# United States Patent [19]

**Kozinski et al.**

[11] **3,864,603**

[45] **Feb. 4, 1975**


[54] **HIGH VOLTAGE SAFETY APPARATUS**


[75] Inventors: **David A. Kozinski**, Palatine; **Bernard W. Siczek**, Chicago; **Kenneth L. Carlson**, Wheeling, all of Ill.

[73] Assignee: **Graco Inc.**, Minneapolis, Minn.



[22] Filed: **Nov. 12, 1973**

[21] Appl. No.: **415,096**

[52] **U.S. Cl.** ..... **317/9 R**, 118/12, 239/15, 317/3

[51] **Int. Cl.** ..... **H02h 3/00**

[58] **Field of Search** ..... 118/12, 620, 621; 117/93.4 R, 93.4 A, 93.4 NC; 309/92, 94; 239/3, 15; 317/3, 9 R



[56] **References Cited**

UNITED STATES PATENTS

| | | | |
|---|---|---|---|
| 2,895,083 | 7/1959 | Quinlan | 307/94 |
| 3,740,612 | 6/1973 | Gauthier et al. | 117/93.4 |



*Primary Examiner*—J. D. Miller

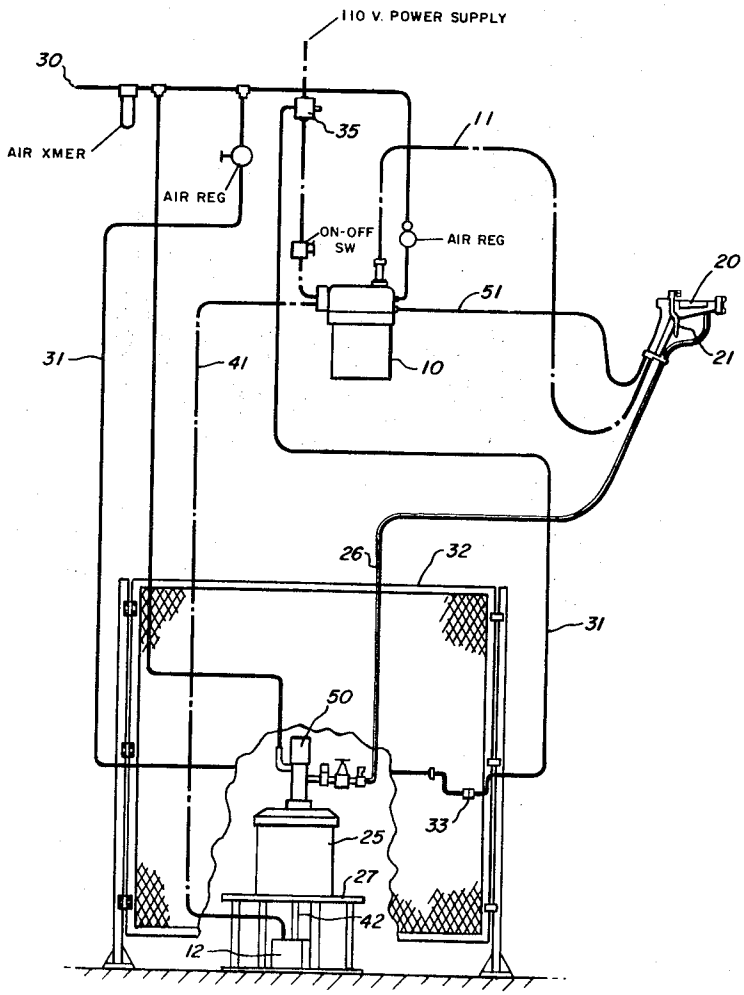
*Assistant Examiner*—Harry E. Moose, Jr.



[57] **ABSTRACT**

Apparatus for discharging residual high voltage charge associated with electrostatic paint spraying equipment, including a safety enclosure for confining equipment which becomes highly voltage-charged and which discharges such voltage when entry is made into the safety enclosure.


