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ABSTRACT

This student guide, one of a series of correspondence training courses designed to improve the job performance of members of the Marine Corps, deals with the skills needed by basic engineer equipment mechanics. Addressed in the four individual units of the course are the following topics: mechanics and their tools (mechanics, hand tools, and power tools and precision measuring instruments); gasoline and diesel engines; power trains; and auxiliary equipment (hydraulic systems, and vehicle frames). Appendixes to the guide contain information on the job duties of basic engineer equipment mechanics, preventive maintenance, and safety. In a separate section following the appendixes are four review units corresponding to the four lessons of the guide. Each unit contains a reading assignment, a lesson objective statement, and a written assignment consisting of a series of study questions for that unit. (MN)

MCI 13.29e

BASIC ENGINEER EQUIPMENT MECHANIC

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1. PURPOSE

This publication has been prepared by the Marine Corps Institute for use with MCI course, Basic Engineer Equipment Mechanic.

2. APPLICABILITY

This manual is for instructional purposes only.

E. J. LLOYD
Lieutenant Colonel, U.S. Marine Corps
Deputy Director

PREFACE

Basic Engineer Equipment Mechanic has been designed to provide privates through lance corporals with a source of study material which will enable them to perform more efficiently the duties of an engineer equipment mechanic, MOS 1341. It discusses the Marine Corps maintenance system and the care and use of the mechanic's tools. The course will instruct the student in the principles of operation of internal-combustion engines, both gasoline and diesel; power trains; and auxilliary equipment and components of chassis, frames, and bodies.

SOURCE MATERIALS

TM-00872A-15	Crane-Shovel, Crawler-Mounted w/Attachments (M-37), Dec 61
TM-00873D-15	Crane-Shovel, Crawler-Mounted MOD 2N, M-62, Jun 63
TM-00922-15/1	Grader, Road, Motorized, M550-M65, Sep 68, w/ch 1, Mar 70
TM-02550B	Truck, Forklift, Rough-Terrain, RKF-060, May 62, w/ch 1, Apr 63
TM-03197B-15	Crane, Wheel-Mounted, M-60, Nov 66, w/ch 1, Sep 69
TM-03285A/03287A-15	Diesel Engines, MOD 3914/4919, Aug 64
TM-03342A-15	Torqmatic Transmissions, May 61
TM-04078A-15	Tractor, Wheeled, MRS-100, Dec 64
TM-06709A-15	Crane, Truck-Mounted, 15-ton, Model M315T, Jul 68
TM-07075A-15	Tractor, Pneumatic-Tired, Diesel-Driven, Model 72-31MP, Jul 70 Supp 1 & 2
TM-07542A-12	Loader, Scoop Type, Full-Tracked JI Case Model MC 1150, 15 Oct 72
TM-07542A-35	Loader, Scoop Type, Full-Tracked JI Case Model MC 1150, 15 Oct 72
TM-2815-15/1	In Line 71 Engines, Detroit Diesel, Maintenance, Oct 72
TM-11275-12/2A	Engineer Equipment Preventive Maintenance Indicators, Jun 68
TM-5-461	Engineer Handtools, Feb 66
TM-9-208-2	Cleaning, Drying, and Abrading Equipment for Cleaning Ordnance Material, Jun 60
MCO P 1200.7	Military Occupational Specialty Manual (MOS Manual), 15 Dec 72 w/ch 1 dtd 15 Aug 73 and ch 2 dtd 15 Feb 74
C-5210-IL-MC	Measuring Tools, Jul 72
C-9100-IL, REV	Lubricants, Oils, and Waxes, Dec 71
SL-3-00456A	Toolkit, Mechanics, General, Dec 71
SL-3-00456B	Tool Set, General, May 72 w/ch 1
NAVMAT P-5100	Safety Precautions for Shore Activities, Mar 70
	ABC's of Hand Tools, General Motors Corporation, 1945
	Terex Maintenance Manual for 82-30M Crawler-Tractor, The Service Department, Terex, Division of General Motors, Hudson, Ohio, Apr 66

CONTENTS

Chapter 1

THE MECHANIC AND HIS TOOLS

Section I. THE MECHANIC

1-1. GENERAL

You, the engineer equipment mechanic, are responsible for performing the maintenance necessary to keep the equipment of your unit in a high state of readiness. When you are sick, you report to sick bay and the doctor treats you, but a machine cannot report to you for repair, it must depend on you and the operator for its proper care.

The equipment officer or chief will assign you where needed to assist in accomplishing the mission or balance the workload. You may be required to assist the equipment operators of your unit in the performance of their duties, or you may be attached to other units to provide maintenance support.

1-2. DUTIES AND TASKS

As an engineer equipment mechanic you will perform the duties and tasks outlined in the MOS description in Appendix I. The degree of supervision you receive while performing these duties is dependent on your rank and experience. For example, as a PFC, you will perform preventive maintenance under general supervision but when performing major repairs you will be closely supervised.

1-3. QUALIFICATION REQUIREMENTS

There are fourteen qualification requirements for E-4 and E-5 and ten for E-3 and below as outlined in Appendix I. All qualification requirements are not covered in this course. Check MCI course offerings in the related subjects such as supply, camouflage, decontamination, and engineer equipment operator.

1-4. POSSIBLE ASSIGNMENTS

There are many units of the Marine Corps that require engineer equipment mechanics. There are five typical T/O billets to which you may be assigned. For example, your T/O billet assignment could be as an engineer equipment mechanic, equipment mechanic, shop mechanic, automotive mechanic, and engineer equipment mechanic foreman in a force service regiment, division service battalion, division engineer battalion or shore party battalion. The Marine air wing also has engineer equipment mechanics in the Marine air base squadrons (MABS), wing equipment repair squadron (WERS) or Marine air control squadrons (MACS).

Section II. HANDTOOLS

1-5. MECHANIC'S TOOLS

a. General. The quality of your work depends on the type and condition of your tools and how you use them. A tool may be used to perform many jobs, but the proper tool will enable you to do the job quickly and safely. Tools are multipliers of your strength--they allow you to do a job more quickly, with less effort, and with more precision. See the booklet ABC's of Hand Tools for discussion of the more common handtools.

b. Toolkit, mechanics (general). You will be issued a toolkit which you will be required to care for and maintain in good, usable, and complete condition. A padlock is furnished for security of the tools. Each lock usually has two keys; one key should be placed in a sealed and marked envelope and kept in the company safe, equipment office, or in the supply office. This will eliminate the need for destroying the lock should you lose your key. Table 1-1 below shows an extract of SL-3-00456A which is a list of the tools contained in the kit mentioned above.

c. Miscellaneous. There are other sets and kits used in the maintenance of Marine Corps equipment which are similar to the general mechanic's toolkit. The unit T/E will list the set your unit rates and supply personnel will assist you in obtaining the proper one.

(TEXT CONTINUES ON PAGE 1-7)

Table 1-1. Toolkit, Mechanics (general)

5180-606-3566 TOOL KIT, MECHANICS (general)

FUNCTIONAL DESCRIPTION:

Tool Kit, Mechanics (general) is comprised of tools, thickness gages and implements required for making adjustments and general repairs to vehicular equipment. It is supplied one (1) per Engineer Equipment Mechanic; Tank Repairman; Turret Repairman; Amphibian Tractor Repairman; Body Repairman; or Automotive Mechanic as authorized by T/O's.

LIST OF COMPONENTS

1 ITEM NO	2 STOCK NUMBER	3 REF DESIG FIG-KEY	4 ITEM IDENTIFICATION	5 UNIT OF MEAS	6 QTY USED IN UNIT	7 FULL SET (BOXED) FSN	8 REDUCED SET (BOXED) FSN	9 INSTALLED ITEMS
1	5180-606-3566		TOOL KIT, MECHANICS (general)	KT				
			SUPPLY SYSTEM RESPONSIBILITY					
2	5120-224-1389		BAR, PRY: 15-1/2 in. lg, 17/32 in. stk dia; FS GGG-B-101	EA	1			
3	5120-223-6986		BIT, SCREWDRIVER: fl tip; 47/64 in. w; fml shk; 1/2 in. sq dr; 1-3/4 in. lg; FS GGG-W-641	EA	1			
4	8020-597-5301		BRUSH, PAINT: oval; hog bristle; w/ chisel edge, 1 in. dia, 5/8 in. thk, 2-1/8 in. lg; FS H-B-0491B	EA	1			
5	5110-222-2128		CHISEL, CAPE, HAND: 3/8 in. w cut; FS GGG-C-313	EA	1			
6	5110-186-7107		CHISEL, COLD, HAND: 1/2 in w cut, 5-3/4 in. lg; FS GGG-C-313	EA	1			
7	5120-494-1889		CLAMP, PLIER: 3-1/8 in. w jaw, 8 in. lg; FS GGG-C-00406	EA	1			
8	5120-243-7326		EXTENSION, SOCKET WRENCH: 1/2 in. sq end, 5 in. lg; FS GGG-W-641	EA	1			
9	5120-227-8074		EXTENSION, SOCKET WRENCH: 1/2 in. sq end, 10 in. lg; FS GGG-W-641	EA	1			
10	5210-250-6245		GAGE, THICKNESS: 1 blade gr; English sys; str blades; 16 blades, 1-3/4 in. lg, 1/4 in. w/at tip; w/blade lock; thicknesses, 0.010 in., 0.012 in., 0.013 in., 0.015 in., 0.016 in., 0.017 in., 0.018 in., 0.020 in., 0.022 in., 0.024 in., 0.025 in., 0.026 in., 0.028 in., 0.030 in., 0.032 in., 0.035 in.	SE	1			
11	5210-223-9191		GAGE, THICKNESS: 1 blade gr; English sys; str blades; 26 blades, 3 in. lg, 1/2 in. w/at tip; w/blade lock; thicknesses, 0.0015 in., 0.002 in., 0.003 in., 0.004 in., 0.005 in., 0.006 in., 0.007 in., 0.008 in., 0.009 in., 0.010 in., 0.011 in., 0.012 in., 0.013 in., 0.014 in., 0.015 in., 0.016 in., 0.017 in., 0.018 in., 0.020 in., 0.022 in., 0.024in., 0.025 in., 0.028 in., 0.030 in., 0.032 in., 0.035 in.,	SE	1			

LIST OF COMPONENTS

1 ITEM NO	2 STOCK NUMBER	3 REF DESIG FIG-KEY	4 ITEM IDENTIFICATION	5 UNIT OF MEAS	6 [illegible]	7 FULL SET (BOXED)	8 REDUCED SET (BOXED) FSN	9 INSTALLED ITEMS
12	5120-241-3585		HAMMER, HAND: 1/2 lb; 1-1/4 in. dia plate face; FS GGG-H-334	EA	1			
			HAMMER, HAND: machinist's; ball-peen; FS GGG-H-86 — Weight of Head (oz)					
13	5120-243-2985		4	EA	1			
14	5120-242-3913		8	EA	1			
15	5120-224-4082		12	EA	1			
16	5120-230-6364		HANDLE, SOCKET WRENCH: brace type; speeder; 1/2 in. dr, 18 in. lg; FS GGG-W-641	EA	1			
17	5120-236-7590		HANDLE, SOCKET WRENCH: hinged type; flex; 1/2 in. dr, 18 in. lg; FS GGG-W-641	EA	1			
18	5120-230-6385		HANDLE, SOCKET WRENCH: rtc type; rev; 1/2 in. dr, 9-1/2 in. lg; FS GGG-W-641	EA	1			
19	5120-241-3142		HANDLE, SOCKET WRENCH: sliding-T-type; 1/2 in. dr, 11 in. lg; FS GGG-W-641	EA	1			
20	5120-595-9244		KEY SET, SOCKET HEAD SCREW: L type hdl; hex dr; w/roll; FS GGG-K-275; C/O	SE	1			
			Size across Flats (in.) — Arm Length (in.)					
	5120-198-5401		.05 — 1-21/32	EA	1			
	5120-198-5398		1/16 — 1-3/4	EA	1			
	5120-224-2504		5/64 — 1-7/8	EA	1			
	5120-242-7410		3/32 — 2	EA	1			
	5120-240-5292		1/8 — 2-1/4	EA	1			
	5120-198-5392		5/32 — 2-1/2	EA	1			
	5120-240-5300		3/16 — 2-3/4	EA	1			
	5120-242-7411		7/32 — 3	EA	1			
	5120-224-4659		1/4 — 3-1/4	EA	1			
	5120-240-5274		5/16 — 3-3/4	EA	1			
	5120-198-5390		3/8 — 4-1/4	EA	1			
21	5120-221-1536		KNIFE, PUTTY: flex.; 1-1/4 in. w/blade; FS GGG-K-481	EA	1			
22	5120-293-1039		LIFTER-SCRAPER, BATTERY TERMINAL: 10-1/2 in. lg.	EA	1			
23	123 004560 00		MARINE CORPS STOCK LIST: Components List, SL-3-00456A dtd August 1968	EA	1			
24	5340-582-2742		PADLOCK: pin tumbler type mech w/dead bolt lkg construction; brz or brs: 1-1/8 in. w, 1-1/16 in. h MS 35647	EA	1			
25	5120-247-5177		PLIERS: lg rd nose; w/cutter; 6 in. lg; FS GGG-P-471	EA	1			
26	5120-528-2265		PLIERS, BRAKE REPAIR: f/bk spg; 12 in. lg.; FS GGG-P-480	EA	1			
27	5110-239-8253		PLIERS, DIAGONAL CUTTING: 6 in. lg; FS GGG-P-471b	EA	1			
28	5120-540-2464		PLIERS, SLIP JOINT: angle nose; mult hole; 5 in. lg; FS GGG-P-471	EA	1			
29	5120-278-0352		PLIERS, SLIP JOINT: angel nose; mult tongue and groove; 10 in. lg; FS GGG-P-471	EA	1			

Table 1-1--contd

LIST OF COMPONENTS

1 ITEM NO	2 STOCK NUMBER	3 REF DESIG FIG-KEY	4 ITEM IDENTIFICATION	5 UNIT OF MEAS	6 QTY USED IN UNIT	7 FULL SET (BOXED) FSN	8 REDUCED SET (BOXED) FSN	9 INSTALLED ITEMS
30	5120-223-7396		PLIERS, SLIP JOINT: str nose; comb. w/ cutter; 6 in. lg; FS GGG-P-471	EA	1			
31	5120-449-7298		PULLER: bat. term.; clamp and bar type; adj; 3/4 in. to 1-1/4 in. jaw cap.	EA	1			
32	5120-699-3589		PUNCH, DRIVE PIN: str type; rd pt; 12 in. lg, 1 in. dia.	EA	1			
			PUNCH, DRIVE PIN: str type; rd pt; FS GGG-P-831 — Length of Point(in.) / Diameter of Point(in.) / Specification Size No.					
33	5120-242-5966		3/4 — 1/8 — 3	EA	1			
34	5120-240-6083		1 — 1/4 — 7	EA	1			
35	5120-273-0001		1 — 3/8 — 9	EA	1			
36	5140-574-2860		ROOL, TOOL: f/elec and ign wrenches; leatherette; 11 pockets	EA	1			
			SCREWDRIVER, CROSS TIP: Phillips tip; plstc hdl; FS GGG-S-121 — Over-all Length(in.) / Length of Blade(in.) / Size of Tip					
37	5120-240-8716		6-1/8 — 3 — 1	EA	1			
38	5120-234-8913		7-1/2 — 4 — 2	EA	1			
39	5120-234-8912		10-1/8 — 6 — 3	EA	1			
40	4120-224-7375		12-5/8 — 8 — 4	EA	1			
41	5120-278-1273		SCREWDRIVER, FLAT TIP: plstc hdl; 1-3/4 in. lg blade, 5/16 in. w tip; FS GGG-S-121	EA	1			
42	5120-236-2140		SCREWDRIVER, FLAT TIP: plstc hdl; 2 in. lg blade, 1/8 in. w tip; FS GGG-S-121c	EA	1			
43	5120-227-7356		SCREWDRIVER, FLAT TIP: plstc hdl; 6 in. lg blade, 3/16 in. w tip; FS GGG-S-121c	EA	1			
44	5120-278-1283		SCREWDRIVER, FLAT TIP: plstc hdl; w/ wrench grip; 6 in. lg blade; 5/16 in. w tip; FS GGG-S-121	EA	1			
			SOCKET, SOCKET WRENCH: 1/2 in. sq dr; 8 pt opng; FS GGG-W-641 — Length(in.) / Size of Opening(in.)					
45	5120-180-1018		1-9/16 — 1/2	EA	1			
46	5120-180-1019		1-9/16 — 9/16	EA	1			
47	5120-180-1020		1-3/4 — 5/8	EA	1			
			SOCKET, SOCKET WRENCH: 1/2 in. sq dr; 12 pt opng; FS GGG-W-641 — Length(in.) / Size of Opening(in.)					
48	5120-189-7924		1-1/2 — 7/16	EA	1			
49	5120-237-0984		1-1/2 — 1/2	EA	1			
50	5120-189-7932		1-1/2 — 9/16	EA	1			
51	5120-189-7946		1-9/16 — 5/8	EA	1			
52	5120-189-7947		1-9/16 — 21/32	EA	1			
53	5120-189-7985		1-9/16 — 3/4	EA	1			
54	5120-189-7933		1-5/8 — 13/16	EA	1			
55	5120-189-7934		1-3/4 — 7/8	EA	1			
56	5120-189-7935		1-3/4 — 15/16	EA	1			
57	5120-189-7927		1-3/4 — 1	EA	1			
58	5120-189-7917		2 — 1-1/4	EA	1			
59	5120-277-1465		2 — 1-1/2	EA	1			

LIST OF COMPONENTS

1 ITEM NO	2 STOCK NUMBER	3 REF DESIG FIG-KEY	4 ITEM IDENTIFICATION	5 UNIT OF MEAS	6 QTY USED IN UNIT	7 FULL SET (BOXED) FSN	8 REDUCED SET (BOXED) FSN	9 INSTALLED ITEMS
			SOCKET, SOCKET WRENCH: d style; 1/2 in. sq dr; 12 pt opng; FS GGG-W-641 — Size of Opening (in.)					
60	5120-235-5898		5/8	EA	1			
61	5120-243-7346		11/16	EA	1			
62	5120-243-7345		13/16	EA	1			
63	5120-243-7342		7/8	EA	1			
64	5120-243-7343		15/16	EA	1			
65	5120-243-7340		1	EA	1			
66	5120-243-7341		1-1/16	EA	1			
67	5120-243-7339		1-1/8	EA	1			
68	5120-611-7525		TERMINAL CLAMP SPREADER, REAMER, POST CLEANER: bat; plier type; 7-1/2 in. lg	EA	1			
69	5140-315-2758		TOOL BOX, PORTABLE: S; w/1 removable tray; 22 in. lg, 8 in. w, 9 in. h; FS GGG-T-558	EA	1			
70	5120-269-7971		UNIVERSAL JOINT, SOCKET WRENCH: 1/2 in. sq end; FS GGG-W-641	EA	1			
71	5120-224-3153		WRENCH, BOX: dbl offset; dbl hd; hex or 12 pt opng; 3/8 in. and 7/16 in. opngs; 4-3/4 in. lg; FS GGG-W-636	EA	1			
72	5120-224-3154		WRENCH, BOX: dbl offset; dbl hd; 12 pt 1/2 in. and 9/16 in. opngs; 5-1/2 in. lg; FS GGG-W-636	EA	1			
73	5120-224-3138		WRENCH, BOX: dbl offset; dbl hd; 12 pt 5/8 in. and 3/4 in. opngs; 6-1/4 in. lg; FS GGG-W-636	EA	1			
			WRENCH, BOX AND OPEN END, COMBINATION: 15 deg offset of box opng; 15 deg angle of open end; hex or 12 pt opng; ea end identi[illegible] size; FS GGG-W-636a — Length (in.) / Size of Opening (in.)					
74	5120-228-9503		3-1/4 — 5/16	EA	1			
75	5120-228-9504		4-3/16 — 3/18	EA	1			
76	5120-228-9505		5 — 7/16	EA	1			
			WRENCH, BOX AND OPEN END, COMBINATION: 15 deg offset of box opng; 15 deg angle of open end; 12 pt opng; ea end identical size; FS GGG-W-636a — Length (in.) / Size of Opening (in.)					
77	5120-228-9506		5-1/4 — 1/2	EA	1			
78	5120-228-9507		5-3/4 — 9/16	EA	1			
97	5120-228-9508		6-1/8 — 5/8	EA	1			
80	5120-228-9509		7 — 11/16	EA	1			
81	5120-228-9510		8 — 3/4	EA	1			
82	5120-228-9511		10-1/4 — 13/16	EA	1			
83	5120-228-9512		10-1/4 — 7/8	EA	1			
84	5120-795-0895		WRENCH, CROWFOOT: MIL-W-40145(QMC)	EA	1			
85	5120-264-3796		WRENCH, OPEN END, ADJUSTABLE: sgle hd; 0 to 1.322 in. jaw opng cap.; 12 in lg; FS GGG-W-631a	EA	1			
			WRENCH, OPEN END, FIXED: dbl hd; 15 deg angle of hd ea end; FS GGG-W-636a — Length (in.) / Size of Opening (in.)					
86	5120-277-2342		4-1/8 — 3/8 and 7/16	EA	1			
87	5120-293-1328		5-3/8 — 1/2 and 19/32	EA	1			
88	5120-293-2134		6 — 9/16 and 11/16	EA	1			
89	5120-293-2111		7-3/[illegible] — 5/8 amd 25/32	EA	1			

Table 1-1--contd

LIST OF COMPONENTS

1 ITEM NO	2 STOCK NUMBER	3 REF DESIG FIG-KEY	4 ITEM IDENTIFICATION	5 UNIT OF MEAS	6 QTY USED IN UNIT	7 FULL SET (BOXED) FSN	8 REDUCED SET (BOXED) FSN	9 INSTALLED ITEMS
			WRENCH, OPEN END, FIXED: dbl hd; FS GGG-W-636e					
			Length(in.) / Size of 15° End Opening (in.) / Size of 60° End Opening (in.)					
90	5120-277-3414		3 / 13/64 / 15/64	EA	1			
91	5120-277-8310		3 / 15/64 / 13/64	EA	1			
92	5120-277-8308		3 / 7/32 / 1/4	EA	1			
93	5120-277-8309		3 / 1/4 / 7/32	EA	1			
94	5120-277-8311		3-1/2 / 9/32 / 5/16	EA	1			
95	5120-277-8312		3-1/2 / 5/16 / 9/32	EA	1			
96	5120-277-8313		3-3/4 / 11/32 / 3/8	EA	1			
97	5120-277-8314		3-3/4 / 3/8 / 11/32	EA	1			
98	5120-293-1349		4-7/16 / 7/16 / 1/2	EA	1			
99	5120-277-1486		WRENCH, PIPE: adj jaw; 1/2 in. to 1-1/2 in. IPS; FS GGG-W-651	EA	1			
100	5120-494-1910		WRENCH, PLIER: curved jaw; w/wire cutter; 7 in. lg; FS GGG-P-471	EA	1			
101	5120-494-1911		WRENCH, PLIER: curved jaw; w/wire cutter; 8-1/2 in. lg; FS GGG-P-471	EA	1			
102	5120-449-8200		WRENCH SET, SOCKET: w/case; C/O	EA	1			
	5120-243-7332		BIT, SCREWDRIVER: 11/16 in. w, fl tip; 3/8 in. sq dr; 1-1/4 in. lg; FS GGG W-641	EA	1			
	5120-184-8384		CROWFOOT ATTACHMENT, SOCKET WRENCH: 3/8 in. dr opng; 1/2 in. wrench opng; FS GGG-W-641	EA	1			
	5120-184-8397		CROWFOOT ATTACHMENT, SOCKET WRENCH: 3/8 in. dr opng; 9/16 in. wrench opng; FS GGG-W-641	EA	1			
			EXTENSION, SOCKET WRENCH: 3/8 in. sq end; FS GGG-W-641					
			Length(in.)					
	5120-227-8107		6	EA	1			
	5120-243-1693		9	EA	1			
	5120-273-9205		18	EA	1			
	5120-240-5364		HANDLE, SOCKET WRENCH: rtc type; rev; 3/8 in. dr; 6 in. lg; FS GGG-W-641	EA	1			
	5120-241-3143		HANDLE, SOCKET WRENCH: slicing-T-type 3/8 in. dr; 7 in. lg; FS GGG-W-641	EA	1			
	5120-240-5396		HANDLE, SOCKET WRENCH: hinged-flex-type; 3/8 in. dr; 8-1/2 in. lg; FS GGG-W-641	EA	1			
	5120-237-4969		HANDLE, SOCKET WRENCH: brace-speeder-type; 3/8 in. dr; 16 in. lg; FS GGG-W-641	EA	1			
			SOCKET, SOCKET WRENCH: 3/8 in. dr; 12 pt opng; FS GGG-W-641					
			Size(in.)					
	5120-232-5711		5/16	EA	1			
	5120-227-6702		3/8	EA	1			
	5120-227-6703		7/16	EA	1			
	5120-837-0977		1/2	EA	1			
	5120-227-6704		9/16	EA	1			
	5120-237-4973		5/8	EA	1			
	5120-232-5706		11/16	EA	1			
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1-6. SPECIAL TOOLS AND EQUIPMENT

The tools issued in the general mechanic's toolkit are insufficient to perform all the service and maintenance on all of the items of equipment; tools such as taps and dies, lubricating equipment, and special tuneup tools are required to supplement the toolkit. These special handtools and equipment are usually kept on a maintenance truck or in a storeroom near the equipment park or maintenance area. The cost of these tools, frequency of use, and the average size and weight prohibit their inclusion in the general mechanic's toolkit.

a. Lubricating and servicing equipment. In addition to the toolkit you will need equipment such as a grease gun, oil measure, can spouts, oiler, and wrenches for removing and replacing plugs and fittings.

(1) Lubricators (fig 1-1). A hand lever pressure lubricator pumps chassis lube (grease) through a grease fitting into the part to be lubricated. The coupler may be attached to a rigid pipe or a flexible hose. The coupler has three metal jaws which require frequent cleaning and inspection for wear; when worn, the grease will escape between the fitting and the coupler. Some coupler jaws can be reversed when one end becomes worn. The head and hand lever screw off the gun for refilling. The gun can be partially filled by holding the open (head) end in the grease and pulling the handle; this will draw the grease into the gun. The handle has a lock position to hold the spring tension while completing the filling by hand. The hand lever gun will hold approximately 1 pound of general purpose (GAA) grease. The tank-type lubricator pumps gear oil (GO) into gearcases and housings. The lubricant is pumped through a flexible hose to a tip that is threaded to screw into lubrication holes or into couplers which connect with a fitting. The top is removed for filling the gun. It will hold approximately 5 gallons of GO. The oil-pressure can is used to pump engine oil onto linkage or other points.

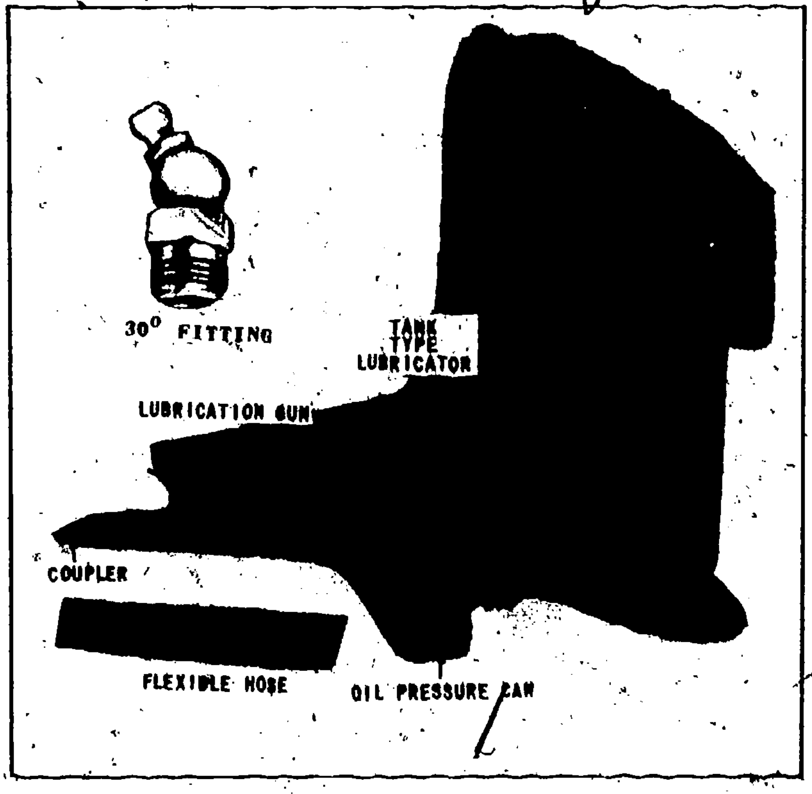


Fig 1-1. Lubricators and fittings.

(2) Measuring cans and spouts (fig 1-2). Oil, water, and fuel should be measured. Although many units operate from estimated quantities, there is space on equipment records for the amount of oil and fuel used. Many gallons of fuel and oil are wasted and many hours are consumed by personnel guessing the amount needed. For example, you will draw too much or too little oil into a 5 gallon container to fill an engine crankcase that requires only 1 gallon. The excess oil will be wasted because it will be contaminated before it

can be used. If you draw too little, time is wasted because you must make another trip. Can spouts are available for use with the 5 gallon expeditionary cans, but operators and maintenance men will spill part of the contents because they have lost or failed to care for the spouts.

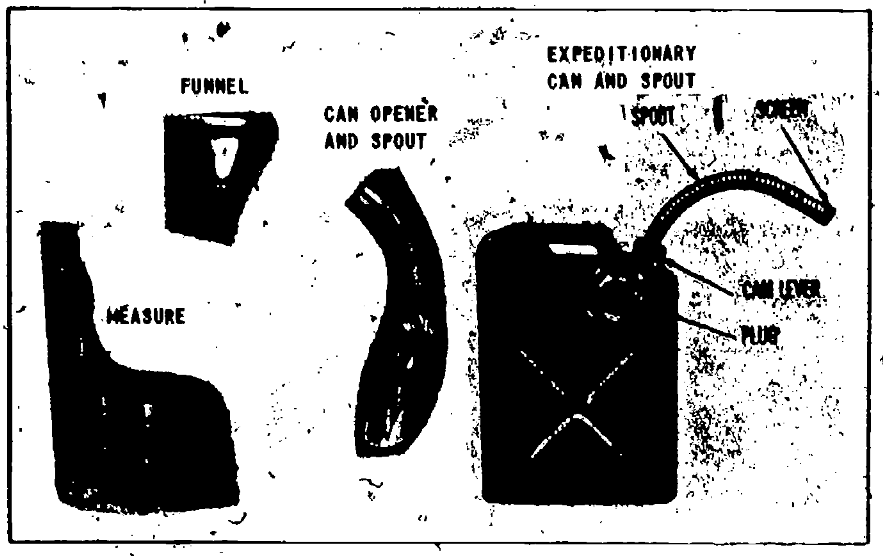


Fig 1-2. Measuring cans and spouts.

(3) Wrenches (fig 1-3). Special wrenches are designed to remove broken grease fittings and install new ones. A plug wrench that will fit female square sockets is used to remove and install fill, level, and drain plugs. Large Allen wrenches are used for some plugs and the large sockets are used for adjusting wheel bearings.

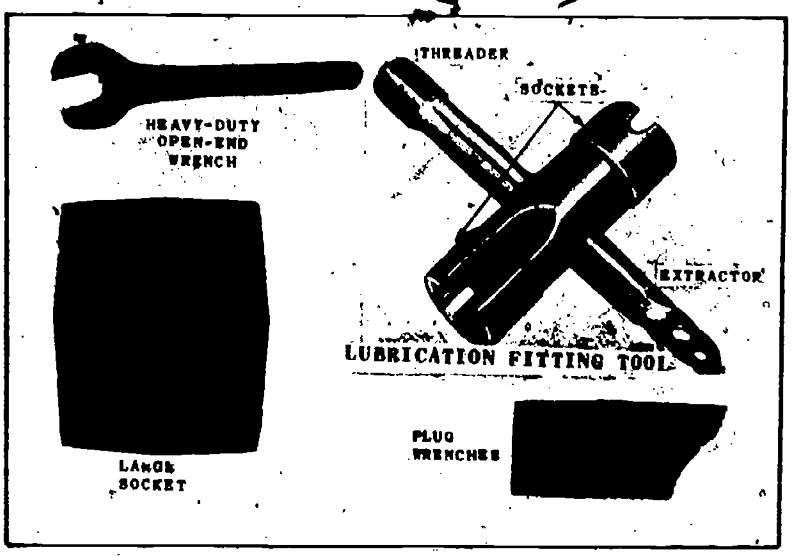


Fig 1-3. Special wrenches for servicing equipment.

(4) Battery service equipment (fig 1-4). A small hose connected to a nonmetallic container is normally used to fill batteries with water. A battery hydrometer is used to measure the specific gravity of the liquid in the battery. A small puller is sometimes needed to remove the battery cable clamps from the battery terminals. Wire brushes and scrapers are used to clean the battery terminal and the cable clamps.

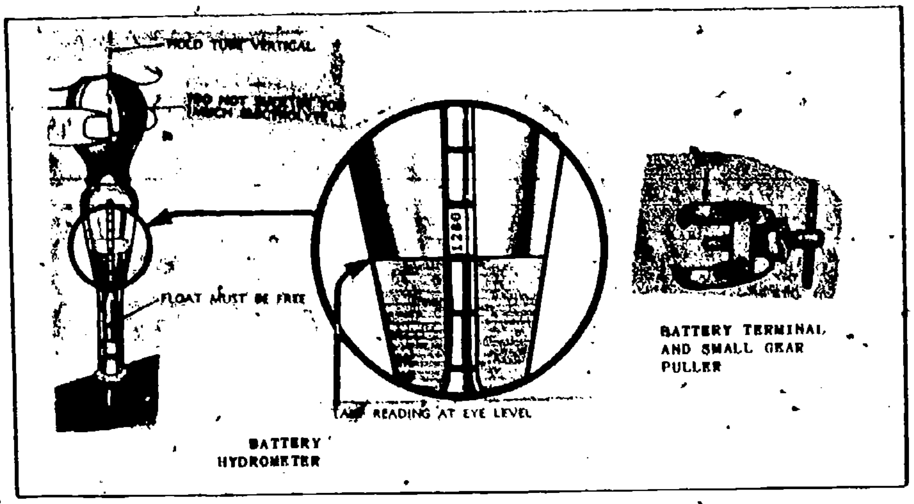


Fig 1-4. Battery service equipment.

b. Detroit diesel engine injector timing tool (fig 1-5). To properly tune-up the Detroit diesel engine, you must adjust the valves and check the injector timing. There are three timing tools with different timing dimensions. Before adjusting the injector timing, check the injector type and number and the tool number. Never use the timing tool as a punch.

c. Stud remover. A stud is a round bar with threads on both ends. It is usually screwed into a large part and a smaller part is attached by a nut screwed on the other end. Removal is usually required because the threads for the nut have been damaged or the stud is bent. In emergencies the stud may be removed with pliers, a pipe wrench, or another tool for round objects, but you should be careful not to damage the new replacement stud. Figure 1-6 illustrates the proper tool for removing and installing studs. Keep the tool clean and don't let it slip on the stud and it will do little or no damage to the stud.

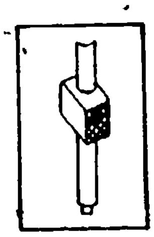


Fig. 1-5. Injector timing tool.

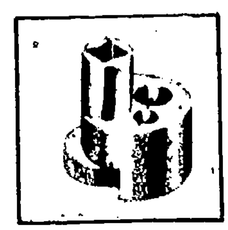


Fig 1-6. Cam-type stud remover.

d. Threading tools (fig 1-7). There are two different sets of taps and dies: one set is for cutting bolt and screw threads and the other set is for cutting pipe threads. A tap cuts internal threads and a die cuts external threads. The bolt and screw set have the tools to cut national coarse (NC) and national fine (NF) threads. The NC and NF mean that there are a specific number of threads per inch in relation to the bolt or screw diameter. For example, an NC bolt 5/8 in. in diameter will have 11 threads per inch while a 5/8 in. NF bolt will have 18 threads per inch. A bolt with NF threads must have NF threads to screw into; it cannot be used with the coarse threads without damaging one or possibly both sets of threads.

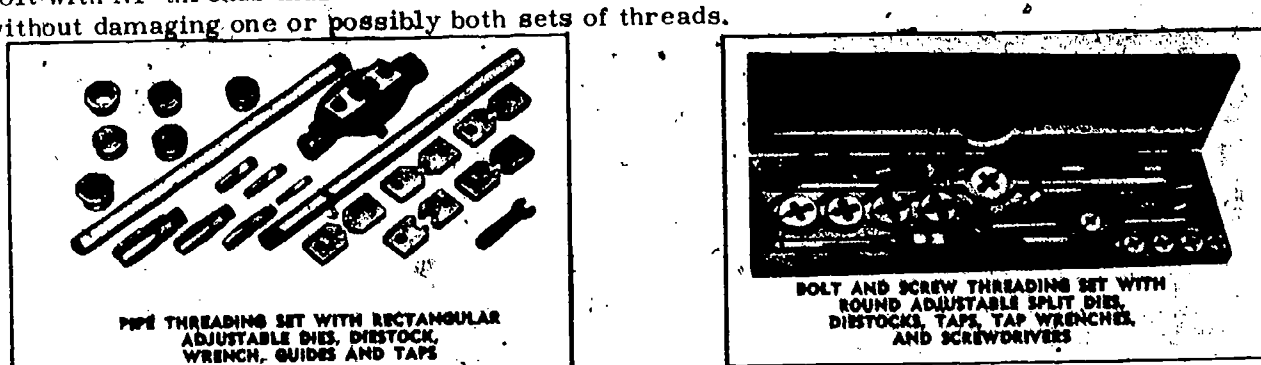


Fig 1-7. Pipe and bolt and screw threading sets.

e. Pullers. Pullers are designed to remove close-fitting parts such as bearings, shafts, wheels, bushings, and sheaves. Some pullers will push or pull and some are specially designed tools used like pry bars.

(1) The push and pull puller set contains the components most used by the engineer equipment mechanic. Figure 1-8 identifies the components of the set and figure 1-9 illustrates how the components are combined to pull a bearing cup. Figure 1-9A illustrates the removal and 1-9B the installation of a bearing cup.

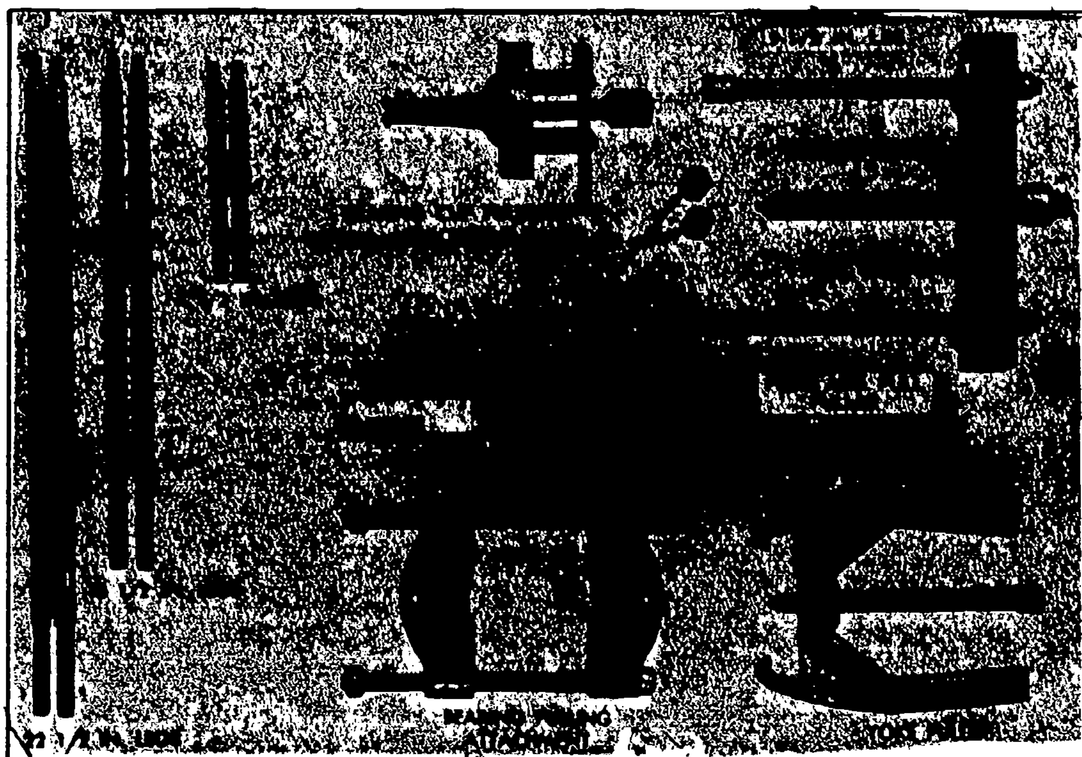


Fig 1-8. Push pull puller set.

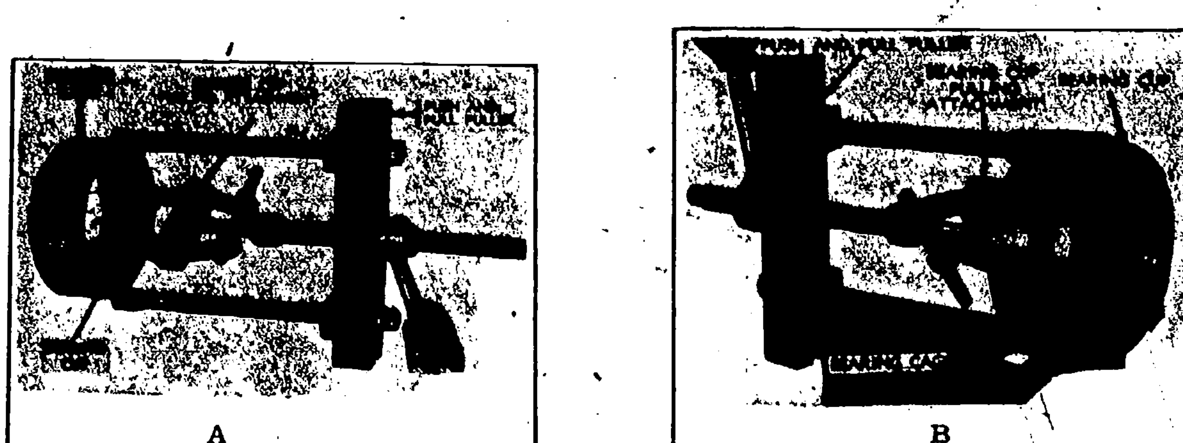


Fig 1-9. Combination uses of puller set components.

(2) A special puller, the injector tool (fig 1-10), designed for removing injector units from the Detroit diesel engine, is often discarded by inexperienced mechanics. However, a roll head pry bar will serve the same purpose.

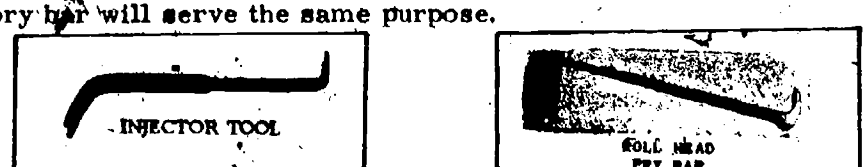


Fig 1-10. Tools for removing injectors.

There are other special pullers and special bolts designed for pulling gears and housings. These bolts require special care; keep the threads protected when not in use and oil lightly when using. Some of the puller bolts have a large head designed to be struck with a hammer; use mechanical judgment in the use of force. Return the puller bolts to their proper storage place when not in use and don't use them as replacement parts on the equipment.

f. Hose and tubing tools.

(1) Hose. With bulk hose and reusable fittings, you can replace or repair most lines on engineer equipment. Although there are some special tools, they are not discussed in this course because you can do the same job with a pocket knife and your general mechanic's tools. The hose is made in several sizes and can be used for low-, medium-, and high-pressure lines. It can be used to replace or splice metal lines. Flexible hose helps overcome vibration damages, but it is easily cut and chafed.

(2) Tubing tools. Tube cutters, benders, and flaring tools are used to repair or fabricate metal low-pressure fuel and oil lines. The cutter has two rollers and a cutter wheel mounted in a lightweight frame (fig 1-11). The cutter wheel is attached to an adjusting screw. Tubing is cut by placing it between the cutter wheel and rollers and adjusting the cutter wheel to cause a slight pressure on the tubing. (Too much pressure will crush the tubing.) The tool is rotated toward the open side and the cutter adjusted to maintain a slight pressure. Some cutting tool rollers have slots which make it possible to cut off only the flared portion of a line. Although tubing can be cut with other tools, the cutting tool helps obtain a square cut more quickly with less waste. Bending and shaping of the line is done after it is cut. All metal lines should have some bends to help absorb the vibrations and allow for expansion and contraction. To prevent kinking the tubing, a tubing bender similar to the one illustrated in figure 1-12 should be used. After the tubing has been shaped and the fittings installed, lines requiring flares can be finished with the flaring tool (fig 1-13). The tubing must be installed in the die block straight or the flare will be offset. It must extend through the die block the proper distance or the flare will be too long or too short.

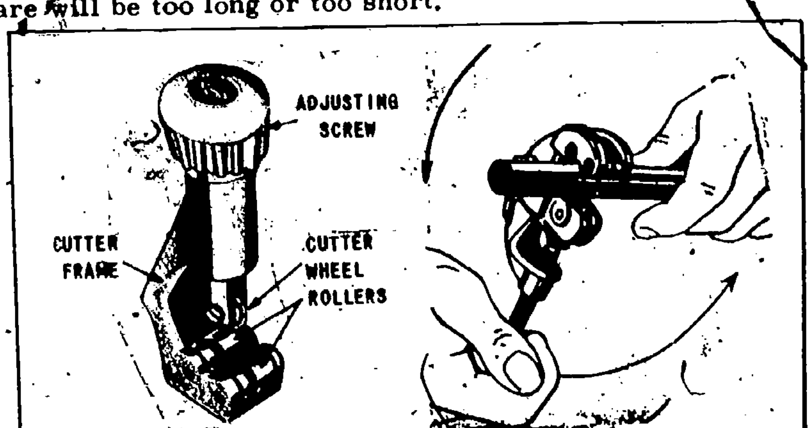


Fig 1-11. Tubing cutter and use.

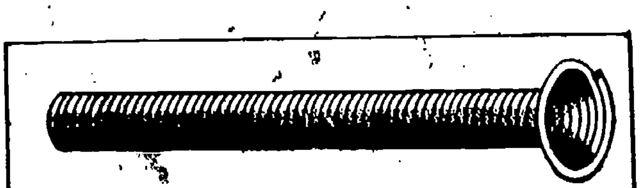


Fig 1-12. Coil wire tube bender.

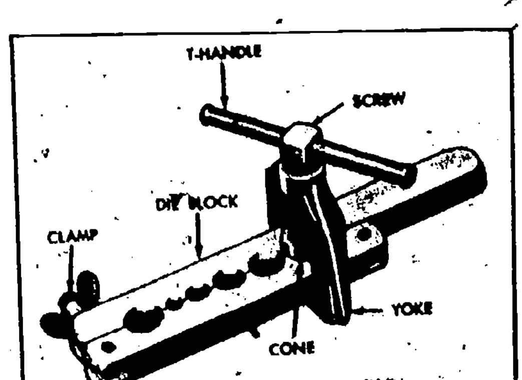


Fig 1-13. Flaring tool.

