Aug. 8, 1961 G. MEISTER ET AL 2,995,463

ENVELOPE COATING METHOD AND APPARATUS

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FIG. 1.

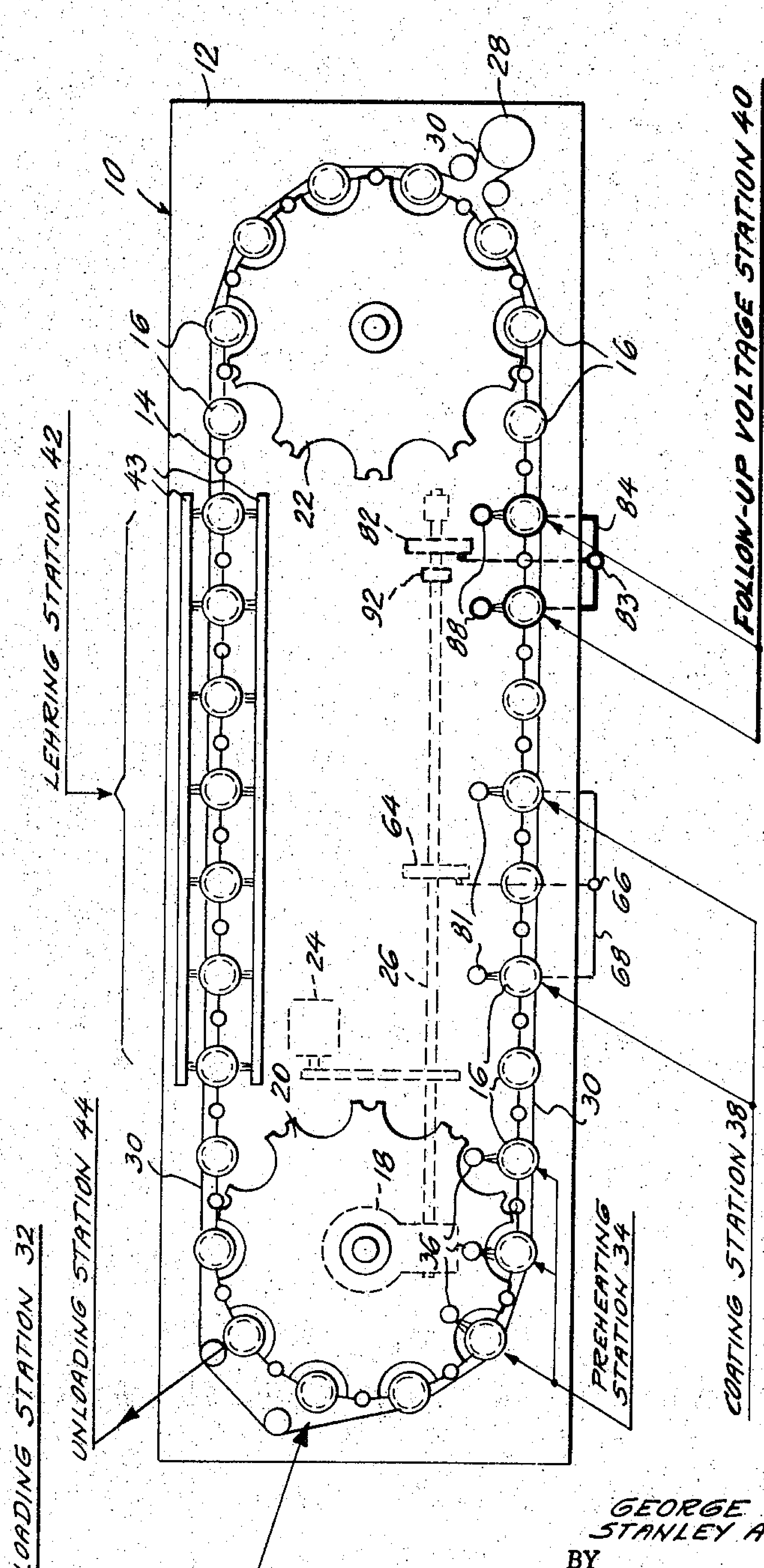

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Fig. 2.

