Jan. 27, 1953 L. J. LAMM 2,626,589

ELECTROSTATIC SPRAY PAINTING APPARATUS

Filed Dec. 1, 1948 3 Sheets-Sheet 1

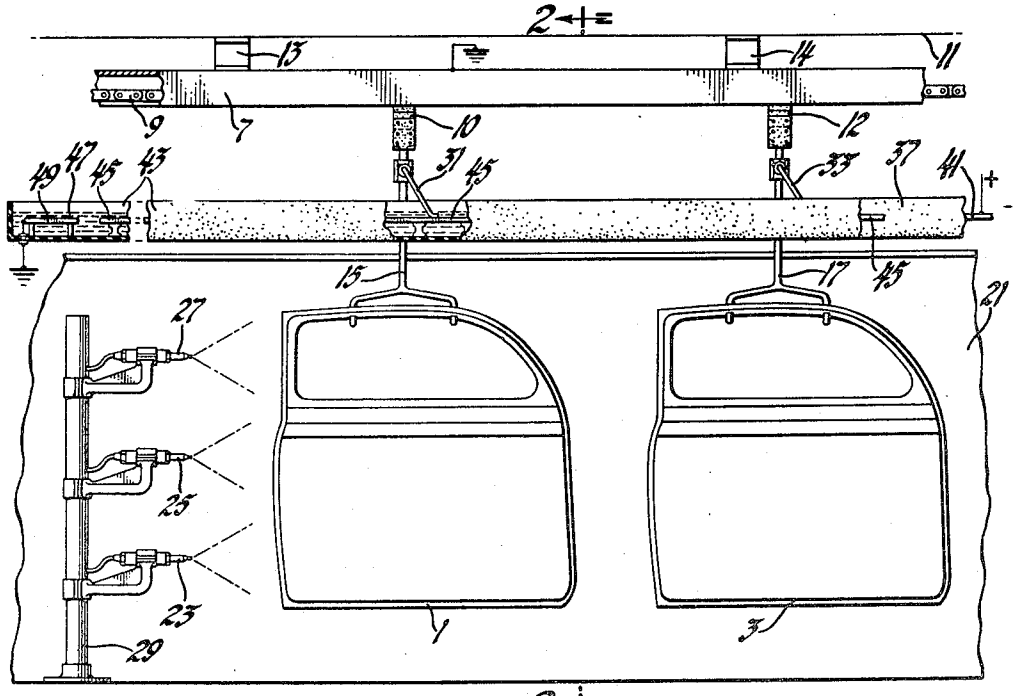

Fig. 1

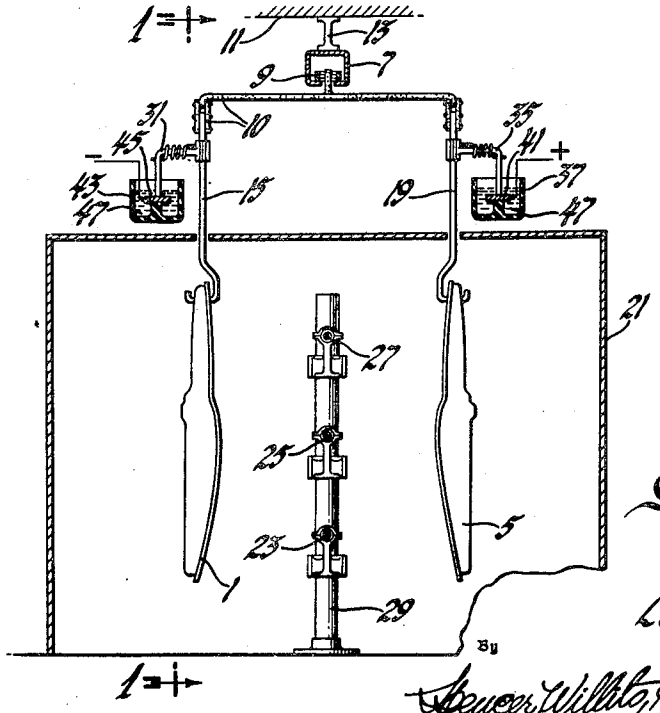

Fig. 2

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Filed Dec. 1, 1948 3 Sheets-Sheet 2

