Nov. 17, 1970 J. M. VAN NAME 3,541,389

ELECTRICALLY CONDUCTIVE FOOT WEAR

Filed Dec. 30, 1968 2 Sheets-Sheet 1

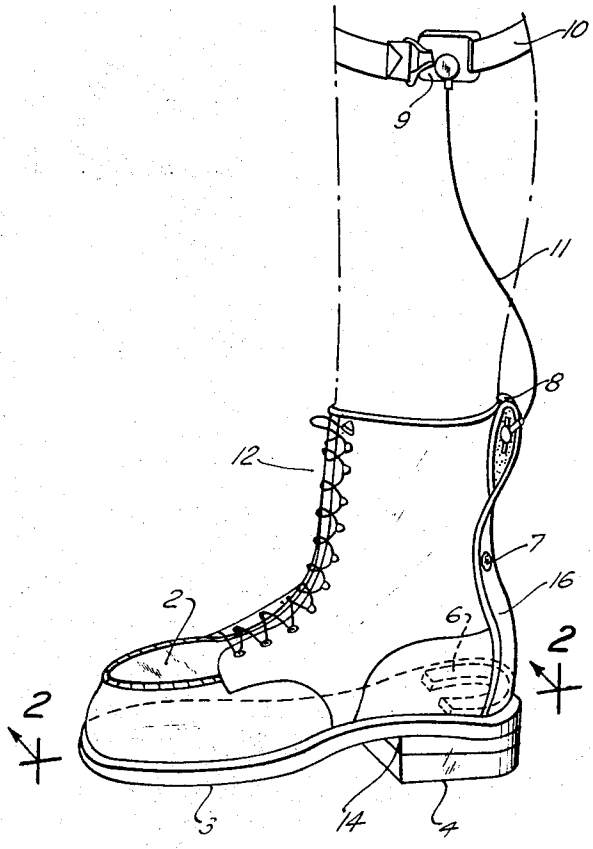



FIG. 1

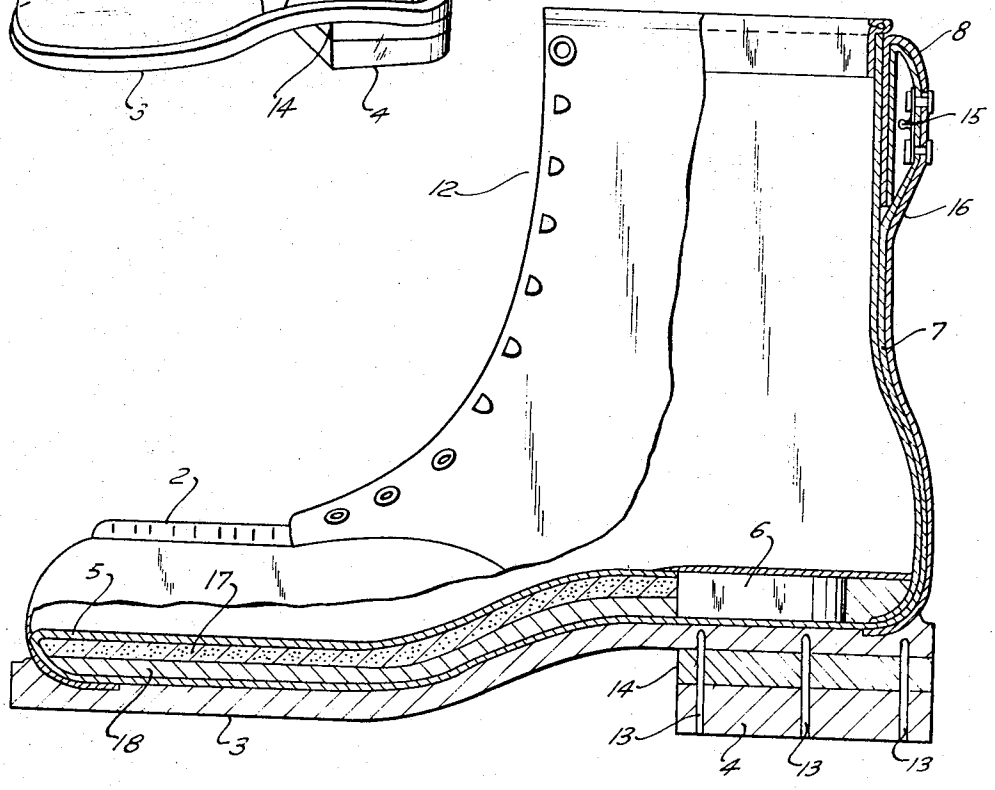



FIG. 2

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FIG. 3

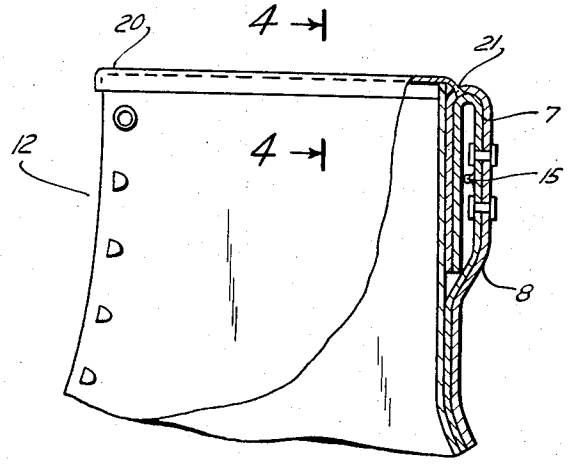



FIG. 4

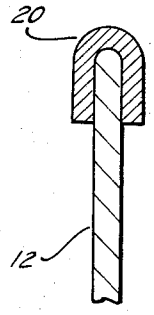
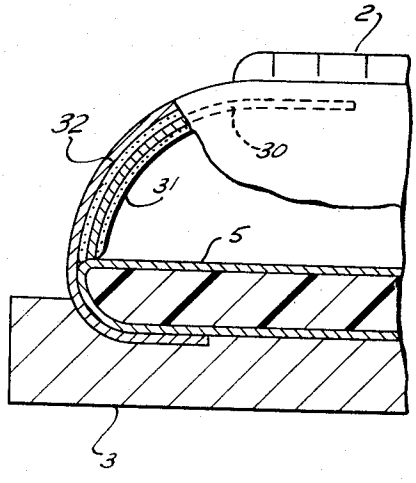



FIG. 5




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# ELECTRICALLY CONDUCTIVE FOOT WEAR

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U.S. Cl. 317—2 5 Claims

## ABSTRACT OF THE DISCLOSURE

An electrically conductive boot or shoe is described which is suitable for use by electrical linemen, maintenance men and construction men working in the vicinity of high voltage equipment. The boot includes conductive inner and outer soles, liners, a conductive strip extending vertically along the outside of the boot and means for connecting the leg of the wearer with the conductive strip. The boot will substantially prevent the accumulation of induced electrical charge and differences of potential between the wearer and adjacent conductive objects, and dissipate induced charges at a substantially rapid rate to preclude injury and avoid discomfort to the wearer. Moreover, the boot will maintain a predetermined electrical potential or voltage between the wearer and conductive objects with which the boot is in contact. When the uppers are formed entirely of conductive material the boot functions as a Faraday shield and prevents current from being induced in the foot of the wearer when exposed to a cyclic electric field.

## BACKGROUND OF THE INVENTION

This invention relates to electrically conductive foot wear and more particularly to an electrically conductive boot or shoe suitable for use by electrical linemen, maintenance men and construction men working in the vicinity of high voltage equipment, including transmission lines, substations, generating stations, and like facilities.

Large electric power utilities transmit electricity by overhead lines at voltages on the order of 500 kv. or 750 kv. The trend in recent years is to transmit at higher voltages and it seems certain that future voltages of 1000 kv. and higher can be expected.

