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Canadian Intellectual Property Office

CA 2903466 C 2018/03/06

(11)(21) **2 903 466**

(12) BREVET CANADIEN / CANADIAN PATENT

(13) **C**

(86) **Date de dépôt PCT/PCT Filing Date:** 2014/03/11
(87) **Date publication PCT/PCT Publication Date:** 2014/09/25
(45) **Date de délivrance/Issue Date:** 2018/03/06
(85) **Entrée phase nationale/National Entry:** 2015/09/01
(86) **N° demande PCT/PCT Application No.:** US 2014/022983
(87) **N° publication PCT/PCT Publication No.:** 2014/150337
(30) **Priorité/Priority:** 2013/03/15 (US13/835,675)

(51) **Cl.Int./Int.Cl.** ***G06N 7/00*** (2006.01),
G01J 3/46 (2006.01)

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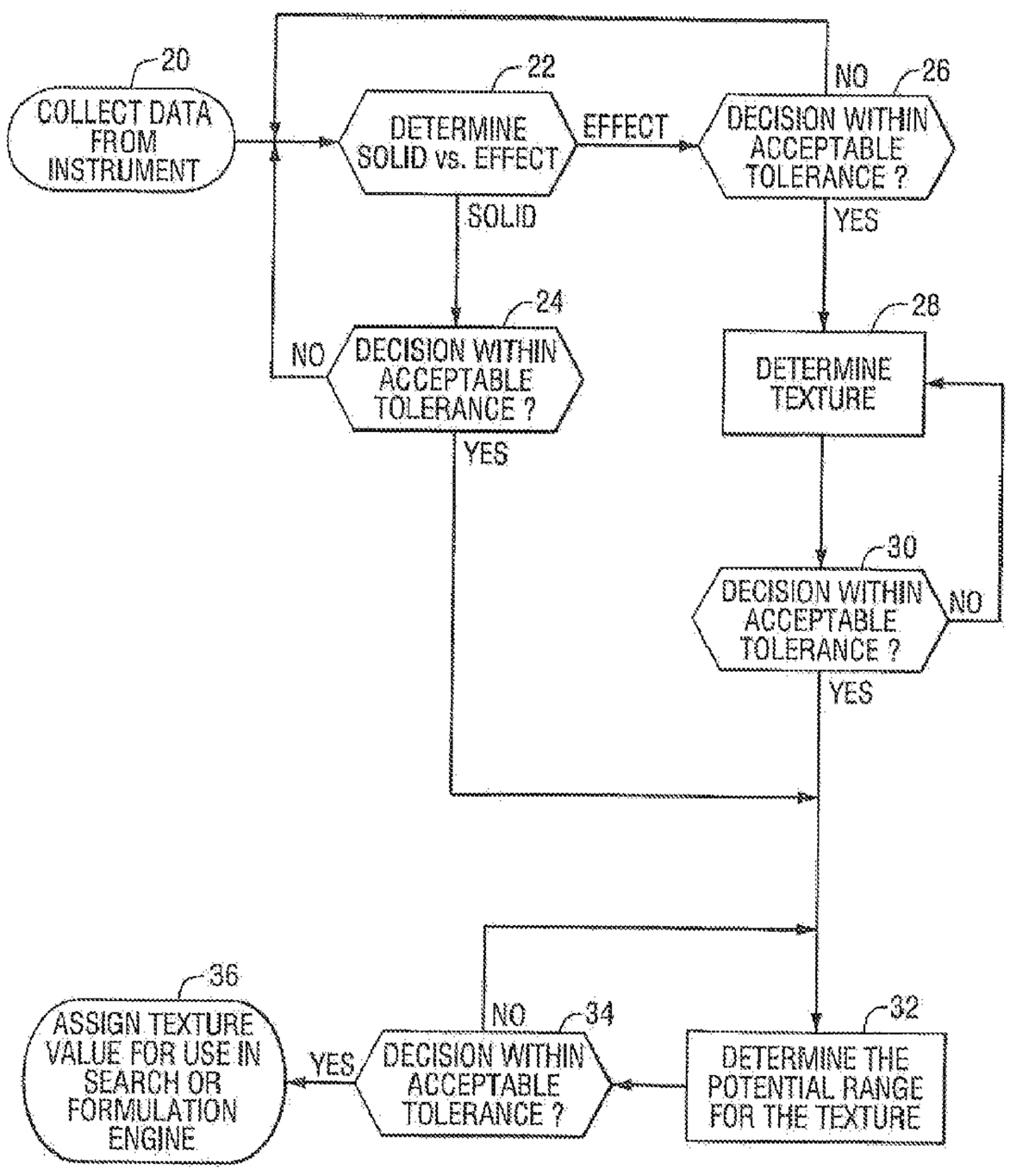
(54) **Titre : SYSTEMES ET PROCEDES POUR L'EVALUATION DE TEXTURE D'UNE FORMULATION DE REVETEMENT**
(54) **Title: SYSTEMS AND METHODS FOR TEXTURE ASSESSMENT OF A COATING FORMULATION**



(57) **Abrégé/Abstract:**
A computer implemented method. The method includes identifying, using a processor, a texture in a target coating, wherein identifying comprises applying a Bayesian process, and assigning, using the processor, a texture value adapted for use by one of a search engine and a formulation engine.

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
25 September 2014 (25.09.2014)

WIPO | PCT

(10) International Publication Number
WO 2014/150337 A3

(51) International Patent Classification:
G06N 7/00 (2006.01) *G01J 3/46* (2006.01)

(21) International Application Number:
PCT/US2014/022983

(22) International Filing Date:
11 March 2014 (11.03.2014)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
13/835,675 15 March 2013 (15.03.2013) US

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(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

[Continued on next page]

