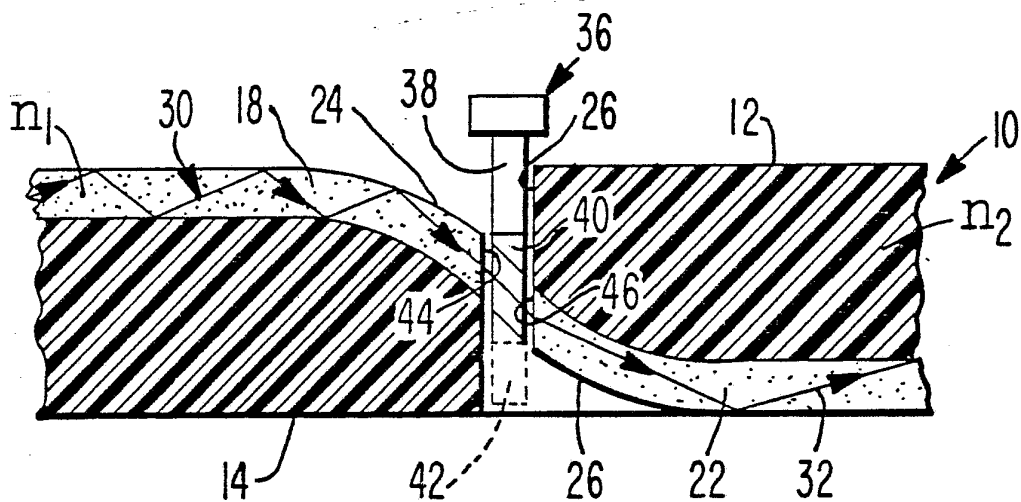




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(54) Title: MOLDED OPTICAL WAVEGUIDE SWITCHING APPARATUS



(57) Abstract

Molded optical waveguide switching apparatus wherein a flat, planar light transmissive plastic member (10) of a refractive index N_2 is premolded with orthogonally arranged obverse and reverse grooves or channels (18, 22) and wherein each such channel or groove is filled-in molded with a light transmissive plastic of a refractive index N_1 (where $N_1 > N_2$) effectively forming front and back light conducting channels or waveguides at right angles to one another on the flat planar member. A gently curved tap (24, 26) is molded into the intersecting area of each row and column waveguide with a through opening or aperture formed adjacent each intersection. The taps of the obverse side are curved downwardly to meet the upwardly curved taps of the reverse side of the planar member. Light blocking and unblocking members (38) are operably disposed in respective apertures to interrupt light from light generating to light receptors.

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MOLDED OPTICAL WAVEGUIDE
SWITCHING APPARATUS

CROSS REFERENCE TO RELATED APPLICATIONS

5 The present application is related to the following listed applications dealing with similar subject matter all assigned to the same assignee as the present application and file concurrently herewith.

"FIBER WRAP KEYBOARD AND SWITCH", USSN 358,825 filed March 16, 1982 in the names of
10 Wunnava V. Subbarao, Richard I. Ely and Carl E. Mosier and James E. Andree;

"MULTI-PLANE OPTICAL MEMBRANE SWITCH APPARATUS", USSN 358,823, filed March 16, 1982, in the names of Richard I. Ely and Wunnava V. Subbarao;

15 "MOLDED OPTICAL KEYBOARD HAVING FIBER OPTIC KEYS", USSN 358,824, filed March 16, 1982, in the names of Wunnava V. Subbarao, Richard I. Ely and Carl E. Mosier.

20 "SINGLE PLANE OPTICAL MEMBRANE SWITCH AND KEYBOARD", USSN 358,822, filed March 16, 1982, in the name of Richard I. Ely.



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BACKGROUND OF THE INVENTION1. Field of the Invention

The invention relates to photo-optical switches and keyboards and more particularly to a flat planar monolithic photo-optical switch and keyboard apparatus.

2. Description of the Prior Art

Fiber optical keyboards and switches are of interest because they reduce the number of light emitting diodes (LED's) and detectors that may be required, unlike the one for one requirement of earlier photo-optical keyboards.

One LED can illuminate a bundle of fibers, each one of which goes to a separate key on the keyboard. At each key another fiber receives the transmitted light and conducts it to a photo-detector. If a key is depressed the light is blocked by the key stem or blade and the detector "sees" the loss of light as an operational signal. By multiplexing the LED's and detectors only one LED is required for each row and one detector for each column in a keyboard matrix.

