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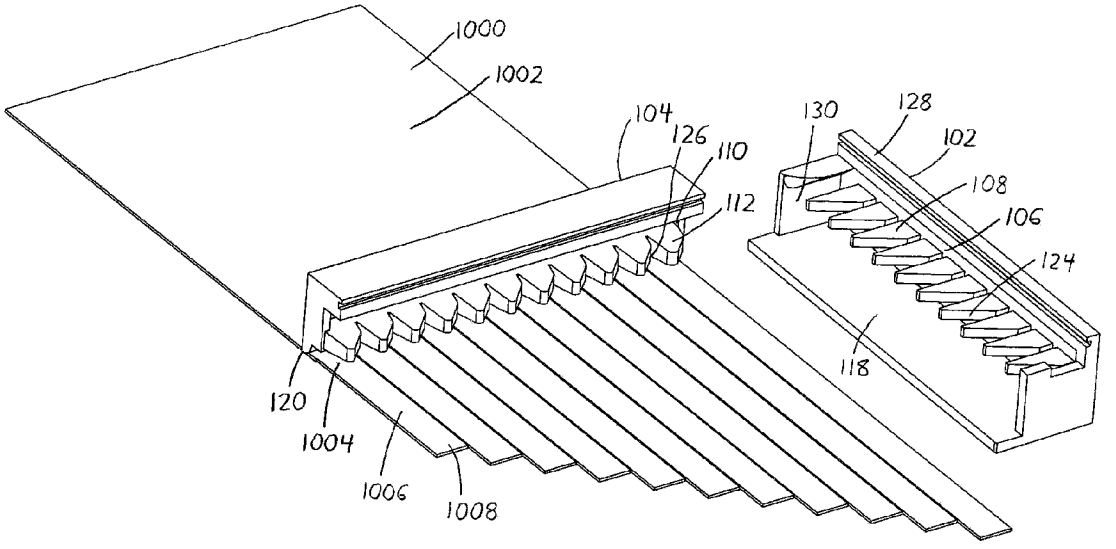
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(54) Title: ILLUMINATION VIA FLEXIBLE THIN FILMS



(57) Abrégé/Abstract:
A film sheet having a series of strips extending from an edge may have the film strips gathered and folded into a stacked array wherein the strips are in parallel abutment. The collected ends of the stacked strips are then suitable for receiving light for transmission into (and emission from) the body of the film sheet. A pair of frame members, when urged toward each other about the strips, may automatically collect and fold the strips into a parallel spaced array. This array may then be gathered by hand, or by a cover member translating adjacent the frame members, to generate the stacked array of parallel abutting strips. The resulting illumination device is particularly useful for illumination of display panels such as liquid crystal displays, organic light-emitting diode displays, or simply signs formed of paper, plastic, and / or other materials.

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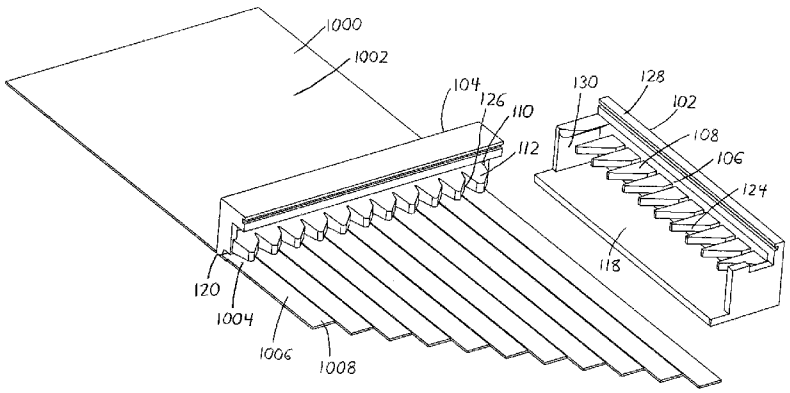
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FIG. 1



(57) Abstract: A film sheet having a series of strips extending from an edge may have the film strips gathered and folded into a stacked array wherein the strips are in parallel abutment. The collected ends of the stacked strips are then suitable for receiving light for transmission into (and emission from) the body of the film sheet. A pair of frame members, when urged toward each other about the strips, may automatically collect and fold the strips into a parallel spaced array. This array may then be gathered by hand, or by a cover member translating adjacent the frame members, to generate the stacked array of parallel abutting strips. The resulting illumination device is particularly useful for illumination of display panels such as liquid crystal displays, organic light-emitting diode displays, or simply signs formed of paper, plastic, and / or other materials.

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ILLUMINATION VIA FLEXIBLE THIN FILMS

Cross-Reference to Related Applications

This application claims priority to the following U.S. Provisional Patent Applications:

U.S. Provisional Patent Application 61 / 147,215 filed 26 January 2009

U.S. Provisional Patent Application 61 / 147,237 filed 26 January 2009.

Field of the Invention

This document concerns an invention relating generally to lightguides such as fiberoptic cable and edge-lit films, and more specifically to edge-lit film assemblies and devices and methods for their rapid assembly.

Background of the Invention

As discussed in International (PCT) Publication No. WO 2009 / 048863, a light guide made of a flexible transparent film sheet can be formed wherein an edge of the sheet is cut or otherwise formed into parallel strips, with the strips then being folded / bent into a stacked array (generally shaped like an elongated beam) through which light can be directed to or from the major area of the sheet (i.e., the portion from which the strips extend). Similar arrangements are seen in U.S. Patent 4,151,582 to *Grunberger* and U.S. Patent 4,824,194 to *Karasawa*. So long as the bends of the strips are not too great (which can disrupt the internal reflection that promotes light transmission within the strips), and / or so long as the bent regions are coated to deter light loss at the bends, illumination of the end of the beam-like stack of strips (as with one or more LEDs) transmits light through the strips and into the major area of the sheet. The major area of the sheet can be treated to emit the light from all or a portion of the major area. Such an arrangement is useful for applications such as general illumination, illuminated signage, and backlighting and/or frontlighting of Liquid Crystal Displays (LCDs) or other

displays. Conversely, light may be collected in the major area of the sheet and transmitted therein to the beam-like stack for reception by a photovoltaic or other device, which can be useful for applications such as light sensors and solar collectors. Thus, a point or concentrated light source (at the stacked strips) can be used to illuminate a large area (the major area of the sheet), or conversely light incident over a large area (at the major area of the sheet) can be concentrated into a small area (at the stacked strips). Such film light guides have significant advantages over light guides formed of rigid transparent plates or the like owing to their lower cost, size, and weight, and their increased flexibility.

Despite the foregoing advantages, illuminators of the foregoing types are rarely used, largely owing to difficulties with their manufacture. Accurate formation of the strips in the film sheet is accomplished easily enough, as by running an array of blades along a film sheet to an edge. However, it is then difficult and time consuming to properly bend and align the strips into a stacked array suitable for receiving light from a light source. If the bending is done by hand, it is time- and labor-intensive, and if done by machine, it is capital-intensive insofar as it is expensive and difficult to build folding machines which precisely bend the fingers without damage (particularly if the machine is to accommodate sheets of different sizes with different strip configurations). It would therefore be useful to have more efficient and economical devices and methods for constructing film illumination devices such as those described in the foregoing patents.

Summary of the Invention

The invention involves a film illumination device which is intended to at least partially solve the aforementioned problems, and which may be assembled rapidly, easily, and inexpensively. To give the reader a basic understanding of some of the advantageous features of the invention, following is a brief summary of preferred versions of the film illumination device, with reference being made to the accompanying drawings (which are briefly reviewed in the following "Brief Description of the Drawings" section of this document) to assist the reader's understanding. Since the following discussion is merely a summary, it should be understood that more details regarding the preferred versions

may be found in the Detailed Description set forth elsewhere in this document. The claims set forth at the end of this document then define the various versions of the invention in which exclusive rights are secured.

In some embodiments, there is provided a film illumination device comprising: a. a light transmitting film comprising an array of strips extended from a major sheet area of the light transmitting film wherein each strip of the array of strips comprises a bend and is stacked to form a stack of strips; b. at least one light source positioned to emit light into the stack of strips, the light propagating by total internal reflection through the array of strips and into the major sheet area; c. a light extracting region defined within the major sheet area positioned to receive and extract light propagating by total internal reflection from the array of strips; and d. at least one frame member comprising an inner face with a protruding array of teeth with faces angled obliquely in relation to the inner face, wherein the bend in each strip of the stack of strips is formed by bending each strip of the array of strips about a protruding tooth of the protruding array of teeth such that the protruding array of teeth restrain the light transmitting film relative to the at least one frame member and each protruding tooth of the protruding array of teeth restrains a strip of the array of strips relative to the at least one frame member.