1-7. HOISTING AND PRESSING EQUIPMENT

The use of hoisting equipment such as chain falls, griphoists, and jacks is necessary in the removal, repair, and replacement of some engineer equipment components. Hoisting equipment makes it possible for one man to do a job that might normally require two. Although it will require more time, hoisting equipment is to be used on any job where raising by hand may result in injuries. The equipment is to be used for hoisting and holding until the job can be properly blocked. It is not used to hold the component while being repaired; do not attempt to repair an item while it is suspended from a hook or supported by a jack.

a. Jacks. The hand hydraulic jack (fig 1-14) is usually the easiest item of hoisting equipment to obtain. The capacity is stamped on a plate and attached to the jack. A jack is a part of the collateral materiel of motor transport vehicles. When placed on a suitable base, the jack will lift most items that require raising for repairs. The jack was designed to be used in the vertical position, but by placing the pump on the low side it can be used horizontally. The height of the jack can be adjusted by turning the threaded screw in or out of the hydraulic piston. Located at the base of the jack near the pump is a valve that controls the return flow of hydraulic oil. The handle of the jack serves as a wrench to close the valve and to operate the pump. The jack should be checked before each use and cleaned after each use. Before returning to storage, push the hydraulic piston all the way down and turn the adjusting screw in to the lowest position, but do not tighten or force it. Keep the screw threads clean and lightly oiled to prevent rust and corrosion.

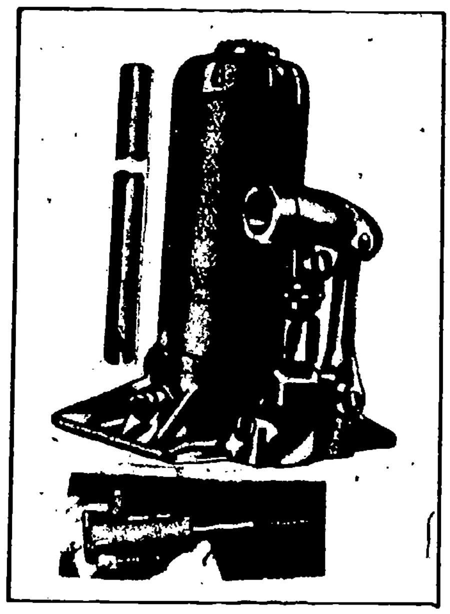


Fig 1-14. Hand hydraulic jack.

b. Griphoist (fig 1-15). This item of equipment is one of the latest pulling and hoisting devices used by the Marine Corps. The Griphoist is used primarily to aid in sectionalizing equipment. It has a single-line capacity of 3,300 lb which can be increased with block and tackle and a 4-part line to pull or lift 6 tons. The Griphoist uses 1/2 in. wire rope usually issued in 60-ft lengths, but the length is not limited. A pressure of 77 lb is required on the 44 1/4-in. telescopic handle to lift a 3,300-lb load. One complete stroke of the handle, which closes to 25 in., will move the load 2 3/4 in. It operates on the draw-vise principle and lifting and lowering of the load is accomplished by two pairs of steel jaws controlled by a hand lever. The cable is held at all times, when loaded, by one pair of jaws. The power stroke lever is keyed to the Griphoist crankshaft by two shear pins designed to shear at about 6,600 lb. The shear pins protect the Griphoist from more serious damage and prevent further lifting or pulling. The load can be released or lowered with broken shear pins. The item should be cleaned and oiled before returning to storage. Excessive amounts of oil or grease will not harm the hoist.

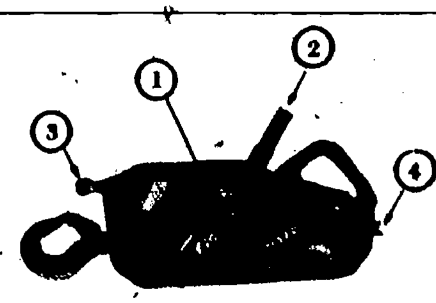


Fig 1-15. Model T-20 Griphoist.

c. Chain hoist (fig 1-16). This is an assembly made up of gears, sprockets, a ratchet assembly, and chains. Straight spur or worm gears can be used to provide the gear ratio required to lift the load. A continuous chain turns one sprocket to operate a hoist sprocket which raises and lowers the lift chain and hook. The ratchet assembly assists the reverse action of the gears to hold the load until it can be blocked. Because the chain hoist requires some type of overhead fixture, it is seldom used outside the maintenance shops. The capacity of the assembly is determined by the capacity of the overhead structure to which it is attached, the capacity of the lift chain and hook, and the gear ratio between the operating sprocket and the lift sprocket. The lower hook of a chain hoist is usually the weakest part of the assembly. The lift chain and hook should be checked prior to each use and the complete assembly including overhead structure should be inspected yearly.

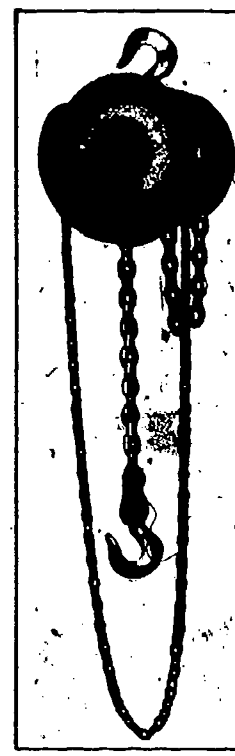


Fig 1-16. Spur gear-type chain hoist.

d. Press. Although a press is not usually an organizational maintenance item, one can usually be found available at the nearest maintenance shop. A 50- to 100-ton hydraulic press and an arbor press are normally set up in the shop; a porta-power (fig 1-17) is usually available for jobs away from the shop. The hydraulic press has a hydraulic assembly mounted at the top of a frame and crossmember which supports the work. The hydraulic assembly is movable from side to side but should be used as near the center as possible. A gage on the hydraulic assembly indicates the pressure exerted on the ram. The hydraulic assembly works like a hand hydraulic jack. The crossmember is adjustable up and down; it can be raised or lowered by cable to the desired height. It is held in position by pins. When using the hydraulic press, use extreme caution to prevent injury to personnel and damage to the item being repaired. The arbor press is a gear and ratchet type unit usually mounted on a bench. Its size and the limited amount of pressure that can be exerted limits its use to small jobs. The porta-power can be used with some of the puller set parts to remove and install parts that require a press; it is portable and has a capacity of approximately 10 tons. There is no gage to indicate the pressure.

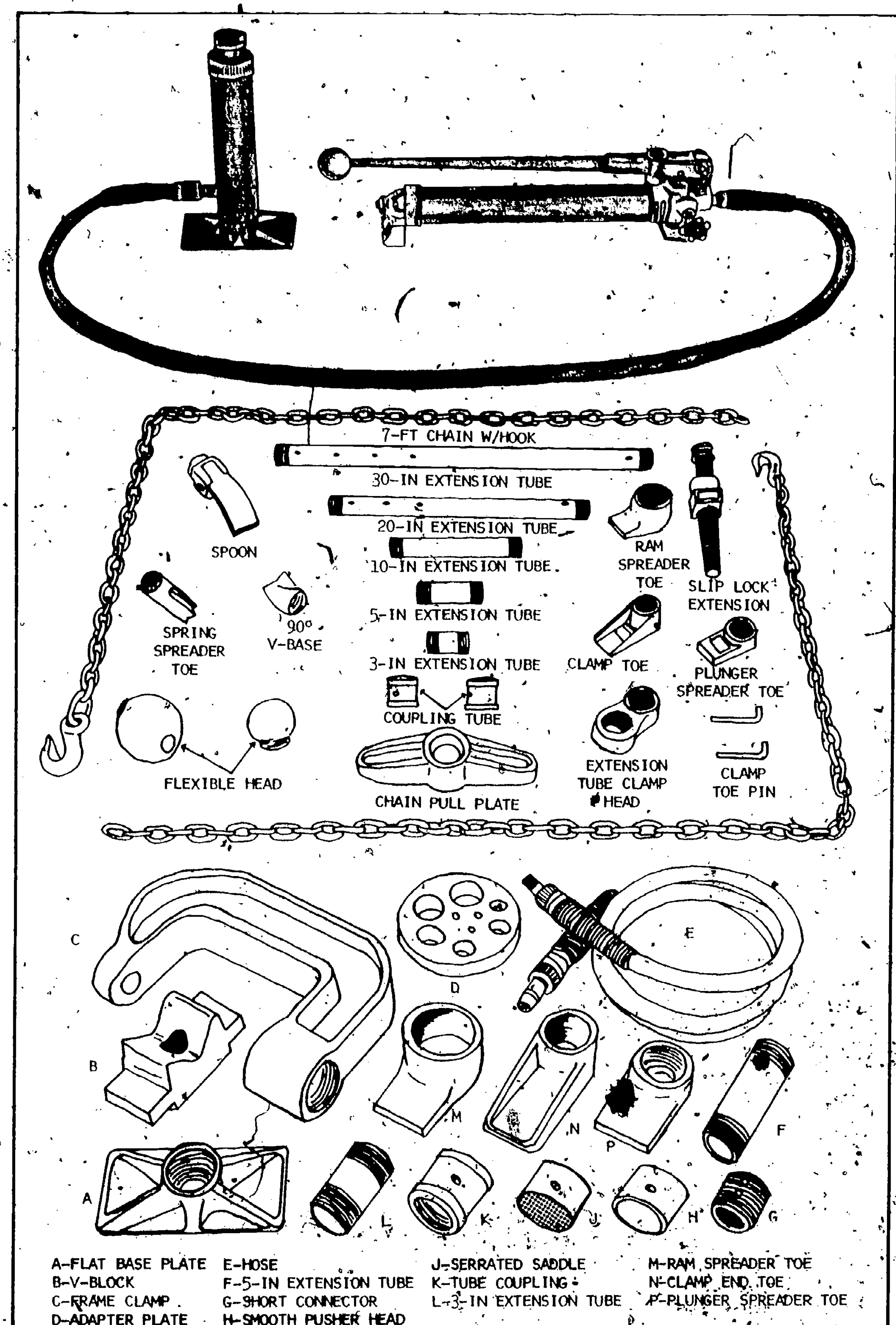


Fig 1-17. Porta-power and attachments.

Section III. POWER TOOLS AND PRECISION MEASURING INSTRUMENTS

1-8. ELECTRICAL TOOLS

a. Drill. The drilling machines most used by engineer equipment mechanics are the 1/2- and 3/4-in. portable electric drills (fig 1-18). The 1/2-in. medium-speed electric drill is used with high-speed steel twist drills. It is also used to turn reamers and hones. The 3/4-inch slow-speed heavy-duty electric drill is used with the carbon steel twist drills. Electric drills are equipped with the gear-type chuck, but can be changed to the socket-type chuck (not shown). They operate from a 110-volt ac or dc electrical source. The size of the electrical drill indicates the maximum size of the twist drill (bit) that should be used. For example, the 1/2-in. drill should not be used to bore a hole larger than 1/2 in. in diameter.

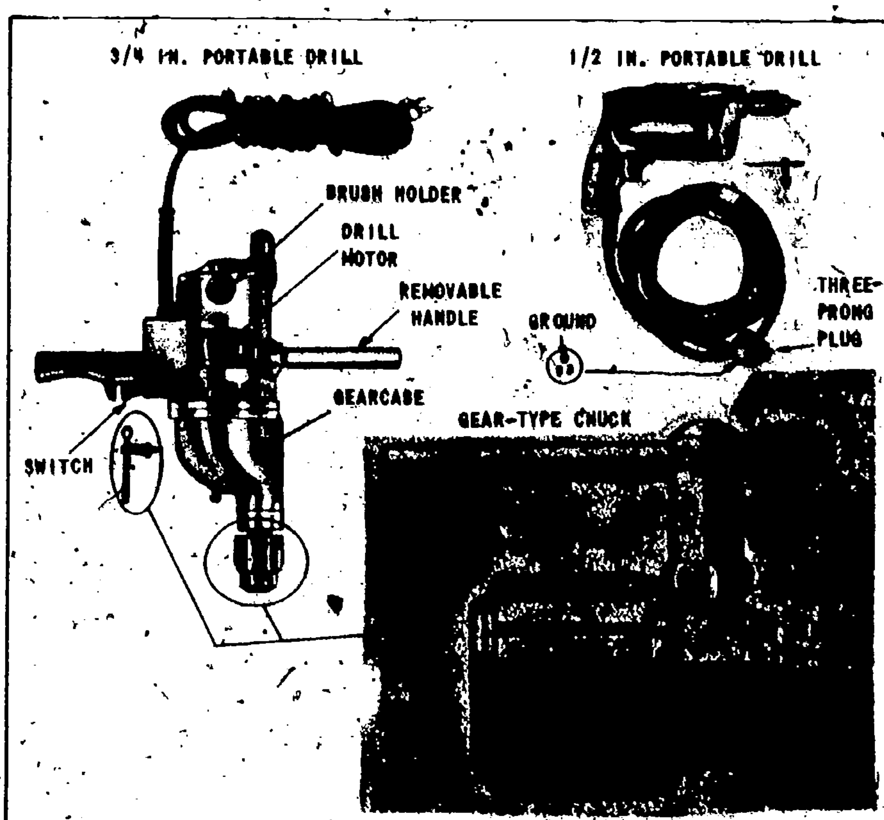


Fig 1-18. Portable electric drills and gear chuck.

The size of twist drills (fig 1-19) is designated in three ways: letters, A to Z; numbers 1 to 80; and fractions of an inch. The letter sizes range from 0.234 (A) to 0.413 (Z); the number sizes range from 0.0135 (80) to 0.228 (1); the fractional sizes range from 1/64th to 1 in. You will find the size of the twist drill stamped on the shank unless it has been mutilated. The three principal parts of a twist drill are the point, body, and shank (fig 1-19). Twist drills are available with different types of shank and two, three, or four flutes. The Morse taper or straight shank twist drills with two flutes are the type normally used by the mechanic. The 3- and 4-flute twist drills are used to enlarge holes. The straight round shank is used with the gear-type chuck and the Morse tapered shank is used with the socket-type chuck. To drill a hole with the portable electric drill, center punch the material at the location for the hole. Select a straight, sharp, twist drill of the proper size (high-speed steel twist drills for machines with high rpm; and carbon steel twist drills for machines with low rpm). Install the shank into the chuck; straight round shank in the gear-type chuck and Morse taper shank into the socket chuck. Tighten the jaws of the gear-type chuck firmly on the drill shank or push the tang of the Morse taper shank into the slot of the socket chuck. Plug the machine into the electrical outlet, making sure prong plug and socket are properly grounded. Start the drill by pulling the switch and then place the tip of the twist drill in the center punch mark. Use enough pressure to make it cut. Figure 1-20 shows the correct chip curl of a good, sharp drill operating at the proper speed with the correct pressure.

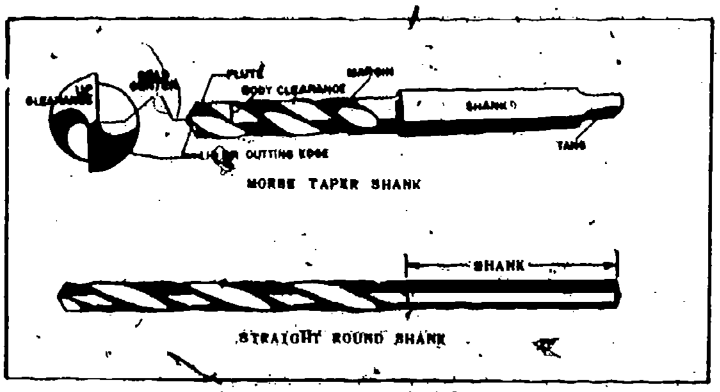


Fig 1-19. Twist drills.

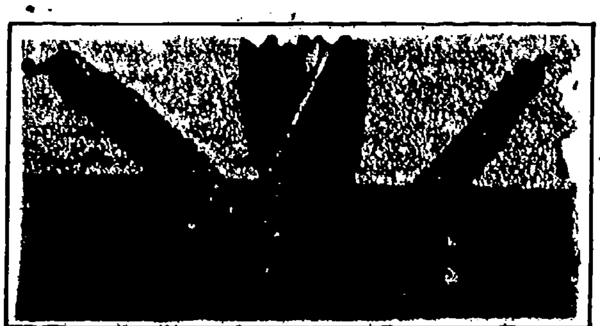
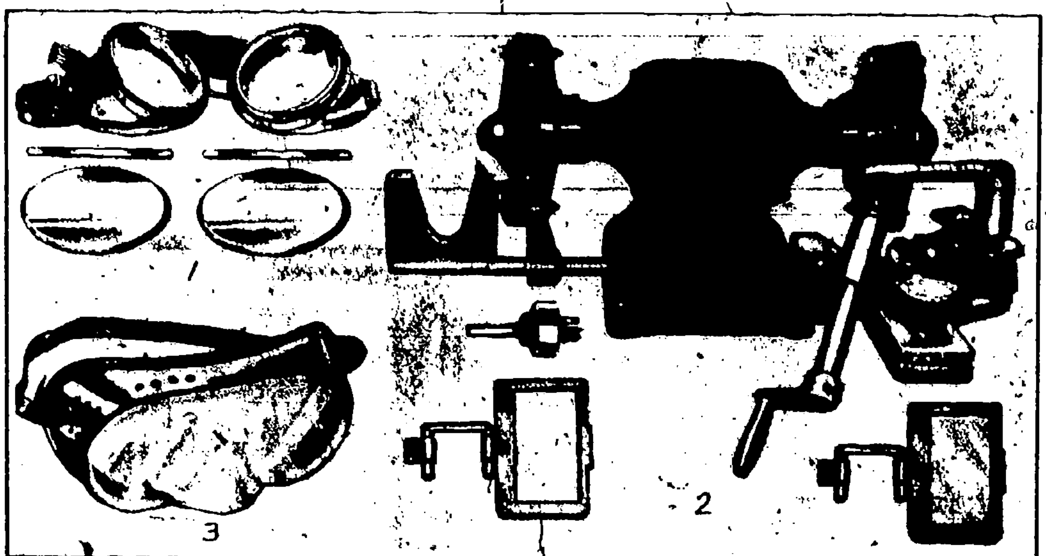


Fig 1-20. Correct curl of chips.

When drilling steel, wrought iron, or copper, use oil on the twist drill and the metal; when drilling brass, keep the drill and metal dry. When the job is completed, remove the drill plug from the electrical outlet. (Note: Don't pull on the electrical cord to remove the plug; grasp the plug itself.) Remove the twist drill from the machine by loosening the jaws of the gear-type chuck or with a special wedge for the socket-type chuck. Clean it and replace it in the box. Keep twist drills separated and don't let the points strike anything. Clean the portable electric drill and return to storage. Maintenance of the machine and twist drills is limited. Machine shops at 3d and 4th echelon repair shops are equipped to sharpen dull or broken twist drills. You should check and clean the drill and check the brushes of the portable electric drill periodically; check and refill the gearcase 1/2 full of ball- and roller-bearing lubricant.

b. Grinders. These are probably the most used power tools in a maintenance facility.

(1) The bench-mounted electric grinder (fig 1-21) should be located centrally away from flammable materials and work spaces where cleanliness is important. The grinder creates sparks which can cause fires and causes abrasive dust which would be harmful to machined parts. It is an electric motor with the shaft extended through each end, on which an abrasive stone or wire-brush wheel is mounted. The grinder is equipped with a tool rest and guards for the operator's protection. The motor is designed to operate at a specified rpm which is usually stamped on a data plate on the motor. Maintenance of the motor is limited to cleaning and inspecting by organizational maintenance personnel. Major repairs can be accomplished by the utility section of engineer maintenance shops. The guards, tool rest, and eye protectors can be removed, repaired, and replaced by organizational maintenance personnel.



1. Goggles with clear lens covers.
2. Grinding machine utility with attachments.
3. Eye protector for use over personal spectacles.

Fig 1-21. Bench grinder and related equipment.

(2) The portable electric grinder is normally stored in the toolroom or on the portable electric arc welder and is taken to the job for use. It is a lightweight electric motor used to turn either an abrasive stone or wire wheel. Located between the electric motor and the abrasive wheel is a gearcase which increases the output shaft speed. The operating rpm stamped on the machine is not the rpm of the motor, but the rpm of the shaft where the abrasive stone is mounted. Organizational maintenance of the tool is limited to cleaning, inspecting, replacing brushes, and cleaning and repacking the gearcase. The portable electric grinder is seldom repaired beyond the organizational maintenance level. It is cheaper to turn in the old grinder and order a new one.

(3) Abrasive stones receive much wear and tear and require close inspection, maintenance, and frequent replacement. They should be checked before each use. The stones are made with different grades or roughness such as coarse, medium, and fine. Some are also numbered like sandpaper: 00, 1, etc. They are designed to be used at a specific speed. Before installing a stone on the shaft, check the rpm of the shaft and the rpm stamped on the stone. Don't use a stone on a machine whose rpm rating is higher than that listed on the stone. If the stone is worn to less than 2 3 its original diameter, it should be replaced. In other words, don't use a 6-inch stone that has worn to less than 4 inches. A stone that is cracked, regardless of how small, should not be used. For those stones that are nicked, the mechanic can smooth the face with a wheel or diamond-point dresser. These dressing tools are allowed to rest on the tool rest and are worked against the abrasive stone as the grinder is operating. The diamond-point dressing tool is an item that requires special care. It appears to be a straight punch and is easily lost; however, the punch-shaped metal has a black diamond embedded in one end and is a very expensive item. It is normally used only on the smoother stones used for precision grinding.

(4) A special-type grinder is the valve face grinding machine (fig 1-22), which is found in the machine shop. It is a special-purpose machine used only for grinding valve faces and stems. By using a dial indicator and properly adjusting the machine, precision grinding can be accomplished. It is equipped with two electric motors; one turns the abrasive stones at high speeds, the other turns the valve and pumps coolant and is relatively slow. The coolant tube is adjusted so that the coolant flows on to that portion of the valve being ground. The stones are specially made in many shapes. They are dressed prior to each use so that the correct angle can be maintained. The dressing tool is fitted into a fixture and can be mounted on the machine. Only a diamond-point dressing tool is used to dress the stones for the valve-grinding machine. Organizational maintenance of the machine is limited to cleaning, tightening, and replacing stones. Higher echelon maintenance personnel can make minor repairs to the electric motors and ordnance maintenance personnel can make minor repairs to other parts of the machine.

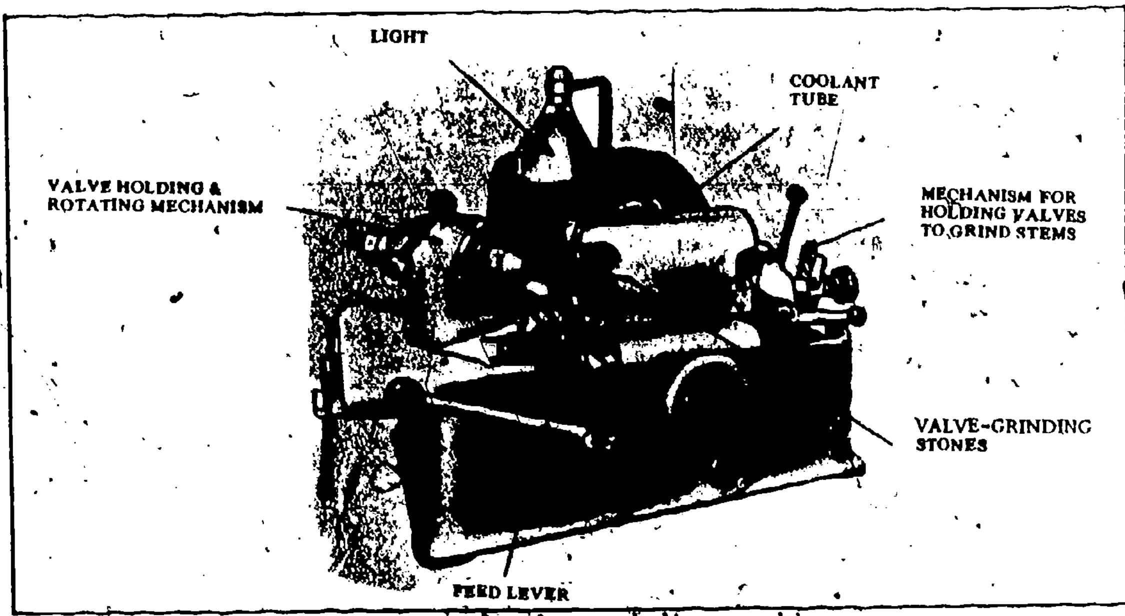


Fig 1-22. Valve face grinding machine.

1-9 PNEUMATIC TOOLS

Compressed air is used to provide power for drills, saws, nail drivers, and other pneumatic tools. Reciprocating percussion and rotary vane are the two general types of tools. In comparison to gasoline engine and electric tools, the pneumatic tools are usually easier to maintain and operate and are not affected by overload or climatic conditions. However, the size of the air hose and the weight of the tool make it undesirable for some jobs. The life of pneumatic tools depends upon proper lubrication.

a. Impact wrench (fig 1-23). The pneumatic impact wrench is the rotary vane-type tool most often used by engineer equipment mechanics. It is used to tighten and loosen nuts and bolts by impact (hammering effect) and rotary motion. The impact unit is synchronized with the rotary motor which turns about 690 to 710 rpm. Insufficient air or lack of lubrication will cause a slow motor speed and slow or erratic impacting. The impact wrench is only one of several rotary-vane-type pneumatic tools which use the same type motor.

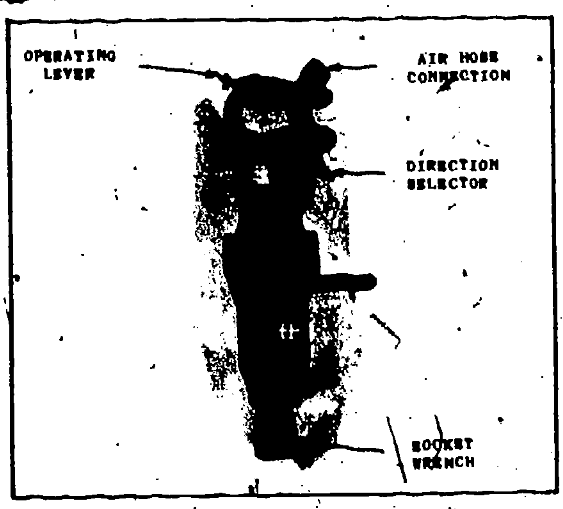


Fig 1-23. Impact wrench.

b. Riveting hammer (fig 1-24). The riveter is one of the reciprocating percussion pneumatic tools used by maintenance personnel to chisel, remove paint, cut tops from oil drums, and for other light hammering jobs. Although the riveter is just as simple and trouble-free as the impact wrench, it is one of the more dangerous of the pneumatic tools. Never point the riveter at anyone; it is possible for the piston to come out with enough force to injure anyone standing in the line of flight. Keep the tool clean and well lubricated and it will provide many hours of useful service.

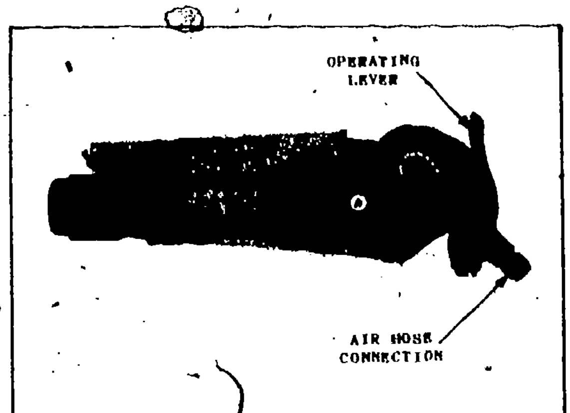


Fig 1-24. Riveter.

c. Line oiler. Connected as close to the tool as practical is a device that will hold from 1 pint to 1 quart of oil. The line oiler provides lubrication for the tool by dropping oil in with the air at a set rate.

1-10. PRECISION MEASURING INSTRUMENTS

a. Torque wrench (fig 1-25). A nut or bolt will take only a specific amount of torque before it will break, stretch, or pull the threads. To control the amount of torque, use a torque wrench which measures torque in pound-inches or pound-feet. The amount of torque required will be found in the TM for the item of equipment. The amount of torque for each bolt will not be found in the TM, but the critical components are parts such as cylinder heads, manifolds, spark plugs for some engines, and injectors are listed. For nuts and bolts not listed you must use your own judgment and learn from experience. After removing broken bolts from the same hole about six times, it should be evident that you are using too much force. The size of a bolt and the number of threads per inch help determine the amount of torque it will take. Figure 1-26 lists the average torque required for different-size bolts and nuts. Like all precision tools, the torque

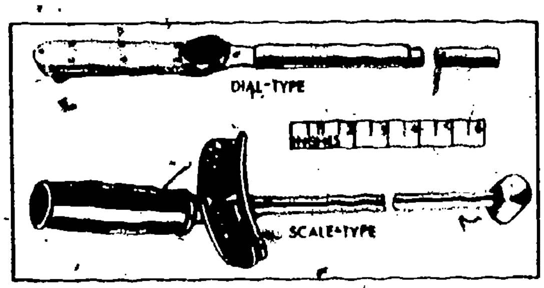


Fig 1-25. Torque wrenches.

SIZE NUT OR BOLT (DIA - TPI)	TORQUE (lb-ft)	SIZE NUT OR BOLT (DIA - TPI)	TORQUE (lb-ft)	SIZE NUT OR BOLT (DIA - TPI)	TORQUE (lb-ft)
1/4 - 20	7-9	7/16 - 20	57-61	3/4 - 10	240-250
1/4 - 28	8-10	1/2 - 13	71-75	3/4 - 16	290-300
5/16 - 18	13-17	1/2 - 20	83-93	7/8 - 9	410-420
5/16 - 24	15-19	9/16 - 12	90-100	7/8 - 14	475-485
3/8 - 16	30-35	9/16 - 18	107-117	1 - 8	580-590
3/8 - 24	35-39	5/8 - 11	137-147	1 - 14	685-695
7/16 - 14	46-50	5/8 - 18	168-178		

DIA - diameter
TPI - threads per inch

NOTE: This chart is NOT for aluminum or other soft-material threads.

Fig 1-26. Average nut and bolt torque.

wrench must be kept clean and handled carefully. Clean the torque wrench with a cloth; don't dip it in cleaning solvent. Keep the wrench stored where it will not be banged. When using the torque wrench, pull on the handle at the place designed for that purpose; pulling from any place other than the handle will give you a false reading. Check the dial and set to zero before torquing each nut or bolt. Don't use a socket extension unless specified in the torque specifications or unless it is necessary.

b. Dial indicator (fig 1-27). This instrument is a precision measuring device which has 0.001-in. graduations. It is used to check inside or outside surfaces, flat surfaces, and movement. The head of a valve or a cylinder bore can be checked for roundness. Clutch surfaces can be checked for warpage and shafts for end play. The operating clearance between two meshing gears can also be checked. For example, by connecting the dial indicator and adapter to the engine block, the pulley or other part can be checked for alinement and out-of-round. It is a simple, but delicate instrument and must be handled with care After use the instrument is cleaned and returned to its storage space. Its accuracy can be checked by ordnance maintenance personnel, but it is usually replaced if found defective.

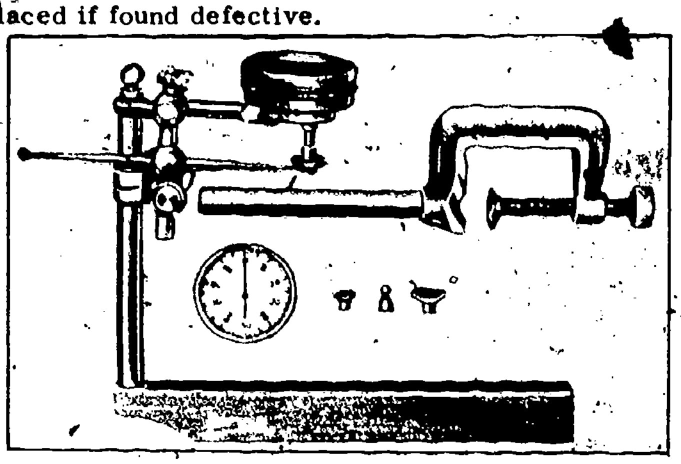
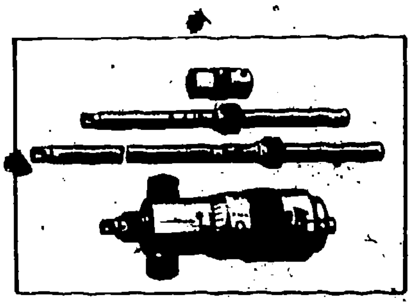


Fig 1-27. Dial indicator and adapters.

c. Micrometers (fig 1-28). These are precision measuring tools designed to accurately measure, within 0.0001-in., inside or outside dimensions. They are provided in sets; one set contains six micrometers with graduated dimensions of 0-1 in., 1-2 in., 2-3 in., 3-4 in., 4-5 in., and 5-6 in. and then there are larger sets. The micrometer is used by mechanics primarily to check for wear of parts such as shafts and cylinder bores. The mechanic adjusts the micrometer by hand when checking dimension, and the most accurate readings are usually obtained by the more experienced personnel. Because the tools are adjusted by hand, improper care and use can severely damage them. Clamping the caliper (outside) micrometer on an object will destroy the tool's accuracy. Some of the outside micrometers have an adjusting ratchet which helps prevent damage from overtightening or clamping. Ordnance maintenance personnel can check the accuracy of the micrometer, but the user is limited to cleaning and carefully returning the tools to their proper storage space.

Caliper micrometer (outside)



Inside micrometer

Fig 1-28. Micrometers.

1-11. SUMMARY

The tools that are available to you, the engineer equipment mechanic, are adequate for the job. You must take good care of them and use them properly. Each tool was designed for a specific purpose and, if you use it in the prescribed manner, you will be more apt to accomplish your job with a minimum of difficulty.

Chapter 2

ENGINES

Section I. ENGINE CHARACTERISTICS

2-1. GENERAL

Engines provide power to operate machinery by converting heat energy into mechanical energy. They can be grouped into types or classes. The engines used in Marine Corps engineer equipment will have an identification plate on the vehicle or the engine to help you identify it (fig 2-1).

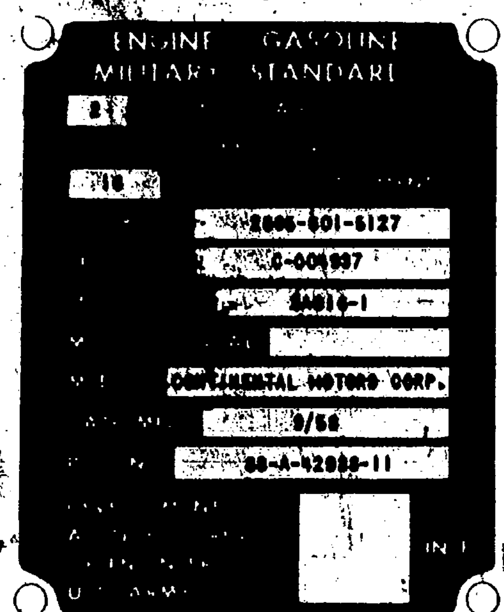


Fig 2-1. Engine identification plate.

a. Engine types. Engines may be typed as external-combustion and internal-combustion engines. An external-combustion engine burns fuel outside the engine; an example is the steam engine. The internal-combustion engine burns fuel within the engine. It creates heat by burning the fuel in a combustion chamber; it then converts the heat to mechanical energy. Most engines in use are the internal-combustion type. Internal-combustion engines are also grouped as gasoline or diesel engines according to the type of fuel they use. You, as an engineer equipment mechanic, will be required to maintain both.

b. Engine classes. An engine can be further classified according to its: cycle, piston action, cylinder arrangement, fuel injection, speed, and application.

(1) Operating cycle. Internal-combustion engines operate on either a 2- or 4-stroke cycle. This means that a piston moves from one end of the cylinder to the other (top to bottom-bottom to top) two or four times for a cylinder to complete a cycle. When a piston has moved from one end of the cylinder to the other (up or down), it has completed one stroke, but only a portion of the cycle. A cycle is the chain of events that occur to get the air and fuel into the cylinder, compress it, burn it to produce the power, and then expel the exhaust. The chain of events is the same for all internal-combustion engines, but the number of strokes required to complete a cycle may be either two or four.

(2) Piston action (fig 2-2). An engine can be classified as single-acting piston engine, double-acting piston engine, or opposed piston engine. A single-acting piston engine uses only one end of the piston (the crown) to receive the force of the expanding gases. A double-acting piston engine uses both ends of the piston to receive the forces. The opposed piston engine is constructed with two pistons in one cylinder. The engines in Marine Corps engineer equipment are single acting piston type.

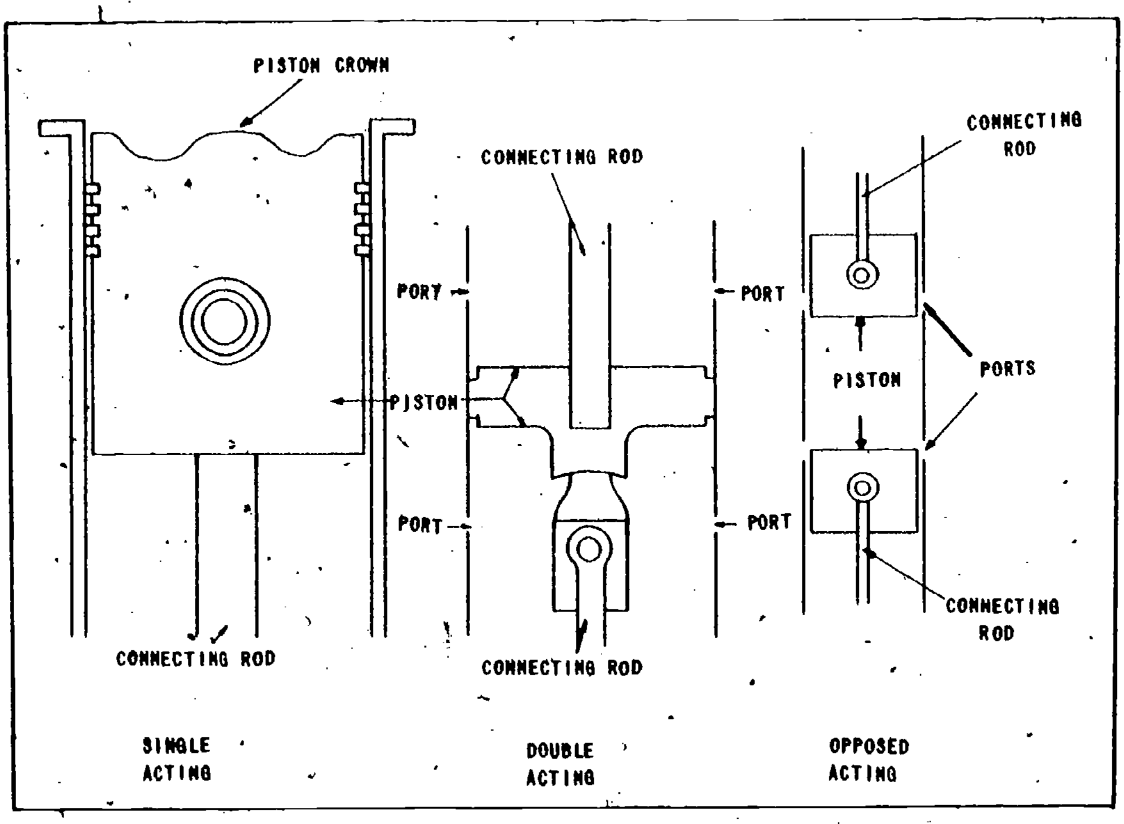


Fig 2-2. Piston actions.

(3) Cylinder arrangement (fig 2-3). -A common engine classification is by cylinder arrangement. An engine with the cylinders one behind the other is classified as an in-line engine. If, when viewed from the end, the cylinders form a V, it is known as a V-engine. Some examples of other arrangements are: the slanted engine and the horizontal engine. Most items of engineer equipment use the in-line or V arrangement.

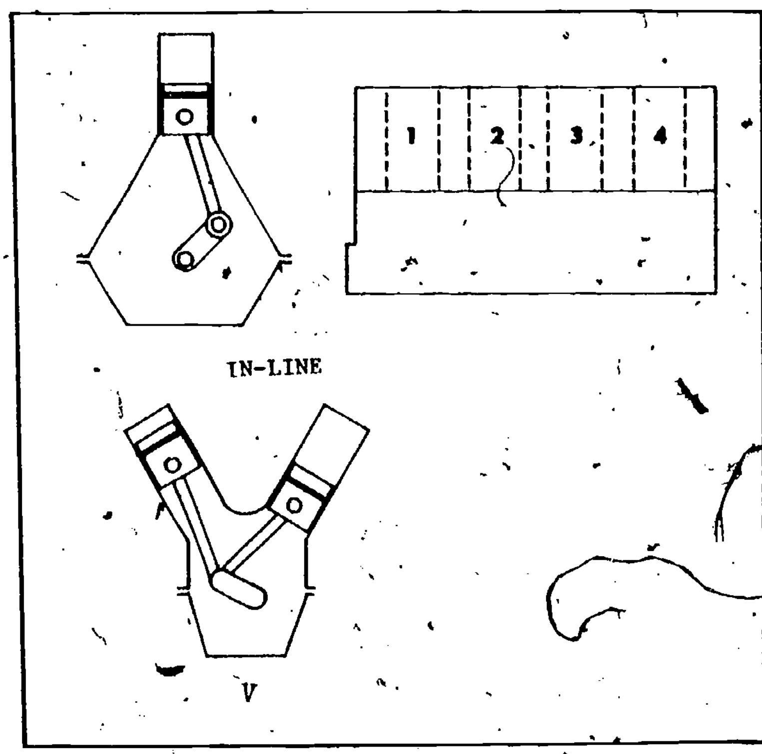


Fig 2-3. In-line and V-engine cylinder arrangement.

(4) Methods of fuel injection. Most gasoline engines use a carburetor to meter and mix the fuel and air; however, some engines are being equipped with solid injection systems. Diesel engines use air injection or solid (mechanical) injection. Marine Corps engineer equipment engines use either the carburetor or solid injection method.

(5) Speed. Engines are classified as low, medium, or high speed. Maximum governed speeds below 350 rpm are low speed; between 350 and 1250 rpm are medium speed; above 1250 rpm are high speed. Marine Corps engineer equipment engines are in the medium- and high-speed classes.

(6) Application. Engines are classified according to their application. An engine used to propel a vehicle is classified as an automotive engine. An engine used to power stationary type equipment such as a generator is classified as an industrial type engine. An engine used to power a boat is classified as a marine engine.

2-2. INTERNAL-COMBUSTION ENGINES

a. Construction. Engine components and parts are produced from a variety of materials. Each material, or combination of materials, is selected to provide the desired qualities for a particular engine. The materials selected must be workable, durable, and economical; they must provide strength and stiffness, and resist wear, corrosion, and heat expansion. These materials are cast (molded) or forged into shape and machined as needed. Some parts or portions of a part are specially treated to increase resistance to wear, heat, and shock. For example, the crankshaft is forged and machined, and then the bearing surfaces are heat-treated to increase life. Piston rings are cast or forged and machined, and some are chrome plated to increase their useful life. Regardless of the type of material used or the size and shape of the finished product, it must be durable and economical. These parts fall into natural groups: structural (stationary) parts, major moving parts, arrangements and systems, and accessories.

(1) Structural parts (fig 2-4). The structural parts support and keep the moving parts alined; provide passages, jackets and chambers; support accessories; and resist forces set up by engine operation. The major structural parts are the engine block, head, and cylinders. The cylinders are sometimes cast as part of the engine block.

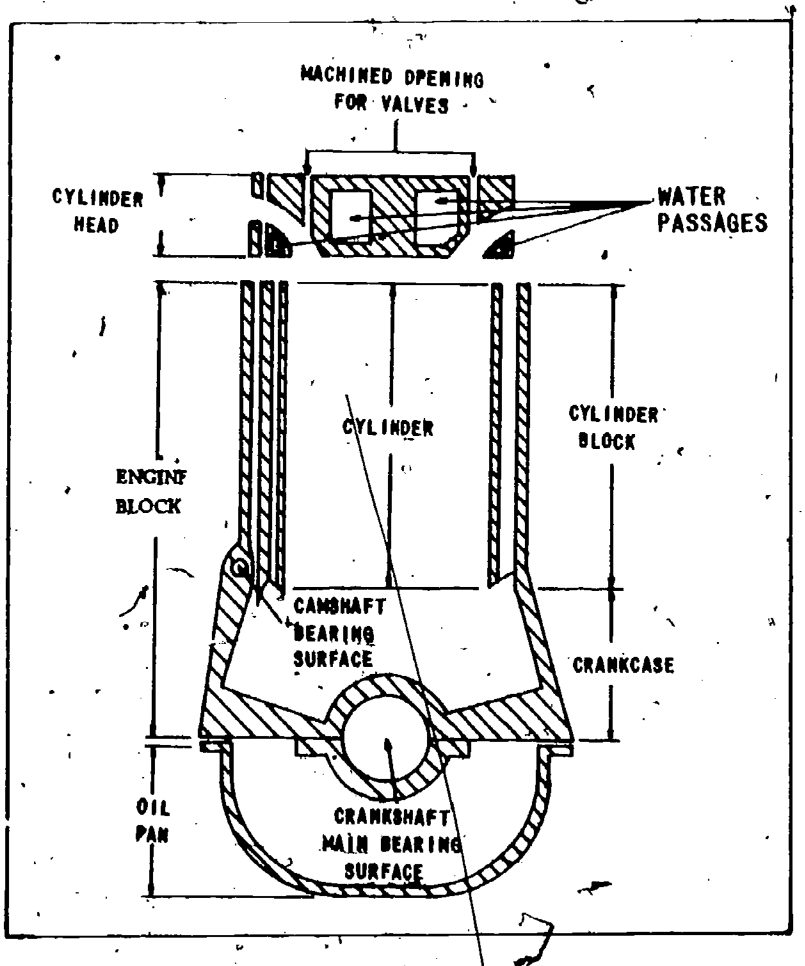


Fig 2-4. Structural engine parts.

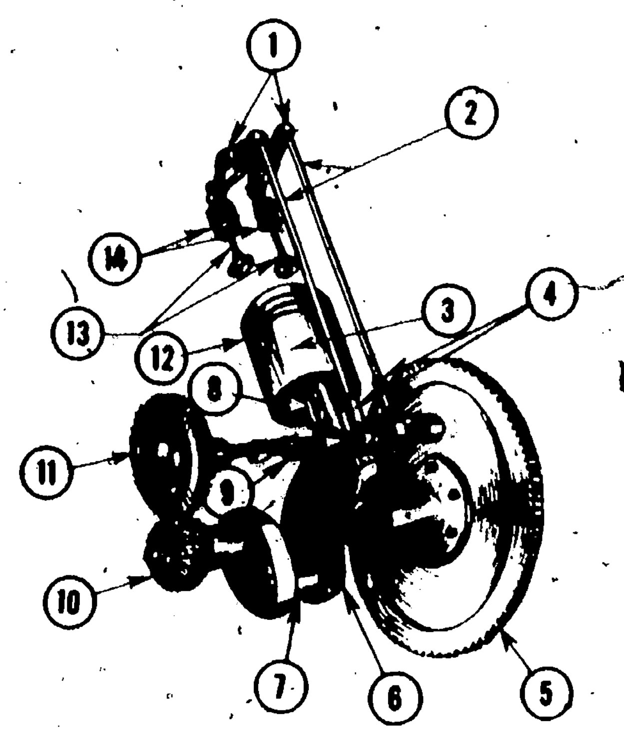
(a) Engine block. The main body of the engine is the block which is composed of the cylinder block and the crankcase. The engine block may be constructed in one or more pieces, but most military engineer equipment uses the 1-piece type. It is cast in one piece with passages for water, air, and oil. The materials are usually cast-iron alloy, aluminum alloy, or steel. The surfaces for attaching crankshaft, camshaft, head, and other parts are machined, and some of the machined areas are specially treated. The upper portion, the area where the cylinders are located, is called the cylinder block. The cylinder bores provide chambers for burning fuel and to keep the pistons alined. They are either cast and machined as a part of the cylinder block, or the cylinder block is cast and machined to receive wet- or dry-type cylinder liners (sleeves). They must resist wear and be able to withstand high temperatures and pressures. The cylinders are surrounded by passages for liquid coolant or by fins for the air to cool. They are lubricated to reduce the friction between the cylinder wall and the piston and rings. The cylinders that are cast in the block and the wet-type liners are in direct contact with the liquid coolant; the dry-type liner is pressed into a bore that is surrounded by the coolant. Oil passages are cast, drilled, or attached to the engine block to direct the flow of oil for engine lubrication. The lower portion of the engine block is the crankcase which supports the crankshaft and other parts.