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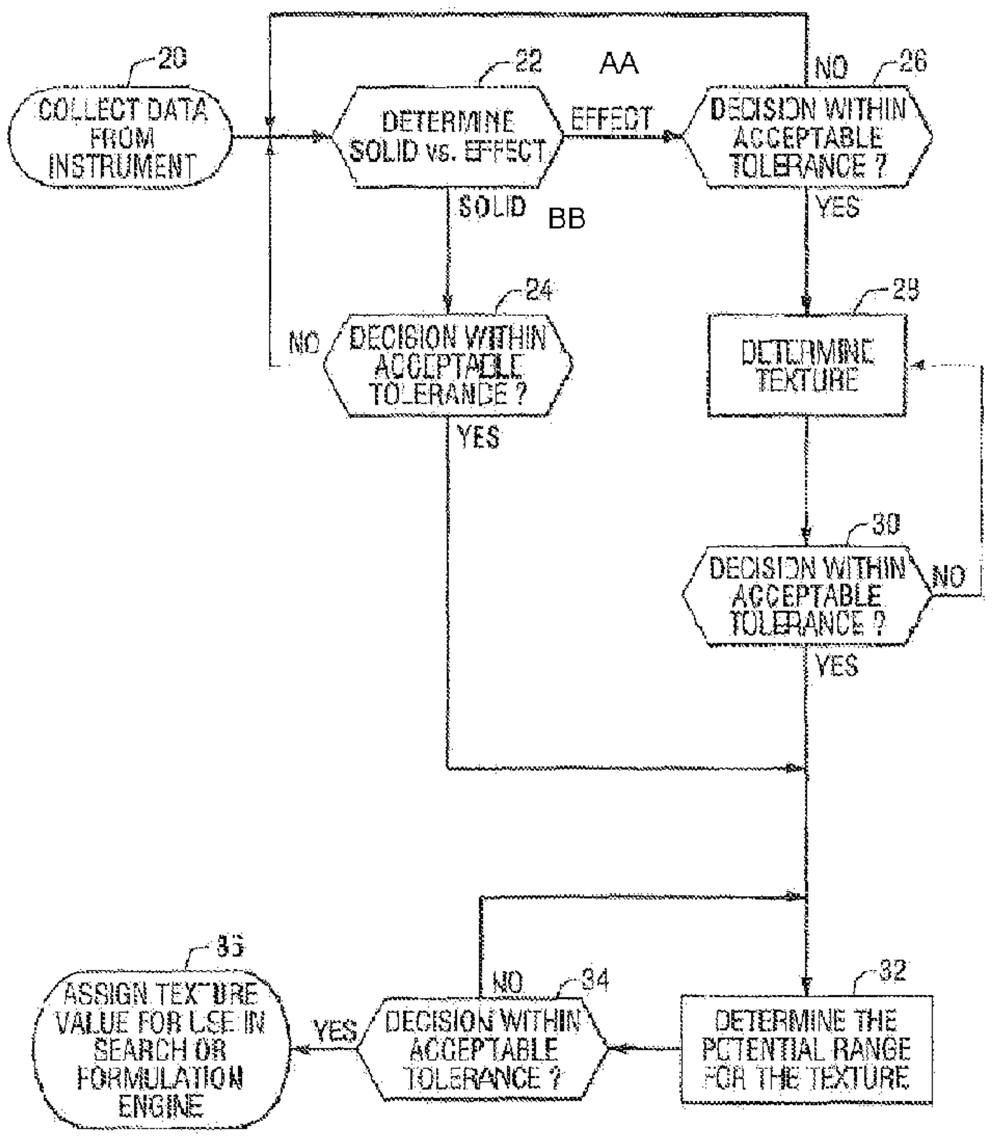

FIG. 7

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Declarations under Rule 4.17:

— *as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))*

— *as to the applicant's entitlement to claim the priority of the earlier application (Rule 4.17(iii))*

Published:

— *with international search report (Art. 21(3))*

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

(88) Date of publication of the international search report:
22 January 2015

SYSTEMS AND METHODS FOR TEXTURE ASSESSMENT OF A COATING FORMULATION

FIELD OF THE INVENTION

[0001] In various embodiments, the present invention generally relates to systems and methods for evaluating colorimetric and physical property attributes of coating mixtures in order to provide a texture quality to a user for use in formulating a coating match, in searching for a coating match in data storage (*e.g,* a database), and in quality assurance.

BACKGROUND OF THE INVENTION

[0002] In order to provide a proper color match to a target sample that is coated with a target coating using formulation or search engines (or a visual process), it is desirable to determine the correct pigmentation of the target coating. If the same pigments or appropriate offsets as those in the target coating are utilized, a formulation or search process may arrive at an apparent optimum solution as to the formulation of the target coating. However, a color match may not precisely provide an entirely matched sample if there is a possibility of varying the textural qualities due to pigment textures. Also, excluding those pigments, either deliberately or inadvertently, from availability will result in a less than optimal color match.

[0003] Several existing match search or formulation engines and methodologies attempt to encompass pigment selection and formulation via various algorithms. Various pigment identification packages and formulation engines take a "brute" force, guess and check type of approach to provide formulations and pigment information to their users. The combinatorial approach, a brute force method, is a frequently used method in which nearly all available pigments are combined in all combinations available given an end number of pigments desired in the final match. Although there have been some methods which restrict the usage of some pigments given certain conditions to optimize the engine's speed, the end result is that the formula combinations are validated against the sample and a selection of one or more formulas most nearly matching the target coating are provided to the user.

[0004] Other solutions require the user to submit a sample set of toners to a search or formulation engine, and still other methods select a predefined subset of

toners to use. These methods have been typically burdensome for users and lack proper "intuition" to provide a streamlined method to a good solution for the user. Additionally, by the nature of such methodology, appropriate pigments necessary to match the target coating may be excluded.

[0005] Neural networks have been used to select color matches from existing databases of pre-generated possible matches or to act as formulation engines themselves. The strength of a neural network is its ability to address both linear and non-linear relationships, but this strength comes at a cost of bulkiness, inflexibility, and a requirement of significant overhead to meticulously manage a sometimes large learning database and structure. The inflexibility, or rigid operation, of a neural network generally must be used in a feedback design to optimize the node weightings leading to and within the hidden layers of the network. A neural network requires this type of backpropagation of errors acquired from desired outputs in order to "learn." The actual learning, or training, of the neural network is based on the reduction of the calculated error given a desired output by repeated reintroduction of the input and adjustment of the weights based on the prior iteration's error.

[0006] As can be seen in Fig. 1, a typical neural network requires a nearly ideally defined input and requires significant effort to update and/or alter the various layers (nodes) if an error needs to be corrected or a new piece of information needs to be considered. Although fewer steps, compared to some prior models, are apparent to the user, a neural network tends to be relatively slow and unidirectional due to its nature of trying to encompass the resolution to a formulation or color search in one massive step. Also, as with the methodologies discussed hereinabove, the exclusion of necessary pigments is a possibility. A neural network also requires precise and somewhat tedious maintenance of the weights, the database, the calculations, the sophisticated and rigid process mapping, and the substantial "training" to be effective.

[0007] Thus, there is a need for systems and methods that have flexibility to partition the processing steps into smaller multidirectional pieces and that utilize a feed forward type of design for speed and accuracy. There is also a need for systems and methods that minimize user interaction and create a flexible stepwise methodology of pigment identification and tolerancing in combination with a formulation engine.

SUMMARY OF THE INVENTION

[0008] In a first aspect, embodiments of the invention provide a computer implemented method. The method includes identifying, using a processor, a texture in a target coating, wherein identifying comprises applying a Bayesian process, and assigning, using the processor, a texture value adapted for use by one of a search engine and a formulation engine.

[0009] In another aspect, embodiments of the invention are directed to a system. The system includes a database and a processor in communication with the database and programmed to: identify a texture in a target coating, wherein identifying comprises applying a Bayesian process, and assign a texture value adapted for use by one of a search engine and a formulation engine.

[0010] In another aspect, embodiments of the invention provide an apparatus. The apparatus includes means for identifying a texture in a target coating, wherein identifying comprises applying a Bayesian process, and means for assigning, using the processor, a texture value adapted for use by one of a search engine and a formulation engine.

[0011] In a further aspect, embodiments of the invention provide a A non-transitory computer readable medium including software for causing a processor to: identify a texture in a target coating, wherein identifying comprises applying a Bayesian process; and assign a texture value adapted for use by one of a search engine and a formulation engine.

