April 11, 1950 H. G. WEHE 2,503,571

APPARATUS FOR COATING SURFACES BY THERMAL VAPORIZATION AT ATMOSPHERIC PRESSURE

Filed May 2, 1947

4 Sheets-Sheet 1

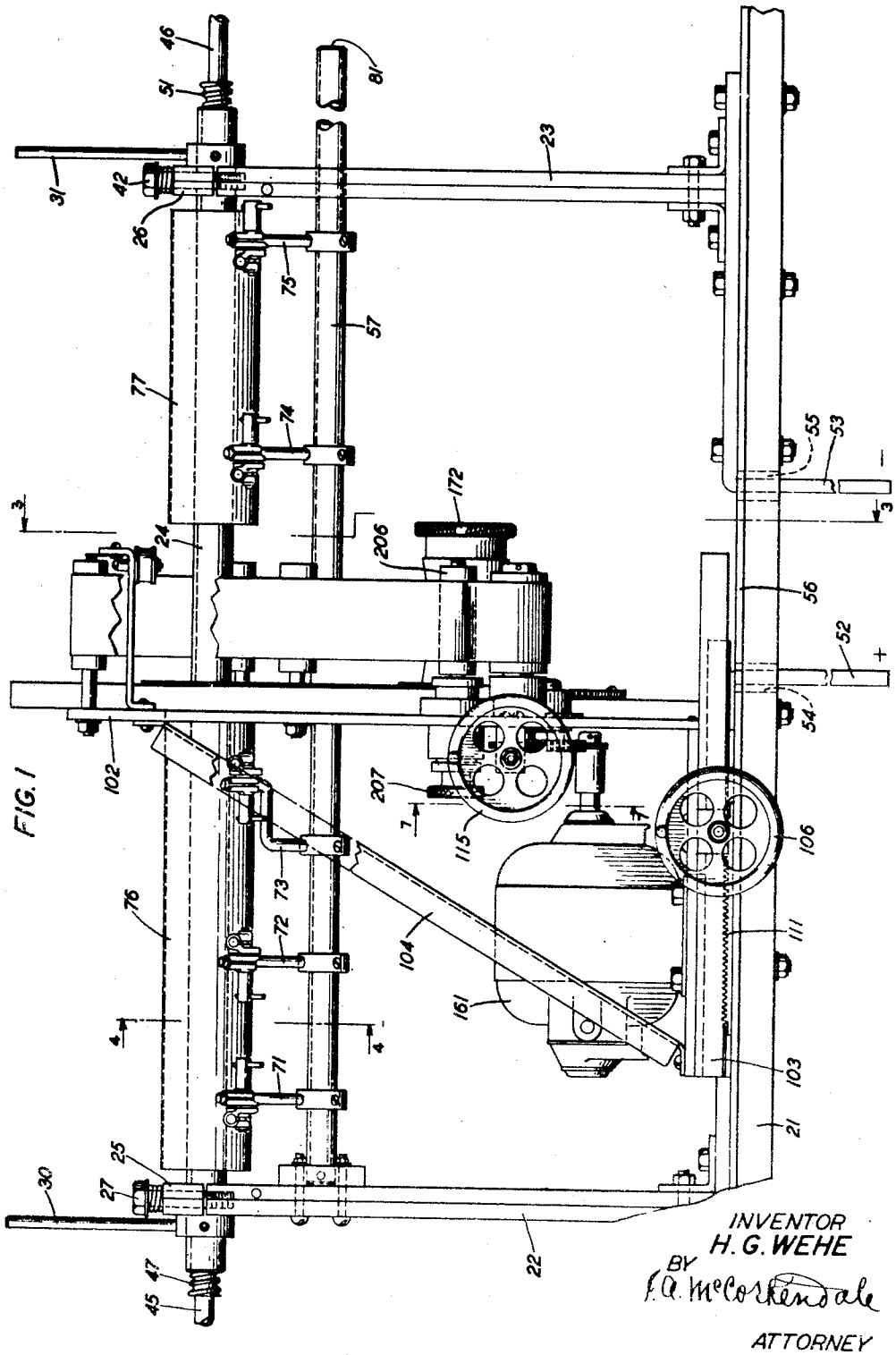

FIG. 1

