An Introduction to High-tensile, Smooth-wire Electric Fencing

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Fencing is a valuable tool for controlling animal distribution and improving rangeland and pasture management. The ideal fence should have a low capital cost, be easy to install, have a long life, have low maintenance cost, and be stock-proof. Electric fences have long been viewed as temporary structures in range operations. Only recently has the technology necessary for permanent electric fences been developed.

Permanent electric fences often are used in intensive grazing systems. They differ from conventional electric fences in that they are constructed with two or more wires, which may or may not be individually charged. The use of two-wire electric fence can result in a 25 to 50 percent savings in labor and material costs, compared to conventional, four-strand, barbed wire fencing. This fact sheet presents tips to help plan and construct durable electric fences for livestock control.

Principle of Electric Fencing

The principle involved in controlling animals with electric fencing is "rule-by-fear." It takes few contacts before animals learn to avoid electric wire fences. Electric fence is largely a psychological barrier, not a physical one as is barbed wire.

Livestock should be trained with electric fences before they are released in a pasture situation. This may be accomplished by constructing an electric fence inside a regular corral and penning the stock over night.

Advantages and Disadvantages

High-tensile electric fencing has several advantages over barbed wire. If properly constructed, it lasts longer, requires less maintenance, causes less animal injury, is less restrictive to wildlife management, and costs less. The cost advantage is greatest in rough terrain. Contrary to popular belief, experience indicates that electric fencing is a useful tool in rough terrain.

While ranchers and livestock have lived with barbed wire for 100 years, electric fencing technology has evolved largely during the last two decades. This suggests a need for an initial demonstration on how to install the fence and how to train livestock to respect it. Electric fences also need to be inspected more frequently than do barbed wire fences. However, smooth wire is safer than barbed wire for livestock and wildlife. Never use barbed wire when building an electric fence.

The following safety tips are also recommended during construction, operation, and maintenance of electric fences:

1. Mark fences with warning signs every 300 feet (especially single-wire fences).
2. Locate fences to avoid contact with power lines or communication equipment.
3. Never hook up an electric fence ground to a power pole grounding system.
4. Maintain a respectable distance from the fence during electrical storms.
5. Do not install or repair the fence while the energizer is on.

Components

Components of an electric fence include an energizer, wire, wire strainer, posts, insulators, stays, and proper braces. Each part must operate continuously for successful operation.

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Energizer

An energizer is the heart of an electric fence. It regulates the amount and frequency of current through the wire. The New Zealand energizers are solid state construction. They produce a series of very short but powerful electrical pulses that provide sufficient shock to control but not harm the animals. Charges (pulses) are produced at the rate of 35 to 65 per minute. They are less than 300 milliamps in intensity, and last .0003 second. This electrical pulse tends to maintain its voltage through wet vegetation and retain its ability to control stock, rather than shorting out as the older thermal-breaker-switch and coil-and-breaker point designs did.

Properly installed energizers can release at least 5,000 volts. To be effective, a shock must be at least 1,000 volts for cattle and 2,000 volts for sheep. One energizer can charge 10 to 75 miles of fence wire. Most energizers have circuit panel modules that can be removed easily for replacement or repair. They may be operated by 110 or 220 volts, or by dry or wet cell batteries. Mainline-operated units provide more consistent power and have the advantages of eliminating the cost and trouble of maintaining and replacing batteries. Batteries are capable of about one-half the voltage of mainline units. They should not be placed on the ground and must be recharged every 2 to 3 weeks. Solar panels are well suited for charging batteries in remote areas.

Energizers can be damaged or destroyed by lightning. Electric fences should not parallel power or telephone lines. It is a good idea, in situations where it is possible, to unplug the power cord and disconnect fence leads from the energizer before a storm hits. At least one lightning arrester should be installed to ground lightning so that it is not routed to the energizer. The arrester should be located where the lead-out wire from the energizer meets the fence and should be grounded with a 6- to 8-foot steel rod driven into the ground.

Failures with New Zealand energizers generally result from poor grounding or splicing, loose wires, breakdown of insulators, loose or corroded connections, radio and telephone interference, and electrostatic fields caused by powerlines within a 1,000-foot radius of the fence. Shock from the charger box, noise in vehicle radios, and frequently blown fuses all indicate a weak ground.

