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Sandorf

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[54] **QUICK CONNECT MODULAR VOLTAGE MULTIPLIER**

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[52] **U.S. Cl.** ..... **321/15**, 174/52 PE, 317/3

[51] **Int. Cl.** **H02m 7/10**

[58] **Field of Search** ..... 321/15; 174/52 PE; 317/3, 317/101 R; 239/15

[56] **References Cited**

UNITED STATES PATENTS

3,412,198	11/1968	Wallis	239/15
3,599,038	8/1971	Skidmore	321/15
3,748,538	7/1973	Shekerjian et al.	317/101 R
3,771,024	11/1973	Dumas	321/15

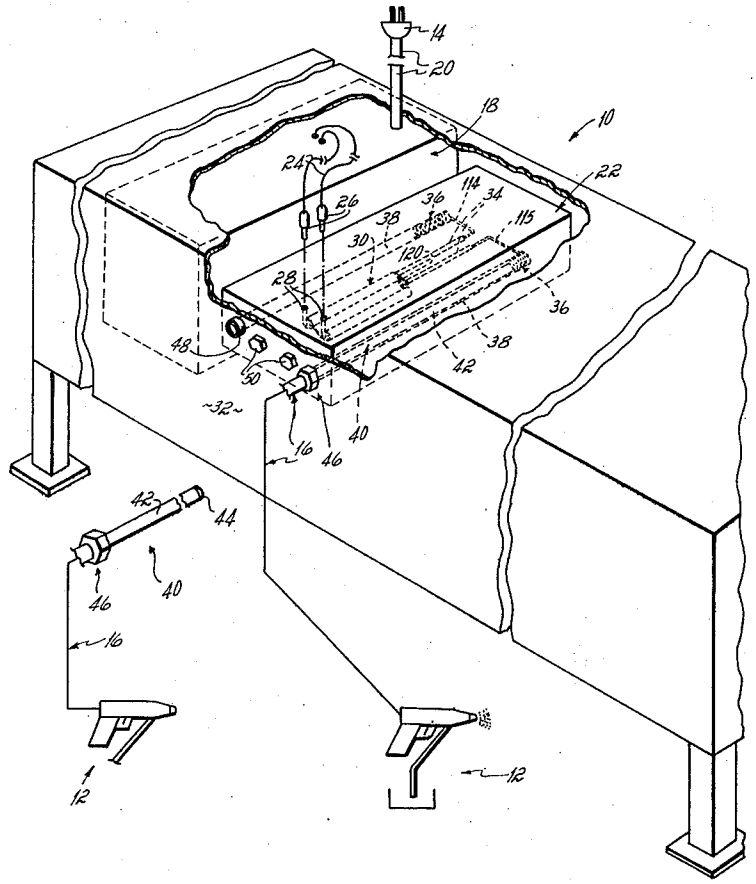
Primary Examiner—William H. Beha, Jr.

Attorney, Agent, or Firm—Wood, Herron & Evans

[57] **ABSTRACT**

A multiplier module for stepping up low voltage from an external source for application to a spray gun electrode via a coaxial cable, the module being encapsulated and provided with female connectors to facilitate quick connect/disconnect operation and its components uniquely arranged to minimize high voltage hazards.

