Consommation et Corporations Canada
Bureau des brevets
Ottawa, Canada K1A 0C9

Consumer and Corporate Affairs Canada
Patent Office

(11) 2,003,661
(22) 1989/11/22
(43) 1991/05/22
(52)

5,103,1/68

(19) (CA) APPLICATION FOR CANADIAN PATENT (12)

(54) Method and Apparatus for Presenting 3-D Motion Pictures

(72) Shaw, William C. - Canada ;
Ferguson, I. Graeme - Canada ;
Kroitor, Roman B. - Canada ;
Harris, Gordon W. - Canada ;
Baker, Ken T. - Canada ;
Panabaker, Paul D. - Canada ;
Toporkiewicz, Marian F. - Canada ;

(73) Imax Systems Corporation - Canada ;

(57) 37 Claims

Notice: The specification contained herein as filed

RBP File No. 0295-350

ROGERS, BERESKIN & PARR

CANADA

Title: METHOD AND APPARATUS FOR PRESENTING 3-D MOTION PICTURES

Inventors: William C. Shaw
I. Graeme Ferguson
Roman B. Kroitor
Gordon W. Harris
Ken T. Baker
Paul D. Panabaker
Marian F. Toporkiewicz

ABSTRACT OF THE DISCLOSURE

A high fidelity 3-D immersion theatre experience is produced by alternately projecting corresponding left-eye and right-eye images onto a dome-shaped projection screen from two separate film strips and through separate wide-angle lenses. The lenses are positioned close together with their projection axes in a common vertical plane to achieve lateral co-incidence of the projected images and oriented in that plane to achieve vertical co-incidence of the images. Each person viewing the motion picture is provided with glasses that have lenses in the form of liquid crystal cells arranged to alternately block the left and right eyes of the person in synchronism with the projection of right-eye and left-eye images respectively, so that a stereoscopic effect is perceived.

FIELD OF THE INVENTION

This invention relates to a method and apparatus for presenting stereoscopic or three-dimensional motion pictures (hereafter called 3-D motion pictures).

BACKGROUND OF THE INVENTION

3-D motion pictures are generally made by simultaneously photographing a subject using two motion picture cameras positioned to provide "left eye" and "right eye" views of the subject. To present the motion picture, the images recorded by the cameras are projected onto a screen and are optically coded in some way so that the left eye of a viewer sees only the images that were recorded by the "left eye" camera while the viewer's right eye sees only the "right eye" images. The viewer then perceives a stereoscopic or 3-D effect.

DESCRIPTION OF THE PRIOR ART

One method of coding the images involves using colour filters (anaglypta). For example, the right eye images may be coloured blue and the left eye images red and the viewer provided with spectacles having filters that are coloured so that the viewer's right eye sees only blue images and the left eye sees only red images. A disadvantage of this technique is of course that it can be used with two colour images only. This method was used by the assignee of the present invention (Imax Systems Corporation) to present computer generated 3-D images in a dome at the Tsukuba Expo '85 fair in Japan.

Full colour 3-D images may be coded by a technique referred to as "alternate eye". This involves the use of what are in effect shuttered spectacles worn by a viewer. The shutters effectively block and unblock the view from each eye alternately in timed relation to projection of the images onto the screen so that the viewer's right eye is blocked when left eye images appear and vice versa. This technique is discussed, for example, in United States Patent No. 4,424,529 (Roese et al.).

Another coding technique involves the use of crossed polarized filters (axes of polarization at 90° to each other) on the projection lenses for the respective images and correspondingly polarized filters in glasses worn by a viewer. This technique was used by Imax Systems Corporation to present full colour 3-D motion pictures at Expo '86 in Vancouver, Canada using large format films such as those that are available under the registered trade marks IMAX and OMNIMAX. The use of large format films is possible as a result of development of the so-called "rolling loop" film transport mechanism for cameras and projectors. United States Patent No. 3,494,524 to Jones discloses the principle of a rolling loop transport mechanism and a number of improvements are disclosed in United States Patents Nos. 3,600,073, 4,365,877 and 4,441,796 (Shaw).

While the polarization technique may be the best currently used commercial method of presenting full colour

3-D motion pictures, it does have some limitations. One of these is that the viewer must keep his or her head erect in order to maintain proper polarizer orientation and avoid "ghost" images. A second limitation is that most materials used for projection screens significantly depolarize the projected light which degrades the quality of the projected image. However, the present inventors have found that the single most significant limitation of the polarization technique is that the polarized light is effectively "rotated" and the polarization effect severely impaired where a curved screen is used for wide field of view presentations. This is due to an effect known as "Brewster's Law".

BRIEF DESCRIPTION OF THE INVENTION

An object of the present invention is to provide an improved method and apparatus for presenting 3-D motion pictures.

In a broad method aspect, the invention involves the steps of providing a dome-shaped projection screen and alternately projecting corresponding left-eye and right-eye images onto the screen. The left and right eyes of each person viewing the motion picture are alternately blocked in synchronism with the appearance of right-eye and left-eye images respectively on the screen, so that a stereoscopic effect is perceived. Preferably, the images are projected from two separate film strips through separate wide-angle lenses having respective projection axes. In this event the lenses are positioned with their projection axes in a common vertical or horizontal plane for co-incidence of the projected images on the screen in a direction at right angles to said plane. The lenses are oriented within the said common plane to achieve co-incidence of the projected images on the screen in the direction of the plane.

In its apparatus aspect, the invention preferably provides a dome-shaped projection screen and means for alternately projecting corresponding left-eye and right-eye images onto said screen from two separate film strips. The projection means includes separate wide-angle lenses for the respective film strips, the lenses having respective projection axes and being positioned directly adjacent one another with their respective axes in a common vertical or horizontal plane for co-incidence of the projected images on the screen in a direction at right angles to that plane and with the lens axes oriented within the said common plane to achieve co-incidence of the images on the screen in the direction of that plane. The apparatus also includes means for alternately blocking the left and right eyes of each person viewing the motion picture in synchronism with the appearance of right-eye and left-eye images respectively on the screen, so that a stereoscopic effect is perceived.

Presentation of images on a dome-shaped projection screen coupled with projection through wide-angle lenses allows the production of 3-D images that can occupy a wide field of view and thus fill the visual field of the audience. Alternate eye 3-D projection allows the use of full-colour images without the disadvantages associated with polarization techniques. Projection of the respective series of images from two separate film strips through separate lenses has been found to minimize eye strain because any unsteadiness in the projected images will be random and this has been found to be much more tolerable to a viewer than what might be termed co-incident unsteadiness if both images were projected from the same filmstrip.

Further, by orienting the lenses as defined previously, it is possible to ensure a high level of co-incidence of left-and right-eye images over a wide area of the screen. This also further minimizes eye strain and is particularly important where high resolution film is used (see later).

It has been found that attention to all of these criteria coupled with the use of high-quality equipment and film stock and high and uniform illumination levels can lead to the presentation of a high fidelity stereoscopic motion picture and a superior theatrical experience for the audience. It is possible to display full-colour 3-D images in a large volume of space that fill the visual field of the audience while causing minimal eye strain, to the point at which members of the audience may not realize that they are watching a motion picture.