A problem with the fiber optic keyboard is the present difficulty in fabricating and/or assembling all the fibers into a keyboard matrix array. It would be difficult to automate and the cost of assembly could conceivably out weigh the cost savings resulting from the reduced numbers of LED's and detectors.

It is an important object therefore of the present invention to solve these and other problems in a new, novel and heretofore unobvious manner.

Another object of the invention is to avoid the necessity or requirement for individual fiber strands or elements thus overcoming the assembly



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problems.

It is also an object of the invention to provide a one piece, molded, integrated optical assembly in the form of a keyboard matrix.

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SUMMARY OF THE INVENTION

An integrated, molded, one piece optical assembly comprises a flat, planar plastic base member of a low index of refraction material having a matrix of orthogonally arranged grooves, disposed in rows and columns, with the grooves forming the rows molded into one surface of the planar member and the grooves forming the columns molded into the opposite, parallel surface of this member. The row and column grooves are filled with a second higher index of refraction type of plastic material effectively producing flat rectangular waveguides (rather than this circular type which would result from employing bundles of fibers). The horizontal rows are formed in the top of the base member while the vertical columns are formed in the bottom of the base member. Curved taps are located adjacent each row and column intersection with an aperture or through opening intermediate the ends of each curved tap. The taps of the rows are curved toward the taps of the columns (i.e. toward the middle of the intersection) so that light from a horizontal row waveguide is transmitted to a vertical column waveguide (i.e. from the top to the bottom of the matrix). A light blocking element such as an opaque member or key blade reciprocally movable within the opening alternately blocks and unblocks the light to the associated light detector.



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In order to increase the light coupling between the upper and lower waveguides the key blade may be fabricated from two different plastic materials, one black and one clear. The clear section would transmit the light when it enters the region of the intersection. The clear portion reduces the effective optical thickness of the gap between the two waveguides. This is similar to the effect that makes objects in water (beneath the surface) appear closer to the surface than they really are.

Additionally, a further increase in the light coupling between upper and lower waveguides can be produced by molding a lens into the key blade.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic top plan view (not to scale) of the structure according to the teachings of the present invention;

Figure 1a is a partial sectional view of the area circled (Figure 1a) in Figure 1;

Figure 1b is a front elevational view of the device of Figure 1a;

Figure 2 is a greatly enlarged portion of the structure of Figure 1 illustrating the aperture between upper and lower waveguides;

Figure 2a is a detail view of one of the curved tap or coupling mechanism; and

Figure 3 is an enlarged detail sectional side elevational view of the portion circled in Figure 2.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The present apparatus provides a one piece, unitary, integrated, molded optical assembly which in the present embodiment is illustrated as a keyboard matrix.



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A single, rigid piece of transparent plastic 10, of generally rectangular or square outline as seen in Figure 1 having a top and bottom surface 12 and 14, respectfully, is molded to provide a plurality of horizontal rows 16 slightly under cut to form depressions or grooves in the top surface 18 in surface 12 extending from one outboard edge of member 10 to within a short distance of the opposite outboard edge of member 10. A plurality of columns 20 having similar undercut depressions or grooves 22 are molded into the opposite surface 14 thereof.

At the intersecting areas between grooves 18 and grooves 22 (top and bottom) upper and lower curved taps 24 and 26 respectively, are provided, shown in Figure 1, but more clearly depicted in Figures 1a and 2. As seen in the enlarged view of Figure 3 the upper tap 24 is curved in two directions i.e. away from its origin and downwardly toward its opposite upwardly curved tap 26 extending upwardly from the opposite surface 14.

At approximately the precise midpoint of the cross over or intersection of the two taps 24 and 26 an aperture or opening 28 is formed in the member 10 and extends into and through this member, as shown quite clearly in Figure 3.

By forming the base plate member 10 of a low index of refraction material N_2 and molding into the grooves 18 and 20 a material of a higher index or refraction N_1 Figure 1, light 30 from light generator 32 will be conducted into and through the row grooves 18 over the tap 24. Across the opening 28 and into the column groove 22 via lower tap 26 to be intercepted by column light receiver 34. Note that the gently curved taps 24 and 26 lead the light 30 across the gap without substantial attenuation.



