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(72) RIZKIN, ALEXANDER, US

(72) RUIZ, DAVID, US

(72) TUDHOPE, ROBERT H., US

(71) PHYSICAL OPTICS CORPORATION, US

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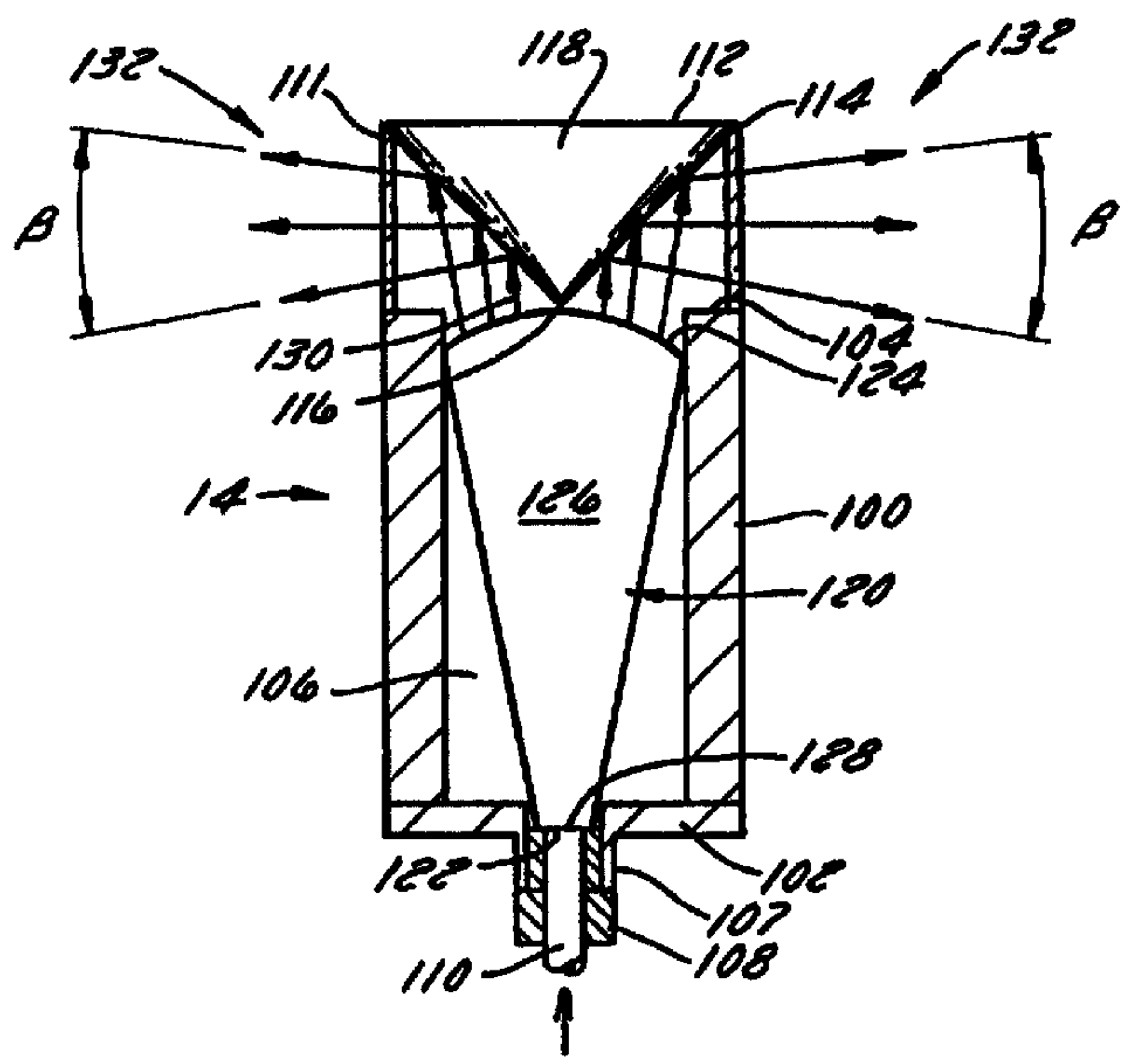
(54) **FORMEUR DE FAISCEAUX POUR UN SYSTEME LUMINEUX D'ECLAIRAGE A DISTANCE ET PROCEDE CORRESPONDANT**

(54) **BEAMFORMER FOR A REMOTELY ILLUMINATED LIGHTING SYSTEM AND METHOD**



(57) La présente invention concerne un système lumineux d'éclairage à distance distribuant depuis une source lumineuse centrale des signaux lumineux à des dispositifs de distribution de lumière distants (14). Chaque dispositif de distribution de lumière distant (14) ou formeur de faisceaux est conçu pour produire à partir de ces signaux lumineux un modèle de distribution hautement précis (132). Par ailleurs, on peut facilement ajuster le modèle de distribution (132), à la fois dans la

(57) A remotely illuminated lighting system distributes from a central illumination source light signals to remote light distribution devices (14). Each remote light distribution device (14) or beamformer, is adaptable to produce a highly precise distribution pattern (132) from the light signals. The distribution pattern (132) may be easily adjusted in both horizontal and vertical directions. In a first preferred arrangement, each beamformer is coupled via a fiber-optic cable to the central light source

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direction horizontale et verticale. Dans un premier mode de réalisation, chaque formeur de faisceaux est couplé à la source lumineuse centrale via un câble à fibres optiques, et comprend un transformateur de lumière par réflexion (120) et un élément conique réfléchissant (112). Dans d'autres modes de réalisation, on ajoute un diffuseur holographique et/ou un élément de masquage afin d'adapter la forme du modèle de distribution de lumière. Enfin, on peut égalent ajouter un élément de masquage à commande électronique permettant de fournir des modèles clignotants, mobiles ou dynamiques de distribution de lumière.

and includes a non-imaging light transformer (120) and a conical reflective element (112). In additional preferred embodiments, a holographic diffuser and/or a masking element are incorporated for adapting the shape of the light distribution pattern. An electronically controlled masking element may be further incorporated for providing flashing, moving or otherwise dynamic light distribution patterns.

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(71) Applicant: FARLIGHT CORPORATION [US/US]; Building 201, 20600 Gramercy Place, Torrance, CA 90501 (US).

(72) Inventors: RIZKIN, Alexander; 1191 Camino De La Costa #403, Redondo Beach, CA 90277 (US). RUIZ, David; 2009 Warfield Avenue, Redondo Beach, CA 90278 (US). TUDHOPE, Robert, H.; 5867 Finecrest Drive, Rancho Palos Verdes, CA 90275 (US).

(74) Agents: NILLES, Andrew, J. et al.; Nilles & Nilles SC, Firstar Center, Suite 2000, 777 East Wisconsin Avenue, Milwaukee, WI 53202 (US).

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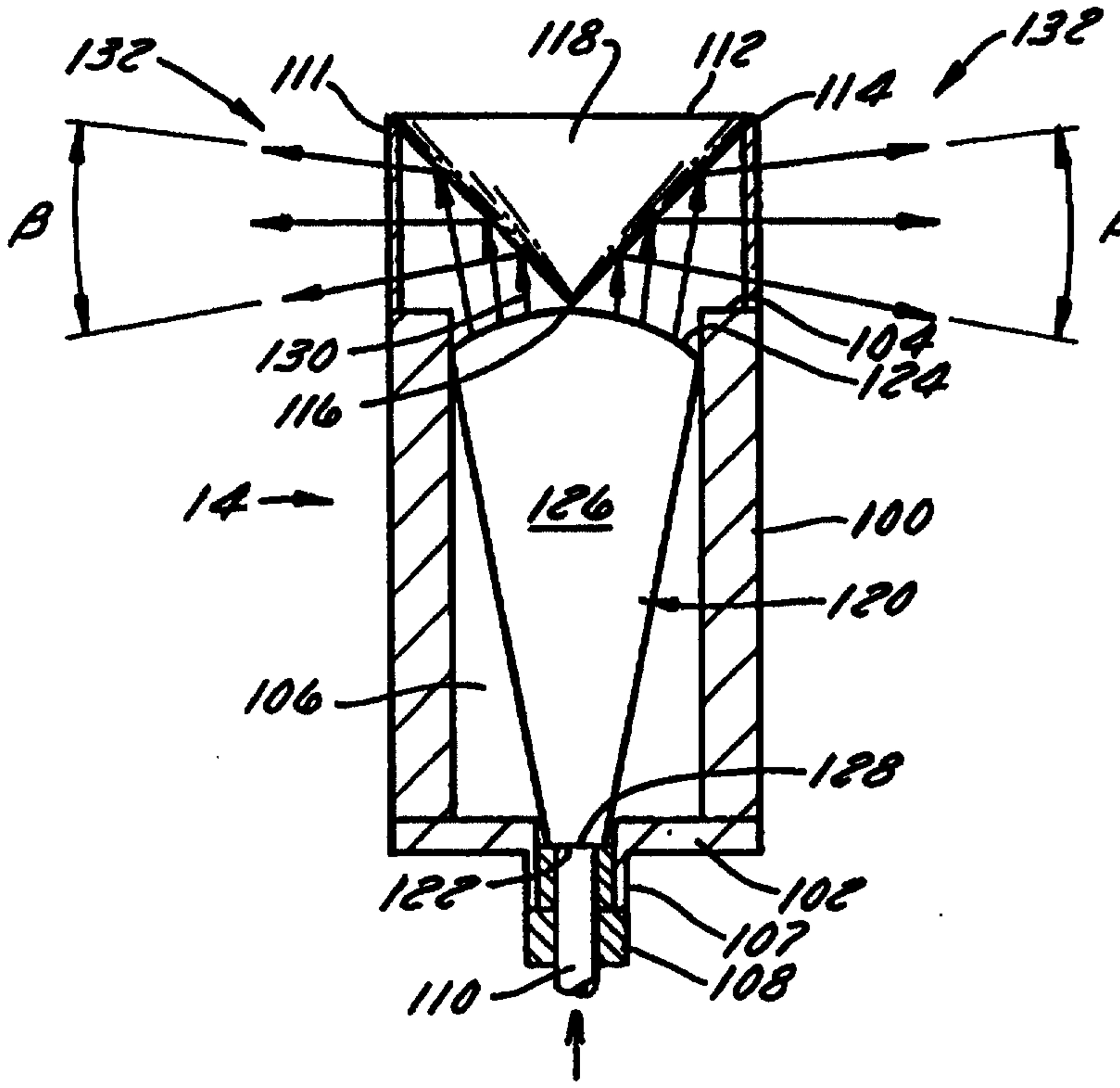
(57) Abstract

