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FILED
2016 MAR 14 PM 3:48
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UNITED STATES DISTRICT COURT

CENTRAL DISTRICT OF CALIFORNIA

COFFELT, Louis, A., Jr., Plaintiff,
v.
Nvidia, Corporation, Defendant,
v.
Autodesk, Inc., Defendant,
v.
Pixar, Defendant.

Case No.: ED CV16-00457 BRO (KKx)

COMPLAINT FOR PATENT INFRINGEMENT,

JURY TRIAL DEMAND

Plaintiff, Louis A. Coffelt, Jr. allege:

JURISDICTION

1. This Court has subject matter jurisdiction pursuant to 28 U.S.C. § 1338(a) any Act of Congress relating to patents or trademarks.

2. This Court has personal jurisdiction over Nvidia Corporation, Autodesk, Inc., and Pixar based on the allegation that Nvidia, Corporation, Autodesk, Inc., and Pixar has committed and continues to commit acts of infringement in violation of 35 U.S.C. § 271. Furthermore, based on the allegation that Nvidia, Corporation, Autodesk, Inc., and Pixar places

infringing products into the stream of commerce, with the knowledge or understanding that such products are sold in the State of California, including this Central District of California. Based on information and belief, Nvidia, Corporation, Autodesk, Inc., and Pixar has substantial revenue from the sale of infringing products within this District, expect their actions to have consequences in this District, and derive substantial revenue from the infringing products through interstate and international commerce.

VENUE

3. Venue is proper within this District under 28 U.S.C. § 1391(b),(c) based on the allegation that Nvidia, Corporation, Autodesk, Inc., and Pixar transacts business in this District, and offers for sale in this District products which infringe Plaintiff's patent. Furthermore, venue is proper in this District based on the fact that Plaintiff resides in this District, and Plaintiff incurred injuries in this District. Pursuant to Local Rule 3-2(c), Intellectual Property Actions are assigned on a district-wide basis.

PARTIES

4. Plaintiff's name is Louis A. Coffelt, Jr. referred to herein as ("Coffelt"). Coffelt's correspondence address is: 231 E. Alessandro Blvd. Ste. 6A-504, Riverside, CA 92508; Coffelt resides at 3706 Oakwood Pl., Riverside, CA 92506.

5. A first Defendant is Nvidia, Corporation referred to herein as ("Nvidia"), incorporated in the state of Delaware, having a Corporate office at: 2701 San Tomas Expressway, Santa Clara, CA 95050

6. A second Defendant is Autodesk, Inc. referred to herein as ("Autodesk"), incorporated in the state of Delaware, having a Corporate office at 111 McInnis Parkway, San Rafael, CA 94903.

7. A third Defendant is Pixar, incorporated in the state of California,

having a Corporate office at 1200 Park Ave, Emeryville, CA 94608.

PRELIMINARY STATEMENT

8. Realistic 3 dimensional (3D) graphics is a media which is immediately recognized. Electronic images simulate real world environments. For example, 3D movies, games, and mobile phone graphics. However, from the start of 3D graphics, the technology has suffered from inherent limitations of 2 dimensional shadows maps. For example, a disc shaped dark region on a flat surface below a sphere.

9. Before August, 2011, shadows were derived by several techniques including, Ambient Occlusion; Deep Shadow Mapping; or Monte Carlo Ray Tracing, where each of these methods utilize 2 dimensional shadow maps.

10. Coffelt is an independent inventor with an educational background in Mathematics and Physics, including Calculus and Tensors.

11. One of Coffelt's pioneering discoveries is a method for deriving pixel color using steradians. For example, 3D shadow maps. Coffelt's new method creates high resolution realistic complex 3D shadows. In December, 2013, a United States Utility Patent was issued for Coffelt's novel method.

12. Nvidia is an American corporation which makes software for visual computing in a worldwide market. For 11 consecutive years prior to August, 2011, Nvidia software utilizes 2 dimensional shadow maps, which is state of the art.

13. Autodesk is an American corporation which makes software for the architecture, engineering, construction, manufacturing, media, and entertainment industries. For 13 consecutive years prior to August, 2011, Autodesk software utilizes 2 dimensional shadow maps, which is state of the art.

14. Pixar is an American corporation which makes software for visual computing in a worldwide market. For 11 consecutive years prior to August,

2011, Pixar software utilizes 2 dimensional shadow maps, which is state of the art.

15. Prior to August 22, 2011, 3D shadow maps do not exist.

16. Shadows created by Coffelt's novel method can be identified by a high resolution shadow boundary cast onto a complex surface. For example, a shadow of a sphere cast onto another sphere.

17. One of the most compelling basis in this action is that these 3 major worldwide software developers are creating high resolution realistic complex 3D shadows where Coffelt's patent is the sole reference to this pioneering technology.

18. Nvidia, Autodesk and Pixar are making and using Coffelt's claimed invention without any authorization. Therefore, Nvidia, Autodesk, and Pixar are committing acts in violation of 35 U.S.C. § 271 Infringement of Patent.

NOTICE OF SEPARATE ACTIONS

19. This complaint filed by Coffelt in United States District Court is essentially 3 separate actions against the 3 defendants Nvidia, Autodesk, and Pixar. Coffelt filed these 3 actions in one complaint in an effort to reduce a quantity of duplicated work imposed on this District Court. For example, an interpretation of Coffelt's patent claims should be identical for each case against each defendant. This complaint includes contentions and relief against each defendant which are separate herein, and identified with their name in all upper case characters.

STATEMENT OF FACTS

20. On August 22, 2011, Plaintiff Coffelt filed a United States Utility Application for Patent, No. 13/199,201. On February 28, 2013, this Application was published as US Publication No. US 20130050231 A1.

21. On December 24, 2013, United States patent No 8,614,710 herein referred to as ("710 patent") was issued for Coffelt's Application; entitled

("Method for Deriving Pixel Color using Steradians"), to which Coffelt owns all rights, title, and interest. A copy of Coffelt's 710 patent is attached as EXHIBIT 1.

22. Claims in the 710 patent comprise methods which utilize steradians for 3D mapping of space. A commercial embodiment of Coffelt's 710 patent claims is utilized to create a high resolution shadow boundary of complex objects. e.g. a high resolution profile of a parabolic surface cast onto a sphere, herein referred to as realistic complex 3D shadows ("realistic 3D shadows").

23. SHADOWS, State of the Art on August 21, 2011

24. Between August, 1993 to August 22, 2011, at least 36 United States Patents were issued which pertain to 2 dimensional shadow maps. Shadows during this period are cast on 2 dimensional surfaces, hair, or fog. For example, a disc shaped dark region below a sphere. This prior technology did not derive realistic 3D shadows. For example, prior to August 21, 2011, methods did not create high resolution shadow boundaries on a complex surface.

25. A list of these patents and selected drawings is included in EXHIBIT 2. These drawings in EXHIBIT 2 expressly show the state of art on August 22, 2011 is 2 dimensional shadow maps.

26. Furthermore, those previous patents in EXHIBIT 2 explicitly show there is a great need for realistic 3D shadows. Our sense of sight uses shadows to determine depth and reality in our environment. This state of the art 2 dimensional shadow maps do not create high resolution complex 3D shadow boundaries. This state of the art 2 dimensional shadow maps provide only a minimal reality to a 3D graphics environment.

27. SHADOWS, State of the Art on August 22, 2011

28. On August 22, 2011, Coffelt's discovery made a significant change

to the state of the art of deriving shadows. Computer graphics methods now have a capability to create realistic 3D shadows.

29. Coffelt created a commercial embodiment of the 710 patent claims, herein referred to as ("Coffelt's Program"). Coffelt's Program was utilized to create a video entitled ("SteelBallsX") and is published on a website entitled ("YouTube"). This video shows a series of spheres moving through a 3D scene with 2 point light sources. There are 2 clips from SteelBallsX attached as EXHIBIT 3. Coffelt's 710 patent claims derive a high resolution shadow boundary on a sphere in SteelBallsX having a shape similar to the character 'S'. This 'S' shaped curve exemplifies a high resolution realistic complex 3D shadow boundary. SteelBallsX also includes shading derived from a method similar to Ambient Occlusion, having a generally elliptic shape.

30. On Saturday, August 24, 2013, 11:14:49 AM Coffelt created a video entitled ("Hex Bolt with Steradians") which includes Coffelt's realistic 3D shadows. On February 26, 2016 Coffelt uploaded this video on ("YouTube") and ("Facebook") website. A clip from this video is attached as EXHIBIT 4, which shows a high resolution shadow boundary on a complex helix 3D surface.

31. Coffelt's Program is comprised of 2 primary methods attached as EXHIBIT 5, which create realistic 3D shadows in Coffelt's videos. A first method is entitled ("SetSteradians") derives parameters of steradians. For example, a total arc length encompassed by a point light source, identified by variable ("lenArcCol"); a resolution of the steradians identified by variable ("StrPpiD"); a steradian radius identified by variable ("strRadius"); and maximum and minimum steradian angles ("cmin")("cmax"). This method, SetSteradians, derives boundaries for each steradian in the graphic environment; and parameters in order to derive steradian column and row indexes.

32. Coffelt's second method entitled ("NextSteradian") derives a current

steradian under evaluation, EXHIBIT 5. e.g. determine a steradian column index identified by variable ("StrColIndx"); and steradian row index identified by variable ("StrRowIndx"). For example, at one point (x, y, z) on a graphic object, NextSteradian determines which steradian point (x, y, z) is disposed in. e.g. a steradian column index; and a steradian row index. Subsequently, a vector length comparison is executed; and results derive whether a point has contact with the light source.

33. A copy of all computer code used to create Coffelt's high resolution realistic 3D shadows will be provided upon request.

34. NVIDIA

35. Nvidia is an American corporation that makes software for visual computing in a worldwide market.

36. Within a period of 11 consecutive years, Nvidia filed 42 United States Applications for Patent which pertain to shadows in computer graphics. Those 42 Nvidia Applications do not pertain to realistic 3D shadows.

37. Nvidia is the maker of software entitled ("ShadowWorks"), ("iray"), and ("mental ray"), including others.

38. Mental Ray is a Nvidia program utilized in an Autodesk program entitled ("3DS MAX").

39. Nvidia's publications before August 22, 2011 are replete with 2 dimensional shadows derived from 2 dimensional shadow maps.

40. For example, a first page of EXHIBIT 6 shows an Nvidia publication dated year 2004, and year 2007 which is explicitly 2 dimensional shadows.

41. Nvidia's publications after August 22, 2011 are replete with realistic 3D shadows.

42. A second page of EXHIBIT 6 shows a furniture scene with Nvidia's realistic 3D shadows cast on furniture.

43. A third and fourth page of EXHIBIT 6 shows a close-up of Nvidia's

realistic 3D shadows cast on the furniture, having a motion corresponding our Sun.

44. A fifth page of EXHIBIT 6 shows realistic 3D shadows cast on an automobile seat, which is derived by Nvidia ("mental ray") program.

45. A sixth page of EXHIBIT 6 shows realistic 3D shadows cast on a vase, derived by Nvidia ("iray") software.

46. A seventh page of EXHIBIT 6 shows Nvidia's ("iray") software utilizes 3D x,y,z shadow mapping.

47. A full URL to Nvidia's images is present on EXHIBIT 6.

48. On January 30, 2016, Coffelt initiated communication with Nvidia. Coffelt sent an email correspondence to M. Hernan, Assistant to Corporate Executive Officer, Jen-Hsun Huang, as shown in EXHIBIT 7. Coffelt notified Nvidia of the alleged infringing acts on Coffelt's 710 patent. As of March 6, 2016, Nvidia has not replied to Coffelt's correspondence in EXHIBIT 7.

49. AUTODESK

50. Autodesk is an American multinational corporation that makes software for the architecture, engineering, construction, manufacturing, media, and entertainment industries. Autodesk has a business office located at 210 Main Street, Venice, CA 90291; telephone (310) 396-1167. On February 23, 2016, Coffelt placed a telephone call to the Autodesk Venice office; and an Autodesk sales person indicated that the Venice location sells shadowing software for Autodesk products.

51. Within a period of 13 consecutive years, Autodesk filed 40 United States Applications for Patent which pertain to shadows in computer graphics. Those 40 Applications do not contain a description or reference to realistic 3D shadows.

52. On March 12, 2013, Autodesk filed a United States Application for Patent entitled:

("Shadow rendering in a 3D scene based on physical light sources"), now US patent No. 9,171,399 referred to herein as ("399 Autodesk patent"). Images in the 399 Autodesk patent show 2 dimensional planar shadows. There is no description or reference in the 399 Autodesk patent which corresponds to realistic 3D shadows.

53. Autodesk is the maker of software entitled ("AutoCAD"). On January 25, 2016, Coffelt utilized AutoCAD 2016 to create realistic 3D shadows, where a copy is attached as EXHIBIT 8. A first sheet shows 3 spheres with realistic 3D shadows. A second sheet shows the 3 spheres after a rotation about an axis. Settings in AutoCAD for Face Style is ("Realistic"); Shadow Display is ("Mapped Object Shadows"). A comparison of this AutoCAD EXHIBIT 8 clearly shows AutoCAD creates 3D shadows which have shadow boundary shapes identical to Coffelt's EXHIBIT 3.

54. On January 24, 2016, Coffelt copied an Autodesk web page, attached as EXHIBIT 9. A full URL for this Autodesk publication is on the EXHIBIT 9 image. This Autodesk publication contains realistic 3D shadows.

55. On January 30, 2016, Coffelt initiated communication with Autodesk. Coffelt sent an email correspondence to Autodesk Corporate Executive Officer, Carl Bass as shown in EXHIBIT 10. Coffelt notified Autodesk of the alleged infringing acts on Coffelt's 710 patent.

56. Autodesk replied using a term ("other than bug fixes") which is indefinite in the context of Coffelt's infringement allegations. According to definitions available on internet sites, the term ("bug fixes") may include any undesirable result of a computer program. Autodesk has not identified any particular desired result for a computer method. Therefore, the term ("bug fixes") in EXHIBIT 10 is indefinite.

57. The 2 Autodesk replies in EXHIBIT 10 do not form a basis for a conclusion pertaining to patent infringement.

58. PIXAR

59. Within a period of 11 consecutive years, Pixar filed 10 United States Applications for Patent which pertain to shadows in computer graphics. Those 10 Pixar Applications do not pertain to realistic 3D shadows.

60. Prior to August 22, 2011, Pixar's publications are replete with the inherent limitations of 2 dimensional shadow maps. Entire background images appear to be relatively flat, and do not have significant realistic shadows.

61. At some point about year 2013, Pixar's shadows diverge significantly from relatively flat 2 dimensional background images, to a photo realistic background. For example, a significant divergence shown in a Pixar movie entitled ("Monsters Inc.")(2012), to a Pixar movie entitled ("Monsters University")(2013).

62. Clips from these Pixar movies are attached as EXHIBIT 11. A review of EXHIBIT 11 clearly shows a background in ("Monster's Inc.") appears to be relatively flat without realistic shadows, as compared to a nearly photo realistic background in ("Monsters University"). There is a significant quantity of high resolution shadows in ("Monsters University").

63. Pixar is also a maker of visual computing software entitled ("Renderman"). Pixar has published promotional images for Renderman, which include realistic 3D shadows, as shown in Exhibit 12. For example, a realistic 3D shadow of an automobile fender cast on a tire; and a realistic 3D shadow of the automobile frame cast on a complex contour seat. A second page of EXHIBIT 12 shows a rectangular plane casting a high resolution complex shadow boundary on a sphere.