The many passages which are cast, drilled, or machined in the engine block have openings which are sealed with gaskets, plugs, and seals. The systems that operate within the engine are designed to operate separately; any leakage because of worn or broken parts will cause engine failure.

(b) Oil pan. Engines are provided with a cover for the lower portion of the crankcase; most engines also utilize this cover for an oil reservoir or sump called an oil pan. However, some manufacturers cast the crankcase and oil reservoir of small engines as one piece and refer to it as the crankcase or base. The oil pan is cast, forged, stamped, or fabricated from a material that will keep out foreign matter and satisfactorily perform the job for which it was designed.

(c) Cylinder head. The cylinder head is cast and machined from materials similar to those used for the engine block. It seals the upper end of the cylinder and supports the moving parts. Coolant and lubricant passages are cast or drilled in the cylinder head. These passages match the passages in the engine block and allow the coolant and oil to flow without restriction. Although there are many passages, ports, and moving parts on or in the cylinder head, its primary purpose is to seal one end of the cylinder bore and form the combustion chamber. It must withstand high temperatures and pressure, and resist warping.

(2) Moving parts (fig 2-5). Of the many moving parts within and on an engine, only the major parts and the parts that will assist in illustrating basic principles will be discussed.



1. Rocker arms	8. Connecting rod
2. Push rods	9. Camshaft
3. Piston	10. Crankshaft gear
4. Valve lifters	11. Camshaft gear
5. Flywheel	12. Piston rings
6. Crankshaft	13. Valves
7. Con. rod bearing surface (Crankarm) (Throw)	14. Valve springs

Fig 2-5. Moving parts of an engine.

(a) Piston (fig 2-6). This is a movable part located in the cylinder bore which transmits the forces of combustion. The piston is cast from different alloys, treated to resist wear and heat, and machined to fit the cylinder bore and to receive other parts. The shape of the piston crown depends upon engine design. The primary functions of a piston are to transmit the forces of combustion and to prevent the escape of expanding gases from the combustion chamber. Rings are fitted in the ring grooves machined on the piston to help seal the chamber, transfer the excess heat to the cylinder wall, and to scrape excess oil from the cylinder wall. A hole machined through the side of the piston provides a point for attaching the connecting rod.

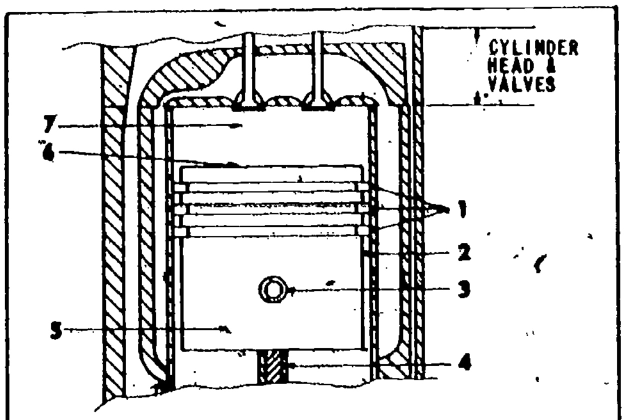


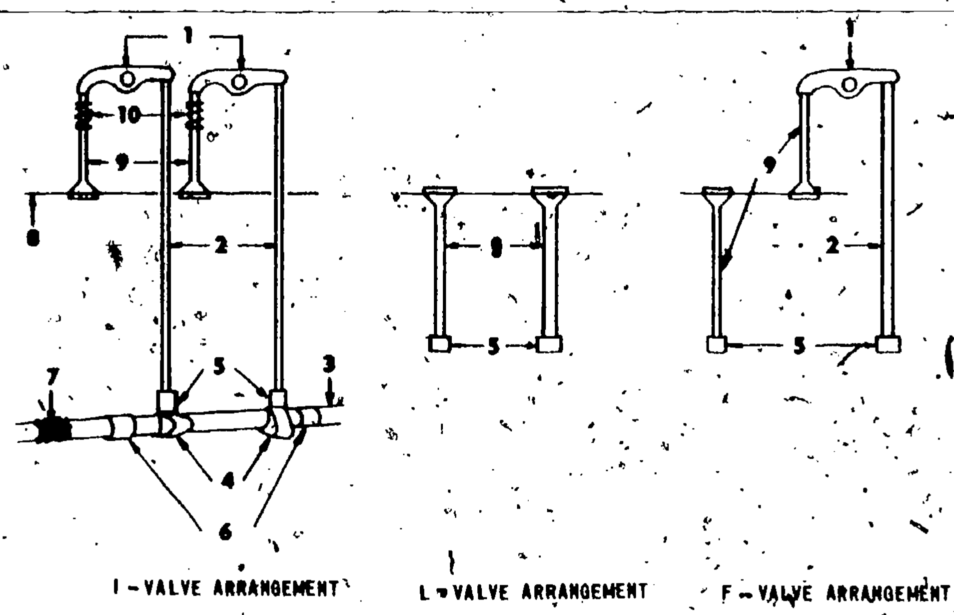
Fig 2-6. Piston and combustion chamber.

(b) Connecting rod and crankshaft. The connecting rod and crankshaft convert reciprocating (up-and-down) motion into rotary motion. A strong forged and machined bar called the connecting rod is attached to the piston by a wristpin (piston pin). It transmits the up-and-down motion of the piston the crankshaft and performs the first step in converting the reciprocating motion to usable rotary motion. The connecting rod is usually made of forged alloy steel with machined bearing surfaces at each end; the crankshaft end is usually split for easy removal and installation. Some connecting rods have a drilled oil passage from one end to the other. The crankshaft which is forged from alloy steels completes the conversion of reciprocating motion to rotary motion. It is treated to withstand shock and torsional (twisting) forces, and the bearing surfaces (journals) are hardened to resist wear. The crankshaft is attached to the lower side of the engine block at the main bearing journals which keep it in place and alined. The connecting rod is attached to the crankarm (crankpin). Forces transmitted to the crankshaft at this point cause it to revolve. Some crankshafts have an oil passage drilled from the main bearing journal to the connecting rod bearing journal. Attached to the crankshaft is a gear or other part which drives other engine or vehicle components. When the piston is forced down, the crankshaft must revolve, and when the crankshaft turns, the piston must move up or down.

(c) Flywheel. Bolted to the rear of the crankshaft is the flywheel, a wheel, disk, or heavy part that will provide inertia to turn the crankshaft and other parts when there is no power being applied by the piston. The flywheel tends to smooth engine operation and in some applications it is used as a clutch face. A ring gear is pressed on to some flywheels to aid in starting the engine; a starter pinion engages the gear and turns the engine for cranking. In some power generators, the generator armature serves as the flywheel. The weight of the moving parts and the weight and diameter of the flywheel affect acceleration, deceleration, and maximum rpm of an engine.

(d) Camshaft and timing gears. The camshaft is a forged, machined, and treated shaft with bearing surfaces and cam lobes. It is supported in the engine block at bearing surfaces and is parallel to the crankshaft. Its primary function is to open the valves. The cam action of the lobes change rotary motion to reciprocating motion. The location of the lobes controls valve opening. The size and angle of the lobes determine how long the valve will remain open. The camshaft is turned by gears powered by the crankshaft. The number of teeth on the gears determine the crankshaft-camshaft speed ratio; the gears are also machined and marked to insure proper installation and alinement. Some engines use a gear machined on the camshaft to drive the oil pump and/or the distributor. Some have extra cam lobes which operate components of the fuel system.

(e) Valve mechanism (fig 2-7). The valves and other parts of the valve mechanism open and close ports for the intake of air or air-fuel mixture and for removal of the exhaust gases. The valve lifter, which is moved by the camshaft lobe, forces the push rod which forces one end of the rocker arm, which in turn pivots and forces the valve open. As soon as the camshaft relieves the pressure, the valve spring pulls the mushroom poppet valve closed and gravity or spring tension forces the other parts back to their original position. These precision machined valves must be able to withstand the effects of extreme temperature of combustion and resist wear. The valve mechanisms of some engines do not require all the parts discussed here, but they perform the same basic job of opening and closing the ports to the combustion chamber. The valve arrangement will differ with the different makes and models, but the three basic arrangements are: (1) Valve in head, overhead, or I-arrangement, (2) valve in block, flat head, or L-arrangement, (3) one valve in head and one valve in block or F-arrangement. Some 2-stroke-cycle engines use the piston to open and close ports in the cylinder wall and do not have valves.



1. Rocker arm
2. Push rod
3. Camshaft
4. Cams (lobes)
5. Lifter
6. Bearing surface
7. Gear
8. Cylinder head
9. Valves
10. Valve springs

Fig 2-7. Valve arrangements.

b. Principles. There are some principles that apply to all internal-combustion engines; other principles apply only to the 2- or the 4-stroke-cycle engines. All internal-combustion engines must have air and fuel; the air or air-fuel mixture must be compressed and ignited. Something must transmit the power of the expanding gases and the exhaust gases must be removed. Fuel must have oxygen to burn. The most complete burning of fuel occurs when there is 11.2 to 16.3 lb of air mixed with 1 lb of gasoline. Compression, temperature, speed of engine, and the type of fuel determine the most efficient air-fuel ratio. A heated air-fuel mixture will ignite quicker than a cold air-fuel mixture and heat is produced when air is compressed. To insure ignition at a precise time, the air or air-fuel mixture is heated by compression.

(1) Four-stroke cycle (fig 2-8). The 4-stroke cycle refers to the number of times a piston must move from one end of a cylinder to the other to complete a cycle. A stroke is the movement of a piston from one end of a cylinder to the other, as from top to bottom or from bottom to top. A cycle is the chain of events necessary to intake air or air-fuel mixture, to burn and produce the power, and to prepare a cylinder for another cycle. In the 4-stroke-cycle engine, a cycle is completed in two down and two up

strokes of a piston. The sequence is: an intake stroke, a compression stroke, ignition of a fuel, power stroke, and exhaust stroke. The major events and how they occur are described below.

(a) Intake. The intake stroke begins when the piston starts down and the intake valve is opened. As the piston moves down, the pressure is lowered in the combustion chamber and the atmospheric pressure forces a charge of air or air-fuel mixture through the intake ports and into the cylinder. The crankshaft will turn 180° and pull the piston through the intake stroke. The camshaft will turn 90° and relieve the pressure and allow the intake valve to close. The speed of the downward movement of the piston and resistance to the flow of air will affect the volume of air that fills the space vacated by the piston. The air or air-fuel mixture that does enter the cylinder is trapped when the intake valve closes.

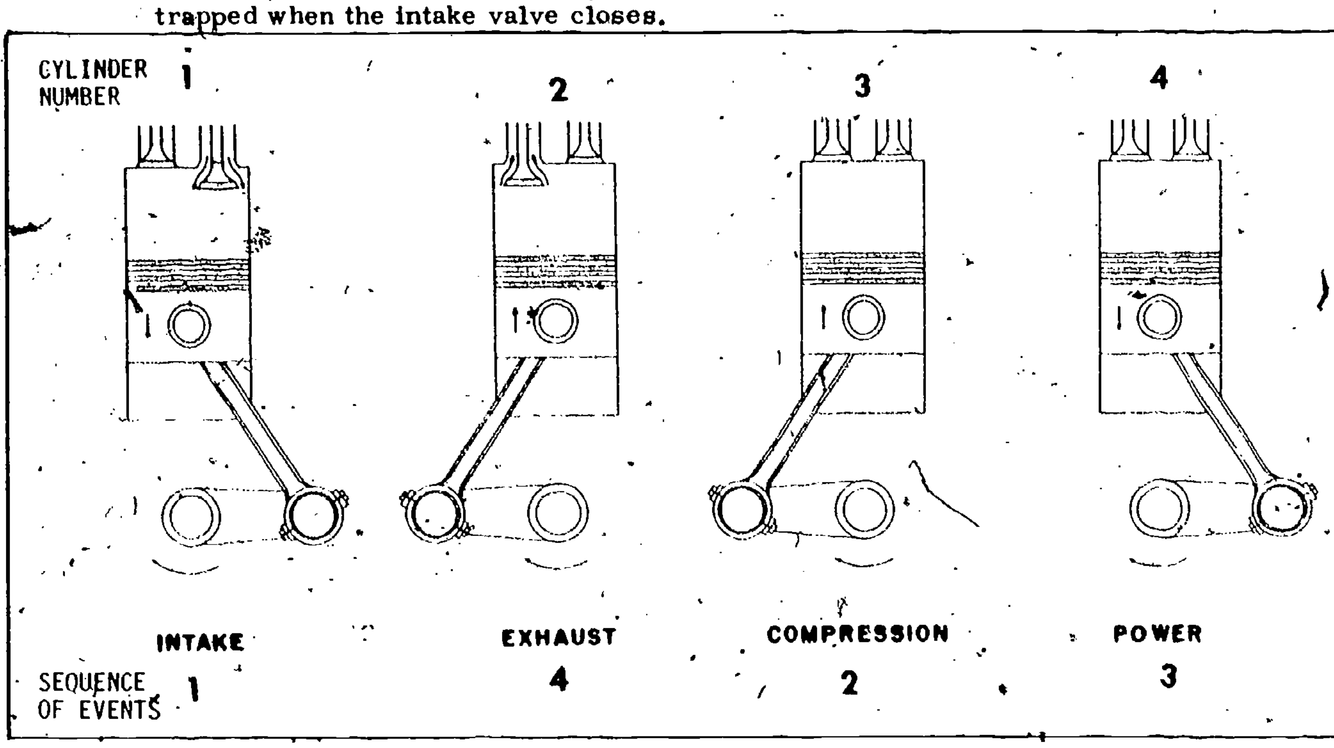


Fig 2-8. Four-stroke-cycle of a 4-cylinder engine.

(b) Compression. If you study figure 2-8 closely, you will note that in multicylinder engines, while one cylinder is on the intake stroke, the other cylinders are performing a different stroke. With both valves closed and the piston moving up, the air or air-fuel mixture is compressed. When the piston was at the bottom of the intake stroke the cylinder had a maximum volume. It is now being compressed to the smallest volume; the ratio of the maximum volume to the least volume is called compression ratio. The compression ratio of an engine determines the type of fuel that can be used most economically; it also determines how the fuel will be ignited. (You learned earlier that a hot mixture is easier to ignite than a cold mixture.) The compression stroke is completed when the piston has reached the top and the mixture is ignited. Ignition can be by an electric spark or by heat of compression. The crankshaft has now turned one full revolution, but the camshaft has only turned 180°. When the piston is at the top on the compression stroke, it is referred to as "top dead center" (TDC).

(c) Power. The power stroke is the only movement of the piston that produces power in a 4-stroke-cycle engine. It begins when the mixture is ignited and expansion of the burning fuel forces the piston down. The mixture burns rapidly, but it does not explode. The mixture continues to burn until all of the fuel or oxygen is used or until the piston reaches its limit and the excess mixture and exhaust gases are allowed to escape through the exhaust port that opens just before the piston reaches the bottom of the stroke. You can see now that the air-fuel ratio and the opening and closing of valves is very important. If the intake valve closes too soon or too late, there will be insufficient mixture. If the mixture is improper, there will be a shortage of fuel or oxygen, and if the exhaust valve opens too soon, you will loose some of the power-producing gases. It should be evident that the crankshaft will turn 180°, 1/2 revolution, for each stroke of the 4-stroke-cycle engine. For the valves to open and close at the proper time, the camshaft must turn in relation to the crankshaft. The lobes are positioned on the camshaft in a manner that will force the proper valve open at the proper time if the camshaft turns at 1/2 the crankshaft speed: the crankshaft turns two revolutions while the camshaft turns one revolution to complete a cycle.

(d) Exhaust. The exhaust stroke starts when the piston starts its upward movement with the exhaust valve open. The piston forces the burned gases through the exhaust port; the velocity of the exhaust is such that when the intake valve opens, a small portion of the air or air-fuel mixture that enters the cylinder escapes through the exhaust. The intake valve opens just prior to the end of the exhaust stroke and the mixture that escapes cleans the remaining exhaust from the cylinder. When the exhaust valve closes, the crankshaft has completed two full revolutions and the camshaft has turned only one revolution. The cycle has been completed and the intake valve is open and ready to start a new cycle.

(2) Two-stroke cycle. The basic principles stated in paragraph 2-2b also apply to the 2-stroke-cycle engine; however, the chain of events is completed in one up and one down movement of the piston. The 2-stroke cycle can best be understood by comparing it to the 4-stroke cycle and explaining the scavenging system.

(a) Comparison (fig 2-9). On the 4-stroke-cycle engine, mushroom-type poppet valves are used to open and close intake and exhaust ports. On a 2-stroke-cycle engine, the valves may or may not be used, but for simplicity, intake ports and exhaust valves are used here to describe the cycles below.

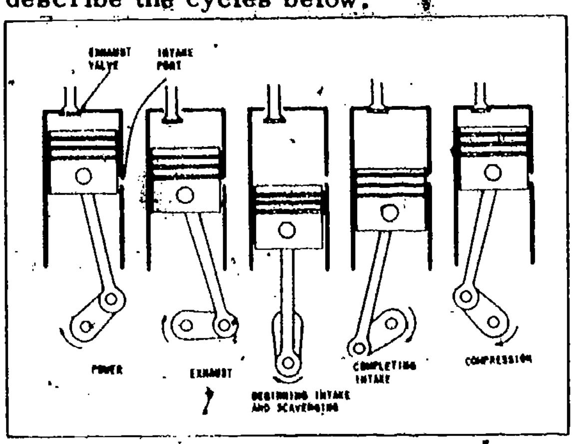


Fig 2-9. Two-stroke cycle.

1. Down stroke. When the piston starts its down stroke, it is on the power event; fuel is burning and producing power. As the piston travels farther down, the exhaust valve opens and allows the exhaust gases to escape. It continues to travel down and opens the intake ports. The air or air-fuel mixture has been pressurized by another system and is forced through the open ports. The pressurized air or air-fuel mixture forces the remaining exhaust out before the valve closes. The piston then completes its downward movement. The crankshaft and the camshaft have turned 1/2 revolution and the piston has completed power and exhaust.

2. Up stroke. The pressure through the intake ports forces the exhaust gases up and out. The exhaust valve closes and the pressurized air or air-fuel mixture fills the cylinder before the piston closes the ports. The upward movement of the piston now starts the compression; both the exhaust valve and the intake port are closed and the piston compresses the trapped mixture. The piston continues to move to the top where the mixture is ignited and the expanding gases force the piston down, starting a new chain of events. The crankshaft and the camshaft have completed one full revolution.

(b) Scavenging. In the 2-stroke cycle, the piston is traveling in the wrong direction to be of any assistance during the intake and exhaust events. This makes it necessary to have some other component to assist these operations. Most engineer-equipment engines use a blower to pump the air or air-fuel mixture into the cylinder under pressure. The pressurized charge through the intake ports flushes all of the exhaust gases from the cylinder and provides a fresh charge for the next cycle of events. On some engines the intake air is directed through the crankcase and the lower part of the piston acts as a pump to pressurize the mixture and force it through the intake ports. The ports are specially drilled and machined to insure the proper time of opening and to direct the flow of air into the cylinder in such a manner that it will sweep out the exhaust and continue a swirling motion to mix the air-fuel mixture. The direction of the air is very important in 2-stroke-cycle engines that use both an intake and an exhaust port; they are located along the cylinder wall and the removal of the exhaust from the upper portion of the cylinder is difficult.

(c) Summary. The same basic principles have again been used to produce the power desired. While the 4-stroke-cycle engine uses two up and two down piston movements, two crankshaft and one camshaft revolution, the 2-stroke-cycle engine uses only one up and one down movement of the piston, one crankshaft and camshaft revolution to complete the cycle of events for all cylinders. The 2-stroke-cycle engine produces a power stroke with each down stroke of each piston, while the 4-stroke-cycle engine produces only one power stroke out of two down strokes. The two engines may operate on different cycles, but the basic principles have remained the same. They both produce power by burning a combustible mixture within a closed chamber to produce heat energy that is converted to mechanical energy.

Section II. GASOLINE AND DIESEL ENGINES

2-3. GASOLINE ENGINE SYSTEMS

An engine must have a method of dissipating excess heat, a method of lubricating the moving parts, a method of getting fuel and air into the combustion chamber, and a method of igniting the fuel-air mixture. Each manufacturer uses the systems that he thinks are best for a particular application.

a. Fuel system (fig 2-10). In the gasoline engine, the fuel is mixed with the air before it enters the combustion chamber.

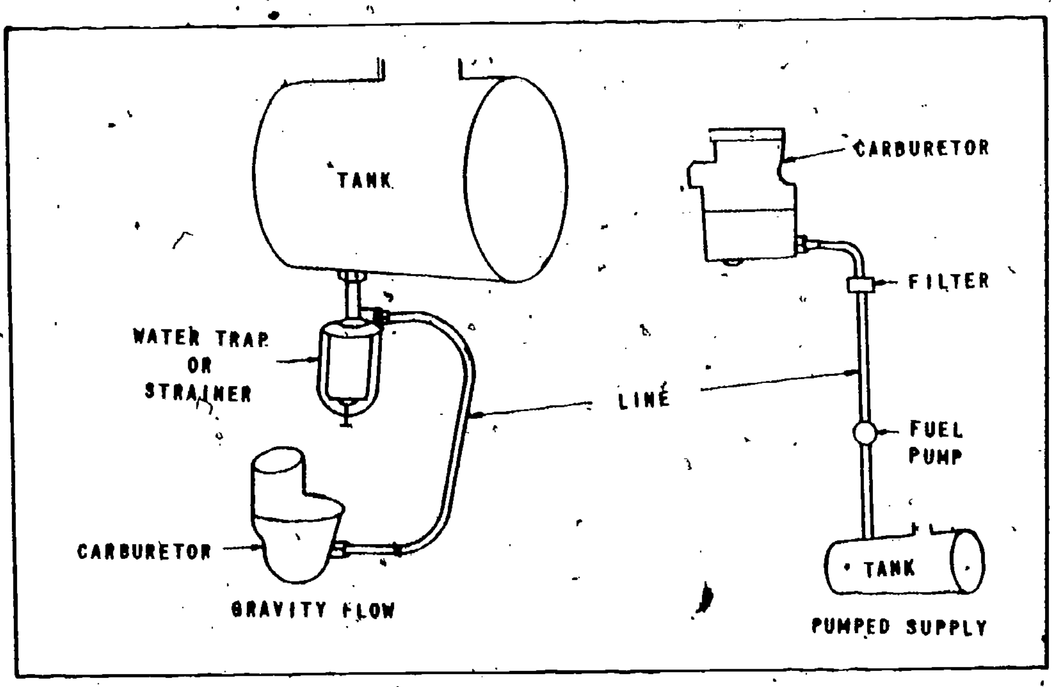


Fig 2-10. Schematic of the gasoline fuel systems.

(1) Fuel tank and lines. A tank made of a corrosion-resistant metal is mounted on the engine or the vehicle. The tank contains baffle plates to prevent excessive sloshing of the gasoline. Some fuel tanks are equipped with a fuel gage to indicate the amount of fuel in the tank at any given time. Fuel is carried from the tank to the carburetor through metal tubes. In areas where vibration would damage metal tubing, a flexible hose is used.

(2) Fuel filters and strainers. An engine may be equipped with a fuel strainer or a fuel filter or with both. The fuel strainer, when used, is normally installed between the fuel tank and the fuel pump. A fuel filter is usually installed between the fuel pump and the carburetor (fig 2-10).

(3) Fuel pump (fig 2-11). If the fuel supply tank is too low for the fuel to flow by gravity with sufficient pressure to the carburetor, a fuel pump is used to draw the fuel from the tank and force it into the carburetor. Fuel pumps are classified as positive and non-positive diaphragm. The positive-type pump continues to pump fuel even when not needed; the nonpostive type pump will fill the carburetor bowl and stop when a specific pressure is reached. Most gasoline engines are equipped with the nonpositive diaphragm-type pump. A lever on the pump is in contact with a cam surface (cam lobe) on the camshaft. As the lever rides up and down on the cam, it pushes a diaphragm in the pump up and down. The diaphragm functions similar to the piston in the engine cylinder. When the diaphragm is down, the fuel forces a 1-way valve off its seat and fills the chamber. When the lever is released and the diaphragm is forced up by a spring, the inlet valve is forced closed and another 1-way valve allows the fuel to be forced out into the carburetor fuel line. When the pressure builds up in the line to the carburetor, the valve will remain seated and the fuel in the fuel pump chamber will hold the diaphragm to keep it from pumping more fuel. The cam and lever cause the diaphragm to draw fuel in and spring tension forces the fuel out under pressure.

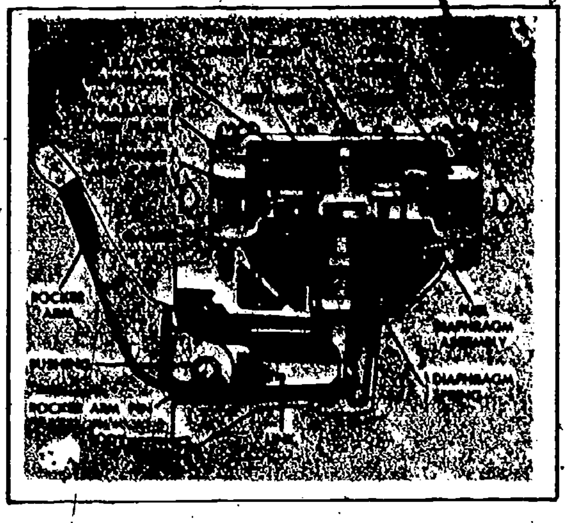


Fig 2-11. Nonpositive diaphragm fuel pump, sectional view.

(4) Carburetor (fig 2-12). Flow of fuel entering a gasoline engine must be metered to control engine speed and to obtain efficient operation. The fuel must also be mixed in proportion with the air to insure complete combustion. Metering and mixing are performed in the carburetor. There are circuits (passages) in a carburetor that function to vary the air-fuel ratio. These circuits are: float, low-speed, high-speed, accelerating pump, and choke. Engines used in engineer equipment may not have the accelerating circuit in the carburetor. Such engines are run at a continuous speed and do not need the extra fuel for accelerating. Fuel flows through the needle valve into the float chamber where it is controlled by the float circuit. As the fuel level rises in the float chamber, the float rises and forces the needle valve to its seat causing the flow of fuel to stop. The fuel in the chamber will enter the passages and fill them to the float level. These passages open into the venturi or at the throttle valve. The venturi is a partial restriction in the air horn which causes the air flow to speed up and create a partial vacuum. A butterfly valve above or below the venturi will change the action of the air flow. If it resists the flow of air more than the venturi, the velocity of the air will be greatest at that point. If the throttle valve in figure 2-12 was vertical, the flow of air rushing past the air bleed would be sufficient to cause the fuel to be sprayed down; this would be the high-speed circuit. But with the throttle valve closed, the air restriction is below the venturi and the vacuum is created at the throttle valve. The decreased volume of air and the restricted fuel opening will allow sufficient fuel to be sprayed down into the engine for the idling circuit. During cold weather, more fuel is required for cranking. To increase the fuel in the mixture, a choke (butterfly valve) circuit (not shown) is added above the venturi. The vacuum created and the atmospheric pressure through the float chamber forces the fuel out into the venturi and through to the engine. By restricting the fuel passages to the air stream you can change the amount of fuel that will be mixed with the air. A restriction in the air stream or any leaks between the carburetor and the combustion chamber will also affect the air-fuel ratio.

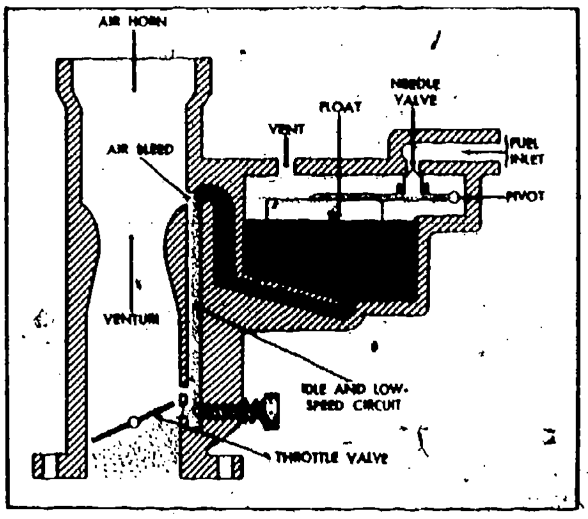


Fig 2-12. Carburetor schematic.

b. Intake and exhaust system. The fuel that entered the air stream was sprayed (atomized) and mixed with the air and forced into the intake manifold. If the engine operates on the 2-stroke cycle, the mixture enters the crankcase where it is pressurized and forced through the ports. In the 4-stroke-cycle engines, the air-fuel mixture is partially vaporized as it enters the combustion chamber through the intake valve port. The engine heat absorbed by the intake manifold aids vaporization. On some engines the exhaust is in contact with the intake manifold to increase the temperature more rapidly and aid vaporization.

c. Ignition system. A spark-ignition system provides a method of using electrical energy to ignite the air-fuel mixture in the combustion chamber. An engine may be equipped with either a battery and distributor-type ignition or with a magneto ignition. They are basically the same; they step up low voltage to a high voltage and distribute the voltage to a spark plug at the proper time.

(1) Battery ignition (fig 2-13). A primary (low) voltage from the electrical energy produced by a battery or generator produces a secondary (high) voltage and is distributed to the proper spark plug for igniting the air-fuel mixture in the combustion chamber.

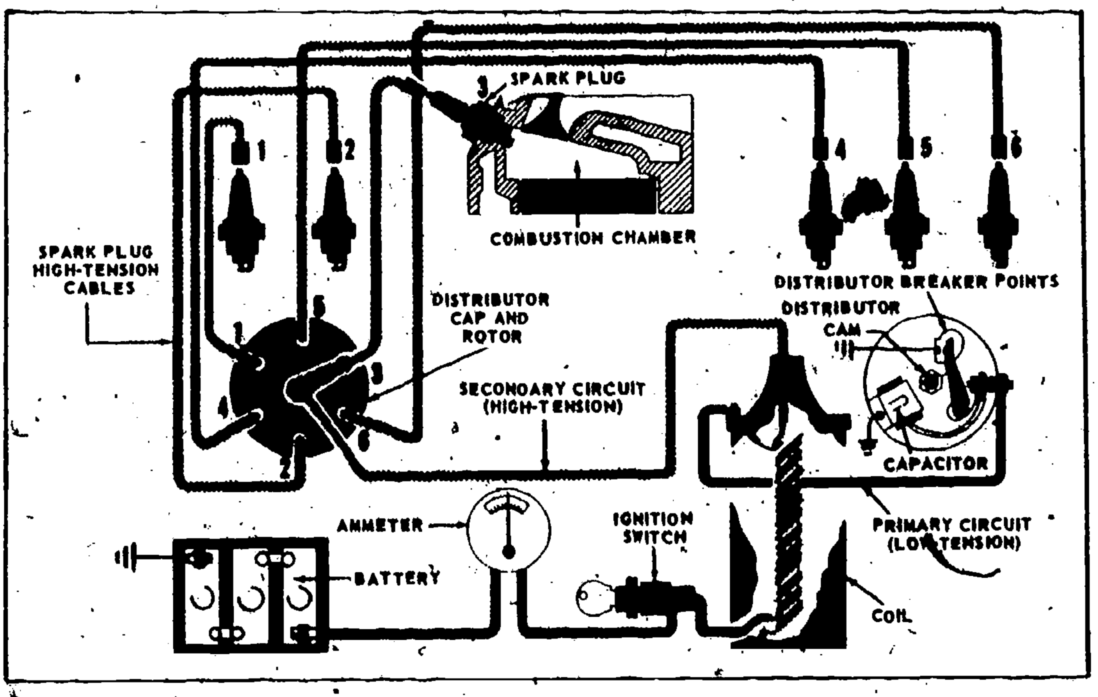


Fig 2-13. Schematic wiring circuits of a battery ignition system.

(a) Principles. The low voltage of the primary circuit is too weak to force an arc across the air gap of a spark plug for ignition, therefore a transformer (ignition coil) is used to step up the low (battery or generator) voltage to a much higher value (15,000 to 20,000 volts) in the secondary circuit. The ignition coil operates on the principle of self-induction; a magnetic field is caused to move across a conductor inducing current in the conductor. A magnetic field produced by an electromagnet will move if the current through the electromagnet is turned on and off. When the circuit is complete (turned on), current will flow through the windings and create a magnetic field; as the field builds up, it crosses another conductor and causes current to flow. When the circuit is opened (turned off), the magnetic field will collapse and move across the conductors again causing more current to flow and creating a high secondary voltage.

(b) Components and function. Current flows through the conductors, ammeter, and ignition switch to the primary windings of the ignition coil. It flows through the windings to the distributor breaker points and to ground (back to source). Attached to the battery side of the points is a capacitor (condenser). Movement of the magnetic field across the windings produces an opposing voltage which, if left uncontrolled, would arc across the points. The capacitor absorbs this voltage and prevents arcing. The high voltage of the secondary circuit flows from the coil through high-tension cables to the distributor cap. Attached to the cap is a high-tension cable for each spark plug. When the rotor is alined with the cable, the high voltage will flow to the spark plug and jump the air gap to ground and back to its source, the coil. The distributor and its parts make and break the circuit and aline the rotor with the correct spark plug (high-tension) lead at the proper time. It is turned by the engine camshaft or other gears. A cam surface on the distributor shaft forces the points open to break the primary circuit; the points close by spring tension. The rotor is attached to the distributor shaft and turns to the correct spark plug lead.

(2) Magneto ignition (fig 2-14). Except for the spark plugs and the high-tension leads to them, the magneto is a self-contained unit. It provides the current for the primary circuit and steps up the voltage for the secondary circuit. It has its own generator and other components which function the same as similar components of the battery ignition system. During cranking and at low engine rpm, the magneto does not turn fast enough to generate primary voltage. To increase the magneto rpm without affecting the ignition timing, an impulse coupling is installed between the engine drive gear and the magneto. The impulse coupling consists of a spring and ratchet drive. As the engine is cranked, the spring is wound tightly and at the proper time the tension is released and the magneto shaft is turned with sufficient speed by spring tension to produce a spark in the combustion chamber. The impulse coupling will lock out at approximately 300 rpm and turn continuously at engine speed.

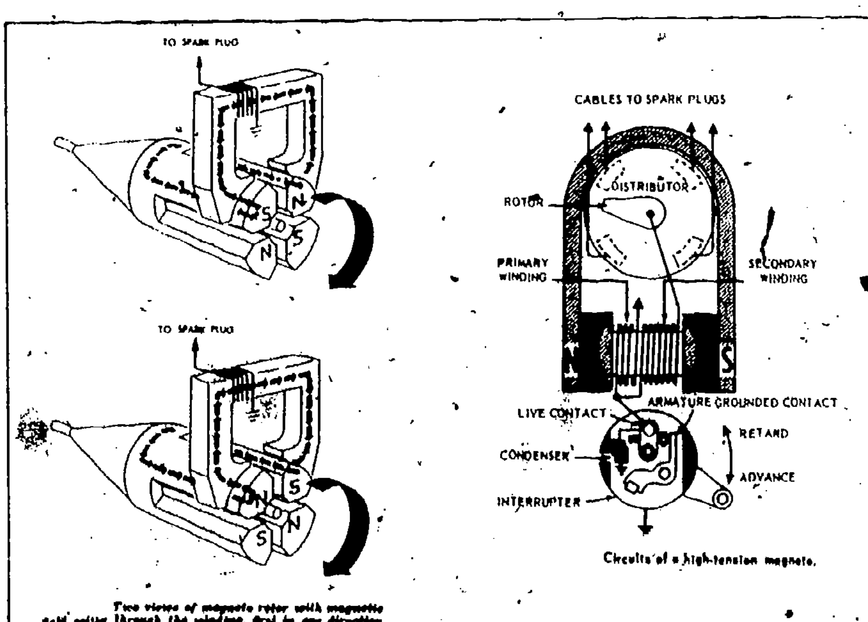


Fig 2-14. Schematic diagrams of a magneto.

d. Lubricating system (fig 2-15). The primary function of a lubricant is to reduce friction. In an engine there are several moving parts that create friction. Heat caused by friction can cause great damage to an engine. The lubrication system reduces friction by forcing or splashing lubricant between the moving parts, preventing metal-to-metal contact. The lubricant also acts as a sealer between the moving parts and helps clean the engine parts. As the lubricant flows through the engine it carries foreign matter with it and absorbs some of the engine heat. There are three types of lubricating systems: splash and force-feed, force-feed, and full force-feed (fig 2-15). The force-feed and full force-feed are used in most engines. Larger engineer equipment engines use the full force-feed system, where the oil is forced through the system by a gear or rotary-type pump. These are positive-displacement pumps with a pressure relief valve. They draw the oil from the oil pan sump and force it into an oil gallery (passage, main oil line) where it is directed to the engine parts and components through drilled passages. On some engines the oil passes through a filter before entering the oil gallery; other engines filter a portion of the oil that enters the oil gallery. After the oil has performed its function, it drains back to the oil pan. Air circulating through the crankcase cools the oil as it returns to the pan. The oil-pressure gage is usually attached to the oil gallery and indicates the pressure within the system. A satisfactory reading on the gage does not insure that the engine parts are being lubricated. A restriction between the oil gallery and the moving parts will stop the flow of oil but still maintain the oil pressure in the gallery.

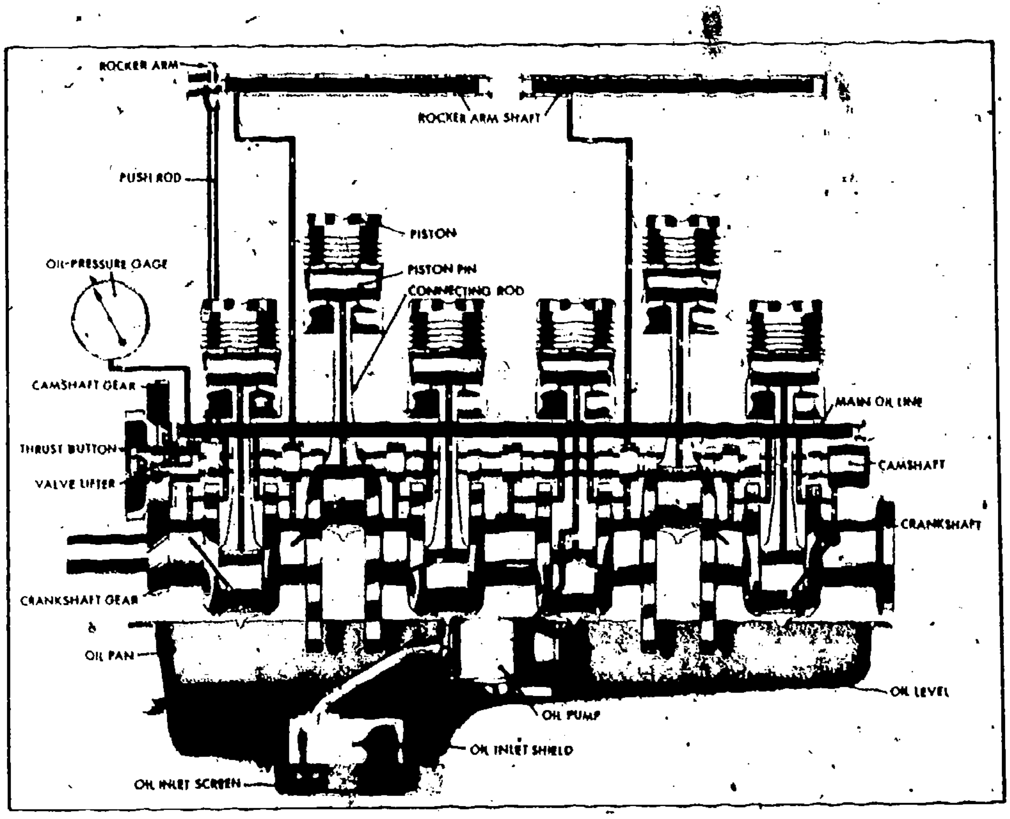
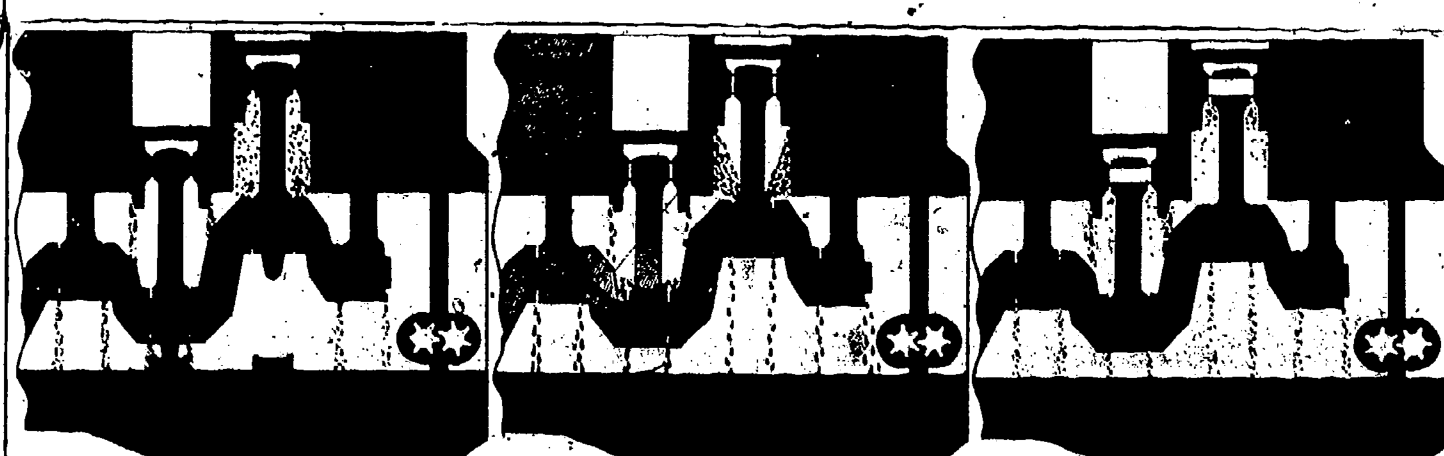


Fig 2-15. Typical full force-feed lubrication system without an oil filter.



A.—Combination splash and force-feed lubrication system.

B.—Diagram of a force-feed lubrication system.

C.—Full force-feed lubrication system.

Fig 2-16. Schematic of lubrication systems.

e. Cooling system. Although some heat is desired for better engine operation, the extreme temperatures of combustion are sufficient to damage the metals used for engine construction and therefore must be dissipated. An engine can be cooled by liquid or air.

(1) Liquid-cooled. In the liquid-cooled sytems, water is circulated through the system and cooled by air flowing between the radiator tubes and fins. Figure 2-17 shows how the liquid is circulated through the engine An impeller-type, temperature-sensitive pump circulates the liquid through the cylinder block and radiator. The thermostat, a unit that functions automatically, controls the flow of liquid. If the engine is cold, the thermostat will keep the liquid from flowing through the radiator and dissipating the heat; this allows faster warmup. If the thermostat is open, the liquid passes on to the top (inlet part) tank of the radiator and dissipates the heat into the air stream as it flows through the radiator core. When the thermostat is closed, the water is circulated through the cylinder block, bypass hose, pump, and back through the block. The thermostat is designed to start opening at a specified temperature, usually 160° F, and to be fully open at the operating temperature. The most efficient operating temperature is just over 212° F, coolant temperature. To attain the higher temperatures and prevent the water from boiling, some cooling systems are equipped with a radiator pressure cap to raise the boiling point. Marine Corps publications list additives that are authorized to be used in the cooling system to prevent rust, corrosion, and freezing.

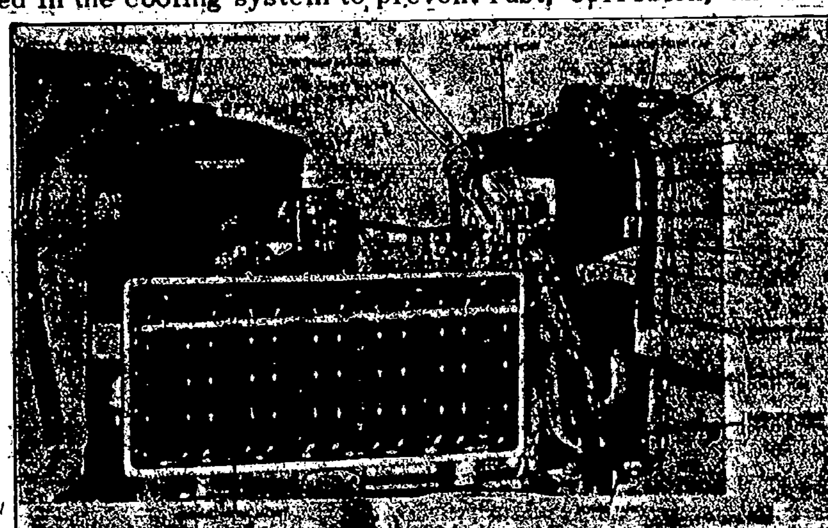


Fig 2-17. Cooling system.

(2) Air-cooled (fig 2-18). In this system the air is directed across the engine parts that require cooling. Some engine cylinder blocks are constructed with fins which provide more area for the air to contact to remove the excess heat. A lightweight metal shield (shroud) usually surrounds these areas and directs the air across the engine. A fan is mounted in an opening of the shield and forces or draws air through the system. A good example of an air-cooled engine is the engine of a small lawnmower.

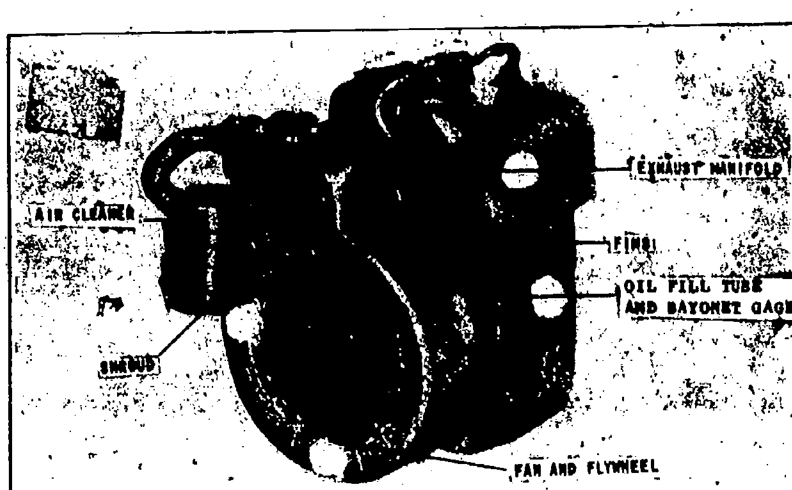


Fig 2-18. Air-cooled engine.