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FIG. 2

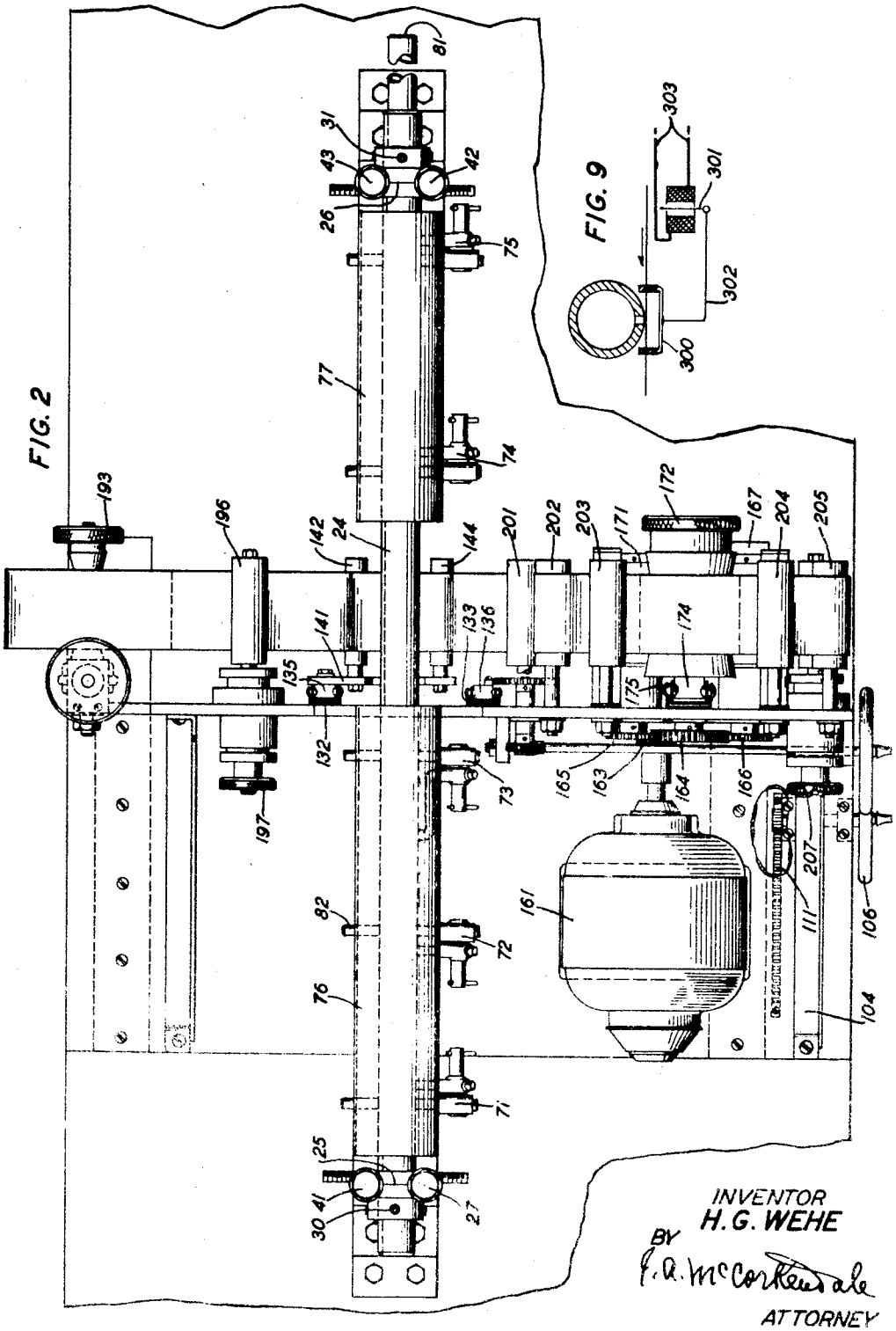

FIG. 9

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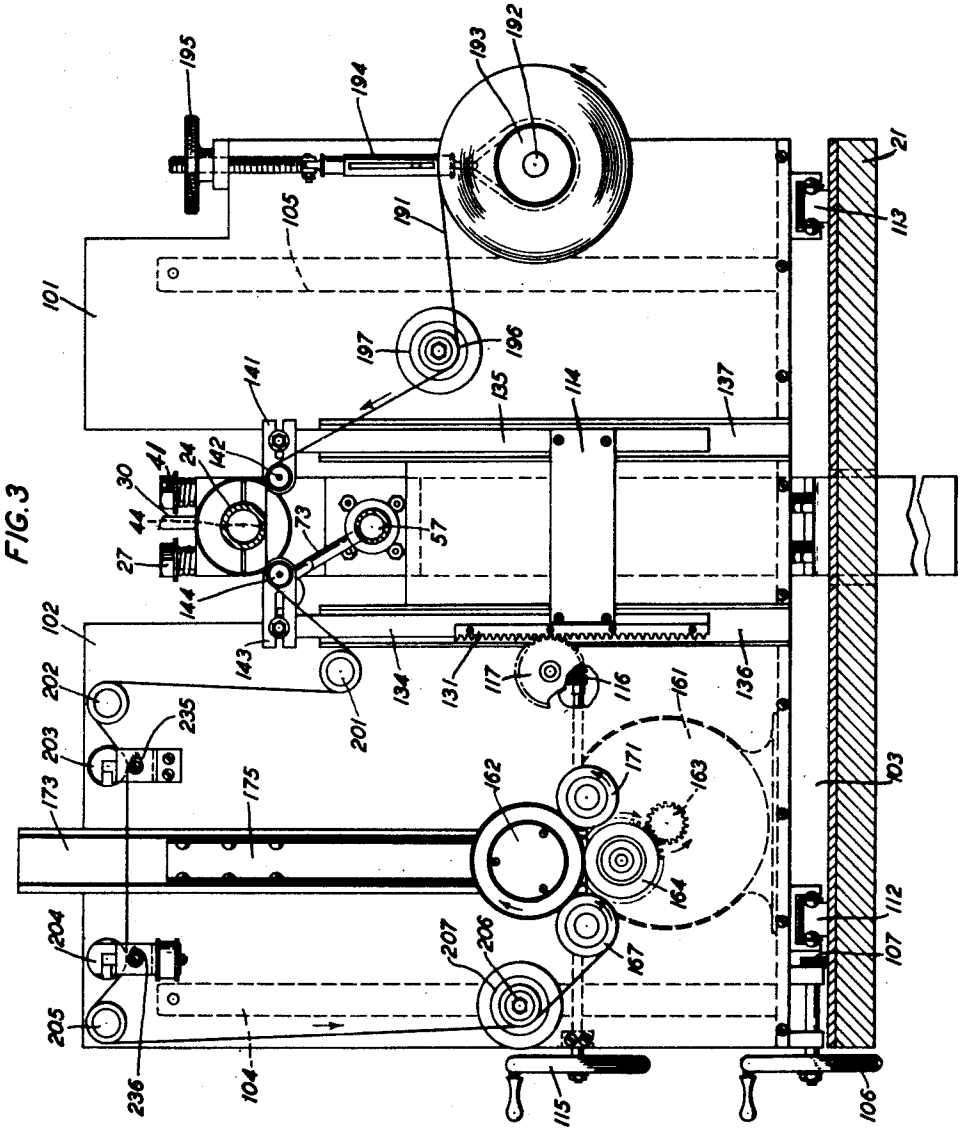
FIG. 3



