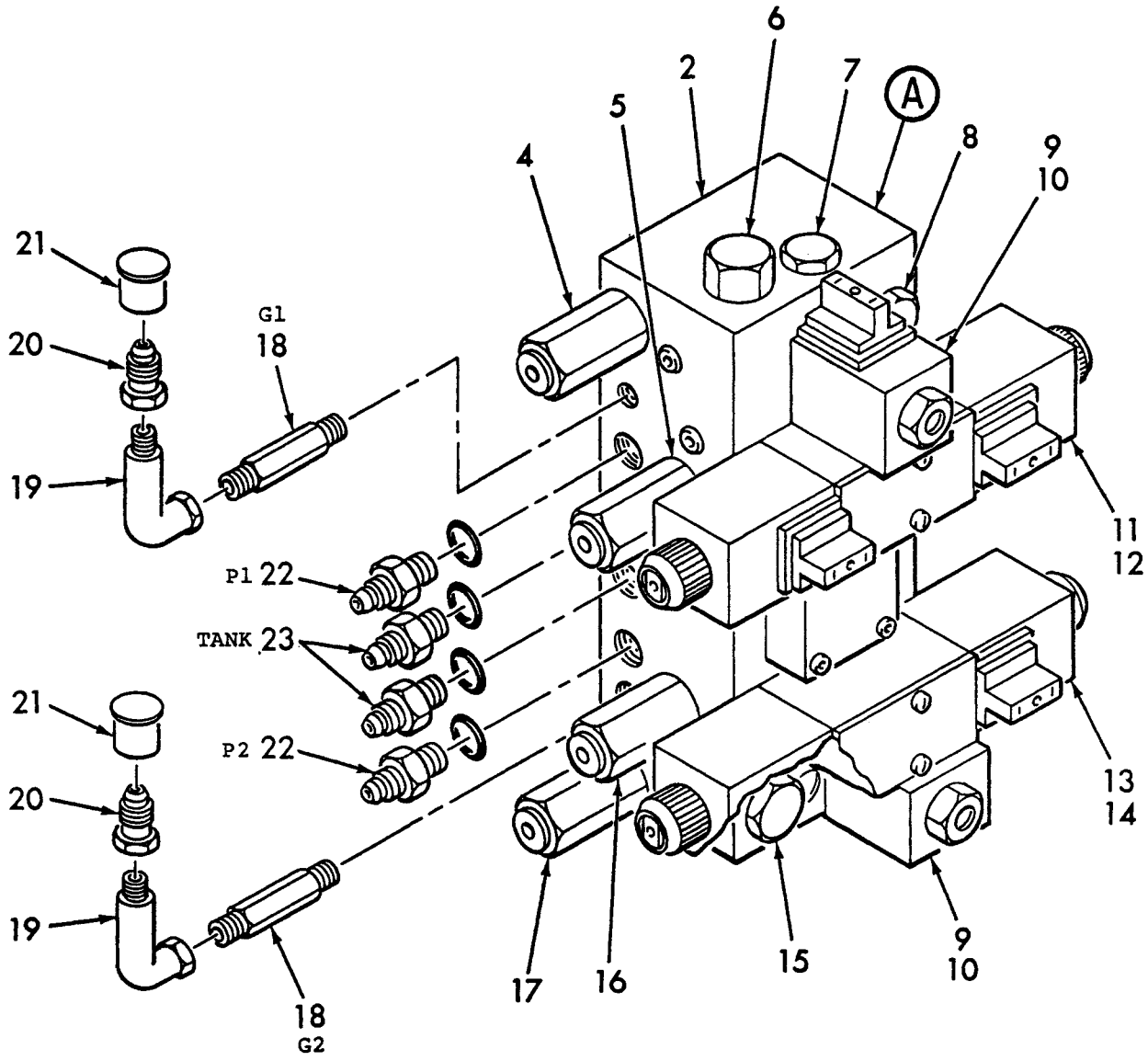
NOTE:
PRIOR TO USE, ITEMS WITH ASTERISK (*) MUST BE ADJUSTED TO THE PRESSURE LISTED ON THE SPECIFIC MACHINE'S HYDRAULIC SCHEMATIC.

VALVE CONTROL ASSEMBLY (M20GP)
(BEFORE LATE 1989)

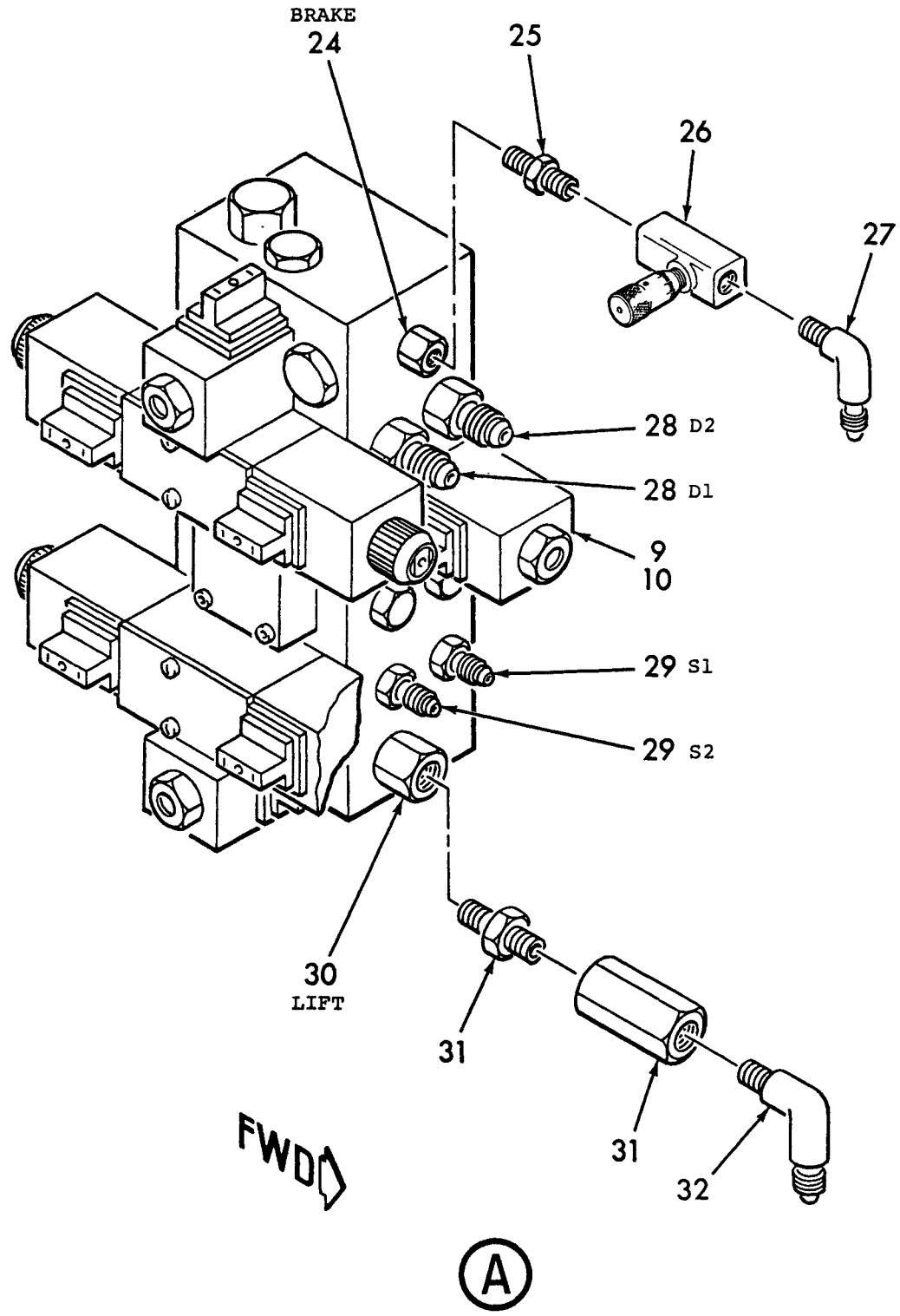
ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
22	51903	. ADAPTER, FEMALE PIPE	1
23	80052-02	. NIPPLE, PIPE	1
24	30884	. VALVE, FLOW CONTROL	1
25	80008-03	. ELBOW, MALE	1
26	80004-03	. CONNECTOR, STRAIGHT THREAD	2
27	80058-03	. REDUCER	1
28	80052-04	. NIPPLE, PIPE	1
29	81137	. VALVE, PRESSURE COMPENSATE	1
30	80008-08	. ELBOW, MALE	1

- ITEM NOT ILLUSTRATED

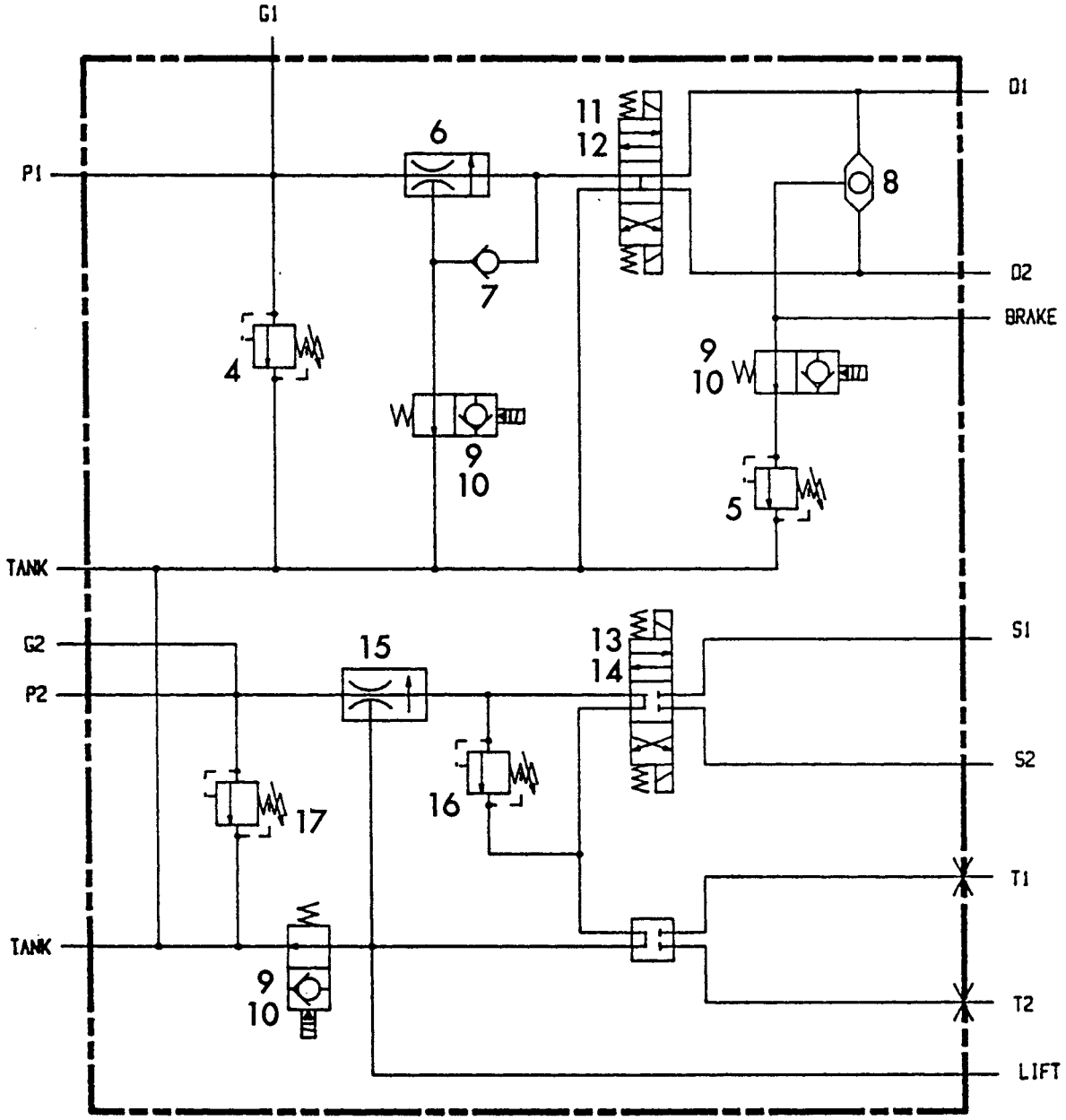
VALVE CONTROL ASSEMBLY (M20GP) (AFTER LATE 1989)



VALVE CONTROL ASSEMBLY (M20GP)
(AFTER LATE 1989)



VALVE CONTROL ASSEMBLY (M20GP)
(AFTER LATE 1989)



VALVE CONTROL ASSEMBLY (M20GP)
(AFTER LATE 1989)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	131847	ASSEMBLY, VALVE CONTROL (See Sect. 3, Fig. 4 for NHA)	REF
2	81330	. VALVE, CONTROL	1
-3	600004	.. KIT, SEAL (COMPLETE VALVE PKGS.)	1
4	68060	.. VALVE, RELIEF*	1
5	68057	.. VALVE, RELIEF*	1
6		.. REGULATOR, FLOW	1
7	600003	.. VALVE, CHECK	1
8	66924	.. VALVE, SHUTTLE	1
9	66920	.. SOLENOID, N.O. POPPET	3
10	66914	... COIL (12 VOLT)	3
11	600002	.. VALVE, DO1	1
12	66913	... COIL, DO1 (12 VOLT)	2
13	67153	.. VALVE, DO1	1
14	66913	... COIL, DO1 (12 VOLT)	2
15	67004	.. REGULATOR, FLOW	1
16	68057	.. VALVE, RELIEF*	1
17	68060	.. VALVE, RELIEF*	1
18	160153	. NIPPLE	2
19	80021-03	. ELBOW, STREET	2
20	2527	. COUPLING	2
21	845	. CAP, QUICK DISCONNECT	2

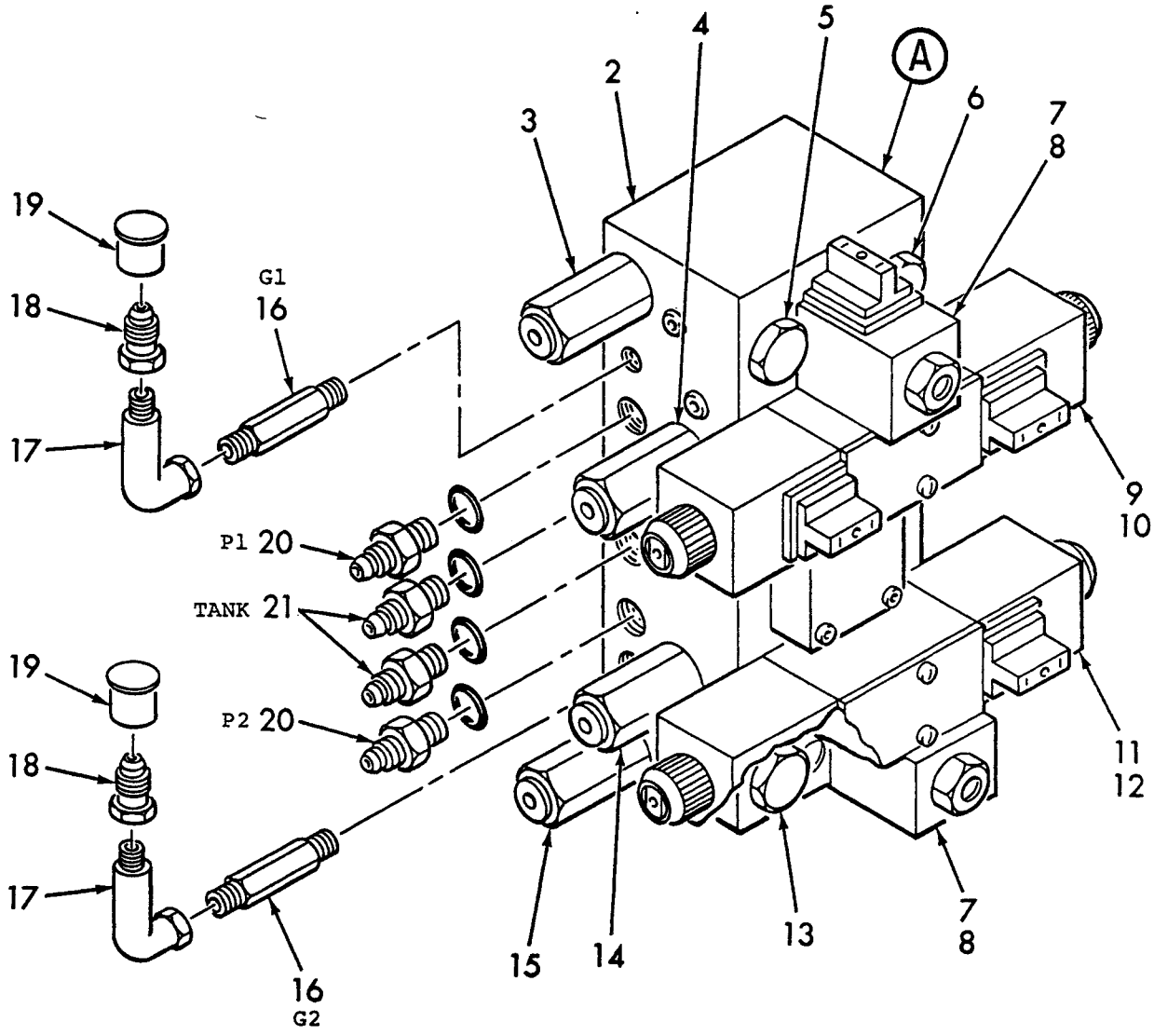
NOTE:
PRIOR TO USE, ITEMS WITH ASTERISK (*) MUST BE ADJUSTED TO THE PRESSURE LISTED ON THE SPECIFIC MACHINE'S HYDRAULIC SCHEMATIC.

VALVE CONTROL ASSEMBLY (M20GP)
(AFTER LATE 1989)

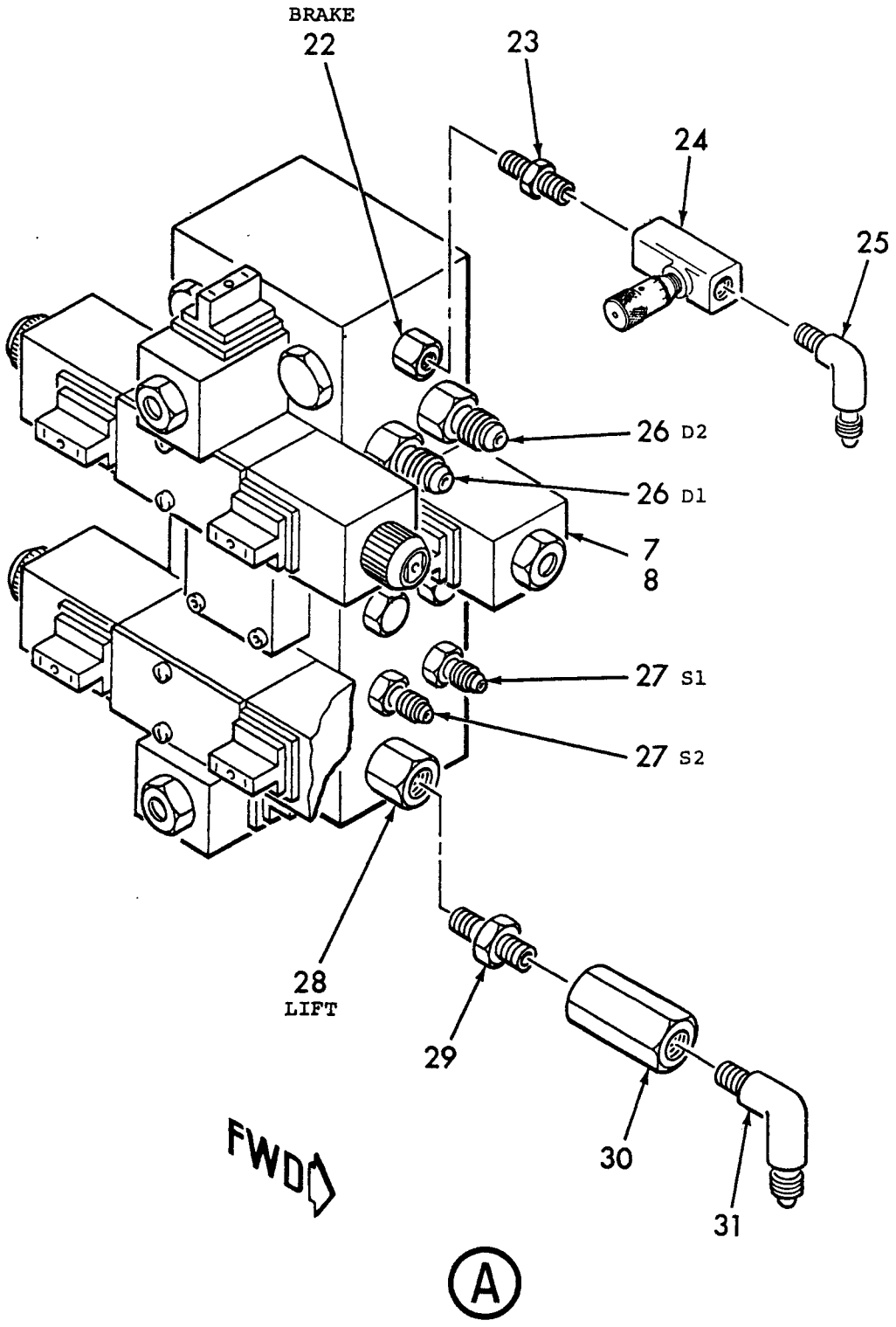
ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
22	80004-12	. CONNECTOR, STRAIGHT THREAD	2
23	80004-16	. CONNECTOR, STRAIGHT THREAD	2
24	51903	. ADAPTER, FEMALE PIPE	1
25	80052-02	. NIPPLE, PIPE	1
26	30884	. VALVE, FLOW CONTROL	1
27	80008-03	. ELBOW, MALE	1
28	80004-11	. CONNECTOR, STRAIGHT THREAD	2
29	80004-03	. CONNECTOR, STRAIGHT THREAD	2
30	80063-01	. ADAPTER, FEMALE PIPE	1
31	80052-04	. NIPPLE, PIPE	1
32	81137	. VALVE, PRESSURE COMPENSATE	1
33	80008-08	. ELBOW, MALE	1

- ITEM NOT ILLUSTRATED

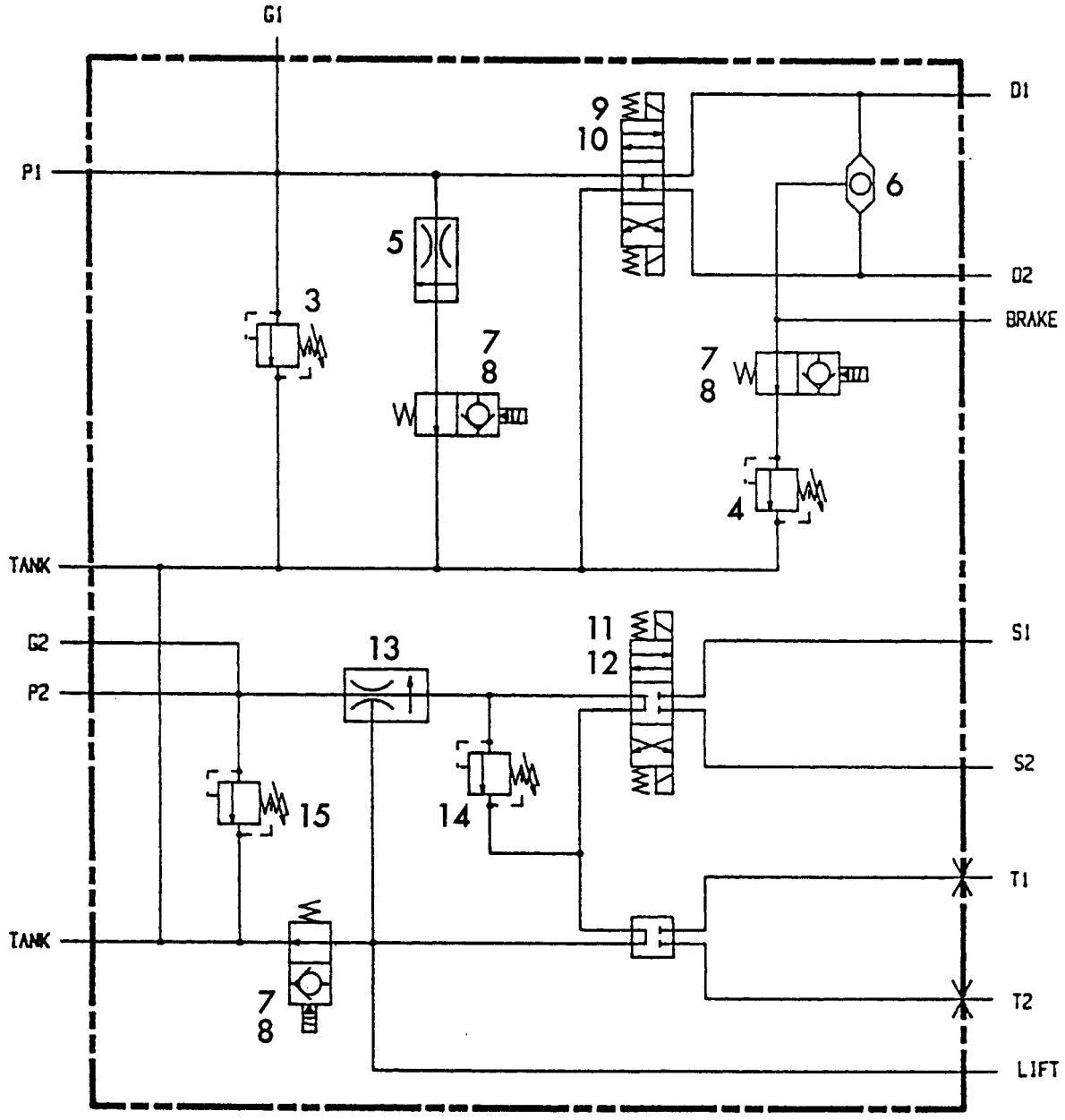
VALVE CONTROL ASSEMBLY (M20E & M25E) (BEFORE LATE 1989)



VALVE CONTROL ASSEMBLY (M20E & M25E) (BEFORE LATE 1989)



VALVE CONTROL ASSEMBLY (M20E & M25E)
(BEFORE LATE 1989)



REV.

VALVE CONTROL ASSEMBLY (M20E & M25E)
(BEFORE LATE 1989)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	131549	ASSEMBLY, VALVE CONTROL (See Sect. 3, Fig. 4A & 4B for NHA)	REF
2	81267	. VALVE, CONTROL	1
3	68060	.. VALVE, RELIEF*	1
4	68057	.. VALVE, RELIEF*	1
5	600000	.. REGULATOR, FLOW	1
6	66924	.. VALVE, SHUTTLE	1
7	67000	.. SOLENOID, N.O. POPPET	3
8	66865	... COIL (20 VOLT)	3
9	600001	.. VALVE, D01	1
10	66864	... COIL, D01 (20 VOLT)	2
11	67159	.. VALVE, D01	1
12	66864	... COIL, D01 (20 VOLT)	2
13	67004	.. REGULATOR, FLOW	1
14	68057	.. VALVE, RELIEF*	1
15	68060	.. VALVE, RELIEF*	1
16	160153	. NIPPLE	2
17	80021-03	. ELBOW, STREET	2
18	2527	. COUPLING	2
19	845	. CAP, QUICK DISCONNECT	2
20	80004-12	. CONNECTOR, STRAIGHT THREAD	2
21	80004-16	. CONNECTOR, STRAIGHT THREAD	2

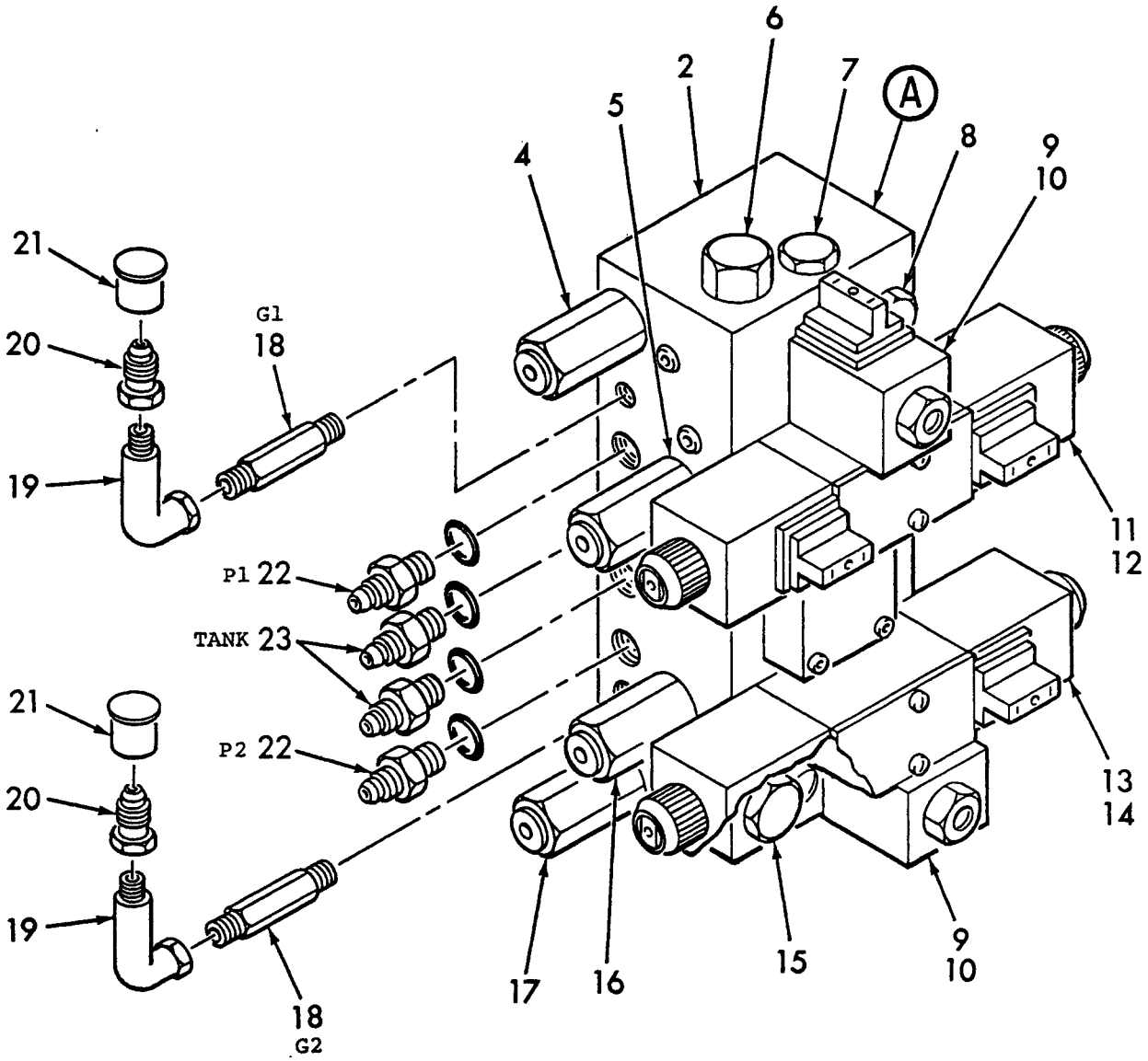
NOTE:
PRIOR TO USE, ITEMS WITH ASTERISK (*) MUST BE ADJUSTED TO THE PRESSURE LISTED ON THE SPECIFIC MACHINE'S HYDRAULIC SCHEMATIC.

VALVE CONTROL ASSEMBLY (M20E & M25E)
(BEFORE LATE 1989)

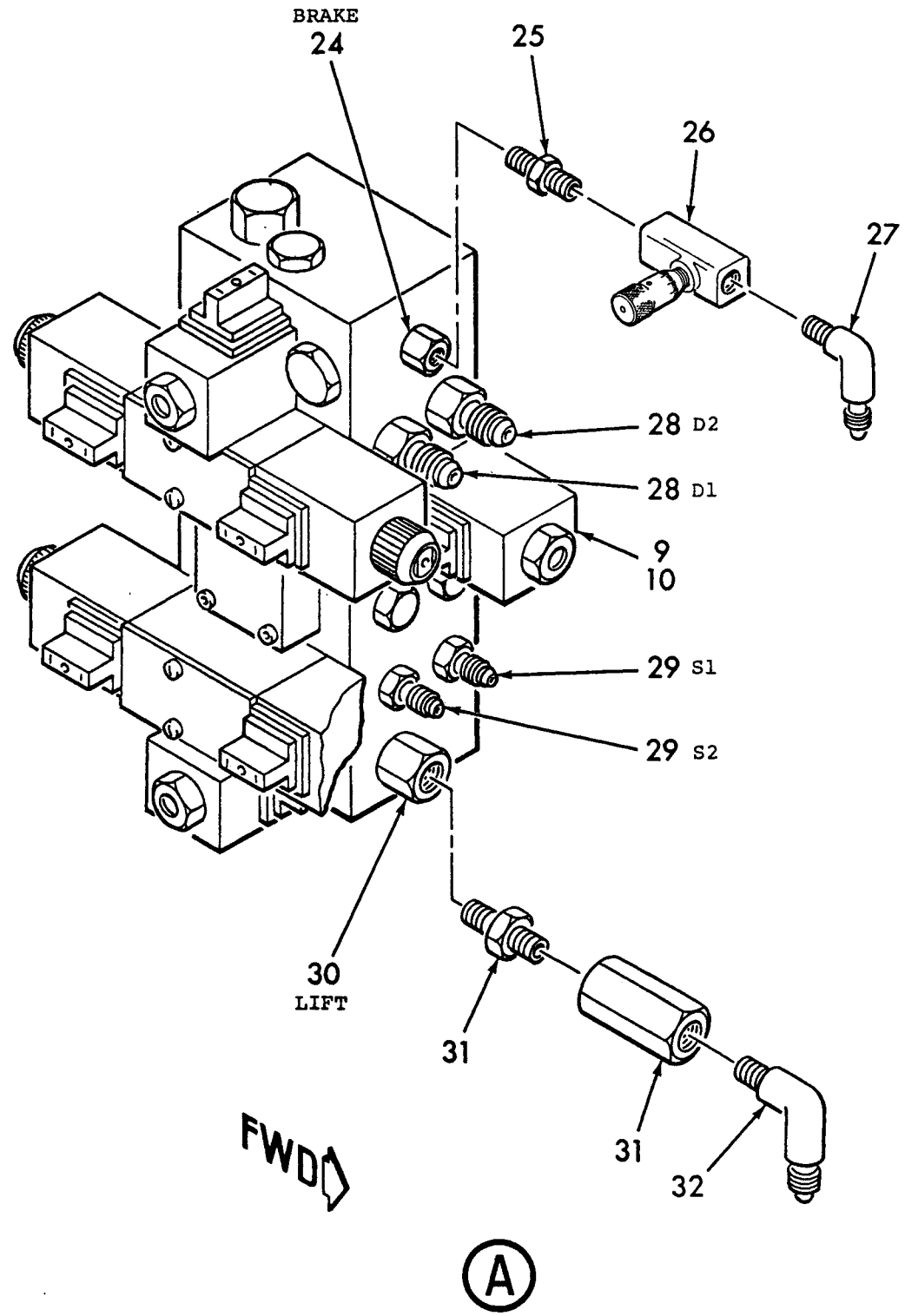
ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
22	51903	. ADAPTER, FEMALE PIPE	1
23	80052-02	. NIPPLE, PIPE	1
24	30884	. VALVE, FLOW CONTROL	1
25	80008-03	. ELBOW, MALE	1
26	80004-11	. CONNECTOR, STRAIGHT THREAD	2
27	80004-03	. CONNECTOR, STRAIGHT THREAD	2
28	80063-01	. ADAPTER, FEMALE PIPE	1
29	80052-04	. NIPPLE, PIPE	1
30	81137	. VALVE, PRESSURE COMPENSATE	1
31	80008-08	. ELBOW, MALE	1

- ITEM NOT ILLUSTRATED

VALVE CONTROL ASSEMBLY (M20E & M25E) (AFTER LATE 1989)

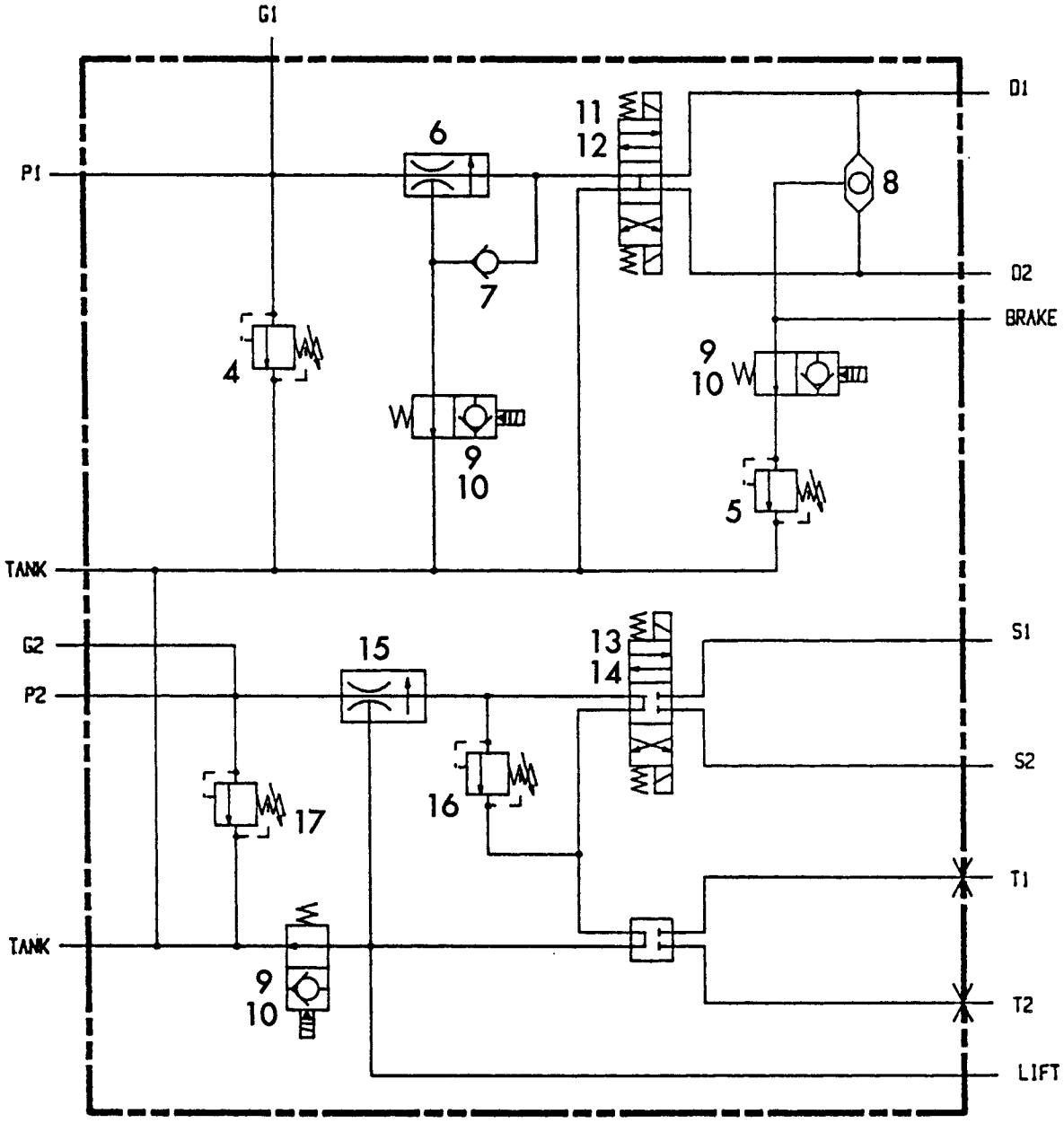


VALVE CONTROL ASSEMBLY (M20E & M25E) (AFTER LATE 1989)



REV.

VALVE CONTROL ASSEMBLY (M20E & M25E) (AFTER LATE 1989)



REV.

VALVE CONTROL ASSEMBLY (M20E & M25E)
(AFTER LATE 1989)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	131845	ASSEMBLY, VALVE CONTROL (See Sect. 3, Fig. 4A or 4B for NHA)	REF
2	81328	. VALVE, CONTROL	1
-3	600004	.. KIT, SEAL (COMPLETE VALVE PKGS.)	1
4	68060	.. VALVE, RELIEF*	1
5	68057	.. VALVE, RELIEF*	1
6		.. REGULATOR, FLOW	1
7	600003	.. VALVE, CHECK	1
8	66924	.. VALVE, SHUTTLE	1
9	67000	.. SOLENOID, N.O. POPPET	3
10	66865	... COIL (20 VOLT)	3
11	600001	.. VALVE, D01	1
12	66864	... COIL, D01 (20 VOLT)	2
13	67159	.. VALVE, D01	1
14	66864	... COIL, D01 (20 VOLT)	2
15	67004	.. REGULATOR, FLOW	1
16	68057	.. VALVE, RELIEF*	1
17	68060	.. VALVE, RELIEF*	1
18	160153	. NIPPLE	2
19	80021-03	. ELBOW, STREET	2
20	2527	. COUPLING	2
21	845	. CAP, QUICK DISCONNECT	2

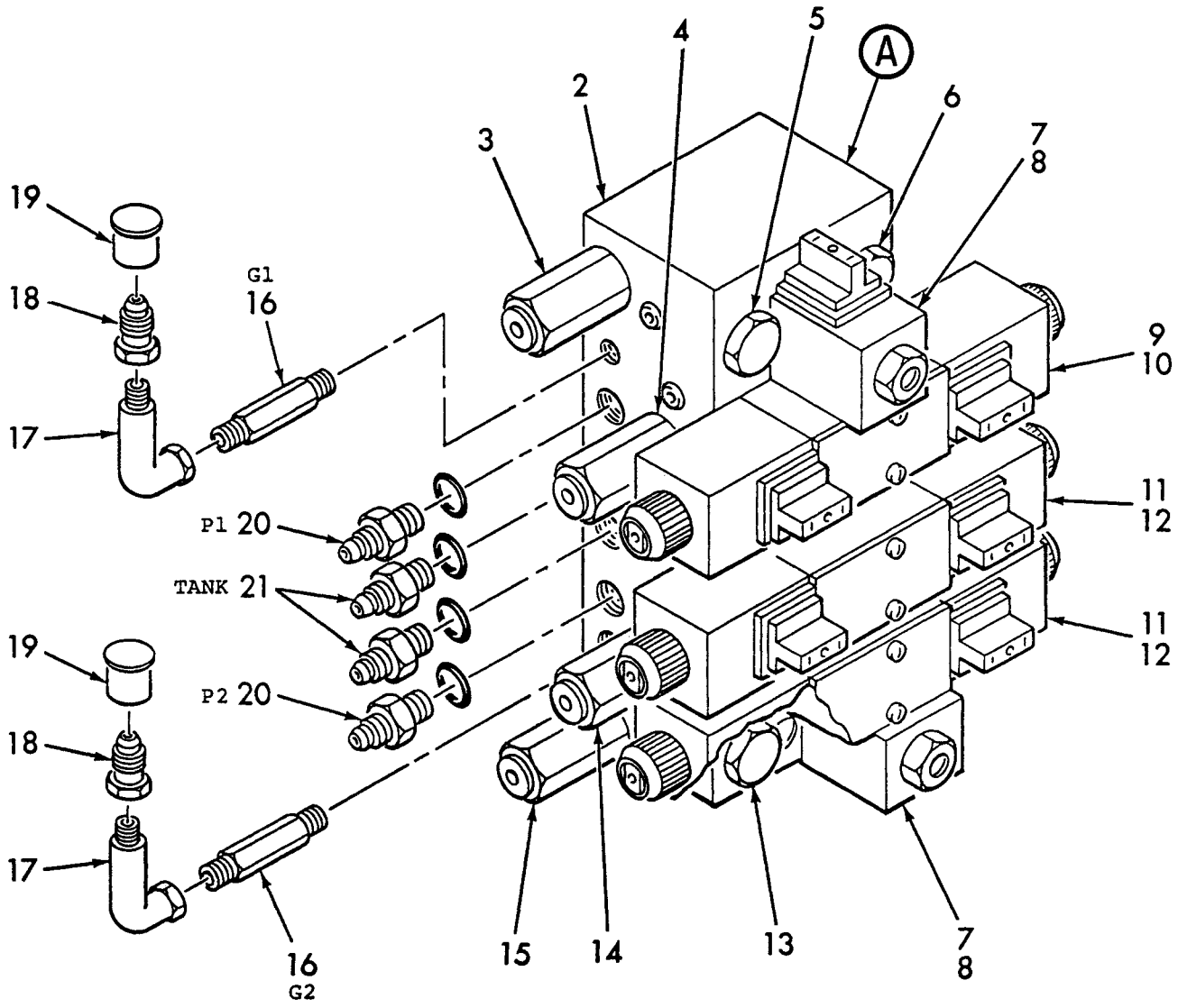
NOTE:
PRIOR TO USE, ITEMS WITH ASTERISK (*) MUST BE ADJUSTED TO THE PRESSURE LISTED ON THE SPECIFIC MAHCINE'S HYDRAULIC SCHEMATIC.

VALVE CONTROL ASSEMBLY (M20E & M25E)
(AFTER LATE 1989)

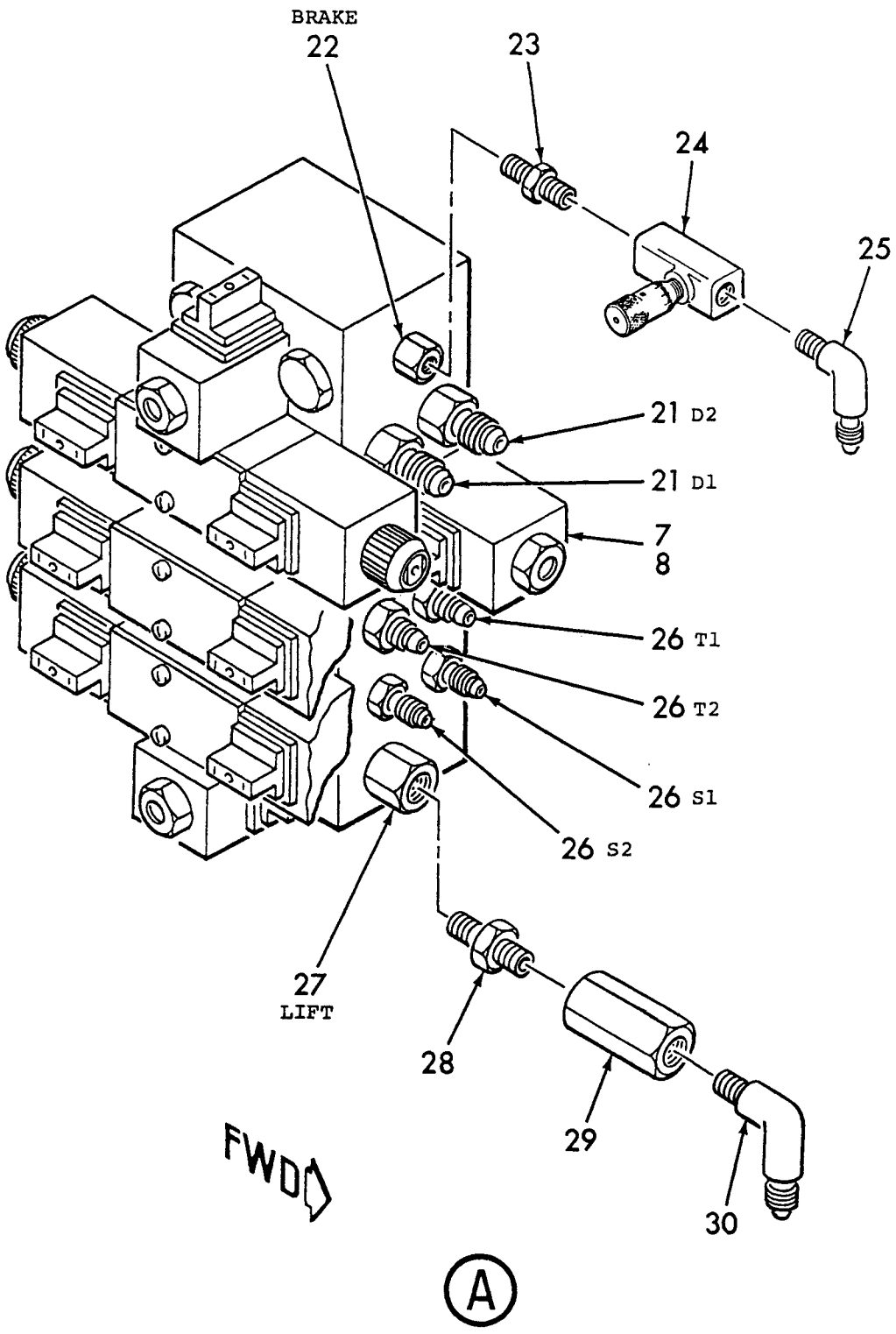
ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
22	80004-12	. CONNECTOR, STRAIGHT THREAD	2
23	80004-16	. CONNECTOR, STRAIGHT THREAD	2
24	51903	. ADAPTER, FEMALE PIPE	1
25	80052-02	. NIPPLE, PIPE	1
26	30884	. VALVE, FLOW CONTROL	1
27	80008-03	. ELBOW, MALE	1
28	80004-11	. CONNECTOR, STRAIGHT THREAD	2
29	80004-03	. CONNECTOR, STRAIGHT THREAD	2
30	80063-01	. ADAPTER, FEMALE PIPE	1
31	80052-04	. NIPPLE, PIPE	1
32	81137	. VALVE, PRESSURE COMPENSATE	1
33	80008-08	. ELBOW, MALE	1

- ITEM NOT ILLUSTRATED

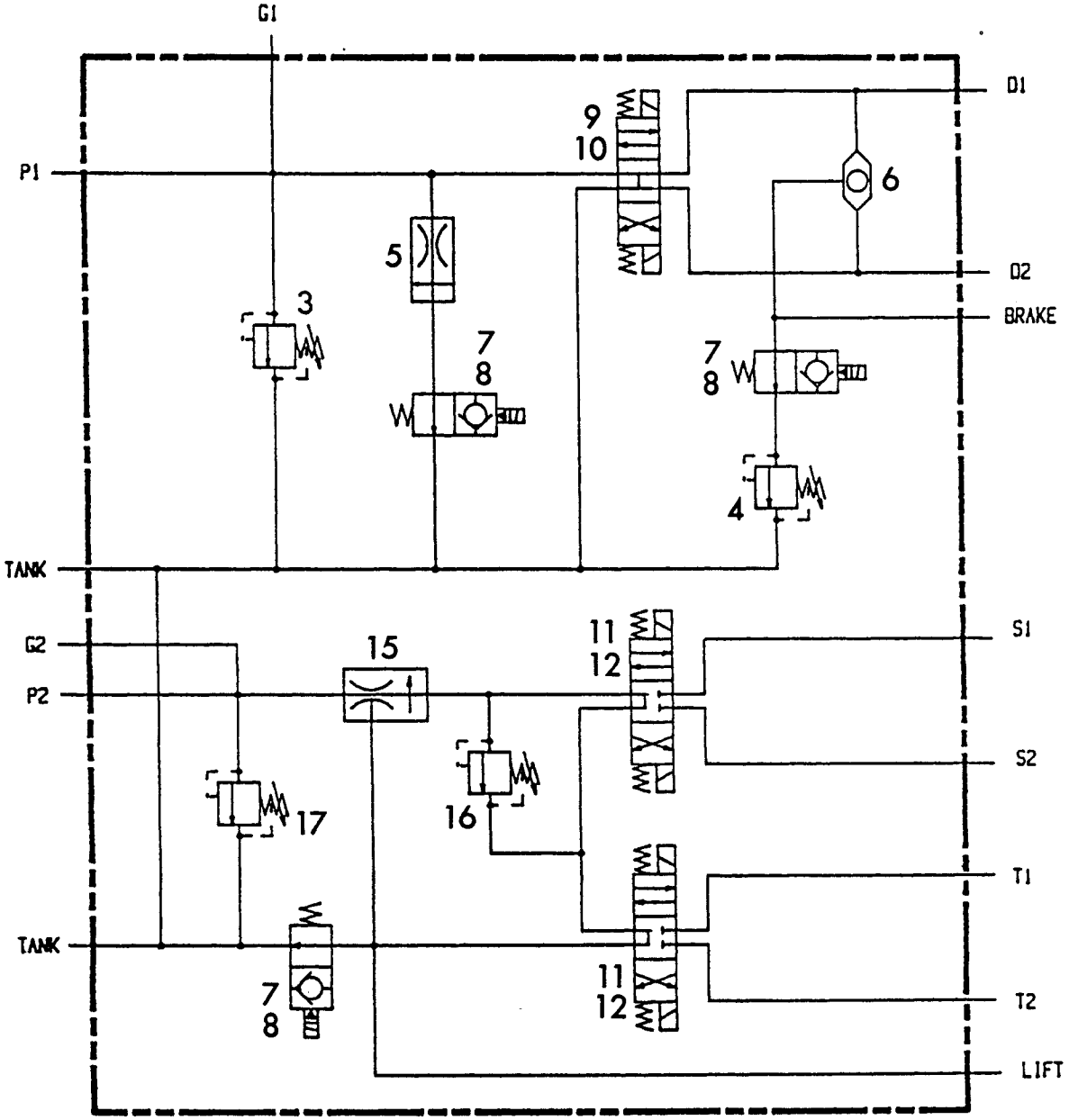
VALVE CONTROL ASSEMBLY (M20ET & M25ET) (BEFORE LATE 1989)



VALVE CONTROL ASSEMBLY (M20ET & M25ET) (BEFORE LATE 1989)



VALVE CONTROL ASSEMBLY (M20ET & M25ET) (BEFORE LATE 1989)



REV.

VALVE CONTROL ASSEMBLY (M20ET & M25ET) (BEFORE LATE 1989)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	131550	ASSEMBLY, VALVE CONTROL (See Sect. 3, Fig. 4C & 4D for NHA)	REF
2	81263	. VALVE, CONTROL	1
3	68060	.. VALVE, RELIEF*	1
4	68057	.. VALVE, RELIEF*	1
5	600000	.. REGULATOR, FLOW	1
6	66924	.. VALVE, SHUTTLE	1
7	67000	.. SOLENOID, N.O. POPPET	3
8	66865	... COIL (20 VOLT)	3
9	600001	.. VALVE, D01	1
10	66864	... COIL, D01 (20 VOLT)	2
11	67159	.. VALVE, D01	2
12	66864	... COIL, D01 (20 VOLT)	4
13	67004	.. REGULATOR, FLOW	1
14	68057	.. VALVE, RELIEF*	1
15	68060	.. VALVE, RELIEF*	1
16	160153	. NIPPLE	2
17	80009-04	. ELBOW, MALE	2
18	2527	. COUPLING	2
19	845	. CAP, QUICK DISCONNECT	2
20	80004-12	. CONNECTOR, STRAIGHT THREAD	2
21	80004-11	. CONNECTOR, STRAIGHT THREAD	4

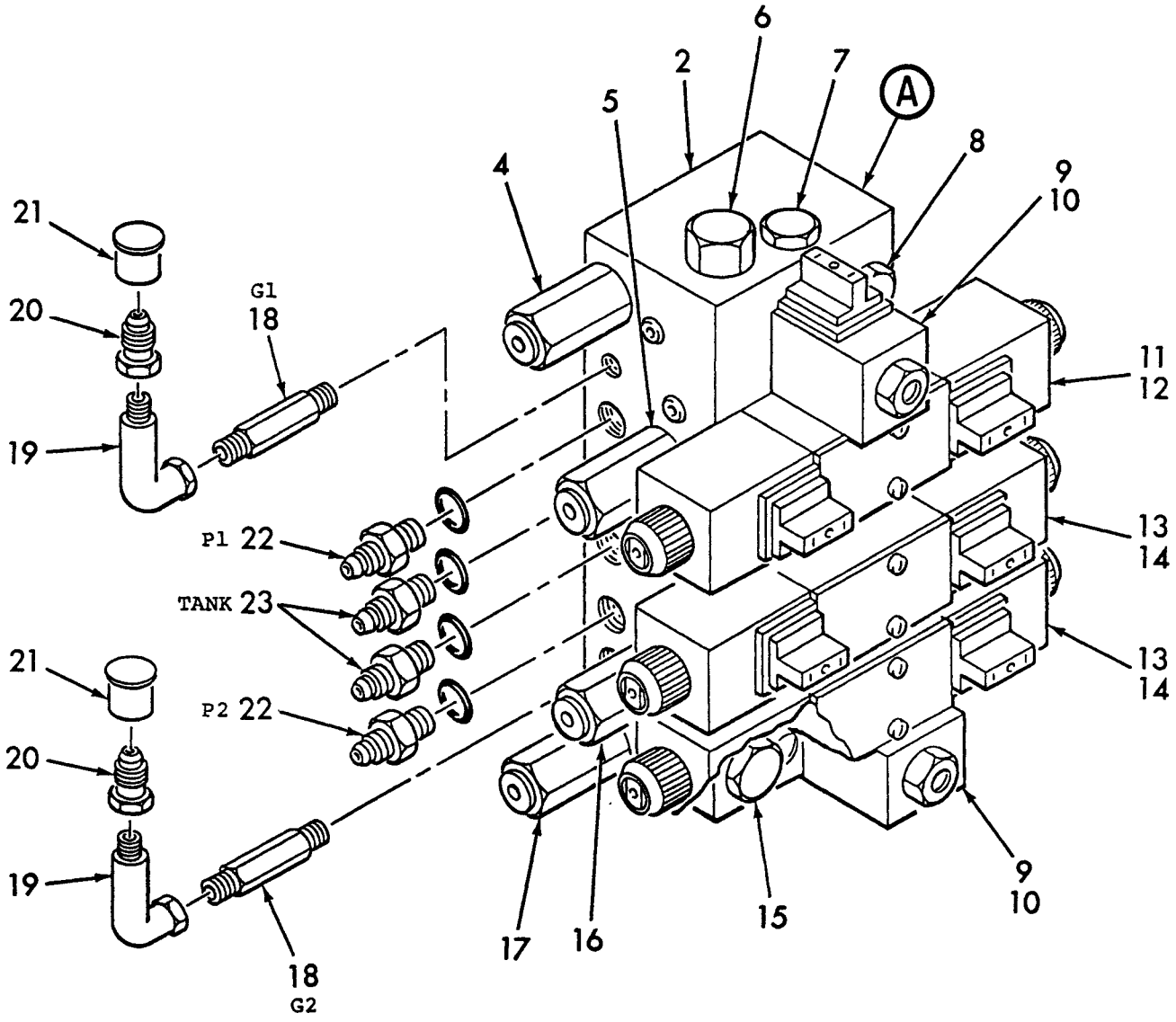
NOTE:
PRIOR TO USE, ITEMS WITH ASTERISK (*) MUST BE ADJUSTED TO THE PRESSURE LISTED ON THE SPECIFIC MACHINE'S HYDRAULIC SCHEMATIC.

VALVE CONTROL ASSEMBLY (M20ET & M25ET)
(BEFORE LATE 1989)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
22	51903	. ADAPTER, FEMALE PIPE	1
23	80052-02	. NIPPLE, PIPE	1
24	30884	. VALVE, FLOW CONTROL	1
25	80008-03	. ELBOW, MALE	1
26	80004-03	. CONNECTOR, STRAIGHT THREAD	4
27	80058-03	. REDUCER	1
28	80052-04	. NIPPLE, PIPE	1
29	81137	. VALVE, PRESSURE COMPENSATE	1
30	80008-08	. ELBOW, MALE	1

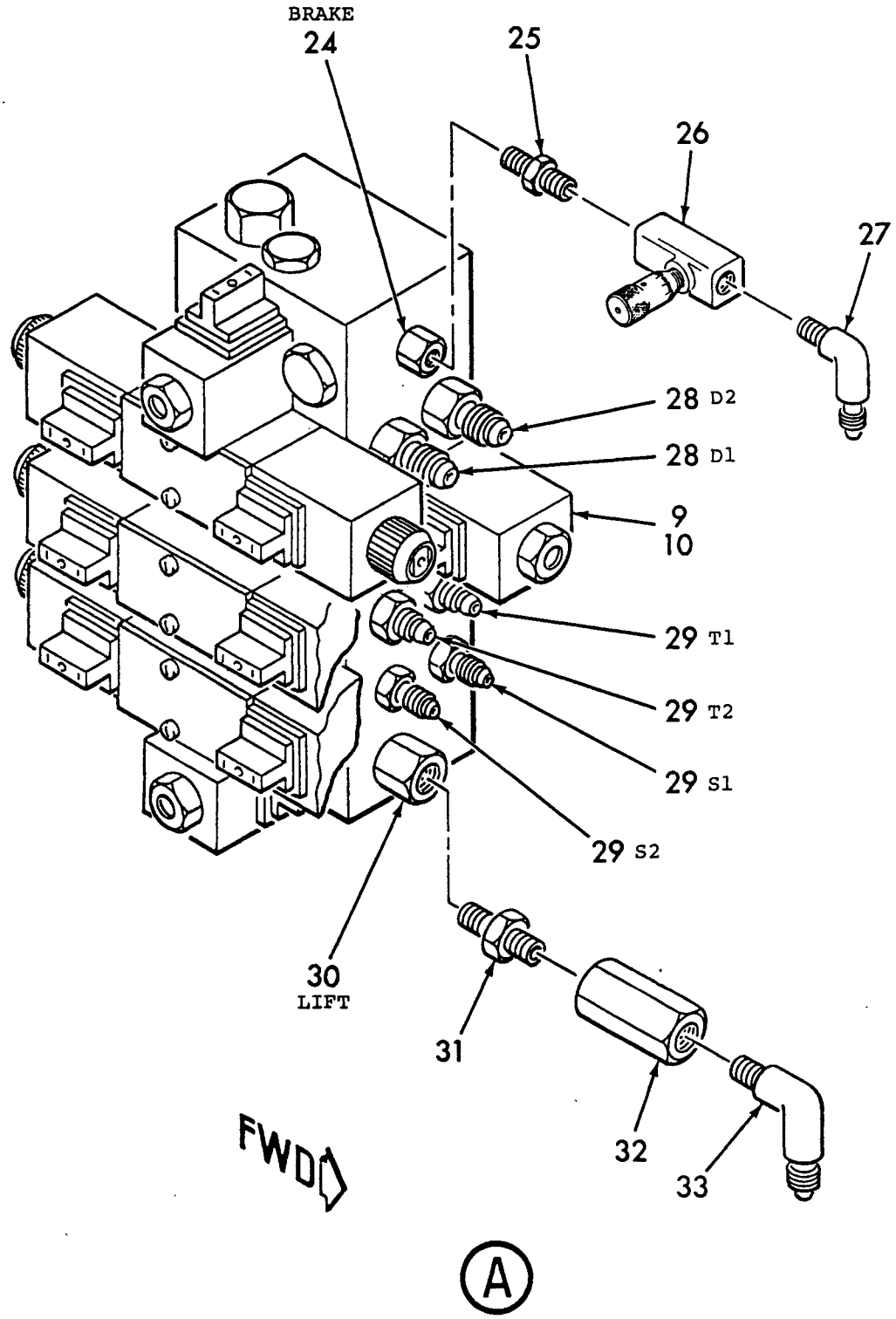
- ITEM NOT ILLUSTRATED

VALVE CONTROL ASSEMBLY (M20ET & M25ET) (AFTER LATE 1989)

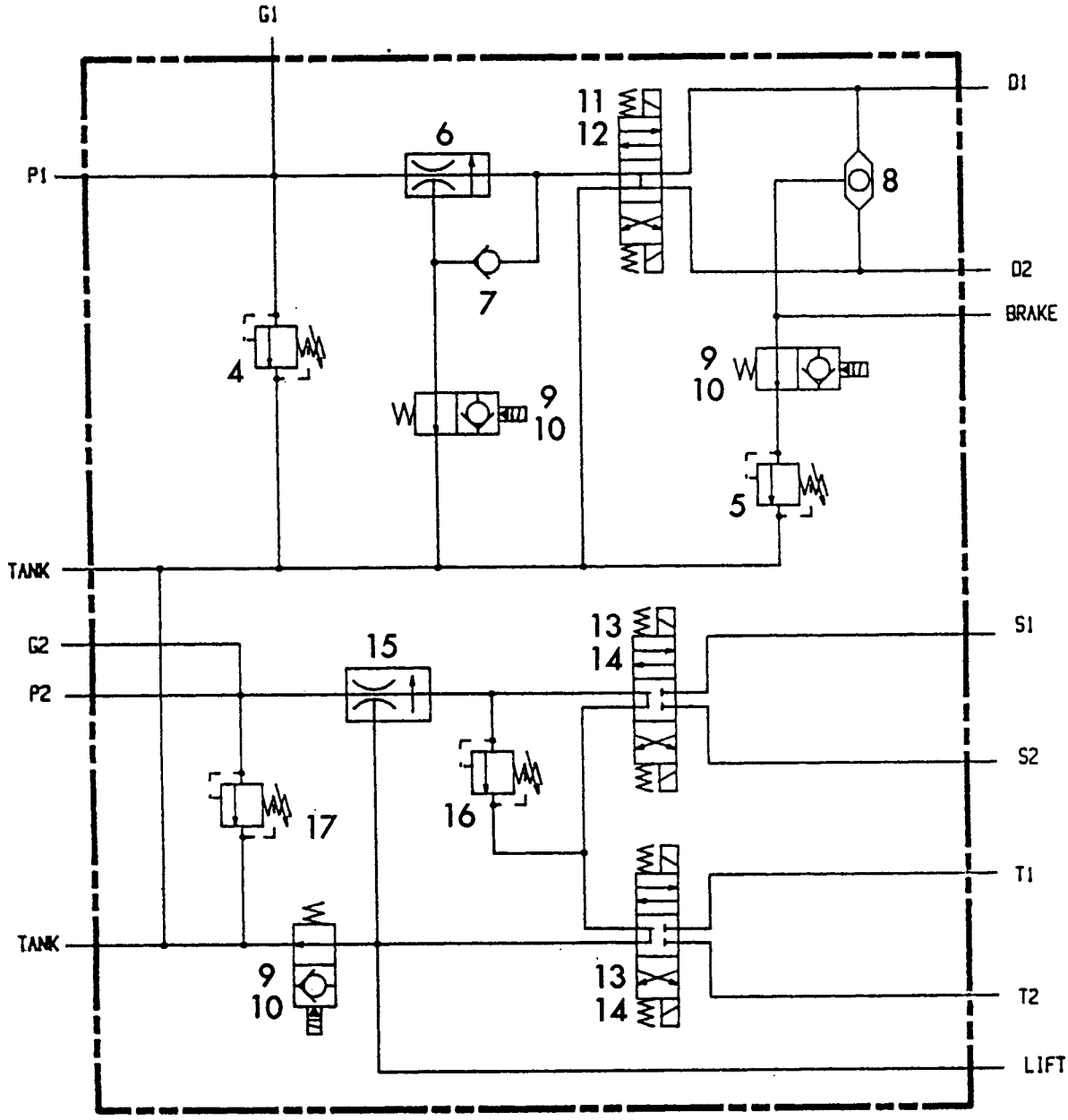


REV.

VALVE CONTROL ASSEMBLY (M20ET & M25ET) (AFTER LATE 1989)



VALVE CONTROL ASSEMBLY (M20ET & M25ET)
(AFTER LATE 1989)



REV.

VALVE CONTROL ASSEMBLY (M20ET & M25ET)
(AFTER LATE 1989)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	131846	ASSEMBLY, VALVE CONTROL (See Sect. 3, Fig. 4C & 4D for NHA)	REF
2	81327	. VALVE, CONTROL	1
-3	600004	.. KIT, SEAL (COMPLETE VALVE PKGS.)	1
4	68060	.. VALVE, RELIEF*	1
5	68057	.. VALVE, RELIEF*	1
6		.. REGULATOR, FLOW	1
7	600003	.. VALVE, CHECK	1
8	66924	.. VALVE, SHUTTLE	1
9	67000	.. SOLENOID, N.O. POPPET	3
10	66865	... COIL (20 VOLT)	3
11	600001	.. VALVE, D01	1
12	66864	... COIL, D01 (20 VOLT)	2
13	67159	.. VALVE, D01	2
14	66864	... COIL, D01 (20 VOLT)	4
15	67004	.. REGULATOR, FLOW	1
16	68057	.. VALVE, RELIEF*	1
17	68060	.. VALVE, RELIEF*	1
18	160153	. NIPPLE	2
19	80021-03	. ELBOW, STREET	2
20	2527	. COUPLING	2
21	845	. CAP, QUICK DISCONNECT	2

NOTE:
PRIOR TO USE, ITEMS WITH ASTERISK (*) MUST BE ADJUSTED TO THE PRESSURE LISTED ON THE SPECIFIC MACHINE'S HYDRAULIC SCHEMATIC.

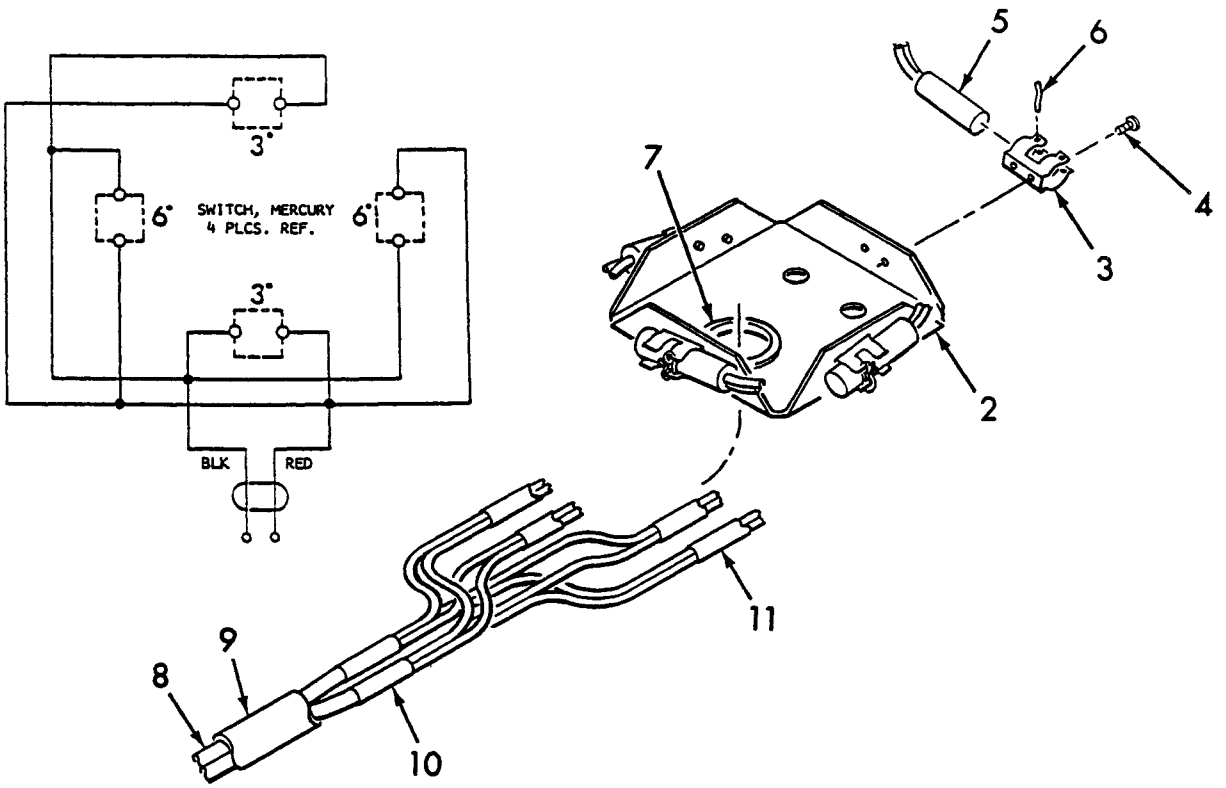
- ITEM NOT ILLUSTRATED

VALVE CONTROL ASSEMBLY (M20ET & M25ET)
(AFTER LATE 1989)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
22	80004-12	. CONNECTOR, STRAIGHT THREAD	2
23	80004-16	. CONNECTOR, STRAIGHT THREAD	2
24	51903	. ADAPTER, FEMALE PIPE	1
25	80052-02	. NIPPLE, PIPE	1
26	30884	. VALVE, FLOW CONTROL	1
27	80008-03	. ELBOW, MALE	1
28	80004-11	. CONNECTOR, STRAIGHT THREAD	2
29	80004-03	. CONNECTOR, STRAIGHT THREAD	4
30	80063-01	. ADAPTER, FEMALE PIPE	1
31	80052-04	. NIPPLE, PIPE	1
32	81137	. VALVE, PRESSURE COMPENSATE	1
33	80008-08	. ELBOW, MALE	1

- ITEM NOT ILLUSTRATED

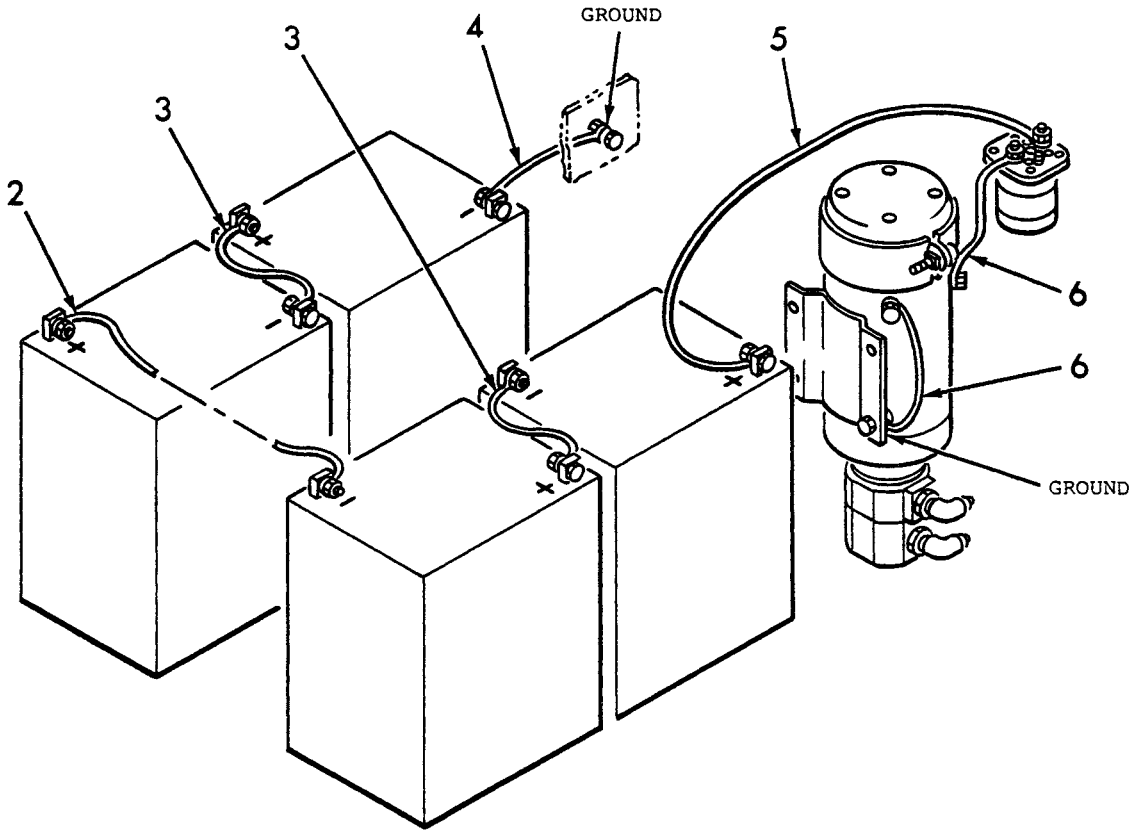
TILT SWITCH ASSEMBLY (ALL MODELS)



ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	130193	ASSEMBLY, TILT SWITCH (See Sect. 3, Fig. 4 thru 4D for NHA)	REF
2	30385	. BRACKET, TILT SWITCH	1
3	199-A	. BRACKET, MICRO SWITCH	4
4	62605	. SCREW, MACHINE	8
5	4014	. SWITCH, MERCURY	4
6	2626	. WIRE, SAFETY	AR
7	70230	. GROMMET, RUBBER	1
8	70023	. CABLE, ELECTRIC	1
9	16307	. TUBE, HEAT SHRINK	1
10	70068	. CONNECTOR, BUTT	2
11	16306	. TUBE, HEAT SHRINK	1

REV.

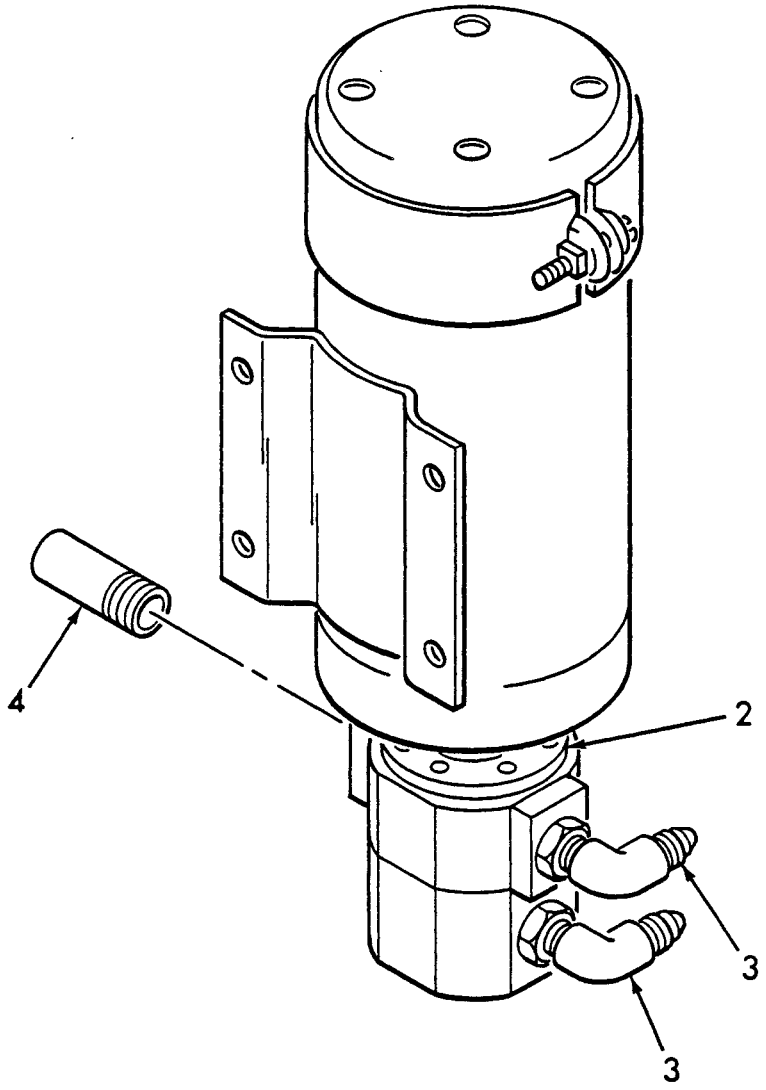
BATTERY CABLE KIT (M20E, M25E, M20ET & M25ET)



ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	131566	KIT, BATTERY CABLE (See Sect. 3, Fig. 1A thru 1D for NHA)	REF
2	13226-0722	. ASSEMBLY, ELECTRICAL CABLE	1
3	13226-0080	. ASSEMBLY, ELECTRICAL CABLE	2
4	13226-0103	. ASSEMBLY, ELECTRICAL CABLE	1
5	13226-0300	. ASSEMBLY, ELECTRICAL CABLE	1
6	13226-0120	. ASSEMBLY, ELECTRICAL CABLE	2

REV.

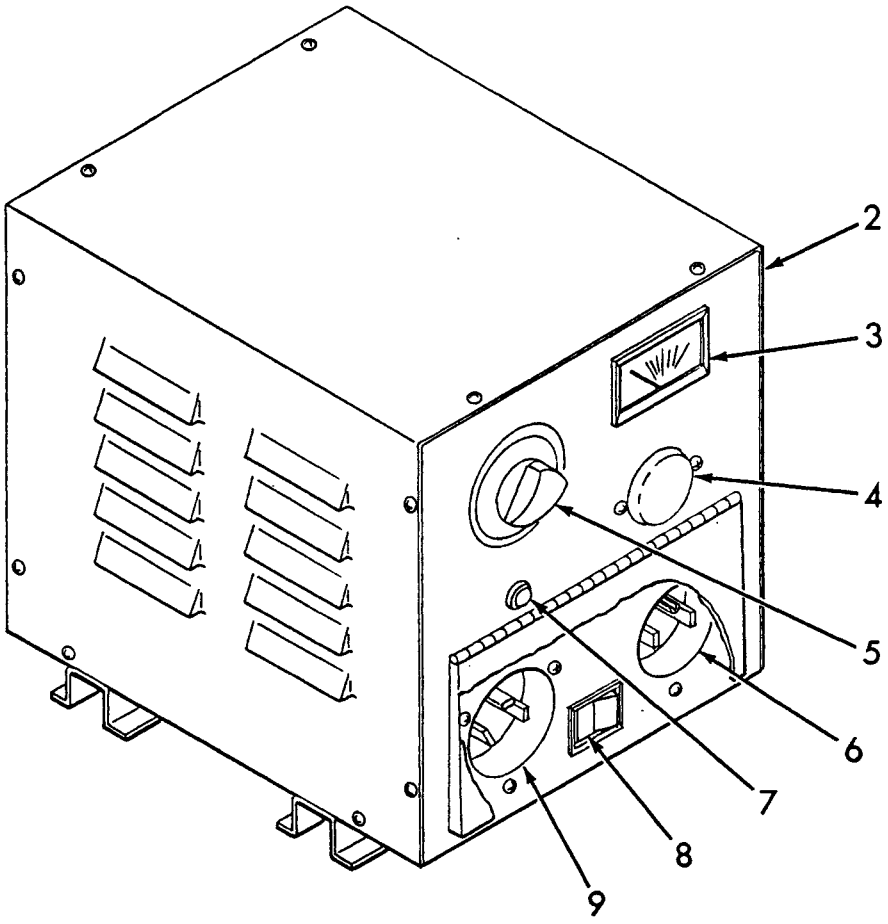
PUMP & MOTOR ASSEMBLY (M20E, M25E, M20ET & M25ET)

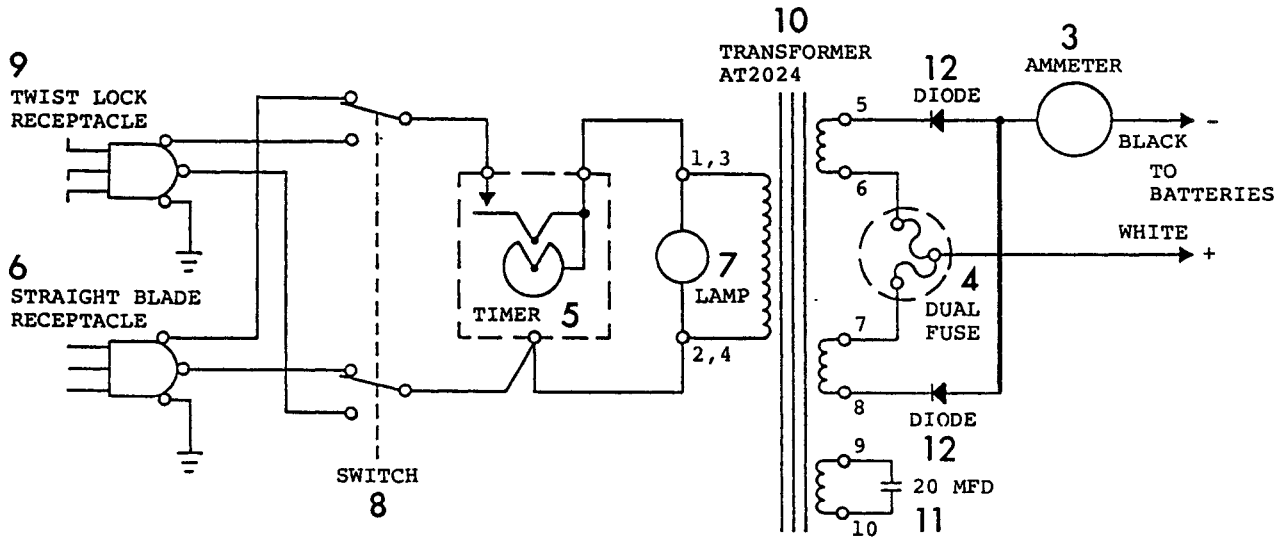


ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	131562	ASSEMBLY, PUMP & MOTOR (See Sect. 3, Fig. 8A thru 8D for NHA)	REF
2	81287	. HYDRAULIC PUMP & MOTOR	1
3	80008-15	. ELBOW, MALE	2
4		. PIPE, STRAIGHT	1

REV.

