April 20, 1954 D. W. BARKLEY 2,676,114

METHOD OF PRODUCING GRADED COATINGS

Filed June 8, 1951 4 Sheets-Sheet 1

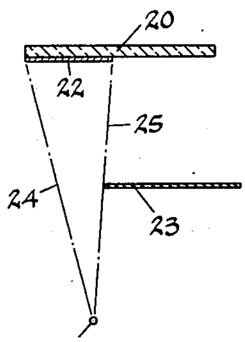


Fig. 1

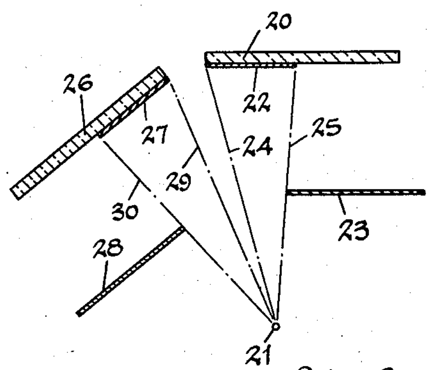


Fig. 2

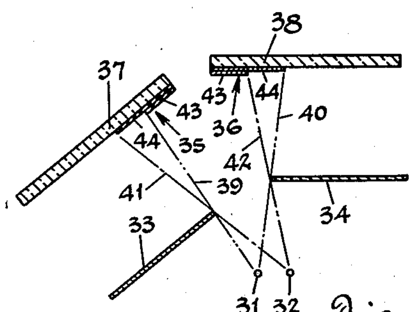


Fig. 3

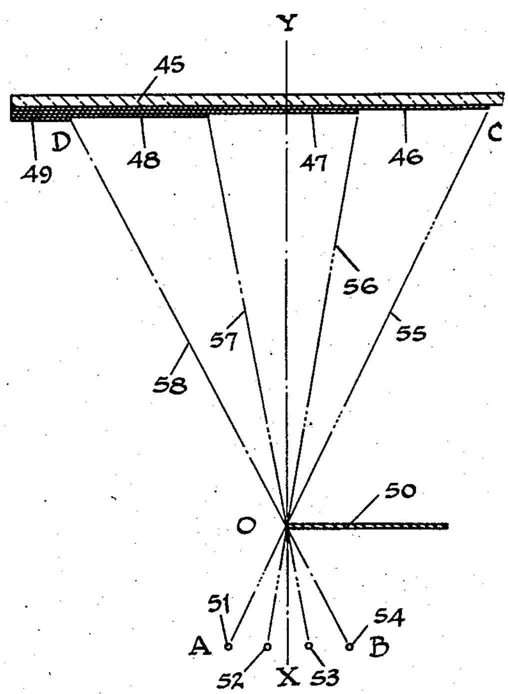


Fig. 4

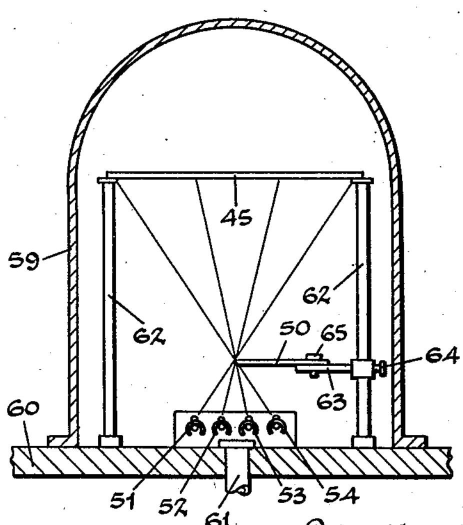


Fig. 5

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METHOD OF PRODUCING GRADED COATINGS

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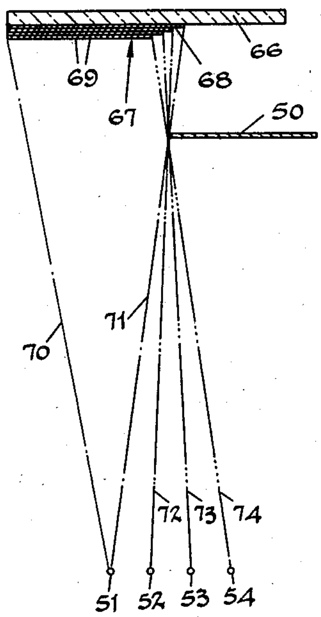


