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# CIV-117 EXAM PREVIEW

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## Exam Preview:

1. According to the reference material, dump trucks should be loaded from the passenger's side whenever possible.
    a. True
    b. False
2. The large rubber tires on a rubber-tired front-end loader provides good traction on unstable surfaces and allow the front-end loader to perform on side slopes of 15 percent and on front slopes up to _ percent.
    a. 25
    b. 30
    c. 35
    d. 20
3. The crawler-mounted front-end loader has a lower speed than a rubber-tired front-end loader, and this decreases its mobility; however, the crawler-mounted front-end loader can be operated on side slopes of up to 35 percent and on front slopes of up to 60 percent.
    a. True
    b. False
4. The "multipurpose (_-in-1) bucket" is also constructed of heavy-duty, all-welded steel with bolted or welded replaceable cutting edges. This bucket also has bolt-on replaceable teeth attached that provide for excavation of medium-to-hard materials.
    a. 2
    b. 3
    c. 4
    d. 5

5. According to the reference material, the rubber-tired front-end loader has ___ manually selected forward gear ranges that permits good mobility when traveling from one jobsite to another.
    a. 5
    b. 4
    c. 3
    d. 2
6. Buckets are supplied in a number of widths, ranging from 24 to 59 inches or more. A bucket is usually slightly narrower at the opening to reduce friction at the sides when digging and to allow easier dumping.
    a. True
    b. False
7. According to the reference material, after the backhoe has been coupled to the front of the front-end loader, raise the boom arm until the boom arm pivot point is approximately __ inches from the ground.
    a. 15
    b. 16
    c. 18
    d. 20
8. According to the reference material, the advantage of truck mounting over track mounting is its capacity for rapid movement from one job to another. The boom can be placed easily in the boom rest for traveling and then driven down the road at 25 to 35 miles per hour.
    a. True
    b. False
9. According to the reference material, the truck-mounted excavator can ordinarily swing in a full 360-degree rotation, but with most attachments, it can work through only __ degrees because of interference presented by the cab and the truck front.
    a. 90
    b. 120
    c. 180
    d. 270
10. According to the reference material, chain ditchers are ideal for lightweight work, such as sprinkler systems, gas lines, and small waterlines. Some of these machines can dig up to 10 inches wide and _ feet deep.
    a. 2
    b. 4
    c. 6
    d. 8

# FRONT-END LOADERS, EXCAVATORS, AND DITCHERS

## BASICS & SAFETY

Front-end loaders, excavators, and ditchers are used to support construction operations anytime there is a need to lift, load, unload, clear, grub, excavate, or trench. A variety of makes and models of this equipment are used in the Navy and the Naval Construction Force (NCF). Each operator is responsible for reading the operator's manual to obtain detailed information about each make and model. his chapter covers the general characteristics and basic principles of operations of front-end loaders, excavators, and ditchers.

### FRONT-END LOADERS

The front-end loader is a self-contained unit mounted on rubber tires or tracks and is one of the most versatile and capable pieces of equipment used in the NCF. The front-end loader can be equipped to operate as a loader, a dozer, a scraper, a clamshell, a forklift, a backhoe, a crane, an auger, or a sweeper.

### RUBBER-TIRED FRONT-END LOADER

Mounted on large rubber tires, the front-end loader has a relatively low ground bearing pressure (approximately 45 pounds) that enables it to perform a large variety of jobs. The rubber-tired front-end loader (fig. 9-1) has three manually selected forward gear ranges that permits good mobility when traveling from one jobsite to another. The full power soft shift transmission allows the gear range and direction of travel changed at anytime without stopping the machine from maintaining a high rate of production. The large rubber tires provide good traction on unstable surfaces and allow the front-end loader to perform on side slopes of 15 percent and on front slopes up to 30 percent. The hydraulic system gives the operator positive control of the front-end loader attachments and steering system.

### CRAWLER-MOUNTED FRONT-END LOADER

Mounted on crawler tracks, the crawler-mounted front-end loader has a low ground bearing pressure that

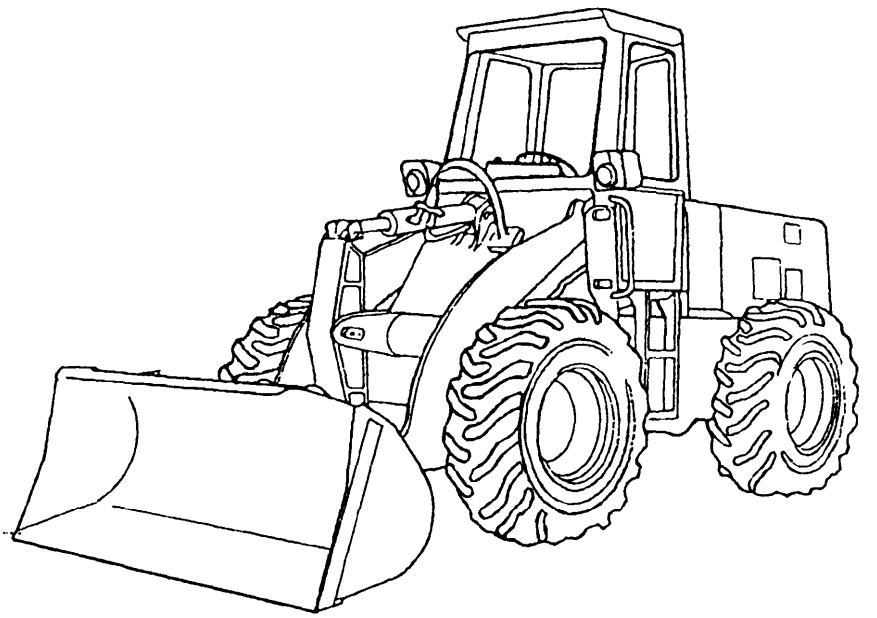


**Figure 9-1.—Rubber-tired front-end loader.**

enables it to operate in areas where wheeled front-end loaders cannot go. The crawler-mounted front-end loader (fig. 9-2) has a lower speed than a rubber-tired front-end loader, and this decreases its mobility; however, the crawler-mounted front-end loader can be operated on side slopes of up to 35 percent and on front slopes of up to 60 percent. The hydraulic system provides positive control of the front-end loader, and the crawler tracks are normally semi-grouser shoes (fig. 9-3) that permit it to work on firm ground with little damage to the surface.

## ATTACHMENTS

Attachments contribute to the efficient performance of front-end loaders. Some loaders used in the NCF are procured with a bucket, forklift, and backhoe attachments (fig. 9-4). These attachments allow the front-end

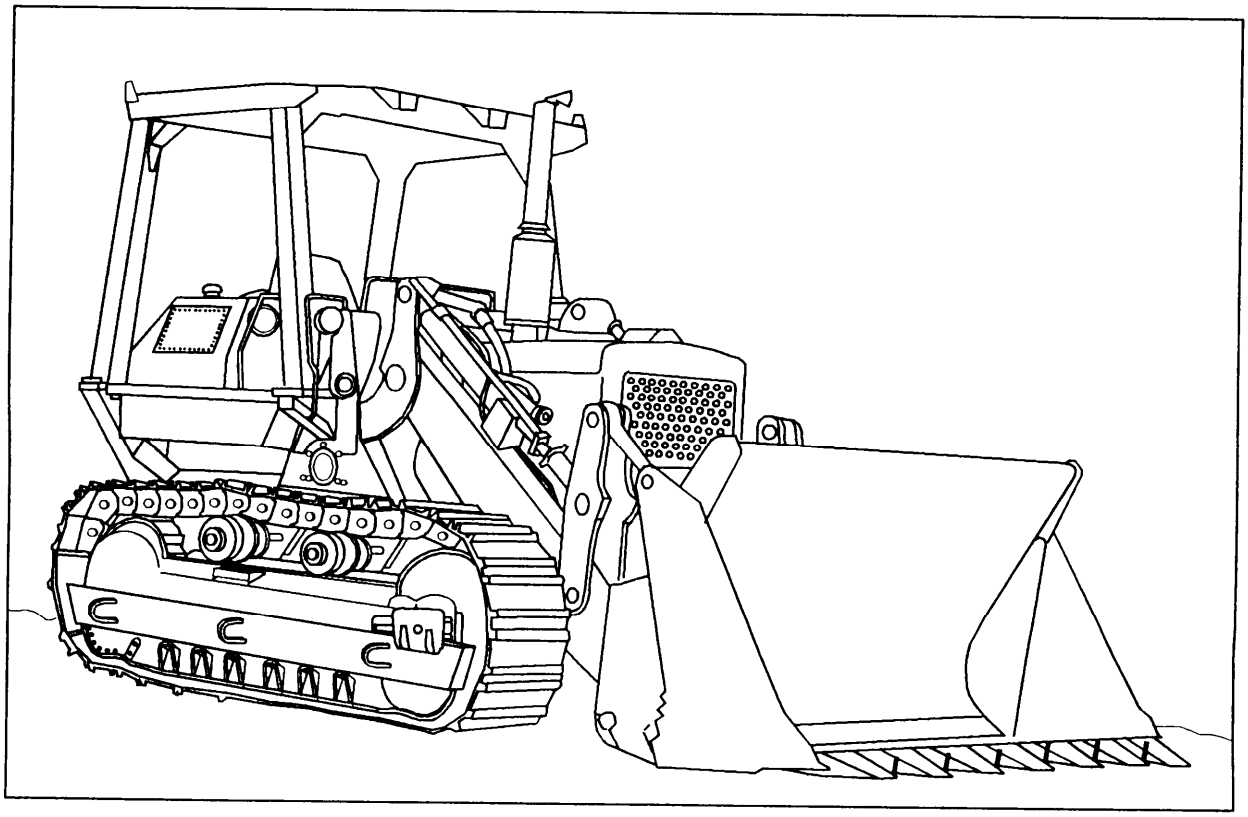


**Figure 9-2.-Crawler-mounted front-end loader.**

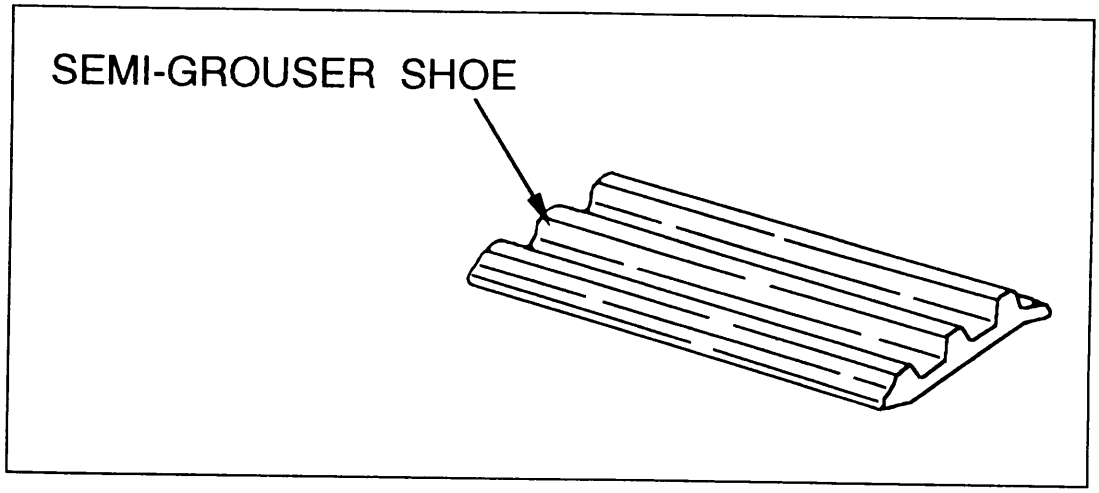



**Figure 9-3.-Semi-grouser shoe.**

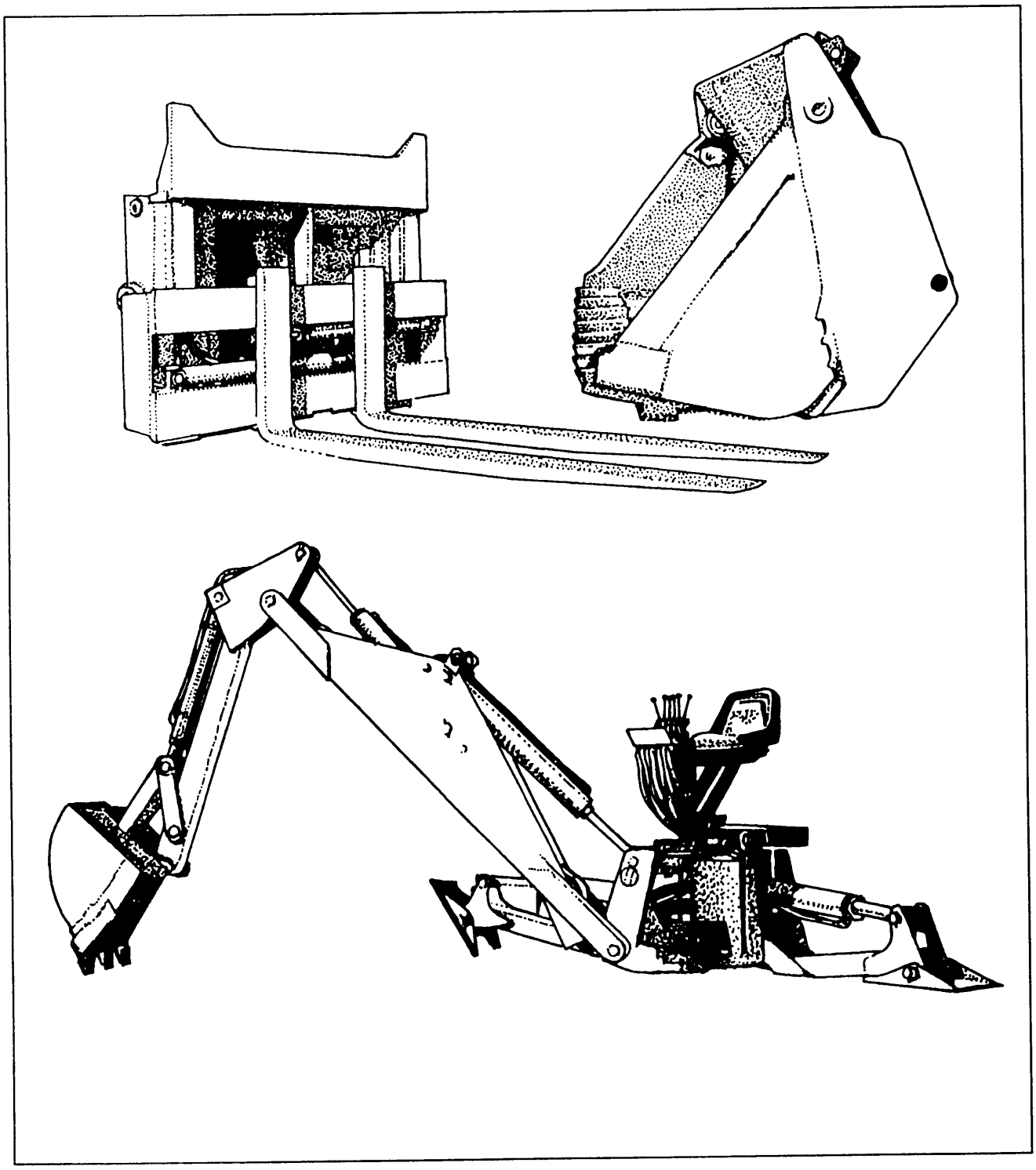


**Figure 9-4.—Front-end loader attachments.**

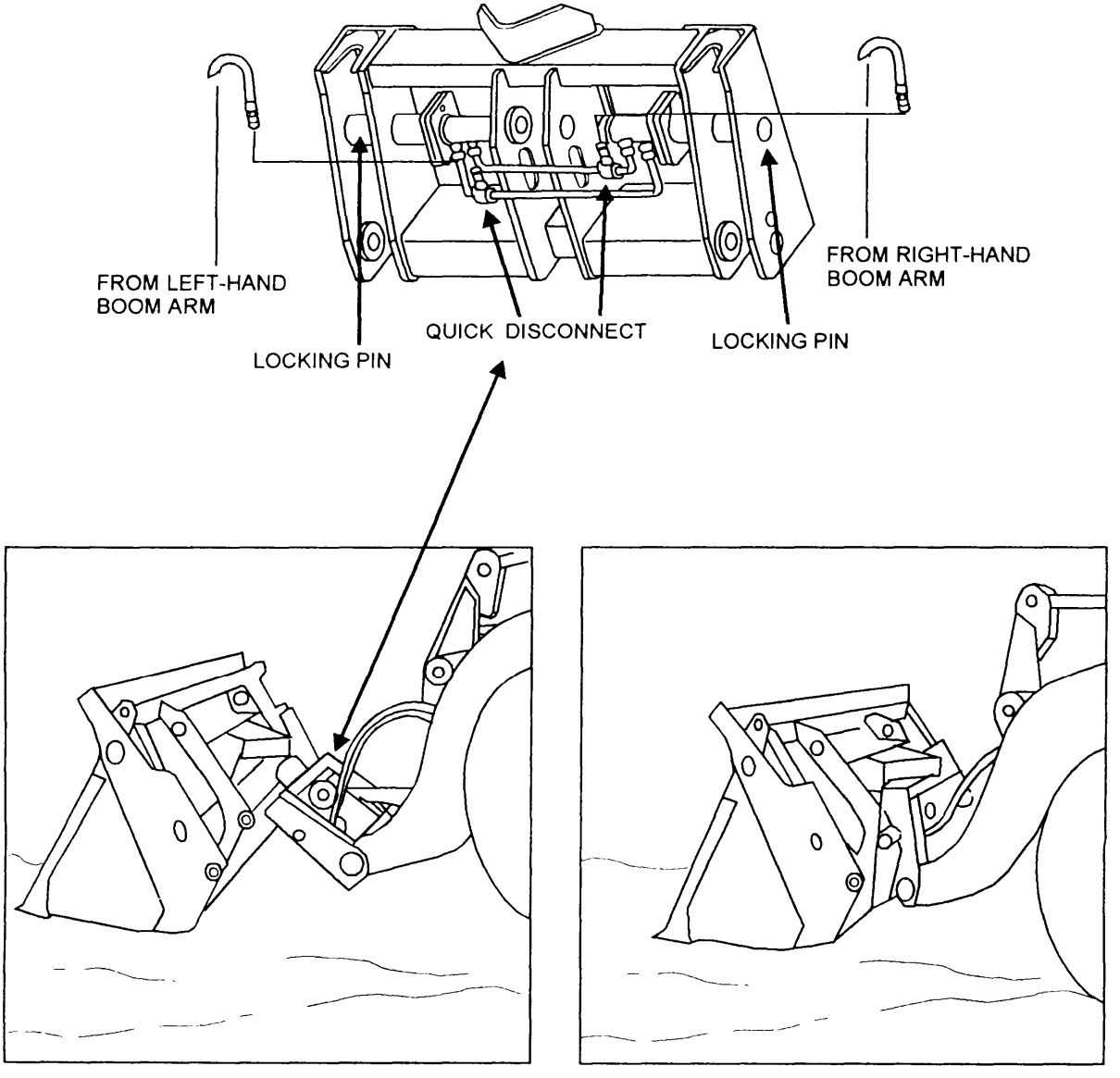



**Figure 9-5.—Attachment connection.**

loader to be an ideal piece of equipment for construction projects, saving the need for numerous pieces of equipment that can be used elsewhere.

Quick-disconnect hydraulic hose fittings and hydraulic controlled locking pins permit these attachments to be changed easily, as shown in figure 9-5.

**Buckets**

Two types of front-end loader buckets are commonly used: a general-purpose bucket (fig. 9-6) and a multi-segment (4-in-1) bucket, also known as a multipurpose (4-in-1) bucket (fig. 9-7). Both types may be equipped on crawler or rubber-tired wheeled loaders.

The **"general-purpose bucket"** is a single-piece bucket constructed of heavy-duty, all-welded steel with bolted or welded replaceable cutting edges. Also attached are bolt-on replaceable teeth (fig. 9-8) that allows the bucket to be used for excavation of medium-to-hard materials.

The **"multipurpose (4-in-1) bucket"** is also constructed of heavy-duty, all-welded steel with bolted or welded replaceable cutting edges. This bucket also has bolt-on replaceable teeth attached that provide for excavation of medium-to-hard materials. However, the multipurpose (4-in-1) bucket has a two-piece construction that makes it more versatile than the

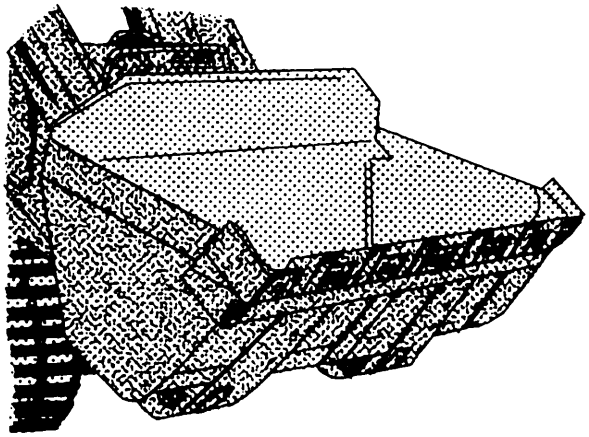


**Figure 9-6.-General-purpose bucket.**

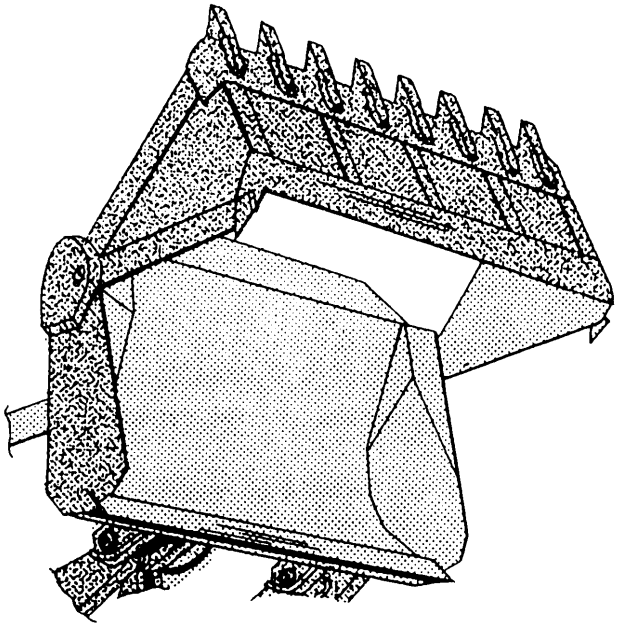


**Figure 9-7.—Multipurpose (4-in-1) bucket.**

general-purpose single-piece bucket. For example, the multipurpose (4-in-1) bucket can be used as a clamshell, a dozer, a scraper, or as a skid shovel.

### Forklift

The forklift attachment is a useful tool at remote project sites for unloading building material. Care must be taken not to overload the loader when using the forklift attachment.