Wire

A high-tensile, galvanized, 12 1/2-gauge, smooth wire is recommended for permanent electric fences. Because of its high-tensile strength, this wire does not stretch or sag as much as barbed wire. Although 14 1/2 or 15 1/2 gauge may also be used, the smaller diameter wire has lower visibility and breaking strength.

The general specifications of the 12 1/2-gauge wire should include a breaking point of at least 1,250 pounds, tensile strength of 180,000 pounds per square inch, and a zinc coat weight of 0.8 ounce per square foot (Class II). The wire is commercially available in 4,000-foot, 100-pound coils, or 2,000-foot, 50-pound rolls. The biggest advantage of high-tensile wire over standard barbed wire, if installed properly, is that high-tensile wire stretches upon impact and will return to its original position when released. High-tensile wire may break easier than barbed wire if bent, however.

Wires on an electric fence must be properly spaced. Spaces should be small enough to allow no more than the animal's head through it. This ensures that an animal is shocked on its face or ears when it challenges the fence. Recommended wire spacing for controlling domestic stock is summarized in Table 1.

Wire Strainers

Strainers are necessary in permanent electric fences to maintain wire tension. Strainers can be loosened for repair work or tightened to prevent sag. They also are

Table 1. Recommended wire number and spacing for permanent electric fences for various kinds of livestock.

Fence type	Kind of livestock	Wire no.	Wire spacing from ground (inches)[1]					Recommendations
Pasture	Cattle	1-wire	(+)26					While one wire may be enough on wet or irrigated ground or as a cross fence, 3 wires may be needed for yearlings or untrained cows.
		2-wire	(-)18-24	(+)24-30				
		3-wire	(+)13-18	(-)24-28	(+)34-40			
	Sheep	2-wire	(+)10	(-)18				
		3-wire	(+)8	(-)16	(+)28			
		4-wire	(-)5-7	(+)12-15	(-)18-24	(+)30-35		
	Cattle and sheep	4-wire	(-)4-7	(+)12-15	(-)18-24	(+)30-34		
	Horses	3-wire	(+)12	(-)22-32	(+)42-52			
Boundary	All livestock	5-wire	(+)8	(-)14(+)20	(-)26	(+)36	(+)40	
		6-wire	(-)5	(+)10-15	(+)21	(-)28	(+)36	

[1](+) = charged wire; (-) = ground wire.

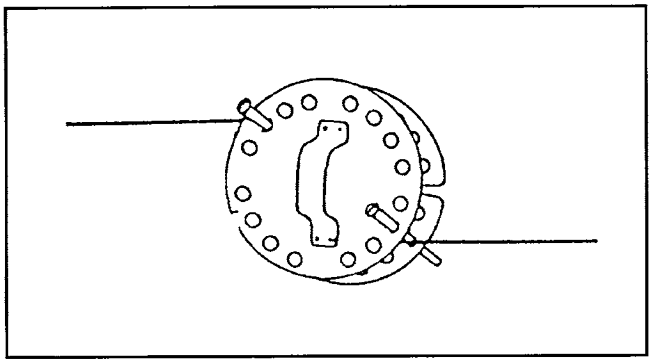

Fig. 1. This strainer can be inserted into a fence line without cutting the wire. The wire is locked by the two pins.

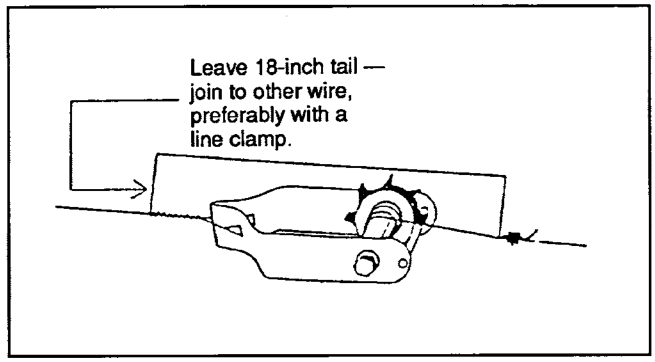

Fig. 2. Wire must be cut before it can be wound onto the automatic locking, non-slip, spool of this strainer. (Adapted from Porter 1983.)

useful in maintaining tension during periods of fluctuating temperatures, because tension increases during hot weather and decreases in cold weather. One model (Fig. 1) has a spool and two pins that lock the wire. It can be inserted into a fence line without cutting the wire. Another model (Fig. 2) requires the wire to be cut before the wire can be wound onto an automatic locking, non-slip spool.