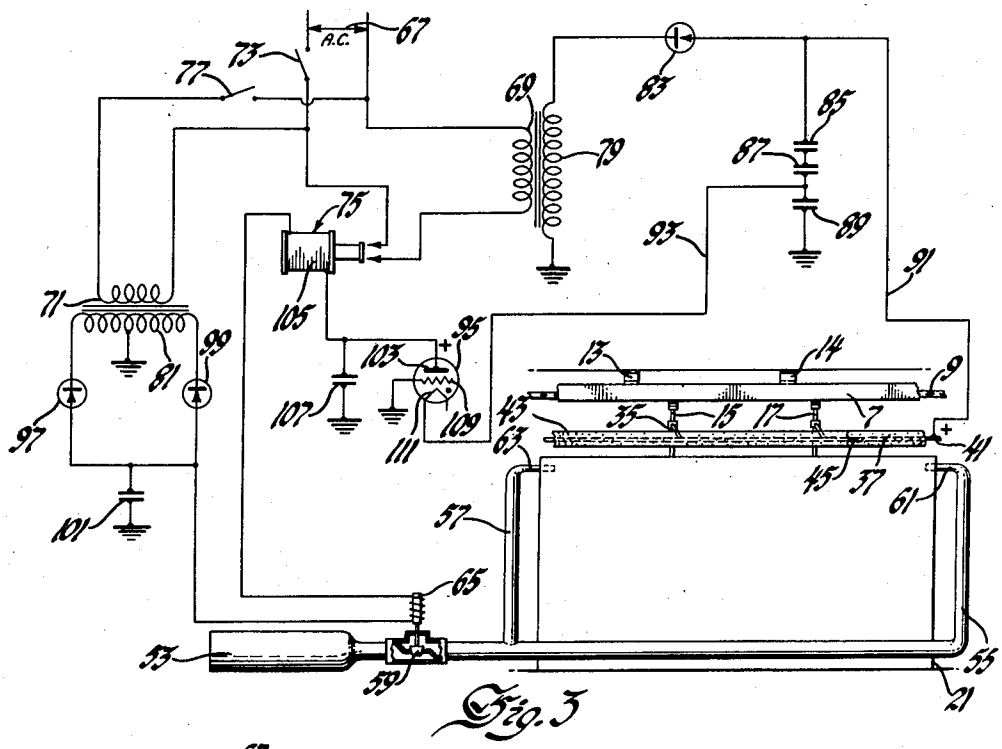

Fig. 3

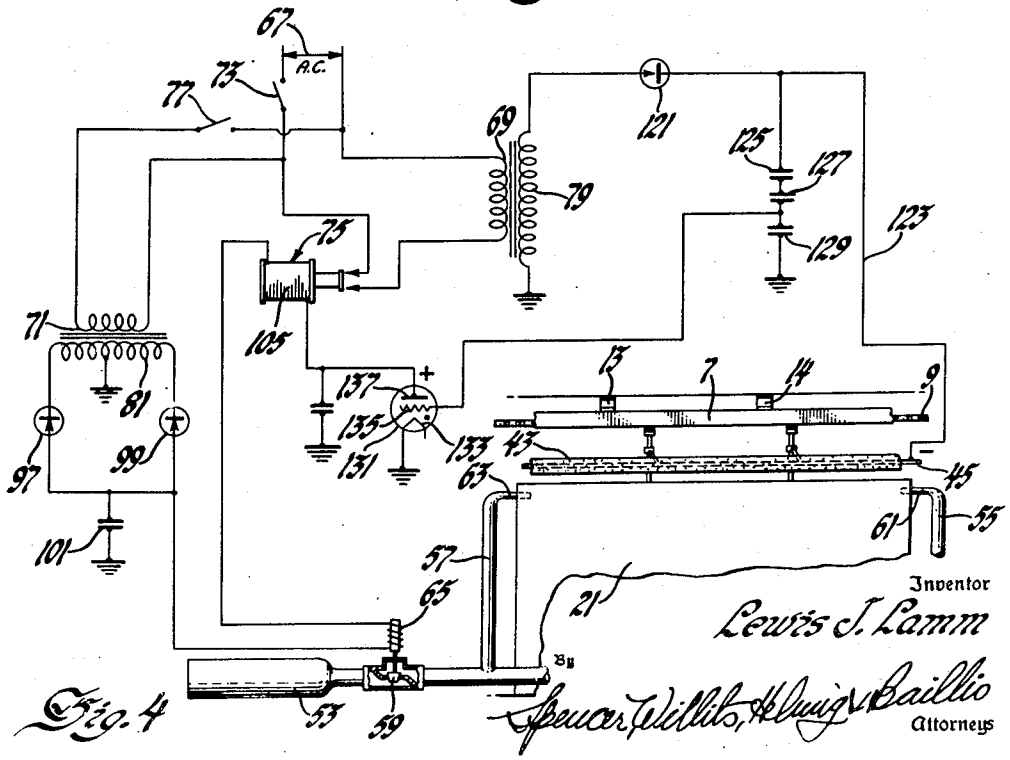

Fig. 4

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ELECTROSTATIC SPRAY PAINTING APPARATUS

Filed Dec. 1, 1948 3 Sheets-Sheet 3

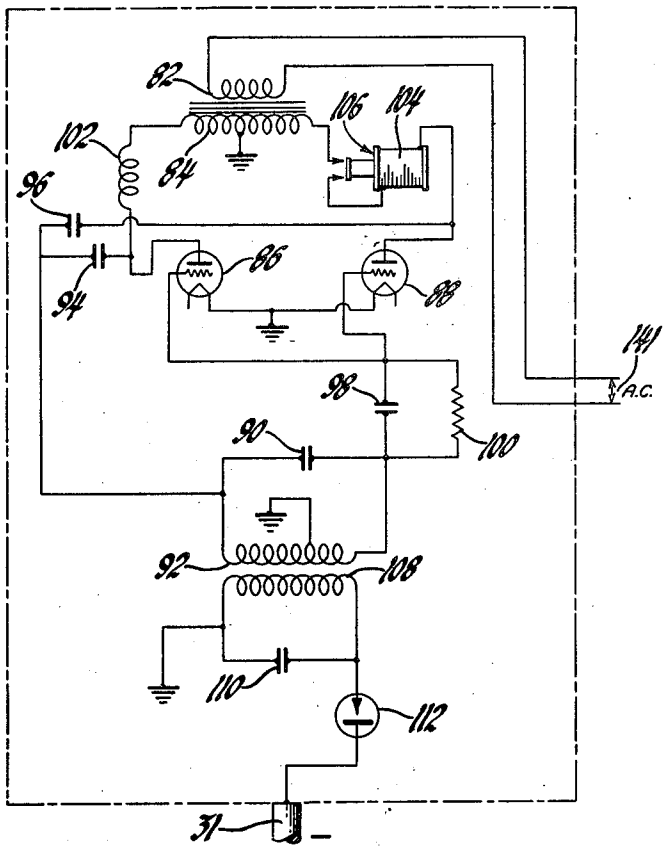

Fig. 5

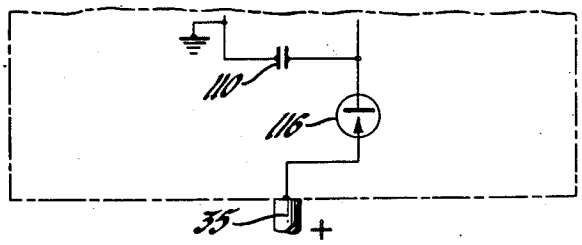

Fig. 6

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Patented Jan. 27, 1953 2,626,589

UNITED STATES PATENT OFFICE

2,626,589

ELECTROSTATIC SPRAY PAINTING APPARATUS

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Application December 1, 1948, Serial No. 62,913

3 Claims. (Cl. 118—51)

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The present invention relates to spray coating apparatus and more particularly relates to apparatus for spray painting in which an electrostatic field is used to influence the deposition of coating materials. This invention further relates to electrostatic coating apparatus in which at least one of the articles being coated is maintained at high potential.