**8 Claims, 3 Drawing Figures**



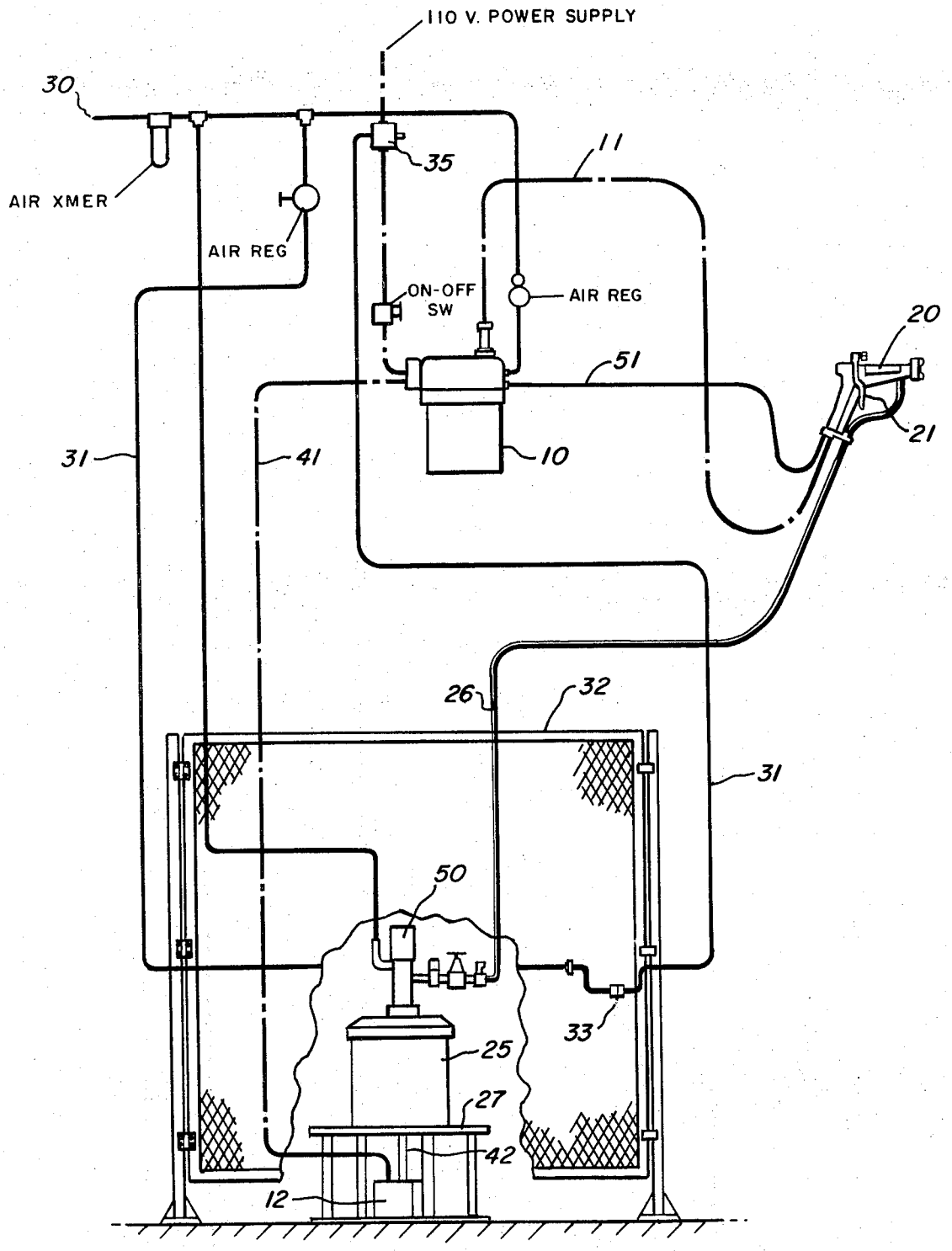

110 V. POWER SUPPLY
30
AIR XMER
AIR REG
35
11
ON-OFF SW
AIR REG
20