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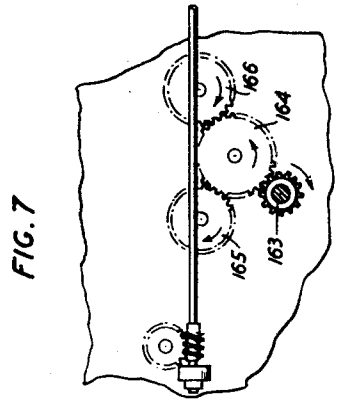

FIG. 7

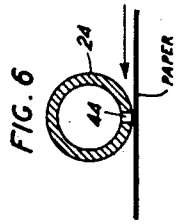

FIG. 6

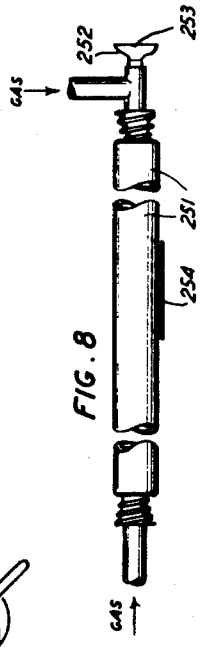

FIG. 8

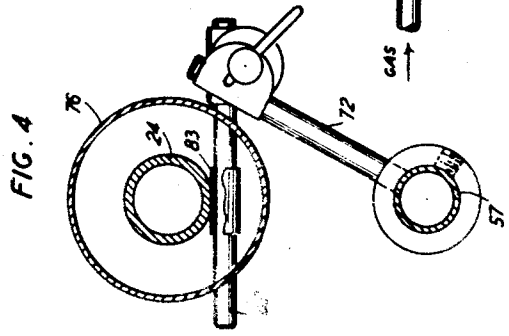

FIG. 4

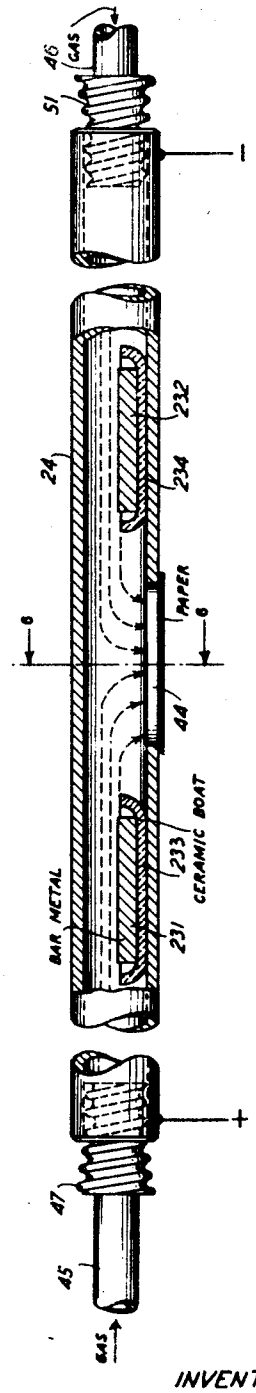

FIG. 5

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Patented Apr. 11, 1950

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UNITED STATES PATENT OFFICE

2,503,571

APPARATUS FOR COATING SURFACES BY THERMAL VAPORIZATION AT ATMOSPHERIC PRESSURE

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Application May 2, 1947, Serial No. 745,601

13 Claims. (Cl. 91—12.2)

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This invention relates to apparatus for applying metallic, semiconductor and non-metallic coatings to objects and more particularly to the application of such coatings by the thermal vaporization process.

An object of the invention is to facilitate the application of such coatings to objects and to improve the resulting product.

A more specific object of the invention is to achieve a practical, durable and efficient coating of metallic, semiconductor or non-metallic material by the thermal vaporization process carried out at atmospheric pressure, i. e., without the use of an evacuated chamber.

A feature of the invention is a vaporizer unit in the form of an elongated open-ended cylinder with an aperture in the wall thereof approximately mid-way between the ends for the emission of the vaporized coating material.

The successful use of practically all thermal vaporization coating arrangements of the prior art has, so far as applicant is aware, necessitated the provision of an evacuation chamber within which the coating process is carried out under conditions of reduced pressure. Provision of the evacuation chamber entails, of course, considerable expense and trouble and the advantages resulting from abandonment of the evacuation chamber while retaining all the advantages of the prior method of thermal vaporization are, of course, obvious.