Due to the necessity of using a very high voltage to produce the necessary electrostatic field, certain difficulties have heretofore been experienced regarding fire hazards and personnel safety. Most of the prior apparatus has utilized a discharge electrode maintained at high potential, to permit electrostatic coating while maintaining the article to be coated at ground potential. Modern continuous conveyor type painting apparatus makes it desirable that the conveyor be maintained at ground potential in order that there will be no requirement of transferring articles from one conveyor to another during the painting and baking operations and in order that the personnel involved in these operations may be protected from contact with conductors carying high potential electricity. It is however quite desirable, for maximum efficiency in painting, that the articles being coated be maintained at high potential. Thus two articles may be painted simultaneously, one article acting as a discharge electrode for the other and vice-versa.

It is therefore an object of the present invention to provide an apparatus for maintaining articles to be coated at high electrical potential during the coating operation.

It is a further object of the present invention to provide means for removing the electrostatic charge from the articles being coated before the emergency of these articles from the spray booth.

It is a further object of the present invention to provide an economical and efficient means of maintaining articles to be coated at high potentials of opposite polarity during the spray coating operation.

It is a further object of the present invention to provide means for disabling the high potential circuit under sparking conditions.

It is a further object of the present invention to anticipate sparking conditions and disable the high potential circuit in response to conditions which may cause sparking.

It is a further object of the present invention to provide means for automatically extinguishing any fire which may occur in the spray booth.

Other objects of this invention will become apparent upon reading the specification and inspection of the drawings and will be particularly pointed out in the claims.

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Referring to the figures in the drawings, Figure 1 is a longitudinal sectional view of part of the apparatus utilized in the present invention taken along the line 1—1 of Figure 2.

Figure 2 is a transverse partial sectional view taken along the line 2—2 of Figure 1.

Figure 3 shows means for charging the articles to be coated at a positive potential.

Figure 4 shows a circuit for charging the articles to be coated at a negative potential.

Figure 5 shows an alternate circuit for charging the articles at a negative potential.

Figure 6 is a partial view of an alternate circuit for charging the articles at a positive potential.

Referring more particularly to Figures 1 and 2, an apparatus is illustrated for maintaining one group of articles carried by a conveyor at a high positive potential and a second group of articles carried in a parallel direction by the same conveyor at a negative potential, and means for discharging the electrostatic charge on these articles before they leave the spray booth. In these Figures, 1, 3 and 5 are articles to be coated, here illustrated as metal automobile doors. All of these articles are suspended from a common monorail conveyor 9 supported by rail 7 which is suspended from the ceiling 11 by means of brackets 13 and 14. This conveyor is of the standard monorail type which may be used throughout the manufacturing establishment and is maintained at ground potential to eliminate any difficulties which would be incurred by having such a conveyor carrying an electrical charge. The articles 1 and 3 are carried by supports 15 and 17 respectively while the article 5 is carried by support 19. The articles 1, 3 and other articles carried on the left side of the conveyor are maintained at negative potential while the article 5 and those carried on the right side of the conveyor are maintained at positive potential. When this system is in operation a continuous double line of articles pass through the spray booth 21, one line of articles being at positive potential and the other at negative potential. These articels proceed through the spray booth 21 from right to left as shown in Figure 1 approaching and passing on either side of the spray guns 23, 25 and 27 which are supported on a common stand 29. These spray guns are here shown as projecting a spray of coating material in a direction generally parallel to the path of travel of the two lines of articles to be coated.

It is however contemplated that under certain conditions of operation while painting articles of specific contours, it will be desirable and perhaps necessary to locate some of these spray guns so as to spray paint at an acute angle towards one or the other of the articles being painted with perhaps alternate guns spraying paint at an acute angle to the articles on each of the conveyors respectively. In order to permit the charging of these articles with high potential voltage without arcing while maintaining the overhead conveyor at ground potential, a novel system has been provided. The hangers **15**, **17** and **19** which support the articles **1**, **3** and **5** respectively are made of conducting material preferably copper or other metal of high conductivity. These metallic hangers are mechanically connected to the conveyor **9** by means of insulators **10** and **12**, which insulators carry a hanger at each extremity thereof and each hanger is attached at its center to the monorail conveyor by suitable means. The purpose of these insulators is to mechanically support the hangers and the articles supported therefrom and to insulate these hangers and articles from the conveyor system. Rigidly attached to the support members **15**, **17** and **19** and in electrical contact therewith are leaf spring resilient contact members **31**, **33** and **35** respectively of conducting material. These contact members are rigidly attached to the conveyor system and a part of the electrical circuit including the individual articles to be coated and their hangers and proceed therewith through the spray booth.

