Electric fence

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An **electric fence** is a barrier that uses electric shocks to deter animals from crossing a boundary. The voltage of the shock may have effects ranging from discomfort to death. Most electric fences are used today for agricultural fencing and other forms of animal control, although they are frequently used to enhance the security of sensitive areas, such as military installations, prisons, and other security sensitive places; places exist where lethal voltages are used.

Electric fence of high tensile wire. Not all strands are electrified, only those attached to the fence posts with black insulators

Contents

Design and function

Electric fences are designed to create an electrical circuit when touched by a person or animal. A component called a power energizer converts power into a brief high voltage pulse. One terminal of the power energizer releases an electrical pulse along a connected bare wire about once per second. Another terminal is connected to a metal rod implanted in the earth, called a ground or earth rod. A person or animal touching both the wire and the earth during a pulse will complete an electrical circuit and will conduct the pulse, causing an electric shock. The effects of the shock depend upon the voltage, the energy of the pulse, the degree of contact between the recipient and the fence and ground and the route of the current through the body; it can range from barely noticeable to uncomfortable, painful or even lethal.

Detail of an electric fence material made of synthetic cord with metal interwoven through it, attached to a steel fence post with a plastic insulator. This material is more visible than wire, but most often used for temporary fencing.

Fence energizers

Early alternating current (AC) fence chargers used a transformer and a mechanically driven switch to generate the electrical pulses. The pulses were wide and the voltage unpredictable, with no-load peaks in excess of 10,000 volts and a rapid drop in voltage as the fence leakage increased. The switch mechanism was prone to failure. Later systems replaced the switch with a solid-state circuit, with an improvement in longevity but no change in pulse width or voltage control.

"Weed burner" fence chargers were popular for a time and featured a longer-duration output pulse that would destroy weeds touching the fence. These were responsible for many grass fires when used during dry weather. Although still available, they have declined in popularity.

Most modern fences emit pulses of high voltage at a given interval of time, and don't take into account whether there is an animal or person touching the conductive wires, except for the voltage multiplier based electric fence charger that stores high voltage potential and dumps its charges as soon as a conductive load (grounded animal/person) touches the wires.

Depending on the area to be fenced and remoteness of its location, fence energizers may be hooked into a permanent electrical circuit, they may be run by lead-acid or dry cell batteries, or a smaller battery kept charged by a solar panel. The power consumption of a fence in good condition is low, and so a lead-acid battery powering several hundred metres of fence may last for several weeks on a single charge. For shorter periods dry cell batteries may be used. Some energizers can be powered by more than one source.

Fencing materials

Smooth steel wire is the material most often used for electric fences, ranging from a fine thin wire used as a single line to thicker, high-tensile (HT) wire. Less often, woven wire or barbed wire fences can be electrified, though such practices create a more hazardous fence, particularly if a person or animal becomes caught by the fencing material (electrified barbed wire is unlawful in some areas). Synthetic webbing and rope-like fencing materials woven with fine conducting wires (usually of stainless steel) have become available over the last 15 to 20 years, and are particularly useful for areas requiring additional visibility or as temporary fencing.

The electrified fence itself must be kept insulated from the earth and from any materials that will conduct electricity and ignite or short out the fence. Fencing must therefore avoid vegetation, and cannot be attached directly to wood or metal posts. Typically, wooden or metal posts are driven into the ground and plastic or porcelain insulators are attached to them, or plastic posts are used. The conducting material is then attached to the posts.

Electrified palisade fences are usually made from painted mild steel, galvanized steel, stainless steel or aluminium. Typically the fences are 2.4 metres (7 ft 10 in). The palisade fence is mechanically stronger than a typical steel cable electric fence to withstand impact from wildlife, small falling trees and wildfires.

History

Residential Electric Palisade Fence in Johannesburg, South Africa. The top spikes are electrified while the bottom slats of the palisade are grounded.

First published in 1832, Chapter 7 of *Domestic Manners of the Americans* by Fanny Trollope describes an arrangement of wires connected with an electrical machine used to protect a display called "Dorfeuille's Hell" in the Western Museum of natural history in Cincinnati,[1] which she herself invented.[2] Published in 1870, Chapter 22 of Jules Verne's *20,000 Leagues Under the Sea*, describes, "The Lightning Bolts of Captain Nemo" the use of electrification of a structure as a defensive weapon. Published in 1889, Mark Twain's novel *A Connecticut Yankee in King Arthur's Court*, uses an electric fence for defensive purposes.

