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***Understanding neutral-to-earth  
and stray voltage***

## Introduction

Electrical systems on farms and electrical supply systems delivering power to farms, homes, and businesses are grounded to the earth to make them as safe as possible and to help ensure their reliability. The grounding of these electrical systems results in some current flow through the earth. Associated with this current is a small voltage which develops at each point where the electrical system is grounded. That voltage is called neutral-to-earth voltage (NEV). When the NEV is found at animal contact points it is frequently called stray voltage.

In past years, it was believed that NEV levels which normally exist on electrical systems were harmless. Most of the time, the levels are only a few tenths of a volt to several volts. Electrical codes and safety standards never considered these small voltages to be dangerous to humans, so they were assumed not to be a problem to animals. In the 1970s certain abnormal animal behavior was alleged to be caused by low levels of voltage. Early research seemed to show that when the voltages were reduced or eliminated, animal behavior concerns returned to normal. This early research stimulated concern for the effects of stray voltage on farm animals and more research followed. Considerable research has been conducted on the subject of NEV and stray voltage over the past 35 years at several universities and public agencies in the United States, Canada, Europe, and New Zealand.

Today much is known about NEV and stray voltage. The various levels of NEV which are considered to affect animals are reported in research literature. The causes of NEV, for the most part, have been identified. And there are step-by-step procedures which now can be used to identify the sources. One complicating factor is that there can be several sources of NEV at the same time. Sometimes one source can partially cancel out NEV caused by another source, making identification of the sources very difficult. It takes considerable training to be an effective NEV investigator. The purpose of this publication is to explain the causes of NEV, the locations where it may affect animals, how it is identified, and its prevention.

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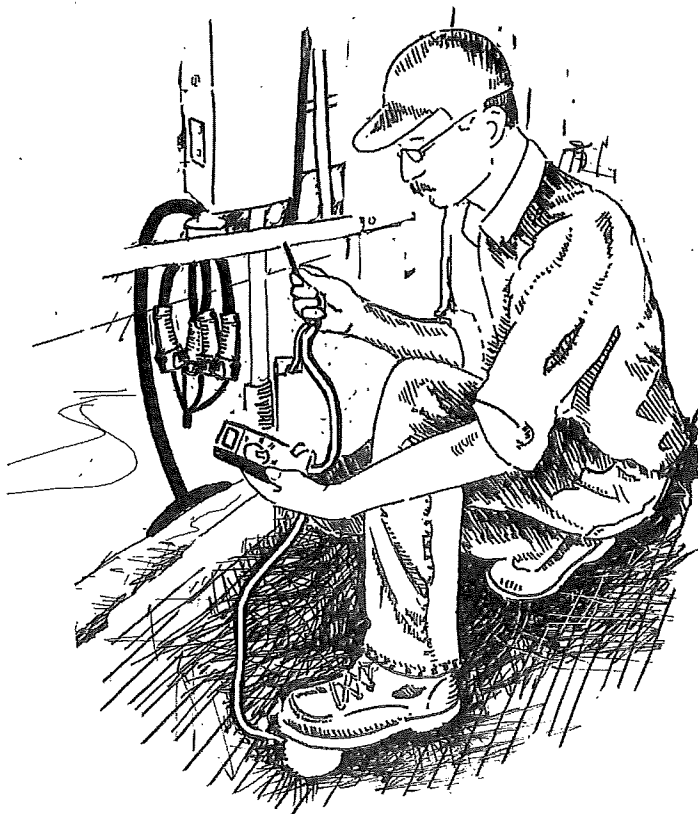
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## WHAT IS NEUTRAL-TO-EARTH VOLTAGE (NEV)?

The term NEV is used to describe a measurable level of voltage which may occur between a metal object and the adjacent floor or earth. It is often called stray voltage when measured between two points that can be simultaneously contacted by livestock. **Figure 1** shows a voltmeter being used to measure stray voltage between the milking parlor steel and the floor. Simply stated, voltage is the pressure that pushes electrical current through wiring systems, lights, and electrical equipment. When a person or an animal feels a tingle or a shock, the person or animal is actually feeling electrical current flowing through the body or a portion of the body. When the voltage between a metal object and the adjacent floor or earth is very low, the amount of electrical current flowing through an animal's or person's body is so low that it cannot be felt. But sometimes, a condition within the wiring on a farm, the wiring at a neighbor's property, or the power lines supplying a farm may cause the voltage between equipment and the adjacent earth or floor to be felt by an animal or person. This stray voltage can range from a slight tingling or burning sensation at a cut to an uncomfortable jolt for animals. **If a person feels an uncomfortable jolt, the condition is probably not NEV but a serious problem with the wiring system or equipment. Such a condition requires immediate attention to find the cause. An investigation needs to be conducted to measure voltage levels on the farm and take corrective action if necessary.**

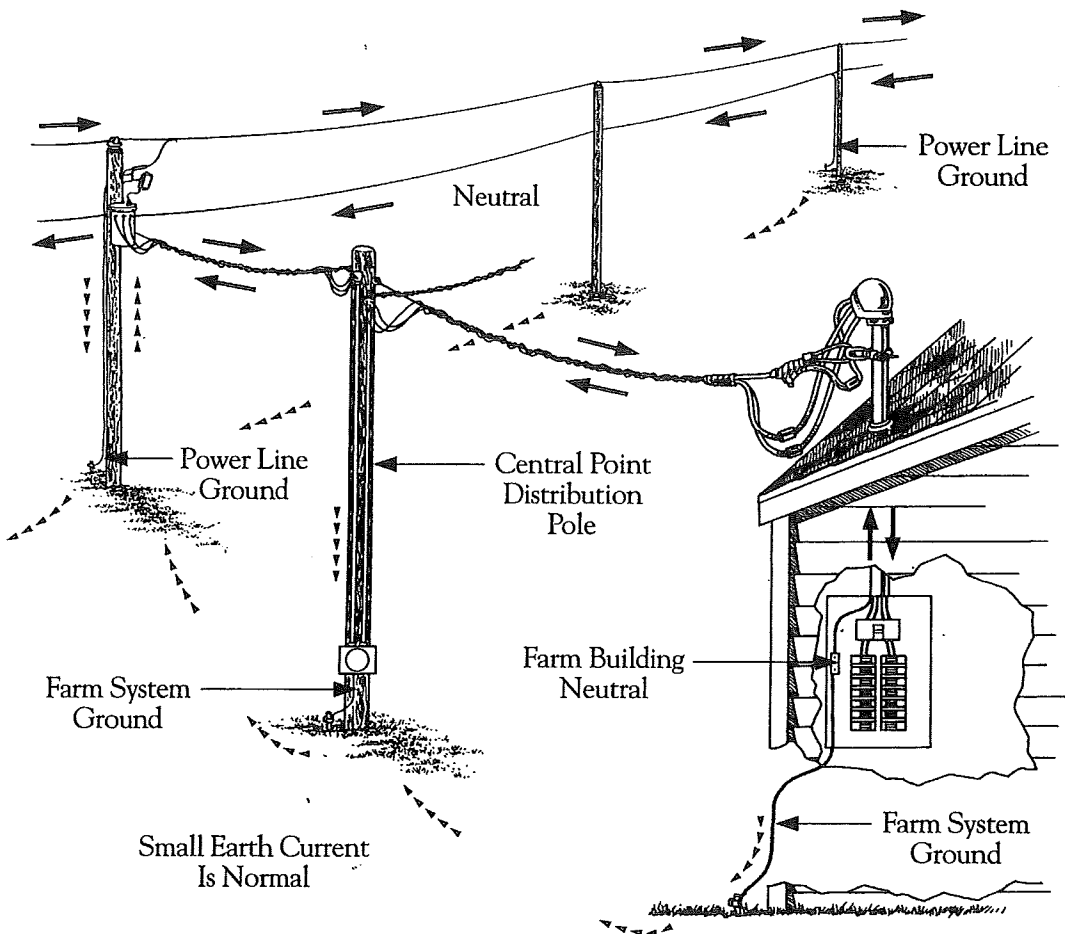
**FIGURE 1**  
*Neutral-to-earth  
and stray voltage  
may occur between  
metal objects and  
the adjacent floor  
or earth.*



The electrical wiring on a farm has a conductor which is grounded to the earth. This conductor is called the neutral conductor and generally is the white wire within the wiring and equipment. The purpose of grounding this wire is to make the electrical system as safe as possible and is required by the electrical code. Also, the primary power lines supplying a farm usually have a conductor which is grounded to the earth to provide

maximum safety and reliability. This is shown in **Figure 2**. Storms and accidents that damage the primary power lines could result in a dangerous voltage which could cause personal injury if the electrical system is not grounded. A grounded electrical system will prevent dangerous voltages from occurring on a customer's wiring system and grounded metal equipment such as water pipes and stalls in a barn. A local problem will result in only the affected electrical system being de-energized, which minimizes the interruption of power to other customers. For example, lightning damage to a transformer will result in only that transformer being disconnected when the transformer fuse blows.

Electrical systems that are grounded to the earth for safety and reliability have a small amount of current flowing through the earth when electrical power is being used. The earth and the grounded primary neutral conductor act as two parallel conductors. The ground rods at each transformer pole and at some poles along the line act as connections between the neutral wire on the poles and the earth. This is illustrated in **Figure 2**. Normal power line current flows back to the source (substation) on the neutral wire, with some flowing through the earth by way of the ground rods. This is normal, and it can result in a small level of NEV between metal objects and the adjacent floor or earth. A damaged neutral wire or a corroded connector, however, can result in an increased current flow on one or more of these ground rods, resulting in an increase in current flow to the earth and an increase in the NEV level at the ground rod.