Exceptionally high quality presentation may be achieved by using high resolution film, for example of IMAX or OMNIMAX format. This format is characterized by a large frame size (so-called 70 millimeter 15 perf. film) and high quality film stock. While this particular format is not essential to the invention, it is believed that a large frame size should be used having a usable image area of at least 1200 square millimeters (approximately two square inches).

BRIEF DESCRIPTION OF THE DRAWINGS

In order that the invention may be more clearly understood, reference will now be made to the accompanying drawings which illustrate a particular preferred embodiment of the invention by way of example, and in which:

Fig. 1 is a schematic vertical sectional view through a theatre for projecting motion pictures in accordance with the invention;

Fig. 2 is a simplified perspective view showing the principal components of a 3-D motion picture projector used in the theatre of Fig. 1;

Fig. 3 is a schematic view showing the two rotors of the projector of Fig. 2;

Fig. 4 is a somewhat schematic side elevational view of the projection lenses of the projector of Fig. 2;

Figs. 5 and 6 are schematic perspective views illustrating alternate eye 3-D projection; and,

Fig. 7 shows a typical frame format for a filmstrip used in the method of the invention.

DESCRIPTION OF PREFERRED EMBODIMENT

Referring first to Fig. 1, a motion picture projection theatre is shown to include a dome-shaped structure 10, the internal surface of which forms a projection screen 12. Within the theatre is a structure generally indicated at 14 that defines seating areas for the audience and a projection room 16 for a projector 20. As will be described in more detail later, the projector is designed to alternately project corresponding left-eye and right-eye images onto the screen 12 from two separate filmstrips through separate wide-angle lenses having respective projection axes oriented to promote a high degree of lateral and vertical co-incidence of the projected images. The viewing audience is provided with glasses that operate in synchronism with the projector to alternately block the left and right eyes of each person in synchronism with the appearance of right-eye and left-eye images on the screen 12, so that a stereoscopic effect is perceived.

Referring to Fig. 2, the projector 20 has a frame 22 which includes three horizontally disposed baseplates 24, 26 and 28 supported in vertically spaced positions by various legs 30. Baseplates 24 and 26 support respective upper and lower rolling loop transport mechanisms that are generally indicated at 32 and 34 respectively. Parts of respective film strips to be transported by the mechanisms are indicated at 38 and 40. Corresponding projection lenses are indicated at 42 and 44, while a common lamphouse containing projection lamps, mirrors and associated lenses is generally indicated at 46. Lenses 42 and 44 are identical wide-angle "fisheye" lenses.

The drawings show only the principal components of the respective rolling loop mechanisms. Reference may be made to the Shaw '073 patent (supra) for a fuller description of the rolling loop film transport mechanism. The two mechanisms 32 and 34 of projector 20 are each essentially the same as the mechanism disclosed in the Shaw patent, except for the features described specifically herein. The disclosure of the Shaw patent is incorporated herein by reference.

Fig. 2 shows that the rolling loop mechanism 32 includes stator means made up of an inlet stator assembly 48 and outlet stator assembly 50 with an aperture plate 52 between the two stator assemblies. Part of a rotor of the mechanism is visible at 54. The rotor co-operates with the stator to define a film passage, and has gaps for receiving film loops, all as described in the Shaw patent. Rotor 54 is supported for rotation about a vertical axis indicated at X in Fig. 2.

Mechanism 32 also includes means for moving film strip 38 through the passage between the rotor and stator, in the form of driven inlet and outlet sprockets 56 and 58 respectively. Mechanism 32 also includes means for locating the filmstrip in registration with the aperture in aperture plate 52, in the form of fixed film registration pins that are located adjacent the film projection aperture for engagement in the marginal perforations typically provided in motion picture film (see Fig. 7).

In accordance with the teaching of the Shaw patent, the film is decelerated as it is located on these registration pins, by a cam unit immediately adjacent to and upstream of the aperture plate 52. The cam unit of mechanism 32 is generally indicated at 60 in Fig. 2.

The lower rolling loop transport mechanism 34 is essentially identical with mechanism 32 and includes a film decelerating cam unit 62. The two cam units are driven by a common drive shaft 63. The other components of mechanism 34 are denoted by primed reference numerals corresponding to the numerals used for the components of mechanism 32. The rotors 54 and 54' of the two mechanisms are identical and are positively coupled together for rotation about axis X.

The two rotors are rotationally offset from one another (see Fig. 3) to an extent sufficient to cause alternate projection of images from the respective filmstrips 38 and 40. However, all of the other components of the two mechanisms will be aligned with one another. For example, as can be seen from Fig. 2, the two input sprockets 56 and 56' are aligned and are mounted on a common driven shaft 64. Similarly, the output sprocket 58 and the corresponding sprocket for mechanism 34 (not visible) are mounted on a common drive shaft 66. Although not visible in Fig. 1, the two drive shafts 64 and 66 are driven from the main drive motor of the projector so that the sprockets are driven in synchronism with the other components of the projector.

Two separate aperture plates are in fact used for the respective mechanisms but the plates are mounted in a common housing indicated at 68. Similarly, the two projection lenses 42 and 44 are vertically aligned and mounted in a common housing 70.

Referring to Fig. 3, the two rotors 54 and 54' are shown as seen in plan but with the lower rotor 54' shown as being of larger diameter than the upper rotor simply for the purpose of illustrating the rotor offset discussed previously; in fact, the two rotors are of identical diameter. The gaps in the two rotors are denoted respectively by the letters G and G' and the lines denoted A and B indicate the gap offset between the respective rotors. Each of the rotors is provided with a curved plate behind each gap that forms a main shutter, and with a "flicker" shutter midway between each pair of gaps, again as described in Shaw '073 patent. As a result of this shutter configuration, each frame in each filmstrip is projected twice.

Fig. 3 shows a practical projector in which each rotor has eight gaps and sixteen shutters. In this configuration, the rotor offset necessary to achieve alternate eye projection (with two images being projected twice) is one quarter of the gap spacing. The angular amount of the offset will therefore amount to one quarter of 45° (the angular spacing of the gaps). If no secondary shutters were used, the offset should be one half of the gap spacing. This amount should be further divided by two for each secondary shutter added between each adjacent pair of gaps.

The two lenses 42 and 44 are vertically aligned in a plane of alignment indicated at P in Fig. 2. This lens orientation ensures that the projected images are laterally co-incident on the projection screen 12 (Fig. 1). Vertical co-incidence is achieved by appropriate orientation of the projection axes of the two lenses as shown in Fig. 4. That view is a schematic illustration taken in plane P. The two lenses 42 and 44 are shown as are their respective axes 42a and 44a. In this particular embodiment, image co-incidence in the vertical direction is accomplished by shifting the two lenses towards one another as indicated by arrows 64. This has the effect of deflecting the images that are projected through lens 42 so that they meet at the screen.

The normal "straight ahead" positions of the lenses 42 and 44 are indicated in ghost outline in Fig. 4. In these positions, the projection axes 42a and 44a would be co-incident with the respective centrelines 66 of the apertures through which the images are projected. However, the lenses are shifted towards one another to the offset positions shown in Fig. 4. The offset between the aperture centrelines 66 and the respective projection axes 42a, 44a is generally denoted by arrows 68 in Fig. 4. The extent of this offset will depend on the particular dimensions of the theatre and the spacing between the two projection lenses but in one practical embodiment was 0.102 millimeters (per lens). The offset will normally be fixed once set and may be applied at either or both of the lenses as shown or at only one lens.