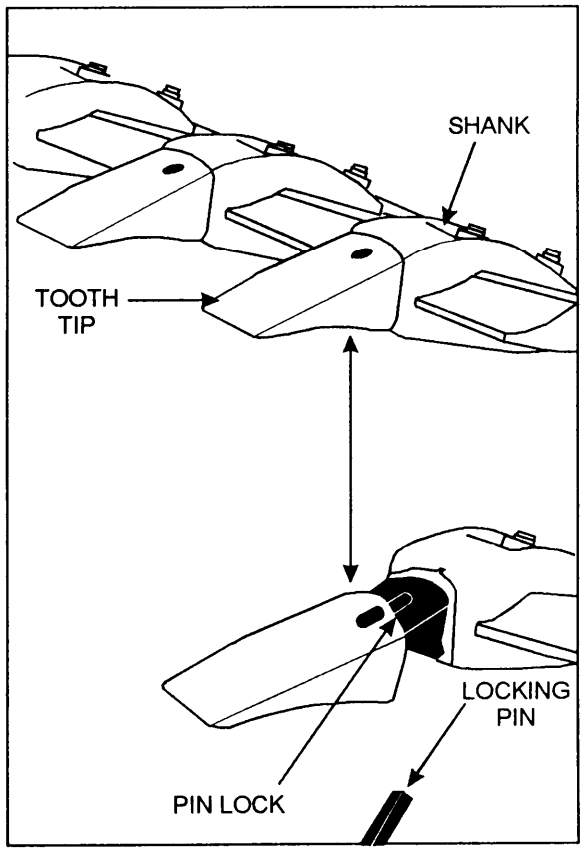



**Figure 9-8.—Bucket teeth.**

**NOTE:** A loader equipped with a forklift attachment must be operated using the same techniques of operation and safety rules designed for forklifts.

### Backhoe

The backhoe attachment is a positive digging tool. It is used to dig below the ground, such as trenches, combat fighting positions, building footers, and foundations.

The backhoe is attached to the loader frame with a ridged coupling. The hydraulics use a quick-disconnect coupling to tap the loader hydraulic system for a power source.

## OPERATING TECHNIQUES

When operating a loader equipped with a skid bucket, keep the engine speed at full throttle and operate in the first or second gear transmission range. Use second and third gear for traveling.

Start all jobs from nearly level ground if possible. When necessary, level an area large enough to provide

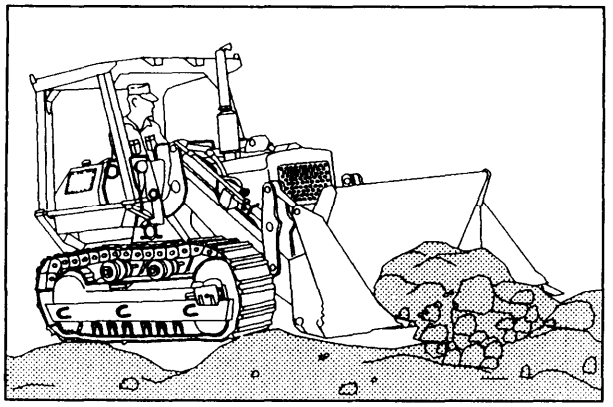


**Figure 9-9.—Up-and-down pitching of a loader on irregular terrain.**

sufficient working space for the loader. This step prevents up-and-down pitching of the loader (fig. 9-9) and results in a smoother digging operation.

Track and wheel spinning should be avoided, because loader tires are expensive and excessive spinning of the tires while loading causes premature wear and tear. Additionally, it converts a smooth working area into ruts that pitch and tilt the loader. A smooth working area is safer and more comfortable. It also puts less wear and tear on the machine and yourself; therefore, production is increased.

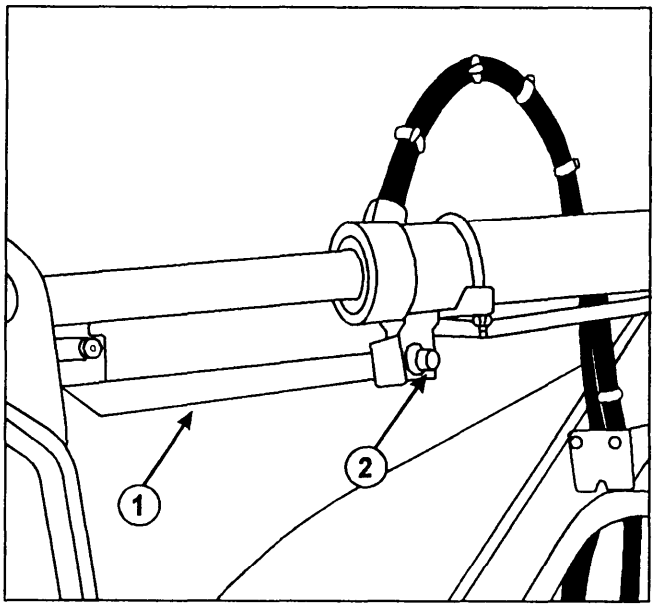
Cross ditches, ridges, rocks, or logs slowly and, if possible, at an angle. This procedure slows the fall, lessens the danger of upsetting the loader, and reduces the jolt of the fall that can harm both the operator and the loader.

A uniform system of hand signals must be used in all front-end loader operations. While the authority for giving signals must be assigned to only one person under normal working conditions, the responsibility for giving an emergency stop signal belongs to anyone in the vicinity who believes such a signal is necessary. The person giving the signals must be clearly visible to the operator at all times. Hand signals used in front-end loader operations are shown in appendix IV.

**NOTE:** You must recognize and understand these signals when operating equipment. Additionally, you must also be able to give them when called on to act as a signalman during any equipment operation.

### Automatic Bucket Leveler

Most 515 B series dresser rubber-tired front-end loaders used in the NCF have an automatic bucket




1. TRIP BAR
2. PROXIMITY SWITCH

**Figure 9-10.—Automatic bucket leveler.**

leveler located on the underside of the bucket cylinder (fig. 9-10).

The automatic bucket leveler is preset to stop the bucket in a horizontal or digging position. A trip bar (1) is attached to and moves with the cylinder rod. The proximity switch (2) creates a magnetic field circuit that is completed by the proximity of the trip bar within the magnetic field. Once the bucket is dumped, place the bucket lever in the bucket "rollback" position. When the bucket reaches its preset position, the trip bar moves out of the magnetic field circuit created by the proximity switch and automatically stops. Then the bucket control lever returns to the "hold" position.

**NOTE:** Refer to the manufacturer operator's manual when the automatic bucket leveler needs adjustment.

### Position Indicator

The general-purpose bucket shown in figure 9-6 is normally used as a skid shovel. The multipurpose bucket shown in figure 9-7 serves as a skid shovel, but can also be used as a bulldozer, scraper, and clamshell.

Most front-end loaders are equipped with six bucket control lever positions, such as **raise, hold, lower, float dump, and rollback.** Dump and rollback can be used

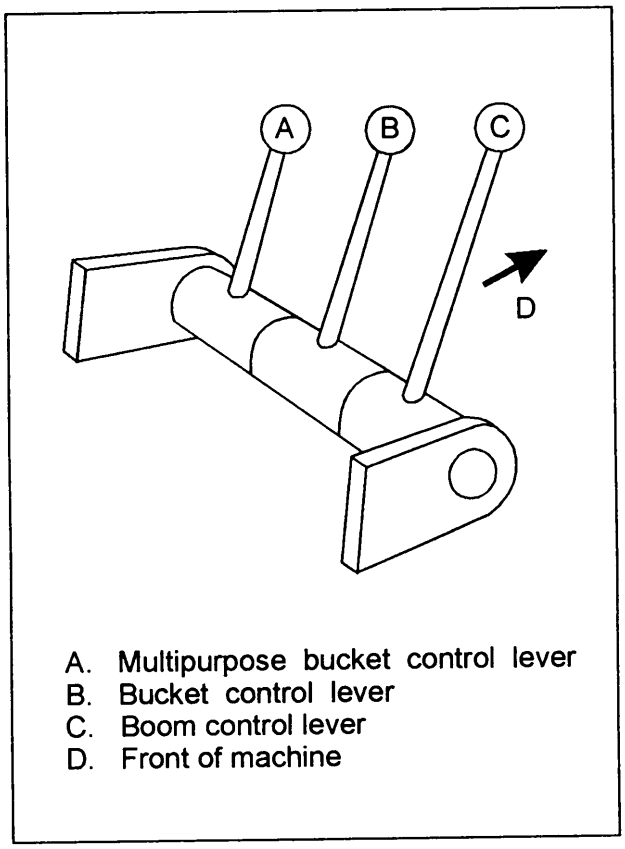



**Figure 9-11 .—Control levers.**

at the same time with any other four positions. Also, most loaders have a position indicator and depth gauge indicator mounted on the bucket.

To set the multipurpose attachment as a bucket, the operator pulls the control lever back (fig. 9-11) until the clamshell indicator is at the "O" setting on the clam product graphic (fig. 9-12).

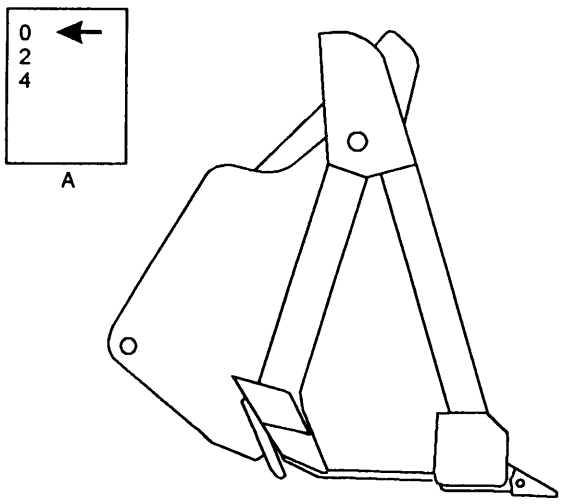



**Figure 9-12.—Multiltipurpose bucket set in "bucket" position.**

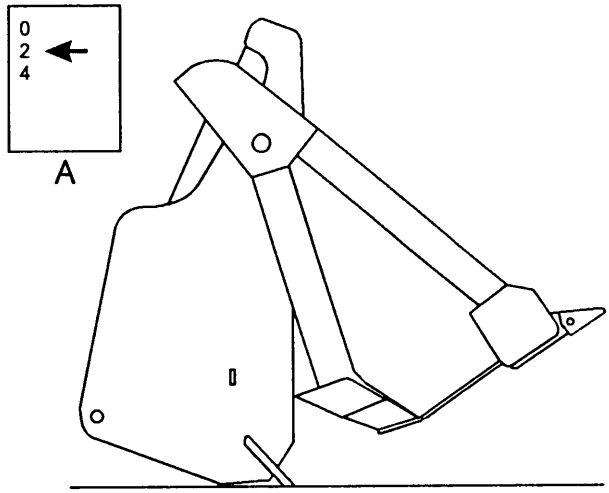



**Figure 9-13.—Multipurpose bucket set in "scraper" position.**

To set the multipurpose bucket as a scraper, you open the clamshell until the indicator points to 2 or 4 on the clam product graphic (fig. 9-13). The more the clamshell is open, the deeper a cut can be made.

To use the multipurpose bucket as a dozer, you open the clamshell until the clamshell indicator is at the bottom of the clam product graphic (fig. 9-14).

When using the multipurpose blade as a dozer, you can adjust the amount of cut by the pitch of the dozer

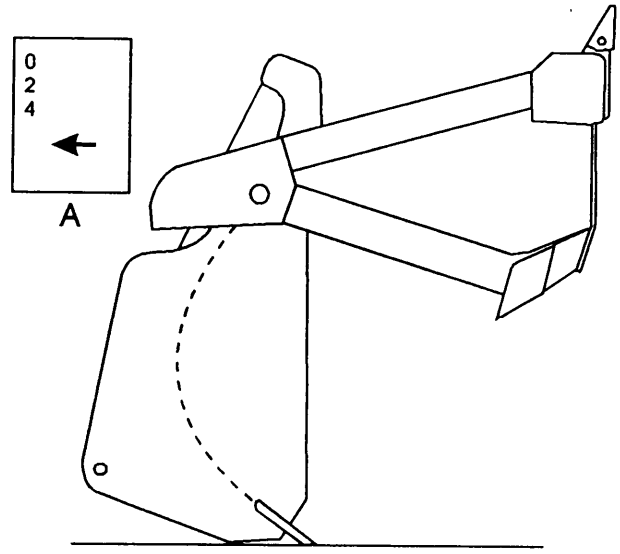



**Figure 9-14.—Multipurpose bucket set in "dozer" position.**

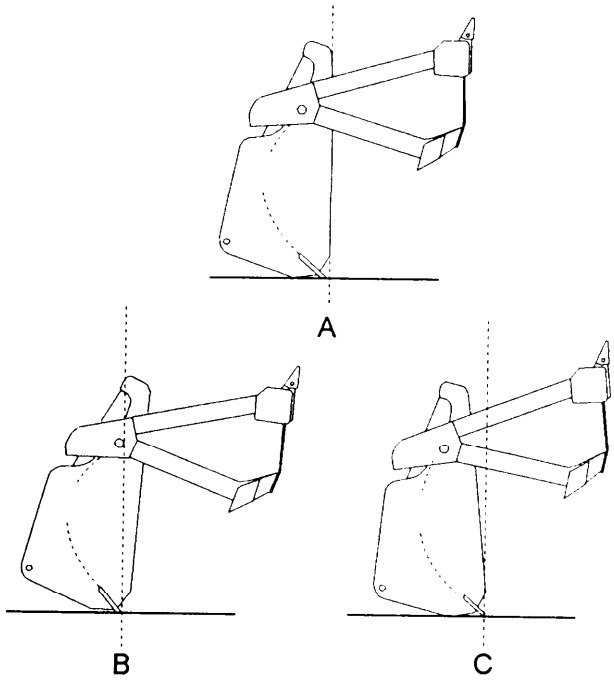



**Figure 9-15.—Dozer blade tilt positions.**

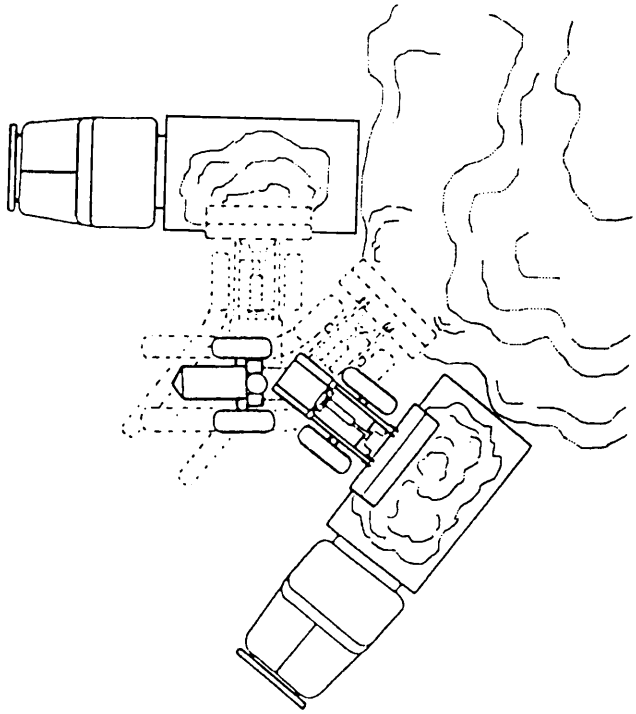


**Figure 9-18.—"V" method of loading.**

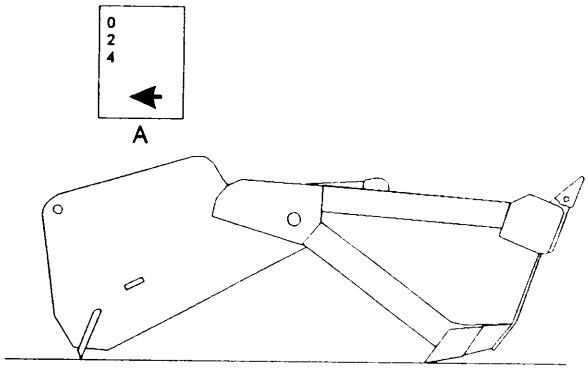



**Figure 9-16.—Multipurpose bucket set in "clamshell" position.**

blade. This is done by tilting the blade forward or backward, as shown in figure 9-15.

To use the multipurpose bucket as a clamshell, you open the clamshell until the clamshell indicator is at the bottom (fig. 9-16). Then you tilt the bucket forward all the way.

**NOTE:** Multipurpose bucket position indicators differ, depending on the manufacturer. Read the operator's manual for the type loader you are assigned to operate.

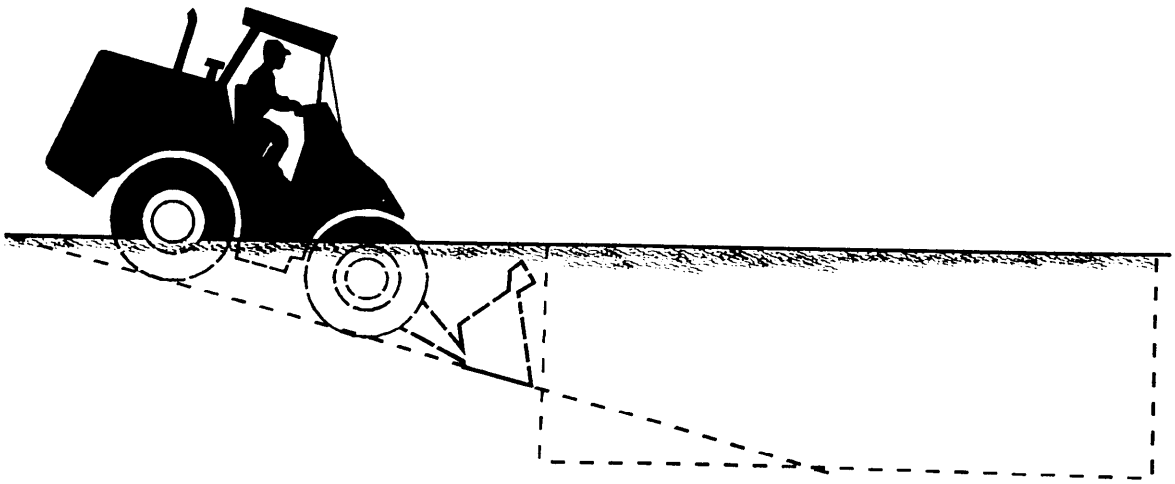


**Figure 9-17.—Ramp construction for belowground excavation.**

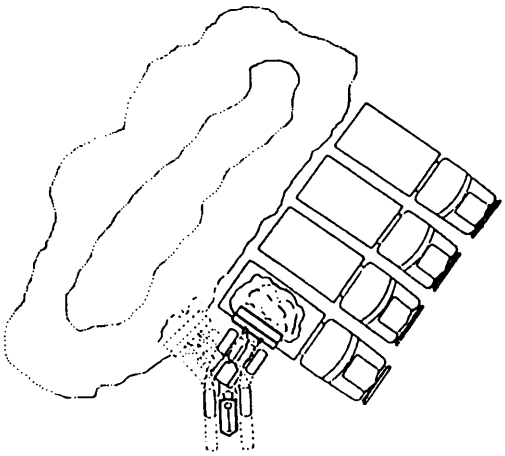
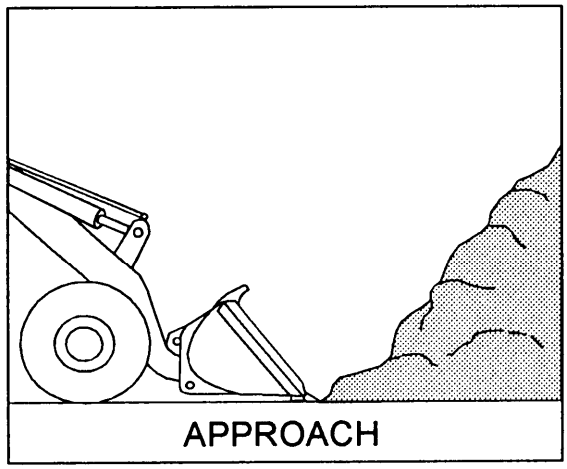
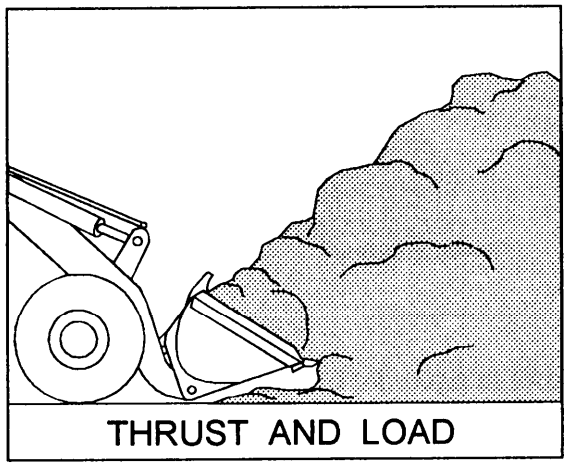


**Figure 9-19.-Step-loading method.**



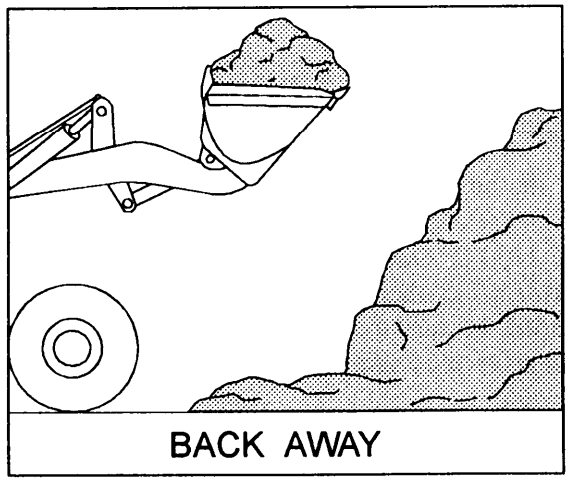




**Figure 9-20.—Bucket-loading technique.**

**Loader Operation**

A front-end loader can dig excavations, such as building foundations and other belowground areas, if the material to be excavated is not too hard. Belowground operations require construction of a ramp into the excavation to bring the material out (fig. 9-17). The slope of the ramp depends on the type of loader operated; for example, a crawler-mounted loader may dig a more abrupt approach to the excavation.

When loading from a bank or stockpile, use the "V" method shown in figure 9-18 or the step-loading method shown in figure 9-19. Position the dump truck at about a 30-degree to a 45-degree angle from the stockpile. Additionally, when possible, load the dump truck downwind to prevent dirt and dust from blowing back into your face. Keep the truck close to the work area to minimize loader travel, and keep the work area clean and level.

The bucket is loaded by moving the loader forward with the bucket at the desired digging level and with the engine at full-governed speed. As the bucket penetrates the material, raise the bucket slightly. When the material fills to the top of the spill board, roll the bucket all the way back (fig. 9-20). The rollback position is maintained to prevent spillage while backing away.

