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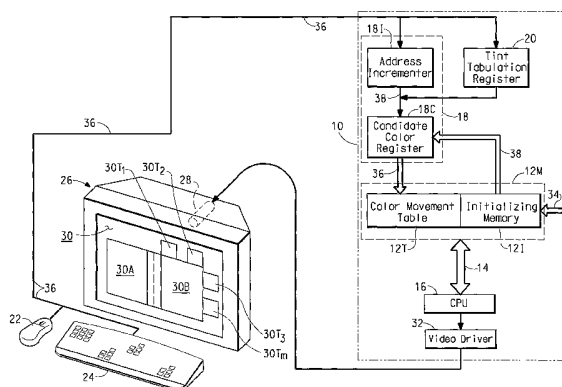
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(54) Title: COMPUTER-IMPLEMENTED COLOR ADJUSTMENT METHOD AND PROGRAM USING STORED COLOR VALUES



(57) Abstract: Renderings of a target paint color and an initial candidate color formed from a combination tints  $T_1$  through  $T_n$  are displaying in respective first and second fields of a video monitor. Upon the selection of one of the tints the display in the second field of the video monitor is updated to display a rendering of a first updated candidate paint color. The first updated candidate paint color is compared to the target paint color to determine an acceptable color match. If, based on the comparison, the color match is unacceptable, the same or a different tint is selected. The color value of a subsequent updated candidate paint color produced by the addition of a predetermined adjustment quantity of the selected tint to the immediately preceding candidate color is recalled from a memory location determined in accordance with the immediately preceding candidate color and the selected tint. The subsequent updated candidate paint color is displayed in the second field. This repetition continues until an acceptable color match is achieved or for M number of iterations, where M is an integer greater than 1, whichever first occurs. The number of adjustment quantities of each tint added to the initial candidate color to produce the last updated candidate color is tabulated. A paint is mixed by adding the tabulated number of adjustment quantities of each tint to a predetermined quantity of a paint of the initial candidate paint color.

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## TITLE

**COMPUTER-IMPLEMENTED COLOR ADJUSTMENT METHOD AND  
PROGRAM USING STORED COLOR VALUES**5                   **CROSS-REFERENCE TO RELATED APPLICATION**

This application claims priority under 35 U.S.C. §119 from U.S. Provisional Application Serial No. 60/625,528, filed November 5, 2004.

**BACKGROUND OF THE INVENTION**

10           **Field of the Invention** This invention relates to an improved computer-implemented method and program for guiding a refinisher through one or more adjustment(s) of a candidate refinishing paint color toward the goal of a color match with a predetermined target paint color.

15           **Description of Related Art** When a vehicle body (e.g., an automobile or a truck) is repaired the repair area must be repainted. For a completed repair to be acceptable the color of the repaired area must match that of the rest of the vehicle so that the repaired area is not distinguishable. Obtaining such a color match is often difficult to accomplish since paint color can vary from one vehicle to the next or even on different portions of the same vehicle.

20           To obtain an acceptable match the refinisher must adjust the color of the refinishing paint by adding small amounts of colored tints. Tints used for color adjustment are generally limited to the same tints that are combined to form the paint being refinished. Commonly, four to eight, or more, tints are used to form the original color. Due to the complexity of such tint combinations a refinisher cannot always visualize the color change caused by addition of a specific tint.

25           To assist refinishers in the art of color matching "shading tips" can be useful. "Shading tips" describe to a refinisher how a given tint affects the color of a refinish paint. For example, when a white tint is added to a blue paint it is intuitive that the blue color will become lighter. However, the resulting blue may also be more or less saturated ("deeper" or "less deep") depending upon the pigments and the ratio of those pigments used in the blue paint.

Verbal descriptions explaining the effect the addition of a given tint will have on the resulting paint color are often ineffective because the color effects being explained are difficult to visualize. A computer-based training tool has been developed and is available to help a refinish trainee  
5 visualize the effect of adding specific tints to a paint.

The tool includes a video monitor that displays in a first field a rendering of a predetermined target paint color. A second field of the video monitor displays a rendering of an initial candidate refinishing paint color formed from a combination of a predetermined quantity of each of a  
10 predetermined number of tints  $T_1$  through  $T_n$ . Also displayed in respective fields of the video monitor is each of the tints  $T_1$  through  $T_n$ . In response to the selection by a trainee of one of the tints the display in the second field is modified to display a rendering of an updated candidate refinishing paint. The set of updated candidate colors is produced by qualitatively  
15 determining the effect on the initial candidate color produced by the addition of each component tint. The updated colors are selected from a color palette offered in a commercially available software package, such as the program Microsoft® PowerPoint®, sold by Microsoft Corporation. Once heuristically determined the updated candidate colors are stored  
20 and displayed when one of the tints is selected by the trainee.

As a further aid to refinishers, the assignee of the present invention has developed a computer-based system known as Chromavision® color retrieval and management system. With this system a spectrophotometer or a colorimeter is used to measure the color of the car being painted. A  
25 database holding the spectral reflectance curves or the CIE  $L^*a^*b^*$  system coordinates of all car colors and the paint formula associated therewith is searched. The stored color most closely matching the measured color is selected as an initial candidate color.

Commercial refinish color matching tools vary in functionality.  
30 Some may test the closest color for other properties such as metamerism and only provide matches low in metamerism. Some may determine whether the color found in the database is an acceptably close match and, if necessary, adjust the formula to improve the match. Once an

acceptable color match is determined, the computer program provides the refinisher its formula. The refinisher produces a paint in accordance with this formula and proceeds to spray the vehicle. An effective program of the type eliminates the need for further color adjustment by the refinisher.

5           Although the system of this type eliminates the need for further color adjustment by the refinisher, the costs associated with the spectrophotometer or a colorimeter make it expensive to implement.

          Accordingly it is believed desirable to provide a less expensive computer-implemented tool that can be used for color matching by a  
10   refinisher to match a target color.

          It is also believed advantageous to provide a computer-implemented tool that permits a refinisher to visually observe color movements of a candidate toward a target color. This instills confidence in the accuracy of the color adjustment, permitting the  
15   refinishing job to be performed more efficiently.