12 Claims, 8 Drawing Figures



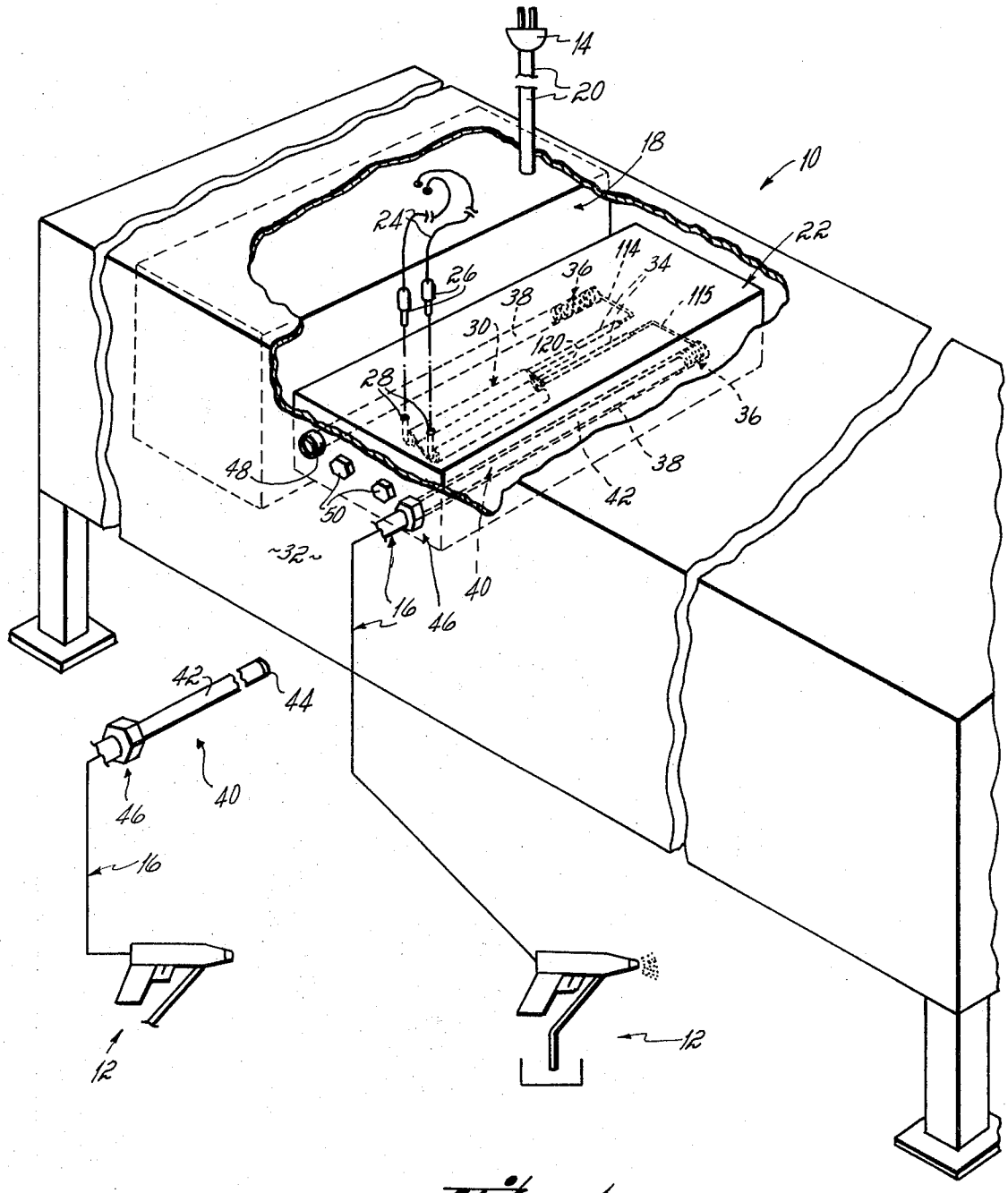

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Fig. 1

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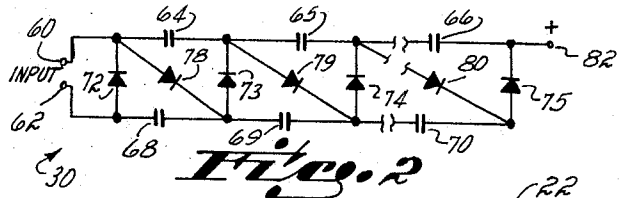