A remotely illuminated lighting system distributes from a central illumination source light signals to remote light distribution devices (14). Each remote light distribution device (14) or beamformer, is adaptable to produce a highly precise distribution pattern (132) from the light signals. The distribution pattern (132) may be easily adjusted in both horizontal and vertical directions. In a first preferred arrangement, each beamformer is coupled via a fiber–optic cable to the central light source and includes a non–imaging light transformer (120) and a conical reflective element (112). In additional preferred embodiments, a holographic diffuser and/or a masking element are incorporated for adapting the shape of the light distribution pattern. An electronically controlled masking element may be further incorporated for providing flashing, moving or otherwise dynamic light distribution patterns.



BEAMFORMER FOR A REMOTELY ILLUMINATED LIGHTING SYSTEM AND METHOD

Background of the Invention

1. Cross-Reference to Related Applications

The present application is related to commonly assigned United States Patent Application Serial No. 08/733,940 entitled "Integrated Beamformer and Method of Manufacture Thereof" filed October 21, 1996, the disclosure of which is hereby expressly incorporated herein by reference. The present application is also related to commonly assigned United States Patent Application entitled "Lighting System Sequencer and Method" filed of even date herewith, the disclosure of which is hereby expressly incorporated herein by reference.

2. Field of the Invention

The present invention relates generally to lighting systems. More particularly, the present invention relates to remotely illuminated lighting systems, and to a beamforming device, or luminaire, for use in a remotely illuminated lighting system to provide a controlled, precise and dynamic light distribution pattern.

3. Discussion of the Related Art

Airports incorporate a system of lighting to provide guidance to approaching aircraft. The conventional aircraft approach lighting system (ALS) includes groups of incandescent lamps distributed over a field, lighting several thousand feet of the approach to the runway within specific requirements for angular light distribution, color and intensity. A major problem with the use of incandescent lamps in the ALS lies with monitoring the many light sources, i.e., each incandescent lamp, for failure. The availability of the ALS is dependent on the number and location of failed lamps in the system. Lamp replacement is a significant cost owing to the required human and equipment resources and the cost of the lamps.

Federal Aviation Administration (FAA) regulations dictate numerous requirements for the ALS. For example, the towers upon which the lamps are mounted must, between the runway threshold and the 1000-foot bar, be of fragile or semi-fragile construction so as to minimize hazards to landing and departing aircraft. Yet, they must also be sufficiently rigid so as to support the lamps under widely varying weather conditions. Additionally, depending on the time of day and weather conditions, the system must be capable of providing up to five illumination intensity levels. Existing systems utilizing incandescent lamps include sophisticated control systems to provide and monitor lamp currents to achieve the required illumination intensity levels. System performance is inferred from measured lamp currents, which for several reasons such as lamp type, aging and current loop resistance differences, may not paint an accurate picture of system performance.

Another application of lighting system technology is the illumination of marine vessels, aircraft and motor vehicles for navigation and identification. These navigation and identification lighting systems must also conform to rigid multinational regulations and requirements as to light intensity, angular distribution and color. The most common technology for achieving these requirements is a distributed system of incandescent lamps coupled to an electrical distribution system. Distributed electrical systems present a number of maintenance considerations, such as monitoring for and replacing failed lamps, design considerations, such as isolating electromagnetic interference (EMI) and safety considerations, such as reducing and/or eliminating ignition sources, for example, to fuel spilled during an accident.

In commonly assigned United States Patent No. 5,629,996 a vast improvement over existing illumination technologies is provided. The system disclosed and described therein, which may be referred to as a remote source lighting (RSL) system, incorporates a centralized light source or light engine. The light source is coupled via a light pipe system to one or more beamformers. Each beamformer, or luminaire, includes a light transformer and holographic diffuser for providing a desired light distribution with minimum intensity loss. System performance is directly, optically monitored. Centralized lighting sources with enhanced operational life greatly reduce maintenance. While, cool operating, spark free beamformers provide safer, reduced cost illumination suitable for use in any number of operating environments.

While great improvements to existing lighting system technology are at hand, further enhancements may be made through enhancement and control of the light distribution from the beamformer. For example, light distribution patterns from high intensity incandescent lamps is typically fixed and limited to a 180° distribution pattern in a horizontal plane. Certain lighting applications, such as mast head navigation lights for marine vessels, require horizontal distribution patterns in excess of 180°, and thus require multiple lamps or beamformers. It would also be desirably to have the ability to adapt the light distribution for a particular application, and to be able to readapt the light distribution for another application. Still more desirable would be an ability to dynamically alter the light distribution pattern. Present systems for providing dynamic light distribution patterns, such as rotating beacon applications, require mechanical drive elements for physically rotating the light source. Thus, there is a need for a beamforming device that provides enhanced range yet precise lighting distributions. There is a further need for a beamformer for use in a remotely illuminated lighting system, which provides a precise, adaptable and dynamic light distribution pattern.

Objects of the Invention

It is therefore a primary object of the invention to provide a beamformer having an enhanced light distribution pattern.

It is also a primary object of the invention to provide a beamformer having a highly precise light distribution pattern.

It is an additional object of the present invention to provide a beamformer adaptable to a remotely illuminated lighting system and which provides a highly precise light distribution pattern.

Still another object of the present invention is to provide a beamformer having an adaptable light distribution pattern.

Yet another object of the present invention is to provide a beamformer having a dynamic light distribution pattern.

An additional object of the present invention is to provide a low cost beamformer having little or no operational maintenance.

Another object of the present invention is to provide a lighting system including a centralized light source and a fiber optic light distribution system and a plurality of beamformers for achieving a precise system of lighting.

A further object of the present invention is to provide a method of providing a light distribution pattern.

Other objects, features, and advantages of the invention will become apparent to those skilled in the art from the following detailed description and the accompanying drawings. It should be understood, however, that the detailed description and specific examples, while indicating preferred embodiments of the present invention, are given by way of illustration and not of limitation. Many changes and modifications may be made within the scope of the present invention without departing from the spirit thereof, and the invention includes all such modifications.

Brief Description of the Drawings

Preferred exemplary embodiments of the invention are illustrated in the accompanying drawings in which like reference numerals represent like parts throughout, and in which:

Figure 1 is a block diagram schematic of a remotely illuminated lighting system incorporating a beamformer in accordance with a preferred embodiment of the present invention;

Figure 2 is a schematic representation in side elevation of a beamformer illustrating the non-imaging light transformer and reflective element thereof in accordance with a preferred embodiment of the present invention;

Figure 3 is a schematic representation of a reflective element suitable for use in the beamformer shown in Figure 2;

Figure 4 is a schematic representation of a first alternative embodiment of the reflective element shown in Figure 2;

Figure 5 is a schematic representation of a second alternative embodiment of the reflective element shown in Figure 2;

Figure 6 is a schematic representation in side elevation of a beamformer illustrating the non-imaging light transformer, holographic diffuser and reflective element thereof in accordance with an alternative preferred embodiment of the present invention;

Figure 7 is a schematic perspective representation of a beamformer illustrating the non-imaging light transformer, holographic diffuser, diffusion mask and reflective element thereof in accordance with an additional alternative preferred embodiment of the present invention;

Figure 8 is a plan view of the diffusion mask shown in Figure 7 and an associated light distribution pattern;

Figure 9 is a schematic perspective representation of a beamformer illustrating the non-imaging light transformer and reflective element thereof in accordance with another alternative preferred embodiment of the present invention;

Figure 10 is a perspective view of a diffusion mask in accordance with an alternative preferred embodiment of the present invention; and

Figure 11 is a schematic perspective representation of a beamformer illustrating the non-imaging light transformer and reflective element thereof in accordance with yet another alternative preferred embodiment of the present invention.

Detailed Description of the Preferred Embodiments

1. Resume

A remotely illuminated lighting system distributes from a central illumination source light signals to remote light distribution devices. Each remote light distribution device, or beamformer, is adaptable to produce a highly precise distribution pattern from the light signals. The distribution pattern may be easily adjusted in both horizontal and vertical directions. In a first preferred arrangement, each beamformer is coupled via a fiber-optic cable to the central light source and includes a non-imaging light transformer and a conical reflective element. In additional preferred embodiments, a holographic diffuser and/or a masking element are incorporated into the beamformer for adapting the shape of the light distribution pattern. An electronically controlled masking element may be further incorporated for providing flashing, moving or otherwise dynamic light distribution patterns.