BRIEF DESCRIPTION OF THE DRAWINGS

[0012] Fig. 1 illustrates a typical neural network.

[0013] Fig. 2 illustrates examples of typical Bayesian systems.

[0014] Fig. 3 illustrates a high level representation of a texture scale identification Bayesian module according to various embodiments of the present invention.

[0015] Fig.4 illustrates a high level representation of a tolerance Bayesian module according to various embodiments of the present invention.

[0016] Fig. 5 illustrates an embodiment of a system which may be used to identify physical property attributes of a coating mixture of a target sample.

[0017] Fig.6 illustrates a high level representation of a Bayesian system according to various embodiments of the present invention

[0018] Fig. 7 illustrates an embodiment of a process for identifying physical property attributes of a coating mixture of a target sample.

DETAILED DESCRIPTION OF THE INVENTION

[0019] In various embodiments, the present invention generally relates to systems and methods comprising a Bayesian belief system that may be independent or dependent Bayesian systems and methods. Embodiments include various modules that may be used in combination to identify the texture qualities of a sample that is coated with an unknown target coating. In another aspect, the modules may be used to determine the texture nature of known samples and/or known pigments.

[0020] While the description herein generally refers to paint, it should be understood that the devices, systems and methods apply to other types of coatings, including stain and industrial coatings. The described embodiments of the invention should not be considered as limiting. A method consistent with the present invention may be practiced in a variety of fields such as the matching and/or coordination of apparel and fashion products.

[0021] Embodiments of the invention may be used with or incorporated in a computer system that may be a standalone unit or include one or more remote terminals or devices in communication with a central computer via a network such as, for example, the Internet or an intranet. As such, the computer or "processor" and related components described herein may be a portion of a local computer system or a remote computer or an on-line system or combinations thereof. The database and software described herein may be stored in computer internal memory or in a non-transitory computer readable medium.

[0022] A Bayesian system is based on probabilistic reasoning from Bayes' Theorem, which is derived from the conditional probability's definition. Examples of Bayesian systems are shown in Fig. 2.

Equation 1: Bayes Theorem

$$P(A|\mathrm{B}) = \frac{P(B|A)P(A)}{P(B)}$$

where: $\mathrm{P(B)} \neq 0$

[0023] By utilizing Bayes theorem a system of dependent and independent decision points may be used to determine the texture nature of an unknown sample.

[0024] A basic Bayesian system consisting of multiple decision points may be used to determine the probability (belief) that a given sample has the attributes of a particular texture type. Basic texture types can be divided into multiple qualitative nominal or ordinal categories. By way of example, some categories may be labeled: Very Fine, Fine, Medium, Less Coarse, Coarse. The categories can be further subdivided by, for example, sparkle characteristics such as high, medium, and low. The various decision points within a Bayesian system that may be used to determine the texture of the target coating may comprise, but are not limited to: Colorimetric values (DE, L, a, b, C, h, X, Y, Z), logarithms of colorimetric values, flop indices, similarity indices, travel indices, travel areas, products of reflectance, various angular spectral data, sum of squares DE, and/or combinations thereof.

[0025] A first decision point in various embodiments is determining if the target coating contains effect pigments or if only solid pigments are present. This can be done by utilizing decision points which consider, but are not limited to, Chroma, Lightness, and Hue. Various probabilistic equations can be evaluated given chroma and lightness to determine the probability a sample contains effect pigmentation or contains only straight shade, solid, pigments. If only solid pigments are present, the texture may be due to the substrate and can be adequately mimicked by placing an appropriately matching colored paint over the identical substrate. If an effect pigmentation is present then further evaluation with Bayesian system and method may be necessary to elicit the proper textural information. An example of a high level representation of a texture determining Bayesian module is shown in Fig. 3.

[0026] Embodiments of the present invention utilize a five angle spectrophotometer, such as the CM64 produced by X-Rite, Incorporated, to generate a variety of weighted simplified decision points for each angle of data provided from the instrument. For example, the decision points for a sample with a chroma value greater than 10 at the 15° angle should contain a logical set of decisions that include emphasis on color considering values when analyzing that particular angle. However, a sample with a chroma below 10 should emphasize lightness and darkness values. Each set of angular data may be split along these lines for determination of the probability that a sample is of one of the 5 coarseness categories discussed herein. In

various embodiments, the sparkle values may be considered in a similar fashion. The combination of the two phenomena results in a texture value which may be summarized by 5 or more (*e.g.,* 15 in background assessments – combination of 3 sparkle and 5 coarseness categories) ranges: from T1-T5 as an example.

[0027] By providing the information for consideration in the various decision points, even simple directional spectrophotometers without cameras may be used to provide textural information of a target coating. The information may then be used to further differentiate the quality of a match previously found through consideration of color related criteria. In various embodiments, camera information, color or otherwise, may also be considered as part of an additional group of decision points. These decision points may be, but are not limited to, the following: intensity of sparkle, concentration of sparkle within a given radius, similarity indices, and principle components. Considering these parameters "simultaneously" during decisions in a Bayesian system may allow for a synergistic approach in which the sum of the decisions is greater than the individual pieces. Further, the sparkle and coarseness values may be combined into a single texture parameter. However, in order to simplify the search for a match to a sample from within a dataset, some generalized information regarding texture may in various embodiments be attributed to each match within the dataset, available pigment, or both. The process for assigning texture values to the dataset is described herein. The texture values from previously developed formulations may then be directly compared to those of the target coating to evaluate compatibility of the match. Comparison with individual pigments or groups of individual pigments may require an additional Bayesian module to account for the contribution to texture of each pigment at various concentrations within the formulation. Embodiments of the present invention may be used as an informational decision point within a formulation engine, whether it be for pigment selection or concentration determination.

[0028] Depending upon the application, a tolerancing module may be used to determine adequate assignment of texture values. A correlation between the visual acceptable limits may be calculated in which a variety of Bayesian decision points may be connected together. Examples of the decision points may be, but are not limited to, the following: colorimetric values such as L, C, h, Delta E, Similarity Indices of spectral information, multlidimensional models of various key

combinations of specular information, a compound match rating system, texture evaluation, or a combined angular normalized spectral "curve." A high level representation of a tolerance Bayesian module is illustrated in Fig. 4.

[0029] Fig. 5 illustrates an embodiment of a system 90 which may be used to identify physical property attributes of a coating mixture of a target sample. A user 92 may utilize a user interface 94, such as a graphical user interface, to operate a spectrophotometer 96 to measure the properties of a target sample 98. The data from the spectrophotometer 96 may be transferred to a computer 100, such as a personal computer, a mobile device, or any type of processor. The computer 100 may be in communication, via a network 102, with a server 104. The network 102 may be any type of network, such as the Internet, a local area network, an intranet, or a wireless network. The server 104 is in communication with a database 106 that may store the data and information that is used and generated by the methods of embodiments of the present invention. Various steps of the methods of embodiments of the present invention may be performed by the computer 100 and/or the server 106.