Fig. 2

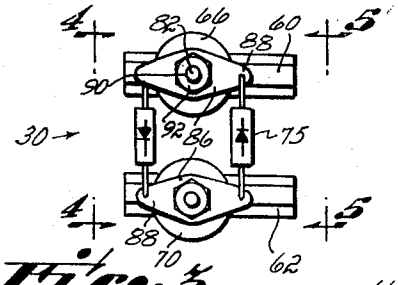


Fig. 3

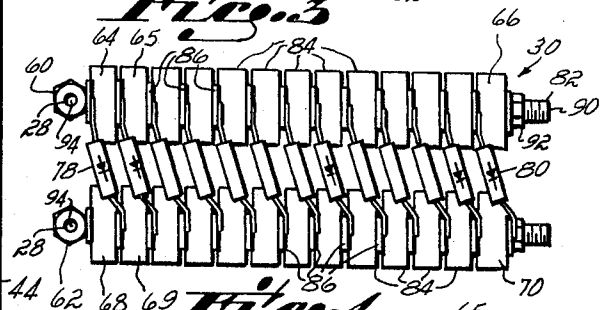


Fig. 4

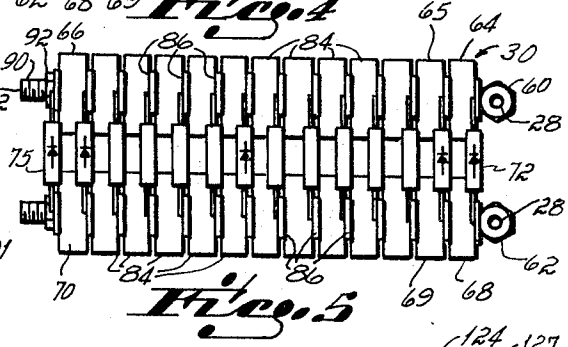


Fig. 5

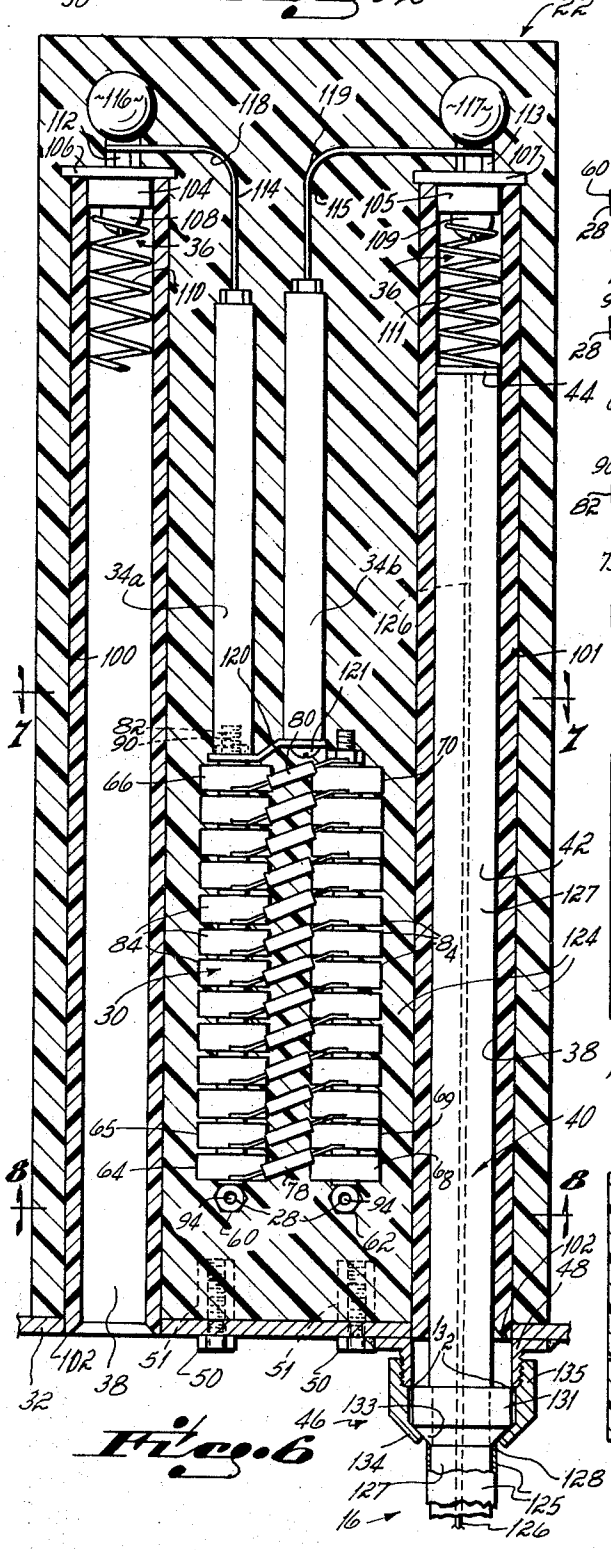


Fig. 6

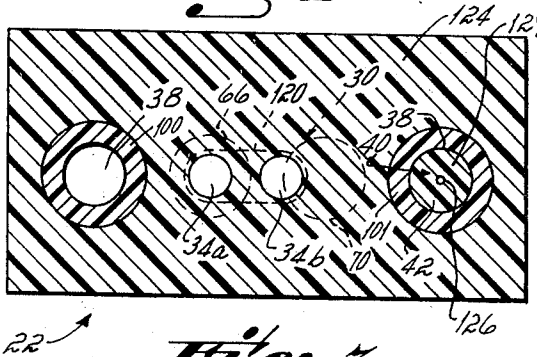


Fig. 7

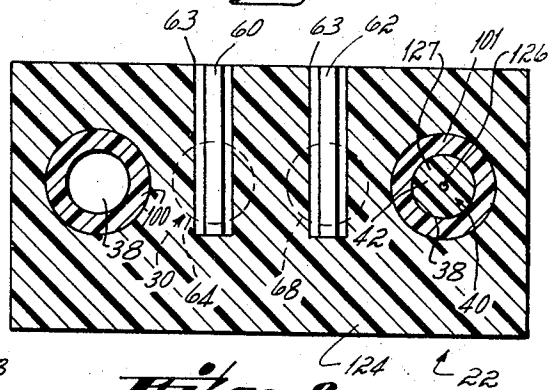


Fig. 8

QUICK CONNECT MODULAR VOLTAGE MULTIPLIER

BACKGROUND OF THE INVENTION

This invention relates to a multiplier module for stepping up a low voltage from an external source for application to the electrode of a spray gun via a coaxial cable and more particularly to an encapsulated module which is provided with female connectors to facilitate quick connect/disconnect operations and has components uniquely oriented to minimize high voltage hazards.

In the field of electrostatic spray coating of paint, powders or the like, a spraying device in the form of a gun is provided for spraying paint, powder, or the like from the nozzle thereof onto an article which is to be coated. In most instances, the article is maintained at ground potential and the particles, as they leave the spray gun nozzle, are charged in an electrostatic field to a very high potential, on the order of 50–200 Kv, by an electrode mounted on the gun near the nozzle which is connected to a high voltage supply. The electrically charged sprayed particles are attracted to the electrically grounded article and adhere thereto.

In most electrostatic spray coating equipment, the high voltage power supply is normally remotely located with respect to the spraying nozzle itself, e.g., on the floor at a distance from the operator, and the particle charging high voltage brought to the gun by a coaxial cable for application to the gun electrode. This is especially true of applications employing hand held spray guns, the reason being that the power supply itself is generally quite large and heavy, and hence too bulky and massive to be incorporated in a spray gun designed for manual use.

Typically, high voltage power supplies for use in electrostatic spray coating equipment include in source of relatively low voltage, e.g., 8 Kv peak-to-peak, and a voltage multiplier circuit for increasing the output of the low voltage source to the desired high voltage charging potential, e.g., 50–100 Kv. The low voltage source normally includes a stepup transformer which produces at its output a signal typically having a magnitude of 8 Kv peak-to-peak. This 8 Kv signal is then applied to the input of a voltage multiplier assembly, usually taking the form of multiple interconnected diode/capacitor voltage doubling stages, which produces at its output a very high direct current voltage which typically is in the range of 50–100 Kv. The high voltage output of the voltage multiplier is then connected to the electrode of a spray gun via a coaxial cable. To facilitate quick connection and disconnection between the cable and the high voltage multiplier output, the cable is provided with a male connector plug and the multiplier with a female connector socket, which socket is usually mounted to the chassis to which the mutiplier and low voltage source are also mounted. Thus, by merely engaging and disengaging the cable plug and multiplier socket, the gun electrode can be energized and de-energized, respectively.

In the operation of electrostatic spray-coating equipment of the type described generally above, failures often occur preventing the supply of high voltage potential to the coaxial cable and hence to the gun electrode. These failures are generally caused by either a malfunction in the electrical connector which connects the output of the voltage multiplier to the coaxial cable,

or a malfunction in the voltage multiplier circuit itself. Since both of these failures manifest themselves in the same manner, i.e., no high voltage is applied to the spray gun electrode, a repairman faced with this type of failure may have to replace the connector, the voltage multiplier, or both in order to correct a mulfunction. Such repairs are costly because of the considerable time required to locate the cause(s) of the failure and then remove and replace the failing element or elements.

A further problem associated with existing high voltage power supplies for electrostatic spray coating equipment arises from the phenomenon of corona discharge. When extremely high voltages are developed in a power supply, the connecting wires to the high voltage often contribute to circuit losses in the form of a corona discharge from the wires themselves. In order to overcome these losses, the physical configuration of the connecting wires carrying the high voltage must be shaped to avoid sharp bends and hence to prevent concentrations of electrical charge at any point along the wire. Repairmen making repairs to a voltage multiplier and/or the female socket output therefrom, often fail to correctly shape the interconnecting high voltage wire, with the result that increased corona discharge is frequently experienced after the repairs have been made.

In view of the foregoing difficulties, it is a primary objective of the invention to provide a multiplier module for stepping up low voltage from an external source to a high voltage for application to the electrode of a spray gun which is adapted for quick connect/disconnect operation, and minimizes high voltage hazards and power loss due to corona discharge.

The foregoing and other objects, advantages and features of the invention are accomplished by completely encapsulating the multiplier module in dielectric material, incorporating female connectors in the encapsulated module for facilitating quick connect/disconnect operation, and orienting the module components and female connectors in a unique configuration.

Included in the module, in a preferred embodiment thereof, is a voltage multiplier circuit consisting of multiple diode/capacitor voltage doubling stages arranged in and elongated stack, with the high voltage output and low voltage input terminals thereof disposed at opposite ends of the stack. The multiplier is axially aligned with an elongated gun resistor, the adjacent end of which is electrically connected to the high voltage terminal of the voltage multiplier. At least one, and preferably two, deep elongated female connector sockets are disposed parallel to the axially aligned voltage multiplier and resistor combination, placing the outer open end of each socket adjacent the low voltage multiplier input terminal, and the inner closed end which is at high voltage adjacent the outermost end of the elongated resistor. Seated within the innermost end of each socket is an electrical contact, preferably a short coil spring, which connects to the outer end of the elongated resistor via a wire which is smoothly curved to minimize corona discharge. A spherical conductive ball is disposed outboard of each coil spring/bent wire junction to facilitate electrical connection between the coil and the wire and to further minimize corona discharge.