Posts

Posts that are driven are about 1 1/2 times more rigid than those set in holes, and have a greater lifting force resistance. Post spacing will vary according to roughness of terrain, type of post, and the use of stays. Without stays, steel and wood posts should be spaced on 40- to 75-foot centers. With stays, line posts can be placed up to 120 feet apart on level terrain. Fiberglass posts should be spaced about 30 to 50 feet apart if stays are not used, and about 100 feet apart if stays are placed every 50 feet. On rough terrain, posts are necessary on the high and low points to maintain effective wire spacing. A 4 x 5-inch wood stabilizing post can be used where needed to strengthen fences constructed with fiberglass posts.

Locate line posts on the side of the wire opposite greatest stock pressure. Fencing across sloping terrain normally will mean posting on the lower side of the fence line.

Post Material

Line posts of permanent, electric fences can be made from a variety of material. There are advantages and disadvantages associated with each:

Wooden posts often are used. They should be treated wood, 3 to 4 inches in diameter, 6 to 7 feet in length, and should be used with a good-quality wood insulator. Self-insulating posts made of dense wood are also available. However, these posts are narrow and are sometimes difficult to drive into rocky areas. A steel pilot guide can be used to start a hole for these posts.

T-shaped fiberglass posts often are used. They are about 70 percent lighter than steel posts and require no insulators. Some types are more visible to grazing animals. The heavy duty posts may be driven into most soil where a conventional steel post can be driven. T-shaped posts should be at least 1 1/2 inches across. These posts may be more expensive than other kinds of posts. In addition, some fiberglass posts are poorly constructed and may snap in freezing weather or break under heavy snow loads.

Sucker rod and re-bar also have been used as line fence posts. However, notches have to be made or holes drilled in these posts to securely attach the insulators. In addition, these posts tend to pull out of the ground if they are used in rough terrain or coulee bottoms. To hold the posts in place, some ranchers use tie-downs. Others drill a hole through the bottom of the post and slip a nail through the hole just before the post is driven.

Conventional steel posts also may be used. Although their strength is an advantage, they must be used with good quality insulators. The most reliable insulators are those that pin-lock into a hole drilled or burned in the posts. This type of insulator will not pop off as snap-on insulators do.

Polypropylene plastic posts have been introduced recently. Although one brand is only 2 3/8 inches in diameter and weighs 1.1 pounds per foot of length, the manufacturer reports that it is stronger than a 4-inch wood post. A 1 1/2-inch, ringed, shank staple reportedly can be driven into it. Although insulators are not needed with these posts, plastic posts are more difficult to drive than steel posts and are about 60 percent more expensive.

Insulators

Permanent wire insulators are made of high-quality porcelain or thick, black, high-density polyethylene. Because porcelain insulators sometimes crack during installation, many operators prefer the polyethylene type. The wire must be free-flowing through the insulators.

Stays

The main purpose of stays is to maintain wire spacing, act as a visual barrier to livestock, and distribute pressure among all wires in the span. Stays are cheaper to purchase and install than additional posts. But the presence of stays may cause the whole wire fence to twist when big game animals cross the fence. Another disadvantage is their weight, which the wire must carry.

Stays can be made of several kinds of materials. While some ranchers cut short pieces of PVC pipe to keep wires properly spaced, most stays are made of wood or fiberglass. Wood stays provide a strong, rigid, visual barrier to livestock.

Fiberglass stays are light, long-lasting, strong, and self-insulating. They are available in 2 1/2- to 8-foot lengths, and are easily attached to fence wires with light-duty clips. They are more expensive than other types of stays, however.

Construction

Permanent electric fences will last 30 to 40 years if properly constructed and maintained. People are the primary reason that electric fences fail. Proper construction includes:

1. Decide on purpose of proposed fence and choose proper design.
2. Determine proper location of fence and purchase materials.
3. Prepare fence line (if necessary) and lay out materials.
4. Locate and assemble one corner end brace.
5. Pull guide wire to other end, construct other end brace, and pull guide wire tight.
6. Set line posts and attach all insulators.
7. Pull out remaining wires and fit permanent wire strainers.
8. Tie wires off.
9. Complete gate assembly, check water gaps, etc.

