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Specifications for Structural Range Improvements

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Abstract

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Construction specifications and illustrations are provided for several types of barbed wire and pole fences, gates, cattle guards, stiles, spring developments, water troughs, stock ponds, trick tanks, and livestock access trails.

Keywords: Range management, structural improvements, fences, gates, cattle guards, water developments, livestock control.

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Introduction

Management of public and private ranges in the Northwest relies on range improvements. Structural improvements (for example, fences, water developments, access trails) are necessary for grazing management systems and must be maintained for the systems to operate effectively. The implementation of new grazing systems typically requires construction of new improvements. Structural improvements are also effective in the management and protection of sensitive riparian areas and tree plantations. Improved range conditions can depend on the installation and maintenance of improvements. A long-time goal of range management is uniform distribution of cattle. Water developments, stock access trails, and fences have effectively been used to help achieve this goal.

Federal handbooks and a few published technical notes provide guides for construction and maintenance of structural range improvements. Federal agencies have developed range improvement handbooks, which are supplemented by the local management units as circumstances warrant. The USDA Forest Service Missoula Technical and Development Center (1987 and 1988) has published two handbooks on constructing fences and livestock handling facilities. One more handbook is being prepared on water developments. The USDA Soil Conservation Service (1982) also has a fine publication on ponds. Vallentine's (1971) book, "Range Development and Improvements," provides a good introduction to the types of improvements available. References for the state-of-the-art specifications of improvements are published in many sources. Generally, several sources have to be reviewed to determine the best method to develop a particular site.

Our objective is to provide the best information from the many sources for structural range improvements. The information contained in this handbook was developed through the Oregon Range Evaluation Project (EVAL) (Sanderson and others 1988) and has been applied to the practices implemented by that project.

The EVAL Project was an 11-year study funded through the USDA Forest Service with headquarters in John Day, Oregon. The study was begun in 1976 as an interagency effort to implement various range management intensities on private and Federal rangeland. The approach was to develop coordinated resource management plans that included private land and associated Federal lands. Each plan set a priority for improvement opportunities and selected, in cooperation with owners and managers, the range improvements that met goals and objectives consistent with resource conservation and management philosophy.

Through EVAL, coordinated resource management plans were developed for 21 ranches and 18 associated allotments. These plans included the selection and scheduling of more than 1,000 range improvements for implementation during a short period. The objective was to apply "state-of-the-art" range management techniques and to monitor a variety of outputs from the sites. An immediate task facing the EVAL management team was to assemble specifications on the state-of-the-art practices. An interagency group was assembled with members from the Soil Conservation Service and the Forest Service (U.S. Department of Agriculture), the Bureau of Land Management (U.S. Department of the Interior), and private ranchers. Beginning with existing guides for improvements and handbooks, the group extracted

the most applicable practices under the conditions of the EVAL program. These specifications represent the results that evolved from this interagency effort, including modifications suggested by ranchers and contractors who implemented and maintained these improvements.

Organization of this Handbook

This handbook is divided into major sections by improvement type. Within each type, further subdivisions are provided to separate types according to specifications. Included with each practice specification is a narrative describing when the practice is appropriate, the equipment needed for construction, materials used, and specifications with drawings and diagrams.

The handbook is intended to be used by ranchers, contractors, resource managers, and anyone who plans, installs, and maintains structural improvements. It can be used as a guide during the construction phase of a project, a decision tool during planning, and a source of specifications when contracts are drafted. It has been specifically designed to be copied as needed for inclusion in contract specifications or project design and guides.

Improvement Specifications

Fences

Range management grazing systems have become dependent on fencing. Herding, as the primary means of livestock control, has essentially been replaced by extensive fencing patterns. Reasons for the shift toward fencing are many. Vallentine (1971) provides 19 advantages of fencing in livestock management and control. The primary reason for fencing is to keep livestock in or out of a specific area. In either event, the fence specifications are generally the same.

Specifications and descriptions are provided for the following types of fences including four barbed-wire fences:

Barbed-wire fences:

- Standard post and wire

- Let-down

- Suspension

- Rock-jack and "figure-4"

Woven-wire fence

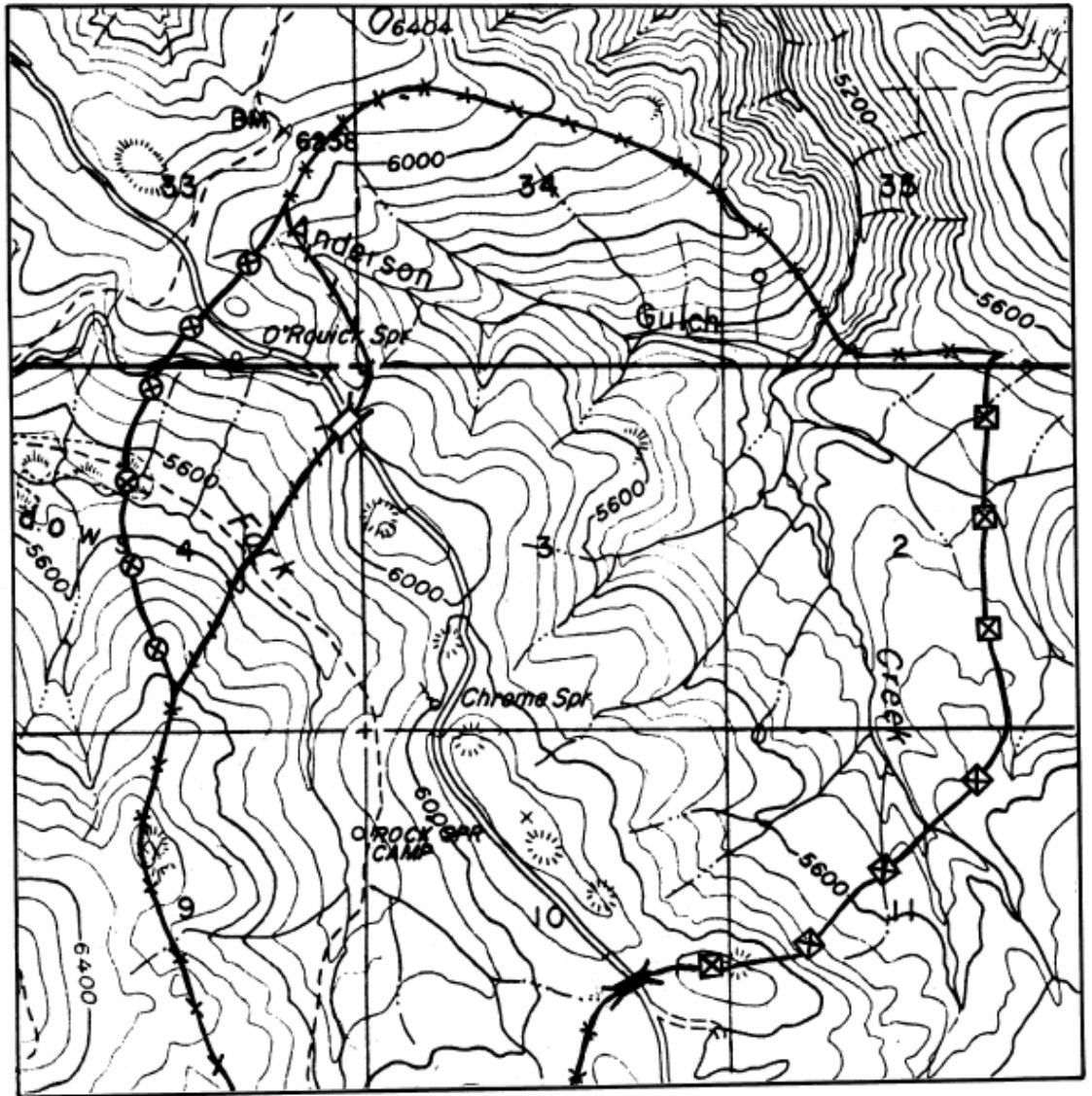
Electric fence

Buck-and-pole fence

Log-worm fence

Block-and-pole fence

Each fence has characteristics making it desirable for different circumstances. During the planning phase of fence design, consideration should be given to costs, aesthetics, kind of livestock, livestock pressure, environment, availability of materials, and accessibility. The location of the fence is determined during this phase of the project. The location should be marked, taking into consideration property boundaries, vegetation types, wildlife migration routes, available water sources, slope, snowdrift areas, stream crossings, areas of heavy livestock use, gate locations, and road crossings. Before the fence is constructed, the fenceline should be flagged to mark the location of the fence and to mark all special structures (fig. 1).



Legend:	Existing fence	
	Fence removal	
	Fence construction	
	Fence reconstruction	
	Existing cattle guard	
	Cattle-guard construction	

Figure 1—Example of a project map showing approximate location of fence removal, new construction, relocation, and existing and new cattle guards.

Guidelines—The construction phase of fencing cannot be precisely specified for all situations, but a general description of the steps required can be provided. The type and standard of fence to be used in each circumstance need to be coordinated with animal control needs and multiple-use considerations.

Planning fence line location:

1. Survey the boundary where fences occur on property boundaries and construct the fence on the boundary.
2. Locate fences as near to a right angle to the slope as possible to reduce possible damage from logging or snow.
3. Layout the fence as straight as possible between turning points.
4. Locate the fence on ridgetops as much as possible and avoid areas just below the ridge and draw bottoms.
5. Locate fences away from the edges of highly desirable vegetation types, such as meadows, to reduce excessive pressure on the fence by livestock.
6. Provide water gaps across all streams and draws subject to high runoff in the spring.
7. Locate cattle guards at safe sight distance from road junctions, curves, and other visual obstructions.
8. Locate gates at cattle guards; secondary road crossings; major trails; major topographic changes such as ridges, saddles, and draws; and fence junctions with a maximum distance of 0.5 mile between gates.
9. Construct fences with corners more than 90° because corners with acute angles can become "cattle traps."

Preconstruction location of fenceline and special structures:

1. Mark the proposed fenceline with flagging at intervals so that at least two flagged locations are always visible.
2. Mark the location of special structures, such as water gaps, cattle guards, stretch points, corners, and so forth.
3. Mark the location of any change in fence construction specification, such as from three-strand barbed-wire construction to four-strand.

Construction procedures:

1. Set corner posts, gateposts, and stretch posts.
2. Layout a single line between set posts (in item 1) to accurately locate fence line.
3. Clear the right-of-way to permit construction and maintenance. Save trees larger than 8 inches d.b.h. (diameter at breast height) and trees larger than 6 inches d.b.h. in the fenceline that may be used in lieu of fenceposts. Complete brush and debris disposal to meet fire protection standards. Consider aesthetics and wildlife needs.

4. Set fenceposts and layout wire on the side of the post that will receive the greatest pressure from livestock or drifted snow.
5. Stretch and staple or clip fence wire, one strand at a time, between brace points. Stretch each wire uniformly with the proper tools. Do not stretch wire with a vehicle.

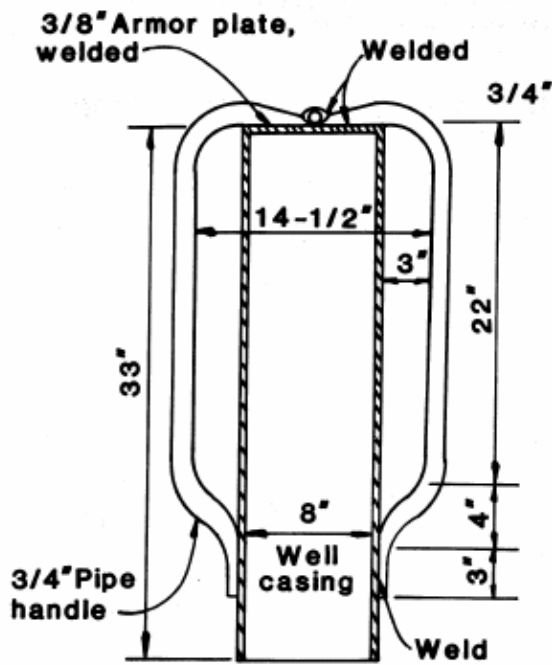
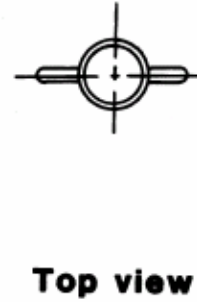
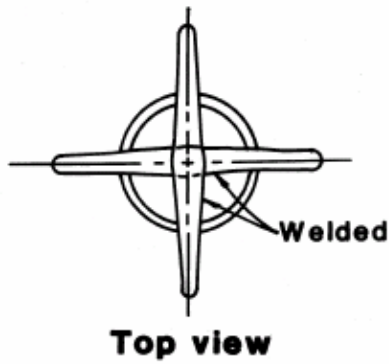
Maintenance of fences—Fences must be maintained to achieve the intended management objective. The objective of maintenance is to keep the fences at, or as near as possible to, the standard to which they were constructed. Annual maintenance consists of thoroughly checking the fenceline, replacing pulled staples or clips, resetting or replacing damaged posts, repairing breaks, and adjusting wire tension to bring the fence to as near the original construction standard as possible. Snow damage and fallen trees are the major problems needing attention each year, but damage from wildlife and hunters are also common. Necessary tools generally include smooth-soft wire, fencing pliers, fence tighteners, hammer, saw, clips for steel fenceposts, and staples.

Special equipment—Equipment manufacturers have realized the large market for fencing equipment and have introduced special machinery to aid in the construction of fences. New equipment is frequently made available, so discussion of the subject is somewhat dated. This section includes the basic equipment being used in the main line of fence construction. We have not tried to include all special areas, but those of primary importance in the construction of fences in northeastern Oregon are included.

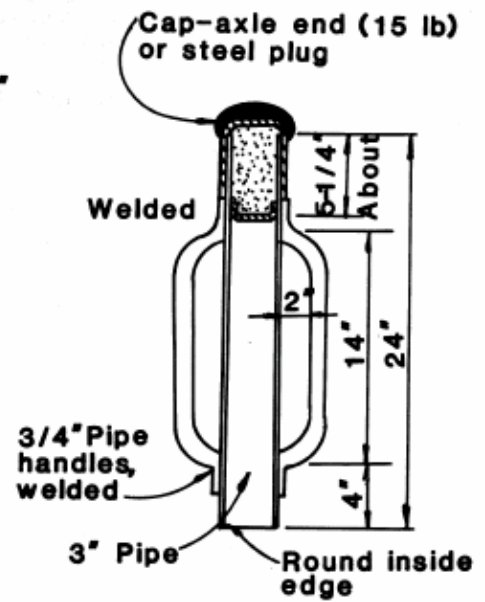
Post-hole augers—Power post-hole augers are of two general types. The tractor-mounted type either rigidly attached to the tractor or is free swinging. The free-swinging type is preferred because it drills vertical holes regardless of slope. The other type is an auger attachment for the two-person chain-saw engine. Neither power auger is well suited for use in rocky ground. All power augers can be dangerous and should be handled with care. Operators should be well trained. Power augers are available from equipment dealers and equipment rental shops. The different types should be examined and information about their suitability for the intended use should be obtained before they are purchased or used.

Post drivers—The use of hammers or mauls for driving posts is slow and dangerous and should be discouraged. Several mechanical post drivers are available for mounting on tractors, trailers, or skids. Usually, two or three people are required to operate them. When ground conditions are favorable, as many as 100 posts an hour can be set with these machines. One- or two-person hand-operated steel or wood post drivers are also available commercially, or they can be constructed in a local shop (fig. 2).

Wire stretchers—Several types of hand-operated wire stretchers are on the market. Some of the newer cable-and-ratchet types are preferred to the rope-and-pulley stretchers because they are much safer and more convenient. Commercial fence-building machines may also be used to stretch wire; but vehicles and other machines are not safe because the correct tension on the wire cannot be judged and the wire may break.



**Section
Wooden post driver**



**Section
Steel post driver**

Figure 2—Hand-operated fencepost driving tools for wooden and steel fenceposts.

Wire-splicing tool—An effective tool for splicing fence wire has been developed. This tool eliminates the need for special twists and bends to splice broken wire and can be used to repair rusted wire, which generally breaks when it is bent or twisted. The tool crimps a special sleeve over the two wire ends to be spliced. Nicopress¹ sleeves are available for various types of wire, gauge, and tensile strength (table 1).

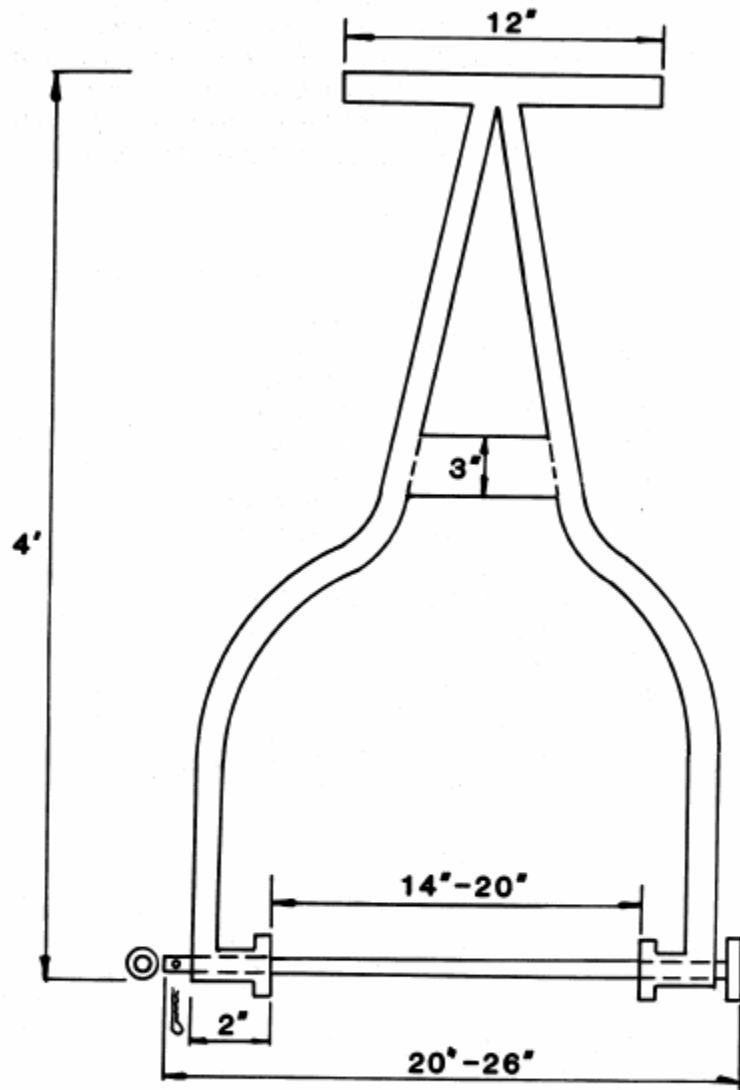
Barbed-wire stringer—Barbed wire can be unrolled mechanically or by hand. If done by hand, safety devices such as shields and leather gloves are necessary. One hand method uses a homemade frame that is pulled by one or two people and rolls the wire out on the ground (fig. 3). This method is much easier and safer than carrying a spool of barbed wire and can be constructed for the size of roll being used. If done mechanically, care should be taken to use only machines specifically designed for safety.

Tamping tools—For adequate support of the fence, the soil around wooden posts must be firmed by tamping. Two satisfactory tamping tools are a steel crowbar with a tamping head and a 1-inch galvanized pipe with a T-joint head.

¹ The use of trade names in this publication is for the information and convenience of the reader. Such does not constitute an official endorsement or approval by the U.S. Department of Agriculture of any product.

Table 1—Nicopress sleeve tensile-holding strength

Stock number	Wire size	Average strength of wire	Tested strength of Nicopress splices
	<i>Gauge</i>	----- <i>Pounds</i> -----	
FW-1-2	14-1/2	475	528
	15-1/2	370	452
FW-2-3	12-1/2	743	777
FW-3-4	10	1,326	1,313
	11	1,100	1,087
	14 barbed	628	683
FW-4-5	9	1,590	1,456
	12-1/2 barbed	954	1,075
	13-1/2 barbed	1,190	1,104



- 12' - 1/2" pipe
- 1 - 1/4" x 3" x 4" plate
- 2 - 1/2" washers
- 1 - 1/4" cotter key
- 2 - 3/4" x 2" pipe
- 1 - 3/8" x 26" steel rod

Figure 3—Barbed-wire stringer is pulled behind one or two people to unroll barbed wire.

Hydraulic log splitter—A commercial hydraulic log splitter was modified to split material as long as 8 feet for fence stays, posts, rock jacks, and rock cribs. The main beam was replaced with a 0.25-inch-thick I-beam about 6 inches wide, 7 inches high, and 11.5 feet long. The I-beam was reinforced with a 0.75-inch-diameter rebar welded along both sides of the vertical beam at the lower junction with the horizontal beam (fig. 4). The splitting wedge was modified to split larger material and could be adjusted for different splitting lengths; the plunger-block was enlarged and reinforced (fig. 5). Specific modifications may vary, depending on the design of the commercial model available.

Replacing small tires with 14- to 16-inch-diameter tires may also be desirable. Work crews raised the log splitter to a more convenient work height and constructed a ramp to move material into position to split logs. This effort reduced the need to bend over and pick up material to be split.

Barbed-wire fences—

Description—The typical barbed-wire fence consists of three or four strands of barbed wire stretched between steel or wooden posts. The fenceposts may be braced in several ways, some of which are locally unique, to provide strength and stability. Barbed-wire fences can include gates, water gaps, and cattle guards.

Application—Barbed-wire fences are the most widely used fences in the Western United States. They are suitable for many conditions and are appropriate as permanent fences that will receive moderate to heavy pressure by livestock. Barbed-wire fences can cross many different ecosystems and terrain conditions to separate ownership and divide interior property. Design specifications may vary depending on snow depth, slope, tree density, and other environmental factors. Construction and maintenance costs and environmental conditions generally determine the type of fence to be constructed. This guide provides descriptions and specifications for four types of barbed-wire fence: standard post-and-wire, let-down, suspension, rock-jack, and figure 4.

The standard post-and-wire barbed wire fence generally consists of wooden or steel posts and three or four strands of barbed wire. It is relatively inexpensive, easy to construct, and widely accepted. The let-down fence also consists of three or four strands of wire, but it can be detached from the posts—let down—to prevent damage caused by deep snow or wildlife. This type of fence has higher maintenance costs, mostly for labor to let it down and put it up each year, than the standard post-and-wire fence. The suspension fence is suspended across relatively long spans between fenceposts. Such fences are used on relatively flat ground and are particularly successful where blowing weeds are a problem because they twist in the wind and dump the weeds.

Rock-jack and figure-4 barbed-wire fences are designed for areas where setting posts is not practical, such as rocky or swampy areas. The post supporting the strands of wire rests on the ground and is braced and held in place by a rock jack, a wooden crib or platform filled with rocks. Another type of post-bracing system is in a configuration of the number 4 and is referred to as "figure-4."

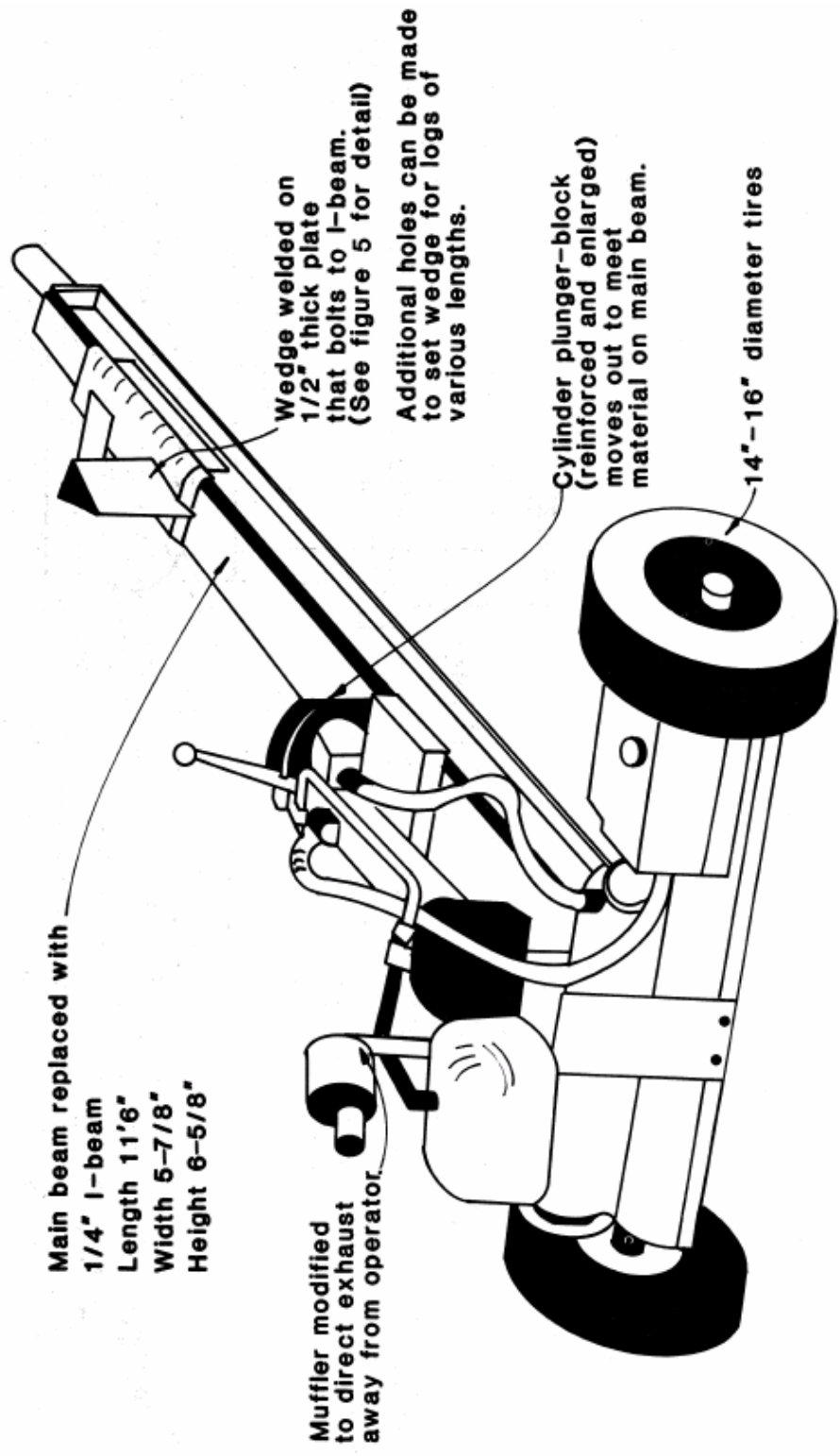


Figure 4—Detail of modified commercial log splitter.

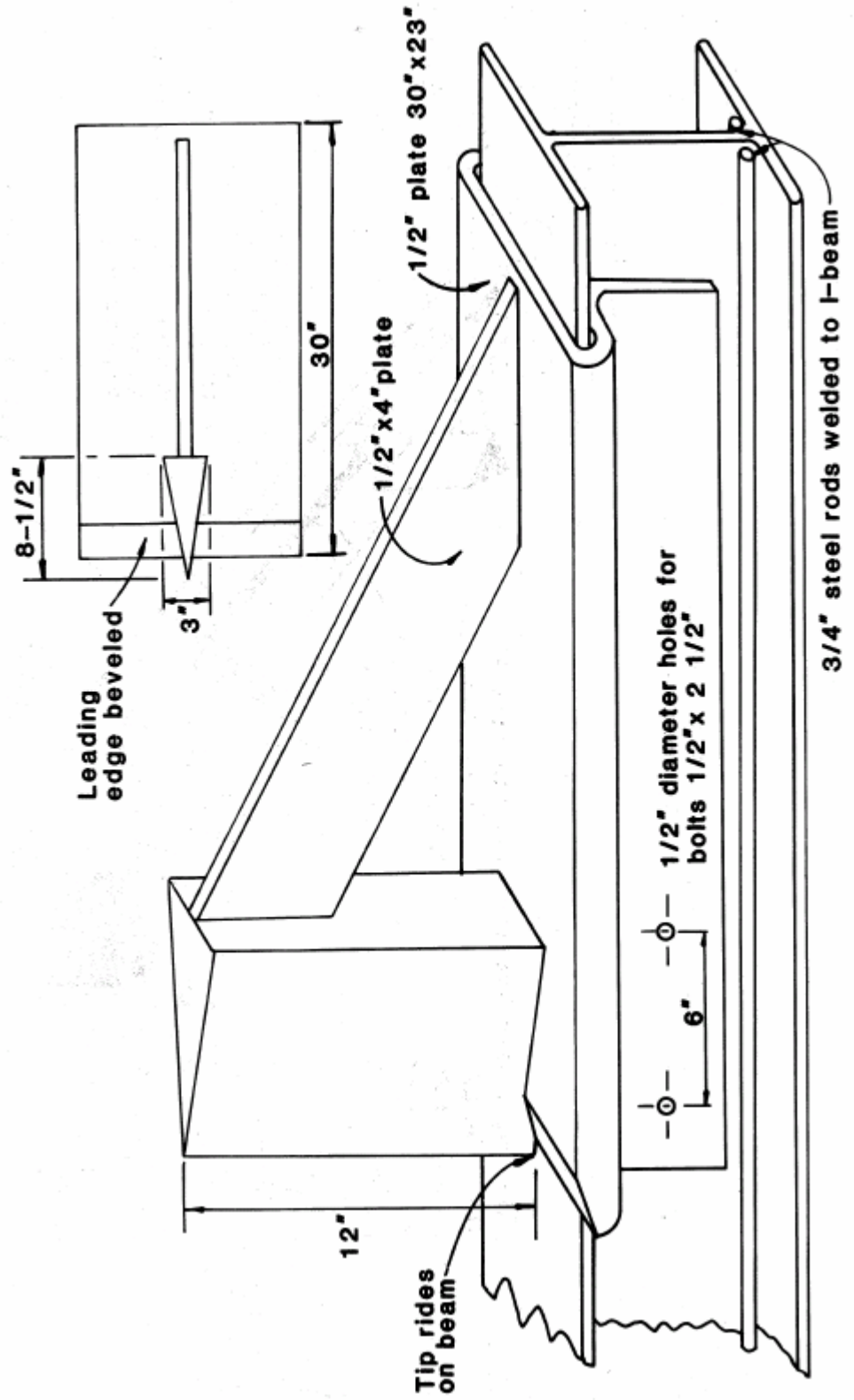


Figure 5—Detail of modified wedge for log splitter.

Table 2—Life expectancy of treated and untreated wooden fenceposts

Kind of wood	Untreated	Treatment		
		Pressure	Hot and cold baths	Cold soak
<i>Years</i>				
Juniper	25-30	—	—	—
Western redcedar	12-15	20-25	20-25	—
Lodgepole pine	2-4	20-25	15-20	10-20
Ponderosa pine	2-4	20-25	15-20	10-20
Aspen, cottonwood	1-3	15-20	10-15	5-10

Equipment—Equipment for constructing barbed-wire fences may include post-hole auger or digger, post driver, wire stretcher, wire-unrolling equipment, tamping tool, fencing pliers, and hammer.

Materials—

Wooden posts—Wooden posts are preferred in areas where significant amounts of snow accumulate because of their strength. They should be of the most durable species available, such as juniper, cedar, larch, or treated lodgepole pine. For treated posts, a preservative should penetrate radically at least 0.75 inch. Commercially pressure-treated posts usually meet this standard. Untreated wooden posts may decay in 1 to 4 years, depending on the kind of wood. Treated fenceposts have a life expectancy of 5 to 25 years, depending on the kind of wood and treatment (table 2).

Standard wooden posts are 6.5 feet long with a 4-inch-minimum-top diameter. In some cases, live trees at least 6 inches in diameter may be used in the fenceline in lieu of posts. Live trees should never have staples driven into them or have wire wrapped around them without being protected. Live trees can be protected by a slab of wood nailed to the side of the tree, with the wires stapled to the slab. Several slabs of wood can be spaced around a tree to protect it if wire is wrapped around the tree. Such slabs of wood prevent injury to the cambium and prevent the tree from growing over the wire. In addition to protecting the tree, slabs of wood also make repair of the fence easier and may prevent damage to saws if the tree is cut down.

Steel posts—Steel posts can be used where strength is not an important factor, or in rocky areas where pounding or drilling is necessary to set a post. Standard T- or U-section posts with a steel anchor plate should be used (table 3). These posts weigh about 1.5 pounds per foot (table 4). Standard length is 5.5 feet. Fence wires should be fastened to steel posts only by steel clips manufactured for this purpose (fig. 6).

Table 3—Comparative strength of U- and T-section posts of the same weight and steel formulation^a

Load	Deflection			
	U-section posts		T-section posts	
	Sand	Clay	Sand	Clay
<i>Pounds</i>	----- <i>Inches</i> -----			
100	1.74	0.80	3.67	4.05
140	—	—	9.53	9.29
150	3.18	1.30	Failure	Failure
200	4.30	1.80		
250	6.29	2.38		
300	Failure	3.12		
350		4.00		

- = no data.

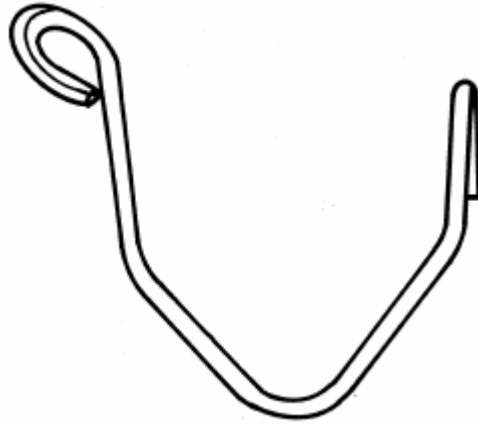
^a Deflection was measured 36 inches above ground level. Force was applied 30-1/2 inches above ground level.

Table 4—Approximate weight of steel posts

Length	Weight range
<i>Feet</i>	<i>Pounds</i>
5	6.20–7.32
5-1/2 ^a	6.76–7.99
6	7.32–8.65
6-1/2	7.88–9.32
7	8.44–9.98
7-1/2	9.00–10.65
8	9.56–11.31

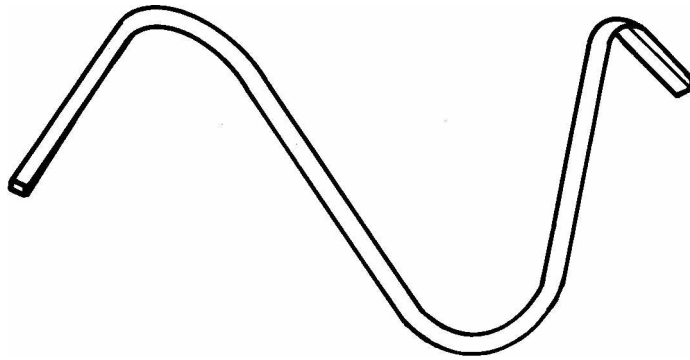
^a Standard length.

Stays—Stays can be wooden or 9.5-gauge galvanized, twisted wire. Wooden stays, at least 2.5 by 3 inches, are preferred in areas of deep snow. Wooden stays should be 44 to 46 inches long, should extend at least 4 inches above the top wire, and may be wired to the fence with 16-gauge galvanized wire and a "telephone tie" for added strength. To make a telephone tie, loop the wire over the barbed wire and around the stay. Cross the ends on the back side of the stay and bring each end back around the stay, wrapping the tie-wire ends snugly around the barbed wire. Extra care is needed to tightly snug the wire around green stays (fig. 7). Wire stays may be installed if the cost is less than that of wooden stays; however, they are suited only for areas receiving little snow. Snow bends the stays and damages the fence.



Preferred style

**Reason: Easy to install with
50d spike or fencing pliers.**



Less preferred style

**Reason: More difficult to install
than type shown above.**

Figure 6—Steel clips used to fasten barbed wire to standard steel T-posts. Style may be difficult to determine in some catalogs.

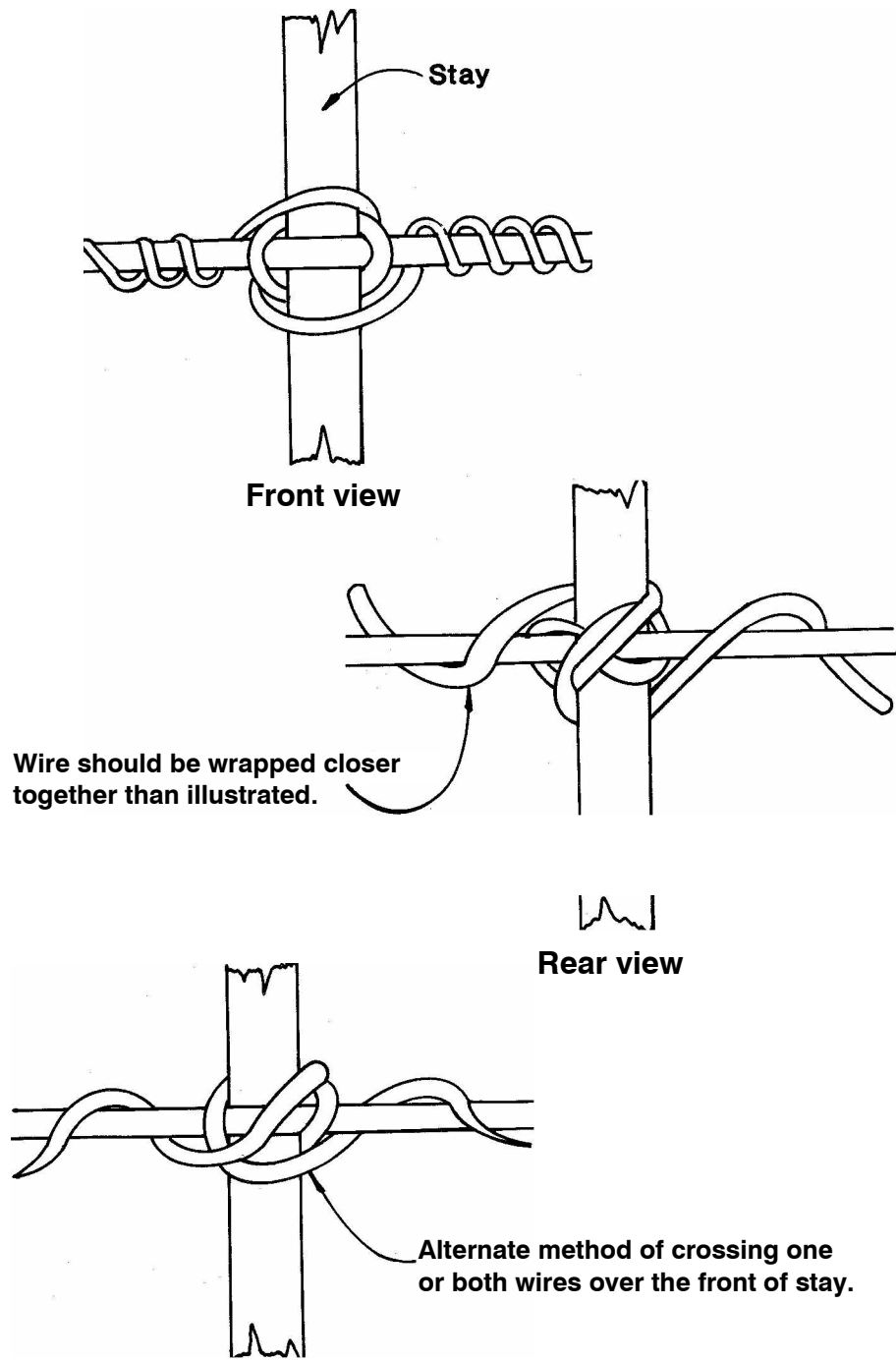


Figure 7— Telephone-wire tie.

Barbed wire, staples, and wire tension—Barbed wire should be 2-point, be 12.5-gauge with 4 to 5 inches between 14-gauge wire barbs, and weigh about 1 pound per rod (table 5). Lighter gauge or 4-point wire can increase maintenance. Staples should be 1.5 inches long. Nails, staples, and smooth wire are generally sold by weight; tables 6-8 give helpful information for buying these items. It is important to buy quality materials to construct a durable and low-maintenance fence.

All line wires should be dead-ended on gate, corner, angle, or line-brace posts. The ends should be wrapped twice around the post, stapled, and twisted back on the stretched wire to prevent the post from twisting. The first few twists around the stretched line wire should be at about a right angle to the line wire for maximum security (fig. 8).

Wire should be tensioned according to ambient air temperature. Wire tensioned too tight on warm days may be stretched beyond the yield point on cold days, and it may sag the next warm season. A good guide to follow is 550 pounds of tension for the coldest day of the year; subtract 2.61 pounds for every degree Fahrenheit between the air temperature at the time it is stretched and the anticipated coldest temperature. For example, if the coldest expected temperature is -10 °F and the present temperature is 80 °F there is a difference of 90 °F. Multiply 90 by 2.61 and subtract the answer, 235, from 550. The proper tension is 315 pounds. The wire should be over stretched on warm days to take out kinks and seat the twist, but not over 500 pounds, and then returned to the proper tension. The wire must be supported on each post by loose staples or a nail during tensioning to relieve the weight of wire and to assure that wire is in the correct position. A simple tension meter can be constructed, which is based on the general static formula for wire tension:

$$\text{Tension} = \frac{\text{length} \times \text{balance reading}}{4 \times \text{vertical displacement}} \quad (\text{fig. 9}).$$

Staples should be set at an angle to the post grain and be driven in just deep enough to snug the line wire without bending it (fig. 10).

Braces—Bracing is the key to prolonged life of wire fences. Brace poles should be at least 5 inches in diameter, peeled, and of sound material. Sawed material of least 4 by 4 inches may be used in lieu of round poles. Line braces should be installed at all breaks in alignment, or at least every 1,320 feet.

Guy wires consist of two complete strands of 9-gauge annealed, or soft, galvanized wire. The brace pole is fitted between the fenceposts near the top wire and double spiked into place. Round or split posts should have a flat surface for the brace pole to fit firmly against the post. The guy wire is double wrapped around the bottom of the post that the fence line wires will be attached to and around of the top of the brace post, stapled, and tied together so the guy wire forms two long narrow circles. A stout stick is placed about the middle of the guy wires, and all four wires are twisted together until the guy wires are tight. Additional bracing can be added where extra strength is needed (figs. 11, 12, and 13). Gates are located between two line braces (fig. 14), or one line brace and a corner brace.

Text continues on page 18.

Table 5—Approximate amount of barbed wire needed for fences of various lengths constructed with 1-, 2-, 3-, or 4-strand wires^a

Length	Approximate weight of barbed wire per strand			
	1	2	3	4
	<i>Pounds</i>			
1 rod	1	2	3	4
1 chain	4	8	12	16
100 feet	6-1/16	12-1/2	18-3/16	25
1 square acre	50-2/3	101-1/2	152	203
1 square mile	1,280	2,564	3,840	5,128
1 side of square mile	320	640	960	1,280

Table 6—Number of common nails per pound by size, length, and gauge

Size	Length	Gauge	Approximate number per pound
	<i>Inches</i>		
4d	1-1/2	12-1/2	316
5d	1-3/4	12-1/2	271
6d	2	11-1/2	181
8d	2-1/2	10-1/4	106
10d	3	9	69
12d	3-1/4	9	63
16d	3-1/2	8	49
20d	4	6	31
30d	4-1/2	5	24
40d	5	4	18
50d	5-1/2	3	14
60d	6	2	11
70d	7		7
80d	8		6
Spike (5/16-inch diameter)	8		4
90d	9		5
100d	10		4
120d	12		3

Table 7—Number of galvanized fence staples per pound

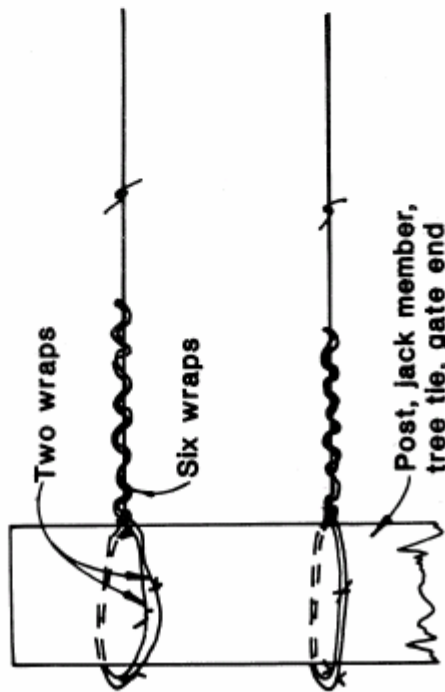
Size	Approximate number per pound
<i>Inches</i>	
1	108
1-1/8	96
1-1/4	87
1-1/2	72
1-3/4	65
2	58

Table 8—Weights and length of smooth wire per unit of measure, by gauge and diameter

Gauge	Diameter	Weight per 100 feet	Length per pound	Weight per mile	Weight per rod
	<i>Inch</i>	<i>Pounds</i>	<i>Feet</i>	<i>----- Pounds -----</i>	
9	0.1483	5.87	17.05	309.7	0.97
10	.1350	4.86	20.57	256.7	.80
11	.1205	3.87	25.82	204.5	.64
12	.1055	2.97	33.69	156.7	.49
12-1/2	.0990	2.64	37.82	139.4	.43
13	.0915	2.23	44.78	117.9	.37
14	.0800	1.70	58.58	90.1	.28
14-1/2	.0760	1.54	64.93	81.3	.25

A question frequently arising is, in which direction do the guy wires go? The easiest way to remember is to recall the purpose of the brace pole and the guy wires. The fence wire is attached to a fencepost that pushes against the brace pole and tries to push the brace post over. The guy wires transfer that pushing force from the top of the brace post back to the bottom of the fence post that the wire is attached to. This brace configuration is strongest when the posts, brace pole, and ground form a rectangle.

