Land-based Vibracoring and Vibracore Analysis: Tips, Tricks, and Traps

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By TODD A. THOMPSON, CHARLES S. MILLER, PAUL K. DOSS,
LINDA D. P. THOMPSON, AND STEVEN J. BAEDKE

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Land-Based Vibracoring and Vibracore Analysis: Tips, Tricks, and Traps

by Todd A. Thompson, Charles S. Miller, Paul K. Doss, Linda D. P. Thompson, and Steven J. Baedke

INTRODUCTION

Vibracorers have seen increasing use since they were introduced in the 1960's. Once a tool of research vessels and institutions along ocean coastlines (Pierce and Howard, 1969; Lanesky and others, 1979; Hoyt and Demarest, 1981; Finkelstein and Prins, 1981), small, portable vibracorers are now used on coastlines throughout the world and in many nonmarine settings (Smith, 1984). Their proliferation is a result of the vibracorers' low construction, field cost, and portability, the relatively undisturbed samples they obtain, and moderate depths to which they penetrate.

Most vibracorers are based on the design of Lanesky and others (1979) and Finkelstein and Prins (1981). Both designs use a concrete vibrator to set up an oscillation in a piece of aluminum irrigation pipe. The base of the core tube liquifies the underlying sediment, and the core tube sinks into the ground under its own or an added weight. All vibracoring systems require the water table to be at or near the ground surface. Consequently, most vibracorers are used at the margins of water bodies, and in or near wetlands along floodplains and coasts.

Personnel at the Indiana Geological Survey (IGS) have used a vibracorer since 1985. More than 200 cores have been collected in coastal, fluvial, and wetland sediments of northwestern Indiana. The cores constitute a valuable data set for describing the shallow subsurface geology of the area and determining the depositional history of Lake Michigan (Thompson, in press). Other cores of slurry-pond sediments have been collected in southwestern Indiana. There, the vibracorer was used to sample fine-grained coal refuse and to install shallow monitoring water wells.

This paper describes the IGS vibracorer and vibracoring techniques. Most vibracorers can collect an undisturbed sample of a variety of sediment types, including sand, silt, and peat, in a range of depths from 10 to 25 feet. Problems encountered with vibracorers (poor penetration and recovery) can be overcome. We present numerous tips and pitfalls in constructing a vibracorer and maximizing core recovery.

EQUIPMENT

MAJOR COMPONENTS

A vibracorer is very simple in design. It consists of a concrete vibrator, engine, a piece of aluminum irrigation pipe, and a tripod with come-alongs (Fig. 1). The vibracorer described in this paper follows the design of Finkelstein and Prins (1981). This design is not the lightest (e.g., Smith, 1987), but it is safe and efficient.

The concrete vibrator is the driver for the vibracorer (Fig. 2). It is connected to a flexible shaft that attaches to a gasoline-powered engine. The vibrator is mounted in a clamp that fixes the vibrator at a right angle to the core tube. The clamp is bolted to the vibrator with lock washers and cross-tightened nuts. It is, in turn, fastened to the core tube with bolts that screw into the flanges on the sides of the hinged clamp. The bolts can be fastened and loosened quickly using hand or power ratchets. Do not compromise on the construction of the clamp. Safety is paramount, and injury could result if the vibrator detaches from the clamp or if the clamp breaks free of the core tube.

Tip: Purchase the largest vibrator you can afford. The extra weight enhances penetration.

The flexible shaft consists of a rubber outer-casing that covers a tightly wound inner cable. The inner cable spins and

Figure 1. Vibracorer consisting of a concrete vibrator, 30-foot aluminum irrigation pipe, and 14-foot-high tripod.

Figure 2. Concrete vibrator and vibrator-head clamp (foreground), extrusion clamp, bar, and needed accessories.

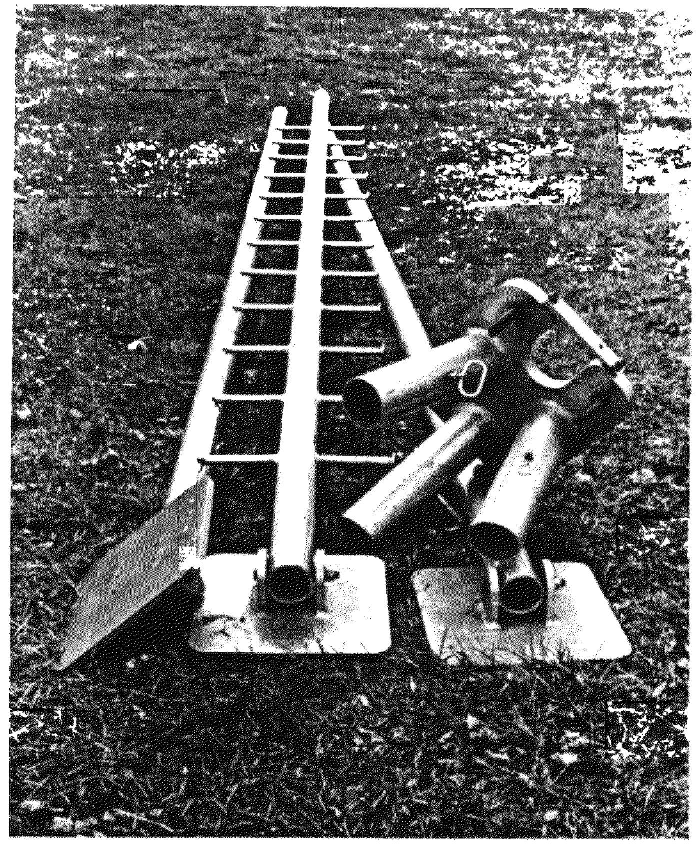

Figure 3. Tripod headplate and legs.

rotates an eccentric cam in the vibrator. This cable must be kept well lubricated. Through time, the outer casing may stretch and disconnect the cable from the vibrator. The casing will then need to be shortened by your dealer.

Tip: The flexible shaft can be purchased in 10- to 20-foot lengths. Purchase two lengths (you'll need a connector) to attach the vibrator near the top of a 30-foot core tube.

Trick: Always attach the flexible shaft to the engine before connecting the shaft to the vibrator. The reverse will cause the inner cable of the shaft to disconnect from the vibrator.

Trap: Because the vibrator is mounted at a right angle to the core tube, the flexible shaft bends sharply after exiting the vibrator. This bend will cause the inner cable of the flexible shaft to fray and eventually break. At no time should the flexible shaft be used to pull down on the core tube.