64. Pixar has technical capabilities to utilize steradians in shadow derivation. Pixar's computer code shown in EXHIBIT 13 shows a variable entitled ("float solidAngle"). According to definition, ("steradian") is a ("solid angle").

65. On February 4, 2016, Coffelt initiated communication with Pixar. Coffelt sent an email correspondence to Pixar legal department, as shown in EXHIBIT 14. Coffelt notified Pixar of the alleged infringing acts on Coffelt's 710 patent.

66. Pixar replied with particular requests in order to evaluate Coffelt's infringement allegation. Coffelt believes Pixar's request for a detailed claim chart is unreasonable; based on the fact that Pixar has personal knowledge that Coffelt does not have access to Pixar's pertinent confidential computer code.

67. Furthermore, Pixar's request in EXHIBIT 14 is unreasonable by the fact that Coffelt's 710 patent is a concise full notice of Coffelt's patent claims; and enablement of how to make and use the claimed invention, which is in accordance with 35 U.S.C. § 112; and 35 U.S.C. § 282 – Presumption of validity.

68. In EXHIBIT 14, Coffelt explicitly identifies a specific example of a Pixar publication as a basis for patent infringement. Coffelt also identified the exact shadow in the image which forms Coffelt's basis for patent infringement. Pixar clearly has immediate access to methods which created the Pixar image and shadow cited by Coffelt in EXHIBIT 14.

69. The following points form an additional basis that Nvidia, Autodesk, and Pixar are committing acts of infringement on Coffelt's 710 patent claims:

(a.) Nvidia, Autodesk, and Pixar shadow methods explicitly utilize ray tracing to derive shadows, as shown in EXHIBIT 15;

(b.) Elements which inherently exist in both ray tracing and Coffelt's 710 patent claim 1 are identified in a USPTO Final Action by Examiner Aaron M. Richer, attached as EXHIBIT 16;

(c.) Elements which inherently exist in both ray tracing and Coffelt's 710 patent Claim 1 are identified in Coffelt's rejected claim 1, EXHIBIT 17;

70. For the reasons set forth above in items (a.) through (c.) above, Coffelt has show a basis that Nvidia, Autodesk, and Pixar are making and using those elements shown in EXHIBIT 17 of Coffelt's 710 patent Claim 1.

71. A review of Coffelt's prosecution history in the USPTO File Wrapper shows Coffelt's addition of a ("steradian radius") placed Coffelts's Application in condition for allowance of patent, EXHIBIT 18.

72. Geometrical Technical Reasoning re: ("steradian radius")

73. The following geometrical technical reasoning shows a basis of how Nvidia, Autodesk, And Pixar are making and using a ("steradian radius") which is Coffelt's element of the 710 patent Claim 1.

74. An example of a 3D computer graphics system is attached in EXHIBIT 19.

75. Fig. A shows a perspective view of an electronic bitmap image.bmp (100); a pixel (110), and pixel (111) located on the bitmap; a graphic object (120); a ray (150) and ray (151) between the graphic object and a view point (120); a point light source (140); a steradian (160); an occlusive object (180); a 3D coordinate system x, y z, for the graphic object.

76. The pixel (110) coordinates are derived by calculating an intersection point of ray (150) with the plane of the image.bmp (100). Each pixel has a particular column and row index.

77. Fig. A also shows 6 distinct rectangular regions identified by digits (1) through (6). Each of these regions (1) through (6) is limited to a specific maximum area. For example, region (3) is 0.00000645 square centimeters is a possible maximum area.

For example, a ray (150) intersects region (3) and corresponds to a pixel (110) at column 10, row 86; a separate ray (151) intersects region (4) and corresponds to a pixel (111) at column 11, row 86. It is this one to one relationship which determines the final image in the bitmap. One distinct region (3) corresponds to one distinct pixel (110); and one distinct region (4) corresponds to one distinct pixel (111).

78. EXHIBIT 19 also includes a Fig. B, which is a top view of Fig. A. Region (4) is located a particular distance from light source (140). Both the maximum area of region (4) and location of region (4) impose a maximum steradian angle (200); and maximum steradian angle (210). A light ray which intersects region (4) must be located within steradian angle (200) and steradian angle (210).

79. This graphics system must be capable to distinguish whether a light ray intersects region (1); region (2); region (3); region (4); region (5); region (6); and the potentially millions of additional object regions.

80. Fig. B shows an occlusive object (180) located in the steradian (160). A method must be capable to derive whether occlusive object (180) is located within the steradian (160). It is the presence of occlusive object (180) which causes region (4) to be a shadow pixel in the bitmap.

81. In light of these requirements of a 3D graphics system shown above in paragraphs 74 through 80, a means must exist to implement these requirements in a computer program. It is well-known that in the science of mathematics and programming, there are alternate methods which attain identical results. One method to impose these requirements is to select a specific spherical surface area (SpArea); and a ("steradian radius") which imposes the maximum steradian angles (200) and (210). For example, SpArea = 0.0000141 square cm ; region (4) = 0.0000062 square cm ; occlusive object (180) = 0.0000015 square cm; and steradian radius (400) = 33.0 cm. This steradian radius also sets parameters to derive steradian row and column indexes.

82. Alternatively, a programmer may set the maximum steradian angle (200) equal to 0.0001136 radians; and steradian angle (210) equal to

0.0001136 radians; and utilize any steradian radius, which is equivalent to the parameters in paragraph 81 above. This selection of radian values provides that object (180) and region (4) are both enclosed in steradian (160). In this case, Any steradian radius may be utilized to derive steradian column and row indexes.

83. It is the one to one correspondence which imposes a ("steradian radius") or equivalent must be included in a ray tracing method in order to derive high resolution shadow boundaries. one steradian must correspond to the limits of region (3) and limits of occlusive object (180); one separate steradian must correspond to the limits of region (4) and another occlusive object; and identically for the potentially millions of additional object regions and occlusive objects.

84. Nvidia, Autodesk, and Pixar are making and using methods which create high resolution complex 3D shadow boundaries.

85. Therefore, for the reasons set forth above in paragraphs 75 through 84 above, Nvidia, Autodesk, and Pixar are making and using Coffelt's claimed element:

("a computer calculating a particular steradian radius of said steradian region of space") shown in EXHIBIT 18; or an equivalent thereof.

86. Therefore, for the reasons set forth above, Nvidia, Autodesk, and Pixar are making and using all of the elements of Coffelt's 710 patent Claim 1.

87. Nvidia does not have authorization to make or use Coffelt's 710 patent Claims. Therefore, for all of the above reasons, Nvidia is committing acts of infringement of Coffelt's 710 patent according to 35 U.S.C. 271(a).

88. Autodesk does not have authorization to make or use Coffelt's 710 patent Claims. Therefore, for all of the above reasons, Autodesk is committing acts of infringement of Coffelt's 710 patent according to

35 U.S.C. 271(a).

89. Pixar does not have authorization to make or use Coffelt's 710 patent Claims. Therefore, for all of the above reasons, Pixar is committing acts of infringement of Coffelt's 710 patent according to 35 U.S.C. 271(a).

FIRST CAUSE OF ACTION

INFRINGEMENT OF PATENT

90. Coffelt incorporates and realleges paragraphs 1 through 89 of this Complaint.

91. Nvidia has infringed and continues to infringe one or more claims of Coffelt's 710 patent by using, selling and/or offering to sell in the United States and/or importing into the United States, Nvidia software entitled ("ShadowWorks"), ("iray"), and ("mental ray"). Nvidia's infringing acts violate 35 U.S.C. 271.

SECOND CAUSE OF ACTION

INFRINGEMENT OF PATENT

92. Coffelt incorporates and realleges paragraphs 1 through 91 of this Complaint.

93. Autodesk has infringed and continues to infringe one or more claims of Coffelt's 710 patent by using, selling and/or offering to sell in the United States and/or importing into the United States, Autodesk software entitled ("AutoCAD"). Autodesk's infringing acts violate 35 U.S.C. 271.

THIRD CAUSE OF ACTION

INFRINGEMENT OF PATENT

94. Coffelt incorporates and realleges paragraphs 1 through 93 of this Complaint.

95. Pixar has infringed and continues to infringe one or more claims of Coffelt's 710 patent by using, selling and/or offering to sell in the United States and/or importing into the United States, Pixar software entitled

("Renderman"). Pixar'a infringing acts violate 35 U.S.C. 271.

CONCLUSION

96. From the start of 3D graphics to August 2011, all media has suffered from inherent limitations of 2 dimensional shadow maps. Evidence of these limits is explicitly shown upon a review of publications during that period.

97. For 35 years, from 1976 to 2011, numerous attempts were directed to improving the 2 dimensional shadow map. Now, after these relentless attempts and failures, Nvidia, Autodesk, and Pixar create high resolution complex 3D shadows, and remain silent to how these shadows are attained.

98. Nvidia, Autodesk, and Pixar are making and using a 3D shadow maps, where Coffelt's 710 patent is the sole reference to this pioneering technology.

99. Coffelt is the owner of all rights, title, and interest in the Intellectual Property described in United States Patent No. 8,614,710, Method for Deriving Pixel Color Using Steradians.

100. Coffelt has set forth sufficient evidence to show Nvidia, Autodesk, and Pixar are making and using Coffelt's patented invention without any authorization, which is a violation of 35 U.S.C § 271.

RELIEF

WHEREFORE, Plaintiff Coffelt requests:

101. NVIDIA

102. A judgment that Nvidia has infringed one or more claims of Coffelt's 710 patent;

103. An order and judgment preliminarily and permanently enjoining Nvidia and it's officers, directors, agents, servants, employees, affiliates, attorneys, and all others acting in privity or in concert with them, and their parents, subsidiaries, divisions, successors, and assigns, from further acts of infringement of Coffelt's 710 patent;

104. A judgment awarding Coffelt all damages adequate to compensate for Nvidia's infringement of Coffelt's 710 patent, and in no event less than a reasonable royalty for Nvidia's acts of infringement, including all pre-judgment and post-judgment interest at the maximum rate permitted by law;

105. A judgment awarding Coffelt all damages, including treble damages, based on any infringement found to be willful, pursuant to 35 U.S.C. 284, together with pre-judgment interest;

106. An order and judgment to award Coffelt actual damages suffered by Coffelt as a result of Nvidia's unlawful conduct, in an amount to be proven at trial, as well as pre-judgment interest as authorized by law;

107. An accounting of Nvidia's profits pursuant to 15 U.S.C. 1117;

108. A judgment trebling any damages pursuant to 15 U.S.C. 1117;

109. Punitive damages pursuant to California Civil Code 3294;

110. Restitutionary relief against Nvidia and in favor of Coffelt, including discouragement of wrongfully obtained profits and any other appropriate relief;

111. AUTODESK

112. A judgment that Autodesk has infringed one or more claims of Coffelt's 710 patent;

113. An order and judgment preliminarily and permanently enjoining Autodesk and it's officers, directors, agents, servants, employees, affiliates, attorneys, and all others acting in privity or in concert with them, and their parents, subsidiaries, divisions, successors, and assigns, from further acts of infringement of Coffelt's 710 patent;

114. A judgment awarding Coffelt all damages adequate to compensate for Autodesk's infringement of Coffelt's 710 patent, and in no event less than a reasonable royalty for Autodesk's acts of infringement, including all pre-judgment and post-judgment interest at the maximum rate permitted by law;

115. A judgment awarding Coffelt all damages, including treble damages, based on any infringement found to be willful, pursuant to 35 U.S.C. 284, together with pre-judgment interest;

116. An order and judgment to award Coffelt actual damages suffered by Coffelt as a result of Autodesk's unlawful conduct, in an amount to be proven at trial, as well as pre-judgment interest as authorized by law;

117. An accounting of Autodesk's profits pursuant to 15 U.S.C. 1117;

118. A judgment trebling any damages pursuant to 15 U.S.C. 1117;

119. Punitive damages pursuant to California Civil Code 3294;

120. Restitutionary relief against Autodesk and in favor of Coffelt, including discouragement of wrongfully obtained profits and any other appropriate relief;

121. PIXAR

122. A judgment that Pixar has infringed one or more claims of Coffelt's 710 patent;

123. An order and judgment preliminarily and permanently enjoining Pixar and it's officers, directors, agents, servants, employees, affiliates, attorneys, and all others acting in privity or in concert with them, and their parents, subsidiaries, divisions, successors, and assigns, from further acts of infringement of Coffelt's 710 patent;

124. A judgment awarding Coffelt all damages adequate to compensate for Pixar's infringement of Coffelt's 710 patent, and in no event less than a reasonable royalty for Pixar's acts of infringement, including all pre-judgment and post-judgment interest at the maximum rate permitted by law;

125. A judgment awarding Coffelt all damages, including treble damages, based on any infringement found to be willful, pursuant to 35 U.S.C. 284, together with pre-judgment interest;

126. An order and judgment to award Coffelt actual damages suffered by

Coffelt as a result of Pixar's unlawful conduct, in an amount to be proven at trial, as well as pre-judgment interest as authorized by law;

127. An accounting of Pixar's profits pursuant to 15 U.S.C. 1117;

128. A judgment trebling any damages pursuant to 15 U.S.C. 1117;

129. Punitive damages pursuant to California Civil Code 3294;

130. Restitutionary relief against Pixar and in favor of Coffelt, including discouragement of wrongfully obtained profits and any other appropriate relief;

131. Costs of suit;

132. Any other remedy to which Coffelt may be entitled, including all remedies provided for in 15 U.S.C. 1117, Cal. Bus. & Prof. Code 17200, et seq., 17500 et seq., and any other California law.

* * * * *

DEMAND FOR JURY TRIAL

Plaintiff, Coffelt hereby respectfully requests a jury trial on all issues raised in this complaint.

* * * * *

Date: March 7, 2016 Respectfully submitted,

Louis A. Coffelt, Jr.
Plaintiff
In Pro Per

EXHIBIT 1

US008614710B2

(12) **United States Patent**
Coffelt, Jr.

(10) **Patent No.: US 8,614,710 B2**
(45) **Date of Patent: Dec. 24, 2013**

(54) **METHOD FOR DERIVING PIXEL COLOR USING STERADIANS**

(76) Inventor: **Louis Arthur Coffelt, Jr.**, Perris, CA (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 101 days.

(21) Appl. No.: **13/199,201**

(22) Filed: **Aug. 22, 2011**

(65) **Prior Publication Data**

US 2013/0050231 A1 Feb. 28, 2013

(51) **Int. Cl.**
G06T 15/50 (2011.01)

(52) **U.S. Cl.**
USPC **345/426**

(58) **Field of Classification Search**
USPC 345/426
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2004/0174360 A1* 9/2004 Deering et al. 345/426
2008/0074418 A1* 3/2008 Shearer 345/420

* cited by examiner

Primary Examiner — Aaron M Richer

(57) **ABSTRACT**

The present invention includes a method for deriving a pixel color in a graphic image. e.g. electronic RGB 48 bpp bitmap. Methods of the present invention include mathematical structure analysis of geometric graphic objects. e.g. sphere, lines, plane, points, and characters. This analysis includes using a particular steradian region of space; and two position vectors located in the particular steradian region of space; and comparing the length of the position vectors; and deriving a pixel color from a result of the length comparison. The position vectors point to a point on the geometric graphic object. A vector having a least length has contact with a light source.