When transporting material, raise the lift arm to give the bucket the same ground clearance as provided by the loader axle. Keep the travel speed reasonable for safe operation. Upon reaching the truck, raise the bucket high enough to clear the truck body. Reduce forward speed and dump the load in the center of the dump bed, as

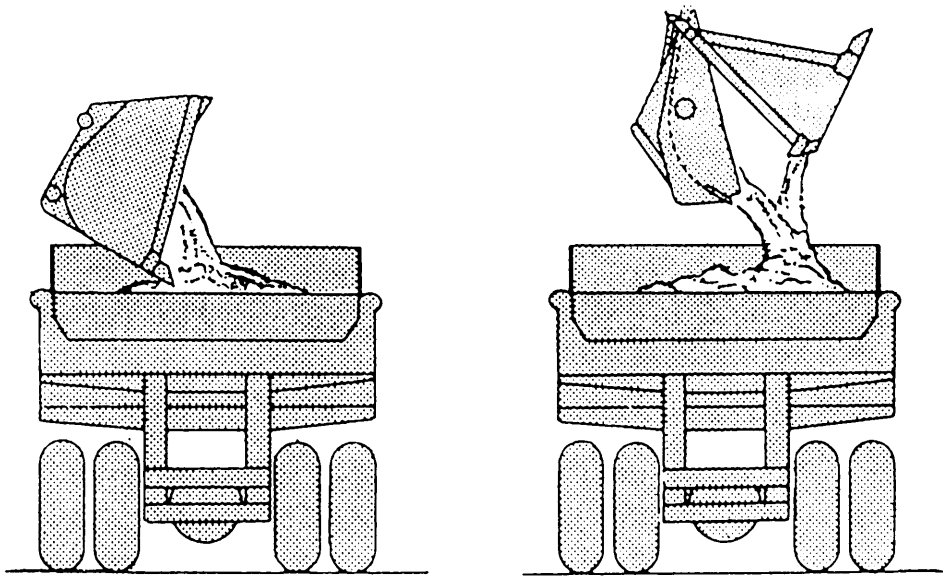


**Figure 9-21.—Loading the dump truck.**

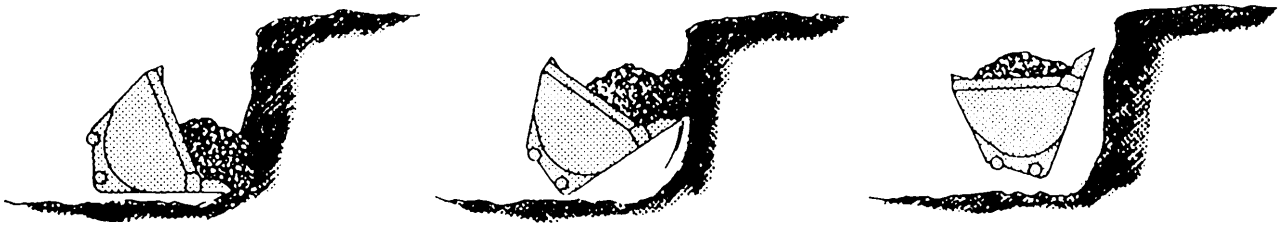


**Figure 9-22.—Bucket positioned for filling from a bank.**

shown in figure 9-21. Shake the bucket to loosen dirt from within. After the load is dumped, back away, lower the bucket to the carrying position, and return to the digging area.

**CAUTION**

A loaded bucket must never be transported in the fully raised position.

**NOTE:** Dump trucks should be loaded from the driver's side whenever possible. When the truck is being loaded, be sure the driver either stays in the cab (on cab-protected trucks) or away from the truck and loader.

When loading from a bank, keep the cutting edge flat, as shown in figure 9-22. Tilting the bucket back too far forces the flat of the cutting edge against the bank, preventing the bucket from digging. This maneuver is nonproductive and causes waste of power, time, and possible damage to the bucket cylinders and linkage.

When stockpiling material, move each load only once and keep the travel distance short. When possible, locate stockpiles as close to the jobsite as possible without hindering other work on the jobsite.

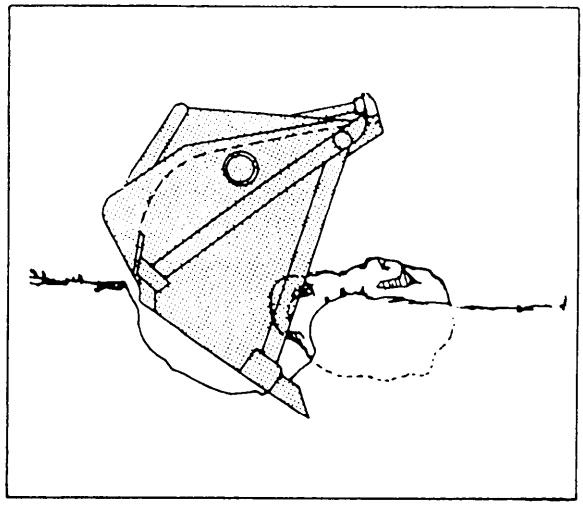


**Figure 9-23.—Bucket positioned for clearing rocks or other solid objects.**

When clearing a rocky area, remove the small and loose rocks first. Large rocks and other solid objects can then be loosened and moved easier.

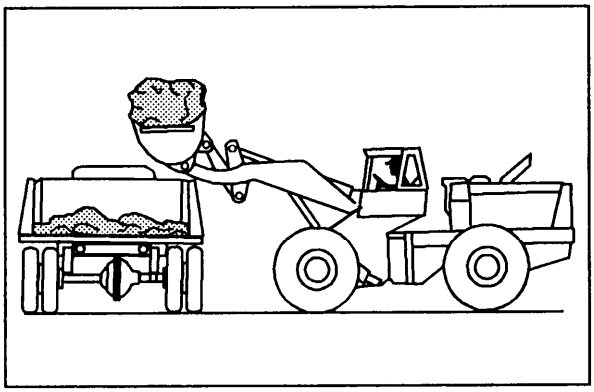


Figure 9-24.—Loading large rocks.

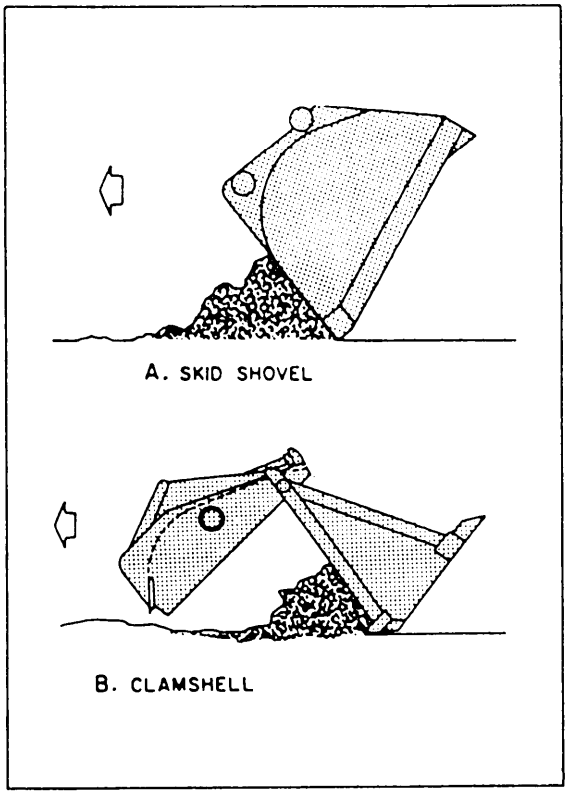



Figure 9-25.-Bucket positioned for back dragging nonsolid materials.

When loosening large rocks or other solid objects, you can get greater force and penetration by digging under the rock with the bucket, as shown in figure 9-23. Lifting the rock with the bucket while pushing increases traction and reduces track or wheel spinning.

When loading large rocks into dump trucks, place a load of dirt or sand into the dump bed. This material acts as a cushioning material and helps protect the dump bed from damage. Then load the large rocks into the center of the dump bed from the lowest possible height (fig. 9-24).

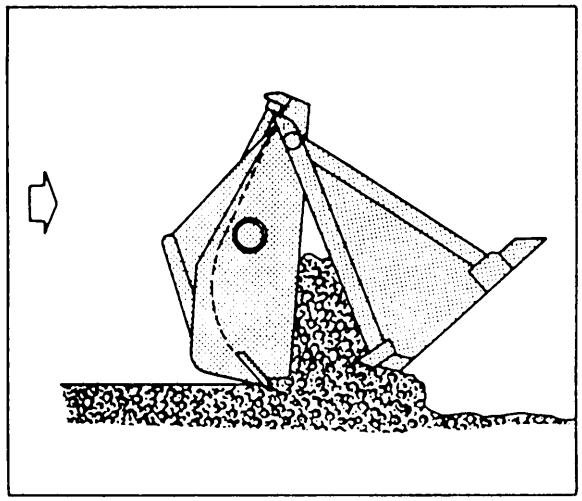


Figure 9-26.—Bucket clamshell positioned for spreading material.

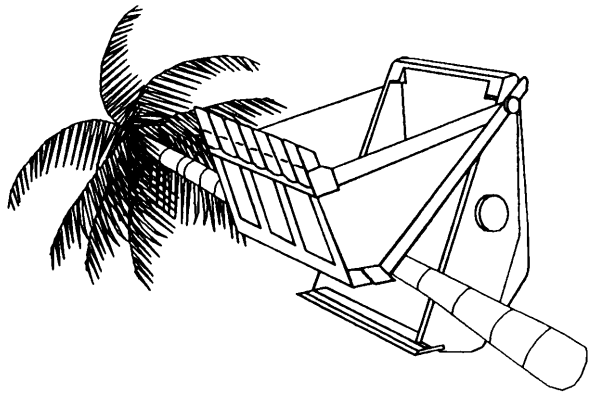


Figure 9-27.—Bucket clamshell positioned for loading trees.

**NOTE:** When you have extended tasking to haul large rocks or riprap, you should have the dump beds lined with wooden planking. This will save time loading sand or dirt and also protect the bed.

When finishing by back dragging in nonsolid materials, position the bucket, as shown in figure 9-25, views A or B.

**NOTE:** Back dragging abrasive materials causes premature wear to the bucket.

By placing the bucket in the scraper position and opening the clamshell slightly, you can spread material on the run. The amount of spread can be controlled by the size of the opening of the clamshell, as shown in figure 9-26.

When transporting trees or other large objects, always balance the load, as shown in figure 9-27.

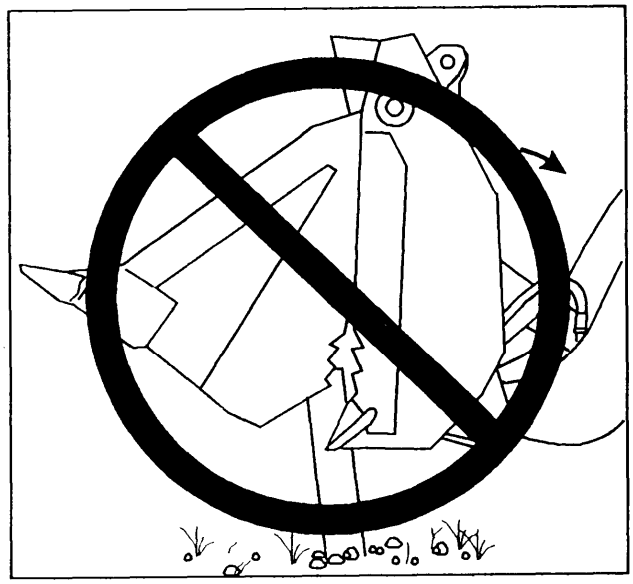


**Figure 9-28.—Removing buried objects using the clamshell by rolling back the bucket.**

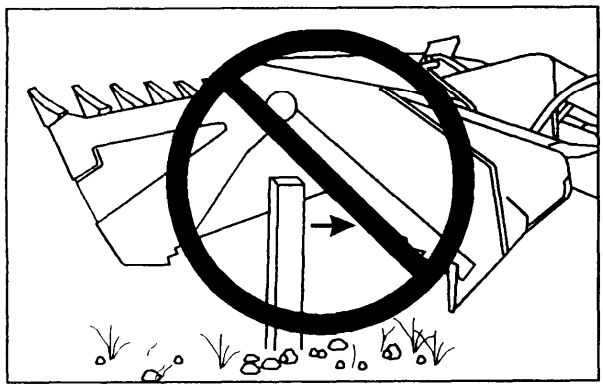


**Figure 9-29.—Breaking off an object using the clamshell by back dragging.**

Balance the load when picking it up to prevent twisting the boom assembly and linkage. When dumping awkward loads, dump slowly to reduce the shock of weight transfer to the rear axle when the bucket is emptied.

### Improper Uses of the Multipurpose Bucket

Equipment Operators have created techniques to perform a variety of construction operations using loaders equipped with the multipurpose (4-in-1) bucket.

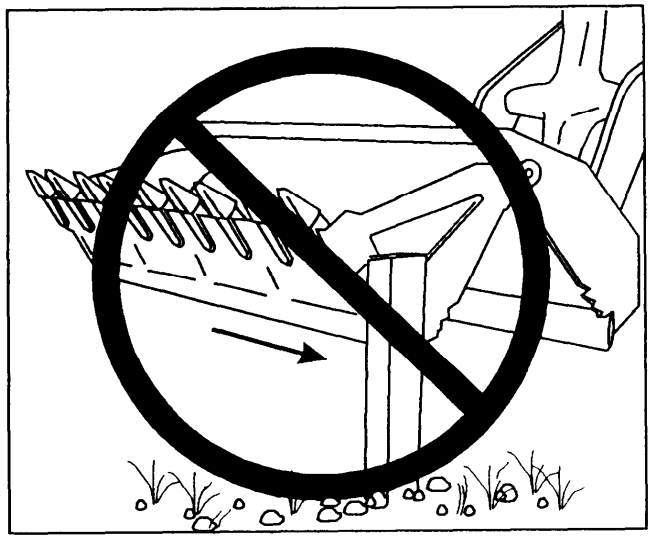


**Figure 9-30.-Breaking off an object by side loading the clamshell.**

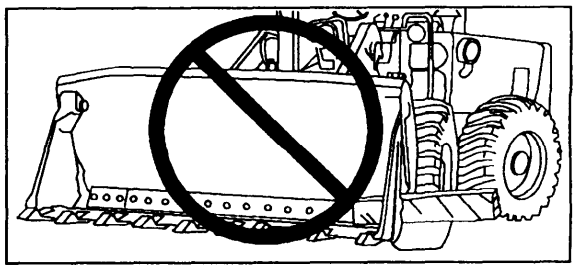


**Figure 9-31.-Clamping an object on only one side of the clamshell.**

However, these techniques can cause **UNNECESSARY DAMAGE** to multipurpose (4-in-1) buckets by subjecting them to conditions they were not designed for. Some of the ways a multipurpose bucket should **NOT** be used are as follows:

**Do NOT** use the rollback as a force to pull stumps or buried objects from the ground, because this may bend the clamshell (fig. 9-28).

**Do NOT** attempt to break off buried or anchored objects with the clamshell by back dragging, because this may bend the clamshell (fig. 9-29).

**Do NOT** attempt to break off buried or anchored objects by side loading the clamshell, especially when opened, because this may bend the sides of the clamshell (fig. 9-30).

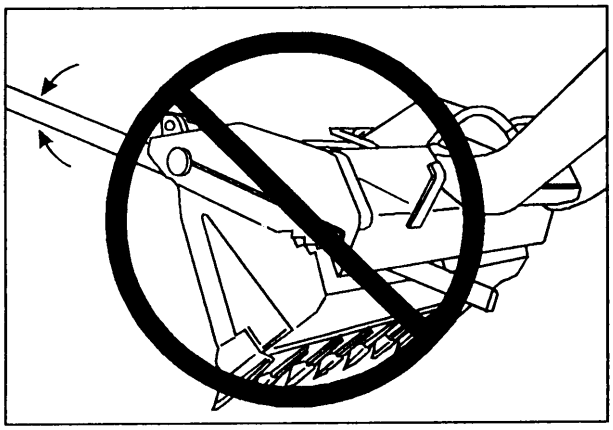


**Figure 9-32.-Clamping an object and using it as a battering**

**Figure 9-33.-Grading with the bucket in the dump position.**

**Do NOT** clamp objects on only one side of the clamshell, because this causes uneven stresses and may twist the clamshell out of alignment (fig. 9-31).

**Do NOT** clamp objects and use them as battering rams, because this may bend the clamshell and the cutting edge (fig. 9-32).

**Do NOT** grade in the forward direction with the bucket in the dump position, because this can cause damage to the tilt cylinder and linkage (fig. 9-33).

**Do NOT** use the bottom of the clamshell as a pile driver, because this will bend the clamshell (fig. 9-34).

**Do NOT** attempt to load material in the bucket with an object caught between the clamshell and blade, because this could twist the clamshell out of alignment (fig. 9-35).

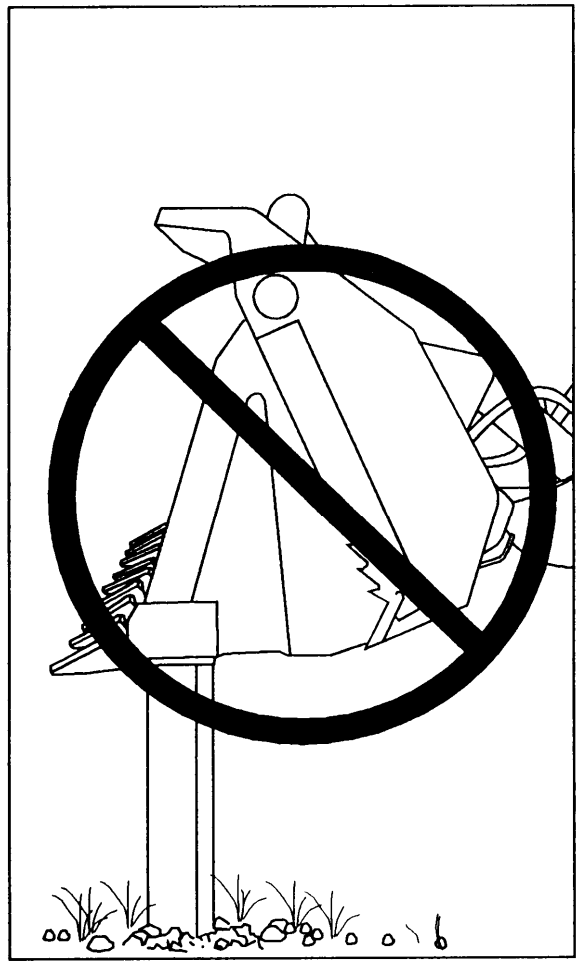


**Figure 9-34.-Using the bottom of the clamshell as a pile driver.**

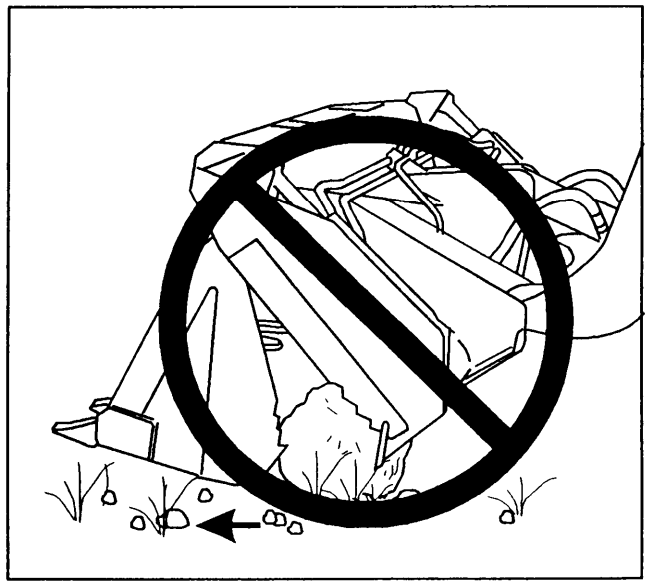


**Figure 9-35.—Attempting to load material with an object caught in the clamshell.**

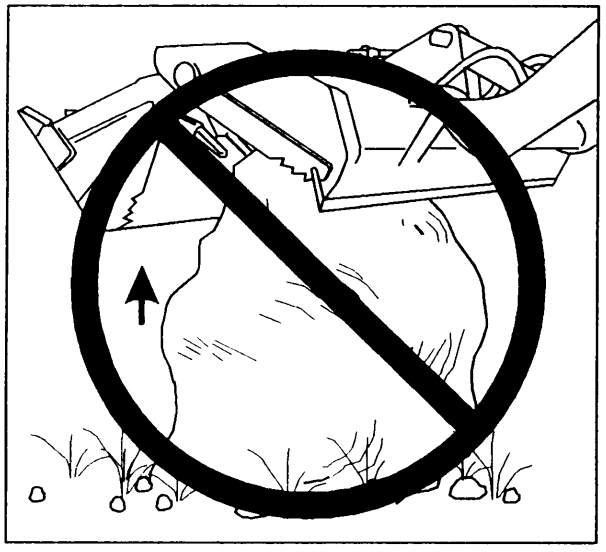


**Figure 9-36.-Attempting to pickup objects too large for the clamshell.**

**Do NOT** attempt to clamshell objects too large to handle, because this may damage both the bucket and linkage (fig. 9-36).

## BACKHOE OPERATIONS

The backhoe attachment shown in figure 9-37 is used to dig hard material because of the positive pressure created by the hydraulic system. Its digging depth is limited by the length of the boom and dipper stick. The backhoe dumps the material into trucks to be hauled away or into piles alongside the excavation to be used as backfill material. Its dumping range is also limited to the length of the boom and dipper stick.