Aluminum irrigation pipe can be purchased from most businesses that deal in irrigation supplies or from farm co-ops. Prices vary considerably; get prices from several vendors. The pipe can be purchased in many lengths and diameters, but 3-inch-diameter pipe in 20- and 30-foot lengths is the most common. Wall thickness is commonly about 1/16 inch. The pipe must not be bent or dented; either can cause fluidization in the core, disrupting stratification and possibly hindering penetration and extraction.

Tip: Purchase 30 foot tubes; each tube can be used twice if the first core is less than or equal to 15 feet.

Tip: Smith (1987) shows that large-diameter tubes achieve the greatest penetration.

The tripod consists of three 15-foot-long legs and a headplate (Fig. 3). All parts are constructed of aluminum to minimize weight. The legs have hinged footpads that are 12 inches in diameter. At this diameter, there is little trouble with the pads sinking into the ground. The legs are inserted into supports on the headplate and fastened in place with pins. One of the legs has rungs for climbing to the headplate.

The headplate is a single plate of aluminum with a 5-inch by 5-inch rounded notch. The notch is used to guide the core tube while it is extracted. A latch can be placed across the notch to secure the core tube. Two eyebolts are bolted through the headplate from underneath. These eyebolts will be used to attach the come-alongs, and therefore they must be durable.

Tip: Trailer hitch pins (Fig. 3) work the best to secure the legs to the headplate, and they can be tied together to prevent their loss.

MINOR COMPONENTS

Several other pieces of equipment are needed to collect a core and extract it from the ground (fig. 2). These include:

1. A clamp to pull the core tube out of the ground. The clamp is similar in construction to the vibrator clamp but has two large eyelets welded to its sides. The eyelets are used to attach a pair of come-alongs.

2. A pair of come-alongs rated at 3,000 lbs each and containing at least 30 feet of cable. Greater cable lengths are preferred.

3. A clamp with a bar welded to it. The clamp is similar to the vibrator clamp and is used to rotate the core and to apply weight. (Note: this item is not necessary but can be very helpful).

4. A plumber's cap to place in the top of the core tube before extracting the core.

5. A toolbox containing ratchets, hacksaw and blades, half-round file, permanent markers, aluminum foil, duct tape, extra bolts and pins, a first-aid kit, and insect repellent. It is prudent to include several screwdrivers and pairs of pliers for onsite emergency repairs.

OPERATION

SELECTING A SITE

Site selection depends on coring needs. Care, however, should be taken to select a site where the water table is at or near the ground surface. These sites are commonly wetlands, beaches, or the banks of rivers. The vibracorer does not work well in gravels and clays. Do not try to core a gravely outwash plain, a clayey diamict, or a dry dune; your efforts will be in vain.

The ground at the core site should be relatively level (less than a 25% grade) and firm. There should be clearance through overhead vegetation for the core tube. Stay at least 10 feet away from the base of trees so roots will not stop or hamper the coring. Never core near power lines; the core tube is too unwieldy to be safe. A carefully planned site and workspace can keep any ecological disturbance to a minimum.

Tip: Place plywood sheets under the pads if you think the footpads will sink into the ground.

Trap: Although sites near roads and trails may be the easiest to occupy, the subsurface sediments may be disturbed, contain buried debris (trash, slag, etc.), or be criss-crossed with sewer, water, phone, and natural gas lines.

SITE PREPARATION

Assemble the tripod, and stand it upright. If the ground slopes, put the tripod leg with the rungs downslope; it is easier to jump off backwards than over the tripod if the tripod should tip over. Push out on the tripod legs to set them with their widest base. Unwind the come-alongs, and attach them to the eyelets on the tripod head.

Cut a downward-pointing "V" at the base of the core tube with a hacksaw. Sharpen the "V" on the inside and outside of the tube with a half-round file, but concentrate most of the sharpening on the outside of the core tube. It is important to have a sharp edge to cut through the surface root mat, clay layers, and any tree roots that you may encounter.

Stand the core tube upright so that it leans against the tripod and fits into the notch of the tripod head. Carry the vibrator to the top of the tripod and attach it to the core tube. Be sure that the flexible shaft is outside of the tripod legs. When the vibrator is secure, the person at the top of the tripod lifts as the person at the base walks the bottom of the core tube under the tripod so that the tube is upright. Some researchers attach the vibrator to the core tube while it is on the ground, secure the base, and walk it upright. We have bent several core tubes using this method and do not recommend it.

Tip: Cut the "V" at the bottom of the core tube as symmetrically as possible. Asymmetric edges cause the tube to bend slightly to one side as it penetrates the ground.

Tip: A simple core catcher of brass shimstock can be added to the base of the core tube (Reddering and Pinter, 1985).

Trap: Leaf litter and twigs can hamper coring. Clear the ground at the point where the core will be obtained.

Trick: Some researchers swear that spraying the core tube with WD-40 enhances penetration; however, you must consider the potential for future use of the site (e.g., ground water sampling) after using the WD-40.

CORING

Make sure the core tube is as close to vertical as possible (this is important when it comes time to extract the core). Start the engine at about half throttle. A high frequency wave will develop in the core tube, and the core tube will begin to enter the ground. If the tube does not immediately begin to penetrate the ground, have the person at the top of the tripod give the tube a couple of half turns to cut through the root mat. When the tube has passed through the root mat, throttle the engine until the highest rate of penetration is reached. The tube will accelerate and decelerate as it passes through different layers. If at any time the core tube suddenly stops, it is because it has encountered a root, thick clay layer, large pebble, or the water table. Rotate the tube to cut through the obstruction. If you are unsuccessful in passing the obstruction, turn off the engine immediately; continued vibration will disrupt the sedimentary structures. If coring stopped on the water table, carefully extract the core tube and reuse the same hole. Put another piece of tubing down the hole, attach the vibrator, and continue coring from the water table down.

As the core tube enters the ground, the rate of penetration slows. Throttle the engine to vary the position and frequency of the wave in the core tube. Ropes can be tied to the tube or someone can stand on the vibrator to apply additional weight. The tube will slow to a crawl after about 15 to 20 minutes. Have someone stand or even jump on the vibrator to pack the bottom sediments into the tube to limit the loss of sediment from the bottom of the tube during extraction. Shut off the engine, and remove the vibrator from the excess tubing above the ground. We feel that it is important to extract the core from the ground quickly before the sediment sets up too tightly around the core tube.

Tip: A prusik knot is the best way to attach a rope to the core tube. Someone can stand in the loop to apply weight (see Smith, 1984, for an illustration).