Proper maintenance includes weekly inspections of the fence. With high voltage-low impedance energizers, failures are generally a consequence of poor grounding or splicing, extremely dry conditions, loose wire, breakdown of insulation, loose or corroded connections, radios and telephone interference, and electrostatic fields caused by powerlines within a 1,000 foot radius of the fence.

A grounding system can be tested as follows:

Tools needed:

- A voltmeter designed to test electric fences
- Extra ground rods (galvanized pipe or rod, 6 to 8 feet)
- Ground rod clamps
- Six steel posts or steel stakes
- Galvanized wire to hook up extra wire connections
- Wire taps, or wire screws, to make wire connections

Steps:

- Short out the hot wire on the fence (lean several steel posts on top hot wire, about 100 yards from the energizer).
- Test the shorted-out fence with a voltmeter. It should read 1,000 volts or less.
- Measure the voltage from the last ground rod in the soil to a point in the ground at least 1 yard from the previous ground rod.
- A voltmeter reading of less than 200 volts indicates adequate grounding. (If the volt reading is well over 200 volts, add additional ground rods.)
- Repeat the ground rod test to see if the additional rods lessen this reverse voltage.

A voltmeter is a also needed to locate shorts. To check the energizer, check the voltage at the energizer with the fence hooked up, and then when it is unhooked from the energizer. If the energizer is okay, take voltmeter readings every 600 feet or so along the fence line. As the short is approached, the voltage will begin to drop.

Remember, periodic inspection is a must. Fence failures are minimized by good construction and by maintaining taut wires.

Designs and Grounding

Poorly constructed fences fail the test of time. Rather than developing a "new and improved design," electric fences should be constructed with a fencing design that has proved effective.

Construct the fence with the appropriate number of wires. One hot wire provides good shocking power in irrigated pastures or in areas that receive more than 25 inches of annual rainfall. Electricity goes from the energizer through the wire to the animal, through the animal to the ground, and back to the ground rods on the energizer. The wire should be placed about shoulder high to whatever kind of livestock is being controlled.

Dry ground causes poor shocking power, which means poor animal control. In areas that receive less than 25 inches of rainfall per year, or under frozen soil conditions, at least one wire on an electric fence should be a ground wire. An animal is shocked when it touches both a hot wire and the ground wire at the same time. The electricity goes from the hot wire, through the animal and to the ground wire, creating maximum shock.

The energizer and cold wires should be grounded to minimize damage and injury from lightning strikes. Some portable energizers can be mounted on a specially-designed metal post that acts as a ground. Units that do not have this feature should be grounded by driving three to five 3/4-inch by 6-foot galvanized steel posts into dry soil (Fig. 3). Posts should be at least 6 feet from each other and 24 feet from any other ground rod connected to another electrical system. Wires extending from the earth terminal of the energizer must be securely clamped or soldered to the stakes. A galvanized nut and bolt or line clamps should be used when joining a copper wire to a galvanized post.

Ground wires along the fence line should be connected to stakes driven deep into the ground every 3,280 feet on wet sites and every 1,600 feet on dry sites. They should also be grounded at gates and at each stretching brace.

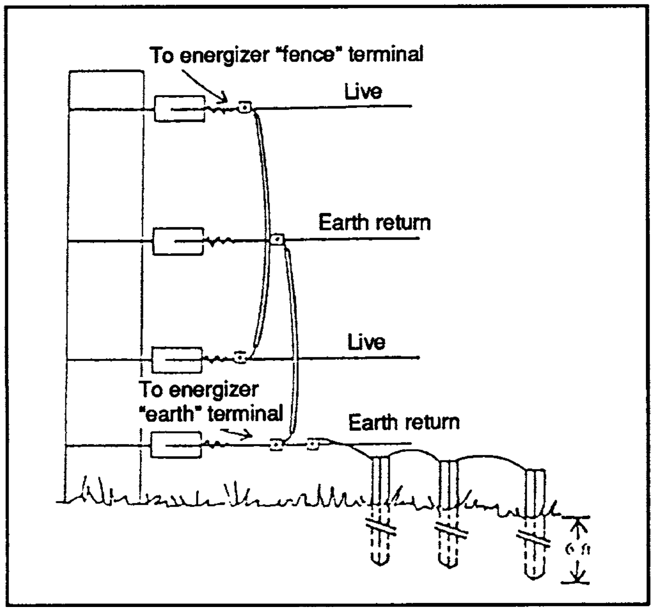

Fig. 3. Hot and ground wires connected parallel. The latter wires are grounded to earth pegs by a lead wire clamped to the post and bottom ground wire. (Adapted from Jepson et al. 1983a.)