David H. Wilson obtained United States Patent 343,939 in 1886, combining protection, an alarm bell, and telephone communications. He constructed an experimental 30-mile electric fence energized by a water wheel in Texas in 1888, but it was not successful.[3]

In 1905, the Russian army improvised electric fences during the Russo-Japanese War at Port Arthur. In 1915, during World War I, the German army installed the "Wire of Death", an electrified fences along the border between Belgium and the Netherlands [4] to prevent unauthorized movement of people across the border. The fences covered 300 kilometres and consisted of several strands of copper wire, backed with barbed wire, and energized to several thousand volts. An estimated 3,000 human fatalities were caused by the fence, as well as the destruction of livestock.

Electric fence in urban environment

Electric fences were used to control livestock in the United States in the early 1930s, and electric fencing technology developed in both the United States and New Zealand.

An early application of the electric fence for livestock control was developed in 1936–1937 by New Zealand inventor Bill Gallagher. Built from a car ignition trembler coil set, Gallagher used the device to keep his horse from scratching itself against his car. Gallagher later started the Gallagher Group to improve and market the design.[5] In 1962, another New Zealand inventor, Doug Phillips, invented the non-shortable electric fence based on capacitor discharge.[6] This significantly increased the range an electric fence could be used from a few hundred metres to 35 km (~20 miles), and reduced the cost of fencing by more than 80%.[7] The non-shortable electric fence was patented by Phillips and by 1964 was manufactured by Plastic Products, a New Zealand firm, under the name "Waikato Electric Fence."[7] This idea was to replace ceramic with plastic insulators. A variety of plastic insulators are now used on farms throughout the world today.

By 1939, public safety concerns in the United States prompted Underwriters' Laboratories to publish a bulletin on electric shock from electric fences, leading to the ANSI/UL standard No. 69 for electric fence controllers.[8]

In 1969 Robert B. Cox, a farmer in Adams County, Iowa, invented an improved electric fence bracket and was issued United States Patent No. 3,516,643 on June 23, 1970. This bracket improved electric fences by keeping the wire high enough above the ground and far enough away from the fence to permit grass and weeds growing beneath the wire to be mowed. The brackets attached to the posts by what may be called a "pivot bind" or "torsion-lock." The weight of the bracket, the attached insulator and the electric wire attached to the insulator bind the bracket to the post.

Electric fences have improved significantly over the years. Improvements include:

- Polyethylene insulators replacing porcelain insulators, beginning in the 1960s. Polyethylene is much cheaper than porcelain and is less breakable.
- Improvements in electrical design of the fence energizer, often called a "charger" (USA) or "fencer" (UK).
- Changes in laws. In some jurisdictions, certain types of electrical outputs for fences were unlawful until the 1950s or 1960s. In other areas, signage requirements and other restrictions limited usability. Many US cities continue to have outdated laws prohibiting electric fences to prevent agricultural fences from entering the city. Houston in Texas for example, changed their ordinance that prohibited electric fencing in 2008.[9]
- Introduction of high tensile (HT) steel fence wire in the 1970s in New Zealand and in the 1980s in the United States.
- Introduction of synthetic webbing and rope-like fencing materials woven with fine conducting wires.
- Design of moveable fence components, such as Tumblewheel.

Uses

Agriculture

Permanent electric fencing is used in many agricultural areas, as construction of electric fences can be much cheaper and faster than conventional fences (it uses plain wire and much lighter construction, as the fence does not need to physically restrain animals). The risk of injury to livestock (particularly horses) is lower compared to fences made of barbed wire or certain types of woven wire with large openings that can entangle the feet.

Its disadvantages include the potential for the entire fence to be disabled due to a break in the conducting wire, shorting out if the conducting wire contacts any non-electrified component that may make up the rest of the fence, power failure, or forced disconnection due to the risk of fires starting by dry vegetation touching an electrified wire. Other disadvantages can be lack of visibility and the potential to shock an unsuspecting human passer-by who might accidentally touch or brush the fence.

Many fences are made entirely of standard smooth or high-tensile wire, although high quality synthetic fencing materials are also beginning to be used as part of permanent fences, particularly when visibility of the fence is a concern.

Conventional agricultural fencing of any type may be strengthened by the addition of a single electric line mounted on insulators attached to the top or front of the fence. A similar wire mounted close to the ground may be used to prevent pigs from excavating beneath other fencing. Substandard conventional fencing can also be made temporarily usable until proper repairs are made by the addition of a single electric line set on a "stand-off" insulator.