Fig. 6

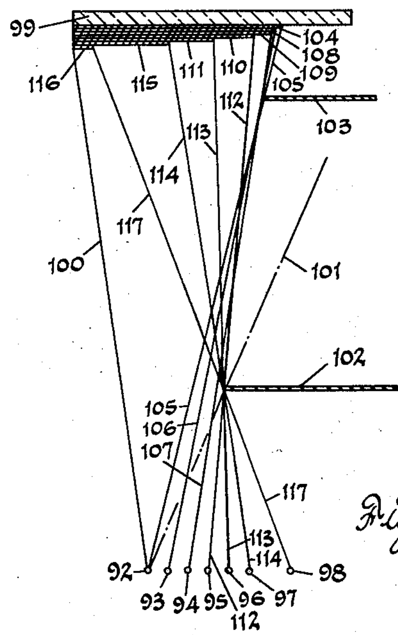


Fig. 9

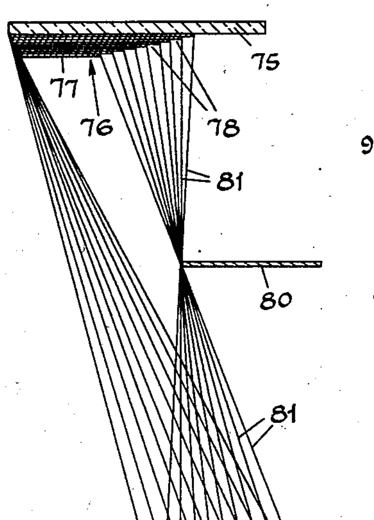


Fig. 7

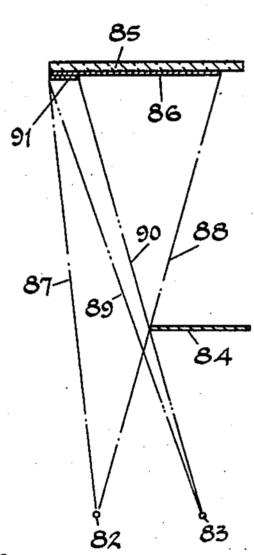


Fig. 8

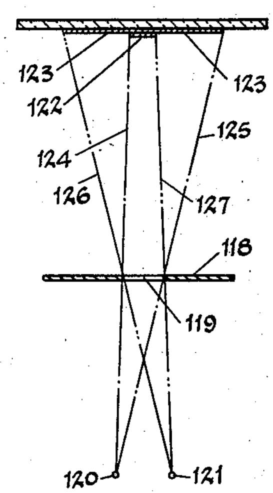


Fig. 10

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METHOD OF PRODUCING GRADED COATINGS

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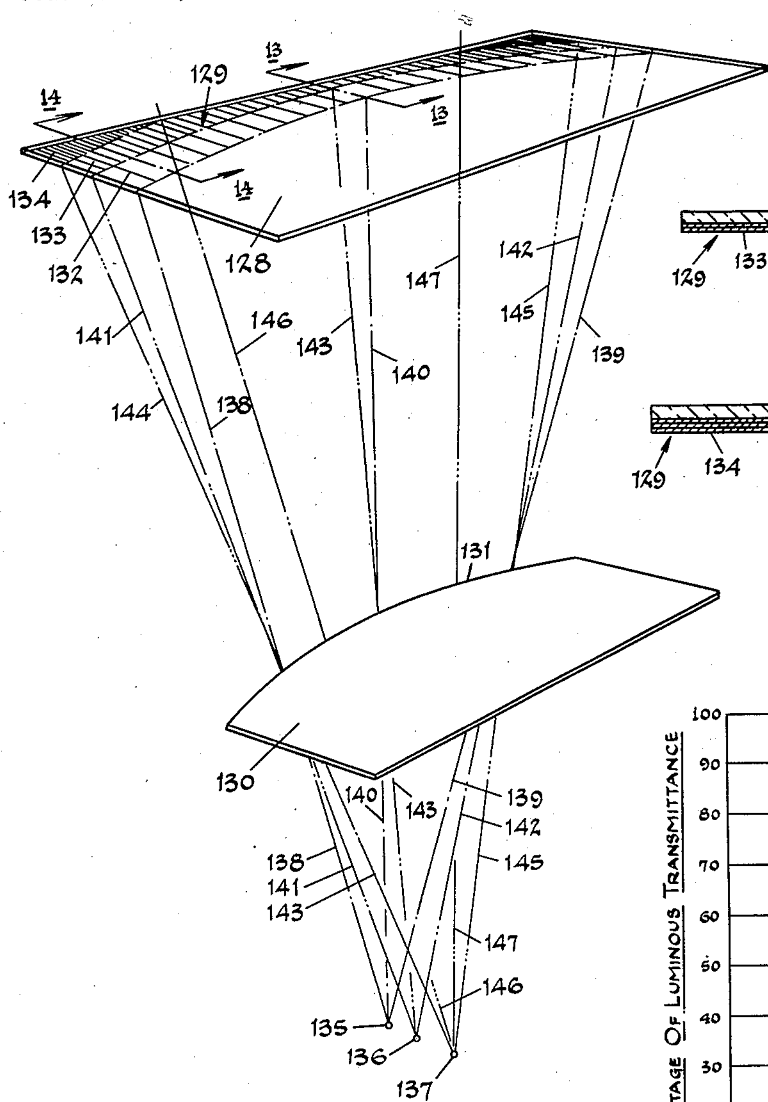


Fig. 12

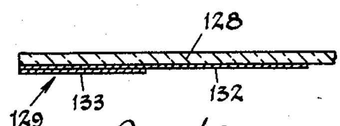


Fig. 13

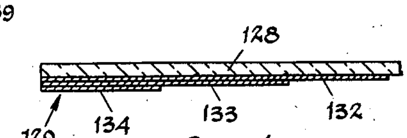


Fig. 14

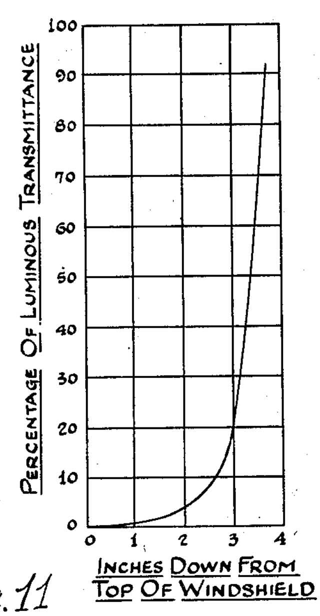


Fig. 11

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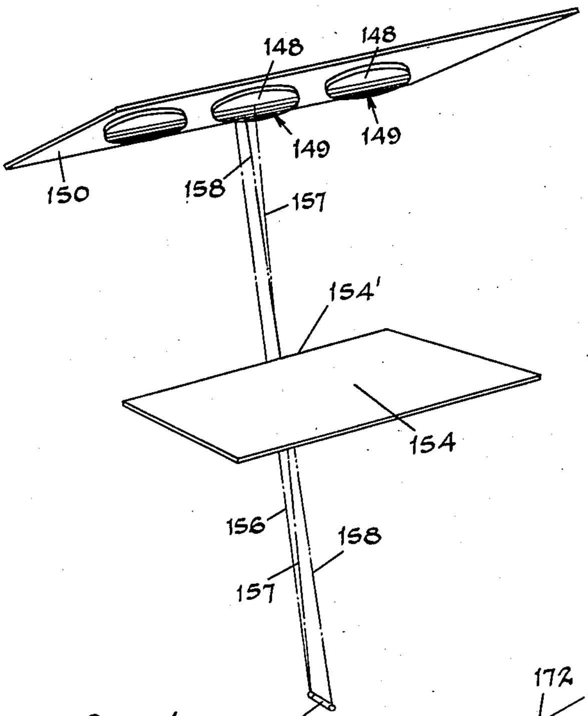