2. Remotely Illuminated Lighting Systems

Referring now to the drawings, and particularly to Figure 1, a remotely illuminated lighting system 10 is adaptable for operation as: 1) an approach lighting system (ALS), 2) a marine navigation lighting system, 3) an aircraft or motor vehicle lighting system 4) an obstruction lighting system or 5) a mine or hazardous area lighting system. Numerous other applications of remotely illuminated lighting system 10 are described in the afore-mentioned U.S. Patent No. 5,629,669, and still many others may be envisioned. The remotely illuminated lighting system 10 includes an illuminator 12 (also referred to as a light engine) providing a centralized source of light to beamformers 14 via a light delivery system 16. Beamformers 14 may be adapted to: 1) lighting towers (such as in an ALS), 2) aircraft, marine vessels and motor vehicles, or 3) remote and/or hazardous environments (such as mines, explosive manufacturing facilities, refineries, laboratories, and the like).

Illuminator 12 includes a controlled power supply 20 suitably coupled to a source of electrical energy (not shown) and a direct optical regulator 26. Power supply 20 and direct optical regulator are coupled to each other and each are coupled to a lighting system controller 18, including a suitable control processor such as a microprocessor, for the communication of control signals. Power supply 26 and direct optical regulator 28 cooperate to control a supply of electrical power to a first light source 22 and a second light source 24. The light signals output from first light source 22 and second light source 24 are coupled through optical switch 28 to a high efficiency coupler 30. High efficiency coupler 30 couples light output from light sources 22 and 24 via optical switch 28 to light delivery system 16. Light delivery system 16 preferably includes an optical splitter and a network of fiber-optic bundles for conducting light signals from illuminator 20 to one or more beamformers 14.

Each of first light source 22 and second light source 24 preferably generate a source of energy in the visible range that is concentrated by an elliptical or parabolic reflector to a focal spot. The high efficiency coupler 20 couples the light concentrated in the focal spot into the optical fibers that form light delivery system 22. As shown, light source 24 is preferably a redundant light source. Direct optical regulator 26 is preferably coupled to optical switch 28 to monitor the light output of both first light source 22 and second light source 24. Under normal conditions, only first light source 22 is supplied electrical power and thus is the only source of light signals. Should first light source 30 fail, the failure is detected by direct optical regulator 26 which causes signals to be sent to: 1) power supply 20 to cut power to first light source 22 and to provide power to second light source 24 and 2) optical switch 28 to receive light energy from second light source 24 for coupling to high efficiency coupler 30.

3. <u>Beamformer Assembly</u>

With the exception of beamformer 14, the forgoing described elements of the present invention are more fully disclosed and preferred constructions therefore are discussed in the afore-mentioned United States Patent No. 5,629,996, and reference is made to the description contained therein. With reference now to Figure 2, a beamformer 14 in accordance with a first preferred embodiment is shown in schematic detail. As seen in Figure 2, beamformer 14 includes a light-tight housing 100 having a generally cylindrical shape including a closed bottom 102, an open top 104 and a cylindrical cavity 106. A flanged aperture 112 is formed in bottom 102 for receiving a fiber-optic cable coupler 108. Fiber-optic cable coupler 108 is a suitable fiber-optic cable coupler for coupling beamformer 14 to a fiber-optic cable 110 of light delivery system 16. Housing 100 is preferably formed from plastic material using an appropriate molding process.

Disposed and secured to top 104 is a transparent annular window 110 preferably constructed from a transparent plastic material. Annular window 110 axially extends cavity 106 and includes a reflective element 112 enclosing an end 114 of annular window 110. Reflective element 112 is preferably cone shaped with a pinnacle 116 thereof substantially aligned with a centerline of housing 100 and directed inwardly toward cavity 106. Reflective element 112 includes an angled reflective surface 118. More particularly, and best seen if Figures 3 - 5, reflective surface 118 is formed to an included angle with respect to the centerline of housing 100. Reflective element 112 may be formed using either a dielectric or a metallic configuration for providing reflective surface 118.

Disposed and secured within cavity 106 is a non-imaging light transformer 120. Light transformer 120 includes a body portion 126 having a light entrance 122 and a light exit 124. Light entrance 122 is aligned closely adjacent coupler 108, and hence, closely adjacent an end 128 of fiber-optic cable 110 for coupling light signals from fiber-optic cable 110 into light transformer 120. Light transformer 120 is preferably of a construction shown and described in the afore-mentioned U.S. Patent No. 5,629,996 for reducing the light flux density per unit area so as to optimize the energy of the light coupled along fiber-optic cable 110 for its intended use in beamformer 14. Light transformer 120 may also be of the construction shown and described in the afore-mentioned United States Patent Application Serial No. 08/733,940. The distributed light signals 130 exit light transformer 120 at light exit 124 and are directed onto reflective surface 118 and are reflected outwardly through annular window 110 forming light distribution pattern 132. In the embodiment shown in Figure 2, light distribution pattern 132 extends radially from beamformer 14 in a 360° horizontal pattern having a vertical distribution angle .

Referring now to Figures 3 - 5, the vertical elevation of light distribution pattern 132 may be adjusted in beamformer 14 by adjusting the configuration of reflective element 112. Figure 3, illustrates reflective element 112 as shown in Figure 2. That is, reflective element 112 is formed with an included angle of 90°. A light ray 134 directed axially along housing 100 and striking reflective element 112 is reflected at an angle to the centerline of housing 100 that is equal to angle or also 90°. The resulting light distribution pattern 132 for reflective element 112 is one that extends substantially radially outwardly from beamformer 14.

As shown in Figure 4, reflective element 136 is formed with an included angle less than 90°. A light ray 134 directed axially along housing 100 and striking reflective element 136 is reflected at an angle to the centerline of housing 100 greater than 90°. In this manner, the resulting light distribution pattern 132 for reflective element 136 is one that is directed upwardly from beamformer 14. As shown in Figure 5, reflective element 138 is formed with an included angle greater than 90°. A light ray 134 directed axially along housing 100 and striking reflective element 138 is reflected at an angle to the centerline of housing 100 less than 90°. In this manner, the resulting light distribution pattern 132 for reflective element 136 is one that is directed downwardly from beamformer 14. As will be appreciated, in controlling the angular shape of the reflective element (112, 136 and 138) precise vertical directional control of the resulting light distribution pattern 132 of beamformer 14 is obtained.

Referring now to Figure 6, a schematic representation of a beamformer 140 in accordance with an alternate preferred embodiment of the present invention is shown. Beamformer 140 includes positioned between light transformer 110 and reflective element 112, a holographic diffuser 142. Holographic diffuser 142 is preferably a volumetric device and is adapted to shape the light signals from light exit 124 prior to striking reflective element 112. In this manner, the light distribution pattern 132, and in particular the vertical distribution angle , can be further controlled.

As shown in Figure 6, holographic diffuser 142 is adapted to direct light rays 144 nearest the centerline of beamformer 140 radially inwardly with respect to the centerline. Light rays 144 thus strike reflective element 112 at an incident angle less than 45° and are thus reflected at an angle $_1$, less than or less than 90°. In this manner, light rays 144 are reflected downwardly. Light rays 146 farthest from the centerline of beamformer 140 are directed radially outwardly with respect to the centerline. In this manner, light rays 146 strike reflective element 112 at an incident angle greater than 45° and are thus reflected at an angle $_2$, greater than or greater than 90°. Light rays 146 are thus reflected upwardly. The resulting overall light distribution pattern 148 for beamformer 140 has a vertical distribution angle $_2$ greater than . It should be appreciated that many other light shaping patterns may be introduced by holographic diffuser for shaping and controlling the light distribution pattern of beamformer 140, and for example, to concentrate the light distribution pattern into a narrow vertical distribution.

Referring now to Figures 7 and 8, a beamformer 150 provides a horizontal light distribution pattern 158 of less than 360°. Beamformer 150 includes positioned between holographic diffuser 142 and reflective element 112 a mask element 152. Mask element 152 includes a substantially transparent portion 154 and a substantially opaque portion 156. Mask element 152 may be formed from a suitable low loss optically transparent material to which a mask coating is applied in the appropriate configuration. The effect of mask element 152 is to block light rays exiting light transformer 120 at light exit 124 from reaching reflective element 112 in predetermined regions. The resulting light distribution pattern 158 thus includes a region 162 in which light rays are reflected from reflective element 112 as described, and a region 160 in which no light rays are reflected. Beamformer 150 is thus suitable for applications requiring a less than 360° horizontal light distribution pattern, such as marine vessel mast head navigation lights. And, in contrast to the previously noted prior art, a greater than 180° horizontal light distribution pattern is possible with a single beamformer 150. Holographic diffuser 142 is shown and is included to provide a desired vertical distribution angle 2; however, it may not be required in every application of beamformer 150. Furthermore, it will be appreciated that holographic diffuser 142 may be coated or otherwise provided with an opaque region to accomplish the function of mask element 152.

The light distribution pattern 158 may also be achieved utilizing the beamformer 170 shown in Figure 9. Beamformer 170 includes light transformer 120 and holographic diffuser 142 and reflective element 172. In all general aspects, reflective element 172 is identical to reflective elements 112, 136 and 138. Reflective element 172 differs in that a portion 174 of reflective surface 118 is made non-reflective. This may be accomplished by a number of methods including 1) not coating portion 174 with reflective material, 2) applying a non-reflective coating to surface 118 in the area of portion 174 or 3) applying a mask to reflective element 172. The effect is that light rays striking portion 174 are not reflected, and hence a light distribution pattern 158 is achieved.

With reference now to Figures 10 and 11, a beamformer 180 and associated electronically controlled mask 182 is shown. Mask 182 is positioned between light transformer 120 and reflective element 112. Mask 182 includes a plurality of liquid crystal cells, individually 201 - 220, respectively coupled to a controller 184 by a plurality of electrical leads 186, and a suitable common ground lead (not shown). Each cell 201 - 220 defines an angular portion of mask 182. Controller 184, preferably including an appropriate processing device, memory and buffer circuits, provides electrical energy to and selectively energizes cells 201 - 220. Energized cells transition from a substantially transparent state to a substantially opaque state. As seen in Figure 9, cells 201 - 203 are energized and are opaque. The remaining cells 204 - 220 remain transparent. In this configuration, mask 182 is operable to form light distribution pattern 158 as seen in Figure 8.