Electric materials are also used for the construction of temporary fencing, particularly to support the practice of managed intensive grazing (also known as rotational or "strip" grazing). It is also popular in some places for confining horses and pack animals overnight when trail riding, hunting, or at competitions such as endurance riding and competitive trail riding. Typically, one or more strands of wire, synthetic tape or cord are mounted on metal or plastic posts with stakes at the bottom, designed to be driven into the ground with the foot. For a hand-tightened temporary fence of electrified rope or web in a small area, these are usually spaced at no more than 12 to 15 feet (about four metres) to prevent the fencing material from sagging and touching the ground. Larger areas where tools are used to stretch wire may be able to set step-in posts at larger distances without risk that the fencing material will sag.

A temporary electric fence of synthetic materials and plastic step-in posts set about 12 feet apart

With temporary electric fencing, a large area can be fenced off in a short period. Temporary fencing that is intended to be left in place for several weeks or months may be given additional support by the use of steel T posts (which are quickly driven in with hand tools and unearthed with relative ease, using a leverage device), to help keep the fence upright, particularly at corners. Livestock owners using rotational grazing in set patterns that are similar from one year to the next, may permanently drive a few permanent wooden fence posts in strategic locations.

Portable fence energizers are made for temporary fencing, powered solely by batteries, or by a battery kept charged by a small solar panel. Rapid laying-out and removal of multiple-strand temporary electric fencing over a large area may be done using a set of reels mounted on a tractor or all-terrain vehicle.

For sheep, poultry, and other smaller animals, plastic electric netting may be mounted on insulating stakes – this is also effective at

keeping out some predators such as foxes.

In practice, once most animals have learned of the unpleasant consequences of touching the fence they tend to avoid it for considerable periods even when it is inactive. However, some animals learn to avoid the shock, either by running under the fence quickly between pulses, or by pushing other individuals through the fence. Animals with thick woolly coats (such as sheep or highland cattle) may learn to push through the fence themselves, using their coats as electrical insulation. Some animals also learn to recognize the slight clicking sound made by some electric fences and thus can sense when the fence is off.

Wild animals

Electric fences are useful for controlling the movements of wild animals. Examples include deterring deer from entering private property, keeping animals off airport runways, keeping wild boar from raiding crops, and preventing geese from soiling areas used by people. Electric fencing has been extensively used in environmental situations reducing the conflict between elephants or other animals and humans in Africa and Asia.[10]

Electric fencing to protect a walkway against wildlife. Pilanesberg Game Reserve, South Africa

Security

Non-lethal fence

Security Electric Fences are electric fences constructed using specialised equipment and built for perimeter security as opposed to animal management. Security electric fences consist of wires that carry pulses of electric current to provide a non-lethal shock to deter potential intruders.
Tampering with the fence also results in an alarm that is logged by the security electric fence energiser, and can also trigger a siren, strobe, and/or notifications to a control room or directly to the owner via email or phone.

In practical terms, security electric fences are a type of sensor array that acts as a (or part of a) physical barrier, a psychological deterrent to potential intruders, and as part of a security alarm system.

Non-lethal electric fences are used by both private and government-sector bodies to prevent trespass. These include freight carriers, auto auctions, equipment rental companies, auto dealers, housing communities, commercial factories or warehouses, prisons, military bases, and government buildings. Many of these electric fences act as monitored security alarm systems in addition to causing an uncomfortable shock. Electrified palisade fences are used to protect isolated property and high security facilities, but also around some residential homes.

Multi-zone security electric fence used alongside a physical barrier.

They can also be used inside a building, for example as a grid behind windows or skylights to prevent people from climbing through. They have even been used on yachts and on large ships to deter pirates.

Electric fences are occasionally employed to discourage suicide attempts on tall structures, and to reduce the incidence of graffiti and other petty crime.