The entire assembly is encapsulated, except for the outer ends of the female connectors sockets, these protruding through the exterior of the encapsulation and therefore accessible for receiving elongated male con-

nector probes to which spray gun electrodes are connected via coaxial cables for energization by the high voltage provided by the voltage multiplier circuit. Extending through one wall of the encapsulated assembly adjacent the elongated female socket openings and electrically connected to the low voltage input of the voltage multiplier are two additional female connectors to facilitate energization of the voltage multiplier with a low voltage from an external source. The encapsulated assembly is fastened to a mounting chassis with the chassis contacting the assembly adjacent the surface thereof containing the open ends of the elongated female sockets, thereby maximizing the distance, and hence the electrical standoff, between the chassis at the open end of the high voltage socket and the high voltage terminals of the voltage multiplier seated deep within the multiplier module to thereby reduce high voltage hazards.

In accordance with a further refinement of the invention, internal corona discharge is further minimized by utilizing an encapsulating material which has a low moisture absorption characteristic. Additionally, since the voltage multiplier components are brittle and easily broken by stresses on them, the encapsulating material should have a low shrinkage characteristic to minimize stress on encapsulated components.

The foregoing and other objects, features and advantages of the invention will become more clear from the following detailed description of the preferred embodiment thereof taken in connection with the drawings which form a part of the original disclosure.

DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic diagram in perspective showing an electrostatic spray coating system including the multiplier module of the invention;

FIG. **2** is an electrical circuit diagram for a voltage multiplier of the type used in the multiplier module of the invention;

FIG. **3** is an end elevational view of the voltage multiplier assembly;

FIG. **4** is a side elevational view of the voltage multiplier assembly as viewed from the left along lines **4—4** of FIG. **3**;

FIG. **5** is a side elevational view of the voltage multiplier assembly as viewed from the right along lines **5—5** of FIG. **3**;

FIG. **6** is a horizontal sectional view taken through the multiplier modules;

FIG. **7** is a vertical view taken along section line **7—7** of FIG. **6**; and

FIG. **8** is a vertical sectional view taken along section line **8—8** of FIG. **6**.

DETAILED DESCRIPTION

Referring first to FIG. **1**, an electrostatic spray-coating system is schematically shown with a power supply, shown generally at **10**, and a spray gun, shown generally at **12**. The power supply **10** receives electrical power through a wall plug or the like, shown generally at **14**, which plugs into a convenient wall socket. The power supply **10** develops an extremely high voltage direct current output having a magnitude in the order of between 50 Kv and 100 Kv which is transmitted from the power supply **10** to the spray gun **12** via a coaxial cable, shown generally at **16**.

The power supply **10** includes a relatively low voltage power supply module **18** which receives alternating current electricity from the plug **14** via a power cable **20**. The low voltage power supply **18** is operative to convert the standard alternating current electricity received on the power cable **20** into an alternating current output having 8Kv peak-to-peak amplitude at a frequency of approximately 15 kHg. This output of the low voltage power supply **18**, while having very high voltage with respect to the voltage received from the power cable **20**, is nowhere near high enough for electrostatic spray-coating applications. Consequently, the 8,000 volt peak-to-peak output must be converted to a much high voltage by a multiplier module, which, according to this invention, is shown generally at **22**. The 8,000 volt peak-to-peak output voltage is transmitted from the low voltage power supply **18** to the multiplier module **22** via wires **24** which have male plugs **26**, such as banana plugs or the like, at the free end thereof. These plugs **26** are designed to plug into female sockets **28** which are accessible from the exterior of the multiplier module **22**.

Encapsulated within the module **22** and electrically connecting with the female sockets **28** is an elongated voltage multiplier assembly **30** which will be described in greater detail later. The low voltage input terminals of the voltage multiplier **30** are located adjacent the female sockets **28** which themselves, for reasons which will become more clear later, are located closely adjacent the support panel **32** which forms one wall of the chassis that surrounds the power supply.

Disposed further away from the panel **32** than the voltage multiplier **30** are a pair of gun resistors **34** which are electrically connected at one end to the high voltage output of the voltage multiplier **30** and at their other end to a contact member **36** disposed deep within the interior of a female socket **38**.

The high voltage at the electrical contact member **36** is electrically connected to the coaxial cable **16** and the spray gun **12** via a male connector shown generally at **40** which includes an elongated member **42** made of an insulator having a metal or conductive tip **44** disposed at its extreme end and electrically connected to the center conductor of the coaxial cable **16**. This conductive tip **44**, when the elongated member **42** is disposd in the female socket **38**, electrically contacts the contact member **36** thereby permitting the high voltage appearing at the contact member **36** to be transmitted to a connected spray gun.

The male connector **40** includes a swivel nut, shown generally at **46** which threadably engages an exteriorly threaded cylindrically shaped connector of the type generally shown at **48**, the connector **48** being axially aligned with the female socket **38** to thereby permit the male connector **40** to be secured in position to permit electrical connection between the high voltage generated by the voltage multiplier **30** and the spray gun electrode.

By reason of the physical configuration for the multiplier module **22**, as will be described in greater detail later, the low voltage input can be quickly disconnected from the low voltage supply by simply unplugging each of the male plugs **26**. Additionally, the spray guns can be simply disconnected from the high voltage output of the multiplier module by simply unscrewing the swivel nut **46** from the connector **48** and withdrawing the elongated male connector member **42** from the

female socket **38.** As such, the electrical connections to the multiplier module are quickly and easily made or broken. Additionally, by reason of the modular assembly which will be described in greater detail later, should be assembly fail to provide a high voltage output to be connected to a spray gun, the module **22** can be easily removed from the power supply **10** by simply disconnecting the securing bolts **50** from the embedded nuts in the module **22.** In this manner the module **22** can be quickly removed from the power supply and a new module quickly installed. As such, failures associated with the multiplier module can be remedied by replacing the module itself in this quick and easy manner. Additionally, as will become more clear later, since the module itself is designed to reduce hazards of high voltage as well as loss due to corona discharge, by simply replacing a whole module **22** the problems of corona discharge associated with repairing and/or replacing parts is eliminated.