The arrangement of the present invention renders feasible the attainment of an entirely satisfactory coating by the thermal vaporization process carried out at atmospheric pressure, i. e., without the requirement of an evacuation chamber.

In accordance with a specific embodiment of the invention, a coating apparatus is provided which utilizes a vaporizer unit in the form of an elongated, open-ended metallic tube, the tube being provided with a slot or slots in one wall mid-way between the two ends. The material to be coated, which may be paper for example, is movably supported in proximity to the slot. The coating material is placed within the tube being supported in suitable "boats" or placed in direct contact with the wall of the tube. Means are included for heating the tube to a sufficiently high temperature to vaporize the material as well as means for introducing an inert reducing, or oxidizing or other suitable gas or a combination of such gases through the open ends of the tube. During use the tube is heated to vaporize the material, and the gas, which is blown in

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through the open ends of the tube, carries the vaporized material out through the slot in the tube and onto the paper or other body being coated which is moved along in proximity to the slot.

According to a modification of the invention a vibratile diaphragm is operated in conjunction with the vaporizer unit to produce a coating in the form of a modulated sound record.

A full understanding of the arrangement contemplated by the present invention and appreciation of the various advantageous features thereof may be gained from consideration of the following detailed description and the accompanying drawings in which:

Fig. 1 is a side elevation view of a coating apparatus embodying features of the present invention;

Fig. 2 is a top view of the apparatus of Fig. 1;

Fig. 3 is a view taken on lines 3—3 of Fig. 1 showing particularly the upright supporting frame and the various guiding means for the material being coated;

Fig. 4 is a sectional view taken on lines 4—4 of Fig. 1 showing particularly the auxiliary support for the vaporizer unit;

Fig. 5 is a detail view, in partial section, of the vaporizer unit;

Fig. 6 is a sectional view, taken on lines 6—6 of Fig. 5, showing the relationship of the paper tape and the vaporizer slot;

Fig. 7 is a view taken on lines 7—7 of Fig. 1 showing details of the take-up reel drive;

Fig. 8 shows a modification of the vaporizer whereby the coating may be applied in the form of a modulated sound record; and

Fig. 9 shows another modification of the arrangement utilized in production of such a record.

Referring now to the drawings, a coating machine is illustrated which includes a base member 21 of suitable material, upon which are mounted upright support members 22 and 23. Cylindrical vaporizer 24 (shown schematically in Fig. 5) of a suitable metal or metal alloy is supported by members 22 and 23, (as shown particularly in Fig. 1) being held in position thereon by respective collars 25 and 26 (Fig. 2); the collars, in turn are secured to members 22 and 23 by machine bolts 27 and 41 and 42 and 43, respectively. This method of supporting vaporizer 24 permits ready rotation thereof about its horizontal axis merely by releasing collars 25 and 26. This rotation is facilitated by the provision of members 30 and 31 which are secured to vaporizer 24.

Vaporizer unit 24 is in the form of an elongated cylinder provided with a slot 44 (Fig. 5) in one wall thereof mid-way between the two open ends thereof. Gas-tight connections of hoses 45 and 46 (through which a reducing or neutral gas, or a combination of reducing and neutral gases is supplied under pressure in a manner and for a purpose to be described subsequently) are made to the respective open ends of vaporizer 24 by suitable connecting members 47 and 51. A suitable electrical source (low voltage, high amperage) for example a storage battery for heating vaporizer 24 is connected across electrodes 52 and 53 (Fig. 1). These electrodes pass through apertures 54 and 55 provided in base 21 and are insulated from said base by insulating member 56; the electrodes are electrically connected to the conductive portions of upright supports 22 and 23 through which the electrical energy is supplied directly to vaporizer 24.

Upright supports 22 and 23 also serve to support a horizontal, hollow supporting bar 57 from which, in turn, are supported brackets 71, 72, 73, 74 and 75. These brackets support jackets 76 and 77 which surround, and are spaced from, vaporizer 24. These jackets serve to trap heat radiated from the outer surface of vaporizer 24 and to reflect the heat back onto the surface of the vaporizer thereby aiding materially in quickly bringing the vaporizer up to the desired temperature and in maintaining such temperature during the vaporization process. It is contemplated also that, when it becomes desirable to cool the vaporizer rapidly, air or other cooling mediums may be forced into jackets 76 and 77 by suitable means to facilitate this; for example, the tubular portions of the brackets may be hollow and in communication with the interior of rod 57 and the interior of the jackets whereby air may be supplied through end 81 of rod 57 and through the respective brackets to the interior of the jackets.

While jackets 76 and 77 are illustrated as being of respectively different lengths, it is contemplated that jackets of equal length will usually be employed, i. e., either the "long" jackets 76 or the "short" jackets 77 as occasion demands.

Brackets 71, 72, 73, 74 and 75 in addition to supporting jackets 76 and 77 also provide additional support for vaporizer 24 at points removed from the points of support by members 22 and 23. Fig. 4 illustrates the manner in which this additional support is provided by bracket 72; this is typical of all of the brackets. Bracket 72, as illustrated, supports a horizontally extending bar 82 which passes through jacket 76 and is positioned adjacent to the under surface of vaporizer 24 thereby providing additional support for the latter. Actual electrical contact between the vaporizer and bar is prevented by insulating bushing 83.

