FM 20-22

DEPARTMENT OF THE ARMY FIELD MANUAL

VEHICLE RECOVERY OPERATIONS

HEADQUARTERS, DEPARTMENT OF THE ARMY

JULY 1970

LOAD RESISTANCE

TERRAIN & GRADE----------------	VEH. WT X1
MUD-------ROADWHEEL DEPTH------	1 x VEH. WT.
FENDER DEPTH---------	2 x VEH. WT.
TURRET DEPTH---------	3 x VEH. WT.
OVERTURNED 1/2 of	VEH. WT.

LOAD RESISTANCE REDUCTIONS

10 Percent - Recovery in the opposite direction from which the mired vehicle was traveling.

40 Percent - Applying power to the tracks of the mired vehicle.

50 Percent - Combination of recovery in the opposite direction and applying power to the tracks of the mired vehicle.

RECOVERY CAPABILITIES

Vehicle Type	*Maximum Capacities (tons) Winch	Lift	Tow
M543 Wrecker Truck------------	22.5	10	15
M578 Recovery Vehicle--------	30	15	30
M88 Recovery Vehicle---------	45	25	56

*Winches pull maximum loads as first layer of cable goes onto drum. Winches havning all cable on drum pull about 1/2 of maximum capacity.

RIGGING FUNDAMENTALS

MECHANICAL ADVANTAGE OF TACKLE

RESISTANCES:

Load: Weight of the vehicle to be recovered divided by applicable terrain factor or multipled by applicable terrain factor for mud.

Overturn: One half vehicles weight.

Tackle: Ten percent of load resistance times number of sheaves.

Total: Load resistance plus tackle resistance.

FORCES:

Fall line: Total resistance divided by mechanical advantage of the Tackle System.

Dead line: Multiple fall line force times number of lines dead line supports.

CAPACITY

Fiber ropes: T = $4 \times D^2$

Wire rope and chain: T = $40D^2$

WIRE ROPE AND CHAIN CAPACITIES

3/8 in. =	5.625 tons	3/4 in. =	22.5 tons
1/2 in. =	10 tons	7/8 in. =	30.625 tons
5/8 in. =	15.625 tons	1 in. =	40 tons

1 1/8 in. =	50.625 tons
1 1/4 in. =	62.5 tons
1 1/2 in. =	90 tons

UNITED STATES ARMY INFANTRY SCHOOL

FORT BENNING, GEORGIA

TITLE

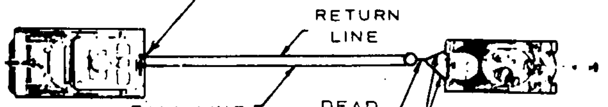
RECOVERY CARD

WINCH
VARIABLE CAPACITIES

Winch Type	Cable Layer	Cable on Drum (ft.)	Capacity (lb.)
10,000 lb.	1	0-39	10,000
	2	40-85	8,450
	3	86-138	7,340
	4	139-199	6,460
	5	200-266	5,780
20,000 lb.	1	0-41	20,000
	2	42-91	16,900
	3	92-148	14,500
	4	149-213	12,800
	5	214-287	11,400
45,000 lb.	1	0-42	45,000
	2	43-93	37,700
	3	94-153	32,500
	4	154-220	28,500
	5	221-296	25,300
	6	297-380	22,800
60,000* lb.	1	0-55	60,000
	2	56-128	52,000
	3	129-208	46,000
	4	209-300	40,000
90,000* lb.	1	0-41	90,000
	2	42-91	76,000
	3	92-149	65,000
	4	150-215	57,000

* Low gear

RIGGING EXAMPLE



LOAD RESISTANCE IS 50 TONS
(50 ton tank times 1 for roadwheel deep mire)

MECHANICAL ADVANTAGE IS 2 TO 1
(50 ton load resistance divided by 45 ton winch capacity)

TACKLE RESISTANCE IS 5 TONS
(10 percent of 50 tons times once for each shove in the rigging)

TOTAL RESISTANCE IS 55 TONS
(50 load resistance plus 5 tons tackle resistance)

FALL LINE FORCE IS 27 1/2 TONS
(55 tons total resistance divded by 2 for mechanical advantage)

DEAD LINE B FORCE IS 55 TONS
(27 1/2 tons fall line force times 2, once for each line the deadline supports.)

91836 Army-Ft. Benning, Ga. 1982

2 Types of Blocks:
(1) Snatch
(2) Conventional

4 methods: (1) Towing (2) Lifting (3) Self-Recovery (4) Winching

RECOVERY CARD

RECOVERY PROCEDURE

RECONNOITER AREA --- Check the terrain for an approach to the load, method of rigging, and natural anchorages.

ESTIMATE SITUATION -- Determine the load resistance and the capacity of the effort available.

CALCULATE RATIO ----- Compute an estimated mechanical advantage for the rigging.

OBTAIN RESISTANCE --- Compute the tackle resistance and total resistance.

VERIFY SOLUTION ----- Compute line forces to compare with the winch and dead line capacities.

ERECT RIGGING ------- Orient the crew, and instruct them to assemble the rigging and then move to a safe location.

RECHECK RIGGING ---- Ensure that the rigging is erected for proper and safe operation.

YOU ARE READY ------ Signal the operator to apply power to the winch and recover the load.

FIELD MANUAL No. 20-22

HEADQUARTERS
DEPARTMENT OF THE ARMY
WASHINGTON, D.C., *30 July 1970*

VEHICLE RECOVERY OPERATIONS

*This manual supersedes FM 20-22, 31 October 1962.

CHAPTER 1

INTRODUCTION

1. Purpose

To provide information and guidance for personnel of all branches of the Army which will enable them to recover vehicles disabled due to terrain conditions, enemy action, or mechanical malfunctions.

2. Scope

a. This manual contains formulas and rules for use in vehicle recovery operations. It covers methods of determining resistances of vehicles disabled by terrain, and application of riggings and equipment to overcome these resistances. It covers expedient repairs, recovery expedients, and safety precautions to be observed in vehicle recovery operations. The fundamentals are applicable without modification to both nuclear and nonnuclear warfare.

b. Users of this manual are encouraged to submit suggestions, changes, or comments to improve this manual. Comments should be keyed to the specific page, paragraph, and line of the text. Reasons should be provided for each comment to insure understanding and complete evaluation. Comments should be prepared using DA Form 2028 (Recommended Changes to Publications) and forwarded direct to U.S. Army Armor School, ATTN: ATSAR–DMP, Fort Knox, Kentucky 40121.

CHAPTER 2

ORGANIZATIONAL METHODS AND LEVELS OF RECOVERY

3. Methods of Recovery

There are four methods of recovery that are performed using organizational personnel and equipment.

a. Winching. Operations performed using winches on special purpose vehicles or cargo type vehicles.

b. Towing. Operations performed using towing capabilities of similar or special purpose vehicles. This is the quickest recovery method.

c. Lifting. Operations performed using special purpose vehicles.

d. Expedients. Used when other methods are not adaptable to the situation or when additional vehicles and equipment are not readily available.

4. Levels of Recovery

Recovery operations performed within an organization are divided into levels. Levels are based on personnel who perform the operations and equipment available to them.

a. Platoon Level. Recovery performed by vehicle drivers and crews, under supervision of squad, section, or platoon leader. At this level, winching, towing, and expedient methods of recovery are employed, using platoon vehicles and equipment.

b. Company and Battalion Levels. Recovery performed by general vehicle repairmen or recovery specialists under the supervision of the recovery chief, using winching, towing, and lifting methods of recovery with special purpose vehicles. Because of the increased number of special purpose vehicles at battalion level, a greater recovery capability exists than at company level.

CHAPTER 3

RECOVERY FUNDAMENTALS

Section I. RESISTANCE

5. Types of Resistance in Recovery Operations

Resistance is any opposing force that tends to prevent movement. Resistances that cause the most concern in recovery situations are the resistances created by vehicles disabled by terrain. The three types of resistance created by vehicles disabled by terrain conditions are: grade, overturning, and mire. Grade resistance is created when a vehicle is moved up a slope, and is caused by the weight of the vehicle affected by gravity. Overturning resistance is that part of the weight of the vehicle that acts against the force exerted to bring it back on its wheels or tracks. Mire resistance is created due to contact of mud between various components of vehicles, such as wheels, tracks, axle or gear housings, or hull.

6. Estimating Resistance of Vehicles Disabled by Terrain

Recovery operations should be accomplished as quickly as possible within the limitation of safety.

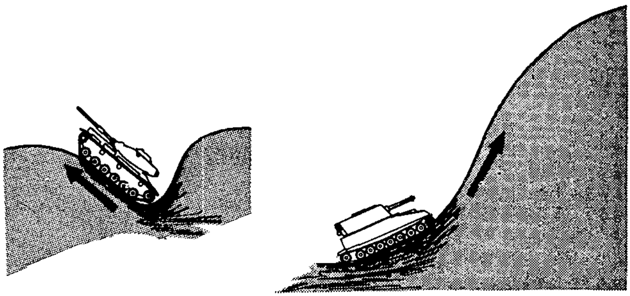


Figure 1. Grade resistance.

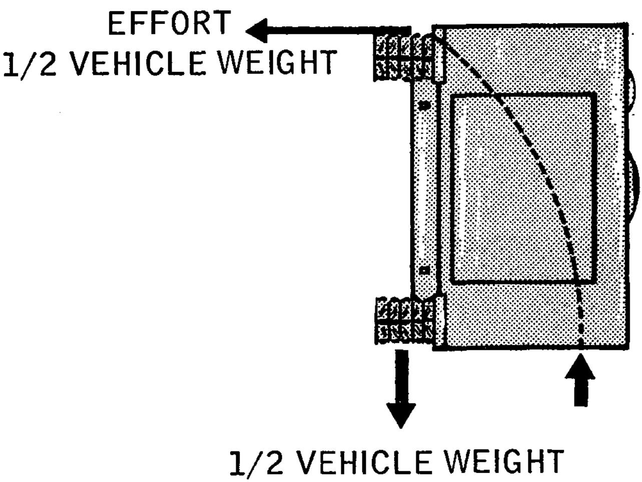


Figure 2. Overturning resistance.

It is time-consuming and difficult to use a mathematical formula to determine a precise amount of resistance for a recovery operation, therefore a fast estimate of the resistance will be accurate enough in most instances.

a. Grade Resistance. The maximum resistance that may be encountered on a grade, even if the grade is vertical, is the disabled vehicle's weight. Grade resistance should be estimated as equal to the vehicle weight (fig 1).

b. Overturning Resistance. Half the vehicle weight is the maximum that will ever be beyond the center of gravity relative to the point where the force will be exerted to upright the vehicle. Overturned resistance should be estimated as equal to one-half the vehicle weight (fig 2).

c. Mire Resistance. A vehicle is mired when it is in mud and can no longer propel itself. Resistance is estimated depending on the depth to which vehicle is mired (fig 3).

(1) *Wheel depth.* When a vehicle is mired at a depth up to the top of the road wheels (tracked vehicle) or wheels (wheeled vehicle), resistance should be estimated as equal to the vehicle's weight.

(2) *Fender depth.* When a vehicle is mired at a depth above the top of the wheels up to but not over the fenders, the resistance should be estimated as twice the vehicle's weight.

(3) *Turret depth.* When a vehicle is mired above the fenders from the turret ring to the top of the turret (on a tank) or up on the hull (light tracked vehicles) or up on the cab (wheeled vehicles) the resistance should be estimated at three times the vehicle weight.

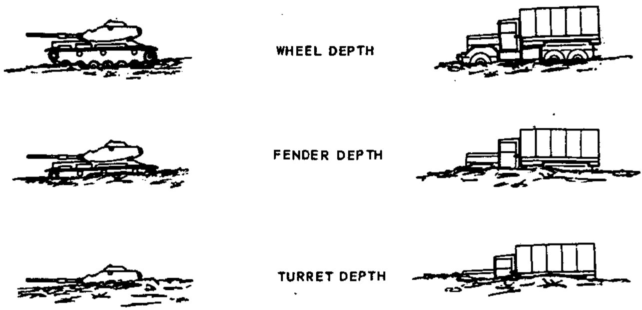


Figure 3. Mire resistance.

Note. If a cargo-type vehicle is mired, the cargo weight must be added to the vehicle weight when estimating resistance. As an example: a cargo truck weighing 6 tons is carrying 2 tons of cargo; at wheel depth the resistance should be estimated at 8 tons, fender depth 16 tons, and cab depth 24 tons.

7. Resistance Reducing Factors

Load resistance of mired tracked vehicles is affected by the situation and mechanical condition of the vehicle. In most mired situations, the vehicle can be recovered in the direction opposite its original travel and estimated resistance will be reduced. Power applied to tracks of a mired vehicle will also reduce resistance. By maintaining a steady pull on a mired tracked vehicle, the resistance may be slowly reduced since water can seep between the mud and the bottom of the vehicle.

a. When a mired vehicle is pulled in the direction opposite that of original travel, the tracks pass through ruts the vehicle created going into

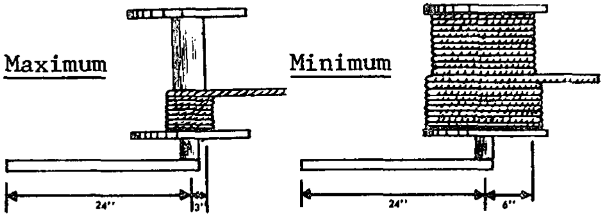


Figure 4. Maximum and minimum winch capacities.

the mire. This action of pulling it through its own ruts will reduce estimated resistance approximately 10 percent. As an example: a 50-tank is mired at wheel depth and can be recovered in the opposite direction of travel. Estimated resistance of 50 tons (para 6*c*(1)) less 10 percent equals 45 tons load resistance.

b. If power is applied to the tracks of a mired vehicle, the movement of tracks will assist in breaking the suction of mud against the belly of the vehicle and cause resistance to be reduced approximately 40 percent. As an example: a 50-ton tank is mired at fender depth and must be recovered in direction of travel. Estimated resistance of 100 tons (para 6*c*(2)) less 40 percent equals 60 tons load resistance.

c. If both reducing factors are applicable, resistance will be reduced 50 percent.

Note. Reducing factors of mired vehicles are not applicable to wheeled vehicles. When trying to apply them to wheeled vehicles, the amount of reduction is so variable (due to lack of traction) their application cannot be relied upon; however, power applied to the wheels may reduce resistance.

Section II. SOURCE OF EFFORT

8. Source of Effort—Similar Vehicles

The most readily available source of recovery effort at platoon level is the towing effort that can be exerted by using similar vehicles. The average vehicle can exert a force equal to its own weight in reverse gear, while on dry, level hardstand. Reverse gear normally provides the greatest gear reduction and affords the driver of the recovery vehicle the greatest visibility. The towing capability of any vehicle is affected by the type or condition of the terrain on which it is operating, thus two or more vehicles may be required to exert a force that one vehicle could exert under ideal conditions.

9. Sources of Effort—Winches

Even though the similar vehicle towing method is normally the quickest means of recovery, there are situations that do not permit its use. In such situations, a winch may be used. A typical situation dictating use of a winch is one in which approaches to the disabled vehicle do not provide necessary traction for towing vehicles. A winch provides a more positive source of effort in this case, as its capacity is not dependent upon terrain conditions.

a. A winch can exert the greatest force or attain its maximum capacity only when pulling by the first layer of cable on the winch drum or that layer of cable next to the bare winch drum. As each successive layer of cable is wound onto the

Table 1. Winch Variable Capacities
(Ordnance Winch, Gar Wood Industries)

Winch Type	Cable Layer	Cable on Drum (ft.)	Capacity (lb.)
10,000 lb.	1	0 - 39	10,000
	2	40 - 85	8,450
	3	86 - 138	7,340
	4	139 - 199	6,460
	5	200 - 266	5,780
20,000 lb.	1	0 - 41	20,000
	2	42 - 91	16,900
	3	92 - 148	14,500
	4	149 - 213	12,800
	5	214 - 287	11,400
45,000 lb.	1	0 - 42	45,000
	2	43 - 93	37,700
	3	94 - 153	32,500
	4	154 - 220	28,500
	5	221 - 296	25,300
	6	297 - 380	22,800
60,000* lb.	1	0 - 55	60,000
	2	56 - 128	52,000
	3	129 - 208	46,000
	4	209 - 300	40,000
90,000* lb.	1	0 - 41	90,000
	2	42 - 91	76,000
	3	92 - 149	65,000
	4	150 - 215	57,000

* Low gear

winch drum, the drum diameter increases and winch capacity decreases (fig 4 and table 1). It is desirable to unreel all or most of the cable from the winch drum when it is being used to winch heavy loads. However, several turns of the cable

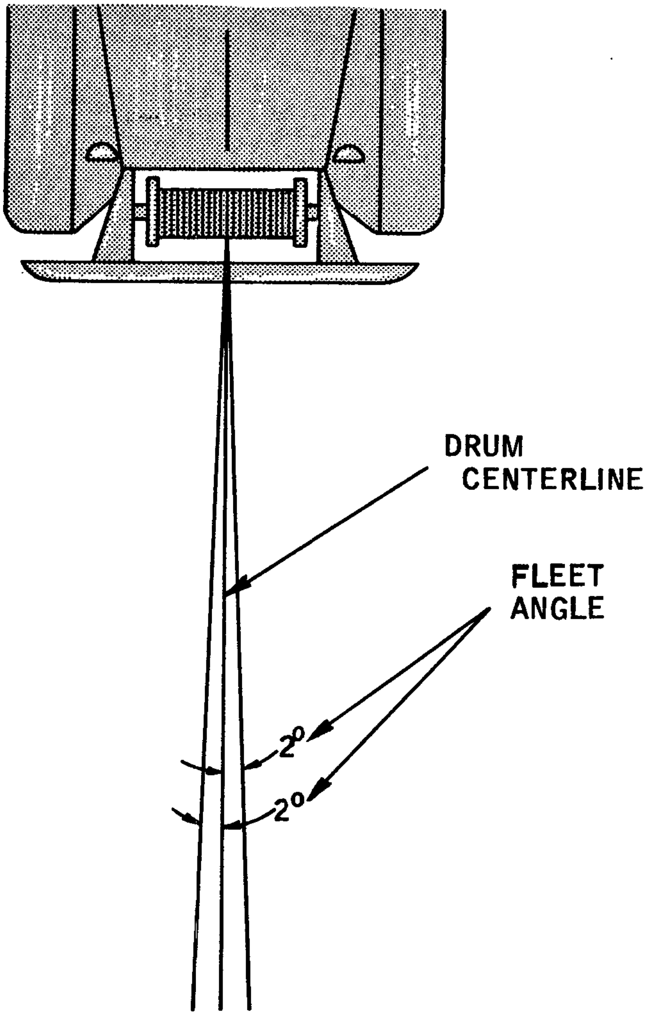


Figure 5. Correct fleet angle.

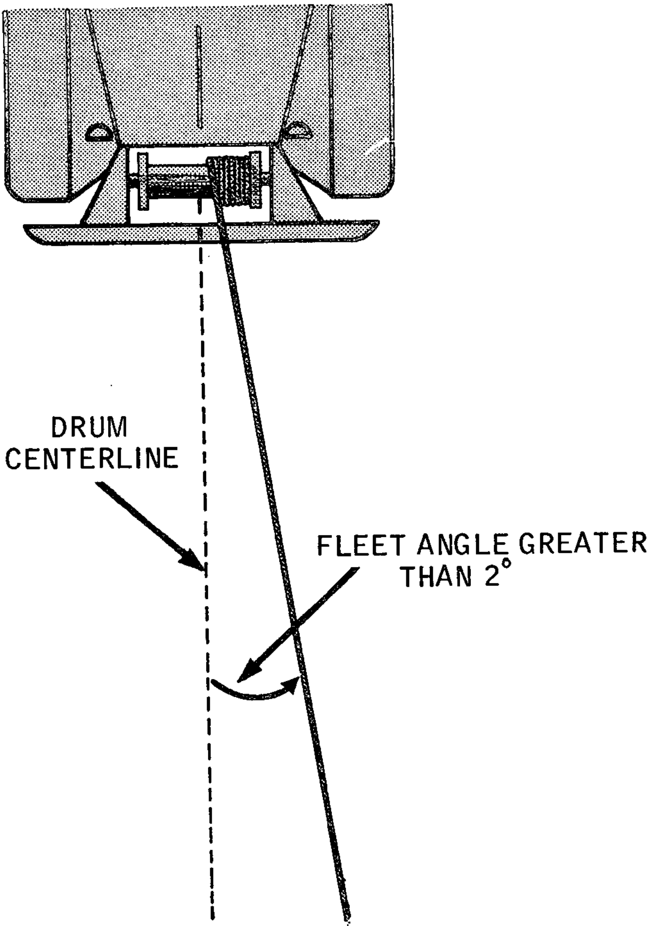


Figure 6. Incorrect fleet angle.

should remain on the winch drum. Another advantage is gained by using the full length of cable,

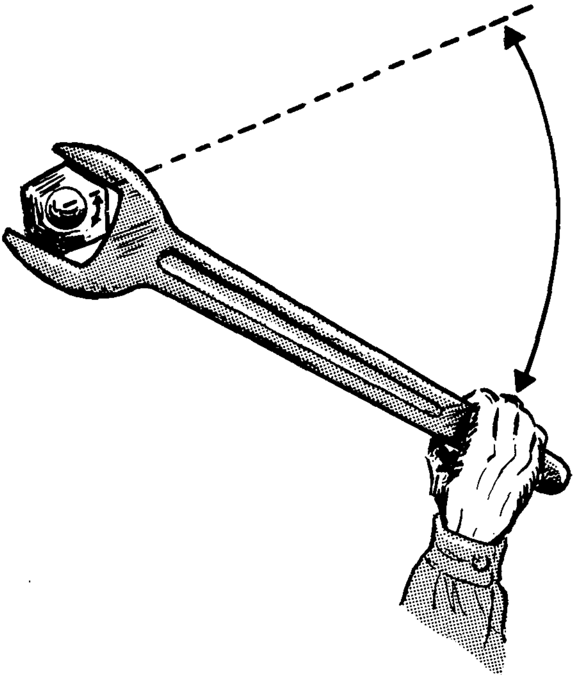


Figure 7. Wench mechanical advantage.

because its natural elasticity or stretch prevents the cable from breaking so readily in instances where sudden impact loads are applied.

b. Ideally, the winch cable should be used in such a manner that a line drawn through the length of cable will continue through the center line of the winching vehicle. Any deflection from this line is called fleet angle (fig 5) and is a very important consideration in winching operations, particularly when the winch is not equipped with a level winding device. If the fleet angle is greater than 2°, the cable will lead to one side of the winch drum, reducing winch capacity and possibly damaging the cable (fig 6).