In some embodiments, there is provided a light emitting device comprising: a. a light transmitting film comprising an array of strips extended from a major sheet area of the light transmitting film wherein each strip of the array of strips comprises a bend and each strip of the array of strips is stacked to form a stack of strips; b. at least one light source positioned to emit light into the stack of strips, the light propagating by total internal reflection through the array of strips and into the major sheet area; c. a light emitting region defined within the major sheet area configured to extract the light from the at least one light source; and d. at least one frame member containing the bend of each strip of the array of strips and comprising an inner face with a protruding array of teeth with faces angled obliquely in relation to the inner face, wherein the bend in each strip of the array of strips is formed by bending each strip of the array of strips about a protruding tooth of the protruding array of teeth such that each strip of the array of strips is restrained relative to the at least one frame member by the protruding array of teeth.

In some embodiments, there is provided a film illumination device including: a. a film sheet having: (1) a substantially planar major sheet area; and (2) an adjacent minor sheet area with film strips extending therefrom, the film strips are elongated, adjacent, and situated at the adjacent minor sheet area: i. in a substantially common plane; and ii. at least substantially parallel to each other in a first direction; b. a frame including a frame member having an inner face with a protruding array of teeth with faces angled obliquely in relation to the inner face, wherein a bend in each film strip of the film strips is formed by bending each film strip of the film strips about a protruding tooth of the protruding array of teeth such that each film strip of the film strips is restrained relative to the frame member by a protruding tooth of the protruding array of teeth, and each film strip of the film strips is stacked to form a stack of strips; and c. a light source positioned to emit light into the stack of strips.

In some embodiments, there is provided a film illumination device comprising: a. a light transmitting film comprising an array of strips extended from a major sheet area of the light transmitting film wherein each strip of the array of strips comprises a bend and is stacked to form a stack of strips; b. at least one light source positioned to emit light into the stack of strips, the light propagating by total internal reflection through the array of strips and into the major sheet area; c. a light extracting region defined within the major sheet area positioned to receive and extract light propagating by total internal reflection from the array of strips; d. at least one frame member comprising a first inner face and a second inner face, the bend of each strip of the array of strips is positioned between the first inner face and the second inner face of the at least one frame member; and e. a first gap defined in the at least one frame member through which a first region of the light transmitting film between the light extracting region and the array of strips extends such that the first region and the array of strips are restrained relative to the at least one frame member at the first gap.

In some embodiments, there is provided a light emitting device comprising: a. a light transmitting film comprising an array of strips extended from a major sheet area of the light transmitting film wherein each strip of the array of strips comprises a bend and each strip of the array of strips is stacked to form a stack of strips; b. at least one light source positioned to emit light into the stack of strips, the light propagating by total internal reflection through the array of strips and into the major sheet area; c. a light emitting region defined within the major sheet area configured to extract the light from the at least one light source; and d. at least one frame member containing the bend of each strip of the array of strips and comprising a gap through which a first region of the light transmitting film between the light emitting region and the array of strips extends such that the array of strips are restrained relative to the at least one frame member at the gap.

Further advantages, features, and objects of the invention will be apparent from the remainder of this document in conjunction with the associated drawings.

Brief Description of the Drawings

FIG. 1 is a perspective view of an exemplary first frame member **102**, an exemplary second frame member **104**, and an exemplary film sheet **1000** having film strips **1006** extending from a major sheet area **1002**, with these components being assembled as shown in **FIGS. 2-4** to generate an exemplary illumination device as in **FIGS. 6-7**.

FIG. 2 is a perspective view of the first frame member **102**, second frame member **104**, and film sheet **1000** of **FIG. 1**, wherein the frame members **102** and **104** are being urged toward each other about the film strips **1006** to begin bending the film strips **1006** into parallel relation.

FIG. 3 is a perspective view continuing from **FIG. 2**, wherein the frame members **102** and **104** are further urged toward each other to further bend the film strips **1006** into parallel relation.

FIG. 4 is a perspective view continuing from **FIG. 3**, wherein a cover member **114** is beginning advancement alongside the frame members **102** and **104** to bend the parallel film strips **1006** into abutting stacked relationship.

FIG. 5 is a top view of the frame members **102** and **104** as they are moved together into abutment, showing the relative locations of their first member teeth **108** and second member teeth **112**.

FIG. 6 is a perspective view continuing from **FIG. 4**, showing an illumination device resulting after the cover member **114** has completed bending the film strips **1006** into abutting stacked relationship to generate a strip stack **1010**.

FIG. 7 is a perspective view showing the illumination device of **FIG. 6** with the film sheet **1000** bent to situate the frame **100** and strip stack **1010** behind the major area **1002**of the film sheet **1000**, and with the major area **1002**of the film sheet **1000** illuminating a display panel **3000**.

FIG. 8 is a perspective view of an exemplary first frame member **202**, an exemplary second frame member **204**, and an exemplary film sheet **2000** having a major sheet area **2002** and an adjacent minor sheet area **2004** from which film strips **2006** extend, with these components being assembled as shown in **FIG. 9** to generate an exemplary illumination device as in **FIG. 10**.

FIG. 9 is a perspective view of the first frame member **202**, second frame member **204**, and film sheet **2000** of **FIG. 8**, wherein the frame members **202** and **204** are urged toward each other to bend the film strips **2006** into two arrays of parallel strips.

FIG. 10 is a perspective view continuing from **FIG. 9**, showing an illumination device resulting after cover members **214** have bent the film strips **2006** into abutting stacked relationship to generate a strip stack **2010**.

Detailed Description of Preferred Versions of the Invention

Looking initially to **FIG. 1**, exemplary first and second frame members **102** and **104** are shown along with an exemplary film sheet **1000** to be illuminated. The film sheet **1000** has a major sheet area **1002** (shown oriented along a plane), and an adjacent minor sheet area **1004** from which an array of elongated adjacent film strips **1006** extend (also shown oriented along a plane), with the film strips **1006** extending along a (first) direction at least substantially parallel to each other to terminate in strip ends **1008**. The first frame member **102** includes a first member inner face **106** with a protruding array of first member teeth **108**, and the second frame member **104** having a second member inner face **110** which also preferably bears a protruding array of second member teeth **112**. The first member teeth **108** are arrayed such that when the first and second frame members **102** and **104** are moved closely adjacent each other (a process shown in **FIGS. 2-4**) to form a frame **100** (with the completed frame **100** being shown in **FIGS. 6-7**), with the array of film strips **1006** situated between the first and second member inner faces **106** and **110** (and more particularly between the first member teeth **108** and the second member teeth **112**, if any), each film strip **1006** is each urged by a first member tooth **108** and by the second frame member **104** (more particularly, by a second member tooth **112**, if any) into a second direction different from the first direction, with the urged film strips **1006** being adjacently situated in at least substantially parallel planes (as best seen in **FIG. 6**). Thus, by simply sandwiching the strips **1006** between the frame members **102** and **104**, the strips **1006** are aligned (see **FIGS. 3-4**) such that they can thereafter be urged in a direction aligned generally parallel to the first member inner face **106** to stack the strips **1006** (or at least the strip ends **1008**) in abutting relationship. This step is shown in **FIGS. 4** and **6**, wherein the strips **1006** are urged by a cover member **114** (to be discussed in greater detail below) into a direction oriented at least substantially perpendicular to the first direction. The strips **1006** then have their strip ends **1008** aligned to define an at least substantially continuous surface at the end of the strip stack **1010**, or the strip ends **1008** can be cut (and possibly polished) to generate an at least substantially continuous surface at the end of the strip stack **1010**, which can then be illuminated to transmit light into the major sheet area **1002** (or conversely light collected along the major sheet area **1002** can be transmitted along the strips **1006** to the collected strip ends **1008**).

The first and second frame members **102** and **104** are preferably designed to complementarily interfit with each other when moved into abutment about the film strips **1006** with the first and second member inner faces **106** and **110** facing each other (as best seen in **FIGS. 4** and **6**). The first and second frame members **102** and **104** may then be joined together by use of adhesives or the like, or they might be mechanically joined by inserting a fastener through aligned fastener apertures defined in the first and second frame members **102** and **104**, and / or by providing complementary mating structures on the first and second frame members **102** and **104** (e.g., a barbed prong on the first frame member **102** which engages an aperture in the second frame member **104**). When the frame members **102** and **104** are moved into abutment about the film strips **1006**, they are also preferably configured to have an open top slot **116** defined therebetween (see **FIG. 4**), wherein the redirected strips **1006** extend through this top slot **116**). A cover member **114** can then usefully be provided to slidably fit between the first and second frame members **102** and **104** along the top slot **116**, such that sliding the cover member **114** between the first and second frame members **102** and **104** at least partially closes the top slot **116**, and at the same time urges the film strips **1006** into an abutting parallel stacked relationship below the cover member **114** (as seen in **FIGS. 4** and **6**).