51
21
31
41
10
26
32
31
50
33
25
27
42
12

FIG. 1

FIG. 2

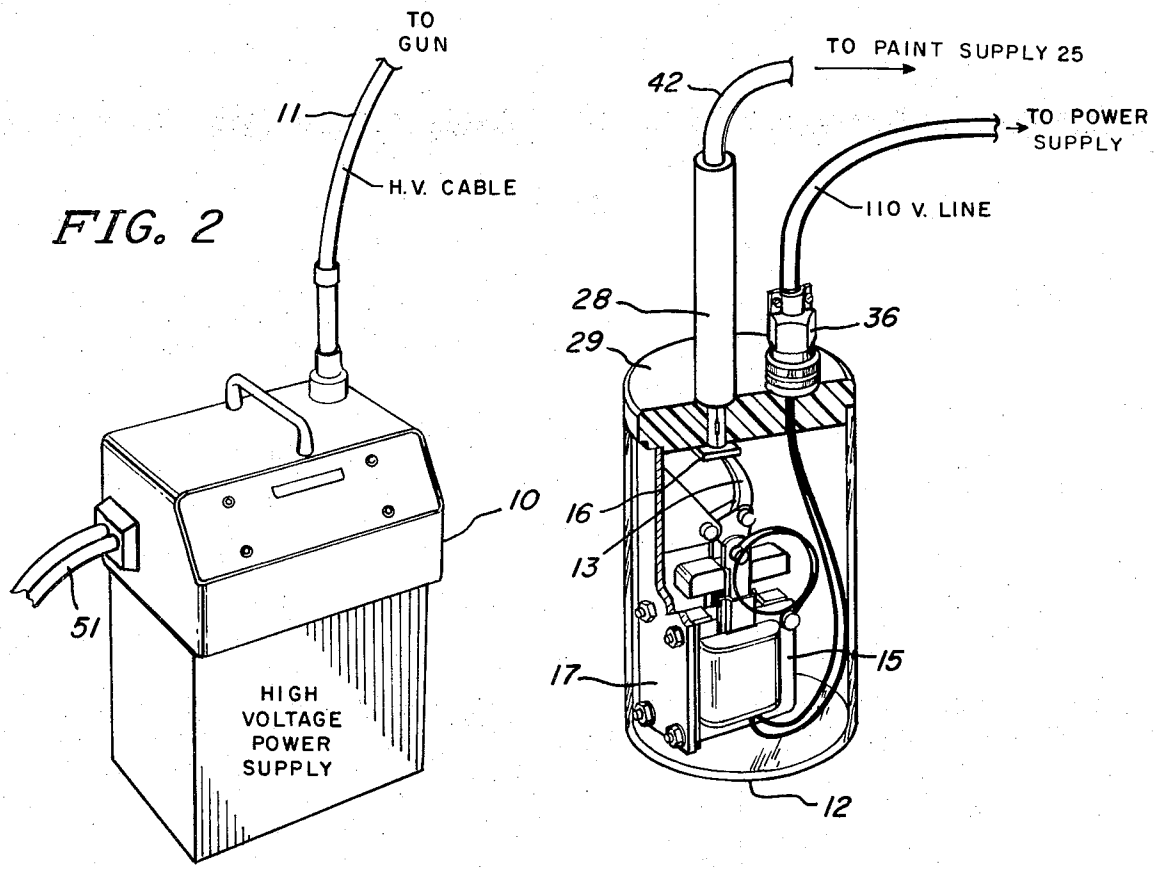
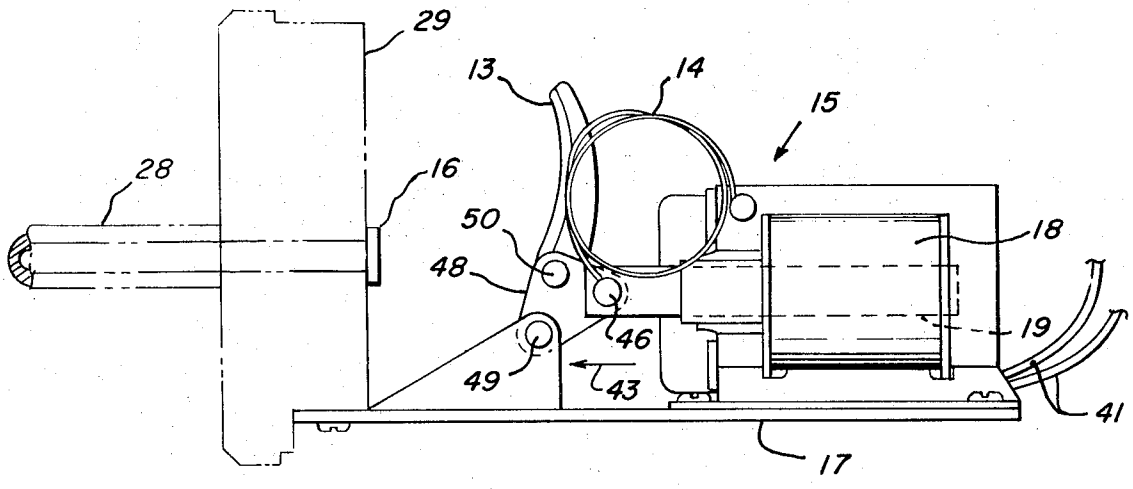