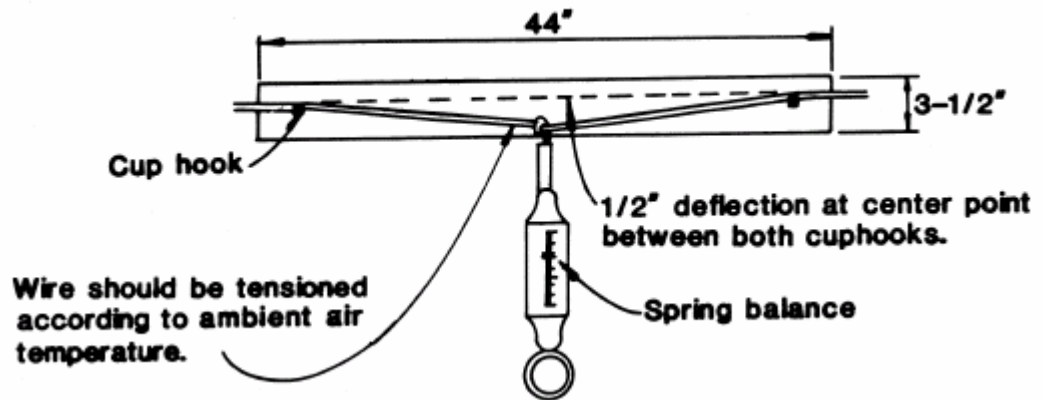
Text continues on page 26.



Splices in the wire are made by wrapping one end of the wire back around itself six times to form an eye at the end of the wire. The other wire is placed through the eye and wrapped back around itself at least six times. The first six wraps are adjacent to each other to form neat, tight wraps.

Ends of line wires should be wrapped twice around the post, stapled, and twisted back on the stretched line wire six times at about a right angle

Figure 8—Barbed- or smooth-wire splice and end ties.



CONSTRUCTION

Screw 2 cup hooks into a 44"x3-1/2"x1/2" board 40" apart and 1" down from the top of the board. Place a wire across the cup hooks and mark a line 1/2" below the wire near the center of the board.

HOW TO USE TENSION METER

Run out and stretch all wires. Staple all wires in major dips and rises. Wire should move freely.

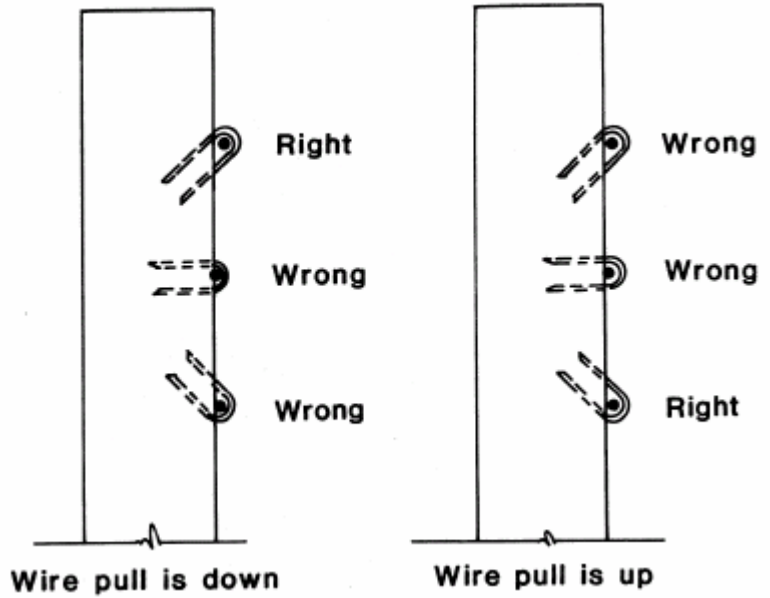
Take reading near the middle of the stretch. Place wire on the cup hooks. Attach a spring balance to the wire midway between the cup hooks and pull the wire down until it is deflected to the 1/2" mark.

Read the balance. Multiply this reading by 20. Answer equals pounds of line tension. For example, 15 lb = 300, 16 lb = 320, and 17 lb = 340. (See text for method to determine the correct tension.)

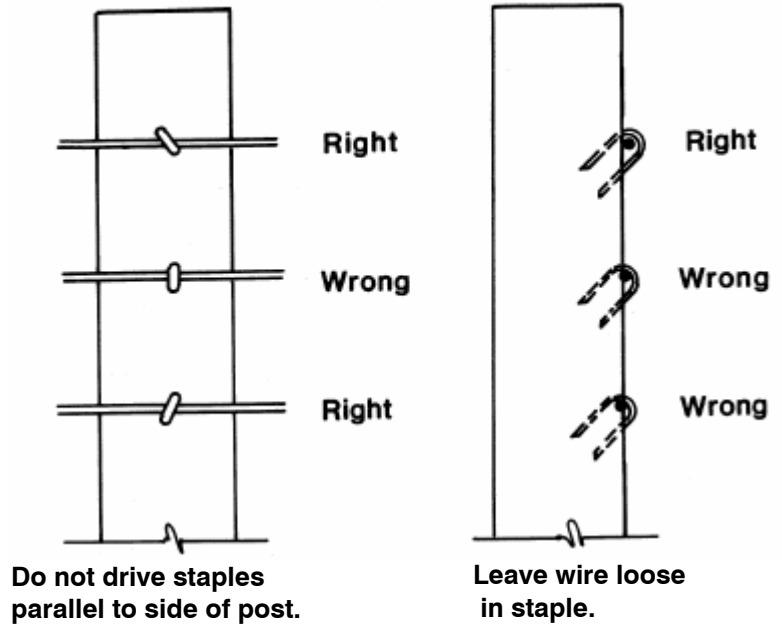
On long spans with 2 or 3 dips or rises, leave 1 or 2 dips or rises unstapled on the end of the wire that the wire is being stretched from. Staple these areas last to evenly tighten the wire. Only experience can judge the correct procedure.

When all wires are tensioned and tied off, staple the rest of the line. First walk the entire line and staple all secondary dips and rises to even out the tension and then staple the rest of the line. Never start at one end and staple through to the other end, unless the stretch is short and flat.

Figure 9—Instructions for construction and use of a simple wire tension tool (Courtesy Waterford Corporation).



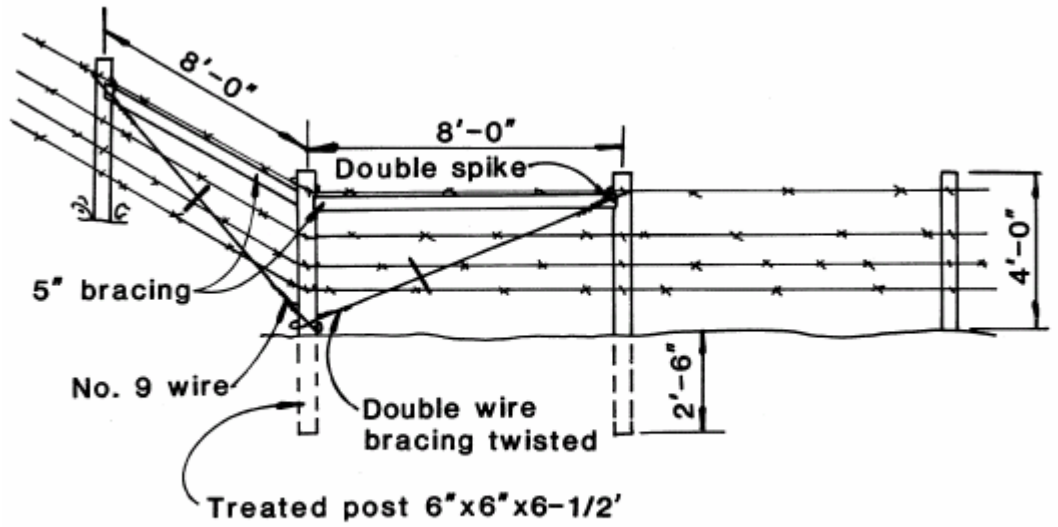
Drive staples at an angle in the same direction as the wire is pulling.



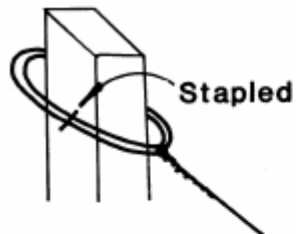
Do not drive staples parallel to side of post.

Leave wire loose in staple.

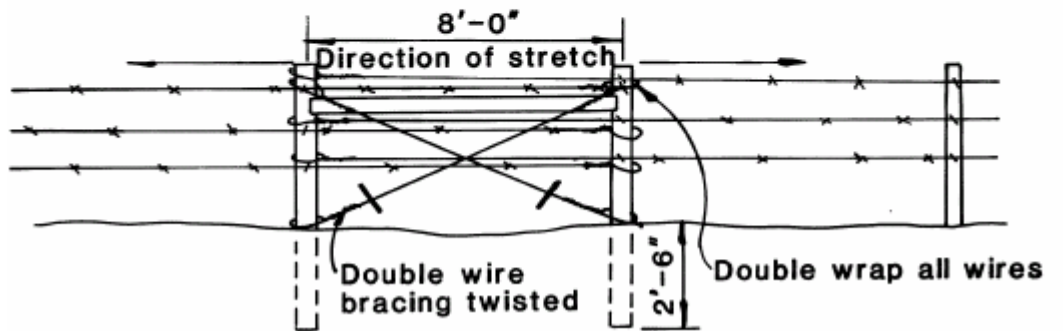
Figure 10— Techniques for stapling wire to wooden posts.



Corner brace

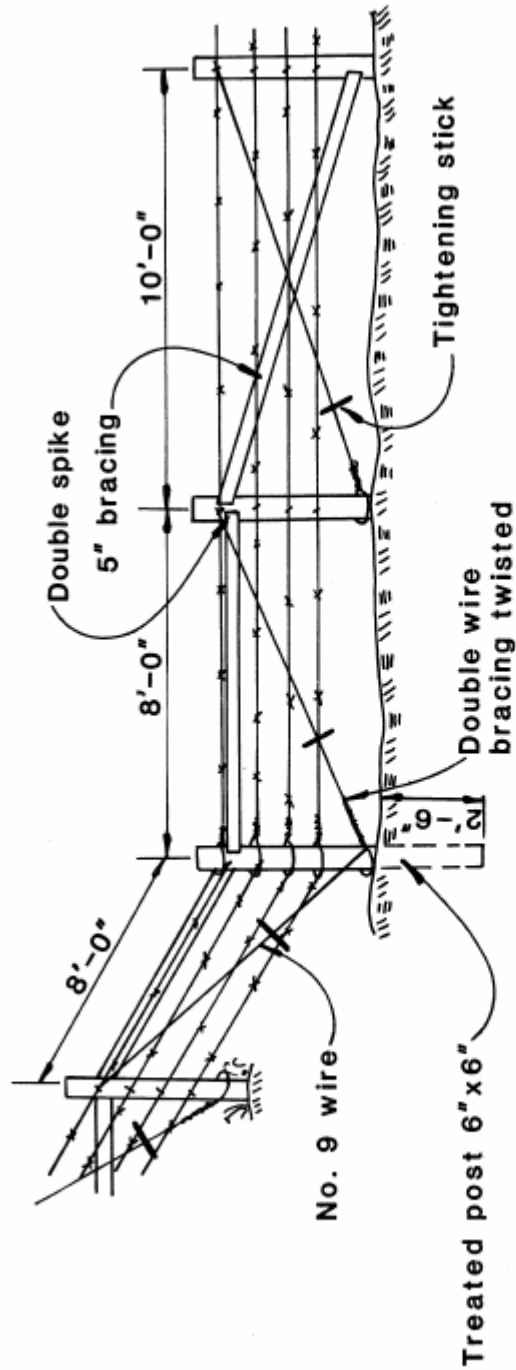


Double-wrap detail



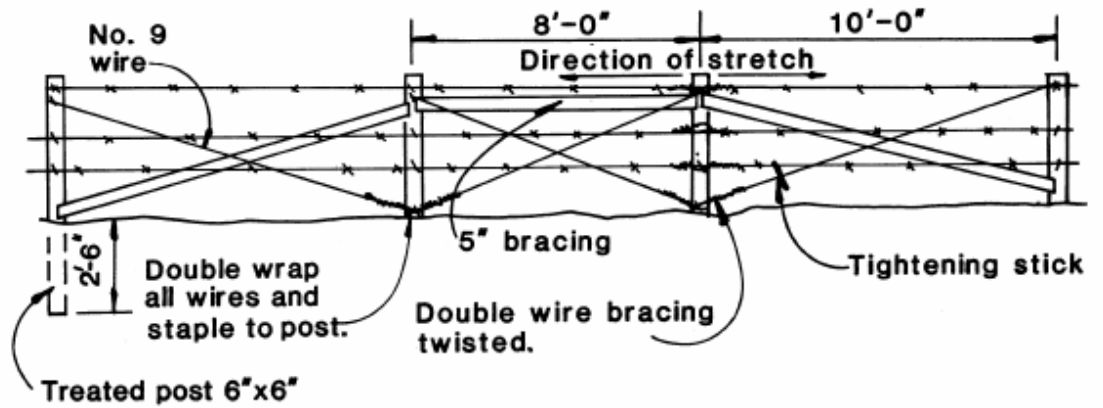
Line brace

Figure 11—Standard corner and line brace detail for wire fences. Sawn material is preferred over round. Notch braces to fit firmly against posts. Install braces every 440 yards and at all changes in alignment.

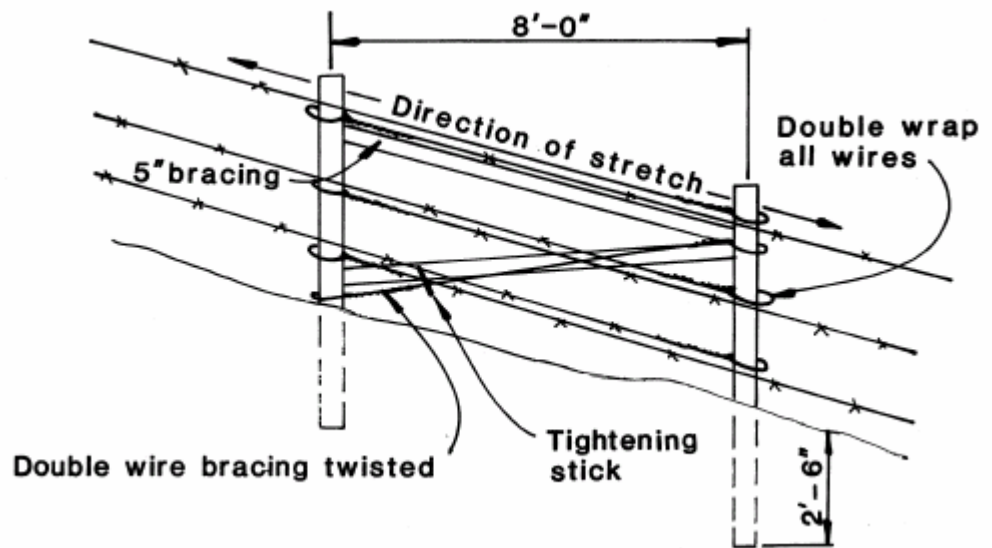


Corner or gate brace

Figure 12—Extra-strength brace for corners or gates for a wire fence. Sawn material is preferred over round. Notch braces to fit firmly against posts.

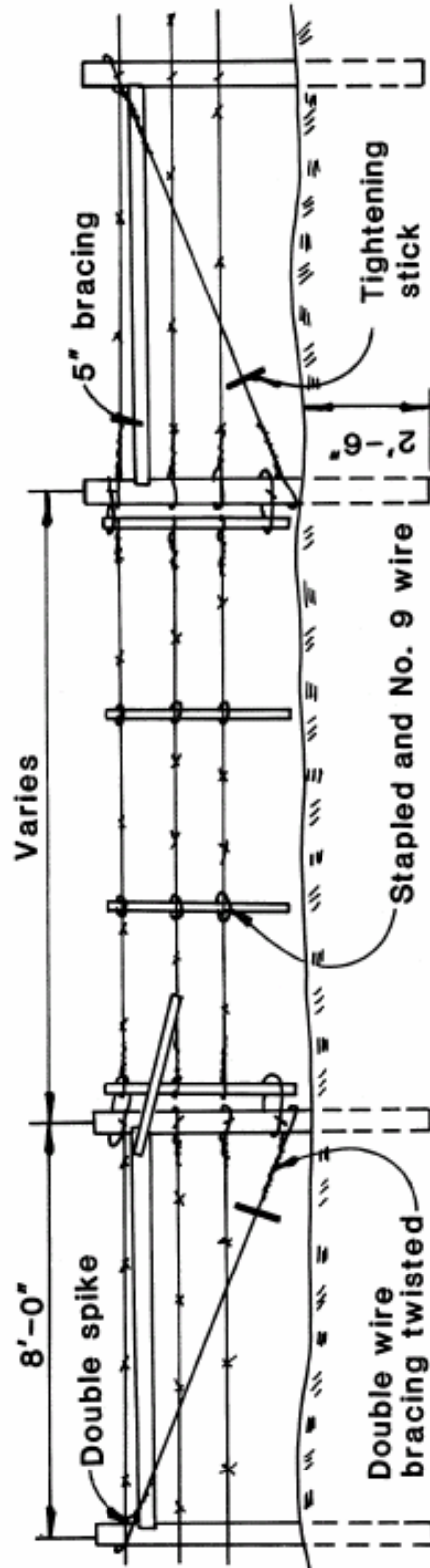


Line brace



Line brace for slopes greater than 30 percent

Figure 13—Extra-strength braces for normal wire fencelines and for those on steep slopes. Sawn material is preferred over round. Notch braces to fit firmly against posts. Install braces every 440 yards and at all changes in alignment.



Gate brace

Figure 14—Standard brace for gate in a wire fence. Sawed material is preferred over round. Notch braces to fit firmly against posts.

Specifications—Spacing line wires is very important, especially in areas where big game are found. The total height should be not more than 42 inches to prevent the top wire from being broken when big game, especially deer, jump over the fence. The distance between the top two wires is critical for adult deer because their hind legs can become entangled between these wires. We recommend that the top wire be at least 10 inches above the next wire. The bottom wire should be at least 16 inches above the ground to allow fawns and antelope to crawl under the fence (fig. 15).

Grounding of wire fences removes some of the risk associated with lightning and other electrical hazards (fig. 16). Where fencelines are parallel to powerlines, grounding should be installed every 1,500 feet. Where the fence crosses under a powerline, the fence should be grounded on each side of the crossing.

The surfaces of posts and braces must be notched or flattened where they are to be joined so that about half the nail will be in each member. Nails should be driven at binding angles to each other (fig. 17). When trees in the fenceline are used to hang wire, wooden strips should be nailed to the tree and the wire stapled to the "nailer" strips (fig. 18). Where trees are within 2 feet of the fenceline, offsets can be used fastening wires to the trees (fig. 19).

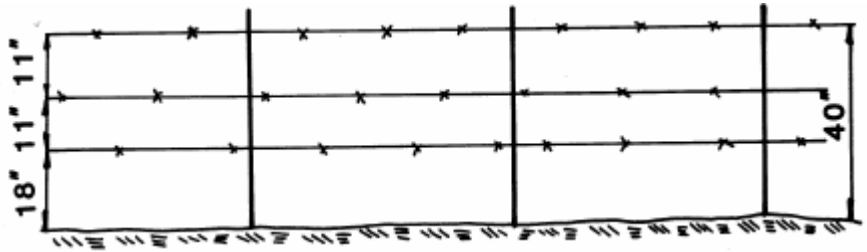
Under conditions of heavy snowfall, posts should be spaced at no more than 16.5 feet apart. Otherwise local conditions should be considered and posts spaced according to stock pressures and fence strength. Spacing posts as far apart as 30 feet may be satisfactory under some conditions.

Standard post-and-wire fence—Barbed wire on set or driven line posts is the most commonly used fence construction. Three strands of barbed wire are usually adequate except where livestock pressures are heavy. In such cases, a fourth strand should be added.

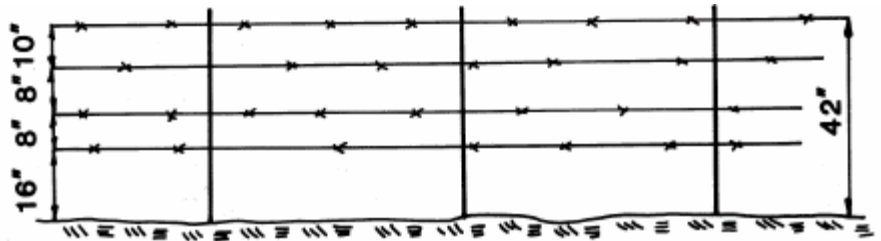
Where heavy snow occurs, wooden posts should be spaced 16 feet apart for maximum strength. In areas where moderate snow occurs, posts may be spaced up to 24 feet apart, with two or three stays between posts. Steel posts may be substituted for wooden posts where strength is not a controlling factor; they are usually satisfactory except for brace and gateposts, which should be wooden (fig. 20). Usually, at least every fifth post should be wooden.

Where construction crosses dry draws, all fence strands should be anchored to heavy rocks, logs, or other durable material with 9-gauge galvanized smooth wire (figs. 21 and 22). Several methods may be used for crossing live streams or very deep draws. The fence should be dead-ended on each side of the crossing with line braces. The section of the fence crossing the stream may be constructed so it can be removed or can swing with high waterflow (figs. 23, 24, and 25).

Text continues on page 38.



Three-Wire spacing



Four-Wire spacing

Figure 15—Barbed-wire spacing for three- and four-wire fences.

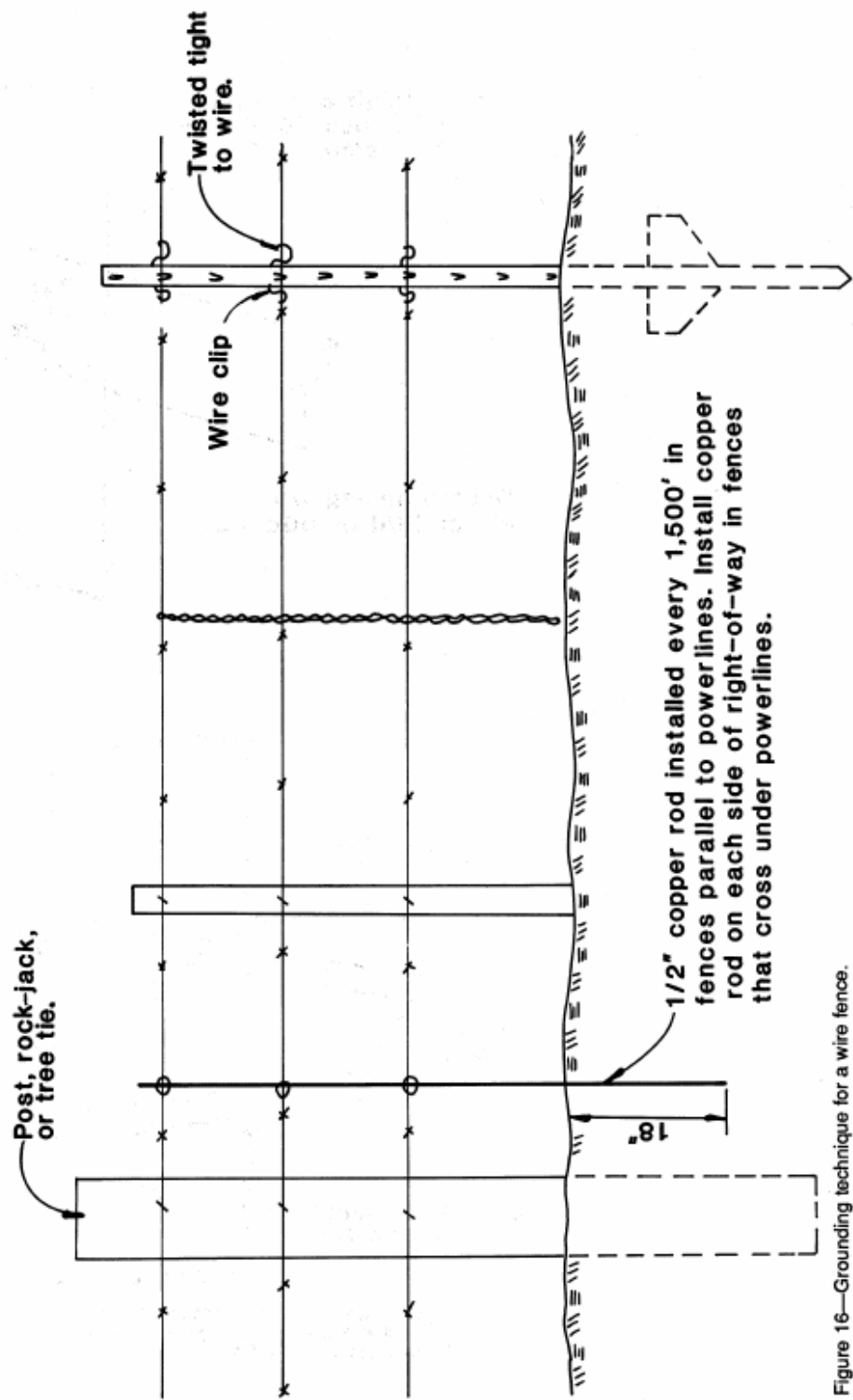


Figure 16—Grounding technique for a wire fence.

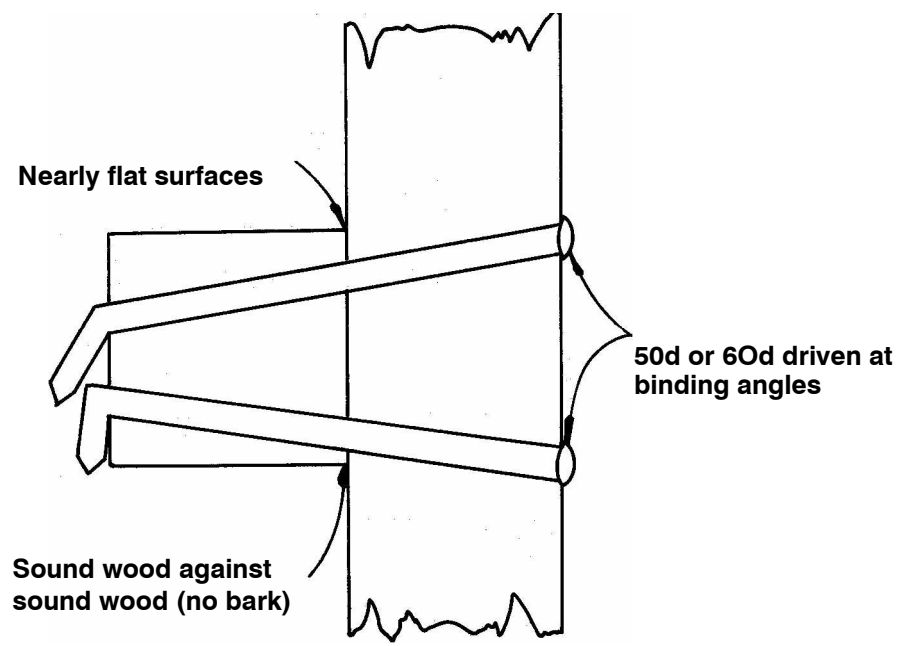
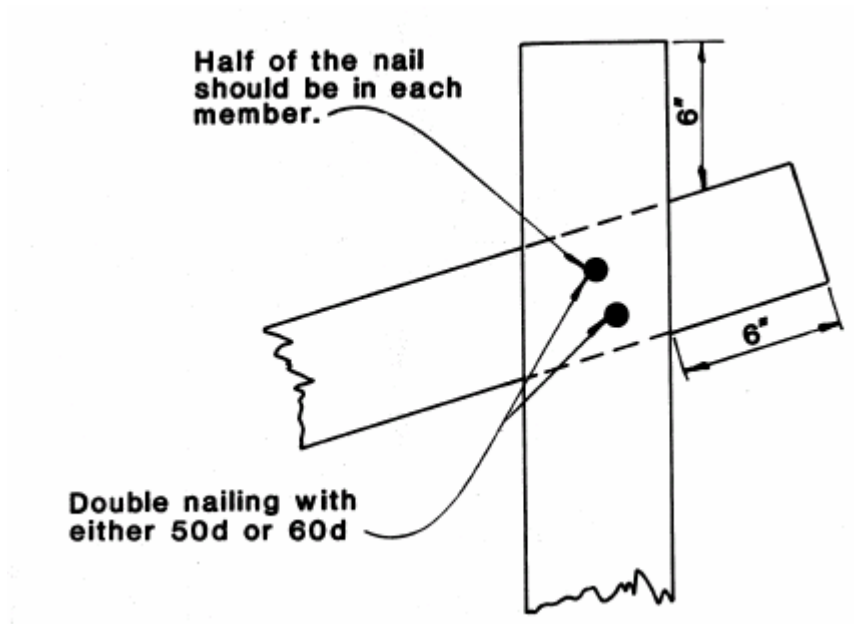


Figure 17—Nailing techniques for fence construction. Bend exposed ends of nails that extend through a member so they are flat and parallel with the timber surface.

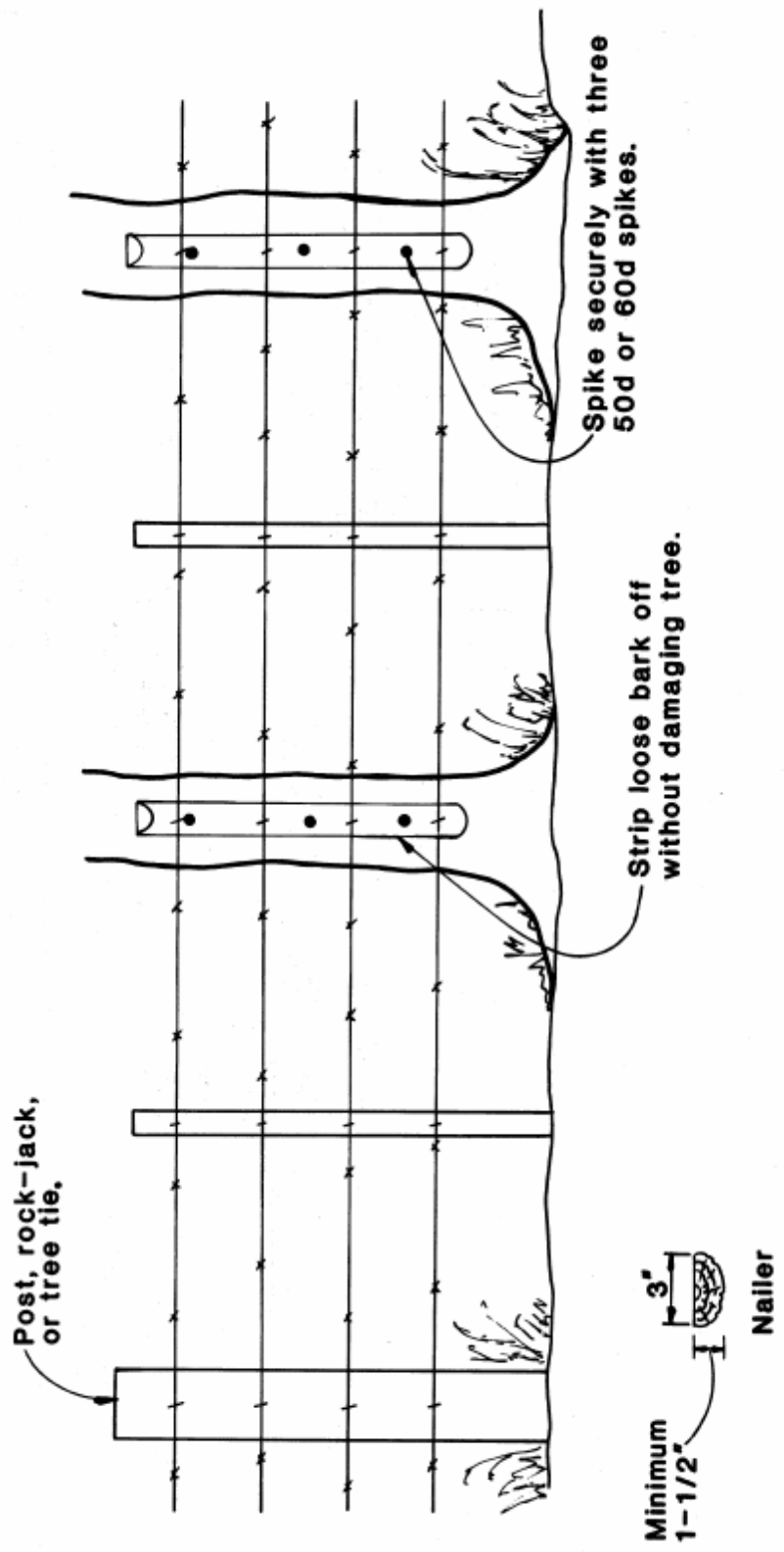
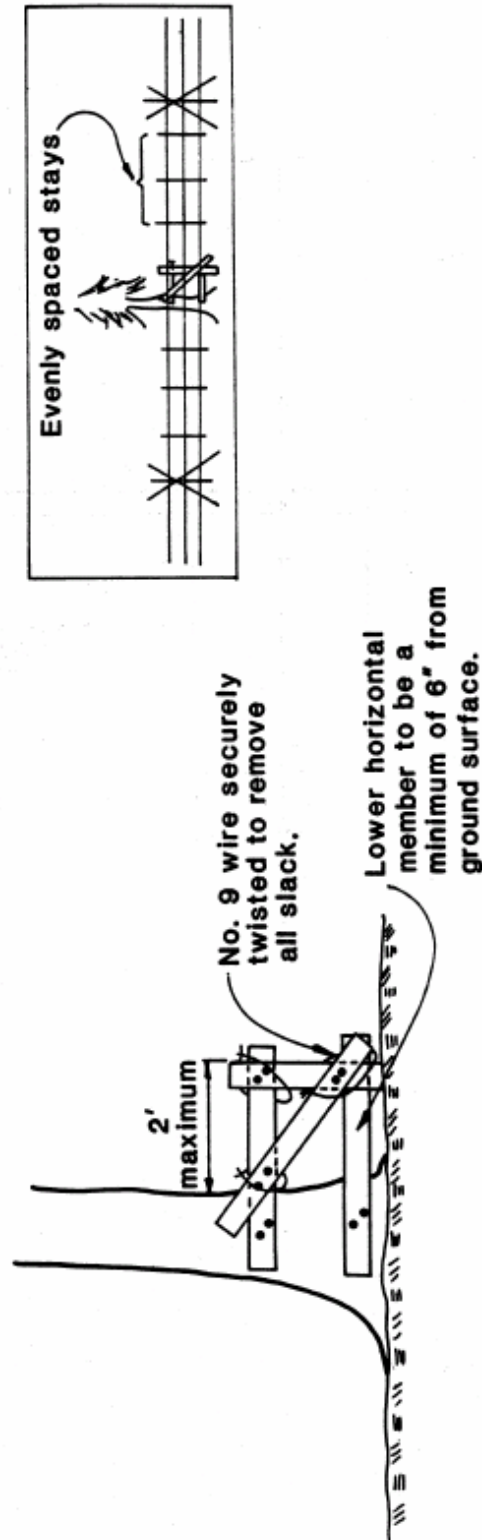


Figure 18—Nailer strips used to fasten wire to trees.



Sound, live trees within 2' of the fenceline may be substituted for fenceposts or rock-jacks by an offset. All offsets should be built with three members and an upright at least 3" thick and 6" wide.

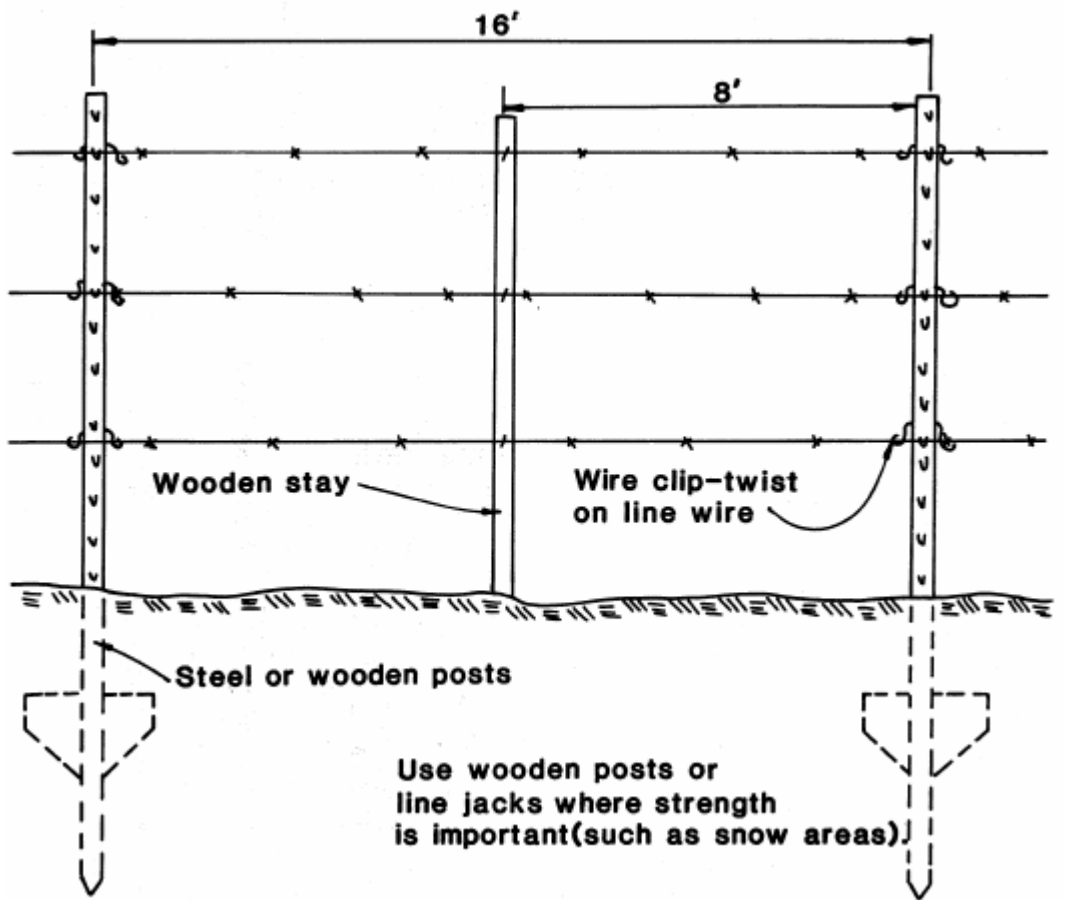
Double spike all joints and secure with no. 9 wire.

Strip off loose bark to provide a sound nailing surface. Trim overhanging branches.

Join members so they do not interfere with the line wires.

Use only sound, live trees at least 8" d.b.h.

Figure 19—Fenceline offsets.



Alternate post and stay spacing for moderate conditions.

Figure 20—Spacing recommendations for steel or wooden posts and wooden stays for standard wire fences.

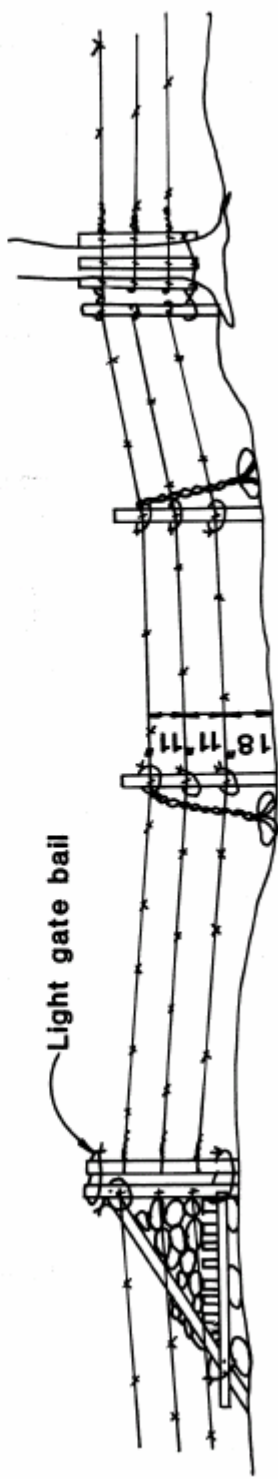
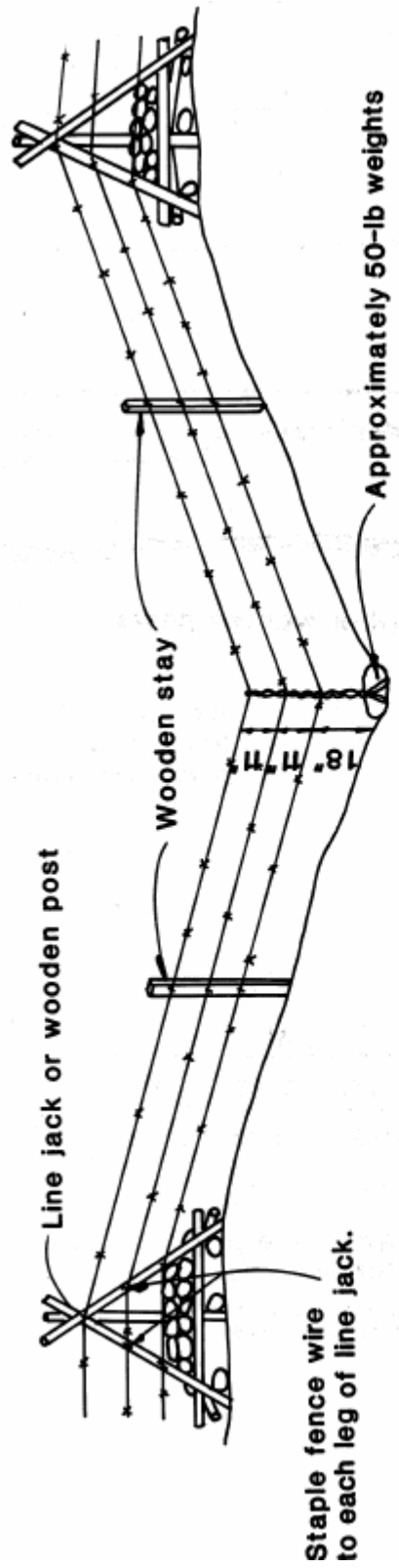
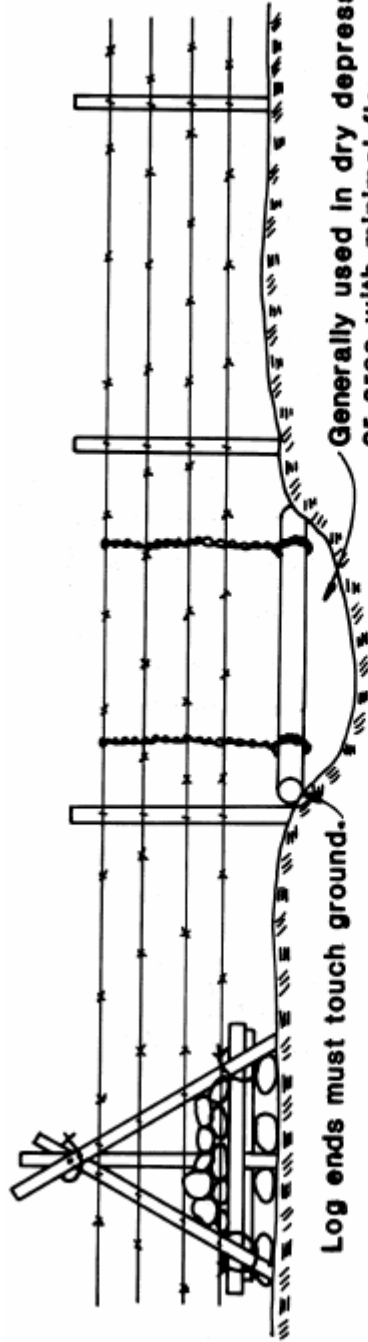


Figure 21—Rock tie-down for draws and depressions. Bottom, tie-down is constructed to be opened to prevent damage from high water.