The material to be coated, in the embodiment illustrated a long strip of paper, is supported and guided by a series of rollers, to be described subsequently, which, in turn, are mounted on an upright frame arrangement comprising, in general, two rectangular members 101 and 102 (Fig. 3). Members 101 and 102 are mounted, in turn, on base member 103 (Fig. 1), braces 104 and 105 (Figs. 1 and 3) being provided to assure rigidity. Base 103 may be moved laterally with respect to main base 21 through the medium of hand wheel 106 and associated pinion gear 107 and rack 111 (Figs. 1 and 3) whereby

to move the upright frame and the paper carried thereby laterally with respect to the vaporizer 24. To facilitate this movement base 103 is provided with ball bearing races 112 and 113 (Fig. 3).

In addition to the lateral motion just referred to, a central panel portion 114 (Fig. 3) is movable vertically with respect to vaporizer 24 through the medium of hand wheel 115 and associated pinion gears 116 and 117 and rack 131 (Fig. 3); to facilitate this latter movement, panel section 114 is provided with ball bearing races 132 and 133 (Fig. 2). The respective end members 134 and 135 are movably positioned in channel end portions 136 and 137 of frame members 102 and 101 respectively; rack 131 is attached to end member 134.

Provision of means for attaining this combined vertical and lateral movement obviously permits the paper to be dropped down from engagement with the slot of vaporizer 24 and/or to be moved laterally with respect thereto as desired as will be later pointed out in greater detail.

End member 135 supports a horizontal extension arm 141 which, in turn, supports rotatable paper guide 142; similarly end member 134 supports horizontal extension arm 143 which, in turn, supports rotatable paper guide 144 (Figs. 2 and 3).

Drive motor 161 is also supported on base 103 and serves to drive through a friction coupling, paper take-up roller or reel 162. Pinion gear 163 of motor 161 rotates counter-clockwise and engages drive gear 164 to cause rotation thereof in a clockwise direction (as seen in Fig. 3 or counter-clockwise as seen in Fig. 7). Gear 164, in turn, drives gears 165 and 166 which are connected by respective shafts to drive rollers 167 and 171. Take-up reel 162 is frictionally engaged by drive rollers 167 and 171 and is rotated thereby in a clockwise direction (as seen in Fig. 3).

Take-up reel 162 is mounted on its shaft by an arrangement adjustable by means of knurled hand nut 172 (Figs. 1 and 2) which clamps the cardboard core upon which the plated paper is wound.

As shown particularly in Fig. 3, an upright channel member 173 is mounted on frame member 102; roller carrying member 174 is positioned in channel member 173 and is vertically movable therein, ball bearing race 175 (Figs. 3 and 2) being provided to facilitate this movement.

The paper tape to be coated, 191, is carried on supply roll or reel 192 (Fig. 3). Reel 192 is mounted on its shaft through an adjustable arrangement, the restraining friction of which may be adjusted by means of knurled hand nut 193 (Fig. 2). A Prony brake mechanism 194 (Fig. 3) is also provided the restraining effect of which may be adjusted by means of knurled hand nut 195. The paper tape then passes under guide roller 196; roller 196 is mounted on frame 101 by an adjustable arrangement the alignment of which may be fixed by rotation of knurled hand nut 197 (Fig. 2).

Tape 191 next passes over guide rollers 142 and 144 which, as shown particularly in Fig. 3, serve to hold the paper smoothly and in close proximity to slot 44 of vaporizer unit 24. The paper tape then passes under guide roller 201, over guide roller 202, under guide and measuring rollers 203 and 204, over guide roller 205 and around side guide roller 206. Roller 206 is mounted in a manner similar to that of 196, the alignment of the mounting being adjustable

through operation of knurled hand nut 207 (Figs. 2 and 1). This arrangement whereby the restraining effect of the guide rollers at two key points may be fixed aids materially in attaining a smooth motion of the paper.

The paper next passes under roller 167, which, in addition to serving as a guide, also aids in driving take-up reel 162 as set forth above, and is then wound upon take-up reel 162.

As the paper builds up on take-up reel 162, the effective outside diameter thereof with respect to drive rollers 167 and 171 will, of course, increase. Accordingly, take-up reel 162 is so mounted that the entire assembly may rise in channel member 174 as its effective diameter increases. Firm driving engagement with drive rolls 167 and 171 is, of course, maintained through gravity.

Considering now the actual operation of the coating apparatus, let us assume that the vaporizer unit 24 is "loaded" with the coating material which, in this instance, we will assume is cadmium. Bars 231 and 232 of the metal are placed within the vaporizer tube (Fig. 5) being supported therein adjacent to slot 44 by ceramic boats 233 and 234. While the use of ceramic boats has been shown, it will be understood that other methods of support may be utilized, for example, the coating material may be positioned in suitable depressions formed in the wall of the vaporizer.

Supply reel 192 is now "loaded" with the paper tape to be coated which is threaded through the machine as described above, the hand wheels being so adjusted that the paper is removed several inches from slot 44. A suitable inert or reducing gas, for example hydrogen, (or a combination of inert and reducing gases) is now supplied under pressure to the vaporizer unit through hoses 45 and 46, the gas sweeping through the vaporizer and passing out through slot 44.

The electrical potential is now applied across electrodes 52 and 53 and the vaporizer heated to a temperature at which it glows with a dull red color; the escaping gas is now ignited.

When the metal vapor is observed emerging from slot 44 in an abundant quantity, the flow of gas is accelerated, through adjustment of the supply means, and motor 161 is set into operation to cause movement of the paper over the path described above. The paper is moved at a speed sufficiently high to prevent it being ignited by the escaping gas, for example it may be moved at a speed of the order of 300 to 400 feet per minute.