Note. For reference relative to operation of various winch types, refer to pertinent technical manuals.

Section III. BASIC PRINCIPLES

10. Effort Versus Resistance

The application of effort to overcome resistance has been a challenge to man since the beginning of civilization. Modern machinery is illustrative of the progress made in this field. Energy released by the burning of a small amount of gasoline in an engine provides the effort required to move an automobile weighing thousands of pounds. The automobile engine is able with the assistance of various mechanical devices to drive the vehicle from a static position throughout a wide range of varying speeds.

11. Mechanical Advantage

The devices built into the automobile provide mechanical advantage. Many applications are made of mechanical advantage as power is transmitted from the engine to the vehicle's wheels; as an example, the gears of the transmission. There are many common applications of mechanical advantage by which every day work is performed. Common hand tools provide a mechanical

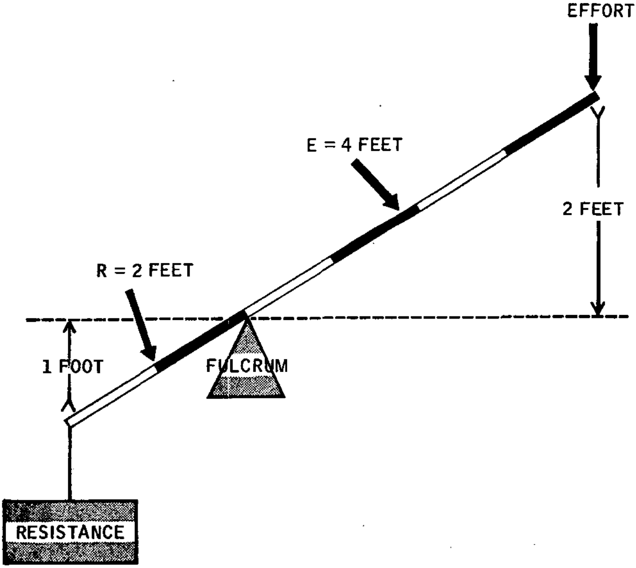


Figure 8. Leverage principle.

advantage to assist the user in performing his task A mechanical advantage is a small amount of force applied over a long distance to move a great load a short distance (fig 7). Mechanical advantage is the multiplication of force.

12. Leverage

a. Leverage Principle. A wrench handle, a can opener, and gears of an automobile gain a mechanical advantage through the leverage principle. The simplest form of a lever is a rigid bar free to turn on a fixed pivot called a fulcrum. When

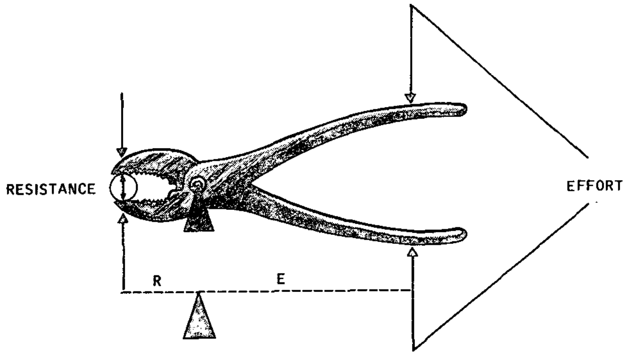


Figure 9. First class lever.

effort is exerted on one end of the bar, the bar will rotate around the fulcrum. A resistance applied to the other end of the bar opposes the effort and tends to cause the bar to rotate in the opposite direction. The part of the bar between the fulcrum and the point on the bar where the effort is applied is called the effort distance or (E); that part of the bar between the fulcrum and the point where resistance is applied is called resistance distance or (R). Mechanical advantage (MA) gained with a simple lever is determined by dividing effort distance by resistance distance ($\frac{E}{R}$ = MA). As an example: In figure 8, R = 2 feet, E = 4 feet. $\frac{E}{R} = \frac{4}{2}$ = 2 to 1 MA. The movement distance of the effort, with relation to distance resistance is moved, is the same as mechanical advantage radio. Effort must move 2 feet to move resistance 1 foot.

b. Lever Classification. Levers are divided into two classes. The class of lever is determined by the location of the fulcrum with relation to effort and resistance.

(1) A first-class lever has the fulcrum located between effort and resistance as illustrated in figure 9. A pair of pliers is a good example of a first class lever.

(2) A second-class lever has the point of resistance between the fulcrum and the effort as illustrated in figure 10. A wheelbarrow is a good example of a second-class lever.

Section IV. APPLICATION OF BASIC PRINCIPLES

13. Tackle

Tackle is a combination of ropes and blocks used to gain a mechanical advantage or to change direction of pull. Tackle is classified as simple or compound.

a. Simple tackle consists of only one rope with one or more blocks (fig 11).

b. Compound tackle consists of more than one rope used with two or more blocks. It is a series of two or more simple tackles; wherein the output of one simple tackle is used as the effort for the other (fig 12). Since a winch has only one cable, simple tackle will nearly always be used during recovery operations.

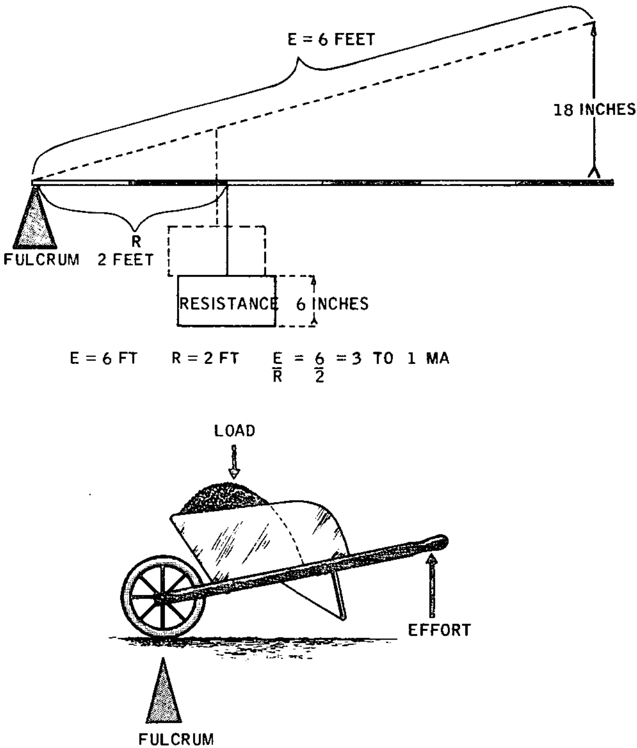


Figure 10. Second-class lever.

14. Blocks, Types by Construction

Blocks consist of a shell or frame in which is mounted one or more grooved wheels called sheaves. The sheaves are mounted on a pin that is supported by the shell. The shell also has a means of attaching the block to a load or to an anchor

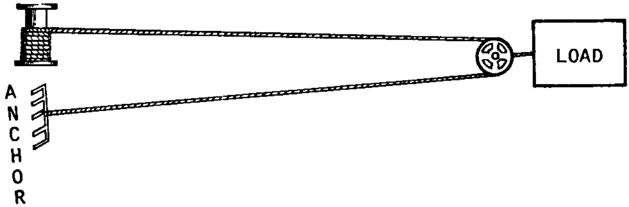


Figure 11. Simple tackle.

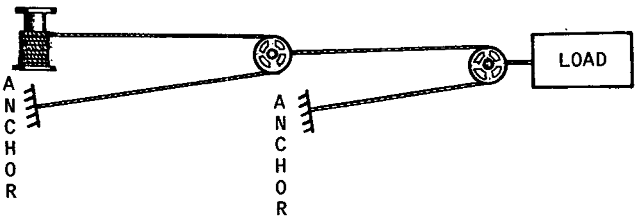


Figure 12. Compound tackle.

(fig 13). Blocks with one or two sheaves are referred to as single or double sheave blocks. Blocks are typed according to their construction.

a. Conventional Block. A conventional block is used with fiber rope. To form a tackle with conventional blocks, the blocks are laid out and the rope must be reeved or threaded through the blocks (fig 14).

b. Snatch Block. Since winch cables have attachments on their free ends, such as hooks or sockets, they cannot be reeved through a block. A snatch block is constructed so the shell can be opened at the base of its attachment to admit a cable without reeving (fig 15).

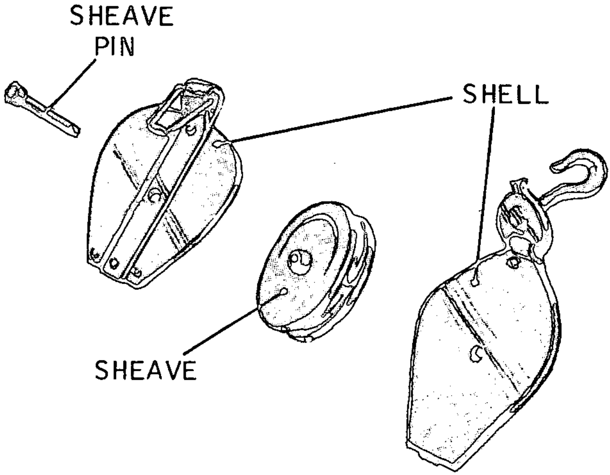


Figure 13. Block components.

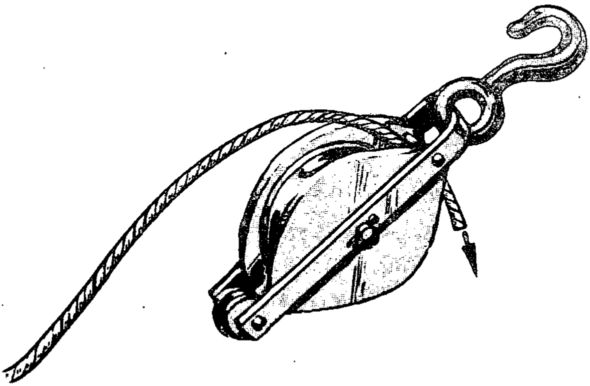


Figure 14. Conventional block.

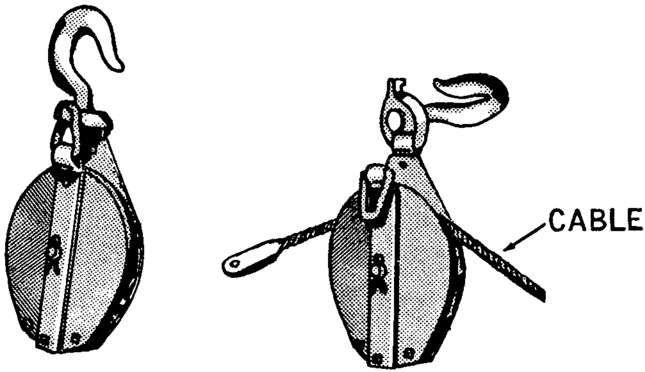


Figure 15. Snatch block.

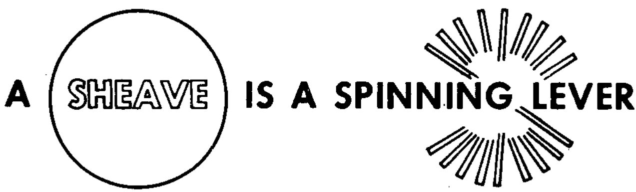


Figure 16. Spinning lever.

15. Blocks, Classification by Usage

The sheave of a block functions as a lever. It performs this function more efficiently than a simple bar lever by providing a continuous lever action, without the necessity of repositioning each time it has moved through its arc. In effect a sheave is a spinning lever (fig 16).

a. Fixed Block. A block attached to a stationary object (anchor) is classified as a fixed block. The sheave of a fixed block permits a change in direc-

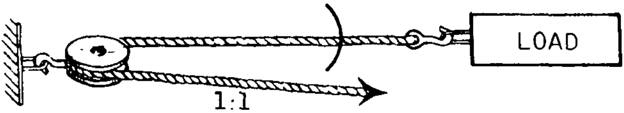


Figure 17. Fixed block.

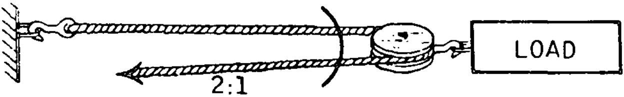


Figure 18. Running block.

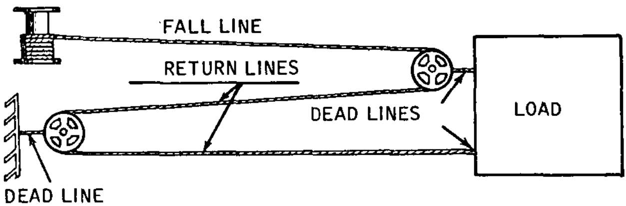


Figure 19. Tackle terminology.

tion of the rope and functions as a first-class lever because the rope enters one side of the sheave from the source of effort, passes around the sheave and returns to the resistance. The sheave pin is the fulcrum, and the distance from the pin to one side of the sheave is equal to the distance from the pin to the opposite side, therefore effort distance (E) and resistance (R) are equal; no mechanical advantage is gained (fig 17).

b. Running Block. A block that is attached to the load and moves with the load is classified as a running block. A running block will always gain a mechanical advantage, and its sheave functions as a second-class lever. The sheave is reeved in the same manner as the fixed block, however, the load location is on the sheave pin; the fulcrum is at one side of the sheave and the effort is exerted on the opposite side. The resistance distance (R) is from the pin to one side of the sheave (radius of the sheave). Effort distance (E) is from one side of the sheave to the opposite side (sheave diameter). Effort distance is twice resistance distance; the mechanical advantage is 2 to 1 (fig 18).

c. Floating Block. A block used with a tow cable to allow the pull of the cable to aline with the source of power is known as a floating block. A floating block provides no mechanical advantage. It allows the pull to be equally distributed to both tow attachments (hooks) of the disabled vehicle (fig 35).

CHAPTER 4

RIGGING FOR RECOVERY

Section I. RIGGING FUNDAMENTALS

16. Rigging

Rigging is the application of fiber or wire rope in various tackle combinations used to raise or move loads. Rigging includes installation of all items of equipment necessary to employ the effort available and may or may not produce a mechanical advantage. The various parts of a tackle are illustrated in figure 19.

a. Fall Line. The line from the source of effort to the first block in the tackle is the fall line. There is only one fall line in a simple tackle system.

b. Return Lines. The lines between the blocks or the line from the sheave of a block to the point where the end of the line is attached are return lines.

c. Dead Lines. The lines used to attach blocks or other equipment to the load or to an anchor are dead lines.

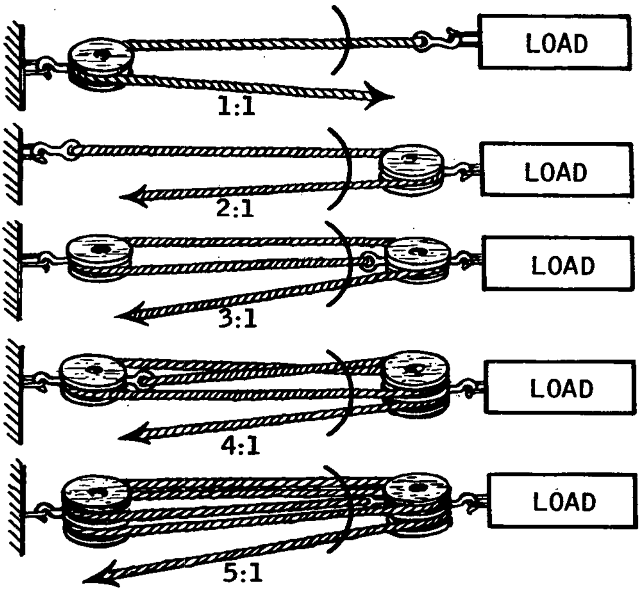


Figure 20. Various tackle mechanical advantages.

17. Mechanical Advantage of Tackle

a. As previously stated, a need for a mechanical advantage exists whenever the load resistance exceeds the capacity of the available effort. The amount of mechanical advantage needed is estimated by dividing the load resistance by the effort.

b. The mechanical advantage (MA) of any simple tackle rigging is equal to the number of lines supporting the load, or number of lines that become shorter as power is applied to the winch,

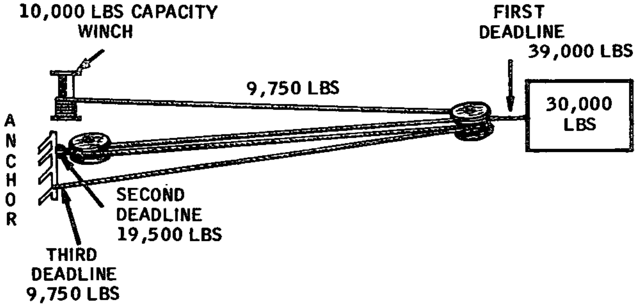


Figure 21. Distribution of line forces.

whether the lines are attached directly or indirectly through a block (fig 20).

18. Tackle Resistance

Due to friction created by a sheave rotating on its pin, flexing of the rope around the sheave, and the rope scuffing in the groove of the sheave, there is a loss in energy as the rope passes around the sheave. This loss is considered as resistance because it must be overcome before the resistance of the load can be overcome. Each sheave in the rigging will create resistance. The rule to determine tackle resistance is: 10 percent of the load resistance times the number of sheaves (not blocks) in the rigging. As an example, a load resistance of 30,000 pounds and a tackle with 3 sheaves is being used, 10 percent of 30,000 pounds equals 3,000 pounds, times 3 (3 sheaves) equals 9,000 pounds tackle resistance.

19. Total Resistance

The tackle resistance must be overcome before the load resistance can be moved, therefore, the tackle resistance must be added to the load resistance. This resistance is referred to as total resistance (the total amount of resistance that must be overcome by the available effort). Using the example given in the preceeding paragraph on tackle resistance, the load resistance of 30,000 pounds plus the tackle resistance of 9,000 pounds equals 39,000 pounds total resistance.

20. Fall Line Force

The amount of force that must be exerted on the fall line relative to the effort available must be considered in every problem. To determine the fall line force, divide the total resistance by the mechanical advantage of the tackle. The fall line force must be less than the capacity of the effort to accomplish the recovery. For example, a 39,000 pound total resistance to be overcome with an effort of 10,000 pounds using a 4 to 1 mechanical advantage tackle. 39,000 pounds divided by 4 (4 to 1 MA) equals 9,750 pounds fall line force. 9,750 pounds fall line force is less than the effort of 10,000 pounds, the mechanical advantage is correct for the recovery.

21. Dead Line Force

Dead lines in most cases must withstand more force than other lines in a tackle rigging. To determine dead line force, multiply the fall line force by the number of lines supported by the dead line. From figure 21 and the fall line force of 9,750 pounds the dead line forces are determined as follows:

a. The first dead line is the sling attachment of a double sheave block to the load. There are 4 lines (the fall line and 3 return lines) supported by the dead line through the block. 4 times (fall line force) 9,750 pounds equals 39,000 pounds on the dead line.

b. The second dead line is used to attach a single sheave block to an anchor, and is supporting two return lines; two times 9,750 pounds equals 19,500 pounds.

c. The third dead line is supporting only one return line, therefore the third dead line is equal to the fall line force (9,750 pounds).

Section II. STRENGTH OF EQUIPMENT

22. Equipment Strength

Strength is the ability to resist force, or the capability of a body to endure the application of force. Ropes and chains have strength, according to their size and the material from which they are made, to endure the application of a certain amount of force without breaking.

23. Fiber Rope

Fiber rope may be used in recovery of relatively light loads. The strength of a fiber rope will vary after it has been used, has been wet, or if dirt has collected between the strands. The strength of a new fiber rope can be determined by using the

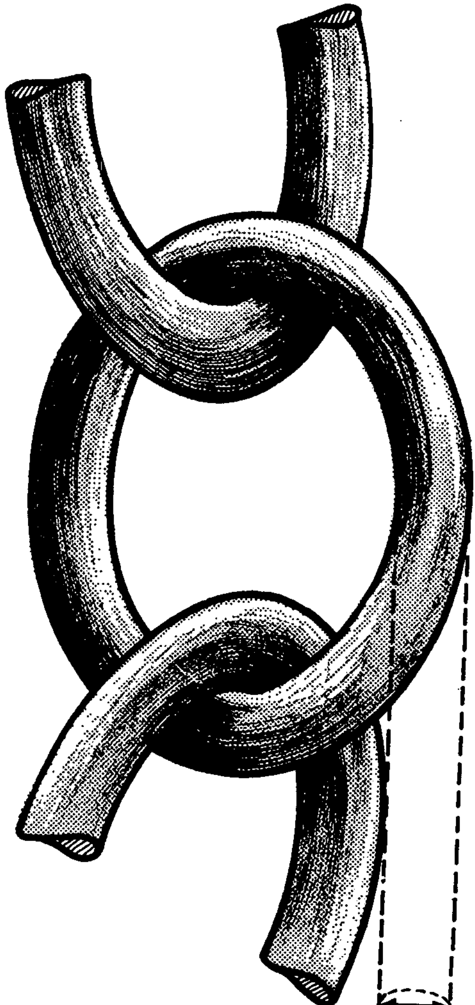


Figure 22. Measurement of chain diameter.

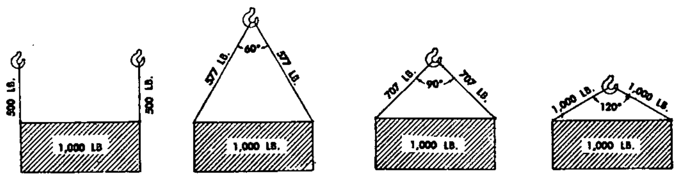
Table 2. Rope and Chain Capacities

DIAMETER (inches)	FIBER ROPE (sisal) $T = 4D^2$ (tons)	WIRE ROPE (IPS) AND CHAIN $T = 40D^2$ (tons)
3/8	.5625	5.625
7/16	.765625	7.65625
1/2	1.	10.
5/8	1.5625	15.625
3/4	2.25	22.5
7/8	3.0625	30.625
1	4.	40.
1-1/8	5.0625	50.625
1-1/4	6.25	62.5
1-1/2	9.0	90.

