DEPARTMENT OF THE ARMY TECHNICAL MANUAL

DEPARTMENT OF THE AIR FORCE TECHNICAL ORDER

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TO 36-1-40

TM 9-207/TO 36-1-40 ORDNANCE MATERIEL IN EXTREME-COLD WEATHER—1959

OPERATION AND MAINTENANCE OF

ORDNANCE MATERIEL IN EXTREME COLD WEATHER 0° TO -65° F

DEPARTMENTS OF THE ARMY AND THE AIR FORCE

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OPERATION AND MAINTENANCE OF ORDNANCE MATERIEL IN COLD WEATHER (0° to −65°F.)

TM 9-207/TO 36-1-40, 7 December 1970, is changed as follows:

1. New and changed material is indicated by a star.

2. Remove old pages and insert new pages as indicated below.

Remove pages	*Insert pages*
1-3 and 1-4	1-3 and 1-4
1-7 through 1-10	1-7 through 1-10
2-3 and 2-4	2-3 and 2-4
2-7 and 2-8	2-7 and 2-8
3-3 through 3-6	3-3 through 3-6

3. File this change sheet in front of the publication for reference purposes.

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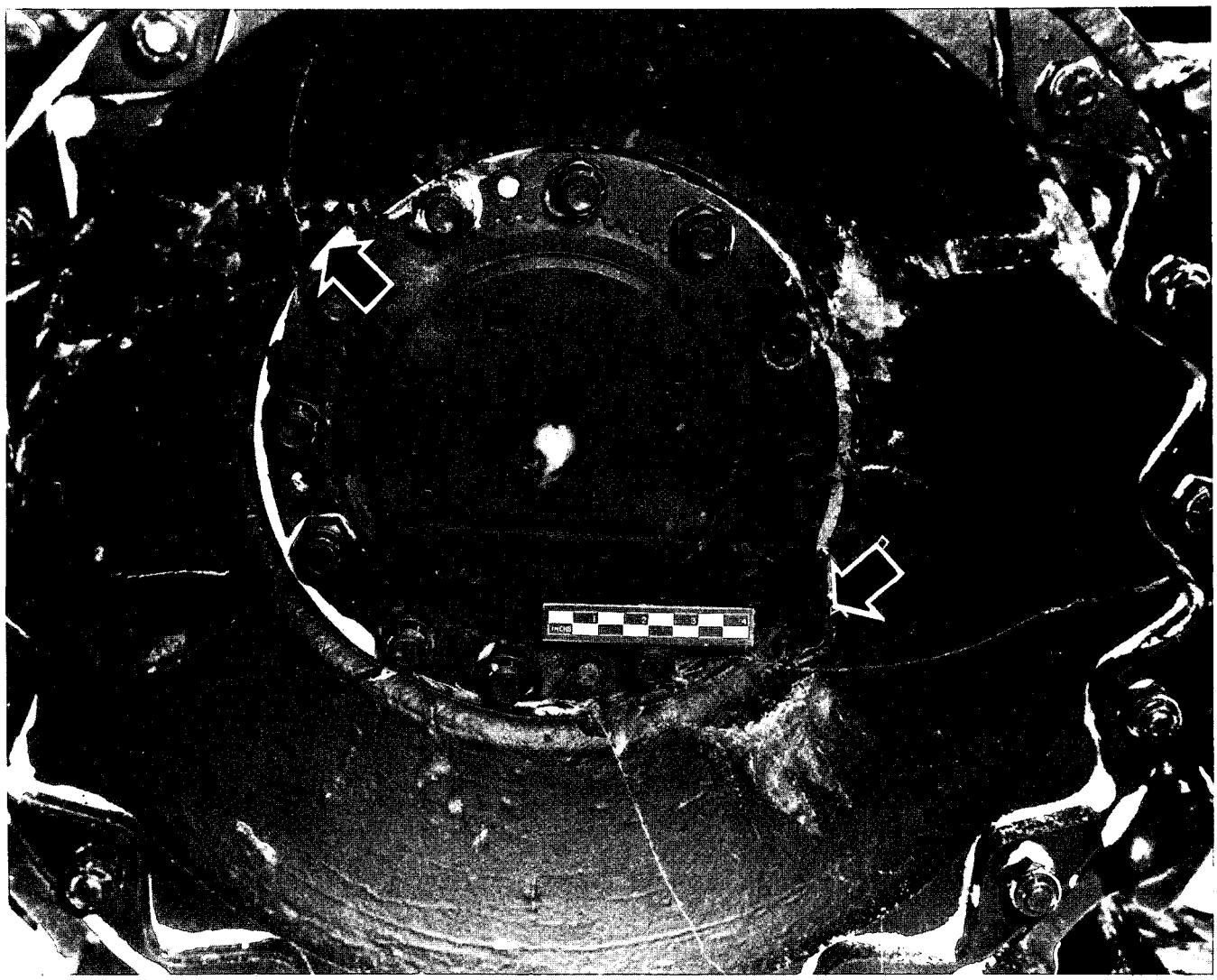

Figure 1-1. Drive wheel broken by extreme cold.

and its alloys (except lead-tin compositions high in tin) have the same capacity to withstand stress as they possess at warmer temperatures. However, low-temperature effects are especially adverse on pure tin solders. Prolonged exposure to low temperatures causes the expansion and eventual disintegration of the tin. There are many alloys that will, in effect, greatly retard or prohibit these effects; and there are yet others that produce no retarding effects and, in fact, accelerate them. These considerations should be kept in mind when selecting solders for equipment that will encounter subnormal temperatures either in storage, transit, or use.

CAUTION

This consideration is extremely important in selecting solders to be used in fuel line connections.

c. Nonmetallic Materials.

(1) *Rubber.* In addition to natural and synthetic rubber, there are hundreds of rubber substitutes. They all resemble rubber and, to a certain extent, react like rubber, but they have different characteristics. Synthetic rubber materials are made from chemicals combined by special processes. These synthetic materials look and usually react like natural rubber, although most of them do not attain a greater flexibility at higher temperatures than does natural rubber. Heated natural rubber may be stretched as much as seven or eight times its original length and then return with a snap to its normal length when released. However, as it is cooled, natural rubber will gradually stiffen, although it retains a large part of its elasticity until temperatures below —20° F. are reached. Below —20° F. certain peculiarities are observed. When cooled gradually but continuously over a short period of time, the rubber will remain flexible until a temperature of approximately —60° F. is reached; then it suddenly loses its elasticity and becomes very brittle. Furthermore, if the rubber is consistently kept at a temperature below —20° F. for a long period of time, even though it does not approach lower temperatures, an effect similar to crystallization occurs, causing it to become brittle.

(2) *Rubber cables.* Extreme care must be taken in handling cables at low temperatures. If the rubber jackets become hard, the cables must be protected from shock loads and bending to preclude short circuits caused by breaks in the covering. If cables are to be bent, they must first be warmed. Neoprene jackets on cables are known to be unsatisfactory. Neoprene becomes very brittle and breaks readily at low temperatures.

(3) *Rubber parts.* Rubber parts such as boots, guards, etc., become brittle and fail in low temperatures.

(4) *Tires.* Rubber tires become rigid in cold, causing flat spots on portions that come in contact with the ground during shutdown periods. At extreme low temperatures sidewalls become brittle and crack (fig 1–2).

(5) *Plastics.* In general, plastics expand and contract much more than metal or glass. Decreased resistance to stress and an increase in brittleness are the two most important effects of cold weather conditions on plastics. Any parts or materials made of plastic must be handled carefully. Many of the vehicular canvas covers have plastic windows, which become very brittle and, in many cases break due to a combination of cold and vibration.

(6) *Glass.* Glass, porcelain, and other ceramics, although sensitive to rapid temperature changes, can be expected to perform normally at low temperatures if handled carefully. Cracking may result if heat should be applied directly to cold windshields or vehicle glass.

(7) *Fabrics.* Fabrics, in general, retain their flexibility even at extremely low temperatures provided they are kept dry. However, tarpaulins present difficulties in conforming to their intended dimensions due to apparent shrinkage. This is usually the result of wrinkles that are extremely difficult to smooth out at subzero temperatures. Whenever possible, tarpaulins should be unfolded in heated enclosures.

(8) *Leather.* Leather does not perform satisfactorily in cold because it cracks, becomes stiff, and is usually ruined if frozen when wet.

★(9) *Wood.* Wood normally can be expected to perform satisfactorily at low temperatures. In general, dry wood will not be affected. Green or moisture-soaked wood may be damaged by cold weather because of embrittlement caused by the freezing of moisture particles within the wood.

nation from exhaust gases caused by leaking gaskets, improper exhaust installations, cracked exhaust pipes, defective personnel heaters, and auxiliary generators.

b. Lighting Equipment. Sufficient lighting equipment must be available to furnish adequate illumination for maintenance services. Lights with ample cable extensions, attachment plugs, connectors, and spare bulbs are essential.

c. Maintenance Personnel, Tools, and Equipment.

(1) A considerable increase in the number of mechanics will be required to maintain equipment in cold weather operations. Providing heated buildings or shelters for maintenance of materiel will be of great value. It must be remembered, that the amount of work performed under cold conditions is considerably less than work accomplished in moderate temperatures.

(2) An adequate supply of battery chargers must be available to meet the heavy requirements for battery maintenance in subzero temperatures. Hydrometers, calibrated for temperatures to —65° F. and indicating temperature correction to +80° F. must be provided.

(3) Welding equipment, tire repair equipment, special tools, and an adequate supply of repair parts are all essential requirements for proper maintenance of materiel.

(4) In general, the tools already provided in the various tool chests are adequate for maintenance at subzero temperatures. However, the additional tools and accessories described in (5) and (6) below, will be of service.

(5) Soldering irons of 300-watt capacity should be available if any soldering is to be done at subzero temperatures; soldering irons of 200-watt capacity or less will not function satisfactorily.

(6) Insulation Tape, 5970–240–0620 (MIL–I–3825) should be used for binding electrical splices. For even greater protection this tape can be used in conjunction with friction tape.

★(7) Handwear may become saturated with fluids when performing maintenance on fuel, lubrication or cooling systems. This will reduce the insulating value of the handwear and possibly result in cold injury to personnel. Therefore, personnel should carry extra handwear when performing maintenance in the field under arctic winter conditions.

★(8) Personnel should avoid leaning on cold-soaked equipment or kneeling and lying on the ground because rapid body cooling caused by heat transfer to the equipment or ground may result in cold injury. Some sort of insulation, such as fiber packing material, corrugated cardboard, rags or tarpaulins, should be placed between the mechanic and the cold-soaked equipment.

★(9) When performing maintenance under arctic winter conditions, a tarpaulin should be placed under the vehicle to catch parts which may be dropped, thus preventing them from becoming lost in the snow. A box or pan should be used to hold small parts to prevent them from being swept off the fender, for example, and being lost in the snow. Items which could easily be lost or damaged such as lug nuts, bolts, screws, etc., should be included in the OVE. The numbers and types can be determined from past maintenance experience.

Section IV. ANTIFREEZE, FUELS, HYDRAULIC FLUIDS, AND LUBRICANTS

1–9. General

a. Antifreeze. The antifreeze materials specified for protection of liquid-cooling systems for operations in cold weather are indicated in table 1.

b. Fuels. Arctic fuels for gasoline or diesel engines are selected to obtain the proper atomization necessary for a combustible, fuel-air mixture in cold weather operations. These fuels are listed table 1.

c. Hydraulic Fluids. Hydraulic fluids specified for shock absorbers, hydraulic systems, recoil mechanisms, and equilibrators are indicated in table 1.

★*d. Lubricants,* Lubrication required for Army equipment is specified in the lubrication order or technical manual pertinent to the equipment. Lubrication orders are based on three anticipated ranges: above 32° F, from 40° to —10° F, and from 0° to —65° F. However, a new lubricant for use from 40° to —65° F. has been developed and is available under a Purchase Description (APG PD No. 1).

1–10. Materials

The materials normally required in preparing ordnance materiel for operation in cold weather are indicated in table 1. These items are listed in

Department of Defense, Federal Supply Catalogs, FSC Groups 68 and 91 which should be consulted when requisitioning. Other items, with specification numbers, unit of issue, stock numbers, and issuing services, are listed herein for requisition through normal supply channels.

1-11. DA Lubrication Orders

a. The provisions of DA Lubrication Orders are mandatory and will be adhered to at all times unless deviation is authorized by Department of the Army.

b. Increased service scheduling from that specified on Lubrications Orders may be necessary to compensate for cold conditions that may destroy the protective qualities of the lubricant. Intervals may be extended during inactive periods provided adequate preservation has been accomplished. The foregoing is done at the discretion of the commanding officer.

c. Military symbols for petroleum and related products indicated in the "KEY" on lubrication orders are standardized in Military Standard MIL-STD-290. Container markings for these items include the NATO and Military Symbol, the Federal Stock Number, Specification Nomenclature, etc., to identify the contents.

★*Table 1. Antifreeze Materials, Fuels, Hydraulic Fluids, and Lubricants for Use in Cold Weather (0° to −65°F)*

Item	*FSN*	*Container size*
ALCOHOL, DENATURED: grade III, O-E-760B	6810-543-7415	1 gal can
	6810-201-0907	5 gal can
	6810-201-0904	55 gal drum
ANTIFREEZE: Arctic-type (−90°F) (MIL-A-11755)	6850-174-1806	55 gal drum
ANTIFREEZE: Ethylene glycol, inhibited, heavy duty, single package	6850-181-7929	1 gal can
	6850-181-7933	5 gal can
	6850-181-7940	55 gal drum
COMPOUND, CLEANING: W/conditioner and inhibitor for engine cooling systems (MIL-C-10597).	6850-598-7328	Pkg
DRY CLEANING SOLVENT: (P-D-680) Type I	6850-264-9037	55 gal drum, 16 ga
Type I	6850-285-8012	55 gal drum, 18 ga
Type II	6850-281-1986	55 gal drum, 16 ga
Type II	6850-285-8011	55 gal drum, 18 ga
FUEL SYSTEM ICING INHIBITOR, MIL-I-27686	6850-753-5061	5 gal can
(Ethylene Glycol Monomethyl Ether)	6850-060-5312	55 gal drum
FUEL OIL, DIESEL: 40 cetane, VV-F-800	9140-286-5284	55 gal drum
Arctic grade (DG-A) (−25°F & below)	9140-286-5283	Bulk
GASOLINE, AUTOMOTIVE, Low Leaded or Unleaded (VV-G-001690)	9130-167-9775	
GASOLINE, AUTOMOTIVE, Combat Grade	9130-160-1830	
GREASE, AIRCRAFT AND INSTRUMENT: (GIA) MIL-G-23827	9150-985-7245	8 oz tube
	9150-985-7246	1 lb can
	9150-985-7247	5 lb can
CLEANING COMPOUND, SOLVENT: (Rifle Bore Cleaner MIL-C-372)	6850-224-6663	1 gal can
GREASE, AUTOMOTIVE AND ARTILLERY (GAA) MIL-G-10924	9150-190-0905	5 lb can
	9150-190-0907	35 lb pail
	9150-190-0904	1 lb can
HYDRAULIC FLUID, NON-PETROLEUM BASE: Brake systems (HBA) MIL-H-13910.	9150-252-6375	1 gal can
HYDRAULIC FLUID, PETROLEUM BASE: Recoil Special MIL-H-13866	9150-252-6374	1 gal can
	9150-252-6377	1 qt
HYDRAULIC FLUID, PETROLEUM BASE, Preservative (OHT) MIL-H-6083C	9150-935-9807	1 qt can
Note. OHT should be used wherever previous documents have specified OHC.	9150-935-9808	1 gal can
	9150-935-9809	5 gal pail
	9150-935-9810	55 gal drum
HYDRAULIC FLUID, PETROLEUM BASE (OHA) MIL-H-5606	9150-252-6383	1 qt can
	9150-223-4134	1 gal can
	9150-265-9408	55 gal drum
INHIBITOR, CORROSION, LIQUID COOLING SYSTEM O-I-490	6850-753-4967	6 oz can
LUBRICATING OIL, Exposed gears and wire ropes (CW IIA) (VV-L-751)	9150-261-7891	35 lb pail
LUBRICATING OIL, Gear Multi-Purpose (GO-80) MIL-L-2105	9150-577-5843	55 gal drum
	9150-577-5841	6 gal drum

★*Table 1. Antifreeze Materials, Fuels, Hydraulic Fluids, and Lubricants for Use in Cold Weather (0° to −65°F)* —Continued

Item	*FSN*	*Container size*
LUBRICATING OIL, Gear, Multi-Purpose, Sub-Zero (GOS), MIL-L-10324	9150-257-5440	5 gal can
LUBRICATING OIL, General Purpose (LO) VV-L-820	9150-252-6173	4 oz can
LUBRICATING OIL, INSTRUMENT MIL-L-6085	9150-257-5449	4 oz can
LUBRICATING OIL, General Purpose (OGP) MIL-L-7870	9150-542-1430	4 oz can
	9150-263-3490	1 qt can
LUBRICATING OIL, General Purpose, preservative (PL-S) VV-L-800	9150-231- 689	1 qt can
	9150-273-2389	4 oz can
	9150-281-2060	55 gal drum, 18 ga
	9150-281-2007	55 gal drum, 16 ga
LUBRICATING OIL, Instrument (OAI) MIL-L-6085	9150-257-5449	4 oz can
	9150-223-4129	1 qt can
LUBRICATING OIL, Internal Combustion Engine, Tactical (OE/HDO-10) MIL-L-2104C.	9150-186-6668	5 gal can
	9150-189-6728	55 gal drum
LUBRICATING OIL, Internal Combustion Engine, (OES) (subzero) MIL-L-10295	9150-242-7602	1 qt can
	9150-242-7603	5 gal can
	9150-242-7605	55 gal drum
LUBRICATING OIL, Internal Combustion Engine, Sub-Zero (APG Purchase Description No. 1).	9150-402-4478	1 qt can
	9150-402-2372	5 gal can
	9150-491-7197	55 gal drum
LUBRICATING OIL, Internal Combustion Engines, Preservative & Break-In, MIL-L-21260B.	Type I (PE 10-1)	
	9150-111-3199	5 gal can
	9150-111-3200	55 gal drum
	Type II (PE 10-2)	
	9150-111-3202	5 gal can
	9150-111-3203	55 gal drum
LUBRICATING OIL, Weapons (LAW) MIL-L-14107A	9150-664-0038	4 oz can
	9150-292-9689	1 qt can
	9150-292- 987	5 gal can
LUBRICATING OIL, Semi-fluid (LSA) MIL-L-46000	9150-889-3522	4 oz bottle
	9150-687-4241	1 qt can
METHANOL, Technical (MOGAS Fuel additive)	6810-597-3608	1 gal can
	6810-275-6010	5 gal can
THINNER, PAINT, MINERAL SPIRITS (TT-T-291, Grade 1)	8010-246-6115	55 gal drum, 16 ga
	8010-246-6116	55 gal drum, 18 ga
	8010-242-2089	1 gal can
	8010-558-7026	5 gal can

Section V. WINTERIZATION EQUIPMENT

1-12. General

a. Special equipment is provided for the vehicle when protection against cold weather (0° to −65° F.) is required. This equipment is issued as specific kits. Winterization will be performed when specified in applicable shipping instructions. However, it is unlikely that winterization kits will be installed until it is definitely known that the vehicle will operate in areas of temperatures of 0° F. or lower.

b. Where the temperature falls only a few degrees below freezing for a short period of time, only ordinary preparations need be made; such as engine oil change to lighter grade, the addition of antifreeze to coolant, and radiator coverage. For anticipated ambient temperatures as low as −25° F., the personnel heater kit and, in some cases, hard top closures will be installed. Operations will not be attempted without winterization kits in areas where temperatures from −25° to −65° F. are likely to be encountered.

1-13. Personnel Heater Kits

a. Two personnel heater kits are used; one for ambient temperatures of 0° F. to −25° F. and the other from −25° F. to −65° F.

b. On gasoline powered vehicles the 0° F. to −25° F. personnel heating kit generally uses a hot water heater either 20,000 BTU/HR or 30,000 BTU/HR. On some diesel or multi-fuel powered vehicles and tank type vehicles, *only* a multi-fuel burning heater is supplied for the 0° F. to −25° F. kit. Diesel or multi-fuel powered vehicles do not generate adquate coolant temperatures to

satisfactorily use a hot water heater in the 0° F. to —25° F. temperature range.

c. The personnel heater kit —25° F. to —65° F. uses a multi-fuel burning heater for all vehicles.

d. Operating instructions for the various personnel heaters are contained in applicable vehicle and heater technical manuals.

1–14. Hard-Top Closure Kit

A hard-top closure kit is provided for all vehicles for protection of the driver and assistant driver. It should be added where temperatures lower than —25° F. are anticipated. All around vision is provided by a glass window on each side, and to the rear.

1–15. Power Plant Heating System

a. Quick Heat System. Quick heat is the technique that allows the vehicle temperature to drop as low as the existing ambient. When vehicle operation is desired, sufficient heat is then applied to the engine, batteries and components as required to raise their temperature to a value that will insure reliable starting. The time to obtain temperatures required for successful engine starts can vary up to one hour. The military objective is not to exceed one hour preheating regardless of the ambient. The quick heat technique cannot be employed in cases where vehicle use demands instant operation. Quick heat systems are generally used on air cooled engines and small gasoline burning engines.

b. Stand-by Heat System. The stand-by system includes an engine coolant heater, coolant hoses, control valves, fuel pump, battery heat exchanger (commonly known as a battery pad) and miscellaneous hardware. Stand-by heat is the technique based on the concept of not permitting the pertinent vehicle components to fall below a certain minimum temperature regardless of the ambient. To accomplish this, the fuel burning heater is continuously operated during the stand-by period to maintain engine and battery electrolyte temperature, at a level to provide maximum cranking and battery recharging potential. This system is a stand-by type, and is not designed to start a vehicle engine after it has cold soaked for an extended period of time in sub-zero temperatures (—25° F. to —65° F.). In an emergency situation the stand-by system can be helpful to obtain an engine start if given adequate time. In prolonged cold soaked situations in extreme cold ambients, refer to TB ORD 390 and SB 9–16.

Type I. For temperatures lower than —54° F., Arctic Grade Permanent Antifreeze will be used.

(*b*) Cooling systems containing ethyleneglycol-water or arctic antifreeze solutions will all be drained and flushed, if required, prior to the advent of freezing temperatures. This solution will be used for one year and tested for freeze point and rust protection in accordance with revised TB 750–651. After the solution meets, or is adjusted to meet established criteria of this TB, it will be used for one additional year, discarded, and the two year cycle repeated.

(2) *Procedures.*

(*a*) When drain plugs have been removed or drain cocks opened to remove liquid from the cooling system of any equipment, the drains will be inspected to be sure none is obstructed. If any drain hole has become obstructed by foreign material, a soft wire should be used to clear the obstruction from the hole to permit thorough drainage.

(*b*) Before adding antifreeze compound, it is necessary that the cooling system be clean and completely free from rust. The system will be cleaned with cleaning compound, using approved methods in accordance with TB 750–651, only if required.

CAUTION

It is essential that antifreeze compounds be kept clean. Use only containers and water that are free from dirt, rust, and oil.

(*c*) Inspect and replace all deteriorated cooling-system hoses and radiator cap gaskets. Hose clamps, plugs, and pet-cocks are to be inspected and tightened if necessary. Radiator leaks will be repaired before adding antifreeze compound. Exhaust gas or air leakage into the cooling system will be corrected. If there are any indications of coolant leakage at the cylinder head, tighten the cylinder-head nuts as specified in the applicable technical manual. Replace the cylinder-head gasket if necessary. Check the applicable technical manual because on some vehicles the torquing of head bolts and replacement of head gaskets is the responsibility of DS/GS maintenance.

(*d*) If engine does not reach normal operating temperature inspect thermostat to see that it closes completely. Look for evidence of sticking in open or closed position. Proper operation of the thermostat can be checked by immersing it in a pail of hot water (fig 2–1)to make certain that it

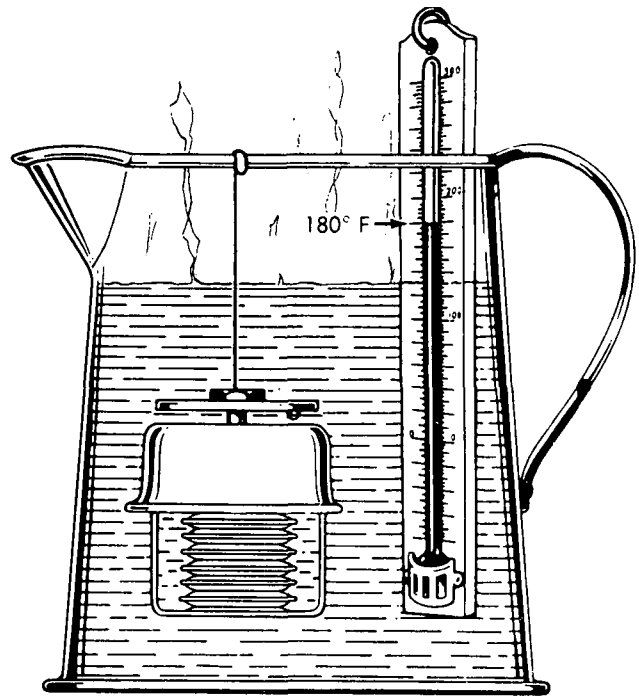

Figure 2–1. Simple shop test for checking thermostat operation.

will open completely. Replace thermostat if it does not open or close completely, does not function freely, or is badly rusted. Where the average temperature will be between 0° and —65° F., a 180° F. thermostat will be installed in those cooling systems which use a 150° F. thermostat in normal operations.

★(*e*) When the cooling system is clean and tight, fill with antifreeze solution to which one ounce of corrosion inhibitor (6850–753–4967 (O–I–490)) has been dissolved in each 2 quarts of water, except for arctic type antifreeze. O–I–490 should be used only in O–A–548 Type I antifreeze solutions. O–A–548 antifreeze is being replaced by MIL–A–46153 single package antifreeze which does not require the additional corrosion inhibitor. Using the proportion required for the lowest expected temperatures as indicated in table 2, the system should be protected to at least 10° F. below the lowest expected Fahrenheit temperatures.

(*f*) Avoid if possible the use of water containing large amounts of minerals or impurities.

(*g*) Run engine until it reaches normal driving temperatures (140° to 180° F.) to release trapped air and to mix solution.

(*h*) After driving temperatures have been reached, the engine should be stopped and the solution checked with an antifreeze tester adding

more antifreeze solution if necessary, and allowing for expansion. Do not overfill.

Table 2. Guide for Preparation of Ethylene-Glycol Antifreeze Solutions

Cooling system capacity in quarts	Quarts of antifreeze required					
	2	4	6	8	10	12
	Degrees fahrenheit					
10	16°	−12°	−62°			
12	19°	0°	−34°			
14		6°	−18°	−54°		
16		10°	− 8°	−34°		
18		14°	0°	−21°	−50°	
20		16°	4°	−12°	−34°	−62°
22		18°	8°	− 6°	−23°	−47°
24		19°	10°	0°	−15°	−34°
26		21°	13°	3°	− 9°	−25°
28			15°	6°	− 5°	−18°

For cooling systems larger than those shown, determine the amount required for a system one-half that size and then double the amount. Add an extra quart to any system that operates with a hot water heater.

NOTE

Following are the required percentages of antifreeze and water for protection to the temperatures indicated:

Antifreeze:	20	25	35	40	50	60
Water:	80	75	65	60	50	40
Protects To:	16°F.	10°F.	0°F.	−12°F.	−34°F.	−62°F.

(*i*) Fill out, sign, and fasten a tag on or near the radiator filler neck indicating the type of antifreeze material that the system contains and the temperature range of protection that is provided. The tag should read: THIS COOLING SYSTEM IS FILLED WITH ETHYLENE-GLYCOL ANTIFREEZE SOLUTION. PROTECTS TO —40° F. (or whatever the correct protection temperature should be) OR THIS COOLING SYSTEM IS FILLED WITH ARCTIC-TYPE ANTIFREEZE. PROTECTS TO —90° F. CAUTION: DO NOT ADD WATER OR ANY OTHER TYPE OF ANTIFREEZE.

★(*j*) At the completion of the cooling system processing, the condition of the cooling system and the degree of freeze protection shall be recorded on DA Form 2408-1, or on DA Form 2409.

c. Air-Cooled System.

(1) Since an air-cooled system does not employ a liquid coolant, it is often assumed that air alone acts as the cooling medium. However, this is not true, since the lubrication systems also help in cooling the engine and a transmission often includes oil pumps that circulate the oil between the engine and the coolers and between the transmission and the coolers, removing heat from the engine and transmission as they do so. Some engine cooling also results from the fuel contacting metal parts prior to combustion.

(2) The effects of cold on an air-cooled system are basically the same as the effects on the engine lubrication system.

(3) Expedient Protection for Air Cooled Engines. At temperatures of —20° F. and colder, air-cooled engines become most difficult to operate. As an example, an air-cooled engine drawing super-cooled air of —40° F. at 40 MPH will freeze within 45 minutes. This situation can be alleviated by surrounding the engine with its own self-generated heat. This can be accomplished by placing the engine in a box constructed specifically for that purpose. Figure 2-2 illustrates the box for the generator and Figure 2-3 illustrates the box for the 50 Gallon Per Minute (GPM) pump. This system has been successfully used in temperatures down to —50° F.

d. Fuel System.

(1) *General.*

(*a*) For a satisfactory start, the engine fuel must be sufficiently volatile to produce a combustible mixture with air. Atomization, which increases the rate of vaporization of the fuel to produce a combustible mixture, is adversely affected by low temperatures. The maximum amount of vaporization obtainable with the regular grade of motor fuel, without the use of a primer or application of heat to the mixture, will provide only sufficient vaporized fuel for starting at a minimum temperature of approximately 0° F.

(*b*) Diesel engines are particularly difficult to start in cold weather. Many fuels suitable for diesel engines contain waxes that congeal at temperatures below 0° F. If this is allowed to occur, the filter will clog and the fuel will not flow.

(*c*) Water will accumulate in tanks, drums, containers, fuel pumps and carburetors, because of condensation of water from the air. At low temperatures, this water will form ice crystals that will clog fuel lines, fuel filters, fuel pumps, injector nozzles, and carburetor jets.

(*d*) All fuel filters should be drained at the end of each day of operation.

(2) *Preparation for operation.* The general instructions below will be followed to prepare fuel systems for operation in cold weather.

★(*a*) Drain fuel systems and refill with arctic-grade fuel. Add Inhibitor, Icing, Fuel Systems (ethylene glycol monomethyl ether) to diesel fuel, and Methanol, Technical, to gasoline. Additives will be admixed with the fuel at a ratio of one pint of additive to 40 gallons of fuel at the time of refueling. Fuel filters must be drained immediately after operation to remove additive-water mixture from the bottom of the filters.

NOTE

★The use of additives in greater proportions will result in poor engine performance and possible engine damage.

★(*b*) Remove and service all carburetor and air compressor air-cleaner elements, including oil-bath-type. Clean with dry-cleaning solvent and reinstall. Fill oil-bath-type cleaners with engine lubricating oil (OES). Dry felt air cleaners should be cleaned with compressed air or with soap and water. When soap and water or dry cleaning solvents are used, air cleaners should be dried thoroughly before reinstallation.

(*c*) Check for any indication of fuel leaks. Trace all leaks to their source and correct or replace parts as necessary.

(*d*) An engine priming system is installed on certain gasoline engine powered vehicles but not on diesel engines and those utilizing multifuel. The priming system consists of a priming pump and injection nozzles or other fittings together with connecting tubing and fittings and, in some cases, with primer filter. The pump is operated by hand and is usually mounted on or near the instrument panel. A connection is tapped into a fuel supply line that leads to the primer pump. Another line leads from the pump to the injector nozzles that are affixed on the intake manifold opposite the entry ports in the engine block. The primer pump delivers fuel at high pressure to the injectors or fittings. The injectors atomize the gasoline that is drawn into the engine cylinders on the intake strokes.

2–4. Conventional-Type Transmission, Transfer Case, Differential and Other Gear Cases

Thoroughly drain and lubricate these items in accordance with pertinent lubrication orders (LO).

NOTE

★When engine oil (SAE 10 or OE/HDO10) is prescribed for gear cases, drain and fill with lubricating oil (OES) (APG PD No. 1) lubricating oil, or sub-zero gear oil (GOS).

2–5. Automatic Transmissions

All trnsmissions will be drained, flushed, and completely refilled in accordance with lubricant prescribed in applicable Lubrication Order/Chart.

2–6. Universal and Slip Joints

Thoroughly lubricate joints with automotive and artillery grease (GAA).

★2–7. Torque Converter

Drain and fill converter with hydraulic fluid (OHA) or (OHT) wherever hydraulic fluid is specified and lubricating oil (OES) or (APG PD No. 1) wherever lubricating oil (SAE 10 or OE/HDO–10) is specified.

Section III. ELECTRICAL SYSTEM

2–8. General

a. The storage battery is adversely affected by cold; its available energy decreases sharply as the temperature falls. Unfortunately, engine starting requirements, so far as current and voltage are concerned, are most sever when the battery is capable of delivering the least power. Current delivered at 15° F. will be only 50 percent of that which would be produced at normal temperatures; while the amount delivered at —30° F. will be only a little over 10 percent of that which would be produced at room temperature (fig 2–4). At —40° F. and below, the available current is practically zero. A fully charged battery will not freeze in extreme-cold climates, but a discharged battery (sp. gr., 1.100) will freeze at 19° F. Frozen batteries rupture and break internally and externally. Table 3 indicates freezing points of batteries at various specific gravities. Unless storage battery is warmed to about 35° F. it will not receive an adequate charge from the generator. The storage battery will be tested for its state of charge a minimum of once weekly. Recharge the battery if the hydrometer reading is less than 1.250.

b. The drive mechanism of starters is extremely

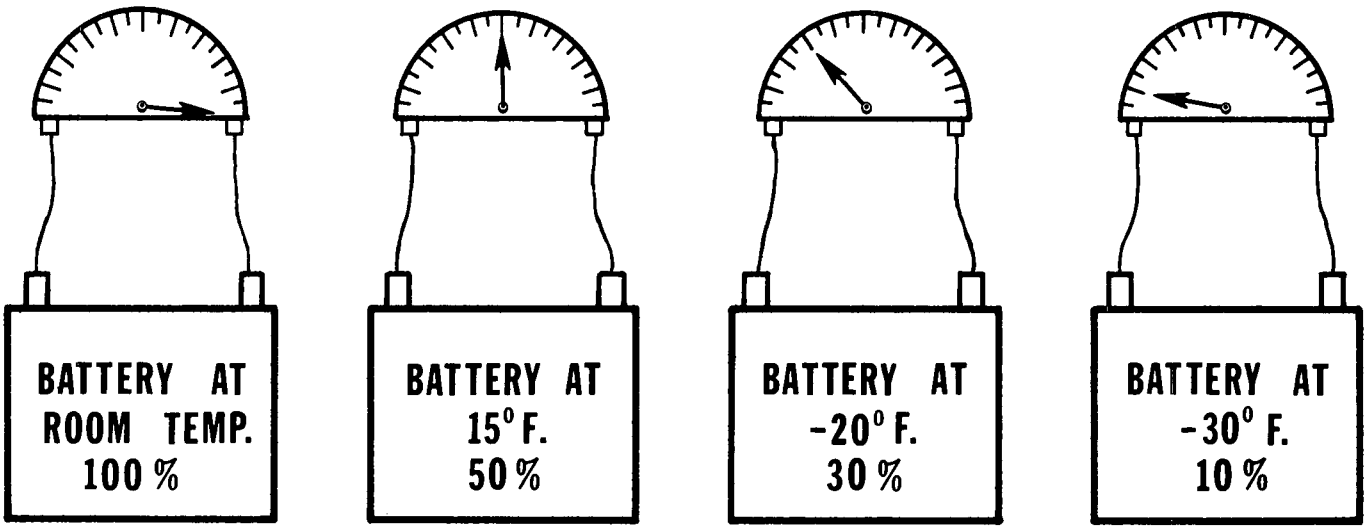

Figure 2-4. Percentages of current available from a fully charged battery at the various temperatures shown.

Table 3. Freezing Points of Batteries at Various Specific Gravities (with Specific Gravity Corrected to 80° F.

Specific gravity of electrolyte (corrected to 80° F.)	Freezing Points of electrolyte (°F.)
1.280	—90
1.250	—62
1.200	—16
1.150	5
1.100	19
1.000	32

susceptible to failure at low temperatures. Grease or dirt on the armature shaft, Bendix drive, or other type of mechanical drive will prevent the gears from meshing properly or cause them to remain in mesh after the engine is started. The latter will damage the starter. An improper lubricant on bushings could congeal and cause the starter to operate unsatisfactorily by placing an excessive drag on the armature. The overrunning clutch or starter drives may fail to release, because lubricant may solidify. Solenoid plungers, unless clean and free of oil, will bind in switch assembly housings. Oil and grease on brushes or commutator will prevent a good contact necessary to carry the large amount of current required to crank an engine.

c. The distributor breaker contact points will oxidize during operation in extreme cold, forming a high resistance between contacting surfaces, and prevent flow of current.

d. The breaker contact-arm bushing will freeze on its pivot unless it is clean and properly lubricated thus preventing the breaker arm from returning when the cam separates the points.

e. Improper oil or presence of excessive dirt will cause automatic advance mechanisms on distributors to become inoperative.

f. Low temperatures will aggravate unsatisfactory performance of magnetos, due to pitted or unclean breaker contact points.

g. Ice caused by condensation will coat spark plugs and may prevent starting of engines.

h. Oil or dirt on brushes or commutator will cause unsteady or low generator output. Generator ball bearings will fail to rotate when an improper lubricant solidifies and may cause drive belt failures.

i. Contraction of the helical springs in subzero temperatures will affect generator regulator adjustments and may result in high voltages. This may be a normal action and should not require special attention.

j. Electric heater motors may operate unsatisfactorily when lubricant congeals in bushings at low temperatures.

k. Insulation on low and high tension cables may crack.

2-9. Preparation for Operation

The procedures below will be followed to prepare the electrical system for cold weather operations.

3–2. Starting Engine Without Towing or Without Using Auxiliary Power (Slave Receptacle)

a. Gasoline Engines.

(1) In cold weather, storage batteries become less efficient and provide much less output than normally. A cold battery cannot energize the starter to turn over the engine at the required cranking speed and also supply the necessary ignition current to the spark plugs. The fuel is often not sufficiently volatile to supply proper fuel-air mixture to combustion chamber.

(2) For a successful start in cold weather, steps must be taken to insure that the conditions in (*a*) through (*d*) below do exist.

(*a*) The viscosity of the engine lubricating oil must permit cranking without overtaxing the capacity of the starting system. The engine oil must splash and be distributed easily by the oil pump to the various parts and bearings requiring lubrication.

(*b*) The battery must be fully charged and sufficiently warm to supply enough current to crank the engine and to supply the necessary spark for combustion.

(*c*) The ignition primary and secondary circuits must be clean and free of cracks, frost, and moisture to prevent shorting or current leakage.

(*d*) The distributor breaker points must be free of oxidation and moisture, in good condition, correctly adjusted and checked frequently.

(3) If slave kit and/or portable heater are unavailable for preheating, ether can be used as an emergency starting aid.

(*a*) Ether can be introduced directly into the air intake with the use of a regular oil can, inserting the ether in small squirts.

(*b*) *Extreme Caution* must be exercised when using ether and should only be used as a last resort in case of mission failure.

b. Diesel Engines. Diesel engines are particularly difficult to start in cold weather without preheating the intake air during the starting period. Since the air is heated by compression, it must attain a temperature hot enough to ignite the injected fuel. This preheating can be accomplished as indicated below:

(1) Heating with an induction manifold air heater, where this heater is a part of an engine, can accomplish sufficient preheating.

(2) By warming the engine with the blast heat from a slave kit (para 1–16) or portable heater, sufficient preheating may also be accomplished.

3–3. Using Auxiliary Power (Slave) Receptacle to Start Engine

a. The auxiliary power (slave) receptacle is used to start a vehicle when its batteries are unable to supply starting current. This applies in both cold weather and temperate zone operations.

b. The procedures in (1) through (6) below, are generally applicable to tactical vehicles, combat vehicles and self-propelled weapons. Refer to the vehicle operators manual for specific instructions and procedures.

(1) Start the engine in the vehicle that is to supply the auxiliary power and adjust the engine idling speed to 650 rpm.

(2) Connect the extension cable to the auxiliary power (slave) receptacle in each vehicle.

CAUTION

The master switch in the vehicle that is to receive the auxiliary power must be in the OFF position while connecting the extension cable.

(3) Start the dead engine and adjust engine idling speed to slow idle.

(4) Disconnect extension cable from both vehicles as soon as receiving vehicle idles at 650 rpm without stalling.

(5) Turn on master switch in the receiving vehicle.

(6) Increase engine speed in receiving vehicle to 1000 to 1200 rpm. Check battery-generator indicator in vehicle to make sure that it shows that battery is being charged. Care must be taken however, because some battery indicators will not indicate a charge until the vehicle has been operated for some time.

3–4. Towing to Start Engine

Towing a vehicle to promote starting as an expedient is poor practice. The application of external power will not solve the problem of internal resistance due to "frozen" parts (i.e., lack of fluid lubrication or hydrostatically locked engine). However, if other starting expedients have failed and it is determined that the conditions in *a* through *d* below, have been met, the vehicle may be towed to start the engine.

NOTE

Insure that the hand brake is released and neither the hand brake and/or service brake linings are frozen to the brake drums. Vehicles should never be started by pushing.

CAUTION

Chains should be used for towing only as a last resort. When towing is necessary, a tow bar should be used. Towing to start vehicle engine will be only resorted to in cases of extreme emergency. Refer to vehicle operators manual for specific instruction, procedures, and caution.

a. Lubricants must be sufficiently fluid to allow the engine to turn over without excessive drag.

b. The lubricants in the transmission and transfer case must be able to permit shifting gears and allow operation without excessive drag on the power train.

c. Lubricants in the wheel bearings and differential must not be congealed.

d. When the engine can be rotated through one complete cycle, the engine is not hydrostatically locked.

Section II. CHASSIS AND BODY COMPONENTS

3–5. Operation

a. General.

(1) Possible accumulation of ice crystals on brake shoe surface while operating the vehicle and rendering the brakes ineffective until after several applications have generated sufficient heat to melt the frost and ice from between the brake shoe and drum.

(2) Build-up and freezing of slush and water around the wheels of an operating vehicle can cause loss of steering ability.

(3) Ice, mud, snow, etc., can build up to such an extent on operating vehicles that it will overload the vehicle components, reduce ground and other clearances and prevent or interfere with normal operation of moving components.

(4) Insure adequate fresh air supply in personnel compartments to prevent depletion of suitable usable oxygen for breathing purposes.

b. Tracks. Avoid quick starts and stops if possible, sharp turns, and side slippage on ice and snow.

★*c. Tires.* If tires have a flat spot where contact with the ground was made, use a light pressure on the accelerator and drive vehicle slowly until generated heat permits tires to round out. Also, during periods of freezing rain or sleet, move wheels around often. To prevent tires from freezing to the surface, place small branches or other insulating material under them before parking. If tires do freeze in place, common table salt can be sprinkled around the tires causing the ice to crack and freeing the tire. A small amount of antifreeze poured around the tires serves the same purpose, except that the antifreeze eats away the ice.

d. Springs. Avoid going suddenly into depressions or over obstacles that may create shocks that could break springs in extreme cold.

e. Cab Inclosures. Cab heaters should be used to maintain adequate temperatures within cab inclosures. When crossing frozen streams or other bodies of water, open cab doors to permit quick escape of personnel in case vehicle should break through the ice.

★*f. Parking Brakes.* Do not park with brakes set because they may freeze in this position and not release. Use chocks to hold wheels or tracks in place. If the brake components do freeze in the set position, an external heat source, such as the portable duct heater, should be used for thawing to prevent damage to the vehicle power train.

3–6. Maintenance

a. Air Brakes. Drain water from compressed air reservoir as a daily maintenance procedure. Drain tanks at night; drain cocks should be closed immediately after draining to prevent freezing in open position. In the morning build up pressure before moving vehicle. Make certain that alcohol evaporator set is operating and that jar is filled with alcohol. Check brake lines, chambers, relay valves, push rods, seals, and slack adjusters for good condition, and that all parts are securely mounted. Check all valves and governor for satisfactory operation.

CAUTION

Drain water from air filters and reservoirs every 8 hours of continuous travel, but not while air-brake system is under

pressure. Also, drain water after temporarily disconnecting the air-brake lines from the towing vehicle.

b. Steering Gear. Repeat all before operation checks.

c. Track Suspension Wheels. Inspect track suspension wheels, arms, sprockets, torsion arm bearings, shock absorbers, snubbers, etc., for good condition and proper lubrication for extreme-cold weather operation. Examine idler bearing seals for leaks and the relief vents, for clogging. Tighten all assembly and mounting bolts to torque tightness specified in vehicle technical manual.

d. Tracks. Check track shoes, connectors, and wedges for good condition. Pay particular attention to dead shoes, loose or excessively worn shoes, connectors, and guides. Check adjustment.

★*e. Tires.* Check valve stems and cores for good condition. Replace core if rubber seal is brittle or shows wear. Examine tire casing for cuts, bruises, or breaks. Make sure caps are installed on all valve stems.

f. Springs. Clips, leaves, U-bolts, hangers, and shackles must be in good condition and correctly and securely mounted. Spring leaves should not be broken or shifted out of their correct position. Tighten all spring U-bolts securely. Tighten all assembly and mounting bolts.

g. Cab Closures. Note whether mountings are secure and in good condition. Replace broken windows. Make certain that inclosures are tight-fitting.

Section III. POWER TRAIN

3–7. Operation

a. Starting, Conventional-Type Transmission. Depress clutch pedal while starting engine with gear shift in neutral. After engine is running smoothly, release clutch cautiously and maintain engine at idle for 2 minutes or longer to warm up lubricant in transmission.

NOTE

If vehicle is equipped with a transfer having a selector lever, transfer lubricant may be heated in the same manner by placing selector lever in neutral and transmission in low.

b. Idling. Adjust the hand throttle to the engine speed specified in operator's technical manual until the engine is running smoothly and engage engine clutch (where applicable) to allow gear case lubricants to warm up. With transfer case levers remaining in "out" position to prevent movement of the vehicle, depress clutch and operate transmission gear shift lever until lever moves freely.

c. During Operation. The driver must be extremely careful when placing the vehicle in motion to be certain that gear case lubricants or wheel bearing greases are not congealed and the tires are not frozen to the ground. An attempt to operate with this condition will destroy parts in the power train, e.g., the clutch facings or gear teeth. The above will not occur when prescribed lubricants are utilized. When placing vehicle in motion, place transmission in low gear and transfer unit (where applicable) in low range. Drive vehicle 100 yards, being careful not to stall the engine, then upshift and continue slowly in the higher gears until the vehicle moves freely and tire thump ceases.

d. After Operation. When preparing a vehicle for a shutdown period, place transmission and trasfer shift levers in the neutral position. This will place these units in readiness for the next start by preventing them from freezing in an engaged position.

Section IV. ENGINE LUBRICATION SYSTEM

3–8. General

a. The mechanical efficiency of an engine depends upon the proper functioning of the lubrication system. Careful attention to preventive maintenance service by the driver and the organizational mechanic is required to keep the system in the best working condition.

b. As soon as an engine starts, check reading on the oil pressure gages. If engine oil pressure is not indicated within 30 seconds after starting, shut own engine and determine the cause. On those vehicles equipped with warning lights, stop engine and investigate the cause if engine-oil-pressure warning light does not go out within 30 seconds after engine has started.

c. Vehicles must be operated with minimum engine temperatures ranging from 160° to 180° F. to afford normal operation. Normal operation temperature can be maintained by proper adjustment of the air inlet shutters or covers and an efficient thermostat.

d. The oil pressure gage and/or warning light must be observed frequently during operation because of the increased failures in extreme cold. Consult the applicable operator's manual for normal oil pressures. Report to maintenance personnel if normal operating oil pressure cannot be maintained. Low oil pressure warning lights will blink off and on at 500 to 650 rpm on OES oil, and should stay off at higher rpm.

CAUTION

If oil pressure indicator drops exceptionally low or warning light comes on, shut off engine immediately and determine cause.

e. After each operating period, the system must be carefully inspected and serviced. This operation must be made to insure optimum conditions for the next starting attempt.

(1) Inspect oil pan, valve covers, gaskets, and any external units of the lubrication system for leaks; correct deficiencies or report them to maintenance personnel.

(2) Check engine oil and fill to prescribed level.

CAUTION

Oil consumption is much higher when using engine lubricating oil (OES). Engines may run out of oil BEFORE using a full tank of fuel. CHECK FREQUENTLY.

(3) At the end of each operating period, and prior to shut down, the vehicle engine must be thoroughly cooled to allow a coating of cooled oil to be retained on the cylinder walls and pistons and to prevent damage at time of restarting. The above can be accomplished by lowering the engine rpm to the prescribed high idling speed (1000–1200 rpm) and retaining it there for approximately five minutes. This procedure is of extreme importance to prevent engine damage and is a *mandatory requirement for all heavy duty gasoline, multifuel, and diesel engines.*

3–9. Maintenance

a. The two most common failures of the engine lubrication system are caused by low or no oil pressure and the accumulation of sludge in the lubricating oil.

★(1) *Low or no oil pressure.* Low oil pressure is normally caused by fuel-diluted oil, hot oil, or low viscosity oil. No oil pressure may be caused by cold, congealed, high viscosity oil, clogged strainer or defective oil pump.

NOTE

Do not overlook the possibility that the oil pressure gage may be defective. If the oil pressure gage is found to be working accurately, the oil is up to the full mark and the oil filter element is not clogged, the failure is probably in the pump or lines.

★(2) *Accumulation of engine sludge in lubricating oil.* Cold weather tends to prevent engines from reaching normal operating temperatures, increases the development of carbon in the engine and increases oil dilution and condensation. These factors all combine to create engine sludge (fig 3–1). To correct a sludge condition, drain and thoroughly flush the lubrication system with lubricating oil (OES) or (APG PD No. 1), install

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TECHNICAL ORDER
No. 36-1-40

DEPARTMENT OF THE ARMY
AND THE AIR FORCE
WASHINGTON 25, D. C., *17 September 1959*

OPERATION AND MAINTENANCE OF ORDNANCE MATERIEL IN EXTREME-COLD WEATHER (0° TO —65° F.)

*This technical manual supersedes TM 9-2855, 29 January 1951; including C 1, 31 October 1952; C 2, 3 January 1955; and C 3, 8 February 1957; and TB ORD 193, 30 September 1944.

CHAPTER 1
INTRODUCTION

Section I. GENERAL

1. Purpose and Scope

a. Purpose. This manual is for the use of all personnel concerned with the preparation, operation, and maintenance of ordnance materiel under conditions of extreme cold (0° to —65° F.). The effect of low ambient temperatures is to render materials more sensitive to rapidly applied loads. When some of the destructive phenomena resulting from climate and environment are understood, they can be guarded against by combining a knowledge of the characteristics of materials involved with that of proper operation and maintenance.

b. Scope.

(1) This manual contains operational and maintenance methods and procedures applicable to ordnance materiel under extreme-cold conditions.

(2) With experience gained in the field, at testing installations, and in laboratories, most of the problems of meeting the effects of extreme-cold conditions upon ordnance materiel are gradually being resolved. Qualified and experienced personnel are being utilized for operations under adverse conditions. Developmental agencies are continually providing lubricants, antifreeze materials, hydraulic fluids, fuels, personnel heaters, clothing, safety devices, winterization kits, and preheating techniques.

(3) The chapters in this manual cover extreme- cold weather techniques and related problems in the operation and maintenance of ordnance materiel and the materials involved.

(4) Any errors or omissions will be recorded on DA Form 2028 and forwarded to the Commanding Officer, Raritan Arsenal, Metuchen, N. J., ATTN: ORDJR-CPRA.

(5) Apendix I contains a list of current references, including supply manuals, forms, technical manuals, and other available publications applicable to this materiel.

2. Forms, Records, and Reports

a. General. Responsibility for the proper execution of forms, records, and reports rests upon the commanding officer of all units operating this equipment. However, the value of accurate records must be fully appreciated by all persons responsible for their compilation, maintenance, and use. Records, reports, and authorized forms are normally utilized to indicate the type, quantity, and condition of materiel to be inspected, to be repaired, or to be used in repair. Properly executed forms convey authorization and serve as records for repair or replacement of materiel in the hands of troops and for delivery of materiel requiring further repair to ordnance shops in arsenals, depots, etc. The forms, records, and reports establish the work required, the progress of work, and the status of materiel upon completion of its repair.

b. Authorized Forms. The forms generally applicable to units operating this materiel are listed in appendix I. For a listing of all forms, refer to current DA Pam 310–2. For instructions in the use of these forms, refer to FM 9–10.

c. Field Reports of Accidents. The reports necessary to comply with the requirements of the Army safety program are prescribed in AR 385–40. These reports are required whenever accidents involving injury to personnel or damage to materiel occur.

d. Report of Unsatisfactory Equipment or Materials. Any deficiencies detected in the equipment covered herein, which occur under the circumstances indicated in AR 700–38, should be reported immediately in accordance with the applicable instructions in cited regulations.

3. General Information Relative to Arctic Regions

A brief description of the regions and their characteristics will assist personnel to understand the adverse conditions that may be encountered and to emphasize the preventive measures required for successful operation in extreme cold.

a. The arctic region in North America, strictly speaking, includes the northern coasts of Alaska and Canada, the Canadian Arctic Archipelago, much of Labrador, and all of Greenland, although south coastal Greenland is partly in the subarctic region. In the arctic region, the mean temperature for the warmest summer months is less than 50° F. and for the coldest month, below 32° F.

b. Most of Alaska, Newfoundland, southwestern Labrador, and most of interior Canada are in the subarctic region. It is a belt of variable width, south of the arctic region, wherein the mean temperature of the warmest month is above 50° F.

c. The arctic is not the coldest region in the Northern Hemisphere; the coldest areas are in the subarctic region, more than 200 miles south of the Arctic Circle. During winter tests, temperatures below —60° F. were recorded at Ladd Field, Alaska, which is in the subarctic region. The northern border states, which are all within the temperate zone, are often exposed to arctic conditions.

d. Winds add to the difficulties of extreme cold and abundant snow. Winds of 9 to 12 mph will carry the snow a few feet off the ground, obscuring surface objects. This is particularly true where there are no trees to break the wind. Wind speeds above 30 mph may cause the snow to be carried to heights up to 100 feet and appear like a low cloud. A peculiar Alaskan wind is the "WILLIWAW," a gust that sweeps with great force down mountain slopes.

e. The tundra marks the limit of tree-like vegetation and is a level or rolling, treeless plain, characteristic of the arctic region. The edge of a tundra forms the "treeline." Tundra areas consists of black, mucky soil that supports a dense growth of mosses, lichens, grasses, and other small plants. These plants have from 2½ to 3 months to complete their vegetative cycle.

(1) Few shrubs and no trees grow in the tundra area. The vegetation is closely interwoven and varies in depth from a few inches to more than a foot. It provides excellent insulation and, even in below-freezing temperatures, the ground beneath it is seldom frozen. A peculiarity of this heavy mat is that there are few roots that extend deeply into the ground and, consequently, there is no bond between the vegetation and the muck beneath it. This vegetation has been described as being "like a rug on a marble floor."

(2) The consistency and depth of the black muck beneath the mat of vegetation varies with the drainage. On rolling ground and on slopes, it varies from 6 or 8 inches to several feet and is quite firm. In flat regions, it is usually deep and very soft, so soft that a man can easily push a ½-inch steel rod several feet into the ground (frequently as much as 10 feet). This soft ground is of a jelly-like consistency and shakes perceptibly over a large area when vehicles cross it and when artillery pieces are fired. The moisture content of the ground is very high and, even on slopes, the water level is within a few inches of the surface.

(3) Soft tundra will be found in valleys and near some landing beaches. Hard tundra is found at higher elevations, due to better drainage.

4. General Cold-Weather Operational Problems

a. Personnel.

(1) One of the major problems confronting units designated to participate in extreme cold weather operation, is the lack of personnel with adequate training in cold weather operation and maintenance. If troops presently stationed in temperate climates are to be expected to move to cold climates and perform their mission, additional training in this phase is of the utmost importance.

(2) A large portion of a man's time and energy in arctic-weather areas is ex-

pended in self-preservation. This, naturally, reduces the efficiency of personnel in the operation and maintenance of materiel. The efficiency is further reduced by the bulk and clumsiness of the clothing that must be worn in extreme-cold areas. As it is impossible to handle cold metal with bare hands, some form of mitten or glove must be worn at all times. The resulting loss of the sense of touch further reduces the efficiency of personnel.

(3) Operators for service in extreme cold must be selected and trained to be more than just operators. They must be able to *anticipate* conditions so far as is humanly possible and properly *diagnose* symptoms of potential failures quickly and accurately. Personnel must learn the expedients and improvisations incident to living and moving in arctic regions.

b. Vapor. One of the effects of low temperatures of —30° to —60° F. is to dry the air, because the colder the air becomes, the less moisture causes condensation of a person's breath, which will form a fringe of frost on clothing such as a parka hood. If a hand is removed from a warm mitt, it will steam, due to the moisture that is always coming from body pores. Bodies of open water that are almost at freezing temperature (but still warm in comparison with temperature of surrounding air) generate clouds of mist. Such clouds rising from open water in an ice-filled sea resemble the smoke of forest fires and are called "steam-fogs." Animals and automotive vehicles leave trails of fog behind them. The exhausts of vehicles in convoy create a dense fog. The effect upon visibility is readily apparent and is a potential source of danger. Condensation of water vapor, particularly when it affects the ignition system, can immobilize a vehicle. Corrective measures are discussed in paragraphs 45 and 47.

c. Materiel.