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A key structure 36, illustrated in outline in Figures 1a and 3 (in a light passing position) includes a blade 38 having a transparent light passing portion 40, Figure 4 (or an opening 41 as seen in Figure 1a) and a light blocking portion 42. The key 36 is shown in the depressed position in which the light passing portion 40 is adjacent the two confronting ends 44 and 46 of the upper and lower waveguide 18 and 22, respectively so that light 30 passes across the opening 26 and produces a signal at the light receptor 34.

Raising the key 36, as by means of a return spring (not shown) causes the light blocking portion 42 to be elevated into the gap area 28 so that light 30 is blocked from the photo-receptor 34. A key blade construction could include a clear or transparent portion 40 and an opaque or black portion 42.

By judicious choice of materials and appropriate parameters of the opening 26 and base 38 a lens or lenses 48 Figure 1a may be employed with the key structure 36 so as to increase the light coupling between the upper and lower wave guide channels.



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WHAT IS CLAIMED IS:

1. Molded optical waveguide switching apparatus comprising;

5 a base member of light transmitting material having an index of refraction N_2 ;

10 said base member including a plurality of obverse and reverse light conducting grooves arranged in an orthogonal array with the horizontal grooves of the obverse side of said base member at right angles to the vertical grooves of the reverse side of said member;

15 an individual tap member disposed at the intersection of each horizontal and vertical column groove with the taps of the horizontal grooves oriented toward the taps of the vertical column grooves;

an individual aperture disposed at each intersecting pair of taps, said aperture extending into and through said base member; and

20 a light blocking/unblocking member arranged for movement within each aperture effective to interrupt light from light generating means to light receptor means indicating switch closure.

2. The invention in accordance with Claim 1 wherein said flat planar member is molded from light transmissive material having a refractive index of N_2 .

3. The invention in accordance with Claim 1 wherein each of the obverse and reverse grooves of said base member are molded of a light transmissive material of a refractive index N_1 where $N_1 > N_2$.



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4. The invention in accordance with Claim 1 wherein each said tap is gently curved out of the horizontal plane and wherein each said tap is curved out of the vertical plane toward its opposite number.

5. The invention in accordance with Claim 1 wherein said light blocking/unblocking member comprises a plastic element having a integral opaque light obstructing portion and a light transmitting portion.

6. The invention in accordance with Claim 1 wherein said molded optical waveguide switching apparatus comprises a single, one piece, flat, planar, monolithic structure wherein both the grooves and
5 apertures are molded filled and formed simultaneously to provide an orthogonal array of switchable light conducting channels.

7. The invention in accordance with Claim 1 wherein said light blocking/unblocking member further includes lens means for increasing the light coupling between adjacent taps effectively increasing light
5 output.



FIG. 1.