**FIGURE 2**  
*Electrical systems are grounded to the earth to provide maximum safety and reliability.*

← Primary and Secondary Current  
- - - - Earth Current

## HOW CAN NEV AFFECT LIVESTOCK?

Although there are many causes of unusual animal behavior on a farm, NEV can cause electrical current flow through the body of an animal, resulting in animal discomfort. A person working around farm animals needs to be aware of certain symptoms which could signal the presence of an excessive level of NEV. The NEV level may increase suddenly and be gone in an instant. A good time to be especially aware of changes in animal behavior is during times of maximum power use. This frequently occurs at evening chore time. Look for abnormal animal behavior as an indication that NEV may be present. The waterer in an animal area is one location to observe animal behavior as shown in **Figure 3**. Other behavioral changes to look for include the following:

- Animals that avoid a watering device or feeder
- Unusual drinking or eating behavior at a waterer or feeder
- When confined, animals that do not stand still but shift their weight frequently or constantly lift their feet
- Animals that show signs of being uncomfortable and difficult to handle
- Animals that may be reluctant to enter or exit a building or area
- Animals that may run or jump out of a building or area quickly when released

The cause of long-term problems with animals, such as mastitis and low milk production, are harder to identify. These long-term symptoms can result from many factors. It is not always obvious that NEV is a factor and to what extent. Researchers generally agree that the long-term problems, when caused by NEV, are the result of animal behavioral changes over a long period of time. Here are some potential problems which may be indirectly linked to NEV over a long period of time on some farms:

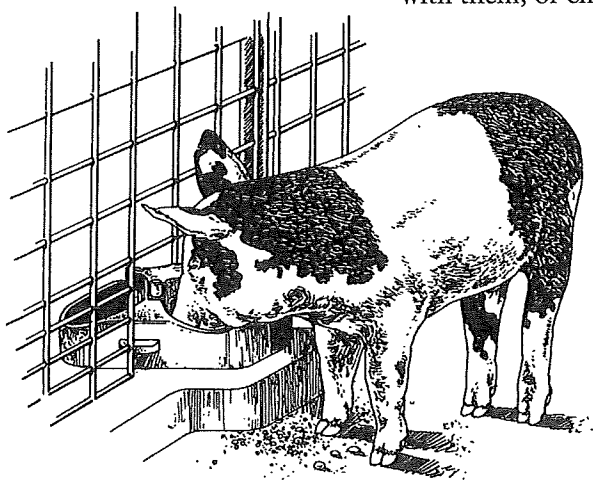
- Weight gain less than expected
- A decrease in milk production of dairy cows not explained by seasonal or lactation changes

Of course, these same problems are also caused by other factors on the farm.

Examples are sudden change in water quality, spoiled or unpalatable feed, improper sanitation procedures, sickness in the animals, improper design and inadequate maintenance of milking equipment, improper treatment of animals, or change in the normal routine of the animals such as adding more animals, different personnel working with them, or changes in the weather.

Reluctance to eat, drink, or enter a milking area can be attributed directly to high levels of NEV. Animal uneasiness or kicking at the milker can also be linked directly to NEV. NEV is usually not from the milker, but a cow may kick at the milker because she is uncomfortable. The best practice is to regularly monitor the levels of NEV on your farm. Your electric power supplier can help you set up your own monitoring program.

**FIGURE 3**  
*The waterer in an animal area is one location to observe animal behavior.*



## WHAT CONDITIONS CAUSE NEV TO OCCUR?

There are a number of conditions that can cause NEV. One of the most common causes is a ground fault condition, where electric current flows into the earth. Another frequent cause is too much voltage drop along the grounded neutral wire. Both of these conditions may occur on a farm, on power supply lines, or sometimes at a neighbor's property.

Ground faults occur when a wire comes loose from a terminal, insulation becomes damaged, or electrical terminals get wet. By properly grounding electrical equipment with a green insulated or bare wire, the fault current is safely conducted back to the service panel. Sometimes, however, the grounding wire becomes broken, corroded, or was never connected to the equipment. This condition can be dangerous.

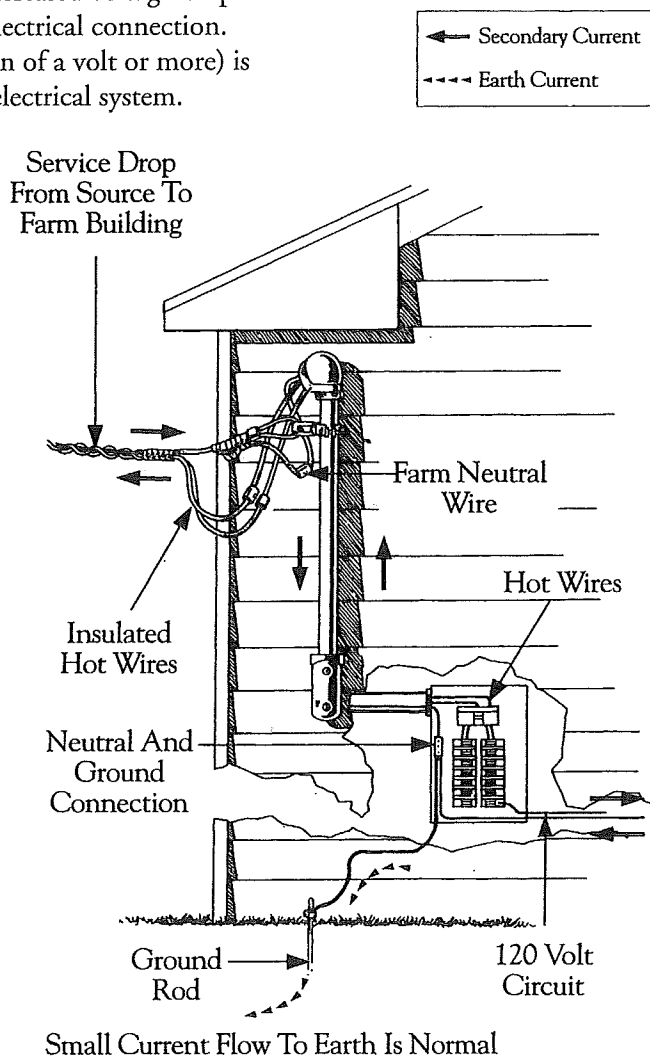
Voltage drop is a normal occurrence when electrical current flows along wires. This is true for power line wires or the wiring on the farm. This voltage drop along the neutral wire results in a difference in the voltage between the different ground rods resulting in a small current flow through the earth as shown previously in **Figure 2**. There will always be some current flow through the earth and NEV will exist when the electrical line is grounded in more than one place. The higher the voltage drop along the neutral wires, the higher the NEV. There are many conditions which contribute to increased voltage drop on the neutral wire to a building. The most common cause is a poor electrical connection.

It is important to know that a small amount of NEV (a fraction of a volt or more) is naturally present when electric power is delivered with a grounded electrical system. The farm's electrical system will produce some NEV naturally and a grounded electrical power supply line will also produce some NEV naturally. If the NEV increases to a level sufficient to bother animals, corrections need to be made to bring the level down to within acceptable limits. The common causes of NEV are explained in more detail in the following sections.

### Electric service to buildings

Electrical power to a building is supplied with one or two ungrounded (hot) wires and a grounded neutral wire. This neutral wire is grounded as required by the electrical wiring code as illustrated in **Figure 4**. It is important for this neutral conductor to be of adequate size for the load and distance from the farm central distribution point. It must always be kept in good repair. A frequent trouble point for the neutral wire is a loose or corroded splice or connection. When this happens, electrical equipment usually will still operate, but high NEV is produced, because some current that would have flowed through the neutral is using the earth as an alternate path back to the power supply. Sometimes this neutral wire will come apart at a loose connector or become broken due to physical damage or corrosion. When lights seem to get unusually bright and dim for no apparent reason, this is a sign that something may be wrong with the neutral wire to the building. The wires that supply power to new buildings are required to have the neutral wire and equipment grounding wire separated (4-wire system) which will help prevent this source of NEV. The 4-wire system is explained on page 20.

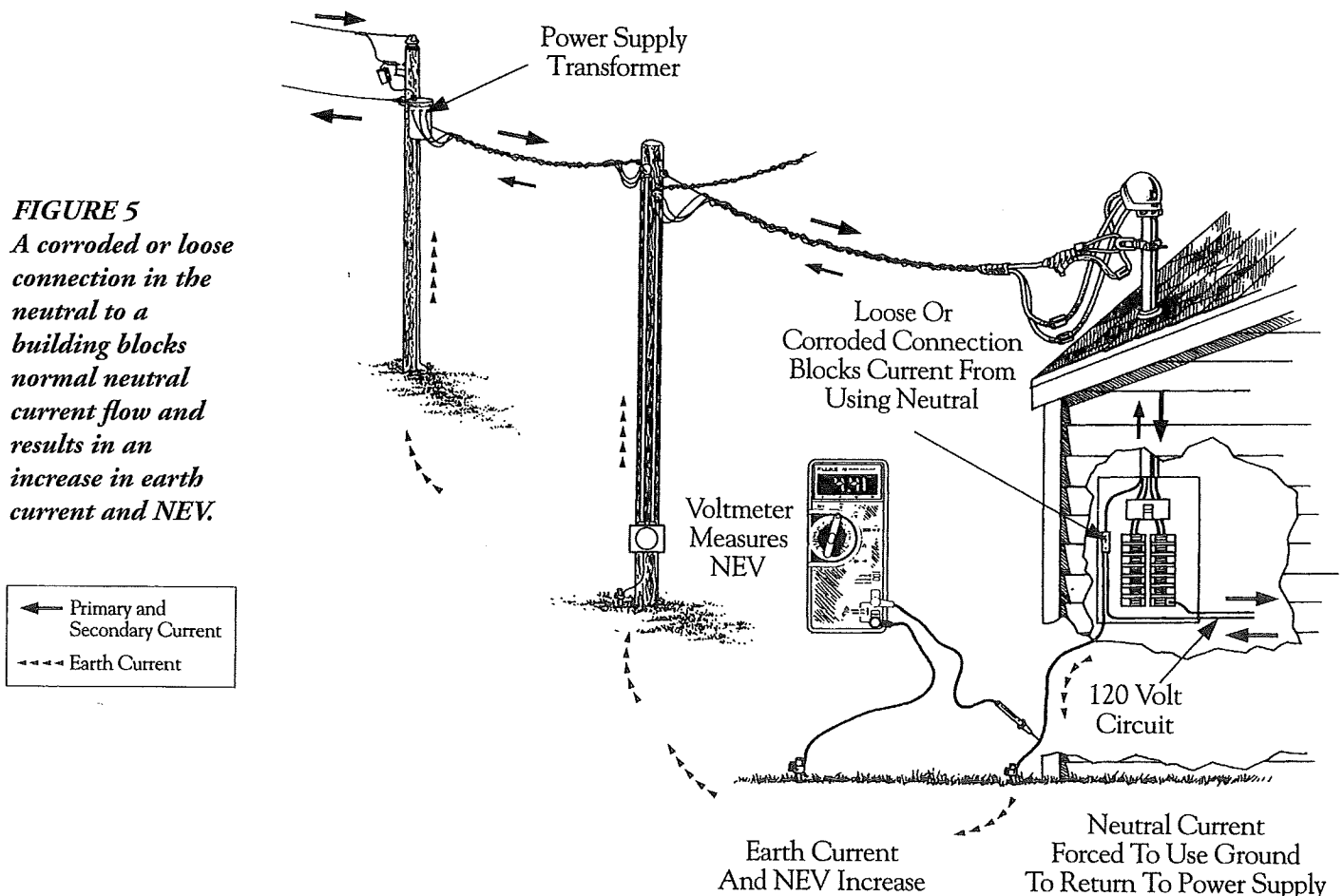
**FIGURE 4**  
*The electrical code requires that every service panel in a building be grounded to the earth.*



A corroded or loose splice or connection in a neutral wire causes NEV. When a splice or connection becomes corroded or loose, it provides resistance to the flow of current on the neutral conductor. The increased electrical resistance makes it difficult for the current to flow back to the power supply. It acts like a dam in a stream. The voltage must build up on the neutral wires to "push" the current through the bad connection. The corroded connection in the neutral wire in **Figure 5** keeps much of the current from using the neutral wire to flow back to the power supply. The current then finds another path; the earth. Not only does the current flow to the earth through the ground rod, but it can also flow to earth through animals. The NEV will increase when current encounters a bad connection in the neutral wire.