(1) *General.* Operation of materiel in temperatures down to —10° F. is not difficult and is similar to operations in the northern portion of the United States during hard winters. From —10° to —40° F., operations are most difficult. At the warmer end of this range, lack of winterization will result in only a slight loss of operating efficiency. Proper training will prevent many failures of materiel as well as injuries to operating personnel. When the temperature is below —40° F., operations become increasingly difficult; at temperatures in the vicinity of —60° F., the maximum efforts of well-trained men are required to perform even a simple task with completely winterized materiel.

(2) *Fits between parts.* Since metals contract when the temperature decreases and expand when the temperature increases, the clearances between parts are considerably less in cold weather than at higher temperatures. In preparing materiel for extreme-cold weather operation, care must be taken to make certain that parts are properly alined and normal clearances exist. This applies to all mechanisms. Lack of attention to proper clearances may result in binding, which will make mechanisms stiff or inoperative regardless of the lubricant used. Scored or roughened bearings and other rubbing surfaces (such as cams and recoil slides) also interfere with easy action and should be inspected and smoothed with special care for operation in cold weather.

(3) *Cleaning and preparing materiel.*

(*a*) Materiel must be in the best mechanical condition at all times to withstand the added difficulties and prevent failures in subzero operation. Special emphasis must be placed on maintenance inspection. Careful servicing of the various components of the materiel must be accomplished before, during, and after each operating period, and all failures must be promptly reported to proper authority. Failure to give this extra service and maintenance will result in actual damage, lost time, unnecessary and unwarranted expense, and improper functioning.

(*b*) Cleanliness is imperative. Corrosion, dirt, gummy oil, or grease in bearing clearances interfere with proper distribution of lubricant, causing sluggish action, if not complete stoppage. In "winterizing" materiel, assemblies and mechanisms must be disassembled sufficiently to permit thorough removal of old oil, grease, and foreign matter. Cleaning is most efficiently done by washing with dry-cleaning solvent or mineral spirits paint thinner; use brushes and scrapers where necessary. All parts and gear cases must be taken not to overlook cleaning small items that may appear insignificant. Field experience has proven that neglect in cleaning small linkages, bearings, and similar parts will cause malfunctioning and stoppage in cold-weather operation.

(*c*) Placing materiel in proper mechanical condition requires time for necessary and careful disassembly, repair, and cleaning. Low temperatures must be anticipated far enough in advance to permit completion of the conditioning before the onset of cold weather. Refer to pertinent operators manuals for operation, lubrication, preventive maintenance, and maintenance under *unusual* conditions.

(4) *Initial operation.* The operator must be very cautious when using materiel that has been inactive for a long period of time. If the lubricant has congealed in the various components, failure of parts could result. Refer to paragraph 24 through 27 for vehicular starting procedure.

d. Functional Problems. Conditions of a general nature that affect operation of materiel that must be answered or corrected by cold-weather procedures and winterization are outlined in (1) through (24) below.

(1) Bearing lubricant congeals.

(2) Oil congeals in gear cases (transmission, transfer, differential, steering, right-angle drives, and final drives).

(3) Rubber becomes rigid.

(4) Brake shoes may freeze fast to brake drums.

(5) Metal, plastic, and rubber parts break more readily.

(6) Paint on materiel cracks very easily when exposed to extreme cold.

(7) Condensation on machined surfaces requires more care to guard against corrosion and icing.

(8) Overlubrication causes parts to bind and lock.

(9) Springs fail and break.

(10) Bearings bind and lock unless properly cleaned and repacked with arctic lubricant.

(11) Leather items crack unless properly treated.

(12) Insulation on wire cables becomes brittle and will crack unless arctic-type cables are used.

(13) Air hoses fail when doubled or straightened unless arctic-type hoses are installed.

(14) Dry-cell batteries fail to function after a few hours exposure to subzero weather.

(15) Cold-weather clothing for personnel hampers operation of some small controls (e.g., choke and throttle controls, switches, triggers, and small latches).

(16) Storage batteries will not accept a charge or furnish sufficient current to operate electrical components.

(17) Ice crystals form in fuel tank from condensation of water vapor and clog fuel system.

(18) Ice forms on windshield and impairs visibility.

(19) Operations in loose or deep snow or icy roads or bodies of ice and partially frozen swamps and tundra result in difficulties in traveling and firing.

(20) Ice crystals form in air brake tanks from condensation of water vapor and clog air system.

(21) Master and wheel brake cylinders become inoperative due to use of insensitive types of hydraulic brake fluid.

(22) Hydraulic brake lines become brittle in extreme cold and are easily broken by shock loads or bending.

(23) Components of hydraulic units become inoperative in extreme cold due to use of insensitive types of hydraulic fluid.

(24) Engine oil congeals.

e. Cross-Country Movements. In arctic operations of Ordnance Materiel cross-country movements present many hazardous conditions. Constant vigilance must be exercised when crossing frozen streams and lakes, through timbered areas and hilly terrain. Many vehicles are unnecessarily damaged and rendered unfit for further service as a result of the conditions prescribed in (1) through (6) below:

(1) Failure to check ice conditions and thickness prior to crossing water courses.

(2) Operation through wooded areas, breaking trail and lack of two-way trails and turnouts.

(3) Fallen timber and snags causing damage to radiators, lamps, power trains, and suspension systems.

(4) Improper and overloading of prime movers and towed vehicles.

(5) Operations through deep snow and over steep grades and side slopes.

(6) Adequate training and experience of vehicle personnel can be the deciding factor in the accomplishment of safe operation of vehicle in cold-weather.

Caution: **Personnel must be constantly on the alert to detect signs of carbon monoxide fumes. Passenger and crew compartments of wheeled and tracked carriers must be inspected at regular intervals to detect any signs of air contamination from exhaust gases caused by leaking gaskets, improper exhaust installations, blocked exhaust pipes, defective personnel heaters, and vehicles equipped with auxiliary generators.**

5. General Problems of Cold-Weather Maintenance

a. The importance of maintenance must be impressed on all concerned, with special emphasis on organizational preventive maintenance. Maintenance of mechanical equipment in extreme cold is exceptionally difficult in the field. Even shop maintenance cannot be completed with normal speed, because the equipment must be allowed to thaw out and warm up before the mechanic can make satisfactory repairs. In the field, maintenance must be undertaken under the most difficult of conditions. Bare hands stick to cold metal. Fuel in contact with the hands results in supercooling due to evaporation, and the hands can be painfully frozen in the matter of minutes. Engine oils, except subzero grade, are unpourable at temperatures below —40° F. Ordinary greases solidify and lose lubricating qualities.

b. These difficulties increase the time required to perform maintenance. At temperatures below —40° F., maintenance requires up to five times the normal amount of time. *For example,* the time required to warm up a vehicle so that it is operable at temperatures as low as —50° F. may be 2 hours. Vehicles in poor mechanical condition probably will not start at all or only after many hours of laborious maintenance and heating. Complete winterization, diligent maintenance, and well-trained crews are the key to efficient arctic-winter operations.

c. Requirements of a general nature that affect maintenance directly and require planning and preparation before a cold-weather operation can be successfully undertaken are as follows:

Shelter for materiel requiring maintenance.

Proper clothing and tools for maintenance personnel.

Adequate portable heaters.

Suitable methods to store and issue antifreeze materials, fuels, hydraulic fluids, and lubricants.

Sufficient lighting equipment.

Supply of repair parts for equipment.

Sufficient equipment for removal of snow and ice.

d. Preventive maintenance consists largely of the application of a few general rules to all types of materiel as follows:

(1) Use materiel only for the purpose for which it was originally intended.

(2) Examine materiel daily to discover any unusual conditions or missing parts.

(3) Observe all applicable instructions.

(4) Call the attention of higher authority to any unusual conditions.

(5) Do not attempt to make alterations or repairs that you are not authorized to do, unless extremely urgent conditions exist that require that you take every possible effort to keep your vehicle, weapon, missile, etc., operating.

6. General Effect of Extreme Cold on Materials

a. Metals.

(1) Metals become more brittle at arctic temperatures; for this reason, metal parts cannot withstand shock loads at low temperatures as well as they can at the higher temperatures of temperate zones. For example, at —20° F., certain steels can stand only 50 percent of the shock load they will stand at room temperature (figs. 2 and 3).

(2) For a given change in temperature, various metals will expand or contract different amounts. *For example,* the expansion or contraction of steel, brass, and aluminum varies in the order of one for steel; one and one-half for brass; and two for aluminum. Thus, for the same drop in temperature, aluminum will contract twice as much as steel. These characteristics will especially affect bearings where the bearing and shaft are of different metals, parts of different-type metals bolted together, and meshing gears of different metals. Special care should be taken in adjusting parts of this type for cold-weather operation, especially when adjusting bearing clearances **(fig. 4).**

b. Nonferrous Metals. Most of the commonly used nonferrous metals or their alloys, with the possible exception of zinc die-castings, do not exhibit the change from ductile to brittle behavior as the temperature drops. *For example,* at low temperatures, aluminum and its alloys and lead and its alloys, except lead-tin compositions high in tin, have the same capacity to withstand stress as they possess at warmer temperatures. However, low-temperature effects are especially adverse on pure tin solders. Prolonged exposure to low temperatures causes the expansion and eventual disintegration of the tin. There are many alloying elements that will, in effect, greatly retard or prohibit these effects; and there are yet others that produce no retarding effects and, in fact, accelerate them. These considerations should be kept in mind when selecting solders for equipment that will encounter subnormal temperatures either in storage, transit, or use.

c. Nonmetallic Materials.

(1) *Rubber.* In addition to natural rubber, synthetic rubber, and rubber substitutes, there are hundreds of different blends of these materials. They all resemble rubber and, to a certain extent, react like rubber, but they have different characteristics. Synthetic rubber materials are made from chemicals combined by special processes. These synthetic materials look and usually react like natural rubber, although most of them lose their flexibility at higher temperatures than natural rubber. A high degree of elasticity is generally associated with

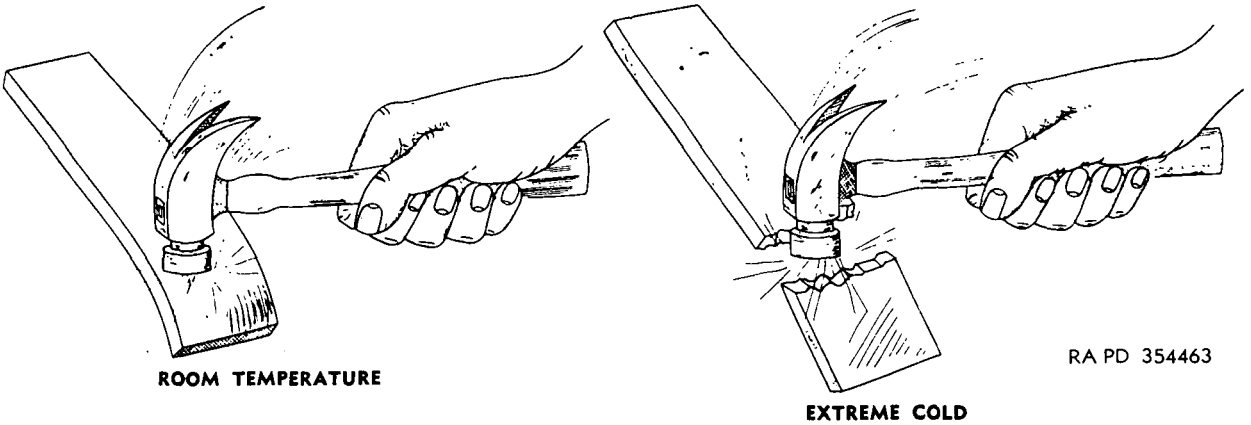


Figure 1. Failure of metals under shock load in extreme cold.

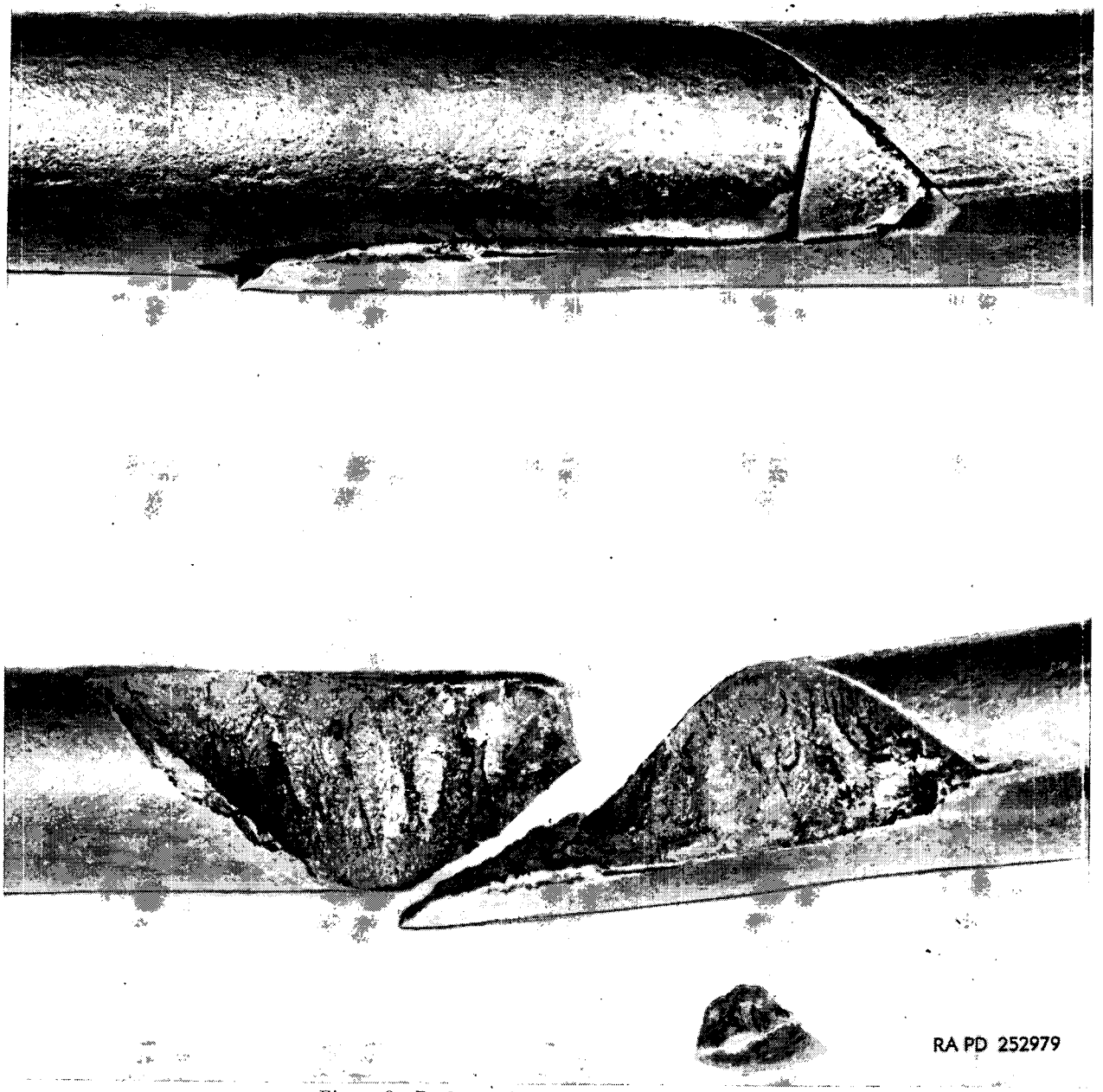


Figure 2. Broken axle shafts due to extreme cold.

natural rubber. It may be stretched as much as seven or eight times its original length and then return with a snap to its normal length when released. However, as it is cooled, natural rubber will gradually stiffen, although it retains a large part of its elasticity until temperatures below —20° F. are reached. Below —20° F., certain peculiarities are observed. When cooled gradually but continuously over a short period of time, the material will remain flexible until a temperature of approximately —60° F. is reached; then it suddenly loses its elasticity and becomes very brittle. Furthermore, if the rubber is consistently kept at a temperature below —20° F. for a long period of time, even though it does not approach lower

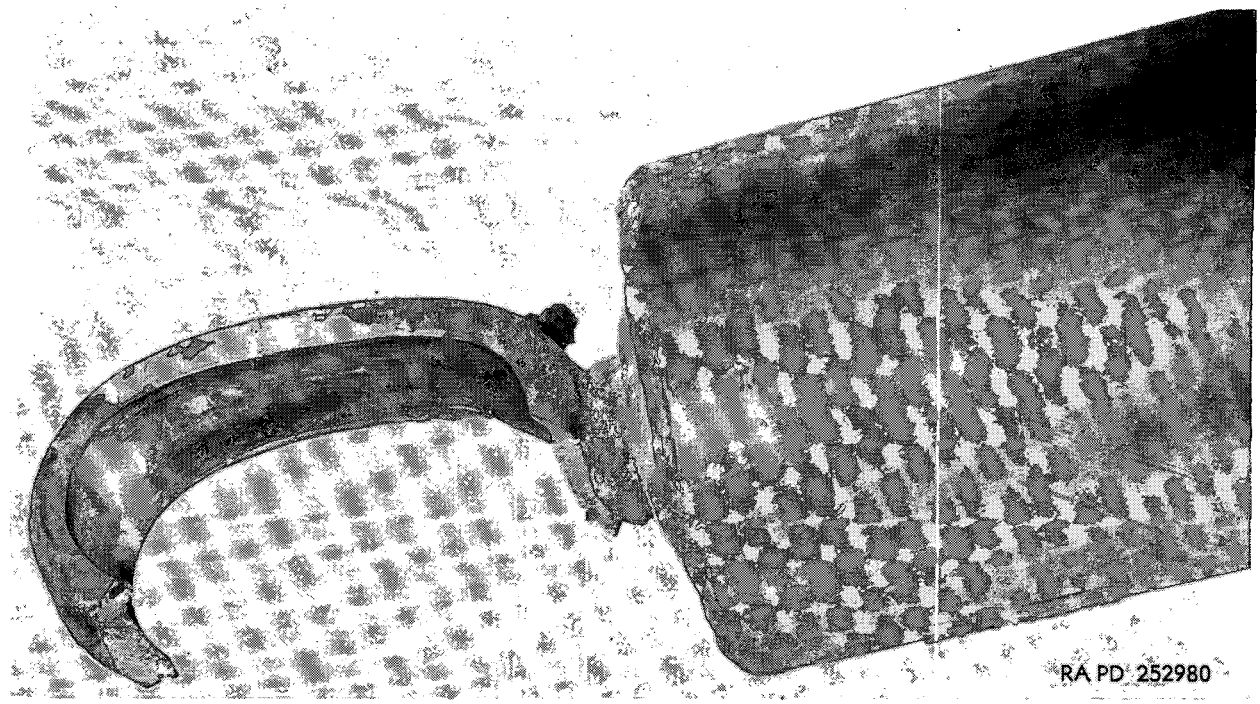


Figure 3. Broken shock absorbers due to extreme cold.

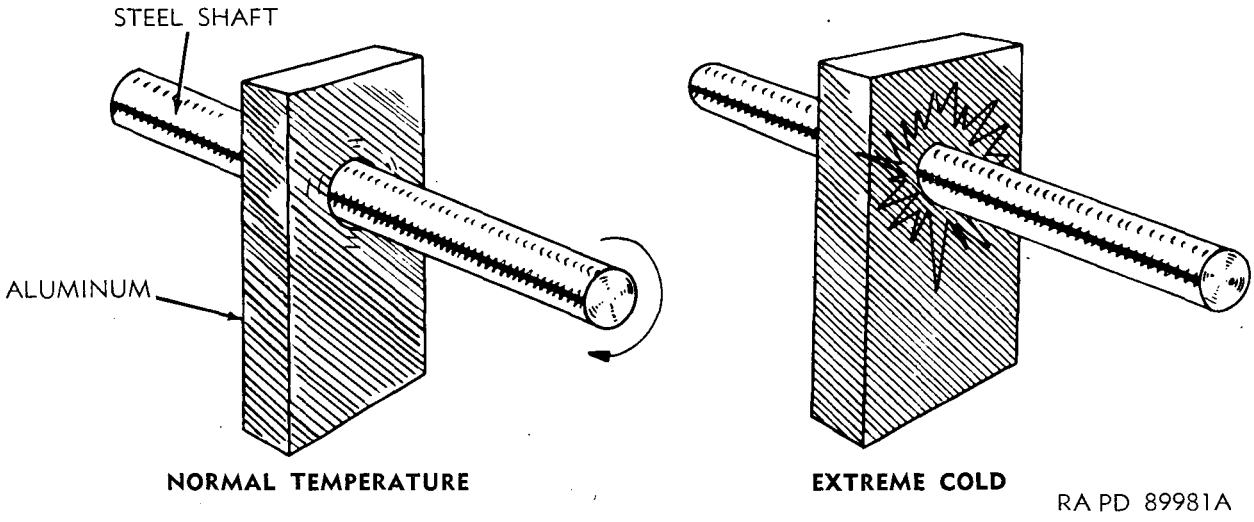


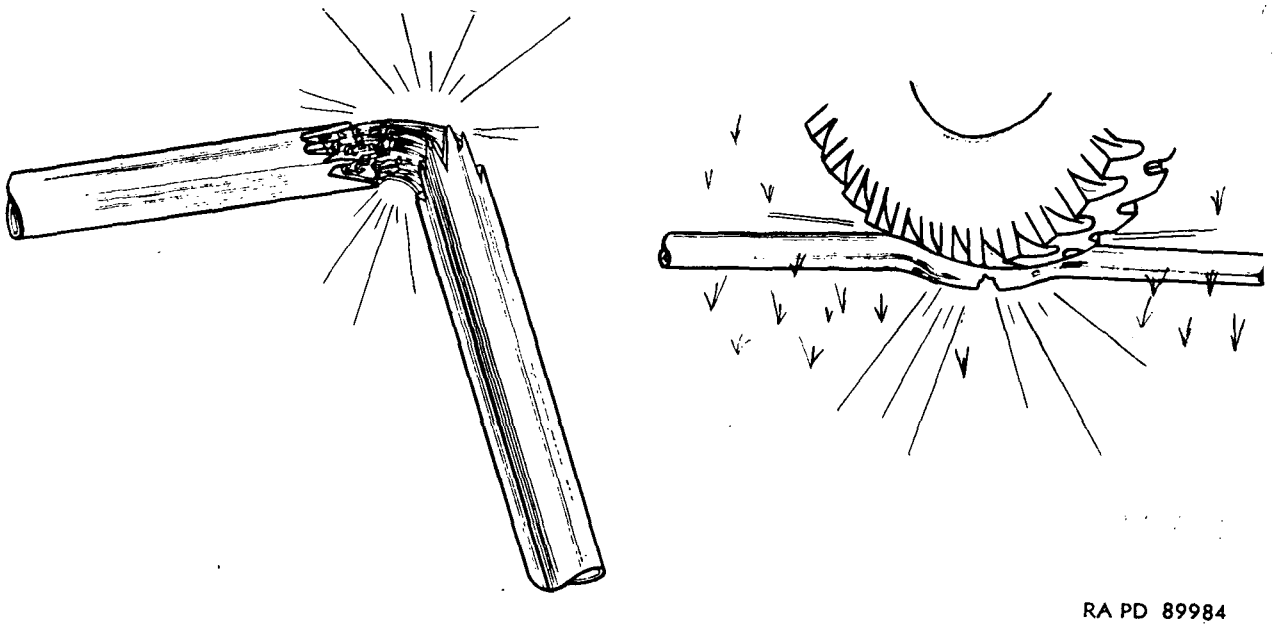
Figure 4. Steel shaft in aluminum bearing in normal and extreme-cold weather.

temperatures, an effect similar to crystallization occurs, causing it to become brittle.

(2) *Rubber cables.* Extreme care must be taken in handling cables at low temperatures. If the rubber jackets become hard, the cables must be protected from shock loads and bending to preclude short circuits, a result of breaks in the covering. If cables are to be bent, they must first be warmed. Neoprene jackets on cables are known to be unsatisfactory. Neoprene becomes very brittle and breaks readily at low temperatures (fig. 5).

(3) *Rubber parts.* Rubber parts such as boots, guards, etc., become brittle and fail in extreme cold.

(4) *Tires.* Rubber tires become rigid in extreme cold, causing flat spots on portions that comin in contact with the ground during shutdown periods. Side walls become brittle and crack.



RA PD 89984

Figure 5. Neoprene jackets on cables break at low temperatures.

(5) *Plastics.* Plastics are often used as substitutes for wood, rubber, glass, and other common materials. In general, plastics expand and contract much more than metal or glass. Decreased resistance to stress and an increase in brittleness are the two most important effects of extreme-cold conditions. Any parts or materials made of plastic must be handled carefully. Many of the vehicular canvas covers have plastic windows, which become very brittle and, in many cases, break due to vibration.

(6) *Glass.* Glass, porcelain, and other ceramics, although sensitive to *rapid* temperature changes, can be expected to perform normally at low temperatures if handled carefully.

(7) *Fabrics.* Fabrics, in general, retain their flexibility even at extremely low temperatures provided they are kept dry. However, paulins present difficulties in conforming to their intended dimensions due to apparent shrinkage. This is usually the result of wrinkles that are extremely difficult to smooth out of subzero temperatures. Whenever possible, paulins should be unfolded in heated enclosures.

(8) *Leather.* Leather is not recommended for arctic use, as it cracks, becomes stiff, and is usually ruined if frozen when wet.

(9) *Wood.* Wood normally can be expected to perform satisfactorily at low temperatures. The dryness and very low humidity of the arctic air often has a great deteriorating effect on wood. It has been shown in tests that an outside temperature of —80° F. and inside temperature of +70° F. results in a relative humidity as low as 1 percent. Under such conditions, the drying effect on wood may be very destructive.

Section II. ANTIFREEZE MATERIALS, FUELS, HYDRAULIC FLUIDS, AND LUBRICANTS

7. General

a. Antifreeze Materials. The antifreeze materials specified for protection of liquid-cooling systems for operation in extreme-cold weather are indicated in tables I and II. Instructions for use are given in paragraphs 30 and 31.

b. Fuels. Arctic fuels for gasoline or Diesel engines are selected to obtain the proper atomi-

zation necessary for a combustible, fuel-air mixture in extreme-cold operations. These fuels are listed in table I; applications are indicated in table II.

c. Hydraulic Fluids. Hydraulic fluids specified for shock absorbers, hydraulic systems, recoil mechanisms, and equilibrators are indicated in tables I and II.

d. Lubricants. Lubrication required for ordnance materiel is specified in the lubrication order or technical manual pertinent to the materiel. Present lubrication orders are based on three anticipated ranges: above 32° F., from 40° to —10° F., and from 0° to —65° F. Lubrication described in this manual is for equipment in the 0° to —65° F. range. Lubricants to be used in extreme cold are listed in table I. Applications for these lubricants are indicated in table II. Substitutes for certain lubricants specified in lubrication orders are indicated in paragraph 10.

8. Materials

The materials normally required in preparing ordnance materiel for operation in extreme cold are indicated in table I. These items are listed in Department of the Army supply publications SM 10–1–9100, SM 3–5–6800, and SB 38–5–3, which should be consulted when requisitioning. Other items, with specification numbers, unit of issue, stock numbers, and issuing services, are listed herein for requisition through normal supply channels. Personnel responsible for the use of these materials should refer to TM 9–1007 for general instructions pertaining to these items.

Table I. Antifreeze Materiels, Fuels, Hydraulic Fluids, and Lubricants for Use in Extreme Cold

Item	Federal stock No.	Container size	Issuing service
ALCOHOL, DENATURED: grade III, Fed. O–E–760*b*	6810–209–0905	1 gal	
	6810–201–0907	5 gal	CML
	6810–201–0904	55 gal	
ANTIFREEZE: permanent, arctic (—90° F.), MIL–C–11755	6850–174–1806	55 gal	ORD
ANTIFREEZE: permanent, ethylene glycol, inhibited (—60° F.), grade 1, Fed. O–E–771*a*.	6850–243–1992	1 gal	
	6850–243–1993	1 gal	ORD
	6850–224–8730	5 gal	
	6850–243–1990	55 gal	
FUEL OIL, DIESEL: 40 centane, Fed. VV–F–800, arctic grade (DF–A) (—25° F. and below).	9140–286–5282	5 gal	
	9140–286–5285	55 gal	QMC
	9140–286–5283	Bulk	
FUEL OIL, DIESEL: 40 centane, Fed. VV–F–800, winter grade (DF–1) (above —25° F.)	9140–286–5287	5 gal	
	9140–286–5289	55 gal	QMC
	9140–286–5286	Bulk	
GASOLINE, AUTOMOTIVE: 82 octane, Fed. VV–M561a, amend. 2, class C (45° F. and below).	9130–171–1105	5 gal	
	9130–160–1819	55 gal	QMC
	9130–273–2381	Bulk	
GASOLINE, AUTOMOTIVE: 88 octane, class C (45° F. and below)	9130–170–9589	5 gal	
	9130–240–8207	55 gal	QMC
	9130–160–1826	Bulk	
GASOLINE, AUTOMOTIVE: combat, 91 octane, MIL–G–3056A, type I, 91A (above 0° F.).	9130–160–1817	5 gal	
	9130–240–8204	55 gal	QMC
	9130–160–1818	Bulk	
GASOLINE, AUTOMOTIVE: combat, 91 octane, MIL–G–3056A, type II, 91C (32° F. and below).	9130–160–1831	5 gal	
	9130–240–8201	55 gal	QMC
	9130–160–1830	Bulk	
GREASE, AIRCRAFT: (GSG) MIL–G–7118, amend. 2	9150–223–4014	1 lb	QMC
GREASE, AIRCRAFT AND INSTRUMENT: (GL) MIL–G–3278A	9150–261–8297	8 oz	QMC
	9150–261–8298	1 lb	
GREASE, AUTOMOTIVE AND ARTILLERY: (GAA) MIL–G–10924, amend. 1.	9150–248–3476	1 lb	
	9150–249–0912	25 lb	QMC
	9150–249–0914	100 lb	
GREASE, AUTOMOTIVE AND ARTILLERY: (GAA) MIL–G–10924, amend. 2.	9150–190–0904	1 lb	
	9150–190–0907	35 lb	QMC
	9150–190–0908	100 lb	

Table I. Antifreeze Materiels, Fuels, Hydraulic Fluids, and Lubricants for Use in Extreme Cold—Continued

Item	Federal stock No.	Container size	Issuing service
GREASE, AUTOMOTIVE AND ARTILLERY: (GAA) MIL–G–10924A	9150–530–7369	120 lb	QMC
HYDRAULIC FLUID, NONPETROLEUM BASE: automatic (arctic) (brake systems) (HBA) MIL–H–13910.	9150–252–6375	1 gal	ORD
HYDRAULIC FLUID, NONPETROLEUM BASE: automotive, AN–F–461 (pour point of —25° F.).	9150–261–7456	1 gal	QMC
HYDRAULIC FLUID, PETROLEUM BASE: preservative (OHC) MIL–O–6083A(2).	9150–265–9413 9150–265–9412 9150–265–9414	1 qt 1 gal 5 gal	ORD
HYDRAULIC FLUID, PETROLEUM BASE: recoil, special (RS) MIL–H–13866.	9150–252–6377 9150–252–6374	1 qt 1 gal	ORD
HYDRAULIC FLUID, PETROLEUM BASE: shock absorbers, hydrospring and hydropneumatic recoil mechanisms (OHA) MIL–O–5606A.	9150–252–6383 9150–223–4134 9150–265–9408	1 qt 1 gal 55 gal	ORD
LUBRICATING OIL, CHAIN - WIRE ROPE - EXPOSED GEAR: (CW–IIA) spec VV–L–751*a*.	9150–234–5197 9150–261–7891 9150–231–9047 9150–530–7293	5 lb 35 lb 100 lb 120 lb	QMC
LUBRICATING OIL, GEAR: (GO75) MIL–L–2105	9150–240–2242 9150–240–2244	5 gal 55 gal	QMC
LUBRICATING OIL, GEAR: (GOS) (subzero) MIL–L–10324A	9150–261–7904 9150–257–5440 9150–257–5443	1 qt 5 gal 55 gal	QMC
LUBRICATING OIL, GENERAL PURPOSE: (LO), Fed. VV–L–820	9150–252–6173 9150–257–5450 9150–252–6174 9150–231–9045	4 oz 1 pt 1 qt 1 gal	QMC
LUBRICATING OIL, GENERAL PURPOSE: (OGP) MIL–L–7870A	9150–542–1430 9150–263–3490	4 oz 1 qt	QMC
LUBRICATING OIL, GENERAL PURPOSE: preservative (PL–special) MIL–L–644A(2).	9150–185–0629 9150–273–2389 9150–231–6689 9150–281–2060	2 oz 4 oz 1 qt 55 gal	QMC
LUBRICATING OIL, INSTRUMENT: (OAI) MIL–L–6085A, amend. 1	9150–257–5449 9150–223–4129	4 oz 1 qt	QMC
LUBRICATING OIL, INTERNAL COMBUSTION ENGINE: (OE–10) (SAE 10) MIL–L–2104A, amend. 1 (pour point of —20° F.).	9150–265–9425 9150–265–9426 9150–265–9430	1 qt 5 qt 55 gal	QMC
LUBRICATING OIL, INTERNAL COMBUSTION ENGINE: (OES) (subzero) MIL–O–10295A.	9150–242–7602 9150–242–7603 9150–242–7605	1 qt 5 gal 55 gal	QMC
LUBRICATING OIL, INTERNAL COMBUSTION ENGINE: preservative (PE–1) grade 1, MIL–L–21260 (pour point of —20° F.).	9150–264–3941 9150–264–3942	5 gal 55 gal	QMC
LUBRICATING OIL, WATCH: (OCW) MIL–L–3918	9150–270–0063	½ oz bottle	QMC
LUBRICATING OIL, WEAPON: (LAW) MIL–L–14107A	9150–664–0038 9150–292–9689	4 oz 1 qt	QMC

Table II. Application of Antifreeze Materials, Fuels, Hydraulic Fluids, and Lubricants in Extreme Cold

Application	Antifreeze materials, fuels, hydraulic fluids, and lubricants[1]
AIR COMPRESSOR:	
Air cleaner (oil-bath-type)	LUBRICATING OIL (OES).
Ball bearings	LUBRICATING OIL (PL, special).
Crankcase (self-lubricating compressor)	LUBRICATING OIL (OES).
AIR CLEANER:	
Air compressor	LUBRICATING OIL (OES).
Auxiliary engine	
Breather system	
Hydrovac cylinder	
Main engine	
AIRCRAFT WEAPONS	LUBRICATING OIL (LAW).
AMMUNITION HOIST:	
Gear case	LUBRICATING OIL (OES).
Hoist rollers	GREASE (GAA).
Radical rollers	
Track cams	
Track rollers	
Track support pivot	
ARTILLERY	GREASE (GAA). GREASE (GL) wherever special LUBRICATING GREASE is specified. LUBRICATING OIL (PL, special) wherever LUBRICATING OIL is specified.
AUXILIARY ENGINE	LUBRICATING OIL (OES).
AUXILIARY GENERATOR:	
Ball bearings (unsealed)	GREASE (GL).
AXLE:	
Bracket	GREASE (GAA).
Housing	LUBRICATING OIL (GOS).
AZIMUTH INDICATOR	GREASE (GL) wherever special LUBRICATING GREASE is specified.
BILGE PUMP:	
Bearing	GREASE (GAA).
Drive chain	LUBRICATING OIL (PL, special).
BOGIE WHEEL BEARINGS	GREASE (GAA).
BRAKES:	
Alcohol evaporator	DENATURED ALCOHOL (grade III).
Camshaft	GREASE (GAA).
Control rod housing	
Cross-shaft	
Hydraulic	HYDRAULIC FLUID (HBA).
Pedal	GREASE (GAA).
BREECH OPERATING HANDLE	LUBRICATING OIL (PL, special).
BREECHBLOCK:	
Crankshaft journal	LUBRICATING OIL (PL, special).
Hinge pin	
Rotating roller	
CAPSTAN:	
Capstan	GREASE (GAA).
Drive shaft bearings	
Gear housing	
CARBURETOR LINKAGE	GREASE (GAA).
CHASSIS	GREASE (GAA).
CLUTCH:	
Control shaft	GREASE (GAA).
Grease fittings	
Linkage	
Other fittings	LUBRICATING OIL (OES).

See footnote at end of table.

Table II. Application of Antifreeze Materials, Fuels, Hydraulic Fluids, and Lubricants in Extreme Cold—Continued

Application	Antifreeze materials, fuels, hydraulic fluids, and lubricants[1]
CLUTCH—continued	
Pedal	GREASE (GAA).
Release bearing	No lubrication—clean and leave dry.
Throwout bearing	Lubricant prescribed on lubrication order.
COMPENSATING IDLER. (*See* SUSPENSION SYSTEM.).	
CONSTANT VELOCITY JOINTS	GREASE (GAA).
COOLING SYSTEM:	
Air-coled engine (w/external oil cooler)	LUBRICATING OIL (OES).
Liquid-cooled engine	ANTIFREEZE.
CRADLE:	
Liner, Trunnion bearings	GREASE (GAA).
CUPOLA RING AND PINION GEAR	GREASE (GAA).
DIFFERENTIAL	LUBRICATING OIL (GOS). Where LUBRICATING OIL (SAE 10) is prescribed, use LUBRICATING OIL (OES).
DISTRIBUTOR:	
Breaker arm	GREASE (GAA).
Breaker arm felt wick, Breaker arm pivot	LUBRICATING OIL (PL, special). Use 1 or 2 drops.
Grease cup, Shaft	GREASE (GAA).
DRAG LINK	GREASE (GAA).
DRAIN PLUGS	GREASE (GAA).
DRAIN VALVES	GREASE (GAA).
ELEVATING RING AND PINION GEAR	GREASE (GAA).
EMERGENCY BRAKES:	
Bellcrank, Cross-shaft, Quadrant, Ratchet arm, Shoe and equilizer pins	GREASE (GAA).
ENGINES:	
Air cleaner, Lubrication system	LUBRICATING OIL (OES).
EQUILIBRATORS (HYDROPNEUMATIC)	HYDRAULIC FLUID (OHC).
EXPOSED GEARS (amphibious items)	LUBRICATING OIL (CW).
FIFTH WHEEL:	
Base	GREASE (GAA).
Cylinder pins	LUBRICATING OIL (GOS).
Pivot bearings, Pivot pins	GREASE (GAA).
FINAL DRIVE	LUBRICATING OIL (OES).
FIRE-CONTROL AND SIGHTING EQUIPMENT	GREASE (GL). LUBRICATING OIL (OAI).

See footnote at end of table.

Table II. Application of Antifreeze Materials, Fuels, Hydraulic Fluids, and Lubricants in Extreme Cold—Continued

Application	Antifreeze materials, fuels, hydraulic fluids, and lubricants[1]
FUEL SYSTEMS:	
Combat and tactical vehicles, gasoline engine-driven generators, marine and rail equipment.	GASOLINE, AUTOMOTIVE: 88 octane premium grade, class C. 1. Overseas—when available. 2. Will be used in Continental United States. 3. Drain fuel tank sump and add ½ pint of DENATURED ALCOHOL (grade III) to each 10 gallons of fuel at time of filling and thereafter. GASOLINE, AUTOMOTIVE: 91 octane, type I (91A) and type II (91C). 1. Overseas. *a.* All combat and tactical transport vehicles. *b.* All materiel and equipment used in maneuvers. *c.* All NATO pipeline movements. 2. Continental United States—all materiel and equipment used in maneuvers. 3. Drain fuel tank sump and add ½ pint of DENATURED ALCOHOL (grade III) to each 10 gallons of fuel at time of filling and thereafter.
Nontactical vehicles, material and equipment, including stationary internal-combustion spark-ignition engines.	GASOLINE, AUTOMOTIVE: 82 octane, amend. 2, regular grade, class C. 1. Overseas—when available. 2. Will be used in Continental United States. 3. Drain fuel tank sump and add ½ pint of DENATURED ALCOHOL (grade III) to each 10 gallons of fuel at time of filling and thereafter. GASOLINE, AUTOMOTIVE: 91 octane, type I (91A) and type II (91C). When prescribed in manufacturer's (or military) specifications or operating manuals.
GEAR CASES (differential, final drives, right-angle drive, steering, transmission, and transfer).	LUBRICATING OIL (GOS). LUBRICATING OIL (OES) wherever LUBRICATING OIL (SAE 10) is specified.
GEARS	LUBRICATING OIL (GOS).
GENERATOR:	
Ball bearings (unsealed)	GREASE (GL).
Generator	LUBRICATING OIL (PL, special).
GOVERNOR:	
Rocker arm	GREASE (GAA).
Valve	LUBRICATING OIL (OES).
GUN:	
Cradle and bushing Elevating and pinion gear Firing mechanism control cable Mount (small arms) Tube (threaded portions at muzzle brake) Tube key	GREASE (GAA).
HOIST-WINCH HYDRAULIC RESERVOIR	LUBRICATING OIL (OES).
HOWITZER:	
Bore Firing mechanism Mount connecting linkage Safety latch	LUBRICATING OIL (PL, special).
Tube	GREASE (GAA).
HYDRAULIC GEARS	HYDRAULIC FLUID (OHC).
HYDRAULIC POWER PACK	HYDRAULIC FLUID (OHC).
HYDROVAC UNITS	HYDRAULIC FLUID (OHC).

See footnote at end of table.

Table II. Application of Antifreeze Materials, Fuels, Hydraulic Fluids, and Lubricants in Extreme Cold—Continued

Application	Antifreeze materials, fuels, hydraulic fluids, and lubricants[1]
MACHINE GUNS:	
Bolt assembly	LUBRICATING OIL (LAW).
Bore	
Feeding mechanism	
Firing mechanism	
Mount	GREASE (GAA).
Oil buffer	LUBRICATING OIL (PL, special).
Oilcan points and grease fittings	GREASE (GAA).
Water jackets (water-cooled)	ANTIFREEZE.
MORTAR (self-propelled):	
Barrel travel lock	LUBRICATING OIL (PL, special).
Bridge locking mechanism	
Standard base and trunnion bearing	
Trunnion pin and bearing	
MUZZLE BRAKE AND EVACUATOR CHAMBER	LUBRICATING OIL (PL, special). Coat threaded portions of tube with GREASE (GAA).
MUZZLE COUNTERWEIGHT	LUBRICATING OIL (PL, special). Coat threaded portions of tube with GREASE (GAA).
OIL COOLER	LUBRICATING OIL (OES).
OVERDRIVE	LUBRICATING OIL (GOS).
PINTLE	GREASE (GAA).
POWER STEERING UNITS	LUBRICATING OIL (OES).
POWER TAKEOFF	LUBRICATING OIL (GOS). LUBRICATING OIL (OES) wherever LUBRICATING OIL (SAE 10) is specified.
PROPELLER SHAFT:	
Center bearing	GREASE.
Pillow block	LUBRICATING OIL (GOS).
RAMMER:	
Buffer mechanism	HYDRAULIC FLUID (OHC).
Chains	LUBRICATING OIL (OES).
Drive sprockets	
Head shaft	GREASE (GAA).
Linkage	LUBRICATING OIL (PL, special).
Reservoir	HYDRAULIC FLUID (OHC).
RAMP HOISTING CABLE	GREASE (GAA).
RECOIL MECHANISMS (HYDROSPRING AND HYDROPNEUMATIC).	HYDRAULIC FLUID (OHC). HYDRAULIC FLUID (RC).
RECOIL MECHANISM SLIDES	GREASE (GAA).
REDUCTION UNITS	LUBRICATING OIL (OES).
REPLENISHER	HYDRAULIC FLUID (OHC).
ROAD WHEELS. (*See* SUSPENSION SYSTEM)	
ROCKET LAUNCHER:	
Barrel coupling lock and contactor latch	LUBRICATING OIL (LAW).
Bore	
Firing mechanism	
RUDDER (amphibious items):	
Cable	LUBRICATING OIL (PL, special).
Connecting linkage	
Control arm	GREASE (GAA).
Post and hinge	LUBRICATING OIL (PL, special).
Pulleys	
Shaft bearing	GREASE (GAA).
Strut bearing	
Stuffing box and bearing	

See footnote at end of table.

Table II. Application of Antifreeze Materials, Fuels, Hydraulic Fluids, and Lubricants in Extreme Cold—Continued

Application	Antifreeze materials, fuels, hydraulic fluids, and lubricants[1]
SCAVENGING SYSTEM (artillery):	
Compressor air cleaner	LUBRICATING OIL (OES).
Compressor gear case	
Compressor sump	
SHOCK ABSORBER BEARINGS	GREASE (GAA).
SHOCK ABSORBERS (except Houdaille)	HYDRAULIC FLUID (OHC).
SHOCK ABSORBERS (Houdaille)	HYDRAULIC FLUID (JAN–F–461)[1].
SHIFTING AND STEERING:	
Linkage	GREASE (GAA).
Manual control box	LUBRICATING OIL (PE–1)—flush only.
SLACK ADJUSTER	GREASE (GAA).
SLIP JOINTS	GREASE (GAA).
SMALL ARMS	LUBRICATING OIL (PL, special). LUBRICATING OIL (LAW).
SPADE:	
Drum shaft	GREASE (GAA).
Latch	
Pinion and gear	
Pins	
SPEEDOMETER ADAPTER	GREASE (GAA).
SPRINGS:	
Bearings	GREASE (GAA).
Bolts	
Shackles	
SPROCKET HUB BEARING	GREASE (GAA).
STARTER:	
Ball bearings (unsealed)	GREASE (GL).
Bearings (plain)	LUBRICATING OIL (PL, special).
Overrunning clutch-type starter splined shaft	LUBRICATING OIL (PL, special).
Reduction gear teeth	GREASE (GAA).
Solenoid-operated Dyer drive and Dyer-splined armature shaft.	LUBRICATING OIL (PL, special).
STEERING GEAR:	
Control housing	LUBRICATING OIL (GOS).
Gear case	
Hydraulic reservoir	LUBRICATING OIL (OES).
Pinion housing	LUBRICATING OIL (GOS).
Shafts and V joints	GREASE (GAA).
STEERING KNUCKLE:	
Bearing	GREASE (GAA).
Housing	
SUPPORT ROLLER. (*See* SUSPENSION SYSTEM.)	
SUSPENSION SYSTEM (tracked and half-tracked vehicles):	
GUARD WHEEL	GREASE (GAA).
IDLER WHEELS (compensating, track tension, and trailing):	
Arm bearing	GREASE (GAA).
Link	
Wheel bearing	
ROAD WHEELS:	
Arm bearings	GREASE (GAA).
Wheel bearings	GREASE (GAA). LUBRICATING OIL (OES) wherever LUBRICATING OIL (SAE 10) is specified.

See footnote at end of table.

Table II. Application of Antifreeze Materials, Fuels, Hydraulic Fluids, and Lubricants in Extreme Cold—Continued

Application	Antifreeze materials, fuels, hydraulic fluids, and lubricants[1]
SUSPENSION SYSTEM (tracked and half-tracked vehicles)—Continued:	
SHOCK ABSORBER BEARINGS	GREASE (GAA).
SLACK ADJUSTER	GREASE (GAA).
SUPPORT ROLLERS	GREASE (GAA).
SWIVEL JOINTS (hydraulic)	GREASE (GAA).
TACHOMETER, ANGLE DRIVE	GREASE (GAA).
TENSION IDLER. (*See* SUSPENSION SYSTEM.)	
TIE ROD	GREASE (GAA).
THROTTLE LINKAGE	GREASE (GAA).
TIRE INFLATING MECHANISM (amphibious)	GREASE (GAA).
TIRE PUMP (amphibious):	
Air cleaner	LUBRICATING OIL (OES).
Crankcase and breather	
Drive chain	LUBRICATING OIL (PL, special).
Drive shaft and V joint	GREASE (GAA).
TORQUE CONVERTER	HYDRAULIC FLUID (OHA) wherever HYDRAULIC FLUID is specified. LUBRICATING OIL (OES) wherever LUBRICATING OIL (SAE 10) is specified.
TORQUE LINK ANCHOR PINS	GREASE (GAA).
TORSION BAR ANCHOR	GREASE (GAA).
TOWING PINTLE	GREASE (GAA).
TRACK TENSION IDLER. (*See* SUSPENSION SYSTEM.)	
TRAILING IDLER. (*See* SUSPENSION SYSTEM.)	
TRANSFER:	
Case	LUBRICATING OIL (GOS). LUBRICATING OIL (OES) wherever LUBRICATING OIL (SAE 10) is specified.
Trunnions	GREASE (GAA).
TRANSMISSIONS:	
Conventional type	LUBRICATING OIL (GOS).
Cross drive	LUBRICATING OIL (OES).
Hydramatic	
Linkage	GREASE (GAA).
Torqmatic	LUBRICATING (OES).
TRAVERSING AND ELEVATING MECHANISMS:	
Drive chains and sprockets	LUBRICATION OIL (OES).
Traversing:	
Control stand	LUBRICATING OIL (OES).
Drive column	
Gear box	
TRAVERSING AND STABILIZER MECHANISMS	HYDRAULIC FLUID (OHA).
TURRET:	
Lock	GREASE (GAA).
Ring and pinion gear	
Support bearings	
UNIVERSAL JOINTS (U JOINTS)	GREASE (GAA).
WATER PROPELLER TRANSFER (amphibious)	GREASE (GAA).
WHEEL BEARINGS	GREASE (GAA).

See footnote at end of table.

Table II. Application of Antifreeze Materials, Fuels, Hydraulic Fluids, and Lubricants in Extreme Cold—Continued

Application	Antifreeze materials, fuels, hydraulic fluids, and lubricants[1]
WINCH:	
Bearings	GREASE (GAA).
Cable	LUBRICATING OIL (PL, special) or LUBRICATING OIL (OES).
Cable and drum (infrequent use)	LUBRICATING OIL (CW).
Case	LUBRICATING OIL (GOS).
Hydraulically operated winch reservoir	LUBRICATING OIL (OES).
Jaw clutch	LUBRICATING OIL (PL, special).
Rollers	GREASE (GAA).
Shear pin	LUBRICATING OIL (PL, special).
Sheaves	GREASE (GAA).
Transmission	LUBRICATING OIL (GOS).
Transmission shaft lever and yoke Trolley	GREASE (GAA).
Worm housings	LUBRICATING OIL (GOS).
WIRE ROPE	LUBRICATING OIL (CW).

[1] Refer to table I for complete nomenclature of specific items.

9. General Lubrication Instructions for Winterization of Bearings, Bushings, and Gears

Note. Refer to table I for complete identification of lubricants indicated in *a* and *b* below.

a. Bearings and Bushings.

(1) *Ball and roller bearings (grease-lubricated).* It is impossible to replace warm-weather grease in ball and roller bearings by forcing in the lubricant prescribed for low-temperature operation. These bearings must be removed from the materiel (if authorized), thoroughly washed in dry-cleaning solvent or mineral spirits paint thinner, dried, and then coated *sparingly* with automotive and artillery grease (GAA, amend. 2). The ball or roller bearings, races, and cages will be coated *lightly.*

(2) *Ball and roller bearings (oil-lubricated).* It is preferable to remove oil-lubricated ball and roller bearings for cleaning. If this is impracticable or unauthorized, flush thoroughly with dry-cleaning solvent or mineral spirits paint thinner, dry, and apply general-purpose lubricating oil (PL, special). Be sure to dry bearings thoroughly before oil is applied. Oil sumps and reservoirs must be drained, cleaned, dried, and then filled with lubricant specified in the lubrication order pertaining to the unit.

(3) *Plain journal bearings and bushings.* It is preferable to disassemble these bearings, remove all heavy oil and grease, smooth off burs, and check for adequate clearances between shaft and bearing. If disassembly is impracticable or unauthorized, heavy lubricant can usually be romoved from the bearings by a thorough flushing with gear lubricating oil (GOS).

(4) *Wick-fed bearings.* The wicks of wick-fed bearings will be removed (if authorized), washed in dry-cleaning solvent or mineral spirits paint thinner, dried, and saturated with general-purpose lubricating oil (PL, special) before assembling. Reservoirs and wick-fed wells must be cleaned, dried, and filled to the prescribed level with general-purpose lubricating oil (PL, special).

(5) *Sealed bearings.* No attempt will be made to clean or lubricate sealed bearings.

b. Gears.

(1) If gears are inclosed in oiltight gear cases filled with engine oil, the oil will be drained and the case filled to the proper level with internal-combustion engine lubricating oil (OES).

Caution: **Do not fill the gear case above the specified level, because the surplus oil will result in unnecessary drag on the movement of the gears.** If a drain or level plug is not provided, the gear case will be disassembled (if authorized), the gears and bearings cleaned with dry-cleaning solvent or mineral spirits paint thinner, dried, lubricated with oil, and assembled in the case. Internal-combustion engine lubricating oil (OES) will then be poured into the case until the lowest gears are dripping. If gear case is not the oil-filled-type, the cover will be removed and the gears thoroughly cleaned, smoothed, and coated lightly with automotive and artillery grease (GAA, amend. 2) before installing cover.

(2) Gear cases containing SAE 75 or SAE 90 universal gear lubricant will be thoroughly drained and filled with gear lubricating oil (GOS) until the lowest gears are dripping. If this oil is not available, internal-combustion engine lubricating oil (OES) may be used as a substitute.

(3) When gears have been lubricated with grease for operation at temperatures above 0° F., it is practically impossible to wash the heavy grease out of a gear case by flushing. Therefore, grease-filled cases will be disassembled (if authorized) and the gears, case, and bearings cleaned with dry-cleaning solvent or mineral spirits paint thinner; thoroughly dried; and all parts coated with automotive and artillery grease (GAA, amend. 2). Use only enough grease for adequate lubrication when filling the case.

10. Substitutes for Lubricants Specified in Some Lubrication Orders

a. Where certain lubricants are prescribed in early lubrication orders, substitutes found to be more suitable for extreme-cold operation should be employed as indicated in (1) and (2) below.

(1) When greases CG, WB, BR, and OG–OO are prescribed in the lubrication order at specified temperatures, substitute automotive and artillery grease (GAA, amend. 2) for extreme-cold weather operation (0° to —65° F.). Clean and wash the items thoroughly before applying the grease. Complete disassembly will be avoided unless absolutely necessary and authorized. Refer to current lubrication order.

(2) When engine lubricating oil SAE 10 (OE–10) is prescribed in the lubrication order for gear cases at specified temperatures, substitute internal-combustion engine lubricating oil (OES) for extreme-cold-weather operation 0° to —65° F.) Refer to current lubrication orders.

b. Reduce service intervals specified on lubrication order (i.e., lubricate more frequently) to compensate for extreme-cold conditions that may quickly destroy the protective qualities of the lubricant. Intervals may be extended during inactive periods commensurate with adequate preservation.

Section III. MAINTENANCE FACILITIES

11. Buildings and Shelters

a. Adequately heated buildings or shelters must be provided for extreme-cold-weather maintenance. Proper and satisfactory servicing is difficult unless personnel are working in temperatures that are reasonably comfortable. Maintenance of many components requires careful and precise servicing. The hands of the mechanic cannot be encumbered with gloves when he is thus employed. Unless sufficient heat is provided, maintenance will suffer. Heat is furnished by various means chiefly the Herman Nelson Space heater which if properly maintained will perform adequately at low temperature. A Herman Nelson Space heater is shown in operation (fig. 6) in —40° F. weather. This heater is being used to defrost the power plant of a vehicle. The heater is also used as a hand warmer by personnel.

