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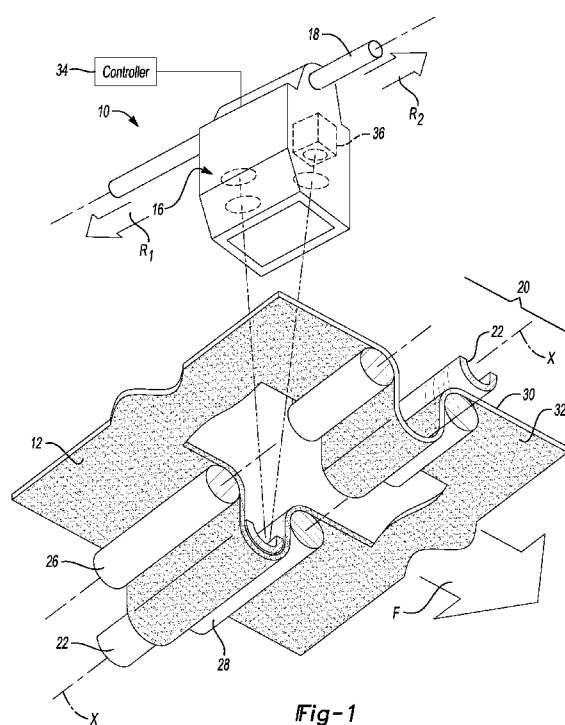
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Declarations under Rule 4.17:

- 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))

(54) Title: METHOD OF DIGITALLY GRADING LEATHER BREAK



(57) Abstract: A method and apparatus for grading leather based upon the size and spacing of the breaks in the leather. All or a portion of a hide is fed to a fixture that compresses a local area of the hide into a concave shape. The outer side of the hide is compressed and the inner side of the hide is expanded to cause breaks to be manifested in a local area. The local area of the hide is scanned with a digitizing profilometer that measures the depth of the breaks as the hide is fed through the fixture. The depth data measured by the digitizing profilometer is recorded by a controller. The depth data is then correlated with location data representing the local area scanned to develop a map of the break.

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METHOD OF DIGITALLY GRADING LEATHER BREAK

TECHNICAL FIELD

[0001] This disclosure relates to a method of measuring, grading and sorting leather hides based upon digitized surface profile mapping of leather break characteristics of the hide.

BACKGROUND

[0002] Leather used in manufacturing products such as leather seats, leather trim and other applications is subjectively graded by visual inspection. Leather “break” is one of the characteristics that are evaluated. Break describes an effect of a loose fiber structure within the leather. Break is manifested on the surface of the leather when it conformed in a concave manner with respect to the top surface (otherwise known as the “grain” surface). The concave conformation is typically achieved by placing the leather, grain side up, into a “half-pipe” or into the cup of your hand. This conformation puts a compressive stress on the grain surface and an expansive stress on the bottom layer (known as the “flesh-side” of the leather). If the fiber structure within the leather is sufficiently loose rather than tightly entwined, the leather will “break” or form pleats on the surface. Leather is graded, in part, based upon the size of the breaks and spacing between breaks in the leather surface. The size of the break is compared to physical standards or photographs of different size break images. Errors in the subjective measurement can lead to customer complaints or reduced yields.

[0003] Different areas on a single hide may have different break gradings. For example, the stomach, and neck areas of a hide are sub-prime because they normally have loose fiber structure and larger breaks compared to prime areas such as the back and flanks of the hide. When pieces are cut from the hide by dies, waterjet cutting, or laser cutting, leather parts used in high visibility and high stress areas are cut from prime areas while some leather parts may be cut from areas having larger break ratings. The location and borders of the prime and sub-prime areas varies by age, gender, type of animal, from hide to hide and batch to batch of hides.

[0004] Prime areas are conservatively designated to avoid quality issues with some peripheral prime areas not being used for prime parts even though they are of sufficient quality. As a result,

maximum utilization of the prime leather of the hides is not achieved and added material cost is incurred.

[0005] Hides are inspected and graded upon receipt. Batches having extensive large break areas are rejected or may be accepted with credits based upon the quality of the hide. Visual inspections of the hides are labor intensive and documenting the quality is difficult because of the subjective nature of the inspection process.

[0006] This disclosure is directed to solving the above problems and other problems as summarized below.

SUMMARY

[0007] According to one aspect of this disclosure, a method of grading leather based upon the size and spacing of the breaks in the leather. The method begins with the step of fixturing all or a portion of a hide to a fixture that conforms a local area of the hide into a concave shape with the grain side of the hide being compressed and the flesh of the hide being expanded to cause a break to be manifested. Scanning the local area of the hide is performed with a digitizing profilometer that measures the depth and width of the breaks as the hide is fed through the fixture. The resultant digital data can be processed in real time or stored for later analysis. The depth data is then related to the scanned hide position to develop a map of the leather break.

[0008] The method may further comprise analyzing the map by measuring a size of the spaces between the break and converting the size of the spaces to digital data. The data may be analyzed to identify the peaks and valleys in the local area. The distance between the break may be converted into wave form data and separated into distinct wave forms that are digitized to grade the local areas of the hide. The wave form data may be correlated to the location data to develop at least a partial map of the break of the hide.

[0009] According to another aspect of this disclosure, a machine is disclosed for inspecting a hide. The machine includes a shaping fixture that bends a local area of the hide to form a grain side surface of the hide into a concave shape and a flesh side of the hide into a convex shape. The digitizing profilometer measures the depth of a break as the hide is fed through the fixture to develop depth data.

A controller records depth data and correlates the depth data with location data representing the local area scanned to develop at least a partial map of the break in the hide.