2-4. DIESEL ENGINES

a. Comparison to gasoline engine. Gasoline and diesel engines are internal-combustion engines and the principles of operation apply to both. The basic difference is the method of supply and ignition of fuel. In a diesel engine, air enters the combustion chamber and is compressed before the fuel is injected and mixed with the air. The fuel is ignited by the heat of compression. Because diesel fuel can be used to produce power more economically than most other fuels, the diesel engine is replacing gasoline and steam engines in many applications. Gasoline is much more volatile than diesel fuel. It burns so rapidly that the full effects of the expanding gas cannot be utilized. For example, an air-fuel mixture in a gasoline engine cylinder may burn to its maximum during the first half of the power stroke, but the slower burning diesel fuel and the increased volume of air (oxygen) permit the continuous burning of the diesel fuel through most of the power stroke of a diesel engine. Because of the high pressure of compression, it is necessary to construct the diesel engine from stronger materials than those in the gasoline engine. Diesel engines, like gasoline engines, operate on either the 2- or 4-stroke cycle.

b. Basic actions of the diesel engine. On the intake stroke of the diesel engine, a sufficient quantity of air is taken into the cylinder to burn the maximum fuel delivered at full speed. This air is compressed into a small volume (the diesel engine has a higher compression ratio than the gasoline engine). To assist in heating the air and to create turbulence, some engine manufacturers use a precombustion chamber. It is nothing more than a small chamber with a small opening located near the top of the cylinder. As the air is compressed, some is forced through the small opening into the chamber. This increases the temperature of the air by friction. When the piston is traveling in the right direction, and at the proper time, the fuel is injected into the chamber. The heat vaporizes and ignites the fuel spray. The expanding gases are forced out of the precombustion chamber into the cylinder. This creates a turbulence and continues to vaporize and mix the fuel with the air supply. The high temperature of compression ignites the vapor when it mixes with the oxygen in the air. This mixing and burning process continues through most of the power stroke, producing a continuous pressure on the piston. By the time the exhaust valve is opened, the fuel, having had sufficient oxygen, is completely burned.

c. Advantages and disadvantages. The diesel engine has the advantage of being more economical due to more complete burning of the fuel than the gasoline engine, but, to obtain this economy, the diesel engine must be constructed of heavier materials and the parts must be machined precisely to contain the very high compression pressures. Diesel fuel is cheaper and it is also less flammable than gasoline, thus offering a greater degree of safety. However, the diesel fuel has a disadvantage in that it will freeze in extreme cold climates.

d. Detroit diesel engines. The Detroit Diesel Engine Division of General Motors Corporation produces the 2-stroke-cycle diesel engine that is used in the Marine Corps. These engines are used to power anything from a 1/2-ton truck to a locomotive, from a portable arc welder to a small ship. The Marine Corps has many items of engineer equipment with the series 71 Detroit diesel engine. The series 71 engines are 2-stroke-cycle, full-diesel engines with two or more cylinders. They are equipped with a 24-volt electrical system and accessories and are used in power generating and earthmoving equipment and vehicles.

(1) Systems. The cooling system is basically the same as those discussed earlier in this chapter. However, the air intake, fuel, and lubricating systems are slightly different.

(a) Air intake (fig 2-19). The 2-stroke-cycle Detroit diesel engine uses intake ports in the cylinder liners for intake, and the valve-in-head arrangement for exhaust. A blower or a supercharger system is used to force air into the air box (chamber) that surrounds the intake ports. At the time the piston moves down below the intake ports, the exhaust valves have been open long enough for the exhaust gases to escape. The air is forced into the cylinder, creating a unidirectional flow of air toward the exhaust valves, producing a scavenging effect. This leaves the cylinder full of fresh air when the piston again covers the intake ports.

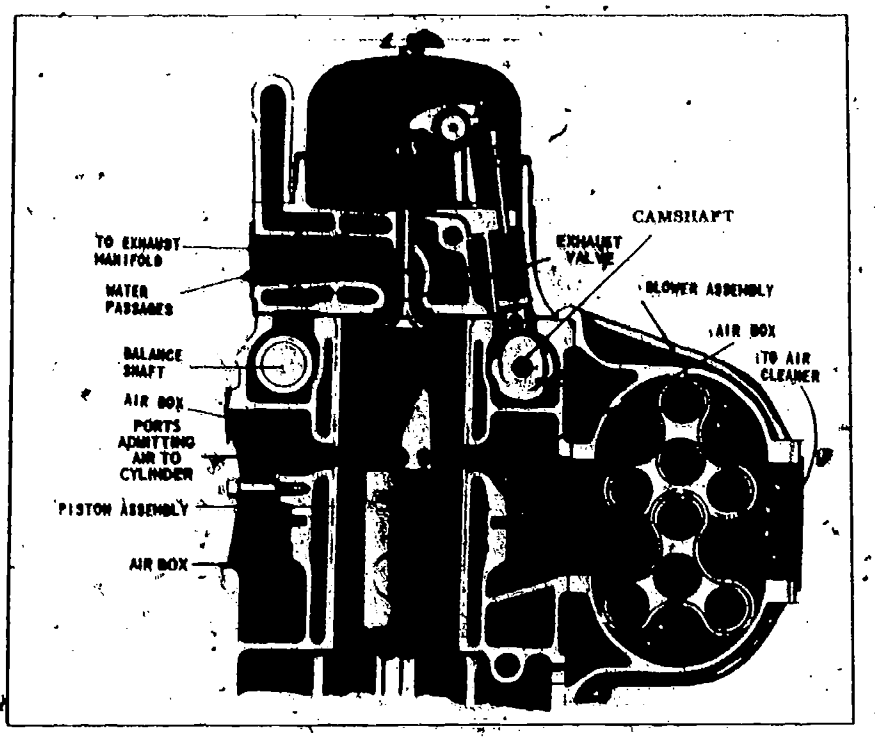
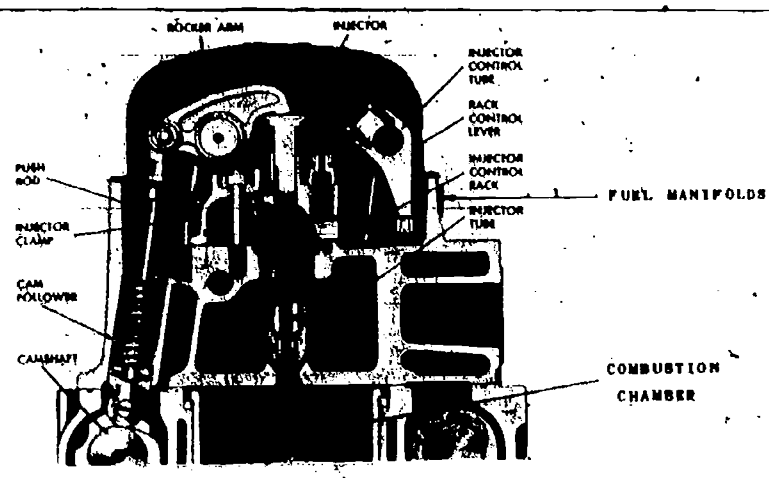


Fig 2-19. Air intake and scavenging system of a 2-stroke-cycle Detroit diesel engine.

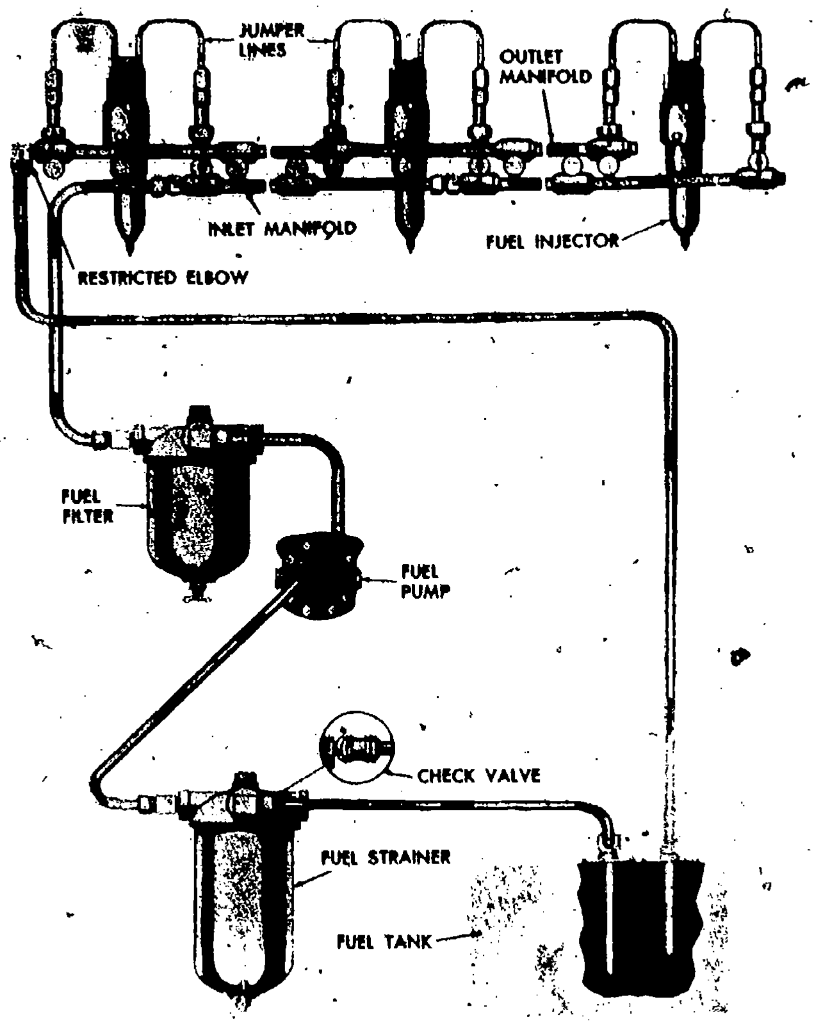
(b) Fuel. The proper charge of fuel must be delivered at the proper time to the correc cylinder to be mixed with air that has been compressed and is hot enough to ignite th fuel. In a Detroit diesel engine this is accomplished by using unit injectors and the solid injection method operated by the camshaft and related parts.

1. Components. The fuel system components and the fuel flow illustrated in figure, 2-20 are typical of the series 71 Detroit diesel engine fuel system and related parts. A fuel supply pump, driven by the blower, draws the fuel from the container (vehicle tank or storage container) through the line and strainer and forces it through the filter to the injectors. A positive displacement gear-type supply pump is used. It provides more fuel than is required for the engine; the surplus fuel flows through the system and cools the fuel system parts. A restricted elbow on the outlet manifold and a pressure relief valve in the pump allow the pump to maintain a 40 to 60 psi pressure on the inlet manifold when the engine is operating at 1,800 rpm. Pressure above the maximum opens the relief valve and allows the fuel to flow back to the inlet side of the fuel supply pump. Fuel enters the injector unit which meters, pressurizes, and sprays it at a controlled rate into the combustion chamber at the proper time. It also atomizes the fuel and distributes it throughout the cylinder. The excess fuel which has been pumped into the injector is returned through the outlet manifold and restricted elbow to the fuel tank.



A

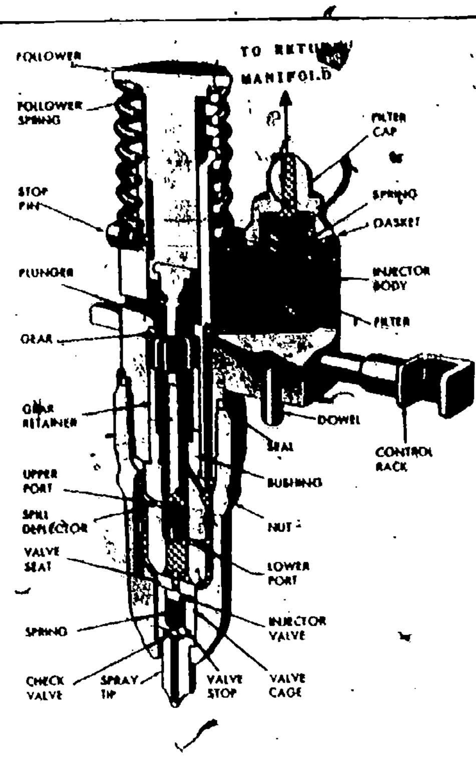
End view cross section of Detroit diesel engine fuel system and related parts.



B

Schematic of fuel system.

Fig 2-20. Detroit diesel engine fuel system.



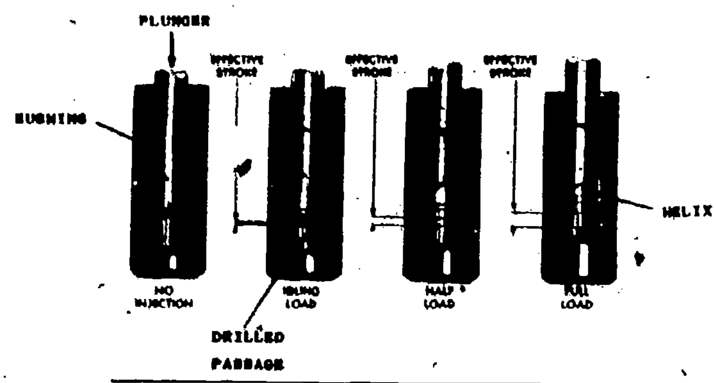
C

Cross section of unit injector

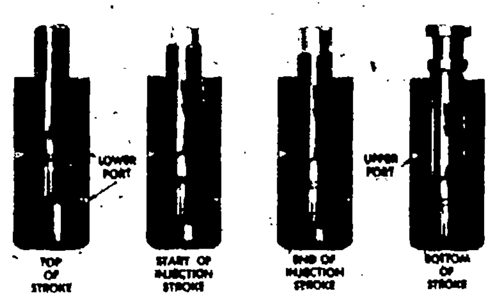
Fig 2-20. Detroit diesel engine fuel system--contd

2. Injector. Injector units (fig 2-20) pressurize, meter, atomize, and provide a continuous flow of fuel for the engine. Any malfunction of this component will cause improper engine operation. The moving parts of the injector are lubricated and partially cooled by the diesel fuel. Only the fuel recommended by the manufacturer should be used in a diesel engine for it will have the required lubricating qualities.

a. Metering (fig 2-21). The amount of fuel that is forced into the cylinder is controlled by a plunger with an upper and lower helix machined on its lower end. Vertical movement of the plunger is caused by a rocker arm; the plunger is rotated by a control rack. Both the vertical stroke and the rotating motion determine the amount of fuel that is sprayed into the cylinder. When the plunger is up, fuel fills the spill deflector and other open spaces surrounding it. The fuel flows through the upper port in the bushing through the helix and through a drilled passage to the area below the plunger. The excess fuel flows on through the lower port in the bushing and back to the supply tank. The rocker arm forces the plunger down and closes the lower port; the upper port remains open depending upon the position of the helix. Because fuel cannot be compressed, it flows back through the drilled passage until the upper port is closed by the plunger. When both ports are closed by the helix, fuel that is trapped in the bushing will be forced into the engine as the plunger moves down. As soon as the lower helix opens the lower port, pressure is relieved and injection is stopped. In figure 2-21, note how the effective stroke of the plunger is controlled by rotating the plunger. Also note the phases of injection operation. (NOTE: The vertical stroke is not changed.) When the rocker arm pressure is released, a spring returns the plunger to the top and a new supply of fuel enters.



Fuel metering.



Phases of injector operation through vertical travel of plunger.

Fig 2-21. Function of injector plunger.

b. Pressurizing. Fuel that is trapped under the plunger must overcome the high pressure of compression. When the inlet and the outlet ports close, the plunger begins to apply pressure on the fuel. An injector valve (fig 2-20) prevents the fuel from leaking until the pressure is greater than the cylinder pressure. The injector valve spring is adjusted to open when a specified pressure is reached. As the plunger continues down, fuel will flow past the injector valve, force the check valve from its seat, and spray into the cylinder. When the outlet port opens, the pressure is relieved and spring tension will close the injector valve and the cylinder pressure will assist in closing the check valve.

c. Atomizing. Fuel in the liquid state must be changed to a gas before efficient burning will take place. The change from a liquid to a gas must be rapid, and to assist this change, the fuel is forced through small holes (orifices) in the spray tip (fig 2-20). The pressure on the fuel and the size of the orifice cause the fuel to be sprayed into the compressed air in the cylinder. The atomized fuel is changed to a gaseous form by the heat of compression and the turbulence within the cylinder. As the atomized fuel is vaporized and mixed with oxygen, it begins to burn.

(c) Lubricating (fig 2-22). The lubrication system of the Detroit diesel engine is a full force-feed system. The engine may be equipped with either full-flow or by-pass filters. The oil pump is a positive displacement gear-type pump driven by the crankshaft gear. Study figure 2-22 and note the flow of oil through the system and the valves which assist in protecting the engine. Note that this system uses an oil cooler which is mounted so that water flowing to the engine cools the oil. The oil then assists in cooling the engine. You should also see that oil is sprayed on the underside of the piston crown to assist in cooling. Although only one filter is shown in the diagram, most engines used in engineer equipment are equipped with dual filters.

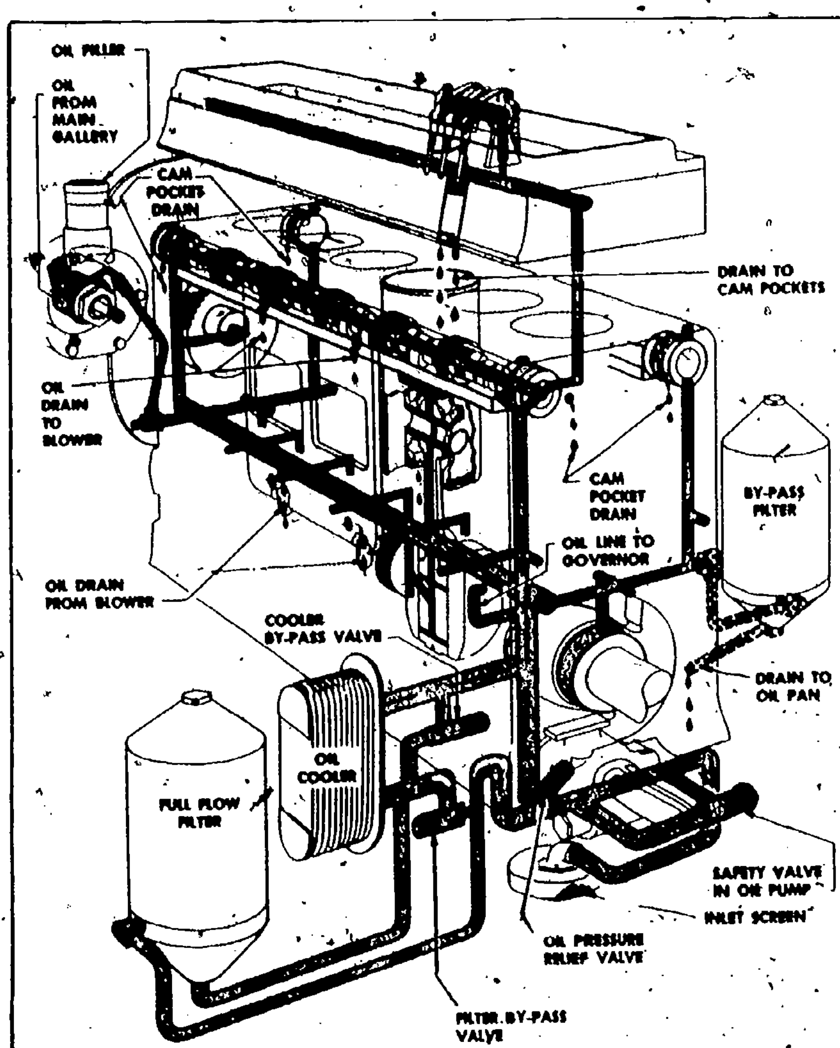


Fig 2-22. Schematic of typical lubricating system.

(2) Governors. Although the governors used on the Detroit diesel engine are produced by different manufacturers, the same principles apply. The engine may be equipped with either a mechanical or a hydraulic governor. Before attempting to perform engine tune-up or governor adjustment, check the nameplate on the governor assembly to determine the type and then review the procedures outlined in the specific TM.

(a) Terms.

1. Speed regulation. A change in an engine's steady speed. The governor and the engine are given time to reach a stable speed for a given load. Speed regulation is directly related to the speed-droop.

2. Speed-droop. The change in governor rotating speed which causes the governor's output shaft to move from full-open to full-closed throttle position or vice versa. To prevent false motion or over-correcting, a governor has permanent or temporary speed-droop. If the speed-droop is temporary, the output shaft will come to rest at the same speed. The steady speed is constant regardless of the load.

3. Isochronous governor. Maintains the engine's steady speed for any given load; speed regulation is zero percent and the speed-droop is temporary.

4. Hunting. Repeated variations of speed due to overcontrol by the engine governor.

5. Dead band. Hesitation in governor action caused by friction and lost motion in the mechanism.

6. Engine speed deviation. Any change in speed from normal. A delay occurs between the moment the load changes and the moment the engine responds. Time is required to correct the fuel rate and for the engine to respond. The inertia of the flywheel and other moving parts will determine how much the speed will deviate before the engine responds to the governor's action.

(b) Types. Governors can be classed as constant-speed, variable-speed, limiting-speed, or overspeed-trip type.

1. Constant-speed. Maintains constant engine speed from no load to full load. It is a governor that is adjusted to maintain an engine speed at one set rpm by moving the engine fuel control (throttle) when there is a change in the engine load.

2. Variable-speed. Maintains any speed selected from idle to full speed. If you set the throttle to operate the engine at 1/2 maximum engine speed, the governor will maintain that speed for you even though the load may vary.

3. Limiting-speed. Controls the engine at maximum or minimum speeds. Speeds other than idle or full speeds can fluctuate because of load variation or the operator's demands.

4. Overspeed-trip. This is a safety device that will stop the engine should its speed exceed the maximum set rpm. The overspeed-trip governor is normally connected to a device in the air intake that will stop the flow of air to the engine blower; it can be connected to a fuel shutoff valve.

(c) Maintenance. Engine governors require very little maintenance, but you, the organizational engineer equipment mechanic, should check the various engine adjustments after 100 hours of operation on new or rebuilt engines and each 1,000 hours thereafter. Governor adjustments and tuneup procedures are contained in the TM for each specific item of equipment.

Chapter 3

POWER TRAIN

3-1. GENERAL

Power from a vehicle's engine is transmitted to its wheels, tracks, and accessories by the power train which is a system of clutches, transmissions, transfer cases, shafts, universal joints, differentials, axles, bearings, and devices for resisting drive torques and thrust. Through these components the vehicle is capable of changing pulling power and its speed of movement, changing the primary direction of travel, operating over smooth or rough terrain, and operating individual accessories. The components of a power train are determined by the design and use of the vehicle and by choice of the manufacturer. For example, a wheeled tractor power train does not have the same components as a truck power train.

a. Wheeled vehicles. The components used in the power train of a wheeled vehicle will depend on the vehicle's use and its accessories. The basic components of a wheeled vehicle power train are shown in figure 3-1. Power for the complete power train flows through the clutch. It flows from the engine through the clutch, transmission, transfer case, propeller shafts, universal joints, differential, and axles to the front and rear wheels. Power for the winch flows through the clutch to the transmission and then through the power-takeoff (PTO), propeller shaft, and universal joints to the gearcase of the winch.

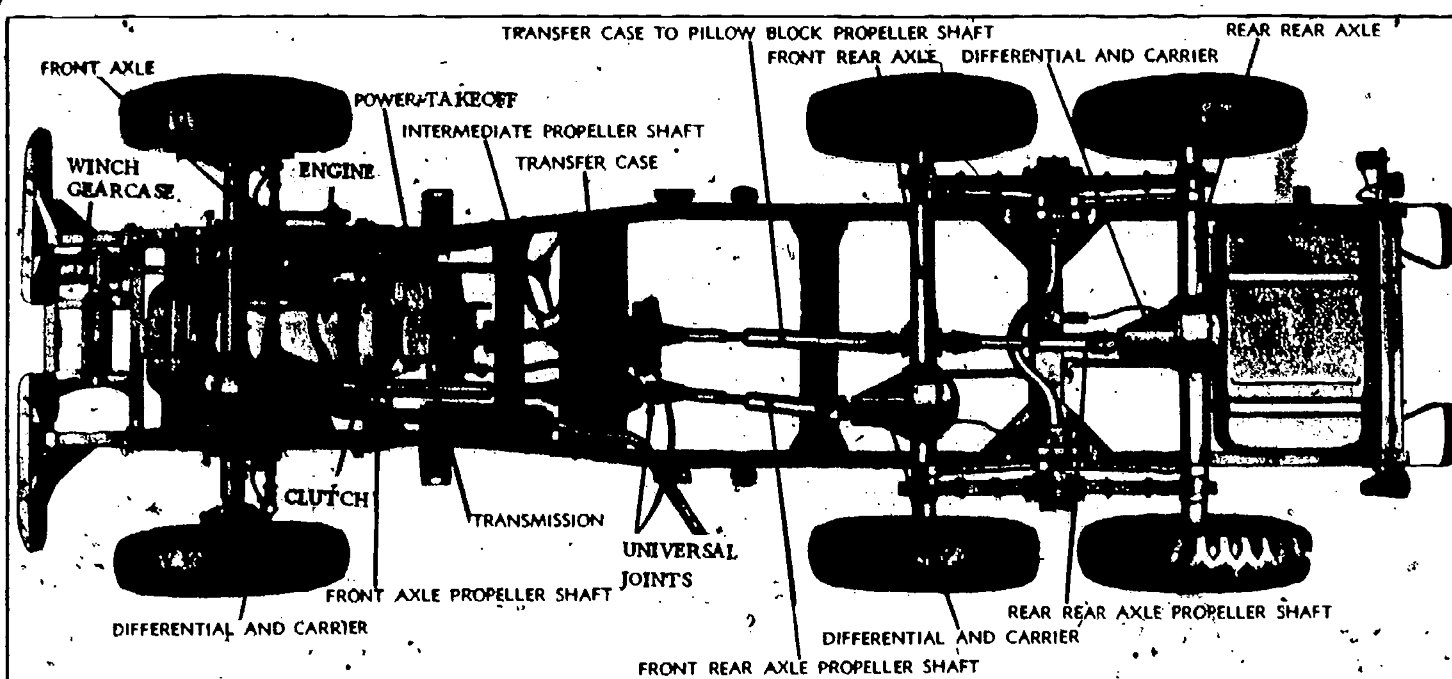


Fig 3-1. Power train components of a wheeled vehicle.

b. Tracked vehicles. The power train of a tracklaying vehicle is usually more ruggedly constructed than that of a wheeled vehicle, but the functioning is the same. The propelling power train of a tracked vehicle is illustrated in figure 3-2. Power from the engine flows through the engine clutch, transmission, pinion and ring gear, steering clutches, final drives, and shafts to drive the sprockets along the tracks. Power can be transferred from the engine to the accessories by several means. For example, power for the single drum winch on some crawler-tractors flows from the transmission through a shaft to the winch gearbox, while power to operate the hydraulic bucket flows through a shaft from the front of the engine to the hydraulic pump which actuates the attachment.

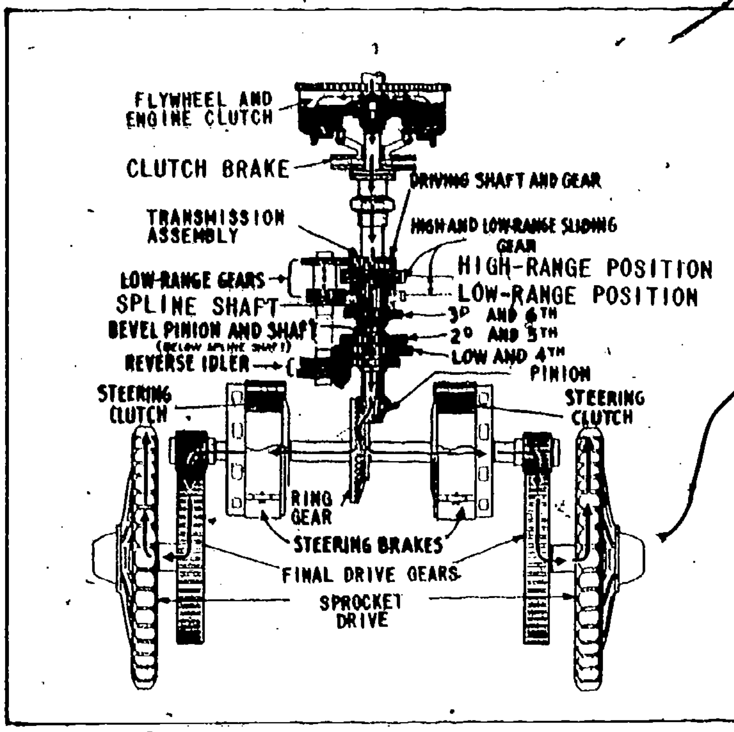


Fig 3-2. Propelling power train of a tracked vehicle.

3-2. CLUTCHES AND BRAKES

a. Purpose. Clutches and brakes control the power flow and motion of a vehicle and its components. Clutches provide a method of engaging or disengaging the power train. A clutch is located between the power source and the operating attachment or vehicle drive. Brakes provide a method of stopping or controlling the speed of a vehicle or attachment.

b. Principle of operation. Clutches and brakes operate by the application of pressure and friction. A clutch may operate by either solid or fluid friction. Fluid friction will be discussed under the heading of fluid couplings. In a solid friction system, friction is created by moving a stationary object into contact with a moving object. If sufficient pressure is applied, the stationary object will either move at the same speed as the moving object or the moving object will stop. The solid friction principle can be demonstrated by placing a book on a flat surface and placing the palm of your hand on top of the book. If you apply sufficient pressure and turn your hand the book will turn. Now turn the book and apply the pressure and notice how the book tends to stop or your hand tries to turn.

c. Nomenclature.

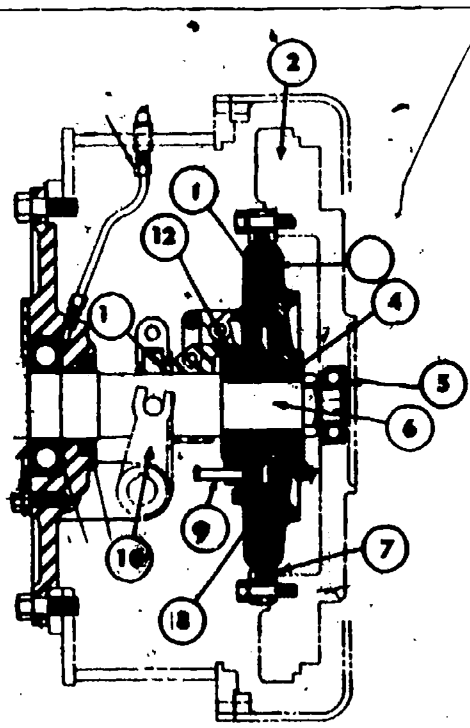
(1) Clutches. The principal parts of a clutch are: the driving member, the driven member, and the controlling mechanism. The driving member rotates with the power source. The driven member contacts the driving member and transmits the power flow to the power train. The controlling mechanism provides a means of applying pressure which establishes friction and a method of transferring the power flow from the driven member to the power train components. Study the engine clutches (spring-loaded, fig 3-3 and snap-over-center, fig 3-4) and you will note that the driving member is bolted to the flywheel of the spring-loaded clutch and splined to the flywheel of this snap-over-center clutch. The driving member and the driven member are constructed or fitted with friction surfaces. The driven disk has a lining bonded (glued or fused) or riveted to the face, while the driving plate is made of a nonmetallic material.

(a) Classification and type. Clutches are classified as engine, steering, or operating by the functions they perform. They are typed according to shape and the method used to bring the friction surfaces into contact.

1. Plate (disk). This type of clutch, normally used on an engine or steering clutch, has a round flat metal plate (the driven member) with the friction surface machined or attached to it, and a driving member which usually has a flat machined surface. The driving member and the driven member each have two friction surfaces. There are single disk (fig 3-3), twin-disk (fig 3-4), and multiple-disk (fig 3-5) plate-type clutches.

1. Engine flywheel
2. Driven disk facing
3. Facing rivets
4. Pressure plate
5. Clutch flywheel ring
6. Adjusting shims
7. Adjusting strap
8. Flywheel ring stud nut
9. Lockwasher
10. Pressure spring
11. Spring equalizer
12. Clutch release bearing
13. Sleeve
14. Lever locking balls
15. Adjusting plate
16. Spring retainer pin
17. Retractor spring
18. Pressure levers
19. Fulcrum rings
20. Snap ring
21. Flywheel ring stud
22. Driven disk assembly

Fig 3-3. Spring-loaded plate-type engine clutch.



1. Driving plate
2. Flywheel
3. Hub and back plate
4. Key
5. Bearing
6. Clutch shaft
7. Driving ring
8. Floating plate
9. Adjusting lock pin
10. Release yoke
11. Sliding sleeve assembly (release bearing)
12. Adjusting yoke assembly

Fig 3-4. Snap-over-center twin-disk engine clutch.

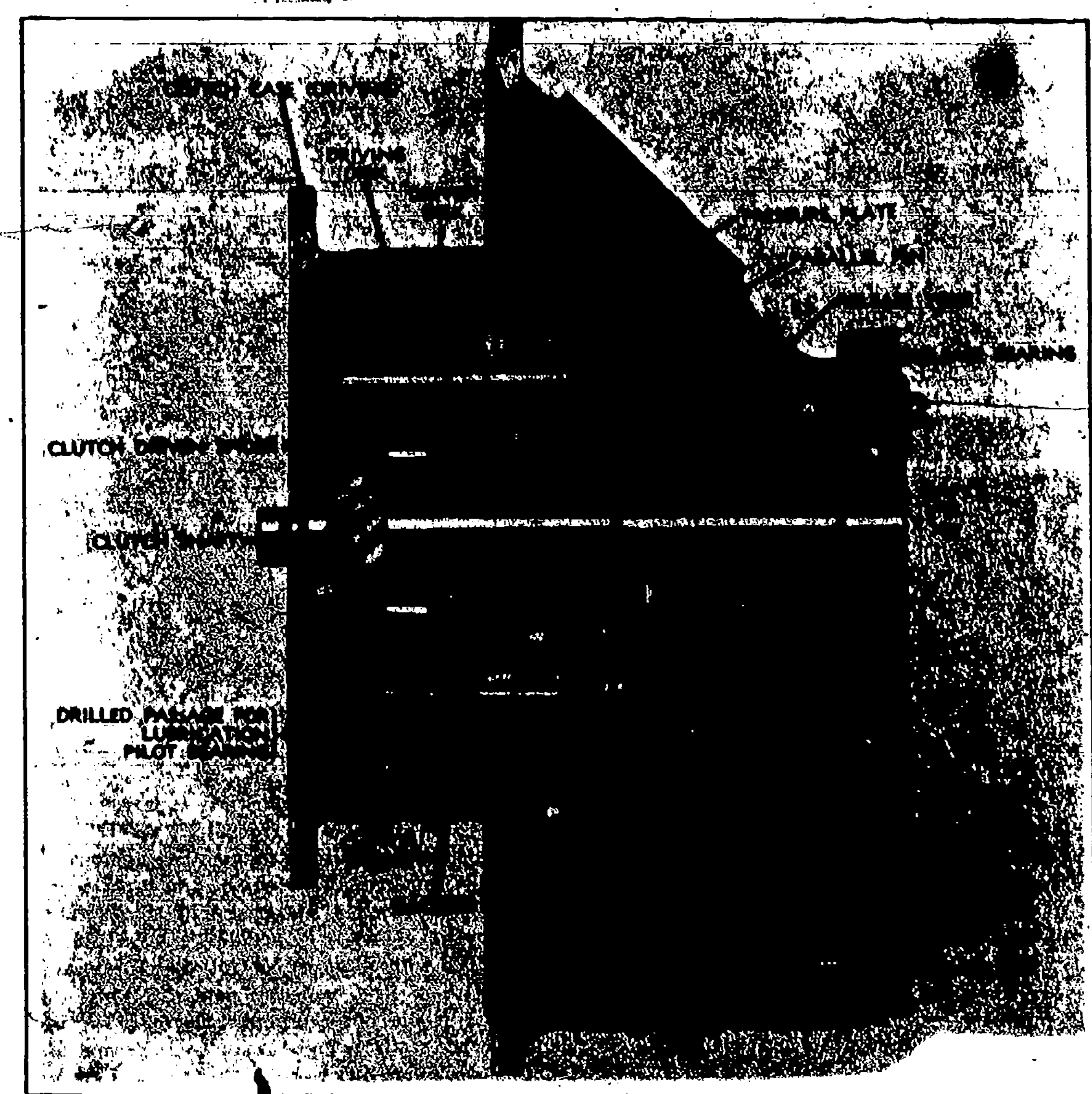


Fig 3-5. Spring-loaded multiple-disk steering clutch.

2. Internal-expanding. This type of clutch (fig 3-6) has only one friction surface for the driving member and one friction surface for the driven member. The clutch fits inside another component and expands to bring the two friction surfaces into contact. The outer friction surface is commonly called a drum. The clutch band or shoes have a nonmetallic lining riveted to them. Either the clutch or the drum can be the driven member.

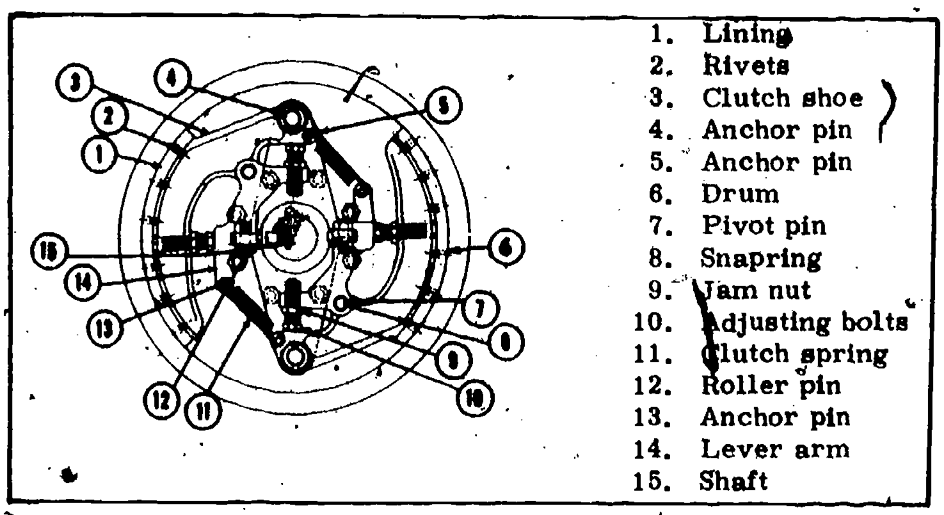
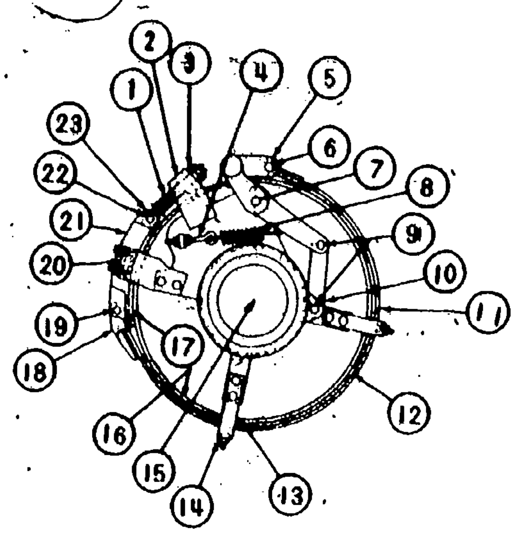


Fig 3-6. Internal-expanding clutch.

3. External-contracting. This type of clutch (fig 3-7) has a band with riveted lining on the inside that fits around a drum or other component. The band contracts bringing the two friction surfaces into contact. Either the clutch or the drum can be the driven member.

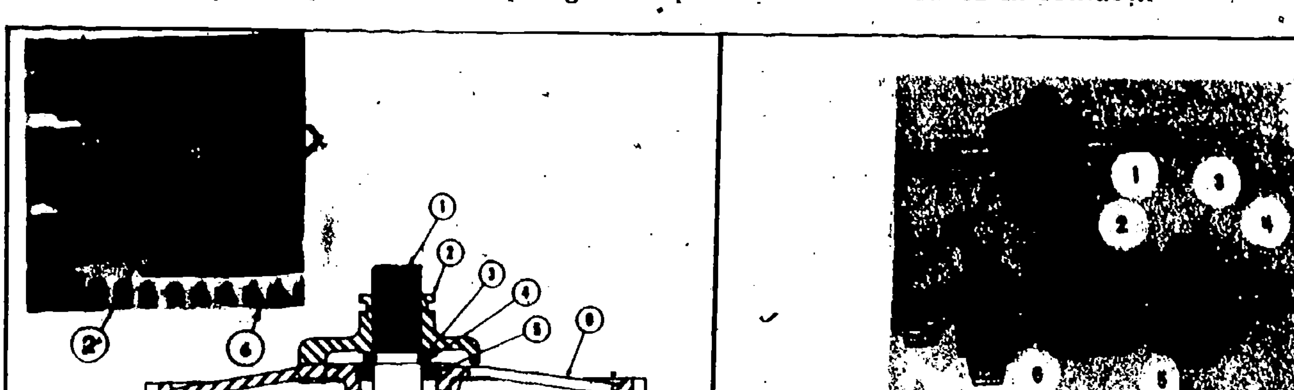


1. Compression spring
2. Clutch carrier
3. Jam nuts
4. Eyebolt
5. Lever
6. Pin
7. Pin
8. Tension spring
9. Pin
10. Link
11. Clutch band
12. Lining and rivets
13. Bar
14. Bolt
15. Shaft
16. Drum
17. Shoe lining
18. Band dead end
19. Pin
20. Bar
21. Shoe
22. Pin
23. Eyebolt

Fig 3-7. External-contracting clutch.

4. Cone. This type of clutch has cone-shaped friction surfaces. Either member can be the driving or driven member, and each member has one friction surface. One cone is forced inside the other to bring the two friction surfaces into contact.

5. Jaw. This type of clutch (fig 3-8) is constructed of gears that have metal-to-metal friction surfaces. Some are spring-loaded, some are positively engaged, and some require continuous pressure by the operator through mechanical linkage. The mating surfaces of the positively engaged clutch (A, fig 3-8) are cut at such an angle that the twisting force will not push them apart; the jaw of one member slides into a slot of the other member. Continuous pressure clutches (B, fig 3-8) have rounded or beveled jaws that can be pushed apart by the twisting force. They require continuous pressure by the operator or a spring to keep the friction surfaces in contact.



1. Shaft
2. Jaw clutch
3. Bolt
4. Clamping collar
5. Ball bearing
6. Gear

A

1. Shifting fork
2. Jaw clutch
3. Gear
4. Shaft
5. Mating jaw
6. Shaft spline

B

Fig 3-8. Jaw clutches.

6. Wet- or dry-type clutches. Clutches such as disk, internal-expanding, and jaw may be either wet or dry. A wet-type clutch operates in oil; it operates cooler than the dry-type clutch, but requires more pressure to engage because the oil has to be squeezed from the friction surfaces to establish friction. Any oil or grease on the friction surfaces of a dry-type clutch will cause severe damage. The lubricants reduce the friction required for proper operation. Lubricants will also cause the nonmetallic lining of a dry-type clutch to swell and deteriorate.

7. Terms. Operating clutch is a term used by maintenance personnel to distinguish between the engine (master) clutch, the steering clutch, and those clutches that control the vehicle attachments.

(b) Clutch control. The most common method of engaging and disengaging a clutch is by simple mechanical linkage. It consists of levers and rods between the operator and the clutch. There are applications where the simple method is impractical; therefore, some clutches are controlled by a combination of mechanical linkage and a hydraulic, electric, air, or vacuum system. Through the control mechanism the operator either applies or releases the pressure required by the clutch to establish friction. Only the spring-loaded and the snap-over-center types are explained in this course, but if you study the method of control and the principles as they are applied to these clutches you will be able to understand the operation of the other clutches.

1. Spring-loaded clutch (fig 3-3). This clutch uses the pressure created by spring tension to hold the driving and driven members in contact and create friction. The pressure spring pulls the inside of the pressure levers and they pivot against the clutch flywheel ring, forcing the outer end of the pressure levers against the pressure plate. By moving a lever or pedal of the control mechanism, an operator can disengage the clutch by applying pressure on the pressure spring. This causes the pressure levers to pivot and pull the pressure plate away from the driven disk. The driven disk which is splined to the clutch shaft moves away from the flywheel and stops because power flow has been interrupted; there is insufficient pressure to create the friction for clutch functioning. The clutch shaft is supported by the pilot bearing in the flywheel and another bearing on the other end of the shaft. When the driven member is stopped, the pilot bearing reduces friction between the clutch shaft and the flywheel. There is no friction at the pilot bearing when the driving and driven members are turning at the same speed. A clutch release bearing reduces the friction between the rotating members and the controlling mechanism.

2. Snap-over-center clutch (fig 3-4). This clutch operates basically the same as the spring-loaded clutch. However, the pressure required to bring the driving and the driven members together is provided by an operator through the controlling mechanism. Levers or cams in contact with the release bearing and the pressure plate rotate or pivot to force the driving and driven members into contact with enough pressure to cause the clutch to function. With the clutch properly adjusted and fully engaged, the levers or cams are slightly over center and toggle in. The camming action of the levers or cams maintains the pressure until the control mechanism is moved to the disengaged position.

(2) Brakes.

(a) General. Brake types, classifications, and principles of operation are similar to clutches. The major difference between a brake and a clutch is that a clutch transmits power, both friction surfaces are free to move, while a brake stops rotation, one friction surface is stationary. There are disk, internal-expanding, and external-contracting brakes. The most commonly used types of brakes are the external-contracting and internal-expanding. The principal parts of a brake are the shoes which have a nonmetallic lining riveted or bonded to them. They are normally anchored to the vehicle to serve as the stationary member. The other friction surface is usually a machined metal surface on a rotating part. The parts of one type of internal-expanding brake are shown in figure 3-9. The length of lining on the primary and the secondary shoe of some internal-expanding brakes is different. Some primary shoes have a shorter lining than the secondary shoe; others are the same length.

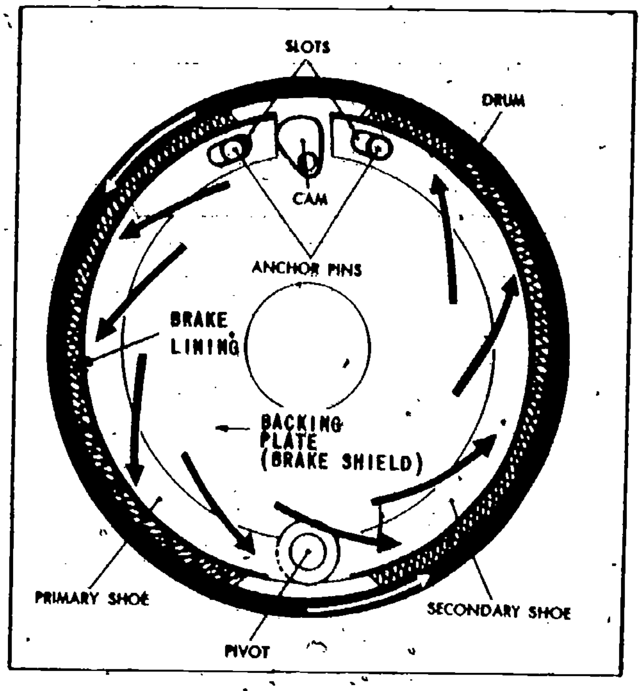


Fig 3-9. Internal-expanding brake.

(b) Brake control and operation. A brake can be controlled by the same methods as a clutch. As indicated in figure 3-9, some brakes are designed to add additional pressure through their action. Brake systems are often referred to as service, parking, transmission, and operating. Service brakes are those used for stopping or controlling vehicle speed under normal conditions. Parking brakes, used to hold the machine when stopped, are sometimes called emergency brakes. Transmission brakes are used to slow or stop the transmission and power train parts for easier and faster shifting of transmission gears. Operating brakes are those used to control the attachments.