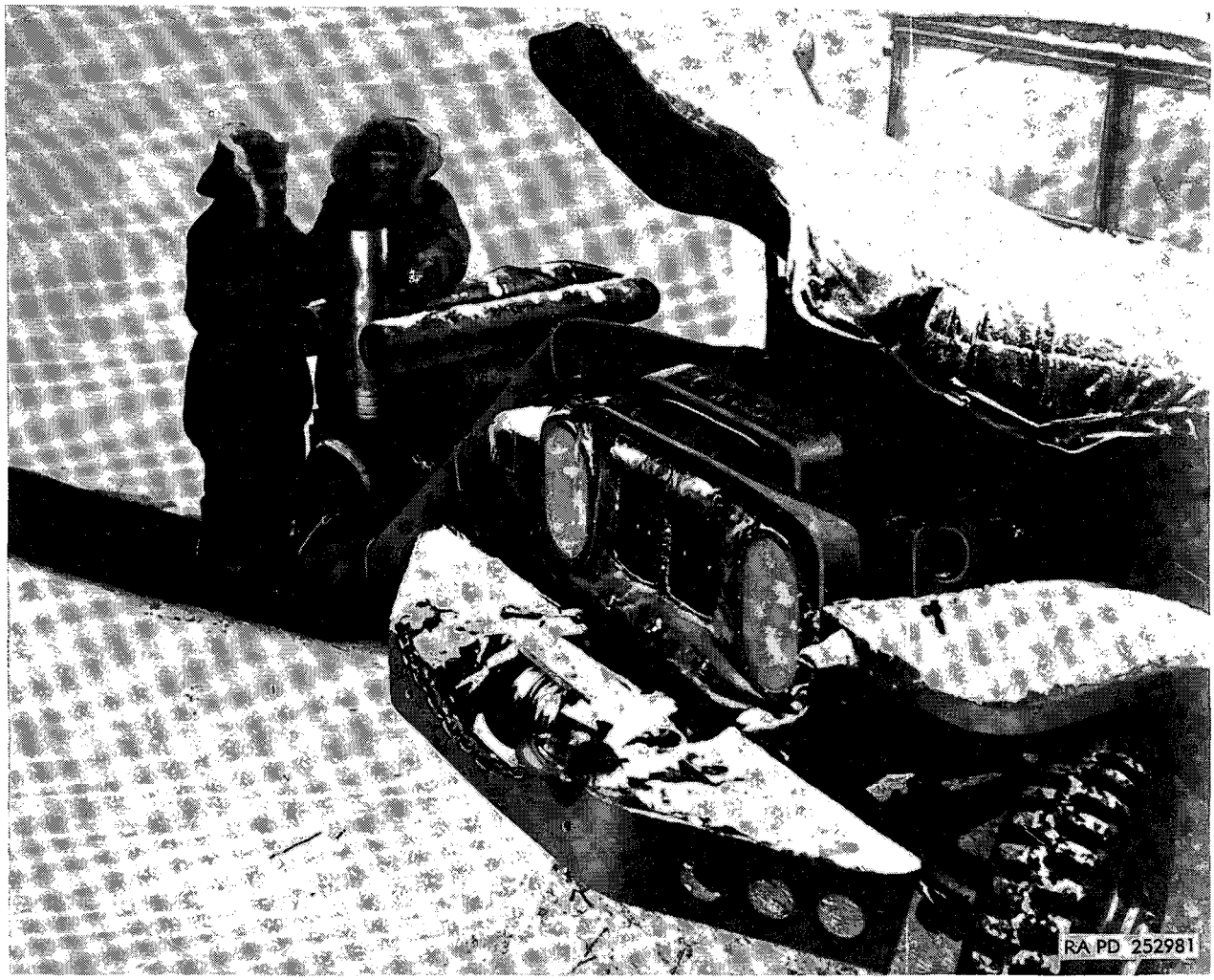


Figure 6. Herman Nelson space heater shown defrosting power plant of vehicle.

b. When buildings are not available, a large tent is a temporary expedient. Wooden flooring should be laid inside all tents and, if possible, in all buildings where men are working. Small, portable wooden platforms, upon which the mechanic can stand, should be provided where there are concrete floors. Space heaters of adequate capacity to maintain satisfactory temperatures are a necessary requirement.

Warning: **Care must be taken for proper ventilation, to avoid the danger of carbon monoxide poisoning from operation of engines or contaminated hot air from defective heaters. Do not use heaters that produce contaminated hot air in shelters or buildings where personnel are present.**

Figure 7 illustrates tents used for sheltering automotive equipment. In the lower picture, a heater is on the left of the tent and a flexible hose, hidden from view, is conducting heated fresh air into the tent.

c. Fuels and lubricants should be stored in shelters. Dispersing equipment and containers must be protected against entry of snow and ice.

12. Lighting Equipment

Sufficient lighting equipment must be available to furnish adequate illumination for maintenance services. High-wattage lights on portable standards, drop lights with ample cable extensions, attachment plugs, connectors, and spare bulbs are essential and must be provided.

13. Personnel, Tools, and Equipment

a. A considerable increase in the number of mechanics required to maintain equipment in extreme-cold operations will be found necessary.

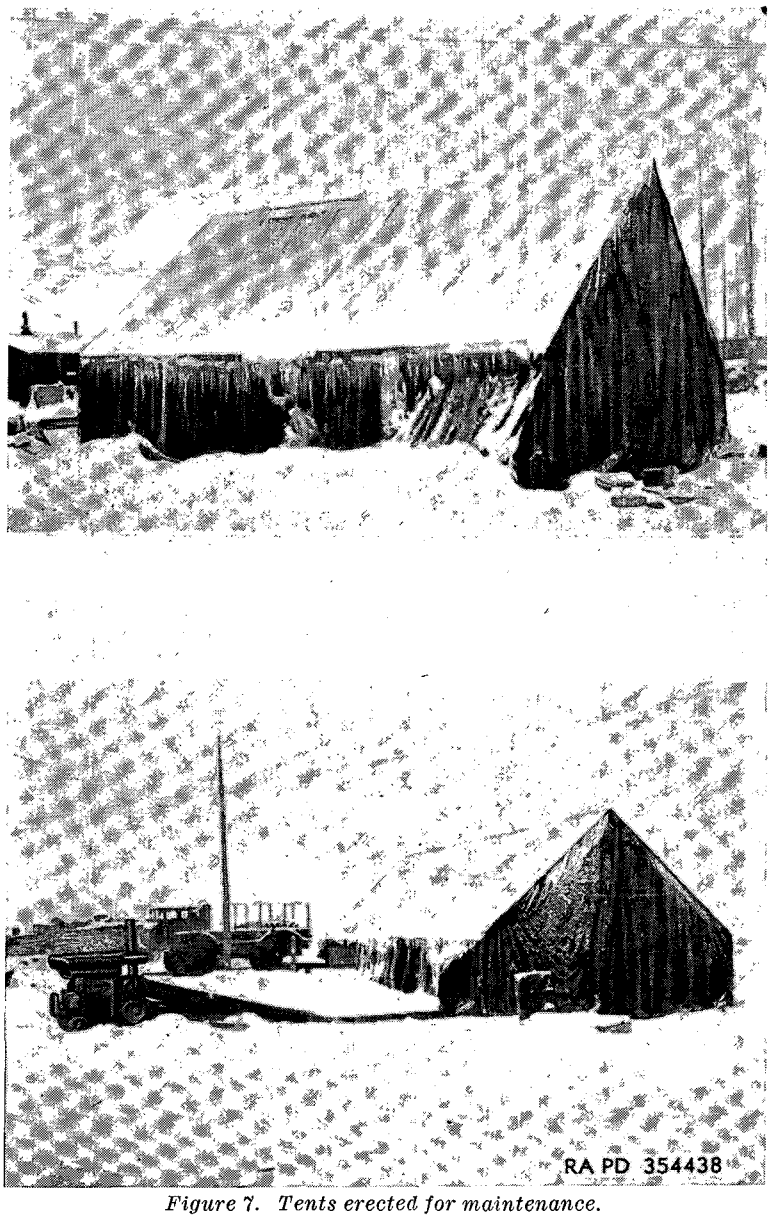


Figure 7. Tents erected for maintenance.

Providing heated buildings or shelters for maintenance of materiel will be of inestimable value. It must be remembered, that the amount of work performed under extreme-cold conditions is considerably less than work accomplished moderate temperatures.

b. An adequate supply of storage battery chargers must be available to meet the heavy requirements for battery maintenance in sub-zero temperatures. Hydrometers, calibrated for temperatures to —65° F. and indicating temperature correction to +80° F. must be provided.

c. Welding equipment, tire repair equipment, special tools, and an adequate supply of repair parts are all essential requirements for proper maintenance of materiel.

d. In general, the tools already provided in the various tool chests are adequate for maintenance at low temperatures. However, the additional tools and accessories described in *e* and *f* below, will be of service. The chief difficulty in performing maintenance at low temperatures is caused by the fact that cold hands are clumsy. It is difficult to handle small parts while wearing gloves or mittens, but without the gloves, the hands get so cold that no work can be done.

e. Soldering irons of 300-watt capacity should be available if any soldering is to be done at sub-zero temperatures; soldering irons of 200-watt capacity or less will not function satisfactorily.

f. A portable canvas tent or shelter that can be used for a windbreak or protection from snow will facilitate maintenance under adverse conditions. The shelter should be about 8 x 8 feet, 6½ feet high, and an overlapping flap for the entrance. The shelter should be heated by an oil or gasoline stove and illuminated by an extension cord or "trouble-light." Even if the shelter cannot be put over the equipment worked on, it can provide a warmup place for maintenance personnel.

CHAPTER 2
AUTOMOTIVE MATERIEL

Section I. WINTERIZATION EQUIPMENT

14. General

a. Special equipment is provided for the vehicle when protection against extreme-cold weather (0° to —65° F.) is required. This equipment is issued as specific kits. The installation of winterization equipment is authorized to be performed only by installations assigned depot maintenance missions for the category of ordnance vehicles to be winterized. Winterization will be performed when specified in applicable shipping instructions. However, it is unlikely that winterization kits will be installed until it is definitely known that the vehicle will operate in areas of continuous temperatures of 0° F. or lower. For general information pertaining to requisitioning and application of winterization kits, refer to SB 9–16. Refer to the TB 9–2855-series for detailed installation instructions on winterization kits for specific vehicles.

b. For cold-weather operation, where the temperature falls only a few degrees below freezing for short-time periods, only ordinary preparations need be made; such as engine oil change to lighter grade, the addition of antifreeze to coolant, and radiator coverage. For anticipated continuous ambient temperatures as low as —25° F., the personnel heater kit and, in some cases, hard top closure will be installed. Operations will not be attempted in areas where temperatures from —25° to —65° F. are likely without the advantages of the arctic winterization kit. General descriptions of winterization kits are given in paragraphs 15 through 17.

c. When installing the winterization kit, make a thorough inspection of all parts of the item for security of all fastenings and general fitness of the vehicle for service under extreme-cold conditions. Operation over hard, frozen ground causes strains that will result in more frequent breakage of screws and components and the development of cracks, as shock resistance of materials is greatly reduced at extremely low temperatures.

d. Thorough cleaning, preservation, and touchup painting will be accomplished. Complete lubrication and change of lubricants will be made as directed in the lubrication order for the minimum temperature anticipated.

e. Clean the oil filter and install new filter element.

15. Personnel Heater Kit

This kit is installed when ambient air temperatures as low as —25° F. are anticipated. It provides an adjustable canvas "winterfront" cover over the front of the radiator, an engine primer system, and an electrically driven, gasoline-burning heater with blower to heat the crew compartment. Installation of electrical fuel pumps and related special equipment required to operate personnel heaters without operation of vehicle engines will be made by Ordnance field maintenance personnel upon approval of the unit commander. Installation of this equipment must be made only on communications and/or command vehicles which have a valid requirement for personnel to be present in the vehicle when it is at the halt.

16. Hard-Top Closure Kit

A hard-top closure kit is provided for the vehicle for protection of the crew. It must be added where temperatures lower than —25° F. are anticipated. All around vision is provided by a glazed door and window at each side and a rear window. The closure kit may be readily removed and knocked down for storage at seasonal changes.

17. Power Plant Heater

This kit is installed on vehicles already equipped with personnel heater and hardtop closure kits in zones where the temperature ranges between —25° to —65° F. The kit includes an electrically driven, gasoline-burning power plant heater, which heats and circulates the coolant of the engine cooling system, and an auxiliary power (slave) receptacle to obtain

current from outside sources, such as the cold-starting aid kit (par. 19). This heater is designed to function during overnight halts, *not* while vehicle is traveling. The battery box or compartment is further insulated against the cold and a heating pad is provided; the engine hood is padded; and a 180° F. thermostat is substituted for the 150° F. thermostat in the cooling system.

18. Arctic Kit

This kit is comprised of three kits, described in paragraphs 15 through 17, issued as a single unit.

19. Cold-Starting Aid Kit (Slave Kit) M40

This self-contained unit (fig. 8) provides an auixiliary source of electrical energy and heat to aid in starting an engine, to warm vital parts of cold vehicles, and to warm vehicle batteries. In an emergency, it can also be used to charge batteries. For complete description, operation, and maintenance, refer to TB ORD 390 and SB 9–16.

20. Auxiliary Power (Slave) Receptacle

This electrical outlet is located at some readily accessible place on the vehicle; it receives current from external sources such as the cold-

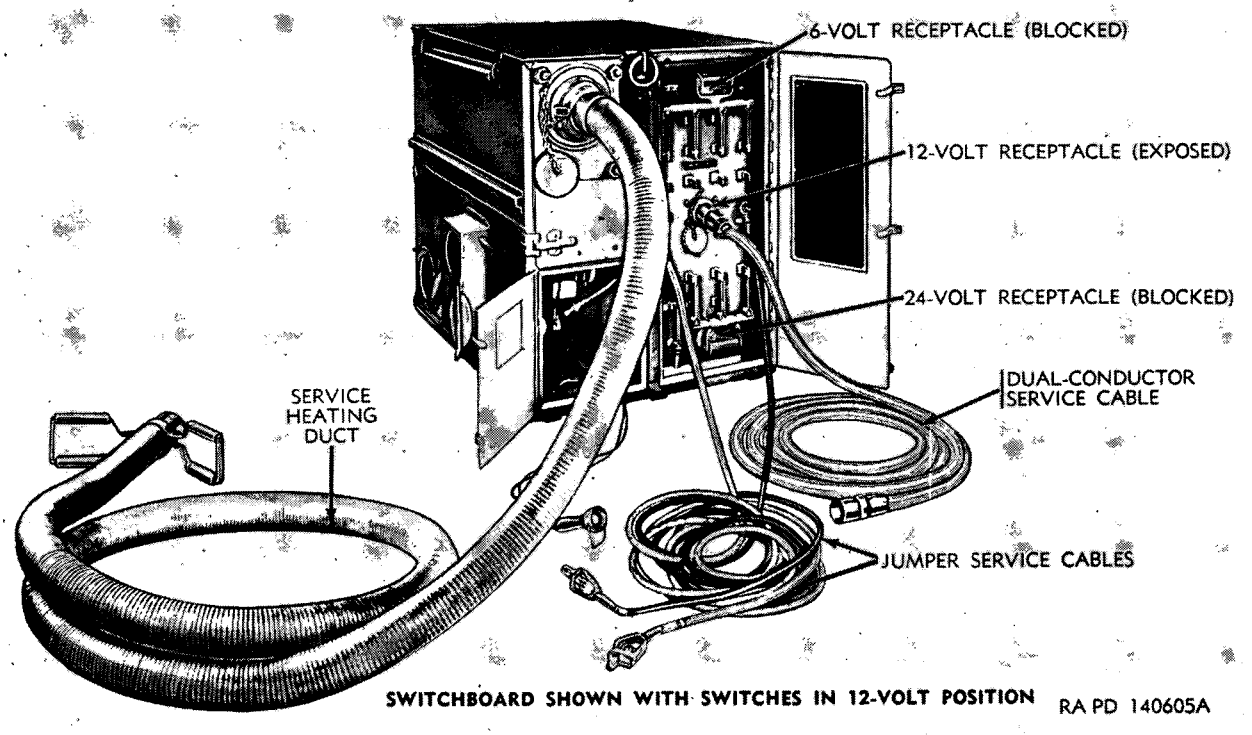


Figure 8. Cold-starting aid kit (slave kit) M40.

starting aid kit for charging batteries or for the direct boosting of vehicle battery current when starting an engine (par. 26) in extreme-cold weather.

21. Dewinterization Procedures

a. When the need for winterization equipment and servicing no longer exists, due to seasonal change to a higher temperature range, or when a vehicle is evacuated to a moderate temperature area, the winterization kits will be removed. Removal will include the heaters, controls, hoses, canvas hood and radiator covers, battery insulation, and hard-top closure and installation of the standard 150° F. engine thermostat.

b. The cooling system will be completely drained, flushed clean, and filled with clean water. The drained antifreeze solution will be discarded.

c. A complete lubrication service must be made, using lubricants and oils as prescribed in the lubrication order for the prevailing temperatures.

d. All parts of the winterization kit will be carefully cleaned, serviced, packed, marked to identify the vehicle from which removed, and stored for reuse or returned to ordnance unit.

e. Openings left upon removal of winterization equipment will be covered by means of improvised closures.

Section II. GENERAL LUBRICATION

22. Cleaning Prior to Lubrication

It is extremely important that all components, particularly antifriction bearings, be cleaned and washed thoroughly to remove all traces of previously used lubricants prior to lubricating with automotive and artillery grease (GAA, amend. 2). Dry-cleaning solvent or mineral spirits paint thinner is suitable for cleaning.

23. Lubrication

All installations and activities are authorized to perform arctic lubrication of ordnance vehicles when specified in applicable shipping instructions provided that the degree of disassembly required to accomplish this is within the scope of their maintenance responsibilities and capabilities. The procedures in *a* through *f* below, govern the lubrication of automotive materiel under conditions of extreme cold to —65° F.

Note. Refer to table I for complete information on lubricants.

a. Engines. For temperatures consistently below 0° F., use internal-combustion engine lubricating oil (OES). Air-cooled engines will also be operated on engine lubricating oil (OES) at temperatures of 0° to —65° F.

Caution: **It is extremely important, when using internal-combustion engine lubricating oil (OES) in automotive materiel, to note any drop in oil pressure during operation. The oil pressure and oil level should be checked frequently, as there will be an increase in oil consumption.**

b. Chassis. Chassis will be lubricated with automotive and artillery grease (GAA, amend. 2).

c. Gears. For temperatures to —40° F., gear lubricating oil (GO–75) may be used. Gear lubricating oil (GOS) must be used for temperatures to —65° F.

d. Track Support Rollers, Bogie Wheel Bearings, Steering Knuckle Balls, Universal Joints, Constant Velocity Joints, and Turrent and Artillery Control Mechanism. Automotive and artillery grease (GAA, amend. 2) is specified for all temperatures.

e. Compensating Idler, Track Tension Idler, and Road Wheel Bearings (Including Compensating Idler Arm Where Applicable). Internal-combustion engine lubricating oil (OES) is specified.

f. Wheel Bearings. The proper method of lubricating the wheel bearings is to pack the bearings themselves with automotive and artillery grease (GAA, amend. 2) between the cage and cone and between the rollers. After the bearings are properly lubricated, pack the hub with sufficient amount of lubricant to uniformly fill it to the inside diameters of the inner and outer bearing races. Coat the spindles and hub caps with a thin layer of lubricant (not over $\frac{1}{16}$ inch) to prevent rusting. Do not fill the hub caps to serve as grease cups under any circumstances. They should be lightly coated, however, to prevent rusting.

Section III. STARTING AND OPERATING VEHICLE ENGINES IN EXTREME-COLD WEATHER

24. General Starting, Operating, and Idling of Vehicle Engines During Periods of Extreme Cold

a. General. Starting vehicles in extreme-cold weather is impossible unless the necessary preparatory steps are taken. The stiff oil on bearings, cylinder walls, and the crankcase causes a high resistance to movement, requiring a tremendous effort to turn over the engine.

b. Idling and Engine Operation-Definitions. For purposes of clarification of the terms idling and engine operation, definitions in (1) and (2) below, will apply.

(1) *Idling.* Operation of a vehicle engine at very low speed and not under load

while vehicle is not in motion.

(2) *Engine Operation.* Operation of a vehicle engine at 1000 – 1200 rpm while vehicle is not in motion for a productive reason, i.e., battery recharging or engine warmup.

c. *Idling Limitations.*

(1) Vehicle engine idling is a wasteful and hazardous practice. It has detrimental effects on supply, tactical missions, and safety for reasons prescribed in (*a*) through (*h*) below.

(*a*) Wastes fuel consumption.
(*b*) Discharges batteries.
(*c*) Dilutes oil in crankcase.
(*d*) Causes excessive and unnecessary engine wear.
(*e*) Causes spark plug fouling.
(*f*) Causes accidental engagement of automatic transmissions.
(*g*) Causes carbon monoxide hazards.
(*h*) Is detrimental to concealment and camouflage.

(2) Vehicle engines must not be idled for periods in excess of 2 minutes while vehicles are awaiting, discharging, or receiving passengers.

(3) Vehicle engines must not be idled for purpose of operating personnel heaters.

(4) Vehicle engines must not be idled to eliminate starting difficulties. Efficient vehicle and power plant heater maintenance must be attained and relied upon.

d. *Operator Requirements.*

(1) A licensed operator must be present in the drivers compartment whenever the main and/or auxiliary engine is being operated.

(2) Lurbicant and coolant levels must be checked prior to starting engine for battery recharge or radio operation periods.

(3) Battery electrolyte levels must be checked daily.

(4) When engine operation is required for battery recharging or engine warmup, an engine speed of 1000 *to* 1200 rpm must be maintained. Occasional variance of speed for short periods is authorized.

e. *Operation of Vehicles Engines Equipped With Power Plant Heaters.* Vehicles equipped with liquid cooled engines are provided with power plant heaters which must be utilized for engine pre-heating at outside ambient temperatures below —20° F. The power plant heaters must be properly maintained year round. Idling or operating vehicles equipped with liquid cooled engines and power plant heater to promote ease-of-starting is prohibited. Power plant heaters *must not* be operated when vehicle engine is operating.

f. *Operation of Vehicle Engines Not Equipped With Power Plant Heaters.* Tank and self-propelled artillery vehicles equipped with air cooled engines (other than amphibious cargo carrier, H76 (OTTER)) not equipped with power plant heaters must be operated at 1000 *to* 1200 rpm at intervals prescribed in (1) and (2) below, when climatic and tactical conditions are as specified. These instructions do not supersede any normal requirements for operating auxiliary generators prior to engaging main engine starter or utilizing auxiliary generator to recharge batteries.

Caution: **Operation of the main engine or auxiliary generator engine when a vehicle is stationary exposes the crew to possible carbon monoxide gas poisoning. The possibility is greatly increased with the necessity for closed hatch doors. To minimize this hazard, position vehicle, when possible, so that the wind will carry fumes away from crew compartment and turn on turret ventilation blower. Be sure gun mantelet cover and engine compartment bulkhead doors are secured before operating engines.**

(1) *In garrison, normal conditions.* Tank main and/or auxiliary engines must not be operated for purposes of engine warming at any temperature above —40° F. Some of the vehicles must be kept in heater shelters to provide an easily started power source for slaving the balance of the organization's vehicles if required. The cold-aid starting kit M40 (slave kit) and/or gasoline portable Herman Nelson heaters must be utilized to minimize engine operation. At temperature below —40° F. the auxiliary generators of the vehicles stored outside *may be* operated at intervals not to exceed 15

continuous minutes each hour with the auxiliary generator heat deflector set in the "winter" position.

(2) *In the field (or when in garrison alert).*

(*a*) Operation of the main and/or auxiliary engines above —20° F. for purpose of engine warming is prohibited.

(*b*) When temperatures of —20° to —40° F. and when tactical situation requires, operate main engine of one vehicle from each platoon every 3 hours at not less than 1000 rpm for not less than 15 nor more than 45 continuous minutes. Engine must reach and maintain normal operating temperature for at least 5 minutes before being turned off. The auxiliary generator must be started prior to engaging main engine starter and operated not more than 15 continuous minutes during this period. When required to assist starting other vehicles in the platoon, this vehicle will be used as the slaving vehicle in accordance with appropriate technical manuals.

g. Operating Engines of Radio-Equipped Vehicles.

(1) Vehicles equipped with auxiliary generators will operate the generator whenever radios are in net. Main engines will not be operated at the halt except for warmup procedure specified for air cooled engines.

(2) Engines of radio-equipped vehicles which are not provided with auxiliary generators will be operated at 1000 *to* 1200 rpm (approximately 20–25 m.p.h. equivalent road speed) at intervals prescribed in (*a*) through (*c*) below, to maintain a satisfactory state of battery charge. Radio operators and drivers of radio-equipped vehicles must be thoroughly trained in the electrical requirements and engine operation procedures of their vehicle and radio equipment. It is estimated that 75 percent of time in net is spent receiving, and 25 percent of the time transmitting. The average ampere draw per hour is computed as rated receiving ampere draw X .75 + rated transmitting ampere draw X .25 = average ampere draw per hour.

(*a*) Vehicles authorized and equipped with 100 ampere generating units by virtue of installed systems and radio equipment will be operated at all times radio is in net.

(*b*) Vehicles mounting radios requiring draw of 8 average ampere hours or less will operate engine during first, third, and fifth and all odd number hours of radio operation thereafter. Engine will be turned off during all even numbered hours.

(*c*) Vehicles mounting radios requiring draw of more than 8 average amppere hours will operate engine at all times radios are in net.

(3) Prior to starting, radio-equipped vehicles must have the following warning stenciled in letters ¼-inch high with white paint on the instrument panel near the ignition switch: SHUT OFF ELECTRIC ACCESSORIES PRIOR TO STARTING. Vehicle mounted radios must be marked with the elecalcomania provided for this purpose which reads: WARNING. RADIO SET MUST BE TURNED OFF BEFORE STARTING MOTOR TO PREVENT DAMAGING ELECTRONIC EQUIPMENT.

Note. Instructions contained in warning notices above, will be strictly adhered to in starting and operating radio-equipped vehicles.

25. Starting Engines Without Towing Vehicle or Without Using Auxiliary Power (Slave) Receptacle

a. Gasoline Engines.

(1) In extreme-cold weather, storage batteries become less efficient and provide much less output than normally. A cold battery cannot energize the starter to turn over the engine at the required cranking speed and also supply the necessary ignition current to the spark plugs. The fuel (gasoline) is often not sufficiently volatile to sup-

ply proper fuel-air mixture to combustion chamber.

(2) For a satisfactory start in extreme-cold weather, steps must be taken to insure that the conditions in (*a*) through (*f*) below, are followed. The first three conditions should be emphasized.

(*a*) The gasoline must be able to produce a combustible mixture with the air.

(*b*) The viscosity of the engine lubricating oil must permit cranking without overtaxing the capacity of the starting system. The engine oil must splash and be distributed easily by the oil pump to the various parts and bearings requiring lubrication.

(*c*) The battery must be fully charged, corrected to 80° F., and sufficiently warm to supply enough current to crank the engine and to supply the necessary spark for combustion.

(*d*) The primary and secondary circuits must be clean and free of cracks, frost, and moisture to prevent shorting or current leakage.

(*e*) The distributor breaker points must be free of oxidation, in good condition, and checked frequently.

b. Diesel Engines. Diesel engines are particularly difficult to start in extreme cold without preheating the intake air during the starting period. Since the air is heated by compression, it must attain a temperature hot enough to ignite the injected fuel. This preheating can be accomplished as indicated in (1) and (2) below.

(1) Heating with an induction manifold air heater ,where this heater is a part of an engine, can accomplish sufficient preheating.

(2) By warming the engine with the blast heat from a slave kit (par. 19) or portable heater, sufficient preheating may also be accomplished.

26. Using Auxiliary Power (Slave) Receptacle To Start Engine

a. The auxiliary power (slave) receptacle (fig. 25) is used to start a vehicle when its batteries are unable to supply starting current. Observe the following cautions:

***Caution* 1: The auxiliary power (slave) receptacle should not be used to charge vehicle batteries.**

***Caution* 2: Because of variation in regulator settings from one vehicle to another, the use of an extension cable to start vehicle with another vehicle should be made with caution.**

***Caution* 3: Check extension cable and connectors for correct polarity assembly.**

***Caution* 4: Connect batteries in parallel with extension cable, positive to positive, negative to negative (*b* (2) below).**

b. The procedures in (1) through (6) below, are applicable to combat tanks and self-propelled weapons.

(1) Start the engine in the vehicle that is to supply the auxiliary power and adjust the engine idling speed to 650 rpm.

(2) Connect the extension cable (fig. 25) to the auxiliary power (slave) receptacle in each vehicle.

Caution: **The master switch in the vehicle that is to receive the auxiliary power must be in the OFF position while connecting the extension cable.**

(3) Start the dead engine and adjust engine idling speed to 650 rpm.

(4) Disconnect extension cable from both vehicles as soon as vehicle idles at 650 rpm without stalling.

(5) Turn on master switch in the receiving vehicle.

(6) Increase engine speed in receiving vehicle to 1,400 rpm to recharge batteries. Check battery-generator indicator in vehicle to make sure that it shows that battery is being charged.

27. Towing To Start Engine

Towing a vehicle to promote starting as an expedient is poor practice. The application of external power will not solve the problem of internal resistance due to "frozen" parts (i.e., lack of fluid lubrication). However, if it is determined that the conditions in *a* through *c* below, have been met, the vehicle may be towed to start the engine.

a. Lubricants must be sufficiently fluid to allow the engine to turn over without excessive drag.

b. The lubricants in the transmission and transfer case must be able to permit shifting gears and allow operation without excessive drag on the power train.

c. Lubricants in the wheel bearings and differential must not be congealed.

Section IV. LIQUID-COOLING SYSTEM

28. Description

The most common type of cooling system (fig. 9) for internal-combustion engines makes use of a liquid as an indirect medium to carry the heat from the inside of the engine and transfer it to the air.

29. Effects of Extreme Cold on Liquid-Cooling Systems

a. The water in liquid-cooled engines will freeze at temperatures below +32° F. unless adequately protected with antifreeze. When frozen, water expands about 9 percent over its original volume and, if confined, can exert tremendous pressure that will cause serious damage to cooling systems, i.e., cylinder blocks and heads, water pumps, or any other component of the vehicle that contains water.

b. To perform the work for which it is designed in an efficient and economical manner, a liquid-cooled gasoline engine must operate at temperatures ranging form 140° to 180° F. (fig. 10). Extreme-cold weather will adversely affect engine operation by preventing the coolant from attaining the desired operating temperatures. Continuous operation at idle speed or relatively low engine temperatures, wastes fuel, increases engine wear, and results in excessive formation of sludge due to the low temperature operation (fig. 30) that will adversely affect engine performance and reduce power.

30. Preparation for Operations in Extreme Cold 32° to —40° F.)

a. Cooling systems will be protected with antifreeze compound (ethylene-glycol-type) for operation at temperatures between 32° and —40° F., except in arctic regions.

b. Cooling systems will be drained to prevent freezing only when an approved antifreeze compound is not available. When drain plugs have been removed or drain cocks opened to remove liquid from the cooling system of any equipment, the drains will be inspected to be sure none is obstructed. If any drain hole has become obstructed by foreign material, a soft wire should be used to clear the obstruction from the hole to permit thorough drainage.

c. Before adding antifreeze compound, it is necessary that the cooling system be clean and completely free from rust. The system will be cleaned with cleaning compound, using approved methods in accordance with TM 9–2858.

Caution: **It is essential that antifreeze compounds be kept clean. Use only containers and water that are free from dirt, rust, and oil.**

d. In addition to the radiator and engine water-jacket heaters, water-cooled compressors and other units in the cooling system must be thoroughly cleaned. When the system is drained, procedures prescribed in the pertinent technical manual are to be followed in order to obtain complete draining.

e. Inspect and replace all deteriorated cooling-system hoses. Hose clamps, plugs, and petcocks are to be inspected and tightened if necessary. Radiator leaks will be repaired before adding antifreeze compound. Exhaust gas or air leakage into the cooling system will be corrected. If there are indications of coolant leakage at the cylinder head, tighten the cylinder-head nuts as specified in the applicable technical manual. Replace the cylinder-head gasket if necessary.

f. Inspect thermostat to see that it closes completely. Look for evidence of sticking in open or closed position. Proper operation of the thermostat can be checked by immersing it in a pail of hot water (fig. 10) to make certain that it will open completely. Replace thermostat if it does not open or close completely, does not function freely, or is badly rusted. Where the average temperature will be between 0° and —65° F., a 180° F. thermostat will be used.

g. When the cooling system is clean and tight, fill with water to about one-fourth capacity. Determine capacity of cooling system in the applicable technical manual. Increase cooling system capacity 1 to 2 quarts for vehicles equipped with hot-water heaters. Then add

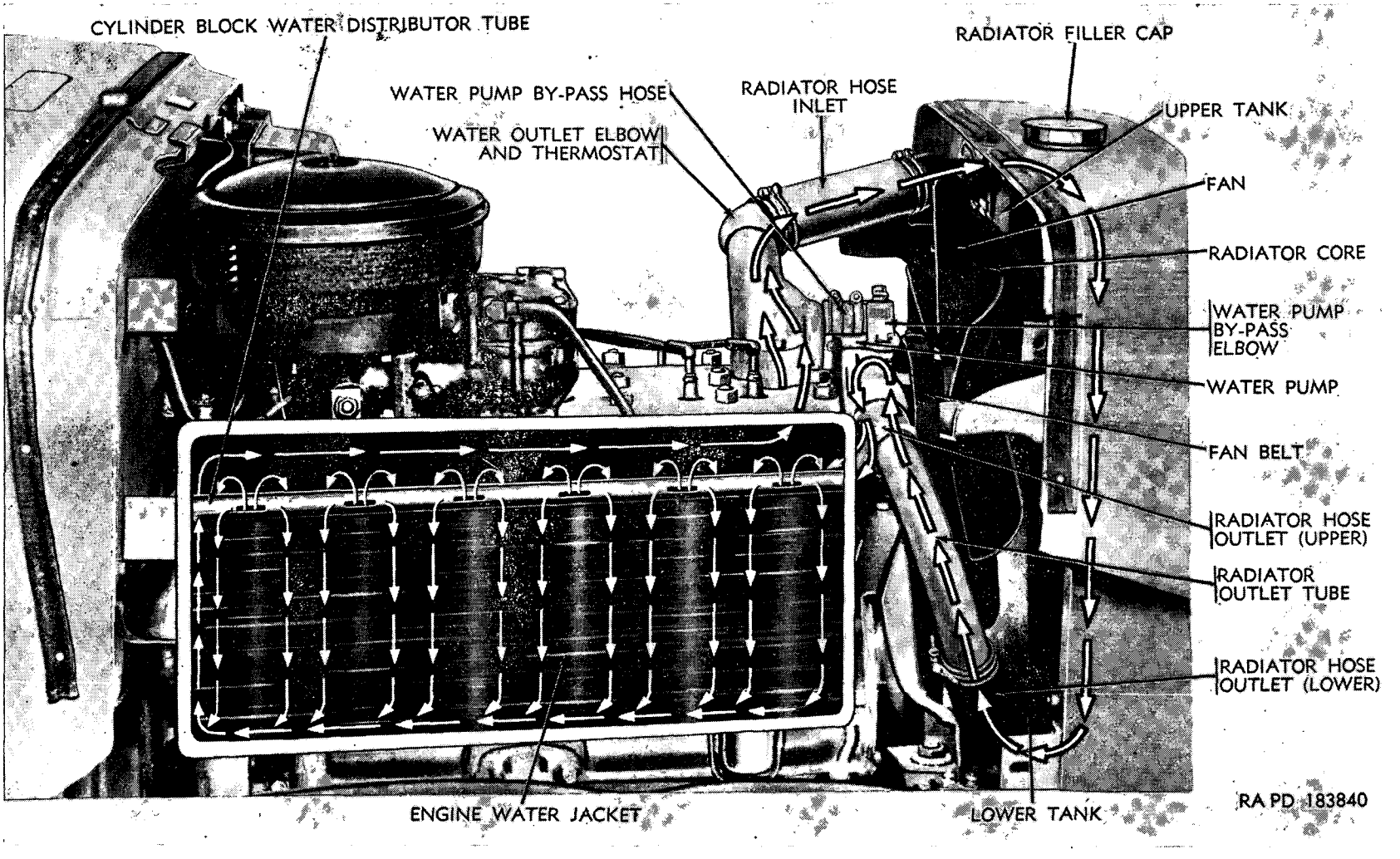


Figure 9. Liquid-cooling-system circulation.

ethylene-glycol antifreeze, using the proportion required for the lowest expected temperatures as indicated in table III. The system should be protected to at least 10° F. below the lowest expected Fahrenheit temperature.

h. After adding ethylene-glycol antifreeze, fill with water to the proper level, allowing room for expansion. Avoid if possible the use of water containing large amounts of minerals or impurities.

Table III. Guide for Preparation of Antifreeze Solutions

Lowest expected ambient temperature (° F.)	Arctic grade antifreeze (—90° F.) (MIL–C–11755)	Ethylene-glycol antifreeze (—60° F.) (spec. O–E–771a, type I)		Denatured alcohol (grade III)[1] Pints per gallon of coolant capacity [2]
		Pints per gallon of coolant capacity[2]	Specific gravity (68° F.)	
+20	Freezing point of —90° F.	1½	1.022	1½
+10		2	1.036	2¼
0	Issued ready for use and must not be mixed with any other liquid	2¾	1.047	2¾
—10		3¼	1.055	3¼
—20		3½	1.062	3½
—30		4	1.067	4½
—40		4¼	1.073	5
—50		4½	—	—
—60		4¾	—	—

[1] Used as temporary emergency expedient when neither arctic grade antifreeze nor ethylene-glycol antifreeze is available.

[2] Includes heaters, etc.

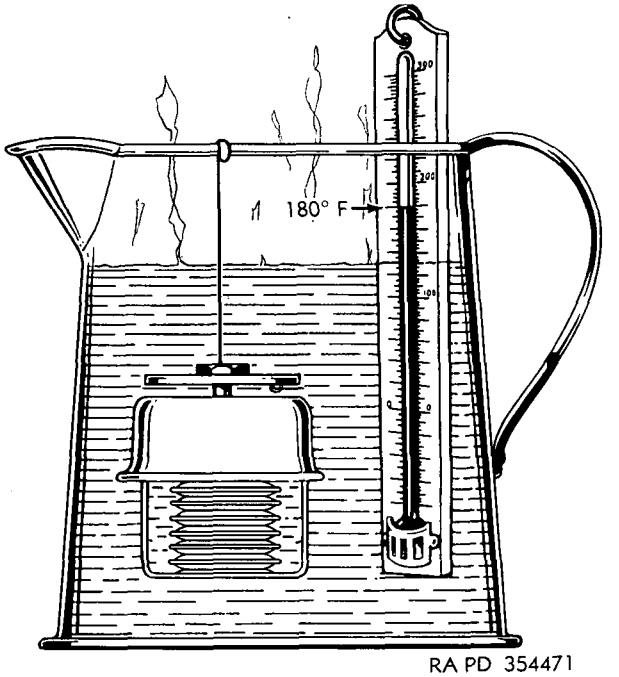


Figure 10. Simple shop test for checking thermostat operation.

i. Run engine until it reaches normal driving temperatures (140° to 180° F.) to release trapped air and to mix solution.

j. After driving temperatures have been reached, the engine should be stopped and the solution checked with a hydrometer (with a correct float), adding more water or ethylene-glycol antifreeze, allowing for expansion. Do not overfill.

Note. To test a hydrometer, use one part ethylene-glycol antifreeze to two parts of water. This mixture should indicate a hydrometer reading of 0° F.

k. Several procedures appear to be in use for mixing ethylene-glycol antifreeze or alcohol.

Note. Alcohol will be used only as a temporary emergency expedient when neither ethylene-glycol antifreeze nor arctic grade antifreeze are available.

One procedure, an example of which is described in *g* above, involves mixing the antifreeze (or alcohol) and water in each individual system. Another procedure, involved mixing in bulk and filling each system with the mixture.

Caution: **Regardless of the procedure followed, proportions given in table III are in terms of pints of antifreeze (or alcohol) in each gallon of solution, not pints of antifreeze added to each gallon of water.**

Note. Ethylene glycol should not be used in concentrated form. Approximately 68 percent ethylene glycol and 32 percent water by volume gives maximum protection.

l. Where the average Fahrenheit temperatures are expected to be between 0° and —65° and below, arctic-type antifreeze will be used

(par. 31). Arctic-grade antifreeze is premixed by the manufacturer and should *not* be mixed or water added to it for installation in cooling systems.

m. Fill out, sign, and fasten a tag on or near the radiator filler neck indicating the type of antifreeze material that the system contains and the temperature range of protection that is provided. The tag should read: "THIS COOLING SYSTEM IS FILLED WITH ETHYLENE-GLYCOL ANTIFREEZE (OR ALCOHOL). PROTECTS TO —40° F." (or whatever the correct protection temperature should be).

31. Preparation for Operation in Extreme Cold (0° to —65° F.)

a. Cooling systems will be protected only with arctic-grade permanent antifreeze for operation in arctic regions.

(1) Drain and flush the cooling system. Watercooled compressors, heaters, and other units in the cooling system must be cleaned in addition to the radiator, engine jacket, and hoses.

(2) Inspect system for leaks during this operation.

(3) Remove thermostat and replace with a unit that will open at 180° F. if not already so equipped. Opening temperature of a thermostat may be checked by heating in a pail of water (par. 30 and fig. 10).

(4) Inspect and service all units of the cooling system, replacing any parts or units that are not in good condition, including radiator, fan, fan belts, water pump, drain cocks, hoses, hose connections, etc. Tighten cylinder-head nuts to torque tightness as specified in applicable technical manual.

(5) When the cooling system is clean and tight, fill with arctic-grade permanent antifreeze (table III). Arctic-grade permanent antifreeze is supplied premixed in proper proportions and is not to be diluted by addition of water or any other substance. This material has been adjusted to permit it to mix with small quantities of water that may be pocketed in the cooling system.

(6) Check the freeze point with a standard ethylene-glycol antifreeze hydrometer or specific gravity float of the appropriate range.

Note. Correct all reading to 80° F.

(7) To indicate arctic-grade antifreeze, fasten a filled out and signed tag on or near the radiator filler neck. The tag should read: THIS COOLING SYSTEM IS FILLED WITH ARCTIC-GRADE ANTIFREEZE. PROTECTS TO —90° F.

Caution: **Do not add water or any other type of antifreeze.**

b. Failure of an engine to reach its normal operating temperature is sometimes caused by improper functioning or failure of the thermostat. Inspect the thermostat to see that it closes completely, also, for evidence of sticking in either the open or closed position. Replace thermostat if it does not open or close effectively or is badly rusted.

c. When arctic-grade is no longer required in the vehicle, it must be drained and discarded. The practice of keeping antifreeze solutions in engine cooling systems throughout the warm period is no longer authorized.

d. Install radiator and engine compartment canvas covers on vehicles as supplied with the various winterization kits. Refer to paragraphs 14 through 21 for information on winterization equipment.

32. Operation in Extreme Cold

a. Before Starting. Inspect the cooling system for sufficient amount of coolant, frozen coolant, and indication of leaks. Inspect fan belts for wear and stiffness. If the belt has stiffened to the point where it will place an added load on the battery when starting, it will be heated before a start is attempted.

Caution: **Use only an air heater to warm the fan belts.**

b. Starting. When the engine is idling after a start, observe the temperature gage to see that the temperature rises gradually. A sudden rise in temperature indicates either a frozen radiator, insufficient coolant, or an inoperative thermostat.

c. During Operation. Vehicles are to be operated at normal engine temperatures as indicated in pertinent operator's technical manual. These temperatures can be maintained by proper adjustment of the engine compartment air inlet shutters or radiator covers.

Caution: **An engine that fails to reach normal operating temperature or overheats must be reported to maintenance personnel for correction. Failure to do this may result in serious damage to the engine.**

Low engine operating temperature results in excessive fuel consumption, dilution of engine oil by unburned fuel, and formation of sludge from condensation of water in cylinders and crankcase. Lubrication failures may follow sludge formation and lead to serious engine damage. Burned fuel vapors also mix with water in the crankcase and form corrosive acids that attack engine parts.

d. After Operation. After each operating period, the system will again be inspected for leaks and loss of coolant.

33. Maintenance in Extreme Cold

a. Difficulties encountered in extreme-cold weather operation of vehicles make it imperative that engine cooling systems be maintained at maximum efficiency at all times. To keep the cooling system constantly in repair and in the best working order requires the most careful attention to preventive-maintenance services by the organizational mechanic.

b. Frozen radiators and failure of the engine to reach normal operating temperatures are the two most common failures in subzero operation. They will be corrected as indicated in (1) and (2) below.

(1) *Frozen radiators.* Vehicles with frozen radiators will be placed in a heated shelter or covered and heated until the coolant thaws.

Caution: **Under no condition will a start be attempted until the frozen radiator has thawed.**

Since the coolant expands when frozen, the system must be carefully inspected for cracks and leaks and parts repaired or replaced as necessary. The coolant will then be drained and replaced with new antifreeze.

(2) *Operating temperature consistently below normal operating temperature.* failure of an engine to reach its normal operating temperature is usually causes by the entrance of extreme-cold winds into the engine compartment or failure of the thermostat to operate properly. To remedy this condition, it is necessary to check the operation of the air inlet shutters or to inspect the engine compartment covers and replace or repair as necessary. The thermostat must be inspected to see that it closes completely. Look for evidence of sticking in the open or closed position. Operation of the thermostat may be checked by heating it in a pail of water to make certain that it will open completely in hot water (fig. 10). If thermostat does not open or close completely, does not function freely, or is badly rusted, it must be replaced.

c. The cooling system must be inspected for leaks and restrictions in air and water passages. Component units of the cooling system must be inspected for worn parts.

(1) *Radiator.* The primary function of the radiator is to transfer heat efficiently from the coolant to the air. This is not possible without clean, straight air fins and unobstructed air passages. The radiator must be inspected for leaks, which may be indicated by streaks of rust on the air fins or around inlet and outlet pipes. All leaks must be repaired or, if necessary, the radiator will be replaced.

(2) *Rubber hose and metal tubing.* Leaks are more common at radiator hose connections than anywhere else in the system. Deterioration of hose usually takes place more rapidly from the inside, so that outside inspection is not always dependable. Usually, possible hose failures can be detected by pinching the hose. A spot softer than the rest of the hose usually precedes a split. Hose failures not only result in leakage, but may also cause restriction of coolant circulation by clogging or

collapsing. Rotted hose may break open without warning and cause sudden, large coolant losses. Frequent outside examination of all hoses and connections and careful inside inspections of hoses whenever connections are opened require little time and can save much trouble.

(3) *Water pump.* Leakage is a common pump failure. In the adjustable gland-type pump, normal wear of the packing will cause leakage unless the gland is tightened periodically and the packing replaced when worn. In the packless-type pumps, the self-adjusting seals are subject to wear, deterioration, and leakage. Bearing and shaft damage, which leads to leakage and pump failure, can result from neglect of lubrication in pumps that require it. Since the results of pump failure, coolant leakage, or air suction into the system can be serious, water pumps require careful maintenance in the form of frequent inspection, periodic tightening, and proper lubrication.

(4) *Cylinder block and head water jacket.* The water jacket has many gasketed water joints and a number of metal-to-metal water joints that may leak. Gaskets deteriorate from the effects of heat, water, and pressure, resulting in leaks. Metal-to-metal joints, such as core hold plugs, drain plugs, shutoff valves, temperature-gage fittings, and connections at water bypass or recirculation tubes, are all subject to leakage. Prompt detection and correction of leaks by replacement of gaskets or parts or tightening of bolts are necessary.

(5) *Cylinder-head gasket.* Failure of the cylinder-head gasket, causing coolant leakage into engine, cannot be detected from outside inspection. If internal leakage is not promptly discovered and corrected, serious damage will result.

(6) *Fan and drive belt.* Fan assembly must be inspected for bent fan blades or a loose, bent, or damaged fan shroud. Inspect fan belt for cracks, wear, and deterioration. A loose adjustment may result in slippage and rapid belt wear. Overtight adjustment also wears the belt and causes early failure of shafts and bearings in the fan, water pump, or generator.

(7) *Accessories connected to cooling system.* Cooling system preventive maintenance includes inspection of all special circulating systems to see that they are secure, leak-proof, and in good condition (includes battery heaters, cab heaters, windshield defrosters, and foot warmers). Refer to paragraph 14 through 21 and 58 through 62 for other accessories that may be connected to the engine cooling system.

Section V. AIR-COOLING SYSTEM

34. Description

Since an air-cooling system does not employ a liquid coolant, it is often assumed that air alone acts as the cooling medium. However, this is not true, since the lubrication systems also help in cooling the engine and transmission. The lubrication systems for an air-cooled engine and a transmission often include oil coolers (fig. 11) that circulate the oil between the engine and the coolers and between the transmission and the coolers, removing heat from the engine and transmission as they do so. Some engine cooling also results from the fuel contacting metal parts prior to combustion.

35. Effects of Extreme Cold on Air-Cooling Systems

The effects of extreme cold on an air-cooling system is basically the effect on the engine lubrication system (par. 49).

36. Preparation for Operation in Extreme Cold

Refer to paragraph 50 for information on preparation of an air-cooled system.

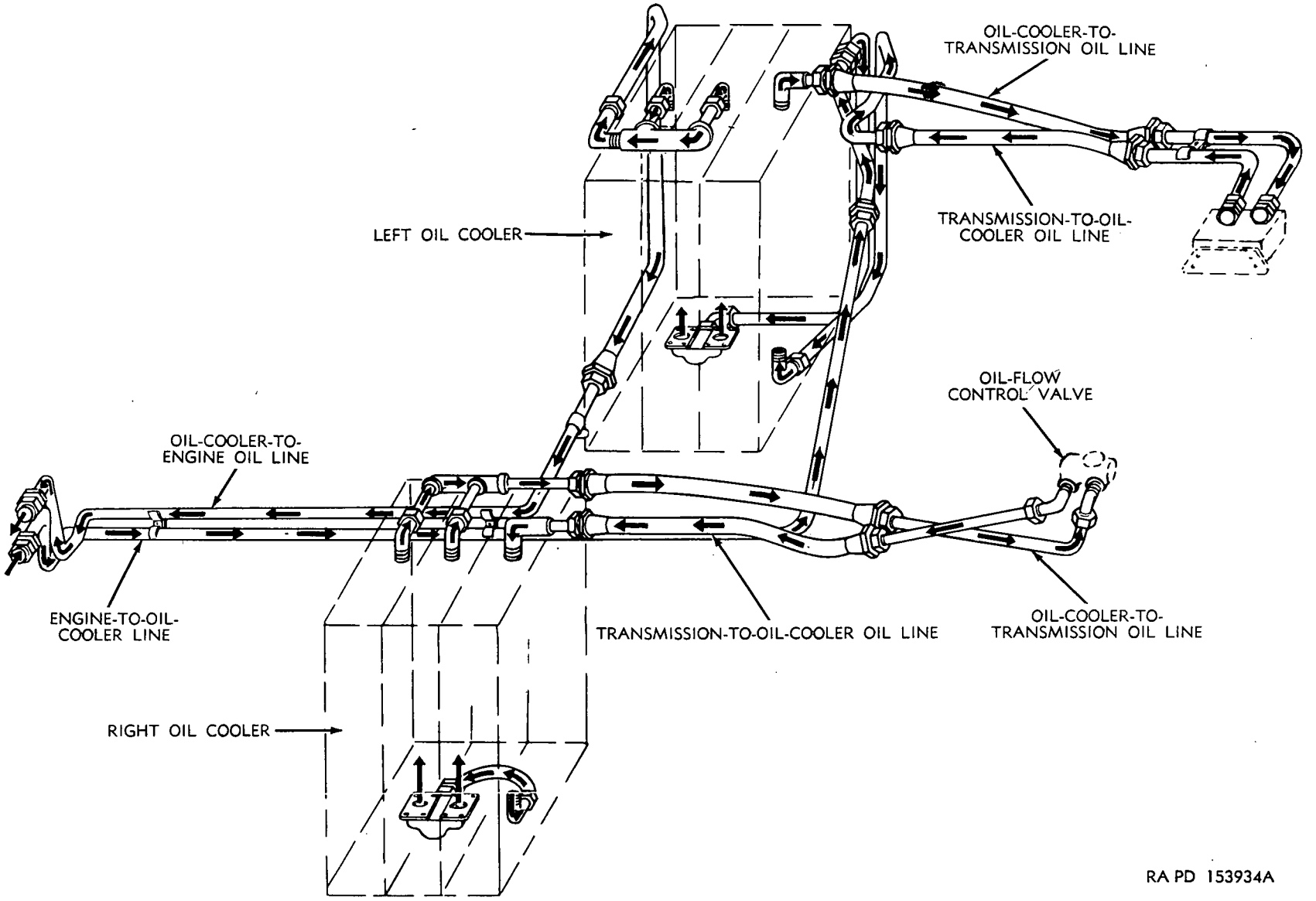


Figure 11. Oil coolers used with an air-cooling system.

37. Operation in Extreme Cold

Refer to paragraph 51 for information on operation in extreme cold.

38. Maintenance in Extreme Cold

Refer to paragraph 52 for information on maintenance in extreme cold.

Section VI. FUEL SYSTEM

39. Function

The function of the fuel system on a vehicle is to store the liquid fuel, pump the fuel to the carburetor, convert the liquid fuel into a highly atomized fuel-air mixture, and to distribute the mixture to the combustion chamber of the engine cylinders. Typical fuel systems are illustrated in figures 12 through 15.

40. Effect of Extreme Cold on Fuel System

a. For a satisfactory start, the motor fuel must be sufficiently volatile to produce a combustible mixture with air. Atomization, which increases the rate of vaporization of the fuel to produce a combustible mixture, is adversely affected by low temperatures. The maximum amount of vaporization obtainable with the regular grade of motor fuel, without the use of a primer or application of heat to the mixture, will provide only sufficient vaporized fuel for starting at a minimum temperature of approximately 0° F.

b. Diesel engines are particularly difficult to start in extreme cold. Many fuels suitable for Diesel engines contain waxes that congeal at temperatures below 0° F. If this is allowed to occur, the filter will clog and the fuel will not flow.

c. Water will accumulate in tanks, drums, containers, fuel pumps, and carburetors, due to condensation of water from the air. At low temperatures, this water will form ice crystals that will clog fuel lines, fuel filters, fuel pumps, injector nozzles, and carburetor jets.

41. Preparation for Operation in Extreme Cold

The general instructions in *a* through *e* below, will be followed to prepare fuel systems (figs. 12 through 15) for operation in extreme-cold weather.

a. Drain fuel systems and provide arctic-grade fuel (table II) as prescribed in (1) through (3) below. Also, make adjustments indicated in (4) below.

(1) When subfreezing temperatures are expected, drain the fuel tank and add denatured alcohol (grade III) at the ratio of ½ pint to each 10 gallons at the time of filling and thereafter.

Note. The use of alcohol in greater proportions will result in poor engine performance, and may cause damage to valves and fuel pump diaphragms. Fuel tank and filters should be drained weekly or more frequently if found necessary to remove water-alcohol mixture from bottom of tank filters.

One-half pint of denatured alcohol (grade III) should be added to fuel (table II) in tank at each refilling.

(2) Remove all carburetor and air compressor air-cleaner elements, including oil-bath-type, clean with dry-cleaning solvent or mineral spirits paint thinner, and install. Fill oil-bath-type cleaners with engine lubricating oil (OES).

(3) Check for any indication of fuel leaks. Trace all leaks to their source and correct or replace parts as necessary.

(4) During extreme-cold-weather tuneups. richen the carburetor mixture and reduce the spark-plug gap.

b. An engine priming system must be installed on all vehicles (figs. 16–18) for operation in extreme cold. The priming system consists of a priming pump and injection nozzles or other fittings together with connecting tubing and fittings and, in some cases (fig. 18), with primer filter. The pump is operated by hand and is usually mounted on or near the instrument panel. A connection is tapped into a fuel supply line that leads to the primer pump. Another line leads from the pump to the injector nozzles that are affixed on the intake manifold opposite the entry ports in the engine block. The primer pump delivers fuel at high pressure to th injectors or fittings. The injectors atomize the gasoline that is drawn into the engine cylinders on the intake strokes.

Note. Radial engines, either seven or nine cylinders, should have only five cylinders primed. The lower cylinders must not be primed, in order to preclude any possibility of hydrostatic lock when cranking.

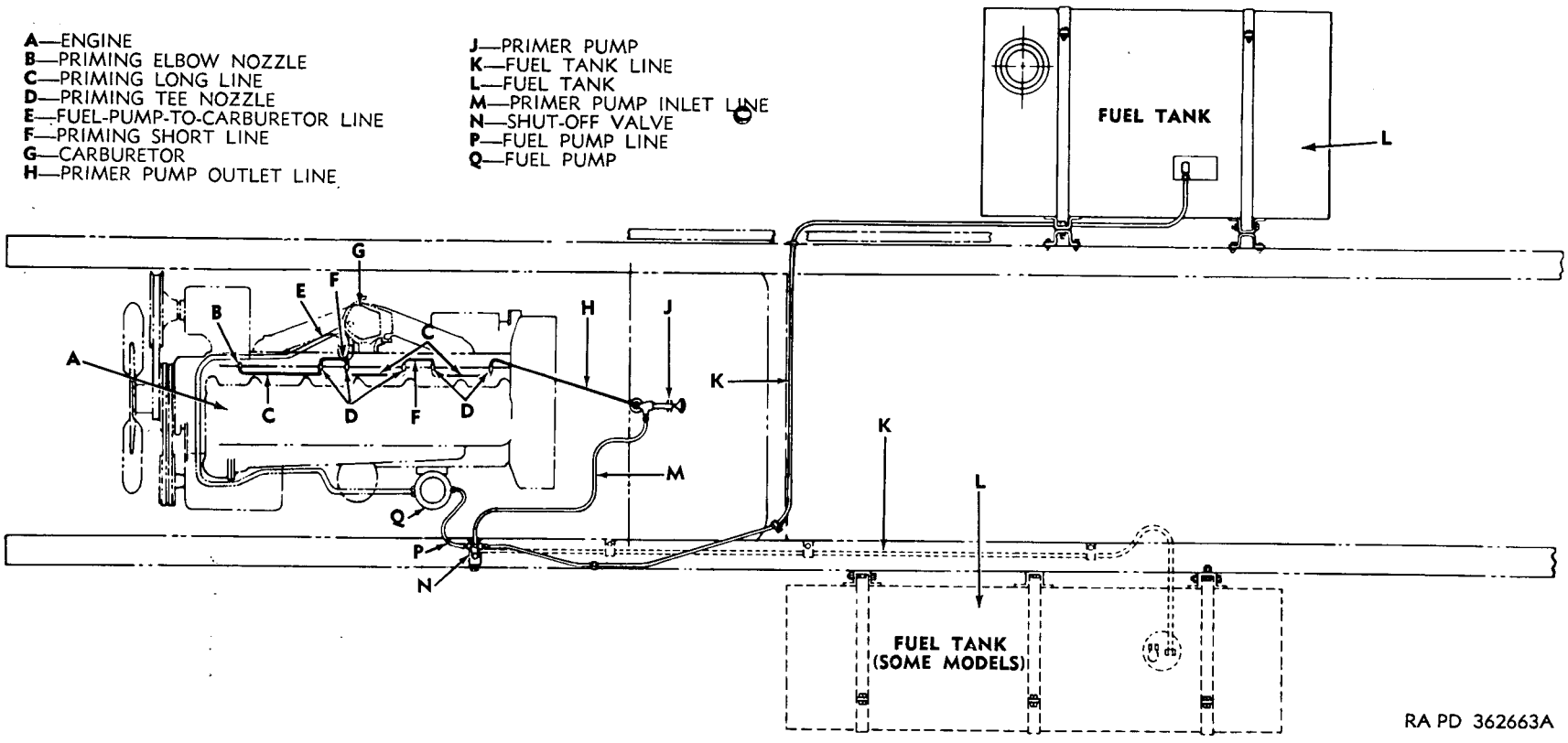


Figure 12. Fuel system for 2½-ton 6x6 trucks.