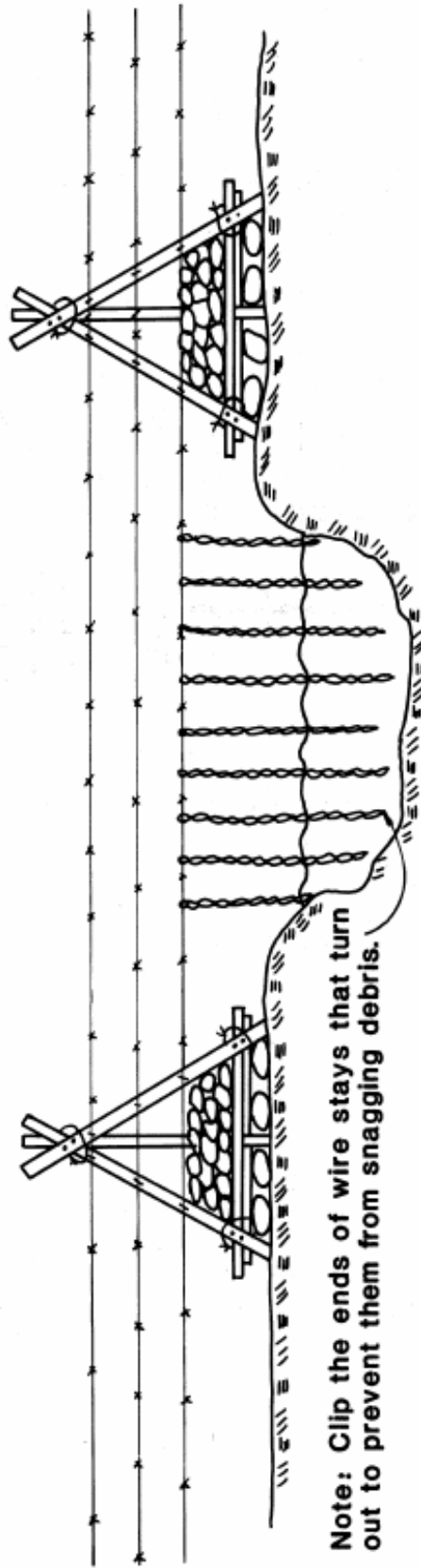


Log ends must touch ground.

Generally used in dry depression or area with minimal flow.

Construct log tie-down with barbed or no. 9 wire. Wrap wire securely around the log a minimum of 12" from each end and staple. Attach to fence wire without changing wire spacing. Log must touch the ground. Use only for depressions less than 15' wide and shallow enough that additional line wires are not needed.

Figure 22—Log tie-downs for use in shallow depressions.



Not out

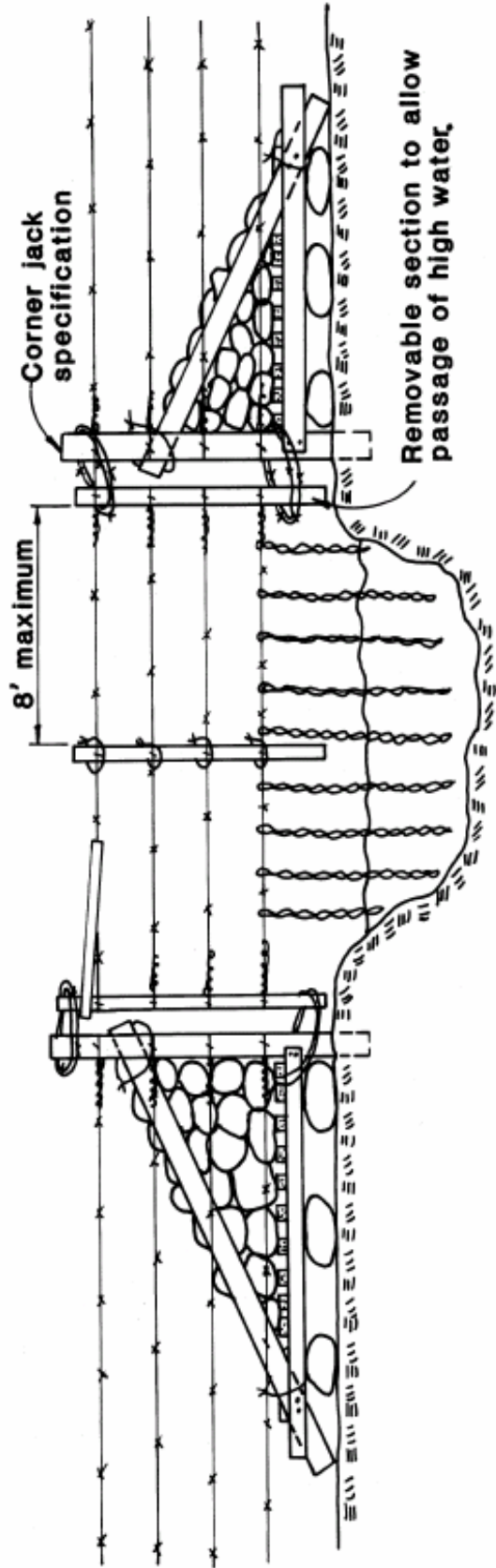
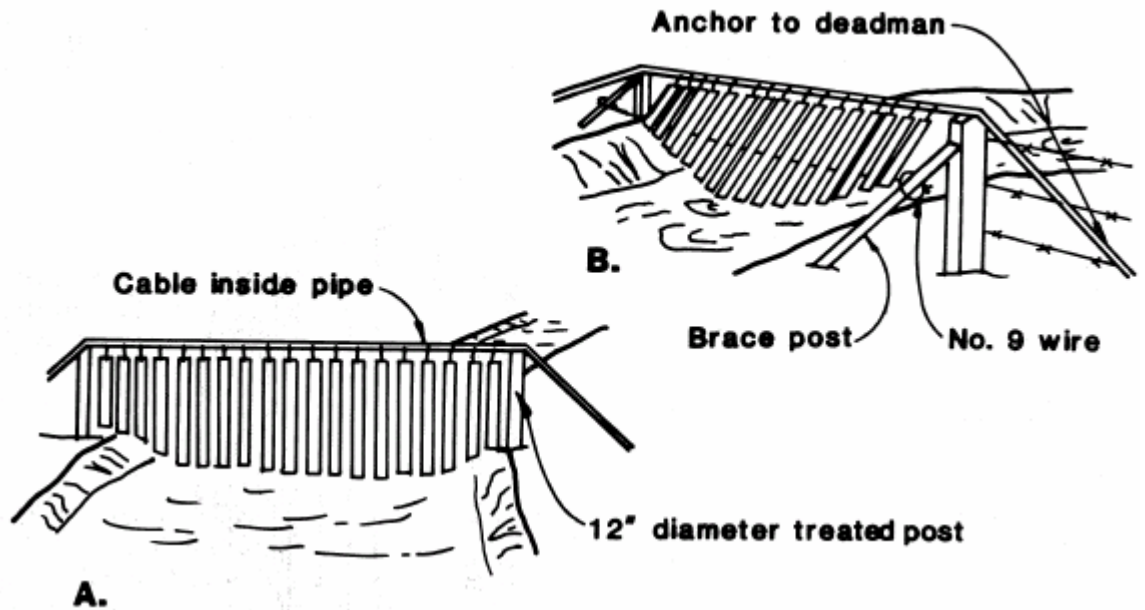


Figure are ch Bottom

Figure 23—Wire stays used for water gaps on small streams are designed to release debris and leave a clear channel. Bottom, removable section allows passage of high water.



CONSTRUCTION DETAILS

Pickets are 2-1/2" x 6" material suspended on 2" x 10" strap iron "U" clamps over 1" diameter pipe. A 5/8"-diameter cable is inside the pipe and anchored at either end with a deadman. The structure is supported by 12"-diameter, treated posts set 5' deep, rock-jacks, or trees at least 10" d.b.h. Pickets are spaced with 10"-long sections of 1-1/4" pipe that is placed between the clamps and slipped over the 1" pipe. The clamps may be greased to reduce wear. Because of the weight of the pickets, this design is recommended for spans 25' or less. Longer spans require heavier cable and pipe.

Figure 24—Swing picket fence designed for water gaps on larger streams. (A.) Pickets hang down into the stream and "float" on the water. (B.) Pickets may be lifted out of the water to prevent ice damage by two stands of no. 9 wire attached to brace posts on either side of the stream.

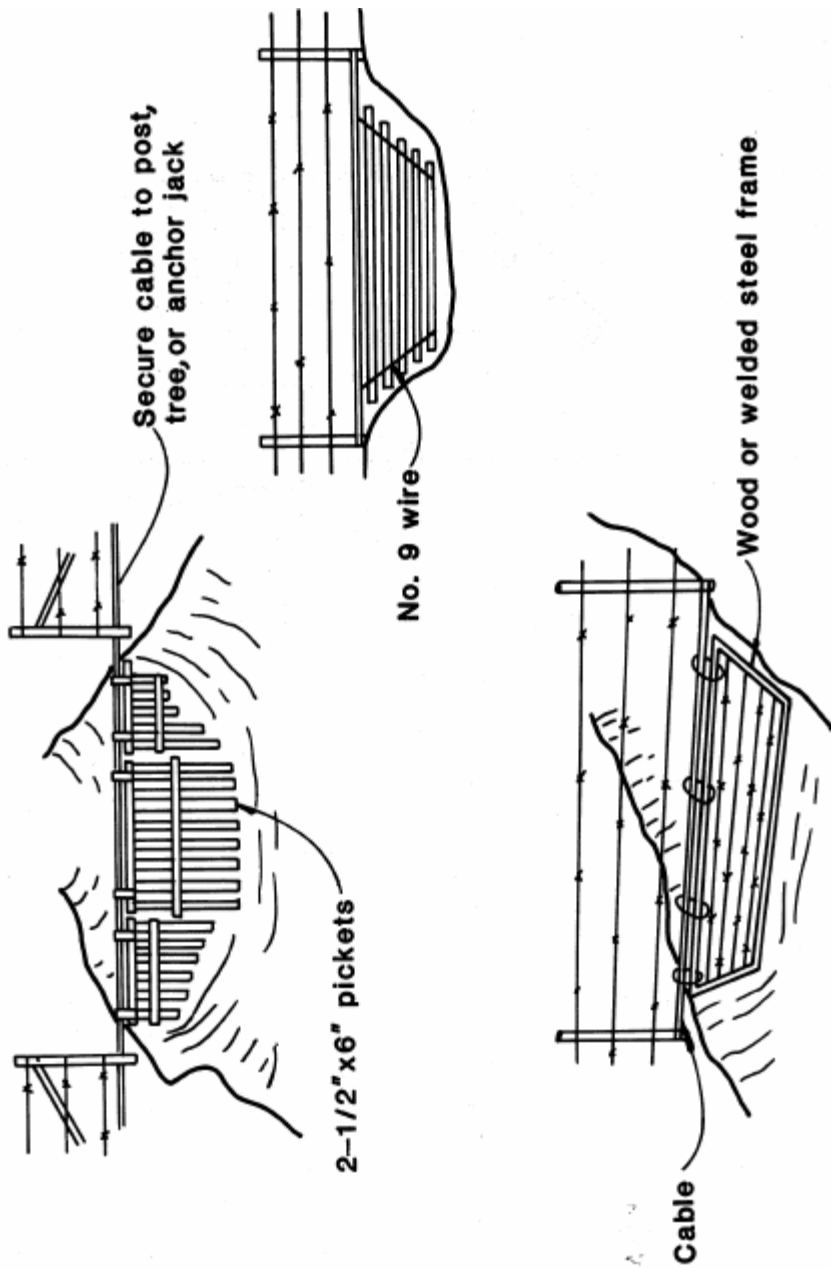


Figure 25—Fending alternatives for water gaps.

Let-down fence—Let-down fences are designed for areas with heavy snow and where seasonal movements of big game must be considered. The tension-cable anchor is critical because it supports the span that will be let down. The anchor can be fastened to a tree or to a permanent fenceline brace (fig. 26). Let-down-fence spans should be planned as straight stretches (fig. 27). Posts may be wood or steel. Line posts may be spaced as far apart as 30 feet, but two or three wooden stays are usually needed for longer spans. Line braces should be set at least each 180 feet. Construction should allow each section between anchor points to be laid down. Wooden stays are used to attach wire at each steel post (figs. 28 and 29), tree (figs. 30 and 31), or rock-jack (fig. 32). Wire loops are used to hold the stay to the line structure during the grazing season. Wire strands should not be stretched as tightly as in regular post-and-wire fences. Wire supports can be used on tree nailers or rock-jack members (fig. 33). A useful tool to let down and put up fence spans can be constructed with a board 30 inches long, or a maul handle, and about 5 feet of chain (fig. 34).

Suspension fence—Suspension fences work well on open, level area but have limited use in mountainous terrain. Such fences are not recommended for sites with deep snow. The advantages are low costs for construction and maintenance.

Wooden line posts are spaced 80 to 128 feet apart with two-piece wire stays 16 feet apart. Three to six strands of barbed-wire are stretched taut between line braces (no more than a 3-inch sag between posts) and fastened to posts with nailed clips or "telephone staples." The wires must be free to move back and forth through the clip, and the stays must not touch the ground. Treated wooden posts are preferred to steel posts.

Suspension fences work well on smooth ground where small depressions or gullies are not prevalent. In areas where windblown weeds are a problem, the suspension fence gives less trouble than conventional fences because they are flexible and can "dump" weeds that pile up against the fence.

Rock-jack and figure-4 fences—Rock-jack and figure-4 fences are very functional and usually have low maintenance requirements. These fences are useful in areas where setting wooden or steel posts is difficult; for example, in swampy or rocky areas. They should also be considered in areas where native material is available on the site and where construction and maintenance costs are less than the cost for fences with set posts. This type of fence is very flexible. Rock-jacks provide the primary support; figure-4's, steel posts, and wooden stays, used in combination to suit site conditions, provide secondary support.

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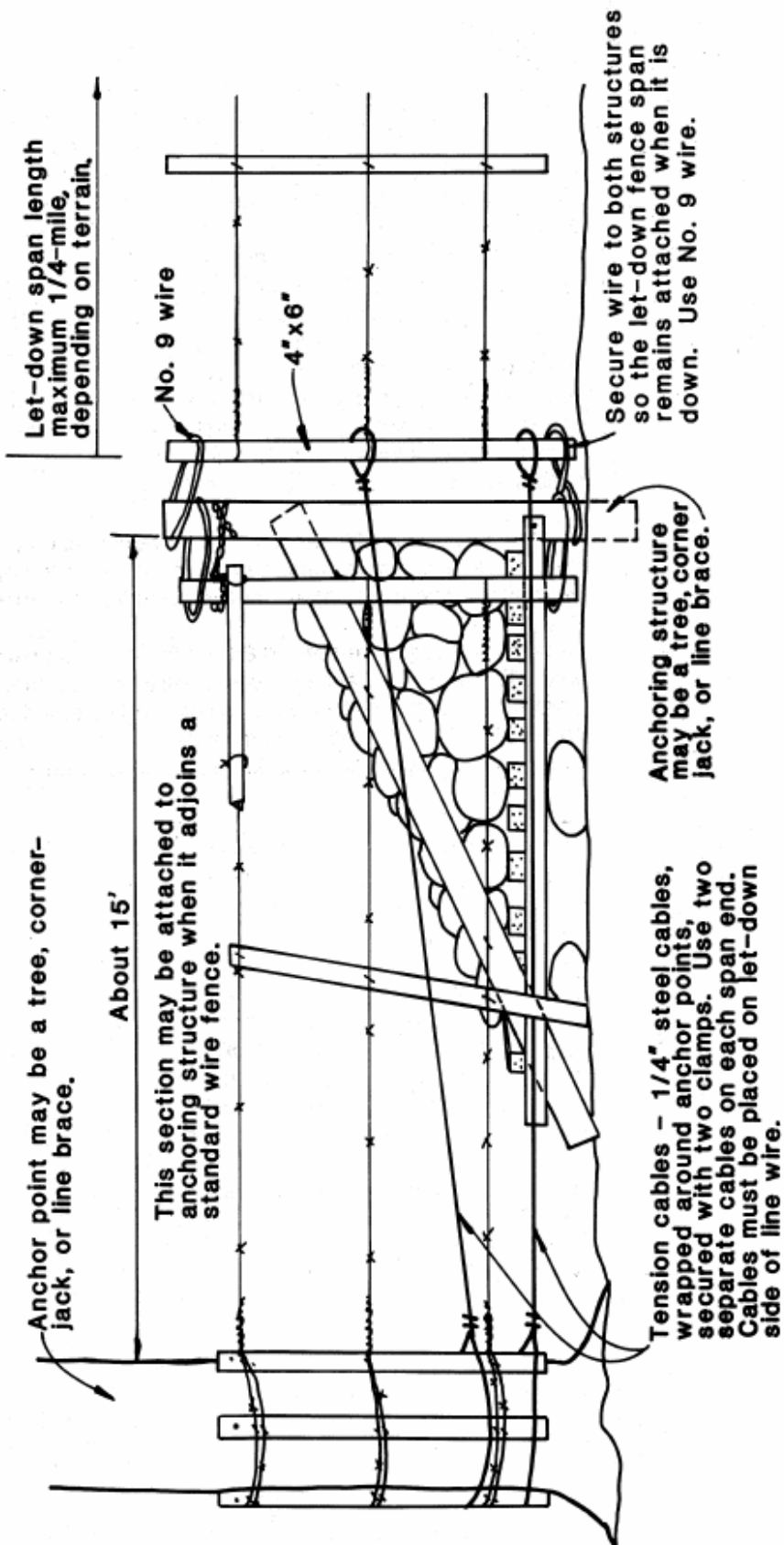
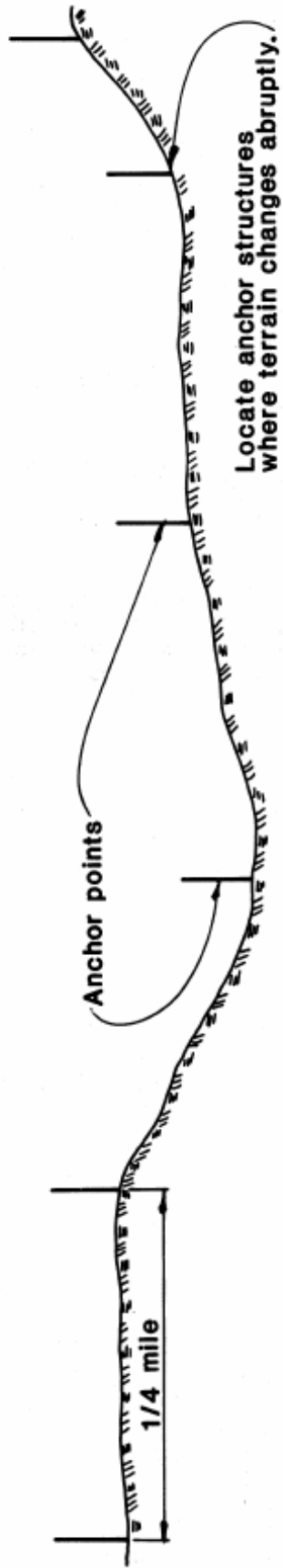
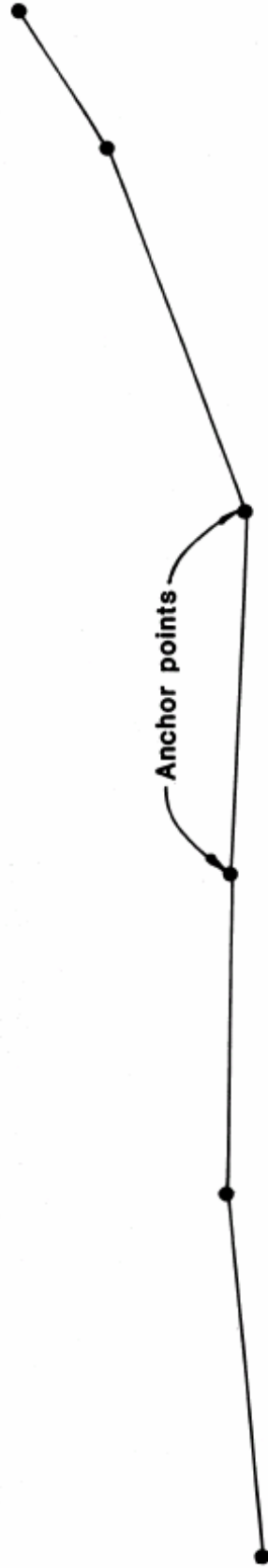


Figure 26—Methods of anchoring let-down fences.

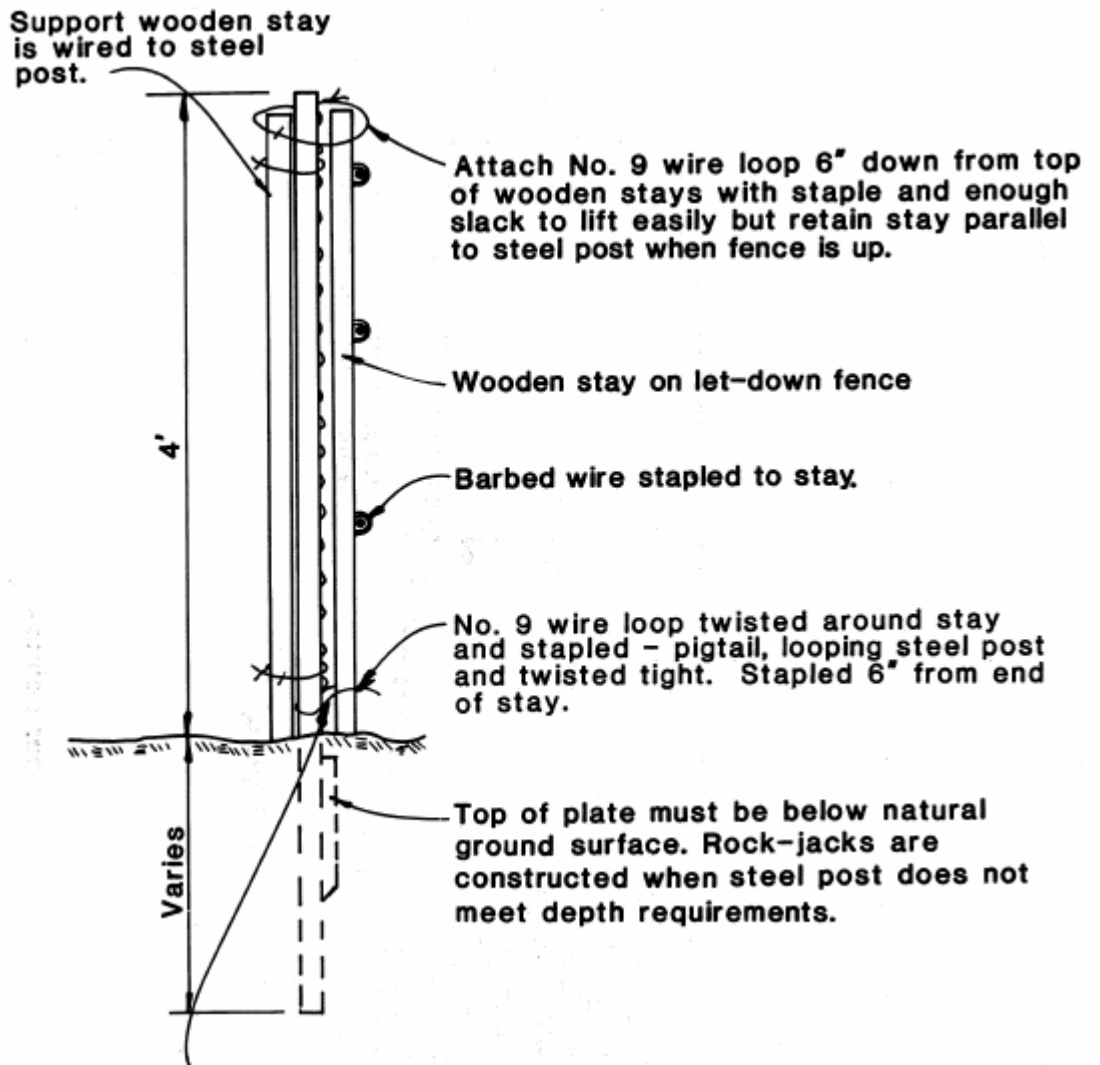


Horizontal View



Aerial view

Figure 27—Examples of layouts for let-down fences. Anchor points may be trees 10 inches d.b.h. or larger, for corner- or gate-jacks, or line or corner braces.



Pigtail has enough slack to allow free movement of stay when fence is put up and let down but will not move stay along fenceline and will be parallel with the steel post when the fence is up.

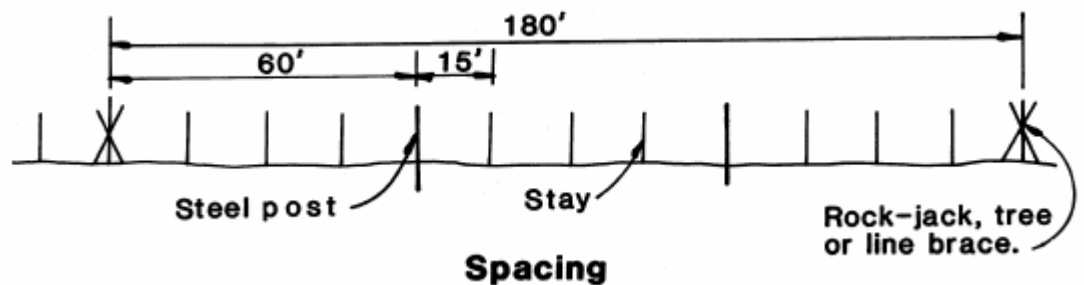


Figure 28—Side view and recommended spacing of steel post and stay structure used to support let-down fences. Steel fenceposts are not suitable for areas that receive heavy snow.

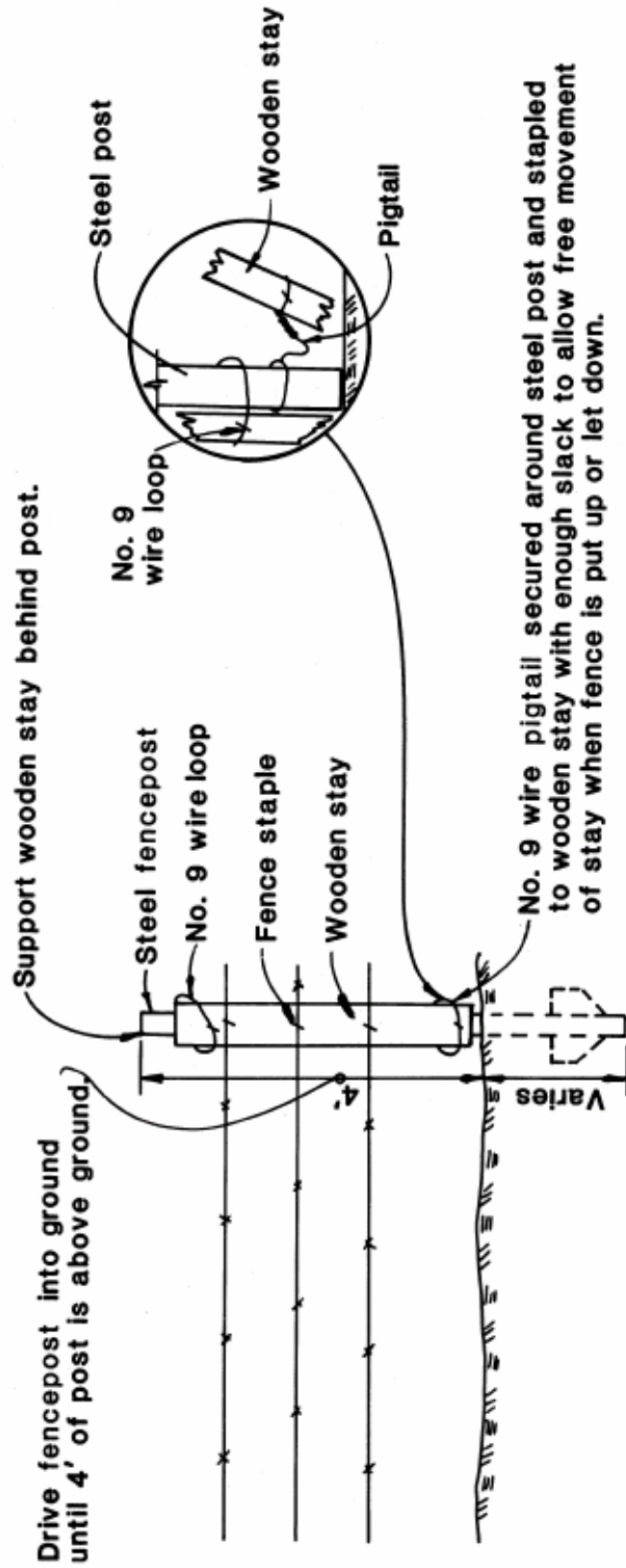
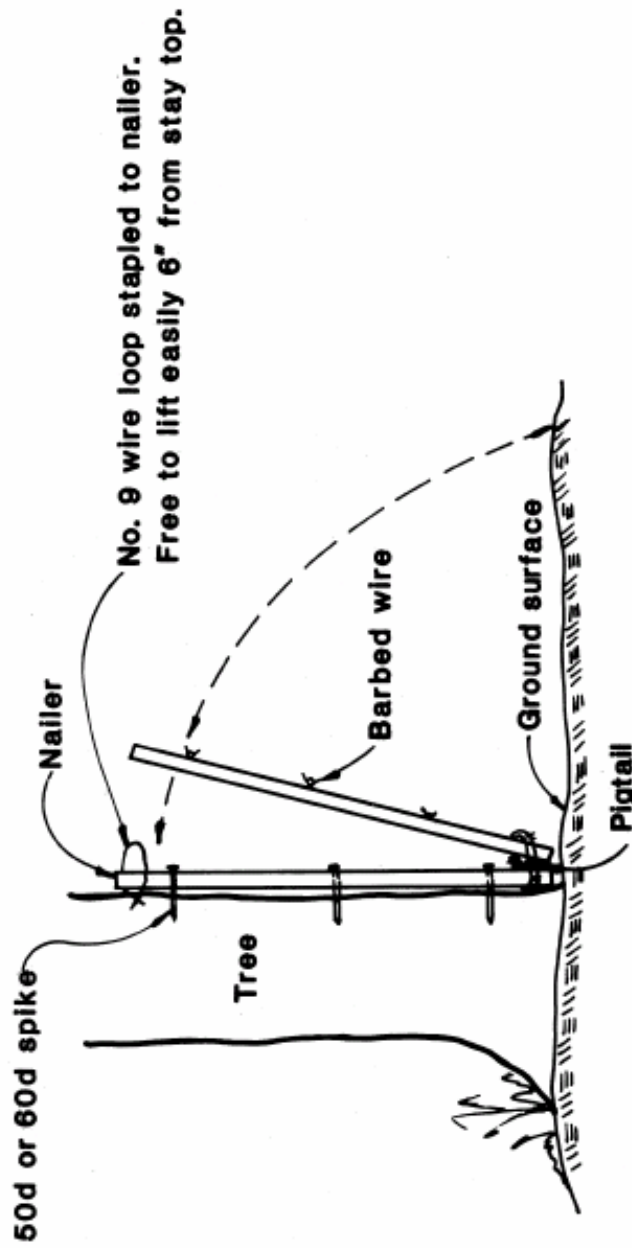


Figure 29—Front view of steel post and stay structure used to support a left-down fence.



No. 9 wire pigtail is secured around nailer and wooden stay with enough slack to allow free movement of stay when the fence is put up or let down. Staple pigtail 6" up from end of nailer and stay.

Figure 30—Side view of a live tree used as a support structure for a let-down fence.

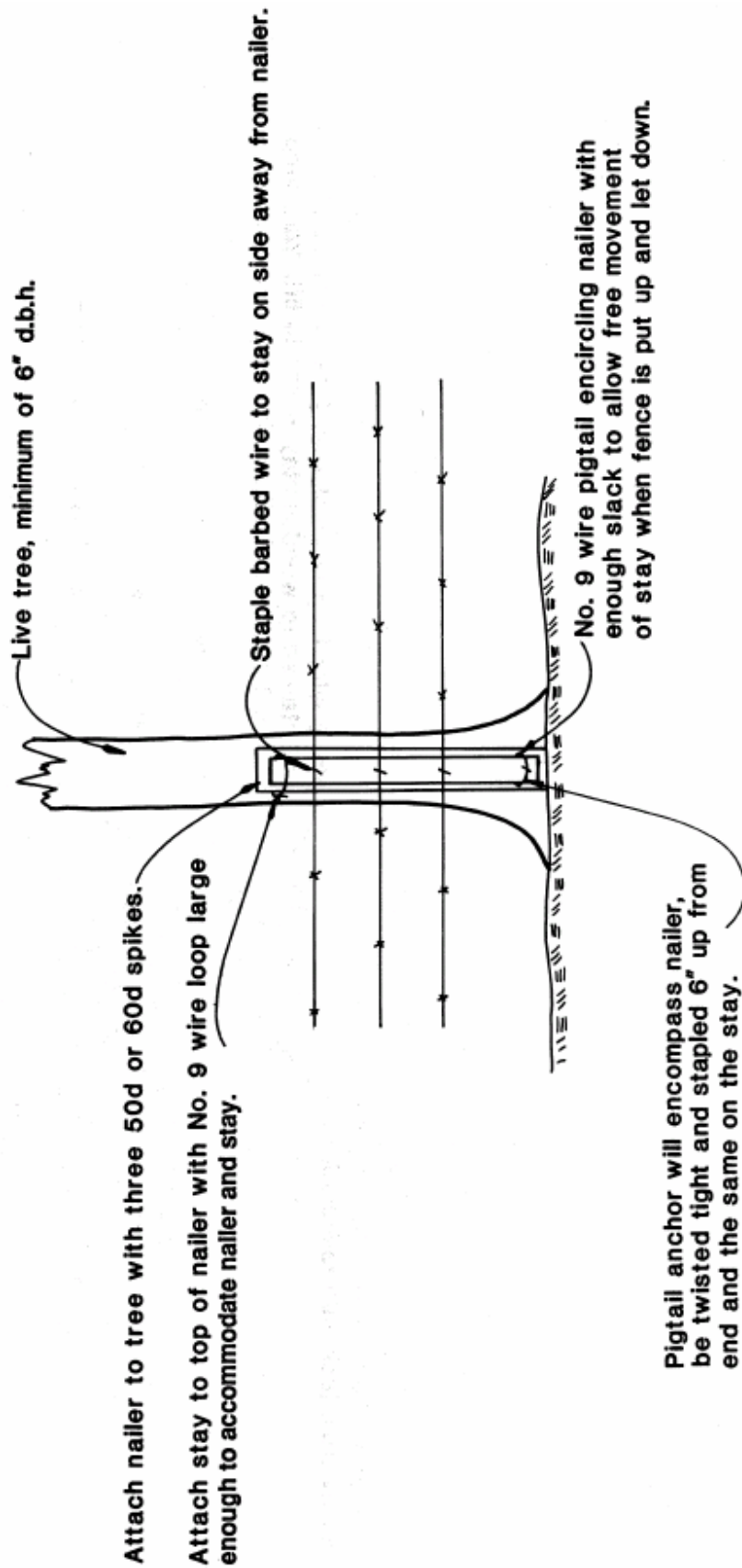
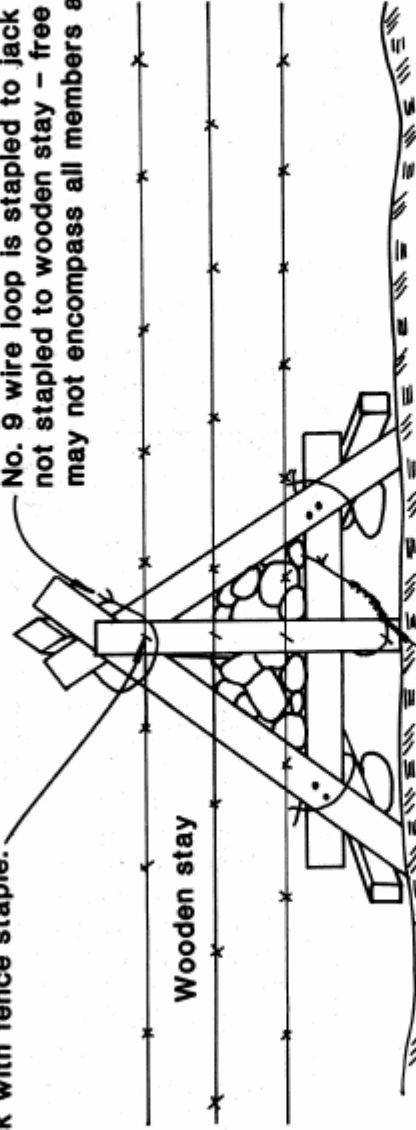


Figure 31—Front view of a live tree used as a support structure for a let-down fence.

Attach barbed wire to stay on side away from jack with fence staple.

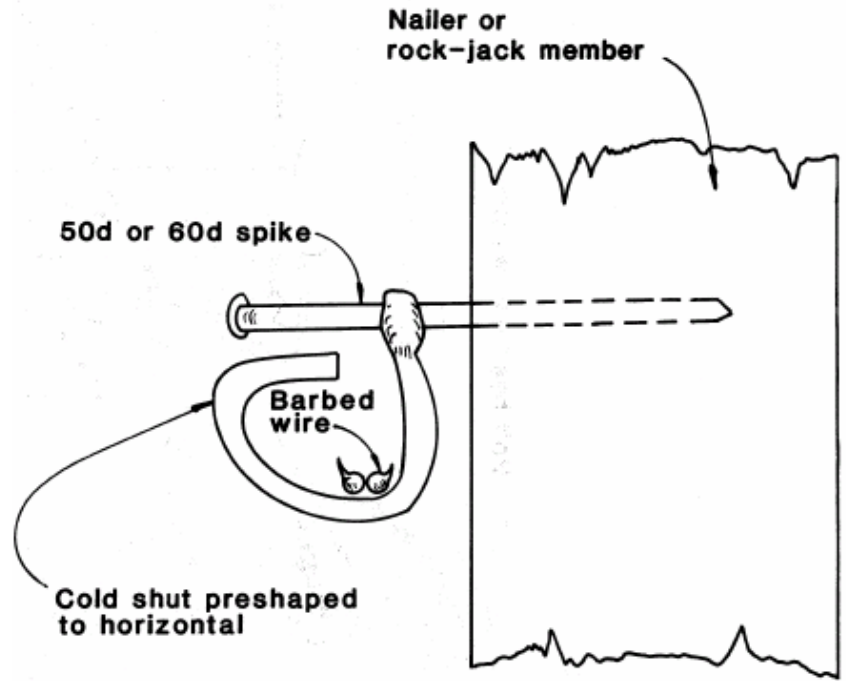
No. 9 wire loop is stapled to jack at one point, not stapled to wooden stay - free to lift. Wire loop may not encompass all members at top of jack.

Wooden stay



No. 9 wire pigtail stapled to stay and anchored to jack member with enough slack to allow free movement of stay when fence is put up and let down but will not move along the fenceline or away from the jack.

Figure 32—Rock-jacks used as a support structure for a let-down fence. See figure 35 for rock-jack construction details.



Cold shut - attach to nailer or rock-jack with 50d or 60d spike. Leave last 1" of spike out to lock wire. Bend over protruding spike ends that extend through timber.

Figure 33—Detail of cold shut used as a wire support on tree nailers or rock-jack supports.

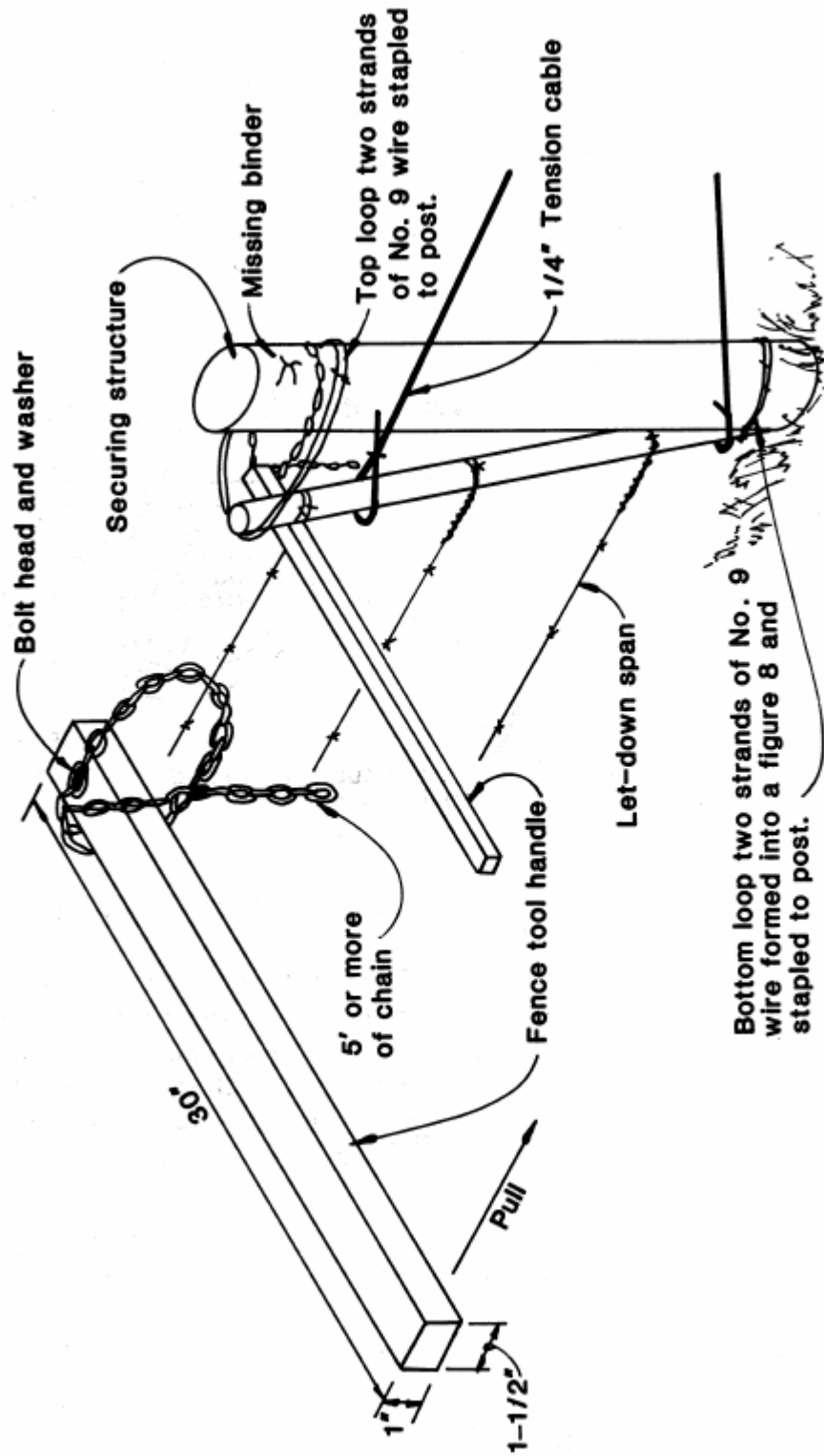


Figure 34—Handmade tool used to release or stretch let-down fence spans when binder is missing or broken. A maul, or other similar tool handle, may be used.

Rock-jacks (fig. 35) and figure-4's (fig. 36) are constructed from split wood. Corner or gate rock-jacks are designed to hold more stress (fig. 37). Rock-jacks are spaced from 50 to 160 feet, depending on snow conditions and the type of intermediate supports. On rocky and moderately level topography, rock-jacks may be spaced every 50 feet with wooden stays every 12.5 feet between jacks. On level forested sites with light snowfall, rock-jacks may be spaced every 100 feet and figure-4's every 25 feet with wooden stays between each span. Steep, rocky slopes or sites with heavy snow loads need to have the rock-jacks spaced closer together to support the fence (fig. 38). On sites where steel posts can be used, rock-jacks may be spaced every 160 feet and steel posts every 20 feet with wooden stays between each span. For areas with moderate snow loads, wooden stays can be used to prevent steel posts from settling into the soil (fig. 39).

As with standard barbed-wire fence construction, log or rock tie-downs should be used to hold the fence in position at draws, depressions, and streams (figs. 21, 22, 23, 24, and 25).

Woven-wire fences—

Description—Woven-wire fences consist of woven wire stretched between line posts, generally with one or two barbed-wire strands above the woven wire. The mesh of the woven wire differs, depending on the animals the fence is designed to control. Some fence construction requires woven wire of smaller mesh in the lower portion of the fence and larger mesh in the upper part. Some designs do not call for barbed wire above the woven wire, and the height of the woven wire ranges up to 8 feet to control wildlife. The line posts are similar to those of standard barbed-wire fences, depending on the height of the fence.