1. Mechanical. Mechanical control methods use a system of levers, linkage, and cams to actuate the brakes (fig 3-10). Movement of the lever is transmitted to the cam through the linkage. The cams rotate and cause pressure to be exerted on the brake lining which contacts the brakedrum and creates sufficient friction to slow or stop the moving part or component. Some brakes use spring pressure to actuate the brakes and the cams to release them. Some of the mechanical systems will toggle in, allowing the operator to leave the machine with the brake applied. The mechanical method of brake control is used on many of the operating brakes of engineer equipment.

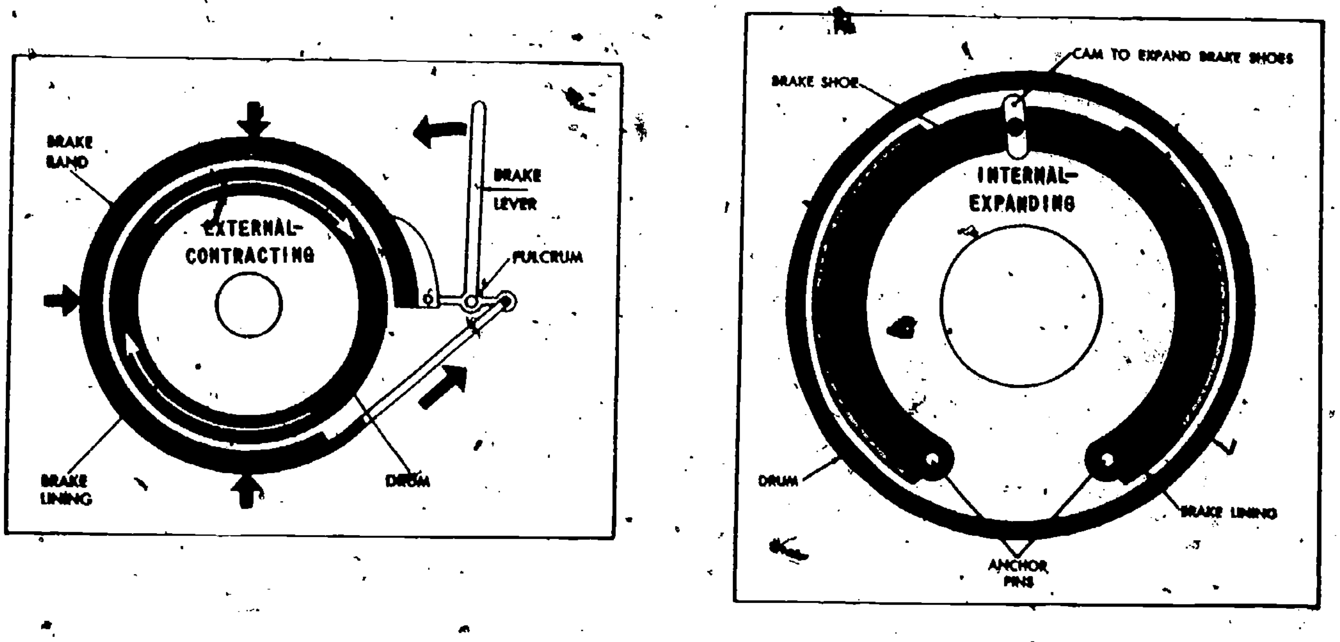


Fig 3-10. Mechanical method of controlling brakes.

2. Hydraulic-actuated (fig 3-11). This is the most used method for controlling passenger vehicle brakes. Through mechanical levers or pedals and linkage, pressure is applied on a hydraulic fluid that is transmitted through lines to the brake control cylinder. Pressure on the fluid causes the cylinder piston to move and a mechanical link transmits the movement to the brake. On an internal-expanding brake, the piston moves out, causing the brake lining to contact the rotating member.

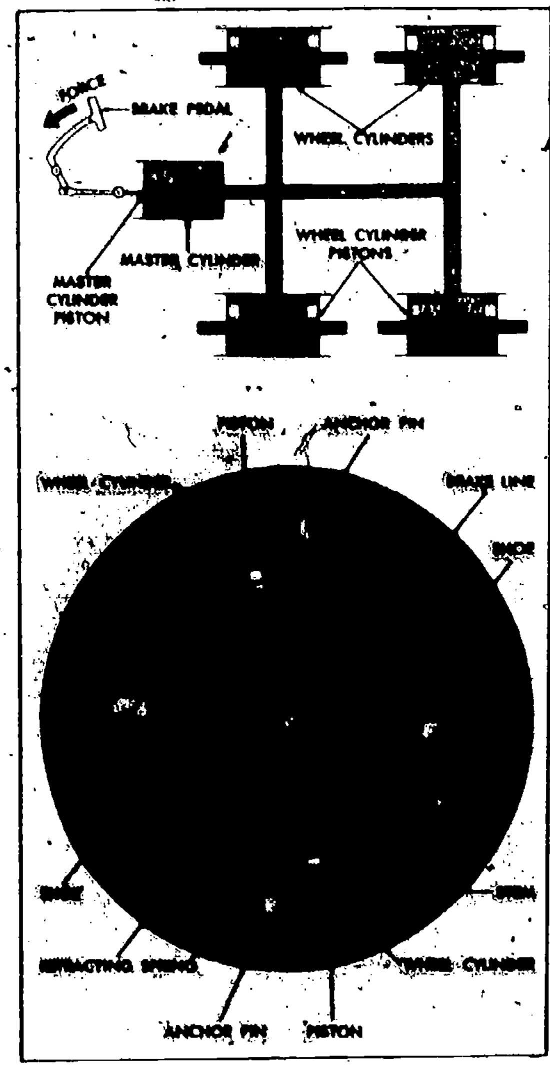


Fig 3-11. Hydraulic brake system.

3. Air-actuated. These brakes are similar to hydraulic brakes. Where the pressure is transmitted by fluid in the hydraulic system, pressure is applied by compressed air or strong springs in the air-actuated system. Some systems use air pressure to engage the brakes (fig 3-12), while others use air pressure to keep the brake released. An air compressor, driven by the engine, compresses the air which is then stored in a reservoir. Air pressure is regulated by a governor which controls the air compressor. Movement of the brake pedal or lever opens a valve which allows the air to flow to the brake chamber. Air pressure in the chamber forces a diaphragm to move and also moves mechanical linkages (slack adjuster) which operate the brake. The system that uses air to release the brakes is very similar. It uses air pressure to overcome spring tension and force the brakes away from the drum.

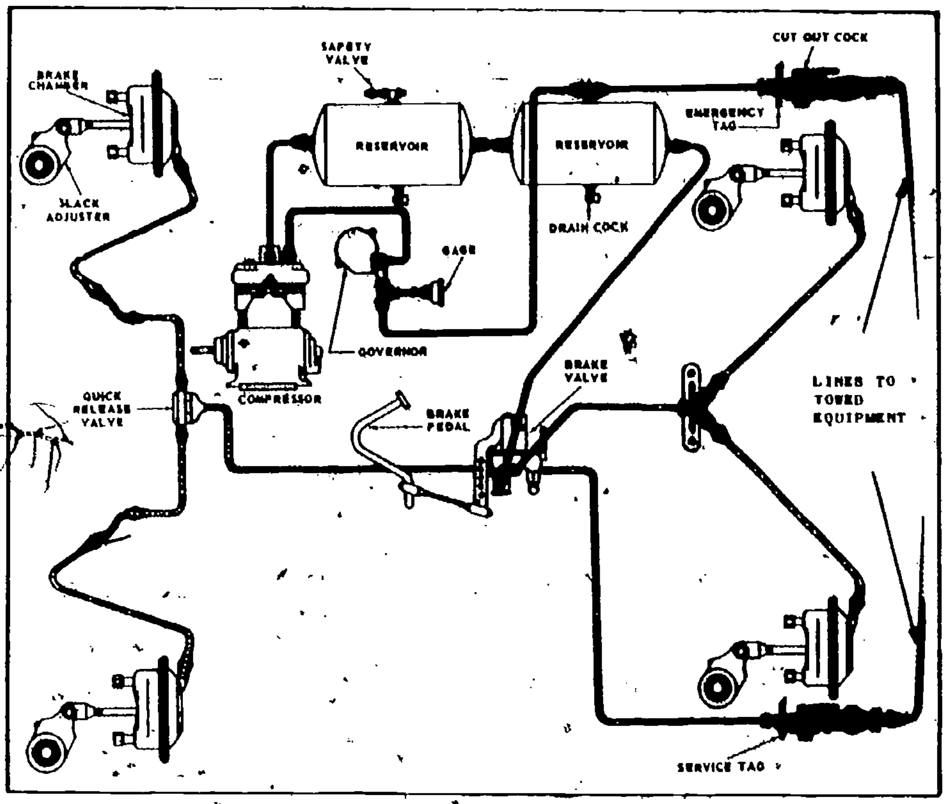


Fig 3-12. Airbrake system.

4. Electrically actuated. These brakes are used primarily to control attachments, although some vehicles use electricity for other brakes. Figure 3-13 shows the electric brake controller and a disassembled view of an electric brake. The operator moves a lever on the controller which varies the current to the brakes according to the position of the controller lever. The current flowing through the magnet assembly creates a magnetic field which attracts the armature assembly. The armature rotates with the rotating unit and, as the magnet pulls toward the armature it also tries to rotate. The rotation of the magnet assembly causes a camming action on the brake, stopping the rotating unit.

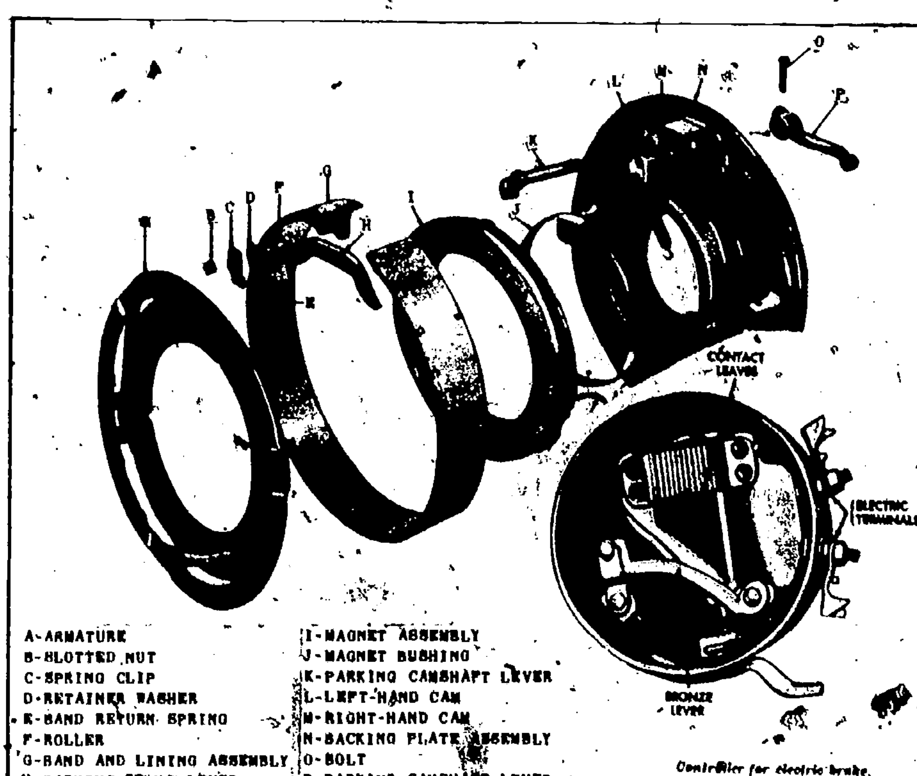


Fig 3-13. Electric brake and brake controller.

d. Miscellaneous. Items of engineer equipment use one or more types of clutches, brakes, and control methods. A crane may use a brake to assist the operator to engage the main clutch or a clutch may be used to rotate a cam which will apply a brake. The scoop loader has air-assisted hydraulic service brakes and a mechanical parking brake. Some crawler-tractors have hydraulic boosters to assist in disengaging the steering clutches. Because there are several types and methods used, you should study the TM for the machine. Study the principles learned from this course and apply them when attempting to replace, repair, or adjust a clutch or brake.

3-3. TRANSMISSIONS, TRANSFERS, AND GEARS

a. General.

(1) Purpose. Transmissions, transfers, and gears provide a method of increasing torque or speed and a method of changing rotation or direction of the power flow. An engine is designed to produce maximum power at a specific rpm and to rotate in one direction. It is through the gears of the power train that an operator can select the direction of travel and a gear ratio that will allow the engine to operate at the most efficient rpm. The component parts of a transmission or transfer are enclosed in a case.

(2) Gear types and ratio. Gears are used to transmit rotary motion. If there is to be a change in speed, direction of rotation, or direction of power flow, the motion will be transmitted from one shaft to another. The gears are selected to fit the application and provide the desired ratio. Gears are mechanical levers; they provide mechanical advantage for rotary motion. Study figure 3-14 and note that moving the long end of the bar 12 in. will only move the short end of the bar 6 in. Also note that it will require 25 lb of pressure on the long end to move the 50-lb box. This is expressed as a ratio of 1 to 2. Now consider the gears as the bar. If you turn the large gear one full turn the small gear will turn two full turns. However, it will require twice as much effort to turn the large gear. In other words you have increased the speed, but you have reduced the torque. This ratio is also expressed as 1 to 2. If the small gear was driving, the ratio would be 2 to 1 or 12 (teeth of driven gear) to 6 (teeth of driving gear). You will also note that two gears in mesh mounted on shafts side by side will rotate in opposite directions. There are several types of gears; each can be used to provide a mechanical advantage, but some also have other functions.

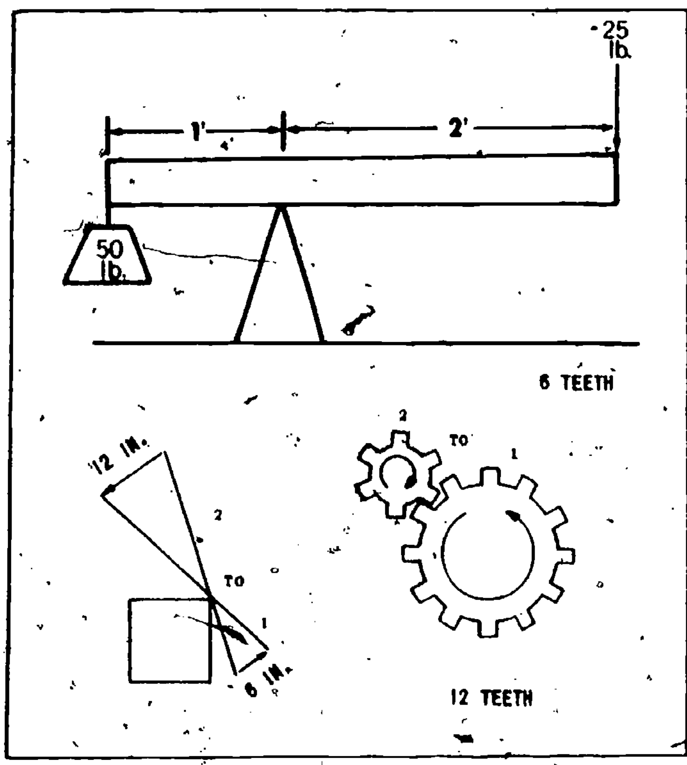


Fig 3-14. Illustration of mechanical advantage.

(a) Spur gears (fig 3-15). These are the most common type of gears. Straight spur gears have teeth cut straight across the gear and are used where the gears must slide in and out of mesh with other gears or where side thrust would be undesirable. Helical spur gears have the teeth cut at an angle and are used where more tooth contact and quieter operation is desirable and where side thrust is no problem. Helical gears are used to operate in constant mesh.

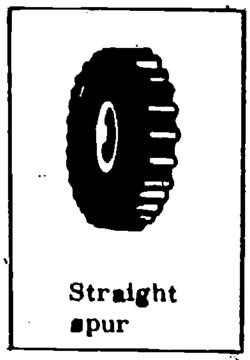
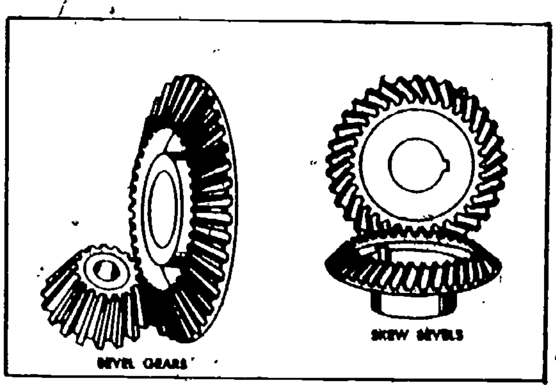


Fig.3-15. Spur gears.

(b) Bevel gears (fig 3-16). These are used to change the direction of power flow. Power enters at one place and emerges at a 90° angle. Like the helical spur gears, bevel gear teeth are cut on a curve or an angle to increase tooth contact. Bevel gears are usually provided in matched sets consisting of a pinion and bevel gear. Some bevel gears are referred to as ring gears because of their application and mounting, such as the ring gear and pinion in the differential of your automobile.



(Straight) (Helical)

Fig 3-16. Bevel gears.

(c) Worm gears (fig 3-17). These also change the direction of power flow. They are generally used for slow speed applications and where their action is needed to resist reverse torque action. The power enters at the worm and drives the gear; should the power flow reverse, the gear would force the worm against the friction surface causing enough friction to reduce or stop the power flow. The most common use for worm gearing is automobile steering. The worm can be compared to the threaded part of a bolt, and the gear to a rounded nut with external teeth to match the bolt threads.

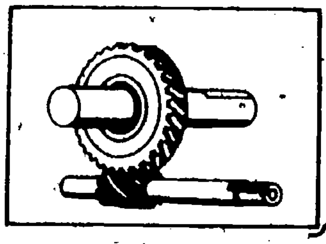


Fig 3-17. Worm gear.

(d) Ring gears (fig 3-18). These gears have teeth either on the inside or the outside and are usually bolted, pressed, or constructed to another part. The most common uses are: the external ring gear that is pressed on the flywheel, the internal ring gear used to join two gears located on the same shaft, and the internal ring gear used in a planetary gear system.

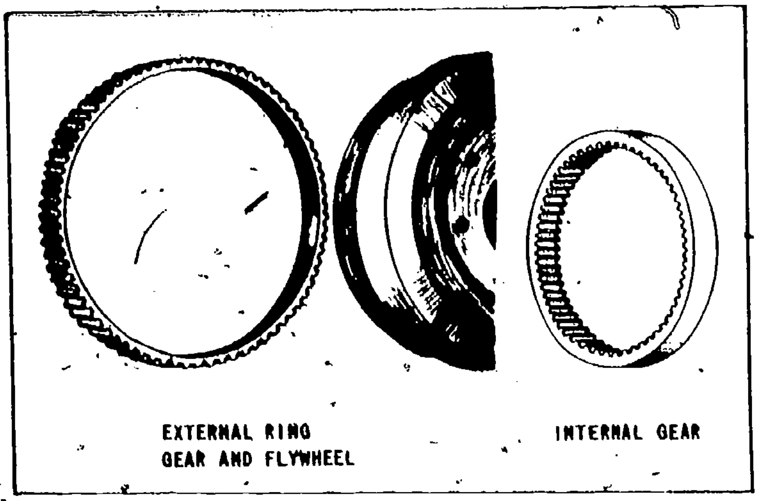
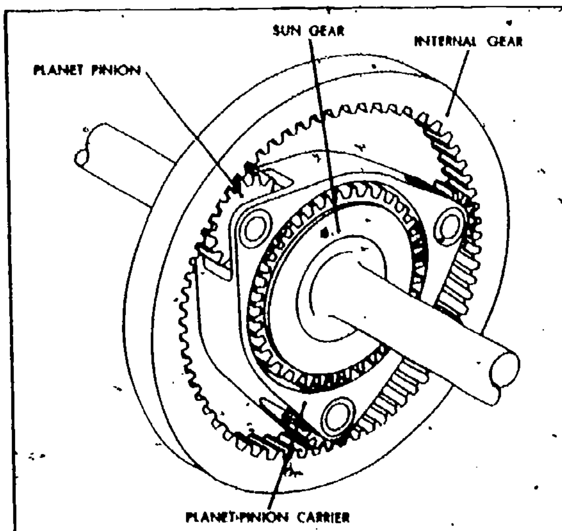


Fig 3-18. Ring gears.

(e) Planetary gear system (fig 3-19). This system is composed of spur gears, ring gears, shafts, bearings, and other components. Although often referred to as a planetary gear, it is a gear system. The system consists of three rotating members: the internal ring gear, the sun gear, and the planet pinion set. The planet pinion set consists of the planet pinions, the planet pinion carrier, and the planet pinion shafts and bearings. Planetary systems are used in transmissions, rear axles, and winches. The system is arranged so that gear ratios can be increased or decreased, and so that the direction of rotation can be reversed by holding one of the rotating members and turning the others. There are six possible selections for the system shown in figure 3-19. For example, in the chart (fig 3-19), if you hold the sun gear and turn the pinion carrier, you will have an increase in speed.



CONDITION	1	2	3	4	5	6
SUN GEAR	H	H	T	IR	I	T
PINION CAGE	T	L	L	H	T	H
INTERNAL GEAR	I	T	H	T	H	LR

H—HOLD
T—TURN
R—REVERSE

I—INCREASE OF SPEED
L—REDUCTION OF SPEED

Fig 3-19. Planetary system and action chart.

(3) Bearings. Within the different gearcases there are bearings and shafts which reduce friction and support and aline the gears. They are produced in many shapes and sizes and are machined and treated to withstand twisting and shock. The gears may be splined on the shaft, keyed or pressed to the shaft, or mounted on bearings on the shaft. There are two general types of bearings: sliding surface and antifriction.

(a) Sliding surface bearings. These slide over each other without turning. An accurately machined surface that allows another accurately machined surface to slide over it is a simple form of the sliding surface bearing. However, to reduce costly replacements, a soft material is used to line or coat one of the surfaces so that only the soft relatively inexpensive material will require replacing. The most common materials used for sliding surface bearings are brass, babbitt, and lead alloys. These are shaped, machined, and treated to reduce friction and wear of the more vital parts.

(b) Antifriction bearings (fig 3-20). These bearings depend upon rolling contact rather than sliding contact. They are the ball bearings and roller bearings which are used throughout the power train. These bearings ordinarily give a warning before complete failure by gradually decreasing the smoothness of operation. The bearings are designed to withstand radial loads, thrust loads, or angular loads. Some will withstand a combination of the different loads. Figure 3-20 illustrates the different bearings and how they are designed to withstand the different loads. These bearings are constructed from very hard materials that have been machined with precision and treated to withstand high speeds and heavy loads. The bearings consist of an inner and an outer race which act as a wear surface or path for the balls or rollers. Although some antifriction bearings are prepacked and sealed, bearing life depends upon proper lubrication and cleanliness; a pit or score no larger than a pin point will cause unsatisfactory bearing operation. The bearings are installed so that one race will turn with the shaft or other rotating member. The balls or rollers roll as the component turns with minimum friction. Antifriction bearings are designed to withstand the different type loads when installed properly. Improper installation will cause the component to fail.

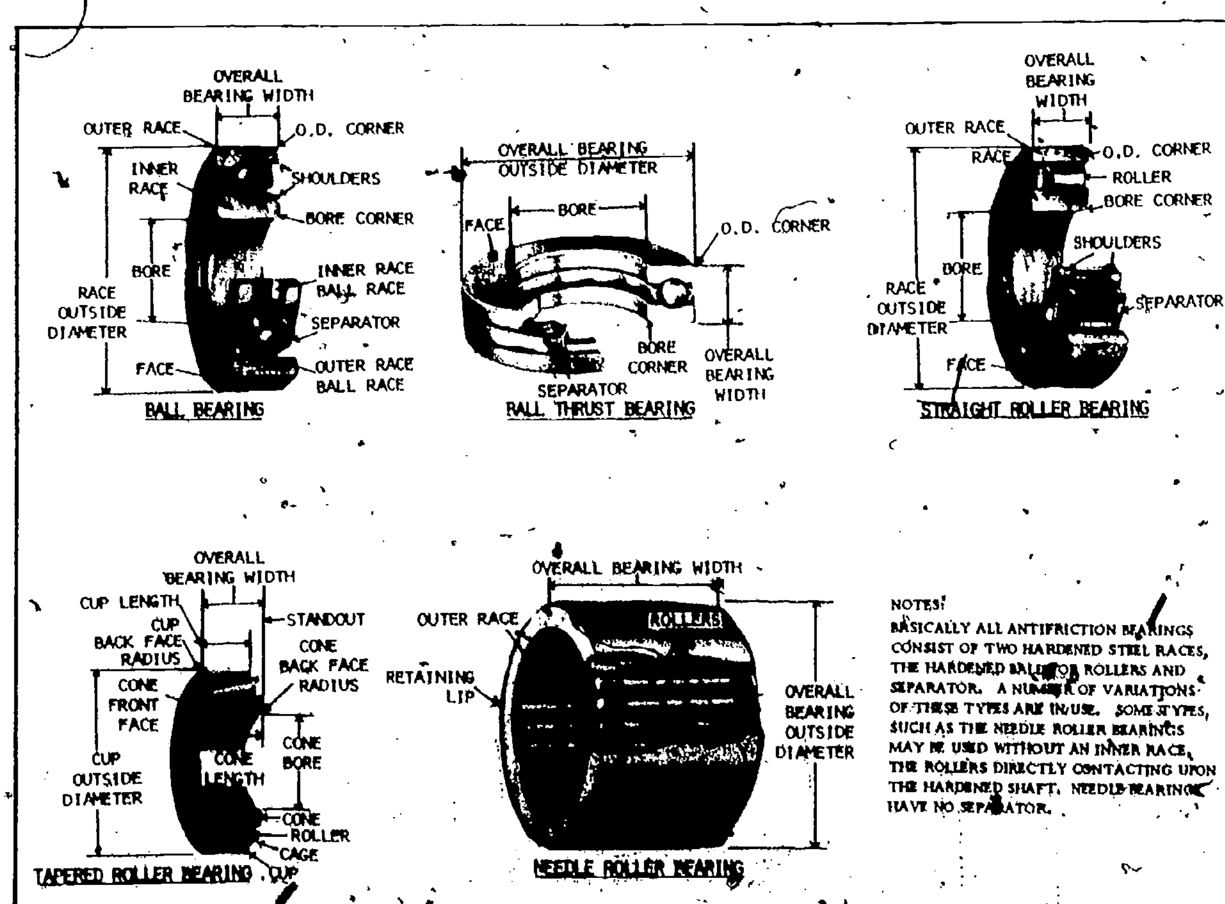


Fig 3-20. Antifriction bearing component parts.

b. Transmission and transfer types. There are two basic types of conventional transmissions: sliding gear and planetary. Marine Corps engineer equipment uses both types. The planetary system is used in the torqmatic transmission and in other vehicle components. There are three kinds of sliding gear transmissions: sliding-spur-gear, constant-mesh, and syncromesh.

(1) Sliding-spur-gear (fig 3-21). This is a simple sliding gear transmission. It is the type used in some crawler-tractors, similar gear trains of cranes, and for some transfer cases. The component parts can be enclosed in a case or they can be exposed. An exposed gear system is referred to as "the gear train."

(a) Components. The transmission (fig 3-21) consists of four shafts, seven gears (reverse idler gear not shown), bearings, seals, linkage, and the case.

1. The input shaft is splined on one end to provide a method of attaching it to the clutch shaft. A gear is pressed or keyed to the opposite end. It is supported by a bearing at the engine flywheel and a bearing in the transmission case.

2. The main drive gear external gear (fig 3-21) is keyed to, pressed to, or constructed as part of the input shaft. It is two gears constructed in one piece. It has external teeth that mesh with the countershaft drive gear and another set of teeth that will mesh with a gear on the main shaft. The teeth that mesh with the main shaft gear can be either internal or external. The main drive gear is also machined to receive a bearing and on some machines splines smaller than the inside diameter of the bearing are cut. The splined portion provides a method of driving an attachment power-takeoff (PTO) shaft.

3. The main shaft is splined so that gears can slide along its length; on some machines it is also hollow. It is supported at one end by the bearing in the main drive gear and at the other end by a bearing in the case.

4. The two main-shaft gears have internal splines and slide on the main shaft. Hub extensions have been machined to the gears for shifter forks to slide them in and out of mesh with the other gears. The second- and third-speed gear has an internal gear (not shown) which can mesh with the external gear on the input shaft. These are the gears moved by the operator through linkage that fits the hub extension.

5. The countershaft is a solid shaft supported at each end by bearings in the transmission case. Some machines have the countershaft extended through the front of the case so that the power will flow back toward the front.

6. The countershaft gears are keyed and pressed to the countershaft. The countershaft is in constant mesh with the main drive gear. The first and second speed countershaft gears are constructed in one piece. When the input shaft rotates, the countershaft and gears also turn.

7. The reverse idler shaft is pressed into the case, and the reverse idler gear is supported by a bearing on the shaft (not shown). The reverse idler gear is in constant mesh with the countershaft reverse gear.

(b) Function. Power from the clutch turns the input shaft and gears. The countershaft drive gear, being in mesh with the main drive gear, will also rotate, but in the opposite direction, causing the countershaft and countershaft gears to rotate. The reverse idler gear will rotate in the opposite direction of the countershaft reverse gear. The main shaft and gears will not rotate unless the power train is moved or the straight spur sliding gears are in proper mesh. If the second- and third-speed gear is moved forward and the internal gear and external gear mesh, the main shaft will rotate in the same direction as the input shaft. If the gear is moved to the rear and in mesh with the countershaft second-speed gear, it will rotate in the same direction as the input shaft, but at a reduced speed because of the different gear ratio. When the first and reverse gear is in mesh with the reverse idler gear, the main shaft will turn in the opposite direction of the input shaft. Study figure 3-21 and note the size of the gears. Trace the power flow through the gears and visualize the gear reductions. Remember that when a large gear is driving a smaller gear there will be an increase in speed and that direction of rotation will change when transmitted from one shaft to another shaft.

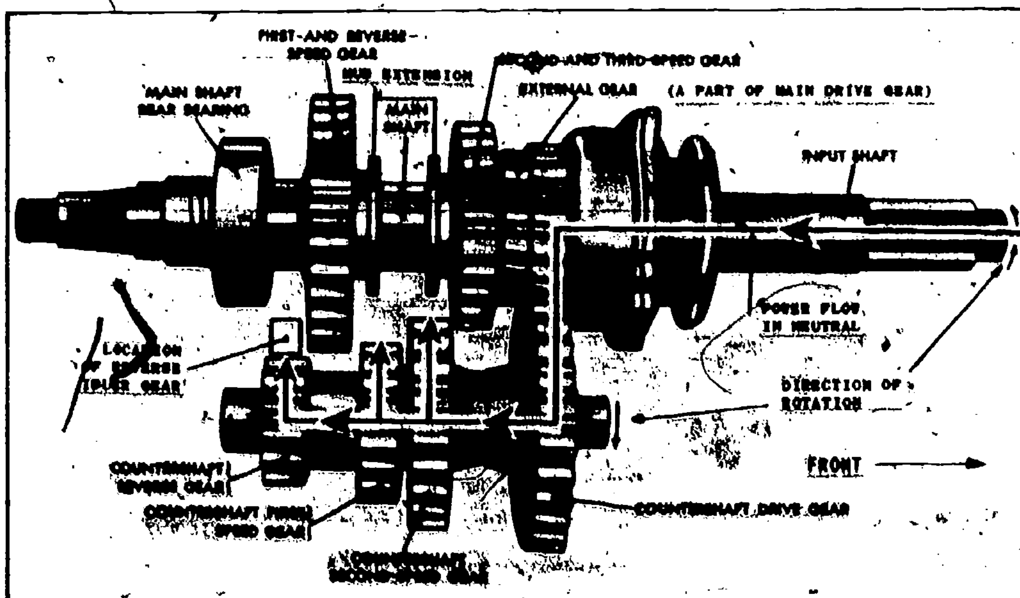


Fig 3-21. Sliding-spur-gear transmission.

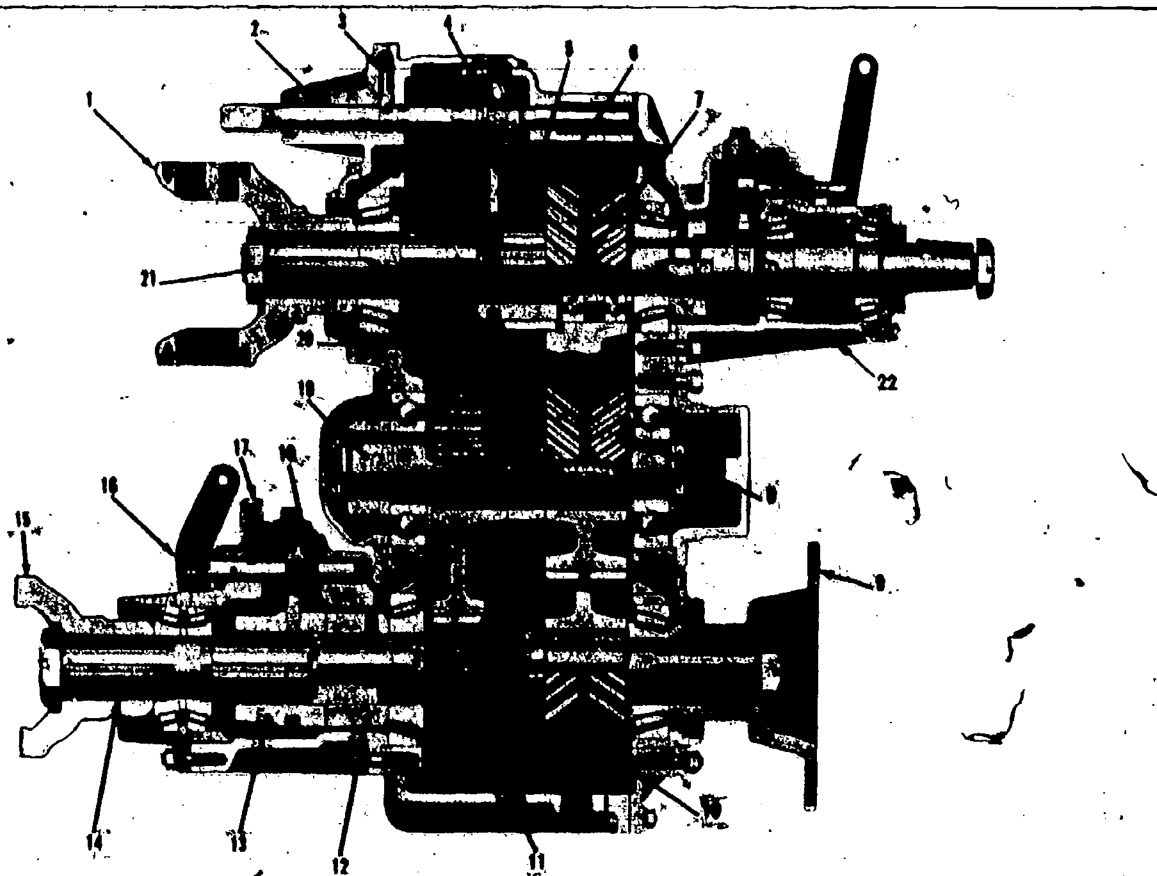
(c) Lubrication. The gears, bearings, and linkage are generally splash-lubricated by a heavy gear oil, GO 90. The case is filled to a specified level and, as the gears rotate, the oil is splashed onto the other parts.

(2) Constant-mesh.

(a) General. Although a transfer case (fig 3-22) is different in nomenclature, the illustration shows that constant-mesh and sliding-spur-gear transmissions and transfer cases are similar in construction and function. In the constant-mesh assemblies, the main shaft gears are mounted on bearings and depend upon another component, the sliding gear (fig 3-22, item 5), to transmit the power from the main shaft to them. The main-shaft gears remain in one place on the shaft; they do not slide along the shaft as the straight spur gears do. They are in constant mesh with the gears on another shaft. The constant-mesh transmissions normally use a straight spur gear for the reverse and first-speed main shaft gear. You will note that the constant-mesh gears (fig 3-22, items 6, 8, and 10) are helical gears; this allows more tooth contact and quieter operation.

(b) Function. Power enters the case and rotates the main shaft and the sliding gear. If the sliding gear is moved forward, it will engage the low-speed gear (idler low-speed gear fig 3-22, item 20), and transmit the power to the driven shaft. The constant-mesh gears will also rotate on their antifriction bearings. If the sliding gear is moved to the rear, the straight spur teeth will mesh with the internal teeth of the main drive gear and transmit the power to the driven shaft.

(c) Miscellaneous. The transfer case in figure 3-22 has four points for attaching units to be driven. Item 1 receives the power, item 22 is an accessory drive assembly, item 9 is the rear wheel drive, and item 15 is the front wheel drive. Also shown are sliding clutches, sometimes referred to as jaw clutches.



1. Companion yoke
2. Shift shaft
3. Lock spring, plunger, and ball
4. Shift fork
5. Sliding gear
6. Main drive gear
7. Ball bearings
8. Idler direct-speed gear
9. Companion yoke
10. Driven gear
11. Driven shaft
12. Declutch driving clutch
13. Sliding clutch
14. Declutch shaft
15. Companion yoke
16. Declutch shift lever
17. Lock spring and ball
18. Shift fork
19. Idler shaft
20. Idler low-speed gear
21. Main shaft
22. Accessory drive assembly

Fig 3-22. Transfer case, sectional view.

(3) Synchromesh (fig 3-23).

(a) General. The straight sliding-spur-gear and the constant-mesh transmissions and transfers require the operator to stop the gears or have them rotating at the same speed before changing to another gear ratio. Synchronizing gear speed is accomplished by a gear system similar to the constant-mesh transmission with friction surfaces on the meshing components in a synchromesh transmission. A synchromesh clutch replaces the sliding gear. It is splined to the main shaft and has a gear with external teeth, friction clutches, and a sliding sleeve with internal teeth. Constant-mesh gears also have small external teeth gears and friction surfaces machined to them. The sliding sleeve will mate with the external teeth, locking them together.

(b) Function. With the power train turning, the operator disengages the engine clutch and moves the selector lever to change the gear ratio. When the original gear is disengaged, the power train continues to turn, but the input shaft and parts stop. As the lever is moved farther, the friction surfaces come together and cause the two gears to rotate. A spring-loaded ball prevents the sleeve from moving far enough to cause the gears to clash. When the speed of the gears is the same, the ball allows the sliding sleeve to engage the external teeth and lock the gears together. The power then flows from the engine clutch to the synchromesh clutch and through the sliding sleeve to the gear.

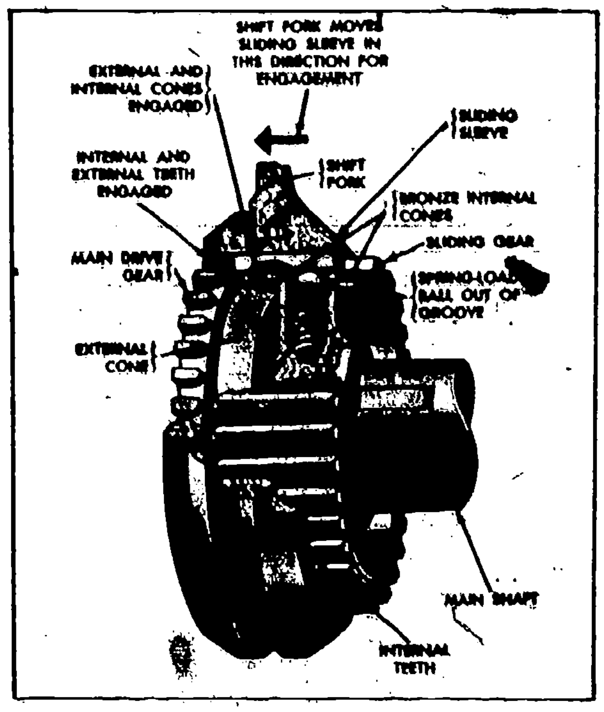


Fig 3-23. Synchromesh clutch.

3-4. HYDRAULIC COUPLINGS AND TRANSMISSION

a. Hydraulic couplings.

(1) Fluid coupling (figs 3-24 and 3-25). The smoothest and simplest method of transmitting torque is by a hydraulic coupling. It is a fluid-friction clutch with a 1 to 1 input-output torque ratio. It consists of a pump and a turbine operating within a case filled with oil. Each element (pump and turbine) has straight, flat, radial blades. As the engine turns, centrifugal force will throw the oil on the pump blades out (rotary flow) and across (vortex flow) the blades.

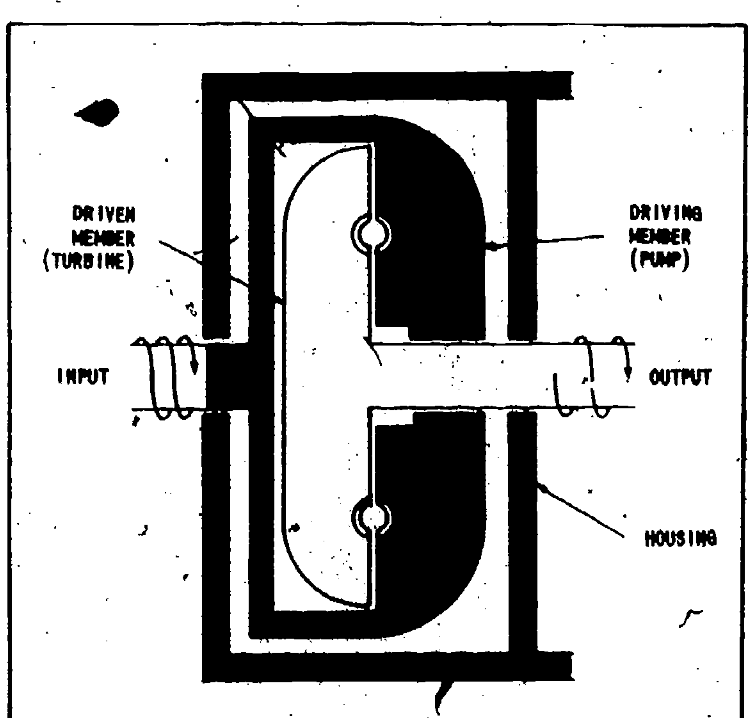


Fig 3-24. Fluid-coupling schematic.

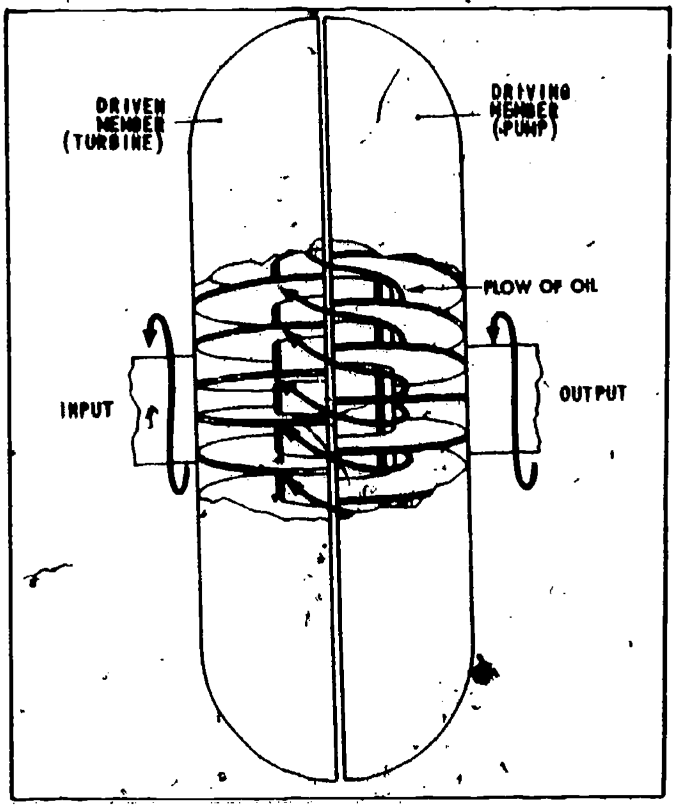


Fig 3-25. Schematic of oil flow in fluid coupling.

When the oil leaves the pump side, it strikes the blades on the turbine, and friction of the oil causes the turbine to rotate. The faster the pump turns, the more pressure the oil will have; this will increase the friction and rotate the turbine faster. When the power flow is reversed and the output shaft is driving, the oil pressure from the turbine will turn the pump. At slow speed or low engine rpm the oil is not moved with sufficient force to overcome the resistance and the elements are free of each other. A fluid coupling is like two fans facing each other. If one fan is running, the movement of the air across the blade of the second fan will start it rotating. If one is suddenly turned off and the other on, it will cause the original driving fan to be driven.

(2) Torque converter. A simple torque converter is similar to a fluid coupling. A torque converter has curved vanes and additional rotatable members that provide a means of torque multiplication and also act as a fluid coupling. A torque converter can be utilized to replace a solid friction conventional clutch and conventional transmission.

(a) Operation. All torque converters have a minimum of three elements: pump, turbine, and stator (rotatable member). The stator changes the direction of the oil for return to the pump. It can rotate, but is stationary when there is a great difference between pump and turbine speed. If the stator did not change the direction of the oil from the turbine, the oil pressure would flow in the opposite direction of pump rotation and act as a brake. A simple torque converter and the oil flow are illustrated in figure 3-26.

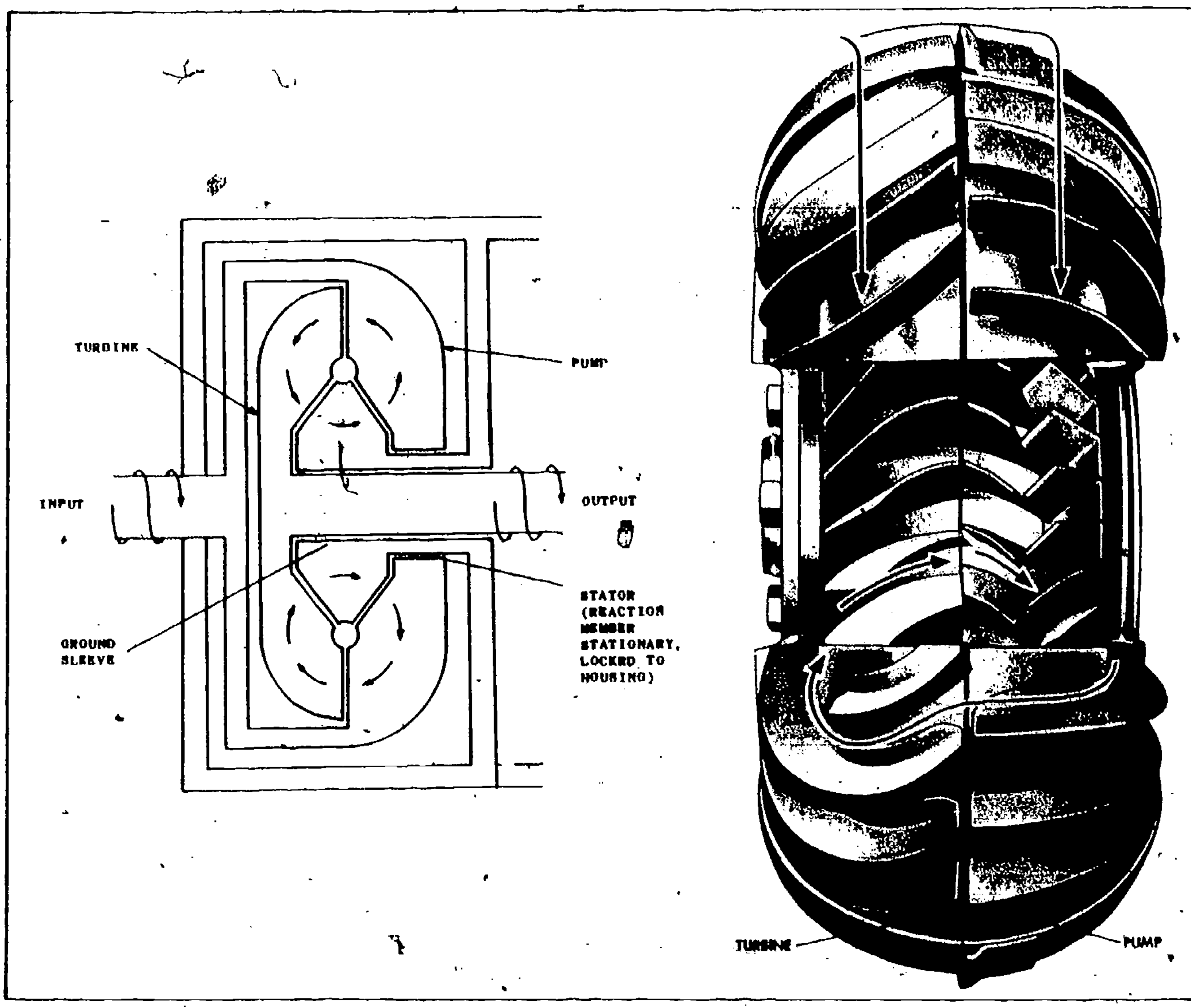


Fig 3-26. Torque converter and oil flow.