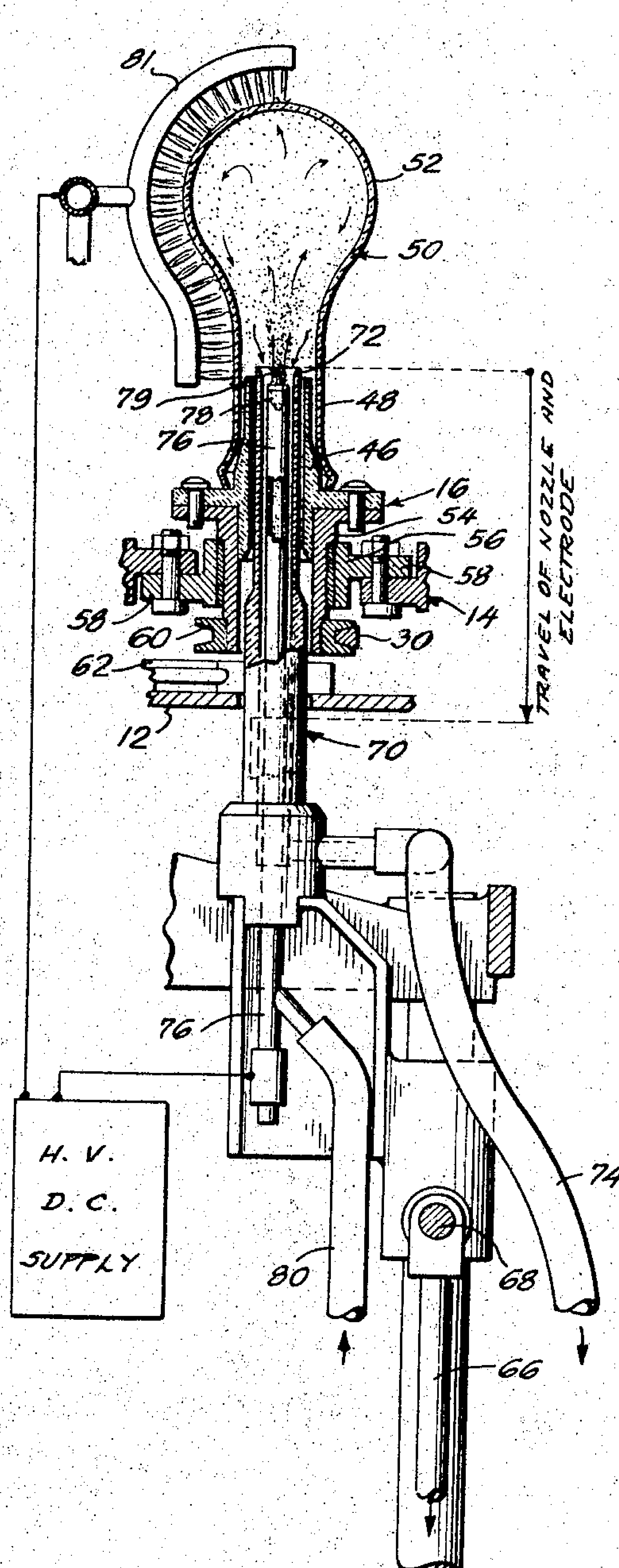
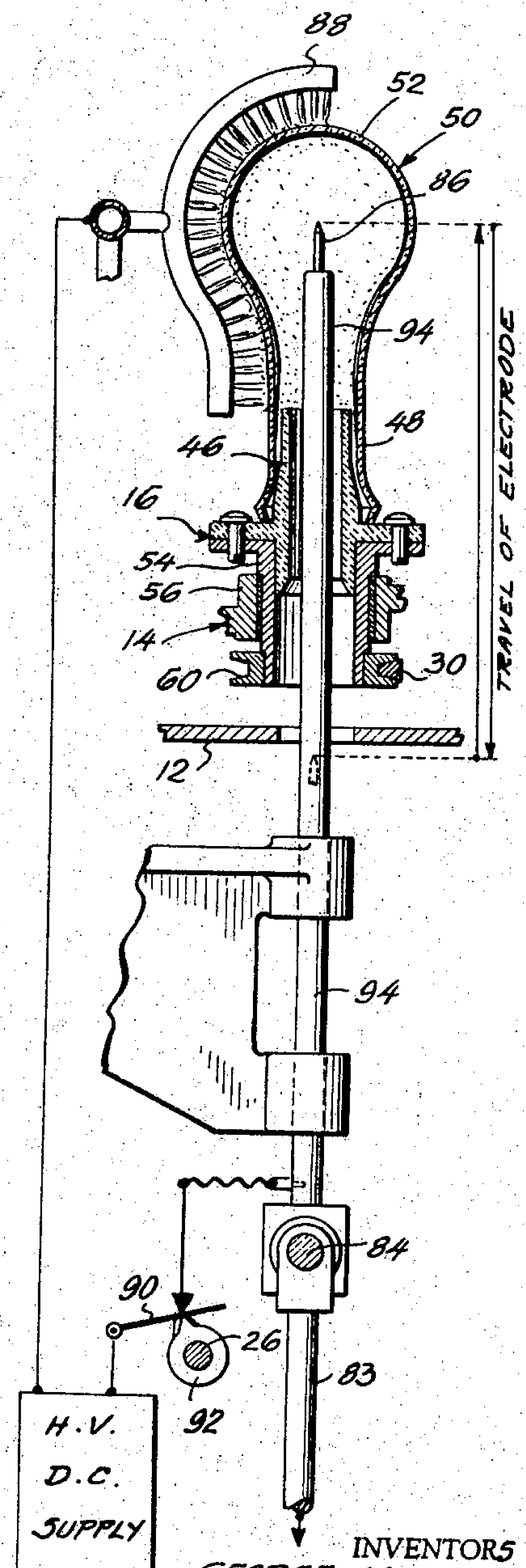


Fig. 3.



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ENVELOPE COATING METHOD AND APPARATUS

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12 Claims. (Cl. 117—17)

This invention relates to a method and apparatus for coating envelopes and, more particularly, to a method and apparatus for improving the adherence of electrostatically-deposited, light-scattering coating materials to incandescent lamp envelopes.

Incandescent lamp envelopes are desirably provided with a coating on the inner envelope surface, which coating normally comprises a finely-divided, light-scattering coating material which provides the lamp, when incandesced, with a very even appearance. The most-commonly-used coating material is finely-divided silica and an electrostatic apparatus for depositing such material onto the inner surface of an incandescent lamp envelope is described in copending application Serial No. 603,636, filed August 13, 1956, now Patent No. 2,811,131, titled "Electrostatic Coating Machine for Incandescent Lamp Envelopes," by Lopenski, Meister and Waino, of which Lopenski and Meister are the coinventors herein, and owned by the present assignee.

