US 20050275759A1

(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2005/0275759 A1**

Itohiya (43) **Pub. Date: Dec. 15, 2005**

(54) **REAR-PROJECTION TYPE IMAGING APPARATUS**

(76) Inventor: **Takashi Itohiya**, Saitama-shi (JP)

Correspondence Address:
JACOBSON HOLMAN PLLC
400 SEVENTH STREET N.W.
SUITE 600
WASHINGTON, DC 20004 (US)

(21) Appl. No.: **10/935,147**

(22) Filed: **Sep. 8, 2004**

(30) **Foreign Application Priority Data**

Jun. 11, 2004 (JP) 2004-174397

Publication Classification

(51) **Int. Cl.**[7] **H04N 5/64**

(52) **U.S. Cl.** **348/744**

(57) **ABSTRACT**

A rear-projection type imaging apparatus, for example, rear-projection television set, capable of projecting, and displaying, an enlarged image onto a screen from the rearward thereof is provided. The rear-projection television set **(100)** comprises a housing **(114)**, a television control unit (signal processing unit) **(128)**, an image display element **(120)**, a projection lens system **(130)**, an image projecting mirror **(140)**, a screen **(150)** onto which an enlarged image is projected from the backward thereof. The projection lens system **(130)** is comprised of a rear-group optical system **(132)**, an intermediate mirror **(132)** and a front-group optical system **(136)**. Lens barrels **(146, 142)** associated with the front-group and rear group optical systems **(136,132)**, respectively, are fastened to each other by fastening means.