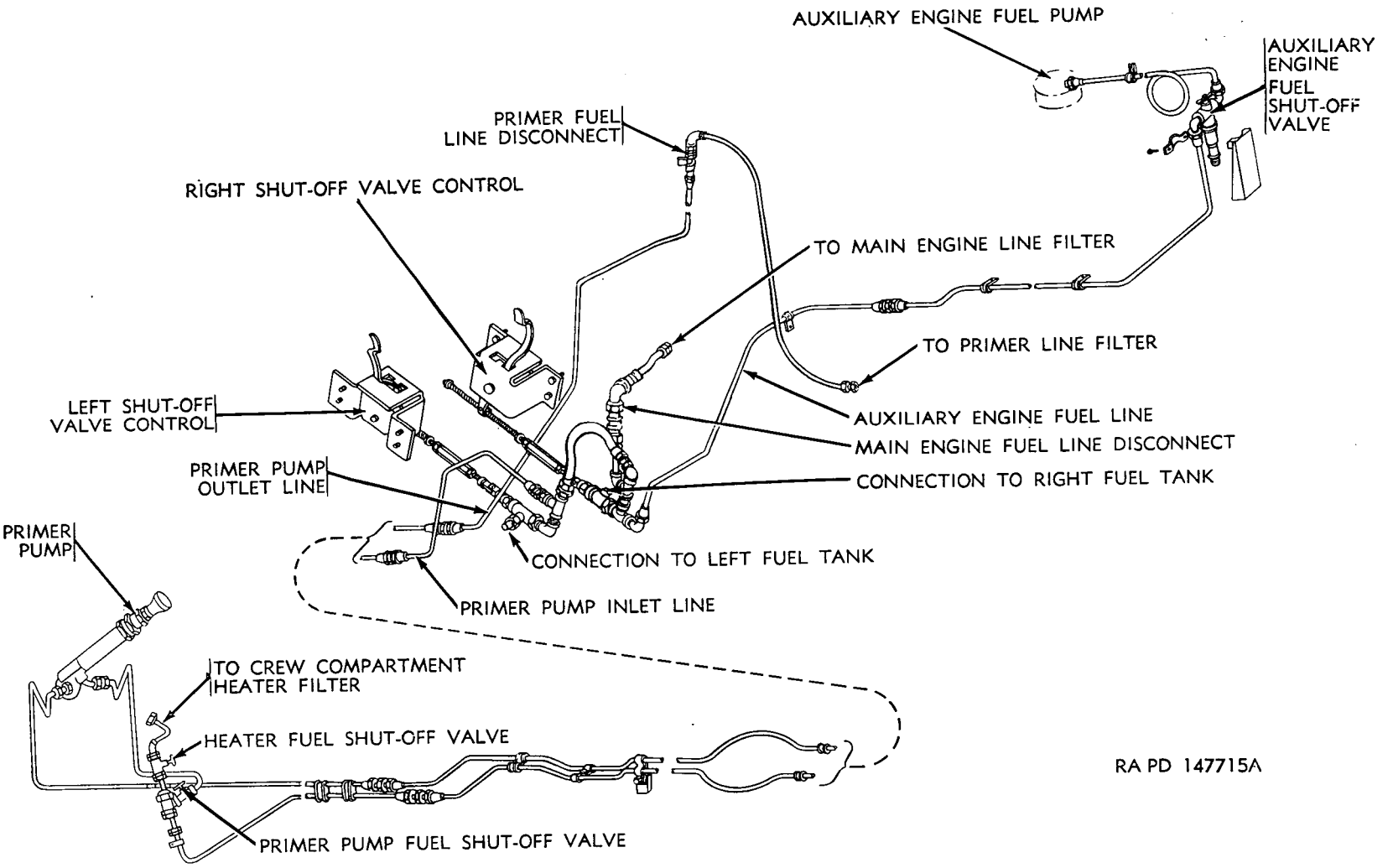


Figure 13. Fuel system for 90-mm gun combat tank.

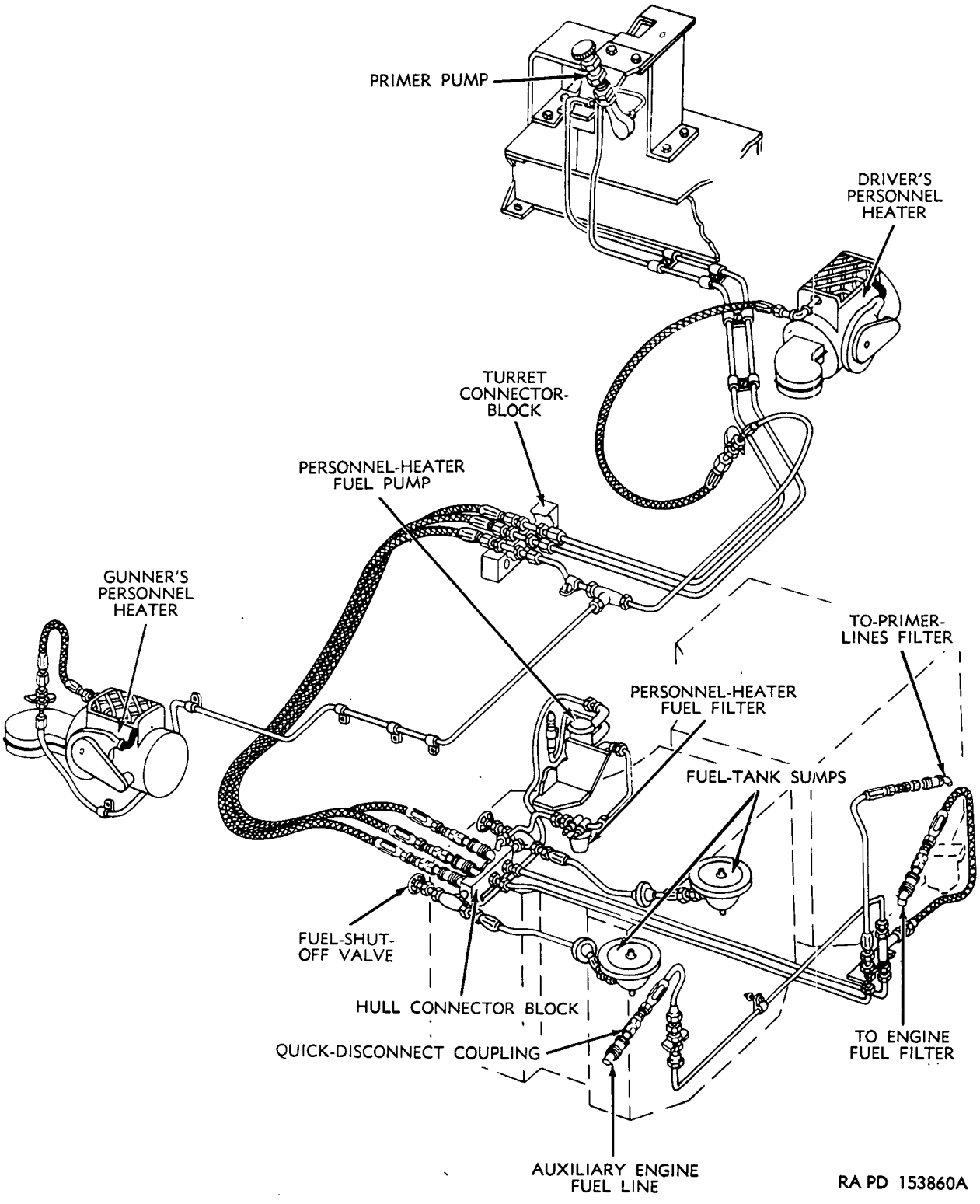


Figure 14. Fuel system for self-propeleld 8-inch howitzer.

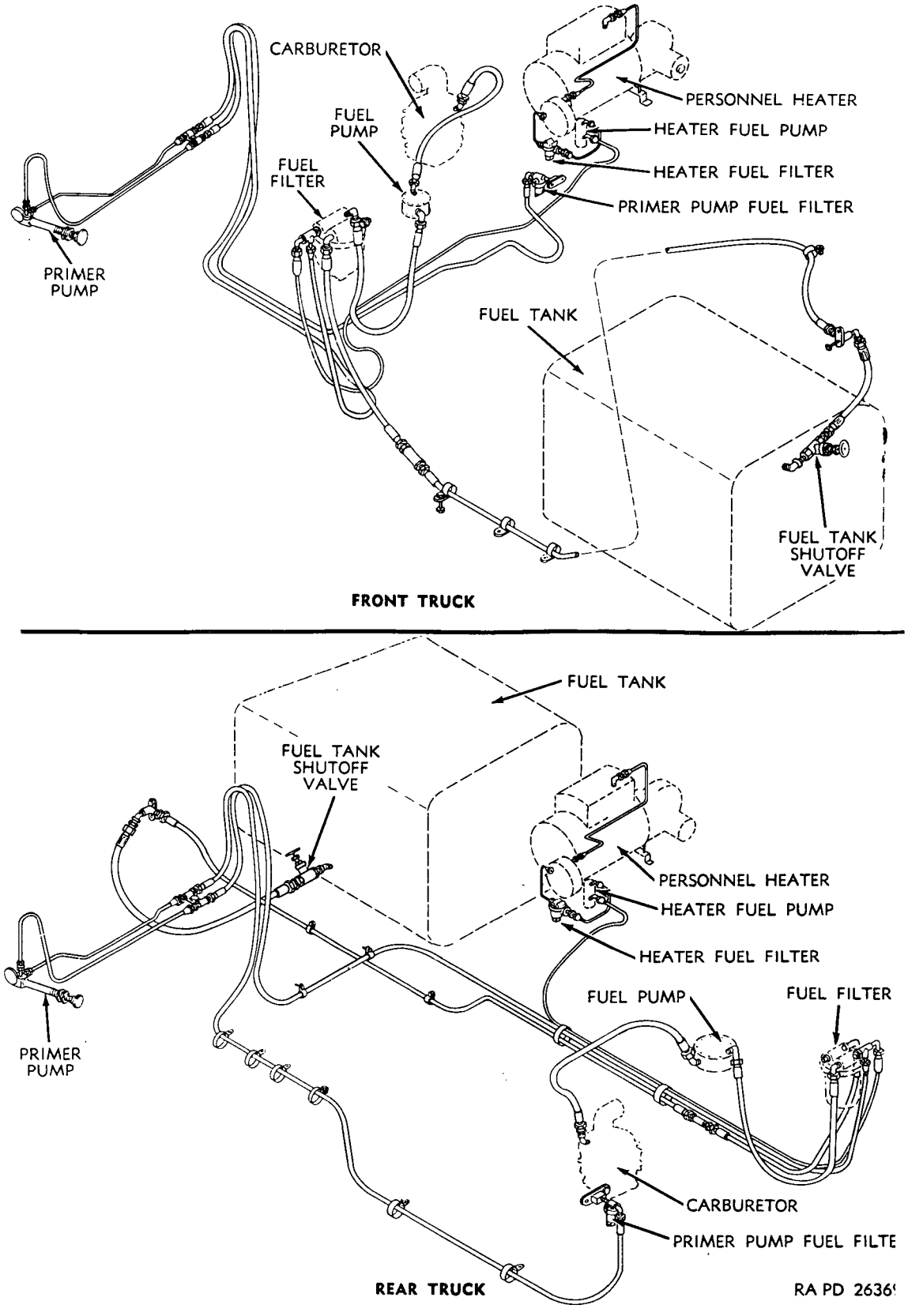


Figure 15. Fuel system for 4x4 heavy gun-lifting trucks.

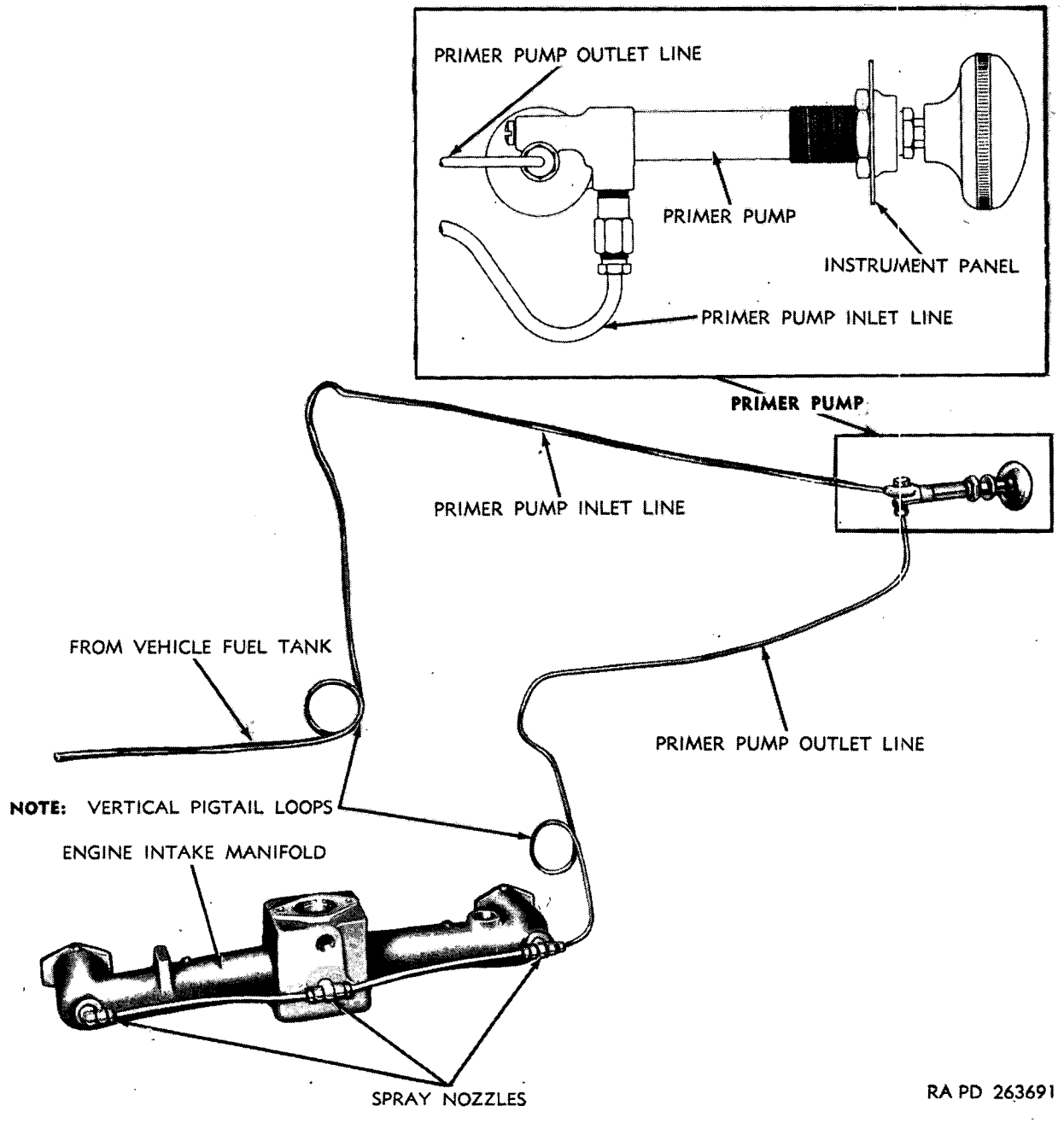


Figure 16. Engine primer system for 2 ½-ton 6x6 trucks.

c. Inspect the intake and exhaust manifolds to see that they are in good condition. See that manifold gaskets are in good condition and are not leaking; tighten manifold if required. On a manually operated manifold heat control (fig. 19), determine if it is in good condition and secure; see that the control valve is set for "winter" or "cold" operation. If the valve is automatic (fig. 20), note whether the vacuum-control valve linkage is in good condition and securely connected to the heat-control valve shaft and mounting. The shaft should operate freely and the spring should control the shaft and valve properly.

d. Make certain that carburetor is correctly adjusted for cold-weather operation. Refer to operator's technical manual for adjustment procedures.

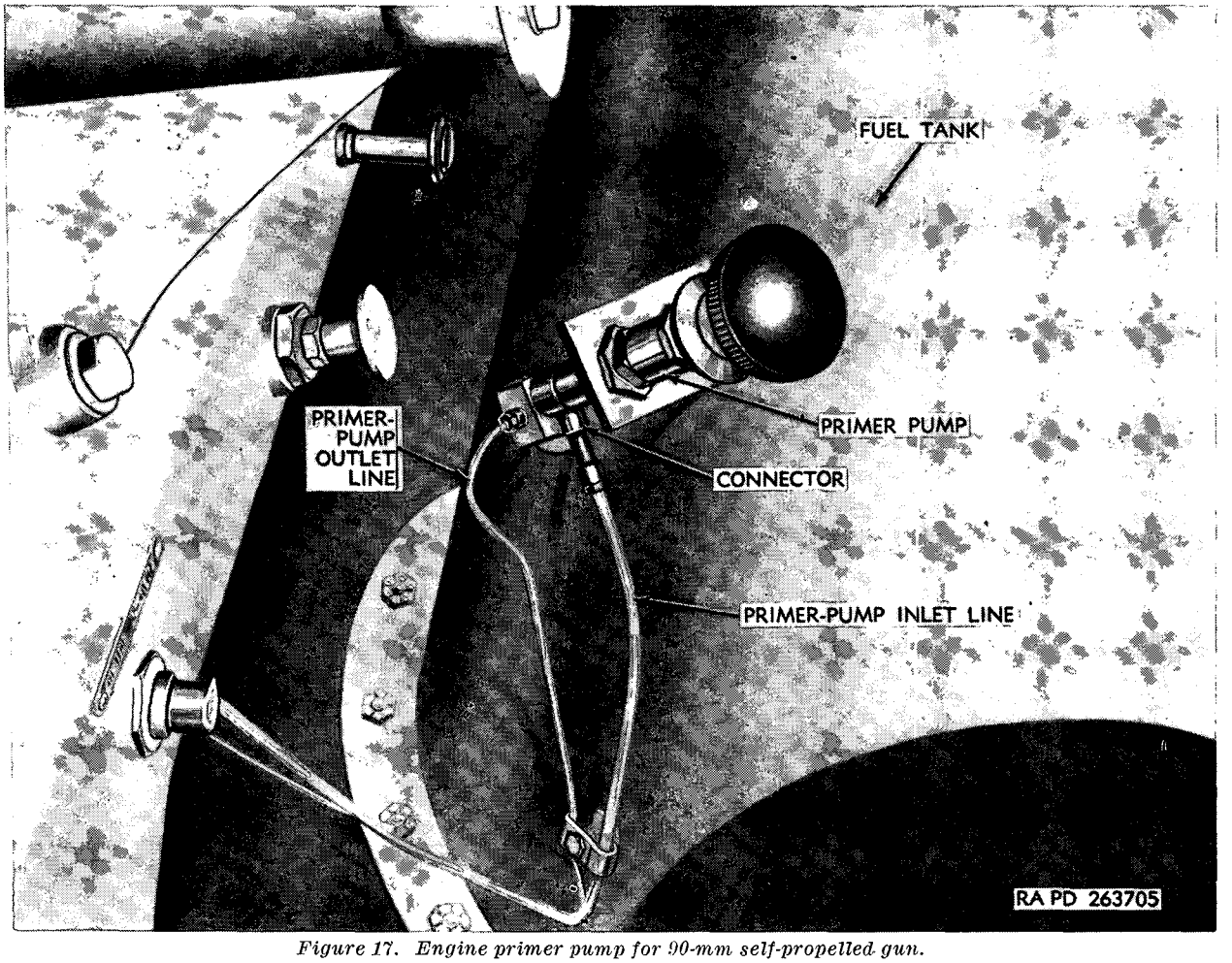


Figure 17. Engine primer pump for 90-mm self-propelled gun.

e. Some carburetors are provided with inlet and outlet hot-spot pipes and manifolds (fig. 20). The inlet pipe carries heated air from the exhaust manifold to the hot-spot manifold to preheat the mixture of fuel and air traveling from the carburetor to the intake manifold. The heated air is returned through the hot-spot outlet pipe. Vacuum-control valves, mounted on the sides of the engine top shroud, control the amount of warm air carried to each carburetor. Check to make sure that these pipes and manifolds are clear and function properly.

42. Operatin in Extreme Cold

a. General. Successful operation of vehicles at extreme-low temperatures will depend to a great extent upon the condition of the fuels used. Water in engine fuel can cause serious difficulties. Trouble will be encountered in some engines even at temperatures above the freezing point of water. When fuel is forced through carburetor jets, the pressure is lowered and the fuel is sprayed or atomized by venturi action. This reduction of pressure in the venturi becomes a refrigerating action and the temperature of the water may be lowered enough to freeze and collect arround the jet. The ice will build up until the fuel supply to the combustion chambers will be cut off and the engine will cease to operate. Water will settle to the bottom of fuel tanks and into the lowest parts of fuel lines so that fuel cannot reach the carburetor, and as a consequence, the engine cannot be started. Contamination of fuels with moisture is the source of many difficulties. Moisture can be the result of snow getting into the fuel; condensation, due to "breathing" of a partially filled fuel container, or moisture may condense from warm air in a partially filled container when taken outdoors from warmer temperatures. The precautions in (1) through (7) below, must be followed.

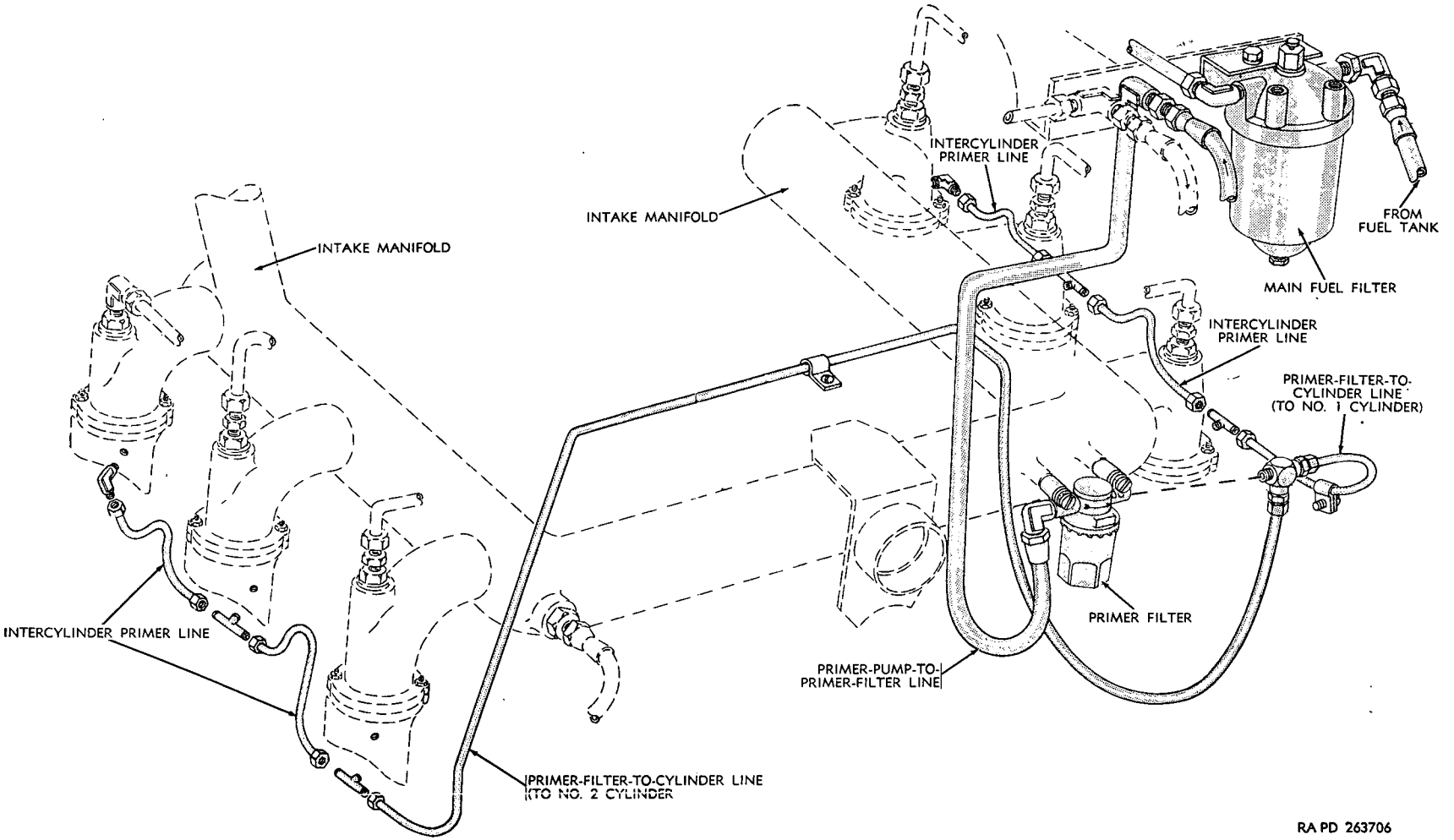


Figure 18. Engine primer system for 90-mm self-propelled gun.

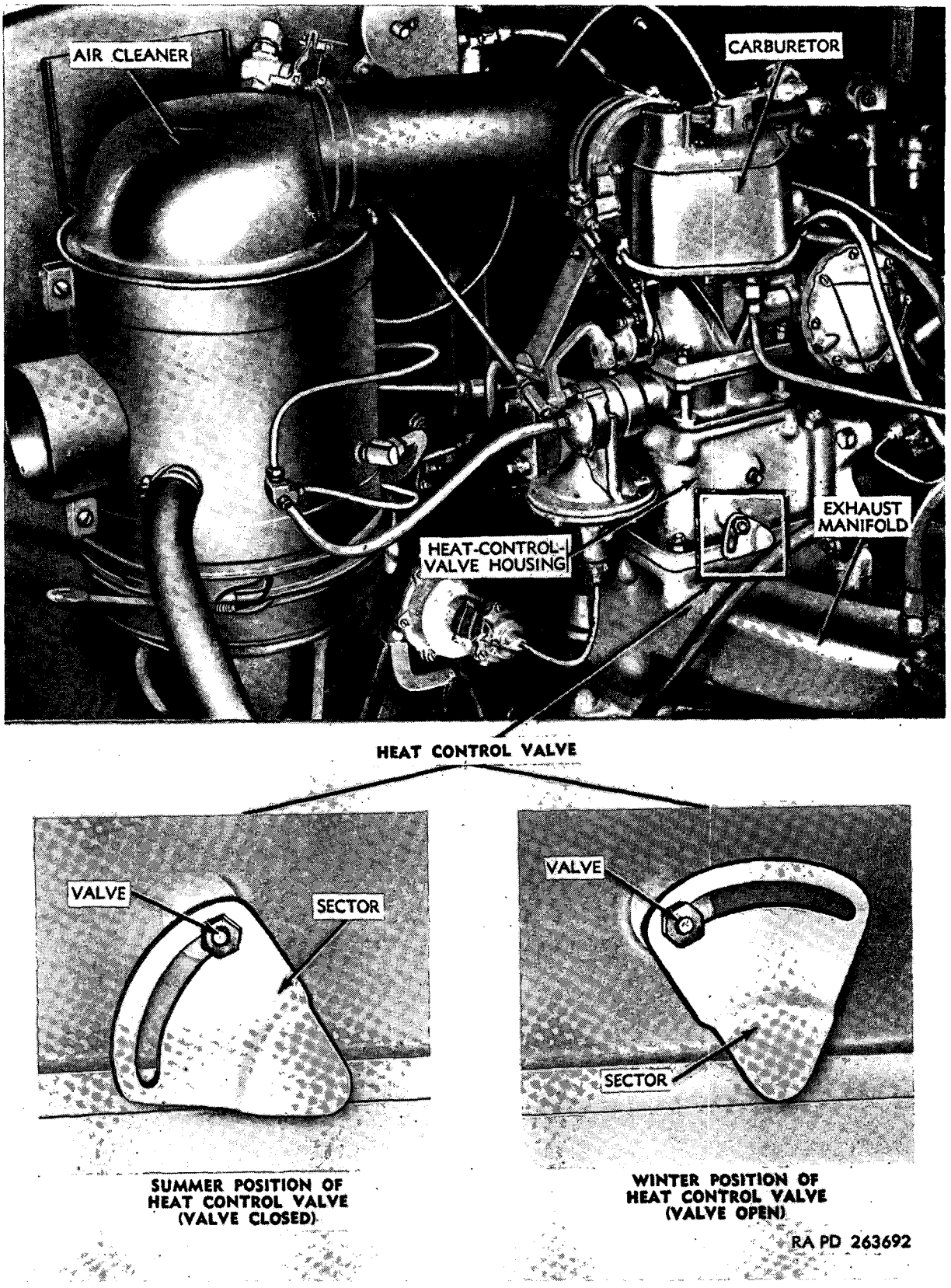


Figure 19. Exhaust-manifold heat-control valve for 2 ½-ton 6x6 trucks.

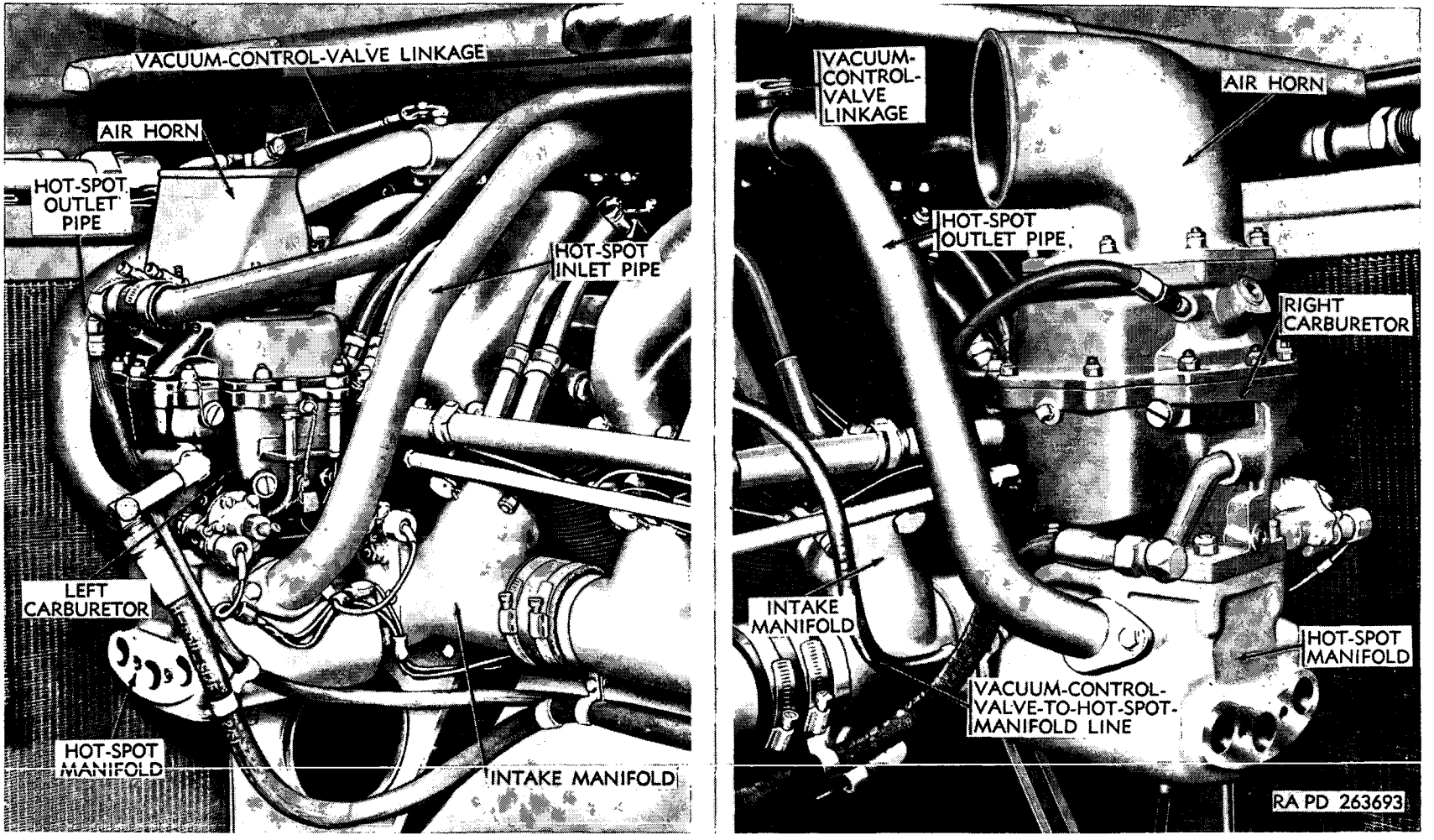


Figure 20. Automatic heat controls for self-propelled 8-inch howitzer.

(1) Make sure that all containers are thoroughly clean and free from rust before storing fuel in them.

Note. Fuel and water mixtures remaining in drums may be poured into a settling tank, allowed to settle, and the fuel drawn off for use. When pumps are not used in fueling operations and fuel is run into containers by gravity, strainers must be used.

(2) If possible, after filling or moving a storage container, allow the fuel to settle for 24 hours before using.

(3) Keep all closures tight on containers to prevent snow, ice, dirt, and other foreign matter from entering.

(4) Wipe all snow or ice from dispensing equipment and around fill cap of fuel tank before removing cap. After filling tank, install cap securely.

(5) For gasoline-powered vehicles, add denatured alcohol at time of filling (par. 41*a*(1)).

(6) Strain the fuel through a filter paper, chamois skin, or any other type of strainer that will prevent the passage of water.

Warning: **Fuel flowing over a surface generates static electricity that will result in a spark unless means are provided to ground the electricity. A metallic contact between the container and the tank must be provided to insure an effective ground.**

(7) Keep fuel tank full if posssible. Refuel immediately after halting to reduce condensation in fuel tanks. The more fuel there is in the tank, the smaller will be the volume of air from which moisture can be condensed. Drain tank frequently to remove water accumulated in the bottom.

b. Before Operation.

Caution: **When refueling, take precautionary steps listed in *a*(1) above.**

(1) Before each operating period, the fuel gage on the instrument panel will be observed to see that fuel tank is full.

(2) The carburetor, fuel pump, filters, and connecting lines in the engine compartment will be inspected. Any leaks or damaged units will be reported to maintenance personnel.

(3) Check the operation of the choke and throttle control wires and accelerator linkage; if frozen apply heat or report to maintenance personnel.

(4) On vehicles equipped with air-cooled engines, place magneto switch in OFF position and press start switch and release quickly to check for engine hydrostatic lockup. If cranking cannot be accomplished, a hydrostatic lock may exist. Remove the spark plugs and again attempt to crank engine with starter. If the engine can be cranked after removing the spark plugs, the engine was locked hydrostatically; notify ordnance maintenance personnel. If the engine cannot be cranked with the spark plugs removed, it indicates a moving part has seized and that the starter, battery, or starter circuit is at fault; check each item according to troubleshooting procedures in operator's technical manual.

c. Starting.

(1) *Gasoline engines.* For a satisfactory start, the fuel must create a combustible mixture with the intake air. A priming system (figs. 16–18) assures a more combustible mixture before the starter is engaged. A priming system is included in the winterization kit for vehicles not so equipped at time of manufacture.

(*a*) *Operation of priming system.* Proper operation of the engine priming system is extremely important. Priming increases the amount of vaporized fuel reaching the combustion chamber and improves the low-temperature starting ability of the engine.

Warning: **Excessive use of the primer pump results in overrich mixtures, with a possibility of hydrostatic lock, wash-down of cylinder wall lubrication, and increased fire hazard.**

The correct manner in which to operate the primer pump and start

an engine is outlined in *1* through *9* below.

1. Close the choke valve and open the throttle one-third to one-half and prime the fuel pump.

2. Operate the primer pump (figs. 16 and 17) two or three strokes; do not pump accelerator.

3. Turn on the ignition switch (on combat vehicles, close master switch, booster coil switch, and magneto switch).

4. Turn on electric fuel pump if so equipped.

5. Operate starter for not longer than 15 seconds.

6. Pump primer slowly while engine is being cranked and continue with steady strokes if engine will not run without this aid. Do not overprime. *Stop priming as soon as engine runs smoothly on choke alone.*

7. If engine fails to start, release starter switch, turn off booster switch, ignition or magneto switch, and electric fuel pump. Wait a few minutes for starter to cool before attempting another start; then repeat the process.

8. If the engine is flooded by overpriming, turn off all switches, including ignition, magneto, booster, and electric fuel pump. Open choke valve. Hold the accelerator wide open and turn the engine over three or four times with starter; then repeat the foregoing starting operations.

9. After engine starts, adjust the throttle and choke control to secure a smooth, fast idle.

Caution: **Do not race engine until it is thoroughly warmed up.**

(*b*) *Extreme-cold and cold-weather procedure for engine starting.* The use of the hand-priming system to start engines on vehicles so equipped is not always necessary at temperatures above —25° F. Starting with the use of the hand choke control only at temperatures down to —25° F. is desirable. The use of the priming system at temperatures below —25° F. is advisable and the necessary procedures to assure engine starts are prescribed in *1* through *8* below.

1. Slightly open hand throttle control.

2. Pull out hand choke control to full choke position.

3. Prime engine with three slow, steady strokes of the priming pump.

4. Depress clutch pedal (on vehicles so equipped).

5. Turn on ignition switch (on combat vehicles, close master switch, booster coil switch, and magneto switch).

6. Engage starter. Do not depress foot throttle control.

7. As soon as engine starts to fire, push hand choke control in *slightly* and prime with slow, steady strokes of the priming pump sufficient to maintain smooth operation. Stop priming as soon as engine runs smoothly on choke-setting alone.

8. Adjust hand throttle and choke controls (figs. 21 and 22) to maintain smooth engine operation during warmup period.

Caution: **Do not race engine until it is thoroughly warmed up.**

(*c*) *Application of heat to intake manifold and carburetor.* If, in an emergency, the arctic grade of motor fuel is not available and it is necessary to use the regular grade, application of heat to the intake manifold and carburetor will assist in forming a more combustible mixture. For vehicles not equipped with an engine coolant heater, heat may be directed to the intake manifold from an outside source, such as a blowtorch, gasoline-fired heater duct, auxiliary slave kit heater, or other portable heater. Another expedient is pouring of hot (not boiling) water over

the intake manifold. Cover carburetor intake and crankcase vent to prevent entrance of water.

Warning: **Extreme care must be taken when an acetylene torch or blowtorch is used, because of the fire hazard.**

(2) *Diesel engines.* Diesel engines are particularly difficult to start under extreme-cold conditions without preheating the intake air during the starting period. The terminal temperatures at the time of injection must be sufficiently high to ignite the fuel. This preheating can be accomplished as prescribed in (*a*) or (*b*) below.

(*a*) By an induction manifold air heater where this is part of the engine.

(*b*) By warming the engine with the blast heat from a slave kit or other portable heater.

d. During Operation. The carburetor air intake must be protected from chilling winds in subzero temperatures. Hood, radiator, and louver covers are provided in winterization kits or can be easily manufactured and applied. Properly installed, the covers will keep out cold winds and materially aid in attaining and maintaining an adequately heated engine compartments. It may be necessary on some vehicles to seal the under side of the engine compartment in addition to the aforementioned covers, by placing a canvas cover underneath the engine and sealing the entire space from side frame to side frame.

e. After Operation. After each operating period, the fuel systems (figs. 12–15) must be carefully inspected for leaks or damage. All defects will be reported to maintenance personnel.

43. Maintenance in Extreme Cold

Satisfactory performance of equipment in extreme cold depends on careful servicing. Proper maintenance by the organization mechanic will preclude many malfunctions and failures that would otherwise occur in subzero temperatures.

a. The choke and throttle controls (figs. 21 and 22) may operate with difficulty at low temperatures. If the engine does not respond properly to operation of controls, check for loose or broken control linkage or cable. Adjust linkage or replace defective parts as required in accordance with operator's technical manual. Wherever linkage extends through panels, brackets, or hull, smooth down linkage, using aluminum-oxide abrasive cloth. Also, clean wires with drycleaning solvent or mineral spirits paint thinner and dry thoroughly.

b. Inspect fuel filters for good condition; clean the filter elements with drycleaning solvent or mineral spirits paint thinner (without disassembly the disk-type filters); dry; and install. Make sure there are no leaks.

c. Assure that fuel pumps and lines (figs. 12–15) are not leaking and are secure and in good condition.

d. Remove screen from carburetor fuel inlet, clean in drycleaning solvent or mineral spirits paint thinner, dry, and install. See that carburetor does not leak and that throttle linkage and governor are in good operating condition. Make certain that the carburetor is properly adjusted for extreme-cold operation.

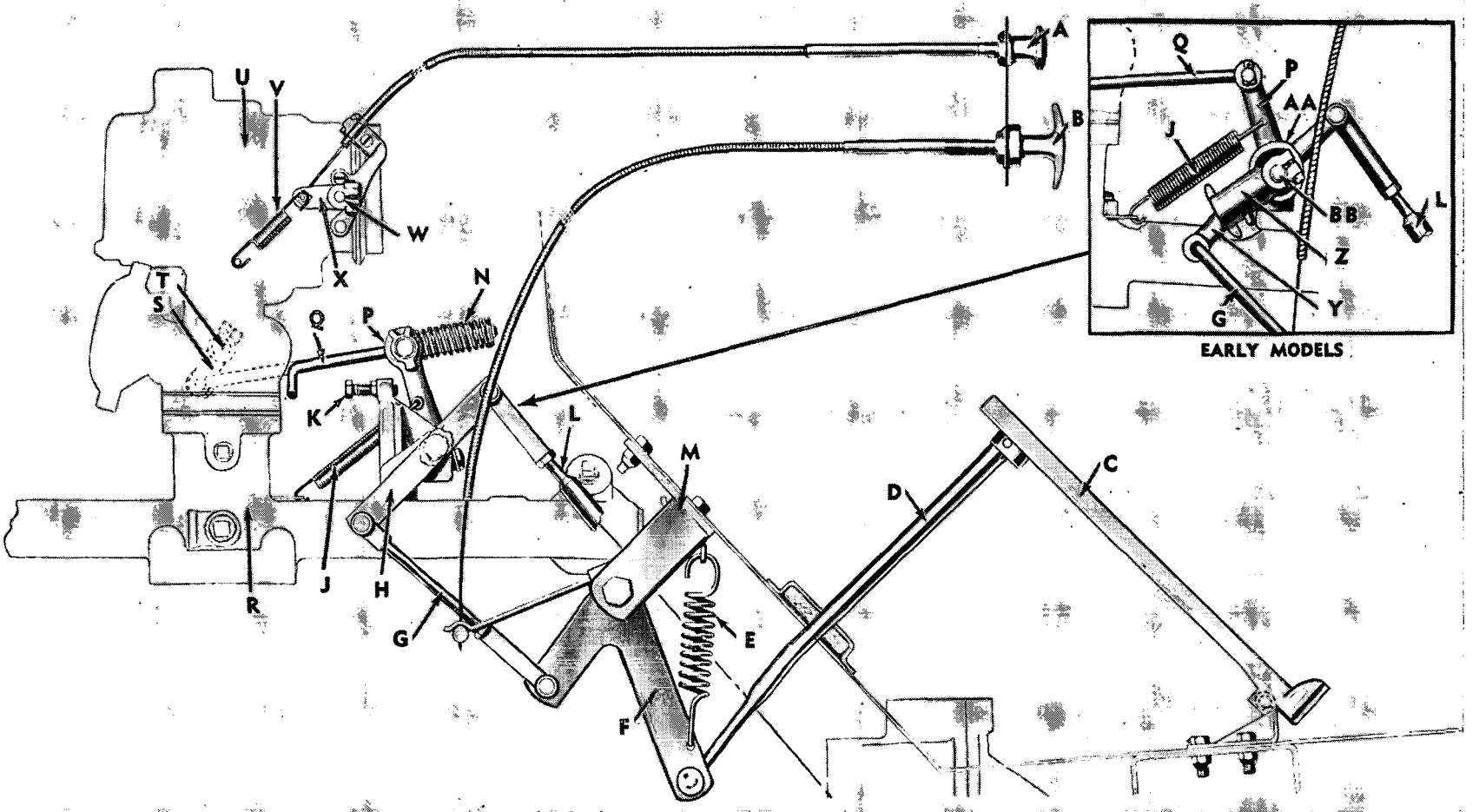
e. Note whether Diesel-fuel injection pump, including any transfer pump, is in good condition, correctly assembled, securely mounted, and that connections do not leak.

f. Observe whether Diesel-fuel nozzles and lines are in good condition.

g. Check primer pump, primer filter, lines, and connections for satisfactory operation and traces of leaks.

Note. The primer injection nozzles located in the intake manifolds will, through long usage, become plugged with carbon or dirt; periodic inspection and servicing or replacement is necessary for satisfactory primer operation.

h. Observe whether fuel gage registers approximate amount of fuel in tank.



A—CHOKE CONTROL ASSEMBLY
B—HAND THROTTLE CONTROL ASSEMBLY
C—ACCELERATOR PEDAL
D—ACCELERATOR ROD
E—ACCELERATOR RETURN SPRING
F—ACCELERATOR IDLER LEVER
G—IDLER-LEVER-TO-CROSS-SHAFT-LEVER ROD
H—CROSS SHAFT (LATE MODELS)
J—CROSS-SHAFT-INNER-LEVER RETURN SPRING
K—THROTTLE OPENING ADJUSTMENT SCREW
L—TRANSMISSION-THROTTLE-VALVE CONTROL ROD
M—IDLER LEVER BRACKET
N—OVERRULE SPRING
P—CROSS SHAFT INNER LEVER
Q—CROSS-SHAFT-INNER-LEVER-TO-CARBURETOR-LEVER ROD
R—INTAKE MANIFOLD
S—CARBURETOR THROTTLE SHAFT LEVER
T—THROTTLE SHAFT
U—CARBURETOR ASSEMBLY
V—CHOKE CONTROL RETURN SPRING
W—CHOKE VALVE PLATE SHAFT
X—CHOKE LEVER
Y—CROSS SHAFT OUTER LEVER (EARLY MODELS)
Z—THROTTLE OVERRULE LEVER (EARLY MODELS)
AA—OVERRULE LEVER SPRING (EARLY MODELS)
BB—CROSS SHAFT (EARLY MODELS)

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Figure 21. Choke and throttle control linkage for 2½ 6x6 trucks.

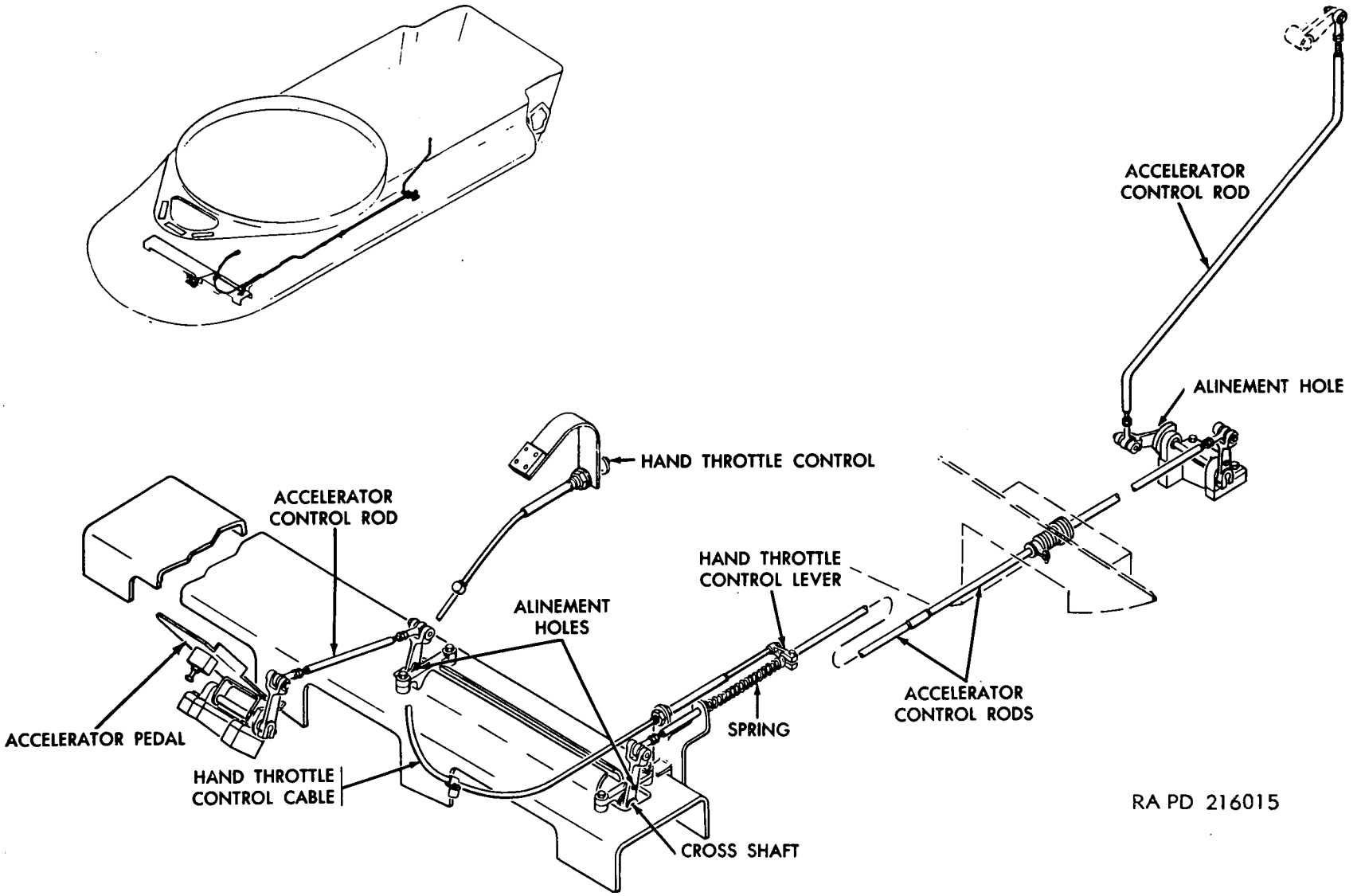


Figure 22. Accelerator and throttle control linkage for 90-mm gun combat tank.

44. Effect of Extreme Cold on Electrical System

a. The storage battery is adversely affected by extreme cold; its available energy decreases sharply as the temperature falls. Unfortunately, engine starting requirements, so far as current and voltage are concerned, are most severe when the battery is capable of delivering the least power. Current delivered at +15° F. will be only 50 percent of that which would be produced at normal temperatures; while the amount delivered at —30° F. will be only a little over 10 percent of that which would be produced at room temperature (fig. 23). At —40° F. and below, the available current is practically zero. A fully charged battery will not freeze in extreme-cold climates, but a discharged battery (sp. gr., 1.100) will freeze at +19° F. Frozen batteries rupture and break internally and externally. Table IV indicates freezing points of batteries at various specific gravities. Unless a storage battery is warmed to above +35° F., it will not receive an adequate charge from the generator.

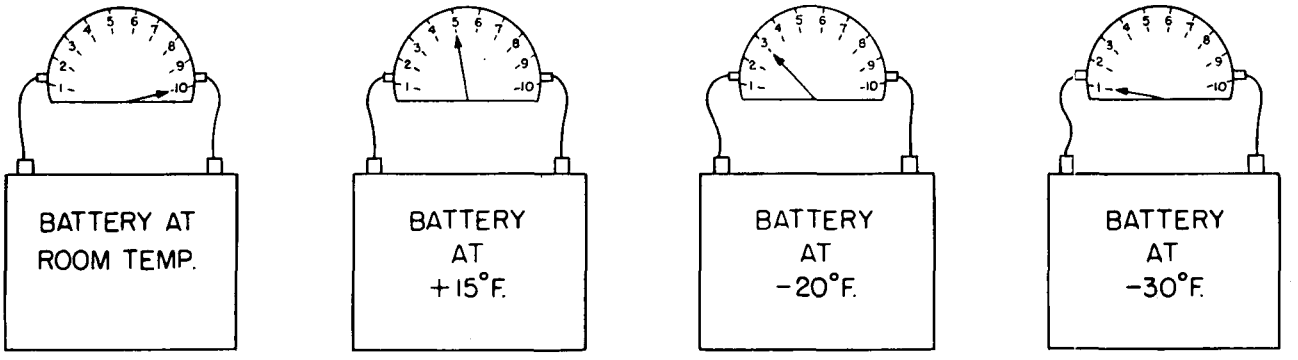


Figure 23. Relative effect of extreme cold on the available energy of a battery

Table IV. Freezing Points of Batteries at Various Specific Gravities (with Specific Gravity Corrected to +80° F.)

Specific gravity of electrolyte (corrected to +80° F.)	Freezing points of electrolyte (° F.)
1.280	—90
1.250	—62
1.200	—16
1.150	+5
1.100	+19
1.000	+32

b. The drive mechanism of starters is extremely susceptible to failure at low temperatures. Grease or dirt on the armature shaft, Bendix drive, or other type of mechanical drive will prevent the gears from meshing properly or cause them to remain in mesh after the engine is started. The latter will damage the starter. An improper lubricant on bushings could congeal and cause the starter to operate unsatisfactorily by placing an excessive drag on the armature. The overrunning clutch on starter drives may fail to release, because lubricant may solidify in extreme cold. Solenoid plungers, unless clean and free of oil, will bind in switch assembly housings. Oil and grease on brushes or commutator will prevent a good contact necessary to carry the large amount of current required to crank an engine in subzero temperatures.

c. The distributor breaker contact points will oxidize during operation in extreme cold, forming a high resistance between contacting surfaces, and prevent flow of current.

d. The breaker contact-arm bushing will freeze on its pivot, preventing breaker arm from returning when the cam separates the points, unless it is clean and properly lubricated.

e. Improper oil or presence of excessive dirt will cause automatic advance mechanisms on distributors to become inoperative.

f. Low temperatures will aggravate unsatisfactory performance of magnetos, due to pitted or unclean breaker contact points.

g. Ice will coat spark plugs, as a result of moisture due to condensation, and may prevent starting of engines.

h. Oil or dirt on brushes or commutator will cause unsteady or low generator output. Generator ball bearings will fail to rotate when an improper lubricant solidifies and may cause driving belt failures.

i. Contraction of the helical springs in subzero temperatures will affect generator regulator adjustments and may result in excessively high voltages. This may be a normal action and should not require special attention.

j. Electric heater motors may operate unsatisfactorily when lubricant congeals in bushings at low temperatures.

k. Insulation on low- and high-tension cables may crack.

45. Preparation for Operation in Extreme Cold

The procedures in *a* through *n* below, will be followed to prepare the electrical system for extreme cold.

a. Storage Batteries.

(1) A storage battery must be in good condition and kept in a fully charged state (1.275 to 1.300 specific gravity corrected to a battery-solution temperature of +80° F.). A specific gravity reading in extreme cold must be corrected to a temperature of +80° F. The normal correction for temperature is 4 (0.004) points of specific gravity for each 10° F. change in temperature of electrolyte above or below +80° F. Subtract 4 (0.004) points for every 10° below +80° F.

Example. If specific gravity reading is 1.282 at 0° F., subtract 4 (0.004) points for each 10° below +80° F. or (0.004 x 8) = 0.032 points. Corrected specific gravity reading (1.282 — 0.032) will be 1.250 (table V).

Table V indicates corrected specific gravity readings for the actual temperature (0° F.) and approximate state of charge (percent).

Table V. Temperature/Specific Gravity Correction Table for Batteries

Actual temperature (° F.)	Specific gravity		Approximate state of charge (percent)
	Actual hydrometer reading [1]	Corrected to +80° F.	
+80	1.280	1.280	100
	1.250	1.250	75
	1.220	1.220	50
	1.190	1.190	25
	1.160	1.160	Little useful capacity
0	1.312	1.280	100
	1.282	1.250	75
0	1.250	1.220	50
	1.222	1.190	25
	1.192	1.160	Little useful capacity
—10	1.320	1.280	100
	1.290	1.250	75
	1.260	1.220	50
	1.230	1.190	25
	1.200	1.160	Little useful capacity
—20	1.324	1.280	100
	1.294	1.250	75
	1.264	1.220	50
	1.234	1.190	25
	1.204	1.160	Little useful capacity
—30	1.328	1.280	100
	1.298	1.250	75
	1.268	1.220	50
	1.238	1.190	25
	1.208	1.160	Little useful capacity
—45	1.334	1.280	100
	1.304	1.250	75
	1.274	1.220	50
	1.244	1.190	25
	1.214	1.160	Little useful capacity
—65	1.340	1.280	100
	1.310	1.250	75
	1.280	1.220	50
	1.250	1.190	25
	1.220	1.160	Little useful capacity

[1] Hydrometer scales normally lack the decimal. Hence, a hydrometer reading of 1,280 is equivalent to a specific gravity of 1.280.