It is desirable for obvious reasons that power supplies for producing the high voltage potentials be maintained in a stationary position. Therefore I have provided two stationary contact systems, one for introducing negative potential to the articles on one side of the conveyor and the other for introducing positive potential to the articles on the other side of the conveyor system.

It will be noted that these contact systems include troughs **37** and **43** respectively of insulating material extending parallel to the direction of travel of the conveyor. One of these troughs of insulating material **37** has rigidly supported therein a conducting contact member **41** which is electrically connected to the power source shown in either of Figures 3 or 6. This trough is filled with a spark inhibiting fluid, of which oil may be considered an example. Under certain conditions of operation this trough may be filled with a gaseous fluid of suitable mechanical and chemical properties; for example, carbon dioxide.

A second similar stationary contact member is shown arranged also parallel to the path of travel of the conveyor system and located adjacent the path of travel of the hangers **15** and **17**. This system includes a trough **43** supporting a contact member **45** immersed in a spark inhibiting fluid **47**. This contact member is so arranged that the contact member **31** slides over the surface thereof and completes an electrical circuit between the power supply which is shown in Figure 4 or 5, and the articles to be coated, here illustrated as **1** and **3**. The trough **43** also supports a contact member **49** maintained at ground potential and in spaced relationship to the contact member **45**. The member **49** is also adapted to be contacted by the arms **31** and **33** to complete an electrical circuit between the articles **1** and **3** and thus discharging to ground any

electrical charge which may remain on these articles after they have passed the zone of coating deposition, and have been disconnected from the high potential power supply contact **45**. The trough **37** supports a similar ground contact arrangement. It may thus be seen that by maintaining the contact member **41** at high postive potential and the contact member **45** at high negative potential, the articles to be coated are brought up to a high electrostatic voltage when the contacts carried by their respective brackets complete an electrical circuit with the stationary contact member **41** or **45**. These articles being coated are maintained at a high potential by reason of this contact until the circuit is broken at the end of the stationary high potential rail. The charge remaining on the article being coated is then removed by member **31**, **33** or **35** contacting the stationary rail which is maintained at ground potential. It may thus be seen that as two parallel moving lines of articles enter the spray booth, each of the articles on these separate lines are raised to a high electrostatic potential (the articles on one line being raised to a positive potential and the articles on the other line being raised to a negative potential) to thus produce an intense electrostatic field therebetween. Coating material from the spray guns **23**, **25** and **27** is projected into this electrostatic field and is influenced to and deposited upon the articles to be coated by means of electrostatic attraction. Thus the loss of paint or other coating material due to over spray is maintained at a minimum. As these articles proceed through the booth and become completely coated, they have their charge removed by the completion of an electrical circuit between the article and ground.

Referring now to Figure 3, a circuit capable of maintaining the stationary rail **41** at high positive electrical potential and incorporating certain safety devices is illustrated. The spray booth is here generally shown as **21** and the overhead conveyor is **9** with its supporting channel **7**. This circuit and the associated equipment illustrated therewith show a means for disabling the circuit under arcing conditions or in case of fire, together with automatic means for extinguishing the fire. It is not intended however that it will always be necessary in particular installations to include both the circuit disabling and the fire extinguishing apparatus in a single installation. It is intended that these two systems may be used individually or in conjunction with each other.

Referring more particularly to Figure 3, a container for high pressure fire extinguishing gas is shown at **53**. This gas may be carbon dioxide or any gas having suitable fire extinguishing properties. The container **53** is connected to conduits **55** and **57** having nozzles **61** and **63** by means of a solenoid operated valve **59**. This solenoid operated valve **59** is opened upon energization of the coil **65**. This allows the fire extinguishing gas to be projected into the spray booth **21** through nozzles **61** and **63**.