6 Claims, 4 Drawing Sheets

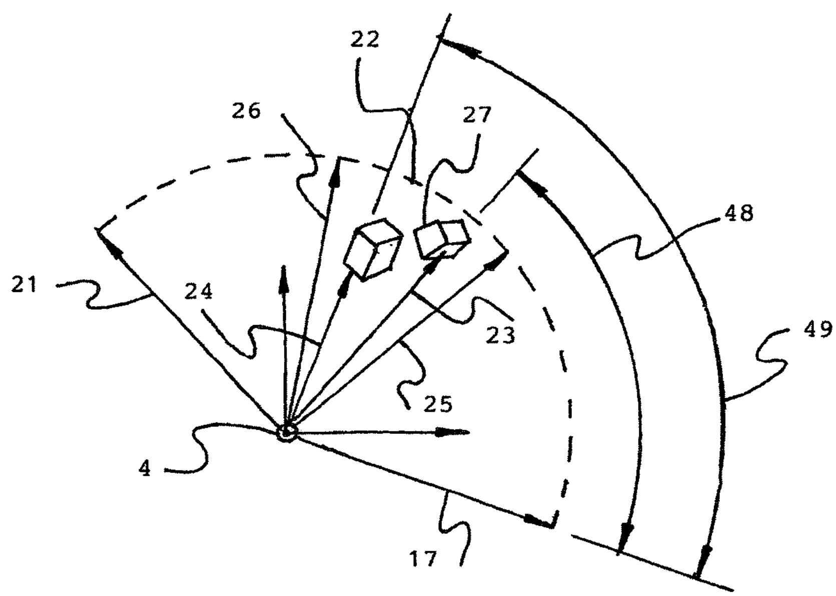


EXHIBIT 1

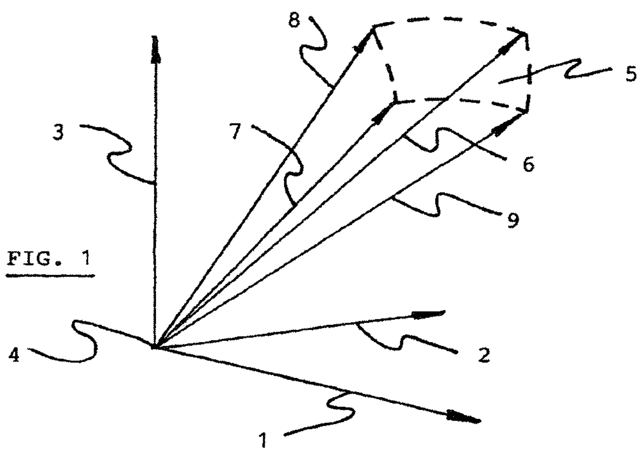


FIG. 1

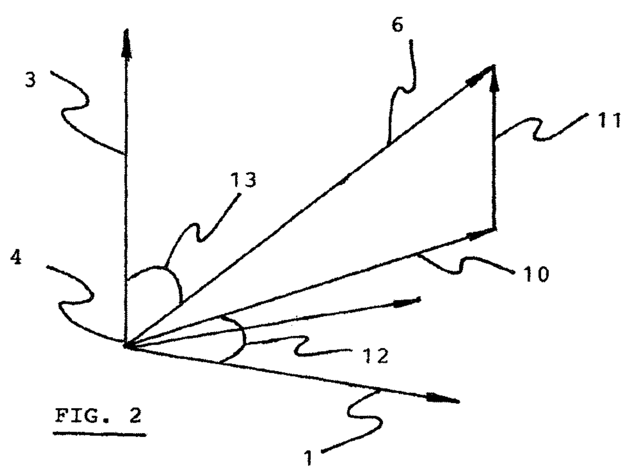


FIG. 2

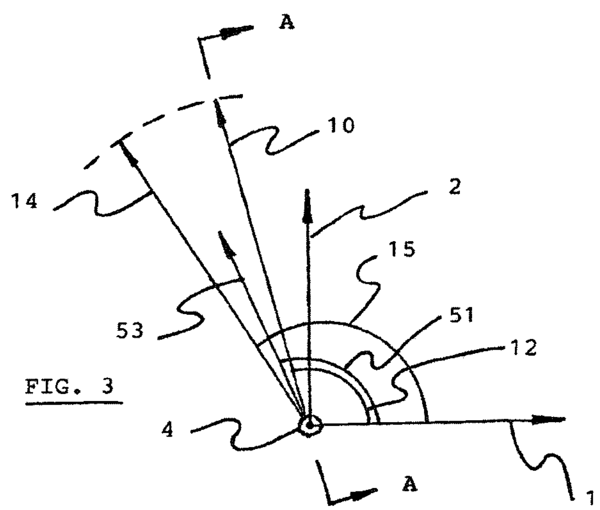


FIG. 3

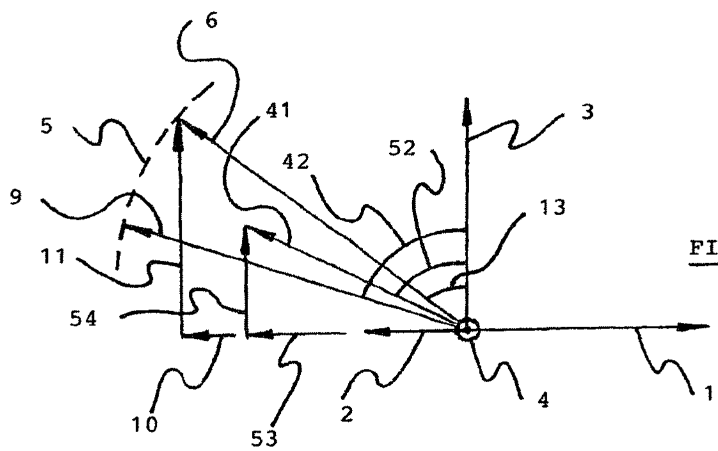


FIG. 4

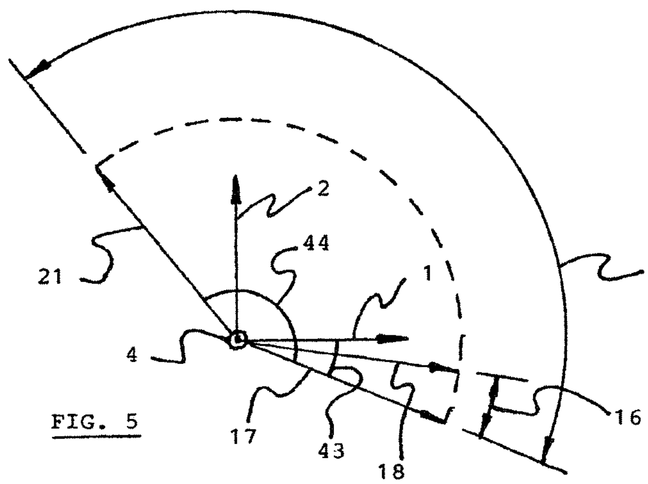


FIG. 5

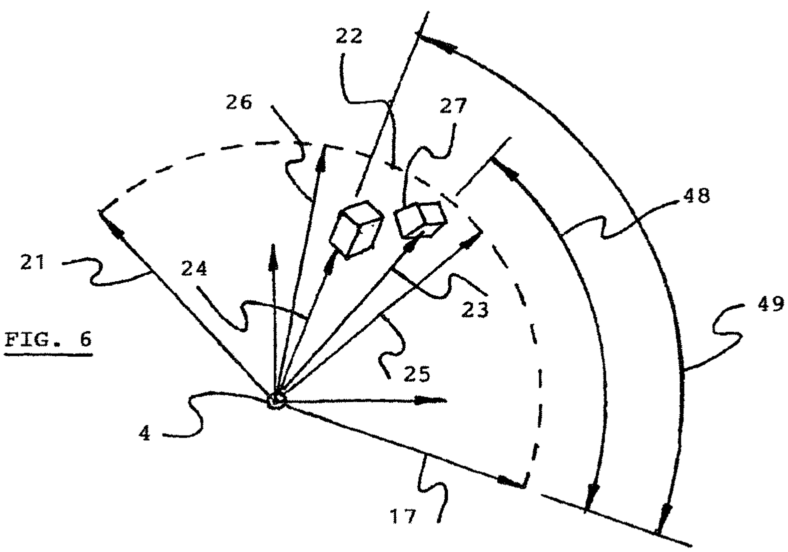


FIG. 6

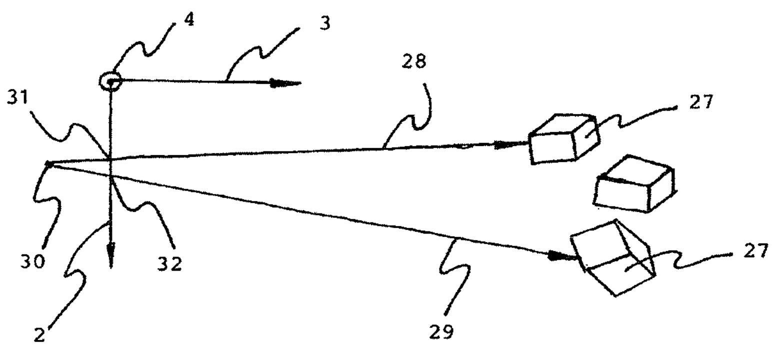


FIG. 7

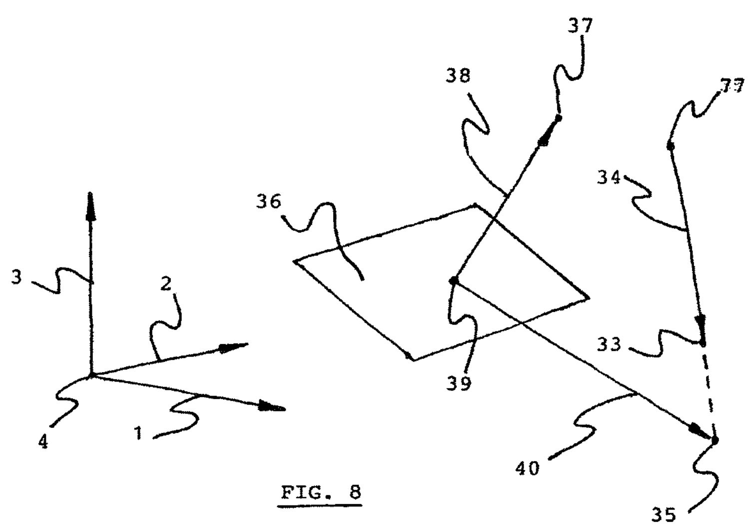


FIG. 8

METHOD FOR DERIVING PIXEL COLOR USING STERADIANS

CROSS REFERENCE TO RELATED APPLICATIONS

Not Applicable

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

Not Applicable

REFERENCE TO A SEQUENCE LISTING

Not Applicable

BACKGROUND OF THE INVENTION

Selecting pixel color in an electronic graphic image is attained by several prior art methods. One method may be to manually select a pixel color. For example, in a software program having a trademark "Photoshop", a group of pixels can be selected. Any color can be manually assigned to those pixels. e.g. in an RGB 48 bpp bitmap, a color red is: R=255, G=0, B=0, color white is: R=255, G=255, B=255, black is: R=0, G=0, B=0. Furthermore, in Photoshop, shadows can be created by setting a light source to particular coordinates. Shadows may have a color with low brightness. e.g. dark gray. In comparison, highlights may have a color with high brightness. e.g. bright blue or white. Highlights indicate that the light source contacts the surface. Shadows indicate that the light source does not contact the surface.

Determining whether a light source contacts a surface is a significant problem in the prior art. Prior methods are inherently limited to creating relatively simple shadows and highlights. For example, a shadow of a sphere on a flat surface. One prior art method to progromaticaly derive a pixel color may be to test a distance from particular elements in the bitmap. For example, if a pixel is less than 10 pixels from the selection, set the pixel color to dark gray.

Prior art methods essentially estimate whether a light source contacts a surface to create shadows and highlights. In the case of complex surfaces, the prior art does not calculate whether the light source contacts a particular surface. For example, in a mathematical model of planets Earth, Venus, Earths moon, and the Sun, the prior art does not calculate whether light rays from the Sun contact Earth, Earths moon, Saturn, or Venus.

In comparison, for example, the present invention calculates a location of each pixel in a complex geometric object; compares distance of points located in the same region of space; and determines whether light rays from the Sun contacts any planet. e.g. the present invention may calculate a solar eclipse of Earth on Venus at any location in their orbital path.

BRIEF SUMMARY OF THE INVENTION

The present invention comprises a method for deriving pixel color in graphic images. e.g. a RGB 48 bpp bitmap. Mathematical structure analysis of a complex geometrical object determines whether a light source contacts a surface on the complex object. This structural analysis includes using steradians. The analysis calculates a vector length for any two points located in the same steradian region of space. Next, these two vector lengths are compared. A vector having a least length has contact with the light source. A vector having greater length does not have contact with the light source. Next, a pixel color may be programaticaly selected accordingly. e.g. bright blue for a point having contact with the light source; or dark gray for a point not having contact with the light source. Furthermore, the present invention may be utilized to create translucent surfaces.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWING

The present invention is further described with reference to the appended drawings where identical or corresponding parts are identified by the same reference character throughout the views of the drawing where:

FIG. **1** is a perspective view of a steradian (**5**); and a 3-dimensional right-handed Cartesian coordinate system.

FIG. **2** is a perspective view of vector (**6**), a rotation an angle (**12**), and azmith angle (**13**).

FIG. **3** is a top view of vector (**10**), vector (**14**), rotation angle (**12**), and position vector (**41**).

FIG. **4** is a sectional view A-A from FIG. **3**. FIG. **4** shows a side view of vector (**6**), vector (**9**), vector (**11**), vector (**10**), position vector (**41**), and azmith angle (**13**).

FIG. **5** is a top view of adjacent steradians (**16**).

FIG. **6** is a top view of one particular steradian (**22**), a position vector (**23**), and a position vector (**24**).

FIG. **7** is a side view of a vector (**28**) and a vector (**29**) intersecting the i-j plane of the coordinate system.

FIG. **8** is a perspective view of a geometric plane (**36**), a vector (**34**), and an intersection point (**35**) of plane (**36**) with vector (**34**).

DETAILED DESCRIPTION OF THE INVENTION

The present invention comprises a method for deriving pixel color in graphic images. e.g. an RGB 48 bpp electronic bitmap. One method includes progromatic analysis of a geometric structure. Results of the analysis will indicate whether a light source contacts a particular point on the structure. For example, indicate that a particular point is a highlight or shadow. A pixel color can be assigned accordingly. e.g. bright blue for a highlight or dark gray for a shadow.

A fundamental element of the present invention includes a steradian. A steradian is a particular region of space with a boundary defined by four vectors. A geometric coordinate system is used to define a particular location of the steradian and vectors. e.g. a right-handed 3-dimensional Cartesian coordinate system. For example, the location of the steradian can be defined by a rotation angle, and an azmith angle. Vectors and coordinate systems are defined in the science of Physics. The geometric structure analysis described herein will be in accordance with the corresponding properties set forth in Physics. e.g. vector addition, vector dot product (cosine of angle between vectors), and coordinate systems.