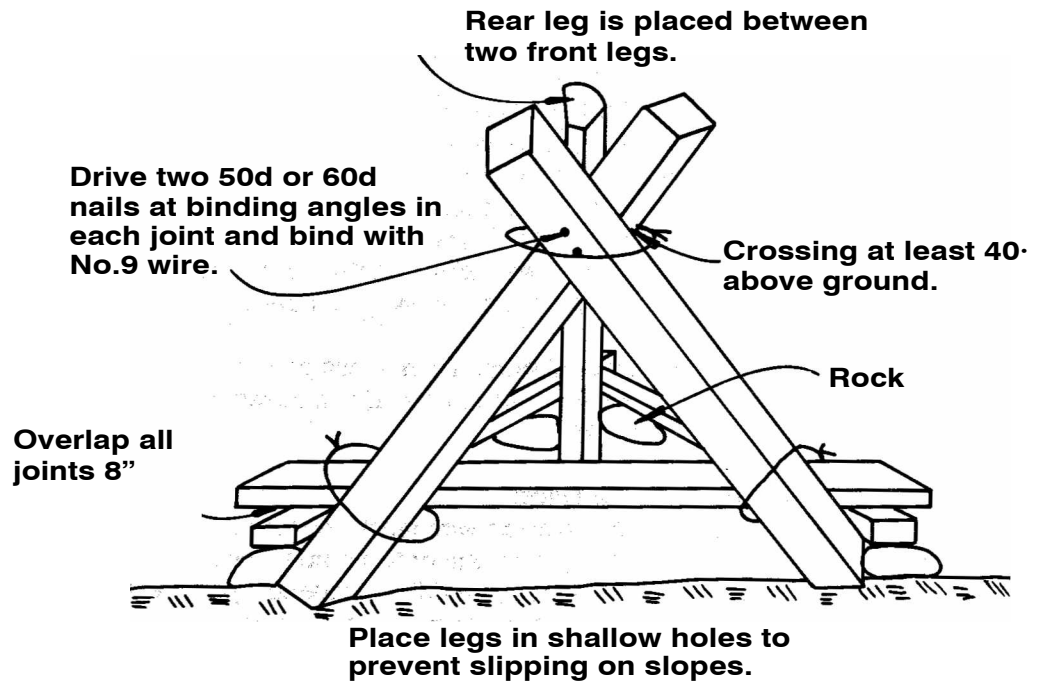
Application—Woven-wire fences are generally used to control livestock, such as sheep and goats. An effective fence consists of 26-inch woven wire hung 2 to 4 inches above the ground with one or two strands of barbed wire above the woven wire. Barbed wire above the woven wire is not necessary if sheep are on both sides of the fence. Woven-wire fences are suited for gentle and rough terrain but generally are not suited for snow country because heavy snow will pull the fence down.

Equipment—The equipment used for barbed-wire fences can be used for the construction of woven-wire fences, except that woven wire must be stretched as a single unit. This can be done by bolting two 2 by 4's together with the end of the woven wire between them to form a clamp. Bolts should be at 8-inch intervals and tightened to prevent slippage. The wire should be stretched reasonably tight, but not over-stretched, because the mesh will collapse. Staple both ways from the center of the stretched section to maintain equal tension between posts.

Materials—Materials needed for woven-wire fences are woven wire, barbed wire, posts, nails, staples, and 9-gauge galvanized smooth wire.

Specifications—The woven-wire fence should be constructed with 12.5-gauge-mesh wires and 10-gauge top and bottom wires and should be galvanized. Horizontal wires may be closer together at the bottom than at the top. Vertical wires are usually about 6 inches apart. Woven wire comes in 20-rod.(330-foot) rolls of different heights.

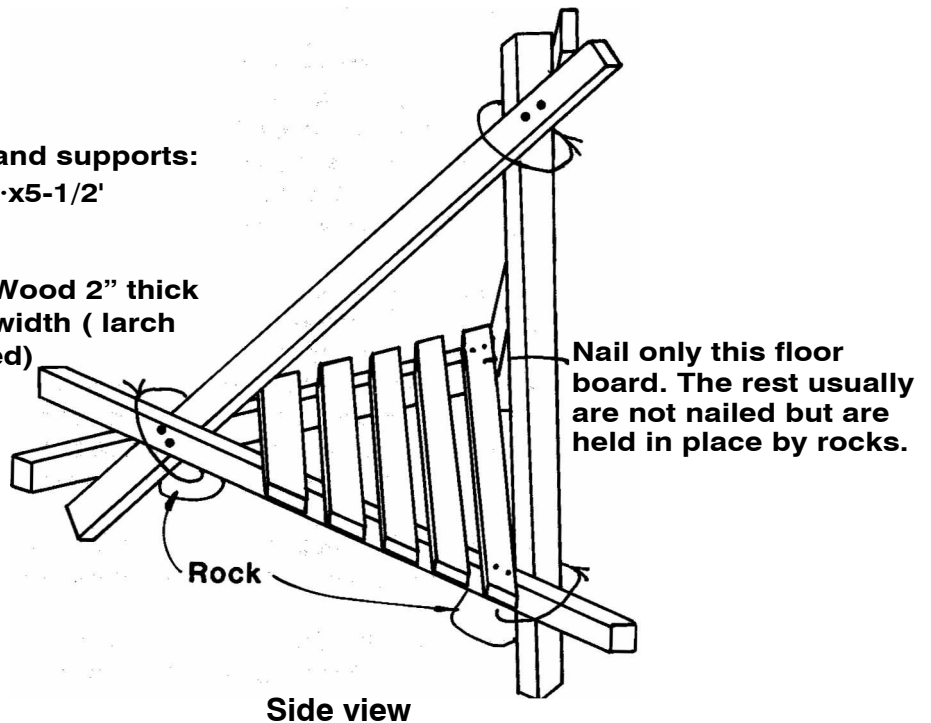
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Front view

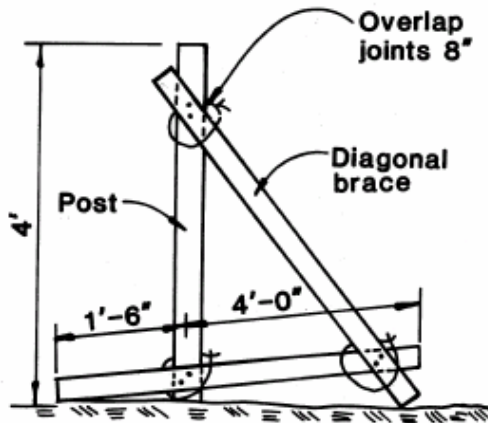
Jack legs and supports:
Six 3-x6-x5-1/2'

Floor:
Sound Wood 2" thick
by any width (larch preferred)

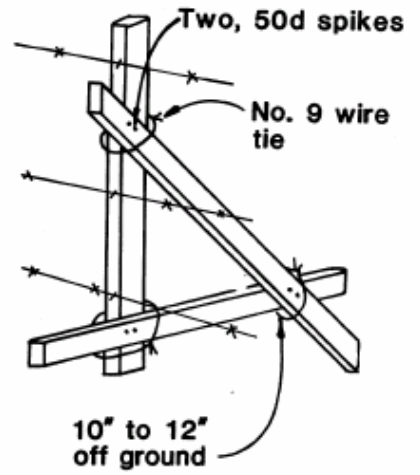


Side view

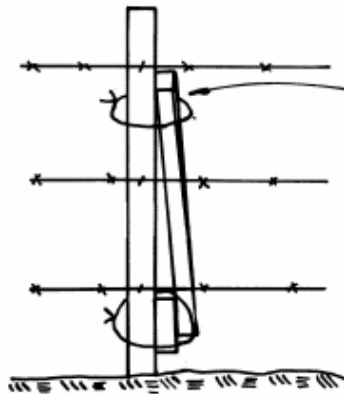
Figure 35-Construction details for rock-jacks used in fenceline. commonly called line-jacks.



Side view



Diagonal view

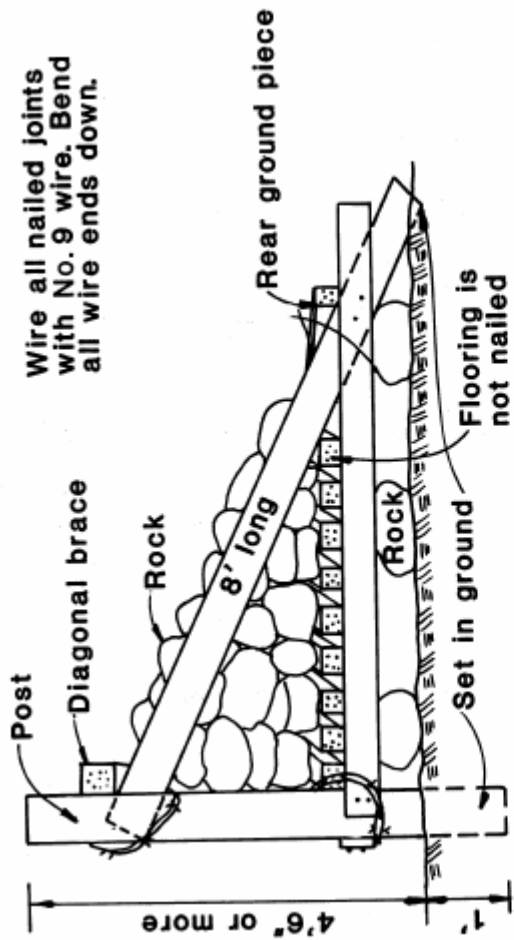


Use two 50d nails at each joint.
Drive nails at a binding angle.
No. 9 wire each joint.

Ground piece } 3"x6"x5'-1/2'
Diagonal brace }
Post 3"x6"x4'

Front view

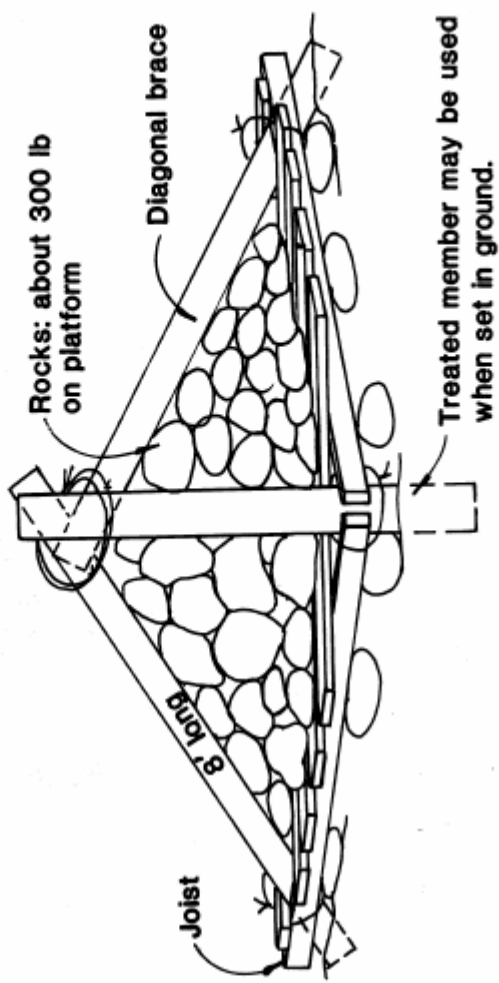
Notch joint for snug fit and to allow half of the nail length to be driven into or through each piece. Drive two 50d or 60d nails at binding angles in each joint and wrap with No. 9 wire. Diagonal braces are parallel with fence. Joists may cross and attach on the same side of post as diagonal braces. Corners wider than 90° may need additional braces and platform joists.



Side view

WOOD SPECIFICATIONS

Posts	5'-6" (4'-6" above ground)
Braces	8' long x 3" x 6"
Ground pieces and flooring (length varies)	3" x 6"
Joists	(length varies) 3" x 6"



Corner view

Figure 37—Construction details for rock-jacks used at fence corners, gates, and other locations, such as water gaps and support structures for let-down fences, where additional support is needed.

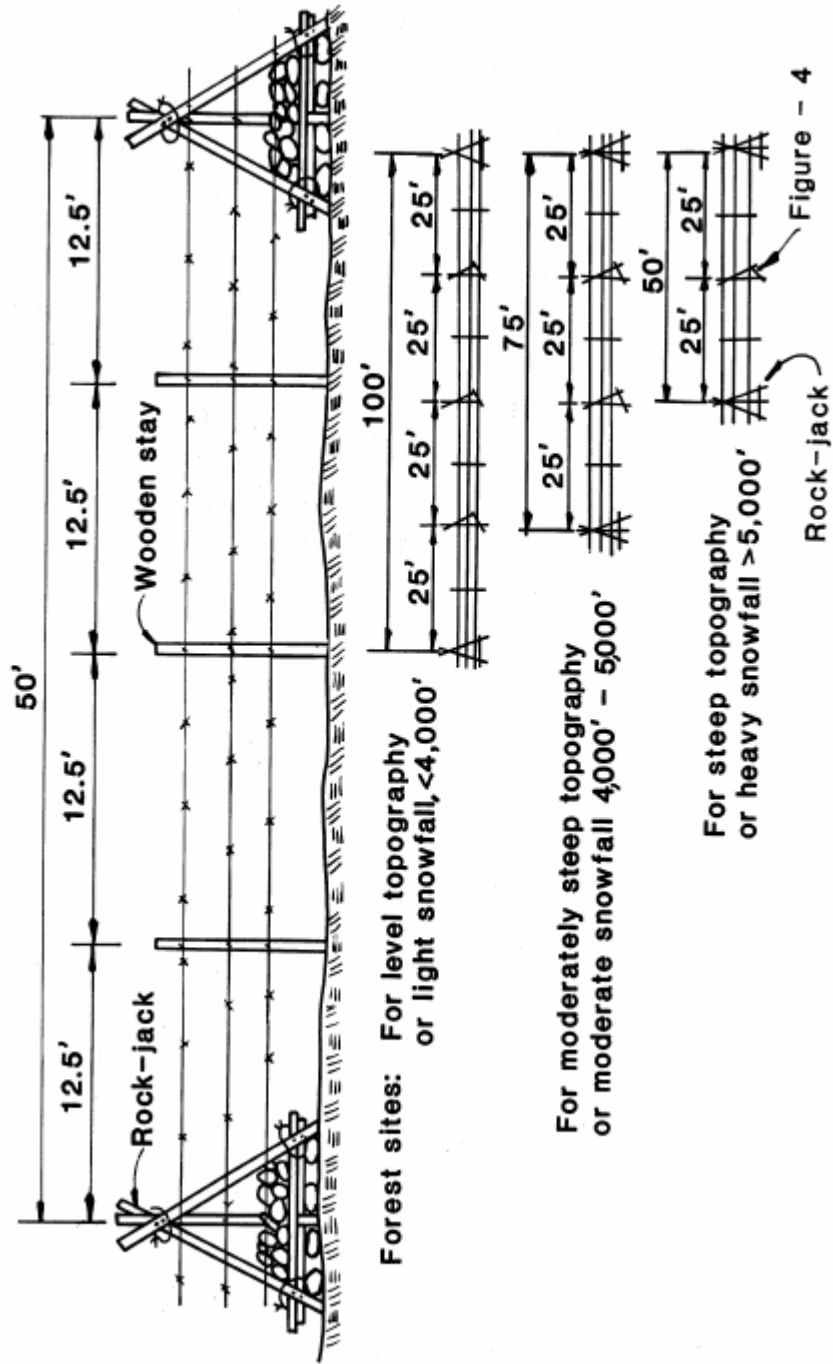
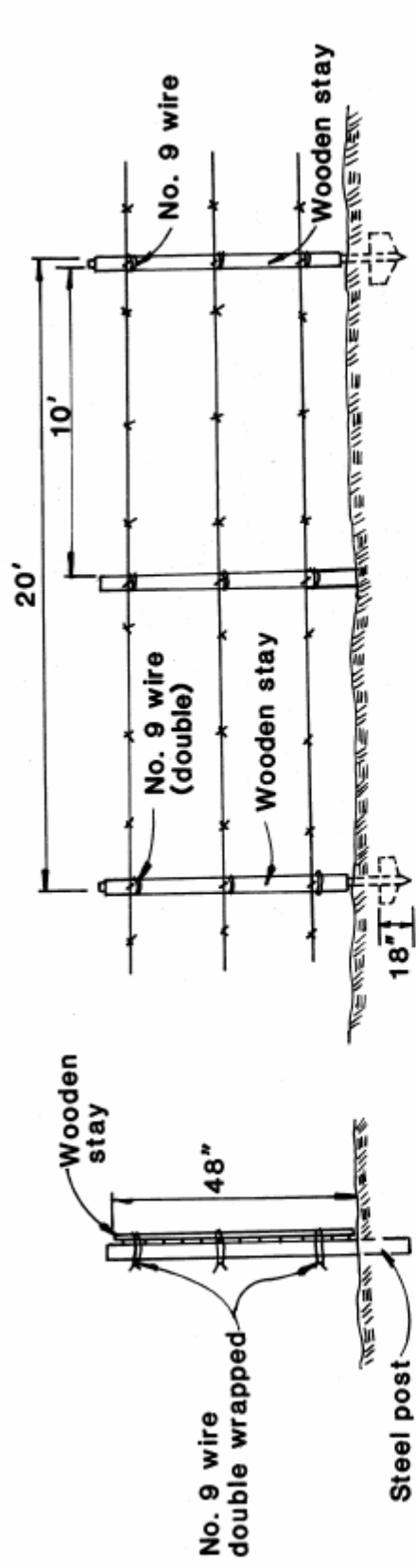


Figure 38—Spacing recommendations for fences that use rock-jacks and figure-4's in forest sites. Place additional rock-jacks at all abrupt breaks in topography.



Side view

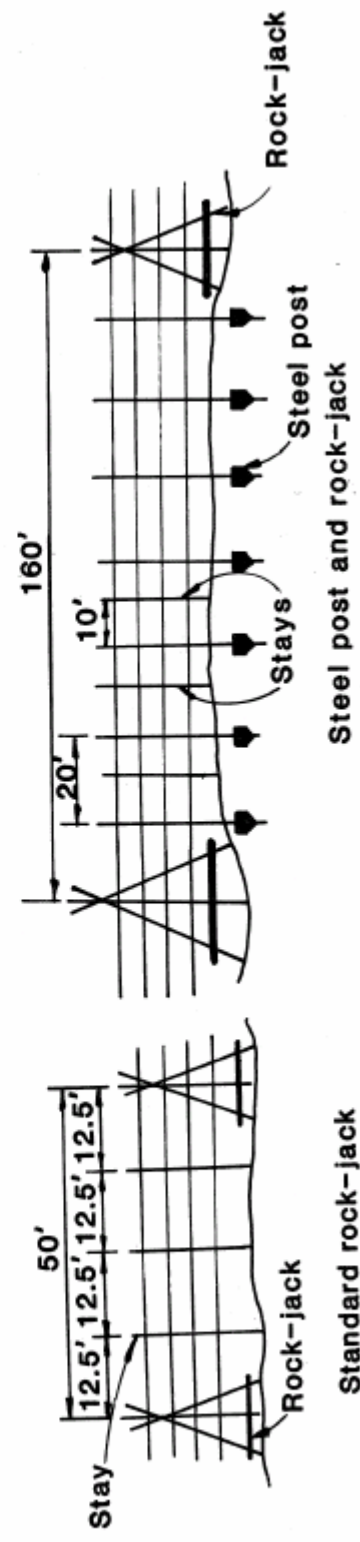


Figure 39—Wooden stays attached to steel posts are used to prevent the posts from settling into the ground under moderate snow conditions (steel-post and rock-jack spacing recommendations).

Standard 26-inch-high woven wire, hung 2 to 4 inches above the ground, should be used to control sheep. No barbed wire is necessary below or above the woven wire when sheep will be on both sides of the fence. If cattle or horses may be in the area, one or two strands of barbed wire are needed above the woven wire. Smooth wire is preferred for horses to prevent injuries. The space between the woven wire and the barbed wire, or wires, is critical for safe passage of wildlife. Special structures, similar to a cattle guard, are needed to allow antelope to pass through woven-wire fences. Posts should be spaced 16.5 feet apart; wooden stays may be needed in areas where snow may damage the fence.

Electric fences-

Description- There are two types of traditional electric fences.-single-wire and two wire. The hot wire, or wires, is supported by fiberglass posts or by insulators attached to steel or wooden posts. Posts are spaced 30 to 50 feet apart, depending on vegetation and topography. The single-wire fence uses one charged wire and uses the earth for the ground circuit. Both wires of the two-wire type may be charged, or only the top wire is charged and the bottom wire is used for the ground. The single-wire fence costs less, but also has the highest risk of failure. The two-wire fence (one charged wire and one ground wire-generally the lower wire) overcomes the disadvantages of the single-wire fence to complete the ground circuit on dry or rocky sites. Best results are obtained on moist ground by charging both wires separately with individual charging unit. This overcomes potential battery failures and provides maximum security.

A recent development in high voltage and high-tensile-strength smooth wire is a "permanent" New Zealand electric fence. High-tensile-strength smooth wire has also been used to construct nonelectrical fences. These types of fences have been installed in a few areas; however, we do not have any experience with them and have not included them in this handbook. Distributors of "New Zealand" fence material should be contacted to obtain specifications.

Application-Electric fences are most often used for temporary fences to control livestock on a nonpermanent basis. They have been used successfully to protect new seedings, plantations, construction sites, and research plots, and to temporarily divide meadows into smaller pastures. They are most effective on moist sites and least effective on dry, rocky sites. For the fence to be effective, vegetation should be kept from contacting the hot wire. Electric fences should never be built under high-voltage powerlines

Costs for other fencing techniques should be compared with costs for electric fencing. It may be cheaper, and perhaps more satisfactory, to install a standard three-wire, barbed-wire fence that can be used to permanently control distribution of livestock.

Equipment- The tools used to construct barbed-wire fences can be used for electric fences. Because these fences are temporary, it is not as necessary to clear the right-of-way beyond what is needed to keep the hot wire from being grounded.

Materials—Special electric fence wire may be used for electric fences; however, smooth 9-gauge wire or barbed wire may be preferred because it can also be used for later fence construction. If wooden or steel posts are used, insulators are needed to support the charged Wires. Fiberglass posts do not need insulators and are usually pushed into the ground by hand. Fence chargers, or circuit controllers, should be installed according to manufacturer's specifications.

Specifications—All electric fences should have signs securely attached to the top wire at frequent intervals to warn people that the fence is charged. Because of possible hazards to humans, electric fences should be used only in areas not frequented by visitors.

Buck-and-pole fences-

Description—Buck-and-pole fences have a scenic, rustic appearance and are constructed almost entirely with wooden poles.

Application—Buck-and-pole fences are suitable for administrative sites, camp grounds, wilderness, and other sites with high scenic values. These fences are also suitable for areas with high snow accumulation. They have a tendency to sink into the ground on very moist sites; however, and are recommended for drier, more rocky areas where the fence material, mostly pole-size trees, is readily available near the proposed fenceline. Buck-and-pole fences are generally more expensive to construct, but they require less maintenance than barbed-wire fences.

Equipment—Chain saws are needed to clear the right-of-way for buck-and-pole fences and for falling and trimming poles. Bucks and poles are usually cut on or near the construction site, and the bark is stripped off. Other equipment includes hammers and hand saws. A miter box with a 30° or 40° angle, constructed out of 2- by 10-inch lumber, is convenient to cut the correct angle to join the buck members.

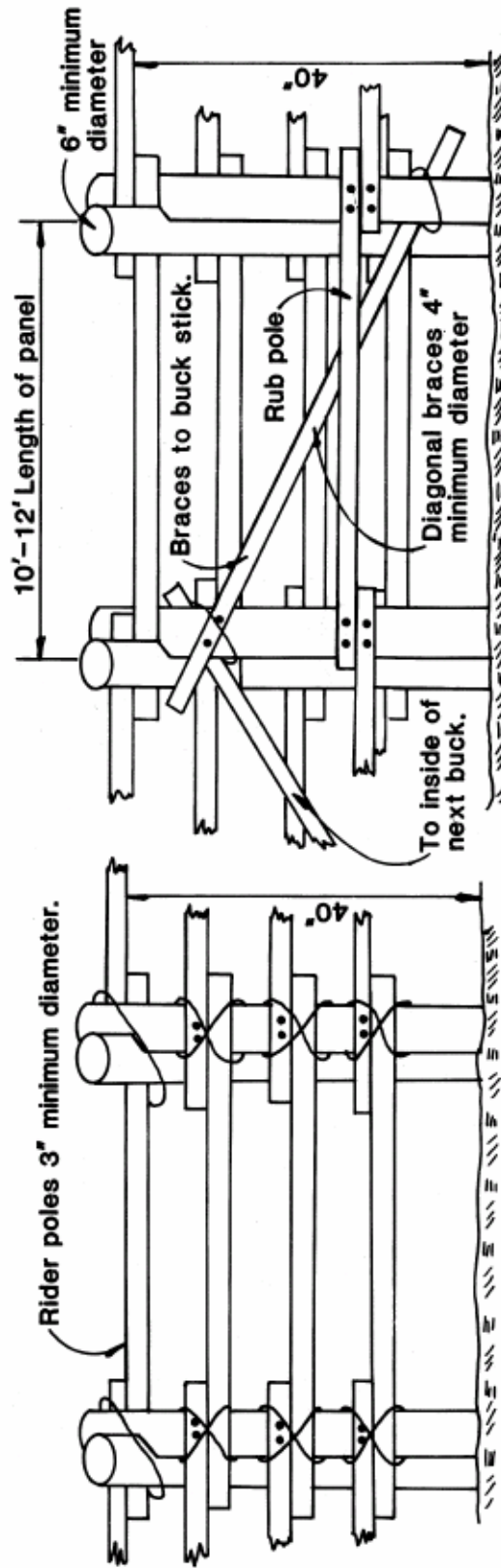
Materials—Well-seasoned lodgepole pine or yellow pine pole material is best for buck-and-pole fences, although other straight species, free of knots, are satisfactory. All material should be peeled or have the bark stripped from at least two sides for quick seasoning.

Specifications—Poles should be cut 12 feet long and have a minimum 3-inch diameter, which allows the bucks to be spaced 10 feet apart. Fir poles should not exceed 12 feet in length with buck spacing at 10 feet. Brace poles (4-inch-minimum diameter) should be placed on every fifth buck, except in steep or heavy snow areas where every panel may need to be braced (fig. 40). Buck sticks are mitered for a close fit and strength (fig. 41). The buck-and-pole fence can be modified for wildlife by using three instead of four poles per panel and reducing the total height (fig. 42). On exposed areas with severe winds, we recommend that buck sticks be spread farther apart (80°).

Log-worm fences-

Description—Log-worm fences are constructed with poles and treated wooden stays and have a zig-zag, or "worm," appearance because each section is at an angle to the previous section. The angle may vary, depending on the strength and stability needed—the sharper the angle, the greater the stability.

Text continues on page 59.



Notch and flatten poles to fit bucks with half of nail length in each.

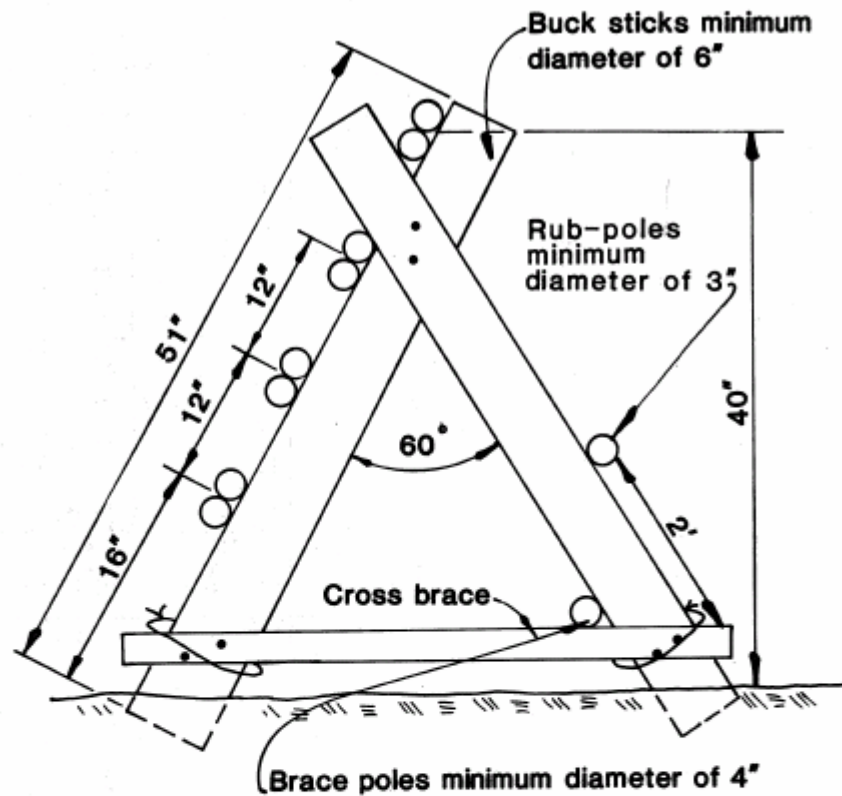
Rider pole detail

Double brace every fifth buck with one diagonal pole in two consecutive spans. Enclosures should be oval; avoid sharp corners. Brace all panels in heavy snow areas.

Drive two 60d nails at each joint and bind with No. 9 wire.

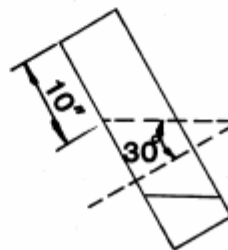
Brace and rub pole detail

Figure 40—Construction details for buck-and-pole fence—rider-pole and braces. All poles should be sound wood that is free of knots and has the bark stripped from at least one side. Brace all panels in areas with heavy snow conditions.



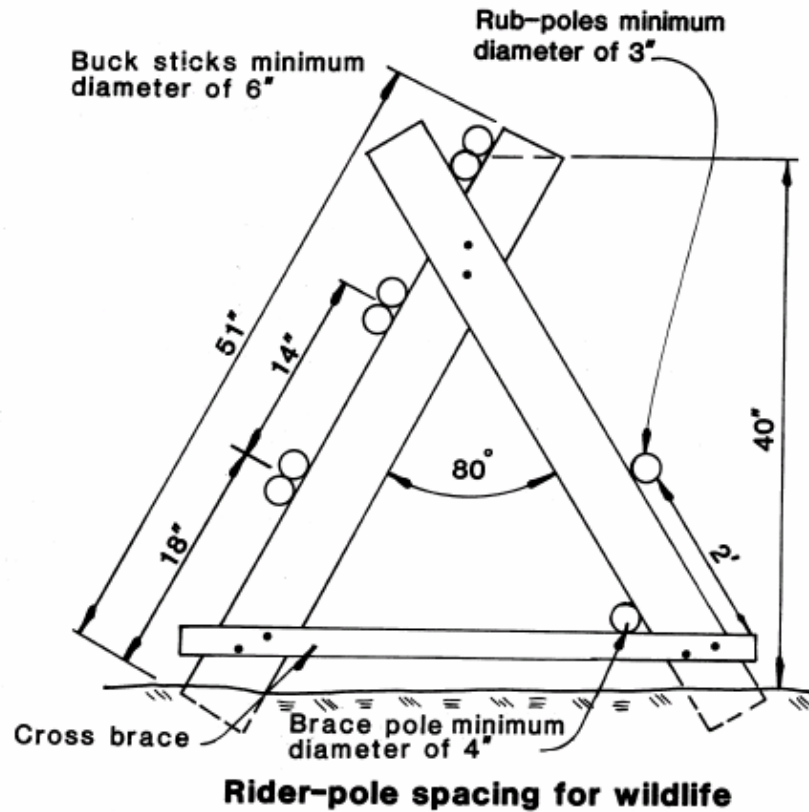
Rider-pole spacing for livestock

40° cut for fences that are subjected to severe wind. Both members are cut the same angle and should fit tight.

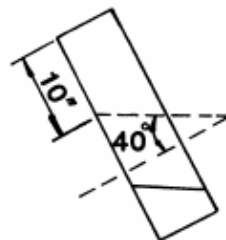


Buck stick detail

Figure 41—Construction details for buck-and-pole fence—rider-pole-spacing recommendations for livestock and detail for buck sticks. A cross-brace is needed to prevent the bucks from spreading in areas with heavy snow conditions.



30° cut for fences that are not subjected to severe wind. Both members are cut the same angle and should fit tight.



Buck stick detail

Figure 42—Construction details for buck-and-pole fence—rider-pole-spacing recommendations for wildlife and detail for buck sticks where fences are subjected to severe wind. A cross-brace is needed to prevent the bucks from spreading in areas with heavy snow conditions.

Application—The log-worm fence is well suited for areas of high snow accumulation and timbered sites. These fences are rustic and are also used for administrative and recreation sites. Maintenance cost is very low, and the fence lasts a long time when it is properly constructed. Log-worm fences can be a barrier to young deer and elk, and care should be taken in selecting locations for long stretches of this fence. Sections of wire let-down fences may be necessary to allow free passage of big game, especially on migratory routes.

Equipment— The equipment needed for log-worm fences is similar to that used in constructing buck-and-pole fences. No miter box is needed, but tools are needed to dig post holes and to cut wire.

Materials—Seasoned lodgepole pine logs are preferred, although other species may be used, including split larch rails. Bark should be stripped from two sides of logs to hasten seasoning. Logs with minimum taper are best; logs should be at least 6 inches in diameter and up to 18 feet long. All tie wires should be 9 gauge and galvanized. Treated wooden stays with a minimum 4-inch diameter or treated 4 by 4's are needed to support the logs.

Specification—Log-worm fences are usually at least 5 feet high. Rocks should be used to keep the bottom logs off the ground. Spans are generally 12 to 14 feet, with 2 feet extending beyond the crossing point. Spans may be longer, depending on the diameter of the logs and the snow depth. As the snow depth increases, larger material is needed to support the heavier snow load. Stays should be treated wooden material at least 4 inches in diameter and buried 18 inches in the ground (fig. 43). Smooth 9-gauge galvanized wire is used to hold the stays together; it should be looped twice around and twisted to tighten.

Block-and-pole fences-

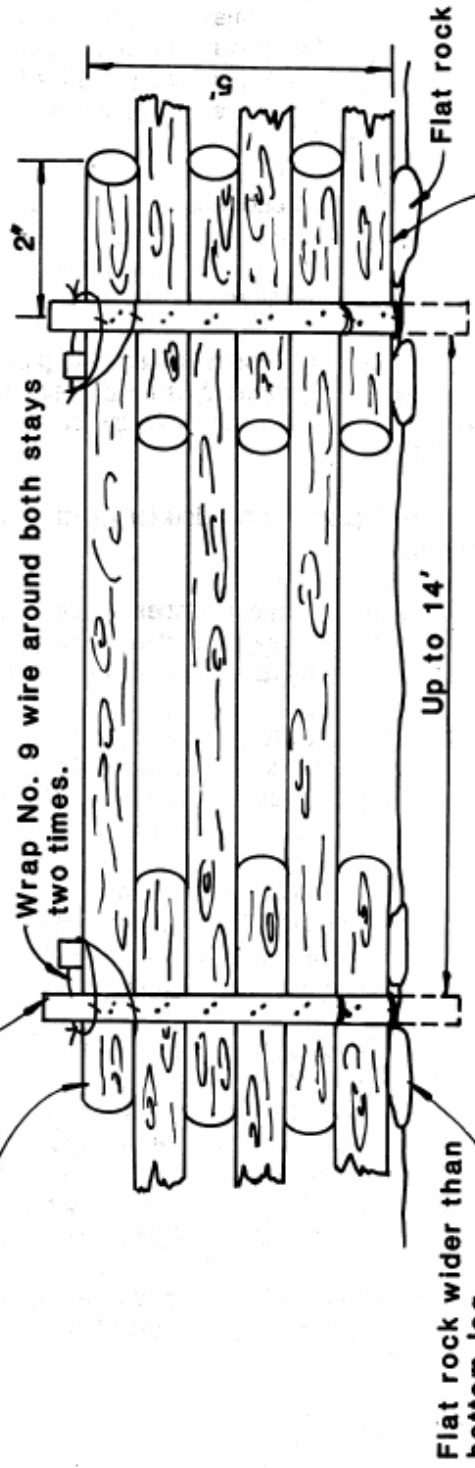
Description—The block-and-pole fence is similar to the log-worm fence, except that short (2-foot) fence sections are at right angles to the main sections and the material is usually larger. These fences are relatively maintenance free and have a rustic appearance.

Application—Like the log-worm fence, the block-and-pole fence can be used in areas of deep, drifting snow and where appearance and durability are important. Availability of materials on site is an important concern because large poles and rocks are needed.

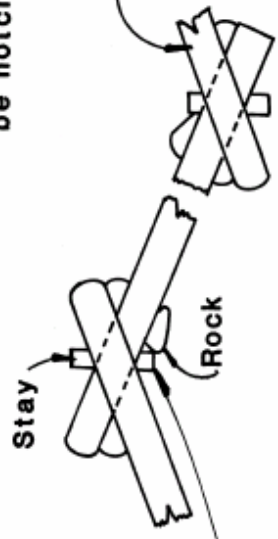
Equipment— The size of the material needed for block-and-pole fences necessitates the use of hoisting equipment capable of handling large logs and rocks; also needed is the equipment used for constructing log-worm fences.

Materials—Logs used for constructing buck-and-pole fences should have at least an 8-inch diameter; larger logs are preferred. Span lengths should not exceed 12 feet. Treated stays are needed to support the logs, and large rocks are used to keep the bottom logs off the ground. Nine-gauge galvanized wire is used to tie the stays together.

Double spike logs together with 60d ringed nails.
 Wooden stays 4"x4" treated post - bury it 18" in the ground.
 Double-spike stays to logs; notch logs to allow stays to fit flush to logs.



6" above ground, log may be notched to fit rock.



Staple No. 9 wire to stays.
 Cradle top log on wire, wire top log down.

Use poles with 6" minimum diameter. Place largest poles on bottom, with large end downhill.

Flat rock wider than bottom log.

Flat rock

Figure 43-Specifications for log-worm fences.

Specifications—For block-and-pole fences, logs with a minimum diameter of 8 inches and a length of 10 to 14 feet are needed. Longer fences require larger diameter logs. Stays should be treated posts buried at least 18 inches in the ground with a minimum diameter of 4 inches (fig. 44). The blocks must be level and have a minimum span of 2 feet to prevent the fence from tipping over. The largest logs are used for the bottom tiers and the smallest logs for the top tiers. Logs should fit snugly. The top log should be tied securely to the block with No.9 galvanized wire.

Log-crib fences-

Description—The log-crib fence is similar to the block-and-pole fence in construction; however, smaller material may be used. The log-crib fence does not have a block section; instead, it has a series of log spans usually forming a square or rectangle to protect a water source.

Application—Log-crib fences are used to protect relatively small areas, such as a bog, a spring, or a pond used as a water source; small structures; or an enclosure. They need little maintenance. Because of the small area enclosed, deer and elk are usually excluded.

Equipment—Equipment needed for log-crib fences is the same as that used for log-worm fences.

Materials—Logs for log-crib fences should have a minimum diameter of 6 to 8 inches and be of suitable length for the site to be enclosed; treated stays with a 4-inch-minimum diameter, 9-gauge wire, and 60d nails are also needed.

Specification—Logs for log-crib fences may be as long as 22 feet; longer spans must be supported midspan with blocks (fig. 45). Log-crib fences are generally square, but other shapes may be more suitable, depending on the site to be protected. These fences have no gates.

Gates

Description—Few fences can fill management objectives without gates. Gates help to organize the movement of livestock and provide access for vehicles, employees, and other users. Gates are usually constructed from the same material used for the attached fence, but manufactured metal gates can be used.

Application—Gates should be planned at each location to provide needed access for livestock, people, or equipment. Gates are generally located at trail crossings, at roads used infrequently, and adjacent to cattle guards. Gates should be considered for each one-half mile of fenceline, at major ridgetops, at saddles, and near the bottom of all major draws or valleys to facilitate moving livestock. The type of fence does not generally change the plans for locations of gates, but does have a dramatic impact on the selection of the appropriate gate to be constructed.

Equipment—The tools needed to construct the gate are the tools used for the fence. If commercial metal gates are installed, transportation and lifting equipment may be needed.

Text continues on page 64.

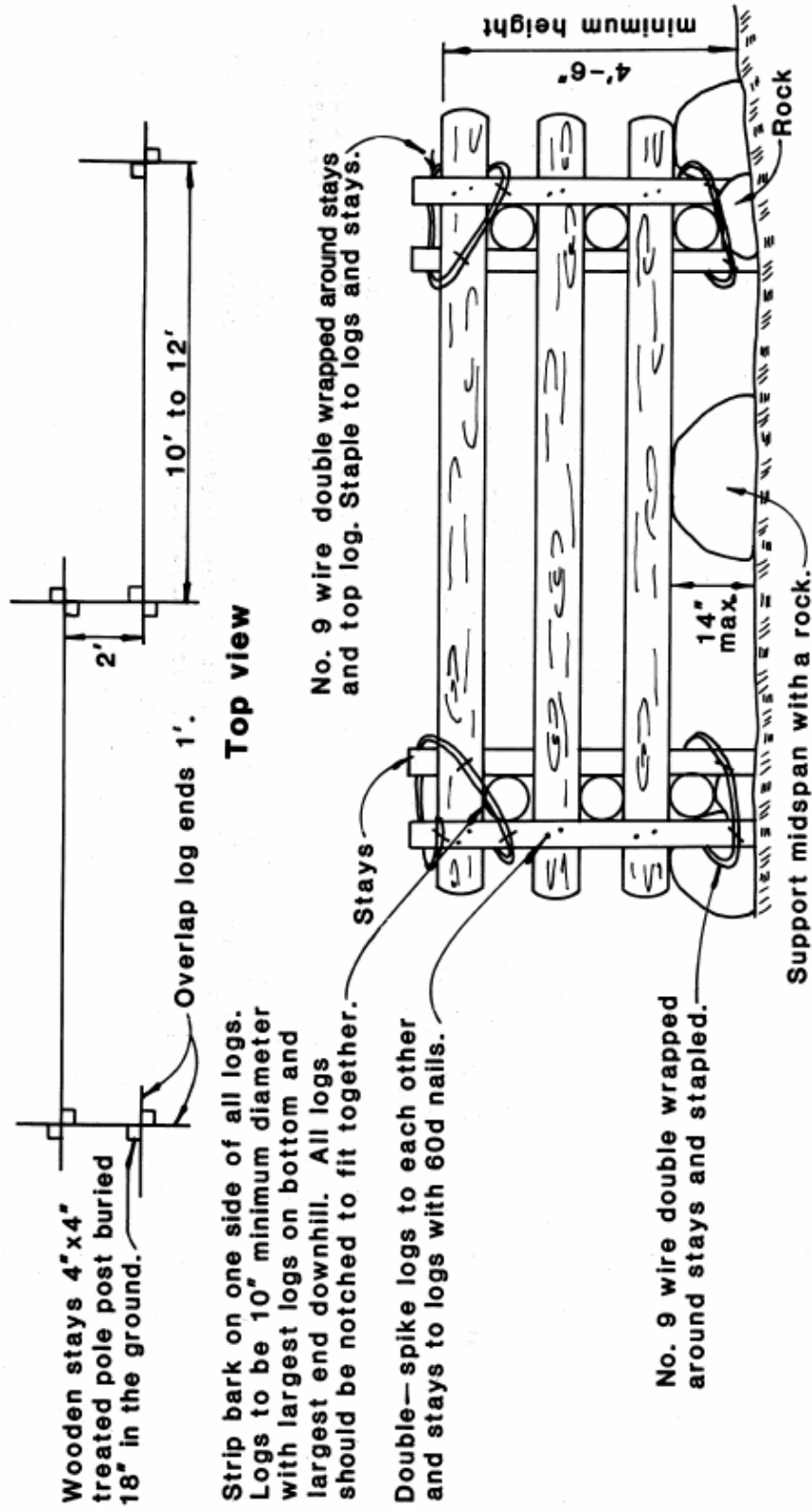
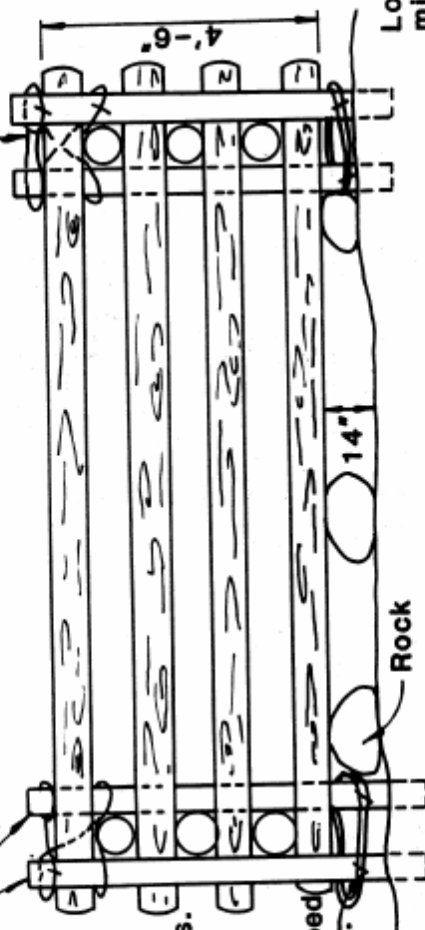


Figure 44—Specifications for block-and-pole fences.

No. 9 wire, double wrap around stays. Cradle top logs on wire and wire top log down. Staple wire to stays.

Span length 18' maximum. If more than 10' use midspan blocking shown below.

Wooden stays 4" x 4" treated posts buried 18" in ground

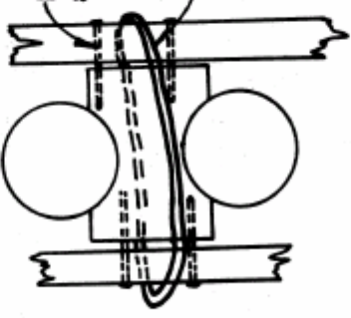


Double spike logs together, use 60d ringed nails. Nail stays to logs.

No. 9 wire, double wrapped around stays and staple.