[0010] The controller may analyze the size of the spaces between the break and convert the size of the spaces to digital data. The controller may convert the size of the spaces by applying a mathematic analysis such as a Fourier transform of the data.

[0011] The controller may analyze the depth data to identify the peaks and valleys in the local area and measure a distance between either the peaks or the valleys to determine the distance between the breaks, and a grade may be assigned based upon the distance between the break in the local areas of the hide. The controller may analyze the distance between the break by converting the data into wave form data to separate the composite wave data into distinct wave forms that are digitized to grade the local areas of the hide. The controller may analyze the wave form data and correlate the data to the location data to develop a map of the break in different local areas of the hide.

[0012] The digitizing profilometer may be a laser surface profiler, for example, an optical confocal lens, a capacitance sensor, a fiber optic sensor, or an acoustic echo sensor.

[0013] The shaping fixture may have a transparent semi-cylindrical guide and the feed system may include a set of feed rollers that feed the hide around the semi-cylindrical guide that forms the hide surface into the concave shape. A set of pinch rollers may be used to pull the hide away from the semi-cylindrical guide. The digitizing profilometer may be used to scan the hide surface in the semi-cylindrical guide as the digitizing profilometer moves parallel to a cylindrical axis of the semi-cylindrical guide.

[0014] The shaping fixture may have a transparent cylindrical roller guide and the feed system may include at least one feed roller that feeds the hide around the roller guide that forms the hide surface into the concave shape. At least one pinch roller may pull the hide away from the cylindrical roller guide. The digitizing profilometer scans the hide surface as the hide is fed around the roller and as the digitizing profilometer moves parallel to a cylindrical axis of the cylindrical roller.

[0015] In another embodiment, the shaping fixture may include a set of feed rollers and a set of pinch rollers that form the hide surface into the concave shape. The digitizing profilometer may be

used to scan the hide surface as the digitizing profilometer moves parallel to an axis of the concave shape.

[0016] The shaping fixture may have a concave semi-cylindrical groove and the feed system may include a set of feed rollers that feed the hide into the semi-cylindrical groove and an extractor roller that pulls the hide away from the semi-cylindrical groove. The semi-cylindrical groove may define a plurality of vacuum ports that are operatively connected to a source of vacuum that draws the hide surface into the concave shape. The digitizing profilometer may scan the hide surface as it moves substantially parallel to a cylindrical axis of the semi-cylindrical groove.

[0017] The above aspects of this disclosure and other aspects will be described below with reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0018] FIGURE 1 is a fragmentary perspective view of a hide inspection machine for inspecting a hide to determine the size and spacing of break in the hide.

[0019] FIGURE 2 is a fragmentary cross-section view of the hide inspection machine shown in Figure 1 that has a laser for measuring the break in a hide as the hide is fed behind a transparent semi-cylindrical guide.

[0020] FIGURE 3 is a diagrammatic view of a local area of a hide showing the hide surface being compressed into a concave shape and the flesh side of the hide being stretched into a convex shape.

[0021] FIGURE 4 is a fragmentary cross-section view of a hide inspection machine having a pair of feed rollers and a pair of pinch rollers that feed a hide past a laser that measures the breaks in the hide as the hide is fed behind a transparent semi-cylindrical guide.

[0022] FIGURE 5 is a fragmentary cross-section view of a hide inspection machine that has a pair of feed rollers and a pair of pinch rollers that feed a hide past a laser that measures the breaks in the hide side as the hide is folded into a concave configuration between the sets of rollers.

[0023] FIGURE 6 is a fragmentary cross-section view of a hide inspection machine that has a feed roller and an extractor roller that feeds a hide past a laser that measures the breaks in the hide as the hide is fed behind a transparent roller.

[0024] FIGURE 7 is a fragmentary cross-section view of a hide inspection machine that has a pair of feed rollers and a pair of pinch rollers that feed a hide past a laser that measures the breaks in the hide as the hide is fed into a groove in the vacuum block that defines a plurality of vacuum ports that are operatively connected to a source of vacuum.

[0025] FIGURE 8 is a plan view of a hide upon which a plurality of leather cutting dies are arranged.

[0026] FIGURE 9 is a diagrammatic view of a scanning pattern for scanning a complete hide.

[0027] FIGURE 10 is a diagrammatic view of a scanning pattern for partially scanning a hide.

[0028] FIGURE 11 is a digital image of a medium size break pattern.

[0029] FIGURE 12 is a digital image of a large size break pattern.

DETAILED DESCRIPTION

[0030] The illustrated embodiments are disclosed with reference to the drawings. However, it is to be understood that the disclosed embodiments are intended to be merely examples that may be embodied in various and alternative forms. The figures are not necessarily to scale and some features may be exaggerated or minimized to show details of particular components. The specific structural and functional details disclosed are not to be interpreted as limiting, but as a representative basis for teaching one skilled in the art how to practice the disclosed concepts.

[0031] Referring to Figure 1, an inspection machine is generally indicated by reference numeral 10 and is shown inspecting a hide 12. A digitizing profilometer 16 is oriented to inspect the hide 12 and is moved with the inspection machine 10 on a track 18, or rail, that traverses the hide 12 as the hide 12 is compressed in a shaping fixture 20.

[0032] In the embodiment shown in Figures 1 and 2, the shaping fixture includes a transparent semi-cylindrical guide 22. The semi-cylindrical guide 22 is at least partially generated about a cylindrical axis X. The hide is fed in a feed direction F by a feed roller 26 to the semi-cylindrical guide 22 while the digitizing profilometer 16 scans the surfaced of the hide 12. The hide 12 has a grain surface 30, or outer surface, and a flesh surface 32, or inner surface. The grain surface 30 is scanned by the digitizing profilometer 16 as the hide 12 is fed around the semi-cylindrical guide 22.