TO GUN
11
H.V. CABLE
10
51
HIGH VOLTAGE POWER SUPPLY
TO PAINT SUPPLY 25
42
TO POWER SUPPLY
110 V. LINE
28
29
36
16
13
15
17
12

FIG. 3


29
13
14
15
28
16
50
48
18
46
19
49
43
41
17

# HIGH VOLTAGE SAFETY APPARATUS

This invention relates to a novel apparatus for insuring the complete electrical discharge of high voltage apparatus used in connection with electrostatic paint spraying. The invention automatically provides a mechanical interlock between ground and a paint supply container which becomes highly voltage-charged during paint spraying operations, both when an electrostatic spray gun trigger is released and when a person comes into close proximity to the highly charged paint supply.

In electrostatic paint spraying systems the paint is applied to a work piece by means of a spray gun which atomizes the paint and includes a circuit which applies an electrostatic charge potential to the paint particles. Typically, the work piece is grounded so that the charged paint particles are attracted to the work piece and tend to uniformly cover all exposed areas of the work piece. The electrostatic charging of the paint particles is either accomplished directly by contact with a spray gun electrode as the particles are emitted, or indirectly by passing the particles through a region of ionized air whereby the particles become charged while passing through the ionized air region. In either event, the spray gun typically has a high voltage needle, probe, or other charging means associated therewith, and this high voltage charging means is maintained at a voltage ranging from several thousand to 100,000 volts. The high voltage potential is generally provided by means of a cable extending to a remotely located power supply.

When conductive paints are used in an electrostatic paint spraying system, the high voltage charge at the spray gun becomes transferred to the paint itself and, because the paint is conductive, is transferred to the paint container all objects conductively attached to it. Therefore, when conductive paints are sprayed in this manner, it becomes necessary to insulate the paint container from its surrounding area and to provide protective shielding to prevent people from coming into contact with the charged apparatus. One of the simplest ways of providing this protection is to construct an enclosure around the paint supply. However, since frequent access to the paint supply must be provided for, it becomes necessary to build a gate into the enclosure for this purpose.

One of the inherent characteristics in utilizing high voltages for electrostatic paint spraying operations is the retention of voltage charge after the high voltage power has been turned off. This charge retention is caused by the capacitive effects of the high voltage cable, power supply, and other apparatus together with the extremely high resistances to ground found in circuits of this type. Because of the voltage charge retention, it is possible for an operator to be severely shocked even though the high voltage power supply has been turned off, and therefore a safeguard against this possibility must be provided. The present invention achieves this safety feature by means of a mechanical interlock connection which automatically grounds the voltage-charged equipment whenever the paint sprayer is not being used. This mechanical interlock is connected to the gate into the enclosure surrounding the paint supply, and serves to ground the paint supply whenever the gate is opened. In this manner the operator is protected against residual charge after he releases the spray gun trigger and is also protected against inadvertent contact with the otherwise highly charged paint supply whenever he enters the enclosure surrounding the paint supply.



Briefly, the invention comprises an enclosure surrounding the paint supply, said enclosure having as an integral part a closed pneumatic link such that when the gate to the enclosure is open the pneumatic link is broken. A pressure switch is connected into the closed pneumatic link to sense drops in pressure caused by opening the gate, and this pressure switch controls a mechanical switch between the incoming power line and the high voltage supply. When the gate is opened, the pressure switch becomes deenergized, cutting off the incoming line voltage to the high voltage power supply. This causes the high voltage to be cut off, which in turn activates a solenoid-operated grounding arm to solidly connect the paint supply container to ground potential. The solenoid-operated grounding arm is also activated whenever the spray gun trigger is released, thereby draining any residual voltage charge from the paint supply.