Similarly, the frame members **102** and **104** can bear structure which at least partially closes about the bottom of the interfit frame members **102** and **104**, where the film strips **1006** enter the space therebetween. As best seen in **FIG. 1**, the first frame member **102** includes a first member floor **118** extending outwardly from the first member inner face **106**. The second frame member **104** has a second member lower edge **120** below the array of second member teeth **112**, with the second member lower edge **120** being situated above the first member floor **118** when the frame members **102** and **104** are interfit so as to define a gap **122** (see **FIG. 6**) into which the film strips **1006** may

extend. The second member lower edge **120** is curved, having decreasing thickness as it extends downwardly, whereby film strips **1006** bearing against this lower edge **120** more easily bend about it as they extend upwardly between the inner faces **106** and **110** of the frame members **102** and **104**, and thus between the first member teeth **108** and the second member teeth **112** (if any).

Referring to **FIG. 1**, each of the first member teeth **108** bear a first member tooth face **124** which is aligned obliquely in relation to the first member inner face **106**. Similarly, each of the second member teeth **112** bear a second member tooth face **126** aligned obliquely in relation to the second member inner face **110**. As then shown in **FIG. 5**, which shows the teeth **108** and **112** of the frame members **102** and **104** when the frame members **102** and **104** are situated as in **FIG. 6**, when the first and second frame members **102** and **104** positioned closely adjacent each other with the first and second member inner faces **106** and **110** facing each other in parallel relation, the first member tooth faces **124** and second member tooth faces **126** are aligned at least substantially parallel to each other (with the tooth faces **124** and **126** here being angled at approximately 15 degrees to each other, though other angles can be acceptable). Additionally, the array of first member teeth **108** is vertically spaced from the array of second member teeth **112**, with the array of first member teeth **108** and the array of second member teeth **112** being situated at different heights above the second member floor (preferably with the array of second member teeth **112** being situated between the second member floor and the array of first member teeth **108**). These arrangements cause the second member teeth **112** to promote the bending / redirection of the film strips **1006** caused by the first member teeth **108**.

FIG. 7 then schematically illustrates a display panel **3000** – e.g., a liquid crystal display, organic light-emitting diode display, or simply a sign formed of paper, plastic, and / or other materials – situated in such a manner that it might be backlit by the major sheet area **1002** of the film sheet **1000**. The frame members **102** and **104** and film sheet **1000** are shown in a particularly preferred arrangement wherein the film sheet **1000** is bent approximately 180 degrees, with the frame members **102** and **104** and film strips

1006 being situated alongside and spaced from the plane of the major sheet area **1002**. An arrangement of this nature is particularly useful because it effectively allows generation of an "edgeless" display: the display **3000**, and the illuminating major sheet area **1002**, need not be bounded by a light source or other matter which defines a frame about the area of the display and sheet (save for perhaps at the bent side of the major sheet, which is also the side at which any leads to the display would likely extend). This in turn allows a variety of space-saving and aesthetically attractive arrangements for matter such as televisions, computer screens, displays of portable devices such as mobile telephones and personal digital assistants, signage, and the like.

It is also possible that once an illumination device such as that in **FIG. 6** is formed, the strips **1006** could be edge-adhered or otherwise held in a bundle, and the frame members **102** and **104** may then be removed. The invention therefore extends to "frameless" illumination devices which include a film sheet **1000** exemplified by that of **FIG. 6**, and formed by processes similar to those depicted in **FIGS. 1-6**, but wherein the frame members **102** and **104** are absent. In these situations, the frame members **102** and **104** essentially provide a temporary fixture used during assembly of the illumination device, but which are removed from the final illumination device.

In similar respects, the invention also extends to illumination devices consisting of frame members **102** and **104** alone, prior to addition of the film sheet **1000** and completed assembly of the devices.

Expanding on the Summary above, film sheets used in the invention are preferably clear, low-light-absorption films which exhibit minimal light-scattering. Polycarbonate film of 0.05 mm to 1 mm thickness is an inexpensive and commonly available film which is suitable for use in the invention, but any film (e.g., polystyrene, polyester, acrylic or others) might be usable as well depending on the application to which the invention is to be applied. To deter light loss (promote internal reflection / transmission), the film can be coated / cladded with material having a lower refractive index than the film, preferably as low of a refractive index as economically possible while still yielding good adhesion between the coating and the film. Any applied coating is preferably as thin as possible to conserve size and costs, and to maximize light intake at the strip stack (shown at **1010** in **FIGS. 6-7**), if the strip ends **1008** are coated in addition to the remainder of the film sheet **1000**. In this respect, a polycarbonate film with 0.5 mm thickness and a TC106 coating (Sun Process Corporation, Mt. Prospect, IL, USA) of 0.01 mm thickness works well for most applications, with only 2% of the cross-section of the strip stack being occupied by the clad.

Strips **1006** (e.g., **FIG. 1**) can be cut in a film sheet **1000** in any suitable manner. An exemplary manufacturing process involves feeding film from a roll through tension rollers; using a knurl roll to imprint a light extraction pattern; applying an array of blades that raise and lower into the film to cut the strips; and a cutoff mechanism which cuts the film and its strips to a desired final length to generate a film sheet as exemplified at **1000** in **FIG. 1**. Heating stations can assist in softening the film to apply the light extraction pattern and to cut the film. Cutting is preferably performed using blades which are sufficiently sharp and smooth that they result in optically smooth cut edges (i.e.,

edges with minimal irregularities from which light loss might occur). Blade coatings, e.g., ceramic or fluoropolymer coatings, can enhance blade smoothness.

Once the strips are aligned in a strip stack **1010**, (e.g., as at **1010** in **FIGS. 6-7**), the stack end is preferably cut and polished, or otherwise processed, to provide an optically smooth coupling surface to which light can be supplied from a light source (or from which a sensor or the like can receive light) with minimal loss. As examples of such processing, cutting and sanding / polishing can achieve such a surface, or flame or chemical polishing might be used with appropriate film materials.

Frame members such as **102** and **104** in **FIGS. 1-7** can be made of any suitable materials, with plastic and metal materials being readily molded or machined to construct the frame members. If the film used in an illumination device is electrochromic, or otherwise has transmission, absorption, and / or reflection properties which are designed to vary with an applied voltage, current, frequency, or other input signal, it can be useful to form one or more of the frame members of a conductive material through which the input signal can be applied. The interior surfaces of the frame members can usefully be coated with a reflective material so that any light lost from the film strips to the interior of the frame might be reflected therein, and possibly redirected back into the strips.

The frame members and film sheets discussed above may have vastly different configurations than those shown in the drawings. The shapes, sizes, and proportions of the frame members, in particular the numbers, shapes, sizes, and proportions of their teeth, are design parameters which depend on the desired size of the illumination device, the numbers, sizes, and desired curvatures of the film strips, and similar factors. For example, a film sheet 20 cm wide with a thickness of 0.01 cm can be cut into fingers having 0.5 cm width to result in a strip stack (as at **1010** in **FIGS. 6-7**) having a light input (or receiving) surface of roughly 0.4 cm by 0.5 cm in size. Films suitable for use in the invention, and which are inexpensive and commonly available (at least at the time this document was prepared), tend to have superior light transmission where any strips are bent with radii of curvature which are at least approximately eight times the film thickness. (Lesser radii are possible – for example, strips can be bent with nearly negligible radii of curvature – but these tend to require surface coatings or similar

measures at the bends to decrease light loss, which can increase costs.) Thus, in general, the frame members will have a height of at least eight times the film thickness, plus the overall strip stack thickness (assuming the stack is to extend within / between the frame members, as within the top slot **116** in **FIGS. 4** and **6**). Similarly, the depth of the combined frame members will generally be approximately the width of the top slot (which is preferably the same as the maximum strip width), plus approximately 1.4 times the bending radius.

Frame members and illumination devices can also vary from those discussed above and shown in the figures in details other than their shapes, sizes, and proportions. To illustrate, **FIGS. 8-10** illustrate first and second frame members **202** and **204** wherein the first frame member **202** urges the film strips **2006** into two arrays of adjacently-situated strips situated in parallel planes, and a pair of cover members **214** then urge these arrays into a stack extending from the center of the lengths of the stack members. When the film sheet **2000** is then bent similarly to that in **FIG. 7**, but at an angle of approximately 90 degrees rather than 180 degrees, the stacked strips **2010** extend behind the major area **2002** of the film sheet **2000**, rather than outwardly from one of its sides (as in **FIGS. 6-7**). This may allow for a more compact and / or convenient arrangement, depending on how the illumination device is to be used. Additionally, a film sheet may bear strips extending from more than one of its edges – e.g., from opposing edges – and frames may be mounted about each of these edges so that the major area of the sheet can be illuminated from more than one edge. Such an arrangement is particularly preferred where the major sheet area is large, since illumination from multiple edges can provide greater illumination of the major sheet area. In similar respects, two or more frames can be mounted on a single edge of a film sheet to provide two or more strip stacks for input of light to, or output of light from, the major sheet area.

