ROCHESTER INSTITUTE OF TECHNOLOGY

A Thesis Submitted to the Faculty of
The College of Imaging Arts and Sciences
In Candidacy for the Degree of
MASTER OF FINE ARTS

AQUANIC
PERSONAL DIVING ASSISTANT TOOL

by
WATCHARAPONG TREERATTANAPHAN

MAY 16, 1998

APPROVALS

Chief Advisor: Craig McArt

Date 9/8/98

Associate Advisor: Doug Cleminshaw

Date 98 Sep 8

Associate Advisor: Kim Sherman

Date 9.8.98

Chairperson: Nancy Ciolek

Date 9. 8. 98

I, Watcharapong Treerattanaphan, hereby grant permission to the Wallace Memorial Library of RIT to reproduce my thesis in whole or in part. Any reproduction will not be for comercial use or profit.

Signature ______________________

Date 9/14/98

CONTENTS

ILLUSTRATIONS

CHAPTER 1
THESIS PROJECT DEFINITION

The purpose of this thesis is to propose an underwater device to be carried or worn by divers. This device would alleviate many problems that divers may encounter, supporting the divers as a communication, navigation, and body and environment monitoring unit.

The Problem

• Difficulties of communication under the water between divers

The ears can distinguish the direction of the sound according to the time delay of sound in the air. Sound can travel through the water much faster than through the air. Our ears receive sound from all directions at the same time in the water, so our brain can not interpret the direction of the sound source.

Even though sign language has been used efficiently for underwater communication, one diver using sign language first needs to get the attention of the other. Due to the difficulties of detecting the direction of the sound under water, using an acoustic device to get attention under water would not be useful when the divers are at any distance. Also, some divers have a problem with sign language. This is especially true for novice divers who have limited experience with diving and communication under water.

• Difficulties of communication between divers and crew members

Some charter boats are equipped with a device that emits a siren sound into the water in order to recall submerged divers back to the surface, but the divers are not able to send messages to the crew members. There is, however, a way for divers at the surface to communicate with crew members. The divers have to stay at the surface and use sign language in order to communicate with crew members from a distance.

• Visibility condition under the water

In very low visibility conditions, losing touch with diving partner is a major concern. Buddy lines utilizing three-strand twisted line with a hand loop at each end are used in order to avoid diver separation, but this may cause entanglement.

Additionally, the divers may dive in the wrong direction and have problems maintaining the depth because of a lack of references. Using sign language and an underwater slate, which is a writable sheet of plastic, may not be effective in low visibility conditions, turbid water, or darkness.

• Navigation under the water

The accuracy of the entry and exit point can be affected by the current. The strong water movement may cause the divers to drift away from the intended destination.

• Safety of diving

The divers are concerned about decompression sickness caused by excess nitrogen in the blood vessels. Time and depth of diving are the primary factors that may cause an excess amount of nitrogen in the blood vessels.

Preventing injuries while diving involves avoiding accidents at the surface and under the surface. At the surface, a dive flag must be placed at the diving site in order to provide a signal for boaters, but sometimes the boaters may not perceive or recognize the purpose of the flag. Under the surface, injuries from animals occur because of the carelessness of divers themselves.

• Complexity of manual dive table and planning

A dive table can be complicated to read and interpret, but it provides accuracy of dive planning. A dive wheel, another version of a dive planning table, is easy to read, but the accuracy can vary. Various pieces of equipment, carried by divers may include a compass, pressure gauge, dive computer, log book and diving wheel or table, mask, and underwater watch.

• Locating the position of the divers

Buddy loss may occur in any situation. There is no way to precisely determine the diver's location under the water. The ability to determine the position of the diver under the water would be useful in an emergency.

The Challenge

There could be solutions that would help the divers to perform diving safely and efficiently

• A two way communication unit using speech instead of sign language

Using sign language may not be an effective way of communication for a novice diver, or for anyone in a low visibility environment or at a distance. Using a speech device would be faster and more accurate.

• Visibility enhancement equipment

Visibility limited by turbid water generally hinders the abilities of the diver in communicating and navigating. Equipment could be developed that could enhance the visibility of the divers under the water when the visibility is poor.

• Monitoring and recording personal diving data including water and body conditions

Safety is a key word for diving. Monitoring and recording personal data in each dive would be beneficial for divers, especially in determining the ascending rate, descending rate, bottom time and interval time.

• Integration of equipment

Due to the amount of equipment that the diver needs to carry, the integration of this equipment is another alternative.

Process of Design

Gathering the information from diving literature and personal diving experiences would lead to an understanding of the situations and the problems that a diver may encounter -

problems that would hinder the performance and jeopardize the health of a diver. Analyzing these problems can lead to defining the objective of the design.

The purpose is to design a device that can enhance the performance and the safety of diving. This device would be used for personal assistance under the water. The product will be projected for the very near future by utilizing existing technologies.

CHAPTER 2
RESEARCH AND ANALYSIS

Visibility Problem

Most problems that may occur to divers have been solved by products using existing technologies to better the performance of the diver. An exception is the visibility problem. The visibility problem under the water seems to be overlooked, since there is no such available technology to solve it. Diving in poor visibility conditions may cause disorientation and loss of communication between divers. For this reason, my research is focused mainly on the problem of improving vision under the water for divers.

Technology

A personal diving assistant tool needs to be carried to the diving site and must attach to the diver's body when diving. Preferred technologies exhibit factors of compactness, low power consumption, light weight, durability, and ease of use.

Difficulties of communication under the water between divers and crew members can be solved by using underwater speech communication units. Utilizing underwater speech communication units reduces the difficulties of communication. The communication will be possible regardless of whether the diver is at the surface or under the water. This device allows diver to speak directly through a water-resistant microphone attached to the mask. Using speech communication would be better than sign language, especially for a novice diver or in an emergency case. The diver's voice is changed to digital data and transmitted by an ultrasonic transmitter. A receiver collects the ultrasonic signal and converts the signal to original sound (see fig. 1).

Visibility enhancement technologies are currently used in on-land applications rather than underwater ones. More technologies for visual enhancement equipment are speculated for the very near future. One such technology that is conceivable for divers would be a heads-up display, although its present size and weight would be prohibitive. In order to be practical, this technology would require a reduction in size and weight. A heads-up display generally has some inherent drawbacks:

- a screen display which is limited to vision angle, screen resolution, and display size
- substantial power consumption
- a comparatively massive size

All of these drawbacks can be countered by Virtual Retina Display (VRD) technology (see fig. 2). By projecting images instantaneously onto the retina utilizing different beams of lights, VRD technology eliminates the bulky shape of equipment that may be caused by the restricted distance between the user's eye and the display.

Power consumption is another critical issue in the operation of this machine. The battery needs to be sufficient to support all of the electronic system including the ultrasonic transmitter and receiver, VRD, microphone, speakers, and central processing unit for at least for one dive. An LCD display unit consumes a considerable amount of power, but VRD has the potential to replace an LCD display. This would considerably reduce the amount of power consumption.

Moreover, utilizing VRD allows users to see through the mask to a certain extent. The diver could perceive the three-dimensional, simulated images superimposed over the actual water conditions viewed through the mask. The diver can turn the simulated mode off when the water condition is good.

In order to generate three-dimensional, simulated images for a diver, there are at least 5 processes to be accomplished (see fig. 3).

1. The boat emits and receives sonar signals.

Ultrasonic technology is used to gather information of the terrain underneath. The sonar is emitted from an ultrasonic transmitter attached to the boat. The sonar waves travel to the bottom and reflect back to an ultrasonic receiver on the boat.

2. A computer translates the reflected sonar to a Digital Elevation Model (DEM) file.

The reflected ultrasonic signal from the bottom is sent to a computer unit in order to translate the signal into a DEM file. The DEM file is a text file describing the elevation for each point on a mesh for a map. Therefore, the DEM file can store the information of the depth of the sea or the underwater terrain height. Concurrently, the DEM file collects the information of the diver's position both vertically and horizontally.

3. A computer deciphers the DEM file into a grayscale image.

The information of the height of the terrain is interpreted into a two-dimensional, grayscale image. The grayscale image represents the height of the terrain in two dimensions by the variation of brightness and darkness. The higher the terrain, the brighter the image. In contrast, the lower the terrain, the darker the image.

4. A computer converts the grayscale image to a three-dimensional image as seen by the diver.

A computer translates the two-dimensional image into a three-dimensional image determined by the variation of brightness and darkness. The three-dimensional image can be displayed as a wireframe image representing a grid on the terrain. The wireframe image may look confusing, but it could allow the diver to judge scale and distance more precisely. Another option would be that of applying shading to the surface of the terrain in order to provide a realistic looking environment.

A computer can also position the location of the diver respective to the bottom terrain and calculate the perspective of the diver to create a simulated view as seen by the diver.

5. A three-dimensional image is sent to the diver's heads-up display.

The image would be sent to the diver by utilizing an ultrasonic signal in different frequencies. The ultrasonic receiver attached to the diver translates the signal into an image projected through VRD. Two VRD projector units are attached to the sides of the mask. Beams of lights are directed from VRD projectors to the lenses and then reflected to the retinas of the diver.

Safety of diving, navigation under the water, and the complexity of manual dive tables and planning problems are solved by using a dive computer. Existing dive computer functions such as a digital pressure gauge, watch, dive table, personal diving record, thermometer, and compass are combined in one unit the size of a watch. This device would alert the diver automatically when the he or she needs to recognize any condition measurement deviating from normal or expected.

CHAPTER 3
IDEATION

The design would feature compactness, durability, low power consumption, video and audio technologies, ergonomics, comfort, ease of use, safety, and streamline shape. Due to the amount of diving gear that a diver needs to carry, integration of equipment needed to be considered. Integrating equipment in one unit might reduce the complexity of usage. Generally, this equipment is comprised of a mask, communication unit, visual simulation unit, and dive computer unit. All of the electronic components would be designed to be contained within a closed shell in order to avoid moisture. Materials that would be chosen would have water resistance, good impact strength, and good sunlight resistance. Polyvinyl Chloride would provide admirable qualities for the mask. A silicone rubber sealing edge could be applied to the seal in order to provide flexibility and comfort to the mask where it presses to the diver's face.

Locations of components were considered in light of their accessibility to the diver (see fig. 4). The product itself should be constantly attached to the diver's body while diving. The personal diving assistant tool should fit the diver's body well. An adjustable joint is necessary for the diver to customize the device for personal use. This product should be effortless to don and operate. The design is focused on reducing the complexity of diving preparation and performance.

This product would function chiefly as a mask. Other features could be turned on and off arbitrarily by the user. The design of the mask was originally concerned with ease of use. The diver could don it conveniently without struggling with the resilient strap, as on an ordinary diving mask. A helmet is a satisfactory solution for ease of use. All the user needs to do is don the mask and use a single hand to close the shield. The diving mask would be more convenient to put on if it used the same approach. In contrast to a helmet, the diving mask would not be opened by using a single hand or single button operation. The diver might accidentally touch and open the mask when under the water. This would jeopardize the diver.

Therefore, releasing the mask should be controlled by using both hands. For the sake of safety, releasing by turning a knob would work better than pressing a button. Moreover, the helmet should be accessible to other persons such as the diver's buddy and crew members. The diver's buddy should also have access to operate the mask when a problem strikes, such as "air free flow," "out of air," "share air," or "unconscious diver." For this reason, the regulator mouth piece connected to the mask, and the mask itself, should be able to be discharged effortlessly.

The shape is derived from ergonomic factors, and has been developed to represent the metaphor of underwater creatures (see fig. 5-40). The development of shape and form is also concerned with accommodating all of the electronic components within. Moreover, the location of all components should not obstruct the visual ability of the diver. Thus, the battery housing and the central processing unit, which require a large space, are located at the back of the helmet. Positioning the battery housing and CPU unit at the back furthermore enhances the ability of the diver to control balance underwater. The VRD is attached to the side within the mask. Operating buttons are located on both sides of the mask. Accessibility from both sides is useful for both right and left handed persons. The lens is wide enough to provide a better view for the diver.

CHAPTER 4
PRESENTATION

The concept of the personal diving assistant tool is a complicated one to present. The goal of the presentation was to explain the concept by providing the audience with a virtual experience of the product's use before the product is produced. This would help audiences and the designer to understand the design more clearly. My presentation includes concepts, technologies, usages, details, and variations. In creating the presentation, I used a computer to generate illustrations both animated and non-animated. In order to accomplish my goal, 2D digital imaging, 2D animation, 3D modeling, sound editing, and video editing software were required.

The 2D digital image programs, Adobe Photoshop and Adobe Illustrator, were the tools used for creating still 2D text, images, and graphics. Adobe After Effects, 2D animation software, was used in compositing moving texts, graphics, and descriptions in the movie. The 3D modeling softwares used were Alias/wavefront, Bryce 3D, and Poser. Alias/wavefront allows the designer to experiment with lights, shadings, shapes, and forms of the product from different angles. Bryce 3D is a tool for generating artificial ambiance in order to provide the simulated environment to the audience. In order to include the right proportions of a face, a human figure from Poser was imported to Alias/wavefront. The 3D animation softwares, Alias/wavefront, Bryce 3D, and Poser, helped me to show the possibilities of how to operate the product in a simulation.

Sounds added into the movie were edited in SoundEdit 16 in order to give the ambiance of technology and the underwater world. The video editing software, Adobe Premiere, was used for combining animation and sound into one movie.

CHAPTER 5
CONCLUSION

Technology

Although, the personal diving assistant tool was designed by utilizing a combination of existing technologies, the visibility enhancement equipment is still in the conceptual state. The synthesis of technologies for virtual vision under the water is projected for the very near future when the performance of computer processors and transfer data rates becomes faster. The size of this equipment is also another concern.

The reliability of the product would depend mainly upon electronic intelligence. A malfunctioning of the circuit may happen and cause danger to the diver while under the water. If the power supply was lost or the system failed to operate, the product would not be able to assist the diver when needed, especially when the visibility conditions were poor. A power backup system should be considered.

Design

The tail shape at the back of the helmet may cause the diver to collide into objects underwater when turning around. The tail should be shortened. Battery and CPU housings may need to be moved slightly up toward the top of the helmet.

Presentation

Since the Aquanic project integrates new and complicated technologies, explaining them to an audience verbally may not be an effective manner. The audience may have difficulties in visualizing technologies and applications. To enhance the visualization and understanding of the audience, an illustration would be an effective tool. The more realistic the illustration, the clearer the audience will understand. A product which may have never existed before can be seen by creating it in a virtual environment in a computer. Not only can the audience see a still image, but can also perceive the product in different views by means of computer animation.

This is a matter of designing the experience before designing the product. I believe designing the experience is another important approach for industrial design to communicate with marketing and engineering. Marketing and engineering could see the potential of a product before bringing it to life. The purpose of this is to simulate the use of the product. Utilizing multimedia as a simulation tool makes the presentation more understandable and attractive. On the other hand, employing multimedia as a tool is a time consuming process which may not be acceptable in some situations. Moreover, producing a designed experience assumes skills of using softwares and tools. The designer must combine industrial design and computer graphic aspects.