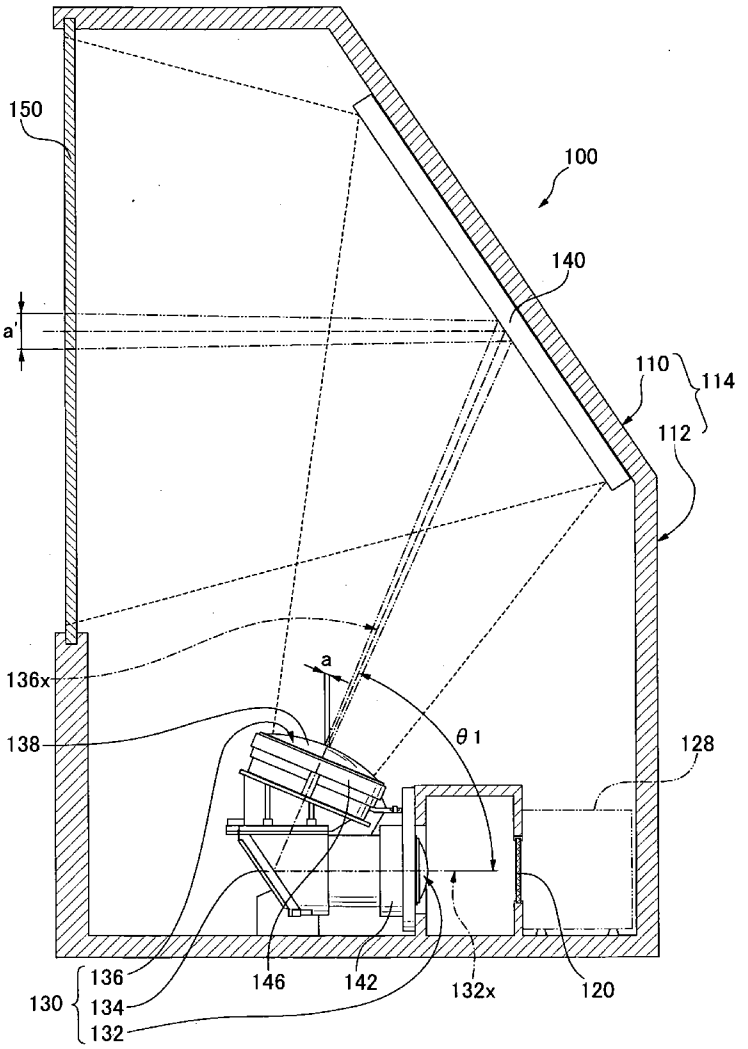


FIG.1

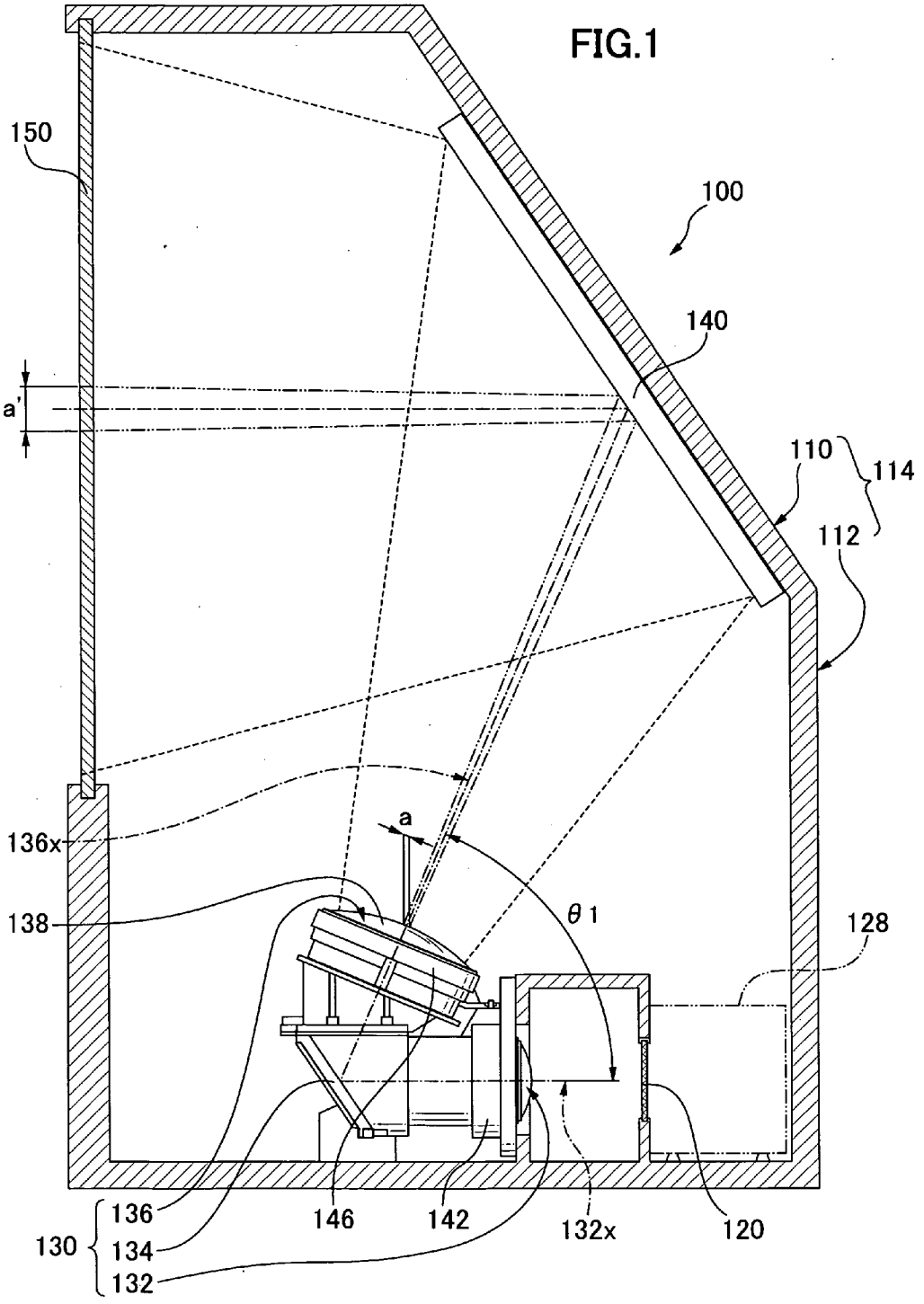

150
100
140
a'
110
114
112
136x
a
138
θ1
128
136
146
142
132x
120
130
134
132

FIG.2

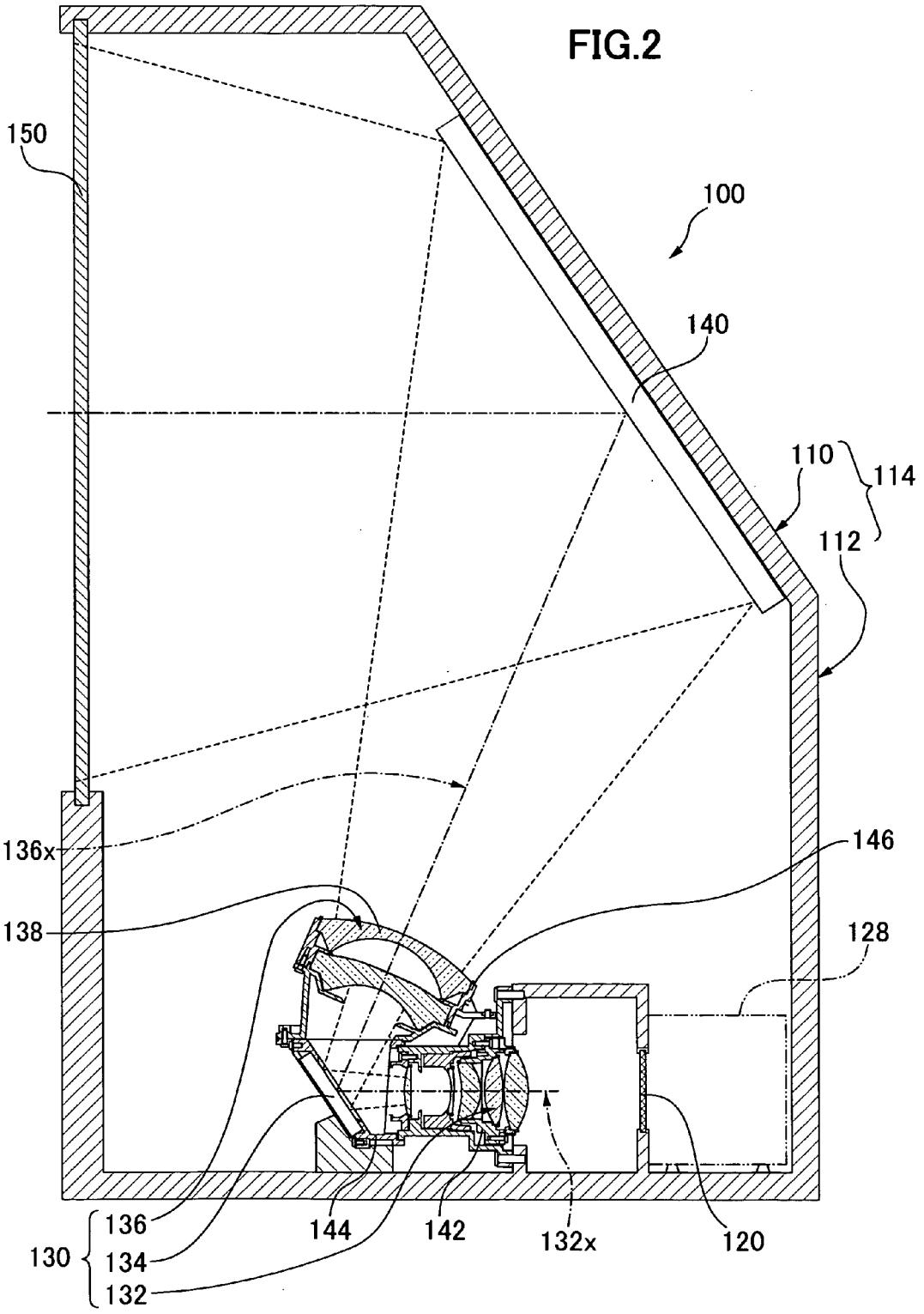

150
100
140
110
114
112
136x
146
138
128
136
134
132
130
144
142
132x
120

FIG.3

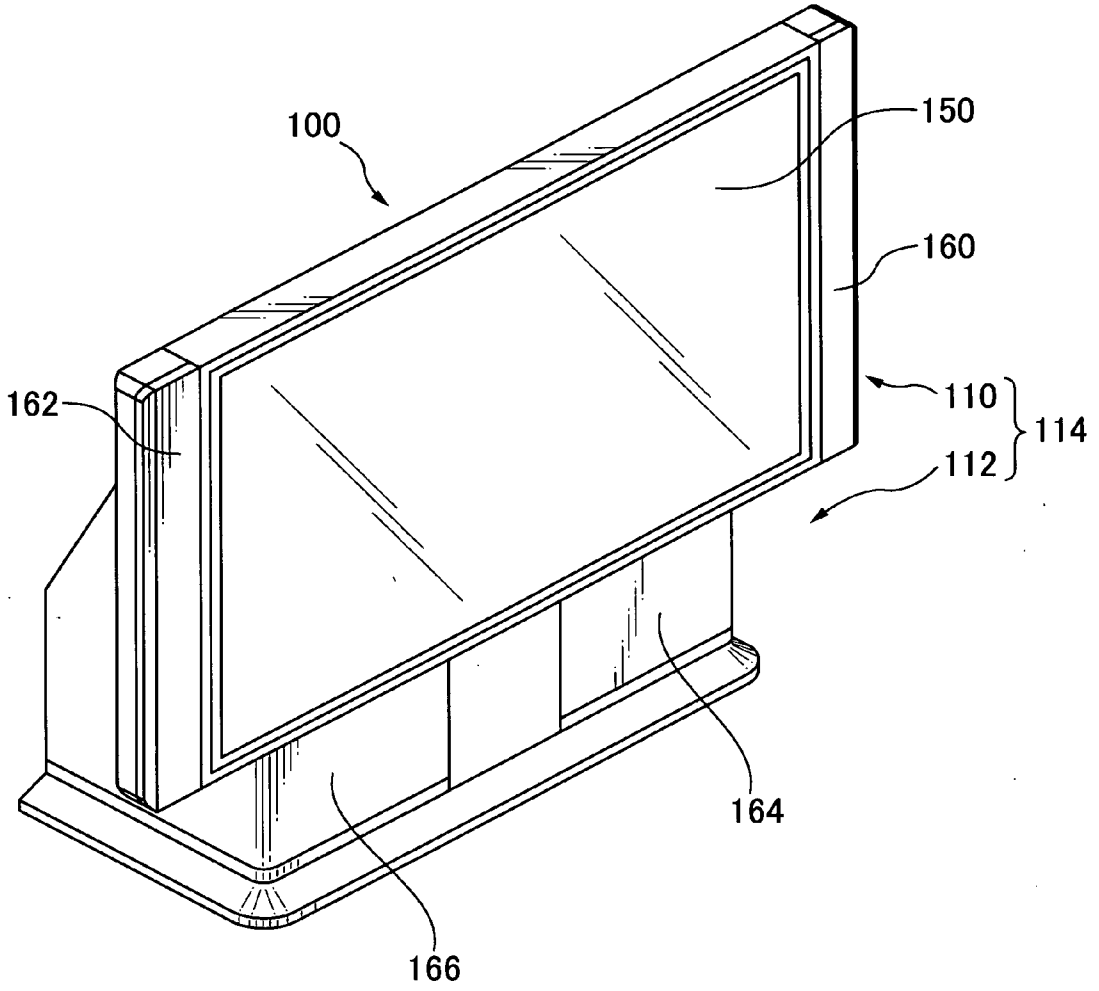


FIG.4

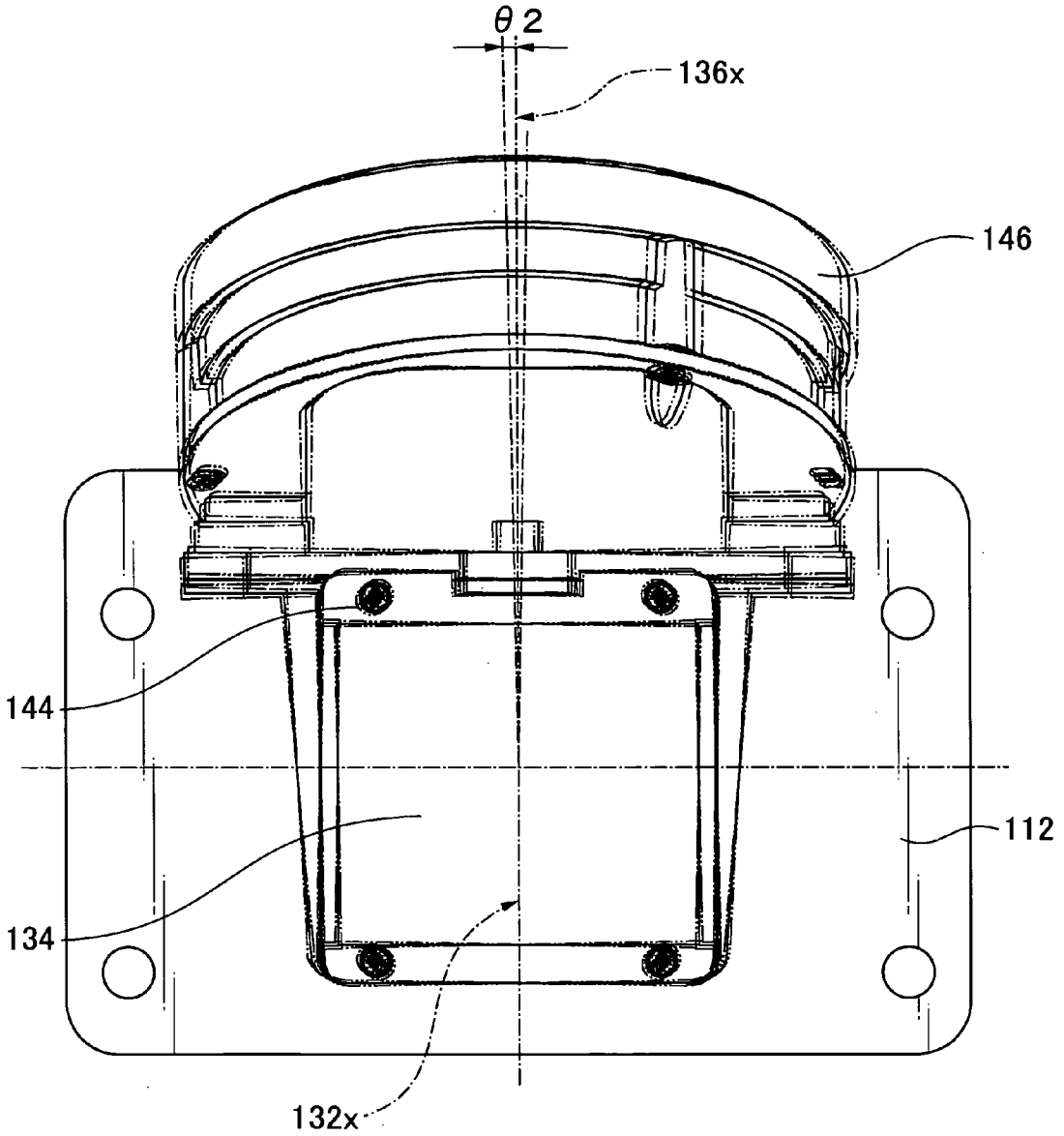


FIG.5

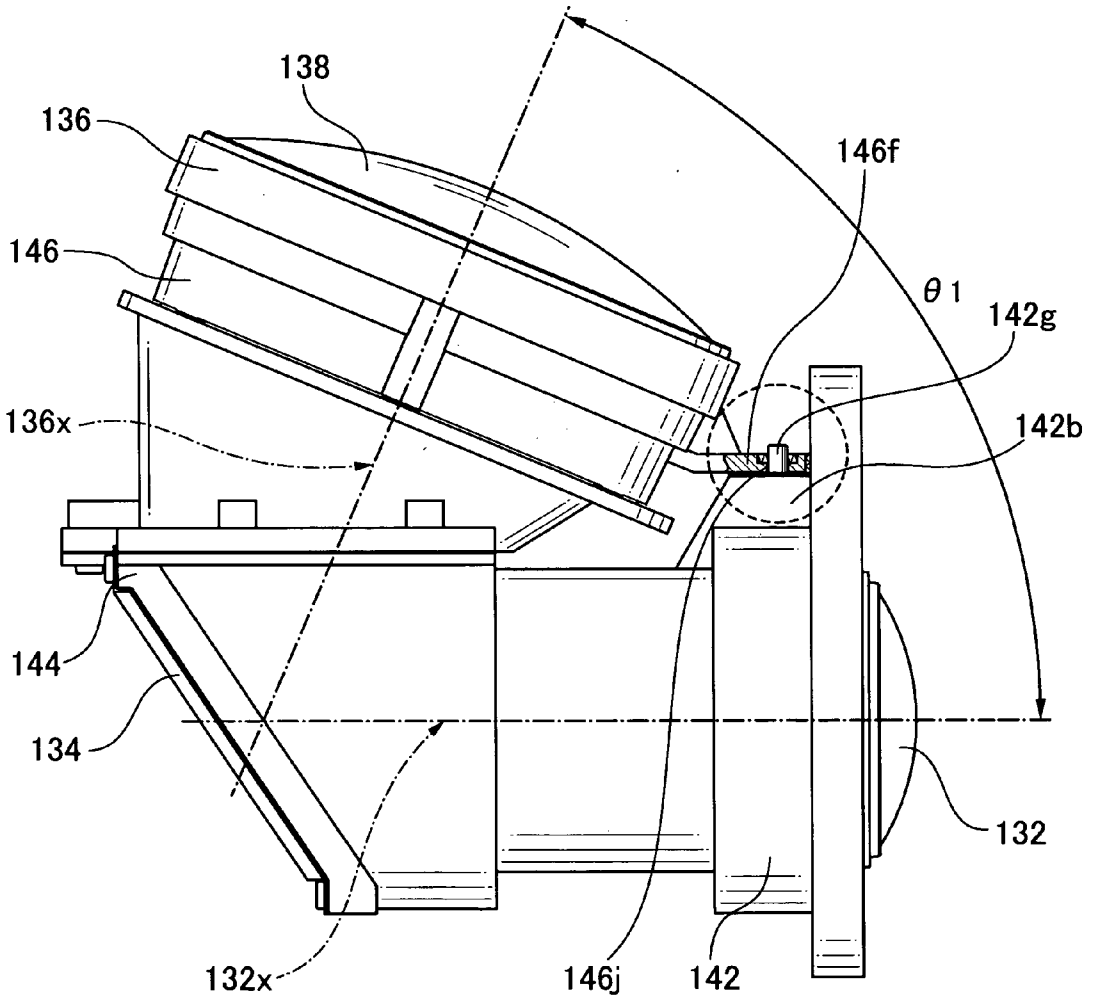


FIG.6

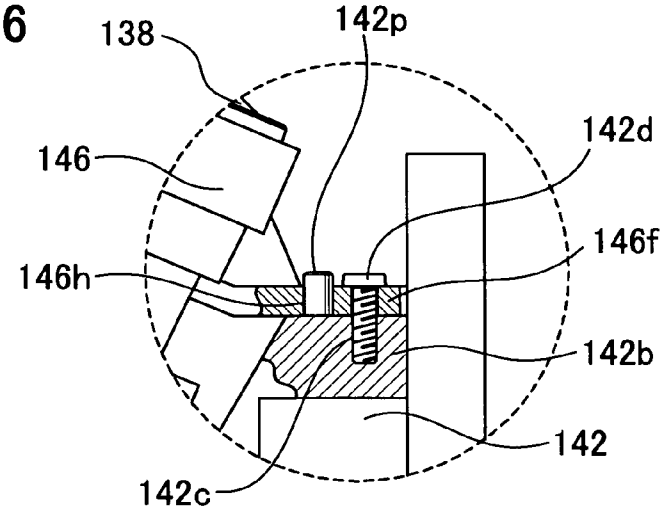


FIG.7

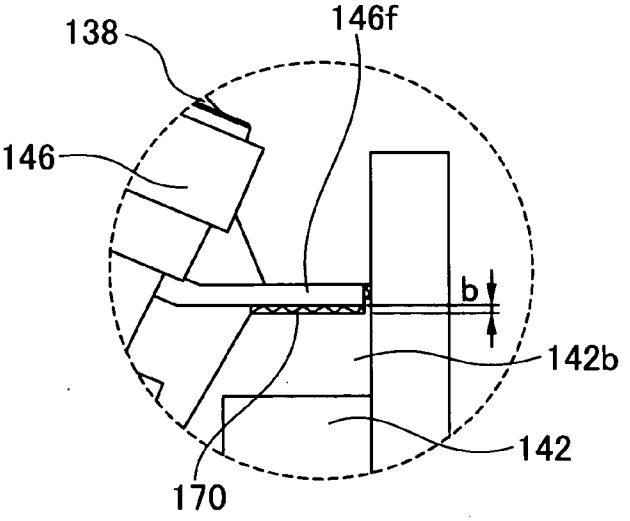


FIG.8

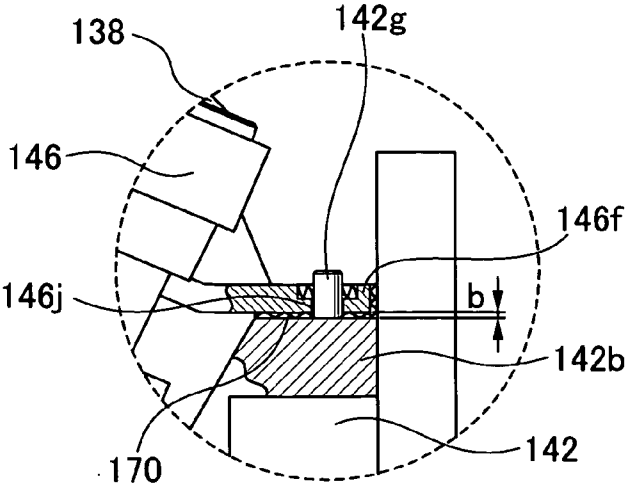


FIG.9

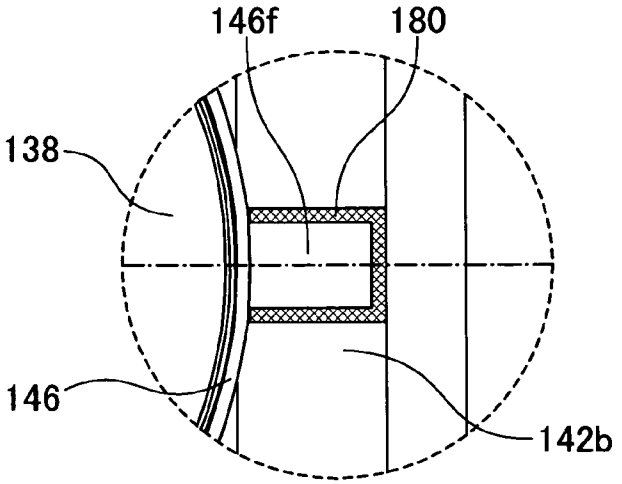


FIG.10

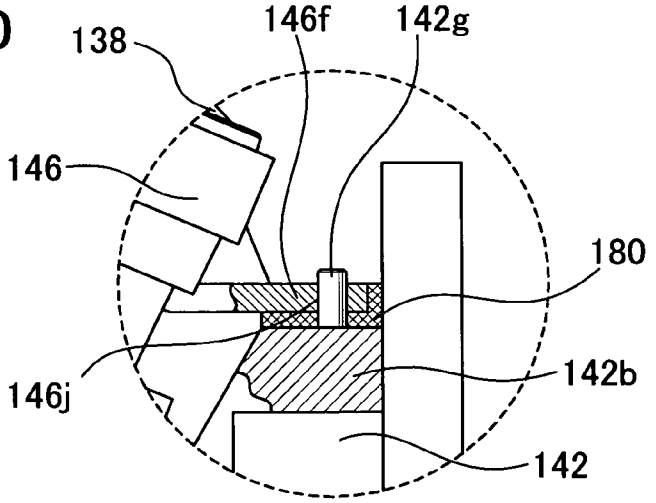


FIG.11

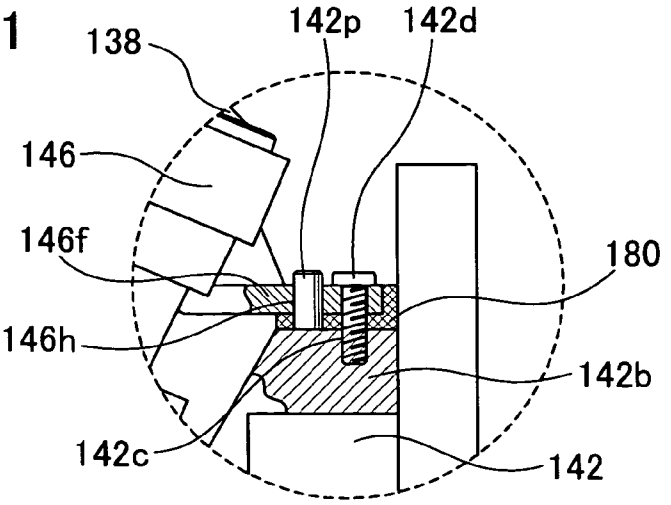


FIG.12

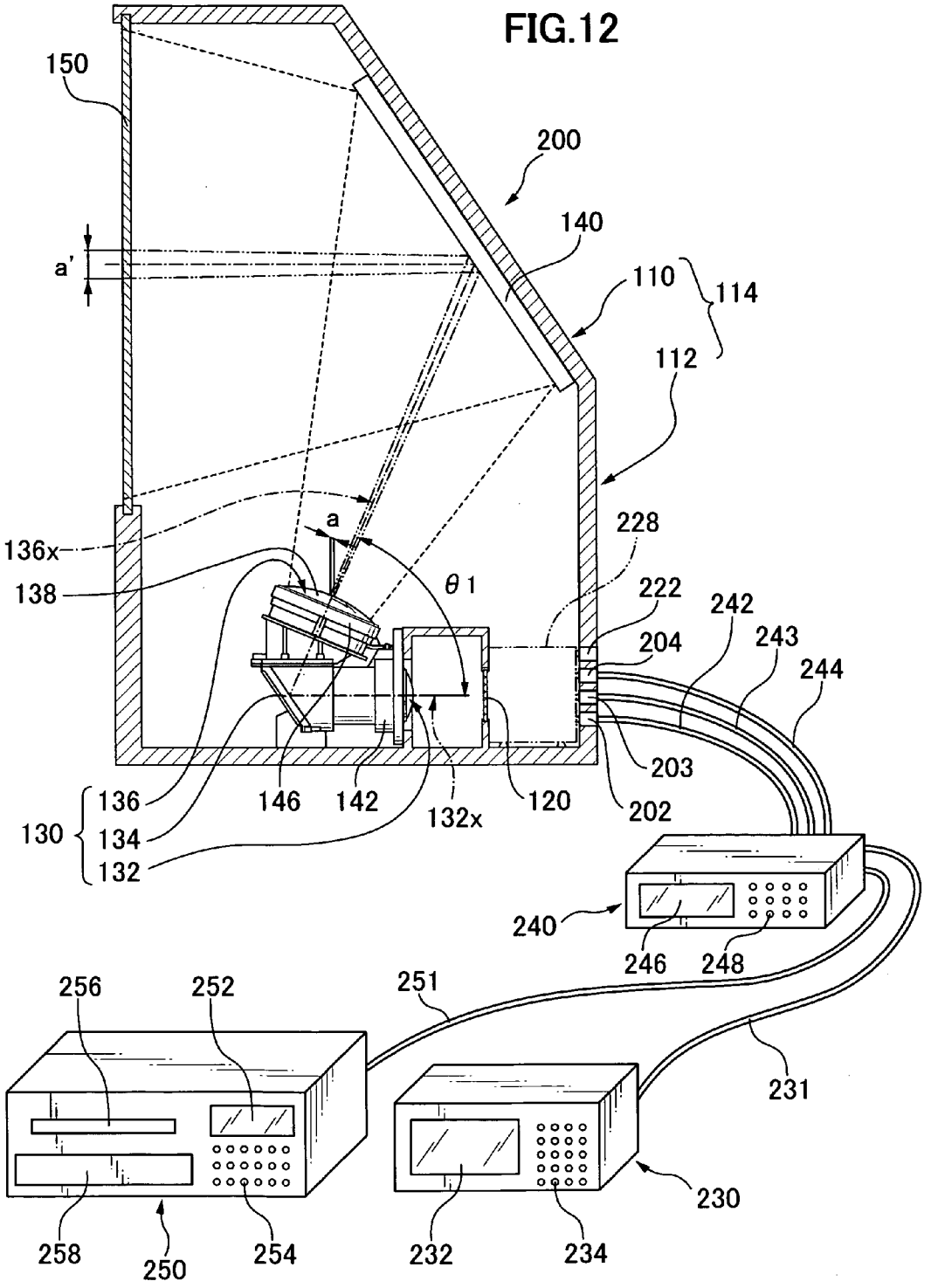

150
200
140
a'
110
114
112
a
228
136x
138
θ1
222
242
243
244
204
203
202
120
132x
146
142
136
134
132
130
240
246
248
256
252
251
231
230
258
250
254
232
234