[0033] A controller 34 receives digital data from a laser surface profiler 36 that can be processed in real time or stored for later analysis. The laser surface profiler 36 shown in Figures 1 and 2 may be used to scan the grain surface 30 of the hide 12. Alternatively, a laser surface profiler, such as an optical confocal lens, an acoustic echo profiler, a capacitance sensor, a fiber optic scanner, or the like may be selected as the laser surface profiler in the digitizing profilometer 16.

[0034] Referring to Figure 2, the digitizing profilometer 16 scans the grain surface 30 of the hide 12 to detect break 38 in the leather hide 12. Break 38 becomes visible in the hide 12 when a local area 40 of the hide is compressed causing pleats to form on the surface. Leather may be graded based upon the size of the break 38 and spacing between pleats in the leather surface. The size of the break 38 is compared to physical standards or photographs of different size break images as will be explained with reference to Figures 11 and 12 below.

[0035] Referring to Figure 3, the hide 12 is shown with the local area 40 being compressed. Arrows C₁ and C₂ show the grain side 30 of the hide 12 being compressed to show the size and spacing of the breaks 38. Arrows E₁ and E₂ show the flesh side 32 of the hide 12 being expanded, or stretched, while the grain side 30 of the hide 12 is compressed.

[0036] Referring to Figure 4, an alternative shaping fixture is illustrated that includes a pair of feed pinch rollers 42 and a pair of extraction pinch rollers 44 that feed the hide 12 into and pull the hide 12 out of the shaping fixture, respectively. The shaping fixture 20 includes the transparent semi-cylindrical guide 22. The grain surface 30 of the hide 12 is compressed as the hide 12 is drawn across the semi-cylindrical guide 22. The digitizing profilometer 16 scans the grain surface 30 through the semi-cylindrical guide 22 to inspect the hide 12 for break 38. The pinch rollers 42 and 44 provide positive control of the hide as it is routed around the semi-cylindrical guide 22.

[0037] Referring to Figure 5, an alternative shaping fixture is illustrated that includes feed pinch rollers 42 and extraction pinch rollers 44 that, respectively, feed the hide 12 into and pull the hide 12 out of the shaping fixture. The shaping fixture forms a compressed area in the local area 40 by controlling the rotational speed of the feed rollers 42 and the extraction rollers 44. The digitizing profilometer 16 scans the local area 40 the grain surface 30 of the hide 12 to detect break 38.

[0038] Referring to Figure 6, an alternative shaping fixture is illustrated that includes the feed roller 26 and the extraction roller 28 that feed the hide 12 into and pull the hide 12 out of the shaping fixture 20, respectively. The shaping fixture forms a compressed area in the local area 40 by partially wrapping the hide 12 around a transparent cylindrical roller 48. The digitizing profilometer 16 scans the local area 40 the grain surface 30 of the hide 12 as the hide 12 passes over the cylindrical roller 48 to detect break 38.

[0039] Referring to Figure 7, an alternative shaping fixture is illustrated that includes the feed pinch rollers 42 and the extraction pinch rollers 44 that feed the hide 12 into and pull the hide 12 out of a vacuum guide block 50 that defines a concave groove. The shaping fixture forms a compressed area in the local area 40 by applying a vacuum through vacuum ports 52 defined by the vacuum guide block. Vacuum is provided from a source of vacuum 54, such as a vacuum pump, to the vacuum ports 52. The digitizing profilometer 16 scans the local area 40 the grain surface 30 of the hide 12 as the hide passes through the vacuum guide block 50 to detect the size and spacing of the break 38. While Figure 7 discloses a vacuum block, it should also be understood that a guide block without vacuum ports could be used instead of the illustrated vacuum guide block 50. A simple guide block defining a concave groove would incorporate feed pinch rollers 42 and the extraction pinch rollers 44 that feed the hide 12 into and pull the hide 12 out of the concave groove.

[0040] Referring to Figure 8 a hide 12 is diagrammatically illustrated to show prime areas 54 and sub-prime areas 56 of a typical hide. The back and flanks of the hide are normally characterized as having less break and pieces are cut out of these areas for seating surfaces, instrument panel areas, and the like because they require prime leather. The belly and neck areas are generally characterized a sub-prime areas and generally will have larger more spaced break 38.

[0041] Pieces, or blanks, are cut from the hide with dies 58 having knife edges (not shown) that are placed on the grain surface of the hide 12. The hide 12 with the dies 58 in position are then placed in a press that exerts pressure on the dies 58 to cut pieces in the desired shape from the hide 12.

[0042] Referring to Figures 9 and 10, two different approaches to scanning the hide 12 are illustrated. In Figure 9 the entire surface of the hide 12 may be scanned and analyzed by controlling the rate that the hide 12 is fed through the shaping fixture 20 (shown in Figure 1) and the speed at which the digitizing profilometer 16 traverses the rail 18. Parts of the scanning area are scanned twice as the digitizing profilometer 16 traverses the Hide 12 in the reciprocating directions R_1 and R_2 . In Figure 10 a partial scan of the hide 12 is performed to reduce the amount of data collected and provide a faster inspection process. The feed rate through the shaping fixture 20 is increased relative to the speed that the digitizing profilometer 16 traverses the hide 12.