Hand wheels 106 and 115 are now operated to bring the paper into proximity to slot 44, usually from $\frac{1}{32}$'' to $\frac{1}{16}$'' away from the slot. The vaporized metal sweeping out through slot 44 is deposited on and solidifies upon the paper tape as it moves along past the slot.

The lateral position of the paper may be adjusted to obtain a properly located coating area thereon, while adjustments in the spacing of the paper from the slot, the speed at which the tape is moved, the flow of gas and the temperature of the vaporizer may be made as desirable. The vaporizer may be rotated, as described above, whereby to obtain the most efficient coating action; this usually is attained when the vaporizer is so positioned that the path of the paper travel is perpendicular to slot 44.

It has been observed that a better quality of coating is usually obtained if the gases sweeping out through slot 44 are actually ignited, as pointed out above, and the paper tape passed through the flame. While the paper tape is actually passed through the flame, therefore, it has been found that it is not ignited or damaged thereby particularly if the motion of the paper tape is fairly rapid and if the flame is kept away from the two edges thereof. Applicant has observed further that excellent coating results are obtained if the unburnt gases in the core of the flame act as a protective blanket for the coating until solidification thereof occurs. Adequate metal depositions have been obtained at both the tip and at the core of the flame.

As pointed out above, the provision of reflecting jackets 76 and 77 aids in maintaining vaporizer 24 at the proper temperature for vaporization of the metal during the coating process.

The quality of the resulting coating may be continuously observed during the coating process by observing the electrical resistance thereof between selected portions of the coated tape. In the embodiment illustrated this may be accomplished by measuring the resistance of the tape (which is electrically insulated from the frame of the apparatus) between guide rollers 203 and 204 (Fig. 3). To facilitate this measurement terminals 235 and 236 are provided. Terminal 235 is electrically connected to roller 203 and terminal 236 is electrically connected to roller 204; rollers 203 and 204, in turn, make electrical contact directly with the metallic coating of paper tape 191 contacted thereby. To observe the electrical resistance (and therefore, the adequacy of the coating) it is merely necessary to connect an ohmmeter across terminals 235 and 236; in accordance with usual practice the ohmmeter normally supplies its own current.

After a desired length of paper tape has been coated, the paper tape may be quickly removed from contact with the heated vaporizer by operation of hand wheel 115 to lower panel 114 and also, if desired, by operation of hand wheel 106 to move the entire sub-base assembly laterally. After removal of the heating potential the temperature of the vaporizer unit may be quickly lowered by supplying a suitable cooling medium, such as air, to the interior of jackets 76 and 77.

For some purposes, for example, in the preparation of condenser dielectrics, it will be found desirable to apply the coating to the central area of the material and to leave the edges thereof uncoated. Desired patterns of coating may be obtained by masking or by precoating portions of the material which are to remain free of the metal coating with a material having a low coefficient of absorption with respect to the metallic vapor; for example a suitable oil may be utilized for this purpose.

There is illustrated in Fig. 8 a modification of the vaporizer unit whereby the coating may be applied in the form of a modulated sound record. In this instance it is contemplated that the general arrangement and operation will be as described above. A funnel-like arrangement 252 is inserted in one end of the vaporizer 251 through a suitable gas-tight coupling, the larger end of the funnel being closed by a flexible diaphragm 253. Applicant has discovered that, if the coating process proceeds as before while the diaphragm is vibrated by the speech or other sounds to be recorded, the coating metal will be deposited on carrier 254 accordingly as the diaphragm is vibrated. This record may subsequently be reproduced by methods well known in the art, for

example by passing light through the moving recorded vibration pattern to a photoelectric cell the output of which is connected to an amplifier and loudspeaker.

Referring now to Fig. 9 a further modification of the invention is disclosed in accordance with which the position of the paper with respect to the slot is modulated in accordance with the output of a loudspeaker. A guide member **300** is provided through which the paper tape passes freely in a lateral direction adjacent to slot **44** of vaporizer unit **24**. The vertical distance with respect to slot **44** is varied however in accordance with the vibrations of loudspeaker armature **301**, joined to guide **300** by lever **302**, whereby to result in a coating on the paper which is modulated in accordance with the varying currents supplied to the loudspeaker over line **303**.

The arrangement contemplated by the present invention has been conclusively proven to be capable of producing an even, low resistance coating fully comparable in quality to the coatings produced by machines of the prior art which operate at reduced pressures and necessitate the expense and trouble of providing an evacuation chamber. Major factors in the successful performance of applicant's novel arrangement reside in the fact that the vaporizer itself is directly heated, that the coating material is contained thereby adjacent to the point of exit and that the paper or other material to be coated is kept closely adjacent to the vaporizer slot thereby providing a very short path of travel for the vapor before it impinges upon the material to be coated. In view of the fact that the vaporizer itself is heated, the slot or other orifice is of course hot and does not tend to clog. For any given heating amperage the location of the coating metal within the vaporizer with respect to the slot determines the amount of vapor generated, the extent of preheating of the sweep gases and the extent of superheating of the vapor before discharge through the slot.

While the provision of a single horizontal slot has been illustrated, it will be obvious that more than one such slot may be provided and, further, that apertures of different shapes and relative directions may be utilized as occasion demands.