The term "position vector" as used herein is a vector which has a particular direction and scalar length. For example, in a coordinate system having axes identified by characters j, k; the geometric point (3.0, 7.0, 1.0) is defined by a position vector 3.0i+7.0j+1.0k

The following description of the present invention is set forth in a right-handed 3-dimensional Cartesian coordinate system with axes i, j, k as shown in the example above. For example, the vector cross-product i cross j equals k (k=i×j).

A fundamental element of the present invention includes calculating a location of vectors, and length of vectors. For

EXHIBIT 1

example, calculating a particular steradian for a position vector, and calculating an angle between vectors.

FIG. 1 shows a perspective view of a steradian (5) in a right-handed 3 dimensional Cartesian coordinate system. The coordinate system has an i axis (1), j axis (2), k axis (3), and origin (4). A boundary of steradian (5) is formed by vector (6), vector (7), vector (8), and vector (9). Steradian (5) is a region of space between these four boundary vectors, vector (6), vector (7), vector (8), and vector (9).

FIG. 2 shows a perspective view of the coordinate system, and boundary vector (6). An azmith angle (13) is between vector (6) and the k axis. Boundary vector (6) is shown equal to a vector sum of vector (10) plus vector (11). Vector (10) is a projection of boundary vector (6) to the i-j axis plane. Vector (11) is parallel to the k axis. For example, vector (6) equals −7.0i+9.0j+11.2k Therefore, vector (10) equals −7.0i+9.0j+0.0k; and vector (11) equals 0.0i+0.0j+11.2k A rotation angle (12) defines a rotational location of steradian (5). Obviously, each boundary vector of steradian (5) will have a particular azmith angle and rotation angle.

FIG. 3 is a top view of vector (10), rotation angle (12), rotation angle (15), rotation angle (51), vector (14), and vector (41). Vector (14) is a projection of vector (8) to the i-j axis plane. For example, vector (8) equals −8.0i+8.124j+11.2k

Therefore, vector (14) equals −8.0i+8.124j+0.0k Rotation Rotation angle (15) is between vector (14) and the i axis. Rotation angle (12) and rotation angle (15) can be calculated using a vector dot product. The following illustrates the mathematical formula for the vector dot product where, (a) is a vector, (b) is a vector; lengtha is the scalar length of vector(a), lengthb is the scalar length of vector(b); ai is the i component of (a); aj is the j component of (a), ak is the k component of (a); bi is the i component of (b), bj is the j component of (b), bk is the k component of (b); theta equals the angle between vector (a) and vector(b):

cos(theta)=(*ai**bi*+*aj**bj*+*ak**bk*)/(length*a**length*b*)

For example, vector (10) equals −7.0i+9.0j+0.0k; i axis equals 1.0i+0.0j+0.0k; length of vector (10) equals 11.402; length of i axis is 1.0; therefore, cos(theta) equals (−7.0*1.0+9.0*0.0+0.0*0.0)/(11.402*1.0); cos(theta)=−0.61394; theta=a cos(−0.61395); rotation angle (12) equals a cos(−0.61394); rotation angle (12) equals 2.2318 radians (127.87 degrees); vector (14) equals −8.0i+8.124j+0.0k; rotation angle (15) equals 2.3485 radians (134.56 degrees); vector (53) equals −7.33i+8.7333j+0.0k; rotation angle (51) equals 2.2690 radians (130 degrees); this example shows that vector (53) is located between vector (10) and vector (14).

FIG. 4 is a sectional side view A-A of vector (6), vector (9), vector (41), vector (53), vector (54), azmith angle (13), azmith angle (42), and azmith angle (52). Calculations of these azmith angles will show that vector (41) is located between vector (6) and vector (9). The example above shows a method for calculating the location of a vector. The location of vector (41) may be derived by similar calculations in the example above. Vector (41) equals the vector sum of vector (53) plus vector (54). Vector (53) is in the i-j plane. Vector (54) is parallel to the k axis.

For example, azmith angle (42) equals 0.24192 radians (13.861 degrees); azmith angle (13) equals 0.17365 radians (9.949 degrees); azmith angle (52) equals 0.20791 radians (11.912 degrees); therefore, vector (41) is located between vector (6) and vector (9).

The description of FIG. 1, FIG. 2, FIG. 3, and FIG. 4 illustrates a method to derive a mathematical relationship between a particular position vector and a particular steradian. For example, determine whether a particular position vector is located in a particular steradian. Furthermore, determine whether two position vectors are both located in one particular steradian.

The rotation angles and azmith angles are relatively greater that typical angle values used for computer graphics. For example, the angle between vector (10) and vector (14) above is 0.1167 radians. An angle between vector (10) and vector (14) for a computer graphic image may be about 0.001 radians. The methods set forth herein are also utilized to calculate vector locations and steradian parameters for these relatively small angles.

FIG. 5 shows a top view of adjacent steradians (16). FIG. 5 also shows a boundary of the steradians. The steradians are located between an initial side vector (17) and a terminal side vector (21). A terminal side vector (18) of steradian (16) is located between vector (17) and vector (21). Vector (17), vector (18), vector (21), i axis, and j axis are all co-planar. Rotation angle (43) defines a location of vector (17) relative to the i axis. A rotation angle (44) defines an angle between vector (17) and vector (21). FIG. 5 also shows an arc (20) between vector (17) and vector (21). Obviously, the steradians may be located in any selected region of space. Therefore, angle (43) and angle (44) may have any selected value between 0.0 to 2 pi radians (360 degrees).

FIG. 5 also shows that vector (17), vector (18), and vector (21) each have one particular length. For example, for a length equal to 17 inches, the vectors may have the following values: vector (17) equals 15.762i−6.3683+0.0k; vector (18) equals 16.074i−5.5346j+0.0k; vector (21) equals −11.594i+12.433j+0.0k; rotation angle (43) equals −0.38397 radians (−22 degrees); rotation angle (44) equals 2.2705 radians (155.0 degrees); length of arc (20) equals 38.598 inches; An arc length for a steradian may be approximately 0.001 inches; therefore, in this example, the total steradians between vector (17 and vector (21) equals total arc length/steradian arc length (38.598/0.001); therefore, total steradians between vector (17) and vector (21) equals 38598. The steradian arc length may typically be commensurate with the resolution of a computer monitor. e.g. 1000 pixels per inch is equivalent to 0.001 inches per steradian arc; 1500 pixels per inch is equivalent to 0.0006 inches per steradian arc.

The steradians (16) in FIG. 5 can be identified with an index. In a zero based index system, the first steradian has an index of 0(zero). For example, in the case described above, there are a total of 38598 steradians. Therefore, indexes for these steradians are 0 thru 38597. These indexes may be assigned a title corresponding to the orientation of the steradians. For example, a steradian column index or steradian row index. Therefore, the steradians in FIG. 5 may be referred to as steradian column 0 thru steradian column 38597.

FIG. 6 shows a top view of a steradian (22), a graphic object (27), a position vector (23), and a position vector (24) each located between vector (17) and vector (21). Vector (25) and vector (26) is a boundary of steradian (22). Therefore, the graphic object (27) is located between vector (25) and vector (26). The graphic object (27) may be any selected mathematical model of any geometric structure. For example, a general form of a line is: j=m*i+b where m is the slope of the line, i is the range coordinate, b is the j axis intercept, and j is the domain coordinate. Therefore, graphic object (27) is: "j=m*i+b"; and a point on this object (27) is the terminal end of a vector (23). Position vector (23) points to graphic object (27). For example, for any non-zero value of m and b, 6.7=m*3.3+b, therefore, a position vector (23) is located between vector (25) and vector (26); a position vector (23) equals 3.3i+6.7j+0.0k for example, a particular point on graphic object (27) is 6.7=−1.2*3.3+10.66; therefore, position vector (**23**) equals 3.3i+6.7j+0.0k; m=−1.2; b=10.66; Therefore, the graphic object point (3.3, 6.7, 0.0) will be tested to determine whether a light source contacts this point.

The structure analysis comprises: a.) calculating a particular position vector (**23**) and a particular position vector (**24**); b.) calculating the length of position vector (**23**) and the length of position vector (**24**); c.) comparing the length of position vector (**23**) to the length of position vector (**24**); d.) declaring a point light source is located at the origin of the coordinate system; e.) deriving a pixel color from a result of the length comparison. A position vector having less length will have contact with the light source. for example, length of position vector (**23**) equals 55.78 inches, and length of position vector (**24**) equals 55.92; therefore, the point at position vector (**23**) has contact with the light source; position vector (**23**) equals 3.3i+6.7j+0.0k; position vector (**24**) equals 3.218i+6.75j+0.0k; point (3.3, 6.7, 0.0) contacts the light source; point (3.218, 6.75, 0.0) does not contact the light source. point (3.3, 6.7, 0.0) is a highlight point; point (3.218, 6.75, 0.0) is a shadow point.

Obviously, the mathematical calculations set forth herein may be executed by various computer programming languages. e.g. c# or c++ To further clarify the meaning of the present invention, c++ code snippets are set forth in the following description. These c++ code snippets may not show some declations. These declarations are obvious. A typical character in c++ programming is the left brace, and right brace. The brace character is not available. Therefore, a substitute characters <[, and]> is used herein. For example, the c++ code: double dx=0.0; is not enclosed by any brace; and the c++ code: <[double dz=3.3;]> is enclosed by a left brace and a right brace. The declation of dz above is enclosed by a left brace and a right brace (substitute character).

These c++ code snippets will have the following format: c++<[C++ lines of code . . .]> The following c++ code snippet shows a method to execute steps a.) thru e.) above:

c++ <[spi=0.0; spj=0.0; spk=0.0; ptai=3.3; b=10.66; ptak=0.0; ptaj=m0*ptai+b; ptbi=3.218; ptbj=17.33*ptbi+2.476; ptbk=0.0; lengtha=sqrt(ptai*ptai+ptaj*ptaj+ptak*ptak); lengthb=sqrt(ptbi*ptbi+ptbj*ptbj+ptbk*ptbk); if(lengtha<lengthb)<[sourcecontactA=true; red=250; green=0; blue=0; row=11; column=13; bitmapxx.SetPixel (row, column, red, green, blue);]> else <[sourcecontactA=false; red=10; green=10; blue=10; row=11; column=13; bitmapxx.SetPixel(row, column, red, green, blue);]>]>

In the c++ code snippet example above, spi, spj, spk is the source point; ptai, ptaj, ptak is position vector (**23**); ptbi, ptbj, ptbk is position vector (**24**); lengtha is the length of position vector (**23**); lengthb is the length of position vector (**24**); if(lengtha<lengthb) is the length comparison of position vectors; a 'true' result for the comparison derives the pixel color is red; a 'false' result for the comparison derives the pixel color is gray.

The c++ code snippet above assigns 11 to row, and 13 to column. This row and column assignment is simplified to focus on the primary objective of the example, which is: light source contacts a point, or light source does not contact a point.

FIG. **6** also shows an arc (**48**), an arc (**49**), a rotation angle (**43**), a rotation angle (**45**), and a rotation angle (**46**). Graphic objects may typically have numerous points which will be programaticaly compared. Furthermore, there may be many graphic object points located in one particular steradian. Therefore, the lengths of position vectors can be saved during runtime. This provides that any two position vectors can be compared as required. One method for saving the length of position vectors is utilizing a c++ array or vector. e.g. c++ <[std::vector<double> positionlength(totalpixels, 1000000000.0);]>

One method to execute the graphic object structure analysis is set forth below in a c++ code snippet. This example sets forth a method for row and column calculations. Also, sets forth a method for saving position vector lengths during runtime. The following is a summary of the c++ code snippet below:

'positionlength' is a c++ <vector> having a size equal to the total pixels in the bitmap; The code first iterates thru each point on a first line; calculate the length of the current position vector; calculate the rotation angle between position vector (**23**) and vector (**17**); calculate the steradian column index; steradian row index is constant to focus on primary objective; read prior position vector length; compare current length to prior length; if the current length is less than the prior length: save the current length in <vector> 'positionlength'; in this first iteration, all values in 'positionlength' <vector> are initialized to a very large value, e.g. 1000000000.0; this this large value ensures that all points in the first length comparison will be entered into the 'positionlength' <vector>; second, iterate thru each point on a second line; repeat same steps above; At this point in runtime, 'positionlenth' <vector> will contain only lengths having the least length (points having contact with the light source); third, iterate thru each point on the first line; calculate the length of the current position vector (**23**); calculate the rotation angle (**45**) between the position vector (**23**) and vector (**17**); calculate the steradian column index; read the prior position vector length; compare the current length to the prior length; calculate the difference between current length and prior length; test if the difference is less than 0.0001: if test result is true: the current point has contact with the light source; assign a pixel color accordingly; set pixel color in the bitmap; This difference of length is used to determine whether the current point is the same as the prior point; fourth, iterate thru each point on the second line; calculate length of the current position vector (**24**); calculate the rotation angle (**46**) between position vector (**24**) and vector (**17**); calculate the steradian column index; read the prior position vector length; calculate the difference between the current length and the prior length; test if the difference is less than 0.0001; if test result is 'true': the current point has contact with the light source; else, the current point does not have contact with the light source; assign a pixel color accordingly; set pixel color in the bitmap.

c++ <[std::vector<double> positionlenth(1000, 1000000000.0); row=0; length**17**=22.23; inchesPerSteradian=0.001; ptai=0.0; ptak=0.0; ptbi=0.0; ptbk=0.0; while (count0<1000)<[ptaj=−2.2*ptai+4.1; currentlength=sqrt (pati*ptai+ptaj*ptaj+ptak*ptak); vector**17***i*=cos(−0.589); vector**17***j*=sin(−0.589); vector**17***k*=0.0; adotb=(ptai*vector**17***i*+ptaj*vector**17***j*+ptak*vector**17***k*)/(currentlength*length**17**); theta=a cos(adotb); arc**48**=length**17***theta; steradian indexD=arc**48**/inchesPerSteradian; steradianindex=unsigned int(steradianIndexD); priorlength=positionlength[steradianindex]; if(currentlength<priorlength)<[positionlength<[steradianindex]=currentlength;]>ptai+=0.001; count**0**++;]> while (count1<800)<[ptbj=3.3*ptbi+2.7; currentlength=sqrt (ptbi*ptbi+ptbj*ptbj+ptbk*ptbk); adotb=(ptbi* vector**17***i*+ptbj*vector**17***j*+ptbk*vector**17***k*)/(currentlength* length**17**); theta=a cos(adotb); arc**49**=length**17***theta; steradianindexD=arc**49**/inchesPerSteradian; steradianindex=unsigned int(steradianindexD); priorlength=positionlength[steradianindex]; if(currentlength<priorlength)<[positionlength [steradianindex]=currentlength;]> ptbi+=0.001; count1++;]> while (count2<1000)<[ptaj=−2.2*ptai+4.1; currentlength=sqrt (ptai*ptai+ptaj*ptaj+ptak*ptak); adotb=(ptai* vector17i+ ptaj*vector17j+ptak*vector17k)/(currentlength* length17); theta=a cos(adotb); arc48=length17*theta; steradianindexD=arc48/inchesPerSteradian; steradianindex=unsigned int(steradianindexD); priorlength=positionlength[steradianindex]; testdiff=abs (currentlength−priorlength); if(testdiff<0.0001)< [sourcecontactsurface=true; red=240; green=0; blue=0; bitmapx.SetPixel(row, steradianindex, red, green,blue)]>; else< [sourcecontactsurface=false; red=11; green=22; blue=8; bitmapx.SetPixel(row, steradianindex, red, green, blue);]> ptai+=0.001; count2++;]> while(count3<800)< [ptbj=3.3*ptbi+2.7; currentlength=sgrt(ptbi*ptbi ptbj*ptbj+ ptbk*ptbk); adotb=(ptbi*vector17i+ptbj* vector17j+ ptbk*vector17k)/(currentlength*length17); theta=a cos (adotb); arc49=lenght17*theta; steradianindexD=arc49/ inchesPerSteradian; steradianindex=unsigned int (steradianindexD); priorlength=positionlength [steradianindex]; testdiff=abs(currentlength−priorlength);if (testdiff<0.0001)<[sourcecontactsurface=true; red=240; green=0; blue=0; bitmapx.SetPixel(row, steradianindex, red, green, blue);]> else<[sourcecontactsurface=false; red=11; green=22; blue=8; bitmapx.SetPixel(row, steradianindex, red, green, blue);]> ptbi+=0.001; count3++;]>

The c++ code snippet above will display a horizontal red line on a computer monitor. The c++ code snippet above is set forth to show a method to derive whether a light source contacts any particular point in a graphic object. The example above does not determine whether a point is 'visible'. The following description shows a method to calculate appropriate row and column indexes for the bitmap pixels. These calculations for bitmap row and column index may be used in conjunction with the above c++ code snippet examples. The following description will also show a method to determine whether a particular point is 'visible'.