Due to the high levels of crime in South Africa, it is common for residential houses to have perimeter defences. The City of Johannesburg promotes the use of palisade fencing over opaque, usually brick, walls as criminals cannot hide as easily behind the fence. In the City of Johannesburg manual on safety, one can read about best practices and maintenance of palisade fencing, such as not growing vegetation in front of palisades as this allows criminals to make an unseen breach.[11]

Types of security electric fences include:

- Piggyback: A Piggyback electric fence is mounted off the back of an existing wire or mesh fence, adding another level of security to the existing perimeter barrier. The piggyback profile is fastened to existing fence posts (e.g. pillars of a palisade fence) using rivets or screws. These are the most commonly used security electric fences.
- Wall top: Wall-top electric fences attach to the top of an existing perimeter barrier such as a masonry wall. These are the second most common type of security electric fences. The existing fence must be at least 1.5 m high.
- Stand alone: Stand-alone electric fences act as the sole perimeter barrier. They are also quite aesthetically pleasing if set up neatly. This type is normally only found as one of many levels of perimeter security around high security establishments, meaning that to touch it someone has had to break through at least one physical barrier before this. The stand-alone fence must be at least 1m away from the nearest barrier.

Stun-lethal fence

A "stun-lethal" electric fence can be set to deliver a shock if touched once, and a fatal jolt if touched a second time.

12-foot-high "stun-lethal" fences have been in use for some time in many US state prisons such as Arizona's. The Federal Department of Corrections added them in 2005 to two prisons in Coleman, Fla., and prisons in Tucson; Terre Haute, Ind.; Hazelton, W.Va.; Pine Knot, Ky.; and Pollock, La.[12] Other Federal Agencies such as the US State Department of Corrections use them for prison security.[13]

Nazi concentration camps were surrounded by electric fences, like this one shown above at Auschwitz, which contained lethal voltages, continuously rather than in pulses

Lethal fence

Electric fences designed to carry potentially lethal currents can be used for anti-personnel purposes.

In 1915, during World War I, the German occupiers of Belgium closed off the border with neutral Netherlands, using a 300 km electric fence running from Vaals to Scheldt. Germany also erected a similar fence to isolate thirteen Alsatian villages from Switzerland.[4]

Electric fences are used in the Korean Demilitarized Zone as a means to seal off North Korea from South Korea. Behind the fence, there is a strip which has land mines hidden beneath it.

Electric fences were used to guard the concentration camps of Nazi Germany during World War II, where potentially lethal voltages and currents were employed, continuously rather than in pulses. Some prisoners used the electric barbed wire fence to commit suicide.[14]

During the Algerian War the French erected the electrified Morice Line.

Sections of the inner German border were lined with a 3 m (10 ft) high electric fence to deter potential defectors from East Germany.[15] Similarly, the Czechoslovak border was lined with high electric fence during Cold War to prevent emigration from Czechoslovakia.

Electric fences continue to be used in similar fashion at some high-security prisons and certain other installations to this day. Typically a nonelectric fence is constructed on either side of such an installation, or the deadly current is carried out of casual reach atop a wall.

North Korea uses electric fences to seal off parts of its border with South Korea.

Other uses

Recent innovations include electrical fence monitoring for intruder detection as opposed to providing an electric shock to discourage entry. It can be used in addition to or as substitute for a host of other fence monitoring systems.

Buried electric fences (also called "invisible fences" or "electronic fences") are sometimes used to contain dogs or livestock. The buried wire radiates a weak radio signal, which is detected by a collar worn by the animal. The collar emits a warning noise near the wire, but if this is ignored, produces a mild shock. Humans and other animals are unaware of the buried line. In a similar system, the collar uses GPS signals to determine proximity to a predetermined "virtual fence" without a physical installation.

Interference and unwanted effects

Poorly designed or badly maintained electric fences can create sufficient electromagnetic interference to cause problems for nearby telephone, radio, and television reception - and has been a particular problem for dial-up Internet users in some rural areas.[16][17]

See also

- Agricultural fencing
- Temporary fencing

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daring hand or foot obtrude itself with the bars, it receives a smart shock, that often passes through many of the crowd, and the cause being unknown, the effect is exceedingly comic; terror, astonishment, curiosity, are all set in action, and all contribute to make 'Dorfeuille's Hell' one of the most amusing exhibitions imaginable." Check date values in: `|date=` (help)
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External links

- Wildlife control at Canadian Airports (http://www.tc.gc.ca/civilaviation/AerodromeAirNav/Standards/WildlifeControl/tp11500/sectionf/SectionF3.htm#Electric)
- Controlling geese (http://www.wildlife.alaska.gov/index.cfm?adfg=birds.goose)
- Uses in Montana (http://www.montana.edu/wwwpb/pubs/mt200010.html)
- Use in prisons (http://www.doc.nv.gov/hdsp/general.php)

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