Patent videotape

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United States Patent [19]

Solano

[11] Patent Number: 4,662,090

[45] Date of Patent: May 5, 1987

[54] BICYCLE SHOE

[76] Inventor: Mike L. Solano, 1416 West Point Dr., Bakersfield, Calif. 93305

[21] Appl. No.: 840,218

[22] Filed: Mar. 17, 1986

[51] Int. Cl.[4] A43B 5/14

[52] U.S. Cl. 36/131; 74/594.6

[58] Field of Search 36/131, 132; 74/594.6

[56] References Cited

U.S. PATENT DOCUMENTS

589,443	9/1897	Rathbun	36/131 X
3,964,343	6/1976	Lauterbach	74/594.6
4,188,737	2/1980	Haver	36/131
4,538,480	9/1985	Trindle	74/594.6

FOREIGN PATENT DOCUMENTS

0015803	9/1980	European Pat. Off.	74/594.6
11890	of 1892	United Kingdom	36/131

Primary Examiner—James Kee Chi

Attorney, Agent, or Firm—Julius L. Rubinstein

[57] ABSTRACT

A bike show is formed with a recess in the sole of the shoe. The recess is defined by front and rear walls transverse to an inwardly and upwardly spaced base, with the recess extending from the opposite sides of the sole forming a channel. The front and rear walls of the recess are spaced apart a distance generally equal to the width of a bike pedal to provide a stable seat for the pedal inside the recess. The recess is located so that the center of the recess is aligned with the center of the ball of the foot of the bike rider when the rider is wearing the bike shoe, for maximum transfer of power from the bike rider to the pedal of the bike.

10 Claims, 4 Drawing Figures

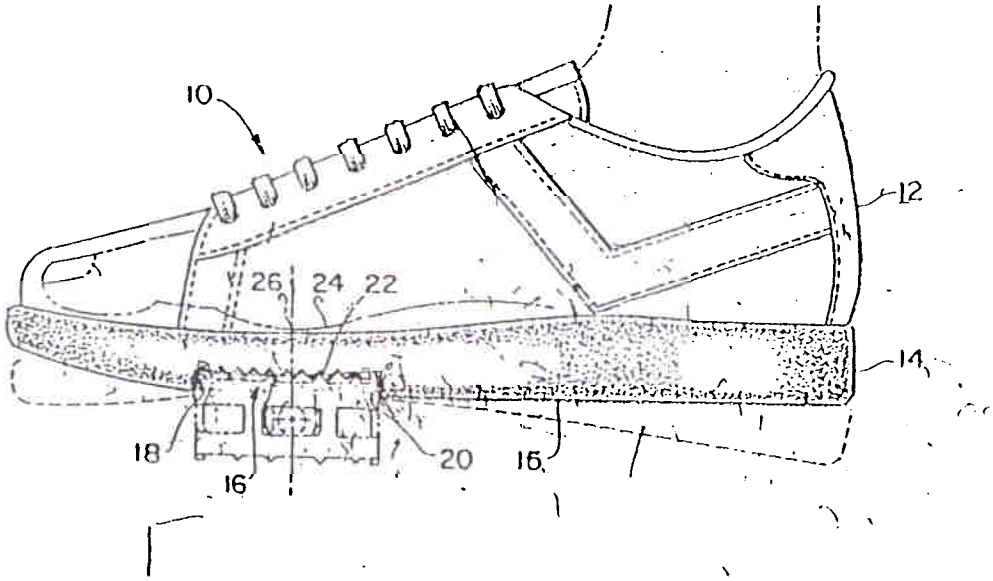


FIG. 1.

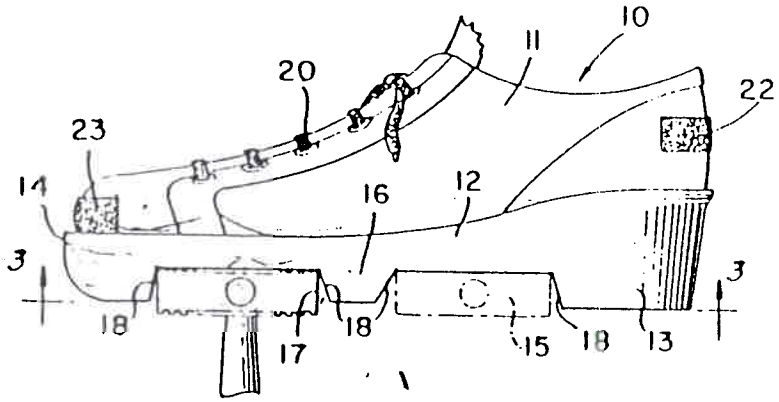


FIG. 2.

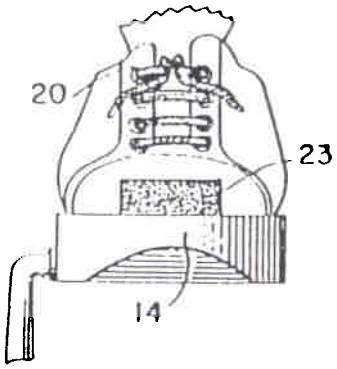


FIG. 3.

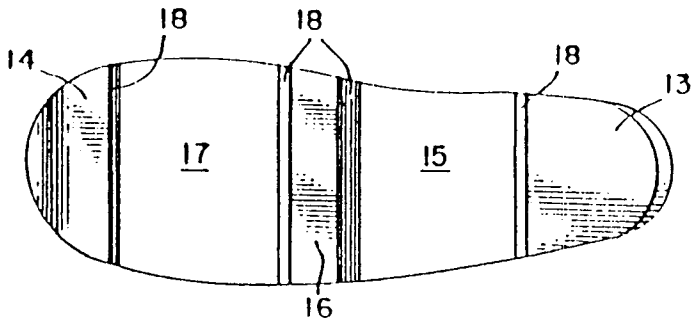


FIG. 5.

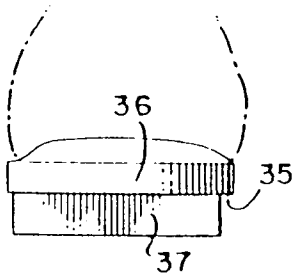


FIG. 4.

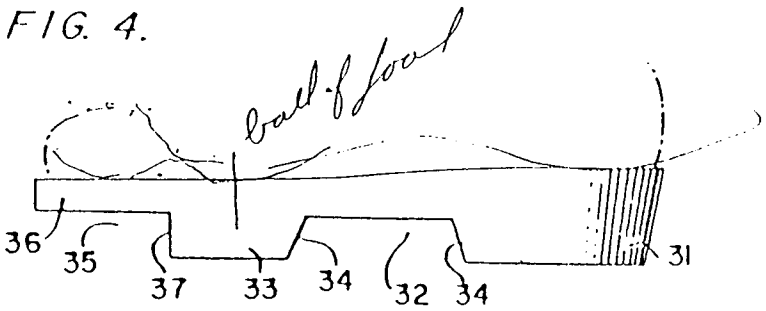
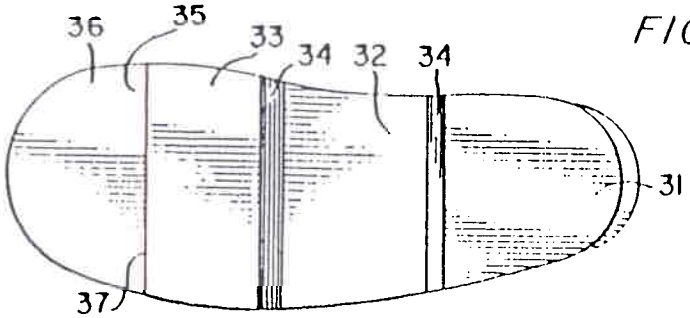


FIG. 6.



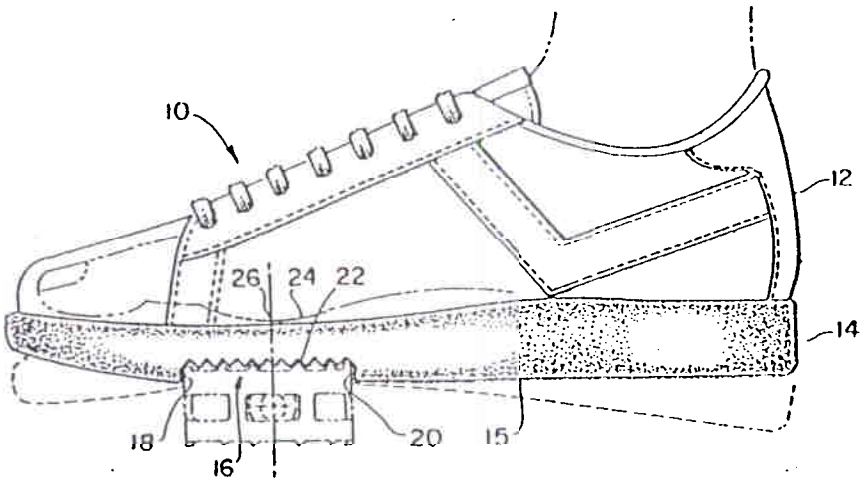


FIG. 1.

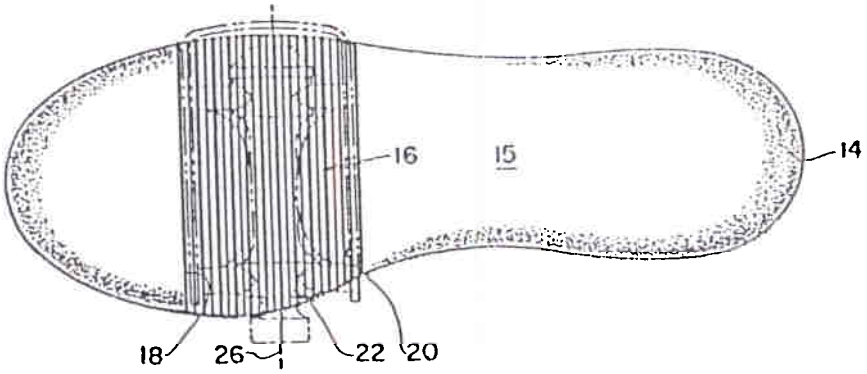


FIG. 2.

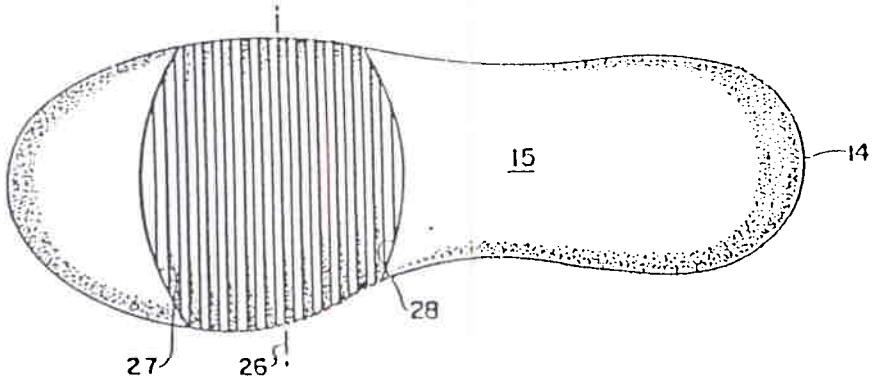


FIG. 3.

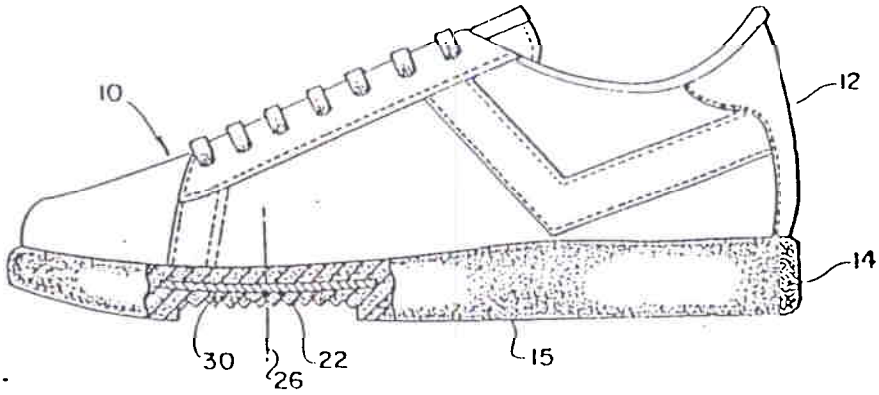


FIG. 4.

BICYCLE SHOE

This invention relates to a shoe and more particularly a shoe for riding bicycles used in Moto Cross competition.

BACKGROUND AND PRIOR ART

In recent years the sport of Moto Cross competition has been gaining increasingly wide acceptance. In this sport, the bicycles are raced along a track full of obstacles which require the rider, among other things, to jump the bicycle over these obstacles. In order to maintain control of the bicycle during these jumps and while the bicycle is travelling over rough terrain, it is essential that the feet of the rider remain in contact with the bike pedal, otherwise, valuable time may be lost while the rider is trying to reposition his feet on the pedal. In addition, successful competition requires that power be transmitted from the bike rider to the pedal of the bike with maximum efficiency.