Logs to be 6" d.b.h. minimum at small end. Place largest logs on the bottom, large end downhill. Overlap log ends 2'. Strip bark on one side of all logs. Notch all logs to fit together.

Double spike block to stays and logs with 60d ringed nails.



No. 9 wire double wrapped around block and stays and staple.

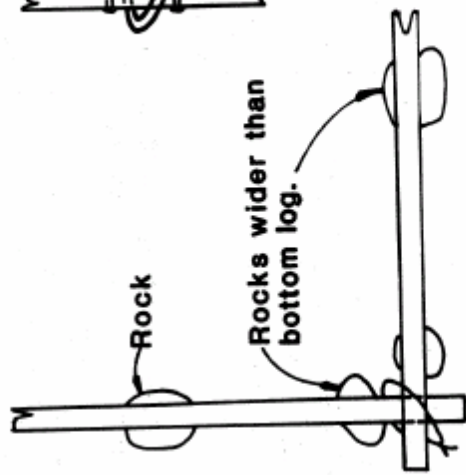


Figure 45—Specifications for log-crib fences. The fence may be three-sided if the length of the span is 10 feet or less.

Materials—The materials used in constructing the fence are also used for the gate; generally 9-gauge smooth wire, barbed wire, wooden stays, brace posts, corner-rock-jacks, and fence panels or poles. Commercial metal gates may need special hinges, latches, and supports that require welding equipment or concrete.

Specifications—Specifications for gates depend on the location and use of the gate. Gates on roads must be large enough to allow passage of vehicles and heavy equipment expected on the road and are generally slightly wider than the road. Gates for livestock range from 8 to 16 feet, generally whatever is convenient to construct. Gates at trail junctions must be wide enough to allow horses to pass safely.

Gates that will be used frequently should swing and be constructed of metal, poles, or boards. Gates used less frequently may be constructed with barbed wire and wooden or wire stays (fig. 46). Pole-wing gates provide easy access because the gate can be swung in either direction and from either end depending on the end the panel is pivoted on and the direction the panel is swung (fig. 47). Vertical three- or four-pole gates can be used for buck-and-pole fences (figs. 48 and 49). Select the appropriate gate for the location and plan the fence corner posts accordingly. Signs with the appropriate wording for closing the gate may be attached.

Cattle Guards

Description—Cattle guards are a convenient means of providing control of cattle and at the same time unimpeded access for vehicles. Painted cattle guards—stripes applied across paved highways that simulate a physical barrier—are effective in controlling livestock, if the livestock are accustomed to metal cattle guards. On unimproved roads, cattle guards are metal structures. Metal cattle guards are constructed over a pit, with treated timbers, concrete, or rock on either side; the ends are open for drainage. The pit must be periodically cleaned out to prevent debris from accumulating below the grates. Gates should be constructed next to cattle guards to provide for livestock access and wildlife. Double cattle guards, placed 150 feet on either side of a fence crossing, can be used to discourage livestock from congregating on a road (fig. 50).

Application—Cattle guards are needed on paved and improved roads frequently used by the public, especially where gates are not appropriate or may be accidentally left open during the grazing season.

Equipment—Earth moving equipment such as backhoes, front-end loaders, or bulldozers are needed to prepare the site for metal cattle guards. Lifting equipment is needed to place cattle guards on the foundation. Concrete-mixing equipment may be needed, depending on the foundation specified. Wrenches and other appropriate hand tools are needed for assembling the cattle guard and attaching it to the fence. Painted cattle guards need appropriate tools to apply the paint or striping material and to construct the end-barriers.

Materials—Metal cattle guards are manufactured and the end-barriers are generally provided to connect the cattle guard to the fence. Treated timbers or concrete are used for the foundation. Painted cattle guards require a high-quality paint or striping material resistant to highway traffic and lumber to construct end-barriers.

Text continues on page 70.

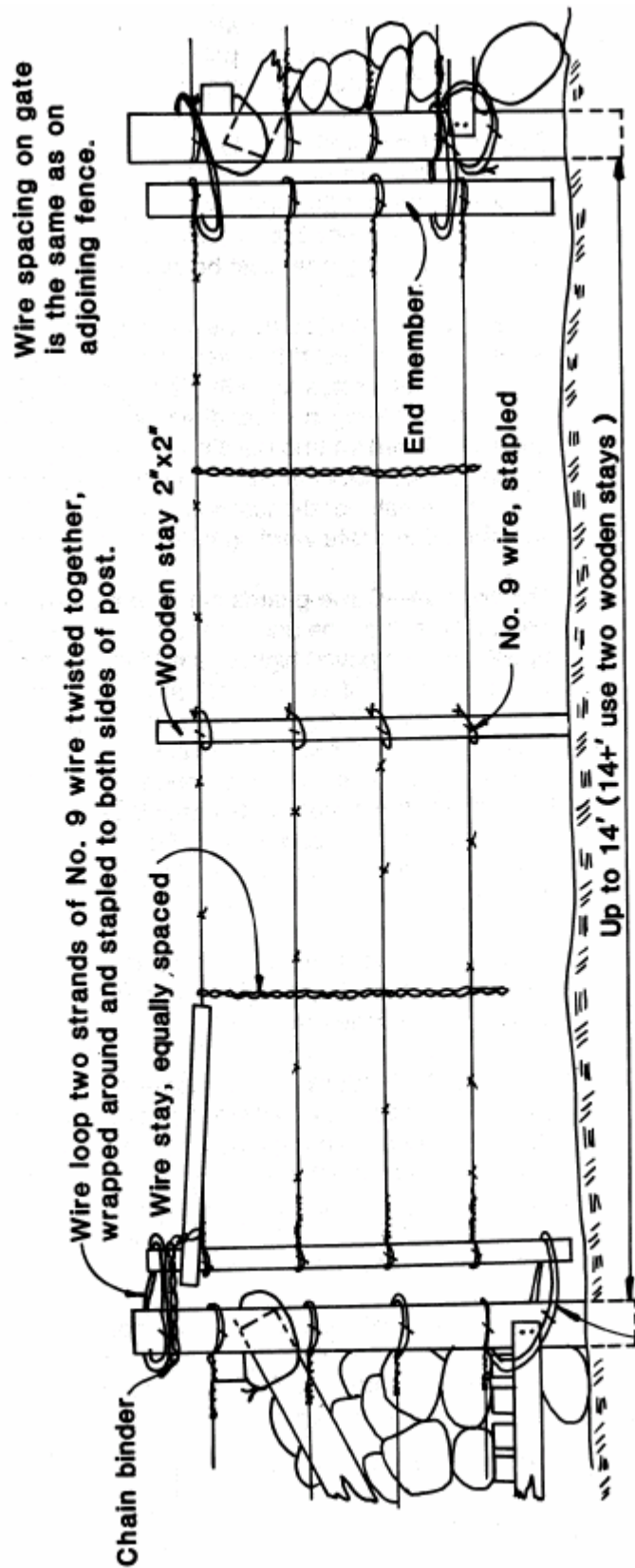


Figure 46—Specifications for standard wire gates. Recommended gate width: 12-16 feet in fenceline, 18-22 feet at roads and cattle guards. Chain binder: handle—3 feet by 3 inches in diameter; welded chain—12-16 inches long by 1/4 inch in diameter. Fasten to handle with no. 9 wire; nail to the post.

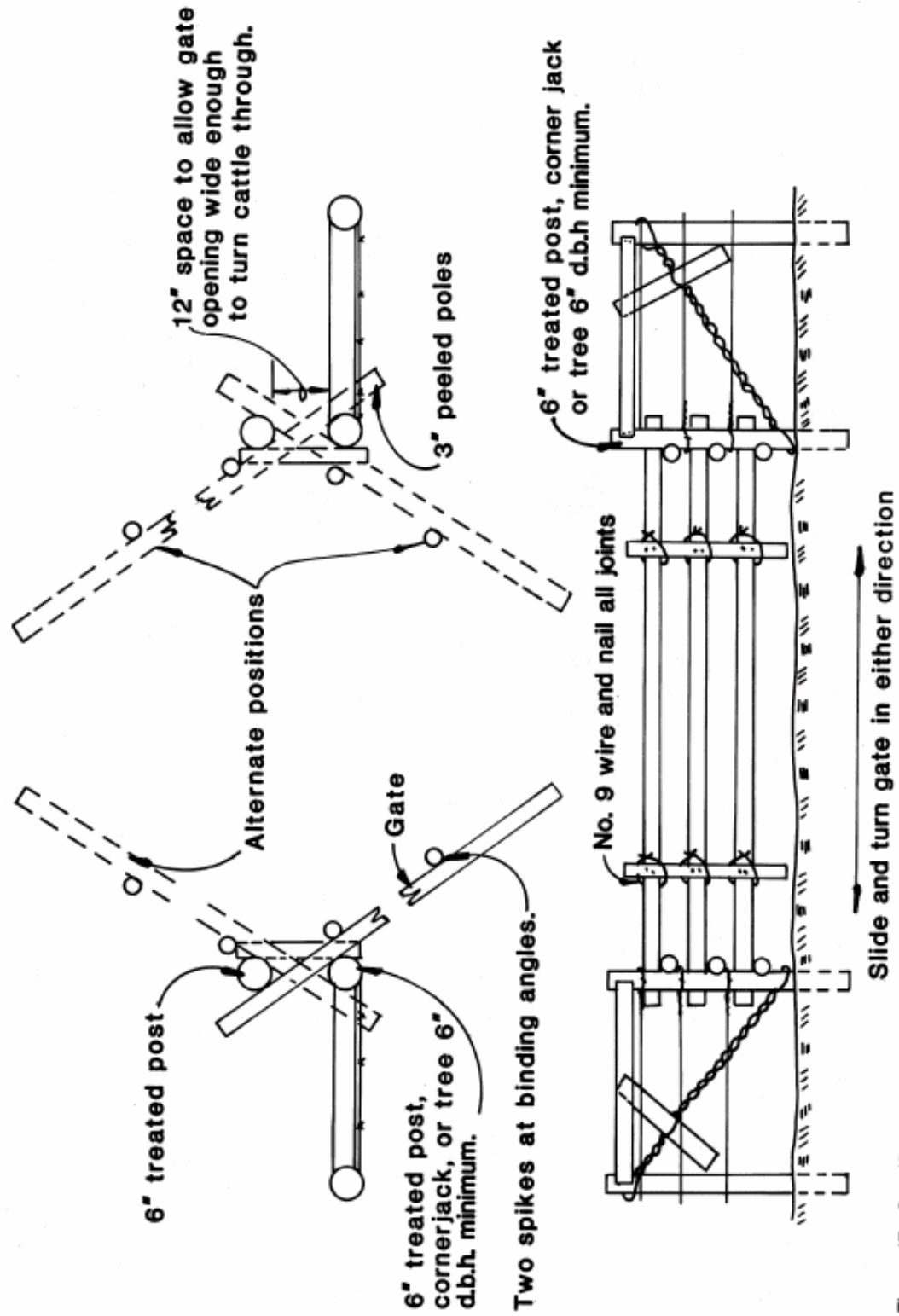
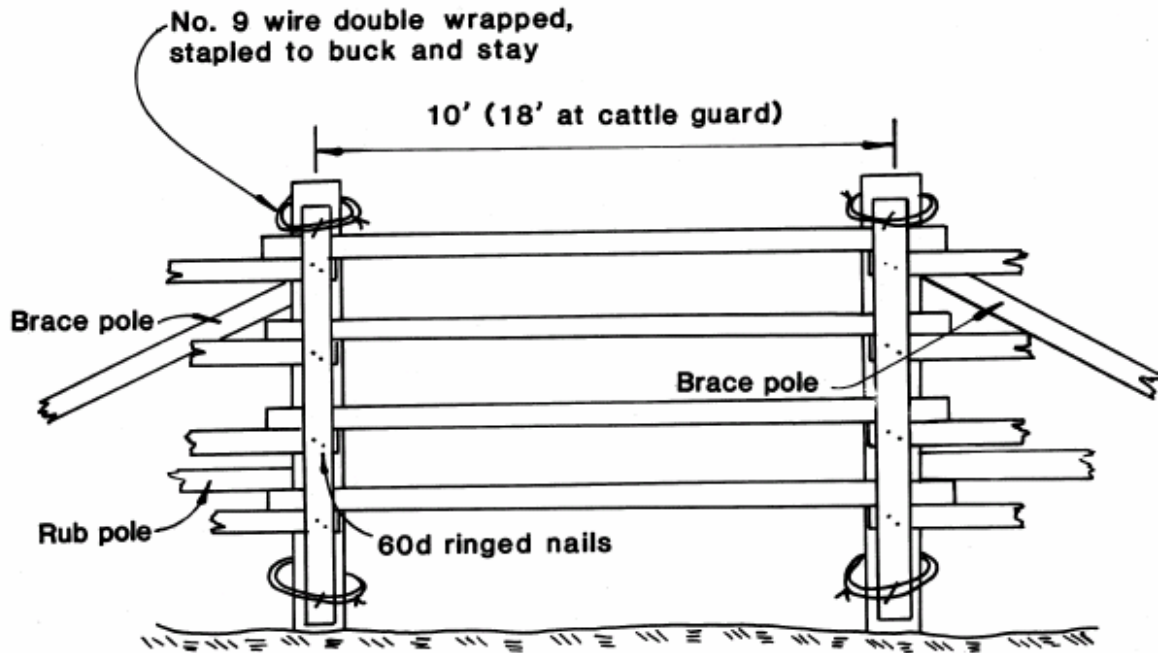
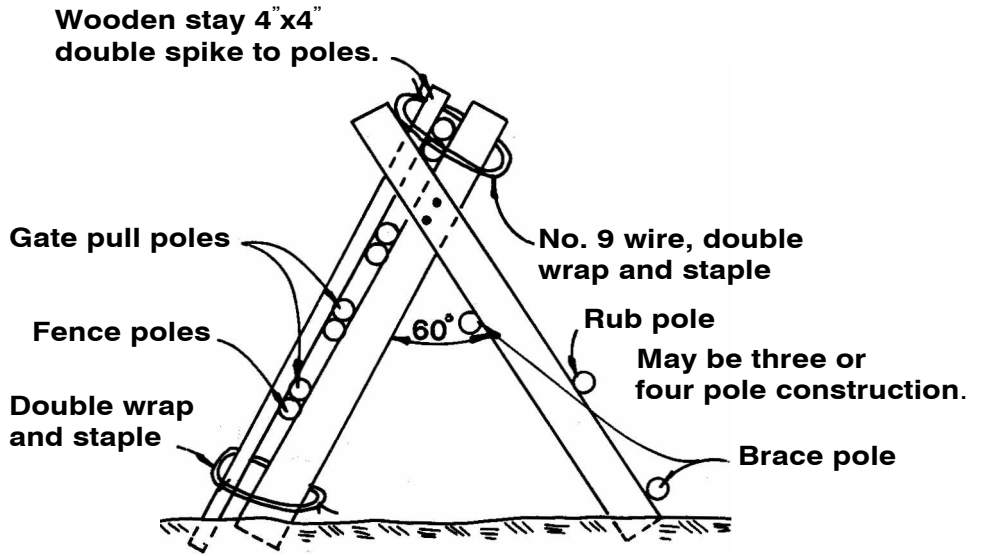


Figure 47—Specifications for pole wing gates. Gates are designed to open from either end and swing in either direction to aid in moving livestock through the opening.



Gate poles are slightly smaller in diameter than fence poles to allow gate poles to slide freely

Figure 48- Specifications for buck-and-pole gates

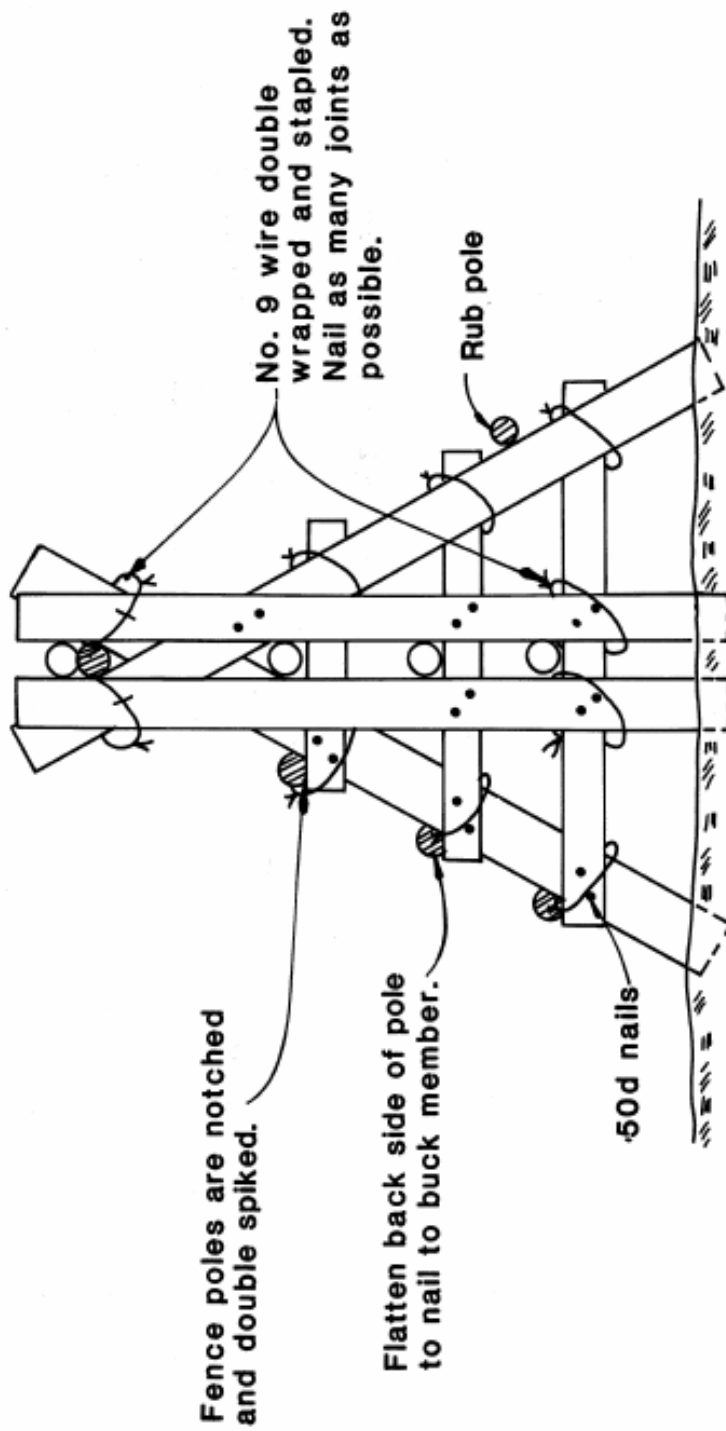


Figure 49—Alternate gate specifications for buck-and-pole fences. A four-pole fence is shown; simple changes can be made to accommodate three-pole fences.

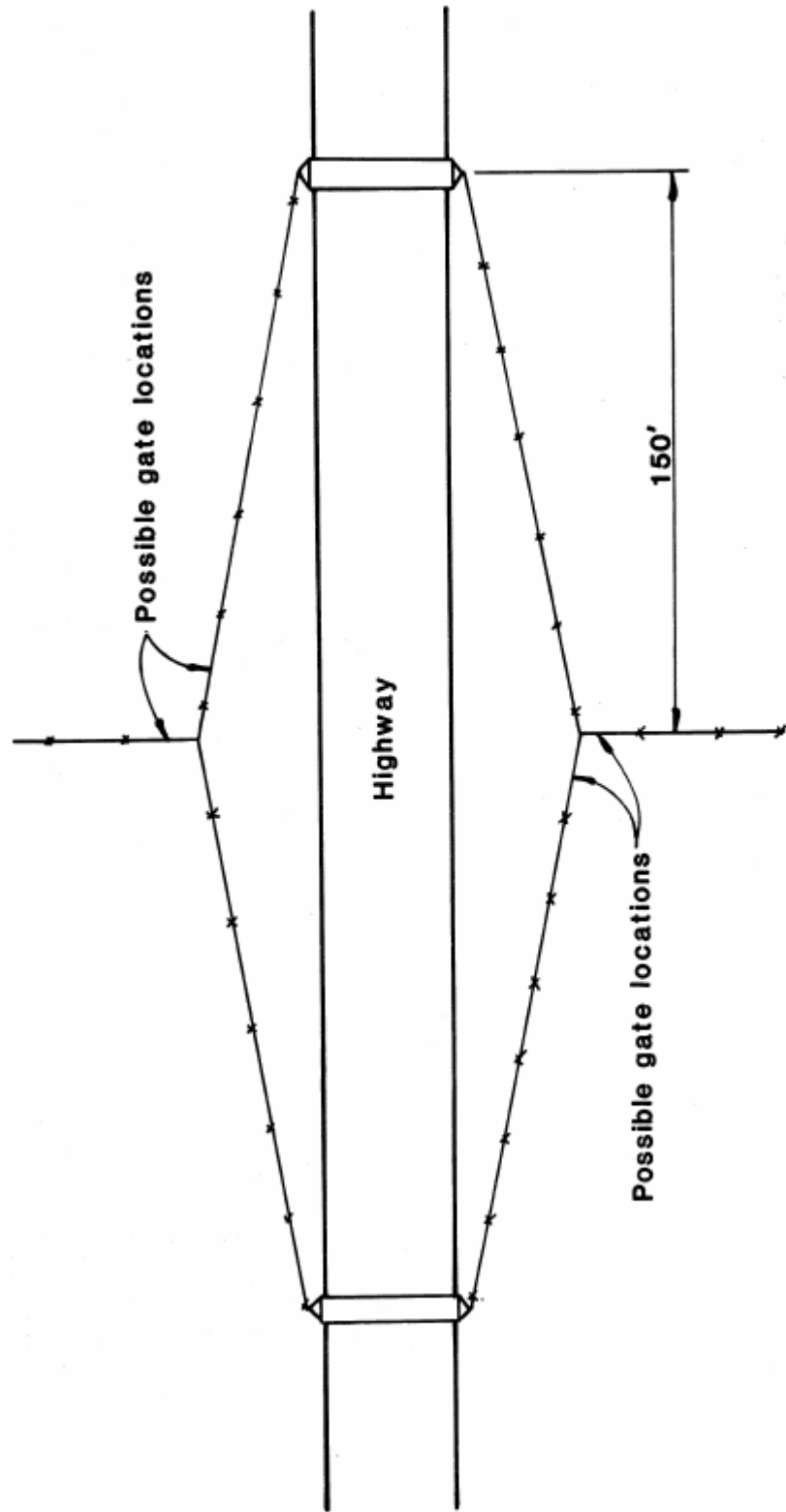


Figure 50.—Double cattle guard layout is designed to prevent livestock from becoming a traffic hazard at cattle guards.

Specifications—Metal cattle guards must be designed to support heavy vehicles such as loaded log trucks. Cattle guards below the road grade, usually the result of new construction, can be raised by using treated timbers (fig. 51).

Painted cattle guards should go all the way across the paved surface. A minimum of eight painted 6-inch-wide strips with 6-inch-wide unpainted stripes are required (fig. 52). Wooden end-barriers are used to connect the painted stripes to the fence and must be painted white and marked with reflectors (fig. 53). A gate should be constructed close to all cattle guards.

Stiles

Description—Stiles, fence ladders, or similar structures are designed to provide safe crossings of fences for hikers and to reduce the damage to barbed-wire fences caused by people climbing over and through the fence. These structures, however, require strict maintenance or they soon become a hazard.

Application—Stiles or fence ladders should be considered wherever people frequently cross barbed-wire fences for access to streams and where trails are intersected by a fence.

Equipment—Hand saw, hammer, and fencing pliers are needed for constructing stiles or fence ladders.

Materials—Materials needed are treated posts or other suitable treated lumber, 9-gauge smooth galvanized wire, and nails. All materials should be sound and stout to provide a sturdy structure.

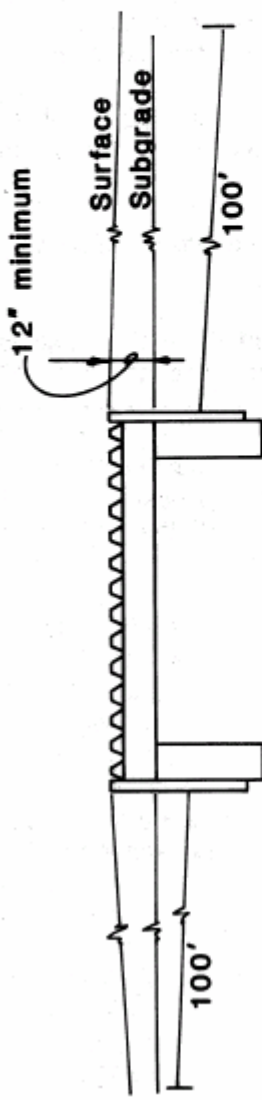
Specifications—The top step of the crossing structure needs to be just above the top line of the fence. A treated post should be buried 12 inches in the ground and should extend 30 inches above the top of the fence to provide a hand hold (fig. 54).

Water Developments

Development of water sources for livestock is usually a high-priority item in any range management system. Water helps to distribute the livestock for efficient use of the available forage. Pastures should be carefully explored to locate all potential water sources, and water developments for livestock should be balanced with the available forage supply. Areas with sparse forage production should be carefully considered to justify the costs of water development projects. On the other hand, we recommend that water developments be at least 0.5 mile apart, even in areas with high forage production. There are always exceptions, especially where forage is plentiful and water is scarce, but water developments should be carefully planned.

The quantity of water an animal needs depends on weather conditions and food consumed. Generally, 12 to 15 gallons a day are required for cattle and horses and 1 to 1.5 gallons for a ewe and a lamb. All livestock in the same pasture often seek water at nearly the same time; therefore, adequate water should be provided for their total daily needs during a 2-hour drinking period. Flowing water can be combined with stored; for example, a pasture with 800 cows and calves needs 12,000 gallons of water a day. If the source delivers water at the rate of 1,000 gallons an hour, 10,000 gallons should be stored and 2,000 gallons delivered during the hours stock are drinking.

Text continues on page 75.



Install on same grade as road.

Cut existing end boards flush with top of existing foundation timbers.

Secure new timbers to existing foundation with 3/4" diameter drift pins.

Secure cattle guard with 3/4" x 6" lag bolts.

Install new end boards with 20d galvanized nails.

All lumber should be pressure treated.

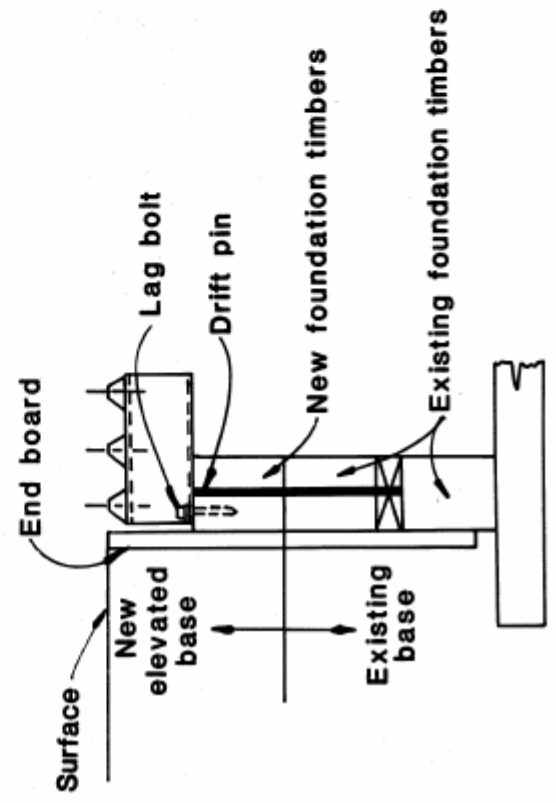


Figure 51—Details for raising cattle guards.

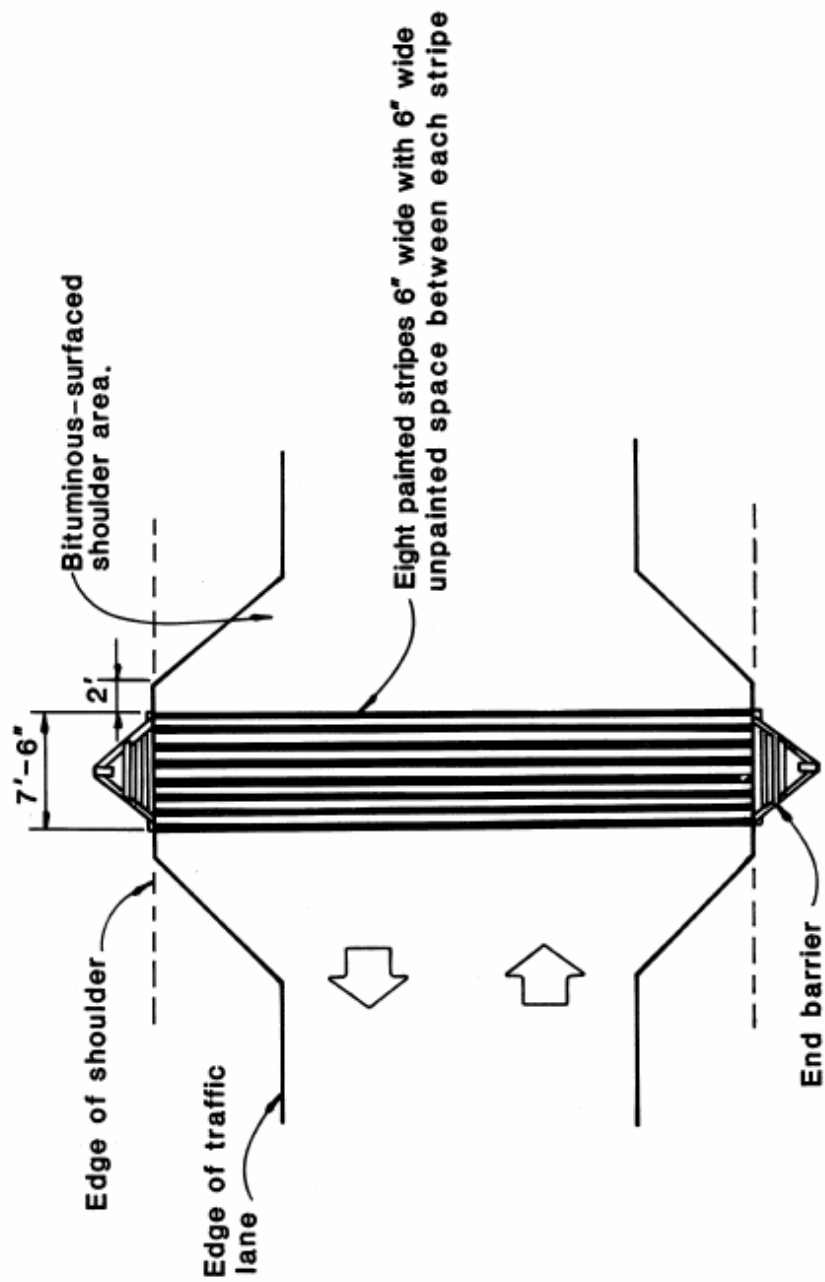
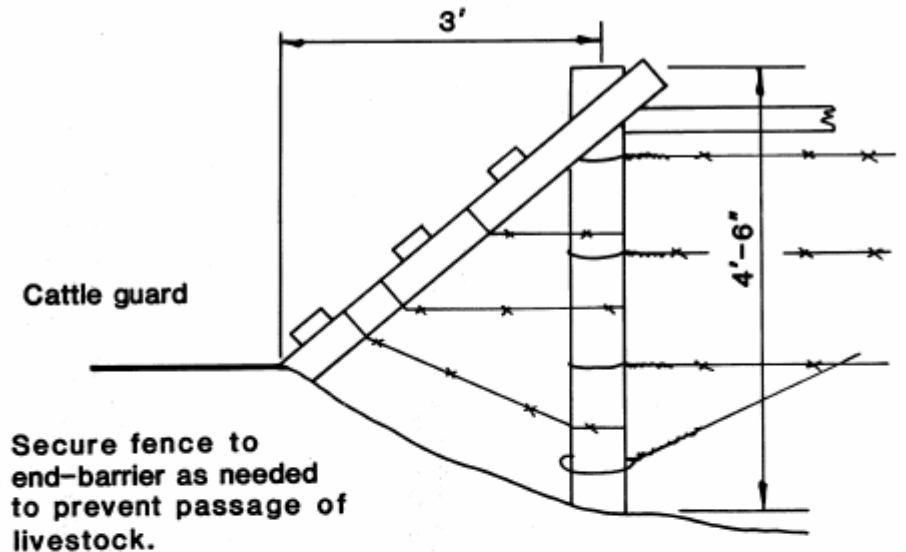
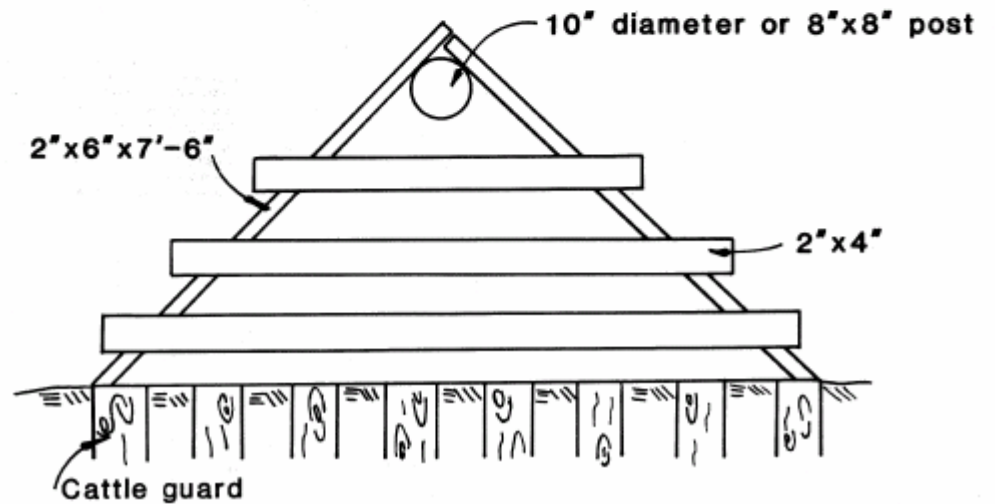


Figure 52—Specifications for painted cattle guards.



Side view



Top view

Wooden end-barrier should be painted white with paint that will adhere to treated wood and marked with white reflectors.

Figure 53-Details for wooden end-barriers used to connect a cattle guard with a fence.

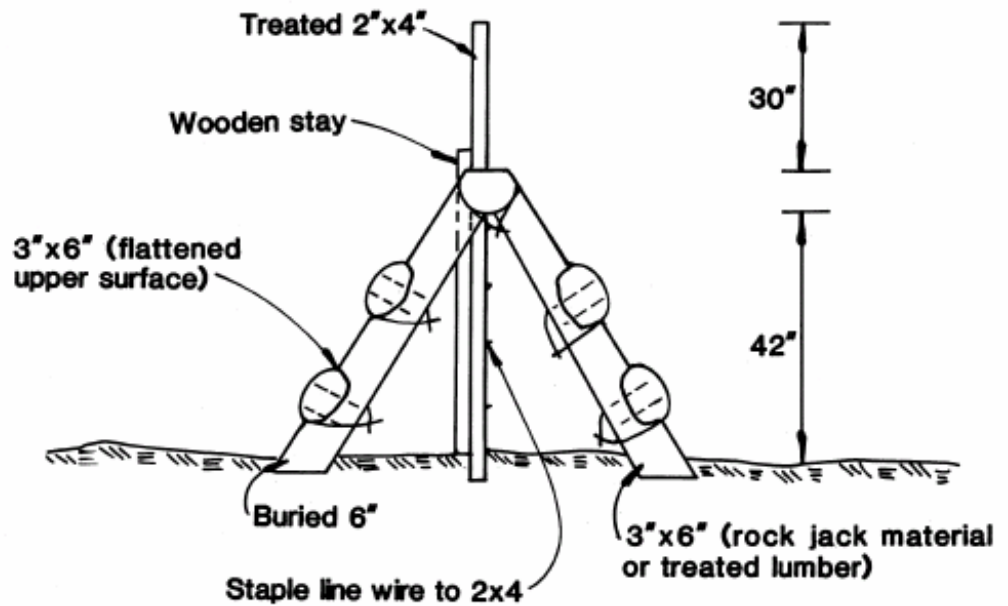
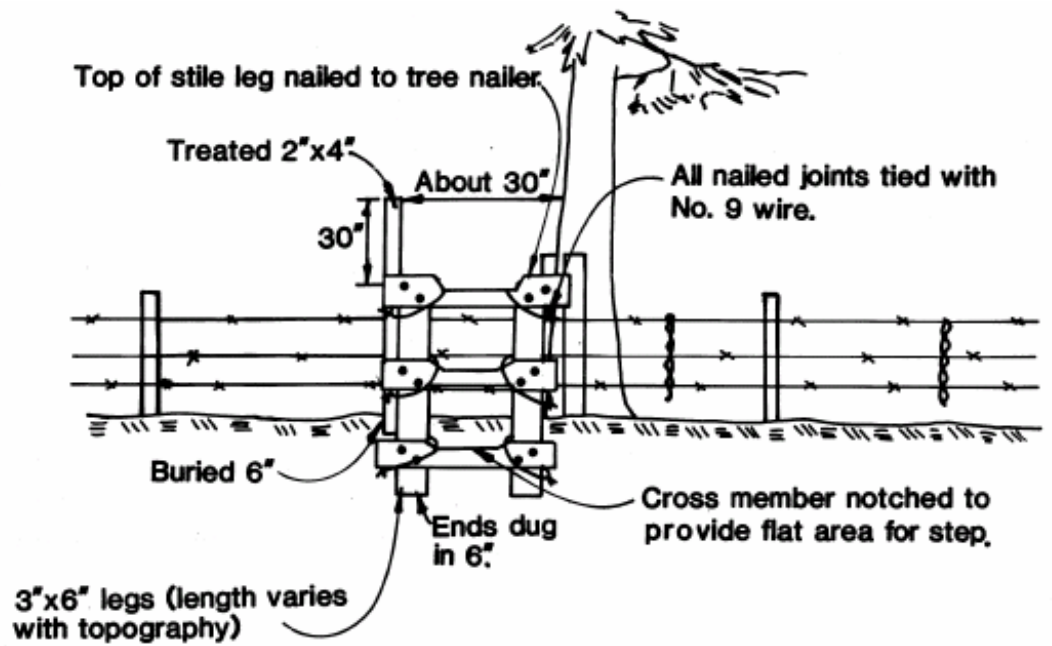


Figure 54-Specifications for fence stiles.

Water developments should be planned to provide access for cattle within 0.5 mile in rough terrain and 1 mile in rolling or level terrain. For sheep, distances can be greater (1 mile in rough terrain and 2 miles in rolling or level terrain).

Water developments use water sources such as springs, ponds, trick tanks, and wells. The selection of one type instead of another is related to site considerations, aesthetics, costs, accessibility, livestock pressure, proximity to other sources of water, and season of use. Careful planning and selection of types of water developments will ensure safe, clean water for livestock.

Some water developments can be made more effective by expanding them with plastic or galvanized pipe and troughs. Costs should be compared with those for other types of water improvements and State water laws should be investigated before development.

Spring developments-

Description—Geologically, springs used to develop stock water are two types, gravity and artesian. There are three classes of gravity springs: depression springs—the ground surface drops below the water table; perched or contact springs—the ground water is collected on an impervious stratum and surfaces on the side of a hill; and fractured and tubular springs—the water emerges from impermeable rock strata through fractures, joints, bedding planes, or solution tunnels. Depression springs are mostly intermittent and depend on seasonal rain or snow. Contact, fracture, and tubular springs are more dependable than depression springs. Artesian springs result when water enters a permeable stratum at a higher elevation than the outflow. This water is channeled downward between two impervious strata and surfaces under pressure (fig. 55).

Spring developments typically consist of a water collection system, either above or below ground; a storage system; and a water distribution system. Where the water supply is adequate, the storage system is incorporated into the collection system, distribution system, and water troughs, including the storage capacity of the pipe (fig. 56).

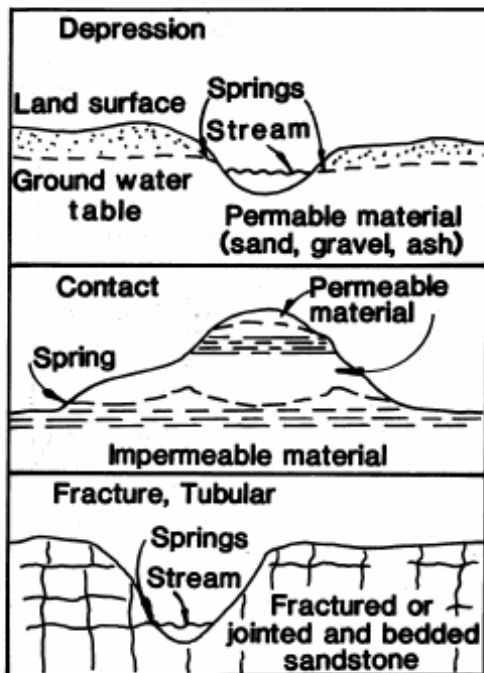
Each spring development depends on the water source, rate of flow, and the quantity of water needed, as well as available forage, slope, ecosystem, proximity to roads, wildlife use, and accessibility to equipment. The water collection system is usually fenced to protect the area from livestock, and the water is piped to the watering, or utility, area.

A detailed diagram should be made for all spring developments to facilitate maintenance.

Application—*Spring* developments are applicable in any area where water is limited, but they generally are not less than 0.5 mile from another source of water.

Equipment—The equipment needed to develop springs depends on the site. In many cases, only hand tools are needed, but backhoes may be needed at springs requiring excavation or where more than a few feet of pipe are to be buried. Some developments may need concrete-mixing equipment.

Gravity Springs

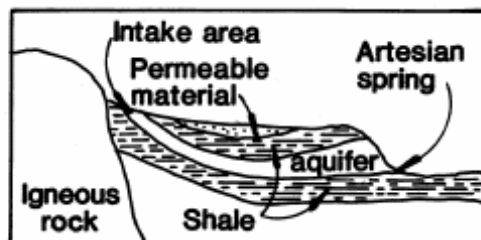


Land surface intercepts water table. Spring may be intermittent.

Contact springs are more permanent than depression springs.

Water supply is more dependable than depression water supply.

Artesian Springs



Outflowing occurs under some pressure at the ground surface.

Figure 55-Types of springs.

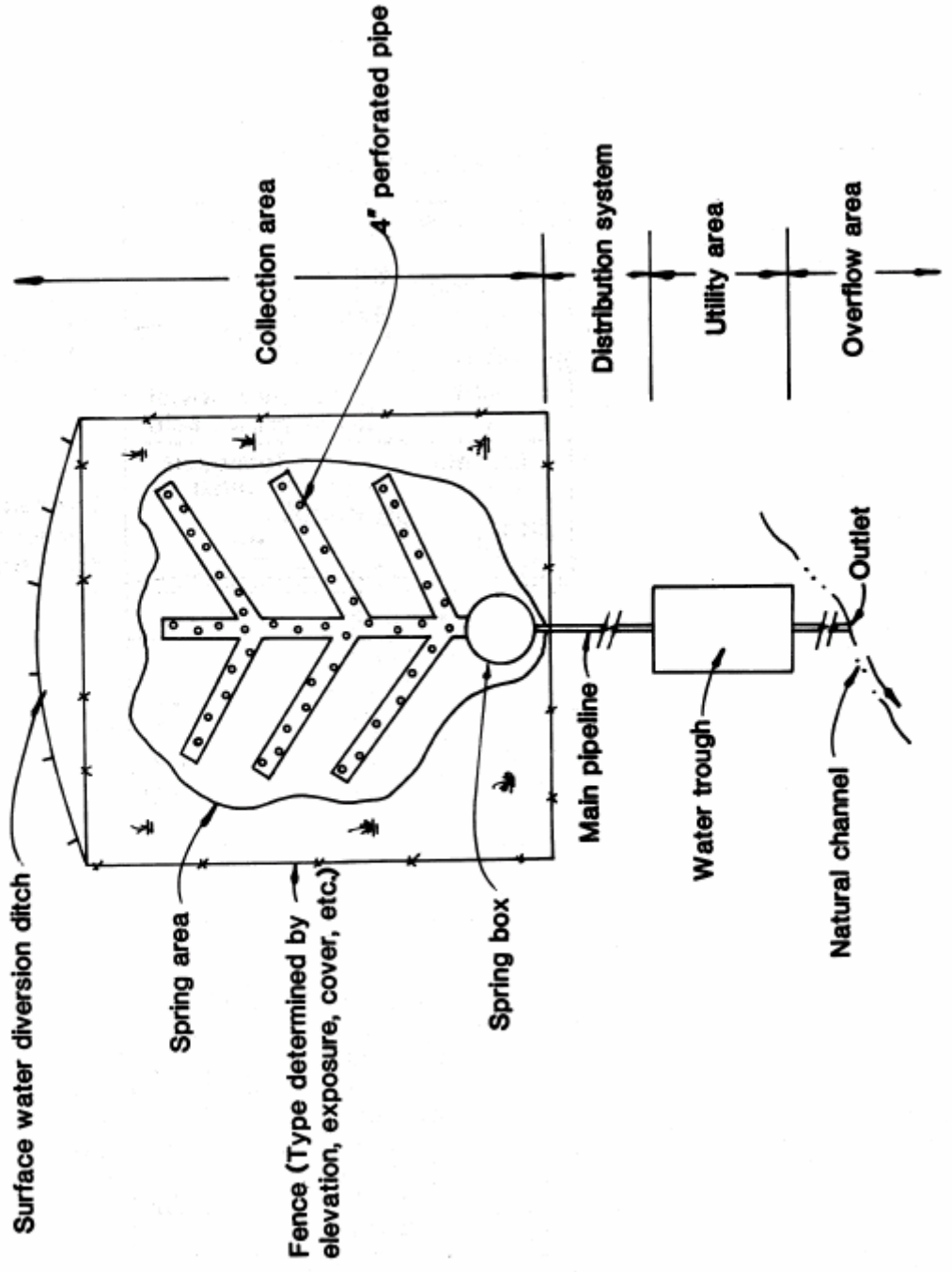


Figure 56—Diagram of a typical spring development.