The teeth used on the frame members need not take the forms of those illustrated in the drawings (e.g., **FIGS. 1** and **5**), which have a roughly sawtooth profile, with a thickness that increases slightly as each tooth extends from its tip to its base in the vertical direction. Examples of other teeth configurations include tetrahedra, rod-like forms (similar to an array of comb teeth, but wherein the teeth might be are angled with

respect to their frame members), and flanges having a C-shaped or J-shaped curve. Further, the teeth might be situated at different locations along the heights of the frame members, as by being located at the first member top edge **128** in **FIG. 1** (though in this case any stack of parallel abutting film strips would rest atop the first frame member **102**, rather than in a slot **116** defined between the first and second slot members **102** and **104**, as in **FIGS. 4** and **6**). In such situations, the first member teeth **108** might be defined by forming notches / depressions in the first member top edge **128** and / or the first member inner face **106**, such that the first member teeth **108** are left to protrude both upwardly and outwardly from the first member inner face **106**. Similar adaptations could be made when providing the second member teeth on the second frame member. Depending on the configuration and location of the teeth, the width of the film strips, and on the degree of bending desired for the strips, the faces of the teeth need not be near parallel (as in **FIG. 5**, which shows the tooth faces **124** and **126** angled at approximately 15 degrees to each other), and in fact could be more perpendicular than parallel. However, for frame members and strips configured and proportioned as in the accompanying drawings, tooth faces which are parallel (or nearly so) are preferred.

As noted previously, the second member teeth help promote the bending / redirection of the film strips caused by the first teeth. This is not necessary, and the second member teeth may be omitted, or might simply be replaced by a single continuous ridge or other member rather than being provided as a series of independent teeth.

Further, while the frame members are depicted in the Figures as having linear arrays of teeth which redirect a planar array of film strips into a stacked array of strips, the arrayed teeth need not necessarily be linear, nor need the film strips input to the teeth be necessarily arrayed in a plane. In some applications (e.g., architectural lighting), curved film sheets and / or strip stacks, or sheets / stacks having other complex shapes, are sometimes desired. Thus, the frames can be constructed in such a manner that they might receive a curved / nonplanar array of strips. In this respect, the frame members illustrated in the accompanying drawings might be formed of a flexible material such as silicone whereby a final illumination device (as shown in **FIGS. 7** and **10**) might be bent to at least partially conform to a curved surface.

The construction of illumination devices such as those shown in **FIGS. 7** and **10** also need not be done solely by hand, and may be done in an automated or semi-automated manner. To illustrate, the frame members **102** and **104** of **FIGS. 1-7** could be defined as portions of a machine wherein a sheet is fed below the second frame member **104** (with an edge then being cut into film strips, if it is not already so cut), and the frame members **102** and **104** are then moved by a suitable mechanism in the manner shown in **FIGS. 1-7** to construct the illumination device of **FIG. 7**. Stated differently, the invention also encompasses frame members which are provided as part of a further device which assists in the assembly of a final illumination device.

Frame members can also include other features. As one example, a frame member may include ports through which gels having a low refractive index, or other materials, may be injected to at least partially surround the film strips within the frame and better deter light loss from the strips. As another example, the frame members can be adapted such that the stacked strips do not extend therefrom, and rather terminate within the frame members at a location at which an LED or other light source (or light sensing / receiving device) is provided. In other words, the light source (or light receiver) can be provided within the frame, as well as any power supplies or other components needed for its operation. The frame members may include features allowing them to be quickly and easily attached and detached to each other, and / or to surrounding structure, and about a film sheet, whereby film sheets may be more easily removed from the frame members and replaced with other desired film sheets (e.g., where a film sheet defining a sign bearing one message is to be replaced by a sign bearing another message). Alternatively, the frame members may bear structure for quick and easy attachment to surrounding structure, whereby an illumination device such as that in **FIG. 7** may be readily removed and replaced in its entirety by another illumination device.

One issue that can be encountered with the frame members discussed above is that if the film sheet is not held with respect to the first frame member (and / or the second frame member) as the aforementioned assembly steps are followed, the film sheet and its strips can displace, making it more difficult to complete the assembly of the

illumination device. Features can be added to one or more of the frame members to help deter such displacement. One example is illustrated in **FIG. 8**, wherein the second frame member **204** bears a central strip aperture **230** along its length, and situated below the second member teeth (not shown). As shown in **FIGS. 8-10**, a central film strip **2012** extending from the film sheet **2000** may be bent to extend through this central strip aperture **230**, thereby at least partially restraining the film strips **2006** and film sheet **2000** with respect to the second frame member **204** as it is moved toward the first frame member **202** to bend the strips **2006** into arrays of parallel spaced strips (as in **FIG. 9**). After the illumination device has been fully assembled (**FIG. 10**), the end of the central film strip **2012** protruding from the second frame member **204** may be cut off or otherwise removed.

As another example, one or more of the frame members -- most preferably the first frame member -- might include pegs or other protruding structure (e.g., on the first member floor), and the film sheet may then bear apertures, or its edges may bear notches, which receive the protruding structure(s). As a result, the film sheet can be placed in the first frame member with the protruding structure(s) deterring slipping of the film sheet as the second frame member is urged toward the first frame member.

Protruding structure(s), and complementary receiving structures such as aperture(s) / slot(s), are not the only structures that can be used to accomplish such a restraining arrangement, and a variety of other arrangements could alternatively or additionally be used. Referring to **FIG. 1** to illustrate, tacky / adhesive surfaces, or elastomeric or other high-friction surfaces, can be situated on the frame members **102** and **104** (e.g., along the first member floor **118** and / or the second member lower edge **120**) to deter slippage of the film sheet as the frame members **102** and **104** are sandwiched about the strips. As another example, tongues / clips could extend outwardly from the first member sidewalls **130** to extend closely adjacent the first member floor **118**, so that the outermost film strips can be slid between the tongues / clips and the first member floor **118** to restrain the sheet with respect to the first frame member **102**.

Sheet restraining arrangements can also or alternatively be used wherein the arrangements do not require additional structure on the frame members, and / or modification of the film sheet. To illustrate, the frame member(s) might bear apertures along the first member floor and / or along the second member lower edge, with these apertures being temporarily connected to a vacuum supply while the film strips are being urged by the frame members into a stacked array. The vacuum supply may thereafter be removed after the illumination device is sufficiently complete.

It should be understood that various terms used throughout this document to refer to orientation and position -- e.g., "top" (as in "top slot"), "lower" (as in "second member lower edge"), "vertically," and the like -- are relative terms rather than absolute ones. In other words, it should be understood (for example) that the top slot being referred to may in fact be located at the bottom of the device depending on the overall orientation of the device. Thus, such terms should be regarded as words of convenience, rather than limiting terms.

To provide a more specific illustration of the invention, following is a description of an exemplary illumination device resembling that of **FIG. 7**, used to illuminate an LCD television display having a 20-inch (50 cm) diagonal dimension. Clear polycarbonate film having 0.01 inch (0.025 cm) thickness, provided on a roll 48 inches (122 cm) wide, was cut to 16 by 40 inch (41 by 102 cm) subsections. An array of blades cut strips in the film 0.733 inches (1.86 cm) wide by 20 inches (50 cm) long. Frame members (and a cap member) having a configuration resembling that in **FIGS. 1-6** were used to define a completed illumination device as depicted in **FIG. 6**, and glue was used to bond the frame members together (and to the stacked strip ends), and to seal the interior of the frame from dust. The stacked strip ends were cut so that their tips extended along a common plane, and were then sanded with 100 and 320 grit sandpaper, followed by using a micro-mesh sanding kit. This resulted in an optically smooth input surface measuring approximately 0.733 inches (1.86 cm) by 0.2 inches (0.51 cm). Light was coupled into the input surface using a PT-120 PhlatLight (Luminus Devices, Billerica, MA, USA). The major area of the film sheet was placed behind the LCD display, and the film sheet was bent from the state shown in **FIG. 6** to that shown in **FIG. 7** to

situate the light source, heatsinks, fans, optics and electronics behind major area of the film sheet. The radius of curvature in the bend was 0.25 inches (0.64 cm), which is approximately 25 times the thickness of the film, resulting in negligible light leakage at the bend. The overall thickness / depth of the LCD display and the illumination device was approximately 1.25 inches (3.2 cm), primarily owing to the size of the heatsinks. The illumination device provided illumination to the display which appeared to be at least equivalent in quality to that provided by common prior methods, e.g., backlighting or frontlighting by Cold Cathode Fluorescent Lamps (CCFL) and/or Light Emitting Diodes (LEDs).

The invention is not intended to be limited to the preferred versions of the invention described above, but rather is intended to be limited only by the claims set out below. Thus, the invention encompasses all different versions that fall literally or equivalently within the scope of these claims.

CLAIMS:

1. A film illumination device comprising:

a. a light transmitting film comprising an array of strips extended from a major sheet area of the light transmitting film wherein each strip of the array of strips comprises a bend and is stacked to form a stack of strips;

b. at least one light source positioned to emit light into the stack of strips, the light propagating by total internal reflection through the array of strips and into the major sheet area;

c. a light extracting region defined within the major sheet area positioned to receive and extract light propagating by total internal reflection from the array of strips; and

d. at least one frame member comprising an inner face with a protruding array of teeth with faces angled obliquely in relation to the inner face, wherein the bend in each strip of the stack of strips is formed by bending each strip of the array of strips about a protruding tooth of the protruding array of teeth such that the protruding array of teeth restrain the light transmitting film relative to the at least one frame member and each protruding tooth of the protruding array of teeth restrains a strip of the array of strips relative to the at least one frame member.

