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(54) **SPEAKER GRILLE**

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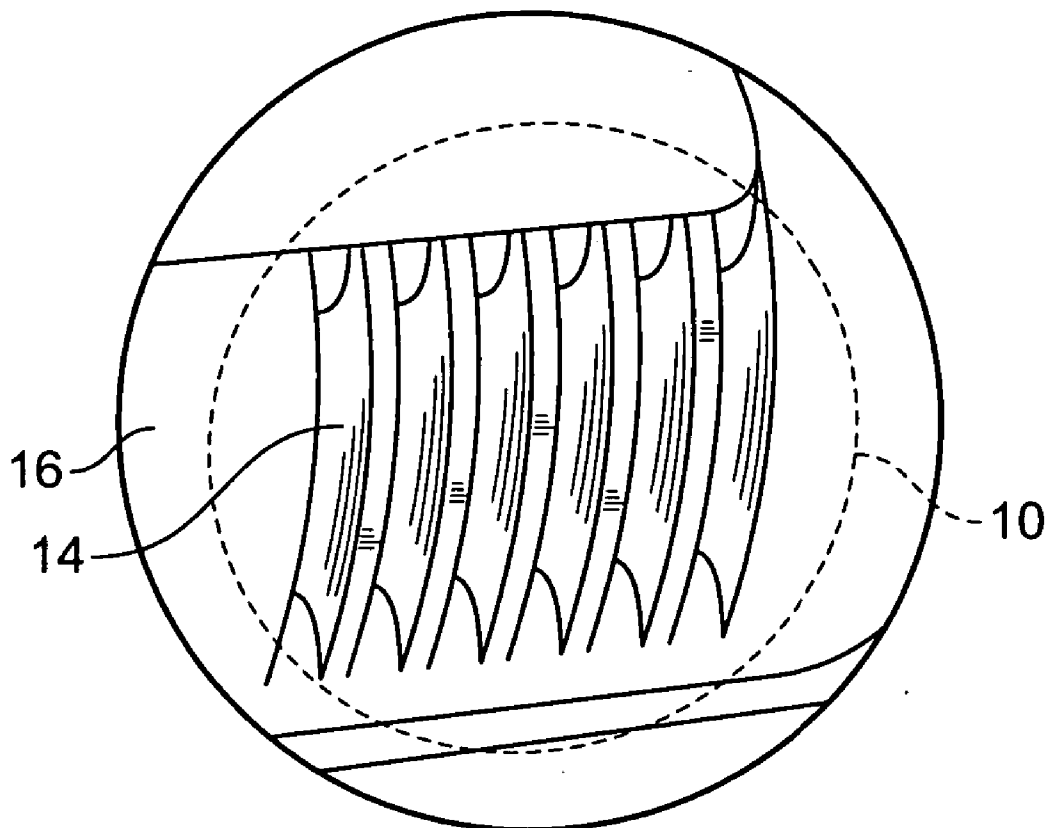
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(57) **ABSTRACT**

A substrate injection molded to a surface of metal, wood, a wood-based product, or leather to form a composite, such that the composite has an acoustical region and a non-acoustical region, and the surface extends continuously from the acoustical region to the non-acoustical region is described.

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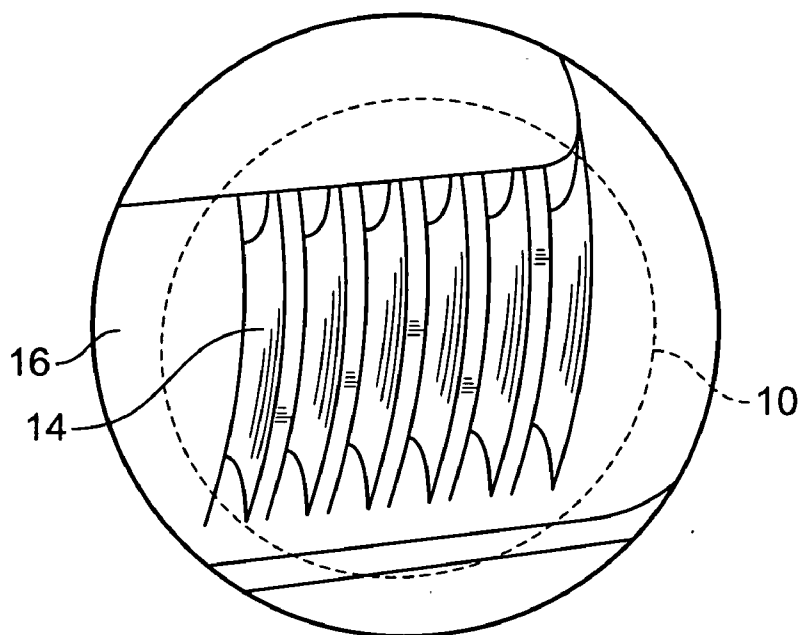