Table 3. Sling Leg Forces

Force per sling leg (2-leg slings) per 1,000 lb. of total resistance.

INCLUDED ANGLE (degrees)	SLING LEG FORCE (pounds)	INCLUDED ANGLE (degrees)	SLING LEG FORCE (pounds)
0	500	90	707
10	502	100	778
20	508	110	872
30	518	120	1,000
40	532	130	1,183
50	552	140	1,462
60	577	150	1,932
70	610	160	2,880
80	653	170	5,734



formula $T = 4D^2$. This formula is based on the weakest fiber used to make rope. The T equals the capacity in tons; D equals the diameter of

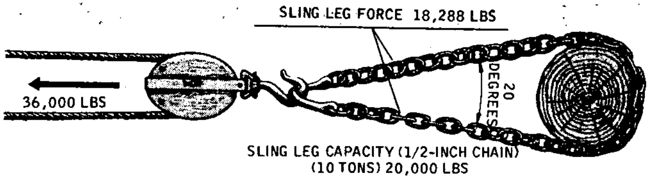


Figure 23. Chain sling to anchor.

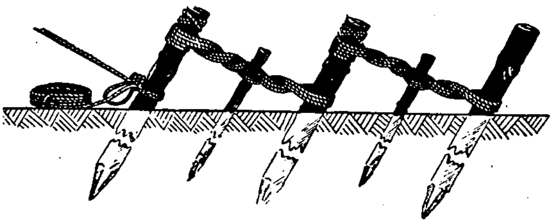


Figure 24. 1–1–1 combination picket holdfast.

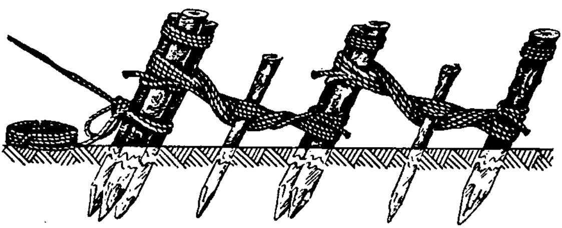


Figure 25. 3–2–1 combination picket holdfast.

the rope in inches. Therefore, when computing the strength of a ½-inch rope, $T = 4 \times (1/2 \times 1/2) = 4 \times 1/4 = 1$ ton. For a 1 inch rope, $T = 4 \times (1 \times 1) = 4 \times 1 = 4$ tons.

24. Wire Rope and Chain

Wire rope is used for winch cables and tow cables.

A wire rope may be constructed with either a fiber rope or a wire rope core. A wire rope with a wire rope core is stronger. The formula used to determine strength is based on wire rope made of improved plow steel (IPS) with a fiber rope core. The formula used is $T = 40D^2$. As with fiber rope, T equals the strength in tons; D the diameter of the rope in inches. In most instances where the diameter of the rope is stated in fractions of an inch, it is easier to convert the fraction to a decimal equivalent before computation. As an example, when computing the strength of a 5/8-inch wire rope, T = 40 × (5/8 × (5/8) or 40(.625 × .625) = .390625 × 40 = 15.625 tons. The strength of chain is determined using the same formula as for wire rope. The diameter of a chain is the diameter of the stock from which the chain links are made (fig 22). The strength of various sizes of ropes and chains are shown in table 2.

25. Sling Leg Forces

In most recovery operations involving winching or lifting a sling is used as a dead line. Slings are usually made of chains or tow cables. The holding ability of a sling attachment depends upon the strength of the material of which the sling is made and the included angle of the sling. The holding ability of a sling can be almost double the strength of the material of which the sling is made. As an example: A 1/2-inch diameter chain sling with an included angle of 20° is used to support a force of 36,000 pounds. For each 1,000 pounds of force imposed on the apex of the sling, will result in 508 pounds of force imposed on each sling leg as illustrated in table 3. Therefore, 36(36,000 ÷ 1,000) × 508 = 18,288 pounds imposed force on each sling leg (fig 23). Note in table 3 that the sling leg force will increase with the included angle of the sling.

Section III. ANCHORS

26. Use of Anchors

Frequently it is necessary to have some anchoring means when heavy loads must be moved with tackle. It is necessary at times to have an anchor assist in holding a winching vehicle, support part of the load during a winching operation, or provide an anchor for a change of direction pull.

27. Natural Anchors

An anchor that does not have to be constructed is considered a natural anchor, such as trees, tree stumps, large rocks, or another vehicle. Avoid dead or rotten trees or tree stumps as their anchoring ability cannot be relied upon. Examine rocks carefully to ensure they are large enough and embedded firmly in the ground.

28. Mechanical Anchors

There are several types of anchors. The types constructed depends upon the holding ability requirements, type of soil, availability of materials, and the situation.

a. Picket Holdfast. To construct a picket holdfast, obtain two or more sound wooden pickets at least 3 inches in diameter and 5 feet long. Drive the pickets about 3 feet into the ground, 3 to 6 feet apart and in line with the dead line. Tie the pickets together with fiber rope by first tying one end of the rope to the top of the front picket with a clove hitch, and make four to six wraps of the rope starting from the top of the front picket to the bottom of the rear picket. Finally, tie the other end of the rope to the bottom of the rear picket with a clove hitch. Pass a stake between rope wraps midway between the pickets, tighten the rope by twisting it with the stake, then drive the stake into the ground. Repeat this operation for each successive pair of pickets (fig 24).

The strength of the holdfast depends mainly on the first or front picket. To reinforce the front picket, drive two or more pickets into the ground close to the front picket, and tie them together before tying to the rear picket (fig 25).

b. Log-Picket Holdfast. For heavier loads in soft or wet earth, the combination log-picket holdfast may be used. With this holdfast, one must fasten the anchor or dead line to a timber supported against several (4–6) picket holdfasts (fig 26). The strength of this type of holdfast depends upon the strength of the log, soil, and pickets. Therefore, select a timber strong enough to withstand the maximum pull on the dead line without bending.

c. Log Dead Man. A dead man is one of the best types of anchor for heavy loads. The dead man consists of a log buried in the ground with the dead line connected to its center. When con-

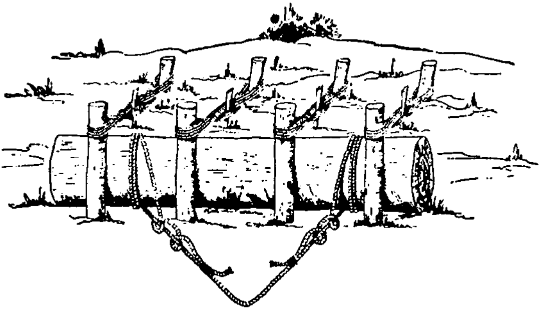


Figure 26. Log-picket holdfast.

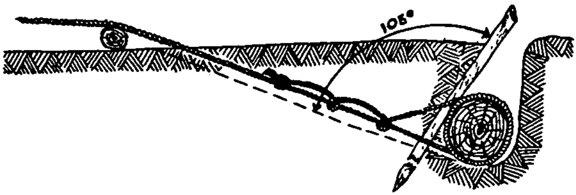


Figure 27. Log dead man.

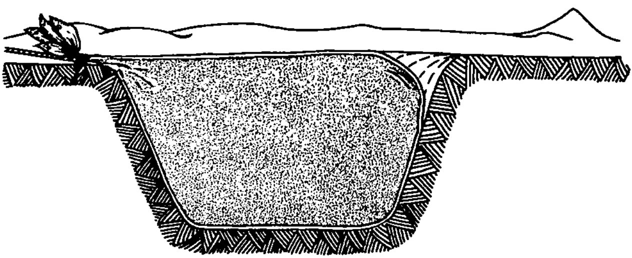


Figure 28. Sand parachute.

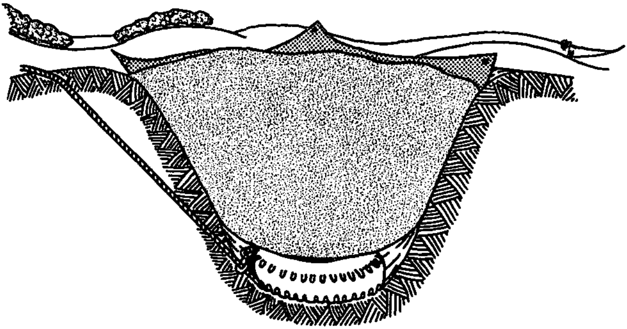


Figure 29. Sand parachute dead man.

structing a dead man, place it where the direction of pull is as nearly horizontal as possible. Take advantage of sharp banks or crests to increase the holding power with less digging. Dig a hole large enough for the dead man and as deep as necessary for good bearing. When digging the hole slant it in the direction of the pull at an angle of about 15° from the vertical. To strengthen the anchor, drive stakes in front of the dead man at each end. Dig a narrow inclined trench for the dead line to the center of the dead man. Tie the dead line to the center of the dead man so the main or standing part of the line leads from the bottom of the dead man. This prevents the dead man from rotating out of the hole. If the dead line has a tendency to cut into the ground, place a small log under the line at the outlet of the trench. A log dead man is illustrated in figure 27. The strength of the dead man depends on the strength of the log and the holding power of the earth.

d. Sand Parachute. In sandy area with no trees, a sand parachute may be used as an anchor. A sand parachute is constructed by digging a large, deep hole and lining it with a tarpaulin. The tarpaulin is then filled with the sand removed from the hole, the four corners of the tarpaulin are lashed together, and the rigging is attached. The sand parachute is illustrated in figure 28.

e. Sand Parachute Dead Man. The sand parachute dead man may be constructed in a similar manner as the sand parachute, however, after the hole is dug, a spare tire is placed in the hole. The dead line is secured to the fire, the tarpaulin emplaced, and the hole refilled. The corners of the tarpaulin are not drawn together. Figure 29 illustrates a sand parachute dead man.

Note. The sand parachute and the sand parachute dead man have limited holding ability and should not be used when a major effort is required.

f. Scotch Anchor.

(1) A scotch anchor is used to anchor a truck during winching operations when natural anchors are not available. To construct a scotch anchor, select a log at least 6 inches in diameter and 10 inches longer than the tread width of the vehicle's front wheels. Dig a shallow trench about 3 or 4 inches deep parallel to the front axle, just ahead of the front wheels. Lay a tow chain across the center of the trench, place the log in the trench, move the vehicle forward until both front tires are against the log, and then attach both chain ends to the vehicle's lifting shackles, removing all the slack from the chain. As power is applied

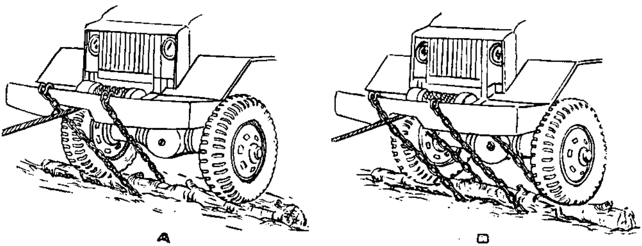


Figure 30. Scotch anchor.

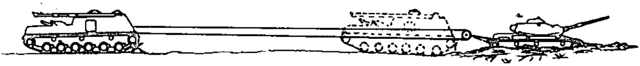


Figure 31. Backup method of rigging.

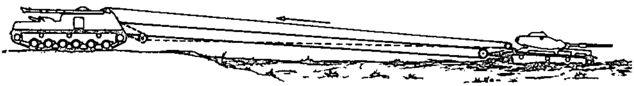


Figure 32. Lead method of rigging.

to the winch, the front wheels will be pulled onto the log making the chain taut and anchoring the vehicle (A, fig 30).

(2) If two chains are available, a similar method may be used as follows: Lay two tow chains across the trench next to the inside of each front wheel, place the log in the trench, move the vehicle forward until both front tires are against the log, and then wrap the chains through the lifting shackles, remove slack from the chain and fasten them together (B, fig 30).

g. Vehicle Anchor. A vehicle may be used as an anchor to assist in recovering another vehicle equipped with a winch. The winch cable is extended to the anchoring vehicle and the mired vehicle winches itself out. The anchor vehicle should not attempt to pull the mired vehicle using the mired vehicle's winch, but should remain only as an anchor. This will eliminate the possibility of damage to the winch.

Section IV. RIGGING TECHNIQUES

29. Methods of Rigging

The rigging method depends on the type of winching vehicle and the distance between the winching vehicle and load.

a. Manpower Method. The manpower method of rigging is used when permitted by the size and weight of the equipment. If the winch cables and other rigging equipment are light weight, and can be carried by the crew members with comparative ease to where it is needed, this method is the most expedient.

b. Backup Method. If the recovery vehicle can be safety positioned within 20 to 25 feet of the disabled vehicle, the backup method of rigging should be used. The recovery crewmen pull out sufficient main winch cable to attach the cable to the recovery vehicle; place the main winch snatch block in the loop of the cable, close the block and attach the block to the object of recovery. The dotted outline in figure 31 shows the recovery vehicle and the rigging attached to the disabled

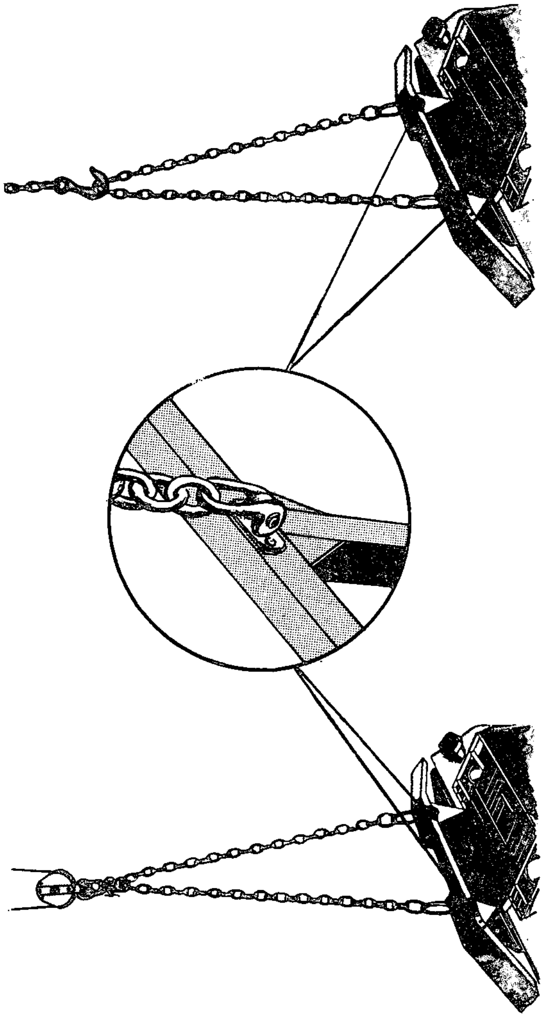


Figure 33. Chain slings to lifting shackles.

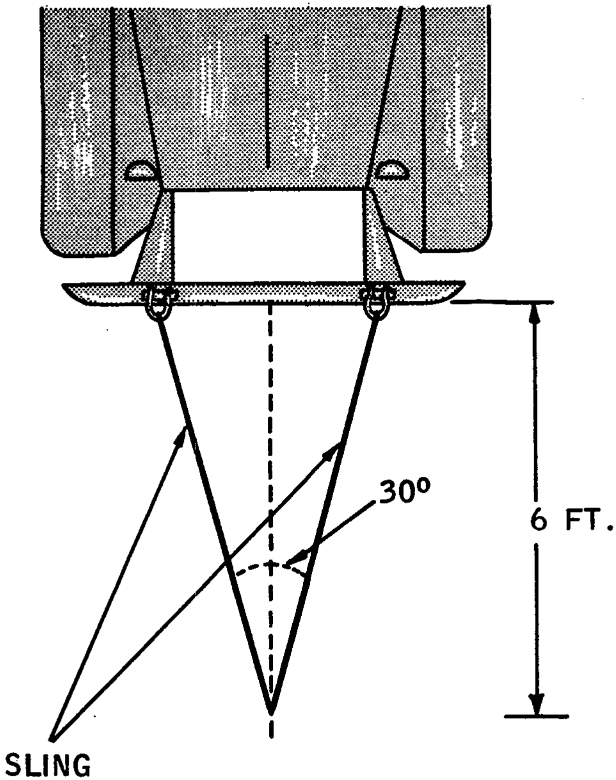


Figure 34. Sling arrangement.

vehicle. The recovery vehicle is then backed up, allowing the main winch cable to be spooled from the winch drum until sufficient cable is removed to obtain maximum winch capacity. The solid lines in figure 31 show the recovery vehicle in position to perform the winching operation.

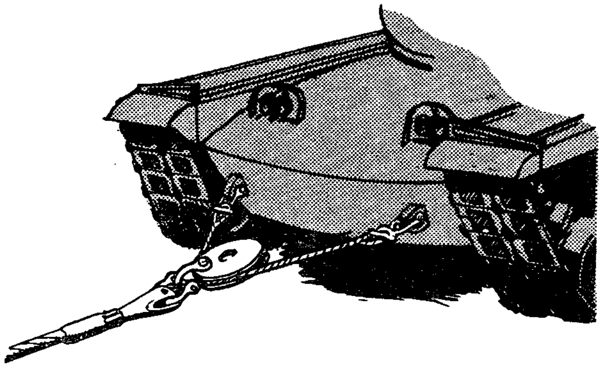


Figure 35. Floating block.

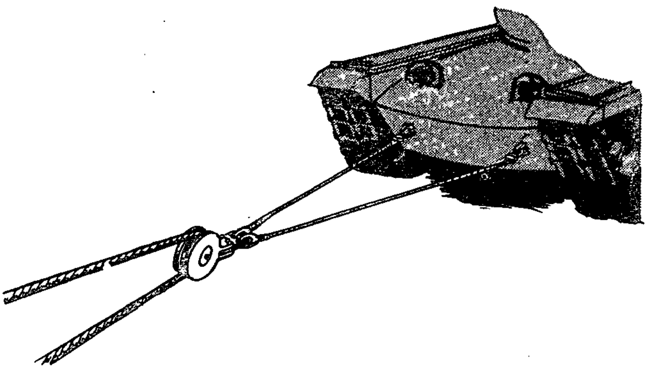


Figure 36. Tow cable attachment.

c. Lead Method. If, because of terrain conditions, the recovery vehicle cannot be safely positioned close to the object of recovery, the lead method of rigging should be used. The lead method consists of using the hoist winch to lead the main winch rigging to the object of recovery. The hoist winch cable weighs less than the main winch cable and can be carried to the object of recovery. To rig for the lead method, the main winch tackle is assembled just in front of the recovery vehicle as in preparation for the backup method. The hoist winch cable end is attached to the main winch tackle snatch block, then the loop formed by the hoist winch cable is manually pulled out and placed into a snatch block attached to the disabled vehicle. This application of the hoist winch cable will provide a change of direction of pull and by paying in hoist winch cable, the main winch tackle will be pulled to the object of recovery. In figure 32, the dotted line indicates the main winch tackle erected at the front of the recovery vehicle with the return line of the hoist winch attached. The solid lines indicate the main winch tackle after it has been led to the disabled vehicle.

30. Methods of Attachment of Tackle

In recovery operations, it is important that the tackle be rigged to the vehicle in such a manner as to prevent further damage to the vehicle or equipment. As an example, in recovery of a mired wheeled vehicle, the effort line should be attached to the lifting shackles on both sides. It the pulling force is attached only to one frame member, it could be pulled out of alinement.

a. Wheeled Vehicle. On wheeled vehicles, whether the pull is made from the front or rear, the effort should be applied to both front or rear lifting shackles, or the pintle hood.

Caution! **Pull on pintle hook should not exceed that which is specified by TM. The lifting shackles are designed to withstand force from a horizontal or a vertical pull. To apply the effort equally to both shackles, a sling attachment must be used (fig 33).**

The most available item of equipment on wheeled vehicles is a tow or utility chain. The force exerted on each leg of the sling will be slightly greater than half the resistance. A 12-foot chain attached in this manner on most wheeled vehicles will form a sling with the apex of the sling approximately 6 feet from the bumper with an included angle of about 30° (fig 34).

b. Tracked Vehicles. When attaching riggings to tracked vehicles, always attach to the towing hooks or lugs. The lifting eyes and towing pintle are not designed to withstand the pulling force required for recovery. To prevent pulling the vehicle sideways and increasing the resistance, use an attachment that will distribute the applied force to each side of the vehicle. If the vehicle will require towing after winching, time can be saved by using the same attachment for winching as for towing.

(1) When a disabled vehicle will not require towing and the resistance is such that a mechanical advantage is not required, the main winch snatch block can be used with one tow cable to form a floating block hookup. This hookup is easy to install and will give an even distribution of the

effort to both tow hooks. To rig a floating block, attach the ends of the tow cable to the two tow hooks; place the snatch block in the loop formed by the tow cable, and attach the winch cable to the snatch block (fig 35).

(2) When a disabled vehicle requires a 2 to 1 mechanical advantage rigging, and may require towing over rough terrain after winching, two tow cables are used to make the attachment as illustrated in figure 36. This attachment is the best method, because it is the quickest to rig.

(3) When a vehicle must be towed over relatively level terrain or on the highway after winching, the tow bar method of attachment should be used. The tow bar is attached to the tow lugs of the disabled vehicle and the winch rigging attached to the lunette of the tow bar (fig 37). After winching the rigging should be disassembled and the tow bar lunette placed in the recovery vehicle tow pintle (fig 37).

(4) If a 3 to 1 mechanical advantage is used, the running block is attached to one of the towing lugs on the disabled vehicle, the change of direction block is attached to the dead man on the recovery vehicle and the end of the winch cable is attached to the other towing lug on the disabled vehicle (fig 38).