The fact that the vaporizer is rotatably supported permits the stream of vapor to be directed in any desired direction with respect to the object being coated. The lateral movement provided for the paper carrying assembly permits easy adjustment with respect to the emerging vapors whereby to attain unplated borders or edges as desired. Further, if desired, the vaporizer unit may itself be shifted laterally with respect to the position of the material being coated.

If desired, lagging may be utilized to reduce heat loss instead of the reflecting drums illustrated and it will be obvious that all such heat loss preventing means may be omitted entirely where purposes of simplicity are paramount. A water jacket may also be provided for cooling the vaporizer at completion of the process if desired.

While the arrangement has been described above in connection with coating a tape, it will be obvious that other types of objects may be coated in the same general manner. For example, rectangular piezoelectric plates may be coated by the apparatus in which instance an endless, movable belt may be utilized for moving the objects past the slot. It will be obvious also that, while coating with metal has been referred to, the method is applicable as well in connection with semiconductors and non-metallic materials of various types.

The embodiments of the invention selected for detailed description above should be looked upon as illustrative and not as restrictive.

What is claimed is:

1. Apparatus for coating a surface of an object with a vaporizable material by the process of thermal vaporization at atmospheric pressure comprising a vaporizer in the form of an elongated, open-ended cylinder having an aperture in the wall thereof approximately mid-way between the ends, means for supporting said vaporizer in a horizontal position, means for supporting a supply of the coating material within said vaporizer in proximity to the aperture, means for heating said vaporizer to a sufficiently high temperature to vaporize the coating material, means for moving the object to be coated past the aperture and in close proximity thereto and means for introducing an inert gas under pressure into said vaporizer through the ends thereof.

2. Apparatus for coating a surface of an object with a vaporizable material by the process of thermal vaporization at atmospheric pressure comprising a vaporizer in the form of an elongated, open-ended cylinder having an aperture in the wall thereof approximately mid-way between the ends, means for supporting said vaporizer in a horizontal position, means for supporting a supply of the coating material within said vaporizer in proximity to the aperture, means for heating said vaporizer to a sufficiently high temperature to vaporize the coating material, means for moving the object to be coated past the aperture and in close proximity thereto and means for introducing a reducing gas under pressure into said vaporizer through the ends thereof.

3. Apparatus for coating a surface of an object with metal by the process of thermal vaporization at atmospheric pressure comprising a vaporizer in the form of an elongated, open-ended cylinder having an aperture in the wall thereof approximately mid-way between the ends, means for supporting said vaporizer in a horizontal position, means for supporting a supply of the coating metal within said vaporizer in proximity to the aperture, means for heating said vaporizer to a sufficiently high temperature to vaporize the coating metal, means for moving the object to be coated past the aperture and in close proximity thereto and means for introducing a combination of inert and reducing gases under pressure into said vaporizer through the ends thereof.

4. Apparatus for coating a surface of an object with a coating material by the process of thermal vaporization at atmospheric pressure comprising a vaporizer in the form of an elongated, open-ended cylinder having an aperture in the wall thereof between the ends, means for supporting said vaporizer in a horizontal position, a cylindrical jacket, means for supporting said jacket in a position surrounding and spaced from said vaporizer, said last-mentioned supporting means being effective also to provide additional support for said vaporizer, means for supporting a supply of the coating material within said vaporizer in proximity to the aperture, means for heating said vaporizer to a sufficiently high temperature to vaporize the coating material, means for moving the object to be coated past the aperture and in close proximity thereto and means for introducing a gas under pressure into said vaporizer through the ends thereof.

5. Apparatus for coating a surface of an object with a vaporizable material by the process of thermal vaporization at atmospheric pressure comprising a vaporizer in the form of an elongated, open-ended cylinder having an aperture in the wall thereof approximately mid-way between the ends, means for supporting said vaporizer in a horizontal position, ceramic boats positioned within said vaporizer in proximity to the aperture for supporting a supply of the coating material, means for heating said vaporizer to a sufficiently high temperature to vaporize the coating material, means for moving the object to be coated past the aperture and in close proximity thereto and means for introducing an inert gas under pressure into said vaporizer through the ends thereof.

6. Apparatus for coating a surface of an object with a coating material by the process of thermal vaporization at atmospheric pressure comprising a vaporizer in the form of an elongated, open-ended cylinder having an aperture in the wall thereof between the ends, means for supporting said vaporizer in a horizontal position, said vaporizer having depressed portions in the wall thereof in proximity to the aperture for holding a supply of the coating material, means for heating said vaporizer to a sufficiently high temperature to vaporize the coating material, means for moving the object to be coated past the aperture and in close proximity thereto and means for introducing an inert gas under pressure into said vaporizer through the ends thereof.

7. Apparatus for coating a surface of a tape with metal by the process of thermal vaporization at atmospheric pressure comprising a first base member, a vaporizer in the form of an elongated, open-ended tube having a slot in a wall thereof between said ends, means for supporting said vaporizer from said base member, means for supporting a supply of the coating metal within said vaporizer in proximity to the slot, means for heating said vaporizer to a sufficiently high temperature to vaporize the coating metal, a second base member supported on said first base member, a supply reel for holding a quantity of tape to be coated, a take-up reel for withdrawing tape from said supply reel, means for rotatably supporting said take-up reel from said second base member, driving means for said take-up reel, means for supporting said driving means from said second base member, guide means supported from said second base member for guiding the tape at a point between said supply reel and said take-up reel into a position wherein it is closely adjacent to the slot in said vaporizer, means for moving said second base member with respect to said first base member whereby to correspondingly move said tape with respect to said vaporizer, and means for introducing a gas under pressure into said vaporizer through the ends thereof.