FIG. 1A

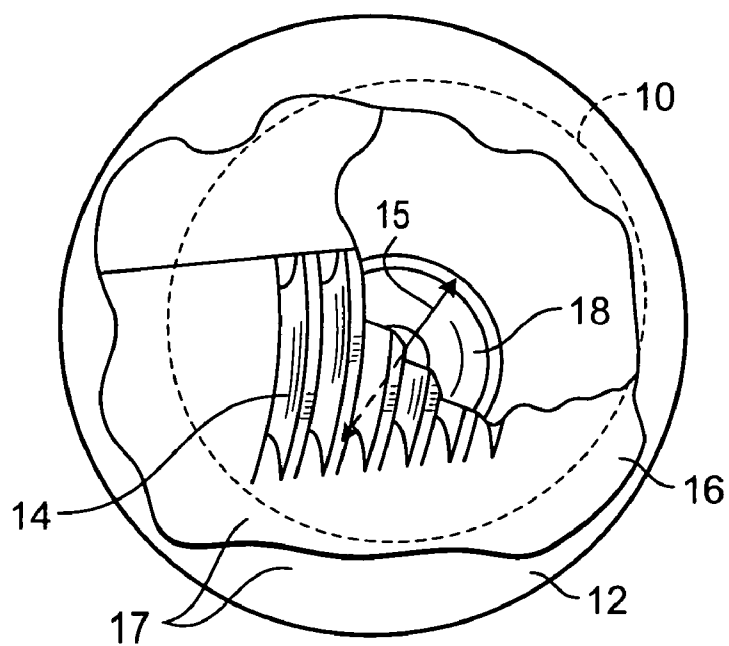


FIG. 1B

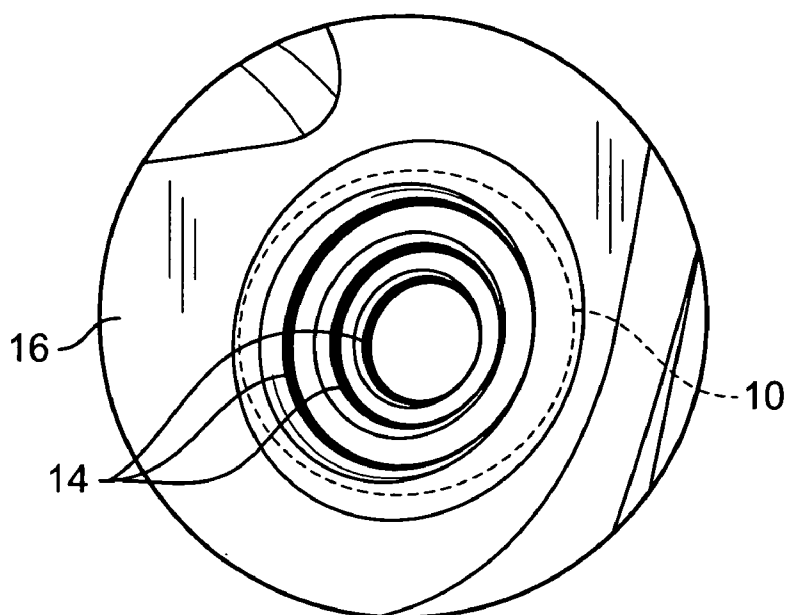


FIG. 1C