Trick: Pour water around the core tube if you are several feet above the water table. This is all you can do to lubricate the tube in the unsaturated zone.

Trap: Adding weight does not always increase penetration. Sometimes the rate of penetration will slow when someone stands on the vibrator.

Trap: Check the gas in the engine before you begin. It is very hard to reestablish downward movement of the core tube if vibration is interrupted.

EXTRACTING THE CORE

Cut off excess core tube at about 1 foot above ground level. Measure from the top of the core tube to the sediment surface inside and outside the tube (fig. 4). The difference is the amount of compaction. Use a marker to mark an orientation (N, S, onshore, alongshore, etc.) and the level of the ground surface. Fill the stick-up with water, and seal the top of the core tube with a plumbers cap. The water and cap will help counteract the suction created when the core is pulled from the ground.

Attach the extrusion clamp to the tube at the ground surface and fasten the come-alongs to the eyebolts of the clamp. Commonly two come-alongs are used to break the core free,

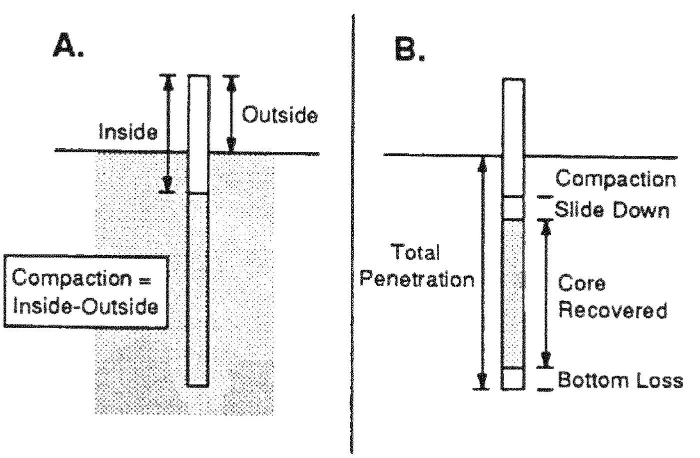

Figure 4. Schematic diagrams of vibracore tubes. A. Inside and outside measurements while the core is in the ground. B. Measurements after the core is extracted.

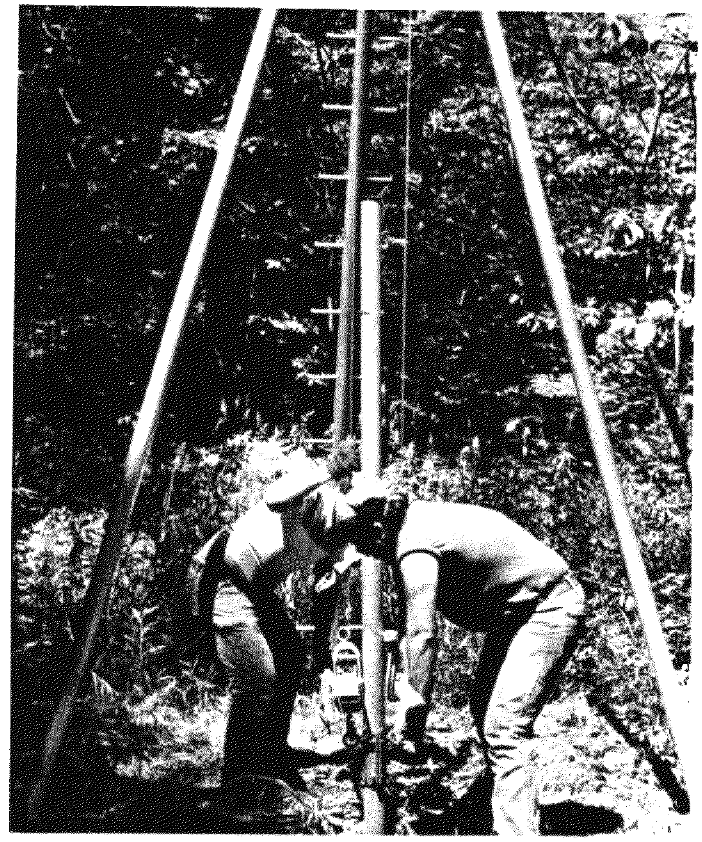

Figure 5. Extracting the core from the ground.

but after the core has loosened, only one come-along is needed (fig. 5). Jack the core out of the ground smoothly and quickly. You may have to reset the extrusion clamp and the come-alongs several times. As the top of the core passes the headplate, insert the tube into the notch. If you close the notch, the core tube cannot tip over. Speed is important to keep sediment from falling out of the base of the core tube. Do not reset when the base is just a couple of feet below the surface. Grab the core and pull it out of the ground. Be careful that the bottom of the core tube does not kick away from the tripod.

Slumping can occur while the core stands upright, so tip the core over immediately. Have someone secure the base of the core while it is walked down to the ground.

At this time, the tripod can be disassembled or another prepared core tube can be inserted in the hole. An additional 3 to 5 feet can be obtained by vibracoring down the same hole twice.

Tip: Buy a come-along that has more than 30 feet of cable and a pulley. The pulley can be attached to the top of the headplate, the cable to the core, and the come-along to a footplate of the tripod. This arrangement permits a full 15-foot pull on the core.

Trick: If the core will not break free, reattach the vibrator, and gently vibrate the core as pull from the come-alongs is applied. This is a last ditch effort; vibrate only as long as is necessary to break free.

Trap: Many researchers let the core fall to the ground. The core will bend if it lands on a fallen limb or irregularity in the ground surface, possibly disturbing the structures inside. Moreover, a bent core tube is difficult to cut in half.

Trap: Do not leave the vibrator on the core tube. It will make the core too top heavy (an unsafe condition) and hard to handle as it is pulled from the ground.

Trap: Always keep a close eye on the condition of the come-along cables. If they become frayed, they may break and injury could occur.

TRANSPORTATION

After the core is safely on the ground, remove the plumbers cap and gently drain the water so that the upper sediments are not disturbed. Transfer the orientation arrow to the middle of the core tube, and measure inside the tube to the sediment. Record the difference from your first inside measurement as the amount of core that slid down the tube as it was extracted (fig. 4). Cut the core tube at the top of the sediment. Place a folded sheet of aluminum foil over the end of the core and tape it in place. Measure the bottom loss from the bottom of the core, cut off the excess, and seal it shut like the top of the core. At this time, thoroughly mark the core and take notes.

Transporting the core requires nothing more than toting it to a vehicle. If the water was drained from the core and the ends are securely capped, there is little chance that bouncing and vibration during transport will disturb the core.