Section V. SAFETY

31. Safety

A successful recovery operation is one that is accomplished quickly and safely. The preceding

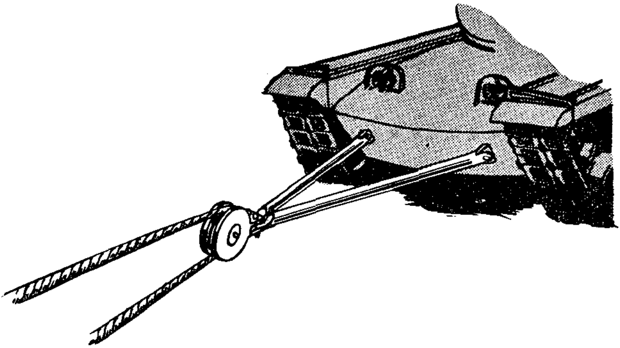


Figure 37. Tow bar attachment.

paragraphs on fundamentals and the techniques of rigging for recovery were to provide information and guidance to accomplish recovery quickly. To accomplish recovery safely, maximum care must be taken during the erection and application of equipment to prevent damage to the vehicles and equipment, and injury to personnel.

32. Handling Cables

Cables or wire ropes may become damaged through use. The wires that make up the strands of the rope may break. Personnel handling wire ropes should wear heavy leather-palmed gloves to prevent hand injuries or cuts from broken wires. A moving cable should never be allowed to slide through the hand even when gloves are worn; a broken wire could cut through the glove.

33. Care of Cables

Care must be taken to prevent damage to cables

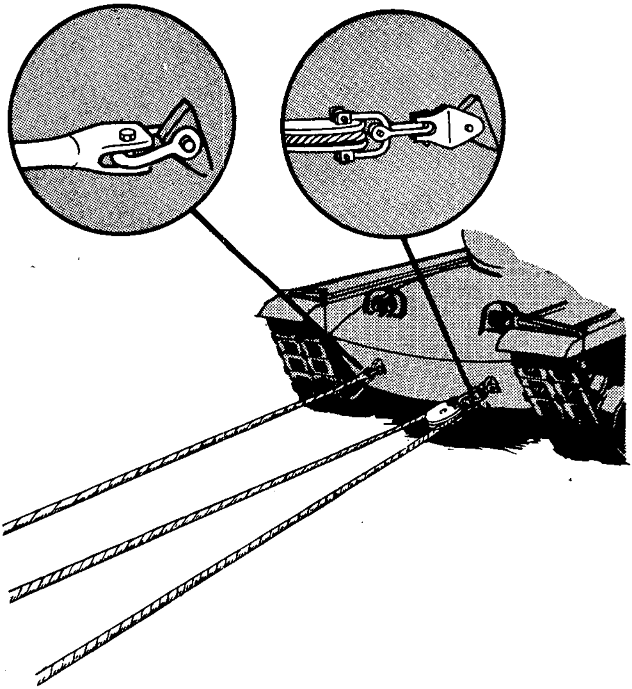


Figure 38. 3 to 1 mechanical advantage.

Figure 39. Kinked cable.

during use. Cables or ropes should not be drawn over rocks, around sharp corners, or through

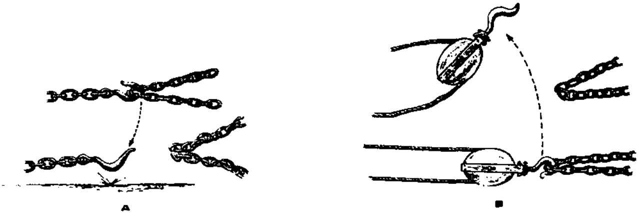


Figure 40. Hook position.

sheaves that are designed for larger or smaller cables. Never drop a heavy object on a wire rope, it could nick or burr the wires and cause them to break. All loops formed in a cable should be removed while the cable is slack and before any force is applied. Force applied to a looped wire rope will cause a kink, the strands will separate or break, and the rope will be weakened (fig 39).

34. Hook Position

A hook used in rigging should be positioned with the open part (throat) upward (A, fig 40). If the hook should straighten out from overload, the tendency will be for the rigging to be forced downward. If the hook were positioned with the open part (throat) down, the rigging could travel upward unrestrained (B, fig 40).

35. Safety Keys

a. Safety keys should be in place on all tow hooks, shackles, or other items of equipment re-

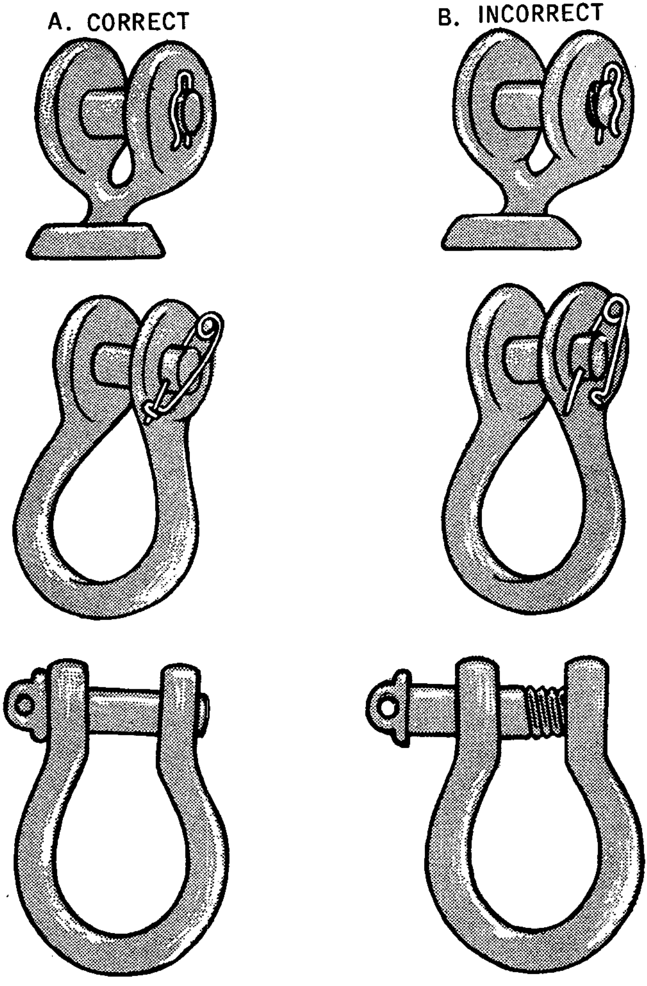


Figure 41. Safety keys and shackle pins.

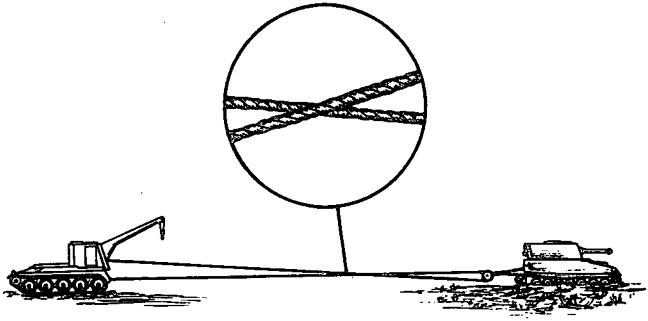


Figure 42. Crossed lines.

quiring them. Even though the safety key supports no appreciable load, its absence can allow a pin to move, placing an excessive force on only a part of a connection. Some shackles use a threaded type pin, and if the pin is not completely threaded into the shackle part, the shackle or pin can be bent or broken when force is applied (fig 41).

b. When using pins with safety keys, such as the type in tow bars, all pins in a vertical plane should have their heads pointing up. Then, even if the safety key should break or fall out, the pin will remain in position if the load shifts.

36. Rigging Between Vehicles

When erecting rigging between vehicles, engines should be off and vehicle brakes applied to prevent possible injury to the rigging personnel or damage to the vehicles, except when erecting riggings using a recovery vehicle the engine must

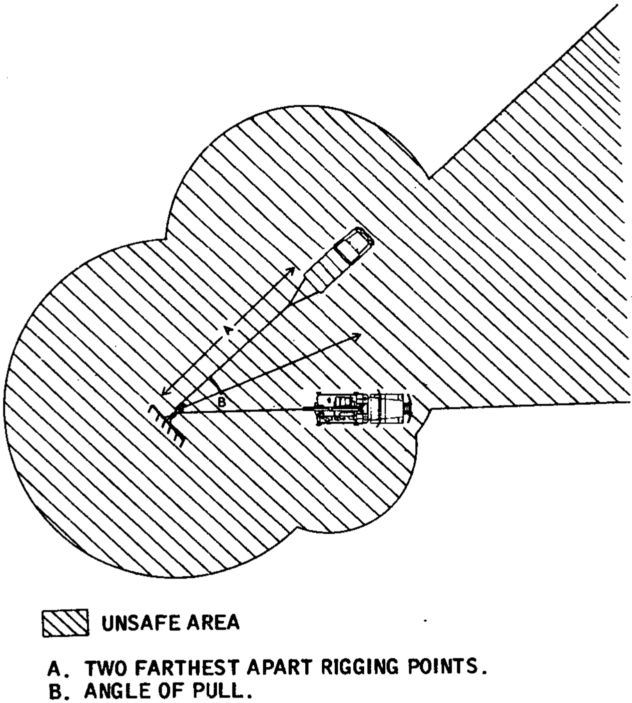


Figure 43. Unsafe areas.

be running to operate the equipment. To prevent injury to personnel or damage to equipment, the recovery vehicle brakes must be applied and the spade or chocks (wheeled vehicle) positioned to prevent movement.

37. Inspecting Rigged Equipment

Equipment should be thoroughly inspected before the recovery operation starts. The recovery vehicle operator should be directed to apply power to the winch and remove the slack from the rigging, then stop the operation so the rigging can be inspected without endangering the personnel.

38. Crossed Lines

If the inspection reveals that the rigging lines are crossing each other, this condition must be corrected before the winching operation is continued. It is possible that crossed rigging lines will rub against each other, causing damage to the cable or an increased amoung of tackle resistance (fig 42). Crossed cables are only recommended for towing a disabled vehicle.

39. Fuel or Oil Spillage

If fuel or oil has spilled as a result of the disablement, no smoking and no open flame precautions should be enforced. Care must be taken to prevent exhaust flash from other vehicles being directed at the vehicle with spilled fuel or oil. The spilled fuel or oil must be cleaned up thoroughly before attempting to start the recovered vehicle's engine.

40. Positioning Gun Tubes

During main battle tank recovery the main gun tube should be so positioned that it will not be damaged in event of a collision. If a gun tube is involved as a result of the disablement such as might occur on a nosed or overturned tank, the gun should be checked by support maintenance personnel before firing.

41. Operator/Driver Safety

Operators and other personnel in both the recovery vehicle and disabled vehicle should keep their hatches closed during a recovery operation and use their periscopes to view hand signals directed to them.

42. Safe Location of Personnel

Before a pull has started, all personnel on the ground must be directed to move to a safe location relative to any rigging before applying power. When a cable is drawn taut and then suddenly released by a break, its back lash can cut a man in half. Consider a winch cable under force stretching like a rubber band and storing up energy. If such a line breaks, its snapping back can be compared to the action of a whip with the velocity of a rifle bullet. A winch rigging that forms an angle is similar to a sling shot. If a block were attached in the angle of the rigging and the attachment were to break, the block would be hurled through the angle at a terrific speed and if the block left the cable it would be propelled a great distance. It stands to reason that personnel should never stand within any angle formed by the rigging. A rule to follow for safe location of personnel on the ground is: stand at a distance from the rigging greater than that distance between the two farthest apart rigging points and never within an angle. Unsafe areas are illustrated in figure 43.

43. Signalman

For safe control of a recovery operation, there should be only one signalman. The operators must know the meaning of the signals to be used and act only on those signals. The signalman must be in a safe location and where his signals can be observed by the operators.

44. Impact Loads

Power should be appplied slowly to avoid possible impact loads on the rigging. An impact load is caused when the slack is removed from a rigging suddenly by dropping the load, moving the vehicle, or accelerating the winch. In either case the same effect occurs—this sudden force of weight times velocity, like the blow of a hammer, places an excessive force on the rigging and usually results in breakage.

CHAPTER 5

RECOVERY PROCEDURE

45. Recovery Procedure

During any recovery operation, a tried and proven procedure should be used to assure quick and safe accomplishment. A haphazard approach to a recovery problem or the trial and error method can only result in a prolonged immobility of the disabled vehicle, loss of valuable time, damage to equipment, and possible injury to personnel. The following eight-step recovery procedure, in the proper sequence, should be used in any recovery involving winching.

46. Step 1—Reconnoiter Area

Check the terrain for an approach to the load, method of rigging, and natural anchors. As with a tactical mission, a recovery crew must know the problem before decisions are made. A complete ground reconnaissance should be made of the area and should include selection of the best route of approach to the disabled vehicle to prevent possible disablement to the recovery vehicle. Determine the method of rigging as explained in

RECOVERY PROCEDURE

RECONNOITER AREA

ESTIMATE SITUATION

CALCULATE RATIO

OBTAIN RESISTANCE

VERIFY SOLUTION

ERECT RIGGING

RECHECK RIGGING

YOU ARE READY

Figure 44. Recovery procedure.

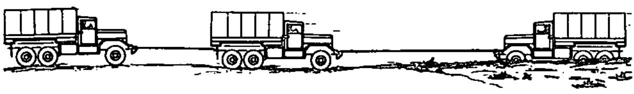


Figure 45. Towing a cargo truck from mire.

paragraph 29, and check for available natural anchors.

47. Step 2—Estimate the Situation

Determine the load resistance and the capacity of effort available. Estimate the resistance created by the load as explained in paragraph 6. For most recovery operations involving winching, the effort available would be the maximum capacity of the winch. In some recovery operations, particularly with the wrecker truck, the maximum distance between the winch and the disabled vehicle may be restricted and the effort available may be as little as half the winch capacity.

48. Step 3—Calculate Ratio

Compute an estimated mechanical advantage for the rigging. Divide the resistance of the load as determined in step 2 by the effort available (the capacity of the winch) as in paragraph 17.

49. Step 4—Obtain Resistance

Compute the tackle resistance and total resistance. Determine the resistance of the tackle as explained in paragraphs 18 and 19. Ten percent of the load resistance determined in step 2, multiplied the number of sheaves in the rigging. Add the determined resistance of the tackle to the load resistance to obtain the total resistance.

50. Step 5—Verify Solution

Compute line forces to compare with the winch and dead line capacities. Divide the total resistance computed in step 4 by the mechanical advantage estimated in step 3; the result is the force of the fall line, as explained in paragraph 20. The fall line force must be less than the capacity of effort; therefore, this step of the recovery procedure is the key step to solving the problem. When verifying the solution, if the computed fall line force is greater than the effort, the mechanical advantage must be increased. Note that no physical work has taken place to this point; therefore, no time is lost moving equipment or having to re-erect rigging equipment. By being able to compute dead line force as outlined in paragraph 21 and determine the strength of equipment and sling leg capacities using information in paragraphs 24 and 25, the correct equipment to use as dead lines may be selected.

51. Step 6—Erect Rigging

Orient the crew and instruct them to assemble the tackle and then move to a safe location. The recovery chief should advise the crew members of the plan and assign them to erect the tackle. Each crew member should be assigned a specific task to perform, a crew member who finished his task should assist those who are having difficulty. The crew members can save much time by having a thorough knowledge of the tackle to be erected and by helping each other. All safety precautions explained in paragraphs 32 through 36 should be observed.

52. Step 7—Recheck Rigging

Insure that tackle is erected for proper and safe operation. The recovery chief will direct the operator to remove most of the slack from the lines; then he will inspect to insure correct assembly as explained in paragraphs 33 through 38. If any corrections must be made, the recovery chief will direct the crew members to make them. He will explain the actions to be taken during the operation to the recovery vehicle operator and the drivers of the other vehicles involved and direct them to be prepared to act on signals as observed through their periscopes. Then the recovery chief will move to a safe location as explained in paragraphs 42 and 43, where his signal can be observed by the operators of both vehicles.

53. Step 8—You Are Ready

Signal the operator to apply winch power and recover the load. The recovery chief must be alert during the operation, ensuring that nothing obstructs the operation of the equipment and that all personnel on the ground remain at a safe location.

Note. This eight-step procedure as outlined in paragraphs 46 through 53, in the proper sequence, should be followed during all recovery operations requiring winching. To assist in memorizing these steps and their sequence, they are so arranged that when in the proper sequence, the first letter of each step will spell out the word *recovery* (fig 44). This plan is not restricted to recovery crews for application and supervision, but is also of value to commanders for determining the efficiency of their recovery crews and the need for training.

CHAPTER 6

VEHICLE RECOVERY OPERATIONS

Section I. SIMILAR VEHICLES

54. Vehicle Recovery Operations

The amount and type equipment employed as the source of effort during any recovery operation is dependent upon the level of recovery as discussed in chapter 2. Every effort should be made by the drivers and crews to accomplish the recovery before calling on support from a higher level. During combat it may be of the utmost importance that cargo reach its destination at a definite time or that personnel or cargo be picked up at a given time or that a combat vehicle be at a given place at a specific time. The use of similar vehicles for recovery usually constitutes the quickest method of recovery because similar vehicles are readily available. Recovery support should be called upon only when the similar vehicles are not adaptable to the situation or when the tactical situation does not permit their use. Engaged combat vehicles should never be diverted for the purpose of recovery.

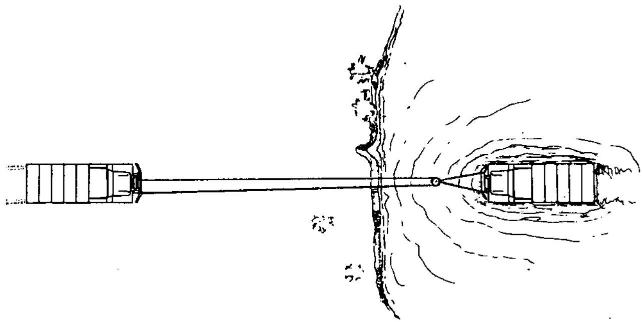


Figure 46. Winching with a similar vehicle.

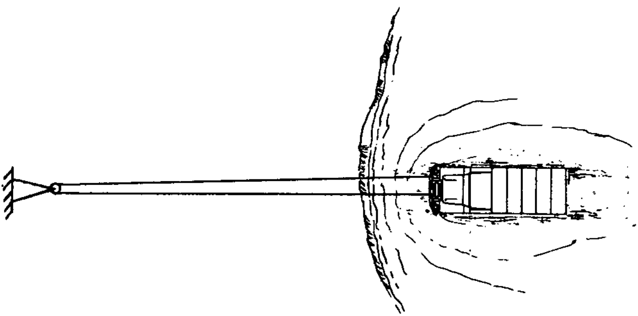


Figure 47. Self-winching operation.

55. Use of Similar-Type Wheeled Vehicles for Recovery

Similar wheeled vehicles can be used as the source of effort to perform recovery by towing and winching.

a. To recover a mired truck by towing with a similar vehicle, a tow chain should be used between the towing and the mired vehicle, attached to one of the lifting shackles of the mired vehicle and a front lifting shackle on the towing vehicle. If a greater working distance is required to enable the towing vehicle to get better traction, then the tow chains from both vehicles should be used. Power must be applied slowly to prevent placing an impact on the chain and lifting shackles. A chain, unlike a cable, will not stretch and can easily be broken by impact. If one towing vehicle cannot attain sufficient towing effort to overcome the resistance, another towing vehicle can be used in tandem with the first (fig 45).

b. To recover a mired cargo truck, a truck of equal or greater capacity should be used to perform the winching operation. As an example, a mired 2½-ton cargo truck may be winched with either a 2½-ton or 5-ton vehicle. All winch-equipped trucks are authorized a single sheave snatch block and one tow chain for rigging. A mechanical advantage is required if the resistance of the mired truck is greater than the winch capacity. The winching vehicle must be positioned in line with the mired vehicle so the correct fleet angle is obtained as explained in paragraph 9*b*. The winch cable must be free spooled from the drum and the free end of the cable attached to one of the winching vehicles front lifting shackles or to a separate anchor. A chain sling is formed between the lifting shackles of the mired vehicle and the snatch block is attached in the apex of the sling. The loop formed in the winch cable is placed in the snatch block

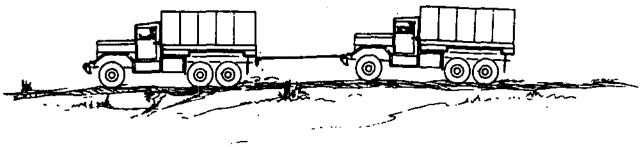


Figure 48. Towing with similar vehicles.

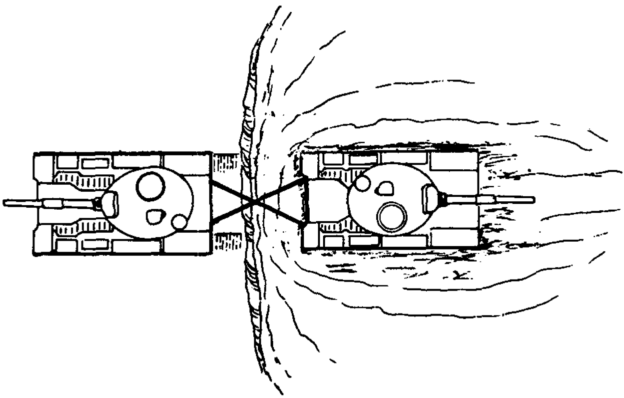


Figure 49. Towing mired tank, using one similar vehicle.

and power is applied to the winch to remove the slack from the cable (fig 46).

c. A winch equipped mired vehicle can perform a self-recovery. The rigging is similar to that used for similar vehicle recovery except the snatch block is attached to a suitable anchor and the free end of the cable attached to one of the mired vehicle's front lifting shackles. A fixed block will gain a mechanical advantage on a self-winching operation even though the sheave of the block is performing as a first-class lever because the source of effort (the winch) is part of the load; therefore, both the fall line and return line are attached to the load and supporting it. Since there are two lines supporting, the load a 2 to 1 mechanical advantage is obtained (fig 47).

56. Towing Disabled Wheeled Vehicles

A vehicle of the same size or larger can be used to tow the disabled vehicle. A tow chain can be used for the hookup. The chain is attached to the lifting shackles as outlined in paragraph 55*a*. A driver must be in the towed vehicle to control it (fig 48). Check the towed vehicle's technical manual for precautions to be observed and the preparations necessary to tow the vehicle. The towing speed never should exceed that which is outlined in the technical manual (TM).