There are three general ways in which electrical linemen carry out maintenance and other work on high voltage transmission lines. These methods are (a) deenergize the line so that no current flows; (b) use long, non-conductive rods having the proper tools affixed to the end so that the lineman works at a distance from the line (commonly termed the hot stick method); and (c) work with bare hands on the transmission line (commonly termed the bare-handed method). For high saturation metropolitan areas it is virtually impossible to completely deenergize the line when maintenance is called for. The technique becoming the most popular with utility companies because it is the most efficient is the bare-handed method in which the electrical lineman works adjacent the line and is maintained at the same electrical potential.

When an electrical lineman works on or near high voltage transmission lines, as in the bare-handed method, he is in a cyclic electric field established between the line or equipment and earth or ground, between one line and another, or between portions of electrically conductive objects with which he is in contact. This cyclic or fluctuating electric field will induce electric current through the lineman's body, the amount depending upon the electrical field strength, the lineman's relative position in the electric field, and the resistance or impedance characteristics of the lineman's body and associated gear such as shoes and clothing. If the lineman is at the potential of the high voltage electric line, as is customary in operations employing the bare-handed work technique, he will be in a relatively strong field since he is near the current carrying conductor and induced body current will be higher than if he were at ground potential.



The induced current is virtually zero on the inside of a hollow conductor positioned in an electric field. Consequently, most electric power companies provide the lineman with a protective shield in the form of a cage made of conducting material and sometimes with an electrically conducting suit. A shield which completely surrounds the lineman prevents the electric field from inducing a charge in the lineman's body. However, since the lineman must be free to carry out his work, it is only practical to partially surround him with the shield. As a result, part of the lineman's body is exposed to the cyclic electric field and an electric charge is caused to be built up in the lineman. Since the electrical potential of the protective shield is usually maintained at that of the high voltage transmission lines, such an induced charge on the lineman will place the lineman at a potential different from the protective shield thus resulting in the possibility of accidental discharge of current between the lineman and the shield or other conducting objects which can be dangerous and perhaps even fatal.

Information of general knowledge in the industry indicates that injury, shock or death due to electrical current flow is directly related to the current density at the point or points of entry to the body as well as the total current. Currents as low as 10 milliamperes concentrated in an area of the body where the sensory perception is greatest, may cause inadvertent movement and muscular contraction in that area. Nerve sensations will also be adversely effected.

For example, in three phase, 60 Hertz alternating current, there may be a build up of electric charge sufficient to permit upon discharge or the establishment of a conducting path, a current of about 23 milliamperes to flow through the lineman's body. Currents of this magnitude will generally result in severe shock, muscular contractions and breathing difficulties. Higher currents on the order of about 100 milliamperes for just a short period of time most probably will result in ventricular fibrillation and possible death.

Although many attempts were made to overcome the general difficulty, the cited specific example, and other related occurrences of induced charge and current flow, none, as far as I am aware, was entirely satisfactory in most respects when carried into practice commercially.

## BRIEF SUMMARY

I have now developed an electrically conductive boot or shoe which will prevent the accumulation of an induced electrical charge or difference of potential between the wearer and conductive objects in close proximity thereto, and will effectively dissipate induced charges at a sufficiently rapid rate and at low current density to avoid injury and discomfort to the wearer. Moreover, the boot will maintain the wearer at a predetermined electrical po-

tential relative to the protective shield or supporting platform and conductive objects with which the boot is in contact. In addition, the electrically conductive boot in accordance with my invention can be made to substantially prevent induction of electrical charge in the foot of the wearer when exposed to a cyclic electric field.

An object of this invention is to provide an electrically conductive boot or shoe which will prevent the accumulation of an electric charge on the wearer while working in the vicinity of high voltage lines and equipment, or electrical equipment carrying a large amount of current.

Another object of this invention is to provide an electrically conductive boot or shoe which will maintain the wearer's body at a predetermined electrical potential.

A further object of this invention is to provide an electrically conductive boot or shoe which will attain the two previously cited objectives without interfering or obstructing the wearer in the accomplishment of required tasks and which will preclude the employment of other specialized devices not readily available.

An additional object is to provide an embodiment of an electrically conductive boot which will substantially prevent induction of electric charge in the wearer's foot when exposed to a cyclic electric field.