Heretofore efforts were made to provide bicycle shoes which were designed to hold the shoe in contact with the pedal. These efforts are exemplified by the patents to Haver, U.S. Pat. No. 4,188,737; Polsky, U.S. Pat. No. 3,952,428; McIntyre, U.S. Pat. No. 598,325; Rathbun, U.S. Pat. No. 589,443, and the French Pat. No 2,532,530 to Danielli and the French Pat. No. 2,301,193 to Soubirac.

These patents solved the problem of maintaining the bike shoe in contact with a bike pedal by forming a recess in the sole of the shoe for engaging at least a part of the bike pedal, or by installing a device on the sole of the shoe for attachment to the pedal. However, none of the prior art bike shoes were particularly suited for competitive Moto Cross competition and many were uncomfortable to walk on.

More importantly, prior art bike shoe designers did not consider the necessity of designing the bike shoe for holding the shoe in a stable position in contact with the pedal while the bicycle is riding over rough terrain during competition. In addition, the prior art bike shoe designers did not adequately consider the importance of designing the shoe to provide for the maximum transfer of power between the bike shoe and the pedal.

The patent to Haver U.S. Pat. No. 4,188,737 which superficially resembles Applicant's bike shoe has the advantage that it is reasonably comfortable to walk on and does not mar or scratch floor surfaces. Its disadvantage from the standpoint of Moto Cross competition is that it does not hold the bike shoe in a stable position in contact with the pedal and the location of the shoe with respect to the pedal does not provide for the maximum transfer of power.

The reason that the bike shoe shown in the Haver patent does not hold the bike shoe in a stable position over the pedal is that the walls of the Haver recess slope inwardly and upwardly. This arrangement permits the pedal to pivot inside the bike shoe recess. Consequently, during competition, while racing over rough terrain, the pedal can easily slip out of the recess so that time is lost while the rider is trying to reposition his feet on the pedal. This is admitted by Haver in his patent, when he states that his structure permits "easy disengagement of the pedal from the recess." This is the exact opposite of what is needed in competitive racing. Moreover, Haver does not locate his recess in alignment with the ball of the foot, which is also necessary for the maximum transfer of power.

The bike shoe described herein provides a stable relationship between the bike shoe and the pedal because the walls of the recess are perpendicular to the plane of the base of the recess and are spaced apart a distance generally equal to the width of the pedal to hold the pedal inside the recess. Consequently, the bike shoe cannot pivot inside the recess. With the recess in the shoe aligned with the ball of the foot, the foot does not exert any torque action on the pedal because the force from the foot is directed perpendicular to the surface of the pedal while the pedal is held parallel to the surface of the ground. This maximizes the transfer of power from the foot of the rider to the pedal of the bike. The reason is, if the center of the recess is located too far back from the center of the ball of the foot, the foot of the bike rider would have to be rotated upwardly in order to keep the pedal in the recess and if the center of the recess is located too far forward of the center of the ball of the foot, the foot would have to be rotated downward to keep the pedal in the recess. In either case, this would decrease power transmitted from the foot of the bike rider to the pedal of the bike.

What is needed therefore, and comprises an important object of this invention is to provide a bike shoe with a recess formed in the sole of the shoe which is sized to snugly embrace a bike pedal and which is located so when the rider wears the shoe, the center of the ball of the foot is aligned with the center of the recess.

This and other objects of this invention will become more apparent when better understood in the light of the accompanying specification and drawing wherein:

FIG. 1 is an elevational view of the bike shoe constructed according to the principles of this invention, disclosing a bike shoe with a pedal receiving recess formed in the sole of the shoe and showing the relationship between the ball of the foot inside the shoe and the pedal receiving recess.

FIG. 2 is a bottom view of the shoe shown in FIG. 1, disclosing the recess in the sole of the shoe sized to receive a pedal which has straight parallel sides.

FIG. 3 is a bottom view of a modified bike shoe showing a recess in the sole of the shoe shaped to conform to a pedal having curved sides, so that the curved sides of the pedal when in the recess will be coextensive with and gripped by the walls of the recess.

FIG. 4 discloses an elevational view of a modified bike shoe provided with a reinforcing shield mounted in the sole of the shoe above the base of the recess, both for controlling the resilence of the shoe and for protecting the foot of the bike rider.

Referring now to FIG. 1 of the drawing, a bike shoe indicated generally by the reference numeral 10 includes an upper portion 12 and a lower portion 14 preferably formed from an elastomeric material. The bottom of the sole of the shoe 15 is provided with a recess 16 extending from the opposite sides of the sole and defining a channel which in this embodiment is transverse to the sides of the shoe. This recess is defined by generally planar front and rear walls 18 and 20 which are transverse to a base 22. Base 22 is generally parallel to and in upwardly spaced relationship to the bottom of the sole. The front and rear walls 18 and 20 are spaced apart a distance corresponding to the width of the pedal, shown in phantom lines in FIG. 1 to provide a stable seat for the pedal inside the recess. With this arrangement, the opposite sides of the pedal will be in

frictional engagement with the sides of the elastomeric walls 18 and 20 of the recess causing them to grip the sides of the pedal. Moreover, since the base of the recess is formed from an elastomeric material, the serrations on the edges of pedals used in Moto Cross competition become embedded in this elastomeric material. This further limits side to side movement of the pedal in the recess. These embedded serrations also prevent or minimize front and rear movement of the pedal inside the recess. With this arrangement, the pedal which will not pivot inside the recess so that the pedal will be snugly gripped in the recess and will be held in a stable position during competition.

Each shoe size has an inner sole portion 24 which receives the ball of the foot of the wearer. This determines the position of the recess 16 which must be located so that the center 26 of the ball of the foot is aligned with the center of the recess (see FIG. 1). With this arrangement, force exerted by the foot of the bike rider is directed perpendicular to the pedal. Consequently, maximum transfer of power from the bike rider to the pedal of the bike is achieved.

Pedals currently in use on bikes used in Moto Cross competition have two shapes. One pedal shape has straight parallel sides as shown in phantom lines in FIG. 2. The other pedal shape has curved sides, see FIG. 3. The recess 16 is designed so the sides of the pedal will be coextensive with and will frictionally engage the walls of the recess to help retain the pedal in the recess during competition. This explains why the recess shown in FIG. 3 has curved sides 27 and 28 while the recess shown in FIG. 1 has straight sides.

As shown in FIG. 1, during competition, the front and rear of the shoe tends to bend or curve around the pedal. This helps achieve a better transfer of power from the foot of the rider to the pedal. In order to optimize this bending, a support 30 as shown in FIG. 4, formed from some suitably resilient material, and in the form of a plate, is embedded in the lower portion 14 parallel to and in upwardly spaced relation to the base 22 of the recess. The materials of the plate is selected to control the resilence of the shoe and the bending of the shoe around the pedal during competition. In addition, the plate has the added function of protecting the sole of the feet in the event the lower portion of the shoe fails during competition. Without this protective plate, and in the event of a failure of the lower portion 14 during intensive competition, the serrations on the edge of the pedal could come in contact with and lacerate the soles of the feet of the rider.

Having described the invention that I claim as new is:

1. A bike shoe for Moto Cross competition comprising an upper portion sized to receive a foot and an attached lower portion, said lower portion having a channel-like pedal embracing recess extending from the sides of the shoe, said recess defined by front and rear walls and a transverse inwardly and upwardly spaced base portion, said walls spaced apart a distance generally equal to the width of the pedal to provide a stable seat for the pedal in the recess and so when a pedal is in the recess, the walls of the recess grip the pedal and releasably keep the pedal in the recess, said recess during hard pedal positioned so the center of the recess is aligned with the center of the inner surface of the portion of the shoe which receives the ball of the foot, whereby the center of the ball of a foot of the bike rider is aligned with the center of the recess.

2. The bike shoe described in claim 1 wherein at least the walls of the recess in said lower portion are formed from an elastomeric material whereby the engagement between the said walls and the sides of the pedal cause the walls to grip the sides of the pedal to prevent side to side movement of the pedal in the recess to releasably retain the pedal in the recess in the bike shoe during hard pedaling yet permitting the shoe to be pulled off the pedal if the bicycle falls during competition.

3. The bike shoe described in claim 2 wherein at least the base of the recess is formed from an elastomeric material so when the pedal is in said recess, serrations on the edge of the pedal become embedded in said elastomeric material, thereby preventing side to side and front and back movement of the pedal inside said recess whereby the pedal is releasably retained in the recess in the bike shoe during hard pedaling.

4. The bike shoe described in claim 1 including combined means for controlling the resilence of the bike shoe and for protecting the base of the foot of the bike rider from injury by the pedal in the event the lower portion of the bike shoe fails during competition.

5. The bike shoe described in claim 4 wherein said combined means comprises a resilient plate embedded in the lower portion of the shoe in upwardly spaced relationship to the base of the recess and parallel thereto.

6. The bike shoe described in claim 3 wherein the front and rear walls of the recess are straight and parallel to each other to accommodate pedals having parallel straight sides.

7. The bike shoe described in claim 3 wherein the front and rear walls of the recess are curved to accommodate pedals whose front and rear sides are similarly curved whereby the engagement between the curved front and rear walls of the recess and the curved front and rear sides of the pedals retain the pedal in the recess.

8. A bike shoe of the class described comprising an upper portion sized to receive a foot and an attached lower portion, said lower portion formed with a pedal embracing recess extending from the sides of the shoe, said recess defined by front and rear walls and a transverse inwardly and upwardly spaced base portion, said walls spaced apart a distance generally equal to the width of the pedal to provide a stable seat for the pedal in the recess and so the walls of the recess can grip the pedal and help keep the pedal in the recess, at least the base of the recess formed from an elastomeric material so metal serrations on the pedal of the bike can bite into the elastomeric material thereby preventing side to side and front and back movement of the pedal in the recess so that the pedal is releasably held in said recess during hard pedaling, said recess positioned in said lower portion so the center of the recess is aligned with the portion of the inner surface of the shoe which receives the ball of the foot in such a way that the center of the recess is aligned with the center of the ball of the foot of the bike rider for maximum transfer of power from the bike rider to the pedal of the bike.

9. The bike shoe described in claim 8 wherein the walls of the recess are formed from an elastomeric material to help grip the sides of the pedal to further limit side to side movement of the pedal in said recess to thereby help retain the pedal in the recess during competition, yet permitting the shoe to be pulled off the pedal in the event the bicycle falls during competition.

10. The bike shoe described in claim 9 including a resilient plate embedded in the lower portion of the shoe in upwardly spaced relationship to the base of the recess and parallel thereto for protecting the bottom of the foot of the bike rider from injury from the pedal in the event the lower portion of the bike shoe fails during competition, the resilence of said plate selected to control the bending of said shoe around the pedal during competition.

* * * * *

pedal-rec

A-5/5

VANDENBERG ENTERPRISES
Marine Products Division
139 Leslie Ct,
Banning, Ca 92220

&

FULL THROTTLE FLOT
7413 Slater Ave.
Huntington Beach,

LIFESEAT®

UL UNDERWRITERS LABORATORY APPROVED

U.S. COAST GUARD APPROVED TYPE 4 PFD

THROWABLE LIFE SAVING CUSHIONS

AIREX

COMFORTABLE U.S.C.G. approved, bouyant closed cell Airex foam is ideal for replacing those old worn out cushions. These will not collapse!

SAFETY: First major change to a Type 4 PFD in over 100 years!

TWO LIFESEATS TOGETHER form a tote bag on the boat or in the water. Works great as an on deck emergency kit for Flare Gun, Flash Light, and First Aid Kit.

EASILY ASSEMBLED with Marine Velcro on 3 sides, with 2 straps for carring.

THREE OR MORE LIFESEATS will form a life saving raft! Helps prevent hypothermia.

U.S. Patent No. 4822309

EASY ASSEMBLY WITH MARINE VELCRO

AS A LIFE SAVING RAFT!

FOR SAFETY OR RECREATION

VANDENBERG ENTERPRISES
Marine Products Division
139 Leslie Ct,
Banning, Ca 92220

&

FULL THROTTLE FLOTATION
7413 Slater Ave.
Huntington Beach, Ca 9

J. Golding

Life Preserver.

No. 65,901. Patented Jun. 18, 1867.

Fig. 1

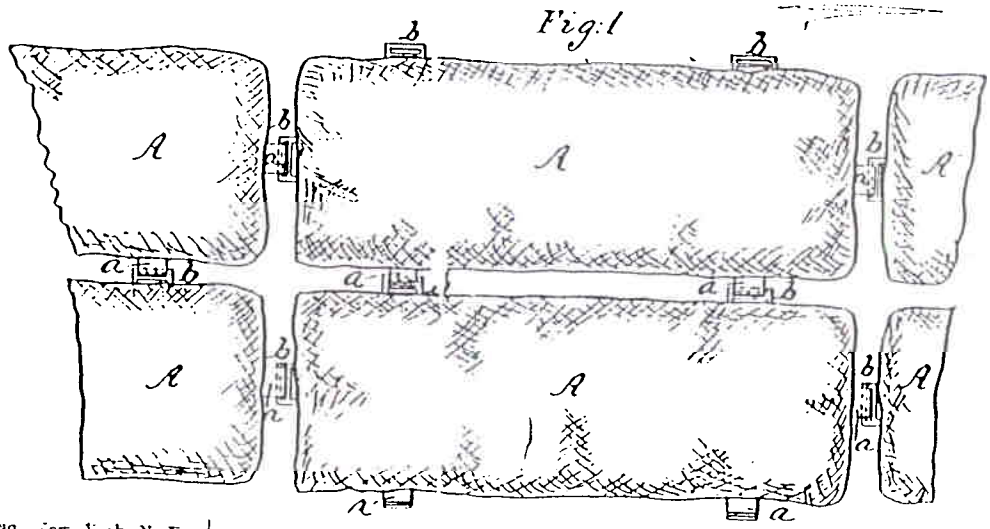
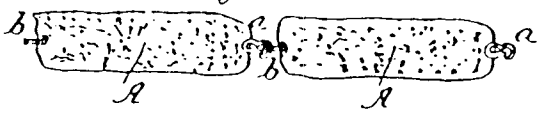


Fig. 2



65,901.—John Golding, New York, N. Y.—*Life Preserving Mattress.*—June 18, 1867.—Explained by the claim and illustration.