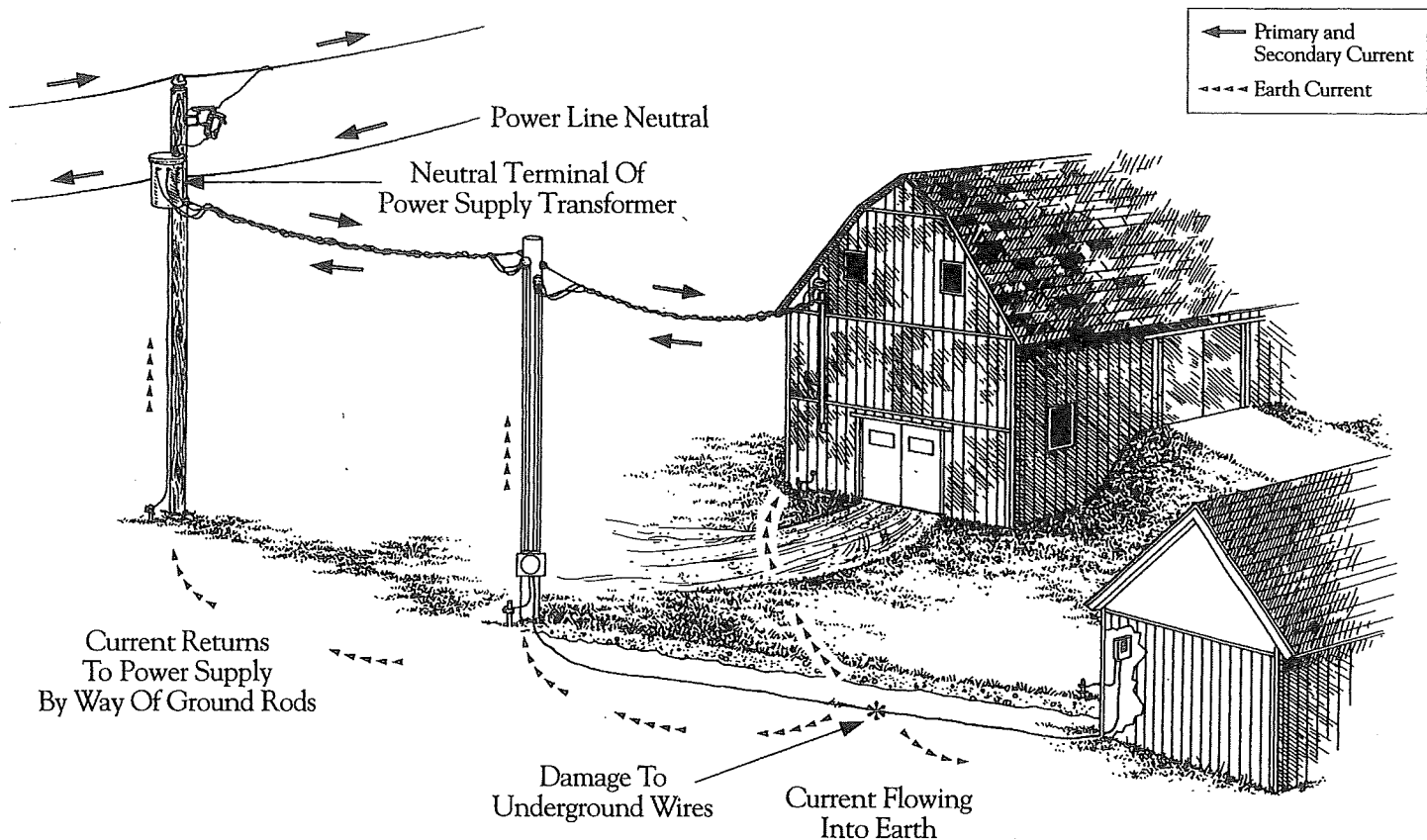
Many farms with single-phase power have buildings supplied with 3-wire supply feeders such as the one shown in **Figure 5**. The electrical code has changed and new buildings are required to be supplied with feeder wires that have a separate neutral and separate equipment grounding wire (a 4-wire feeder) as shown in **Figure 19**. With this 4-wire system, neutral current is prevented from flowing in the earth and causing NEV.

**FIGURE 5**  
*A corroded or loose connection in the neutral to a building blocks normal neutral current flow and results in an increase in earth current and NEV.*



## Damage to electrical wiring or equipment

If wiring or equipment becomes damaged, electrical current may flow into the earth. This condition is called a ground fault. When electrical current flows into the earth, it is seeking a path back to the grounded terminal of the power supply transformer serving the farm. The electrical current in the earth flows to the neutral conductor by way of the ground rods and other metal connections to earth, as illustrated in **Figure 6**. This current flow at the ground rods creates NEV.

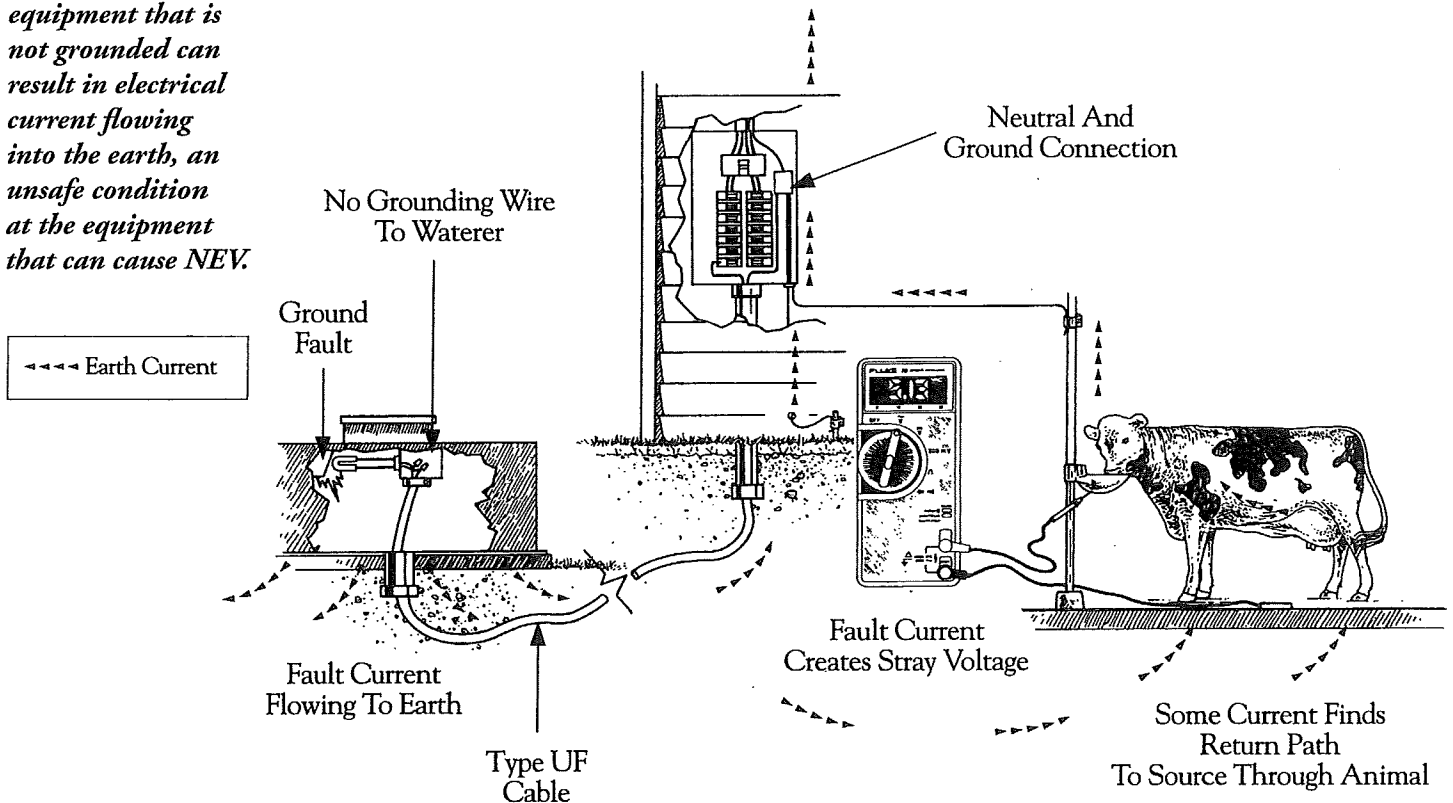


**FIGURE 6**  
*Damaged wiring or insulation may result in current flow into the earth which seeks a path back to the grounded terminal of the power supply transformer thus causing an increase in NEV on the farm.*

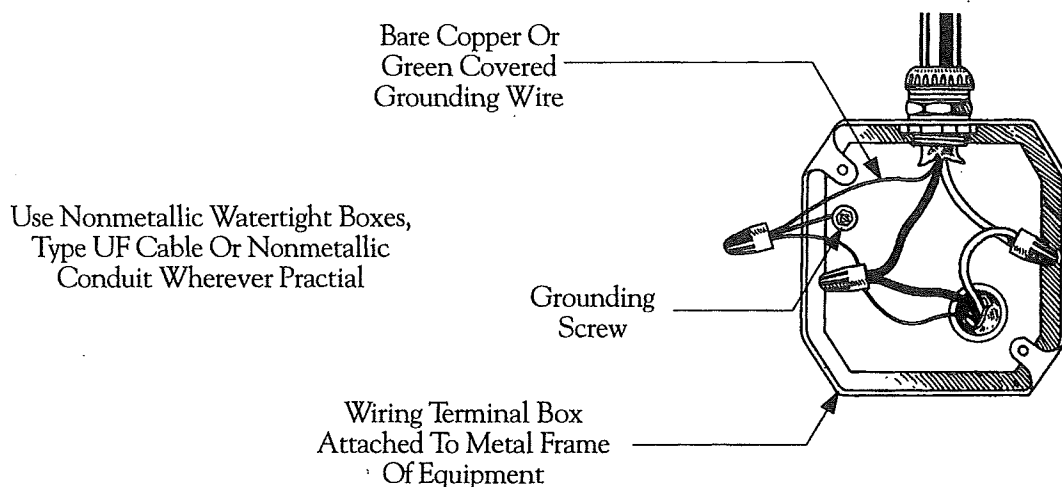


Damaged wiring or wet terminals in equipment such as electrically-heated livestock watering devices can result in a ground fault where current flows into the earth. **Figure 7** illustrates current flowing in the earth from the faulting waterer. The waterer has a broken or missing bare or green grounding wire. This fault current flowing in the earth seeks ways to get back to the neutral wire so it can return to the supply transformer. This current can flow through an animal and to metal objects leading back to the power supply. Broken or missing grounding wires to equipment, such as a livestock waterer, is potentially dangerous to livestock and humans, and the conditions should be corrected.