With continued reference to Figure 11, all cells 201 - 220 but cell 212 are energized and opaque. Under operation of controller 184, and in accordance with an appropriate sequencing algorithm which may be retained in the memory of controller 184 or hard programmed in, for example, an application specific integrated circuit, adjacent cell 211 is energized as cell 212 is deenergized. Next, and in a like manner, cell 210 is energized as cell 211 is deenergized. This process repeats progressively for each cell 201 - 220 of mask 182. In this manner, the resulting light distribution pattern will have the effect of a beam of light rotating about beamformer 180. Thus, a rotating beacon effect is created. As will be further appreciated, all cells 201 - 220 may be selectively, and concomitantly, energized and deenergized. The resulting light distribution pattern is that of a flashing beacon, such as an obstruction-warning beacon. One will readily appreciate that numerous dynamic light distribution patterns may be achieved through the selective energization and deenergization of cells 201 - 220.

Beamformer 180 is shown with 20 cells, namely, cells 201 - 220. The angular resolution in the horizontal plane is thus approximately 18°. Coarse and fine resolution adjustment may be attained by including less or more cells, respectively, to mask 182. In addition, the cells need not be formed as angular sections of mask 182, but may be formed in various configurations providing a wide variety of light distribution patterns.

In certain applications it may be necessary to provide a colored light. For example, navigation lights are colored red for port, blue for starboard and white for stern, respectively. Obstruction lights are typically colored red. In this regard, beamformers 14, 140, 150 170 and 180 may include a suitable colored filter disposed between light transformer 120 and reflective element 112. In the alternative, colored filters or colored light sources may be employed in illuminator 20.

Many changes and modifications could be made to the invention without departing from the fair scope and spirit thereof. The scope of some changes is discussed above. The scope of others will become apparent from the appended claims.

I Claim:

1. A beamforming device comprising:

A) a housing having a top and a bottom, the bottom being adapted to accept a source of light,

B) a light transforming member arranged within the housing and coupled to the source of light, the light transforming device adapted to project the source of light from the bottom to the top; and

C) a reflective element secured to the top and positioned to direct the source of light into a distribution pattern.

2. The beamforming device of claim 1, wherein the light transforming member comprises a non-imaging optical element.

3. The beamforming device of claim 1, comprising a diffusive element disposed between the light transforming member and the reflective element.

4. The beamforming device of claim 3, wherein the diffusive element comprises a holographic diffuser.

5. The beamforming device of claim 1, wherein the distribution pattern comprises an 360° arc about the beamforming device.

6. The beamforming device of claim 1, wherein the distribution pattern comprises a portion of a 360° arc about the beamforming device.

7. The beamforming device of claim 1, comprising a mask element disposed between the light transforming member and the reflective element, the mask including at least one optically opaque areas.

8. The beamforming device of claim 1, comprising a mask element disposed between the light transforming member and the reflective element, the mask including a plurality of regions, each region having a first substantially opaque state and a second substantially transparent state.

9. The beamforming device of claim 8, wherein the plurality of regions are responsive to an electrical signal for transitioning from the first state to the second state.

10. The beamforming device of claim 9, comprising a controller for selectively applying an electrical signal to selected ones of the plurality of regions.

11. The beamforming device of claim 1, wherein the light source comprises a remotely located illuminator and a light pipe.

12. The beamforming device of claim 1, wherein the reflective element has a generally conical configuration.

13. The beamforming device of claim 12, wherein the reflective element has a substantially 90° included angle.

14. The beamforming device of claim 12, wherein the reflective element has an included angle less than 90°.

15. The beamforming device of claim 12, wherein the reflective element has an included angle greater than 90°.

16. An apparatus for forming a light distribution pattern comprising:
   A) a housing having a generally cylindrical shape, a closed bottom and an open top, the bottom including a coupler for accepting a fiber-optic cable and the housing defining a cylindrical cavity;
   B) a light transforming member disposed within the cylindrical cavity, the light transforming member having an optical entrance adjacent to the coupler and a light distributing optical exit projecting towards the top;
   C) an optically transparent annular member secured to the top;
   D) a reflector secured to the annular member, the reflector having a reflective surface disposed towards the light distributing optical exit; and
   E) a light-shaping member disposed between the light transforming member and the reflector.

17. The apparatus of claim 16, wherein the light-shaping member comprises one of the group consisting of a diffuser and a mask.

18. The apparatus of claim 17, wherein the diffuser comprises a volumetric holographic diffuser.

19. The apparatus of claim 17, wherein the mask comprises a plurality of regions, each of the plurality of regions having a first substantially opaque state and a second substantially transparent state.

20. The apparatus of claim 19, wherein the plurality of regions are responsive to an electrical signal for transitioning from the first state to the second state.

21. The apparatus of claim 20, comprising a controller for selectively applying the electrical signal to selected ones of the plurality of regions.

22. The apparatus of claim 16, wherein the reflector has a generally conical shape.

23. The apparatus of claim 22, wherein the reflector has a substantially 90° included angle.

24. The apparatus of claim 22, wherein the reflector has an included angle less than 90°.

25. The apparatus of claim 22, wherein the reflector has an included angle greater than 90°.

26. A method for forming a light distribution pattern comprising the steps of:
A) providing a light signal;
B) transforming a characteristic of the light signal;
C) directing the light signal toward a reflective element; and
D) distributing the light signal from the reflective element in a predetermined light distribution pattern.

27. The method of claim 26, wherein the step of transforming a characteristic of the light comprises transforming a flux density of the light signal.

28. The method of claim 26, further comprising, between Step B and Step C, the step of shaping the light signal.

29. The method of claim 28, wherein the step of shaping the light signal comprises passing the light through a light shaping device.

30. The method of claim 28, wherein the light shaping device comprises a holographic diffuser.

31. The method of claim 26, wherein the step of directing the light signal toward a reflective element comprises directing a portion of the light signal toward the reflective element.

32. The method of claim 26, wherein the step of directing the light signal toward a reflective element comprises blocking a portion of the light signal from the reflective element.

33. The method of claim 26, wherein the step of directing the light signal toward a reflective element comprises, alternately directing the light signal toward the reflective element and blocking the light signal from the reflective element.

34. A light distribution system comprising:

A) a centralized source of light signals;

B) a light distribution system coupled to the centralized source of light signals at a proximal end; and

C) at least one light distribution device coupled to a distal end of the light distribution system, the light distribution device comprising:

1) a housing having a top and a bottom,

2) a light transforming member arranged within the housing and coupled at the bottom to a distal end of the light distribution system for receiving the light signals, the light transforming device adapted to project the light signals from the bottom to the top; and

3) a reflective element secured to the top and positioned to redirect the light signals from the light transforming member into a distribution pattern.

35. A remotely illuminated lighting system comprising:

A) an illumination source including:

1) a controlled power supply for selectively supplying a source of electrical energy to a first light source and a second light source,

2) an optical switch coupled to the first light source and the second light source for selectively coupling light signals from the first light source and the second light source to an optical coupler;

B) a light distribution system having:

1) an input coupled to the optical coupler,

2) a plurality of outputs, and

3) at least one light distribution path coupled at a proximal end to one of the plurality of outputs; and

C) a beamformer having:

1) an input coupled to a distal end of the at least one light distribution path;

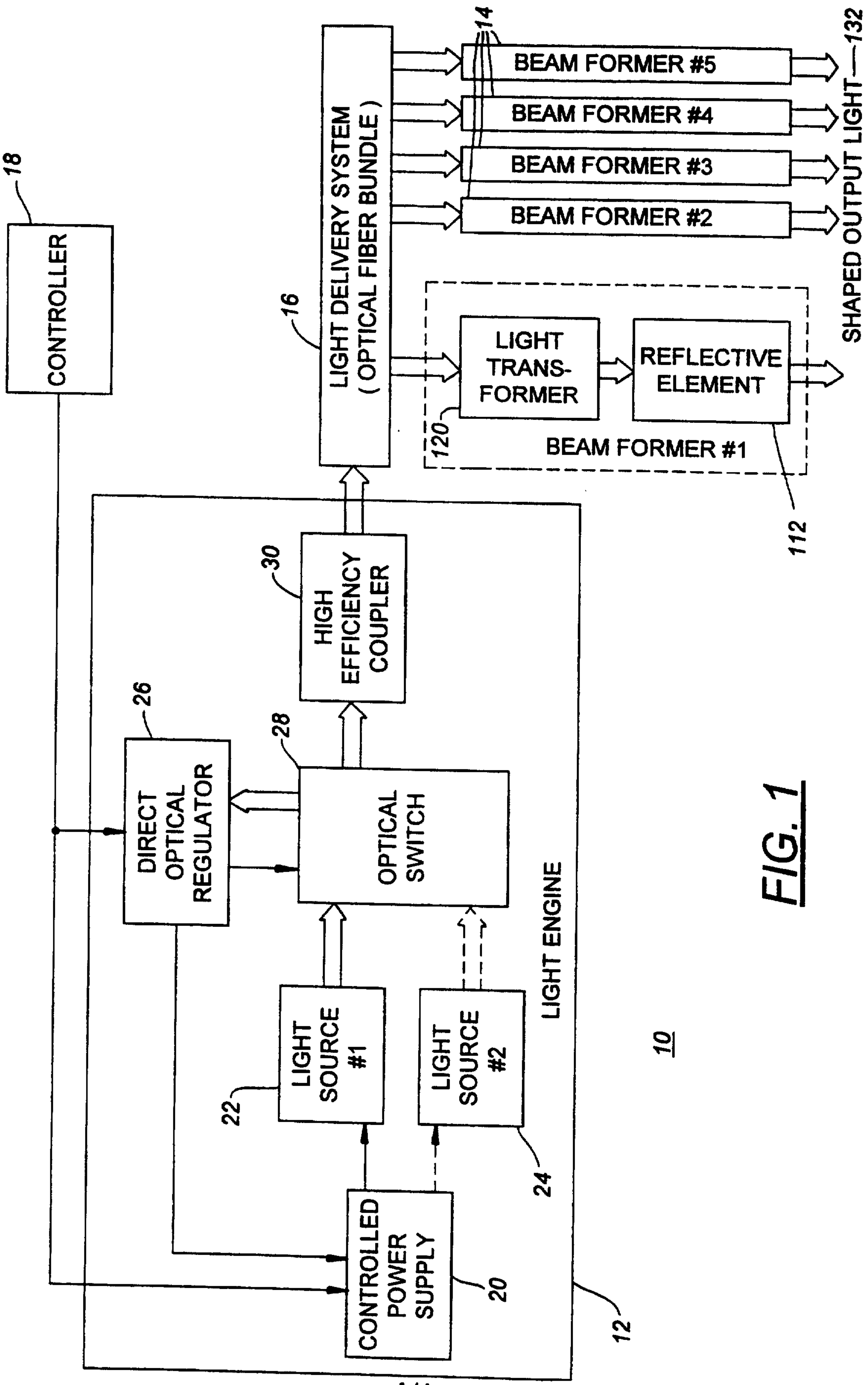
2) a housing having a generally cylindrical shape, a closed bottom and an open top, the housing defining a cylindrical cavity;