Claim.—The life raft constructed as described, consisting of the cork mattresses or floats, secured together by means of the spring hooks *a*, and staples *b*, as herein set forth for the purpose specified.

Witnesses

Thos Tuseke

J. A. Service

Inventor

John Golding

Per Munn & Co.

Attorneys

B-2/11

C. THOMAS
T-531
4/30/84

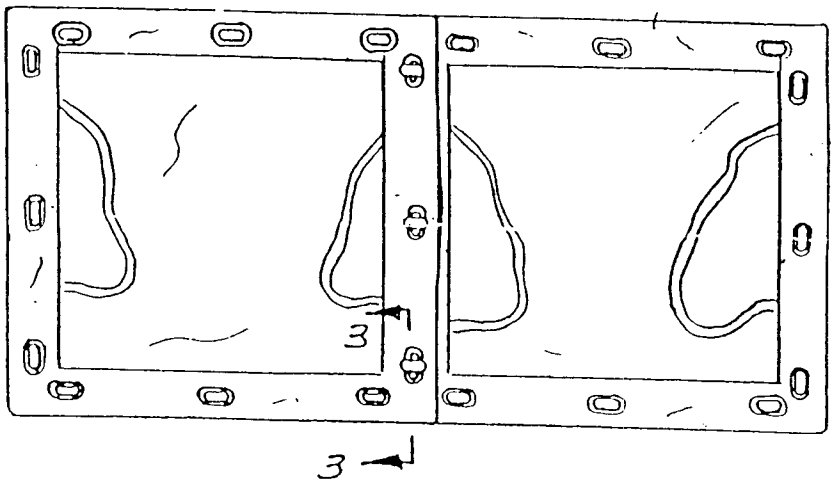


FIG 1

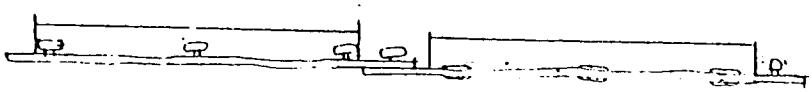


FIG. 2

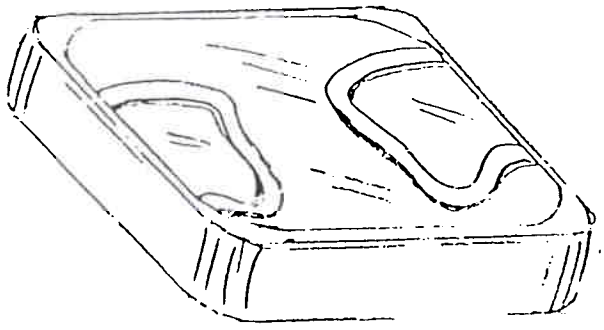


FIG. 3

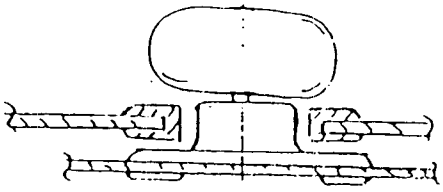


FIG. 4

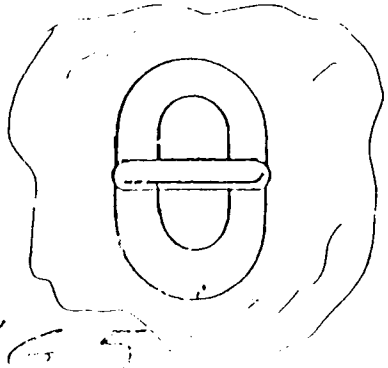


FIG. 5

B-3/11

United States Patent [19]

Vandenberg

[11] Patent Number: 4,822,309

[45] Date of Patent: Apr. 18, 1989

[54] COMBINED LIFE PRESERVER CUSHION AND TOTE BAG

[76] Inventor: John A. Vandenberg, 3186 Petaluma Ave., Long Beach, Calif. 90808

[21] Appl. No.: 59,324

[22] Filed: Jun. 8, 1987

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 832,037, Feb. 21, 1986, abandoned.

[51] Int. Cl.[4] A45C 9/00

[52] U.S. Cl. 441/35; 441/125; 297/180; 5/465

[58] Field of Search 441/35, 80, 125, 126, 441/127, 129, 130; 24/591; 5/462, 465, 466; 150/55, 106; 297/456, 250, 216, 217, 188

[56] References Cited

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4,242,767	1/1981	McMullen et al.	5/465
4,459,714	7/1984	Lin	5/465

Primary Examiner—Joseph F. Peters, Jr.
Assistant Examiner—Edwin L. Swinehart
Attorney, Agent, or Firm—Julius Rubinstein

[57] ABSTRACT

The invention comprises generally square buoyant cushions. A separate fabric skirt is attached to each side of each cushion. Each skirt has fastening means so the skirts on one cushion can be fastened to the skirts on another cushion. If the cushions are stacked one on top of another, and the skirts of the stacked cushions are connected together, the skirts are sufficiently long so the buoyant compartment formed by the facing surfaces of the cushions and the connected skirts of the cushions will have sufficient volume for storing emergency supplies. In another configuration the skirts on the cushions can be connected together in side by side relationship to form a chain of buoyant cushions or a raft which can support a number of people so they will not drift apart in the water.

11 Claims, 3 Drawing Sheets

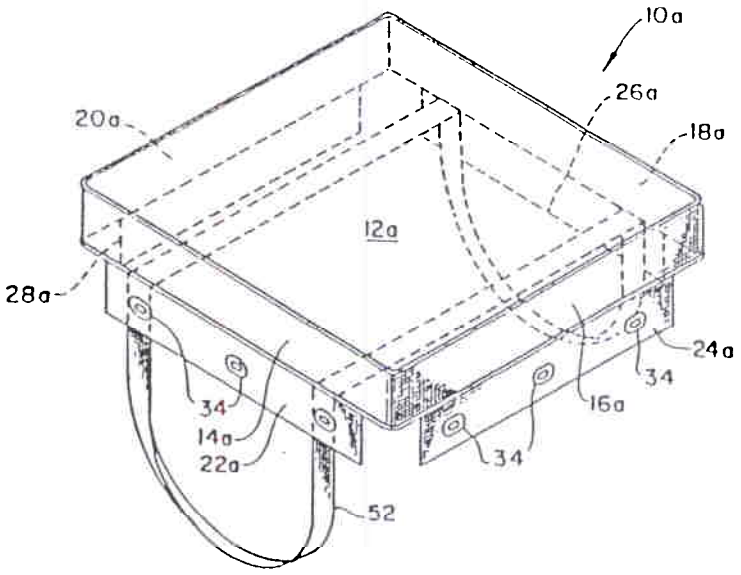


FIG. 1.

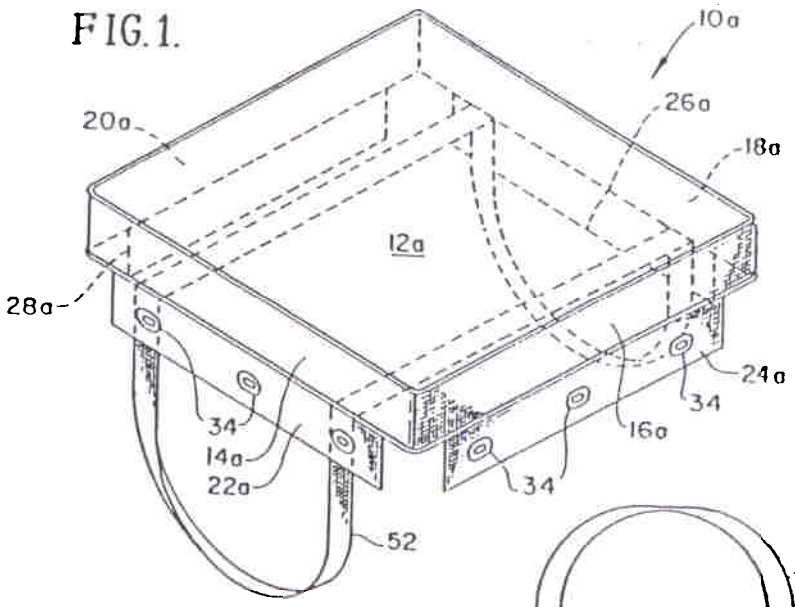
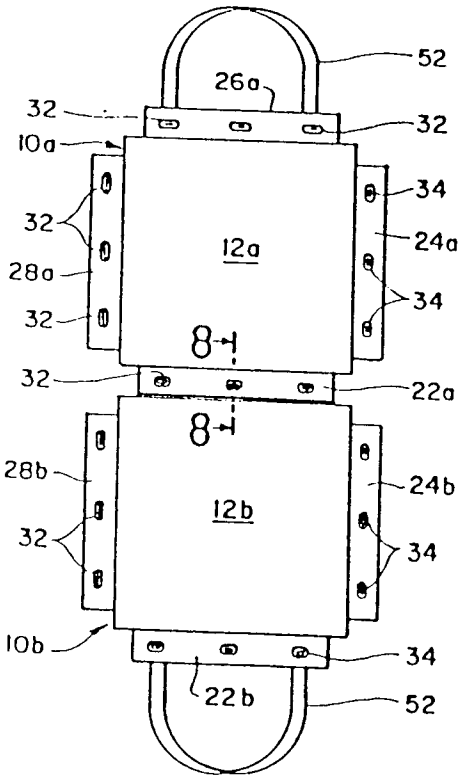


FIG. 3.



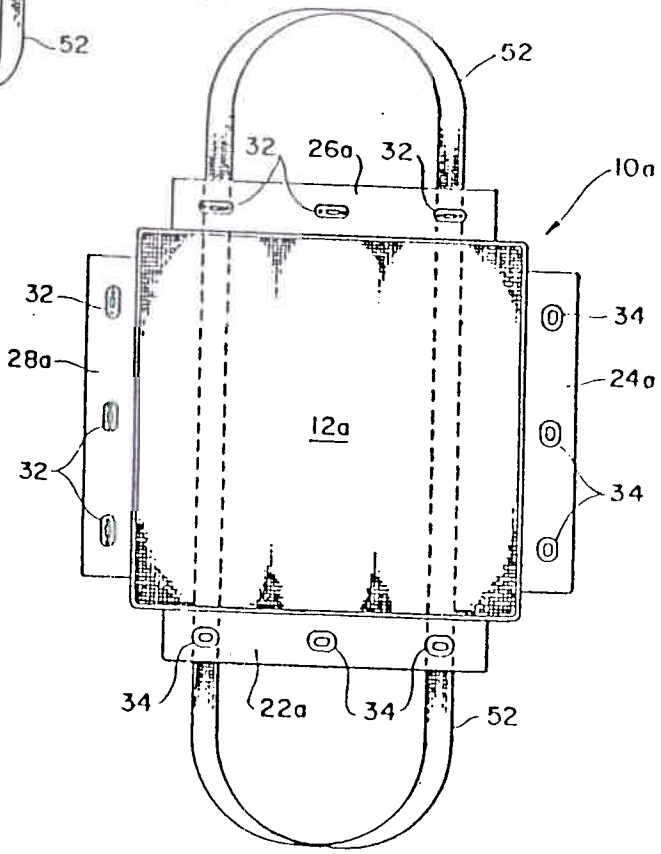


FIG. 2.

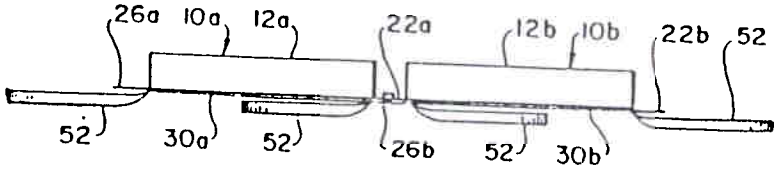


FIG. 4.