BATTERY CHARGER
(M20E, M25E, M20ET & M25ET)





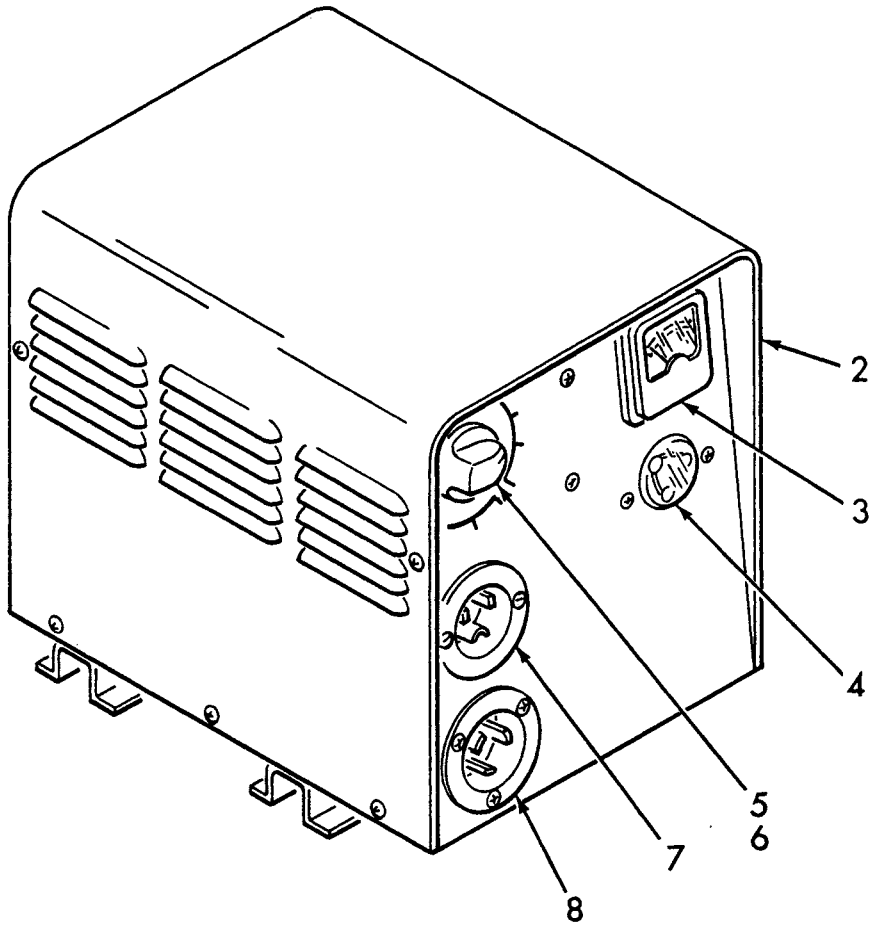
REV.

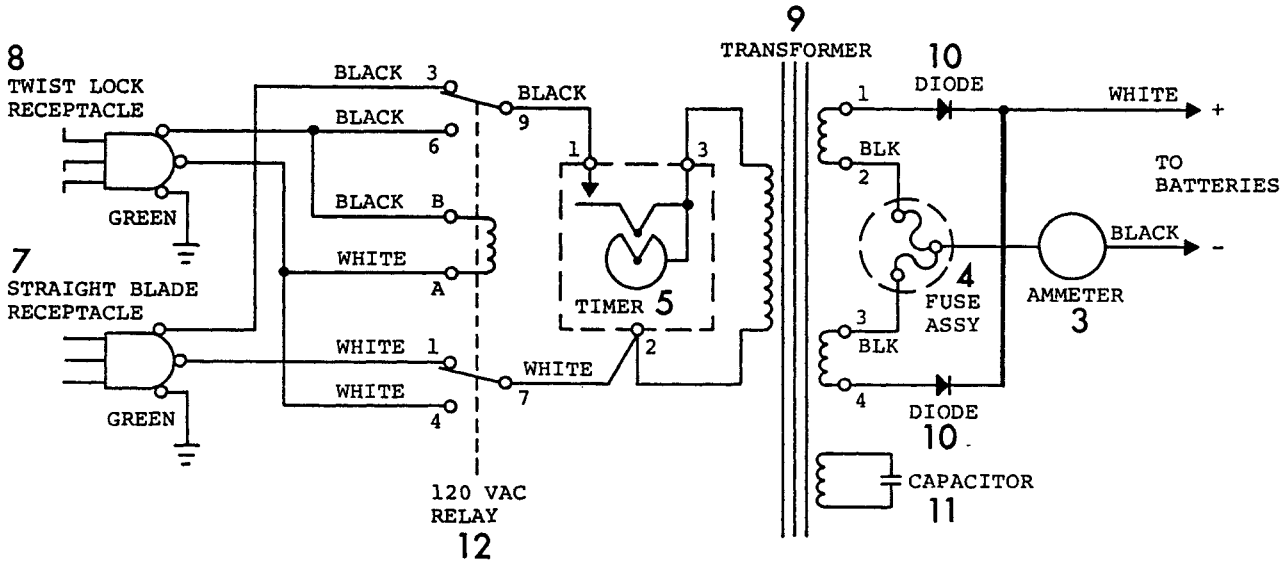
BATTERY CHARGER
(M20E, M25E, M20ET & M25ET)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	70478	CHARGER, BATTERY (115V/60 Hz, 24V/40A) (See Sect. 3, Fig. 1A thru 1D for NHA)	REF
2		. HOUSING (WHITE IN COLOR)	1
3	67969	. AMMETER	1
4	66727	. FUSE, DUAL	1
5	66732	. TIMER, 12 HOUR	1
6	70050	. RECEPTACLE, STRAIGHT BLADE	1
7	67964	. LAMP, INDICATOR	1
8	67963	. SWITCH, DPDT	1
9	66183	. RECEPTACLE, TWIST LOCK	1
10	67961	. TRANSFORMER	1
11	67969	. CAPACITOR	1
12	67966	. DIODE	2

- ITEM NOT ILLUSTRATED

BATTERY CHARGER
(M20E, M25E, M20ET & M25ET)





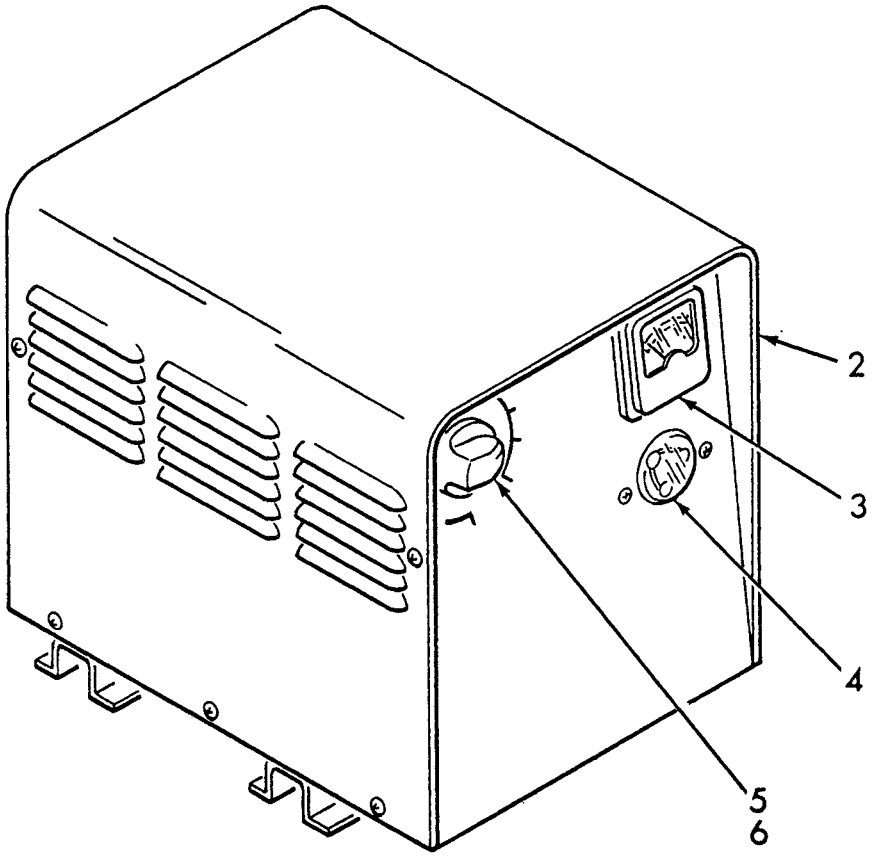
REV.

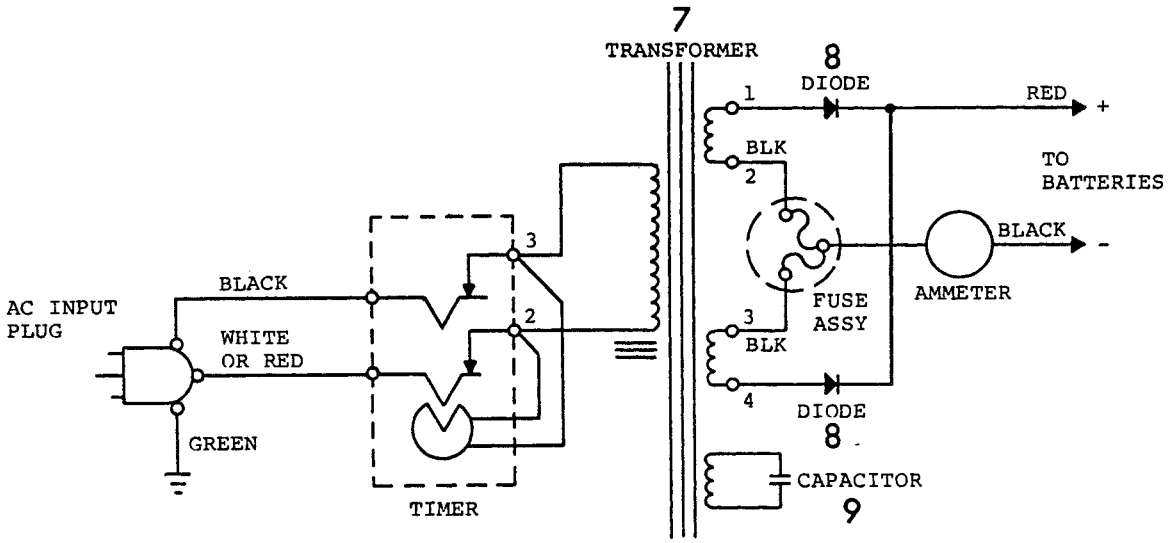
BATTERY CHARGER
(M20E, M25E, M20ET & M25ET)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	70321	CHARGER, BATTERY (120V/60 Hz, 24V/36A) (See Sect. 3, Fig. 1A thru 1D for NHA)	REF
2		. HOUSING (SILVER IN COLOR)	1
3	66747	. AMMETER	1
4	66726	. FUSE	1
5	66732	. TIMER, 12 HOUR	1
6	66733	. KNOB, TIMER	1
7	66734	. RECEPTACLE, STRAIGHT BLADE	1
8	66736	. RECEPTACLE, TWIST LOCK	1
9	66984	. TRANSFORMER	1
10	66730	. DIODE	2
11	66750	. CAPACITOR	1
12	66728	. RELAY	1

- ITEM NOT ILLUSTRATED

BATTERY CHARGER
(M20E, M25E, M20ET & M25ET)





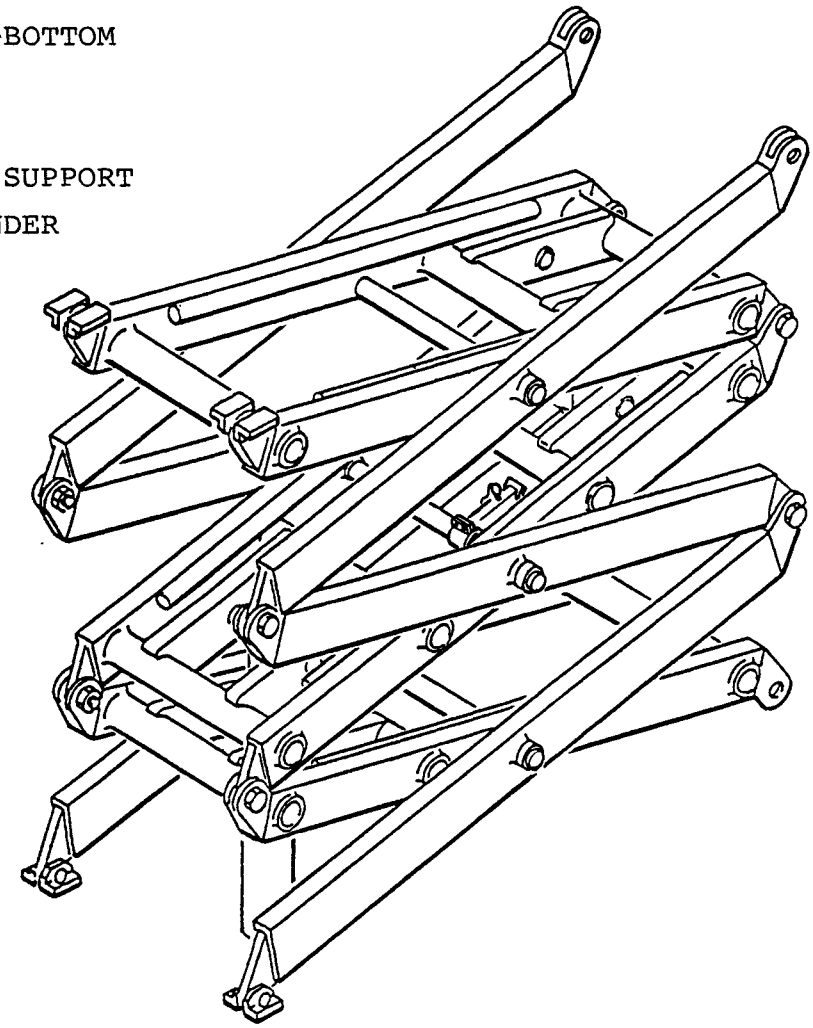
REV.

BATTERY CHARGER
(M20E, M25E, M20ET & M25ET)

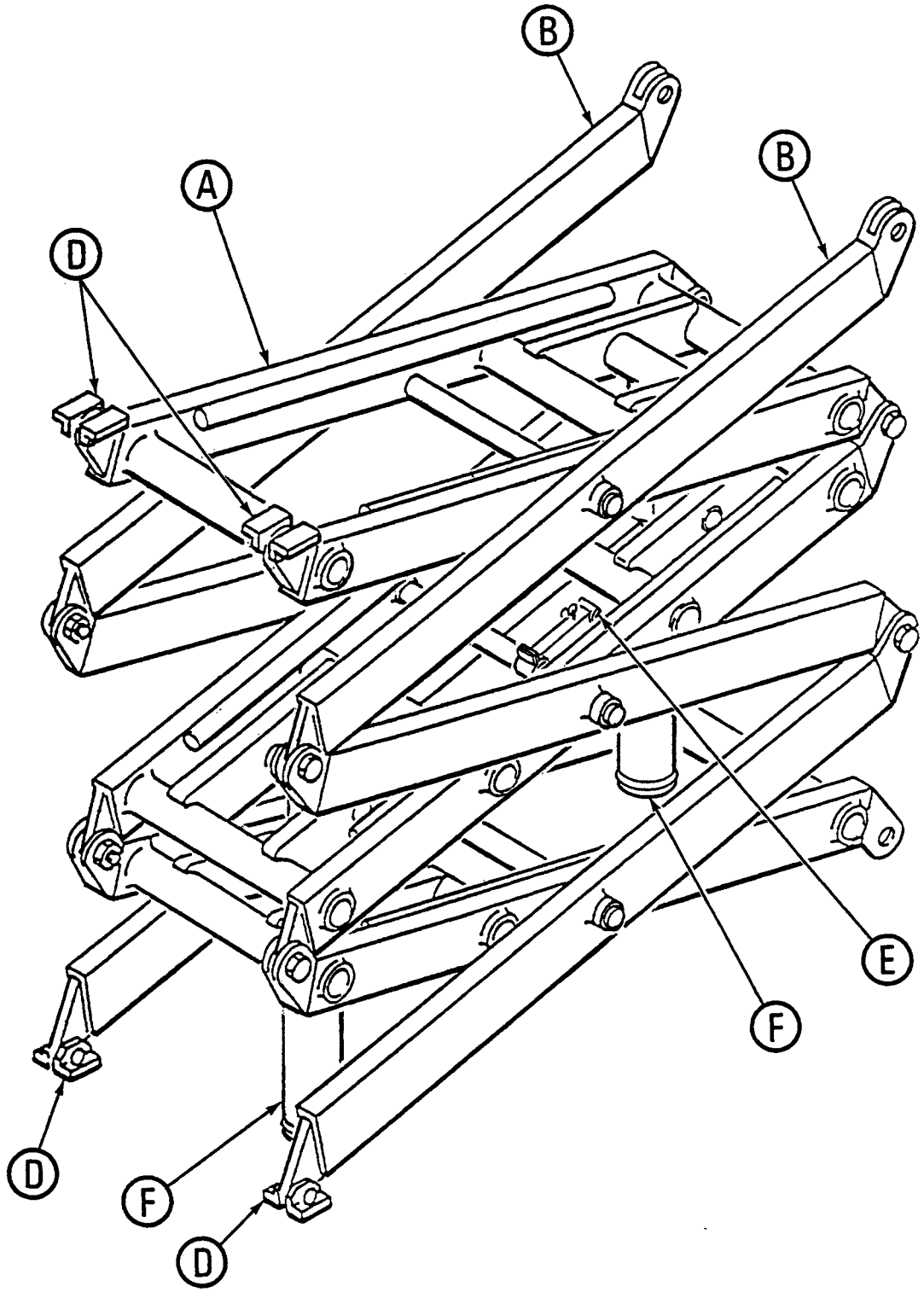
ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	70430	CHARGER, BATTERY (230V/50 Hz, 24V/30A) (See Sect. 3, Fig. 1A thru 1D for NHA)	REF
2		. HOUSING (SILVER IN COLOR)	1
3	66747	. AMMETER	1
4	66727	. FUSE	1
5	67971	. TIMER, 12 HOUR	1
6	66733	. KNOB, TIMER	1
7	67973	. TRANSFORMER	1
8	66731	. DIODE	2
9	66750	. CAPACITOR	1

- ITEM NOT ILLUSTRATED

SECTION 4 CONTAINS:

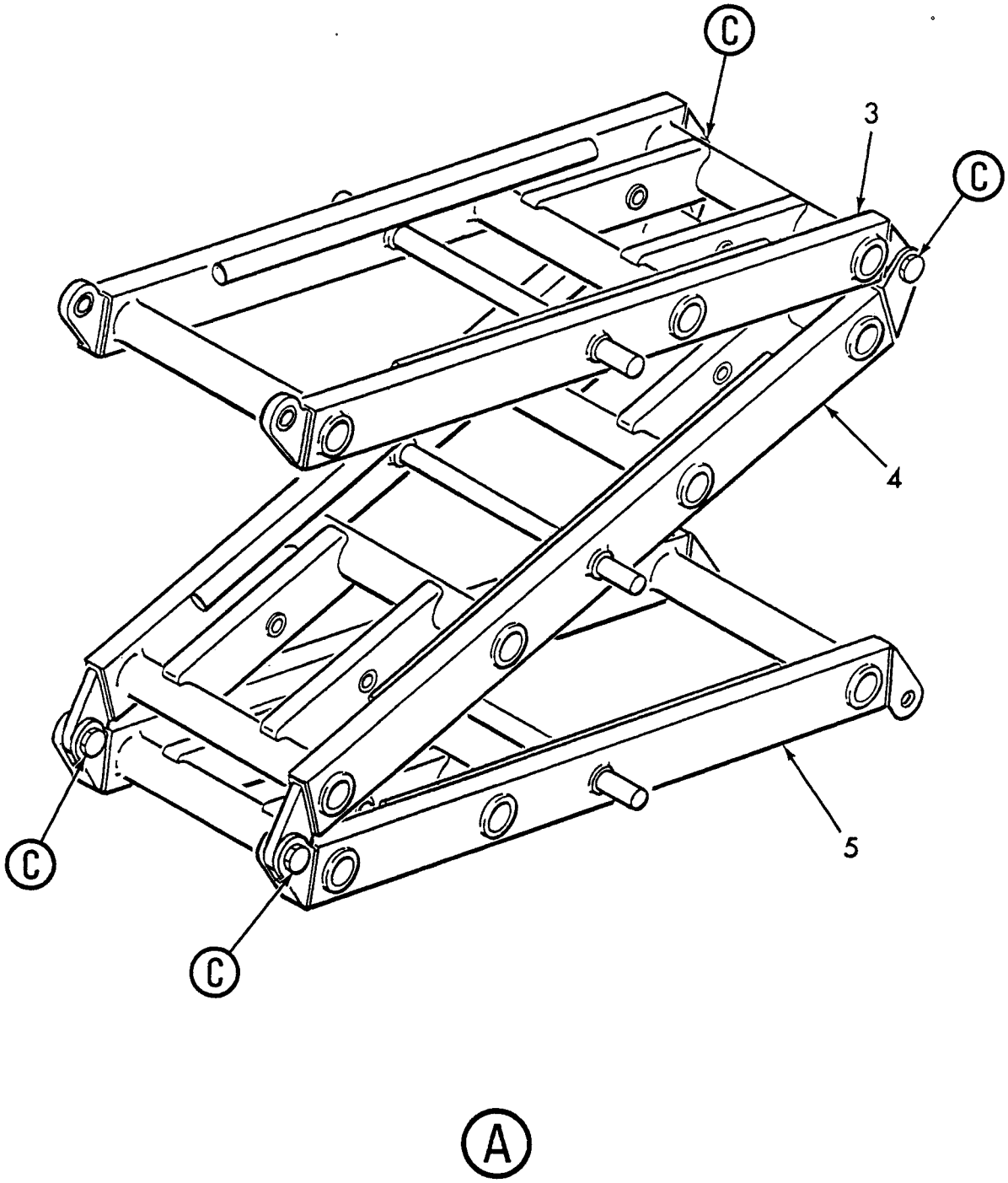


SCISSOR ASSEMBLY (M20GP, M20E & M20ET)



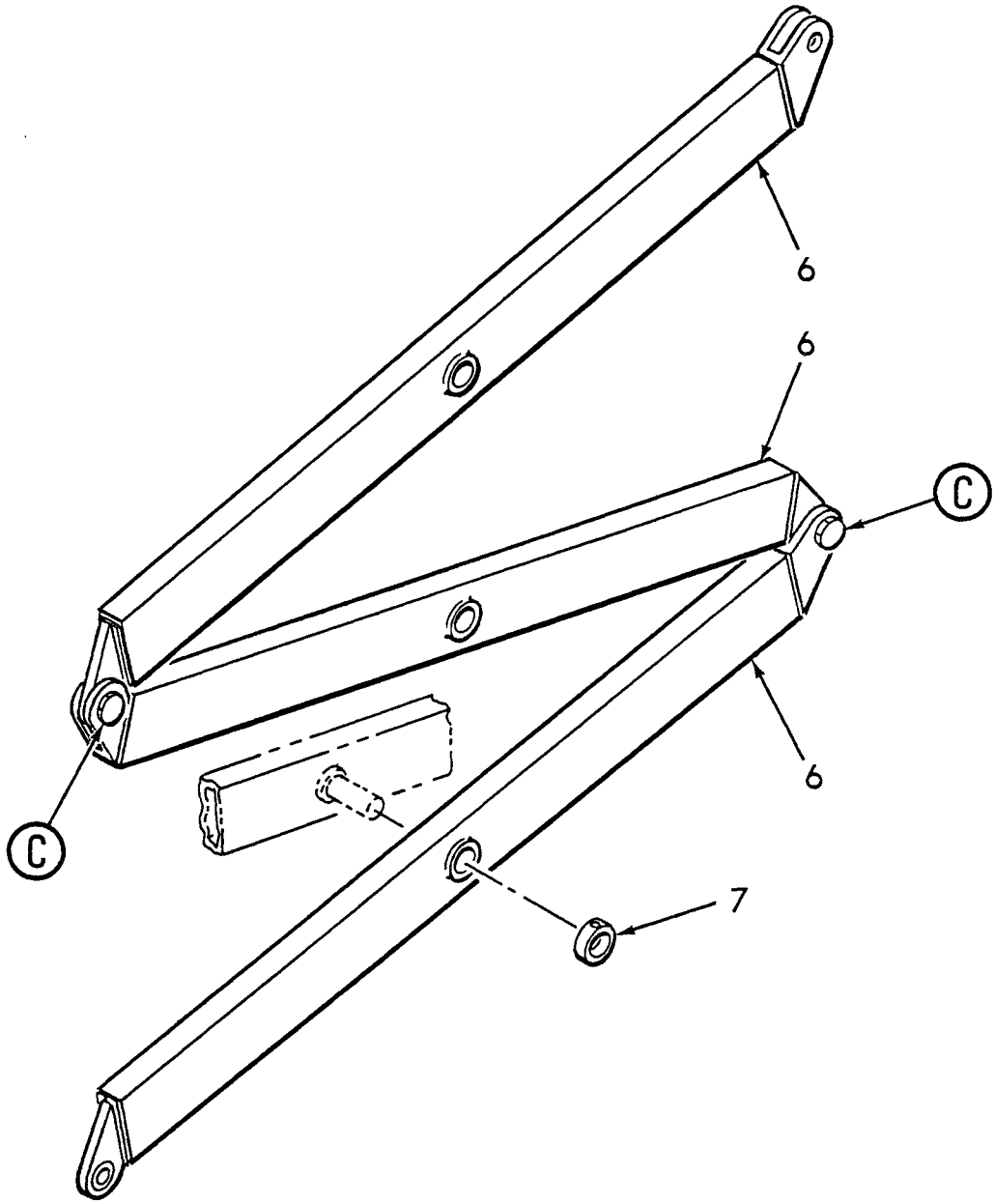
REV.

SCISSOR ASSEMBLY (M20GP, M20E & M20ET)



REV.

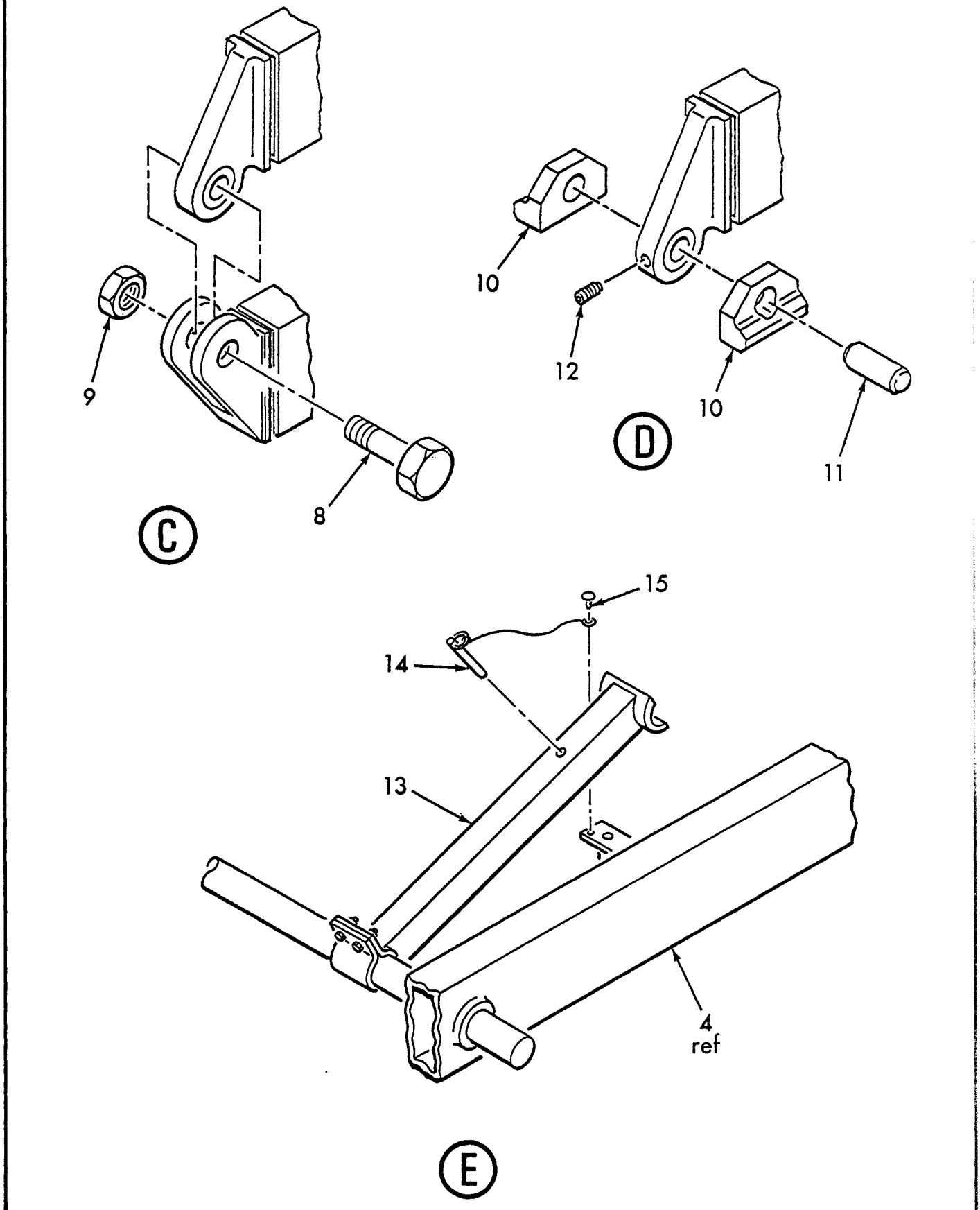
SCISSOR ASSEMBLY (M20GP, M20E & M20ET)



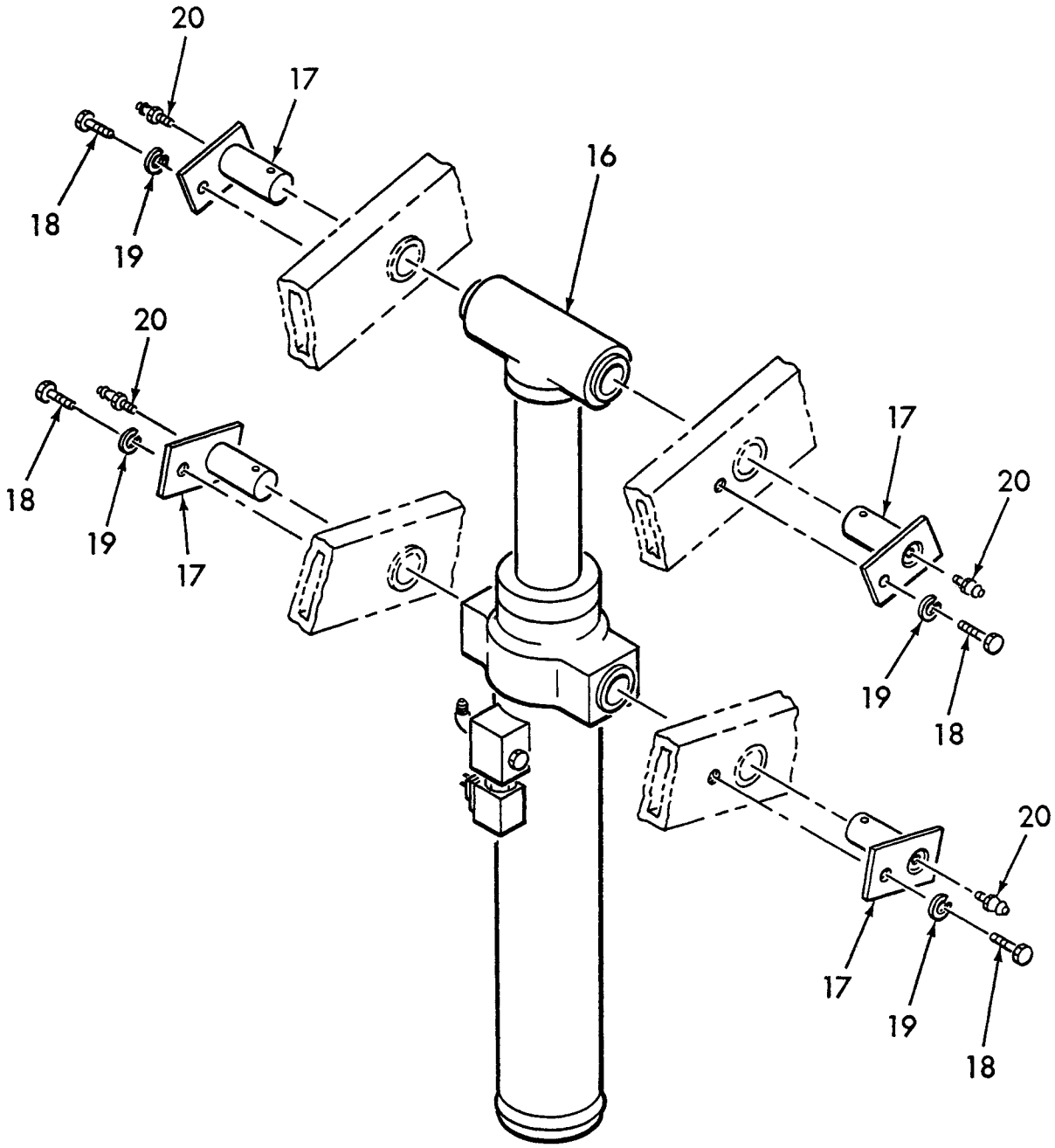
B

REV.

SCISSOR ASSEMBLY (M20GP, M20E & M20ET)



SCISSOR ASSEMBLY (M20GP, M20E & M20ET)



F

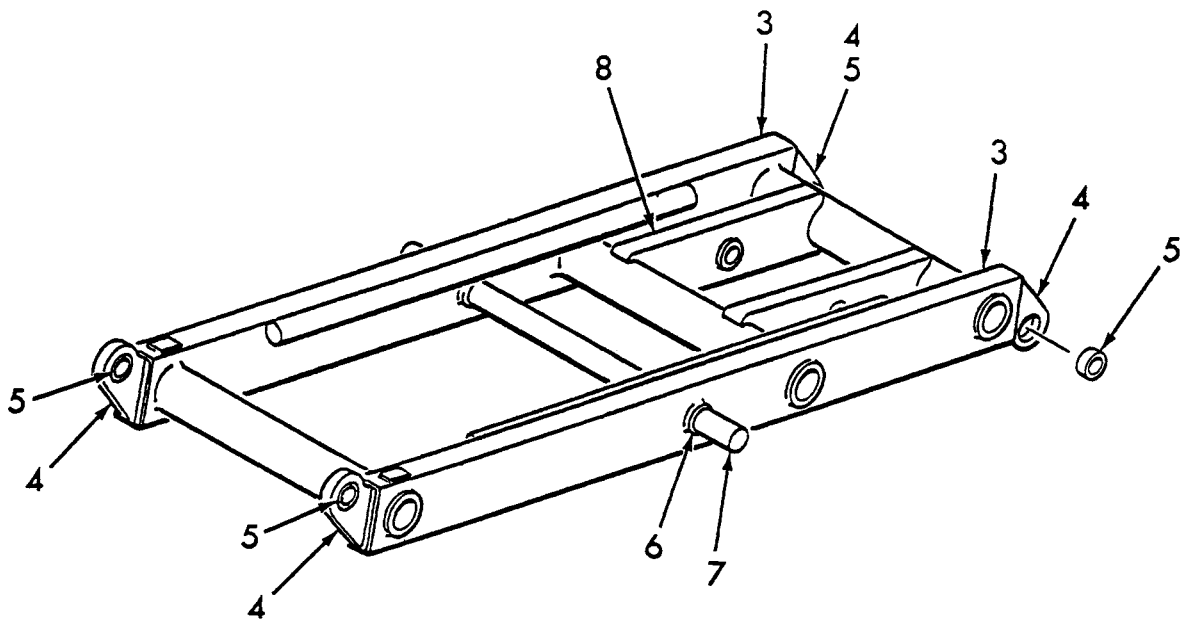
REV.

SCISSOR ASSEMBLY (M20GP, M20E & M20ET)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	131578	ASSEMBLY, SCISSOR (M20GP) (See Sect. 2, Fig. 1 for NHA)	REF
-1	131423	ASSEMBLY, SCISSOR (M20E & M20ET) (See Sect. 2, Fig. 1A or 1C for NHA)	REF
-2	131424	. SUB-ASSEMBLY, SCISSOR	1
3	130272	.. ASSEMBLY, INNER ARM-TOP (See Sect. 4, Fig. 2 for Details)	1
4	130268	.. ASSEMBLY, INNER ARM-CENTER (See Sect. 4, Fig. 3 for Details)	1
5	130262	.. ASSEMBLY, INNER ARM-BOTTOM (See Sect. 4, Fig. 4 for Details)	1
6	130254	.. ASSEMBLY, OUTER ARM (See Sect. 4, Fig. 5 for Details)	6
7	65577	.. COLLAR, SHAFT	6
8	130696	.. BOLT, EAR PIVOT	8
9	61249	.. NUT, HEX	8
10	131534	. PAD, WEAR	8
11	130327	. PIN, WEAR PAD	4
12	160168	. SCREW, SET	4
13	130511	. ASSEMBLY, INNER ARM SUPPORT (See Sect. 4, Fig. 6 for Details)	1
14	12007	. PIN, BALL-LOC DETENT	1
15	63653	. RIVET	1
16	131579	. ASSEMBLY, LIFT CYLINDER (M20GP) (See Sect. 4, Fig. 7 for Details)	2
16	131421	. ASSEMBLY, LIFT CYLINDER (M20E & M20ET) (See Sect. 4, Fig. 8 for Details)	2
17	131453	. PIN, TRUNNION	8
18	60533	. SCREW, CAP	8
19	63302	. WASHER, LOCK	8
20	65103	. FITTING, GREASE	8

- ITEM NOT ILLUSTRATED

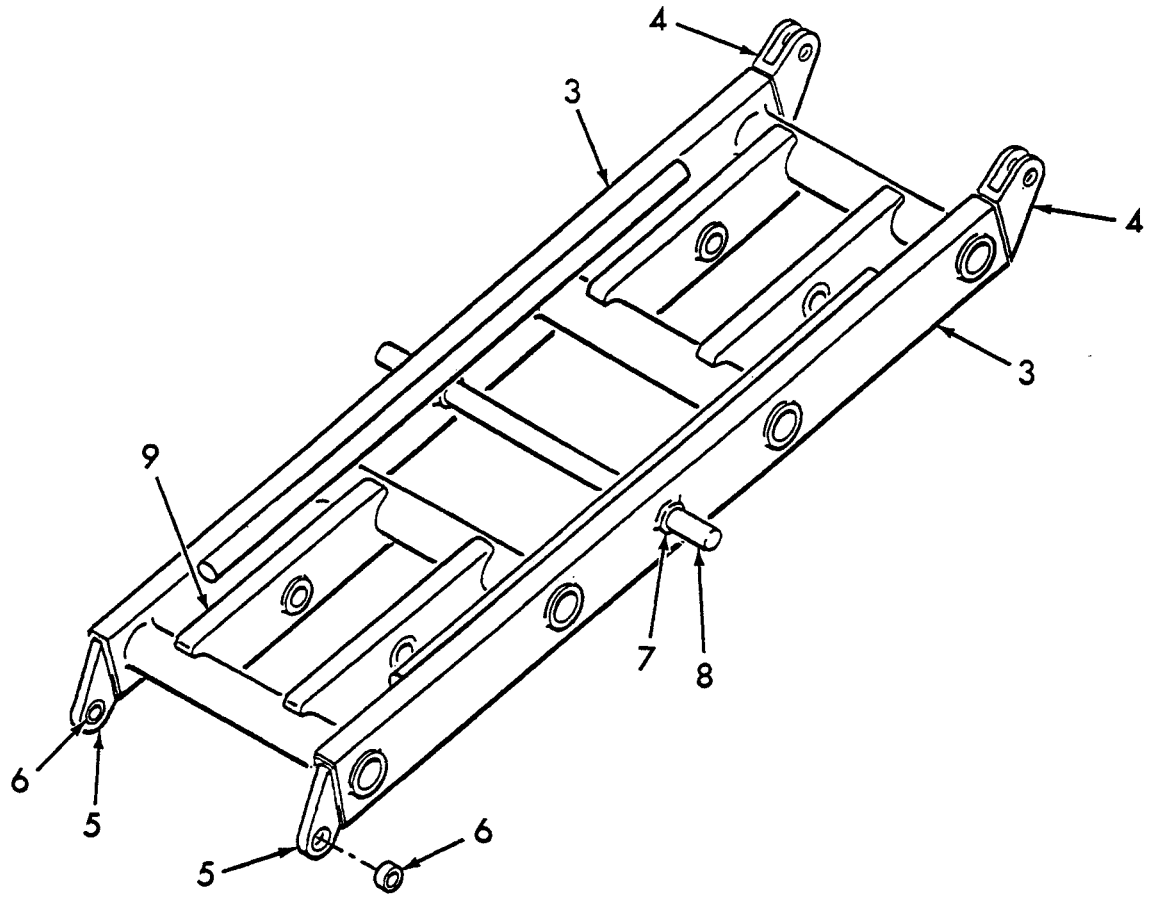
INNER ARM-TOP ASSEMBLY (M20GP, M20E & M20ET)



ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	130272	ASSEMBLY, INNER ARM-TOP	REF
-2	130271	. SUB-ASSEMBLY, INNER ARM	2
3	130270	.. ARM*	1
4	131585	.. EAR, ARM END (MALE)	2
5	916	.. BUSHING	2
6	130275	.. SLEEVE*	1
7	130274	. SHAFT, CENTER PIVOT*	1
8	130273	. SUPPORT, TRUNNION CYLINDER*	1
		* NON-SERVICEABLE ITEM	

REV.

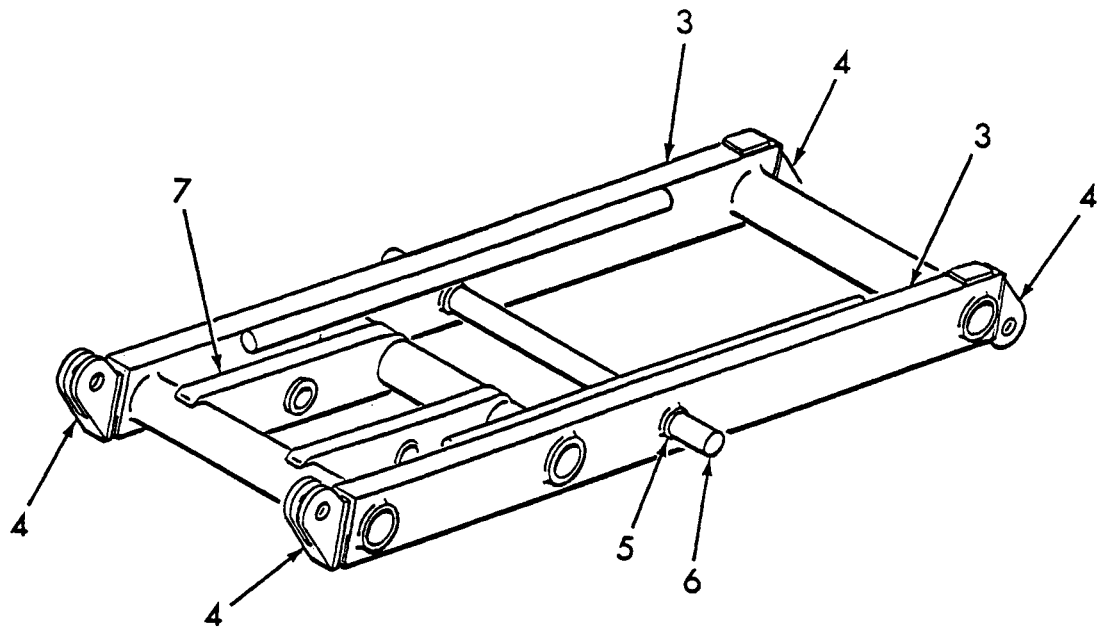
INNER ARM-CENTER ASSEMBLY (M20GP, M20E & M20ET)



ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	130268	ASSEMBLY, INNER ARM-CENTER	REF
-2	130267	. SUB-ASSEMBLY, INNER ARM	2
3	130266	.. ARM*	1
4	131586	.. EAR, ARM END (FEMALE)	1
5	131585	.. EAR, ARM END (MALE)	1
6	916	.. BUSHING	1
7	130275	.. SLEEVE*	1
8	130274	. SHAFT, CENTER PIVOT*	1
9	130273	. SUPPORT, TRUNNION CYLINDER*	2
		* NON-SERVICEABLE ITEM	

REV.

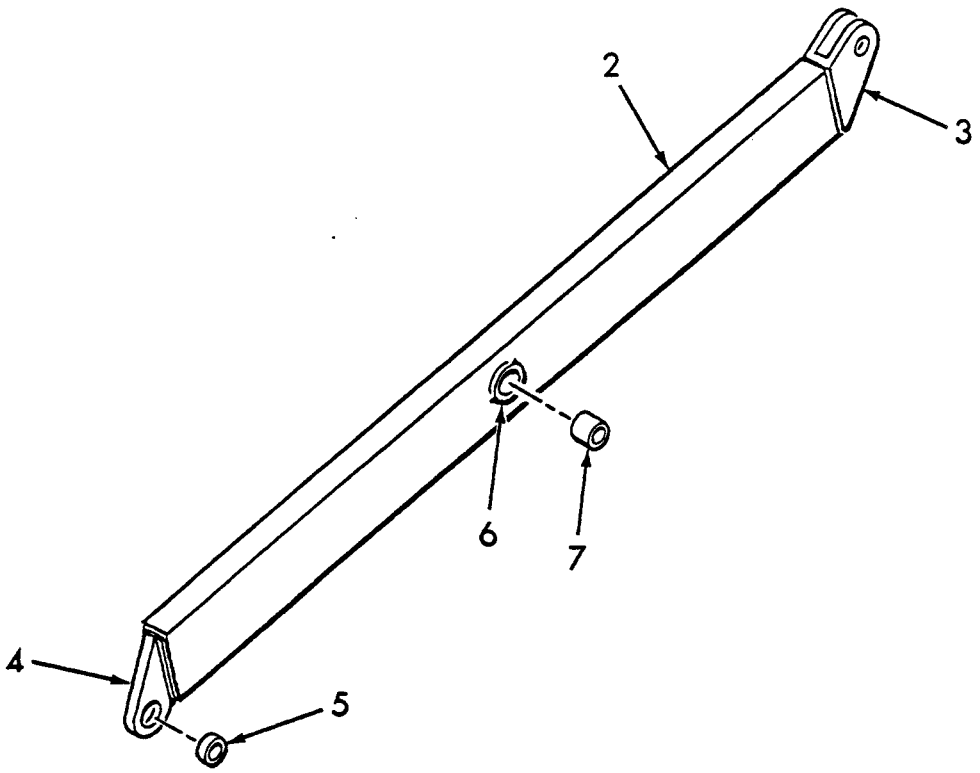
INNER ARM-BOTTOM ASSEMBLY (M20GP, M20E & M20ET)



ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	130262	ASSEMBLY, INNER ARM-BOTTOM	REF
-2	130261	. SUB-ASSEMBLY, INNER ARM	2
3	130260	.. ARM*	1
4	131586	.. EAR, ARM END (FEMALE)	2
5	130275	.. SLEEVE*	1
6	130274	. SHAFT, CENTER PIVOT*	1
7	130273	. SUPPORT, TRUNNION CYLINDER*	1
		* NON-SERVICEABLE ITEM	

REV.

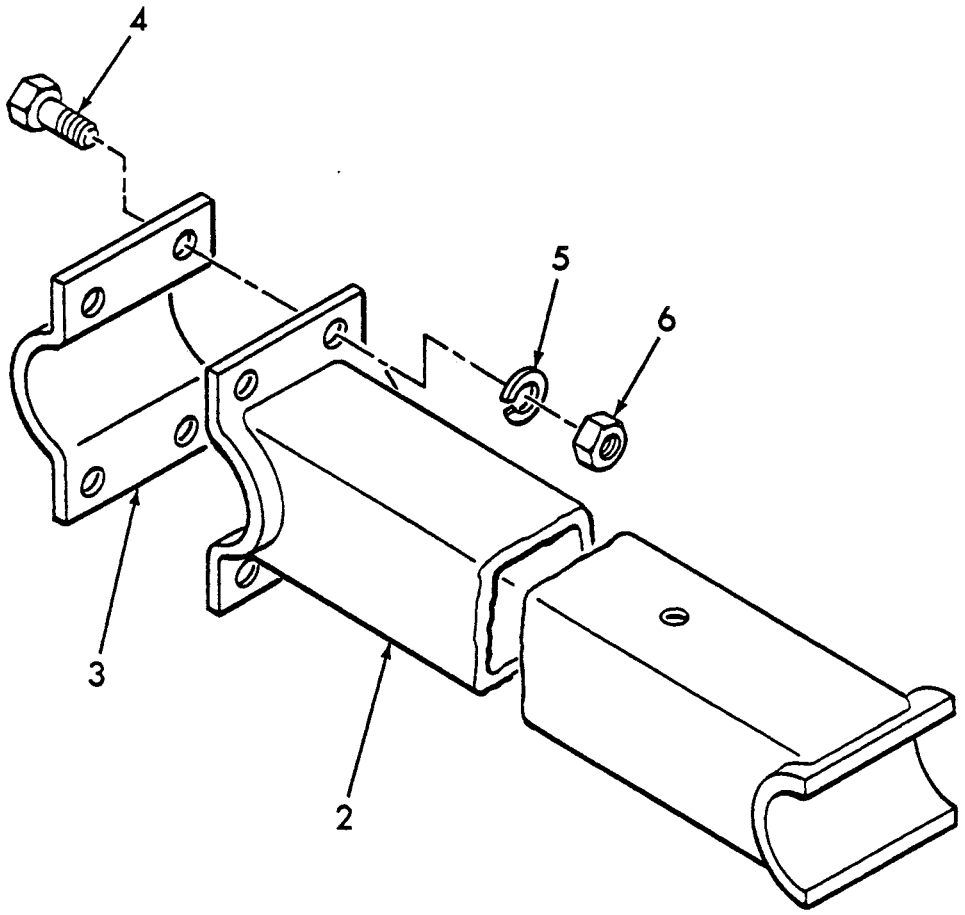
OUTER ARM ASSEMBLY (M20GP, M20E & M20ET)



ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	130254	ASSEMBLY, OUTER ARM	REF
2	130253	. ARM	1
3	131586	. EAR, ARM END (FEMALE)	1
4	131585	. EAR, ARM END (MALE)	1
5	916	. BUSHING	1
6	130275	. SLEEVE	1
7	64922	. BUSHING	1

REV.

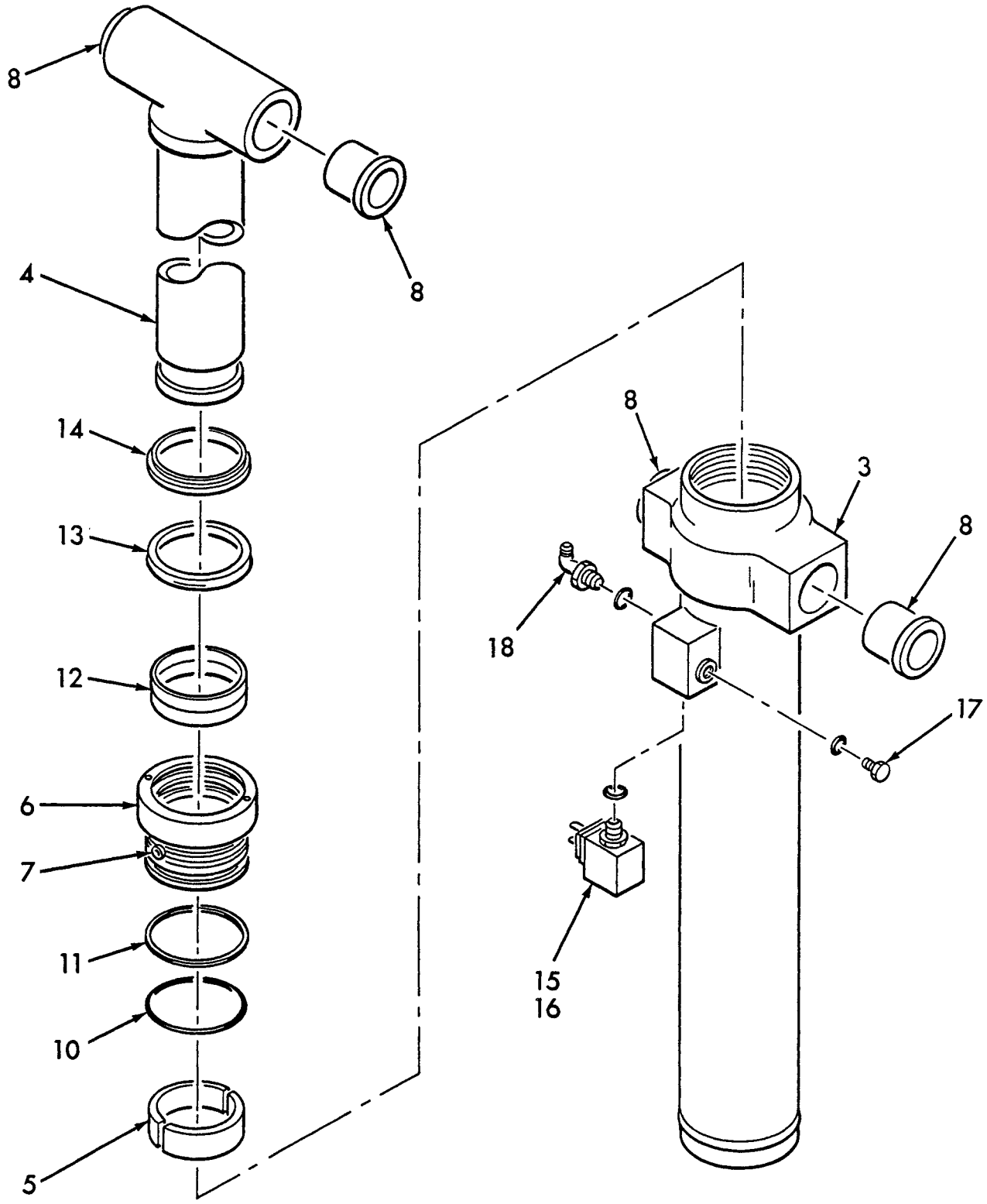
INNER ARM SUPPORT ASSEMBLY (M20GP, M20E & M20ET)



ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	130511	ASSEMBLY, INNER ARM SUPPORT (See Sect. 4, Fig. 1 for NHA)	REF
2	130512	. WELDMENT, INNER ARM SUPPORT	1
3	30693	. CLAMP, INNER ARM SUPPORT	1
4	60343	. SCREW, CAP	4
5	63303	. WASHER, LOCK	4
6	60703	. NUT, HEX	4

REV.

LIFT CYLINDER ASSEMBLY (M20GP)



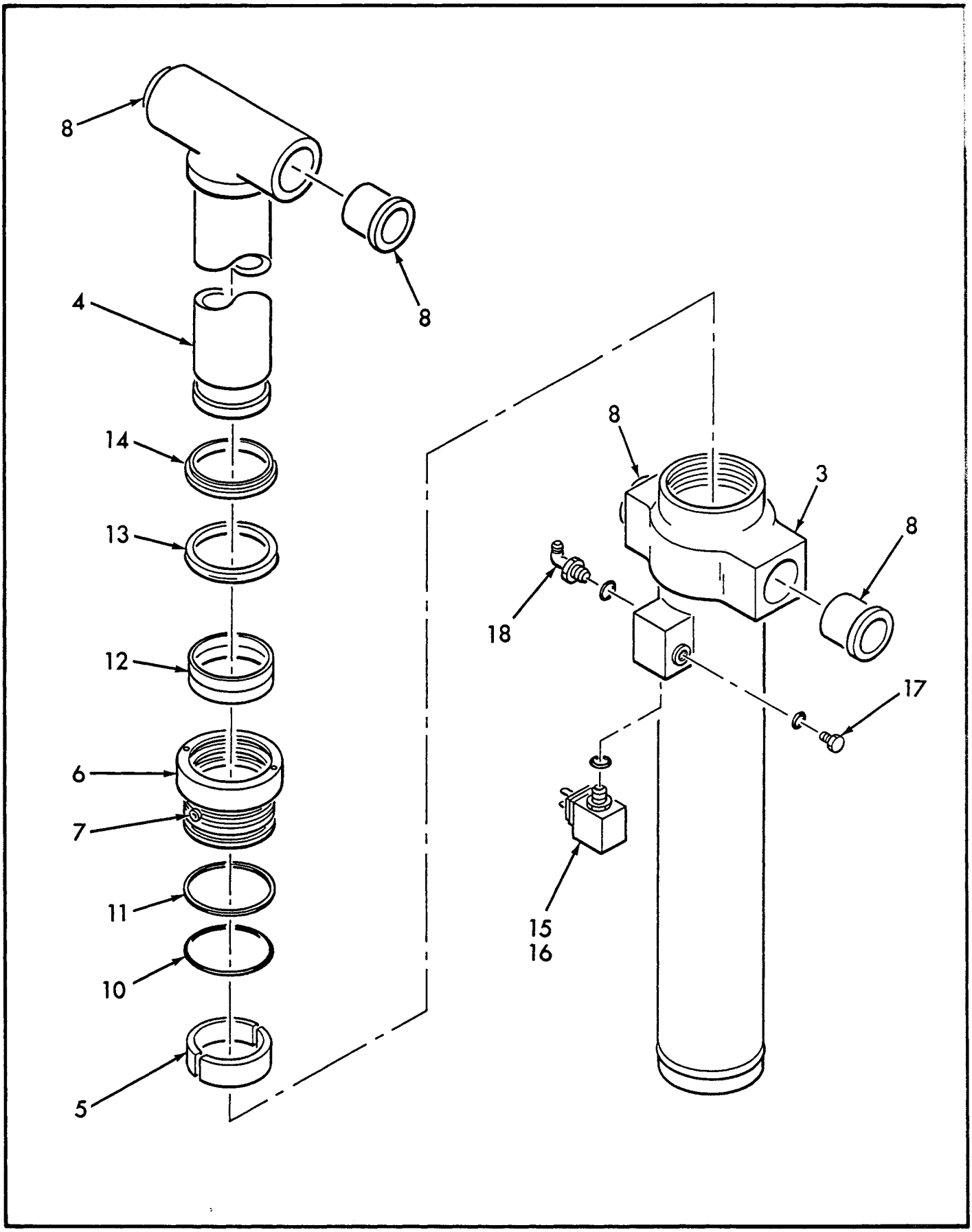
REV.

LIFT CYLINDER ASSEMBLY (M20GP)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	131579	ASSEMBLY, LIFT CYLINDER (See Sect. 4, Fig. 1 for NHA)	REF
-2	131411	. CYLINDER, LIFT	1
3	67828	.. BARREL	1
4	67829	.. ROD	1
5	67831	.. PISTON, SPLIT	1
6	67832	.. GLAND	1
7	67862	.. PLUG, NYLON	4
8	67830	.. BUSHING, FLANGED BRONZE	4
-9	67676	.. KIT, SEAL	1
10		... 'O' RING	1
11		... RING, BACK-UP	1
12		... RING, WEAR	2
13		... U-CUP, LOADED ('O' RING)	1
14		... WIPER, ROD	1
15	81314	. SOLENOID, ELECTRIC CHECK	1
16		.. COIL (12 VOLT)	1
17	80050-03	. PLUG, 'O' RING	1
18	80012-08	. ELBOW	1

- ITEM NOT ILLUSTRATED

LIFT CYLINDER ASSEMBLY (M20E & M20ET)



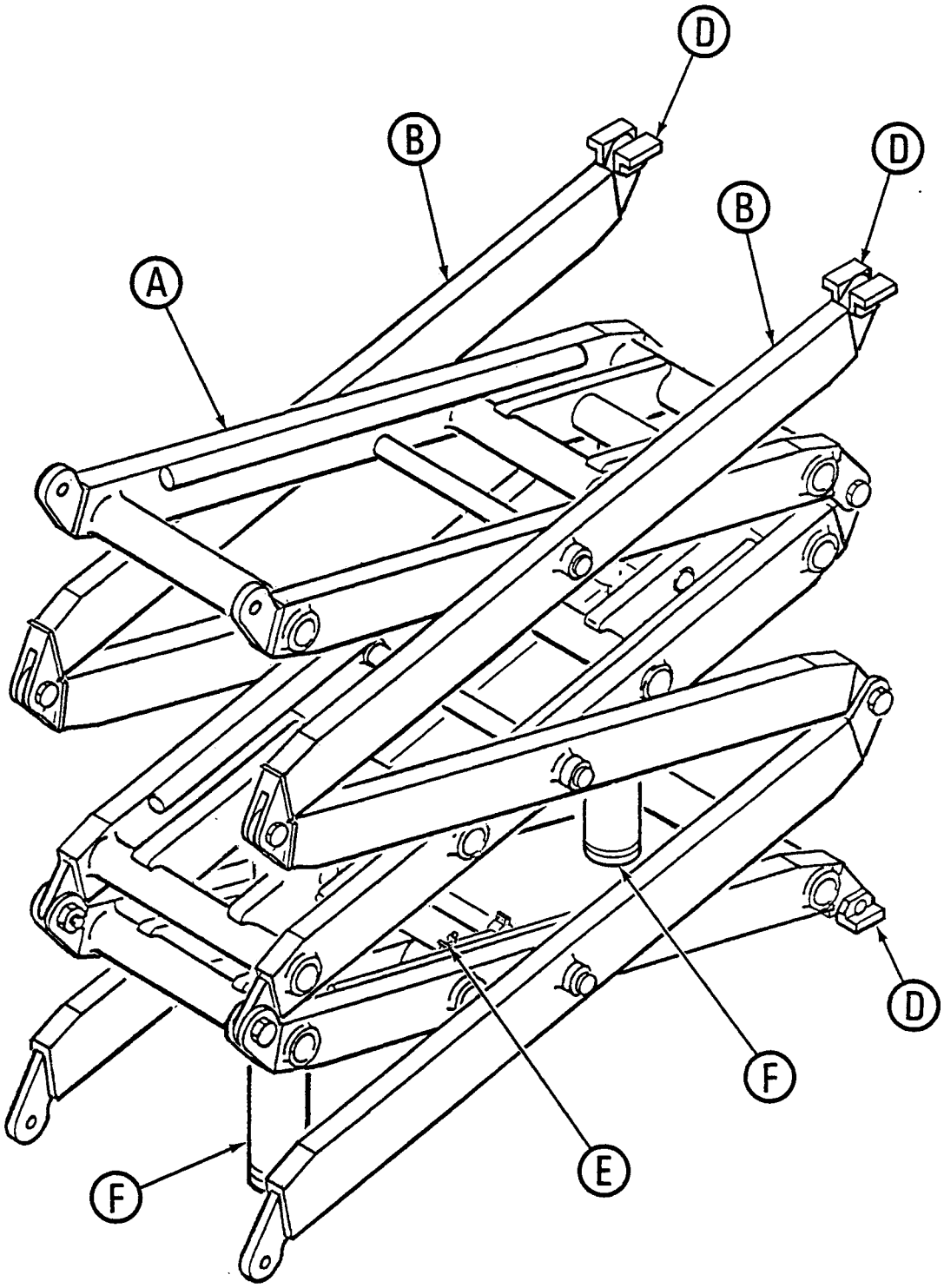
REV.

LIFT CYLINDER ASSEMBLY (M20E & M20ET)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	131421	ASSEMBLY, LIFT CYLINDER (See Sect. 4, Fig. 1A or 1C for NHA)	REF
-2	131411	. CYLINDER, LIFT	1
3	67828	.. BARREL	1
4	67829	.. ROD	1
5	67831	.. PISTON, SPLIT	1
6	67832	.. GLAND	1
7	67862	.. PLUG, NYLON	4
8	67830	.. BUSHING, FLANGED BRONZE	4
-9	67676	.. KIT, SEAL	1
10		... 'O' RING	1
11		... RING, BACK-UP	1
12		... RING, WEAR	2
13		... U-CUP, LOADED ('O' RING)	1
14		... WIPER, ROD	1
15	81028	. SOLENOID, ELECTRIC CHECK	1
16		.. COIL (20 VOLT)	1
17	80050-03	. PLUG, 'O' RING	1
18	80012-08	. ELBOW	1

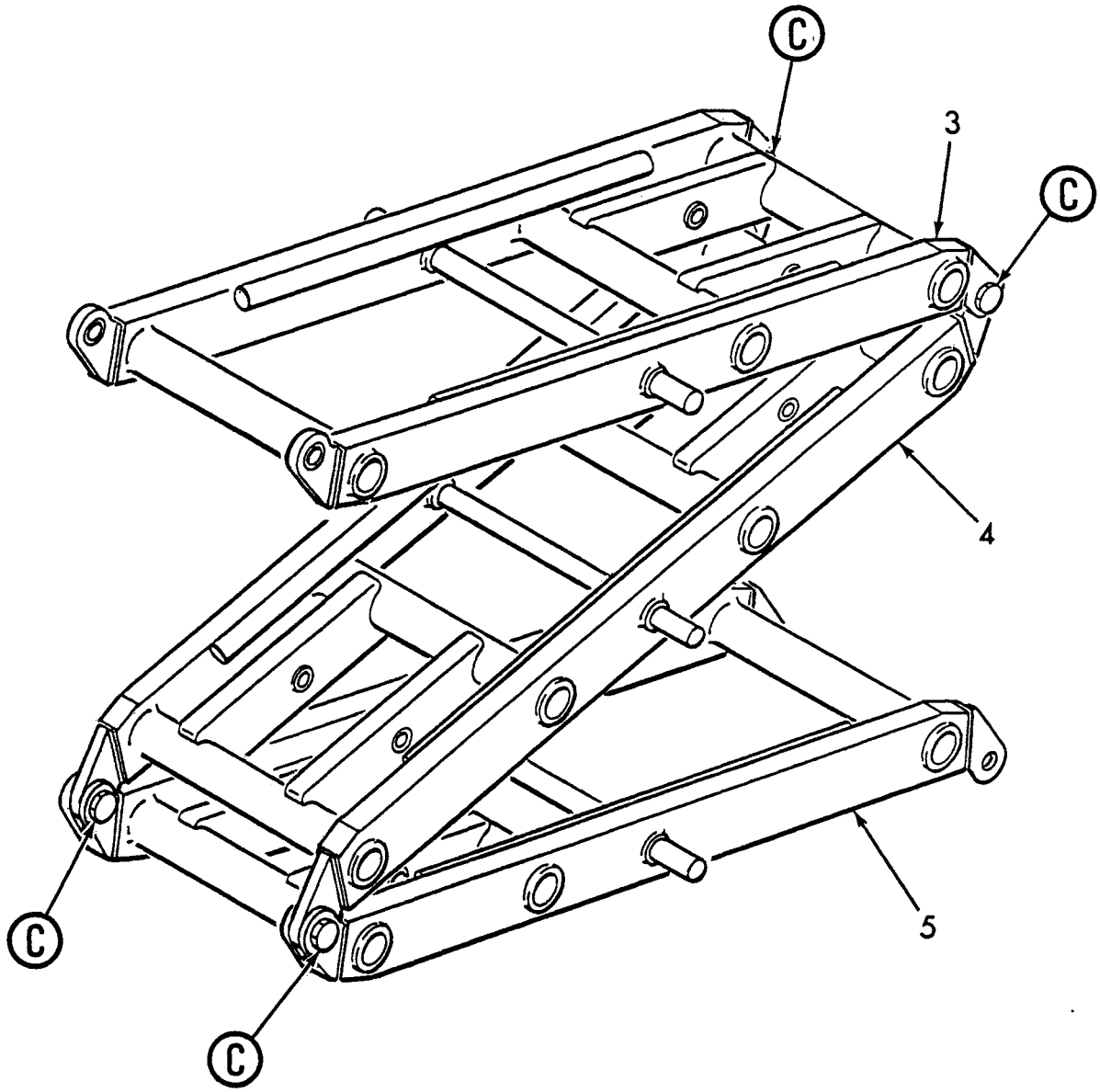
- ITEM NOT ILLUSTRATED

SCISSOR ASSEMBLY (M25E & M25ET)



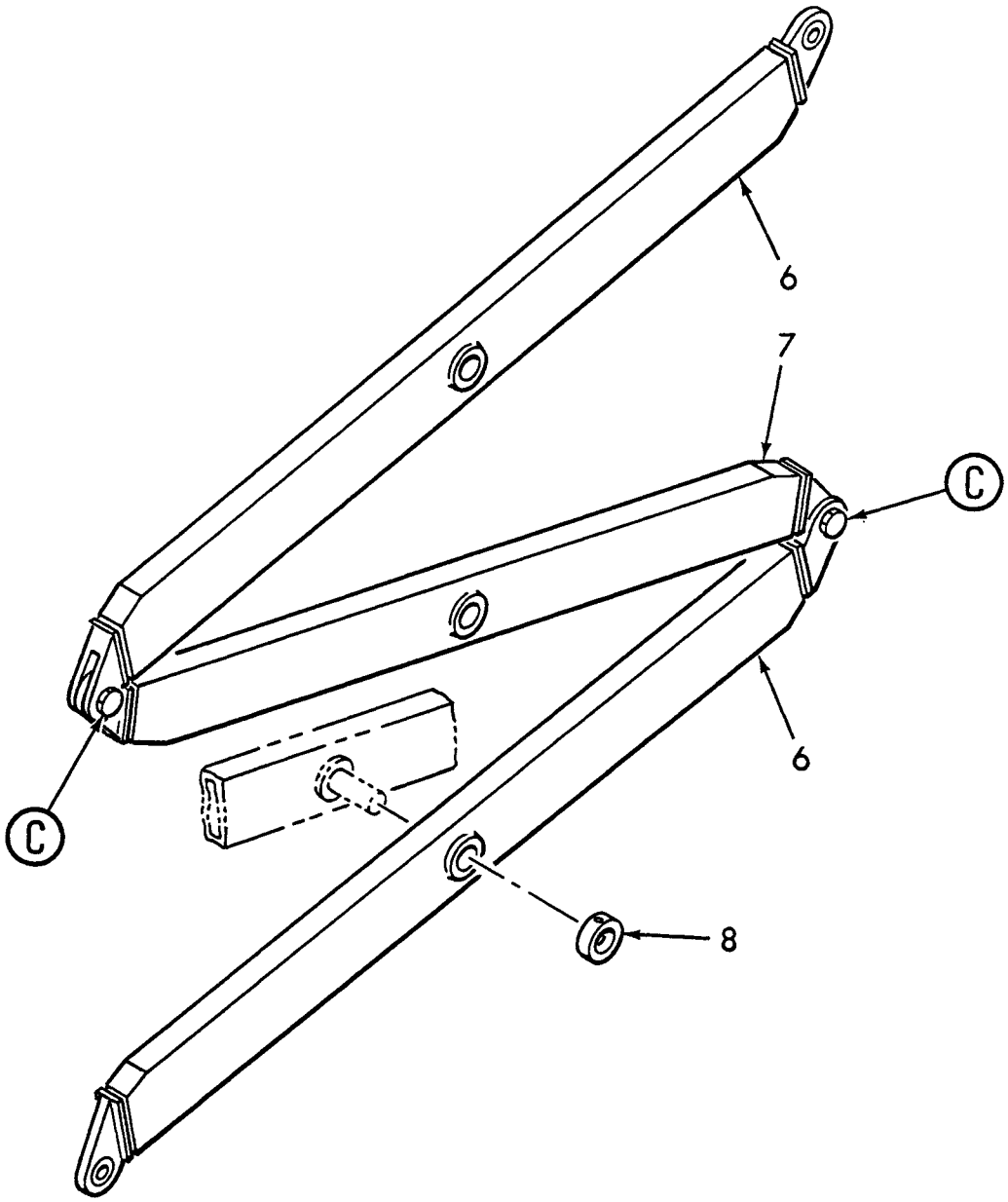
REV.

SCISSOR ASSEMBLY (M25E & M25ET)

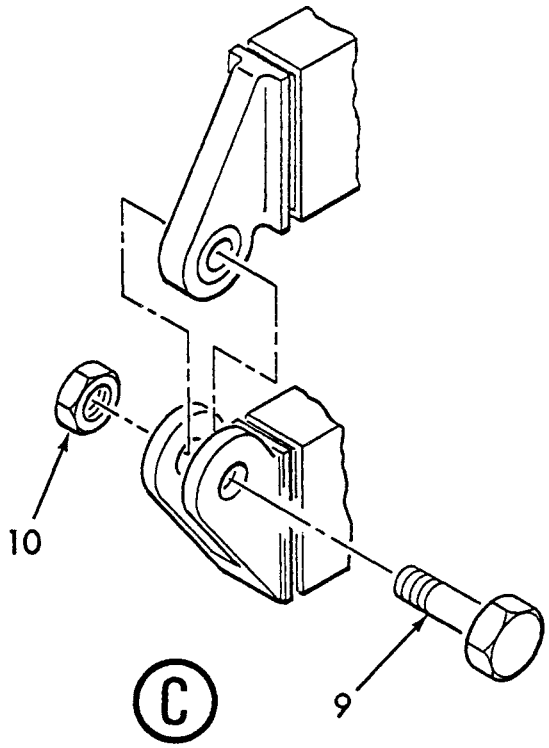


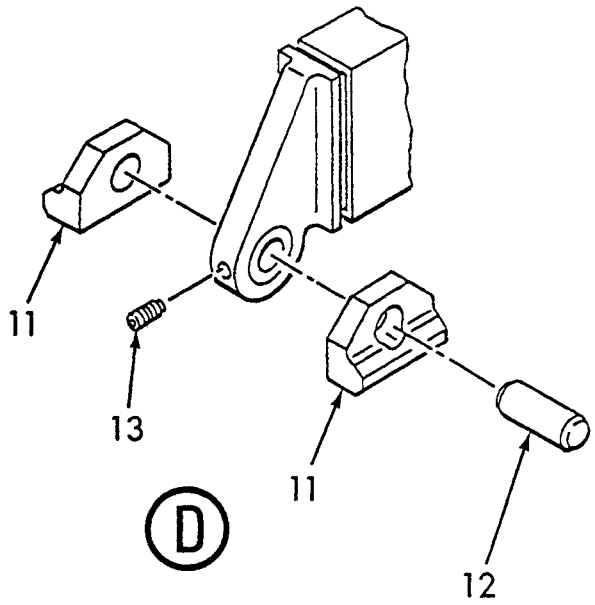
REV.