### 515 Dresser Backhoe

The 515 dresser backhoe attachment couples easily to the front of the loader frame, using hydraulic controlled pins and quick- disconnect hydraulic fittings. The procedure for setting up the backhoe attached to the 515 dresser is as follows:

1. After the backhoe has been coupled to the front of the front-end loader, raise the boom arm until the

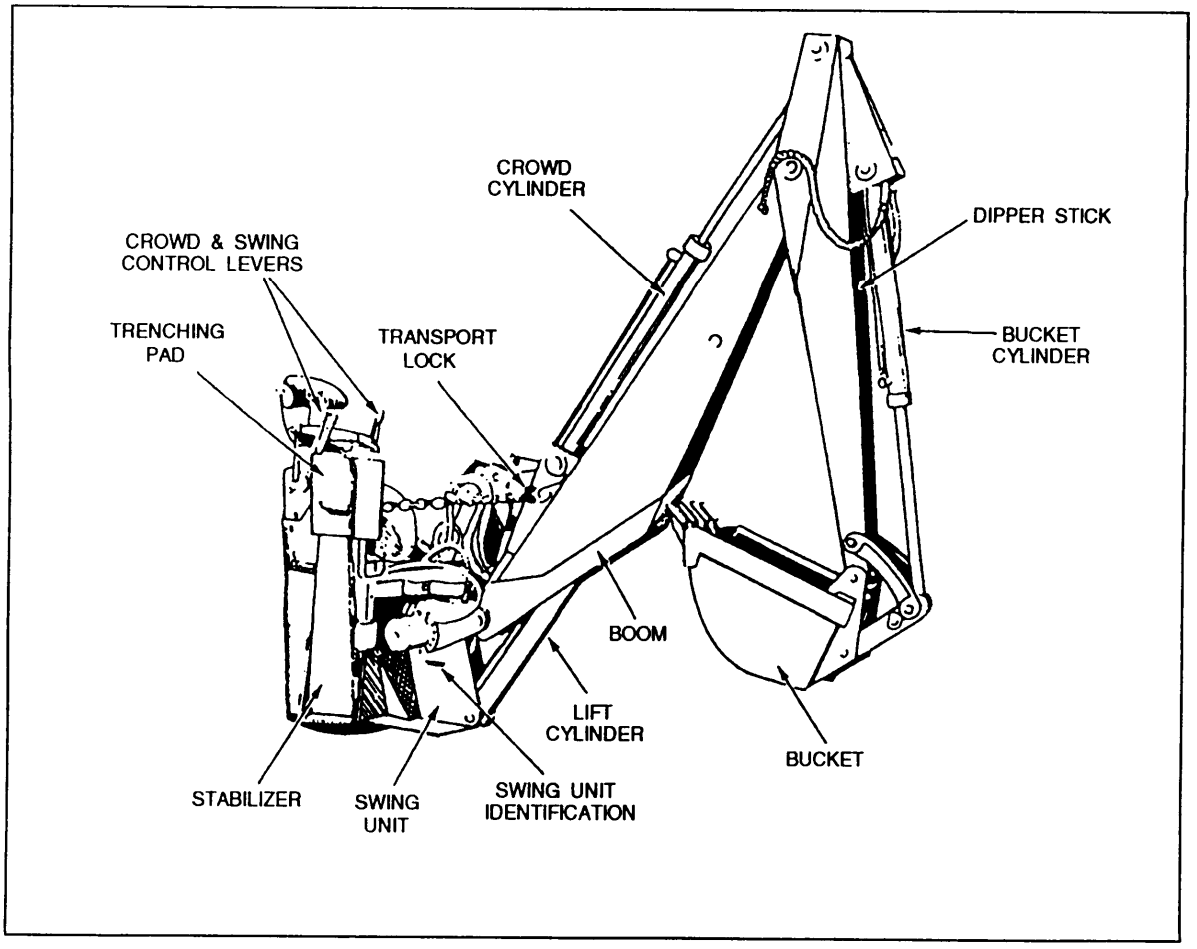



**Figure 9-37.-Backhoe attachment.**

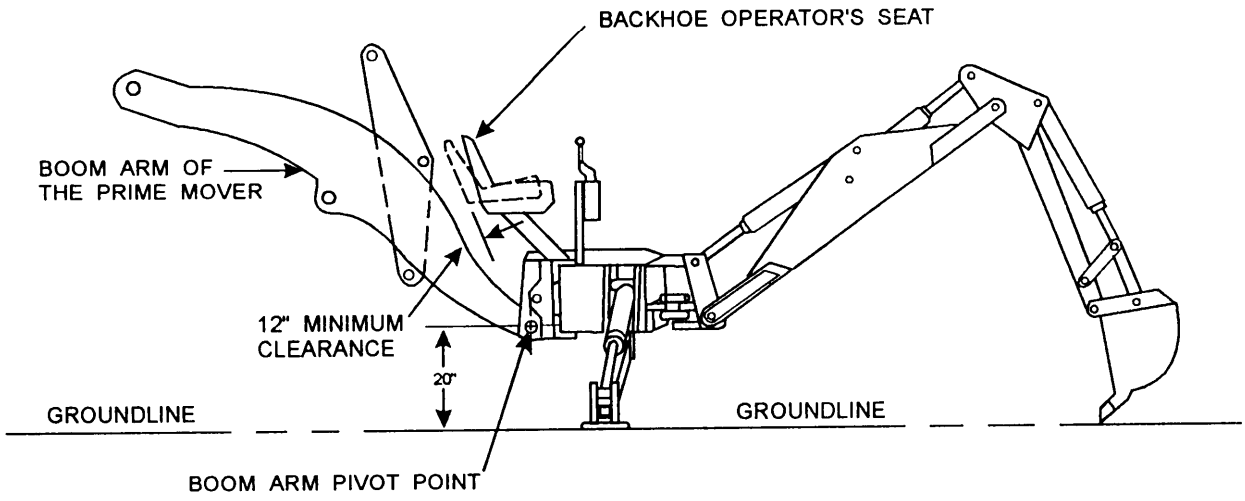



**Figure 9-38.-Backhoe boom arm pivot point.**

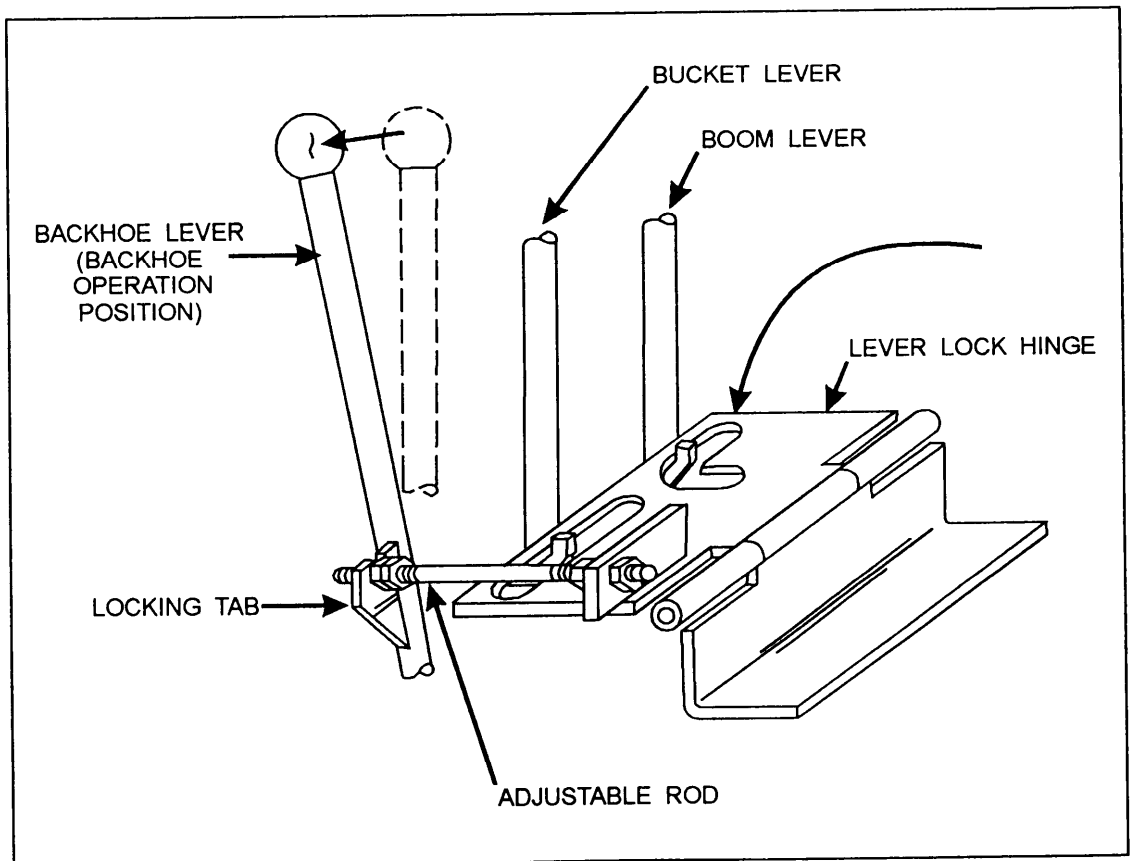



**Figure 9-39.—Backhoe operation locking lever locking plate.**

boom arm pivot point is approximately 20 inches from the ground, as shown in figure 9-38.

2. Using the bucket control lever, tilt the backhoe main frame until the top of the main frame is parallel with the ground.

3. For backhoe operations, place the two levers fiut.best from the operator in the hold position. Place the lever closest to the operator in the forward position. Move the locking plate in the position shown in figure 9-39, locking the lever in the forward position and the two other levers in the hold position.

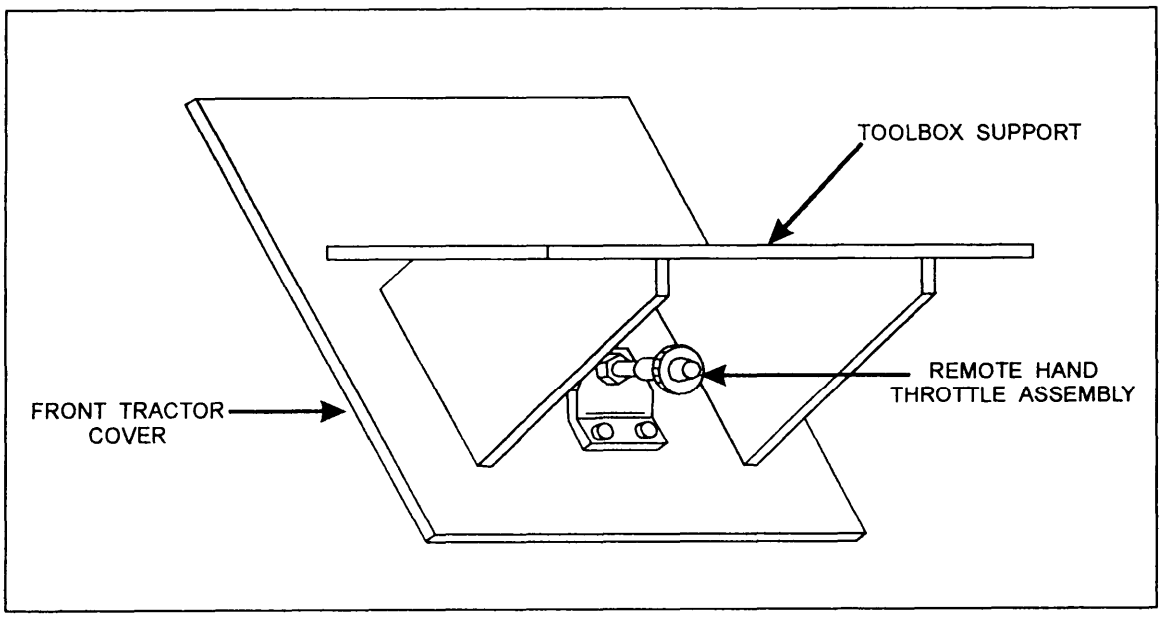



**Figure 9-40.—Remote hand throttle assembly.**

4. The loader is equipped with a remote hand throttle assembly (fig. 9-40) located on the front cover of the loader, which is behind the backhoe operator's seat. The hand throttle is preset to the backhoe specifications to deliver the proper amount of hydraulic oil flow for backhoe operations. The speed of the engine determines the volume of hydraulic oil delivered to the backhoe and the speed of the cylinder movements. Because of this, you should set the engine at a low speed until you are familiar with the control lever pattern.

**NOTE:** The backhoe is designed to operate efficiently at a preset gallons per minute flow of hydraulic fluid. Setting the engine throttle in excess of that set for backhoe operations creates excessive hydraulic temperatures and pressures that can damage hydraulic and structural components.

5. Lower the backhoe stabilizer legs to fix the backhoe in position.

6. Warm up the backhoe hydraulic system by extending and retracting each hydraulic cylinder piston rod several times to circulate warm oil through the hydraulic system. When the backhoe hoses feel warm when touched, the backhoe is ready for operation.

**WARNING**

Before performing maintenance on the backhoe, you must extend the dipper stick fully and set the bucket and stabilizer on the ground. Shut down the engine, and actuate all of the control levers back and forth to relieve the hydraulic pressure in the system.

**Loader Backhoe**

The loader backhoe tractor (fig. 9-41) is equipped with a 1.3-cubic-yard bucket mounted on the front and the backhoe mounted on the rear.

The loader is equipped with a four-speed transaxle that permits the gears to be shifted from first or second to third or fourth and back again to third without stopping. When shifting gears, always make sure the engine speed remains in the green area of the tachometer.

The loader also has a differential lock that gives equal power to both rear wheels when the machine is stuck or before the loader is operated through a soft or muddy area. When the loader is stuck, the differential lock is actuated as follows:

1. Make sure the rear wheels are not turning.
2. Push down the clutch cutout pedal (fig. 9-42).
3. Push down the differential lock pedal.
4. Release the clutch cutout pedal.
5. Increase the engine speed and release the differential lock pedal.

**NOTE:** The differential lock releases automatically when the load is removed.

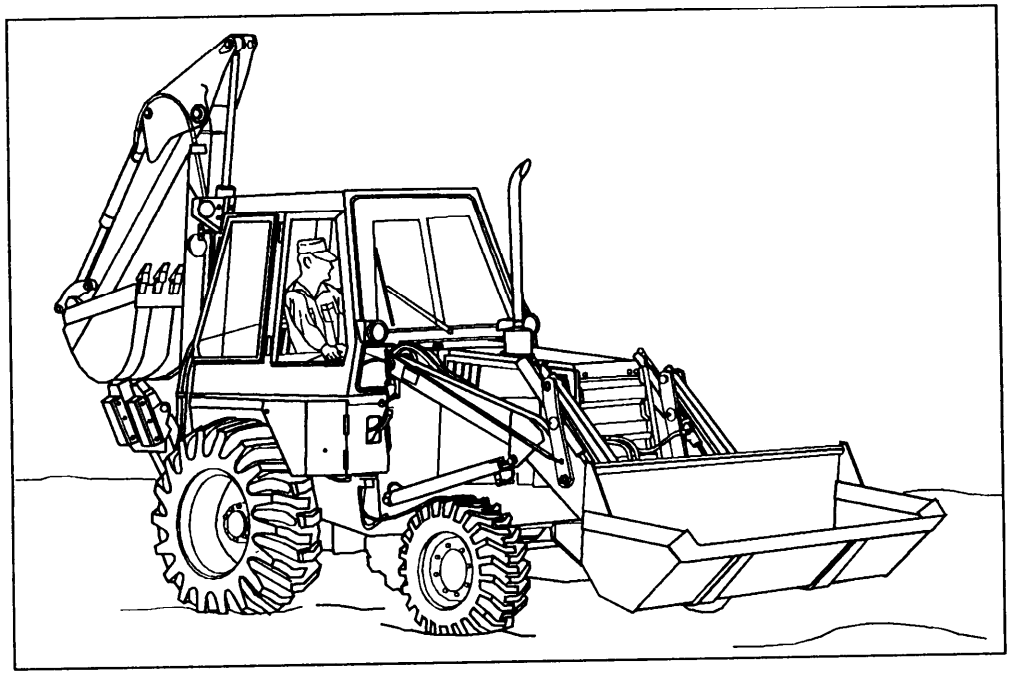


**Figure 9-41 .—Loader backhoe.**

Before operating through a soft or muddy area, you can actuate the differential lock as follows:

1. Before moving the loader through an area that is soft or muddy, make sure that the loader is moving in a straight direction and that one of the rear wheels is not rotating faster than the other rear wheel.

2. Push down the differential lock pedal while the loader is moving through the soft or muddy area.

3. After the loader has moved through the area, release the differential lock pedal.

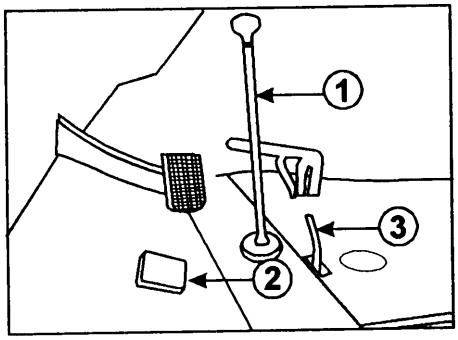
**NOTE:** Engaging the differential lock when the loader is turning or if one rear wheel is rotating faster than the other wheel can cause damage to the transaxle.

When servicing the engine with the loader lift arms raised, always use the support strut (fig. 9-43).

The procedure for attaching the support strut is as follows:

1. Empty the loader bucket and raise the loader lift arms to the maximum height and stop the engine.

2. Remove the rear pin from the support strut and lower the strut onto the cylinder rod.




1. Four speed transaxle control
2. Clutch cutout pedal
3. Differential lock

**Figure 9-42.—Transaxle controls.**

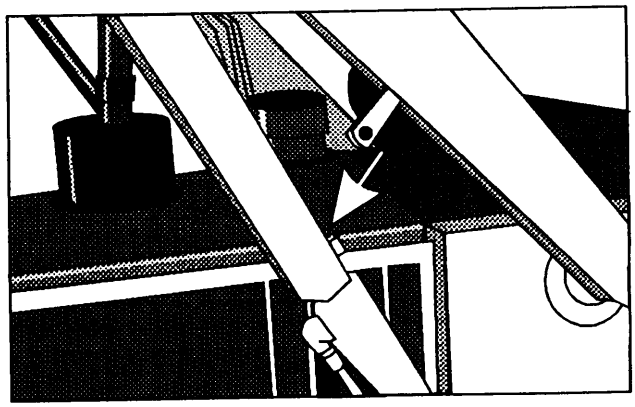


**Figure 9-43.-Support strut.**

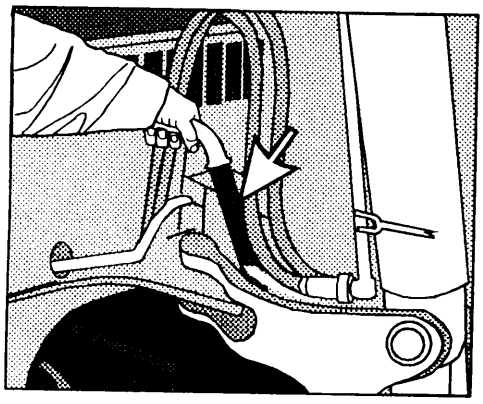


Figure 9-44.-Swing lockpin.

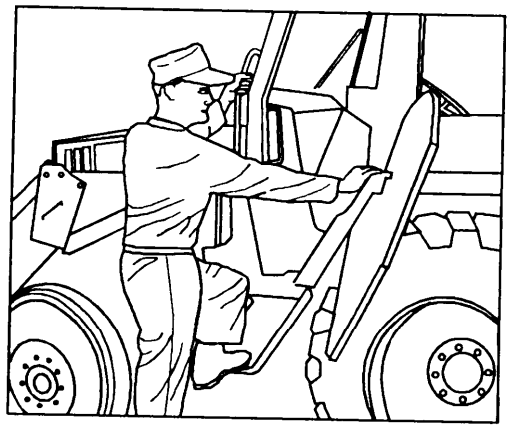


Figure 9-45.—Use handrails and steps to climb into the operator's seat.

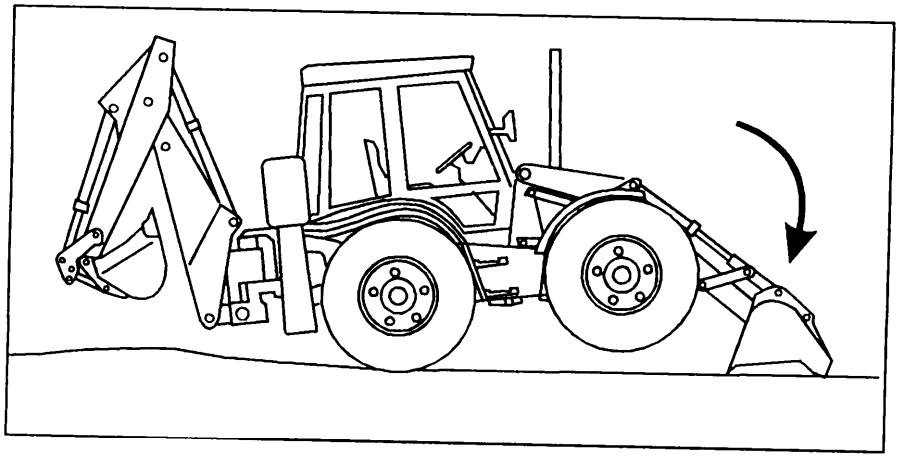


Figure 9-46.—Lower the bucket to raise the front wheels a few inches above the ground.

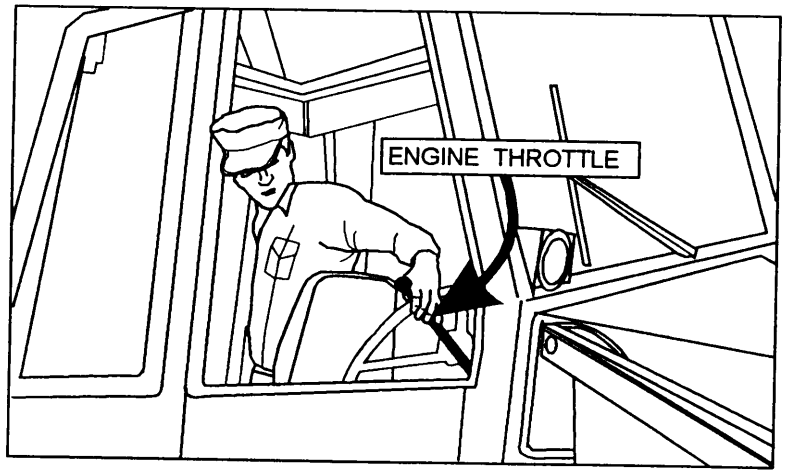



Figure 9-47.—Rotate the operator's seat and increase the engine throttle.

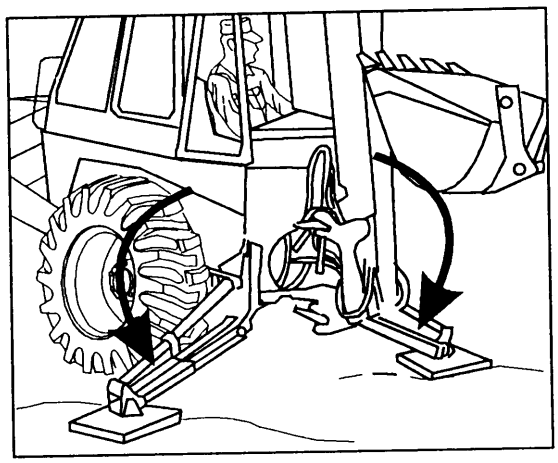


**Figure 9-48.-Lower the stabilizers to raise and level the loader.**

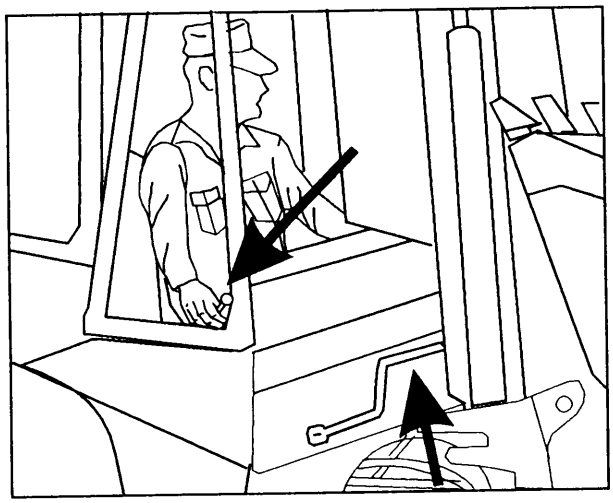


**Figure 9-49.—Release the boom latch.**

3. Install the rear pin in the support strut.

4. Slowly lower the lift arms onto the support strut.

**WARNING**

Failure to use the support strut when servicing the engine can result in **serious injury or death** if the loader arms are lowered by accident.

Backhoe operation is as follows:

1. Removed the swing lockpin (fig. 9-44).

2. Climb into the loader using handrails and steps (fig. 9-45).

3. Rotate the loader bucket into the dump position and lower it to the ground. Lower the bucket until the front wheels are a few inches above the ground (fig. 9-46).