ILLUSTRATIONS

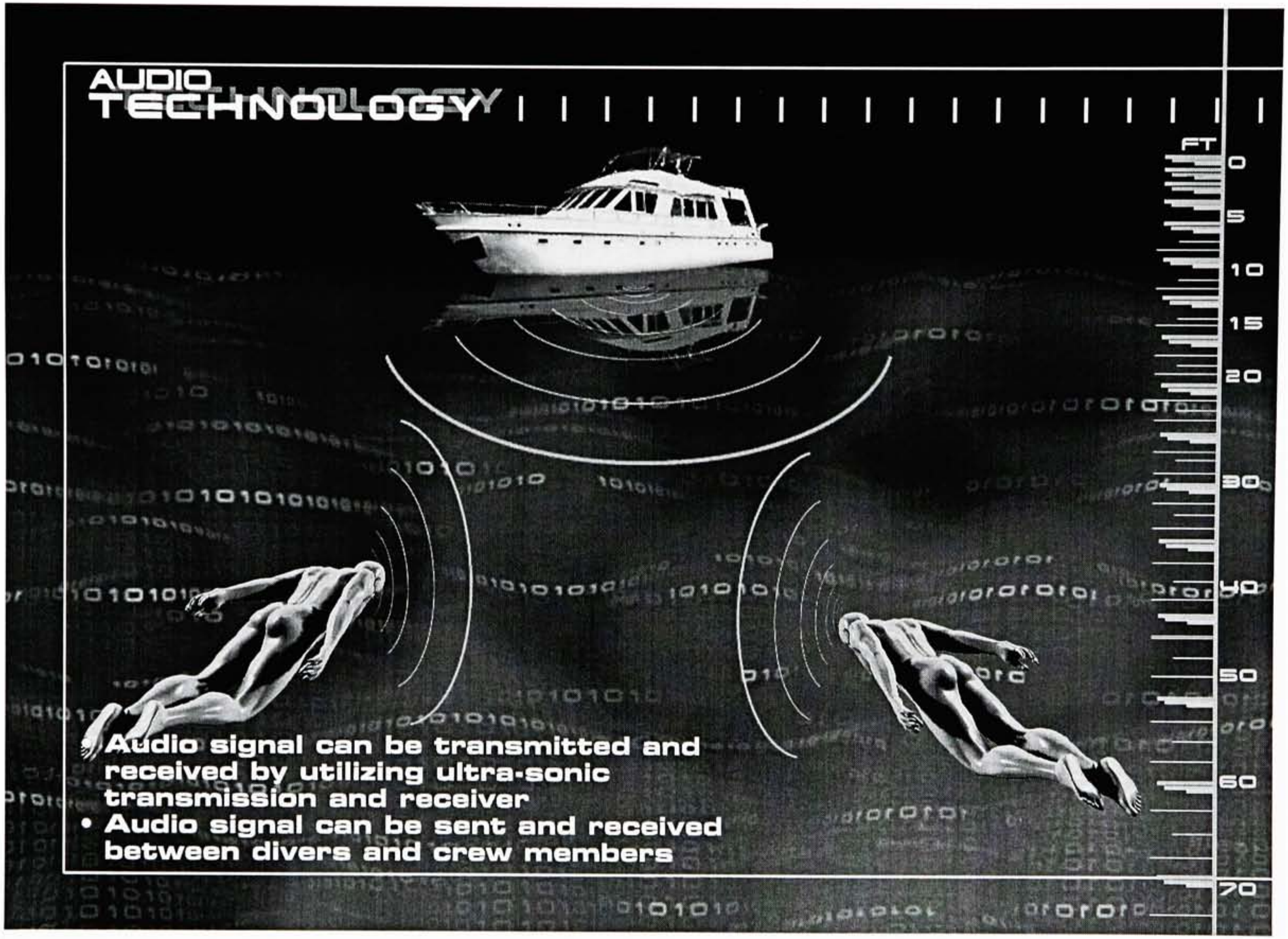


Fig. 1. Audio Technology.

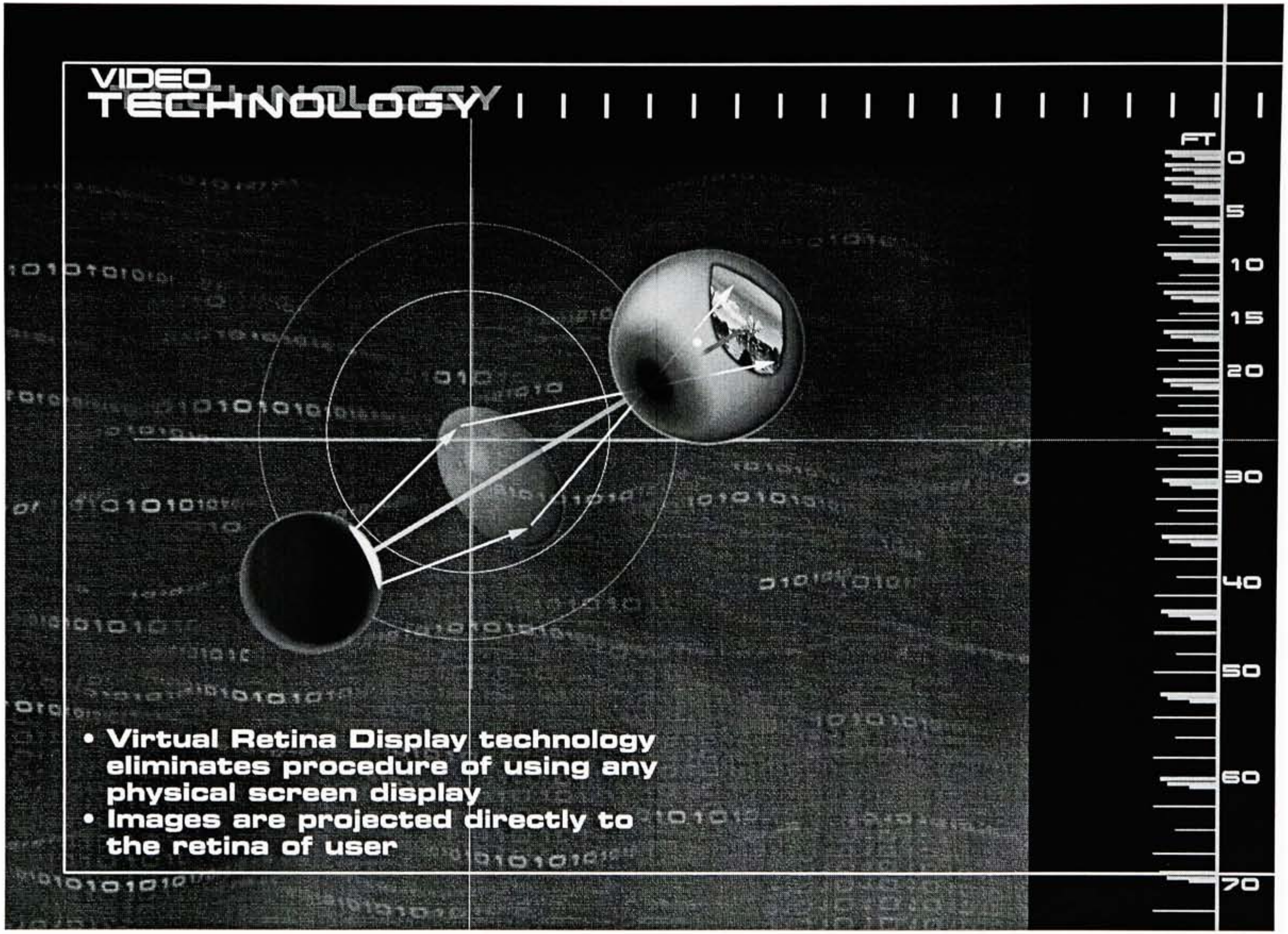


Fig. 2. VRD Technology.

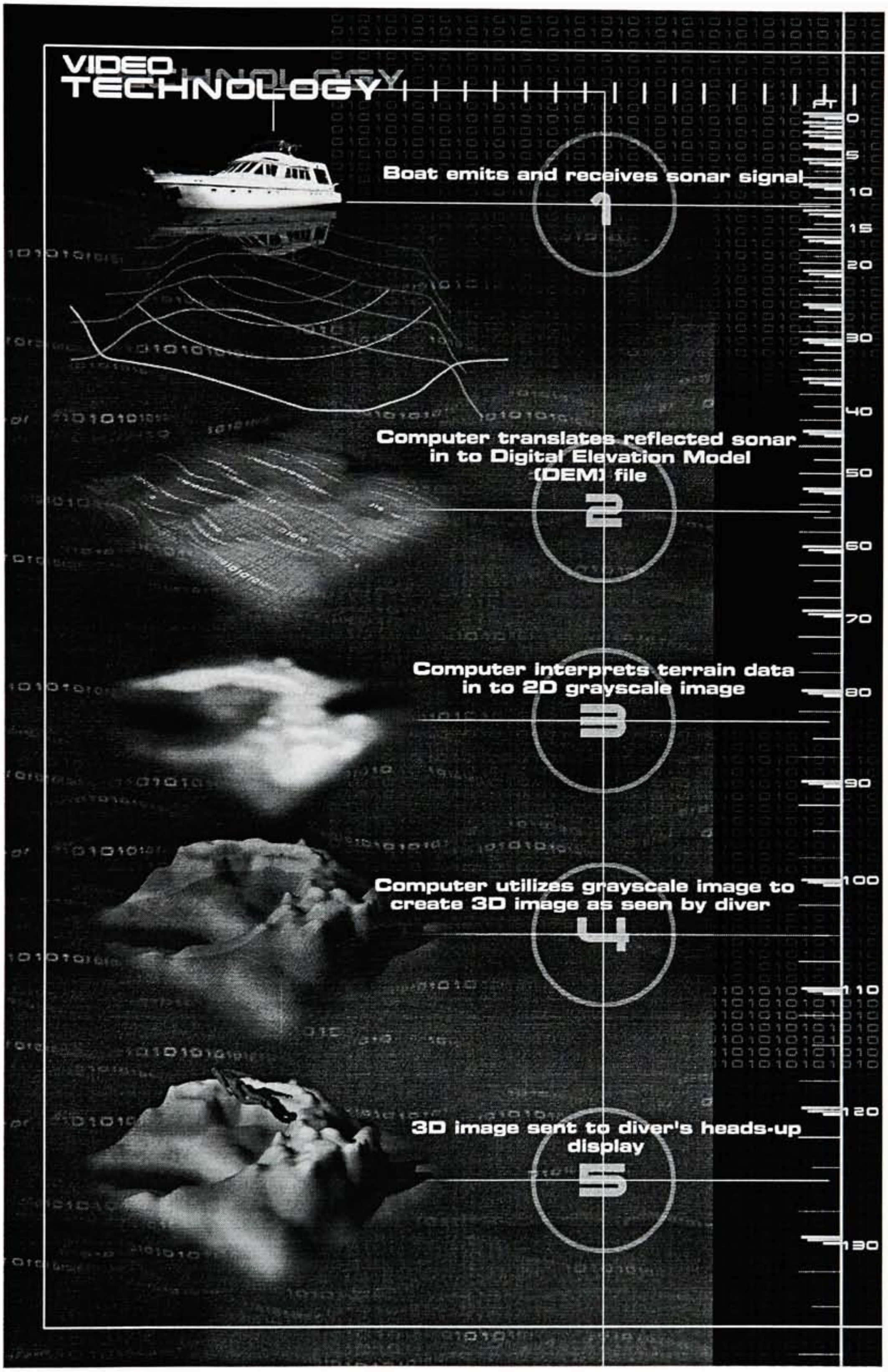


Fig. 3. Video Technology

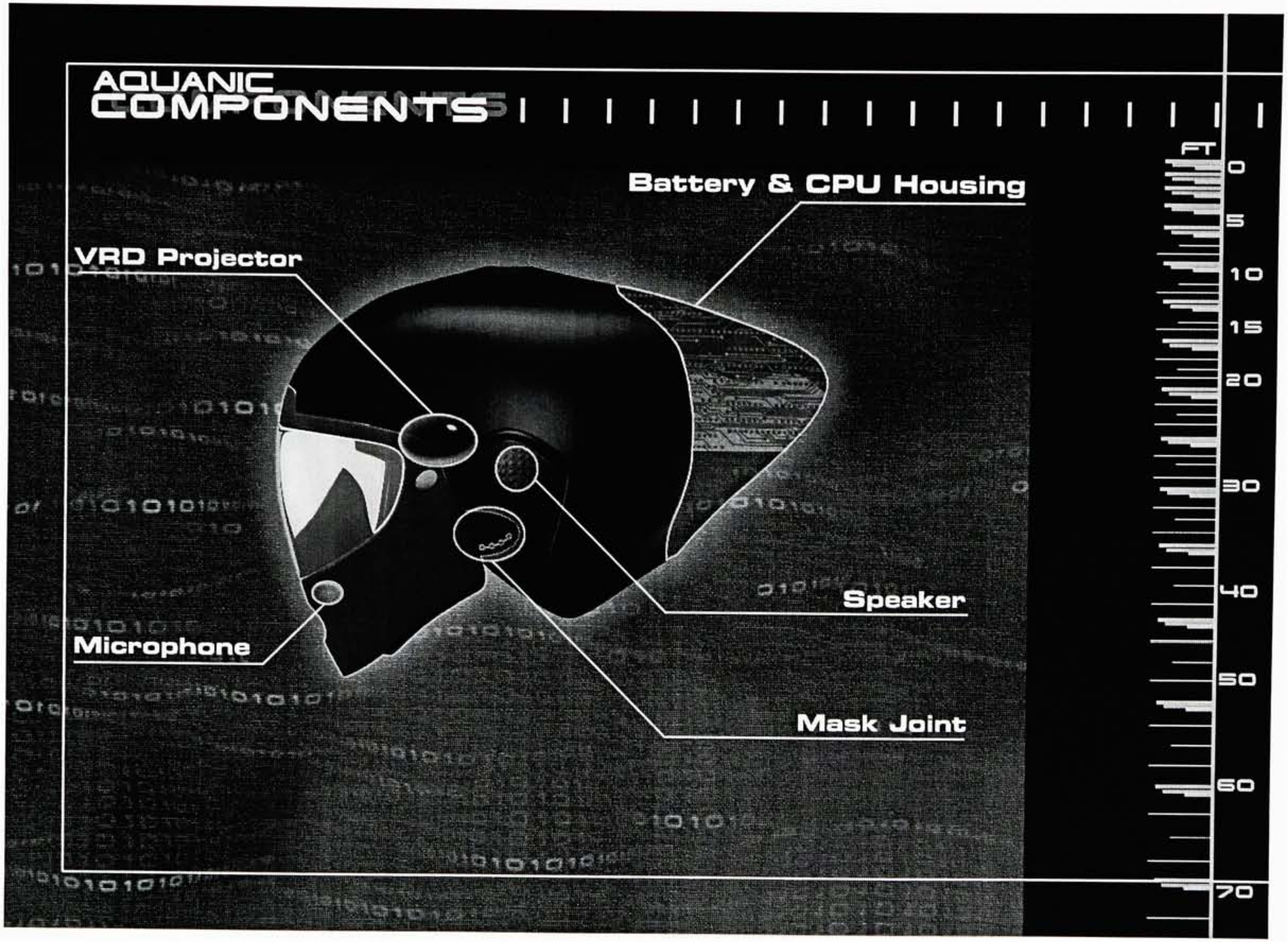
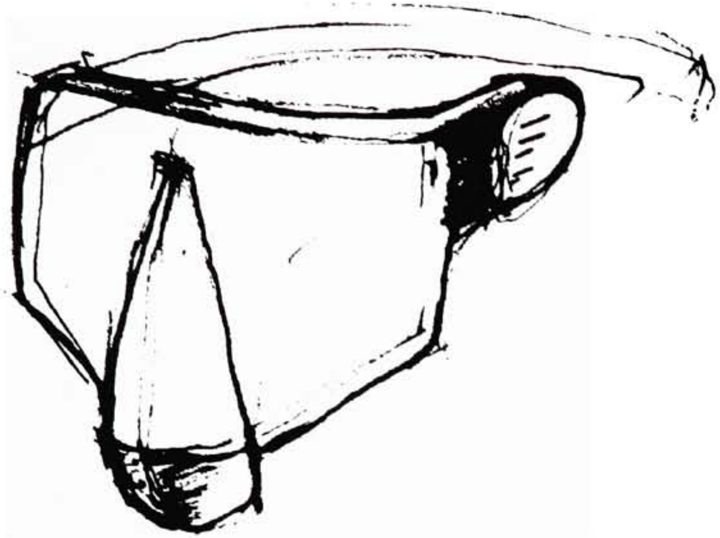


Fig. 4. Location of each component of the Aquanic helmet.