When light-scattering materials, such as silica, are deposited by the electrostatic apparatus described in this aforementioned copending application, troubles are sometimes encountered with respect to sufficient adherence of the coated silica to the envelope. Normally the adherence is quite satisfactory, but the margin of safety between "satisfactory" and "unsatisfactory" adherence is not as great as desired, with the result that slight misadjustments of the equipment may result in coatings which are not satisfactory with respect to adherence. A coating which is poorly adherent to the lamp envelope normally manifests itself in the form of "blow-offs" which are encountered during the manufacture of the lamp. In explanation, after the envelope has been coated, a reentrant stem press is sealed to the neck portion. Thereafter the envelope is evacuated and filled with an inert gas which is inserted through a tubulation which opens into the lamp envelope at a location proximate the envelope neck. With a poorly-adherent coating, the puff of fill gas which emanates from the tubulation into the envelope has a tendency to blow off a small area of the coated, light-scattering material. These so-called "blow-off areas" are deleterious to the appearance of the completed lamp. Also, the presence of "blow-off areas" in the neck portion of the envelopes is indicative that the general adherence of the coating to the envelope may be unsatisfactory. It is thus desirable to insure that the adherence of the light-scattering, envelope coating material is always satisfactory even though slight misadjustments of the coating equipment may occur.

It is the general object of this invention to provide a method for increasing the adherence of electrostatically-deposited, finely-divided coating material to the interior surface of an envelope.

It is a further object to provide a method for increasing the adherence of electrostatically-deposited, finely-divided, light-scattering coating material, preferably silica, to the interior surface of an incandescent lamp envelope.

It is another object to provide a method for electrostatically depositing a coating of finely-divided, light-scattering silica particles onto the interior surface of an incandescent lamp envelope so that the deposited silica will have very good adherence to the envelope.

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It is an additional object to provide an improved incandescent lamp envelope electrostatic coating apparatus for producing lamp envelopes with very-adherent coatings.

The aforesaid objects of the invention, and other objects which will become apparent as the description proceeds, are achieved by providing a follow-up, travelling, electrostatic field for a minimum specified time to the coated envelope, which follow-up field increases the adherence of the electrostatically-deposited, finely-divided coating material to the interior surface of the envelope. Also provided is an improved apparatus which incorporates a follow-up-voltage station wherein a travelling, follow-up electrostatic field is applied between the envelope surface and an electrode which reciprocates into the interior of the envelope.

For a better understanding of the invention, reference should be had to the accompanying drawings where:

FIG. 1 is a diagrammatic plan view of the improved electrostatic coating apparatus;

FIG. 2 is an elevational view, partly in section, taken at the first coating position shown in FIG. 1;

FIG. 3 is an elevational view, partly in section, taken at the first follow-up-voltage position shown in FIG. 1.

While the method and apparatus described hereinafter are useful for increasing the adherence of electrostatically-deposited, finely divided coating material to the interior surface of any type of envelope, they are particularly useful for improving the adherence of such material, and particularly silica, to the interior surface of incandescent lamp envelopes and hence they have been so illustrated and will be so described.

With specific reference to the form of the invention illustrated in the drawings, in FIG. 1 is shown in diagrammatic form an electrostatic coating machine **10**. This machine and the operation thereof may be identical with that machine disclosed in heretofore-mentioned Patent No. 2,811,131, which may be referred to for details, except that a follow-up-voltage work station, described in detail hereinafter, has been added. The electrostatic coating machine **10** generally comprises a stationary table **12** having mounted thereon an indexing conveyor unit **14**, which conveyor carries a plurality of bulb-receiving and bulb-retaining heads **16** through a plurality of work stations, as described hereinafter. These conveyor-carried heads **16** are adapted to be indexed sequentially between each of the individual positions located about the table **12** and to remain for a predetermined period at each of the positions. In the embodiment as shown, there are thirty such positions. Indexing is accomplished by means of a motor-driven indexing drive **18** which in turn connects to a sprocket drive **20** and driven sprocket **22**, which index the conveyor **14** about the table **12**. The driving motor **24** for the indexing drive **18** also connects to a cam shaft **26**, so that the motions of the individual cams carried by the shaft **26** are synchronized with the indexing of the heads **16** about the table **12**. The envelope-carrying portion of each of the individual heads **16** is adapted to be rotated with respect to the table **12** and this rotation is accomplished by a motor drive **28** which connects to the individual heads **16** by a belt **30** to effect a rotation of the lamp-envelope-carrying portion of the heads **16**.