57. Use of Similar-Type Tracked Vehicles for Recovery

The number of tracked vehicles required for a specific recovery is dependent upon the resistance to be overcome, the type of disablement, and the conditions of the terrain on which the towing vehicles must be operated. The rigging is accomplished using the vehicle tow cables attached to the tow hooks of the vehicles. All main battle tanks carry two tow cables; light tracked vehicles carry one tow cable.

a. Whenever two tow cables are used between two vehicles, they should be crossed. This prevents the cables from entangling in the tracks on turns and maintains alinement of the vehicles (fig 49). If a greater working distance between the pulling vehicle and the mired vehicle is required, tow cables can be joined together by using tow hooks.

If two towing vehicles are required for an operation, only one tow cable is required between the towing vehicles because the strength of one tow cable is slightly greater than the pulling effort of the second pulling tank; however when two tow cables are available they should be used to maintain alinement and equalize the pulling effort (fig 50).

b. The recovery of a nosed tracked vehicle may require as many as three similar vehicles, depending on the degree to which it is nosed and the conditions of the terrain on which the pulling vehicles must operate. In extreme situations, a source of effort may be necessary to lift the front of the nosed vehicle. To use a lifting vehicle, two or more tow cables should be connected together to obtain a greater working distance between the nosed vehicle and the lifting vehicle. The lifting vehicle should be positioned facing the nosed vehicle. The cables of the pulling vehicles are connected in the same manner as for recovery of a mired vehicle. Power should be applied to all the assisting vehicles at the same time, until the front of the nosed vehicle is raised, and starts moving rearward; then the lifting vehicle should move *forward* slowly supporting the vehicle until it is recovered. If there has been any spillage of oil or fuel in the nosed vehicle, its engine should not be operated until such spillage has been cleaned up (fig 51).

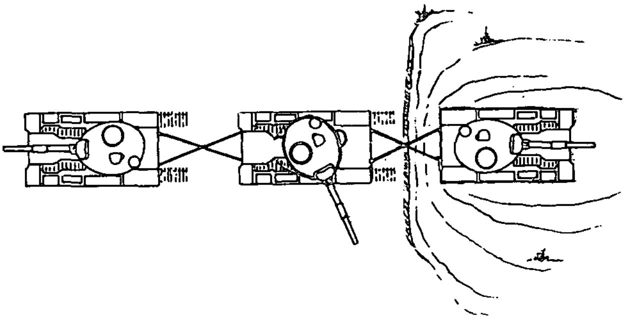


Figure 50. Towing mired tank, using two similar vehicles.

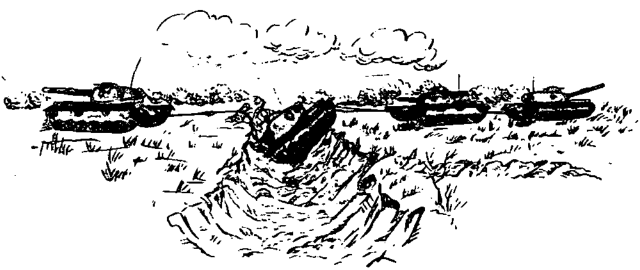


Figure 51. Recovering nosed tank with similar vehicles.

c. An overturned tracked vehicle can be uprighted by using three similar vehicles. One vehicle is used to pull the overturned vehicle upright; the other two vehicles are used to hold and retard the fall of the overturned vehicle to prevent its crashing down on the suspension system. Tow cables should be connected together in pairs to allow safe working distance. The cable used to upright the overturned vehicle should be con-

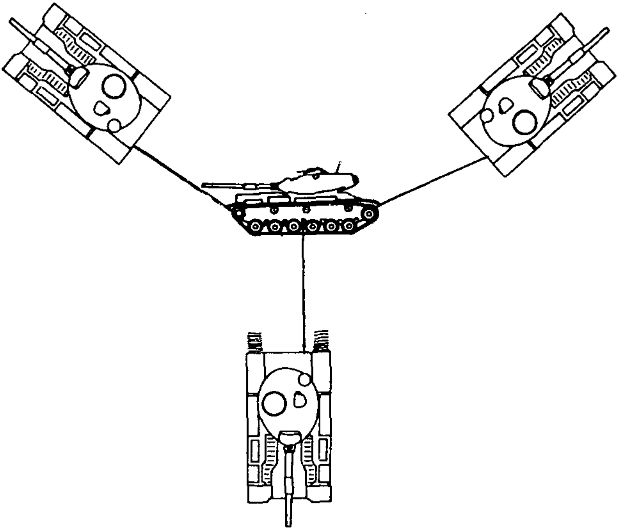


Figure 52. Recovering overturned tank with similar vehicles.

Figure 53. Towing disabled tank with similar vehicles.

nected to the nearest center roadwheel arm support housing on the upper side of the overturned vehicle. Never connect to any other part of the suspension system, turret, or the tie down eyes. The two vehicles used for holding should be positioned at a 30 to 45° angle from the overturned tank with their cables connected to the tow hooks on the high side of the overturned vehicle. The holding vehicles are so positioned to prevent damage to the cables or the fenders and lights of the overturned vehicle as it is uprighted. Drivers of the holding vehicles shift to low range; the pulling vehicle applies power gradually in reverse, while the holding vehicles move forward only enough to keep their cables taut until the overturned vehicle passes through the point of balance. As the overturned vehicle passes through the balance point, the holding vehicles move forward slowly, supporting the overturned vehicle and lowering it onto its suspension system (fig 52). Because of spilled oil and fuel that will normally be present, extreme caution must be exercised to prevent smoking or open flames near the overturned vehicle.

58. Towing Disabled Tracked Vehicles

A disabled tracked vehicle can be towed by a similar vehicle of the same weight class using two tow cables. The tow cables should be crossed to prevent entanglement with the tracks. A driver will be required in the towed vehicle to operate the brakes. The driver in the towed vehicle should be alternated frequently with the driver in the towing vehicle, because of carbon monoxide gas. The technical manual pertaining to the towed vehicle should be checked to determine the preparations necessary and the precautions to be used to prevent further damage to the towed vehicle. The towing speed should never exceed that which is outlined in the TM. If the disabled vehicle has defective brakes or its universal joints are disconnected, another similar vehicle will be required for holding (fig 53).

Section II. RECOVERY EXPEDIENTS

59. Recovery Expedients

Military operations will require vehicles to operate in remote areas where, should disablement occur, assistance would not be readily available. Under these conditions, the driver or crew must attempt self-recovery by the use of expedients. An expedient is an improvised method and is accomplished with the materials on hand.

60. Substitutes for a Jack

a. When an outside dual tire becomes flat, and a jack is not available, the inside dual may be run up on a small log or rock. This takes the weight from the outside wheel and allows it to be removed for repair or replacement (fig 54).

Note. This expedient is applicable to those vehicles with dual wheels that are secured separately.

b. Another variation that may be used when no jack is available, is to cut a piece of timber longer than the distance from the axle to the ground. Place one end of the timber against the axle at an angle with the other end in a shallow hole, and drive the vehicle onto the timber. Set the brakes and block the vehicle securely (fig 55).

c. To raise the front wheel of a cargo truck, secure a timber approximately 5 feet long to the front bumper at an angle with a chain or rope,

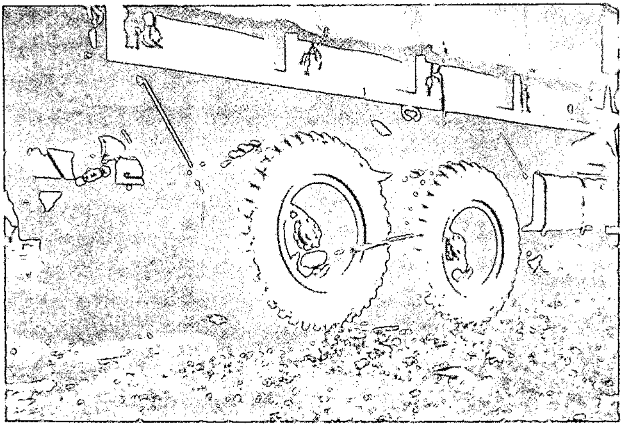


Figure 54. Substitute for jack to remove outside dual wheels.

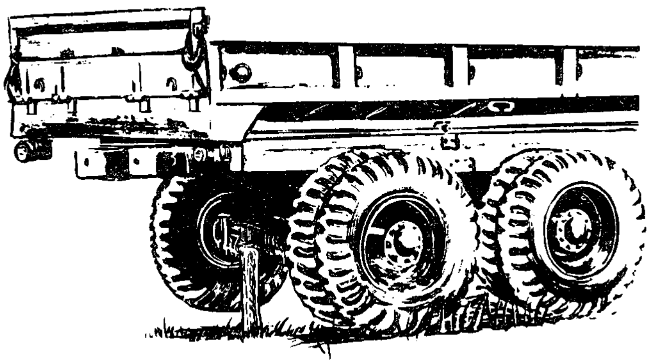


Figure 55. Substitute for jack to remove tandem wheels.

place bottom end of timber in a shallow hole, then move the vehicle forward until the timber is in a vertical position and the wheel clears the

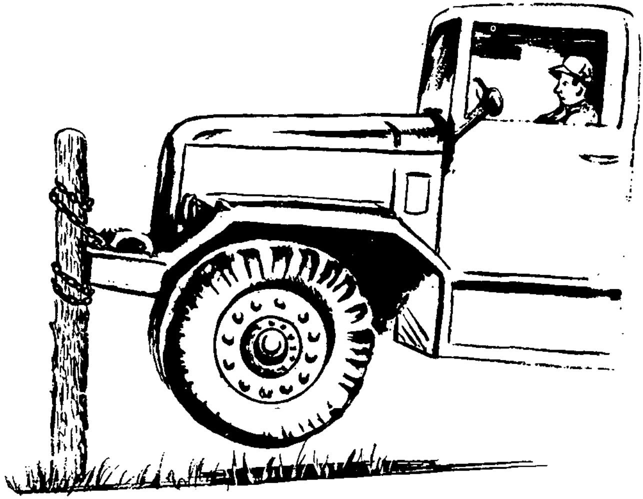


Figure 56. Substitute for jack to remove front wheel.

ground (fig 56). Set the brake and block the vehicle securely.

61. Use of a Pry

A pole can be used to pry a 1/4-ton truck out of a ditch by lifting the front end of the truck with the pole as illustrated in figure 57, and applying power to the truck in reverse gear.

62. Use of Wheels for Winching

On wheeled vehicles not equipped with a winch, the rear wheels may be used to assist in recovering the vehicle. On a dual-wheeled truck, a rope with one end fastened to the wheel hub and the other end anchored, will cause the rope to be

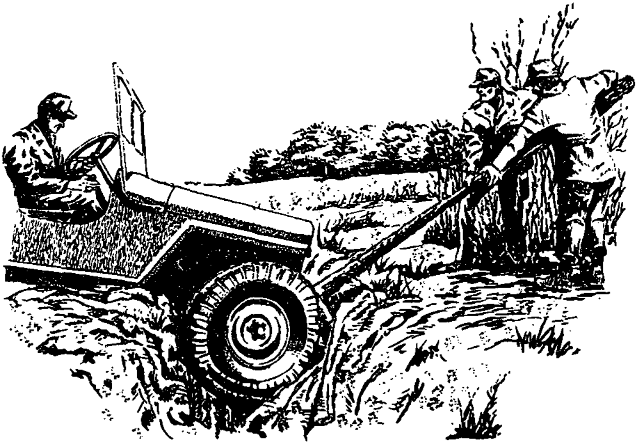


Figure 57. Pole used as a pry.

wound between the dual wheels providing the same action as a winch. The end of the rope that is fastened to the wheels should be run between the duals and through one of the holes in the wheel disk. Care should be taken not to place the rope through a hole in the wheel disk where the valve stem is located. A bowline knot is tied in the end of the rope and slipped over the hub (fig 58). Tie a second rope in the same manner to the dual wheels on the other end of the axle (fig 59), then place the vehicle in reverse gear; the ropes will wind between the two duals, causing the vehicle to move rearward.

If the truck has single wheels, such as the M715 and M151, the same expedient can be used by placing a bar through the hole in the end of the

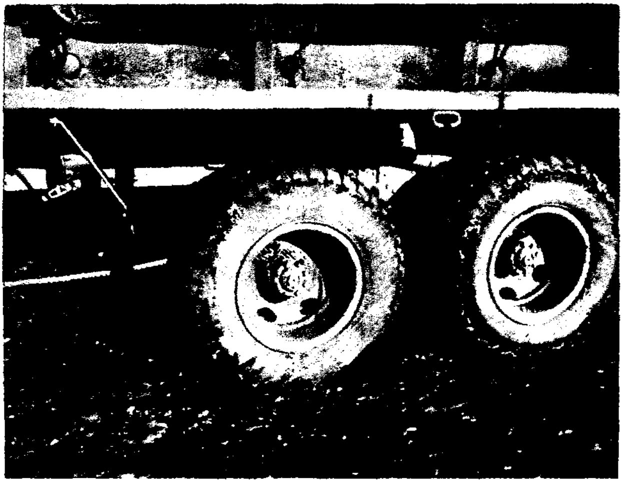


Figure 58. Attachment of rope to dual wheels to be used as a winch.

axle flange. A rope is attached to the wheels on each side of the vehicle by fastening them to the bars with figure 8 hitches (fig 60). Applying power will cause the ropes to be wound around the hubs and move the vehicle.

63. Use of an A-Frame

Frequently a truck will become nosed in a shell hole or narrow ditch. When a truck becomes disabled in this manner, both lifting and pulling forces are required to make the recovery. The lifting force can be obtained from an A-frame. To construct an A-frame, two poles approximately 8 feet long and large enough in diameter to

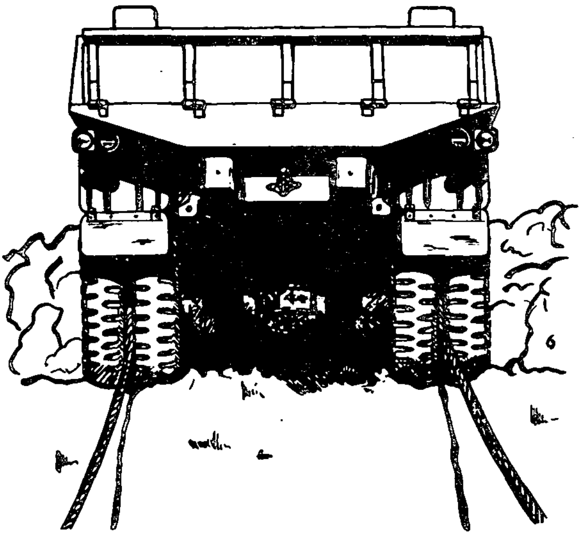


Figure 59. Using wheels as a winch.

support the front end of the truck will be needed. The poles should be lashed together at the top by a figure 8 or girth hitch (fig 61). The lower end of the poles should be placed in the ground 10 to 12 inches deep to prevent them from sliding when power is applied. The upper end of the A-frame is laid across the hood of the vehicle and the attachment made as in figure 62. If the nosed truck is equipped with a winch, the winch cable should be rigged for a 2 to 1 mechanical advantage, with the end of the cable secured to the apex of the A-frame.

64. Anchoring Tracks

Vehicles often become bellied (high centered) on

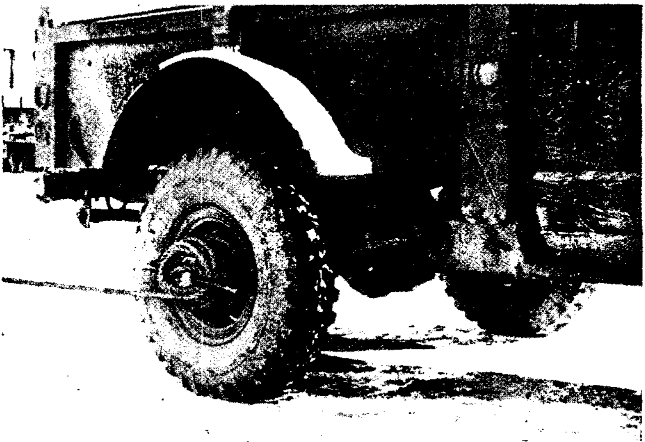


Figure 60. Attachment of rope to single wheels to be used as a winch.

stumps, rocks, dry ridges, or mire. In this position, vehicles are immobilized because of the lack of traction.

a. To recover a bellied vehicle obtain a log long enough to span the width of the vehicle and of sufficient diameter to support the vehicle weight. The log is placed against both tracks and a tow cable is placed so one end of the cable goes over the log and through the tracks from the inside. The other end of the tow cable is placed underneath the log, and the ends of the cable are connected together with a tow hook on the outside of the track to facilitate disconnecting. The same procedure is followed to attach the log to the track on the opposite side of the vehicle (fig 63). By gradually applying power to the tracks, the

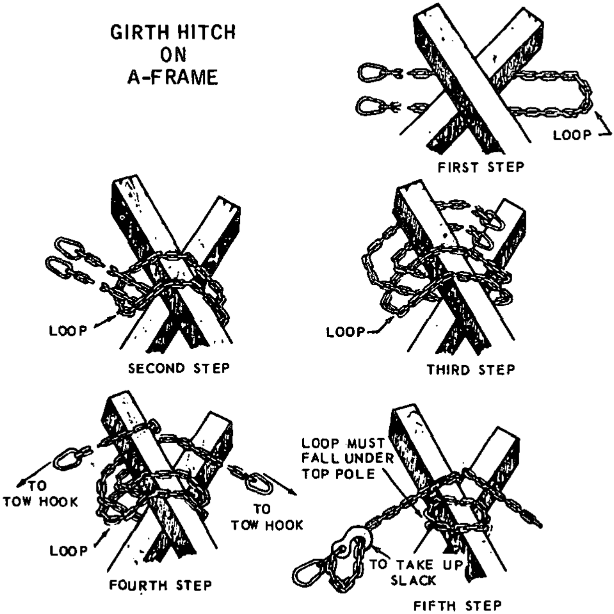


Figure 61. Tying girth hitch to A-frame

slack in the tow cables will be taken up, pulling the log underneath the tracks until it comes in contact with the obstacle, anchoring the tracks and causing the vehicle to move.

Caution. **Care must be taken to stop the vehicle before the log reaches the fenders, to prevent damage to the fenders and tow cables.**

b. For a bellied disablement other than mire, the tracks can be anchored using two tow cables.

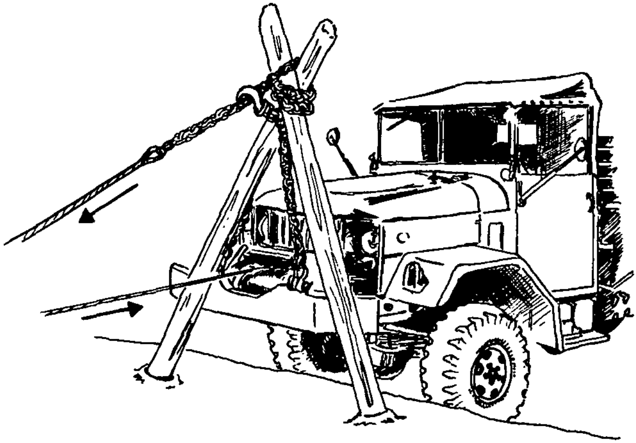


Figure 62. Recovery of a nosed truck using an A-frame.

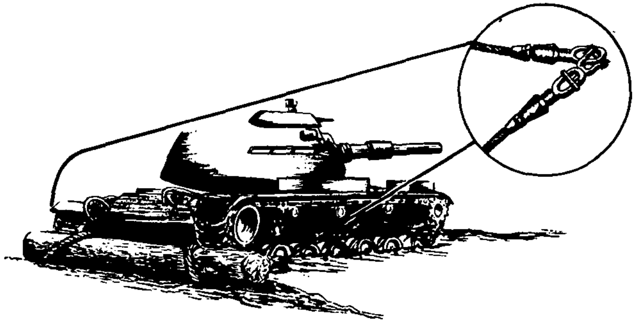


Figure 63. Log used to anchor tracks.

Connect the tow cables together with a tow hook and attach the cables to both tracks by passing the ends of the cables through the tracks from

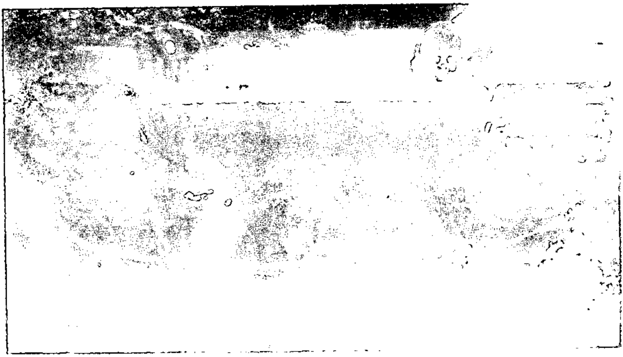


Figure 64. Cables used to anchor tracks.