It is the principal object of this invention to provide a system for safeguarding against high voltage shock when operating an electrostatic paint spraying apparatus.

It is another object of this invention to provide an apparatus for draining residual electrostatic charge from the high voltage circuits whenever the electrostatic spray gun is not being used.

It is another object of this invention to provide a positive mechanical connection between the highly charged paint supply of an electrostatic paint spraying system and ground to eliminate shock hazards.

These and other objects will be described in the following specification and drawings in which:

FIG. **1** is a schematic illustration of the entire apparatus of this invention;

FIG. **2** illustrates the high voltage discharging arrangement; and

FIG. **3** shows the mechanical interlock and solenoid apparatus of this invention.

Referring first to FIG. **1**, the invention is shown in schematic representation. A high voltage power supply **10** generates the electrostatic voltage required for the paint application, typically of magnitude 50,000–100,000 volts. This high voltage is conveyed via high voltage cable **11** to a spray gun **20**. High voltage cable **11** is constructed from materials suitable for the transfer of the extremely high voltages required in electrostatic painting applications, and has an outer conductive sheath which is solidly connected to ground potential. The grounded cable sheath is connected to the body of spray gun **20** in order to insure that all exterior metal parts of spray gun **20** are securely electrically grounded. The high voltage conveyed thereby is connected within spray gun **20** to a suitable electrostic ionizing means, using any of the concepts available for this purpose and known in the prior art.

A source of compressed air is required for use in conjunction with the invention. Air is introduced into the system at inlet **30** and is conveyed via air lines and hoses, shown as solid lines in FIG. **1**, to the various system components. The incoming air pressure may be reduced through an air transformer or regulated through an air regulator as desired. The air is used generally for two purposes: to supply the transfer medium for deliv-

ering and atomizing paint at the spray gun outlet, and for providing the safety interlock means to be hereinafter described. If the invention is used with a paint system that does not require air for delivering and atomizing paint, the air may still be used as a part of the safety interlock means. Alternatively, another source such as an interruptible light beam with appropriate optical sensing means, may be used to provide the safety interlock means which forms a part of the invention.

The electrical lines used with the invention are illustrated in FIG. **1** as broken lines, and the paint delivery hose **26** is illustrated as a double line.

A paint container **25** is connected to a paint hose **26** which feeds paint from container **25** to the spray gun **20.** The paint feed mechanism **50** may be a pumping device for transferring the paint from the container **25** to the hose **26** under suitable pressure. Among the types of paint which may be used with this apparatus are conductive paints, such as water-based paint composition. Because of the conductive nature of these paints, paint container **25** is insulated from earth ground by means of an insulated stand **27.**

Surrounding the paint supply is an enclosure which includes an air hose **31.** Air hose **31** is coupled to a source of compressed air via inlet **30** and provides a complete closed path around the paint supply. Hose **31** is also attached to a gate **32** in the enclosure surrounding the apparatus. Typically, the enclosure is constructed of electrically grounded steel mesh material and gate **32** is a conventional hinged gate providing access into the enclosure from without. Hose **31** is fitted with a quick-disconnect coupling **33** at the point where gate **32** may be opened. Therefore, the opening of gate **32** will cause the coupling **33** to disconnect and thereby relieve the air pressure in hose **31.** A pressure switch **35** senses the drop in air pressure caused by opening gate **32** and activates an electrical contact which opens the electrical circuit for deenergizing a solenoid within solenoid container **12.** The solenoid is deenergized by means of a voltage cutoff, and a solenoid spring return grounds the paint supply **25.** The detailed mechanical operation of the solenoid will be described hereinafter. With respect to the other elements in this circuit path, pressure switch **35** may be any of a number of well-known switches which are responsive to pressure drops to cause an electrical contact to activate, such as switch type 69GBR7, manufactured by Furnas Electric Co., Batavia, Ill. Spray gun trigger **21** is mechanically connected to an air valve located within gun **20;** when the trigger is depressed the air valve opens and causes air to flow through hose **51** and gun **20.** This air flow is detected by a flow switch of conventional design located in power supply **10,** to cause the activation of electrical switch contacts when air is flowing in hose **51.** When air flow stops the flow switch contacts open and cause the high voltage power supply to deenergize its high voltage output. This also causes the solenoid energizing voltage on lines **41** to be removed, thereby deenergizing solenoid **15** within container **12.**