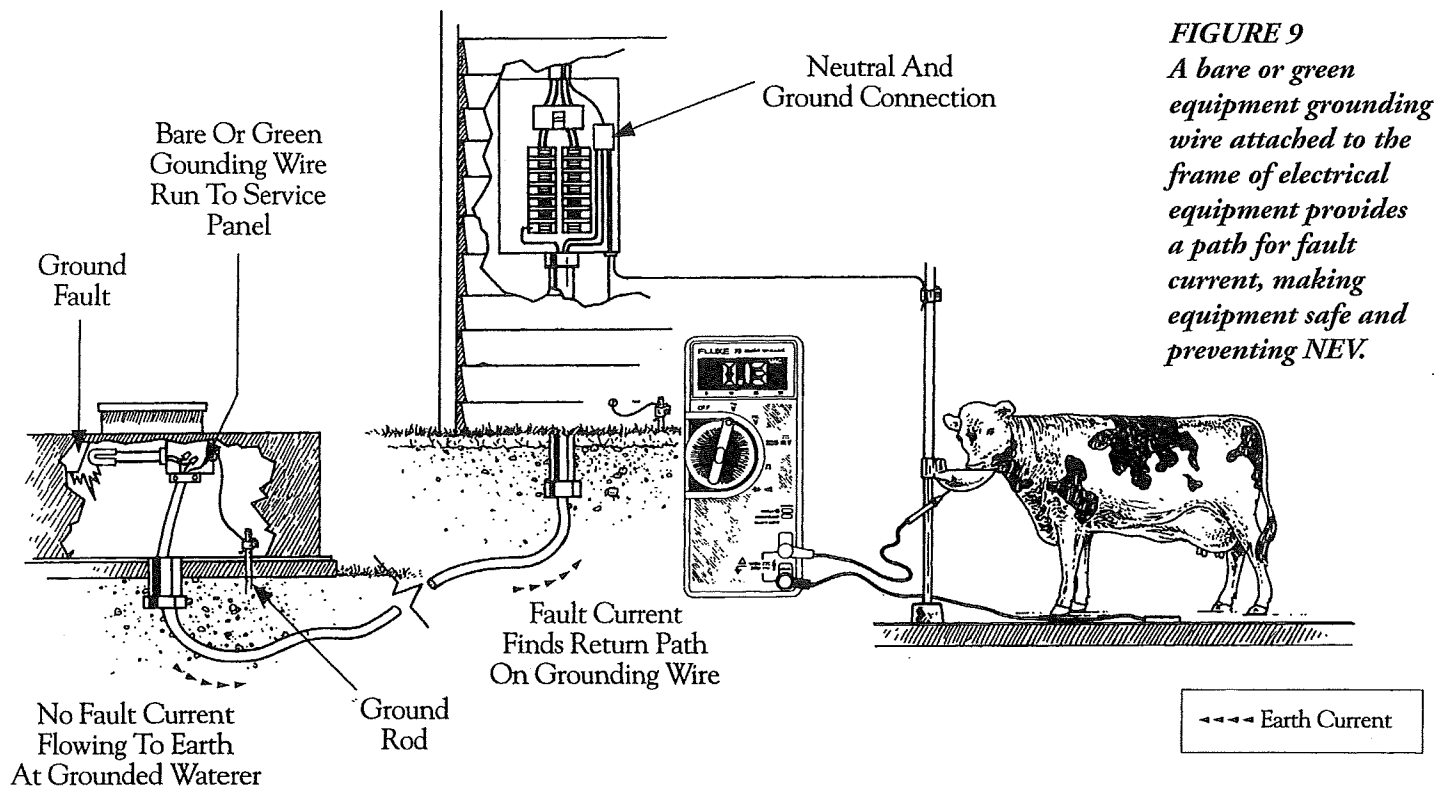
**FIGURE 7**  
*Damaged wiring or wet terminals in electrical equipment that is not grounded can result in electrical current flowing into the earth, an unsafe condition at the equipment that can cause NEV.*



The electrical code requires that all electrically-powered equipment include a separate grounding wire connected to the metal frame of the equipment as shown in **Figure 8**. This grounding wire is very important. If a ground fault occurs in a piece of equipment as shown in **Figure 9**, the grounding wire will safely conduct the current back to the power supply. Most of the fault current will follow the path of least resistance which is the grounding wire. A properly connected grounding wire will prevent ground faults from causing NEV and will make it possible for the fuse or circuit breaker to disconnect power and eliminate a shock hazard.



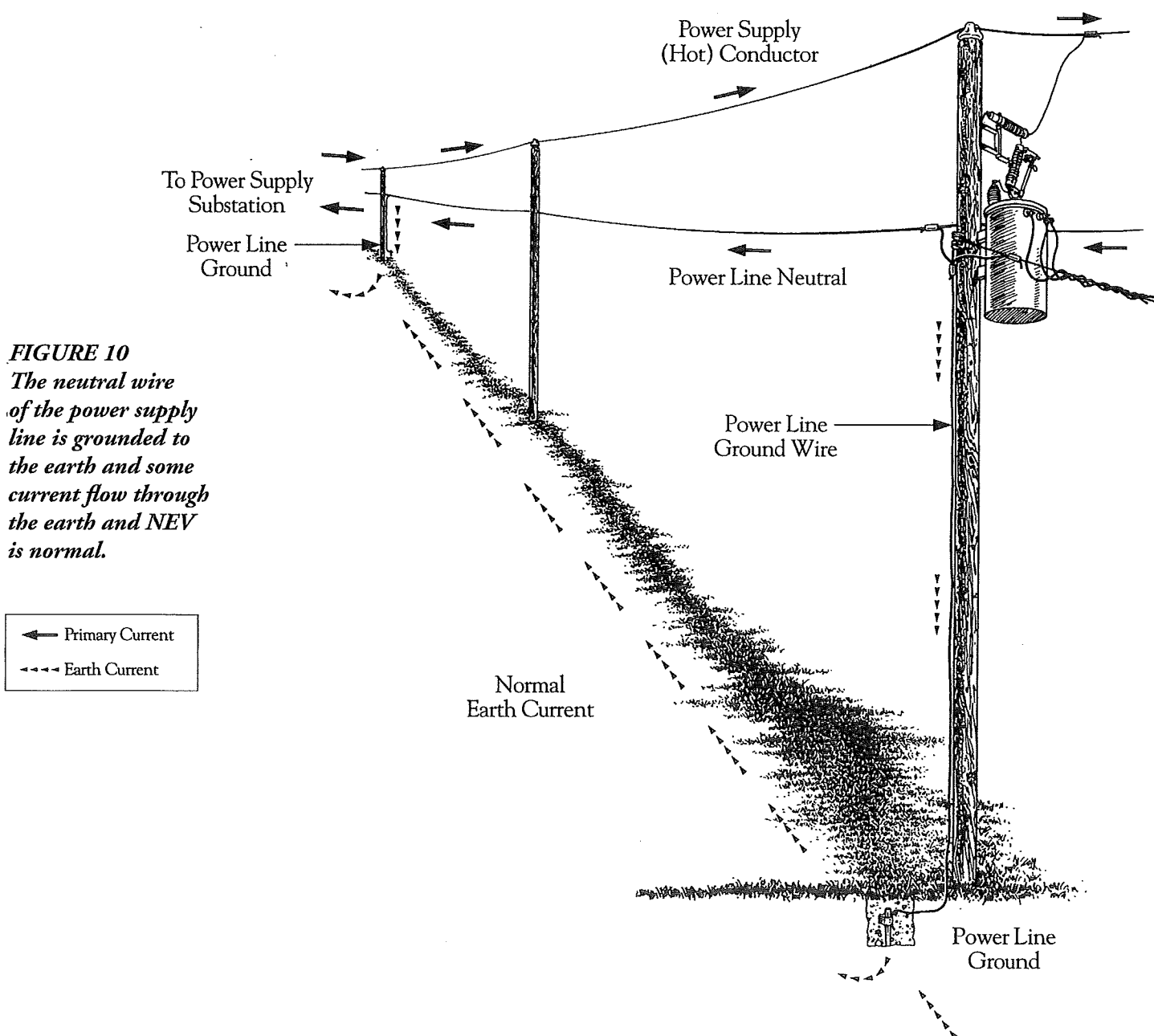
**FIGURE 8**  
A bare or green wire is required by the electrical code to be connected to a grounding terminal of all electrical equipment and wiring.



**FIGURE 9**  
A bare or green equipment grounding wire attached to the frame of electrical equipment provides a path for fault current, making equipment safe and preventing NEV.