### **SUMMARY OF THE INVENTION**

          This invention is directed to an improved computer-implemented method and program for guiding a refinisher-user through adjustment(s) of a candidate refinishing paint color formed from a combination of a  
20   predetermined number of tints  $T_1$  through  $T_n$  toward a predetermined target paint color.

          In accordance with the improved method and program of the present invention a rendering of the predetermined target paint color and a rendering of an initial candidate refinishing paint color are displaying in  
25   respective first and second fields of a video monitor. The initial candidate refinishing paint color is formed from a combination of a predetermined quantity of each of a predetermined number of tints  $T_1$  through  $T_n$ . Each tint is also displayed in a respective field of the video monitor.

          In response to the selection of one of the  
30   tints, a first updated candidate paint color produced by the addition of a predetermined adjustment quantity of the selected tint to a predetermined quantity of the initial candidate color is recalled from a predetermined storage location in a memory. The display in the second field of the video

monitor is updated to display a rendering of the first updated candidate paint color. The first updated candidate paint color rendered in the second field is compared by the refinisher-user to the target paint color rendered in the first field to determine an acceptable color match.

- 5           If, based upon the results of the comparison, the color match is deemed unacceptable, the same or a different tint is selected. The color value of a subsequent updated candidate paint color produced by the addition of a predetermined adjustment quantity of the selected tint to the immediately preceding candidate color is recalled from a memory location.
- 10       The address of the memory location is determined in accordance with the immediately preceding candidate color and the selected tint. The subsequent updated candidate paint color is displayed in the second field.

- This repetition continues until an acceptable color match is achieved between the renderings of a final subsequent updated candidate
- 15       color and the target color or for M number of iterations, where M is an integer greater than 1.

- Upon achievement of an acceptable color match or after M iterations, whichever first occurs, the number of adjustment quantities of each tint added to the initial candidate color to produce the final
- 20       subsequent updated candidate color is tabulated. A paint is mixed by adding the tabulated number of adjustment quantities of each tint to a predetermined quantity of a paint of the initial candidate paint color.

- The values of the subsequent candidate colors stored in the memory are determined by experience or by creating the updated color
- 25       and measuring its properties.

- As preliminary steps, renderings of a color tinting chart are displayed on the video monitor. The charts have a color spectrum with indicia in predetermined positions of the spectrum identifying each of the available paint color formulations. Both the predetermined target color
- 30       and the initial candidate refinishing color may be selected from a color tinting chart for display in the appropriate fields of the video monitor.

## BRIEF DESCRIPTION OF THE DRAWINGS

The invention will be more fully understood from the following detailed description, taken in connection with the accompanying drawings, which form a part of this application and in which:

5           Figure 1 is stylized diagram of a computing system for executing a program implementing the method of the present invention, the stylized diagram including a representation of a screen display generated by a computer when implementing the method and program of the present invention;

10           Figure 2 is a diagram illustrating the color movements which form the basis of the color movement table portion of the color memory; and

            Figure 3 is stylized diagram of a screen display of tinting charts used to assist in the selection of a target color and an initial candidate color.

## 15           DETAILED DESCRIPTION OF THE INVENTION

Throughout the following detailed description similar reference numerals refer to similar elements in all figures of the drawings.

            The present invention is directed to a computer-implemented method and program for guiding a refinisher through one or more  
20   adjustment(s) of a candidate refinishing paint color toward the goal of a color match with a predetermined target paint color. The predetermined target paint color is that color that the refinisher is desirous of reproducing on a given vehicle under repair. The candidate refinishing paint color is formed from a combination of a predetermined number of tints  $T_1$  through  
25    $T_n$ . Each tint is typically comprised of a single pigment colorant adjusted for color and strength with one or more selected pigments, resins, solvents or dispersions.

            With reference to Figure 1 shown is a stylized block diagram of the architecture of a computing system generally indicated by the reference  
30   character 10 for executing a program implementing the improved method of the present invention. The computing system 10 may be configured using any standard microprocessor-based computing system having a memory 12 that communicates over a bus 14 with a central processing

unit (CPU) 16. The memory 12 is partitioned into a program memory portion (not expressly indicated) and a color memory 12M. In the discussion that follows the color values stored in the color memory 12M are assumed to be stored directly as red (R), green (G), and blue (B) color values.

Memory addresses for accessing memory locations in the color memory 12M are generated using a memory address generator 18. The address generator 18 includes a candidate color register 18C and an address incrementer 18I, as will be described. A portion of memory functioning as a tint tabulation register 20 is operatively associated with the address incrementer 18I.

The refinisher operating the system 10 may provide inputs to the CPU 16 using any input device, such as a mouse 22 and/or keyboard 24. Output from the system 10 to a refinisher-user is provided through a color video monitor generally indicated by the reference character 26. The video monitor 26 includes an electron gun 28 that directs three beams of electrons [for each of the primary colors red (R), green (G), and blue(B)] toward an array of locations lining the inner surface of the screen 30 of the video monitor 26.

As is well understood by those skilled in the art each screen location has a set of phosphor dots excitable by the incidence of electrons thereon to produce visible light corresponding to the colors red, green and blue. Appropriate red, green and blue (R, G, B) video signals driving the electron gun 28 to excite the appropriate phosphor dots at each given location are provided by a color video driver 32 operating under the control of the CPU 16.

The program memory stores the program instructions that cause the computing system 10 to implement the improved method of the present invention. The program instructions may be encoded onto and carried by any suitable computer readable medium, such as a magnetic or optical disk, semiconductor memory or tape.

The color memory 12M includes an initializing section 12I and a multi-tiered color movement table section 12T.

The initializing section 12I of the color memory 12M stores the color values corresponding to an operator-selected target color, to an operator-selected initial candidate color, and to the tints  $T_1$  through  $T_n$  that form the initial candidate color. The preferred manner by which such  
5 information is loaded (e.g., via a bus 34) to the memory 12M is discussed in more detail herein.

The color movement table 12T stores the color values produced by the addition of a predetermined adjustment quantity of a selected tint to an immediately preceding candidate color. The appropriate addresses for  
10 locations within the color movement table 12T are provided from the address generator 18 over the address bus 36.