Still another object of this invention is to provide an electrically conductive boot or shoe which is specifically adapted for use by electrical linemen, maintenance men, or construction men working in the vicinity of high voltage electrical equipment.

Other objects and advantages will become apparent from the following description taken in conjunction with the accompanying drawings in which:

FIG. 1 is a perspective view of an electrically conductive boot or shoe particularly suitable for use by linemen;

FIG. 2 is a partial sectional view taken along the line 2—2 of FIG. 1;

FIG. 3 is a side elevational view partly in section of the upper part of the conductive boot showing a conductive band surrounding the uppermost part of the boot and connecting to the conductive strip;

FIG. 4 is a sectional view taken along the line 4—4 of FIG. 3 showing the conductive band straddling the boot upper on both the inside and the outside;

FIG. 5 is a sectional view of the toe of the electrically conductive boot showing the inclusion of a steel plate and surrounding thermal insulating and electrically conductive material.

In accordance with my invention, charges induced in the exposed parts of an electrical lineman's body by the electric field (as, for example, in the bare handed work technique referred to above) will be rapidly dissipated and chances of building up a charge sufficient to cause electrical breakdown will be substantially eliminated. To maintain the lineman at the same electrical potential as the protective shield or suit, I provide an electrically conductive boot which includes a conductive outer sole and conductive inner sole substantially co-extensive with the outer sole and in electrical contact therewith. In addition, the boot has a conductive strip electrically connected to the soles and extending vertically along the outside of the boot. The boot is also provided with means for electrically connecting the leg of the wearer with the electrically conductive strip so that as an electrical charge is induced in the wearer it will be dissipated at a sufficiently rapid rate without injury or discomfort. Thus, the wearer will remain at a predetermined electrical potential.

## PREFERRED EMBODIMENTS

Referring now to the drawings, FIGS. 1 and 2 show an electrical lineman's boot **2** having electrically conductive outer sole **3** and electrically conductive heel **4** attached to a leather heel spacer **14**. Conducting heel **4** is in electrical contact with outer sole **3** by means of conducting nails **13**. A conductive inner sole comprises a first conducting member **5** wrapped about combined foam



or sponge cushion **17** laminated to a second conducting member **18**. The inner sole is in electrical contact with, and substantially coextensive with, the outer sole. Conductive heel plug **6** is in electrical contact with the inner sole in the rear heel portion of the boot. Conductive strip **7** connects to conducting member **5** of the inner sole and extends vertically along the rear of the boot forming a loop **8** at the upper rear portion. A leg-stat is composed of leg-engaging conducting plate **9** attached to the calf of the wearer by garter **10**. The leg-engaging plate is in electrical contact with electrically conductive strip **7** by means of connecting wire **11**. Boot upper **12**, as well as the backing liner **16**, can be made of leather while strip **7** and conducting member **5** are preferably made of an electrically conductive plastic which is static free. The cutaway of FIG. 1 shows conductive strip **7** positioned beneath insulated backing liner **16**.

Conductive heel filler or plug **6** is positioned in the boot so that it makes direct contact with the insole. Thus, current paths are established through the inner sole to the outer sole or through the heel plug to the inner sole and then to the outer sole. Since the outer sole is in direct contact with the working or supporting platform or shield (not shown), there will be a substantially continuous dissipation of electrical charges induced in the body of the wearer through the sole to the platform or shield. Consequently, the boot maintains the body of the lineman essentially at a predetermined electrical potential such, for example, as the potential of the working platform or protective shield.

FIG. 2 is a partial sectional view of the conductive boot showing outer sole **3** in electrical contact with the inner sole. Conductive heel **4** is attached to the outer sole **3** with conducting nails **13** which, for example, can be formed of brass. The induced current in the wearer's body is conducted from leg-engaging plate **9** down conducting wire **11** to conductive strip **7** extending vertically along the rear of the boot. The current then passes down conductive strip **7** to the inner sole, to the outer sole, and then to the protective shield or ground as the case may be.