Referring now to the electrical circuit shown in this figure, **67** is a standard source of single phase alternating current. Ths source may be 110, 220 or 440 volts as is available for a particular installation, allowance being made in the transformers **69** and **71** for the potential of this voltage. This power source is connected to the low voltage primary of the transformer **69** through the main switch **73** and the relay **75**. It

is connected to the primary of the transformer 71 by means of disabling switch 77. The transformer 69 has a high voltage secondary 79 which, together with rectifier 83 and condensers 85, 87 and 89, produces a D. C. voltage on the rail 41 through conductor 91 of sufficient magnitude for use in electrostatic deposition. I have found that a D. C. potential of 50 kilovolts on rail 41 and a like voltage on the rail 45 of opposite polarity is satisfactory. The condensers 85, 87 and 89 are so proportioned as to produce a D. C. potential of low voltage on conductor 93 suitable for negative grid bias of the gas filled tube 95.

Referring now to the transformer 71 a center tapped secondary 81 is shown which, together with rectifiers 97 and 99 and condenser 101, provide a full wave rectifier suitable to produce a D. C. voltage on the plate 103 of the gas filled tube 95 filtered by the circuit including coil 65, coil 105 and condenser 107. The coil 105, similar to the coil 65, has a second function, namely, that of a solenoid for operating the relay 75 which relay is operated together with valve 59 under conditions where the gas filled tube 95 is conducting plate current. The grid 109 of this gas filled tube is maintained at ground potential while its cathode 111 is maintained at the positive potential impressed on the conductor 93. It may thus be seen that the grid 109 is thereby maintained at a sufficiently negativ bias with respect to cathode 111 to prevent the tube "firing" and conducting current from the positive plate 103. Under normal operating conditions the stationary contact 41 is thereby maintained at very high D. C. potential to permit energization of the articles to be coated by electrostatic deposition. Under these normal conditions the plate 103 of the gas filled tube 95 is maintained at a positive potential with no current flowing through either the solenoid 65 or 105, the tube 95 under these conditions being biased beyond cutoff by the voltage produced across the condenser 89. If we assume that the article 5 which is in electrical contact with the rail 41 touches a grounded portion of the spray booth or spray guns so as to cause arcing, this arcing would immediately load the low capacity high resistance secondary 79 sufficiently to reduce the D. C. voltage output of the system to a few hundred volts. This would immediately reduce the voltage across the low capacity condensers 85, 87 and 89 proportionate amounts and thus reduce the positive bias on the cathode 111 sufficiently with respect to the grid 109 to allow firing of the tube 95. Under these conditions the tube fires permitting a high current to flow from the plate 103 to ground. This causes a high current through the solenoids 65 and 105. Under these conditions the relay 75 is tripped causing deenergization of the power supply circuit for the contact member 41. Simultaneous with the operation of this relay a solenoid 65 raises the valve 59 allowing carbon dioxide or other inert gas to be projected into the spraying booth through nozzles 61 and 63. In this manner a fire in the spray booth is prevented or extinguished immediately.

If we assume that a fire has started in the spray booth by some means other than the grounding of an article being coated, so that this circuit is not loaded by said grounding, we must look to other means of causing actuation of the circuit than metallic contact between the high potential circuit and ground. It is well-known that burning gases are ionized and that ionized gases of this type are comparatively good conductors. Under these conditions current is permitted to flow between the high potential circuit and ground or between the two high potential circuits thus causing loading of the high resistance secondary 79 as described above. Under these conditions the voltage across the condenser 89 falls as explained above allowing the tube 95 to fire with resulting energization of the coils 65 and 105, thus causing deenergization of the power supply circuit and the introduction of carbon dioxide gas through the nozzles 61 and 63 to extinguish the fire as described above.