For example, FIG. 7 shows the origin (4) of the coordinate system, point (0.0, 0.0, 0.0), and the i axis (1). The i axis vector (1) points toward an observer viewing the page of the drawing. The terminal end of i axis vector is point (1.0, 0.0, 0.0). This point (1.0, 0.0, 0.0) is 'visible' in FIG. 7; and point (0.0, 0.0, 0.0) is Not 'visible' in FIG. 7. This concept of 'visible' is similar to calculations in regard to a light source contacting a surface. Vectors having a least length are 'visible'. Vectors having a greater length are not 'visible'.

FIG. 7 shows a side view of a vector (28), a vector (29) and a view point (30) in the coordinate system. A terminal end of vector (28) is on a first graphic object (27). The tail end of vector (28) is on view point (30). The terminal end of vector (29) is on a second graphic object (27). The tail end of vector (29) is on view point (30).

FIG. 7 also shows an intersection point (31), and intersection point (32). Vector (28) intersects the i-j plane at point (31). Vector (29) intersects the i-j plane at point (32).

The following is a summary of steps to derive 'visible' pixels on a graphic object, and derive bitmap row and column index values:

a.) Declare a c++<vector> lengthy, initialize all values to 1000000000.0; b.) Declare a bitmap pixel height, and pixel width; c.) Declare pixel per inch value for the bitmap; d.) Calculate width and height of the bitmap in inches; e.) Declare coordinates of a view point (30); f.) Iterate thru all points in a first graphic object (27); g.) Calculate a vector (28); h.) Intersect vector (28) with the i-j plane; i.) Test if intersection point (31) is located within boundary of the bitmap width and height; j.) If 'true' result: calculate bitmap row and column index; k.) Read prior length; l.) calculate current length of the current vector (28); m.) Compare current length to prior length; if current length is less than prior length: save current length value in lengthy <vector>; n.) Increment to next pixel in first graphic object (27); repeat steps g.) thru n.) above; o.) Iterate thru all points in a second graphic object (27); p.) Execute steps g.) thru n.) above for a vector (29) and intersection point (32); lengthy <vector> now contains only points which are 'visible'; q.) Iterate thru all points in the first graphic object (27); Calculate a vector (28); Intersect vector (28) with i-j plane; r.) Test if intersection point (31) is located within boundary of bitmap width and height; s.) if 'true': calculate bitmap row and column index; t.) Read prior length; u.) calculate current length; v.) Calculate difference between current length and prior length; w.) Test difference in length is less that 0.0001; if 'true': current point is 'visible'; x.) Increment to next point if first graphic object; y.) Repeat steps q.) thru x.) above; z.) Iterate thru all points in the second graphic object (27); Execute steps q.) thru y.) above; If source contacts the surface and the point is 'visible': set pixel color to highlight, else, set pixel color to shadow. In these c++ examples, '<vector>positionlength' contains values pertaining to a light source contacts a surface; and '<vector> lengthy' contains values pertaining to deriving a 'visible' point.

The c++ boolean character for 'or' is not available. Therefore, the word 'or' is used herein as a substitute character for the boolean character.

c++ <[std::vector<double> lengthv(2520000, 1000000000.0); double bitmapHeightInches=0.0; double bitmapWidthInches=0.0; unsigned int bitmapPixelHeight=1400; unsigned int bitmapPixelWidth=1800; double bitmapPixelHeightD 1400.0; double bitmapPixelWidthD=1800.0; unsigned int pixelsPerInch=1000; double pixelsPerInchD=double(pixelsPerInch); bitmapHeightInches=bitmapPixelHeightD/pixelsPerInchD; bitmapWidthInches=bitmapPixelWidthD/pixelsPerInchD; viewpti=bitmapWidthInches/2.0; viewptj=bitmapHeightInches/2.0; viewptk=−11.22; m0=3.3; m1=−2.2; N1i=0.0; N1j=0.0; N1k=−1.0; N0i=0.0; N0j=0.0; N0k=0.0; unsigned int count0=0; unsigned int count1=0; unsigned int count2=0; unsigned int count3=0; double pti=0.0;double ptj=0.0; double ptk=0.0; double testd=0.0; double currentlength=0.0; double priorlength=0.0; double difference1=0.0; unsigned int Indexx=0; double rowD=0.0; double columnD=0.0; unsigned int row=0; unsigned int column=0; unsigned int red=0; unsigned int green=0; unsigned int blue=0; bitmap bitmapx; while(count0<700)< [ptj=m0*pti−4.3; vppti=vpi−pti; vpptj=vpj−ptj; vpptk=vpk−ptk; IntersectVectorWithPlane(intpti, intptj, intptk, vpi, vpj, vpk, pti, ptj, ptk, N1i, N1j, N1k, N0i, N0j, N0k); if(intpti<0.0 or intpti> bitmapWidthInches or intptj<0.0 or intptj> bitmapHeightInches)<[pti+=0.001; count)++; if(count0<700)< [continue;]> else <[break;]>]> rowD=ptj*pixelsPerInchD; row=unsigned int(rowD); columnD pti*pixelsPerInchD; column=unsigned int(columnD); Indexx=row*bitmapPixelWidth+column; priorlength=lengthv[Indexx]; currentlength=sqrt (vppti*vppti+vpptj*vpptj+vpptk*vpptk); if(currentlength<priorlength)<[lengthv[Indexx]=currentlength;]> pti+=0.001; count0++;]> while(count1<900) <[ptj=m1*pti−2.89; vppti=vpi−pti; vpptj=vpj−ptj; vpptk=vpk−ptk; IntersectVectorWithPlane(intpti, intptj, intptk, vpi, vpj, vpk, pti, ptj, ptk, N1i, N1j, N1k, N0i, N0j, N0k); if(intpti<0.0 or intpti> bitmapWidthInches or intptj<0.0 or intptj> bitmapHeightInches)<[pti+=0.001; count1++; if(count1<900)<[continue;]> else <[break;]>]> rowD=ptj*pixelsPerInchD; row=unsigned int(rowD);

columnD=pti*pixelsPerInchD; column=unsigned int(columnD); Indexx=row*bitmapPixelWidth+column; priorlength=lengthv[Indexx]; currentlength=sqrt (vppti*vppti+vpptj*vpptj+vpptk*vpptk); if(currentlength<priorlength) <[lengthv[Indexx]=currentlength;]> pti+=0.001; count1++;]> while(count2<700) <[ptj=m0*pti−4.3; vppti=vpi−pti; vpptj=vpj−ptj; vpptk=vpk−ptk; IntersectVectorWithPlane(intpti, intptj, intptk, vpi, vpj, vpk, pti, ptj, ptk, N1*i*, N1*j*, N1*k*, N0*i*, N0*j*, N0*k*); if(intpti<0.0 or intpti> bitmapWidthInches or intptj<0.0 or intptj> bitmapHeightInches)<[pti+=0.001; count2++; if(count2<700)<[continue;]> else <[break;]>]> rowD=ptj*pixelsPerInchD; row=unsigned int(rowD); columnD=pti* pixelsPerInchD; column=unsigned int(columnD); Indexx=row* bitmapPixelWidth+column; priorlength=lengthv[Indexx]; currentlength=sqrt (vppti*vppti+vpptj*vpptj+vpptk*vpptk); difference1=abs (currentlength−priorlength); if(difference1<0.0001)< [pointIsVisible=true; red=240; green=0; blue=0; bitmapx.SetPixel(row, column, red, green, blue);]> else <[pointIsVisible=false;]> pti+=0.001; count2++;]> while (count3<900)<[ptj=m1*pti−2.89; vppti=vpi−pti; vpptj=vpj−ptj; vpptk=vpk−ptk; IntersectVectorWithPlane(intpti, intptj, intptk, vpi, vpj, vpk, pti, ptj, ptk, N1*i*, N1*j*, N1*k*, N0*i*, N0*j*, N0*k*); if(intpti<0.0 or intpti> bitmapWidthInches or intptj<0.0 or intptj> bitmapHeightInches)<[pti+=0.001; count3++; if(count3<900)<[continue;]> else<[break;]>]> rowD=ptj*pixelsPerInchD; row=unsigned int(rowD); columnD=pti*pixelsPerInchD; column=unsigned int(columnD); Indexx=row*bitmapPixelWidth+column; priorlength=lengthv[Indexx]; currentlength=sgrt (vppti*vppti+vpptj*vpptj+vpptk*vpptk); difference1=abs (currentlength−priorlength); if(difference1<0.0001)< [pointIsVisible=true; red=0; green=0; blue=250; bitmapx.SetPixel(row, column, red, green, blue);]> else <[pointIsVisible=false;]> pti+=0.001; count3++;]>]>

FIG. **8** shows a perspective view of a vector (**34**) intersecting a plane (**36**) at point (**35**). A normal vector (**38**) of plane (**36**) is shown. The normal vector is formed by point N**0** (**39**) and point N**1** (**37**). Point N (**39**) is on plane (**36**). Vector (**34**) is formed of any two points, point (**77**) and point (**33**). Vector (**40**) is formed of two points, point (**35**) and point (**39**). Vector (**40**) is in plane (**36**). The following c++ code shows an example of 'Vector Plane Intersection', and is the function used above. where, intpti, intptj, intptk is intersection point (**35**); pt1 is point (**77**); pt**0** is point (**33**); N**0** is point (**39**); N**1** is point (**37**):

c++ <[void IntersectVectorWithPlane(double& intptiP, double& intptjP, double& intptkP, double pt**1***i*, double pt**1***j*, double pt**1***k*, double pt**0***i*, double pt**0***j*, double pt**0***k*, double N**1***i*P, double N**1***j*P, double N**1***k*P, double N**0***i*P, double N**0***j*P, double N**0***k*P)<[double Ni=N**1***i*P−N**0***i*P; double Nj=N**1***j*P−N**0***j*P; double Nk=N**1***k*P−N**0***k*P; double testdenom=abs(pt**1***i*−pt**0***i*); if(testdenom<1.0e−9)<[return;]> double mji=(pt**1***j*−pt**0***j*)/(pt**1***i*−pt**0***i*); double mki=(pt**1***k*−pt**0***k*)/(pt**1***i*−pt**0***i*); testdenom=abs(Ni+Nj*mji+Nk*mki); if(testdenom<1.0e−9) <[return;]> tempi=(N**0***i*P*Ni+Nj*mji*pt**0***i*−Nj*pt**0***j*+Nj*N**0***j*P+Nk*mki*pt**0***i*−Nk*pt**0***k*+Nk*N**0***k*P)/(Ni+Nj*mji+Nk*mki); intptiP=tempi; intptjP=mji*(tempi−pt**0***i*)+pt**0***j*; intptkP=mki*(tempi−pt**0***i*)+pt**0***k*;]>]>

The general formula for intptiP is formed by combining a general formula for a plane with a general formula for a line. More specifically, the projection of a vector to the i-j plane, and the projection of the vector to the i-k plane. The general formula for a plane is set in an equation that any vector in the plane dotted with the planes normal vector is zero. N dot v is zero. where N is the normal vector of the plane, and v is any vector in the plane. A general formula for a line is: j=mji*(i−i0)+j0 where i**0**, j**0**, and mji are given. Also, k=mki*(i−i0)+k0 where i**0**, k**0**, and mki are given. These two equations for a line are substituted in the equation for a plane; and solved for i. This substitution eliminates variables j and k. Only i remains in the equation. Solving for i yields the equation above in the c++code snippet.

The graphic object structure analysis may also include reflection vectors. A reflection vector can be derived for any point in a graphic object. This reflection vector may intersect any graphic object. e.g. any plane, sphere, or surface. The intersection point can be assigned any selected pixel color. For example, a light source contacts a particular point on a blue surface; a reflection vector is calculated at this particular point; the reflection vector intersects a red sphere; the intersection point is set to blue. The following c++code snippet sets forth an example to calculate a reflection vector.

c++ <[void ReflectionVector(double& rpti, double & rptj, double& rptk, double Ni, double Nj, double Nk, double s**1***i*, double s**1***j*, double s**1***k*, double ai, double aj, double ak)< [double si=s**1***i*−ai; double sj=s**1***j*−aj; double sk=s**1***k*−ak; double lengths=sqrt(si*si+sj*sj+sk*sk); double lengthN=sqrt(Ni*Ni+Nj*Nj+Nk*Nk); double NdotS=(Ni*si+Nj*sj+Nk*sk)/(lengthN*lengths); double testDot=abs(NdotS); if(testDot<1.0e−6)<[return;]> else if(testDot>0.9999)<[rpti=s**1***i*; rptj=s**1***j*; rptk=s**1***k*; return;]> double phi=a cos(NdotS); double Nri=0.0; double Nrj=0.0; double Nrk=0.0; double rxi=0.0; double rxj=0.0; double rxk=0.0; double tlen=2.0*lengths*sin(phi); Nri=Nj*sk−sj*Nk; Nrj=−(Ni*sk−si*Nk); Nrk=Ni*sj−si*Nj; rxi=Nj*Nrk−Nrj*Nk; rxj=−(Ni*Nrk−Nri*Nk); rxk=Ni*Nrj−Nri*Nj; double lengthrx=sqrt(rxi*rxi+rxj*rxj+rxk*rxk); if(lengthrx>1.0e−6)<[cx=tlen/lengthrx;]> else <[return;]> double tri=cx*rxi; double trj=cx*rxj; double trk=cx*rxk; rpti=s**1***i*+tri; rptj=s**1***j*+trj; rtpk=s**1***k*+trk;]>]>

In the above example for the reflection vector, The tail end of the reflection vector is ai, aj, ak; the terminal end of the reflection vector is rpti, rptj, rptk. The reflection vector is: (rpti−ai)i+(rptj−aj)j+(rptk−ak)k; ai, aj, ak, the intersection point of a light source vector with the plane. Ni, Nj, Nk is the normal vector of the plane.