FIG.13
(PRIOR ART)

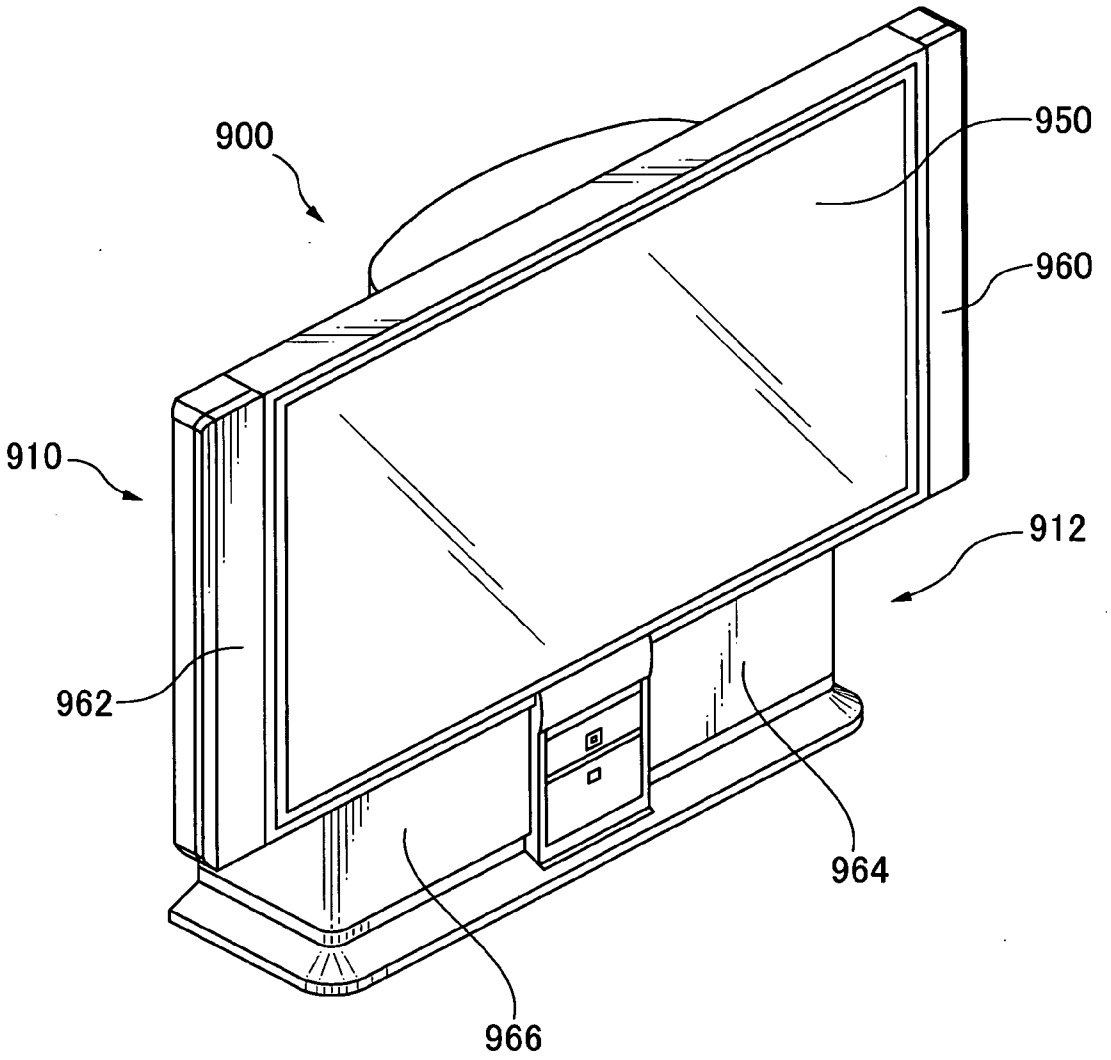
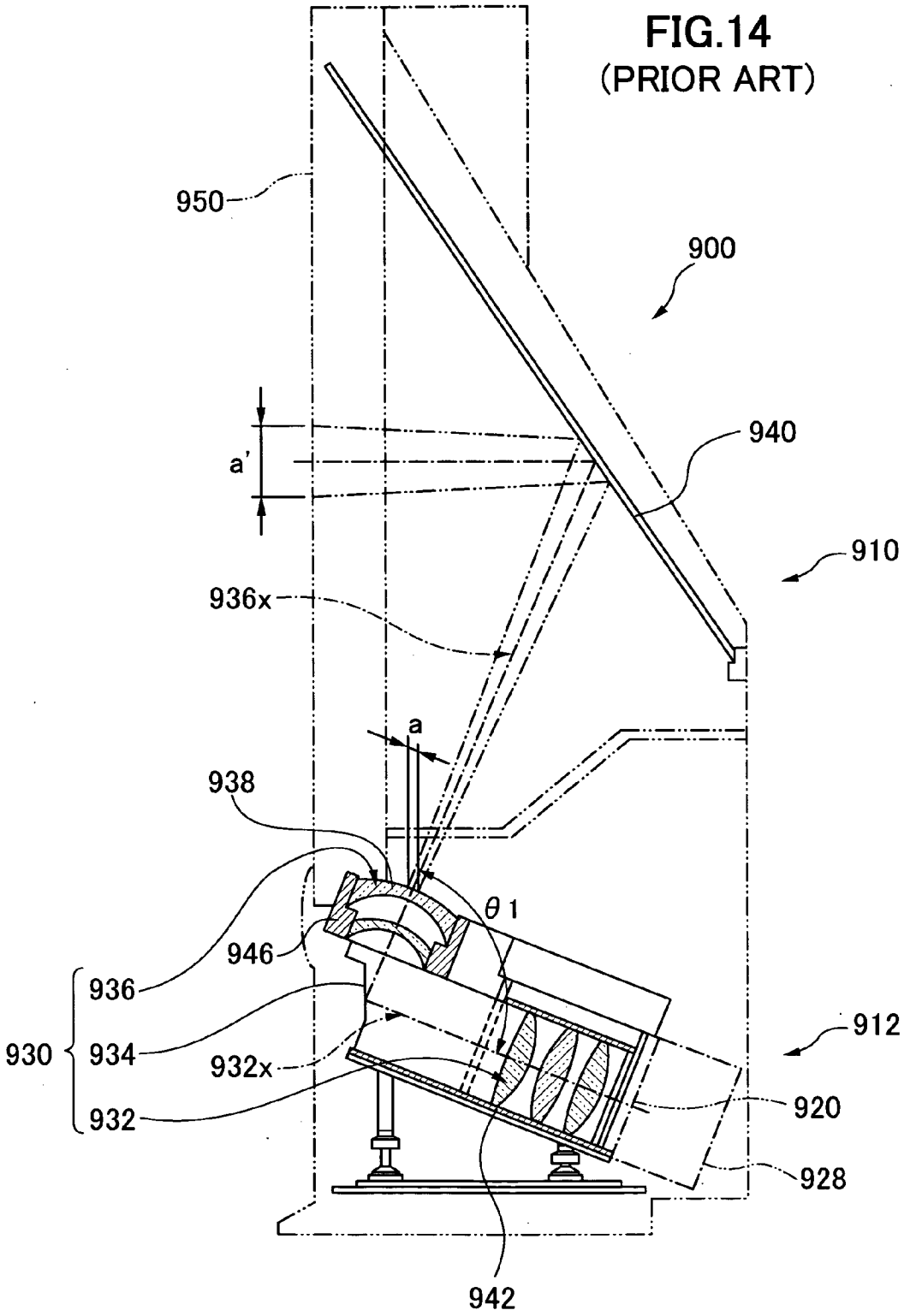


FIG.14
(PRIOR ART)



REAR-PROJECTION TYPE IMAGING APPARATUS

BACKGROUND OF THE INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a rear-projection type imaging apparatus which can project, and display, an enlarged image onto a screen from the rearward thereof, such as rear-projection television sets or rear projectors. In particular, the present invention relates to a rear-projection type imaging apparatus configured to reduce vibration in a projection lens system due to sounds coming out of woofers.

[0003] 2. Background Art

[0004] Conventional rear projectors comprise a lower cabinet containing an image forming section and a main screen body, and are configured to project an enlarged image (or enlarged picture) onto the main screen body from the backward thereof (e.g., see Japanese Patent Laid-Open Application No. 2003-274314 (particularly, Pages 4-6, FIGS. 1-7 thereof)). Conventional back projection type imaging apparatuses are also of such a structure that comprises an upper cabinet and a lower cabinet and that is configured to project, and display, an enlarged image (or enlarged picture) onto a screen from the backward thereof. The lower cabinet is provided with a light source and a speaker arranged in the lower cabinet (e.g., see Japanese Patent Laid-Open Application No. HEISEI-9(1997)-98359 (particularly, Pages 2-4, FIGS. 1-3 thereof)). Furthermore, conventional rear-projection television sets comprise an upper cabinet including a screen and mirror disposed therewithin and a lower cabinet which contains various main components, i.e., an imaging apparatus, a drive/control circuit, an optical unit including projection lenses and a source of light (e.g., see Japanese Patent Laid-Open Application No. HEISEI-9(1997)-98357 (particularly, Pages 3-4, FIGS. 1-6 thereof)).