In addition to this lens offset, it may be desirable to impart to one or both of the lenses a programmable lens shift in order to correct for inaccuracies in the location of the images on the two filmstrips. A technique for accomplishing this lens shift is disclosed in United States patent application Serial No. 365,633 filed June 13, 1989.

Figs. 5 and 6 illustrate schematically the step of alternately blocking the left and right eyes of each person viewing the motion picture in synchronism with the appearance of right-eye and left-eye images respectively on the screen. The projector is generally indicated by a cylinder denoted 20 and the two views may be taken as illustrating projection of sequential frames, namely a right-eye frame 70 from the upper filmstrip 38 through projection lens 42 (Fig. 5) and a left-eye frame 72 from the lower filmstrip 40 through projection lens 44. Each viewer of the motion picture is provided with a pair of glasses 74 comprising a headband 76 and respective left-eye and right-eye lenses 78 and 80 carried in a frame 82 which is suspended from the headband 76. The two lenses 78 and 80 are liquid crystal cells that can be electrically actuated to alternate between an opaque state and a transmissive state. In Fig. 5, the left-eye lens 78 is shown as opaque while the right-eye lens 80 is transmissive so that the viewer will see the right-eye image 70 on the screen. In Fig. 6 on the other hand, the lens states have been reversed so that the viewer can see the left-eye image 72.

Electrical circuitry for actuating the lenses is accommodated within a housing 84 carried by the headband 76. The circuitry includes an infrared receiver which receives infrared synchronizing signals illustrated at 86 from a transmitter 88 that is triggered in synchronism with the projection of right-eye and left-eye images from projector 20. In Figs. 5 and 6, this synchronization is shown schematically as being derived from a rotary timing shutter 90 that is driven by a mechanical drive mechanism 92 from the main drive shaft of the projector. Shutter 90 has peripheral notches 94 and has associated therewith an optical detector 96 that is respectively blocked and unblocked as the shutter rotates and the notches 94 move through the detector.

Neither the infrared transmission and receiving means nor the electrical circuitry for actuating the glasses lens have been explained in detail since they may be accomplished in accordance with the teachings of the prior art, for example the Roese, et al. Patent No. 4,424,529 discussed previously. Preferably, however, proprietary technology is utilized for example in accordance with the teachings of a co-pending patent application entitled "Projection Synchronization System" of Imax Systems Corporation. It should also be noted that, while infrared triggering of glasses containing liquid crystal cells is believed preferable, there is no restriction to this particular technology. In principle, mechanically shuttered glasses could be used and/or a different synchronization technique could be employed (e.g. through an electrical cord).

In summary projector 20 projects alternate left- and right-eye images and at the same time transmits infrared synchronizing signals to the glasses 74 so that the viewer's eyes are alternately blocked and unblocked in synchronism with the projection of the left- and right-eye images onto the screen so that a stereoscopic effect is perceived.

Referring back to Fig. 1, the images are projected onto the projection screen 12 at the inside surface of the dome 10. The dome has the shape of a segment of a hemisphere, the centre of which is indicated at 98. The overall size of the dome will depend on audience seating capacity and other factors and may, for example, be of approximately 24 metres in diameter (d). In this embodiment, the dome has an angular extent about centre 98 of 160° defined by the two chain-dotted lines denoted 100 and 102 respectively, each of a length d/2. The dome is inclined at an angle of approximately 28° indicated at 104 in Fig. 1 and defined between the horizontal and a line 106 between diametrally opposed points at the bottom of the dome-shaped surface. As mentioned previously, the audience will be seated on structure 14; as such, the dome is in effect tilted down in front of the audience for better viewing the projected images. In an actual theatre, each of the steps 14a of structure 14 will accommodate a row of seats.

Projector 20 is located within projection room 16 and is oriented so that the projection axis 108 is tilted upwardly, in this case at an angle 110 of 13.5° to a horizontal reference line R. The particular wide-angle projection lenses used are designed to give a field of view represented by angle 112 of 123° comprising 35° below the projection axis 108 and 88° above that axis. The lateral field of view (not illustrated) is 180°.

Projector 20 is located laterally so that its projections lenses 42 and 44 are located in the common vertical plane P referred to previously with plane P extending through the centre 98 of the dome. The lenses are spaced from one another so that the separation between the lens axes is 101.6 millimeters. It is believed that the lenses should be positioned as close together as possible preferably at a spacing in the range 100 to 160 millimeters. The projector itself is positioned slightly above the geometric centre of the dome. Specifically, the projector is located so that the projection point (the midpoint of a line joining the rear "nodal" points of the two projection lenses is located a distance (a) above centre point 98 and a distance (b) forward of that point (closer to the screen). It is believed that the ratios of these distances relative to the diameter of the dome (d) should be approximately a:d = 1:35 and b:d = 1:60. In this particular embodiment (a) is 690 millimeters, (b) is 400 millimeters and (d) is 24000 millimeters (24m).

The "nodal" points of a lens are two points on the optical axis of the lens 50 so located that any incident ray directed at one such point will produce a parallel emergent ray directed through the other point. In a projector, the rear nodal point is the point closest to the film.

Preferably, the light reflecting properties of the screen 12 are selected to provide high "gain" (defined as the relationship between the intensity of the incident and reflected light rays). This can be accomplished by a combination of surface texture and metallic paint. The on-axis gain (normal to the screen surface) should preferably be in the range of 1.5 - 2.0 and the off-axis gain should taper off to levels of less than 0.5 at angles of about 40°. At angles greater than 45°, the gain should quickly decrease to avoid unwanted reflection of light onto other locations of the screen. Techniques for achieving high gain projection are known in the art. For example, reference may be made to United States Patent No. 3,354,738 (Forehand, et al.) entitled "Front Projection Screen with Precision Gain Control". A high gain screen is at least highly desirable, particulary where the liquid crystal cells used in the viewing glasses (74) have relatively low light transmission properties in the transmissive state. However, high screen gain may be of less importance where the transmission properties of the cells are higher.

Fig. 7 shows a typical frame format that might be used for the filmstrips 38 and 40 in accordance with the method of the invention. The format shown is the existing OMNIMAX format of Imax Systems Corporation. The filmstrip itself is generally denoted by reference numeral 114; only one frame on the filmstrip is shown and is denoted 116. In this embodiment, the images on the filmstrip were shot using fisheye lenses, as a result of which the actual image recorded on the film has an overall shape which resembles a circle that has been flattened at the bottom as shown by the area denoted 118 in Fig. 7. If the film is shot using fisheye lenses and then projected using fisheye lenses, distortion of the projected image is minimized. However, in some cases, such distortion may be acceptable or even desirable, in which case the film could be shot using lenses of longer focal length which would result in a rectangular image on the film.

The usable image area of the frame is the rectangular area 120 between the marginal perforations 122 and within which the image area 118 is located. The particular frame format shown is known as 70 mm 15 perf. because the film is 70 millimeters wide and the length of each frame corresponds to fifteen of the perforations 122 (which are of standard size and pitch). The usable image area 120 for each frame in OMNIMAX format is 3,376 sq. mm and the actual image area 118 is 2,653 sq. mm. The dimensions of the usable image area 120 are 69.6 mm x 48.5 mm.