## Power lines supplying electricity to the farm

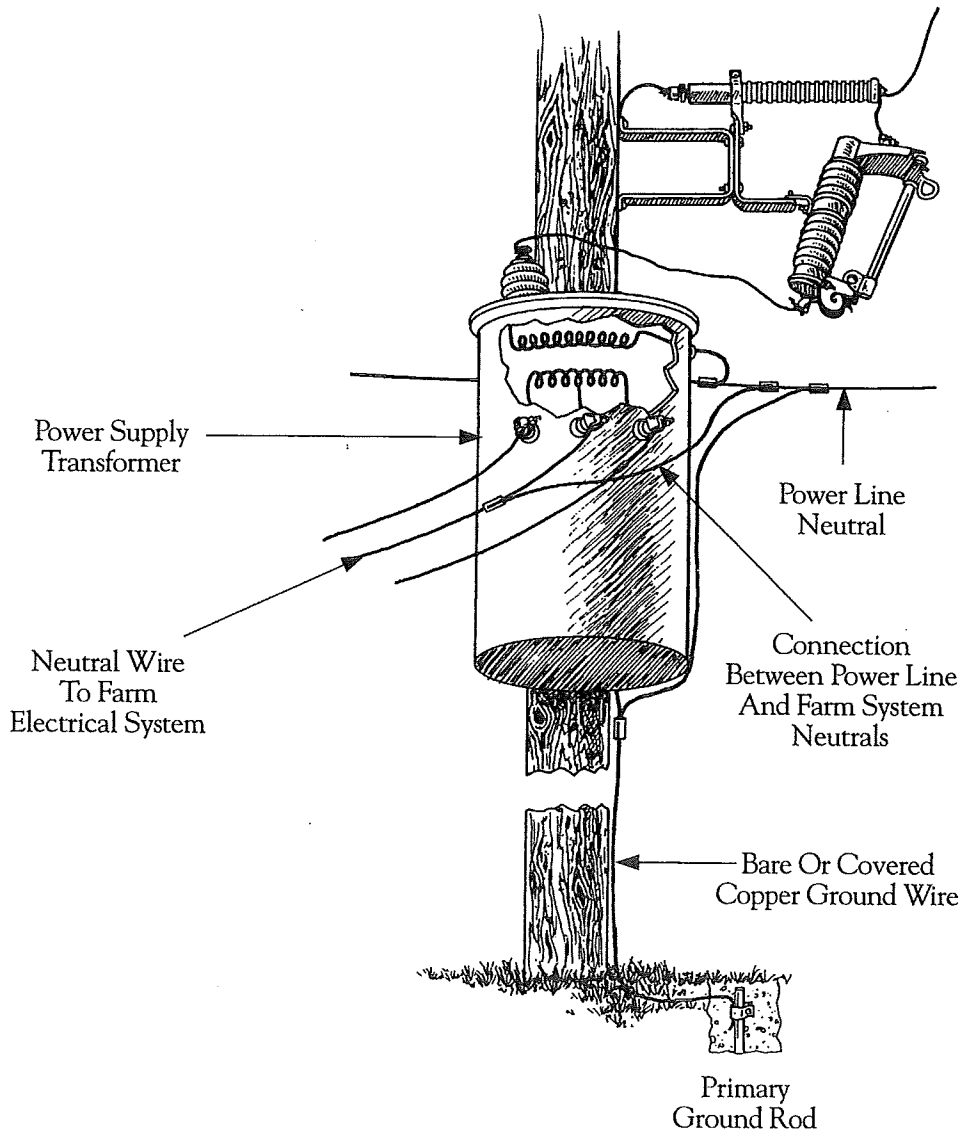
The typical power distribution line supplying power to farms has two conductors. One is the power supply (hot) conductor which carries current out to the farm. The second conductor is the power line neutral which carries current back to the power supply substation. The neutral conductor, which is grounded to the earth to ensure safety and reliability, is required to be connected to the earth by means of ground rods or similar means a minimum of four locations for each mile of line. When electrical current flows along this grounded conductor, a portion of the current will also flow through the earth. This earth current flow is normal and will result in some NEV (a fraction of a volt or more) along the line. This is illustrated in **Figure 10**. Usually NEV produced in this way is too small to be felt by animals.



**FIGURE 10**

*The neutral wire of the power supply line is grounded to the earth and some current flow through the earth and NEV is normal.*

The power line neutral of the power distribution line is normally connected to the neutral wire of the farm electrical system at the supply transformer. This is done to ensure maximum safety to the customer in the case of an accident, such as a storm knocking down wires or damaging equipment. But, this connection between the two neutrals permits power distribution line NEV to get onto the farm neutral. The connection between the grounded wire of the power line and the grounded wire of the farm electrical system is shown in **Figure 11**.

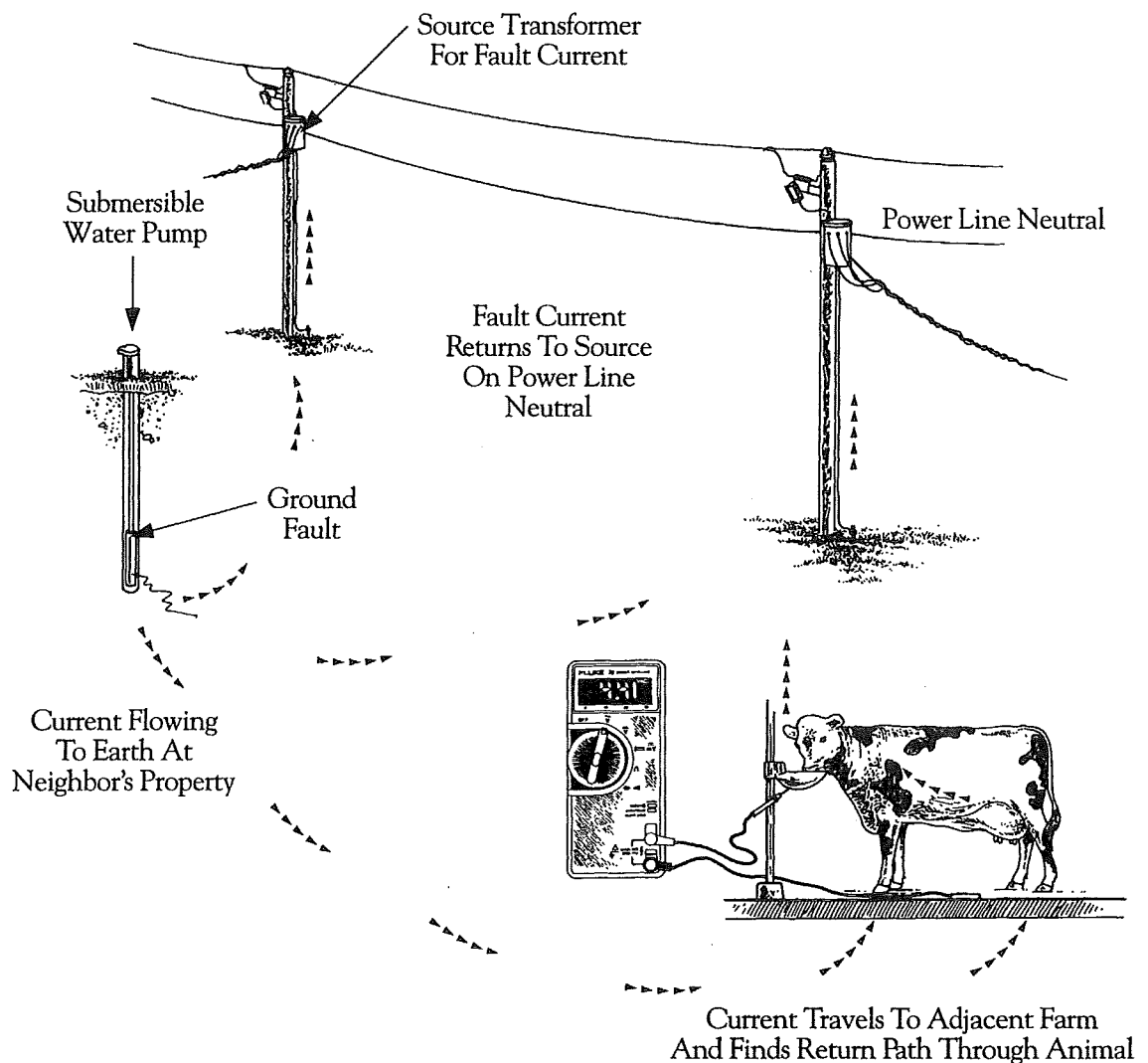


**FIGURE 11**  
*The grounded neutral wire of the power line is usually connected to the grounded neutral wire of the farm electrical system to ensure maximum safety.*

## Defective equipment at a remote location

NEV can be caused when there is an electrical failure in a piece of equipment allowing current to flow outside of the insulated conductors. This is a ground fault. A loose terminal, damaged insulation, or a poor splice in wet conditions can lead to an electrical fault. The equipment grounding conductor, which is either bare or covered with green insulation, will safely conduct the current back to the electrical panel. When the grounding wire is broken, corroded, or missing, the current will flow to the earth by an alternate means. This is especially true at water system pumps and drainage pumps. The current flowing into the earth is simply returning to its source transformer. Sometimes the current will travel from a neighbor's property and flow up from the ground. **Figure 12** illustrates how current flowing from a submersible water pump can travel through the earth to a nearby farm and then flow up from the earth. The current is simply trying to find its way to the power line neutral so it can return to its source transformer. The cause of the NEV is actually at a neighbor's property but it uses the low resistance ground at a nearby farm to find its way back to its supply transformer.

**FIGURE 12**  
*Electrical current faulting into the earth, such as at a submersible water pump, can travel from a neighbor's property to a nearby farm to find a path back to its source transformer.*



## DEFECTIVE ELECTRIC FENCE

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Defective electric fences can cause conditions which may look like NEV. Livestock sometimes avoid certain areas for reasons which aren't readily apparent. Sometimes cattle will not clean out one end of a feed bunk, may avoid one side of a free-stall barn, or are noticeably nervous entering or leaving some areas. Sometimes, the cause is traced to a defective or improperly installed electric fence.

Electric fences typically are charged with very short low current, high voltage pulses. Some are even designed to burn grass and weeds which come into contact with the fence wires. Electric fences are very effective because livestock become conditioned to know that the high voltage pulse will be uncomfortable when they come into contact with the fence wire.

Properly installed, these fences present no hazard to people or livestock. However, when a fence wire is improperly installed, or an insulator is missing or defective, the electric fence can be a source of great discomfort to your livestock. The fence charger must have its own ground rods. Never ground it to the electrical system grounds. Most fence chargers for proper operation require a minimum of three ground rods driven eight feet into the earth and spaced at least six feet apart.

Due to the high voltage generated by the fence charger, the quality of insulators on fence posts, as well as the insulation rating on any wire leading from the fence charger to the fence is very important. All components in the fence system need to be rated for these high voltages.

If the fence charger cannot be installed near the electric fence, then a conductor with high voltage insulation needs to be connected between the fence and the charger. It should be installed such that the insulation is not damaged by staples or chaffing against its supporting structure. Normal house type wiring, which has an insulation rating of 600 volts should never be used. The high voltage on the wire easily finds its way to ground through the insulation.

Some fences have defective insulators on wood fence posts, or no insulators at all. Often, the fence was properly installed, but maintenance was insufficient to keep it in proper working order. When the fence wire comes into contact with any conductor, such as a metal or wooden fence pole, barn siding, metal fence gates, concrete feed bunk, water trough, etc., the voltage spikes on the fence wire travel through these unintended paths seeking ground and a path back to the ground terminal of the fence charger.