[0005] **FIGS. 13 and 14** show an example of conventional rear projectors. Referring to **FIGS. 13 and 14**, there is shown a rear projector **900** which comprises an upper cabinet **910** and a lower cabinet **912**. An operation control section **928** is provided to receive external signals relating to image and audio information and to output image and audio signals for controlling the operation of the rear projector. The operation control section **928** is disposed within the central portion of the lower cabinet **912** at the rearward part thereof. An image display element **920** for displaying an image (or picture) is disposed within the central portion of the lower cabinet **912** at the rearward part thereof, the image display element **920** being located forward of the television control section **928**. A projection lens system **930** is disposed within the central portion of the lower cabinet **912** at the forward part thereof and located forward of the image display element **920** for enlarging and projecting the image displayed by the image display element **920**. An image projecting mirror **940** is disposed in the rearward slope of the upper cabinet **910** for reflecting the image projected by the projection lens system **930**. The reflection face of the image projecting mirror **940** is oriented at an angle of 55 degrees relative to the horizontal plane. A screen **950** onto which the enlarged image reflected from the image projecting mirror **940** is projected from the backward of the screen, is disposed on the front face of the central portion of the upper cabinet **910**. The display area of the screen **950** is positioned at an angle of 90 degrees relative to the horizontal plane. A first tweeter **960** is located on the right side of the upper cabinet **910**. A second tweeter **962** is located on the left side of the upper cabinet **910**. A first woofer **964** is located on the rightward portion of the lower cabinet **912**. A second woofer **966** is located on the leftward portion of the lower cabinet **912**.

[0006] The image display element **920** is connected to the operation control section **928** and can receive the image signal from the operation control section **928** to display the image information thereon. The tweeters **960**, **962** and the woofers **964**, **966** are also connected to the operation control section **928** and can receive the audio signals from the operation control section **928** to generate sounds. The projection lens system **930** comprises a rear-group optical system **932** including a plurality of convex lenses for converging rays from the image displayed by the image display element **920**, an intermediate mirror **934** for reflecting the rays passing through the rear-group optical system **930** and a front-group optical system **936** including a plurality of concave lenses for diffusing the rays reflected by the intermediate mirror **934**. The rear-group optical system **932** is disposed forward of the image display element **920**. The rear-group optical system **932** is supported within a lens barrel **942**. The intermediate mirror **934** is disposed forward of the rear-group optical system **932**. The front-group optical system **936** is disposed upward and rearward of the intermediate mirror **934**. The front-group optical system **936** is supported within a lens barrel **946**. The rear-group optical system **932** defines an optical axis **932***x* which is oriented at an angle of 20 degrees relative to the horizontal plane. The reflecting face of the intermediate mirror **934** is positioned at an angle of 90 degrees relative to the horizontal plane. The front-group optical system **936** defines an optical axis **936***x* which is oriented at an angle of 70 degrees relative to the horizontal plane. The image displayed on the image display element **920** is reflected by the intermediate mirror **934** after passed through the rear-group optical system **932**, enlarged by the front-group optical system **936** after passed therethrough and then reflected by an image projecting mirror **940** toward the screen **950** so that the image will be projected onto the screen **950** from the backward thereof. Such a structure can cause a user to view the image displayed by the image display element **920** in an enlarged scale from the front side of the screen **950**.

[0007] In recent years, the rear-projection television sets have been required to be increasingly reduced in thickness or of more low profile by advent of low profile or thinner plasma television sets. However, reduction of the rear-projection television set in thickness requires shortening of the distance of projection in a projection lens system. To shorten the distance of projection in the projection lens system, then, it is further required to shorten its focal distance and to widen its angle. As the angle of the projection lens system is widened, however, the diameter of a forwardmost lens in the projection lens system is correspondingly increased, thus leading to the increased weight of the forwardmost lens in the projection lens system. Also, for inexpensive and mass production, projection lens barrels have been often made of plastic material which can form the barrels more easily than metals. When the projection lens barrel is formed of plastic material, the rigidity of the projection lens barrel will be reduced in comparison with the weight of the forwardmost lens in the projection lens system.

This presents a problem in that the projection lens system will be vibrated due to the heavy bass produced by the woofers. The same is true of the rear projector.

[0008] Referring to **FIG. 14**, the image projected onto the screen **950** in the rear projector **900** is one that is provided by scaling up an original image in the image display element **920** such as a liquid crystal panel by as much as several tens of times. If the forwardmost lens **938** of the projection lens system **930** is caused to vibrate during the projection, an angle θ**1** formed between the optical axis **936***x* of the front-group optical system **936** and the optical axis **932***x* of the rear-group optical system **932** will be changed to create a width of deflection "a" at the tip of the forwardmost lens **938** in the projection lens system **930**. Even if such a width of deflection a is only slight, the deflection is enlarged to create a width of deflection "a'" at the screen **950**. Thus, the vibration of the forwardmost lens **938** during the projection may lead to an appreciable vertical sway in the image being projected onto the screen **950**. Also, any torsion force exerted onto the forwardmost lens **938** can cause an appreciable horizontal sway in the image projected onto the screen **950**. The sway often becomes more conspicuous, particularly, if an image including straight lines as in a building or if subtitles are projected.

[0009] It is therefore an object of the present invention is to provide a rear-projection type imaging apparatus such as a rear projection television set or rear projector, which can prevent a sway of image which would result from vibration in a projection lens system produced by the heavy bass from the woofers or the like.

[0010] Another object of the present invention is to provide a rear-projection type imaging apparatus which less require to ensure accuracy in component parts associated with the projection lens system and which can be disassembled and reassembled in an easy and simple manner.

SUMMARY OF THE INVENTION

[0011] The present invention relates to a rear-projection type imaging apparatus capable of projecting, and displaying, an enlarged image onto a screen from the rearward thereof, comprising a housing for containing components, a signal processing unit for receiving signals relating to image and audio information and controlling operation of the rear-projection type imaging apparatus, an image display element coupled to the signal processing unit for receiving the image signals generated by the signal processing unit and displaying the image thereon, woofer means coupled to the signal processing unit for receiving the audio signals generated by the signal processing unit and outputting bass sounds, and a projection lens system for enlarging and projecting the image displayed on the image display element, the woofer means and the projection lens system being disposed in the housing, the projection lens system being comprised of a rear-group optical system including at least one convex lens adapted to converge rays from the image displayed on the image display element and a front-group optical system including at least one concave lens adapted to diffusing the rays which has passed through the rear-group optical system. According to an aspect of the rear-projection type imaging system of the invention, the rear-group optical system is supported within a corresponding lens barrel, the front-group optical system is also supported within a corresponding lens barrel, and the respective lens barrels for the front-group and rear group optical systems are fastened to each other by fastening means. Such an arrangement can prevent any image sway which would otherwise occur due to vibration in the projection lens system created by the heavy bass from the woofer means.

[0012] According to another aspect of the rear-projection type imaging apparatus of the invention, it is preferred that the lens barrels for the front-group and rear-group optical systems are fastened to each other by means of the fastening means which includes a locating pin and a fixing screw. With such an arrangement, it is possible to effectively prevent any change in the angle between the respective optical axes of the front-group and rear-group optical systems due to the vibration in the forwardmost lens of the projection lens system during projection as well as any run-out of the optical axis of the front-group optical system if the torsion force is exerted on the forwardmost lens.

[0013] According to another aspect of the rear-projection type imaging apparatus of the invention, the lens barrels for the front-group and rear-group optical systems can be fastened to each other by use of an adhesive. With such an arrangement, the respective lens barrels for the front-group and rear-group optical systems can be securely attached to each other regardless of accuracy of the component parts since the adhesive may flow into any gap which would exist between the lens barrels.

[0014] According to another aspect of the rear-projection type imaging apparatus of the invention, the lens barrels for the front-group and rear-group optical systems can be fastened to each other by means of fastening means including a boss and an adhesive between the lens barrels. With such an arrangement, the respective lens barrels for the front-group and rear-group optical systems can be securely attached to each other regardless of accuracy of the component parts since the adhesive may flow into any gap which would exist between the lens barrels. In addition, the provision of the boss can provide a more robust structure since the boss may effectively resist relative movement of the lens barrels when a greater force is applied to the forwardmost lens of the projection lens system.

[0015] According to another aspect of the rear-projection type imaging apparatus of the invention, a cushion member can be disposed between the respective lens barrels for the front-group and rear-group optical systems. With such an arrangement, the respective lens barrels for the front-group and rear-group optical systems can be closely engaged to each other regardless of accuracy of the component parts by means of the cushion member disposed between the lens barrels so as to fill any gap which would exist therebetween.

[0016] According to another aspect of the rear-projection type imaging apparatus of the invention, the lens barrels for the front-group and rear-group optical systems can be fastened to each other by means of fastening means including a boss, in addition to the cushion member disposed therebetween. With such an arrangement, the respective lens barrels for the front-group and rear-group optical systems can be closely engaged to each other regardless of accuracy of the component parts by means of the cushion member disposed between the lens barrels so as to fill any gap which would exist therebetween. In addition, the provision of the boss can provide a more robust structure since the boss may effec-

tively resist relative movement of the lens barrels when a greater force is applied to the forwardmost lens of the projection lens system.

[0017] According to another aspect of the rear-projection type imaging apparatus of the invention, the lens barrels for the front-group and rear-group optical systems can be fastened to each other by means of fastening means including a locating pin and a fixing screw, in addition to the cushion member disposed therebetween. With such an arrangement, the respective lens barrels for the front-group and rear-group optical systems can be closely engaged to each other regardless of accuracy of the component parts by means of the cushion member disposed between the lens barrels so as to fill any gap which would exist therebetween. Also, with such an arrangement, it is possible to effectively prevent any change in the angle between the respective optical axes of the front-group and rear-group optical systems due to the vibration in the forwardmost lens of the projection lens system during projection as well as any run-out of the optical axis of the front-group optical system if the torsion force is exerted on the forwardmost lens.