Tip: Plastic caps for cylindrical map-cases can be used instead of aluminum foil to cap the end of the core tube. They can even be left on the core when it is split.

Trick: The sum of the compaction, slide down, bottom loss, and core recovered is the total depth of penetration (fig. 4). This number may be important if a series of cores always stop at the same horizon. For example, vibracores commonly stop on the gravely plunge-point at the base of foreshore deposits in the Indiana Dunes. We have only occasionally collected this gravel. The total penetration yields the altitude of the plunge point, which is the closest estimate that can be obtained of actual lake level when the beach ridge formed.

Trap: A core weighs about 10 lbs/ft. This is an important consideration when selecting your field crew.

CORE ANALYSIS

SPLITTING

It is possible to vibrate the sediment from the core tube (Smith, 1984). This technique allows the core tube to be reused. Most researchers, however, cut the core tube.

Several methods are possible. We use the splitting table described by Meisburger and others (1980) and a circular saw (fig. 6). Place the core in the trough of the table with the proper orientation, and run a circular saw with a tungsten-carbide-tipped blade and a guide along one side of the core. Control the depth of cut so that the blade just cuts through the core tube. Rotate the core tube 180° and cut again. Lift the core from the table. Be careful when lifting the sawed core from the trough; it may split, spilling its contents. Tape can be used to secure the halves of the tube.

After the core is removed from the splitting table, place it on a flat surface, and pull a thin wire through the core along the cuts. A knife may be needed where roots are encountered. Do not drag a root or pebble along with the wire; it will damage the core. Roll the core so the cuts are vertical, and gently pull the two halves apart. A knife or trowel may be needed to split sticky clay and rooted layers. Clean the two halves by scraping and slicing with a trowel. Make sure you follow stratification. Let the cores sit overnight to dry. This will enhance the stratification because coarser laminae will dry and become lighter in color.

Tip: Make the trough of the splitting table slightly wider than the core tube. This extra space will accommodate the spreading of the tube that takes place after the first cut.

Tip: Smear paraffin along the cut line before cutting to keep the circular-saw blade sharp.

Trap: Pulling the wire through the core can artificially produce grading in laminae. Be sure to clean the core with a trowel before examining the core.

Figure 6. Core splitting table and circular saw.

PROCESSING

We could not begin to cover the many methods of describing core and logging data (cf. Compton, 1985). We can, however, make some suggestions:

1. Use a description form. Forms force the describer to make observations.
2. Make sure grain size, rounding, sorting, and color charts are handy. A binocular magnifying scope is equally useful.
3. Oversample. It is easier to discard unneeded samples than to collect a new core. This is especially true for organic material that will dry or rot.
4. Take your time.
5. Reposition lights to provide a new perspective.
6. Take photographs.
7. Make peels to enhance stratification (artificial outcrop) and preserve the core.
8. Save half of the core for future reference.

Tip: Thin laminae can be sampled by gluing glass slides to an adjustable crescent-wrench. The wrench can be opened to the width of the laminae and the glass slides inserted into the core and then extracted with the sample between the slides (Leatherman and Williams, 1978).

STORAGE CONSIDERATIONS

The cores will dry and eventually fall apart if they are not properly stored. Even with proper storage, many cores will not last to the end of a project. A peel of the core is the best way to preserve it. There are many useful glues and backing materials for making peels. We prefer latex as a glue with masonite (fiberboard) as a backing. Our reasons for using latex are:

1. Latex can be purchased, or at least ordered, at almost all craft stores.
2. It is water soluble, and its viscosity can be easily controlled by adding water.
3. It is almost clear when it dries.
4. If it is spilled, it can be left to dry and rolled off the table like rubber cement.
5. The peel that is produced is flexible and can be transported without grains and clasts detaching.

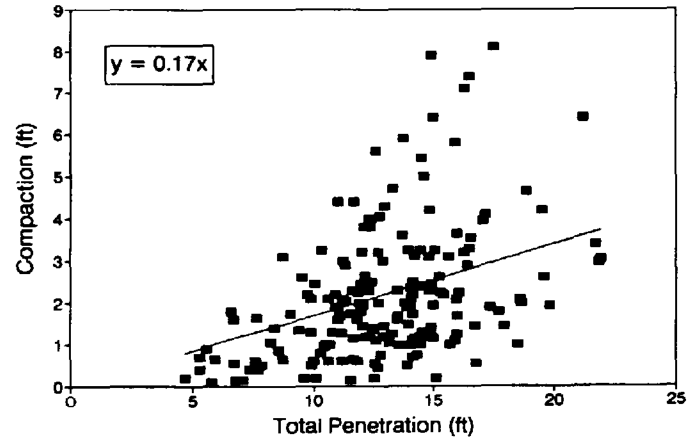

Figure 7. Compaction versus total penetration for 170 cores collected in northwestern Indiana.

MAKING A PEEL

Clean the surface of the core, and make sure it is level. Using a spatula, smear the latex across the core. The correct viscosity of the latex depends on your needs, and you will have to experiment to find the right consistency for the material at hand. In general, the thinner the latex, the thicker the peel. Do not try to smear the latex on a dry core; it will only roll up and disrupt stratification (see trick below). Lay a piece of masonite on the core after the latex has dried a few minutes, and flip the core and masonite over. Try not to let the masonite and core slide past one another. Be sure to transfer depths, core numbers, and orientations to the masonite. Let the core sit to dry on the masonite for 2 1/2 days.

Flip the core and masonite back over so that the masonite is on top. Tap the top of the masonite to free the peel. You may need to cut the peel free from peat and rooted horizons and where it has adhered to the core tube. The peel will still be wet (white). Let it sit overnight, and the last of the latex will dry. Use a brush to remove excess sediment. If there is any doubt that the latex is not set, do not brush the peel.

Tip: Do not run the latex over the edges of the aluminum when you are smearing it on the core, it will cause the aluminum to stick to the masonite when the peel is removed.

Tip: Peels can be stored easily by hanging them upright.

Trick: A spray bottle and a solution of very dilute latex with water can be used to put a crust on a core that has dried completely. Spray the core a couple times, letting it dry between applications. A thin crust will form that can be smeared with latex.

Trick: Brush along laminae to enhance stratification.

Trap: Pouring the latex on the core will cause a ridge in the core along the pouring line.

Trap: Let the peel dry thoroughly before brushing. You can create artificial laminae if the latex is still damp.

STORING THE CORE

After the peel is made, the core can be wrapped in plastic wrap or inserted into a plastic sleeve (Hoyt and Demarest, 1981). Whatever the method, the core will probably dry after a couple of years. Racks can be constructed to hold the cores.