Fig. 15

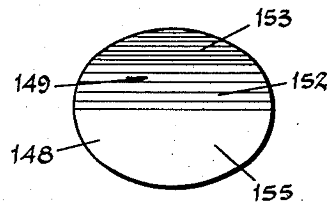


Fig. 16

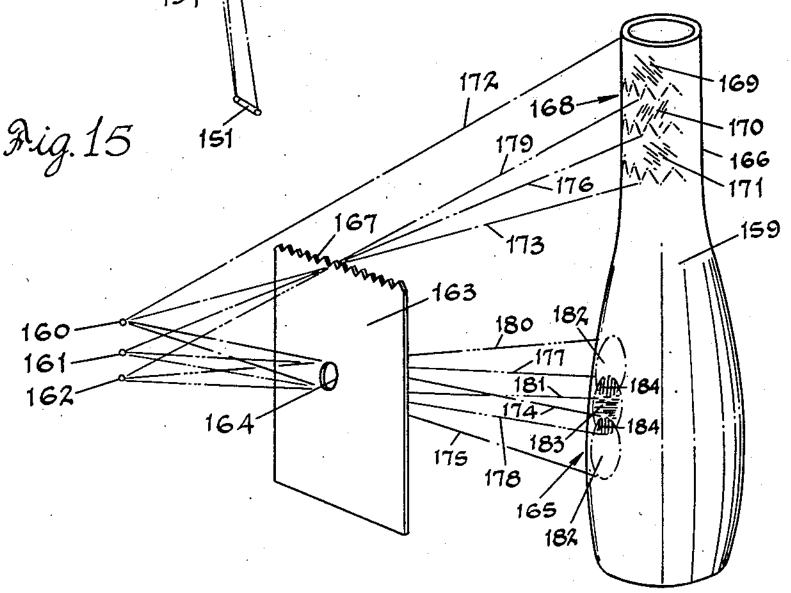


Fig. 17

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Patented Apr. 20, 1954 2,676,114

# UNITED STATES PATENT OFFICE

2,676,114

## METHOD OF PRODUCING GRADED COATINGS

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Application June 8, 1951, Serial No. 230,583

6 Claims. (Cl. 117—38)

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The present invention relates broadly to the surface coating of glass or plastic and more particularly to an improved method of producing a graded coating upon a base or support body by thermal evaporation.

It is an aim of this invention to provide such a method wherein coatings of predetermined width and gradation can be deposited upon the glass or other support body by thermal evaporation without the use of movable shields as has been customary in the past.

Another object of the invention is the provision of such a method wherein the depositing of a coating of predetermined width and graduation upon the glass or other support body is effected in a single evaporation cycle and is controlled by the use of one or more stationary shields positioned at a predetermined location between the support body and the source of evaporation of the material to be laid down.

Generally stated, the method of this invention comprises locating the support body of glass or other material to be coated in a vacuum chamber facing a plurality of independent sources of material to be evaporated spaced from one another and corresponding in number to the desired number of graded areas to be produced. A hypothetical line is then drawn diagonally between one end of the series of material evaporation sources and a point adjacent the diagonally opposite end of the area on the support body to be coated with the graded film, a second hypothetical line is then drawn diagonally between the other end of the series of material evaporation sources and the diagonal opposite end of the graded area on said support body and which second line intersects the first line at a point between the support body to be coated and sources of evaporation. A stationary shield is then located at the point of intersection of the two hypothetical diagonal lines, after which the material from the several sources of evaporation are evaporated preferably simultaneously to produce in a single operation a graded coating upon the support body including areas of predetermined width and graduation dependent upon the number of sources of evaporation and the spacing thereof from one another.

Other objects and advantages of the method will be apparent from the following description when taken in connection with the accompanying drawings, wherein:

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Fig. 1 illustrates diagrammatically the depositing of a uniform coating upon a support body from a single source;

Fig. 2 illustrates diagrammatically the depositing of two coatings of uniform thickness upon two support bodies also from a single source;

Fig. 3 illustrates diagrammatically the depositing of graded coatings upon two support bodies from two sources of evaporation and employing the method of this invention to effect the grading of the respective coatings;

Fig. 4 is an enlarged view showing a method of producing a graded coating having four different thicknesses;

Fig. 5 is a vertical sectional view through an evaporation chamber used for carrying out the method of Fig. 4;

Fig. 6 is a diagrammatic view illustrating the depositing of a coating on a support body in which the graded areas are of relatively narrow width;

Fig. 7 illustrates diagrammatically the laying down of a graded coating from a continuous line source of evaporation and in which the line source is disposed at an angle with respect to the support body to thereby produce a substantially continuous grading;

Fig. 8 illustrates diagrammatically the formation of a graded coating from two sources of evaporation;

Fig. 9 is a diagrammatic view illustrating the formation of a graded coating employing two shields to produce two different types of gradings;

Fig. 10 illustrates diagrammatically the formation of a coating of relatively greater thickness at the center and graded outwardly therefrom employing a perforated shield;

Fig. 11 is a graph of the luminous transmittance of a glass sheet having a continuous graded coating of a character similar to that produced in accordance with Fig. 7;

Fig. 12 illustrates diagrammatically the formation of a graded coating on a window or windshield from three sources of evaporation and the use of a special shield;

Fig. 13 is a cross-sectional view taken substantially on line 13—13 of Fig. 12;

Fig. 14 is a similar cross-sectional view taken substantially on line 14—14 of Fig. 12;

Fig. 15 illustrates diagrammatically the formation of graded coatings upon a plurality of lenses;

Fig. 16 is a front view of a lens having a graded coating thereon; and

Fig. 17 illustrates diagrammatically the formation of graded coatings from three sources of evaporation to produce artistic and decorative effects upon bottles, jars, and the like.