[0030] The combination of a Bayesian texture determining module with a Bayesian tolerancing module may adequately describe the texture of a given target coating and may provide increasingly accurate texture values with increasingly more informative spectrophotometers. However, the texture assessment from even the simplest of units can provide ample information for an adequate texture assignment. An example of a Bayesian system comprising the modules disclosed herein is presented in Fig. 6.

[0031] Fig. 7 illustrates an embodiment of a process for identifying physical property attributes of a coating mixture of a target sample. The process begins at step 20, where data is collected from an instrument (*e.g.,* the spectrophotometer 96). At step 22, the process determines whether a solid or effect is present. If a solid is present, at step 24 the process determines, using the tolerancing module, whether the decision at step 22 is within an acceptable tolerance. If not, the process returns to step 22. If an effect is present as determined at step 22, the process advances to step 26, where the process determines, using the tolerancing module, whether the decision at step 22 is within an acceptable tolerance. If not, the process returns to step 22.

[0032] If the decision at step 22 is within an acceptable tolerance as determined at step 26, the process advances to step 28 where the texture scale

identification module identifies the texture in the target coating. At step 30, the process determines, using the tolerancing module, whether the texture identification is within an acceptable tolerance. If not, the process returns to step 28. If the texture identification is within an acceptable tolerance, the process advances to step 32 potential range for the texture is determined. At step 34, the process determines, using the tolerancing module, whether the texture range is within an acceptable tolerance. If not, the process returns to step 32. If the refined pigment identification is within an acceptable tolerance, the process advances to step 36 where the texture value is assigned for use in a search or formulation engine. Whether a value or other property, such as for example a texture identification and/or a texture range, is within an acceptable tolerance may be determined by assessing or determining if the value or property is within a predetermined tolerance.

[0033] Although various embodiments have been described herein as having decision points made inside Bayesian systems, it is contemplated that such decisions may be made outside of a Bayesian system.

[0034] In another aspect, the invention may be implemented as a non-transitory computer readable medium containing software for causing a computer or computer system to perform the method described above. The software can include various modules that are used to enable a processor and a user interface to perform the methods described herein.

[0035] It will be readily appreciated by those skilled in the art that modifications may be made to the invention without departing from the concepts disclosed in the forgoing description. Such modifications are to be considered as included within the following claims unless the claims, by their language, expressly state otherwise. Accordingly, the particular embodiments described in detail herein are illustrative only and are not limiting to the scope of the invention which is to be given the full breadth of the appended claims and any and all equivalents thereof.

CLAIMS:

1. A computer implemented method, comprising:

obtaining data for a target coating from a spectrophotometer;

identifying, using a processor, a texture type in the target coating, wherein identifying comprises applying a Bayesian process with multiple decisions points making use of the obtained spectrophotometric data; and

assigning, using the processor, based on the identifying step, a texture value to the target coating, wherein the assigned texture value represents the probability that the target coating has the attributes of the identified texture type;

using the assigned texture value for searching a coating matching to the target coating in a database by a search engine or for formulating a coating that matches the target coating by a formulation engine.

2. The method of claim 1, further comprising determining, using the processor, whether the texture identification is within a predetermined tolerance, wherein determining whether the texture identification is within a predetermined tolerance preferably comprises applying a Bayesian process.

3. The method of claim 1, further comprising determining, using the processor, a range of the determined texture type.

4. The method of claim 3, further comprising determining, using the processor, whether the range is within a predetermined tolerance, wherein determining whether the range is within a predetermined tolerance preferably comprises applying a Bayesian process.

5. A system, comprising:

a database;

a spectrophotometer and

a processor in communication with the database and in communication with the spectrophotometer and programmed to:

obtaining data for a target coating from the spectrophotometer

identify a texture type in the target coating, wherein identifying comprises applying a Bayesian process with multiple decisions points making use of the obtained spectrophotometric data; and

assign, based on the identifying step, a texture value to the target coating, wherein the assigned texture value represents the probability that the target coating has the attributes of the identified texture type;

use the assigned texture value for searching a coating matching to the target coating in a database by a search engine or for formulating is a coating that matches the target coating by a formulation engine.

6. The system of claim 5, further comprising a display device in communication with the processor.

7. A computer implemented apparatus, comprising:

means for obtaining data for a target coating from a spectrophotometer;

means for identifying a texture type in the target coating, wherein identifying comprises applying a Bayesian process with multiple decisions points making use of the obtained spectrophotometric data; and

means for assigning, based on the identifying step, a texture value to the target coating, wherein the assigned texture value represents the probability that the target coating has the attributes of the identified texture type;

means for using the assigned texture value for searching a coating matching to the target coating in a database by a search engine or for formulating a coating that matches the target coating by a formulation engine.

8. The apparatus of claim 7, further comprising means for determining whether the texture identification is within a predetermined tolerance, wherein the means for determining whether the texture identification is within a predetermined tolerance preferably comprises means for applying a Bayesian process.

9. The apparatus of claim 7, further comprising means for determining a range of the determined texture type.

10. The apparatus of claim 9, further comprising means for determining whether the range is within a predetermined tolerance,

wherein the means for determining whether the range is within a predetermined tolerance preferably comprises means for applying a Bayesian process.

11. A non-transitory computer readable medium including software for causing a processor to:

obtain data for a target coating from a spectrophotometer;

Identify a texture type in the target coating, wherein identifying comprises applying a Bayesian process with multiple decisions points making use of the obtained spectrophotometric data; and

Assign, based on the identifying step, a texture value to the target coating, wherein the assigned texture value represents the probability that the target coating has the attributes of the identified texture type;

use the assigned texture value for searching a coating matching to the target coating in a database by a search engine or for formulating a coating that matches the target coating by a formulation engine.

12. The medium of claim 11, further comprising software causing the processor to determine whether the texture identification is within a predetermined tolerance.

13. The medium of claim 11, further comprising software causing the processor to determine a range of the determined texture type, optionally further comprising software causing the processor to determine whether the range is within a predetermined tolerance.