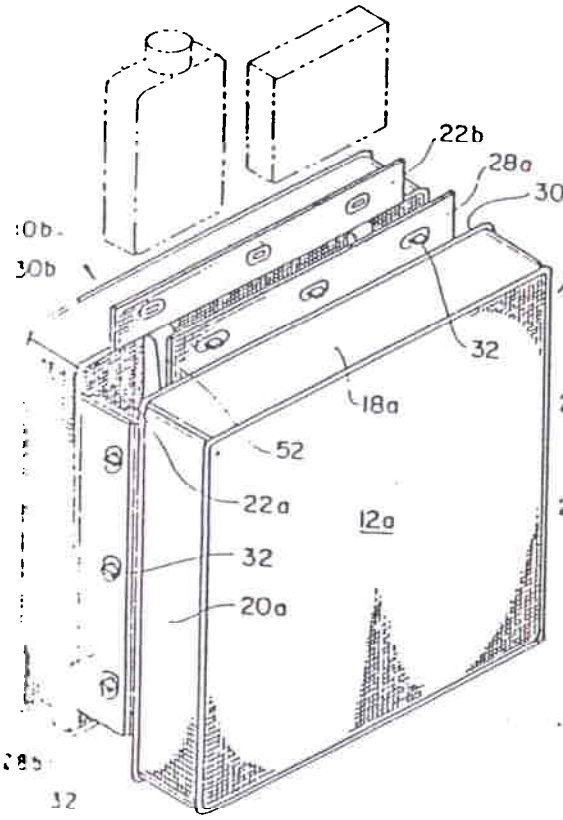


FIG. 5.

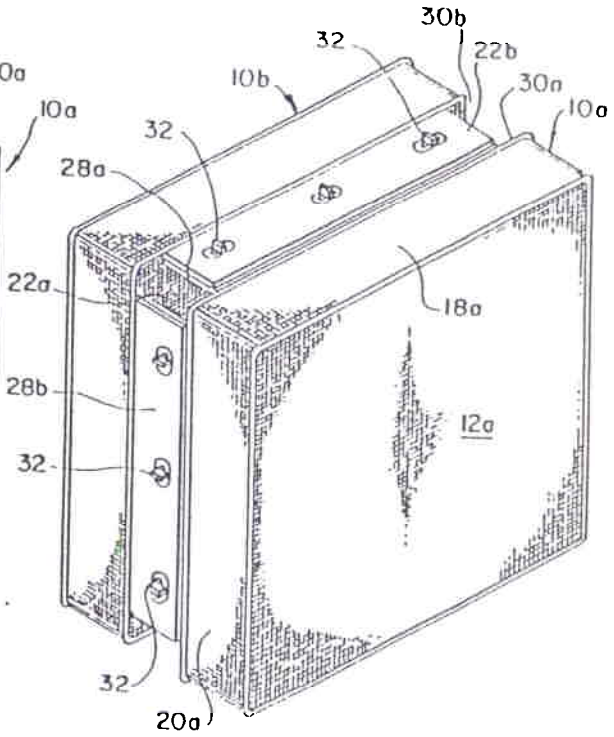


FIG. 6.

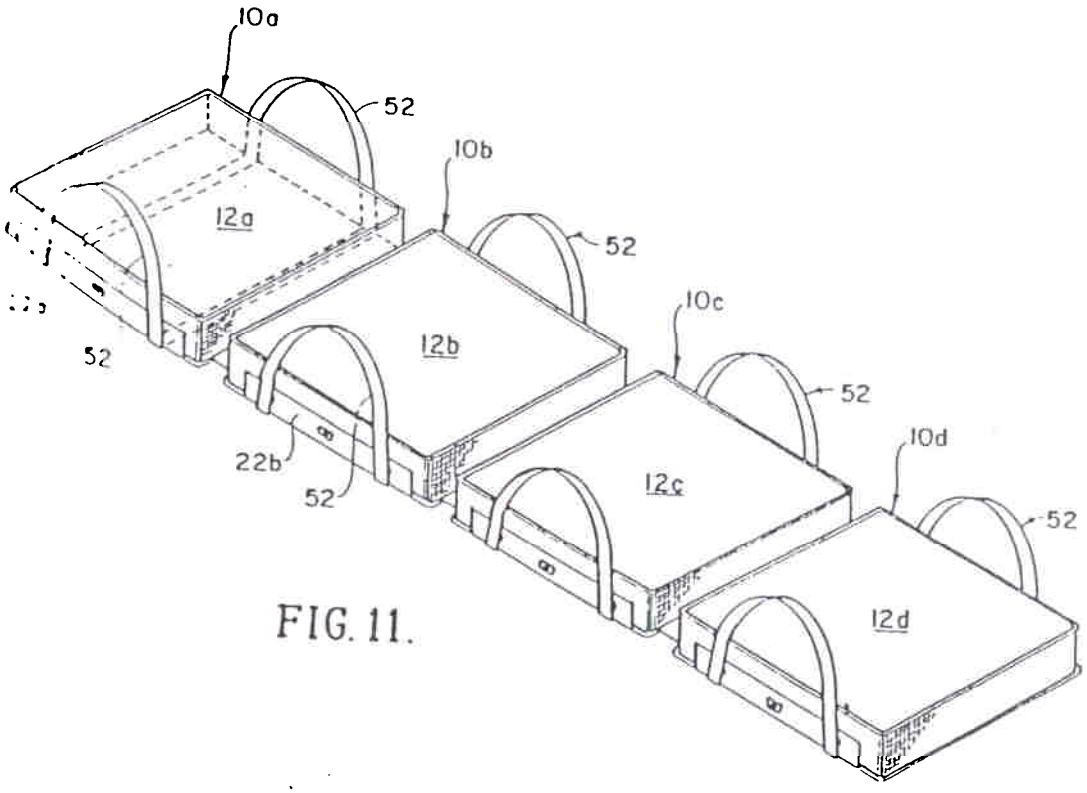


FIG. 11.

FIG. 7.

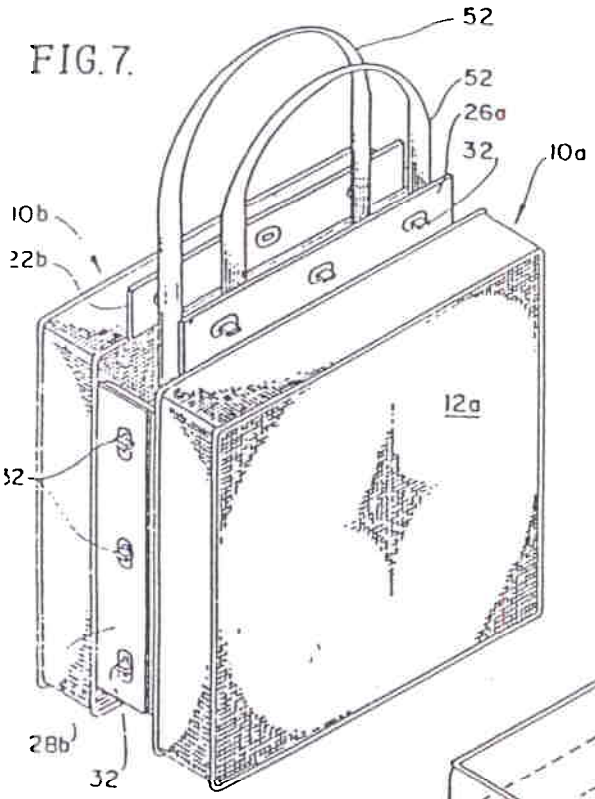


FIG. 7a.

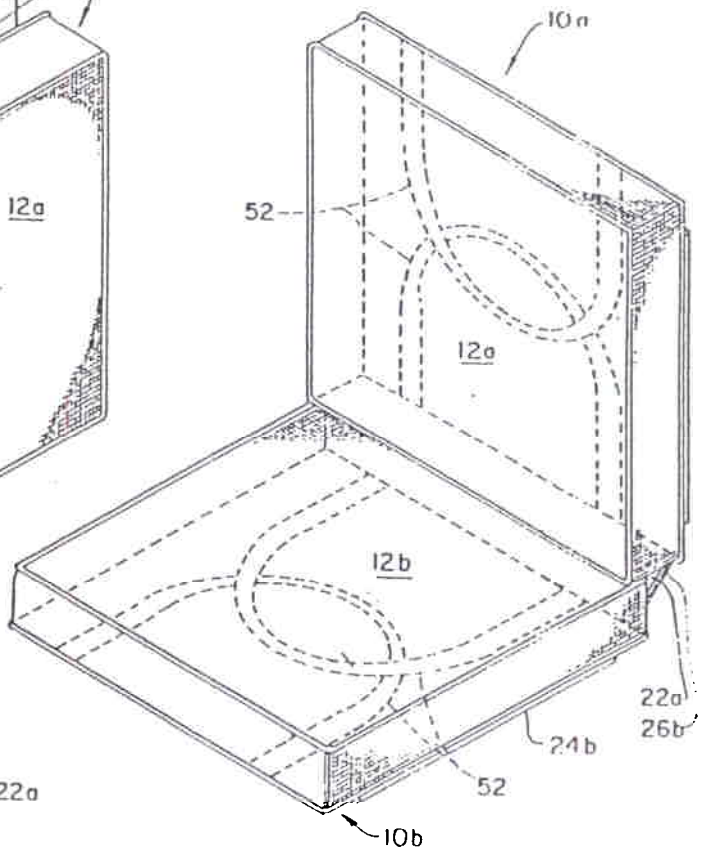
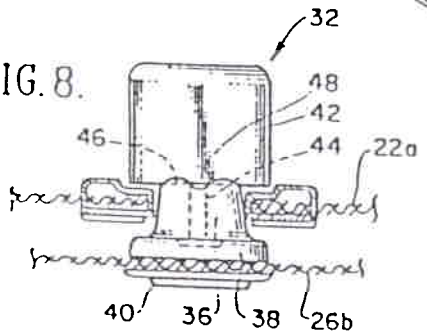


FIG. 8.



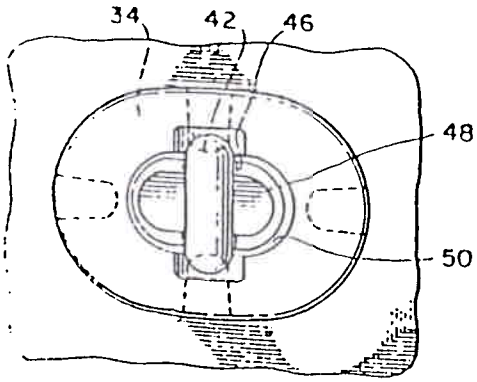


FIG. 9.

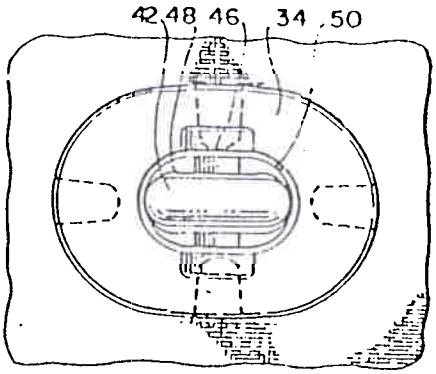


FIG. 10.

COMBINED LIFE PRESERVER CUSHION AND TOTE BAG

This is a continuation in part of patent application Ser. No. 832,037 filed Feb. 21, 1986 now abandoned.

This invention relates generally to buoyant life preserver cushions which can be connected together to form a chain of cushions or a buoyant compartment for storing emergency supplies, or which can be connected together to form a tote bag which can carry blankets and food and beverages and which can be reconnected in such a way that one cushion serves as a seat cushion and the other cushion serves as a cushioned back rest.

PRIOR ART AND BACKGROUND OF INVENTION

Life preserver cushions have long been used in boats. Some as exemplified by the patent to Golding U.S. Pat. No. 65901 and Wood U.S. Pat. No. 264814 are designed to be connected together and can form a raft sufficient in size to support a number of persons and to carry emergency provisions.

Typically the life preserver cushions have a buoyant polyethelene foam core positioned inside a surrounding cover of water impervious material. When not used in an emergency situation they serve as cushions on the boat. The advantage of this use is that they are kept above deck so that in an emergency they can, as exemplified by the patents cited above, be connected together and thrown in the water where they can support a number of persons.

The advantage of using floatation cushions that can be connected together is that in an emergency situation the people in the water clinging to the connected cushions will stay together where they can help each other, and they will be more visible. Consequently, they can be more easily found be searchers, than a single person holding on to a single seat cushion.

However emergencies can happen very fast, and when a boat has to be abandoned there may be no time to gather emergency supplies.

There may be only enough time to abandon ship and cling to the cushions. Once in the water the persons clinging to the cushions may be able to connect the cushions together.

SUMMARY OF INVENTION

The present invention is a rectangular seat cushion designed to be used as a life preserver. The seat cushion is formed from a polyethelene foam pad encased in a water impervious fabric cover. In addition, the cushion is provided with a fabric border or skirt extending outwardly from all four sides of the pad. In this particular embodiment, male fasteners are located on two adjacent skirts of the pad, and female fasteners are located on the remaining adjacent skirts of the pad. The male and female fasteners are designed to be releasably interlocked with each other. In this way an unlimited number of seat cushions can be connected together to form a life raft or a chain of cushions.

In an alternate arrangement, two cushions can be stacked one on top of the other in such a way that the skirts of one cushion can be interlocked with the skirts of the other cushion to form a storage compartment defined by the facing surfaces of the cushions and the connected skirts of the cushions which form the walls of the compartment. This compartment would be filled with emergency supplies, prior to need. In this way if an emergency occured, the connected stacked cushions when thrown in the water would contain emergency supplies such as flares, a radio transmitter, and some food and water where it would serve as a flotation device and a floating container for emergency supplies.