With reference now to the drawings, and particularly to Fig. 1, there is shown diagrammatically a support body 20 which may consist of a sheet or plate of glass or plastic and a single source of evaporation 21 from which the material is evaporated upon the support body to form a coating 22 of uniform thickness throughout the entire width of said coating. The effective width of the coating 22 is controlled by the position of the stationary shield 23 located at a predetermined point between the support body 20 and source of material evaporation 21.

As is ordinarily true in producing thermally evaporated coatings, the degree of vacuum employed in performing the invention is such that the evaporated material travels out radially from the evaporation source in straight lines as indicated at 24 and 25 in Fig. 1 until it contacts the surface to be coated. Therefore, by moving the shield 23 to the left, the width of the coating 22 will be reduced whereas movement of the shield to the right will result in an increase in the width of said coating.

In Fig. 2 is illustrated the manner in which a second support body 26 can be provided with a separate coating 27 simultaneously with the coating of the support body 20. Coatings of respective uniform thickness can thus be obtained on two separate and properly arranged support bodies 20 and 26 from the single source of evaporation 21. The effective area of the material evaporated from the single source 21 is increased to effect the coating of the two glass bodies 20 and 26 by arranging the two bodies at an angle to one another and employing separate shields 23 and 28 respectively. The material evaporated from the source 21 is deposited upon the support bodies as coating 22 between lines 24 and 25 and coating 27 between similar lines 29 and 30. As in Fig. 1, the width of these coatings may be selectively varied by moving the shields 23 and 28 inwardly or outwardly.

It will be appreciated that the coatings laid down in either Fig. 1 or Fig. 2 are substantially uniform in thickness, particularly when the article being coated is located at a considerable distance from the evaporation source or filament carrying the material to be vaporized such that all points of the surface to be coated are substantially at the same distance away from the filament. In the following description and accompanying drawings, it is assumed that such conditions prevail and that the variation in thickness in the various areas or segments of graded films produced are in no way produced by variation in the distance of the article to be coated away from the filament. On the other hand, the graded films of this invention are produced by the employment of stationary shields associated with the filament and surface to be coated in a novel and improved manner.

Fig. 3 illustrates diagrammatically one form of the invention in which two spaced evaporation sources or filaments 31 and 32 are employed in connection with separate stationary shields 33 and 34 to deposit graded coatings 35 and 36 simultaneously on the two support bodies 37 and



38 respectively. As will be evident, the material evaporated from source 31 covers the area between lines 39 and 40, while the material from source 32 covers the area between lines 41 and 42. Thus, as will be seen from an inspection of Fig. 3, the material evaporated from the two sources 31 and 32 combines and overlaps so as to jointly deposit upon the inner marginal portion of each support body 37 and 38 the graded coatings 35 and 36 respectively, each having a relatively thick portion 43 and a contiguous relatively thinner portion 44.

In Fig. 4 is shown a method of producing upon the undersurface of a horizontally disposed support body 45 a graded deposit of four different thickness areas 46, 47, 48 and 49 by the use of a stationary shield 50 and four evaporation sources or filaments 51, 52, 53 and 54. As herein shown, the four filaments are arranged in alignment and each is spaced from the adjacent filament or filaments a distance which corresponds proportionately to the width of the coated areas in the graded film.

The shield 50 is placed at the intersection of a hypothetical line 55 drawn through the end filament 51 diagonally to the extreme outer edge of the coated area 46, with a similar line 56 drawn from the next adjacent filament 52 to the other end of the first graded area 46 and the beginning of the second graded area 47. The diagonal arrangement of these lines will be through the same coextensive intersection or loci of similar hypothetical lines 57 and 58 drawn through the other evaporation sources 53 and 54 to the successive limiting borders of the graded coated areas 47, 48 and 49 of progressively greater thicknesses.

The shield 50 is located at the intersection of hypothetical lines 55 and 58 drawn diagonally from the two extreme evaporation sources 51 and 54 to the limiting borders of the graded coated deposits, as for example the coated deposit in graded area 46 and the similar deposit in graded area 49. Specifically, the shield 50 is located at the intersection of a hypothetical line 55 drawn from an end evaporation source, such as filament 51, to the extreme edge of the thinnest coated area 46, with a similar line 58 drawn from the evaporation source most distant or fartherest away from the first evaporation source, such as the filament 54, and to the margin between the thickest coating 49 and the next thinnest coating 48.

Examination of Fig. 4 will show that where the plane of the surface being coated and the plane of the evaporation sources are substantially parallel that a simple geometric relationship is immediately apparent in that similar triangles can be envisioned by the use of the hypothetical lines. Thus, a hypothetical line X—Y considered as taken normal to both the plane of the surface to be coated and to the line of the evaporation sources provides immediate geometrical principles of similar triangles, such as triangles OAB and OCD. Thus, the portions OY and OX of the line X—Y are perpendicular to the bases of the triangles and are related to each other in a proportional manner the same as the bases of the two triangles are related proportionately, namely, as the distances A—B and C—D. Expressed simply, this is as follows:

$$\frac{OX}{OY}=\frac{AB}{CD}$$

It is also apparent that the sum of the two normals or perpendiculars is equal to the total distance from the plane of the filaments to the plane of the object to be coated; that is

$$OX+OY=XY$$

By solving for the distance at which the shield is to be located away from the object to be coated and substituting in the first equation, it is apparent that

$$OX=\frac{AB(XY-OX)}{CD}$$

$$OX=\frac{AB(XY)}{AB+CD}$$

Thus, by such calculation, employing the dimensions CD of the grading to be produced and the dimensions AB of a filament arranged to define the loci, the shields may be properly located. The shields may also be located very simply in practice by actually sighting along the suggested hypothetical lines.