A1



A2

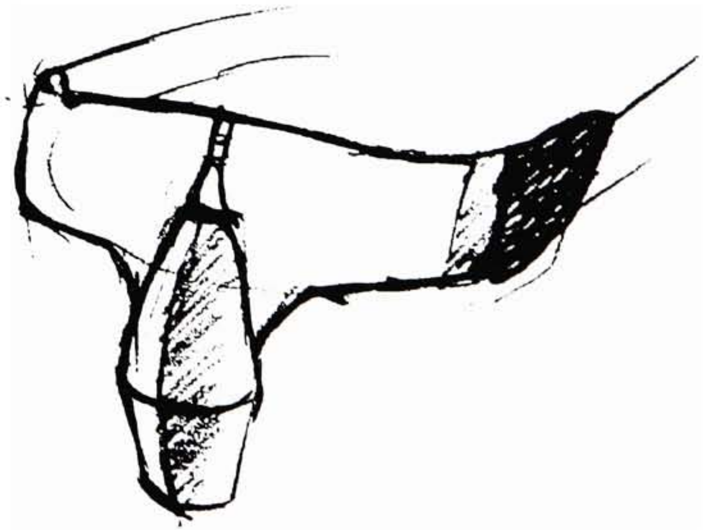
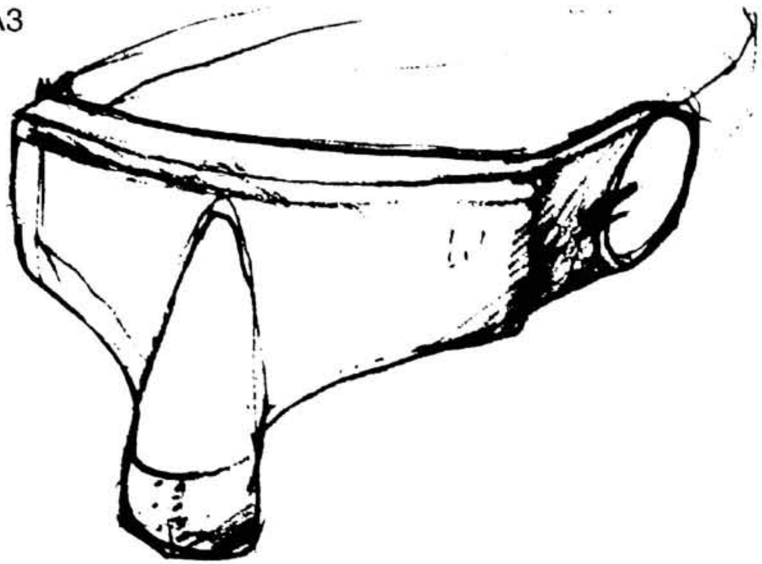


Fig. 5. Design concept A1 and A2.

A3



A4

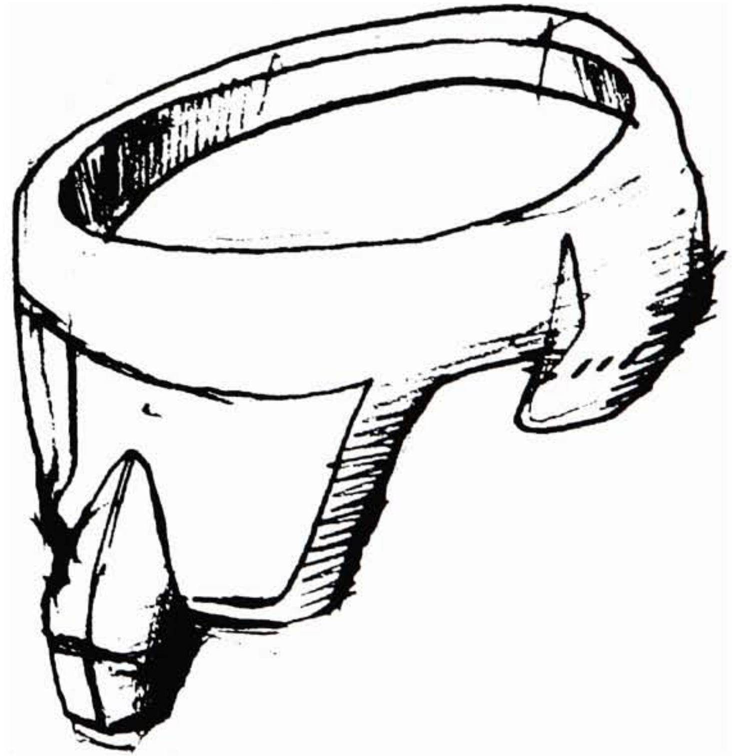
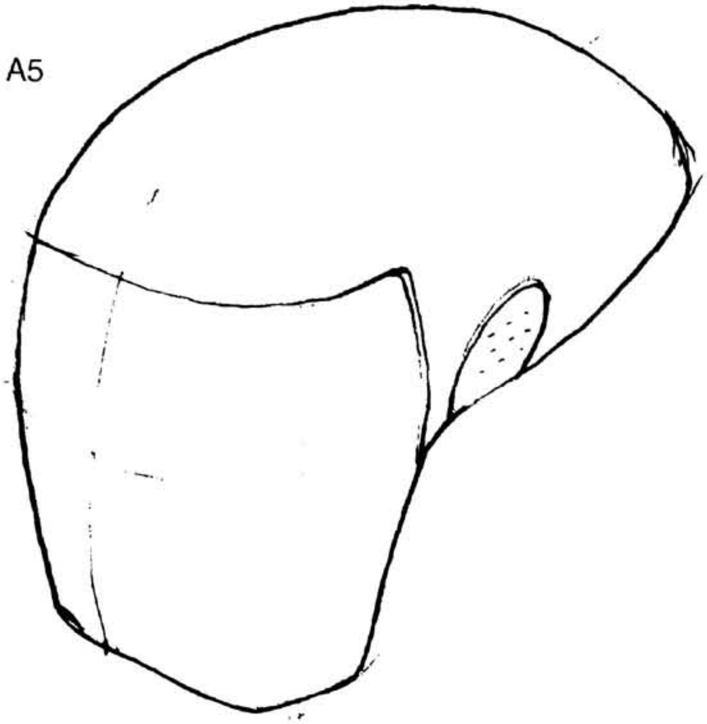


Fig. 6. Design concept A3 and A4.

A5



A6

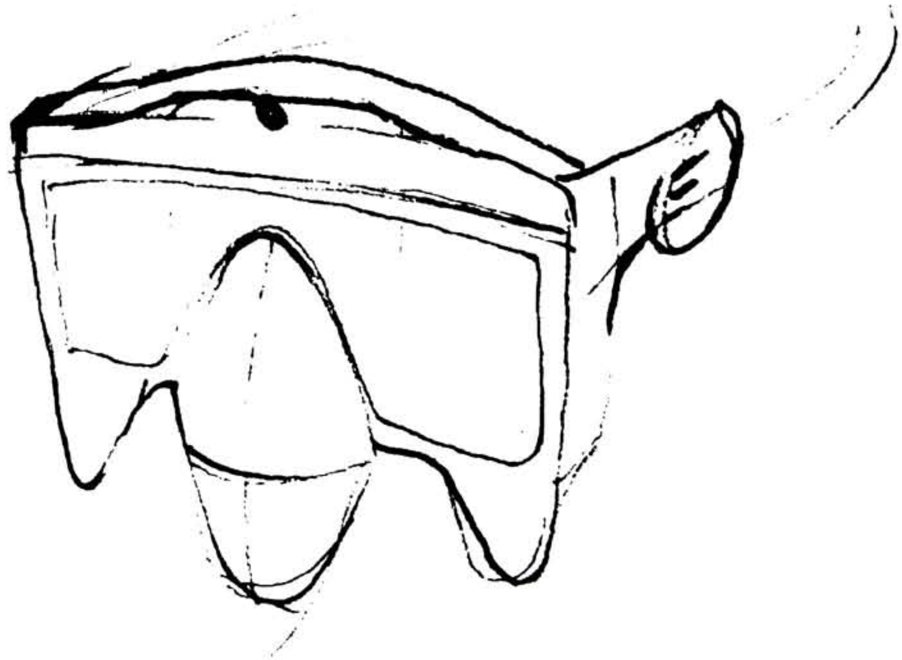
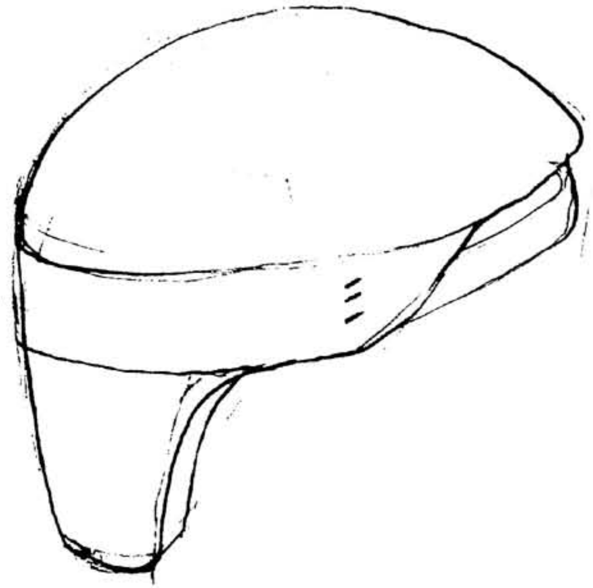


Fig. 7. Design concept A5 and A6.

A7



A8

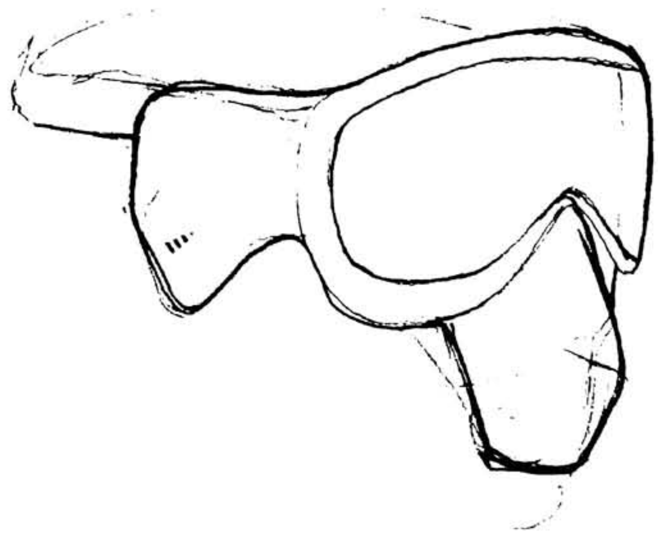


Fig. 8. Design concept A7 and A8.

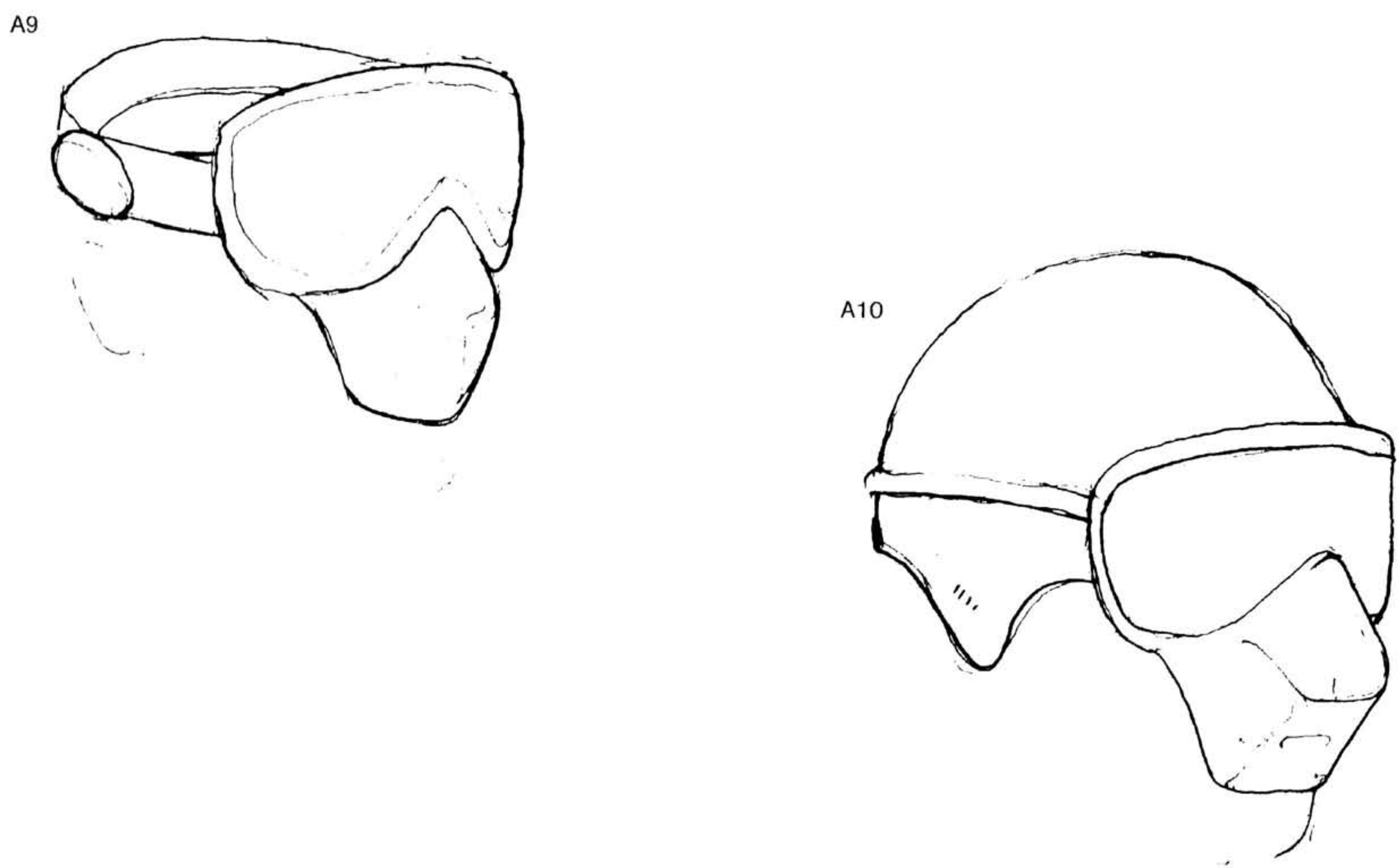


Fig. 9. Design concept A9 and A10.