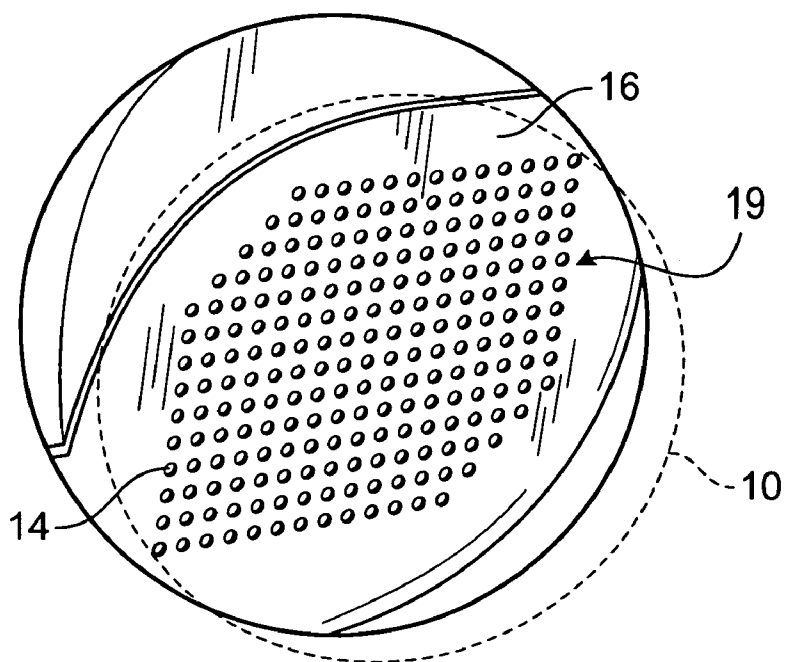
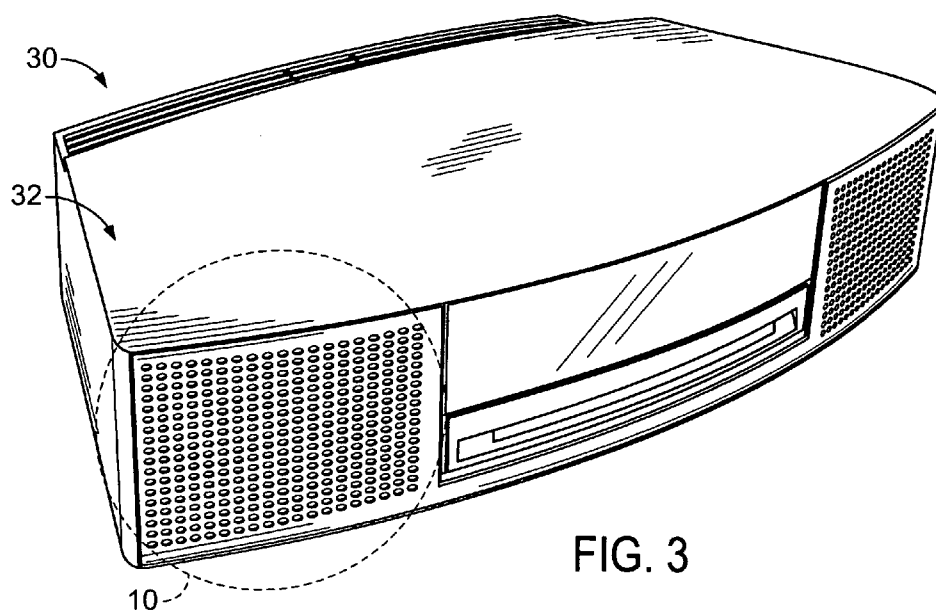
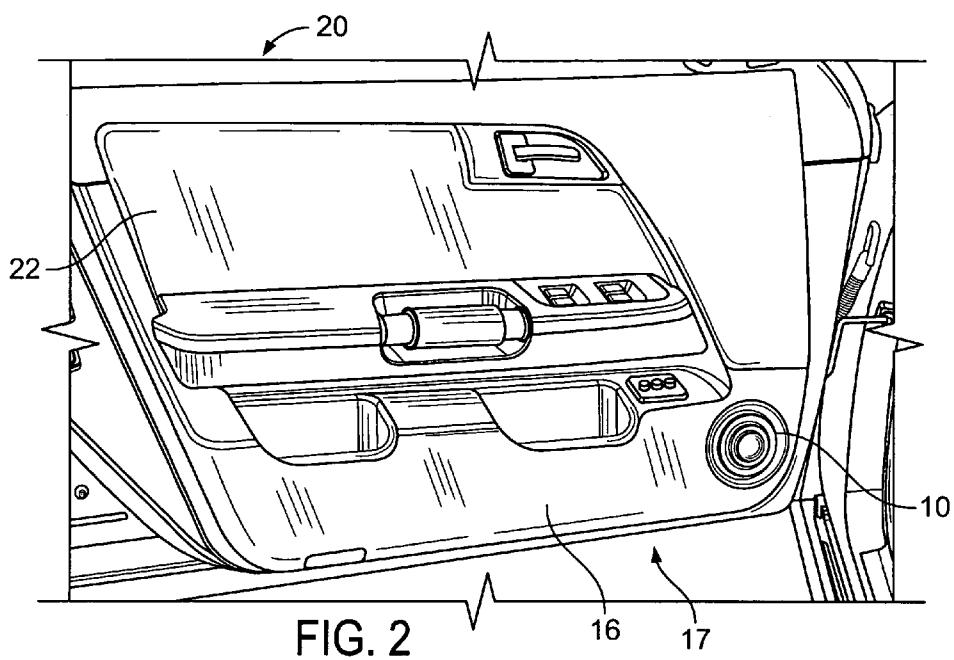