COMMENTS ON COMPACTION

A vibracore commonly collects a relatively undisturbed sample to a depth of 10 to 25 feet. This core may contain some disturbance and almost always has some compaction (fig. 7). We feel that most of this compaction occurs in the upper part of the core and areas of disturbance within the core. We do not want to rule out, however, that the core tube may penetrate the ground without any sediment entering the core tube (rodding).

Compaction in coastal and paralic deposits of northwestern Indiana is most prevalent in eolian sand along the landward margin of beach ridges and in the center of parabolic dunes. In these areas, we have obtained compactions greater than 50%. The compactions are consistent with the mode of sediment accumulation for these areas. Both receive sand by grainfall and grainflow, which are the most poorly packed of eolian stratification types (Hunter, 1978).

We have also found large compactions in wetlands where the surficial peat is fibrous but the underlying peats are well decomposed. Hand auguring and probing with a rod indicate that the peat column can compact more than 60%.

SUMMARY

Vibracoring is becoming the tool-of-the-trade for many geologists studying unconsolidated deposits. It is especially useful for hydrologists because it provides an undisturbed sample of the shallow surficial aquifer and provides a hole for installing a monitoring well. Most importantly, vibracoring produces a core in areas inaccessible to truck-mounted rigs and at a fraction of their cost.

This report was written to summarize the steps in constructing and operating a vibracorer. We hope that the suggestions will permit the reader to vibracore without the trial-and-error encountered in using a new coring system. We welcome comments on the techniques and would like to hear of your own tips, tricks, and traps.

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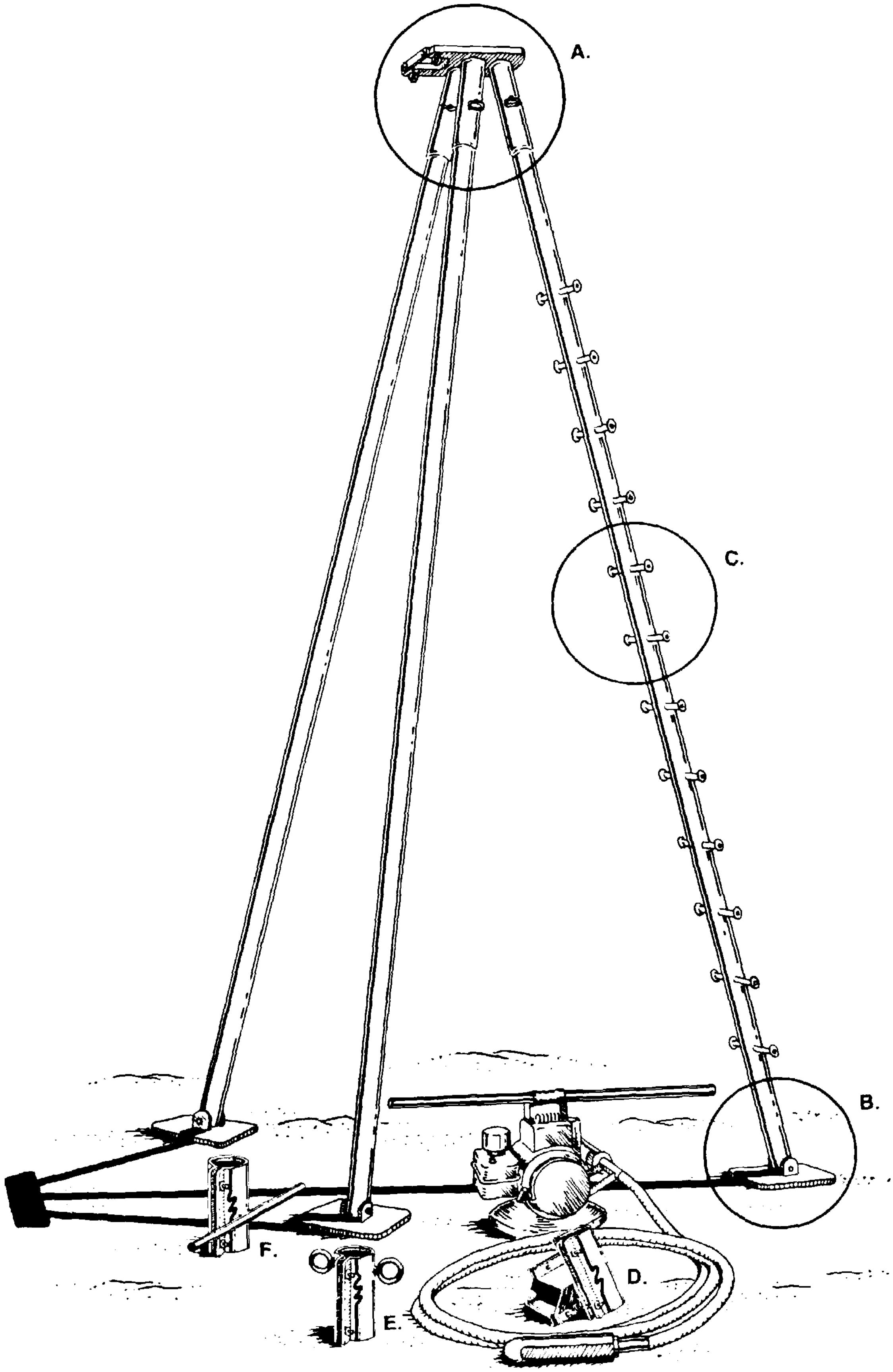
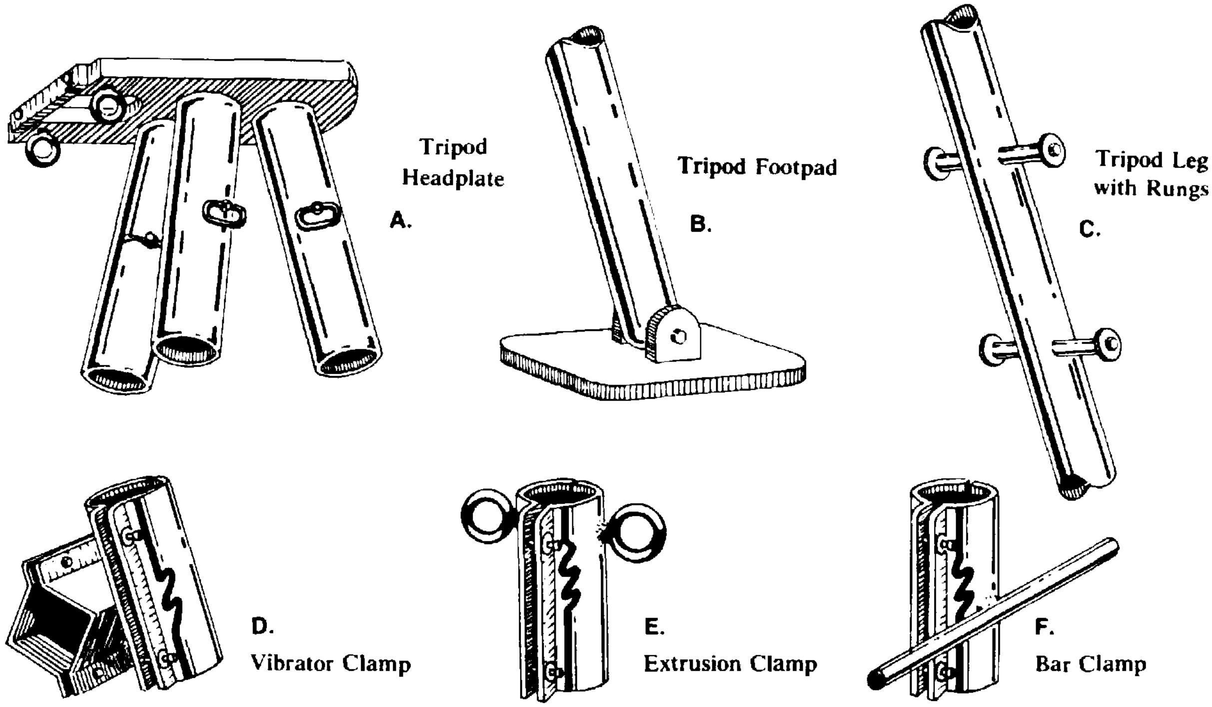