[0043] Referring to Figures 11 and 12, two examples of break are illustrated. In Figure 11 a digital image of a medium size break 60 is illustrated. In Figure 12 a digital image of a large size break 62 is illustrated. While different grading scales may be used. In one example, the hide 12 may be graded with grade 1 being quality leather having an average break size of 0.0-0.5 mm. Other grades of leather may be graded with grade 2 having an average break size of 0.5-1.0 mm; Grade 3 having an average break size of 1.0-1.5 mm; Grade 4 having an average break size of 1.5-2.0 mm; and Grade 5 having an average break size of more than 2 mm.

[0044] The embodiments described above are specific examples that do not describe all possible forms of the disclosure. The features of the illustrated embodiments may be combined to form further embodiments of the disclosed concepts. The words used in the specification are words of description rather than limitation. The scope of the following claims is broader than the specifically disclosed embodiments and also includes modifications of the illustrated embodiments.

WHAT IS CLAIMED IS:

1. A method of grading leather comprising:
fixturing all or a portion of a hide in a fixture that compresses a local area of the hide into a concave shape with a grain side of the hide being compressed and a flesh side of the hide being expanded to cause a break to be manifested;
scanning the local area of the hide with a digitizing profilometer that measures depth and width of the break as the hide is fed through the fixture;
recording depth and width data as measured by the digitizing profilometer; and
correlating the depth data with hide position data representing the local area scanned to develop a map of the break.
2. The method of claim 1 analyzing the map by measuring a size of spaces between the break and converting the size of the spaces to digital data.
3. The method of claim 2 wherein the step of converting the size of spaces between the break is performed by applying a Fourier transform of the depth data and location data.
4. The method of claim 1 wherein the depth data is analyzed to identify peaks and valleys in the local area, and wherein a distance between either the peaks or the valleys is used to grade breaks in the local area.
5. The method of claim 4 wherein the distance between the break is converted into wave form data and separated into distinct wave forms that are digitized to grade the local areas of the hide.
6. The method of claim 5 wherein the wave form data is correlated to location data to develop at least a partial map of the break of the hide.
7. The method of claim 1 wherein the step of fixturing the portion of the hide includes feeding the hide through the fixture.

8. A machine for measuring a hide for break comprising:
 - a shaping fixture for conforming a local area of the hide to form a grain surface of the hide into a concave shape and a flesh surface of the hide into a convex shape;
 - a digitizing profilometer measures a depth of a break as the hide is fed through the fixture and develops depth data; and
 - a controller that records break data and correlates the break data with position data representing the local area scanned to develop a map of the depth data of the break.
9. The machine of claim 8 wherein the controller analyzing a size of spaces between the break and converts the size of the spaces to digital data.
10. The machine of claim 9 wherein the controller converts the size of spaces by applying a Fourier transform of the depth data and location data.
11. The machine of claim 8 wherein the controller analyzes the depth data to identify peaks and valleys in the local area, and wherein a distance between either the peaks or the valleys is used to determine a distance between the break, wherein a grade is assigned based upon the distance between break in the local areas of the hide.
12. The machine of claim 11 wherein the controller analyzes the distance between break by converting the data into wave form data and separating the wave form data into distinct wave forms that are digitized to grade the local areas of the hide.
13. The machine of claim 12 wherein the controller analyzes the wave form data and correlates the wave form data to location data to develop a break map for the hide.
14. The machine of claim 8 wherein the digitizing profilometer is a laser surface profile scanner.
15. The machine of claim 8 wherein the digitizing profilometer is a capacitance sensor.