FIG. **2** shows a schematic diagram for a known voltage multiplier circuit. This voltage multiplier circuit has input terminals **60** and **62** for receiving an alternating current input voltage typically having a peak-to-peak voltage of approximately 8 Kv and having a frequency in the range of between 10–15 kHz, although the input voltage may have other frequencies and peak-to-peak voltages. The voltage mutliplier circuit itself includes two stacks of series connected capacitors, the first stack including capacitors **64, 65** and **66** with the second stack including capacitors **68, 69** and **70.** The voltage multiplier circuit also includes a plurality of shunting diodes **72, 73, 74** and **75** and also a plurality of diagonally shunting diodes **78, 79** and **80** connected as shown.

In operation, the voltage multiplier circuit of FIG. **2** responds to the input voltage of the type described generally above the produce a very high output voltage at the mutliplier circuit output terminal **82.** The exact voltage multiplication that occurs will depend on the number of series connected diode/capacitor stages in the mutliplier. It will be recognized by those skilled in the art that numerous other voltage multiplier circuits are known in the prior art and that these circuits may also be utilized in the present multiplier module. Additionally, the multiplier may include a very high resistance bleeder resistor connected between ground and the high voltage output terminal for discharging the capacitors in the multiplier when the multiplier is not in use.

The particular circuit configuration shown in FIG. **2,** however, is particularly advantageous because it lends itself to being constructed in an elongated stack. FIG. **3,** for example, is an end view of an assembly voltage multiplier having a circuit configuration like that shown in FIG. **2.** The circuit elements which can be viewed in FIG. **3** correspond identically with those identified in the circuit diagram of FIG. **2.**

The assembly details of the voltage multiplier circuit, however, are better understood by reference to FIGS. **4** and **5** which show side elevational views of the voltage multiplier assembly shown in FIG. **3** taken from the left and from the right respectively. As viewed in FIG. **4,** for example, the first string of series connected capacitors including capacitors **64, 65** and **66** also include a plurality of other capacitors **84** which are also series connected to the previously mentioned capacitors in the first string. Each capacitor in this first string comprises typically a disc ceramic capacitor having a cylindrical body with electrical connectors disposed at opposite ends thereof along the axis of the body itself. Each of the capacitors in the first group of series connected capacitors are axially aligned and the capacitor connections soldered to connector tabs **86,** each of which has an ear portion like that shown generally at **88** in FIG. **3** which extends outwardly beyond the body of each capacitor to permit the shunting and diagonal shunting diodes of the voltage multiplier to be connected electrically to the capacitors.

It will be noted from FIGS. **3–5,** that each capacitor which comprises one of a plurality of capacitors in each series connected string is axially aligned to form a stack. The shunting diodes, such as diode **75,** are all disposed on one side of the two stacks of series connected capacitors while the diagonal shunting diodes, such as diode **80,** are disposed on the other side of the two stacks of series connected diodes.

The output terminal **82** of the voltage multiplier assembly has a threaded stud **90** soldered or otherwise connected too the outermost connector **86** on the first string of series connected diodes. A bolt **92** engages the threaded stud **90** and this bolt can be used to secure solder lugs or the like to the output terminal of the voltage multiplier. The input terminals **60** and **62,** on the other hand, are constructed of elongated bodies with an outer circumference being hexagonally shaped. The elongated bodies have a cylindrical bore **94** extending longitudinally through the elongated bodies and centered substantially about the longitudinal axis thereof. This cylindrical bore **94** provides the female socket, identified as **28** in FIG. **1,** for receiving male plug connectors **26** to thereby electrically connect the input terminals **60** and **62** of the voltage multiplier assembly to the low voltage input received from a low voltage power supply, such as **18** in FIG. **1.**

The elongated bodies which comprise the input terminals **60** and **62** are disposed with their longitudinal axis being arranged perpendicularly to the longitudinal axes of the two stacks of series connected capacitors. The input terminal **60** is soldered to the connector **86** which in turn is soldered to the capacitor **64.** The input terminal **62** is also soldered to a connector **86** which is in turn soldered to the capacitor **68.**

The voltage multiplier assembly as shown in FIGS. **3–5** comprises only a portion of the multiplier module of this invention. The remainder of the module is better shown in FIG. **6** which shows a horizontal sectional view taken through the module **22.** The voltage multiplier, shown generally at **30,** is of the type previously described and is located within the module **22** adjacent the mounting panel **32** with the low voltage input terminals **60, 62** being disposed adjacent the panel **32.** The high voltage output, shown generally at **82,** for the voltage multiplier **30** is disposed away from the mounting panel **32** to reduce electrical shock hazard and corona discharge.

Mounted within the module **22** are two elongated interiorly threaded bodies **51** which are disposed at the end of module **22** adjacent the mounting panel **32.** These bodies **51** are so positioned that the interior threaded portion thereof is accessible through the surface of the module **22** so that the threaded bolts **50** can pass through the mounting panel **32** and engage the interiorly threaded portion of the bodies **51** thereby securing the module **22** of the mounting panel **32.** While

a particular mounting approach has been described, it will be clear to those of skill in the art that other mounting approaches will permit the module **22** to be rigidly affixed to a mounting panel **32.** For example, an alternative approach could involve embedding a threaded bolt in the module **22** and having the threaded portion of these bolts extend outwardly from the module **22** through aligned holes in the mounting panel **32.** The theaded ends of these bolts are then engaged by threaded nuts tightened agains the mounting panel **32** to thereby secure the assembly to the panel **32.** Other approaches may also be utilized to secure the module **22** to the panel **32.**

The module **22** includes two elongated tubes **100** and **101** which are disposed within the module **22** on either side of the voltage multiplier **30.** These tubes **100** and **101** are preferably constructed of fiberglass or other insulative material. The open end of these tubes **100** and **101** extend outwardly of the module **22** wall adjacent the mounting panel **32** and engages a mating hole in the panel **32.** The extreme outward end of the tubes **100** and **101,** however, extend outwardly from the module **22** a distance sufficient that the end of the tubes **100, 101** will be flush with the exterior surface of the mounting panel as shown generally at **102.**