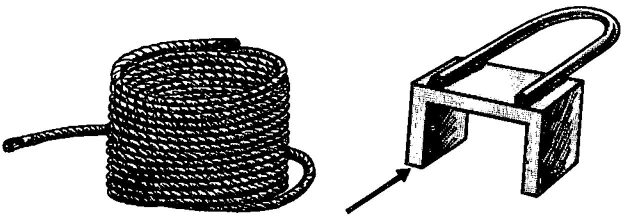


Figure 65. APCAT expedient kit.

the outside and attaching them to the standing parts of the cables with tow hooks (fig 64). When power is applied to the tracks the cable will contact the obstacle and anchor the tracks. The same caution must be exercised as outlined in *a* above.

c. APCAT (Armored Personnel Carrier Anchoring Tracks) device. Armored personnel carriers may fail to exit the water after swimming

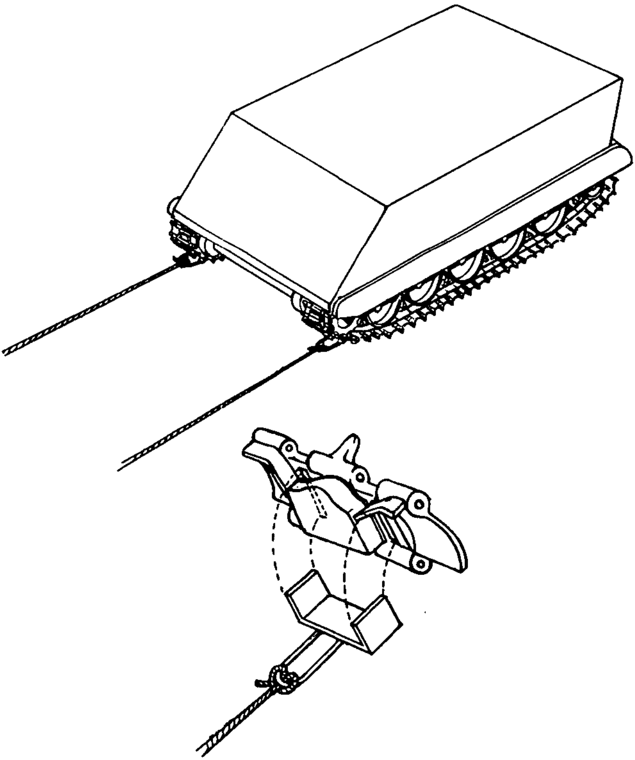


Figure 66. APCAT expedient.

due to steep banks or adverse terrain conditions. As an aid to water exit, the APCAT expedient can be used. The APCAT expedient kit consists of one pair of track anchor blocks fabricated locally and 200 feet of 1-inch fiber rope (fig 65). The track anchor blocks are placed in the vehicle

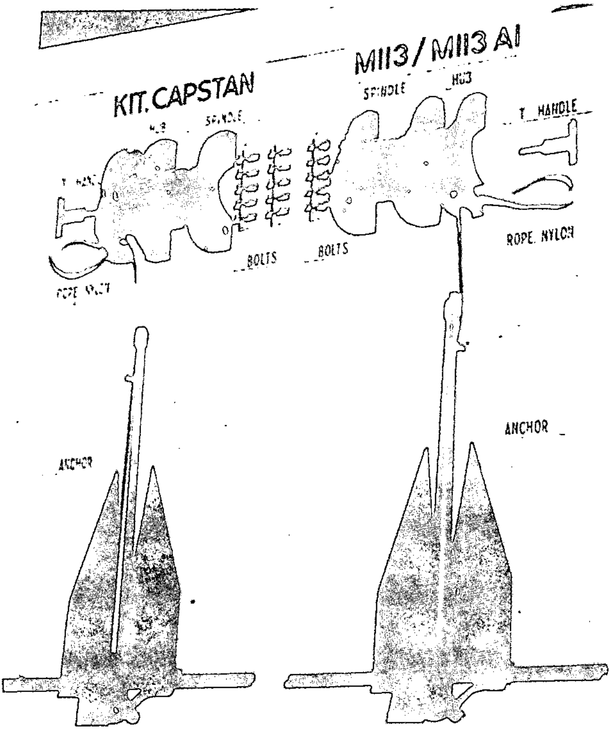


Figure 67. Capstan kit.

track sprocket holes in each track and the rope is then attached from the blocks to suitable anchorages. As power is gradually applied, the tracks will anchor themselves to the blocks and cause the vehicle to move (fig 66). This expedient may also be used in mire or bellied situations.

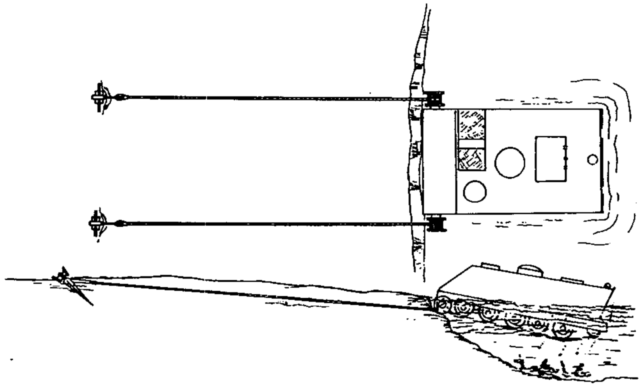


Figure 68. Capstan recovery of an armored personnel carrier.

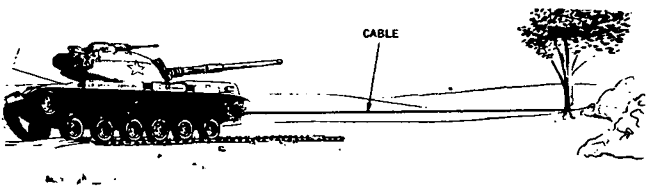


Figure 69. Moving a vehicle with both tracks broken.

65. Capstan Winching of Armored Personnel Carrier

When leaving water after swimming operations, an armored personnel carrier may become disabled because of the steep angle of the bank, the muddy or slippery surface of the bank or a combination of both, and cannot exit. A capstan expedient can be used for a self-recovery. The cap-

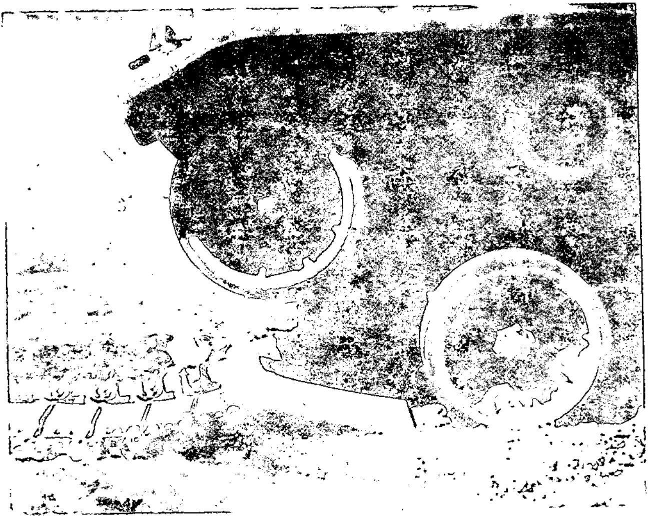


Figure 70. Moving a vehicle onto a track.

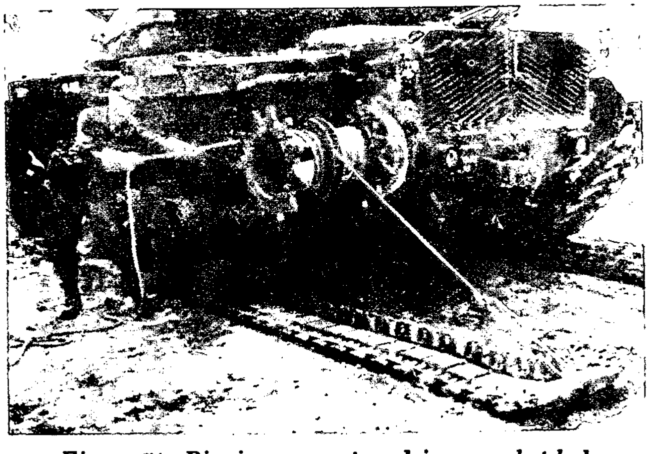


Figure 71. Rigging a rope to a drive sprocket hub.

stan kit consists of one pair of capstan adapters that bolt to the drive sprocket hub, one pair of capstan drums with mounting tee bolts, nylon rope, and one pair of ground anchors (fig 67). Normally the capstan adapters are permanently mounted to the drive sprocket hubs with the metal shroud plates cut away. The capstan drums can be very quickly installed to the adapters with the drum tee bolts. The rope is secured to each mounted capstan drum, and wrapped two or three turns around the drums on both sides of the vehicle. Care must be taken to ensure that the anchors are positioned in line with the capstan drums. The ropes must extend from the *underside* of the capstan drums to the anchors, and all slack must be removed from the ropes before they are tied to their respective anchors. By applying power to the tracks, the ground anchors will imbed in the ground, and the winching action of the capstan drums will cause the vehicle to move (fig 68).

66. Moving Tracked Vehicle With Both Tracks Broken

When both tracks of a tracked vehicle are thrown, it may become necessary to break both tracks in order to move the vehicle so the tracks can be remounted. Break one track and attach a cable from the drive sprocket hub to an anchor. This will support the vehicle so the other track can be broken. Chocking must be used to prevent the vehicle from rolling out of control. As the engine power is applied to the drive sprocket attached to the cable, and steering action is applied,

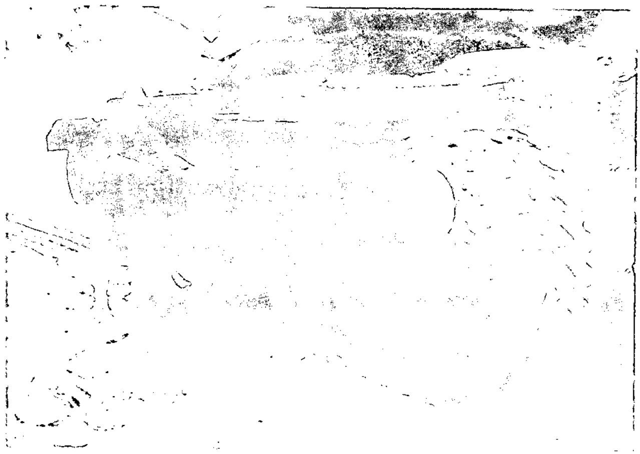


Figure 72. Installing a track.

the vehicle will move by the winching action of the drive sprocket hub (fig 69).

67. Moving a Vehicle onto a Track

To move a vehicle onto a track, the vehicle is first alined with the track, and then a plank type ramp is positioned on the end of the track. In a situation where a ramp is not available, a shallow ditch is dug for the end of the track to lay in for the same results (fig 70).

68. Installing a Broken Track

To install a broken track, aline the track with the road wheels so center guides will pass between the road wheels when the vehicle is moved. The vehicle is stopped so that the road wheel is resting forward enough to allow the track to be passed over the sprocket. A rope is then tied to the center of the track pin on the rear track link, the rope is then passed over the center guide groove of the sprocket hub, around and between the rear support roller wheels, and back around the sprocket hub making two turns as illustrated in figure 71.

As power is applied to the sprocket and the free end of the rope is held taut, the end of the track is pulled up to the sprocket (fig 72). Once the sprocket has engaged a minimum of three track links, the sprocket is stopped, and the rope is removed from the sprocket hub and extended forward over the compensating idler wheel to guide the track as the vehicle is moved forward. When end of the track has passed over the compensating idler, the track can be connected.

69. Helicopter Recovery of Mired Vehicles

Cross-country operation of tracked vehicles in inundated areas, such as rice paddies and swamps, may result in a vehicle becoming mired in such a position that other vehicles cannot get close enough to perform the recovery without becoming mired. In this type of situation, use of a helicopter may be the best method because the helicopter's mobility is not affected by the terrain; it can hover above a disabled vehicle, allowing a rigging to be attached to the disabled vehicle. The recovery of the M113 APC and some wheeled vehicles has been accomplished using a helicopter with a lifting capability of approximately 7½ tons.

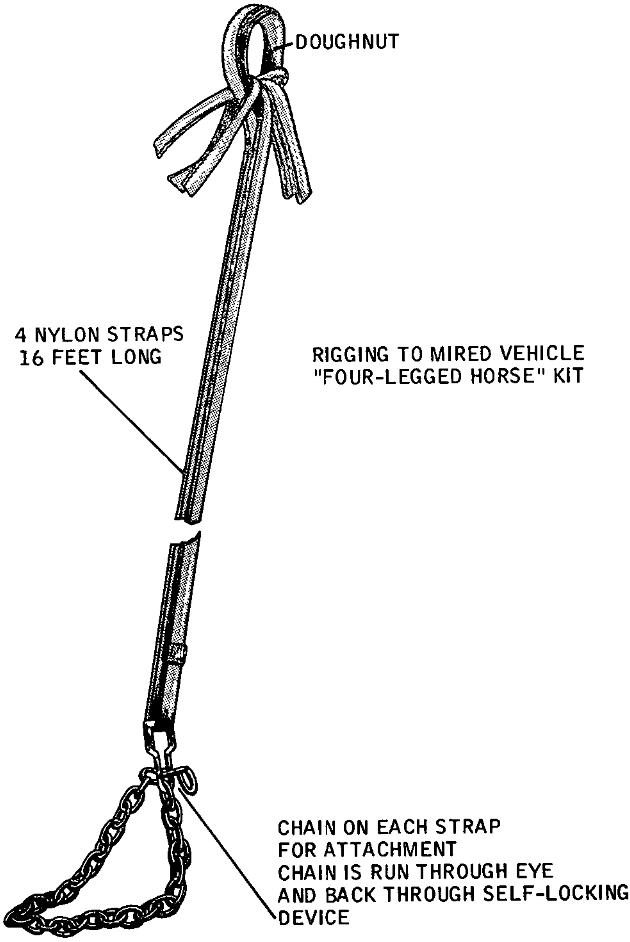


Figure 73. "Four-legged horse" kit.

a. The attachment used between the helicopter and the mired vehicle is a standard lifting sling

Figure 74. Two sling legs attached to each front towing lug.

used to transport equipment. This sling is termed as a *"four-legged horse"* kit, with a strength of 15,000 pounds. The legs of the sling are made of nylon straps with a chain and a self locking device on their free end (fig 73). The sling in application can be attached to either the four lifting eyes, or to the towing lugs (eyes). The place

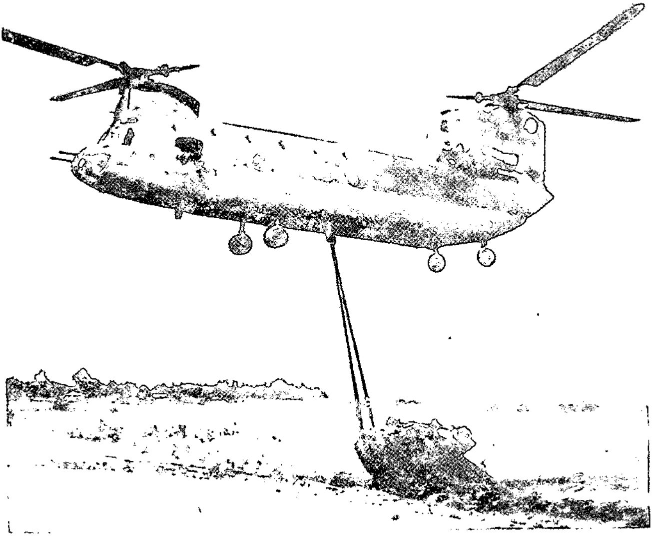


Figure 75. Recovery with sling attached to towing lugs.

where the sling is attached on the mired vehicle depends on the mire situation.

b. In a mire situation in which the towing lugs are exposed. The helicopter drops the sling onto the mired APC, and the crew members then attach two sling legs to each of the front towing lugs, as in figure 74. The helicopter hovers over the mired vehicle, so the doughnut of the sling can be attached to the helicopter lifting hook. The helicopter then lifts and pulls on the vehicle concurrently with power being applied to the tracks of the mired vehicle for the recovery (fig 75).

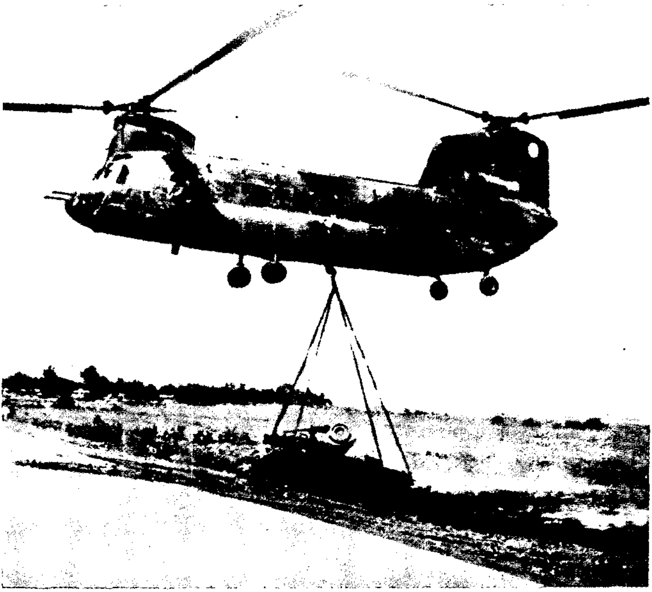


Figure 76. Recovery with sling attached to all four lifting eyes.

c. In a situation in which the towing lugs were not exposed, the sling can be attached to the four lifting eyes (fig 76) or to only two lifting eyes (fig 77).

Section III. EXPEDIENT REPAIRS

70. Expedient Repairs

Should mechanical malfunctions disable a vehicle, expedient repairs can be performed by the

Figure 77. Recovery with sling attached to only two lifting eyes.

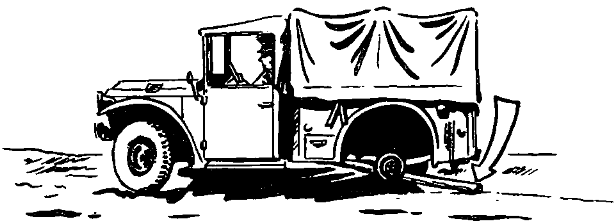


Figure 78. Skid expedient.

crew. Expedient repairs are such that crewmen with limited mechanical training can apply them

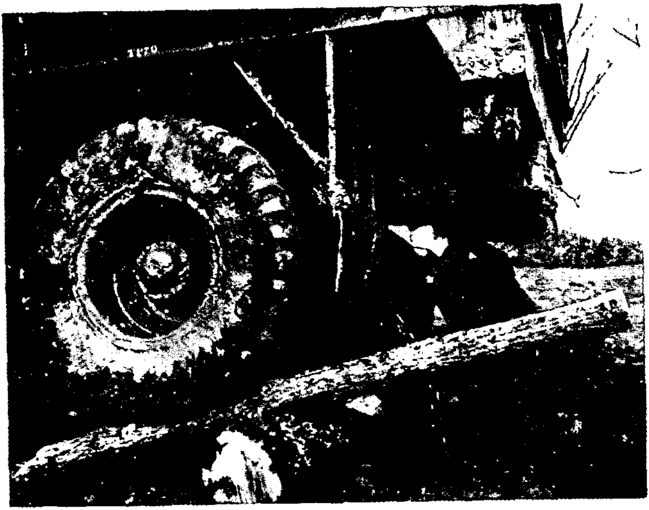


Figure 79. Raising tandem axle.

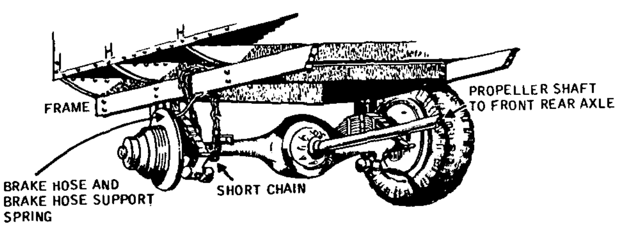


Figure 80. Attaching tandem axle to frame.

with a sufficient amount of accuracy to restore operation to the disabled vehicle. However, expedient repairs are to be used as an emergency measure only and will never be used in lieu of normal maintenance repair procedures.

71. Damaged Wheel

When a driver finds himself in an isolated area with a flat tire or damaged wheel and he does not have the equipment to repair it, a skid may be used on 4-wheel-drive type vehicles. The skid should be used on the rear wheel (fig 78). (Wheels can be changed from one hub to another to accomplish this.) A pole approximately 4 inches in diameter and 6 to 8 feet long should be used. After the vehicle is raised, one end of the pole is placed above the frame crossmember near the transmission and the other end on the ground. The pole should pass under the spring U-bolts, aline with the spring, and be lashed securely to the spring. The pole will then support the weight of the vehicle on the side with the defective wheel. By engaging the front wheel drive, the vehicle will move under its own power.

72. Disabled Tandem Axle

When a tandem axle has a burned-out bearing or damaged wheel that would disable the vehicle or cause further damage if continued in operation, the axle may be tied up and made inoperative. The wheel of the disabled axle should be moved onto a rock, log, or similar object to raise the wheel as high as possible (fig 79).

While the wheel is raised, the axle should be tied as tightly as possible to the frame by using heavy wire or a tow chain (fig 80). Caution should be exercised to prevent the chain or wire from causing damage to the brake lines. If the wheel bearing is burned out, or for some similar reason the

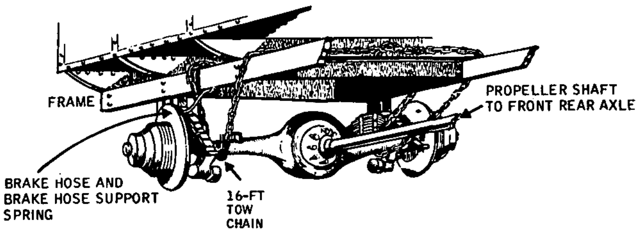


Figure 81. Disabled tandem axle.

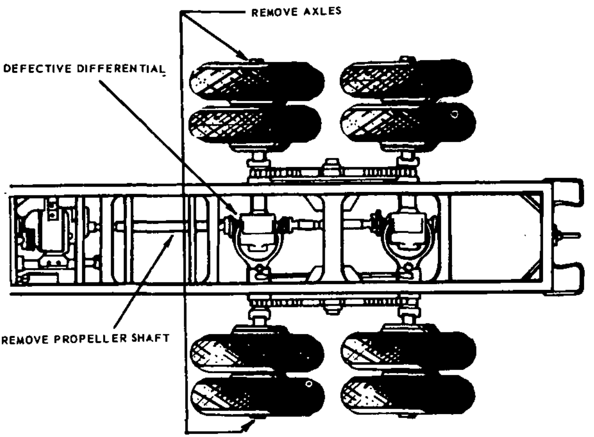


Figure 82. Defective differential.

wheel should not turn, the axle shaft should be removed from the axle housing and the hole in the hub stuffed with rags to keep out foreign matter. This expedient will allow the other wheels to drive.

This same expedient may be applied to both ends of the axle if both wheels are defective (fig 81).

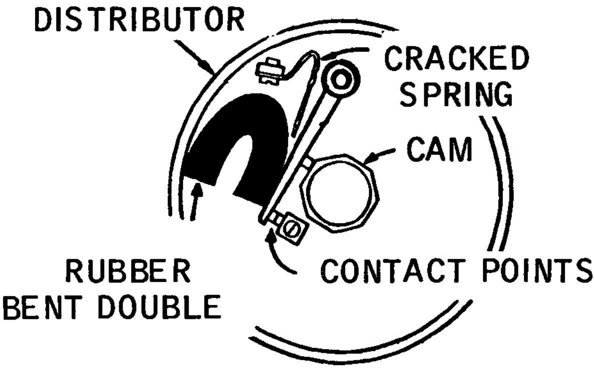


Figure 83. Substitute for distributor point spring.