Figure A1. Schematic diagram of the vibracorer.



Hardware specifications (modified from Finkelstein and Prins, 1981).

VIBRATOR				
Engine -(1) Gasoline powered, 5-hp.				
Vibrator -(1)	length	width	height	
	14 in	2.25 in	2.25 in	
Flexible shaft - (1) 20 ft, (1) 13 ft				
TRIPOD (aluminum alloy 6061)				
Headplate -(1)	length	width	thickness	
	15 in	12 in	1 in	
Leg Supports -(3) Schedule 40 aluminum pipe (3 in)	length	wall thickness	o.d.	i.d.
	1.0 ft	0.216 in	3.5 in	3.068 in
Legs -(3) Schedule 40 aluminum pipe (2.5 in)	length	wall thickness	o.d.	i.d.
	15.0 ft	0.203 in	2.875 in	2.469 in
Ladder Rungs - (12) Solid round	length	diameter		
	1.5 ft	0.75 in		
Foot Pads -(3)	length	width	thickness	
	1.0 ft	1.0 ft	0.5 in	
Foot Pad Pivots - (6)	length	width	thickness	
	4.0 in	3.25 in	0.5 in	
EXTRUSION CLAMP				
Clamp to Core Tube - (1) Schedule 40 iron pipe	length	wall thickness	o.d.	i.d.
	8.0 in	0.216 in	3.5 in	3.068 in
Eyebolts - (2) 2.5 in				
VIBRATOR CLAMP				
Clamp to Core Tube - (1) Schedule 40 iron pipe	length	wall thickness	o.d.	i.d.
	8 in	0.216 in	3.5 in	3.068 in
Clamp to Vibrator - (1) Angle iron (2.5 x 2.5 x 0.25)	length			
	8 in			
BOX CLAMP				
Clamp to Core Tube - (1) Schedule 40 iron pipe	length	wall thickness	o.d.	i.d.
	8 in	0.216 in	3.5 in	3.068 in
Box - (1) 1-in pipe	length			
	18 in			

Figure A2. Schematic diagrams and hardware specifications for major parts needed for vibracoring.