By way of comparison, so-called 4 perf. 35 mm film has a usable image area of 306 sq. mm (20.1 mm x 15.2 mm) and the actual image where a fisheye lens is used to shoot the film is 241 sq. mm. It has been found that this frame format is unacceptable for use in the method of the invention and that the usable image area (as area 120 in Fig. 7) should be at least 1,200 sq. mm in order to achieve satisfactory resolution of the projected image.

In summary, it has been found that certain specific criteria must be adopted in order to achieve a high fidelity 3-D immersion theatre having high resolution full-colour 3-D images that can occupy a large volume of space and thus fill the visual field of the audience. These criteria include the use of a dome-shaped projection screen (e.g. as shown in Fig. 1), coupled with alternate eye image presentation, projection of the images through wide-angle lenses and accurate positioning of the lenses to achieve lateral and vertical image co-incidence. The images should be projected from separate filmstrips preferably having a large frame format. The projection lenses should be closely spaced, preferably at a maximum separation of 100 to 160 mm (4-6 inches) and the projector should preferably be positioned close to the geometric centre of the dome-shaped projection screen.

It should finally be noted that the preceding description relates to a particular preferred embodiment of the invention and that many modifications are possible within the broad scope of the invention. Some of those modifications have been specifically indicated and others will be apparent to a person skilled in the art.

For example, while the disclosure refers specifically to use of OMNIMAX format film projected using a twin stacked rotor rolling loop projector, and while this film format and method of projection is preferred, others may be used. For example, two separate projectors could be employed (rolling loop or conventional) and the projected images could be brought together for projection by optical means. The particular projector illustrated has the significant practical advantage that the two rotors are rigidly coupled together so that there is no possibility of loss or delay in synchronization of the projected images such as could occur if two synchronized projectors were used.

The projection screen itself should be dome-shaped as described previously, preferably but not essentially a segment of a true hemisphere. The dome itself can be a non-structural screen erected within a larger building or can form a structural enclosure for the audience. Preferably, the images are projected from a projection point in the vicinity of the geometrical centre of the dome as discussed previously. However, within the broad scope of the invention, the images could be projected into the dome from outside, for example from below the bottom edge of the dome in the embodiment illustrated in Fig. 1.

It should finally be noted that references to the projection lenses being located in a "vertical" plane are to be interpreted as meaning that the plane is vertical relative to the normal orientation of the projector when supported on a horizontal surface. For example, if the projector were to be located on an inclined surface, the "vertical" plane would be at right angles to that surface.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A method of presenting a 3-D motion pictures, comprising the steps of:

providing a dome-shaped projection screen;

alternately projecting corresponding left-eye and right-eye images onto said screen; and,

alternately blocking the left and right eyes of each person viewing the motion picture, in synchronism with the appearance of right-eye and left-eye images respectively on the screen, so that a stereoscopic effect is perceived.

2. A method of presenting a 3-D motion pictures, comprising the steps of:

providing a dome-shaped projection screen;

alternately projecting corresponding left-eye and right-eye images onto said screen from two separate filmstrips bearing said images, each image being located within a usable image area on the relevant filmstrip of at least 1,200 square millimeters, the images being projected through separate lenses having respective projection axes;

positioning the lenses at a spacing from one another within the range of 100 to 160 millimeters and with their respective projection axes in a common vertical or horizontal plane for co-incidence of the projected images on the screen in a direction at right angles to said plane;

prior to presenting the motion picture shifting at least one of said lenses in said vertical plane to achieve co-incidence of the projected images on the screen in the direction of said plane; and,

alternately blocking the left and right eyes of each person viewing the motion picture, in synchronism with the appearance of right-eye and left-eye images respectively on the screen, so that a stereoscopic effect is perceived.

3. A method of presenting a 3-D motion pictures, comprising the steps of:

providing a projection screen having a dome-shape extending about a geometric centre;

alternately projecting corresponding left-eye and right-eye images onto said screen from two separate filmstrips bearing said images, each image being located within a maximum usable image area on the relevant filmstrip of at least 1,200 square millimeters, and the images being projected through separate lenses, the lenses having respective projection axes and defining a projection point mid-way between the rear nodal points of the lenses;

positioning the lenses closely adjacent one another with said projection point adjacent said geometric centre but between said centre and the screen; and,

alternately blocking the left and right eyes of each person viewing the motion picture, in synchronism with the appearance of right-eye and left-eye images respectively on the screen, so that a stereoscopic effect is perceived.

4. A method of presenting 3-D motion pictures, comprising the steps of:

providing a dome-shaped projection screen;

alternately projecting corresponding left-eye and right-eye images onto said screen from two separate filmstrips bearing said images, the images being projected through separate wide-angle lenses having respective projection axes;

positioning the lenses directly adjacent one another with their respective projection axes in a common vertical or horizontal plane for co-incidence of the projected images on the screen in a direction at right angles to said plane;

orienting the lenses within said common plane to achieve co-incidence of the projected images on the screen in the direction of said plane;

alternately blocking the left and right eyes of each person viewing the motion picture, in synchronism with the appearance of right-eye and left-eye images respectively on the screen, so that a stereoscopic effect is perceived.

5. A method as claimed in claim 1, wherein said

lenses are positioned with their projection axes parallel to one another but spaced by a distance in the range 100-160 millimeters.

6. A method as claimed in claim 4, wherein the images carried by the respective filmstrips each having a usable image area of at least 1,200 square millimeters.

7. A method as claimed in claim 4, wherein said step of orienting the lenses to achieve vertical co-incidence of the projected images on the screen is accomplished prior to presenting the motion picture, by positioning the lenses with their respective projection axes co-incident with the centrelines of the respective projection apertures, and shifting at least one of said lenses towards the other while maintaining the projection axes parallel to one another, to an extent sufficient to achieve said vertical image co-incidence.

8. A method as claimed in claim 4, wherein said step of alternately blocking the left and right eyes of each person viewing the motion picture is performed by providing each said person with a pair of glasses for viewing the motion picture, each said pair of glasses having left and right lenses each comprising a liquid crystal cell capable of actuation to alternate between an opaque state and a transmissive state, and causing the respective states of

the two lenses to alternate in synchronism with the appearance of right-eye and left-eye images respectively on the screen.

9. A method as claimed in claim 8, wherein said alternation of the transmissive states of the glasses lenses is accomplished by transmitting infrared synchronizing signals in synchronism with the projection of right-eye and left-eye images, and using said synchronizing signals to alternate the transmissive states of the lenses.

10. A method as claimed in claim 4, wherein the projector is located above the geometric centre of the dome.

11. A method as claimed in claim 10, wherein the projector is located so that the midpoint of a line joining the rear nodal points of the projection lenses is located a distance (a) above the geometric centre of the dome and a distance (b) closer to the screen than said centre, wherein (a) and (b) are defined relative to the diameter (d) of the dome by the approximate ratios a:d = 1:35 and b:d = 1:60.

12. A method as claimed in claim 4, wherein said projection screen is formed by a dome having the shape of a 160° segment of a sphere.

13. A method as claimed in claim 12, wherein said dome is arranged in a tilted orientation with respect to a horizontal plane so that persons viewing a motion picture from within the dome can comfortably look towards the centre of the dome.