2. The film illumination device of claim 1 wherein the at least one light source is positioned within the at least one frame member.

3. The film illumination device of claim 1 further comprising a display panel extending parallel and adjacent to the major sheet area.

4. The film illumination device of claim 1 wherein the light extracting region:

a. is oriented along a plane; and

b. the major sheet area is bent by at least ninety degrees, such that the at least one frame member and the stack of strips are situated

(1) behind the light extracting region; and

(2) spaced from the plane of the light extracting region.

5. A light emitting device comprising:

a. a light transmitting film comprising an array of strips extended from a major sheet area of the light transmitting film wherein each strip of the array of strips comprises a bend and each strip of the array of strips is stacked to form a stack of strips;

b. at least one light source positioned to emit light into the stack of strips, the light propagating by total internal reflection through the array of strips and into the major sheet area;

c. a light emitting region defined within the major sheet area configured to extract the light from the at least one light source; and

d. at least one frame member containing the bend of each strip of the array of strips and comprising an inner face with a protruding array of teeth with faces angled obliquely in relation to the inner face, wherein the bend in each strip of the array of strips is formed by bending each strip of the array of strips about a protruding tooth of the protruding array of teeth such that each strip of the array of strips is restrained relative to the at least one frame member by the protruding array of teeth.

6. A film illumination device including:

a. a film sheet having:

(1) a substantially planar major sheet area; and

(2) an adjacent minor sheet area with film strips extending therefrom, the film strips are elongated, adjacent, and situated at the adjacent minor sheet area:

i. in a substantially common plane; and

ii. at least substantially parallel to each other in a first direction;

b. a frame including

a frame member having an inner face with a protruding array of teeth with faces angled obliquely in relation to the inner face, wherein a bend in each film strip of the film strips is formed by bending each film strip of the film strips about a protruding tooth of the

protruding array of teeth such that each film strip of the film strips is restrained relative to the frame member by a protruding tooth of the protruding array of teeth, and each film strip of the film strips is stacked to form a stack of strips; and

c. a light source positioned to emit light into the stack of strips.

7. The film illumination device of claim 6 wherein the film strips are adjacently situated in substantially parallel planes, and bent such that the film strips are oriented in a second direction different from the first direction.

8. The film illumination device of claim 6 wherein the frame further comprises an adhesive positioned between the frame member and the film sheet that restrains the film sheet with respect to the frame member.

9. The film illumination device of claim 6 further comprising a restraining structure that defines an aperture in the film sheet and a protruding structure in the frame member that are operatively configured to restrain the film sheet with respect to the frame member.

10. A film illumination device comprising:

a. a light transmitting film comprising an array of strips extended from a major sheet area of the light transmitting film wherein each strip of the array of strips comprises a bend and is stacked to form a stack of strips;

b. at least one light source positioned to emit light into the stack of strips, the light propagating by total internal reflection through the array of strips and into the major sheet area;

c. a light extracting region defined within the major sheet area positioned to receive and extract light propagating by total internal reflection from the array of strips;

d. at least one frame member comprising a first inner face and a second inner face, the bend of each strip of the array of strips is positioned between the first inner face and the second inner face of the at least one frame member; and

e. a first gap defined in the at least one frame member through which a first region of the light transmitting film between the light extracting region and the array of strips extends such that

the first region and the array of strips are restrained relative to the at least one frame member at the first gap.

11. The film illumination device of claim 10 wherein the at least one light source is positioned within the at least one frame member.

12. The film illumination device of claim 10 further comprising a display panel extending parallel and adjacent to the major sheet area.

13. The film illumination device of claim 10 further comprising a display panel wherein the film illumination device is a frontlight for the display panel.

14. The film illumination device of claim 10 wherein the light extracting region:

a. is oriented along a plane; and

b. the major sheet area is bent by at least ninety degrees, such that the at least one frame member and the stack of strips are situated

(1) behind the light extracting region; and

(2) spaced from the plane of the light extracting region.

15. A light emitting device comprising:

a. a light transmitting film comprising an array of strips extended from a major sheet area of the light transmitting film wherein each strip of the array of strips comprises a bend and each strip of the array of strips is stacked to form a stack of strips;

b. at least one light source positioned to emit light into the stack of strips, the light propagating by total internal reflection through the array of strips and into the major sheet area;

c. a light emitting region defined within the major sheet area configured to extract the light from the at least one light source; and

d. at least one frame member containing the bend of each strip of the array of strips and comprising a gap through which a first region of the light transmitting film between the light emitting region and the array of strips extends such that the array of strips are restrained relative to the at least one frame member at the gap.

16. A display panel comprising the light emitting device of claim 15 wherein the light emitting device is a frontlight for the display panel.

17. The light emitting device of claim 15 further comprising an adhesive positioned between the at least one frame member and the light transmitting film that restrains the light transmitting film with respect to the at least one frame member.

18. The light emitting device of claim 15 further comprising a restraining structure that defines an aperture in the light transmitting film and a protruding structure in the at least one frame member that are operatively configured to restrain the light transmitting film with respect to the at least one frame member.

19. The light emitting device of claim 15 wherein the at least one frame member comprises a floor extending from an inner surface of the at least one frame member and the first region of the light transmitting film is physically restrained to the floor.