With both ends of axle tied up, the truck should not be loaded too heavily.

73. Defective Differential

If the defect is in the differential of a 4 x 4 or 6 x 6 vehicle, the propeller shaft and drive axles may be removed from the defective assembly and the vehicle operated on power supplied by the other axles. For example, if the front rear differential is defective and the rear propeller shaft is removed, the vehicle may still be powered by the front wheels. When the axle shafts are removed, the openings in the ends must be covered securely to keep out dirt and foreign matter (fig 82).

74. Broken Distributor Point Spring

A brcken distributor point spring will result in

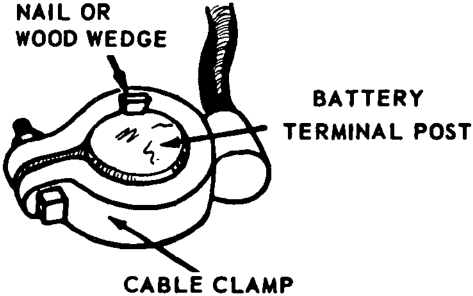


Figure 84. Battery cable clamp repair.

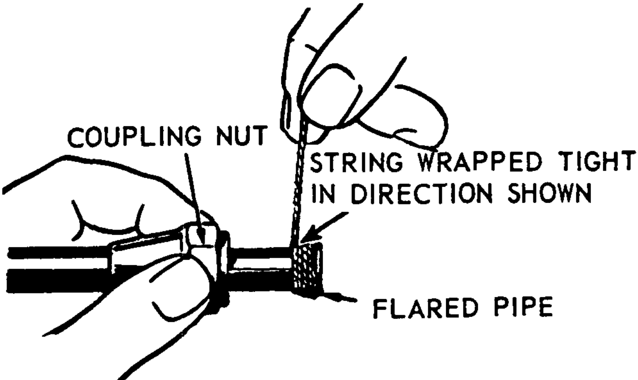


Figure 85. Leaking low-pressure line fitting.

the engine cutting out and finally stopping. To substitute for a broken spring cut a piece of rubber from a tire, or vacuum hose, and double it and place it between the movable point and the distributor housing (fig 83). The rubber will act as a distributor point spring. The engine will then start and perform at low speeds, but the

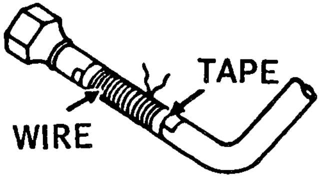


Figure 86. Repair of cracked low-pressure oil or fuel line.

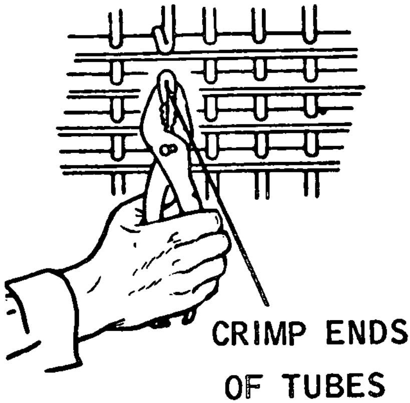


Figure 87. Repair of puncture radiator core.

rubber cannot close the points fast enough to perform properly at high speed. The rubber may work itself out of position and have to be replaced occasionally.

75. Loose Battery Clamp

When a battery cable clamp becomes loose and cannot be tightened anymore, a nail or metallic wedge may be used to make contact between the battery post and the cable clamp. The clamp must be loosened, the wedge inserted between the battery post and clamp, and the clamp tightened (fig 84). When working with tools around batteries and battery clamps, care must be taken to prevent arcing, causing possible damage to vehicle electrical components or personal injury.

76. Leaking Low-Pressure Line Fitting

To repair a leaking low-pressure line fitting, a string or rag may be wound tightly around the line behind the flare (fig 85). Slide the coupling nut over the material, screw it onto its connection, and tighten it securely against the packing string with a wrench. The string will act as a gasket and seal the leak. The string should be wound clockwise—in the same direction the coupling nut is turned to be tightened.

77. Cracked Low-Pressure Oil or Fuel Lines

Cracked low-pressure oil or fuel lines usually are caused from extreme pressure, vibration, or defective metal. The leak may be stopped by wrapping the line tightly with friction tape held in place by wire. The wire will help the tape withstand pressure, and usually the leak will be stopped until a permanent repair can be made (fig 86).

78. Punctured Tube-Type Radiator Core

Radiators are punctured frequently when vehicles are operating in wooded or combat areas. When this happens, the cooling fins should be cut and pushed away from leaking tubes, cut the leaking

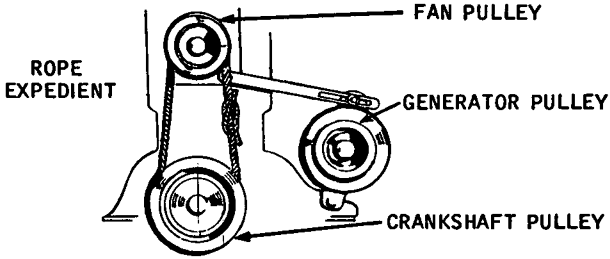


Figure 88. Fan belt substitute.

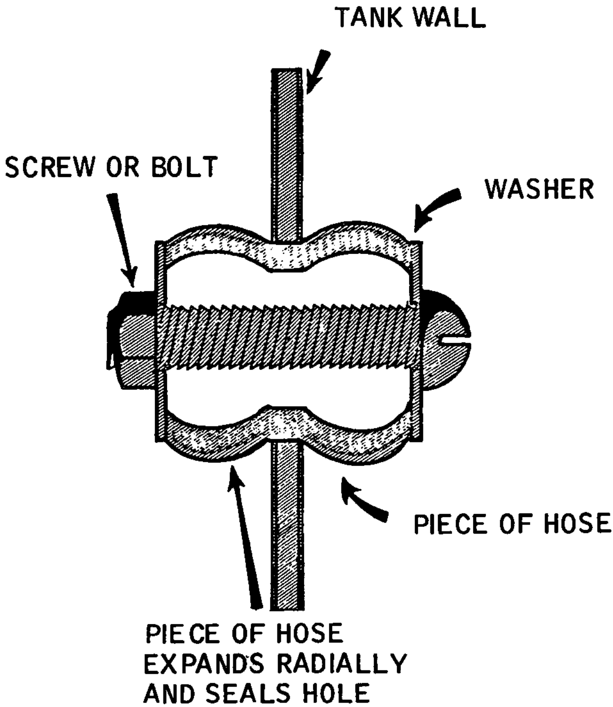


Figure 89. Repair of punctured fuel tank.

tube in half, and fold the ends of the tube back about three-fourths of an inch. Close the tube ends by pressing them flat with pliers (fig 87). The efficiency of the cooling system is reduced when several tubes are cut, and the engine may overheat. When field expedient repairs of the radiator have been made, the radiator cap should be loosened to keep radiator pressure from building up, thereby reducing the possibility of breaking the repair.

79. Damaged Front Axle Brake System

When damage has occurred to the front axle brake system, a method of repair is to close the line at the junction block to the axle. This will assist the driver in maintaining steering control while braking and will allow pressure buildup in the rear brakes.

80. Broken Fan Belt

When a fan belt breaks and a replacement is not readily available, a fiber rope from the vehicle tarpaulin or a piece of field telephone wire may be used as a substitute. The rope or wire should be looped around the pulleys three or four times, pulled as taut as possible, and tied with a square knot (fig 88).

81. Broken Fan Blades

A broken fan blade will cause excessive vibration of the engine, making it dangerous to operate the engine. Remove the remainder of the blades. The vehicle may be operated, however, caution should be exercised to prevent over heating.

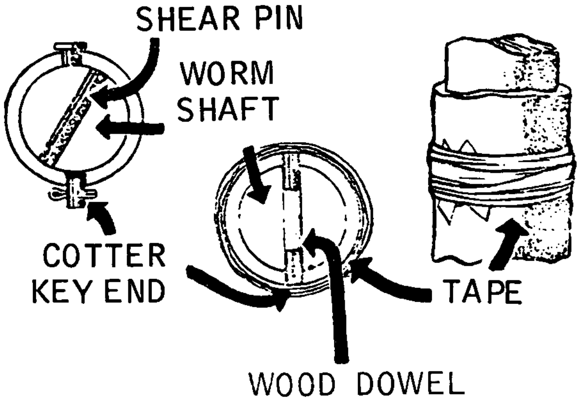


Figure 90. Substitute shear pin.

82. Punctured Fuel Tank

To repair a punctured fuel tank, use a piece of hose about the size of the punctured hole in the fuel tank, a bolt, nut, and two flat washers. Assemble the washers and piece of hose on the bolt and screw the nut down snugly. Enlarge the hole in the fuel tank, if necessary, so the assembled bolt and hose will pass into it and fit snugly; then hold the hose to prevent its turning, and tighten down on the bolt. This will cause the piece of hose to expand in the hole and seal the leak (fig 89).

83. Shear Pin Substitute

A substitute for a broken shear pin may be made by punching out the remains of the broken shear pin, cutting the remains in half, and inserting the two shear pin halves with a short, wooden dowel between them as illustrated in figure 90.

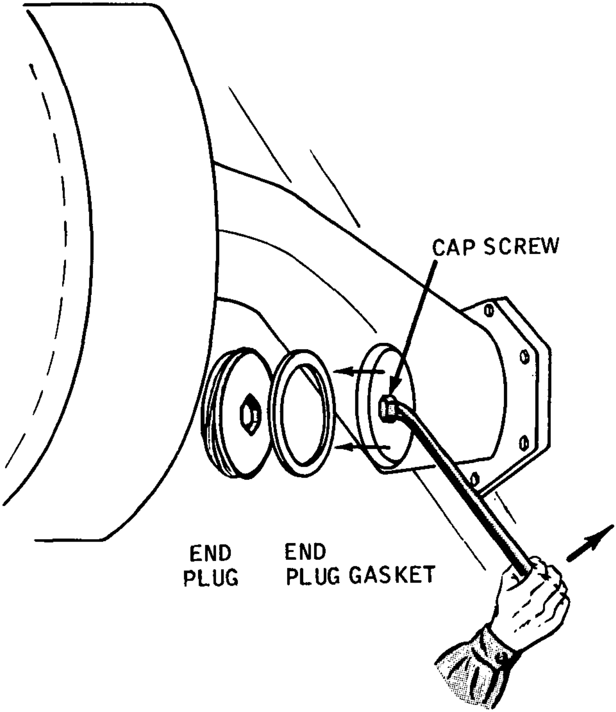


Figure 91. Expedient method for removing torsion bar.

Wrap friction tape around the shaft to cover the shear pin hole and prevent the end of the substitute shear pin from dropping out. A steel bolt, spike, nail, or screwdriver blade should not be used as a substitute shear pin, because it may result in damage to the winch and cable.

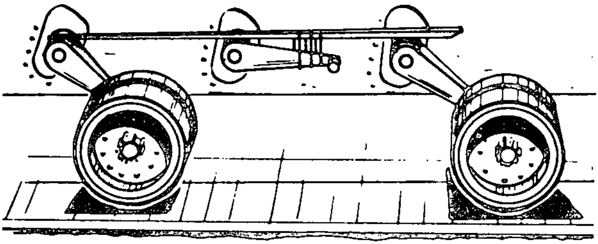


Figure 92. Road wheel expedient applied.

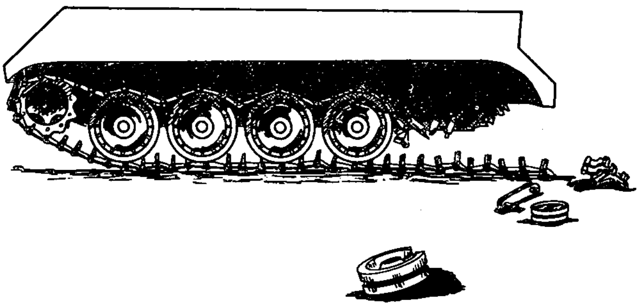


Figure 93. Damaged track and suspension.

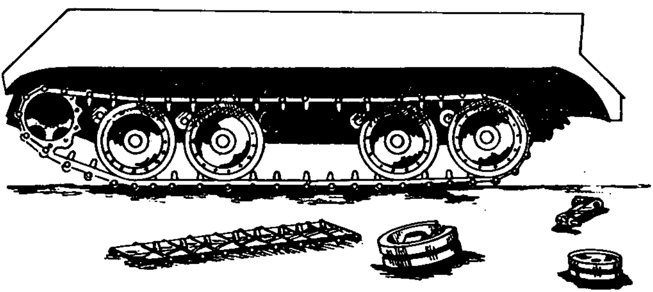


Figure 94. Short track expedient applied.

Figure 95. Direct-pull winching operation.

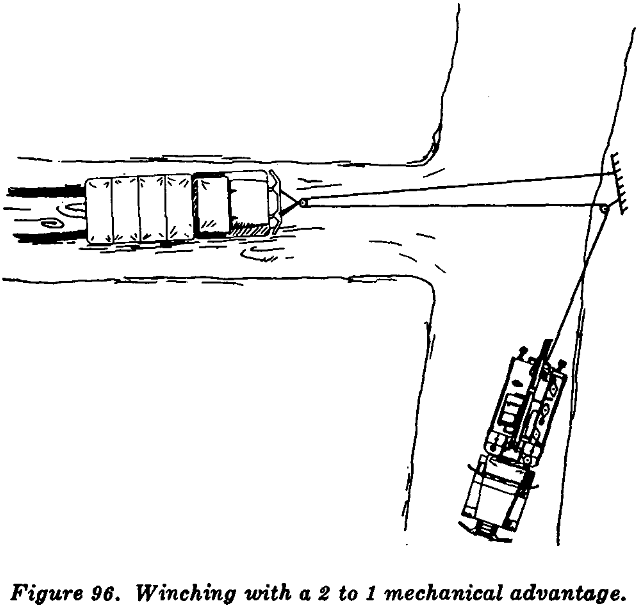


Figure 96. Winching with a 2 to 1 mechanical advantage.

84. Damaged Road Wheel Components

To operate a vehicle with a damaged road wheel, spindle, or road wheel arm, the arm must be tied up out of the way. To tie the road wheel arm up, the torsion bar must be removed. This can be done by positioning the vehicle across a ditch narrow enough to permit the front and rear road wheels to support the weight of the vehicle, and deep enough to permit the track to sag away from the defective road wheel. If a ditch is not available, a trench can be dug. The vehicle in this position will allow the road wheel assembly to sag and remove the tension from the torsion bar. The torsion bar is then removed by removal of its capscrew and end plug, replacing capscrew in the torsion bar, and prying behind the capscrew head with a track fixture handle as illustrated in figure 91.

The vehicle is then repositioned on level ground where the road wheel is removed, a crowbar positioned across two torsions bar support housings, and the road wheel arm tied in a raised position to the crowbar with rope from the vehicle tarpaulin (fig 92). This expedient is only applicable to intermediate road wheels.

85. Damaged Suspension Components

A armored personnel carrier with a damaged track, rear road wheel arm, and idler wheel (fig 93), can be operated by using the short track expedient. To apply this expedient, companion components to the damaged suspension parts such as the rear shock absorber, track adjuster, road wheel arm and torsion bar must be removed. To give the vehicle better stability, number 3 road wheel with arm is moved to the rear road wheel position. Due to the absence of the idler wheel, sufficient track blocks must be removed to permit the track to be connected (fig 94).

Section IV. SPECIAL PURPOSE VEHICLES

86. Special Purpose Vehicles

This section describes and explains recovery operations performed with wrecker trucks and recovery vehicles. Recovery operations using these special purpose vehicles is performed by the repairmen of the companies or battalion. Special purpose vehicles are used for recovery when the methods used by the platoon are unsuitable to the situation, or when their efforts have been unsuccessful. Wrecker trucks are designed for the recovery of wheeled vehicles and recovery vehicles are designed for the recovery of tracked vehicles. The methods of recovery performed, using special purpose vehicles, are winching, lifting, and towing, as explained in chapter 2.

Note. This manual discussses the application of the vehicle's capability to winch, lift, and tow. Refer to the pertinent technical manuals for information relative to the operation of the equipment and the specific capabilities.

87. Mired Truck

Factors that must be considered during the recovery of a mired truck using a wrecker truck are: the resistance of the load, the approach to the load, and the distance between the wrecker and the mired vehicle. An example of a very simple winching operation is illustrated in figure 95. A direct pull is used because the resistance cre-

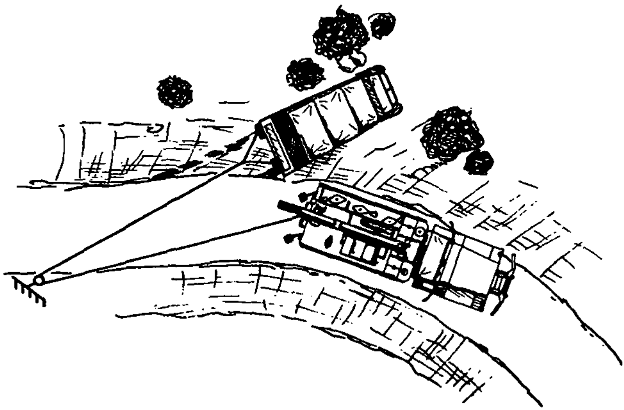


Figure 97. Change of direction winching operation.

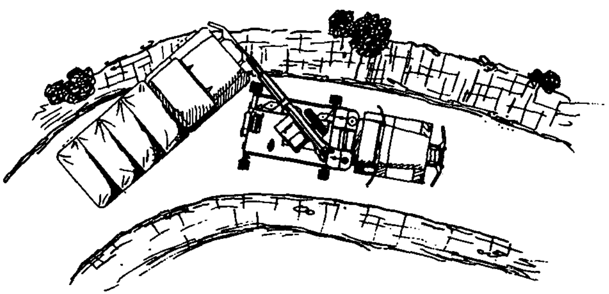


Figure 98. Lifting operation with wrecker truck.

ated by the mired vehicle is less than the winch capacity of the wrecker.

An example of a more complicated winching operation is illustrated in figure 96. A mechanical advantage and a change of direction pull is used because the mired truck offers a resistance greater than the winch capacity of the wrecker, and the wrecker is unable to position itself in alinement due to the terrain.

88. Nosed Truck

The recovery of a nosed truck using a wrecker truck may require only a towing operation. Some situations may require all three of the wrecker truck's capabilities (winching, lifting, and towing) to complete the recovery. An example would be the recovery of a 2½-ton cargo truck that is nosed off a narrow road and is mechanically disabled. To perform the recovery, the wrecker truck is positioned on the road so that when the nosed truck is pulled back up on the road, its front end will be in line with the rear of the wrecker truck. A change of direction pull using the wrecker rear winch is used to pull the truck onto the road as illustrated in figure 97.
Then the front of the truck is lifted and the crane traversed to place the truck directly behind the wrecker truck in preparation for towing (fig 98).

89. Overturned Truck

To upright an overturned truck using the wrecker truck, a sling method of attachment must be used on the overturned truck, because a pulling force applied to only one point of the frame will usually result in a bent frame. The sling attachment is made of two utility chains or 1 inch fiber rope. The sling ends are attached to the front and rear lifting shackle on the high side of the overturned truck, and then the winch cable is attached to the center of the sling. A holding effort will be required to prevent the vehicle from crashing onto its wheels. The holding force could be another vehicle or a rope block and tackle with man-power, the attachment for the holding force would be through another sling attached to the same points on the overturned truck as the pulling sling. If a holding vehicle is not available, rig a 4 to 1 mechanical advantage tackle from the equipment on the wrecker truck, attach it between the holding sling and an anchor, and wrap its fall line around a tree as illustrated in figure 99. Apply power gradually to the wrecker truck winch until the overturned truck is past the vertical position, and then lower the truck to its wheels with the holding tackle. Caution must be exercised to prevent smoking or open flames near the overturned truck, because of the danger of igniting spilled fuel and oil. If neither holding vehicle nor holding tackle can be used, the wrecker boom may be used to hold the load. Whenever the wrecker boom is used in this manner, maximum use of the boom jacks should be made. When lowering the overturned truck to its wheels, always lower it using the hoist winch, rather than booming out with the crane.

Caution. **Do not overload crane capacity.**

90. Towing Wheeled Vehicles

Frequently, it will be necessary to tow the recovered vehicle to a repair shop with the wrecker truck. The method of towing depends primarily upon the terrain over which the vehicle must be towed, and the mechanical condition of the dis-

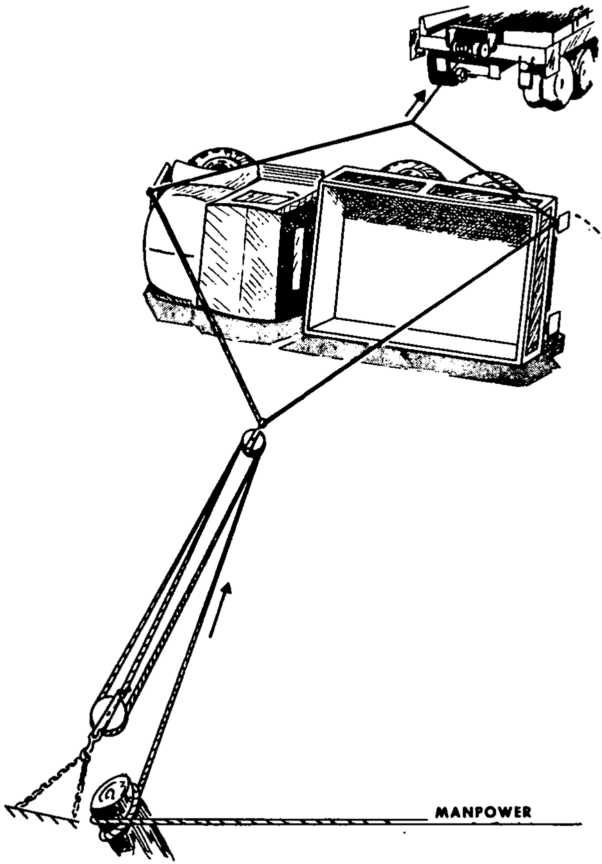


Figure 99. Recovery of overturned truck.

abled vehicle. A wrecker truck is capable of towing vehicles by the following methods:

a. Highway Tow. The tow bar is attached to

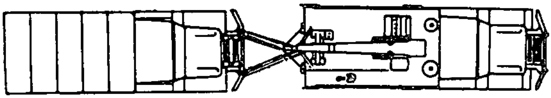


Figure 100. Highway tow using wrecker truck.