4. Rotate the operator's seat to the rear of the loader for backhoe operation and increase the engine speed to full throttle (fig. 9-47).

5. Lower the stabilizers and raise and level the loader (fig. 9-48).

6. To release the boom latch, push the boom latch control lever to the left and hold it until the boom is released (fig. 9-49).

7. Extend the boom and bucket to start digging operations, as shown in figure 9-50.

8. To dig with the backhoe, move the dipper stick inward and fill the bucket (fig. 9-51, view A). Once the bucket is filled, curl the bucket inward (fig. 9-51, view B). Swing the boom and dump the material from the bucket (fig. 9-51, view C). Return to the trench and lower the bucket (fig. 9-51, view D).

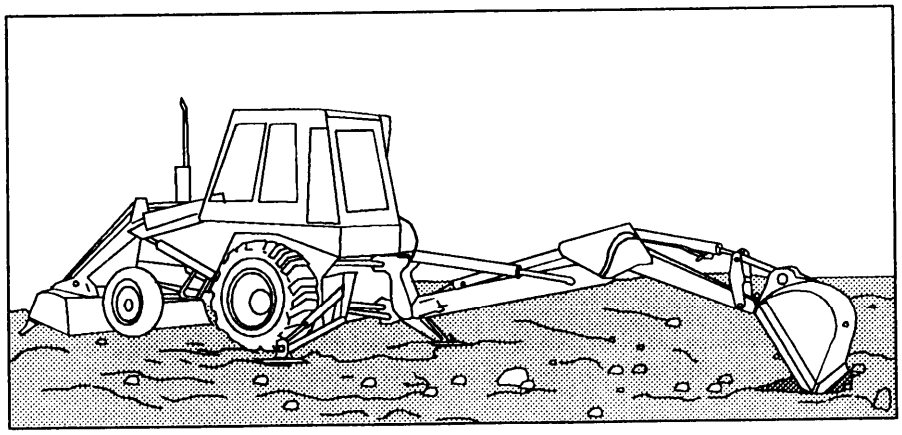
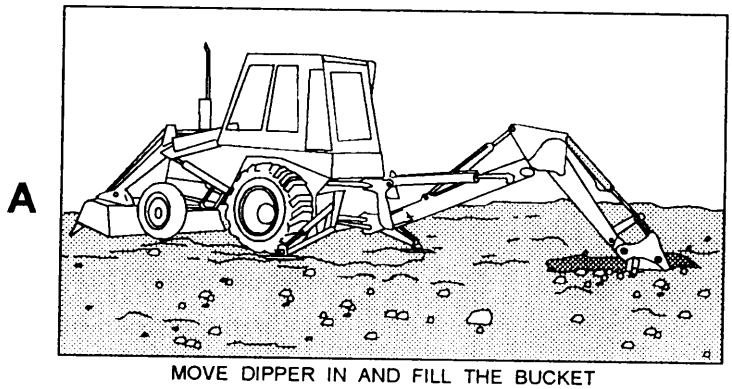
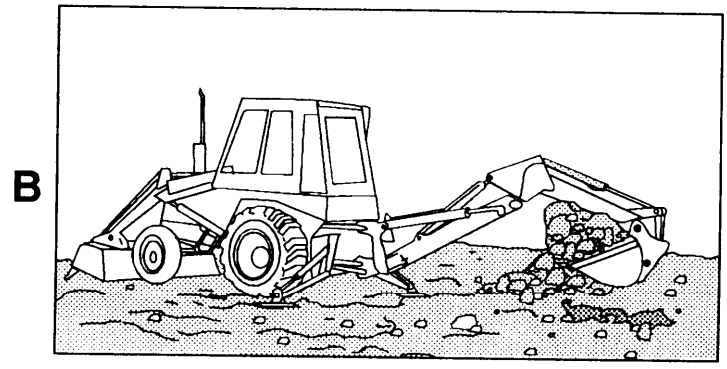


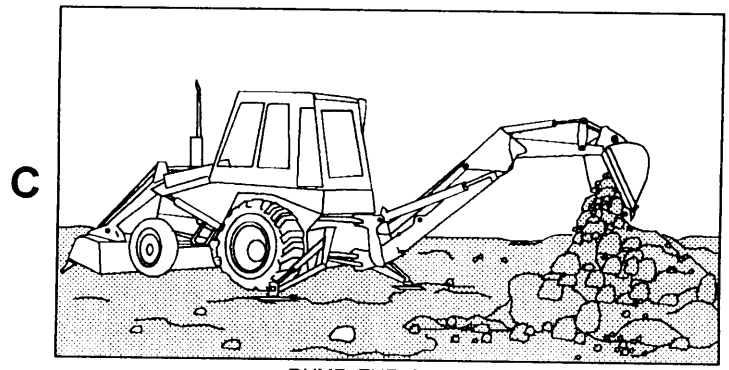
**Figure 9-50.—Bucket and boom in position for digging operations.**



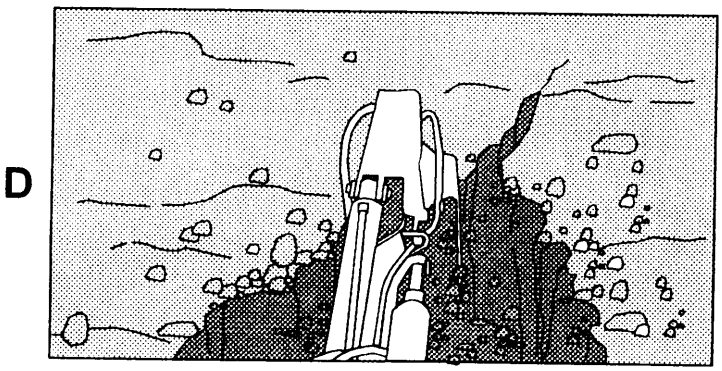

MOVE DIPPER IN AND FILL THE BUCKET




ROTATE BUCKET IN




DUMP THE BUCKET




RETURN TO THE TRENCH AND LOWER BUCKET

**Figure 9-51.—Digging With the backhoe.**

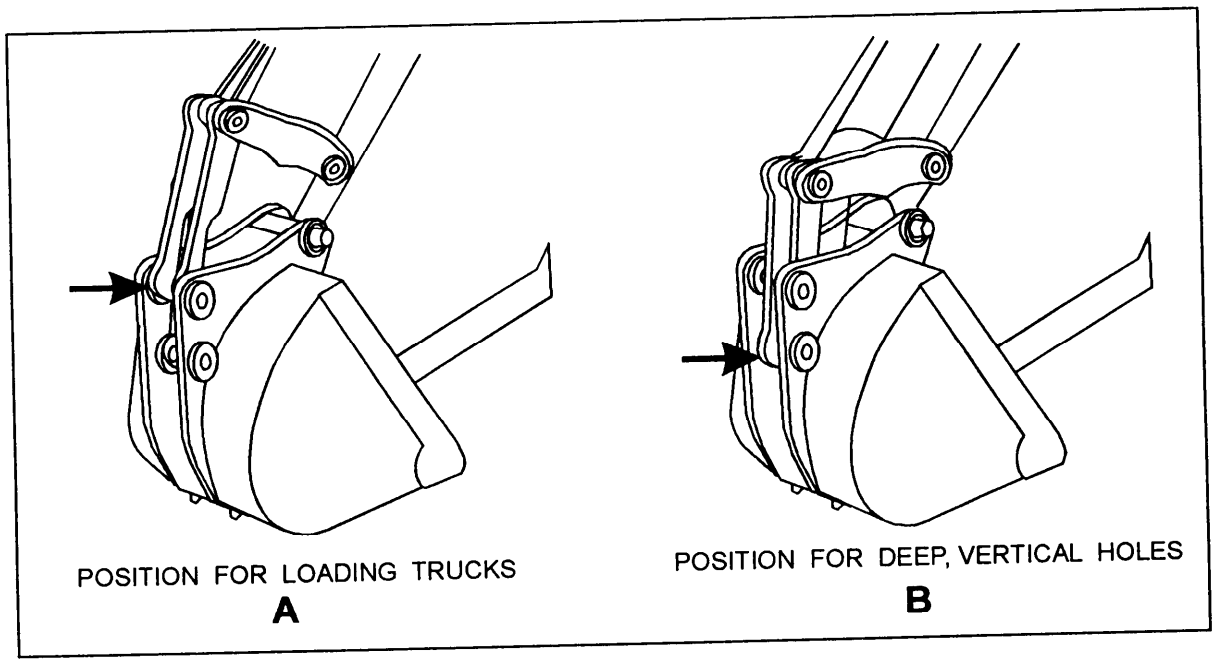



**Figure 9-52.—Backhoe bucket adjustment digging positions.**

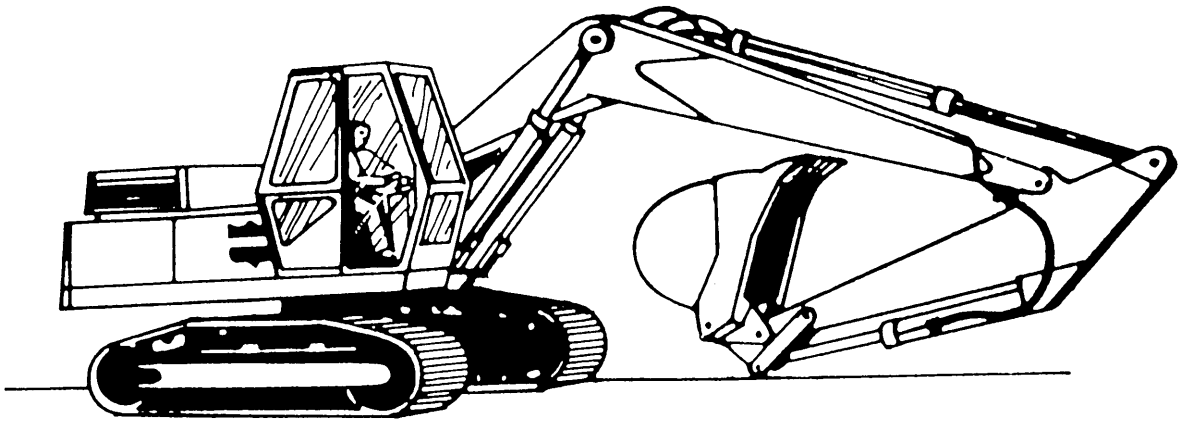


**Figure 9-53.—Track-mounted excavator.**

The backhoe bucket can be adjusted for two digging positions. The position for loading dump trucks is shown in figure 9-52, view A. The position for digging deep, vertical holes is shown in figure 9-52, view B.

The backhoe can dig more material in less time when a smooth, short dig cycle is used. When the bucket is forced to excavate a load that is too large (when the dipper stick control lever is pulled back and the bucket is not moving), a "hydraulic stall" results in the loader hydraulic system. When this occurs, the main relief valve of the hydraulic system makes a noise, alerting the operator to release the control lever.

**NOTE:** Hydraulic stalls cause the temperature of the hydraulic fluid to increase that can cause premature wear to the hydraulic system.

## EXCAVATORS

Excavators are large backhoes used for heavier construction tasting. The types used in the NCF are either track mounted (fig. 9-53), truck carrier

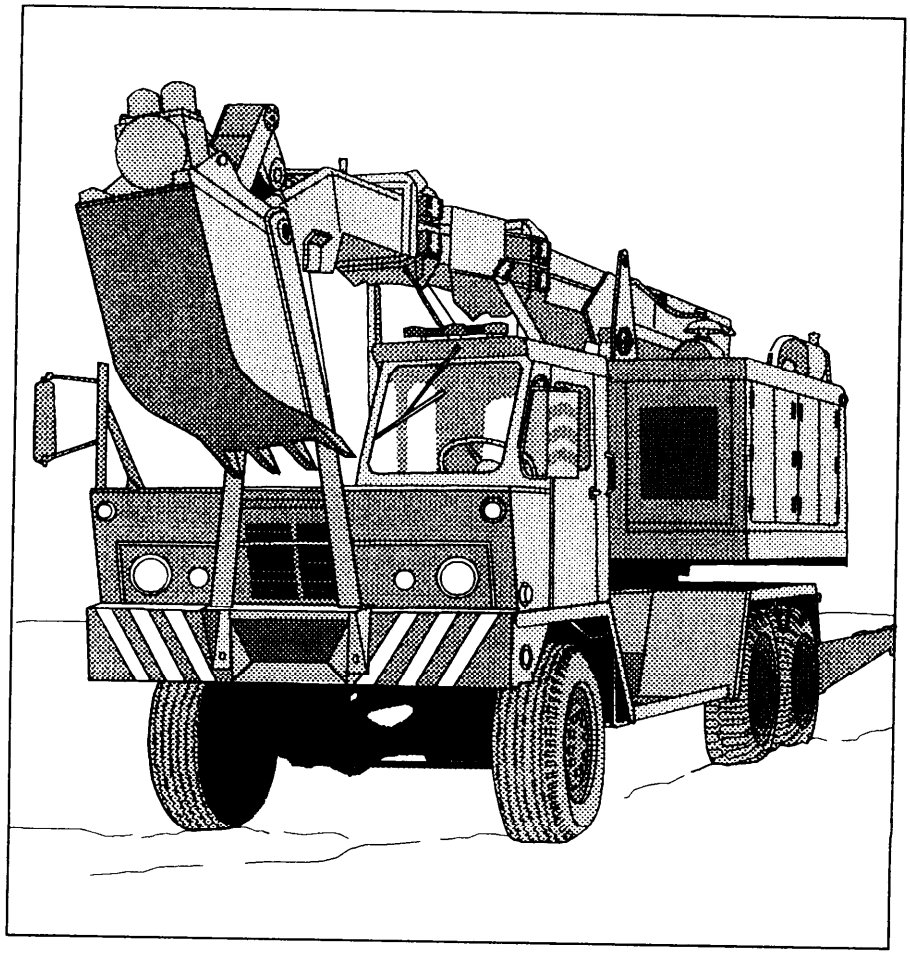


**Figure 9-54.-Truck carrier-mounted multipurpose excavator.**

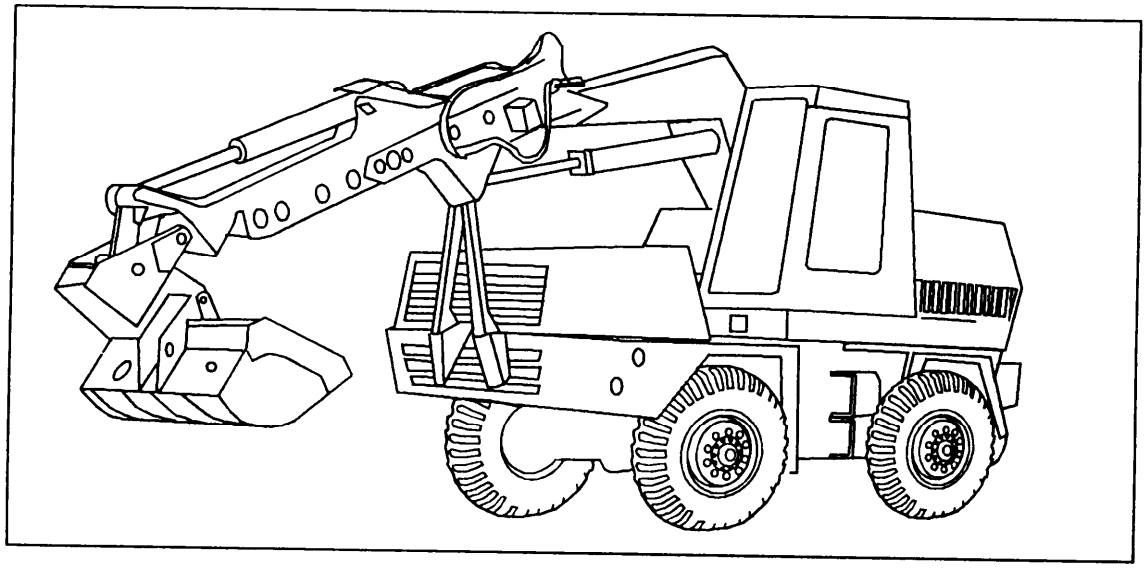


**Figure 9-55.-Self-propelled wheel-mounted excavator.**

mounted (fig. 9-54), or self-propelled wheel mounted fig. 9-55).

These excavators are hydraulic powered and consist of three structures: the revolving unit, the travel base, and the attachment.

## REVOLVING UNIT

The revolving unit rests and revolves on a turntable and is normally a rectangular steel deck that carries the engine, the pumps, the attachments, the controls, and the operator's cab. The center of rotation is usually forward of the center of the revolving unit that places a major part of the revolving unit weight at the rear. This serves to counterbalance the weight and pull of the backhoe when performing excavation operations.

The swing axis is centered in the travel unit, so the rear edge of the revolving unit overhangs. This overhang must be accounted for when the revolving unit is rotated from side to side to avoid hitting personnel, equipment, and buildings.

The operator's cab is either mounted to the right or left of the boom and is the location of controls, gauges, and warning lights for all phases of operation. Some units may have fixed or removable front and side windows and a roof window that is helpful in watching out for and avoiding wires and tree branches. These windows should be cleaned during the prestart operation and anytime an amount of dust and dirt that has accumulated on the window obstructs your vision.

## TRAVEL UNIT

The excavator travel unit may be track (crawler) mounted, truck mounted, or self-propelled wheel mounted. Of the three, the most common mounting is the track.

### Rack Mounted

Track frames are single or double beams welded to the outer ends of the dead axles in the car body. The car body is a massive frame that includes the turntable and the dead axles or cross members that transmit its weight to the track flames. The track may be the link-shoe construction that is made up of a number of identical shoes cut and drilled at their ends, so they can be fastened together by pins (fig. 9-56). Wedge-shaped projections are cast into the upper surfaces of the shoes to provide a grip for the drive sprockets and to keep the tracks centered on the idler and rollers.

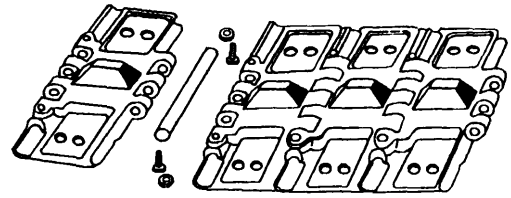


**Figure 9-56.—Link-shoe construction.**

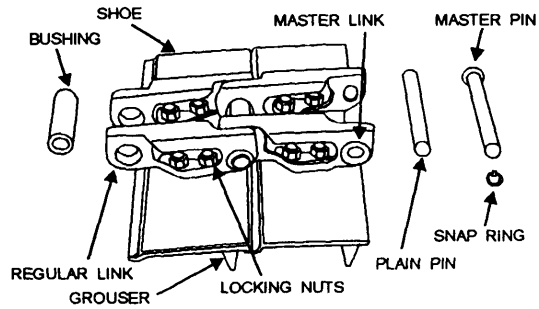



**Figure 9-57.—Track links and bolt-on shoes.**

The other type of track is the roller chain with bolt-on shoes. Each linked pair is fastened together with a bushing at one end. A pin goes through the bushing and holds the overlapping ends of the next pair of links (fig. 9-57). The track is assembled on a hydraulic press that is able to force the slightly oversized pins and bushings into the links that very seldom work apart in service. The pins turn easily in the bushing, providing the necessary hinge action.

The propel, traction, or travel drive may come from a pair of live axles set across the center of the car body or a pair of reversible hydraulic motors fastened to the track frame.

### Truck Mounted

The revolving unit is carried on a turntable fastened to a truck chassis. Some units may have an engine mounted in the revolving unit to provide power for the upper unit controls and a engine mounted in the truck to be used for traveling. Some truck-mounted units may only have one engine used to power both the revolving unit and truck.

The truck-mounted excavator can ordinary swing in a full 360-degree rotation, but with most attachments, it can work through only 270 degrees because of interference presented by the cab and the truck front.

**NOTE:** A common rule of thumb is to never swing or perform work with a revolving unit over the cab or front of the truck.

Some truck-mounted units are equipped with outriggers mounted on the rear that increase the stability of the truck. These outriggers are normally hydraulically actuated and controlled from the cab of the truck and provide a much larger and more rigid base than tires.

The advantage of truck mounting over track mounting is its capacity for rapid movement from one job to another. The boom can be placed easily in the boom rest for traveling and then driven down the road at 25 to 35 miles per hour. This is better than the slow laborious job of trailer loading, securing, hauling, and unloading a track-mounted excavator.

The truck-mounted excavator suffers from a lack of maneuverability compared to the track mounting, because it requires a large area to turn around or to sidestep. Additionally, an important weakness is the ease with which it can get stuck. Constant care must be exercised to keep away from soft ground during or after it rains. Also, tire damage can occur when working in garbage dumps or a rock quarry.

### Self-Propelled Wheel Mounted

The self-propelled single-engine unit has a two-range transmission, enabling it to travel between 3 and 28 miles per hour. Maneuverability on the job is subject to the same limitations as the truck mounted, except the short wheelbase, and in some models, four-wheel steering allows it in tighter places.

The self-propelled model has front axle oscillation lock levers. These levers are used to lock out the front axle from oscillating up or down, holding the axle rigid and level with the main chassis. The lock lever is used to help stabilize the excavator when working over the side.

**NOTE:** When reading, make sure the oscillation lock levers are up in the oscillate position, allowing the axle freedom to oscillate up or down.

The self-propelled model has a set of outriggers used to increase the stability of the unit. These outriggers are hydraulically actuated and are controlled from the cab and provide a much larger and more rigid base when the revolving unit is placed in the working position.

When traveling, always check the travel route for weight, height, and width limits, make sure the boom and steering selector are placed in the travel position, and the swing brake is engaged. Do not travel with the boom over the side of the excavator, and if traveling off of the road, do not travel faster than 5 miles per hour.

**NOTE:** After 2 hours of highway travel or every 50 miles, whichever occurs first, stop the machine to let the tires cool for 1/2 hour. Heat damages the tires and can cause tire failure.

## ATTACHMENTS

All hydraulic excavator attachments are made of three strong structural members, such as the boom, the dipper stick, and the bucket (fig. 9-58). The structural members are hinged to each other, and the boom is hinged to the revolving unit. Movement at each hinge is controlled by two-way hydraulic cylinders.

### Boom

The boom is normally concave towards the ground that allows space to pull the bucket closer to the excavator, permits deeper digging without interference from the travel unit, and enables the operator to see past it more easily when it is raised. There are two holes for connecting the boom cylinder rod eye to the boom (fig. 9-59). The top hole is for maximum digging depth, and the bottom hole is for maximum dump height. Be sure to read the operator's manual for instructions on the boom height-depth adjustment.

The outer end of the boom is usually prolonged into a two-piece bracket, in which the dipper stick is held by a heavy hinge pin or pins.

### Dipper Stick

The dipper stick is usually one-piece, but some models may hydraulically extend and retract by a telescoping boom. The dipper stick hydraulic crowd cylinder is either connected on the top or on the bottom of the dipper, and the bucket and bucket dump arms are connected at the end.

If the dipper stick hydraulic crowd cylinder is mounted on the top, extending the cylinder forces the bucket in towards the machine, known as “crowding.” Retracting the cylinder forces the bucket outward, known as “extending.” When the cylinder is mounted underneath the boom, retracting the cylinder crowds the dipper stick, and extending the cylinder extends the dipper stick.