Materials—Depending on the spring development, materials may include 1.5-inch plastic or galvanized pipe, 4-inch-diameter perforated tile or plastic pipe, pipe fittings, storage tank, treated posts, fence wire, gravel, 2-foot-diameter metal culvert 2 to 5 feet long, 2.5-foot-diameter 0.25-inch-thick steel plate to cover spring box, concrete, and bentonite.

Specifications—

Water collection system-Water can be collected from a surface ditch, but it is better to dig to firm ground, hardpan, or rock to obtain maximum flow. Perforated tile or plastic pipe or unglazed open-joint tile buried in a trench with 1.5- to 3-inch clean gravel may also be used to collect spring water where the source cannot be located (figs. 57 and 58). If the source can be located, the water can be collected directly into a spring box (fig. 59). Sealing the downhill side of trenches with plastic or bentonite may be necessary to divert more water into the spring box.

Some spring developments do not need spring boxes, and the water goes directly into the distribution or storage system (fig. 60). The collection pipe is coupled directly to the outlet pipe by a reducer. In some cases a "no-hub" coupler may be needed if the proper reducer is not available, especially when 4-inch tile is used to collect the water (fig. 61).

Spring box-Generally, the water is concentrated into a headworks, or spring box, that can be opened periodically for inspection and maintenance. Spring boxes may be concrete, galvanized metal, or other durable material and should always be covered (figs. 62 and 63). The water supply line leaving the spring box should have an air vent to prevent siphoning (fig. 64). Spring boxes are best buried and the location marked with a steel or treated wooden post for maximum protection from livestock and human activity. Burying spring boxes also prevents contamination from debris and small animals falling into the water, vegetation from growing in the water, and injury to livestock or people.

So that all the available water is captured, a soil dam of impervious material, such as bentonite, should be constructed just below the spring box or the water collection area (figs. 57 and 60). A union should be placed in the outlet pipe, about 1 foot from the spring box and below the bentonite-soil seal, to facilitate maintenance or replacement of either the spring box or main pipeline.

Fencing the source of water is usually desirable where the ground is wet or boggy, or the water must be collected by tile, drains, or other means. Log-crib fences are an effective in fencing water sources and need little maintenance (fig. 45); however, if the water comes from a single source and if the spring area itself is not subject to trampling, the area may be covered rather than fenced. Boggy areas that are typically damaged by trampling of livestock should be entirely fenced.

Treating springs to increase yield is a technical job requiring knowledge of hydrologic engineering and geology. It should be undertaken only with the advice of experienced and competent specialists, particularly in an attempt to increase the flow by blasting. This procedure appeals to many, yet it usually results in reducing the flow rather than increasing it.

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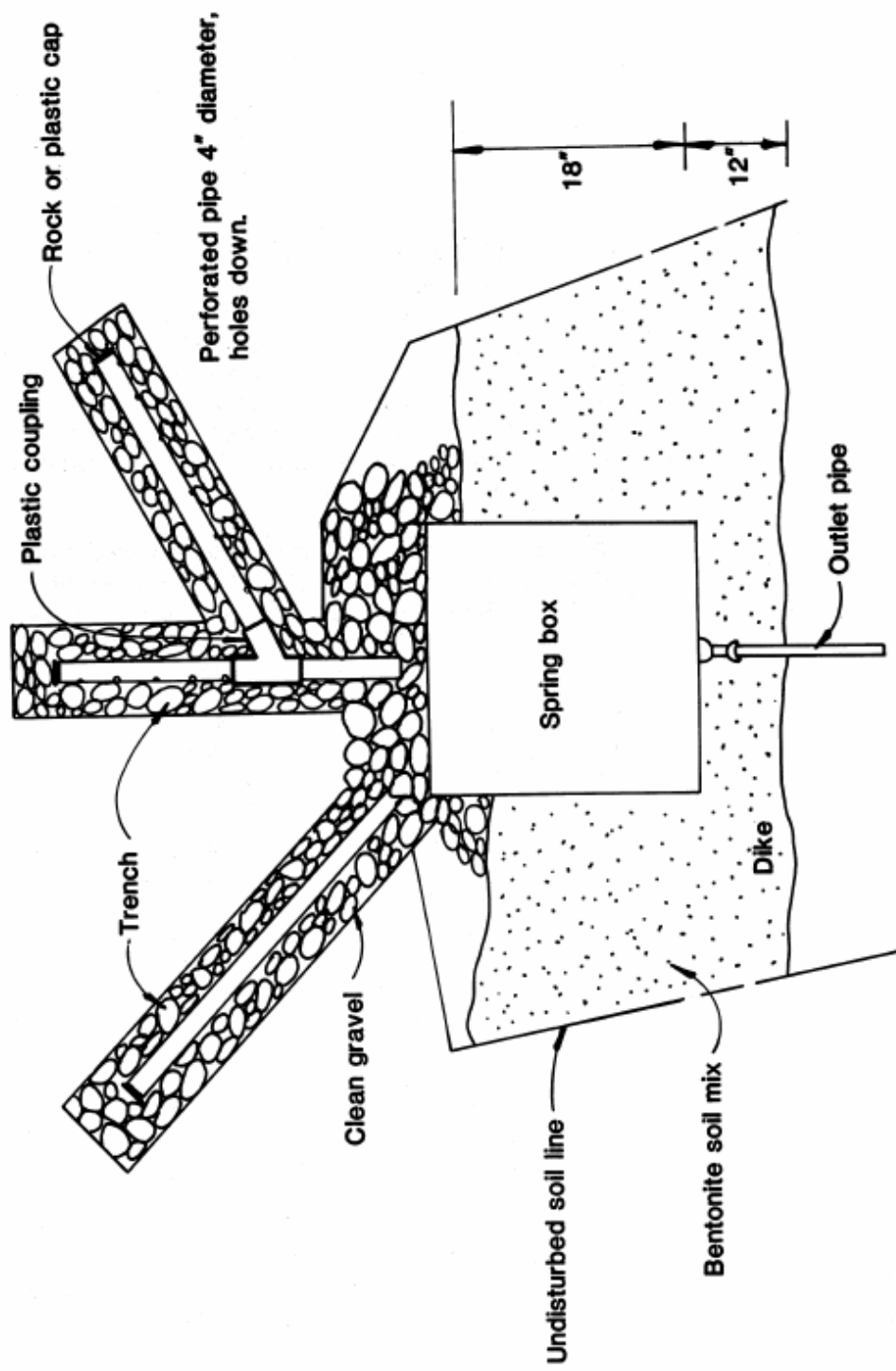


Figure 57—Spring development showing typical feeder trenches and spring-box installation. Perforated pipe concentrates water source and diverts water toward the spring box, but pipe does not connect into the spring box.

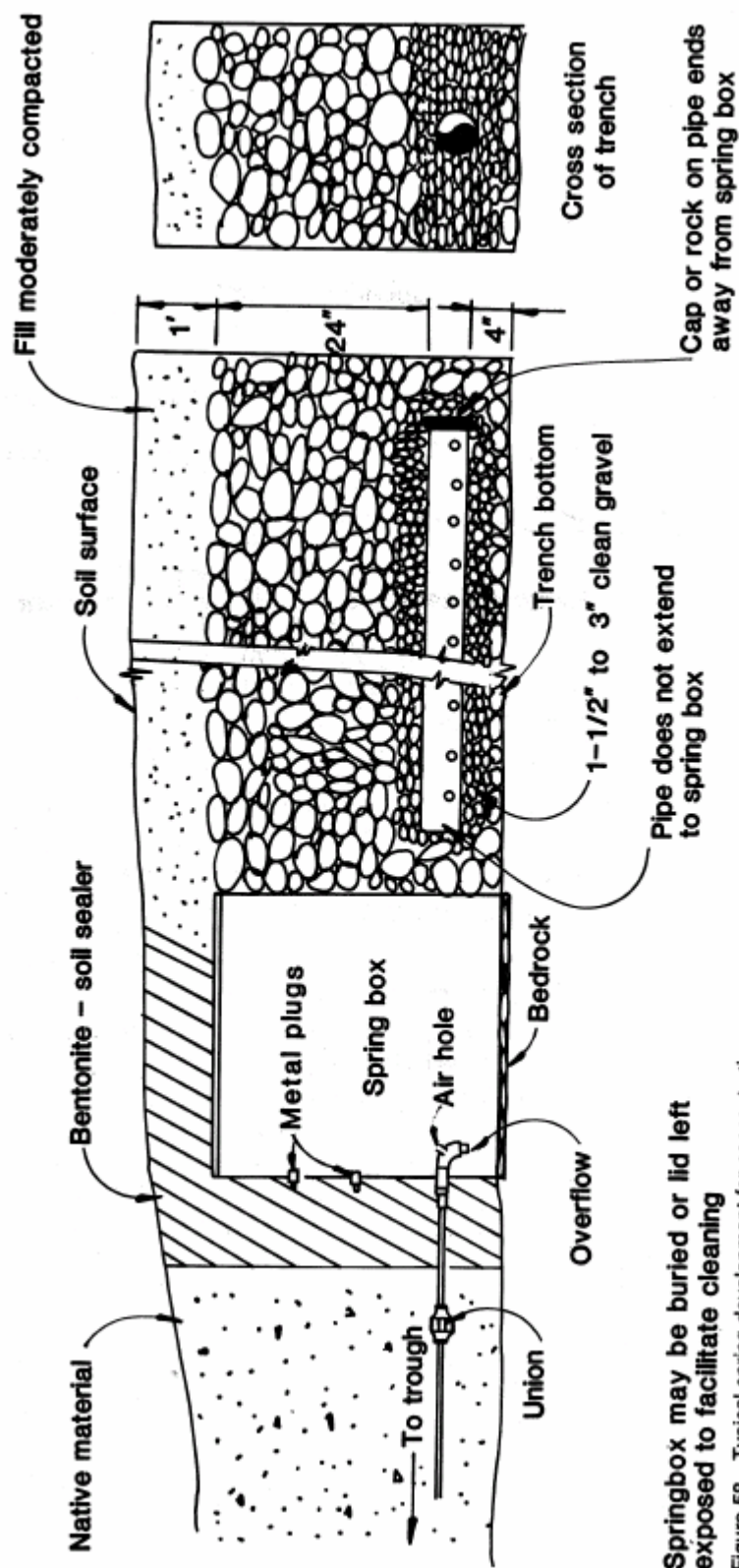
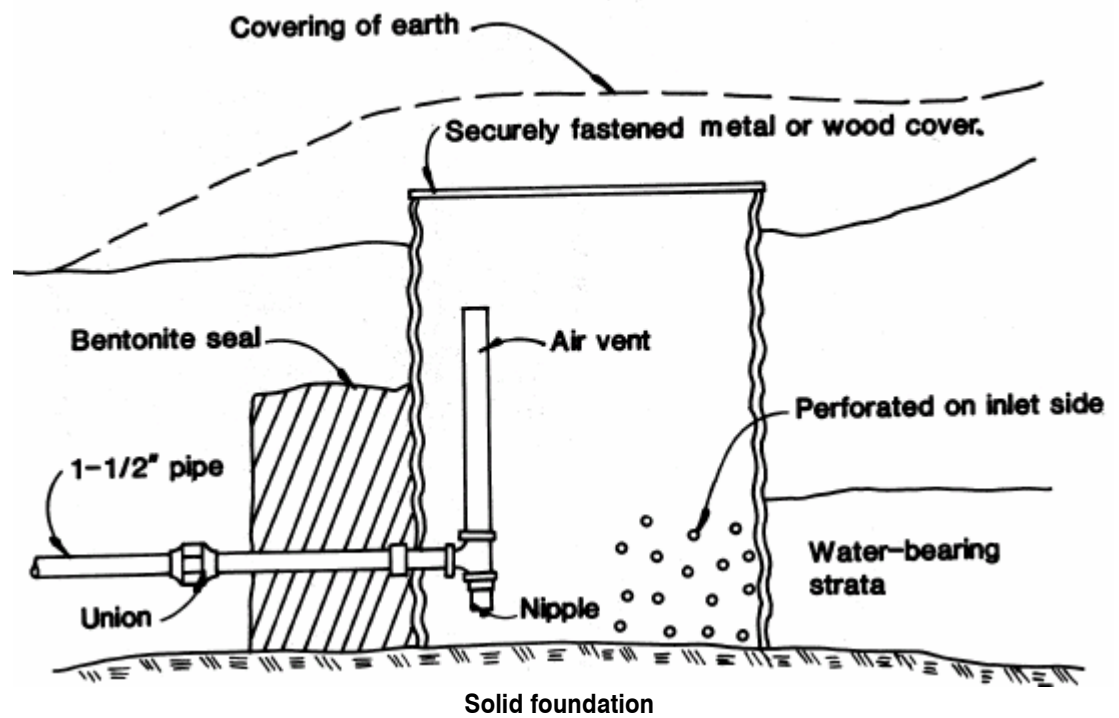


Figure 58—Typical spring development for concentrating water.



The spring box is located so it is in direct contact with the water-bearing strata, and the water flows directly into the spring box through the perforations. The bentonite seal prevents water passage past the spring box.

Figure 59-Spring box designed to collect water directly from the source.

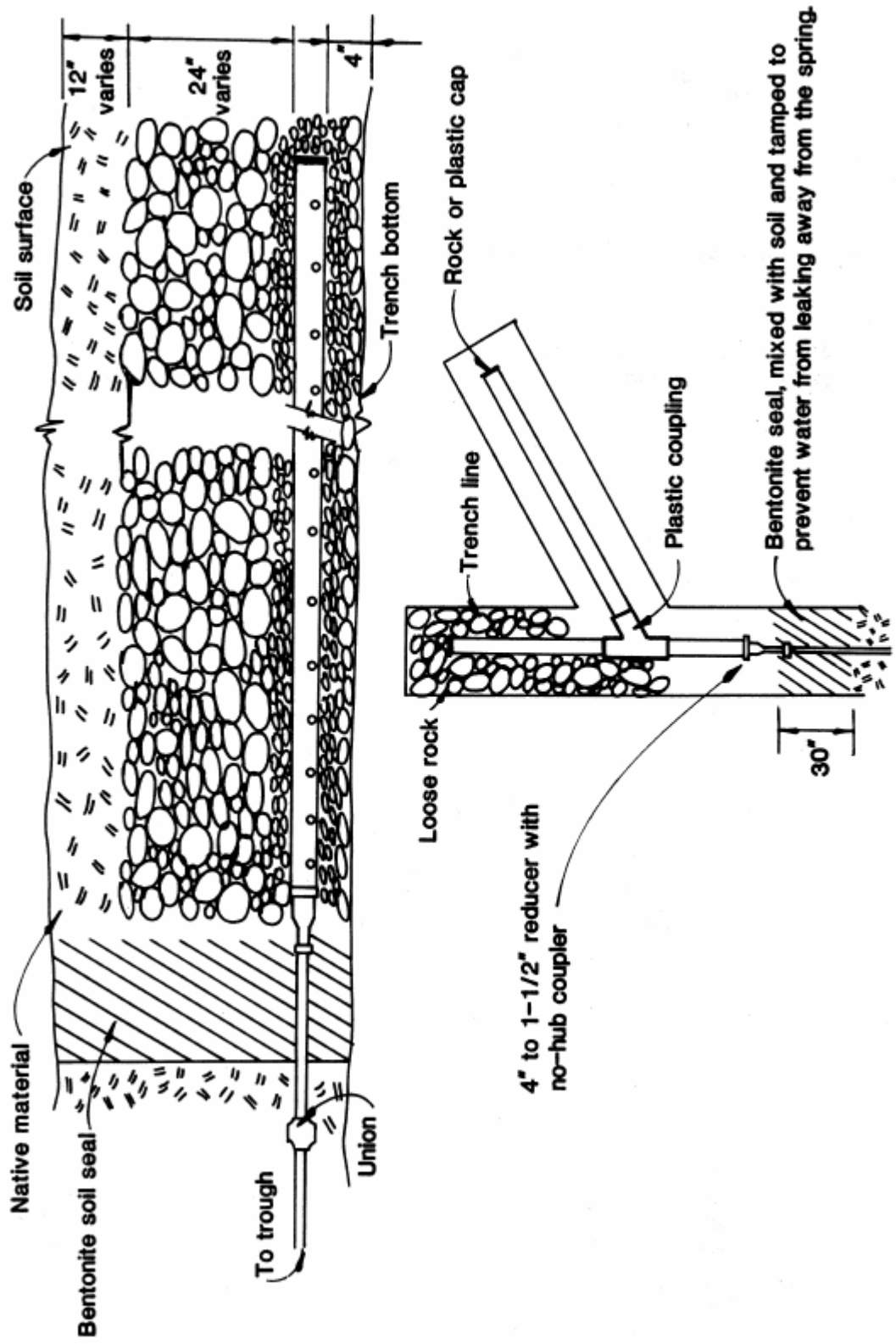
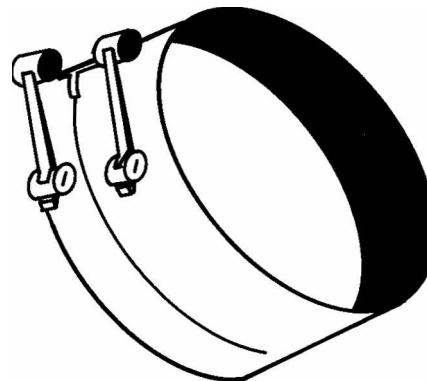
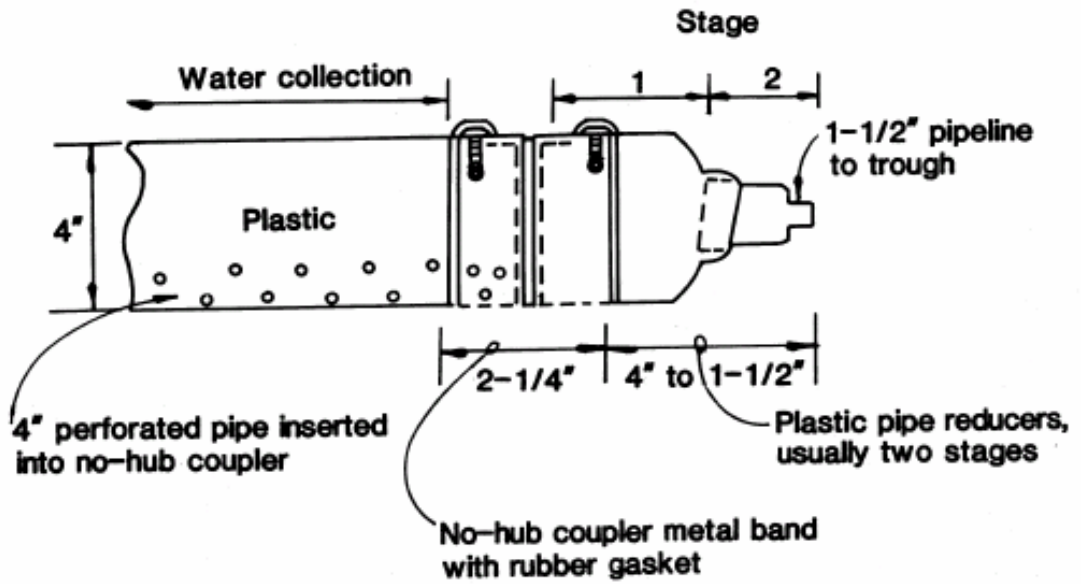
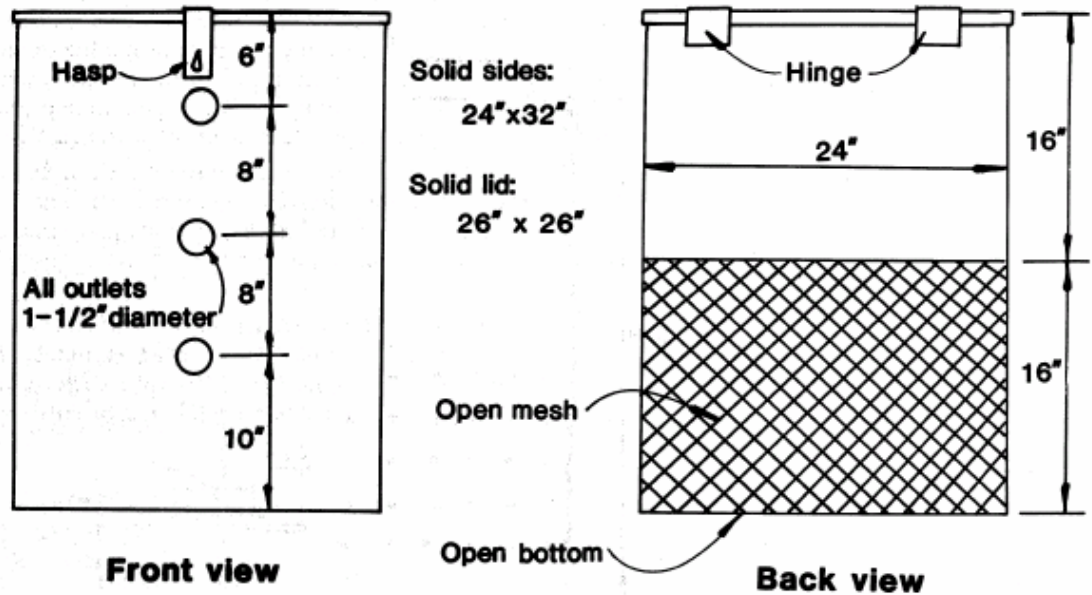


Figure 60—Spring development for a water source that does not require a spring box. See figure 61 for no-hub coupler.

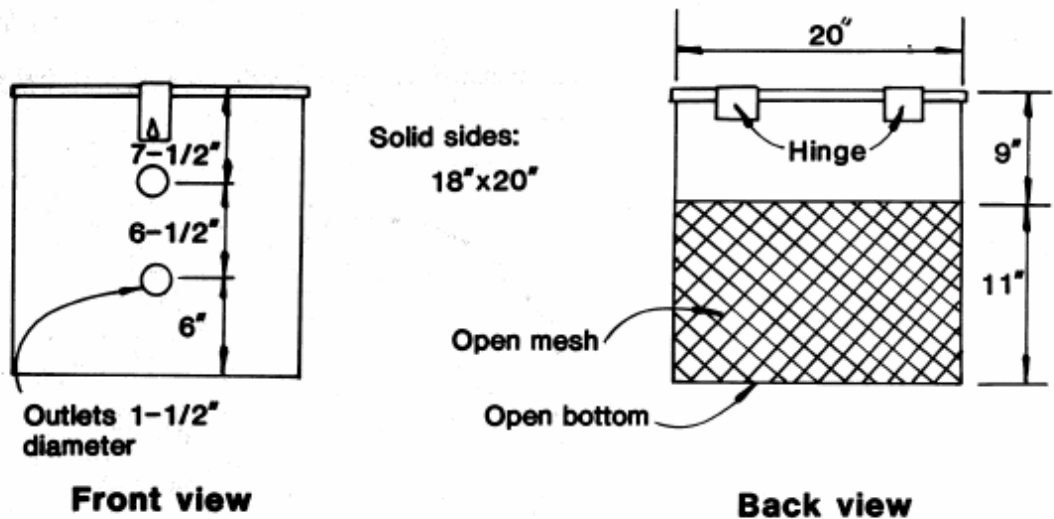


The no-hub coupler is used at a spring installation where a spring box is not installed. The no-hub coupler attaches the 4-inch perforated pipe on one side to the 4-inch to 1-1/2-inch reducers on the opposite side.

Figure 61-No-hub coupler used to connect the water collection pipe directly to the water supply pipe when standard reducers are not available.



24"x24"x32" spring box



1. 14 gauge steel
2. Provision for locking
3. Hot-dipped in asphalt

18"x18"x20" spring box

Figure 62-Specifications for metal fabricated spring box.
Overlap the lid about 3/4 of an inch to seal spring box.

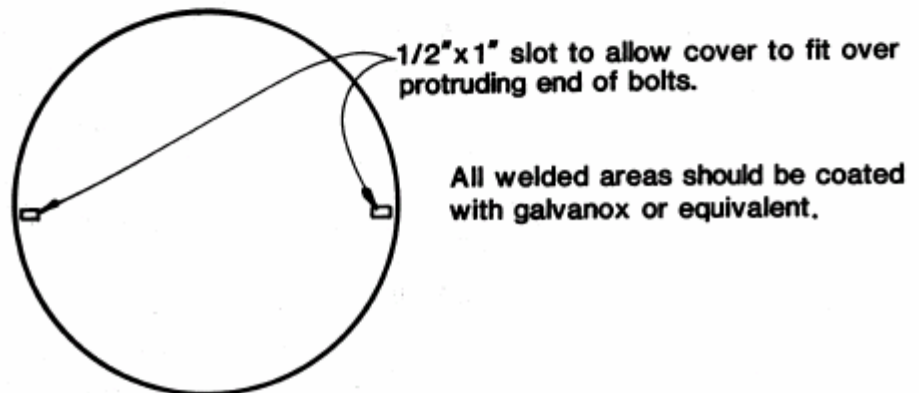
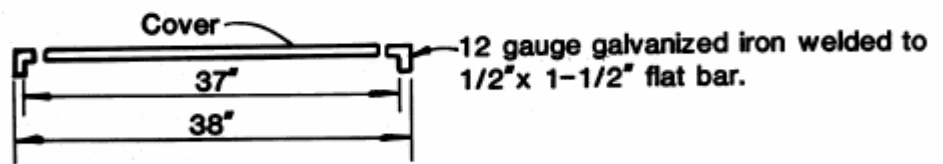
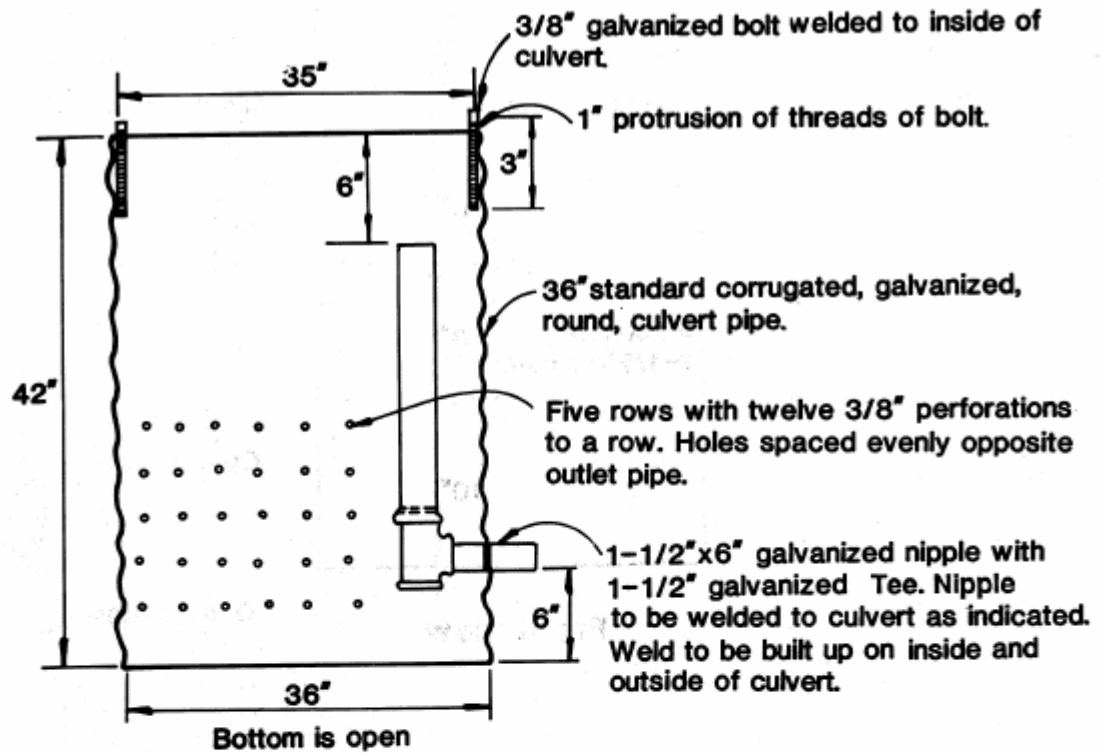
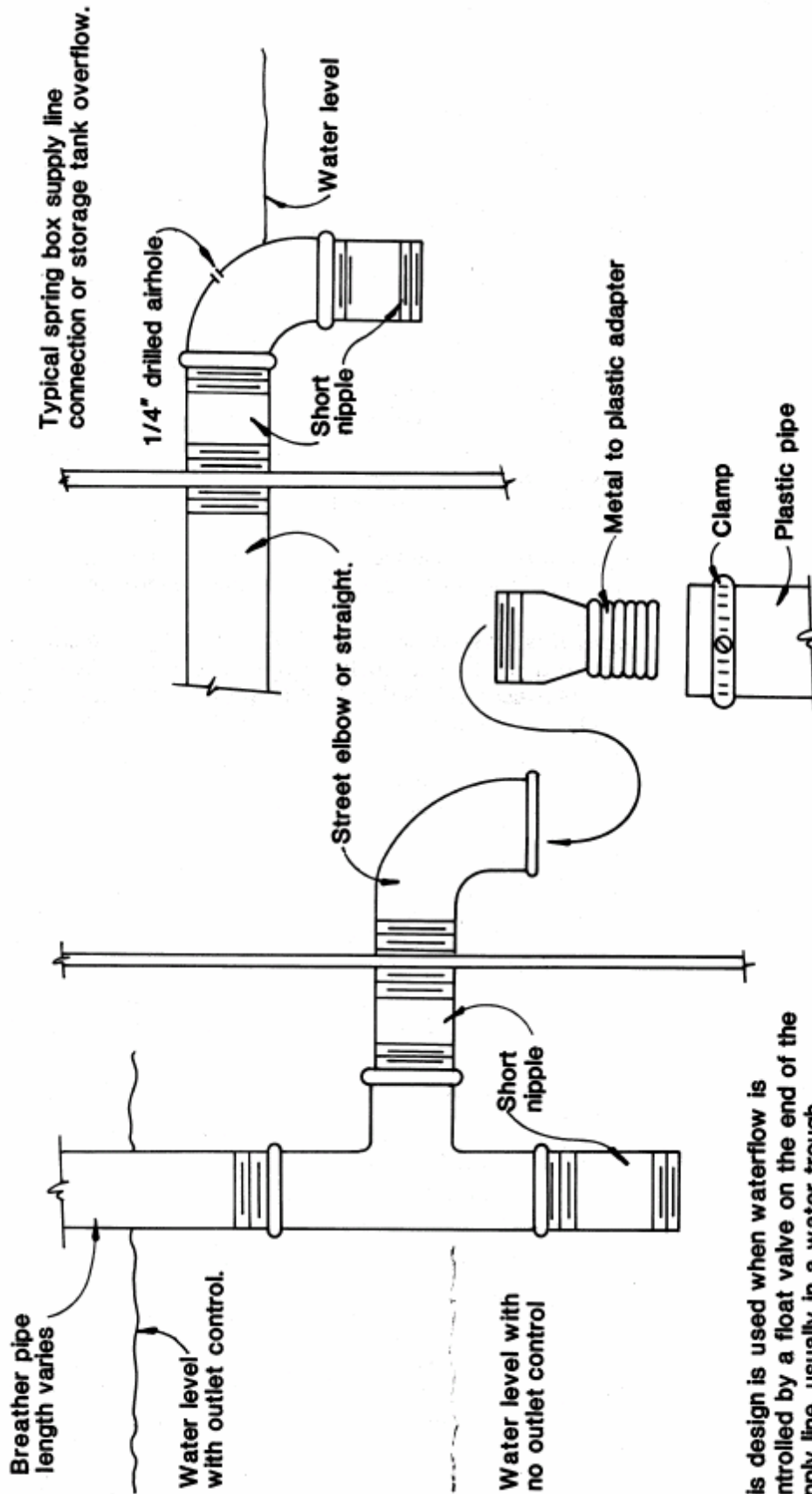


Figure 63-Specifications for corrugated steel-culvert fabricated spring box; The cover is designed to overlap the culvert pipe.



This design is used when waterflow is controlled by a float valve on the end of the supply line, usually in a water trough.

Figure 64—Details for spring box and storage tank overflow.

Storage tanks—

Description—Often, water is available only during winter or spring but not during the grazing season, or the source produces an inadequate amount of water when it is needed. Tanks can be used to collect water when it is available, store it, and make it available when it is needed. Storage tanks may be metal, fiberglass, concrete, or rubber pillows, whatever is most convenient and economical. Storage tanks can be constructed aboveground or buried.

The most common type of storage tank is round and constructed of metal; some have open tops and need board covers, and some are completely enclosed. Round tanks are available in several heights and diameters. The size of tank selected depends on the site requirements and needed capacity (table 9). The storage capacity of the pipe used in the water development may also be important (table 10).

Equipment—The equipment needed to construct storage tanks depends on the material and the size of the tanks and whether they are above or below ground level.

Materials—In addition to the storage tanks, pipe, pipe fittings, and valves are needed. Gravel or concrete may be needed for foundations and lumber for covers.

Specifications—All tanks constructed aboveground should be supported by level and solid foundations, such as gravel or concrete. Open tanks should be covered to reduce evaporation and to prevent growth of algae; the tanks should have inspection hatches. Storage tanks should have valves and pipe unions on both the intake and outflow pipes to facilitate inspection and maintenance, and a way to rapidly drain the tank. Each tank should have an overflow to pipe the excess water away from the tank, preferably back into a natural water course (fig. 64).

Water troughs—

Description—Different types of troughs can be purchased, from manufactured round and rectangular metal troughs complete with inlet and outlet pipe fittings to bottomless, round troughs with corrugated-metal side sections that are assembled at the site and have a poured concrete bottom. Troughs, except bottomless troughs, are placed on either a concrete or a treated-timber foundation, and gravel is spread around the trough to keep the area from becoming a muddy bog. The size of the trough may be determined by the amount of water needed for a single drinking period, as well as by the rate of flow and the storage capacity of the system (tables 11 and 12).

Application—Water troughs are appropriate at any location where water is needed for livestock, including such sites as ponds. Troughs may also be located in areas with no water source and the water hauled in by a tank truck. Water provided in troughs is generally of higher quality than water available from stock ponds, lakes, or streams, because livestock cannot walk, urinate, or defecate in the trough.

Equipment—Equipment is needed to transport the trough, gravel, timbers, and concrete, depending on the foundation specifications, and to prepare a level location. If the trough is to be located at the same time a water source is being developed, the necessary equipment may already be available. A pipe tap may be needed to clean metal pipe threads of rust, rolled edges, dirt, or paint.

Table 9—Capacity of round, water storage tanks

Tank inside diameter	Capacity by depth (feet)						
	2	4	6	8	10	12	14
<i>Feet</i>	<i>Gallons</i>						
4.0	188	376	564	752	940	1,128	1,316
4.5	238	476	714	951	1,189	1,427	1,665
5.0	294	587	881	1,175	1,468	1,762	2,056
5.5	355	711	1,066	1,421	1,777	2,132	2,487
6.0	423	846	1,269	1,692	2,114	2,537	2,960
6.5	496	993	1,489	1,985	2,482	2,978	3,474
7.0	576	1,151	1,727	2,302	2,878	3,454	4,029
7.5	661	1,322	1,982	2,643	3,304	3,965	4,625
8.0	752	1,504	2,255	3,007	3,759	4,511	5,263
8.5	849	1,697	2,546	3,395	4,244	5,092	5,941
9.0	952	1,903	2,855	3,806	4,758	5,710	6,661
9.5	1,060	2,121	3,181	4,241	5,302	6,362	7,423
10.0	1,175	2,350	3,525	4,700	5,875	7,050	8,225
10.5	1,307	2,615	3,922	5,230	6,537	7,844	9,152
11.0	1,421	2,843	4,264	5,686	7,107	8,528	9,950
11.5	1,536	3,107	4,661	6,214	7,768	9,321	10,875
12.0	1,696	3,393	5,089	6,785	8,482	10,178	11,875
12.5	1,835	3,671	5,506	7,342	9,177	11,013	12,848
13.0	1,985	3,970	5,956	7,941	9,926	11,911	13,897
13.5	2,141	4,282	6,423	8,564	10,704	12,845	14,986
14.0	2,302	4,605	6,907	9,210	11,512	13,815	16,117

1 cubic foot = 7.48 gallons water.

Table 10—Dimensions and capacities of galvanized pipe

Pipe size	Actual diameter		Capacity per 100 feet
	Inside	Outside	
	<i>Inches</i>		<i>Gallons</i>
3/4	0.824	1.05	2.8
1	1.048	1.315	4.5
1-1/4	1.38	1.66	7.8
1-1/2	1.61	1.9	10.5
2	2.067	2.375	17.4
2-1/2	2.468	2.875	24.9
3	3.076	3.5	38.6
3-1/2	3.548	4.0	51.4
4	4.026	4.5	66.1
4-1/2	4.508	5.0	82.6
5	5.045	5.563	103.9
6	6.065	6.625	150.1
7	7.023	7.625	201.3
8	7.982	8.625	259.9
9	8.937	9.625	325.9
10	10.019	10.75	409.6

231 cubic inches = 1 gallon.

Table 11-Capacity of rectangular water trough

Width	Height	Length	Capacity
----- Feet -----			Gallons
2	2	4	120
2	2	5	150
2	2	6	180
2	2	7	209
2	2	8	239
2.5	2	8	299

1 cubic foot = 7.48 gallons water.

Table 12-Capacity of round water troughs with flat bottoms

Tank inside diameter	Capacity by depth (feet)						
	2	4	6	8	10	12	14
Feet	----- Gallons -----						
2.0	47	94	141	188	235	282	329
2.5	73	147	220	294	367	440	514
3.0	106	211	317	423	529	634	740
3.5	146	293	439	585	732	878	1,024

1 cubic foot = 7.48 gallons of water.

Materials—Materials needed are treated timbers or concrete for the foundation, pipe fittings for inlet and overflow, float valve, wildlife escape ramp, and treated-posts; also, lumber to anchor the trough and prevent animals from falling into the water. troughs should be made of at least 14-gauge galvanized metal.

Specifications—Even if the water source is some distance away, all troughs should be located on level, solid ground to minimize maintenance costs and increase use (fig. 65). It is preferable to locate troughs on a rocky Surface or spread a layer of coarse gravel over a 10-foot area around the trough to prevent trampling during wet weather. Troughs should be far enough away from trees so that needles or leaves cannot drop into the trough and clog the overflow outlet. Excavated sites may need a retaining wall, fence, or other barrier to prevent dirt from sloughing into the trough or the watering area. Easy access for livestock to the full drinking area of the trough is very important. All troughs should be set on a durable solid foundation. Uneven settling is a very common and costly maintenance problem.

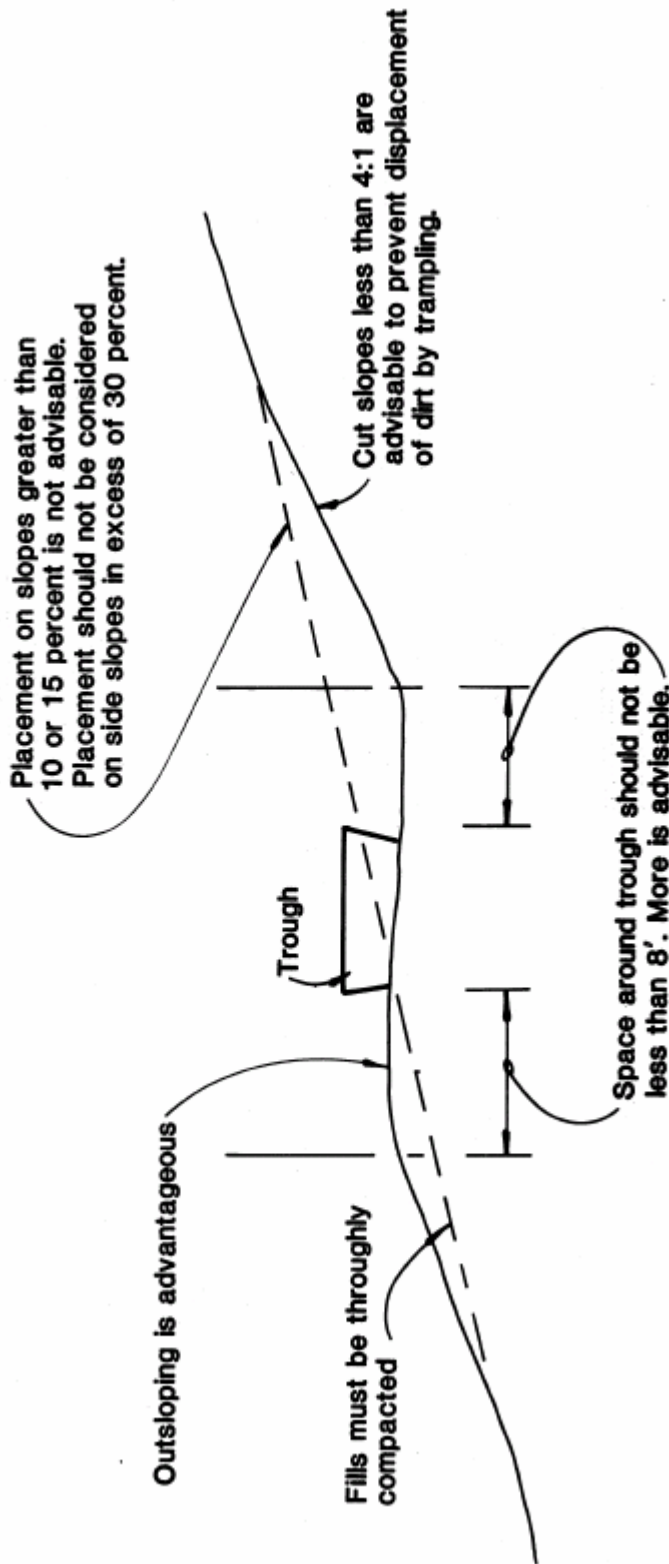


Figure 65—Recommendations for placement of water troughs.

Round and rectangular metal trough with a solid bottom- Troughs with metal bottoms may be set on 6- by 6-inch treated timbers or on a poured 6- to 8-inch-thick reinforced concrete slab that extends 2 to 3 feet beyond each side of the trough (fig. 66). The trough should be firmly anchored to the foundation. A coat of asphalt roofing material may be applied to the outside bottom of the trough to provide added protection against corrosion and to help prevent leakage.

Bottomless metal trough- The bottomless trough is usually round and is set on a 6- to 8-inch reinforced concrete foundation with at least the bottom 2 inches of the trough imbedded in the concrete. The bottom of the trough surface is sloped slightly toward the outlet drain. The bottomless trough may also be set in impervious clay if precautions are taken to prevent the area around the outside of the trough from becoming eroded below the trough. In some cases, the inlet pipe may be located in the center of the trough and should be installed before the concrete is poured. If a float valve is needed, a short section of 36-inch perforated culvert may be used to protect the float valve.

Metal flume trough- Metal flume troughs, ideal for watering sheep, come in several widths and lengths. Two common widths are 25.5 and 29.25 inches. The 29.25-inch-wide flume is 14 inches deep and holds about 14.5 gallons per linear foot. Several sections may be fastened together, or individual sections can be placed on different ground levels. How many sections are to have open ends and how many closed ends must be specified. Six-foot sections are the best size for transporting to different locations. The flume trough is difficult to level and should be supported by concrete or treated timbers spaced 4 to 8 feet apart; wooden posts can be used at temporary locations.

Trough frame- A wooden frame should be constructed over rectangular troughs to prevent damage to the trough and pipes and to prevent livestock from accidentally falling or being pushed into the troughs (fig. 67).

Trough maintenance—Leaks can be repaired with asphalt-saturated burlap or canvas. Extra coats of asphalt should be spread over the patch. Bullet, or larger, holes can be repaired with leather or rubber-backed washers bolted in place. These patches should also be covered with asphalt. Fiberglass repair kits are excellent for making field repairs. Compounds in squeeze tubes such as "plastic aluminum" and "liquid steel" may also be used.