FIG. 1

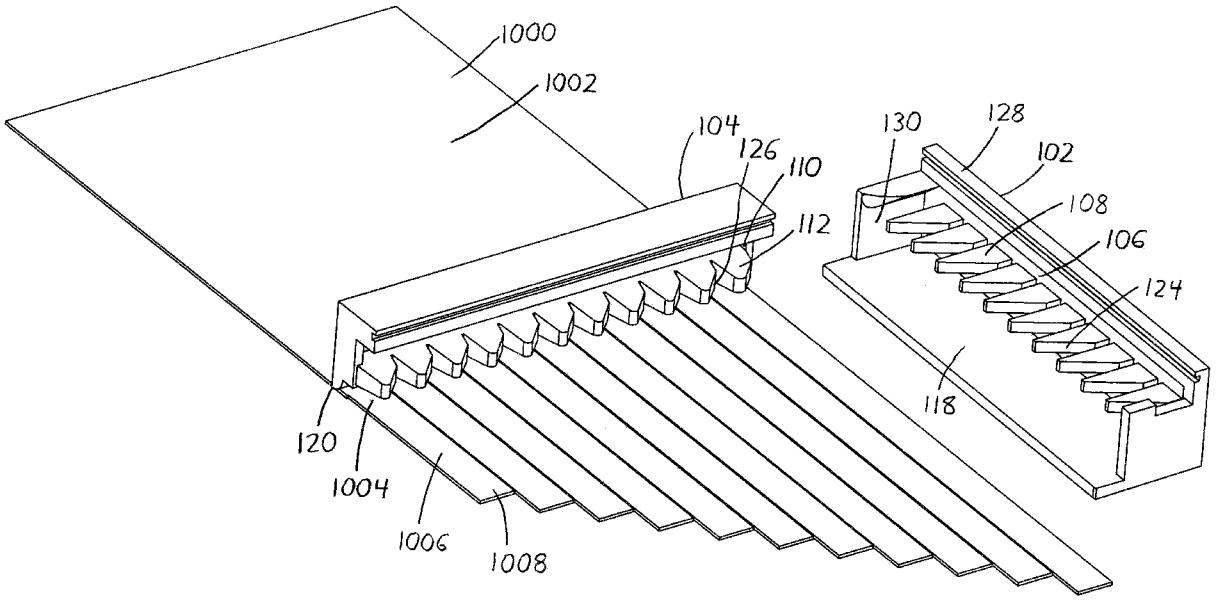

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FIG. 2

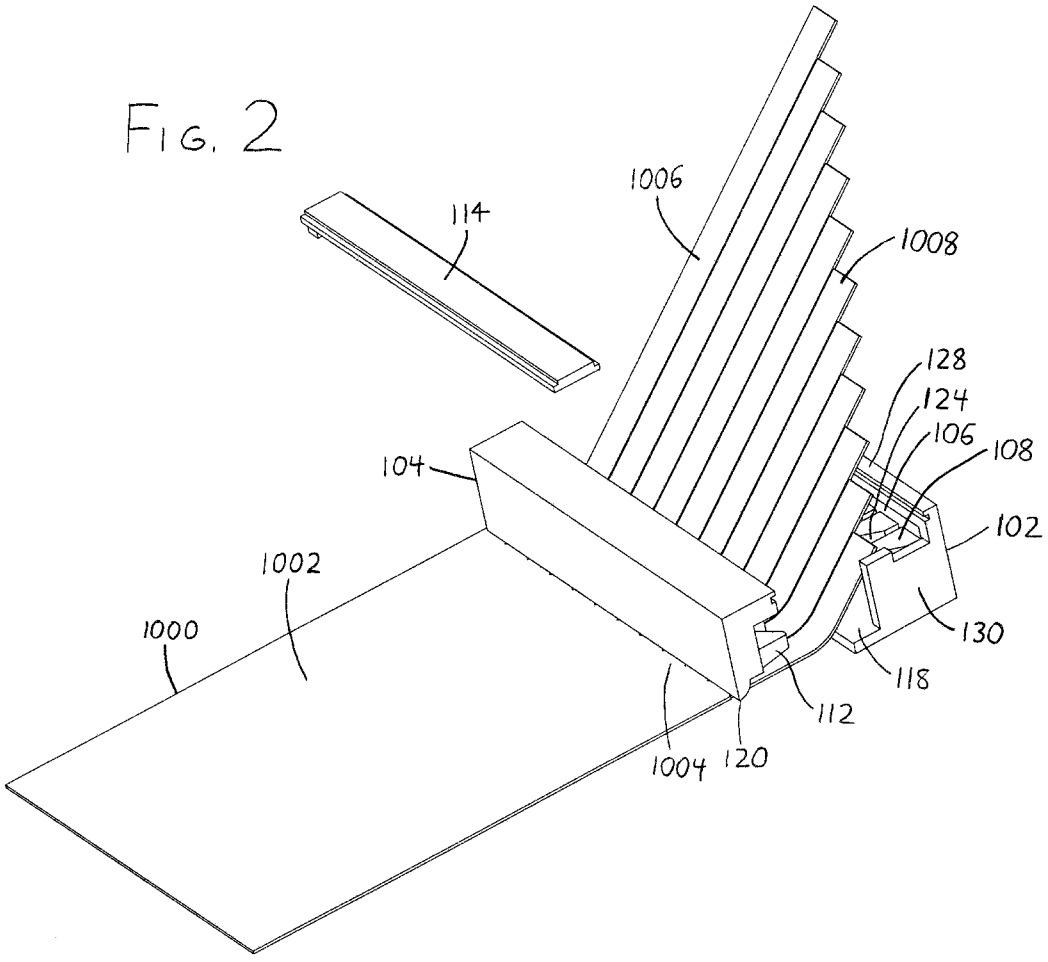

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FIG. 3

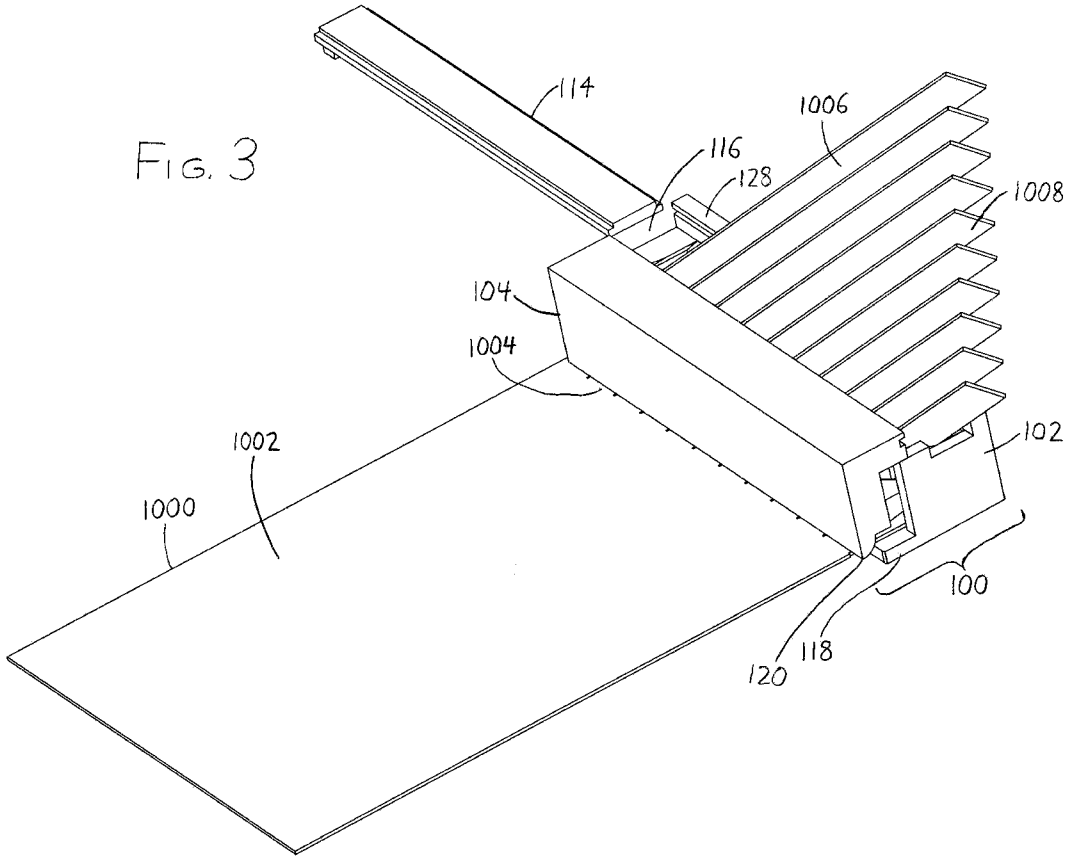

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FIG. 4

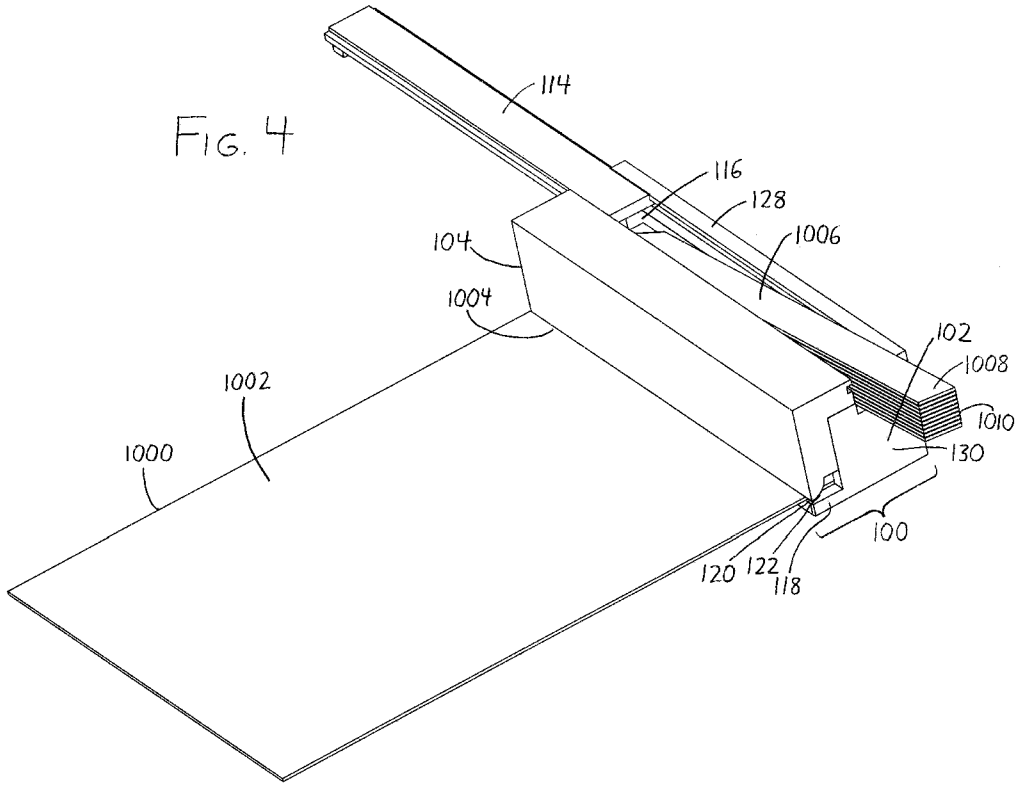