16. The machine of claim 8 wherein the digitizing profilometer is a fiber optic sensor.

17. The machine of claim 8 wherein the digitizing profilometer is an acoustic echo profiler.

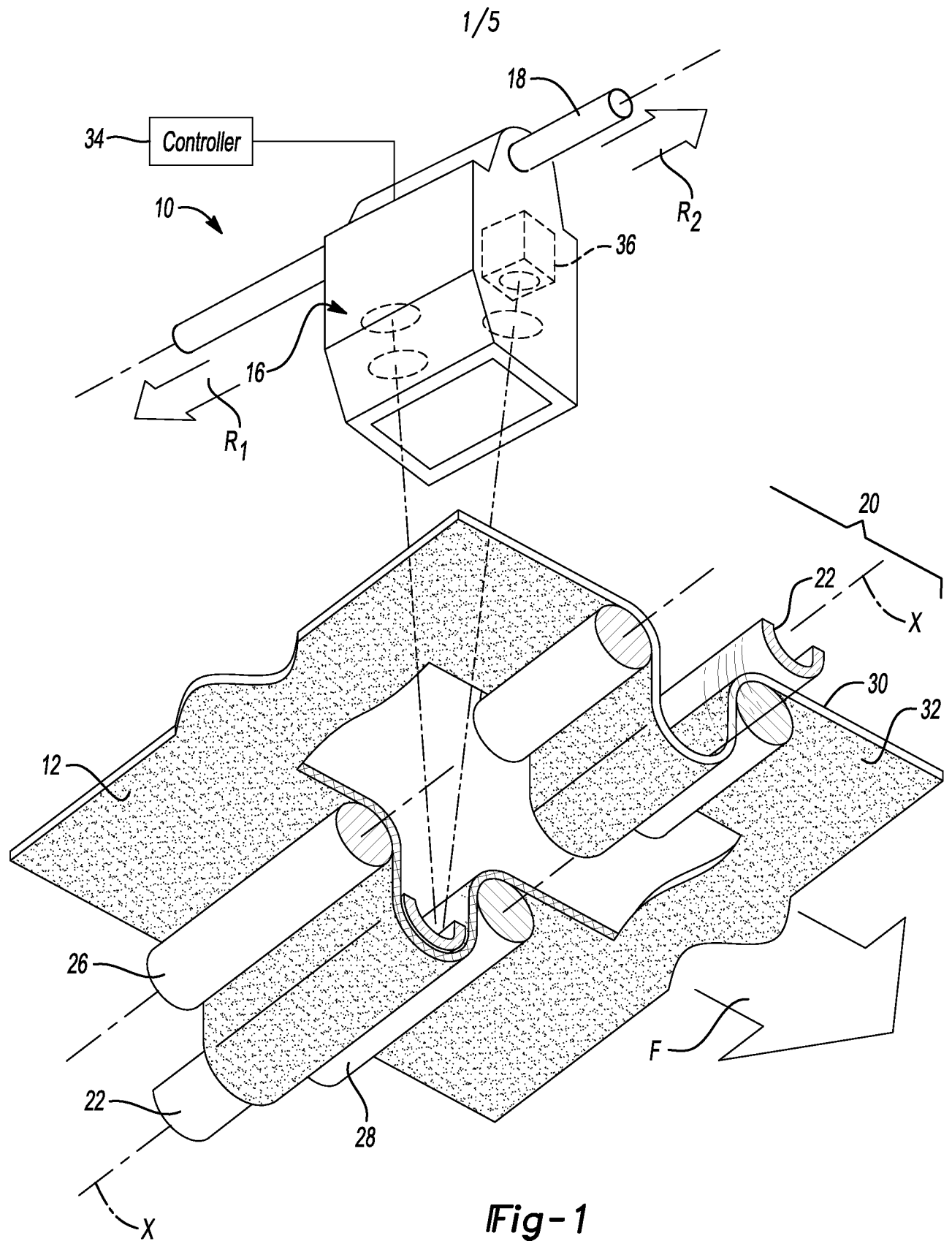
18. The machine of claim 8 further comprising:
a feed system, wherein the shaping fixture has a transparent semi-cylindrical guide and the feed system includes a set of feed rollers that feed the hide around the semi-cylindrical guide that forms the hide surface into the concave shape and a set of pinch rollers that pull the hide away from the semi-cylindrical guide, and wherein the digitizing profilometer scans the hide surface on the semi-cylindrical guide as the digitizing profilometer moves parallel to a cylindrical axis of the semi-cylindrical guide.

19. The machine of claim 8 further comprising:
a feed system, wherein the shaping fixture has a transparent roller guide and the feed system includes at least one feed roller that feeds the hide around the roller guide that forms the hide surface into the concave shape and at least one extractor roller that pulls the hide away from the roller guide, and wherein the digitizing profilometer scans the grain surface as the hide is fed around the roller guide and as the digitizing profilometer moves parallel to a cylindrical axis of the roller guide.

20. The machine of claim 8 further comprising:
a feed system, including a set of feed rollers and a set of pinch rollers that form the hide surface into the concave shape, and wherein the digitizing profilometer scans the hide surface as the digitizing profilometer moves parallel to an axis of the concave shape.

21. The machine of claim 8 further comprising:
a feed system, wherein the shaping fixture has a concave semi-cylindrical groove and the feed system includes a set of feed rollers that feed the hide into the semi-cylindrical groove and pinch rollers that pull the hide away from the semi-cylindrical groove, wherein the semi-cylindrical groove defines a plurality of vacuum ports that are operatively connected to a source of vacuum that

draws the hide surface into the concave shape, and wherein the digitizing profilometer scans the hide surface as the digitizing profilometer moves parallel to a cylindrical axis of the semi-cylindrical groove.