B1

B2

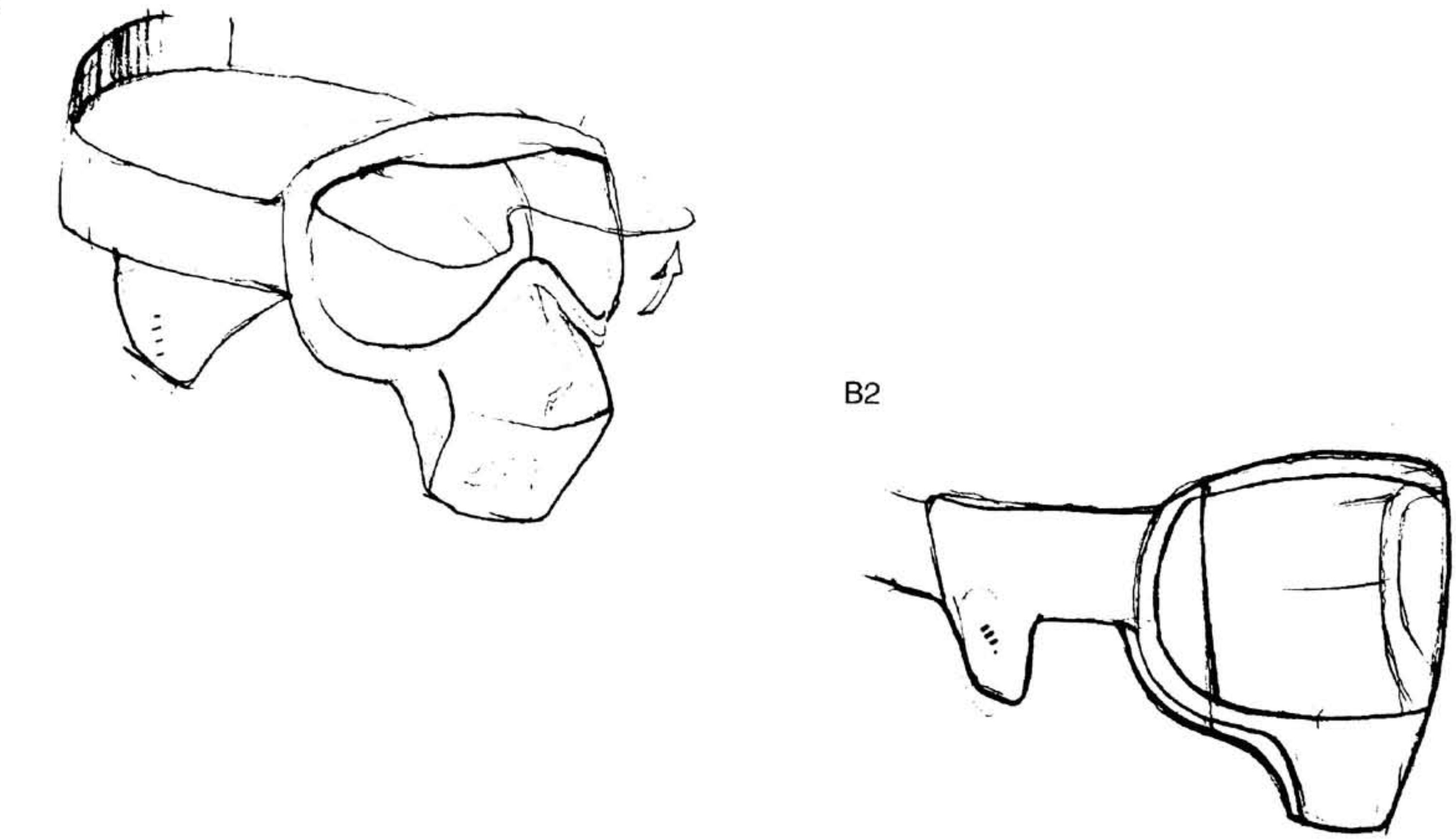
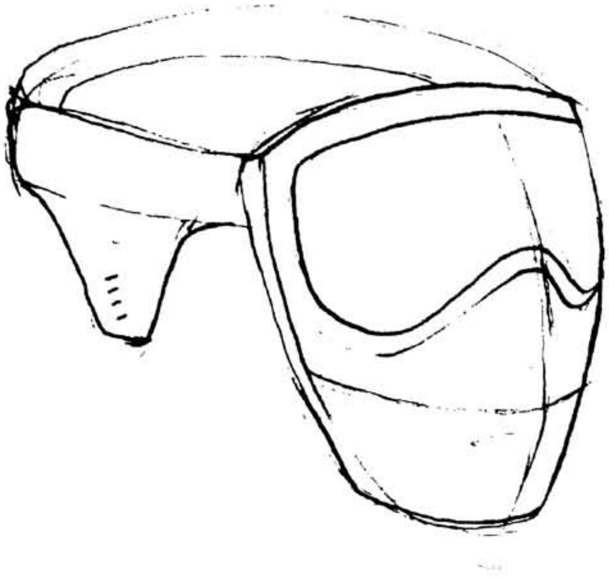


Fig. 10. Design concept B1 and B2.

B3



B4

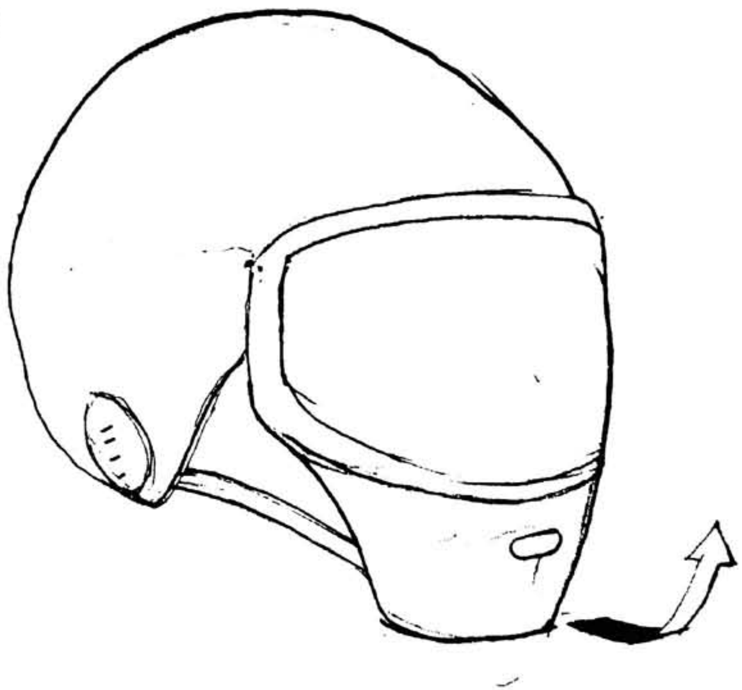
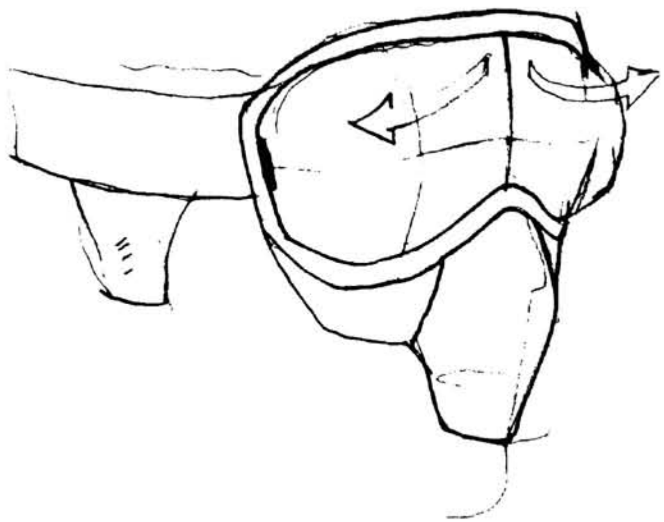


Fig. 11. Design concept B3 and B4.

B5



B6

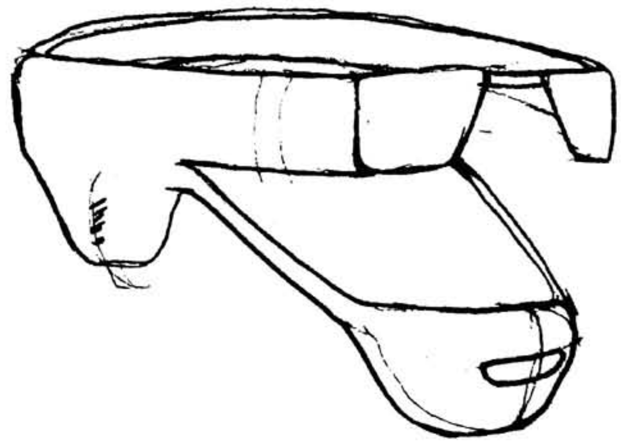
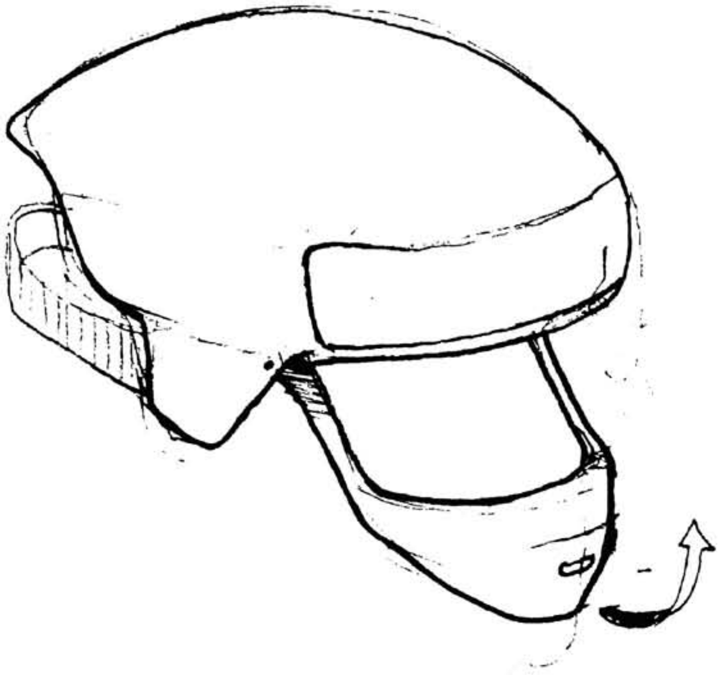


Fig. 12. Design concept B5 and B6.

B7



B8

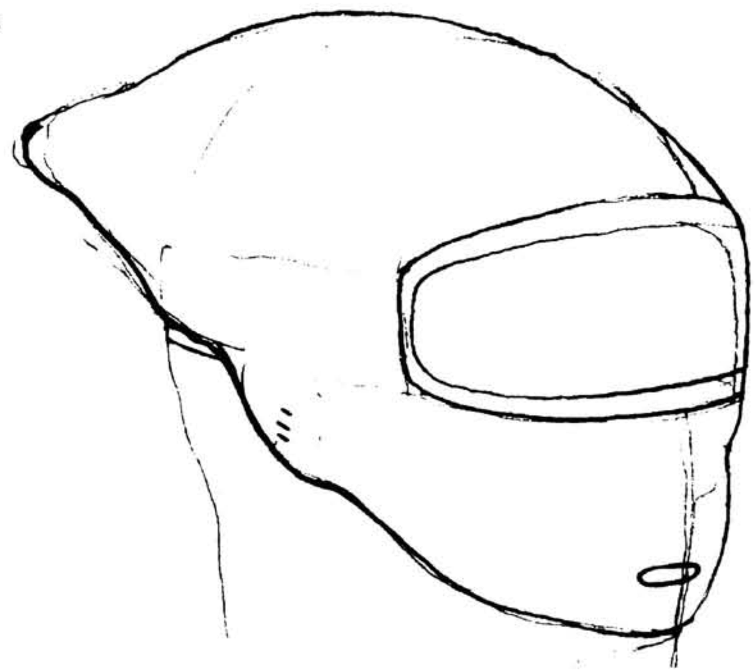
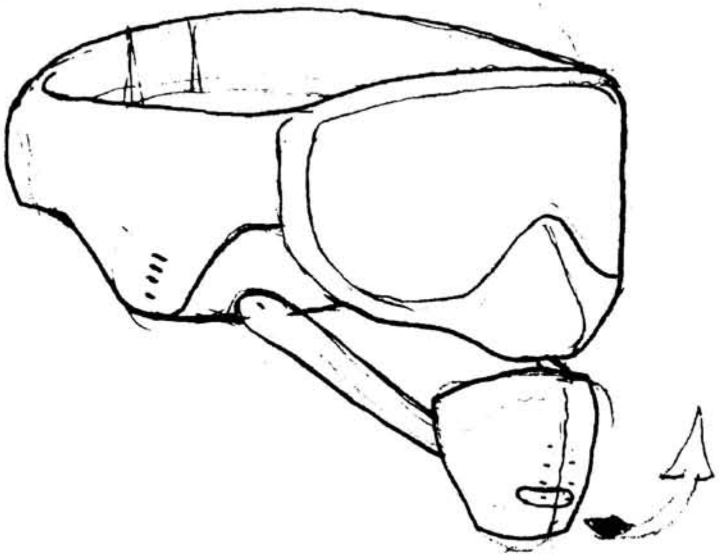


Fig. 13. Design concept B7 and B8.

B9



B10

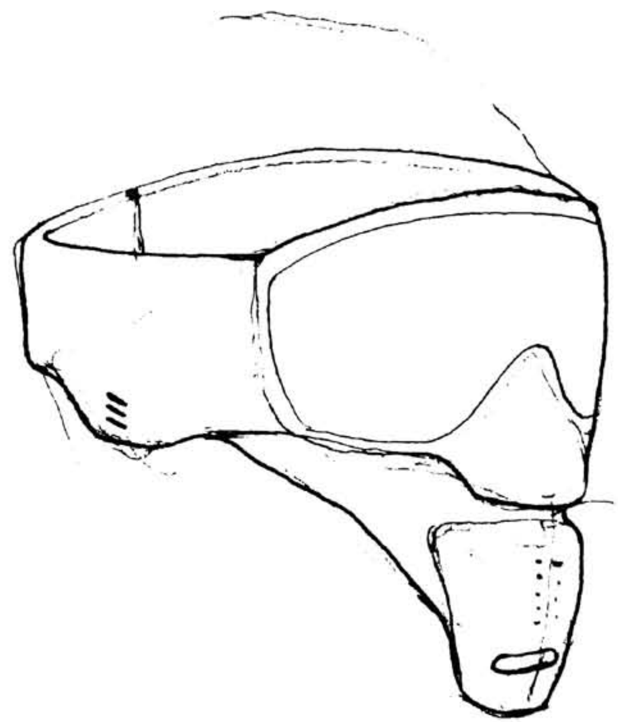


Fig. 14. Design concept B9 and B10.

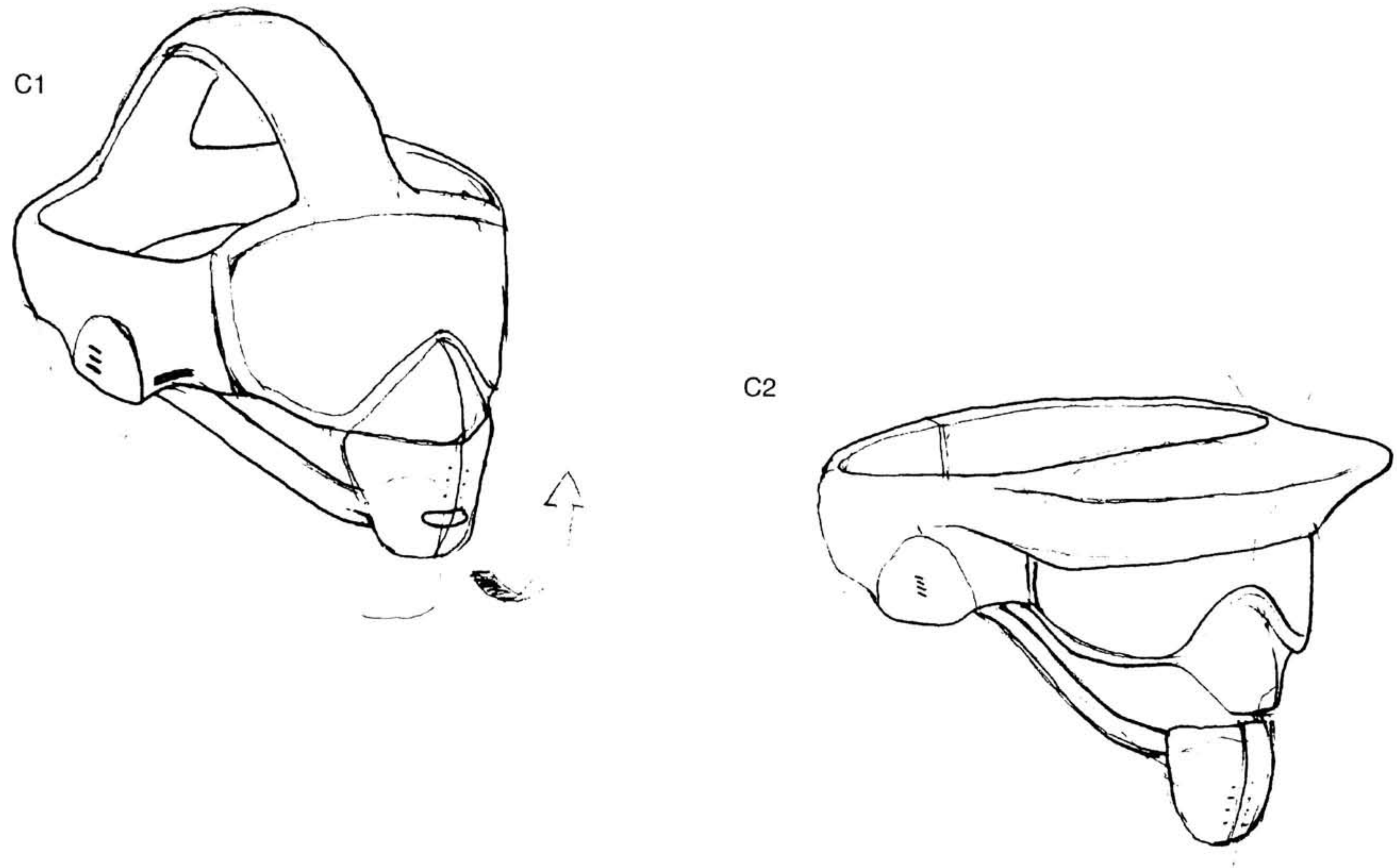
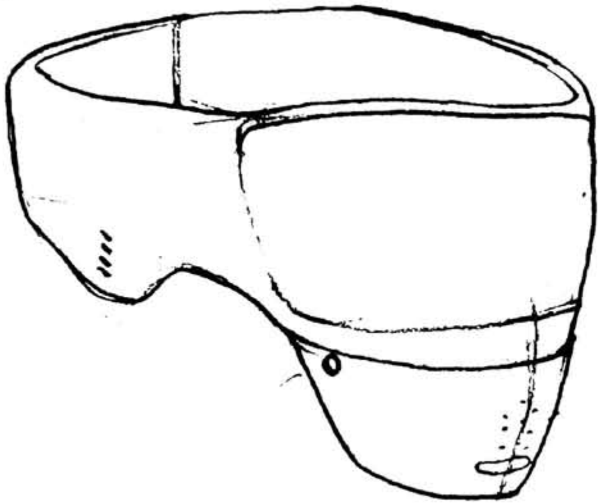


Fig. 15. Design concept C1 and C2.