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FIG. 5

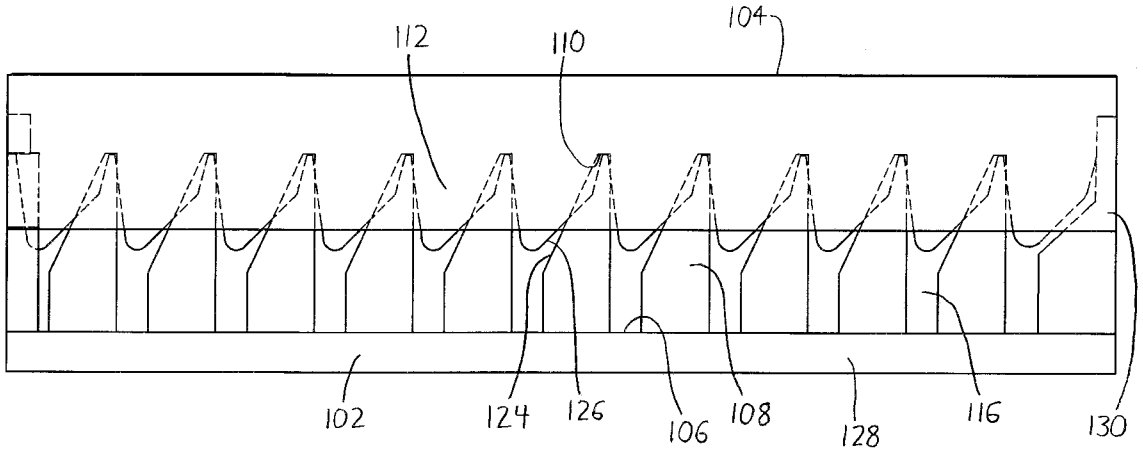

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FIG. 6

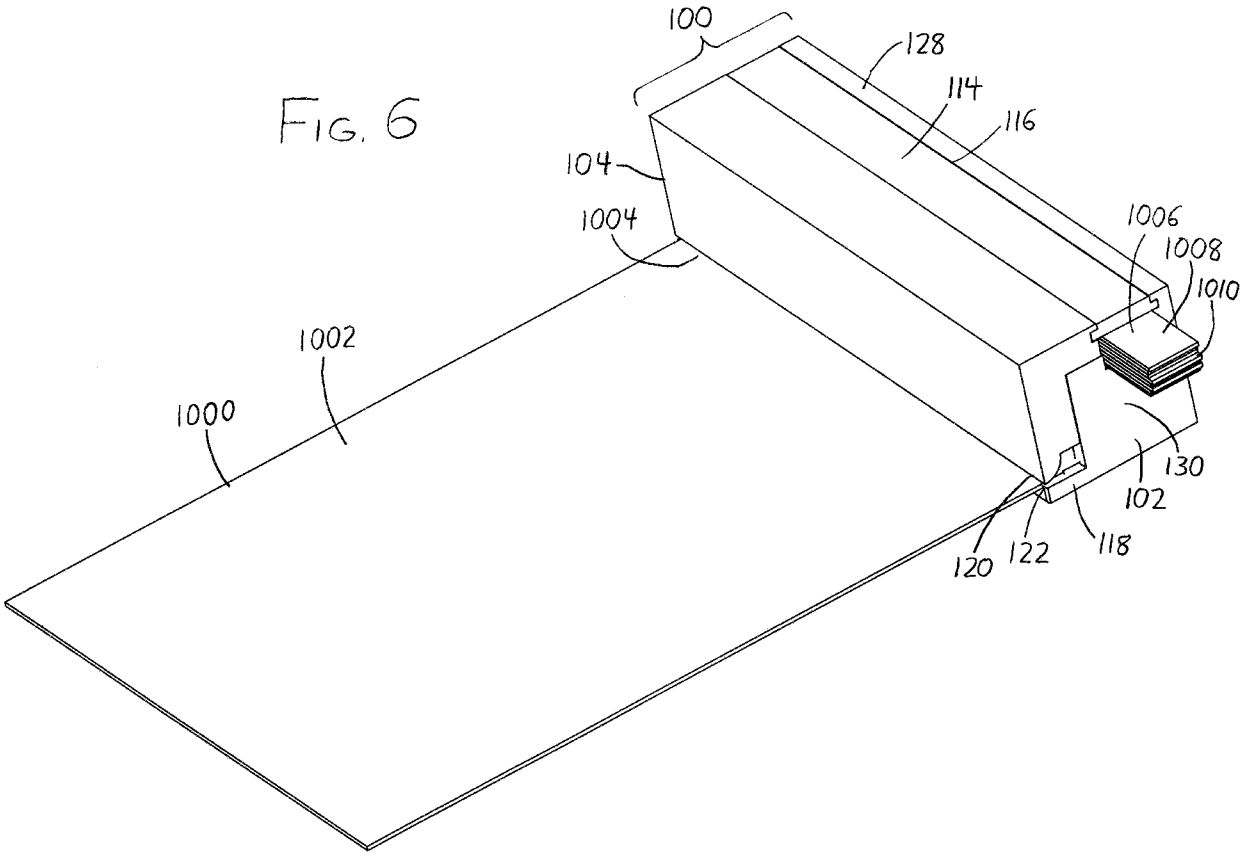

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FIG. 7

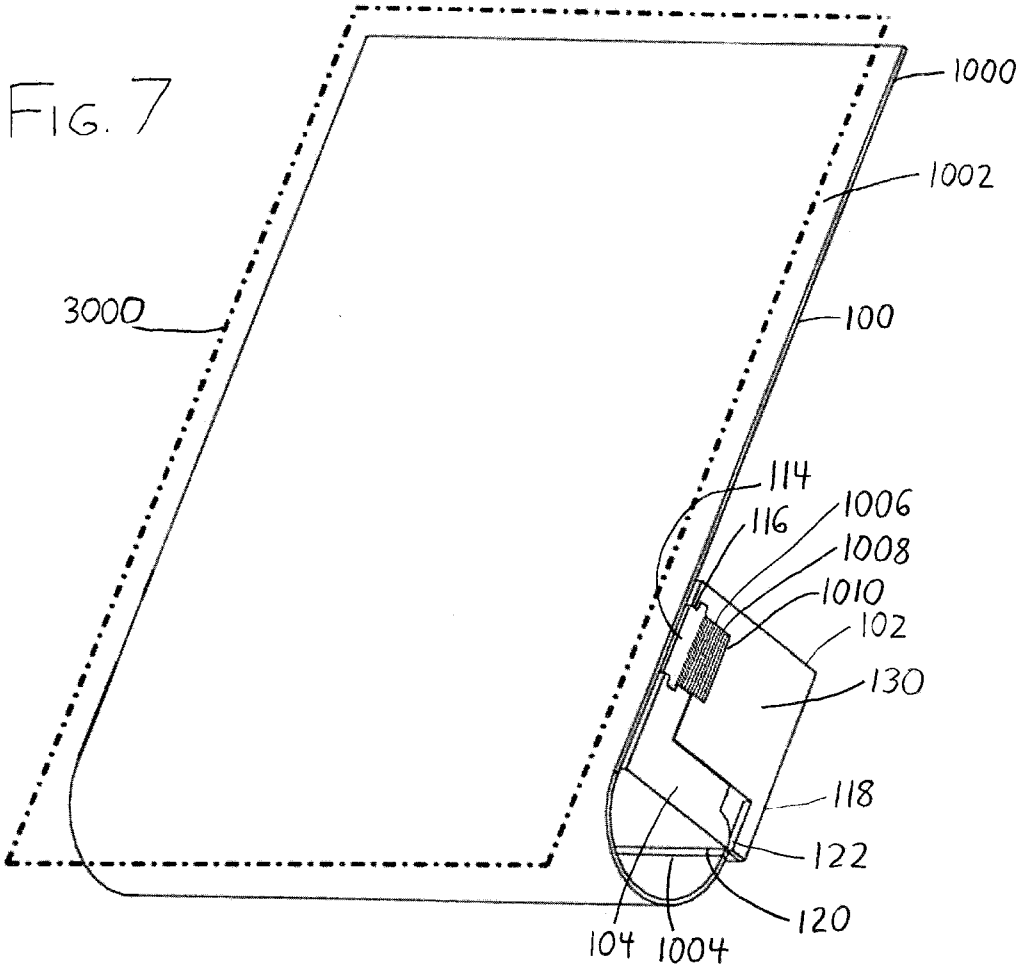

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FIG. 8