(2) Where batteries are continuously exposed to low temperatures, insulating the interior of the battery box with nonmetallic material, such as rock wool, cellulose fiber, asbestos, spun glass fibers, etc., will aid in maintain-

ing a uniformly higher temperature. Insulating material must surround all sides, including bottom and top of the battery. When fastening insulation to the interior of the battery box, do not use any metal screws or bolts that may come in contact with the battery, as the metal will act as a heat-loss conductor from the interior of the box. The use of wooden strips to fasten insulation is advised. Where it is necessary to use bolts or screws, countersink bolt or screw-heads in wooden strips to avoid contact with the battery. A wooden battery box can be built to enclose batteries on vehicles where they are mounted in open frames. Construct the box of sufficient size to permit the use of insulation. Where winterization kit provides an air duct for directly heating air to battery box, set for winter operation.

(3) It is essential that every vehicle be equipped with an auxiliary power (slave) receptacle (figs. 24 and 25). A suitable powercord extension may then be used to carry an auxiliary current supply to aid in starting an engine in cold weather. The use of the auxiliary cold-starting aid kit (slave kit) requires an auxiliary power (slave) receptacle installation (figs. 24 and 25).

(4) It can be readily observed from table V that a battery apparently fully charged according to a hydrometer reading (actual reading 1.280) is in reality only half charged at —65° F. when specific gravity reading is corrected to +80° F. (corrected reading 1.220). A battery should be preferably above +20° F. in order to deliver sufficient current for starting. If the vehicle is equipped with a battery heater (fig. 26), it must be operated in

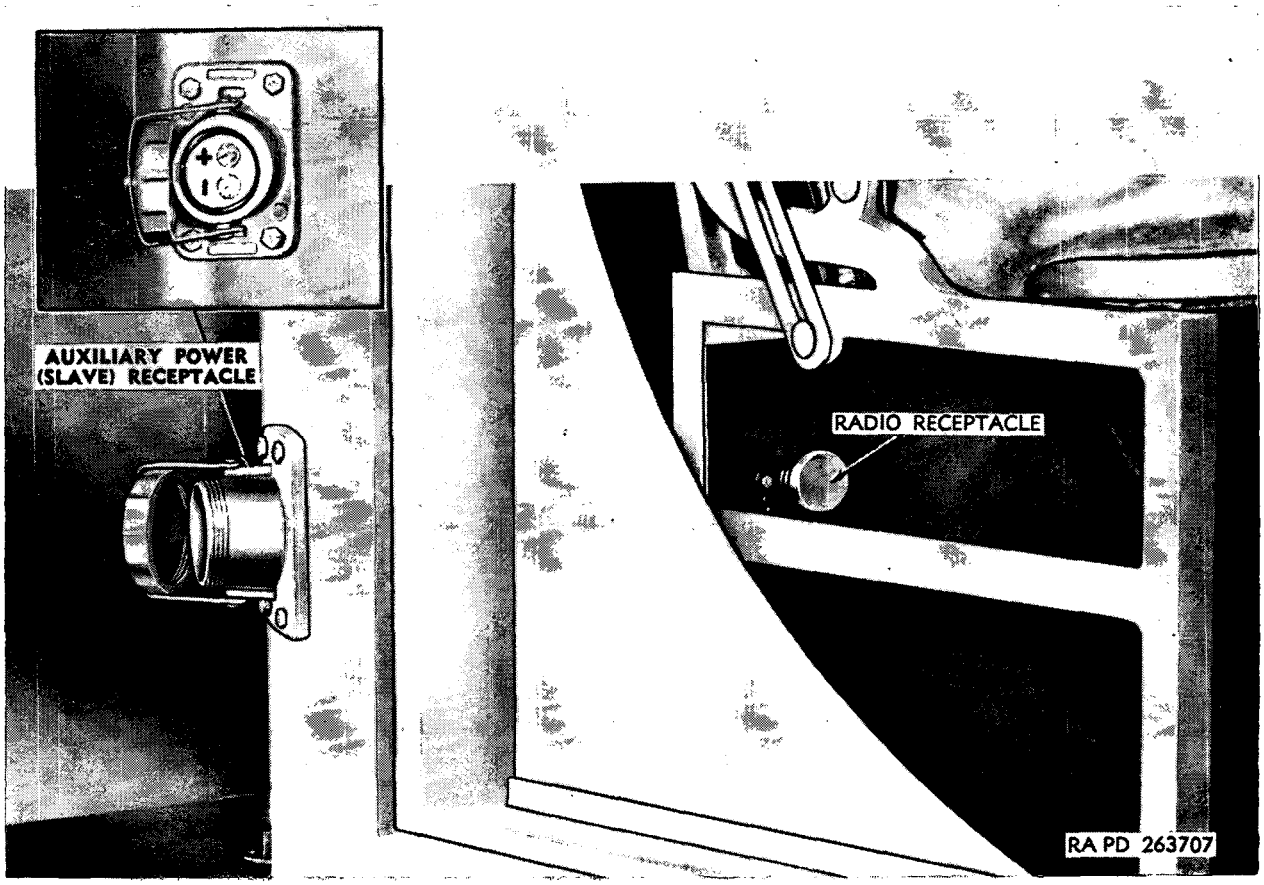


Figure 24. Auxiliary power (slave) receptacle for 2½-ton 6x6 truck.

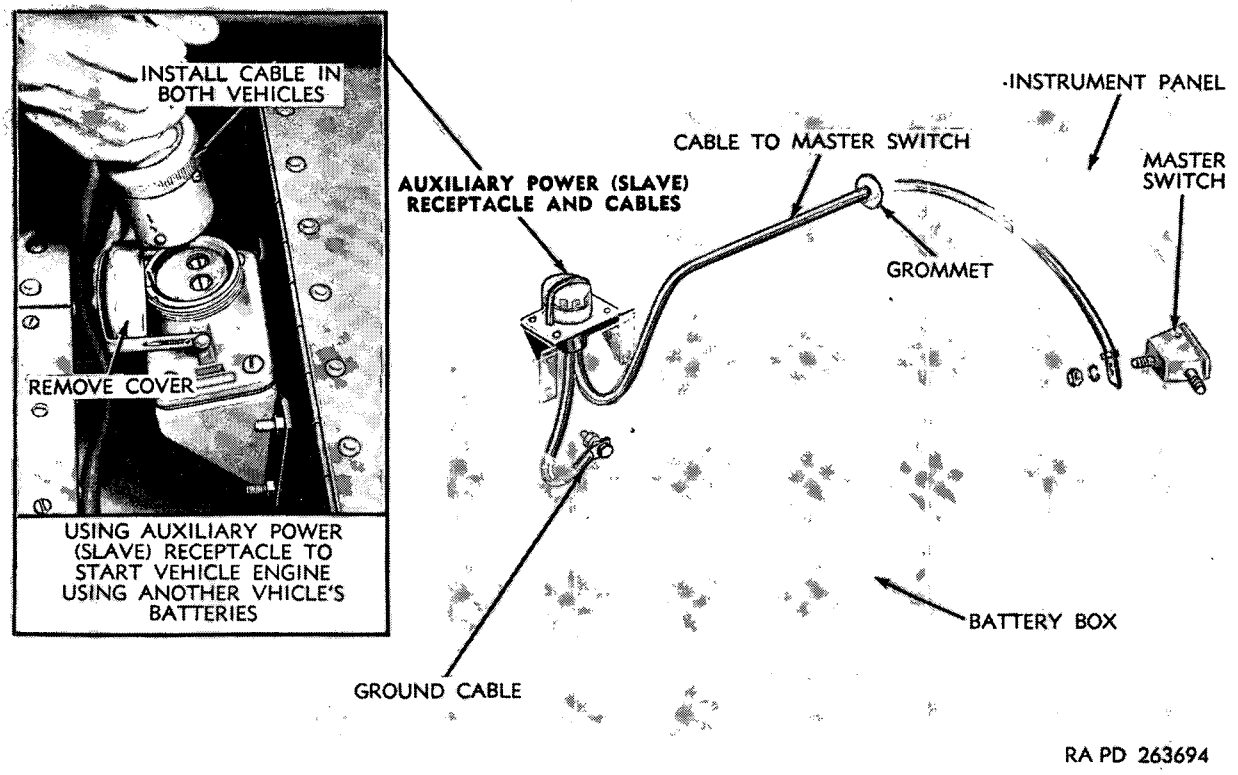


Figure 25. Auxiliary power (slave) receptacle for 90-mm self-propelled gun.

accordance with instructions supplied with the winterization kits.

b. Wiring. Check, clean, and tighten all electrical connections, especially the battery terminals and cables. Inspect battery ground strap and connection for good condition and contact. Care should be taken that no short circuits exist. Make certain that wiring insulation is not cracked.

c. Starter.

(1) Check brushes for wear and free movement and check springs for correct tension. Make certain that commutator is not scored, out-of-round, dirty, or burned and that there is no high mica between commutator bars.

(2) Clean and wash plain bearings and oil lightly with general-purpose lubricating oil (PL, special). Thoroughly wash unsealed ball bearings in drycleaning solvent or mineral spirits paint thinner and lubricate with aircraft and instrument grease (GL).

(3) Wash the throwout mechanism and gear in drycleaning solvent or mineral spirits paint thinner to remove grease and dirt.

(4) On overrunning-clutch-type starters, clean and wash the splined shaft and apply a very thin film of general-purpose lubricating oil (PL, special). Do not attempt to wash or service the overrunning clutch.

(5) On heavy-duty starters with solenoid-operated Dyer drive, clean and wash the splined armature shaft and Dyer drive. Apply a very thin film of general-purpose lubricating oil (PL, special) to the splined shaft.

(6) Clean and wash the solenoid plunger, dry thoroughly, and do not lubricate.

(7) Clean and wash reduction grease in drycleaning solvent or mineral spirits paint thinner. Place approximately 3 ounces of automotive and artillery grease (GAA, amend. 2) around the teeth of the reduction gears. Clean the plain bearings of the shafts in drycleaning solvent or mineral spirits paint thinner and lubricate with gen-

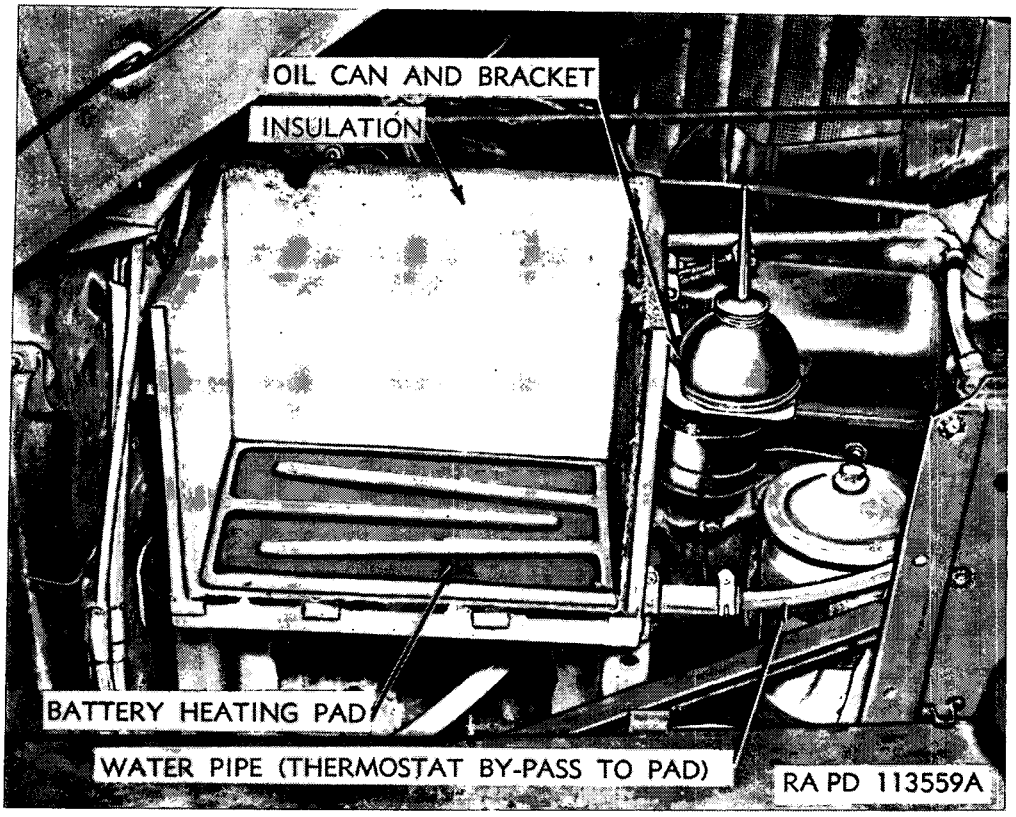


Figure 26. Insulated battery box and heating pad for 2½-ton 6x6 truck.

eral-purpose lubricating oil (PL, special).

(8) No attempt will be made to clean or lubricate sealed bearings (regular-type). Sealed bearings will be replaced, unless known to be lubricated with aircraft and instrument grease (GL), and ball bearings (sealed or unsealed) lubricated with the proper low-temperature grease. Vehicles having the 24-volt electrical system are equipped with sealed bearings containing the proper all-temperature lubricant. Sealed bearings in vehicles equipped with other than 24-volt electrical systems will be warmed with air heaters (slave kit heater) to facilitate ease of starting.

d. Generators. Inspect generators for sticking or worn brushes, rough, out-of-round, dirty, or burned commutator, and high mica between commutator bars. Test brush springs for correct tension. Clean and wash ball bearings (if not of the sealed-type) in drycleaning solvent or mineral spirits paint thinner, and lubricate them with automotive and artillery grease (GAA). If authorized, replace sealed-type ball bearings (unless lubricated with aircraft and instrument grease (GL)) with ball bearings lubricated with the proper low-temperature grease if available.

Note. If sealed bearings with the proper arctic lubricant are not available, warm bearings with air heaters (slave kit heater) before attempting to start engine in extreme cold.

e. Generator Regulators. Seals may be broken and adjustments made only by technically qualified and authorized personnel. Check generator regulators for proper adjustments (par. 47*f*).

f. Distributors. Clean distributor thoroughly and replace the breaker contact points if pitted, oxidized, or burned. Check for correct contact point opening and spring pressure; also, check to see if breaker arm turns freely on pivot. Clean pivot and lubricate with 1 or 2 drops of general-purpose lubricating oil (PL, special). Inspect cap and rotor for cracks, chipped places, or burned paths that would permit high-tension leakage to ground. Check rotor for good condition. Apply a tract of automotive and artillery grease (GAA, amend. 2) on the breaker cam.

Apply 1 or 2 drops of general-purpose lubricating oil (PL, special) on the felt wick in the breaker cam under the rotor if so equipped. If the distributor is equipped with a grease cup, clean thoroughly and fill with automotive and artillery grease (GAA, amend. 2). Test the condenser. Check centrifugal advance mechanism for proper operation. Check timing. The spark must be set according to instructions in the applicable technical manual for the vehicle.

g. Ignition Coils. Clean coils and see that connections are tight. Inspect high-tension cables for general condition. Make sure that connections in cap and coil terminal are secure.

h. Magnetos and Booster Coils. Inspect magnetos and booster coils for security of mounting. Inspect contact points and replace if burned, oxidized, or pitted. Check timing.

i. Spark Plugs. Clean spark plugs in accordance with TM 9–8638 and adjust gap to that recommended by the applicable technical manual for the vehicle. Replace plugs if necessary and adjust gap. Use spark plugs of proper ignition rating when installing new plugs. Make certain new gaskets are installed in all cases.

Caution: **Spark plugs must be handled in an extremely careful manner at subzero temperatures to avoid breakage of insulators.**

j. Switches. Test the operation of all switches; make certain they operate freely without binding. Clean and tighten all connections.

k. Lights. Test all head lights, stop, tail, blackout, instrument, and warning lights. Replace all defective bulbs. Check terminals, plugs, and connections for cleanliness and good contact.

l. Turret Items. Check and prepare the turret electric motors and motor generators in a manner similar to starters and generators, except where applicable parts are not present. No attempt will be made to clean or lubricate sealed bearings. If it is known that sealed bearings are not lubricated with correct low-temperature grease, replace if authorized with sealed bearings lubricated with aircraft and instrument grease (GL) if available. Drain hydraulic oil from traversing and elevating systems and fill with petroleum-base hydraulic fluid (OHC). Lubricate turret ring sparingly with automotive and artillery grease (GAA, amend. 2).

m. Application of Ignition-Insulation Compound.

Note. Waterproofing protection is currently provided for critical units when vehicles are manufacturer. However, earlier manufacture vehicles may require application of ignition-insulating compound.

As a protection against moisture, especially where it affects the ignition system, ignition-insulation compound (MIL–V–138–B) will be applied as prescribed in (1) through (4) below.

(1) Thoroughly clean the exterior of spark plugs, distributor (especially the cap), high-tension cables, primary wiring, ignition coil, and all terminals or connections of the ignition system. Thoroughly dry all parts.

(2) Remove distributor cap and rotor. Clean the rotor and the inside of distributor thoroughly, then dry all parts. Spray the inside of the distributor cap and rotor with a thin coat of ignition-insulation compound. Wipe compound from center contact button and metal segments in distributor cap and from metal parts of rotor. Allow compound to dry for at least 5 minutes before installing rotor and distributor cap.

(3) With ignition-insulation compound, thoroughly spray the interior of the engine compartment, including exterior of engine, carburetor, fuel pump, air cleaner, distributor, ignition coil, high-tension cables, primary wiring, spark plugs, generator regulator, generator, starter, engine manifolds, and all other components within the engine compartment.

Note. It is recommended that the spark plugs, high-tension cables, distributor, and ignition coil be sprayed with ignition-insulation compound a second time after the first application has dried, to assure a thorough seal against penetration of moisture.

(4) Spray the entire rear of instrument panel with ignition-insulation compound, making certain to coat all wiring and connections at rear of panel.

n. Sealing and Venting. Make sure that all units are properly sealed; but that any venting that is provided in the design of the unit is left open to prevent condensation and icing.

46. Operation in Extreme Cold

a. Before Operation.

(1) Before each operating period, the storage battery will be tested for its state of charge. The battery must be fully charged, indicated by a hydrometer reading of between 1.275 and 1.300 temperature corrected (par. 45*a*). The battery must be warmed, preferably above +20° F., in order to deliver sufficient current for starting. To receive an adequate charge, the battery temperature must approximate +35° F. If no winterization equipment is installed on the vehicle, the battery can be heated by removing the battery and placing it in a heated room or by directing hot air to it from a portable heater or from the heater on the auxiliary cold-starting aid kit (slave kit) (TB ORD 390). The batteries on the slave kit can be used if necessary to supply the electrical energy to the starter.

Caution: **Do not add water to a cold battery. Add it only when the battery is warm, about +40° F., and when it is being charged.**

Check the battery terminal connections tions for cleanliness and good contact. Check the ground connections and strap.

(2) Check connections to the starter. They must be clean and tight to assure a good electrical contact.

(3) Inspect the distributor breaker contact points. If the color of the contact surface of the points is blue, indicating oxidation, replace and adjust the points in accordance with operator's technical manual. Make certain that the breaker arm does not bind on its pivot.

(4) Make certain that the distributor cap, rotor and breaker plate assembly, and ignition coil are free of ice or moisture. Distributor must be dry. If necessary, apply heat to dry any moisture before attempting to start engine. Heat can be conducted to the distributor by means of the flexible tubing attached to the heater on the slave kit.

(5) Inspect magneto and booster coil; prepare as noted in (4) above, if ice or moisture is present. Make certain that the booster is operating by listening for buzzing sound of interrupter.

(6) The spark plugs must be thoroughly dry. Presence of ice or moisture on the plugs will prevent starting. It may be necessary to remove plugs and heat them to dry moisture on the inside of the shell, insulator, and insulated electrode.

Caution: **Insulators of spark plugs are easily broken in extreme cold. Handle plugs carefully.**

(7) Remove any ice or moisture from the high-tension cables connected to the spark plugs and from cable connecting the ignition coil to distributor cap.

b. Engine Starting. Refer to paragraph 42*c* for instructions relative to use of the primer and precautionary steps to be taken before attempting to start the engine.

(1) Do not operate the starter for periods longer than prescribed in the operator's technical manual. If engine fails to start, discontinue starter operation and turn off all switches that are being used to start the engine (e.g., ignition, magneto, booster coil, and electric fuel-pump). Wait a few minutes for starter to cool before attempting another start; then repeat the starting process.

(2) An interesting phenomenon at low temperatures, and frequently a useful one, occurs when each discharge is followed by a short charge. The following battery discharge then becomes improved both in voltage and discharge time. Even a few minutes of charge at a low current will frequently be enough to increase the cranking speed of an engine to enable a start otherwise impossible.

c. During Operation.

(1) Allow the engine to warm up to the recommended temperature for subzero operation (thermostat opens at 180° F.).

(2) Check operation of instruments during warmup, especially the oil-pressure gages and warning lights.

(3) On some vehicles, provisions are made to permit warm air to circulate throughout the engine compartment during extreme-cold weather. This heating is by means of a heat exchanger, usually located in the auxiliary-engine exhaust manifold.

(4) Advantage must be taken of any and all methods available to keep the batteries at recommended temperatures. If the battery is sufficiently warm to absorb a charge (above +35° F.), the ammeter reading, with all lights and accessories turned off, may range from 20 to 55 amperes on the positive side of the dial immediately after starting but will drop off as the battery becomes fully charged. The initial high-charging rate occurs because the battery voltage is lower, having cranked the engine. If no charge is indicated on ammeter immediately after starting it may be due to a cold battery.

(5) A fully charged battery and a high-charging rate indicate the generator regulator is not operating properly.

(6) Note any unusual noise in the generator.

(7) Note any misfiring of the engine.

(8) Notice if the lights are unusually brilliant, due to higher voltage when engine speed is increased above normal rpm.

(9) Note operation of traversing and elevating systems on self-propelled weapons and other vehicles. Note operation of stabilizing systems where applicable.

d. After Operation.

(1) When engine is stopped and all lights and accessories are turned off, notice if the ammeter dial indicates "0."

(2) Inspect spark plugs and note if insulators are in good condition and if there is any leakage around the insulators or gaskets.

(3) Check battery to see that it does not leak, is secure, and clean.

47. Maintenance in Extreme Cold

Maintenance of equipment in subzero temperatures is of the greatest importance. Special emphasis must be placed on the proper care of electrical systems to assure efficient operation.

a. Storage Batteries.

(1) Inspect the batteries externally to see that their cases, posts, and cell straps are in good condition and secure. Note whether the cases are leaking. Test the specific gravity of each cell. If the corrected hydrometer reading (table V) is below 1.250, place battery on charge until it stabilizes at three consecutive hourly readings. Refer to TM 9-6140-200-15 for information on correct charging methods.

(2) If it is necessary to recharge a storage battery under low-temperature conditions (electrolyte not frozen), the charging voltage should be low enough to prevent excessive gassing or boiling of the electrolyte. At low temperatures, the permissible charging current will be considerably less than at higher temperatures and will, therefore, require a proportionately longer charging time.

(3) Check the level of the electrolyte; it should not be above level indicated on cell cover or vent plug. Water should never be added to a cold battery; add it when the battery is warm and charging. If water is added to a battery when exposed to subzero temperatures and not being charged, the layer of water will stay at the top and freeze before it has a chance to mix with the acid.

Caution: **If water is added to a battery at temperatures of +32° to approximately +50° F., do not fill to level indicated on cell cover or vent plug, since the electrolyte will expand as it is heated and the battery will flood. Acid or electrolyte should never be added to a battery in lieu of water unless electrolyte has been spilled or lost through leakage, as this would only cause further damage to battery.**

(4) Clean the top of the battery and carrier. Tighten holddown devices, but do not overtighten.

b. Battery Cables and Terminals. Check cables and terminals to see that they are in good condition. Inspect ground strap. Make certain ground connection is clean and secure. Examine insulated cables for defects in insulation. Remove battery cable terminals from battery posts; clean off corrosion if present; connect and apply a light coating of asbestos-sealing compound (GK) to exterior surfaces of terminals.

c. Wiring. Examine all electric wiring to see that it is in good condition and properly supported and connected. Look for worn spots in the insulation and for loose or missing grommets. Pay special attention to insulation on high-tension cables.

d. Starter. Examine starter for good condition and secure mounting. Inspect brushes to see that they are clean, move freely in the brush holders, and are not excessively worn. Check for brush-spring tension and inspect commutator to see that it is clean and not out-of-round. If commutator cannot be cleaned with flint abrasive paper (grade 2/0) or has low spots, it must be disassembled by authorized personnel and turned down in a lathe. Note particularly if starter drive mechanism engages and operates properly without unusual noise and at adequate cranking speed. If difficulty is experienced in engaging drive assembly, starter must be repaired or replaced.

e. Generator Inspect the brushes, brush springs, and commutator. Replace excessively worn brushes and weak brush springs. Turn down commutator if it is out-of-round, and undercut high mica or filled slots. It it is not known whether the proper lubricant was used previously, replace bearings (par 45*d*). Check the generator drive belt or belts. They must be in good condition and tension must be properly adjusted.

f. Generator Regulators. The generator regulators must be checked for correct adjustment. Table VI lists the minimum and maximum voltage settings for the 6-, 12-, and 24-volt systems. The settings in table VI are for temperatures as low as —40° F.; however, if the minimum setting specified for the various voltages at —40° F. is used, satisfactory results will be obtained at temperatures down to —65° F. Examine contact points to make sure they are not burned, oxidized, or pitted.

Note. Seals may be broken and adjustments made only by authorized technically qualified personnel.

Table VI. Voltage-Regulator Settings

Type of system	Type of circuit	Air Temperature	Voltage-regulator settings (volts)	
			Minimum	Maximum
6-volt system	Open or closed circuit	—40	7.3	7.8
12-volt system	Open circuit	—40	14.3	15.3
	Closed circuit	—40	14.2	15.0
24-volt system	Open or closed circuit	—40	28.8	30.0

g. Distributors.

(1) Replace the distributor cap and rotor if they have cracks, chipped places, or burned spots. Discard rotor if spring is cracked or contact button is loose on spring. Replace breaker contact points if they are oxidized, pitted, or burned. Make certain that contact points are properly adjusted. Replace breaker arm if rubbing block and/or bushing is worn or loose.

(2) Check shaft for excessive stiffness or looseness; check centrifugal advance mechanism for proper operation. If distributor shaft bushing is worn and advance mechanism is defective, replace distributor. Test the capacitor (condenser) and replace if it is not in accordance with test specifications.

(3) If distributor is equipped with a grease cup, fill cup with automotive and artillery grease (GAA, amend. 2) and turn cup one or two complete revolutions to force grease into bushing. Place a trace of grease (GAA) on the breaker cam. Apply 1 or 2 drops of

general-purpose lubricating oil (PL, special) on the felt wick in the center of breaker cam under the rotor. Place 1 or 2 drops of the same oil on the breaker arm pivot.

(4) Check the timing, making certain that spark is set according to instructions in operator's technical manual for vehicle.

(5) The distributor cap, rotor, and breaker plate assembly must be kept clean and free of ice and moisture. This is very important if vehicle is to start and operate satisfactorily.

h. Ignition Coils. Examine and test the coil to see that it is in good condition, clean, and securely mounted. Make certain there is no crack or burned patch in the insulator surrounding high-tension terminal. Replace coil if defective in any manner. Make certain that all high-tension wiring is in good condition. Insulation and connections must be clean and free of ice or moisture.

i. Magnetos and Booster Coils. Make certain that magnetos and booster coils are in good condition. Remove the breaker contact point inspection cover and make certain the points are clean and in good condition. Points must be well alined and gaps correctly adjusted.

j. Spark Plugs. Examine installed spark plugs to see that their insulators are in good condition and that there is no leakage around the insulators or gaskets. Remove the spark plugs and check for broken insulators, excessive carbon deposits, and electrodes that may be burned thin. Replace unserviceable plugs that are defective or which tests prove unsatisfactory. Use new gaskets when installing plugs. Spark plugs must be kept clean and free of ice or moisture.

k. Lights and Switches Operate the switches and note whether the lights respond properly. Note whether any lights remain on with the switches off. Check for dirty or broken lenses or discolored reflectors. Examine all connections; make certain they are clean and securely positioned. Adjust the aim of the lamp-unit beams according to specifications.

l. Turret Items.

(1) Traverse the turret through its full 360° range by operating both the manual and power traversing controls and observe whether there is any indication of binding

(2) Elevate and depress weapon through its entire range by operating both the manual and power elevating controls and observe whether there is any indication of binding.

(3) Check the power pack electric motor, and service it in a manner similar to that described for the starters and generators except for components not applicable to the unit (*d* and *e* above).

Section VIII. ENGINE LUBRICATION SYSTEM

48. Description

The function of a lubrication system in an internal-combustion engine is to supply a lubricant for the various bearing surfaces to prevent metal-to-metal contact, to provide a seal between the piston rings and cylinder walls to prevent "blow-by" of combustion gases, to cool the hot metal surfaces, and to clean the engine parts as it lubricates. The types of lubrication systems are: the "splash" system, the "full-pressure" system, or some combination of the two systems.

a. Splash System. The absolute splash lubrication system is no longer used because its lubricating effect is too uncertain to meet today's varied operating conditions. A modified splash lubrication system is often used that provides a uniform splashing effect even thought there may be variations in the amount of oil in the crankcase. In a modified splash system, a plunger-type pump is commonly used to force the oil from the crankcase to the various oil troughs into which the connecting rods or other moving parts dip, thus maintaining a constant level into which dippers can dip.

b. Full-Pressure System. In a full-pressure system (figs. 27–29), either a gear- or van-type pump is used to lift the oil from the crankcase and force it under pressure through the various lines and passages to all bearing surfaces.

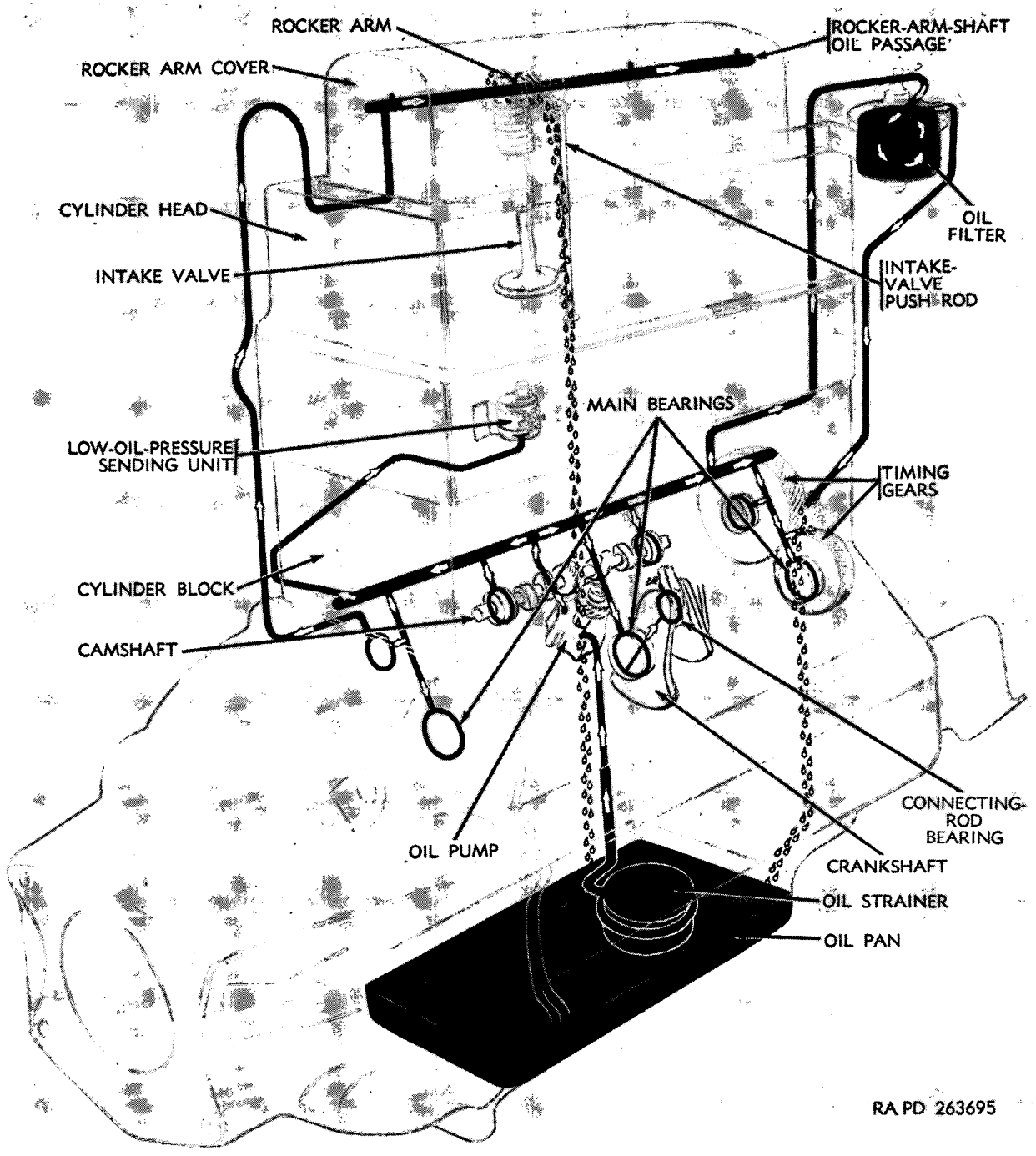


Figure 27. Engine lubrication system for ¼-ton 4x4 truck.

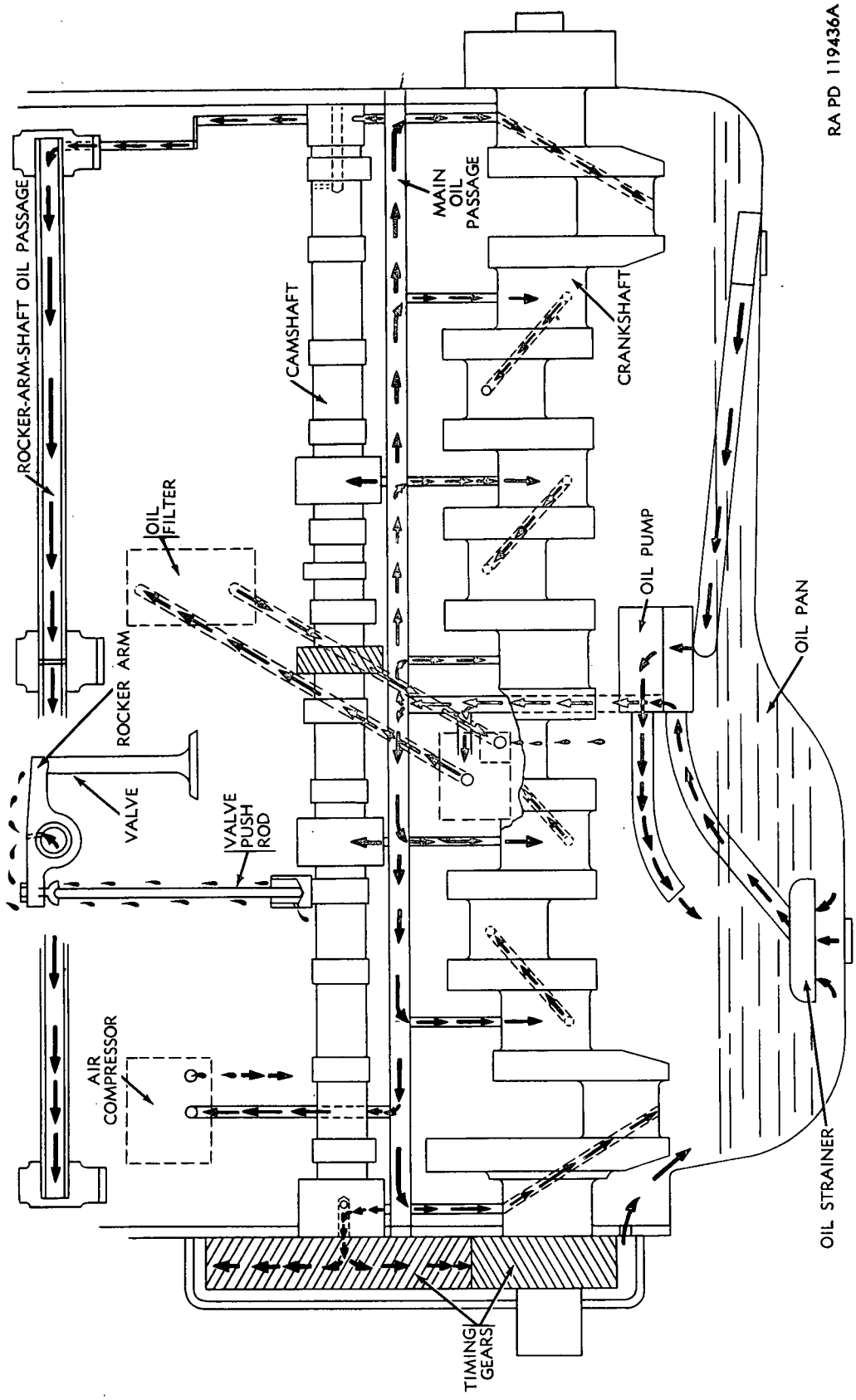


Figure 28. Engine lubrication system for 2½-ton 6x6 truck.

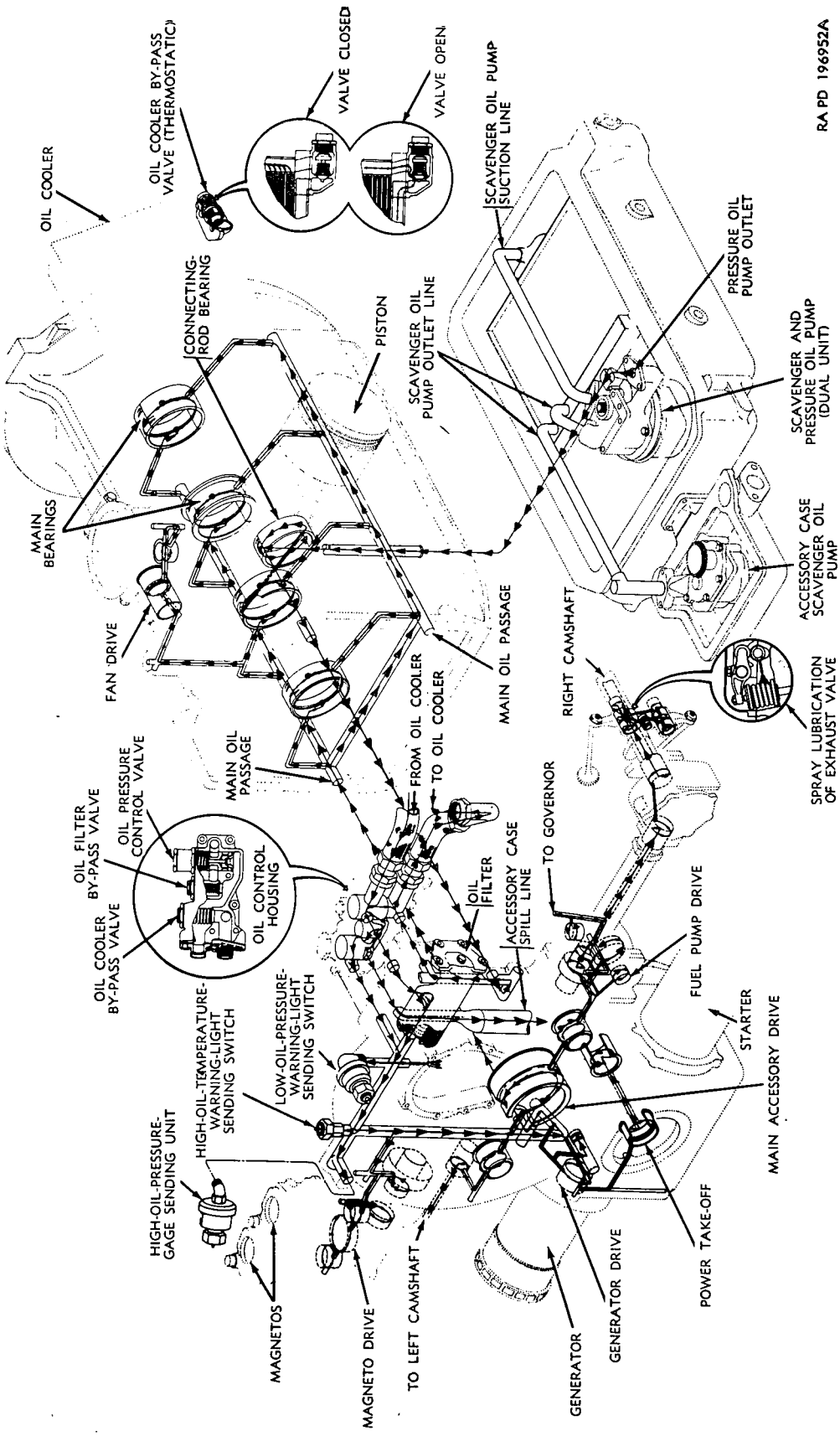


Figure 29. Engine lubrication system for armored infantry vehicle.

49. Effect of Extreme Cold on Lubrication System

a. Because it is a natural tendency of oil to thicken in cold weather, it is easy to see that in extremely cold weather oils will solidify. Oil does not freeze as hard as ice, but solidifies somewhat in the manner of cold butter. Obviously, oil in this state cannot be pumped. Eventually, the engine will warm up the congealed oil but, by that time, the damage caused by a lack of sufficient oil in the lubricating system may have already occured. Refer to paragraphs 7 through 10 for additional information on characteristics and selection of oils.

b. The increased viscosity of oil in cold weather will increase the fluid friction of the oil on the cylinder walls and bearings to the extent that it is not possible to crank the engine with the ordinary storage battery.

c. Since cold weather, in many cases, prevents the engine from reaching normal operating temperature, there will be an increase in engine sludge (fig. 30). Although engine sludge normally will not cause immediate failures, it will seriously affect the overall life and mechanical condition of an engine.

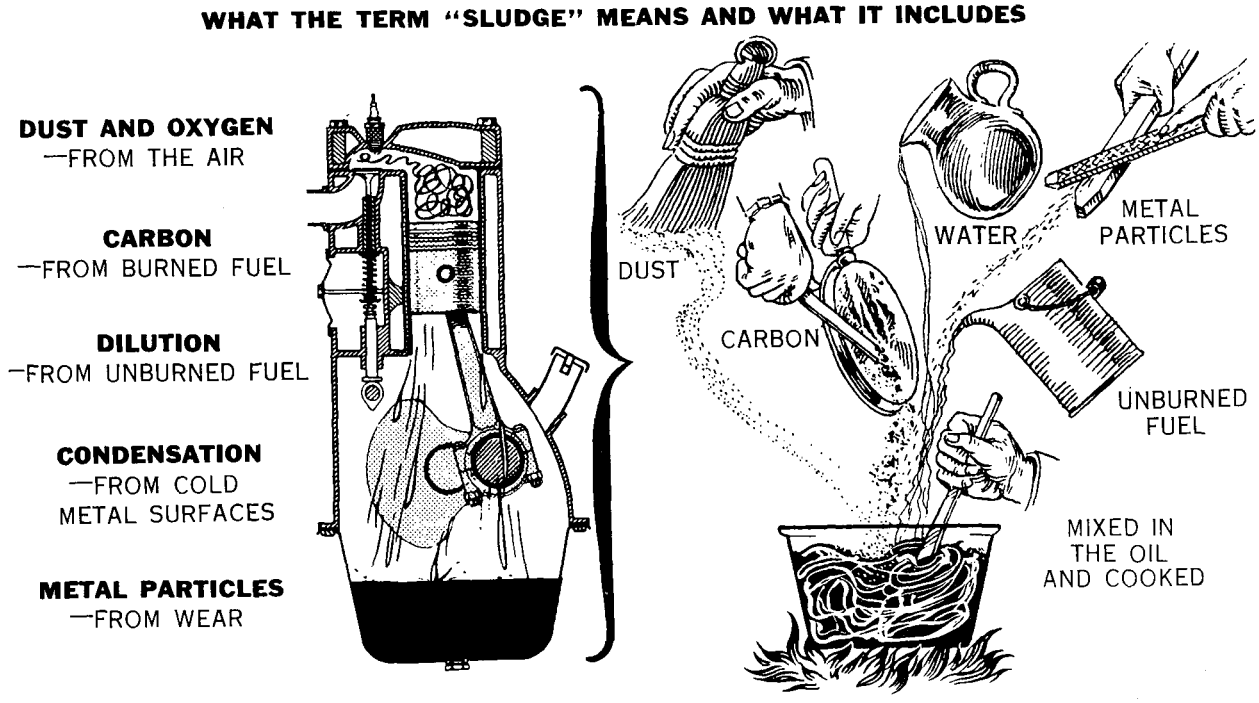


Figure 30. Formation of engine sludge.

50. Preparation for Operation in Extreme Cold

a. Unusual cold-weather problems in lubrication necessitates that only equipment in the best possible condition be selected for arctic operation. Particular attention should be given to the condition of the engines. Automotive materiel can be operated efficiently at low temperatures if the instructions contained herein are followed.

b. Equipment being prepared for future arctic operation must utilize arctic-type lubricants (pars. 7–10), even if considerable operation in warmer climates is involved prior to arctic operation. This will eliminate disassembly of components for lubrication when low

temperatures are encountered. Engine lubricated components are not included in this requirement, since these can be readily changed.

c. The following general procedures ((1)–(7) below) will govern the preparation of the lubrication system for extreme-cold operation.

(1) If possible, lubricating oils and grease should be stored in a warm place. They will be much easier to pour or apply if they are warm. Care should be taken to prevent snow or moisture from entering crankcase or hydraulic system when it is being filled. Only newly opened cans of hydraulic oils should be used. This will eliminate possibility of using contaminated oil.

(2) All lubricating equipment will be kept free of moisture, snow, ice, or dirt to avoid contamination.

(3) The presence of even a small quantity of warm-weather grease will "freeze" bearings and prevent operation of the materiel at subzero temperatures. All grease prescribed for warm-weather lubrication must be removed from bearings and gear cases and must be replaced with suitable low-temperature lubricants (table I) when subzero temperatures are expected. If necessary, materiel will be disassembled by technically qualified authorized personnel to accomplish this. Once grease has solidified, it cannot be removed from bearings or gear cases without applying heat to melt it or disassembling the unit and washing the parts with drycleaning solvent or mineral spirits paint thinner.

(4) Inspect the engine oil pan and gasket for indication of leaks; correct as necessary.

(5) Drain the engine lubrication system when warm. Replace the oil filter element if necessary. When the system is clean, fill with internal-combustion engine lubricating oil (OES) in the amount specified in the applicable operator's technical manual. Run engine for 10 minutes. Stop engine and check oil level. Make certain that oil is at proper level.

Note. Internal-combustion engine lubricating oil (OES) does not require a diluent. It should not only be used for initially filling crankcase to proper level but should also be used for replenishing the oil.

Caution: **Vehicle engines will not be idled for more than 15 minutes at a time. Other engines should be set at fast idle (1,000 rpm) if necessary to run without loads.**

(6) Install equipment furnished with the applicable winterization kit. Instructions pertaining to requisitioning and application of winterization kits are included in SB 9–16. Instructions for installation are furnished in the TB 9–2855-series and are also inclosed in the various winterization kits.

(7) Bypass the oil-cooler from lubrication system if vehicles are so equipped.

d. No change in instructions or materials will be made for the operation of the materiel when a temporary rise in temperature is encountered. Lubricant levels and lubrication points, however, will be closely observed and proper steps taken to replenish lubricants when required. Instructions in present lubrication orders will apply when a definite change to higher temperatures is not only anticipated but is expected to be of long duration, as in change of seasons.

51. Operation in Extreme Cold

a. Before Operations. Before a start is attempted, the engine oil must be checked for grade, quantity, and fluidity. Viscosity of the oil must be sufficiently low to permit cranking at a suitable speed without requiring excessive energy from the starting system. In temperature of —20° to —65° F., the use of the power plant heater to provide warmth to the battery, coolant, and other engine components is necessary if satisfactory starts are to be made.

Note. Existing arctic winterization kits contain equipment to apply standby heat to the oil pan. This equipment was developed before the engine lubricating oil (OES) was available and, by keeping the oil pan warm, fluidity of the oil preparatory to starting the engine was assured.

b. Starting.

(1) Start the engine after it has been determined that the engine oil is fluid

and that the fuel and electrical systems are prepared for engine starting.

Caution: **If there is a warning tag attached in the driver's compartment, follow instructions on the tag before attempting an engine start.**

(2) As soon as engine starts, check reading on the oil presure gages. If engine oil pressure is not indicated within a few seconds after starting, shut down engine and determine the cause. On those vehicles equipped with warning lights, stop engine and investigate the cause if engine-oil-low-pressure warning light does not go out within 30 seconds after engine has started.

c. During Operation.

(1) Engine oil consumption with the sub-zero grade will be higher during operation, and the oil level must be checked more freqnently to be certain it is at proper level. Make certain that adequate oil pressure is maintained. If pressure fails as indicated by gage or warning light, stop engine immediately. Engines showing unusually high oil consumption should be turned in for inspection.

(2) During operation, provisions must be made to prevent the extremely cold winds from coming into direct contact with the engine oil pan.

(3) Vehicles must be operated with minimum engine temperatures ranging from 160° to 180° F. to afford normal operation. Normal operating temperature can be maintained by proper adjustment of the air inlet shutters or covers and an efficient thermostat. A low engine operating temperature results in an excessive collection of sludge (fig. 30) in engine lubricating oil.

(4) The oil pressure gage and/or warning light must be observed frequently during operation because of the increased failures in extreme cold. Consult the applicable operator's technical manual for normal oil pressures. Report to maintenance personnel if normal operating oil pressure cannot be maintained.

Caution: **If oil pressure indicator drops exceptionally low or warning light comes on, shut off engine immediately and determine cause. Do not idle engine for periods exceeding 15 minutes.**

d. After Operation. After each operating period, the system must be carefully inspected and serviced. This operation must be made to insure optimum conditions for the next starting attempt.

(1) Inspect oil pan, valve covers, gaskets, and any external units of the lubrication system for leaks; correct deficiencies or report them to maintenance personnel.

(2) Check engine oil and fill to prescribed level.

Caution: **Consumption is higher when using engine lubricating oil (OES).**

52. Maintenance in Extreme Cold

a. When starting an engine in extreme cold, the mechanical efficiency of an engine depends largely upon the proper functioning of the lubrication system. Careful attention to preventive-maintenance service by the organizational mechanic is required to keep the system in the best working condition.

b. The two most common failures are low or no oil pressure in the system and the accumulation of sludge in the lubricating oil. They will be corrected as indicated in (1) and (2) below.

(1) *Low or no oil pressure.* Low or no oil pressure is normally caused by thickened oil. Remove oil level gage and check for quantity and viscosity of oil.

Note. Do not overlook the possibility that the oil pressure gage may be defective.

If the oil pressure gage is found to be working accurately and the oil is up to the full mark, the failure is probably in the pump or lines.

(2) *Accumulation of engine sludge in oil.* Drain and thoroughly flush the lubrication system with engine oil. Repeat flushing until cleaner material indicates system has been thoroughly cleaned. Remove and thoroughly clean oil pan and oil-pump strainer. Install

a new gasket. Install oil filter element. Fill crankcase with engine lubricating oil (OES).

c. Inspect oil pan, valve cover, timing-gear cover and gaskets, and external oil lines for indication of oil leak; correct as necessary.

Section IX. POWER TRAIN

53. Function

The function of the power train (figs. 31–33) is to transmit engine power to the driving wheels or sprockets of vehicles and to component accessories such as winches, hydraulic pumps (for hydraulically operated steering units, hoists, and/or winches), and/or oil cooler fans.

54. Effect of Extreme Cold on Power Train Units

a. Extreme-cold weather will stiffen and solidify the regular-grade lubricants in gear cases and bearings throughout the power train. An attempt to operate the vehicle when this condition exists will result in serious failures.

b. Clutch facings often fail in extreme-cold weather operations due to the added drag in the power train caused by stiffened and congealed lubricants.

55. Preparation for Operation in Extreme Cold

The procedures in *a* through *f* below, will be followed to prepare the power train for extreme-cold weather operation.

Note. When authorized, partial disassembly is performed to clean parts; complete disassembly will be avoided unless absolutely necessary.

a. Power Train. Power train units must be thoroughly cleaned before application of arctic lubricants (table II). Disassembly is necessary to clean lubricants from units such as track suspension units and bearings. Carefully inspect all units for indication of leaks; replace gaskets and seals as necessary.

Caution: **Make certain that seals are new and properly installed.**

(1) Remove old lubricants from clutch linkages and lubricate with automotive and artillery grease (GAA, amend. 2).

(2) Clean the clutch-release-bearing sliding sleeve with mineral spirits paint thinner or drycleaning solvent; do not lubricate. Sliding surfaces are to remain clean and dry.

(3) Clutch throwout bearings need not be relubricated. Allow existing lubricant, prescribed by lubrication order, to remain on parts.

c. Universal and Slip Joints. Thoroughly lubricate joints with automotive and artillery grease (GAA, amend. 2).

d. Conventional-Type Transmission, Transfer Case, Differential, and Other Gear Cases. Thoroughly drain and lubricate these items with gear lubricating oil (GOS).

Note. When engine oil (SAE 10 or OE 10) is prescribed for gear cases, drain and fill with lubricating oil (OES).

e. Hydramatic, Torqmatic, and Cross Drive Transmissions. Drain and fill these items with engine lubricating oil (subzero) (OES).

f. Torque Converter. Drain and fill converter with hydraulic fluid (OHA) wherever hydraulic fluid is specified and lubricating oil (OES) wherever lubricating oil (SAE 10 or OE 10) is specified.

56. Operation in Extreme Cold

a. Starting.

(1) *Conventional-type transmission.* Depress clutch pedal while starting engine with gear shift in neutral. After engine is running smoothly, release clutch cautiously and maintain engine at idle for 2 minutes or longer to warm up lubricant in transmission.

Note. If vehicle is equipped with a transfer with a selector lever, transfer lubricant may be heated in the same manner by placing selector lever in neutral and transmission in low gear.

(2) *Hydramatic, torqmatic, or cross drive transmission.* Place transmission shift lever and transfer shift lever (where applicable) in neutral for starting and warming up the engine.

b. Idling. Adjust the hand throttle to an engine speed specified in operator's technical manual until the engine is running smoothly and engage engine clutch (where applicable) to allow gear case lubricants to warm up. With transfer case levers remaining in "out" position to prevent movement of the vehicle, depress clutch and operate transmission gear shift lever until lever moves freely.