C3



C4

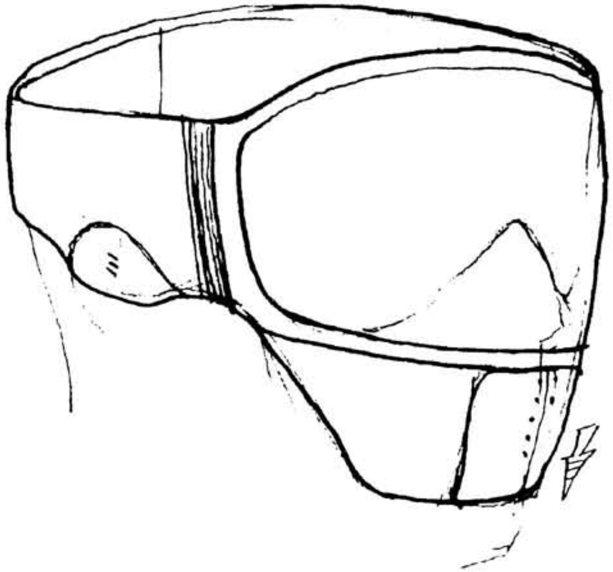
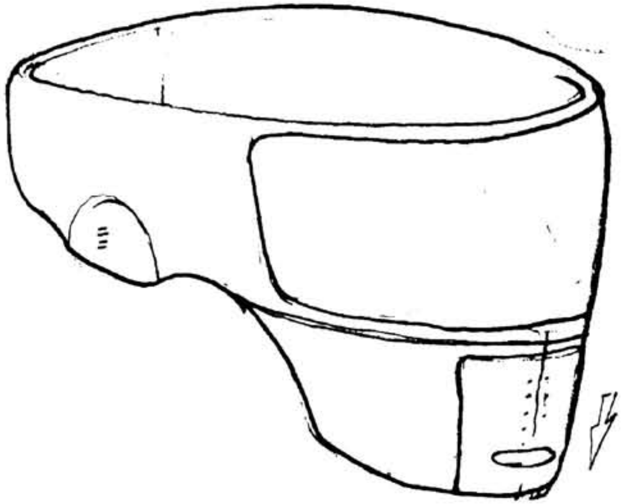


Fig. 16. Design concept C3 and C4.

C5



C6

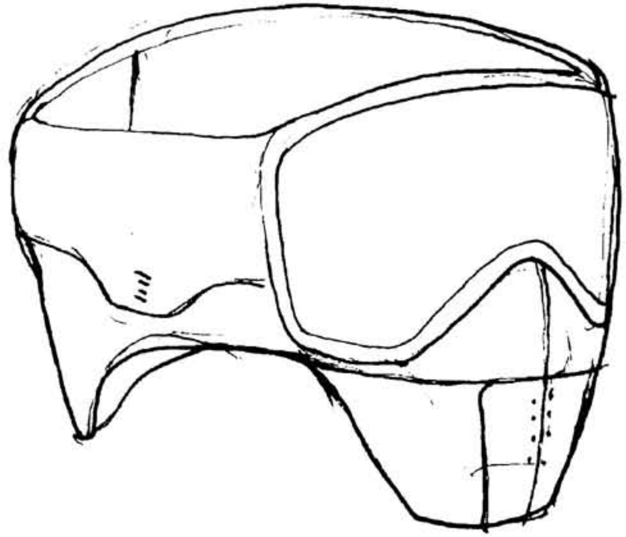
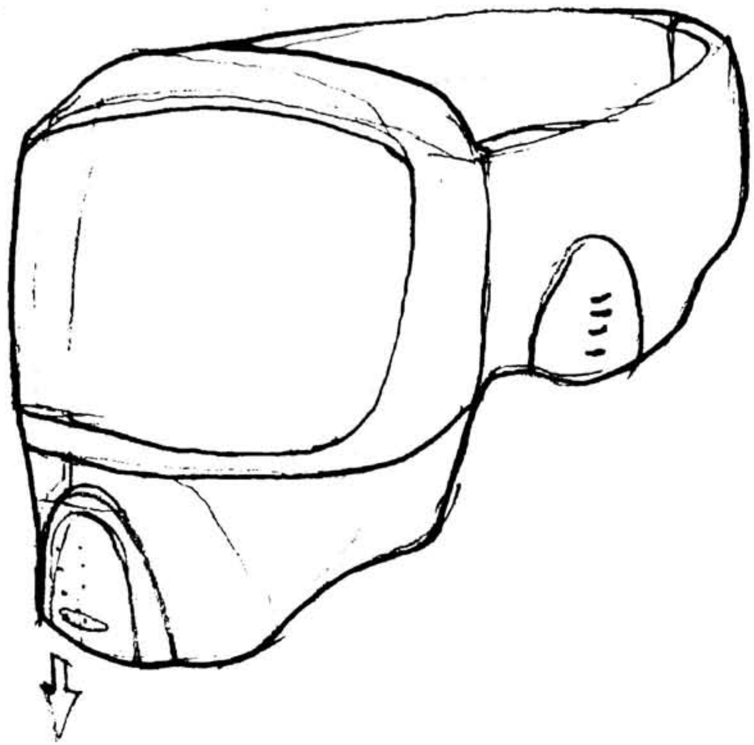


Fig. 17. Design concept C5 and C6.

C7



C8

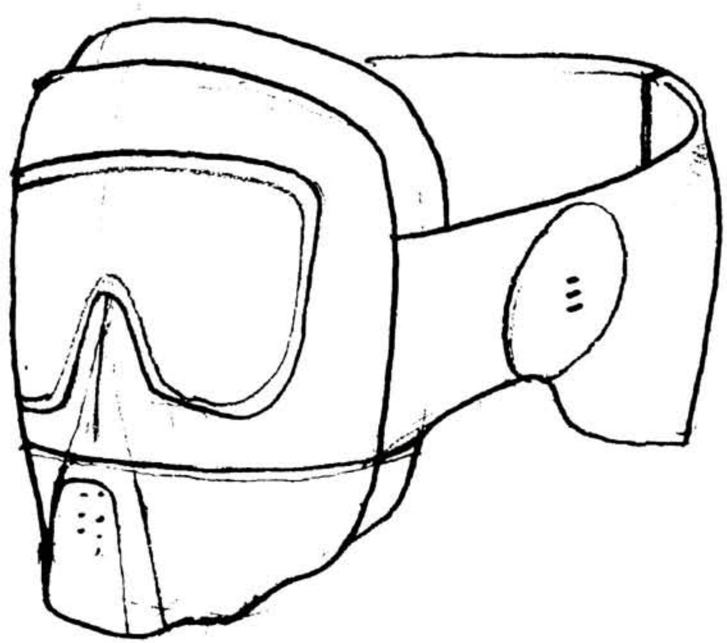


Fig. 18. Design concept C7 and C8.

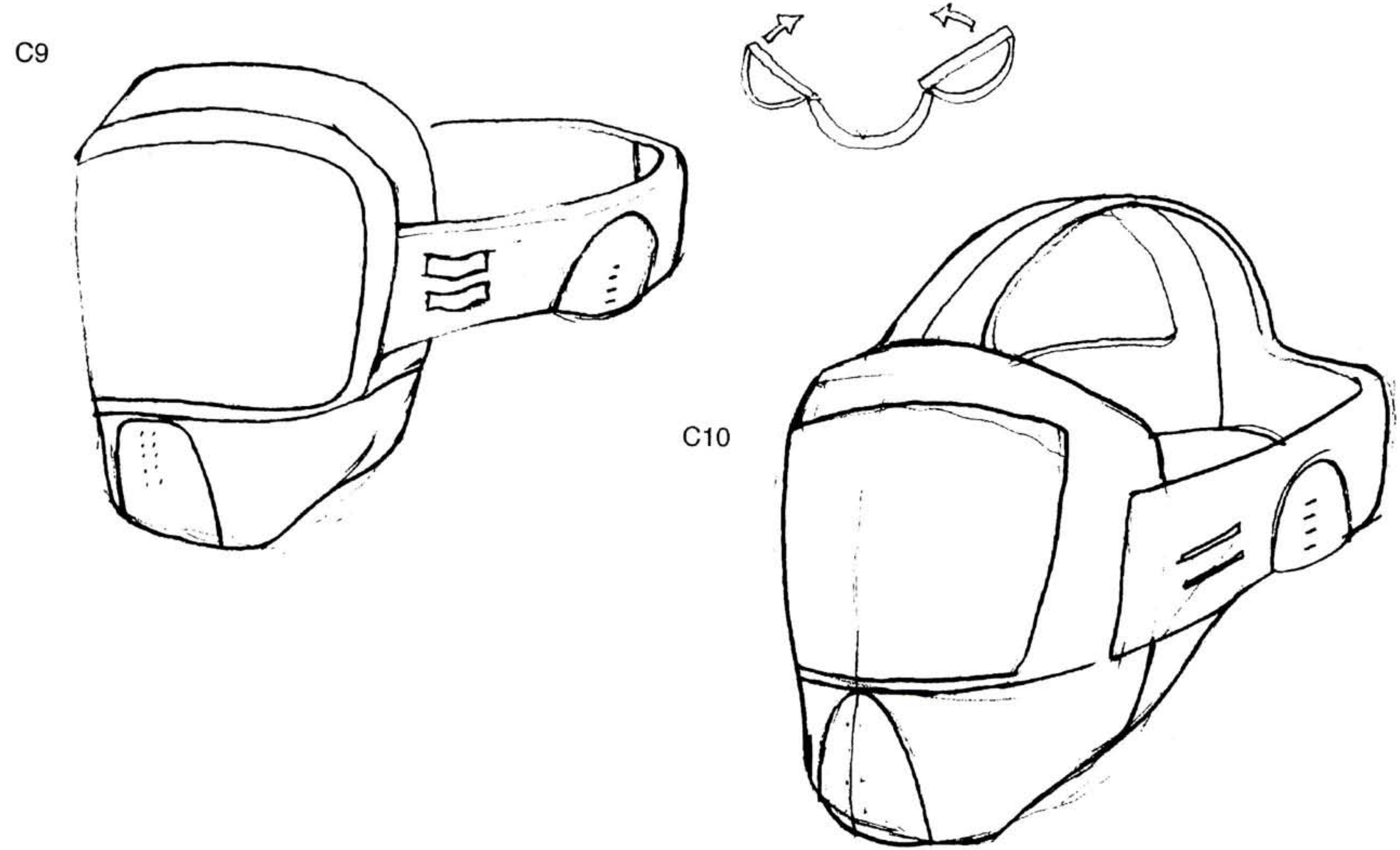


Fig. 19. Design concept C9 and C10.

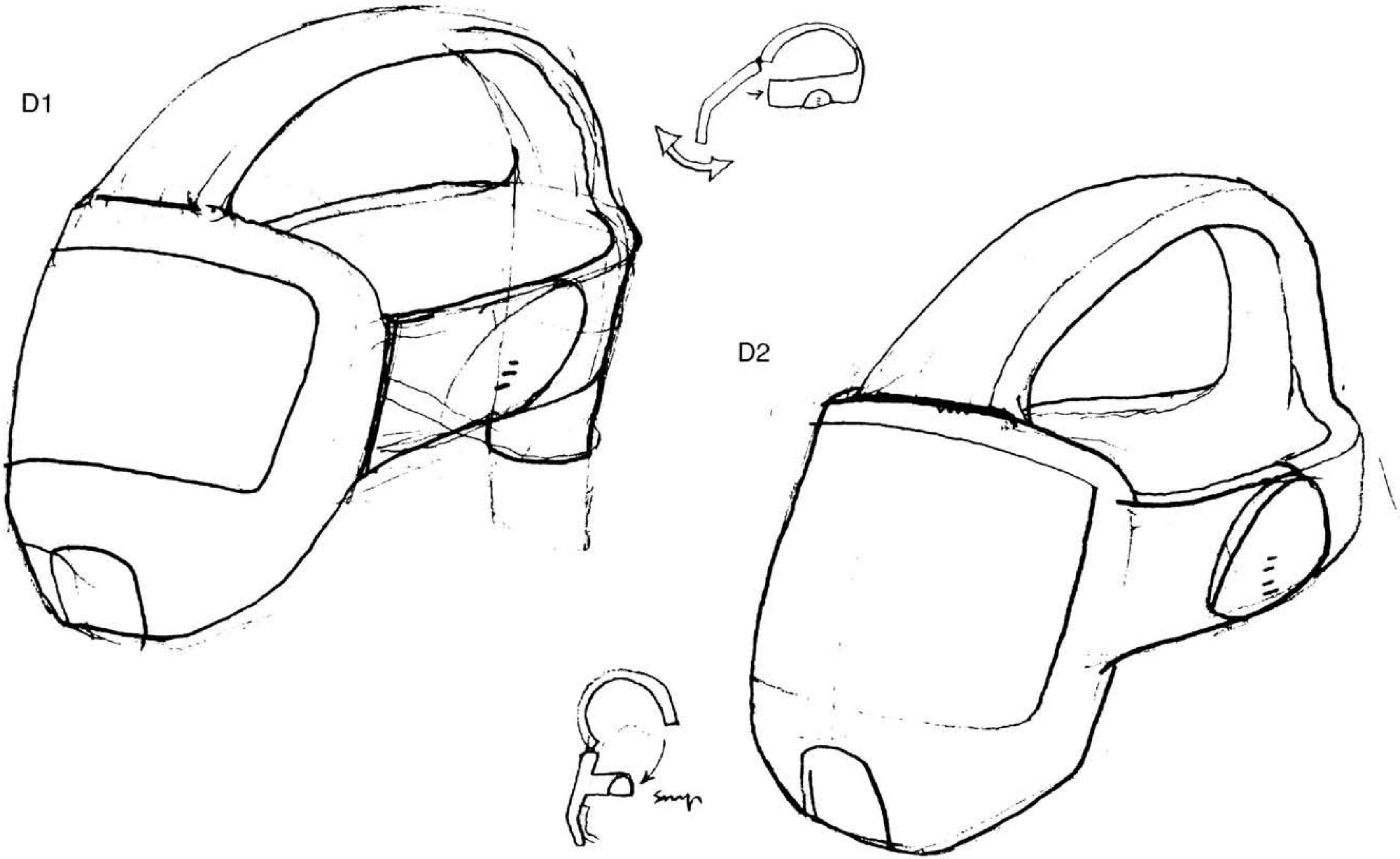


Fig. 20. Design concept D1 and D2.