In Fig. 5 is illustrated one type of apparatus which may be employed to carry out the method illustrated in Fig. 4, and the same numerals are used to designate the same parts. This apparatus includes a conventional evaporation chamber or bell jar 59 mounted upon a base 60 and being connected with a suitable source of vacuum through conduits 61. The four filaments or sources of evaporation are shown at 51, 52, 53 and 54 and each carries a charge of material to be evaporated. The support body 45 to be coated is carried in a horizontal position above the sources of evaporation in any desired manner such as by supporting it upon posts 62. The shield 50 can be secured to a bracket 63 slidably carried by one of the posts 62 for vertical adjustment and secured in place by thumb screw 64. The shield 50 may also be carried on the bracket 63 in such a manner that by means of a thumb screw 65 it can be adjusted laterally in a horizontal plane. The material to be evaporated may be a metal or it may be a non-metal such as to produce the desired properties in the coated product. Examples are aluminum, chromium, magnesium fluoride, and quartz.

In Fig. 6 is diagrammatically shown the use of the same four filaments 51 to 54 inclusive, spaced from one another and positioned with respect to the stationary shield 50 to produce on the undersurface of the support body 66 a coating 67 having a rather small graded area 68 along the inner marginal portion thereof in which the grading drops sharply through the layers 69 of different thicknesses. It will be seen that the only difference in the arrangement of parts to produce this type of coating as against widely spaced graded segments produced in Fig. 4 has been to move the shield 50 further away from the filaments 51 to 54 inclusive and closer to the plate 66 being coated, so that the coated area from the filament 51 will be between lines 70 and 71 while the gradings through the layers 69 will be produced according to the intersection of the lines 72, 73 and 74 at the shield 50 with the line 71.

It is therefore apparent that given a definite distance between extreme filaments, a desired width of grading, and a distance of evaporation from the evaporation sources to the object to be coated that there is only one locus at which the shield can be located. This locus can be determined as already described.

In Fig. 7 is shown diagrammatically a means of producing on the undersurface of the support body 75 a graded coating 76 in which the areas 77 of slightly different thickness are of relatively narrow width and of such gradual change in thickness as to produce a continuous graded area or sloping surface 78. This is accomplished by introducing a large number of evaporation sources 79 which are closely adjacent one another or preferably the use of an evaporation source of a continuous line type in which evaporation is occurring from all points along such line. This can be easily accomplished by the use of an electroplated filament wire coated with the desired material to be evaporated, or it can be provided by the use of a filament to which a material is applied which, when molten, is strongly wetting and spreads out over the entire surface and thus evaporates from all points on the filament such, for example, as aluminum or inconel on a tungsten filament.

While it is usually preferred that the line of the filament or filaments extends parallel to the plane of the surface of the support body being coated, this is not always necessary as shown in Fig. 7. The location of the shield 80 can be determined as before by the intersection of the hypothetical lines 81 carried through the filaments to the extreme edges of the graded area to be produced.

Where it is desired to produce deposits of a coating in graded areas which will have considerable width as in Fig. 4, the shield 50 may be positioned closer to the filaments and the deposits in such step graded areas will obviously be of a materially wider area than those shown, for example, in Fig. 6. However, where a distinct difference in area width is to be obtained, the filaments 82 and 83, as shown in Fig. 8, may be more widely spaced and the shield 84 positioned so that it will cut off a greater amount of the coating material directed toward the support body 85. Thus, the effective coating area 86 of the filament 82 is determined by the position of the shield and as between lines 87 and 88, while the effective coating area of the filament 83 is defined by lines 89 and 90 to form the coat 91. A graded coating is thus obtained wherein the thinner area 86 will be of substantial width in comparison to the thicker marginal area 91.

It will thus be apparent that the spacing between the adjacent evaporation sources and/or the total number of said sources will directly determine to a proportionate degree the spacing or width of the graded area.

In Fig. 9 is shown the production of a graded deposit having areas of differing width and consequently somewhat irregular although progressively controlled and of predetermined thicknesses, which graded areas may be produced by the use of two shields interposed between the evaporation sources and the support body to be coated. As will be noted, the filaments 92 to 97 inclusive are substantially equally spaced from each other, while the end filament 98 is spaced a relatively greater distance from the adjacent filament 97. As hereinbefore discussed, the effective width of the coating deposited on the support body 99 from the filaments 92 to 97 will, by reason of the equal spacing of these filaments, result in a series of graded areas of proportionately equal width. The first filament 92 would then normally deposit a coating between the lines 100 and 101, since the edge of the coated area would be established by the relative position of the shield 102 to the first filament 92. However, by interposing a second or auxiliary shield 103 between the shield 102 and support body 99, the edge of the area 104 normally determined by the line 101 will actually be cut off by the auxiliary shield 103 and consequently the edge of the area 104 will be as produced along the line 105. This will result in an area 104 of perceptibly narrower width. Likewise, the evaporated material from the second and third filaments 93 and 94 will be subject to both interposed shields 102 and 103 first as to the general effective span of the evaporated material at the first shield 102 and, secondly, according to the position of the shield 103 which will directly act to establish the edge of the coated areas along lines 106 and 107 such as indicated at 108 and 109. As will be noted, the filaments 95, 96 and 97 are equally spaced with relation to each other and the previous filaments and will, by reason of their relative spaced positions to shield 102, produce coated areas 110 and 111 of substantially equal width. More specifically, the line 112 from filament 95 will intersect with similar lines 113 and 114 from filaments 96 and 97 at the shield 102. If the filament 97 produced a graded deposit 115 between the lines 100 and 114, the thickness of the deposit 115 would be uniform from line 114 to the edge of the support body. However, in accordance with the arrangement of the filament 98 relative to filament 97, there is produced a relatively thicker graded area 116 along the marginal portion of the support body or between lines 109 and 117.