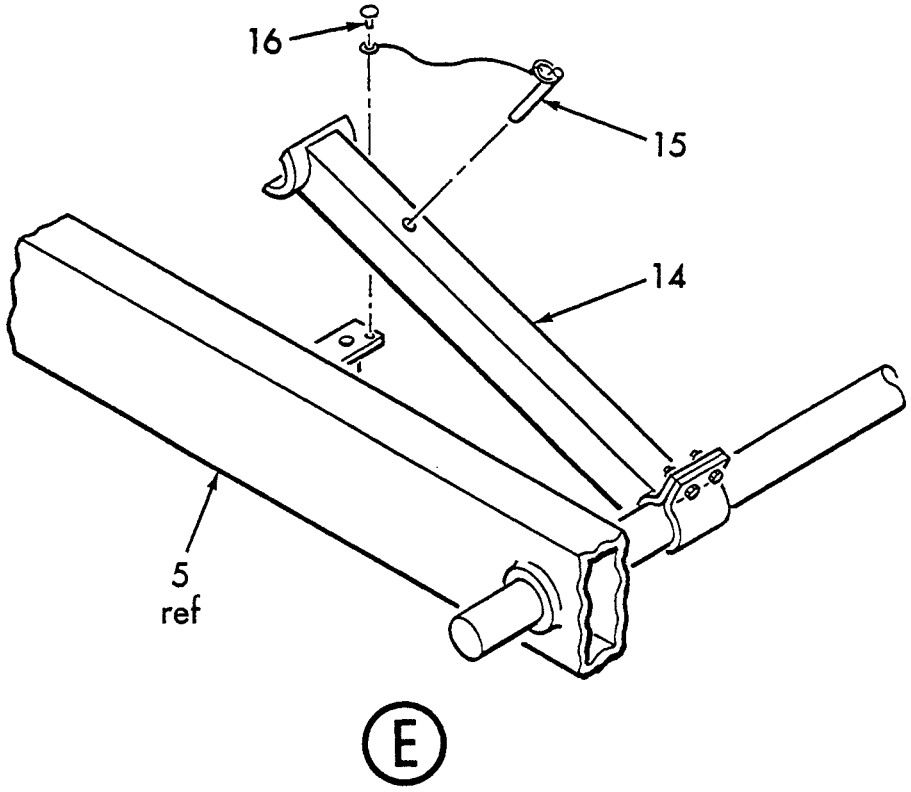
SCISSOR ASSEMBLY (M25E & M25ET)



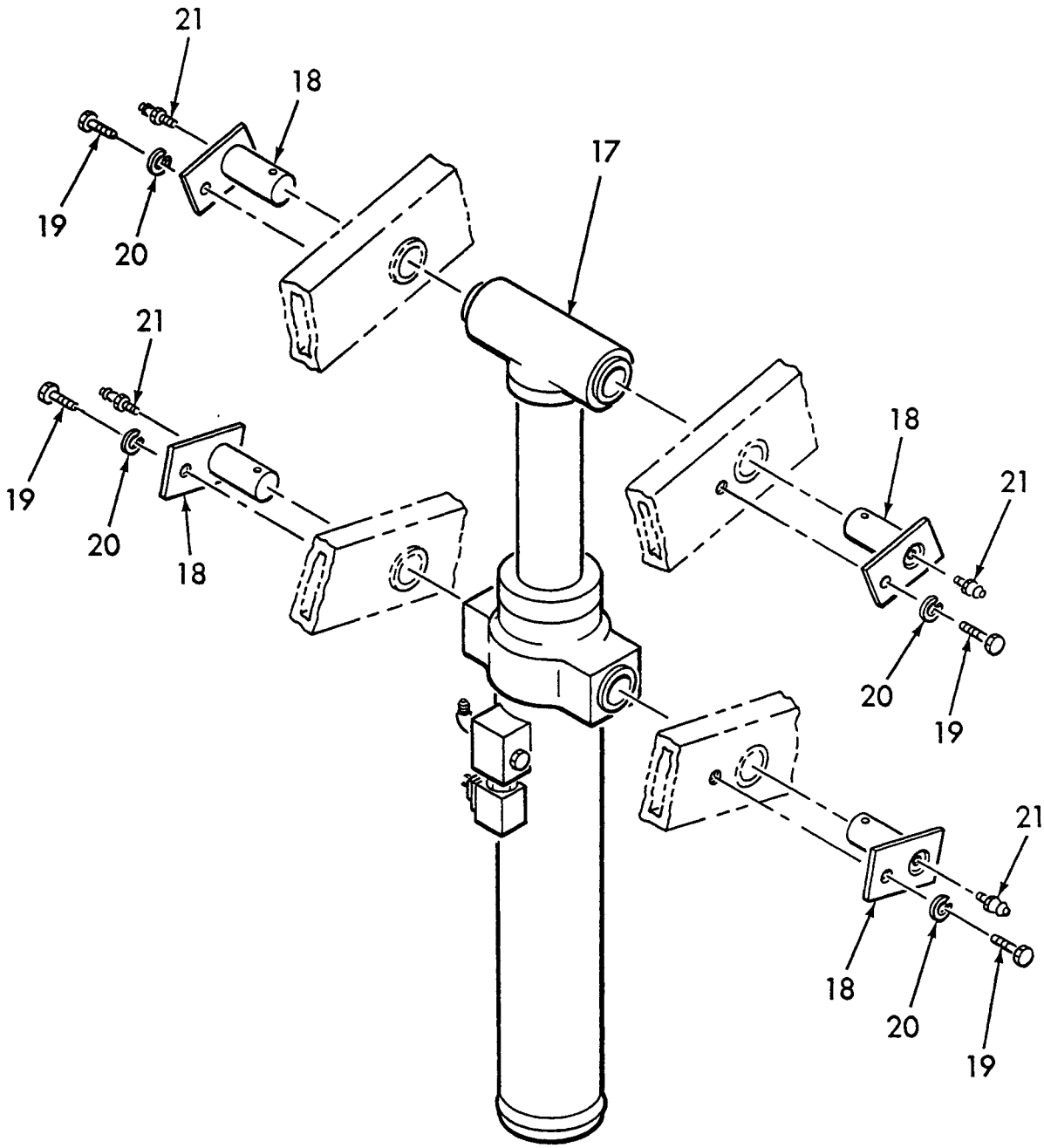
SCISSOR ASSEMBLY (M25E & M25ET)







SCISSOR ASSEMBLY (M25E & M25ET)

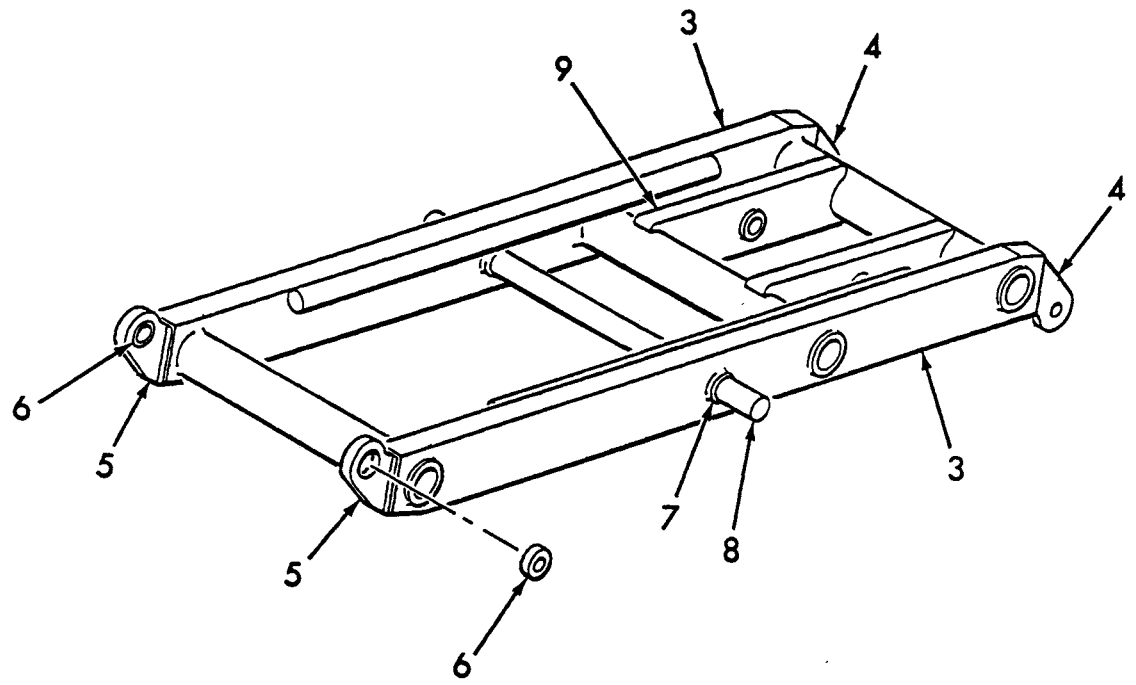


SCISSOR ASSEMBLIES (M25E & M25ET)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	131531	ASSEMBLY, SCISSOR (See Sect. 2, Fig. 1B or 1D for NHA)	REF
-2	131532	. SUB-ASSEMBLY, SCISSOR	1
3	130400	.. ASSEMBLY, INNER ARM-TOP (See Sect. 4, Fig. 2A for Details)	1
4	130408	.. ASSEMBLY, INNER ARM-CENTER (See Sect. 4, Fig. 3A for Details)	1
5	130510	.. ASSEMBLY, INNER ARM-BOTTOM (See Sect. 4, Fig. 4A for Details)	1
6	130410	.. ASSEMBLY, OUTER ARM (See Sect. 4, Fig. 5A for Details)	4
7	130412	.. ASSEMBLY, OUTER ARM (See Sect. 4, Fig. 6A for Details)	2
8	65454	.. COLLAR, SHAFT	6
9	130696	.. BOLT, EAR PIVOT	8
10	61249	.. NUT, HEX	8
11	131534	. PAD, WEAR	8
12	130327	. PIN, WEAR PAD	4
13	62201	. SCREW, SET	4
14	130518	. ASSEMBLY, INNER ARM SUPPORT (See Sect. 4, Fig. 7A for Details)	1
15	12007	. PIN, BALL-LOC DETENT	1
16	63653	. RIVET	1
17	131422	. ASSEMBLY, LIFT CYLINDER (See Sect. 4, Fig. 8A for Details)	2
18	131453	. PIN, TRUNNION	8
19	60533	. SCREW, CAP	8
20	63302	. WASHER, LOCK	8
21	65103	. FITTING, GREASE	8

- ITEM NOT ILLUSTRATED

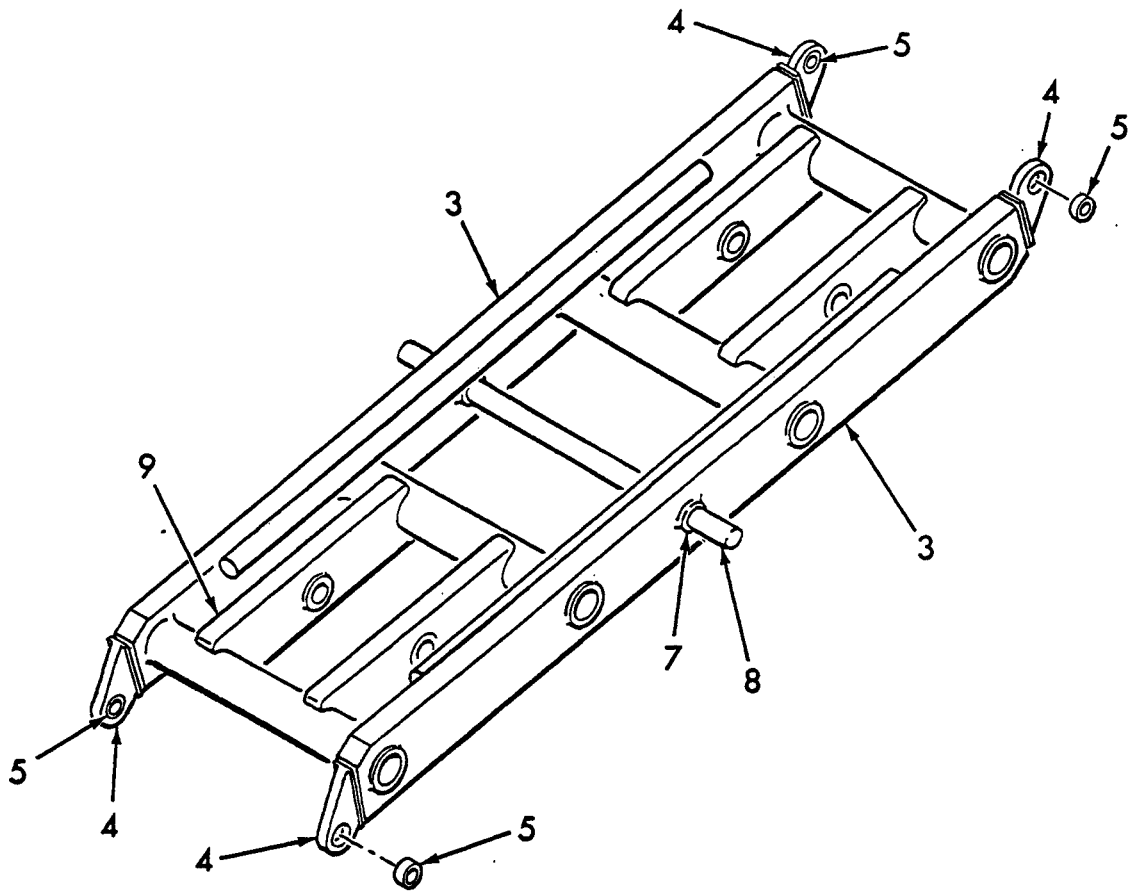
INNER ARM-TOP ASSEMBLY (M25E & M25ET)



ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	130400	ASSEMBLY, INNER ARM-TOP	REF
-2	130404	. SUB-ASSEMBLY, INNER ARM	2
3	130403	.. ARM*	1
4	131586	.. EAR, FEMALE	1
5	131585	.. EAR, MALE	1
6	916	.. BUSHING	1
7	130414	.. SLEEVE*	1
8	130413	. SHAFT, CENTER PIVOT*	1
9	130415	. SUPPORT, TRUNNION CYLINDER*	1
		* NON-SERVICEABLE ITEM	

REV.

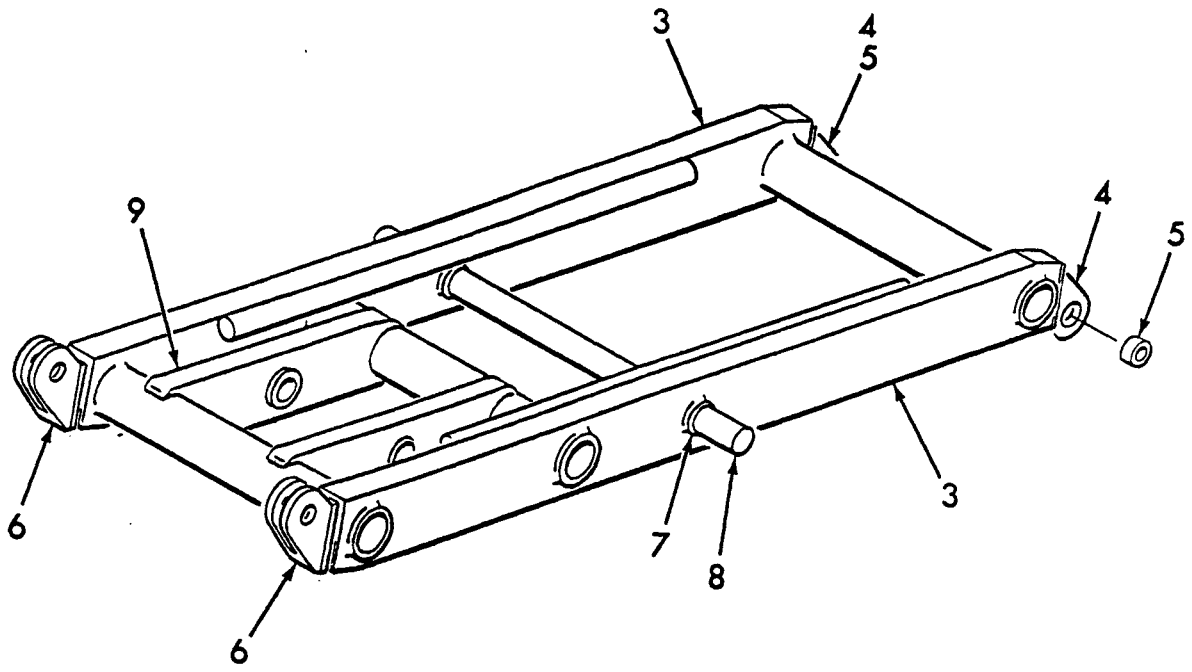
INNER ARM-CENTER ASSEMBLY (M25E & M25ET)



ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	130408	ASSEMBLY, INNER ARM-CENTER	REF
-2	130407	. SUB-ASSEMBLY, INNER ARM	2
3	130406	.. ARM*	1
4	131585	.. EAR, MALE	2
5	916	.. BUSHING	2
6	130414	.. SLEEVE*	1
7	130413	. SHAFT, CENTER PIVOT*	1
8	130415	. SUPPORT, TRUNNION CYLINDER*	2
		* NON-SERVICEABLE ITEM	

REV.

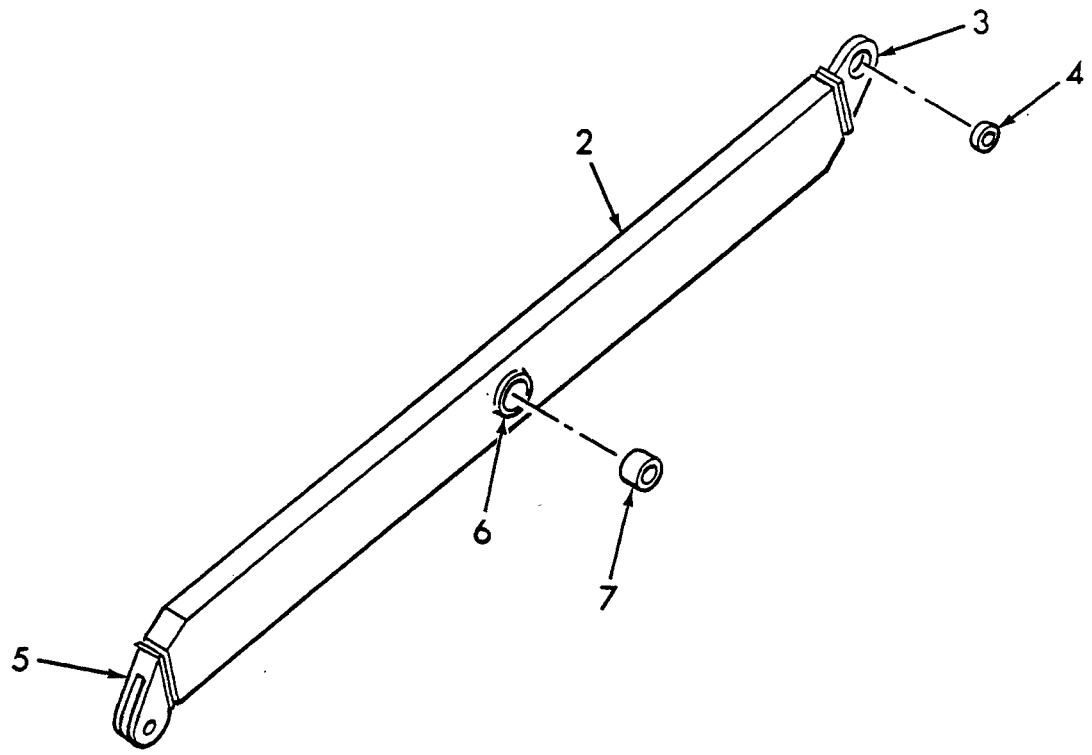
INNER ARM-BOTTOM ASSEMBLY (M25E & M25ET)



ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	130510	ASSEMBLY, INNER ARM-BOTTOM	REF
-2	130404	. SUB-ASSEMBLY, INNER ARM	2
3	130403	.. ARM*	1
4	131585	.. EAR, MALE	1
5	916	.. BUSHING	1
6	131586	.. EAR, FEMALE	1
7	130414	.. SLEEVE*	1
8	130413	. SHAFT, CENTER PIVOT*	1
9	130415	. SUPPORT, TRUNNION CYLINDER*	1
		* NON-SERVICEABLE ITEM	

REV.

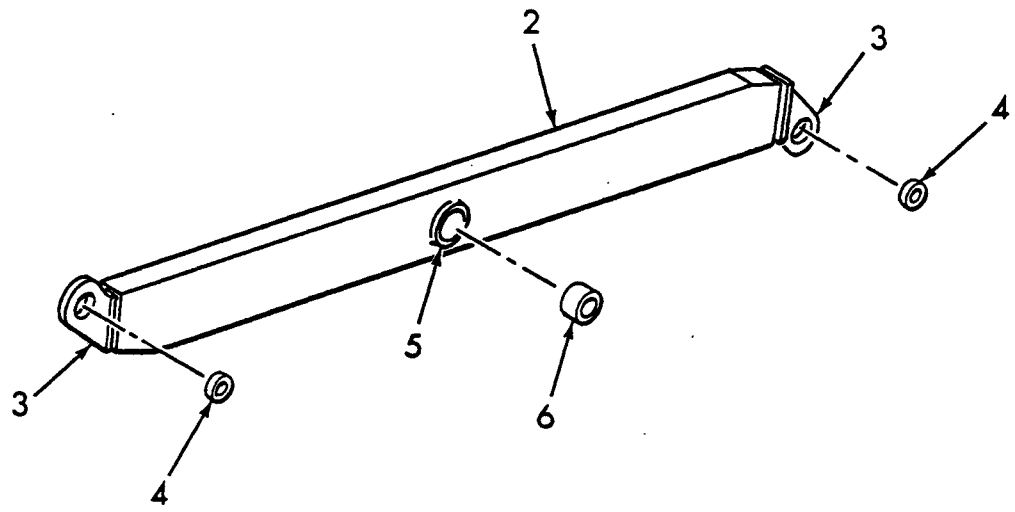
OUTER ARM ASSEMBLY (M25E & M25ET)



ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	130410	ASSEMBLY, OUTER ARM	REF
2	130409	. ARM	1
3	131585	. EAR, ARM END (MALE)	1
4	916	. BUSHING	1
5	131586	. EAR, ARM END	1
6	130424	. SLEEVE	1
7	64924	. BUSHING	1

REV.

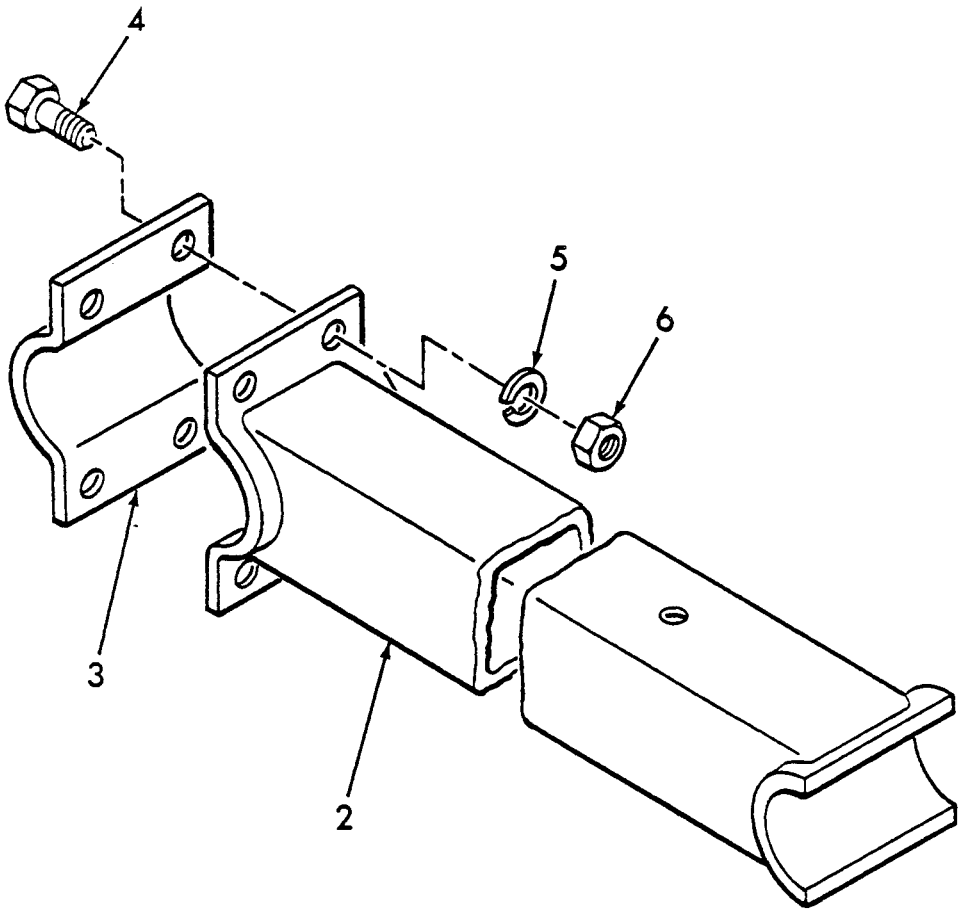
OUTER ARM ASSEMBLY (M25E & M25ET)



ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	130412	ASSEMBLY, OUTER ARM	REF
2	130411	. ARM	1
3	131585	. EAR, ARM END (MALE)	2
4	916	. BUSHING	2
5	130424	. SLEEVE	1
6	64924	. BUSHING	1

REV.

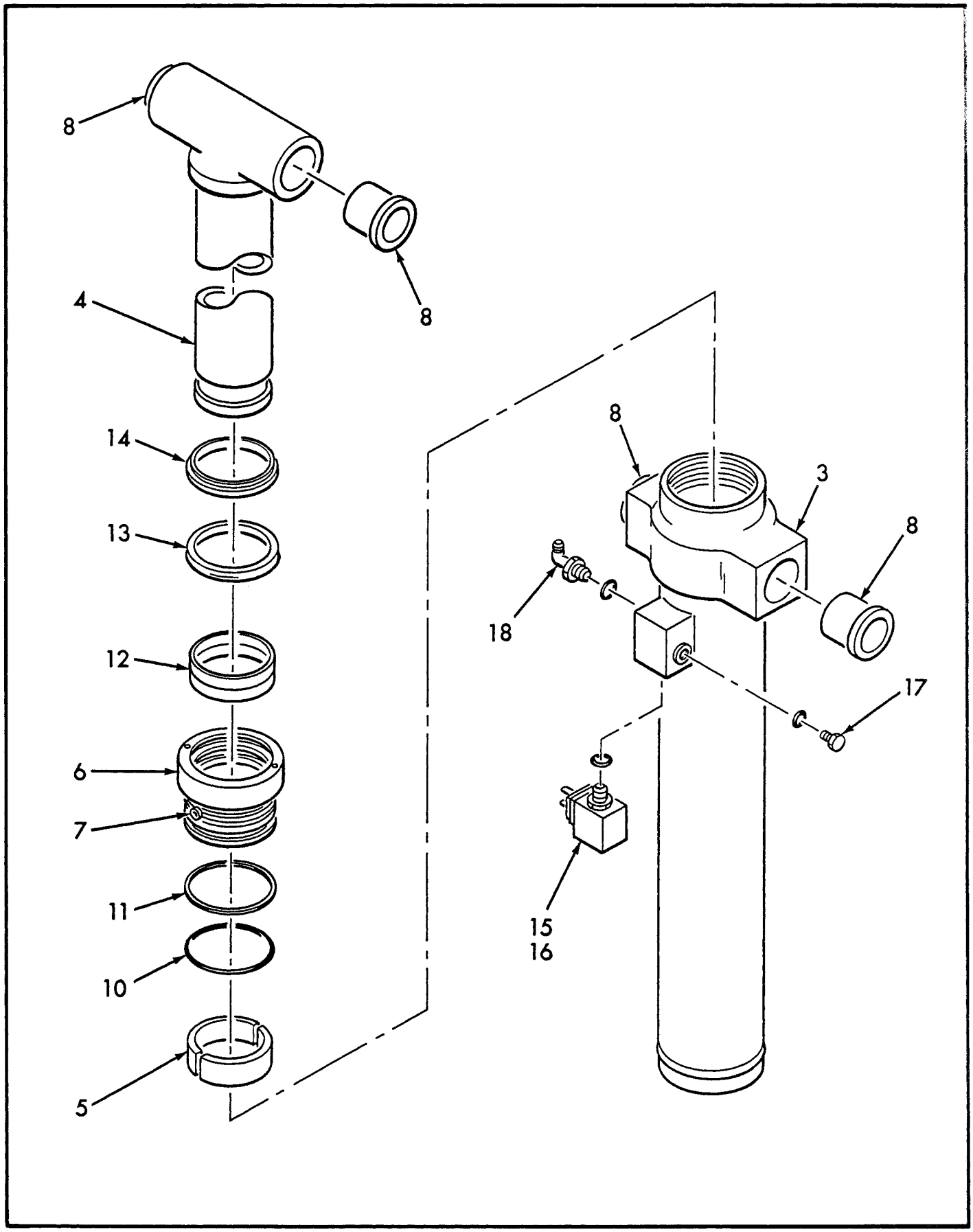
INNER ARM SUPPORT ASSEMBLY (M25E & M25ET)



ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	130518	ASSEMBLY, INNER ARM SUPPORT (See Sect. 4, Fig. 1A for NHA)	REF
2	130519	. WELDMENT, INNER ARM SUPPORT	1
3	30693	. CLAMP, INNER ARM SUPPORT	1
4	60343	. SCREW, CAP	4
5	63303	. WASHER, LOCK	4
6	60703	. NUT, HEX	4

REV.

LIFT CYLINDER ASSEMBLY (M25E & M25ET)



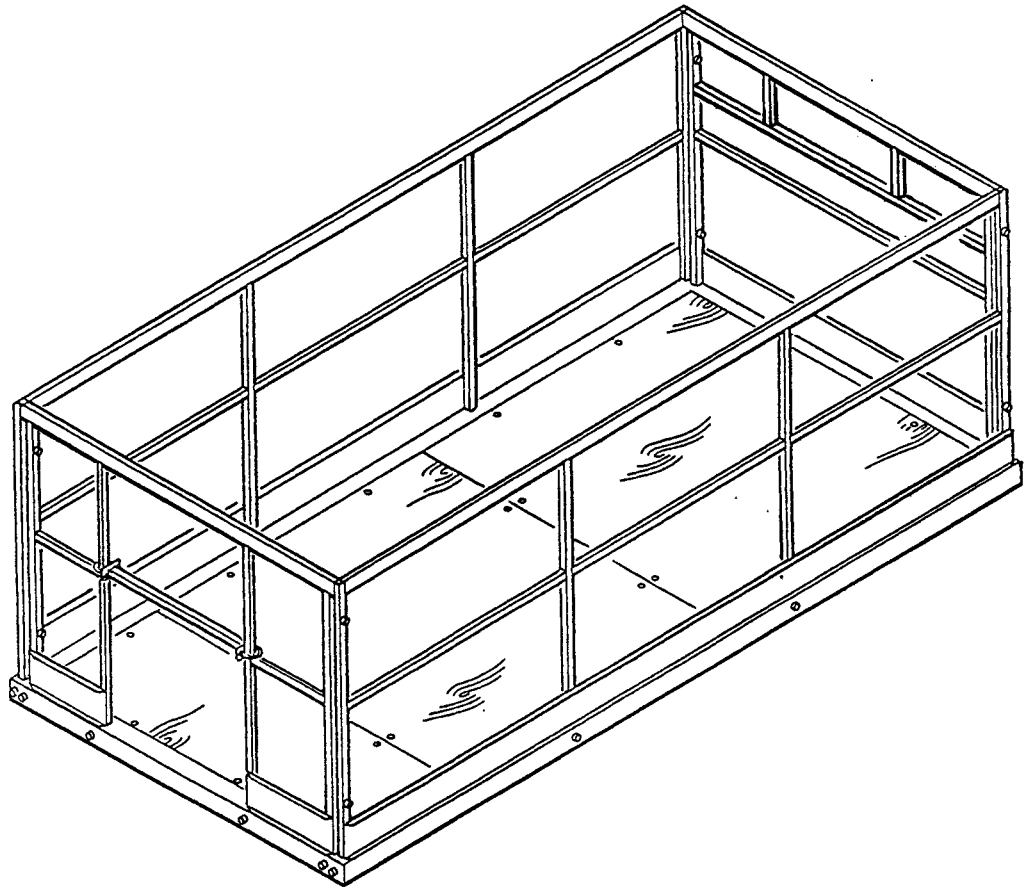
REV.

LIFT CYLINDER ASSEMBLY (M25E & M25ET)

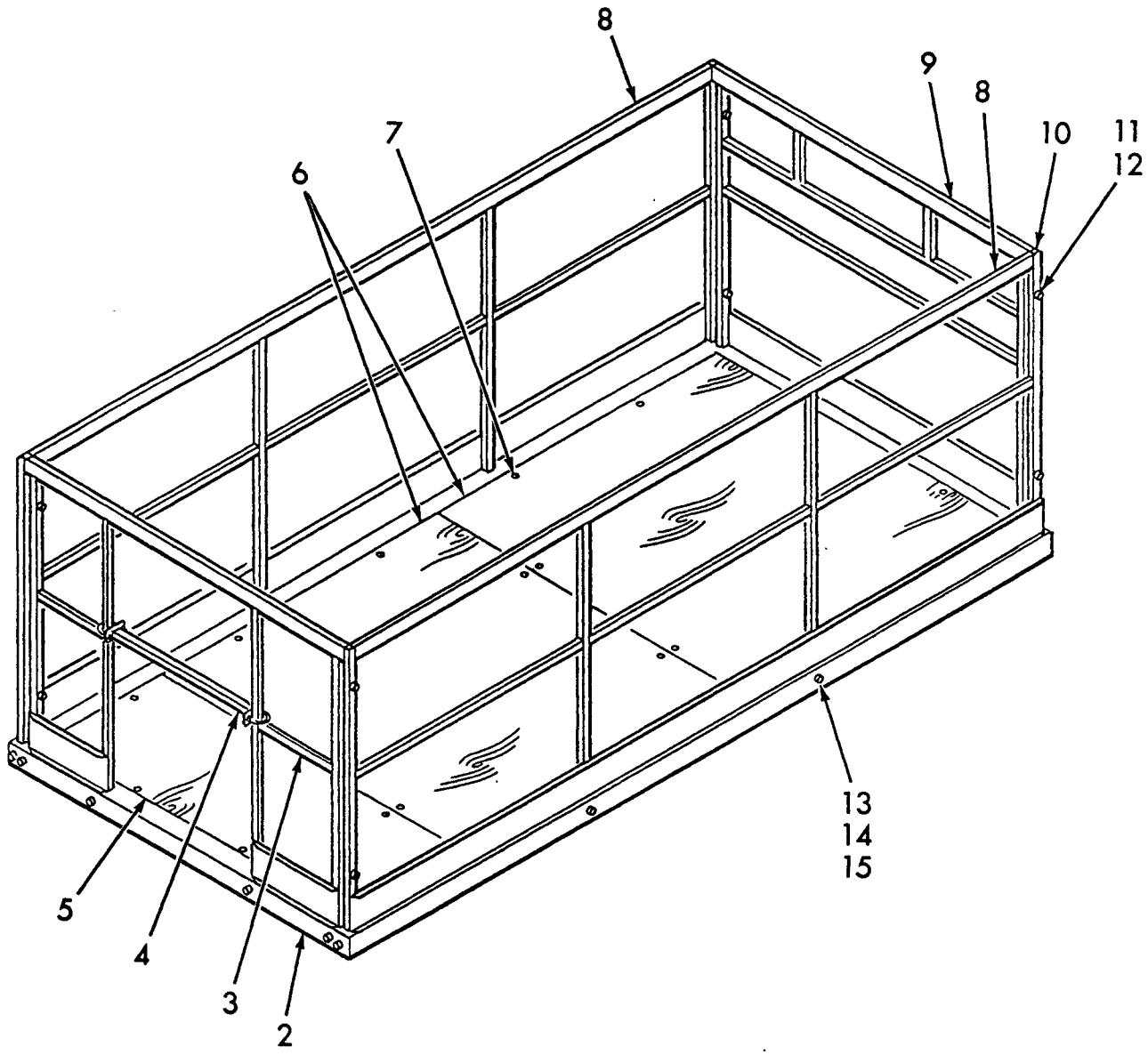
ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	131422	ASSEMBLY, LIFT CYLINDER (See Sect. 4, Fig. 1A for NHA)	REF
-2	131411	. CYLINDER, LIFT	1
3	67828	.. BARREL	1
4	67829	.. ROD	1
5	67831	.. PISTON, SPLIT	1
6	67832	.. GLAND	1
7	67862	.. PLUG, NYLON	4
8	67830	.. BUSHING, FLANGED BRONZE	4
-9	67676	.. KIT, SEAL	1
10		... 'O' RING	1
11		... RING, BACK-UP	1
12		... RING, WEAR	2
13		... U-CUP, LOADED ('O' RING)	1
14		... WIPER, ROD	1
15	81028	. SOLENOID, ELECTRIC CHECK	1
16		.. COIL (20 VOLT)	1
17	80050-03	. PLUG, 'O' RING	1
18	80012-08	. ELBOW	1

- ITEM NOT ILLUSTRATED

SECTION 5 CONTAINS:



PLATFORM ASSEMBLY (M20GP)

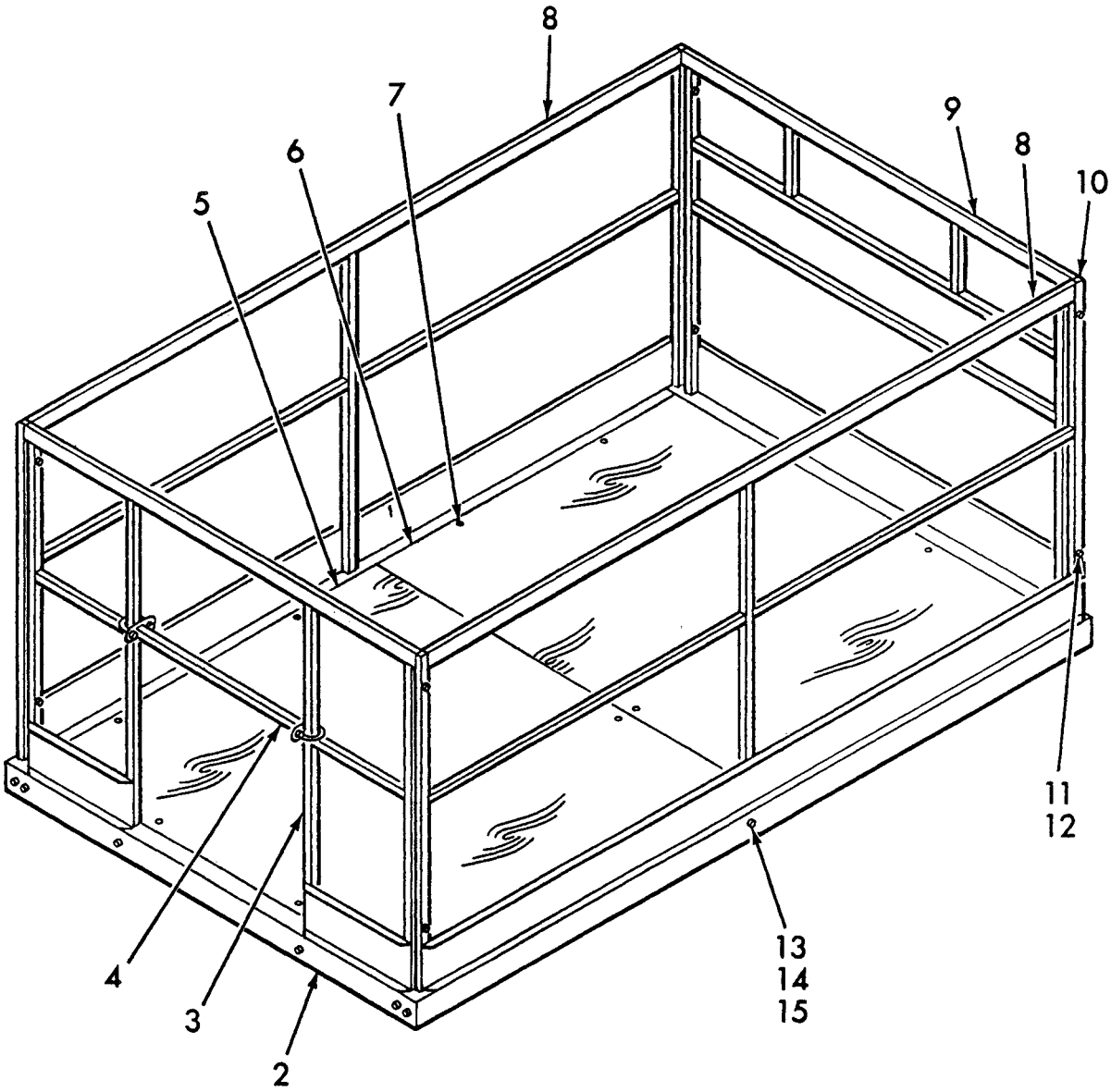


REV.

PLATFORM ASSEMBLY (M20GP)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	131450	ASSEMBLY, PLATFORM (See Sect. 2, Fig. 1 for NHA)	REF
2	131443	. WELDMENT, PLATFORM	1
3	131456	. RAIL, REAR GUARD	1
4	32741	. ASSEMBLY, SLIDE BAR (See Sect. 5, Fig. 2 for Details)	1
5	131537	. PLYWOOD, PLATFORM	1
6	131536	. PLYWOOD, PLATFORM	2
7	61713	. SCREW, SELF TAP	24
8	131455	. RAIL, SIDE GUARD	2
9	131454	. RAIL, FRONT	1
10	91541	. CAP, PLUG	4
11	60337	. SCREW, CAP	8
12	61227	. NUT, LOCK	8
13	60337	. SCREW, CAP	14
14	63301	. WASHER, LOCK	14
15	60701	. NUT, HEX	14

PLATFORM ASSEMBLY (M20E)



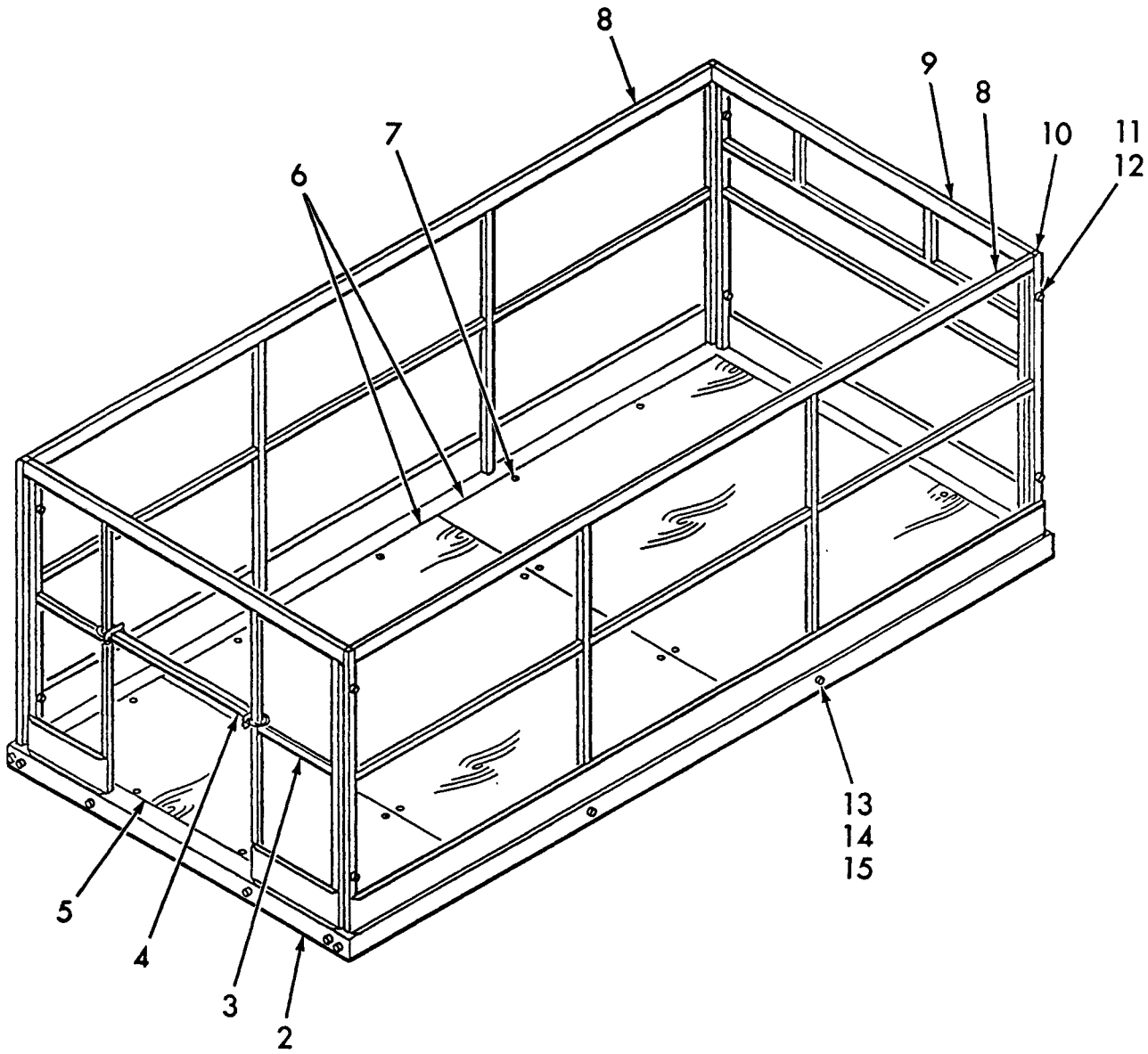
REV.

PLATFORM ASSEMBLY (M20E)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	131451	ASSEMBLY, PLATFORM (See Sect. 2, Fig. 1A for NHA)	REF
2	131444	. WELDMENT, PLATFORM	1
3	131456	. RAIL, REAR GUARD	1
4	32741	. ASSEMBLY, SLIDE BAR (See Sect. 5, Fig. 2 for Details)	1
5	131554	. PLYWOOD, PLATFORM	1
6	131536	. PLYWOOD, PLATFORM	1
7	61713	. SCREW, SELF TAP	16
8	131556	. RAIL, SIDE GUARD	2
9	131454	. RAIL, FRONT	1
10	91541	. CAP, PLUG	4
11	60337	. SCREW, CAP	8
12	61227	. NUT, LOCK	8
13	60337	. SCREW, CAP	12
14	63301	. WASHER, LOCK	12
15	60701	. NUT, HEX	12

- ITEM NOT ILLUSTRATED

PLATFORM ASSEMBLY (M25E)



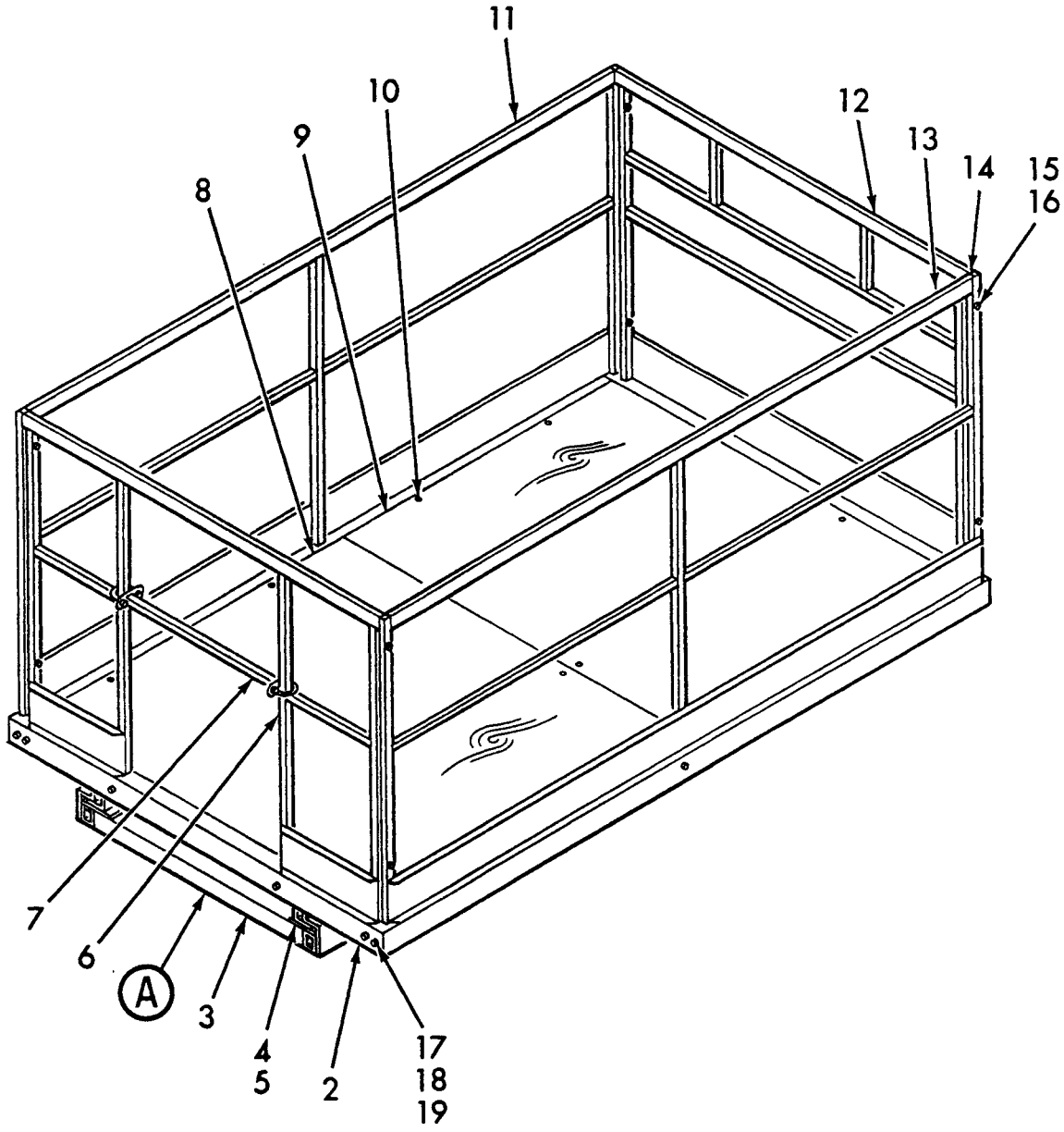
REV.

PLATFORM ASSEMBLY (M25E)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	131452	ASSEMBLY, PLATFORM (See Sect. 2, Fig. 1B for NHA)	REF
2	131445	. WELDMENT, PLATFORM	1
3	131456	. RAIL, REAR GUARD	1
4	32741	. ASSEMBLY, SLIDE BAR (See Sect. 5, Fig. 2 for Details)	1
5	131537	. PLYWOOD, PLATFORM	1
6	131536	. PLYWOOD, PLATFORM	2
7	61713	. SCREW, SELF TAP	24
8	131455	. RAIL, SIDE GUARD	2
9	131454	. RAIL, FRONT	1
10	91541	. CAP, PLUG	4
11	60337	. SCREW, CAP	8
12	61227	. NUT, LOCK	8
13	60337	. SCREW, CAP	14
14	63301	. WASHER, LOCK	14
15	60701	. NUT, HEX	14

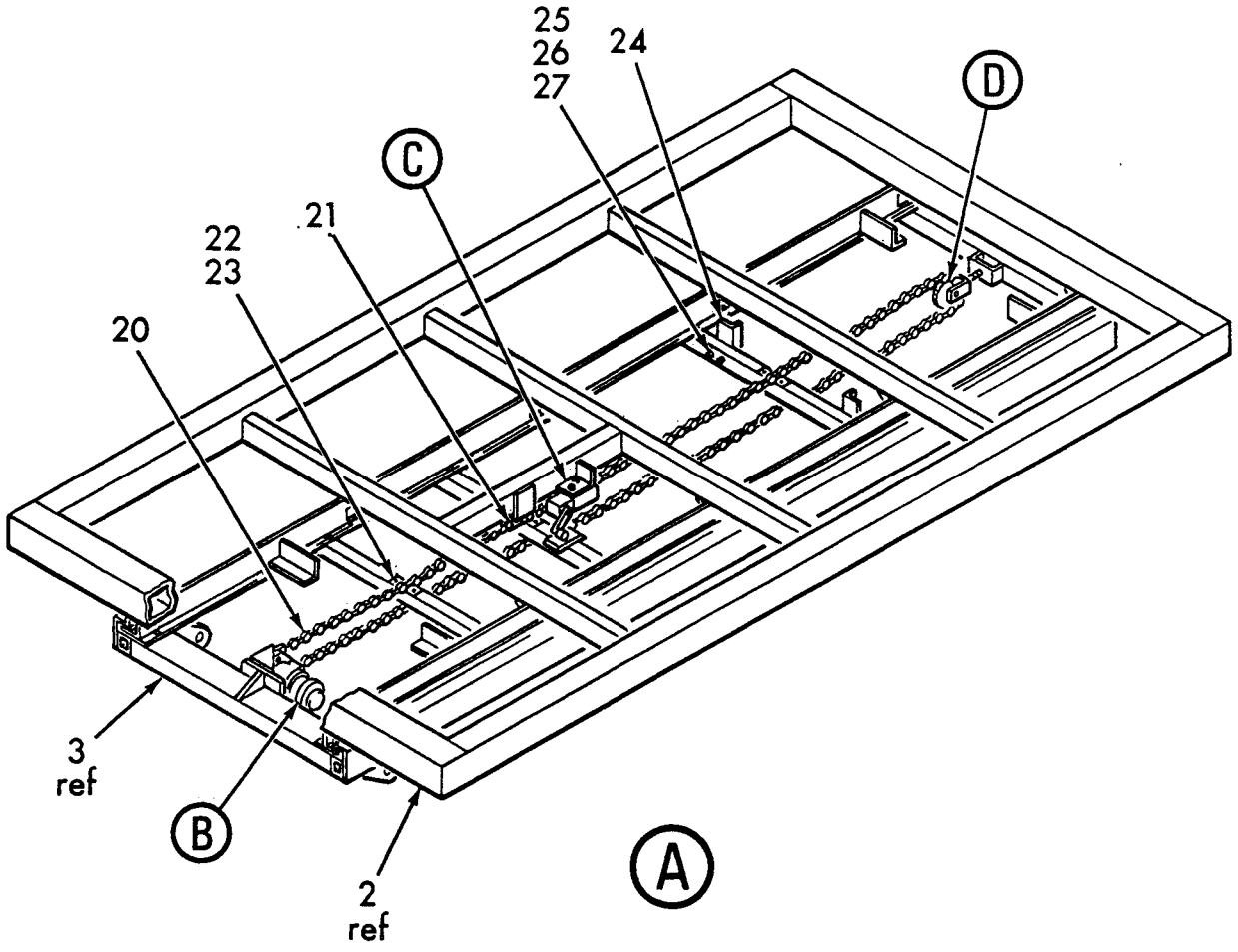
- ITEM NOT ILLUSTRATED

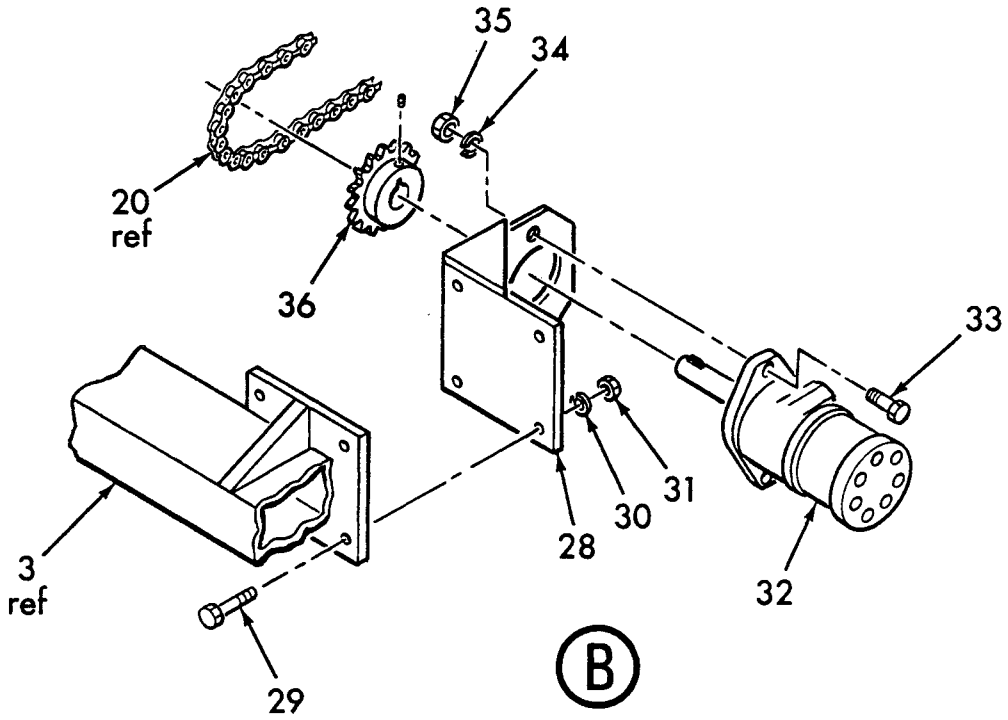
PLATFORM ASSEMBLY (M20ET)



REV.

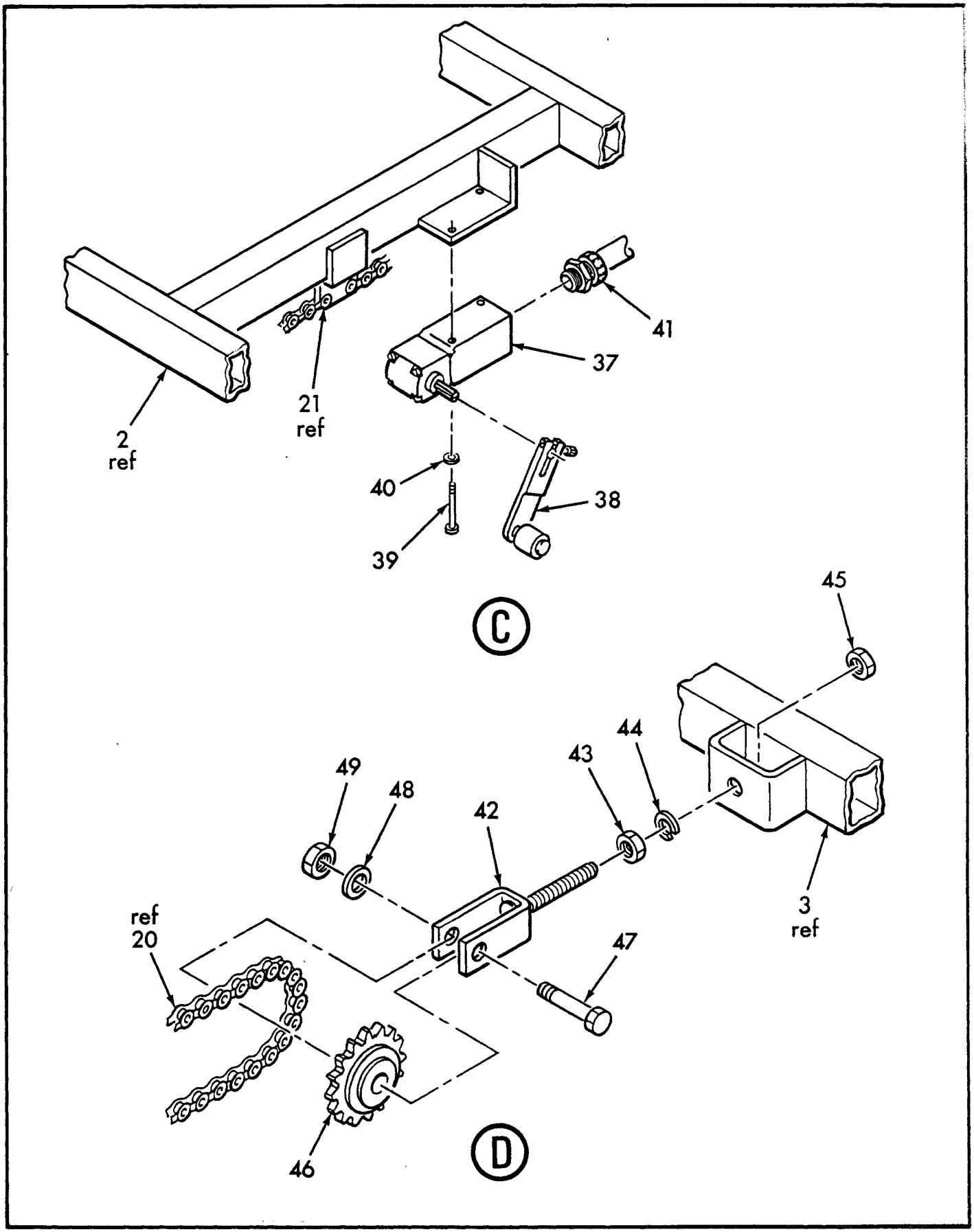
PLATFORM ASSEMBLY (M20ET)





REV.

PLATFORM ASSEMBLY (M20ET)



REV.

PLATFORM ASSEMBLY (M20ET)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	131513	ASSEMBLY, PLATFORM (See Sect. 2, Fig. 1C for NHA)	REF
2	131516	. WELDMENT, PLATFORM	1
3	131517	. WELDMENT, TOP FRAME	1
4	31058	. PAD, WEAR	2
5	16217	. RIVET, POP	12
6	131456	. RAIL, REAR GUARD	1
7	32741	. ASSEMBLY, SLIDE BAR (See Sect. 5, Fig. 2 for Details)	1
8	131536	. PLYWOOD, PLATFORM	1
9	131554	. PLYWOOD, PLATFORM	1
10	61713	. SCREW, SELF TAPPING	16
11	131556	. RAIL, SIDE GUARD	1
12	131454	. RAIL, FRONT GUARD	1
13	131556	. RAIL, SIDE GUARD	1
14	91541	. CAP, PLUG	4
15	60337	. SCREW, CAP-HEX	8
16	61227	. NUT, LOCK	8
17	60337	. SCREW, CAP-HEX	10
18	63301	. WASHER, LOCK	10
19	60701	. NUT, HEX	10
20	65579	. CHAIN, SELF LUBRICATING	1
21	65580	. LINK, MASTER	2
22	130399	. PAD, WEAR	4
23	16217	. RIVET, POP	8
24	130371	. STOP	2
25	60318	. SCREW, CAP	4

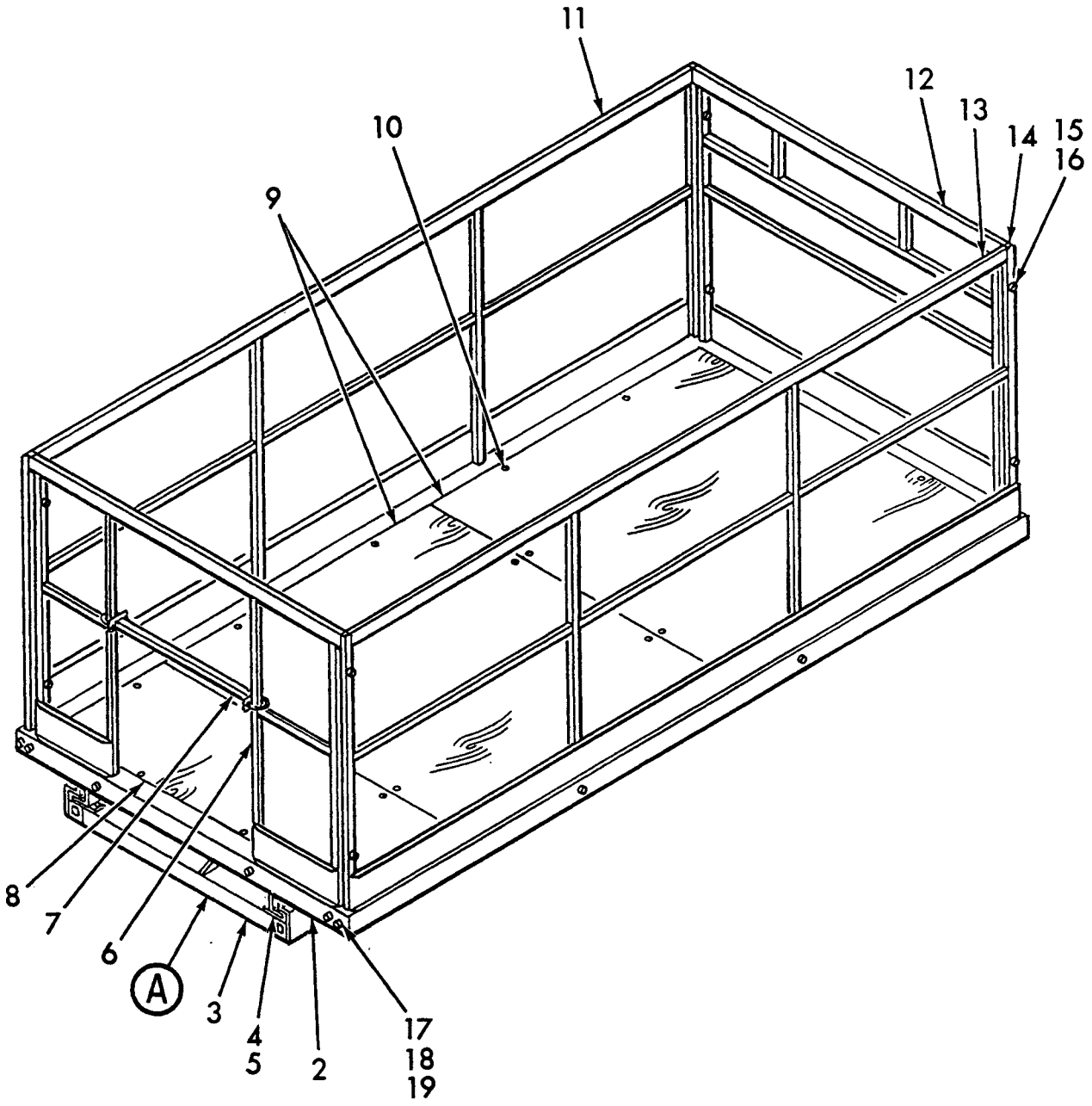
- ITEM NOT ILLUSTRATED

PLATFORM ASSEMBLY (M20ET)

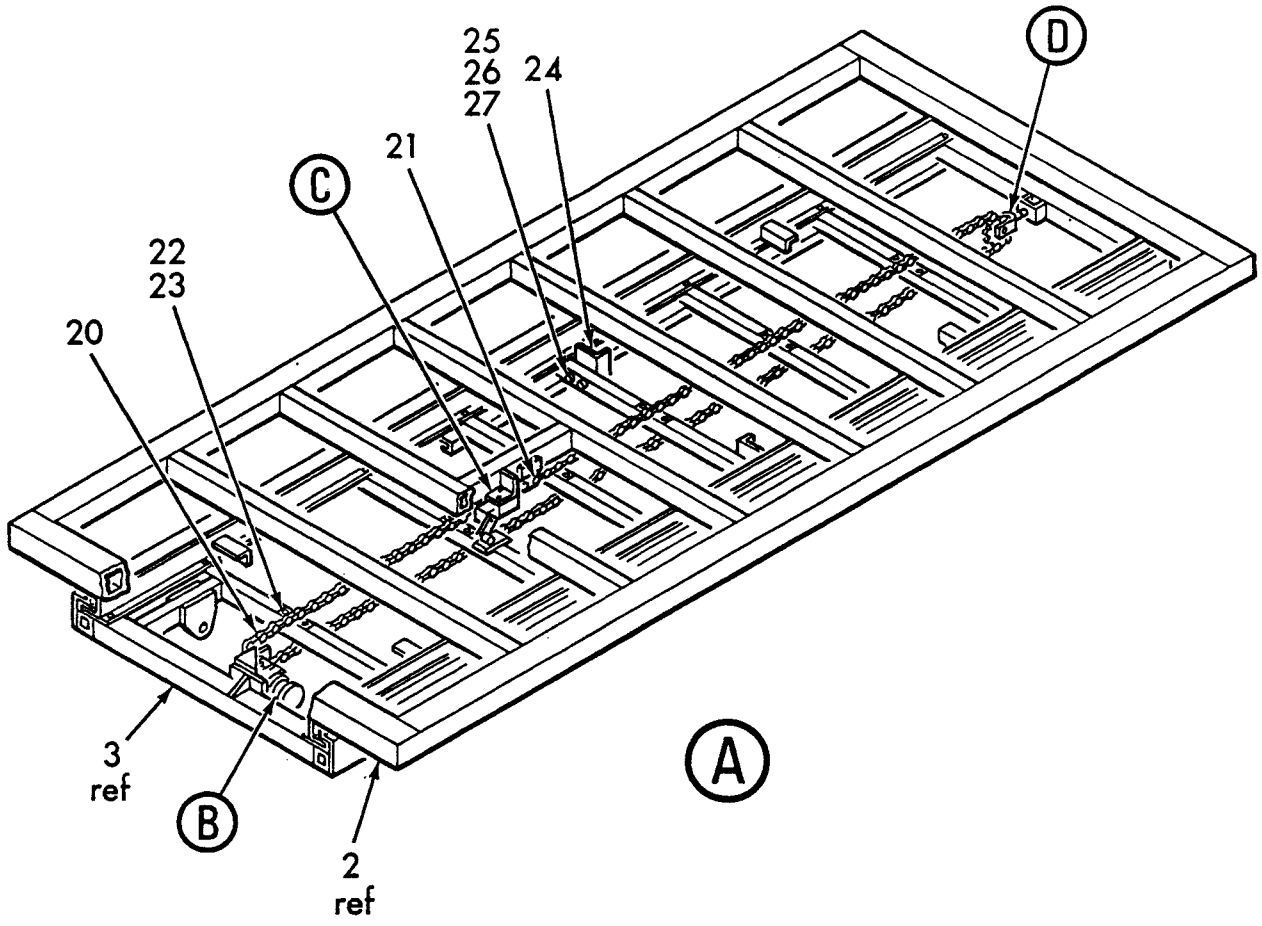
ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
26	63301	. WASHER, LOCK	4
27	60701	. NUT, HEX	4
28	130319	. WELDMENT, HYDRAULIC MOTOR BRACKET	1
29	60307	. SCREW, CAP HEX	4
30	63319	. WASHER, LOCK	4
31	60703	. NUT, HEX	4
32	130341	. ASSEMBLY, HYDRAULIC MOTOR (See Sect. 5, Fig. 3 for Details)	1
33	60326	. SCREW, CAP HEX	2
34	63305	. WASHER, LOCK	2
35	60705	. NUT, HEX	2
36	65578	. SPROCKET, STEEL 5/8 PITCH	1
37	70173	. SWITCH, LIMIT	1
38	70169	. LEVER, LIMIT SWITCH	1
39	62615	. SCREW	2
40	63313	. WASHER, LOCK	2
41	2806	. RELIEF, STRAIN	1
42	130320	. WELDMENT, CLEVIS	1
43	60705	. NUT, HEX	1
44	63305	. WASHER, LOCK	1
45	61242	. NUT, LOCK	1
46	65585	. SPROCKET, IDLER	1
47	60370	. SCREW	1
48	63415	. WASHER	1
49	61242	. NUT, LOCK	1

- ITEM NOT ILLUSTRATED

PLATFORM ASSEMBLY (M25ET)



REV.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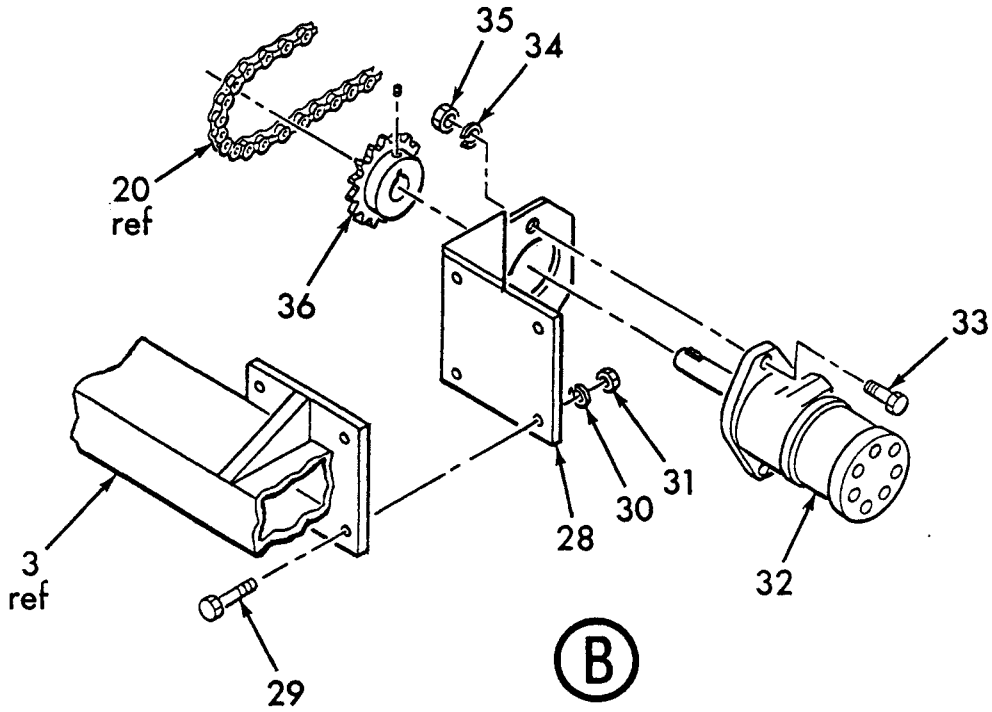
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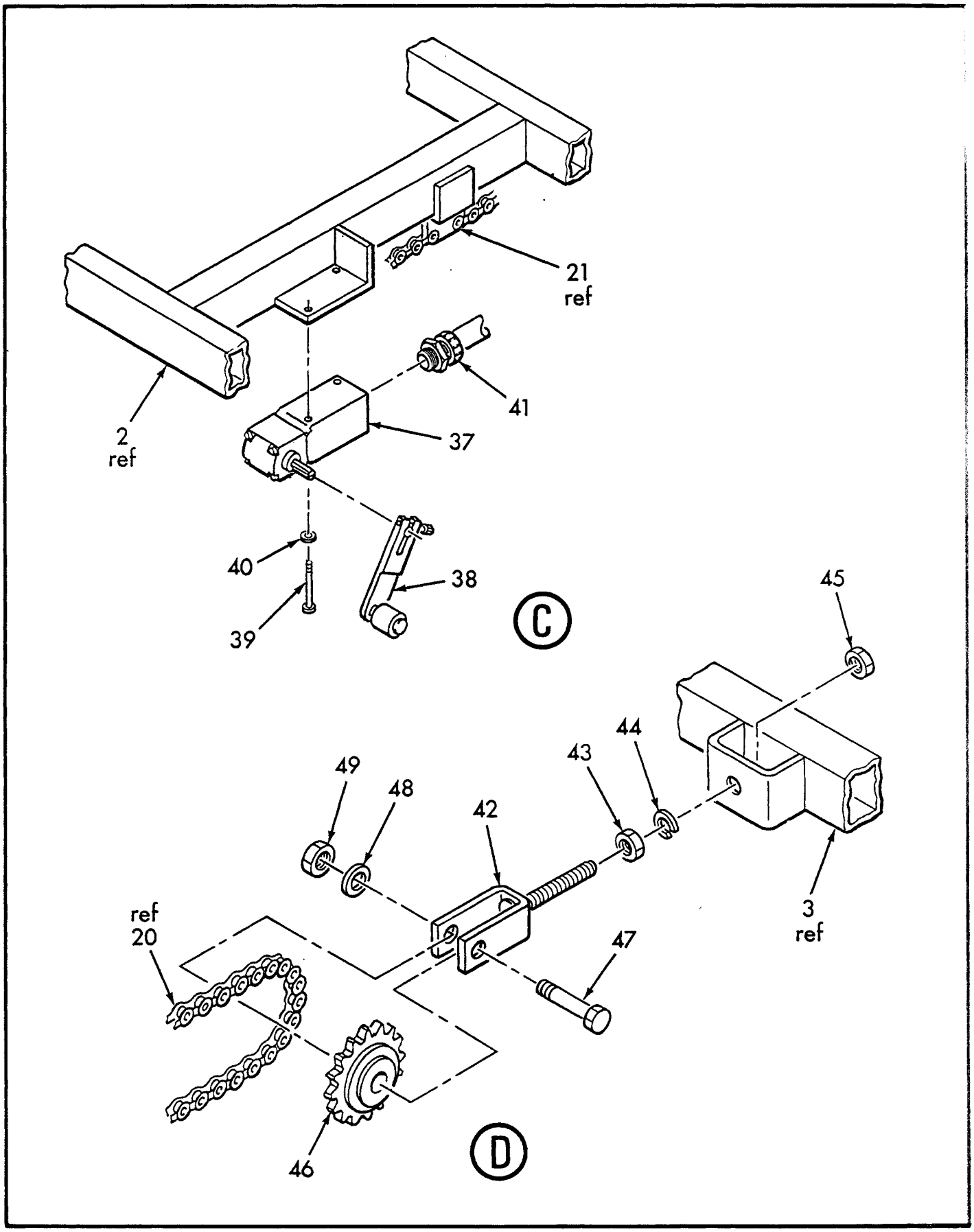
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47
46
D

PLATFORM ASSEMBLY (M25ET)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	131512	ASSEMBLY, PLATFORM (See Sect. 2, Fig. 1D for NHA)	REF
2	131514	. WELDMENT, PLATFORM	1
3	131515	. WELDMENT, TOP FRAME	1
4	131563	. PAD, WEAR	2
5	16217	. RIVET, POP	1
6	131456	. RAIL, REAR GUARD	1
7	32741	. ASSEMBLY, SLIDE BAR (See Sect. 5, Fig. 2 for Details)	1
8	131537	. PLYWOOD, PLATFORM	1
9	131536	. PLYWOOD, PLATFORM	2
10	61713	. SCREW, SELF TAPPING	24
11	131455	. RAIL, SIDE GUARD	1
12	131454	. RAIL, FRONT GUARD	1
13	131455	. RAIL, SIDE GUARD	1
14	91541	. CAP, PLUG	4
15	60337	. SCREW, CAP-HEX	8
16	61227	. NUT, LOCK	8
17	60337	. SCREW, CAP-HEX	10
18	63301	. WASHER, LOCK	10
19	60701	. NUT, HEX	10
20	160152	. CHAIN, SELF LUBRICATING	1
21	65580	. LINK, MASTER	2
22	130399	. PAD, WEAR	6
23	16217	. RIVET, POP	12
24	130371	. STOP	2
25	60318	. SCREW	4

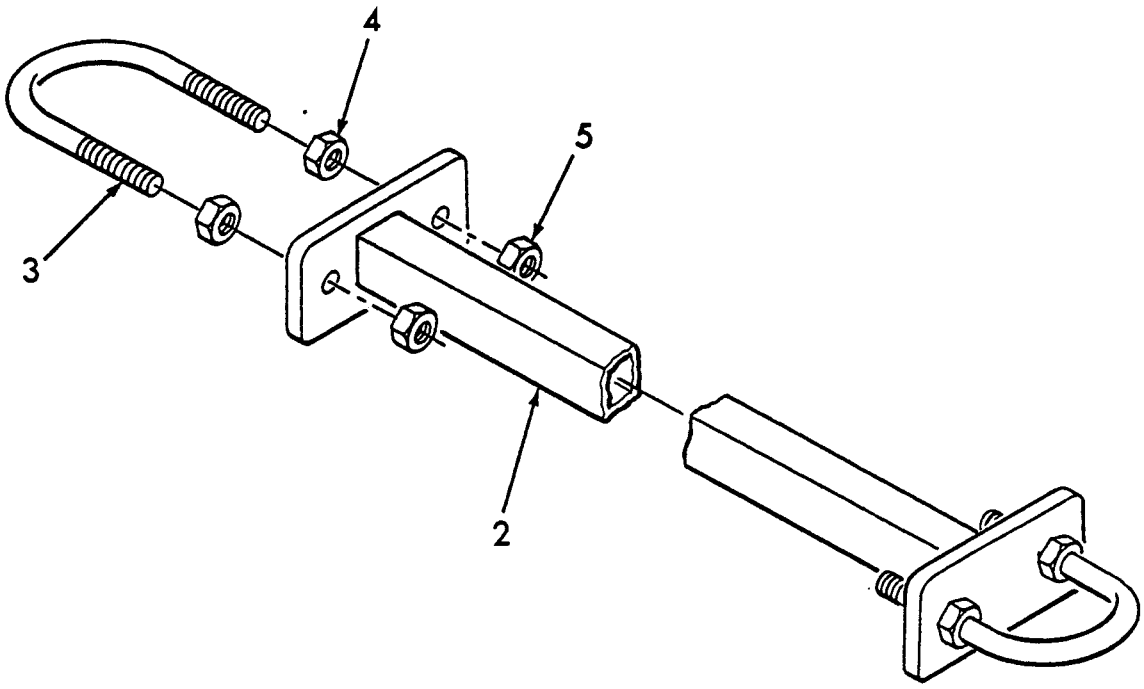
- ITEM NOT ILLUSTRATED

PLATFORM ASSEMBLY (M25ET)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
26	63301	. WASHER, LOCK	4
27	60701	. NUT, HEX	4
28	130319	. WELDMENT, HYDRAULIC MOTOR BRACKET	1
29	60307	. SCREW, CAP HEX	4
30	63319	. WASHER, LOCK	4
31	60703	. NUT, HEX	4
32	130341	. ASSEMBLY, HYDRAULIC MOTOR (See Sect. 5, Fig. 3 for Details)	1
33	60326	. SCREW, CAP HEX	2
34	63305	. WASHER, LOCK	2
35	60705	. NUT, HEX	2
36	65578	. SPROCKET, STEEL 5/8 PITCH	1
37	70173	. SWITCH, LIMIT	1
38	70169	. LEVER, LIMIT SWITCH	1
39	62615	. SCREW	2
40	63313	. WASHER, LOCK	2
41	2806	. RELIEF, STRAIN	1
42	130320	. WELDMENT, CLEVIS	1
43	60705	. NUT, HEX	1
44	63305	. WASHER, LOCK	1
45	61242	. NUT, LOCK	1
46	65585	. SPROCKET, IDLER	1
47	60370	. SCREW	1
48	63415	. WASHER	1
49	61242	. NUT, LOCK	1

- ITEM NOT ILLUSTRATED

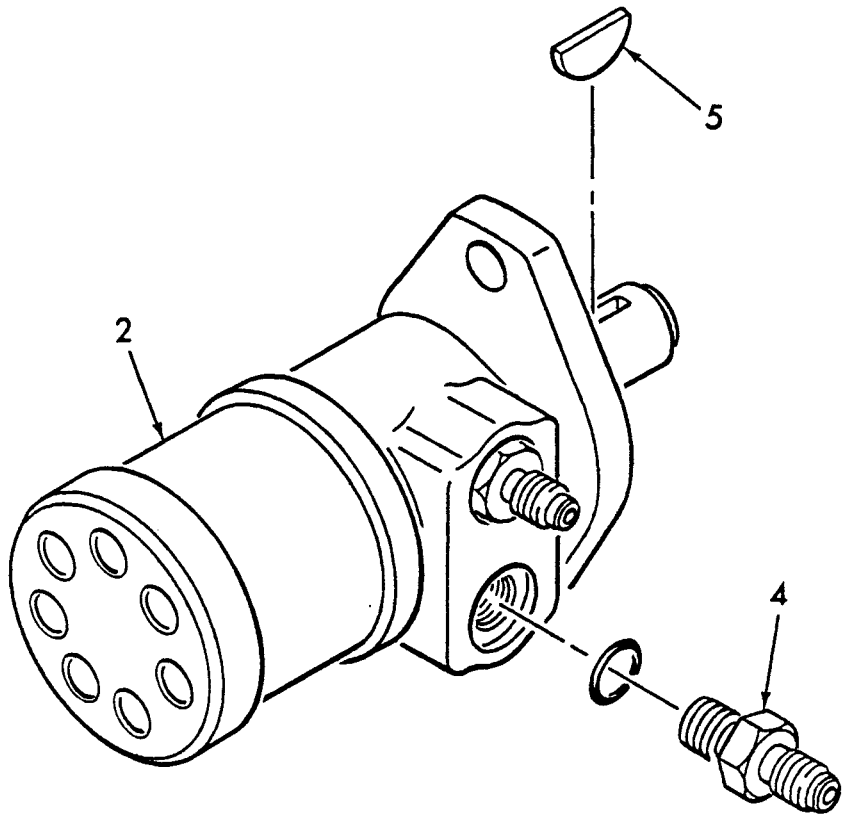
SLIDE BAR ASSEMBLY



ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	32741	ASSEMBLY, SLIDE BAR (See Sect. 5, Fig. 1 thru 1D for NHA)	REF
2	32740	. WELDMENT, SLIDE BAR	1
3	160017	. U-BOLT	2
4	60703	. NUT, HEX	4
5	61318	. NUT, LOCK HEX	4

REV.

HYDRAULIC MOTOR ASSEMBLY (M20ET & M25ET)



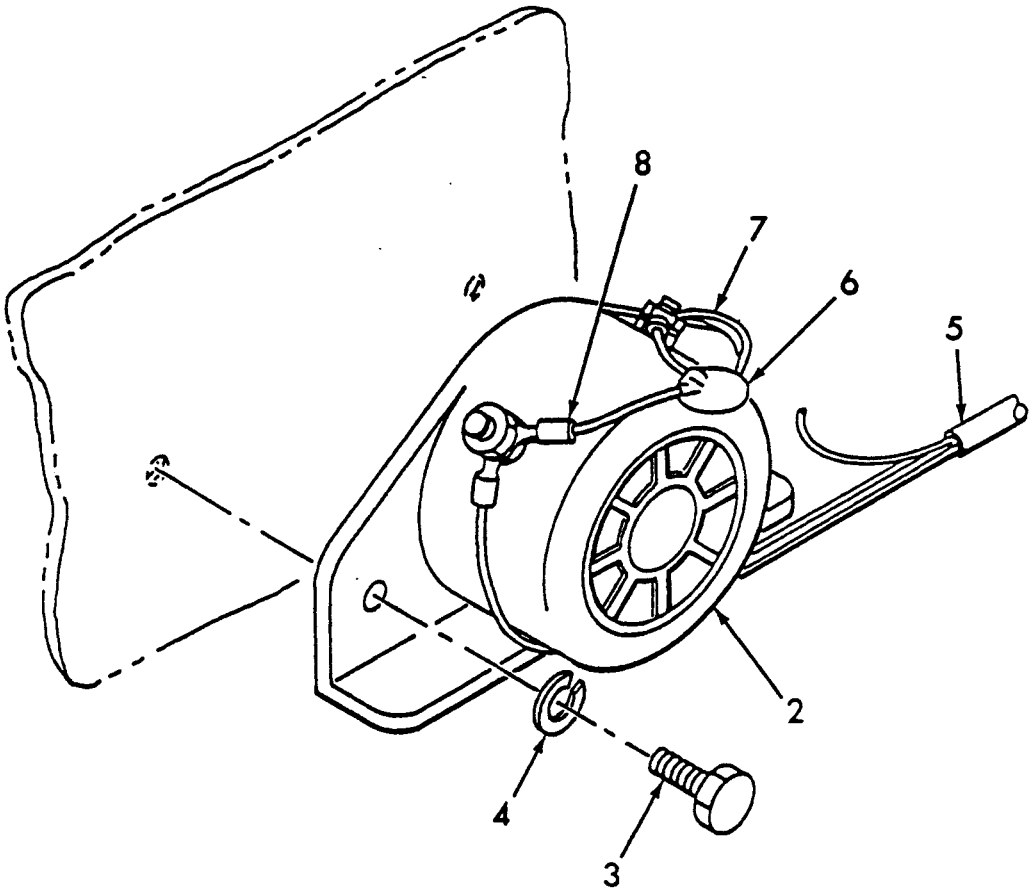
ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	130341	ASSEMBLY, HYDRAULIC MOTOR (See Sect. 5, Fig. 1C or 1D for NHA)	REF
2	81025	. MOTOR, HYDRAULIC	1
-3	66965	.. KIT, SEAL	1
4	80001-05	. CONNECTOR, MALE	2
5		. KEY, WOODRUFF (1/8 inch)	1

REV.