Torque converters used in Marine Corps equipment are similar to the 2-stator assembly in figure 3-27. The stators are designed to freewheel and act as a fluid coupling or automatically lock to provide the reaction for torque multiplication. The stators are mounted on cams on the ground sleeve. The cams will let the stator rotate freely in the direction of the pump, but they lock to the housing if they try to turn against pump rotation. They are like the coaster brakes on a bicycle that allow the pedal to turn in one direction only. Oil is passed from the pump to the turbine and directed toward the center. The oil that leaves the turbine has not expended all of its energy. This oil strikes the stator, which tries to rotate, but locks. The blades of the stator change the direction of the oil so that the energy will assist rather than resist pump rotation. The engine speed remains steady and the energy of the oil is added to the energy of the engine which provides torque multiplication. As the turbine gains speed, the oil will strike the back of the stator blades causing it to freewheel (rotate in the same direction as the pump and turbine). When all elements are operating at the same speed, the torque converter acts as a fluid coupling. The friction of the oil across and through the system can create enough heat to do damage. The movement of the parts also causes friction heat. Consequently, friction heat and foreign matter which cause wear or restriction create most converter maintenance problems. The greatest amount of friction occurs when there is maximum torque.

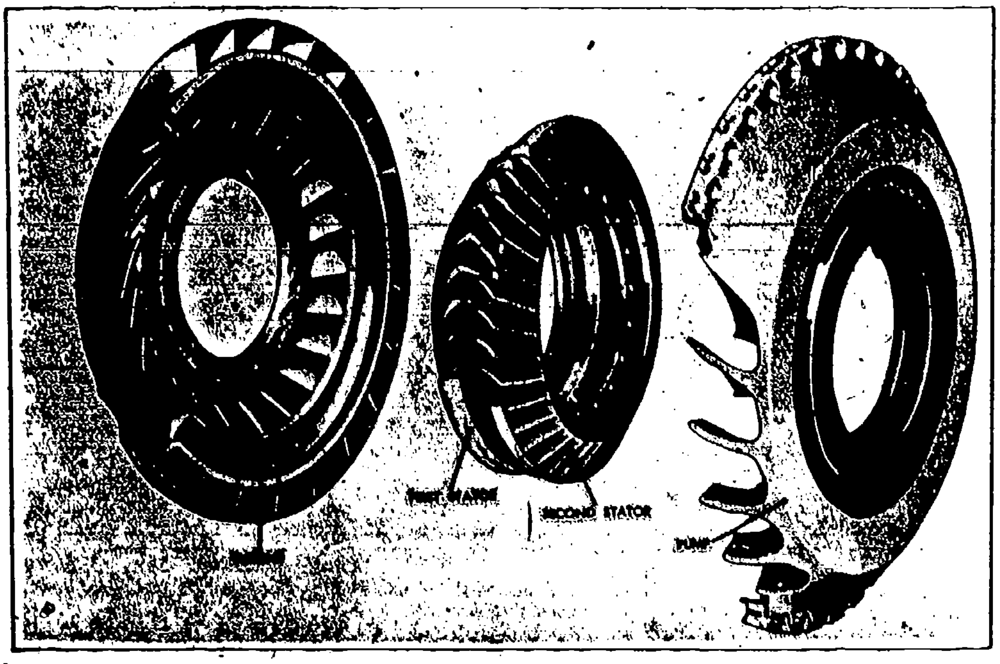


Fig 3-27. Four-element torque converter.

(b) Application. A torque converter can be used with or without a solid-friction clutch. The torque converter used in crane-shovels is equipped with a solid-friction clutch between the engine and the converter. The equipment that has the torqmatic transmission has a similar torque converter that receives its power directly from the engine. In the torqmatic transmission application, the torque converter will also perform other functions.

b. Torqmatic transmission. The torque multiplication of the torque converter is further extended through a constant-mesh planetary gear system. The torque converter and the gear system have been combined into the torqmatic transmission that has three speed ranges forward and three speed ranges reverse. The gear train is controlled by multiplate, oil-cooled, friction clutches.

(1) Principles of operation. Earlier in this chapter you noted that a simple planetary system will provide six different conditions (three forward and three reverse speeds). Figure 3-28 illustrates the direction of rotation and how the gear ratio is affected.

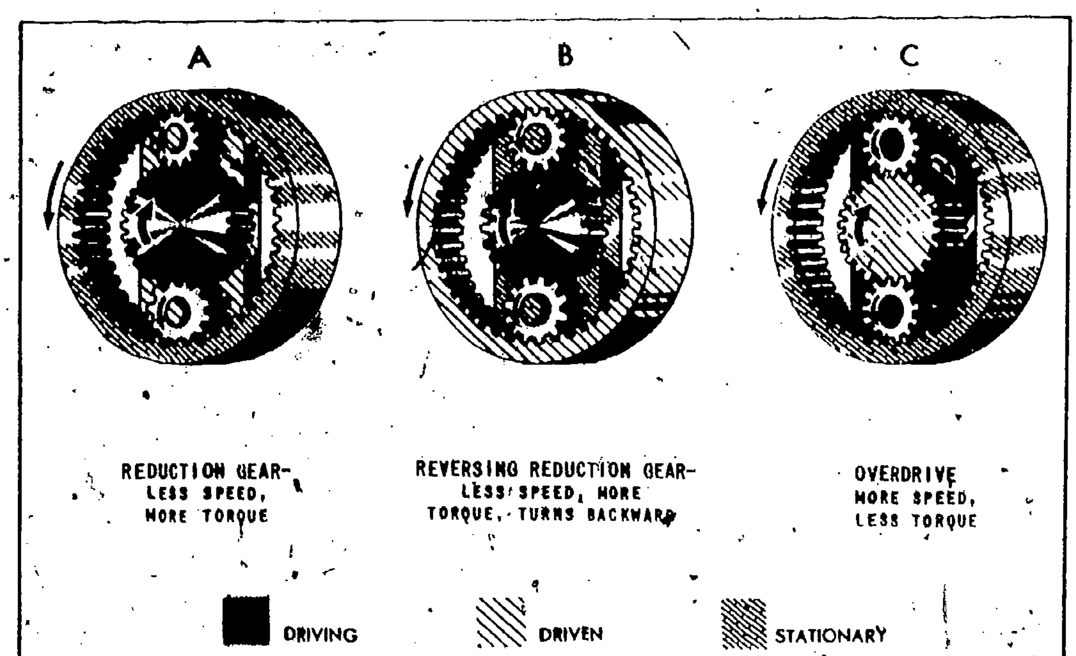


Fig 3-28. Planetary output combinations.

As illustrated in figure 3-19 and figure 3-28, the direction of rotation and the speed of the output shaft are controlled by the size of the gears and the member that is held stationary. The torqmatic transmission uses five clutches which are hydraulically applied and spring-released to control the planetary systems. Figure 3-29 illustrates the position of the clutches in relation to the planetary system. Oil pressure from a pump in the torque converter flows through the control valve assembly where the operator selects a range and a direction. Study the schematic and note that the reverse planet pinion cage can be held by the clutch. You should also note that the reverse ring gear and the forward planet carrier form the planet pinion cage for the forward clutch; the high-range planet carrier and the low-range sun gear form the planet pinion cage for high-range clutch. This is a compound planetary gearing system. All gears within the system remain in constant mesh; there is no need to slide the gears in and out of mesh since this can be accomplished by engaging or disengaging clutches. When the torque converter output shaft is turning, there is power available to the forward and reverse sun gears. By engaging one of the clutches, the power will be transmitted on through the planetary gearing to the range planetary systems. When one of the range clutches is engaged, the power will flow through the transfer drive gears to the output shafts.

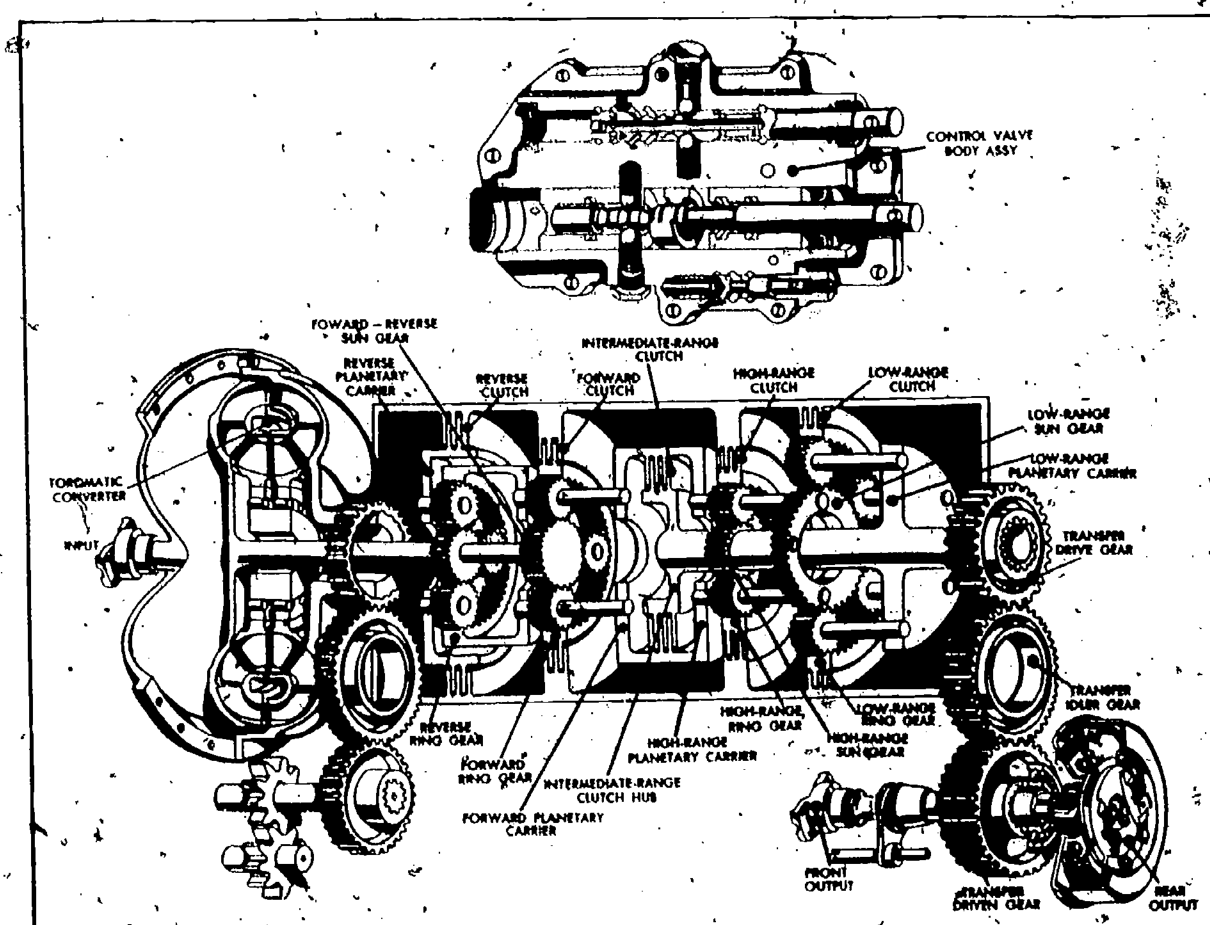


Fig 3-29. Torqmatic transmission and selector valve assembly.

(2) Application. The torqmatic transmission is used in the forklift, wheeled tractor, scoop-loader, and the 3-ton hydraulic crane. Variations of the planetary system will be found in other items of equipment and other components, such as the wheels of the MRS-100. The transfer drive is arranged to provide front and rear output shafts and a method of driving accessories.

(3) Maintenance. Maintenance of the torque converter and the torqmatic transmission is limited to changing the oil and replacing the filter. At the present time, faulty transmissions are replaced with a new or factory rebuilt unit. Most problems you encounter will be due to improper operation or neglected operator's maintenance. Remember that there is friction within the unit and friction causes heat; NEVER allow the converter-out temperature to exceed 250° F. The transmission clutches are engaged by oil pressure and released by spring; if there is no oil or oil pressure, the item will not move. Broken or weak springs or a restricted oil passage will prevent the clutch from releasing. Before servicing the equipment, you should refer to the specific TM for the item of equipment.

3-5. PROPELLER SHAFT

a. Introduction. The vehicle's power, having been transmitted through a component such as the transmission, is carried along the power train by a propeller, or drive, shaft. Propeller shaft is the common term; however, either can be used and is correct. In amphibious vehicles both terms are used; propeller shaft, to indicate the device that carries power to the propeller, and drive shaft, to indicate the device that delivers power to the wheels. The propeller shaft may be either solid or tubular. The twisting stress in a shaft varies from zero at the axis to a maximum at the outside. Since the center of the shaft resists only a small portion of the load, hollow shafts are used wherever practicable. It is attached to the components such as the transmission and differential of automotive vehicles by a universal joint or joints, and slip joints.

b. Slip joints.

(1) Because flexing of the springs, component mounting, or operation cause the component housing to move forward and backward, a slip joint is installed. This allows the propeller shaft to lengthen and shorten as required by operating conditions.

(2) A slip joint consists of a male and a female spline, a grease seal, and a lubrication fitting. The male spline is an integral part of the propeller shaft (fig 3-30) and the female portion is fixed to the universal joint directly behind the driving component. As the component housing moves forward and backward, the slip joint gives freedom of movement in a horizontal direction and yet is capable of transmitting rotary motion.

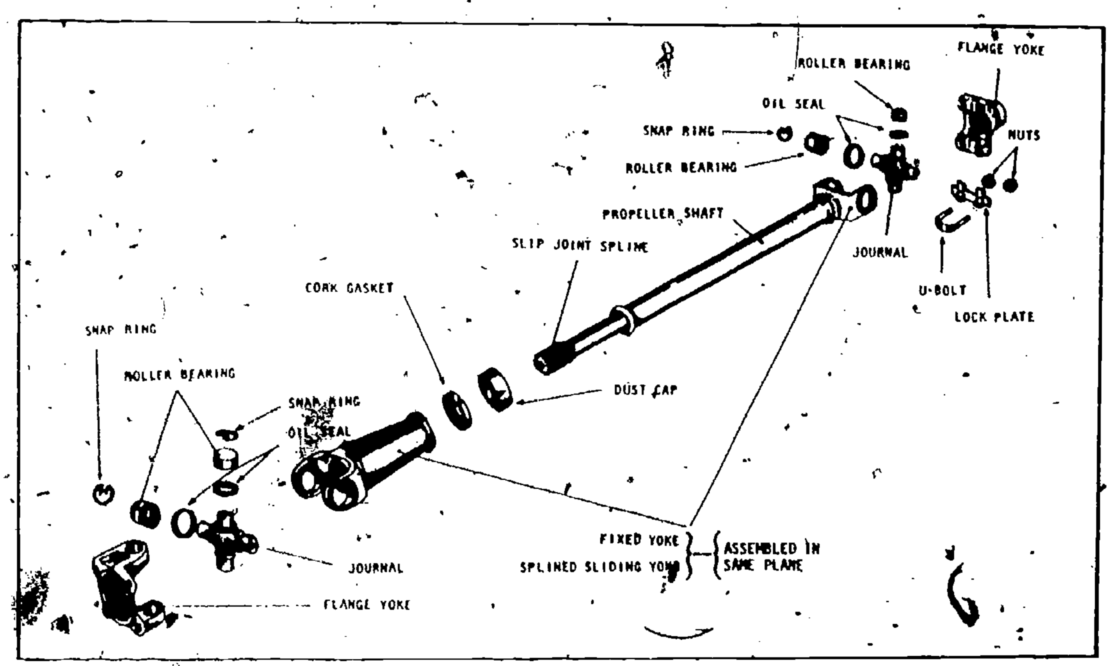


Fig 3-30. Propeller shaft disassembled.

c. Universal joint. A simple universal joint (fig 3-31) is composed of three basic units: one journal, and two yokes. The construction permits each yoke to pivot on the axis of the journal, and carries the rotary motion from one yoke to the other. As a result, the universal joint can transmit the power from the engine through the propeller shaft to the differential, which is constantly moving up and down in relation to the frame.

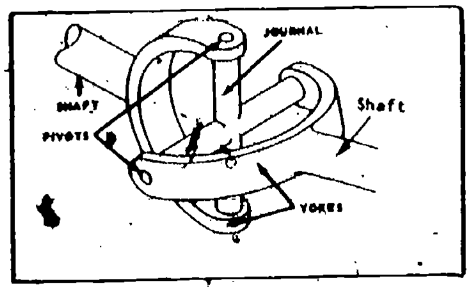


Fig 3-31. Simple universal joint.

(1) Characteristics of universal joints. A peculiar characteristic of the universal joint is that it causes a driven shaft to rotate at a variable speed with respect to the driving shaft. This variation is in the form of acceleration and a deceleration of the speed, twice during each revolution of the driving shaft.

This variation of speed cannot be eliminated when a simple universal joint is used. Its effect can be minimized, however, by using two universal joints (one at each end of the shaft). If only one joint is used between the transmission and the differential, the acceleration and deceleration caused by the joint is resisted on one end by the engine and on the other end by the inertia of the vehicle. The combined action of these two forces produces great stress on all parts of the power train, resulting in a nonuniform force being applied to the wheels. When two universal joints are used, the second joint compensates for the speed fluctuations caused by the first. To accomplish this, the angle between the transmission shaft and the propeller shaft must be the same as the angle between the propeller shaft and the differential. Another requirement is that the two yokes of the universal joints, which are attached to the propeller shaft, be in the same plane. If the yokes of the joints attached to the propeller shaft are in the same plane, the driving yoke of the first joint will be at an angle of 90° with the driving yoke of the second. The two yokes attached to the propeller shaft act as the driven yoke of the second joint. With this arrangement, the first joint is producing its maximum fluctuation at the same time the second joint is producing its minimum fluctuation. This results in a nonvarying wheel speed for a given engine speed, even though the speed of the shaft between the joints is constantly changing.

In a universal joint, bearings are included at the four points where the journal is attached to the yokes. In addition, one of the yokes usually incorporates a splined slip joint. In one type of universal joint the joint itself incorporates a feature that permits variations in length of the propeller shaft.

(2) Journal-type universal joint. There are several variations of the journal-type universal joint, two of which are shown in figures 3-32 and 3-33. The universal joints of this type vary from each other mainly in the manner in which the journal is attached to the driving and driven yokes. For example, in the universal joint shown in figure 3-32, the journal is assembled in the shaft and slip yokes; the bearing assemblies are inserted from the outside, and are secured by spring bearing retainers inside the yokes. The bearings on the transverse ends of the journal are clamped to the flange yokes and secured outward movement by bearing retainers. The universal joint shown in figure 3-33 differs from that shown in figure 3-32 in the manner in which the journal is attached to the flange yoke. In this universal joint, the bearing assembly is contained in bearing blocks. The blocks are mounted against the flange yokes and secured with bolts extending longitudinally through the yokes.

Fig 3-32. Journal-type universal joint with journal assembly in shaft and slip yoke.

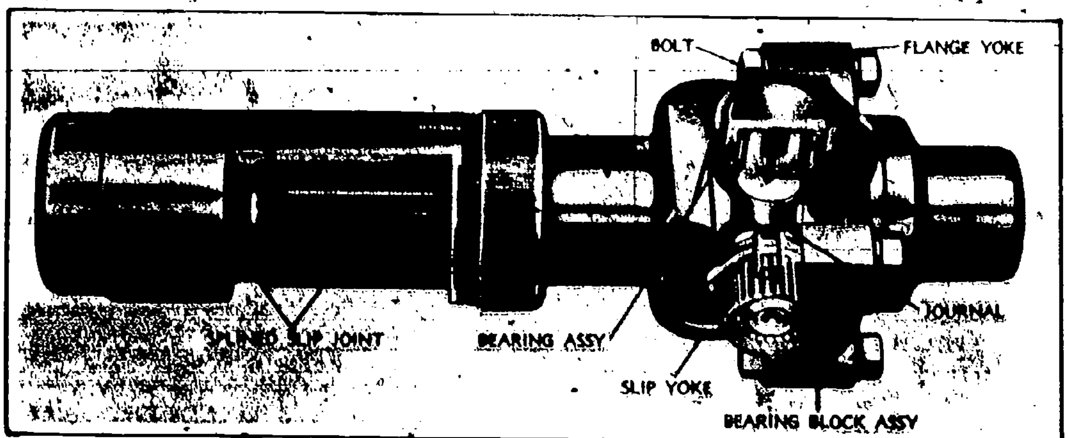


Fig 3-33. Journal-type universal joint with journal attached to flange yoke.

(3) General points.

(a) The universal joint just discussed is the most common on Marine Corps vehicles. Other types of joints may be found, especially on vehicles with 4-wheel drive where a constant-velocity universal joint must be used in the front axle; it reduces speed variations. For more detail on special universal joints, check the TM.

(b) Most universal joints do not require any maintenance for the life of the unit. Others may require disassembly and lubrication periodically.

(c) Worn universal joints will make noise. Check for worn universal joints by turning the propeller shaft by hand. Excessive backlash or looseness can be felt by hand pressure. Roughness at low to moderate speeds often indicates worn universal joints.

3-6. DIFFERENTIAL AND FINAL DRIVE

The propelling power train must be divided and directed to each driving wheel or track. This is accomplished by a differential or a final drive. The flow of power is turned 90°. The methods of directing the power flow for representative items of equipment are discussed below.

a. M37 crane-shovel. This vehicle uses a differential similar to that shown in figure 3-34. It is located near the center on the underside of the lower base assembly. The power enters at the vertical propelling shaft (pinion shaft) and rotates each differential propelling shaft (axle shaft). The bevel drive pinion splined to the vertical propelling shaft rotates the ring gear (bevel drive gear). A differential case is splined to the ring gear and rotates with it. Enclosed in the differential case are four differential pinion (spider) gears and two differential side gears. These gears are in mesh with each other, but are free to rotate in the differential case. The differential propelling shafts (one long and one short) are splined to the side gears. If the resistance is equal on both side gears, they do not rotate in the differential case, but turn with the assembly. When there is more resistance on one side gear than on the other, it tries to stop. This will cause the pinions to walk around the gear with the most resistance. The pinions being in mesh with the other side gear cause it to rotate. The difference in the gear ratio will cause it to rotate faster. As soon as the resistance equalizes, the pinions and side gears stop rotating independently and rotate as a unit with the ring gear and differential case.

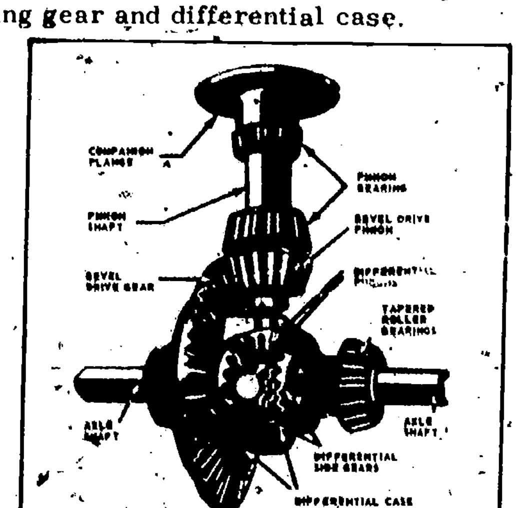


Fig 3-34. Differential with part of differential case cut away.

b. Grader. Attached to the rear of the grader lower transmission is the final drive assembly (fig 3-35). It turns the power flow 90° just as a differential in other machines, but it does not allow one wheel to rotate while the other is being held. Wheels on both sides of the grader are receiving power when power is being transmitted through the final drive. Power is transmitted by the bevel pinion gear, which is made as a part of the lower transmission pinion shaft, being in mesh with and rotating the ring gear. The ring gear is keyed to a shaft and bull pinion; the component is called the jack shaft assembly when the ring gear and parts are assembled. The bull pinion is in mesh with and rotates a bull gear. Splined to each side of the bull gear are axle shafts which transmit the power to both tandem assemblies. The gear on the lower transmission pinion shaft and the ring gear are the spiral bevel type. This provides more tooth contact and quieter operation. The bull gear and the bull pinion are the straight spur gear type. The bull gear and the jack shaft assembly are mounted on tapered roller bearings which require adjustment. The bearing preload is adjusted by adding or removing shims on the jack shaft assembly and an adjusting nut on the bull gear assembly.

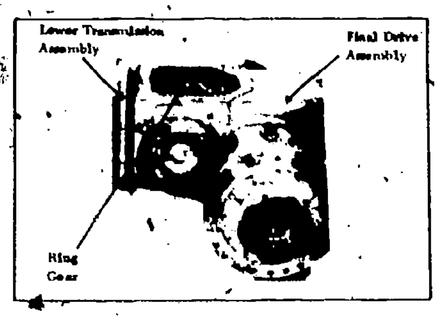
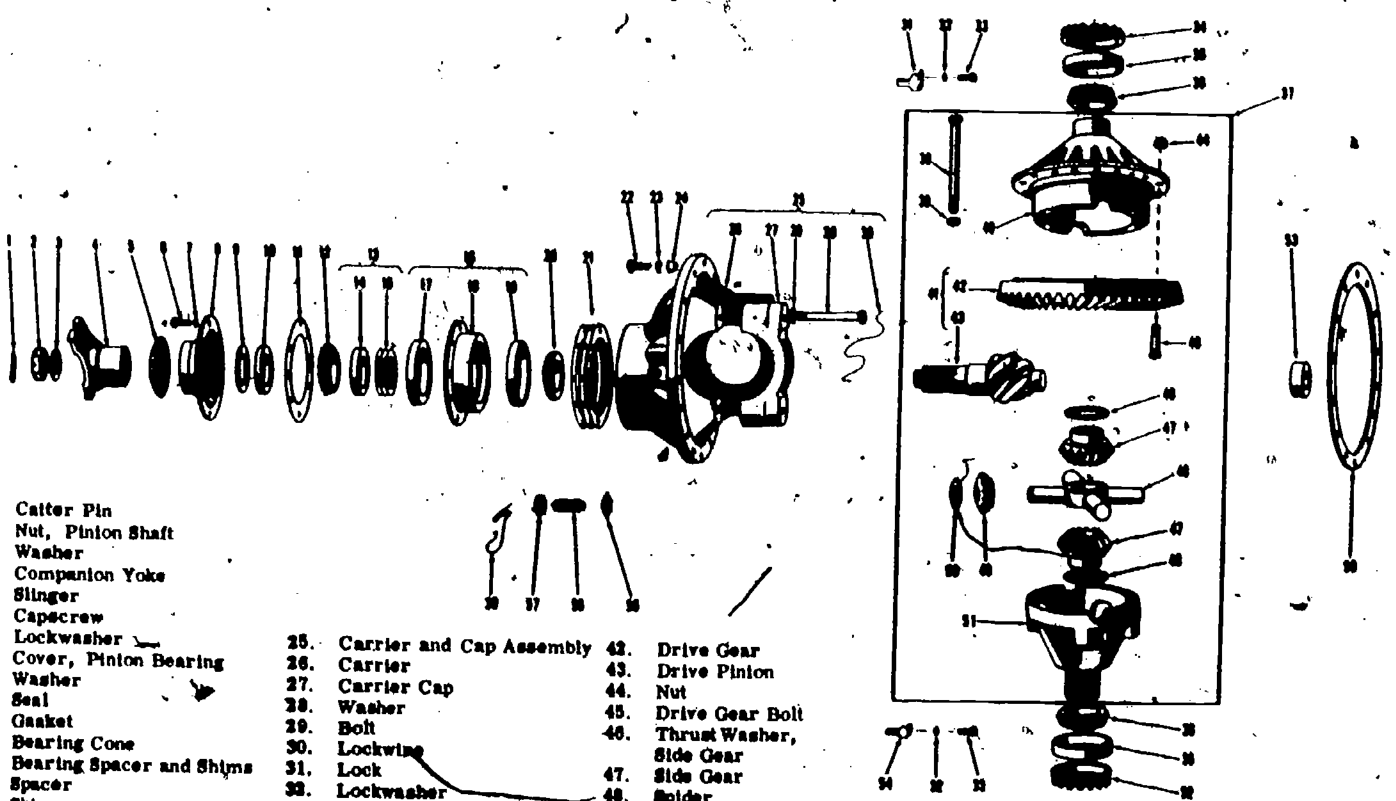


Fig 3-35. Final drive assembly.

c. MRS-100 wheeled tractor. This vehicle is equipped with two identical axle assemblies. The only difference between the two is the manner in which they are connected to the tractor. The rear axle has a rigid connection with the tractor frame. The front axle is connected so that it can swivel, preventing torsional strain when traveling over rough terrain. Each axle consists of an axle housing, a differential, two axle shafts with constant-velocity-type universal joints, two steering spindle groups, and wheels. Some of the parts other than the differential will be discussed briefly because they must be removed to perform differential repairs and must be considered when diagnosing problems.

(1) Axle assembly. The differential (fig 3-36) used in these assemblies is very similar to the differential used in the M37 crane-shovel. It performs four functions: transmits torque from the drive pinion to the axle shafts, changes the direction of rotation of the drive parts 90°, provides for a reduction in the double-reduction axle, and allows one wheel to turn at a different rpm from the opposite wheel. This tractor is also equipped with a differential lock which prevents wheel-spinning where the traction is poor. When the locks are engaged, the two wheels will rotate at the same rpm regardless of resistance. The axle is a double-reduction axle assembly; the first reduction is in the differential and the second reduction is in the planetary gearing in the wheels. Power from the propelling shaft enters the axle housing at the drive pinion. The drive (ring) gear is bolted to the differential case and is in mesh with the drive pinion. Therefore, it will rotate when the drive pinion rotates. The differential pinions and side gears function the same as those in the M37 crane-shovel differential unless the differential locks are engaged. The axle shafts rotate with the side gears or the differential case. Splines on one side of the differential case and a splined sleeve on one axle (fig 3-37) allow the operator to lock that axle shaft to the case by moving a collar to engage both sets of splines. With the axle shaft splined to the side gear and locked to the case, the side gear must rotate at the same speed as the case. This prevents wheel-spin because one side gear must rotate faster and one slower than the differential case during wheel-spin.



1. Cotter Pin
2. Nut, Pinion Shaft
3. Washer
4. Companion Yoke
5. Slinger
6. Capscrew
7. Lockwasher
8. Cover, Pinion Bearing
9. Washer
10. Seal
11. Gasket
12. Bearing Cone
13. Bearing Spacer and Shims
14. Spacer
15. Shims
16. Bearing Cage Assembly
17. Bearing Cup
18. Bearing Cage
19. Bearing Cup
20. Bearing Cone
21. Shims
22. Capscrew
23. Lockwasher
24. Dowel (Tapered)
25. Carrier and Cap Assembly
26. Carrier
27. Carrier Cap
28. Washer
29. Bolt
30. Lockwire
31. Lock
32. Lockwasher
33. Capscrew
34. Adjusting Ring
35. Bearing Cup
36. Bearing Cone
37. Differential, Drive Gear and Pinion Assembly
38. Case Bolt
39. Nut
40. Case, Half, Flanged
41. Gear Set
42. Drive Gear
43. Drive Pinion
44. Nut
45. Drive Gear Bolt
46. Thrust Washer, Side Gear
47. Side Gear
48. Spider
49. Differential Pinion (Four)
50. Thrust Washer (Four)
51. Case Half, Plain
52. Adjusting Ring
53. Bearing (Drive Pinion ;Hose)
54. Lock
55. Nut Lock
56. Thrust Screw
57. Jam Nut

Fig 3-36. Exploded view of MRS-100 wheeled tractor differential.

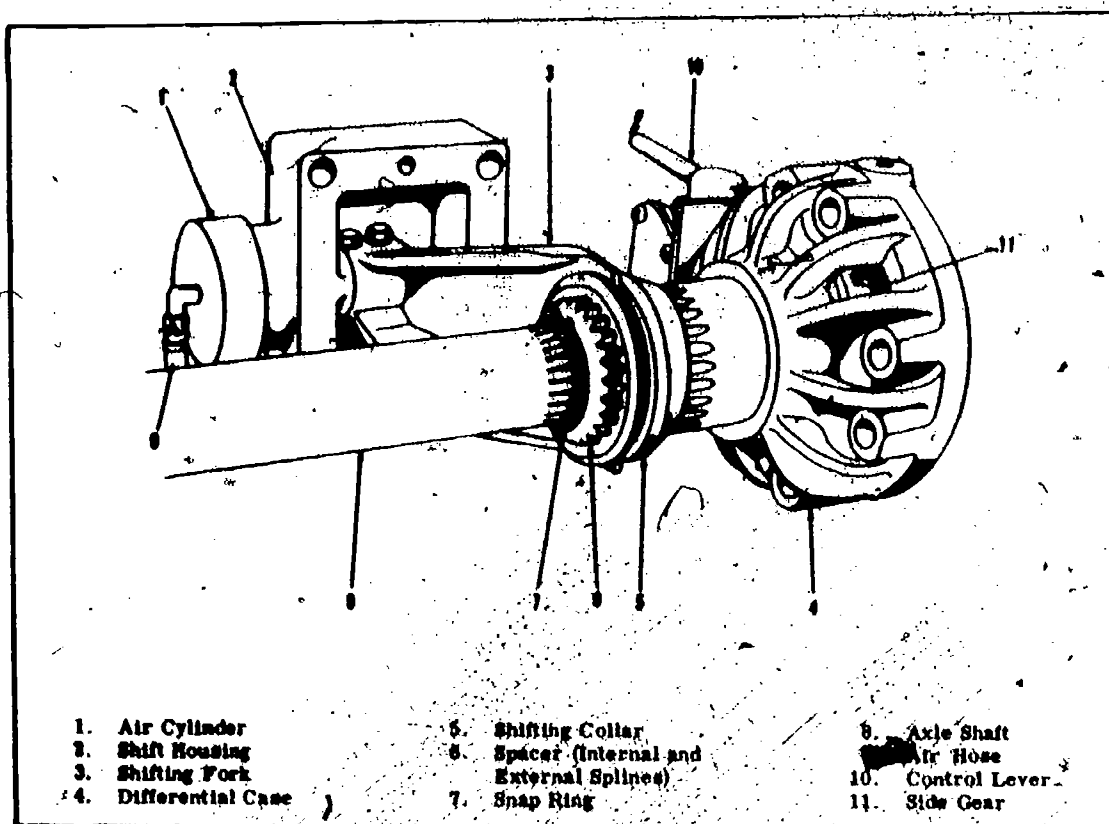


Fig 3-37. Differential lock.

It was stated earlier in this course that unless a special universal joint is used there will be fluctuation in the speed of the shaft. To prevent this, a constant-velocity universal joint similar to that shown in figure 3-38 is used. The universal joint provides a means of transmitting power to the wheels as they are turned at different angles. The spindle group (fig 3-39) serves as a means of supporting and steering the wheels. It also houses the constant-velocity universal joint. Removal of the spindle group is necessary to remove the differential.

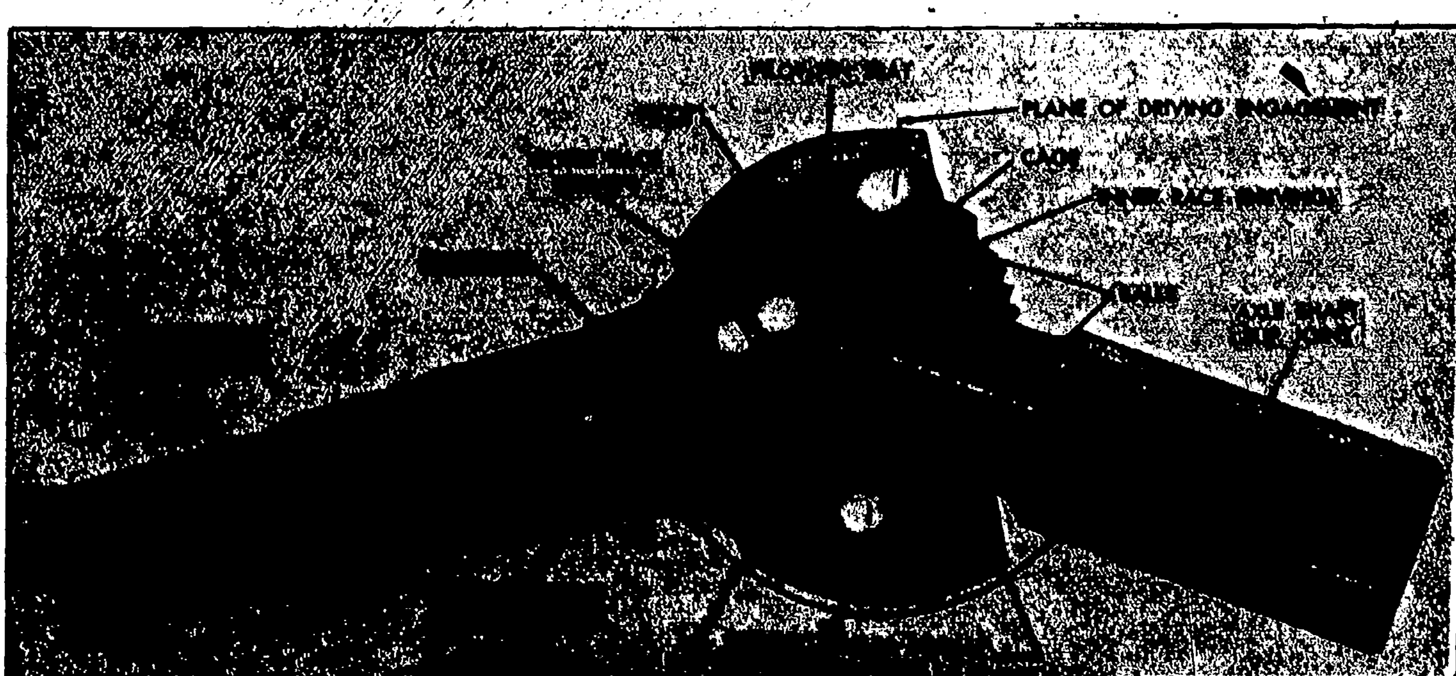
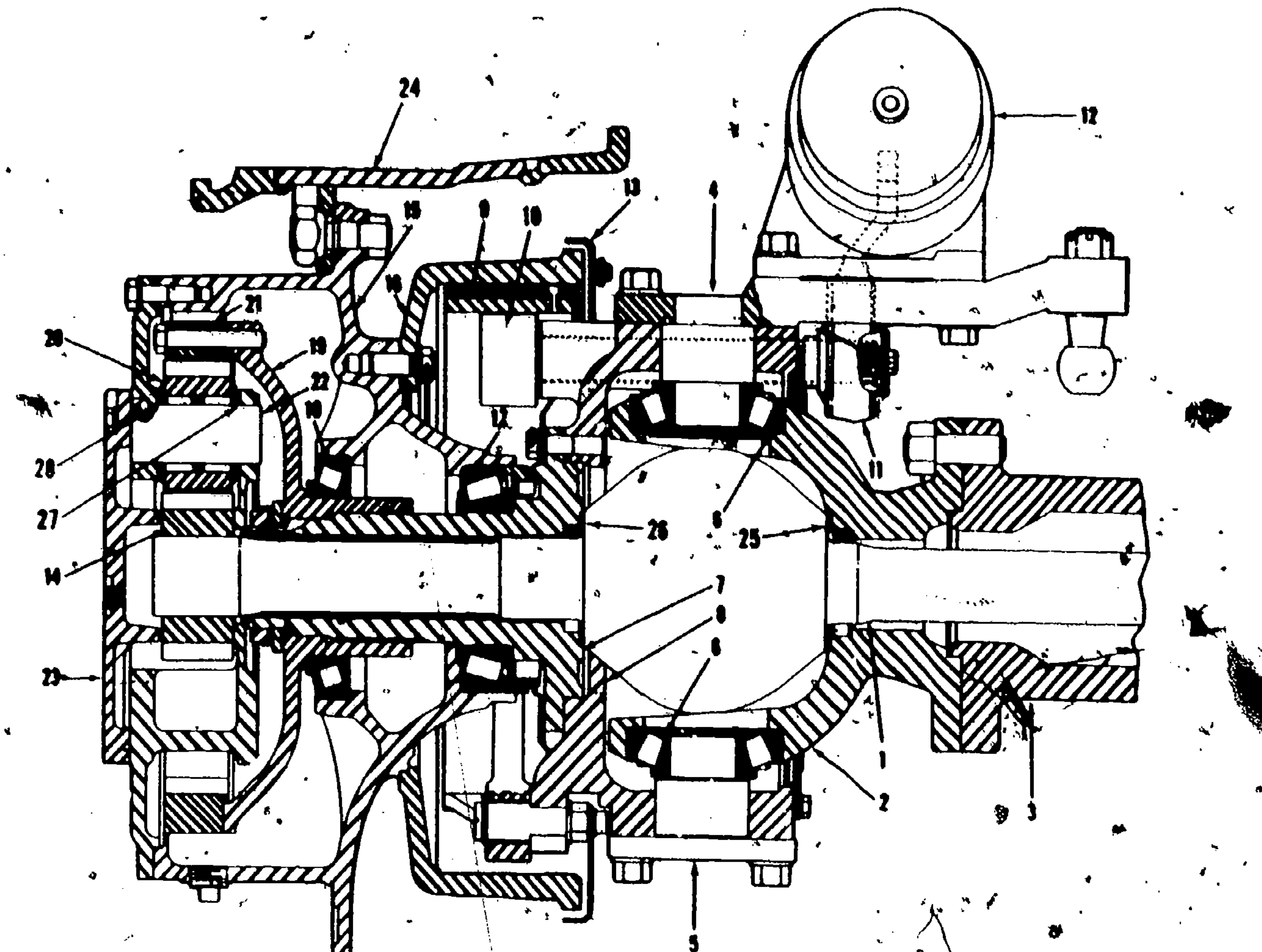


Fig 3-38. Constant-velocity universal joints.



1. Axle Shaft
2. Housing Outer End
3. Axle Housing
4. Steering Arm and Upper Trunnion
5. Lower Trunnion
6. Roller Bearing
7. Spindle
8. Spindle Support
9. Brake Shoe
10. Brake Camshaft
11. Slack Adjuster
12. Brake Chamber
13. Brake Rock Guards
14. Sun Gear
15. Wheel
16. Brake Drum
17. Roller Bearing
18. Roller Bearing
19. Ring Gear Spider
20. Planet Gear
21. Ring Gear
22. Planetary Gear, shaft
23. Hub Cap
24. Rim
25. Thrust Washer, Inner
26. Thrust Washer, Outer
27. Thrust Washer, Inner
28. Thrust Washer, Outer

Fig. 3-39. Sectional view of axle steering end.

(2) Relation to other vehicles. The axle assemblies used on the MRS-100 wheeled tractor are very similar to those used on other wheeled vehicles. Some parts of the axle assemblies are interchangeable, but be sure to check the stock number before substituting one of the parts. The axle assemblies of the MRS-100 tractor, the M60 crane, the scoop loader, and the forklift function alike. However, some of the vehicles are not equipped with differential locks and some of the axle assemblies are not steerable.

Chapter 4

AUXILIARY EQUIPMENT

4-1. HYDRAULIC SYSTEMS

a. Principles. In a hydraulic system, pressure applied at one place will be transmitted by the liquid throughout the system. The hydraulic systems used in engineer equipment work on the principle that a liquid cannot be compressed. Another hydraulic principle is that a force exerted at any point on a confined liquid will be distributed equally in all directions throughout the system (fig 4-1). Hydraulic pressure and piston area provide mechanical advantage. For example, the 5 sq in. piston in figure 4-1 with a weight of 20 lb gives a pressure of 4 pounds per square inch (psi). This example can be reversed and you can visualize that 4 psi is developing a total force of 20 lb (5 sq in. x 4 psi) on the large piston. Travel distance of the piston is related to the volume displaced. Volume and travel distance are illustrated in figure 4-2. Note that the small piston must move 4 inches to displace the volume of liquid required to move the large piston 1 inch.

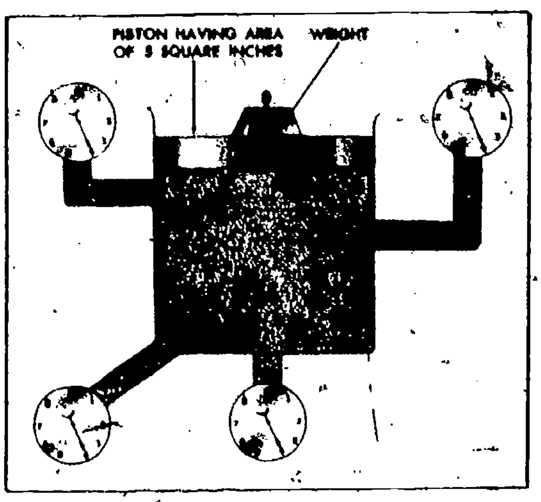


Fig 4-1. Distribution of hydraulic pressure.

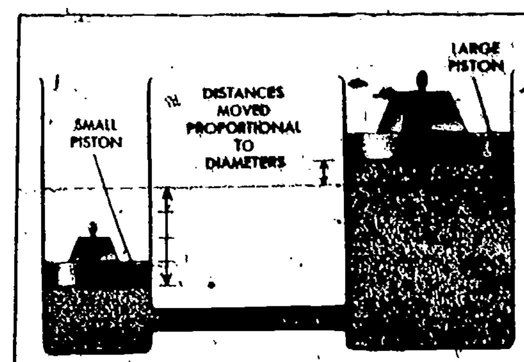


Fig 4-2. Piston movement and volume displacement.

b. Basic hydraulic system components (fig 4-3). Hydraulics can be used to push, pull, or turn components for operation. Some of the systems require a large volume of liquid for operation while other systems are similar to the hydraulic brake system.