3) a light transforming member disposed within the cylindrical cavity, the light transforming member having an optical entrance adjacent to the input and a light distributing optical exit projecting toward the top;

4) an optically transparent annular member secured to the top;

5) a reflector secured to the annular member, the reflector having a reflective surface disposed toward the light distributing optical exit; and

6) a light shaping member disposed between the light transforming member and the reflector.


CONTROLLER
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LIGHT DELIVERY SYSTEM (OPTICAL FIBER BUNDLE)
16
14
BEAM FORMER #5
BEAM FORMER #4
BEAM FORMER #3
BEAM FORMER #2
SHAPED OUTPUT LIGHT
132
LIGHT TRANS-FORMER
REFLECTIVE ELEMENT
BEAM FORMER #1
120
112
HIGH EFFICIENCY COUPLER
30
DIRECT OPTICAL REGULATOR
26
OPTICAL SWITCH
28
LIGHT SOURCE #1
22
LIGHT SOURCE #2
24
LIGHT ENGINE
CONTROLLED POWER SUPPLY
20
12
10

FIG. 1

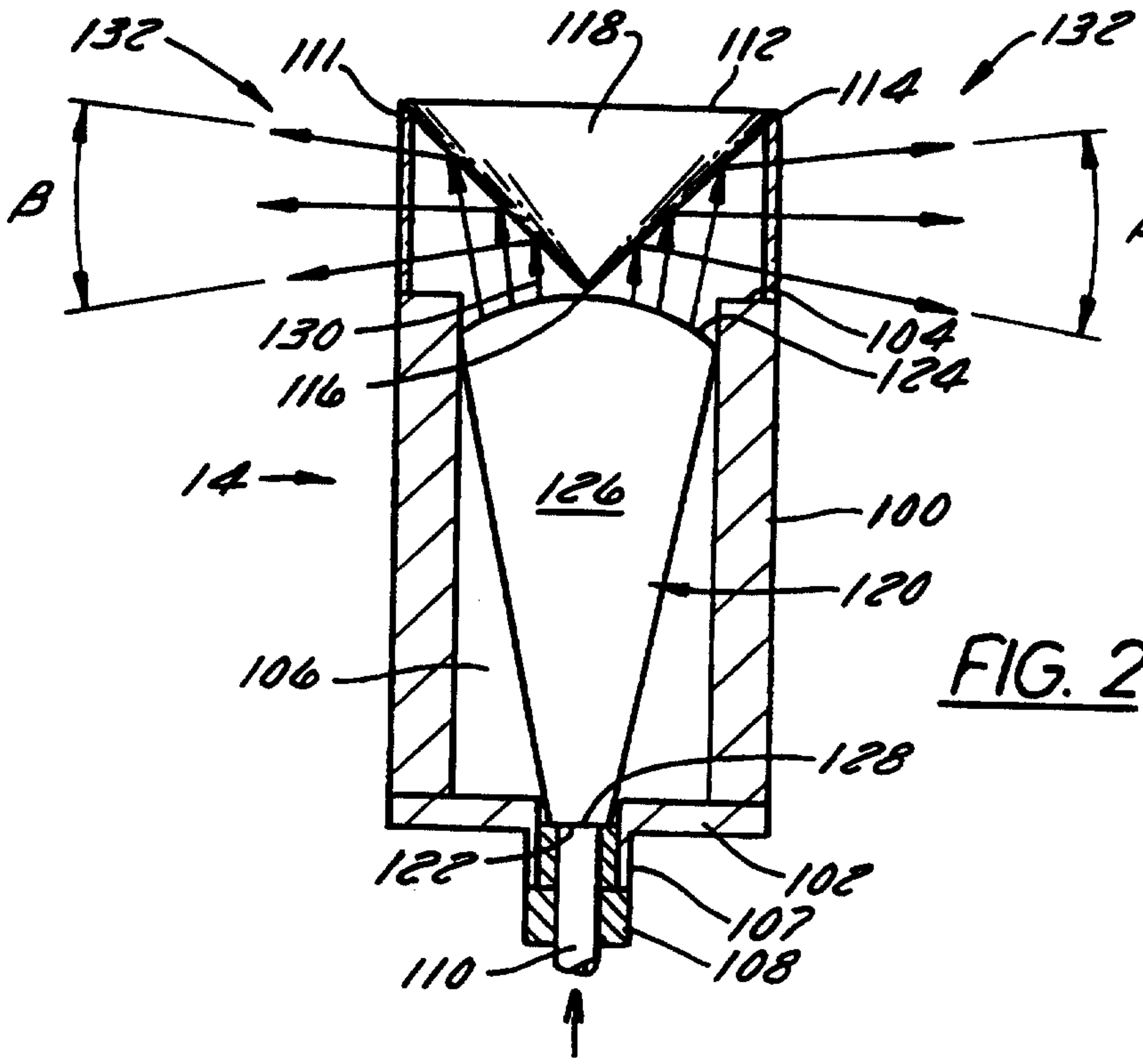
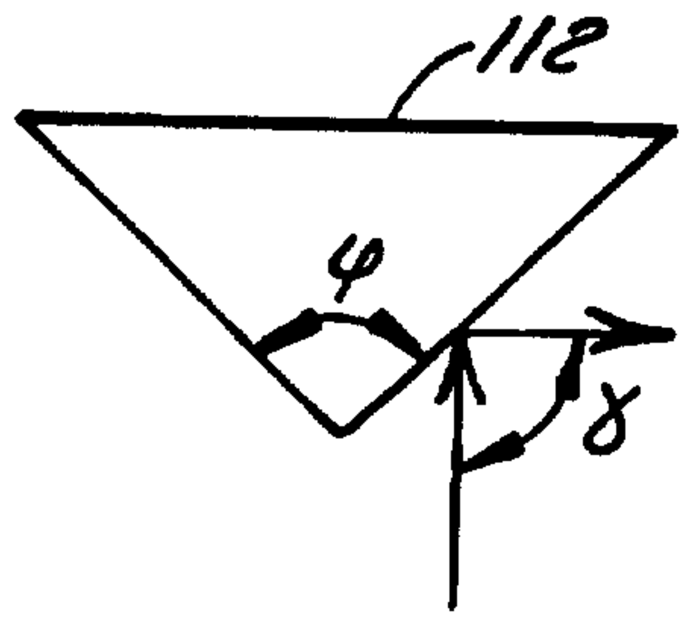
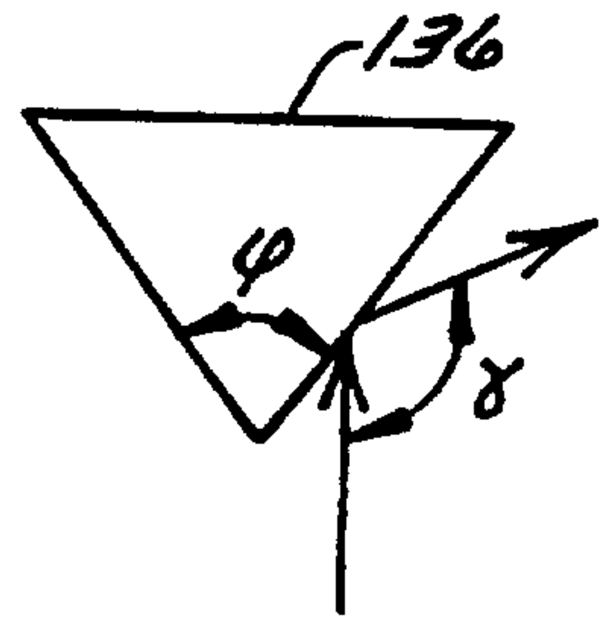