In operation, upon selection by the operator-refinisher of a selected target color and an initial candidate color the corresponding locations in the initializing portion 12I of the color movement memory 12M are  
15 addressed. The color values corresponding to the selected target color, the initial candidate color, and the tints  $T_1$  through  $T_n$  forming the initial candidate color are output to the video driver 32. The address of the initial candidate color is also loaded into the address generator 18 over a bus 38.

20 The display generated on the screen 30 of the color video monitor 22 when implementing the method and program of the present invention is illustrated in Figure 1. Under control of the CPU 16 a rendering of the predetermined target paint color is displayed in a first field 30A of the screen 30 of the video monitor 22. Displayed in a second field 30B of the  
25 screen 30 of the video monitor 26 is a rendering of an initial candidate refinishing paint color believed by the refinisher to match the predetermined target paint color. The candidate refinishing color is formed from a combination of a predetermined quantity of each of a predetermined number of tints  $T_1$  through  $T_n$ . A rendering of each of the  
30 predetermined number of tints  $T_1$  through  $T_n$  is displayed in a respective dedicated display field 30 $T_1$  through 30 $T_n$ .

In the preferred implementation the first field 30A (the target color) and the second field 30B (the candidate color) are adjacent but spaced

slightly apart (a spacing that appears to a viewer to be on the order of about one-eighth of an inch (0.125 inch). However, the first field 30A (the target color) and the second field 30B (the candidate color) may be juxtaposed in abutting relationship against each other, as suggested by the dashed lines in Figure 1. In addition, the tint fields 30T<sub>1</sub> through 30T<sub>n</sub> are juxtaposed in abutting relationship with the second field 30B, but may likewise be slightly spaced therefrom, if desired. The screen 30 should be rendered in a neutral surrounding background color (e.g., gray) for chromatic adaptation.

10           With a rendering of both the predetermined target paint color and the candidate refinishing paint color on the screen 30 of the monitor 22 the refinisher is able to make an assessment as to the acceptability (in the sense of a color match) between the two. If it were felt that the initial candidate refinishing paint color I is sufficiently close to the predetermined target color P the color selection process would be complete.

15           However, in the event there is a perceived difference between the target paint color and the candidate paint color the method and program of the present invention assist the refinisher through the adjustment of the candidate color to effect a closer color match. In accordance with the present invention the refinisher makes a determination as to which of the constituent tints should be added to drive the candidate color closer to the target color. The refinisher selects the tint to be added by asserting ("clicking") the mouse in the dedicated tint field 30T<sub>1</sub> through 30T<sub>n</sub> of the selected tint.

20           A signal indicating the identity of the particular tint T<sub>1</sub> through T<sub>n</sub> is applied over a line 36 to the address incrementer 18I and to the tint tabulation register 20.

25           In response to the selection of one of the tints 30T<sub>1</sub> through 30T<sub>n</sub> the address of the initial candidate color in the candidate color register 18C is updated by an address increment corresponding to the tint selected applied over a line 38. As may be understood with reference to Figure 2 the memory location corresponding to the updated address has stored therein the color values of a first

updated candidate paint color. This first updated candidate paint color is produced by the addition of a predetermined adjustment quantity of the selected tint to a predetermined quantity the initial candidate color. The color value at the addressed location is applied to the video driver 32.

- 5 The second field 30B of the video monitor 26 is changed to display a rendering of the first updated candidate paint color.

The first updated candidate paint color rendered in the second field is comparing to the target paint color rendered in the first field 30A to determine an acceptable color match. If the comparison indicates that  
10 further modification to the candidate color is required, one of the tints is again selected.

A signal indicative of the particular tint selected in this second iteration is applied over the line 36 to both the address incrementer 18I and the tint tabulation register 20. The then-current address in the  
15 candidate color register 18C (corresponding to the first updated candidate color) is incremented by an amount corresponding to the particular tint selected to produce a second updated address.

The memory location corresponding to the second updated address has stored therein the color values of a second updated  
20 candidate paint color. As seen in Figure 2 this second updated candidate paint color is produced by the addition of a predetermined adjustment quantity of the selected tint to a predetermined quantity the first updated candidate color.

The color value at the addressed location is applied to the video  
25 driver 32. The second field 30B of the video monitor 26 is again changed to display a rendering of the first updated candidate paint color.

The iterations are repeated until either M number of iterations have been performed (where M is an integer greater than 1) or until the color match between the renderings of a final subsequent updated candidate  
30 color and the target color is deemed acceptable. For each iteration 1, 2, ... M, the address of the memory location holding the updated candidate color is determined in accordance with the address of the immediately

preceding candidate color and an address increment corresponding to the selected tint.

Upon the occurrence of the earlier of M iterations or an acceptable color match the number of adjustment quantities of each tint (as stored in the tint tabulation register 20) added to the initial candidate color to produce the final subsequent updated candidate color. Using the formula of the initial candidate color and the adjustment quantity of each of the tint(s) needed to achieve a color deemed by the refinisher to be sufficiently close to the target color, a paint is mixed.

The color values stored in color movement table 12T must be created for each color. The movements produced by each colorant addition may be determined through visual experience. The red, green and blue (R, G, B) values for each movement may be determined by selecting the color from a color selector provided by many commercially available programs, such as the program Microsoft® PowerPoint®, sold by Microsoft Corporation. Alternatively, the movements produced by each colorant addition may be determined by creating each addition in the paint. The  $L^*$ ,  $a^*$ ,  $b^*$  values of the paint are measured (as by a spectrophotometer). The  $L^*$ ,  $a^*$ ,  $b^*$  data are converted into video display by determining the corresponding R-G-B data for the color characteristics obtained. The algorithms and procedures for this conversion are described in ASTM E 1682, "Standard Guide for Modeling the Colorimetric Properties of a Visual Display Unit", ASTM International, 100 Bar Harbor Drive, PO Box C700, West Conshohocken, PA 19428-2959.