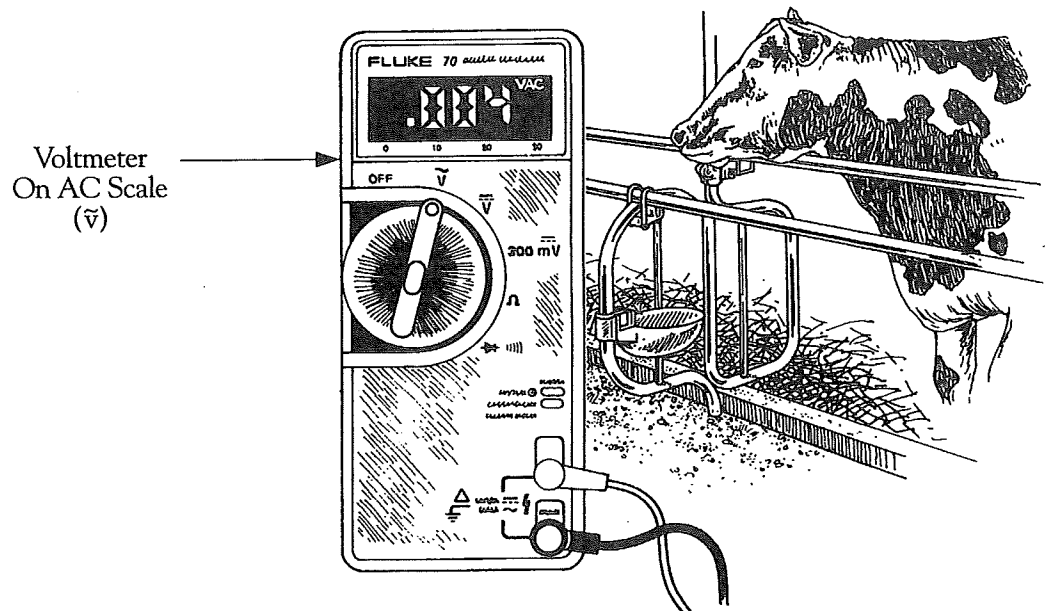
Once the current leaves the wire, in the form of short, high voltage pulses, it often can be detected on other objects with which it comes into contact. Pulses on the fence which are on the order of several thousand volts, may reach the animals at levels sufficient to be uncomfortable. These voltage pulses may cause unusual animal behavior and lead to problems.

Many of the behavioral clues listed in the section "How Can NEV Affect livestock?" can also apply to exposure to voltage from a defective or improperly installed electric fence or cow trainer. The best cure and prevention of electric fence related problems is by proper initial installation and by conducting regular preventive maintenance to keep the fence or cow trainer system in good working order.

## HOW CAN STRAY VOLTAGE BE IDENTIFIED ON A FARM?

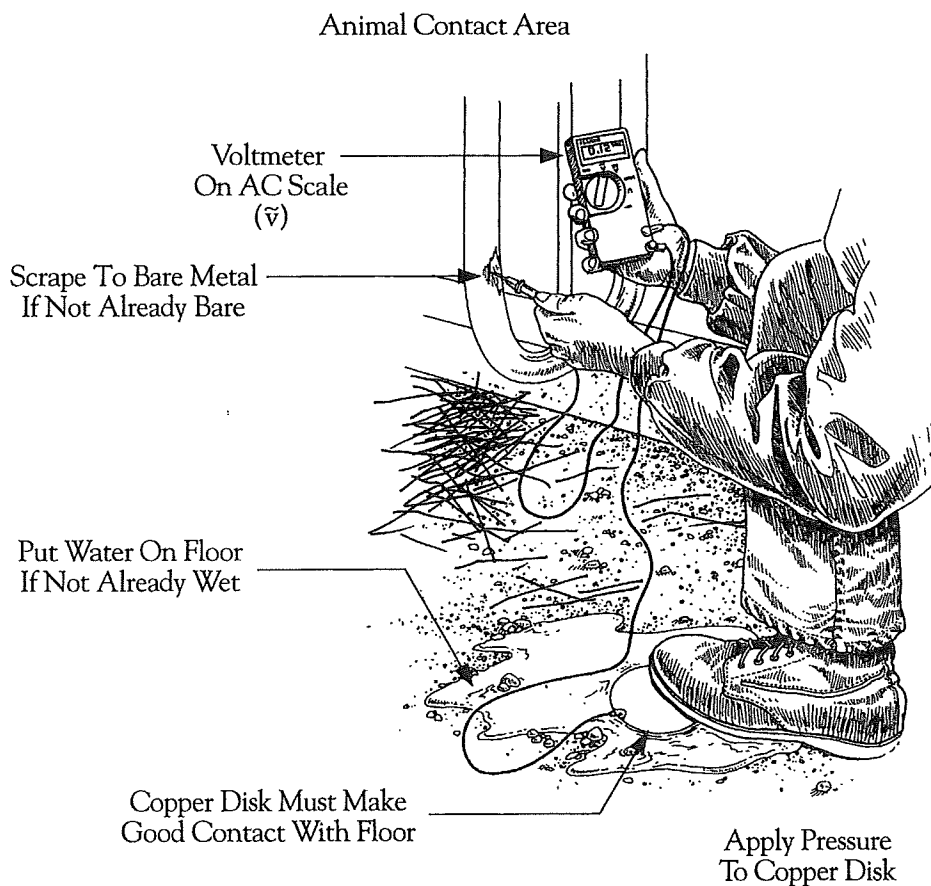
Unusual animal behavior can be observed with as little as a few milliamperes flowing through the animal's body. Two milliamperes is two-thousandths (0.002) of an ampere. Animals may become irritated and hard to handle. They may raise and lower their feet in an attempt to avoid contact with the floor or earth. They may be reluctant to eat or drink, as though something is making them uncomfortable at the feeder or waterer. Measuring the actual current flowing through the body of an animal is difficult. However, measuring the voltage between two points which can be contacted by an animal, normally called stray voltage, is the next best way to determine if they are being affected by electrical current. An instrument called a voltmeter is used to make these measurements. A typical voltmeter suitable for measuring NEV is shown in **Figure 13**.

**FIGURE 13**  
*A voltmeter which will accurately measure low levels of AC voltage is used to measure NEV.*



Voltage measurements should be made at locations where animals can make contact with metal objects which may have stray voltage. Watering devices, feeders, and metal stall dividers are the most common locations where an animal can make contact with stray voltage. Sometimes an animal will make contact with two metal objects with a voltage between them. But usually the contact is with one metal object, wherein the current flows through the animal's body to the floor. Therefore, it is necessary to measure from the floor or earth where the animal stands to adjacent metal objects the animal might touch. Typical locations are from a heated stock waterer to the earth, an electrically-powered feeder to the floor or earth, and from water bowls in a barn to the floor. Making a voltage measurement to a floor or the earth is not always easy. To prevent an error, stray voltage measurements must be made carefully. Voltage levels can change throughout the day or may be present only when certain equipment is operating. Stray voltage measurements at animal locations should be made at different times of the day. Observing animal behavior may give an indication when the stray voltage may be at the highest level.

The proper method for measuring stray voltage from metal equipment to the floor is illustrated in **Figure 14**. The tip of the meter probe should be touching bare metal of the stall divider or other metal object. If the floor is not wet, water should be poured on the floor where animals stand and allowed to soak for a couple of minutes. Mixing a little table salt in the water makes the water a better electrical conductor. Next, place a copper disk on the wet floor and connect the lead wire to the voltmeter. Place a weight on the copper disk or have someone stand on it. Place the disk near the location for the animal's rear feet to measure the stray voltage which could be affecting the animal. Avoid placement of the disk next to metal structures.



**FIGURE 14**  
*A copper disk test lead is placed in a wet spot on the floor and used as one point to measure the stray voltage which an animal may contact.*

A trained NEV investigator will usually perform a series of tests in an attempt to determine the source of the NEV. Usually the stray voltage is first identified at locations that can be contacted by animals. Then the investigator will conduct a series of tests to check the wiring on and off the farm. Sometimes a resistor is placed across the input of the voltmeter to help the investigator evaluate the strength of the source causing the stray voltage. The investigator may decide to make voltage measurements at a ground rod called a reference ground, which has been driven into the earth outside of the barn. This is similar to taking a measurement at the floor, but it provides one common point to make all voltage measurements. This is, however, not the same voltage that may be at an animal location. It is easier to diagnose the various voltage measurements if they are all measured to the same common ground. The investigator can conduct a series of tests which will indicate if there is a problem with the farm wiring or with wiring off the farm. These tests are performed by operating different electrical devices on the farm, such as large motors or lighting circuits in the barn. A trained investigator may connect a device called a load box to the wiring system when performing these tests.

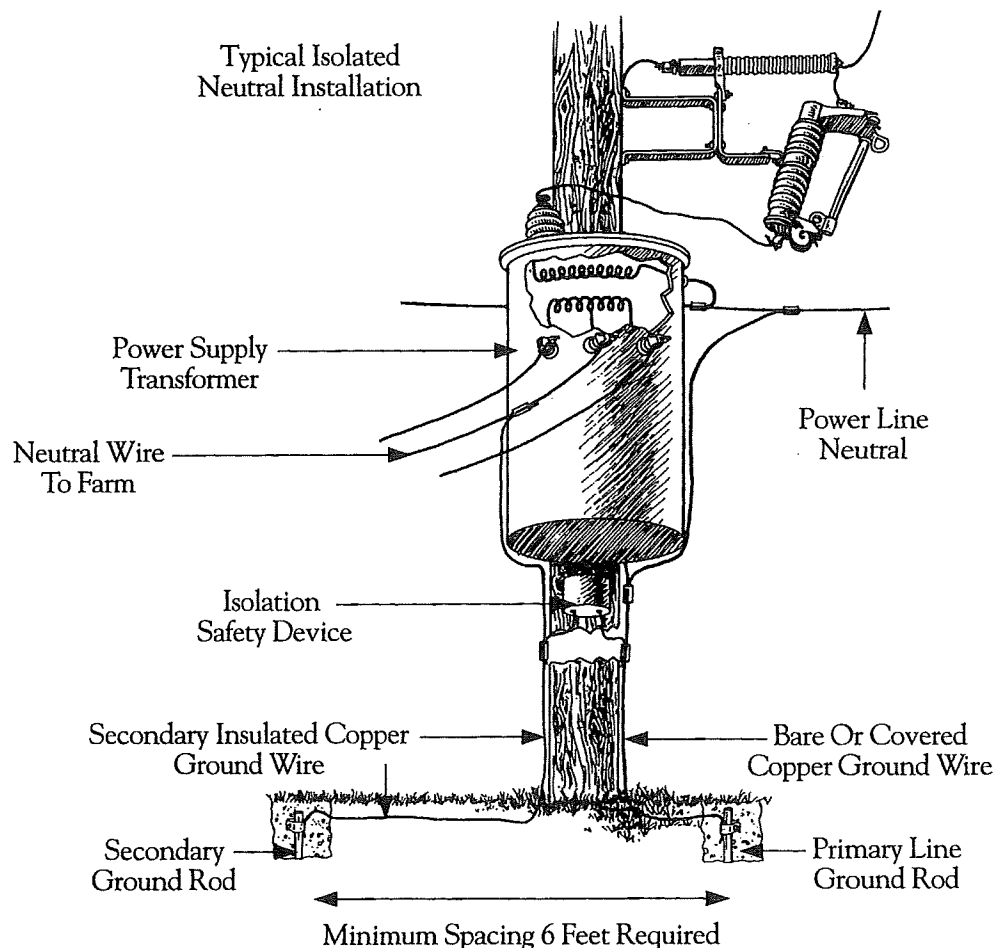


## HOW CAN NEV CONDITIONS BE CORRECTED?

NEV on farms can be reduced to a level that does not affect livestock once the source has been identified. If a faulty electrical circuit on the farm is found to be the source of the NEV, the circuit or equipment can be repaired. When a bad connection in a neutral conductor supplying a building is found, the connection can be repaired. Sometimes the neutral wire is too small for the load and distance from the central point distribution pole. In this case, it may be necessary to replace the wire with a larger conductor. The person performing the NEV investigation may find that the electrical current flow on a farm neutral conductor is unusually high. The current on the neutral conductor frequently can be reduced by a technique called load balancing. It is possible to reduce the neutral current to near zero when the barn is operating at full power. The circuits in the electrical panel should be rearranged so that half of the 120 volt loads, such as lights, are operated from each of the two hot conductors.