In the operation of the electrostatic coating machine, uncoated envelopes are loaded at the loading station **32**, either by hand or by an automatic transfer mechanism, such as are commonly used. Thereafter, the uncoated envelopes are indexed through a preheating work station **34**, which may comprise three positions for example, where they are heated by gas-air burners **36** and may be simultaneously flushed with air in order to remove any lint. Preheating of the envelopes is required in order to render them substantially uniformly electrically conductive. In explanation, it is well known that glass has a negative temperature coefficient of resistance and that heating glass will cause it to become relatively electrically conductive. As a specific example, for a soda-lime-silica type glass, a preheating temperature of 100° C. is quite satisfactory to cause the envelopes to become substantially uniformly electrically conductive for the intended purposes. This preheating temperature may be varied over a wide range if desired, as the degree of preheating is not critical. Desirably the uncoated envelopes are rotated at the preheating work station 34 with respect to the gas-air burners 36 in order to effect uniform preheating, but if desired, the preheating could be effected by infrared-type heaters, utilizing an infrared heating tunnel where rotation of the envelopes with respect to the table 12 could be eliminated. Thereafter the preheated envelopes are indexed through the coating work station 38, which may comprise two positions for example, and through the follow-up-voltage work station 40, which may comprise two positions for example. The envelopes are then indexed through the lehring work station 42, which may comprise seven positions for example. At the lehring work station 42, substantially all residual moisture is removed from the coated envelopes by means of an infrared-heated lehring tunnel 43, while simultaneously blowing hot, dry air through the interior of the coated envelopes. After lehring, the coated envelopes are indexed to the unloading station 44 where they may be unloaded either by hand or by conventional automatic transfer mechanism. If desired, the preheat, coating and lehring stations may be identical with those as described in the aforementioned Patent No. 2,811,131. A head 16, when indexed to one position of the coating work station 38, is shown in elevational view in FIG. 2. Each head 16 may be identical and generally comprises a hollow chuck 46 made of a refractory material such as lava and conformed to receive the neck portion 48 of the envelope 50 to retain same throughout the coating operation. Each envelope 50 is generally symmetrical and comprises a bulbous portion 52 terminating in the neck portion 48 which is open at this state of the lamp manufacture. The chuck 46 of each head 16 is secured to a metal bearing 54 which rides within a journal bearing 56 to facilitate rotation of the lava chuck 46 with respect to the table 12. Each of the heads 16 is hinged together through an extension 58 of the journal bearing 56 to form the conveyor 14 and in FIG. 2 these extensions 58 have been shown offset from their actual positioning for purposes of illustration. A pulley 60 connects to the bearing 54 to cooperate with belt 30 to facilitate rotation of the lava chuck 46 with respect to the table 12. A blow-back manifold 62 is provided at the coating station 38 for the purpose of blowing undeposited coating material from the supply conduits and aforementioned Patent No. 2,811,131 is referred to for details.

As each envelope-carrying head 16 is indexed to the coating station 38, the coating lift cam 64 (see FIG. 1) actuates a push rod 66 which connects to a guided reciprocating bar 68 and which in turn connects to the nozzle and return-conduit assembly 70. An upward movement of the push rod 66 causes the nozzle and return-conduit assembly 70 to move into smoke-delivering position within the head-carried envelope 50. The nozzle and return-conduit assembly 70 generally comprises a hollow, cylindrical return conduit 72 which is fabricated of non-conducting material such as porcelain, for example, and which connects to a flexible, powder-blow-back conduit 74. The nozzle feed conduit 76 is coaxially positioned within the return conduit 72 and is fabricated of electrically conducting material such as brass. The upper portion of the nozzle feed conduit 76 terminates in a smoke-diffusing orifice or nozzle 78 which may carry an electrode 79. The lower end of the nozzle conduit 76 is connected to a flexible feed conduit 80, which in turn connects to a smoke-generator unit (not shown) which is adapted to generate a smoke of finely-divided, light-scattering material for coating the interior of the incandescent lamp envelopes.

A high-voltage, direct-current supply is connected between the electrically-conducting nozzle conduit 76 and the gas-air burners 81, which are positioned at the coating work station 38 to maintain the envelopes 50 in a heated condition and to facilitate electrical contact to the envelopes by virtue of the ionized nature of the gas flame. Preferably the negative side of the high-voltage D.C. potential is connected to the nozzle conduit 76 with the other side of the high-voltage D.C. supply being connected to the gas-air burners 81, one of which is provided at each position of the coating station 38. Preferably the gas-air burners are grounded to minimize shock hazard. The D.C. supply may be either pulsating or steady with respect to voltage, but from the standpoint of economy it is desirable to use a pulsating high-voltage, direct-current supply which may be variable from about 8 to about 25 kilovolts, for example. Even in the case of a pulsating D.C. voltage, the resulting integrated electrostatic field will be unidirectional. As a specific example, for an envelope designed for a 100 watt lamp, the D.C. voltage may be 15 kilovolts.

When the nozzle 78 is reciprocated into smoke-delivering position within the envelope 50, a gaseous medium such as air, carrying a smoke of finely-divided, light-scattering material such as silica, is forced from the smoke generator (not shown) through the flexible feed conduit 80, into the nozzle feed conduit 76 and through the nozzle 78. This charges at least a portion of the finely-divided, light-scattering material and simultaneously the high-voltage D.C. is applied between the nozzle feed conduit 76 and the gas-air burner 81. This causes a strong electrostatic field to be set up between the conducting nozzle 78 and electrode 79 positioned with the interior of the envelope 50 and the electrically-conducting surface of the envelope 50 and a substantial portion of the finely-divided material which forms the smoke is directed to the envelope wall where it adheres. In the case of silica, it has been found that approximately 50% of the silica which is injected into the envelope as a smoke is deposited thereon. The remainder of the silica smoke which is not deposited is carried by the gaseous medium from the envelope 50, through the smoke-return conduit 72 and through the blow-back tube 74, where the undeposited smoke may be collected for further use. After the nozzle has been in smoke-delivering position for one second, for example, the lift cam 64 has rotated sufficiently that the return-conduit and nozzle assembly 70 is retracted from its position within the head 16 and the envelope-carrying head 16 is indexed to the next station. In the diagrammatic view shown in FIG. 1, two individual coating positions have been provided for applying the light-diffusing coating to the envelopes. In practice, it is often desirable to use only one of the individual coating positions and in such case, the unused coating position is not actuated during the coating operation. Thus the coating work station 38 may be comprise one or more individual similar positions, if desired.

In order that the coating material will be deposited in a uniform manner on the envelope 50, it is necessary to effect a rotation between the nozzle 78 and the envelope 50 while the smoke is blown into the envelope and while the electrostatic field is applied to cause a substantial portion of the material comprising the smoke to deposit on the envelope. This is desirably accomplished by rotating the envelope 50 during coating with respect to the table 12 and with respect to the gas-air burner 81. Since the envelope 50 is substantially uniformly electrically conductive, the electrostatic field which is applied from the electrode to the surface of the envelope is evenly distributed.