Solid colors, those that appear the same at all angles of illumination and view, can be described well by a single value for each of the three coordinates,  $L^*$ ,  $a^*$ ,  $b^*$ . Gonioapparent colors, those that change color depending on angle of illumination and view, can be created by addition of metallic or pearlescent flakes. These colors must be described by  $L^*$ ,  $a^*$ ,  $b^*$  determined at more than one angle. It has been shown [e.g., U.S. Patent 4,479,718 (Alman); Rodrigues, Die Farbe, Band 37, 65-78, 1990] that three angles of measurement are sufficient to characterize commercial gonioapparent colors. Such angles are one very near the

angle of specular (surface) reflectance, called the near-specular angle, one far from the specular direction, called the flop angle, and one in between called the face angle (ASTM E 284). Thus, gonioapparent colors require an  $L^*$ ,  $a^*$ ,  $b^*$  value at each of these three angles.

5           Addition of a colorant to a gonioapparent color can cause a very different color movement at each of these angles. For example, addition of more aluminum flake to a gray metallic color typically causes a large movement in  $L^*$  at the near specular angle, less at the face angle and still less at the flop angle. Addition of white to a light silver metallic causes the  
10   lightness to increase at the flop angle but decrease at the near specular angle and may have a small movement in either direction at the face angle. Thus, color vectors must be determined at each of these three angles, which results in nine dimensions.

          Current commercial spectrophotometers allow up to five (5) angle  
15   measurements that result, analogously, in fifteen (15) dimensions. There is no theoretical limit to the number of possible dimensions used. The teachings of the present invention are applicable to any multi-dimensional color space.

          Although the description heretofore has been given in the context  
20   of a three-dimensional color space it should be understood that the invention is not limited thereto. Thus, metallic or pearlescent paints may be color matched using the three angle measurements or the fifteen-dimensional representation for five angle measurements. In such multi-angle implementations the fields 30A, 30B on the screen 30 would display  
25   the target and candidate colors at each of the three or five measurement angles, as the case may be. Alternatively, a rendering of a curved panel could be produced on the screen. Respective portions of the panel would have a rendering of the candidate color as observed at each of viewing angle of the multi-angle system. Portions of the panel intermediate the  
30   angle positions would have renderings of interpolated candidate colors.

**PREPARATORY STEPS** As noted earlier various inputs are provided to the system 10 over the line 34 and stored in the data memory. These inputs include: the color coordinates  $P_{L^*}$ ,  $P_{a^*}$ ,  $P_{b^*}$  of a

predetermined target color P; the color coordinates  $L^*$ ,  $a^*$ ,  $b^*$  of an initial candidate refinishing color I; the color coordinates  $T_{1L}^*$ ,  $T_{1a}^*$ ,  $T_{1b}^*$ ;  $T_{2L}^*$ ,  $T_{2a}^*$ ,  $T_{2b}^*$ ; . . .  $T_{nL}^*$ ,  $T_{na}^*$ ,  $T_{nb}^*$  of each predetermined number of tints  $T_1$  through  $T_n$  that form the initial candidate color; and the adjustment vectors

5 corresponding to each tint  $T_1$  through  $T_n$ .

These inputs may be derived in a variety of ways.

For example, the coordinates of the predetermined target color point and/or the initial candidate refinishing color in a multidimensional color space may be determined using a spectrophotometer, if such a

10 device is available to the refinisher. The target color may be obtained by spectrophotometric analysis of the vehicle under repair. The candidate color may be obtained by spectrophotometric analysis of a test panel sprayed with the initial candidate color. This is generally done by the paint supplier, who creates the candidate colors from which the refinisher

15 chooses.

A spectrophotometer measures the percentage of light reflected at each wavelength over the visible region of the electromagnetic spectrum. Typically these readings are taken at ten nanometer (10 nm) intervals from four hundred to seven hundred nanometers ((400-700 nm). A plot of

20 the percent reflectance as a function of wavelength is referred to as a "spectral curve". Viewing a spectral curve one can determine the hue of a color represented from the peak of the curve, e.g., the spectral curve of a blue color would peak in blue wavelengths. A light color would reflect more light across the spectrum, a darker color reflects less light. A high

25 chroma color would have a reasonably sharper peak and reflect considerably less light at other wavelengths. A low chroma color would have a curve with little difference between peak and trough. Grays would tend to be very flat. Thus, a qualitative assessment of the color is possible from a spectral curve.

30 However, color as seen by a human observer is dependent not only on the spectral curve of the color but also the spectral characteristics of the light source under which it is viewed and the spectral sensitivity of the observer. The human eye has three sensors for color vision-a blue

sensor, a green sensor and a red sensor. In 1931, the International Committee on Illumination (CIE) standardized the mapping of color in a three-dimensional X, Y, Z space, allowing for the spectral characteristics of the color, the light source and the observer. However it is still difficult to visualize a color from its tristimulus values X, Y, Z. Also, these values do not provide a visually uniform three-dimensional mapping of color.

The foregoing difficulties are addressed by using mathematical transformations to "uniform color space" known today as L\*, a\*, b\* data, which are described in COLOR VISION IN INSTRUMENTAL COLOR MATCHING OF SOLID AND METALLIC COLORS by A. B. J. Rodrigues (Proceedings of the Sixteenth International Conference in Organic Coatings Science and Technology, Athens Greece, 1990) and in ASTM E 308.

As is well known, the L\*, a\*, b\* values of the color describes the position of the color in a three-dimensional color space. The L\*, a\*, b\* data of each color in a three-dimensional rendering of the color space in Cartesian coordinates in which a lightness axis (L\*), a red-green axis (a\*), and a yellow-blue axis (b\*), are described by the following equations:

$$L^* = 116 (Y/Y_0)^{1/3} - 16 \quad (1)$$

$$a^* = 500 [(X/X_0)^{1/3} - (Y/Y_0)^{1/3}] \quad (2)$$

$$b^* = 200 [(Y/Y_0)^{1/3} - (Z/Z_0)^{1/3}] \quad (3)$$

In the foregoing equations  $X_0$ ,  $Y_0$  and  $Z_0$  are the tristimulus values of a perfect white color for a given illuminant; and X, Y and Z are the tristimulus values for the color to be evaluated. Additional information is also proved in an article entitled "Theory and Implementation of Modern Techniques of Color Conception, Matching and Control" by A. B. J. Rodrigues, which is described in the Fifth International Conference in Organic Coatings Science and Technology Proceedings, Vol. 3, Advances in Organic Coatings Science and Technology Series, p. 272-282, (1979), U.S. Patent 4,403,866, and ASTM E 308.