Ground and hot wires should be connected in parallel at each of these locations.

Corner, Line, and Gate or Fence-end Brace Designs

The success and longevity of a fence depends on corner and end stretch braces. Poorly designed stretch braces result in loss of wire tension and loss of fence effectiveness. Stretch braces are recommended every 1,320 feet, depending on terrain.

The horizontal "H" brace assembly (Fig. 4) has proved effective and generally is used. However, a diagonal corner, line, gate, or fence-end brace (Fig. 5) requires only one post and less labor to construct. It is equal in strength and holding force to the horizontal "H" brace, and has the same lifting force on the corner post as a horizontal brace of the same size. One diagonal brace (Fig. 6) can replace two horizontal braces (Fig. 7). However, problems may arise if stock rub on the diagonal brace.

Footed braces also are recommended for corner, line, and fence-end braces (Fig. 8). This design uses only one upright post. The post is placed in a hole and set with about 6 inches of tamped soil. The foot(s) (blocks 3x3x12 inches long) are attached to 4-foot wires and placed in the hole, and the hole is then filled and tamped. After the post is set and the foot(s) anchored to the post, a brace is placed against the center of the vertical or upright post. The brace extends to the ground, where it butts against a horizontal brace block placed below ground. On sites where soil moisture is likely to rust the wire holding the footed braces, small blocks of treated wood can be secured to the bottom of the set post and tamped in. This will help hold the set post in the soil and prevent frost heaving from

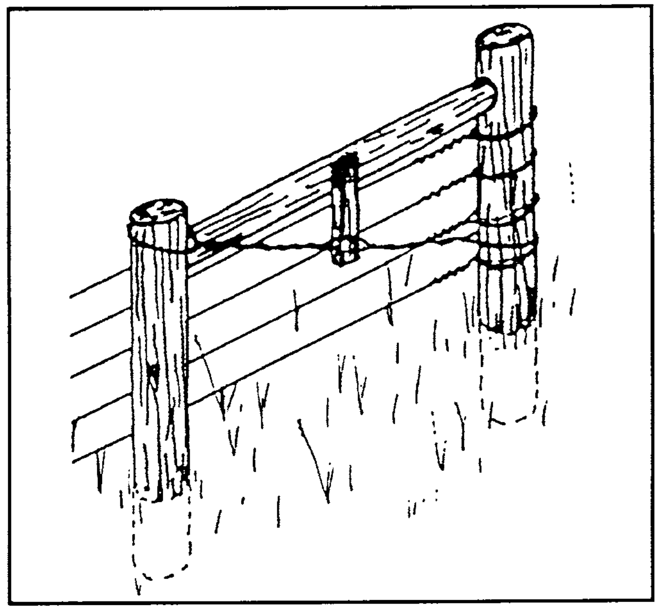

Fig. 4. Horizontal corner, line, gate, or fence and brace. (Taken from Jepson et al. 1983b.)

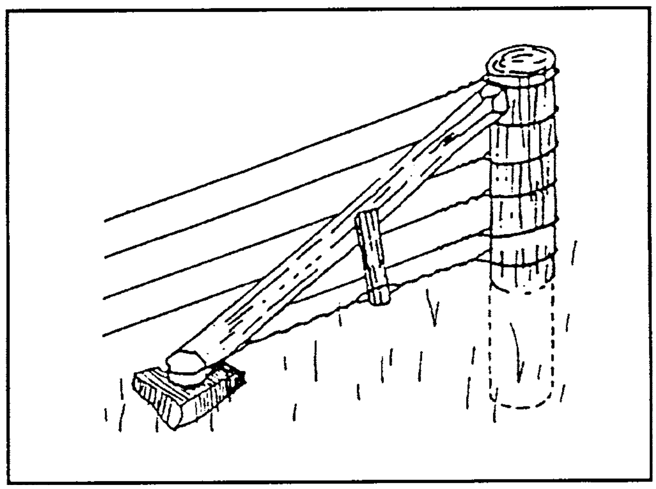

Fig. 5. Diagonal line, corner, gate, or fence-end brace. (Taken from Jepson et al. 1983b.)