After the envelopes have been coated, the envelope-carrying heads 16 are indexed to the follow-up-voltage work station 40, one position of which is shown in detail in FIG. 3. A follow-up-voltage lift cam 82 (see FIG. 1) actuates a push rod 83 which connects to a reciprocating bar 84 and which in turn connects to a guided electrode 86. An upward movement of the push rod 83 causes the electrode 86 to be reciprocated within the coated envelope 50. Simultaneous with reciprocation of the electrode 86 into the envelope, a high-voltage D.C., which may be similar to, or slightly greater than that used in the initial coating, is applied between the moving electrode 86 and the conducting surfaces of the envelope 50 by means of the gas-air burners 88, one of which is provided at each position of the follow-up-voltage station 40 to maintain the envelopes at this work station substantially uniformly electrically conducting and to facilitate electrical contact to the surfaces of the envelopes. During the application of the electrostatic field and while the electrode 86 travels within the envelope 50, the envelope is rotated with respect to the stationary gas-air burner 88 in order to maintain same substantially uniformly electrically conductive so that the electrostatic field which is applied between the electrode 86 and the envelope surface is evenly distributed. The speed of rotation of the envelope may be 180 r.p.m. for example, and this speed of rotation may be varied considerably.

Alternately, the envelope 50 could be held stationary if desired and the gas-air burner rotated thereabout during the application of the follow-up electrostatic field in order to achieve the same effects. Rotating gas-air burner arrangements are frequently used in the lamp-making-equipment art. Also, the envelope and gas-air burner could be held stationary with respect to one another during the application of the follow-up electrostatic field. Such an embodiment, however, would normally necessitate an encircling-type of gas-air heater so that the surfaces of the envelope would be substantially uniformly heated and so that the follow-up electrostatic field would be evenly distributed.

The electrode 86 desirably is reciprocated into the envelope 50 with an even motion and the follow-up electrostatic field desirably is applied between the electrode 86 and the conducting envelope 50 for the entire period thta any part of the electrode 86 is moving within the enevlope 50. The electrostatic field applied between the electrode 86 and the substantialy uniformly electrically conductive envelope 50 is actually moving or travelling in nature since the electrode and conductive envelope have a relative motion therebetween. The travelling electrostatic field will normally vary somewhat in intensity since the spacing between the uppermost portion of the electrode and the envelope surface will vary as the electrode is moved within the interior of the envelope. Such variations in field intensity are not objectionable. Thus the travelling electrostatic field is actually applied between the surface of the envelope 50 and a plurality of locations which are within the envelope, preferably extending from a location proximate the mid-point of the envelope neck portion 48 to a location proximate the maximum diameter of the bulbous portion 52 of the envelope 50. In the preferred embodiment as illustrated, the electrode traverses the center line of the envelope. The electrode may be offset slightly, if desired, although care should be taken so that the electrode does not contact the envelope coating or it will tend to knock off coating material. Also, the electrode 86 may be reciprocated to an extreme position well within the coated envelope 50, even approaching the uppermost bulbous portion 52 of the envelope 50, provided the electrode 86 is always spaced apart from the envelope coating.

The follow-up voltage should be applied between the electrode 86 and the conducting envelope 50 for a total period of at least 0.5 second while the electrode is moving within the envelope. This minimum time for the application of the follow-up electrostatic field is necessary in order to enable the adherence of the coating material to the enevlope to be improved to the required degree. Proper timing of the applied follow-up voltage may be accomplished by applying the voltage between the electrode 86 and the burner 88 in a continuous fashion, in which case the electrode lift cam 82 will serve as a timing means for controlling the application of the follow-up voltage. It is desirable, however, to provide an additional follow-up-voltage timing means, so that the follow-up voltage is applied between the electrode 86 and the conducting envelope for a total period of at least 0.5 second while the uppermost portion of the electrode traverses a path defined by a location proximate the neck portion 48 of the envelope 50 and a location well within the interior of the bulbous portion 52 of the envelope 50. Such additional voltage-timing means may be simple make-and-break contact 90 actuated by a cam 92 on the cam shaft 26.

In the diagrammatic view shown in FIG. 1, the follow-up-voltage station 40 has been shown as comprising two individual positions. In practice, it is often desirable to use only one of the individual follow-up voltage positions and in such case, the unused follow-up voltage position may be disconnected. Of course, more than two follow-up-voltage positions could be used if desired. Whether the follow-up voltage is applied at one or more work positions on the apparatus, the total time for which the voltage is applied in the manner as indcated should be at least 0.5 second.

In the preferred embodiment as described hereinbefore, the electrostatic fields are applied in such a manner that their direction is from the interior of the envelopes to the envelope surfaces, that is, the negative potential is applied to the electrodes at both the coating work station 38 and the follow-up-voltage work station 40 and a ground potential is applied to the envelope surfaces through the conducting gas flames. This causes the electrostatic fields to be directed from locations within the interior of the envelopes to the surface of the envelopes and this is desired in order to achieve the best coating. If the electrodes are made positive with respect to the envelope surfaces, at either the coating or follow-up-voltage work stations, or both, it has been found that there will be small striations or corona-appearing lines, particularly at the neck portions of the coated envelopes and this impairs somewhat the appearance of the finished lamps. Such striation effects, however, may be tolerated for some applications and the adherence of the coating material to the envelopes will be enhanced by the follow-up field as specified, no matter what the polarity of the electrodes with respect to the conducting envelopes.