Again, once the color characteristics, such as the L\*, a\*, b\* data, are obtained, the color characteristics are converted into video display by determining the corresponding R-G-B data for the color characteristics are

obtained using the algorithms and procedures for this conversion described in the above-referenced ASTM E 1682, "Standard Guide for Modeling the Colorimetric Properties of a Visual Display Unit", ASTM International.

5           Alternatively, the target paint color may be selected by the refinisher-user from a suitable color selection chart or by experience. Supplier databases normally contain the color coordinates for each of these candidate paints. The color movements for each of the tints that are used to form these candidate paints may also be stored by the  
10   supplier.

          A yet further alternative method of identifying the predetermined target paint color is through the use of a tinting chart rendered on the screen 30 of the video display monitor 22. Figure 3 is a stylized pictorial representation of an amalgamation of one or more screen display(s)  
15   guiding the refinisher user through the identification of such colors. These selections are performed as preparatory steps prior to the rendering illustrated in Figure 1.

          As seen from Figure 3, in a first field 30-1 of the screen of the video monitor is displayed a rendering of a generally circular color tinting chart  
20   40. Similarly, in a second field 30-2 is displayed a rendering of a second color tinting chart 42. The color tinting charts 40 and 42 each have a color spectrum that is illustrated in Figure 3 as varying shades of gray. It should be understood that that charts are actually rendered in color, with the color red occupying the "3 o'clock" position on each chart. Moving anti-  
25   clockwise on each chart, the colors move through orange, yellow, green blue, violet and back to red. A particular color become more chromatic as one moves from the center of the chart toward the periphery.

          The color tinting chart 40 in the first field 30-1 of Figure 3 depicts a color spectrum having each of the available target paint colors indicated at  
30   predetermined positions thereon. Similarly, the color tinting chart 42 in the second field 30-2 of Figure 3 depicts a color spectrum having each of the available candidate paint colors formulations indicated at predetermined positions thereon.

These selections from the fields 30-1, 30-2 allow a choice of hue and saturation. Selection of lightness is effected through the use of a lightness bar 44, 46 respectively disposed adjacent each of the charts 40, 42. By clicking or dragging actions the lightness of the samples in the charts 40, 42 is adjusted.

In response to on-screen prompts or instructions the refinisher-user selects both the predetermined target color and the initial candidate refinishing color from the appropriate color tinting chart.

The color coordinates of the color selected from the tinting chart 40 are stored and the color is rendered in the first field 30A of the screen display (Figure 1). The color coordinates of the color selected from the tinting chart 42 are also stored and the color rendered in the second field 30B of the screen display (Figure 1). In addition, selection of an initial candidate color carries with it the identification of the tints forming the same. For example, selection of a given color on the tinting chart 42 may address suitable memory locations wherein the identity of the constituent tints are stored.

Another method for selecting the candidate color position is for the paint supplier to suggest possible positions for a given car code. The refinisher can determine the car color code, usually located on a label in the car door jamb or under the hood. Suppliers predetermine paint formulas to match each car color as well as variations (commonly referred to as "Alternates" or "Alts") representative of the car population.

The color tinting chart 42 may also include indicia identifying these formulations of various candidate paints. Two such indicia are illustrated on the color tinting chart 42 of Figure 3 by the terms "Alt 1", "Alt 2". When the refinisher chooses the Alt closest to the target color, the constituent tints are automatically provided from a database.

Renderings of the target color, candidate color and constituent tints may then be made in the appropriate display fields 30A, 30B, 30T<sub>1</sub> through 30T<sub>n</sub> (Figure 1).

From the foregoing description it may be appreciated that the present invention provides a rapid, cost effective and efficient tool that a

refinisher can use to match a color for repair of a damaged vehicle. This present invention overcomes the shortcomings of the use of "shading tips" which use verbal means to describe color changes, rather than the much more effective visual means used in this invention. It also overcomes the  
5 limitation of the Chromavision<sup>®</sup> system that requires expensive equipment to be used effectively.

Those skilled in the art, having the benefit of the teachings of the present invention as hereinabove set forth may effect numerous modifications thereto. Such modifications are to be construed as lying  
10 within the contemplation of the present invention, as defined by the appended claims.

**WHAT IS CLAIMED IS:**

1. A computer-implemented method for matching a candidate paint color  
5 formed from a combination of a predetermined number of tints  $T_1$  through  $T_n$  to a target paint color, the method including the steps of:
  - (a) displaying in a first field of a video monitor a rendering of a target paint color;
  - (b) displaying in a second field of the video monitor a rendering of  
10 an initial candidate paint color;
  - (c) displaying in respective other fields of the video monitor a rendering of each of the tints  $T_1$  through  $T_n$ ;
  - (d) in response to the selection of one of the tints, recalling from a storage location a first updated candidate paint color produced by the  
15 addition of a predetermined adjustment quantity of the selected tint to a predetermined quantity the initial candidate color;
  - (e) updating the display in the second field of the video monitor to display a rendering of the first updated candidate paint color; and
  - (f) comparing the first updated candidate paint color rendered in the  
20 second field to the target paint color rendered in the first field to determine an acceptable color match;
- wherein the improvement comprises the steps of:
  - (g) based upon the results of the comparison, iteratively repeating steps (d) through (f) by selection of any of the tints, such that, for each  
25 iteration,
    - a subsequent updated candidate paint color produced by the addition of a predetermined adjustment quantity of the selected tint to the immediately preceding candidate color is recalled from a memory location determined in accordance therewith and displayed in the second field,  
30 the repetition continuing until an acceptable color match is achieved between the renderings of a final subsequent updated candidate color and the target color; and

(h) upon achievement of an acceptable color match or after M number of iterations, where M is an integer greater than 1, tabulating the number of adjustment quantities of each tint added to the initial candidate color to produce the final subsequent updated candidate color.