A graphic object structure may also include translucent surfaces. A translucent surface can be derived by intersecting a vector with one or more surfaces. Next, set the selected pixel color at a relatively less pixel per inch resolution. For example, for a bitmap having a resolution of 1000 pixels per inch, a translucent surface can be attained by setting a background image at about 500 pixels per inch. For example, a foreground rectangular translucent blue surface; and a background linear red surface; initially all pixels in the bitmat are blue; Next, the program iterates thru the equation of the line; and assign a red pixel at a density of 500 pixels per inch.

One method to create a translucent surface is using a 'next least length' concept. This concept is related to a 'visible' point on the geometric object. Opaque surfaces described above, have only one point per steradian which is 'visible'. In comparison, for a translucent surface, there may be to or three or more points in one particular steradian which are 'visible'. e.g. the visible points are 2 points having the least position vector length. The following is an example c++ code snippet showing a method to calculate a translucent surface:

The following is a summary of c++ code for translucent surface calculation: This code may be set in line with the above c++ code examples; c++ <vector> priorLength0, <vector> priorLength1, and <vector> priorLength2 contain values having a respective next least length; for example, at index **33**, priorLength0[33]==22.15; priorLength1[33]==28.76; prior-

Length2[33]==30.85; first, a current position vector length is calculated; read priorLength0, priorLenght1, and priorLength2; calculate 3 test values, test if currentLength is the first least value; if true: shift existing values to next vector; and assign currentLength to priorLength0; else test if currentLength is the second least value; if true: shift existing values to next vector; and assign currentLength to priorLength1; else test if currentLength is the third least value; if true: assign currentLength to priorLength2; repeat steps above for each graphic object point; Next loop: calculate currentLength; read priorLength0, priorLength1, and priorLength2; calculate 3 test values, the difference between respective length; test if currentLength is the first least length; if true: set IsFirstSurface=true; else test if currentLength is the second least length; if true: set IsSecondSurface=true; else test if currentLength is the third least length; if true: set IsThirdSurface=true; repeat for each point in the geometric objects.

currentLength=23.33; pLength0=priorLength0[indexx]; pLength1=priorLength1[indexx]; pLength2=priorLength2[indexx]; testd0=abs(currentLength−pLength0); testd1=abs(currentLength−pLength1); testd2=abs(currentLength−pLength2); if(currentLength<pLength0 && testd0>1.0e−5)<[priorLength1[indexx]=pLength0; priorLength2[indexx]=pLength1; priorLength0[indexx]=currentLength;]> else if(currentLength<pLength1 && testd1>1.0e−5)<[priorLength1[indexx]=currentLength; priorLength2[indexx]=pLength1;]> else if(currentLength<pLength2 && testd2>1.0e−5)<[priorLength2[indexx]=currentLength;]>]>//next loop <[pLength0=priorLength0[indexx]; pLength1=priorLength1[indexx]; pLength2=priorLength2[indexx]; currentLenght=34.57; testd0=abs(currentLength−pLength0); testd1=abs(currentLength−pLength1); testd2=abs(currentLength−pLength2); if(testd0<1.0e−5)<[IsFirstSurface=true;]> else if(testd1<1.0e−5)<[IsSecondSurface=true;]> else if(testd2<1.0e−5)<[IsThirdSurface=true;]>]>

Calculating a Position Vector of a Geometric Structure

FIG. 3 shows an example of a position vector (**23**). Position vector (**23**) points to a geometric object (**27**). The tail end of position vector (**23**) is at origin (**4**). Therefore, the following c++ code snippet shows an example of calculating a position vector of a geometric structure:

c++ <[pti=3.3; ptk=7.8; ptj=7.65*pti+6.48;]> The calculations of pti, ptj, and ptk above creates a position vector (**23**) equal to $3.3i+31.725j+7.8k$

Calculating a Particular Steradian Region of Space

FIG. 1 shows an example of a particular steradian (**5**). The following c++ code snippet shows an example of calculating a particular steradian region of space:

c++ <[AdotB=(ai*bi+aj*bj+ak*bk)/(lengthA*lengthB); theta=a cos(AdotB); arcLength=steradianRadius*theta; columnIndex=arcLenght/0.001; AdotB=(ai*di+aj*dj+ak*dk)/(lengthA*lengthD); theta=a cos(AdotB); arcLength=steradianRadius*theta; rowIndex=arcLength/0.001;]> where 'a' is a position vector (**23**); 'b' is a vector (**17**); 'd' is the k axis vector; the value 0.001 declares that the steradian arc width is 0.001 inches; steradian arc width, and steradian radius are both selected to be any suitable value. 'steradian radius' is the length of vector (**17**); 'theta' is the angle between position vector (**23**) and vector (**17**); 'arcLength' is the length of arc (**48**); 'AdotB' is the vector dot product of position vector (**23**) and vector (**17**): next, 'AdotB' is the vector dot product of position vector (**23**) and the k axis vector; This example calculates that the particular steradian region of space is located at 'rowIndex' and 'columnIndex', and has a steradian arc width of 0.001 inches. FIG. 1 shows an example of the boundary of this particular steradian region of space.

The Position Vector is Located in One Particular Steradian Region of Space

A steradian may be located in any selected region of space. FIG. 5 shows an initial side vector (**17**), and terminal side vector (**21**) of adjacent steradians (**16**). Vector (**17**) and vector (**21**) may be at any selected location. Both the steradian and position vector have the property of direction and scalar length. Furthermore, both a steradian and position vector originates from the origin (**4**). These properties of direction and location show that a position vector is located in one particular steradian region of space. A position vector (**23**) is located between 4 boundary vectors of the steradian (**16**).

FIG. 6 shows an example of two position vectors located in one particular steradiane region of space. Both position vector (**23**) and position vector (**24**) are located between the four boundary vectors of steradian (**22**). FIG. 1 shows an example of one particular steradian (**5**); and the boundary vector (**6**), boundary vector (**7**), boundary vector (**8**), and boundary vector (**9**).

Calculating a Length of a Position Vector

The following c++ code snippet shows an example of calculating a length of a position vector:

c++ <[currentLength=sqrt(pti*pti+ptj*ptj+ptk*ptk);]> where pti, ptj, ptk are the coordinates of the position vector, and currentLength is the length of the position vector.

Comparing a First Position Vector Length to a Second Position Vector Length

The following c++ code snippet shows an example of Comparing a First Position Vector Length to a Second Position Vector Length:

c++ <[if(currentLength<priorLength)]> where currentLength is a first position vector length; and priorLength is a second position vector length. The result of this comparison is boolean true or false.

Deriving a Pixel Color From a Result of the Position Vector Length Comparison

A fundamental component of the present invention is shown in FIG. 6: Two position vectors both located in one particular steradian region of space. The length of these two position vectors is compared; and a result of the comparison is either true or false. The position vector having a least length has contact with a light source. This result of least length provides that the program can set an appropriate pixel color accordingly. Obviously, variations of the pixel color may be attained by additional steps not shown herein. The following c++ code snippet shows an example of deriving a pixel color from a result of position vector length comparison:

c++ <[currentLenght=28.75; priorLength=48.62; if(currentLength<priorLength)<[sourceContactSurface=true; red=255; green=0; blue=0; bitmapx.SetPixel(row, column, red, green, blue);]>else <[sourceContactSurface=false; red=11; green=10; blue=22; bitmapx.SetPixel(row, column, red, green, blue);]>]>

The values of 'red', 'green', and 'blue' color assigned above are dependent on the result of the boolean comparison 'if(currentLength <priorLength)'; Therefore, the color (red, green, blue) above is derived from the result of the boolean comparison.

The best mode for using the present invention is set forth in the description above, and the appended drawings.

The industrial applicability of the present invention includes creating 3-dimensional graphic effects in any graphic image. for example, reflective images, highlights, shadows, translucent surfaces. e.g. electronic bitmaps, RGB 48 bpp bitmap.

The description above sets forth specific examples of the present invention. Obviously, many variations of the present invention are possible. Therefore, limitations should only be imposed as those set forth in the appended claims.

I claim:

1. A method for deriving a pixel color comprising the steps of:

a computer calculating a first position vector for a geometric graphic object;

a computer calculating a particular steradian region of space;

a computer calculating a particular steradian radius of said steradian region of space;

a computer calculating that said first position vector is located in said particular steradian region of space;

a computer calculating a second position vector for a geometric graphic object;

a computer calculating that said second position vector is located in said particular steradian region of space;

a computer calculating a length of said first position vector;

a computer calculating a length of said second position vector;

a computer comparing said first length to said second length;

for a first pixel, a computer deriving a pixel color for said first position vector from a result of said length comparison;

for a second pixel, a computer deriving a pixel color for said second position vector from a result of said length comparison.

2. The method for deriving a pixel color according to claim 1 where said result is said first length is less than said second length; and said first pixel is a highlight point; and said second pixel is a shadow point.

3. The method for deriving a pixel color according to claim 1 where said computer is an electronic computer.

4. The method for deriving a pixel color according to claim 1 further including, a computer calculating a particular rotation angle position of said steradian region of space;

a computer calculating a particular azimuth angle position of said steradian region of space.

5. The method for deriving a pixel color according to claim 4 further including, a computer calculating a steradian row index derived from said azimuth angle and said steradian radius; and a computer calculating a steradian column index derived from said rotation angle and said steradian radius.

6. The method for deriving a pixel color according to claim 5 where said rotation angle is in an i j axis plane of a coordinate system; and said azimuth angle is from a k axis of said coordinate system.

* * * * *

EXHIBIT 2

search results uspto.gov specification: shadow map specification: pixel

patent no.	filing date	assignee / title
7,970,168	October 25, 2010	The Research Foundation of State University of New York, Binghamton, NY Hierarchical Static Shadow Detection Method
8,896,599	April 8, 2010	Samsung Electronics Co., Ltd, Suwon-Si (KR) Image Processing Apparatus and Method
8,872,824	March 3, 2010	Nvidia Corporation (Santa Clara, CA) System, Method, and Computer Program Product for Performing Shadowing Utilizing Shadow Maps and Ray Tracing
8,471,853	October 10, 2008	VIA Technologies, Inc. New Taipei (TW) Reconstructable Geometry Shadow Mapping Method
7,826,640	April 29, 2008	State University New York, Binghamton, NY Hierarchical Static Shadow Detection Method
8,648,856	December 20, 2007	Nvidia Corporation (Santa Clara, CA) Omnidirectional Shadow Texture Mapping
8,159,490	October 16, 2007	Dreamworks Animation LLC, Glendale, CA Shading of Translucent Objects
8,189,003	May 8, 2007	Dreamworks Animation LLC, Glendale, CA System and Method for Rendering Computer Graphics Utilizing a Shadow Illuminator
7,817,823	April 27, 2007	Adobe Systems, Inc. San Jose CA Calculating Shadow from Area Light Sources Using a Spatially Varying Blur Radius
7,969,438	February 16, 2007	Pacific Data Images LLC, Redwood City, CA Soft Shadows for Cinematic Lighting for Computer Graphics
7,675,518	Sept 5, 2006	Adobe Systems, Inc. San Jose CA System and Method for Generating Image Shadows with Ray-Coherent Integration of Extruded Transparency Maps
8,139,059	March 31, 2006	Microsoft Corporation (Redmond, WA) Object Illumination in a Virtual Environment
8,300,059	February 3, 2006	ATI Technologies ULC, Markham, Ontario (CA) Method and Apparatus for Selecting a MIP Map Level Based on a MIN-Axis Value for Texture Mapping
8,462,156	December 22, 2005	Nvidia Corporation (Santa Clara, CA) Method and System for Generating Shadows in a Graphics Processing Unit
7,233,332	November 14, 2005	Pixar (Emeryville, CA) Method and Apparatus for Rendering Shadows
7,567,248	April 28, 2005	Mark et al. System and Method for Computing Intersections Between Rays and Surfaces
7,924,281	March 9, 2005	ATI Technologies ULC, Markham, Ontario (CA) System and Method for Determining Illumination of a Pixel by Shadow Planes
8,803,879	March 4, 2005	Nvidia Corporation (Santa Clara, CA) Omnidirectional Shadow Texture Mapping
7,158,133	August 24, 2004	S3 Graphics Co., Ltd. (Grand Cayman, KY) System and method for shadow rendering
7,508,390	August 17, 2004	Nvidia Corporation (Santa Clara, CA) Method and System for Implementing Real Time Soft Shadows using Penumbra Maps and Occuluder Maps

2 Dimensional Shadow Map

EXHIBIT 2

7,307,631 March 26, 2004 STMicroelectronics Limited, Bristol (GB)
Computer Graphics

7,348,977 March 25, 2004 Pixar (Emeryville, CA)
Subsurface Scattering Approximation Methods and Apparatus

7,023,438 October 14, 2003 Pixar (Emeryville, CA)
Method and apparatus for rendering shadows

7,119,806 Sept 30, 2003 Nvidia Corporation (Santa Clara, CA)
System, method and article of manufacture for shadow mapping

6,876,362 July 10, 2002 nVidia Corporation (Santa Clara, CA)
Omnidirectional shadow texture mapping

6,690,372 December 5, 2000 NVIDIA Corporation (Santa Clara, CA)
System, method and article of manufacture for shadow mapping

6,664,962 November 28, 2000 Nintendo Co., Ltd. (Kyoto, JP)
Shadow mapping in a low cost graphics system

6,791,544 Sept 18, 2000 S3 Graphics Co., Ltd. (Grand Cayman, KN)
Shadow rendering system and method

6,593,923 August 16, 2000 Nvidia Corporation (Santa Clara, CA)
System, method and article of manufacture for shadow mapping

6,760,024 July 19, 2000 Pixar (Emeryville, CA)
Method and apparatus for rendering shadows

6,771,263 December 10, 1999 GMD-Forschungszentrum Informationstechnik GmbH (Sankt Augustin, DE)
Processing volumetric image data with shadows

6,437,782 January 6, 1999 Microsoft Corporation (Redmond, WA)
Method for rendering shadows with blended transparency without producing visual artifacts in real time applications

6,567,083 Sept 25, 1997 Microsoft Corporation (Redmond, WA)
Method, system, and computer program product for providing illumination in computer graphics shading and animation

5,742,749 February 20, 1996 Silicon Graphics, Inc. (Mountain View, CA)
Method and apparatus for shadow generation through depth mapping

5,613,048 August 3, 1993 Apple Computer, Inc. (Cupertino, CA)
Three-dimensional image synthesis using view interpolation