Water supply, overflows, and outlets—Plastic pipe is generally of sufficient strength to connect troughs with the water source. The exceptions are where the pipe passes under roads and where the pipe is exposed at the trough; steel pipe should be used at these locations (fig. 68). The supply pipe should pass through the trough bottom or over the side and down into the water-exiting 10 inches below the water level to discourage human use (figs. 69 and 70). Drain cocks should be provided at all depressions to prevent freezing damage and should be marked above-ground to facilitate draining. Pipe not buried may be damaged by livestock and should be protected. Vertical pipes can be protected by posts; horizontal pipes can be protected by placing the pipe under a fence, by wiring treated posts or poles on both sides of the pipe, or by covering the pipe with rock. If pipe is to be exposed, galvanized pipe is better than plastic pipe.

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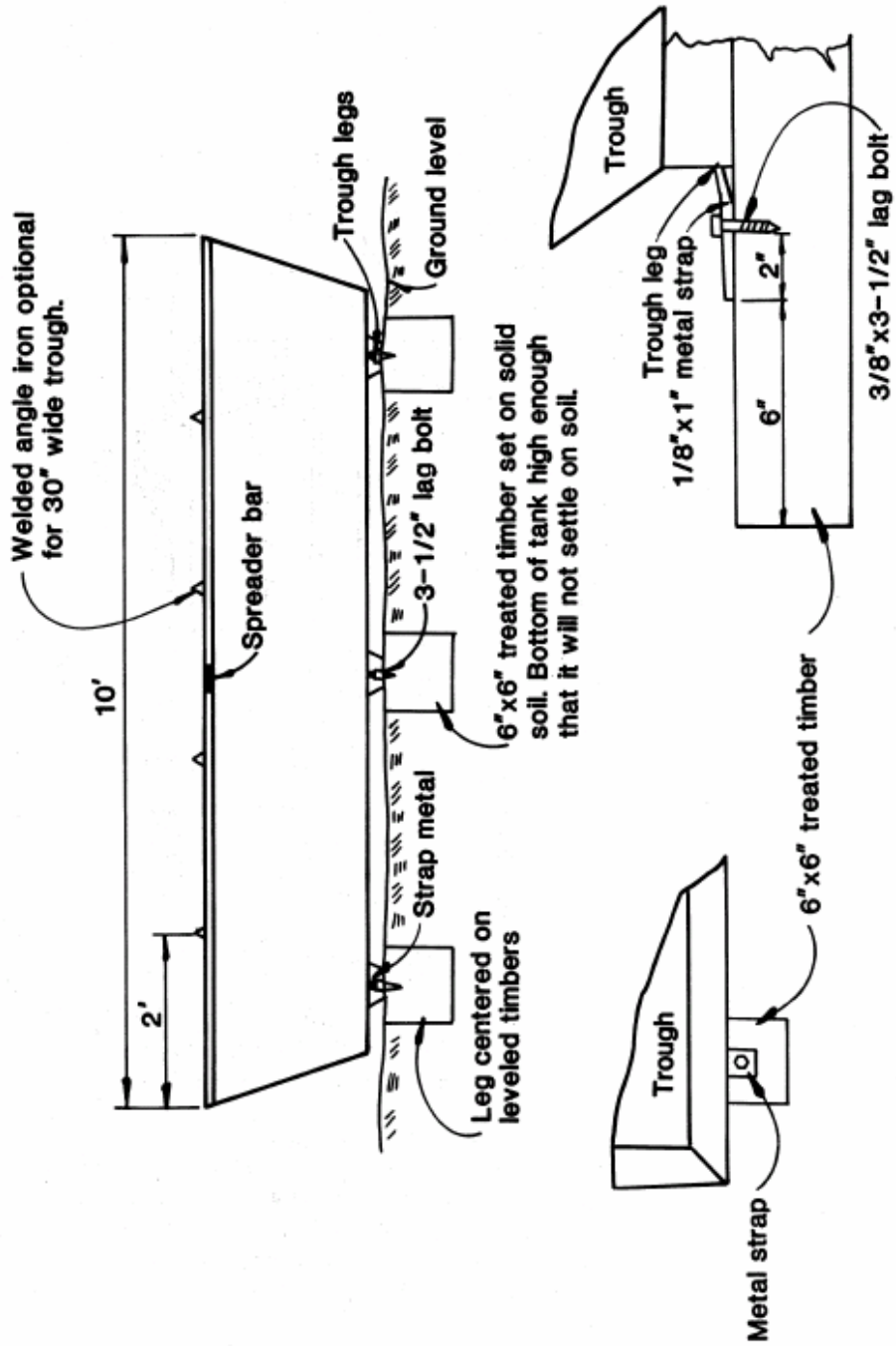


Figure 66—Specifications for installing water troughs.

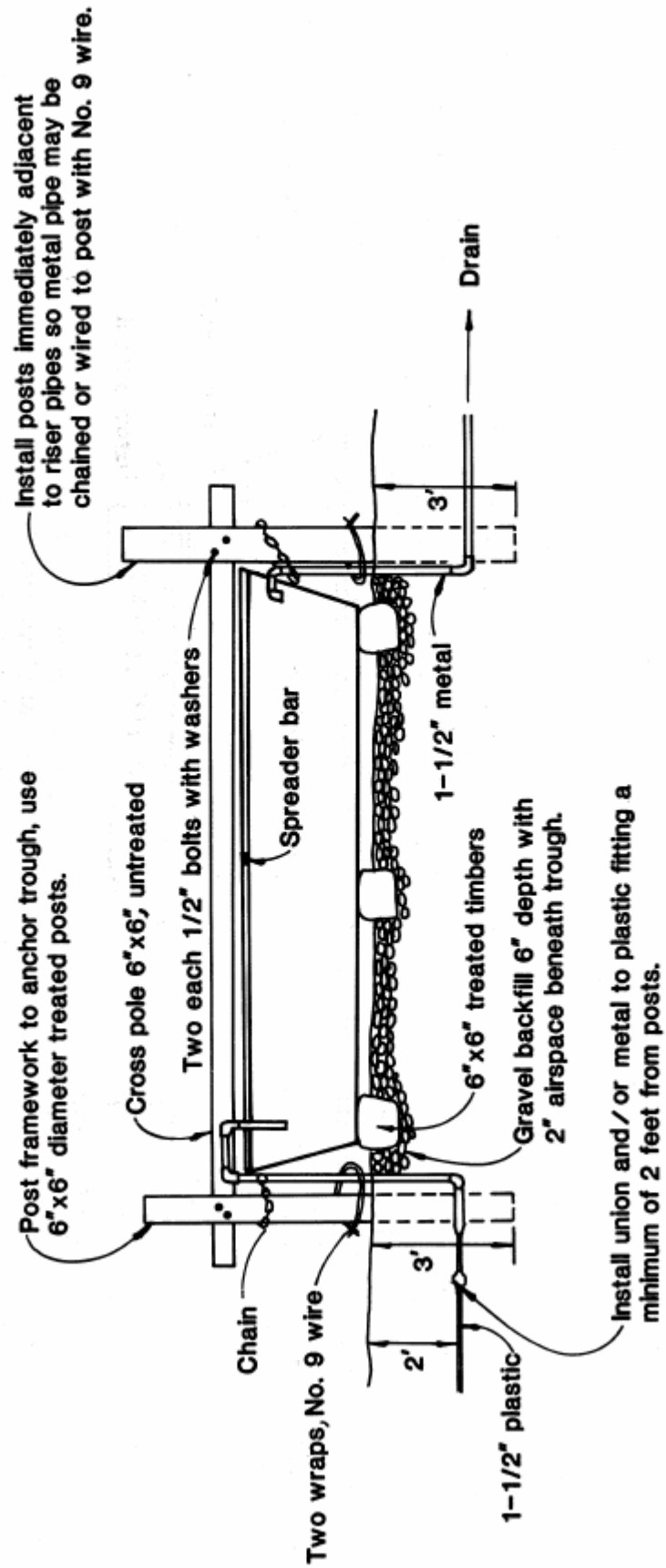


Figure 67—Wooden frame designed to keep livestock out of water troughs.

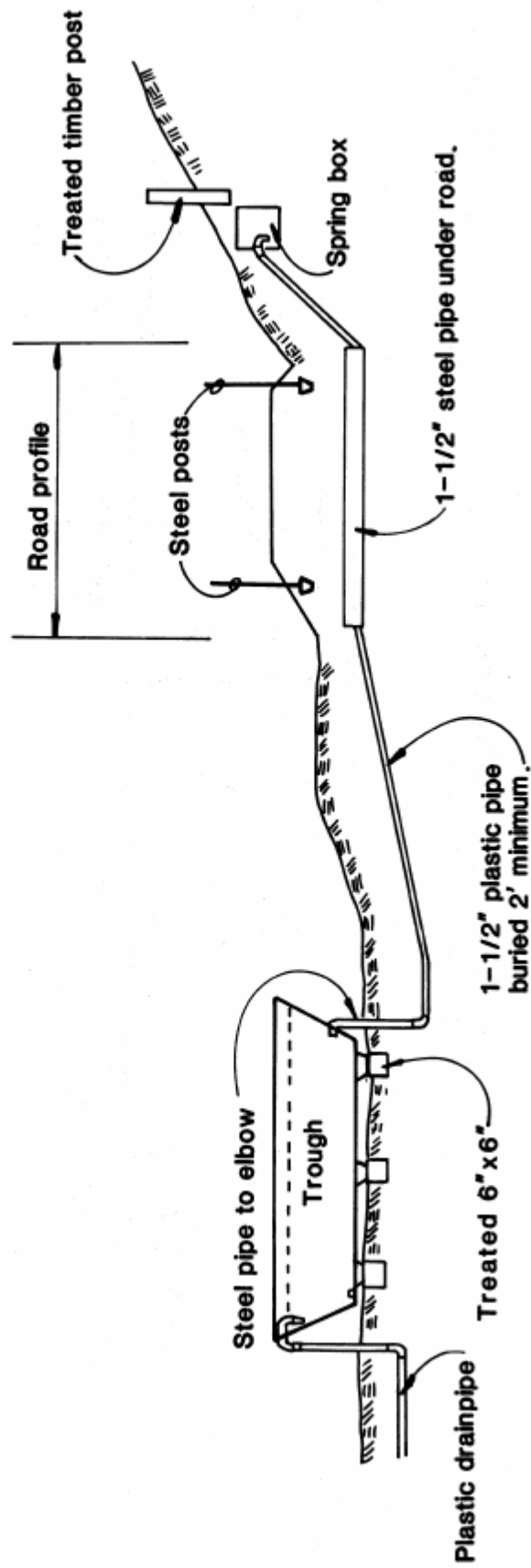


Figure 68—Specifications for water supply transmission lines.

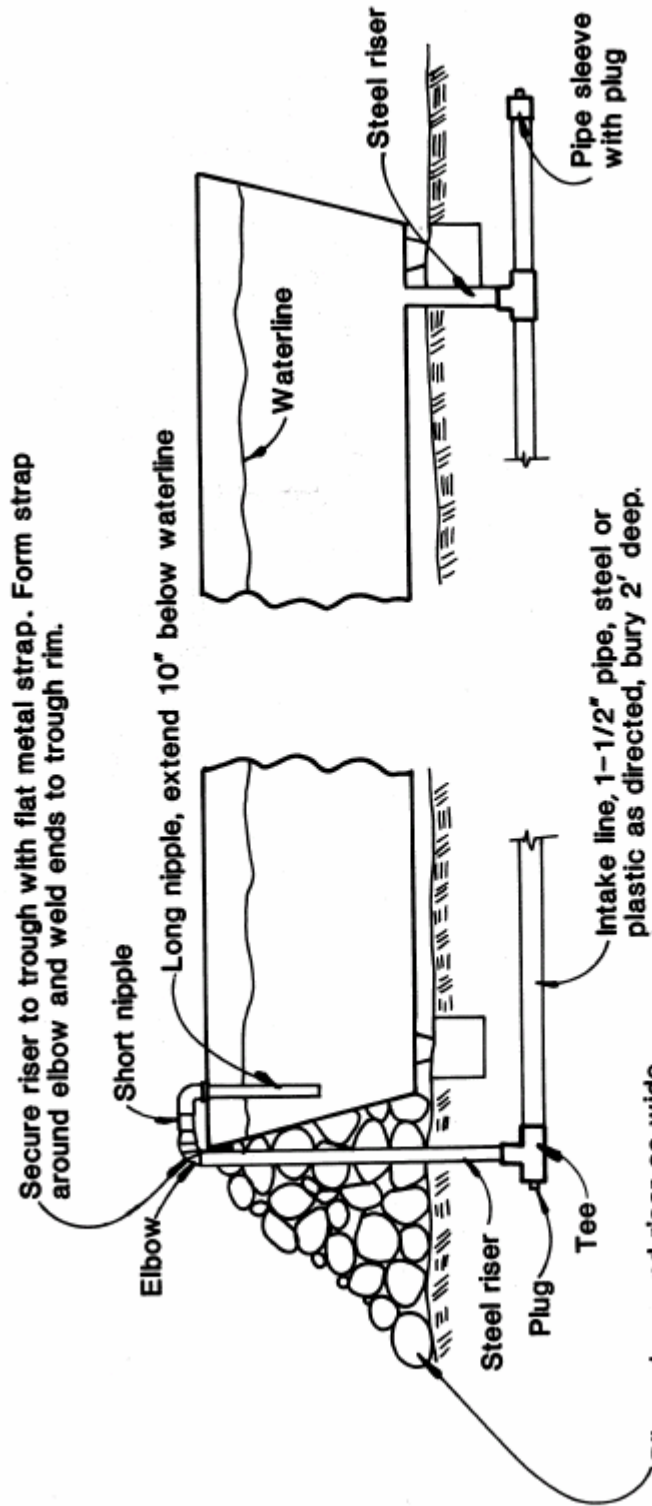


Figure 69—Intakes for water supply in trough. Left, water line comes over the side or end of trough; right, water line is attached to the bottom of the trough. Both examples have provisions to drain supply line by removing a plug, or the supply line extends to other water troughs.

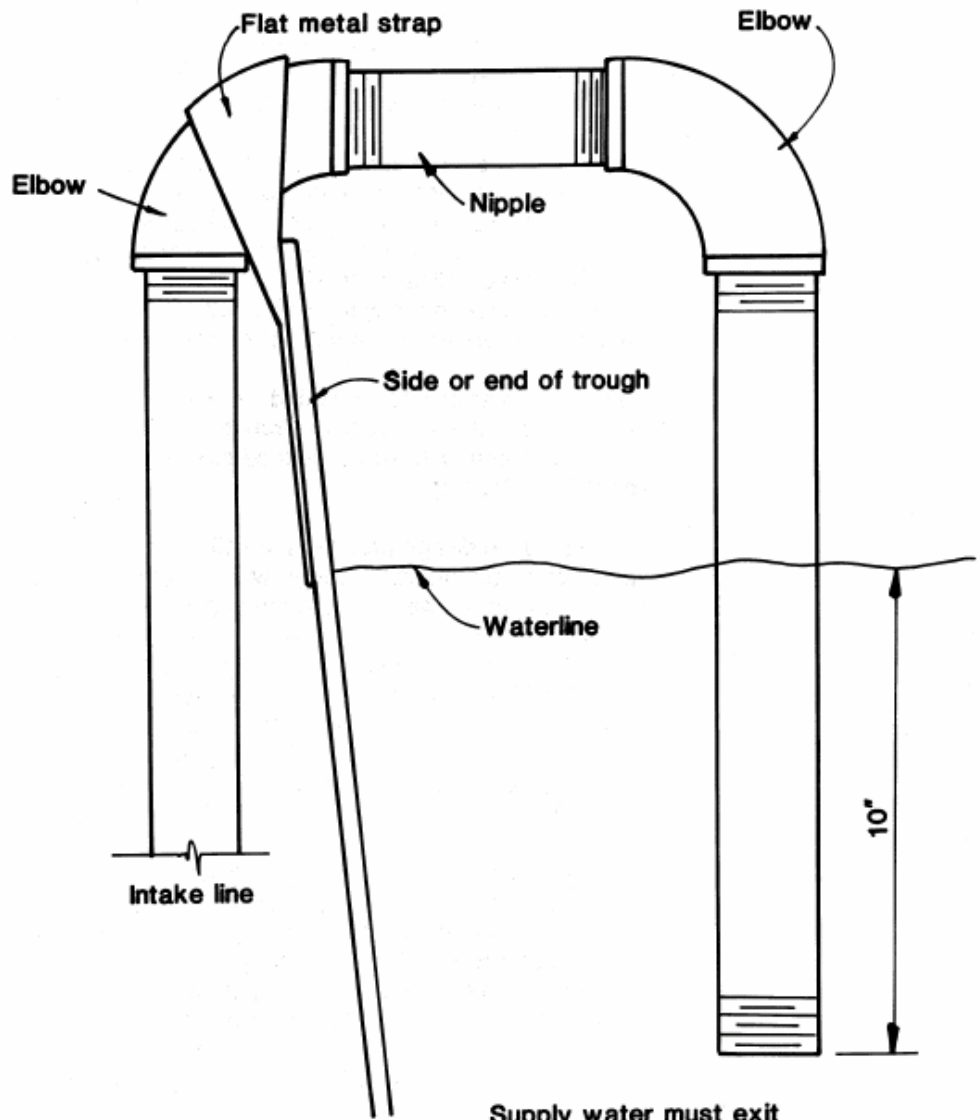


Figure 70-Detail for water trough intake passing over the side or the end of the trough. May need to be modified to attach to troughs with a rolled or flat rim.

Where more than one trough is supplied from stored water, each trough should have a float valve installed to control inlet water (fig. 71). The float valve will keep the trough full and ensure that water is available for the other troughs. Each trough should have an overflow set above the normal water level in case the float fails to close. The float valve should be protected by expanded metal, which can also serve as a wildlife escape ramp (fig. 72).

The overflow pipe may be 1.5 inches larger in diameter than the supply pipe, if the water supply exceeds the capacity of the overflow, and is generally located at the opposite side or end of the trough. The outlet pipe begins about 6 inches below the water level, which helps to keep the pipe from becoming clogged; a "reverse head" has an airhole drilled in the top to prevent siphoning (fig. 73). A piece of 9-gauge wire may be left in the pipe or close by to use to unclog the outlet. The water level should be maintained about 2 inches below the trough rim.

Overflow water should be carried far enough away from the trough area to prevent a wet area in the vicinity of the trough, preferably back into a natural watercourse (fig. 74). A threaded plug should be provided on the side of the trough near the bottom for draining.

An alternative design provides protection from frost and vandalism. The buried inlet pipe comes up through a culvert with an outlet into the tank and continues up and loops back down the culvert to the overflow area (fig. 75). The top of the loop determines maximum level of the water in the trough. A valve can be installed at the T-joint to shut off the flow to the trough. The culvert should be about 36 inches in diameter and extend 2 feet above the pipe; it should be filled with sawdust and covered by a locked lid to keep the sawdust dry and prevent vandalism. This design does not need a float valve, which may also be subject to vandalism. The flowing water reduces the chance of frozen pipes, and the outlet is not as apt to become clogged.

Another method for controlling waterflow is a "float-valve box." The float valve is located in a box placed in the supply waterline instead of at the trough (fig. 76). The disadvantage of the float-valve box is that the water level in the trough is controlled by the water level in the box. Care must be taken to place the box at about the same elevation as the water level in the trough to provide the proper flow. The advantages of the float-valve box are that the float valve is protected from vandalism, it removes air from the pipeline, and it can be designed to protect the valve assembly from freezing.

Control of moss-A green algae growth, commonly called "moss," grows in many water troughs. The growth of this plant can be controlled with blue vitriol (crystallized or powdered copper sulfate). To prevent corrosion of galvanized surfaces and control solution concentration, the blue vitriol should be placed in bottle with a small notch in the cork. A copper screen, wire, or other copper object can be placed in the spring box or trough with the same results.

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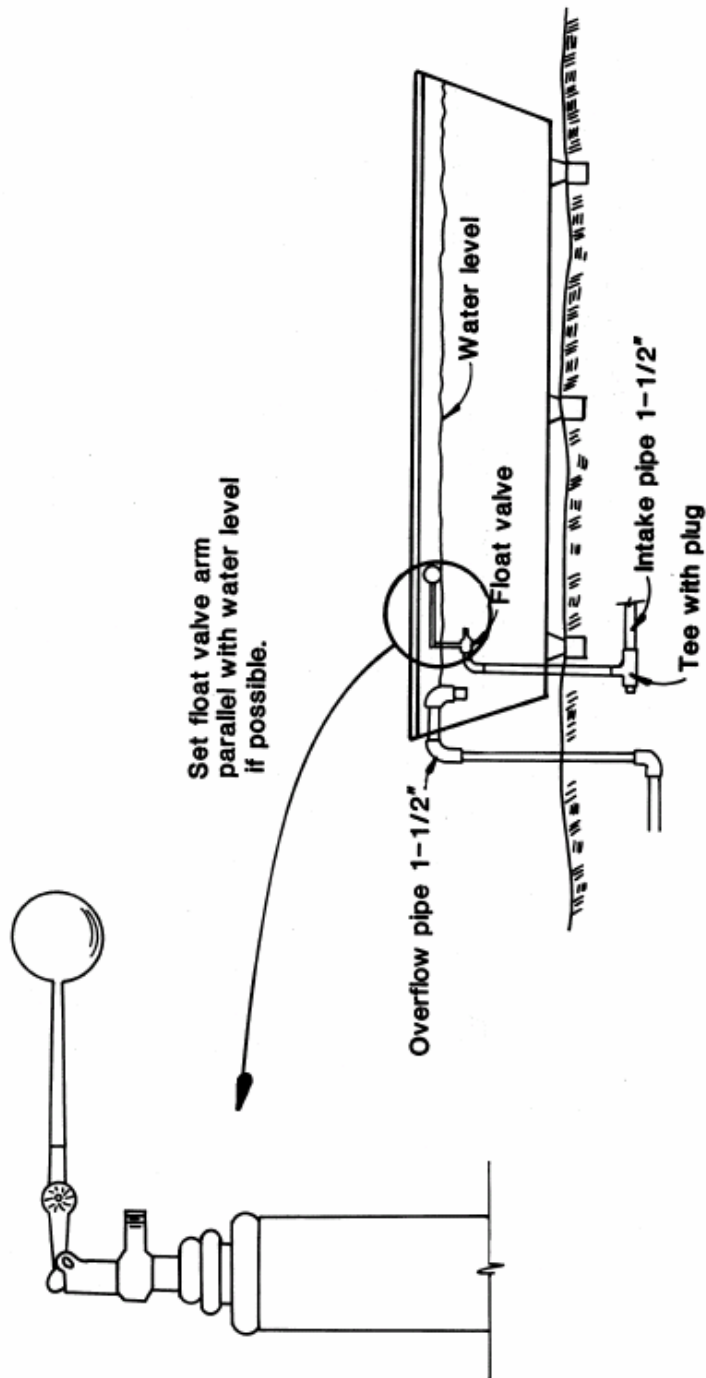
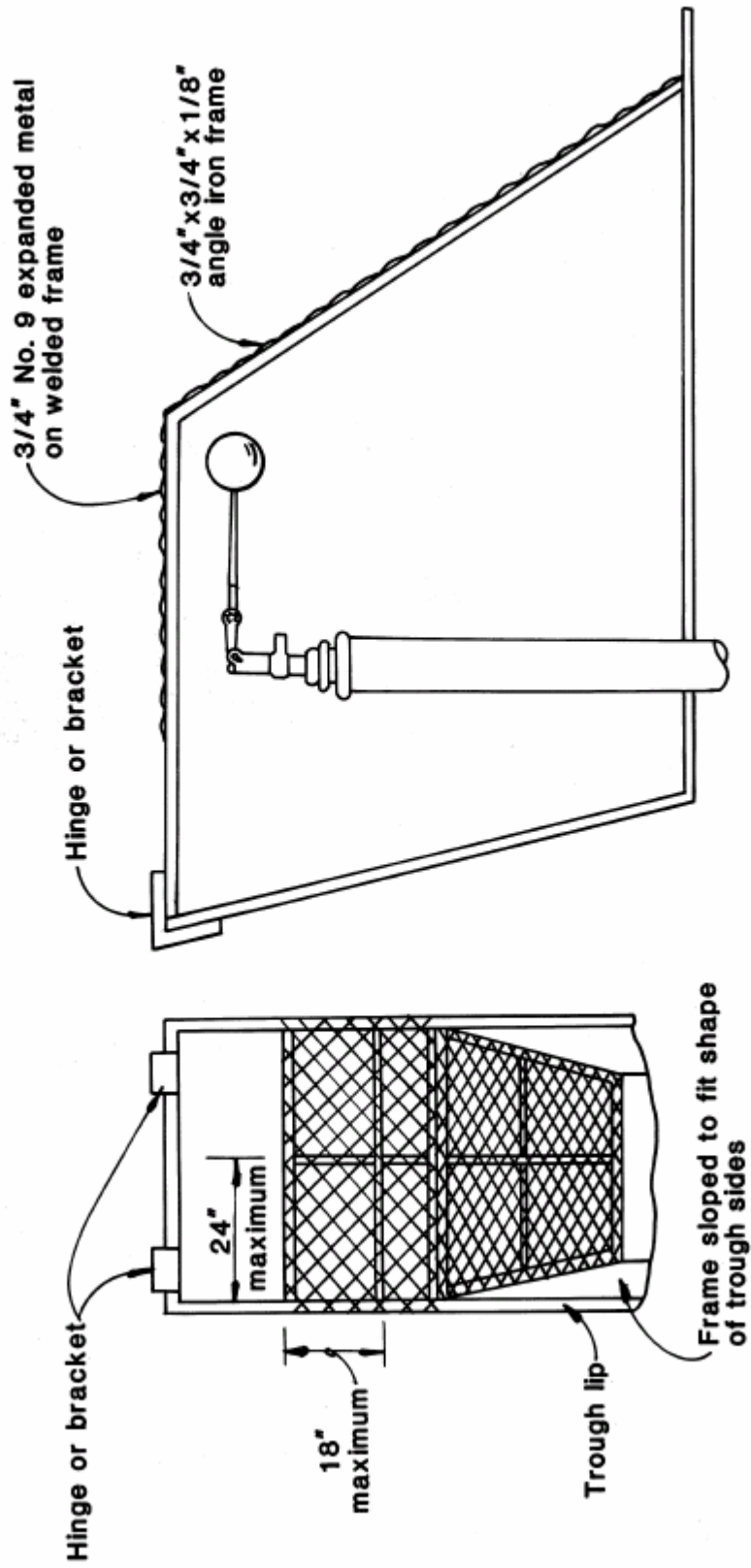


Figure 71—Detail of float valves.



Side view

Figure 72—Wildlife escape ramp used to protect float valve.

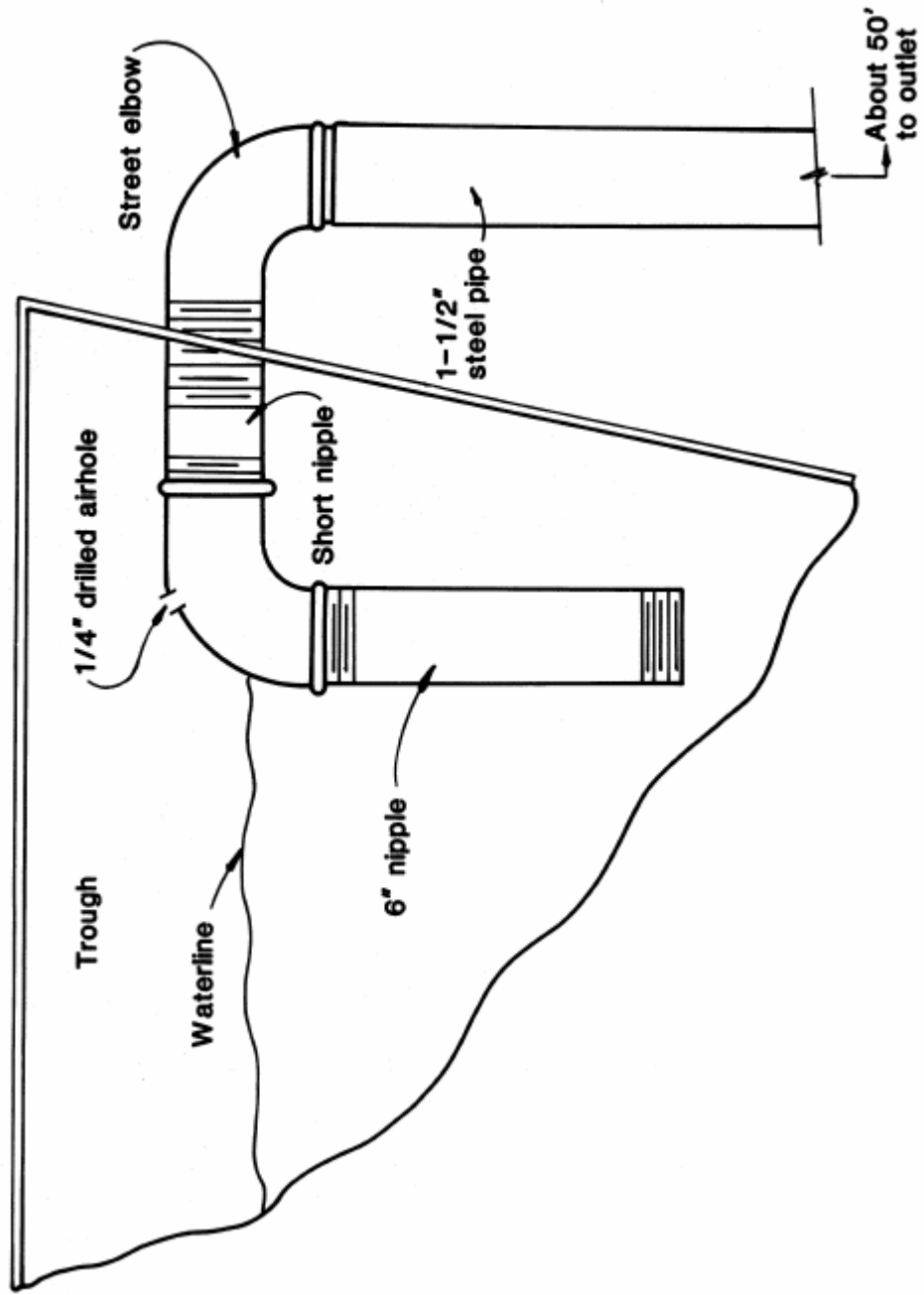


Figure 73—Reserve head overflow. Airhole is drilled in top of overflow to prevent siphoning.

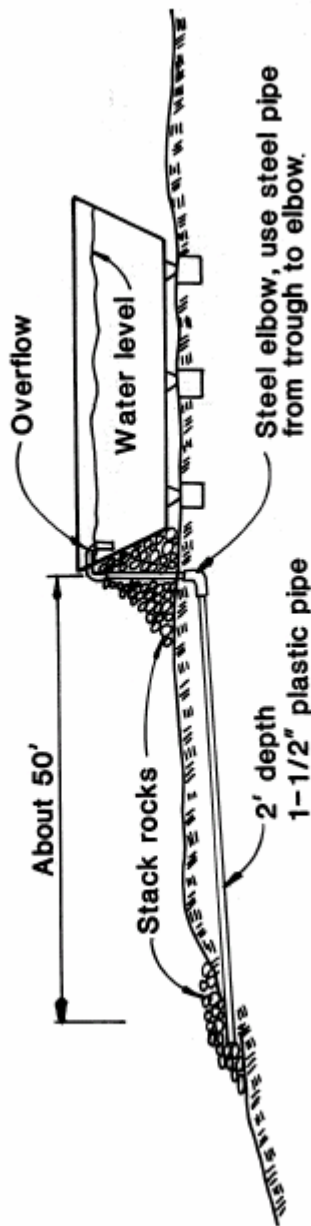
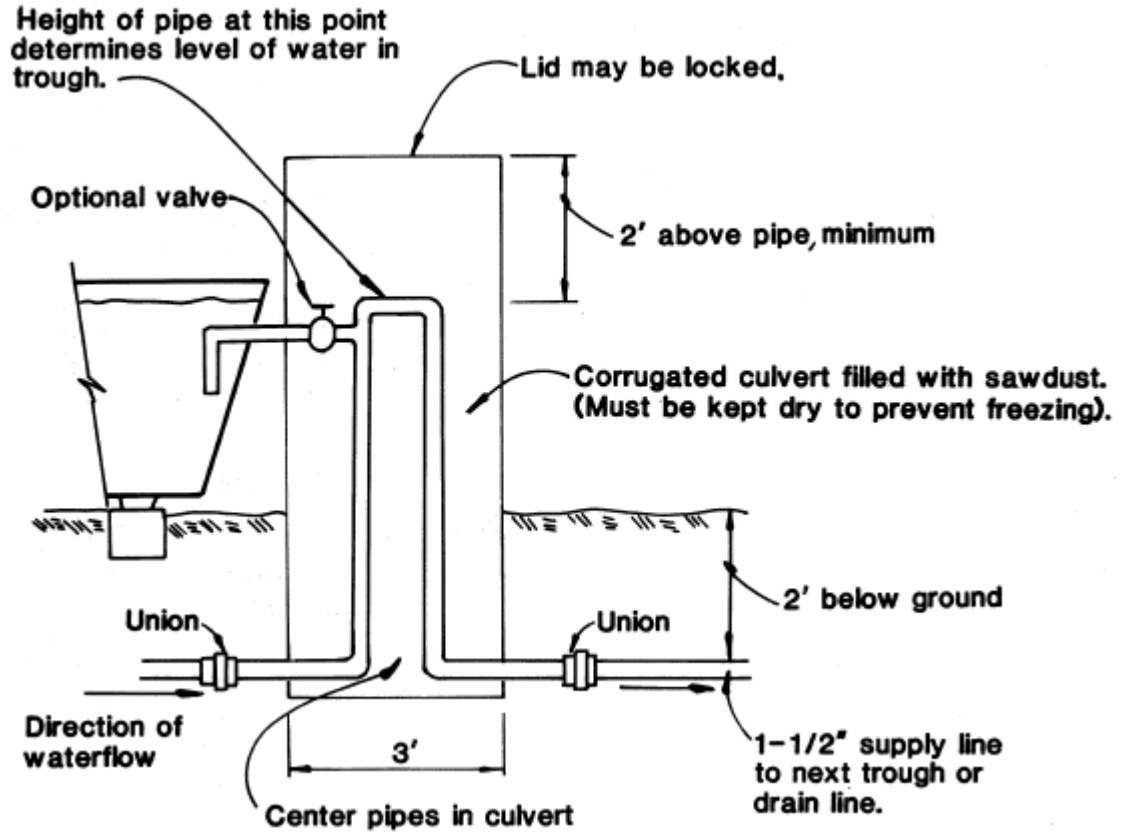


Figure 74—Typical overflow system returns surplus water to a natural drainage to prevent a wet area around the trough.



ADVANTAGES

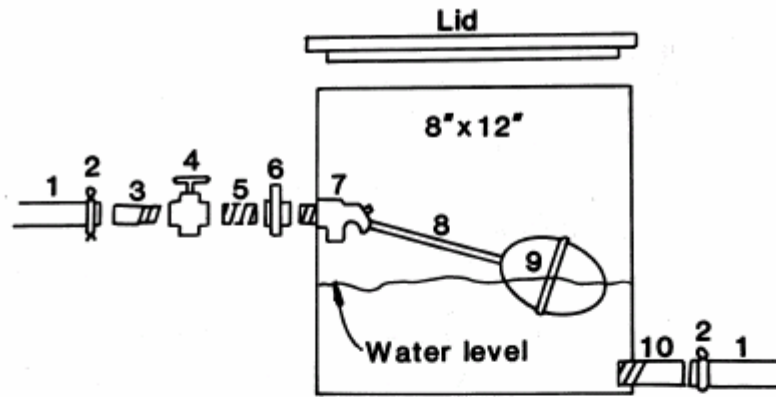
Simpler to install than float valve and no float valve exposed to vandalism.

Water continues to flow through pipeline, and water remains at fixed level in trough.

Less chance of frozen pipes.

Less opportunity for plugged outlets.

Figure 75—A frost-proof water supply system that reduces vandalism and maintenance.



Materials

<u>No.</u>	<u>Item</u>	<u>Amount</u>
1.	Pureflow pipe - 1"	As needed
2.	Stainless clamp	2
3.	Nipple 3"x3/4"	1
4.	Gate valve 3/4"	1
5.	Nipple (close) 3/4"	1
6.	Union (Galv.) 3/4"	1
7.	Float valve 3/4"	1
8.	Brass rod 1/4"	1
9.	Styrofoam ball	1
10.	Adapter 1"	1

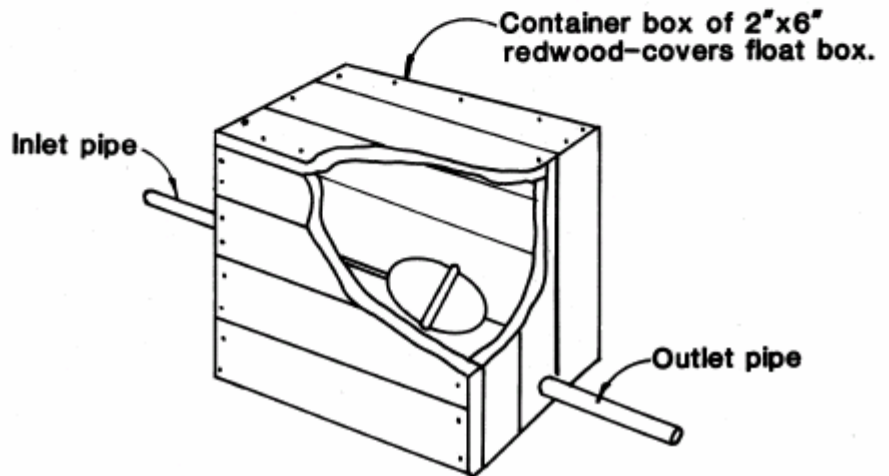


Figure 76—An in-line float valve box controls water supply for a water fountain or trough.

Small mammal and bird escape ramps—Small mammals and birds are attracted to any source of water and may fall into troughs with steep sides and drown. Dead animals contaminate the water and discourage use by livestock. All troughs therefore should be equipped with a wildlife escape ramp. It can be as simple as a board with one end floating in the water and the other end secured to the top rim of the tank or to a post adjacent to the tank. The board is best located along the edge of the trough because swimming animals will go to the edge to escape. If the ramp is not at the edge of the trough, they may not find it. Large wooden or plastic foam platforms may also prevent tank damage caused by ice pressure. Expanded metal reinforced with metal straps and welded or wired to the tank rim can also serve as a wildlife escape ramp (figs. 77 and 78).

Stock ponds—

Description—Stock ponds include simple water storage structures, such as pit tanks or dugouts and reservoirs, behind small dams less than 10 feet high. Dams higher than 10 feet generally require special permits and should be professionally designed. Where soil depths and geologic formations are favorable, small stock ponds, such as pit tanks or dugouts are inexpensive to construct and maintain and are designed to store small supplies of water from bogs, seeps, or springs and to collect and store surface runoff. Larger stock ponds, or reservoirs, usually require an engineered dam and are suitable for impounding water from springs or streams with relatively large watersheds.

Pit tanks differ from reservoirs in that most of the impounded water is below the original ground line. A dam may not be needed, although the excavated material is placed around the excavation or on the downhill side to increase the storage capacity. Livestock generally have direct access to the stored water.

Reservoirs are created by constructing a dam; they represent a relatively large investment. Fencing the dam to protect it from livestock damage is desirable, and the entire reservoir should be fenced to control diseases and maintain water quality.

Application—Stock ponds are recommended at locations with suitable soil, topographic conditions, and an adequate source of water. Larger ponds can provide water for storage and serve several livestock watering areas. Secondary uses of larger ponds include fire control, fish, wildlife, and recreation.

Equipment— The equipment needed to construct stock ponds differs with the geology, ecosystem, and capacity of the proposed structure. Small stock ponds generally require a bulldozer or backhoe to excavate the pond area and pile the excess material. Large reservoirs require large equipment such as bulldozers, draglines, land levelers, and dump trucks. Fencing, welding materials, and other special equipment may be needed for some sites, depending on the specifications.

Materials—Small stock ponds do not require any special materials. Larger ponds and reservoirs may need fence supplies, bentonite for the core of the dam, pipe, culvert, valves of various sizes, screen, gravel, and concrete.

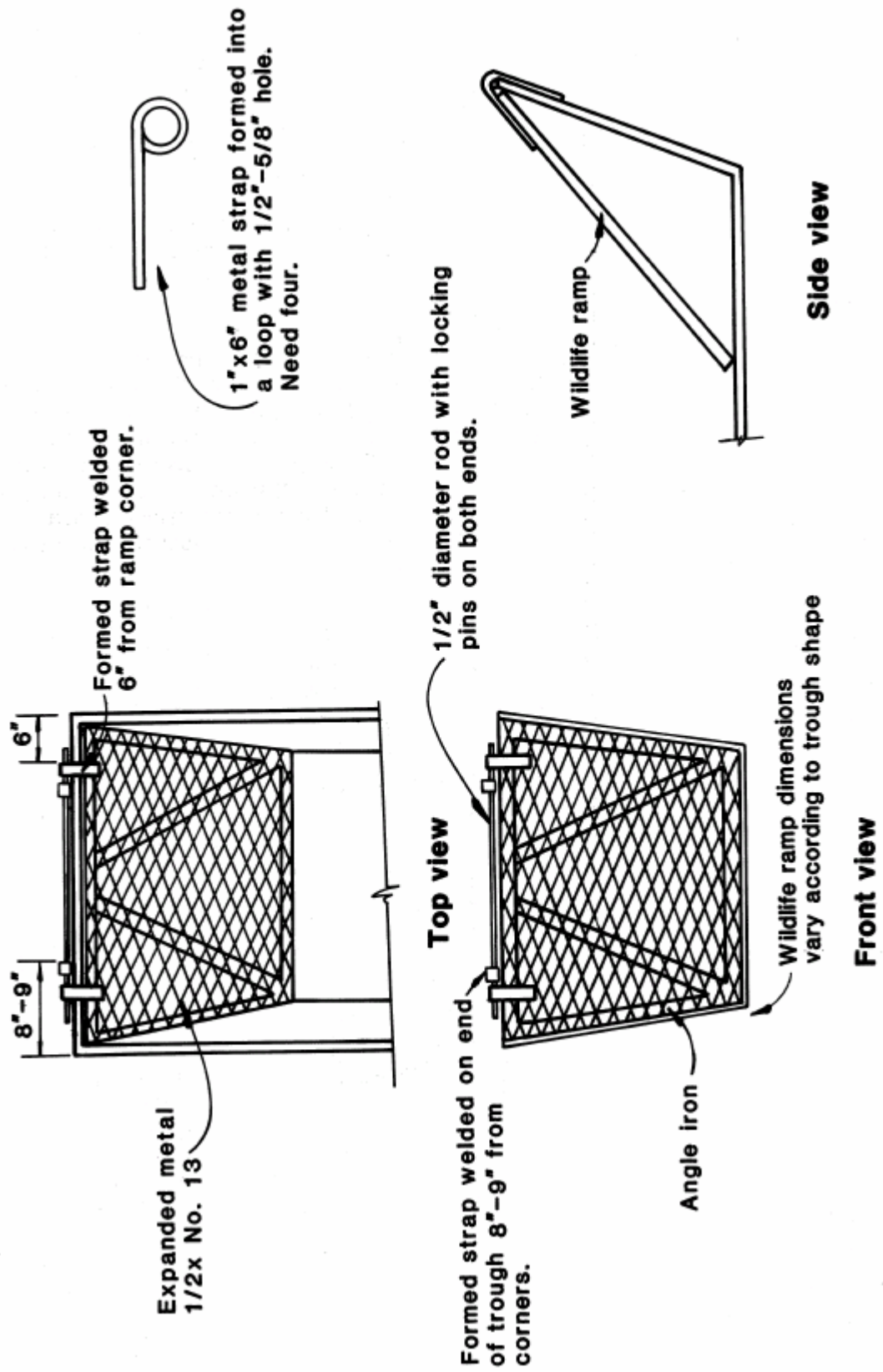


Figure 77—Specifications for hinged wildlife escape ramp.