5

2. The improved method of claim 1 further comprising the step of:

(i) mixing a paint by adding the tabulated adjustment quantities of each tint to a predetermined quantity of a paint of the initial candidate paint color.

10

3. The improved method of claim 1 further comprising, prior to the displaying step (a), the preparatory steps of:

(i) displaying on the video monitor a rendering of a color tinting chart, the chart having a color spectrum identifying each of the available

15 target paint colors; and

(j) selecting the predetermined target color from the color tinting chart.

4. The improved method of claim 3 further comprising, prior to the displaying step (b), the preparatory steps of:

(k) displaying on the video monitor a rendering of a color tinting chart, the chart having a color spectrum identifying each of the available candidate paint colors; and

25 (l) selecting the initial candidate refinishing color from the color tinting chart.

5. The improved method of claim 4 wherein the color tinting chart having the color spectrum identifying each of the available candidate paint colors also includes indicia identifying the formulation of the candidate

30 paint.

6. The improved method of claim 1 wherein the second field is juxtaposed in an abutting relationship against the first field on the display.

7. The improved method of claim 1 wherein the first field is closely adjacent to but spaced from the second field on the display.

5           8. The improved method of claim 1 wherein the field for each of the tints is juxtaposed in an abutting relationship against the second field on the display.

9. The improved method of claim 1 wherein the field of the video  
10 screen is rendered in a neutral surrounding background color for chromatic adaptation.

10. A machine readable storage medium containing program instructions for causing a digital computer to perform a computer-  
15 implemented method for adjusting a candidate refinishing paint color formed from a combination of a predetermined number of tints  $T_1$  through  $T_n$ , the method including the steps of:

(a) displaying in a first field of a video monitor a rendering of a target paint color;

20           (b) displaying in a second field of the video monitor a rendering of an initial candidate paint color;

(c) displaying in respective other fields of the video monitor a rendering of each of the tints  $T_1$  through  $T_n$ ;

(d) in response to the selection of one of the tints, recalling from a  
25 storage location a first updated candidate paint color produced by the addition of a predetermined adjustment quantity of the selected tint to a predetermined quantity the initial candidate color;

(e) updating the display in the second field of the video monitor to display a rendering of the first updated candidate paint color; and

30           (f) comparing the first updated candidate paint color rendered in the second field to the target paint color rendered in the first field to determine an acceptable color match;

the method being improved in that it further includes the steps of:

(g) based upon the results of the comparison, iteratively repeating steps (d) through (f) by selection of any of the tints, such that, for each iteration,

5 a subsequent updated candidate paint color produced by the addition of a predetermined adjustment quantity of the selected tint to the immediately preceding candidate color is recalled from a memory location determined in accordance therewith and displayed in the second field, the repetition continuing until an acceptable color match is achieved between the renderings of a final subsequent updated candidate  
10 color and the target color; and

(h) upon achievement of an acceptable color match or after M number of iterations, where M is an integer greater than 1, tabulating the number of adjustment quantities of each tint added to the initial candidate color to produce the final subsequent updated candidate color.

15

11. The machine readable storage medium of claim 10 wherein the improved method further comprises the step of:

(i) mixing a paint by adding the tabulated adjustment quantities of each tint to a predetermined quantity of a paint of the initial candidate  
20 paint color.

12. The machine readable storage medium of claim 10 wherein the improved method further comprises, prior to the displaying step (a), the preparatory steps of:

25 (i) displaying on the video monitor a rendering of a color tinting chart, the chart having a color spectrum identifying each of the available target paint colors; and

(j) selecting the predetermined target color from the color tinting chart.

30

13. The machine readable storage medium of claim 12 wherein the improved method further comprises, prior to the displaying step (a), the preparatory steps of: (k) displaying on the video monitor a rendering

of a color tinting chart, the chart having a color spectrum identifying each of the available candidate paint colors; and

(l) selecting the initial candidate refinishing color from the color tinting chart.

5

14. The machine readable storage medium of claim 13 wherein the color tinting chart having the color spectrum identifying each of the available candidate paint colors also includes indicia identifying the formulation of the candidate paint.