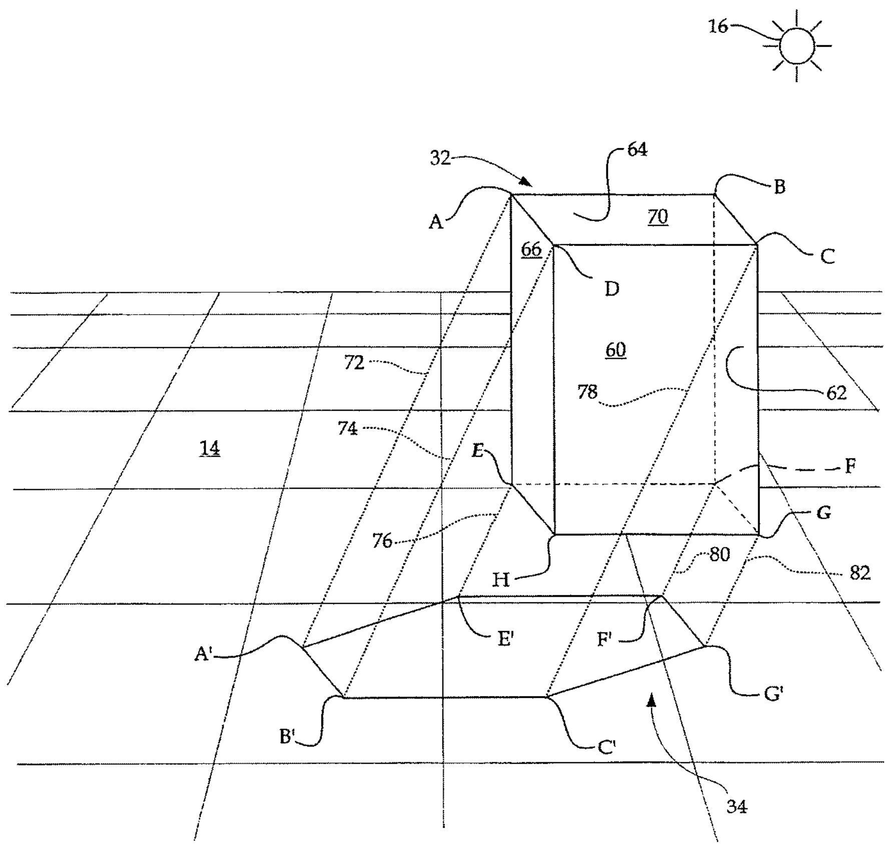


Figure 9C

2 Dimensional Shadow Map

EXHIBIT 2

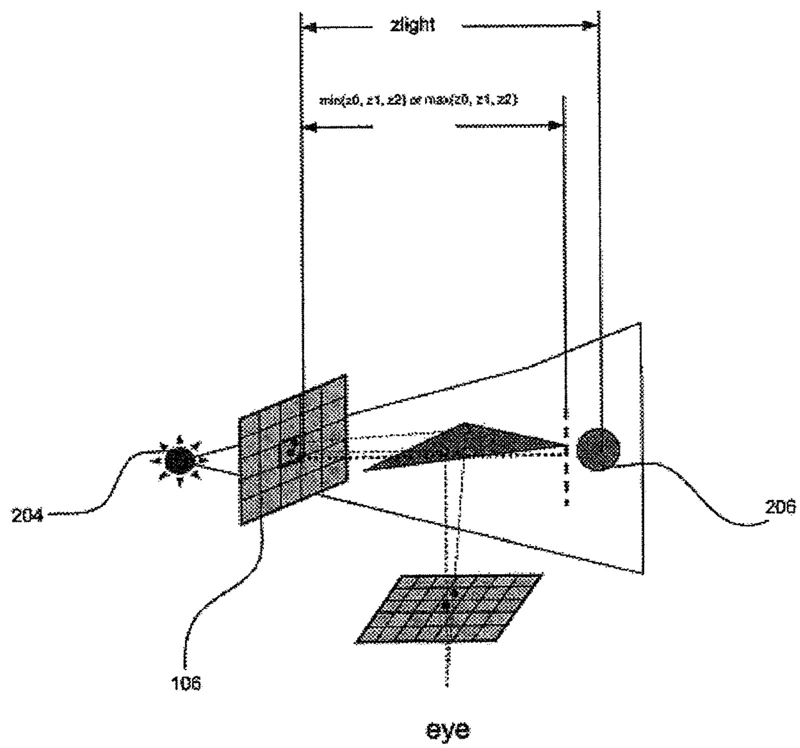
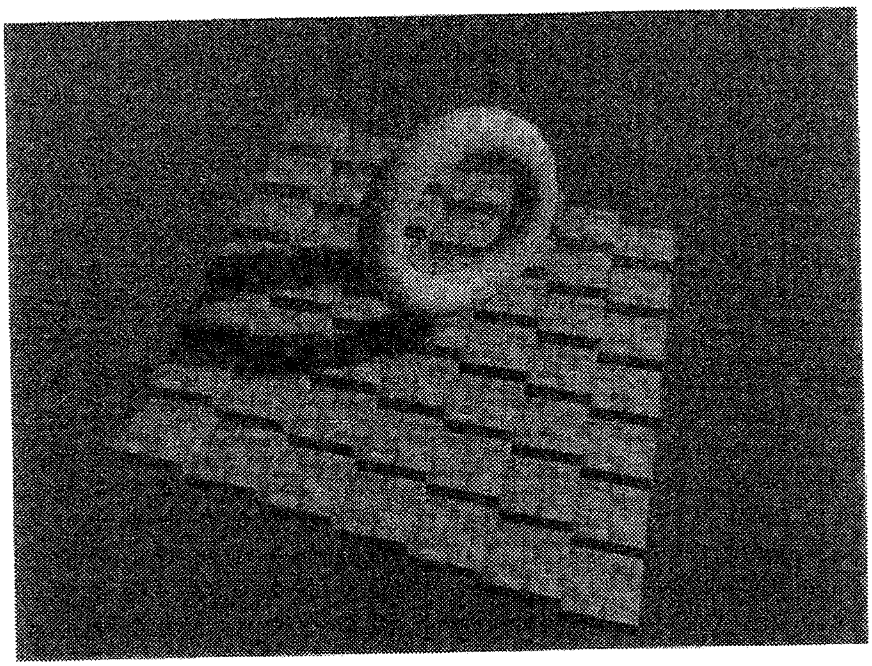