Loop **8** at the top of the rearward part of the boot provides a recessed and protected position for electrical contact point **15** of wire **11** and strip **7**. This recessed position permits the lineman freedom of movement and minimizes the chances of accidental breakage of electrical contact between wire **11** and strip **7**.

A second embodiment of my invention is shown in FIGS. 3 and 4. This embodiment can be employed if the lineman is not inclined to wear socks which extend above the top of the boot as, for instance, during summer weather. Conductive band **20** is positioned within the upper part of the boot and extends downwardly inside the boot for a short distance. Thus, when the boot is laced the leg of the wearer is placed in contact with conductive band **20**. A current path is established between the leg of the wearer through band **20** to conductive strip **7** by means of electrically conducting connector **21**. This embodiment can be used when the leg stat is not desired to be worn by the electrical lineman. However, during cold weather an electrical lineman is likely to wear long woolen socks which might prevent good electrical contact between the wearer's leg and band **20** in which case the use of the leg stat is preferred.

FIG. 5 shows the addition of a steel safety plate **30** embedded in the toe of the boot which is helpful in preventing injury to the lineman working with heavy objects which might cause injury to the toes. As can be seen in FIG. 5, safety plate **30** is surrounded by thermal insulating material **31** and **32** which prevent the toe of the wearer from becoming excessively cold during outdoor exposure to winter temperatures. Safety plate **30** extends downwardly and is in electrical contact with conductive member **5** of the inner sole. A continuous electrical path exists therefore between safety plate **30** and outer sole **3**.

An important feature of my invention resides in the multiple conducting paths established through the boot to the supporting platform. Thus, the heel, sole and toe of the wearer are electrically connected to the platform through the conducting soles. However, should the wearer's foot not be enough to maintain contact through sole **5**, such as when the lineman stands lightly or leans or rests his foot, an electrical path exists through leg-engaging plate **9** or band **20**, as the case may be, to the inner and outer soles. In most instances, the socks worn by the lineman are sufficiently conductive to permit a substantial electrical connection through the sock to conducting member **5** even with reduced foot sole pressure or contact.

If heel spacer **14** is formed of electrically conductive material and conductive glue is used to attach heel **4** to outer sole **3**, conductive nails **13** can be eliminated.

Furthermore, the outer surfaces of boot uppers **12** can be made conductive by treating the leather, for example, with a conductive chemical or with a suspension of carbon black in a suitable light polyolefin which evaporates to leave the carbon particles in the pores of the leather. A proprietary anti-static spray marketed by Walter G. Legge Company, Inc. of 101 Park Ave., New York, N.Y. 10017, under the trademark STATICO has been found particularly effective for the purpose. Leg-engaging plate **9** could also be made of similar conductive leather or cloth material, if desired.

Under certain conditions a lineman's foot may not be within the area established by the protective shield resulting in the formation of induced current. The problem of adequate shielding of the foot can be easily solved by forming boot upper **12** from conductive material. Since the boot is then substantially entirely conductive, it will function as a Faraday shield for the lineman's foot and prevent an electric current from being induced in the foot or toes of the wearer exposed to a cyclic electric field. Although the boot functions much the same as a Faraday shield, it will also function as a conductor. For example, if the wearer's leg and boot are exposed to a cyclic electric field, a current would be induced in the wearer's leg but not in his foot and the induced current would be conducted downwardly through the boot to the platform.

Conductive strip **7** can be extended to connect directly to conductive clothing worn by the lineman to permit continuous dissipation of discharge on the clothing through the boot to the conductive shield or platform. Both the wearer and the protective clothing will then be maintained at the same predetermined electrical potential.

The electrical resistance of the conductive boot should be as low as possible to quickly and rapidly dissipate induced electrical charges without injury or discomfort to the wearer. The electrical resistance of the boot shown in the drawings can be about 10,000 ohms and which will readily dissipate induced electrical charge in the wearer even for transmission line conditions of a 750 kv. and 2000 amperes (line to line potential for three phase, 60 Hertz system) alternating current transmission line system, or a 750 kv. (line plus to line minus direct current system). For conditions of voltage and current that exceed these values, or where clearance or distance stiuations and requirements cause changes in the amount of induced charge and resulting potential difference, the resistance of the boot should preferably be lower to maintain the same potential difference and resulting current flow.