FIG. **2** illustrates the high voltage discharge arrangement. High voltage is delivered to the spray gun ionizing means via cable **11,** which cable develops and retains a voltage charge because of its inherent distributed capacitance. The ionizing means contacts the conductive paint as it is sprayed, and the voltage charge is thereby conducted back to the paint supply system via the paint in delivery hose **26.** The paint supply system thus becomes highly voltage-charged, and is required to be insulated from ground by insulated stand **27.** However, a conductive path is provided between the paint supply system **25** and solenoid container **12** via line **42.** This conductive path terminates within container **12** at contact plate **16.** Contact plate **16** serves as a conductive striking plate for solenoid arm **13** when solenoid **15** is deenergized. Insulated cover plate **29** is sealably fitted into the top of solenoid container **12** in a manner which isolates the inside of container **12** from the exterior. Because of this isolation, any sparkling that occurs when solenoid arm **13** comes into contact with contact plate **16** is contained entirely within container **12,** thus eliminating the possibility of the spark igniting paint or solvent vapors which may exist exterior to container **12.**

A pair of wires **41** are used to energize and deenergize solenoid **15** as hereinbefore described. Solenoid **15** is rigidly mounted on a metal conducting base **17.** Base **17** is, in turn, electrically connected to ground potential through suitable conductors (not shown).

FIG. **3** illustrates the mechanical interlock and solenoid apparatus of this invention. Solenoid **15** has a coil of wire **18** wrapped around a slidable solenoid plunger **19.** The ends of coil **18** are brought out and connected to wires **41** as previously described. When a suitable voltage is applied to wires **41** a current flows through coil **18** and creates an electromagnetic field which causes plunger **19** to slide into the body of solenoid **15** as illustrated in FIG. **3.** In this energized position, coil spring **14,** which is connected between the frame of solenoid **15** and an extension of plunger **19,** is constrained inwardly from its normally quiescent position. This causes the spring **14** to develop a force in opposition to the electromagnetic force of solenoid **15** but of insufficient magnitude to oppose the inwardly sliding motion of plunger **19** when the coil **18** is energized.

When the voltage on the wires **41** is removed, the electromagnetic field generated within coil **18** disappears and the spring tension of spring **14** causes solenoid plunger **19** to slide outwardly in the direction indicated by arrow **43** of FIG. **3.** Since the outer extension of plunger **19** is pivotally connected to bracket **48** at pivot pin **46,** the outward motion of plunger **19** causes bracket **48** to pivot to the left about its pivot pin **49.** Solenoid arm **13** is rigidly connected to bracket **48** by bolt or rivet **50.** Therefore, the motion of plunger **19** is transmitted to solenoid arm **13** to cause arm **13** to move sharply to the left. The positioning of the relative pivot points illustrated in FIG. **3** creates a snap-action effect at the end of solenoid arm **13** to cause a decisive contact to be made by the end of solenoid arm **13** against contact plate **16,** as shown in FIG. **2.** This decisive contact insures a solid connection between contact plate **16** and ground, which, as hereinbefore described, is connected to base plate **17.**

It is possible to modify the general configuration of solenoid **15** within the spirit of this invention. Any solenoid configuration which can insure a positive electrical contact between contact plate **16** and ground may be suitably used in this invention. Similarly, the means for energizing and deenergizing solenoid **15** may be accomplished by wiring in ways different from that shown herein; it being necessary to the invention only that the solenoid be activated to discharge the high voltage potential when the spray gun trigger is released and also when the enclosure gate is open.