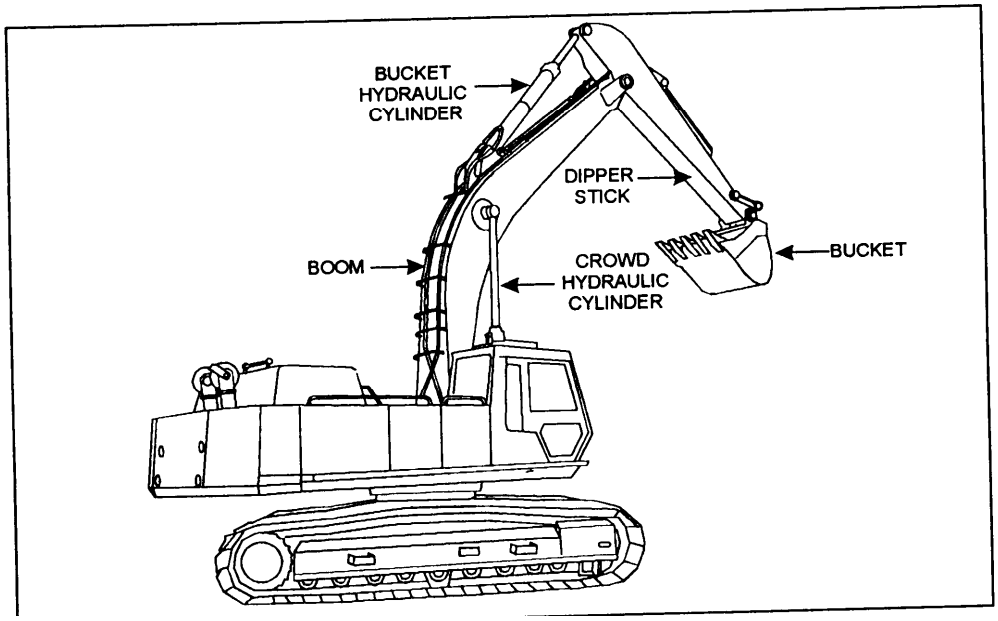



**Figure 9-58.—Hydraulic excavator structural members.**

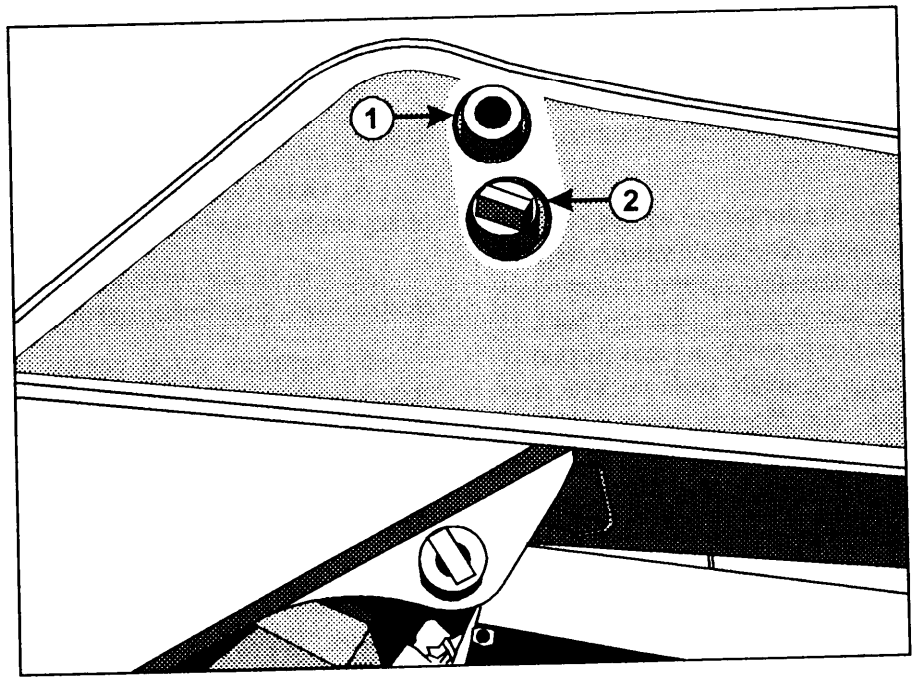



**Figure 9-59.—Boom depth-height adjustment.**

**WARNING**

When working off the rear of an excavator that has the dipper stick hydraulic cylinder mounted on the bottom, in deep digging, caution must be taken to keep the dipper stick hydraulic cylinder far enough from the excavator to allow proper clearance when swinging.

The bucket cylinder is hinged to the top or front side of the dipper stick. The hydraulic cylinder rod is connected to the bucket dump arms that are hinged to the dipper stick.

### Bucket Mounting

The bucket mounting is normally connected to the lower end of the dipper stick by a hinge pin and to a

triangular set of paired dump arms. The other two angles of the arms are hinged to the bucket cylinder rod and to the dipper stick.

Dump arms supply the required around-a-curve reach and prevent the cylinder from being pulled in against the dipper stick when extending. The arm is necessary, because the bucket has such an extended arc of rotary movement around the dipper stick hinge that the piston arm could not follow it. When the hydraulic cylinder is extended, the bucket teeth move inward in a curling or digging motion. When the hydraulic cylinder is retracted, the bucket dumps, opens, or extends.

### Bucket

The bucket can be attached to the bucket mounting in a variety of ways. One way is the slow process of removing cotter pins and manually driving out hinge pins to change the attachment. Another way is a "quick-latch" mounting where the pins are retained in the attachment and the quick-latch mounting latches on the pins and is secured to the attachment by a large bolt. A third way is a quick disconnect that uses hydraulic controlled locking pins that the operator controls from the cab.

Buckets are supplied in a number of widths, ranging from 24 to 59 inches or more. A bucket is usually slightly wider at the opening to reduce friction at the sides when digging and to allow easier dumping. Narrow buckets tend to be deep in proportion to width and may fill poorly in chunky or rocky digging, while wide buckets may have poor penetration. The digging edge is almost always equipped with teeth that are removable for reversing, sharping, or replacement (fig. 9-60).

In the NCF, there are other attachments that are used in excavator operations. These attachments range from a grader blade, hydraulic power compactor, perforated dredge bucket, bull prick (jackhammer), ripper, and so forth. These attachments are maintained by the attachment custodian in the transportation yard.

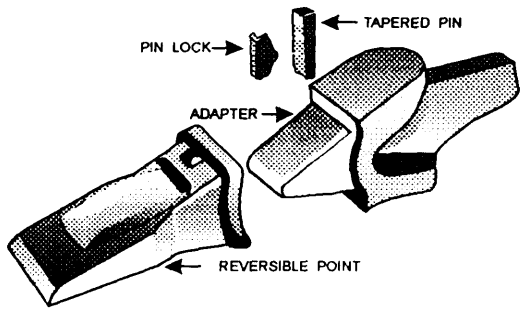



**Figure 9-60.-Detachable tooth.**

When you are using attachments, remember these rules: (1) always maintain clearance between the attachment and the cab to prevent equipment damage and possible injury; (2) when not in use, store attachments on a hardstand or wood to keep the items out of sand, mud, and water; and (3) seal hydraulic lines and fittings for protection from dirt and moisture.

## DIGGING PROCEDURES

If you are unfamiliar with the control or basically have not operated a backhoe in a while, use a slow engine speed while you familiarize yourself with each control. At first, operate the controls separately, then operate two or more controls at the same time. Basic digging procedures are as follows:

1. Wear the proper personal protective equipment for the job, including steel toe safety shoes, a hard hat, and gloves.

2. Check the ground conditions before you start to dig.

3. Obtain a digging permit and know the location of any underground cables and pipelines.

4. Check for overhead obstructions, such as electric lines, tree limbs, and awnings.

5. Remove large rocks, stumps, or other obstructions before you begin to dig.

6. When you are digging, use a digging stroke that will fill the bucket. Full buckets are more efficient and faster than half-full buckets.

7. Try different digging angles with the bucket to find the best cutting effort for the material you are removing. The best digging angle cuts the material as you fill the bucket.

8. When filling the bucket, keep the bottom of the bucket parallel with the cut, as shown in figure 9-61, view A.

9. Let the bucket teeth and the cutting edge cut through the ground like a knife blade, as shown in figure 9-61, view B.

10. Curl the bucket to retain the cut material, as shown in figure 9-61, view C.

11. The type of material excavated will determine how much material can be excavated with each cycle.

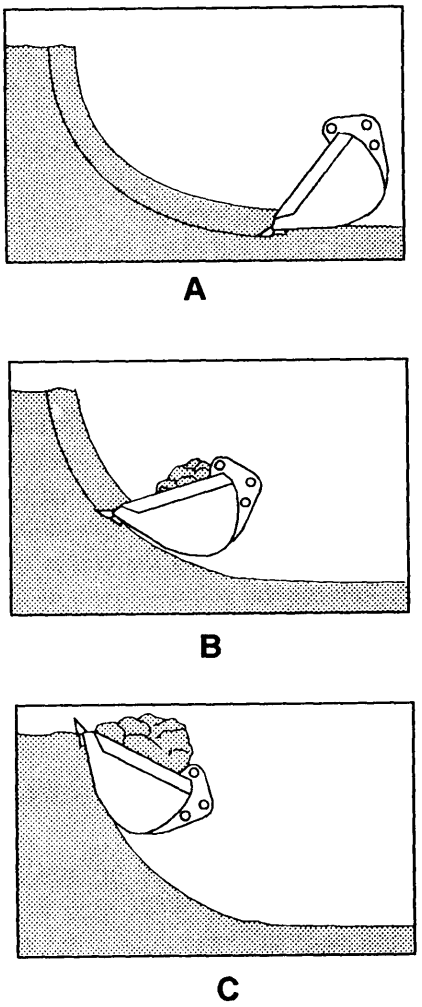



**Figure 9-61.—Filling the bucket.**

## JOB LAYOUT

Many excavation jobs are small and routine. Other jobs may be quite extensive. On small jobs, you will normally be shown where to dig and to what depth you must dig. On larger jobs, you maybe shown the plan of the proposed ditches. Grade stakes on the projects are marked to indicate to what depth the ditches must be excavated. (Chapter 15 covers grade stakes in detail.)

**NOTE:** Before starting any excavation, you must ensure a valid digging permit is present that covers the area you are tasked to excavate.

When arriving at the project site, you may notice two rows of grade stakes: one row on the center line of the proposed ditch and the other row offset a given distance from the center line. Do not disturb the offset stakes. They are the stakes you will follow while excavating the ditch that have information relative to the depth of the excavation written on the side.

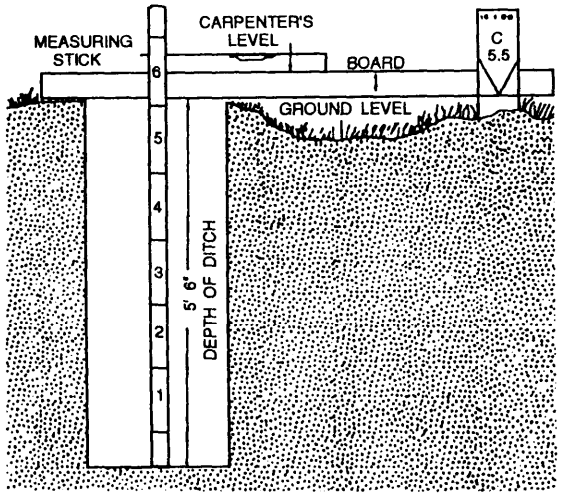



**Figure 9-62.—Measuring the depth of a ditch.**

As a guideline, you can use a string drawn taut from the first centerline stake to the following centerline stakes for a distance of several hundred feet ahead of the machine. Then spray paint over the string with a bright-colored paint that will mark the ground to be excavated. With the bucket centered over the first centerline stake, you will be able to excavate the painted line. If you get off center, you can bring the backhoe back into alignment gradually by steering the machine in the desired direction.

Check your grade (ditch depth) frequently. You can do this by using a straight board, a carpenter's level, and a measuring stick or tape measure. Align the corner bottom of the horizontal board on the crowfoot cut, marking of the offset stake. Place the level on the horizontal board and adjust the board opposite the stake until the level indicates the board is level. Measure from the bottom edge of the board to the bottom of the ditch, as shown in figure 9-62. This measurement should correspond to the amount of cut indicated on the stake. All of the stakes will be cut stakes. You should always try to excavate to the depth specified on the stakes.

**NOTE:** It is better to excavate an inch or two below grade than not excavate deep enough.

## FOUNDATION EXCAVATION

The backhoe is used to make excavations for basements or any other square- or rectangular-shaped job. It is also used extensively for digging wide trenches for laying water and sewer pipe. When the backhoe is used for the digging of square- or rectangular-shaped jobs, the procedures may vary with the shape of the job, restrictions caused by surrounding buildings, or special

requirements for disposal of the spoil. In all cases, the starting point and digging sequence must be planned, so the backhoe conveniently works itself out into the clear. Improper procedures will not only trap the machine, but can lead to situations where the machine cannot be positioned to complete the job. In this situation, hand digging may be required to complete the excavation.

An accepted starting and digging sequence that can be followed for excavating a small foundation is shown in figure 9-63. Remember that digging time is lost each time the machine must be moved. The digging sequence is planned, so a maximum amount of spoil can be excavated before the machine is moved to the next position.

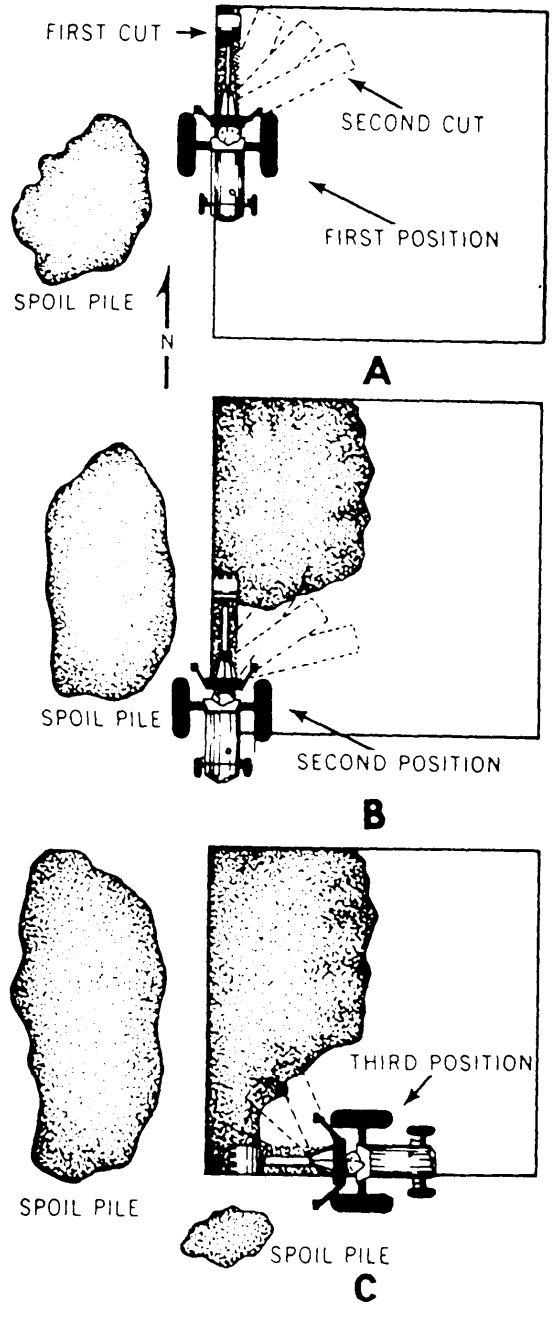



**Figure 9-63.—Foundation excavation.**

For example, the first cut is to be made on the west line (fig. 9-63, view A). The starting position of the machine would be on the west line at a point where the boom and dipper stick will reach the northwest corner. The machine and boom are lined up parallel with the west cutting line, so the outer edge of the bucket is exactly in line with the cutting line.

The first cut is made by digging a ditch along the west cutting line. The ditch should be dug to its full depth and grade. This depth and grade serves as a depth guide for the other cuts. When the west wall has been dug as close as possible to the machine position, you then swing the boom to reach near the center of the north cutting line. The second cut, as shown in figure 9-63, view A, is made by digging a trench back from the north wall. The material cut in the angle formed between these two trenches is removed in layers until the bottom grade is reached.

**NOTE:** Ensure that the desired grade is reached before moving the backhoe.

The backhoe is then backed up into the second position, as shown in figure 9-63, view B. Digging is continued in steps, as shown in figure 9-63, view A. The ditch is dug first along the west line. The boom is then swung around to cut the angle trench and the material is removed to grade. Digging is continued in this manner until the south line is reached.

The backhoe is then moved to the unexcavated portion of the south line. This position is shown in figure 9-63, view C. Here, the backhoe is positioned with the bucket in the excavation at the southwest corner to begin the ditch along the south cutting line. Again, after the ditch is dug along the cutting line, you should swing the boom toward the center to remove as much spoil as possible from this machine position.

You should continue to move the backhoe around the excavation, repeating the digging steps until all four cutting lines are cut and the spoil removed. To make the final cut to remove the material, you may have to position the machine at the edge so the bucket can dig straight up. This cannot be done unless the soil type is known to have good-bearing qualities. Cave-ins will result if the soil will not support the weight of the machine.

**NOTE:** Before excavating at a jobsite, always consult with the project supervisor or crew leader about your excavation plans. Keep in mind that the area you

might be placing the spoil material might be an area for other construction tasking. Excavating at a jobsite must be a well-thought-out plan.

## SAFETY

Safety precautions that apply when you operate front-end loaders, backhoes, and excavators are as follows:

- Clear the immediate area of personnel or obstructions before starting the engine.
- Keep the bucket as close to ground level as possible when transporting loads on grades or slopes.
- Never operate any control from any position except in the operator's seat.
- Be extra careful when working on banks or hillsides.
- Always keep the machine in gear when going down steep grades. Never coast or freewheel.
- Drive at speeds slow enough to ensure safety and complete control especially over rough terrain.
- Reduce speed when making turns or applying brakes.
- Always lower the lift arms or boom to the ground or block them securely before performing any service or when leaving the machine unattended.
- Never dismount the loader, backhoe, or excavator when it is in motion.
- Never permit anyone to ride on the equipment.
- Do not oil, lubricate, or make adjustments when the engine is running or the bucket is raised and unblocked.
- Never refuel when the engine is running.
- Do NOT smoke when refueling.
- Never operate in a closed area; provide proper ventilation.
- Do not wear loose fitting clothing which may catch in moving parts.
- Always wear seat belts, steel toe safety shoes, hard hats, gloves, and other required personal protective equipment.

## DITCHERS

A ditcher, despite its name, is seldom used for digging a ditch, which is a slot cut in the earth's surface and left open. The ditcher is a mechanical excavator used to dig trenches, which is a temporary cut in the earth for underground utilities, such as pipelines and conduit to handle water, fuel, electric cable, and sewage. Once these materials are placed, the trench is covered. Additionally, the ditcher may also be used to dig footers for building foundations.

All ditchers have bucket teeth (fig. 9-64). The ditcher teeth cut the earth and play a major role in how

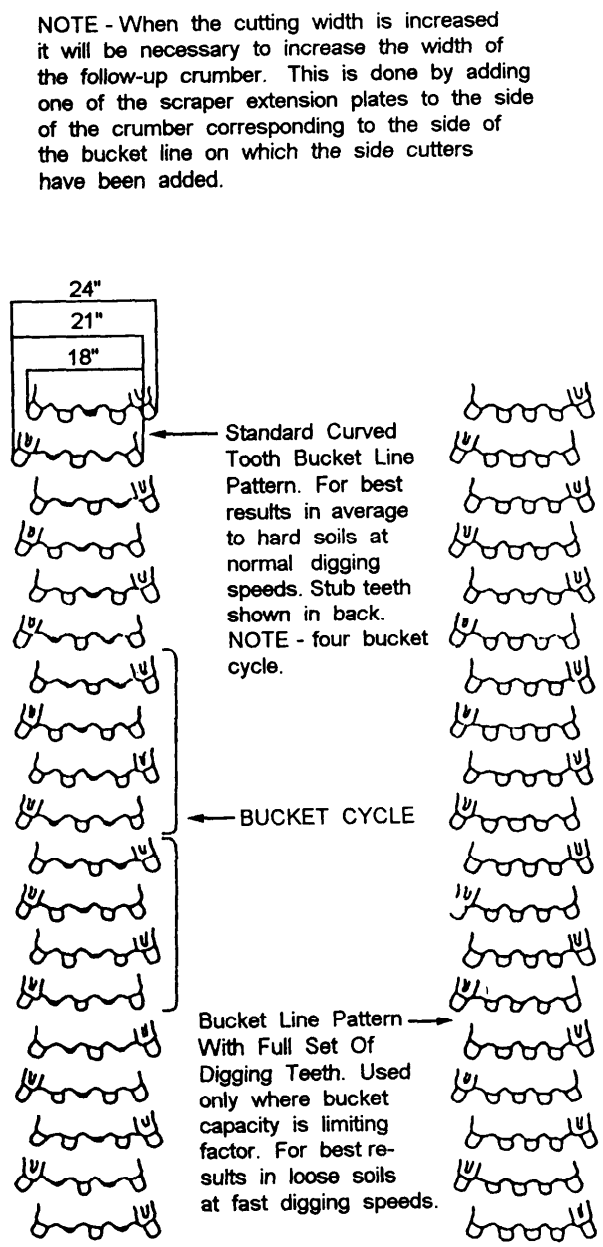



**Figure 9-64.-Two basic bucket teeth designs.**

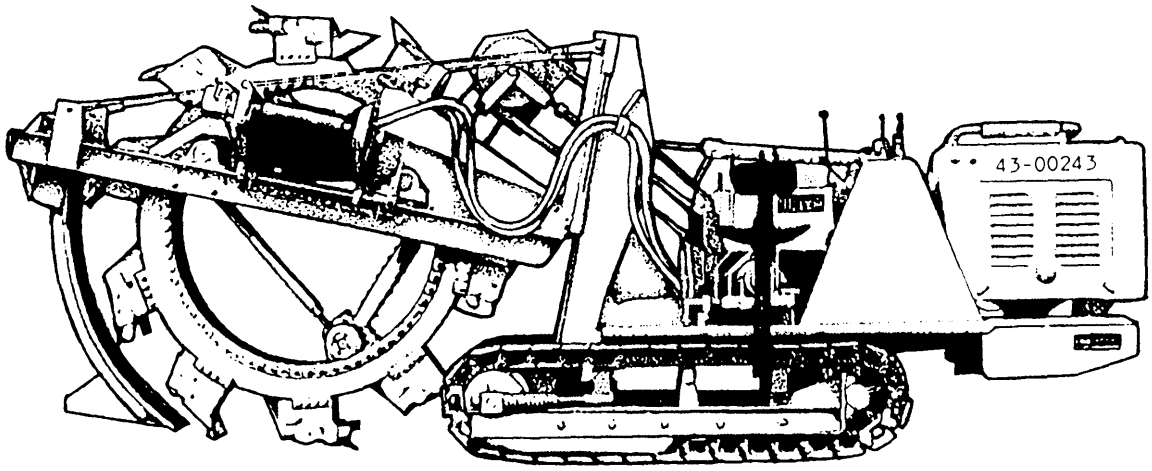



**Figure 9-65.—Wheel ditcher.**

your machine performs. Figure 9-64 shows two examples of teeth patterns normally used. When the teeth wear down about one-half inch and before the face of the bucket shows wear, ensure the teeth are reversed or replaced.