In accordance with my invention therefore induced current in the body of the wearer will be dissipated through the soles of the boot to the protective shield, platform or suit at a sufficiently rapid rate and at low current density to avoid discomfort to the wearer. In addition, the conductive boot in accordance with my invention prevents the passage of electric current through the legs and into or through sensitive body areas, such, for example, as the heart where fatal injury may occur at surprisingly low current values.

A mere shunt connection such, for example, as a garter with leg-engaging element connected to a metallic plate positioned beneath the instep of an otherwise non-conducting shoe, is generally not satisfactory and can actually be detrimental. By connecting the leg of the lineman directly to the protective shield, suit, or other conducting objects, the current flow through the leg will still result in a difference of potential between the leg attachment point and the wearer's foot or sole of his foot. Furthermore, due to the cyclic electric field the metallic plate at the instep, the sole of the wearer's foot and the conducting object upon which the wearer is standing will behave as a capacitor and will build up a potential difference therebetween because a conductive path of sufficiently low resistance or impedance is not available. If the potential difference increases due to the charging effects in the electrical circuit, the non-effective components will provide a current path to permit a great increase in total charge buildup. Upon breakdown and conduction, the magnitude of this built up current will be great and probably cause shock, burning, injury and, depending upon the current path and other factors, possible death. Moreover, the shunt connection positioned beneath the instep is also unsatisfactory to an electrical lineman since it will interfere with the lineman's movement and might cause him to trip and fall with disastrous results thus creating a safety hazard. In addition, this plate would not maintain constant electrical contact with the conductive supporting platform or shield during normal maneuvering of the lineman, e.g., standing on his toes when reaching upwards, resting his foot, etc. When electrical contact is broken between the conductive boot, or in this case the conductive instep, the electrical charge induced in the wearer will be given the opportunity to build up to a higher potential.

Although the present invention has been described in conjunction with preferred embodiments, it is to be understood that modifications and variations may be resorted to without departing from the spirit and scope of the invention as those skilled in the art will readily understand.

What is claimed is:

**1.** An electrically conductive boot suitable for use by electrical lineman and others working in the vicinity of a cyclic electric field caused by the operation of high voltage equipment includes, a conductive outer sole, an electrically conductive heel in electrical contact with the outer sole, a conductive inner sole substantially coextensive with the outer sole and in electrical contact therewith, a conductive strip electrically connected to the inner sole and extending vetrically along the boot outside and at the rear of the boot, forming a rearwardly extending loop near the top of the boot to provide a completely recessed position with the loop, a conducting wire connected to the upper part of the strip within the loop, a leg-engaging plate connected to the other end of the conducting wire, the resistance of the boot being such so that if an electrical charge is induced in the wearer by the electric field it will be dissipated by a discharge current distributed over a substantial area of skin contact, at a sufficiently rapid rate to avoid injury or discomfort and the wearer will remain substantially at a predetermined electrical contact and whereby the completely recessed connection between the conductive strip and conducting wire substantially minimizes the danger of accidental disconnection.

**2.** An electrically conductive boot in accordance with claim **1** including an electrically conductive safety plate positioned in the toe of the boot and electrically connected to the soles.

**3.** An electrically conductive boot in accordance with claim **1** wherein the electrical resistance of the boot does not substantially exceed about 10,000 ohms.

**4.** An electrically conductive boot in accordance with claim **1** which includes a boot upper formed of electrically conductive material whereby substantially the entire boot is electrically conductive, so that if the foot

of the wearer is exposed to the electric field substantially no electric current will be induced therein.

5. An electrically conductive boot in accordance with claim 1 which includes a boot upper formed of material whose outer surface is electrically conductive, so that if the foot of the wearer is exposed to the electric field substantially no electric current will be induced therein.


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174—5.1; 317—262