Figure 10

2 Dimensional Shadow Map

EXHIBIT 2

Fig. 15



2 Dimensional Shadow Map

EXHIBIT 2

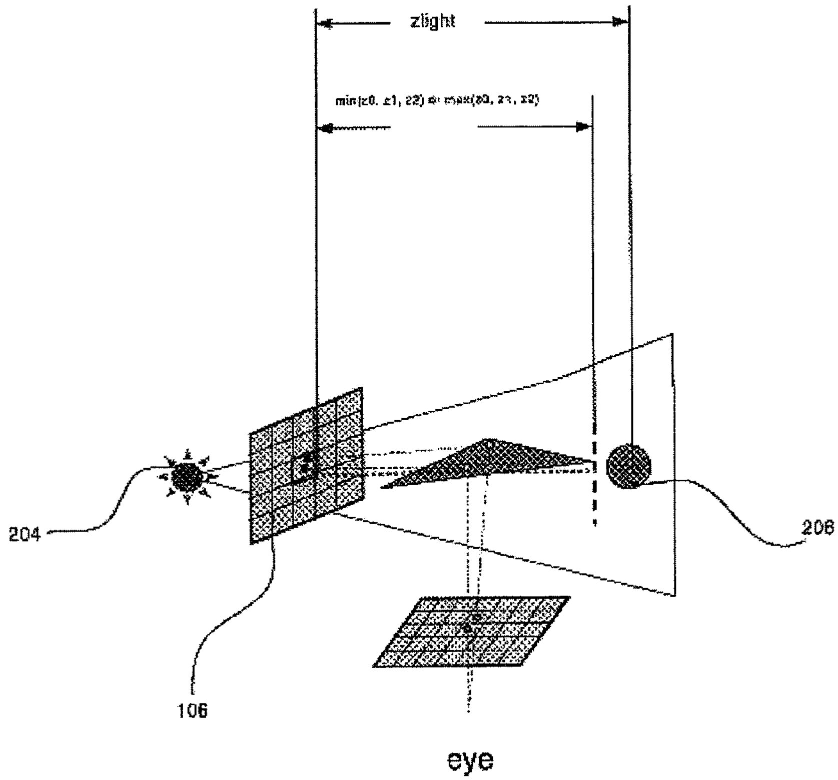


Figure 10

2 Dimensional Shadow Map

EXHIBIT 2

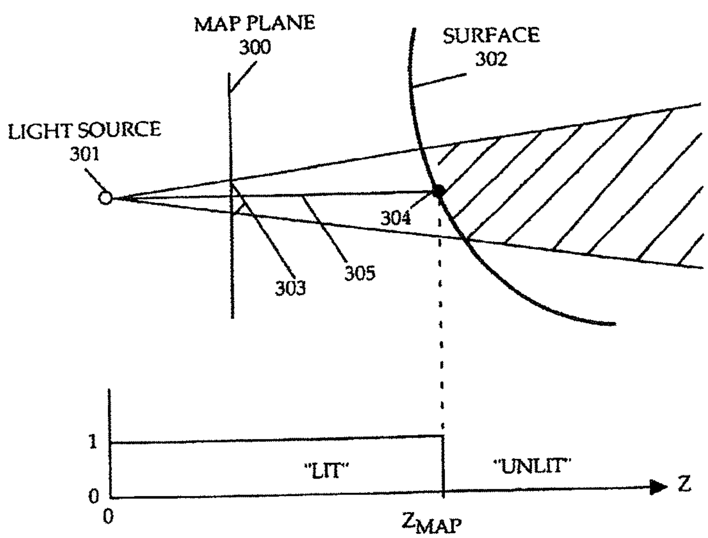


FIGURE 3

PRIOR ART

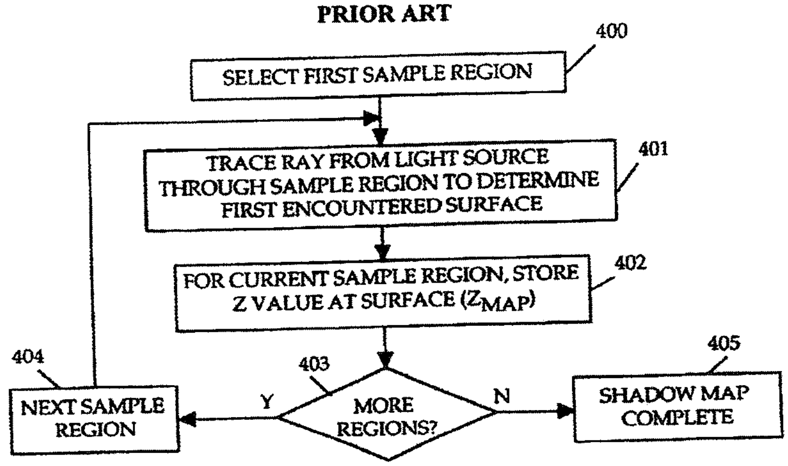


FIGURE 4

PRIOR ART

2 Dimensional Shadow Map

EXHIBIT 2

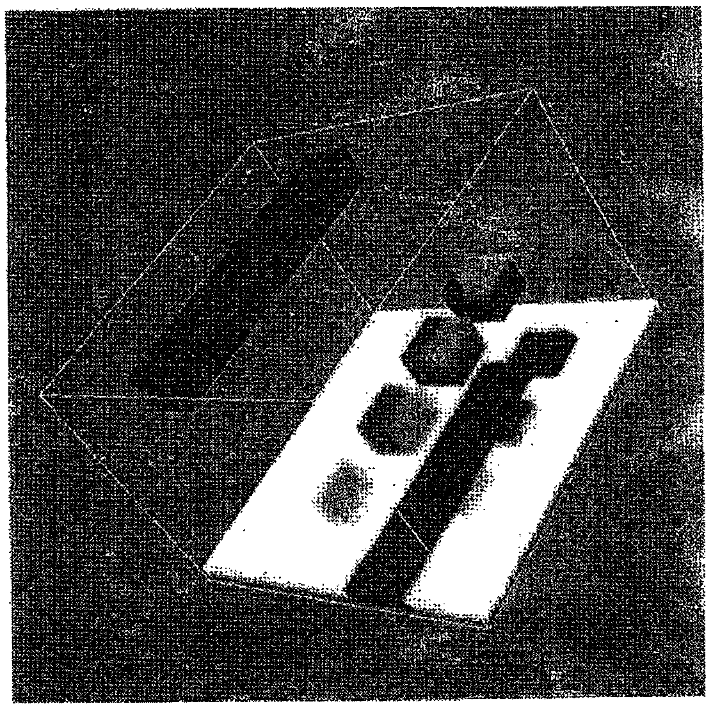


FIG 7B

2 Dimensional Shadow Map

EXHIBIT 2

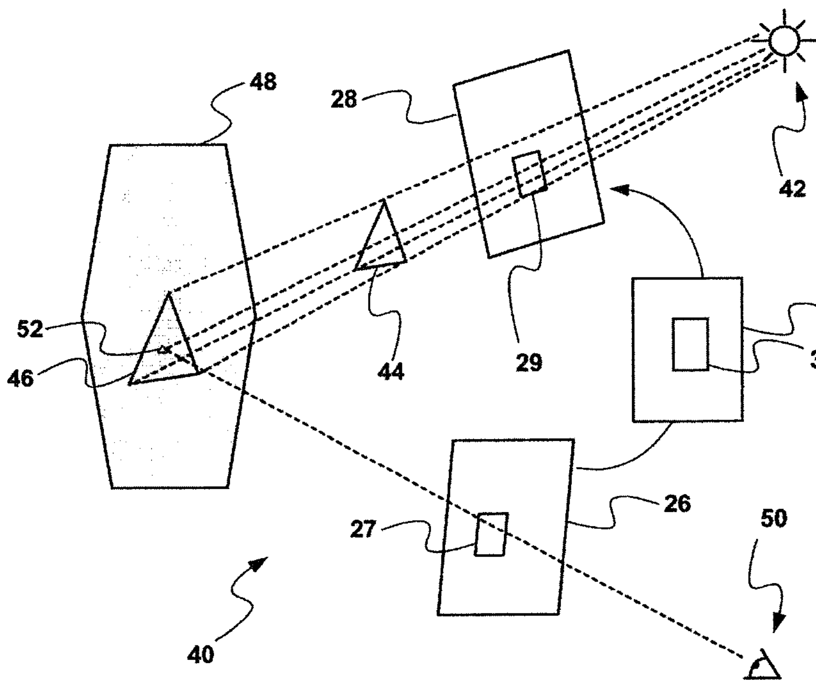


FIG. 2

2 Dimensional Shadow Map

EXHIBIT 2

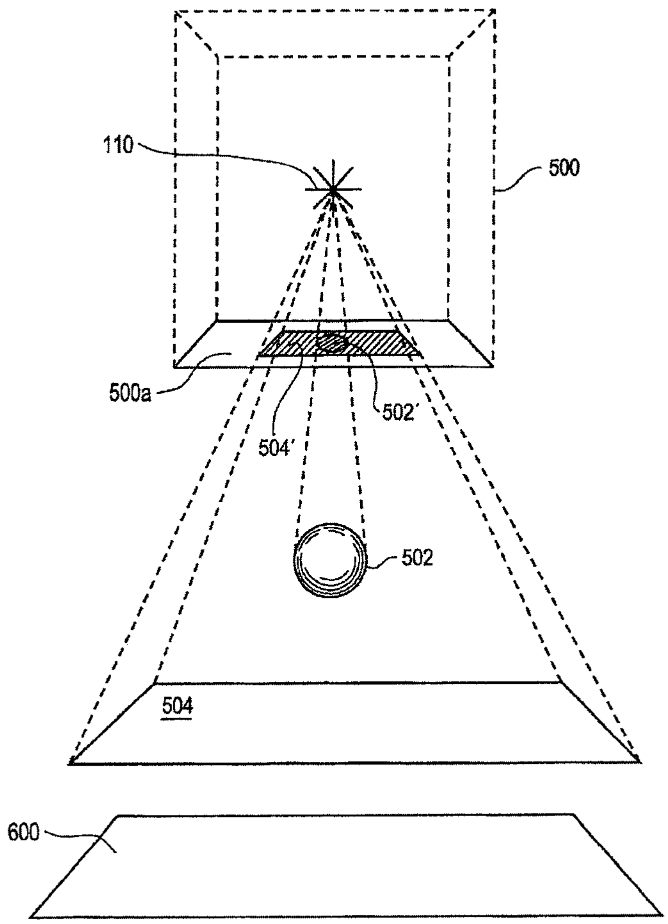


FIG. 6

2 Dimensional Shadow Map

EXHIBIT 2

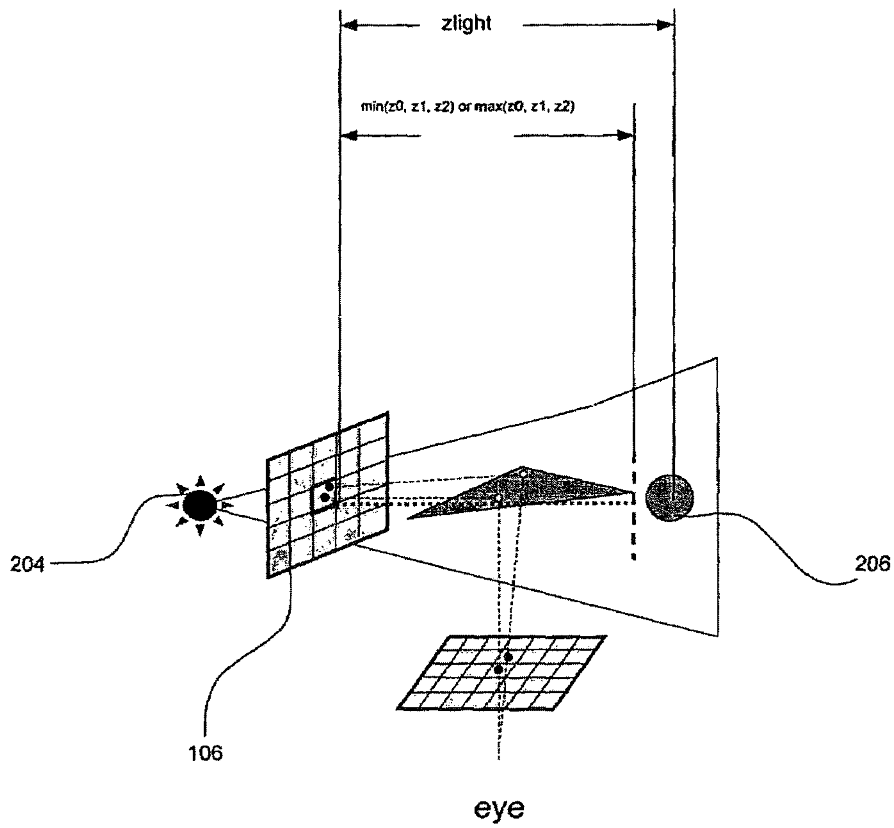


Figure 10

2 Dimensional Shadow Map

EXHIBIT 2

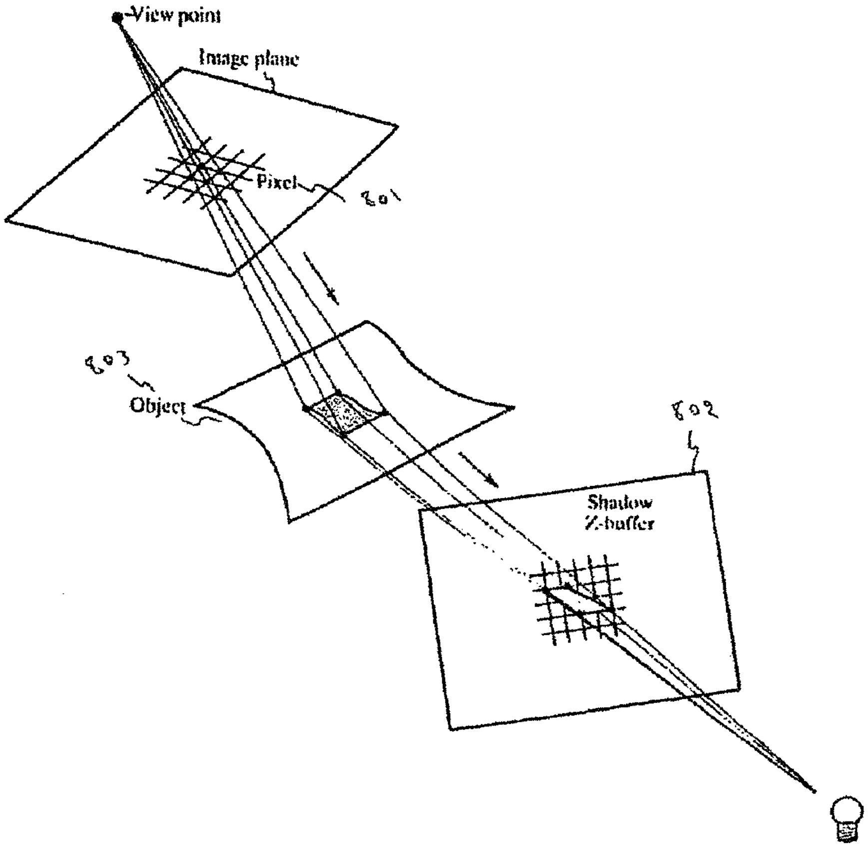


FIG. 8

2 Dimensional Shadow Map

EXHIBIT 2

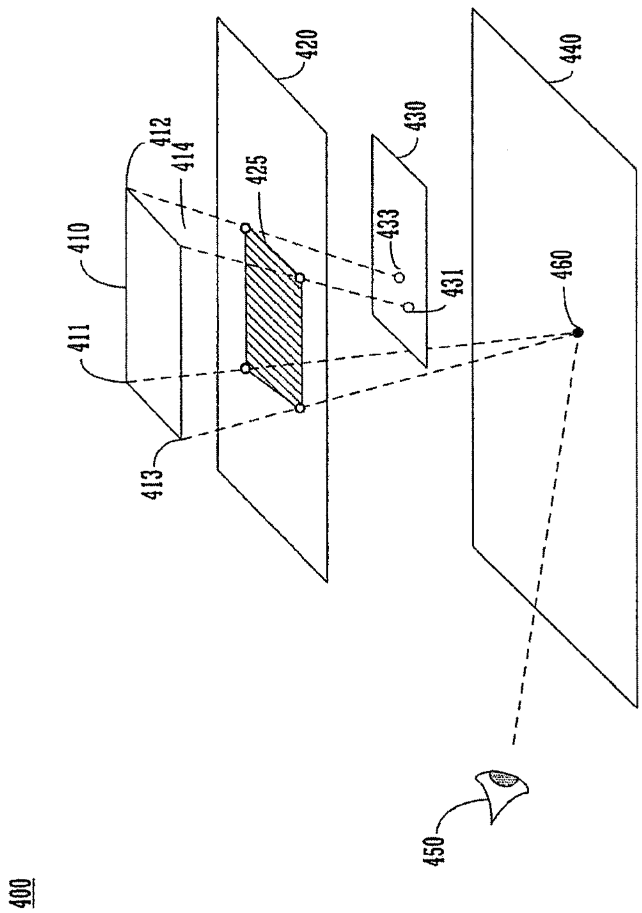
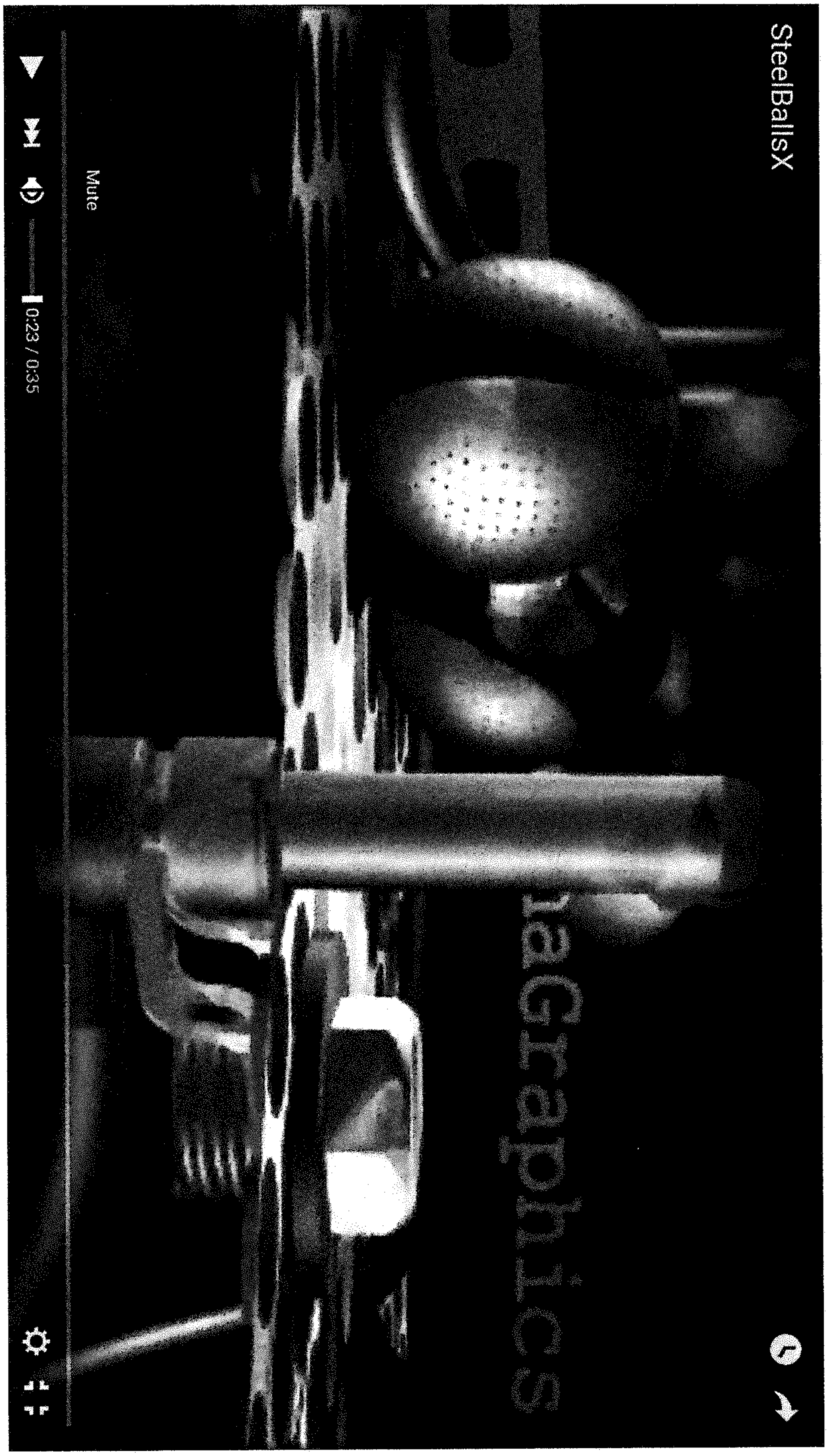


FIGURE 4

2 Dimensional Shadow Map

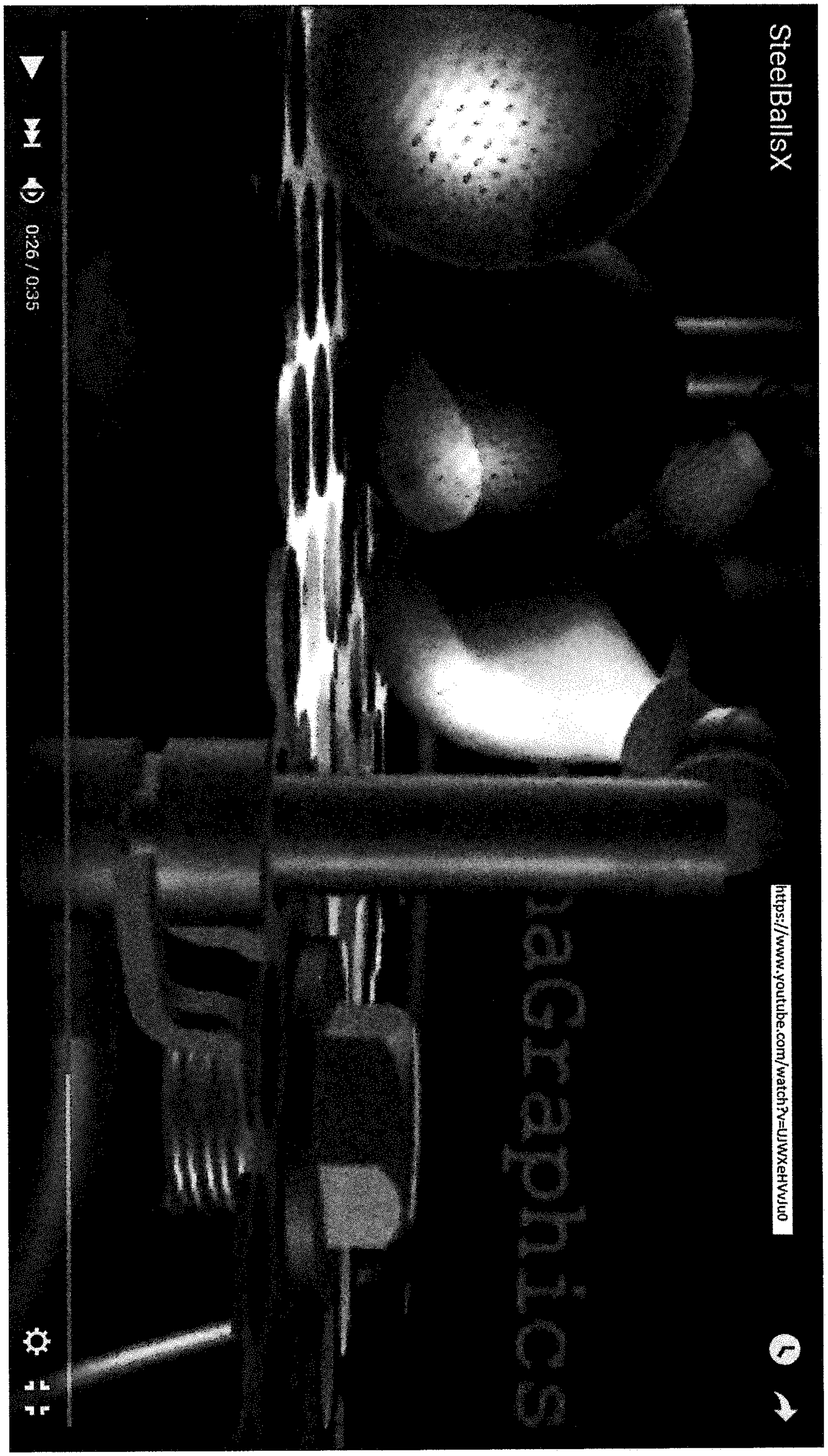
EXHIBIT 2

EXHIBIT 3



Coffelt's SteelBallsX video using 710 patent claims

EXHIBIT 3



Coffelt's SteelBallsX video using 710 patent claims

EXHIBIT 3

GFX1133 Coffelt's Complaint (46 / 76)

EXHIBIT 4