SECTION 6 CONTAINS:

*M20E, M25E, M20ET & M25ET

TRAVEL WARNING HORN ASSEMBLY

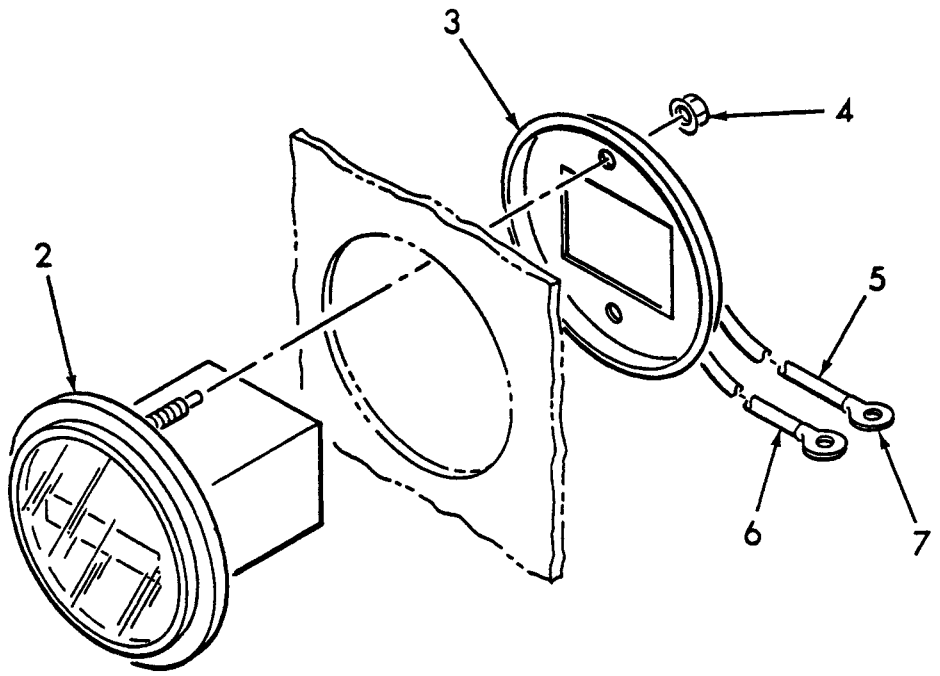


ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	131901	ASSEMBLY, TRAVEL WARNING HORN	REF
2	70053	. HORN, WARNING	1
3	60309	. SCREW, CAP	2
4	63301	. WASHER, LOCK	2
5	16201	. WIRE	3 FT
6	130705	. VARISTOR	1
7	70007	. WIRE, YELLOW	6 IN
8	117-C	. CONNECTOR, RING	10

REV.

Drawing for **Mark Industries**
Part No. 131900 was not
available this edition

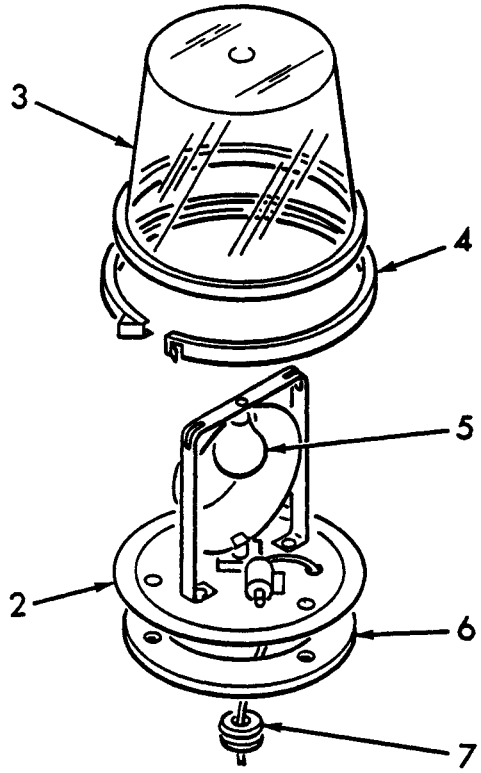
HOURMETER ASSEMBLY



ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	131065	ASSEMBLY, HOURMETER	REF
2	20571	. HOURMETER	1
3		. COVER, BACK	1
4		. NUT, LOCK	2
5	70232	. WIRE, WHITE	1.5 FT
6	70008	. WIRE, YELLOW/GREEN	1.5 FT
7	117-C	. RING, CONNECTOR	2

REV.

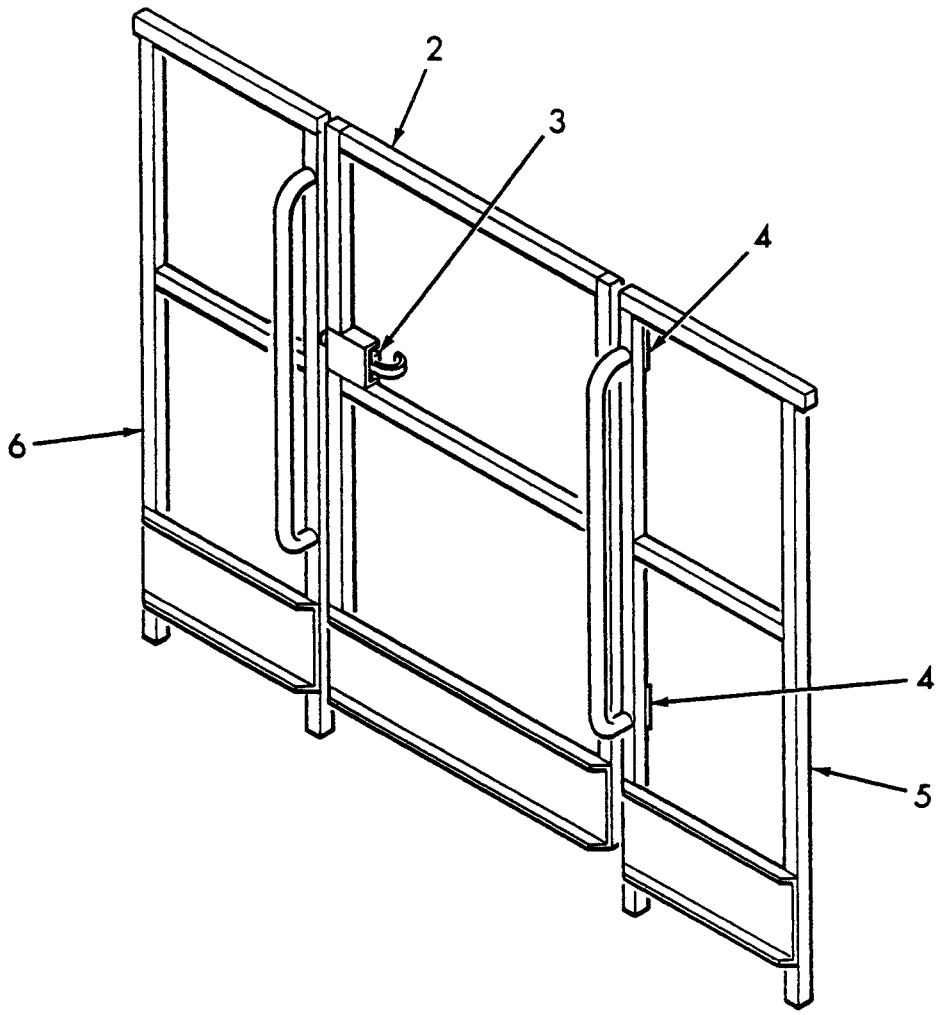
ROTATING AMBER BEACON ASSEMBLY



ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	130921	ASSEMBLY, ROTATING AMBER BEACON	REF
2		. BODY	1
3		. BULB	1
4		. CLAMP	1
5		. CAP	1
6		. GASKET	1
7	729	. GROMMET	1

REV.

SWING GATE ASSEMBLY



ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	131988	ASSEMBLY, SWING GATE	REF
2	131778	. WELDMENT, SWING GATE	1
3	16231	.. BOLT, LATCH	1
4	12005	.. HINGE, SPRING	2
5	131776	. RAIL, REAR L.H. GUARD	1
6	131777	. RAIL, REAR R.H. GUARD	1

REV.

PLATFORM WORK LIGHT ASSEMBLY (12V) (M20GP)

Drawing for **Mark Industries**
Part No. 131928 was not
available this edition

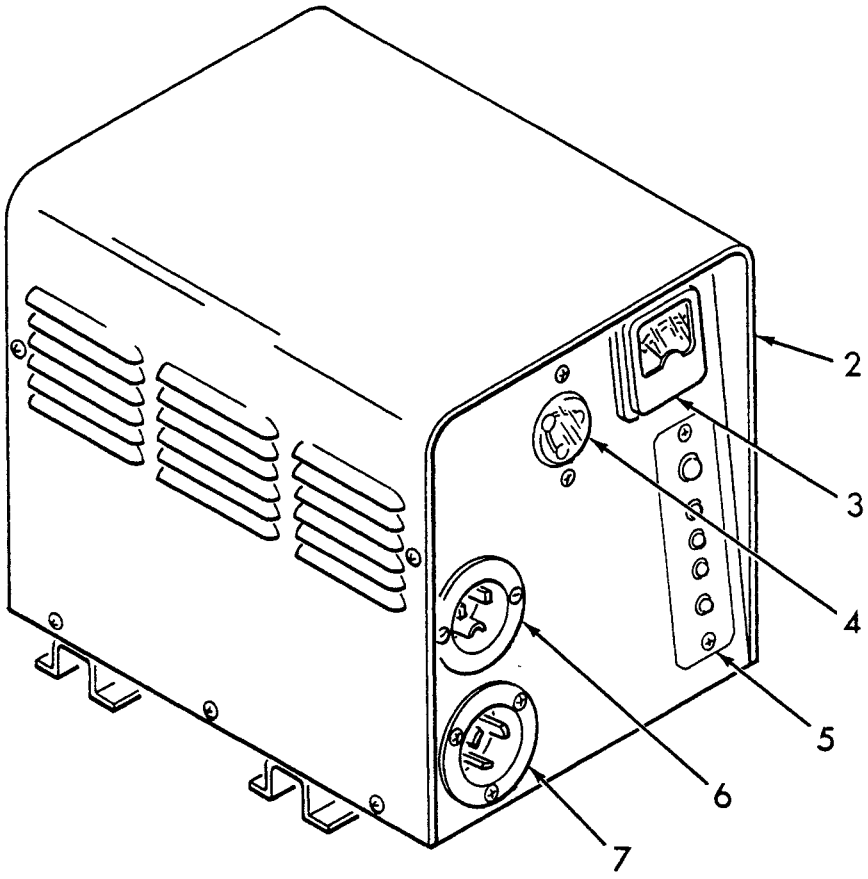
Drawing for **Mark Industries**
Part No. 132047 was not
available this edition

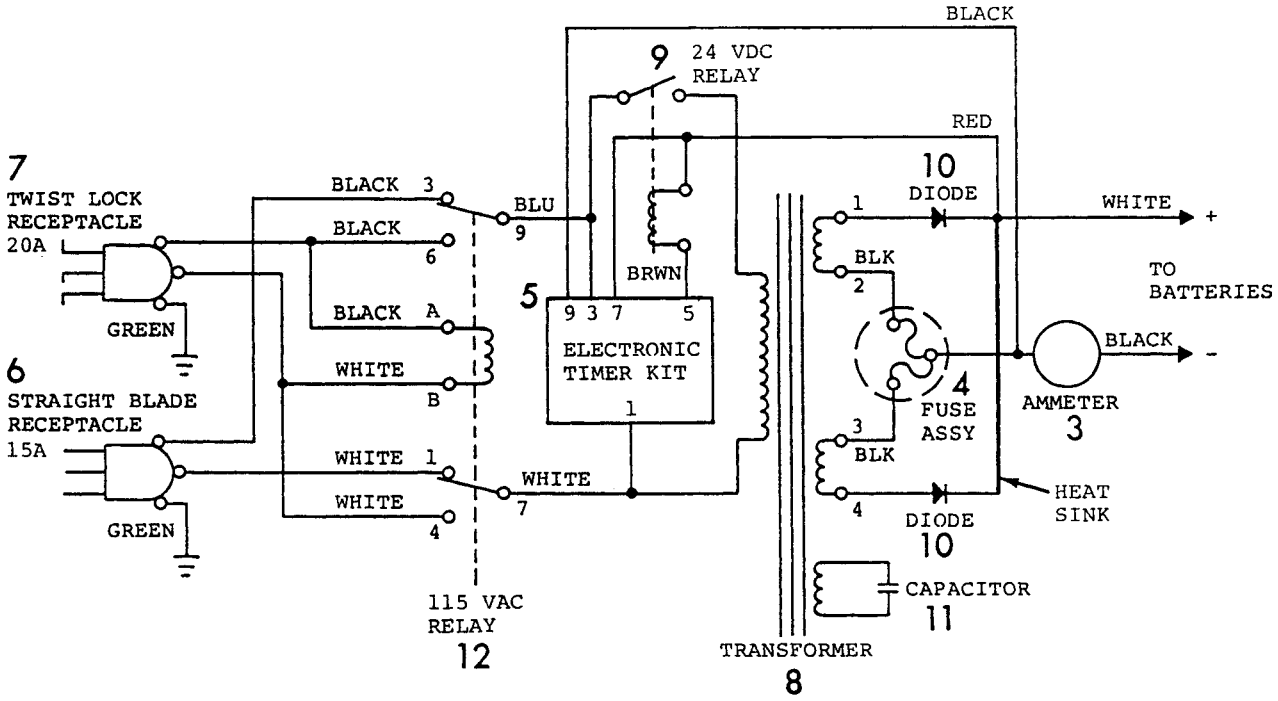
PROPORTIONAL DRIVE CONTROL ASSEMBLY
(M20GP)

Drawing for **Mark Industries**
Part No. 132040 was not
available this edition

Drawing for **Mark Industries**
Part No. 132023 was not
available this edition

AUTOMATIC BATTERY CHARGER
(M20E, M25E, M20ET & M25ET)





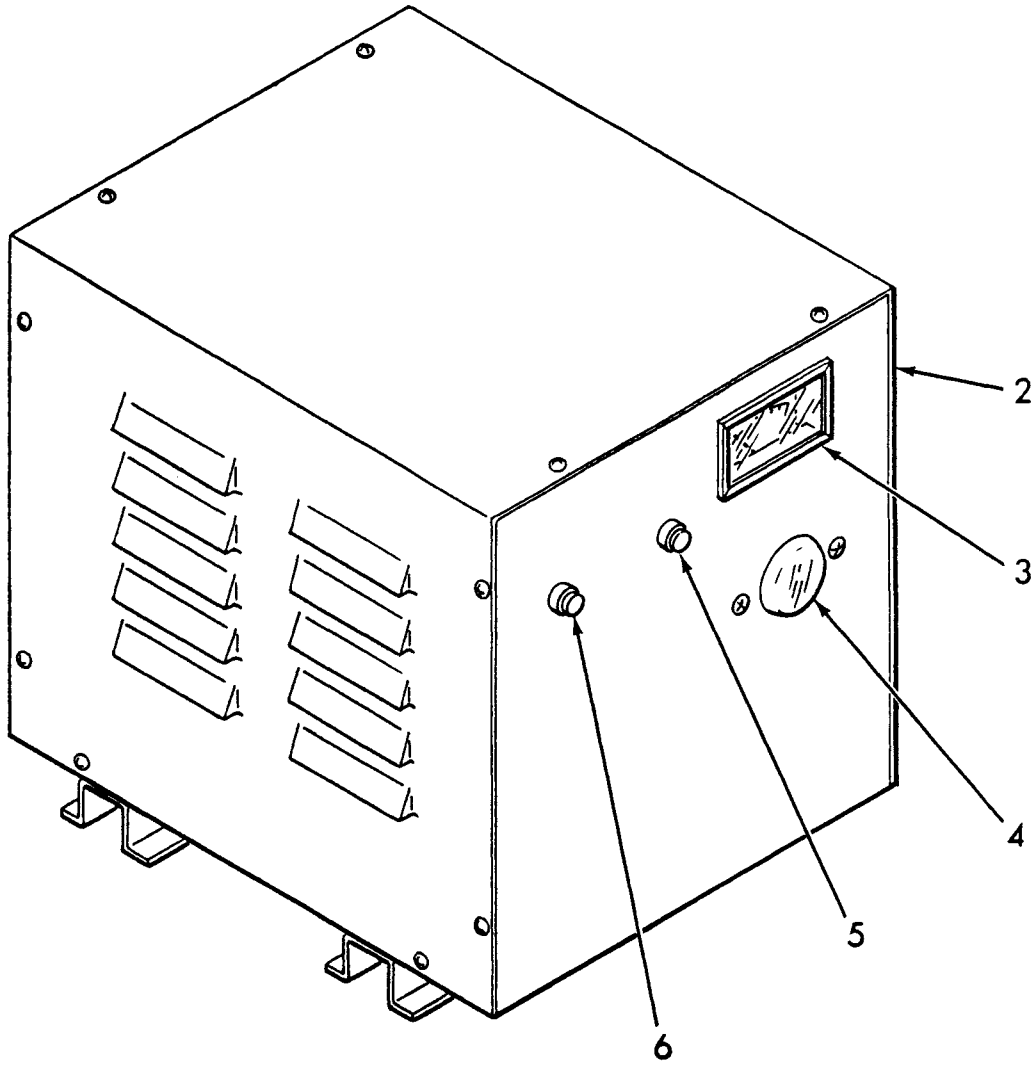
REV.

AUTOMATIC BATTERY CHARGER
(M20E, M25E, M20ET & M25ET)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	70228	CHARGER, BATTERY (115V/60 Hz, 24V/36A) (See Sect. 3, Fig. 1A thru 1D for NHA)	REF
2		. HOUSING (SILVER IN COLOR)	1
3	66747	. AMMETER	1
4	66727	. FUSE	1
5	66725	. KIT, ELECTRONIC TIMER	1
6	66734	. RECEPTACLE, STRAIGHT BLADE	1
7	66736	. RECEPTACLE, TWIST LOCK	1
8	67978	. TRANSFORMER	1
9	66729	. RELAY, 24 VDC	1
10	66731	. DIODE	2
11	66750	. CAPACITOR	1
12	66728	. RELAY, 120 VAC	1

- ITEM NOT ILLUSTRATED

BATTERY CHARGER
(M20E, M25E, M20ET & M25ET)



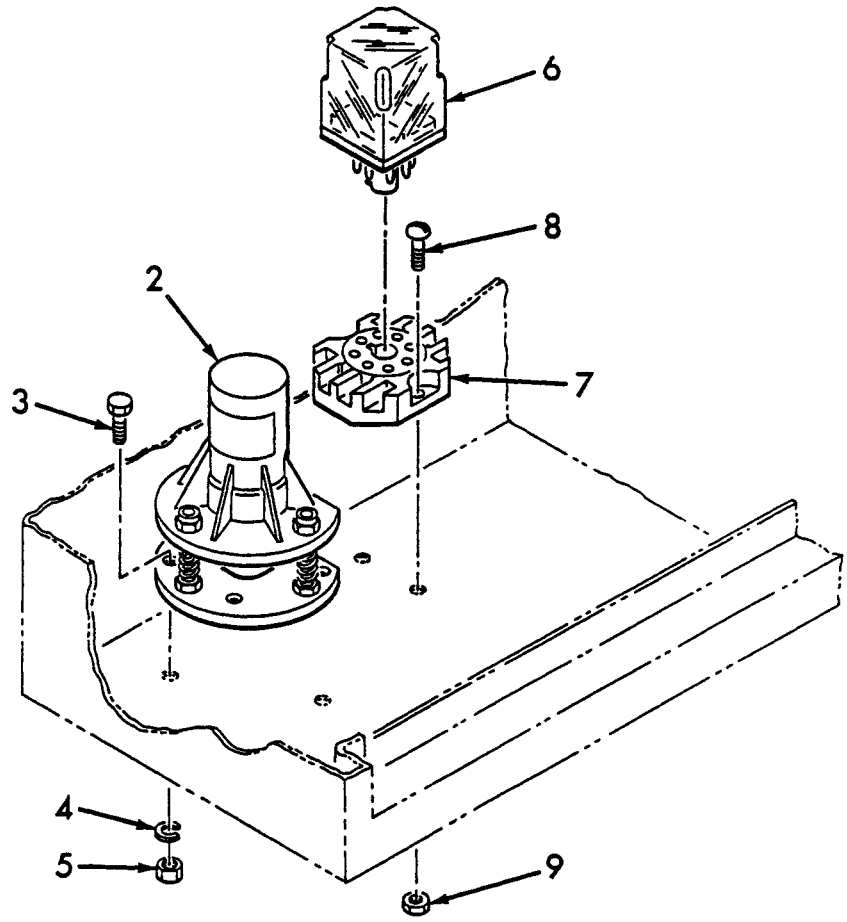
NO SCHEMATIC AVAILABLE

REV.

BATTERY CHARGER
(M20E, M25E, M20ET & M25ET)

ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	70310	CHARGER, BATTERY (230V/50 Hz, 24V/30A) (See Sect. 3, Fig. 1A thru 1D for NHA)	REF
2		. HOUSING (WHITE IN COLOR)	1
3	67968	. AMMETER (50 AMPS)	1
4	66726	. FUSE, DUAL (30 AMPS)	1
5	600014	. LED, GREEN	1
6	600015	. LED, RED	1
-7	600012	. TRANSFORMER	1
8	600013	. BOARD, CONTROLLER (TIMER)	1
9	600016	. RECTIFIER	1
10	600017	. CAPACITOR (6 MFD, 660)	1

SOLID STATE SLOPE SENSOR ASSEMBLY



ITEM	PART NUMBER	DESCRIPTION 1234567	UNIT PER ASSY.
-1	132036	ASSEMBLY, SOLID STATE SLOPE SENSOR	REF
2	31074	. SENSOR, SLOPE	1
3	60309	. SCREW, HEX	2
4	63301	. WASHER, LOCK	2
5	60701	. NUT, HEX	2
6	70238	. RELAY	1
7	70239	. SOCKET	1
8	62623	. SCREW, CAP	2
9	61532	. NUT, HEX	2

REV.

VENDOR SECTION CONTAINS:


TROJAN
The better battery
TROJAN
T-105
TROJAN
mileage master
TROJAN
T-90
TROJAN
mileage master
TROJAN
T-135
TROJAN
mileage master

REV.

THE 10 COMMANDMENTS OF GOOD BATTERY CARE

1. Add approved water only--never acid.
2. Keep electrolyte level above separator protectors.
3. Keep battery top clean and dry.
4. Keep flame and metal away from battery top.
5. Keep vent caps tightly in place.
6. Do not use battery with specific gravity below 1.120.
7. Cool before charging or operating if battery is above 115°F.
8. Charge only at proper voltage and ampere-hours.
9. Keep truck compartment and battery cover open during charging.
10. When in doubt, call your Trojan Battery service representative for long, reliable battery life.

Watering Instructions

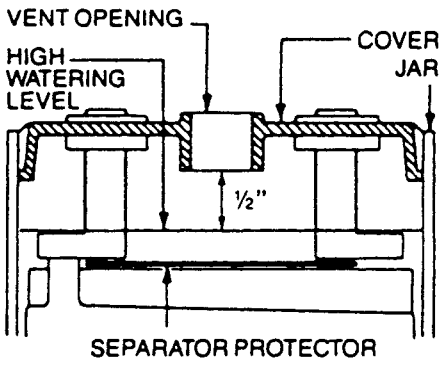
Approved Water

In most areas of the United States, tap water is satisfactory for use in lead acid batteries. The local Trojan Battery office will advise, upon request, if the public water is approved. Use distilled water when in doubt or if the public water source is not approved.

CAUTION—DO NOT OVERFILL. MOISTURE ON THE TOPS OF THE BATTERIES INDICATES OVERFILLING HAS OCCURRED.

Proper Electrolyte Level

The electrolyte level must be kept between the "High Warning Level" and the separator protectors as shown in the sketch The batteries should be filled only at the end of the charging cycle.



Installation Instructions for Motive Power Batteries

TROJAN
The better battery
Trojan Battery Company
12380 Clark Street
Santa Fe Springs, California 90670
(213) 946-8381 (714) 521-8215
Outside California (800) 423-6569

Receiving a Battery

Inspecting the Shipping Container — Immediately upon receiving a battery, inspect the outside of the corrugated container (or crate) and the pallet. Look for wet spots on the sides and bottom. Wet spots generally indicate that the battery jars are broken, or that the battery was tipped over in transit.

Making a Claim — Shipments are generally made FOB, Trojan Battery Plant stocking location. Therefore, making a claim to the carrier is the responsibility of the customer. If there is evidence that the battery was damaged in shipment, a proper claim should be filed with the carrier.

The services of a professional industrial battery repairman may be required to evaluate the extent of the damage. Contact Trojan Battery or the nearest Trojan Battery representative.

Lifting Batteries — The ideal rig for lifting batteries is an overhead hoist equipped with an adjustable, insulated battery lifting beam. When attached to the lifting "eyes" of a battery, the lifting beam exerts a vertical pull on the eyes. This method prevents damage to a battery that would occur using lifting methods that tend to squeeze or stretch the battery tray. If there is a possibility that the chain or cable of the hoist might come in contact with the battery post, cover the battery with a piece of plywood another type of non-conducting material.

Immediate Repairs to Damaged Batteries — If the electrolyte level in a particular cell drops quickly after water is added, the jar in this cell is leaking and should be replaced. When service facilities and personnel are available, replacement of the leaking jar should be made within one week of discovery. If repairs cannot be made, contact the nearest Trojan Battery Sales or Service Location for other arrangements.

Treatment for Repaired Cells — After the element is installed in a new jar, fill the jar with electrolyte of the same specific gravity as the rest of the cells in the battery. Charge the battery at the finishing rate until the battery specific gravity stops rising.

Placing a Wet Battery in Service

After determining that a battery was not damaged in shipment, give it a freshening charge of three to six hours, then install the battery.

Installing the Battery

The battery compartment of the vehicle must be well ventilated to allow the heat generated by the battery during discharge to dissipate. The battery compartment should also have drain openings in the floor. Most vehicle manufacturers are aware of both these needs and have provided the necessary louvers, slots and/or holes in the battery compartment. If the battery is to be installed in a metal compartment, make sure the compartment is clean and dry prior to installation.

Seat the battery in the compartment firmly and evenly. Then block it in position. Many vehicles have adjustable clips for blocking the battery into place. Allow ¼" to ½" clearance between the block (or clip) and the battery tray. Do not wedge the battery into the compartment because some room is needed for expansion.

All vent caps must be in place. Uncapped cells will allow the electrolyte to splash and cause corrosion to the tray and vehicle.

NOTICE

The electrolyte level has been adjusted and checked at the factory prior to shipment. During shipment and storage the electrolyte level may vary.

To maintain the electrolyte level for proper operating efficiency and life, *do not* add water until the battery has been given a freshening charge.

For proper future maintenance, water should only be replaced at the end of charge.

Printed in U S A

1. NEW BATTERY RECEIVAL AND INSTALLATION

1. **Always** inspect incoming shipments of batteries for damage.

   Look for and pay particular attention for damage to or wet spots on the shipping cartons, examine those batteries for signs of breakage.

2. If damaged batteries are found secure acknowledgment of the damage from the carrier's representative and file a claim against the transportation company. Contact your supplier for battery replacement.

3. If batteries are received wet and **not** immediately placed in service, they must be charged at regular intervals as follows:

Storage Temperature	Charge
Below 40° F	None required
40° F to 60° F	Every 2 months
60° F and above	Once a month

4. Never stack one battery directly on top of another. Post damage and/or container damage can occur from improper stacking. If batteries are stored individually, place supporting boards between layers. **Do not** stack layers more than three (3) high and rotate stock so that the oldest batteries can be used first.

5. Dry charge batteries should be activated in accordance with instructions of the battery manufacturer.

6. Batteries should be installed in accordance with the vehicle manufacturer's instructions. Connections should be made tight enabling good contact between connector lugs and battery terminals. Always charge sets of batteries immediately after installation into the car.

2. MAINTENANCE- INSPECTION PROCEDURES

1. **Water batteries at least once a week.**

   a. Add only approved water to the cells. Distilled water is recommended, high mineral content water must not be used. Maximum allowable impurities in percent-iron (.003), chloride (.004), fixed residue (.075).

   b. Remove vent caps and water batteries preferable after charging to prevent over flow of acid due to expansion.

   c. Fill all cells to the proper level. **Do not overfill cells.** Fill to level indicator or 1/2 inch over the top of the separators if there is no level indicator. Do not use a hose to water batteries.

   d. Spot check cells between weekly waterings to assure electrolyte is above separators. Excess water usage indicates the presence of any one or all of the following conditions which should be checked.

      1. Overcharging
      2. High temperature operation
      3. Nearing end of service life

   e. **Do not allow the electrolyte level to drop** below the top of the separators since this will lead to shortened battery life.

2. **Clean batteries after weekly watering or when washing cars.**

   a. Wash the tops of the batteries making sure the vent caps are in place. Do not allow water or other foreign matter to enter the cells.

   b. Use a solution of bicarbonate of soda and water to wash batteries if there is an accumulation of acid.

3. **Inspection** to insure good conditions which will give better battery service.

   a. When watering batteries inspect battery and other terminal connections for:

      1. **Corrosion** -- If any exists, clean connection and apply a non-metallic grease or protective spray to retard further corrosion.

      2. **Loose Connections** -- Be sure all connections are tight and that good contact is made between terminals.

3. **Broken or Frayed Cables** -- Be sure all cable connections are good and that no loose or broken wires are exposed. Replace any which look suspicious.

b. Once a week after the batteries have been charged, spot check two (2) or more cells for specific gravity reading. Gravity should be 1.250-1.280. If low readings are noted:

1. Check charger to insure that proper charge is being returned to the batteries.

2. Check connections as specified under **inspection 3a.**

3. Check all cells to determine if batteries are near the end of life. This should be done to the same procedure as called for under **Section IV** covering **"Troubleshooting" of batteries.**

c. On a regular interval, check car as outlined in the instruction manual for:

1. Brake drag
2. Proper tire pressure
3. Proper alignment
4. Proper lubrication
5. Proper operation of electrical system
6. Proper operation of drive and transmission system
7. Condition of charger plug and receptacle in car

Any of these conditions which are detrimental to car operation will shorten battery life.

3. CHARGING PROCEDURE

1. Become familiar with instructions issued with the charger car manual.

2. Batteries are to be charged after each day's use as soon as play has been completed. Charging between rounds is permissible if it is determined feasible to do so.

3. **Do not charge batteries** if car was not used that day.

4. **Do not allow batteries to sit in discharged condition** for prolonged periods of time.

5. **Always be sure batteries are fully charged** each day prior to starting play.

4. TROUBLE SHOOTING FOR WEAK OR BAD BATTERIES

When a car fails to operate properly performing less than one round of gold, the car is to be brought into the shop and the batteries examined as follows:

1. Check terminal connections for corrosion, loose connections and broken or frayed cables.

2. If terminal connections appear to be in good condition, check all cells with a hydrometer for variation in specific gravity among cells. A variation of .030 points or more between cells of a battery is cause for suspect. Mark the low cells.

3. Recharge the batteries as recommended by the manufacturer.

4. Read all gravities again after recharge. Be sure that batteries are fully charged at gravities of 1.250 to 1.280. If cells vary by .030 points or more it is an indication of possible trouble within that battery.

5. Connect a load tester to the set of batteries and discharge the batteries at 75 Amps and record the time to a terminal voltage of 31.5 volts. Testers are now available having an automatic Shut-Off at this voltage. New batteries should run a minimum of 75 minutes on this test.

    a. If the batteries run less than 40 minutes they have either reached the end of life or a defective battery is in the circuit. Battery replacement is then necessary.

    b. If batteries run 40-50 minutes they have lost capacity and may be nearing the end of their useful life. In golf car service one round of golf may be expected on an average golf course.

    c. If batteries run more than 50 minutes, they are in good condition and satisfactory for continued service. Prior to putting the car back in serviced it should be checked for the existence of other trouble as outlined in the instruction manual.

5. BATTERY REPLACEMENT

Defective Batteries (Premature Failures)

1. Defective battery can be determined either by observation of gravity variance at the end of the 75 Amp discharge (.030 or more points between cells of a battery) or by turning the discharge tester back on and determining the battery or cell which is defective by use of a voltmeter.
2. Mark the defective battery.
3. Recharge the batteries with the defective battery in the circuit.
4. Remove the defective battery and replace with new battery or battery of comparable age which is fully charged.

Worn Out Batteries

1. Remove old set of batteries.
2. Clean and recondition battery trays, holddowns and cables.
3. Inspect new batteries for broken containers and proper electrolyte level before installing in the car.
4. Install batteries in car being sure that they are properly held down, firm but not too tight.
5. Replace cables, being sure terminals and connectors are clean and connections are tight.
6. Apply a light coating of non-metallic grease or protective coating.

6. WINTER STORAGE OF WET BATTERIES

1. Prior to storing car, batteries should be cleaned, fully charged and properly leveled.

2. While in storage the batteries should be recharged to full charge at time intervals shown below:

Storage Temperature	Charge
Below 40° F	None required
40° F to 60° F	Every 2 months
60° F and above	Once a month

3. Check batteries after car has been removed from storage and before service begins. Follow **inspection and troubleshooting procedures** to determine the condition of the batteries.

A PRIMER ON THE LEAD-ACID BATTERY

1. **Q.** WHAT IS A STORAGE BATTERY?

   A. A reservoir which may be used repeatedly for storing energy. Energy is put into it and removed from it in the form of electricity, but it is stored as chemical energy.

2. **Q.** WHAT ARE AMPERES?

   A. Units of quantity of electric current. The current forced through a resistance of one ohm by a pressure of one volt is one ampere.

3. **Q.** WHAT ARE VOLTS?

   A. Units of force or pressure of electric current. In an industrial truck, running speed, lifting speed and controller operations are dependent upon battery voltage. The voltage of a battery depends on the number of cells. Each lead-acid cell has 2 volts; a 6-cell battery has 12 volts and an 18-cell battery has 36 volts.

4. **Q.** WHAT ARE WATTS?

   A. The product of volts times amps. (Volume of electric current times pressure of electric current.) The total power is measured in watts.

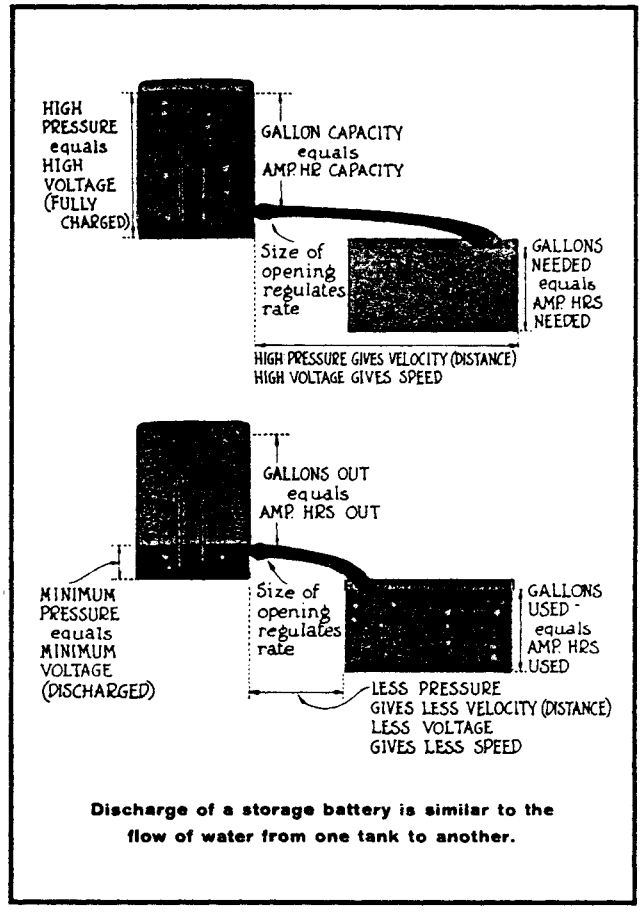
5. **Q.** WHAT IS AMPERE HOUR (A.H.) CAPACITY?

   A. Product of amps multiplied by time. It refers to the volume of electricity that can be drawn from a battery. Other things being equal*, higher ampere hour capacity batteries will run a truck longer than those with lower ampere hour capacities. A.H. capacity of a battery depends on the number and design of plates per cell.

   *"Other things" refers to number of cells in battery, truck resistance, truck motor, rate of discharge, etc.

6. **Q.** WHAT IS KILOWATT HOUR (K.W.H.) CAPACITY?

   A. A kilowatt is 1,000 watts. The kilowatt hour capacity is the total amount of power (volts x amps x hours divided by 1,000) that can be drawn from a battery. It is the watt or kilowatt which does the work—not amps alone.



Discharge of a storage battery is similar to the flow of water from one tank to another.

7. **Q.** HOW ARE BATTERIES RATED?

   A. Lead-acid batteries are rated at the six hour rate. For example: a 16 cell, 19 plate lead-acid battery will deliver a total of 765 ampere hours if it is discharged at a continuous rate of 127.5 amperes per hour for six hours.

8. **Q.** WHAT IS ELECTROLYTE?

   A. In lead-acid batteries, it is a mixture of sulfuric acid and water. The operation of the batteries is affected by the specific gravity, quantity, purity, etc. of the electrolyte within the cell.

9. **Q.** WHAT IS MEANT BY "SPECIFIC GRAVITY" OF BATTERY ELECTROLYTE?

   A. It is the weight of the sulfuric acid-water mixture compared to an equal volume of water. Pure water has a specific gravity of 1.000.

10. **Q.** WHAT EFFECT DOES MAXIMUM SPECIFIC GRAVITY HAVE ON A BATTERY?

    A. Experience has proved that the optimum specific gravity of a new lead-acid industrial truck battery is 1.265-1.285. If the maximum gravity of a new battery is higher than that, slightly more ampere hour capacity will result but battery life will be shortened.

11. **Q.** WHAT IS MEANT BY BATTERY LIFE?

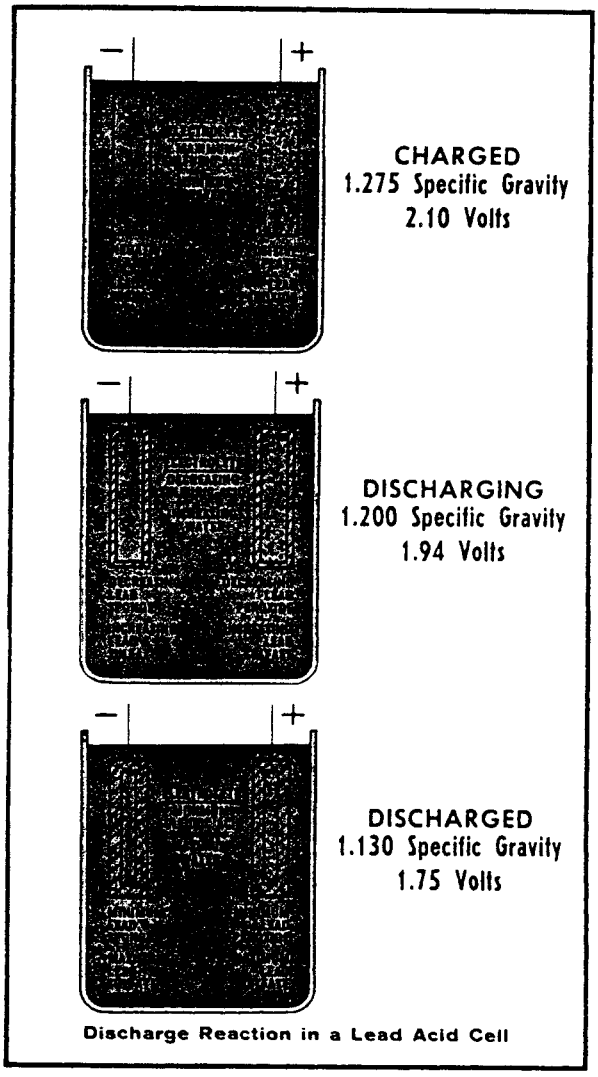
    A. Battery life normally refers to the number of times that a battery can be charged and discharged before it is no longer able to do a required day's work. One complete charge and one complete discharge is called a cycle. The number of complete cycles a battery will give depends on: 1) construction of the battery, 2) charging procedure, 3) maintenance, 4) operation.

12. **Q.** HOW DOES SPECIFIC GRAVITY VARY WITH DISCHARGE?

    A. This normal range of a lead-acid battery from full charge to full discharge is from 1.275 to 1.130. By the time the specific gravity gets down to 1.130 the rated capacity is usually out of the battery and a maximum amount of acid has combined with the active material on the plates. If discharge is frequently continued below the 1.130 point, battery life will be shortened.

13. **Q.** DOES VOLTAGE (FORCE OR PRESSURE) VARY AS THE BATTERY IS DISCHARGED?

    A. Yes, voltage drops as specific gravity of the electrolyte drops. A full charged lead-acid battery with a specific gravity of 1.275 has an average initial discharge cell voltage of 2.03 volts. It is considered to be fully discharged when the average cell voltage is 1.75. Since truck speed is dependent on battery voltage, the truck will go approximately 14% slower at the end of discharge than it did at beginning of discharge. This difference cannot be detected in the average operation.



Discharge Reaction in a Lead Acid Cell

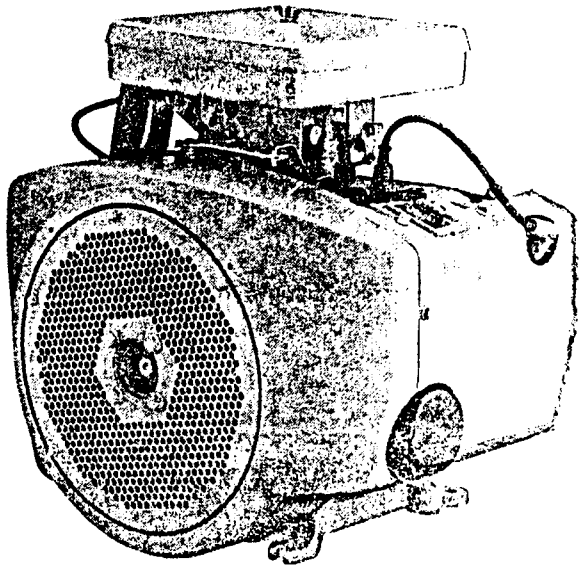
14. **Q.** HOW DOES THE ELECTRICAL SIZE (K.W.H.) OF THE BATTERY AFFECT INDUSTRIAL TRUCK OPERATION?

    A. The work that can be done by an industrial truck is proportional to the total kilowatt hour capacity of the battery. A 16-cell, 19-plate lead-acid battery has a 23.57 kilowatt hour capacity. It will do approximately the same total amount of work as an 18-cell, 17-plate battery which is rated at 23.56 kilowatt hours, *if it is used in the same truck.*

Lead Industries Association
292 Madison Ave.
New York, New York 10017

Operators Manual

P216
P218
P220
Engine



Safety Precautions

It is recommended that you read your engine manual and become thoroughly acquainted with your equipment before you start the engine.

⚠DANGER ***This symbol if used warns of immediate hazards which will result in severe personal injury or death.***

⚠WARNING ***This symbol refers to a hazard or unsafe practice which can result in severe personal injury or death.***

⚠CAUTION ***This symbol refers to a hazard or unsafe practice which can result in personal injury or product or property damage.***

Fuels, electrical equipment, batteries, exhaust gases and moving parts present potential hazards that can result in serious, personal injury. Take care in following these recommended procedures. All local, state and federal codes should be consulted and complied with.

⚠WARNING ***This engine is not designed or intended for use in any type of aircraft. Use of this engine in aircraft can result in engine failure and causes serious personal injury or death.***

General

- Provide appropriate fire extinguishers and install them in convenient locations. Use an extinguisher rated ABC by NFPA.
- Make sure that all fasteners on the engine are secure and accurately torqued. Keep guards in position over fans, driving belts, etc.
- If it is necessary to make adjustments while the engine is running, use extreme caution when close to hot exhausts, moving parts, etc.

Protect Against Moving Parts

- Do not wear loose clothing in the vicinity of moving parts, such as PTO shafts, flywheels, blowers, couplings, fans, belts, etc.
- Keep your hands away from moving parts.

Batteries

- Before starting work on the engine, disconnect batteries to prevent inadvertent starting of the engine.
- DO NOT SMOKE while servicing batteries. Lead acid batteries give off a highly explosive hydrogen gas which can be ignited by flame, electrical arcing or by smoking.
- Verify battery polarity before connecting battery cables. Connect negative cable last.

Fuel System

- DO NOT fill fuel tanks while engine is running.
- DO NOT smoke or use an open flame in the vicinity of the engine or fuel tank. Internal combustion engine fuels are highly flammable.
- Fuel lines must be of steel piping, adequately secured, and free from leaks. Piping at the engine should be approved flexible line. Do not use copper piping for flexible lines as copper will work harden and become brittle enough to break.
- Be sure all fuel supplies have a positive shutoff valve.

Exhaust System

- Exhaust products of any internal combustion engine are toxic and can cause injury, or death if inhaled. All engine applications, especially those within a confined area, should be equipped with an exhaust system to discharge gases to the outside atmosphere.
- Do not use exhaust gases to heat a compartment.
- Make sure that your exhaust system is free of leaks. Ensure that exhaust manifolds are secure and are not warped by bolts unevenly torqued.

Exhaust Gas is Deadly!

Exhaust gases contain carbon monoxide, a poisonous gas that can cause unconsciousness and death. It is an odorless and colorless gas formed during combustion of hydrocarbon fuels. Symptoms of carbon monoxide poisoning are:

- Dizziness
- Headache
- Weakness and Sleepiness
- Vomiting
- Muscular Twitching
- Throbbing in Temples

If you experience any of these symptoms, get out into fresh air immediately, shut down the unit and do not use until it has been inspected.

The best protection against carbon monoxide inhalation is proper installation and regular, frequent inspections of the complete exhaust system. If you notice a change in the sound or appearance of exhaust system, shut the unit down immediately and have it inspected and repaired at once by a competent mechanic.

Cooling System

- Coolants under pressure have a higher boiling point than water. DO NOT open a radiator pressure cap when coolant temperature is above 212°F (100°C) or while engine is running.

Keep the Unit and Surrounding Area Clean

- Make sure that oily rags are not left on or near the engine.
- Remove all unnecessary grease and oil from the unit. Accumulated grease and oil can cause overheating and subsequent engine damage and present a potential fire hazard.

Table of Contents

⚠WARNING

INCORRECT SERVICE OR REPLACEMENT OF PARTS CAN RESULT IN SEVERE PERSONAL INJURY AND/OR EQUIPMENT DAMAGE. SERVICE PERSONNEL MUST BE QUALIFIED TO PERFORM ELECTRICAL AND/OR MECHANICAL SERVICE.

Introduction

KNOW YOUR ENGINE

Read this manual carefully, observing all *WARNINGS* and *CAUTIONS*. Operating instructions, adjustments and periodic maintenance procedures are given so you . . . the owner, can keep your unit running like new and expect many years of dependable service from it. Remember . . . any machine, regardless of design or type, will perform only in relation to the service it receives. Regularly scheduled maintenance lowers operating costs.

ENGINE MODEL REFERENCE

Identify your model by referring to the *MODEL* and *SPEC* (specification) *NO.* as shown on the unit nameplate. Always use this number and the engine serial number when making reference to your engine.

If a major repair or an overhaul is necessary, Onan recommends that a competent mechanic either do the job or supervise and check the work of the mechanic assigned to do the job to ensure that all dimensions, clearances and torque values are within the specified tolerances.

An engine service manual and complete parts catalog are available at additional cost. Contact your nearest authorized dealer or Onan Parts and Service Center.

These instructions contain the SI metric equivalents following immediately in parentheses after the U.S. customary units of measure.

SPECIFICATIONS

SPECIFICATION	UNIT OF MEASURE	SERIES P216	SERIES P218	SERIES P220
Number of Cylinders		2	2	2
Bore	in (mm)	3.250 (82.55)	3.250 (82.55)	3.250 (82.55)
Stroke	in (mm)	2.620 (66)	2.875 (73)	2.875 (73)
Displacement	cu in (cm^3)	43.3 (710)	47.7 (782)	47.7 (782)
Compression Ratio		6.5 to 1	7.0 to 1	7.0 to 1
Power at Rated Speed (3600 rpm)	BHP (kW)	16 (11.9)	18 (13.4)	20 (14.9)
Oil Filter		Full Flow	Full Flow	Full Flow
Oil Capacity Without Filter	Qts (litre)	1.5 (1.4)	1.5 (1.4)	1.5 (1.4)
Oil Capacity With Filter Change	Qts (litre)	1.7 (1.6)	1.7 (1.6)	1.7 (1.6)
Valve Clearance (Cold)				
Intake	in (mm)	.005 (.13)	.005 (.13)	.005 (.13)
Exhaust	in (mm)	.013 (.33)	.013 (.33)	.013 (.33)
Spark Plug Gap	in (mm)	.030 (.76)	.030 (.76)	.030 (.76)
Ignition Timing	BTC	20°	20°	20°

Engine Set-Up

Inspect the engine visually. Check for loose or missing parts and any damage that may have occurred in shipment.

⚠CAUTION ***Oil and fuel have been drained from the engine prior to shipping from Onan. Severe engine damage will result if engine is started without oil.***

BATTERIES

The batteries and battery cables used for starting the engine should be of sufficient size to provide prompt starting. Undersized batteries will result in poor starter operation and a very short starter service life.

⚠WARNING ***Ignition of explosive battery gases can cause severe personal injury. Do not smoke while servicing batteries.***

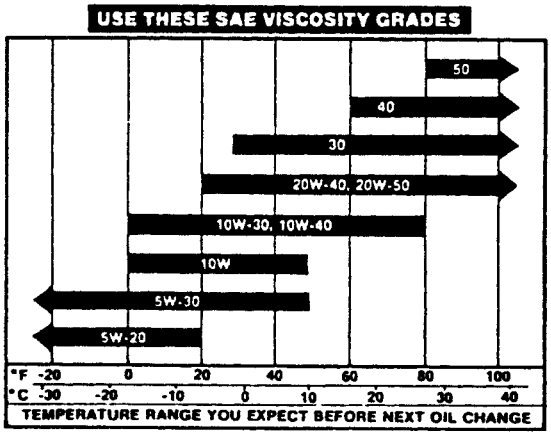
⚠CAUTION ***This engine uses a 12 volt, negative ground system. Alternator must be connected to battery at all times when engine is running. Reversing positive and negative battery will damage the engine electrical system.***

CRANKCASE OIL RECOMMENDATIONS

Fill crankcase with correct amount of oil. Refer to *SPECIFICATIONS* for crankcase capacity. Use oils meeting the American Petroleum Institute (API) classification SF or SF/CC.

⚠WARNING ***Crankcase pressure can blow out hot oil and cause serious burns. Do NOT check oil while the engine is operating.***

⚠CAUTION ***Do not overfill crankcase. Excess oil causes high oil consumption and oil accumulation in air cleaner housing.***



Oil Level

Check oil level at least every 8 hours of operation. Check more frequently on a new or reconditioned engine as oil consumption is higher until the piston rings seat properly.

When adding oil between oil changes, it is preferable to use the same brand, as various brands of oil may not be compatible together. Refer to *MAINTENANCE* section for recommended oil change intervals and procedures.

FUEL RECOMMENDATIONS

⚠WARNING ***Ignition of fuel can cause serious personal injury or death by fire or explosion. Do not permit any flame, cigarette, or other igniter near the fuel system.***

Use clean, fresh, unleaded gasoline. Regular leaded gasoline may also be used but is not a preferred fuel. Do not use highly leaded premium gasoline. Use of unleaded gasoline results in less maintenance.

⚠CAUTION ***Do not use gasoline de-icers. Gasoline de-icers can cause internal damage to carburetor and fuel pump parts. Do not use fuels containing alcohol concentrations greater than ten percent. Fuel containing alcohol may cause poor engine performance and internal engine damage.***

If regular leaded gasoline is used continually, carbon and lead deposits should be removed from the cylinder heads as required because of engine power loss. Unleaded gasoline may be used safely after lead deposits have been removed.

⚠WARNING ***Spilled fuel can ignite and cause serious personal injury or death. Never fill the fuel tank when the engine is running.***

EXHAUST SYSTEM

Exhaust products of any internal combustion engine are toxic and can cause injury, or death if inhaled. All engine applications, especially those within a confined area, should be equipped with an exhaust system to discharge gases to the outside atmosphere.

⚠WARNING ***Inhalation of exhaust gases can result in serious personal injury or death. Use extreme care during installation to ensure a tight exhaust system.***

Operation

STARTING

Most engines are equipped with a start-stop switch and cable controlled choke and throttle.

1. Place the throttle control in the *SLOW* position and the choke into the *FULL* choke position.
2. Turn the ignition switch on and engage starter. If engine fails to start after 30 seconds determine the cause. Wait one minute before recranking.

   If the engine fails to start at first attempt, rust inhibitor oil used at the factory may have fouled the plugs. Remove the plugs, clean in a suitable solvent, dry thoroughly and reinstall. Heavy exhaust smoke when the engine is initially started is normal and usually caused by rust inhibitor oil.

3. When the engine starts, gradually push the choke lever in until the engine runs smoothly.
4. Black smoke from the exhaust and a rough running engine usually indicate over-choking.
5. To stop the engine, turn the ignition switch to the *OFF* position.

BREAK-IN PROCEDURE

Controlled break-in is the ideal fitting of all internal moving metal parts. Using the proper oil and applying a conscientious maintenance program during this period helps assure satisfactory service from your Onan engine.

Maintain the proper cooling and lubrication during break-in. Run the engine at half load for the first three hours with intermittent periods of full load to control engine break-in.

⚠CAUTION ***Using the wrong grade and weight of oil and high engine operating temperatures during break-in can cause engine damage.***

Check the oil level at least every five operating hours. Add oil to keep it at the proper level, but never overfill as overfilling may cause the oil to foam and enter the breather system, resulting in high oil consumption and oil accumulation in air cleaner housing.

HOT WEATHER OPERATION

When operating the engine in temperatures above 100°F (38°C), pay particular attention to the following items to prevent damage:

1. Keep the engine cooling fins clean and free of obstruction.

⚠CAUTION ***Plugged or clogged cooling fins can cause overheating and engine damage.***

⚠WARNING ***Contact with rotating machinery can cause serious personal injury or death. Stay clear of rotating components and ensure that protective shields and guards are in place and secured before operating machinery.***

2. See that nothing obstructs air flow to and from the engine.
3. Ensure that you are using the proper grade and weight of oil for ambient temperatures. Check the oil level each time you fill the fuel tank.
4. Check the battery water more frequently than every 50 hours which is recommended under normal conditions. High temperatures cause faster evaporation.
5. Change crankcase oil and filter more frequently than recommended under normal conditions.

COLD WEATHER OPERATION

When the engine is being used in temperatures below 32°F (0°C), check the following items closely:

1. Use the correct grade and weight of oil for the temperature conditions. Change the oil only when the engine is warm. If an unexpected temperature drop occurs when the engine is filled with summer oil, before starting the engine, move it to a warm location until the oil will flow freely.
2. Use fresh fuel. Fill the fuel tank after each day's use to protect against moisture condensation.
3. Keep the battery in a well-charged condition.

DUST AND DIRT

1. Keep unit clean. Keep cooling system clean.
2. Service air cleaner as frequently as required.
3. Change crankcase oil and filter more often than recommended under normal conditions.

OUT-OF-SERVICE PROTECTION

Protect an engine that will be out-of-service for more than 30 days as follows:

1. Run the engine until it reaches normal operating temperature.
2. Turn off the fuel supply and run the engine until it stops.
3. Drain oil from oil base while the engine is still warm. Refill with fresh crankcase oil and attach a tag stating viscosity used.

4. Remove spark plugs. Pour 1 ounce (2 tablespoons or 28 grams) of rust inhibitor or SAE #50 oil into the cylinders. Crank the engine over a few times. Reinstall spark plugs.
5. Service air cleaner as outlined in *MAINTENANCE* section.
6. Clean governor linkage and protect by wrapping with a clean cloth.
7. Plug exhaust outlet to prevent entrance of moisture, dirt, bugs, etc.
8. Wipe entire unit. Coat rustable parts with a light film of grease or oil.
9. Provide a suitable cover for the entire unit.
10. If battery equipped, disconnect and follow standard battery storage procedure.

RETURNING UNIT TO SERVICE

1. Remove cover and all protective wrapping. Remove plug from exhaust outlet.
2. Check tag on oil base and verify that oil viscosity is still correct for existing ambient temperatures.
3. Clean and check battery. Measure specific gravity (1.260 at 77°F [25°C]) and verify level to be at split ring. If specific gravity is low, charge until correct value is obtained. If the level is low, add distilled water and charge until specific gravity is correct.
4. Check that fuel filter and fuel lines are secure, with no leaks.
5. Check that carburetor throttle lever and governor linkage move freely.
6. Connect battery.
7. Start Engine.

After engine has started, excessive blue smoke is exhausted until the rust inhibitor has burned away.

⚠WARNING

EXHAUST GAS IS DEADLY!

Exhaust gases contain carbon monoxide, a poisonous gas that can cause unconsciousness and death. It is an odorless and colorless gas formed during combustion of hydrocarbon fuels. Symptoms of carbon monoxide poisoning are:

- ***Dizziness***
- ***Headache***
- ***Weakness and Sleepiness***
- ***Vomiting***
- ***Muscular Twitching***
- ***Throbbing in Temples***

If you experience any of these symptoms, get out into fresh air immediately, shut down the unit and do not use until it has been inspected.

The best protection against carbon monoxide inhalation is proper installation and regular, frequent inspections of the complete exhaust system. If you notice a change in the sound or appearance of exhaust system, shut the unit down immediately and have it inspected and repaired at once by a competent mechanic.

Maintenance

⚠WARNING ***Accidental starting of the engine can cause severe personal injury or death. Disconnect the battery cable when repairs are made to the engine, controls panel, or associated equipment.***

DAILY CHECKS OR EVERY 8 HOURS

The operator should daily make a complete visual and audible inspection of the engine. Check the following before starting the engine for the first time each day:

1. Check all fuel lines and fittings for possible leakage.
2. Inspect exhaust system for possible leakage and cracks. Locate leaks in muffler and piping while the engine is operating. Repair all leaks immediately after they are detected for personnel safety.
3. Inspect air cleaner system for leaks. Make certain that all clamps and fittings are tight and free of potential leaks.
4. Check crankcase oil level with the engine off. If oil level is at or below "add" mark on dipstick (Figure 1), add sufficient oil of the proper viscosity as specified in the *ENGINE SET-UP* section to bring oil level to the full mark on the dipstick. Do not operate engine with oil level below the "add" mark.

Allow a minimum of 10 minutes for the oil to drain down before checking. The best time to check the oil is after an overnight shut-down period.

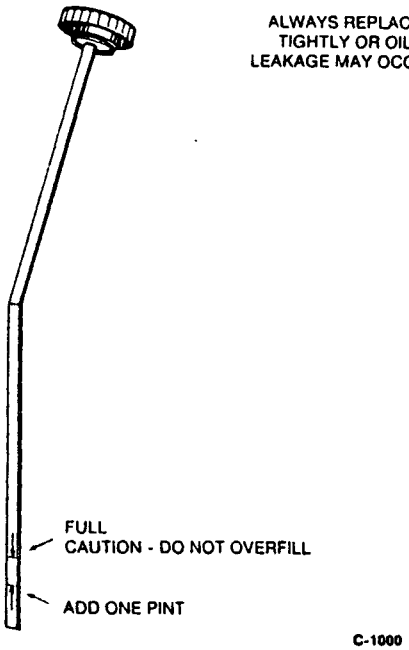


FIGURE 1. CRANKCASE OIL FILL

OIL CHANGE

Change crankcase oil after the first 25 hours of operation. Thereafter change crankcase oil every 50 hours on engines equipped with oil filter and every 25 hours on engines without oil filter. If operating in extremely dusty, high ambient, or low ambient conditions change oil more often.

Run engine until thoroughly warm before draining oil. Stop the engine, place a pan under the drain outlet and remove the oil drain plug or open the drain valve. After the oil is completely drained, replace the drain plug or close the drain valve. Refill with oil of the correct API classification and appropriate SAE viscosity grade for the temperature conditions (refer to *ENGINE SET-UP* section).

⚠WARNING ***Hot crankcase oil can cause burns if it is spilled or splashed on skin. Keep fingers and hands clear when removing the oil drain plug and wear protective clothing.***

Oil level should be to the "full" mark of the dipstick. Start engine and run for a short time to check for oil leaks around the drain plug.

OIL FILTER CHANGE

Replace oil filter (Figure 2) after the first 25 hours of operation, and every 100 hours thereafter. If operating in extremely dusty, high ambient, or low ambient conditions change oil filter more often.

Spin off oil filter element and discard it. Thoroughly clean filter mounting surface and install new element, making sure new gasket is inserted in the element. Apply a thin film of oil to the gasket. Spin element down by hand until gasket just touches mounting pad and then turn down an additional 1/4-1/2 turn. Do not overtighten.

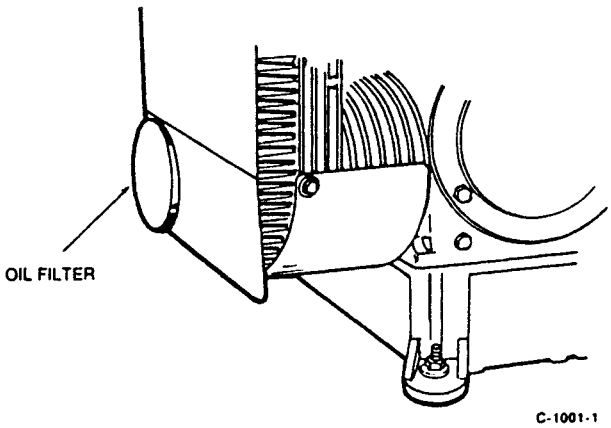


FIGURE 2. OIL FILTER CHANGE

With oil in crankcase, start engine and check for leaks around filter element. Retighten only as much as necessary to eliminate leaks, but do not overtighten.

IGNITION

Spark Plugs

Check, and regap spark plugs every 200 hours of operation (Figure 3). Replace spark plugs that show signs of fouling or electrode erosion.

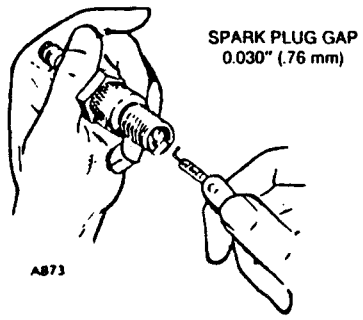


FIGURE 3. SPARK PLUG GAP

Solid State Ignition

Ignition timing is set at the factory and is not adjustable. The solid state ignition components are not adjustable and require no routine maintenance.

COOLING SYSTEM

Check and clean cooling fins and chaff screen at least every 50 hours. Remove any dust, dirt or oil which may have accumulated. See SERVICE MANUAL if removal of cylinder air housing is required.

BATTERIES

Disconnect negative ground strap from the battery before working on any part of the electrical system or engine.

Disconnect positive terminals before charging batteries to avoid damaging ignition system alternator or regulator.

⚠WARNING ***Ignition of explosive battery gases can cause severe personal injury. Do not smoke while servicing batteries.***

Cleaning Batteries

Keep the batteries clean by wiping them with a damp cloth whenever dirt appears excessive.

If corrosion is present around the terminal connections, remove battery cables and wash the terminals with an ammonia solution or a solution consisting of 1/4 pound of baking soda added to 1 quart of water.

Be sure the vent plugs are tight to prevent cleaning solution from entering the cells.

After cleaning, flush the outside of the battery, the battery compartment, and surrounding areas with clear water.

Keep the battery terminals clean and tight. After making connections, coat the terminals with a light application of petroleum jelly or non-conductive grease to retard corrosion.

Checking Specific Gravity

Use a battery hydrometer to check the specific gravity of the electrolyte in each battery cell.

Hold the hydrometer vertical and take the reading. Correct the reading by adding four gravity points (0.004) for every five degrees the electrolyte temperature is above 80° F (27°C) or subtracting four gravity points for every five degrees below 80°F (27°C). A fully charged battery will have a corrected specific gravity of 1.260. Charge the battery if the reading is below 1.215.

Checking Electrolyte Level

Check the level of the electrolyte (acid and water solution) in the batteries at least every 50 hours of operation.

Fill the battery cells to the bottom of the filler neck. If cells are low on water, add distilled water and recharge. If one cell is low, check case for leaks. Keep the battery case clean and dry. An accumulation of moisture will lead to a more rapid discharge and battery failure.

⚠CAUTION ***Do not add water in freezing weather unless the engine is to be run long enough (two or three hours) to assure a thorough mixing of water and electrolyte.***

Storing Batteries

If the engine is to be stored for more than 30 days, remove the batteries. With the electrolyte level at the bottom of the split ring, charge the battery before storing it. After every 30 days the battery is in storage, bring it back up to full charge. To reduce self-discharge, store the battery in as cool a place as possible so long as the electrolyte does not freeze.

CRANKCASE BREATHER

This engine uses a crankcase breather valve and "Pack" for maintaining crankcase vacuum. If the crankcase becomes pressurized as evidenced by oil leaks at the seals, clean pack and valve screens in a suitable solvent. Check and clean valve and baffle every 1000 hours of operation. See Figure 4.

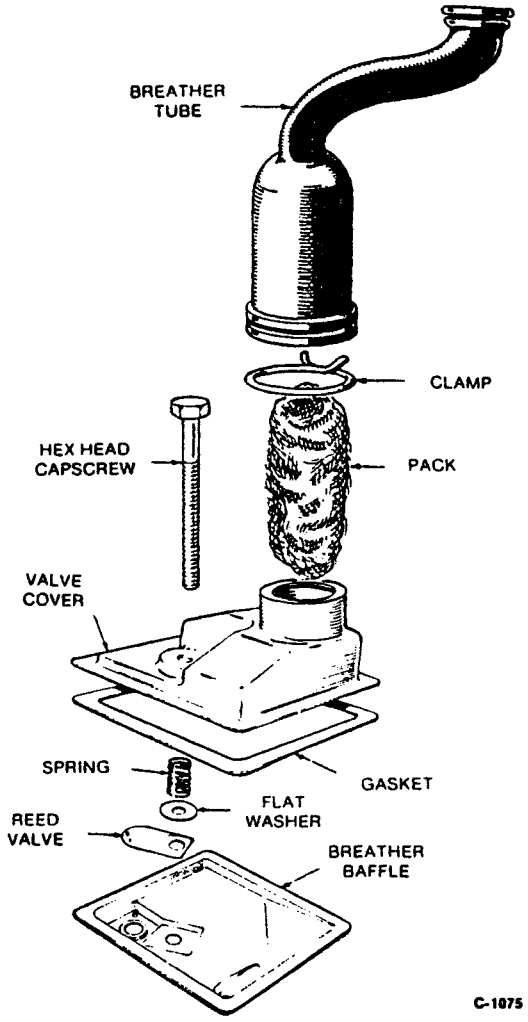


FIGURE 4. CRANKCASE BREATHER

EXHAUST SYSTEM

Make regular visible and audible inspections of the exhaust system throughout the entire life of the engine. Locate leaks in muffler and piping while the engine is operating. Repair all leaks immediately after they are detected for personnel safety.

⚠WARNING ***Inhalation of exhaust gases can result in serious personal injury or death. Inspect exhaust system audibly and visually for leaks daily. Repair any leaks immediately.***

AIR CLEANER

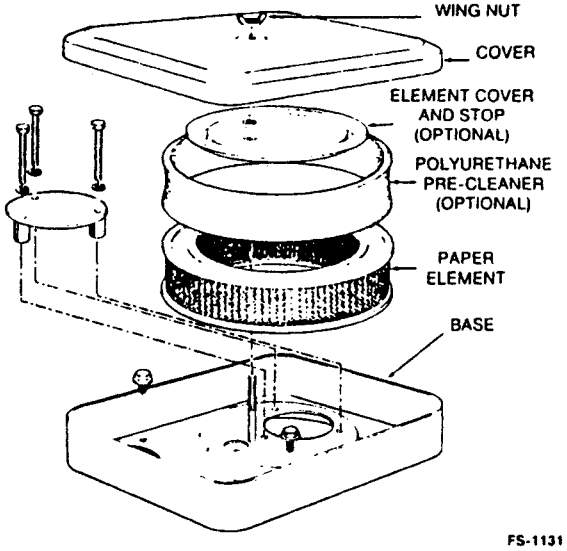
Cartridge Air Cleaner

Check air cleaner element every 25 hours (Figure 5). Replace the air cleaner element every 200 hours. Replace more frequently in dusty operating conditions.

Air Cleaner Wrapper (Pre-Cleaner [if used])

Wash in water and detergent and squeeze dry like a sponge (Figure 5). Allow to dry, then coat evenly with two tablespoons (28 grams) of SAE 30 engine oil. Knead into and wring excess oil from pre-cleaner. Reinstall over air cleaner element.

Failure to adequately wring out excess oil from the wrapper may cause drop in engine horsepower due to an increased restriction of inlet air.



1. WASH
2. SQUEEZE DRY
3. COAT WITH OIL
4. INSTALL OVER PAPER ELEMENT

FIGURE 5. AIR CLEANER ASSEMBLY

PERIODIC MAINTENANCE SCHEDULE

Follow a regular schedule of inspection and servicing, based on operating hours (see *Periodic Maintenance Schedule*). Keep an accurate logbook of maintenance, servicing, and operating time. Use the factory recommended Periodic Maintenance Schedule (based on favorable operating conditions) to serve as a guide to get long and efficient engine life. Regular service periods are recommended for normal service and operating conditions. For continuous duty, extreme temperature, etc., service more frequently. For infrequent use, light duty, etc., service periods can be lengthened accordingly. Neglecting routine maintenance can result in engine failure or permanent damage.

For any abnormalities in operation, unusual noises from the engine or accessories, loss of power, overheating, etc., contact your nearest Onan Service Center.

PERIODIC MAINTENANCE SCHEDULE

SERVICE THESE ITEMS	AFTER EACH CYCLE OF INDICATED HOURS					
	8	25	50	100	200	1000
Inspect Engine Generally	X[1]					
Check Oil Level	X					
Service Air Cleaner		X[2]				
Change Crankcase Oil (with filter)		X[3]	X[2]			
Change Crankcase Oil (without filter)		X[2]				
Check Battery Electrolyte Level			X			
Clean Cooling Fins			X[2]			
Replace Oil Filter		X[3]		X[2]		
Check or Replace Spark Plugs					X	
Clean Breather Valve						X[2]
Replace Air Cleaner Element					X[2]	
Check Valve Clearance					X[4,6]	X[4,5]
Clean Carbon and Lead Deposits (Cylinder Head)						X[7]

X[1] - Check for fuel leaks. With engine running, visually and audibly check exhaust system for leaks.
X[2] - Perform more often when running under severe operating conditions.
X[3] - Initial break-in check only.
X[4] - For detailed maintenance, contact an Onan Service Center or refer to the SERVICE MANUAL.
X[5] - For engines with extended service life package. This interval for standard engines is 200 hours.
X[6] - For standard engines without extended service life package. This interval for extended service life packages is 1000 hours.
X[7] - Clean carbon more frequently when running under continuous light load and/or on leaded fuel. Use of Onan 4C carburetor and combustion cleaner is recommended every 200 hours to help reduce carbon buildup.

⚠WARNING ***Inhalation of exhaust gases can result in serious personal injury or death. Do NOT use the air cleaner or exhaust elbow as a supporting step. Damage to these and connecting parts might cause an exhaust leak.***

Governor

Carburetor mixture adjustments are set for maximum efficiency at the factory. Idle fuel adjustment is restricted to 1/4 of a turn by a limiting cap. There is no main fuel adjustment screw.

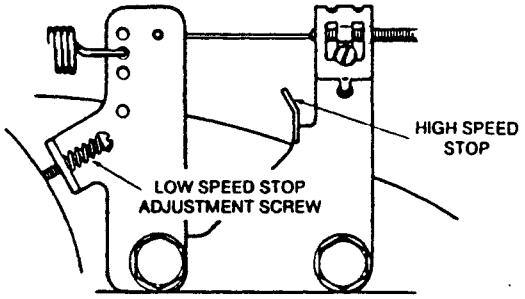
1. Start the engine and allow it to warm up thoroughly (at least 10 minutes).

   Some equipment manufacturers may require higher throttle stop speed and governor low speed rpm settings. Refer to equipment manufacturer's Operator's Manual for the correct rpm settings. When rpm settings are not specified by the equipment manufacturer use the rpm settings listed in Steps 2 and 4.

2. Move the engine speed control to the slow position. Bend or turn the low speed stop on the governor so that the throttle stop screw on the carburetor controls engine speed. Adjust the throttle stop screw for 1000 rpm idle.

3. Adjust the governor low speed stop for 1100 rpm idle.

4. Move the engine speed control to the fast position. Bend the high speed stop on the governor so the engine runs at the vehicle manufacturer's recommended speed.



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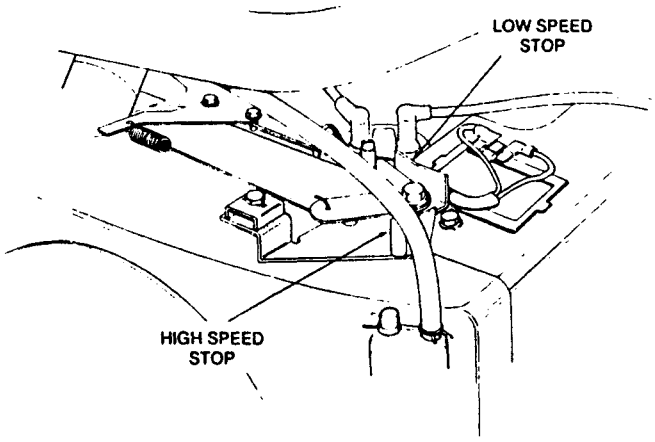
SIDE PULL GOVERNOR ASSEMBLY



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FRONT PULL GOVERNOR ASSEMBLY

FIGURE 6. GOVERNOR SPEED ADJUSTMENT

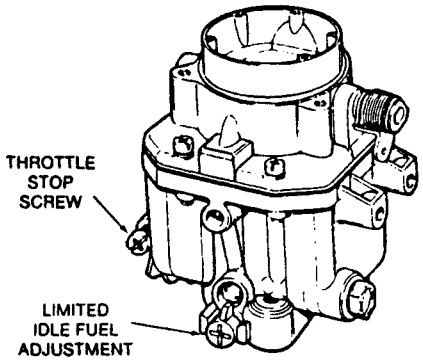

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FIGURE 7. CARBURETOR ADJUSTMENTS

Service Manual

P216
P218
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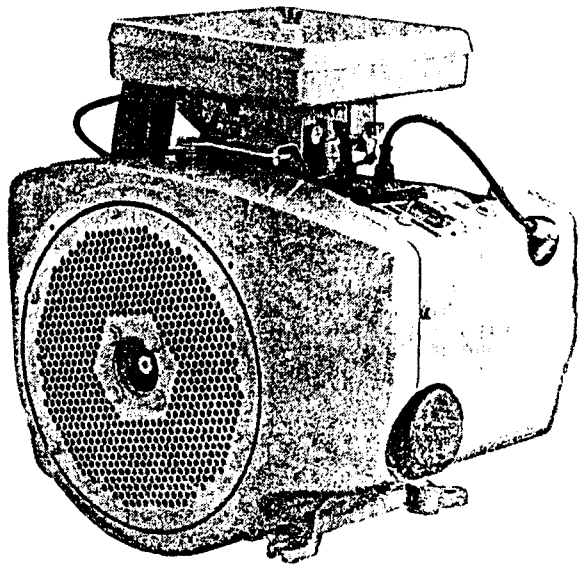
Engine



Safety Precautions

It is recommended that you read your engine manual and become thoroughly acquainted with your equipment before you start the engine.

⚠DANGER ***This symbol if used warns of immediate hazards which will result in severe personal injury or death.***

⚠WARNING ***This symbol refers to a hazard or unsafe practice which can result in severe personal injury or death.***

⚠CAUTION ***This symbol refers to a hazard or unsafe practice which can result in personal injury or product or property damage.***

Fuels, electrical equipment, batteries, exhaust gases and moving parts present potential hazards that can result in serious, personal injury. Take care in following these recommended procedures. All local, state and federal codes should be consulted and complied with.

⚠WARNING ***This engine is not designed or intended for use in any type of aircraft. Use of this engine in aircraft can result in engine failure and causes serious personal injury or death.***

General

- Provide appropriate fire extinguishers and install them in convenient locations. Use an extinguisher rated ABC by NFPA.
- Make sure that all fasteners on the engine are secure and accurately torqued. Keep guards in position over fans, driving belts, etc.
- If it is necessary to make adjustments while the engine is running, use extreme caution when close to hot exhausts, moving parts, etc.

Protect Against Moving Parts

- Do not wear loose clothing in the vicinity of moving parts, such as PTO shafts, flywheels, blowers, couplings, fans, belts, etc.
- Keep your hands away from moving parts.

Batteries

- Before starting work on the engine, disconnect batteries to prevent inadvertent starting of the engine.
- DO NOT SMOKE while servicing batteries. Lead acid batteries give off a highly explosive hydrogen gas which can be ignited by flame, electrical arcing or by smoking.
- Verify battery polarity before connecting battery cables. Connect negative cable last.

Fuel System

- DO NOT fill fuel tanks while engine is running.
- DO NOT smoke or use an open flame in the vicinity of the engine or fuel tank. Internal combustion engine fuels are highly flammable.
- Fuel lines must be of steel piping, adequately secured, and free from leaks. Piping at the engine should be approved flexible line. Do not use copper piping for flexible lines as copper will work harden and become brittle enough to break.
- Be sure all fuel supplies have a positive shutoff valve.

Exhaust System

- Exhaust products of any internal combustion engine are toxic and can cause injury, or death if inhaled. All engine applications, especially those within a confined area, should be equipped with an exhaust system to discharge gases to the outside atmosphere.
- Do not use exhaust gases to heat a compartment.
- Make sure that your exhaust system is free of leaks. Ensure that exhaust manifolds are secure and are not warped by bolts unevenly torqued.

Exhaust Gas is Deadly!

Exhaust gases contain carbon monoxide, a poisonous gas that can cause unconsciousness and death. It is an odorless and colorless gas formed during combustion of hydrocarbon fuels. Symptoms of carbon monoxide poisoning are:

- Dizziness
- Headache
- Weakness and Sleepiness
- Vomiting
- Muscular Twitching
- Throbbing in Temples

If you experience any of these symptoms, get out into fresh air immediately, shut down the unit and do not use until it has been inspected.

The best protection against carbon monoxide inhalation is proper installation and regular, frequent inspections of the complete exhaust system. If you notice a change in the sound or appearance of exhaust system, shut the unit down immediately and have it inspected and repaired at once by a competent mechanic.

Cooling System

- Coolants under pressure have a higher boiling point than water. DO NOT open a radiator pressure cap when coolant temperature is above 212°F (100°C) or while engine is running.

Keep the Unit and Surrounding Area Clean

- Make sure that oily rags are not left on or near the engine.
- Remove all unnecessary grease and oil from the unit. Accumulated grease and oil can cause overheating and subsequent engine damage and present a potential fire hazard.

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⚠WARNING

EXHAUST GAS IS DEADLY!

Exhaust gases from all fuels (including diesel, gasoline, liquid propane, natural gas) contain carbon monoxide, an odorless and colorless gas. Carbon monoxide is poisonous and can cause unconsciousness and death. Symptoms of carbon monoxide poisoning can include:

- *Dizziness*
- *Nausea*
- *Headache*
- *Weakness and Sleepiness*
- *Throbbing in Temples*
- *Muscular Twitching*
- *Vomiting*
- *Inability to Think Coherently*

IF YOU OR ANYONE ELSE EXPERIENCE ANY OF THESE SYMPTOMS, GET OUT INTO THE FRESH AIR IMMEDIATELY. If symptoms persist, seek medical attention. Shut down the unit and do not operate until it has been inspected and repaired.

Protection against carbon monoxide inhalation includes proper installation, ventilation and regular, frequent visual and audible inspections of the complete exhaust system.

General Information

INTRODUCTION

This manual deals with specific mechanical and electrical information needed by engine mechanics for troubleshooting, servicing, repairing, or overhauling the engine.

Use the separate PARTS MANUAL for parts identification and for establishing their proper location on assemblies. The PARTS MANUAL contains detailed exploded views of each assembly and the individual piece part numbers and their proper names for ordering replacement parts.

The illustrations and procedures presented in each section apply to the engines listed on the cover. The flywheel-blower end of the engine is the front end so right and left sides are determined by viewing the engine from the front. The No. 1 cylinder is on the left, No. 2 cylinder is on the right.

If a major repair or an overhaul is necessary, a competent mechanic should either do the job or supervise and check the work of the mechanic assigned to the job to ensure that all dimensions, clearances and torque values are within the specified tolerances.

Use the table of contents for a quick reference to the separate engine system sections.

The troubleshooting guide is provided as a quick reference for locating and correcting engine trouble.

The wiring diagram shows how the electrical components are interconnected.

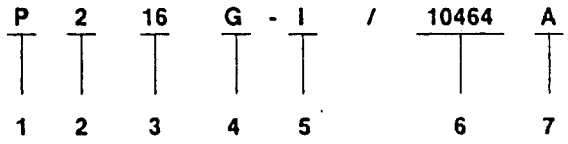
The disassembly section contains major overhaul procedures for step by step removal, disassembly, inspection, repair, and assembly of the engine components.

Use only Genuine Onan replacement parts to ensure quality and the best possible repair and overhaul results. When ordering parts, always use the complete model and spec number as well as the serial number shown on the nameplate.

ENGINE MODEL REFERENCE

Identify your model by referring to the model and specification (spec letter) as shown on the unit nameplate. Always use these numbers and the engine serial number when making reference to your engine.

How to interpret MODEL and SPEC NO.



1. Factory code for general identification of basic engine series.
2. Number of cylinders.
3. BHP rating.
4. Fuel required (G = gasoline).
5. Engine duty cycle.
6. Factory code for designated optional equipment, if any.
7. Specification (spec letter) which advances with factory production modifications.

⚠WARNING

INCORRECT SERVICE OR REPLACEMENT OF PARTS CAN RESULT IN SEVERE PERSONAL INJURY AND/OR EQUIPMENT DAMAGE. SERVICE PERSONNEL MUST BE QUALIFIED TO PERFORM ELECTRICAL AND/OR MECHANICAL SERVICE.

Specifications

This manual contains SI metric equivalents that follow immediately in parentheses after the U.S. customary units of measure.