FIG. 1D



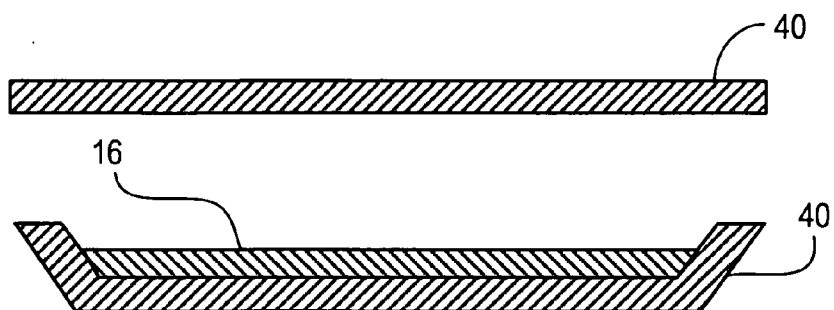


FIG. 4A

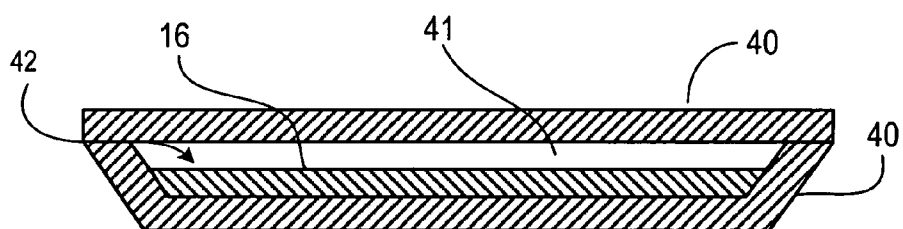


FIG. 4B

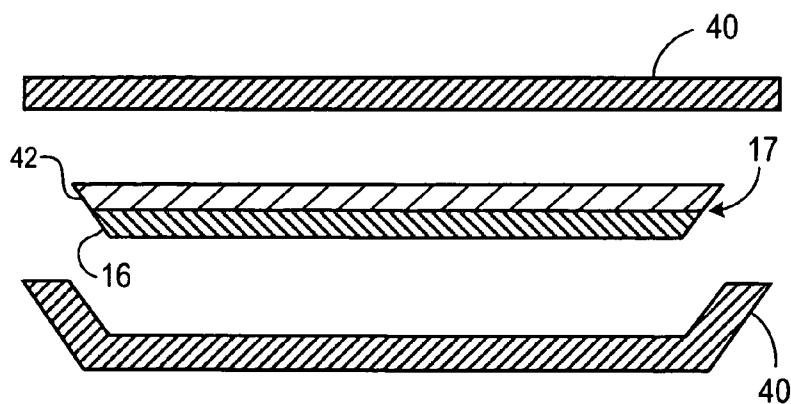


FIG. 4C

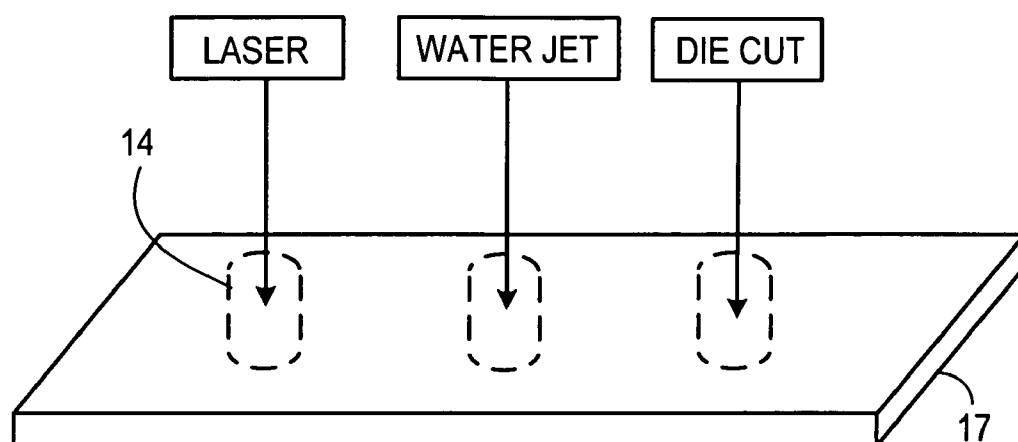
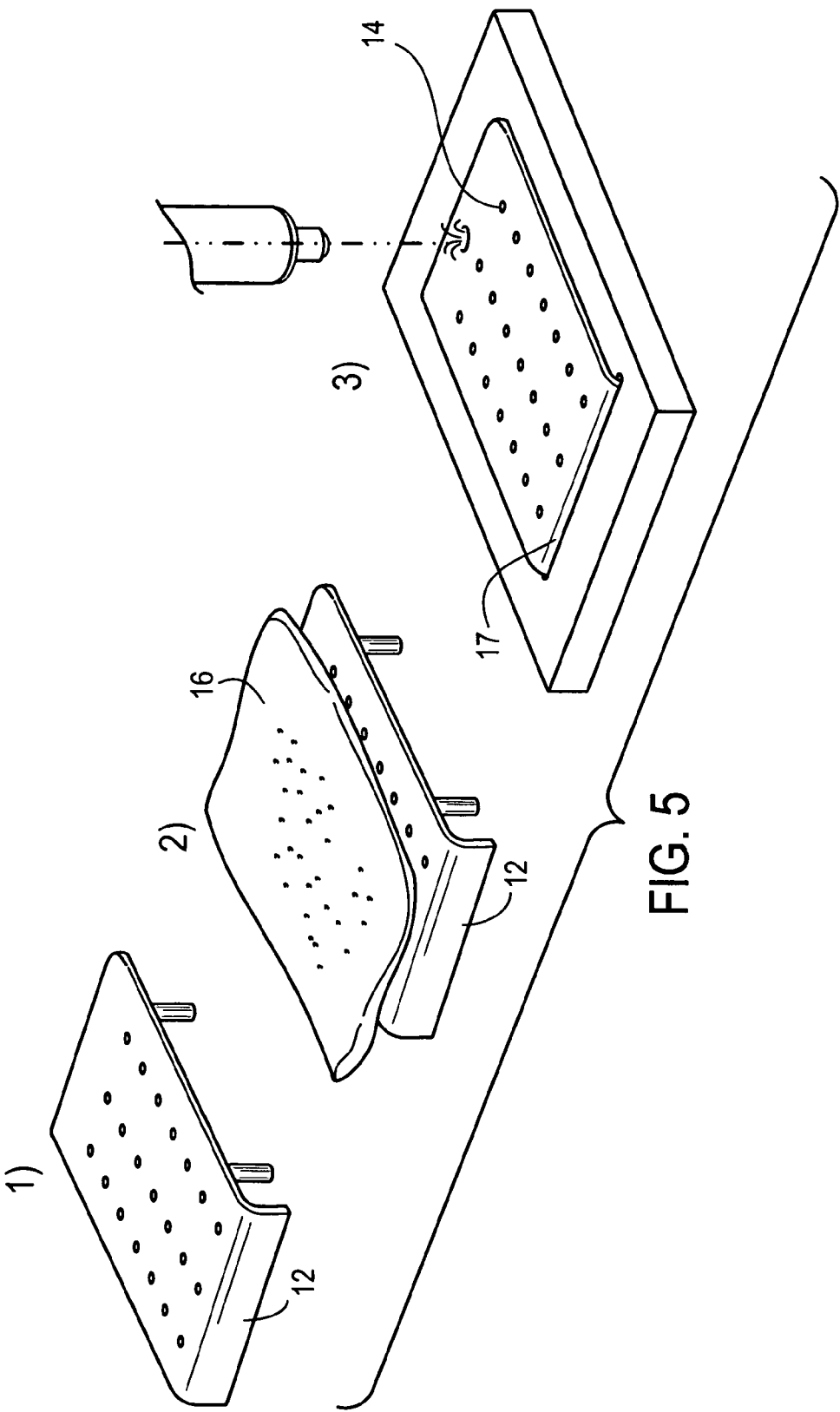


FIG. 4D



## SPEAKER GRILLE

### BACKGROUND

[0001] A loudspeaker can be protected from physical damage by partially obstructing it using a speaker grille. Speaker grilles are typically configured to obstruct only a relatively small amount of acoustic energy emitted by the loudspeaker. For example, speaker grilles often have holes to let the energy pass from the loudspeaker through the grille. Additionally, speaker grilles are often used to enhance the aesthetic appearance of the loudspeaker or the area around the loudspeaker.

### SUMMARY

[0002] In general, in one aspect, the apparatus and techniques disclosed here features a substrate injection molded to a surface of metal, wood, a wood-based product, or leather to form a composite, such that the composite has an acoustical region and a non-acoustical region, and the surface extends continuously from the acoustical region to the non-acoustical region.

[0003] Implementations may include one or more of the following features. The substrate is substantially coextensive with the surface. The surface is on a sheet of material. The non-acoustical region comprises more than half of an area of the surface. An audio device to which the composite is mounted. An automobile door to which the composite is mounted. The acoustical region bears holes. A loudspeaker in a vicinity of the acoustical region.