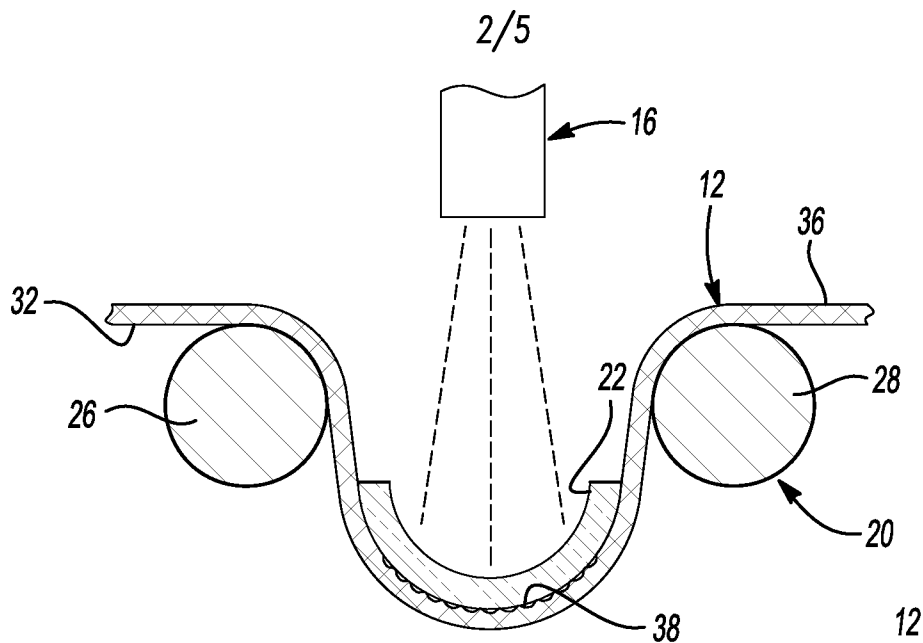


Fig-2

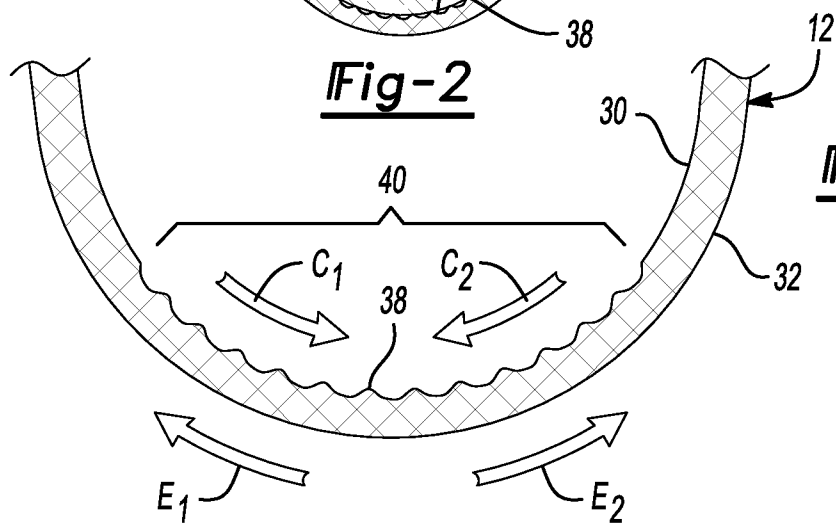


Fig-3

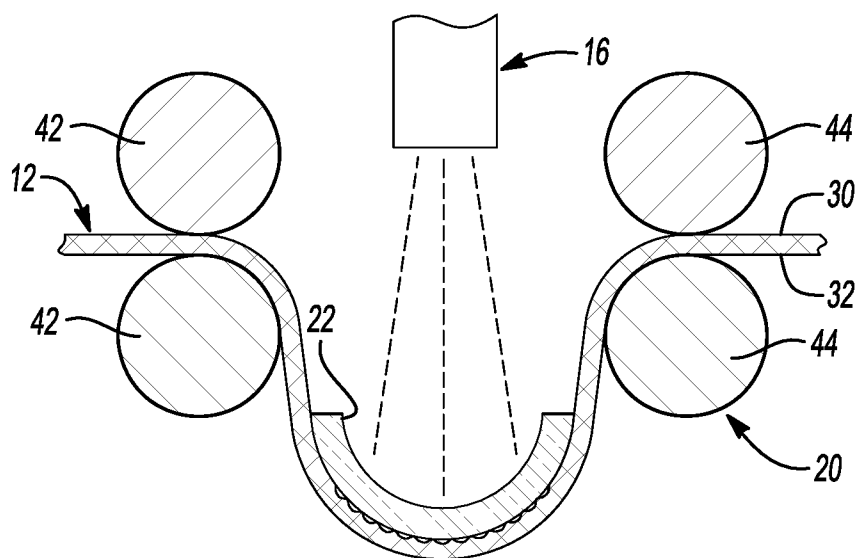


Fig-4

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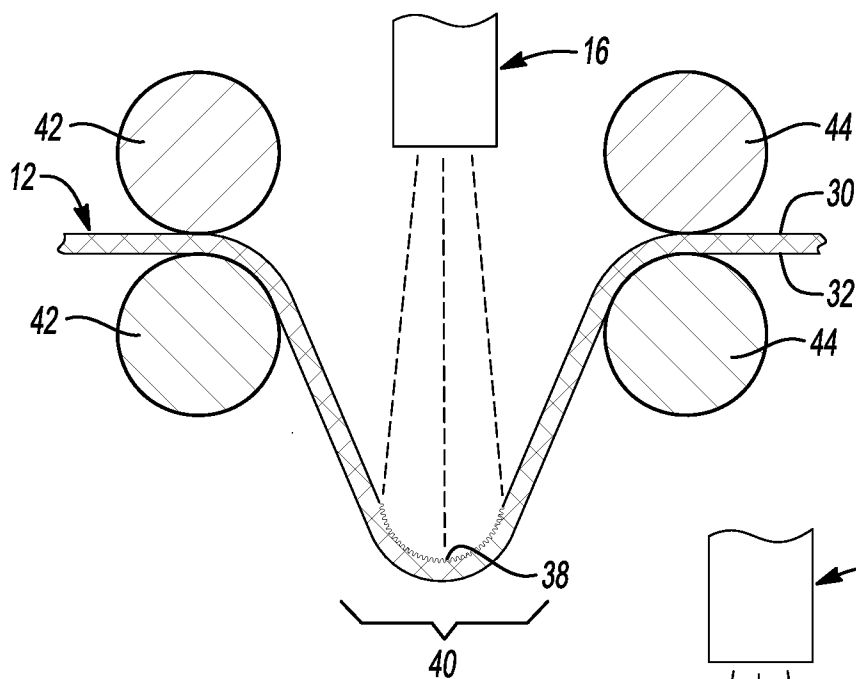