FIG. 2



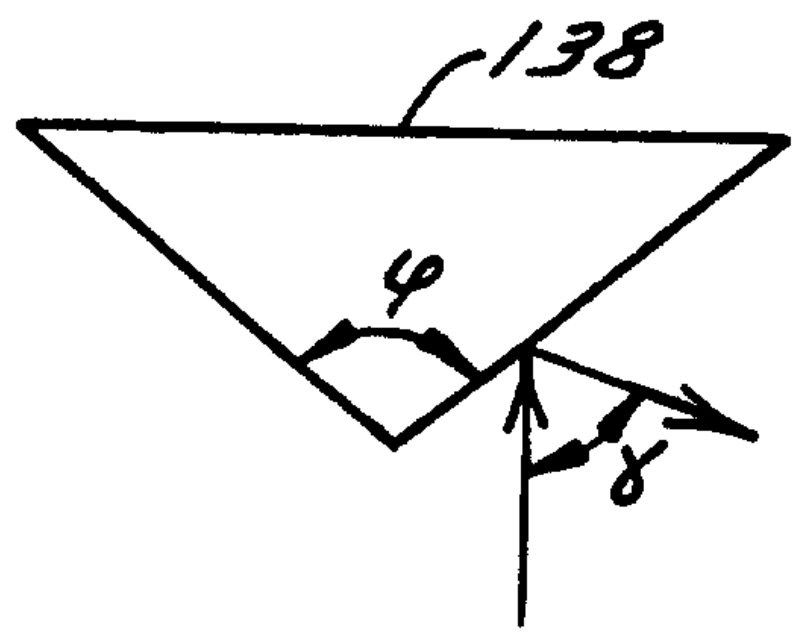
φ = 90°
γ = 90°

FIG. 3



φ < 90°
γ > 90°

FIG. 4



φ > 90°
γ < 90°

FIG. 5

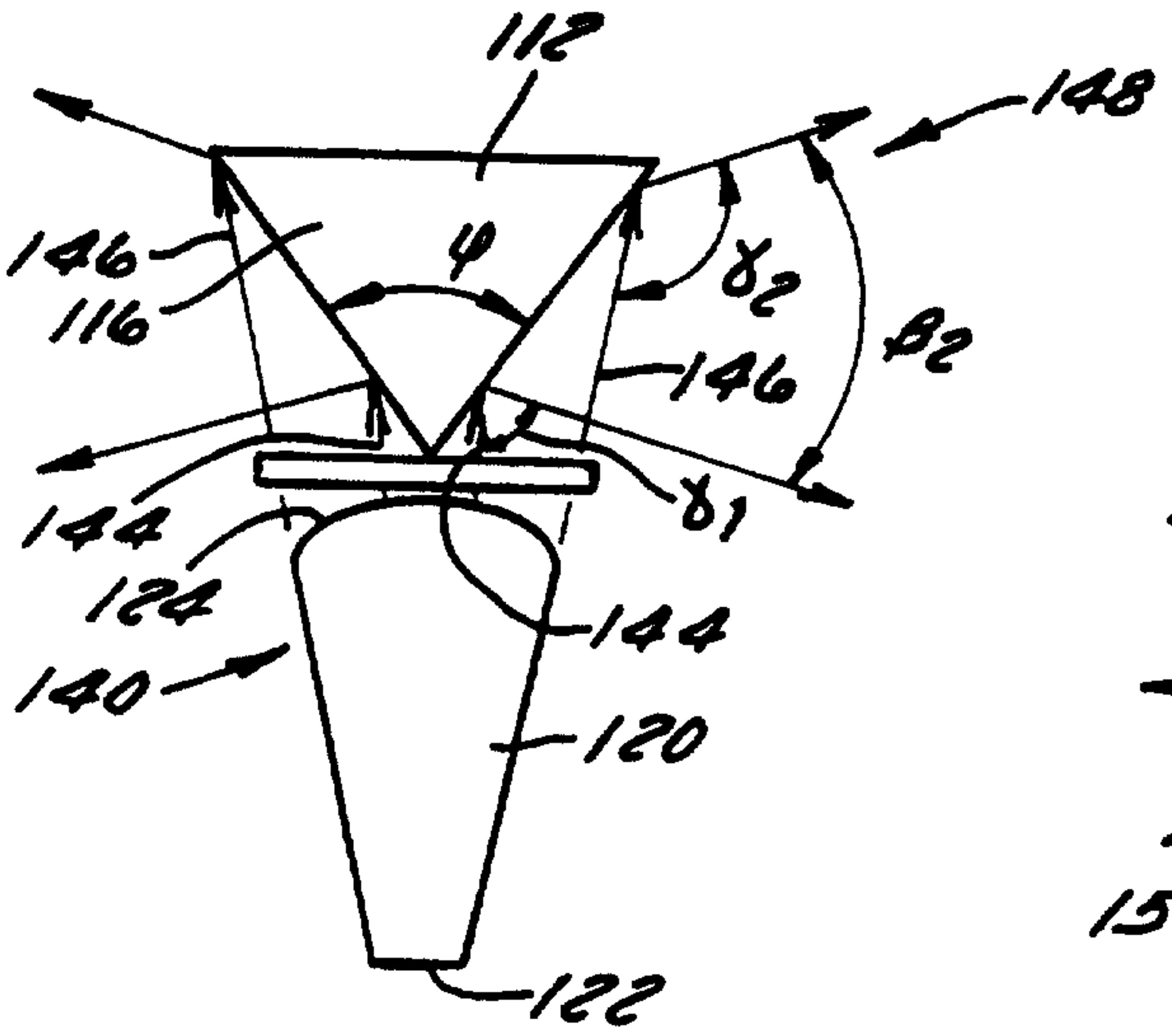


FIG. 6