In another use, cushions, which need not be buoyant, can be connected together to form a tote bag filled with a blanket and food and beverages. In this use, the tote bag would be carried, for example, to a football game, and the cushions separated in such a way that one cushion serves as seat cushion, and the other cushion serves as a cushioned back rest. Alternatively the cushions can be completely seperated so both serve as seat cushions while the blanket and supplies carried in the compartment are available for us.

The above described objects of this invention along with other objects will become more apparent when better understood in the light of the accompanying specification and drawings wherein:

FIG. 1 is a perspective view of a single seat cushion constructed according to the principles of this invention.

FIG. 2 is a top plan view of the cushion shown in FIG. 1.

FIG. 3 is a top plan view of two cushions connected together.

FIG. 4 is a side elevational view of the cushions shown in FIG. 3.

FIG. 5 is a perspective view of two cushions connected together to form a compartment for emergency supplies with two skirts left unconnected and serving as the opening to the container.

FIG. 6 is a perspective view of the cushions shown in FIG. 5 but with the skirts forming the opening to the container connected together closing off the compartment and securing the emergency supplies in the compartment.

FIG. 7 is a perspective view disclosing another use of the cushions wherein they are connected together to form a tote bag.

FIG. 7*a* is a perspective view of the cushions shown in FIG. 7 wherein the tote bag has been disconnected in such a way as to form a cushioned seat and back rest.

FIG. 8 is an enlarged sectional detail taken on the line 8—8 of FIG. 3.

FIG. 9 is an enlarged top plan view of the male and female fasteners connected together in a locked condition.

FIG. 10 is an enlarged top plan view of the male and female fasteners shown in FIG. 9 in an unlocked condition.

FIG. 11 discloses another use of the cushions wherein a plurality of cushions are connected together to form an emergency stretcher or litter for carrying disabled persons.

Referring now to FIG. 1 of the drawing, a single floatation cushion indicated generally by the reference numeral 10*a*, comprises a generally planar surface 12*a*, side surfaces 14*a*, 16*a*, 18*a*, 20*a*, and a generally planar bottom surface 30*a*, see FIG. 1 and 4. As seen in FIG. 2, the cushion is generally square in shape and is constructed from a buoyant pad of polyethelene foam encased in a canvas cover. In the embodiment shown, the cushion is approximately fifteen inches on a side and three inches in thickness.

As shown in FIG. 2 four generally rectangular, fabric skirts 22*a*, 24*a*, 26*a*, and 28*a*, formed from a canvas like

material extend out from each side of the cushion about two inches and in the same plane as the bottom surface 30*a*, see FIG. 4. As seen in FIG. 3, the length of the skirts connected to the edge of the bottom surface of the cushion are no longer than the length of the connected edge of the bottom surface of the cushion, and in this embodiment are substantially shorter. This permits the skirts to be bent individually without affecting the other skirts.

The skirts 26*a* and 28*a* at adjacent sides or corners of the cushion are provided, in this particular embodiment, with male fastening members 32, while skirts 22*a* and 24*a* at the opposite sides or corners of the cushion are provided with female fastening members 34. In this particular embodiment, each skirt is provided with three fastening members, either male or female although, under some circumstances a different number may be provided. In addition canvas straps 52 are attached to the bottom surface 30*a* extending, in this embodiment, from opposite sides of the cushion to provide hand holds or arm holds for a person in the water, see FIG. 2.

Each male fastening member 32 comprises an upstanding pedestal 36 which rises from a base 38. The base 38 is securely attached to a skirt by means of a pair of rivet connections 40. Each male fastener 32 has an elongated flat, narrow twistable head 42 which is rotatably mounted relative to the pedestal 36 by means of an integral vertical connecting post 44 which is rotatably mounted in the upper surface of the pedestal 36. see FIGS. 9 and 10. The twistable head seats in either of two perpendicular pairs of grooves or detent depressions 46 and 48 formed in the upper surface of the pedestal. With this arrangement the twistable head will tend to remain in one or the the other of the orthogonal positions. Moreover, this arrangement permits the head 42 to be twisted to the correct position in the dark, because when the head is rotated the person making the connection can feel when the head is aligned properly with the groove.

Each female fastening member 34 is a reinforced grommet or eyelet having an elongated opening 50 extending therethrough and having a length sufficient to accomodate insertion of the head 42 of the male fastening members 32 when the head 42 is aligned lengthwise with the opening 50 as illustrated in FIG. 10. When the head 42 is twisted perpendicular to the alignment with the opening 50, as depicted in FIG. 9, it is releasably locked to the female fastening member 34. In this position, the head 42 resides in registration with the detent depression 46*b* in the upper surface of the grommet 34.

The cushions are normally used as seat cushions in a boat. In the event the boat capsizes or sinks the cushions will bob to the surface and a person in the water can bring two of the cushions together and sequentially align each male fastening member on one skirt to a female fastening member on a skirt on another cusihon and then insert the head 42 of the male fastening member on one cushion into the opening 50 in the female member on another cushion. Then the head 42 would be twisted so it is at right angles to the opening. In this way, any number of cushions can be connected together to form a life raft or a chain of cushions, as illustrated in FIG. 11. By way of illustration, two cushions 10*a* and 10*b* are connected together see FIGS. 3 and 4 with the heads 42 on skirt 26*b* attached to cushion 10*b* inserted in the openings 50 in skirt 24*a* attached to cushion 10*a* to hold the cushions together.

As stated above, emergencies can happen very fast, as when a boat suddenly capsizes or sinks and there may be no time to gather emergency supplies. In anticipation of such an event, two cushions can be connected together, one on top of the other, to form a compartment for the storage of emergency supplies as shown in FIG. 5 and 6. In this configuration, the cushions are stacked so surface 30*a* on cushion 10*a* and surface 30*b* on cushion 10*b* face each other. The male fastening members on skirt 28*b* attached to cushion 10*b* are connected to the female fastening members on skirt 22*a* attached to cushion 10*a*. The male fastening members 26*b* attached to cushion 10*b* are connected to the female fastening members on skirt 24*a* attached to cushion 10*a*. The male fastening members on skirt 26*a* attached to cushion 10*a* are connected to the female fastening members on skirt 24*b* attached to cushion 10*b*, leaving skirts 22*b* attached to cushion 10*b* and skirts 28*a* attached to cushion 10*a* unconnected to serve as the opening for the insertion or the emergency supplies indicated in dotted lines in FIG. 5.

When all the emergency supplies have been stored, the male fastening members on skirt 28*a* attached to cushion 10*a* are connected to the female fastening members on skirt 22*b* attached to cushion 10*b* to hold the emergency supplies in the compartment defined by the facing surfaces 30*a* and 30*b*, and the walls of the compartment defined by the connected skirts as shown in FIG. 5 and 6. It is understood that the size of the containers holding the emergency supplies is larger than the openings at the corners of the compartment so that supplies stored in the compartment cannot fall out.

In this particular embodiment the cushions are about fifteen inches on each side and the skirts are about two inches long. Consequently the compartment formed by connecting the cushions as shown in FIGS. 5 and 6 would have a volume of about 450 cubic inches which is large enough to store flares, an emergency radio, a flashlight, and some high energy food. If required the size of the compartment could be varied by changing the size of the cushions or the length of the skirts.

When the cushions are stacked as shown in FIGS. 6 with the emergency supplies in the compartment described above, the cushions could still be used to sit on. But in an emergency as when the boat capsizes, the stacked cushions with the emergency supplies stored in the compartment would bob to the surface of the water where they could be used by persons in the water.

A land use of the cushions described above is contemplated. In this use two cushions are connected to form a combined tote bag and seat and back cushion as shown in FIGS. 7 and 7*a*. In this use, the cushions are connected together on three sides with the strap members fastened and assembled as shown in FIG. 7 positioned to be used as hand grips for the tote bag. A blanket and food and beverages may be carried in the compartment of the tote bag. If the tote bag formed this way were taken, for example, to a football game, the cushions would be separated to form a cushioned seat and cushioned back rest or two seperate cushioned seats and the blanket and other supplies, such as food and beverages would be conveniently available.

In addition, although the drawings disclose a pair of identical rectangular cushions, it is contemplated that the cushions could have shapes which are not rectangular and with pairs of cushions which are not identical.

For example, the cushions could be circular having peripheral skirts which extend out beyond the periphery of the cushion far enough so they can be connected to the peripheral skirts on another cushion. Moreover although the skirts are described as formed from a fabric, other materials which are not fabric or flexible, are contemplated. For example the skirts could be formed from a rigid plastic connected to the periphery of the cushion by a narrow strip of fabric or by stitching or by glue.

It is also noted that the invention could be practiced using only one cushion. Referring to FIG. 5 it is evident that if cushion 10*a* were decreased in thickness until it was a thin sheet of fabric or a plastic like material, with the skirts 22*a*, 24*a*, 26*a*, and 28*a*, attached to it, the sheet 10*a* would become the cover of the compartment. In this way either an aquatic safety device or a tote bag having a storage compartment could be formed using one cushion and a cover.

Having described the invention what I claim as new is:

1. A combined aquatic safety device and tote bag comprising a pair of rectangular buoyant cushions stacked one on top of the other, each cushion comprising a top surface and a generally rectangular planar bottom surface, said top and bottom surfaces on each cushion connected together by four side surfaces, the bottom planar surfaces on the stacked cushions facing each other, four separate rectangular skirts on each cushion extending out beyond each of the four edges of the said bottom surface of the cushion, the length of the part of the skirt connected to each edge of the bottom surface of a cushion selected so each skirt can be bent transverse with respect to the bottom surface of the cushion without affecting the other skirts, means on each skirt on one stacked cushion adapted to be connected to another skirt on the other cushion, the width of each skirt sufficiently long so that if the cushions are stacked one on top of the other and the skirts are bent transverse to the bottom surface of the cushion so the skirts extend toward each other, and overlap each other enough to be attached together by said connecting means to form a supply compartment between the facing bottom surfaces of cushions with walls of the supply compartment defined by the overlapping connected skirts on the stacked cushions.

2. The aquatic safety device described in claim 1 wherein the top and bottom surfaces of each cushion are generally planar.

3. The aquatic safety device described in claim 1 wherein the connecting means include male fastening members secured to two of the skirts attached to each cushion and female fastening members are secured to the remaining two skirts on each cushion whereby the skirts on one cushion can be attached to the skirts on another cushion..

4. The aquatic safety device described in claim 3 wherein male fastening members are secured to adjacent skirts on one corner of the cushion and female fastening members are secured to the adjacent skirts at the opposite corner of the cushion, whereby the male fastening members secured to the skirts of one cushion may be attached to the skirts of another cushion so that any number of cushions can be connected together to form a raft.

5. The combined aquatic safety device described in claim 4 wherein said male fastening members comprise rotatably mounted heads, said rotatably mounted heads located at spaced intervals with respect to each other on two of the skirts of each cushion, a plurality of female fastening members on the remaining two skirts of each cushion, said female fastening members comprising head receiving openings extending through the skirt, the rotatably mounted heads on the skirts of one cushion adapted to penetrate the head receiving openings on the skirts of another cushion, the width of the rotatably mounted heads larger than the width of the head receiving openings so when a rotatably mounted head extends through a head receiving opening and is rotated transverse to said head receiving opening, the male and female fasteneing members are locked together to form a raft or a pair of stacked cushions with a compartment formed between them.

6. The aquatic safety device described in claim 5 including means associated with said male and female fastening members for feeling when the rotatably mounted head is transverse to the said head receiving openings whereby the rotatably mounted heads can be rotated transverse to the head receiving openings in the dark to lock the male and female fastening members together.

7. The aquatic safety device described in claim 6 wherein said means for locking and unlocking said male and female fastening members in the dark comprise transverse grooves associated with each rotatably mounted head, one groove aligned with a head receiving opening and one groove transverse to said head receiving opening, whereby when the rotatably mounted head in a head receiving opening is rotated so it is transverse to a head receiving opening and is in the groove transverse to said head receiving opening, the rotation of said head until said head engages the groove transverse to the length of the head receiving opening can be felt in the dark, whereby the male and female fastening members can be locked and unlocked in the dark.

8. The aquatic safety device described in claim 7 wherein each of said male fastening members comprises a pedestal, said pedestal having a top surface, said transverse grooves formed in the top surface of said pedestal, said rotatably mounted head having an integral post depending therefrom, said post rotatably mounted in said top surface of said pedestal.

9. An aquatic safety device comprising a plurality of rectangular buoyant cushions, each cushion comprising a rectangular top surface and a generally planar rectangular bottom surface, said top and bottom surfaces on each cushion connected together by four side surfaces, four separate rectangular skirts on each cushion, each rectangular skirt connected to an edge of the bottom surface of the cushion and substantially in the plane of the bottom surface of the cushion and extending out beyond the edge of said bottom surface of the cushion, means on each skirt on one cushion for attachment to another skirt on another cushion, the width of each skirt long enough so if the cushions are close enough together and the skirts extend toward each other in the plane of the bottom surface of the cushion, the skirts overlap each other sufficiently so the skirts can be attached together to hold the cushions in side by side relationship whereby the cushions form a raft formed from any number of cushions, so persons holding on to the raft will not drift apart.