14. A method as claimed in claim 13, wherein the dome is tilted at an angle of approximately 28° with respect to the horizontal.

15. A method as claimed in claim 13, wherein the projector is located so that the projection axes of the respective lenses are inclined upwardly with respect to a horizontal reference plane.

16. A method as claimed in claim 15, wherein the said projection axes are tilted at an angle of approximately 13.5° to said horizontal reference plane.

17. A method as claimed in claim 16, wherein said projection lenses are selected to project images within a field of view extending approximately 35° below and 88° above said projection axes.

18. A method as claimed in claim 4, wherein said screen has a projection surface selected to provide an on-axis gain in the range of 1.5 to 2.0.

19. A method as claimed in claim 4, wherein said step of alternately projecting corresponding left-eye and right-eye images is performed by providing a rolling loop projector having two rotors stacked vertically one above the other and rotatable about a common vertical axis, for transporting the respective said filmstrips, and wherein one of said rotors is rotationally offset with respect to the other rotor to cause said alternate image projection.

20. A method as claimed in claim 19, wherein each said filmstrip has a large frame format having a usable image area of at least 1,200 square millimeters, and wherein the images on said filmstrips are of a shape produced by recording each said image through a wide-angle lens and occupy less than said usable image area.

21. An apparatus for presenting 3-D motion pictures comprising:

a dome-shaped projection screen;

means for alternately projecting corresponding left-eye and right-eye images onto said screen from two separate filmstrips, said projecting means including separate wide-angle lenses for each said filmstrip, having respective projection axes, and said lenses being positioned directly adjacent one another with their respective projection axes in a common vertical or horizontal plane for co-incidence of the projected images in a direction at right angles to said plane, the lenses being oriented in said common plane to achieve co-incidence of the projected images in the direction of said plane; and,

means for alternately blocking the left and right eyes of each person viewing the motion picture in synchronism with the appearance of right-eye and left-eye images respectively on the screen, so that a stereoscopic effect is perceived.

22. An apparatus as claimed in claim 21, wherein said lenses are positioned with their projection axes parallel to one another but spaced by a distance in the range 100-160 millimeters.

23. An apparatus as claimed in claim 21, wherein the images carried by the respective filmstrips each having a usable image area of at least 1,200 square millimeters.

24. An apparatus as claimed in claim 21, wherein said lenses are positioned with their respective projection axes co-incident with the centrelines of the respective projection apertures, and wherein at least one of said lenses is shifted towards the other while maintaining the projection axes parallel to one another, to an extent sufficient to achieve said vertical image co-incidence.

25. An apparatus as claimed in claim 21, wherein said

means for alternately blocking the left and right eyes of each person viewing the motion picture comprises a pair of glasses for each said person, each said pair of glasses having left and right lenses each comprising a liquid crystal cell capable of actuation to alternate between an opaque state and a transmissive state, and means for causing the respective states of the two lenses to alternate in synchronism with the appearance of right-eye and left-eye images respectively on the screen.

26. An apparatus as claimed in claim 25, wherein said means for causing alternation of the transmissive states of the glasses lenses comprises means for transmitting infrared synchronizing signals in synchronism with the projection of right-eye and left-eye images, and receiver means in each pair of glasses for causing said synchronizing signals to affect the transmissive states of the lenses.

27. An apparatus as claimed in claim 21, wherein the projector is located above the geometric centre of the dome.

28. An apparatus as claimed in claim 27, wherein the projector is located so that the midpoint of a line joining the rear nodal points of the projection lenses is located a distance (a) above the geometric centre of the dome and

a distance (b) closer to the screen than said centre, wherein (a) and (b) are defined relative to the diameter (d) of the dome by the approximate ratios a:d = 1:35 and b:d = 1:60.

29. An apparatus as claimed in claim 21, wherein said projection screen is formed by a dome having the shape of a 160° segment of a sphere.

30. An apparatus as claimed in claim 29, wherein said dome is arranged in a tilted orientation with respect to a horizontal plane so that persons viewing a motion picture from within the dome can comfortably look towards the centre of the dome.

31. An apparatus as claimed in claim 30, wherein the dome is tilted at an angle of approximately 28° with respect to the horizontal.

32. An apparatus as claimed in claim 30, wherein the projector is located so that the projection axes of the respective lenses are inclined upwardly with respect to a horizontal reference plane.

33. An apparatus as claimed in claim 32, wherein the said projection axes are tilted at an angle of approximately 13.5° to said horizontal reference plane.

34. An apparatus as claimed in claim 33, wherein said projection lenses are selected to project images within a field of view extending approximately 35° below and 88° above said projection axes.

35. An apparatus as claimed in claim 21, wherein said screen has a projection surface selected to provide an on-axis gain in the range of 1.5 to 2.0.

36. An apparatus as claimed in claim 21, wherein said projector comprises a rolling loop projector having two rotors stacked vertically one above the other and rotatable about a common vertical axis, for transporting the respective said filmstrips, and wherein one of said rotors is rotationally offset with respect to the other rotor to cause said alternate image projection.

37. An apparatus as claimed in claim 36, wherein each said filmstrip has a large frame format having a usable image area of at least 1,200 square millimeters, and wherein the images on said filmstrips are of a shape produced by recording each said image through a wide-angle lens and occupy less than said usable image area.