Fig-5

Fig-6

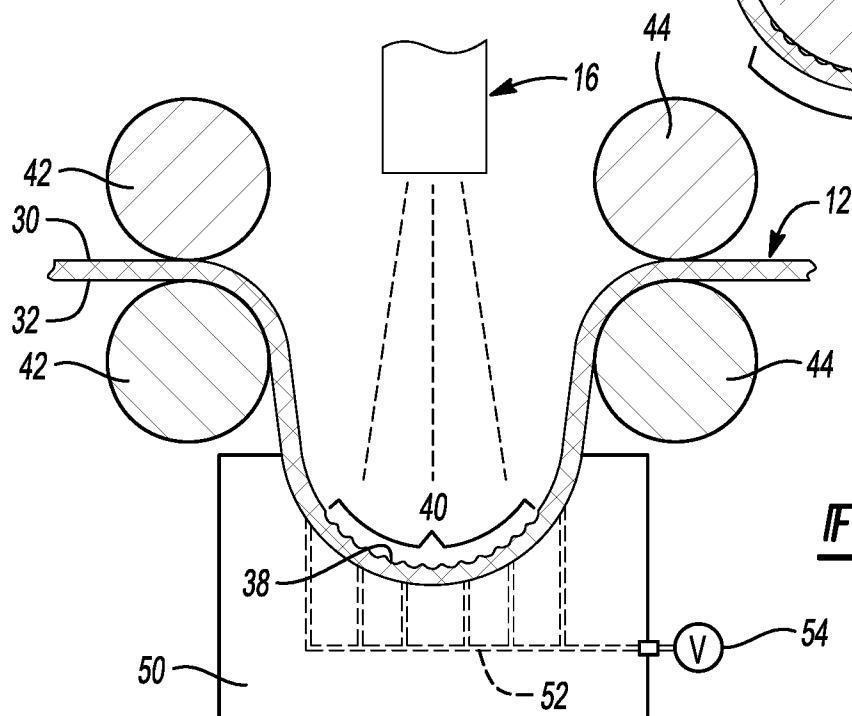
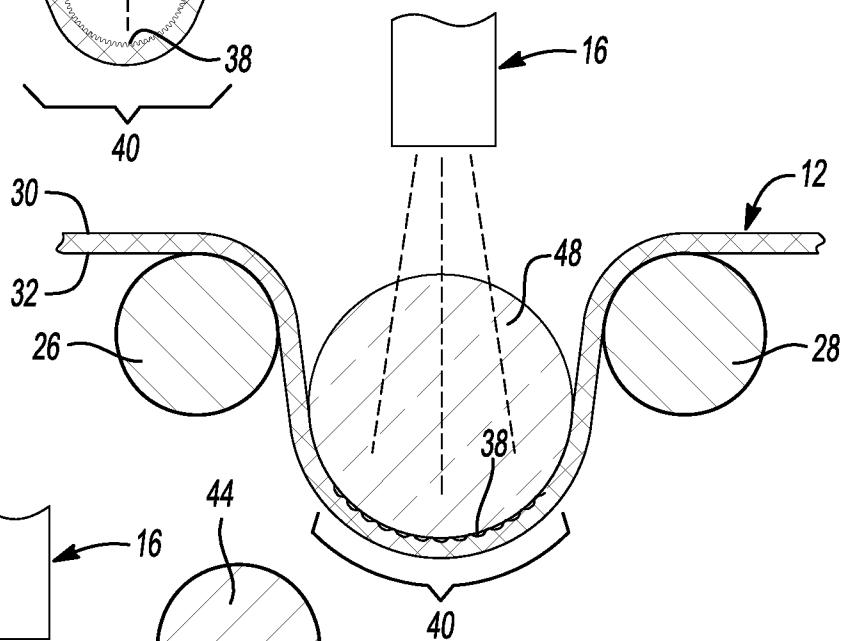


Fig-7

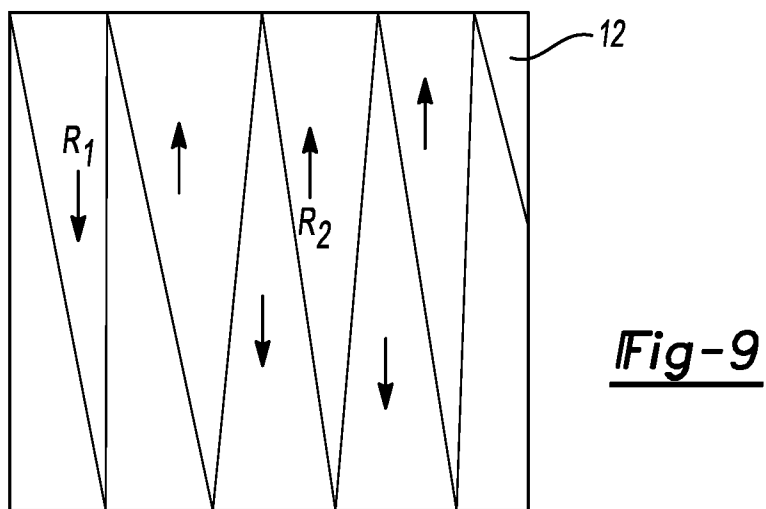
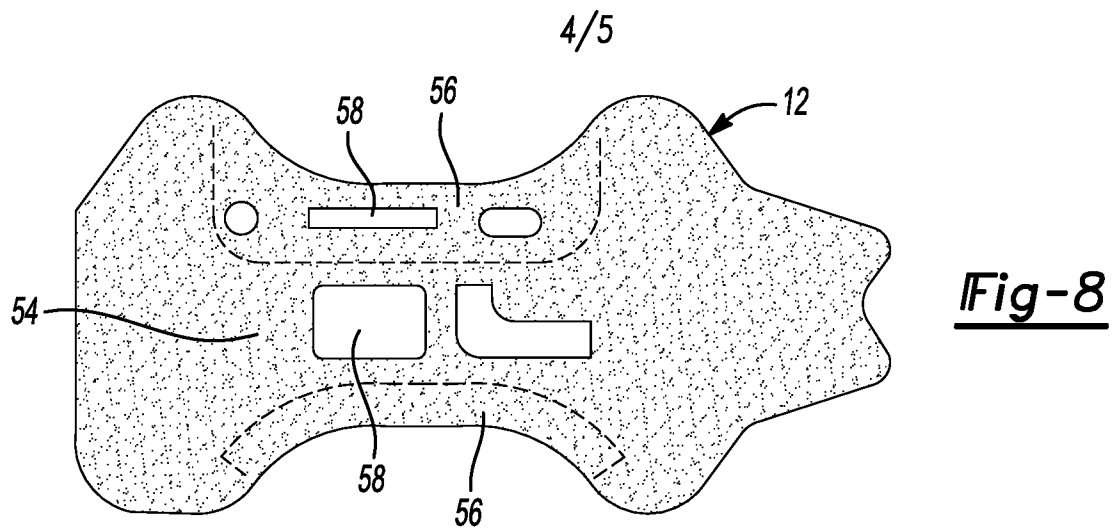
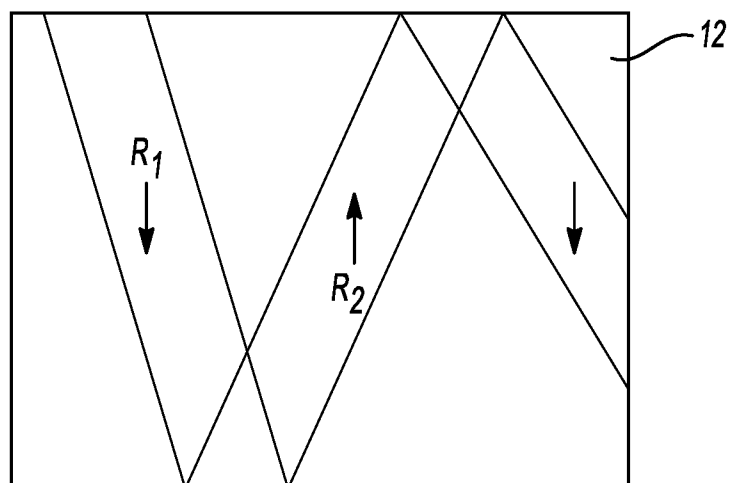