10. A combined aquatic safety device and a tote bag comprising a pair of substantially identical rectangular buoyant cushions stacked one on top of the other, each

cushion positioned so the bottom surface of each cushion faces each other, said top and bottom surfaces connected to each other by four side surfaces attached to the edges of said top and bottom surfaces, separate rectangular skirts secured to each of the said bottom surfaces and extending out beyond each of the four edges of said bottom surface of each cushion, skirt fastening means relensably secured to each of the said skirts in such a way that the skirts on one cushion can be connected to the skirts on another cushion to form an emergency storage compartment defined by the facing bottom surfaces of cushions and side walls formed by the connected skirts of the cushions, a skirt of each cushion being initially unconnected together to serve as the mouth of the compartment so that supplies can be inserted in the compartment and then the pair of unconnected skirts can be connected together to close the mouth of the compartment to hold the supplies inside the compartment.

11. A combined aquatic safety device and tote bag comprising a pair of rectangular cushions stacked one on top of the other, said cushions having a top surface and a bottom surface, and stacked so the bottom surface of each cushion faces each other, said top and bottom surfaces connected together by four side surfaces, four separate rectangular skirts, each rectangular skirt connected to an edge of the bottom surface of the cushion and substantially in the plane of the bottom surface of the cushion and extending out beyond the edge of the bottom surface of the cushion, the length of the part of the skirt being connected to the edge of the bottom surface of the cushion in such a way that each skirt can be bent transverse with respect to the bottom surface of the cushion without affecting the other skirts, means on each skirt for connection to another skirt, the width of each skirt sufficiently long so that if the cushions are stacked one on top of the other and the skirts are bent transverse to the bottom surface of the cushion so the skirts on one cushion extend toward the skirts on another cushion, the skirts overlap each other enough so they can be connected together by said connecting means to form a supply compartment between the facing bottom surfaces of cushions with walls of the supply compartment defined by the said connected skirts, whereby blankets, food and beverages can be stored in said compartment, said means for connecting said skirts together arranged so the skirts can be partially disconnected to permit the stacked cushions to be opened transverse to each other so one cushion can serve as a cushioned seat and the other cushion can serve as a cushioned back rest, while the blanket, food and beverages carried in the compartment are available for use.

* * * * *

US005355241A

United States Patent [19]

Kelley

[11] Patent Number: 5,355,241

[45] Date of Patent: Oct. 11, 1994

[54] IDENTIFICATION FRIEND OR FOE DISCRIMINATOR

[76] Inventor: Clifford W. Kelley, 29414 Whitney Collins, Rancho Pales Verdes, Calif. 90274

[21] Appl No.: 100,299

[22] Filed: Aug. 2, 1993

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 804,011, Dec. 9, 1991, abandoned.

[51] Int. Cl.[5] H04B 10/00

[52] U.S. Cl. 359/170; 359/169; 342/45

[58] Field of Search 359/152, 154, 155, 169, 359/170; 350/4, 28; 342/45, 53, 54

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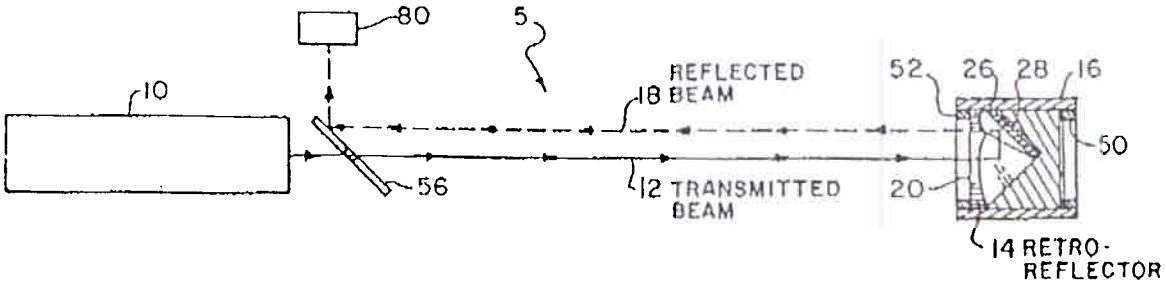
Primary Examiner—Richard E. Chilcot, Jr.
Assistant Examiner—Rafael Bacares
Attorney, Agent, or Firm—Julius Rubinstein

[57] ABSTRACT

An IFF device comprises a beam generator for directing an unmodulated beam at a target. The target has a plurality of retro-reflectors mounted on it. These retro-reflectors have internal reflecting surfaces for reflecting the unmodulated beam penetrating the retro-reflector. A device is associated with the internal reflecting surfaces for modulating the beam at a predetermined frequency so that the reflected beam emerging from the retro-reflector is modulated at the same frequency. A tuner is positioned in the path of the reflected modulated beam and tuned to predetermined frequency, so that if the tuner receives a signal, it indicates the target is friendly.

6 Claims, 2 Drawing Sheets



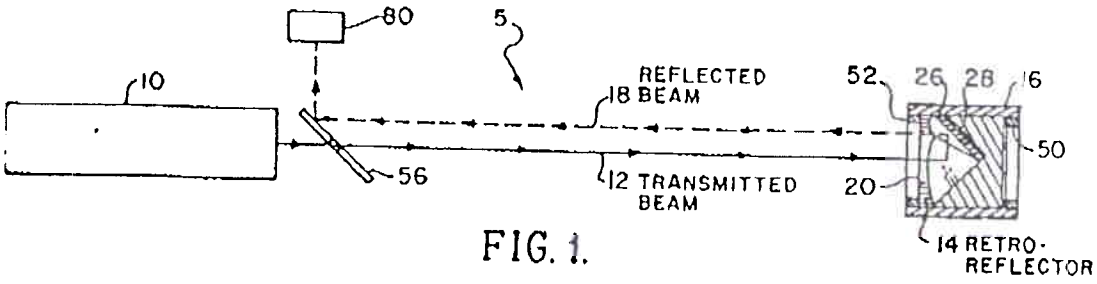


FIG. 1.

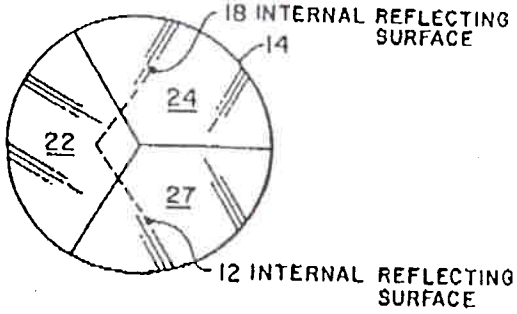


FIG. 2.

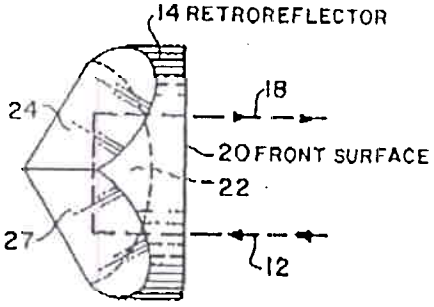


FIG. 3.

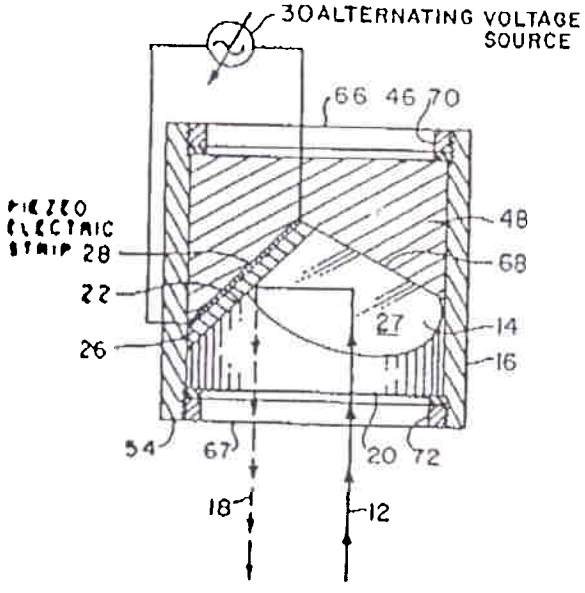


FIG. 4.

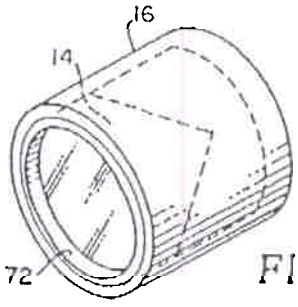


FIG. 5.

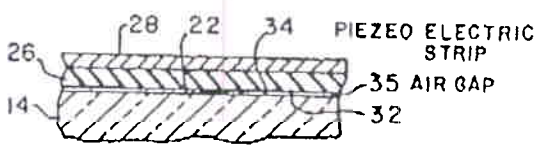


FIG. 6.

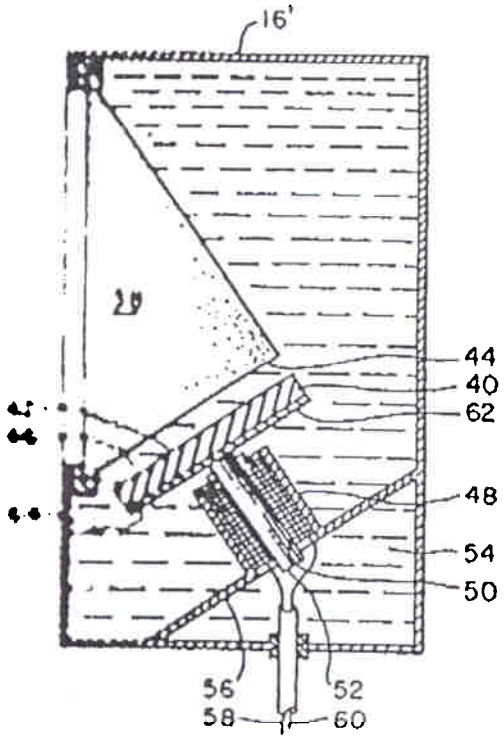


FIG. 7.

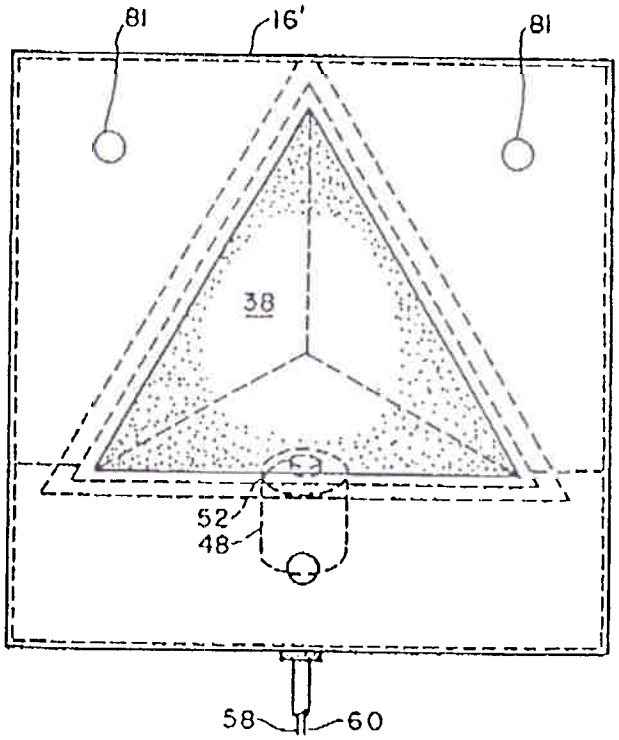


FIG. 8.

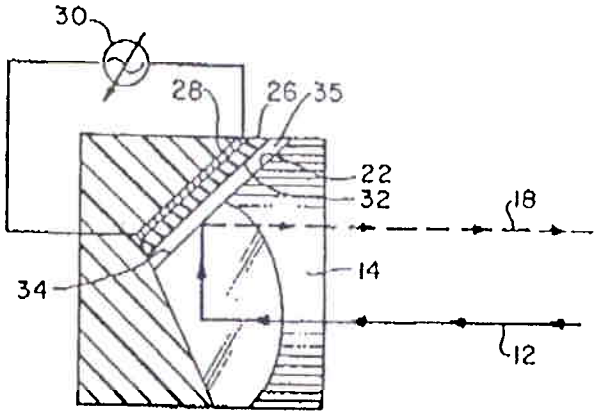


FIG. 9.

IDENTIFICATION FRIEND OR FOE DISCRIMINATOR

This patent application is a continuation in part of U.S. patent application Ser. No. 07/804,011 filed Dec. 9, 1991 now abandoned.

This invention relates to an identification friend or foe discriminator (hereafter referred to as an IFF device) and more particularly to a device which can discriminate between friendly and unfriendly military units, or between different friendly units.

FEDERALLY SPONSORED RESEARCH

No part of this patent application was developed with the aid of any federally sponsored research and development.

BACKGROUND AND RELATED ART

For military purposes it is often necessary to be able to determine whether unknown or unseen objects are friendly or unfriendly, and for civilian uses it may be necessary to be able to identify unknown objects. Because of this, a great deal of research has been done to find practical economically feasible solutions to these problems. The requirements of such a device are severe because the identification device must be able to function over a wide range of temperatures and over a broad frequency range.