[0004] In general, in another aspect, the apparatus and techniques disclosed here features a loudspeaker, a screen in the vicinity of the loudspeaker, such that the screen has holes and includes a substrate injection molded onto a surface of metal, wood, a wood-based product, or leather.

[0005] Implementations may include one or more of the following features. The surface includes leather. The loudspeaker has a diameter and at least one dimension of at least one of the holes spans the diameter of the loudspeaker. The loudspeaker has a circumference and a radius of curvature, and at least one of the holes has a radius of curvature equal to the radius of curvature of the circumference. The holes are generally rectangular. The holes are arcuate. The holes are generally circular.

[0006] In general, in another aspect, the apparatus and techniques disclosed here features forming holes in the surface of an article having a substrate molded onto a surface of metal, wood, a wood-based product, or leather, after the substrate has been molded onto the surface.

[0007] Implementations may include one or more of the following features. Forming holes includes laser-cutting the surface. Forming holes includes applying water jets to the surface. Forming holes comprises punching the surface.

[0008] Other features, and advantages will be apparent from the description and the claims.

### DESCRIPTION

[0009] FIGS. 1A-D are perspective views of speaker grilles. FIG. 1B is a cutaway view.

[0010] FIG. 2 is a perspective view of an automobile door.

[0011] FIG. 3 is a perspective view of an audio console.

[0012] FIGS. 4A-D and FIG. 5 illustrate manufacturing steps.

[0013] Referring to FIGS. 1A and 1B, a grille 10 is formed from a sheet material 16 fixed to a molded substrate 12 having holes 14. The substrate 12 together with the sheet material 16 form a composite unit 17. In FIG. 1B, the grille 10 is shown positioned in the vicinity of (in this case, directly in front of) a loudspeaker 18. In this position, the grille 10 can act as a screen for the loudspeaker 18 (which we also call simply a "speaker").

[0014] The sheet material 16 can be leather; a leather-like product such as vinyl; wood; a wood-based product such as paper; veneer; or metal. The substrate 12 can be any moldable plastic such as ABS, nylon, polystyrene, polypropylene, or numerous other thermoplastic or thermoset moldable materials. The plastic is chosen so that the substrate 12 is rigid enough to support itself, the sheet material 16 and, optionally, the loudspeaker 18. The substrate 12 is also rigid enough to protect the loudspeaker 18 from ordinary physical damage. In some examples, the sheet material 16 extends across the entire surface of the substrate 12. In some examples, the sheet material 16 extends beyond the surface of the substrate 12. The portion of the sheet material 16 extending beyond the substrate 12 can be directly mounted or attached to another structure. In some examples, the sheet material 16 extends over only a proper subset of the surface of the substrate 12.

[0015] The holes 14 can be: generally rectangular as shown in FIGS. 1A and 1B; configured in a series of concentric circular arcs or other arcuate shapes as shown in FIG. 1C; or configured in an array 19 of small holes as shown in FIG. 1D. The holes 14 can individually have a wide variety of other shapes, or can be arranged in other patterns, according to aesthetic preferences or other considerations.

[0016] The holes 14 allow acoustic energy to pass from the speaker 18 through the grille 10, ultimately to the ears of a listener. Thus, the dimensions, shape, and patterns of the holes 14 are compatible with the speaker shape, size, location, and orientation of the speaker 18. For example, in the embodiment of FIG. 1A, the holes 14 are generally rectangular, and the length of a single hole is chosen to be substantially equal to or greater than a span 15 of the loudspeaker 18, the span 15 being a distance between opposing pairs of points on the boundary of the speaker 18. For a circular loudspeaker 18, the dimension of a single rectangular hole may be substantially equal to or greater than the diameter of the speaker 18. When the grille 10 has holes 14 arranged in a series of concentric circles as shown in FIG. 1C, the outermost circle may be chosen to have a diameter compatible with or greater than a span 15 of the loudspeaker 18. For a circular loudspeaker 18, the circumference of the outermost circular hole may be chosen to substantially overlap or extend beyond the circumference of the loudspeaker 18. When the grille 10 has holes 14 arranged in an array 19 of small holes as shown in FIG. 1D, the contours of the array 19 may be chosen to be substantially coincident with or extend beyond the contours of the loudspeaker 18 when the grille 10 is placed in the vicinity of the loudspeaker 18.