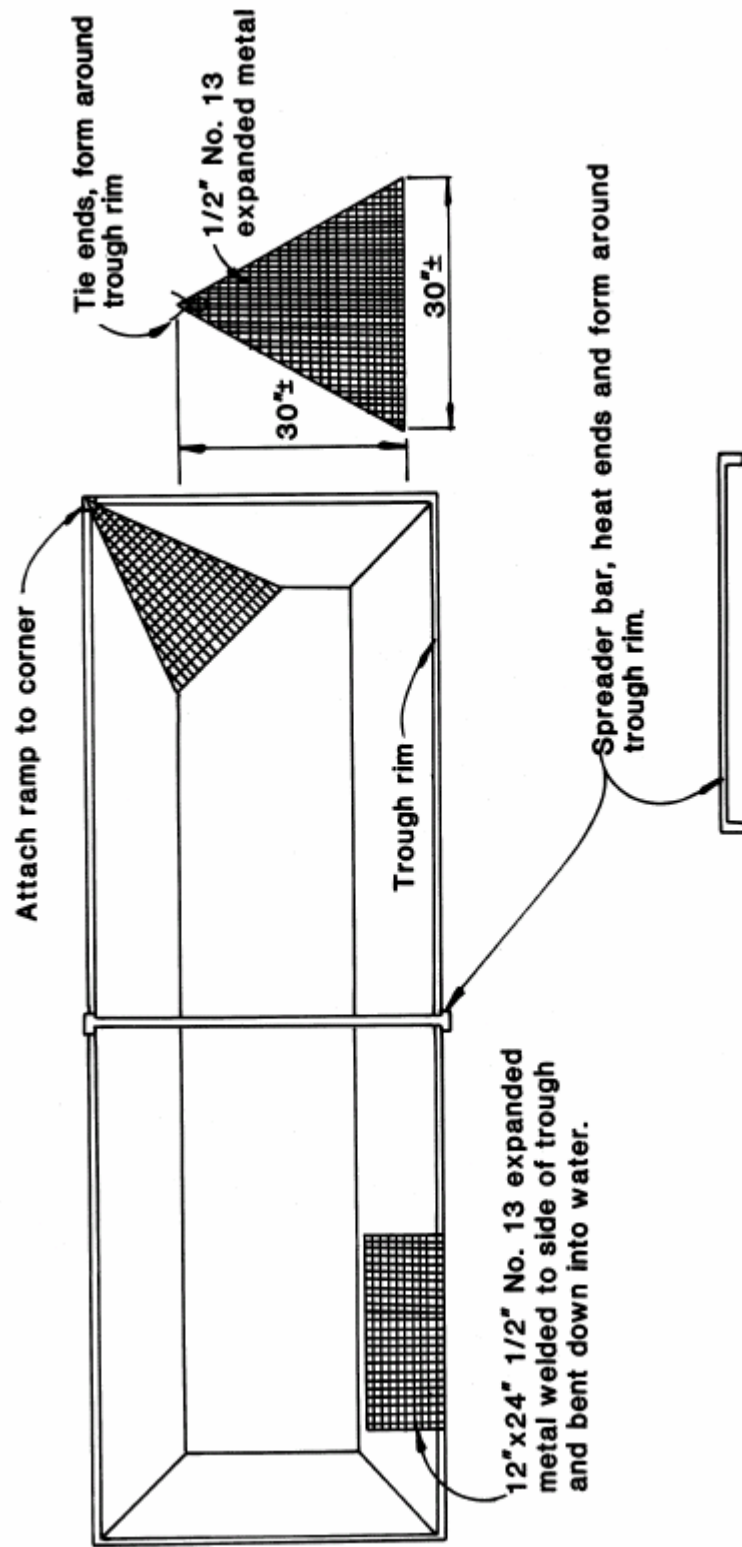


Figure 78—Details of an alternative wildlife escape ramp and water trough spreader bar.

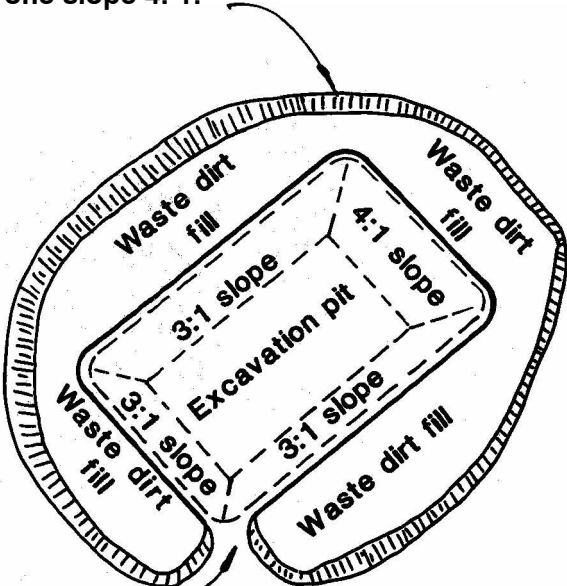
Specifications— The size and depth of stock ponds are important because the amount of water used by livestock is minor compared with losses from evaporation and seepage. A deep pond with minimum surface area will have noticeably less evaporation than a shallow one. Livestock will drink from ponds with relatively steep sides, but usually will not wade in the water. Stock ponds designed to provide direct access for livestock to the water should have at least two sides with slopes no greater than 3:1; a 4:1 slope is preferred. Water should be at least 8 feet deep, or deeper to minimize evaporation loss.

Pit tank or dugout—Pit tanks should have three sides with a 3:1 slope; the fourth side should have a 4:1 slope (fig. 79). Extracted material is used to build an embankment around the excavation except for the spillway area. The spillway should lead water back to a natural stream course. The distance between the high-water level of the tank and the top of the fill should be at least 3 feet. Each layer of excavated dirt should be packed as it is deposited. An alternative design is to place all the excavated material on the downhill side of the excavation to form a small dam. This method is commonly used in small drainages to catch and store surface, runoff. Pit tanks can also be constructed next to streams such that the overflow channel provides an inlet to fill the pit tank during high flow.

Small reservoirs—Although dams less than 10 feet high usually do not require special permits, they do have some specific requirements to be structurally sound. The dam surface on the upstream side should have a 3:1 slope and on the downstream side a 2:1 slope. The crown should have a minimum width of 10 feet. Small dams should be constructed with an impermeable core that is keyed into a core trench, 5 feet wide and 2 feet deep minimum, across the total width of the dam. Material for constructing the dam can be excavated beginning at least 10 feet upstream from the toe of the dam. The sides of the excavation pit should have 3:1 slopes, and the farthest upstream slope 4:1 (fig. 80).

Installing a pipe through the dam to one or more watering areas instead of allowing livestock direct access to the stored water is desirable. The pipe can be designed to provide two functions: (1) to release the water behind the dam to make repairs or reduce overflow damage and to release water for downstream needs, and (2) to provide stock water. This system requires 4- to 6-inch-diameter pipe with a trash guard on the inlet and a gate valve on the outlet. A 1.5-inch outlet, with a shutoff, is installed just before the gate valve to supply water to livestock (fig. 81). An alternative is to place the valve near the inlet, but this design requires supports for the valve stem; also, stock water has to be piped through the dam. All pipes passing through the dam must have antiseep collars, generally on both sides of the core material. It is most convenient to install the pipe during the dam construction, otherwise a trench must be dug through the dam.

Site must be scarified before excavation or fill.
 Each layer of fill must be compacted before another layer is added. Side slopes will be a minimum of 3:1 and one slope 4:1.



Spillway must drain into existing natural channel or vegetation to avoid erosion. Freeboard (distance between spillway and top of fill) shall be 3' minimum.

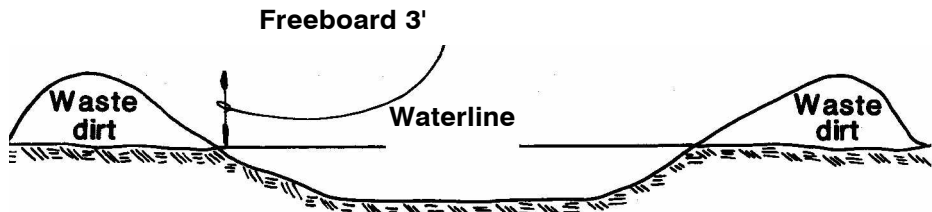


Figure 79—Specifications for pit tanks.

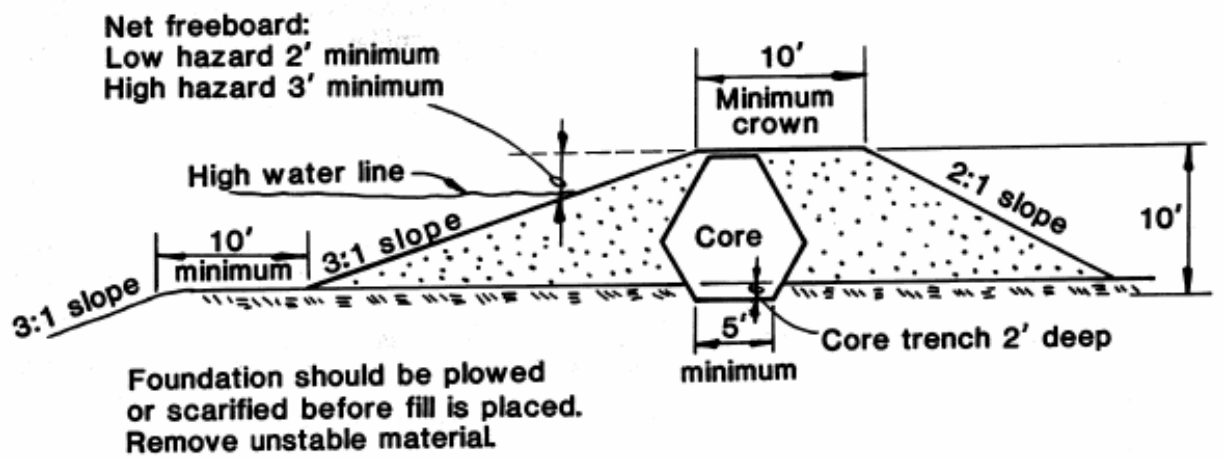
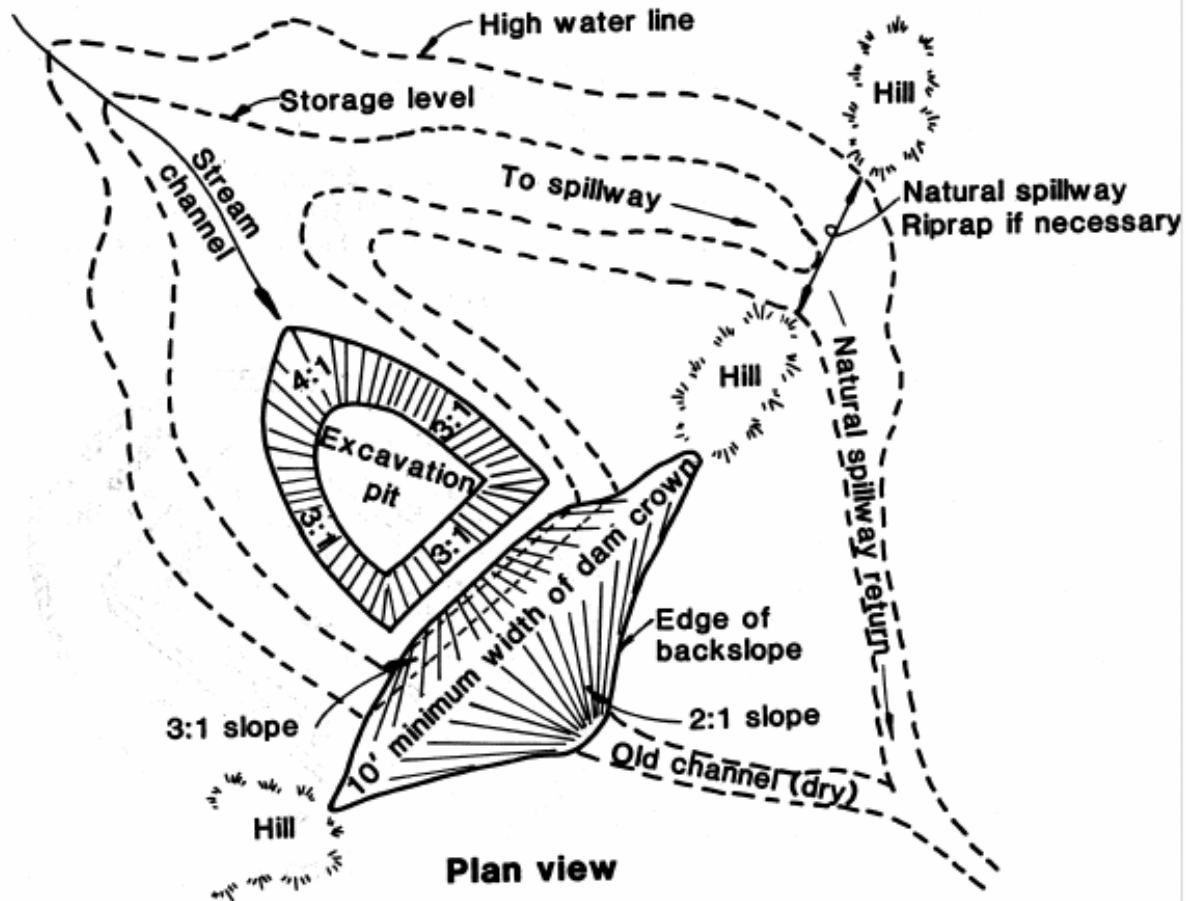


Figure 80—Specifications for reservoir dam, core, and excavation pit.

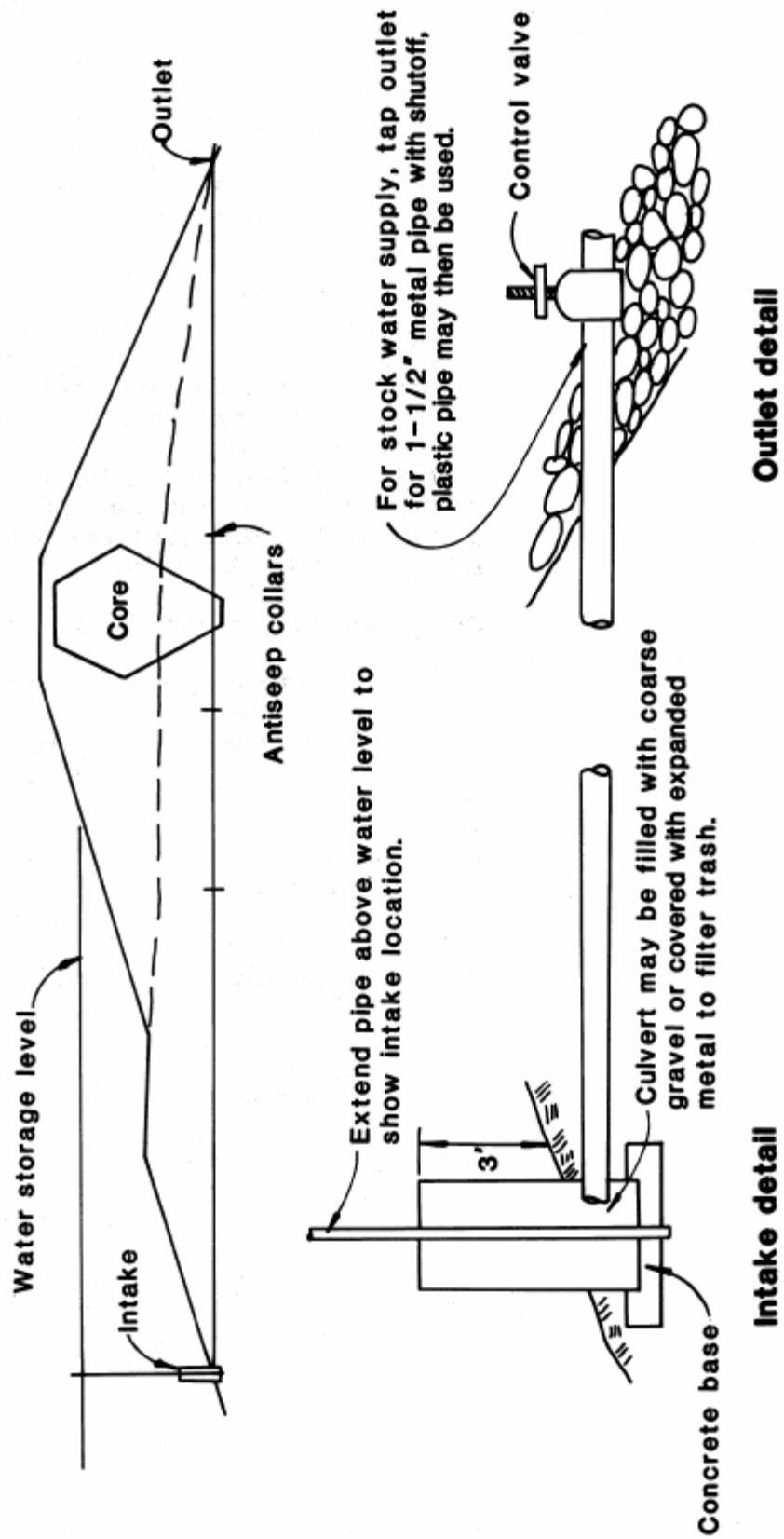


Figure 81—Details for pipe to pass through a dam structure.

Design of the spillway is critical in the construction of small dams. The best design follows a natural watercourse away from the face of the dam (fig. 82). Where this is not possible, the spillway should be constructed with an inlet channel as level as possible around the berm of the dam and into a channel that will carry the water away from the dam and return it to the natural channel well below the toe of the dam. Such spillways should be lined with a rock rip rap and should have a wing dike to protect the dam (fig. 83). Spillways and the overflow channel also should be designed to protect the dam structure. The overflow channel can be protected from erosion with vegetation or a rock lining.

Stock pond seepage and repair—New stock ponds often lose water through seepage; however, when stock ponds do not seal within 2 years, a sealant such as bentonite clay should be applied. Local deposits are commonly used, or bentonite may be purchased. If the water contains calcium, bentonite may not be effective. Water with high calcium concentrations should be tested before bentonite is applied.

Generally, bentonite is applied at the rate of about 1 pound per square foot, depending on the quality of the bentonite and the chemical analysis of the soil. Bentonite quality and soil chemistry should be determined in areas where there are problems in sealing reservoirs by this method.

One of the following methods should be used to apply bentonite:

1. Drain and dry the reservoir basin. Remove 4 to 6 inches of soil and pile it for later use. Smooth the reservoir bottom with hand rake, land plane, roller, or similar means. Cover the entire basin area with an even layer of bentonite at the predetermined rate. Replace the piled soil by carefully spreading it over the bentonite. Roll or tamp the whole area.
2. Drain and dry the reservoir basin. Remove all vegetation, rocks, and debris from reservoir basin. Smooth the surface reasonably well and plow to a depth of 4 to 6 inches. Allow the soil to dry. Scatter bentonite evenly over the plowed surface at the predetermined rate and mix it with the soil by hand rake, spiketooth harrow, or disk and roll or tamp the entire area.
3. Granular bentonite applied directly on the water surface often gives good results if the seepage is not too serious. The granules sink and are drawn into the seepage cracks, where they swell or gel to plug the leak.

Rock salt, also applied directly on the water surface, can be used to seal certain types of soil. It is most effective for soils having 20 percent or more clay particles 2-microns or less in diameter and less than 15 percent clay dispersion. A high content of lime in the soil or a high content of organic matter in the water shortens the benefits of salt application. Several soil samples should be collected and tested to determine the effectiveness of salt treatment before the actual treatment. Testing can generally be done locally or by any soils laboratory.

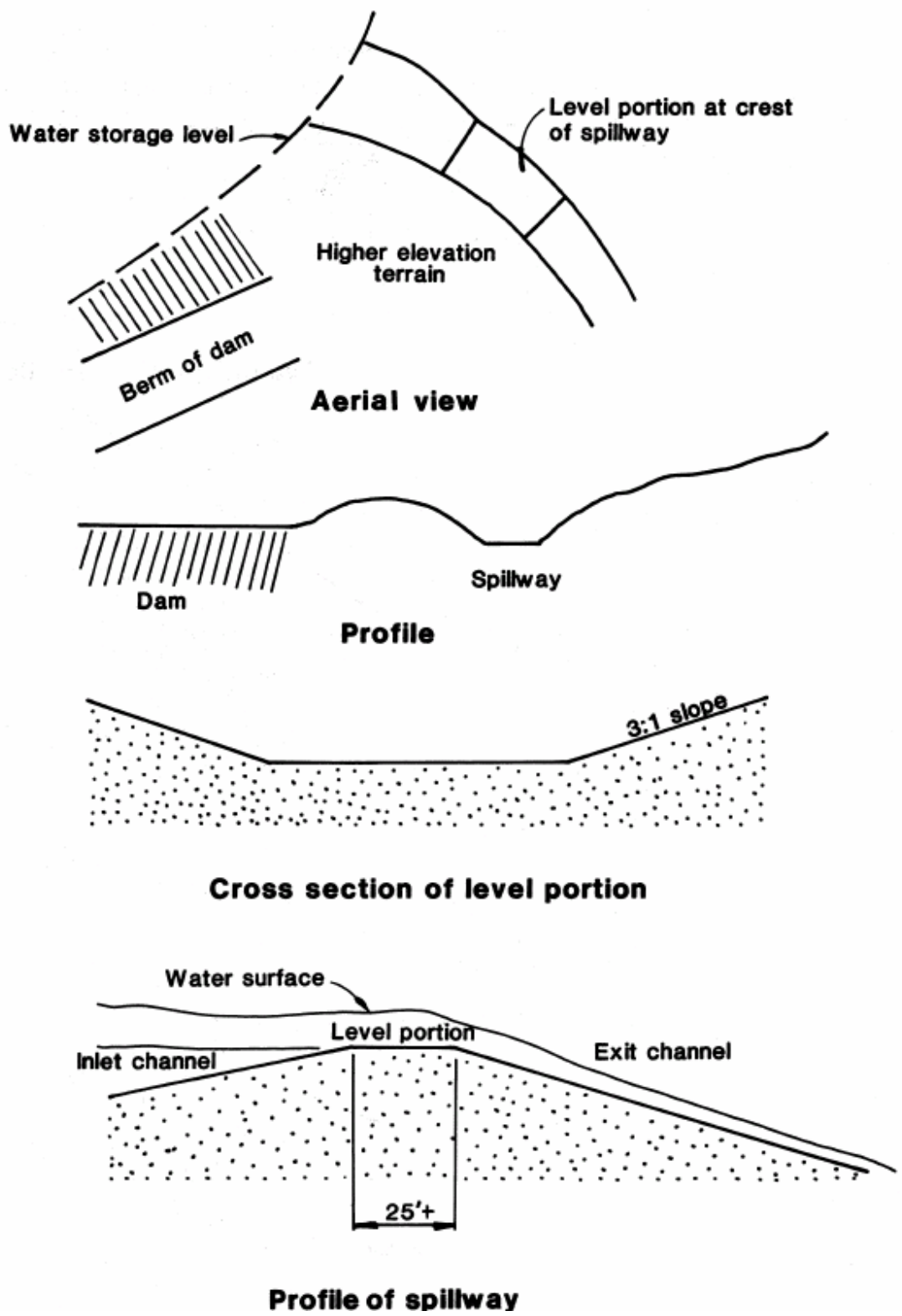
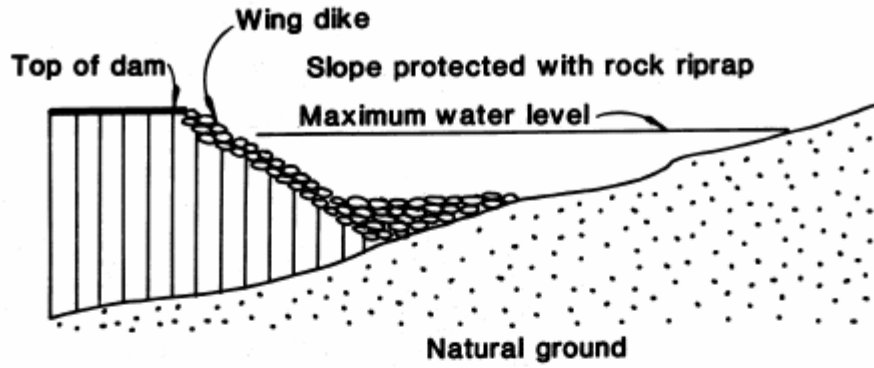
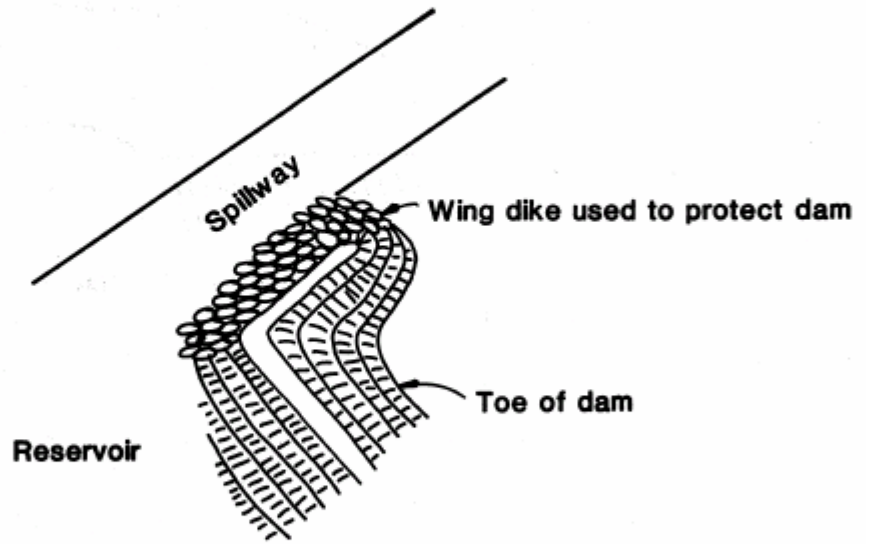


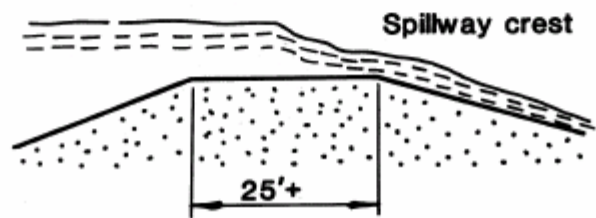
Figure 82—Earth spillway constructed through a natural channel.



Typical control section



Top view



Profile

Figure 83—Earth spillway constructed around the toe of a dam.

Trick tanks and guzzlers—

Description—Trick tanks and guzzlers collect precipitation on some kind of apron and store the water. Trick tanks generally use a corrugated metal apron that is constructed above the storage tank, or tanks (which may or may not be buried), to collect precipitation. The apron can be sloped in one direction with a gutter at the lower end to catch and divert the water into the storage tank (fig. 84). The collection apron can be V-shaped, with the water diverted directly into a round water trough, which may also serve as the storage tank.

Guzzlers generally use an impermeable apron placed directly on the ground. The apron, of asphalt or butyl rubber, collects the precipitation and diverts it directly into an underground storage tank by a sloping ramp that also provides access for birds and small mammals. Water for livestock is generally piped to a trough located at a convenient site below the storage tank. The guzzler apron must be fenced to protect it from damage by livestock.

Trick tanks and guzzlers generally use relatively large storage tanks because such systems usually rely on winter precipitation for water for the summer grazing season. We recommend that the storage tanks be placed underground to protect them from freezing and to reduce evaporation. If the facility must be built on a relatively level site, dirt can be "borrowed" from a watering site to cover the storage tanks (fig. 85).

Application—Costs for trick tanks and guzzlers are relatively high compared with costs for other water developments, and rainfall in arid areas may limit the usefulness of such systems. Consequently, they are generally used only where no other water source is available. Trick tanks can be constructed on any surface, whereas guzzlers need a gentle slope for the apron. Snow fences can be located specifically to create large drifts on collection aprons, but they can generate heavy silt deposits in areas where dust storms occur.

Equipment—Trucks are needed to transport the materials for trick tanks and guzzlers to the site, and a backhoe is generally needed to bury the storage tanks and to assist in unloading and maneuvering them into position. A backhoe is also needed to bury pipelines and to locate the watering facility, usually a trough. Special equipment may be needed to construct the catchment apron for guzzlers.

Materials—Materials needed include storage tanks and fencing. Materials needed for the catchment apron will depend on the design specifications (asphalt, butyl rubber sheeting, corrugated sheet metal, concrete).

Specifications—The total area of the apron, or collection surface, depends on minimum annual precipitation and the water storage requirements. About 160 square feet of catchment apron in an area that has an annual minimum precipitation of 10 inches will collect about 1,000 gallons of water in a year (table 13). Guzzler aprons must be on smooth ground, with a slope no greater than 10 percent, and must be protected from livestock damage. Damage by big game should also be considered, depending on the type of material used for the apron. The apron should be protected from outside waterflows either by ditching or a berm, or both.

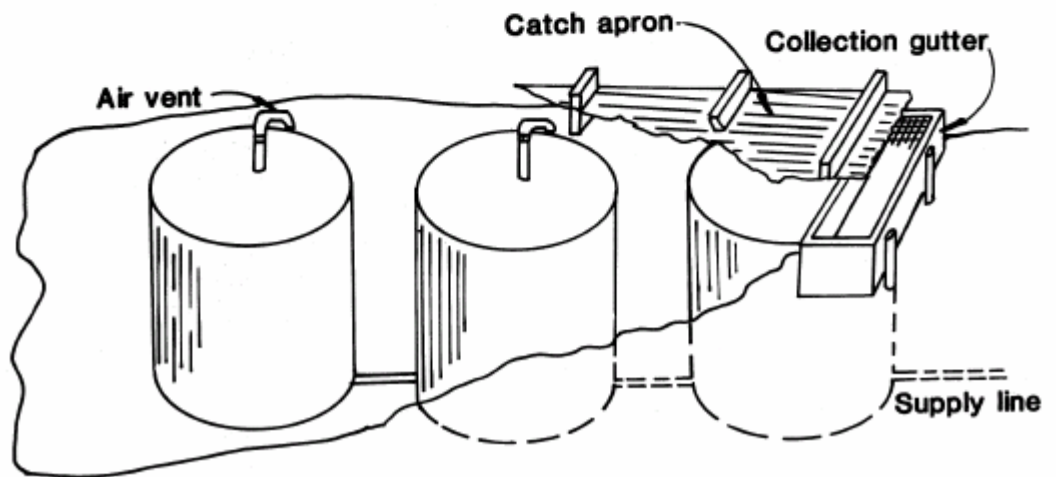
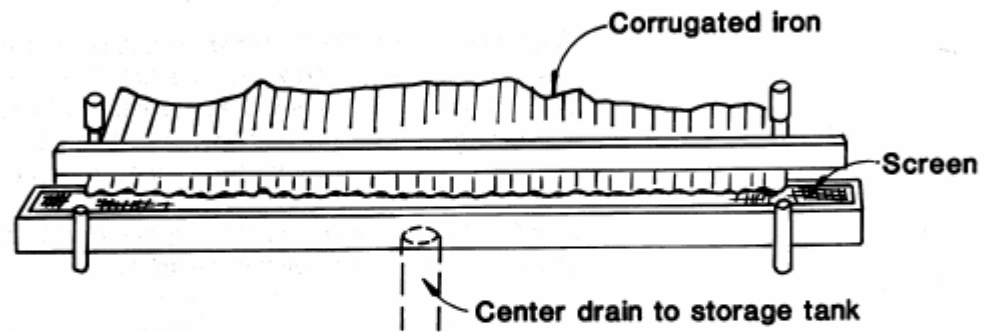
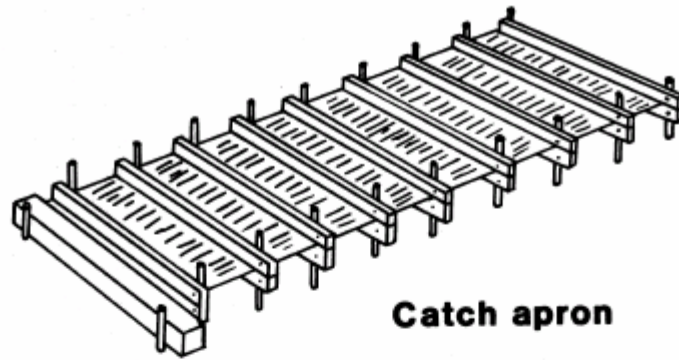


Figure 84— Trick-tank catch apron, gutter, and storage tanks. Dimensions and storage capacity must be calculated according to water demands and rainfall.

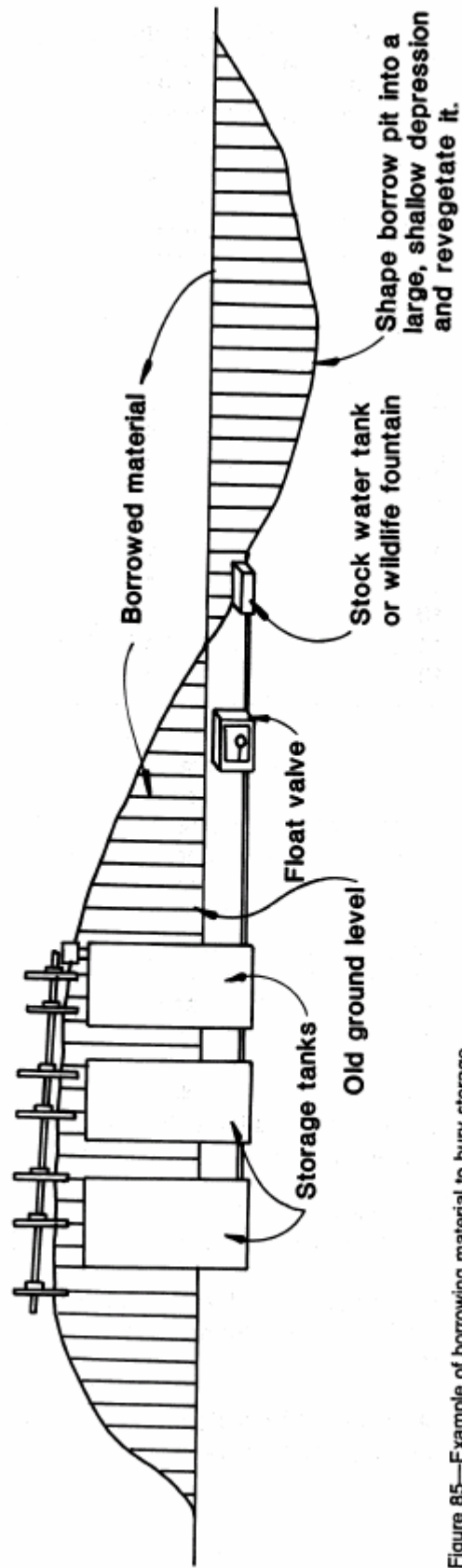


Figure 85—Example of borrowing material to bury storage tanks and support catch apron for trick-tank water source.

Table 13—Amount of catchment apron (collection surface) needed to collect 100 and 1,000 gallons of water in areas with 1 to 12 inches of annual precipitation

Minimum annual precipitation	Required collection surface	
	100 gallons	1,000 gallons
<i>Inches</i>	<i>----- Square feet -----</i>	
1	161	1,164
2	80	807
3	54	539
4	40	406
5	32	322
6	27	270
7	23	231
8	20	202
9	18	179
10	16	162
11	15	147
12	13	134

Storage tanks are metal, concrete, or plastic and are available in various depths and diameters. Storage capacity needed is determined by multiplying the expected animal months of use by the number of gallons required for one animal month. One cow or horse requires 360 to 450 gallons per month, whereas one sheep needs about 40 gallons. Consideration should be given to the season of use as well as to the class of livestock. If grazing occurs during the dry season and no refilling can be expected, the storage capacity must be large enough to water the full herd for the total season of use at that water installation, plus loss from evaporation, leakage, and waste. Storage tanks should be built at locations that will permit the stored water to be distributed by gravity flow.

Livestock Access Trails

Description—livestock access trails are paths specifically constructed to allow livestock to pass through such obstacles as dense or fallen timber and dense brush and across steep or rocky slopes.

Application—livestock access trails are used to provide access to forage or water. Improved distribution of livestock and better use of forage are the goals of such trails.

Equipment—Bulldozers and backhoes are the most common means of constructing livestock access trails; however, hand tools can be effective in clearing timber from trail rights-of-way. Explosives may be needed to clear large obstacles.

Materials—Few materials are needed to construct livestock access trails, unless blasting is necessary.

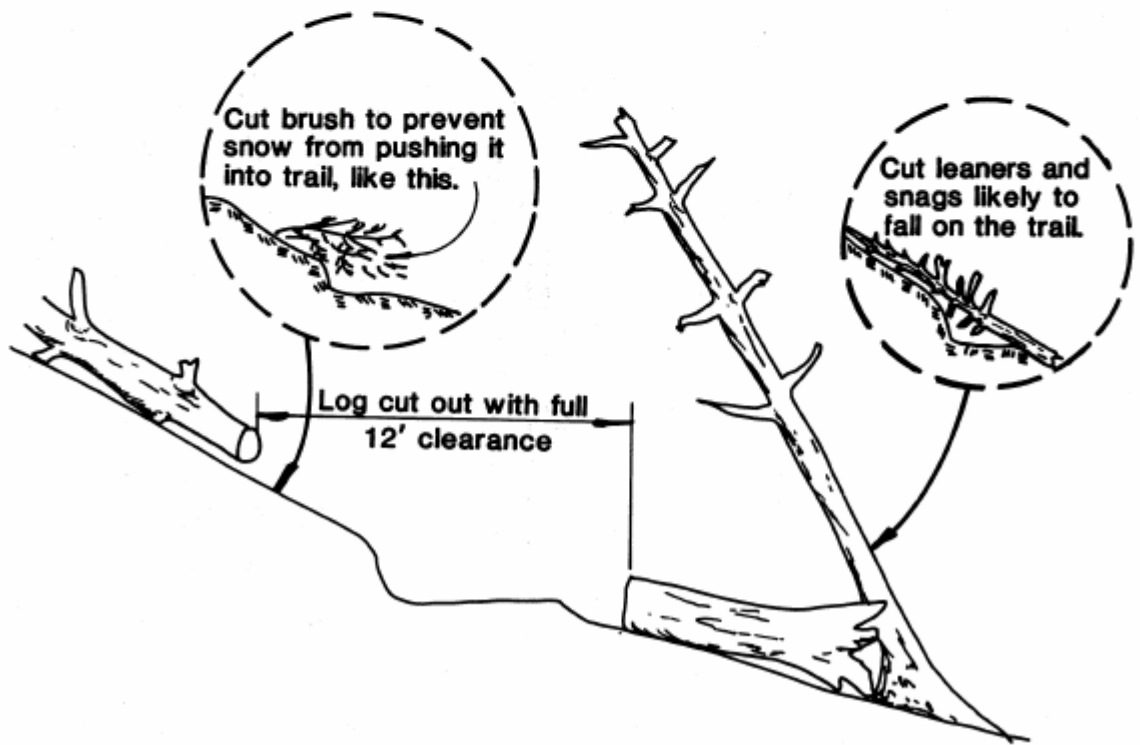
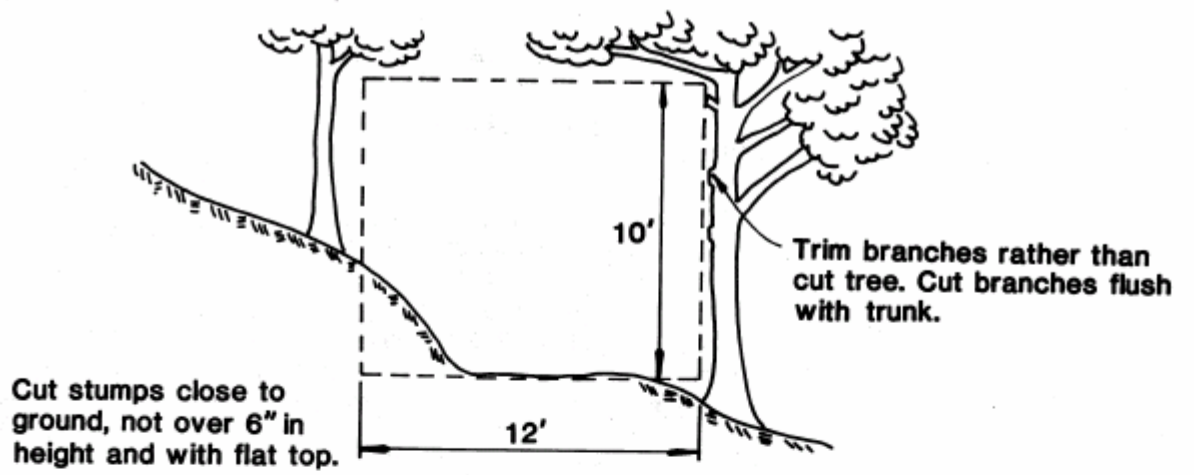


Figure 86—Clearance specifications for livestock access trails.

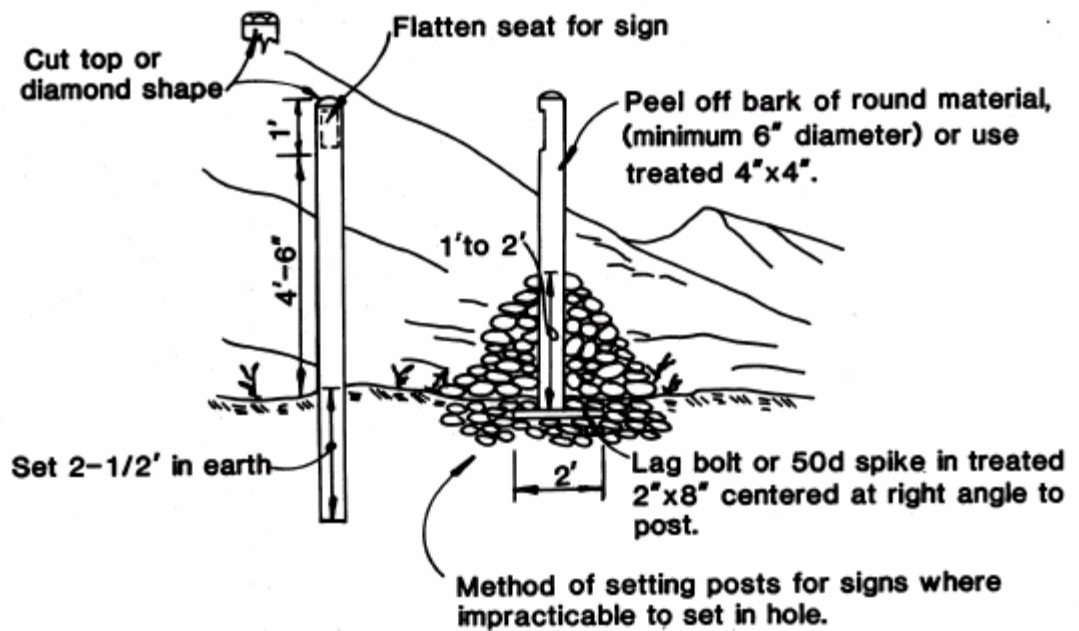
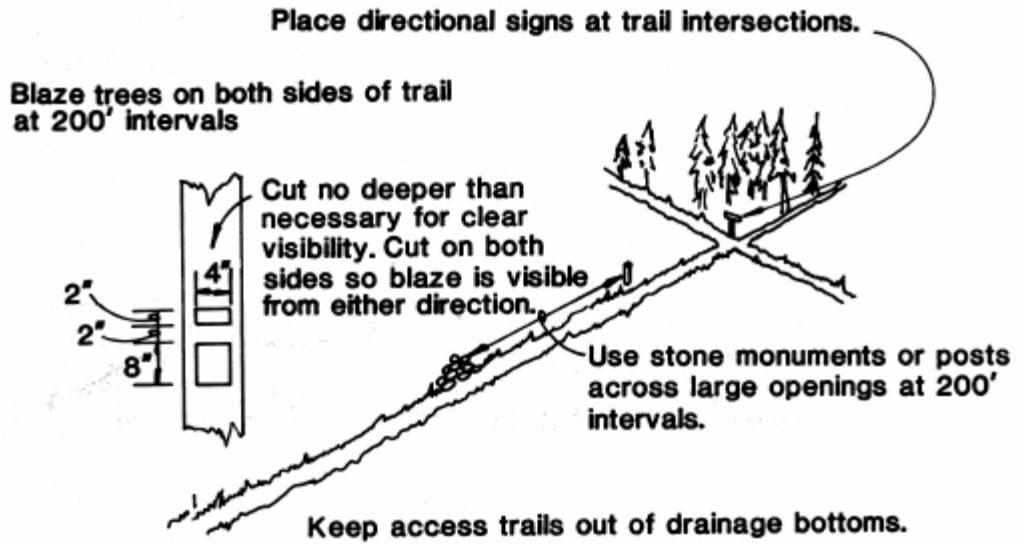


Figure 86—Clearance specifications for livestock access trails.

Specifications—Access trails should be constructed to minimize erosion problems by using such measures as water bars, seeding, and riprap. Natural routes of travel should be followed and excessively steep slopes, rocky areas, and wet and marshy areas avoided as much as possible. Sharp turns and straight, steep pitches should be avoided or livestock may not use the trails.

Standing and down material should be removed to allow livestock and horseback riders to pass; generally, a 12-foot horizontal and a 10-foot vertical clearance are enough (fig. 86). Consideration should be given to fire protection standards when brush is cleared. Where access trails cross other travel routes or open areas, signs may be needed to identify the trail (fig. 87).

Acknowledgments

A number of people, including ranchers and agency personnel who participated with the EVAL project, have provided comments and recommendations for these specifications, and we thank them all. In addition, we acknowledge the fine work Maurine Chmara did in converting "cowboy" sketches into understandable drawings.

Conversion Table

1 mile = 80 chains = 320 rods = 1,760 yards = 5,280 feet
1 chain = 66 feet
1 rod = 16.5 feet

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Research Station. 120 p.

Construction specifications and illustrations are provided for several types of barbed wire and pole fences, gates, cattle guards, stiles, spring developments, water troughs, stock ponds, trick tanks, and livestock access trails.

Keywords: Range management, structural improvements, fences, gates, cattle guards, water developments, livestock control.

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