DESCRIPTION OF PRIOR ART

Heretofore, as exemplified by the patent to Meyzonett et al U.S. Pat. No. 4,887,310 identification devices having means for modulating a reflected laser beam have been developed. But those previously developed were very expensive and not sensitive enough because their aperture was comparatively small and in military operations a target could be missed. In addition, there were the patents to Sepp, U.S. Pat. No. 4,731,879 and Kita, (Japanese) 2-233030 A, and Lego U.S. Pat. No. 4,131,791. These patents utilize liquid crystals to modulate a reflected beam. But liquid crystals are undesirable because of their temperature limitations and decreased reflectivity in a reflecting device, and any liquid crystal placed in front of a retro-reflector as in the Sepp patent decreases its sensitivity and acceptance angles. In contrast, the retro-reflector in applicants device receives an unmodulated beam which penetrates the retroreflector and reaches an internal reflecting surface and is there modulated. In addition and in contrast to the present invention, the index of refraction of the reflecting surfaces of these patents cited above plays no part in their operation.

This invention utilizes a property of a preferably glass retroreflector device which has a much larger aperture so that the target is much easier to find. These devices have the property that any laser, electromagnetic, or sound beam or ray entering the larger more effective aperture will be reflected and emerge from the entrance/exit parallel to itself but in the opposite direction back to its source. As a consequence, these properties are, within acceptance angles, independent of the orientation of the retroreflector. Retroreflectors, therefore, find frequent applications in situations where orientation is difficult or impossible to control and where a mirror or other reflecting device would therefore be unsatisfactory.

Retroreflectors have acceptance angle limitations, but the geometry of the retroreflector is complicated so the acceptance angle limitations cannot be simply specified. For that reason, it is usually possible to choose a retroreflector orientation such that for all practical purposes the acceptance angle limitations are nonexistent. As a result, it is always possible to guarantee, by appropriate orientation of neighboring reflectors in a retroreflector array consisting of at least two retroreflectors, that part of the array will be functional even at very large angles of incidence. This is in contrast to the patent to Meyzonett U.S. Pat. No. 4,887,310, Sepp U.S. Pat. No. 4,731,879, and Kita, Japan, #2-233030. In the present invention, acceptance angle limitations can be reduced at the cost of several percentage points reduction in reflective efficiency by applying coatings such as aluminum, at rear reflecting surfaces and thereby avoiding total internal reflection failure. Acceptance angle limitations can also be reduced by using a material with a proper index of refraction so that radiation falling on an internal surface of the retroreflector is reflected back even over a grazing angle.

However, retroreflectors are not by themselves sufficient for identification purposes because the object of this invention is to be able to distinguish between friendly and unfriendly units and various kinds of friendly units. Consequently merely receiving a reflection from a retroreflector does not provide sufficient information to determine whether or not the unit the retroreflector is mounted on is friendly or unfriendly. For this reason, identification requires a pre-determined modulation of the returning beam.

Applicant's device in this embodiment, depends on the property of a retro-reflector in that it reflects the incident beam back to the source of the beam by reflecting off all three internal surfaces in the retroreflector. One of these surfaces will be in total internal reflection in which all radiation reflects from an interface going from a high to a low index of refraction. This reflection can be reduced (known as a frustrated total internal reflection) by bringing another surface with about the same index of refraction as the index of refraction of the retroreflector in close proximity to this interface defining thereby an air gap. This suggests that moving this surface toward and away from the interface changes the intensity of the reflected beam in the retroreflector accordingly.

Applicant in this instance has discovered that by placing a layer or strip of some suitable elastomeric material, such as rubber (index of refraction 1.52, see Handbook of Chemistry and Physics, 37th edition, Hodgman, Weast, Selby, page 1470 Chemical Rubber Publishing Company) which has about the same index of refraction as glass (index of refraction 1.52, see Fundamentals of Physics, third edition, Halliday, and Resnick, page 867), very close to a reflecting surface in the retroreflector where the elastomeric material is backed by a material such as a piezoelectric material which varies in size in according with the voltage applied to it and then applying an alternating voltage having a predetermined frequency to the piezoelectric strip, the size of the piezoelectric strip will change at the frequency of the voltage applied to it. This will alter the pressure exerted by the piezoelectric strip on the elastomeric material at the same frequency, thereby squeezing the elastomeric material and changing the dimensions of the air gap (index of refraction 1, see the above citation to the Fundamentals of Physics) between the surface of

the retroreflector and the elastomeric layer. These changes in the dimensions of the air gap, bounded by the facing surfaces of the retroreflector and the elastomeric material, also change the intensity of the reflected beam at the same frequency as the alternating voltage so the intensity of the reflected beam will be a function of the air gap dimension. Consequently if the frequency of the voltage applied to the piezoelectric strip is known, the frequency of the intensity variation in the reflected beam coming from the retroreflector can be compared with the frequency in the comparator for identification purposes. If the reflected beam does not have the same frequency as the frequency in the comparator, the unit is not recognized as friendly.

Although to this point an alternating voltage is described as applied to a piezoelectric strip which is a backing for an elastomeric material, a piezoelectric strip is not essential. It is understood that the pressure on a suitable material can be varied at any predetermined frequency by many means including directing pulses of air or water or some other fluid against a material to cause it to change or move in such a way as to alter the size of the air gap. For example, a solenoid, powered by an alternating voltage having a predetermined frequency such as shown in FIG. 7 can be used with a properly shaped armature to cause its armature to press against an elastomeric material to change the size of the air gap at the same frequency as the alternating voltage.

The operation of the concept of frustrated internal reflection, is exactly analogous to the quantum-mechanical phenomenon of penetrating or tunneling of a plane wave through a one dimensional rectangular barrier. This requires the beam to strike and penetrate the retroreflector whereby the intensity of the reflected beam is modulated at the internal surface of the retroreflector. It is also to be understood that the modulation of the intensity of the reflected beam inside the retroreflector can be done by other means besides using a piezoelectric strip.

What is needed therefore, and comprises an important object of this invention is to arrange an array of retroreflector devices on a friendly unit, so that a beam directed against a surface of the unit on which the retroreflector devices are mounted causes the reflected beam going back to the IFF device to be modified in a predetermined way for identification purposes.

A further object of this invention is to modify a retroreflective device so that intensity of the reflected beam will vary at a predetermined frequency in the form of pulses.

Yet another object of this invention is to provide a retroreflective device which has means for changing the frequency of the intensity of the reflected beam.

Still another object of this invention is to provide a retroreflective device wherein at least one internal surface in the retroreflector is in close proximity to a layer of elastomeric material backed by a piezoelectric strip and providing means for applying alternating voltages at a predetermined frequency to the piezoelectric strip to change the intensity of the reflected beam at the same frequency as the predetermined frequency applied to the piezoelectric strip to determine whether the reflected beam is from a friendly or unfriendly unit.

Yet another object of this invention is to provide a retroreflector mounted so a reflecting surface in the retroreflector is in close proximity to a layer of elastomeric material defining an air gap therebetween along with means for applying periodic pressure pulses at a predetermined frequency to the elastomeric material to vary the size of the air gap at the same frequency and thereby modulate the intensity of the reflected beam at the same frequency.

These and other objects of this invention will become more apparent when better understood in the light of the accompanying drawings and detailed descriptions of preferred embodiments of the invention, and specification:

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS OF THE INVENTION

In order to facilitate understanding of the present invention, reference will be made to the appended drawings of preferred specific embodiments of the present invention. Such drawings should not be construed as limiting the invention, which is properly set forth in the appended claims.

FIG. 1 is a diagrammatic representation of the full concept of the invention.

FIG. 2 is an end view of the solid glass trihedral retroreflector.

FIG. 3 is a side elevational view of the retroreflector shown in FIG. 2.

FIG. 4 is a cross-sectional view showing the mounting of the retroreflector in a housing.

FIG. 5 is a perspective view of the housing where the retroreflector is mounted.

FIG. 6 is an enlarged section of a portion of the reflecting surface of a retroreflector, showing the reflecting surface backed by a layer of rubber and a piezoelectric strip.

FIG. 7 is a side elevational view of a retroreflector designed for use under the water and showing a solenoid coil and plunger positioned to exert pressure on a rubber strip positioned close to a retroreflector.

FIG. 8 is a front elevational view of the retroreflector mounted in a housing under water.

FIG. 9 is an elevational view of the glass retroreflector shown in FIGS. 1 and 2 and disclosing a rubber strip backed by a piezoelectric strip, separated from a facing surface of the glass retroreflector by an air gap which has a much lower index of refraction than glass, and showing an alternating voltage source connected to the piezoelectric strip.

Referring now to FIG. 1, the preferred embodiment 8 comprises a laser beam transmitter indicated generally by the reference numeral 10. This transmitter, something like a flashlight, emits a laser beam 12 which is directed at an unknown target. Each retroreflector 14 is securely mounted in a housing 16 mounted on the target.

The retroreflectors 14 or 38 are rigidly in the housing 16 by any suitable means. Referring to FIG. 4, the rear portion 66 of the housing 16 is filled with a suitable plastic with a recess 68 sized to receive the rear portion of the glass retroreflector 14 whereby the retroreflector 14 is held in position in the housing. Cylindrical retaining rings 70 and 72 are mounted by any suitable means at ends 66 and 67 of the housing 16 to hold the retroreflector inside the housing.

The physical characteristics of a retroreflector is that it reflects a beam 18 such as a laser beam, parallel to itself but in an opposite direction back to the laser beam transmitter. To do this, the laser beam must penetrate the front surface 20 of the retroreflector, and be reflected from the internal surfaces 27, 22 and 24 in the

retroreflector before it emerges as a reflected beam 18 parallel to the incoming beam 12 and back to its source, see FIGS. 1 and 3.

To identify the target and determine whether its friendly or not, a rubber strip 26 is placed in close proximity to one of the surfaces, e.g. 22 of the retroreflector, see FIG. 4. The strip of rubber 26 is covered by a piezoelectric strip 28, see FIGS. 4 and 6. An alternating voltage source 30 is connected to the strip 28, see FIG. 4. A characteristic of piezoelectric material is that when voltage is applied to it, its dimensions change.

Referring to FIGS. 6 and 9, the facing surface 32 of the rubber strip 26 is pressed against the facing surface 34 of the retroreflector 14 leaving an air gap 35 between the facing surface 34 of the retroreflector and the facing surface 32 of the elastomeric material. The air gap 35 is enormously enlarged in FIG. 9 for purposes of illustration but in reality it is so small, that the gap could not be seen with the naked eye.

When an alternating voltage 30 is applied to the piezoelectric strip 28, the piezoelectric strip 28 presses against the facing surface 32 of the rubber strip 26, thereby changing the dimensions of the air gap 35, in accordance with the frequency of the alternating voltage, see FIG. 9. This as shown in FIGS. 1 and 9 changes the intensity of the reflected beam 18 at the same frequency as the frequency of the alternating voltage 30 applied to the piezoelectric strip. This change in intensity in reflected beam 18 is indicated by the spaced arrows shown in FIG. 1 and the reflected beam is directed back toward the beam generator 10, see FIG. 1. The frequency of these pulses or changes in beam intensity provide a means for identifying the target.

A comparator or tuner 80, see FIG. 1, like that in U.S. Pat. No. 4,731,879 by Sepp, see Column 9 lines 15 to 22 is provided. This comparator is something like a tuner on a radio or a television set and can be tuned to a desired frequency. The comparator is positioned so it is in the path of the reflected beam 18. If the comparator or tuner is adjusted to the pre-determined frequency of the reflected modulated beam and detects the reflected modulated beam, it indicates the target is friendly. If they do not match, it =/indicates that the target is unfriendly.

A characteristic of retroreflectors used in this way, is that the distribution of the retroreflectors on the target is not critical. This means that the location of the retroreflectors and the direction of the beam does not have to be extremely precise to get a response.

IFF devices based on retroreflectors have many uses. In addition to locating the enemy, they can be used to locate the distribution of friendly units. This makes them helpful for coordinating the movement of friendly units.

To this point the retroreflector has been used above ground or above the surface of the water. Since high frequency sound travels under water, these devices, suitably modified could be used underwater, e.g. to identify friendly or unfriendly submarines, or for mine sweeping operations to locate friendly mines that have drifted away from their moorings. This requires a modification of the structure of the retroreflector.

For use under water, the retroreflector 38, see FIG. 7, would be formed from a suitable sound reflecting material, such as an elastomeric material, see FIGS. 7 and 8. The shape of the elastomeric retroreflector 38 would be like the glass retroreflector 14 shown in FIG. 3 and a beam of high frequency sound would be directed against the retroreflector.

As described in connection with the glass retroreflector, to operate, the facing sound reflecting surface 42 of a rubber strip 40 must be in close proximity to a facing surface 44 of the elastomeric retroreflector 38 leaving a water gap 46 between them. In order for the water gap 46 (index of refraction 1.33, see Fundamentals of Physics, cited above) to change its dimension and thereby modulate the intensity in the beam reflected from the retroreflector, means must be provided for pressing the facing surface 42 of the rubber strip 38 against the facing surface 44 of the retroreflector 38 at a predetermined frequency. To do this, in this particular embodiment, a solenoid 48 is mounted on a bracket 56 in the housing 16'. The solenoid may be cylindrical and has an axially positioned armature receiving bore 50. A magnetic armature or plunger 52 is movably mounted in the bore 50. Means are provided for connecting an alternating voltage to said solenoid. The means may comprise a conventional alternating voltage power source (not shown) connected to the solenoid by electric cables 58 and 60.