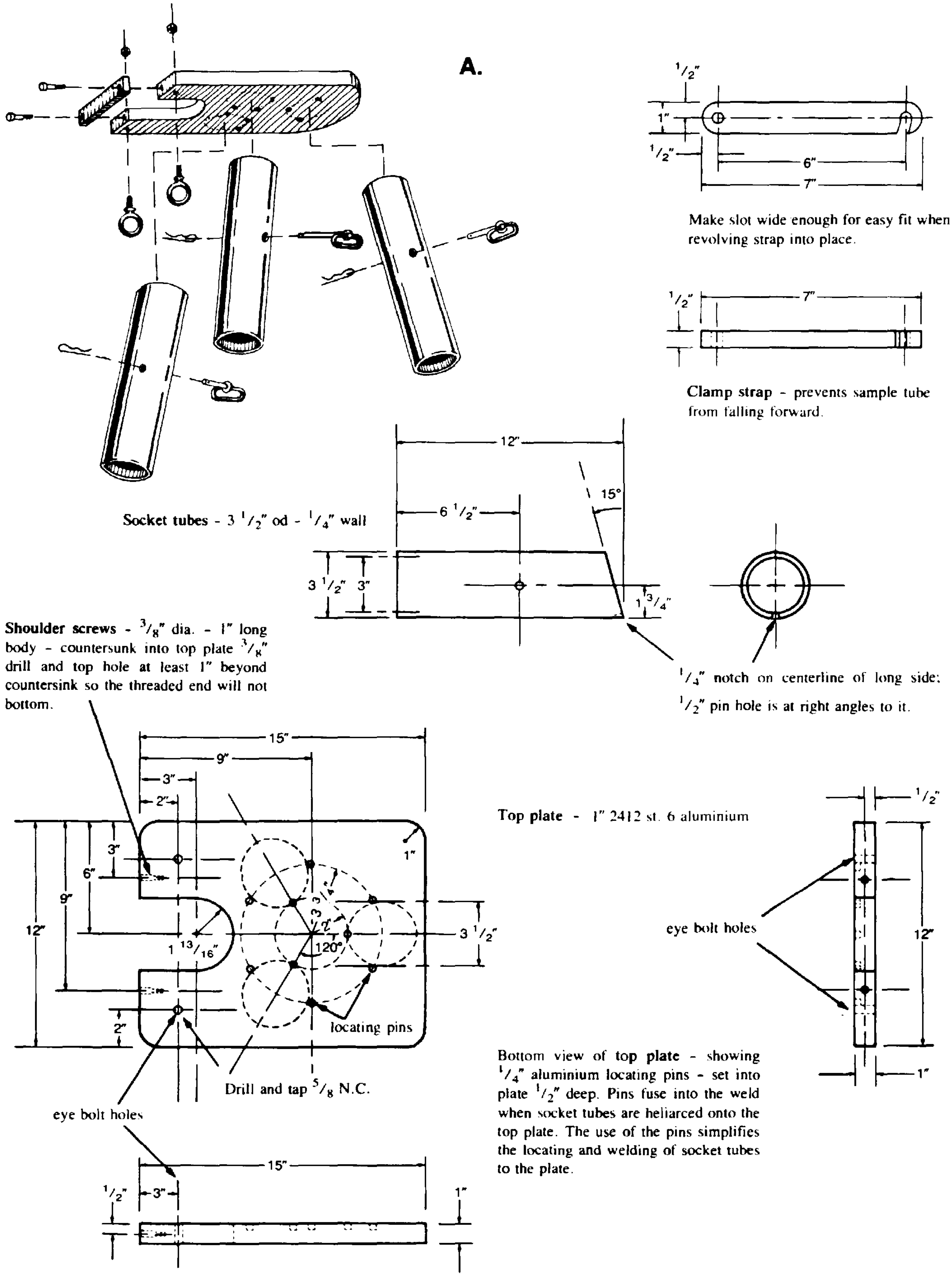


Figure A3. Construction plans for tripod headplate.

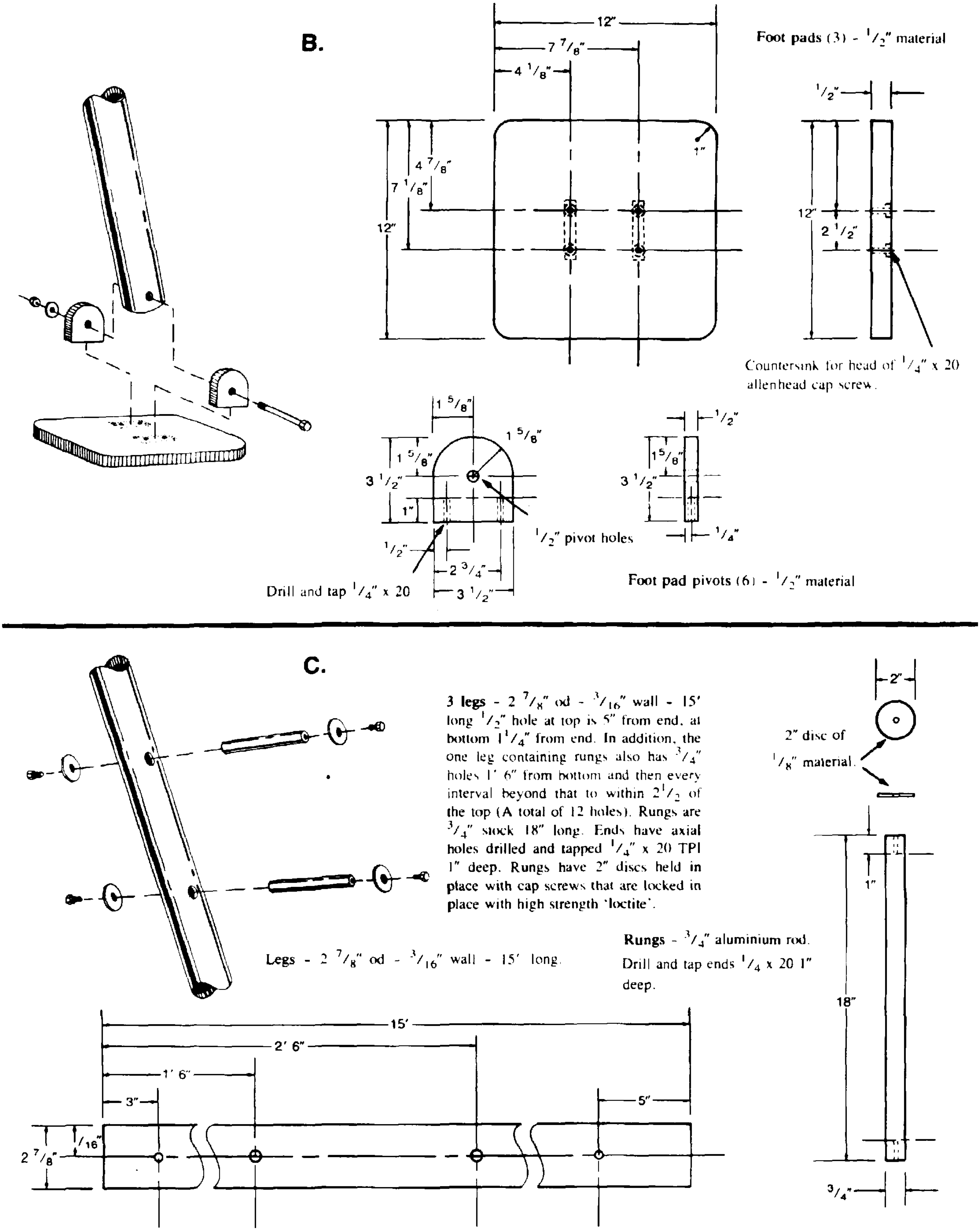


Figure A4. Construction plans for tripod footplate and tripod leg with rungs.