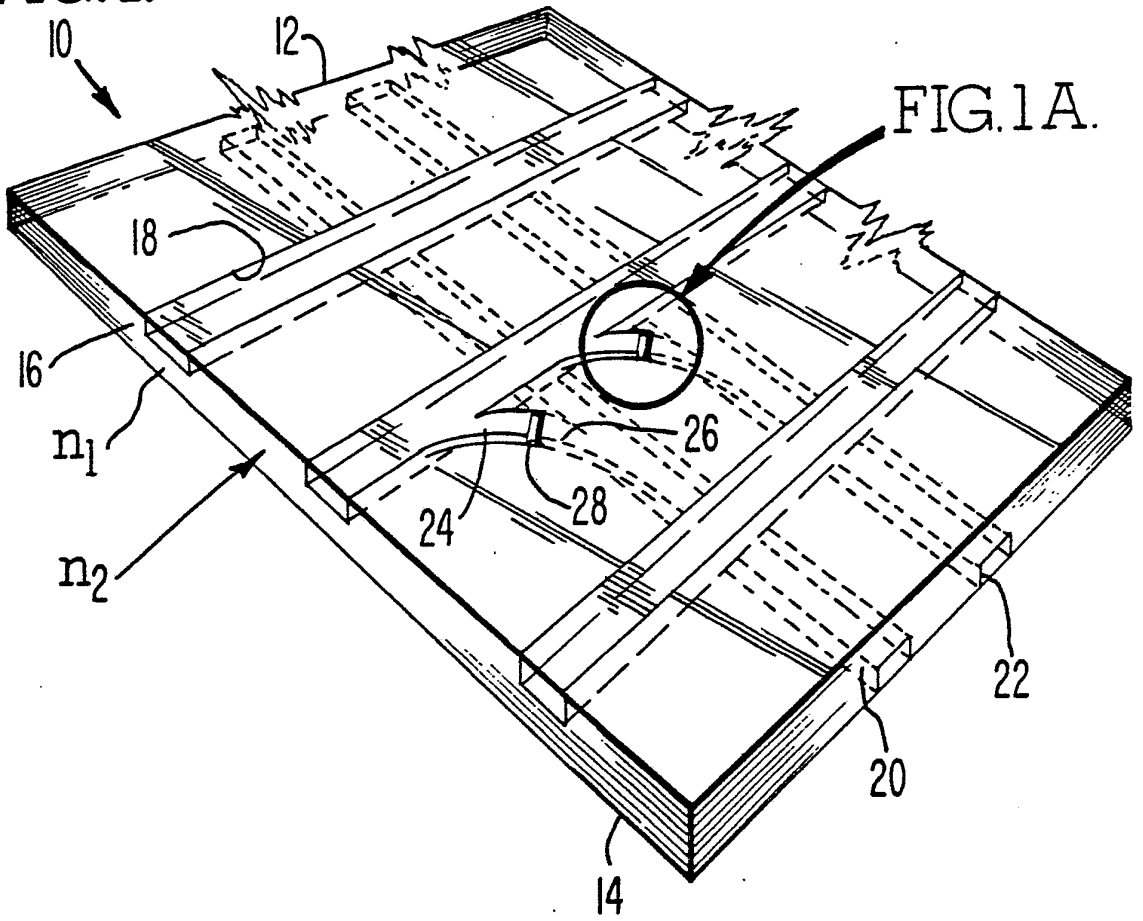


FIG. 1A.

FIG. 1A.