SPECIFICATION	UNIT OF MEASURE	SERIES P216	P218	P220	P224
Number of Cylinders		2	2	2	2
Bore	in (mm)	3.250 (82.55)	3.250 (82.55)	3.250 (82.55)	3.560 (90.42)
Stroke	in (mm)	2.620 (66.55)	2.875 (73.01)	2.875 (73.01)	3.000 (76.20)
Displacement	cu in (cm^3)	43.3 (710)	47.7 (782)	47.7 (782)	59.7 (983)
Compression Ratio		6.5 to 1	7.0 to 1	7.0 to 1	7.0 to 1
Rated Speed (Maximum)	RPM	3600	3600	3600	3600
Power at Rated Speed	BHP (kW)	16 (11.9)	18 (13.4)	20 (14.9)	24 (17.9)
Oil Capacity					
Standard Base Without Filter	Qts (litre)	1.5 (1.4)	1.5 (1.4)	1.5 (1.4)	1.5 (1.4)
High Capacity Base Without Filter	Qts (litre)	2.7 (2.6)	2.7 (2.6)	2.7 (2.6)	2.7 (2.6)
Oil Filter Capacity	Qts (litre)	.3 (.3)	.3 (.3)	.3 (.3)	.3 (.3)
Crankshaft Rotation (viewed from flywheel)		Clockwise	Clockwise	Clockwise	Clockwise
Valve Clearance (Cold)					
Intake	in (mm)	.005 (.13)	.005 (.13)	.005 (.13)	.005 (.13)
Exhaust	in (mm)	.013 (.33)	.013 (.33)	.013 (.33)	.013 (.33)
Spark Plug Gap	in (mm)	.025 (.64)	.025 (.64)	.025 (.64)	.025 (.64)
Ignition Timing	BTC	20°	20°	20°	20°
Cylinder Compression	psi (kPa)	75 to 115 (517 to 793)	75 to 115 (517 to 793)	75 to 115 (517 to 793)	75 to 115 (517 to 793)

Dimensions and Clearances

P216, P218, P220

All clearances given at room temperature of 70°F. (21°C). All dimensions in inches (approximate millimeter dimensions in parentheses) unless otherwise specified.

DESCRIPTION	MINIMUM Inches	MINIMUM (mm)	MAXIMUM Inches	MAXIMUM (mm)
CYLINDER BLOCK				
Cylinder Bore Honed Diameter	3.2490	(82.52)	3.2500	(82.55)
Maximum Allowable				
Taper			0.005	(0.13)
Out-of-Round			0.003	(0.08)
Main Bearing Inside Diameter (Without bearing)	2.1870	(55.55)	2.1880	(55.58)
Main Bearing Inside Diameter (Installed service bearing)	2.0015	(50.84)	2.0040	(50.90)
Camshaft Bearing Bore (Installed service bearing)	1.3757	(34.94)	1.3787	(35.02)
CRANKSHAFT				
Main Bearing Journal Diameter	1.9992	(50.78)	2.0000	(50.80)
Main Bearing Clearance	0.0024	(0.061)	0.0042	(0.107)
Connecting Rod Journal Diameter	1.6252	(41.28)	1.6260	(41.30)
Crankshaft End Play	0.0060	(0.152)	0.0120	(0.305)
CONNECTING ROD				
Large Bore Diameter (Rod bolts properly torqued)	1.6280	(41.35)	1.6285	(41.36)
Connecting Rod Side Clearance	0.0020	(0.051)	0.0160	(0.406)
Piston Pin Bushing Bore (Finished bore)	0.6879	(17.47)	0.6882	(17.48)
Bearing to Crankshaft Clearance	0.0020	(0.051)	0.0033	(0.084)
CAMSHAFT				
Bearing Journal Diameter	1.3740	(34.90)	1.3745	(34.91)
Bearing Clearance	0.0015	(0.038)	0.0030	(0.076)
End Play	0.0110	(0.279)	0.0480	(1.219)
Lobe Height				
P216, P218 Intake		1.1370	(28.88)	
P216, P218 Exhaust		1.1570	(29.39)	
P220 Intake		1.1670	(29.64)	
P220 Exhaust		1.1570	(29.39)	
PISTON				
Clearance in Cylinder				
Measure 90° to pin 1.187 inch below top of piston	0.0033	(0.084)	0.0053	(0.135)
Piston Pin Bore	0.6877	(17.47)	0.6882	(17.48)
Ring Groove Width				
Top Compression Ring	0.0800	(2.032)	0.0810	(2.057)
Middle Compression Ring	0.0800	(2.032)	0.0810	(2.057)
Bottom Oil Control Ring	0.1880	(4.775)	0.1890	(4.800)

P216, P218, P220

DESCRIPTION	MINIMUM Inches	MINIMUM (mm)	MAXIMUM Inches	MAXIMUM (mm)
PISTON PIN				
Clearance in Piston	0.00004	(0.001)	0.00064	(0.016)
Clearance in Connecting Rod	0.0002	(0.005)	0.0007	(0.018)
Diameter	0.6875	(17.46)	0.6877	(17.47)
PISTON RINGS				
Clearance				
Top Groove	0.0030	(0.076)	0.0080	(0.203)
Ring End Gap in Cylinder	0.0100	(0.254)	0.0200	(0.508)
INTAKE VALVE				
Stem Diameter	0.2795	(7.099)	0.2800	(7.112)
Clearance (Stem to Guide)	0.0010	(0.025)	0.0025	(0.064)
Valve Face Angle			44°	
INTAKE VALVE SEAT				
Seat Bore Diameter in Block	1.4395	(36.56)	1.4405	(36.59)
Seat Outside Diameter	1.4700	(37.34)	1.4710	(37.36)
Valve Seat Width	0.0310	(0.787)	0.0470	(1.194)
Valve Seat Angle			45°	
EXHAUST VALVE				
Stem Diameter	0.2780	(7.061)	0.2785	(7.074)
Clearance (Stem to Guide)	0.0020	(0.051)	0.0035	(0.089)
Valve Face Angle			44°	
EXHAUST VALVE SEAT				
Seat Bore Diameter in Block	1.1890	(30.20)	1.1900	(30.23)
Seat Outside Diameter	1.1920	(30.28)	1.1930	(30.30)
Valve Seat Width	0.0310	(0.787)	0.0470	(1.194)
Valve Seat Angle			45°	
VALVE GUIDE				
Intake Inside Diameter	0.2810	(7.137)	0.2820	(7.163)
Exhaust Inside Diameter	0.2805	(7.125)	0.2815	(7.150)
TAPPET				
Body Diameter	0.7475	(18.99)	0.7480	(19.00)
Bore Diameter	0.7500	(19.05)	0.7515	(19.09)
Clearance in Bore	0.0020	(0.051)	0.0040	(0.102)
VALVE SPRINGS INTAKE AND EXHAUST				
Valve Spring Free Length (Approx.)		1.600	(40.64)	
Valve Spring Length				
Valve Open		1.055	(26.80)	
Valve Closed		1.346	(34.19)	
Spring Load (Valve Open Length)		55 lb.	(25 kg)	
Spring Load (Valve Closed Length)		25 lb.	(11 kg)	
GEAR BACKLASH				
Timing Gear	0.0010	(0.025)	0.0050	(0.127)
Oil Pump Gear	0.0010	(0.025)	0.0080	(0.203)

Assembly Torques

The torque values given in Table 1 have been determined for specific applications. Standard torque values must not be used where those listed in Table 1 apply. The engine assembly torques given here will assure proper tightness without danger of stripping threads. All threads must be clean and lubricated with new engine oil before torquing.

Tighten all studs, nuts, and capscrews as required to keep them from working loose. Refer to the *PARTS MANUAL* for the location of washers and capscrews.

TABLE 1.

P216, P218, P220 DESCRIPTION	TORQUE SPECIFICATION Ft.-Lb.	Nm	P216, P218, P220 DESCRIPTION	TORQUE SPECIFICATION Ft.-Lb.	Nm
Gearcase Cover	8-10	11-14	Intake Manifold Mounting Screws	6-10	8-14
Rear Bearing Plate Screws	25-27	34-37	Exhaust Manifold Mounting Screws	9-11	12-15
Starter Mounting Bolts	19-21	25-28	Other 1/4" Cylinder Block Stud and Nuts	7-9	10-12
Connecting Rod Bolts	12-14	16-19	Other 5/16" Cylinder Block Stud and Nuts	8-10	11-14
Flywheel Capscrews	50-55	67-75	Other 3/8" Cylinder Block Stud and Nuts	18-23	24-31
Oil Base	18-23	24-31			
Oil Pump	7-9	10-12			
Valve Cover	1-2	1-3			
Cylinder Head Bolts (Cold)					
Asbestos Gasket	16-18	22-24			
Graphoil Gasket	14-16	19-22			

P224 DESCRIPTION	TORQUE SPECIFICATION Ft.-Lb.	Nm	P224 DESCRIPTION	TORQUE SPECIFICATION Ft.-Lb.	Nm
Gearcase Cover	8-10	11-14	Intake Manifold Mounting Screws	20-23	27-31
Rear Bearing Plate Screws	25-27	34-37	Exhaust Manifold Mounting Screws	9-11	12-15
Starter Mounting Bolts	19-21	25-28	Other 1/4" Cylinder Block Stud and Nuts	7-9	10-12
Connecting Rod Bolts	27-29	37-39	Other 5/16" Cylinder Block Stud and Nuts	8-10	11-14
Flywheel Capscrews	50-55	67-75	Other 3/8" Cylinder Block Stud and Nuts	18-23	24-31
Oil Base	18-23	24-31			
Oil Pump	7-9	10-12			
Valve Cover	4-8	5-11			
Cylinder Head Nuts (Cold)					
(w/Compression Washers)	14	19			
(w/o Compression Washers)	17	23			

Special Tools

The following special tools are available from Onan. For further information see *TOOL CATALOG 900-0019.*

Valve Seat Driver
Valve Guide Driver
Oil Seal Guide and Driver
Combination Bearing Remover (Main and Cam)
Combination Bearing Driver (Main and Cam)
Flywheel Puller

Engine Troubleshooting

GASOLINE ENGINE TROUBLESHOOTING GUIDE

TROUBLE / CAUSE	Backfire at Carburetor	Bearing Wear	Black Exhaust	Blue Exhaust	Burned Valves	Connecting Rod Wear	Cranks Slowly	Cylinder Wear	Engine Stops	Failure to Start	Governor Hunting	High Oil Pressure	Low Oil Pressure	Loss of Coolant (Water Cooled)	Mechanical Knocks	Misfiring	Overheating (Air Cooled)	Overheating (Water Cooled)	Piston Wear	Poor Compression	Ring Wear	Sticking Valves
STARTING SYSTEM																						
Loose or Corroded Battery Connection						●			●													
Low or Discharged Battery						●			●													
Faulty Starter						●			●													
Faulty Start Solenoid									●													
IGNITION SYSTEM																						
Ignition Timing Wrong	●				●				●					●	●	●	●					
Wrong Spark Plug Gap									●					●	●							
Bad Ignition Coil									●						●							
Faulty Spark Plug Wires									●						●							
Bad Ignition Module or Trigger Ring									●	●					●							
FUEL SYSTEM																						
Out of Fuel - Check								●	●													
Lean Fuel Mixture					●				●	●				●	●	●						
Rich Fuel Mixture or Choke Stuck	●		●						●					●	●							
Engine Flooded	●		●					●	●													
Poor Quality Fuel	●		●		●				●					●	●							
Dirty Carburetor	●							●	●	●					●							
Dirty Air Cleaner	●	●	●				●		●						●			●		●		
Dirty Fuel Filter									●	●					●							
Defective Fuel Pump								●	●	●					●							
INTERNAL ENGINE																						
Wrong Valve Clearance					●				●					●	●				●			
Broken Valve Spring					●									●	●				●		●	
Valve or Valve Seal Leaking				●	●					●					●				●			
Piston Rings Worn or Broken				●					●					●					●			
Wrong Bearing Clearance		●				●	●					●		●								
COOLING SYSTEM (AIR COOLED)																						
Poor Air Circulation															●	●						
Dirty or Oily Cooling Fins															●	●						
Blown Head Gasket									●	●					●				●			
LUBRICATION SYSTEM													●	●								
Defective Oil Gauge													●	●								
Relief Valve Stuck																						
Faulty Oil Pump		●			●		●						●		●				●		●	
Dirty Oil or Filter		●			●		●						●						●		●	●
Oil Too Light or Diluted		●		●	●		●						●		●	●			●		●	
Oil Level Low		●			●		●						●		●	●			●		●	
Oil Too Heavy						●							●									
Dirty Crankcase Breather Valve		●		●									●									
THROTTLE AND GOVERNOR																						
Linkage Out of Adjustment									●	●												
Linkage Worn or Disconnected										●												
Governor Spring Sensitivity Too Great										●												
Linkage Binding										●												

Oil System

CRANKCASE OIL

Refer to *Periodic Maintenance Schedule* (located in the Operator's Manual) for oil change interval. If operating in extremely dusty, high ambient, or low ambient conditions, change oil more often.

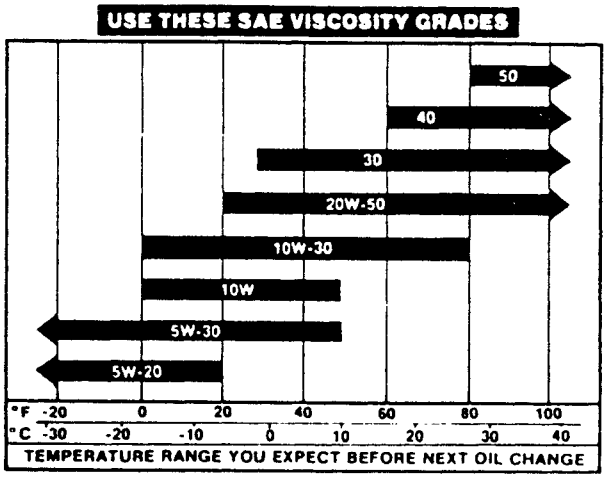
⚠WARNING ***Hot crankcase oil can cause burns if it comes in contact with skin. Wear protective clothing and keep fingers and hands clear when draining oil.***

⚠CAUTION ***Excess oil can cause high oil consumption, high operating temperatures, and oil foaming. Do not overfill crankcase.***

Run engine until thoroughly warm before draining oil. Stop the engine, place a pan under the drain outlet and remove the oil drain plug. After the oil is completely drained, clean and replace the drain plug. Fill crankcase with correct amount of oil. Refer to *SPECIFICATIONS* for crankcase capacity. Use oils meeting the API classification SF, SF/CC, or SF/CD. Refer to chart to determine the proper viscosity grade of oil to use. Straight weight oils are recommended for severe duty use and at temperatures above 32°F (0°C) for minimum oil consumption.

⚠WARNING ***Crankcase pressure can blow out hot oil, which can cause severe personal injury. Do not check oil while the engine is running.***

Oil level should be to the FULL mark of the dipstick. Start engine and run for a short time to check for oil leaks around the drain plug.



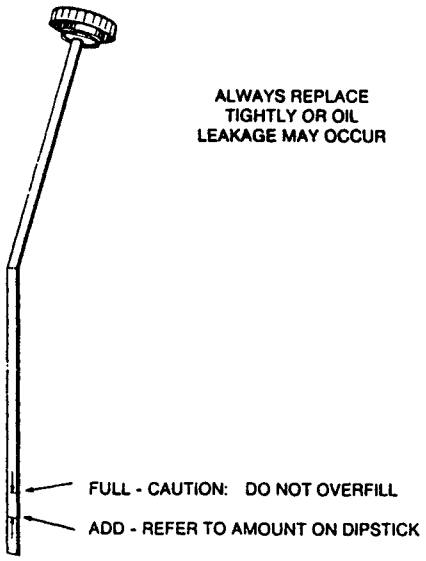


FIGURE 1. CRANKCASE OIL FILL

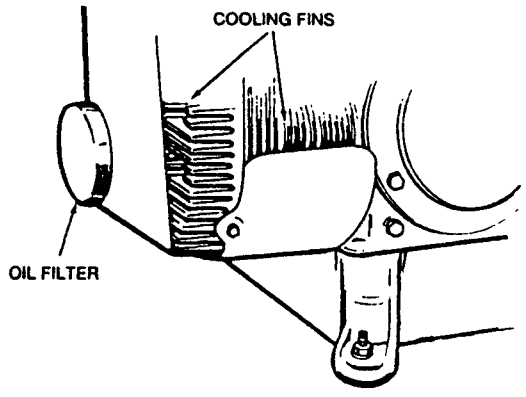


FIGURE 2. OIL FILTER

OIL FILTER CHANGE

Refer to *Periodic Maintenenace Schedule* (located in the Operator's Manual) for oil filter change interval. If operating in extremely dusty, high ambient, or low ambient conditions, change oil filter more often.

Spin off oil filter element and discard it. Thoroughly clean filter mounting surface and make sure new gasket is inserted in the element. Apply a thin film of clean oil to the gasket. Spin element down by hand until gasket just touches mounting pad and then turn down an additional 1/2-3/4 turn. Do not overtighten.

With oil in crankcase, start engine and check for leaks around filter element. Retighten only as much as necessary to eliminate leaks; do not overtighten.

CRANKCASE BREATHER

The crankcase breather prevents pressure from building up in the crankcase. It also prevents oil contamination by removing moisture or gasoline vapors and other harmful blow-by materials from the crankcase. These vapors are routed to the carburetor where they are mixed with incoming air and burned in the combustion chamber. A sticky breather valve can cause oil leaks, high oil consumption, rough idle, reduced engine power, and a rapid formation of sludge and varnish within the engine.

Crankcase Breather Service

If the crankcase becomes pressurized as evidenced by oil leaks at the seals or excessive oil in the air cleaner housing, use the following procedure to service.

⚠WARNING ***Most parts cleaning solvents are flammable and can cause severe personal injury or death if used improperly. Follow the manufacturer's recommendations when cleaning parts.***

P216, P218, P220

Remove the breather tube from the valve cover (Figure 3A). Remove capscrew, flatwashers, valve cover, pack, spring, washer, reed valve, and breather baffle. Discard gasket and clean all parts in part cleaning solvent.

⚠CAUTION ***Overtightening the valve cover can cause engine damage. Do not overtighten valve cover.***

The reed valve must be flat with no sign of a crease. Assemble using a new gasket. Refer to *ASSEMBLY TORQUES* for valve cover capscrew torque specification.

P224

Remove the breather hose from cap and valve assembly. Remove cap and valve assembly and wash in a suitable solvent. Replace cap and valve if balls do not move freely. Pull pack out and wash in solvent. To allow free operation of the valve, screens must be positioned as shown in Figure 3B.

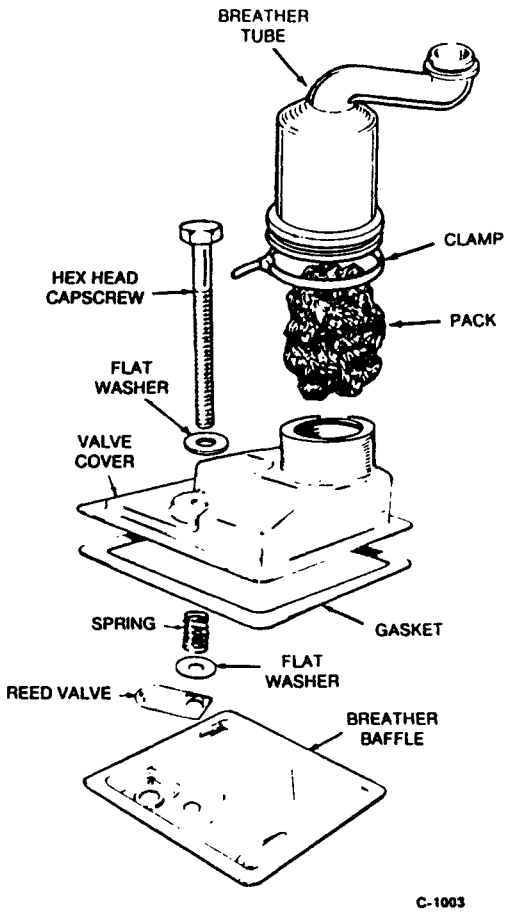


FIGURE 3A. CRANKCASE BREATHER - P216, P218, P220

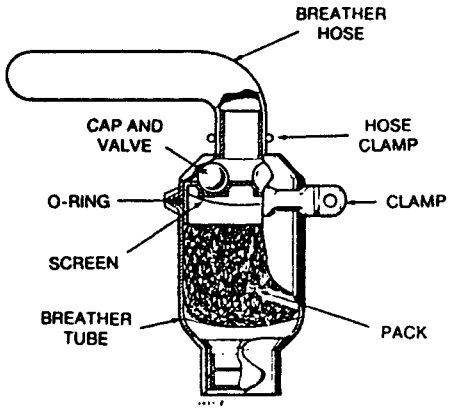


FIGURE 3B. CRANKCASE BREATHER - P224

PRESSURE LUBRICATION

All engines use an oil pump to provide a constant flow of oil to the engine parts. The oil supply collects in the oil base where it is picked up by the oil pump pick-up cup. A by-pass valve is used to control oil pressure. Drain oil before removing oil base and always use a new gasket when replacing the oil base.

Oil Pump

The oil pump (Figure 4) is mounted behind the gear cover and is driven by the crankshaft gear. Inlet pipe and screen assembly are attached directly to the pump body. A discharge passage in pump cover registers with a drilled passage in the crankcase. Parallel passages distribute oil to the front and rear main bearing and the oil bypass valve.

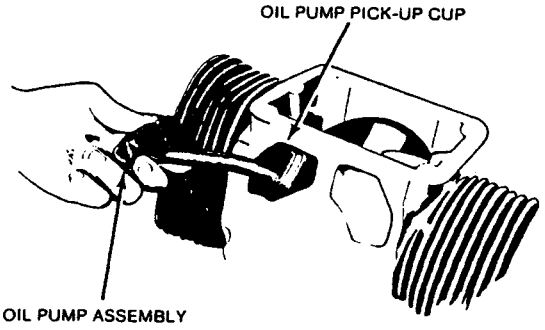


FIGURE 4. OIL PUMP ASSEMBLY

Circumferential grooves in the main bearings supply oil to connecting rod bearings through drilled passages from each main journal. A drilled passage connects the front main bearing oil supply to the front camshaft bearing; rear cam bearing is splash lubricated.

Normal oil pressure should be 8 psi (55 kPa) or higher at 1500 rpm when the engine is at normal operating temperature. If pressure at 1500 rpm drops below this value, inspect oil system for faulty components.

Check oil pump thoroughly for worn parts. Oil pump to prime it before reinstalling. Except for gaskets and pick-up cup, component parts of the pump are not available individually. Install a new pump assembly if any parts are worn.

Oil By-Pass Valve

The by-pass valve (located to the right and behind gear cover) controls oil pressure by allowing excess oil to flow directly back to the crankcase. The valve limits oil pressure to a maximum of about 20 psi (138 kPa) on the P216, P218, and P220, and about 30 psi (207 kPa) on the P224 at normal operating temperature.

The valve is non-adjustable and normally does not need maintenance. Determine if valve is operating correctly by inspecting plunger action as follows:

1. Remove the cap screw located behind gear cover and under governor arm.
2. Remove spring and plunger with a magnetic tool.
3. Determine proper valve operation by checking the spring and plunger according to the following measurements:

   Plunger Diameter ..... 0.3105 to 0.3125 in. (7.89 to 7.94 mm)

   Spring
   Free Length ..... 1.00 inch (25.4 mm)
   Load .....2.6 ± 0.2 lbs (11.6 ± 0.9 N) when compressed to 0.5 inch (12.7 mm)

4. Check the valve seat and clean away any accumulation of metal particles which could cause erratic valve action. Verify that the valve seat is not damaged.
5. Clean plunger and spring in parts cleaning solvent and install.

Fuel System

CARBURETOR

All carburetors have a fixed main jet. An optional fixed main jet is available for altitude compensation above 5,000 feet.

The carburetor idle mixture was set for maximum efficiency at the factory and should normally not be disturbed. If adjustments seem necessary, first be sure the ignition system is working properly and governor sensitivity is properly adjusted.

The carburetor has a limited adjustment range between stops of ±1/8 turn. The screw should only be adjusted within these limits; in to lean the mixture, out to richen.

⚠CAUTION ***Overtightening the mixture adjustment screw will cause carburetor damage. Turn mixture adjustment screw in only until light tension can be felt.***

If replacing idle mixture screw, turn in until lightly seated, then turn screw back out 1-1/4 turns for the P216, P218, and P220 carburetors, and 1-1/2 turns for the P224 carburetor. Replace limiter cap with the plastic stop approximately centered.

Carburetor Speed Settings

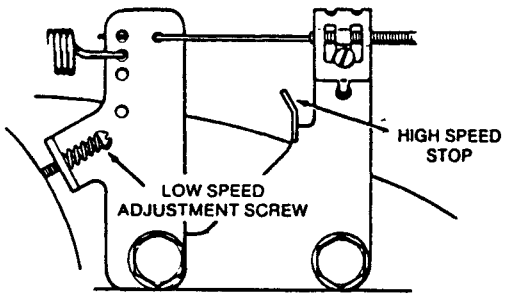
1. Start the engine and allow it to warm up thoroughly (at least 10 minutes).

   Some equipment manufacturers may require higher throttle stop speed and governor low speed rpm settings. Refer to equipment manufacturer's Operator's Manual for the correct rpm settings. When rpm settings are not specified by the equipment manufacturer, use the rpm settings listed in Steps 2 and 3.

2. Move the engine speed control to the slow position. Bend or turn the low speed stop on the governor so the throttle stop screw on the carburetor controls engine speed. Adjust the throttle stop screw for 1000 rpm idle (Figures 1 and 2).

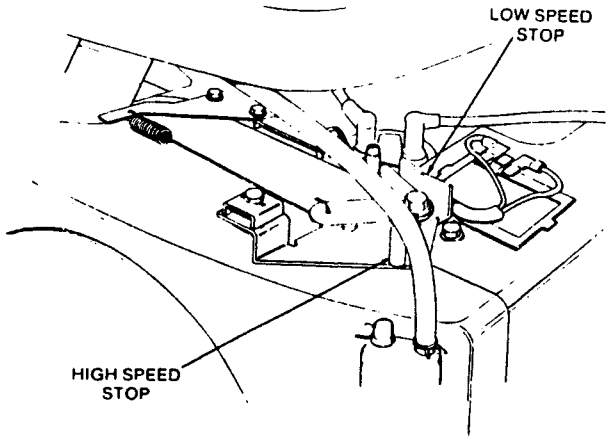
3. Adjust the governor low speed stop for 1100 rpm idle.

4. Move the engine speed control to the fast position. Bend the high speed stop on the governor so the engine runs at the equipment manufacturer's recommended speed.



FS-1000

SIDE PULL GOVERNOR ASSEMBLY



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FRONT PULL GOVERNOR ASSEMBLY

FIGURE 1. GOVERNOR SPEED ADJUSTMENT

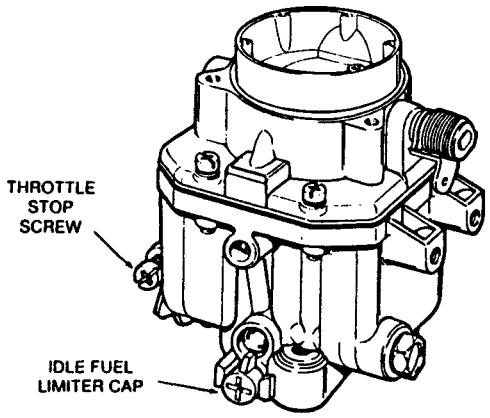


FIGURE 2. CARBURETOR ADJUSTMENTS

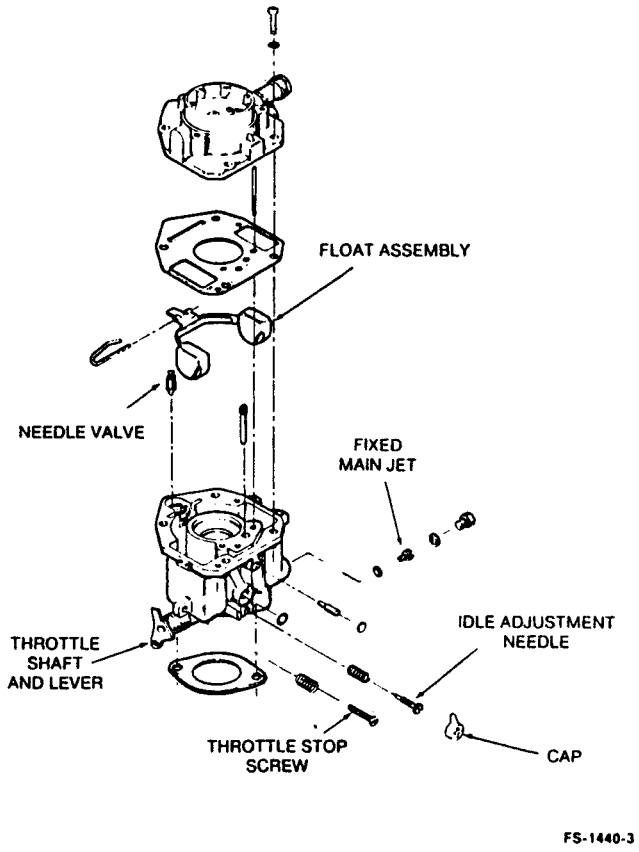


FIGURE 3. CARBURETOR ASSEMBLY

CARBURETOR OVERHAUL

Carburetion problems that are not corrected by mixture adjustments are usually a result of gummed-up fuel passages or worn internal parts. The most effective solution is a carburetor overhaul.

In general, overhauling a carburetor consists of disassembly, a thorough cleaning, and replacement of worn parts. Carburetor overhaul kits are available.

General instructions for overhauling a carburetor are given below. Carefully note the position of all parts while removing to assure correct placement when reassembling. Read through all the instructions before beginning for a better understanding of the procedures involved. Carburetor components are shown in Figure 3.

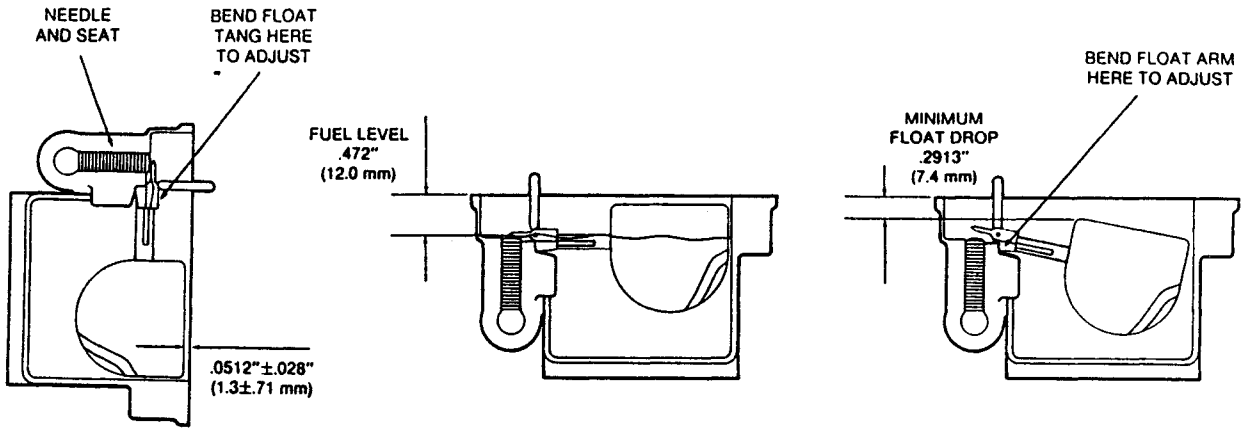
⚠WARNING ***Ignition of fuel can result in severe personal injury or death. Do not smoke or allow any spark, pilot light, or arcing equipment near the fuel system.***

Removal

1. Remove air cleaner assembly.
2. Disconnect governor and throttle linkage, choke control, and fuel line from carburetor.
3. Remove the four intake manifold cap screws and lift complete manifold assembly from engine.
4. Remove carburetor from intake manifold.

Disassembly

1. Remove main jet and idle adjustment needle.
2. Remove attaching screws and separate upper and lower carburetor sections.
3. Carefully note position of float assembly parts, then pull out retaining pin and float assembly.
4. Remove needle valve.



When checking float level and float drop, measure to float body, not seam.

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FIGURE 4. CARBURETOR FLOAT LEVEL ADJUSTMENTS

Cleaning and Repair

1. Soak all metal components not replaced in carburetor cleaner. Do not soak non-metal floats or other non-metal parts. Follow the cleaning manufacturer's recommendations.
2. Clean all carbon from the carburetor bore, especially where the throttle and choke plates seat. Be careful not to plug the idle or main fuel ports.
3. Dry out all passages with low pressure air (35 PSI). Avoid using wire or other objects for cleaning which may increase the size of critical passages.
4. Check the condition of the adjustment needle; replace if damaged. Replace float if loaded with fuel or damaged.
5. Check the choke and throttle shafts for excessive play in their bore. This condition may necessitate replacement of the carburetor.
6. Replace old components with new parts.

Reassembly and Installation

1. Install needle valve, main jet, and float assembly. Make sure float pivot pin is properly placed and float moves freely without binding.
2. Turn carburetor on its side and measure float level (Figure 4). Adjust float level only if necessary. Measure float drop (the distance from the top of carburetor body to top of float). Adjust only if necessary.
3. Position gasket on lower carburetor section and install upper carburetor section.
4. Install idle adjustment screw, throttle stop screw, and fixed main jet plug.
5. Mount carburetor on intake manifold and install assembly on engine.
6. Connect governor and throttle linkage, choke control, and fuel line. Mount air cleaner assembly.
7. Adjust carburetor and governor according to directions given in this section.

PULSATING-DIAPHRAGM FUEL PUMP

Pulsating-diaphragm fuel pumps, or pulse pumps, rely on changes in crankcase vacuum to create a pulsating movement of the pump diaphragm. As the engine's pistons move outward, a vacuum is created. This vacuum is transmitted to the pump diaphragm causing it to pull back and suck fuel into the pump. As the engine's pistons move inward, crankcase vacuum is reduced and the diaphragm return spring pushes the pump diaphragm forward, forcing fuel through the pump outlet.

Fuel Pump Test Procedure

Before testing make certain the fuel pump vacuum and fuel line connections are tight and free of leaks.

1. Operate engine at an idle for five minutes to ensure that carburetor is full of fuel.

⚠WARNING ***Ignition of fuel can result in severe personal injury or death. Thoroughly clean up any spilled fuel.***

2. Shut engine off and remove fuel inlet line from fuel pump.

3. Connect a vacuum gauge to fuel pump inlet using a piece of fuel hose with clamps.

4. Start engine and allow to idle for at least five seconds. Record vacuum gauge reading.

5. Move throttle control to high idle position. Wait at least five seconds and record vacuum gauge reading.

6. Shut engine off and remove vacuum gauge hose from fuel pump inlet. Connect fuel inlet line to fuel pump.

⚠WARNING ***Ignition of fuel can result in severe personal injury or death. Thoroughly clean up any spilled fuel.***

7. Remove fuel outlet line from fuel pump.

8. Connect a pressure gauge to fuel pump outlet using a piece of fuel hose with clamps.

9. Start engine and allow to idle for at least five seconds. While holding pressure gauge level with pump outlet record pressure gauge reading.

10. Move throttle control to high idle position and allow engine to run for at least five seconds. While holding pressure gauge level with pump outlet record pressure gauge reading.

11. Shut engine off and remove pressure gauge hose from fuel pump outlet. Connect fuel outlet line to fuel pump.

Replace the fuel pump if test readings are not within the values specified in TABLE 1.

TABLE 1
PULSE PUMP TEST SPECIFICATIONS

ENGINE SPEED	PUMP INLET VACUUM (Minimum)	PUMP OUTLET PRESSURE (Minimum)
Low Idle	2.6 inches of mercury	1.7 psi
High Idle	2.6 inches of mercury	1.7 psi

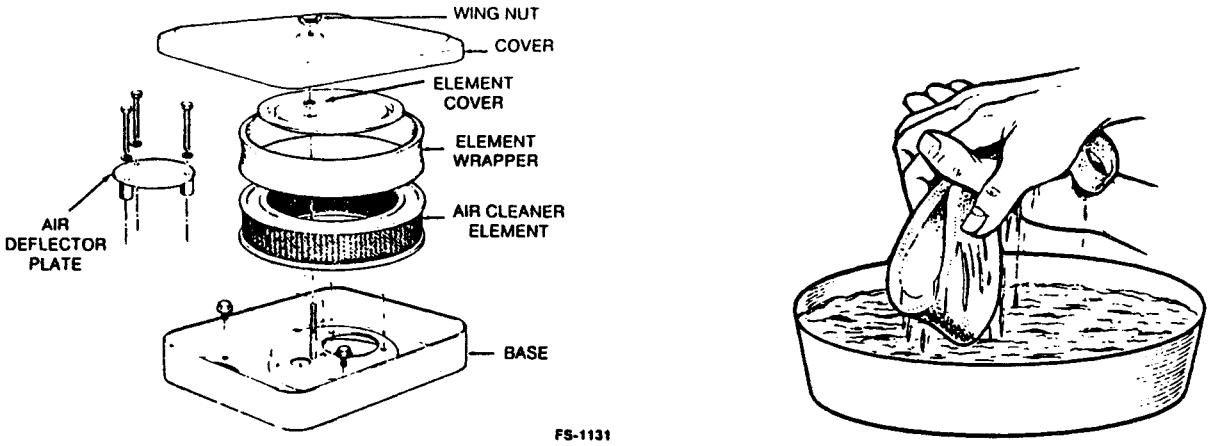


FIGURE 5. AIR CLEANER ASSEMBLY

AIR CLEANER

⚠CAUTION ***A dirty air cleaner element can cause engine damage. Ensure air cleaner element is kept clean and free of excess debris.***

Engine is equipped with a paper element. If the engine is equipped with an element wrapper, it must be removed, cleaned, and oiled every 25 hours of operation; more often under extremely dusty conditions.

1. To clean element wrapper, wash in water and detergent (Figure 5). Remove excess water by squeezing like a sponge, and allow to dry thoroughly. Distribute one tablespoon of SAE 30 engine oil evenly around the precleaner. Knead into precleaner and wring out excess oil.

2. Depending on conditions in which the engine is operating, the inner paper element should be replaced whenever it becomes excessively dirty or oily.

⚠CAUTION ***Running engine without air cleaner element will result in engine damage. Do not run engine without air cleaner element installed.***

GOVERNOR SENSITIVITY

These engines are adapted for use where a wide range of speed settings is desired. Engine speed is controlled at any given point between minimum and maximum by simply shifting the throttle lever on the control panel until the desired speed is reached.

A reliable instrument for checking engine speed is required for accurate governor adjustment. Engine speed can be checked with a tachometer.

Check the governor arm, linkage, throttle shaft, and lever for binding condition or excessive slack and wear at connecting points. A binding condition at any point will cause the governor to act slowly and regulation will be poor. Excessive looseness may cause a hunting condition and regulation could be erratic. Work the arm back and forth several times by hand while the engine is idling to check for above conditions.

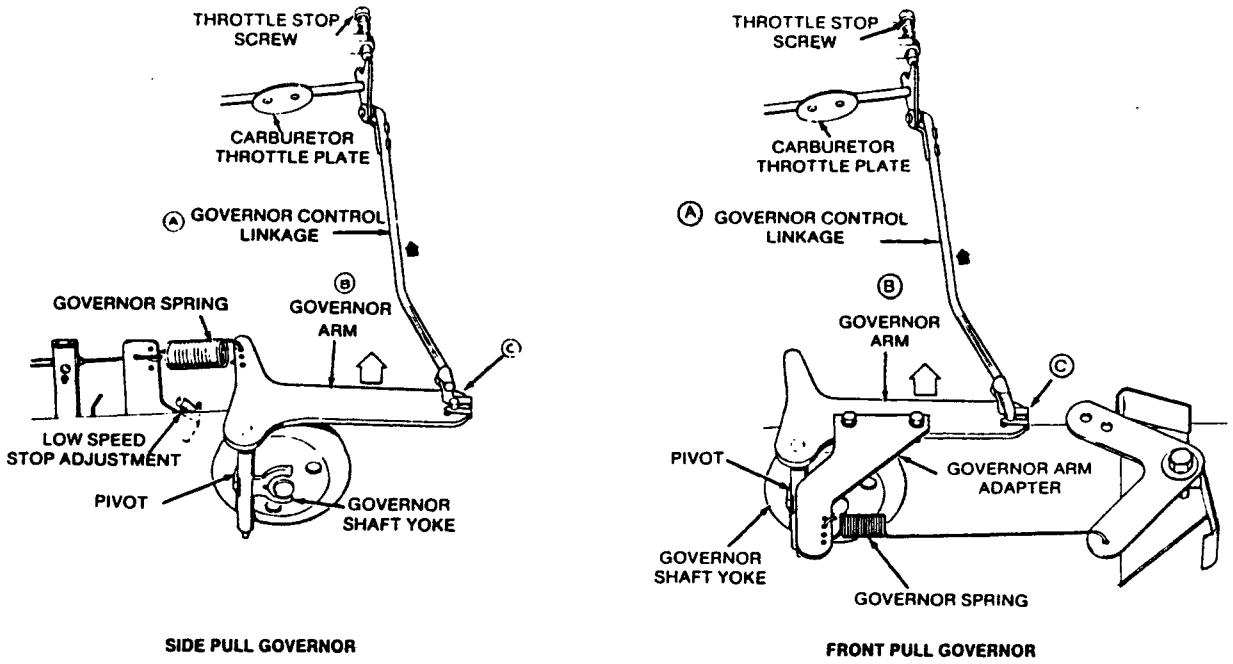


FIGURE 6. VARIABLE SPEED GOVERNOR ADJUSTMENTS

If the governor is hunting or not operating properly, adjust as follows (Figure 6):

1. Disconnect linkage (A) from one of holes (C).
2. Push linkage (A) and governor arm (B) as far back toward carburetor as they will go.
3. Holding linkage and governor arm toward direction of carburetor, insert end of linkage into whichever hole (C) in governor arm lines up the closest. If between two holes, insert in next hole out.

On side pull governors the governor spring is set by the factory in the third hole of the governor arm (third hole from pivot). On front pull governors the governor spring is set by the factory in the second hole of the governor arm adapter (second hole from pivot). To increase sensitivity, move spring loop into a hole closer to the pivot. To decrease sensitivity, move spring loop into a hole farther away from the pivot. After sensitivity has been set, recheck the low speed rpm setting. Adjust if necessary.

Ignition and Battery Charging

IGNITION SYSTEM DESCRIPTION

This engine is equipped with an electronic battery ignition system. Both spark plugs fire simultaneously, thus the need for a distributor is eliminated. The electronic ignition module is located on the engine gear cover behind the flywheel. The module receives a timing signal from magnets within the trigger ring which rotates with the engine crankshaft (Figure 1). If the electronic ignition is suspected of malfunctioning, proceed as follows:

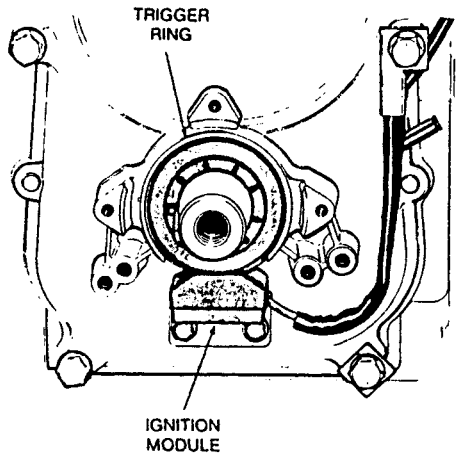


FIGURE 1. IGNITION MODULE AND TRIGGER RING

1. Check all electrical connections to be sure they are clean and tight. If all connections are good and wiring is intact, go to step 2.

2. Refer to IGNITION COIL section to test coil for proper resistance. If coil checks out good, go to step 3.

⚠WARNING ***The electronic ignition produces current which can cause electrical shock. Do not touch electrical components or wires while ignition is on.***

⚠WARNING ***Accidental starting of the engine can result in severe personal injury or death. Remove spark plugs before proceeding.***

⚠WARNING ***Ignition of cylinder gases can cause severe personal injury. Ground spark tester away from spark plug hole.***

3. Pull spark plug wires off spark plugs and remove spark plugs. Connect an approved spark tester to each of the spark plug wires and ground them away from spark plug hole. Turn key on and crank engine over for 5 seconds while watching for spark. If a spark occurs regularly, the problem is not in the ignition system. If no spark occurs, go to step 4.

⚠CAUTION ***Incorrect wiring can cause electronic ignition damage. Do not attach any lead or jumper with power (such as B+) to coil negative terminal.***

4. Connect a jumper lead directly from the positive battery terminal to the positive (+) coil terminal (smaller diameter of the two threaded posts). Crank engine over while watching for spark. If spark occurs, the problem is in the low oil pressure cut out switch (if equipped) or related wiring, the lubricating system (low oil pressure), or in the other circuitry bringing voltage to the coil. If no spark occurs, go to step 5.

5. Connect positive side of voltmeter to negative (-) coil terminal (larger diameter of the two threaded posts) and negative side of voltmeter to engine ground. Turn key on and rotate flywheel slowly by hand while observing voltmeter. Voltage should switch between battery voltage and 1-1.5 for each revolution. If voltage does not switch properly, replace ignition module.

⚠CAUTION ***Incorrect wiring can cause electronic ignition damage. Do not attach any lead or jumper with power (such as B+) to coil negative terminal.***

6. Install spark plugs and wires. If ignition module is being replaced, be sure to connect red lead from new ignition module to positive (+) terminal of coil, black lead from module to negative (-) terminal of coil.

IGNITION TIMING

The ignition timing is preset at the factory and is not adjustable. For troubleshooting purposes, it is possible to make an approximate check of the ignition timing using reference marks on the blower housing and flywheel (Figure 2). This check can be performed by a continuity test.

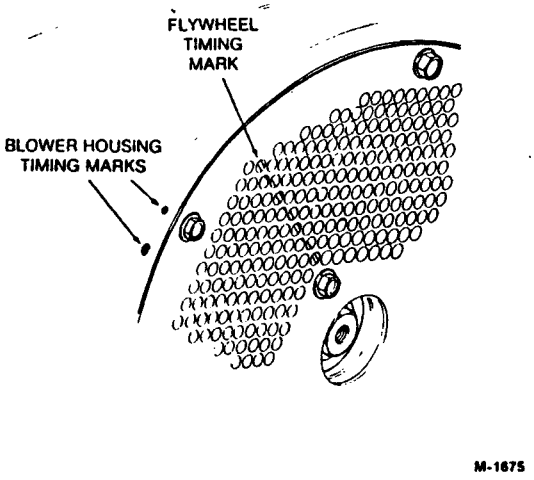


FIGURE 2. IGNITION TIMING MARKS

Continuity Test

1. Pull spark plug wires off spark plugs and remove spark plugs.

   ⚠WARNING ***Accidental starting of the engine can result in severe personal injury or death. Remove spark plugs before proceeding.***

2. Turn ignition on.

3. Connect a voltmeter between the negative (-) coil terminal (larger diameter of the two threaded posts) and a good engine ground.

   ⚠WARNING ***The electronic ignition produces current which can cause electrical shock. Do not touch electrical components or wires while ignition is on.***

4. Rotate the flywheel slowly by hand in the clockwise direction until the voltmeter reading switches from approximately 1 volt to battery voltage. At this point, one of the chaff screen screws should lie between the two timing marks on the blower housing. To recheck timing, the flywheel must be rotated another complete revolution in the clockwise direction. Moving the flywheel back and forth across the reference timing mark will not activate the electronic ignition control.

5. Install spark plugs and wires.

IGNITION COIL

To test primary and secondary windings within the ignition coil first make sure the ignition power is off and coil is at room temperature of 70°F (21°C).

1. Use a Simpson 260 VOM or equivalent.

2. Place a black lead on negative (-) coil terminal and red lead to positive (+) coil terminal. Primary resistance should read between 2.90-3.60 ohms.

3. Change resistance setting on ohmmeter. Place ohmmeter leads inside of spark plug cable holes (Figure 3). Secondary resistance should read between 14,500-19,800 ohms.

4. If either of the above resistances are not within specification, replace coil.

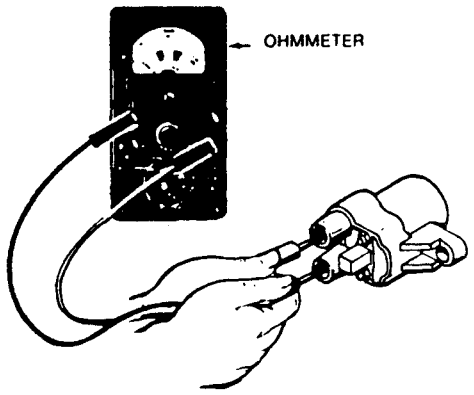


FIGURE 3. COIL TEST

SPARK PLUGS

Check or replace spark plugs as recommended in the *Periodic Maintenance Schedule* (located in Operator's Manual). Replace spark plugs that show signs of fouling or electrode erosion.

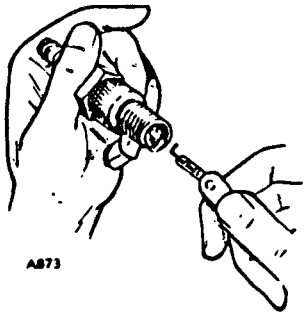


FIGURE 4. SPARK PLUG GAP

BATTERY INSPECTION

⚠WARNING ***Ignition of explosive battery gases can result in severe personal injury. Do not smoke or allow any ignition source near the battery.***

Check battery cells with a hydrometer (Figure 5). Specific gravity reading should be between 1.260 and 1.290 at 77°F (25°C).

If one or more cells are low on water, add distilled water and recharge. Keep the battery case clean and dry. An accumulation of moisture or dirt will accelerate discharge and battery failure.

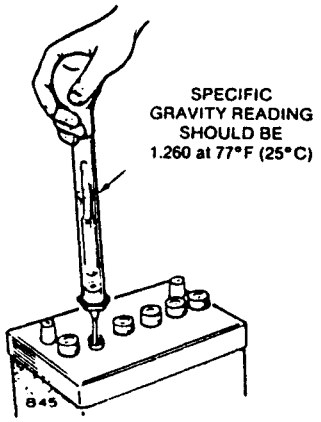


FIGURE 5. SPECIFIC GRAVITY TEST

Keep the battery terminals clean and tight. Push the cable terminal down flush with or slightly below the top of the battery post (Figure 6). After making connections, coat the terminals with a light application of petroleum jelly or grease to retard corrosion.

Poor contact at the battery cable connections is often a source of trouble. Make sure battery cables are in good condition and that contacting surfaces are clean and tightly connected. Do not reverse battery leads. Use recommended battery tools when disconnecting leads to avoid mechanical battery damage.

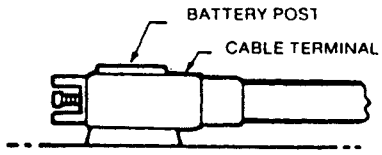


FIGURE 6. BATTERY CABLE CONNECTION

BATTERY JUMP STARTING

Occasionally, it may be necessary to jump start (charge) a weak battery using a charged booster battery. If jump starting is necessary, the following procedure is recommended to prevent starter damage, battery damage, and personal injuries.

1. Disconnect engine load.
2. Use a battery of the same voltage (12V) as is used with your engine.
3. Attach one end of the positive booster cable (red) to the positive (+) terminal of the booster battery. Attach the other end of the positive cable to the positive (+) terminal of your engine battery.

⚠WARNING ***Electrical arcing can cause severe personal injury. Do not allow positive and negative cable ends to touch.***

4. Attach one end of the negative booster cable (black) to negative (-) terminal of booster battery. Attach other end of negative cable to a solid chassis ground on your engine.

5. Jump starting in any other manner may result in damage to the battery or the electrical system.

⚠CAUTION ***Overcranking the engine can cause starter damage. Allow 5 minutes for starter to cool if engaged for longer than 30 seconds.***

⚠WARNING ***Jump starting a battery incorrectly can cause battery to explode, resulting in severe personal injury or death. Do not smoke or allow any ignition source near the battery, and do not jump start a frozen battery.***

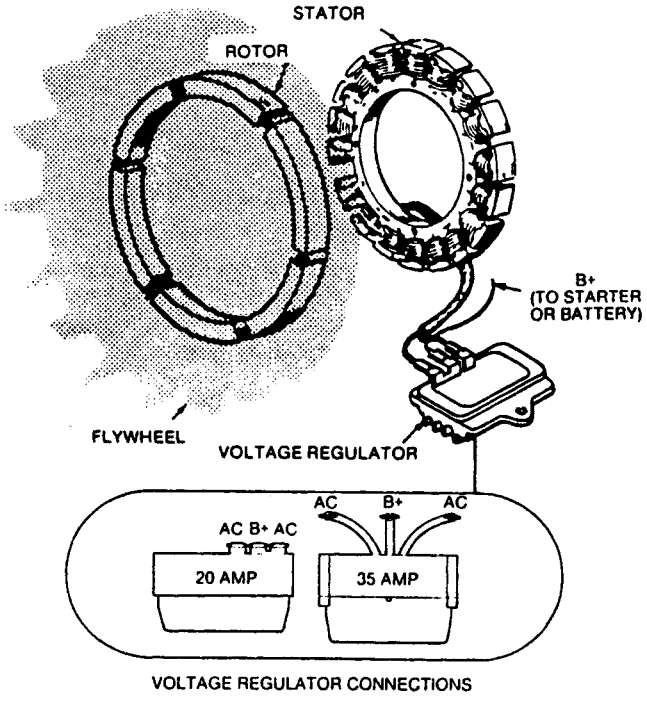
6. Turn ignition switch to ON to start engine.

FLYWHEEL ALTERNATOR

This unit is equipped with a permanent magnet flywheel alternator and solid-state voltage regulator-rectifier (Figure 7). As with all solid-state electrical units, precautions are necessary when servicing.

⚠CAUTION ***Reversing positive and negative battery connections or allowing engine to run without being connected to the alternator will result in engine electrical system damage. Do not switch battery connections or allow engine to run without being connected to the alternator.***

Weak ignition spark or a discharged battery indicates trouble in the charging system. Before testing the engine's charging system, always check the battery for serviceability.



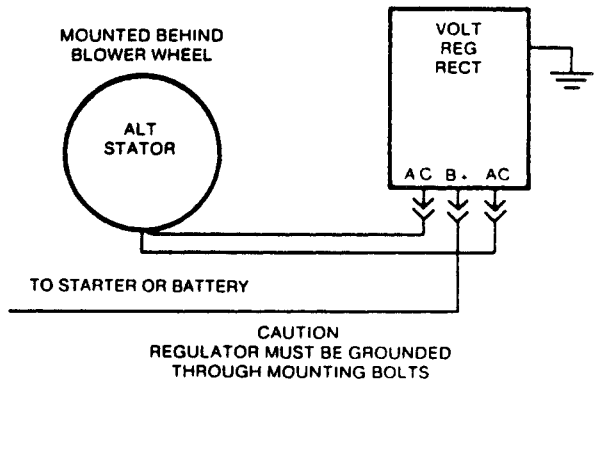


FIGURE 7. FLYWHEEL ALTERNATOR SYSTEM

Keep these points in mind when testing or servicing the flywheel alternator:

1. Be sure engine is being run long enough and fast enough to recharge battery after each start. Charging system tests require a full charged battery. Alternator output is reduced in direct proportion to engine rpm. Also, power required for accessories reduces power available to recharge battery.

2. The regulator-rectifier has built in protection against open circuits or short circuits on the alternator output (B+) terminal. Either condition will cause the regulator-rectifier to shut off and appear as if it is not functioning. Prior to checking the regulator-rectifier, check all wiring between the regulator-rectifier B+ terminal and the battery positive (+) terminal to assure it is free of open circuits, resistances or short circuits. Also, if the battery is extremely discharged it may have insufficient power to "turn on" the regulator-rectifier.

3. Be sure regulator-rectifier plug (connector) is inserted properly. Plug must bottom in receptacle; this eliminates any resistance due to a poor connection. Keep clean and tight.

4. Make sure alternator stator leads are not shorted together.

5. Be sure regulator-rectifier has a good ground connection. Mating surface for mounting must be clean and fasteners tightened properly.

6. Never reverse the battery leads.

When the engine is running between 1800 to 2600 rpm, observe the panel ammeter (if not already equipped, connect a test ammeter). If no charging is evident, proceed with the *Alternator Output Test.*

ALTERNATOR OUTPUT TEST

Use a volt-ohmmeter, such as the Simpson 270, when testing the charging system.

1. Check battery voltage with unit not running. If not within specifications (Table 1) charge battery before proceeding to step 2.

2. With the engine running, check the battery terminal voltage (regulator output) using a DC voltmeter. Voltage output should be within the values specified in Table 1. If voltage is greater than specified, replace regulator-rectifier assembly. If voltage is less than specified, proceed to step 3.

3. Examine all wires for loose, corroded, broken connections, short circuits, etc. Check fuses. Repair as needed to assure complete circuits from regulator-rectifier B+ terminal to battery positive (+) terminal and from battery negative (-) terminal to regulator-rectifier case. If battery voltage remains low with engine running, proceed to step 4.

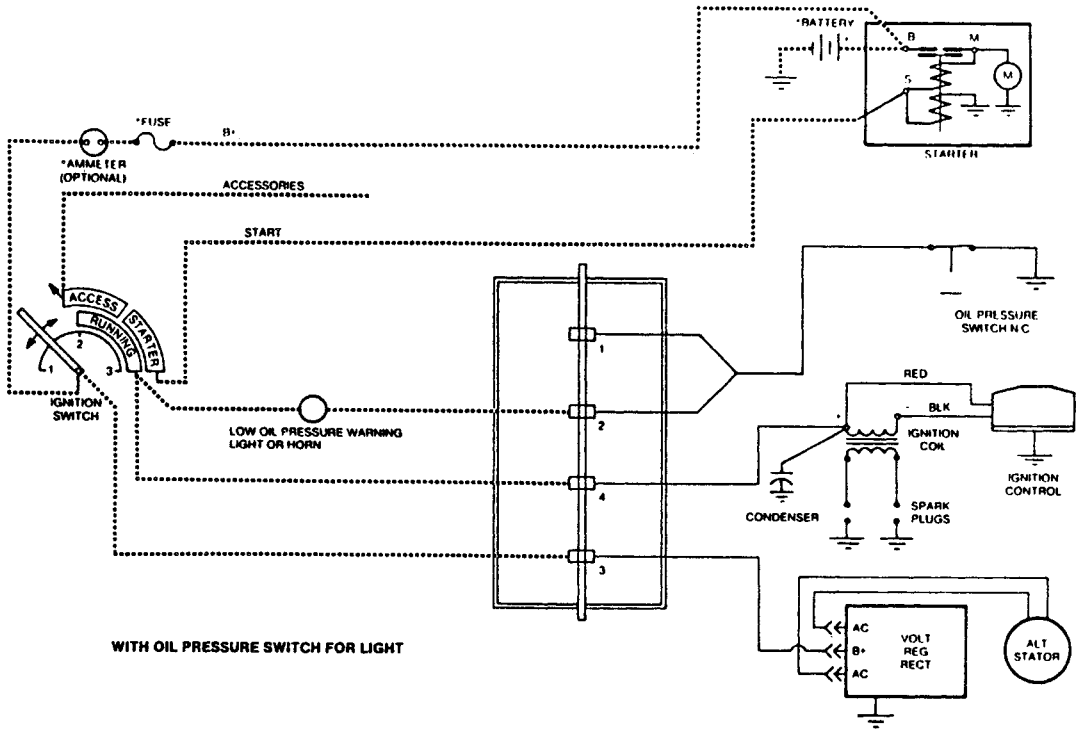
4. Disconnect plug from regulator-rectifier and test the AC voltage at the plug with engine running. If AC voltage reads more or less than specified in Table 1, proceed to step 5. If AC voltage is as specified but DC voltage is low, replace regulator-rectifier.

5. Use the Rx1 scale on the ohmmeter for detecting an open or ground in the stator (unit not running). Disconnect plug from the regulator-rectifier. Connect one ohmmeter test lead to a stator wire, connect the other test lead to ground. Reading should show an open (no continuity). If it doesn' t, stator must be replaced. If reading shows no continuity connect one ohmmeter lead to each wire coming from the stator. Refer to Table 1 for resistance specifications. If resistance is not as specified, replace stator. If stator resistance readings are as specified and windings are not shorted or open, low AC voltage may be due to loss of magnetism. If so, blower wheel assembly must be replaced.

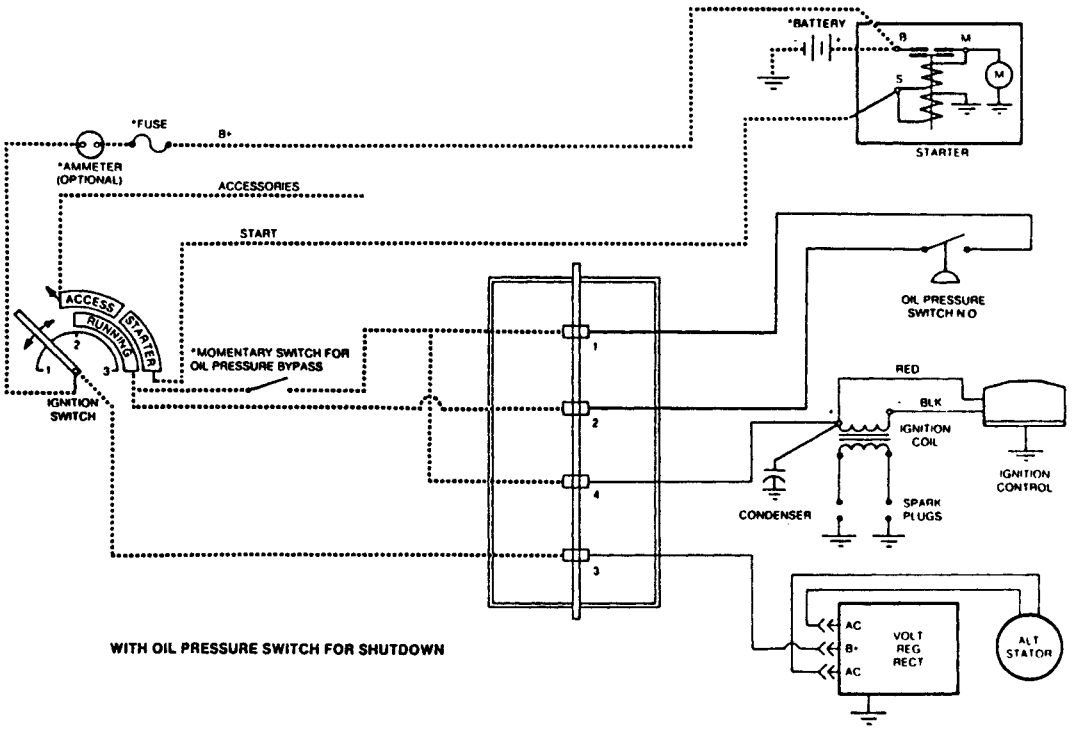
TABLE 1. TESTING 20 AND 35 AMPERE SYSTEMS

BASIC TEST	BATTERY	REGULATOR	STATOR AC VOLTAGE	STATOR RESISTANCE
PROCEDURE	Refer to *Alternator Output Test*	Refer to *Alternator Output Test*	Refer to *Alternator Output Test*	Refer to *Alternator Output Test*
SPEC A 20 AMP	12 to 13 VDC	13.6 to 14.7 VDC	Approximately 21 VAC @ 1800 rpm Approximately 41 VAC @ 3600 rpm	0.06 to 0.10 Ohms
BEGIN SPEC B 20 AMP	12 to 13 VDC	13.6 to 14.7 VDC	Approximately 29 VAC @ 1800 rpm Approximately 57 VAC @ 3600 rpm	0.10 to 0.19 Ohms
35 AMP	12 to 13 VDC	13.6 to 14.7 VDC	Approximately 24 VAC @ 1800 rpm Approximately 47 VAC @ 3600 rpm	0.06 to 0.10 Ohms

TYPICAL WIRING DIAGRAM



WITH OIL PRESSURE SWITCH FOR LIGHT



WITH OIL PRESSURE SWITCH FOR SHUTDOWN

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These typical wiring diagrams show the basic wiring necessary for operation of the engine. Your engine may differ in circuitry and features depending on how the equipment manufacturer chose to configure the final product.

Starting System

ELECTRIC STARTER

Normally the starter will require little or no service other than possible brush replacement. However, if through accident or misuse, the starter requires service or overhaul, the following will provide the information necessary to perform this service.

Service

When starting engine, note starter motor action. The pinion gear should mesh quickly with flywheel ring gear and spin engine. Once engine starts and solenoid opens, the starter should disengage and stop. If starter cranks engine slow, or not at all, check start circuit components. Failure to crank is normally caused by low battery charge, defective battery cables, corroded or poor connections, or low temperatures. If after checking these variables, starter continues to crank slowly, starter must be removed and repaired.

Starter Removal

⚠WARNING ***Accidental starting of the engine can result in severe personal injury or death. Disconnect the negative battery cable and spark plug wires while servicing engine, controls, or associated equipment.***

1. Remove both battery cables from battery. Disconnect ground cable first.
2. Disconnect battery cable and electrical lead wires from starter.
3. Remove starter motor.

Starter Disassembly

1. Remove "M" terminal nut and wire lead from solenoid (Figure 1).
2. Remove the two solenoid mounting screws and remove solenoid.
3. Scribe a mark across frame and rear bracket to aid in assembly. Remove the two through bolts.
4. Remove rear bracket and frame assembly.
5. Carefully remove armature and lever from front bracket. Note direction of lever and retainer.
6. Remove the two brush mounting screws, and remove the rear bracket.
7. Remove brush holder assembly from the frame by pulling the brushes out.

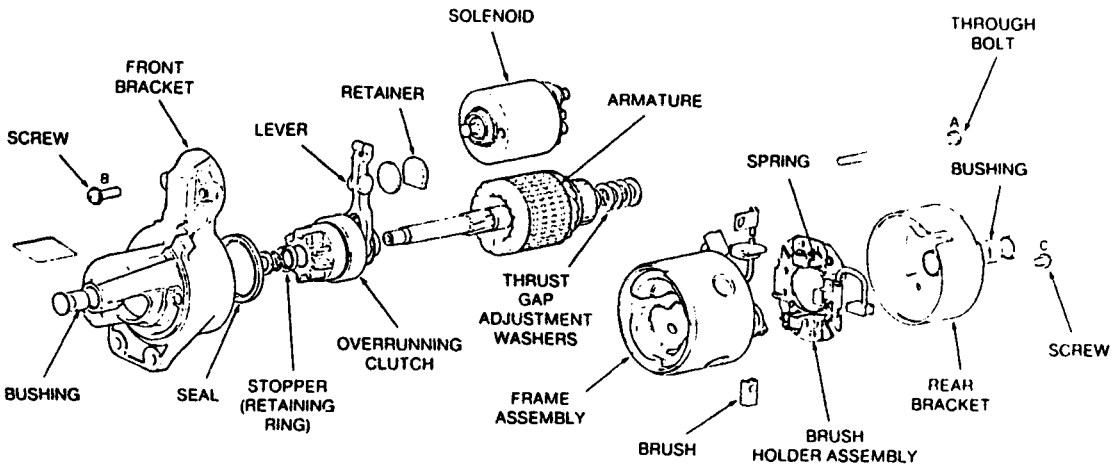

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FIGURE 1. STARTER MOTOR

8. Push stopper toward pinion and remove snap ring (Figure 2).

9. Remove stopper and overrunning clutch from armature shaft.

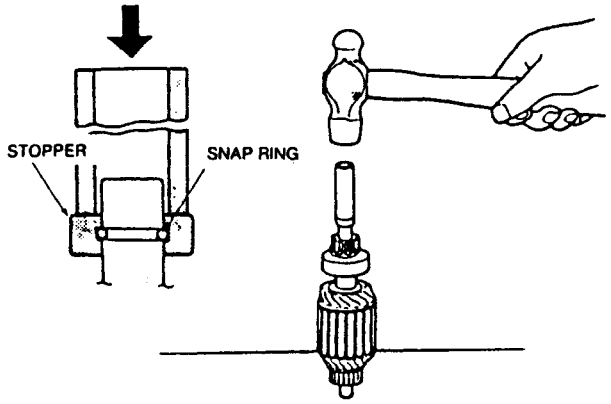


FIGURE 2. REMOVING OVERRUNING CLUTCH

10 Inspect starter for damaged or worn parts.

11. Repair or replace all damaged or worn parts as needed.

Starter Assembly

1. Install seal in nose housing. Install overrunning clutch on the armature shaft.

2. Slide stopper on the armature shaft. Position snap ring in groove in armature shaft.

3. Pull stopper all the way over snap ring (Figure 3). It may be necessary to tap snap ring into groove with a punch while maintaining tension on stopper.

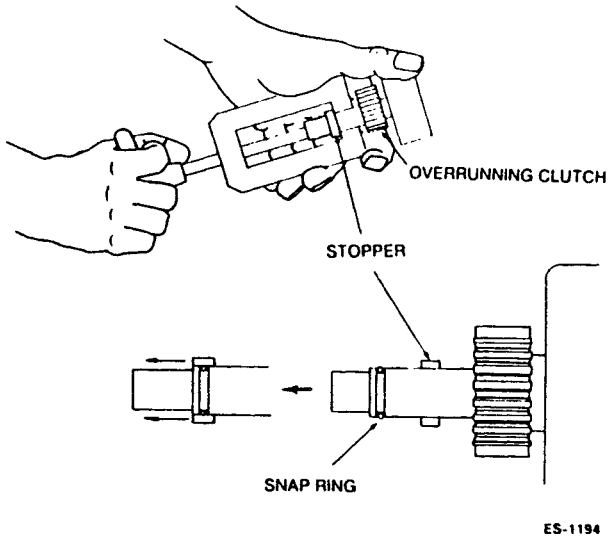


FIGURE 3. INSTALLING STOPPER

4. Lubrication: When starter motor is assembled apply grease to each of the following points (Recommended grade: Multemp PS No. 2):

   - Armature shaft spline
   - Both bushings (Both ends of armature)
   - Stopper on armature shaft
   - Pinion gear
   - Sliding portion of lever

5. Fit overrunning clutch into lever, and install with armature in the front bracket.

6. Install lever retainer and spacer. Position frame assembly over armature on the front bracket.

7. Install brush holder assembly. Position brushes in brush holder. Make certain positive lead wires are not grounded.

8. Install washers, as required, on the rear end of armature shaft to obtain an armature shaft thrust gap of 0.002 to 0.02 inch (0.05 to 0.5 mm). New washers are required if rear bracket is replaced.

Table 1. Starter Assembly Torques

Solenoid Screws	54 in.-lb.	(6.1 Nm)
Brush Retaining Screws	33 in.-lb.	(3.7 Nm)
Through Bolts	51 in.-lb.	(5.8 Nm)

9. Install rear bracket. Secure brush holder to rear bracket with two machine screws.

10. Install and tighten the two through capscrews.

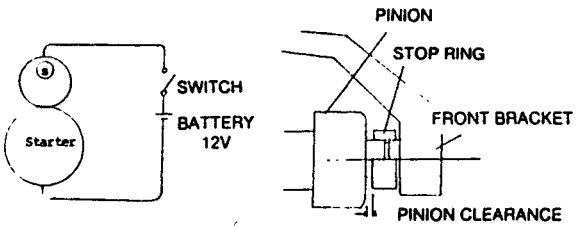
11. Install solenoid plunger in lever. Secure solenoid to front bracket with two machine screws.

12. Install wire lead to the terminal "M" on solenoid.

13. After assembly, adjust pinion clearance. Pinion clearance should be 0.02 to 0.08 inch (0.5 to 2.0 mm); if not, check as follows (Figure 4):

    A. Connect starter to a battery. Close switch. This will shift pinion into cranking position.

    B. Push pinion back by hand and measure pinion clearance. If clearance does not fall within the specified limits, adjust by adding or removing shims located between solenoid and front bracket. Adding shims decreases clearance; removing shims increases clearance. Shims are included with replacement solenoid.



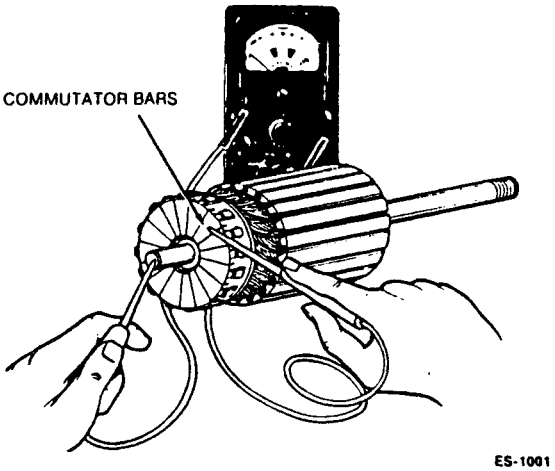
ES-1623

FIGURE 4. PINION CLEARANCE ADJUSTMENT

Inspection and Testing

Inspect the starter components for mechanical defects before testing for grounds or shorts.

Testing Armature for Grounds: Touch armature shaft or core and the end of each commutator bar with a pair of ohmmeter leads (Figure 5). A low ohmmeter reading indicates a grounded armature. Replace grounded armature.

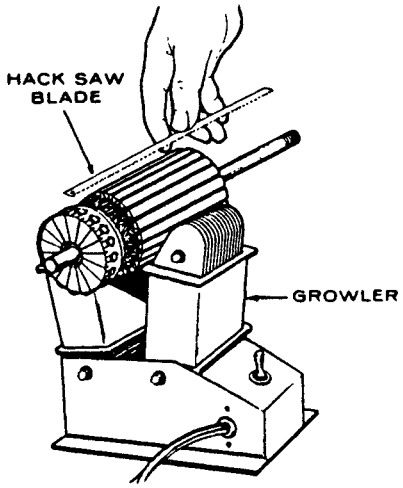


ES-1001

FIGURE 5. TESTING ARMATURE FOR GROUNDS

Testing Armature for an Open Circuit: Using an ohmmeter, check for continuity between the commutator segments. If there is no continuity (high resistance), the segments are open and armature must be replaced.

Testing Armature for a Short Circuit: Use a growler for locating shorts in the armature (Figure 6). Place armature in growler and hold a thin steel blade (e.g. hacksaw blade) parallel to the core and just above it while slowly rotating armature in growler. A shorted armature will cause the blade to vibrate and be attracted to the core. If armature is shorted, replace with a new one.



ES-1002

FIGURE 6. TESTING ARMATURE FOR SHORT CIRCUITS

Commutator Inspection: If commutator is dirty or discolored, clean with number 00 to 000 commutator paper. Blow grit out of armature after cleaning.

If commutator is scored, rough, or worn, turn it down in a lathe.

Field Coil: Use an ohmmeter to check for continuity between brushes. If there is no continuity, the field coil is open and must be replaced. With field coil mounted in the frame, check for continuity between the field coil and frame. Replace frame assembly if there is continuity.

Brushes: Clean around brushes and holders, wiping off all brush dust and dirt. If brushes are worn shorter than .4528 inch (11.5 mm) replace them (Figure 7).

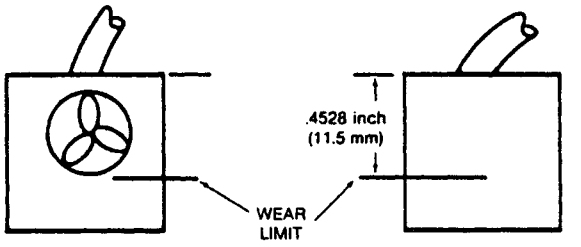


FIGURE 7. BRUSH WEAR LIMIT

Check for shorts between positive side of brush holder and brush holder base. If there is continuity, replace holder assembly. Check for free movement of brushes. All brushes should move freely in the brush holders.

Overrunning Clutch: Inspect pinion and spline teeth for wear or damage.

If pinion gear is worn or damaged, inspect flywheel ring gear also. Rotate pinion. It should turn free when turned in one direction, and lock when turned in the opposite direction.

⚠CAUTION ***Cleaning overrunning clutch in liquid cleaning solution will result in starter damage. Do not clean overrunning clutch in liquid cleaning solutions.***

Solenoid: Push solenoid plunger in and release it. The plunger should return to its original position. While holding plunger all the way in, check for continuity between terminals "M" and "B". If there is no continuity, replace the solenoid (Figure 8). After replacing solenoid check pinion clearance.

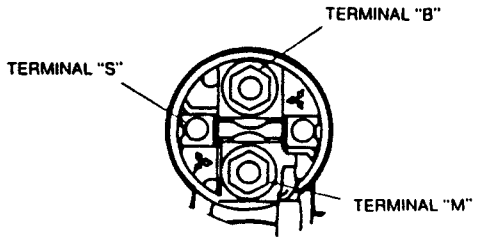


FIGURE 8. SOLENOID TERMINALS

Bushings: If either the front or rear bushing show signs of wear or damage, replace them. Bushing and rear bracket are replaced as an assembly. Check armature shaft thrust gap if rear bracket is replaced.

Remove front bushing by tapping bushing from inside with a 7/16 inch tap. Do not remove cap from front bracket. Thread capscrew, same size as tap, into bushing. Using a slide hammer remove bushing from front bracket. Press new bushing into front bracket. Use care not to distort inside diameter of bushing.

Brush Replacement: Cut old positive brush from pigtail at the brush. Be careful not to damage field coil. Clean 1/4 to 3/8 inch (6.5 to 9.5 mm) of brush end of pigtail with sandpaper or emery cloth. (Figure 9).

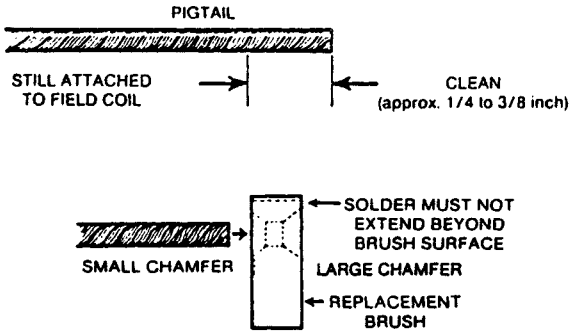


FIGURE 9. BRUSH REPLACEMENT

Push prepared end of pigtail lead into hole in replacement brush from the small chamfered side. Solder pigtail lead to replacement brush on the large chamfered side, using 50/50 tin/lead, rosin core solder and a standard 240/325 Watt soldering iron. Use a file to remove any excess solder that may extend beyond brush surface.

⚠CAUTION ***Material protruding from soldered side surface of brush can cause equipment damage. Do not use excessive solder or heat and file any excess material from brush surface.***

Starter Mounting

Before installing starter motor, make sure the starter mounting surface on the engine base is clean and free of oil.

To install starter use the following procedure. The starter pinion gear lash does not require adjustment.

1. Install starter motor and torque mounting capscrews to that specified in *ASSEMBLY TORQUES.*

2. Connect battery cable and wires to starter. Connect battery cables to battery. Connect ground cable last.

Engine Disassembly

DISASSEMBLY/ASSEMBLY

When complete engine disassembly is necessary, first remove all complete assemblies. Individual assemblies such as fuel pump and carburetor can be disassembled and repaired at another time.

Suggested Disassembly Order

1. Drain crankcase.
2. Disconnect all exhaust and electrical lines.
3. Remove engine from its mountings and place on a suitable bench or work stand.
4. Remove all housings, shrouds, blower housings, etc.
5. Remove flywheel, using a puller.
6. Remove ignition trigger and gear cover, being careful to protect oil seal from keyway damage.
7. Remove crank gear, using a gear puller and ring.
8. Remove all accessories such as oil filter, starter, intake manifold, fuel lines, spark plugs, etc.
9. Remove oil base, oil pump and cylinder heads.
10. Remove valves, springs, lifters, etc.
11. Remove camshaft and gear assembly.
12. Remove connecting rods and pistons.
13. Remove rear bearing plate, crankshaft, and front bearing.

Keep all parts in their respective orders. Keep valve assemblies together. Return rod caps to their respective pistons. Analyze the reasons for parts failure.

Suggested Assembly Procedure

Engine assembly is normally the reverse of the disassembly procedure, observing proper clearances and torques. Use a torque wrench to assure proper tightness. Coat the internal engine parts with oil as they are assembled. After the internal engine parts are assembled, the engine should turn over by hand freely. Use only genuine Onan parts and special tools when reassembling your engine.

1. Use proper bearing driver to install front main bearing after coating it with a light film of oil.
2. Insert rear main bearing in rear bearing plate.
3. Insert crankshaft, rear bearing plate, and crankshaft gear.
4. Install pistons and connecting rods.
5. Install camshaft and gear assembly; align crank gear mark with cam gear mark.
6. Install valve assemblies, oil pump, oil base, and cylinder heads.
7. Install all accessories such as oil filter, starter, fuel lines and spark plugs.
8. Install gear cover with oil seal, trigger ring, and flywheel.
9. Check valve clearance.
10. Install all housings and air cleaner.
11. Fill crankcase with oil.

Operation

Start engine and check oil pressure. Run for approximately 15 minutes to bring engine to operating temperatures. Check for oil leaks, fuel leaks, and exhaust leaks. Adjust carburetor and governor for speed and sensitivity.

Testing Compression

The compression tester is used to determine the condition of valves, pistons, piston rings and cylinders.

To check compression:

1. Run the engine until thoroughly warm.
2. Stop engine and remove spark plugs.
3. Remove air cleaner and place throttle and choke in the wide open position.
4. Insert the compression gauge in one spark plug hole.
5. Crank the engine and note the reading.

Refer to *SPECIFICATIONS* for compression pressures. There may be variations due to equipment, temperature, atmospheric conditions and altitude. These pressures are for a warm engine at cranking speed (about 300 rpm).

Tappet Adjustment

The engine is equipped with adjustable valve tappets. The valve tappet clearance should be checked and adjusted as specified in the *Periodic Maintenance Schedule* (located in the Operator's Manual). Adjust the valve clearance only when engine is at ambient temperature. Proceed as follows:

1. Remove ignition key to prevent accidental starting.
2. Remove all parts necessary to gain access to valve tappets.
3. Remove spark plugs to ease the task of turning the engine over by hand.
4. Place a socket wrench on the flywheel capscrew and rotate the crankshaft in a clockwise direction until the left intake valve (viewed from flywheel end) opens and closes. Continue turning the crankshaft until the TC mark on the flywheel is lined up with the TC mark on the gear cover. This should place the left piston (#1) at the top of its compression stroke. Verify that the left intake and exhaust valves are closed and there is no pressure on the valve lifters.
5. The correct feeler gauge for the valve adjustment (see *SPECIFICATIONS)* should pass freely between valve cap (P216, P218, P220) or valve stem (P224) and tappet; a 0.002 inch (0.05 mm) thicker gauge should not (Figure 1).
6. To correct valve clearance, use a 7/16 inch open end wrench to turn the adjusting screw to obtain the correct clearance. The screw is self-locking and will stay where it is set. A 9/16 inch (14 mm) open end wrench is required to hold the tappet while turning the adjusting screw.
7. To adjust valves on the right hand cylinder, turn engine one complete revolution and again line up mark on the flywheel and the TC mark on the gear cover. Then follow adjustment procedure given for left hand cylinder.
8. Replace all parts removed in Step 2. Tighten all screws securely. Torque manifold bolts to specified torque.