**NOTE:** Always install a complete set of teeth on a bucket when reversing or replacing teeth.

If only a few new teeth are installed here and there along the bucket line, the new teeth will cut the most and wear down much faster than would a whole new set. However, if only one or two teeth show too much wear or are broken or chipped, they may be reversed or new ones installed in their place if the rest of them are in good shape.

Three types of ditchers used in the NCF are the wheel ditcher, the ladder ditcher, and the chain ditcher. The most common ditcher is the ladder ditcher. Read the operator's manual to obtain detailed information on the care, maintenance, and operation of a given ditcher.

## WHEEL DITCHER

On the wheel ditcher (fig. 9-65), the digging buckets are mounted on a large wheel. The wheel is attached to a frame type of horizontal boom that can be raised and lowered, and the ditcher has a spoil conveyor for carrying the excavated material out to either side of the machine.

To start a cut, lower the turning wheel into the ground, and then watch the bucket teeth start to dig. As the ditcher itself is stationary, apply enough pressure to the buckets so they fill "heaping" without gouging deep enough to slow the wheel.

The ditch will have a rounded beginning, as shown in figure 9-66, views A and B. Be sure the position of the center of the wheel is over the starting point for the full depth of the ditch, so the ditcher has enough room to dig down to the desired depth at the beginning of the cut (fig. 9-66, view B).

**NOTE:** Before starting any excavation, you must ensure a valid digging permit is attained that covers the area you are tasked to ditch.

### Digging

When the wheel is at the correct depth, you should move the machine forward just fast enough to keep the buckets reasonably full. Crowding too hard overworks the engine and strains the digging parts without adding to the output.

Soft rock usually responds best to a high-wheel speed with very slow walking speed. If dirt is soft, you may crowd it so the dirt in excess of the bucket capacity piles on each side of the ditch without damage.

Experience will help when selecting the right combination of digging and travel speeds for various types of soil; however, consult the operator's manual for

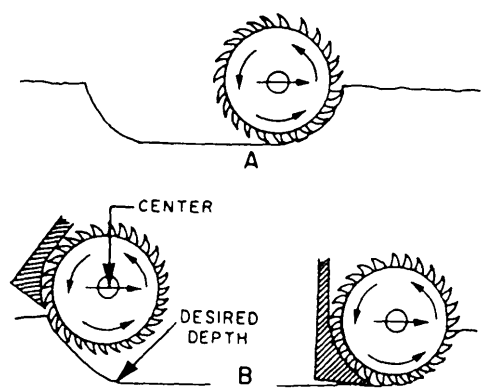



**Figure 9-66.-Starting a cut with a wheel ditcher.**

guidance on digging and travel speeds for the type of ditcher used.

**Obstructions**

Where boulders, heavy roots, or pipelines could be met, you should adhere to the following guidelines:

- Both walking and wheel speeds should be slow.

- Soft boulders are cut through by the teeth. Depending on how buried a hard boulder is, it may be pulled to the surface or forced forward. This is because the deeper boulder not only is held down by a greater weight of dirt but also the direction of the tooth contact tends to force it forward, rather than up.

- The wheel will usually ride over embedded boulders that cannot be removed by the ditcher. If a large boulder is near the surface of the cut, it may stop the forward motion of the machine; in which case, power should be cut off promptly.

- If a boulder is pulled to the surface, it may land in an inconvenient spot, forward of the wheel and between the tracks. You may have to lift the wheel into transporting position, work forward until clear of the rock, push it out of the way, and backup until the wheel can be lowered to the ditch bottom. If the boulder is too large for the wheel to clear, release the wheel drive clutch so the wheel can turn as it is pulled over it.

- When the wheel is lifted above grade to clear any obstruction, it maybe worked back to grade at the other side in the same way the cut is started.

- Turn with caution while digging. Slight turns cause the wheel to move sideways in the trench. If the buckets have long side teeth or side-cutting bars and the earth is soft, you can make a gradual turn without damaging the wheel assembly. Sharp turns may cause severe damage, such as bending the wheel frame, bending the wheel itself, or pulling the wheel frame off the vertical track.

## LADDER DITCHER

The boom on the ladder ditcher (fig. 9-67) cannot be brought closer than about 35 degrees to the vertical.

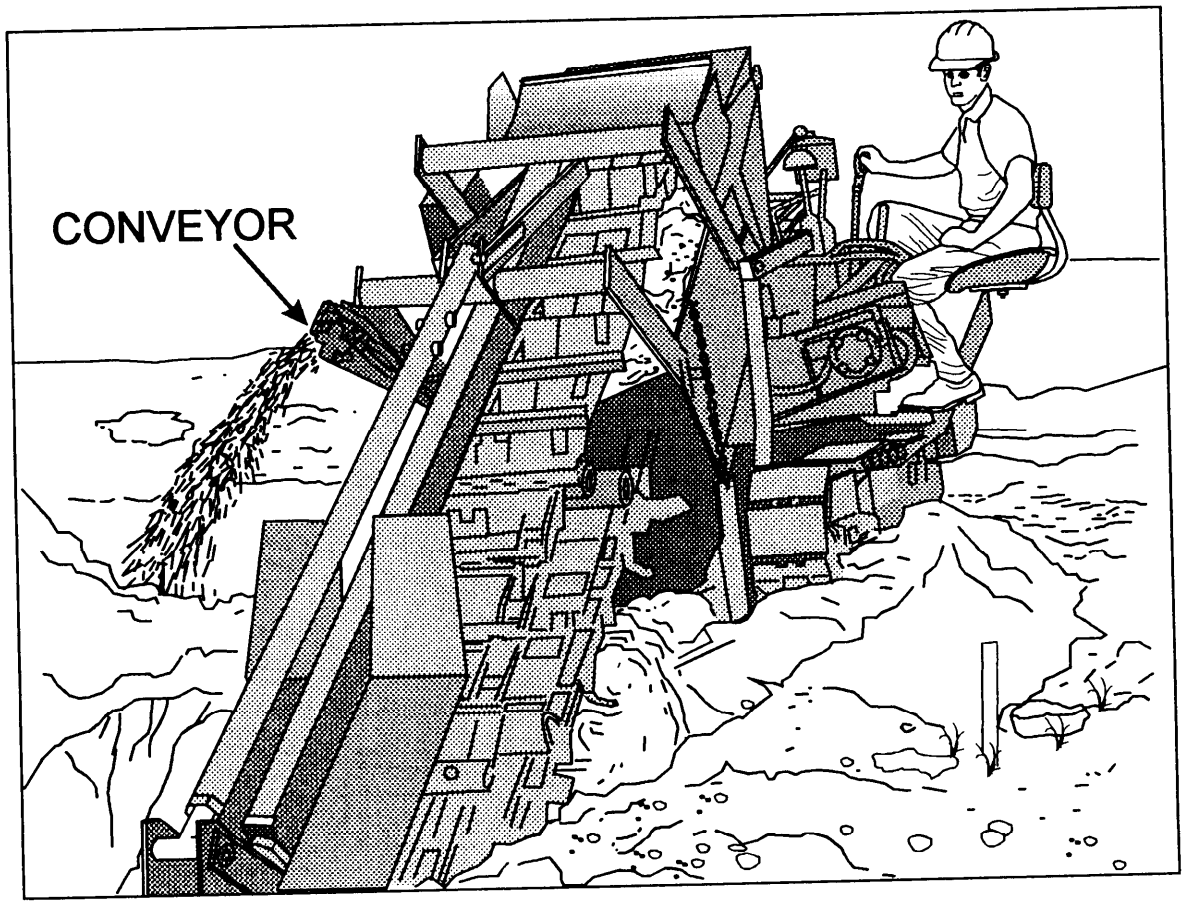



**Figure 9-67.—Ladder ditcher.**

With the ladder ditcher, excavating is done by buckets attached to the bucket line chain; the chain travels on the drive sprockets on the boom assembly. Like the wheel ditcher, the ladder ditcher has a spoil conveyor to carry the excavated material out to one side or the other. The radius of a curve depends mainly on the density of the soil to be excavated. Turns should be made cautiously at a slow-digging speed and only to where the boom starts binding between the trench walls.

The crumber shown in figure 9-68 has a major job to clean out and smooth the ditch after the teeth have cut the material. The crumber is adjustable and should be adjusted so it will clean the ditch of loose materials behind the teeth.

## CHAIN DITCHER

The chain ditcher, as shown in figure 9-69, has teeth attached to a chain similar to a chain saw. The chain teeth pull or drag the cuttings to the surface, rather than lifting them in a bucket. The cuttings are usually moved back from the edge of the ditch by rotating augers.

Chain ditchers are ideal for lightweight work, such as sprinkler systems, gas lines, and small waterlines. Some of these machines can dig up to 10 inches wide and 4 feet deep.

## CAPABILITIES AND LIMITATIONS OF DITCHERS

A ditcher can dig earth material ranging in texture from soft to hard; however, as the material being excavated increases in hardness, the production rate decreases. Table 9-1 gives maximum trenching rates for classes of soils in feet per minute.

A limitation of a wheel, ladder, or chain ditcher is that ramps are left at the bottom of the trench ends and around buried objects. To obtain a flat-bottom trench, you must remove these ramps by hand. The wheel ditcher digs faster in dense material and is preferred for cross-country digging where speed is needed.

## OPERATING TECHNIQUES

In most ditching work, keep the machine in line and working at the proper depth. Unable to see the ditch bottom, you (the operator) must use surface controls.

First, the ditch is surveyed and the depth of cut is determined by the EAs from the blueprints. You, the EO, establish a guideline at a fixed and constant distance above the bottom grade of the trench and offset from the center line of the trench beyond the track line of the ditcher.

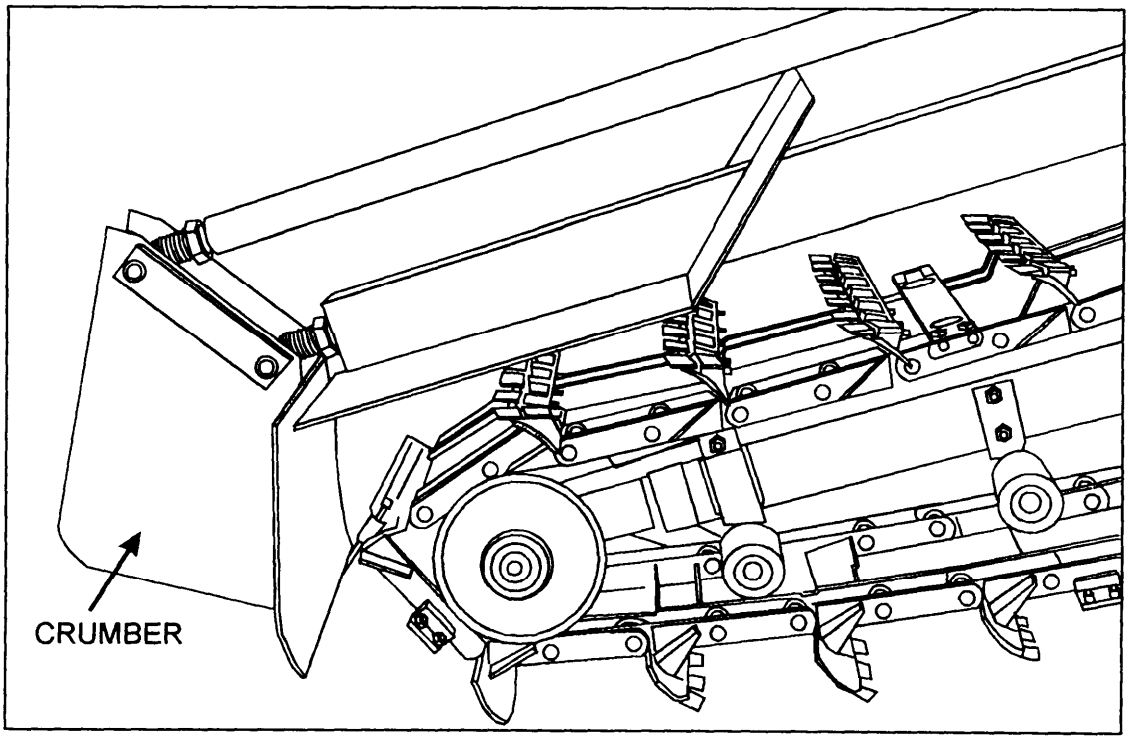



**Figure 9-68.-Crumber.**

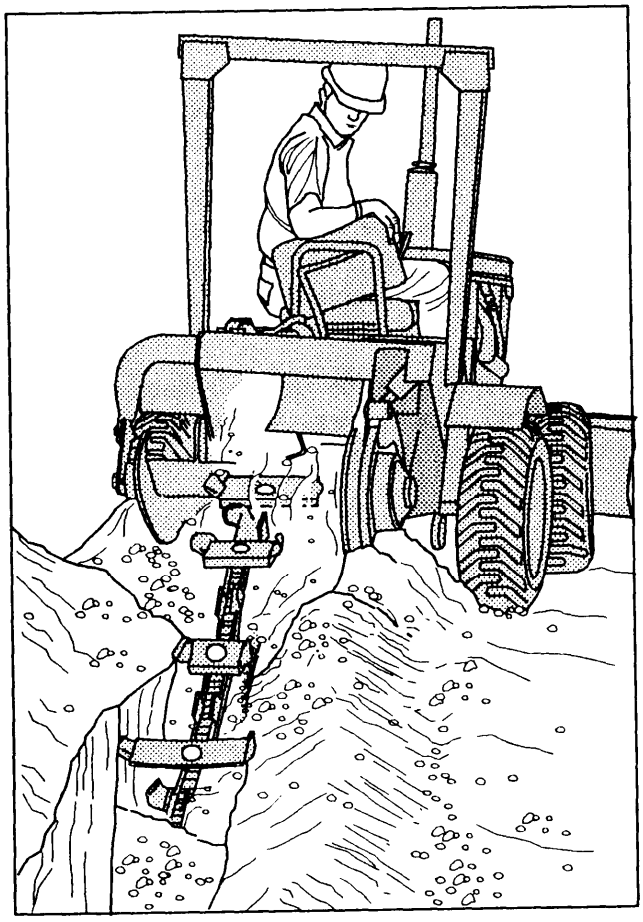


**Figure 9-69.—Chain ditcher.**

The guideline should be established at a height that will put it at least a few inches above the ground at all points, stakes driven along it, and the exact height or depth of the cut marked. Then a string line is stretched along the stakes on these markings.

A rigid bar is fastened to the front of the power unit of the ditcher with one end over the string when the ditcher is centered on the ditch line. A plumb bob or other weight is fastened to the bar, so it hangs directly over the string. The operator can then keep the machine on center of the trench, cut by keeping the plumb bob just over the string. If the ground is irregular and causes the ditcher to go up and down, the cord holding the plumb bob can be run through eyes or pulleys, so the operator can reach an end of the cord to raise and lower it.

The same device (plumb bob or other weight) can be fastened on the side beam of the boom or wheel with a fixed length of string to control the depth of cut and center line travel of the ditcher.

**Table 9-1.—Crawler Ditcher Maximum Trenching Rates**

| PRODUCTION IN FEET PER MINUTE | | | | | |
|---|---|---|---|---|---|
| DEPTH OF TRENCH | DRY TO MOIST SAND | SOFT DRY CLAY | MOIST CLAY | HARD CLAY & GRAVEL | STICKY CLAY |
| 1 ft. 6 in. | 32 | 28 | 26 | 22 | 16 |
| 2 ft. | 25 | 22 | 20 | 17 | 12 |
| 2 ft. 6 in. | 20 | 18 | 16 | 14 | 10 |
| 3 ft. | 16 | 15 | 13 | 11 | 8 |
| 3 ft. 6 in. | 14 | 13 | 11 | 10 | 7 |
| 4 ft. | 12 | 11 | 10 | 8 | 6 |
| 4 ft. 6 in. | 11 | 10 | 9 | 7 | 5 |
| 5 ft. | 10 | 9 | 8 | 6 | 4 |

### Cutting Curves

The radius of a curve cut while excavating a trench with the ditcher depends mainly on the density of the soil excavated. In sandy or loose soil, the radius can be much less than in hard, compacted, and rocky soil. The turn for the ditcher should be made cautiously at a slow digging speed and only to where the boom starts binding between the trench walls.

### Muddy Trenching

The two major problems when trenching in muddy materials are loss of traction and a buildup of material in the buckets. The traction can be increased by putting planking under the tracks or by adding wider crawler pads. To cope with material sticking to the teeth and buckets, you can run the digging chain faster, so the material will not be forced into the cut. In this way, you do not force and pack wet, sticky material into the bucket and between the teeth; otherwise, the material in the bucket gets stuck and cannot empty completely.

### Transporting

A ditcher is slow and must be hauled between jobsites. It must be loaded and unloaded safely and properly. The design of the ditcher requires that it be used on a smooth, gradual incline. When loading on a tilt-bed trailer, you must be careful; the sharp incline of the trailer could make the ditcher hang up. Additionally, the smooth tracks of the ditcher tend to slip.

**NOTE:** Do not load a ditcher on a tilt-bed trailer in damp, wet weather.

The combination of the ditcher design, brakes, and smooth tracks makes it almost impossible to stop on an incline while loading or unloading; therefore, it is important to use a proper ramp or loading platform to load the ditcher. For safety, load and unload the ditcher in low gear, and if you do not have a proper ramp, see that a crane is used to load and unload the ditcher.

**SAFETY**

The following are standard safety precautions for ditchers:

- Do not leave the operator's seat unless you have stopped the ditcher and disconnected all power from the engine to the ditcher.
- Do not engage the engine clutch too fast. Let it engage gradually to prevent damage to the gear cases and other moving parts.
- Do not fill the fuel tank with the engine running.
- Do not let bolts and keys come loose. Be alert for unusual sounds or odors. These are danger signs and should be investigated to prevent downtime.
- When the ditcher is secured, the bucket line must always be raised clear of the trench.
- Ditches left open must be flagged by day and properly lighted at night.
- Do not let anyone work or stand close to the digging boom. In a cave-in, the person might be pulled into the boom or other moving parts. Also, if an electrical line is hit, people standing nearby could be hurt.
- Before digging, be sure you have a digging permit. You should know and have marked all underground obstructions.

**CAUTION**

Never try to remove an object from the conveyor belt while the conveyor is running.

- Never raise the boom of the ditcher more than you have to while on an incline, because the ditcher is easily upset.
- Wear the required personal protective equipment, such as steel toe shoes, hard hat, and gloves.

# APPENDIX I

# GLOSSARY

**AGGREGATE—** Crushed rock or gravel, screened to sizes for use in road surfaces, concrete, or bituminous mixes.

**ANGLING DOZER** (Angledozer)—A bulldozer with a blade that can be pivoted on a vertical center pin so as to cast its load to either side.

**APRON—** The front gate of a scraper body.

**ASPHALT—** A dark brown to black cementitious material in which the predominating constituents are bitumens that occur in nature or are obtained in petroleum processing. Asphalt is a constituent in varying proportions of most crude petroleums.

**ASPHALT CEMENT—** A fluxed or unfluxed asphalt specially prepared as to quality and consistency for direct use in the manufacture of asphalt pavements.

**ASPHALT CONCRETE—** High-quality thoroughly controlled hot mixture of asphalt cement and well-graded, high-quality aggregate, thoroughly compacted into a uniform, dense mass.

**ASPHALT LEVELING COURSE—** A course (asphalt aggregate mixture) of variable thickness used to eliminate irregularities in the contour of an existing surface before a superimposed treatment or construction.

**ASPHALT, MEDIUM-CURING (MC)—** Cutback asphalt, composed of asphalt cement and a kerosene type of diluent of medium volatility.

**ASPHALT, RAPID-CURING (RC)—** Cutback asphalt, composed of asphalt cement and naphtha or gasoline type of diluent of high volatility.

**ASPHALT, SLOW-CURING (SC)—** Cutback asphalt, composed of asphalt cement and oils of low volatility.

**AUGER—** A rotating drill having a screw thread that carries cuttings away from the face.

**AUXILIARY—** A helper or standby engine or unit.

**AXIS OF ROTATION—** The vertical line around which the upper structure rotates.

**AXLE, LIVE—** A revolving horizontal shaft.

**BACKFILL—** (1) The material used in refilling a ditch or other excavation. (2) The process of such refilling.

**BAIL BLOCK—** Block attached to a dragline bucket, through which rope line is reeved. Also referred to as "PADLOCK."

**BAIL (BUCKET)—** A yoke or spreader, hinged to the sides of a dragline bucket, to which is attached a connecting sheave or chain for hoisting and dragging operations.

**BALL JOINT—** A connection, consisting of a ball and socket, that will allow a limited hinge movement in any direction.

**BANK—** Specifically, a mass of soil rising above a digging or trucking level. Generally, any soil that is to be dug from its natural position.

**BANK GRAVEL—** Gravel found in natural deposits, usually more or less intermixed with fine material, such as sand or clay, and combinations thereof; gravelly clay, gravelly sand, clayey gravel, and sandy gravel indicate the varying proportions of the materials in the mixture.

**BASE COURSE—** The layer of material immediately beneath the surface or intermediate course. It may be composed of crushed stone, crushed slag, crushed or uncrushed gravel and sand, or combinations of these materials. It also may be bound with asphalt.

**BANK YARDS—** Yards of soil or rock measured in its original position (before digging).

**BEDROCK—** Solid rock, as distinguished from boulders.

**BENCH—** A working level or step in a cut that is made in several layers.

**BINDER—** (1) Fines which hold gravel together when it is dry. (2) A deposit check that makes a contract valid.

**BITUMEN—** A class of black or dark-colored (solid, semisolid, or viscous) cementitious substance, natural or manufactured, composed principally of

high molecular weight hydrocarbons, or which asphalts, tars, pitches, and asphaltites are typical.

**BLASTING MAT–** A heavy, flexible fabric of woven wire rope or chain, used to confine blasts.

**BLEEDING OR FLUSHING–** Is the upward movement of asphalt in an asphalt pavement, resulting in the formation of a film of asphalt on the surface. The most common cause is too much asphalt in one or more of the pavement courses, resulting from too rich a plant mix, an improperly constructed seal coat, too heavy a prime or tack coat, or solvent-carrying asphalt to the surface. Bleeding or flushing usually occurs in hot weather.

**BLUE TOPS—** Grade stakes with blue tops to indicate finish grade level, usually a 2-inch by 2-inch by 6-inch hub stake.

**BM—** Bench mark.

**BODY—** The load carrying part of a truck or scraper.

**BOGIE AXLE—** Two or more axles, mounted to a frame so as to distribute the load between the axles and permit vertical oscillation of the axles.