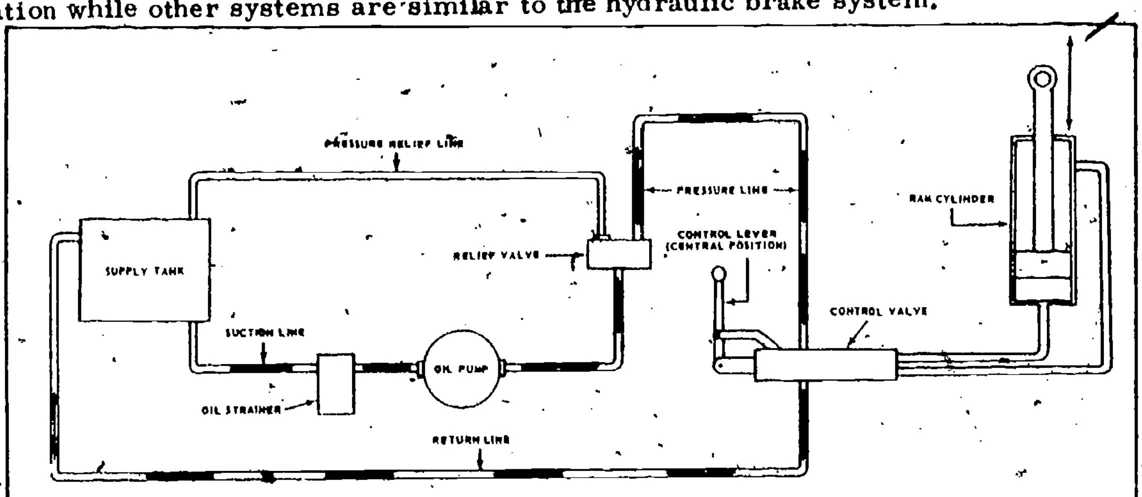
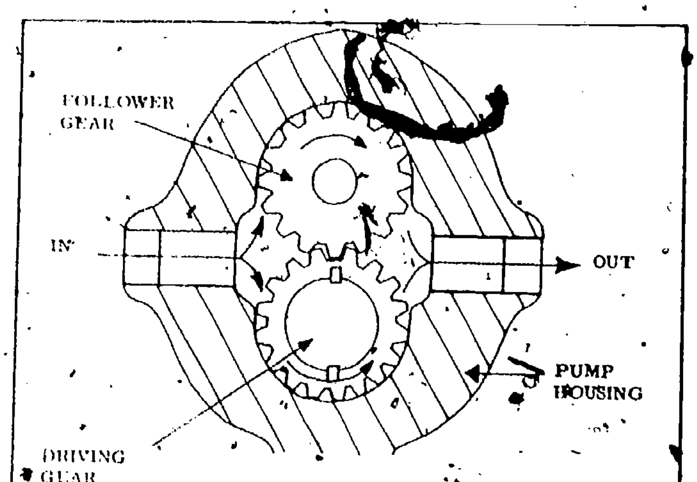


Fig 4-3. Components and flow of basic hydraulic system.

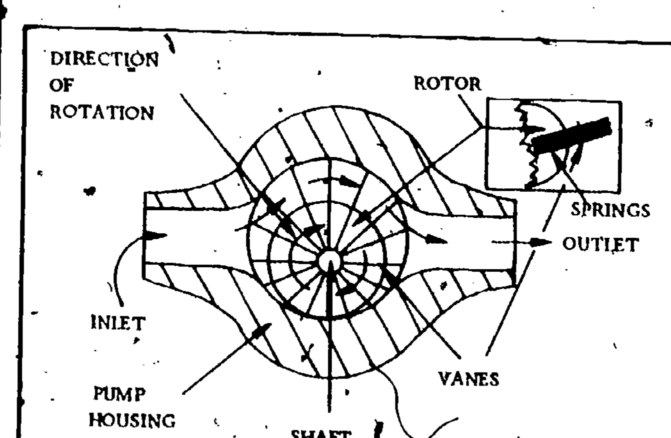
(1) Oil pump. The oil pump is a device for converting mechanical energy into hydraulic energy. It can be driven directly from the engine or by one of the vehicle components. It can also be used to serve more than one system. There are various kinds of pumps, such as plunger, gear, and vane used in hydraulic systems. These can be further classified as positive or non-positive displacement types. They are rated according to the volume of output in gallons per minute (gpm). Regardless of the type or classification, they can also be a fixed or variable volume type. The fixed volume is changed by speed only while the variable volume pumps have mechanical means for changing the volume. Pumps do not create pressure, but they produce the flow necessary to develop pressure. The pressure is created by a resistance to the flow. For example, a pump will cause liquid to flow through a line until the line is closed and it fills. If the pump continues to operate, the addition of more fluid will develop pressure. The pressure will act in all directions and restrict the flow. The flow from a non-positive pump can be stopped by this pressure, but from a positive displacement pump some protective device is required to prevent damage.

(a) Gear-type pump. There are both positive and non-positive displacement gear-type pumps. The pump illustrated in A, fig 4-4 is a positive displacement type which is used most often in the engineer equipment hydraulic systems where high pressures and volume are required. One of the gears is turned and drives the other (follower) gear. As they rotate, oil is trapped between the gear teeth and the pump housing and pushed out the outlet side. The gears mesh closely and have very little clearance between them and the pump housing.

(b) Vane-type pump. Vane-type pumps can also be positive or non-positive displacement types. The pump illustrated in B, figure 4-4 is a positive displacement type pump. It has a slotted rotor which is off center to the pump housing. Fitted into the slots are the vanes which are free to move outward, but side movement is restricted by the pump housing end plates. On some pumps, the vanes may have springs which push them out to the housing while others depend upon centrifugal force to keep them out. As the rotor rotates with the vanes, liquid on the inlet side is trapped between the vanes, the rotor, and the pump housing. Since the rotor is offset, the liquid is squeezed out on the outlet side of the pump.



A. Gear-type pump.



B. Vane-type pump.

Fig 4-4. Oil pump.

(c) Reciprocating-type pump. A simplified reciprocating (plunger) is illustrated in fig 4-5. There are many variations of this simple pump, but the principles of operation are basically the same. It is a cylinder equipped with an inlet and outlet check valve and a piston. For some applications the check valves are replaced by ports which are opened and closed by the pump piston or by another piston. One such application is the brake system master cylinder. Some hydraulic engine governors also use this type pump. These pumps are normally used where large volumes are not required. As the piston moves away from the inlet port, a partial vacuum allows the liquid to force the inlet check valve open and fill the cylinder. When the piston starts in the opposite direction, the pressure builds up and forces the inlet valve closed and the outlet valve open.

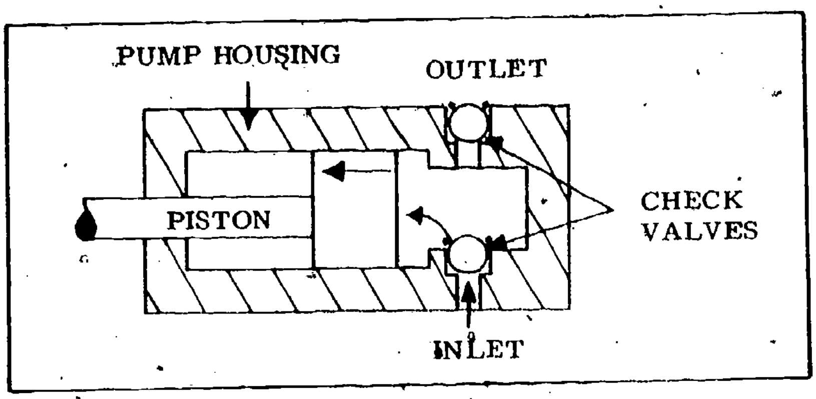


Fig 4-5. Reciprocating-type pump.

(2) Supply tank. The supply tank is large enough to supply the complete system and to maintain a reserve. On some vehicles the supply tank may serve more than one system.

(3) Oil strainer. The oil strainer protects the hydraulic pump by trapping the larger particles of foreign matter that may enter the suction line. It may be installed in the tank or in the suction line as illustrated.

(4) Valves. Valves are used in hydraulic systems to control pressure and the direction and rate of fluid flow. The valve name is generally related to its function such as pressure control valve or relief valve. There are too many valve configurations to cover them all, but representative type pressure and directional control valves are discussed below.

(a) Pressure control valve. There are four basic types of pressure relief valves: pilot type, differential piston type, guided piston type, and spring loaded poppet type. The pressure relief valve is the most common of the pressure control valves and is used to protect the system from overload. Figure 4-6 illustrates a simple spring-loaded poppet relief valve. The system pressure works against a spring-loaded poppet ball. When the system pressure overcomes the spring pressure, the ball will unseat and allow the fluid to flow to the supply tank. When the system pressure lowers, the spring will cause the ball to seat and stop the flow. Some valves of this type are adjustable; the pressure setting is changed by changing spring tension.

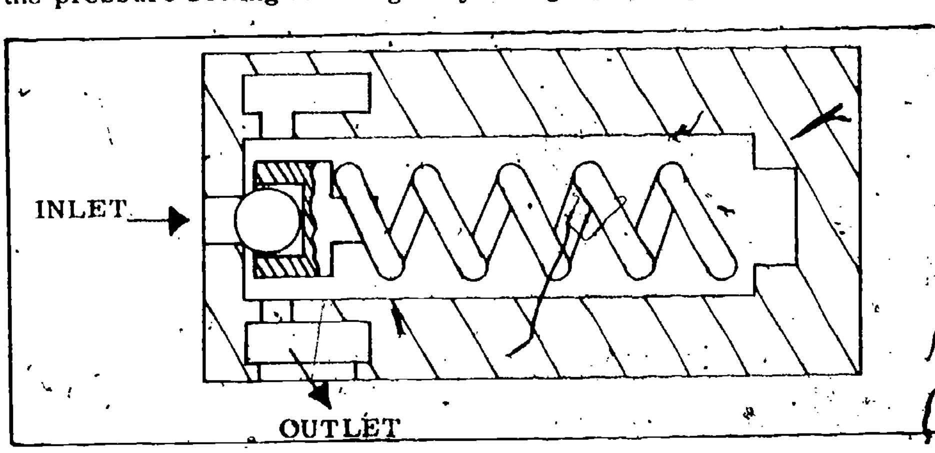


Fig 4-6. Simple relief valve.

(b) Directional control valve. This valve directs the fluid flow to the desired part of the hydraulic system. Some of the valves work automatically, but the one illustrated in figure 4-7 is moved by the operator or another force. The valve shown blocks the fluid flow or opens ports to allow flow. It will allow the fluid to flow in one direction only, but there are valves which provide passages for fluid return and bypass. Study the illustration and you can see that when both large passages are open the fluid flows to the work. By moving the spool valve the passage from the pump can be closed off and stop the flow, but the fluid to the work is also trapped. The drains at each end prevent leakage by the spool (hydrostatic lock) causing the valve to lock in position. By combining two of these valves, a return passage for the fluid from the work could be provided.

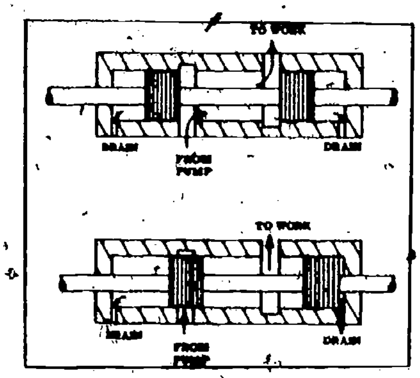


Fig 4-7. Simple directional control valve.

(5) Ram cylinder. The ram cylinder is connected by linkage to the part that is to be controlled. Oil enters the cylinder on one end and forces the piston to move; as the piston moves it will force out the oil on the other side of the piston. Although there is only one ram cylinder illustrated (fig 4-3), most hydraulic systems will have several.

(6) Lines. The lines carry the oil through the system. They may be pipe, tubing, or flexible hose with strength enough to withstand the pressure. The line must be large enough to carry the volume without significant loss.

c. Maintenance. General maintenance of the system consists of keeping the supply tank filled to the proper level with the proper liquid, changing the filters or cleaning the strainer, cleaning, and repairing leaking connections. The most important single item of maintenance that will insure trouble-free operation is cleanliness; clean oil, clean filters and strainers, and clean vents. Most hydraulic systems except brakes use a light mineral base engine oil (such as OE-10). The oil must provide lubrication and transmit the power; it should also have a wide operating temperature range.

d. Applications. Hydraulic systems are used to control or assist in controlling clutches and brakes, to power attachment lifts and hoists, and to operate shop tools and equipment such as jacks and lubrication equipment.

4-2. COMPRESSOR

a. Application. An air compressor is used to supply the air requirements for air-controlled components of engineer equipment. It provides the air for airbrake systems, for tires, for cleaning, and for air-operated lubrication equipment.

b. Operating principle. Construction of the reciprocating compressors (fig 4-8) used on Marine Corps engineer equipment is similar to the internal-combustion engine. They are belt- or gear-driven by the engine. As the crankshaft is turned, the piston moves up and down. On the down stroke, atmospheric pressure forces the unloading valve off its seat and fills the cylinder. When the piston starts up and the pressure has become equal on both sides of the valve, a spring will close the valve, trapping the air in the cylinder. Note that this unit does not use a camshaft to open the valve. The piston continues upward compressing the air, and when the air pressure is sufficient to overcome spring tension of the discharge valve, it pops open and the air flows to the air receiver. When the air pressure in the receiver reaches the set psi, the air governor functions and directs the air pressure to operate the unloading lever. The unloading lever holds the unloading valve open and the piston cannot compress the air enough to overcome the discharge valve spring tension.

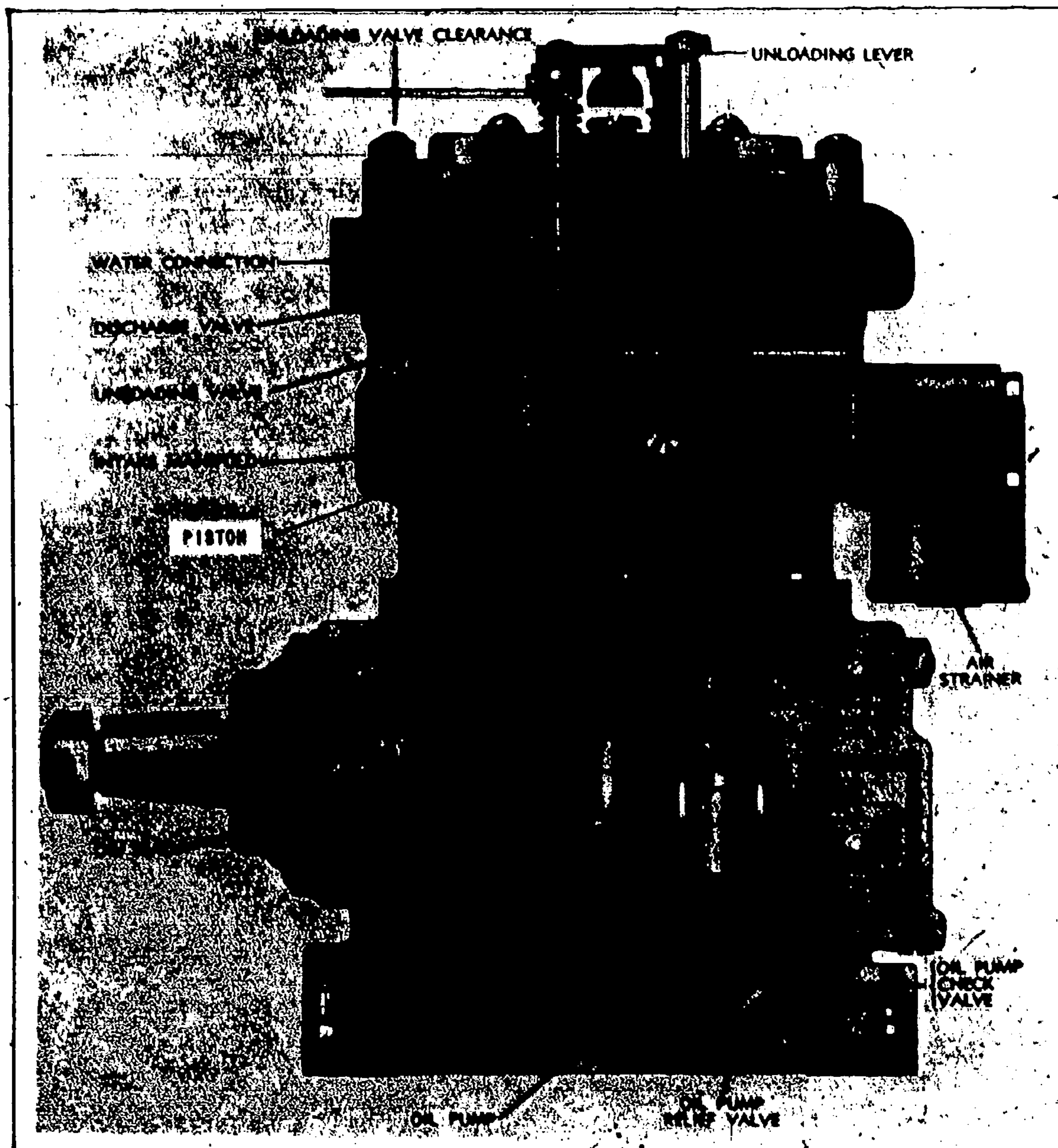


Fig 4-8. Two-cylinder, self-lubricated, reciprocating air compressor.

4-3. ELECTRICAL SYSTEM

a. Introduction. The electrical system consists of a generating (charging) circuit, starting circuit, ignition circuit (not required for all equipment), lighting circuit, and instrument circuit. The mechanical operation of the many parts and components used in these circuits can be observed and understood, but the force (electricity) produced, transmitted, and used by them cannot be seen and is difficult to understand. Only the behavior of electricity can be observed. The physical components can be repaired or replaced, but a knowledge of electrical theory is necessary to test the components and diagnose the problems which may arise in them. These theories are discussed in other MCI courses and some TM's. Because the theory will have an effect on the test readings and observations, some basic points are discussed briefly in this course to emphasize their importance.

(1) Direct-current (d.c.) electricity flows in only one direction. It flows from the negative battery post or generator terminal through the circuit and back to the positive battery post or the generator frame.

(2) It requires 1 volt to force 1 ampere through 1 ohm of resistance. Resistance is affected by the size (diameter and length) and composition of a conductor.

(3) Current flowing through a conductor will create heat in the conductor and a magnetic field around it. Electricity is produced by moving a conductor through a magnetic field, and current flowing through a conductor can be used to produce a magnetic field.

b. Charging circuit. The function of the charging circuit is to keep the storage batteries charged. The circuit consists of a generator or alternator, voltage regulator, ammeter, batteries, and conductors. The battery is the source of electrical energy when the engine is stopped, when the engine is idling too slow for the generator to supply the electricity, or when the circuit or some of its components fail. The other parts and components of the circuit transmit, control, measure, and use the electricity produced by the generator or the battery.

(1) Generator. Most engineer equipment is equipped with a generator to convert mechanical energy from the engine into electrical energy. However, some of the newer items of equipment are equipped with an alternator. Both components provide dc electricity for charging the battery or supplying the other electrical system components. Both components produce alternating current (a.c.); however, the generator uses brushes to pick up the current from a commutator and does not get the ac. The alternator picks up the current from a stator and must pass it through a diode or rectifier to change it to dc for use in the electrical system. A diode or rectifier will allow the current to flow one way, but will not allow it to flow the other. By using a specific number of diodes, all of the current produced by the alternator can be used while only half of that produced by a generator is picked up and used. Either one is designed to produce sufficient current to keep the battery fully charged and have sufficient reserve to carry the load of the other electrical system components. They produce enough electricity to destroy themselves if not properly controlled. The current produced depends on the number and length of conductors that pass through the magnetic field, the strength of the magnetic field, and the speed of the generator (the speed at which the conductors pass through the magnetic field). The rpm is related to the engine rpm, but this is not an effective method of controlling generator output. However, the rpm can be changed by changing the diameter of the generator or engine drive pulley. Output is most effectively controlled by changing the strength of the magnetic field. The magnetic field strength is controlled by the amount of current flowing through the field coils. Some generating components are controlled by internal resistance or parts while others are controlled by external parts or a combination of internal and external parts. These parts, whether internal or external, change the amount of resistance to the flow of current in the circuit that produces the magnetic field. Figure 4-9A shows the path of current flow in a standard-duty type shunt generator. Notice that the field coil is connected to the insulated brush and is grounded outside the generator. This circuit is also known as an "A" type circuit. Figure 4-9B is a heavy-duty type circuit of a shunt generator. Notice that this generator has the field coil grounded to the grounded brush. This circuit is also known as the "B" type circuit.

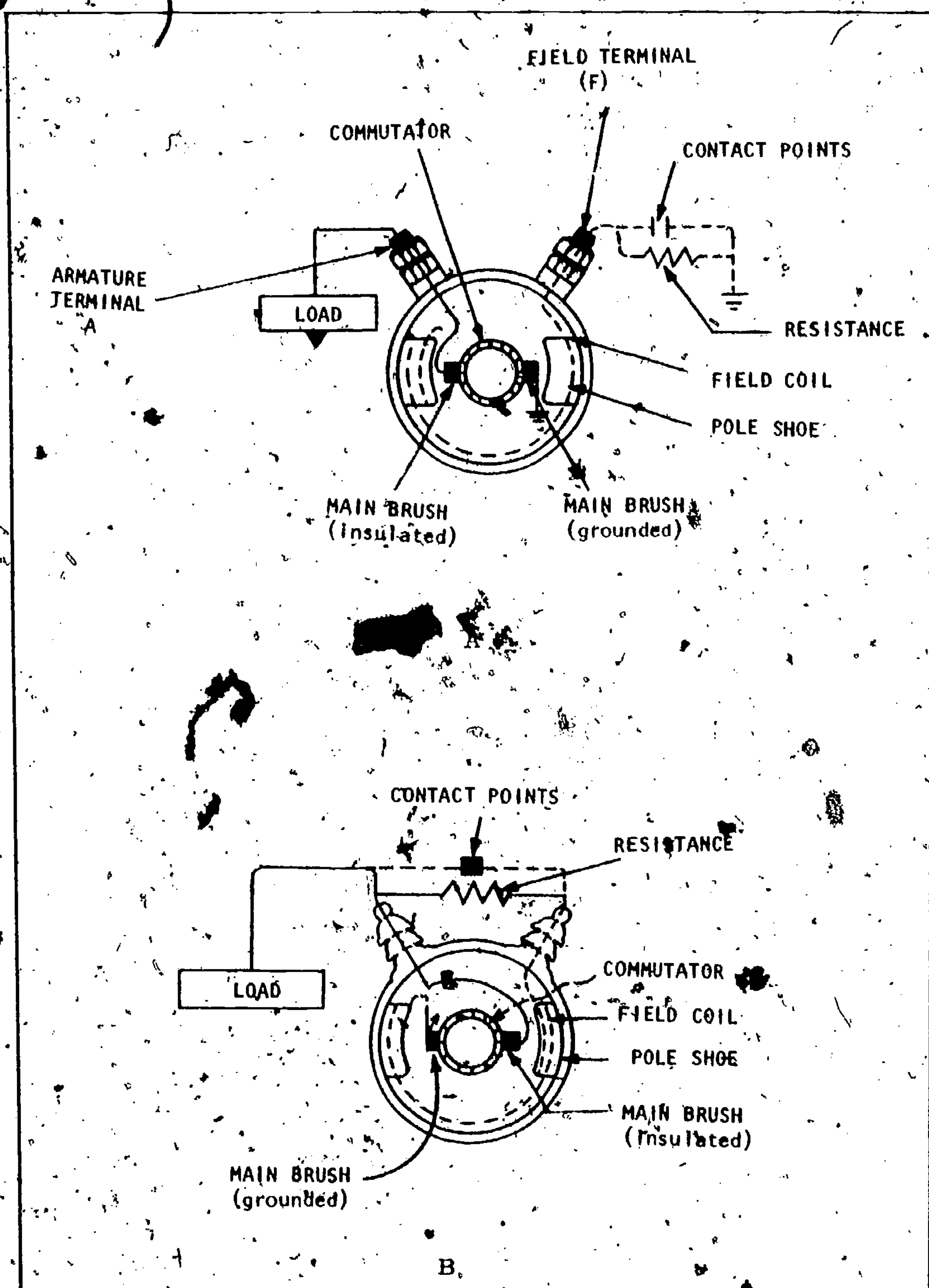


Fig 4-9. "A" and "B" type shunt generators.

There are also other types of generator circuits in use. Figure 4-10 is a cutway view of an alternator. The field coils of this component rotate with the rotor while the current is produced in the stator winding. Current flow for the field, but not for external use, is transmitted through brushes and slip rings. A newer alternator is presently being tested for use on engineer equipment. It is a long-life, internally controlled, sealed unit with only one external connection.

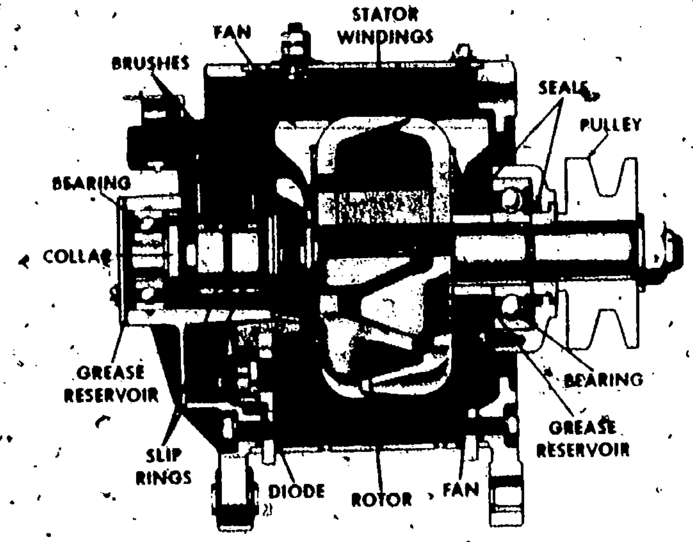


Fig 4-10. Cutaway view of typical alternator.

(2) Regulator. This is the component that protects the generator by regulating the current and voltage output and disconnects the battery from the generator when the generator is not operating. Figure 4-11 is a wiring diagram of a regulator for use with externally grounded generator field windings. The windings of the cutout relay and current and voltage regulator units produce a magnetic field to open or close contact points to control current flow through the generator field. Magnetism from the windings is opposed by spring tension. Notice that this regulator also has shunt windings to oppose the series windings. There are several types of regulator assemblies, each designed to be used with a particular type of generator and electrical system. For example, a regulator such as the one in figure 4-11 is designed to be used with a generator like that in figure 4-9A. Figure 4-12 is a wiring diagram of a regulator used with alternators in a negative ground circuit. In this system, the battery connections are very important.

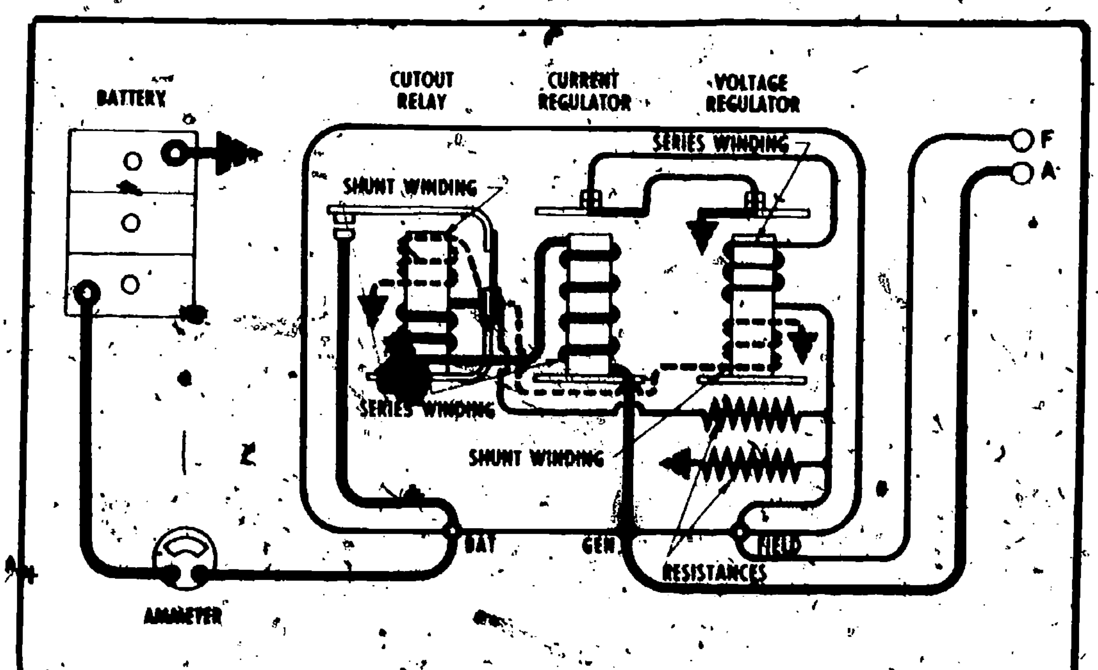


Fig 4-11. Schematic of generator regulator circuit.

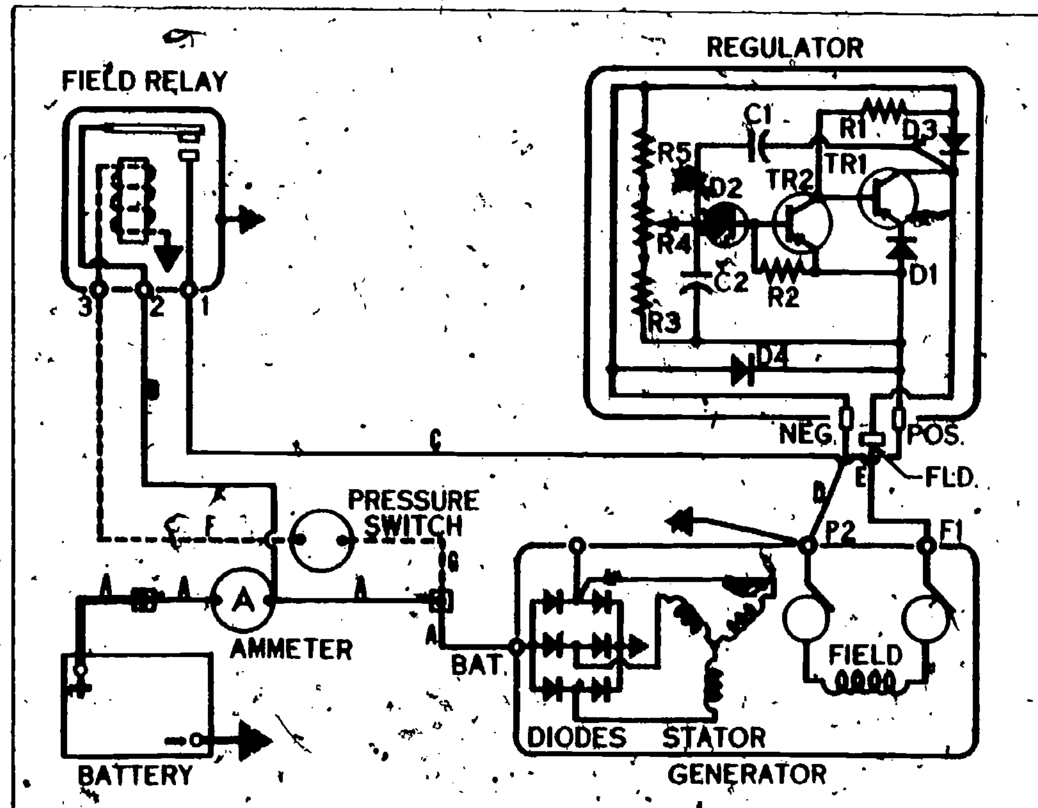


Fig 4-12. Schematic of alternator charging circuit.

(3) Ammeter. This component is connected in series between the voltage regulator assembly and the battery (fig 4-11). It measures the amount of current flowing in the circuit. It also serves as a terminal to supply other circuits with electricity. When the conductors are properly installed, the ammeter will show the amount of current flowing to or from the battery except the current used by the cranking motor.

(4) Conductors. Conductors used in the circuit are a specific size (diameter) and composition. Although the length of a conductor affects the amount of resistance, the diameter and composition are the most important factors. Conductors are used throughout the electrical system and they must be large enough and of a composition that will allow the current to flow freely unless specified resistance is required. They must be insulated to prevent shorting of the circuit. The connectors must be tight to the conductor and clean and tight at the terminal junctions.

c. Starting circuit. This part of the electrical system uses electrical energy from the storage battery to crank the engine. The basic components of the circuit are the conductors, switches, and a cranking motor. The conductors transmit the electrical energy, the switches open and close the circuit, and the cranking motor converts electrical energy into mechanical energy. Any starting circuit performs these basic functions, but there are many designs, each with various parts and components. Solenoids may be used to operate the switches and engage the cranking motor drives. A solenoid will require an electrical circuit to control its operation. The solenoid has a winding that creates a magnetic field to move linkage and perform its operation. Although it is a separate circuit, it is considered part of the starting circuit. The cranking motor is constructed like the generator, but the internal wiring is designed to create a much stronger magnetic field. It operates on the principle of magnetic repulsion: like magnetic poles repel. The field and armature windings will allow more current to flow with less resistance than a generator and create stronger magnetic fields. Current transmitted to the cranking motor divides; some flows through the field coils to ground and some through brushes to the commutator, armature, and to ground. The two magnetic forces repel each other and cause the armature to rotate. A drive assembly connected to the armature either engages the engine part automatically or is shifted into engagement by a solenoid. Some solenoids are designed to engage the drive and close the starting circuit, others just close the circuit or connect more batteries in series to increase the voltage available for cranking. The amount of current flowing through the circuit is limited by the condition and capacity of the battery and the resistance of the parts. However, there is sufficient current to destroy the cranking motor. To prevent this destruction, never operate the cranking motor longer than 30 seconds. Allow it to cool for approximately 60 seconds before recranking.

d. Lighting circuit. This part of the system provides the circuitry and components necessary for illumination and for warning lights. The circuit consists of conductors, fuses and/or circuit breakers, switches, and light bulbs. It is made up of one or more circuits. The light bulbs may be single- or double-contact, bayonet- or screw-type, or 3-terminal sealed beam. They may have one or more filaments which produce light. Most bulbs use the base as a ground, but some of the sealed units use one of the contacts or terminals as a ground. The contact or terminal is connected to a wire that also connects to the vehicle frame. Some lighting circuits use two wires, others use only one. In the single-wire circuit, the vehicle frame serves as the circuit return (ground). This is the most common type in use today. The bulbs in a circuit, except the turn signals, are connected in parallel and controlled by a switch connected in series. The turn signals are connected in series on most vehicles. The filament of a light bulb is designed to perform its function with a certain number of amperes at a specific voltage. An increase in the voltage will cause the bulb to fail. The current from the battery may pass through a resistor to reduce the voltage, depending on the voltage of the system and the voltage required for the circuit. A light bulb provides resistance, but circuit breakers and fuses are used to protect the wiring in case it shorts. If the conductor shorts, the increased flow of current through the circuit breaker will cause the metal contact in it to heat and warp. This action opens the circuit and stops the current flow. The switch provides the operator with a method of opening and closing the circuit. The lead that provides the current for the lights is usually connected to the generator side of the ammeter or to a junction block in the circuit between the generator and the ammeter. Connecting in this manner allows the ammeter to show how much current is being used from the battery to operate the lights, but it does not show the amount of current that is provided by the generator for lighting.

e. Instruments. Some instruments used on engineer equipment are electrically operated. They use a sending unit connected to a gage by a conductor. The sending unit mounted on the component (such as the fuel tank) is a variable-resistance switch that activates the gage. Although emergency shutdown devices are not considered to be instruments, they have sending units connected to solenoids or magnetic switches. Both types of sending units operate because of levers, pressure, heat, electricity, or speed. Some of the sending units serve to ground the circuit; others have two wires connected, and open and close the circuit between the two. The gages react to the amount of current flowing through them. The solenoid becomes activated as soon as the circuit is opened or closed depending on the manner in which it was designed to operate. The cutout relay is an example of a type of solenoid that functions as soon as current flow stops. The solenoid used on the starter requires current flow to activate it. Some of the emergency shutoff devices have an overriding switch that prevents operation of the emergency shutoff devices.

4-4. STEERING SYSTEMS

a. Introduction. The maneuverability of engineer equipment depends on the vehicle being able to make short turns. It must be easily steered while operating over the roads or in rough terrain. Crawler-type vehicles use steering clutches and brakes while the wheeled vehicles use a rugged automotive-type steering. Some systems have independent rear brakes to assist steering.

b. Mechanical. Figure 4-13 is a diagram of a mechanical steering mechanism. The operator turns the steering wheel which is connected to a worm in the steering gear assembly. The worm rotates a gear connected to a shaft and pitman arm. As the arm moves, other attached linkage causes the spindles and wheels to turn right or left. The steering knuckle arms are rigidly attached to the spindles.

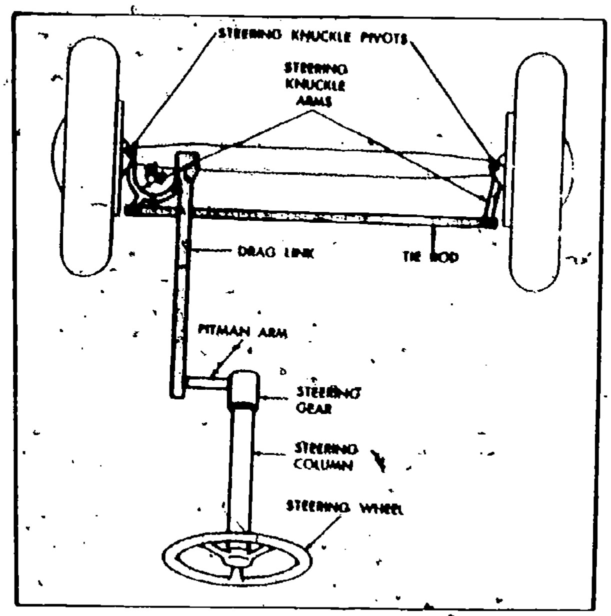


Fig 4-13. Mechanical steering mechanism.

The vehicle ought to be easy to steer, and the effects of rough terrain on the wheels should not be transmitted back to the steering wheel. Figure 4-14 is one type of steering gear designed for easy steering. Balls serving as bearings between the worm and gear reduce friction. However, it still acts as a worm and gear and if a force is transmitted from the opposite direction the gear will rotate, forcing the worm to bind. The binding reduces the force transmitted to the steering wheel.

1. Column jacket
2. Housing
3. Ball nut
4. Steering arm shaft
5. Lash adjuster screw
6. Side cover
7. End cover
8. Worm bearing thrust screw
9. Worm lower bearing
10. Worm
11. Steering arm
12. Ball guides
13. Worm upper bearing

Fig 4-14. Phantom view of recirculating ball-type steering gear.

c. Power. The power steering system is similar to the mechanical system except that hydraulics are used to assist the operator and, on some vehicles, hydraulic components replace parts of the mechanical system. A control valve is attached to the steering gear assembly so that movement of the worm gear in and out will move the control valve plunger. For those vehicles steered by hydraulics only, the control valve plunger is controlled by the operator. A double-acting cylinder is attached between the vehicle frame and the steering linkage. Movement of the control valve plunger allows the oil to act on the piston, forcing it in or out, which causes the wheels to turn right or left.

4-5. VEHICLE FRAMES

a. General. The wheels and frames of engineer equipment serve the same purpose as the wheels and frames of automotive vehicles; however, the framework is of heavier construction, the suspension system is different, and some of the wheels contain planetary systems.

b. Wheeled vehicle.

(1) Components and function.

(a) Frame. The frame supports and keeps alined on the components of the power train and vehicle attachments. It is constructed from materials that will withstand twisting, bending, and road shocks. It may be welded, bolted, or riveted together and on some vehicles the case of the power train component is part of the frame.

(b) Wheel and axle assemblies. The wheel and axle assemblies are connected to the vehicle frame and transmit the power flow to the ground. The axle assembly may be connected so that it can pivot and absorb shock when operating over rough terrain. Within the axle housing are gears arranged to increase or decrease torque and speed, and to change direction of the power flow. Most assemblies contain a differential with spider gears which allow one wheel to turn faster than the other; under certain conditions all the power is directed to one side. The spider gears will direct the power flow to the side with the least resistance. Bolted to the end of the axle housing is the planetary ring gear spider. The planet pinion cage drives the wheel. The axle is splined to the differential side gears and has the planetary sun gear attached to its outer end. If the axle is steerable, it will have a universal joint. The bearings between the wheel and the axle housing provide a pivot point for front-to-rear pivoting. The center of one axle housing is connected to the frame by a pin which provides a point for the pivoting from side to side.

(c) Propeller shafts and universal joints. The propeller shafts and universal joints are not a component of the vehicle frame or wheels, but transmit the rotary motion from one component to the other along the framework. The universal joint allows the direction of power flow to be changed slightly. Some propeller shafts are supported by bearings in the driving component and in the driven component. Most propeller shafts have a slip joint that is free to extend or contract the length of the propeller shaft when distance between the driving and the driven component is changed due to operation or terrain. The slip joint is usually a loose-fitting internal and external spline.

c. Tracked vehicle.

(1) General. The track frame assembly of crawler-type engineer equipment supports the machine and its attachments and provides a type of platform (tracks) for the machine to travel across. Marine Corps tracked vehicles are equipped with either a rigid- or a semirigid-type track frame assembly.

(2) Rigid-type track frames. These frames do not pivot in any direction. They provide stability for the vehicles when operating on level terrain, but a slight rise in the terrain will cause the vehicle to rock.

(3) Semirigid track frames. These frames are attached to the vehicle in a manner that will allow the assemblies to pivot up and down. One end of the assembly is bearing-mounted to a shaft on the vehicle frame, and the other end is supported by a heavy spring or other shock absorbing assembly mounted between the track frame and the vehicle frame. This system will allow one track to travel over a hump while the other track remains on level ground. The oscillation of the track assemblies absorbs some of the jolts when operating over rough terrain.

(4) Components and function of track frames.

(a) Track assembly. The track assembly is composed of a track chain and track pads or shoes. It is a movable platform for the vehicle to travel across. The track chain is linked together and forms a continuous path that is laid out in front of the track frame assembly, picked up after the vehicle has moved across, and pulled across the top of the track frame assembly to be placed again. The track pads or shoes are bolted to the track chain.

(b) Drive sprocket. A drive sprocket or tumbler receives the power from the power train and propels the vehicle along the track. The drive sprocket is usually installed at the track frame pivot point mounted on bearings on a shaft attached to the vehicle frame. Marine Corps crawler crane-shovels use a drive chain to transmit power from the propelling shaft to the drive tumbler which is bearing-mounted on a shaft in the track frame assembly.

(c) Track rollers and track idlers. Track rollers and track idlers are mounted on bearings on shafts attached to the track frame. The track rollers are mounted on the bottom of the track frame. They keep the track assembly under the track frame and support the weight of the vehicle. Flanges on the rollers fit the track chain and move it from side to side. The track idlers mounted on top of the track frame support the weight of the track as it is pulled across the top. Some types of crawler equipment have special rollers such as single and double flange which are to be installed at a specific point on the track frame. Study the TM before replacing track rollers.

(d) Front idler. The front idler, which is mounted on bearings, maintains track tension. It is designed to slide along the track frame assembly. An adjusting bolt or hydraulic assembly is provided to move the front idler to tighten or loosen the track. On crawler tractors, the adjusting bolt is attached to a shock absorbing mechanism to absorb the shock on the front idler when operating over rough terrain.

(5) Maintenance. It should be noted that the adjustments listed in the specific TM's are to be used as a guide. When you operate in loose soil, such as sand, the track chains should be loosened to prevent soil from building up in the tracks and causing them to bind. When you operate in hard soil such as rock, the track chains should be tightened to prevent them from coming off. Jolting and turning will cause the flanged rollers to jump the track chain and run off the track. Keep the track chains adjusted so that they will operate freely without being sloppy.

APPENDIX I

MOS 1341 (W)

ENGINEER EQUIPMENT MECHANIC (EngrEquipMech)

SSgt thru Pvt

I. MOS DESCRIPTION

Summary: Inspects, services, maintains and repairs engineer equipment.

Duties and Tasks: Performs preventive maintenance and makes repairs to diesel engines and gasoline and diesel driven construction equipment such as tractors, power shovels, road machinery, air compressors, saw mills, concrete mixers, and other engine driven construction equipment. Diagnoses malfunctions of engineer equipment by visual inspection, operational test or by the use of precision instruments. Disassembles, repairs, adjusts, cleans and installs new or rebuilt components, assemblies, parts, and reassembles to specified tolerance, using standard or special repair tools and equipment. Tests in accordance with recognized procedures. Compiles data for reports. Processes or prepares diesel engines and construction equipment for storage, deep water fording, landing operations or shipment. Camouflages, protects and decontaminates engineer equipment. Enforces safety regulations and production standards.

II. SPECIAL REQUIREMENTS

1. Must be able to manually lift fuel and lubricant containers weighing 40 pounds.
2. Must be able to endure long hours of equipment operation under all weather and extreme dust conditions.

III. MOS REQUIREMENTS

A. BASIC QUALIFICATIONS

SSgt thru Pvt

1. Be able to start, operate and service all engineer equipment.
2. Be able to perform preventive maintenance and make repairs to engineer equipment at the level appropriate to grade.
3. Be able to perform complete scope of organizational maintenance on engine generator sets.
4. Know safety precautions to be observed on and around engineer equipment and in shop areas.
5. Be able to understand and use technical manuals and other publications issued for the operations and maintenance of engineer equipment.
6. Be able to assist in the performance of command and technical inspections at the level appropriate to grade.
7. Be able to waterproof equipment for deep water fording and landing operations.
8. Know general nomenclature and principles necessary to effect repairs to both diesel engines and engineer equipment.
9. Be able to prepare and maintain records and reports pertaining to maintenance and repair of engineer equipment.
10. Know types and designations of fuels and lubricants used in servicing engineer equipment.

SSgt thru Cpl

11. Be able to use and care for precision instruments and measuring devices.
12. Be able to prepare gasoline and diesel engines and construction equipment for storage or shipment.
13. Be able to operate power tools, such as drills, grinders and valve facing machines used in engineer equipment repair.
14. Know methods of protecting and decontaminating engineer equipment.

SSgt and Sgt

15. Be able to diagnose malfunctions and to overhaul diesel engines and engineer construction equipment.

16. Be able to make repairs to power tools and equipment.

17. Be able to establish and administer facilities for maintenance and repair of engineer equipment.

18. Know regulations governing accountability and responsibility for government property as pertains to engineer equipment.

SSgt

19. Be able to make an accurate estimate of time and materials required on complex repair jobs.

20. Be able to maintain an operating level of parts and materials.

B. SKILL DESIGNATORS

NONE

IV. T/O BILLET TITLES

Engineer Equipment Mechanic
Equipment Mechanic
Shop Mechanic
Automotive Mechanic
Engineer Equipment Mechanic Foreman

APPENDIX II

PREVENTIVE MAINTENANCE

II-1. MAINTENANCE SYSTEM

a. Introduction. The successful accomplishment of engineer missions in garrison, in the field, and in combat depends to a great extent on the proper maintenance of assigned equipment. Maintenance can be described as the action taken to keep material in, or restore material to, a serviceable condition. It includes inspection, testing, servicing, serviceability classification, replacement, repair, rebuilding, and reclamation of equipment.

Every Marine and every unit has certain responsibilities for the maintenance of individual and organizational equipment. The Marine Corps maintenance system establishes a maintenance structure which is designed to assist both the individual Marine and the various units in the Marine Corps in accomplishing their responsibilities in a timely and effective manner. You, as an engineer equipment mechanic, are a member of the maintenance team, consequently, you should know your responsibilities and their relation to the overall system.

b. Categories and echelons of maintenance. The Marine Corps maintenance system is organized into three categories of maintenance: organizational, intermediate, and depot, which are further broken down into five echelons as shown in figure II-1 below.

CATEGORY	ECHELON	UNIT	PERSONNEL	RESPONSIBILTIES
ORGANIZATIONAL	1st	INDIVIDUAL UNIT	OPERATOR	INSPECTION, LUBRICATION, A JUSTMENT, OPERATION
	2nd	DSG UNITS SER, CO, H & S BN DSG	MECHANIC	REPAIR OR REPLACE PARTS, MINOR ASSEMBLIES; INSPECTION, SCHEDULED PM's, MAJOR ADJUSTMENTS.
		MWSG UNITS H & MS FSSG UNITS INDIVIDUAL BATTALIONS	MECHANIC	
INTERMEDIATE	3d 4th	FSSG MAINT BN	MECHANIC	REPAIR OR REPLACE PARTS, SUBASSEMBLIES OR MAJOR ASSEMBLIES.
DEPOT	5th	MARINE CORPS LOGISTIC SUPPORT BASE	MECHANIC	OVERHAUL AND REBUILD, RETURN TO STOCK.