VALVE SYSTEM

A properly functioning valve system is essential for good engine performance. All engines utilize an L-head type valve design as shown in Figure 1. Access to the valve system can be obtained by removing the cylinder heads and the valve covers on top of the engine. A valve spring compressor must be used to remove valves from the cylinder block.

A valve stem seal is used on the intake valve guides. This seal must be replaced each time the valve is removed.

Place valves, springs, retainers, and tappets in a rack as they are removed from cylinder block so they can be identified and reinstalled in their original locations. Discard old valve stem seals and replace with new ones during assembly.

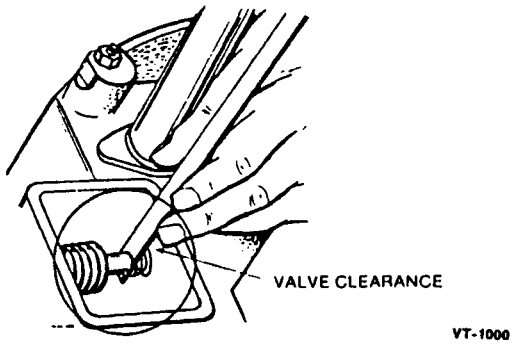
Use the following procedures to inspect and service the valve system.

Inspection

Clean carbon from the valves, valve seats, valve guides, and cylinder block.

Valves: Check the valve face for evidence of burning, warpage, out-of-round, and carbon deposits.

Burning and pitting are caused by the valve failing to seat tightly. This condition is often caused by hard carbon particles on the seat. It may also be due to weak valve springs, insufficent tappet clearance, warpage, and misalignment.



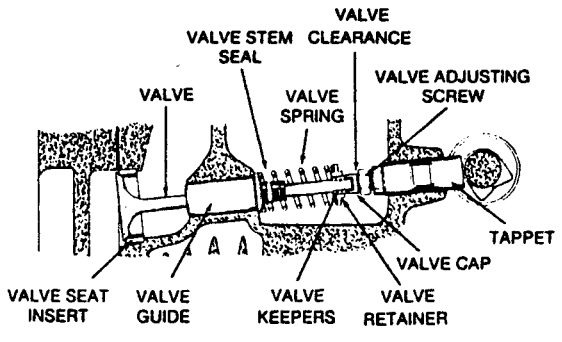


FIGURE 1A. INTAKE VALVE ASSEMBLY - P216, P218, P220

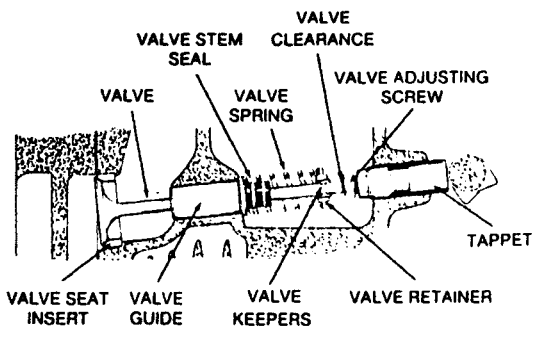


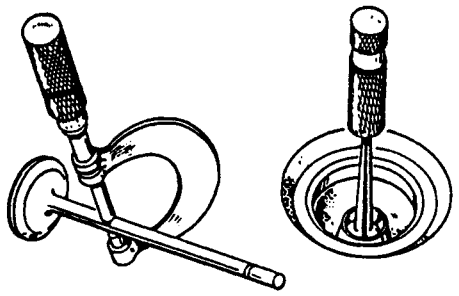
FIGURE 1B. INTAKE VALVE ASSEMBLY - P224

Warpage occurs chiefly in the upper stem due to its exposure to intense heat. Out-of-round wear follows when the seat is pounded by a valve whose head is not in line with the stem and guide. If a valve face is burned or warped, or if the stem is worn, install a new valve.

Too much clearance in the intake guide admits air and oil into the combustion chamber, upsetting carburetion, increasing oil consumption, and making heavy carbon deposits. Carbon reduces heat dissipation. Clean metal is a good heat conductor but carbon insulates and retains heat. This increases combustion chamber temperatures which causes warping and burning.

Unburned carbon residue gums valve stems and causes them to stick in the guide. Deposits of hard carbon with sharp points projecting become white hot and cause pre-ignition and pinging.

Refinish valves that are slightly pitted or burned on an accurate valve grinder. If valves are badly pitted or have a thin margin when refacing, replace them.



VT-1020

FIGURE 2. VALVE STEM AND VALVE GUIDE INSPECTION

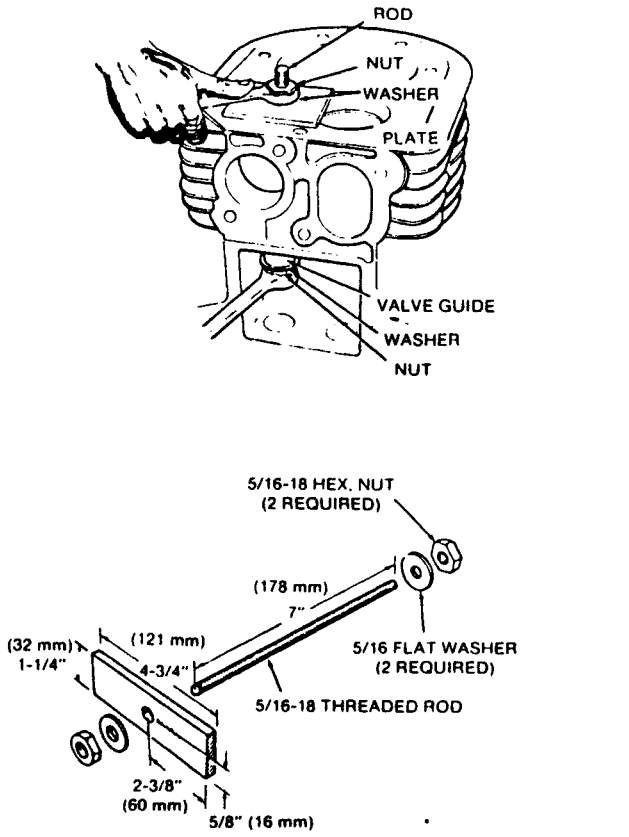
Stems and Guides: Always check valve stems and guides for wear (Figure 2). Use a hole gauge to measure the valve guide. When clearance with stem exceeds that specified in *DIMENSIONS AND CLEARANCES* replace either valve or guide or both, as may be necessary. Always regrind seat to make concentric with the newly installed guide.

Worn valve stem guides can be replaced from inside the valve chamber (a seal is provided behind the intake valve guides only). The smaller diameter of the tapered valve guides must face toward the valve head. Tappets are also replaceable from the valve chamber after first removing the valve assemblies.

Valve Guide Removal: Before removing valve guides, use an electric drill with a wire brush to remove carbon and other foreign material from top surface of guides. Failure to perform this operation may result in damage to the guide bores. Drive the guides out with a hammer and valve guide drive.

⚠CAUTION ***Driving out old valve guides can cause guide and tappet bore damage. Do not strike guide or tappet bores with driver during removal.***

Valve Guide Installation: Run a small polishing rod covered with crocus cloth through valve guide holes to clean out carbon and other foreign materials. Place a new gasket on the intake valve guide, and coat the outer edge of each new guide with oil. Place guide in cylinder block and press in until guide protrudes 11/32 inch (8.7 mm) from valve box side of block. A suggested method of installation is shown in Figure 3.



VT-1023

FIGURE 3. VALVE GUIDE INSTALLATION

Valve Stem Seals (intake only): Do not reuse valve stem seals. Each time the valves are removed from cylinder block, a new seal must be used when valve is reinstalled.

⚠CAUTION ***Removing a valve after installing valve stem seal can cause seal damage. Do not allow valve stem groove to come in contact with valve stem seal after installation.***

Valve Spring: Check valve springs for cracks, worn ends, distortion, and tension. If spring ends are worn, check valve spring retainer for wear. Check for spring distortion by placing spring on a flat surface next to a square. Measure height of spring and rotate it against square edge to measure distortion. If distortion exceeds 0.06 inch (1.5 mm) replace spring. Check spring tension at the installed height for both the valve open and closed position using an accurate valve spring tester. Replace any valve spring that is weak, cracked, worn, or distorted.

Valve Rotators: The P216, P218, and P220 engines use free-rotating intake and exhaust valves. While in the open position, the valves must rotate freely.

The P224 engine uses positive type valve rotators on the exhaust valves. When functioning properly, the valves are rotated a fraction of a turn each time they open. While in the open position, the valves must rotate freely. There is no easy way to determine if a valve rotator is good or bad. Onan recommends that valve rotators be replaced at each major overhaul or if a build up of carbon is noted on valve face and valve seat.

Valve Seats: Inspect valve seat inserts. If seats are loose, cracked or severely pitted, new ones must be installed. Remove valve seat inserts using a valve seat removal tool. If valve seat insert bores in cylinder block are damaged or worn so that a press fit cannot be obtained when installing new standard size valve seat inserts, the bores must be machined for an oversize seat.

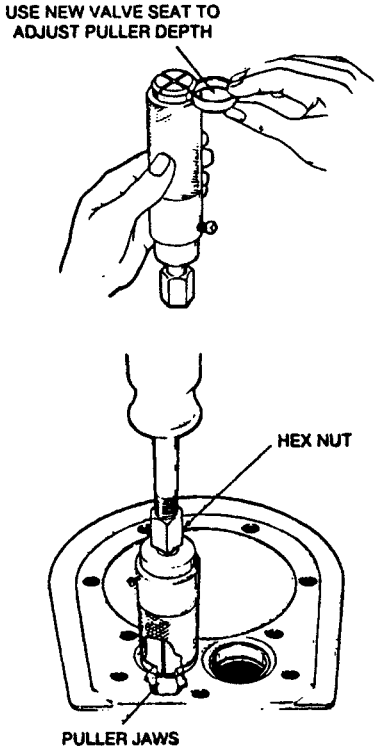


FIGURE 4. VALVE SEAT REMOVAL

Valve Seat Removal: Remove carbon and combustion deposits from valve seat. Select proper puller size determined by inside diameter of valve seat. On some pullers use a new seat as a guide to adjust puller depth (Figure 4). Puller jaws must expand into cylinder block at the point where bottom of valve seat insert rests on cylinder block. Position puller on valve seat and tighten hex nut. Clamp cylinder block to a solid bench. Attach slide hammer to puller. Tighten hex nut between each blow with the slide hammer.

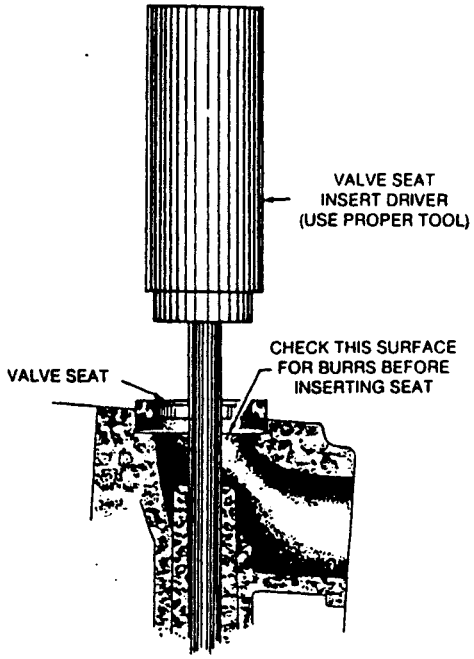


FIGURE 5. INSERTING NEW VALVE SEAT

Valve Seat Installation: After the old seat has been removed, clean out any carbon or metal burrs from the seat insert recess. Use a valve seat insert driver and hammer to install the insert (Figure 5). Drive the valve seat insert in so the insert enters the recess evenly. Make certain that the valve seat insert rests solidly on the bottom of the recess all the way around its circumference.

To assure a tight valve seat fit and eliminate the danger of seat loosening in the bore, valve seat must be staked.

Insert valve seat staker into valve seat or guide in cylinder block. Using a lead hammer, strike the staking tool a sharp blow to wedge new valve seat securely in place. It will be necessary to refinish valve seat inserts before installing valves.

TAPPETS

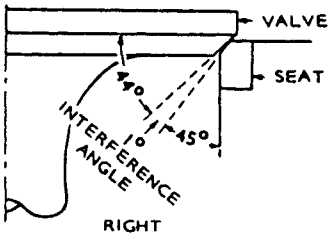
Very little wear takes place on tappet diameters or in tappet bores. If the clearance between tappet and bore in cylinder block exceeds specifications, replace the tappet.

Inspect the tappet faces which contact camshaft lobes for roughness, scuffing, or concave wear. Replace any worn tappets. If tappets are worn, inspect camshaft for wear.

VALVE FACE AND SEAT GRINDING

Before installing new valves or previously used valves, inspect valve seats for proper valve seating. If used valves are reinstalled, the valve stems should be cleaned and valve faces ground to their specified angles of 44°. Refinish valve seats to a 45° angle. When refacing valves and seats, remove all evidence of pitting and grooving. If end of valve stem is pitted or worn, true it and clean it up on the refacer wheel. A very light grind is usually enough to square stem and remove any pits or burrs. The valve guide should be thoroughly cleaned. If valve guide is worn, or valve is warped, the necessary parts must be replaced.

By grinding the valve face and seat at slightly different angles, a fine line of contact on face and seat is obtained, eliminating the need to lap the seating surfaces. The one degree difference in angles is defined as the interference angle (Figure 6). The seat angle is greater than that of the valve face. This assures contact at the maximum diameter on valve seat seating surface.



VT-1021

FIGURE 6. VALVE INTERFERENCE ANGLE

Refinish valve faces to a 44° angle on a valve refacing machine. The first cut from valve face must be a light grinding. Check if there is an unevenness of metal being removed. If only part of valve's face has been touched, check to see if valve is properly seated in machine or if valve is warped, worn, or distorted. When cut is even around the whole valve face, keep grinding until complete face is ground clean. Be sure the correct valve face angle is maintained. When valve head is warped, a knife edge will be ground (Figure 7) on part or all of the head due to the large amount of metal that must be removed to completely reface valve. Heavy valve heads are required for strength and good heat dissipation. Knife edges lead to breakage, burning, and pre-ignition due to heat localizing on the edge.

Replace any valve that cannot be entirely refaced while keeping a good valve margin (Figure 7) or is warped, worn, or damaged in any way. The amount of grinding necesary to true a valve indicate whether valve head is worn or warped.

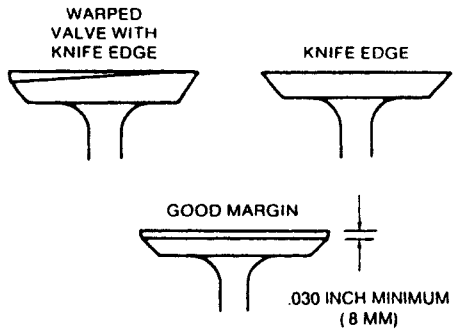


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FIGURE 7. VALVE HEAD MARGIN

When new valve seats are installed, or previously used seats reground, refinishing must be done with a valve seat grinder used according to the manufacturer's directions.

Valve seats should be ground with a 45 degree stone and the width of the seat band should be 1/32 inch to 3/64 inch (0.8 to 1.2 mm) wide. Grind only enough to assure proper seating.

Place each valve in its proper location. Check each valve for a tight seat. Make several marks at regular intervals across the valve face using machinist's bluing. Observe if the marks rub off uniformly when the valve is rotated part of a turn against the seat. The valve seat should contact the valve face evenly at all points. The line of contact should be at the center of the valve face.

FLYWHEEL

Removing the flywheel is a relatively simple process, but the following procedure must be followed to avoid damage to the gear case and possible injury to the operator.

1. Turn the flywheel mounting screw outward about two turns.

   ⚠WARNING ***Incorrect flywheel removal can result in severe personal injury. Do not remove flywheel screw completely when using flywheel puller.***

2. Install a puller bar on the flywheel (Figure 8).

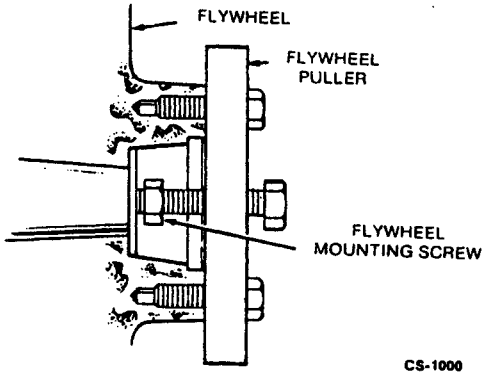

FIGURE 8. BLOWER WHEEL PULLEY

3. Turn the puller bar bolts in, alternately, until the wheel snaps loose on the shaft.

   ⚠CAUTION ***Improper flywheel removal can cause gear case damage. Do not use any tools to pry against gear cover when removing flywheel.***

4. Unscrew the puller from the flywheel, remove the flywheel mounting screw and washer and pull the flywheel off the shaft. Take care not to drop the wheel. A bent or broken fin will destroy the balance.

GEAR COVER

After removing the mounting screws, tap the gear cover gently with a soft faced hammer to loosen it.

When installing the gear cover, make sure the pin in the gear cover engages the nylon lined (smooth) hole in the governor cup. Turn the governor cup so the nylon lined hole is at the three o'clock position. Use a small amount of grease to assist in holding governor cup in position. The smooth side of the governor yoke must ride against the governor cup. Turn the governor arm and shaft clockwise as far as possible and hold in this position until the gear cover is installed flush against the crankcase. Be careful not to damage the gear cover oil seal (Figure 9).

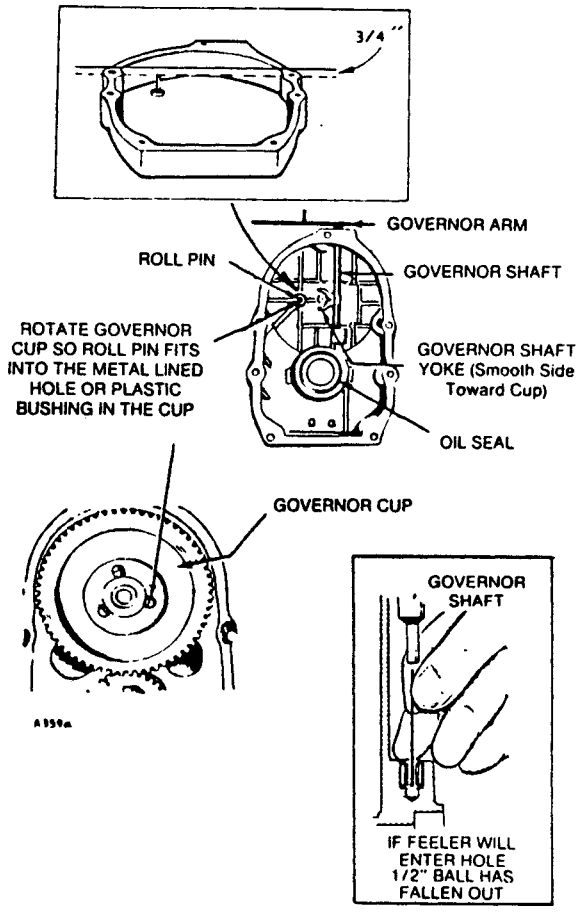

FIGURE 9. GEAR COVER ASSEMBLY

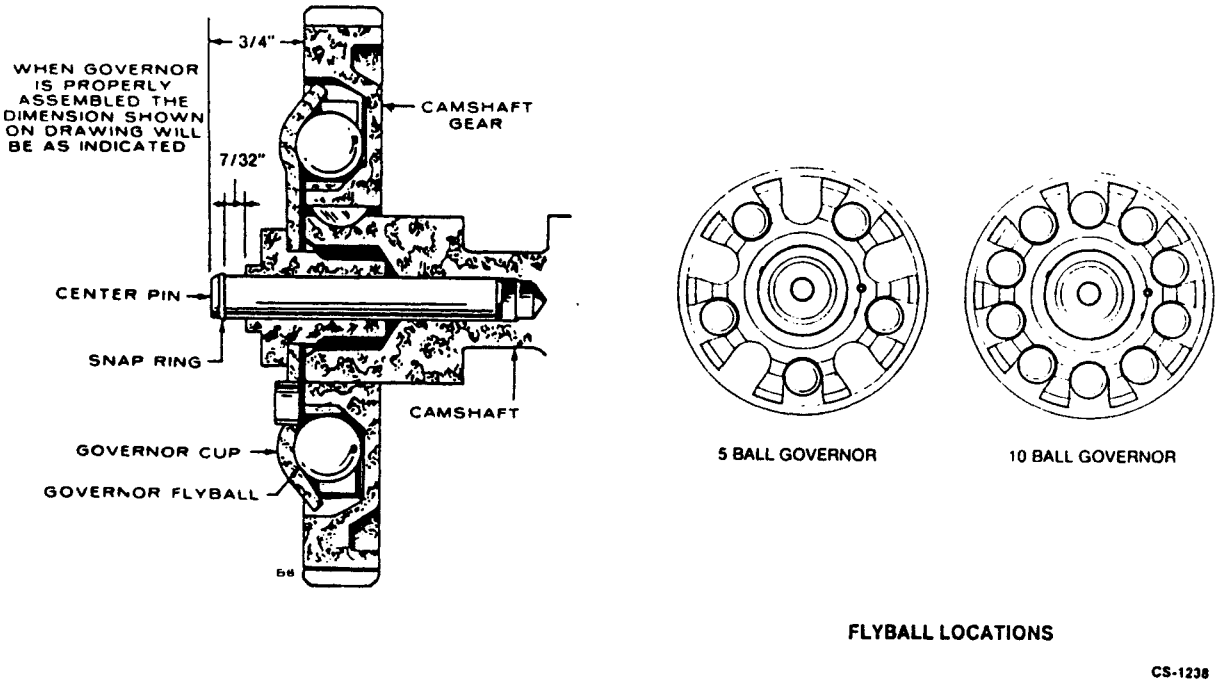

FIGURE 10. GOVERNOR CUP DETAILS

GOVERNOR CUP

With the gear cover removed, the governor cup can be taken off after removing the snap ring from the camshaft center pin. Catch the flyballs while sliding the cup off (Figure 10).

Replace with a new part any flyball which is grooved or has a flat spot; the ball spacer if its arms are worn or otherwise damaged; the gear/spacer assembly if loose on gear hub, and the governor cup if the race surface is grooved or rough. The governor cup must be a free-spinning fit on the camshaft center pin, but without any excessive play.

When installing the governor cup, tilt the engine so the gear is up, put the flyballs in place (Figure 10), and install the cup and snap ring on the center pin.

The camshaft center pin extends out 3/4 inch (19 mm) from the end of the camshaft. This distance provides an in-and-out travel distance of 7/32 inch (5.6 mm) for the governor cup, as illustrated. Hold the cup against the flyballs when measuring. The camshaft center pin cannot be pulled outward or removed without damage. If the center pin extends out too far, the cup will not hold the flyballs properly. If the distance is less than 7/32" (5.6 mm), the engine will race, especially at no load. Remove the center pin and press in a new pin.

TIMING GEARS

If replacement of either the crankshaft gear or the camshaft gear becomes necessary, always install both gears new.

The camshaft and gear must be replaced as an assembly. Before removing the camshaft and gear assembly, remove the cylinder head and valve assemblies.

To remove the crankshaft gear, first remove the snap ring and retainer washer, then attach the gear pulling ring using two No. 10-32 screws (Figure 11). Tighten the screws alternately until both are tight. Attach a gear puller to the puller ring and proceed to remove the gear.

Each timing gear is stamped with "O" near the edge. The gear teeth must mesh so that these marks exactly coincide when the gears are installed in the engine. When installing the camshaft gear and shaft assembly, be sure the thrust washer is properly in place behind the camshaft gear. Then install the crankshaft retaining washer and lock ring.

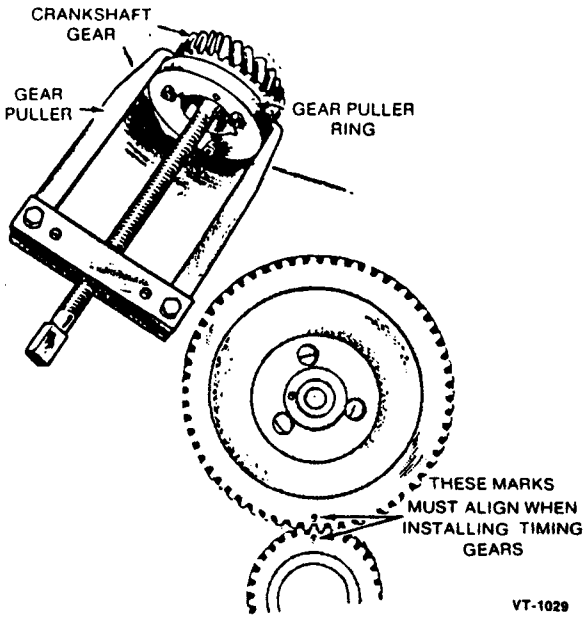

FIGURE 11. TIMING GEAR REMOVAL AND INSTALLATION

PISTONS AND CONNECTING RODS

Observe the following procedure when removing pistons and connecting rods from the engine.

1. Drain oil.
2. Remove the cylinder head and oil base pan from the engine.
3. Remove the ridge from the top of each cylinder with a ridge reamer before attempting piston removal (Figure 12).

⚠CAUTION ***Improper piston removal can cause piston damage. Use ridge reamer to remove cylinder ridge before removing piston.***

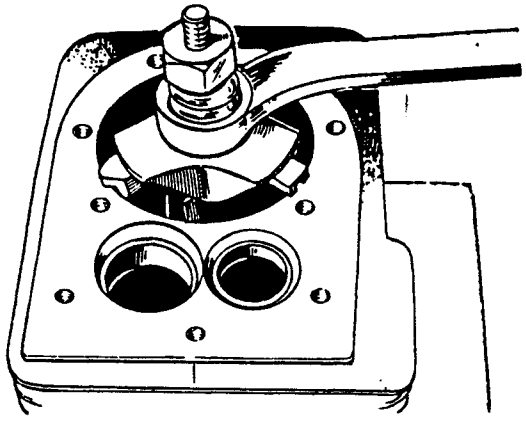

FIGURE 12. REMOVING RIDGE FROM CYLINDER

4. Turn the crankshaft until the piston is at the bottom of its stroke and remove the connecting rod nuts. Lift the rod bearing cap from the rod and push the rod and piston assembly out through the top of the cylinder using a hammer handle. Do not scratch the crankpin and cylinder wall when removing the piston and rod.
5. Mark each piston and rod assembly so they can be returned to their respective cylinders after overhaul. Keep connecting rod bearing caps with their respective rods.
6. Remove the piston rings from the piston with a piston ring spreader (Figure 13). Remove the piston pin retainer and push the piston pin out.

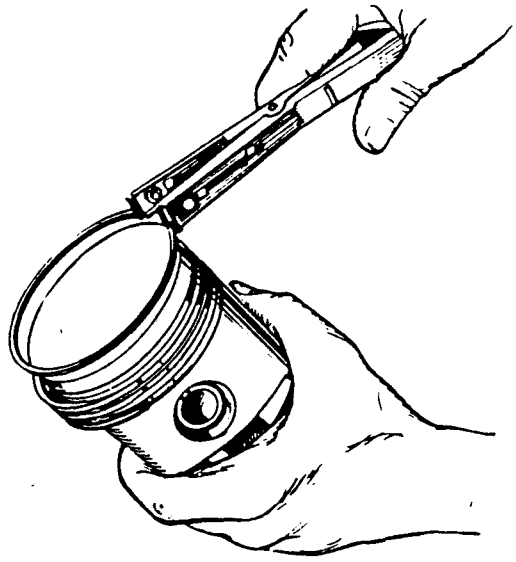

FIGURE 13. REMOVING PISTON RINGS

7. Remove dirt and deposits from the piston surfaces with an approved cleaning solvent. Clean the piston ring grooves with a groove cleaner or the end of a piston ring filed to a sharp point (Figure 14). Care must be taken not to remove metal from the groove sides.

⚠CAUTION ***Improper piston cleaning can cause piston damage. Do not use a caustic cleaning solvent or wire brush for cleaning pistons.***

8. Clean the connecting rods in solvent. Blow out all passages with compressed air.

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Engines that have been filled with 0.005 inch (0.13 mm) oversize pistons at the factory are identified by the letter E after the serial number. Number is stamped on the cylinder block and on the unit nameplate.

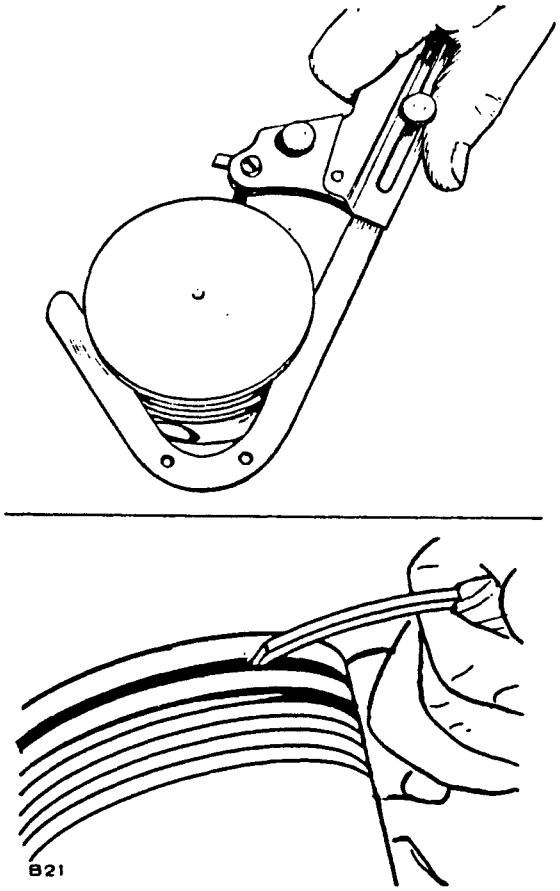


FIGURE 14. PISTON GROOVE CLEANING

Inspection

Follow the procedures given below when inspecting pistons and connecting rods.

Piston Inspection:

1. Inspect the pistons for fractures at the ring lands, skirts and pin bosses. Check for wear at the ring lands using a new ring and feeler gauge (Figure 15). Replace the piston when the side clearance of the top compression ring reaches that specified in *DIMENSIONS AND CLEARANCES.*

2. Replace pistons showing signs of scuffing, scoring, worn ring lands, fractures or damage from preignition. Excessive piston wear near the edge of the top ring land indicates preignition.

Connecting Rod Inspection:

Replace connecting rod bolts and nuts that have damaged threads. Replace connecting rods that have deep nicks, signs of fractures, scored bores, or bores with dimensions which exceed that specified in *DIMENSIONS AND CLEARANCES.*

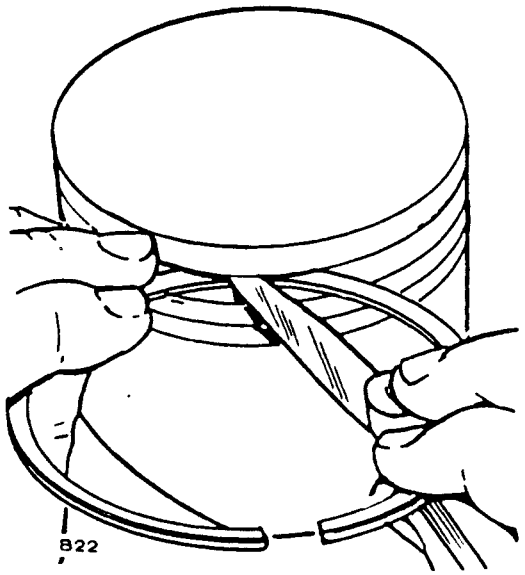


FIGURE 15. CHECKING RING SIDE CLEARANCE

Measuring Pistons:

1. Proper piston tolerances must be maintained for satisfactory operation.

2. Refer to *DIMENSIONS AND CLEARANCES* to determine where to measure piston to be sure the total clearance follows specifications.

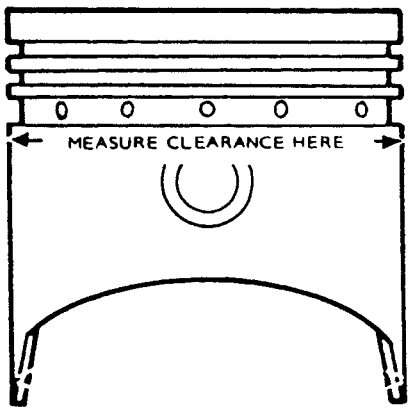


FIGURE 16. MEASURING PISTON CLEARANCE

Measuring Piston Rings:

1. Install the piston ring in the cylinder bore. Invert the piston and push the ring to the end of ring travel, about halfway into the bore, which trues the ring end gap. Check the gap with a feeler gauge (Figure 17).

2. The practice of filing ring ends to increase the end gap is not recommended. If the ring end gap does not meet specifications, check for the correct set of rings and the correct bore size. A cylinder bore that is 0.001 inch (0.03 mm) under size will reduce the end gap 0.003 inch (0.08 mm).

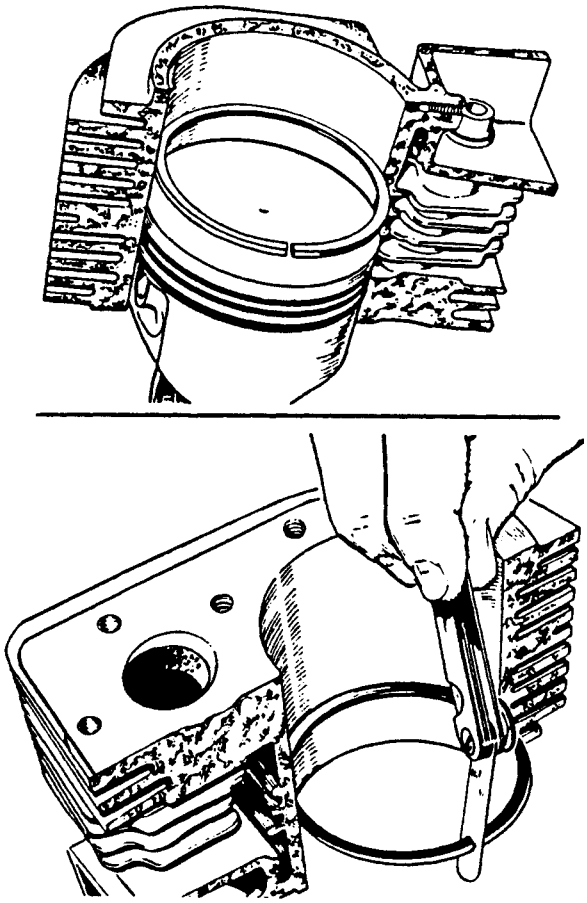


FIGURE 17. POSITIONING OF PISTON RING AND MEASURING OF END GAP

CYLINDER BLOCK

The cylinder block is the main support for all other basic engine parts. Crankshaft and camshaft are supported by the block, assuring alignment of the crankshaft and cylinder bores.

Cleaning

After removing pistons, crankshaft, cylinder heads, etc., inspect block for cracks and wear. If block is still serviceable, prepare it for cleaning as follows:

1. Scrape all old gasket material from block. Remove oil by-pass to allow cleaning solution to contact inside of oil passages.

2. Remove grease and scale from cylinder block by agitating in a bath of commercial cleaning solution or hot soapy washing solution.

3. Rinse block in clean hot water to remove cleaning solution.

Inspection

When rebuilding the engine, thoroughly inspect block for any condition that would make it unfit for further use. This inspection must be made after all parts have been removed and block has been thoroughly cleaned and dried.

1. Make a thorough check for cracks. Minute cracks may be detected by coating the suspected area with a mixture of 25 percent kerosene and 75 percent light motor oil. Wipe the part dry and immediately apply a coating of zinc oxide (white lead) dissolved in wood alcohol. If cracks are present, the white coating will become discolored at the defective area. Always replace a cracked cylinder block.

2. Inspect all machined surfaces and threaded holes. Carefully remove any nicks or burrs from machined surfaces. Clean out tapped holes and clean up any damaged threads.

3. Check top of block for flatness with a straight edge and a feeler gauge.

Cylinder Bore Inspection: Inspect cylinder bores for scuffing, scratches, wear, and scoring. If cylinder bores are scuffed, scratched, worn, or scored, they must be rebored and honed for the next oversize piston.

When the appearance of cylinder bores is good and there are no scuff marks, check cylinder bore for wear or out of roundness as follows:

1. Check cylinder bore for taper, out of round, and wear with a cylinder bore gauge, telescopic gauge, or inside micrometer. These measurements should be taken at four places: top and bottom of piston ring travel, parallel and perpendicular to axis of crankshaft (Figure 18).

2. Record measurements taken at top and bottom of piston travel as follows:

   A. Measure and record as "A" the cylinder bore diameter (parallel to crankshaft) near the top of cylinder bore.

   B. Measure and record as "B" cylinder bore diameter (parallel to crankshaft) at the bottom of piston travel.

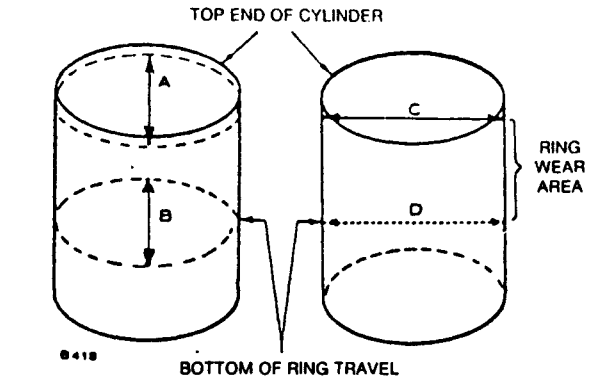
   C. Measure and record as "C" cylinder bore diameter (perpendicular to crankshaft) near the top of cylinder bore.

   D. Measure and record as "D" cylinder bore diameter (perpendicular to crankshaft) at the bottom of piston travel.

   E. Reading "A" subtracted from reading "B" and reading "C" subtracted from reading "D" indicates cylinder taper.

      If cylinder taper exceeds that specified in *DIMENSIONS AND CLEARANCES* rebore and hone cylinder to the next oversize.

   F. Reading "A" compared to reading "C" and reading "B" compared to reading "D" indicate whether or not cylinder is out of round. If out of round exceeds that specified in *DIMENSIONS AND CLEARANCES* the cylinders must be rebored and honed to the next oversize.



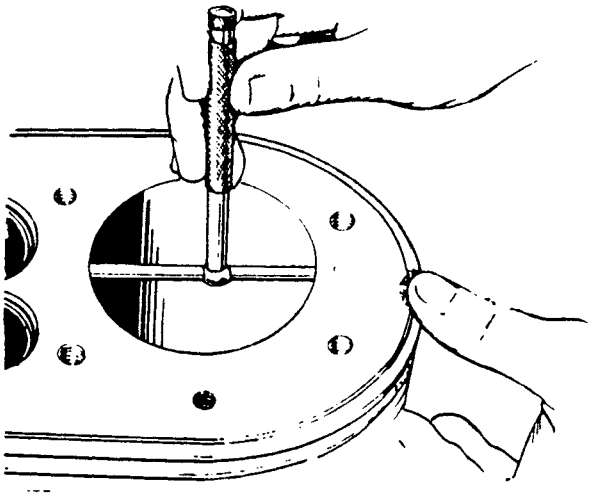


FIGURE 18. METHODS OF MEASURING THE DIAMETER OF A CYLINDER BORE

Reboring the Cylinder

Rebore and hone engine whenever cylinder bore is worn, damaged, out of round, or if cylinder taper exceeds specifications. A worn cylinder bore should be resized to the smallest standard oversize diameter at which it will clean up. The final finish and bore diameters should then be obtained by honing. Final bore diameter should equal the standard diameter added to the oversize.

⚠CAUTION ***Improper boring will result in engine damage. Boring must be done by qualified mechanics.***

After boring to the correct oversize cylinder bore dimension piston and ring clearance should be appropriate. There is no need to adjust or "fit" pistons and rings.

When reboring cylinders, take the following precautions:

1. Make sure cutting tool is properly ground before using it.

2. Be sure top of engine block is smooth and deposit free.

3. Clean base of boring bar before bar is set up. Deposits under boring bar will cause it to tilt and the cylinder will be distorted after boring.

4. Make an initial rough cut, followed by a finish cut. Then hone cylinder bore to the specified oversize.

Honing Cylinders (Using Precision Hones)

Refer to hone manufacturer's recommended grit size to produce specified surface finish of 20 to 40 RMS. Too rough of a finish will wear out the rings and too smooth of a finish can retard piston ring seating.

1. Position block solidly for either vertical or horizontal honing. Use either a drill press or heavy-duty drill which operates at approximately 250 to 450 rpm.

2. Follow hone manufacturer's instructions for the use of oil or lubricant on stones. Do not use lubricants with a dry hone.

3. Insert hone in bore and adjust stones to fit snugly to the narrowest section. When adjusted correctly, the hone should not shake or chatter in cylinder bore, but will drag freely up and down when hone is not running.

4. Connect drill to hone and start drill. Feel out bore for high spots, which cause an increased drag on stones. Move hone up and down in bore with short overlapping strokes about 40 times per minute. Usually bottom of cylinder must be worked out first because it is smaller. As cylinder takes a uniform diameter, move hone up and down all the way through cylinder bore.

5. Check diameter of the cylinder regularly during honing. A dial bore gauge is the easiest method but a telescoping gauge can be used. Check size at six places in bore: measure twice at top, middle and bottom at 90-degree angles.

6. Crosshatch formed by the stones should form an included angle of 23 degrees. This can be achieved by moving the rotating hone (250 to 450 rpm) up and down in cylinder bore about 40 times per minute.

7. Clean cylinder bores thoroughly with soap, water and clean rags. A clean white rag should not become soiled on wall after cleaning is complete. Do not use a solvent or gasoline since they wash oil from the walls but leave the metal particles.

8. Dry crankcase and coat it with oil.

Deglazing Cylinder Bores

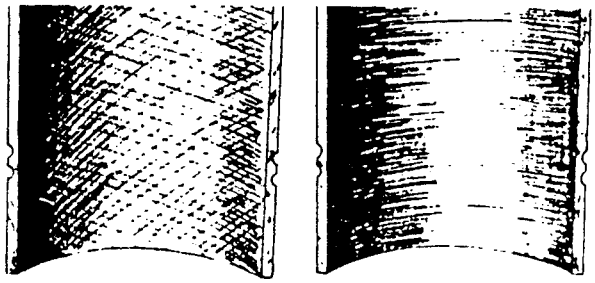
Deglaze the cylinder bores if there are no scuff marks and no wear or out of round beyond specifications before installing new rings. Deglazing gives a fine finish, but does not enlarge cylinder diameter, so the original pistons with new rings may still be used.

The reason for deglazing a cylinder is to provide cavities to hold oil during piston ring break-in.

1. Wipe cylinder bores with a clean cloth which has been dipped in clean, light engine oil.

2. Use a brush type deglazing tool with coated bristle tips to produce a crosshatch pattern in the cylinder bore.

3. Use a slow speed drill to drive the deglazing tool. Move deglazing tool up and down in cylinder (10 to 12 complete strokes) rapidly enough to obtain a crosshatch pattern (Figure 19).



PRODUCE CROSSHATCH SCRATCHES FOR FAST RING SEATING

AVOID THIS FINISH

FIGURE 19. CROSSHATCHING

⚠CAUTION ***Improper cylinder cleaning will result in engine damage. Do not use gasoline, solvents, or commercial cleaners to clean cylinder bores.***

4. Clean cylinder bore thoroughly with soap, water and clean rags. Continue cleaning until a clean white rag shows no discoloring when wiped through cylinder bore.

CRANKSHAFT

Clean crankshaft thoroughly and inspect journals for scoring, chipping, cracking, or signs of overheating. If crankshaft has overheated, is scored, or excessively worn, reconditioning or replacement will be required. Examine bearing journals for cracks if overheating has occurred.

Measure crankshaft main bearing and connecting rod journals at several places on their diameter to check for roundness and taper.

The only recommended method of reconditioning the crankshaft is regrinding, as required to accommodate undersize bearings. Metalizing of bearing journals is not recommended.

If regrinding of crankshaft journals is necessary, the work should be done by a reputable machine shop that has suitable equipment to handle precision work of this type. Undersize main bearings and connecting rods are available.

Whenever making major repairs on the engine, always inspect the drilled passages of the crankshaft. Clean them to remove any foreign material and to assure proper lubrication of the connecting rods.

BEARINGS

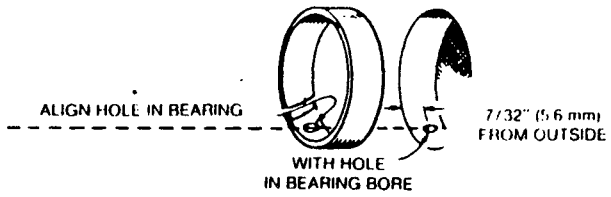
With camshaft and crankshaft removed, use a micrometer to measure diameter of bearing journals. Use a dial bore gauge or a telescopic gauge and micrometer to measure inside diameter of bearings. Refer to *DIMENSIONS AND CLEARANCES* to determine if clearances are within specifications.

Any bearing that is scored, chipped, pitted or worn beyond the specified limits must be replaced.

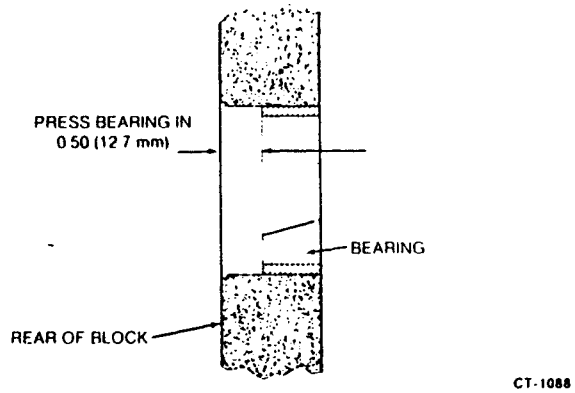
Removal of the camshaft bearings requires complete disassembly of the engine. Use a press or a suitable driver to remove bearings. Support casting to avoid distortion and to avoid damaging the bearing bore during removal and installation.

Replacement camshaft bearings are precision type which do not require line reaming or line boring after installation. Clean outside of the bearing and bearing bore in the block. Before installing cam bearings use Locktite Bearing Mount on outside diameter of bearing. Use a combination bearing driver to install bearings.

Place the bearing on the crankcase over the bearing bore with the lubricating hole (front only) in the proper position. Be sure to start the bearing straight. Press in the front bearing flush with the outside end of the bearing bore. Front cam bearing oil hole must line up with oiling hole in cylinder block (Figure 20). Press in the rear camshaft bearing to the dimension shown (Figure 20). Lubricate bearing surfaces with oil after installing.



FRONT CAMSHAFT BEARING



REAR CAMSHAFT BEARING

FIGURE 20. CAMSHAFT BEARINGS

New crankshaft main bearings are precision type which do not require line reaming or line boring after installation. Use a press or a suitable driver to remove bearings. Support casting to avoid distortion and to avoid damaging the bearing bore during removal and installation.

Before installing main bearings, expand bearing bore by placing the casting in an oven heated to 200°F (94°C). If practical, cool the precision bearing to shrink it.

Before installing the front main bearing, use the towelette included with the bearing kit to clean the outside of the bearing and bearing bore in the block.

⚠WARNING ***Breathing vapor from towelette and prolonged contact with skin can be harmful. Use only in well ventilated area and avoid prolonged contact with skin.***

After allowing three to four minutes for drying, apply the Locktite from the small tube to the mating surfaces of the bearing and the bearing bore. Align the oil holes in the bearing with the oil holes in the bearing bore (Figure 22). The oil passage should be at least half open. Install the bearing flush with the block, using the combination driver. Wipe off excess Locktite around the bearing. Allow at least one hour for hardening at room temperature.

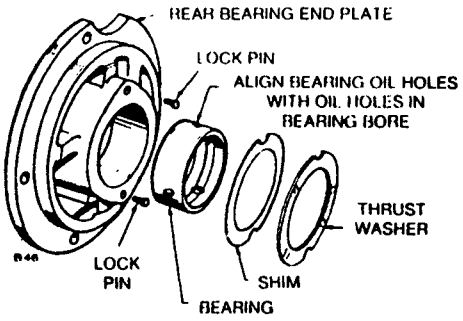


FIGURE 21. BEARINGS FOR REAR BEARING PLATE

Engines shipped from the factory have separate thrust washers and main bearings for both front and rear of engine. Front bearing replacement part is a one piece bearing (with attached thrust washer) as shown in Figure 22. Do not add an additional thrust washer to this front bearing.

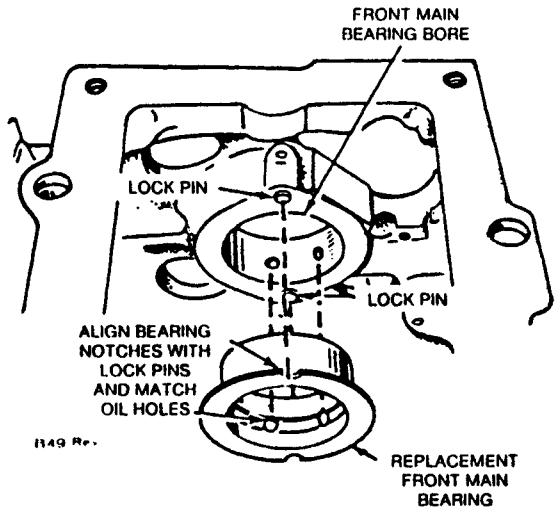


FIGURE 22. FRONT BEARING INSTALLATION

In the rear bearing plate, install the bearing flush to 1/64 inch (0.40 mm) below the end of the bore. Be sure to align the oil holes in the bearing with the oil holes in the bearing bore (Figure 21). The oil passage must be at least half open. Lubricate bearing after installation.

If head of lock pin is damaged, use side cutters or Easy Out tool to remove and install new pin. Oil grooves in thrust washers must face the crankshaft, and washers must be flat (not bent). The two notches on each washer must fit over the two lock pins to prevent riding on the crankshaft (Figure 21).

Lubricate the front main bearing lightly with oil and insert the crankshaft. With the rear bearing plate gasket in place and the rear plate bearing lubricated, slide the thrust washer (grooves toward crankshaft) and plate over the end of the crankshaft. A light film of oil on the thrust washer may hold it in place while installing bearing plate over crankshaft. Line up notches of thrust washer with lock pins before tightening end plate or lock pins will be damaged.

CRANKSHAFT ENDPLAY

After the rear bearing end plate has been tightened, using the torque recommended in *ASSEMBLY TORQUES AND SPECIAL TOOLS*, check the crankshaft endplay (Figure 23). If there is too much endplay (see *DIMENSIONS AND CLEARANCES* for minimum and maximum endplay), remove the rear bearing end plate and add a shim (Figure 21) between the thrust washer and plate. Reinstall the end plate, making sure the thrust washer and shim notches line up with the lock pins. Torque and recheck endplay of the crankshaft.

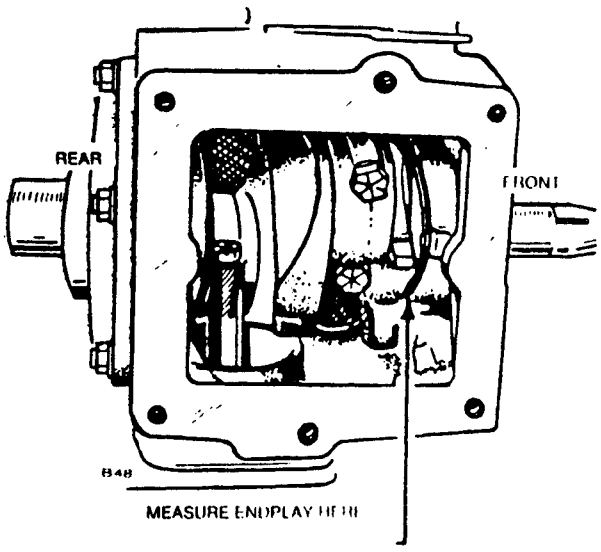


FIGURE 23. CRANKSHAFT ENDPLAY

CHECKING CONNECTING ROD BEARING CLEARANCE WITH PLASTIGAUGE

1. Make certain that all parts are marked or identified so they are installed in their original positions. Using a clean dry cloth, thoroughly clean all oil from crankshaft journal and connecting rod. If connecting rod bearing inserts are being replaced (P224 only), install them in rod and cap.

2. Place a piece of correct size Plastigauge in the bearing cap the full width of the journal surface and about 1/4 inch (6.35 mm) off center (Figure 24).

3. Rotate the crankshaft about 30 degrees from bottom dead center and reinstall the bearing cap; tighten rod bolts to the torque specified in *ASSEMBLY TORQUES AND SPECIAL TOOLS*. Do not turn the crankshaft.

4. Remove bearing cap. The flattened Plastigauge will be found adhering to either the bearing cap or crankshaft.

5. Compare flattened Plastigauge with the graduations on Plastigauge envelope to determine clearance.

   The number within the matching graduation on the envelope indicates total clearance in millimeters or thousandths of an inch.

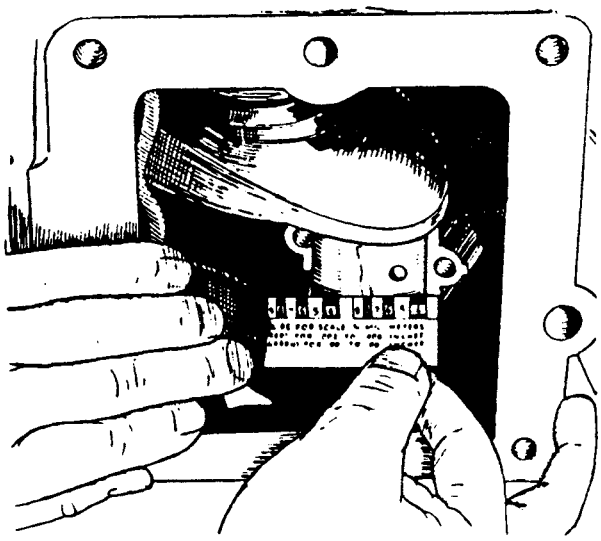


FIGURE 24. MEASURING BEARING CLEARANCE

OIL SEALS

The bearing plate must be removed to replace the oil seal (Figure 25). Drive the oil seal out from the inside.

Before installing seals, fill the space between lips with a multi-purpose grease. This will improve sealing.

When installing the gear cover oil seal, tap the seal inward until it is .645 inch (16.4 mm) from the front of the gear cover.

When installing the bearing plate oil seal, tap the seal into the bearing plate bore to bottom against the shoulder in the plate bore. Use a seal expander or place a piece of heavy paper around the end of the crankshaft, when replacing the bearing plate to avoid damaging the seal. Remove the paper as soon as the plate is in place.

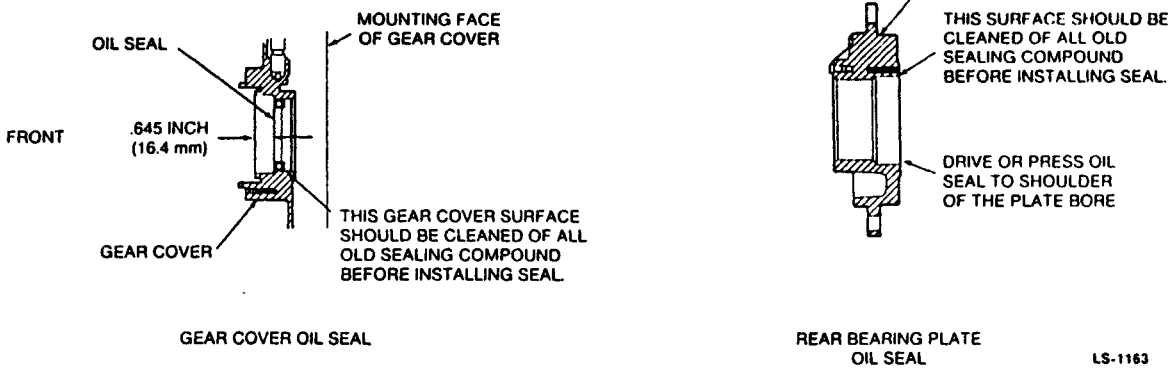


FIGURE 25. GEAR COVER AND REAR BEARING PLATE OIL SEALS

PISTON ASSEMBLY

1. Lubricate all parts with engine oil.
2. Position piston on its respective rod and install the pin.
3. Install the rings on the pistons starting with the oil control ring (Figure 26). Use a piston ring spreader to prevent twisting or excessive expansion of the ring. Compression rings have a dot or the word "top" on one side of the ring to indicate which side faces the top of the piston. Unmarked piston rings can be installed either way. The oil control ring has an expander; install the expander first and then close until the expander ends butt. The joint should be 180 degrees from the gap of that ring.

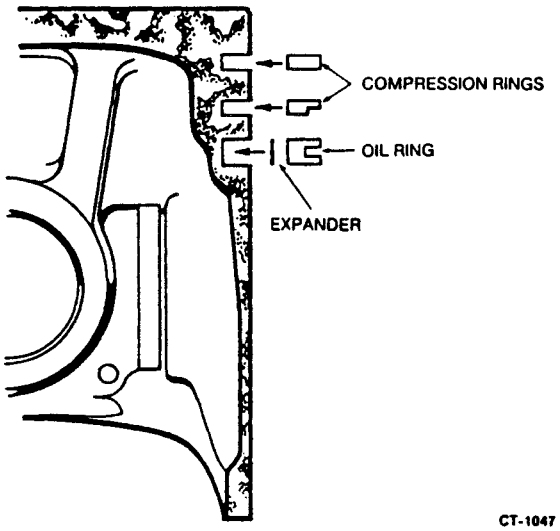


FIGURE 26. PISTON RINGS

INSTALLATION OF PISTON IN CYLINDER

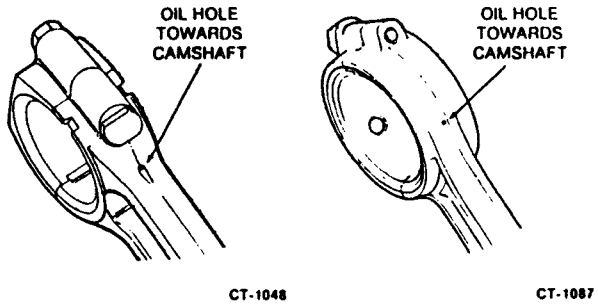
1. Turn the crankshaft to position the number one rod bearing journal at the bottom of its stroke.
2. Lubricate the number one piston assembly and inside of the cylinder. Compress the rings with a ring compressor (Figure 27).
3. Position the piston and rod assembly in the cylinder block. Oil squirt hole of connecting rod must face camshaft.
4. Tap the piston down into the bore with the handle end of a hammer until the connecting rod is seated on the journal (Figure 27). Install the bearing cap on the rod.

P216, P218, P220

Install one fastener and tighten to 5 ft-lbs (7 Nm). Repeat this for the other fastener. Tighten both fasteners down to the torque specified in *ASSEMBLY TORQUES.*

P224

Install and tighten the nuts evenly in steps, to the torque specified in *ASSEMBLY TORQUES.*



P216, P218, P220 CONNECTING ROD P224 CONNECTING ROD

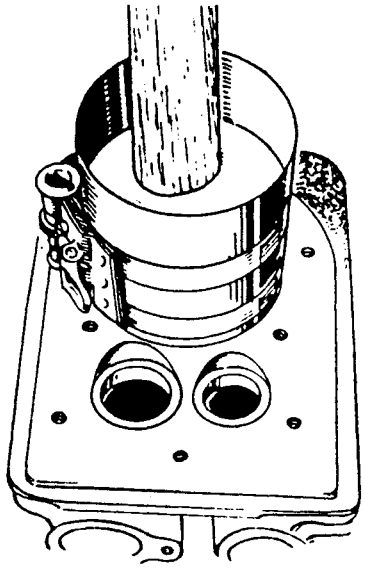


FIGURE 27. INSTALLING PISTON AND CONNECTING ROD

5. Install the remaining piston and rod in the same manner. Crank the engine over by hand to see that all bearings are free.
6. Install the oil base with a new gasket.
7. Install the cylinder heads. See *Cylinder Head* section for torques and torquing procedure.
8. Replace oil and break in engine.

CYLINDER HEADS

Remove the cylinder heads for carbon cleaning and gasket change at intervals specified in the *Periodic Maintenance Schedule* (located in the Operator's Manual).

1. Use a 1/2 inch (13 mm) socket wrench to remove cylinder head bolts or nuts. Lift heads off.

   ⚠CAUTION ***Torquing or removing cylinder heads when hot (above 100° F [37° C]) will result in head damage. Allow heads to cool to below 100° F (37° C) before torquing or removing.***

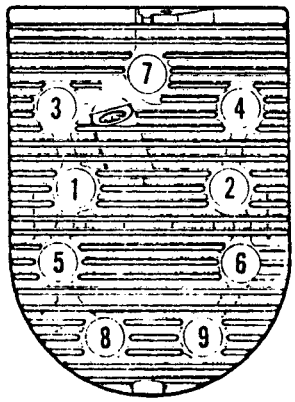
2. After removing heads, clean out all carbon deposits. Be careful not to damage the outer sealing edges where gaskets fit. The heads are made of aluminum and can be damaged by careless handling.

3. Use new head gaskets and clean both the heads and the cylinder block thoroughly where the head gaskets rest.

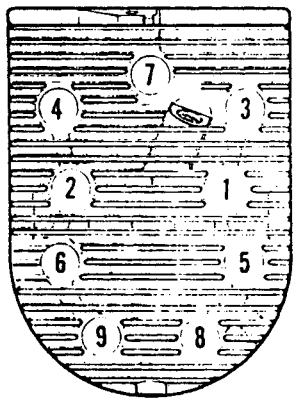
P216, P218, P220 Installation

1. Place a head gasket on the cylinder block and align the holes in the gasket with the holes in the cylinder block. While holding the gasket against the cylinder head, carefully install the cylinder head on the engine. Do not attempt to slide the head bolts through the gasket without the cylinder block behind it or the gasket may tear.

2. Follow the head torque sequence shown in Figure 28. Tighten all bolts to 5 ft-lbs (7 Nm), then 10 ft-lbs (14 Nm), then to the torque specified in *ASSEMBLY TORQUES*. Recheck all head bolts for correct torque.



NO 1 CYLINDER (LH)



NO 2 CYLINDER (RH)

C-1002

FIGURE 28. CYLINDER HEAD TORQUE SEQUENCE

P224 Installation

1. Place a head gasket on the cylinder head and align the stud holes in the gasket with the stud holes in the cylinder head. While holding the gasket against the cylinder head, carefully install the cylinder head on the engine. Do not attempt to slide the gasket over the studs without the cylinder head behind it or the gasket may tear.

2. Install a flat washer, two compression washers, and nut on each of the top six studs (Figure 29 for correct sequence). When properly installed, only the outside edges of the compression washers will be in contact with each other. Install a flat washer and nut on each of the four bottom studs.

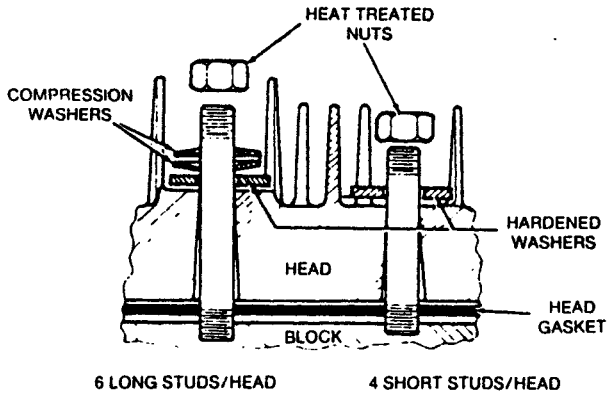


FIGURE 29. CYLINDER HEAD WITH COMPRESSION WASHERS

⚠CAUTION ***Over torquing nuts can cause engine damage. Do not over torque nuts.***

3. Follow the head torque sequence shown in Figure 30. Tighten all nuts to 5 ft-lbs (7 Nm), then 10 ft-lbs (14 Nm), then to the torque specified in *ASSEMBLY TORQUES*. Recheck all nuts for correct torque.

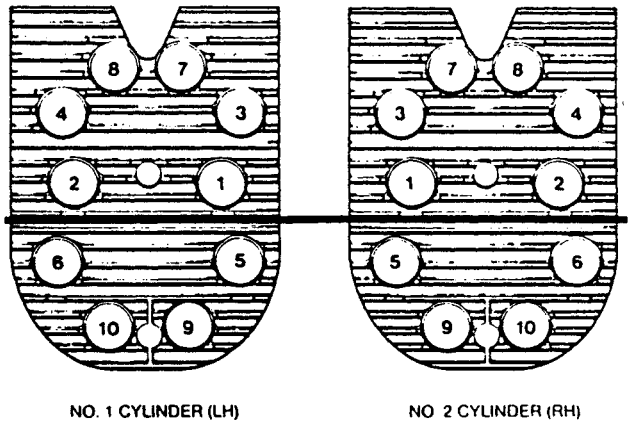
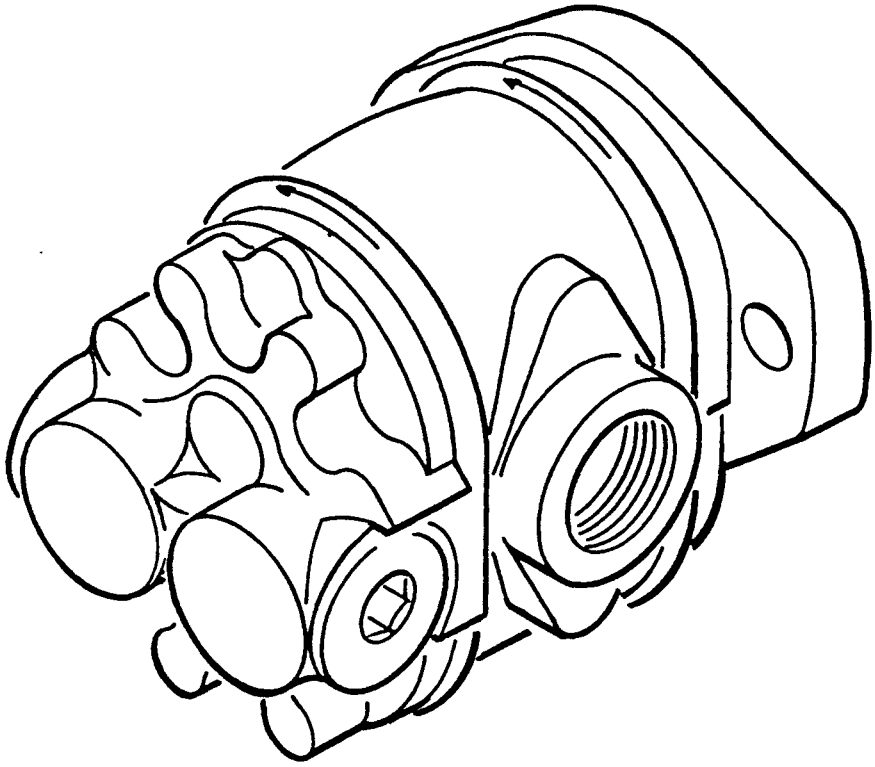


FIGURE 30. CYLINDER HEAD TORQUE SEQUENCE

4. Recheck torque when the engine has run a total of 50 hours.

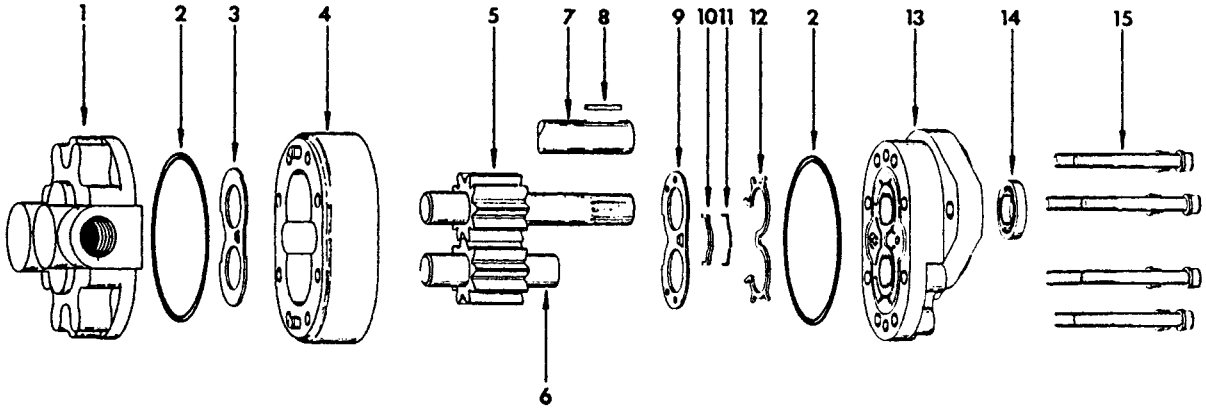
Service Manual



Model 25300 High Pressure Gear Pump

Inspection/Servicing

SINGLE PUMP



PARTS LIST

REF. NO.	DESCRIPTION	REQ'D. PER ASSY.	REF. NO.	DESCRIPTION	REQ'D. PER ASSY.
1	Back plate assembly	1	9	Wear plate	1
2	O-ring	2	10	Bearing seal	1
3	Optional thrust plate	1	11	Molded o-ring	1
4	Body	1	12	Back-up gasket	1
5	Spline drive gear assy.	1	13	Front plate assy.	1
6	Idler gear assy.	1	14	Shaft seal	1
7	Keyed drive gear assy.	1	15	Cap screw	8
8	Key	1			

Note: For pumps with Flow Divider, Flow Control or Relief Valve backplates refer to page 7.

DISASSEMBLY

1. Remove key (8) from drive shaft if keyed drive gear assembly (7) is used.
2. Thoroughly clean outside of pump.
3. Use sharp tool to mark across front plate, body and backplate. This will assure proper reassembly.
4. Clamp pump in vise, shaft up.
5. Remove cap screws (15) eight each.
6. Remove pump from vise, hold pump in hands and bump shaft against wooden block to separate front plate (13) from back plate (1). Body (4) will remain with either front plate or backplate.
7. If backplate was removed first, remove optional thrust plate (3) from body gear pockets (4). If the front plate was removed first, remove wear plate (9) from body gear pockets (4).
8. Remove drive gear assembly (5) or (7) and idler gear assembly (6) from body (4).
9. To separate body (4) from the plate it remains with, place drive gear assembly (5) or (7) in bushing and tap protruding end with plastic hammer or rawhide mallet.
10. Remove o-ring (2) from front plate (13) and backplate (1).
11. Remove back-up gasket (12) from front plate (13) by prying with a sharp tool.
12. Remove bearing seal (10) from front plate (13) by prying with a sharp tool.
13. Remove molded o-ring (11) from front plate (13).
14. Remove shaft seal (14) from front plate (13) by prying with a screwdriver.

INSPECT PARTS FOR WEAR

GENERAL

1. Clean and dry all parts.
2. Remove all nicks and burrs from all parts with emery cloth.

GEAR ASSEMBLY

1. Check drive shaft spline for twisted or broken teeth or check keyed drive shaft for broken or chipped keyway.
2. Inspect both the drive gear and idler gear shafts at bushing points and seal area for rough surfaces and excessive wear.
3. If shaft measures less than .748 in bushing area, the gear assembly should be replaced. (one gear assembly may be replaced separately; shafts and gears are available as assemblies only.)
4. Inspect gear face for scoring and excessive wear.
5. If gear width is below the following figures — the gear assembly should be replaced.

Pump Disp.	.50	.66	.84	1.02	1.20	1.37	1.54	1.69	1.87
Gear Width	.384	.510	.636	.762	.888	1.014	1.140	1.266	1.392

6. Be sure snap rings are in grooves on either side of drive and idler gears.
7. If edge of gear teeth are sharp, break edge with emery cloth.

FRONT AND BACKPLATE

1. Oil groove in bushings in both front plate and backplate should be in line with dowel pin holes and 180° apart. This positions the oil grooves closest to respective dowel pin holes.
2. If I.D. of bushings in front plate or backplate exceed .755 front or backplate should be replaced. (Bushings are not available as separate items.)
3. Bushings in front plate should be flush with face of front plate.
4. If optional thrust plate is not used, check for scoring on face of backplate. If wear exceeds .0015, backplate should be replaced.

BODY

1. Check inside gear pockets for excessive scoring or wear.
2. Body should be replaced if I.D. of gear pockets exceeds 1.713.

GENERAL INFORMATION

It is important that the relationship of the backplate, thrust plate, body, wear plate and front plate is correct. You will note two half moon cavities in the body which must face away from the front plate. Note: The smaller half moon port cavity must be on the pressure side of the pump. Side of thrust plate and wear plate with mid section cut out must be on suction side of pump. Suction side of backplate is always side with larger port boss.

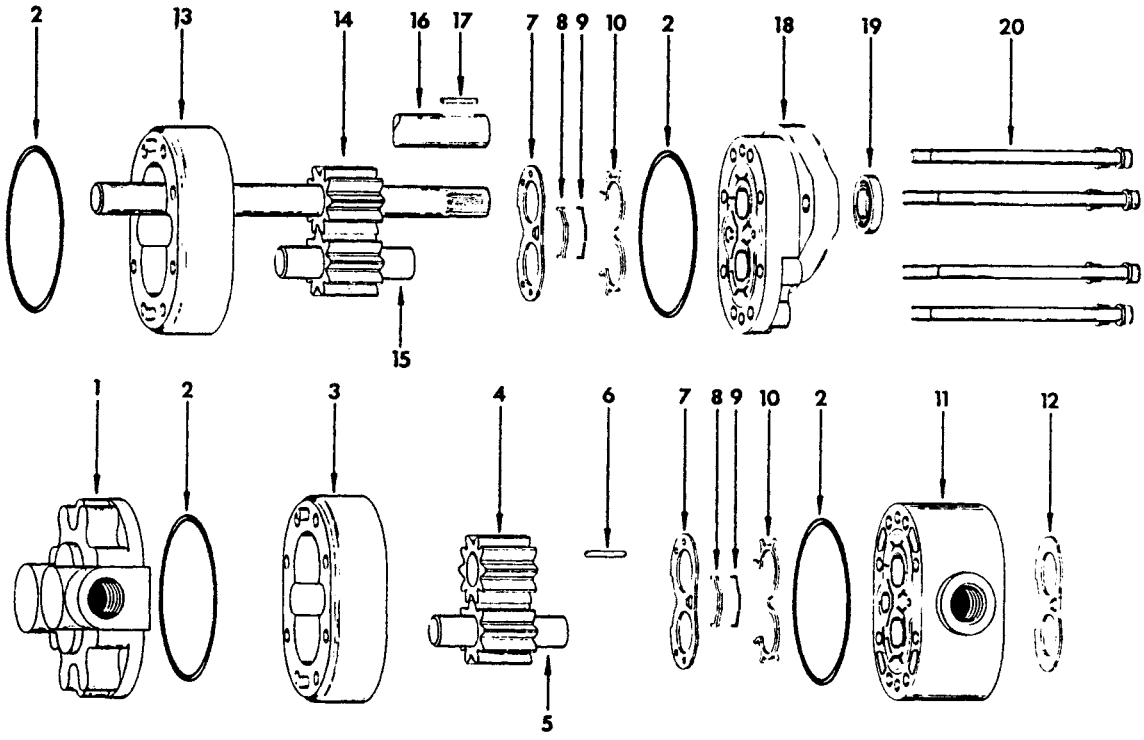
REASSEMBLY

1. The optional thrust plate, wear plate, bearing seal, molded o-ring, back-up gasket, shaft seal and o-rings should be replaced as new parts.
2. Install o-ring (2) in groove of front plate (13).
3. Tuck back-up gasket (12) into groove in front plate (13) with open part of "V" section down.
4. Place molded o-ring (11) in groove in front plate. Place bearing seal (10) over molded o-ring — groove side down.
5. Apply a thin coat of heavy grease to both milled faces of body. Slip body onto front plate — half moon port cavities in body must face away from front plate.

   Note: The small half moon port cavity must be on the pressure side of pump.
6. Place wear plate (9) on top of back-up gasket with bronze face up. The side with the mid section cut away must be on suction side of pump. (Be sure to note difference between wear plate (9) and optional thrust plate (3).
7. Dip gear assemblies into oil and slip into front plate bushings.
8. Install optional thrust plate (3) — bronze face toward gears. The side with mid section cut out must be on suction side of pump. Thrust plate must fit inside gear pockets.
9. Install o-ring (2) in groove in backplate (1).
10. Slide backplate (1) over gear shafts until dowel pins are engaged.
11. Install bolts (15). Tighten evenly to 25/28 ft. lbs. torque.
12. Liberally oil shaft seal (14) and carefully work over drive shaft being careful not to cut rubber sealing lip.
13. Place 1-5/16" O.D. sleeve over shaft and press in shaft seal (14) until flush with front surface of front plate.
14. Install key (8) on keyed shaft (7).

Note: Refer to Trouble Shooting and Start-up Procedure on page 6.

DOUBLE PUMP



PARTS LIST

REF. NO.	DESCRIPTION	REQ'D. PER ASSY.	REF. NO.	DESCRIPTION	REQ'D. PER ASSY.
1	Back plate assembly	1	11	Adapter plate	1
2	O-ring	4	12	Optional thrust plate	1
3	Rear body	1	13	Front body	1
4	Gear (slip fit)	1	14	Spline drive gear assy.	1
5	Idler gear assy. (rear)	1	15	Idler gear assy. (front)	1
6	Round key	1	16	Keyed drive gear assy.	1
7	Wear plate	2	17	Key	1
8	Bearing seal	2	18	Front plate assy.	1
9	Molded o-ring	2	19	Shaft seal	1
10	Back-up gasket	2	20	Cap screw	8

Note: For pumps with Flow Divider, Flow Control or Relief Valve backplates refer to page 7.

DISASSEMBLY

1. Remove key (17) if keyed drive gear assembly (16) is used.
2. Clean outside of pump thoroughly.
3. Use sharp tool to scribe a mark across all sections of the pump. This will assure proper reassembly.
4. Clamp pump in vise, shaft up and remove cap screws (20) eight each.
5. Remove pump from vise, hold pump in hands and bump shaft against wooden block to separate front pump sections. Body (13) will remain with either front plate (18) or adapter plate (11).
6. Remove idler gear (15) from either front plate or adapter plate.
7. Remove backplate (1) from body (3) by tapping on backplate with plastic hammer or rawhide mallet.
8. Remove idler gear (5), slip fit gear (4) and key (6). Remove drive gear assembly (14 or 16) from adapter plate. Remove optional thrust plate (12) from adaptor plate (11).
9. Place drive gear assembly in bushing and tap protruding end with plastic hammer or rawhide mallet to remove bodies (3) or (13) from plates they remained with.
10. Remove wear plate (7) from front plate (18).
11. Remove wear plate (7) from adapter plate (11).
12. Remove o-rings (2) from front plate (18), adapter plate (11), and backplate (1).
13. Remove back-up gasket (10), bearing seal (8) and molded o-ring (9) from front plate (18) and adapter plate (11) by prying out with a sharp tool.
14. Remove shaft seal (19) from front plate (18) by prying with a screwdriver.

INSPECT PARTS FOR WEAR

GENERAL

1. Clean and dry all parts.
2. Remove nicks and burrs from all parts with emery cloth.

GEAR ASSEMBLY

1. Check drive shaft spline (14) for twisted or broken teeth or check keyed drive shaft (16) for broken or chipped keyway. Check for broken keyway in shaft where slip fit gear is installed for double pump.
2. Inspect both the drive gear and idler gear shafts at bushing points and seal area for rough surfaces and excessive wear.
3. If shaft measures less than .748 in bushing area, the gear assembly should be replaced. (One gear assembly may be replaced separately; shafts and gears are available as assemblies only. The slip fit gear is available separately).
4. Inspect gear face for scoring and excessive wear.
5. If gear widths are below the following figures the gear assembly should be replaced.

Pump Disp.	.50	.66	.84	1.02	1.20	1.37	1.54	1.69	1.87
Gear Width	.384	.510	.636	.762	.888	1.014	1.140	1.266	1.392

6. Be sure retaining rings are in grooves on either side of drive and idler gears.
7. If edge of gear teeth are sharp, break edge with emery cloth.

FRONT PLATE, BACKPLATE & ADAPTER PLATE

1. Oil gooves in bushing in both front plate, backplate and adapter plate should be in line with dowel pin holes and 180° apart. This positions the oil grooves closest to the respective dowel pin holes.
2. If I.D. of bushings in front plate, backplate or adapter plate exceed .755 the front plate, backplate, or adapter plate should be replaced. (Bushings are not available as separate items).
3. Bushings in front plate and back-up gasket side of adapter plate should be flush with face.
4. If optional thrust plates are not used check for scoring on face of backplate and adapter plate. If wear exceeds .0015 backplate or adapter plate should be replaced.

BODY

1. Check inside gear pockets for excessive scoring or wear.
2. Body should be replaced if I.D. of gear pockets exceed 1.713.

GENERAL INFORMATION

It is important that relationship of the backplate, body, wear plate and front plate is correct. You will note two half moon cavities in the body which must face away from the front plate. Note: The smaller half moon port cavity must be on the pressure side of the pump. Side of thrust plate and wear plate with mid section cut out must be on suction side of pump. Suction side of backplate is always side with larger port boss.

REASSEMBLY

1. Optional thrust plate, wear plates, bearing seals, molded o-rings, back-up gaskets, shaft seal and o-rings should be replaced as new parts.
2. Install o-rings (2) in groove of front plate (18), adapter plate (11), and backplate (1) with a small amount of grease to hold in place.
3. Tuck back-up gasket (10) in front plate (18) and adapter plate (11) with open part of "V" section down.
4. Place molded o-ring (9) in groove in front plate and adapter plate. Place bearing seal (8) over molded o-ring, groove side down.
5. Apply a thin coat of heavy grease to both milled faces of body. Slip body onto front plate-half moon port cavities in body must face away from front plate. Note: The small half moon port cavity must be on the pressure side of pump.
6. Place wear plate (7) on top of back-up gasket with bronze face up. The side with the mid section cut away must be on suction side of pump.
7. Dip drive gear assembly (14 or 16) and idler gear assembly (15) into oil. Slip both gear assemblies into gear pocket of body and into front plate bushings.
8. Install optional thrust plate (12) into body (13) bronze face toward gears with mid section cut away towards suction side of pump
9. Install adapter plate (11) in place on front body (13). Check positioning mark on all sections of pump.
10. Install second body (3) onto adapter plate (11) and install wear plate (7).
11. Install key (6) in slot of drive gear assembly shaft (14 or 16). Dip slip fit gear (4) in oil and slip on shaft and into gear pocket of body. Check key for proper location.
12. Dip idler gear (5) in oil and install in gear pocket of body (3).
13. Position backplate (1) over shafts until dowel pins in body are engaged.
14. Install cap screws (20). Tighten evenly to 25/28 ft. lbs. torque.
15. Work shaft seal (19) over drive gear shaft, being careful to not cut rubber sealing lip (Oil seal liberally before installing). Place 1-5/16 O.D sleeve over shaft and press in shaft seal (19) until flush with front surface of front plate.
16. Install key (17) on keyed shaft (16).