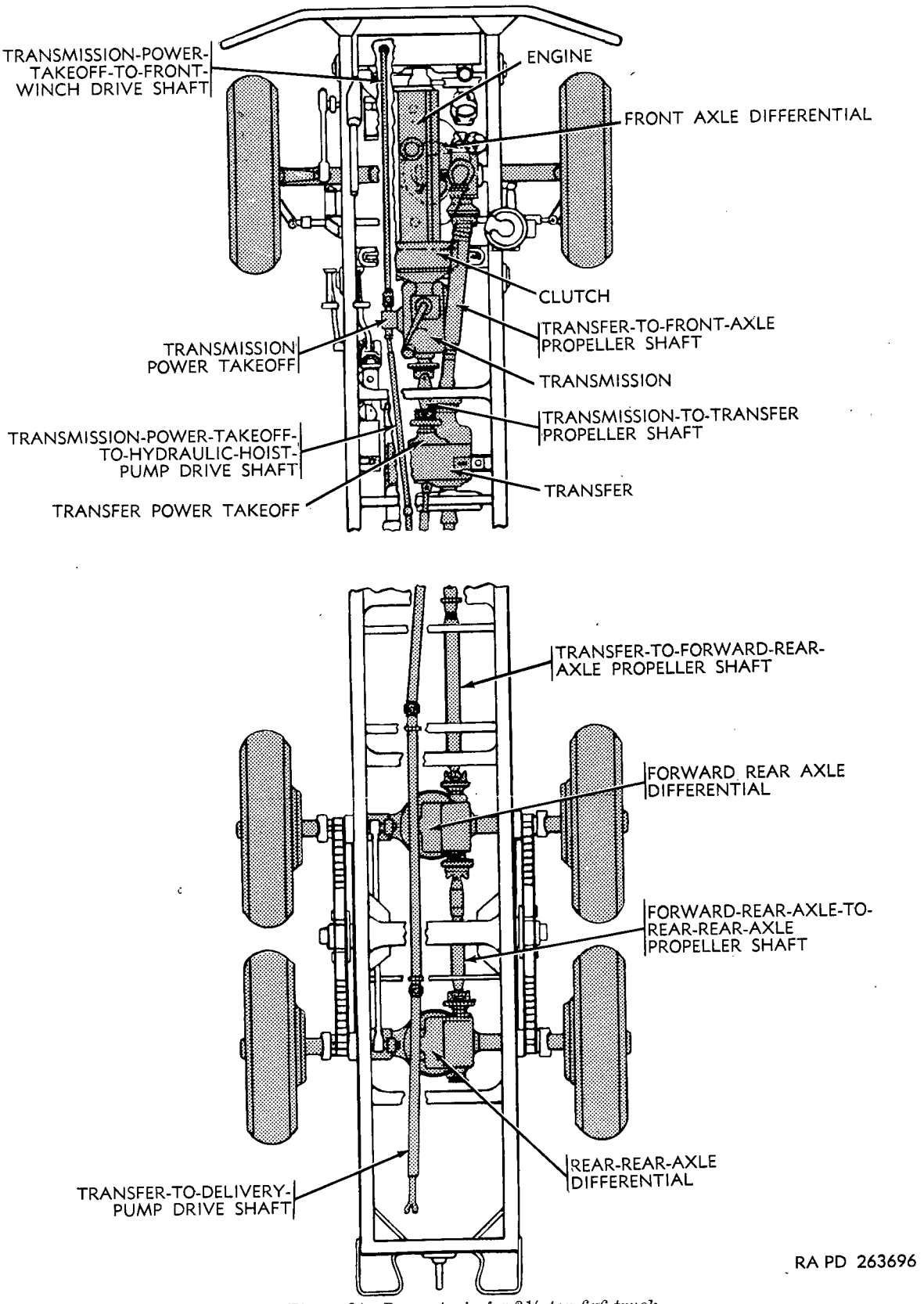
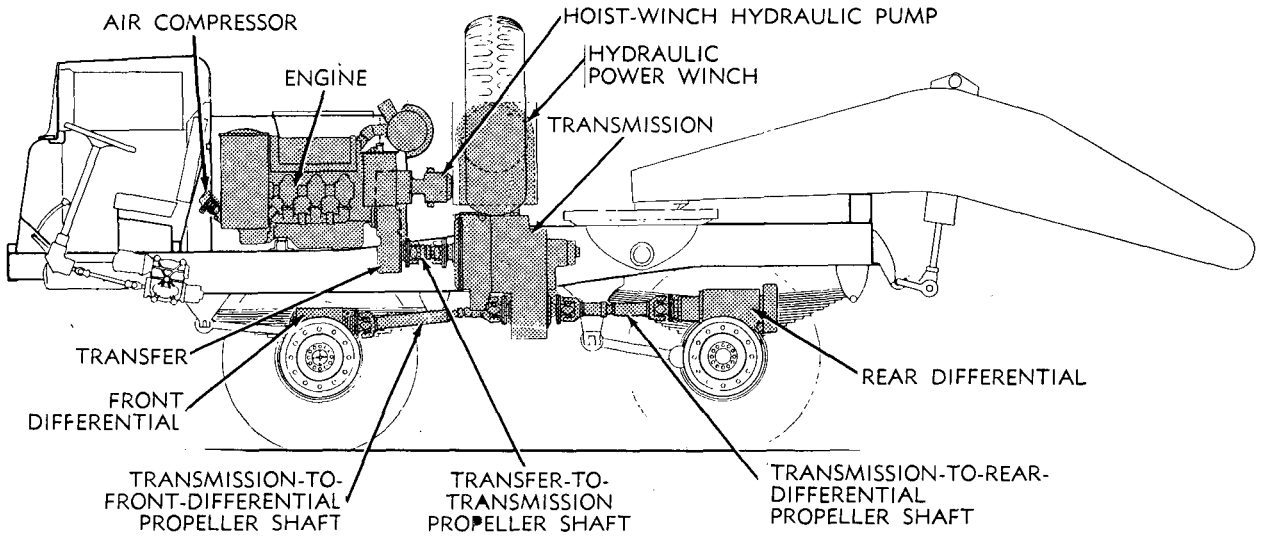
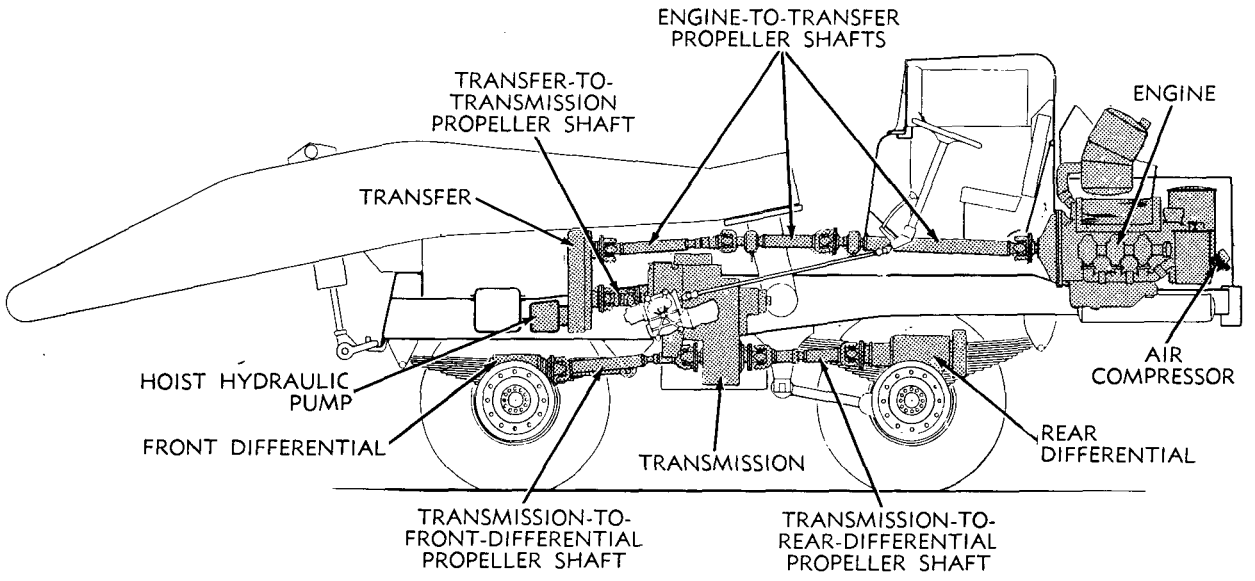


Figure 31. Power train for 2½-ton 6x6 truck.



FRONT TRUCK



REAR TRUCK

RA PD 263697

Figure 32. Power train for heavy gun-lifting trucks.

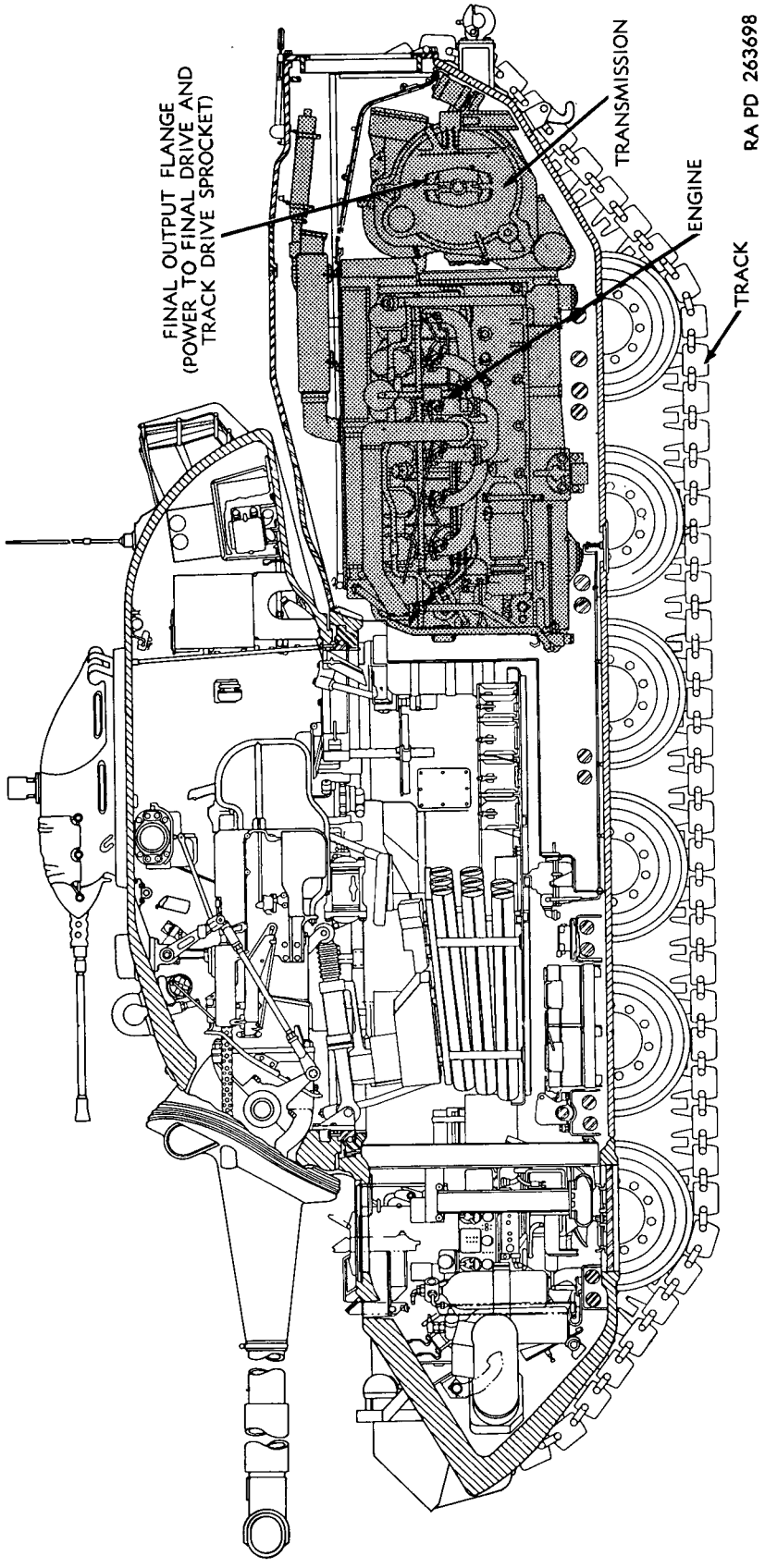


Figure 33. Power train for 90-mm gun combat tank.

c. During Operation. The driver must be extremely careful when placing the vehicle in motion to be certain that gear case lubricants or wheel bearing greases are not congealed. An attempt to operate with this condition will destroy parts in the power train, e.g., the clutch facings or gear teeth. It may be necessary to apply heat to the power train before operation can be successfully undertaken. When placing vehicle in motion, place transmission in low gear and transfer unit (where applicable) in low range. Drive vehicle 100 yards, being careful not to stall the engine.

d. After Operation. When preparing a vehicle for a shutdown period, place transmission and transfer shift levers in the neutral position. This will place these units in readiness for the next start by preventing them from freezing in an engaged position.

57. Maintenance in Extreme Cold

a. Gear Cases. Inspect gear cases for leaks and replace gaskets or seals as necessary. Check operation of shifting controls or levers. Tighten all mounting bolts or screws to torque tightness specified in applicable technical manual. Check the lubricant level in the various gear cases and, where required, add the proper grade of lubricant as indicated in (1) through (3) below and table II.

(1) *Conventional-type transmission, transfer case, differential, and other gear cases.* Check for quantity and proper lubricant; replenish with gear lubricating oil (GOS).

Note. When engine oil (SAE 10 or OE 10) is prescribed for gear cases, replace with lubricating oil (OES).

(2) *Hydramatic, torqmatic, or cross drive transmissions.* Check for quantity and proper lubricant; replenish with lubricating oil (OES).

(3) *Torque converters.* Check for quantity and proper lubricant; replace with hydraulic fluid (OHA) wherever hydraulic fluid is specified and lubrication oil (OES) wherever lubricating oil (SAE 10 or OE 10) is specified.

b. Clutch. Follow instructions given in paragraph 55*b*.

c. Universal and Slip Joints. Lubricate universal and slip joints with automotive and artillery grease (GAA, amend. 2).

Section X. AUXILIARY EQUIPMENT

58. General

Auxiliary equipment supplements standard components of a vehicle and aids in its operation It also provides for extra or special functions. The auxiliary equipment (*a* through *d* below) is discussed in paragraphs 59 through 62.

a. Air compressors.
b. Auxiliary engines and generators.
c. Power takeoff assemblies.
d. Winches

59. Air Compressors

a. Description. An air compressor is an engine-driven device used to compress air to predetermined and controlled pressures for use in air-brake and air-hydraulic brake systems (figs. 34 and 35) on vehicles so equipped.

b. Effect of Extreme Cold on Air Compressors.

(1) Unless adequately protected with antifreeze compound, the coolant in liquid-cooled air compressors (fig. 36) will freeze at temperatures of +32° F. and below.

Note. Liquid-cooled compressors are connected to the vehicle engine cooling system for their coolant supply.

(2) Moisture from condensation may freeze within the compressor. Follow daily maintenance procedure by drawing water out of air compressor tank.

(3) Lubricating oil normally prescribed for use in a temperate climate will congeal and cause bearing failures and scored pistons and cylinder walls.

(4) With improper lubricant, the crankshaft bearings will be difficult to rotate and the drive coupling may become damaged in addition to unnecessary stress placed on the crankshaft.

c. Preparation for Extreme-Cold Operation.

(1) Make certain that the two crankshaft bearings do not contain an improper lubricant that will congeal at subzero

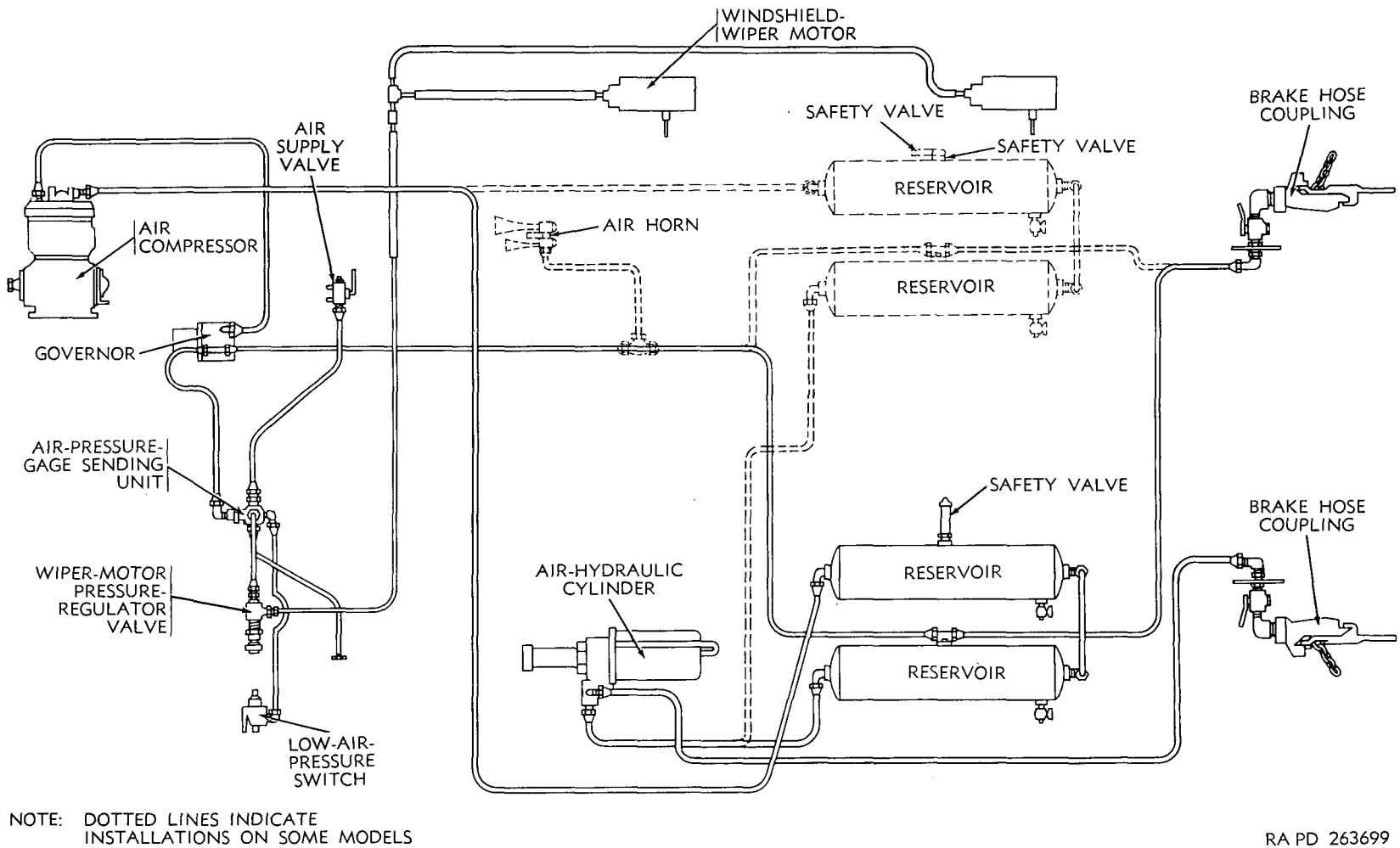


Figure 34. Air-brake system for 2½-ton 6x6 trucks.

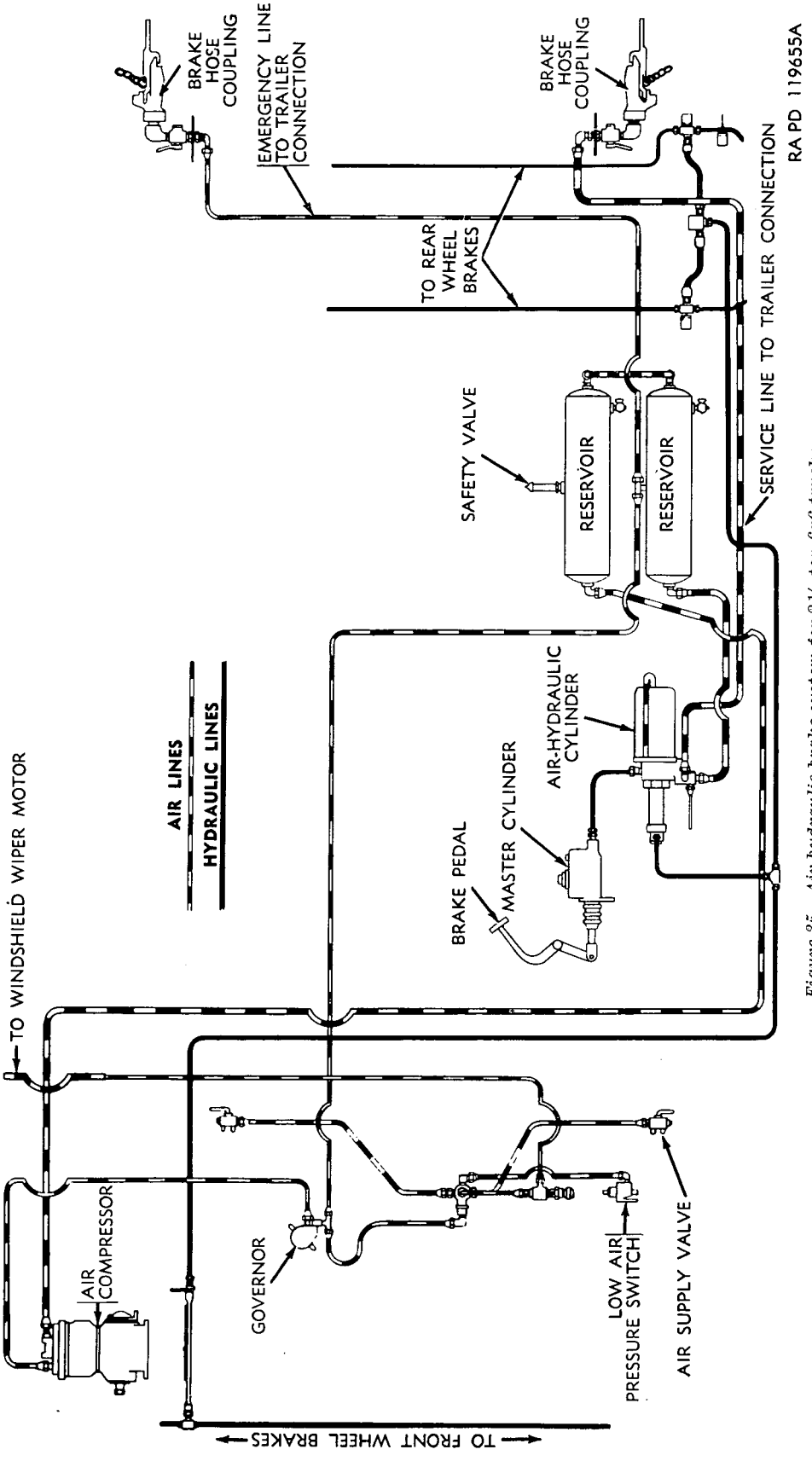


Figure 35. Air-hydraulic brake system for 2½-ton 6x6 trucks.

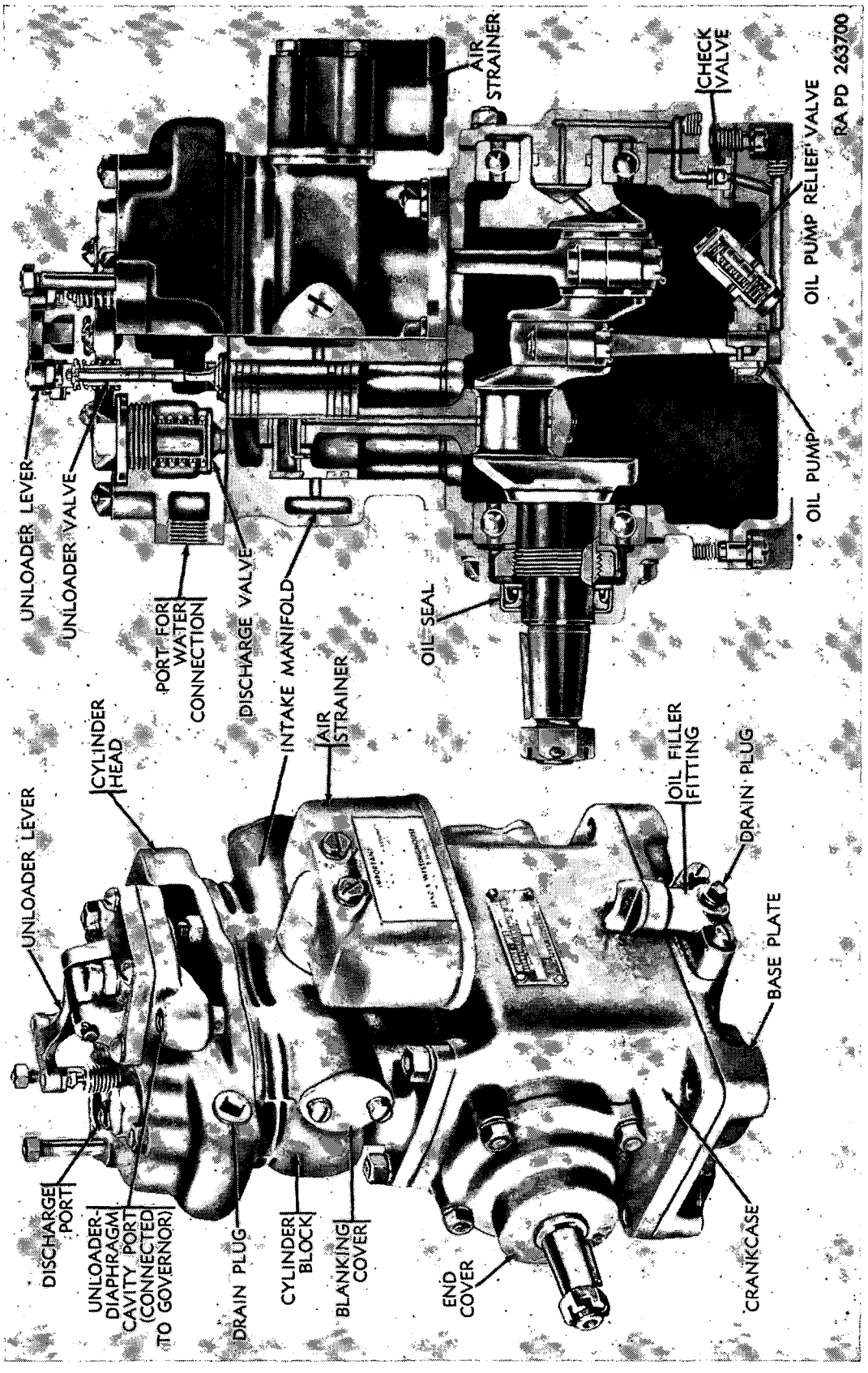


Figure 36. Two-cylinder self-lubricating liquid-cooled air compressor.

temperatures. If any doubt exists, wash and clean bearings in drycleaning solvent or mineral spirits paint thinner, dry them, and immediately lubricate them with general-purpose lubricating oil (PL, special). This will protect bearings while compressor is being assembled. Replace ball bearings while compressor is being assembled. Replace ball bearings (sealed), unless lubricated with aircraft and instrument grease (GL), with ball bearings (sealed or unsealed) lubricated with a correct low-temperature grease. If correctly lubricated sealed bearing replacements are not available, the bearings will be warmed with air heaters (slave kit heaters) before attempting to start compressors in extreme cold. Install new oil-seal and end-cover gaskets whenever compressors are assembled.

(2) Air compressors either have their own lubricating system (self-lubricated) (fig. 36) or are lubricated from the engine lubrication system (fig. 37).

(*a*) No further preparation is necessary for the engine-lubricated air-cooled compressor (fig. 37), provided the engine crankcase has been filled with lubricating oil (OES).

(*b*) The crankcase of the self-lubricated air compressor (fig. 36) must be drained, flushed, and filled to the proper level with subzero engine lubricating oil (OES).

(3) Disassemble air strainer, wash and clean strainers, install curled hair, and assemble.

Note. If oil-bath-type cleaner is used on compressor crankcase, drain the oil, and clean crankcase in dry-cleaning solvent or mineral spirits paint thinner and fill with lubricating oil (OES).

(4) The cooling system of liquid-cooled air compressors is connected to the cooling system of the vehicle engine. Drain, flush, and clean the compressor cooling system and inspect for leaks. Check all connections for good condition. Tighten cylinder-head bolts to correct torque-tightness specified in the pertinent vehicle technical manual. Connect compressor to engine cooling system. The engine coolant system must be adequately protected with antifreeze compound as instructed in paragraph 31. Inspect compressor for any leaks.

(5) If vehicle is equipped with an alcohol evaporator, fill jar with alcohol.

d. Operation in Extreme Cold. The air compressor requires no further attention for extreme-cold operation, except to note whether compressor is maintaining required pressure and there are no coolant or oil leaks or excessive noise.

a. Maintenance in Extreme Cold.

(1) Examine air compressor to see that it is in good condition, properly alined with its drive pulleys, and securely mounted.

(2) Make certain that all water, oil, and air lines within the engine compartment are in good condition and securely fastened and that there are no leaks.

(3) Check oil in self-lubricated air compressors to determine proper condition.

60. Auxiliary Engines and Generators

a. Description. The auxiliary engine and generator (fig. 38) is operated when batteries are being charged, when auxiliary electrical equipment is being used while the main engine is not running, or when the current furnished by the main engine is inadequate for the imposed load.

b. Effect of Extreme Cold on Auxiliary Engines and Generators. The auxiliary engine-generator unit is affected in a manner similar to the main engine and its generator (pars. 24–52).

Note. Some auxiliary engines are air cooled and contain no coolant.

c. Preparation for Extreme-Cold Operation. Prepare the auxiliary engine, generator, spark plugs, and magneto in a manner similar to the main engine and pertinent components (pars. 24–52). Two-cycle auxiliary engines are lubricated by engine oil mixed in the fuel. Add 1 pint of engine lubricating oil (OES) to 1 gallon of gasoline and mix thoroughly before pouring into the fuel tank. Thorough mixing of the oil and gasoline is essential to prevent fouling of

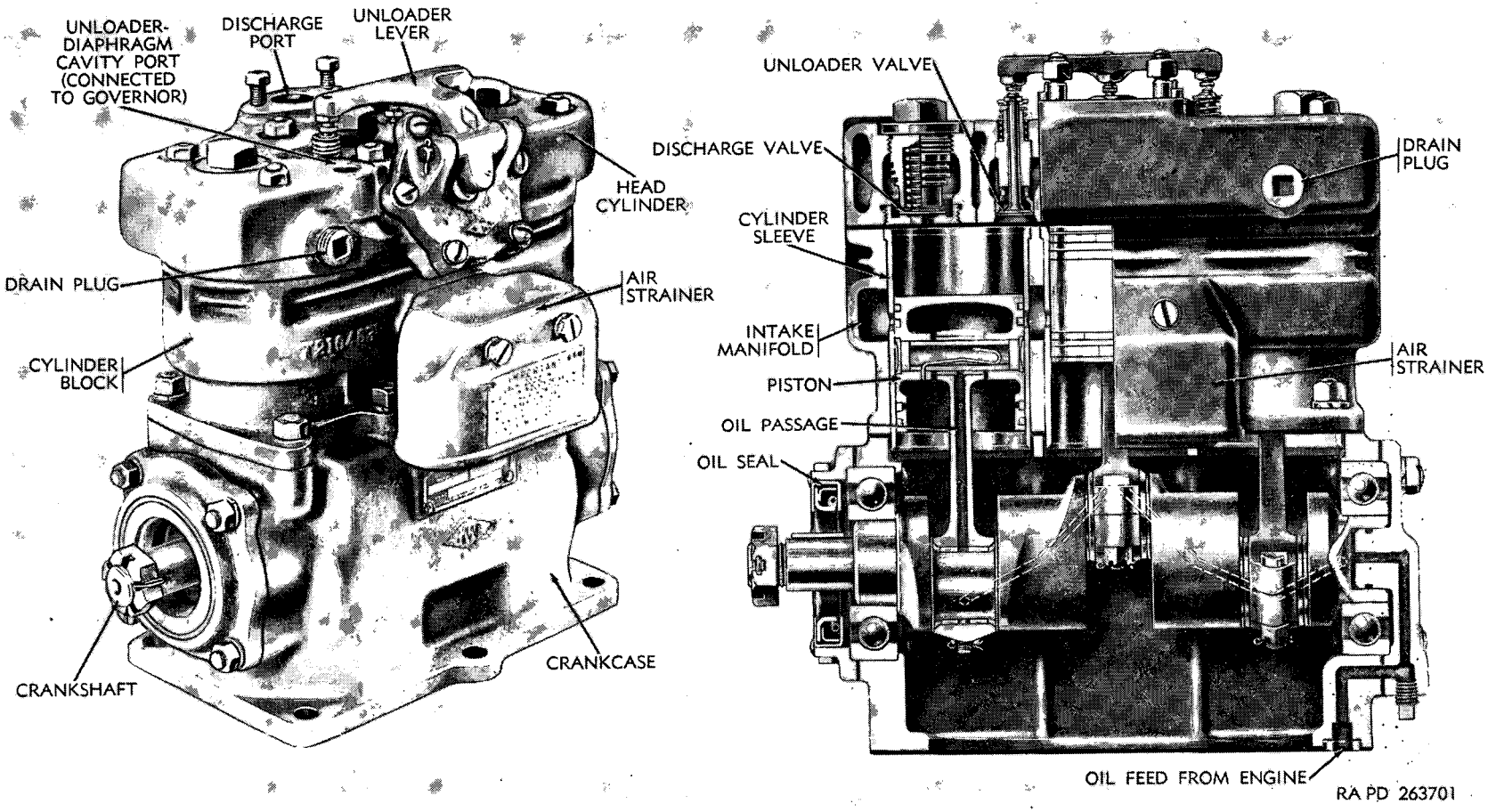


Figure 37. Three-cylinder engine-lubricated air-cooled air compressor.

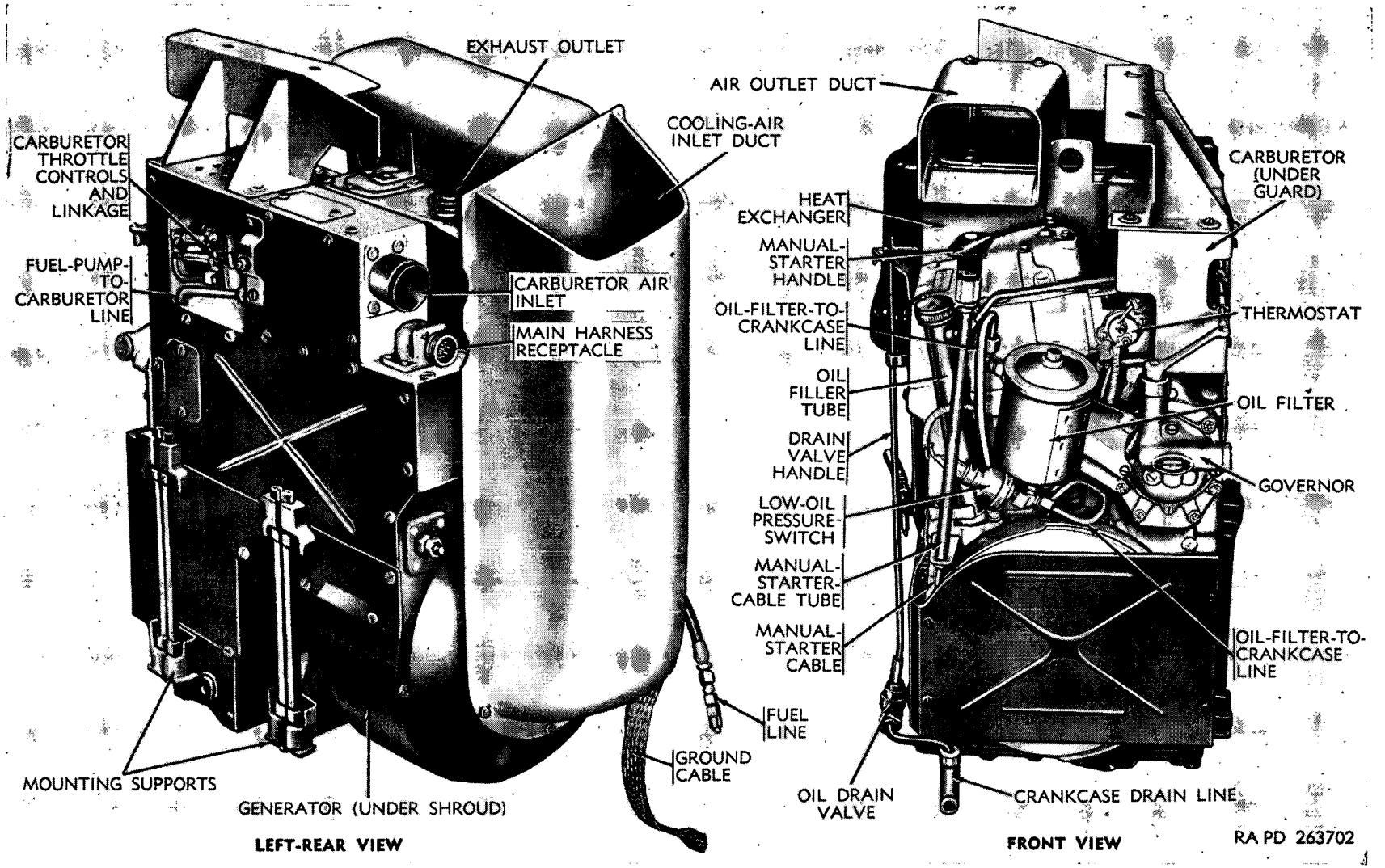


Figure 38. Auxiliary engine and generator for 90-mm gun combat tank.

the spark plugs and to assure proper lubrication of the engine.

d. Operation in Extreme Cold.

(1) If necessary, the auxiliary engine may be started with the manual starting system. Refer to operator's technical manual for manual starting instructions. This method should be used only when there is insufficient current or no exterior power source to start the engine electrically. In all other cases, use batteries or outside power source for starting. Remove and recharge batteries when necessary.

(2) Refer to operator's technical manual for electrical starting instructions.

(3) The auxiliary engine and generator should be kept in operation when any of the conditions listed in (*a*) through (*e*) below, exist.

(*a*) Turret electrical units, such as the traversing or stabilizing mechanism, are being used.

(*b*) When it is necessary to provide heat for the main engine compartment as an aid in extreme-cold weather starting.

(*c*) When batteries are to be brought up to a fully charged condition.

(*d*) When extensive use of radio communications is necessary.

(*e*) When auxiliary electrical equipment is to be used while the main engine is not being used.

e. Maintenance in Extreme Cold.

(1) Make certain that the engine crankcase, fan, housing, cylinder shield, mountings, exhaust manifold, and heater are secure and in good condition. Note whether oil is up to proper level and not leaking. On an engine having the oil supply in the crankcase, note whether the heater duct is clean.

(2) If engine is liquid-cooled, check cooling system for leaks and sufficient coolant.

(3) Remove each spark plug and clean in accordance with TM 9–8638 and adjust gap to that recommended by the applicable manual. Test plugs and if satisfactory, install, using new gaskets. If plug is unsatisfactory, replace with new plug, adjusting gap to recommended setting. Use spark plugs of proper ignition rating.

(4) See that the magneto, points, and wiring are in good condition and securely mounted. Make certain the interior of the magneto and rotor arm is clean and in good condition and that the breaker points are clean and properly adjusted.

(5) Check carburetor and air cleaner for good condition. Look for indications of fuel leaks. If oil-bath-type air cleaner is used, fill with lubricating oil (OES) after cleaning and washing. Carburetor must be properly adjusted for extreme-cold operation with satisfactory choke operation. Clean the fuel-filter sediment bowl and screen.

(6) See that generator is in good condition. Brushes must be clean and not excessively worn. Check for proper brush-spring tension. Clean commutator by placing a strip of flint abrasive paper (grade 2/0) over a wooden block of the correct size and, with engine running slowly, press flint paper against the commutator until it is clean. Blow out with compressed air.

(7) Inspect control box, ammeter, buttons, and wiring to see that they are in good condition and correctly and securely connected.

61. Power Takeoff Assemblies

a. Description. Power takeoff assemblies are usually mounted on the side of the transmission (fig. 39) and sometimes on the side of the transfer (fig. 40). They provide a means for taking power from the engine to operate a chain-driven winch, a hydraulic pump (for hydraulically operated winch, dump mechanism, or gasoline delivery to tank), or other various auxiliary power-driven machinery (earth-boring machine and crane).

b. Effect of Extreme Cold on Power Takeoff Assemblies. Improper lubricants will solidify, making operation of power takeoff difficult or impossible.

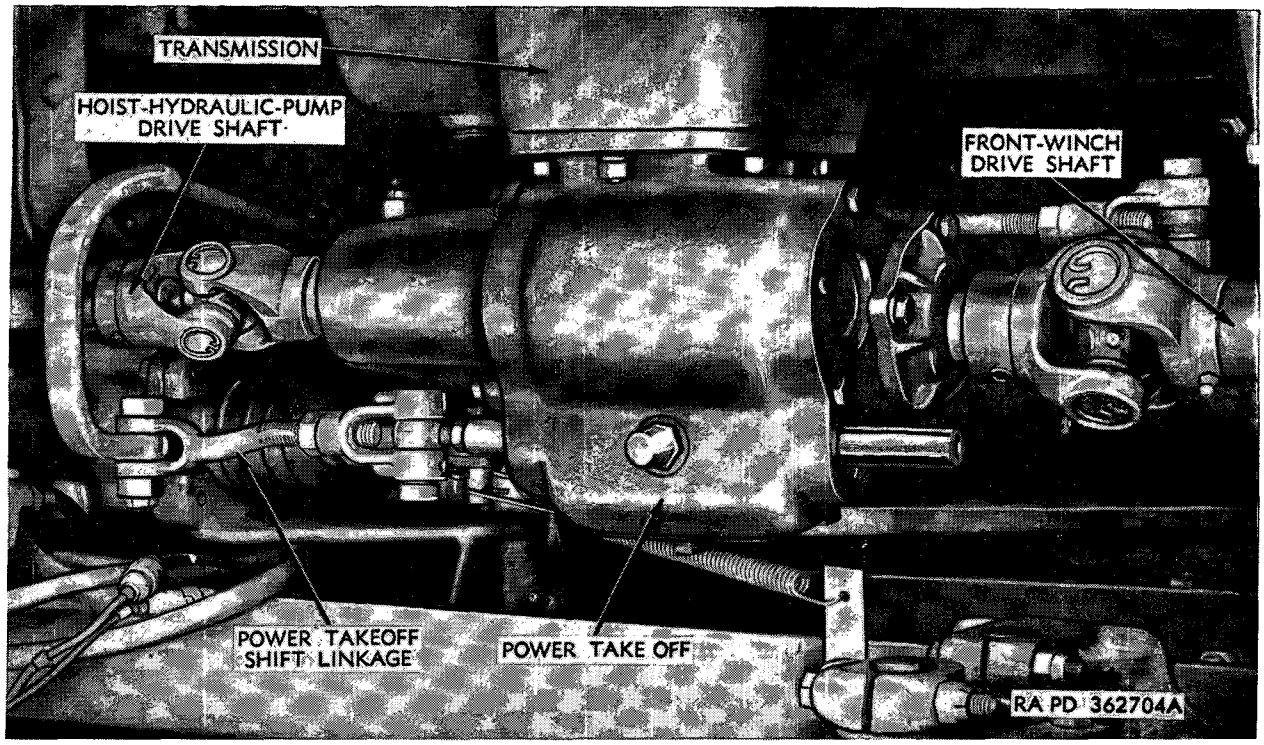


Figure 39. Transmission power takeoff for 2½-ton 6x6 truck.

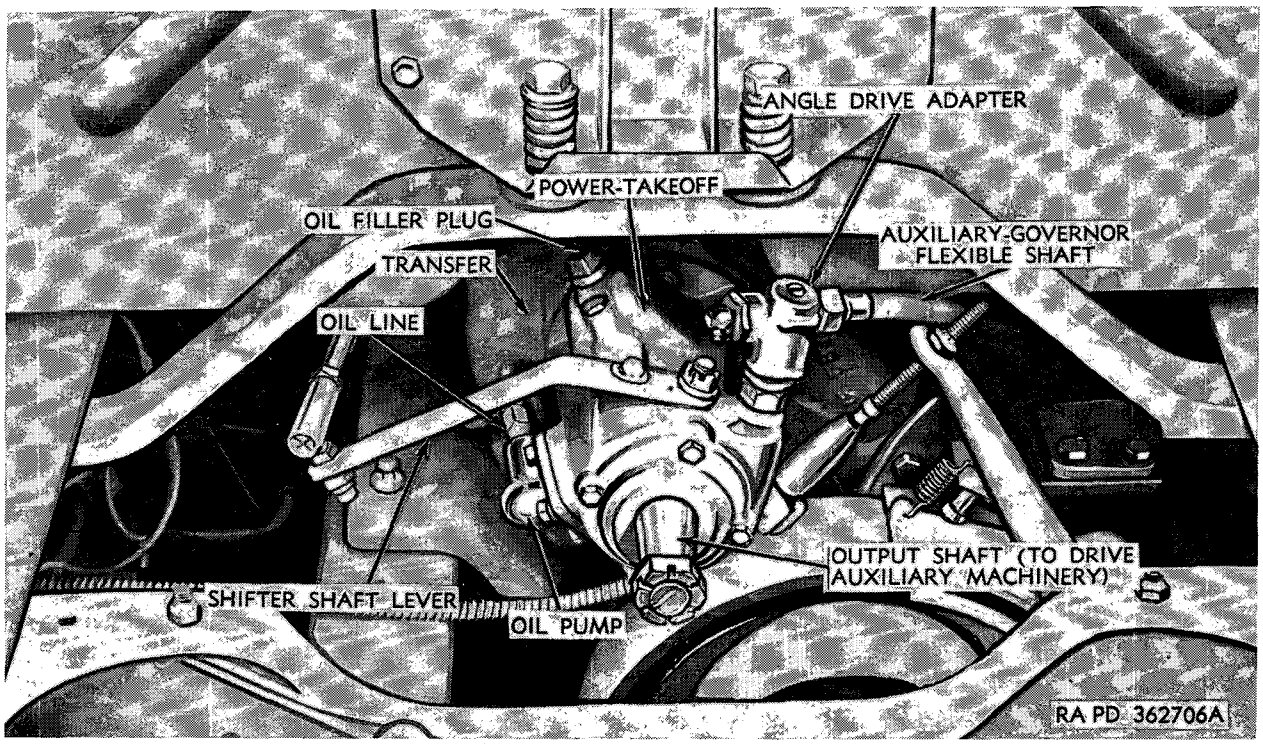


Figure 40. Transfer power takeoff for 2½-ton 6x6 truck.

c. Preparation for Extreme-Cold Operation. As the power takeoff operates from the transmission or transfer, the lubricant will be that specified for subzero temperatures for these units (table II). Drain the gear cases while warm and fill with prescribed grade of gear lubricant.

d. Operation and Maintenance in Extreme Cold. See that the power takeoff and control linkage are in good condition and securely mounted, and that the seals do not leak. Make certain that proper subzero lubricant is used and that it is at the proper level. See that the transmission and/or breather and ventilation openings and lines are clear. Tighten all mounting bolts, power takeoff assembly screws, and bolts, to torque tightness specified in pertinent technical manual.

62. Winches

a. Description.

(1) *Front winch.* A front winch (fig. 41) is usually mounted at the front of the vehicle on support brackets attached to frame side members and is driven by a drive shaft connected to a transmission power takeoff (fig. 39).

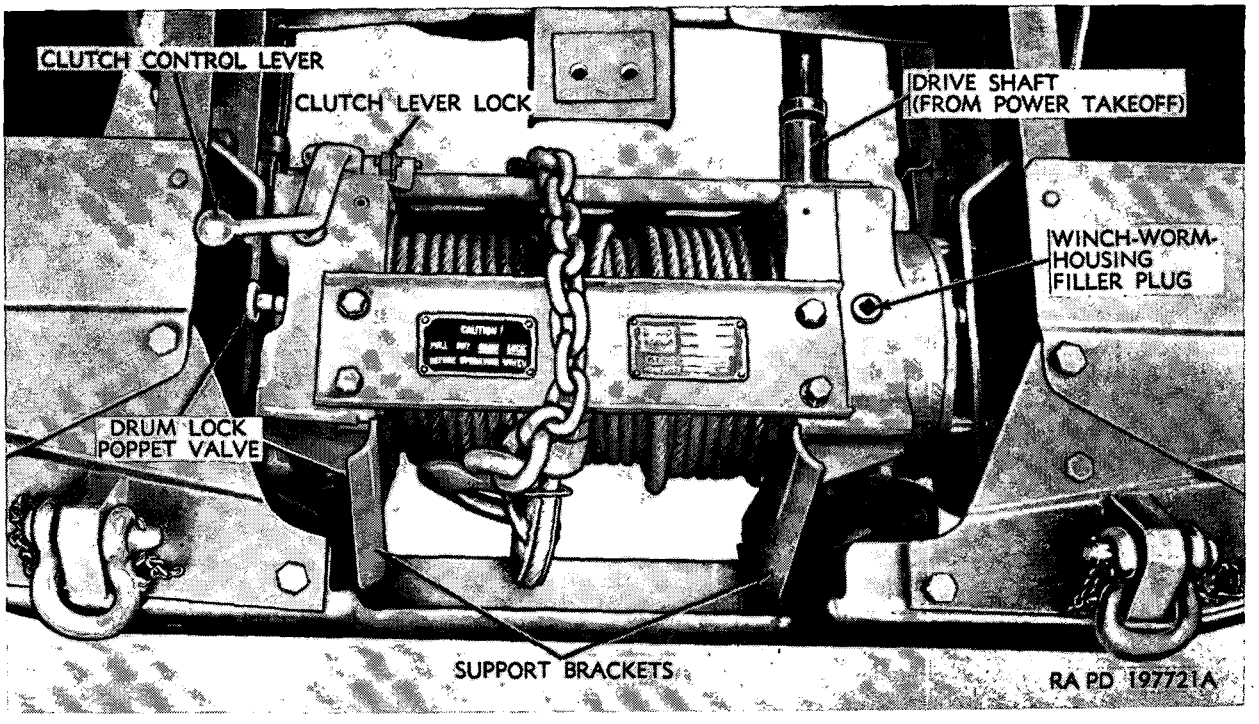


Figure 41. Front winch for 2 ½-ton 6x6 truck.

(2) *Rear winch.* A rear winch (fig. 42) is usually mounted behind the vehicle cab and is chain-driven from a pillow block assembly, which, in turn, is driven by a drive shaft from the transfer, power takeoff output shaft (fig. 40).

(3) *Hydraulically operated winch.* A hydraulically operated winch (fig. 43) is located in a position to enable winching operations to be performed from either the front or rear of the vehicle. Hydraulic pressure to operate the winch is supplied by a hydraulic pump driven by the transfer.

b. Effect of Extreme Cold on Winch.

(1) Improper lubricants will solidify, making operation difficult or impossible.

(2) Since the ability of metals to withstand shock loads becomes less as the temperature drops, breakage of cables and winch components will result if extreme care is not exercised.

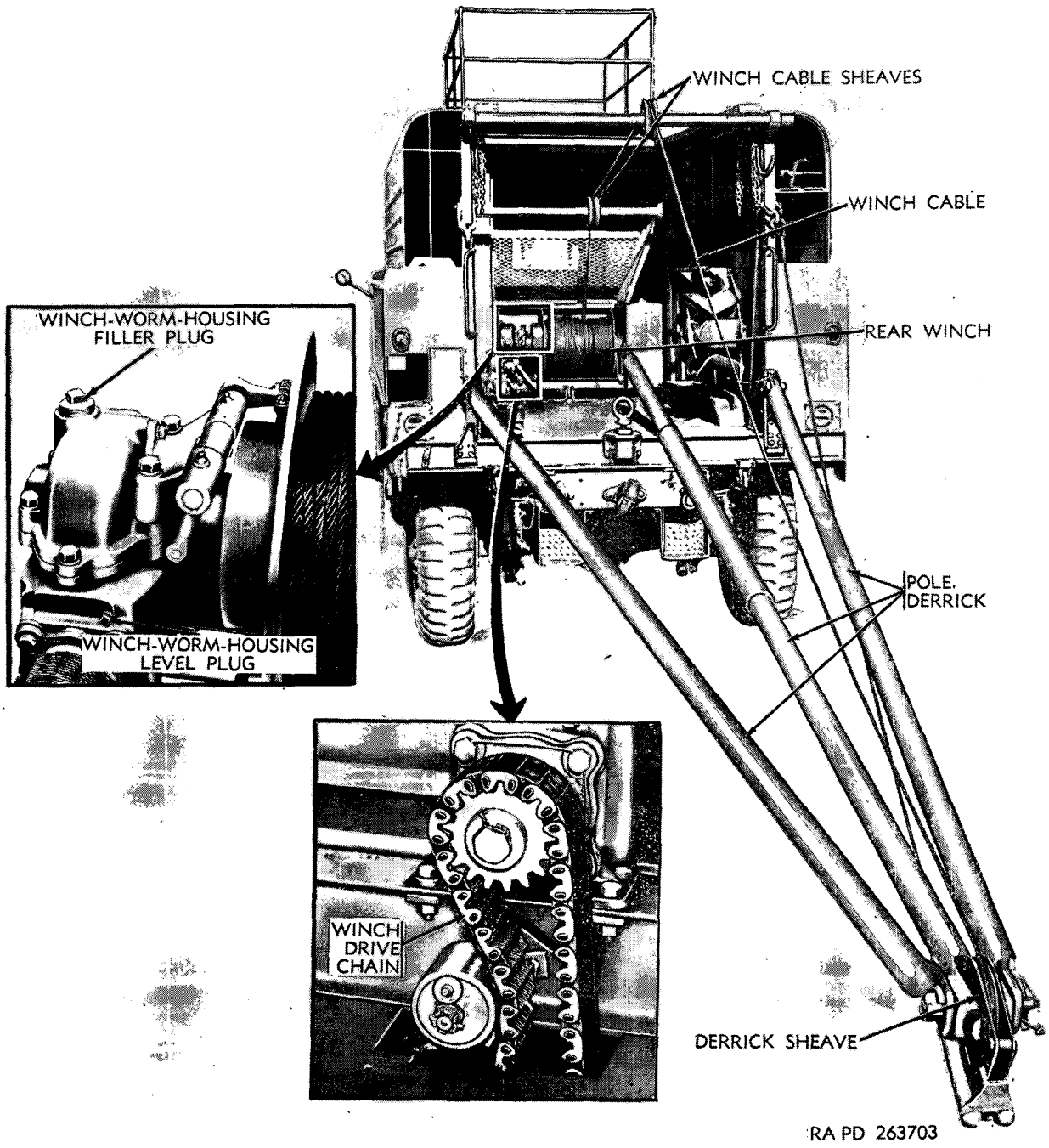


Figure 42. Rear winch for 2 ½-ton 6x6 truck.

c. Preparation for Extreme-Cold Operation. Remove mud, dirt, and rust from exterior of winch. Inspect cable for rust and apply lubricating oil (PL, special). Flush and clean worm housing (fig. 41) and fill to level with universal gear lubricant (GOS). Inspect safety brake for satisfactory operation. Check drum brake and adjust if necessary. On hydraulically operated winches, flush and clean reservoir and fill to level with lubricating oil (OES). Also, check for iced bleed and selector valves, controls and linkage, and winch cable sheaves. Where a winch cover has been furnished, make sure it is correctly in place to prevent ice from forming on parts of winch.

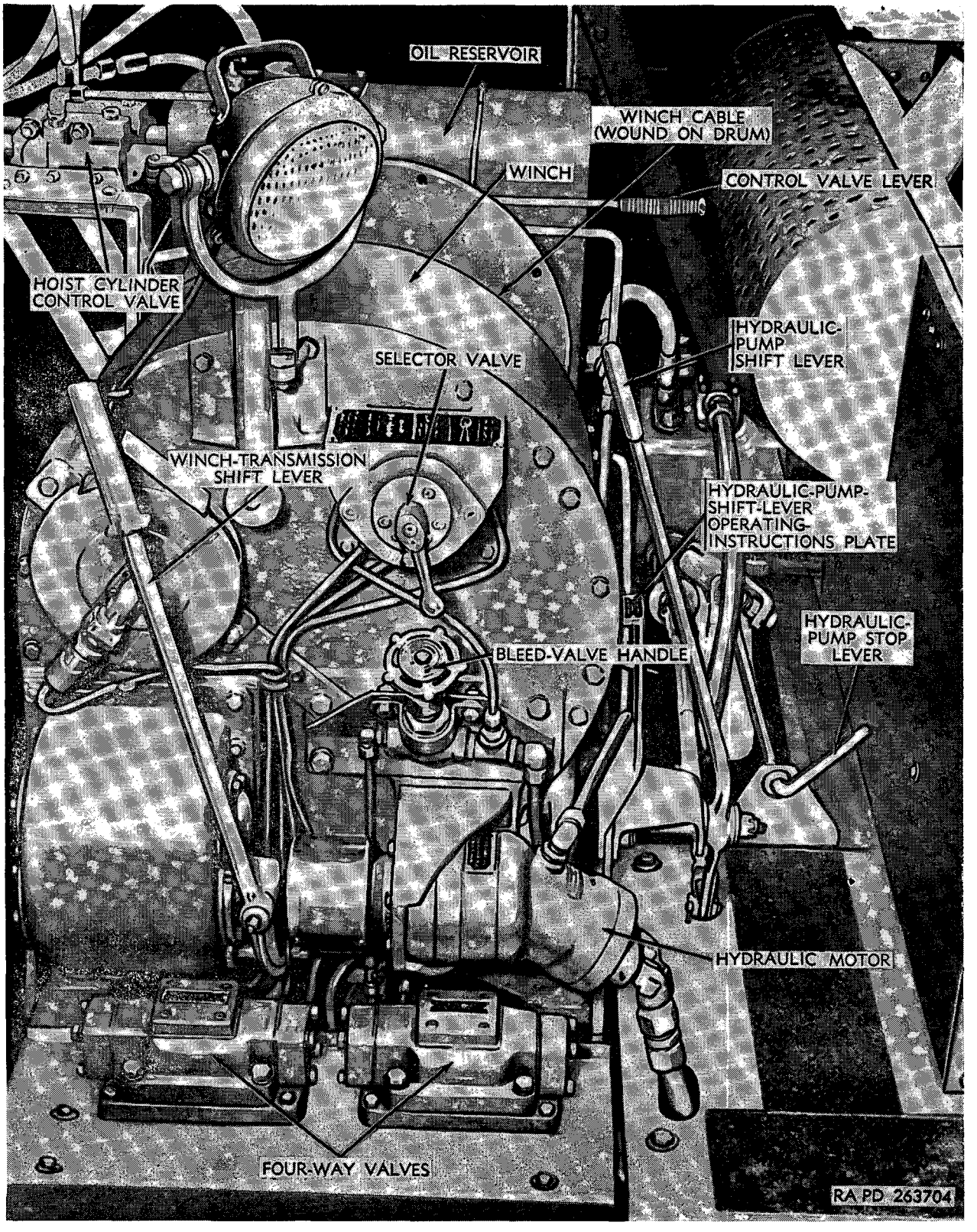


Figure 43. Hydraulically operated winch for heavy gun-lifting truck.

d. Operation in Extreme Cold.

(1) Operate vehicle engine at a reasonable speed in accordance with operator's manual; high engine speeds are likely to damage the winch mechanism.

(2) Read all caution plates and estimate a 25-percent reduction in capacity when determining load.

Example. If capacity of winch is specified as 5,000 pounds on "Winch Caution Plate," lower the rated capacity for cold-weather operation by 25 percent, making capacity 3,750 pounds. This safety factor is essential to prevent damage to winch.

(3) To reverse winch operation with engine running at idling speed, depress the vehicle clutch pedal and move winch control lever to the unwind position. Slowly release the vehicle clutch pedal.

e. Maintenance in Extreme Cold.

(1) See that winch is in good condition, correctly assembled, and securely mounted. Test clutch for free movement in both engaged and disengaged positions, and see that it latches securely.

(2) Inspect automatic brake for proper and satisfactory operation.

(3) Check drive shaft and see that the proper shear pin has been installed. The drive shaft front yoke should slide freely on the worm shaft in order to take full advantage of the safety feature of the shear pin.

(4) If winch is chain driven, inspect chain and sprockets for good condition and proper adjustment.