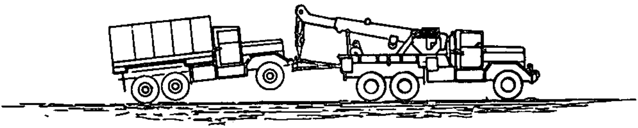


Figure 101. Cross-country tow with wrecker truck.

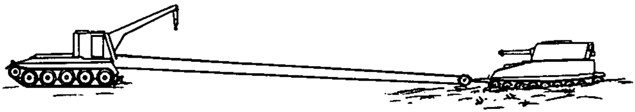


Figure 102. Recovery of a mired tracked vehicle with a 2 to 1 mechanical advantage.

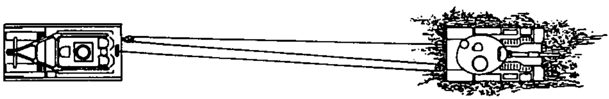


Figure 103. Recovering a mired tank with recovery vehicle using a 3 to 1 mechanical advantage.

the disabled vehicle's lifting shackle eyes and the wrecker truck tow pintle. All wheels of the towed vehicle are on the ground. A driver in the towed vehicle is not required (fig 100).

b. Cross-country Tow. A cross-country tow provides better control of the towed vehicle when towing over rough terrain. To rig for the cross-country tow, attach a chain lifting sling or the hoisting bar between the truck's front lifting shackles. Attach a tow chain from the wrecker tow pintle to the disabled truck lifting shackles. Place the hoist block hook in the lifting sling and hoist the truck until the front wheels are approximately 12 inches off the ground. Extend the boom to remove the slack from the towing chain; this is done to prevent the towed vehicle from jamming into the rear of the wrecker truck. The boom should be supported with the shipper braces to prevent impact loads on the crane mechanisms (fig 101). If the front end of the vehicle is damaged, the cross-country method of tow may be required even though the disabled vehicle is being towed on the highway. The tow bar may be used in place of a tow chain.

c. Towing Precautions for Wheeled Vehicles. Extreme care must be exercised when towing disabled vehicles to prevent further damage to the vehicle. The vehicle technical manual should be checked for preparation of the vehicle for towing and the precautions that must be exercised. The following general precautions should be exercised in any towing operation.

(1) *Long and short hauls.* Refer to pertinent vehicle manual for preparation of vehicle.

(2) *Towing speed.* Never exceed 15 miles per hour while towing any type of wheeled vehicle.

91. Mired Tracked Vehicles

a. Recovery With One Recovery Vehicle. In most mired tracked vehicle situations, the recovery can be accomplished using only one recovery vehicle. In preparation for winching, the recovery vehicle must be positioned as nearly in line as possible with the mired vehicle and at a distance to obtain maximum winching capacity as described in paragraph 29*b* and *c* to erect the rigging. When a 2 to 1 mechanical advantage is required (fig 102), the block is attached to the mired vehicle by the procedure described in paragraph 30*b*. If the resistance is such that a 3 to 1 mechanical advantage is required, then one snatch block is attached to a towing lug on the mired vehicle; another block attached to the dead man lug on the recovery vehicle, and the free end of the winch cable attached to the other towing lug on the mired vehicle (fig 103).

b. Recovery With Two Recovery Vehicles. When the load resistance of a mired tracked vehicle is so great that the calculated fall line force is greater than the winch capacity of one recovery vehicle with a 3 to 1 mechanical advantage, a second recovery vehicle is necessary for the operation. Rig each recovery vehicle main winch with a 2 to 1 mechanical advantage. Attach the snatch block of each rigging to a towing lug of the mired vehicle. The recovery vehicles should be positioned side by side to allow the same lengths of winch cable to be used because of their variable capacity winches (fig 104). To synchronize winch speeds, both recovery vehicle opera-

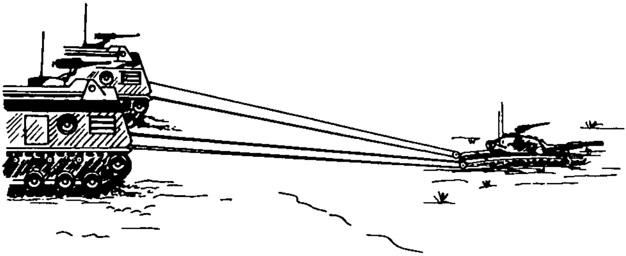


Figure 104. Recovering a mired tank with two recovery vehicles.

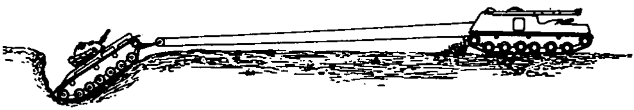


Figure 105. Winching a nosed tank with a recovery vehicles.

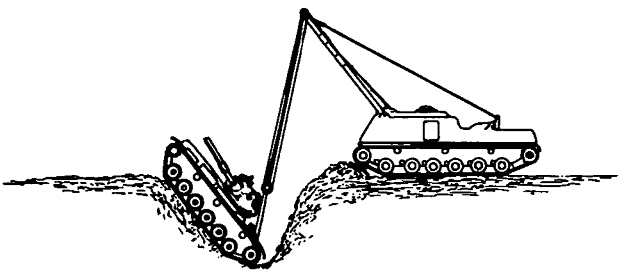


Figure 106. Lifting operation to recover a nosed tank.

tors should set their engine speed at the desired rpm with the hand throttle, and compensate with the winch control lever to maintain taut cables.

92. Nosed Tracked Vehicle

The method used in recovery of a tracked vehicle nosed in a deep trench or ravine with a recovery vehicle depends upon the factors involved in the nosed situation. If the condition of the terrain behind the nosed vehicle is level the recovery may be accomplished by towing. If the nosed vehicle cannot assist in its own recovery and the condition of the terrain is not suitable for towing, a winching operation can be performed as illustrated in figure 105.

If terrain features are such that the recovery vehicle cannot be safely positioned behind the nosed vehicle, then the recovery can be accomplished with the recovery vehicle positioned on the opposite side of the ditch. Using the recovery vehicle's boom with its maximum mechanical advantage rigging, attach its hoist block to the front lifting eyes on the nosed tank with a V-chain as illustrated in figure 106, the vehicle can be lifted to the horizontal. If no oil or fuel spillage existed on the nosed vehicle, it may assist in its recovery by applying power in reverse at the same time the recovery vehicle is lifting. If the nosed vehicle is not able to assist, then the front of the tank would be lifted and pulled to the opposite side of the ditch, where a towing or winching operation could be used to complete the recovery. By constructing a rigging similar to the type illustrated in figure 107, a combination winching and hoisting operation may be used to recover the nosed vehicle. By coordinating the hoist winch and the tow winch, the weight and

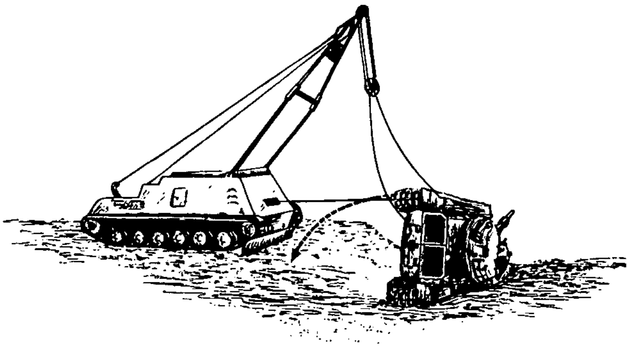


Figure 107. Recovering an overturned tank with a recovery vehicle.

movement of the disabled vehicle can be controlled during the entire recovery operation.

93. Overturned Tracked Vehicle

To upright an overturned tracked vehicle with a recovery vehicle, position the recovery vehicle facing the bottom of the overturned vehicle at a distance away that is equal to the width of the overturned vehicle, plus 2 feet. For the uprighting source of power, attach the main winch cable to the near center road-wheel arm support housing on the high side, using a utility chain. For the holding source of power, rig the boom with its maximum mechanical advantage rigging, and attach its hoist block to two tow cables to form a sling. The opposite ends of the sling are passed under the track and attached to the front and

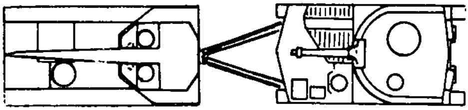


Figure 108. Highway tow with recovery vehicle.

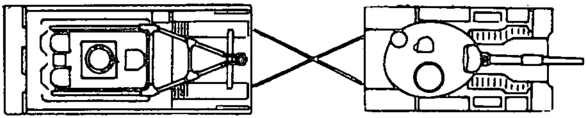


Figure 109. Cross-country tow with recovery vehicle.

rear tow hooks on the high side of the overturned vehicle as illustrated in figure 107. To upright the overturned vehicle, power is applied to the main winch until the vehicle is pulled past its point of balance and is being supported by the hoist rigging. Then by lowering the hoise winch rigging slowly, lower the overturned vehicle onto its suspension system. Because of spilled oil and fuel that will normally be present, smoking or open flames will not be permitted near the overturned vehicle.

94. Towing Tracked Vehicles

Frequently, it will be necessary for the recovery vehicle to tow a disabled vehicle to some point where a repair is to be made. The method of tow used depends primarily upon the type of terrain over which the vehicle is to be towed.

a. Highway Tow. The recovery vehicle's tow bar is used. It is attached to the towing lug of the disabled vehicle as explained in paragraph 30*b*(3), with the lunette of the tow bar installed

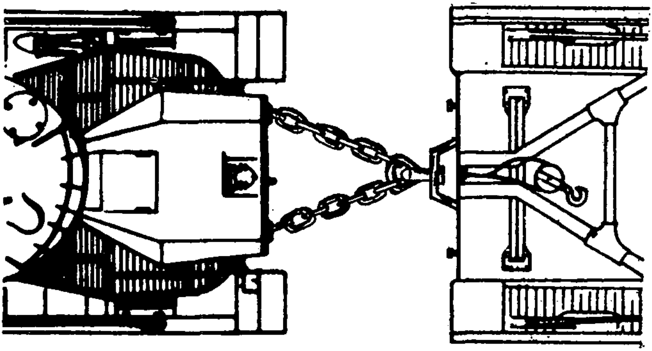


Figure 110. Combat tow with a recovery vehicle.

in the recovery vehicle's tow pintle (fig 108). A driver would not be required in the towed vehicle.

b. Cross-country Tow. To perform a cross-country tow with a recovery vehicle, crossed tow cables are used between the recovery vehicle and the disabled vehicle (fig 109) as when towing similar vehicles. A driver is required to apply the brakes on the towed vehicle to prevent it from overrunning the recovery vehicle on down grades.

c. Combat Tow. The combat tow is used when it is necessary to make a towing connection under fire to provide the least possible exposure of personnel. The lifting V-chain is attached to the recovery vehicle's tow pintle before it is moved to the disabled vehicle's location. The recovery vehicle is moved into the area, backed up until contact is made with the back of the disabled vehicle. One of the disabled vehicle's crew members can slip through the escape hatch and connect the

V-chain legs to the front tow hooks of the disabled vehicle. After the hookup is made he reenters through the escape hatch, and the recovery vehicle moves out, towing the disabled vehicle (fig 110).

d. Towing Precautions for Tracked Vehicles. When a disabled tracked vehicle is being towed, care must be exercised to prevent further damage to the towed vehicle. The vehicle technical manual should be checked for towing precautions peculiar to the vehicle.

(1) For short hauls (less than ¼-mile), the gearshift control lever must be in *neutral* (N) position.

(2) For long hauls (over ¼-mile), to prevent possible damage to the transmission, the power train should be disconnected at the universal joints to the final drives.

(3) Never exceed speed outlined in the technical manual of the towed vehicle.

CHAPTER 7

UNDERWATER VEHICLE RECOVERY

95. Underwater Vehicle Recovery

Due to the development of an underwater fording capability for the main battle tank and the fact that numerous other vehicles in the inventory have a swimming capability, it is highly probable that some of these vehicles are going to become disabled while performing fording or swimming operations. As in land disablements, vehicles disabled in or under water must be restored to normal operation quickly and safely. The same methods of recovery apply and at all levels within the organization. Special training of personnel to enable them to work under water is required. The expedient method of recovery is not applicable to underwater recovery; however, some expedient repairs may be accomplished, after the vehicle has been recovered from the water.

96. Load Resistance in Water

The resistances encountered during underwater recovery operations are determined in the same manner as for land recovery. When flooded vehicles are being pulled from water to land, the weight of the water must be considered when determining the resistance. In some instances, the resistance to be overcome will be less than the rolling resistance of the same vehicle on land.

a. Floating-Type Vehicles.

(1) The resistance of a mechanically disabled floating-type vehicle to being moved on the water is negligible, as compared to its rolling resistance on land and can be caused to move with a small amount of effort.

(2) If a floating-type vehicle is flooded and submerged, the resistance to movement on the river bottom is determined in the same manner as on land by considering the weight of the vehicle and the river bottom conditions—sand, gravel, or mud. As an example: if the situation involves an M113 APC (weight 11 tons) flooded and located on the river bottom in mud at roadwheel depth, the resistance is estimated at 11 tons.

(3) The greatest resistance encountered with flooded floating-type vehicles is the resistance created as the vehicle is being pulled from the water to land. Due to a great volume of water contained in a submerged floating-type vehicle such as an M113 APC, the weight of the water must be considered when estimating the resistance created by vehicle as it is pulled from the water. The weight of the water is estimated as being equal to the vehicle's weight. Therefore, an M113 APC's weight as it is pulled from the water would be 22 tons, and the resistance created

would depend on this weight and the terrain condition of the exit area.

b. Non-Floating-Type Vehicle.

(1) The kinds of terrain disablements encountered during fording operations are the same as on land operations—mire, nosed, and overturned. The resistances are estimated in the same manner by considering vehicle weight and type of disablement. The resistance afforded by a flooded fording-type vehicle underwater is the same as a similar type mechanically disabled on land.

(2) The weight of a flooded fording-type vehicle is greater than the vehicle's actual weight, for the same reason as that given for flooded floating-type vehicles. However, the volume of water contained in a fording-type vehicle is much less than that contained in a floating type. The weight of water contained in a flooded fording-type vehicle is estimated as ⅛ the vehicle weight. As an example: a flooded 50-ton tank's weight as it is pulled out of the water is estimated to be 50 tons plus ⅛ its actual weight or 56.25 tons. The amount of resistance created as the vehicle is pulled from the water depends on vehicle weight (56.25 tons) and the condition of the terrain in the exit area—sand, gravel, or mud.

97. Sources of Effort

a. Similar Vehicles. Similar vehicles may be used as the source of effort much the same as for recovery on land and with the same restrictions governing their use. The towing capability of a fording-type vehicle is considered to be the same as on land and can be adapted to the same type of disablements as on land. The gun tube of the towing vehicle will require repositioning to prevent possible collision with the disabled vehicle. A floating-type similar vehicle can be used to tow a floating-type vehicle on the water, even though the floating-type vehicle does not have a towing capability in water comparable to its towing capability on land. The resistance of a floating vehicle is negligible.

b. Special Purpose Vehicles. Wrecker trucks and recovery vehicles are readily adaptable to underwater recovery operations. The winch cables of the recovery vehicles are long enough to allow winching operations from land to water in most situations.

98. Locating Submerged Vehicles

The first problem in any underwater recovery operation is the location of the disabled vehicle. This will not be difficult if the vehicle conning tower or guide rod is visible above the surface. If the vehicle has rolled over on its side or dropped into an underwater depression, it will be necessary to conduct search operations. It may be necessary in some situations to use dragging devices to locate the disabled vehicle. After the vehicle is located, it is necessary for divers to go down and find the front and rear of the vehicle to establish the approach route of the recovery vehicle. Lines and floats should be used to mark the position of the vehicle. Empty water or gasoline cans can be used as floats.

99. Methods of Attachment

The same attachments are made to vehicles disabled under water as are made to those disabled on land whether the recovery effort is similar vehicles or a winch. The only deviation from the normal method of attachment is when the object of recovery is a floating vehicle. The resistance of a floating vehicle is considerably less than its weight, therefore, it is more expeditious to attach the rigging to the lifting eyes. This allows the personnel who are making the attachment to do so without having to work in the water except to disconnect the tow hooks on the disabled vehicle. One tow hook would be attached to each of the two lifting eyes front or rear and the tow cables attached to the tow hooks (fig 111). If a similar vehicle is used for the operation, its tow hooks would be attached to the lifting eyes before

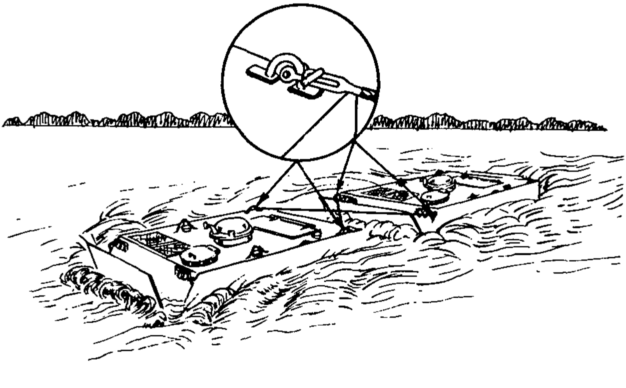


Figure 111. Towing a floating vehicle with a swimming vehicle.

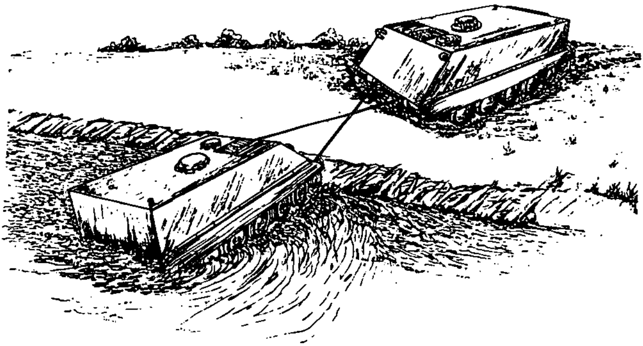


Figure 112. Towing a floating-type vehicle from water to land.

entering the water. The tow cables would be attached and crossed as in the normal tow until the disabled vehicle is towed to the shore (fig 112). The tow hooks should be reattached to the towing lugs to tow the vehicle from the water onto land.

100. Methods of Rigging

The methods of rigging for underwater recovery normally are restricted to the manpower and lead methods. The backup method may be used only when the recovery vehicle is on the shore line, or in very shallow water. The method of rigging employed depends upon distance from winching source to disabled vehicle, type of disabled vehicle, type of recovery vehicle used, amount of equipment available (floats, boats, and ropes, etc.), and condition of the disabled vehicle.

a. Lead Method. The lead method of rigging is accomplished in the same manner as on land; however, some modification of the preparation must be made when the hoist winch rigging is transported through or on the water to the object of recovery. The hoist winch cable and snatch block can be manually transported on the river bottom if the distance is not too great, and underwater visibility is good enough for divers to keep the disabled vehicle in sight at all times. With a power boat available, two divers will be able to lead the hoist winch cable and transport the snatch block to the object of recovery (fig 113). A similar fording-type vehicle can be used to transport the main winch rigging to a disabled vehicle, providing the condition of the river bottom would permit its use.

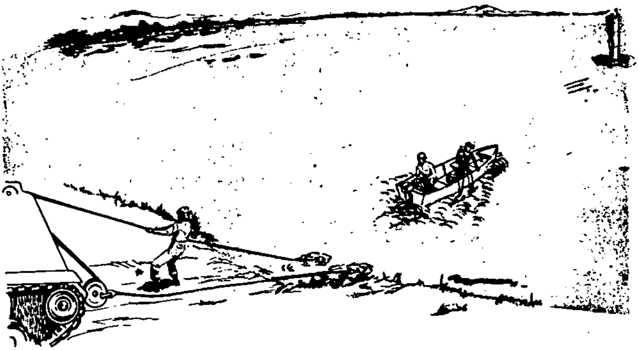


Figure 113. Transporting hoist winch cable to vehicle disabled under water.

b. Manpower Method. The manpower method of rigging is acomplished in the same manner as discussed in paragraph 29*a*. A winch cable can be transported to a floating or submerged disabled vehicle by using a series of floats to support the cable on the water (fig 114) or attaching a rope to the cable end, swimming with the rope to the object of recovery, and then pulling the cable to the vehicle.

Figure 114. Floating winch cable to object of recovery.

APPENDIX A

REFERENCES

1. Field Manuals (FM)

21–5	Military Training.
21–6	Techniques of Military Instruction.
21–30	Military Symbols.

2. Army Regulations (AR)

310–25	Dictionary of United States Army Terms.
310–50	Authorized Abbreviations and Brevity Codes.

3. Technical Manuals (TM)

5–725	Rigging:
9–2320–211–10	Operator's Manual For 5-Ton 6x6 Truck, Chassis: M39, M40, M40C, M61, M61A2, M63, M63A2, M63C, M139, M139C, M139D, M139F, M139A2F; Truck, Cargo: M41, M54, M54A1,

	M54A2, M55, M55A2; Truck, Dump: M51, M51A2; Truck, Tractor: M52, M52A1, M52A2; Truck, Tractor, Wrecker: M246; Truck, Van: Expansible, M291A2, M291A2C; Truck, Wrecker, Medium, M62, M543, M543A2.
9–2320–222–10	Recovery Vehicle, Full Tracked, Medium M88.
9–2320–238–10	Recovery Vehicle, Full Tracked, Light, Armored M578.

4. Miscellaneous

DA Pam 310–3	Index of Doctrinal, Training, and Organizational Publications.
DA Pam 310–4	Index of Technical Manuals, Technical Bulletins, Supply Manuals, Supply Bulletins, and Lubrications Orders.
ASubjScd 5–5	Rigging.
ASubjScd 9–20	Practical Application—Ordnance Recovery Personnel.

INDEX

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