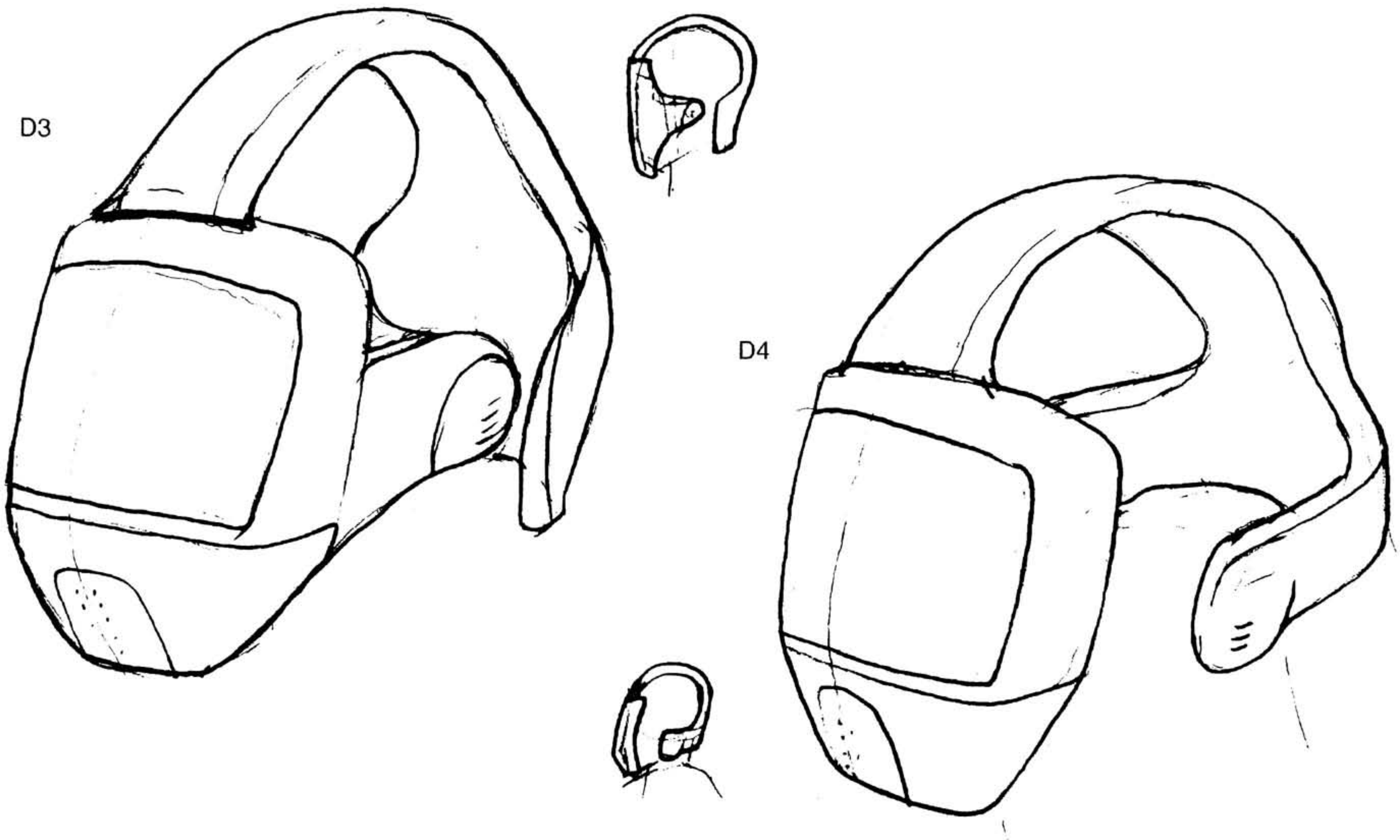


Fig. 21. Design concept D3 and D4.

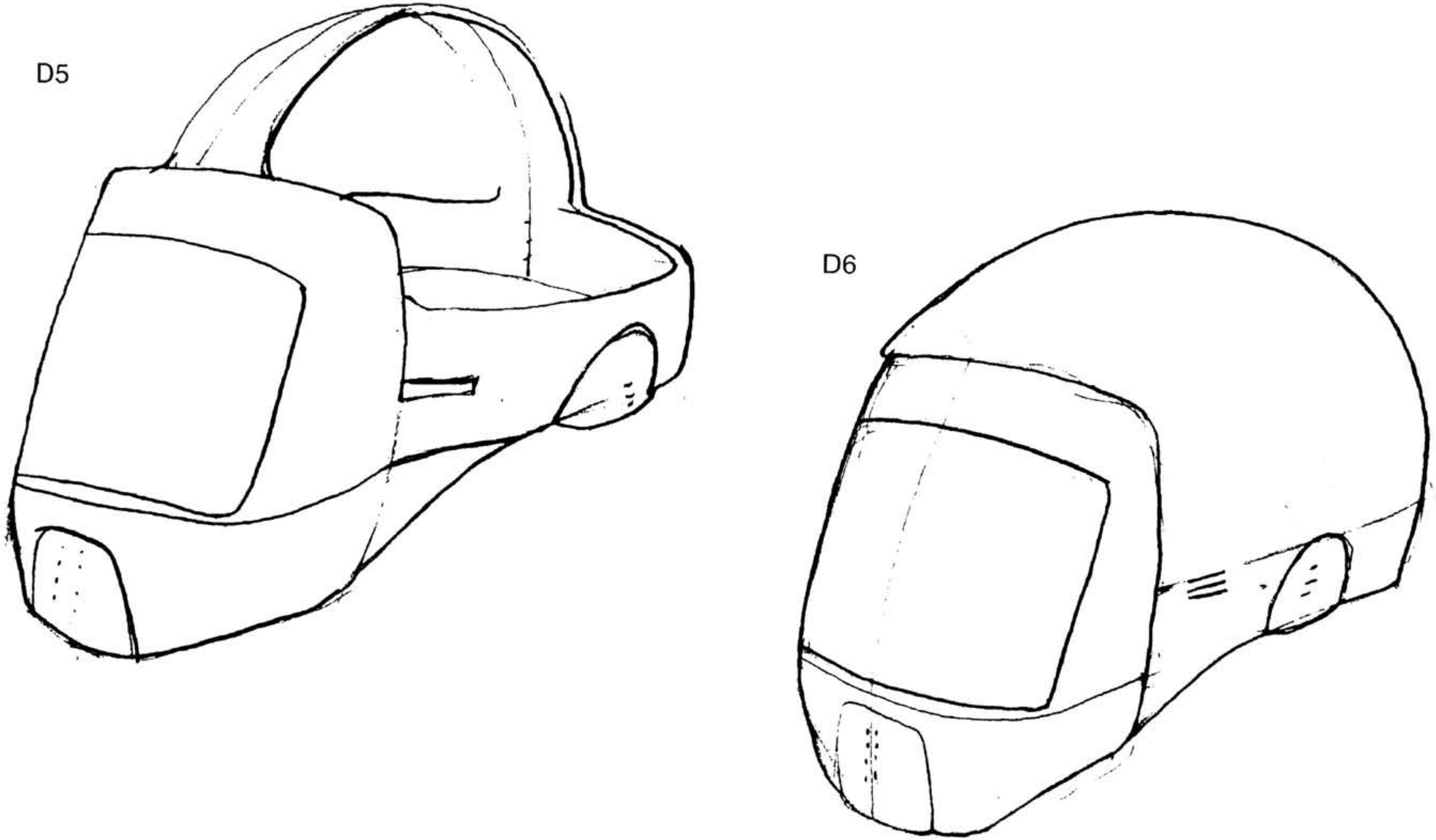
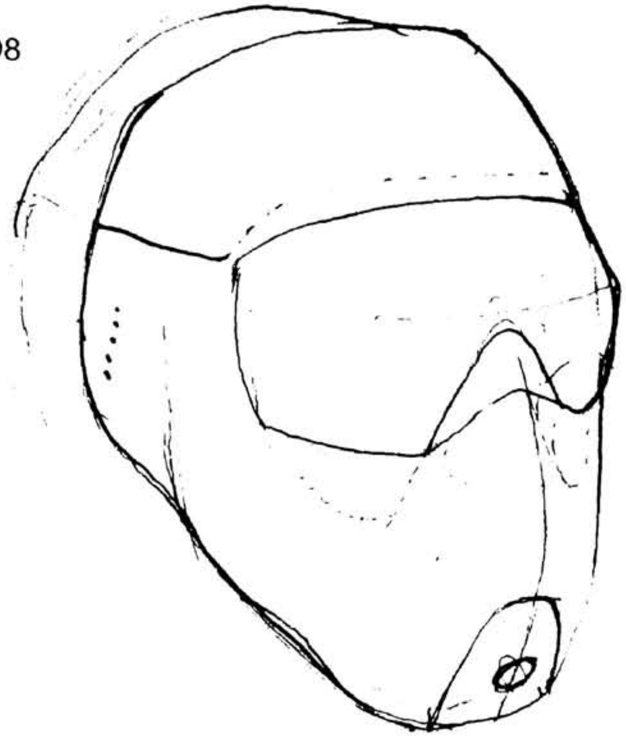


Fig. 22. Design concept D5 and D6.

D7

Fig. 23. Design concept D7 .

D8



D9

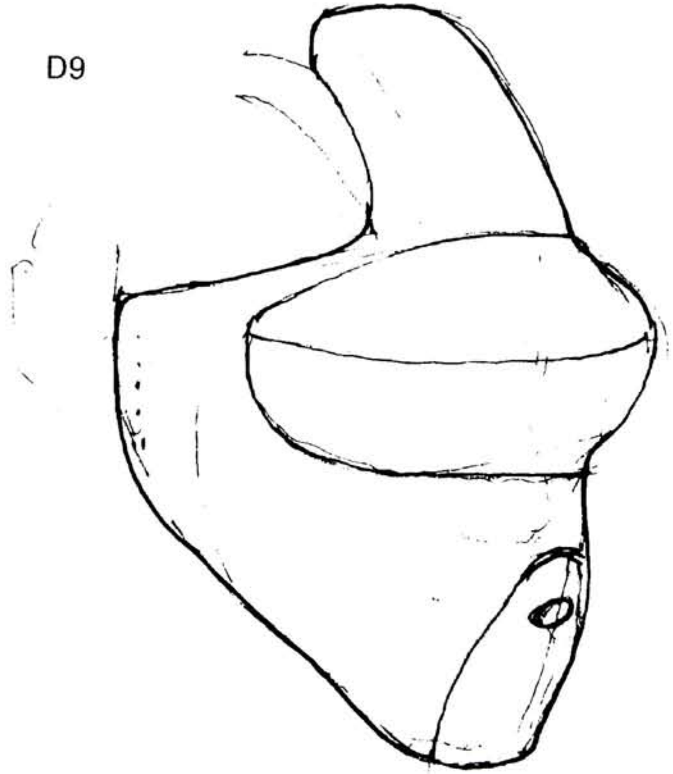


Fig. 24. Design concept D8 and D9.

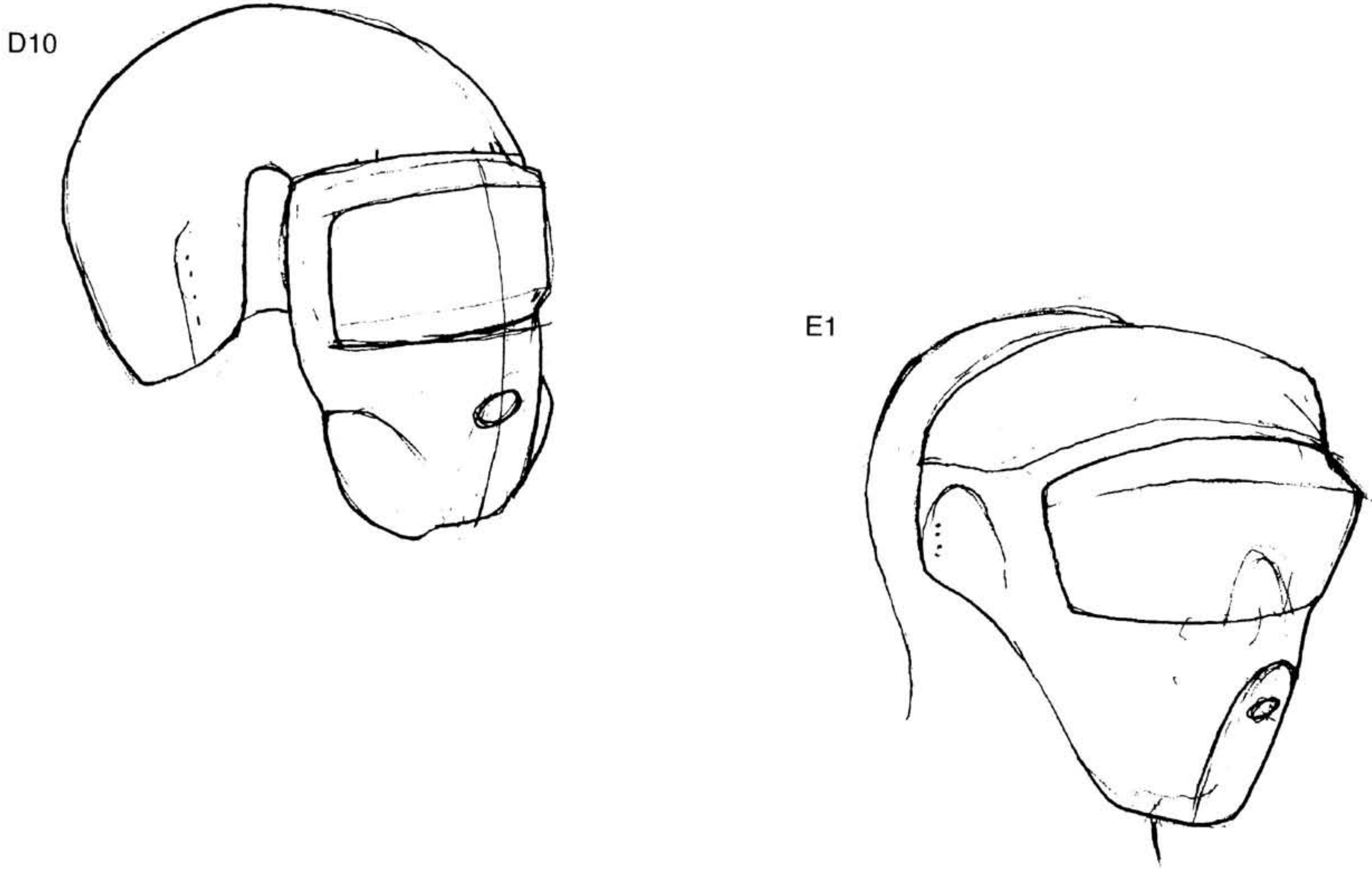


Fig. 25. Design concept D10 and E1.

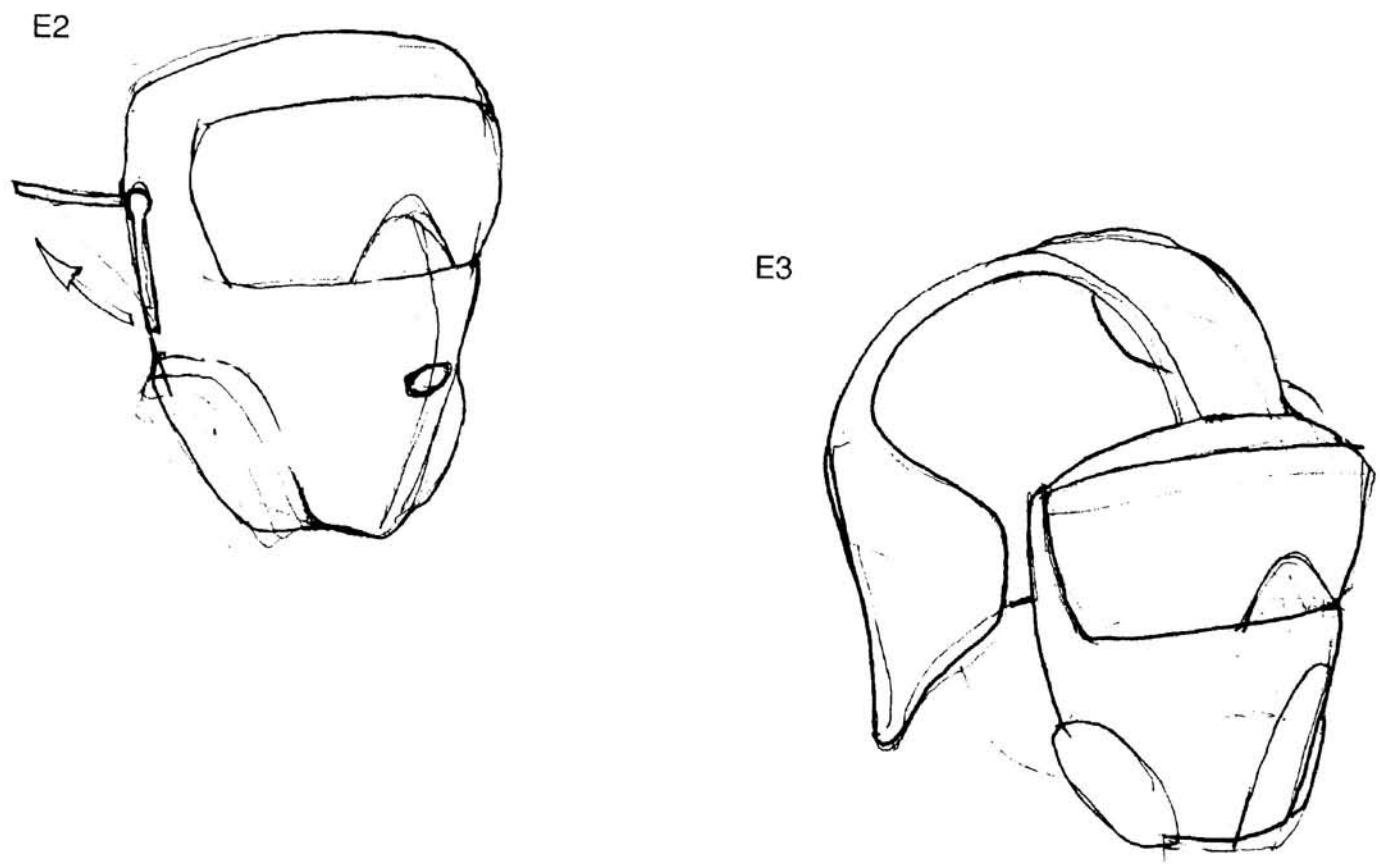


Fig. 26. Design concept E2 and E3.