[0017] In determining a geometry for the arrangement of holes 14 in the grille 10, the percentage of open area of the

grille 10 affects the quality of the sound of the loudspeaker 18. A greater percentage of open area will allow more acoustic energy to pass from the loudspeaker 18 through the grille 10. For any particular one of the holes 14, a relatively large hole may allow more acoustic energy to pass through, but will afford the loudspeaker 18 relatively less protection from physical damage. Additionally, the user's aesthetic preferences may partially determine the dimensions of the holes 14.

[0018] Another consideration for the dimensions of the holes 14 are the limitations of the manufacturing process. In some embodiments, discussed in more detail below, the composite unit 17 is manufactured in part as described in U.S. patent application Ser. No. 10/767,011, filed Jan. 29, 2004, and entitled IMPROVED MOLDED PARTS WITH METAL OR WOOD SURFACE AREAS AND PROCESSES FOR THEIR PRODUCTION ('011 application), the entire contents of which are incorporated by reference here. The production methods disclosed in the '011 application have tolerance limitations that may make the methods unsuitable to form a substrate 12 with holes 14 of a particular dimensional limit. If holes 14 smaller than this limit are desired, they can be formed by secondary operations such as laser cutting, water jet cutting, or punching.

[0019] The range of possible compositions of the sheet material 16 allow the speaker 18 and grille 10 to be incorporated into or mounted on a wide variety of different structures such that the sheet material 16 matches the exterior surface of the structure. Incorporating or mounting the speaker grille 10 as such produces a relatively "seamless" appearance, which is aesthetically desirable to some people. Additionally, if the exterior surface of the structure has a decorative pattern, the sheet material 16 may be supplied with a matching decorative pattern.

[0020] For example, one such structure is an automobile door 20, shown in FIG. 2. Automobile doors commonly have a surface 22 composed of leather, vinyl, or wood. A composite unit 17 formed from sheet material 16 which matches the door surface material can be used as a component in the door to impart a uniform aesthetic appearance, in which material of a single type appears to flow continuously from the surface 22 to the speaker grille 10, without sacrificing the functionality of a speaker grille 10. Such an approach is an alternative to the commonly-employed approach of using a material distinct from the door's surface 22—such as a metallic mesh or grate—to form a speaker grille. The uniformity and continuity between the speaker grille 10 and the door surface 22 is aesthetically desirable to some people.

[0021] In the example shown in FIG. 3, a desktop audio console 30 may have an exterior surface 32 of leather, wood, or other common exterior surface. The exterior surface 32 may have a pattern (such as a cross-hatch, a decorative design, or other artistic features), which the sheet material 16 of the speaker grille 10 may be selected to match. Similarly, matching the appearance of the speaker grille 10 to outer surface 32 of the audio console is aesthetically desirable to some people.

[0022] The speaker grille 10 may be manufactured by first forming the composite unit 17 which contains the substrate 12 and the sheet material 16. If the speaker grille 10 is to be incorporated into a structure such as an automobile, the substrate 12 should be manufactured with a shape consistent

with the composite unit's eventual incorporation. This may include, for example, providing the composite unit 17 with mounting points which mate with corresponding points of the structure so as to hold the mounted composite unit 17 in place.

[0023] A composite unit 17 to be incorporated into an automobile door may be given the shape generally coincident with the outer periphery of the door. The composite unit 17 may be shaped so as to constitute substantially the entire inner surface of the door. Other shapes of the composite unit 17 are possible, with any proportion of the composite unit's surface area being attributable to the speaker grille 10. When the composite unit 17 will be incorporated into an automobile door, mounting points can be formed in the composite unit 17. The mounting points can allow the composite unit 17 to be mounted, for example, by a snap fit or a press fit, or with fasteners such as a threaded fastener, or by other conventional mounting techniques. There are sufficiently many mounting points to allow the composite unit to be adequately supported in the automobile door. For example, if the composite unit 17 is generally rectangular, a mounting point may be formed in the region of each corner of the composite unit 17.

[0024] Similarly, when the composite unit 17 will be incorporated into an audio console, mounting points as described above are formed in the composite unit 17. In this context, the composite unit 17 may be mostly attributable to the grille 10. The composite unit 17 could then be snap fit or press fit onto the audio console, for example in the vicinity of a loudspeaker of the audio console or around a rectangular section of the enclosure assembly of the audio console. In another example, the composite unit 17 is attributable to an entire face of the audio console, and composite unit 17 is provided with mounting points which allow it to mate with holes or bosses in the enclosure of the audio console. There are numerous other possible geometries and for the composite unit, and numerous other possible mounting scenarios.