Due to the ion sheath around the individual grid wires, the grid of a gas filled tube is unable to regain control while the tube is conducting. The relay 75 will therefore remain energized thus continuing its disabling action of the high voltage power supply and the solenoid 65 will remain energized thus continuing the spray of carbon dioxide gas into the spray chamber regardless of the fact that the contact within the spray chamber which caused the arcing condition has been broken so no current flows in the conductor 91. This is necessary since under any other conditions the circuit breaker may continue to make and break thus causing a continuous arcing condition. The power supply circuit for the plate 103 of the gas filled tube 95 may be disabled by opening either switch 73 or 77. This would allow the relay 75 to be reset and the grid 109 to regain control of conduction within the gas filled tube 95. Upon reclosing of the switches 73 and 77 the system is again in condition for operation.

Referring now to Figure 4, a circuit is shown capable of producing a potential of opposite polarity to that produced by the circuit shown in Figure 3. This circuit may be used in conjunction with one of the type shown in Figure 3 for energizing the opposite line of articles to be spray coated. The circuit here shown is in general similar to that shown in Figure 3 but is modified as necessary to produce a negative potential on the stationary contact 45. Because of the similarity of these two figures, only those elements and circuits which are peculiar to Figure 4 will be described. In this circuit a rectifier 121 is provided of the same general type as the rectifier 83 in Figure 3. It is however reversed in Figure 4 so as to produce a negative D. C. potential on the conductor 123 and across the series condensers 125, 127 and 129. These condensers are so proportioned as to produce a low negative voltage across the condenser 129 of magnitude suitable for the negative grid bias of gas filled tube 131. This gas filled tube is similar to the gas filled tube 95 described in connection with Figure 3. The plate 137 is provided with a positive plate potential by a circuit similar to that circuit providing plate voltage for the plate 103 in Figure 3. The cathode 133 is connected to ground and the grid 135 is provided with suitable negative grid bias under normal operating conditions by the voltage drop across the condenser 129. Under normal operating conditions there is very small current drain on the conductor 123 similar to that on conductor 91 in Figure 3. The current drain on this conductor is however increased in a similar manner as that described in connection with 91 in Figure 3 under conditions where arcing is promoted, such as ionized conditions between the high voltage electrode and ground and under conditions of arcing when a high current is passed or under conditions of the area between the electrodes being ionized by flame from a fire, the current drain is sufficient to cause a very great drop in voltage. Under these conditions

the voltage across the condenser 129 approaches zero thus removing the negative grid bias from the grid 135. In a manner similar to that described in connection with Figure 3, the grid loses control and the tube 131 conducts plate current thus operating the relays and the solenoid valve to energize the circuit and cause the introduction of fire inhibiting gases into the spray booth.

The circuits of Figures 3 and 4 may be interconnected so that both these circuits operate a common solenoid valve 59 and/or a common relay 75 which relay controls the energization of both circuits. Thus these two circuits may be used in conjunction with each other or separately without departing from the scope of the present invention.

Referring now to Figure 5, a novel circuit incorporating certain features of the present invention is illustrated. It is well-known in the electrical art that the loading of the secondary of a double tuned circuit reflects resistance back into the primary causing loading of that circuit. It is also well-known that in certain types of oscillators the loading of the plate circuit will cause the oscillator to go out of oscillation. These two phenomena are utilized in Figures 5 and 6 to provide a circuit which anticipates sparking conditions and operates to deenergize the circuit in response thereto. The secondary circuit will load under arcing or arc anticipating conditions where there is a flame ionizing the electrostatic field sufficiently to load the primary circuit and thus deenergize the circuit.