E4

Fig. 27. Design concept E4.

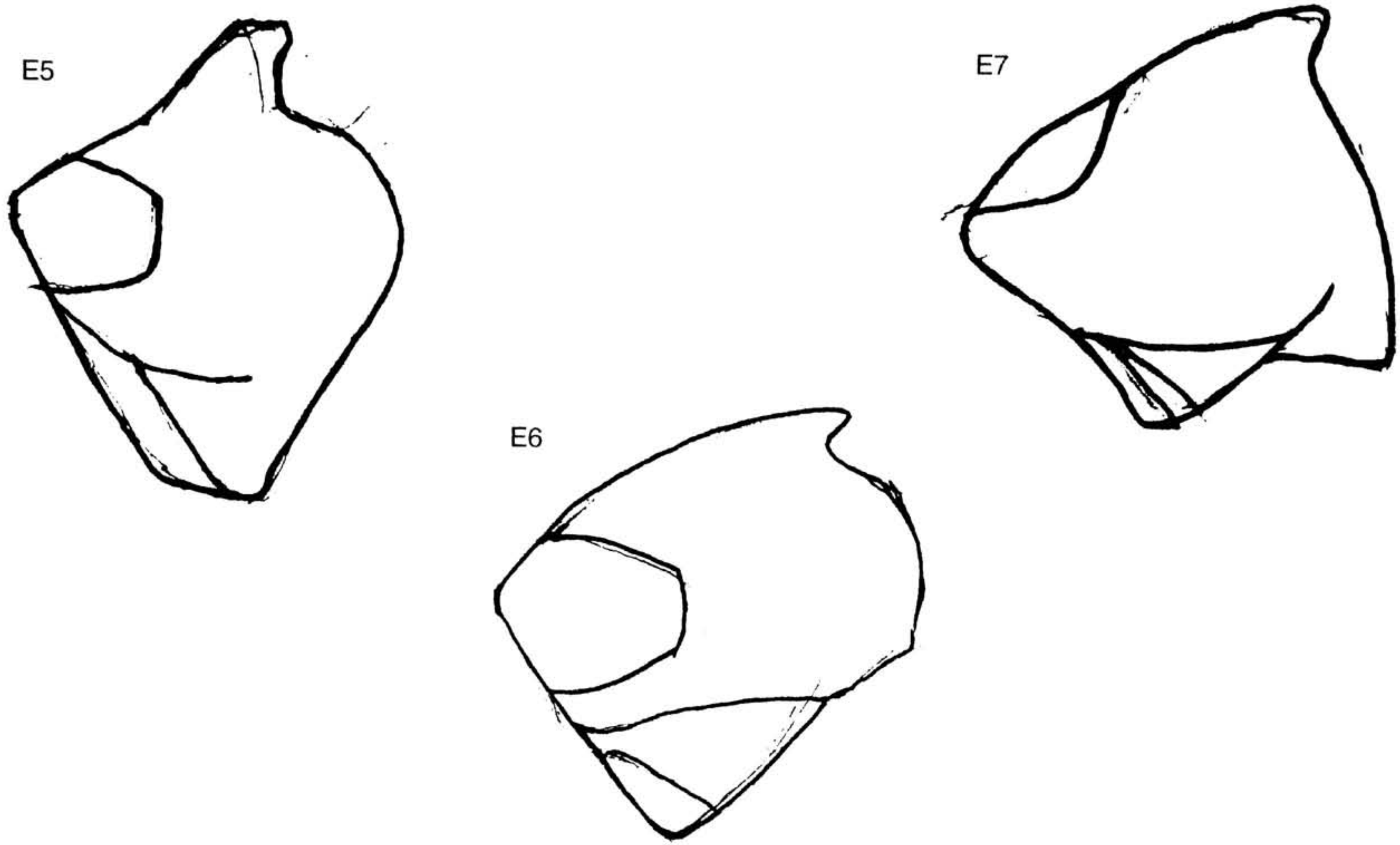


Fig. 28. Design concept E5, E6 and E7.

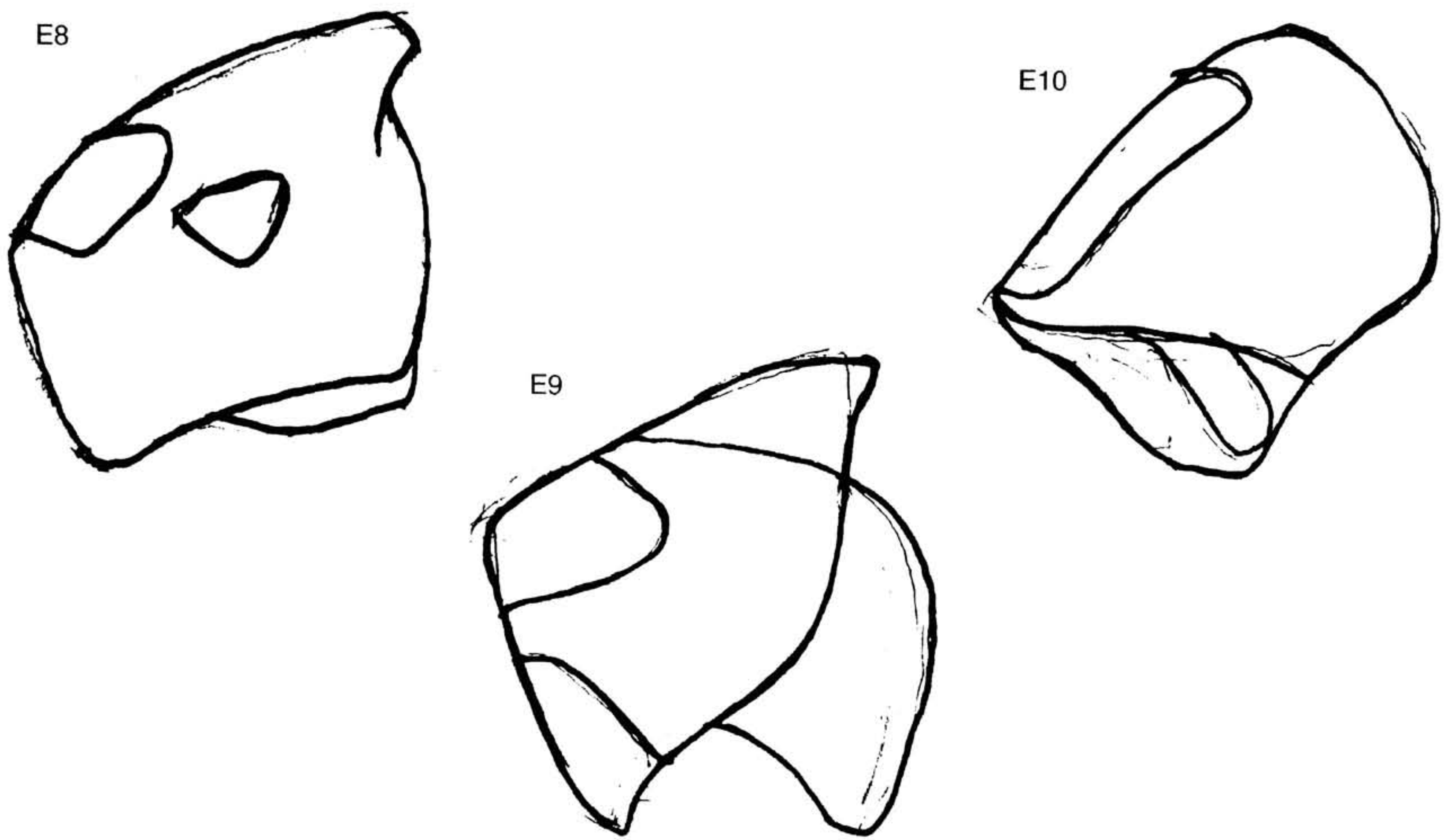


Fig. 29. Design concept E8, E9 and E10.

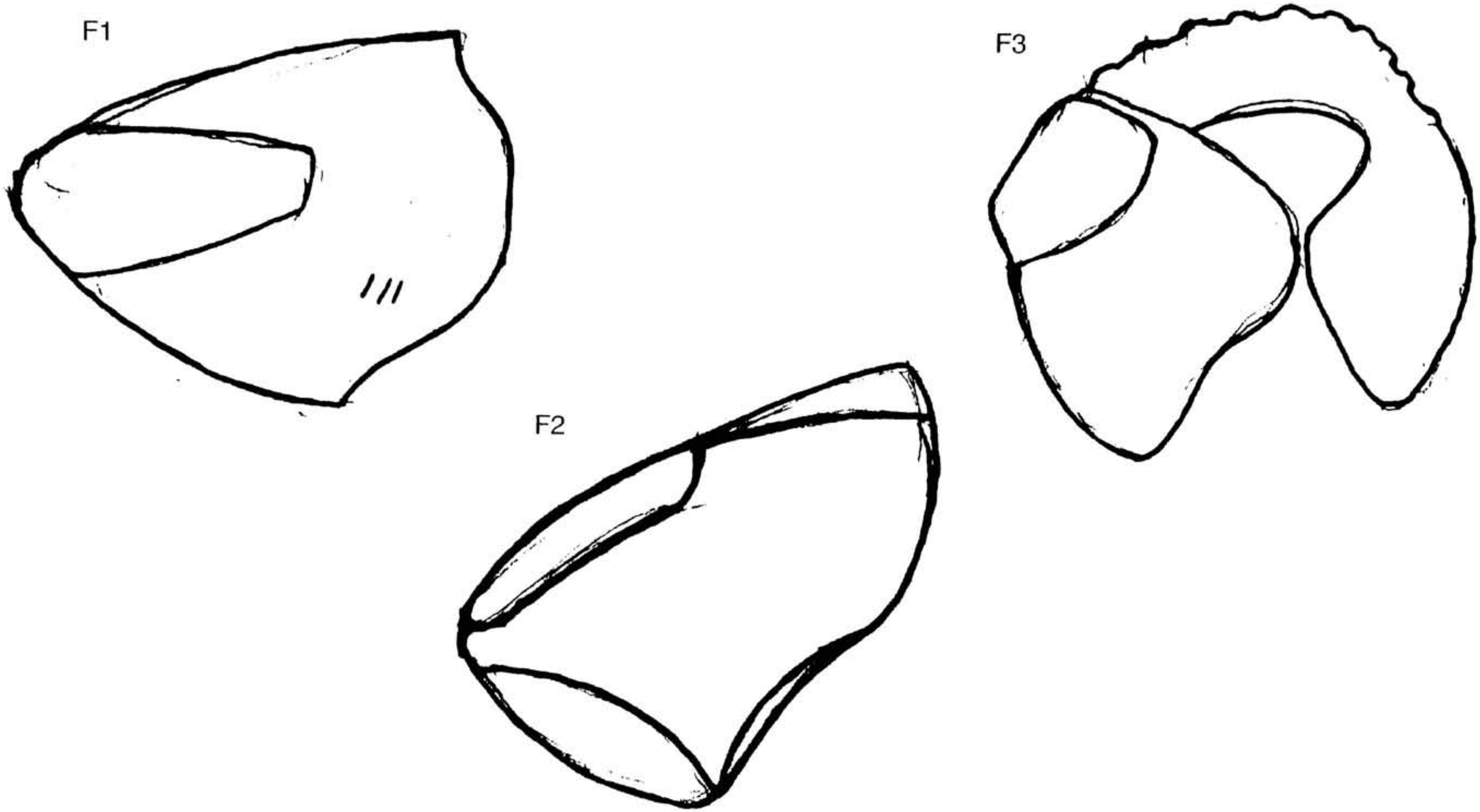


Fig. 30. Design concept F1, F2 and F3.

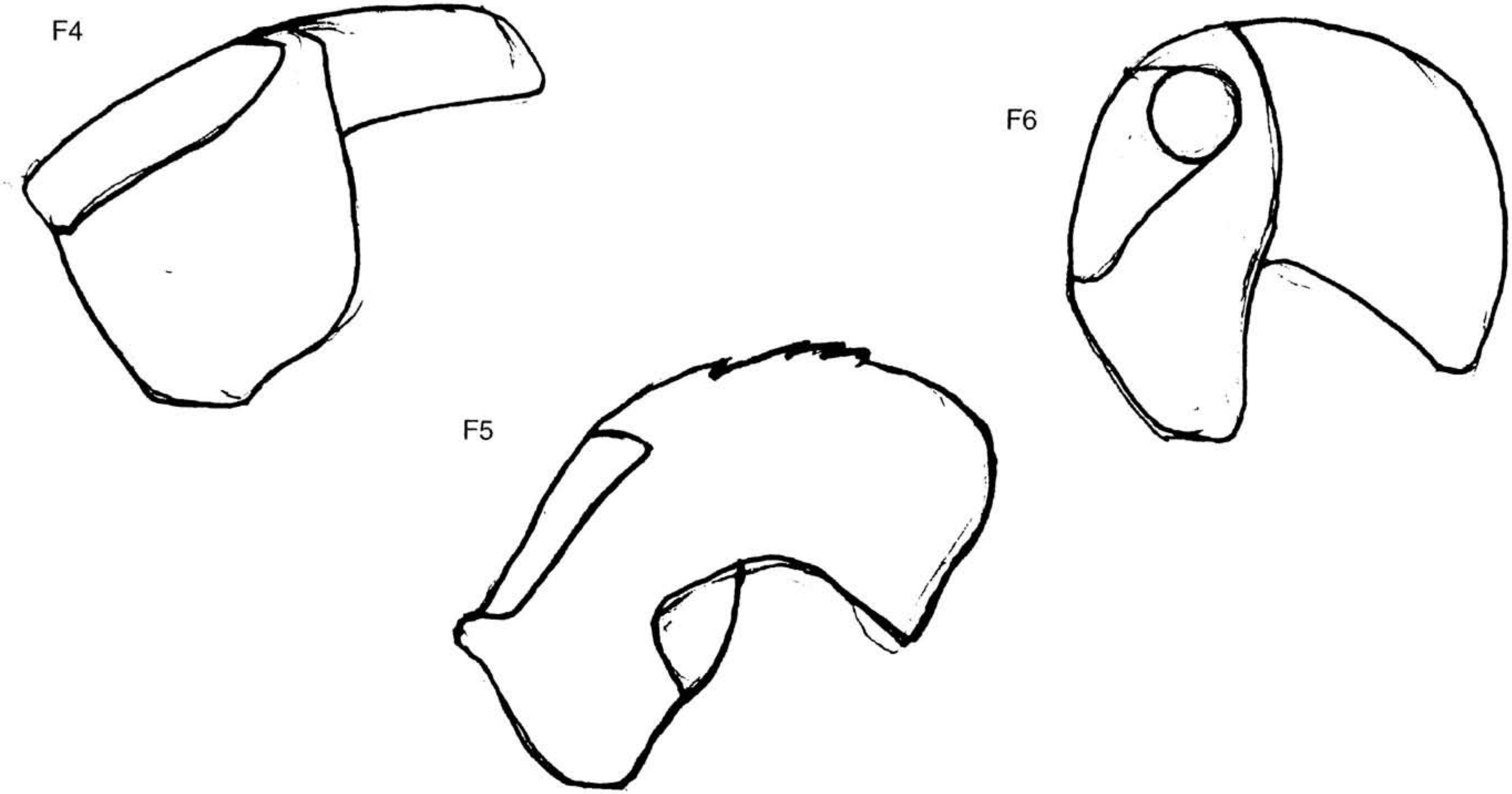


Fig. 31. Design concept F4, F5 and F6.