If a significant level of NEV is found to be coming from sources off the farm, it may not be possible to reduce it below a level of concern. In these situations, the electrical connection between the power line neutral conductor and the farm neutral conductor can be removed by the power supplier. A safety reconnecting device, called an isolator, or isolation safety device, is installed between the power line neutral and the farm neutral wire. This is illustrated in **Figure 15**. This technique will prevent off-farm sources of NEV from entering the farm, however, it will not stop on-farm sources from affecting livestock. Ground separation of communications system cables supplying the farm may also be necessary.

**FIGURE 15**  
*Separating the power line neutral from the farm neutral wire and installing an isolation safety device will prevent off-farm sources of NEV from getting onto the farm but it will not stop on-farm sources.*



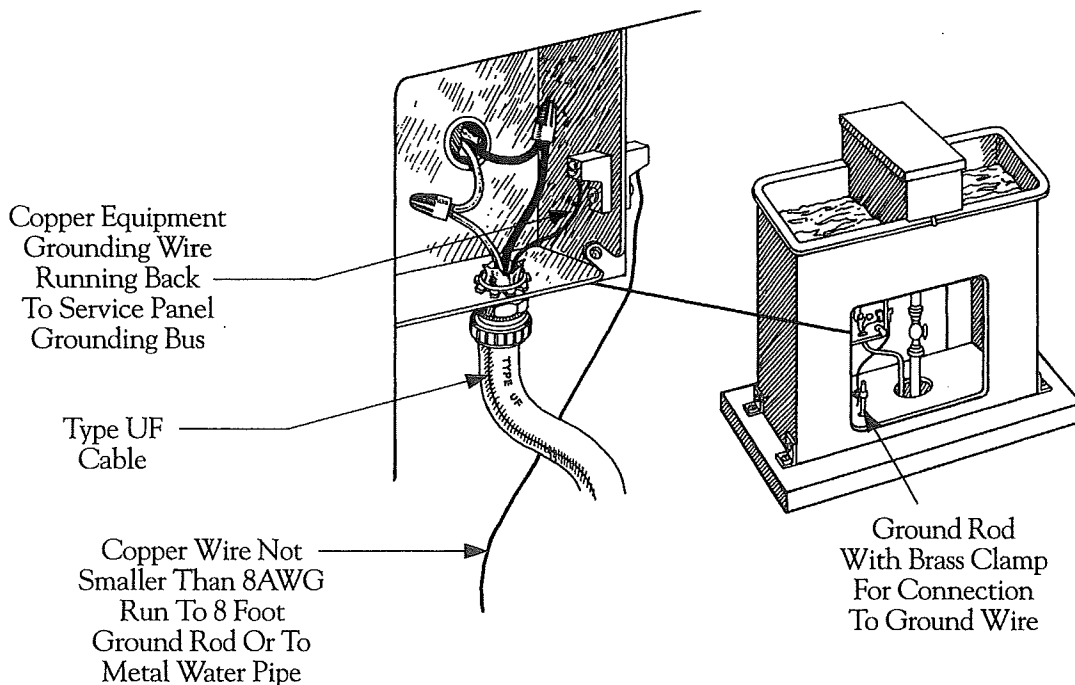
## WHAT CAN BE DONE TO PREVENT NEV?

There are cases when the power line neutral and the farm neutral are separated but the NEV can bypass this disconnection through the telephone line or other communications line. This is why it is important to remember the symptoms of NEV. A source of NEV can develop on a farm at any time, or the power line neutral can be accidentally reconnected to the farm neutral through a communications cable connection.

Prevention of NEV on livestock farms is a continuous task. Just like farm machinery, on-farm electrical systems need maintenance. Animals, machinery, weather, moisture, vapors, and chemicals will cause deterioration of on-farm wiring systems.

### Maintain the wiring on a farm in good repair.

The electrical wiring on livestock farms should be checked from time to time and repairs made when needed. Water and corrosive vapors are frequently present, causing damage to electrical wiring, connections and terminals. Usually corrosion and damage due to excessive heating can be detected by a periodic inspection. It is very important to make sure that wiring at water devices, feeders, and other equipment contacted by animals is in good repair. If the wiring becomes damaged, the result can be extremely hazardous. It is especially important that a copper equipment grounding wire be run with the circuit conductors and connected to electrical equipment frames for fault protection. This is especially true for a heated livestock waterer. **Figure 16** shows the wiring for a livestock waterer with an insulated copper equipment grounding wire connected to the frame of the waterer.



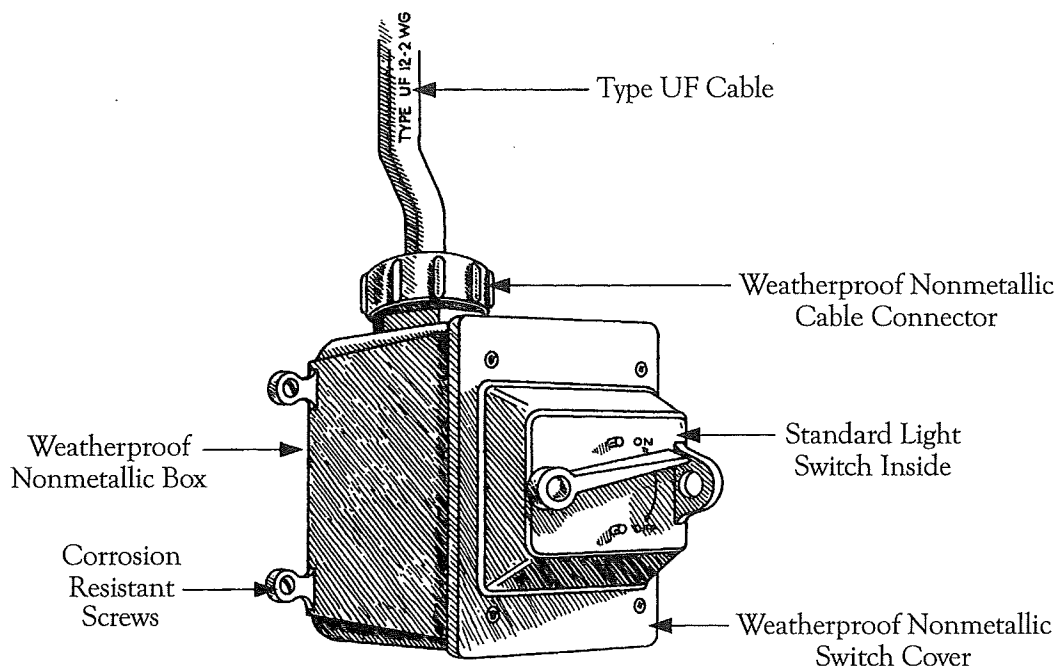
**FIGURE 16**  
*A copper equipment grounding wire must be run with the circuit wires and connected to the grounding terminal of all electrically powered equipment to ensure safety and to prevent NEV in the event of an electrical fault in the equipment.*

Covers need to be on electrical boxes. There should be no openings where the cables enter the boxes. Electrical equipment boxes can produce heat causing rodents to try to enter the equipment through very small openings to keep warm. Rodents will chew cable insulation down to bare wires in a very short time. Whenever possible, run cables so they can be easily seen. Otherwise, rodents can cause severe damage without detection.

Corrosion of metal boxes and equipment is a problem on farms. Whenever practical, nonmetallic conduit and cable with a nonmetallic covering should be used for wiring in livestock buildings. Boxes and enclosures for switches and other equipment should be weatherproof. Take advantage of the special weatherproof nonmetallic switch covers which are manufactured for switches and receptacle outlets for use on farms.

**Figure 17** shows a weatherproof box for a switch used in a livestock barn.

**FIGURE 17**  
*Nonmetallic weatherproof boxes and covers with weatherproof connectors and type UF nonmetallic sheathed cable will help to prevent corrosion of wiring and moisture in the wiring.*