(5) See if winch cable is in good condition. Note whether it has broken or frayed strands and flat or rusty spots. Clean and oil cable in accordance with instructions in *c* above.

(6) If winch is hydraulically operated, inspect all valves, controls, and linkage for good condition. Check level and grade of fluid in reservoir; replenish as necessary, using lubricating oil (OES).

Section XI. CHASSIS AND BODY COMPONENTS

63. Description

The component parts that will be covered in this section are wheel bearings, brakes, shock absorbers, steering gear, tracks and track suspension wheels, tires, springs, and cab inclosures.

64. Effect of Extreme Cold on Chassis and Body Components

a. Wheel Bearings (fig. 44). Wheel bearings will fail to rotate in subzero temperatures unless the proper lubricant is used.

b. Hydraulic Brakes (fig. 45). An improper fluid in hydraulic brake systems becomes insensitive in extreme cold. Excessive pedal pressure is required to apply the brakes and difficulty is experienced in releasing the brakes once they are applied. Brake lines leak and burst because of crystallization of the rubber and the abnormal pressure required to operate the brakes. Wheel cylinders (figs. 44 and 45) become inoperative because of leaks in rubber-type end covers. Metal-type covers and their adjusting screws freeze and rust. Brakes freeze and bind or lock when vehicle is parked.

c. Air Brakes (fig. 46). Frozen moisture in the air brake system will seriously affect operations. Brake lines, brake chambers, push rods, and seals are subject to defects and failure in extreme cold.

d. Shock Absorbers (figs. 47 and 49). Shock absorber fluid congeals in subzero temperatures, resulting in breakage of the shock absorber arms and links.

e. Steering Gear (fig. 48). Improper lubricant will congeal making steering difficult or impossible. Hydraulic steering gears are subject to the same difficulties experienced with hydraulic brake system (*b* above).

f. Track Suspension Wheels (fig. 49). Improper bearing lubricant stiffens and extra power is required to obtain motion.

g. Tracks (fig. 49). Ice and snow adhere to tracks, hindering satisfactory operation. Extreme cold contracts metals and makes rubber brittle A track that is tight in a warm shelter will break easily after being in temperatures of —40° F. and below.

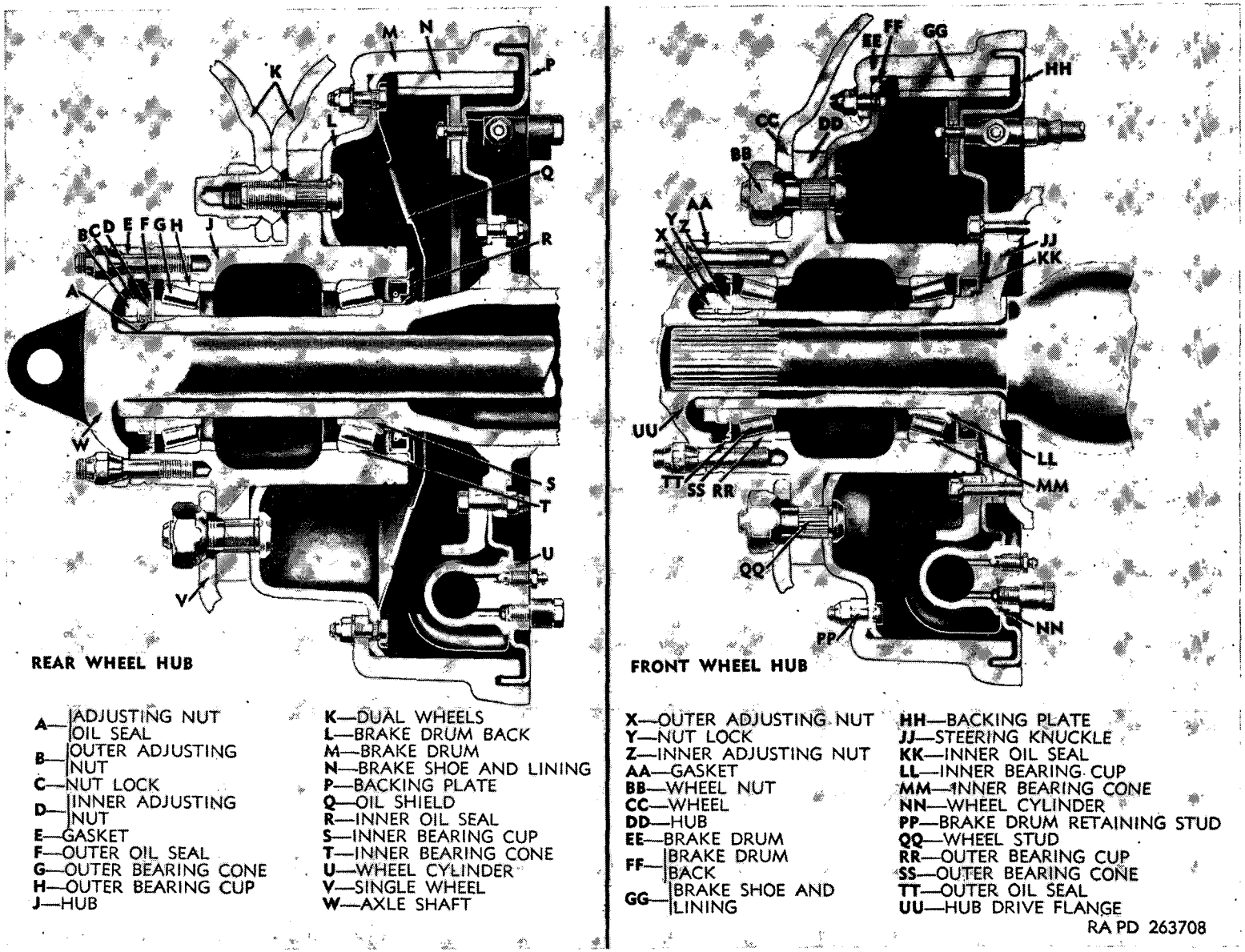


Figure 44. Hubs, bearings, and oil seals for 2½-ton 6x6 truck.

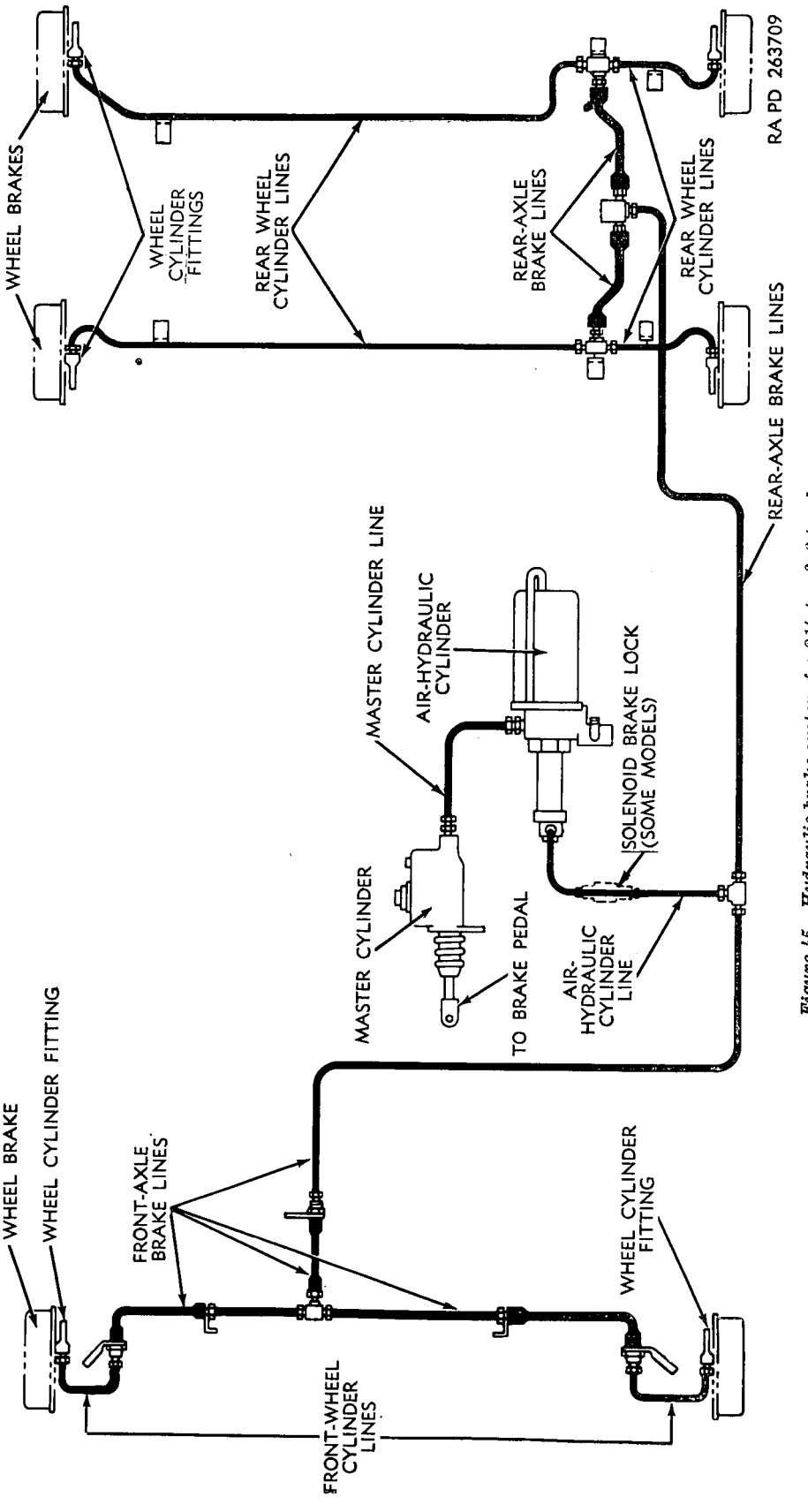


Figure 45. Hydraulic brake system for 2½-ton 6x6 truck.

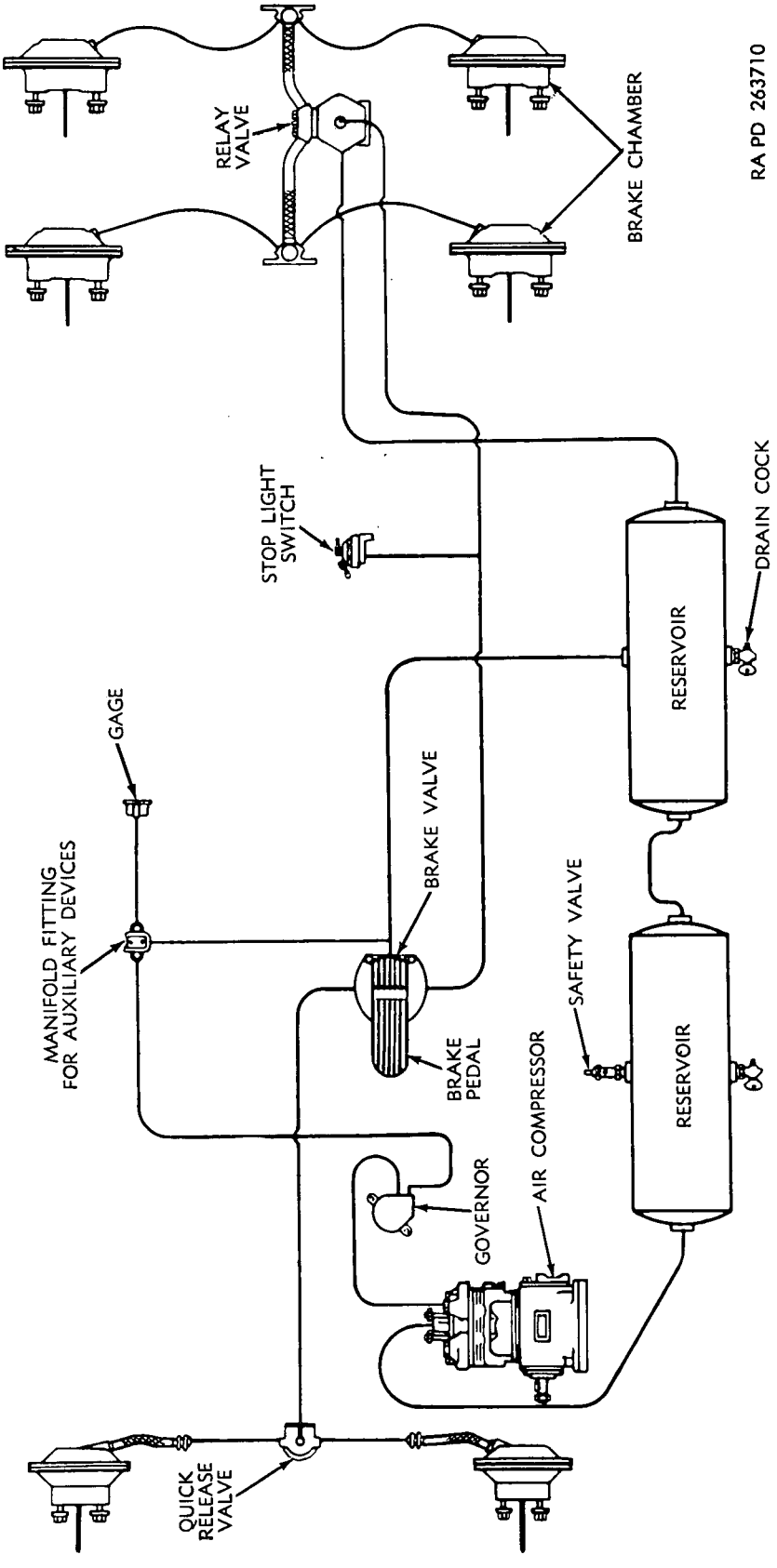


Figure 46. Air brake system for 2½-ton 6x6 truck.

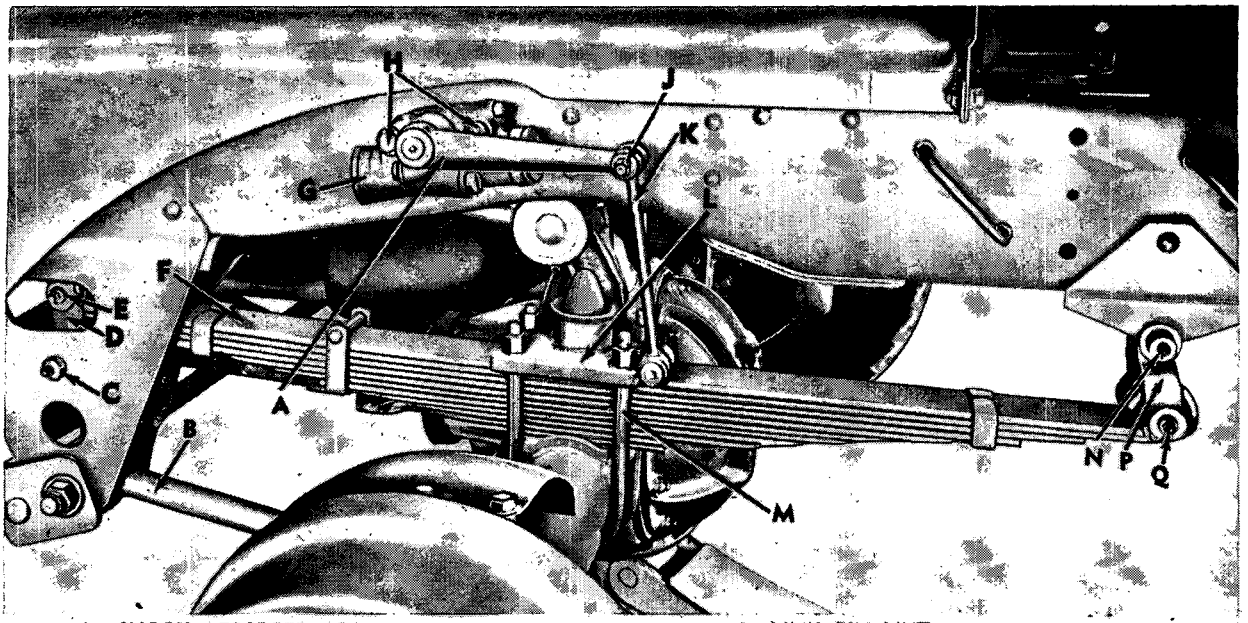


Figure 47. Front spring and shock absorbers for 2½-ton 6x6 truck.

h. Tires. At —50° F., tires become rigid enough to support a load at 0 pressure without apparent deflection Moisture in valve cores freezes and causes loss of air pressure in tubes. Side walls become brittle and crack. Tires flatten and become rigid where contact with ground is made during shutdown periods. Brass valve stems become brittle and break.

i. Springs (fig. 47). Springs break easily, as metal becomes extremely brittle at low temperatures.

j. Cab Inclosures. Unless personnel are protected against subzero temperatures and wind by adequate clothing and cab inclosures, operation may be hampered or stopped.

65. Preparation for Operation in Extreme Cold

a. Wheel Bearings (fig. 44). Inspect bearings for looseness and proper adjustment. Remove, clean, and wash bearings thoroughly in drycleaning solvent or mineral spirits paint thinner; dry; then lubricate with automotive and artillery grease (GAA, amend. 2). Inspect inner and outer oil seals for good condition and replace as required. If in doubt, install new seals.

Note. To clean and wash properly before lubricating, wheel bearings must be disassembled.

b. Hydraulic Brakes (fig. 45). Drain brake fluid and flush system with denatured alcohol (grade III) (table I).

Caution: **Do not use flushing fluids containing mineral oil, kerosene, gasoline, carbon tetrachloride, or similar fluids.**

Repeat flushing process, using clean brake fluid to remove the flushing alcohol from the system. Fill the brake system, including reservoir, with nonpetroleum-base hydraulic fluid (HBA). Check brake lines, brake shoes, master cylinder, and wheel cylinders. Brake shoes and wheel cylinder mechanism must be kept as dry as possible.

Caution: **Make certain that rubber-type end covers are not deteriorated.**

Metal covers and their adjusting screws must be free of rust and moisture. Observe if wheel cylinders are leaking; if so, correct. Make certain that all component parts of the brake system operate satisfactorily.

c. Air Brakes (fig. 46). Drain compressed air reservoir of accumulated water. Make certain that alcohol evaporator kit, if part of system, is

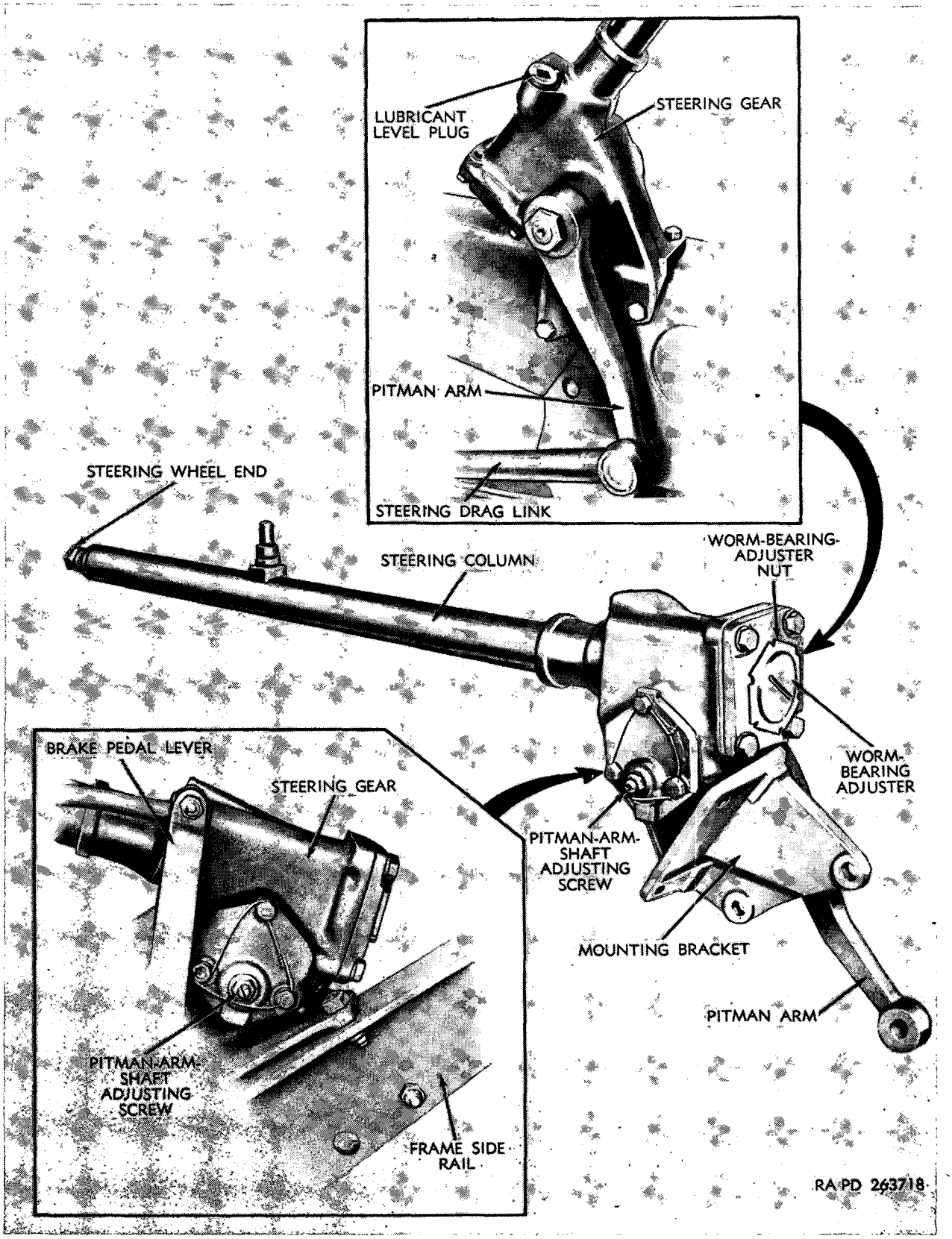


Figure 48. Steering gear for 2 ½-ton 6x6 truck.

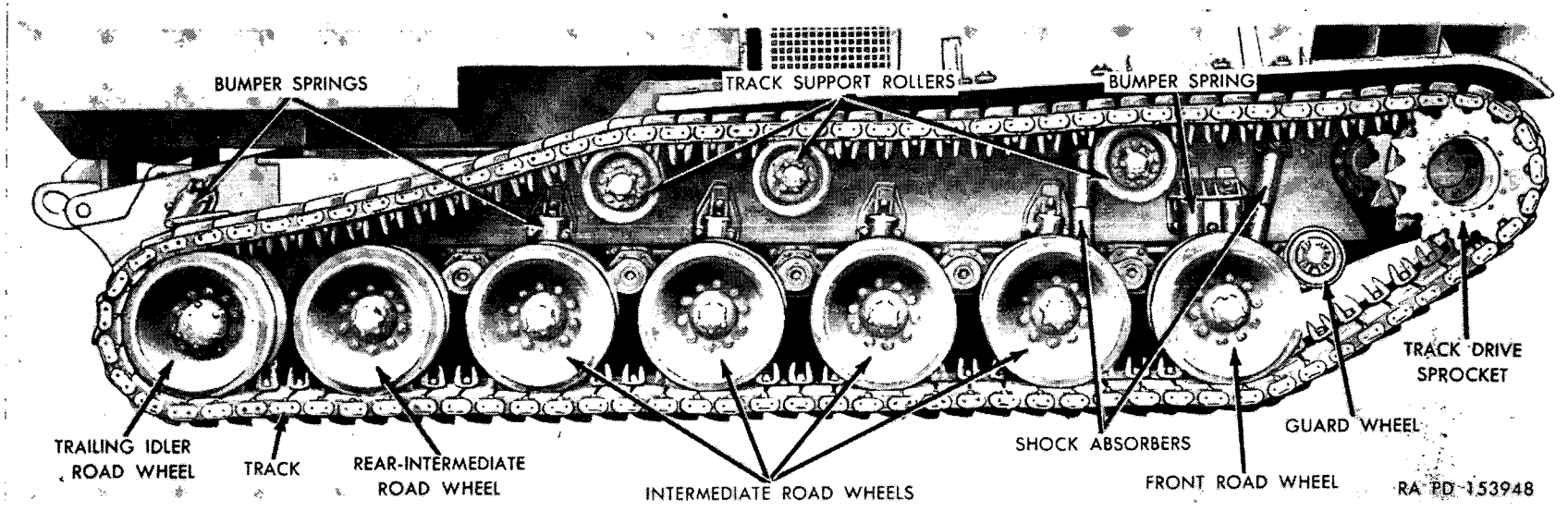


Figure 49. Suspension system for self-propelled howitzer.

functioning Check brake lines, brake chambers, relay valves, push rods, seals, and slack adjusters. Check air compressor, unloader valve, and governor for good condition and satisfactory operation. With the air pressure at the governed maximum and the breaks applied, stop the engine. There should not be a noticeable drop in pressure within 1 minute.

d. Hydrovac System. Locate air cleaner and listen closely for sound of air movement while the brake pedal is being operated. The engine should be running so that this test may be repeated several times. Also, apply this test with engine stopped, as a check for leaks in the vacuum system. If no air rush can be noticed, it is an indication that the system is inoperative. Lubricate air chamber with petroleum-base hydraulic fluid (OHC).

e. Shock Absorbers (figs. 47 and 49). Drain and fill all shock absorbers, except the Houdaille-type, with petroleum-base hydraulic fluid (OHC).

Note. Houdaille shock absorbers must be disconnected and tied up out of the way.

See that shock absorber bodies are properly secured to frame, that links which connect their arms to the axle are in good condition, and that there are no fluid leaks.

f. Steering Gear (fig. 48). Inspect steering gear for lost motion or binding Make certain steering column and steering wheel are in good condition and secured. Drain, flush, and fill gear housing with gear lubricating oil (GOS). Disassemble steering gear joints, clean thoroughly, and lubricate with automotive and artillery grease (GAA, amend. 2).

g. Track Suspension Wheels (fig. 49). Track suspension wheel and idler bearings must be disassembled, cleaned, and washed in drycleaning solvent or mineral spirits paint thinner, thoroughly dried, and lubricated with automotive and artillery grease (GAA, amend. 2).

h. Tracks (fig. 49). Remove dirt and ice from tracks. Do not adjust tracks too tightly in a warm shelter, as they will tighten and break easily in temperatures of —40° F. and below. Adjust track so that slack is 50 percent greater than that specified for normal operation in manual applicable to vehicle.

Note. Field adjustments made on a cold vehicle while it is operating under extreme-cold weather conditions should allow only the normal amount of slack specified for temperate operations.

i. Tires. Keep tires clean and free of ice. To minimize freezing of the tires to the ground, place scrap lumber, tar paper, or straw under the tire before parking. Make certain tire valves are in good condition and do not leak. Moisture must not be present in valve stems. Keep tires at reduced pressure for operation in deep snow. In some cases, it has been necessary to reduce the pressure at least 10 psi below that specified for normal conditions.

j. Springs (fig. 47). Clean springs of rust and ice Make certain that spring shackles move freely.

Note. Frozen shackles (corroded) can be loosened by injecting Diesel fuel into them with a grease gun.

k. Cab Inclosures.

(1) If vehicle is not equipped with a cab inclosure, one should either be obtained with the applicable winterization kit (pars. 14–21), if available, or improvised by using plywood or lumber obtained from shipping cases.

(2) Equip vehicle with cab heaters or foot warmers and with windshield defrosters as supplied in the various winterization kits.

66. Operation in Extreme Cold

a. General. Drivers must be very cautious when using vehicles for towing or pushing. Steel becomes very brittle at low temperatures, causing bumpers and towing hooks or pintles to fracture or pull out.

b. Wheel Bearings (fig. 44). If subzero lubricant is used and bearings are properly adjusted, no difficulties should be experienced. Check to see if bearings become overheated or if seals are defective, indicated by leaks.

c. Brakes. Do not park with brakes set, as they may freeze in place and will not release. Use chocks to hold wheels in place. Thy hydrovac piston may operate slowly and this possibility must be remembered when stopping the vehicle.

d. Shock Absorbers. If, for any reason, shock absorbers become inoperative, disconnect links (fig. 47) at axle to prevent breakage.

e. Steering Gears. With proper lubricant, no difficulty should be experienced.

f. Track Suspension Wheels. No attention is required.

g Tracks. Avoid quick starts and stops if possible.

h. Tires. If tires have a flat spot where contact with ground was made, use a light pressure on the accelerator and drive vehicle slowly until generated heat permit tires to round out. Also, during periods of freezing rain or sleet, move wheels around often.

Note. If necessary, heat may be applied by use of the slave kit.

i. Springs. Avoid going suddenly into depressions or over obstacles that may create shocks that could break springs in extreme cold.

j. Cab Inclosures. Cab heaters and foot warmers should be used to maintain adequate temperatures within cab inclosures. When crossing frozen streams or other bodies of water, open cab doors to permit quick escape of personnel in case vehicle should break through the ice.

k. Drain Valves and Access Covers. Drain valves should be kept closed during extreme-cold weather operation except for draining operations. Check to see that all access covers are present and secure.

67. Maintenance in Extreme Cold

a. Wheel Bearings (fig. 44). Inspect wheel bearings for loose adjustment. Revolve wheels and listen for indications of dry or damaged wheel bearings. Check for damaged oil seals. Make certain that proper lubricants for subzero temperatures are used (table II).

b. Hydraulic Brakes (fig. 45). Examine brake lines and fittings for good condition and to see that there are no leaks. Inspect wheel cylinder for condition and leaks. Check rubber- and metal-type end covers. Check master cylinder for good condition. Make certain that hydraulic fluid is at proper level. Brake system within drums must be free of ice.

c. Hydrovac System. Check system for good condition and that all parts are securely mounted. Examine connection for tightness and leaks.

d. Air Brakes (fig. 46). Drain water from compressed air reservoir as a daily maintenance procedure. Drain tanks at night; in the morning, close cocks and build up pressure before moving vehicle. Make certain that alcohol evaporator set is operating and that jar is filled with alcohol. Check brake lines, chambers, relay valves, push rods, seals, and slack adjusters for good condition, correct assembly, and that all parts are securely mounted. Check all valves and governor for satisfactory operation.

Caution: **Drain water from air filters and reservoirs every 8 hours of continuous travel, but not while air-brake system is under pressure. Also, drain water between movements after temporarily disconnecting the air-brake lines from the towing vehicle.**

e. Shock Absorbers (figs. 47 and 49). See that shock absorber bodies are securely mounted to the frame and that links are in good condition. Check and fill if necessary all shock absorber bodies, except Houdaille-type, with specified fluid for extreme cold operation. Work the arm several times and add fluid; repeat this operation until all air is expelled and the reservoir is full. Houdaille-type shock absorbers must not be filled. Replace if shock absorbers are leaking or if action is unsatisfactory.

f. Steering Gear (fig. 48). Examine arms, tie rod, drag link, seals and boots, Pitman arm, gear, column, and wheel for good condition and secure mounting. See that gear case is not leaking and that gears are properly adjusted. Check level of lubricant and make certain that gear lubrication oil (GOS) is used.

g. Track Suspension Wheels (fig. 49). Inspect track suspension wheels, arms, sprockets, torsion arm bearings, shock absorbers, snubbers, etc., for good condition and proper lubrication for extreme-cold weather operation (table II). Examine idler bearing seals for leaks and the relief vents if used for clogging. Tighten all assembly and mounting bolts to torque tightness specified in vehicle technical manual.

h. Tracks (fig. 49). Check track shoes, connectors, and wedges for good condition. Pay particular attention to dead shoes, loose or excessively worn shoes, connectors, and guides. Check adjustment.

Note. Slack for extreme-cold operation should be 50 percent greater than that specified for normal operation in pertinent manual.

i. Tires. Check valve stems and cores for good condition. Replace core if rubber seal is brittle or shows wear. Check for leaks in tubes. Examine tire casing for cuts, bruises, or breaks. Deflate tires at least 10 psi below recommended

pressure for deep-snow operation. Make sure caps are installed on all valve stems.

j. Springs (fig. 47). Clips, leaves, U bolts, hangers, and shackles must be in good condition and correctly and securely mounted. Spring leaves should not be broken or shifted out of their correct position. Tighten all spring U bolts securely. On track suspension systems, note whether volute springs have taken an excessive set. If two or more coils are resting on the seat, the spring will be considered as having taken an excessively permanent set and should be replaced. Tighten all assembly and mounting bolts.

k. Cab Inclosures. Note whether mountings are secure and in good condition. Replace broken windows. Make certain that inclosures are tight-fitting.

CHAPTER 3
WEAPONS MATERIEL AND RELATED SIGHTING AND FIRE-CONTROL MATERIEL

Section I. COLD-WEATHER PROBLEMS

68. General

Note. The general information in chapter 1 pertains to weapons materiel and sighting and related fire-control materiel. Refer to chapter 2 for information on automotive-type items (e.g., chassis, brakes, etc. and to chapter 4 for in formation on small-arms materiel.

a. When materiel is scheduled to operate continuously in extreme-cold areas for long periods, winterization measures will be accomplished as soon as the materiel acts sluggish or temperatures below freezing are anticipated. Windblown snow may necessitate subzero weather protection before this extreme-cold temperature is reached.

b. Operation of weapons, sighting, and fire-control materiel at subzero temperatures presents problems that demand special precautions in servicing by operators and maintenance personnel. Only through this special care can casualties to personnel and poor performance or total functional failures of materiel be avoided. Particular emphasis must be placed on crew maintenance and on intimate liaison between the using organization and ordnance maintenance units. Careful inspection and servicing of components must be accomplished before the advent of subzero weather. Suitable inspection and servicing before, during, and after each travel and firing period is imperative. All exposed finished surfaces must be wiped dry and oiled daily. All failures or symptoms indicating potential failures must be detected, investigated, diagnosed, and promptly corrected or reported to the proper authority.

Warning: **Failure to give this extra service and maintenance will result in injury to personnel, damage to materiel, unnecessary and unwarranted expenditure of critical parts, and loss of the use of the weapon.**

c. Cleanliness is imperative for cold-weather operations.

d. Since metals contract when the temperature decreases and expand when the temperature increases, the clearances between bearing surfaces are considerably more in cold weather than at higher temperatures.

e. Placing materiel in proper mechanical condition requires time for necessary disassembly, repair, and cleaning that must be done carefully.

69. Functioning

Special cold-weather procedures and winterization of weapons are intended to meet problems peculiar to operations in extreme cold to effect efficient and safe functioning of weapons at subzero temperatures. The problems or conditions of a general nature that affect operation of materiel that must be corrected by cold-weather procedures and winterization are outlined in *a* through *w* below.

a. Gear case oils congeal.

b. Exposed gears and racks (e.g., elevating arc, traversing rack, and pinions) collect snow and ice in sufficient amounts to impede movement. Snow and ice also contaminate the lubricant.

c. Hydraulic or recoil fluids offer greater resistance to motion as their viscosity increases with lowered temperature. This is indicated by stiffness of operation and lengthening of the recoil cycle (*g* below).

d. Lubricants congeal in bearings.

e. Tires become rigid, crack at side walls, and form flat spots when vehicle is left standing supporting a load. Underinflated tires will appear properly inflated until warmed by travel.

f. Metal, plastic, and rubber parts become brittle and their ability to withstand impact lessens.

g. Recoil-cycle time is lengthened by increased viscosity of the recoil fluid. Greater

resistance is offered to the motion of recoil and counter-recoil, resulting in greater stresses on the parts involved.

h. Increased viscosity of lubricants requires the use of lighter lubricants to overcome sluggish action between rotating or reciprocating shafts and rods.

i. Paint tends to crack very easily when exposed any great length of time in extreme cold.

j. Condensation, produced by changes in temperature, causes icing and corrosion of machined surfaces.

k. The bore of a weapon is particularly subject to the formation of condensation and subsequent icing and corrosion.

l. Overlubrication in cold weather causes parts to bind, causing the weapon to be out of service. Overlubrication of the firing mechanism will cause misfires in cold weather.

m. Handwheel effort is increased on both elevating and traversing mechanisms.

n. Improperly packed wheel bearings may become inoperative, hindering the mobility of the weapon.

o. Gas check pads fail to seal perfectly and deteriorate very rapidly. Scoring of the gas check seat is possible.

p. Excessive friction, resulting from overlubrication, causes springs to fail.

q. Ball and roller bearings will become inoperative unless properly cleaned and packed with arctic lubricant.

r. Wire cable insulation if not arctic-type becomes brittle and will crack.

s. Air hoses if not arctic-type fail when doubled or straightened.

t. Hand brakes must not be applied while artillery (towed) weapon is parked. This may result in frozen brakes and render the weapon immobile or cause serious damage.

u. Equalizing bars and travel locks of towed weapons must be covered or wrapped prior to towing the weapon over snow-covered terrain.

v. In cross-country operations a prime mover of the same tread must be utilized to insure tracking.

w. Firing lanyards must be kept dry and covered to prevent freezing and breakage.

Section II. LUBRICATION IN EXTREME-COLD WEATHER

70. General Requirements

a. Proper lubrication is one of the most important services that can be given a weapon. Lubricants are provided for two reasons: first, to assure functioning of a weapon and second, to prevent atmospheric corrosion. It is very important that the proper lubricant be used and that it be used in the manner prescribed in paragraphs 71 through 80. The lack of lubricant will permit formation of rust on the uncoated surfaces and, also, result in friction between rubbing surfaces, which impedes the functioning the weapon.

b. It is essential that the lowest possible friction be maintained, as the operating power of the gun cannot be increased to take care of this extra drag. On the other hand, use of too much lubricant may impede the motion of the components or result in a coating of oil or grease on the parts, forming a place for dirt, dust, sand, and other materials to settle. This material if caught in the mechanism will rapidly wear out the equipment while it is being operated.

c. It is equally essential that the proper type and grade of lubricant be used (table I). Certain lubricants are selected for different types of equipment and for different temperatures ranges, because the physical properties of oils and greases vary with changing temperatures, usually becoming thick and viscous as the temperature drops. Thus, a lubricant designed for use at room temperatures may become thick and, therefore, unsatisfactory at subzero temperatures or may become thin and drip from the metal surfaces at high temperatures.

d. To provide satisfactory lubrication and protection against rust, all metal parts should be cleaned and dried before applying a lubricant or preservative. In damp climates, the patches used for drying should be truly dry, not damp with atmospheric moisture. At subzero temperatures, the lubricant should be applied sparingly. The oil should be applied by rubbing the parts with a patch that has been wet with oil and wrung out. External parts may be degreased thoroughly and left dry. Internal friction surfaces should be given a light film of lubricant.

e. Lubrication orders for care of weapons under special conditions are listed in DA Pam

310–4 and in pertinent operator's technical manuals.

f. To insure adequate lubrication and satisfactory performance of weapons materiel in subzero temperatures, the instructions included in this section must be followed. The general applications of lubricants for operating weapons materiel in extreme-cold weather are included in table II.

71. General Procedures

a. Weapons Materiel. Artillery weapons will be winterized in depot shops. Prior to issue, recoil mechanisms will be modified to assure satisfactory operation to —25° F. In many cases, preparation of artillery requires special winterization component parts. Instructions in pertinent lubrication orders and technical manuals will be followed, with exceptions as indicated in (1) through (5) below.

(1) Lubrication intervals will be reduced by one-half.

(2) Automotive and artillery grease (GAA, amend. 2) is prescribed for all temperatures.

(3) Petroleum-base hydraulic fluid (OHC) will be used in hydraulic gears as well as in hydrospring and hydropneumatic recoil mechanisms. This oil replaces special recoil oil and a mixture of special recoil oil and light recoil oil for low-temperature operation. The changeover to petroleum-base hydraulic oil in recoil mechanisms will be accomplished as outlined in (*a*) through (*c*) below.

(*a*) Dismount the recoil mechanism and drain existing recoil oil. Raise, lower, and rotate the mechanism to aid in removing the original oil.

(*b*) Fill recoil mechanism with the petroleum-base hydraulic fluid (OHC). Establish oil reserve and install mechanism on carriage or mount.

Caution: **Extreme care must be taken to assure that moisture snow, ice, and dirt are not introduced into the mechanism during the changeover process.**

(*c*) Recoil mechanism filler plug should be painted with buff enamel when the mechanism is filled with petroleum-base hydraulic fluid (OHC).

(4) Wherever special lubricating grease is specified, aircraft and instrument grease (GL) will be used.

(5) Wherever preservative lubricating oil or lubricating oil is specified, general-purpose lubricating oil (PL, special) will be used.

b. Fire-Control Materiel. Fire-control materiel will not be lubricated in the field, with the exception of the antiaircraft fire-control system M33, which will be lubricated in accordance with applicable lubrication orders.

72. Breech and Firing Mechanisms

The breech and firing mechanisms must be disassembled for lubrication. Clean all parts as described in paragraph 88, apply a light film of general-purpose lubricating oil (PL, special) by wiping the surfaces of the parts with a clean cloth that has been wet with oil and tightly wrung out. Excessive lubrication of the firing mechanism will cause misfires.

Note. During below-freezing temperatures, daily cleaning and lubrication is mandatory.

73. Recoil Mechanisms

Parts such as recoil and counterrecoil rods and variable recoil cams are wiped dry daily. Protect these parts against corrosion by applying a film of general-purpose lubricating oil (PL, special) to all metal surfaces with a lightly oiled, clean cloth.

74. Recoil Slides

After the daily cleaning prescribed in paragraph 68*b*, lightly lubricate the recoil slide surfaces. If the weapon technical manual specifies grease as the lubricant for the recoil slides, lubricate the surfaces sparingly with automotive and artillery grease (GAA, amend. 2). If the weapon technical manual prescribes oil as the lubricant for the recoil slides, apply a light film of general-purpose lubricating oil (PL, special).

75. Equilibrators

a. Lubricate the designated equilibrator parts with automotive and artillery grease (GAA, amend. 2) at the intervals prescribed in the lubrication orders and the weapon technical manuals.

(1) If a grease other than automotive and artillery grease (GAA, amend. 2) has been applied to the bearings of an equilibrator, wash the bearing thoroughly with dry-cleaning solvent or mineral spirits paint thinner, dry thoroughly, and lubricate with automotive and artillery grease (GAA, amend. 2). It will be necessary to remove the equilibrator in order to wash bearings properly.

(2) Since automotive and artillery grease (GAA, amend. 2) is satisfactory for all temperatures (—65° to +125° F.), it need not be removed when the temperature rises.

b. After the daily cleaning and drying of the equilibrator piston rod or tube as prescribed in paragraph 68, protect the smooth unpainted surfaces against corrosion by applying a very light firm of general-purpose lubricating oil (PL, special). Wipe the metal surfaces with a clean cloth that has been wet with the oil and tightly wrung out.

76. Sighting and Fire-Control Materiel

a. When the lubrication order for fire-control materiel specifies oil, lubricate sparingly with instrument lubricating oil (OAI). In extreme-cold-weather operations, a thin film of oil is more effective for lubricating fire-control mechanisms than a heavy application; it also affords adequate corrosion protection.

b. When the lubrication order for fire-control materiel specifies grease, lubricate sparingly with aircraft and instrument grease (GL).

77. Bearings

For general extreme-cold lubricating instructions applying to ball and roller bearings (both grease- and oil-lubricated), plain journal bearings and bushings, and to wick-fed bearings, refer to paragraph 9.

78. Wheel Bearings

Wheel bearings will fail to rotate in subzero temperatures unless the proper lubricant is used. If a lubricant other than automotive and artillery grease (GAA, amend. 2) has been used in the wheel bearings, remove bearings and wash thoroughly in dry-cleaning solvent or mineral spirits paint thinner; then dry thoroughly and lubricate with automotive and artillery greace (GAA, amend. 2) (par. 23*f*).

Note. Wheel bearings must be disassembled in order to clean and dry them properly before lubricating.

79. Brakes

Lubricate and prepare brakes as prescribed in pertinent manual and in paragraph 65. Apply the lubricant to all connections and joints.

Caution: **Keep lubricant away from brake drum and shoes.**

80. Generators

Lubrication of generating units as specified by the lubrication order is satisfactory for all low temperatures. Too much grease and oil will cause as much trouble in extreme-cold-weather operation as too little or none at all. When the crankcase oil is to be changed, drain it while the oil is still warm.

Section III. GENERAL OPERATION AND MAINTENANCE

81. General Requirements

a. Preventive Maintenance.

(1) It is not possible to design materiel that will function in a satisfactory manner regardless of abuse and the conditions under which it is operated. Although the designer undertakes to construct the weapon to resist most of the troubles to which it will be subjected, the user must cooperate in this effort and give some attention and care to materiel. It has been learned through experience that much maintenance can be avoided and greater service obtained from weapons if the user will take care of the weapon and exercise preventive maintenance, that is, if he will avoid the conditions that cause difficulty, rather than wait until they occur and require correction.

(2) All equipment should be inspected daily, to insure that it is complete and in satisfactory operating condition. Further maintenance consists largely in the application of commonsense. Weapons should be cleaned and oiled

or lubricated according to applicable regulations and instructions. Only proper authorized type of ammunition should be fired and authorized accessories and tools used with them.

b. Precautions for Idle Materiel.

(1) Whenever materiel is to remain idle for a period of time, care should be taken to secure all covers for protection. Wind will drive the snow under the covers unless they are snugly and securely fastened. This will result in the formation of ice on parts, rendering the materiel inoperative.

(2) When weapons or fire-control materiel is placed directly on the ground, ice, or snow, it will freeze in place, making it difficult, if not impossible, to move equipment without digging or thawing it out. To prevent materiel from freezing to ground, prepare a footing of planks, brush, or matting beneath it. Straw or hay may also be used for this purpose if available. Pedestals, trails, outriggers, skids of generating units, and points of tripods that go into the ground can also be covered with grease to prevent them from freezing to the ground.

(3) Make sure that all parts of materiel are free of ice or snow and that all exposed openings are sealed. Keep the ends of canvas paulins off the ground, to prevent them from freezing to the ground.

c. Prevention of Condensation.

(1) When weapons, sighting and fire-control materiel, parts, or assemblies are brought indoors after having been outside at low temperatures, water vapor in the warm air will condense on the cold parts. This condensed moisture may cause corrosion of the parts if not immediately removed by drying. In some cases, drying without disassembly is practically impossible. If the materiel is operated indoors while this moisture is present, the moisture will form an emulsion with the lubricants. Such a condition will necessitate removing all the grease and cleaning and lubricating the materiel. If the materiel is taken outside into low temperature before the condensed moisture is removed or has evaporated, the parts may freeze and cover parts with frost or ice.

(2) Do not bring fire-control materiel indoors unless it is absolutely necessary. It is better to leave it outdoors, but covered to protect it from snow. Snow-tight lockers that stay at outdoor temperatures are recommended as a place for keeping binoculars, telescopes, and other fire-control equipment.

(3) If it is necessary to bring instruments or other materiel from low outdoor temperatures into higher room temperatures, "anticondensation" containers should be used to prevent the condensation of moisture on instruments. These containers can be specially made boxes, covered cans, barracks bags, or any other fairly airtight container with heat-conducting walls. Keep containers outside at prevailing temperatures until it is desired to bring an instrument indoors. Put the instrument into a container, close the container tightly, then bring it indoors let it come into equilibrium with the room temperature. It can be put near a stove to hasten the warmup.

(4) The air in the container is cold and dry; when it is heated the air expands and breathing is outward; therefore, no warm, humid air from the room can come in contact with the instrument, thereby preventing condensation. When the instrument and container reach room temperature, the instrument can be removed from the container without the danger of moisture condensing on it.

82. Precautions for the Operator When Using Sighting and Fire-Control Materiel

a. When height finders are being used at subzero temperatures, operators' hands will need protection. It is, therefore, recommended that wool liners be worn inside of leather-faced mittens. Since the mechanical motions of most of the knobs and levers will be less free than at milder temperatures, most of the adjustments

will seem awkward and difficult at first, particularly to operators accustomed to working with bare hands. It is highly desirable that crews practice using the instrument as much as possible under the new conditions. Most of the initial difficulties and awkwardness will be overcome within a week or so.

b. Keeping the hands at the side of the body whenever possible will help to keep them warm.

c. Although personnel should return indoors as frequently as possible, they should avoid rapid warming of the hands or face over stoves or other heating units.

d. Because many knobs and handwheels are too small to be manipulated properly while wearing arctic mittens or gloves, it is sometimes necessary to use the bare hands to adjust them. Operator's discomfort can be greatly alleviated by wrapping three or four layers of adhesive tape around these knobs or handwheels, so that the bare hands will not come in direct contact with the metal.

e. If personnel find it necessary to use bare hands for handling small items, the hands should not be exposed for more than 10- to 15-second periods. By returning the hands to the mittens even after such brief exposure, total working time can be reduced.

f. Cold, steel seats are extremely uncomfortable to sit on for any length of time. Insulating-type seat covers, such as felt or blanket pads, should be used so that the body heat of the operator is not carried away by the cold metal seats.

g. Insulation of felt or other material should be provided on hard or metal cheek rests and eyepieces so that the operator's face will not touch these parts.

h. The use of issue blankets over observers' heads has the further advantage of "cutting the wind," especially when ranging is being done facing windward. Observing becomes increasingly difficult after an hour of exposure.

Section IV. WEAPONS MATERIEL OPERATION AND MAINTENANCE

83. General

The operation and maintenance procedures in paragraphs 84 through 94 are for all weapons materiel and procedures in paragraphs 95 through 99 are for specific materiel. Section V contains the procedures for related fire-control materiel.

84. Exercising

The weapon should be elevated and traversed at intervals that will assure operation when the weapon is needed. Where applicable, the rammer and fuze setter should be cycled several times before ramming rounds and at intervals to assure proper operation. See that the rammer brake and fuze setter actuating mechanism brake stop the mechanisms. The recoil mechanism can be moved only a short distance under normal cold conditions. If exercising by gymnasticating is considered necessary due to extremely low temperatures, notify ordnance maintenance personnel. Always exercise the recoil mechanism before firing, to make sure the recoil parts are not iced up.

85. Daily Care

Inspect materiel daily. Whenever possible, use gun covers and shelters for protection. To provide maximum protection for the weapon, the following points in *a* through *d* below, cannot be overemphasized.

a. Keep all parts thoroughly clean.

b. Clean and oil the bore and breech machanism daily.

Caution: **When cleaning, do not dilute rifle-bore cleaner solvent cleaning compound or add an antifreeze.**

c. Lubricate *sparingly.*

d. Do not let snow and ice collect on moving parts.

86. Travel of Weapon

a. Before starting a road trip, make a thorough inspection and provide as much protection as possible for all parts. Vinyl-resin-coated nylon fibre covers will be used for all antiaircraft and field artillery weapons when operating in extreme-cold weather.

(1) Be sure all covers are properly installed and securely lashed. If covers are inadequate, additional covers may

be improvised by using canvas, burlap, adhesive tape, or any other suitable or available material.

(2) Use sleds if available for travel over snow, ice, frozen ruts, swamps, and tundra. Use and operation of skis or sleds are covered in pertinent weapon technical manuals. When a weapon is to be towed in tundra, the drawbar should be immobolized so that it cannot swing from side to side. This improves tracking in tundra (i.e., following in the same path as the tractor or prime mover).

(3) Perform all the preventive-maintenance operations and precautions prescribed in manuals pertinent to the materiel.

b. During travel, more than usual driving care should be taken, because suspension assemblies become stiff in cold weather and are easily broken. Refer to FM 31–70 and FM 31–71 for precautions to be observed by driver of prime mover.

87. Emplacement of Weapon

a. The selection and preparation of a weapon site in ice and snow requires more consideration than when the weapon is to be emplaced on bare, level ground. If melting snow and ice are encountered, select a site that will not become mired or flooded.

b. Prepare a platform of pierced planking (material used for improvised airstrips, etc.), boards, brush, or matting at the spot chosen for the emplacement and push or tow the weapon onto the platform so that the platform is beneath the wheels and firing jack float (or auxiliary firing jack platform. Prepare recoil pit and spade positions as required. When an artillery piece is to be fired from tundra, a deeper recoil pit must be dug in preparation for the sinking of the weapon during firing.

Note. Much more time will be required to prepare recoil pit and spade positions for emplacing a weapon on frozen ground than on ground that is not frozen.

c. Coat all metal parts of the trails and spades coming in contact with snow or frozen ground with waste lubricant. This will prevent freezing in place and facilitate subsequent shifting of the trail. The waste lubricants may be used on any parts, except rubber, that touch the ground.

d. Special, large frost-spades or spade attachments (fig. 50) may be improvised to suit local conditions. In hard, frozen ground, protect trails against tendency to buckle and break by placing trail logs between the spades and ground for added resilience.

e. The firing jack and its locking lug may become covered with ice and frozen mud in transit. Ice and mud must be entirely removed before the jack can be completely lowered and locked in firing position. Swab the exterior of the jack with automotive and artillery grease (GAA, amend. 2). See that all seals are tight and serviceable.

Caution: **Do not pack grease within the housing.**

f. In soft tundra, twice the usual area in contact with the ground is required for stability. This applies to wheels or firing jack floats and trail spades. Frost spades, planks, logs, etc., can be used to accomplish stability.

g. Aiming posts should not be driven into frozen ground. A hole should first be made with a pick or crowbar. Manufacture of a stand that will rest on top of frozen ground or ice is an approved method of supported the aiming post for use in weapon alinement. An aiming post is self-supporting in about 26 inches of packed snow. Use of the aiming light, involving dry-cell batteries, will not be possible except for short periods of time. The battery is kept warm and in serviceable condition until used by carrying the batteries or light next to the body.

88. Breech and Firing Mechanisms

a. A frozen-in breechblock usually cannot be forced to move. If ice prevents opening or closing the breech, use portable heater for thawing. Remove the breechblock and dry it thoroughly. Keep the breech mechanism tightly covered.

b. Satisfactory operation in extreme-cold weather depends upon a high degree of cleanliness and proper daily lubrication. Clean all parts daily, except gas-check pads, with dry-cleaning solvent or mineral spirits paint thinner and lubricate as prescribed in paragraph 72.

Caution: **Do not use dry-cleaning solvent, mineral spirts paint thinner, or rifle-bore cleaner solvent cleaning compound on gas-check pad. Simply wipe it clean and permit it to dry; do not lubricate.**

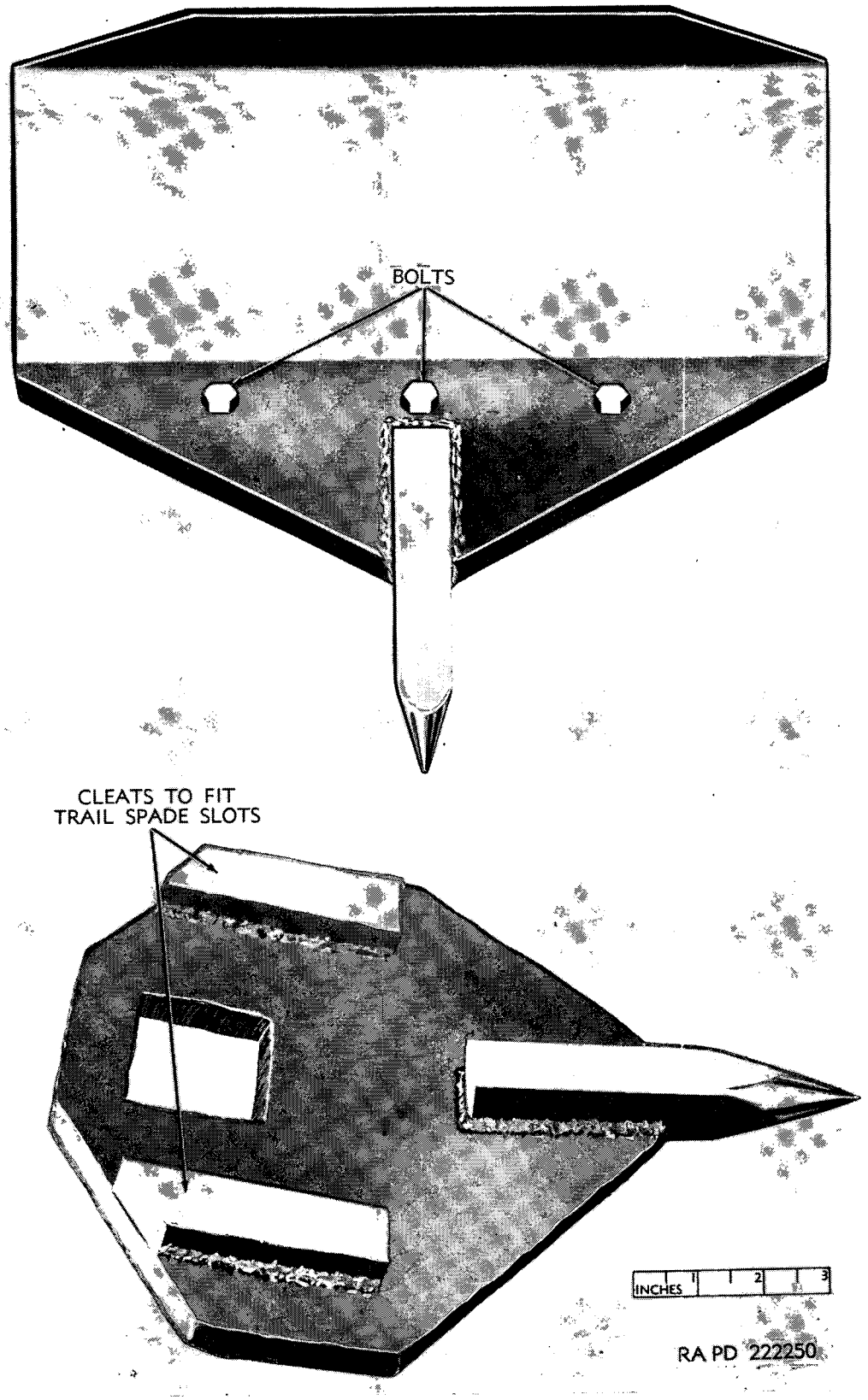


Figure 50. Improvised spade attachment for operations in tundra.

c. Check manual and electric firing linkages. Frosted linkages will render weapon useless. Especially, check items such as solenoids that may be frosted and, therefore, unable to close contacts for electric firing.

d. After firing, the breech and firing mechanisms on weapons using fixed and semifixed ammunition will be disassembled, cleaned with dry-cleaning solvent or mineral spirits paint thinner, dried, and oiled sparingly. Mechanisms on weapons using separate loading ammunition will be disassembled, and all parts, except gascheck pad and electrical ring mechanisms, will be cleaned with rifle-bore cleaner solvent cleaning compound, dried, and oiled sparingly.