In the embodiment as shown in FIG. 3, the metallic electrode 86 has provided over the lower portion thereof a high-electrical-breakdown coating 94 which may be formed of quartz, for example. Such a coating is not required, but it is desirable to provide such a protective coating 94 over the portions of the electrode 86 which are proximate the neck portion 48 of the envelope 50 when the electrode 86 is positioned well within the lamp envelope. This tends to minimize somewhat any striation-appearing lines which are apt to occur in the coating proximate the envelope neck if a corona-type discharge occurs directly from the electrode 86 to the envelope neck portion 48 for any appreciable period of time. The follow-up voltage applied between the electrode 86 and the conducting surface of the coated envelope 50 is not particularly critical and may vary over a wide range of from about 15 kv. to about 30 kv. for example, with the preferred follow-up voltage for a 100-watt-size envelope being about 20 kv. When using relatively high follow-up voltages to produce the follow-up electrostatic field, it is desirable to provide the electrode 86 with the high-electrical-breakdown coating 94.

The improved adherence of the coating material to the envelope resulting from the follow-up electrostatic field is apparently due to a compacting or densification of the bulk density for the coating material. In explanation, where coating finely-divided silica, for example, which has a true density of about 2.2, coating-material bulk density variations of from 0.042 to 0.094 gram per cc. have been observed. While a very fluffy coating material is desirable from the standpoint of the light-scattering properties of the coating, it has been observed that where the coating-material bulk density approaches the lower end of the observed range, the adherence of the coating material to the envelope may be unsatisfactory. The foregoing follow-up electrostatic field tends to increase somewhat the coating bulk density to cause the coating to adhere better. Even with the follow-up electrostatic field, however, the coating bulk densities, in the case of the specified silica for example, still normally do not exceed the maximum observed value of 0.094 gram per cc.

The improved adherence characteristics of the coating material to the envelope are best measured with a relatively-strong air blast, the velocity of which greatly exceeds the velocity of the puff of fill gas which is forced through the tubulation during the gas-fill step in the lamp fabrication. In testing silica-coated envelopes with a high-velocity, controlled air blast, the coated envelopes which had no follow-up voltage applied thereto displayed a blow area having a diameter of $^{13}\!/_{16}$ inch, that is, the diameter of the envelope section from which the coating was removed by the air blast was $^{13}\!/_{16}$ inch. Coated envelopes fabricated at the same time under the same conditions, but compacted with a follow-up electrostatic field as specified hereinbefore, had a blown area with a diameter of only $^{5}\!/_{16}$ inch. It is thus apparent that the adherence of the coating material to the envelopes is greatly improved where the follow-up electrostatic field is applied.

While silica has been found to be the most satisfactory bulb-coating material, the foregoing process and apparatus are not limited to the deposition of silica and the following materials have been found to be suitable for deposition with the process and apparatus as illustrated and described: alkaline-earth and magnesium stannates, oxides, carbonates and silicates; alkaline-earth sulfates; zinc oxide; alumina; talcs; sodium or calcium alumino-silicates (zeolite); and zirconium silicate. Of course the foregoing materials should be very finely divided in order to scatter effectively the light and these particles should appear substantially white under reflected light in order not to absorb excessive amounts of light, at least where a white-appearing lamp is to be produced. The average ultimate particle size for the finely-divided, light-scattering material may vary over a very wide range, such as from about 0.02 micron to about 1 micron, for example, and even this range may be extended if desired.

It will be recognized that the objects of the invention have been achieved by providing a method for increasing the adherence of electrostatically-deposited, finely-divided coating material, preferably silica, to the interior surface of an envelope such as an incandescent lamp envelope, as well as a method for electrostatically depositing such silica material so that it will have very good adherence for the envelope. In addition there has been provided an improved incandescent lamp envelope electrostatic coating machine for producing coatings which are very adherent to the lamp envelopes.

As an alternative embodiment, the follow-up electrostatic field may be interrupted during the period the electrode **86** is positioned within the envelope **50**. In effect, this will still result in a travelling electrostatic field. If such an interrupted schedule is to be utilized, the follow-up voltage should be applied at least when the upper portion of the traveling electrode **86** is proximate the neck portion **48** of the envelope **50** and when the electrode **86** is well within the bulbous portion **52** of the envelope **50**, preferably when the upper portion of the traveling electrode **86** is proximate the midpoint of the maximum diameter of the envelope **50**. Such an interrupted follow-up voltage may be effected by a simple make-and-break arrangement. Of course the total time which the follow-up electrostatic field is applied should always be at least 0.5 second.

As a further embodiment, the method for increasing the adherence of the electrostatically-deposited coating material as described hereinbefore may be carried out by hand as well as by the apparatus described. As an example, the coated envelope **50** could be removed from the electrostatic coating machine **10** after the envelope is indexed from the coating work station **38**. The envelope could then be placed by hand onto an individual head and the electrode manually reciprocated into the coated envelope while the follow-up voltage as required to produce the follow-up electrostatic field was applied between the electrode and the conducting surface of the envelope. Thereafter, the coated envelope could be placed back on the machine **10** to be indexed through the lehring and unloading stations as indicated.

While the follow-up electrostatic field should be applied for a period of at least 0.5 second while the electrode is travelling or moving with respect to the conducting envelope, this period may be extended if desired. Also, from the standpoint of equipment design it may be desirable to have the electrode pause when it is fully reciprocated within the lamp envelope. During such pause, the follow-up electrostatic field may be continued if desired.

While in accordance with the patent statutes, one best-known embodiment of the invention has been illustrated and described in detail, it is to be particularly understood that the invention is not limited thereto or thereby.