It would be possible to substitute for the air hose surrounding the apparatus of this invention, an electrical analogous circuit. The preferred embodiment illustrates an air hose for the reason that the use of a non-electrical means to accomplish this function is believed to constitute less of a fire hazard. Most available electrical devices which might be utilized for this purpose have some risk of sparking when circuits are broken. Because of the likelihood of paint and solvent vapors being found in the immediate vicinity of the apparatus, an airdisconnect system was preferably selected for this invention. However, other safe devices, such as an interruptable light beam, could be equally well suited for this purpose.

In operation, solenoid **15** remains energized and solenoid arm **13** remains retracted from contact with contact plate **16** for so long as both of two conditions exist. These conditions are: the air pressure in hose **31** remains pressurized; and the trigger **21** on spray gun **20** is depressed. If either the air pressure drops or the trigger is released, solenoid **15** becomes deenergized and thereby causes solenoid arm **13** to come into contact with contact plate **16** to ground the high voltage potential present on the paint supply. Because the invention operates in this manner, it is a completely fail-safe apparatus. Failure of the air supply, of the solenoid power supply, or of the spray gun trigger mechanism will all cause the solenoid **15** to become deenergized and will ground the high voltage potential. It is to be assumed that the high voltage power supply has a built-in overload circuit breaker which detects instances when high voltage has been shorted to ground. In these instances the internal overload circuit will become activated to shut off the high voltage power at the supply, cutting the power to the solenoid, thus deactivating the solenoid, and directing the stored voltage charge to ground.

What is claimed is:

**1.** Safety apparatus for confining voltage-charged paint spraying equipment and for discharging components thereof retaining residual voltage charges, comprising:

a. enclosure means for enclosing said voltage-charged equipment, including an access gate for entry and exit;

b. pneumatic alarm means, attached to said enclosure means, for providing a pneumatic signal when said access gate is opened, said pneumatic alarm means including an interruptable pressurized connection at said gate opening point;

c. pneumatic signal receiving means connected to said alarm means for receiving said pneumatic signal indicating an open access gate and for generating a corresponding first voltage signal;

d. a sealed container having therein a spring-biased solenoid, said solenoid having a first solenoid arm position in electrical contact with said components retaining residual voltage charges and a second solenoid arm position displaced from electrical contact, said solenoid being activated by the first voltage signal from said pneumatic signal receiving means, and said solenoid arm being electrically connected to ground potential.

**2.** The apparatus of claim **1**, further comprising a trigger-actuated electrostatic paint spray gun having a circuit for detecting the position of said trigger and for generating a second voltage signal responsive thereto, and means for connecting said second voltage signal to activate said solenoid.

**3.** Apparatus as claimed in claim **2** wherein said first and second voltage signals are caused to energize said solenoid when said gate is closed and said trigger depressed respectively, and said solenoid arm correspondingly remains in said second position, and said solenoid spring bias causes said solenoid arm to travel to its first position when said solenoid is deenergized.

**4.** Apparatus as claimed in claim **3** wherein said sealed container further comprises an internal conductor forming the solenoid first arm position electrical contact, and a conductive path to the container exterior; and means for connecting said internal conductor to said conductive path.

**5.** Apparatus as claimed in claim **4** wherein said alarm means further comprises a pressurized air line and said interruptable connection comprises an air line coupling.

**6.** Apparatus as claimed in claim **5** wherein said signal receiving means further comprises a pressure-sensitive switch.

**7.** Apparatus as claimed in claim **6** wherein said enclosure means further comprises an electrically-grounded wire mesh fence.

**8.** Apparatus for electrically discharging voltage-charged components in a paint supply system, comprising:

a. a fenced enclosure surrounding said paint supply system, said enclosure having a hinged gate;

b. a pressurized air line attached to said enclosure and extending across said enclosure gate, said air line having a disconnectable coupling at said gate opening point;

c. a pressure switch connected to said air line and responsive to pressure drops in said line to activate electrical contacts;

d. a power supply switch connected to said electrical contacts and responsive to activation thereof to disconnect said source of voltage of said voltage-charged components;

e. a solenoid having its energizing coil connected to said power supply switch and having a movable solenoid arm electrically grounded and movable upon deenergization of said solenoid coil into electrical contact with said voltage-charged components; and

f. a sealable housing enclosing said solenoid, said housing having electrical connections therethrough for connecting to said solenoid coil, said solenoid arm deenergized position, and electrical ground.

* * * * *