[0025] Generally, the composite unit 17 is formed by an injection molding process. Among other ways, the composite unit 17 may be manufactured as described in the '011 application. Referring to FIGS. 4A-D, manufacturing the speaker grille 10 requires making a mold 40 for the substrate 12. The mold 40 is formed from two component parts which are moveable relative to each other. The mold has at least two states: an open state and a closed state. In the closed state (FIG. 4B), the two components of the mold are held against each other so that they define a cavity 41. They are held together with sufficient force so as to form an air-tight seal. In the open state (FIGS. 4A, 4C), the two components are disposed a relatively large distance from each other, allowing objects to be placed in or removed from either component of the mold 40. At least one of the component parts includes a region which at least partially corresponds to the speaker grille 10. If the speaker grille 10 is to be incorporated into another structure, the mold 40 also accounts for the shape of the structure.

[0026] Referring to FIG. 4A, with the mold 40 in the open state, sheet material 16, which optionally has been die cut to give it a particular shape, is placed within the mold 40. Optionally, an adhesive may be applied to the sheet material 16.

[0027] In FIG. 4B, the mold 40 is closed, and molten plastic 42 is injected into cavity 41 defined by the mold 40 under pressure. The pressure is sufficiently high so that bubbles do not form between the sheet material 16 and the plastic 42. The high pressure also facilitates the plastic 42 bonding to the sheet material 16. The seal between the two components of the mold 40 is sufficiently tight so as not to allow molten plastic 42 to escape.

[0028] In FIG. 4C, when the plastic 42 is cooled, the mold is opened, revealing a composite unit 17 composed of the plastic 42 fixed to the sheet material 16.

[0029] In FIG. 4D, the composite unit 17 is further processed in a secondary operation to cut away excess sheet material 16 lying over holes 14 in the grille 10 or elsewhere. In some embodiments, the precise locations of the holes 14 are known from computer-aided design ("CAD") software which was used to import hole-forming features in the mold 42. Thus, the secondary operations used to form holes in the sheet material 16 can be precisely controlled to match the holes 14 in the substrate 12. Any method of cutting appropriate to the sheet material can be used, e.g. laser cutting, water jets, punching, or the like. Additionally, if the substrate 12 is to bear holes smaller than the injection-molding process can create, these holes may be formed in this secondary operation. The processed composite unit 17 may then be mounted on a structure, e.g. an automobile door or an audio console.

[0030] In another embodiment, in FIG. 5, the substrate 12 can be formed first by injection molding techniques. Then, sheet material 16 can be adhered to the substrate, thereby forming a composite unit 17. Finally, portions of the sheet material 16 lying over holes 14 in the substrate 12 may be cut away using the methods described above.

[0031] Other embodiments are within the scope of the following claims.

What is claimed is:

1. An apparatus comprising
  - a substrate injection molded to a surface of metal, wood, a wood-based product, or leather to form a composite, the composite having an acoustical region and a non-acoustical region;
  - the surface extending continuously from the acoustical region to the non-acoustical region.
2. The apparatus of claim 1 in which the substrate is substantially coextensive with the surface.

3. The apparatus of claim 1 in which the surface is on a sheet of material.

4. The apparatus of claim 1, wherein the non-acoustical region comprises more than half of an area of the surface.

5. The apparatus of claim 1, further comprising an audio device to which the composite is mounted.

6. The apparatus of claim 1, further comprising an automobile door to which the composite is mounted.

7. The apparatus of claim 1 in which the acoustical region bears holes.

8. The apparatus of claim 1 further comprising a loudspeaker in a vicinity of the acoustical region.

9. An apparatus comprising

a loudspeaker;

a screen in the vicinity of the loudspeaker, the screen having holes and comprising a substrate injection molded onto a surface of metal, wood, a wood-based product, or leather.

10. The apparatus of claim 9, wherein the surface comprises leather.

11. The apparatus of claim 9, wherein the loudspeaker has a diameter and at least one dimension of at least one of the holes spans the diameter of the loudspeaker.

12. The apparatus of claim 9, wherein the loudspeaker has a circumference and a radius of curvature, and at least one of the holes has a radius of curvature equal to the radius of curvature of the circumference.

13. The apparatus of claim 9, wherein the holes are generally rectangular.

14. The apparatus of claim 10, wherein the holes are arcuate.

15. The apparatus of claim 9, wherein the holes are generally circular.

16. A method comprising

in an article having a substrate molded onto a surface of metal, wood, a wood-based product, or leather, forming holes in the surface after the substrate has been molded onto the surface.

17. The method of claim 16, wherein forming holes comprises laser-cutting the surface.

18. The method of claim 16 wherein forming holes comprises applying water jets to the surface.

19. The method of claim 16 wherein forming holes comprises punching the surface.

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