10

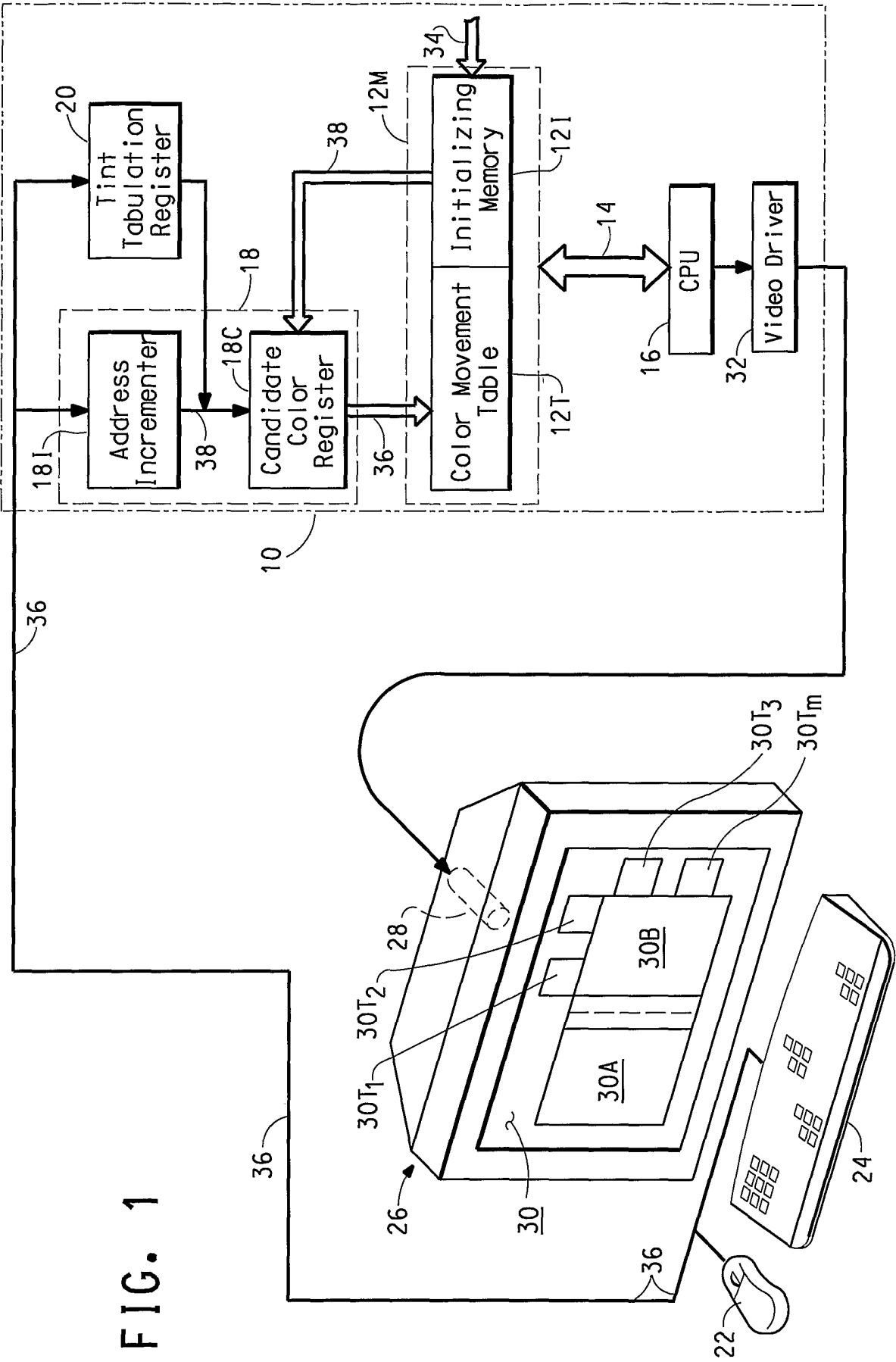
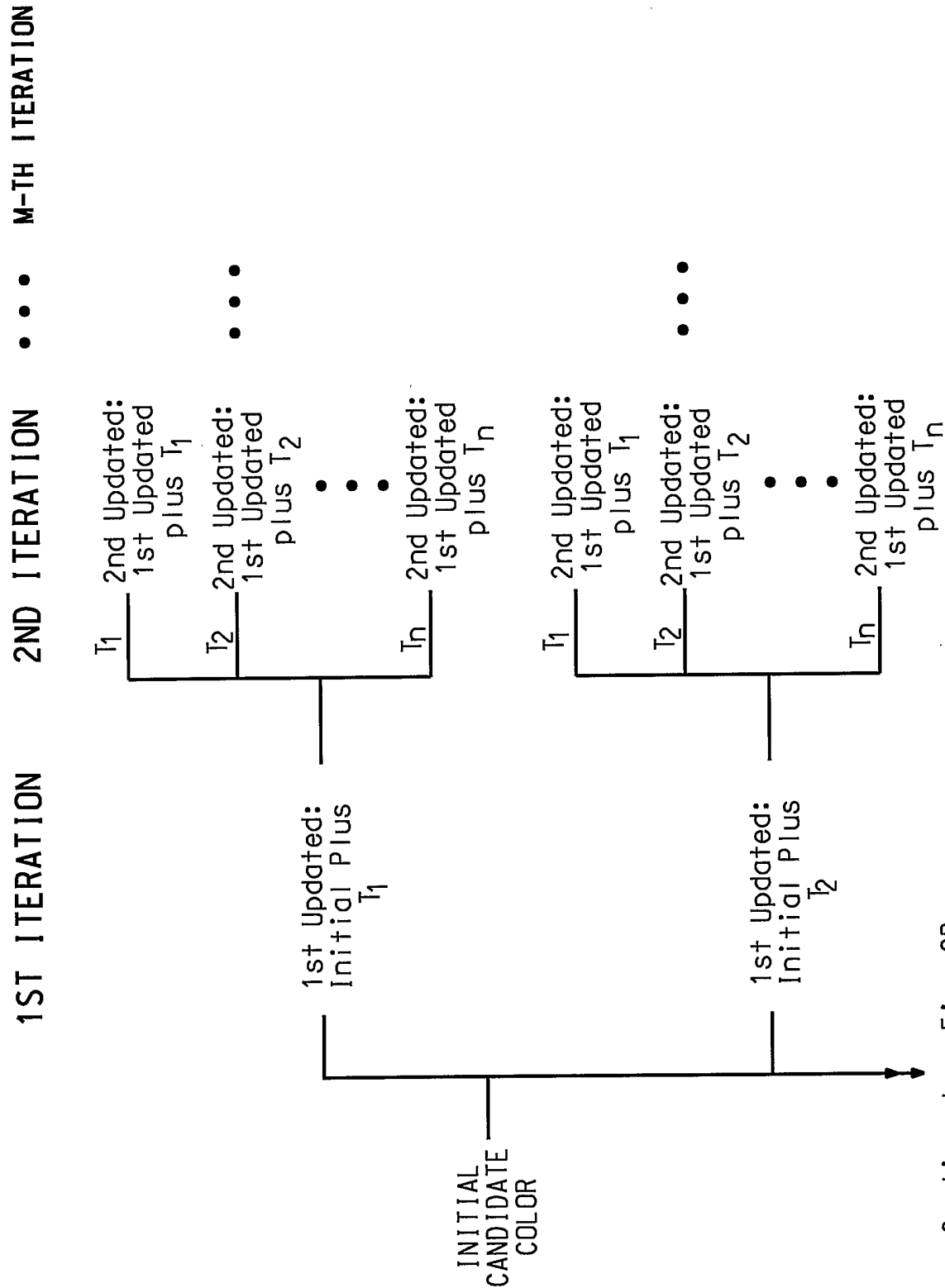