We claim:

1. The method of increasing the adherence of electrostatically-deposited finely-divided material to the interior surface of a light-transmitting glass envelope having a neck portion, comprising heating the material-coated envelope to render it substantially uniformly electrically conductive, and applying for a period of at least 0.5 second a travelling high intensity electrostatic field between the envelope surface and locations within said envelope spaced from the material coating, including a location bounded by the neck portion of said envelope and a location well within the interior of said envelope, to compact said deposited finely divided material and improve the adherence thereof to the interior surface of said glass envelope.

2. The method of increasing the adherence of electrostatically-deposited finely-divided light-scattering coating material to the interior surface of a light-transmitting glass envelope having a neck portion and a bulbous portion, comprising heating the material-coated envelope to render it substantially uniformly electrically conductive, and applying for a period of at least 0.5 second a travelling high intensity electrostatic field between the envelope surface and locations within said envelope spaced from the material coating and bounded by the neck portion and the bulbous portion to compact said deposited finely divided coating material and improve the adherence thereof to the interior surface of said glass envelope.

3. The method of increasing the adherence of electrostatically-deposited finely-divided silica coating material to the interior surface of an incandescent lamp glass envelope having a neck portion and a bulbous portion, comprising heating the silica-coated envelope to render it substantially uniformly electrically conductive, and applying for a period of at least 0.5 second a travelling high intensity electrostatic field between the envelope surface and locations within said envelope spaced from the silica coating and bounded by the neck portion and

the bulbous portion to compact said deposited finely divided coating material and improve the adherence thereof to the interior surface of said glass envelope.

4. The method of increasing the adherence of electrostatically-deposited finely-divided light-scattering coating material to the interior surface of an incandescent lamp glass envelope having a neck portion and a bulbous portion, comprising heating the material-coated envelope to render it substantially uniformly electrically conductive, and applying for a period of at least 0.5 second a travelling high intensity electrostatic field between the envelope surface and locations within said envelope positioned proximate the envelope centerline and spaced from the material coating and bounded by the neck portion and the bulbous portion to compact said deposited finely divided coating material and improve the adherence thereof to the interior surface of said glass envelope.

5. The method of increasing the adherence of electrostatically-deposited finely-divided light-scattering coating material to the interior surface of an incandescent lamp glass envelope having a neck portion and a bulbous portion, wherein the lines of force comprising the electrostatic field which effected the material deposition extended from the interior of the envelope to the envelope surface, comprising heating the material-coated envelope to render it substantially uniformly electrically conductive, and applying for a total time of at least 0.5 second a travelling high intensity electrostatic field between the envelope surface and locations within said envelope spaced from the material coating and bounded by the neck portion and the bulbous portion to compact said deposited finely divided coating material and improve the adherence thereof to the interior surface of said glass envelope, with the lines of force comprising said applied field extending from the locations within said envelope to the envelope surface.

6. The method of increasing the adherence of electro statically-deposited finely-divided silica coating material to the interior surface of an incandescent lamp glass envelope having a neck portion and a bulbous portion, wherein the lines of force comprising the electrostatic field which effected the silica deposition extended from the interior of the envelope to the envelope surface, comprising heating the silica-coated envelope to render it substantially uniformly electrically conductive, and applying for a total time of at least 0.5 second a travelling high intensity electrostatic field between the envelope surface and locations within said envelope spaced from the silica coating and bounded by the neck portion and the bulbous portions to compact said deposited finely divided coating material and improve the adherence thereof to the interior surface of said glass envelope, with the lines of force comprising said applied field extending from the locations within said envelope to the envelope surface.

7. The method of increasing the adherence of electrostatically deposited finely-divided light-scattering coating material to the interior surfaces of an incandescent lamp glass envelope having a neck portion and a bulbous portion, wherein the lines of force comprising the electrostatic field which effected the material deposition extended from the interior of the envelope to the envelope surface, comprising heating the coated envelope to render it substantially uniformly electrically conductive, and applying for a total time of at least 0.5 second a travelling high intensity electrostatic field between the envelope surface and locations within the envelope interior extending from a point proximate the midpoint of the envelope neck portion to a point proximate the midpoint of the maximum diameter of the envelope bulbous portion to compact said deposited finely divided coating material and improve the adherence thereof to the interior surfact of said glass envelope, with the lines of force comprising said applied field extending from the locations within said envelope to the envelope surface.

8. The method of electrostatically depositing a coating of finely-divided light scattering silica particles onto the interior surface of an incandescent lamp glass envelope having an open neck portion and a bulbous portion, comprising heating the envelope to render it substantially uniformly electrically conductive, forcing a gaseous medium carrying finely-divided light-scattering silica into said conducting envelope to charge at least a portion of the finely-divided silica carried within said envelope, simultaneously applying a high intensity electrostatic field between a location within the interior of said envelope and the envelope surface so that a substantial portion of the silica particles carried within said envelope will be so attracted to and will coat the interior surface of the envelope and so that the uncoated remainder of said silica particles carried within said envelope will be carried by said gaseous medium from said envelope through the envelope open neck portion, thereafter maintaining said coated envelope substantially uniformly electrically conductive, and applying for a period of at least 0.5 second a travelling high intensity electrostatic field between the envelope surface and locations within said envelope spaced from the material coating and bounded by the neck portion and the bulbous portion to compact said deposited finely divided coating material and improve the adherence thereof to the interior surface of said glass envelope.