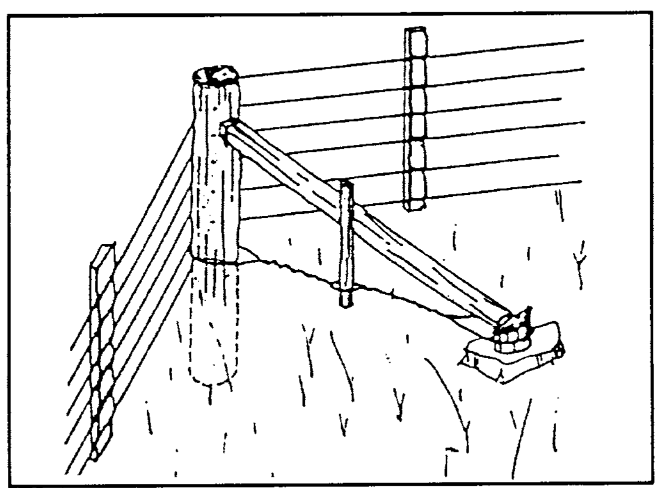

Fig. 6. Diagonal brace used as corner brace on a high-tensile, smooth-wire fence. (Taken from Jepson et al. 1983b.)

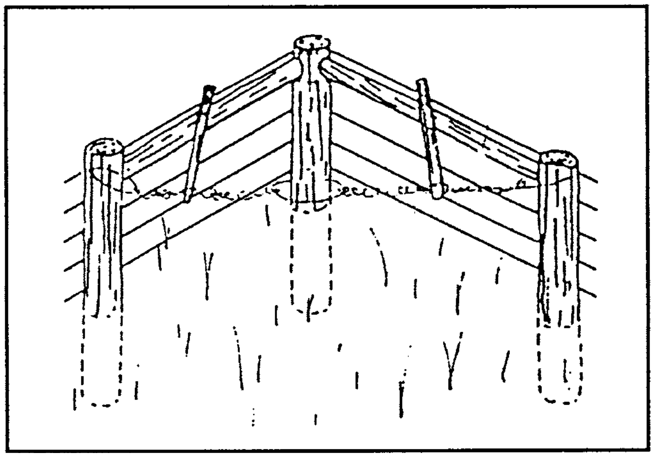

Fig. 7. Two horizontal braces on a corner post, which can be replaced by a single diagonal brace in firm, well-drained soils. (Taken from Jepson et al. 1983b.)

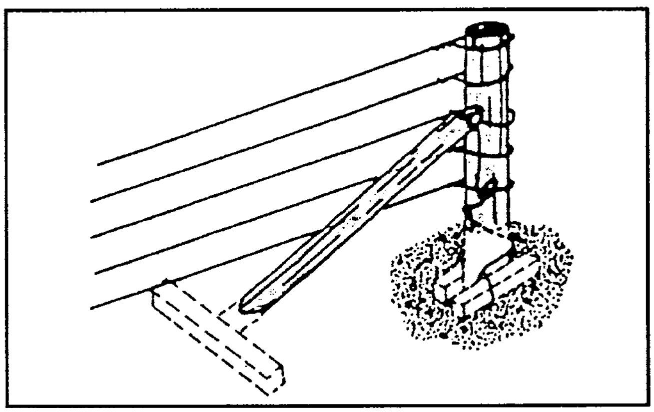

Fig. 8. New Zealand footed-brace design. (Taken from Jepson et al. 1983b.)

loosening the brace. Properly treated wood should always be used to make footed braces and brace blocks.

Tension of Wire

Hand-tighten wires. Pull wires tight enough to take the sag out of them, but do not over-tighten. Permanent wire strainers should be used to adjust tension at later dates, not to tighten the wire during construction.

Permanent wire strainers normally should be placed near the center of a stretch of fence so that they will pull both ways. A stretch of 1,800 feet poses no problem. If there is more resistance from angles, etc., near one end of the fence, strainers should be placed near that end.