[0018] According to a further aspect of the rear-projection type imaging apparatus of the invention, the signal processing unit can be configured to receive television signals from TV stations, output signals relating to image and audio information, and control the operation of the rear-projection television set. With such an arrangement, the rear-projection television set can be constructed in such a manner as to prevent any image sway which would result from vibration in a projection lens system produced by the heavy bass from the woofers or the like.

[0019] The present invention provides a rear-projection type imaging apparatus which is constructed to effectively prevent any vibration in a front-group optical system of a projection lens system, thereby avoiding any image sway in an efficient and effective manner. Accordingly, a user can view the rear-projection type imaging apparatus comfortably with his/her eyes not becoming tired. Also, the rear-projection type imaging apparatus of the present invention less requires to ensure accuracy in parts associated with the projection leans system and can be disassembled and reassembled in an easy and simple manner. Therefore, the rear-projection type imaging apparatus of the present invention requires less number of steps to manufacture as well as less time to perform maintenance or the like.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] **FIG. 1** is a side elevation view, partly in section, showing a structure of each of a projection lens system, a reflecting mirror and a screen of a rear-projection television set according to a first embodiment of the invention;

[0021] **FIG. 2** is a sectional view showing the structure of the rear-projection television set of the first embodiment of the invention;

[0022] **FIG. 3** is a perspective view showing the general construction of the rear-projection television set of the first embodiment of the invention;

[0023] **FIG. 4** is a top view showing a structure of the projection lens system of the rear-projection television set of the first embodiment of the invention;

[0024] **FIG. 5** is a side elevation view showing a structure of the projection lens system of the rear-projection television set of the first embodiment of the invention;

[0025] **FIG. 6** is a fragmentary side elevation view, partly in section, showing a structure of a first type of a fastening structure for use with the projection lens system of the rear-projection television set according to the first embodiment of the invention;

[0026] **FIG. 7** is a fragmentary side elevation view showing a structure of a second type of the fastening structure for use with the projection lens system of the rear-projection television set according to the first embodiment of the invention;

[0027] **FIG. 8** is a fragmentary side elevation view, partly in section, showing a structure of a third type of the fastening structure for use with the projection lens system of the rear-projection television set according to the first embodiment of the invention;

[0028] **FIG. 9** is a fragmentary side elevation view, partly in section, showing a structure of a fourth type of the fastening structure for use with the projection lens system of the rear-projection television set according to the first embodiment of the invention;

[0029] **FIG. 10** is a fragmentary side elevation view, partly in section, showing a structure of a fifth type of the fastening structure for use with the projection lens system of the rear-projection television set according to the first embodiment of the invention;

[0030] **FIG. 11** is a fragmentary side elevation view, partly in section, showing a structure of a sixth type of the fastening structure for use with the projection lens system of the rear-projection television set according to the first embodiment of the invention;

[0031] **FIG. 12** is a side elevation view, partly in section, showing a general construction of a rear projector according to a second embodiment of the invention and includes a perspective view of various components of the rear projector;

[0032] **FIG. 13** is a perspective view showing the general construction of a rear-projection television set of the prior art; and

[0033] **FIG. 14** is a sectional view showing a structure of each of a projection lens system, a reflecting mirror and a screen of the rear-projection television set shown in **FIG. 13**.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0034] Several preferred embodiments of the present invention will now be described with reference to the accompanying drawings. A rear-projection type imaging apparatus according to the present invention is based on or includes a concept that provides an imaging apparatus configured to project an enlarged image onto a screen from the backward thereof, such as a rear projection television set or a rear projector.

(1) First Embodiment

[0035] A first embodiment of the present invention relates to a rear-projection television set among rear-projection type

imaging apparatuses. Referring to **FIGS. 1 and 3**, the rear-projection television set **100**, which is a rear-projection type imaging apparatus according to one embodiment of the present invention, is configured such that an enlarged image from the television set can be projected and displayed onto a screen from the backward thereof. The rear-projection television set **100** comprises a housing **114** for receiving various components. The housing **114** preferably includes an upper cabinet **110** and a lower cabinet **112**. Alternatively, the housing **114** may be of an integral structure without dividing into upper and lower cabinets.

[**0036**] A television control unit **128** is disposed in the central portion of the lower cabinet **112** at the rearward part thereof for receiving television signals from TV stations, outputting signals relating to image and audio information and controlling the operation of the rear-projection television set. A receiver antenna (not shown) may be connected to the television control unit **128**. An image display element **120** is disposed in the central portion of the lower cabinet **112** at the rearward part thereof and also forward of the television control unit **128** for receiving the image signals from the television control unit **128** and displaying a television image (or picture) thereon. The television control unit **128** may be disposed in any position at the rearward part of the lower cabinet **112**. The television control unit **128** also forms a signal processing unit in the rear-projection television set **100**.

[**0037**] The image display element **120** may be in the form of a liquid crystal panel. A projection lens system **130** is disposed in the central portion of the lower cabinet **112** forward of the image display element **120** for enlarging and projecting the image displayed by the image display element **120**. An image projecting mirror **140** is disposed on the rearward part of the upper cabinet **110** for reflecting the image projected by the projection lens system **130** and projecting it onto a screen from the backward thereof. Preferably, the image projecting mirror **140** is fixedly mounted and supported on the rearward part of the upper cabinet **110**. The reflecting face of the image projecting mirror **140** is oriented at an angle of 60 degrees relative to the horizontal plane. The reflecting face of the image projecting mirror **140** may be positioned at any angle other than 60 degrees relative to the horizontal plane. Alternatively, the imaging apparatus may comprise a plurality of image projecting mirrors. Furthermore, the imaging apparatus may be configured so that a projection lens system can project an image onto a screen from the backward thereof without the use of the image projecting mirror.

[**0038**] A screen **150** onto which the enlarged image reflected at the image projecting mirror **140** is projected from the backward of the screen is disposed in the central portion of the upper cabinet **110** at the front side thereof. Preferably, the screen **150** is fixedly mounted and supported on the front side of the upper cabinet **110**. The display area of the screen **150** is positioned at an angle of 90 degrees relative to the horizontal plane. The display area of the screen **150** may be positioned at any angle other than 90 degrees relative to the horizontal plane. A first tweeter (right-side tweeter) **160** is disposed on the right side of the upper cabinet **110**. The first tweeter **160** is connected to the television control unit **128** and adapted to receive audio signals from the television control unit **128** for outputting treble sounds. A second tweeter (left-side tweeter) **162** is disposed on the left side of the upper cabinet **110**. The second tweeter **162** is connected to the television control unit **128** and adapted to receive audio signals from the television control unit **128** for outputting treble sounds. A first woofer (right-side woofer) **164** is disposed on the right side of the lower cabinet **112**. The first woofer **164** is connected to the television control unit **128** and adapted to receive audio signals from the television control unit **128** for outputting bass sounds. A second woofer (left-side woofer) **166** is disposed on the left side of the lower cabinet **112**. The second woofer **166** is connected to the television control unit **128** and adapted to receive audio signals from the television control unit **128** for outputting bass sounds. The woofers **164**, **166** and projection lens system **130** are received in the lower portion of the housing **114** (or within the lower cabinet **112**) adjacent to one another.

[**0039**] The image display element **120** is connected to the television control unit **128** and can receive image signals from the television control unit **128** for displaying image information. Referring to **FIG. 2**, it is particularly preferable that the image display element **120** is fixedly mounted and supported on the lower cabinet **112**. It is also preferable that the television control unit **128** is fixedly mounted and supported on the lower cabinet **112**. The tweeters **160**, **162** and the woofers **164**, **166** are adapted to be connected to the television control unit **128** and to receive audio signals from the television control unit **128** for outputting audio sounds.

[**0040**] The projection lens system **130** comprises a rear-group optical system **132** including a plurality of convex lenses for converging rays from the image displayed by the image display element **120**, an intermediate mirror **134** for reflecting the rays passing through the rear-group optical system **130**, and a front-group optical system **136** including a plurality of concave lenses for diffusing the rays reflected at the intermediate mirror **134**. The rear-group optical system **132** may comprise a single convex lens or a combination of one or more convex lenses with one or more concave lenses. The front-group optical system **136** may comprise a single concave lens or a combination of one or more concave lenses with one or more convex lenses. Alternatively, each of these optical systems may be combined with an additional convex lens and/or a convex lens. Furthermore, the image projection system **130** may be configured so that the optical axes of the front-group and rear-group optical systems **136**, **132** will be aligned with each other without the provision of the intermediate mirror **134**. The rear-group optical system **132** and/or the front-group optical system **136** may be configured to include one or more lenses which are movable to perform the focusing of the optical systems in the direction of optical axis.

[**0041**] The rear-group optical system **132** is disposed forward of the image display element **120**. The rear-group optical system **132** is supported within a lens barrel **142** which can be formed by aluminum die-casting or of an engineering plastic (e.g., polycarbonate, PPS, etc.). Referring to **FIG. 2**, it is particularly preferred that the barrel **142** for the rear-group optical system is firmly supported on the lower cabinet **112** using any fastening means such as screw fastening. The intermediate mirror **134** is disposed forward of the rear-group optical system **132**. The intermediate mirror **134** includes an intermediate mirror retaining member **144** which is supported on the barrel **132** for the rear-group optical system using any fastening means such as

fitting/fixing means. The front-group optical system **136** is disposed upward of the intermediate mirror **134**. The front-group optical system **136** is supported within a barrel **146** for the front-group optical system. The barrel **146** can be made of aluminum die-casting or of an engineering plastic (e.g., polycarbonate, PPS, etc.). The front-group optical system barrel **146** is supported on the intermediate mirror retaining member of the intermediate mirror **134** using any fastening means such as screw fastening. The optical axis **132***x* of the rear-group optical system **132** is oriented parallel to the horizontal plane. The optical axis **132***x* of the rear-group optical system **132** may be oriented at an angle relative to the horizontal plane.

[**0042**] The reflecting face of the intermediate mirror **134** is positioned at an angle of 60 degrees relative to the horizontal plane. The reflecting face of the intermediate mirror **134** may also be oriented at an angle other than 60 degrees relative to the horizontal plane. The optical axis **136***x* of the front-group optical system **136** is oriented at an angle of 60 degrees relative to the horizontal plane. The optical axis **136***x* of the front-group optical system **136** may also be oriented at an angle other than 60 degrees relative to the horizontal plane. The image displayed at the image display element **120** is reflected by the intermediate mirror **134** after passed through the rear-group optical system **132**, enlarged by the front-group optical system **136** and then reflected by the image projecting mirror **140** toward a screen **150** so that the image will be projected onto the screen **150** from the backward thereof. By utilizing such a structure, a user can view the image displayed by the image display element **120** in an enlarged scale from the front side of the screen **150**. The user can operate the rear-projection television set **100** using a remote controller (now shown). The upper cabinet **110** and/or the lower cabinet **112** may include a control unit including a display section and switches.