Referring now particularly to Figure 5, an alternating current 141 from a standard 110, 220 or 440 volt power source is introduced across the transformer primary 82. This primary is magnetically coupled to a center tapped secondary 84 capable of producing an A. C. plate voltage for the tubes 86 and 88. These tubes combine to produce a push-pull oscillator with a common output tank circuit consisting of condenser 90 and inductance 92. The inductance 92 is tapped to ground. One end of the inductance 92 is connected to the grids of the tubes 86 and 88 to produce self oscillation. The plates of these two tubes are energized respectively by alternate half cycles of the power supply voltage. The plates of the tubes 86 and 88 are both connected to the other end of the inductance 92 through condensers 94 and 96 respectively. It may thus be seen that the tuned circuit including the condenser 90 and the inductance 92 is thereby kept in continuous oscillation. The condenser 98 and resistance 100 provide a self-biasing circuit for the grids of these two tubes. The coils 102 and 104 provide a certain amount of filter action, while the coil 104 in addition to providing filter action, also provides actuation for the overload relay 106. The electrical characteristics of coils 102 and 104 are similar. The tank circuit, consisting of condenser 90 and inductance 92, has a high natural resonant frequency in the order of magnitude of several kilocycles. The inductance 92 is magnetically coupled to the coil 108, which together with the condenser 110, has the same resonant frequency as the tank circuit previously referred to. The coils 92 and 108 are so wound that their mutual inductance provides approximately critical coupling. A rectifier 112 is connected to the high voltage side of the resonant circuit including the secondary inductance 108 and its tuning condenser 110. This rectifier performs the same function as the rectifier 121 in Figure 4. It may thus be readily seen that the high voltage high frequency current produced across the secondary tuned circuit in Figure 5, is rectified so that a high voltage D. C. is produced on the electrode 45.

Under normal operating conditions, the D. C. drain on the electrode 45 is very small and in the order of a few milliamperes. However, under short circuiting conditions, the current drain on this electrode is limited only by the power output of the power supply and may easily reach proportions sufficient to cause sparking. In the present invention the loading of the secondary tuned circuit by such short circuiting reflects a resistance back into the tuned circuit 90—92 thus causing the tank circuit to be heavily loaded and stop oscillation of the circuit. Under these conditions the tubes 86 and 88 have very high current drain thus causing sufficient current to pass through the coil 104 to actuate the manually reset relay 106. This deenergizes the oscillator circuit and thus quenches the arc formed at the short circuit.

Referring to Figure 6, the rectifier 116 is identical to the rectifier 112 in Figure 5 except that its polarity is reversed. The rest of the circuit is identical with that shown in Figure 5. The circuits shown in Figures 5 and 6 may be substituted for those shown in Figures 3 and 4 respectively and used on opposite conveyors as mentioned above. The circuits shown in Figures 5 and 6 will of course be actuated in response to current flow caused by fire ionizing the gas in the electrostatic field very similar to the circuits shown in Figures 3 and 4 and may also be similarly used to control the introduction of fire extinguishing gas into the spray booth.

While I have described above a complete system showing a method of and apparatus for electrostatic spray coating of articles of manufacture, it is to be contemplated that the circuits shown in Figures 3 to 6 may be used in conjunction with the specific apparatus shown in Figures 1 and 2 or that these circuits may be used singularly and that the apparatus may be used in conjunction with other circuits for providing high voltage without departing from the intended scope of the present invention. While this description covers a specific embodiment of the present invention, it is not intended that the invention should be limited to this specific embodiment but that it should be construed as broad as possible in conformance with the hereto appended claims.

I claim:

1. In electrostatic spray coating apparatus for coating two articles of manufacture simultaneously including, a conveyor capable of transporting simultaneously a multiplicity of pairs of articles to be coated in two spaced parallel paths, means for projecting coating material into a zone between said pairs of articles, two stationary electrical contact members arranged parallel to each other and to the direction of travel of the conveyor and adjacent each of said parallel paths of travel respectively, electrical contact means for said articles to be coated carried by said conveyor and electrically insulated therefrom and carrying said articles to be coated in electrical connection therewith, means for surrounding said stationary contact members with inert fluid, and means for bringing said electrical contact means into electrical contact with said stationary contact members during the time said articles are in said zone.

2. In electrostatic spray coating apparatus as

claimed in claim 1 in which the coating material is projected in a direction generally parallel to the paths of travel of the articles to be coated.

3. In electrostatic spray coating apparatus as claimed in claim 1 in which grounded stationary contacts are located longitudinally adjacent one end of the first mentioned stationary contacts, said grounded stationary contacts being surrounded by an inert fluid and adapted to be engaged electrically by the movable contact carrying the articles to be coated subsequent to said movable contacts breaking electrical engagement with said first mentioned stationary contact members.

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