8. Apparatus for coating a surface of a tape with metal by the process of thermal vaporization at atmospheric pressure comprising a first base member, a vaporizer in the form of an elongated, open-ended tube having a slot in a wall thereof between said ends, means for supporting said vaporizer from said base member, means for supporting a supply of the coating metal within said vaporizer in proximity to the slot, means for heating said vaporizer to a sufficiently high temperature to vaporize the coating metal, a second base member supported on said first base member, a supply reel for holding a quantity of tape to be coated, a take-up reel for withdrawing tape from said supply reel, means for rotatably supporting said take-up reel from said second base member, driving means for said take-up reel, means for supporting said driving means from said second base member, an upright member supported from said second base member, guide means mounted on said upright member for guiding the tape at a point between said supply reel and take-up reel into a position wherein it is closely adjacent to the slot in said vaporizer, means for moving said second base member with respect to said first base member whereby to move said tape laterally with respect to said vaporizer, means to move said upright member with respect to said base members whereby to move said tape vertically with respect to said vaporizer, and means to introduce a gas under compression into said vaporizer through the ends thereof.

9. Apparatus for coating a surface of a tape with metal by the process of thermal vaporization at atmospheric pressure comprising a vaporizer in the form of an elongated, open-ended cylinder having an aperture in the wall thereof approximately midway between the ends, means for supporting said vaporizer in a horizontal position, means for supporting a supply of the coating metal within said vaporizer in proximity to the aperture, means for heating said vaporizer to a sufficiently high temperature to vaporize the coating metal, an assembly including a tape supply reel, a tape take-up reel, a drive for said take-up reel and guiding means whereby to move the tape being coated from the supply reel, past the slot in said vaporizer to the take-up reel, means for moving said assembly laterally with respect to said vaporizer, means for moving a portion of said assembly including said guiding means vertically with respect to said vaporizer, and means for introducing a gas under pressure into said vaporizer through the ends thereof.

10. Apparatus for coating a surface of an object with metal by the process of thermal vaporization at atmospheric pressure comprising a vaporizer in the form of an elongated, open-ended cylinder having an aperture in the wall thereof approximately midway between the ends, means for supporting said vaporizer in a horizontal position, means for supporting a supply of the coating metal within said vaporizer in proximity to the aperture, means for heating said vaporizer to a sufficiently high temperature to vaporize the coating metal, means for moving the object to be coated past the aperture and in close proximity thereto, means for introducing a gas under pressure into said vaporizer through one end thereof, and a vibratile diaphragm forming a portion of a wall of said vaporizer.

11. Apparatus for coating a surface of an object with metal by the process of thermal vaporization at atmospheric pressure comprising a vaporizer in the form of an elongated, open-ended cylinder having an aperture in the wall thereof between the ends, means for supporting said vaporizer in a horizontal position, a cylindrical jacket, means for supporting said jacket in a position surrounding and spaced from said vaporizer, said last-mentioned supporting means being effective also to provide additional support for said vaporizer, means for supporting a supply of the coating metal within said vaporizer in proximity to the aperture, means for

heating said vaporizer to a sufficiently high temperature to vaporize the coating metal, means for moving the object to be coated past the aperture and in close proximity thereto, means for introducing a gas under pressure into said vaporizer through the ends thereof and means for supplying a cooling medium to the space between said vaporizer and the surrounding jacket.

12. Apparatus for coating a surface of a tape with metal by the process of thermal vaporization at atmospheric pressure comprising a vaporizer in the form of an elongated, open-ended cylinder having an aperture in the wall thereof approximately mid-way between the ends, means for supporting said vaporizer in a horizontal position, means for supporting a supply of the coating metal within said vaporizer in proximity to the aperture, means for heating said vaporizer to a sufficiently high temperature to vaporize the coating metal, means for moving the tape to be coated past the aperture and in close proximity thereto, means for introducing an inert gas under pressure into said vaporizer through the ends thereof, and means for continuously measuring the electrical resistance of the coating applied to said surface.

13. Apparatus for coating a surface of a tape with metal by the process of thermal vaporization at atmospheric pressure comprising a first base member, a vaporizer in the form of an elongated, open-ended tube having a slot in a wall thereof between said ends, means for supporting said vaporizer from said base member, means for supporting a supply of the coating metal within said vaporizer in proximity to the slot, means for heating said vaporizer to a sufficiently high temperature to vaporize the coating metal, a second base member supported on

said first base member, a supply reel for holding a quantity of tape to be coated, a take-up reel for withdrawing tape from said supply reel, means for rotatably supporting said take-up reel from said second base member, driving means for said take-up reel, means for supporting said driving means from said second base member, guide means supported from said second base member for guiding the tape at a point between said supply reel and said take-up reel into a position wherein it is closely adjacent to the slot in said vaporizer, means for moving said second base member with respect to said first base member whereby to correspondingly move said tape with respect to said vaporizer, and means for introducing a gas under pressure into said vaporizer through the ends thereof, said means for rotatably supporting said take-up reel from said second base member being arranged to permit vertical movement, between limits, of said take-up reel with respect to said second base member.

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