Fig II-1. Maintenance system.

c. Factors affecting maintenance echelons. The echelon of maintenance at which a particular repair or replacement is going to be performed depends on a number of factors. These include the combat situation, the nature of the repair, the time available, the number and skills of the available mechanics, and the availability of tools, test equipment, and repair parts. Repair is performed by the lowest echelon of maintenance which is capable of performing it. Higher echelons of maintenance perform the category of maintenance which is assigned to their units. They also perform, within their capabilities, the overflow maintenance of the supported using units. The lower echelons of maintenance should not attempt to perform repairs which are assigned to a higher echelon. This generally leads to cannibalization of equipment and usually causes the lower echelon to neglect the work that is their primary responsibility. The effectiveness of the maintenance system depends on how well the men at the various echelons know and perform their own responsibilities. The breakdown of individual responsibilities within the system provides for a balanced workload, and there is generally more than enough work at all levels to keep everyone busy.

(1) Organizational maintenance. This level of maintenance is the responsibility of, and is performed by, the using unit. Its responsibilities include correct operating, inspecting, servicing, lubricating, adjusting, and replacing of parts, minor assemblies, and subassemblies. Organizational maintenance is the foundation upon which the remainder of the system rests. If using unit maintenance is ineffective, equipment availability will be low and it will place a heavy demand on the maintenance capability of higher echelons. Organizational maintenance is broken down into two echelons: 1st, performed by the operator; and 2d, performed by the unit mechanics.

(a) First echelon. First echelon maintenance is performed by the user, wearer, or operator. It consists primarily of correct operation, servicing, inspecting, lubricating, and performing minor adjustments. Just as organizational maintenance is the foundation of the whole maintenance system, so 1st echelon or operator services are the foundation of good organizational maintenance. The equipment operator and the services he performs are two of the most important factors in the success of the maintenance system.

(b) Second echelon. Second echelon is performed by specially trained personnel in the using organization, the unit mechanics. It consists primarily of inspecting, performing major scheduled lubrication services, making major adjustments, and replacing parts and minor assemblies. Depending on the organization, 2d echelon maintenance services may be performed either at company level or in centralized battalion maintenance shops. While the mechanic is responsible for parts replacements, both the operator and mechanic will generally combine their efforts in performing scheduled preventive maintenance services and making adjustments.

(2) Intermediate maintenance. This level of maintenance is authorized and performed by a designated maintenance activity in direct support of the using organization, or by higher echelon maintenance units supporting the direct-support maintenance activity. It is normally limited to the replacement and repair of parts, subassemblies, and major assemblies. When necessary, intermediate maintenance units support lower echelons by providing technical assistance, mobile repair crews, and repair parts. Intermediate maintenance consists of 3d and 4th echelons of maintenance.

(a) Third echelon. Third echelon maintenance is performed in direct support of the using units by the FSSG. Third echelon maintenance shops have the necessary special tools, machine shops, mechanics, and repair parts to perform more specialized maintenance than the using units. Since many organizations in a Marine division contain varying amounts of similar engineer equipment (for example, the Case MC 1150 Scooploader found in DSG, engineer, and artillery units), 3d echelon maintenance capabilities have been centralized in the engineer maintenance company, FSSG. This reduces the number of mechanics, spare parts, and special tools required; prevents duplication of effort; and results in savings of manpower and equipment.

(b) Fourth echelon. Fourth echelon maintenance is also performed by FSSG in support of the DSG. The FSSG has more elaborate shop facilities and more mechanics, and is limited only by the tools, test equipment, and repair parts authorized. Fourth echelon maintenance is the highest level of intermediate maintenance, and any equipment requiring more specialized repair or complete rebuild is forwarded to the last category of maintenance, depot.

(3) Depot maintenance. This level of maintenance consists of a single echelon of maintenance, 5th. It normally supports the supply function by rebuilding and returning to stock, parts, subassemblies, assemblies, or the whole item of equipment on a scheduled basis. Fifth echelon maintenance is generally performed at the two Marine Corps logistic support bases located at Albany, Georgia and Barstow, California or by civilian contractors. Specific authorization may be granted for deployed organizations to perform limited 5th echelon repairs.

d. Repair flow. In order to better understand the maintenance system, let us see how it would function in a specific case which required 4th echelon maintenance. Let's say that you are an equipment operator in "A" Company, Combat Engineer Battalion, DSG. Upon inspecting your tractor, you find a large puddle of oil beneath it. You would indicate your findings on your trip ticket (NAVMC 10523) and then report it to your section leader for a determination as to whether the equipment should be operated. If the section leader decides that the equipment should not be operated, you would now close out your trip ticket and turn the tractor back in to the dispatcher. The dispatcher will then inform the equipment chief of the discrepancy. The equipment chief has the tracker checked out and determines that a defective rear engine seal is causing the leak. At this time an Equipment Repair Order (NAVMC 10245) is made up. All 1st echelon (operators) maintenance is performed and the record jacket (DD 696d) and the ERO are forwarded with the tractor to the 2d echelon shop (Service Company, Headquarters and Service Bn., DSG. The 2d echelon shop chief determines that the replacement of the seal is beyond his shop's authorized capabilities. The tractor is now forwarded with a new ERO to intermediate maintenance unit, (Engineer Maintenance Company, Maintenance Battalion, FSSG). At this point the seal will be replaced and the tractor will be returned down the maintenance chain to your unit.

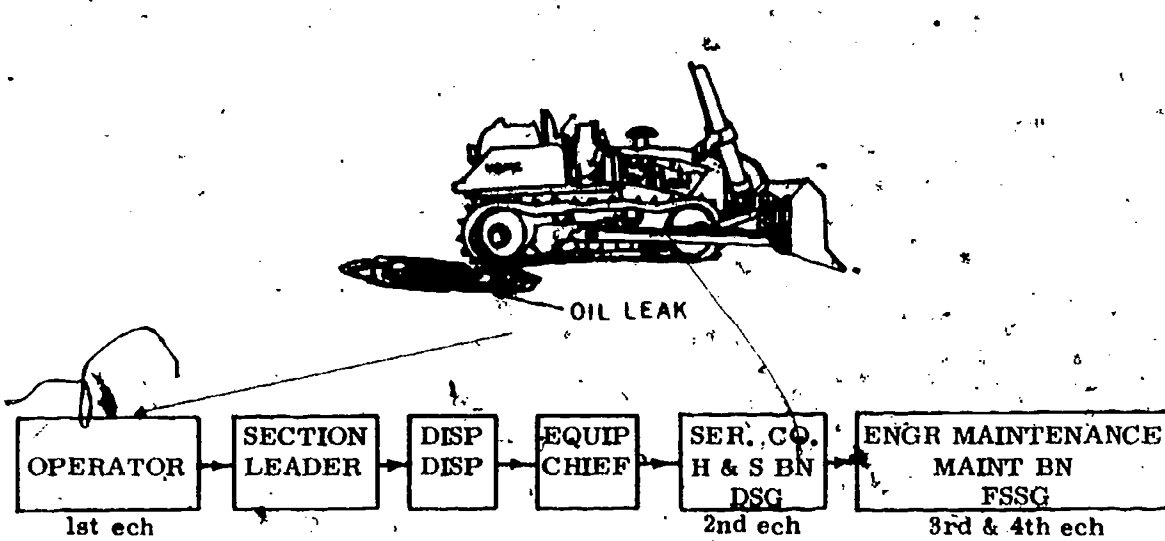


Fig II-2. Equipment repair flow.

II-2. MAINTENANCE INTERVAL

a. General. Preventive maintenance is performed by the operator and the mechanic. In this section, any reference to the operator means the individual actually using the vehicle. This includes the mechanic who will operate a piece of equipment from time to time while diagnosing/or testing it. The most important phase of engineer equipment maintenance is the performance of preventive and scheduled maintenance. An effective maintenance program will do more to make the operator's and mechanic's job easier and keep the number of deadlined (out of service) items to a minimum than all the repair units combined. Preventive maintenance consists of such items as inspecting, lubricating, tightening, and correcting any possible failures before they occur. It is the services performed by operational and maintenance personnel to keep the equipment in the best possible operating condition. Most preventive maintenance is performed on an hourly or calendar time schedule. The maintenance schedules for engineer items of equipment are listed in the applicable TM for each item which should be used as a guide and checklist for performing any preventive maintenance. For example, daily service is considered 8 to 10 hours, weekly service 40 to 50 hours, and quarterly service 250 hours, but some items require 25- and 100-hour maintenance. To allow for the differences in hours and to prevent interruption of work, preventive maintenance is performed at any convenient time within reason. For example, 10-hour maintenance can be performed between the 8th and 1[illegible] hours of operation. Some maintenance should be performed at the time a problem occurs. For example, you have your car tuned-up every 10,000 miles, but you wouldn't wait that long to replace a fouled spark plug or broken spark plug lead. In your daily or weekly services you would check your tires for wear and air pressure, but you would not wait until the scheduled day to replace a flat tire. The reward for the extra time required to inspect, check, and service an item of equipment is knowing that it and its attachments are ready when called for, and that there is a decrease in the number of hours required for repairs.

b. Daily. These are the services indicated by an A or D on LI's and TM's, listed as before-, during-, and after-operation services on NAVMC 10523-SD, Engineer Equipment Operational Record. Daily maintenance is normally required between 8 and 12 hours of operation, but the before-, during-, and after-operation services are performed each time the vehicle is started on a new job or whenever there is a change of operators. During 24-hour-a-day operations, the equipment will receive two daily lubrication services and be checked before, during, and after operation by each change of operators or when the vehicle is restarted for a new job. The equipment is usually available 20 hours per day for operation and 4 hours per day for maintenance. The mechanic and the operator usually have 2 hours after each shift to service and prepare the equipment for the next 10-hour shift. Daily services are periodically performed on stored, deadlined, and standby equipment. During normal operations, 8 hours is considered one day of operation. As you gain experience in the engineer equipment maintenance field, you will learn that the equipment hourmeter will only show a portion of the time. For example, the hourmeter for a Terex will sometimes show only 6 hours' operation when working on a 10-hour job because part of the time the tractor was sitting at an idle and the hourmeter was calibrated to show full-throttle operations; it operates on the rpm of the engine.

(1) The 10-hour lubrication and service is performed at the end of the day or upon completion of the job if the hourmeter shows sufficient number of elapsed hours. The services are recorded on NAVMC 10523-SD, Engineer Equipment Operational Record and NAVMC 10524, Consolidated Engineer Equipment Operation Log and Service Record. In a combat zone, these services may be performed by a contact team at a time designated by the CO. Items that require daily maintenance, but are not being used, are lubricated and serviced weekly. Use good mechanical judgment to prevent overlubricating deadlined or stored equipment.

(2) The before-operation services are performed prior to each starting. Many things can happen to a vehicle in a short period of time or some deficiency may have been overlooked at the last service check. In a combat zone the item could possibly have been sabotaged. The before-operation services also help prevent accidents caused by persons under or working on the equipment.

(3) During-operation, the operator continually checks his equipment for proper operation and unusual noises and odors. The operator corrects the deficiencies within his echelon and capabilities and reports all deficiencies whether corrected or not to the dispatcher and equipment chief.

(4) The after-operation services are performed to prepare the vehicle for future jobs. The item is inspected, serviced, and defects corrected so that the equipment can be placed into service on short notice. During normal operations, the 8- or 10-hour services are performed at the same time as the after-operation services.

c. Weekly. The TM for each item of equipment prescribes certain checks and preventive maintenance services. Some TM's list 50-hour maintenance while the newer TM's list weekly maintenance as 25 or 40 hours or 5 work days. During 24-hour-per-day operations the 40- and 50-hour schedule will come due approximately twice each week. Together, an operator and a mechanic perform the weekly maintenance using the TM and LI as a guide and checklist. Maintenance is performed on the basic machine and all attachments requiring weekly maintenance that have been used with the basic machine. For example, if a tractor used to tow a scraper is receiving weekly maintenance, it should also be performed on the scraper.

d. Quarterly. These are services performed to provide for cleaning, inspecting, tightening adjusting, and lubricating the equipment to insure trouble-free operation. Quarterly services are performed at the time scheduled in pertinent TM's or other Marine Corps publications, when directed by the unit commander, or as dictated by conditions. Time schedules listed in the TM's are the minimum requirements for normal operating conditions. When vehicles operate in adverse conditions such as water, mud, or sand, and also after fording, the quarterly maintenance is performed more frequently than prescribed in the TM. The unit mechanic, assisted by the operator, will perform the quarterly maintenance when required, using pertinent TM's, LI's, and NAVMC 10560-SD, Work Sheet for Preventive Maintenance and Technical Inspection of Engineer Equipment, as a checklist. When the equipment is lubricated, the water and abrasives must be removed, but parts such as clutches and brakes must be kept oil-free. As each item on the checklist is completed it is recorded on the NAVMC 10560-SD. After the equipment has been serviced and the Work Sheet for Preventive Maintenance and Technical Inspection of Engineer Equipment completed, the preventive maintenance roster is updated. If repairs are required, a Tactical Equipment Repair Order is initiated and the repairs are made at the earliest date.

APPENDIX III

SAFETY

III-1. GENERAL

Unsafe practices in the operation and maintenance of construction equipment take the lives of many people yearly. Unsafe practices with equipment of great weight and power increase the danger to you. Given a tool or machine, and a distraction, you can hurt, cripple, or kill yourself or others. This is commonly called an accident. Accidents are caused; they do NOT just happen. Machines and tools will do only what you cause them to do. A grader will not run over an embankment and turn over unless you drive it there. A wrench will not break or slip and cause you to cut yourself unless you make it do so. Brakes don't fail unless you neglect the proper maintenance. Machines don't fall unless you fail to block them properly. Accidents will happen because you neglected something or because you lacked the knowledge to prevent them. Below are listed some of the general safety precautions that you should observe.

III-2. OPERATIONAL SAFETY

a. Study and comply with local safety regulations.

b. Study and comply with the safety regulations listed in the technical manual for a specific item of equipment.

c. Inspect the equipment for damage or loose material before starting the engine. Before moving equipment, check for nearby personnel or equipment that could be injured or damaged. Keep a close watch for damage or malfunctions that may occur during operation.

d. Keep the machine free of grease, tools, and other materials which may cause you to fall or that could be thrown by the machine.

e. Keep your hands and shoes free of grease and mud that may cause you to fall while boarding or prevent proper operation of an item of equipment.

f. Insure that all safety devices such as warning lights, guards, fire extinguishers, brakes, horn, and emergency shutoff devices are installed and functioning.

g. Operate the equipment at safe speeds for the conditions and location.

h. Operate the equipment with only the required and authorized personnel aboard.

i. Never board or allow another person to board a moving vehicle. Before dismounting, stop the equipment, lower all attachments to the ground, set the brakes, place the transmission in neutral, and engage the clutch. Note: Crane clutches are left disengaged if engine is running.

j. Study the terrain over which you are operating. Beware of hidden pits and cliffs that might throw you off the equipment or give way and turn the machine over. Beware of flying debris that might hit you or damage the equipment.

k. Use the equipment to do the job for which it was designed.

l. Use a signalman when working in a dangerous area or when vision is restricted.

m. Stop the machine before attempting to clean, service, or repair it.

n. Never swing a load or attachment over other personnel.

o. Use caution when working around or traveling over or under electric power or communication lines. Don't swing an attachment closer than 10 ft to a powerline. Use dunnage to protect lines that are traveled over, and do not damage underground cables.

p. Park and secure equipment on level ground and block it if it could possibly roll.

q. Do not overload the equipment, attachments, slings, or tow cables.

III-3. SHOP SAFETY

Most accidents in the shop are caused by fires, falls, falling objects, or electric shocks. Injuries can result from clothing or parts of the body becoming entangled in moving machinery, acid or objects in the eyes, or cuts from sharp or flying objects. Strained muscles can result from lifting heavy objects incorrectly.

a. Refuel equipment before securing for the day, but after the engine is stopped. Do NOT fill the gas tank of a hot engine.

b. Service the equipment after operation, but not while the equipment is running.

c. Make only the necessary adjustments with the engine running; first make a preliminary adjustment with the engine stopped. Have some person stand by to stop the equipment in case of an emergency.

d. To prevent falls and fires, keep the decks and working spaces clean.

e. To prevent falls or falling objects, keep parts, tools, and maintenance equipment in proper place.

f. Wear protective clothing and equipment for the eyes, hands, and feet. Wear the uniform properly to prevent loose clothing being entangled in the machines.

g. Run engines in well-ventilated areas; exhaust fumes can irritate the eyes or cause headaches or they can even cause death if breathed too long or in high concentration.

h. Keep all tools clean and in proper condition for correct use.

i. Never work on equipment that is hanging or on a jack. Place the equipment on a suitable stand, bench, or cribbing.

j. Use only the specified and authorized cleaning solvents.

k. Be sure electric power tools are grounded. Do not operate them while standing in water.

l. Check hoisting equipment and attachments prior to each use.

m. To prevent accidental starting, disconnect the battery ground strap; when removing both cables, disconnect the battery ground terminal first.

n. Use an assistant when lifting heavy objects.

o. Never allow horseplay on or around equipment.

p. Smoke in authorized areas only.

III-4. GENERAL SAFE PRACTICES

Understand the safe way to perform any given task. Help new personnel to avoid unsafe practices. Promptly report to the supervisor any instance where instruction is required.

a. When guiding a vehicle onto a lube rack, do not stand in front of it. Before starting to lubricate a vehicle, make sure the ignition is off, the gearshift is in neutral, brake is set, and the wheels are blocked. When servicing a vehicle, stand so that the body is clear in case the vehicle starts to roll. Unless it is in a pit, work under equipment only when it is properly blocked. Remove clothing without delay if it has been soaked in gasoline or oil. Wash with soap and water and put on clean clothing. Do not put gasoline-soaked rags in pockets.

b. Know the means of calling the closest firefighting equipment. Give the alarm immediately in case of fire and know how to use available firefighting equipment. Should a fire start in the vicinity of a vehicle while a fuel nozzle is in the tank, LEAVE THE NOZZLE IN THE TANK, stop the pump, warn the occupants of the vehicle to get out, then smother the flames with wet cloths or, if available, use a fire extinguisher.

c. Report all injuries promptly so that proper first aid or medical treatment can be given. Notify the safety officer of any observed unsafe condition.

d. When using tools, inspect them and all similar equipment before use. Replace splintered, broken, rough, or loose tool handles. Keep cutting edges sharp and use the tool only for its designed purpose.

e. Wear safe clothing. Do not wear thin-soled shoes or loose or ragged clothing. Keep coats buttoned and shoestrings tied. Do not wear oversized trousers.

f. When lifting and carrying heavy objects, provide enough men to do the job. Keep the arms and back as straight as possible, bend the knees and lift with the leg muscles, lifting with a smooth even motion. When carrying, keep the load close to the body.

g. Wear approved safety goggles or eyeshields when grinding, chipping, welding, cutting, pouring, or handling hot metals or acids.

h. Do not talk to anyone while operating machines. Pay attention to the job at hand.

III-5. REPAIR SHOPS

a. Operating requirements. Effective general ventilation should be provided in buildings where gasoline or diesel engines are running. Exhaust gases are to be ventilated to the outside. Each power tool is to be provided with an individual, easily accessible control switch. Cracked or chipped grinding wheels are to be removed from service immediately. An abrasive wheel dresser, with a guard over the cutters, is to be used when facing a wheel.

b. Safe practices.

(1) When using hand wrenches, observe the following rules:

(a) Do not use a pipe or another wrench over the handle of a wrench to increase leverage.

(b) When pulling on the wrench, stay out of the line of movement.

(c) Use pipe wrenches on round objects only. Place the wrench so that the teeth in the center of the jaws grip the object.

(d) Repair or discard wrenches which are fractured; which have broken handles, springs, or other parts; or which have jaws that are sprung, bent, have dull teeth, or are out of alinement.

(2) When working with portable electrical tools, check insulation for breaks. Be sure that the tool housing or framework is grounded.

(3) Weld fuel containers or tanks only after they have been drained, washed, steamed, or otherwise cleaned and purged of all flammable gases and liquids. Be on guard against flashes or explosions of gasoline vapors, antifreeze solution vapors, or hydrogen vapors from storage batteries.

(4) All loads must be blocked up before working under them. Never depend on jacks or chain hoists alone to support a load. Place blocks under a load as it is being raised.

(5) Do not keep gasoline in open containers.

(6) Use the safety grip (thumb and fingers on the same side of the handle) when it is necessary to crank engines by hand.

(7) Permit no one to handle the starting button or lever of a machine while mechanics are working on it, and do not tamper with the controls of a machine on which someone else is working.

(8) When using a grinding wheel, observe the following rules:

(a) Use goggles.

(b) When starting a grinding wheel, stand to one side of the wheel for a full minute after turning it on.

(c) Use the tool rest, and keep it close to the wheel.

(d) Do not grind on the side of the wheel.

(e) Do not crowd a grinding wheel. Cold wheels are particularly dangerous. Pressure should be applied gradually and the wheel allowed to warm up.

c. Personal protective clothing. The following protective clothing should be worn, when appropriate, during shop operations:

(1) Safety shoes.

(2) Appropriate goggles in any area where flying materials or harmful light rays might cause eye injury.

(3) Coveralls and work gloves.

III-6. SERVICE AREAS

a. General operating requirements. Keep premises clean and free of tripping hazards. Provide proper storage for air and water hoses, tools, jacks, water cans, and all movable objects. Use warning signs and barricades to protect personnel when construction, repair, or paint work is in progress.

b. Handling gasoline and diesel fuel.

(1) Gage a storage tank before filling to determine the amount of fuel it will hold and to avoid the fire hazard from an overflow.

(2) Remove empty oil and gasoline containers from the working areas as promptly as possible.

(3) Keep drums or other containers holding gasoline, diesel fuel, or other highly flammable liquids outside the building. Flammable materials should be stored no closer than 50 ft from buildings, equipment, or other facilities that may be damaged by fire. Make periodic inspections for leakage from containers. If leaking containers cannot be made sound by tightening the bung or cap, transfer the fuel to a sound container. Drums are always stored on their sides to prevent the entry of water.

(4) Never transfer flammable liquids in the presence of any flame or burning material, including cigarettes.

(5) All equipment, such as pumps, tanks, vehicles, or storage tanks, when used in fuel transfer operations, are to be electrostatically grounded. Bonding connections must be made before hose connection, and these bonds are not removed until the hose has been disconnected. When gasoline is being poured from one container into another, maintain metal-to-metal contact to avoid possible static discharges.

III-7. BATTERY SHOPS

a. Operating requirements.

(1) Locate the battery shop in a separate area, preferably in a cage-type enclosure.

(2) Keep the temperature of the battery shop below 95° if possible.

(3) Equip the battery shop with an adequate ventilation system to remove the highly volatile and flammable hydrogen gas.

(4) Do not permit smoking, open-type switches, lights, or flames in the vicinity of the batteries on charge.

(5) Provide running water and approved first-aid materials to neutralize any acid spilled on the body.

b. Safe practices.

(1) Exercise care not to short-circuit battery terminals when using tools around batteries.

(2) Avoid striking metallic surfaces or causing sparks.

(3) Use only tools with insulated handles when removing or replacing batteries.

(4) Do not make repairs to the battery while the circuit is energized.

(5) Make certain that the charging current is off before batteries are connected to, or disconnected from, the charging line.

(6) Use premixed electrolyte if available. However, if mixing is required, NEVER POUR WATER INTO ACID. The acid must be poured slowly into the water, using a glass or earthenware container.

(7) Guard the eyes and the skin from splashing acid.

(8) Never store sulfuric acid in locations where freezing temperatures are possible.

c. Personal protective equipment. The following protective equipment is necessary for battery shop operations: Rubber gloves, rubber aprons, protective shoes or boots, and approved goggles. These are to be worn to protect the eyes and the body when mixing electrolyte and filling batteries.

III-8. COMPRESSED-AIR EQUIPMENT

a. Operating requirements.

(1) Complete enclosure of compressor is desirable. Guards are to be installed on all belts, pulleys, flywheels, and other moving parts.

(2) Open air-tank drainpipe valves and drain the tank at regular intervals. Inspect automatic traps regularly.

(3) Test all spring pop safety valves at regular intervals, and provide inspection of receivers at least once a year by a qualified inspector.

(4) Clear cylinders, valves, discharge pipes, and receivers at regular intervals.

(5) Inspect all air lines, both pipe and hose, at regular intervals.

b. Safe practices:

(1) Do not operate the air receiver at a pressure higher than the maximum allowable working pressure, except when the safety valve or valves are blowing. At such a time, the maximum allowable working pressure should not be exceeded by 6%.

(2) Do not apply too much oil to air compressors. Excessive oil increases the danger of an explosion.

(3) Never wear gloves when operating a portable air drill or reamer.

(4) Never point a pneumatic machine at anyone and do not stand in front of such machines even though they are equipped with tool holders.

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UNITED STATES MARINE CORPS
MARINE CORPS INSTITUTE, MARINE BARRACKS
BOX 1775
WASHINGTON, D.C. 20013

BASIC ENGINEER EQUIPMENT MECHANIC

Course Introduction

BASIC ENGINEER EQUIPMENT MECHANIC is designed to instruct pvt's through cpl's in the basic qualification requirements of a 1341 MOS. It covers the mechanic's tools and their uses, engines and their characteristics and functions, power trains, final drives, and auxiliary equipment. It is an aid to on-the-job training.

ORDER OF STUDIES

Lesson Number	Study Hours	Reserve Retirement Credits	Subject Matter
1	2	0	The Mechanic and His Tools
2	3	1	Engines
3	3	1	Power Train
4	3	1	Auxiliary Equipment
	2	1	FINAL EXAMINATION
	13	4	

EXAMINATION: Supervised final examination without textbook or notes; time limit, 2 hours.

MATERIALS: MCI 13.29e, Basic Engineer Equipment Mechanic.

ABC's of Hand Tools

Lesson sheets and answer sheets.

RETURN OF MATERIALS: Students who successfully complete this course are permitted to keep the course materials.

Students disenrolled for inactivity or at the request of their commanding officer will return all course materials.

* * *

UNITED STATES MARINE CORPS
MARINE CORPS INSTITUTE, MARINE BARRACKS
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The Mechanic and His Tools

Lesson 1

Tools and Equipment

STUDY ASSIGNMENT: Information for MCI Students.
Course Introduction
ABC's of Hand Tools, pp 1-38
MCI 13.29e, Basic Engineer Equipment Mechanic, chap 1.

LESSON OBJECTIVE: Upon successful completion of this lesson, you will be able to identify procedures necessary for care and use of handtools, power tools, and precision measuring instruments.

WRITTEN ASSIGNMENT:

A. Multiple Choice: Select the ONE answer which BEST completes the statement or answers the question. After the corresponding number on the answer sheet, blacken the appropriate box.

Value: 1 point each

1. What should the mechanic remember when using the screwdriver?

   a. Use long-handle screwdrivers only.
   b. The width of tip should equal the length of the screw slot.
   c. The width of tip should be slightly less than the length of the screw slot.
   d. The ferrule length should equal the length of the screw slot.

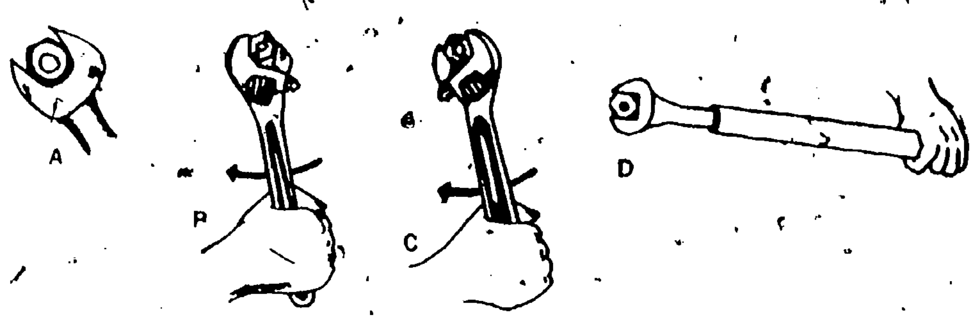
2. How are ball peen hammers classified?

   a. By length of handle and head weight
   b. By head weight
   c. By size of face and ball peen
   d. By the material they are made of

3. Which pliers are BEST used to remove cotter pins when the proper tool is not available?

   a. Combination
   b. Side-cutting long-nose
   c. Snap ring
   d. Diagonal-cutting

4. Which illustration shows the proper use of a wrench? (A= a on the answer sheet, B=b, etc.)



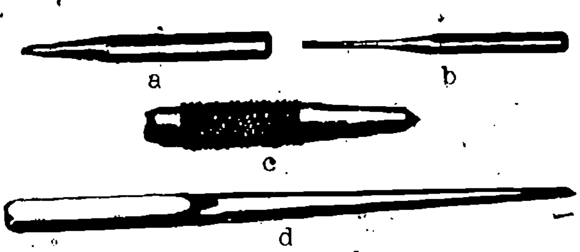
5. To loosen a very tight bolt, which wrench would be most suitable?

a. Hinged handle w/socket
b. Ratchet w/socket
c. Speed handle w/socket
d. Crescent wrench

6. What determines the size of a chisel?

a. Width of the handle
b. Length of the blade
c. Width of the cutting edge
d. Diameter of the chisel

7. Which illustrated punch is used to start a pin from a hole?



8. What is the proper tool to clean a flat file with?

a. Scraper
b. Knife
c. File card
d. Scrub brush

9. You are cutting mild steel with a hacksaw. For the most efficient cutting, how many strokes per minute should you make?

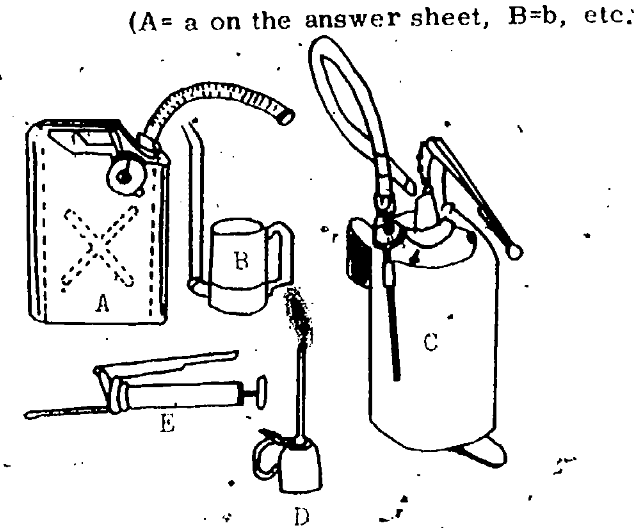
a. 60-70
b. 50-60
c. 40-50
d. 20-30

10. If the feeler gage blade is marked 2, this would indicate its size as _____ in. thick.

a. .2
b. .02
c. .002
d. .0002

11. Which illustrated container would be the proper one to use to fill an engine crankcase requiring only 1 gallon?

(A= a on the answer sheet, B=b, etc.)



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12. For removal of drain plugs when the regular drain plug wrench is not available, the large _____ can be used.

a. screwdriver
b. chisel
c. Allen wrench
d. driftpin

13. When the special injector puller tool is not available, which tool can be substituted?

a. Cold chisel
b. Roll head pry bar
c. Yoke puller
d. Bearing cup pulling attachment

14. A pressure of 77 lb is required to lift 3,300 lb on the model T-20 Griphoist. The capacity of the hoist can be increased to 6 tons with the aid of a

a. longer leverage handle
b. block and tackle and a 2-part line.
c. block and tackle and a 4-part line.
d. block and tackle and a 6-part line.

15. The porta-power press has a capacity of approximately _____ tons.

a. 5
b. 10
c. 15
d. 25

16. The 1/2-in. drill should not be used to drill holes larger than

a. 1/4 in.
b. 1/2 in.
c. 3/4 in.
d. 1 in.

17. You should keep both the drill and the metal being drilled dry when drilling which metal?

a. Steel
b. Iron
c. Copper
d. Brass

18. Before installing an abrasive stone, you should match the stone with the grinder's

a. shank size.
b. rpm.
c. diamond-point dresser.

19. Abrasive stones for the grinder should be replaced when they have worn to _____ of their original diameter.

a. 1/4
b. 1/2
c. 2/3
d. 3/4

20. What would cause the impact wrench to slow down and have erratic impacting?

a. Pneumatic hose too long
b. Lack of lubrication
c. Direction selector turned off
d. Pneumatic hose too short

21. Which type of mechanism listed below drives the working attachment of a pneumatic tool?

a. Rotary percussion
b. Reciprocating percussion
c. Armature
d. Internal combustion

22. Which wrench would be used to lessen the chance of breaking a nut and pulling or stretching its threads?

a. Crescent wrench
b. Torque wrench
c. Open-end wrench
d. Vise grips

23. To obtain an accurate reading with the torque wrench, it should be pulled with

a. one hand on the handle and the other on the shaft.
b. only the handle grip being used.
c. one hand on the handle and the other on the item being torqued.
d. both hands on the handle grip.

24. The head of a valve is checked for roundness with a

a. dial indicator.
b. caliper micrometer (outside).
c. caliper micrometer (inside).
d. dwell-tach.

25. Which is a true statement concerning the use of a micrometer?

a. The mechanic is authorized to calibrate the micrometer.
b. To obtain an accurate measurement, the micrometer must be tightened against the part being measured with a wrench.
c. The micrometer is adjusted by hand until contact is made.
d. The micrometer is kept with the other tools in the mechanic's toolkit.

Total Points: 25

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BASIC ENGINEER EQUIPMENT MECHANIC

Lesson 2

Engines

STUDY ASSIGNMENT: MCI 13.29e Basic Engineer Equipment Mechanic, chap 2.

LESSON OBJECTIVE: Upon successful completion of this lesson, you will be able to identify engines characteristics and the principles of operation of gasoline and diesel engines.

WRITTEN ASSIGNMENT:

A. Multiple Choice: Select the ONE answer which BEST completes the statement or answers the question. After the corresponding number on the answer sheet, blacken the appropriate box.

Value: 1 point each

1. An engine is a machine that converts _____ into mechanical energy.

   a. heat energy
   b. electrical energy
   c. steam heat
   d. oxygen and fuel mixture.

2. Which is an internal-combustion engine?

   a. Steam engine
   b. Starter
   c. Air compressor
   d. Gasoline engine

3. What is the stroke of a piston?

   a. Size of the piston and the distance it travels
   b. Movement of the piston from one end of cylinder to the other
   c. Movement of the piston to complete a cycle
   d. One revolution of the crankshaft

4. What is required to complete the cycle of operational events of an internal-combustion engine?

   a. Two down strokes of a piston
   b. Two up strokes of a piston
   c. Intake of air and fuel, compression, ignition, and exhaust
   d. Movement of piston, intake of air and fuel, and exhaust

5. An engine classified according to application would be either

   a. automotive, industrial, or marine.
   b. internal combustion, automotive, or self-propelled vehicle.
   c. external combustion, two-stroke cycle, or automotive.
   d. internal combustion, automotive, or industrial.

6. What are the major stationary parts of an engine?

   a. Valves, cylinder head, and exhaust system
   b. Engine frame, cylinder head, and cylinders
   c. Pistons, crankshaft, and connecting rods
   d. Engine frame, crankshaft, and oil pan

7. Which statement is INCORRECT?

a. Cylinder liners are cast and machined as part of the cylinder block.
b. Cylinder liners are cast, machined, and installed in the cylinder block.
c. Cylinder liners are in direct contact with cooling air.
d. Cylinder liners are in direct contact with liquid coolant.

8. The primary purpose of the cylinder head is to

a. support the valves.
b. provide water and oil passages.
c. provide intake and exhaust passages.
d. seal one end of the cylinder bore.

9. What engine parts change reciprocating motion to rotary motion?

a. Piston and connecting rod
b. Connecting rod and crankshaft
c. Crankshaft and flywheel
d. Camshaft and pushrods

10. The crankshaft is supported by the engine frame at

a. the main bearing journals.
b. each end of the crankshaft.
c. the crankarm journal.
d. the flywheel.

11. What is the function of the flywheel?

a. Turns the crankshaft during the idle strokes of the piston
b. Convert rotary motion to reciprocating motion
c. Increases the engine's rated horsepower
d. Aline the engine with power train

12. What is the primary function of the camshaft?

a. Opens and closes the valves
b. Closes the valves and ports
c. Opens the valves
d. Drives the accessories

13. What closes the exhaust valves?

a. Camshaft
b. Spring tension
c. Cam lobes
d. Pistons

14. Which engine may not have valves?

a. Gasoline
b. Diesel
c. Four-stroke cycle
d. Two-stroke cycle

15. How many degrees will a crankshaft rotate to complete one stroke?

a. 90
b. 180
c. 270
d. 360

16. In a four-stroke cycle engine, how many crankshaft revolutions are required to complete one cycle?

a. 1
b. 2
c. 3
d. 4

17. In a four-stroke cycle engine, when both valves are closed, a piston that is moving up would be on the ______ stroke.

a. intake
b. compression
c. power
d. exhaust

18. In a two-stroke cycle engine, how many crankshaft revolutions are required to complete a cycle?

a. 1
b. 2
c. 3
d. 4

19. Where is the fuel strainer located?

a. In the fuel tank
b. Between the tank and fuel pump
c. Between the pump and the inlet manifold
d. Between the inlet manifold and the injector unit

20. Which component of a gasoline engine fuel system meters the fuel and mixes it with air?

a. Fuel strainer
b. Fuel pump
c. Carburetor
d. Wet type air cleaner

21. Which carburetor circuit will stop the flow of fuel from the fuel pump?

a. Float
b. Low speed
c. High speed
d. Choke

22. Which carburetor circuit is used to increase the fuel in the air-fuel mixture?

a. Float
b. Low speed
c. High speed
d. Choke

23. What are the two types of spark ignition?

a. Compression and electrical
b. Glow plug and compression
c. Battery-distributor and magneto
d. Magneto and glow plug

24. When a magnetic field moves across a conductor and produces a current, it is operating on the principle of ________ induction.

a. chemical
b. electromagnetic
c. self

25. What are the two most common lubrication systems?

a. Splash and force-feed
b. Force-feed and full force-feed
c. Splash and bypass
d. Full force-feed and bypass

26. What is the purpose of a radiator pressure cap?

a. Decrease engine temperature
b. Raise the boiling point of the water
c. Prevent water from splashing out
d. Cause the engine to warm up quicker

27. What is the purpose of the fins on an air cooled engine?

a. Lighten the engine
b. Strengthen the cylinder walls
c. Retain engine heat
d. Provide more area for heat dissipation

28. What is the basic difference between gasoline and diesel engines?

a. Cooling
b. Ignition
c. Lubrication
d. Number of strokes per cycle

29. What type of fuel supply pump is used on the Detroit diesel engine?

a. Positive diaphragm
b. Positive displacement gear
c. Nonpositive diaphragm
d. Nonpositive gear

30. What component of a series 71 Detroit diesel fuel system meters and sprays the fuel into the cylinder?

a. Supply pump
b. Injection nozzle
c. Injector unit
d. Injection pump

31. The amount of fuel delivered to a series 71 Detroit diesel engine cylinder is varied by rotating the

a. crankshaft.
b. camshaft.
c. plunger.
d. control rack.

32. What type lubricating system is used on the series 71 Detroit diesel engine?

a. Splash
b. Splash and force-feed
c. Force-feed and full force-feed
d. Full force-feed

Total Points: 32

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BASIC ENGINEER EQUIPMENT MECHANIC

Lesson 3

Power Train

STUDY ASSIGNMENT: MCI 13.29e, Basic Engineer Equipment Mechanic, chap 3.

LESSON OBJECTIVE: Upon successful completion of this lesson, you will be able to identify the components of a power train and the principles of its operation.

WRITTEN ASSIGNMENT:

A. Multiple Choice: Select the ONE answer which BEST completes the statement or answers the question. After the corresponding number on the answer sheet, blacken the appropriate box.

Value: 1 point each

1. What is the purpose of a clutch?

   a. Stop the power flow
   b. Engage and disengage the power flow
   c. Increase engine torque
   d. Provide a method of selecting gears

2. Clutches and brakes operate on the principle of

   a. friction and heat.
   b. contact and movement.
   c. internal expansion.
   d. pressure and friction.

3. What are the two friction principles of clutches?

   a. Solid and fluid
   b. Pressure and friction
   c. Engaged and disengaged
   d. Mechanical and hydraulic

4. What part of an engine clutch rotates with the engine flywheel in both engaged and disengaged positions?

   a. Driven member
   b. Driving member
   c. Clutch shaft
   d. Clutch disk

5. What type clutch has four or more friction surfaces?

   a. Internal-expanding
   b. External-contracting
   c. Plate disk
   d. Cone

6. Lubricants on the friction surface of a dry-type clutch will cause deterioration, excess heat, and

   a. grabbing.
   b. crystallization.
   c. slipping.
   d. burring.

7. The term operating clutches refers to _____ clutches.

   a. engine
   b. steering
   c. attachment control
   d. jaw

8. On an engine clutch, where is the pilot bearing usually located?

a. In the transmission case
b. At the clutch release yoke
c. In the flywheel
d. On the transmission end of the clutch shaft

9. What is the purpose of the pilot bearing?

a. Reduce friction when the clutch is engaged
b. Reduce friction when the clutch is disengaged
c. Reduce friction of the releasing linkage
d. Reduce friction created by transmission gears

10. Which statement concerning brake linings is TRUE?

a. The primary brake shoe lining is always the longer.
b. The primary brake shoe lining is usually the shorter.
c. The primary and secondary brake shoe linings are always interchangeable.

11. A large gear driving a small gear will cause the small gear shaft to

a. increase speed.
b. increase torque.
c. decrease speed.
d. rotate in the same direction.

12. What determines the gear ratio of two meshing gears?

a. Diameter of the gears
b. Number of teeth on the gears
c. Rpm of the gears
d. Direction of gear rotation

13. What type gears will resist reverse torque and change the direction of power flow?

a. Bevel gear and pinion
b. Worm and gear
c. Reverse idler
d. Countershaft

14. How many rotating members are there in a planetary gear system?

a. 1
b. 2
c. 3
d. 4

15. What type bearings are normally used to support heavy loads at high speed?

a. Antifriction
b. Sliding surface
c. Bushing
d. Babbit

16. Which statement about bearings is INCORRECT?.

a. All bearings are prepacked with lubricant and sealed.
b. There are two general types of bearings.
c. Antifriction bearings ordinarily give a warning before complete failure.
d. Bearing life depends upon proper lubrication and cleanliness.

17. What type gears are used in the sliding spur gear transmission?

a. Helical spur
b. Spiral bevel
c. Straight spur
d. Worm

18. A torque converter operates on the principle of

a. fluid friction.
b. solid friction.
c. mechanical linkage.
d. internal expansion.

19. What is the purpose of a torque converter stator?

a. Decrease torque
b. Change direction of oil flow
c. Resist engine power
d. Act as a fluid coupling

20. What part of the torque converter makes it capable of torque multiplication?

a. Pump
b. Stator
c. Turbine

21. How many clutches are used to control the torqmatic transmission planetary gear systems?

a. 2
b. 3
c. 4
d. 5

22. Power from the engine through the transmission is transmitted to the differential and wheels by the

a. propeller shaft.
b. universal joint.
c. crankshaft.
d. camshaft.

23. The universal joint allows up and down movement between the propeller shaft and

a. wheels.
b. clutch.
c. frame.
d. differential.

24. The direction of power flow along the propeller shaft is changed 90° by the

a. clutch.
b. differential.
c. universal joint.
d. slip joint.

25. On the MRS-100 tractor, speed fluctuation of the propeller shaft is prevented by use of a ______ universal joint.

a. sliding joint
b. differential lock
c. constant-velocity
d. double reduction

Total Points: 25

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BASIC ENGINEER EQUIPMENT MECHANIC

Lesson 4

Auxiliary Equipment

STUDY ASSIGNMENT: MCI 13.29e, Basic Engineer Equipment Mechanic, chap 4.

LESSON OBJECTIVE: Upon successful completion of this lesson, you will be able to identify the principles of operation of vehicle hydraulic systems, compressor, electrical system, steering system, and frames.

WRITTEN ASSIGNMENT:

A. Multiple Choice: Select the one answer which BEST completes the statement or answers the question. After the corresponding number on the answer sheet, blacken the appropriate box.

Value: 1 point each

1. How much force will a piston whose area is 5 sq in. have with a pressure of 20 psi acting on it?

   a. 4 lb
   b. 20 lb
   c. 100 lb
   d. 500 lb

2. What type pump is most often used for a hydraulic system in engineer equipment?

   a. Positive diaphragm
   b. Non-positive diaphragm
   c. Positive displacement gear
   d. Non-positive displacement gear

3. What is the most important item of hydraulic system maintenance?

   a. Cleanliness
   b. Proper pressure
   c. Control of heat
   d. Proper operation

4. What type fluid is used in a hydraulic system that provides attachment power?

   a. Hydraulic brake fluid
   b. Engine oil
   c. Transmission oil
   d. Any liquid

5. When does the vehicle air compressor governor function and direct the air pressure to operate the unloading lever?

   a. Before the air pressure in receiver reaches a preset PSI.
   b. After the air pressure in receiver reaches a preset PSI.
   c. When atmospheric pressure is greater than receiver pressure.

6. Hydraulic oil pumps are rated according to volume of output in

   a. feet per second.
   b. gallons per second.
   c. gallons per minute.
   d. gallons per hour

7. To direct fluids to the desired part of the hydraulic system a _______ is needed.

   a. pressure relief valve
   b. pressure control valve
   c. directional control valve
   d. ram cylinder

8. What type air compressor is used to supply the airbrake systems of engineer equipment?

a. Rotary
b. Reciprocating
c. Heavy-duty
d. Air-cooled

9. What is the force that causes electric current to flow?

a. Amperage
b. Resistance
c. Voltage
d. Inductance

10. Current flowing through a conductor will produce

a. heat and a magnetic field.
b. heat and electrical energy.
c. heat and resistance.
d. chemical energy and a magnetic field.

11. Which is NOT part of the charging circuit?

a. Generator
b. Generator regulator
c. Conductor
d. Ohmmeter

12. Which converts mechanical energy into electrical energy?

a. Battery
b. Generator
c. Starter
d. Regulator

13. Which three are required to mechanically produce an electric current?

a. Generator, battery, and conductor
b. Generator, magnetic field, and conductor
c. Magnetic field, conductor, and brushes
d. Magnetic field, conductor, and movement

14. What will NOT affect generator output?

a. Size of battery
b. Strength of magnetic field
c. Speed of armature
d. Length of conductor passing through the magnetic field

15. What is the purpose of the generator regulator?

a. Control output and protect the generator
b. Control generator output
c. Protect the generator
d. Control speed of generator

16. What does an ammeter measure?

a. Voltage
b. Resistance
c. Current flow
d. Ohms

17. What device converts electrical energy into mechanical energy?

a. Generator
b. Cranking motor
c. Battery
d. Coil

18. What is the purpose of a starter solenoid?

a. Close the electrical circuit and engage the starter drive assembly.
b. Close the charging circuit and charge the battery.
c. Engage the starter drive assembly.
d. Turn the engine and control the current flow.

19. To reduce the effects of rough terrain transmitted to the steering wheel, mechanical steering systems often employ a

a. rack and pinion.
b. worm and gear.
c. hydraulic shock absorber.
d. steering brake.

20. Some power steering systems use a double-acting hydraulic cylinder in place of part of the mechanical system. Where is this cylinder attached?

a. To the steering gear assembly
b. Between the steered wheels
c. Between the drag link and the tie rod
d. Between the frame and the steering linkage

21. What supports the weight of vehicle tracks as they are pulled across the top?

a. Sprocket
b. Idlers
c. Rollers
d. Drive chains

22. When you operate in loose soil, why should the track chains be loosened?

a. Better shock absorbing
b. Assist soil build up in tracks
c. Prevent tracks from binding
d. Protect track rollers

Total Points: 22

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