It will therefore be seen that use of the second shield 103 determines the hypothetical limiting lines at or in the vicinity of the innermost edge of the graded area and particularly at the edge where the grading desired would be the thinnest. Location of this second shield and resultant width of coated areas, however, operates in the same manner as the first shield 102, and the location of the shield 103 may be determined in exactly the same way as previously described, by sighting hypothetical lines through certain limiting evaporation sources to the support body and locating the shield at the intersection of such lines.

In Fig. 10 is shown a diagrammatic arrangement of a shield 118 having a perforation or circular opening 119 in combination with two evaporation sources 120 and 121 to produce a coating which is thickest at the center 122 and grades downwardly in a thinner coated area 123 towards the edges. Obviously, more than two filaments might be used to increase the total thicknesses through which the grading is produced, and it is apparent that the perforation may be circular, square, or any other shape. Thus, as shown in Fig. 10, the particular shape and size of opening 119 will control the coating from filament 120 between lines 124 and 125 and likewise from the filament 121 between lines 126 and 127.

The shields employed in the practice of the invention are of solid materials capable of supporting their own weight and are preferably made from aluminum or other metals, particularly those which are free of sputtering.

It will be more apparent from the following examples that the invention is concerned not alone with coating of flat plates but is particularly useful in connection with a coating of shaped articles such as lenses, and decorative ware such as bottles, jugs, etc. In the coating of such materials, it will be apparent that the edges of the shields need not be straight but may be of a curved, serrated or other shape so as to produce the graded patterns in definite desired limited areas of somewhat similar contour.

*Example 1*

An automobile windshield 14" x 30" was produced which had a graded coating along the top only and starting with the most dense area at the top and graduated downwards in thickness for a distance of three and one-half inches from the top edge of the windshield. The product actually produced had a luminous transmittance as shown by the curve in Fig. 11 in the upper three and one-half inches, no coating being applied to the glass beyond the three and one-half inches down from the top.

In producing this windshield with the graded deposit at the top, the same was arranged at a distance of twenty-two inches from a tungsten filament formed by twisting three strands of .020" tungsten wire together. The filament was further coiled into a spiral so as to provide over a distance of eight inches, ten or more turns. Upon each of the ten equally spaced turns, there was applied a small hook of inconel wire. This inconel wire (approximately 80% nickel, 13% chromium, and 6½% iron) was .060" in diameter and a one-half inch piece of such wire was used to form the hooks. Molten inconel wets tungsten well and evaporation from the filament was thus secured all along the entire eight inches as a continuous line source.

Between the filament and the windshield to be coated, a flat, rectangular metal shield was placed at a distance of fifteen inches away from the filament and arranged in front of the windshield so as to obscure most of its surface and protect the same from receiving any deposit. Preferably, the shield was of approximately the same size and shape as the windshield. The shield was then moved into position and arranged according to hypothetical lines by sighting along the extreme ends of the filament to the upper edge of the windshield and to a point three and one-half inches down from the upper edge, or to the extremes of the area which was to be coated with the grading. The shield edge was thus definitely located at the intersection of these hypothetical lines which placed the shield at the distances as previously indicated from the filament and from the windshield. The bell jar was then closed and evacuated to approximately $10^{-4}$ mm. and the filament was heated, the inconel melted and wetted the entire tungsten surface. As a result, the grading secured upon the windshield was extremely uniform in nature and the eye could not discern any definite breaks or lines of differing transmission in the coating. This is more clearly shown by the smoothness of the graph in Fig. 11 which shows how gradually the light transmission varies with the distance from the top of the windshield. That is to say, at the upper edge of the windshield, the transmittance of light was substantially zero and as the distance increased toward three and one-half inches, the curve defining this transmittance rose slowly in the upper marginal areas and then gradually in a smooth upward course toward approximately 90% luminous transmittance or more.

With reference now particularly to Figs. 12, 13 and 14, the windshield 128 therein illustrated as an example of another form of the invention has a graded coating 129 composed of a plurality of graded areas which are of arcuate form and deposited upon the sheet of glass 128 or the like by the employment of a shield 130 having a similarly curved edge 131. The glass sheet 128 will thus be provided with the three graded areas 132, 133, and 134 which are formed by the deposition of material evaporated from three sources of evaporation 135, 136 and 137 arranged in line with one another and spaced a predetermined distance from one another as described above. As will be apparent, material evaporated from all three sources 135, 136 and 137 will be deposited upon the glass to form the band 134, while the material from two filaments 135 and 136 is deposited upon the sheet to form the relatively reduced band 133, and material from only the single filament 135 will be deposited upon the glass to form the still thinner deposit or band 132.

Due to the curved edge 131 of the shield 130 and the relative positions of the evaporation sources 135, 136 and 137, the bands 132, 133 and 134 will not be in the form of straight, continuous bands of uniform width across the top portion of the windshield 128 but will conform with the curvature of the edge 131 of the shield. Thus, the curved edge 131 of the shield will control the extent of the coating from the evaporation source 135 downwardly from the top edge of the windshield to the innermost edge of the area 132 to be coated as indicated by lines 138 and 139. Thus, the material evaporated from filament 135 will produce a coating of uniform thickness over the unshielded area of the windshield, the innermost edge of said coating being curved to conform with the curved edge 131 of said shield as indicated by line 140.