Splicing Wires

The breaking strength of wires is greatly reduced if wires are simply twisted together or loop knots are used. Wires should be spliced with a figure 8 (Fig. 9) or a simple square knot (Fig. 10). The figure 8 knot provides up to 75 percent of the breaking strength of the wire.

Crimping sleeves provide a quick and efficient method of splicing wires (Fig. 11). However, certain types are relatively expensive.

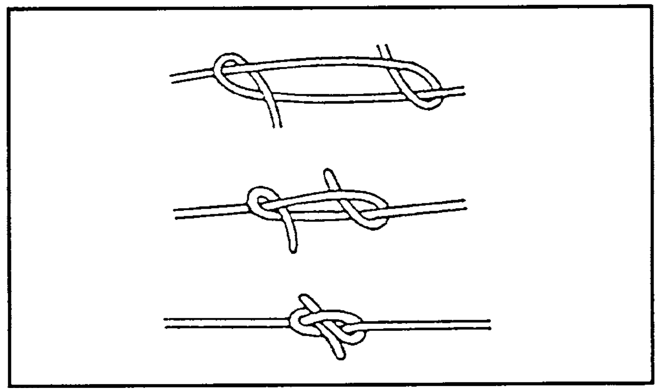

Fig. 9. The figure 8 knot is effective for splicing wires.

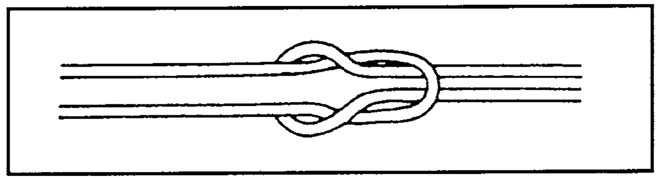

Fig. 10. The simple square knot can be used to splice wires.

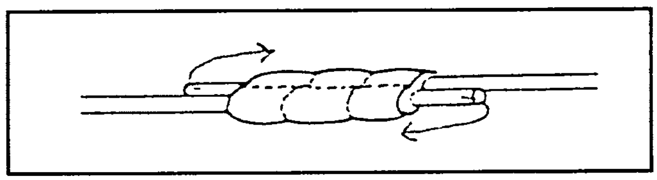

Fig. 11. This crimping sleeve is effective if wire ends are bent up to prevent slips.

Costs of Fencing

High-tensile electric fencing costs less than barbed wire fencing. Specifications, construction materials, and estimated material cost per mile, based on 1985 prices, are summarized:

4-wire conventional barbed wire fence	**Approximate cost**
Wood posts: wire stays bracing every 1,320 feet, posts every 16.5 feet, stays every 8.25 feet	
9 brace posts (8 feet x 5 inches)	$ 65
318 line posts (5 1/2 feet in conventional/fence $2.20 ea)	704
5 rails (8 feet x 4 inches)	26
17 rolls (80-rod) barbed wire	546
45 lb 1 1/4-inch staples	19
3 pound nails (40d)	1
318 wire stays	86
labor	1,410
Total	$2,857

3-wire permanent electric fence[1]	**Approximate cost**
Fiberglass posts, fiberglass stays, 3 wires — smooth, high-tensile, bracing every 3,960 feet, posts every 100 feet, stays every 50 feet	
6 corner and brace posts (8 feet x 5 inches)	$ 43

52 line posts (6 feet)	215
4 rails (8 feet x 4 inches)	21
4 — 4,000 foot spools, high-tensile wire	335
12-inch line strainers	30
12 porcelain insulators	3
2 cut-out switches	6
54 stays — 4 foot light-duty fiberglass	70
156 wire fasteners for heavy duty posts	7
216 wire fasteners for stays	6
gates, ground rods, connectors, lightning arrestor, underground wire, nails, etc.	101
labor	492
Total	$1,329

[1]Energizer is not included. Effective energizers cost $166 to $282 (main line), depending on length of fence and wet vegetation. A 2-wire fence would cost several hundred dollars less.

Summary

Permanent electric fences are a collection of dependent parts, all of which must work or none will work. Construction shortcuts should not be used. Permanent electric fences are already economical. They should be made reliable with good materials and careful workmanship.

Permanent electric fences now cost less than conventional fences, and are long standing and versatile. They are also easy to install and maintain, and are the most practical kind of fence for many situations. The cost of managing rangeland and producing livestock will be reduced as fencing technology continues to develop.

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