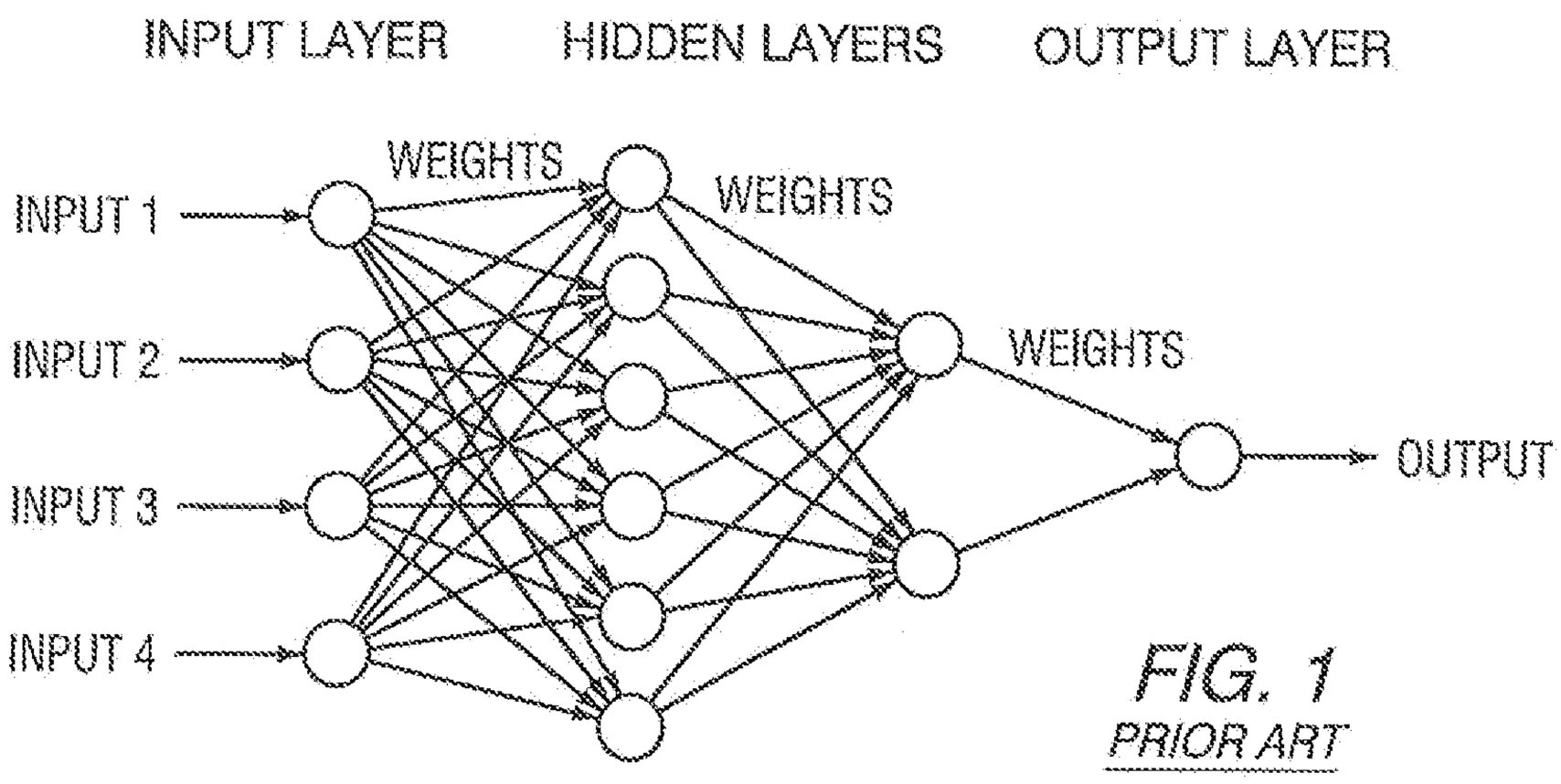


FIG. 1
PRIOR ART

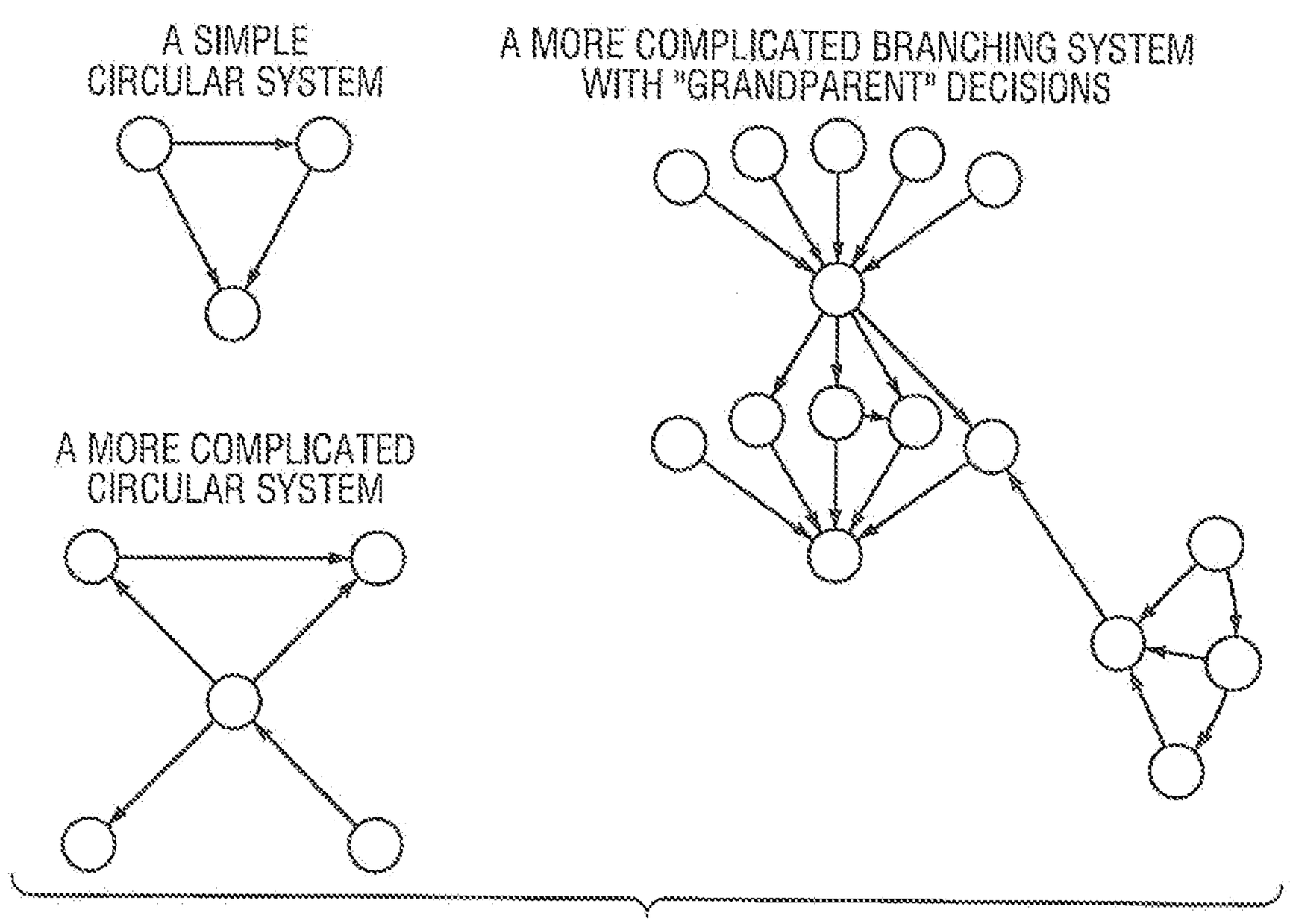


FIG. 2
PRIOR ART

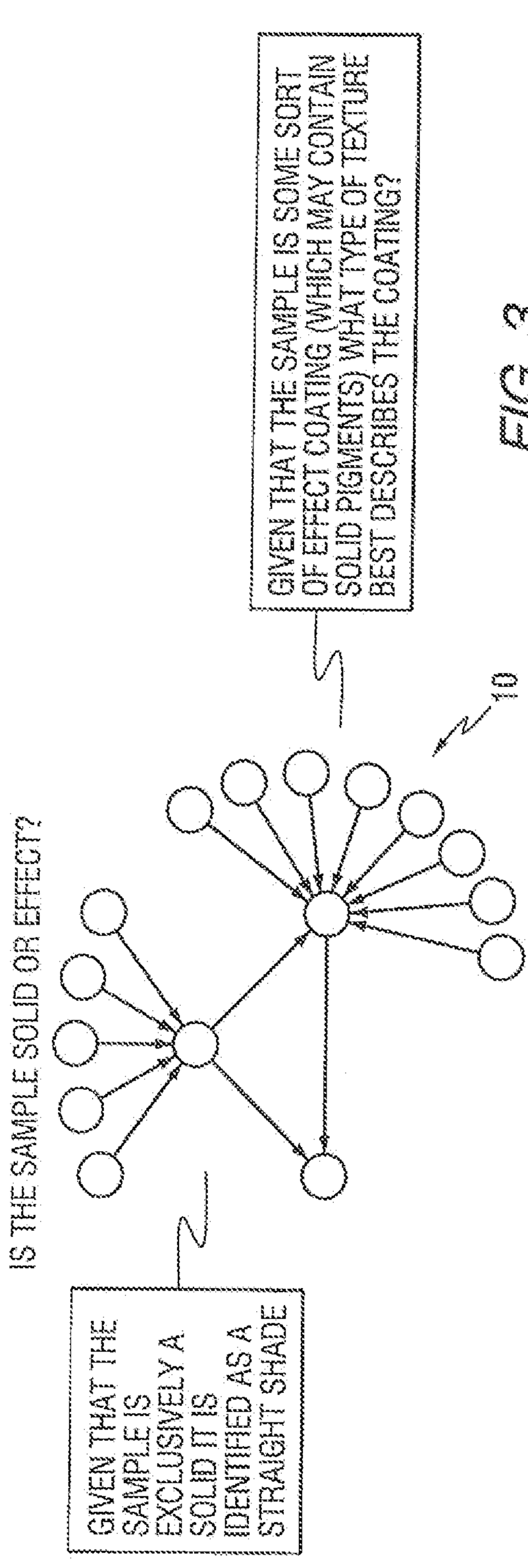

IS THE SAMPLE SOLID OR EFFECT?
GIVEN THAT THE SAMPLE IS EITHER A STRAIGHT SHADE OR EFFECT TYPE, WHAT IS THE POTENTIAL RANGE OF THE TEXTURE?
GIVEN THAT THE SAMPLE IS SOME SORT OF EFFECT COATING (WHICH MAY CONTAIN SOLID PIGMENTS) WHAT TYPE OF TEXTURE BEST DESCRIBES THE COATING?