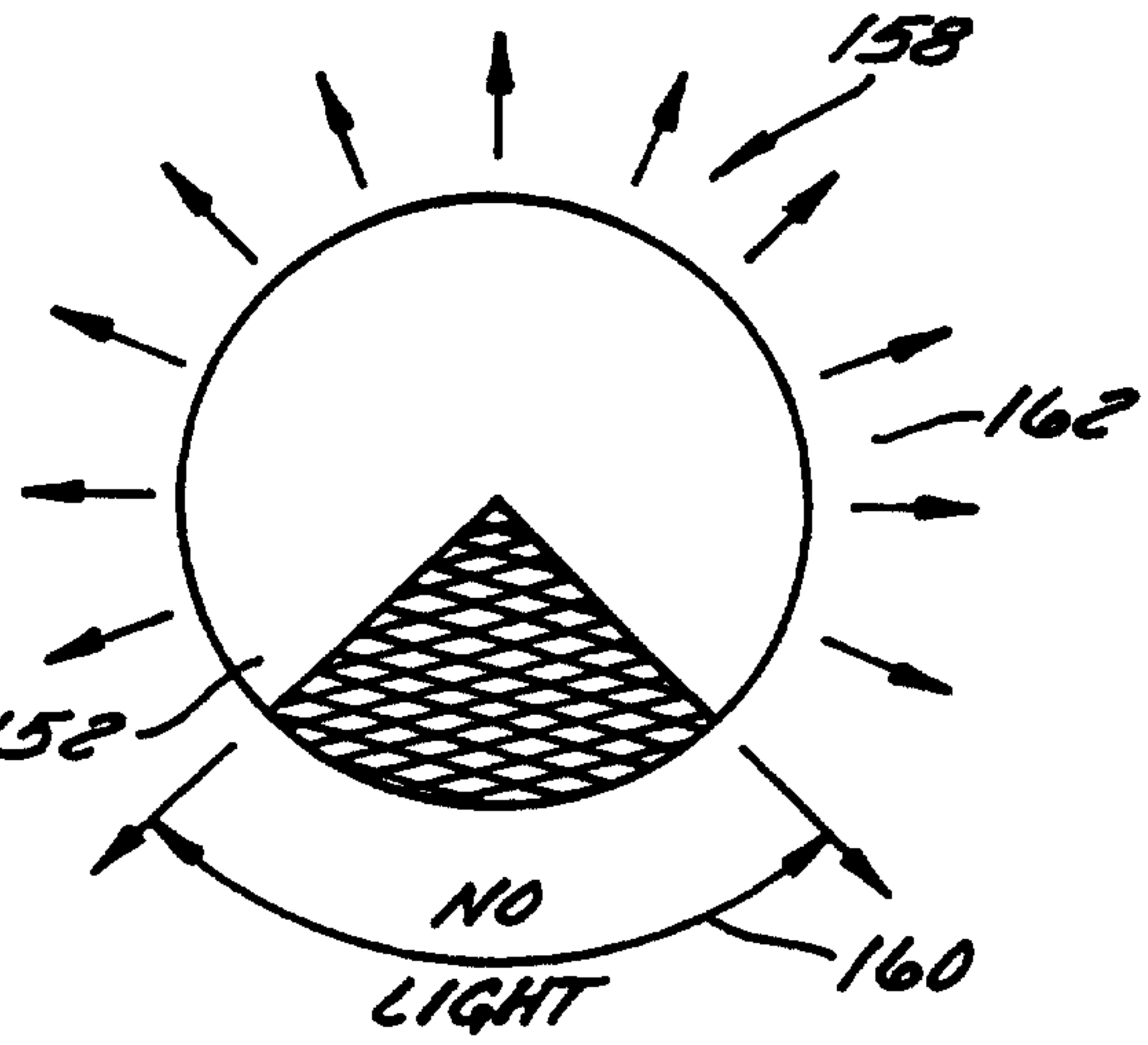


FIG. 8

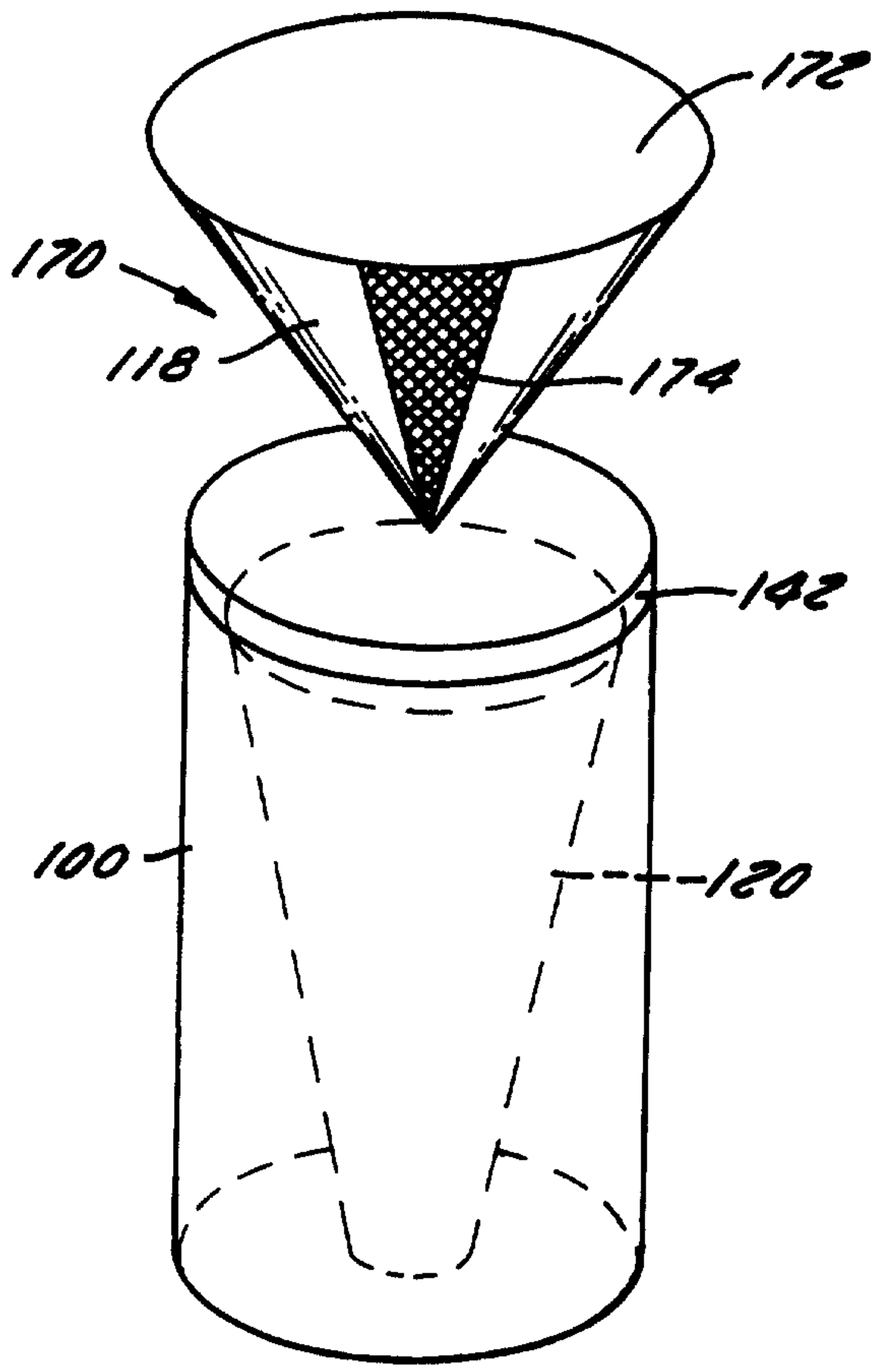


FIG. 9

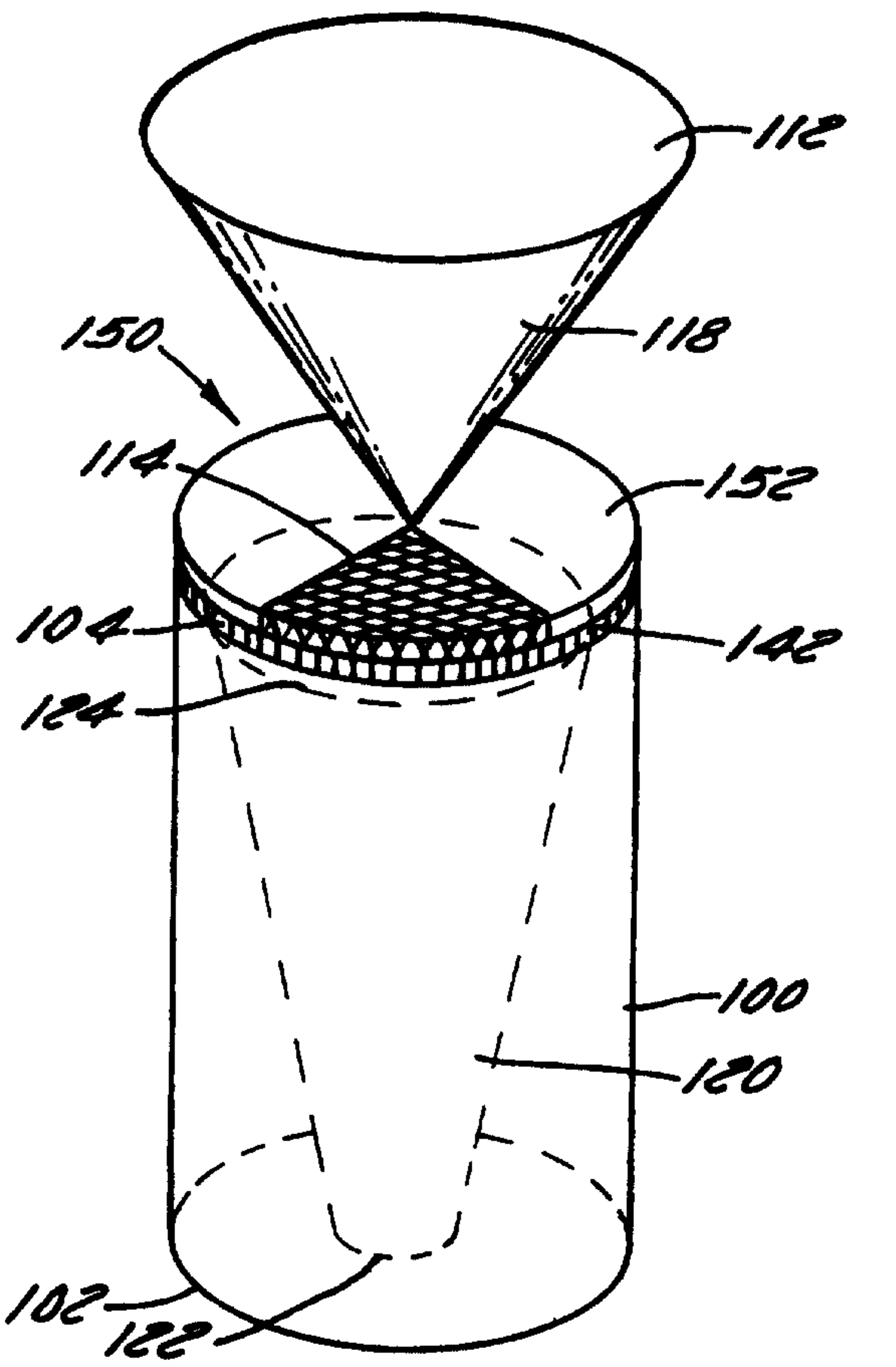


FIG. 7

SUBSTITUTE SHEET (RULE 26)