Disposed at the extreme inner end of the tube **100** and **101** are the contact members or end plugs **36.** These end plugs **36** are contructed with interior fitting portions **104, 105** which fit snugly into the extreme inner end of the tubes **100, 101,** respectively. The plugs **36** also include end cap portions **106, 107** which have flanges extending radially outwardly of the portions **104, 105** so as to be in abutting relation with the end of the tubes **100, 101.**

The plugs **36** are preferably made of aluminum or some other easily shaped metal which is electrically conductive. Each of the plugs **36** has a hole passing therethrough which is aligned with the longitudinal axis of the tubes **100, 101** and these holes permit threaded bolts **108, 109** to pass therethrough. The heads of these bolts **108, 109** are located within the tubes **100, 101** and are provided to secure coiled spring contacts **110,** 111 to the plugs **36** respectively.

Disposed on the opposite side of the plugs **36** from the heads of the bolts **108, 109** are nuts **112, 113** which are tightened down against the exposed surface of the cap portions **106, 107** respectively to thereby secure the coiled spring contacts **110, 111** to the plugs **36.**

The threaded portion of the bolts **108, 109** extend beyond the nuts **112, 113** so that electrical contact can be made with gently bent wires **114, 115.** These wires **114, 115** are bent around and are in electrical contact with the theaded portion of the bolts **108, 109** respectively. These wires **114, 115** are secured in electrical contact with the bolts **108, 109** respectively by interiorly threaded ball connectors **116, 117** which threadably engage the exposed portion of the bolts **108, 109.** These ball connectors **116, 117** are tightened down to effect the electrical connection of the wires **114, 115** to these bolts **108, 109.** The ball connectors **116, 117** are made of an electrically conductive metal and are spherically shaped so as to resist corona discharge.

The wires **114, 115** electrically interconnect the bolts **108, 109** with the gun resistors **34.** These wires **114,** 115 are gently bent in the regions shown generally at **118** and **119** respectively so as to prevent corona discharge along the length of these wires as well.

The gun resistors **34** are elongated cylindrically shaped resistors having threaded connector members at opposite ends thereof to permit easy electrical connection to other components. At the high voltage output **82** of the voltage mutliplier **30,** the threaded member **90** has a bracket **120** electrically connected by soldering or other connections to the capacitor **66** and this threaded member **90** extends through the resistor mounting bracket **120** to engage internal threads (not shown) of the resistor **34***a*. By tightening down this resistor **34***a* agaisnt the mounting bracket **120,** this bracket **120** can be fixed in spacial relationship to the remaining module parts. The mounting bracket **120** is preferably made of an electrically conductive material such as copper, aluminum or the like and is shaped with a bend so that it can electrically engage the resistor **34***b* and not connect electrically to any other portions of the voltage multiplier **30.** As viewed in FIG. **6,** a threaded screw **121** passes through the mounting bracket **120** to engage the threaded connector portion of the resistor **34***b*. By tightening down this resistor **34***b*, onto the screw **121,** the resistor **34***b* can be electrically connected to the high voltage output of the voltage multiplier assembly **30** as well as rigidly positioned with respect to the other module parts. It should also be noted that the gun resistors **34** are thus mounted in axial alignment with the voltage multiplier **30.**

Referring again to the voltage multiplier input terminals **60, 62** as shown in FIG. **8,** these input terminals comprise elongated bodies having an exterior hexagonal shape and an interior cylindrical bore. These elongated bodies are soldered or otherwise electrically connected to the low voltage inputs to the voltage mutliplier assembly **30** of the type previously described with the longitudinal axis thereof arranged perpendicularly to the axis of the capacitor stacks which comprise a voltage multiplier. The elongated bodies are sufficiently long so that they are flush mounted, as viewed generally at **63,** with the upper surface of the module **22** thereby permitting easy electrical connection with the low voltage input to the voltage multiplier. Typically, a banana plug such as the plugs **26** in FIG. **1** are pressed into the interior bore of the connectors **60, 62** to thereby electrically connect with the low voltage input to the voltage multiplier assembly. Since banana plugs or the like are used to make this electrical connection, the low voltage source can easily be disconnected from the low voltage input to the module simply by pulling the banana plug out of engagement with the connectors **60, 62.**

All of the above mentioned components of the module **22** are encapsulated in a material indicated generally at **124** which is in the shape of an elongated rectangular solid. The encapsulating material itself preferably has low moisture absorption and low shrinkage characteristics. Low moisture absorption is necessary to reduce corona discharge within the module. On the other hand, low shrinkage is necessary to prevent warping of the assembly as well as component destruction. Since the voltage multiplier uses diodes which are very brittle, shrinkage of the modular assembly must be minimized or the diodes will crack thereby causing an electrical failure in the voltage multiplier. A two part epoxy such as the two part epoxy made of Stycast 2850 FT Blue mixed with catalyst No. 11 and manufactured by Emerson Cuming is a suitable encapsulating material.

Other encapsulating materials which do not absorb moisture and do not shrink may also be used.

In order to make an electrical connection with the high voltage output of the voltage multiplier **30** which is electrically connected in a manner described above with the coiled spring connectors **110, 111,** an elongated male plug **40** must be inserted into the open ends of the tubes **100, 101.** In the preferred embodiment of this invention, this elongated plug **40** is constructed on the end of a coaxial cable **16** which has an electrically conductive outer braid **125** and a centrally disposed electrical conductor **126** which is electrically insulated and spaced from the braid **125** by an insulating material **127.** The outer braid **125** is stripped from the end of the coaxial cable **16** from the point shown generally at **128** so that the center conductor **126** and the insulating material **127** can extend into the socket **38** formed by the tube **101** as indicated generally at **42.** Located at the extreme inner end of this portion of the coaxial cable from which the braid **125** has been stripped is the circular contact tip **44** made of an electrically conductive material and electrically connected by soldering or other electrical connection to the center conductor **126.** This circular tip **44** is in electrical contact with the coiled spring contact **111** so as to permit electrical connection between the center conductor **126** of the coaxial cable **16** and the high voltage output of the voltage multiplier **30.** The portion of the coaxial cable shown at **42** from which the outer braid **125** has been stripped must be of a sufficient length so as to extend into the tube **101** to permit some compression of the coiled spring connector **111** so that a good electrical contact can be made between the connector **111** and the tip **44.** When this compression of the coiled spring connector **111** occurs, however, a force is exerted on the portion of the cable **42** to force the cable out of the tube **101.** The coaxial cable **16,** however, is secured in position by the swivel nut assembly shown generally at **46.**