Likewise, the curved edge 131 of the shield 130 will control the application of the coating from the evaporation source 136 upon the windshield from the top edge downwardly to the inner edge of the band 133 as indicated by lines 141 and 142 that intersect with the lines 138 and 139 from evaporation source 135 at the curved edge 131 of the shield. The curved character of the band 133, as controlled by the edge of the shield, is also indicated by the line 143 which intersects with the line 140 at said curved edge 131.

The heaviest areas 134 of the coating 129 are formed in a similar manner along lines 144 and 145 from the evaporation source 137 and since these lines intersect with lines 138—141 and 139—142 respectively at the curved edge of the shield, the width of the band 134 will be determined by the unshielded portion of the evaporated material from the source 137. Also, since the curved line establishing the width of the band 133 will be controlled by the curved edge 131 of the shield, the actual areas or bands 134 coated from the source 137 will substantially disappear at the top of the windshield as indicated by lines 146 and 147 from said source, along the edge of the shield and to the windshield.

As will be noted in Fig. 13, the central area of the windshield will thus have only the two bands 132 and 133 while, as shown in Fig. 14, the opposite upper corner areas will carry the combined deposits 132, 133 and 134 from the three evaporation sources 135, 136 and 137.

*Example 2*

With reference ot Fig. 16, several lenses 148 were produced having their upper half carrying a graded coating 149 of inconel of varying thicknesses and densities upon one surface thereof. In producing this coating, the lenses were mounted, as shown in Fig. 15, upon a support 150 in definite alignment at a distance of 17.3 inches away from a tungsten filament wound spirally of .040″ wire so as to produce some ten loops within a distance of two inches of coil. As herein shown, there was thus provided a continuous evaporation source 151 two inches long,



the two ends of which are indicated in the drawing. This filament arrangement is capable of producing deposits of varying thicknesses and, more especially, a thin area 152 adjoining a materially thicker area 153.

In front of the support 150 carrying the lenses and between such support and the evaporation source 151, a solid, rectangular shield 154 was arranged at a distance of 14.2 inches away from the evaporation source. The shield was such as to cover completely the lower halves 155 of the lenses so as to prevent any deposition on such surface. The position of the shield 154 will thus determine and control the coating from the evaporation source 151 and progressive thicknesses of deposit will be applied as between the lines 156 and 157 to the innermost edge of the coated area, which line 157 strikes the edge 154′ of the shield 154 and the line 158 from the opposite end of the continuous source 151. The intersection of lines 157 and 158 at the edge of the shield will thus determine the over-all width of the coating 149 and also the progressive increase in thickness of the coating between the area 152 and the area 153.

The shield was such as to produce a graded coating on the upper half of the lenses by reason of the evaporated material being laid down by various portions of the source or filament 151. Upon each of the coils of the filament there was hung a small piece of inconel wire weighing .069 gram. When the vacuum chamber was closed and the filament heated, the inconel evaporated from all portions of the coil and deposited upon the upper half of the lenses in the definite graded type deposit which varied in light transmission from 10% at the upper edge down to 60% at the lower edge of the coating, and the lower half of the lenses were completely uncoated and showed the normal transmission of glass of something over 90%. The continuous filament 151 was arranged in this work in a direction such that it was parallel to the direction in which the grading 149 was to be produced upon the lenses 148, and the arrangement of the shield 154 and support 150 carrying the lenses was substantially as shown in Fig. 15.

*Example 3*

As a further illustration of the uses of the invention, there was produced a decorative jar 159 which had areas of different colors and of different reflectivities. The method of producing the decorations upon this jar is illustrated diagrammatically in Fig. 17 in which is shown evaporation of material from three evaporation sources 160, 161 and 162. These sources were tantalum filaments and each was loaded with a material which would provide a transparent coating, the material actually used being magnesium fluoride to the amount of 0.5 gram in the two extreme filaments and 0.3 gram in the middle filament. The filaments were located approximately two inches apart. Between the filaments and the jar which was to receive the coating, there was arranged in the vacuum chamber a shield 163 of sufficient width and height to generally protect the jar from receiving any coating other than above the upper serrated edge of the shield. In the center of the shield, there was a perforation 164 in the shape of a round hole. This hole was one-half inch in diameter and through it a deposit was formed upon the sides of the bottle in the shape of circles as indicated at 165. To obtain other and varied effects on the upper portion or neck 166 of the jar, the upper edge 167 of the shield was suitably crenelated, serrated or otherwise formed. Simultaneously with the deposition through the perforation 164, a portion of the evaporated material was accordingly also directed toward said jar neck 166.

The jar 159 was preliminarily coated all over with a reflective coating of chromium in a separate operation. The precoated, highly reflective jar was then placed in a vacuum chamber at a distance of twenty inches away from the filaments 160 to 162 inclusive, and the shield 163 was moved into proper position at a distance of seventeen inches away from the filaments or three inches away from the jar, the shield being arranged so that deposits 168 were formed upon the neck 166 of the jar through the shadowing effects of the serrated edge 167 of the shield while the circular deposits 165 were formed upon the side of the jar. As shown in Fig. 17, three definite sharp graded steps 169, 170 and 171 of decreasing thicknesses of deposit of magnesium fluoride were thus produced depending upon the action of the shield and the various weights of magnesium fluoride applied to the filaments. That is, from the filament 160 the graded step or band 171 on the neck of the jar 159 will be effected between lines 172 and 173 and a simultaneous coating in one of the circular deposits 165 between lines 174 and 175 which indicate the range of the circular pattern established by the round opening 164 in the shield 163. The band 170 likewise will be created as between the lines 172 and 176 from the filament 161 and the unshielded portion of the evaporated material along the line 176 will intersect with line 173 at the serrated edge 167 of the shield 163 and determine the actual width of the band 171. A second circular deposit will also be formed from the filament 161 between lines 177 and 178. From the filament 162, the heaviest area of deposited material 169 will be formed as between lines 172 and 179, the shielded portion of the material along line 179 also creating the opposite edge of the coated area 170, since the line 179 will intersect with lines 173 and 176 at the upper serrated edge 167 of the shield. From this filament 162, the third circular deposit will be formed by the unshielded portion of the material through the round opening 164 of the shield 163 between lines 180 and 181. The three bands or segments 169, 170 and 171 upon the neck 166 of the jar each had a margin of saw-tooth pattern and each of the segments was of a different color due to light interference effects produced by the magnesium fluoride deposit upon the reflective coated bottle, since each of the graded deposit sections was of a different thickness of magnesium fluoride.