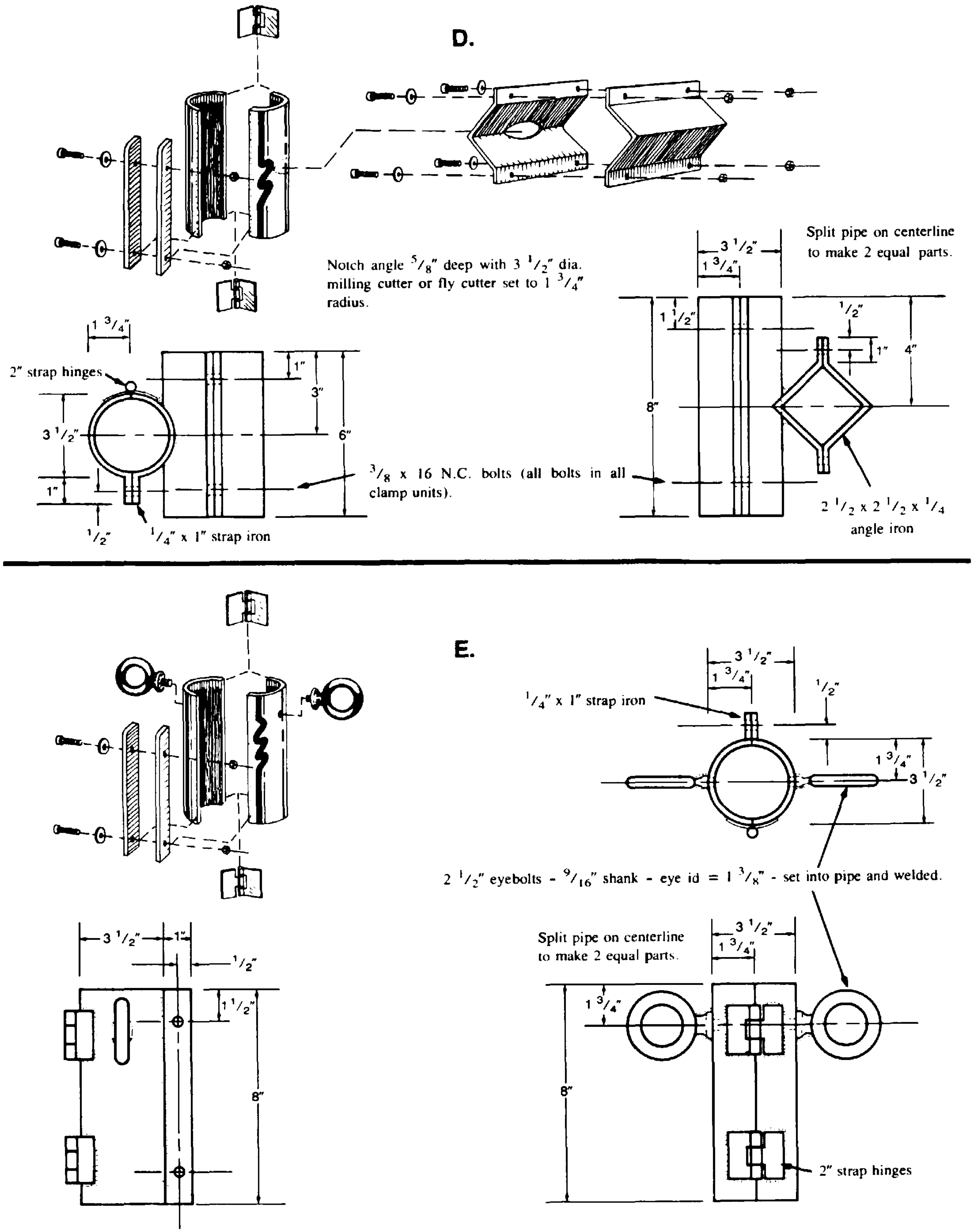


Figure A5. Construction plans for extrusion clamp and vibrator clamp.

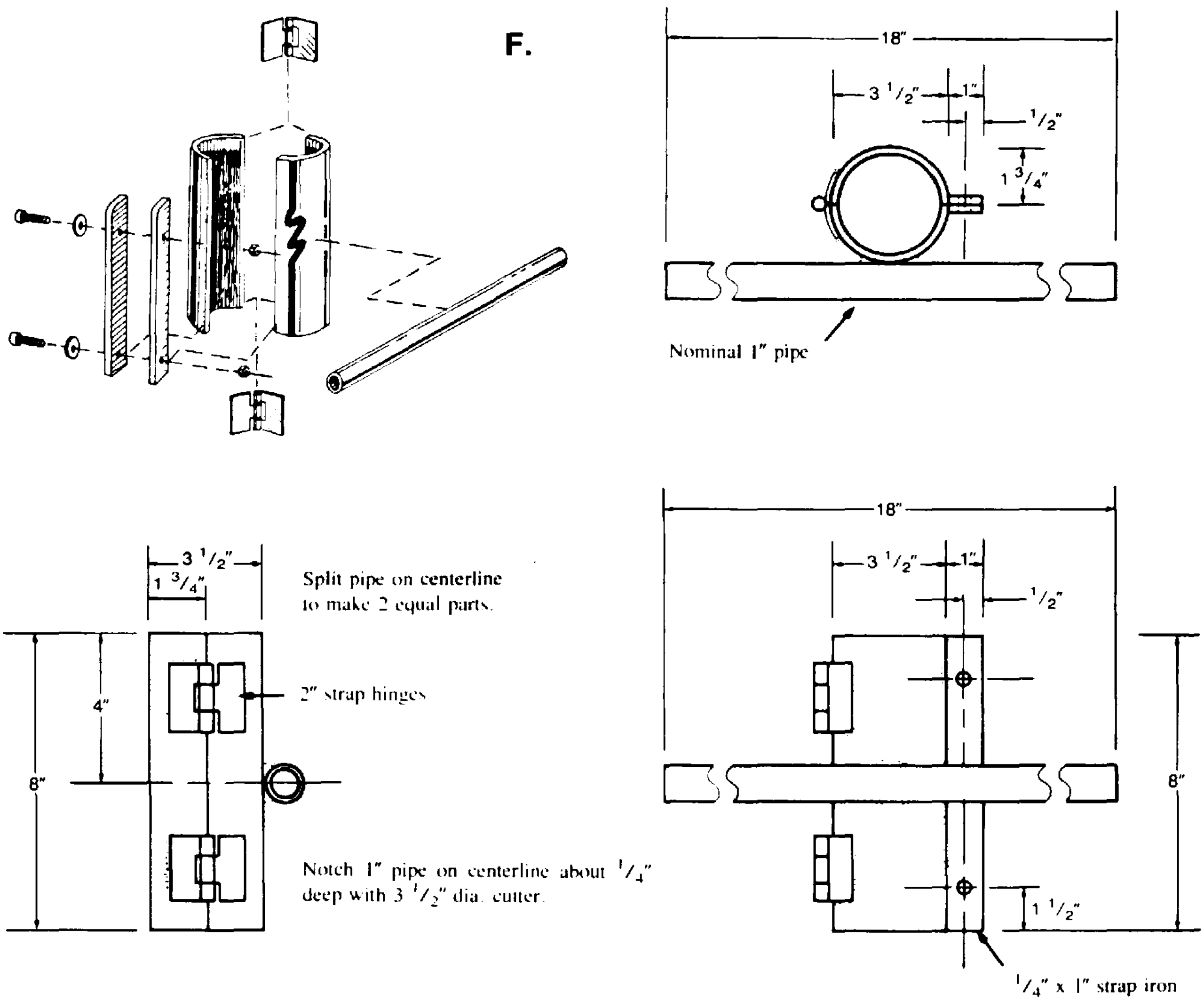


Figure A6. Construction plans for bar clamp.