Fig-10



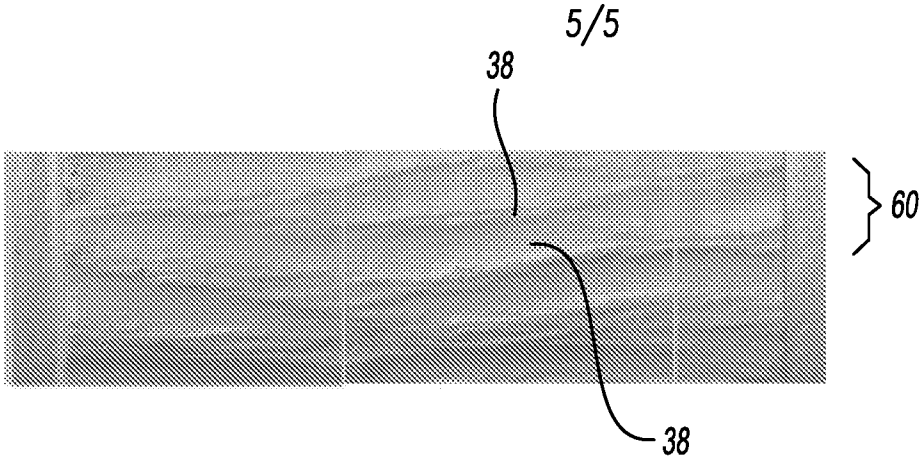


Fig-11

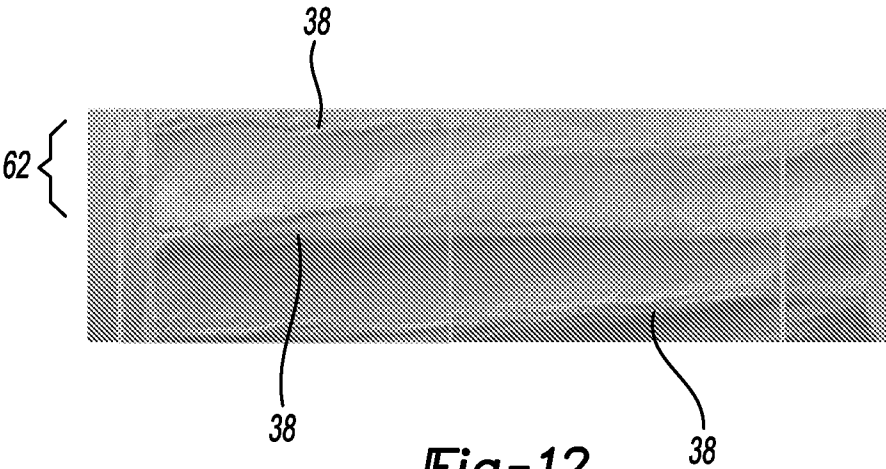


Fig-12

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US18/33837

A. CLASSIFICATION OF SUBJECT MATTER

IPC - G01N 21/88, 21/89, 21/95, 23/18, 33/44; C14B 1/30 (2018.01)

CPC - G01N 21/88, 21/8806, 21/8851, 21/89, 21/8915, 21/892, 21/95, 23/18, 33/44; C14B 1/30

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

See Search History document

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

See Search History document

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

See Search History document

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US 6,157,730 A (ROEVER, DE et al) 05 December 2000; figure 1A; column 2, lines 15-25; column 3, lines 1-5, 24-32, 54-65; column 4, lines 5-10; column 5, lines 23-55; column 6, lines 5-16, 33-47; column 13, lines 48-57	1-21
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☐ Further documents are listed in the continuation of Box C.

☐ See patent family annex.

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