**BOOM CHORD—** A main corner member of a lattice type of boom.

**BOOM, CRANE—** A long, light boom, usually of lattice construction.

**BOOM HOIST—** Mechanism to control the elevation of the boom and to support it.

**BOOM LACING–** Structural truss members at angles to and supporting the boom chords of a lattice type of boom.

**BOOM, LATTICE—** A long, light boom fabricated of crisscrossed steel or aluminum angles or tubing.

**BOOM LENGTH—** Boom length is a straight line through the center line of the boom pivot pinto the center line of the boom point load hoist sheave pin, measured along the longitudinal axis of the boom.

**BOWL—** (1) The bucket or body of a carrying scraper. (2) Sometimes the moldboard or blade of a dozer.

**BUCKET—** A part of an excavator that digs, lifts, and carries dirt.

**BULLDOZER—** (1) A tractor equipped with a front pusher blade. (2) In a machine shop, a horizontal press.

**CAPILLARY ATTRACTION—** The tendency of water to move into fine spaces, as between soil particles, regardless of gravity.

**CASING—** A pipe lining for a drilled hole.

**CAT—** (1) A trademark designation for any machine made by the Caterpillar Tractor Company. (2) Widely used to indicate a crawler tractor of any make.

**CAT HEAD—** A capstan winch.

**CATWALK—** A pathway, usually of wood or metal, that gives access to parts of large machines.

**CENTRIFUGAL FORCE—** Outward force exerted by a body moving in a curved line. It is the force that tends to tip a car over in going around a curve.

**C-FRAME—** An angling dozer lift and push frame.

**CHECK VALVE—** Any device that will allow fluid or air to pass through it in only one direction.

**CHOKER—** A chain or cable so fastened that it tightens on its load as it is pulled.

**CIRCLE REVERSE—** The mechanism that changes the angle of a grader blade.

**CLAM—** A clamshell bucket.

**CLAMSHELL—** (1) A shovel bucket with two jaws that clamp together by their own weight when it is lifted by the closing line. (2) A crane equipped with a clamshell bucket.

**CLAMSHELL BUCKET—** Usually consists of two or more similar scoops hinged together and a head assembly connected to the outer corners by struts. When the head and hinge are pulled toward each other, the scoops are forced together to dig and hold material. Control is by a holding line reeved over a boom point sheave and attached to the head assembly to support the bucket in open position and usually by a closing line also reeved over a boom point sheave, ending in a force amplifying tackle or other means between the head assembly and scoop hinge to close the bucket.

**CLAMSHELL BUCKET, HYDRAULIC—** Usually consists of two or more scoops hinged to a head assembly housing the hydraulic cylinder or cylinders and the force amplifying linkage to open and close the scoops and to supply the digging force for the scoops. The bucket assembly is suspended from the boom by a rope. Because digging ability is largely dependent upon bucket weight, buckets are supplied in various weight classes which range from

light, for easily dug stockpiled materials, to heavy, for excavating hardpan material and the like.

**CLAMSHELL EQUIPMENT—** Machines with clamshell attachments are used to load material from stockpiles, gondola cars, barges, and the like, or from virgin soil generally out of small-area holes, deep trenches, or from below water. Orange peel buckets, grapples, and similar rope suspended attachments are included in this classification.

**CLOSING LINE—** The rope reeved from the hoist drum to control closing of a rope-operated clamshell bucket.

**COFFERDAM—** A set of temporary walls, designed to keep soil and/or water from entering an excavation.

**COLLAR—** A sliding ring, mounted on a shaft so that it does not revolve with it, used in clutches and transmissions.

**COMPACTION—** The act of compressing a given volume. Insufficient compaction of the asphalt pavement courses may result in channeling on the pavement surface. Compaction is usually accomplished by rolling.

**CONVEYOR BELT—** An endless belt of rubber-covered fabric that transports material on its upper surface.

**CORRUGATIONS (WASHBOARDING) AND SHOVING—** Are types of pavement distortion. Corrugation is a form of plastic movement typified by ripples across the asphalt pavement surface. Shoving is a form of plastic movement, resulting in localized bulging of the pavement surface. These distortions usually occur at points where traffic starts and stops, on hills where vehicles brake on the downgrade, on sharp curves, or where vehicles hit a bump and bounce up and down. They occur in asphalt layers that lack stability. Lack of stability may be caused by a mixture that is too rich in asphalt, has too high a proportion of fine aggregate, has coarse or fine aggregate that is too round or too smooth, or has asphalt cement that is too soft. It may also be due to excessive moisture, contamination due to oil spillage, or lack of aeration when placing mixes using liquid asphalt.

**CRACKS—** Breaks in the surface of an asphalt pavement.

**CRACKS, ALLIGATOR—** Interconnected cracks forming a series of small blocks resembling an alligator's skin or chicken wire, caused by excessive deflection of the surface over unstable subgrade or lower courses of the pavement.

**CRACKS, EDGE JOINT—** Are the separation of the joints between the pavement and the shoulder, commonly caused by the alternate wetting and drying beneath the shoulder surface. Other causes are shoulder settlement, mix shrinkage, and trucks straddling the joint.

**CRACKS, LANE JOINT—** Longitudinal separation along the seam between two paving lanes caused by a weak scam between adjoining spreads in the courses of the pavement.

**CRACKS, REFLECTION—** Cracks in asphalt overlays that reflect the crack pattern in the pavement structure underneath. They are caused by vertical or horizontal movements in the pavement beneath the overlay, brought on by expansion and contraction with temperature or moisture changes.

**CRACKS, SHRINKAGE—** Are interconnected cracks forming a series of large blocks, usually with sharp corners or angles. Frequently they are caused by volume change in either the asphalt mix or in the base or subgrade.

**CRACKS, SLIPPAGE—** Are crescent-shaped cracks that are open in the direction of the thrust of wheels on the pavement surface. They result when there is a lack of good bond between the surface layer and the course beneath.

**CRANE—** A mobile machine, used for lifting and moving loads without the use of a bucket.

**CRANE MATS—** A device, used for supporting machines on soft ground, usually of timber construction.

**CREEP—** (1) Very slow travel of a machine or a part. (2) Unwanted turning of a shaft due to drag in a fluid coupling or other disconnect device.

**CRUMBER—** A blade that follows the wheel or ladder of a ditching machine to clean and shape the bottom.

**CULVERT—** A pipe or small bridge for drainage under a road or structure.

**CURVE, VERTICAL—** A change in gradient of the center line of a road or pipe.

**CUTBACK ASPHALTS—** Mixture of asphalt cement and a cutting agent. There are three main types.

**DATUM—** Any level surface taken as a plane of reference from which to measure elevations.

**DEADHEADING—** Traveling without a load, except when traveling from the dumping area to the loading point.

**DENSITY—** The ratio of the weight of a substance to its volume.

**DIESELING—** In a compressor, explosions of mixtures of air and lubricating oil in the compression chambers and/or other parts of the air system.

**DOLLY—** A unit consisting of a draw tongue, an axle with wheels, and a turntable platform to support a gooseneck trailer.

**DOUBLE-CLUTCHING—** Disengaging and engaging the clutch twice during a single-gear shift (change of gears) to synchronize gear speeds.

**DOWNSTREAM FACE—** The dry side of a dam.

**DOZER—** Abbreviation of bulldozer.

**DRAFT—** Resistance to movement of a towed load.

**DRAGLINE—** A crane with a dragline attachment, used to excavate material from below the grade on which the crane is sitting.

**DRAWBAR—** A fixed or hinged bar, extending to the rear of a tractor and used as a fastening for lines and towed machines or loads.

**DRAWBAR HORSEPOWER—** A tractor's flywheel horsepower minus friction and slippage losses in the drive mechanism and the tracks or tires.

**DRAWBAR PULL—** The pull that a tractor can exert on a load attached to the drawbar. Depends on power, weight, and traction.

**DRILL COLLAR—** Thick-walled drill pipe, used immediately above a rotary bit to provide extra weight.

**DRILL, PERCUSSION—** A drill that hammers and rotates a steel and bit. Sometimes limited to large blast hole drills of the percussion type.

**DRILL PIPE—** The sections of a rotary drilling string, connecting the kelly with the bit or collars.

**DRIVE SPROCKET—** A drive roller with teeth that engage matching recesses or pins (bushings) in the track assembly.

**DROP HAMMER—** A pile-driving hammer that is lifted by a cable and that obtains striking power by falling freely.

**DRUM, SPUDDING—** In a churn drill, the winch that controls the drilling line.

**EJECTOR—** A clean-out device, usually a sliding plate.

**EMBANKMENT—** A fill whose top is higher than the adjoining surface.

**EROSION—** Wear caused by moving water or wind.

**FACE—** (1) The more or less vertical surface of rock exposed by blasting or excavating or the cutting end of a drill hole. (2) An edge of rock used as a starting point in figuring drilling and blasting. (3) The width of a roll crusher.

**FACTOR OF SAFETY—** The ratio of the ultimate strength of the material to the allowable or working stress.

**FAIRLEAD—** A device which lines up cable so that it will wind smoothly onto a drum.

**FEATHER—** To blend the edge of new material into the old surface smoothly.

**FIFTH WHEEL—** The weight-bearing swivel connection between highway type of tractors and semitrailers.

**FILL—** An earth or broken rock structure or embankment. Soil or loose rock used to raise a grade. Soil that has no value except bulk.

**FLOAT—** In reference to a dozer blade, to rest by its own weight or to be held from digging by upward pressure of a load of dirt against its moldboard.

**FOOT—** In tamping rollers, one of a number of projections from a cylindrical drum.

**FOOT-POUND—** Unit of work equal to the force in pounds multiplied by the distance in feet through which it acts. When a 1-pound force is exerted through a 1-foot distance, 1 foot-pound of work is done.

**FOUR BY FOUR (4 x 4)—** A vehicle with four wheels or sets of wheels, all engine-driven.

**FREE FALL—** Lowering of the hook (with or without a load) without it being coupled to the power train with the lowering speed being controlled by a retarding device, such as a brake.

**FRONT-END LOADER—** A tractor loader with a bucket that operates entirely at the front end of the tractor.

**FROST—** Frozen soil.

**FROST LINE—** The greatest depth to which ground may be expected to freeze.

**GANTRY—** (1) An overhead structure that supports machines or operating parts. (2) An upward extension of the revolving frame of a crane that holds the boom line sheaves.

**GEAR—** A toothed wheel, cone, or bar.

**GOOSENECK—** An arched connection, usually between a tractor and a trailer.

**GRADE—** (1) Usually the elevation of a real or planned surface. (2) Also means surface slope.

**GRADER—** A machine with a centrally located blade that can be angled to cast to either side with an independent hoist control on each side.

**GRADE STAKE—** A stake indicating the amount of cut or fill required to bring the ground to a specified level.

**GRAVEL—** (1) Rock fragments from 2mm to 64 mm (.08 to 2.5 inches) in diameter. (2) A mixture of such gravel with sand, cobbles, boulders, and not over 15 percent fines.

**GRIEF STEM—** See "KELLY."

**GRIZZLY—** (1) A coarse screen used to remove oversize pieces from earth or blasted rock. (Maybe spelled "grizzlie.") (2) A gate or closure on a chute.

**GROUND PRESSURE—** The weight of a machine, divided by the area in square inches of the ground directly supporting it.

**GROUSER—** Projecting lug(s) attached to or integral with the ma chine track shoes to provide additional tract ion.

**GRUBBING—** Digging out roots.

**HAND LEVEL—** A sighting level that does not have a tripod, base, or telescope.

**HARDPAN—** (1) Hard, tight soil. (2) A hard layer that may form just below plow depth on cultivated land.

**HAUL DISTANCE—** (1) Is the distance measured along the center line or most direct practical route between the center of the mass of excavation and the center of mass of the fill as finally placed. (2) It is the distance the material is moved.

**HOLDING LINE—** The cable reeved from a hoist drum for holding a clamshell bucket or grapple suspended during dumping and lowering operations.

**HOOK, PINTLE—** A towing bracket, having a fixed lower part and a hinged upper one, which, when locked together, makes a round opening.

**HOPPER—** A storage bin or a funnel that is loaded from the top and discharges through a door or chute in the bottom.

**HORSEPOWER—** (1) A measurement of power that includes the factors of force and speed. (2) The force required to lift 33,000 pounds 1 foot in 1 minute.

**HORSEPOWER, DRAWBAR—** Horsepower available to move a tractor and its load after deducting losses in the power train.

**HOLDING LINE—** The hoist cable for a clamshell bucket.

**IDLER—** Large end roller of a track assembly at the opposite end from the drive sprocket; the roller is not power-driven.

**INJECTOR—** In a diesel engine, the unit that sprays fuel into the combustion chamber.

**JACK—** (1) A mechanical or hydraulic lifting device. (2) A hydraulic ram or cylinder.

**JACKKNIFE—** A tractor and trailer in such an angle that the tractor cannot move forward.

**JAW—** (1) In a clutch, one of a pair of toothed rings, the teeth of which face each other. (2) In a crusher, one of a pair of nearly flat faces separated by a wedge-shaped opening.

**JIB BOOM—** An extension piece, hinged to the upper end of a crane boom.

**KELLY—** A square or fluted pipe which is turned by a drill rotary table, while it is free to move up and down in the table. Also called a "GRIEF STEM."

**LAGGINGS—** Removable and interchangeable drum spool shells for changing the hoist drum diameter to provide variation in rope speeds and line pulls.

**LAY—** The direction of twist in wires and strands in wire rope.

**LAY, REGULAR—** A wire rope construction in which the direction of twist of the wires in the strands is opposite to that of the strands in the rope.

**LEVEL—** To make level or to cause to conform to a specified grade.

**LIFT—** A layer or course of paving material, applied to a base or a previous layer.

**LIP—** The cutting edge of a bucket. Applied chiefly to edges including tooth sockets.

**LOAD BINDER—** A lever that pulls two grab hooks together and holds them by locking over the center.

**LOADER, FRONT-END—** A tractor loader that both digs and dumps in front.

**LOAM—** A soft easily worked soil, containing sand, silt, and clay.

**LOOSE YARDS—** Measurement of soil or rock after it has been loosened by digging or blasting.

**LOW BED—** A machinery trailer with a low deck.

**LUFFING—** Operation of changing the boom angle in the vertical plane. See "BOOM HOIST."

**LUG DOWN—** To slow down an engine by increasing its load beyond its capacity.

**MASS DIAGRAM—** A plotting of cumulative cuts and fills, used for engineering computation of construction jobs.

**MINERAL DUST—** The portion of the fine aggregate passing the 0.075-mm (No. 200) sieve.

**MINERAL FILLER—** A finely divided mineral product, at least 70 percent or which will pass a 0.075-mm (No. 200) sieve. Pulverized limestone is the most commonly manufactured filler, although other stone dust, hydrated lime, portland cement, and certain natural deposits of finely divided mineral matter are also used.

**MISFIRE—** Failure of all or part of an explosive charge to go off.

**MOLDBOARD—** A curved surface of a plow, dozer blade, grader blade, or other dirt-moving implement that gives dirt moving over it a rotary, spiral, or twisting movement.

**MUCK—** Mud rich in humus.

**OIL—** Any fluid lubricant, but not water.

**OPEN-GRADED ASPHALT FRICTION COURSE—** A pavement surface course that consists of high-void, asphalt plant mix that permits rapid drainage of rainwater through the course and out the shoulder. The mixture is characterized by a large percentage of one-sized coarse aggregate. This course prevents tire hydroplaning and provides a skid-resistant pavement surface.

**OPTIMUM—** Best.

**OSCILLATION—** Independent movement through a limited range, usually on a hinge.

**OUTRIGGER—** An outward extension of a frame that is supported by a jack or block, used to increase stability.

**OVERBURDEN—** Soil or rock lying on top of a pay formation.

**PAN—** A carrying scraper.

**PAWL—** A tooth or set of teeth, designed to lock against a ratchet.

**PENETRATION—** The consistency of a bituminous material expressed as a distance in tenths of a millimeter (0.1mm) that a standard needle penetrates vertically a sample of the material under specified conditions of loading, time, and temperature.

**PERCENT OF GRADE—** Measurement of slope, expressed as the ratio of the change in vertical distance (rise) to the change in horizontal distance (run) multiplied by 100.

**PETCOCK—** A small drain valve.

**PILE CAP—** An adapter between the pile-driving unit and the upper end of the pile, used to center the pile under the pile-driving unit and to reduce damage to the upper end of the pile.

**PIONEERING—** The first working over of rough or overgrown areas.

**PIONEER ROAD—** A primitive, temporary road built along the route of a job to provide means for moving equipment and men.

**POND—** A small lake.

**PORT—** Left side of a ship or boat.

**POTHOLE—** A small steel-sided hole caused by traffic wear.

**POWER EXTRACTOR—** A unit hanging from the hoist line or block and attached to the upper end of the pile and containing within itself a member (ram) which is caused to reciprocate either by means of externally supplied air, steam, or hydraulic fluid under pressure, or by internal combustion within the unit. Upward pull from the hoisting machinery supplements the extraction forces.

**POWER PLANT—** The power plant (or plants) includes the prime power source (which may be an internal combustion engine or electric motor) and the power takeoff.

**POWER TAKEOFF—** A place in a transmission or engine to which a shaft can be so attached as to drive an outside mechanism. A power takeoff may be direct drive, friction clutch, fluid coupling,

hydrodynamic torque converter, hydrostatic, or an electric generator type.

**POWER TRAIN—** All moving parts connecting an engine with the point or points where work is accomplished.

**PRIME MOVER—** A tractor or other vehicle used to pull other machines.

**PROPELLER SHAFT—** Usually a main drive shaft fitted with universal joints.

**PSI or psi—** Pressure in pounds per square inch.

**PUMP, DIAPHRAGM—** A pump that moves water by the reciprocating motion of a diaphragm in a chamber having inlet and outlet check valves.

**PUSHER—** A tractor that pushes a scraper to help it pick up a load.

**RAKE BLADE—** A dozer blade or attachment made of spaced tines.

**RAKE, ROCK—** A heavy-duty rake blade.

**RANGE POLE—** A pole marked in alternate red and white bonds, 1 foot high.

**RED TOPS—** Grade stakes with red tops to indicate finish subgrade level, usually a 2-inch by 2-inch by 6-inch hub stake.

**REFUSAL—** The depth beyond which a pile cannot be driven.

**RIPRAP—** Heavy stones placed at the edge of the water to protect the soil from waves or current.

**RIPPER—** A towed machine, equipped with teeth, used primarily for loosening hard soil and soft rock.

**ROAD OIL—** A heavy petroleum oil, usually one of the slow-curing (sc) grades.

**ROCK—** The hard, firm, and stable parts of earth's crust.

**ROTARY TILLER—** A machine that loosens and mixes soil and vegetation by means of a high-speed rotor equipped with tines.

**RPM or rpm—** Revolutions per minute.

**RUBBLE DRAINS—** French drains.

**RULE OF THUMB—** A statement or formula that is not exactly correct but is accurate enough for use in rough figuring.

**SAND—** A loose soil, composed of particles between 1/16 mm and 2 mm in diameter.

**SCRAPER (Carrying scraper) (Pan)—** A digging, hauling, and grading machine, having a cutting edge, a carrying bowl, a movable front wall (apron), and a dumping or ejecting mechanism.

**SCREEN—** (1) A mesh or bar surface, used for separating pieces or particles of different sizes. (2) A filter.

**SEIZE—** To bind wire rope with soft wire to prevent it from raveling when it is cut.

**SEMITRAILER—** A towed vehicle whose front rests on the towing unit.

**SHEEPSFOOT—** A tamping roller with feet expanded at their outer tips.

**SHOE—** (1) A ground plate, forming a link of a track or bolted to a track link. (2) A support for a bulldozer blade or other digging edge to prevent cutting down. (3) A clean-up device following the buckets of a ditching machine.

**SIDECASTING—** Piling spoil alongside the excavation from which it is taken.

**SNATCH BLOCK—** A pulley in a case that can be easily fastened to lines or objects by means of a hook, ring, or shackle.

**SPILLWAY—** An overflow channel for a pond or a terrace channel.

**SPROCKET—** A gear that meshes with a chain or a crawler track.

**STOCKPILE—** Material dug and piled for future use.

**STONE—** Rock.

**SUPERCHARGER—** A blower that increases the intake pressure of an engine.

**SURGE BIN—** A compartment for temporary storage.

**SWELL (Growth)—** Increase of bulk in soil or rock when it is dug or blasted.

**SWING LOCK—** A swing lock is a mechanical engagement device, not dependent on friction, to hold the upper structure in one or more fixed positions with respect to the undercarriage. When provided, it must be constructed to prevent unintentional engagement or disengagement.

**SWING BRAKE (Dynamic)—** A dynamic swing brake is a device to stop, hold, or retard the rotating motion of the upper structure with respect to the undercarriage.

**SWITCHBACK—** A hair-pin curve.

**TAG LINE—** A line from a crane boom to a clamshell bucket that holds the bucket from spinning out of position.

**TAMP—** Pound or press soil to compact it.

**TERRACE—** A ridge, a ridge and hollow, or a flat bench built along a ground contour.

**TERRAIN—** Ground surface.

**TOE—** The projection of the bottom of a face beyond the top.

**TOOTH ADAPTER—** Main part of bucket or dipper to which a removable tooth is fastened.

**TOPOGRAPHIC MAP—** A map, indicating surface elevation and slope.

**TOPSOIL—** The topmost layer of soil, usually refers to soil containing humus that is capable of supporting good plant growth.

**TORQUE—** The twisting force exerted by or on a shaft (without reference to the speed of the shaft).

**TRACK—** A crawler track.

**TRACK CARRIER ROLLERS—** Rolling elements in/on a track frame that support and guide the upper track shoes or chain.

**TRACK SHOES—** The members of the track assembly that distribute the load to the supporting surface.

**TRACTION—** The total amount of driving push of a vehicle on a given surface.

**TRENCH—** A ditch.

**TRUNNION (Walking beam or bar)—** (1) An oscillating bar that allows changes in angle between a unit fastened to its center and another attached to both ends. (2) A heavy horizontal hinge.

**UNDERCARRIAGE—** The undercarriage is an assembly that supports the upper structure of the crane. It consists of an undercarriage frame, a swing bearing, or hook and load rollers, travel mechanism, and steering mechanism. The undercarriage may be either a crawler or wheeled type.

**VISCOSITY—** The resistance of a fluid to flow. A liquid with a high viscosity rating will resist flow more readily than will a liquid with a low viscosity. The Society of Automotive Engineers (S.A.E.) has developed a series of viscosity numbers for indicating viscosities of lubricating oils.

**VOIDS—** Empty spaces in a compacted mix, surrounded by asphalt-coated particles.

**VOLTS—** The electromotive force that will cause a current of 1 ampere to flow through a resistance of 1 ohm.

**WATERLOGGED—** Saturated with water. If conditions are too wet, you will be unable to work construction equipment.

**WATERSHED—** Area that drains into or pasta point.

**WATER TABLE—** The surface of underground, gravity-controlled water.

**WHEEL AND AXLE ARRANGEMENT—** The wheeled undercarriages.

**WINCH—** A drum that can be rotated so as to exert a strong pull while winding in a line.

**WINDROW—** A ridge of loose dirt.

**WING WALL—** A wall that guides a stream into a bridge opening or culvert barrel.

**WORKING CYCLE—** A complete set of operations. In an excavator, it usually includes loading, moving, dumping, and returning to the loading point.