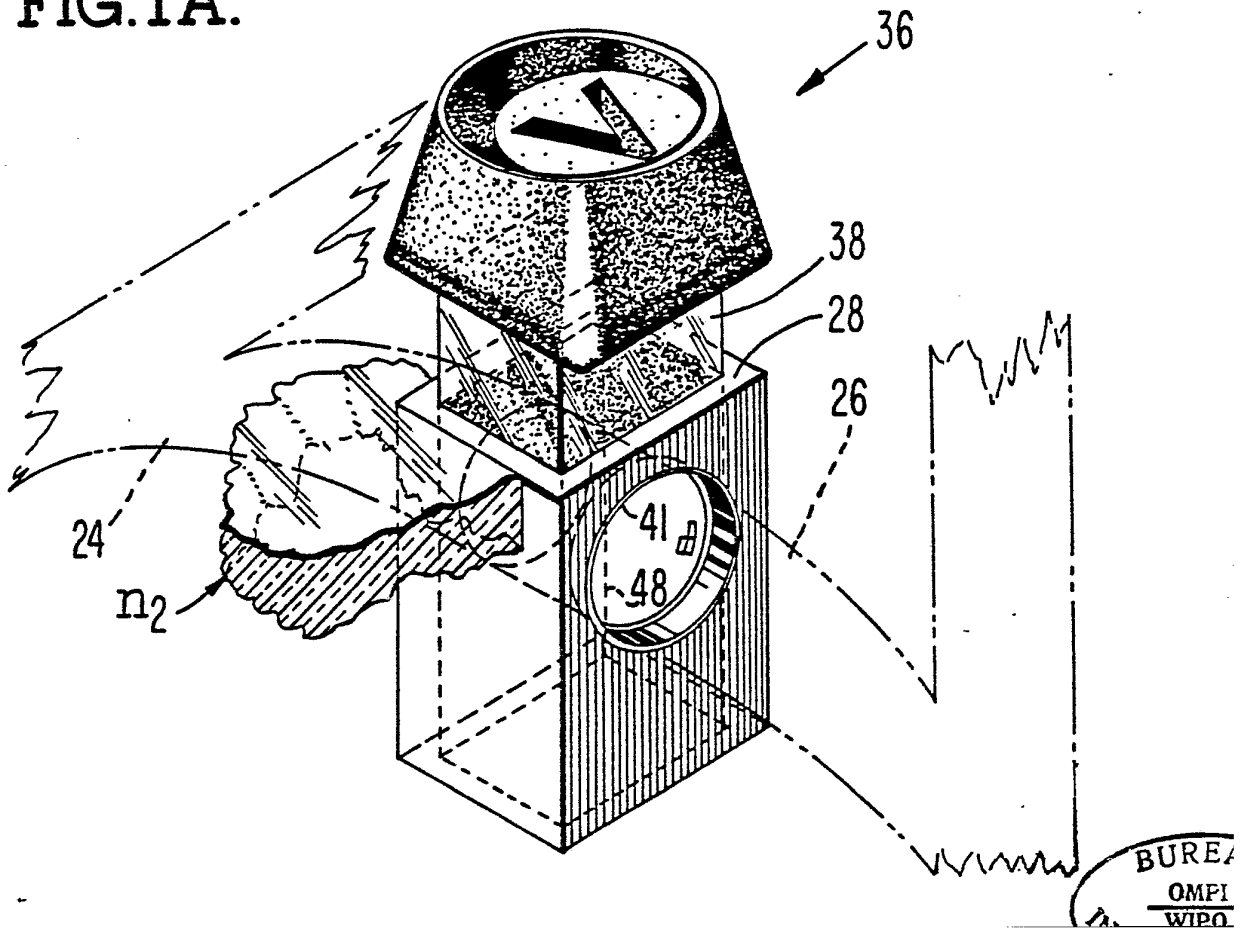


FIG. 2.

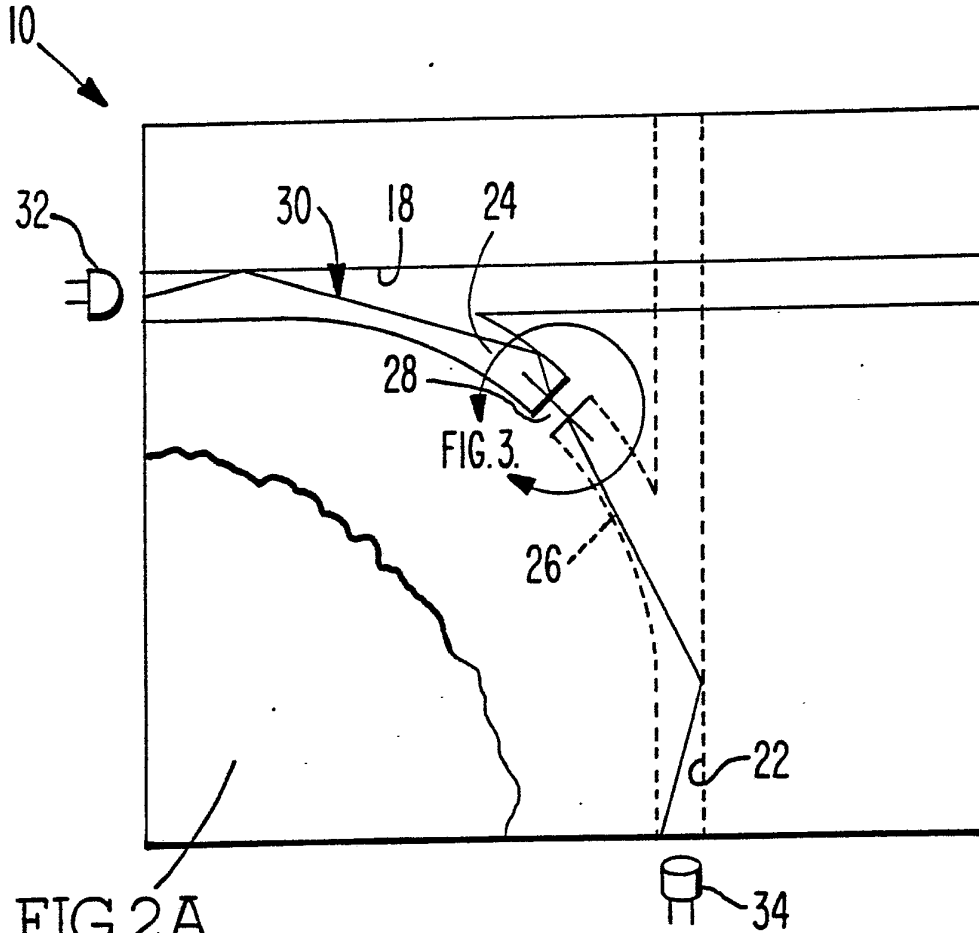


FIG. 2A

FIG. 3.