GIVEN THAT THE SAMPLE IS EXCLUSIVELY A SOLID IT IS IDENTIFIED AS A STRAIGHT SHADE
GIVEN THAT VISUAL ACCEPTANCE FOR A MATCH HAS A CERTAIN RANGE, IS THE DETERMINED TEXTURE ADEQUATE?

FIG. 3

FIG. 4

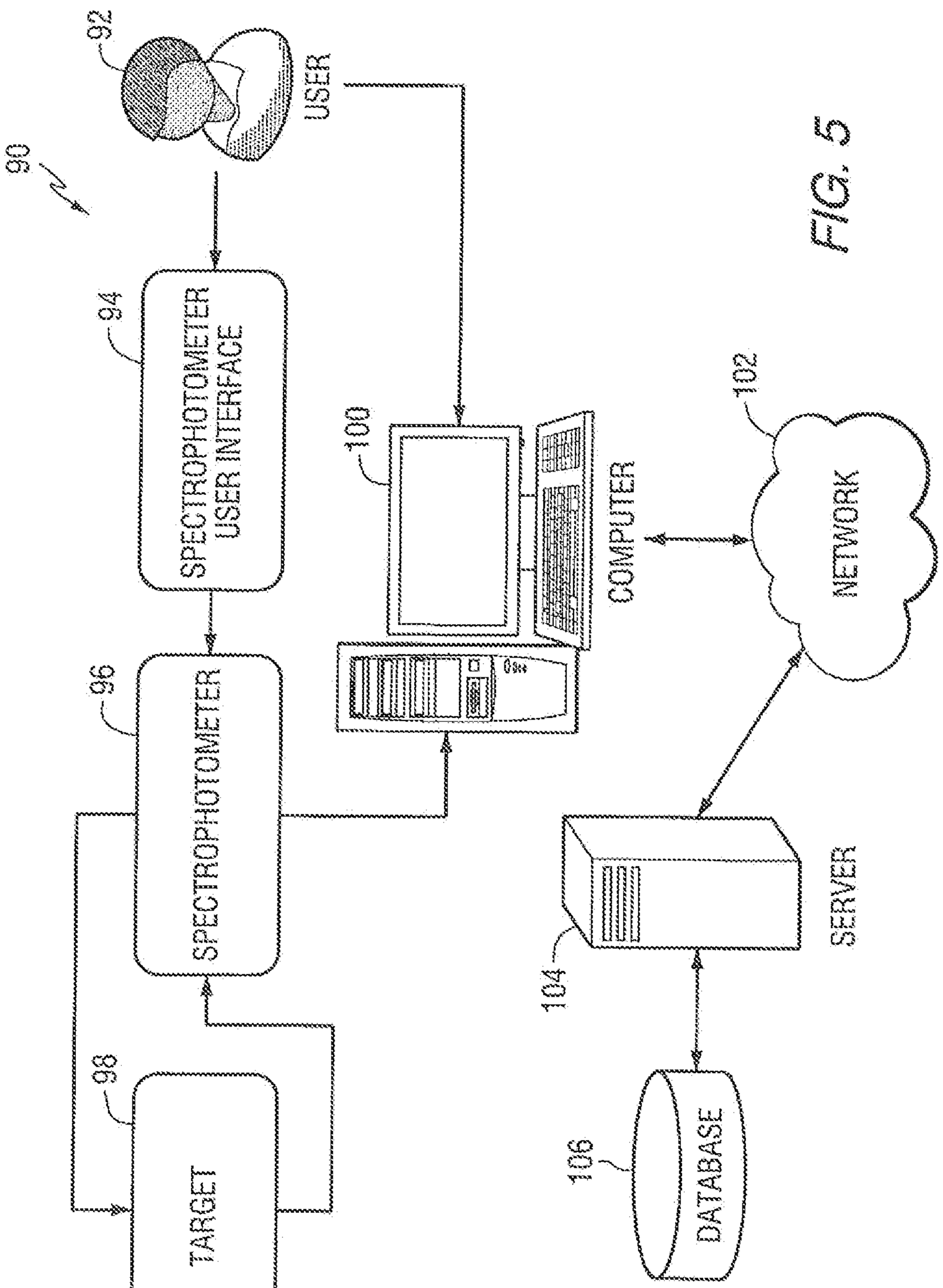

92
USER
90
94
SPECTROPHOTOMETER USER INTERFACE
100
COMPUTER
102
NETWORK
96
SPECTROPHOTOMETER
SERVER
104
98
TARGET
106
DATABASE