[**0043**] Referring to **FIGS. 1 and 5**, the image projected onto the screen **150** of the rear-projection television set **100** is one that is provided by enlarging an original image on the image display element **120** such as liquid crystal panel to several tens of times. When the forwardmost lens **138** of the projection lens system **130** is vibrated during projection, an angle θ**1** included between the optical axis of the front-group optical system **136** and the optical axis of the rear-group optical system **132** is changed to create a width of deflection "a" at the tip of the forwardmost lens **138** in the projection lens system **130**. Even if such a width of deflection "a" is only slight, the deflection will be enlarged to create a width of deflection "a'" at the screen **150**. In other words, when the forwardmost lens in the projection lens system **130** is vibrated during projection, a great sway in the vertical direction may be created in the image projected onto the screen **150**. When a torsion force acts on the forwardmost lens **138** to change the optical axis **136***x* of the front-group optical system **136** only by an angle θ**2** as shown in **FIG. 4**, a great sway in the horizontal direction may be created in the image projected onto the screen **150**.

[**0044**] In the rear-projection television set **100** of the present invention, the front-group optical system barrel **146** and rear-group optical system barrel **142** are fastened to each other to reduce the occurrence of said width of deflection "a" and/or the horizontal sway. In other words, the fastening part of the front-group optical system barrel **146** is fastened to the fastening part of the rear-group optical system **142** through a fastening structure. With such an arrangement, these angles θ**1** and θ**2** can be prevented from being changed, this resulting in reduction of the sway in the image. Referring to **FIG. 6**, there is shown a first type of fastening structure which includes a mount **146***f* provided on the outer periphery of the front-group optical system barrel **146** at the rearward part thereof. The mount **146***f* may be in the form of a flange. The mount **146***f* of the front-group optical system barrel **146** has a guide hole **146***h* formed therethrough. A retaining member **142***b* is provided on the upper part of the rear-group optical system barrel **142**. The retaining member **142***b* may be in the form of a pedestal. A locating pin **142***p* is provided on the top face of the retaining member **142***b*. A threaded hole **142***c* is prodided in the top face of the retaining member **142***b*.

[**0045**] With the locating pin **142***p* inserted into the guide hole **146***h*, a fixing screw **142***d* is screwed into the threaded hole **142***c* such that the mount **146***f* can be fixedly attached to the retaining member **142***b*. An internal thread may have been formed in the threaded hole **142***c*. Alternatively, if the fixing screw **142***d* is in the form of a self-taping screw, the threaded hole **142***c* may be replaced by a simple hole without an internal thread. With such an arrangement, it is possible to effectively prevent any change in the angle θ**1** between the optical axis of the front-group optical system **136** and the optical axis and the rear-group optical system **132** due to the vibration in the forwardmost lens **138** of the projection lens system **130** during projection. Furthermore, with such an arrangement, it is possible to effectively prevent a run-out of the optical axis **136***x* of the front-group optical system **136** by the angle θ**2** when the torsion force is exerted on the forwardmost lens **138**.

[**0046**] Alternatively, referring to **FIG. 7**, there is shown a second type of fastening structure which includes a mount **146***f* provided on the outer periphery of the front-group optical system barrel **146** at the rearward part thereof. A retaining member **142***b* is provided on the upper part of the lens barrel **142**. The mount **146***f* can be securely attached relative to the retaining member **142***b* by means of an adhesive **172**. With this arrangement, the secure attachment of the mount **146***f* to the retaining member **142***b* can be performed regardless of accuracy of the component parts since the adhesive **172** can flow into a gap "b" which would exist between the lower surface of the mount **146***f* and the upper surface of the retaining member **142***b*. Accordingly, with such arrangement, it is not necessary that designed dimensions of the component parts should be held to very close tolerances in order to eliminate any gap "b". Also, with such an arrangement, it is possible to effectively prevent any change in the angle θ**1** between the optical axis of the front-group optical system **136** and the optical axis and the rear-group optical system **132** due to the vibration in the forwardmost lens **138** of the projection lens system **130** during projection as well as a run-out of the optical axis **136***x* of the front-group optical system **136** by the angle θ**2** when the torsion force is exerted on the forwardmost lens **138**.

[**0047**] Alternatively, referring to **FIGS. 5 and 8**, there is shown a third type of fastening structure which includes a mount **146***f* provided on the outer periphery of the front-group optical system barrel **146** at the rearward part thereof. The mount **146***f* of the front-group optical system barrel **146** has a guide hole **146***h* formed therethrough. A boss **142***g* is provided on the upper surface of the retaining member **142***b*.

With the boss **142***g* extending through the guide hole **146***j*, the mount **146***f* can be securely attached relative to the retaining member **142***b* by means of an adhesive **172**. Such secure attachment of the mount **146***f* to the retaining member **142***b* can be performed regardless of accuracy of the component parts since the adhesive **172** can flow into a gap "b" which would exist between the lower surface of the mount **146***f* and the upper surface of the retaining member **142***b*. The provision of the boss **142***g* on the upper surface of the retaining member **142***b* provides a more robust structure since the boss may effectively resist relative movement of the mount **146***f* when a greater force is exerted on the forwardmost lens of the projection lens system **130**.

[**0048**] Alternatively, referring to **FIG. 9**, there is shown a fourth type of fastening structure which includes a mount **146***f* provided on the outer periphery of the front-group optical system barrel **146** at the rearward part thereof. A retaining member **142***b* is provided on the upper part of the lens barrel **142**. A cushion member **180** can be disposed between the lower surface of the mount **146***f* and the upper surface of the retaining member **142***b* for establishing a closely engaging relationship between the mount **146***f* and the retaining member **142***b*. Such close engagement can be attained regardless of accuracy of the component parts by means of the cushion member **180** which is inserted into and fill a gap "b" which would exist the lower surface of the mount **146***f* and the upper surface of the retaining member **142***b*. The cushion member can comprise NBR, rubber or the like. With this arrangement, the cushion member **180** can accommodate any change in the angle θ**1** between the optical axis of the front-group optical system **136** and the optical axis and the rear-group optical system **132** due to the vibration in the forwardmost lens **138** of the projection lens system **130** during projection. Furthermore, with this arrangement, easy disassembly of the component parts can be performed because of use of the cushion member **180**, but no use of any adhesive.

[**0049**] Alternatively, referring to **FIG. 10**, there is shown a fifth type of fastening structure which includes a mount **146***f* provided on the outer periphery of the front-group optical system barrel **146** at the rearward part thereof. The mount **146***f* of the front-group optical system barrel **146** has a guide hole **146***h* formed therethrough. A retaining member **142***b* is provided on the upper part of the lens barrel **142** associated with the rear-group optical system. A boss **142***g* is provided on the upper surface of the retaining member **142***b*. A cushion member **180** can be placed between the lower surface of the mount **146***f* and the upper surface of the retaining member **142***b* and may establish a closely engaging relationship between the mount **146***f* and the retaining member **142***b* with the boss extending through the guide hole **146***j*. Such close engagement can be attained regardless of accuracy of the component parts by means of the cushion member **180** which is inserted into and fill a gap "b" which would exist the lower surface of the mount **146***f* and the upper surface of the retaining member **142***b*. The cushion member can comprise NBR, rubber or the like. Furthermore, the provision of the boss **142***g* on the upper surface of the retaining member **142***b* provides a more robust structure since the boss may effectively resist relative movement of the mount **146***f* when a greater force is exerted on the forwardmost lens of the projection lens system **130**. Also, with such an arrangement, it is possible to effectively prevent any change in the angle θ**1** between the optical axis of the front-group optical system **136** and the optical axis and the rear-group optical system **132** due to the vibration in the forwardmost lens **138** of the projection lens system **130** during projection as well as a run-out of the optical axis **136***x* of the front-group optical system **136** by the angle θ**2** when the torsion force is exerted on the forwardmost lens **138**. Furthermore, with this arrangement, easy disassembly of the component parts can be performed because of use of the cushion member **180**, but no use of any adhesive which would otherwise must be removed.

[**0050**] Alternatively, referring to **FIG. 11**, there is shown a sixth type of fastening structure which includes a mount **146***f* provided on the outer periphery of the front-group optical system barrel **146** at the rearward part thereof. The mount **146***f* of the front-group optical system barrel **146** has a guide hole **146***h* formed therethrough. A retaining member **142***b* is provided on the upper part of the lens barrel **142** associated with the rear-group optical system. A locating pin **142***p* is provided on the top face of the retaining member **142***b*. A threaded hole **142***c* is formed in the top face of the retaining member **142***b*. A cushion member **180** can be disposed between the lower surface of the mount **146***f* and the upper surface of the retaining member **142***b*. With the cushion member **180** disposed between the lower surface of the mount **146***f* and the upper surface of the retaining member **142***b* and also with the locating pin **142***p* engaged by the guide hole **146***h*, the fixing screw **142***d* is screwed into the threaded hole **142***c* such that the mount **146***f* can be fixedly attached to the retaining member **142***b*. An internal thread may have been formed in the threaded hole **142***c*. Alternatively, if the fixing screw **142***d* is in the form of a self-taping screw, the threaded hole **142***c* may be replaced by a simple hole without an internal thread. Even if there is a gap "b" between the lower surface of the mount **146***f* and the upper surface of the retaining member **142***b*, the cushion member **180** can disposed in the gap "b" so that the mount **146***f* may closely engage the retaining member **142***b* regardless of accuracy of the component parts. The cushion member can comprise NBR, rubber or the like. Furthermore, the provision of the boss **142***g* on the upper surface of the retaining member **142***b* provides a more robust structure since the boss may effectively resist relative movement of the mount **146***f* when a greater force is exerted on the forwardmost lens of the projection lens system **130**. Also, with such an arrangement, it is possible to effectively prevent any change in the angle θ**1** between the optical axis of the front-group optical system **136** and the optical axis and the rear-group optical system **132** due to the vibration in the forwardmost lens **138** of the projection lens system **130** during projection as well as a run-out of the optical axis **136***x* of the front-group optical system **136** by the angle θ**2** when the torsion force is exerted on the forwardmost lens **138**. Furthermore, with this arrangement, easy disassembly of the component parts can be performed because of use of the cushion member **180**, but no use of any adhesive.