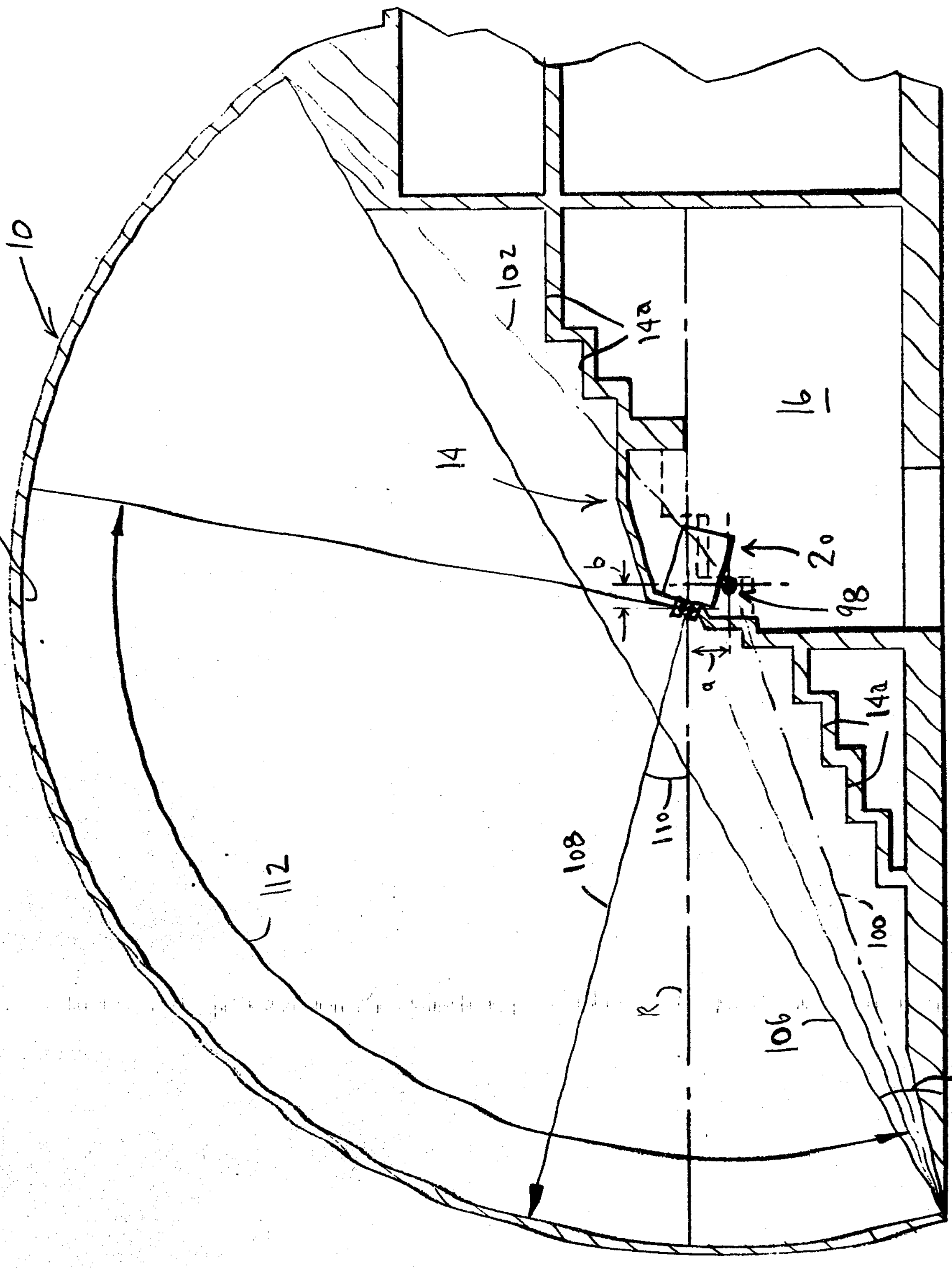
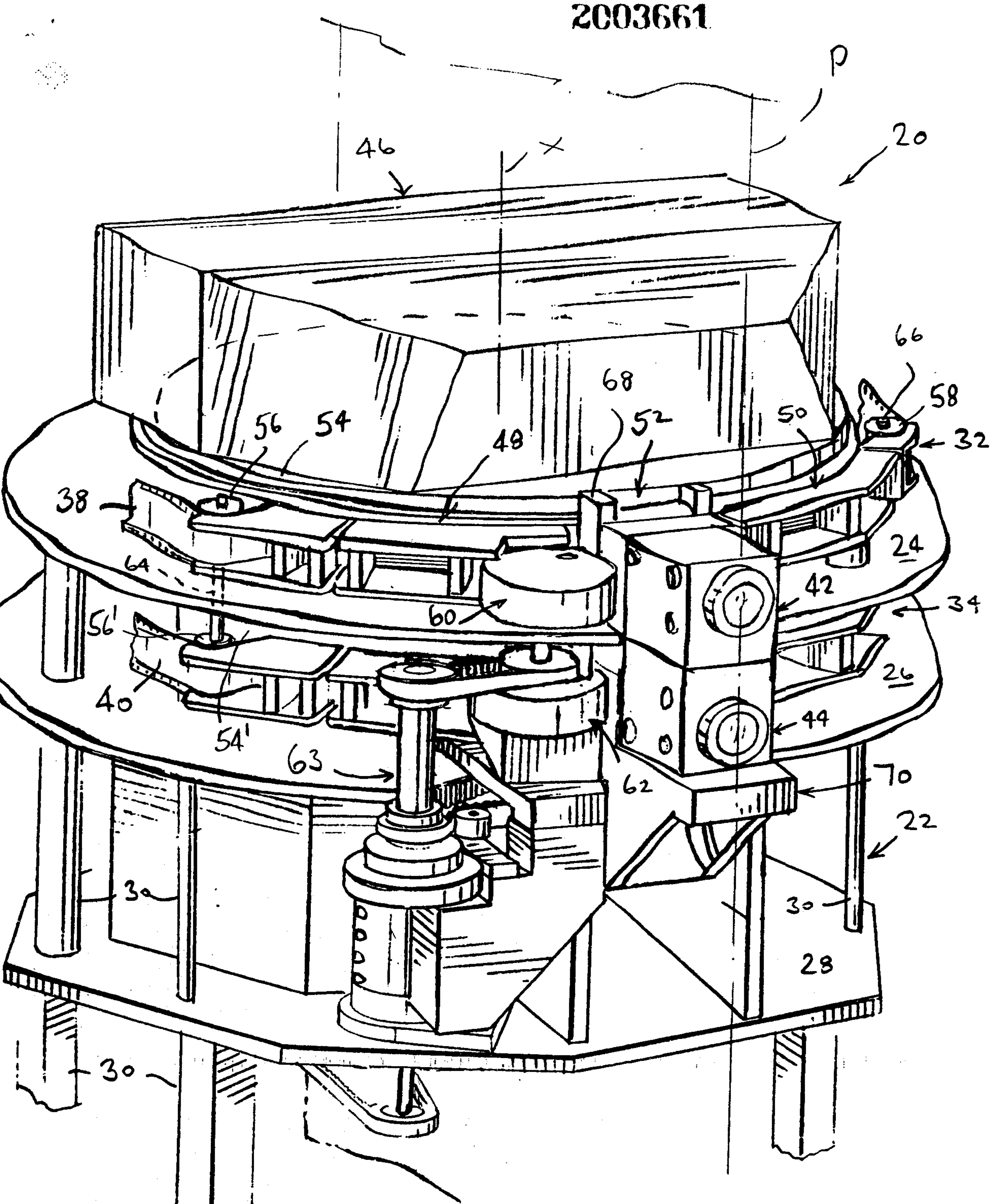