Note. At temperatures below —20° F., rifle-bore cleaner solvent cleaning compound must be warmed sufficiently to permit effective use.

Warning: **Rifle-bore cleaner solvent cleaning compound must be heated only to a temperature that is not to hot to be touched with bare hands.** All traces of powder fouling and primer residue should be carefully removed. The gascheck pad will be wiped with a dry cloth and left dry.

e. The asbestos covering of Gerdom-type gascheck pads becomes very brittle in extreme cold. Inspect to see if the asbestos has cracked and if any of the wire mesh is exposed. If the wire is exposed, it will cause the gas-check seat to become scored and this cannot be repaired. Install a new pad if wire is exposed.

89. Bores

a. Before Firing. Before firing, wipe the bore and chamber dry. Clean and coat bore evacuator, muzzle brake, blast deflector, and/or counterweight as prescribed in appropriate technical manual.

b. During Firing. Inspect the muzzle end of the tube, bore evacuator, muzzle brake, blast deflector, counterweight (as applicable), and the breech ring at every opportunity. Examine for development of cracks. In extreme cold, metal tends to embrittle and become more readily susceptible to failure under impact loads such as a cannon receives when it is fired. Cracks are generally an indication of material deficiencies or metal fatigue. However, note that tool marks may be mistaken for cracks and that some cracks are not always visible. Cease firing when cracks develop and notify ordnance maintenance personnel.

c. After Firing. Clean the bore evacuator, muzzle device, bore and chamber with rifle-bore cleaner solvent cleaning compound while the cannon is still warm. Do not apply solvent cleaning compound to a weapon while the weapon is too hot to be touched with the bare hand. For temperatures below —20° F., warm the solvent cleaning compound before using so that it will be thin enough to use effectively. Do not heat solvent cleaning compound to a temperature that would be too hot to touch comfortably with the bare hands. It is important that all cleaner be wiped off. Any cleaner remaining in the tube will freeze and make firing dangerous. Accomplish second and third cleaning of the bore and chamber after firing as prescribed for usual (mild, moderate) conditions in the pertinent lubrication orders and technical manuals.

d. Daily Care. In below-freezing temperature, wipe the bore dry every day and apply a light film of general-purpose lubricating oil (PL, special).

90. Recoil Mechanisms

All hydropneumatic and hydrospring recoil mechanisms will be filled with hydraulic fluid (OHC) in preparation for cold-weather operations. Keep close check on length of recoil during extreme-cold weather firing. System pressure should be relieved at end of each day and pumped to normal before vehicle operation. Take precautions to prevent snow, water, or dirt from entering reservoir.

a. Hydropneumatic mechanisms are affected by reduction of gas pressure at low temperatures as well as thickening of recoil oil.

Warning: **The possibility of injury to personnel or damage to materiel is present when the gas pressure in the recuperator is adjusted.** Therefore, adjusting the gas pressure in the recuperator will be a function of ordnance maintenance personnel. The officer in charge of a weapon is responsible for having the gas pressure in the recuperator adjusted to correspond with the existing temperature conditions.

b. Care of recoil mechanisms will be nearly the same during cold weather as it is under normal conditions. Using units must maintain a careful check on recoil mechanisms.

(1) Condensation and ice tends to form on a weapon during freezing tempera-

tures, and parts such as recoil and counterrecoil rods and variable recoil cam must be wiped dry and lubricated lightly every day as outlined in paragraph 73.

(2) While the oil is cold, the cycle of recoil may take longer than usual. As further firing is conducted, the action gradually warms the recoil oil and thins it, so that normal cycle time is obtained. Do not condemn the recoil mechanism until there is definite proof of malfunction.

c. A sticking recoil mechanism may result in severe damage to the weapon when it is fired.

(1) Exercise mechanism frequently. Intervals of exercise will depend upon the existing temperature. Exercise the recoil mechanism more frequently as the temperature decreases.

(2) In order to insure that recoil parts are free from frost binding, exercise the recoil mechanism prior to firing whenever the weapon is subjected to a freezing rain, wind-blown snow and ice, or to fluctuating temperatures.

(3) Refer to pertinent weapon technical manuals for methods of exercising the recoil mechanism.

d. If the recoil mechanism is equipped with an adjustable respirator, it should be opened as far as possible when commencing to fire in extreme cold.

Caution: **Extreme caution must be exercised to keep the parts of a respirator free of snow and ice.**

e. Check the oil level in the recoil mechanism at the intervals prescribed in the pertinent weapon technical manual and whenever there is a marked change in temperature. Discard all partially filled containers of petroleum-base hydraulic fluid, to avoid the possibiilty of contamination by condensation in the partially filled containers. Use the smallest size container available for storing and replacing hydraulic fluid.

91. Recoil Slides

Friction between recoil slides and guides absorbs an appreciable amount of recoil energy. Thickened or congealed lubricants increase friction, shorten recoil, and retard counterrecoil. Snow and condensation on the slides contaminates the lubricant and destroys its lubricating properties. To insure proper recoil and counterrecoil action, remove the old lubricant from the slides every day by using dry-cleaning solvent or mineral spirits paint thinner. Smooth all surfaces and lubricate lightly in accordance with paragraph 74. When exposed to wind-blown snow and ice, dry operation of the recoil slides and other exposed metal working surfaces may be necessary but lubrication should be applied during standby periods.

92. Equilibrators

a. Clean, dry, and lightly lubricate (par. 75) the piston rods or tubes of equilibrators every day during cold-weather operation to prevent icing. Clean off all accumulated ice or frozen mud on the firing jacks or their locking lugs. Carefully examine and remove any corrosion or marring of the smooth, unpainted surfaces with crocus abrasive cloth.

b. Adjust the nitrogen pressure of pneumatic-type equilibrators to provide proper equalizing action. If the equilibrator is equipped with a low-temperature control, make adjustment in accordance with the temperature scale provided.

93. Elevating and Traversing Mechanisms

Snow and ice particles will frequently collect on the arcs and pinions and cake under pressure of the gears. Since this will interfere with elevating and traversing operations, the snow must be removed by vigorous brushing with a stiff bristle or wire brush before manipulation of the piece is attempted. After snow is removed, the parts should be *left dry for firing* or swabbed with a light application of general-purpose lubricating oil (PL, special) to permit smooth and easy operation and prevent rusting.

94. Cradle, Sleigh, Carriage, and Mount

Completely disassamble the mechanisms as required to obtain access to all parts. Thoroughly clean all parts, making sure that all rust, dirt, and old lubricant are removed before applying prescribed lubricant; lubricate sparingly as prescribed in lubrication orders and technical manuals.

95. Mortars (85-mm, 4.2-Inch, Etc.)

a. The matter of breakage in mortars is a minor one, since there are few parts. However, firing pins often become brittle and break. The baseplate must be solidly positioned to prevent sliding. It may be necessary to dig into the ground to accomplish this. When the weapon is emplaced on frozen ground, the combination of the cold making the metal brittle and the tremendous shock that the baseplate receives when a round is fired, occasionally, may cause the baseplate to crack. Frozen ground has no resiliency, and the baseplate and other bracing parts of the weapons absorb the entire shock of firing. To reduce the possibility of a cracked baseplate, embed the entire baseplate in the ground with loose earth filled in around the plate or place a brush matting under the baseplate. If matting is used, it should be thick enough to act as a shock absorber but not so thick as to cause the baseplate to bounce out of its dug-in position. Another method of positioning the weapon is to place bags of dry sand or snow beneath the baseplate. The sandbags will provide the weapon with a solid, yet resilient, shock-absorbing base.

b. An additional problem with the mortars is that they cannot be handled without touching bare metal as can other infantry weapons with wooden or plastic handles and stock. The crew must keep their gloves or mittens on and avoid touching the metal surface with bare flesh.

c. There are practically no lubrication or ice fog problems with the mortars. Malfunctions are also quite infrequent.

d. The ammunition is affected by the cold in the same manner as the other types of ammunition. The VT-fuze-type ammunition is considered the only really effective mortar ammunition for use in extreme-cold weather. Other contact-detonated ammunition will penetrate the snow before exploding and much of its effectiveness will be lost and dissipated in the snow. A greater frequency of short rounds may be experienced at low temperatures (e.g., as much as 1,000 to 1,500 yards short from the 4.2-inch mortar).

96. Recoilless Rifles (57-mm, 106-mm, Etc.)

a. Since there is no burning propellant in the projectile itself, the crew is quite safe from flying particles when firing the recoilless rifles. Due to the slow-burning qualities of the propellant, however, the firing data for warm weather cannot be used and the weapon must be zeroed for the temperature in which it is being fired. Once zeroed, the weapon is highly accurate. The backblast area in extreme-cold weather is almost triple that of the area of the weapon in warm weather. Refer to the operator's technical manual for information on blackblast area. In cold weather, when the propellant burns slowly, the rate of fire will be slower because, after the round leaves the muzzle, burning gases remain in the barrel and the weapon cannot be reloaded until they burn out. This phenomenon is known as "afterburn." Gunners should exercise extreme care to avoid premature explosion of the round in the weapon. A period of at least 60 seconds must elapse between firing and reloading. One of the major problems in the firing of the recoilles rifle is the ice fog effect (par. 113*d*), requiring displacement of weapons.

b. The cal. .50 spotter-tracer rifle M8C, atop the 160-mm recoilless rifle, creates problems due to the fact that its trajectory and that of the recoilles round do not coincide. The spotter-tracer rifle M8C is also subject to breakage of metal parts, such as the firing pins, which become brittle due to the cold. The working parts should be lubricated with lubricating oil (LAW). If lubricating oil (LAW) is unavailable, the weapon is best fired dry.

c. Another phenomenon occurs in extreme cold affecting recoilles rifles. The problem is a deformity of the barrel due to solar radiation or the heating of the atmosphere and ground. This will happen if the weapon is boresighted, for example, prior to sunrise. If the sight reticle and the bore have been placed on the same target in the early morning hours, after the sun rises, the bore may be pointing at one target and the sight reticle at the original one. The barrel has actually bent slightly due to the increase in temperature and thus the "0" has been lost. After the weapon has been fired for several rounds, it is again boresighted and retains its high accuracy. Therefore, this phenomenon concerns itself primarily with gaining first round hits; the gun crew must be aware of this condition and how to correct it. The gunner should not trust the firing tables in low

temperatures, but should make his own data for extreme-cold-weather conditions.

97. Combat Tank Weapons (75-mm, 90-mm, Etc.)

a. The problems of lubrication and breakage are greatly diminished for combat tank weapons, due to the fact that most of the working parts of the weapon are inclosed in a warmed turret.

b. The major problem is the effect of temperature changes on the ammunition. Ammunition stored inside the turret will be warm and have the same general ballistic characteristics of ammunition fired in temperate climates. The weapon is probably zeroed with this warm ammunition. Other ammunition is stored outside the tank where the temperature is extremely cold. When this ammunition is fired, the powder will burn slowly and it will have completely different ballistic characteristics, thus rendering the initial zero useless. If possible, the ammunition brought in from the outside should be heated in the turret before firing. However, in a combat situation, this is not practical because the ammunition may have to be used immediately. The gunner must have his own data for cold ammunition or be ready to hastily rezero the weapon. In either case, he will have to make sight adjustment. There is also a problem with ice fog, muzzle blast fog, and snow particles being blown up in front of sights and obscuring the visibility of the gunner.

98. Self-Propelled Weapons (155-mm Gun, 8-Inch Howitzer, Etc.)

The self-propelled weapons have many of the problems of the recoilless rifle (par. 96). Breakage and malfunctions are few. The two primary problems are the formation of ice fog when the weapons are fired and distortion of the tube caused by solar radiation (par. 96*c*). The gunner is required to recompute his firing data. The weapon must be traversed in each direction from stop block to stop block to check for binding cause by accumulated ice or snow. The index marks on the traverse stop block must be checked to see that they aline with the fixed pads. In addition, the elevating controls must be operated to determine whether elevating or depressing the weapon requires excessive force.

99. Ammunition

Any temperature limitation at which certain ammunition may be used is stamped on the ammunition itself, along with the type, model, and lot number. *For example,* "TEMP. LIM. —20° F. to +120° F." is stamped on the rocket head, together with the type, model, and lot number of the 3.5-inch rocket M28A2.

Warning: **Do not use ammunition at temperatures below that specified on the ammunition.**

Section V. RELATED SIGHTING AND FIRE-CONTROL MATERIEL OPERATION AND MAINTENANCE

100. General

The operation and maintenance procedures in paragraphs 101 through 106 are for all fire-control materiel and procedures in paragraphs 107 through 111 are for specific materiel.

101. Precautions

a. Sighting and fire-control materiel will operate satisfactorily at subzero temperatures if it is properly winterized and certain adjustments are made.

b. Ordnance maintenance of fire-control equipment in extreme-cold weather will be difficult, especially where shop facilities are scarce. Therefore, all materiel should be thoroughly inspected and winterized before the onset of cold weather. Extreme-cold-weather lubrication is described in paragraph 76.

c. Whether it is planned to use a piece of equipment in shelter or in a heated trailer, the materiel should be prepared to operate at the lowest expected temperatures, so that if shelter is not available, the materiel will not be deadlined.

d. Sighting and fire-control materiel should not be transformed suddenly from cold to warm or warm to cold temperatures. Condensation induced by this action may cause clouding of optics and rusting of internal parts. Strains may be set up in parts. Use "anticondensation" containers as prescribed in paragraph 81*c*.

e. Do not put severe bends in interconnecting cables. All electrical cables should be removed periodically from beneath accumulated snow. This eliminates locating and digging out cables when preparing to shift the emplacement. Use a cable reel to take up cable when shifting positions and take care not to allow kinks to form.

f. Use stake markers to define cable paths, in order to prevent heavy equipment from running over interconnecting cables. Markers will also facilitate locating cables for repairs or when a movement is planned.

102. Fogging of Eyepieces

a. When using optical instruments in extreme-cold weather, the operator should be careful not to breathe on the eyepieces. When warm breath comes in contact with the eyepieces, the moisture in the breath condenses on the lenses and turns to frost. The frost fogs the eyepiece, making observation impossible.

b. There is no antifog solution that is satisfactory for use on eyepieces of optical instruments at low temperatures. Some solutions prevent fogging, but they streak the lens, making observation difficult or impossible.

c. A face mask is the most satisfactory method of keeping the breath away from the eyepieces. The face mask can be of any type, as long as it directs the breath away from the lens or absorbs the moisture from the breath. An especially serviceable face mask can be made from a piece of chamois. If chamois is unavailable, a piece of gauze tied across the face just below the eyes may be used. Either of these will not only protect the operator's face from the wind but will deflect the breath away from the lens. The mask must be changed periodically to avoid freezing the face.

d. When using a height finder, a blanket thrown over the operator and part of the tube increases the time during which observations can be made from 2 to 3 minutes to about 20 minutes before eyepieces fog.

e. Optical surfaces should be cleaned by using tissue lens paper moistened with a few drops of optical lens liquid cleaning compound.

Note. Ethyl alcohol may be used in place of cleaning compound. If neither lens cleaning compound nor alcohol is available, use dry lens paper.

Wrap lens paper around the end of a sliver of wood to make a swab. Dip the swab in optical lens liquid cleaning compound, shake off the excess, and clean lens. Wipe away any compound with lens paper, rubbing from the center outward in a spiral pattern.

Caution: **The alcohol should never be poured directly on the lens surfaces, as excess alcohol will injure the lens sealing compound.**

103. Hydraulic Mechanisms of Remote Control Systems

Before operation in extreme cold, hydraulic systems will be drained and filled with petroleum-base hydraulic fluid (OHC). This oil need not be changed when the surrounding temperature increases, as its use is authorized for a wide range of temperatures from —65° to +125° F.

104. Batteries

a. Storage Batteries. Storage batteries of the commonly used lead-acid type can be used successfully at very low temperatures if certain precautions are exercised. Low temperatures cause decreased chemical activity, with a resultant loss of electrical capacity. For operation and maintenance of lead-acid-type storage batteries, refer to paragraphs 44 through 47 and TM 9–6140–200–15.

b. Dry Batteries.

(1) Dry batteries may be expected to lose considerable electrical capacity because of decreased chemical activity. These batteries may be used to operate equipment at low temperatures if the internal temperature of each battery is kept high enough to permit normal chemical activity. Dry batteries preheated to approximately 70°F. prior to use retain sufficient heat for an appreciable period of use before replacement is necessary. The period of use depends on the rate that heat is conducted away from the battery; the period of use can be extended if the batteries are insulated from heat-conducting surfaces by means of nonconductive materials.

(2) When replacement batteries must be carried by using personnel, the following means may be used to retard heat loss: After preheating, the batteries may be placed in bags lined with

kapok, spun-glass fiber materials, or animal skins; wrapped in woolen clothing; or carried close to the body.

Caution: **Batteries in use fail rapidly if not protected from cold, and any improvised means of keeping the battery warm pays dividends in the form of extended operating life.**

Under certain conditions, it is advantageous to carry the batteries outside the using equipment and to use a connecting cord and plug. This arrangement may require certain modifications to the using equipment to permit installation of the connecting cord and plug, but, in most cases, the necessary modifications will be minor and may be accomplished readily by the using organization. If replacement batteries can be carried by vehicle, a well-insulated box that has small heater elements powered from the vehicle battery will insure maximum usable life of the batteries without heat loss in transit.

105. Protection of Tube Extensions and Eyepieces

a. Snow will collect in uncovered eyepieces and objective tube sunshades or extensions, rendering the instrument useless until the snow is removed. Do not try to blow the snow out of these parts or wipe it out with gloves or the bare hands. Some of the particles of snow will melt and freeze on the lenses, causing further difficulty. Use a small, stiff brush or small, rubber bulb with nozzle to remove the snow.

b. Equipment, such as telescopes on directors, should be covered while n toin use. If a cover cannot be made to include the whole instrument, bag-type cloth covers should be made to go over the eyepieces and tube extensions. Cloth covers are better than airtight covers, such as the leather covers provided for some instruments, because the cloth covers allow breathing of the air in contact with the lens, preventing condensation when the instrument is subjected to lower temperatures. Cloth bag covers can be made with a spring, elastic, or drawstring at the mouth, so they can be held in place and, also, easily and quickly removed.

c. A temporary method of keeping snow out of eyepieces and objective tube extensions is by putting loose wads of tissue lens paper into them when the instrument is not in use. These wads can be removed easily.

106. Compasses, Binoculars, and Other Optical Instruments

a. The liquid in the lensatic compass in extreme cold will become thickened. The heavy liquid slows the action of the compass and may make it inaccurate. This type of compass should be carried near the body in the inner clothing in order to keep the liquid warm and thin. The dry-type compass is not affected by extreme-cold weather.

b. Binoculars and other liquid-free optical instruments are not affected by cold weather. However, condensation does form when instruments are taken from cold air into warm air. Therefore, instruments should be left outside or "anticondensation" containers should be used (par. 81*c*(3)).

107. Local Control Systems M16A1E1, M16A1, and M22

a. The local control systems M16A1E1, M16A1, and M22 can be expected to operate satisfactorily at temperatures down to —25° F. and can be stored at temperatures down to —80° F.

b. The oil gears utilized on the systems will be lubricated for cold-weather operation as prescribed in (1) through (6) below.

(1) Lubricating oil (OES) is substituted for engine oil (OE) in all cold-weather operations.

(2) Drain oil from hydraulic oil reservoir (2 gal). Remove, clean, dry, inspect, and install filter screen. Fill reservoir with petroleum-base hydraulic fluid (OHC).

(3) Fill and level (if required) the oil gear drive gears with lubricating oil (OES).

(4) Lubricate the output-shaft-bearing oil gear with aircraft and instrument grease (GL).

(5) Clean and grease the output coupling with automotive and artillery grease

(GAA, amend. 2), and clean and install the band.

(6) Remove output-gear-clutch cover. Clean the gear teeth and lubricate sparingly with automotive and artillery grease (GAA, amend. 2).

c. Drive controllers M12A1 and M12E2 utilized on local control systems in *a* above, do not require additional cold-weather lubrication.

d. Azimuth indicators should perform satisfactorily at low temperatures without special internal lubrication. However, the linkage points should be relubricated in accordance with latest lubrication orders and as prescribed in (1) and (2) below.

(1) Lubricate the azimuth-indicator shaft with aircraft and instrument grease (GL).

(2) Lubricate the azimuth-indicator bearing with automotive and artillery grease (GAA, amend. 2); also, lubricate the antibacklash gears, but, only when the azimuth indicator is required to be removed from the vehicle.

108. Computing Sights M38, M19A1, and M13A1

a. Computing sights M38, M19A1, and M13A1 will operate satisfactorily at temperatures down to —25° F. and storage to —80° F.

b. Cold tests on computing sight M38 indicate satisfactory operation down to —65° F.

c. Relubrication in anticipation of extreme-cold-weather operations is normally not required for the computing sights.

d. Lubricate the computing sights as specified in the operator's technical manual, replacing the lubricants prescribed by cold-weather lubricants specified in table I.

e. In all cases, necessary lubrication beyond the scope of organizational maintenance must be performed only by authorized personnel.

109. Antiaircraft Fire-Control System M33

a. The antiaircraft fire-control system M33 is designed to operate at all temperatures. However, for maximum performance at low temperatures, the provisions in (1) through (3) below, should be followed.

(1) Replace all 393A thyratrons by 6901 thyratrons (Ord No. 766086).

(2) All RG 64/U cables must be replaced by the latest-type Neoprene cables (class C).

(3) Requisition winterization kit (5800824) for the antiaircraft fire-control system M33. This kit contains strip heaters for the track and acquisition antennas.

b. The winterization kit (*a*(3) above) should be assembled to the acquisition radar pedestal for protection against wind and snow and for protection of personnel while performing maintenance.

Note. Refer to TM 9-6092-1-1 for additional information on extreme-cold-weather operation.

c. Extreme-cold-weather lubrication will be performed in accordance with LO 9-6092.

d. Provisions have been made for insulating trailer floors. Where 60,000 BTU heaters are supplied, these should be operated in accordance with pertinent technical manuals.

110. Antiaircraft Fire-Control System M38

a. The antiaircraft fire-control system M38 is designated to operate at temperatures down to —40° F. and for safe storage to —80° F. when utilizing thermostatically controlled heaters.

b. In order to obtain optimum performance of the system M38 in extreme-cold-weather areas, the pertinent modification work orders must be applied. Refer to DA Pam 310-4 for a listing of these modification work orders.

c. Refer to latest applicable lubrication order for proper lubrication. Additional lubrication is not necessary, since the system is completely lubricated for low-temperature operation. However, where excess lubrication is found to be evident, clean the parts with drycleaning solvent or mineral spirits paint thinner and lubricate lightly. If incorrect lubricants are suspected, relubrication should be accomplished.

d. For operation of the heater system at low temperatures, the procedures in (1) and (2) below, will be followed.

(1) The three ventilating ports on the computer console cover must be opened; all others are to remain closed.

(2) The following switch positions will apply:
Computer console switch DRY
Power control heater switch NORMAL

Radar heater switch ON
Radar power switch ON

e. For low-temperature storage, a suitable cable must be supplied for the storage heater outlet on the computer console from a 115-volt, 60-cycle, single-phase power source. During storage-heating, the following switch positions will apply:

Computer heater switch NORMAL
Power control heater switch NORMAL
Radar switch OFF
Radar switch OFF

111. Generating Units

a. Generating units are vital to weapon units operating in remote control, because without them, the directors cannot compute data or send it to the gun and the gun will not operate by power control. The generating unit must be able to start quickly and deliver full power, so that the unit can function in remote control when an alert is called. If the generating unit cannot be started or starting takes so long that the target has passed, the rest of the fire-control materiel is useless. The importance of taking precautionary measures cannot be overemphasized. Use of protective covers, proper winterization treatment, and regular operation are essential to insure efficient functioning of generators.

b. The generating unit should be kept covered with a canvas or paulin (fig. 51) when not in use. Windblown snow, especially fine, dry snow, will enter small openings until the interior of the unit is packed full (fig. 52). If temperatures stay below the freezing point, the snow will probably have no effect on the starting of the engine. However, when the unit is started, the heat from the engine will melt the snow and the resultant moisture may short the ignition, causing the engine to miss or stall under load. When the unit is shut down, the melted snow will freeze on the linkage, switches, and controls, making it difficult, if not impossible, to start or operate the engine again. The same thing will happen if the temperature rises and the snow inside the generating unit melts. If snow does get into a unit despite the use of protective covers, it should be brushed out immediately.

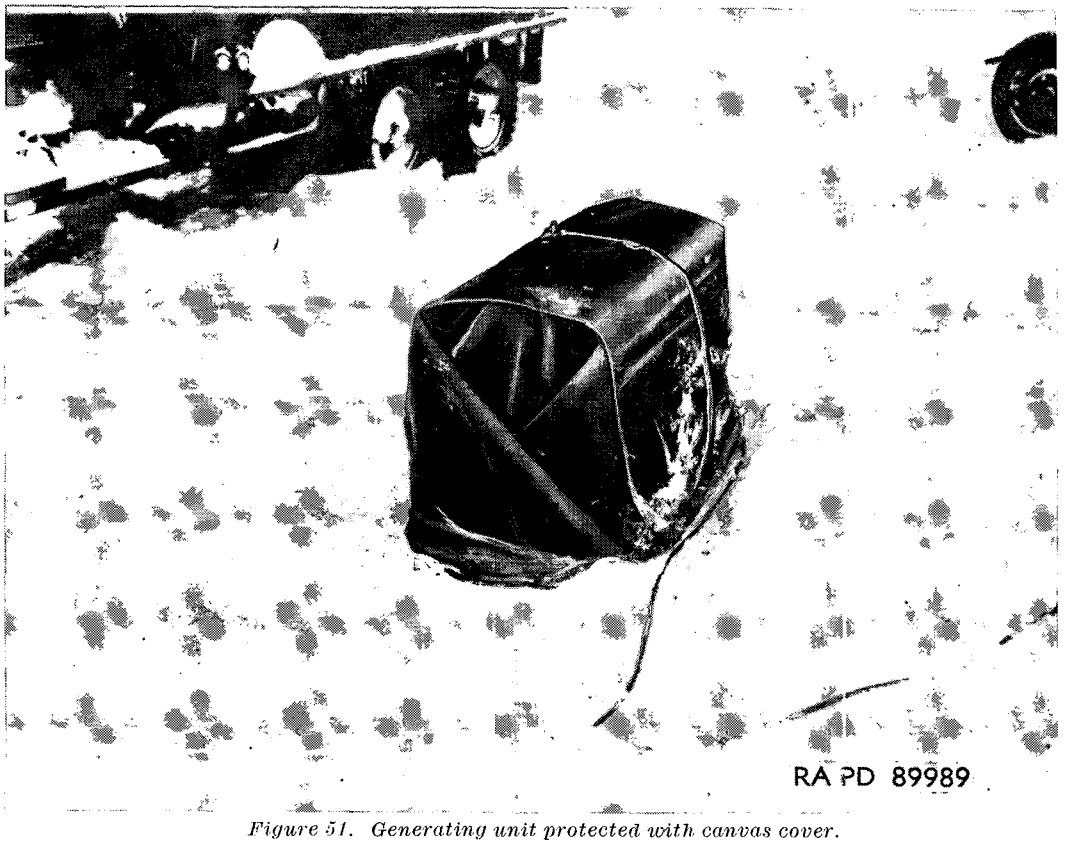


Figure 51. Generating unit protected with canvas cover.

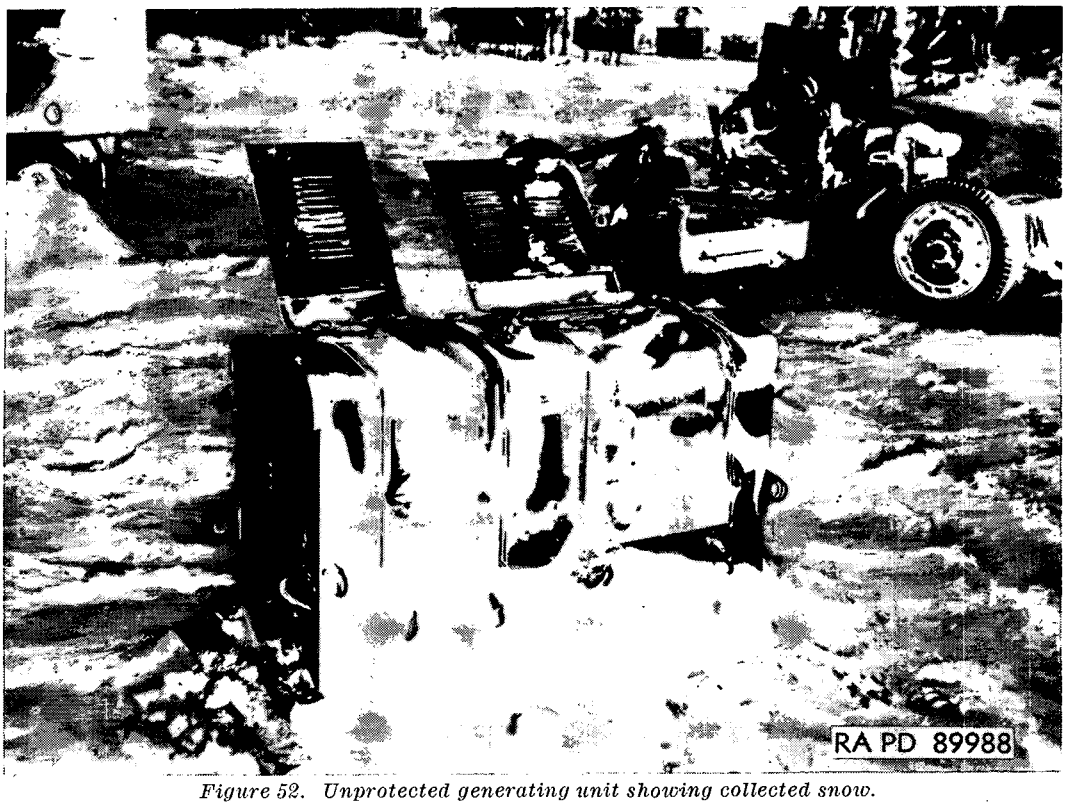


Figure 52. Unprotected generating unit showing collected snow.

c. If the generating unit has been properly winterized and is in good mechanical condition, it will operate at the lowest subzero temperatures likely to be encountered.

(1) All linkages should be very lightly lubricated with automotive and artillery grease (GAA, amend. 2), so that they will operate easily at low temperatures.

(2) Assemblies on the starters must be kept clean and free of ice or snow. They will not be lubricated.

(3) The governor linkage should be lightly lubricated with automotive and artillery grease (GAA, amend. 2) and the joints kept free of ice and snow, or the governors will not function and the engine will "run away" when it is first operated.

(4) The choke and throttle control wires and knobs may become hard to operate at low temperatures. The panel knobs will be removed and the shafts that go through the panel smoothed down with aluminum-oxide abrasive cloth or crocus abrasive cloth. Remove wires from their casings; clean the wires and inside of the casings with dry-cleaning solvent or mineral spirits paint thinner; then, lubricate lightly with general-purpose lubricating oil (PL, special).

(5) Remove the tachometer cable from its sheath, and clean the inside of the sheath and cable with drycleaning solvent or mineral spirits paint thinner. Lubricate the cables with a light coat of general-purpose lubricating oil (PL, special).

CHAPTER 4
SMALL-ARMS MATERIEL

Section I. COLD-WEATHER PROBLEMS

112. General

Note. The general information in chapter 1 pertains to small-arms materiel. Refer to chapter 3 for information on weapons materiel other than small-arms materiel and related sighting and fire-control materiel.

In extreme-cold weather many conditions will greatly affect the operation and maintenance of small arms. All individuals must be well aware of these conditions, in order that they may properly lubricate, operate, and maintain their weapons under these adverse circumstances.

113. Effects of Extreme Cold on Small Arms

a. Sluggishness. The most important and common problem is the sluggishness of the operation of the weapon in extreme cold. Normal lubricants thicken in low temperature and stoppage or sluggish action of firearms results. During the winter, weapons must be stripped completely and cleaned with a dry-cleaning solvent or mineral spirits paint thinner to remove all lubricants and rust-preventive compounds. The prescribed application of lubricating oil (LAW) should then be made. These lubricants will provide proper lubrication during extreme-cold weather and help minimize snow and ice from freezing on the weapons.

b. Breakages and Malfunctions. Another problem that faces the user in the areas of severe cold is a higher rate of breakages and malfunctions. These can also be attributed primarily to the cold, although snow in a weapon may cause stoppage and malfunctions. The tempered metal of automatic weapons, for example, will cool to a point where it cannot be touched by human flesh. This extreme cold makes the metal brittle. When the weapon is fired at subzero temperatures, the temperature of the barrel and gun will rapidly rise to between 200° and 700° F., depending upon the number of rounds fired. This again reduces the temper and, because the parts are working, breakages will occur early in the firing while the weapon is warming up. Many malfunctions also occur during this period due to the presence of ice or snow in the weapon or freezing of working parts. The weapons should first be fired at a slow rate of fire. Once the parts have warmed up, the rate of fire may be increased. One of the main problems is to insure that snow and ice do not get into the working parts, sights, or barrel. The weapon must be carefully handled during movement through the snow-covered woods and, especially, under combat conditions in deep snow. In the bivouac area, an improvised stand should always be constructed to protect the weapons from the elements.

c. Condensation on the Weapons. Condensation forms on weapons when they are taken from the extreme cold into any type of heated shelter. This condensation is often referred to as "sweating." When the weapon is taken out into the cold air, the film of condensation freezes, especially in the internal parts, and stoppages and malfunctions result. For this reason, the weapons must be left outdoors or stored in unheated shelters. When weapons are taken into heated shelter for cleaning purposes, "sweating" may continue for as long as 1 hour. Therefore, when time is available, wait 1 hour, remove all condensation, and then clean and lubricate the weapon (pars. 114 and 115). In addition, this action will prevent corrosion.

d. Ice Fog. A problem of visibility close to the ground occurs when an automatic weapon is fired in temperatures below —20° F. As the round leaves the weapon, the heat it generates causes condensation and crystallization of the vapor in the air, creating minute ice particles and producing ice fog. This fog will hang over the weapon and follow the path of the projectile, obscuring the gunner's vision along his line

of fire. If the air is still, the ice fog will remain for many minutes and hover in one place. Therefore, the weapon will have to be displaced to the right or left to again secure use of its sights if firing is to be continued.

e. Emplacement. Most crew-served infantry weapons need a natural "base" or gun platform to raise the barrel above the snow surface so it may be fired accurately. In summer, the ground provides a solid base, yet has enough resilience to act as a shock absorber. In winter, the soft snow gives under the fire of the gun. If the weapon is emplaced on the solid frozen ground, there is no "give" and all the shock of firing is absorbed by the weapon itself, resulting in breakage. Also, the slippery surface of the frozen ground may allow the weapon to slide. If the snow is not too deep and if time is available, tripods and baseplates should be dug into the ground or solidly positioned by expedient means to keep them from moving.

Section II. LUBRICATION IN EXTREME-COLD WEATHER

114. Cleaning Prior to Lubrication

It is extremely important that all small-arms materiel, including mounts, be thoroughly cleaned and washed. Use dry-cleaning solvent or mineral spirits paint thinner to clean items prior to lubrication (par. 115).

115. Lubrication

The procedures in *a* and *b* below will govern the lubrication of small-arms materiel under conditions of extreme cold to —65° F. Weapons fired without lubrication function sluggishly at these temperatures.

Note. Refer to table I for complete information on lubricants.

a. After small arms have been cleaned and washed (par. 114), use a cleaning patch saturated with weapons lubricating oil (LAW) when temperatures are below 0° F. to lubricate parts. Wring out patch to remove surplus oil and wipe patch over all surfaces of operating mechanisms, thereby, depositing a thin film of oil. Weapons must be lubricated very lightly, as a slight excess of lubricant at low temperatures will cause the action to be sluggish and may result in malfunctions.

Note. For small arms exposed to salt-water atmosphere, use general-purpose lubricating oil (PL, Special).

b. Lubricate mounts with automotive and artillery grease (GAA, amend. 2).

Section III. OPERATION AND MAINTENANCE

116. General

The operation and maintenance procedures in *a* through *e* below, are for all small-arms materiel and procedures in paragraphs 117 through 125 are for specific items. Paragraph 126 contains procedures for ammunition items.

a. Weapons will function under extreme-cold conditions, provided they are properly maintained. Normal lubricants thicken in cold weather and stoppages or sluggish action of firearms will result.

Note. Weapons must be stripped completely and cleaned (par. 114) to remove all lubricants and rust-preventive compound.

The prescribed application of lubricants should then be made (par. 115). These lubricants will provide proper lubrication during extreme-cold weather and help minimize the freezing of snow and ice on and in weapons.

b. The user must insure that snow and ice do not get into the working parts, sights, or barrell of the weapon. Even a small amount of ice or snow may cause malfunction of the weapon. An improvised stand should be constructed to hold weapons. Muzzle and breech covers should be used. Before firing a weapon, it must be examined carefully, especially the barrel, which may be blocked with ice or snow and burst when fired. Snow on the outside if not removed may drop into the breech and later form ice, causing malfunctioning of weapon.

c. Condensation (par. 113*c*) forms on weapons when they are taken from the extreme cold into any type of heated shelter. When weapons are taken into a heated shelter, "sweating" may continue for as long as 1 hour. Therefore, when time is available, men should wait 1 hour and then remove all condensation and clean the weapon.

d. During the breakup period or the freezup period, the danger of rust and corrosion is at its

greatest. In extreme-cold weather, the lack of mositure in the air decreases this danger, but the problem of ice and snow will necessitate frequent checking and cleaning of weapons.

e. Should parts of a weapon become frozen, warm them slightly and move them gradually until unfrozen. If the weapon cannot be warmed, all visible ice and snow should be removed and parts moved gradually until action is restored. An application of rifle-bore cleaner solvent cleaning compound will help. Ice in the barrel can be removed with warm rifle-bore cleaner solvent cleaning compound if slow warming is not possible.

Caution: **When firing, do not let the hot parts of the weapon come in contact with the snow. The snow will melt and, on cooling, form ice. When changing barrels, do not lay them on the snow; rapid cooling may warp them.**

117. Cal. .45 Automatic Pistol

The cal. .45 automatic pistol cannot be fired while one is wearing arctic mittens. The firer must remove his mittens or use the lightweight trigger finger mitten. The only other difficulty that may be encountered is the breakage of moving parts due to the cold. However, this is not as serious as with the larger automatic weapons.

118. Cal. .30 Rifle, Cal. .30 Automatic Rifle, and Cal. .30 Carbine

Firing of the cal. .30 rifle, automatic rifle, or carbine necessitates the use of trigger finger mittens. This means that the individual cannot operate the weapon over a sustained period of time in extreme-cold weather. All these weapons create ice fog (par. 113*d*). However, since the firer can readily move his position, this poses no problem. The main problem is that more malfunctions and breakages are caused in firing due to the cold or fouling of the weapons with snow or ice. The carbine is sensitive and also the most difficult to repair because the parts of the weapon are small and difficult to handle with gloves or mittens on. The rifle M1 has, in addition, the problem of the gas port locking screw freezing. Moving parts, especially those affected by recoil, are most subject to breakage. These parts are the sear, firing pin, and operating rod. Malfunctions of the automatic rifle may also be caused by defective and plugged magazines. Special care must be taken to keep magazines free from snow. Also, the wing nuts on the bipod, bipod parts, and bipod ring tend to freeze together or to the barrel of the weapon. To avoid this problem, apply lubricating oil (LAW) on the part concerned.

119. Rifles M14 and M15

Tests under extreme-cold weather conditions have shown the rifles M14 and M15 to be very satisfactory for use in subzero temperatures. The weapons were found to be highly accurate and to have less breakages and malfunctions than the cal. .30 rifle, carbine, automatic rifle, and submachine gun that they replace.

120. Cal. .30 and Cal. .50 Machine Guns

The cal. .30 and cal. .50 machine guns must be well lubricated because of their many moving parts. If weapons lubricating oil (LAW) is unavailable, cold weapons may be operated dry at a slow rate of fire. This procedure will result in fewer malfunctions. Once the parts have warmed up, general-purpose lubricating oil (PL, Special) may be applied and the rate of fire may be gradually increased. Machine guns have a high rate of breakage and malfunction due to the cold weather. Parts especially affected are sears and bolt parts. Extra repair parts of this type should be readily available. The most common malfunction, occurring early in the firing, is called "short recoil' (bolt does not recoil fully to the rear). Applying immediate action will reduce this stoppage and, as the metal warms, the problem will diminish. A second malfunction is caused by freezing and hardening of the buffer. This, in turn, causes great shock and rapid recoil, thereby increasing the cyclic rate of the weapon. When this happens and the gun continues to fire, something has to give and, generally, parts will break. Condensation will cause the freezing of parts, as on most other weapons. Ice fog greatly impairs the operation. Therefore, two to three alternate gun positions must be prepared.

121. Machine Gun M60

The machine gun M60 is a comparatively effective weapon in extreme-cold weather areas. It is subject to some breakage of recoiling parts and, occasionally, the buffer freezes, increasing

the cyclic rate of fire. The weapon is readily assembled or disassembled due to the larger parts that are much easier to handle with gloves on. The main problems with the gun concern visibility (due to ice fog), lubrication (which is corrected by the use of weapons lubricating oil (LAW)), and the malfunction of a short recoil with cold guns.

122. Cal. .45 Submachine Gun

The cal. .45 submachine gun has problems similar to the other small arms, especially with condensation, because it is normally carried inside a warm vehicle. The magazine should be well protected from the snow.

123. Rifle Grenade Launcher

The rifle grenade launcher does not pose any special problems, except that the range may be slightly reduced due to the slower burning of the crimped cartridge. As a result, the sight may not hold true and may have to be adjusted in accordance with procedures in the pertinent operator's manual.

124. 3.5-Inch Rocket Launcher

The main problem of the 3.5-inch rocket launcher concerns the ammunition used. The 3.5-inch round has a burning propellant that moves it toward the target. This propellant, due to the effect of the blast and its slow-burning quality in extreme-cold weather, is highly dangerous at low temperatures. Also, the range is reduced due to the slow-burning propellant. The gunner has to make his own firing tables and probably sight slightly high, especially at longer ranges. The weapon should not be fired in a peacetime situation at temperatures below 0° F. Due to the simplicity of the weapon, there are few malfunctions and breakages with the launcher. The weapon has no emplacement problems, but will creat ice fog and, thus, will have to be moved when the fog persists.

Warning: **The gunner and loader can be burned and lacerated by particles of the burning propellant that are thrown back as the round leaves the muzzle of the launcher. The backblast area will be greatly increased and precaution must be exercised in operating behind these weapons. Also, both gunner and loader must be equipped with face masks and gloves.**

125. Portable Flame Thrower M2A1

The portable flame thrower M2A1 has limited use in extreme-cold weather areas. The rubber components, particularly the fuel hose, become rigid at subzero temperatures. Servicing of the flame thrower must be accomplished outside shelters, to prevent frost from accumulating in the air pressure regulator. When firing the flame thrower at low temperatures, two or more ignition charges should be used to insure ignition of the fuel. The preparation of thickened flame thrower fuel at low temperatures according to prescribed mixtures is less dependable and sample batches of prepared fuel should be test-fired whenever the situation permits.

126. Ammunition

a. Extreme-cold weather does not materially affect the accuracy of weapons nor the performance of small-arms ammunition. Ammunition should be kept at the same temperature as the weapon. It should be carried in the bandoleers and the additional ammunition placed in the pockets of the outer parka and in the rucksack. Ammunition, clips, and magazines must be cleaned of all oil and preservative and must be checked frequently; all ice, snow, and condensation should be removed. Cartridge containers, magazines, and ammunition drums must be kept closed, in order to prevent the formation of rust or ice.

b. Ammunition should be stored in its original container, raised off the ground and covered with a paulin. Ammunition so stored should be suitably marked, in order to locate and identify it in the event it becomes covered with snow.

c. Resupply of ammunition may be restricted. All personnel must be made aware of the necessity for ammunition economy and fire discipline. Loaded clips, magazines, or single rounds dropped into the snow are quickly lost; therefore, careful handling of ammunition is essential.

CHAPTER 5

GUIDED-MISSILES MATERIEL (NIKE-AJAX AND NIKE-HERCULES ANTIAIRCRAFT GUIDED MISSILES)

127. General

a. The NIKE-AJAX and NIKE-HERCULES antiaircraft missile systems are designed to operate at temperatures down to —10° F. for indefinite periods of time and at temperatures down to —60° F. for shorter periods of time. TM 9–1970–2 lists the time periods for minimum safe-firing temperatures of the rocket motor units.

b. Information concerning extreme-cold weather procedures for materiel associated with the guided-missiles materiel is contained elsewhere as follows:

(1) Antifreeze materials, fuels, hydraulic fluids, and lubricants—chapter 1, section II.
(2) Personnel heaters—chapter 2, section I.
(3) Auxiliary equipment (e.g., air compressors, auxiliary engines, power takeoffs, etc.)—chapter 2, section X.
(4) Fire-control materiel—chapter 3.

128. Winterization Kits

a. Two winterization kits are provided for the NIKE-AJAX guided missile round. The launcher modification winterization kit, for blanket heater power connections, provides outlet plugs at the test stations along the launching rails. This kit is listed in ORD 7 SNL Y5 as part number 8162297 (FSN 1050–098–8565). The electric-blanket kit, listed in ORD 7 SNL Y5 under part number 8162296 (FSN 1050–098–8564), consists of five blankets (four electric and one unheated), installation manual, two fin webbing straps (includes one spare), and four main-disconnect webbing straps (includes two spares). For surface-battery installations, four blanket kits should be used for each launcher; for subsurface installations, one blanket kit should be sufficient. These kits will be issued contingent upon geographical location and on the basis of requisitions approved by the Army commander.

b. The external blankets mentioned in *a* above protect only the rocket-motor bottles. A canvas weather cover protects the missile externally. Internal heating circuits within the missile are covered thoroughly in TM 9–5001–12.

129. Lubrication

Refer to the latest applicable lubrication order for proper lubrication. Ordinarily, it will be necessary to change grades of lubricant only when air temperatures fall consistently in the next higher or lower range; above 32° F., from 40° to —10° F., and from 0° to —65° F. Sluggish operation during extreme-cold weather is usually an indication of thickening lubricant. This can be corrected by changing to the lubricant grade specified for the next lower temperature range. Refer to paragraphs 7 through 10 for general information concerning lubricants and lubricating practices in extreme-cold weather.

130. Operation and Maintenance

a. General.

(1) Heating blankets and internal heaters may cause moisture to collect in the vicinity of the heated area. Any noticeable collection of moisture on the missile surfaces should be removed. Inspect the inside of heating blankets and weather covers for condensation during the daily check of the missile.
(2) The missile must be kept free of any accumulation of frost or ice. Ice forming on the movable control surfaces will restrict their movement. Ice or frost forming on the skin may destroy the aerodynamic stability of the missile.

(3) Exposed connectors should be inspected daily for condensation around the pins. Do not jam or force connectors during mating. Metal becomes brittle in extreme cold and the male pins will break off very easily.

b. Oil-Filled Variable Resistors. Oil-filled variable resistors must be lubricated in accordance with the applicable lubrication order. However, for operation at temperatures consistently below —10° F., the oil must be drained and the variable resistor operated with no oil in the reservoir. Flush the reservoir with the prescribed oil once a month. When temperature rises above —10° F. and remains there consistently, flush the reservoir and fill to the proper level.

c. Electron Tubes. Certain electron tubes may be affected by extreme cold to such a degree that operation of the associated circuitry becomes erratic. This condition is due to ambient temperatures below the point at which ionization of the gas within the eletcron tube occurs. Such a condition will cause abnormally low or no current flow from plate to cathode of the tube. To avoid this condition, all JAN 393A tubes presently used will be replaced with electron tube type 6901—7660686 in tactical systems located in areas where temperatures are expected to go below 10° F. Tubes should be warmed up before operating them in extreme-cold weather. This may be accomplished by permitting the compartment door of the radar cabinet to remain open for 30 minutes, to permit the cool air circulated by the ventilator blower to bypass the tubes. Also, place a piece of cardboard or something similar over any ventilating openings that permit the blower from moving air past tubes to cool them. If the air flow is blocked, the tubes heat up faster. Leave the cardboard in place for the first 15 or 20 minutes.

d. Antennas. Snow and ice impose severe hardships on the target and missile tracking radars and on the personnel who operate and maintain this equipment. Snow packing into the openings of the track antenna lens and ice forming on the lens and trunnion assembly will unbalance the antenna. This will impose a severe strain on the drive motors and bearings and result in erroneous target and missile information to the computer. Use of a track antenna sleeve 8514983 will protect the track antenna from blowing snows and, to a limited extent, from ice formations. Use of a track antenna equipment enclosure 8513345 will protect maintenance personnel from adverse climatic conditions while performing maintenance on the missile and target tracking radars. The acquisition radar can be emplaced in a combat-type igloo. Distribution of these shelters is controlled by USARADCOM. Rotate the antennas manually before operating in subzero temperatures. This permits the antennas to loosen up if frozen stiff.

131. Storage of Missile Rounds

Acceptable static storage conditions for the missile rounds are given in table VII.

Table VII. Static Storage Limits for Missile Rounds

Storage temperature (° F.)	Maximum storage time (hours)
—20	Indefinitely
—25	75
—30	50
—35	40
—40	34
—45	31
—50	29
—55	27
—60	24
—65	22
—70	19
—80	14

CHAPTER 6
TOOLS AND EQUIPMENT

132. General

The general information in chapter 1 pertains to tools and equipment. Refer to chapter 2 for information concerning automotive-type items and to paragraph 111 for information on generating units.

133. Shop Truck and/or Trailer Equipment

a. Equipment such as latches, milling machines, shapers, drilling machines, and grinders mounted in shop trucks or trailers should not be operated until the temperature inside the truck or trailer is at least 32° F.

b. Before performing machining operations, start the machines to be used and allow it to run without load until the lubricants are thoroughly distributed over the critical bearing surfaces. An additional warmup period should be allowed for precision machines having spindles or other operating parts with close clearance tolerances. This warmup period will require from 5 to 30 minutes and must be of sufficient duration to allow critical moving parts to expand to their normal size, in order that proper clearances are attained.

134. Arc-Welding Machine

a. General. The arc-welding machine scheduled for operation in extreme-cold weather requires extensive preparation. Generally, extreme cold will cause lubricants to thicken or congeal, batteries to freeze or furnish insufficient current for cold-weather starting, and insulation to crack and form short circuits; it will also prevent fuel from vaporizing and properly combining with air to form a combustible mixture for starting and cause the various construction materials to become brittle and easily subject to damage. A winterization kit may be provided for the arc-welding machine when protection against extreme-cold weather is required. The kit is provided with installation and operating instructions.

b. Operation.

(1) When placing the arc-welding machine in operation, be on the alert for indications of the effect of cold weather. Congealed lubricants may cause failure of parts. Allow a warmup period before loading the machine, to permit the gears, bearings, and other moving parts to reach normal operating temperatures. Constantly, note instrument readings and stop the operation and investigate the cause if instruments consistently deviate from normal.

(2) If arc-welding machine is equipped with a winterization kit, start engine heater immediately after engine "shutdown" and make certain it is operating effectively. If no winterization kit is provided, remove battery and store in a warm place.

Note. Do not drain engine oil (OES), as it will remain fluid even though unheated.

(3) Place the arc-welding machine broadside to any wind and leave the side doors in place on the side from which the wind is blowing. Partially cover the machine with paulin in such a manner to permit circulation of cooling and to avoid covering the muffler-to-manifold exhaust or exhaust tail pipes.

(4) Remove the arc-welding machine to a heated inclosure or cover with paulins, but keep the ends of the paulin off the ground, to prevent them from freezing to the ground.

(5) Refuel immediately, in order to prevent condensation in the fuel tank.

c. Maintenance.

(1) Check the specific gravity of the battery electrolyte (par. 45*a*).

(2) Check fuel system for presence of water and clean as necessary.

(3) Check radiator coolant, using hydrometer to test strength (par. 30*j*). Add water or strengthen solution as required.

(4) Fill engine crankcase with engine oil (OES) (table I (par. 8)).

(5) Operate engine, but do not weld until engine operating temperature is in normal range (140° to 180° F.).

(6) Keep side doors in place when arc-welding machine is not in use.

APPENDIX
REFERENCES

1. Publication Indexes

The following indexes should be consulted frequently for latest changes or revisions of references given in this appendix and for new publications relating to materiel covered in this manual.

Index of Army Motion Pictures, Film Strips, Slides, and Phono-Recordings	DA Pam 108–1
Military Publications:	
Index of Administrative Publications	DA Pam 310–1
Index of Blank Forms	DA Pam 310–2
Index of Graphic Training Aids and Devices	DA Pam 310–5
Index of Supply Manuals—Ordnance Corps	DA Pam 310–29
Index of Technical Manuals, Technical Bulletins, Supply Bulletins, Lubrication Orders, and Modification Work Orders.	DA Pam 310–4
Index of Training Publications	DA Pam 310–3

2. Supply Manuals

The following Department of the Army supply manuals pertain to this materiel:

Chemical and Chemical Products	SM 3–5–6800
Fuels, Lubricants, Oils, and Waxes	SM 10–1–9100
Launcher, Monorail, Guided Missile, M22, M22A1, M22A2, and M22A3 (NIKE-AJAX Antiaircraft Guided Missile System).	ORD 7 SNL Y–5

3. Forms

The following forms pertain to this materiel:

DA Form 2028 Recommended Changes to DA Technical Manual Parts Lists or Supply Manual 7, 8 or 9.

DD Form 6, Report of Damaged or Improper Shipment.

4. Other Publications

The following explanatory publications pertain to this materiel:

Ammunition: Antiaircraft Guided Missile M1 (NIKE-AJAZ); Identification, Description, Packing, Care, Handling, Preservation, and Destruction.	TM 9–1970–2
Artillery Materiel and Associated Equipment	TM 9–2300
Care and Maintenance of Pneumatic Tires	TM 9–1870–1
Cold-Starting Aid Kit (Slave Kit) M40; Operation and Maintenance	TB ORD 390
Cooling Systems: Vehicles and Powered Ground Equipment	TM 9–2858
Fuel-Burning Heaters for Winterization Equipment	TM 9–8662
Fundamentals of Small Arms	TM 9–2205
General Supply; Winterization Equipment for Automotive Materiel	SB 9–16
Guided Missile System, XSAM–A–7 (NIKE–I) Launcher and Launcher Control Materiel, Operator's Notes, Vol I.	TM 9–5001–12
Inspection Guide: Care and Maintenance of Ball and Roller Bearings	TM 37–265
Logistics (General): Unsatisfactory Equipment Report	AR 700–38
Lubrication	TM 9–2835
Lubrication Order: Fire Control System, Antiaircraft M33	LO 9–6092
Military Symbols	FM 21–30 AFM 55–3

Military Terms, Abbreviations, and Symbols:	
Authorized Abbreviations and Brevity Code	AR 320–50
Dictionary of United States Terms	SR 320–5–1
Military Training	FM 21–5
NIKE-AJAX and NIKE-HERCULES System Winterization Kits and Heating Blankets.	SB 9–160
Operation and Organizational Field and Depot Maintenance: Storage Batteries Lead-Acid Type.	TM 9–6140–200–15
	TO 36Y4–1–194
Ordnance Maintenance and General Supply in the Field	FM 9–10
Ordnance Maintenance: Materials Used for Cleaning, Preserving, Abrading and Cementing Ordnance Materiel, and Related Materials Including Chemicals, Lubricants, Indicators, and Hydraulic Fluids.	TM 9–1007
Organizational Maintenance: Spark Plugs Used in Ordnance Materiel	TM 9–8638
Painting Instructions for Field Use	TM 9–2851
Preventive Maintenance, Supply, Inspection, and Training Procedures—Tactical Motor Vehicles.	TM 9–2810
Principles of Artillery Weapons	TM 9–3305–1
Principles of Automotive Vehicles	TM 9–8000
Principles of Fire Control Materiel	TM 9–3305–2
Safety: Accident Reporting and Records	AR 385–40
Small Arms Materiel and Associated Equipment	TM 9–2200
Special Operations:	
Basic Arctic Manual	FM 31–70
Operations in the Arctic	FM 31–71
Supply Procedures: List of Standard Lubricants, Hydraulic Fluids, Liquid Fuels, and Preservative Materiel Used by the Army.	SB 38–5–3
Techniques of Military Instruction	FM 21–6
Use of Antifreeze Solutions in Engine Cooling Systems	TB ORD 651
Welding Theory and Application	TM 9–237
	TO 34W4–1–5
Winterization Kits for Automotive Material	TB 9–2855-series

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NG: State AG (3); TOE units—same as Active Army except allowance is one copy per unit.

USAR: None

For explanation of abbreviations used, see AR 320–50.

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