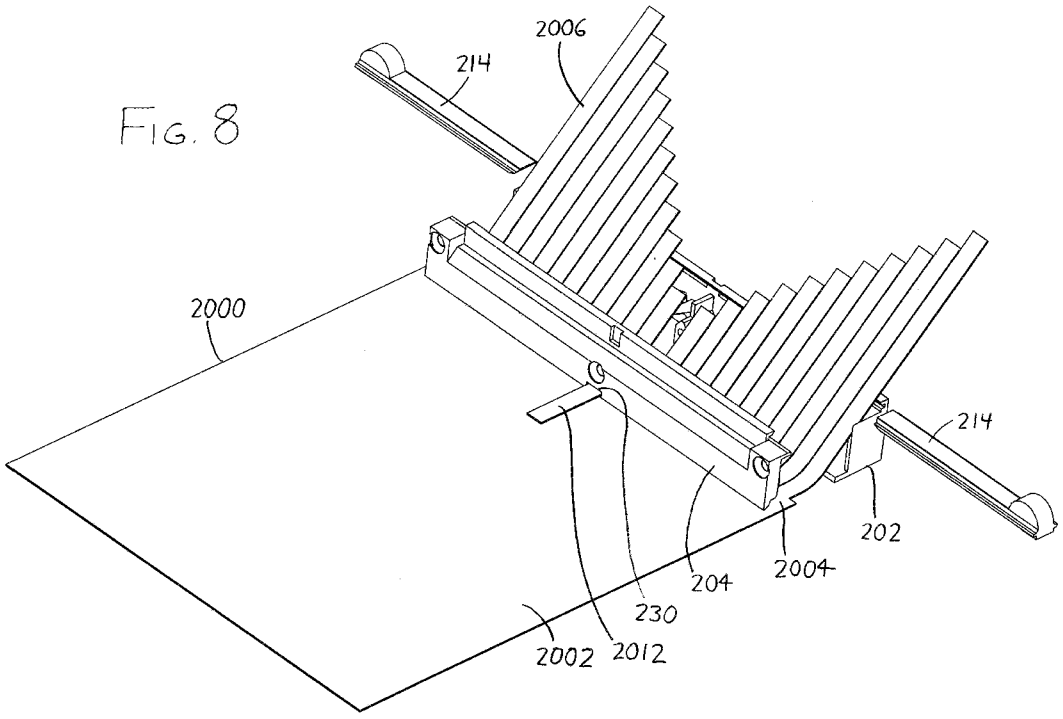

2006
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FIG. 9

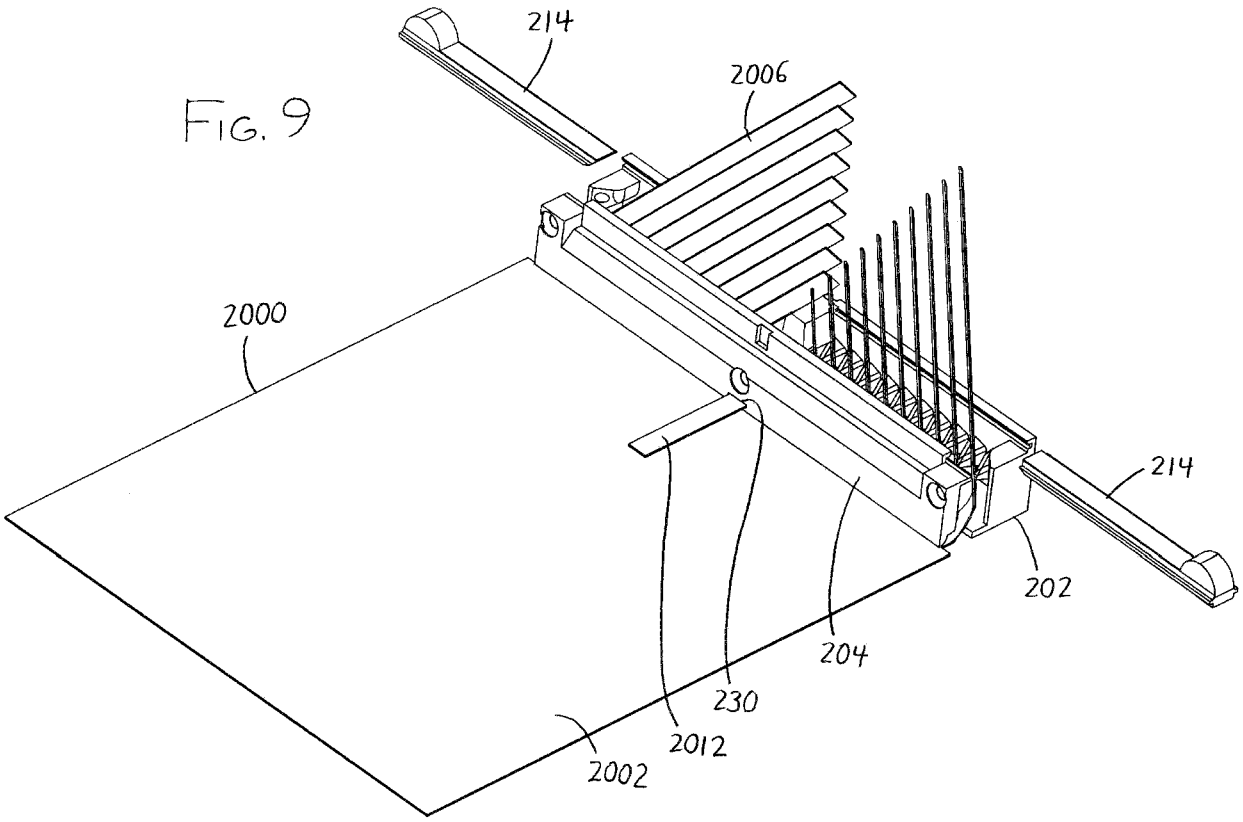
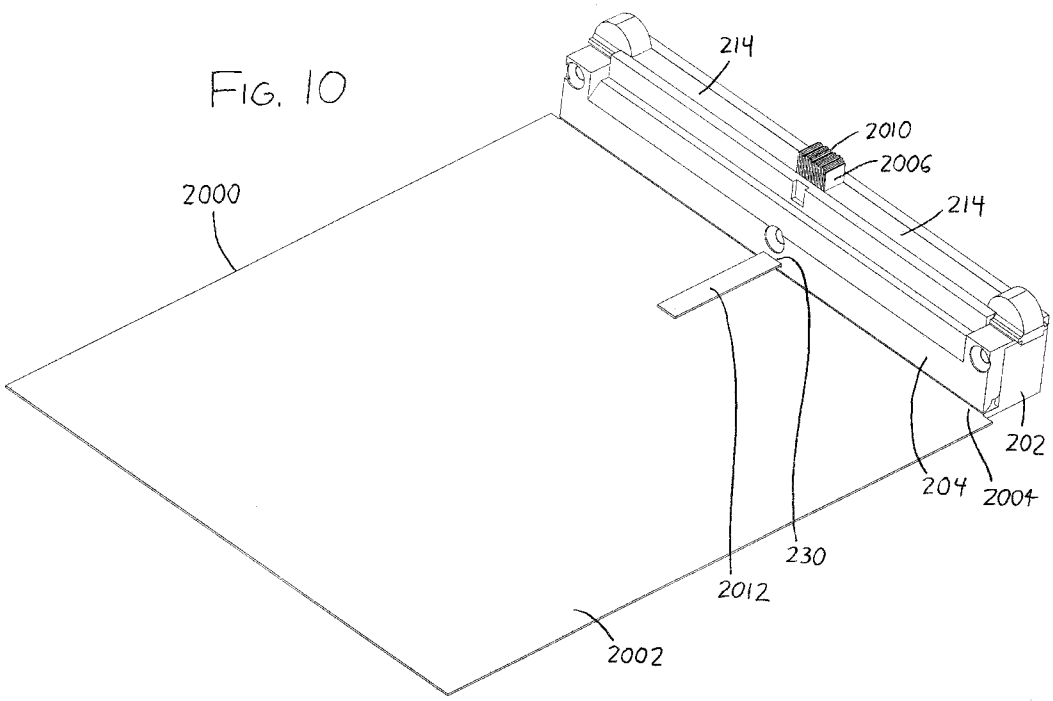
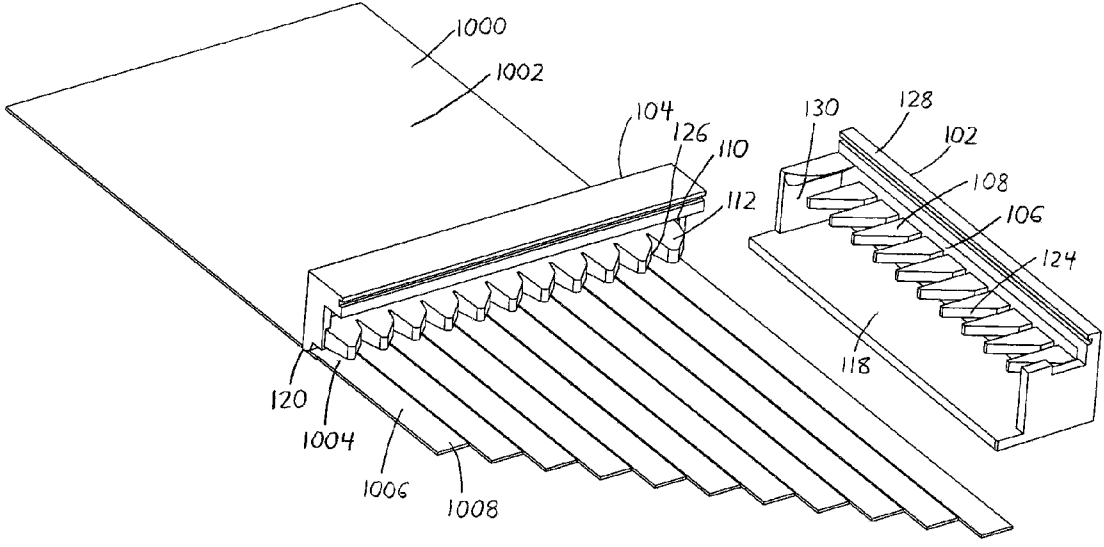

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FIG. 10


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