Fig 1



P
20
46
X
66
68
58
56
54
52
50
32
38
48
24
64
42
60
34
56'
26
40
54'
44
63
62
70
22
30
30
28
30

Fig. 2

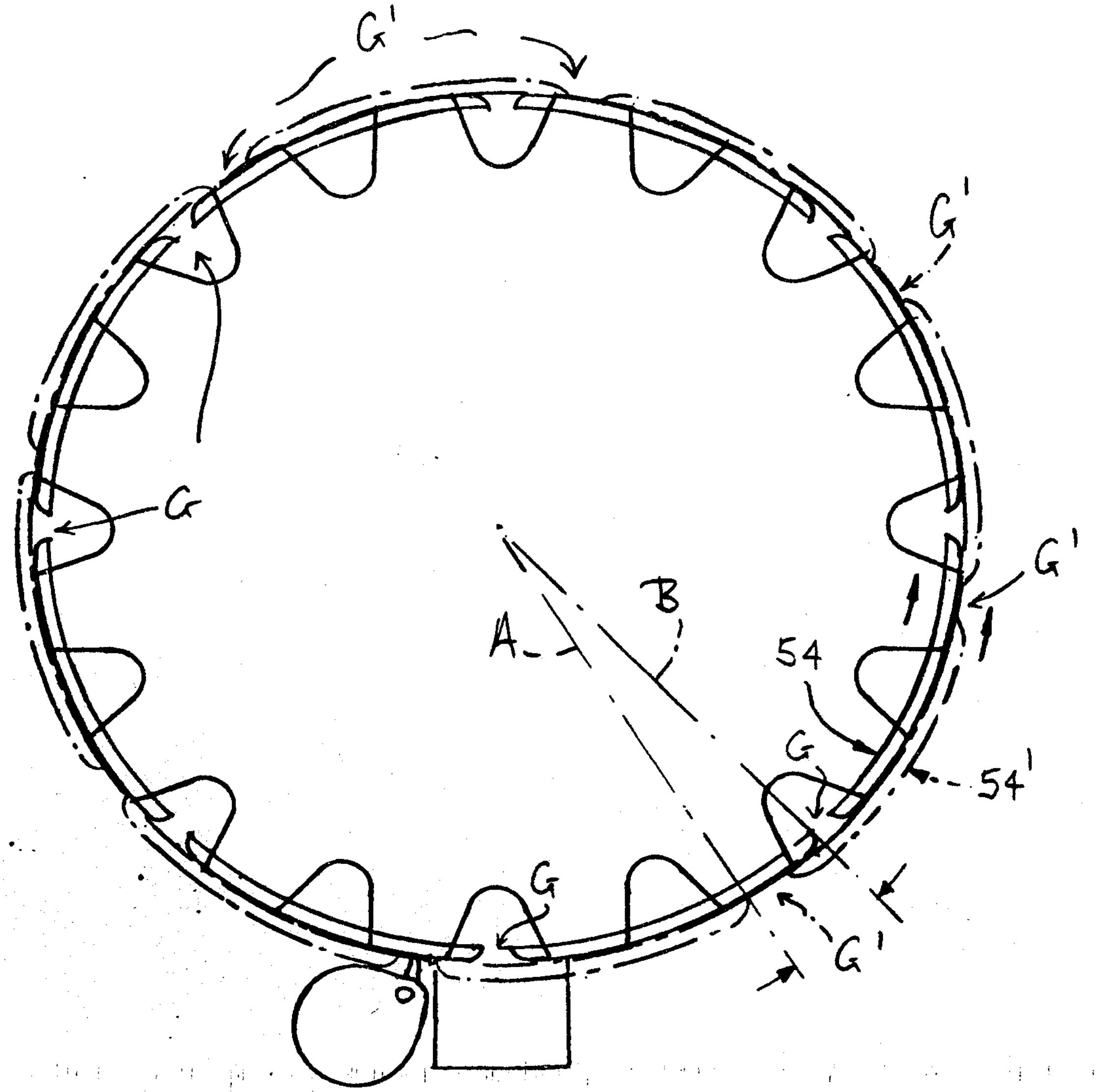


Fig. 3