As seen in FIG. 7 a metal strip 62 is secured to the surface 64 of the rubber strip 40 opposite surface 42. In this way, when an alternating electric current flows through the solenoid, the armature or plunger 52 is repeatedly forced against the metal strip 62 on the rubber strip 40 at the frequency of the alternating electric current. This forces the rubber strip 40 against surface 44 retroreflector changing the size of the water gap 46 at the same frequency as the frequency of the alternating current in the solenoid. This causes the reflected modulated sound beam to vary or be pulsed at the same frequency as the frequency of the current supplied to the solenoid.

In use the retroreflectors are mounted at various locations on a target. When the identification device is used in air, a beam, such as a laser beam, is directed against the target. The reflected beam is deflected by the one way vision mirror 78, see FIG. 1 to comparator 80 where the frequency of the pulses in the reflected beam 18 is compared with the programmed frequency in the comparator 80. If the frequencies coincide, the target is identified as friendly. Otherwise the target is unknown and presumed unfriendly.

Having described the invention, what I claim as new is:

1. An IFF device comprising a beam generating means for directing a beam at a target, at least one retroreflecting device adapted to be mounted on a target, each retro-reflecting device having internal reflecting surfaces shaped so an unmodulated beam striking the reflecting device penetrates said retro-reflecting device and strikes the internal reflecting surfaces, means associated with said internal reflecting surfaces for modulating said beam inside said retroreflector by changing its intensity at the internal surfaces of the retroreflector at a predetermined frequency whereby the modulated beam is reflected back out of the retro-reflecting device in a direction parallel to and back toward the beam generating means, a tuner, said tuner positioned in the path of the modulated reflected beam and having means for adjusting the tuner to the predetermined frequency of the reflected beam whereby if the tuner receives the modulated signal from the reflected beam it indicates the target is friendly.

2. An IFF device comprising a beam generating means for directing a beam at a target, at least one retro-reflecting device adapted to be mounted on a target, each retro-reflecting device having internal reflecting surfaces shaped so an unmodulated beam striking the reflecting device penetrates said retro-reflecting device and strikes the internal reflecting surfaces, means associated with said internal reflecting surfaces for modulating said beam inside said retro-reflecting device by changing its intensity at a predetermined frequency whereby the modulated beam is reflected back out of the retro-reflecting device in a direction parallel to and back toward the beam generating means, said means comprising a layer of elastomeric material positioned close to one of said internal reflecting surfaces in said reflecting device and separated therefrom by a gap, a piezoelectric strip secured to the surface of the elastomeric material remote from surface facing the said internal reflecting surface, whereby when alternating voltage is applied to said piezoelectric strip the dimensions of the elastomeric material and the width of said gap change in accordance with the frequency of alternating voltage causing the width of said gap to vary at the same frequency, thereby causing changes in the intensity of the reflected beam to occur at the same frequency as the frequency of the alternating voltage, a tuner, said tuner positioned in the path of the modulated reflected beam and having means for adjusting the tuner to the predetermined frequency of the reflected beam whereby if the tuner receives the modulated signal from the reflected beam it indicates the target is friendly.

3. An IFF device comprising a beam generator for directing a beam at a target, at least one trihedral retro-reflector adapted to be mounted on a target, said trihedral retro-reflector having internal reflecting surfaces shaped so an unmodulated beam striking the trihedral retro-reflector penetrates said trihedral retro-reflector and strikes said internal reflecting surfaces, means associated with said internal reflecting surfaces for modulating said beam inside said retroreflector by changing its intensity at the internal surfaces of the retroreflector at a predetermined frequency, whereby the modulated beam is reflected out of said trihedral retro-reflector in a direction back toward the beam generator, and a tuner, said tuner positioned in the path of said reflected modulated laser beam and having means for adjusting the tuner to the frequency of the reflected modulated beam, whereby if the tuner receives the signal from the reflected intensity modulated beam, the target is friendly.

4. An IFF discriminator comprising a beam generating means for directing a beam at a target, at least one retro-reflecting device adapted to be mounted on the target, each retro-reflecting device having internal reflecting surfaces shaped so an unmodulated beam penetrating said retro-reflector strikes the internal reflecting surfaces, means external to one of said internal reflecting surface for modulating the internal reflected beam inside the retro-reflector by changing its intensity at the internal surfaces of the retroreflector at a predetermined frequency, whereby the modulated beam is reflected back out of the retro-reflector in a direction parallel to and back toward the beam generating means, a tuner, said tuner positioned in the path of the modulated reflected beam and having means for adjusting the frequency to the selected frequency controlled by the said external means, whereby if the tuner received the modulated signal from the reflected beam, it indicates the target is friendly.

5. An IFF device having a beam generating device for directing a beam at a target, at least one retro-reflecting device adapted to be mounted on a target, each retro-reflecting device formed from material having an index of refraction greater than air and having internal reflecting surfaces arranged so a beam striking the retro-reflecting devices penetrates said retro-reflecting device and strikes the internal reflecting surfaces, a material having an index of refraction close to the index of refraction of the retro-reflector positioned close to an internal reflecting surface defining an air gap, means for moving said material toward and away from the said internal reflecting surface at a predetermined frequency, causing said air gap to change in size so that when the said beam absorbing material moves away from said internal reflecting surface said material frustrates the intensity of the reflected beam as the size of the air gap increases, whereby the frequency of the change in the intensity of the reflected beam varies at the same frequency as the said predetermined frequency, a tuner, said tuner positioned in the path of modulated reflected beam, means for tuning said tuner to the frequency of the modulated reflected beam, whereby if the tuner receives the modulated signal the target is friendly.

6. An IFF device comprising a beam generating means for directing a beam at a target, at least one retro-reflecting device adapted to be mounted on a target, each retro-reflecting device having internal reflecting surfaces shaped so an unmodulated beam striking the reflecting device penetrates said retro-reflecting device and strikes the internal reflecting surfaces, a layer of elastomeric material positioned close to one of said internal reflecting surfaces in said reflecting device and separated therefrom by an air gap, means for causing said elastomeric material to vibrate at a predetermined frequency whereby the dimensions of the elastomeric material vary in accordance with the frequency of alternating voltage causing the width of said air gap to vary the same way thereby causing changes in the intensity of the reflected beam to occur inside the retro-reflecting device at the internal surfaces of the retroreflector at the same frequency as the said predetermined frequency, a tuner, said tuner positioned in the path of the modulated reflected beam and having means for adjusting the tuner to the predetermined frequency of the reflected beam whereby if the tuner receives the modulated signal from the reflected beam it indicates the target is friendly.

* * * * *

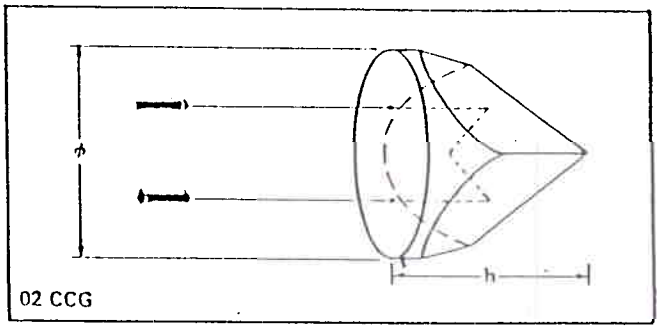
The trihedral retroreflector or corner cube reflector has the property that any ray entering the effective aperture will be reflected and emerge from the entrance/exit face parallel to itself, but with opposite direction of propagation. An incident beam, filling the effective aperture, is reflected exactly back on itself. These properties are, within acceptance angle limits, independent of the orientation of the retroreflector. Retroreflectors therefore find frequent application in situations where orientation is difficult or impossible to control and where a mirror would therefore be unsatisfactory.

The retroreflector, like the right angle prism, depends upon the principle of total internal reflection (TIR) for its operation. Like TIR right-angle prisms, retroreflectors have acceptance angle limitations. Because the geometry of the retroreflector is complicated, the acceptance angle limitations cannot be simply specified.

It is usually possible to choose a retroreflector orientation such that acceptance angle limitations are, for all practical purposes, nonexistent. It is always possible to guarantee, by appropriate orientation of neighboring reflectors in a retroreflector array (consisting of at least two retroreflectors), that part of the array will be functional even at very large angles of incidence. All acceptance angle limitations can be removed, at the cost of several percentage points reduction in reflective efficiency, by applying reflective coatings to the rear reflecting surfaces and thereby avoiding TIR failure.

Success of the TIR process at the rear surfaces of the retroreflector demands that these surfaces be kept scrupulously clean. When retroreflectors are used as elements of high-power laser cavities, survival of the retroreflector may depend upon the cleanliness of these surfaces. In applications where a retroreflector must be frequently handled or otherwise cannot be kept scrupulously clean, and where powers are not so high as to assure coating destruction, we suggest that the three rear reflecting surfaces be coated with protected aluminium or with internal silver overcoated with copper or Inconel and paint. This assures reliable reflectivity of these surfaces and removes acceptance angle limitations. Where this slight reduction in reflective efficiency is unacceptable, multilayer reflective coatings can be used. Antireflection coatings are available for the entrance/exit face.

We maintain tight control over angles and surface accuracy in manufacture, assuring a parallelism between incident and returned beams of two arc seconds or better. Roof and other edges are lightly beveled to minimize the risk of chipping.



02 CCG

SPECIFICATIONS: SOLID GLASS RETROREFLECTORS

Dimensions: ±0.15mm
Deviation: 180 degrees ± 2 arc seconds
Wavefront Distortion: <λ/4 at 632.8nm
Material: BK 7 grade A fine annealed
Coatings: MgF_2 (/066), HEBBAR™ (/078) or V-coatings by appending appropriate Coating Suffix
Cosmetic Surface Quality: 60-40 scratch and dig

Solid Glass Retroreflectors; Uncoated

Diameter ϕ (mm)	h (mm)	PRODUCT NUMBER
15.0	11.3	02 CCG 001
25.0	18.8	02 CCG 003
38.0	28.5	02 CCG 005
50.0	37.5	02 CCG 007
70.0	52.5	02 CCG 008

These retroreflectors may be conveniently mounted using the retroreflector holders described in the Component Holders section of this guide.

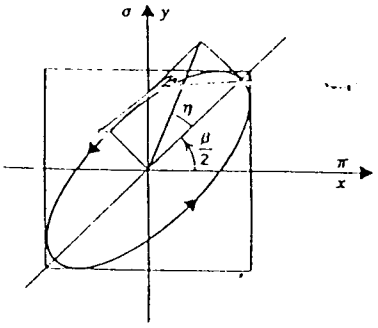


Fig. 11.26

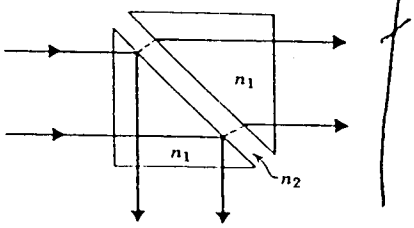


Fig. 11.27

Here $\tan\chi = A_y/A_x = 1$. Then $2\chi = \pi/2$. Equation (10.20*b*) then gives $\beta/2 = \pi/4$. Equation (10.20*a*) yields

$$\tan\phi = -\tan 2\eta$$

which means the light is LEP, and that $\eta = (-\phi)/2 = 18.5°$. Thus the axial ratio of the ellipse (Fig. 11.26) is

$$\tan\eta = \tan 18.5 = 0.335$$

4. Frustrated Total Internal Reflection. The exponential decay $E \sim e^{-z/\delta}$ of the fields in the second medium can be detected if a second interface is placed at a certain depth z in that medium. Often the third medium has the same refractive index as the first, as in the example shown in Fig. 11.27. If d is somewhat larger than the skin depth δ, we can neglect multiple reflection effects – the first multiple reflected beam will travel a distance $3d$ and hence will be attenuated by the factor $e^{-3d/\delta}$, which we assume is much less than $e^{-d/\delta}$.

Just inside the second interface the transmitted field for, say, the π component will be given by

$$E_{t\pi} = E_{i\pi}\tau_\pi\tau'_\pi e^{(-d/\delta)} e^{i(\omega t - \nu k_{i\nu})} \qquad (11.115a)$$

where $E_{i\pi}$ is the incident electric field just outside the first interface. There is a similar expression for the σ component. Our previous results for the τ's hold with the parameter a replaced by $i\gamma$. In particular, we have

$$\tau_\pi\tau'_\pi = 1 - \rho_\pi{}^2 = 1 - e^{2i\phi_\pi}.$$

The coefficient for energy transmission across the gap is then given by

$$T_\pi = 2e^{-2d/\delta}(1 - \cos 2\phi_\pi) \qquad (d \gg \delta) \qquad (11.115b)$$

and, since there are no dissipative, loss-producing mechanisms, by the principle of energy conservation, the beam reflected by the $n_1 - n_2 - n_1$ "sandwich" would be described by a reflectivity

$$R_\pi = 1 - T_\pi$$

When d is not greater than a few times the skin depth, these results must be modified to take multiple reflections into account or, equivalently, to take the proper boundary conditions into account. (See Eqs. (11.123*a*, *b*) below.)

The phenomenon of frustrated total reflection is exactly analogous to the quantum-mechanical phenomenon of penetrating or tunneling of a plane wave through a one-dimensional rectangular barrier.

5. Attenuated Total Reflection (ATR). An interesting modification of the phenomenon of total internal reflection occurs when the