The assembly shown at **46** includes the threaded, somewhat cylindrically shaped body **48** which is secured to the outer surface of the mounting panel **32** in alignment with the tube **101.** A second body like the threaded body **46,** although not shown in FIG. **6,** is attached to the outer surface of the mounted panel **32** in alignment with the tube **100** thereby permitting a second coaxial cable to be simultaneously connected to the high voltage output of the voltage multiplier **30.**

The assembly **46** also includes a metallic body **131** which has a central circular aperture passing therethrough having a diameter slightly smaller than the diameter of the insulated portion **127** of the coaxial cable **16.** The portion **42** of the cable extends through this aperture of the body **131** and, because this diameter is smaller than that of the insulated portion **127,** the body **131** compresses the insulated portion **127** and becomes securely affixed to the insulated portion **127.** At the point shown generally at **128,** the metal braid **125** of the coaxial cable **16** is electrically connected to the body **131** thereby further securing this body **131** to the coaxial cable **16.** The body **131** is of a diameter which is sufficient to engage the outer end of the body **48** as shown at **132** thereby permitting electrical connection between the outer braid **125** and the mounting panel **32.**

The body **131** additionally includes a tapered flange portion shown generally at **133.** This tapered flange **133** engages a similar shaped tapered flange **134** of a threaded cylindrically shaped swivel nut **135** which threadably engages the body **48.** By tightening the nut **135** onto the body **48,** the body **131** becomes locked against the end of the body **48** thereby securing the coaxial cable **16** to the mounting panel **32.** As such, the circular tip **44** will be secured in electrical contact with the coiled spring connector **111** thereby permitting electrical connection of an electrostatic spray gun at the opposite end of the coaxial cable **16** at the gun (FIG. **1**) with the high voltage output of the voltage multiplier **33.**

In operation, the modular assembly **22** shown in FIG. **6** is electrically connected in a manner described earlier to a relatively low voltage alternating current source at the low voltage input connectors **60, 62.** The voltage multiplier **30** multiplies the input voltage in a manner well known in the art for voltage multipliers of the type previously described and produces a high voltage DC signal at its output. This high voltage passes through the bracket **120,** the gun resistor **34***b*, the gently bent wire **115** to the coiled spring connector **111.** This connector **111** is in electrical contact with the circular tip **44** disposed at the end of the coaxial cable **16.** At the opposite end of this cable **16** (FIG. **1**), is an electrostatic spray gun having a high voltage probe electrically connected to the center conductor **126** of the coaxial cable **16.** In this manner, the spray gun probe can be electrically connected to the high voltage output of a voltage multiplier. It will be clear that a second spray gun can be connected via the other connector in the modular assembly.

In the case of a failure in the electrical circuitry which, as indicated earlier, frequently occurs in the electrical connector or in the voltage multiplier, the module **22** can be easily disconnected and replaced in the following manner. The coaxial cable **16** can be disconnected from the modular assembly **22** simply by unscrewing the swivel nut **46** and withdrawing the portion **42** from the tube **101.** Then, the banana plugs or similar input connection to the terminals **60, 62** are electrically removed. The bolts **50** are then unscrewed and the modular assembly can be completely removed. This process, when reversed, will permit the installation of a similar module **22** to replace the defective module. As such, replacing the module is an extremely simple operation as compared to the extended repair time required to make a similar repair in prior art power supplies.

While the foregoing description has been made with particular emphasis on a preferred embodiment of the invention, it will be recognized by those skilled in the art that numerous modifications in form may be made thereto without departing from the spirit and scope of the invention as defined by the following claims.

What is claimed is:

1. A quick connect/disconnect modular voltage multiplier assembly comprising, in combination:

an elongated voltage multiplier with low voltage input terminals disposed at one end thereof and a high voltage output terminal disposed at the opposite end thereof;

at least one elongated female socket with an open end for receiving an elongated plug with a conductive tip, said socket being disposed in substantially parallel relation to said elongated voltage multiplier with said open end being disposed adjacent said input terminals, said socket including a closed

end disposed adjacent said high voltage output terminal;

an electrical connection means disposed at said closed end of one said socket for electrically connecting the tip of an elongated plug when inserted into said socket, with said high voltage output terminal, said electrical connection being physically shaped to minimize corona discharge;

an encapsulation having at least first and second differently disposed external faces for completely surrounding and supporting said voltage multiplier, said socket and said electrical connection means, said encapsulation being shaped so that said open end of each said socket and said input terminals are accessible through said first and second faces, respectively, of said encapsulation so that external plugs can quickly connect or disconnect relative thereto, by movement thereof in different directions corresponding to the directions of said differently disposed first and second external faces.

2. The quick connect/disconnect modular voltage multiplier assembly of claim **1** wherein said input terminals comprise elongated hollow bodies having a centrally located cylindrical bore, said hollow bodies being disposed to permit access to said cylindrical bore so that male electrical connectors can quickly connect or disconnect to said low voltage input terminals.

3. The quick connect/disconnect modular voltage muliplier assembly of claim **2** wherein the axis of each said cylindrical body forming said input terminals is disposed substantially perpendicularly to the axis of each said female socket.

4. The quick connect/diconnect modular voltage multiplier assembly of claim **1** additionally including mounting means embedded in said encapsulation adjacent the open end of said female sockets for securing the assembly to a mounting panel.

5. The quick connect/disconnect modular voltage multiplier of claim **1** additionally including:

an elongated resistor with two electrical terminals, said resistor being connected between said high voltage output terminal and said electrical connection means, said resistor being in substantial axial alignment with said elongated voltage multiplier, one said resistor electrical terminal being connected to said high voltage output terminal and the other said resistor electrical terminal being connected to said electrical connection means.