[**0051**] While the above description relates to the first to sixth types of fastening structures wherein the mount **146***f* and the retaining member **142***b* are provided on the lens barrels **146** and **142** associated with the front-group and rear-group optical systems **136** and **132**, respectively, the mount **146***f* and the retaining member **142***b* can be provided on the lens barrels **142** and **146** associated with the rear-group and front-group optical systems **132** and **136**, respectively. Accordingly, the locating pin **142***p* can be provided

either on the retaining member on the lens barrel **146** or on the retaining member on the lens barrel **142**. The threaded hole **142***c* can also be provided either in the retaining member on the lens barrel **146** or in the retaining member on the lens barrel **142**. The guide hole **146***h* can be can also be provided either in the mount on the lens barrel **146** or in the mount on the lens barrel **142**. The boss can be provided either on the retaining member of the lens barrel **146** or on the retaining member of the lens barrel **142**.

[**0052**] Also, while the above description relates to the first to sixth types of fastening structures wherein the single mount **146***f* and retaining member **142***b* are provided on the lens barrels **146** and **142** associated with the front-group and rear-group optical systems **136** and **132**, respectively, a plurality of the mounts **146***f* and the retaining members **142***b* can be provided on the lens barrels **142** and **146** associated with the rear-group and front-group optical systems **132** and **136**, respectively.

[**0053**] As described above, the present invention provides a rear-projection type imaging apparatus which is constructed to effectively prevent any vibration in a front-group optical system of a projection lens system due to the heavy bass from the woofers or the like, thereby avoiding any image sway in an efficient and effective manner. Also, the rear-projection television set of the present invention less requires to ensure accuracy in parts associated with the projection leans system and can be disassembled and reassembled in an easy and simple manner.

(2) Second Embodiment

[**0054**] A second embodiment of the rear-projection type imaging apparatus of the present invention will now be described. The following description relates largely to differences between the first and second embodiments of the rear-projection type imaging apparatus of the present invention. Therefore, as to matters which are not described hereinafter with respect to the second embodiment, reference should be made to the foregoing description of the first embodiment of the rear-projection type imaging apparatus of the present invention. The second embodiment of the present invention relates to a rear projector among the rear-projection type imaging apparatus.

[**0055**] Referring to **FIG. 12**, the rear projector **200**, which is depicted as an example of the rear-projection type imaging apparatus, is constructed such that an enlarged image can be projected and displayed onto a screen from the backward thereof. The rear projector **200** comprises a housing **114** for containing various components. The housing **114** includes an upper cabinet **110** and a lower cabinet **112**. A signal processing unit **228** is disposed in the central portion of the lower cabinet **112** at the rearward part thereof for receiving signals relating to image and audio information from the outside, outputting image and audio signals and controlling the operation of the rear projector **200**. An image display element **120** is disposed in the central portion of the lower cabinet **112** at the rearward part thereof and also forward of the signal processing unit **228** for receiving the image signals outputted from the signal processing unit **228** and displaying the image (or picture). The signal processing unit **228** may be disposed in any position at the rearward part of the lower cabinet **112**. First input terminal **202** is disposed on the lower cabinet **112** for receiving a left audio signal from an external device. Second input terminal **203** is disposed on the lower cabinet **112** for receiving a right audio signal from the external device. Third input terminal **204** is disposed on the lower cabinet **112** for receiving an image signal from the external device. Also, an auxiliary input terminal **222** is disposed on the lower cabinet **112** for receiving signals such as image and/or audio signals from various image and/or audio output equipments. The auxiliary terminal **222** also is connected to the signal processing unit **228**. The user can operate the rear projector **200** using a remote controller (not shown).

[**0056**] A tuner **230** is provided for receiving television signals from TV stations and outputting signals relating to image and audio information and has its output terminal connected to one of input terminals (not shown) on an amplifier **240** via a connecting cable **231**. A receiver antenna (not shown) can be connected to the tuner **230**. the connecting cable **231** can be configured to transmit the right and left audio signals, and the image signal. When it is desired that the right and left audio signals and the image signal are separately transmitted, a total of three separate connecting cables can be utilized for transmitting these signals separately. The tuner **230** is provided with display **232** for indicating states of operation of the tuner and a control panel **234** for controlling the tuner **230**. The display **232** can comprise a liquid crystal panel, LED or the like. The control panel **234** can comprise a pushbutton, a rotary dial, a slide switch, a touch-sensitive switch or the like. The tuner **230** can be controlled to receive the television signals and provide signals relating to image and audio information to the signal processing unit **228** of the rear projector **200**. A remote controller (not shown) can be used to control the tuner **230**.

[**0057**] A video player **250** is provided for receiving signals relating to image and audio information stored in recording media, such as video tapes, DVD discs, DVD-R's, CD-ROM's or the like and outputting signals relating to image and audio information provided and has its output terminal connected to another input terminal on an amplifier **240** via a connecting cable **251**. The connecting cable **251** can be configured to transmit the right and left audio signals, and the image signal. When it is desired that the right and left audio signals and the image signal are separately transmitted, a total of three separate connecting cables can be utilized for transmitting these signals separately. The video player **250** is provided with display **252** for indicating states of operation of the video player, a control panel **254** for controlling the video player **250**, a DVD disc compartment **256** for receiving a DVD disc, DVD-R's, CR-ROM's etc., and a video tape compartment **258** for receiving a video tape etc. The display **252** can comprise a liquid crystal panel, LED or the like. The control panel **254** can comprise a pushbutton, a rotary dial, a slide switch, a touch-sensitive switch or the like. The video player **250** can be controlled to read the image and audio signals off the recording media, such as video tapes, DVD discs, DVD-R, CD-ROM or the like and provide them to the signal processing unit **228** of the rear projector **200**. A remote controller (not shown) can be used to control the video player **250**.

[**0058**] The amplifier **250** is provided with display **246** for indicating states of operation of the amplifier **230** and a control panel **248** for controlling the amplifier **230**. The display **246** can comprise a liquid crystal panel, LED or the

like. The control panel **248** can comprise a pushbutton, a rotary dial, a slide switch, a touch-sensitive switch or the like. First output terminal (for example, for transmitting the right audio signal) (not shown) of the amplifier **240** is connected to the first input signal **202** of the rear projector **200** via a connecting cable **242**. Second output terminal (for example, for transmitting the left audio signal) (not shown) of the amplifier **240** is connected to the second input signal **203** of the rear projector **200** via a connecting cable **243**. Third output terminal (for example, for transmitting the image signal) (not shown) of the amplifier **240** is connected to the third input signal **204** of the rear projector **200** via a connecting cable **242**. A remote controller (not shown) can be used to control the video player **250**.

[**0059**] Also, any one of various image and/or audio output equipments, such as a video camera is coupled to the auxiliary terminal (AUX terminal) **222** via a connecting cable (not shown). In this way, the image and/or audio signals from the external image and/or audio output equipments can be transmitted to the signal processing unit **228**.

[**0060**] The present invention provides a rear-projection type imaging apparatus, such as a rear-projection television set, a rear projector or the like which is constructed to reduce vibration in a projection lens system due to sounds coming out of woofers. The present invention also provides a rear-projection type imaging apparatus which can be disassembled and reassembled in an easy and efficient manner.

LIST OF REFERENCE NUMERALS

[**0061**] **100** rear-projection television set

[**0062**] **110** upper cabinet

[**0063**] **112** lower cabinet

[**0064**] **114** housing

[**0065**] **120** image display element

[**0066**] **128** television control unit

[**0067**] **130** projection lens system

[**0068**] **132** rear-group optical system

[**0069**] **134** intermediate mirror

[**0070**] **136** front-group optical system

[**0071**] **140** image projecting mirror

[**0072**] **142** lens barrel for rear-group optical system

[**0073**] **142***b* retaining member

[**0074**] **142***c* threaded hole

[**0075**] **142***d* fixing screw

[**0076**] **142***p* locating pin

[**0077**] **146** lens barrel for front-group optical system

[**0078**] **146***f* mount

[**0079**] **146***h* guide hole

[**0080**] **150** screen

[**0081**] **160**.**162** tweeter

[**0082**] **164**,**166** woofer

[**0083**] **200** rear projector

[**0084**] **202** television input terminal

[**0085**] **204** video input terminal

[**0086**] **206** auxiliary terminal

[**0087**] **228** signal processing unit

[**0088**] **230** tuner

[**0089**] **250** video player

1. A rear-projection type imaging apparatus capable of projecting, and displaying, an enlarged image onto a screen from the rearward thereof, comprising:

a housing for containing components;

a signal processing unit for receiving signals relating to image and audio information and controlling operation of the rear-projection type imaging apparatus;

an image display element coupled to the signal processing unit for receiving the image signals generated by the signal processing unit and displaying the image thereon;

woofer means coupled to the signal processing unit for receiving the audio signals generated by the signal processing unit and outputting bass sounds; and

a projection lens system for enlarging and projecting the image displayed on the image display element;

said woofer means and the projection lens system being disposed in the housing;

said projection lens system being comprised of a rear-group optical system including at least one convex lens adapted to converge rays from the image displayed on the image display element and a front-group optical system including at least one concave lens adapted to diffuse the rays which has passed through the rear-group optical system;

said rear-group optical system being supported within a corresponding lens barrel;

said front-group optical system being supported within a corresponding lens barrel; and

said respective lens barrels for the front-group and rear group optical systems being fastened to each other by fastening means.

2. An rear-projection type imaging apparatus as defined in claim 1, wherein said lens barrels for the front-group and rear-group optical systems are fastened to each other by means of the fastening means which includes a locating pin and a fixing screw.

3. An rear-projection type imaging apparatus as defined in claim 1, wherein said lens barrels for the front-group and rear-group optical systems can be fastened to each other by use of an adhesive.

4. An rear-projection type imaging apparatus as defined in claim 1, wherein said lens barrels for the front-group and rear-group optical systems are fastened to each other by means of fastening means including a boss and an adhesive.

5. An rear-projection type imaging apparatus as defined in claim 1, further comprising a cushion member disposed between said lens barrels for the front-group and rear-group optical systems.

6. An rear-projection type imaging apparatus as defined in claim 1, further comprising a cushion member disposed between said lens barrels for the front-group and rear-group optical systems, said lens barrels for the front-group and rear-group optical systems being fastened to each other by means of fastening means including a boss.

7. An rear-projection type imaging apparatus as defined in claim 1, further comprising a cushion member disposed between said lens barrels for the front-group and rear-group optical systems, said lens barrels for the front-group and rear-group optical systems being fastened to each other by means of fastening means including a locating pin and a fixing screw.

8. An rear-projection type imaging apparatus as defined in claim 1, wherein said signal processing unit are configured to receive television signals from TV stations, output signals relating to image and audio information, and control the operation of the rear-projection television set.

* * * * *