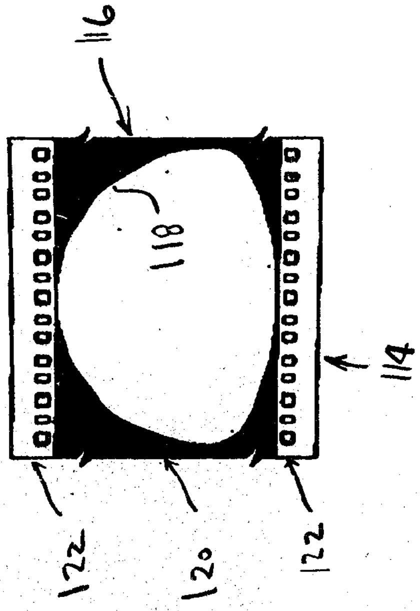


Fig 7

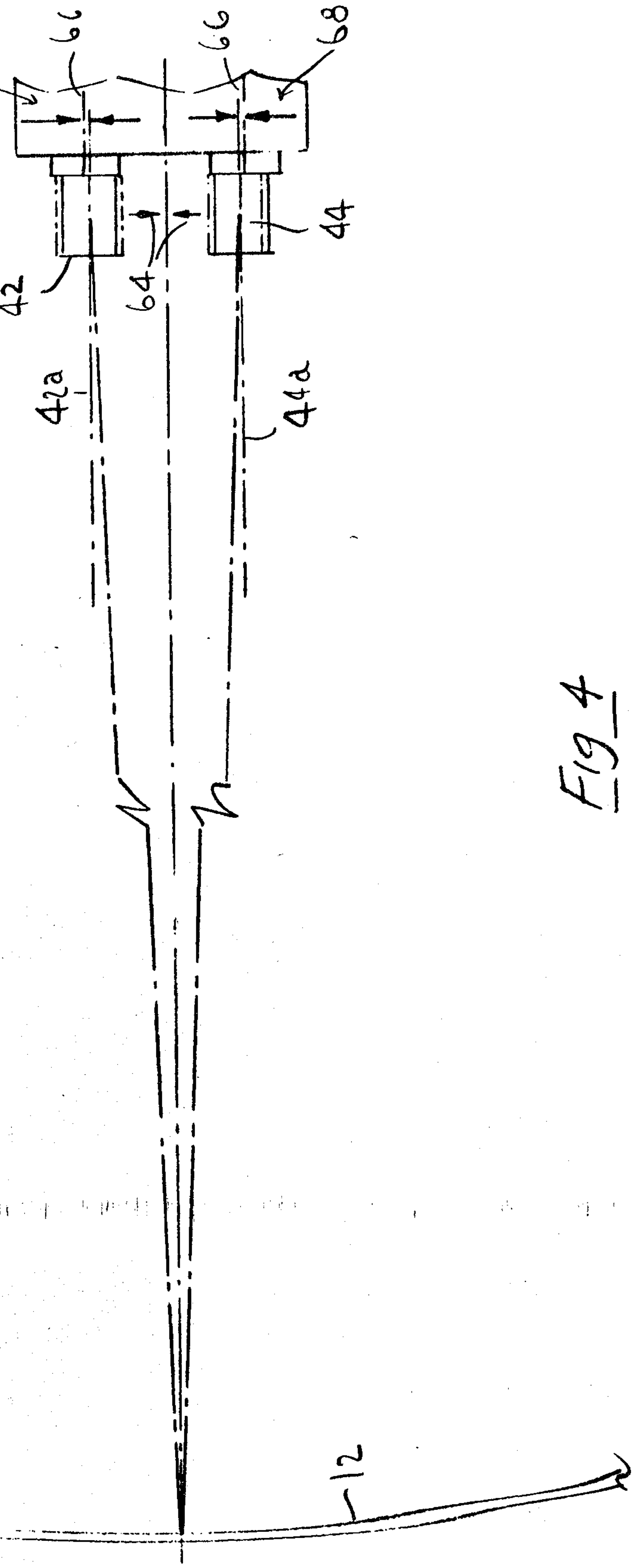


Fig 4

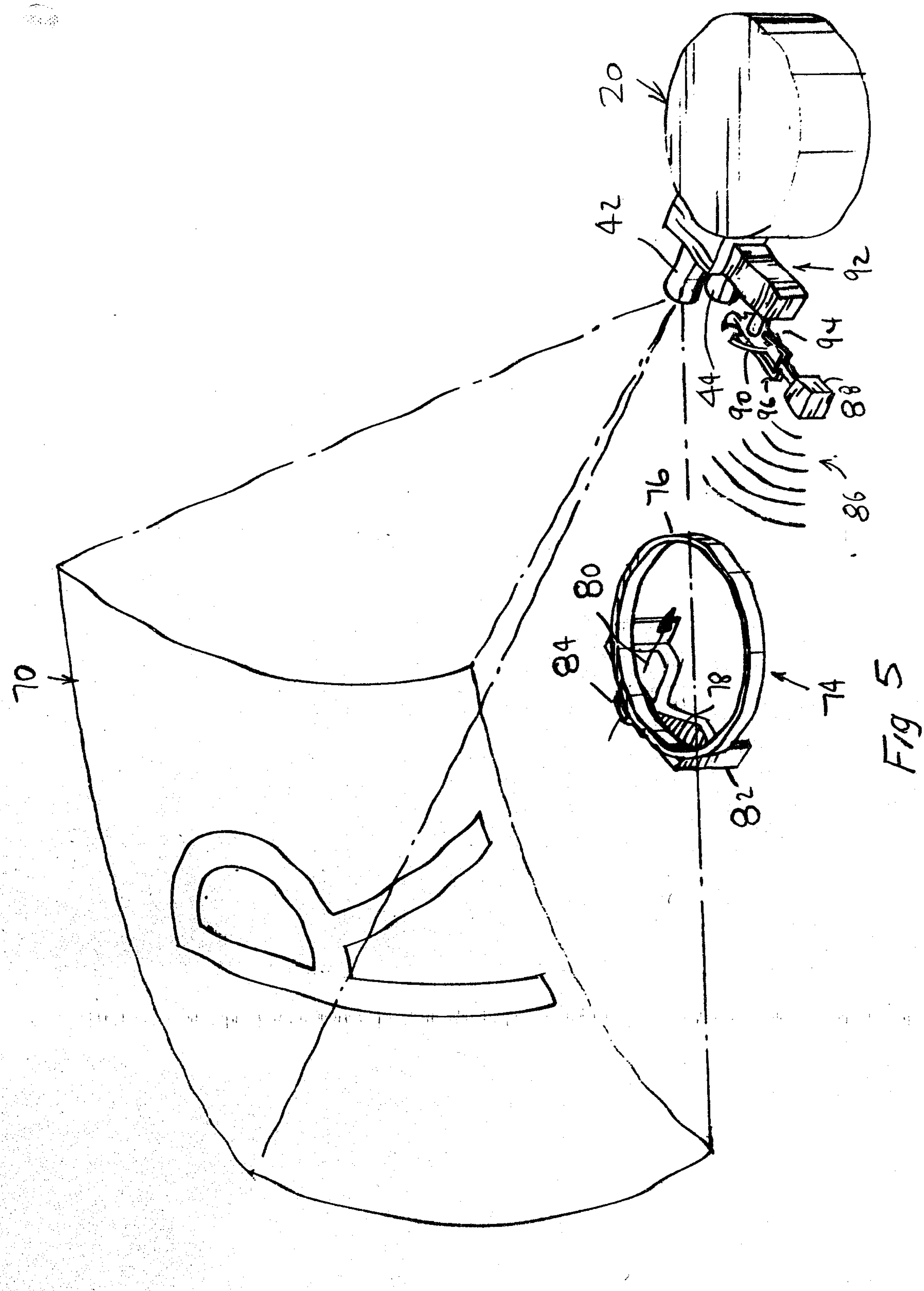


Fig 5

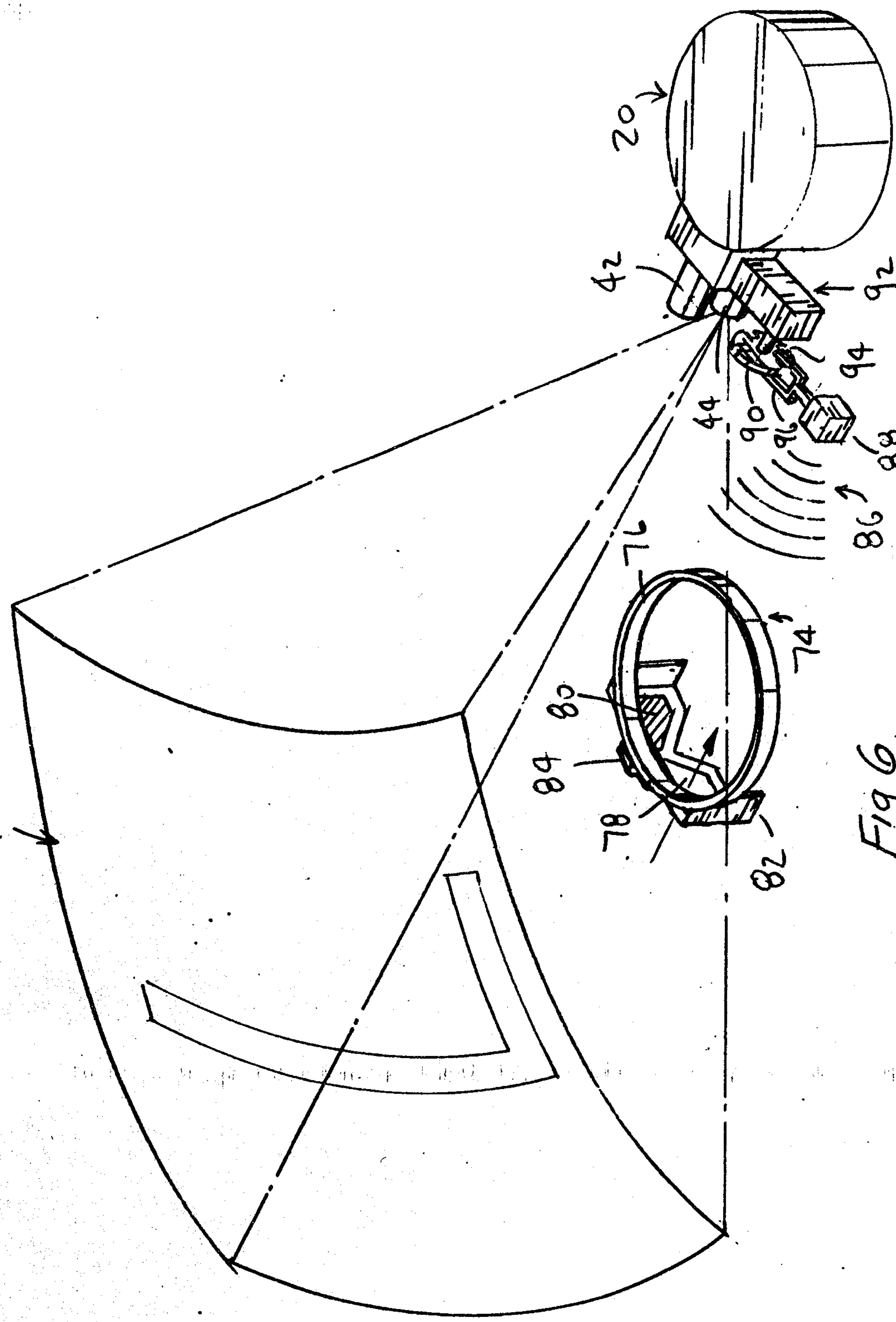


Fig 6