FIG. 5

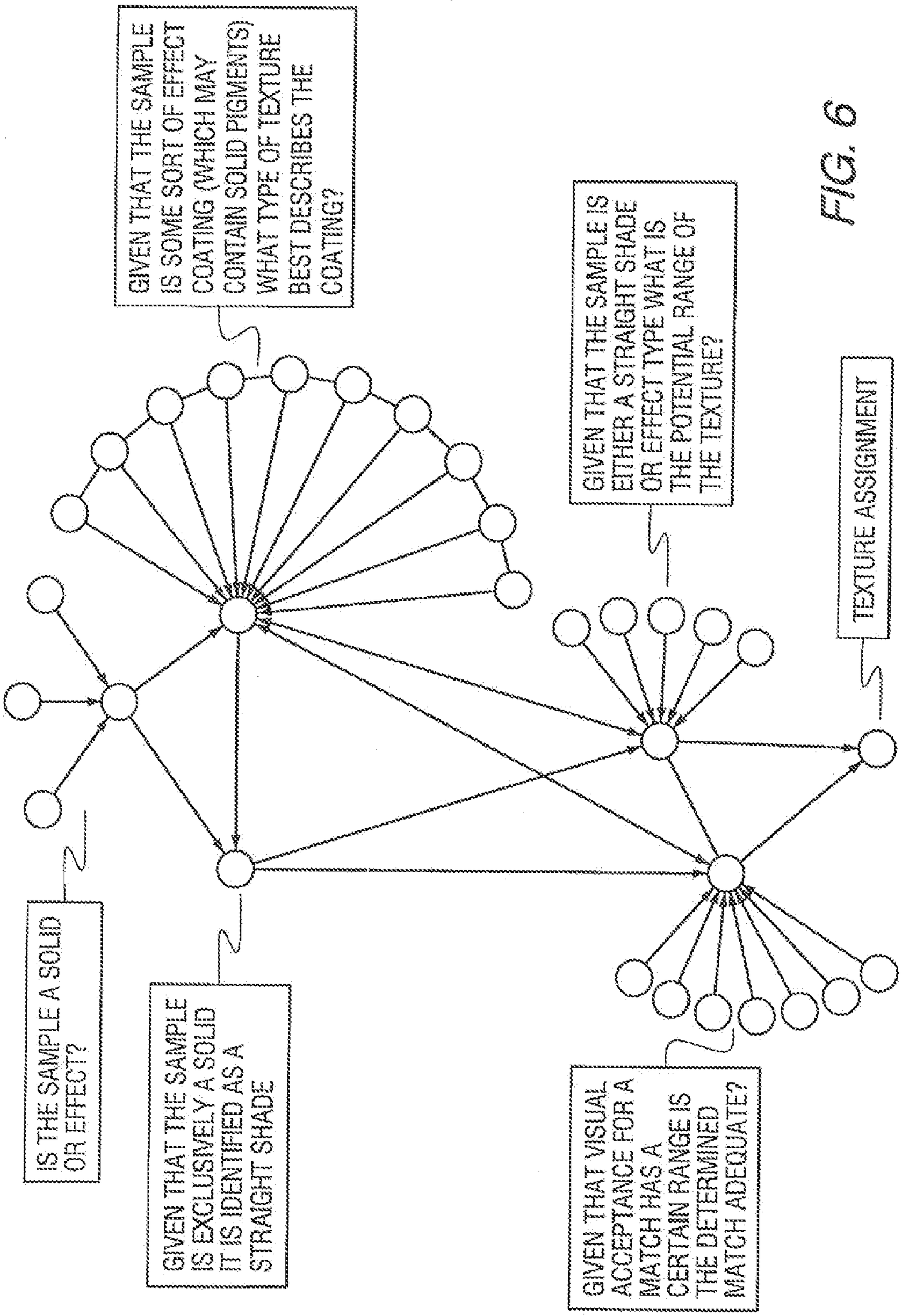
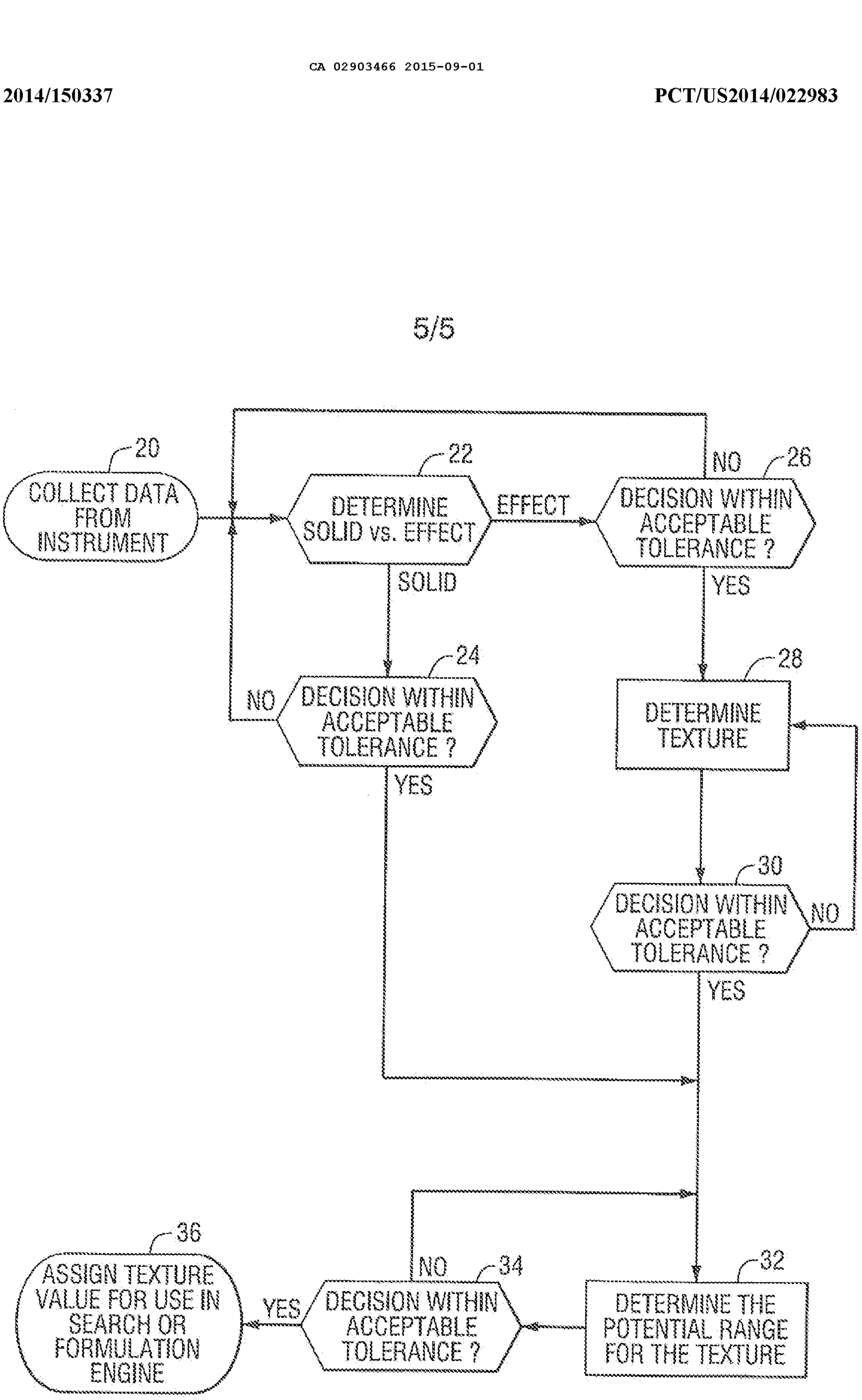