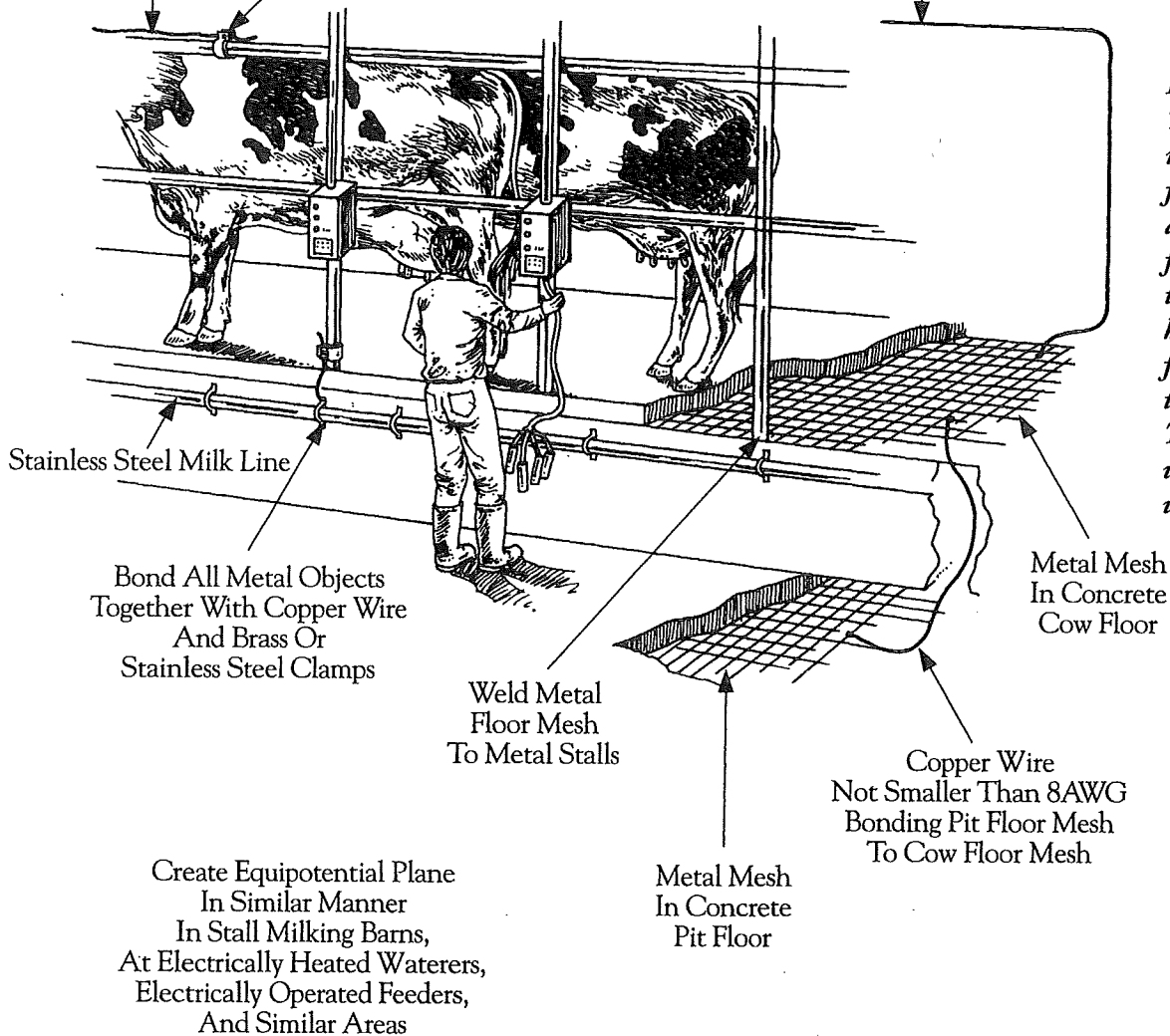
### **When building new facilities or remodeling present facilities.**

A number of things can be done to help prevent NEV from making contact with livestock, even when a source of NEV unexpectedly develops. The cost can be quite minimal when livestock facilities are constructed or remodeled. One suggestion is to place metal wires or metal mesh in the floor to form what is known as an equipotential plane. Animals cannot get a shock if everything they touch is at the same voltage level. If a new milking parlor is installed, steel mesh should be placed in the concrete. The steel mesh should be welded together so that it acts as one continuous grid. Tie wires made for the purpose are also acceptable. If it is welded to the steel supports of the milking parlor, it forms an "equipotential plane". When the cows are in the milking parlor, the floor and everything they can touch, have no voltage difference. Consequently, there will be no current flow through the animal bodies. This same idea should be used in stall barns, and near feeders and waterers. An equipotential plane in a milking parlor is illustrated in **Figure 18**.

Copper Wire  
Not Smaller Than 8AWG  
Run To Grounding  
Bus Of Electrical  
Service Panel

Brass Grounding  
Pipe Clamp

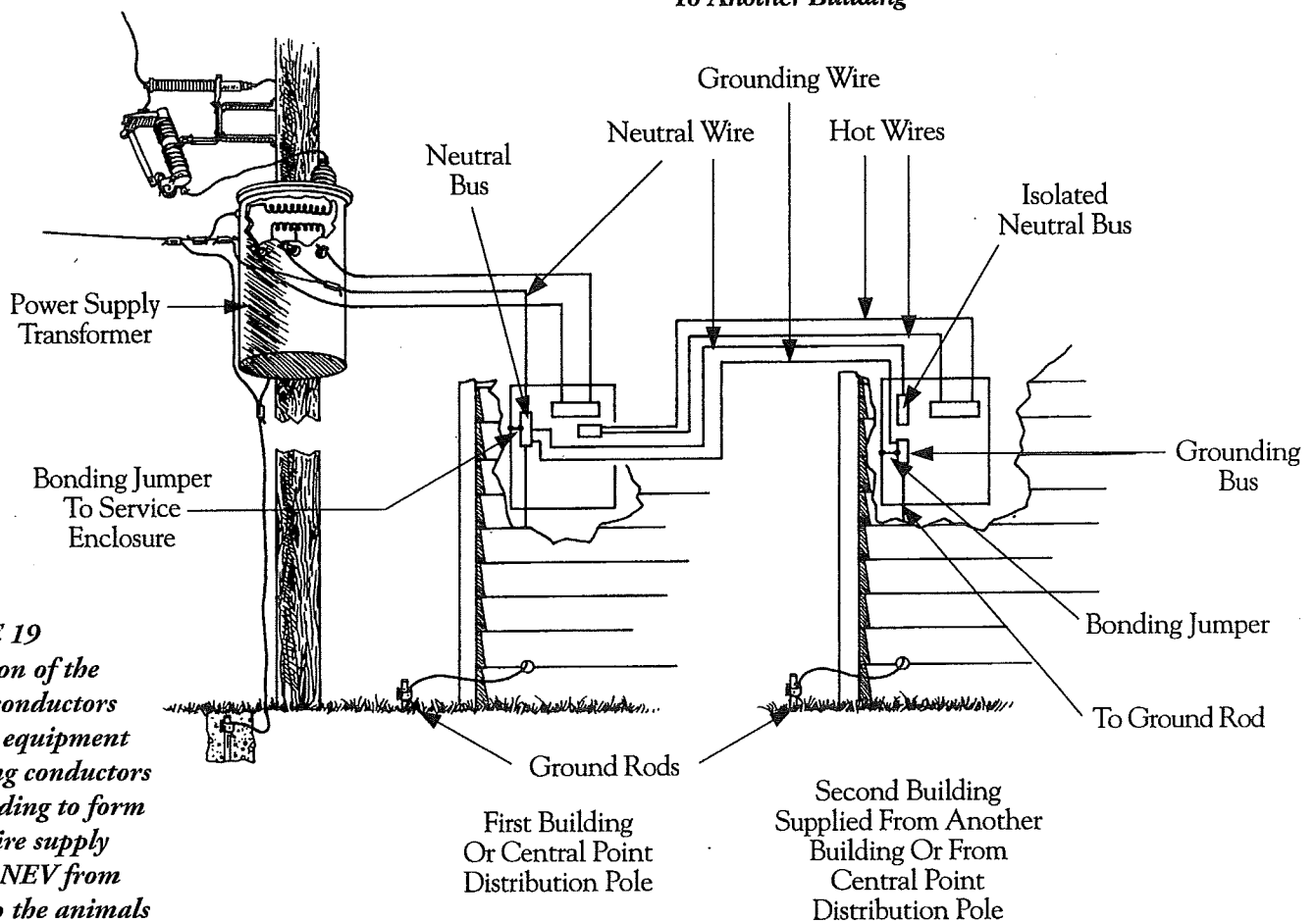
Copper Wire  
Not Smaller Than 8AWG  
Run To Grounding  
Bus Of Electrical  
Service Panel



**FIGURE 18**  
*The installation of metal mesh in the floor connected to all exposed metal forms an equipotential plane which helps prevent animals from being exposed to stray voltage. The size 8 AWG bonding wire should be solid where practical.*

A practice required for all new buildings is the separation of the neutral wires from the equipment grounding in the building. Then, if a faulty connection in the neutral should develop, the current will not flow through the building grounds to the animals. When the overhead or underground feeder wires are very long, separation of the neutral wire from the equipment grounding wire is recommended as a replacement for existing electrical supply to buildings. But some work will be required to separate equipment grounds and neutral wires in the building service panel. When the power has to travel great distances, there is an increased chance that the neutral conductor can cause NEV due to the high resistance of the neutral. **Figure 19** is a diagram of how this separation is made with a separate grounding wire and a separate neutral wire run with the two hot wires to a livestock building.

#### **4-Wire Electrical Feeder To Another Building**



**FIGURE 19**  
*Separation of the neutral conductors from the equipment grounding conductors in a building to form a four wire supply prevents NEV from getting to the animals when caused by a corroded or loose neutral connection.*

Energy efficiency is an important source of financial savings on farms. It results in the use less energy to produce the same amount of output with equal or sometimes better performance. Energy conservation can have many benefits such as lower utility bills and reduced demand on the farm electrical system. Reduced power demand can have the potential of reducing NEV on a farm.

Your electrical supplier has information about the different methods of preventing NEV when building or remodeling. Good planning can help prevent NEV and other problems in the future. Call your electrical power supplier today for assistance. Some of the publications listed on the next page can be helpful when remodeling or building new facilities.

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The following publications contain more information about farm wiring systems and NEV.  
You can find out how to obtain copies by going to the “web” or you can contact your power supplier for assistance.

- *Agricultural Wiring Handbook*, Rural Electricity Resource Council, [www.nerc.org](http://www.nerc.org).
- A Review of Stray Voltage Research, Effects on Livestock, E-2606, R.J. Fick and T.C. Surbrook, Biosystems and Agricultural Engineering Dept., Michigan State University, [www.egr.msu.edu/age](http://www.egr.msu.edu/age).
- *Interpreting the National Electrical Code*, T.C. Surbrook and J.R. Althouse, [www.cengagelearning.com](http://www.cengagelearning.com), ISBN 9781111544423.
- Meta-Analysis of Stray Voltage on Dairy Cattle, L.E. Erdreich, D.D. Alexander, M.E. Wagner, and D. Reinemann, *Journal of Dairy Science*, 92:5951-5963. American Dairy Science Association.
- *Wiring handbook for Rural Facilities*, Publication 28, Midwest Plan Service, Iowa State University, ISBN 0-89373-104-8, [www.mwps@iastate.edu](mailto:www.mwps@iastate.edu).
- Stray Voltage Questions and Answers, E-2605, Biosystems and Agricultural Engineering Dept., Michigan State University, [www.egr.msu.edu/age](http://www.egr.msu.edu/age).
- Safe and Effective Electric Fences, E-2706, Biosystems and Agricultural Engineering Dept., Michigan State University, [www.egr.msu.edu/age](http://www.egr.msu.edu/age).
- Effects of Electrical Voltage/Current on Farm Animals, How to Detect and Remedy Problems, USDA Agricultural Handbook 696, U.S. Government Printing Office: 1992-617-013/46592.

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