6. The quick connect/disconnect modular voltage multiplier of claim **5** additionally including an electrically conductive mounting bracket connected to said high voltage output terminal, said bracket having at least one hole therethrough,

a threaded screw passing through said hole, and

at least one said resistor electrical terminal including an interiorly threaded connector engagable with said threaded screw when said screw is passed through said bracket hole.

7. A quick connect/disconnect modular voltage multiplier assembly comprising, in combination:

a solid encapsulation formed of an insulating material having a low shrinkage characteristic and a low water absorption characteristic;

an elongated voltage multiplier disposed completely within said encapsulation, said voltage multiplier including low voltage input terminals at one end thereof and a high voltage output terminal disposed at the other end thereof;

electrically conductive input terminals electrically connected to said low voltage input terminals to said voltage multiplier, said input terminals being elongated and having a centrally disposed cylindrical bore, the axis of said cylindrical bore being arranged perpendicular to the axis of said elongated voltage multiplier, said cylindrical bore being accessible through the surface of said encapsulation;

a pair of elongated cylindrical tubes made of insulating material, said tubes being disposed on either side of said voltage multiplier with the longitudinal axis of each said tube being parallel to the longitudinal axis of said multiplier, one end of each said tube being accessible through the surface of said encapsulation, said accessible end of each tube being disposed adjacent said voltage multiplier input terminals;

electrical connector means disposed at the inner end of each said tube, said electrical connector means being shaped to minimized corona discharge;

a pair of elongated electrical resistors disposed in axial alignment with the axis of said voltage multiplier, one end of each said resistors being electrically connected to said high voltage output terminal;

an electrical connecting wire for connecting each said connector disposed at the inner end of each said tube with the opposite end of one said resistor, each said wire being shaped to minimize corona discharge.

8. The quick connect/disconnect modular voltage multiplier assembly of claim **7** wherein said electrical connector disposed at the inner end of each said tube comprises a coiled spring connector, a screw and a threaded ball connector, said coiled spring being disposed within said tube, said spring connector being positioned by said screw in electrical contact therewith and passing through the end of said tube, said screw being engaged by one said wire and also engaged by said threaded ball connector tightened down on said screw to form an electrical contact between said coiled spring and said wire, said ball connector being operative to substantially reduce corona discharge associated with said connector disposed at the inner end of each said tube.

9. The quick connect/disconnect modular voltage multiplier assembly of claim **7** wherein said encapsulation material is made of a material which has a low moisture absorption characteristic to minimize corona discharge and a low shrinkage characteristic to prevent component destruction.

10. The quick connect/disconnect modular voltage multiplier assembly of claim **7** including means to mount said assembly to a conductive panel, said mounting means being disposed adjacent said accessible end of said tubes so that said electrical connector means is disposed away from said panel to minimize high voltage hazards.

11. A quick connect/disconnect modular voltage multiplier assembly comprising, in combination:

an elongated voltage multiplier with low voltage input terminals disposed at one end thereof and a high voltage output terminal disposed at the opposite end thereof;

at least one elongated socket with an open end for receiving an elongated plug with a conductive tip, said open end being disposed adjacent said input terminals, said socket including a closed end disposed adjacent said high voltage output terminal;

an electrical connection means disposed at said closed end of one said socket for electrically connecting said tip of said elongated plug inserted in said socket with said high voltage output terminal, said electrical connection means including a coiled spring connector disposed at said closed end of each said socket, said coiled spring being positioned at said closed end by a threaded screw electrically connected to said coiled spring connector and passing through said closed end of each socket, the exposed end of said screw passing through said closed end and electrically engaging a wire, said wire being gently bent and connected at its opposite end to said high voltage output terminal, said wire being secured to said screw by an interiorly threaded ball connector which is tightened down onto said screw, said ball connector and said gently bent wire being shaped to reduce corona discharge of said electrical connection means; and

an encapsulation for completely surrounding and supporting said voltage multiplier, said socket and said electrical connection means, said encapsulation being shaped so that said open end of each socket and said input terminals are accessible through the encapsulation so that an external plug can quickly connect or disconnect to each said terminal.

12. A quick connect/disconnect modular voltage multiplier assembly comprising in combination:

a solid encapsulation formed of an insulating material having a low shrinkage characteristic and a low water absorption characteristic;

an elongated voltage multiplier disposed completely within said encapsulation, said voltage multiplier including low voltage input terminals at one end thereof and a high voltage output terminal disposed at the other end thereof;

electrically conductive input terminals electrically connected to said low voltage input terminals to said voltage multiplier, said input terminals being elongated and having a centrally disposed cylindrical bore, the axis of said cylindrical bore being arranged perpendicular to the axis of said elongated voltage multiplier, said cylindrical bore being accessible through the surface of said encapsulation;

a pair of elongated cylindrical tubes made of insulating material, said tubes being disposed on either side of said voltage multiplier with the longitudinal axis of each said tube being parallel to the longitudinal axis of said multiplier, one end of each said tube being accessible through the surface of said encapsulation, said accessible end of each tube being disposed adjacent said voltage multiplier input terminals;

electrical connector means disposed at the inner end of each said tube, said electrical connector means being shaped to minimize corona discharge;

a pair of elongated electrical resistors disposed in substantial axial alignment with the axis of said voltage multiplier, at least one end of each said resistor including an interiorly threaded electrical connection;

a mounting bracket electrically connected to said high voltage output terminal, said mounting bracket having at least two holes therethrough;

a plurality of threaded screws each passing through one said hole in said bracket and engaging one said interiorly threaded resistor connection; and

an electrical connecting wire for connecting each said connector disposed at the inner end of each said tube with the opposite end of a different one of said resistors, each said wire being shaped to minimize corona discharge.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 3,870,946

DATED : March 11, 1975

INVENTOR(S) : Robert E. Sandorf

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, line 20, change "50-200 KV" to --50-100 KV--.

Column 2, line 6, change "mulfunction" to --malfunction--.

Column 2, line 44, change "and" to --an--.

Column 3, line 51, insert the word "sectional" between "vertical" and "view".

Column 5, line 5, change "be" to --the--.

Column 5, line 53, change "assembly" to --assembled--.

Signed and Sealed this

thirtieth Day of *September 1975*

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks

UNITED STATES PATENT OFFICE

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