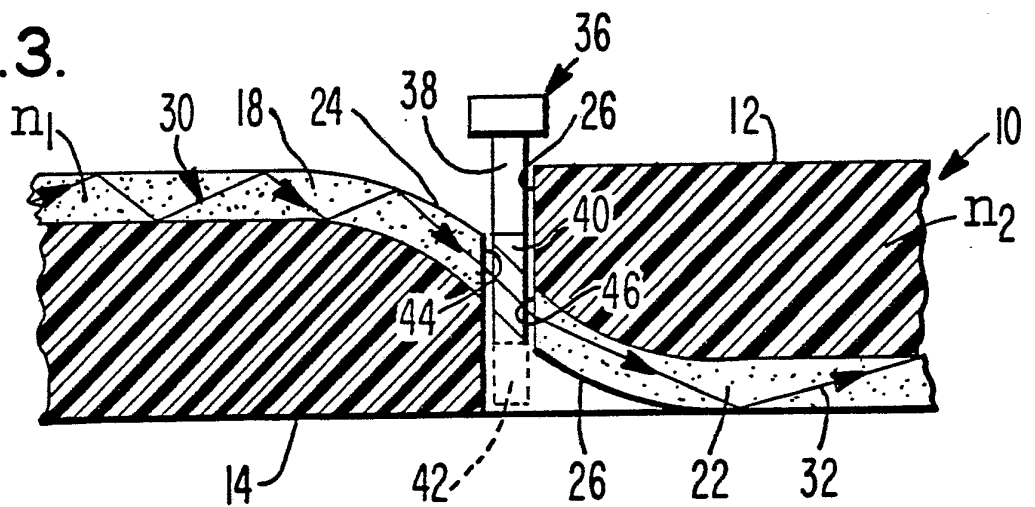


FIG. 2A.