In a similar manner, the circular deposits 165 of magnesium fluoride on the center of the bottle provided areas 182, 183 and 184 of three different contrasting colors and different reflectivites due to the three different thicknesses in the areas as shown in the figure. which were secured through the combined action of the hole 164 in the shield 163 and the different loadings upon the three filaments. Thus, the central area 183 coming from the central filament 161 and between lines 177 and 178 primarily was of a different color than the areas 182 which came from the two extreme filaments of different loadings 160 and 162 and between the respective line 174—175 and 180—181. The two areas 184 were of a third color, due to a still greater thickness of deposit, since in such areas material was received from the central filament and from an extreme filament in each such area. Accordingly, the areas 182, 183 and 184 were of progressively greater thickness and of entirely different colors from each other. The method of employing the shield has thus permitted the deposition of coatings of transparent materials such as magnesium fluoride and other semi-transparent materials such as zinc sulphide, quartz, aluminum oxide, or metals such as aluminum, chromium, etc. for the purpose of securing vari-colored and decorative effects.

It is apparent that the three circular areas produced on the bottle might have been arranged in some other decorative design rather than a single vertical arrangement of circles. Thus, a pyramid arrangement of the three circles would result if the three filament sources were definitely not in a linear alignment but disposed with respect to each other in a triangular arrangement. It is thus apparent that the evaporation sources may be arranged with respect to each other in various ways other than in direct linear arrangement whenever the grading desired need not be of a type where the grading is of a single linear nature.

The term "graded area" or "area to be coated with the grading," as employed in the claims, means the area coated with deposits ranging in thickness from a margin of no coating or thickness to a margin between a coating of maximum thickness and the next thinner coating, i. e., between C—D in Fig. 4. In fact, the invention is not concerned with the area having the thickest coating since such coated area receives deposits from all evaporation sources without any limiting effects from the shields employed. Thus, the term "graded area" covers that area in which the gradings are controlled by the cooperative effects of the shield or shields with the filaments and the location of such filaments and the object to be coated.

I claim:

1. The method of producing a graded coating upon a support body by thermal evaporation, which comprises arranging the support body in position to be coated in a vacuum chamber, providing a linear source of evaporation in said chamber, projecting a hypothetical diagonal line between one end of the evaporation source and the opposite end of the area on the support body to be coated with the grading, projecting a second hypothetical diagonal line between the other end of the evaporation source and the opposite end of the area on the support body to be coated with the grading and which second line intersects the first line at a point between the support body and evaporation source, placing a shield between said support body and evaporation source at the intersection of the two hypothetical diagonal lines, and evaporating coating material from the evaporation source as said shield is held stationarily at said intersection to produce a graded coating.

2. The method of producing a graded coating upon a support body by thermal evaporation as defined in claim 1, wherein the shield is of plate-like form having one of its edges located at the intersection of the two hypothetical lines and the body portion thereof covering the area of the support body to be left uncoated.

3. The method of producing a graded coating upon a support body by thermal evaporation, which comprises arranging the support body in

position to be coated in a vacuum chamber, providing a plurality of sources of evaporation spaced from one another in said chamber, projecting a hypothetical diagonal line between one extreme evaporation source and the opposite end of the area on the support body to be coated with the grading, projecting a second hypothetical diagonal line between the other extreme source of evaporation and the opposite end of the area on the support body to be coated with the grading and which second line intersects the first line at a point between the support body and the sources of evaporation, placing a shield between said support body and evaporation source at the intersection of the two hypothetical diagonal lines, and evaporating coating material from the several sources of evaporation as said shield is held stationarily at said intersection to produce a graded coating.

4. The method of producing a graded coating upon a support body by thermal evaporation as defined in claim 3, wherein the shield is of plate-like form having one of its edges located at the intersection of the two hypothetical lines and the body portion thereof covering the area of the support body to be left uncoated.

5. The method of producing a graded coating upon a support body by thermal evaporation, which comprises arranging the support body in position to be coated in a vacuum chamber, providing a plurality of independent sources of evaporation in said chamber spaced from one another and corresponding in number to the number of graded areas to be produced, projecting a hypothetical diagonal line between one extreme source of evaporation and the opposite end



of the area on the support body to be coated, projecting a second hypothetical diagonal line between the other extreme source of evaporation and the opposite end of the area on the support body to be coated and which second line intersects the first line at a point between the support body and the sources of evaporation, placing a shield between said support body and evaporation source at the intersection of the two hypothetical diagonal lines, and simultaneously evaporating coating material from the several sources of evaporation as said shield is held stationarily at said intersection to produce a graded coating having areas of predetermined width and gradation dependent upon the number of sources of evaporation and the spacing thereof.

6. The method of producing a graded coating upon a support body by thermal evaporation as defined in claim 5, wherein the shield is of plate-like form having one of its edges located at the intersection of the two hypothetical lines and the body portion thereof covering the area of the support body to be left uncoated.


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