GIVEN THAT THE SAMPLE IS SOME SORT OF EFFECT COATING (WHICH MAY CONTAIN SOLID PIGMENTS) WHAT TYPE OF TEXTURE BEST DESCRIBES THE COATING?
GIVEN THAT THE SAMPLE IS EITHER A STRAIGHT SHADE OR EFFECT TYPE WHAT IS THE POTENTIAL RANGE OF THE TEXTURE?
TEXTURE ASSIGNMENT
IS THE SAMPLE A SOLID OR EFFECT?
GIVEN THAT THE SAMPLE IS EXCLUSIVELY A SOLID IT IS IDENTIFIED AS A STRAIGHT SHADE
GIVEN THAT VISUAL ACCEPTANCE FOR A MATCH HAS A CERTAIN RANGE IS THE DETERMINED MATCH ADEQUATE?

FIG. 6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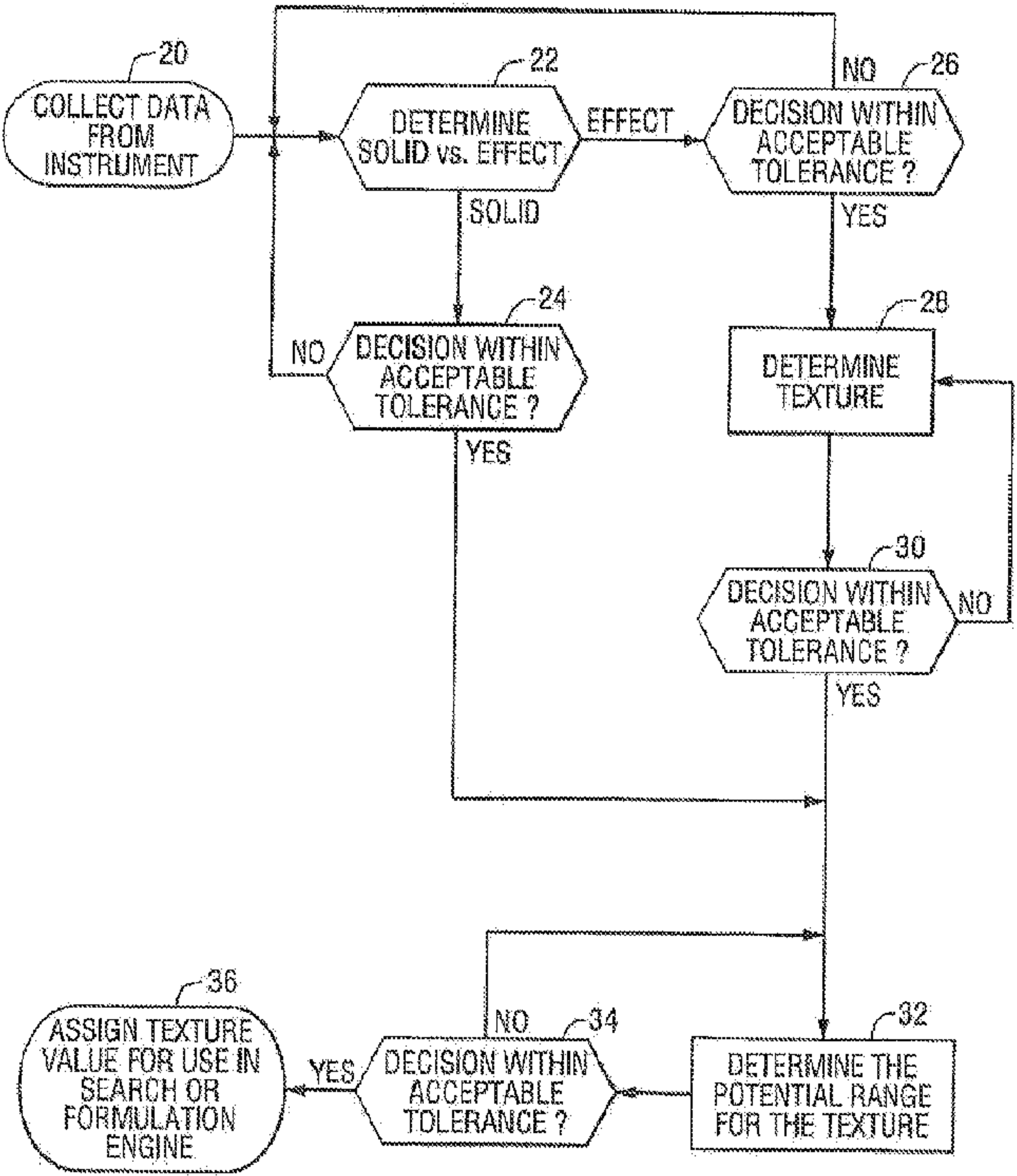
COLLECT DATA FROM INSTRUMENT
22
DETERMINE SOLID vs. EFFECT
EFFECT
SOLID
NO
26
DECISION WITHIN ACCEPTABLE TOLERANCE ?
YES
24
NO
DECISION WITHIN ACCEPTABLE TOLERANCE ?
YES
28
DETERMINE TEXTURE
30
DECISION WITHIN ACCEPTABLE TOLERANCE ?
NO
YES
36
ASSIGN TEXTURE VALUE FOR USE IN SEARCH OR FORMULATION ENGINE
YES
NO
34
DECISION WITHIN ACCEPTABLE TOLERANCE ?
32
DETERMINE THE POTENTIAL RANGE FOR THE TEXTURE

FIG. 7


20
COLLECT DATA FROM INSTRUMENT
22
DETERMINE SOLID vs. EFFECT
EFFECT
SOLID
NO
26
DECISION WITHIN ACCEPTABLE TOLERANCE ?
YES
24
NO
DECISION WITHIN ACCEPTABLE TOLERANCE ?
YES
28
DETERMINE TEXTURE
30
DECISION WITHIN ACCEPTABLE TOLERANCE ?
NO
YES
36
ASSIGN TEXTURE VALUE FOR USE IN SEARCH OR FORMULATION ENGINE
YES
NO
34
DECISION WITHIN ACCEPTABLE TOLERANCE ?
32
DETERMINE THE POTENTIAL RANGE FOR THE TEXTURE