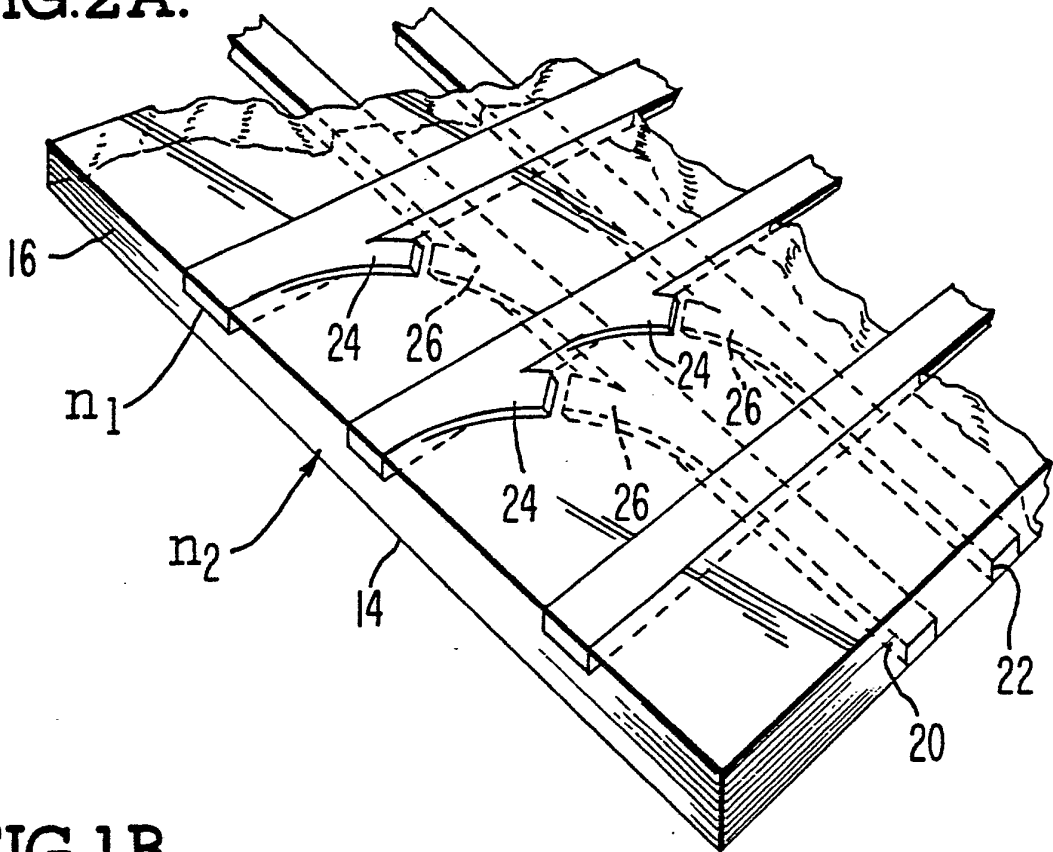
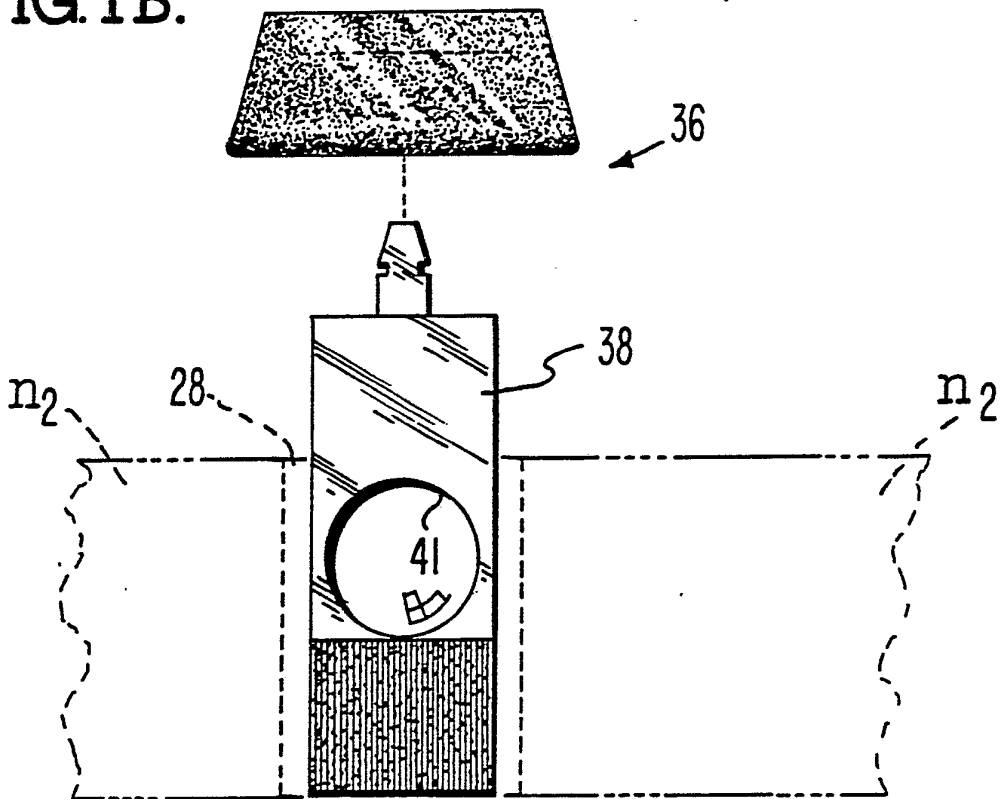


FIG. 1B.



INTERNATIONAL SEARCH REPORT

International Application No PCT/US83/00343

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ³		
According to International Patent Classification (IPC) or to both National Classification and IPC		
INT. CL. ³ G02B5/14		
U.S. CL. 250/227		
II. FIELDS SEARCHED		
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Classification System	Classification Symbols	
U.S.	250/216, 227, 229 350/96.15, 96.16, 96.18, 340/365P	
Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched ⁵		
III. DOCUMENTS CONSIDERED TO BE RELEVANT ¹⁴		
Category [*]	Citation of Document, ¹⁶ with indication, where appropriate, of the relevant passages ¹⁷	Relevant to Claim No. ¹⁸
A	US, A, 3,779,628, published 18 December 1973, (Kapron et al.)	1-7
A	US, A, 3,947,087, published 30 March 1976, (Furuta et al)	1-7
A	US, A, 3,648,050, published 07 March 1972, (Koo et al.	1-7
A	US, A, 3,526,775, published 01 September 1970, (Friedrich et al)	1-7
<p>[*] Special categories of cited documents: ¹⁵</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&" document member of the same patent family</p>		
IV. CERTIFICATION		
Date of the Actual Completion of the International Search ²	Date of Mailing of this International Search Report ³	
20 June 1983	24 JUN 1983	
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