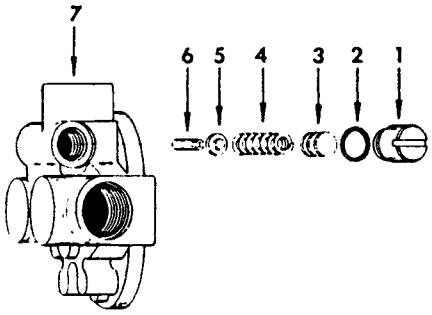
PLACING PUMP BACK INTO SERVICE

1. If shop test stand is available, the following procedure for testing rebuilt pumps is recommended:
   - A. Mount pump on test stand making sure that the proper level of clean oil is available in the reservoir. Check suction line for leaks and obstructions.
   - B. Start pump and run for three minutes at zero pressure.
   - C. Intermittently load pump to 500 P.S.I. for three minutes.
   - D. Intermittently load pump to 1000 P.S.I. for three minutes.
   - E. Intermittently load pump to 2000 P.S.I. for three minutes.
   - F. Remove pump from test stand and check for freeness of drive shaft. Check for leaks.
2. If shop test stand is not available, the following procedure for testing rebuilt pumps is recommended:
   - A. Mount pump on equipment and run pump at 1/2 engine speed at zero pressure.
   - B. By operating control valve build pressure intermittently for three minutes.
   - C. Increase engine speed to full throttle and build pressure intermittently for three minutes.
   - D. Idle engine and check for leaks.

SINGLE OR DOUBLE PUMP TROUBLE SHOOTING

PUMP TROUBLE	PROBABLE CAUSE	REMEDY
1. Noisy pump caused by cavitation.	a. Oil too heavy. b. Oil filter plugged. c. Suction line plugged or too small.	a. Change to proper viscosity b. Clean filters. c. Clean line and check for size.
2. Oil heating	a. Oil supply low. b. Contaminated oil. c. Setting of relief valve too high or too low. d. Oil in system too light.	a. Fill reservoir b. Drain reservoir and refill with clean oil c. Set to correct pressure. d. Drain reservoir and refill with proper viscosity oil.
3. Shaft seal leakage	a. Worn shaft seal. b. Worn shaft in seal area c. Broken bearing seal or back-up gasket d. Bushings out of position. e. Excessive internal wear.	a. Replace shaft seal b. Replace drive shaft c. If replacing the shaft and shaft seal does not stop seal leakage, the pump should be disassembled and checked for items 3, c & d d. Disassemble pump and replace front plate e. Disassemble pump inspect parts and replace as needed.
4. Foaming oil	a. Low oil level. b. Air leaking into suction line. c. Wrong kind of oil.	a. Fill reservoir. b. Tighten fittings. c. Drain and fill reservoir with non-foaming oil.

RELIEF VALVE BACKPLATE



PARTS LIST

REF. NO.	DESCRIPTION	REQ'D. PER ASSY.
1	Slotted plug	1
2	O-ring	1
3	Shims	As Reqd
4	Spring, Relief Valve	1
5	Plug Seat	1
6	Seat	1
7	Backplate	1

DISASSEMBLY

1. Use slotted socket and remove relief valve plug (1), shims (3), spring (4), plug seat (5) and seat (6) from backplate (7).

Note: Do not remove internal relief valve cartridge assembly. Cartridge assembly has been set to a predetermined depth with locktite applied.

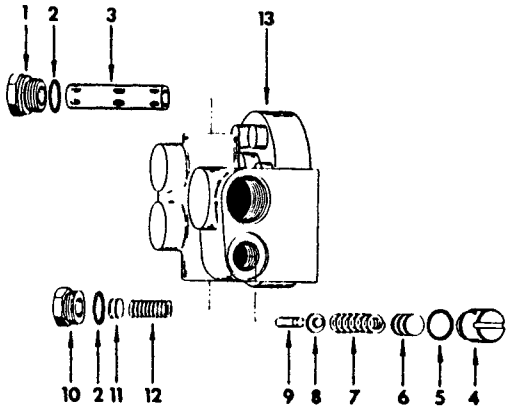
INSPECTION

1. Clean and dry all parts.
2. The o-rings need not be inspected as they should be replaced as new items.
3. Remove all nicks and burrs from all parts with emery cloth.
4. Oil grooves in bushings should be in line with dowel pin holes and 180 degrees apart. This positions the oil grooves closest to the respective pin holes.
5. If I.D. of bushings in backplate exceed .755, the backplate should be replaced. (Bushings are not available as separate items).
6. If optional thrust plate is not used, check for scoring on face of backplate. If wear exceeds .0015, backplate should be replaced.
7. Check shims (3) for wear.
8. Check spring (4) for weakness or breakage.
9. Wash backplate in clean solvent, direct compressed air into relief valve cavity in backplate to dry relief valve cartridge assembly. The procedure removes any trapped contamination.

REASSEMBLY

1. Install relief valve parts in backplate (7), seat (6), plug seat (5), spring (4), same number of shims (3), new o-ring (2) on plug (1) and torque plug to 21 to 24 ft. lbs.

FLOW DIVIDER/FLOW CONTROL BACKPLATE



PARTS LIST

REF. NO.	DESCRIPTION	REQ'D. PER ASSY.
1	Hex Plug	1
2	O-ring	2
3	Flow Divider Spool	1
4	Slotted Plug	1
5	O-ring	1
6	Shims	As Req'd
7	Spring, Relief Valve	1
8	Plug Seat	1
9	Seat	1
10	Hex Plug	1
11	Shims	As Req'd
12	Spring, Flow Divider	1
13	Backplate	1

DISASSEMBLY

1. Use slotted socket and remove relief valve plug (4), shims (6), spring (7), plug seat (8) and seat (9) from backplate (13).
   Note: Do not remove internal relief valve cartridge assembly. Cartridge assembly has been set to a predetermined depth with locktite applied.
2. Remove plug (1), spool (3), plug (10), shims (11) and spring (12) from backplate (13).

INSPECTION

1. Clean and dry all parts.
2. The o-rings need not be inspected as they should be replaced as new items.
3. Remove all nicks and burrs from all parts with emery cloth.
4. Oil grooves in bushings should be in line with dowel pin holes and 180 degrees apart. This positions the oil grooves closest to the respective pin holes.
5. If I.D. of bushings in backplate exceed .755 the backplate should be replaced. (Bushings are not available as separate items).
6. If optional thrust plate is not used, check for scoring on face of backplate. If wear exceeds .0015, backplate should be replaced.
7. Inspect backplate spool bore for scoring or contamination.
8. Inspect spool O.D. for scratches, it should be smooth and free of nicks and burrs. Spool should slide freely inside backplate bore.
9. Check shims (6) and (11) for wear.
10. Check springs (7) and (12) for weakness or breakage.
11. Wash backplate in clean solvent, direct compressed air into relief valve cavity in backplate to dry relief valve cartridge assembly. The procedure removes any trapped contamination.

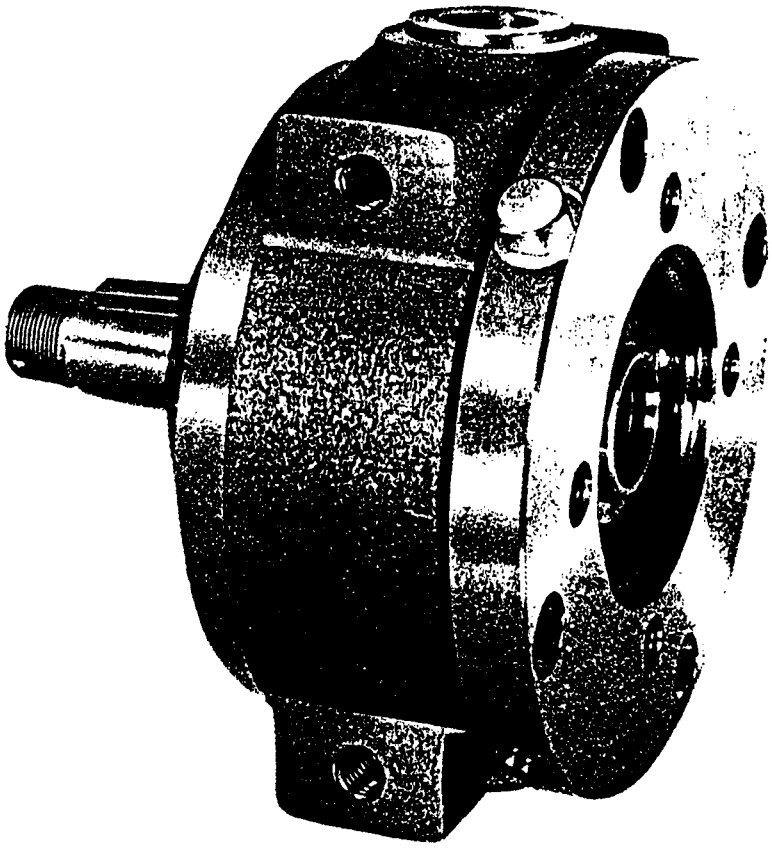
REASSEMBLY

1. Install relief valve parts in backplate (13), seat (9), plug seat (8), spring (7), same number of shims (6), new o-ring (5) on plug (4) and torque plug (4) to 21 to 24 ft. lbs.
2. Install flow divider parts in backplate (13) spool (3), spring (12), same number of shims (11), new o-rings (2) on plugs (1) and (10) and torque plugs (1) and (10) to 27 to 30 ft. lbs.

FLOW DIVIDER/FLOW CONTROL TROUBLE SHOOTING

FLOW DIVIDER TROUBLE	PROBABLE CAUSE	REMEDY
1. External leakage.	a. Spool plug o-ring. b. Relief valve plug o-ring.	a. Remove spool plug and replace o-ring. b. Remove relief valve plug and replace o-ring.
2. Low priority pressure.	a. Low relief valve setting.	a. Replace weak or broken spring b. Shim as required. c. Replace backplate assy.
3. Low priority flow.	a. Relief valve open or leaking. b. Scratched machined sealing surface in relief valve. (Either in seat or poppet within cartridge) c. Contaminant lodged in relief valve. d. Missing spring shims. e. Weak Spool spring.	a. Replace weak or broken spring. b. Replace parts as required. c. Clean relief valve cavity. d. Add shims as required. e. Replace spool spring.
4. No priority flow.	a. Broken spool spring. b. Orifice inside spool plugged.	a. Replace spool spring b. Check for contaminant lodged in orifice.
5. No secondary flow.	a. Spool sticking.	a. Remove and clean spool bore.
6. Low secondary flow.	a. Pump flow degradation due to wear.	a. Check pump for worn parts and replace.

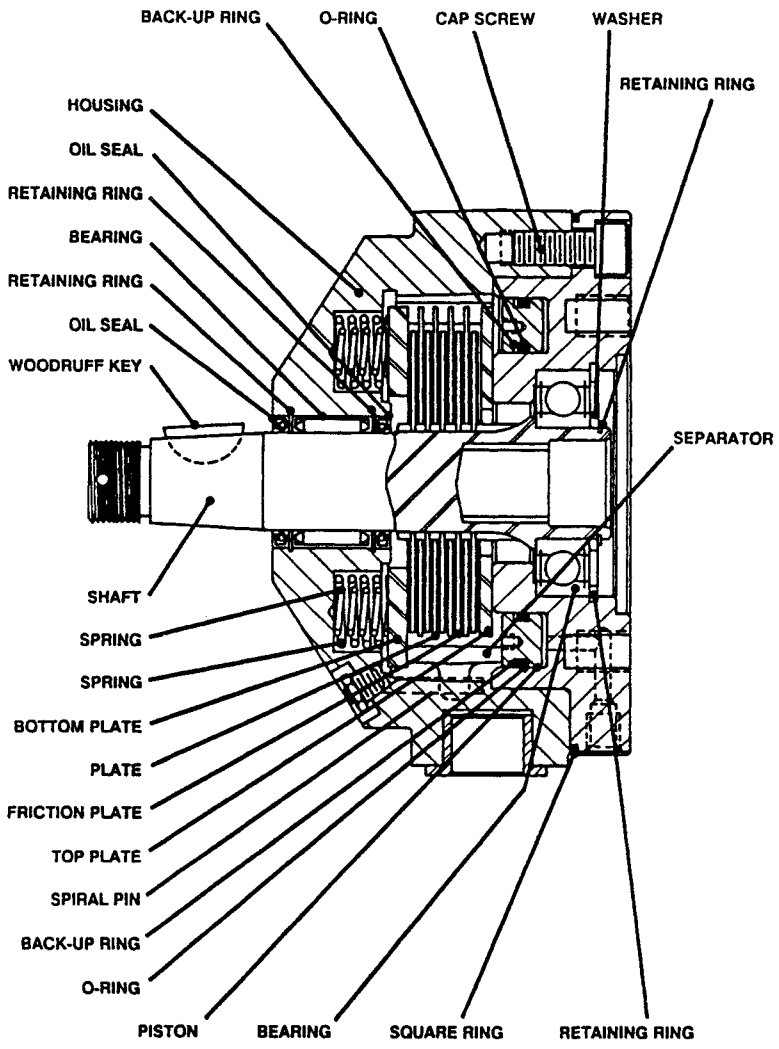
Service Manual



MULTIPLE DISC BRAKE

(trunnion)

TYPICAL TRUNNION BRAKE



DESCRIPTION AND OPERATION OF THE MICO MULTIPLE DISC BRAKE

The MICO Multiple Disc Trunnion Brake (dry design) is a wheel mount brake designed specifically for use with vehicles requiring parking or emergency brake capabilities on their steering axle.

This Multiple Disc Trunnion Brake provides consistent braking torque, positive hold, and long life in rugged environments.

The Brake will reduce maintenance and downtime because contaminants which cause brake lining wear are prevented from entering the brake.

Braking is provided by a pack of rotating friction discs splined to the shaft, and stationary separator plates restrained by broached slots in the housing. Force is transmitted to the disc pack through a hydraulic piston and a series of preloaded springs. The brake is released by hydraulic pressure applied to the piston to compress the springs. The brake is self-applying since any function which reduces the hydraulic system pressure of the brake will start to initiate a brake application. Zero pressure produces maximum brake torque.

DISASSEMBLY

1. Remove woodruff key (item 27) from shaft (item 20).
2. Remove cover (item 6) from housing (item 26) by removing four cap screws (items 1).

   CAUTION: Cover is under spring tension of approximately 1500 pounds. The four cap screws should be loosened evenly to relieve this force. If a hydraulic press is available (3000 lbs. max.) the cover can be held in position while removing the cap screws.

3. Tap threaded end of shaft with a soft mallet to dislodge cover and shaft assembly from housing (item 26).
4. Remove retaining rings (items 2 & 3) and washer (item 4) from cover (item 6). Then separate shaft (item 20) and bearing (item 5) from cover.
5. Separate bearing (item 5) and shaft (item 20).
6. Remove square ring (item 7) from cover (item 6).
7. Remove piston (item 10) from cover (item 6) by inserting two 1/4 - 20 UNC bolts into threaded holes in piston. By turning and pulling, piston can be removed from bore.
8. Remove o-rings (items 9 & 12) and back-up rings (item 8 & 11) from piston (item 10).
9. Remove separators (item 13) from housing (item 26).
10. Remove top plate (item 14), friction plates (items 15), plates (items 16) and bottom plate (item 17) from housing (item 26).
11. Remove springs (items 18 & 19) from housing (item 26)
12. Remove oil seals (items 21 & 25), retaining rings (items 22 & 24) and bearing (item 23) from housing (item 26).

ASSEMBLY

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

1. Clean all parts thoroughly before assembly.
2. Press new bearing (item 23) into housing (item 26) and hold in place with new retaining rings (items 22 & 24).
3. Press new oil seals (items 21 & 25) into housing (item 26). Note direction of seals.
4. Insert springs (items 18 & 19) into housing (item 26).
5. Install new bottom plate (item 17) into housing so it is resting on springs.
6. Install new friction plates (items 15) and new plates (items 16) in an alternating pattern starting with a friction plate (item 15).
7. Install new top plate (item 14) over stack of friction plates (items 15) and plates (items 16).

   NOTE: Chamfered side of tabs must face downward towards housing (item 26).

8. Insert separators (items 13) over spiral pins in housing (item 26).
9. Insert shaft (item 20) into housing (item 26) engaging splines of shaft with splines of friction plates (items 15) until shaft bottoms out against oil seal (item 21).
10. Install new o-rings (items 9 & 12) and new back-up rings (items 8 & 11) on piston (item 10). Insert piston assembly into cover (item 6) being careful not to shear o-rings or back-up rings. Inserting 1/4 - 20 UNC bolts in piston may simplify installation.
11. Install new square ring (item 7) on cover (item 6).
12. Position cover (item 6) on housing (item 26). Install four cap screws (items 1) and tighten evenly to draw cover (item 6) to housing (item 26). Torque cap screws to 55 ft. lbs.

    NOTES:

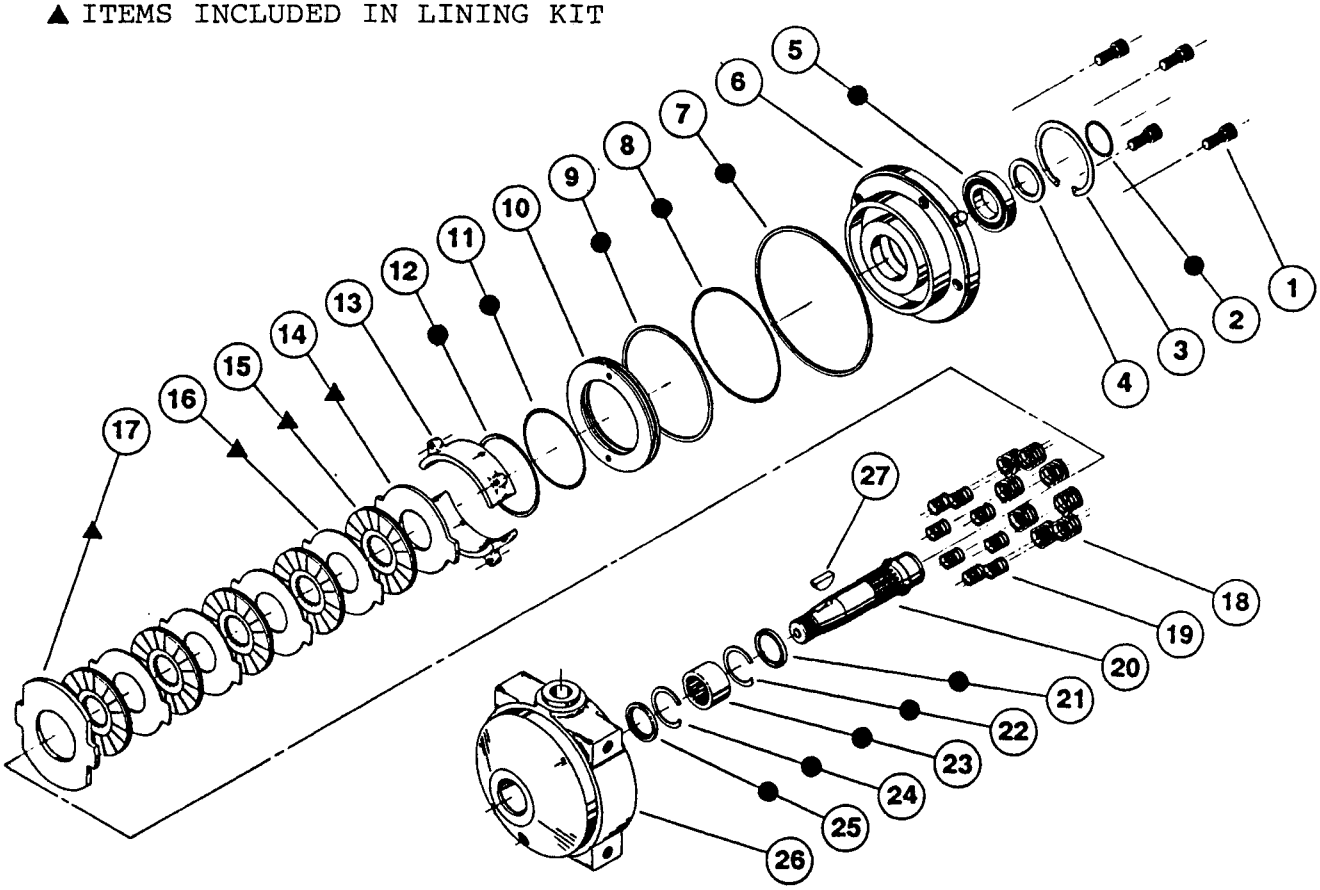
    1) If available, a hydraulic press will simplify installation of cover on housing. Clamp cover in position while tightening the cap screws.

    2) Top plate (item 14) is not engaged with broached slots in housing (item 26) during assembly. Therefore, alignment of tabs with broached slot is critical.

13. Move shaft (item 20) upward so that bearing shoulder on shaft is slightly above bearing shoulder in cover (item 6). With shaft held in this position press new bearing (item 5) until it shoulders on shaft (item 20).
14. Install washer (item 4) and new retaining ring (item 2) on shaft to hold bearing (item 5) in place.
15. Press outer race of bearing (item 5) until it shoulders out in cover (item 6).
16. Install retaining ring (item 3) in cover (item 6) to retain bearing (item 5) in position.
17. Install woodruff key (item 27) in shaft (item 20).

● ITEMS INCLUDED IN SEAL KIT

▲ ITEMS INCLUDED IN LINING KIT



ITEM	DESCRIPTION
1	CAP SCREW (4)
● 2	RETAINING RING
3	RETAINING RING
4	WASHER
● 5	BEARING
6	COVER
● 7	SQUARE RING
● 8	BACK-UP RING
● 9	O-RING
10	PISTON
● 11	BACK-UP RING
● 12	O-RING
13	SEPARATOR
▲ 14	TOE PLATE

ITEM	DESCRIPTION
▲ 15	FRICTION PLATE (5)
▲ 16	PLATE (4)
▲ 17	BOTTOM PLATE
18	SPRING (8)
19	SPRING (8)
20	SHAFT
● 21	OIL SEAL
● 22	RETAINING RING
● 23	BEARING
● 24	RETAINING RING
● 25	OIL SEAL
26	HOUSING
27	WOODRUFF KEY
▲ ●	MOUNTING GASKET (NOT SHOWN)

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

BRAKE WON'T RELEASE

1. Insufficient release oil pressure.
2. Damaged o-rings (items 9 or 12).
3. Damaged piston (item 10).
4. Damaged bearings (items 5 or 23).
5. Discs (items 15 & 16) warped or welded together due to excessive heat.

BRAKE WON'T APPLY

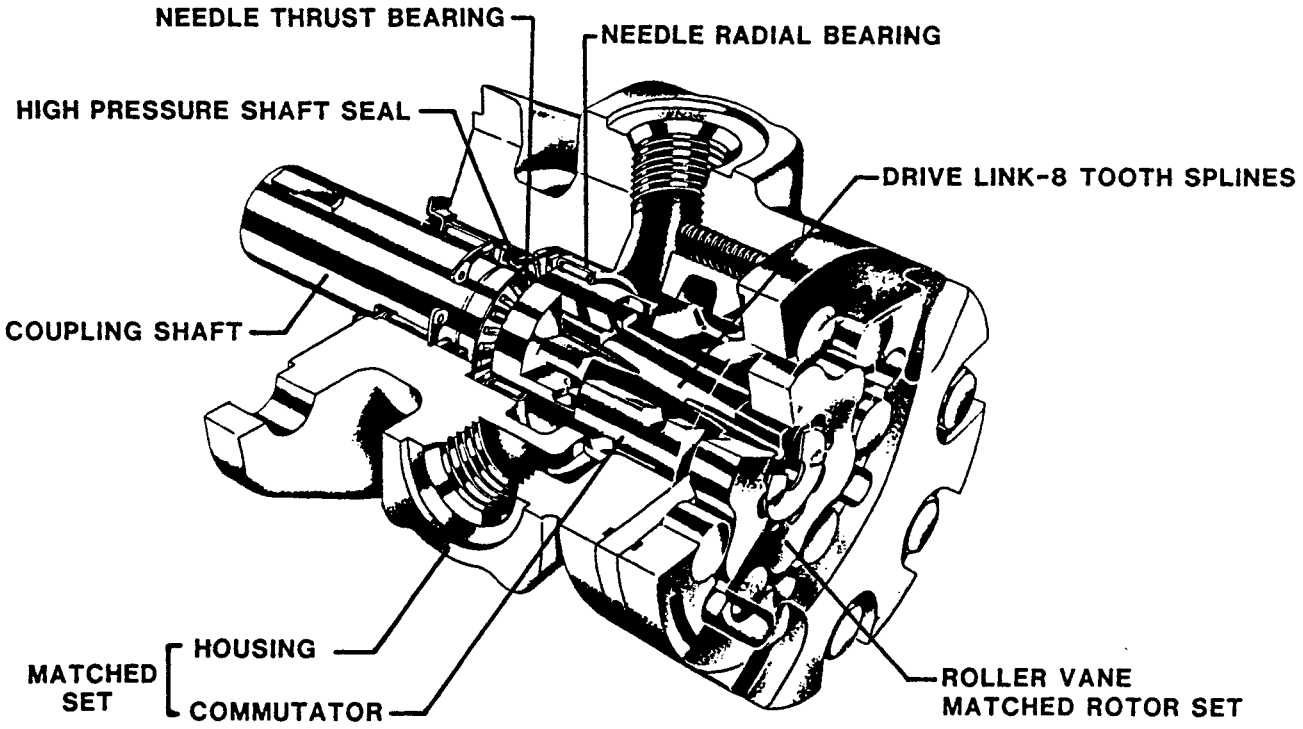
1. Residual oil pressure in release section of brake.
2. Damaged spring (items 18 & 19).
3. Damaged piston (item 10).
4. Broken cap screws (items 1) allowing cover (item 6) to move away from housing (item 26).

BRAKE APPLIES BUT
TORQUE LOW

1. Residual oil pressure in release section of brake.
2. Springs (items 18 & 19) have taken permanent set due to excessive heat.
3. Friction discs (items 15) worn out.
4. Oil leakage into plate area of brake.

Torqmotor™

MAF Series Service Procedure



MAF Design Features

Torqmotor™

MAF Design Features

- New standard for compactness and light weight relative to power output, increases installation design latitude.
- Displacements range from 20 cubic inches (328 CM^3) down to 3 cubic inches (49 CM^3) per revolution.
- Continuous rated pressure up to 1750 psi (120.7 BAR), depending on displacement with fully competitive volumetric efficiency.
- Patented roller vanes for high performance and durability.
- Commutation radially independent of load induced shaft movement, minimizing wear induced commutation leakage.
- Coupling shaft mounted in steel caged needle radial and thrust bearings to withstand higher side and thrust loads.
- Optimized drive link contact with 8 tooth spline drive to reduce wear.
- Unique high pressure shaft seal allows MAF Torqmotors to be run in series without need for case drains. Only simple direct-line circuitry required.
- Standard SAE porting and mounting configurations.
- Fewer parts reduced maintenance, while maintaining quality performance.

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 MAF 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 MAF**

Patents

Table of Contents

Introduction

Service Manual for Model MAF

This service manual has one purpose: to guide you in maintaining, troubleshooting, and servicing the MAF Torqmotor™ (low-speed, high-torque hydraulic motor, MAF).

Material in this manual is organized so you can work on the MAF 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 MAF.

This manual also contains troubleshooting information and checklist. If you must service the MAF, 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 MAF. 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. Pay special attention to the notes, cautions, and warnings.

A foldout page with an MAF exploded assembly view 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 parts are available through the Original Equipment Manufacturer (OEM) or Ross approved MAF Distributors.

As you gain experience in servicing the MAF, 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 MAF 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 but the MAF 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 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.

preliminary checks

Hydraulic systems are often trouble-free. 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 not properly repaired, or that should have been replaced; and
- improperly spec'd replacement parts.
- 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. 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 MAF 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.

It may be necessary that you run hydraulic tests on the performance of the hydraulic components. To do so, consult the manuals published by the equipment or component manufacturers.

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 (5) deteriorated by excess heat	Replace oil seal rings by disassembling MAF unit.
	3. Special bolt (2) loose or its sealing area deteriorated by corrosion	(a) Loosen then tighten single bolt to 22-26 ft.-lbs. (30-35 N m) (b) Replace bolt.
	4. Internal shaft seal (16) worn or damaged	Replace seal by disassembling MAF unit.
	5. Worn coupling shaft (11) and internal seal (16)	Replace coupling shaft and seal by disassembling MAF 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 MAF unit.
	3. Severely worn or damaged internal splines	Replace rotor set, drive link and coupling shaft by disassembling MAF unit.
	4. Excessive heat	Locate excessive heat source in the system and correct the condition.
Low mechanical efficiency or undue high pressure required to operate MAF unit	1. Line blockage	Locate blockage source and repair or replace.
	2. Internal interference	Disassemble MAF 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	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

MAF service manual

Clean, petroleum-based solvent

Emery paper

Vise with soft jaws

Air pressure source

Arbor press

Screw driver

Retaining ring pliers (internal)

Breaker bar

1/2 inch thin wall socket

Torque wrench - foot pounds

Adjustable crescent wrench or hose fitting wrenches

Marking pencil or chalk

SAE 10W40 oil

Clean grease

Feeler gage .005 inch (.127 mm)

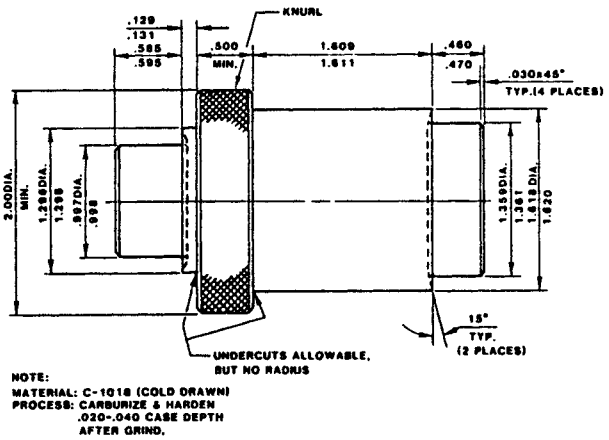
Blind hole bearing puller for 1 inch (25.4 mm) and 1.38 inch (35.1 mm) diameter bearing,

Special bearing mandrel (SEE FIGURE 1)

Special rotor set assembly tool (See FIGURE 2) or large locking pliers and two 16 penny nails or equivalent #8 US gage (.162 Dia. [4.1 mm]) metal rods (See FIGURE 62)

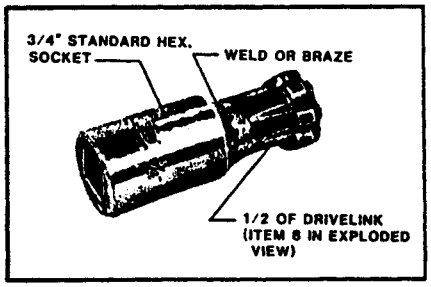
CONVERSIONS

INCHES	mm	INCHES	mm
.020	.51	.998	25.35
.030	.76	1.296	32.92
.040	1.02	1.298	32.97
.129	3.28	1.359	34.52
.131	3.33	1.361	34.57
.460	11.68	1.609	40.87
.470	11.94	1.611	40.92
.500	12.70	1.618	41.10
.585	14.86	1.620	41.15
.595	15.11	2.00	50.8
.997	25.32		



Bearing Mandrel
(Fabricate if considered necessary)

FIGURE 1



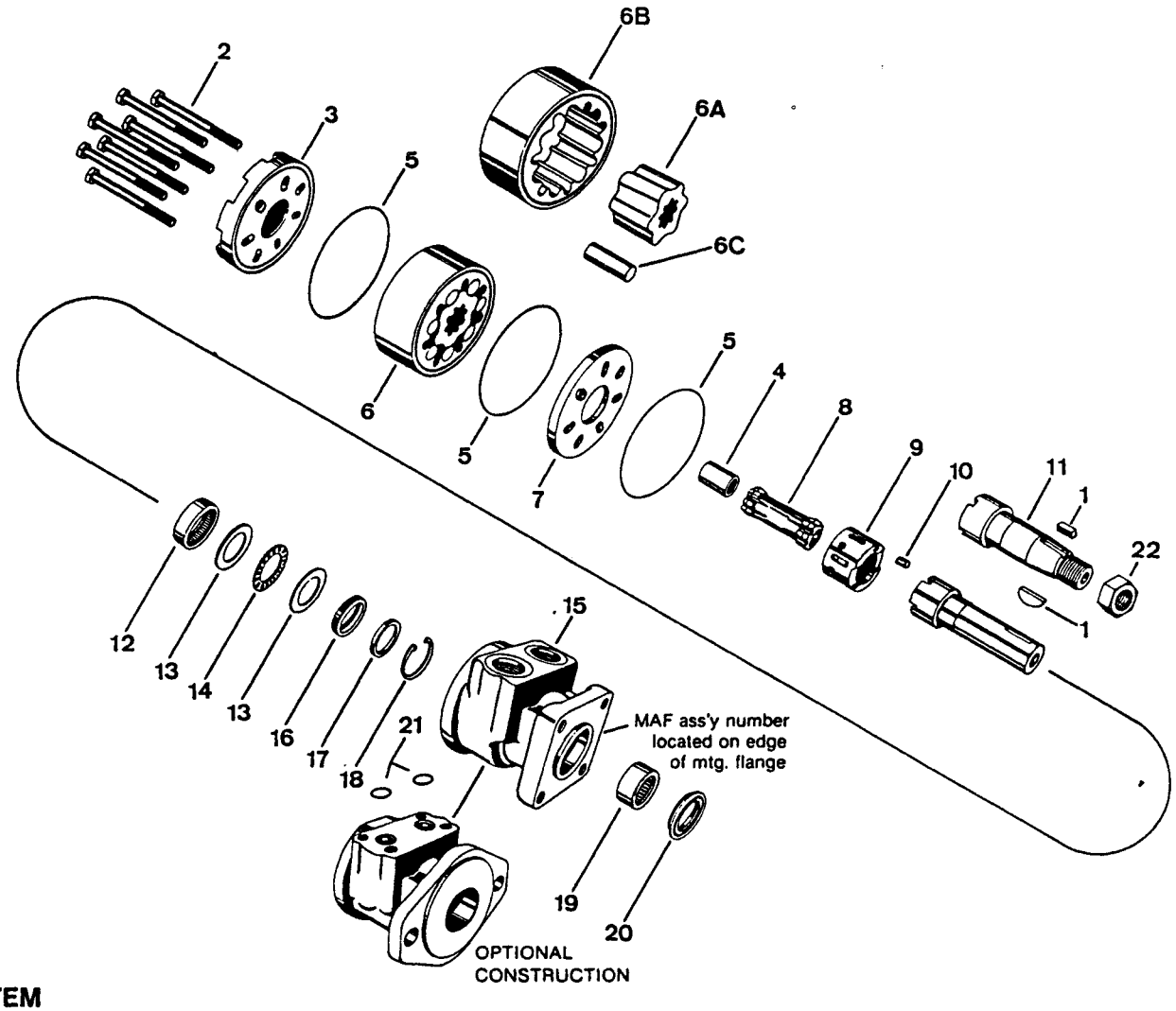
Rotor Set Assembly Tool
(Fabricate if considered necessary)

FIGURE 2

Torque Chart

Part Name	Item Number	Torque
bolt 5/16 24	2	22-26 ft. lbs. (30-35 Nm)

MAF Torqmotor™ Exploded Assembly View - Typical



ITEM NO.	DESCRIPTION
1	WOODRUFF KEY
2	BOLT 5/16 24 (7)
3	END COVER
4	SPACER/WASHER
5	SEAL RING (3)
6	ROTOR ASSY. SET (Matched set, not serviced separately)
6A	ROTOR
6B	STATOR
6C	VANE (7)
7	WEAR PLATE
8	DRIVE LINK
9	COMMUTATOR-(Matched with housing as a set. Not serviced separately)
10	DRIVE PIN
11	COUPLING SHAFT
12	BEARING - INNER
13	THRUST WASHER (2)
14	THRUST BEARING
15	HOUSING-(Matched with commutator as a set. Not serviced separately)
16	SEAL - INNER
17	BACKUP WASHER
18	RETAINING RING
19	BEARING
20	SEAL - DIRT & WATER
21	O-RING (2)
22	NUT

MAF: Disassembly and Inspection

(Preparation Before Disassembly)

- Before you disassemble the MAF 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 MAF.
- Refer to page 7A for tools and other items required to service the MAF, and have them available.
- Thoroughly clean off all outside dirt, especially from around fittings and hose connections, before disconnecting and removing the MAF. Remove rust or corrosion from coupling shaft.
- Remove coupling shaft connections and hose fittings, and immediately plug port holes and fluid lines.
- Remove the MAF 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 MAF before you start to disassemble the unit.
- As you disassemble the MAF, clean all parts, except seals, in clean petroleum-based solvent, and blow them dry.

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.

CAUTION 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 MAF. Replace all seals, seal rings and any damaged or worn parts with genuine Ross or OEM approved service parts.

Disassembly and Inspection

position Torqmotor™ in a vise.

1. Position the MAF assembly in a soft jawed vise, with coupling shaft (11) pointed down, the vise jaws clamping firmly on the sides of the housing (15) mounting flange. SEE FIGURE 3.

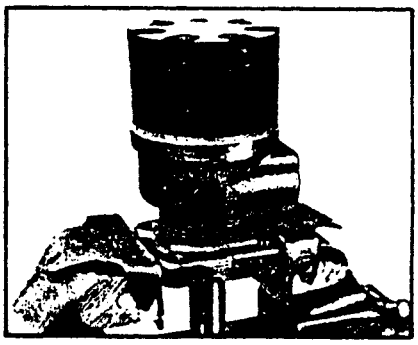


Figure 3

CAUTION

CAUTION: Do not clamp the housing port area between the vise jaws as it might distort the housing around the commutator (9), preventing the disassembly of the commutator.

WARNING

WARNING: IF THE MAF ASSEMBLY IS NOT FIRMLY HELD IN THE VISE, IT COULD FALL AND INJURE SOMEONE.

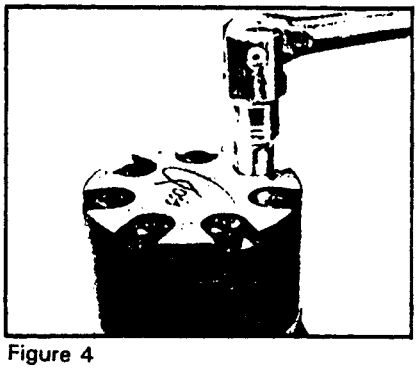


Figure 4

remove special bolts & inspect bolts

2. Remove the seven special ring head bolts (2) using a ½ inch thin wall socket to enter the end cover bolt head recess. SEE FIGURE 4. Inspect bolts (2) for damaged threads, or sealing ring, under the bolt head. Replace damaged bolts. SEE FIGURE 5.

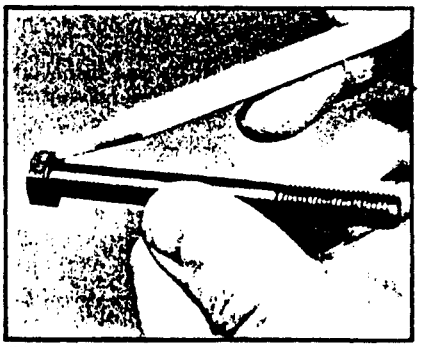


Figure 5

remove end cover & seal ring

3. Remove end cover (3) and seal ring (5). Discard seal ring (5). SEE FIGURE 6.

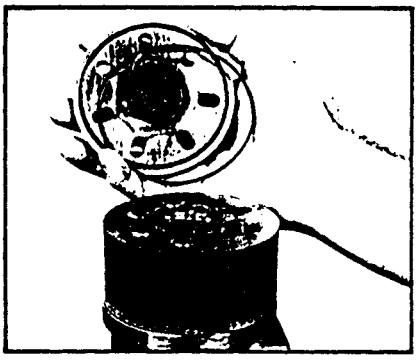


Figure 6

inspect end cover

4. Inspect the end cover (3) for severe wear, nicks, burrs and spalling on the ground surface that has the seal ring groove. Inspect the bolt head recesses where the bolt head sealing ring makes contact for damage that would prohibit good sealing contact. Replace cover if any of these conditions exist.

Figure 7

NOTE

NOTE: A polished pattern on the cover surface from rotation of the rotor (6A) is normal. Discoloration would indicate excess fluid temperature, thermal shock or excess speed and require system investigation for cause, and very close inspection of end cover, rotor set, and wearplate.

remove & inspect drive link spacer/washer

5. Remove drive link spacer/washer (4). Inspect it for badly burred or nicked ends that would interfere with rotor and drive link rotation. Replace if necessary. SEE FIGURE 7.

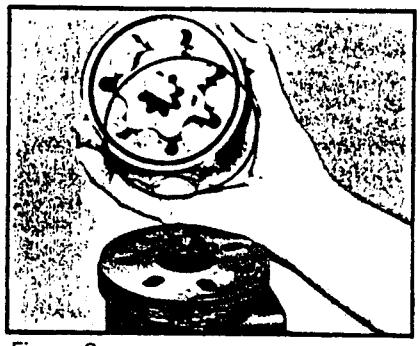


Figure 8

remove & inspect rotor set and seal ring

6. Remove rotor set (6), retaining it in its assembled form, if possible, to avoid an involved reassembly procedure. Inspect the rotor set in its assembled form, for nicks, scoring, or spalling, on any surface, and broken or worn rotor splines. If any of the rotor set components require replacement, the complete rotor set must be replaced as it is a matched set. SEE FIGURE 8. Discard seal ring (5).

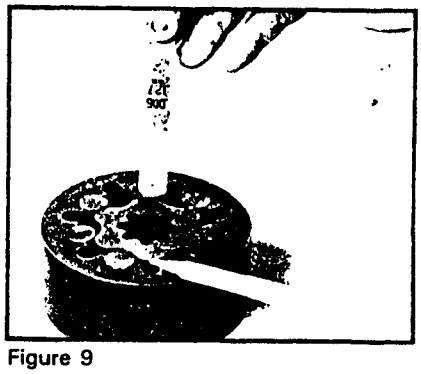


Figure 9

check clearance

7. Using a feeler gage, check the rotor (6A) to vane (6C) clearance. The rotor should be centered at the pencil point. SEE FIGURE 9. If there is more than .005 inches (.13 mm) of clearance, replace rotor set.

remove & inspect wearplate

8. Lift off wearplate (7) and inspect it for scoring or brinelling (dinging) on the rotor and commutator contact and sealing surfaces. Replace wearplate if any of these conditions exist. SEE FIGURE 10.

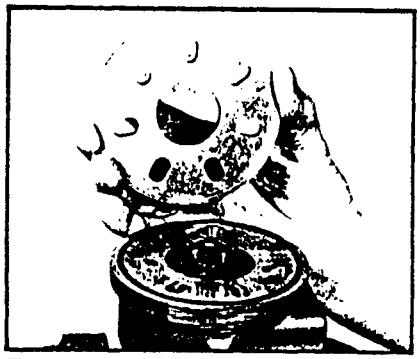


Figure 10

NOTE

NOTE: A polished pattern from rotor or commutator rotation is normal.

remove drive link

9. Remove drive link (8) and inspect it for cracks and for chipped or damaged splines. No perceptible lash (play) should be noted between mating spline parts. Replace, if necessary SEE FIGURE 11.

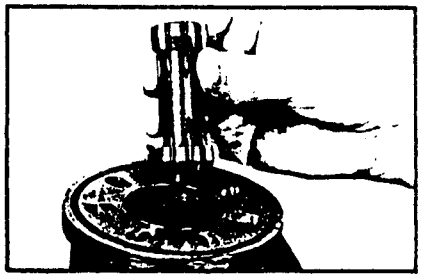


Figure 11

remove & discard seal ring

10. Remove seal ring (5) from housing (15) seal ring groove and discard seal ring. SEE FIGURE 12.

Figure 12

remove & inspect commutator

11. Remove commutator (9) which is a close slip fit into housing (15), by inserting two fingers into its center cavity and lifting. SEE FIGURE 13. The commutator drive pin (10) will probably be in the commutator when the commutator is removed. Inspect the commutator for nicks, burrs, or brinelling on the outside diameter surface. Inspect for broken edges on the commutation slots. Inspect the exposed area of the drive pin slot for extreme wear or damage. Only the commutator drive pin can be serviced separately. A worn or damaged commutator will require a new matched housing and commutator service assembly set.

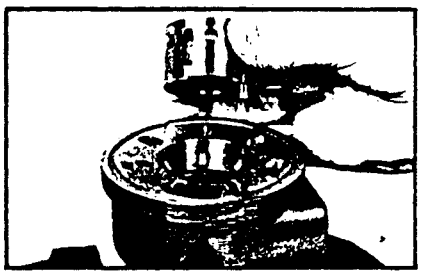


Figure 13

remove commutator drive pin

12. Remove commutator drive pin (10) only if it must be replaced. If the pin does not readily pull out of the commutator, clamp the exposed portion of the drive pin in a vise and twist the commutator from the drive pin by hand only. SEE FIGURES 14 and 15.

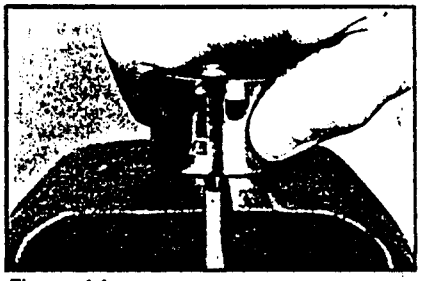


Figure 14

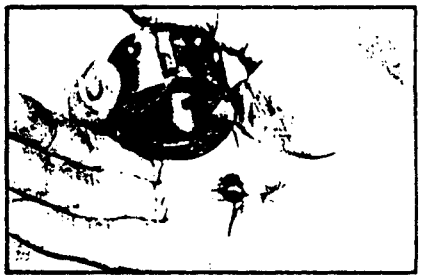


Figure 15

check thrust bearing operation

13. Replace drive link (8) into mesh with coupling shaft (11) and exert a downward force on it with the palm of one hand while pulling down and rotating the coupling shaft with the other hand. SEE FIGURE 16. A damaged thrust bearing (14) package would be indicated by roughness "felt" or heard during this procedure and would require thrust bearing and thrust washer (13) removal for further inspection in subsequent procedures. Remove drive link.

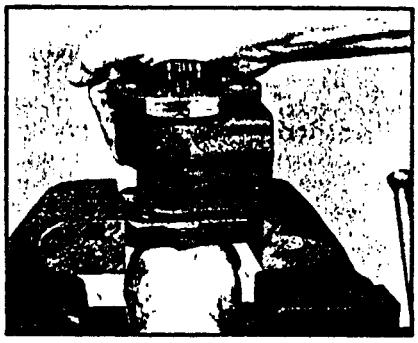


Figure 16

check coupling shaft for rust or corrosion

14. Check exposed portion of coupling shaft (11) to be sure you have removed all signs of rust and corrosion which might prevent its withdrawal through the seal. Crocus cloth or fine emery paper may be used. SEE FIGURE 17.

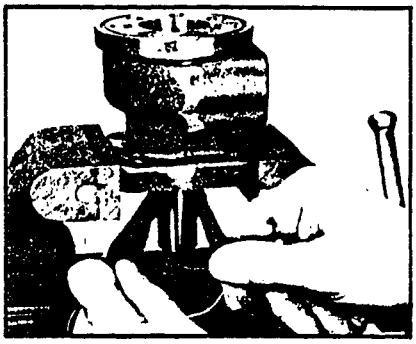


Figure 17

remove & inspect coupling shaft

15. Remove coupling shaft (11), by pushing on the output end of shaft. Inspect coupling shaft bearing and seal surfaces for spalling, nicks, grooves, severe wear or corrosion and discoloration. SEE FIGURE 18. Inspect for damaged or worn internal and external splines, drive pin slot, and keyway. SEE FIGURE 19. Replace coupling shaft if any of these conditions exist.

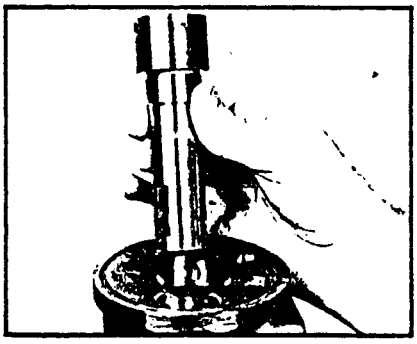


Figure 18

NOTE

NOTE: Minor shaft wear in seal (17) area is permissible. If wear exceeds .020 inches (.51mm) diametrically, replace coupling shaft.

A slight "polish" is permissible in the shaft bearing areas. Anything more would require coupling shaft replacement.

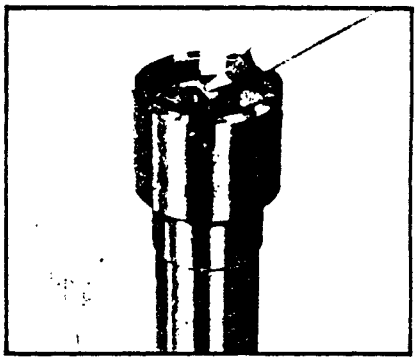


Figure 19

NOTE

NOTE: If commutator (9) was discarded as worn or damaged in Step 10, discard housing (15) assembly as well. If this is the case, the disassembly of the MAF Torqmotor™ is now complete. If, however, the commutator passed inspection, continue the disassembly procedures.

remove seals

16. Remove housing (15) from vise and place it on a clean flat work surface with wearplate end down. Pry out and discard the dirt and water seal (20) and inner seal (16) using a dull-edged screw driver. Be careful not to gouge or nick other components during the process. SEE FIGURE 20 and 21.

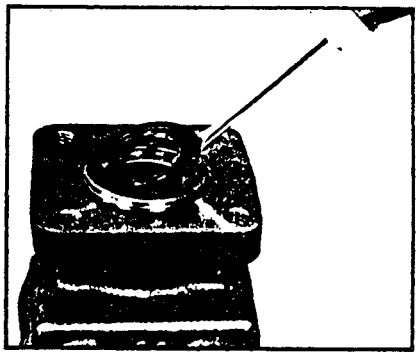


Figure 20

inspect housing assembly

17. Inspect the housing (15) assembly for cracks, the housing machined surfaces for nicks, burrs, brinelling or corrosion. Remove burrs that can be removed without changing dimensional characteristics. Inspect the tapped holes for thread damage. SEE FIGURE 22. If the housing is defective in these areas, discard the housing (15) assembly and commutator (9) assembly and the disassembly of the MAF Torqmotor™ is completed. If the housing assembly passed inspection to this point, continue the inspections per Step 18.

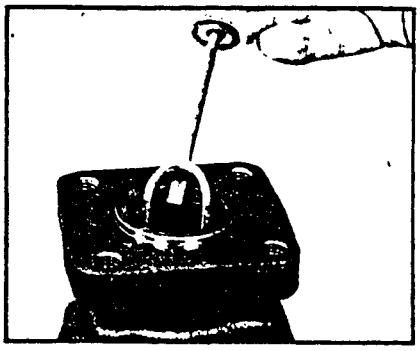


Figure 21

inspect housing bearings, thrust washers & backup washer

18. Inspect the outer bearing (19), the inner bearing (12), the thrust bearing (14), thrust washers (13), and back-up washer (17), while assembled in the housing (15). The bearing rollers should be firmly retained in the bearing cages, but must turn and revolve freely. The full complement of bearing rollers and the thrust washers must be free of brinelling and corrosion. Seal back-up washer must be free of cracks, chipped edges or burrs. SEE FIGURE 23. If the housing assembly passed this inspection, and the inspections in Step 13 and 17, the disassembly of the MAF Torqmotor™ is completed.

    If only the bearings, thrust washers, or back-up washer show deterioration, they can be replaced. Go to the next step.

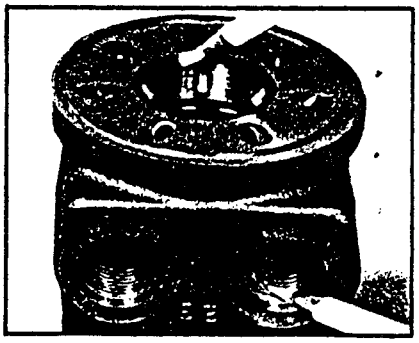


Figure 22

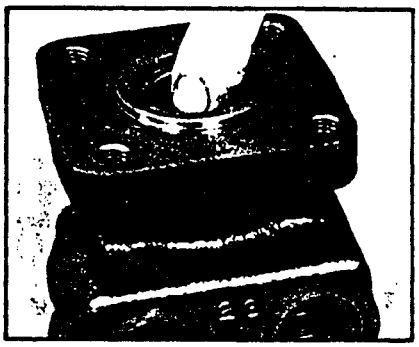


Figure 23

remove inner bearing

19. If the inner bearing (12), thrust washers (13), thrust bearing (14), or back-up washer (17), need replacement, place housing back into the vise as in disassembly Step 1. Insert a puller for a 1.38 inch (35.1mm) diameter bearing, through the wearplate end of the housing, through bearing (12). SEE FIGURE 24. Expand bearing puller and remove bearing (12) and discard. SEE FIGURE 25.

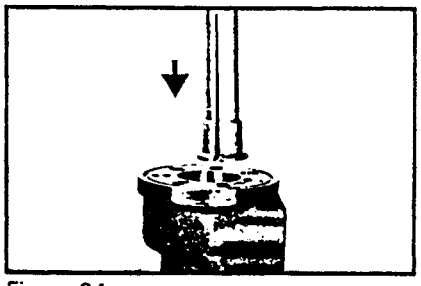


Figure 24

CAUTION

CAUTION: Use care when pulling the bearing, that the commutator bore in the housing is not scored or damaged during the process.

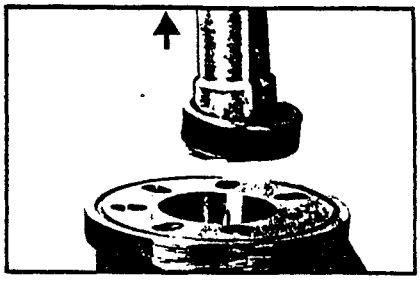


Figure 25

remove & inspect thrust washers, thrust bearings, & back-up washer

20. Remove and inspect thrust washers (13), thrust bearing (14), and back-up washer (17), again per Step 18. These parts can be retained for reassembly if they pass this inspection, but it is recommended that they be replaced if removed. These are included in the bearing service kit. SEE FIGURE 26.

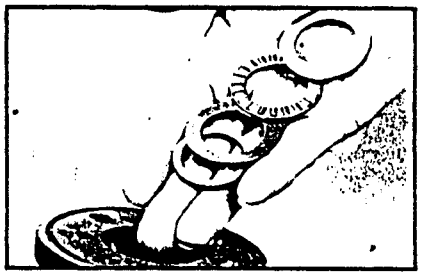


Figure 26

remove retaining ring

21. If the outer bearing is to be removed, remove retaining ring (18) using the appropriate retaining ring pliers. SEE FIGURE 27. A damaged or deformed retaining ring should be replaced.

remove outer bearing

22. Invert housing (15) in the vise, clamping on the mounting flange. Insert a puller for a 1.00 inch (25.4mm) diameter bearing, through outer bearing (19) from the flange end of the housing, expand puller and remove and discard bearing. SEE FIGURE 28.

The MAF Torqmotor™ disassembly is now complete.

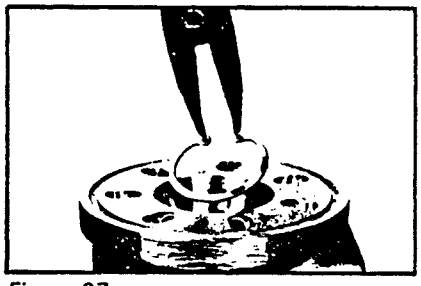


Figure 27

NOTE

NOTE: A service bearing package kit is available which includes inner bearing (12), thrust washers (13), thrust bearings (14), inner seal (16), back-up washer (17), retaining ring (18), outer bearing (19), and dirt and water seal (20). If a housing bearing or thrust bearing requires replacement, it is recommended that all the housing bearings and relative components be replaced that are available in this service kit.

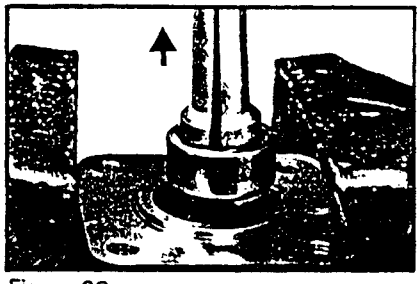


Figure 28

MAF Assembly

- Replace all seals and seal rings with new ones each time you reassemble the MAF 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 29. The parts should be available through most OEM parts distributors or Ross approved MAF 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, stator, wearplate and housing and from port and sealing areas.

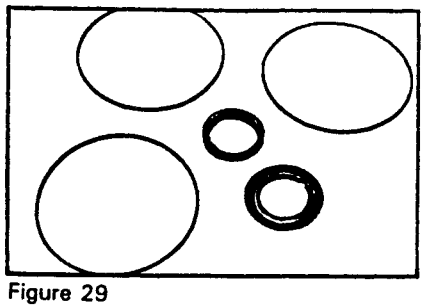


Figure 29

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.

service housing and commutator replacement

1. If a service housing and commutator assembly set has been procured for the MAF unit being serviced, the housing components are already installed. Start the assembly procedure with Step 9.

housing seal replacement only

2. If the housing assembly (15) is being reused with original bearings intact, place housing on a clean work surface with the housing wearplate surface up. Apply a small amount of clean grease to a new inner seal (16). Deform the seal between two fingers and insert the seal into the housing seal cavity between the back-up washer (17) and a thrust washer (13). SEE FIGURE 30. The seal must be properly seated and against the back-up washer (17), with the seal lip facing the thrust washer (13). The back-up washer (17) must be seated against the retaining ring (18). Go directly to assembly procedure #8.

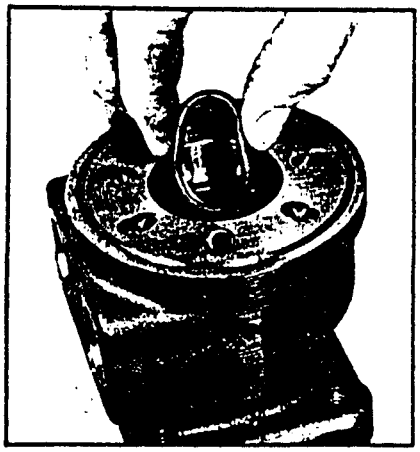


Figure 30

NOTE

NOTE: You will probably have to pick-up the housing and use fingers through each end of the housing to seat the seal into the correct position.

install retaining ring

3. If the housing (15) has been completely disassembled, place the housing, mounting flange end down, on a clean work surface. Install retaining ring (18) into the housing retaining ring groove. Be sure the rounded edge of retaining ring is facing in toward the larger housing cavity. Use appropriate retaining ring pliers. SEE FIGURE 31.

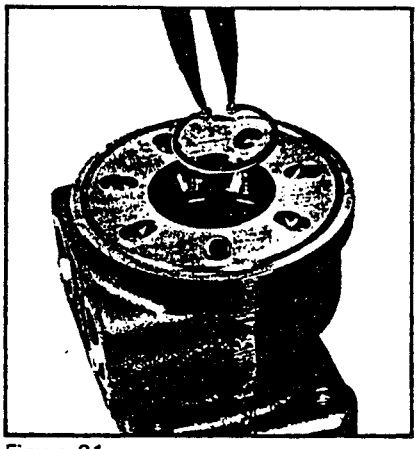


Figure 31

press in bearing

4. Thoroughly grease the rolls of a NEW bearing (19) with clean wheel bearing grease. Press the bearing into housing (15) from the mounting flange end of the housing bore, using bearing mandrel (special tool FIGURE 1, Page 7A) against the lettered end of the bearing shell. SEE FIGURES 32 and 33. Take care during this procedure that the housing is square with the press base and that the bearing is not cocked. The bearing mandrel will control the bearing (19) press depth to the required .135/.125 inches (3.43/3.18 mm) from the flange end of the housing.

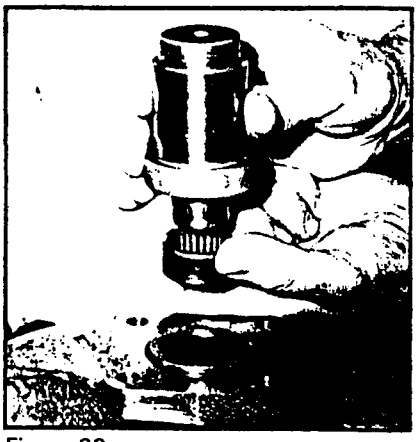


Figure 32

NOTE:

NOTE: If the bearing mandrel shown is not available, alternate methods may be used to press in the bearing but the bearing depth location must be maintained.

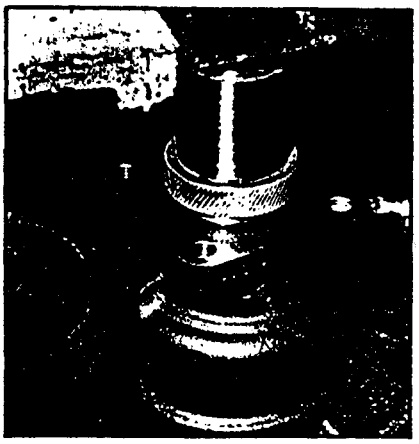


Figure 33

CAUTION

CAUTION: The controlled press depth of bearing (12) and (19) into the housing is required to ensure adequate bearing support, and correct bearing relationship to adjacent components when assembled.

CAUTION

CAUTION: Because bearings (12) and (19) have a press fit into the housing, they must be discarded if removed from the housing. They must not be reused.

install backup washer & seal

5. Place housing (15), wearplate surface up, on a clean work surface. Apply a small amount of clean grease to inner seal (16). Install back-up washer (17) then seal (16) into housing coupling shaft bore from the wearplate end of the housing (15). Seat the back-up washer against the retaining ring (18) and the seal against the back-up washer, with the seal lip facing away from the back-up washer. SEE FIGURE 34.

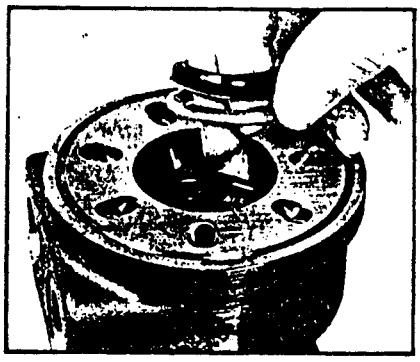


Figure 34

install thrust washers & thrust bearing

6. Install a thrust washer (13), the thrust bearing (14) and then another thrust washer (13) into the housing (15) inner bearing bore until they are seated at the bottom of the bore. SEE FIGURE 35.

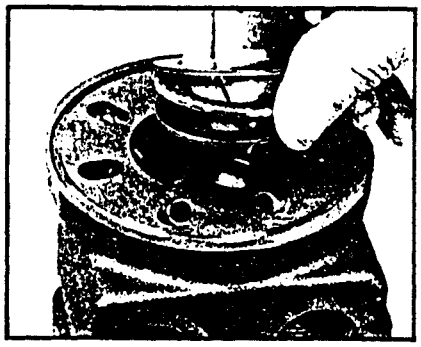


Figure 35

press in bearing

7. Press a ***new*** bearing (12) into the housing (15) inner bearing bore, from the wearplate face end, using bearing mandrel (special tool SEE FIGURE 1, Page 7A) against the lettered end of the bearing shell. Take care during this procedure that the housing is square with the press base and that the bearing is not cocked. The bearing mandrel will control the bearing press depth to the required 1.618/1.598 inches (41.10/40.59mm) from the wearplate face of the housing. SEE FIGURES 36 and 37.

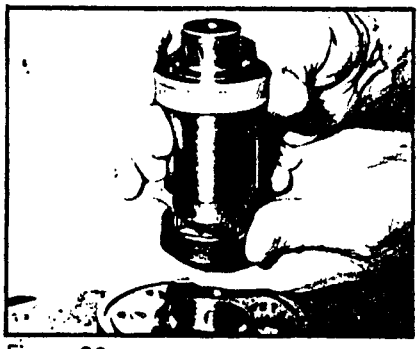


Figure 36

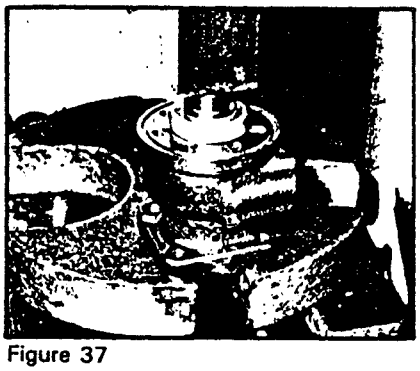


Figure 37

NOTE

NOTE: If the bearing mandrel shown is not available, alternate methods may be used to press in the bearing but the bearing depth location must be maintained.

insert dirt & water seal

8. Place housing (15), wearplate surface down, on a clean work surface. Apply a small amount of clean grease to a new dirt and water seal (20) and press the seal into the housing seal cavity. The end of a hammer handle would be an appropriate tool. Be sure the seal is not cocked or deformed as it enters housing seal bore. SEE FIGURE 38.

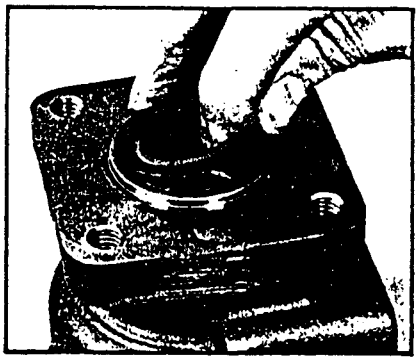


Figure 38

place housing assembly into vise

9. Place housing (15) assembly into a soft-jawed vise with coupling shaft bore down, and clamp the vise jaws against the edges of the mounting flange. SEE FIGURE 39.

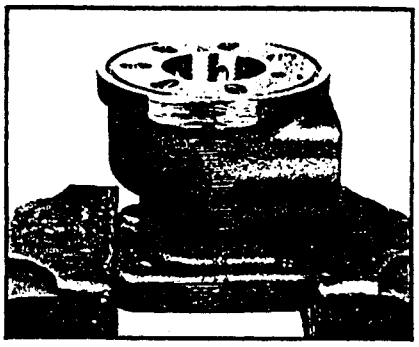


Figure 39

CAUTION

CAUTION: Clamping on the body of the housing in the area of commutator bore could distort the housing and prevent the assembly of the commutator (9).

NOTE

NOTE: The assembly of the rotor set (6) components, if required, should be done at this time in order to utilize the housing in the vise, as a rotor set assembly "Fixture". SEE "Rotor Set Component Assembly Procedure" on page 23.

NOTE

NOTE: The coupling shaft (11) has a timing mark on the small (output) end that is radially in line with two internal spline teeth and a "commutator drive pin slot" that transverses the opposite end of the coupling shaft, SEE FIGURE 40. The "commutator drive pin slot" indicated by the timing mark is the only slot of two oil passage slots across the large end of the coupling shaft, wide enough to engage the commutator drive pin (10) at assembly. This orientation of the coupling shaft splines and drive pin slot is important to subsequent assembly procedures that will produce the required rotor (6A) lobe and commutator (9) "fixed" radial relationship at assembly.

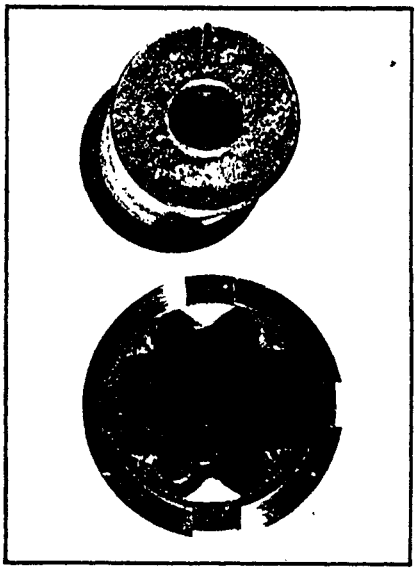


Figure 40

NOTE

NOTE: FIGURE 40, shows two coupling shafts to better illustrate the relative positioning of the timing mark, drive pin slot and internal spline tooth.

extend timing mark

10. Using chalk or marking pencil, extend the timing mark that is on the end of coupling shaft (11) up the side of the coupling shaft so that the timing mark location will be visible for alignment purposes when the coupling shaft is assembled into the housing held in the vise. SEE FIGURE 41.

Figure 41

install coupling shaft

11. Be sure that a generous amount of clean wheel bearing grease is applied to housing bearing (19) then install coupling shaft (11) into housing (15) seating it against thrust washer (13). SEE FIGURE 42. The coupling shaft must rotate smoothly on the thrust bearing package.

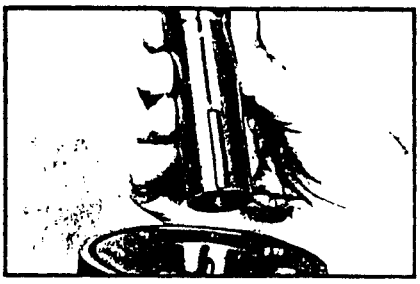


Figure 42

insert new drive pin

12. Insert new drive pin (10) if it was removed, into the commutator (9) drive pin hole until it bottoms out. SEE FIGURE 43.

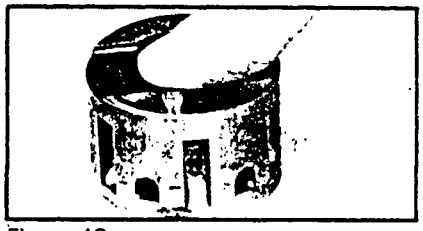


Figure 43

install commutator assembly

13. Install commutator (9) assembly into housing (15) commutator bore. SEE FIGURE 44. The commutator must not be cocked as it enters the bore and the drive pin (10) must be in line with the coupling shaft (11) commutator drive pin slot indicated by the timing mark. Engage the drive pin (10) protruding from the commutator into the coupling shaft drive pin slot, rotating the coupling shaft if necessary. The commutator must be below the housing wearplate surface when correctly seated. SEE FIGURE 45.

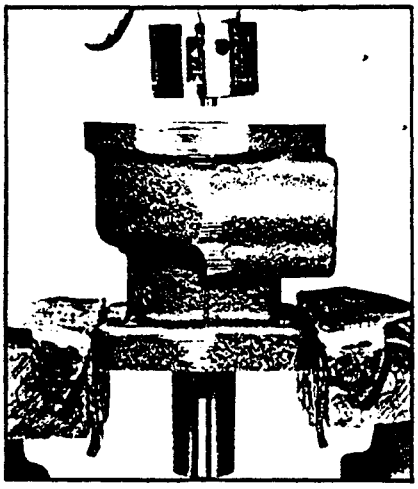


Figure 44

NOTE

NOTE: The commutator drive pin (10) and coupling shaft (11) drive pin slot, at this point in the assembly, are visible through the commutator center cavity for coupling pin engagement purposes in addition to the timing mark.

CAUTION

CAUTION: Do not force commutator into bore. It is a close slip fit and must rotate.

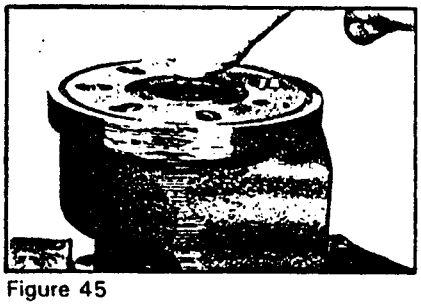


Figure 45

install drive link

14. Install either end of the drive link (8) through the commutator (9) cavity and engage the lower drive link splines into mesh with the internal splines in the coupling shaft (11). SEE FIGURE 46. A spline valley on both ends of the drive link will now be in line with the commutator drive pin (10) and coupling shaft timing mark.

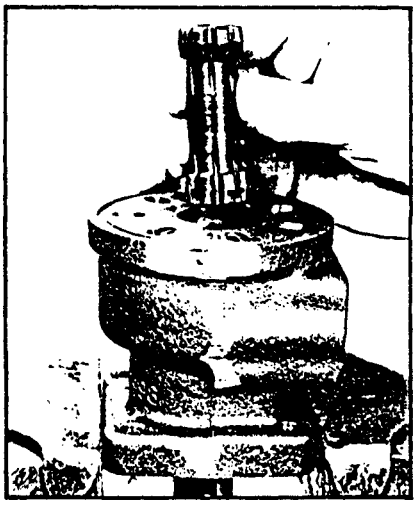


Figure 46

insert seal ring into housing

15. Apply a small amount of clean grease to a new seal ring (5) and insert the seal ring into housing (15) seal ring groove. SEE FIGURE 47.

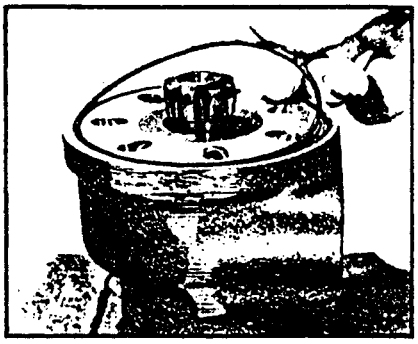


Figure 47

insert seal ring into stator

16. Place assembled rotor set (6) on a clean work surface with the stator (6B) seal ring groove up. Apply a small amount of clean grease to a new seal ring (5) and insert the seal ring into the stator (6B) seal ring groove. SEE FIGURE 48.

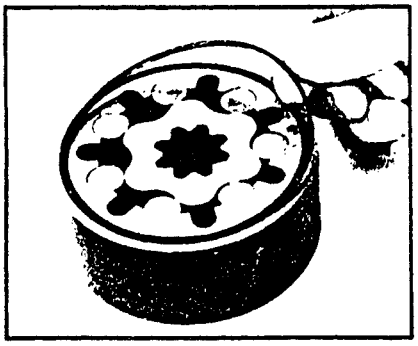


Figure 48

place wearplate on rotor set

17. Place wearplate (7) either side up, onto the rotor set (6) and align wearplate bolt holes with the stator (6B) bolt slots. SEE FIGURE 49.

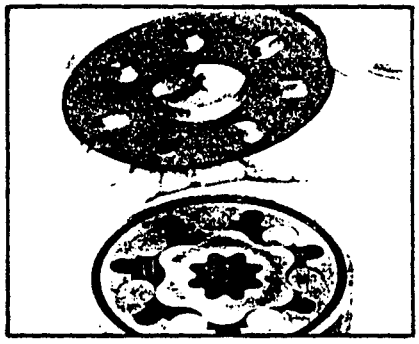


Figure 49

install rotor set & wearplate on housing

18. Locate on the rotor (6A) the only two spline teeth, 180° apart, that are diametrically aligned (on the same center line) with two rotor lobes. SEE FIGURE 50. Take the rotor set (6), seal ring (5) and wearplate (7) as a unit and align these two just located rotor spline teeth to mesh with the two drive link (8) spline valleys that are diametrically aligned with the timing mark on the coupling shaft (11) and install this unit onto the housing (15) with the wearplate against the housing. SEE FIGURE 51. With the rotor set (6) now correctly in mesh with the drive link, rotate the rotor set (6) wearplate (7) drive link (8) and coupling shaft (11) to align the stator (6B) and wearplate bolt holes with the bolt holes in the housing. SEE FIGURE 52.

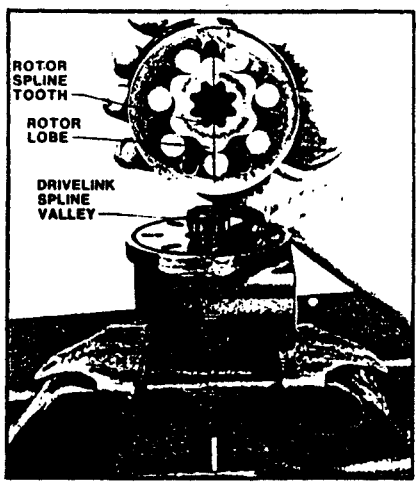


Figure 50

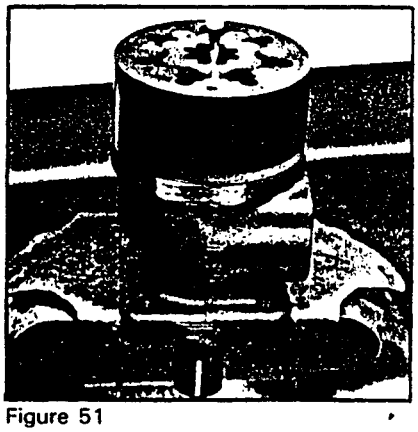


Figure 51

CAUTION

CAUTION: Be careful not to disengage the rotor, drive link or coupling shaft while aligning bolt holes as this could affect the timing you just achieved.

CAUTION

CAUTION: The meshing of the precise rotor (6A) teeth with the precise drive link (8) spline valleys as described above is absolutely crucial to a correctly timed and functional MAF Torqmotor™. Misalignment by one spline tooth will be indicated by the timing mark on the coupling shaft (11) being radially 45° from the specified rotor lobe. Refer to "Final Checks" Page 25.

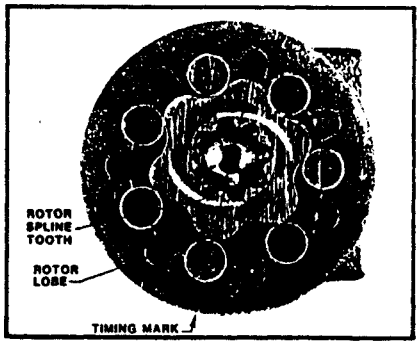


Figure 52

install drive link spacer/washer

19. Install drive link spacer/washer (4) into the rotor spline cavity onto the end of the drive link (8). SEE FIGURE 53.

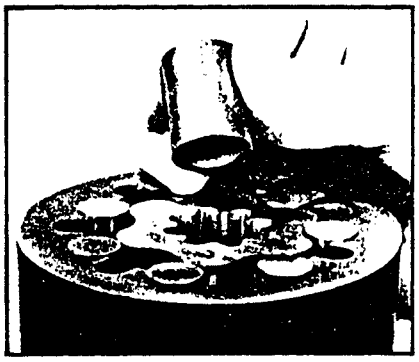


Figure 53

insert seal ring

20. Apply a small amount of clean grease to a seal ring (5) and insert the seal ring into the end cover (3) seal ring groove. SEE FIGURE 54.

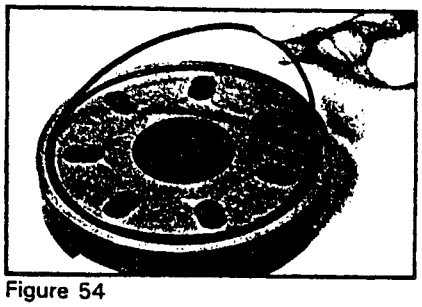


Figure 54

install end cover

21. Install end cover (3) assembly onto the rotor set (6) with seal ring (5) against the stator (6B) and align the end cover bolt holes with the stator (6B) bolt holes. SEE FIGURE 55.

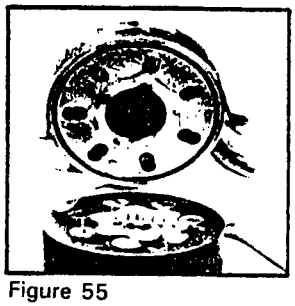


Figure 55

install & torque bolts

22. Install 7 bolts (2) into the assembly bolt holes finger tight, then torque the bolts to 22-26 foot pounds, (30-35Nm), in the sequence shown, using the appropriate torque wrench. SEE FIGURES 56, 57 and 58.

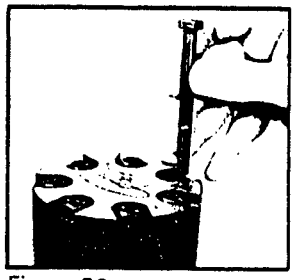


Figure 56

The assembly of the MAF Torqmotor™ is now complete, except for the woodruff key (1), port manifold o-rings (21) or nut (22), if required, at Torqmotor™ installation. See Page 25 for final checks.

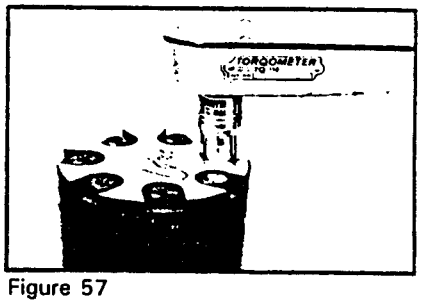


Figure 57

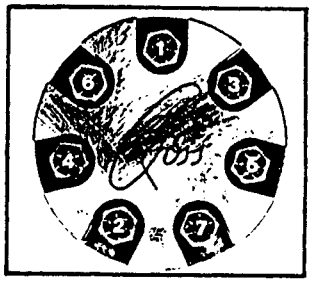


Figure 58

Rotor Set Component Assembly Procedure

place housing in vise

1. Place housing (15) in a vise per MAF motor assembly procedure #9 and FIGURE 39 (Page18).

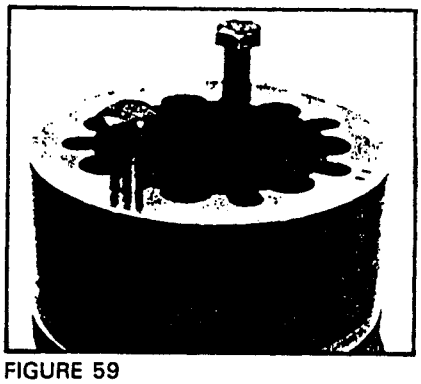


FIGURE 59

place wearplate & stator on housing

2. Place wearplate (7) and then stator (6B) on the housing (15) and align the bolt holes of the three parts.

insert two bolts

3. Insert two bolts (2) into bolt holes finger tight, approximately 180° apart to retain the stator (6B) and wearplate (7) stationary on the housing (15). SEE FIGURE 59.