9. In combination with an open-necked incandescent lamp glass envelope electrostatic coating machine having a plurality of work stations including an envelope preheating station, an envelope electrostatic coating station and a coated envelope lehring station, together with means for indexing envelopes from work station to work station in the foregoing work-station sequence, the improvement which comprises a follow-up-voltage station following said envelope coating station, said follow-up-voltage station comprising: a heating means for heating the surface of coated envelopes received on station to render same substantially uniformly electrically conductive and to facilitate electrical contact to such coated envelopes, a reciprocating electrode adapted to move within coated envelopes received on station from a position proximate the open necks of such coated envelopes to an extreme position well within such coated envelopes, electrode timing means to control the travel of said electrode within coated envelopes received on station so that said electrode moves within such coated envelopes for a period of at least 0.5 second, means for applying a unidirectional high-voltage potential between said electrode and conducting envelopes on station while said electrode is moving within such envelopes, voltage timing means for applying said potential between said electrode and conducting envelopes on station for at least 0.5 second while said electrode is within such conducting envelopes, including positions proximate the neck portion of such envelopes and well within such envelopes, means for holding coated envelopes in position on station, and means for indexing coated envelopes to and from station.

10. In combination with an open-necked incandescent lamp glass envelope electrostatic coating machine having a plurality of work stations including an envelope preheating station, an envelope electrostatic coating station and a coated envelope lehring station, together with means for indexing envelopes from work station to work station in the foregoing work-station sequence, the improvement which comprises a follow-up-voltage station following said envelope coating station, said follow-up-voltage station comprising: gas-air burner heating means for heating the surface of coated envelopes received on station to render same substantially uniformly electrically conductive and to facilitate electrical contact to such coated envelopes, a reciprocating electrode adapted to move within each coated envelope received on station from a position proximate the midpoint of the open necks of such coated envelopes to an extreme position proxi-

mate the midpoint of the maximum diameter of such coated envelopes, electrode timing means to control the travel of said electrode within coated envelopes received on station so that said electrode moves within such coated envelopes for a period of at least 0.5 second, means for applying a unidirectional high-voltage potential between said electrode and the conducting envelopes on station while said electrode is moving within such envelopes with the lines of force comprising the resulting electrostatic field extending from said electrode to such conducting envelopes, voltage timing means for applying said potential between said electrode and conducting envelopes on station for at least 0.5 second while said electrode is positioned within such conducting envelopes and traverses a path defined by electrode positions proximate the neck of such envelopes and proximate the midpoint of the maximum diameter of such coated envelopes, means for holding coated envelopes in position on station and for effecting a rotation between such coated envelopes and said gas-air burner heating means when said electrode is moving within such coated envelopes and voltage is applied thereto, and means for indexing coated envelopes to and from station.

11. In combination with an open-necked incandescent lamp glass envelope electrostatic coating machine having a plurality of work stations including an envelope preheating station, an envelope electrostatic coating station and a coated envelope lehring station, together with means for indexing envelopes from work station to work station in the foregoing work-station sequence, the improvement which comprises a follow-up-voltage station following said envelope coating station, said follow-up-voltage station comprising: stationary gas-air burner heating means for heating the surface of coated envelopes received on station to render same substantially uniformly electrically conductive and to facilitate electrical contact to such coated envelopes, a reciprocating electrode adapted to move within each of the coated envelopes received on station from a position proximate the midpoint of the open necks of such coated envelopes to an extreme position well within such coated envelopes, a high-electrical-breakdown coating provided over the portions of said electrode which are adjacent the necks of coated envelopes received on station when said electrode is projected well within such coated envelopes, electrode timing means to control the travel of said electrode within coated envelopes received on station so that said electrode moves within such coated envelopes for a period of at least 0.5 second, means for applying a unidirectional high-voltage potential between said electrode and conducting coated envelopes on station while said electrode is moving within such envelopes, voltage timing means for applying said potential between said electrode and conducting envelopes on station for at least 0.5 second while said electrode is positioned within such conducting envelopes and traverses a path defined by electrode positions proximate the necks of such envelopes and well within such envelopes, means for holding coated envelopes received on station in position on station and for effecting a rotation between such coated envelopes and said stationary gas-air burner heating means when said electrode is moving within such coated envelopes and voltage is applied thereto, and means for indexing coated envelopes to and from station.

12. In combination with an open-necked incandescent lamp glass envelope electrostatic coating machine having a plurality of work stations including an envelope preheating station, an envelope electrostatic coating station and a coated envelope lehring station, together with means for indexing envelopes from work station to work station in the foregoing work-station sequence, the improvement which comprises a follow-up-voltage station comprising at least one follow-up-voltage position following said envelope coating station, each said follow-up-voltage position comprising: a heating means for heating the surface of received coated envelopes to render same substantially uniformly electrically conductive and to facilitate electrical contact to such coated envelopes, reciprocating electrode means adapted to project within each received coated envelope from a position proximate the midpoint of the open necks of such coated envelopes to an extreme position well within such coated envelopes, timing means to control the travel of said electrode means within received coated envelopes from a position proximate the midpoint of the open necks of such coated envelopes to an extreme position well within such coated envelopes, timing means to control the travel of said electrode means within received coated envelopes so that said electrode means moves within such coated envelopes for a period of at least 0.5 second, means for applying a unidirectional high-voltage potential between said electrode means and received conducting envelopes while said electrode means is moving within such envelopes, voltage-timing means for applying said potential between said electrode means and received conducting envelopes for at least 0.5 second while said electrode means is positioned within such conducting envelopes and traverses a path defined by electrode positions proximate the necks of such envelopes and well within such envelopes, means for holding received coated envelopes in position and for effecting a rotation between such coated envelopes and said heating means when said electrode means is moving within such coated envelopes and voltage is applied thereto, and means for indexing coated envelopes to and from the individual follow-up-voltage positions comprising said follow-up-voltage station and to and from said follow-up-voltage station.

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