FIG. 1



Continued on Fig. 2B

FIG. 2A

1ST ITERATION                      2ND ITERATION                      ...                      M-TH ITERATION

Continued from Fig. 2A

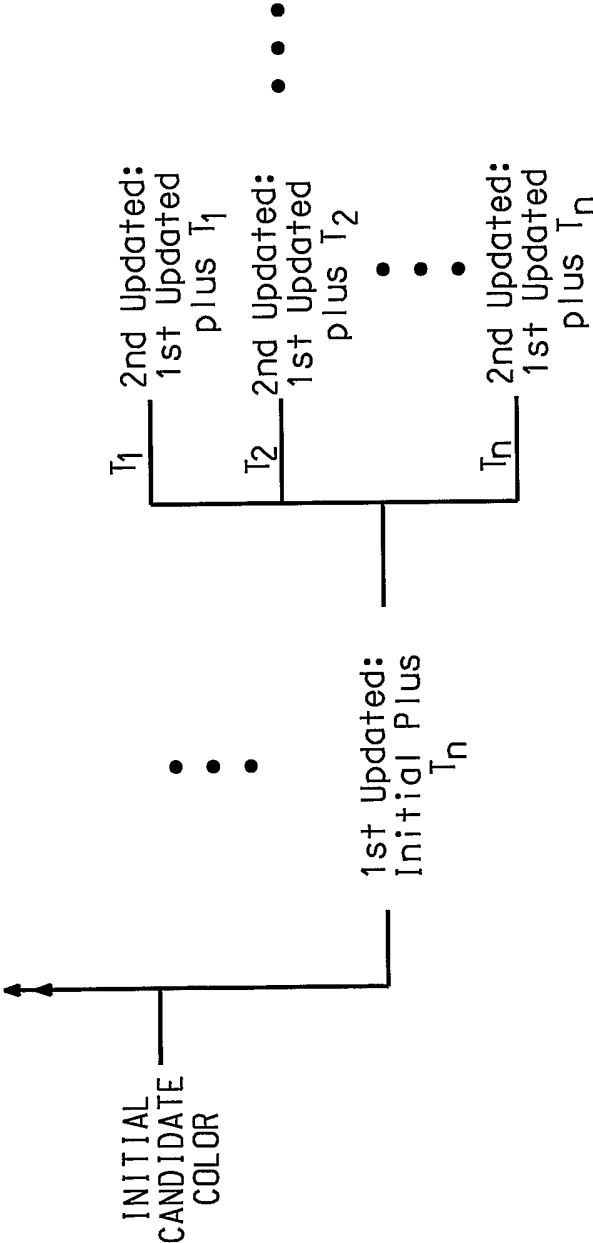


FIG. 2B

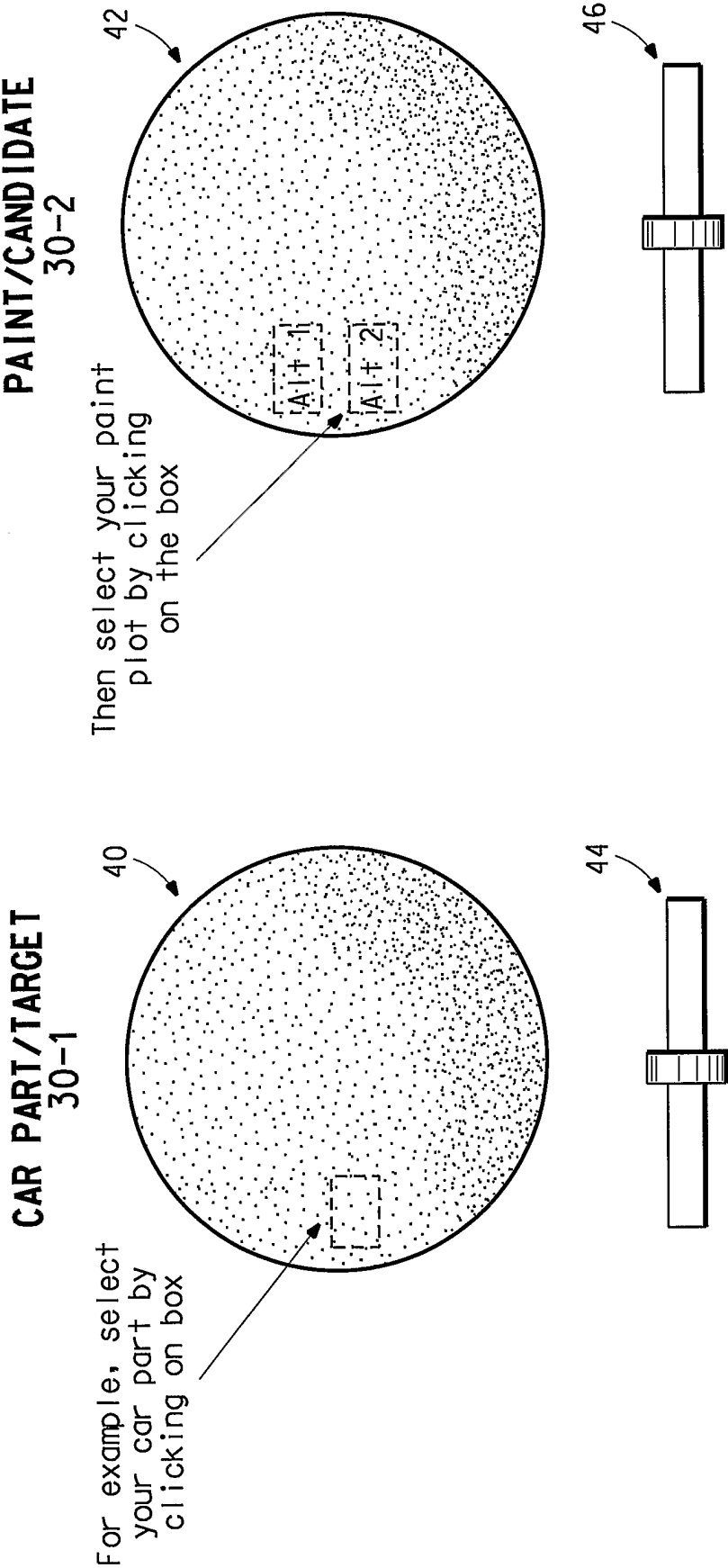


FIG. 3