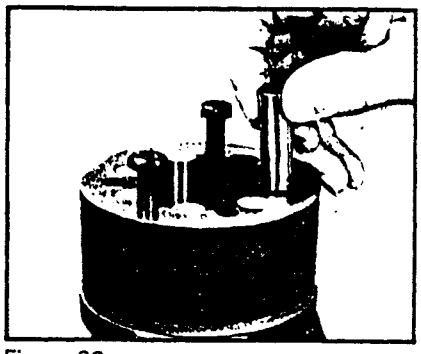


Figure 60

assemble six stator vanes & rotor

4. Assemble the rotor (6A) into the stator (6B) with six vanes (6C) or as many vanes that will readily fit into the stator vane pockets. SEE FIGURE 60 and 61.

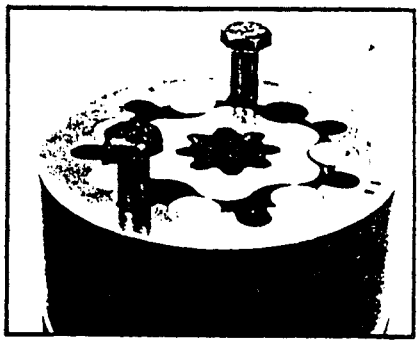


Figure 61

NOTE

NOTE: A special tool (See Page 7A) or the drive link (8) held in large locking pliers between two rods or nails to protect the drive link splines (SEE FIGURE 62) will be required to rotate the rotor in the following procedure.

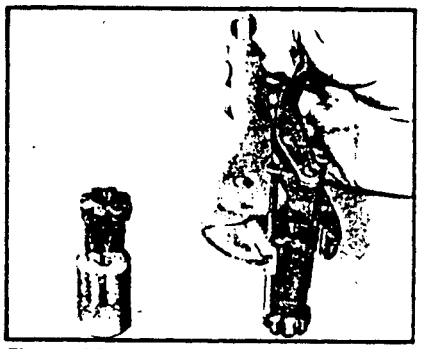


Figure 62

assemble seventh stator vane

5. Rotate the rotor (6A) using the tool described above to seat the rotor and assembled vanes (6C) into the stator (6B) and to create necessary clearance to assemble the seventh or full complement of seven vanes. Assemble the seven vanes using minimum force. SEE FIGURE 63.

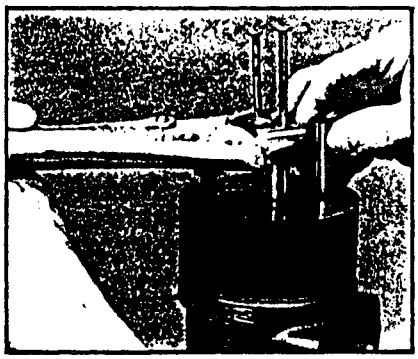


Figure 63

CAUTION

CAUTION: Too much force used to push the rotor vanes into place could shear off the coating applied to the stator vane pockets. Use care during this procedure to prevent damage to rotor set and the drive link splines, if you use your drive link as the assembly tool as shown in FIGURE 63.

remove tool, bolt, rotor set & wear plate

6. Remove drive link tool, the two bolts, then the assembled rotor set (6) and wearplate (7) as a unit from the housing and set them aside for subsequent Torqmotor™ assembly procedures. SEE FIGURE 64.

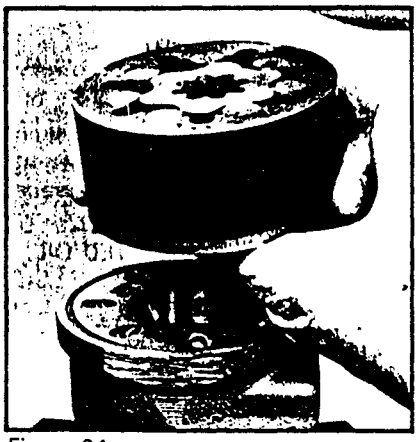


Figure 64

NOTE

NOTE: Go to the notes preceding Step 10 of the MAF Assembly Procedure if the MAF Assembly Procedure was interrupted after MAF Assembly Step 9, to assemble the rotor set.

Final Checks

Pressure port with "A" cast under it on housing (15) 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.

CAUTION: If the MAF Torqmotor™ is reassembled with rotor and coupling shaft internal splines one tooth (45°) or three teeth (135°) out of phase in either direction, the MAF will not function.

If the MAF Torqmotor™ is reassembled with rotor and coupling shaft internal splines two teeth (90°) out of phase, in either direction, it is fully functional but, the direction of rotation of coupling shaft will be reversed to what is designated for a pressurized port "A" or port "B".

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.

Cautions required for Proper Torqmotor™ Hydraulic System Operation

CAUTION: Do not weld, braze, solder or any way alter any Torqmotor™ component.

CAUTION: Maximum operating pressure must not exceed recommended Torqmotor™ pressure capacity.

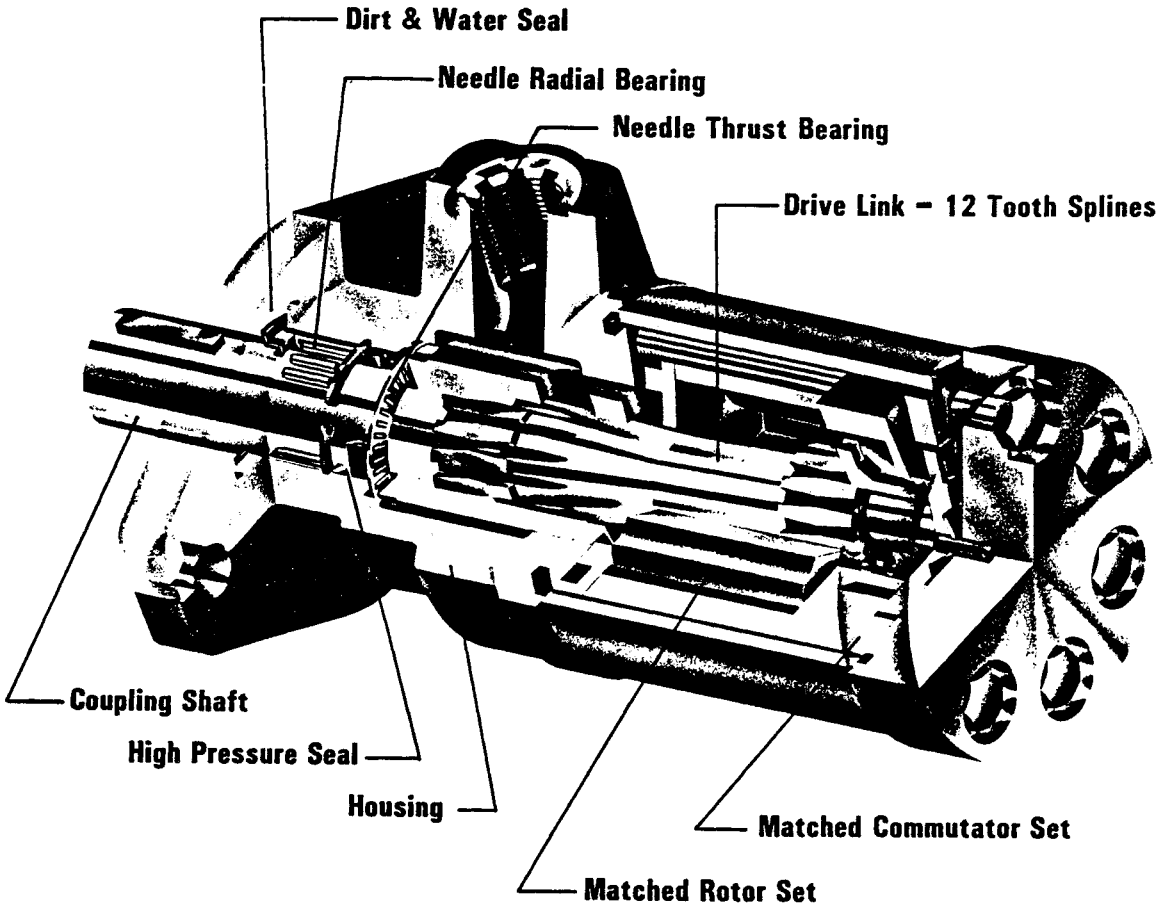
CAUTION: Always carefully inspect any system component that may have been struck or damaged during operation or in an accident. Replace any component that is damaged or that is questionable.

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.

Torqmotor™

MAG Series Service Procedure



MAG Design Features

Torqmotor™ MAG Design Features

- Displacements range from 23.6 cubic inches (387 CM^3) down to 3 cubic inches (49 CM^3) per revolution.
- Continuous rated pressure up to 1500 psi (103.4 BAR), depending on displacement with fully competitive volumetric efficiency.
- Coupling shaft mounted in steel caged needle radial and thrust bearings to withstand higher side and thrust loads.
- Optimized drive link contact with 12 tooth spline drive to reduce wear.
- Unique high pressure shaft seal allows MAG Torqmotors to be run in series without need for case drains. Only simple direct-line circuitry required.
- Standard SAE porting and mounting configurations.
- Fewer parts reduced maintenance, while maintaining quality performance.
- Full flow spline lubrication minimizes spline wear.
- Disc valve commutation maintains timing to promote efficiency and increase durability.
- Dirt and water shaft seal and corrosion resistant grease give added protection from environment.

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 MAG 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 MAG.

Patents

Ross Gear Division products and systems described in this manual are protected by the following United States patents: 3,606,601. In addition, patents have been issued or patent applications have been filed in Canada, Japan, The United Kingdom, and West Germany.

Table of Contents

Introduction

Service Manual for Model MAG

This service manual has one purpose: to guide you in maintaining, troubleshooting, and servicing the MAG Torqmotor™ (low-speed, high-torque hydraulic motor, MAG).

Material in this manual is organized so you can work on the MAG 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 MAG.

This manual also contains troubleshooting information and checklist. If you must service the MAG, 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 MAG. Column 1 gives a brief key for each procedure. Column 2 explains in detail the procedure you should follow. Column 3 illustrates this procedures with photographs. Pay special attention to the notes, cautions, and warnings.

A foldout page with an MAG exploded assembly view 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 parts are available through the Original Equipment Manufacturer (OEM) or Ross approved MAG Distributors.

As you gain experience in servicing the MAG, 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 MAG 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 MAG 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 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.

Preliminary Checks

Hydraulic systems are often trouble-free. 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 MAG 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 MAG 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 MAG unit.
	3. Special bolt (1) loose or its sealing area deteriorated by corrosion	(a) Loosen then tighten single bolt to 22-26 ft.-lbs. (30-35 N m) (b) Replace bolt.
	4. Internal shaft seal (16) worn or damaged	Replace seal by disassembling MAG unit.
	5. Worn coupling shaft (12) and internal seal (16)	Replace coupling shaft and seal by disassembling MAG 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 MAG unit.
	3. Severely worn or damaged internal splines	Replace rotor set, drive link and coupling shaft by disassembling MAG 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 MAG unit	1. Line blockage	Locate blockage source and repair or replace.
	2. Internal interference	Disassemble MAG 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 MAG 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

MAG service manual

Clean, petroleum-based solvent

Emery paper

Vise with soft jaws

Air pressure source

Arbor press

Screw driver

Retaining ring pliers (internal)

Breaker bar

1/2 inch thin wall socket

Torque wrench - foot pounds or Newton meter

Adjustable crescent wrench or hose fitting wrenches

SAE 10W40 SE or SF oil

Special bearing mandrel (SEE FIGURE 1)

Feeler gage .005 inch (.13 mm)

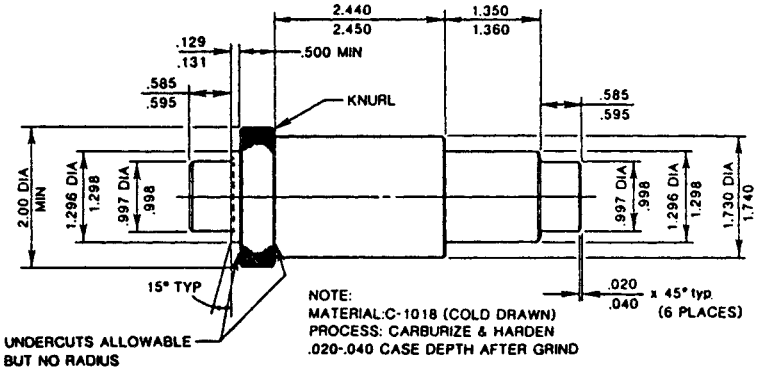
Clean corrosion resistant grease. Recommended grease is E/M Lubricant #K-70 Alternate compatible greases are:

- Shell Darina #2
- Lubriplate #930AA
- Union High Temp 2
- Sunoco High Temp 2

CAUTION: Mixing greases that have different bases can be detrimental to bearing life.

CONVERSIONS

INCHES	mm	INCHES	mm
.020	.51	1.296	32.92
.040	1.02	1.298	32.97
.129	3.28	1.350	34.29
.131	3.33	1.360	34.54
.500	12.70	1.730	43.94
.585	14.86	1.740	44.20
.595	15.11	2.00	50.8
.997	25.32	2.440	61.98
.998	25.35	2.450	62.23

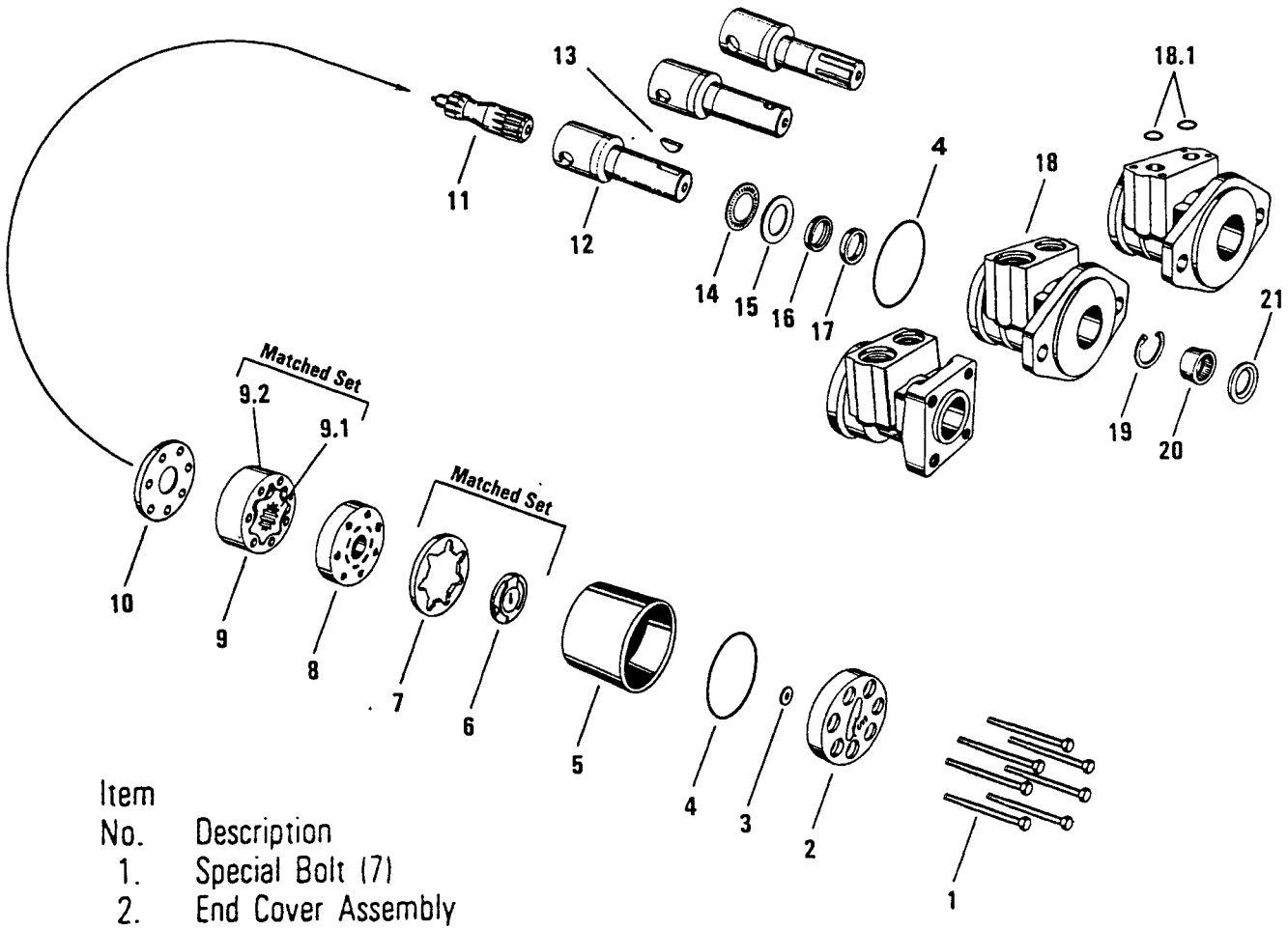


Bearing Mandrel (Fabricate if considered necessary)
Figure 1

Torque Chart

Part Name	Item Number	Torque
bolt 5/16 24 thread	1	22-26 ft. lbs. (30-35 N m)

MAG Torqmotor™ Exploded Assembly View-Typical



Item No.	Description	Item No.	Description
1.	Special Bolt (7)	13.	Woodruff Key
2.	End Cover Assembly	14.	Thrust Bearing
3.	Washer	15.	Thrust Washer
4.	Seal Ring(2)	16.	Seal
5.	Sleeve	17.	Spacer
6.	Commutator	18.	Housing
7.	Commutator Ring	18.1	"O" Ring
8.	Manifold	19.	Retaining Ring
9.	Rotor Set	20.	Needle Bearing
9.1	Rotor	21.	Seal
9.2	Stator		
10.	Wearplate (Spacer)		
11.	Drive Link		
12.	Coupling Shaft		

MAG Torqmotor Exploded View

MAG: Disassembly and Inspection

(Preparation Before Disassembly)

- Before you disassemble the MAG 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 MAG.
- Refer to page 7A for tools and other items required to service the MAG, and have them available.
- Thoroughly clean off all outside dirt, especially from around fittings and hose connections, before disconnecting and removing the MAG. Remove rust or corrosion from coupling shaft.
- Remove coupling shaft connections and hose fittings, and immediately plug port holes and fluid lines.
- Remove the MAG 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 MAG before you start to disassemble the unit.
- As you disassemble the MAG, 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 MAG. Replace all seals, seal rings and any damaged or worn parts with genuine Ross or OEM approved service parts.

Disassembly and Inspection

position Torqmotor™ in a vise

1. Position the MAG assembly in a soft jawed vise, with coupling shaft (12) pointed down, the vise jaws clamping firmly on the sides of the housing (18) mounting flange. SEE FIGURE 2. Remove manifold port O-Rings (18.1) if applicable.

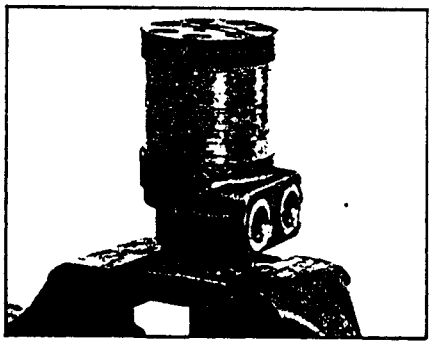


Figure 2

WARNING

WARNING: IF THE MAG ASSEMBLY IS NOT FIRMLY HELD IN THE VISE, IT COULD BE DISLODGED DURING THE SERVICE PROCEDURES, CAUSING INJURY.

remove special bolts & inspect bolts

2. Remove the seven special ring head bolts (1) using a 1/2 inch thin wall socket to enter the end cover bolt head recess. SEE FIGURE 3. Inspect bolts for damaged threads, or sealing ring, under the bolt head. Replace damaged bolts. SEE FIGURE 4.

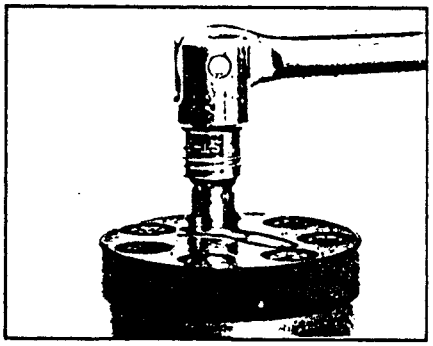


Figure 3

remove end cover & seal ring

3. Remove end cover assembly (2) and seal ring (4). Discard seal ring. SEE FIGURE 5.

NOTE

NOTE: The pin in the end cover must not be removed as it is serviced only as an integral part of the end cover.

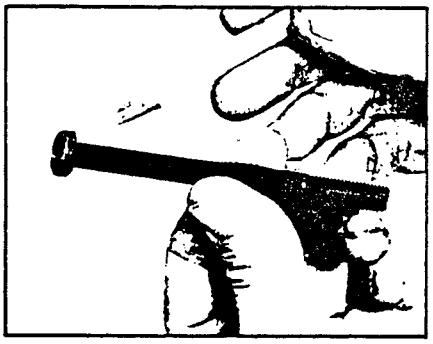


Figure 4

inspect end cover

4. Inspect the end cover (2) for severe wear, nicks, burrs and spalling on the ground surface that has the seal ring groove. Inspect the integral pin for out of round condition (flats). Inspect the bolt head recesses where the bolt head sealing ring makes contact for damage that would prohibit good sealing contact. Replace cover if any of these conditions exist.

NOTE

NOTE: A polished pattern on the cover from rotation of the commutator (6) 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, rotor set, spacer and washer.

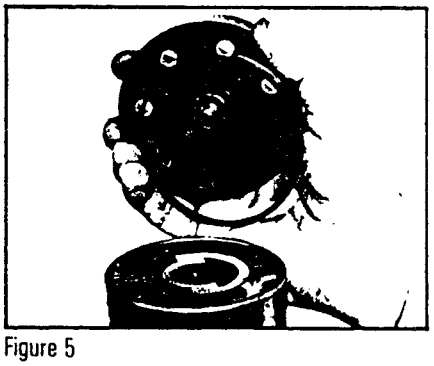


Figure 5

remove & inspect drive link washer

5. Remove drive link washer (3) from the commutator (6) or from the end cover if it was removed with the end cover. Replace washer if it shows signs of wear, spalling, nicks or is bent or has other deformation that could interfere with commutator or drive link rotation. SEE FIGURE 6.

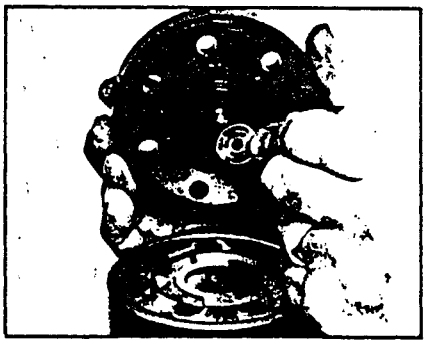


Figure 6

remove & inspect sleeve

6. Remove sleeve (5) and inspect if for deformation from the original cylindrical shape to a "barrel" or "hour glass" shape. Inspect the ends for severe nicks or burrs. Replace sleeve if any of these conditions exist. SEE FIGURE 7.

Figure 7

NOTE

NOTE: Minor burrs can be removed.

remove & inspect commutator ring

7. Remove commutator ring (7). SEE FIGURE 8. Inspect commutator ring for cracks, or burrs.

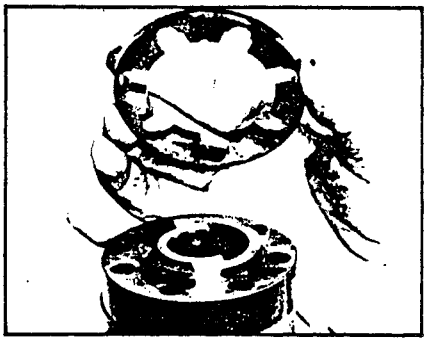


Figure 8

remove & inspect commutator

8. Remove commutator (6) and inspect its ground surfaces for scoring, spalling, brinelling (denting) or wear. SEE FIGURE 9. Inspect the drive link pin slot and cover pin hole for wear. Inspect for cracks. If any of these conditions exist replace the commutator and commutator ring as a matched set.

Figure 9

remove manifold

9. Remove manifold (8) and inspect for cracks, surface scoring, brinelling or spalling. Replace manifold if any of these conditions exist. SEE FIGURE 10. A polished pattern on the ground surfaces from commutator or rotor rotation is normal.

Figure 10

remove & inspect rotor set

10. Remove rotor set (9) retaining it in its assembled form if possible, to maintain the same rotor to stator contact surfaces. Inspect the rotor set for nicks, scoring or spalling on any surface, and broken or worn rotor splines. Replace as a matched rotor set if either component exhibits any of these conditions. SEE FIGURE 11.

NOTE

NOTE: The rotor (9.1) may become disassembled from stator (9.2) 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™. Be sure to remove all foreign material from rotor set before reassembly into Torqmotor™.

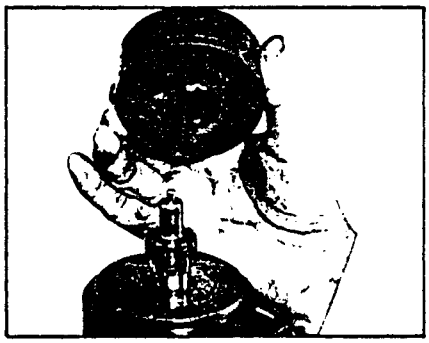


Figure 11

check rotor, stator clearance

11. Using a feeler gage, check the rotor (9.1) to stator (9.2) tip clearance with the rotor centered in the stator. SEE FIGURE 12. If there is more than .005 inches (13 mm) of clearance, replace rotor set.

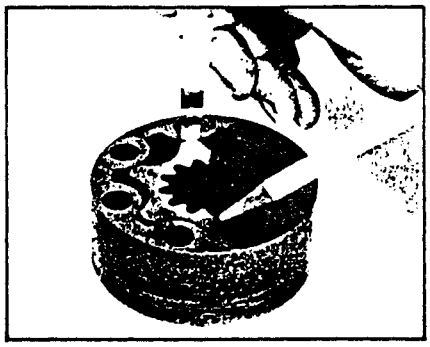


Figure 12

remove & inpect spacer

12. Lift off wearplate (10) and inspect it for scoring or brinelling on the rotor contact surface. Inspect for cracks. Replace wearplate if any of these conditions exist. SEE FIGURE 13.

NOTE

NOTE: A polished pattern from rotor rotation is normal.

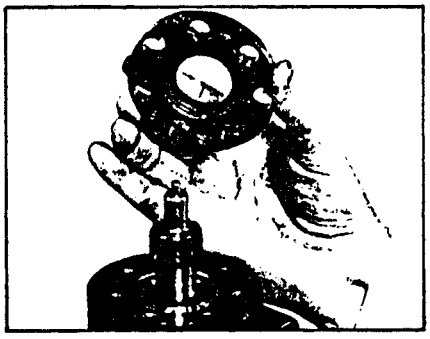


Figure 13

remove & inspect drive link

13. Remove drive link (11) and inspect it for cracks and for chipped, worn or damaged splines. No perceptible lash (play) should be noted between mating spline parts. SEE FIGURE 14. Inspect the pin in the end of the drive link for flats or wear. Replace drive link if these conditions exist.

NOTE

NOTE: The pin in the end of drive link is serviced as an integral part of the drive link and is not subject to disassembly.

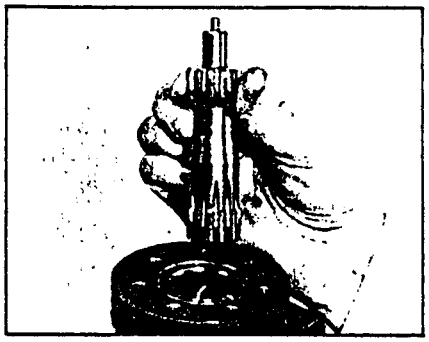


Figure 14

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 15.

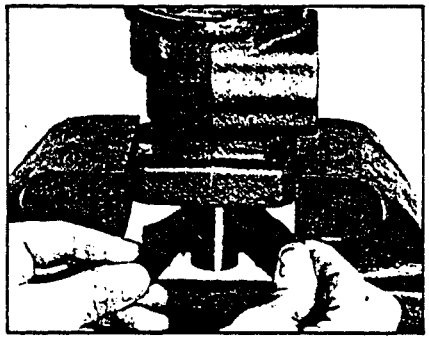


Figure 15

remove & inspect coupling shaft

15. Remove coupling shaft (12), by pushing on the output end of shaft. Inspect coupling shaft bearing and seal surfaces for spalling, nicks, grooves, severe wear or corrosion and discoloration. SEE FIGURE 16. Inspect for damaged or worn internal and external splines or keyway (FIG. 17). Replace coupling shaft if any of these conditions exist.

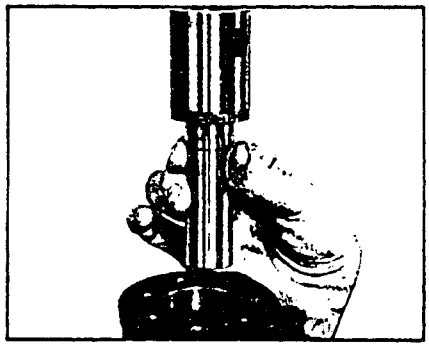


Figure 16

NOTE

NOTE: Minor shaft wear in seal area is permissible. If wear exceeds .020 inches (.51 mm) diametrically, replace coupling shaft.

A slight "polish" is permissible in the shaft bearing area. Anything more would require coupling shaft replacement.

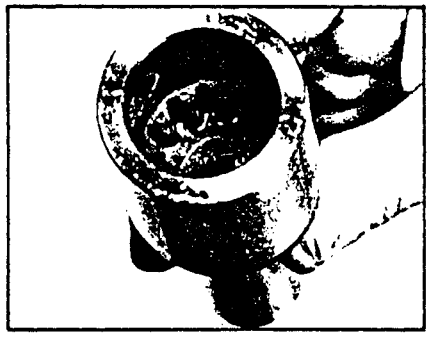


Figure 17

remove seal ring from housing

16. Remove and discard seal ring (4) from housing (18). SEE FIGURE 18.

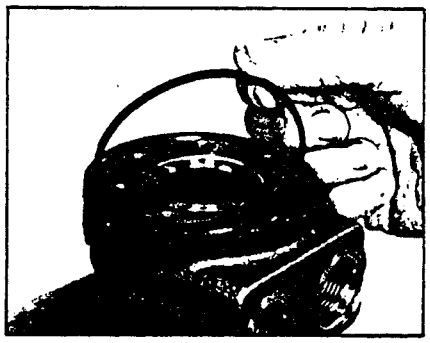


Figure 18

remove & inspect thrust bearing, washer

17. Remove thrust bearing (14) and thrust washer (15). Inspect for wear, brinelling and corrosion. The full complement of bearing rollers must be firmly retained in the bearing cage but revolve freely. Replace as required. SEE FIGURE 19.

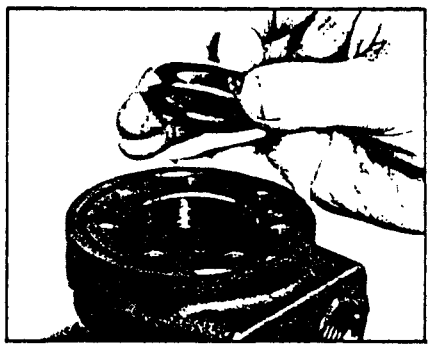


Figure 19

remove seal & spacer

18. Remove seal (16) and spacer (17). Discard both. SEE FIGURE 20.

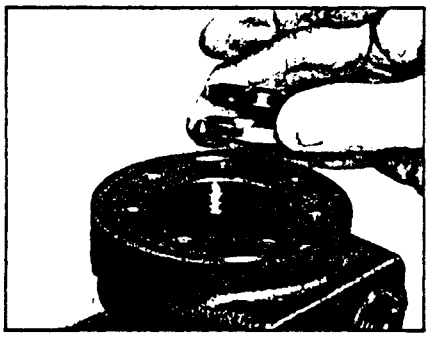


Figure 20

remove seal

19. Remove housing (18) from vise, invert it and remove and discard seal (21). SEE FIGURE 21.

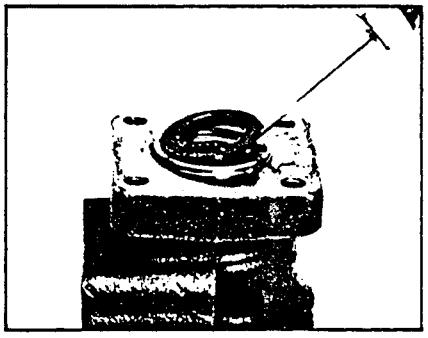


Figure 21

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 22. If the housing is defective in these areas, discard the housing assembly.

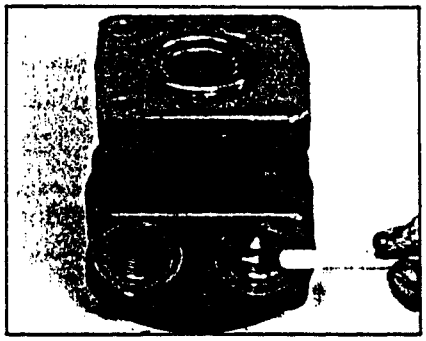


Figure 22

inspect housing bearing

21. If the housing assembly has passed inspection to this point, inspect the housing bearing (20) and retaining ring (19). The bearing rollers must be firmly retained in the bearing cage but must rotate and orbit freely. The full complement of rollers must be free of brinelling and corrosion. A bearing that does not pass this inspection must be replaced. SEE FIGURE 23.

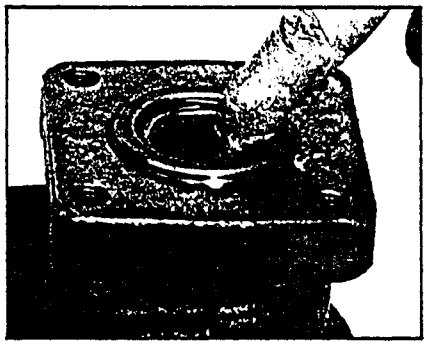


Figure 23

remove retaining ring & bearing

22. Only if the bearing (20) must be replaced, remove retaining ring (19) and press the bearing out of the mounting face end of the housing using a 1.300 inch (33.02 mm) maximum diameter shaft or appropriate bearing mandrel (reference FIG. 1). SEE FIGURE 24 & 25.

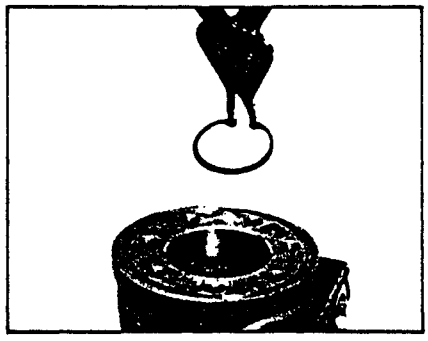


Figure 24

The MAG Torqmotor™ disassembly is now complete.

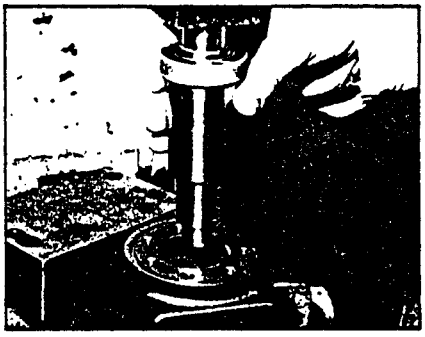


Figure 25

MAG Assembly

- Replace all seals and seal rings with new ones each time you reassemble the MAG 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 26. The parts should be available through most OEM parts distributors or Ross approved MAG 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, sleeve, and housing and from port and sealing areas.

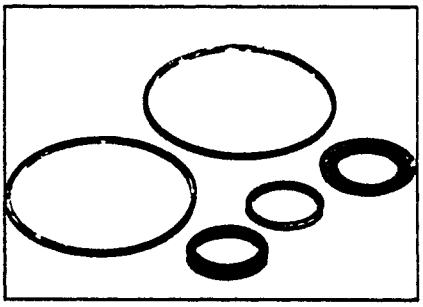


Figure 26

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.

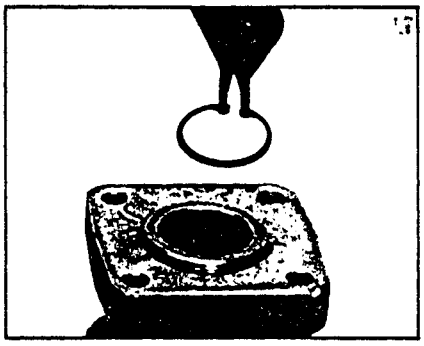


Figure 27

install retaining ring

1. If the housing (18) has been completely disassembled, place the housing, mounting flange end up, on a clean work surface. Install retaining ring (19) into the housing retaining ring groove. Be sure the rounded edge of retaining ring is facing in toward the larger housing cavity. Use appropriate retaining ring pliers. SEE FIGURE 27.

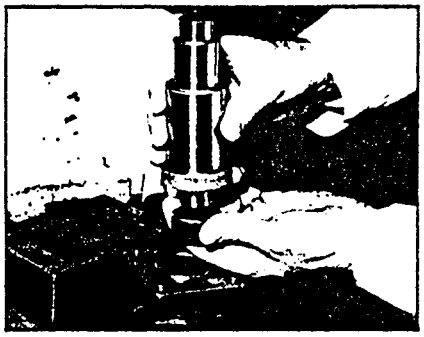


Figure 28

press in bearing

2. Thoroughly grease the rolls of a NEW bearing (20) with clean corrosion resistant grease recommended in the material section, Page 7A. Press the bearing into housing (18) from the mounting flange end of the housing bore, using bearing mandrel (special tool FIG. 1, Page 7A) against the lettered end of the bearing shell. SEE FIGURE 28 & 29. Take care during this procedure that the housing is square with the press base and that the bearing is not cocked. The bearing mandrel will control the bearing press depth to the required .135/.125 inches (3.43/3.18 mm) from the flange end of the housing.

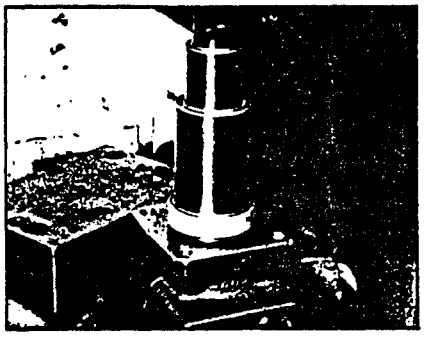


Figure 29

NOTE

NOTE: If the bearing mandrel shown is not available alternate methods may be used to press in the bearing but the bearing depth location must be maintained.

CAUTION

CAUTION: The controlled press depth of bearing (20) into the housing is required to ensure adequate bearing support, and correct bearing relationship to adjacent components when assembled.

CAUTION

CAUTION: Because the bearing (20) has a press fit into the housing, it must be discarded if removed from the housing. It must not be reused.

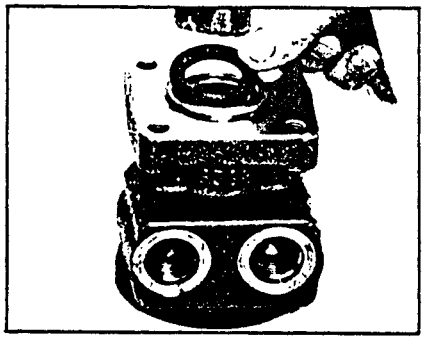


Figure 30

insert dirt & water seal

3. Place housing (18), wearplate surface down, on a clean work surface. Apply a small amount of clean grease to a NEW dirt and water seal (21) and press the seal into the housing seal cavity. The end of a hammer handle would be an appropriate tool. Be sure the seal is not cocked or deformed as it enters housing seal bore. SEE FIGURE 30.

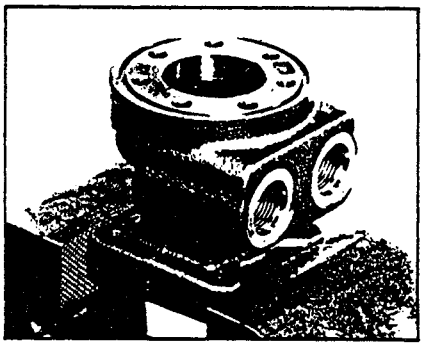


Figure 31

place housing assembly into vise

4. Place housing (18) assembly into a soft-jawed vise with coupling shaft bore down, and clamp the vise jaws against the edges of the mounting flange. SEE FIGURE 31.

install backup washer & seal

5. Apply a small amount of clean grease to a NEW seal (16). Install a NEW spacer (17) then seal (16) into housing coupling shaft bore from the sleeve end of the housing (18). Seat the spacer against the retaining ring (19) and the seal against the spacer, with the seal lip facing away from the spacer. SEE FIGURE 32.

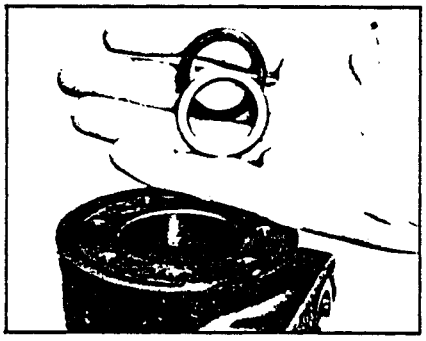


Figure 32

install thrust washer & thrust bearing

6. Install the thrust washer (15) and then the thrust bearing (14) into housing (18), until they are seated at the bottom of the counterbore. SEE FIGURE 33.

Figure 33

install coupling shaft

7. Be sure that a generous amount of a clean corrosion resistant grease, recommended in the materials section, Page 7A, is applied to housing bearing (20). Then install coupling shaft (12) into housing (18), seating it against thrust bearing (14). SEE FIGURE 34.

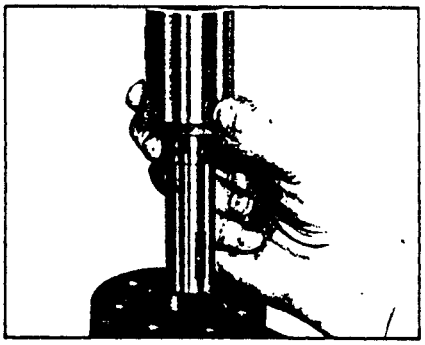


Figure 34

NOTE

NOTE: The coupling shaft must be flush with or below the housing surface when properly seated and rotate smoothly on the thrust bearing package.

insert seal ring

8. 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 35.

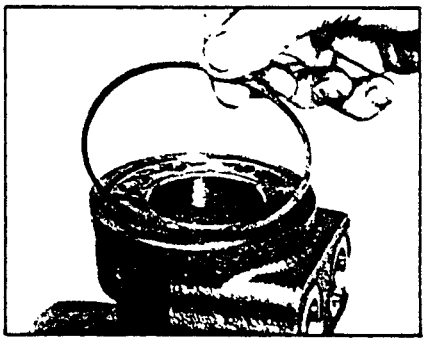


Figure 35

install drive link

9. Install drive link (11), pin end up, into coupling shaft (12) and engage drive link splines into mesh with coupling shaft splines. SEE FIGURE 36.

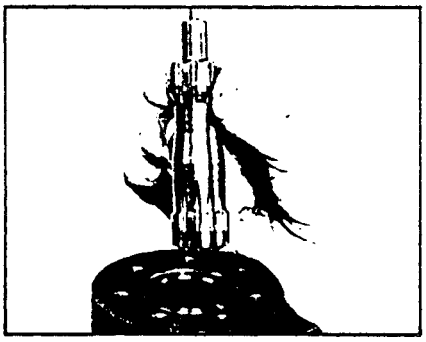


Figure 36

assemble spacer

10. Assemble wearplate (10) onto the housing (18) with recessed (cavity) side down and bolt holes aligned. SEE FIGURE 37.

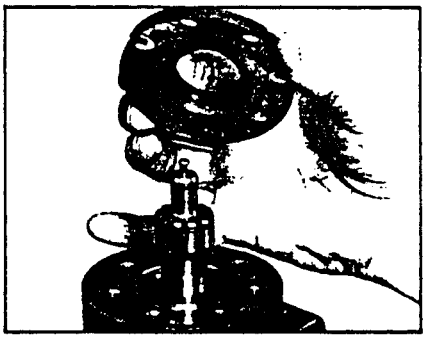


Figure 37

assemble rotor set

11. Assemble rotor set (9) onto wearplate (10) with rotor (9.1) counter bore side down and splines into mesh with drive link (11) splines. SEE FIGURE 38. Align stator bolt holes.

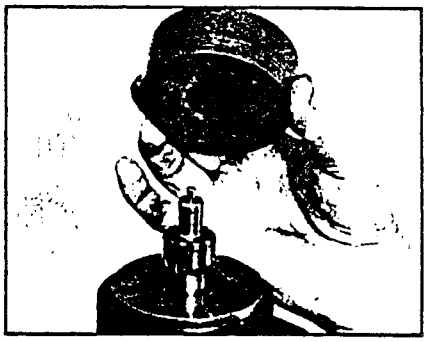


Figure 38

NOTE

NOTE: The rotor set counterbore side must be down against wearplate for drive link clearance and to maintain the original rotor-drive link spline contact. A rotor set without a counterbore can be reinstalled using the drive link spline contact pattern on the rotor splines to determine which side was down.

assemble manifold

12. Assemble manifold (8) onto the rotor set (9) so that the side with slots closest to the inside diameter is up. SEE FIGURE 39. Align bolt holes.

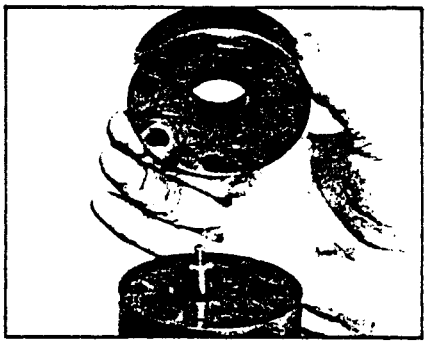


Figure 39

assemble commutator ring

13. Assemble commutator ring (7) either side up onto manifold (8) and align bolt holes. SEE FIGURE 40.

Figure 40

assemble commutator

14. Assemble commutator (6) onto manifold (8) with counterbore (washer recess) side up. The elongated hole must be engaged over the drive link (11) pin. SEE FIGURE 41.

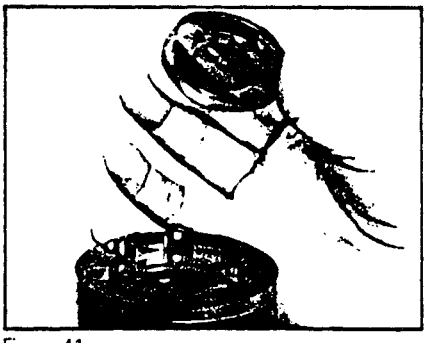


Figure 41

assemble sleeve

15. Assemble sleeve (5) over the stacked components onto the housing (18). SEE FIGURE 42.

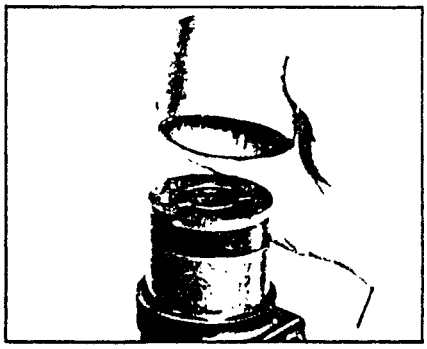


Figure 42

assemble washer

16. Assemble a generous amount of clean grease to washer (3) and assemble washer over pin in end cover assembly (2). SEE FIGURE 43.

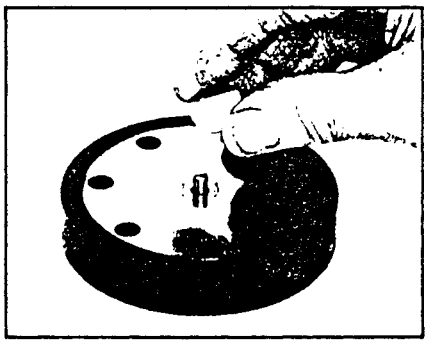


Figure 43

assemble seal ring

17. Apply a small amount of clean grease to a NEW seal ring (4) and insert it into the cover assembly (2) seal ring groove. SEE FIGURE 44.

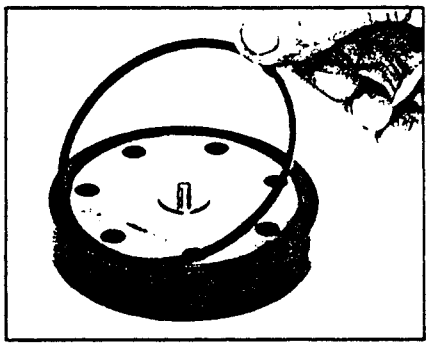


Figure 44

assemble end cover assembly

18. Assemble end cover assembly (2) with washer (3) and seal ring (4) attached onto the sleeve (5) and commutator set. The cover pin must be inserted into the center hole in the commutator (6) and the bolt holes aligned. SEE FIGURE 45.

Figure 45

NOTE

NOTE: It may be necessary to use one or two bolts (1) as probes to align the bolt holes of the components for bolt installation.

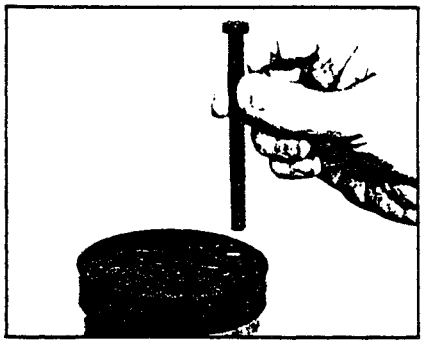


Figure 46

install and torque bolts

19. Install 7 bolts (1) into the assembly bolt holes finger tight, then torque the bolts to 22-26 foot pounds, (30-35 N m), in the sequence shown, using a 1/2 inch, thin wall socket and appropriate torque wrench. SEE FIGURES 46, 47, 48.

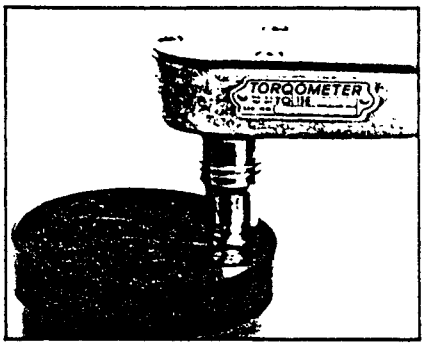


Figure 47

The assembly of the MAG Tormotor™ is now complete, except for woodruff key (13) and/or two port manifold O-Rings (18.1) if applicable at Torqmotor installation. See Page 21 for final checks.

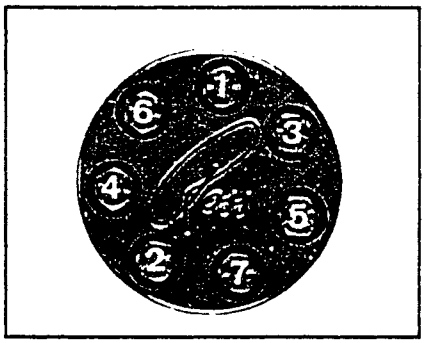


Figure 48

Final Checks

Final Checks

- Pressurize the Torqmotor™ with 100 p.s.i. dry 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) .
- 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.
- 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.

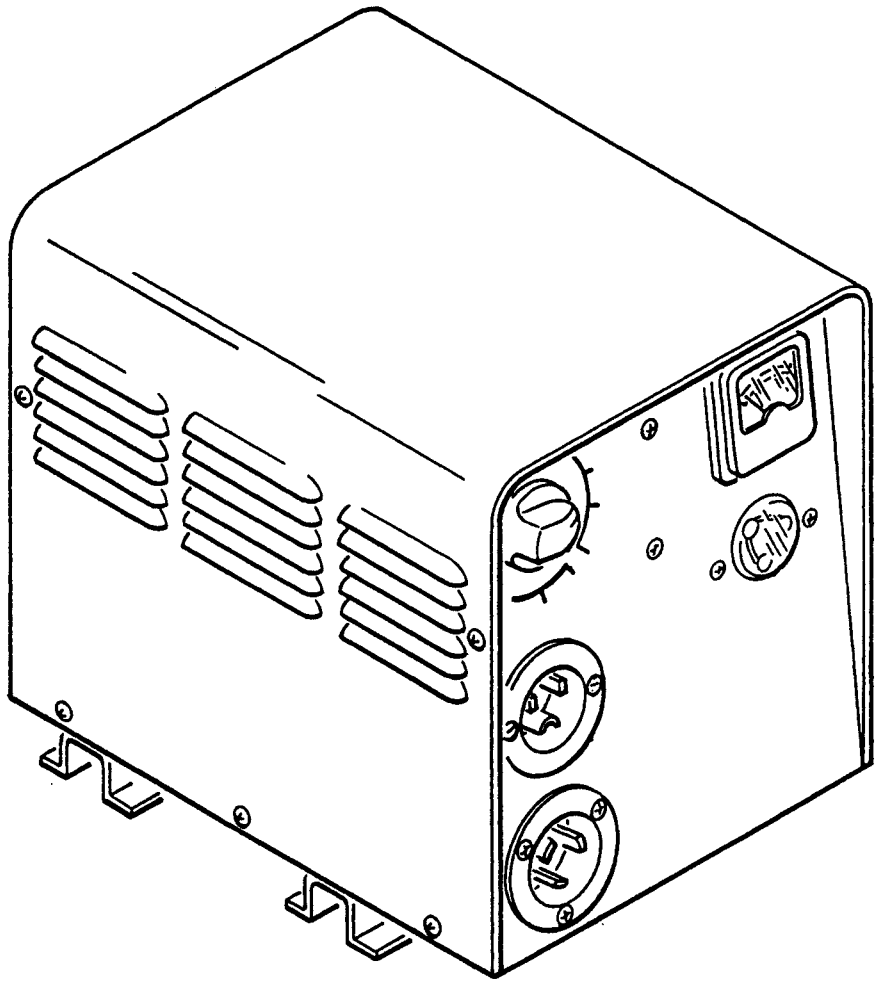
CAUTION: Maximum operating pressure must not exceed recommended Torqmotor™ pressure capacity.

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.

Operators Manual



BATTERY CHARGER

MANUAL BATTERY CHARGER OPERATION

INTRODUCTION

The Lester-Matic battery charger is a highly reliable, line compensating unit. When used according to instructions, the Lester-Matic will tend to lengthen battery life with less frequent additions of water.

INITIAL INSTALLATION

Provide adequate circuit breaker or fuse protection in the AC line to which the charger is to be plugged. Refer to electrical specifications on charger nameplate for input power requirements. When it is necessary to use an AC extension cord to the charger, use a three conductor No. 12 AWG cord with ground, and keep as short as possible. Instructions printed on the charger case are for daily reference.

NORMAL OPERATION

1. Provide adequate ventilation for both batteries and charger. The convection-cooled design requires an unobstructed flow of cooling air for proper operation.

2. Connect charger DC output cord to batteries.

3. Turn timer to "ON" for well discharged batteries or to "7" for lightly discharged batteries. Charger shuts off automatically at end of set period.

The state of discharge of the batteries will be slightly different each time they are put on charge, but the Lester-Matic varies automatically the initial charge rate, and taper of charge rate over the charge period. For well discharged batteries the charge rate at the start of the charge period should correspond to the "DC AMPS" rating on the charger nameplate. The rate should then taper gradually down to a lower finish rate. Normal charging at the low finish rate during the last 1-3 hours is necessary to achieve equalization of all battery cells. This equalization period allows the specific gravity of the battery electrolyte solution to rise to its full charge value. Since the taper of the charging rate (in amps, as indicated by the ammeter needle) is controlled by the rising voltage of the batteries being charged, proper performance of the charger and resulting good battery life is dependent upon the following factors:

a. An adequate AC line to handle the power required.

b. All cells of the batteries must be good, rising to approximately 2.5 DC volts per cell while still on charge or near the end of a charging period. When in doubt, check each cell with a single cell volt-meter while still on charge. If a low reading is obtained, check the low cells with a temperature corrected hydrometer. NOTE: Hydrometer float must be thoroughly clean to obtain accurate specific gravity readings.

c. Connections on the battery terminals and connector wiring must be clean and tight.

The necessity of adding water more frequently than two or three weeks, and/or hot battery cases at the end of the charging cycle, indicates the finish rate is too high, due to one or both of the following:

a. One or more bad cells in the batteries.

b. Batteries are starting to age to the point where hours of charge should be reduced gradually to obtain prolonged battery life.

4. To determine approximate full charge at start of day's use, turn timer knob to "1". Drop of ammeter needle to the low finish rate within 15 minutes indicates full charge.

5. Always turn timer to "OFF" before disconnection charger from batteries.

STORAGE

Charger may be left connected to the batteries and should be turned on for a full charge period once a month. In extremely cold conditions it may be necessary to charge more frequently. Check with your battery manufacturer. After each charge cycle the charger should be checked to insure that it has turned off. Severe overcharging and possible damage to the batteries could result if the charger remains on for prolonged periods of time.

CAUTION

THIS CHARGER IS FOR USE ONLY ON BATTERY SYSTEMS AS SPECIFIED ON THE CHARGER NAMEPLATE. USE OTHERWISE WILL DAMAGE CHARGER AND/OR BATTERIES.

Due to the electrical characteristics of this charger, it is possible to improperly hook up batteries and not blow the fuses when charging. When installing batteries, be sure polarity is correct. With a DC voltmeter, check terminal voltage and polarity at the battery connector.

When working near capacitor terminals be sure charger is turned off. With charger "on" transformer capacitor terminals provide a very high voltage. Care is to be shown.

MALFUNCTION SYMPTOMS AND THEIR REMEDIES

The Lester-Matic charger is designed with as few parts as possible making it a very reliable unit. Since each component can be tested individually, trouble shooting is a simple task. The following is a list of symptoms with their associated test procedures and remedies.

NO TRANSFORMER HUM AND AMMETER DOES NOT REGISTER

In the event no hum is detected from the transformer, check the AC cord to be sure it is securely plugged into a live AC outlet. When three-prong or two-prong adapters are used, they tend to work loose giving a poor connection. If the cord connection is secure and still no hum is noticed, a continuity test of the AC circuit is necessary. Turn the timer to "ON" and with a suitable continuity tester, check circuit across the AC plug prongs. CIRCUIT SHOULD BE COMPLETE. If not complete, individually check the AC cord, timer, primary transformer coil, and all connections.

TRANSFORMER HUMS BUT NO AMMETER INDICATION

Inspect the charger DC output connection to the batteries and also check to insure that the batteries are connected properly. If there is still no ammeter indication, a continuity test of the charger DC circuit must be performed. Turn the timer to "OFF" and disconnect the A.C. and D.C. plugs. Perform the following tests, using a low voltage test light, to check the continuity of the DC circuit.

(a) Connect tester clip to negative (-) blade and probe to positive (+) blade. CIRCUIT SHOULD BE COMPLETE. If not complete, first check the DC fuse link. If one or both fuses have blown, the link will be broken and usually the clear plastic fuse cover will be discolored. Refer to "Fuse Link Blowing" for test procedures. If fuses are good, individually check the fuse connections, DC cord, and diode connections (each may be checked with the continuity test light).

(b) If the circuit in (a) is complete, reverse test light leads. CIRCUIT SHOULD NOT BE COMPLETE. If circuit is complete, check DC cord for a "short" between the two wires. More probably, one or both diodes have "shorted". Refer to "Fuse Link Blowing" part (b) for continuity test of diodes.

(c) If (a) and (b) check good, assume the capacitor is shorted. Remove one wire from a capacitor terminal and place continuity tester clip to one terminal and probe to other. If circuit is complete, capacitor is "shorted" and must be replaced.

CHARGER DC FUSE LINK(S) BLOWS

This condition may be caused by:

(a) Reverse polarity between charger and batteries, such as incorrect installation of batteries, wiring of DC connector or charger plug.

(b) A short circuit failure of one or both diodes. First disconnect one diode. Using a low voltage continuity tester check each diode. Then reverse the tester leads and check each diode again. If the diode conducts current in both directions the diode is shorted and must be replaced. Replace either the entire heat-sink assembly or the defective diode. When replacing a single diode be sure the new diode is pressed squarely into the hole and that it does not extend beyond the rear surface of the heat sink plate.

(c) If (a) and (b) fail to reveal the malfunction, check wiring of both charger and battery connections against their respective wiring diagrams. The charger wiring diagram is shown on the enclosed sheet along with the parts list.

CHARGER OUTPUT IS LOW

The most probable cause is one diode shorting and blowing one fuse. Refer to "Fuse Link Blowing" part (b) to check the diodes. If a diode is shorted, both the defective diode/heat sink and the defective fuse assembly must be replaced.

CHARGER DOES NOT TURN OFF

In models equipped with timers, this is due to an inoperative timer. In this case replace timer assembly.

AC LINE FUSE OR CIRCUIT BREAKER BLOWS

If this occurs when charger is turned on without being plugged into the vehicle, the AC cord, timer motor coil, or the transformer may be shorted. To check the AC cord, insure that the timer is "OFF" and connect the continuity tester across the AC plug prongs. If circuit is complete the LAC cord is shorted and must be replaced. To check the timer motor coil, disconnect one of the timer motor wires and connect continuity tester to the motor coil leads. If the lamp glows, the coil is shorted. To test the transformer, first disconnect all the secondary leads to the diodes. Then reconnect the AC cord and turn timer "ON". If the AC fuse or circuit breaker still blows, the transformer is probably shorted internally and must be replaced.

PROPER CARE OF MOTIVE POWER BATTERIES

1. New batteries should be given a full charge before their first use because it is difficult to know how long the batteries have been in storage without a charge.

2. Limit use of new batteries between charges for the first 5 cycles. New batteries and older batteries which have been in storage are not capable of their rated output until they have been discharged and charged a number of times.

3. During the first month of use, particularly when temperatures are below 60°F, new batteries should be given an extra full charge once a week. The ampere-hours of energy that batteries can deliver and their charge acceptance varies directly with battery temperature.

4. As long as the charger tapers down to the specified finish charge rate near the end of the charge cycle, the batteries should be given a full charge. All cells in a set of batteries do not react identically to the same discharge and charge current. In a normal charge, the last 1 to 3 hours at the low finish charge rate equalize the cells for better battery life.

5. When batteries age to the point where the charge rate will no longer taper into the low finish rate area, reduce the hours of charge progressively. Reducing the charge period will prevent excessive battery heating and the resultant high water use rate.

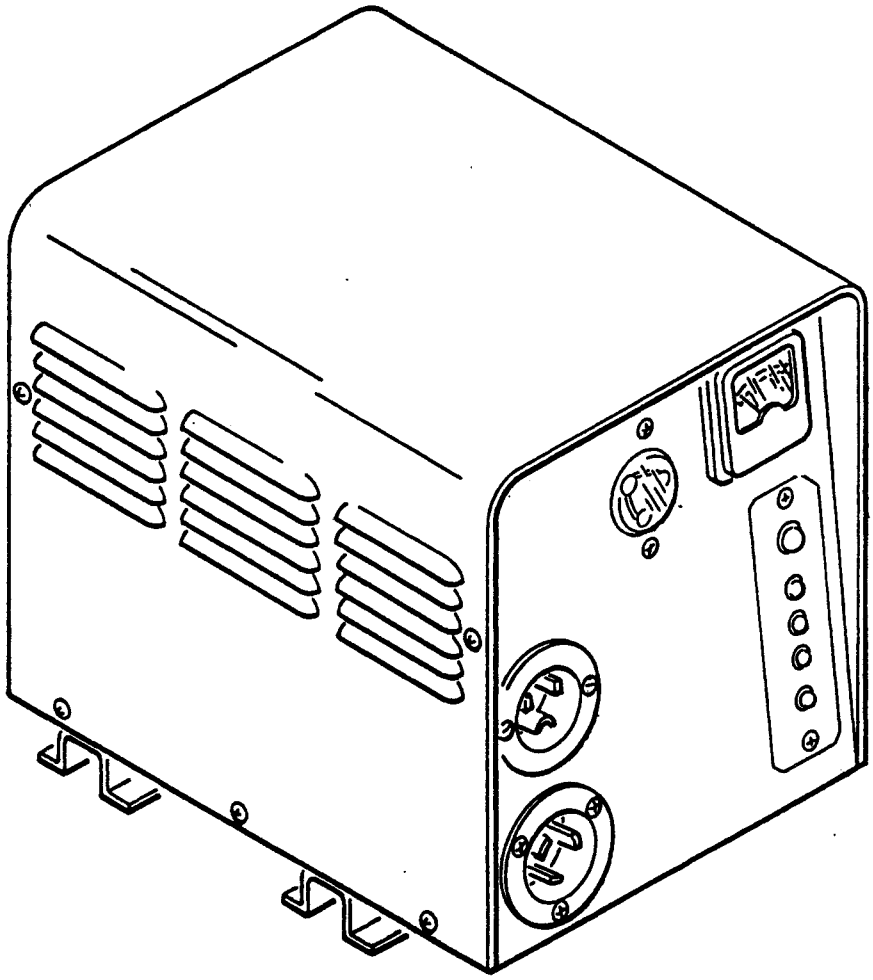
6. Prior to each day's use, turn the charger on and check to see if charger ammeter needle jumps smartly upward and then tapers down to the finish rate area within 15 minutes. This will provide a very simple means of verifying that the batteries were charged.

7. Add water carefully to the proper level in cells as required after they have beenfully charged. Do not fill them so high that they bubble over while charging. New batteries require very little addition of water, whereas very old batteries may need additional water two or three times a week. Water (electrolyte) level in the cells settles when batteries are discharged and rises during charge. The probability of overfilling can be reduced by adding water when batteries are fully charged.

8. When the temperature falls below 65°F, batteries should be placed on charge as soon after use as possible. In these low temperatures a 4 hour equalizing charge once a week will improve state of charge and battery life.

9. Keep tops of batteries and battery hold-downs clean and dry at all times. This will reduce the amount of current leakage between batteries and the frame.

Operators Manual



BATTERY CHARGER

AUTOMATIC BATTERY CHARGER

INPUT: 115 VAC, 60 HZ.
OUTPUT: 24 VDC, 30 AMP.

CAUTION

THIS CHARGER IS INTENDED FOR THE CHARGING OF A 12 CELL (24V) LEAD ACID STORAGE BATTERY ONLY. USE OF THIS CHARGER ON ANY OTHER BATTERY COULD CAUSE DAMAGE TO THE BATTERY AND/OR TO THE CHARGER.

THIS MANUAL CONTAINS VITAL INFORMATION FOR THE SAFE USE AND EFFICIENT OPERATION OF THE BATTERY CHARGER. CAREFULLY READ THIS MANUAL BEFORE USING CHARGER, AND RETAIN FOR FUTURE REFERENCE. FAILURE TO ADHERE TO INSTRUCTIONS COULD RESULT IN SERIOUS BODILY INJURY OR PROPERTY DAMAGE. ALL REPAIRS SHOULD BE MADE BY QUALIFIED PERSONNEL ONLY.

CAUTION

DO NOT EXPOSE CHARGER TO WATER, MOISTURE, CLEANING AGENTS OR POWER WASH.

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CHARGER OPERATION

1. CHARGER INSTALLATION: MOUNT THE CHARGER IN THE VEHICLE AND CONNECT THE CHARGER POSITIVE (WHITE) DC CORD LEAD TO THE POSITIVE BATTERY TERMINAL AND CONNECT THE CHARGER NEGATIVE (BLACK) DC CORD LEAD TO THE NEGATIVE BATTERY TERMINAL.

2. ELECTRICAL SUPPLY: THIS CHARGER MUST BE OPERATED FROM A PROPERLY GROUNDED 115 VOLT, 60 HZ AC OUTLET ONLY.

3. CHARGER OPERATION:

   A. STARTING THE CHARGER, INSERT THE AC PLUG INTO THE APPROPRIATE CHARGER AC RECEPTACLE. THE CHARGER WILL START WHEN THE AC PLUG IS INSERTED.

   B. MONITOR METERS: THE AMMETER SHOULD INDICATE AN INITIAL CHARGE RATE OF APPROXIMATELY 30 AMPS. THE CHARGE RATE WILL GRADUALLY TAPER TO A FINISH RATE OF FROM 2 TO 10 AMPS.

   C. MONITOR LIGHTS (LIGHT EMITTING DIODES - L.E.D.):

      (1) THE GREEN "AC POWER ON" LIGHT SHOULD GLOW AT ALL TIMES WHEN THE AC CORD IS PLUGGED INTO A "LIVE" 115 VAC 60 HZ OUTLET AND THE DC CORD IS CONNECTED TO THE BATTERY.

      NOTE: THE GREEN LIGHT, DUE TO THE CHARACTERISTICS OF THE L.E.D., MAY NOT BE HIGHLY VISIBLE WHEN THE CHARGER IS LOCATED IN A BRIGHTLY LIGHTED AREA.

(2) THE RED LIGHT "CHARGE ON/COMPLETE" SHOULD BLINK WHEN THE CHARGE STARTS AND REMAIN BLINKING UNTIL THE CHARGE IS COMPLETED. WHEN THE CHARGE IS COMPLETE THE LIGHT WILL STOP BLINKING AND GLOW CONTINUOUSLY. IF THE RED LIGHT IS "OFF", NOT GLOWING OR BLINKING, THEN A POSSIBLE PROBLEM EXISTS.

(3) THE YELLOW LIGHT "AC INTERRUPT" WHEN GLOWING INDICATES THAT THE 115 VAC POWER SOURCE HAS BEEN INTERRUPTED WHILE THE CHARGE WAS IN PROGRESS. ALL LIGHTS WILL BE OFF DURING THE ABSENCE OF THE AC POWER.

NOTE: IF THE CHARGE IS TERMINATED BY UNPLUGGING THE AC CORD OR IF THE "AC INTERRUPT" LIGHT IS GLOWING WHEN THE AC CORD IS UNPLUGGED, THE STOP/RESTART SWITCH MUST BE MOMENTARILY ENGAGED PRIOR TO THE NEXT CHARGE TO PREVENT THE "AC INTERRUPT" LIGHT FROM GLOWING WHEN THE NEXT CHARGE IS STARTED.

(4) THE ORANGE LIGHT "CHECK BATTERY" INDICATES ONE OF THE FOLLOWING TWO CONDITIONS: THAT THE BATTTERIES ARE NOT BEING CHARGED BEFORE THE PRESET MAXIMUM TIME HAS ELAPSED, OR THE BATTERY POTENTIAL OF 2.35 VOLTS/CELL HAS NOT BEEN REACHED IN THE COURSE OF THE CHARGE. THIS LIGHT SHOULD NOT GLOW UNDER NORMAL CIRCUMSTANCES. IF THE ORANGE LIGHT GLOWS AFTER THE CHARGE IS TERMINATED, CHECK THE BATTERY FOR WEAK CELLS.

D. CHARGE TERMINATION: THE CHARGER AUTOMATICALLY TERMINATES THE CHARGE WHEN THE BATTERIES ARE FULLY CHARGED OR WHEN THE PRESET MAXIMUM TIME HAS ELAPSED OR IF THE BATTERY POTENTIAL AFTER REACHING 2.16 VOLT/CELL STOPS INCREASING FOR A TIME PERIOD OF 80 MINUTES BEFORE REACHING 2.35 VOLTS/CELL. THE CHARGE MAY ALSO BE TERMINATED MANUALLY BY MOMENTARILY ENGAGING THE STOP/RESTART SWITCH. IF THE SWITCH IS DEPRESSED BEFORE (SIX) 6 MINUTES OF CHARGE TIME HAS ELAPSED OR IF THE BATTERY VOLTAGE IS BELOW 2.35 VOLT/CELL THE FAULT LIGHT WILL GLOW. IF VOLTAGE IS HIGHER THAN 2.35, THE COMPLETE LIGHT WILL GLOW. THE PRESET MAXIMUM CHARGE TIME IS TWENTY (20) HOURS.

CAUTION

DO NOT DISCONNECT THE DC CORD FROM THE VEHICLE DURING CHARGE. IF THE BATTERY MUST BE DISCONNECTED, STOP CHARGER WITH THE STOP/RESTART SWITCH, THEN UNPLUG AC CORD.

E. CHARGE TIME: THE TIME REQUIRED TO FULLY CHARGE THE BATTERIES WILL NORMALLY BE 8 TO 12 HOURS.

F. FULL CHARGE TEST: TO TEST FOR A FULL CHARGE ON A 24V BATTERY, RESTART THE CHARGER WITH THE STOP/RESTART SWITCH. IF THE BATTERY IS FULLY CHARGED, THE CHARGE RATE SHOULD DROP TO APPROXIMATELY 8 TO 15 AMPS WITHIN 10 TO 20 MINUTES. THE CHARGER WILL AUTOMATICALLY SHUT OFF WITHIN 45 TO 90 MINUTES OR IT MAY BE SHUT OFF WITH THE STOP/RESTART SWITCH.

G. AC POWER FAILURE: IF AN AC POWER FAILURE OCCURS DURING THE CHARGE, THE CHARGER WILL AUTOMATICALLY RESUME THE CHARGE WHEN THE AC POWER RETURNS. ALL CHARGER TIMING IS RESET TO ZERO TIME. THE "AC INTERRUPT" LIGHT WILL GLOW TO INDICATE THAT THE AC POWER HAS FAILED.

H. CHARGER RESTART: THE CHARGER MAY BE RESTARTED AFTER IT HAS SHUT OFF BY UNPLUGGING THE AC POWER CORD FOR A FEW SECONDS (3 TO 5 SECONDS) AND THEN PLUGGING THE CORD BACK IN. ALSO, THE CHARGER MAY BE RESTARTED BY MOMENTARILY ENGAGING (3 TO 5 SECONDS) THE STOP/RESTART SWITCH.

IF THE CHARGER AC CORD REMAINS CONNECTED TO THE 115 VAC 60 HZ AND THE DC CORD REMAINS CONNECTED TO THE BATTERIES AFTER THE CHARGER HAS FINISHED THE FIRST CHARGE, THE CHARGER WILL AUTOMATICALLY RESTART AFTER A PRESET NUMBER OF DAYS (24 HOUR PERIODS). THE CHARGE TIME (PROVIDED THE BATTERIES ARE UNLOADED) WILL NORMALLY BE 15 TO 90 MINUTES. THE CHARGER WILL AUTOMATICALLY SHUT OFF AND AGAIN TURN ON AFTER THE PRESET NUMBER OF DAYS. THIS CYCLE (CALLED A STORAGE MODE) WILL CONTINUE AS LONG AS THE CHARGER REMAINS CONNECTED TO THE AC POWER AND BATTERIES. THE PRESET NUMBER OF DAYS FOR TURN "ON" IS FOUR (4).

NOTE: THE ALLOWABLE MAXIMUM CHARGE TIME BEFORE SHUT OFF IS AUTOMATICALLY REDUCED IN THE STORAGE MODE TO PREVENT POSSIBLE OVERCHARGING OF THE BATTERIES. THE MAXIMUM CHARGE TIME IN THE STORAGE MODE IS THREE (3) HOURS.

IF AN AC POWER FAILURE OCCURS WHEN THE CHARGER IS IN THE STORAGE MODE THE CHARGER WILL START WHEN THE AC POWER RETURNS AND CONTINUE OPERATING IN THE STORAGE MODE.

IF THE BATTERY VOLTAGE DROPS TO APPROXIMATELY 21 VOLTS WHEN THE CHARGER IS "OFF" IN THE STORAGE MODE, THE CHARGER WILL AUTOMATICALLY RESTART WITHOUT WAITING FOR THE PRESET NUMBER OF DAYS TO ELAPSE. THE STORAGE MODE WILL CONTINUE AFTER THE BATTERIES ARE FULLY CHARGED.

TROUBLESHOOTING INSTRUCTIONS FOR CHARGER

THE FOLLOWING IS A LIST OF POSSIBLE PROBLEMS AND REMEDIES WHICH MIGHT OCCUR TO THE CHARGER.

THE VOM USED FOR MEASUREMENTS SHOULD HAVE A RESISTANCE OF 20,000 OHMS/VOLT DC, 5000 OHMS/VOLT AC OR GREATER.

IF A PROBLEM OCCURS IN THE CHARGER, DISCONNECT THE CHARGER FROM THE 115 VAC OUTLET AND BATTERIES AND EXAMINE THE AC AND DC CORDS FOR DAMAGE OR LOOSE CONNECTIONS. AFTER THE COVER HAS BEEN REMOVED, EXAMINE THE INTERNAL PARTS AND CONNECTIONS FOR SIGNS OF DAMAGE OR LOOSE ELECTRICAL CONNECTIONS.

1. GREEN LIGHT (L.E.D.) DOES NOT GLOW AND CHARGER DOES NOT WORK WHEN CHARGER IS CONNECTED TO 115 VAC 60 HZ AND BATTERIES:

NOTE: IF THE CHARGER WORKS WHEN USING ONE OF THE AC RECEPTACLES ONLY, THEN THE AC RELAY SHOULD BE REPLACED.

CAUTION

USE EXTREME CARE WHEN WORKING INSIDE THE CHARGER WHEN IT IS CONNECTED TO THE 115 VAC LINE AND/OR THE BATTERIES IN ORDER TO PREVENT ELECTRICAL SHOCK OR TO PREVENT POSSIBLE DAMAGE TO THE PRINTED CIRCUIT BOARD COMPONENTS.

READ THE AC VOLTAGE BETWEEN PINS 1 AND 3 OF THE COMPU-TIME 4 PRINTED CIRCUIT BOARD EDGE CONNECTOR. THE VOLTAGE SHOULD BE THE SAME POTENTIAL AS THE 115 VAC POWER. IF THE VOLTAGE IS NOT PRESENT, CHECK FOR LOOSE ELECTRICAL CONNECTIONS. IF THE VOLTAGE IS CORRECT, THE P.C. BOARD IS FAULTY AND MUST BE REPLACED. READ THE PRECAUTIONS BELOW ON HANDLING P.C. BOARD BEFORE REMOVING THE BOARD FROM THE CHARGER.

2. GREEN "AC POWER ON" LIGHT GLOWS BUT CHARGER WILL NOT START OR STARTS BUT WILL NOT SHUT OFF WHEN CONNECTED TO THE 115 VAC AND THE BATTERY: THESE PROBLEMS COULD BE CAUSED BY THE P.C. BOARD AND THE FOLLOWING VOLTAGE MEASUREMENTS SHOULD DETERMINE IF THAT IS THE CASE.

A. P1 VOLTAGE READINGS (P1 IS THE EDGE CONNECTOR OF THE P.C. BOARD), ALL VOLTAGE READINGS ARE REFERENCED TO PIN 9.

PIN	APPROXIMATE PIN VOLTAGE
7	SAME AS BATTERY VOLTAGE
5	CHARGER ON = LESS THAN 1 VDC CHARGER OFF = BATTERY VOLTAGE

IF ALL VOLTAGES ARE CORRECT, CHECK THE CONNECTOR TERMINALS TO BE SURE THEY ARE MAKING PROPER CONTACT WITH PINS. IF VOLTAGES ARE NOT CORRECT, REPLACE THE P.C. BOARD AND RETURN THE DEFECTIVE BOARD TO THE FACTORY FOR REPAIR.

CAUTION

BEFORE REMOVING THE P.C. BOARD, FIRST DISCONNECT THE CHARGER FROM THE 115 VAC AND BATTERIES. THEN REMOVE THE TWO MOUNTING SCREWS FROM THE FRONT PANEL AND REMOVE THE BOARD BY PULLING IT OUT THRU THE FRONT OF THE CHARGER. UNPLUG THE EDGE CONNECTOR.

DO NOT ATTEMPT TO REPLACE INDIVIDUAL COMPONENTS ON THE BOARD. DO NOT HANDLE THE BOARD ANY MORE THAN NECESSARY. SOME OF THE COMPONENTS ON THE BOARD COULD BE DAMAGED BY STATIC ELECTRICITY. PLACE THE BOARD IN AN ANTI-STATIC BAG OR CARDBOARD BOX AND SHIP TO FACTORY.

TO INSTALL A NEW PRINTED CIRCUIT BOARD, REVERSE THE REMOVAL PROCEDURES DESCRIBED ABOVE.

IF THE PRINTED CIRCUIT BOARD IS NOT THE PROBLEM, CHECK THE RELAY TO SEE IF THE CONTACTS ARE CLOSING OR STICKING.

3. CHARGER OPERATES AT A REDUCED RATE OF CHARGE CURRENT AND/OR TRIPS AN AC POWER CIRCUIT BREAKER OR BLOWS DC FUSES: (A BLOWN DC FUSE WILL DISCOLOR THE BUBBLE WINDOW ON THE FUSE HOLDER. BEFORE CHANGING DC FUSE, CHECK BOTH DIODES FOR SHORTING CONDITION.)

   THE PROBLEM COULD BE A FAILED DIODE: DISCONNECT THE CHARGER FROM THE 115 VAC OUTLET AND BATTERIES AND CHECK CONTINUITY ACROSS THE DIODES WITH THE VOM. REMOVE THE TRANSFORMER LEADS FROM THE DIODES BEFORE READING CONTINUITY. IF A DIODE SHOWS APPROXIMATELY ZERO OHMS IN BOTH DIRECTIONS, IT IS SHORTED AND SHOULD BE REPLACED. IF A DIODE SHOWS AN OPEN CIRCUIT IN BOTH DIRECTIONS, IT IS OPEN AND SHOULD BE REPLACED.

   IF THE DIODES ARE OK, CONNECT THE TRANSFORMER LEADS BACK TO THE DIODES. RECONNECT THE CHARGER TO THE BATTERIES AND PLUG IN THE AC CORD TO THE 115 VAC OUTLET AND MAKE THE FOLLOWING VOLTAGE MEASUREMENTS.

DANGER: USE EXTREME CAUTION WHEN WORKING NEAR THE CAPACITOR.

PLACE METER LEADS ACROSS	*APPROXIMATE VOLTAGE READINGS	
	WITH CAPACITOR CONNECTED	WITH CAPACITOR DISCONNECTED
(1) AMMETER POST TO EACH DIODE ANODE (TRANSFORMER LEAD)	25-30 VAC	15-16 VAC
(2) AMMETER POST TO DIODE CATHODES (HEAT SINK)	27-31 VDC	26-31 VDC
(3) TRANSFORMER LEADS CONNECTED TO THE CAPACITOR	560-665 VAC	350 VAC

*NOTE: THESE READINGS WILL VARY AS SHOWN DEPENDING ON THE VOLTAGE OF THE BATTERIES AT THE TIME OF THE READING.

IF THE READINGS ARE THE SAME WITH THE CAPACITOR CONNECTED AS THEY ARE WITH THE CAPACITOR DISCONNECTED, THE CAPACITOR SHOULD BE REPLACED.

IF READING # (2) ONLY IS ABOUT ONE HALF OF THE VALUES SHOWN, A DIODE IS OPEN. RECHECK DIODE CONTINUITY AS WAS DONE ABOVE JUST PREVIOUS TO READING VOLTAGES.

IF THE VOLTAGES ARE STILL NOT CORRECT AND THE CAPACITOR AND DIODES ARE GOOD, THE TRANSFORMER MAY HAVE FAILED AND SHOULD BE REPLACED.

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.