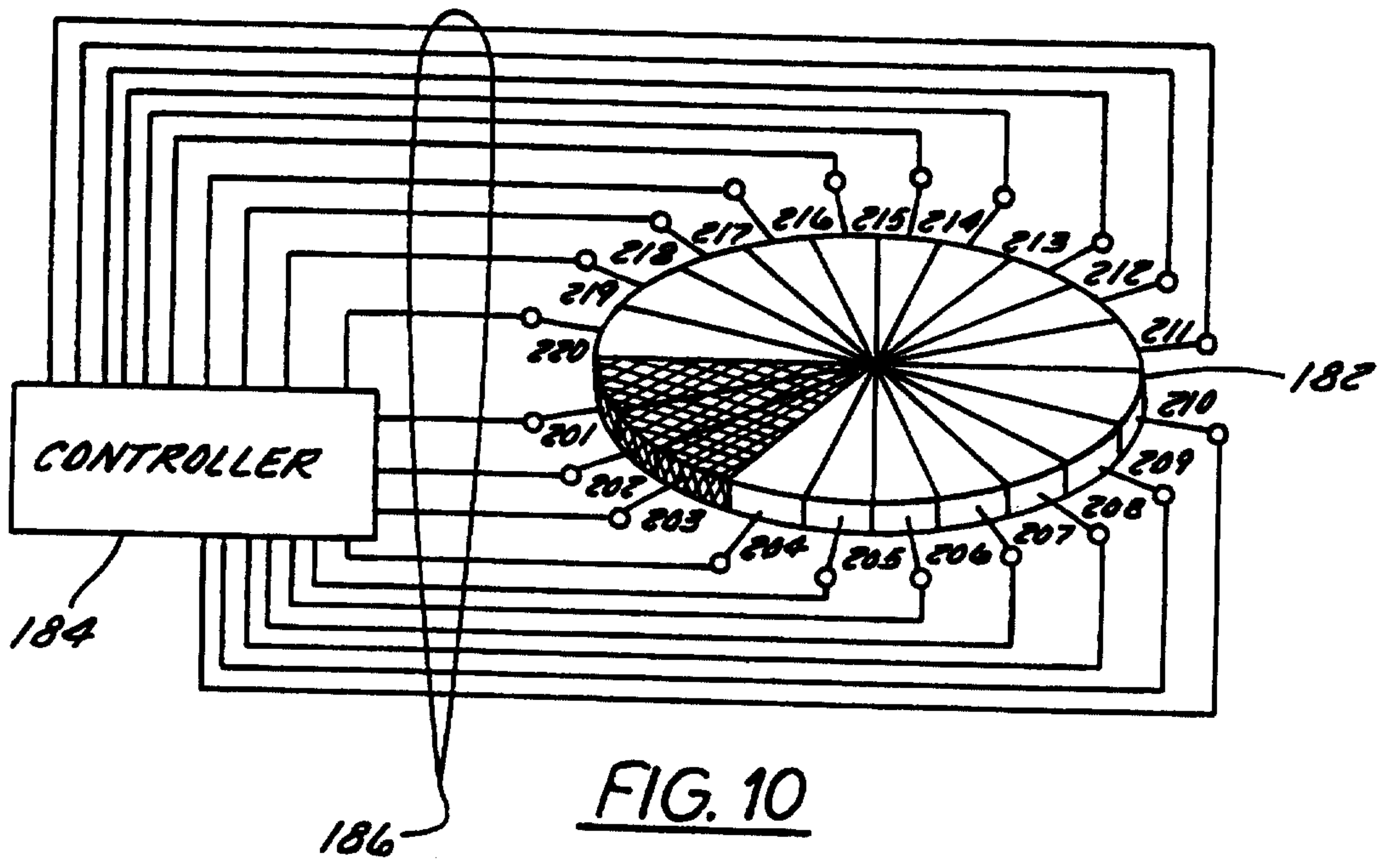

CONTROLLER
182
184
186
201
202
203
204
205
206
207
208
209
210
211
212
213
214
215
216
217
218
219
220

FIG. 10

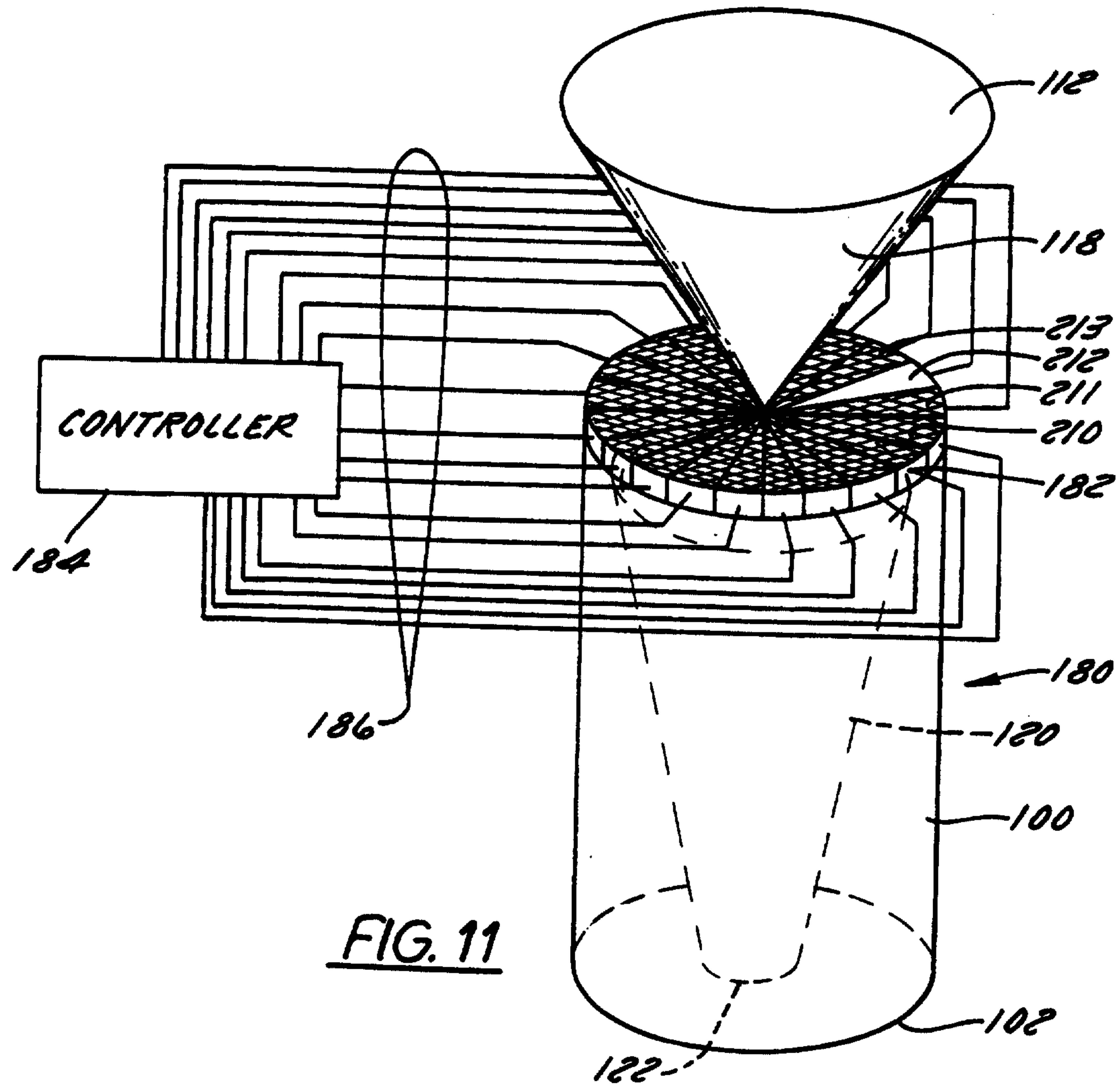
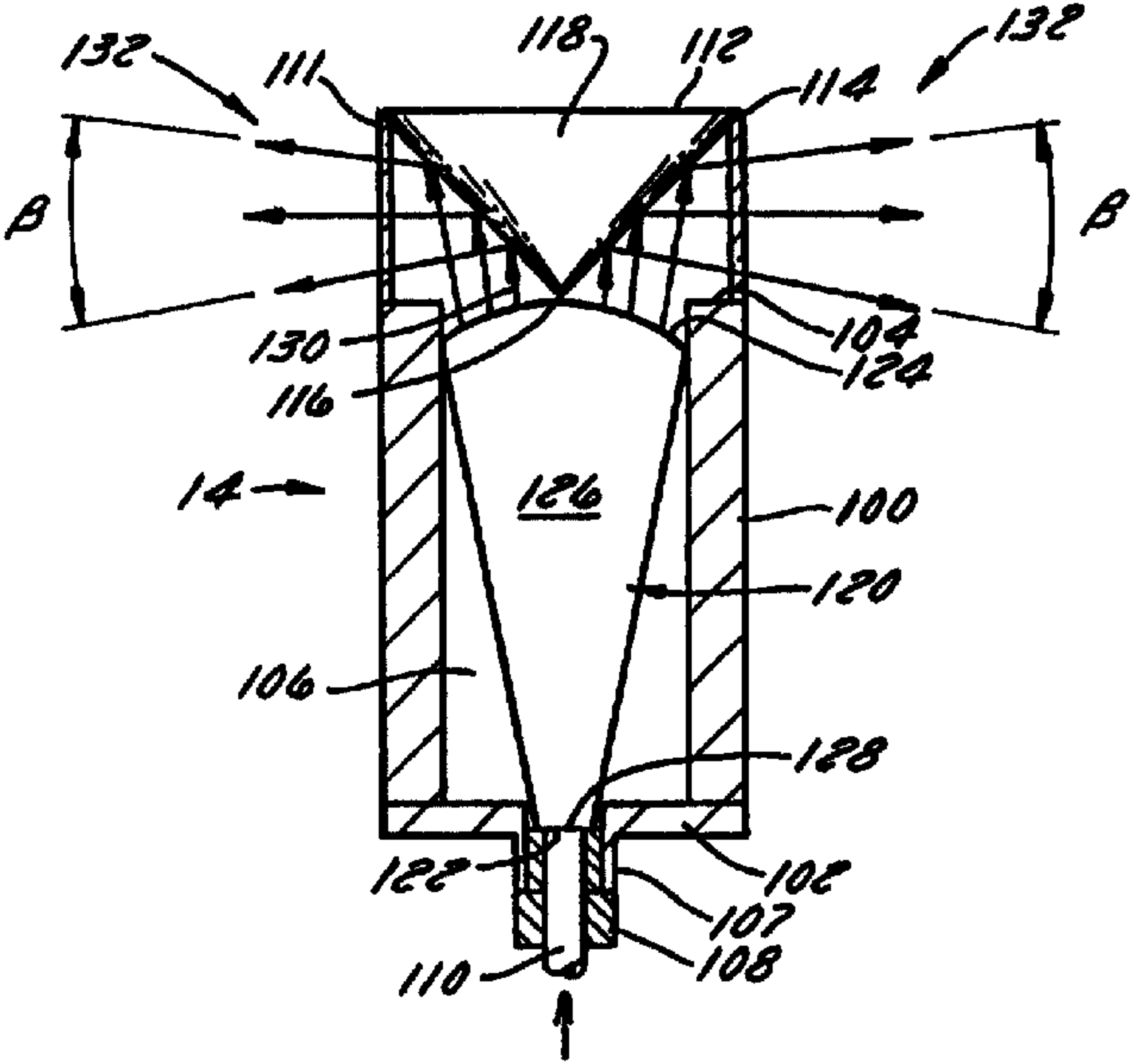

CONTROLLER
112
118
213
212
211
210
182
184
180
186
120
100
102
122

FIG. 11


132
118
112
132
111
114
β
β
130
104
116
124
14
126
100
120
106
128
122
102
107
110
108