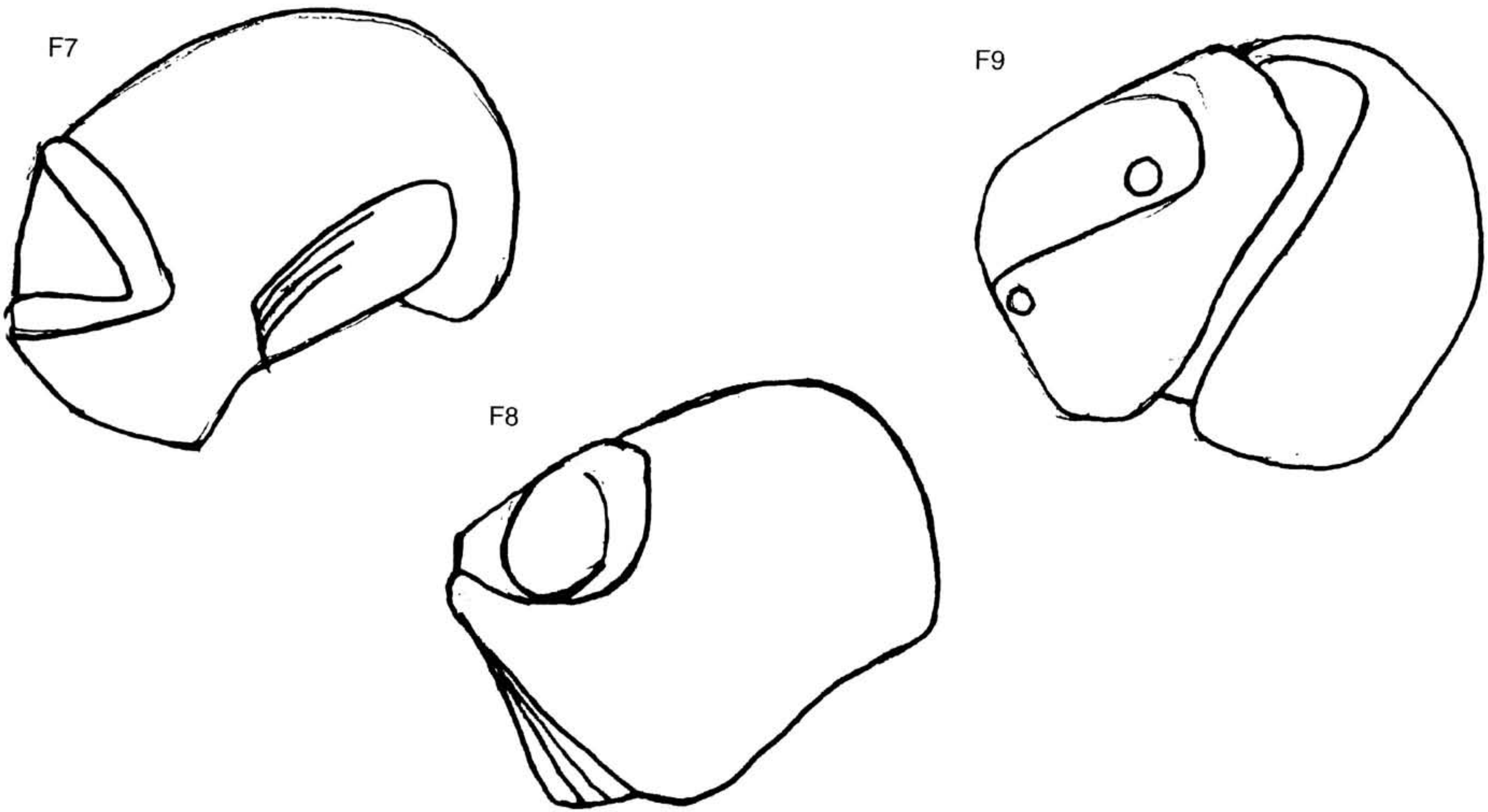


Fig. 32. Design concept F7, F8 and F9.

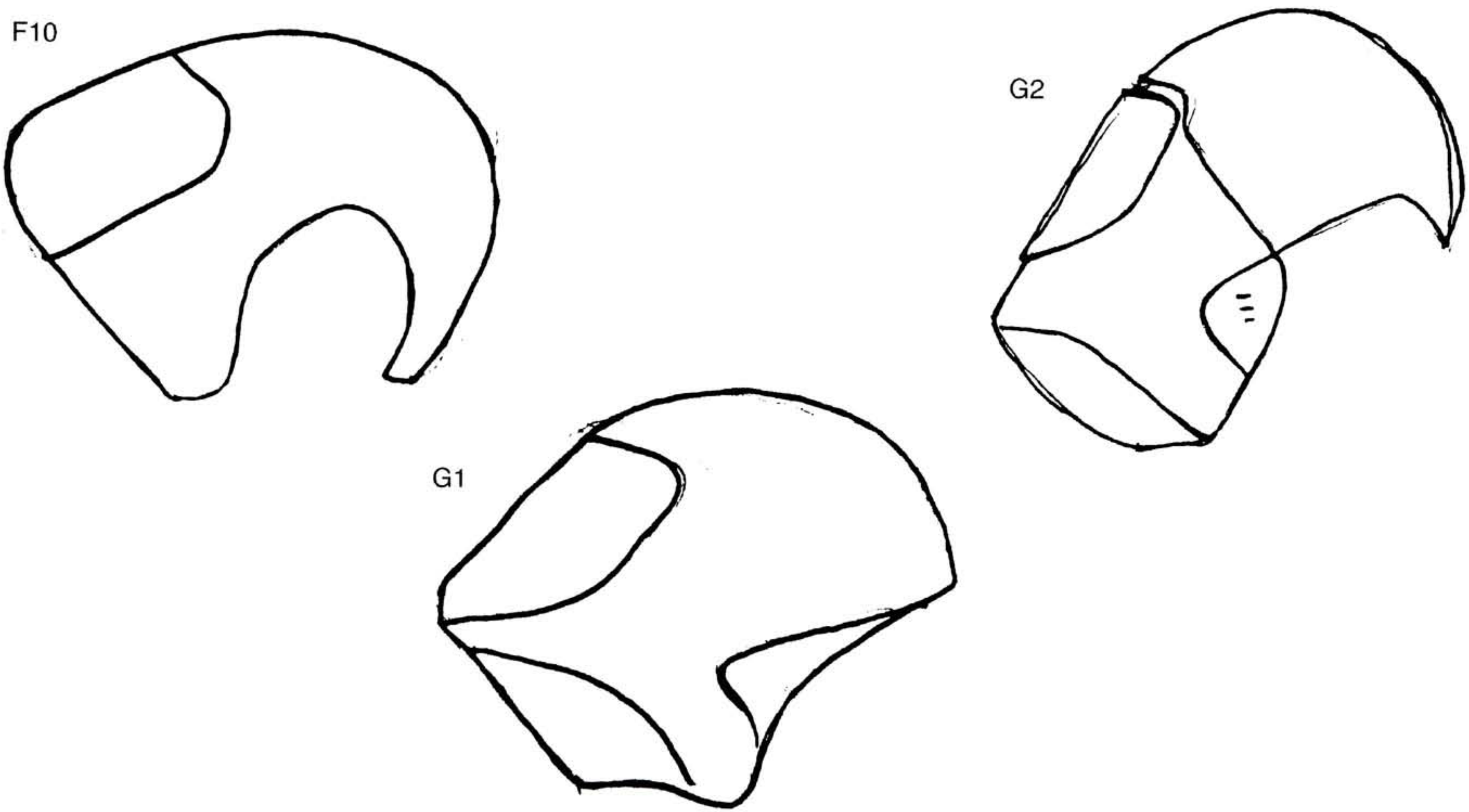


Fig. 33. Design concept F10, G1 and G2.

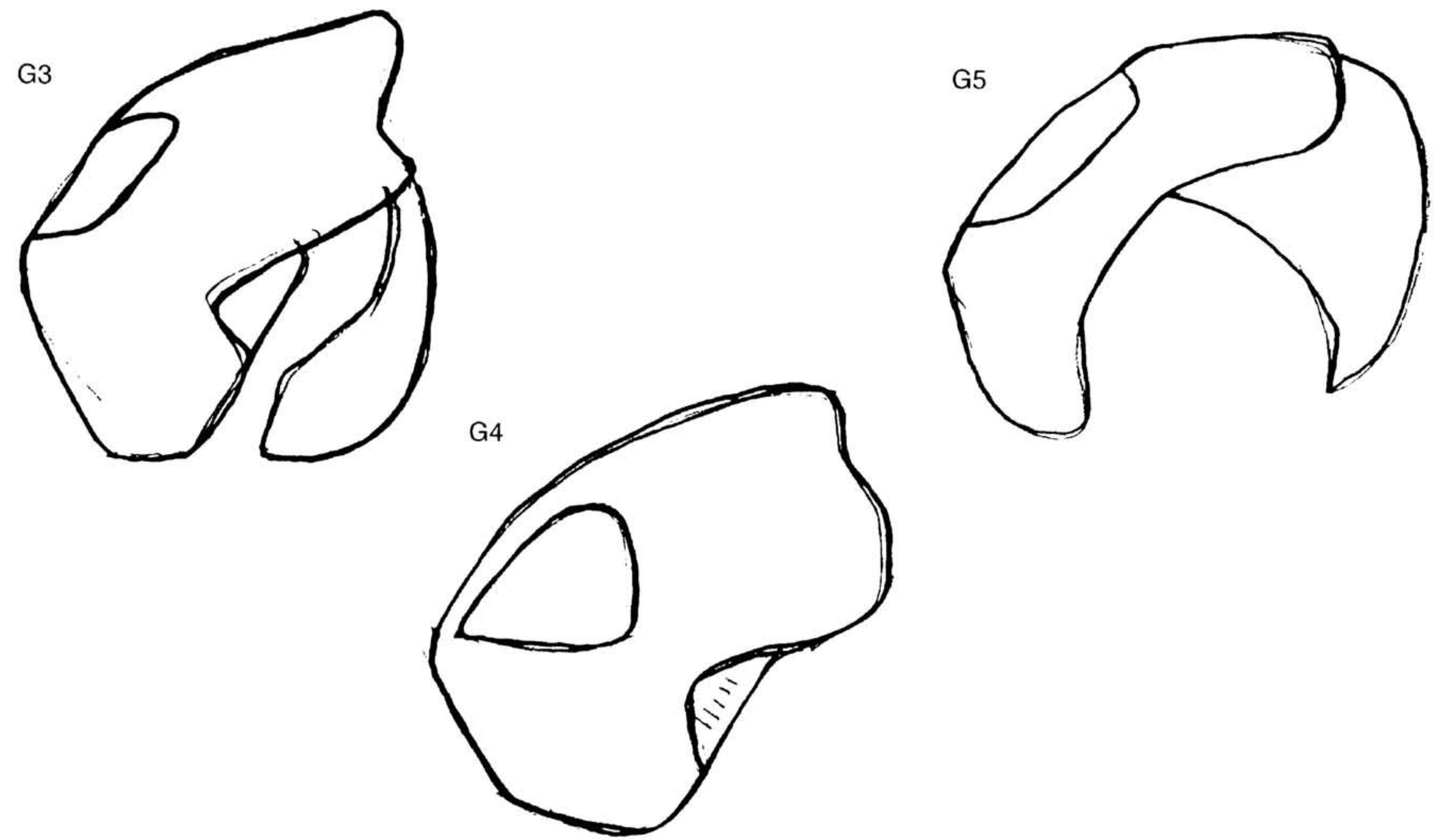


Fig. 34. Design concept G3, G4 and G5.

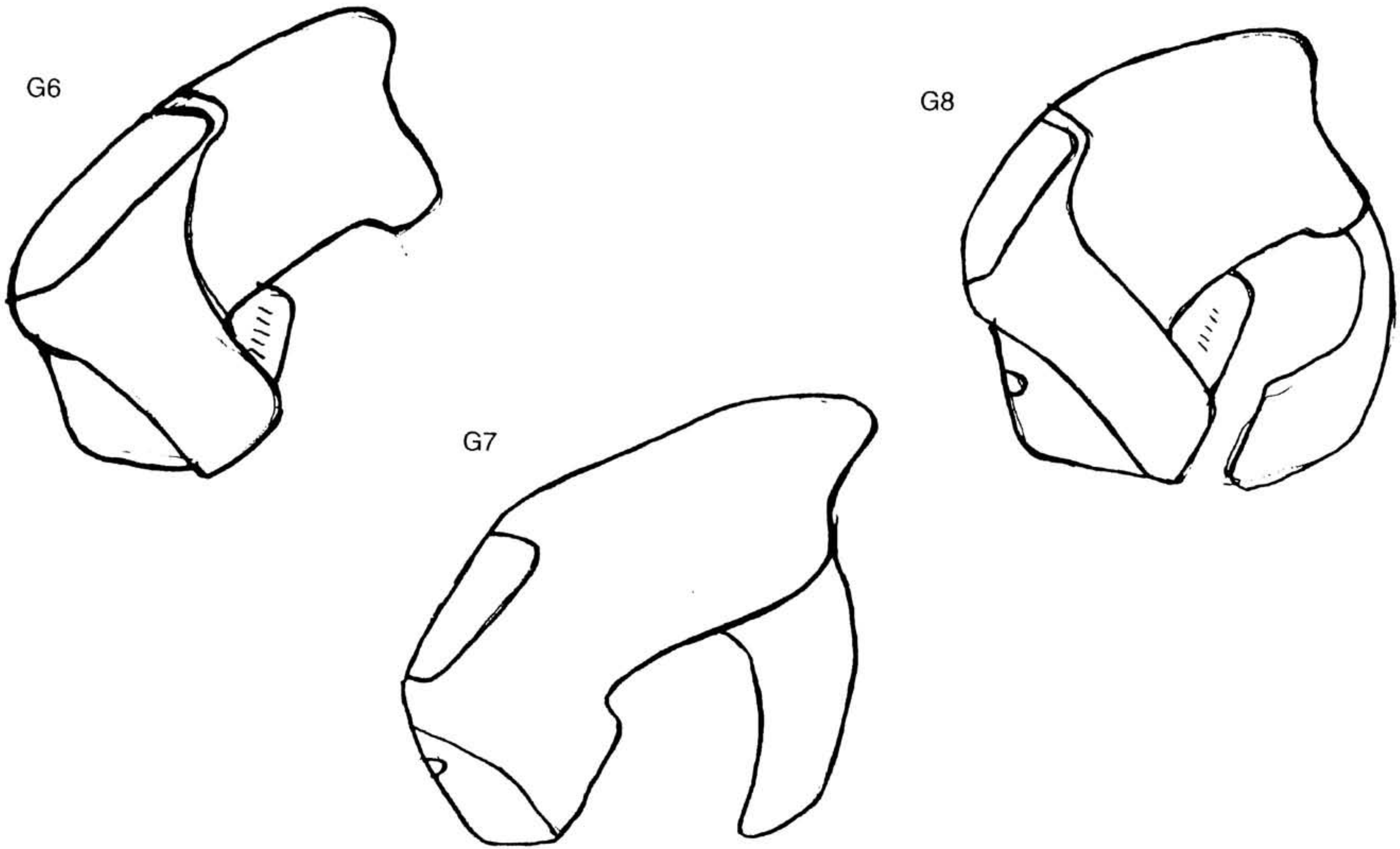


Fig. 35. Design concept G6, G7 and G8.

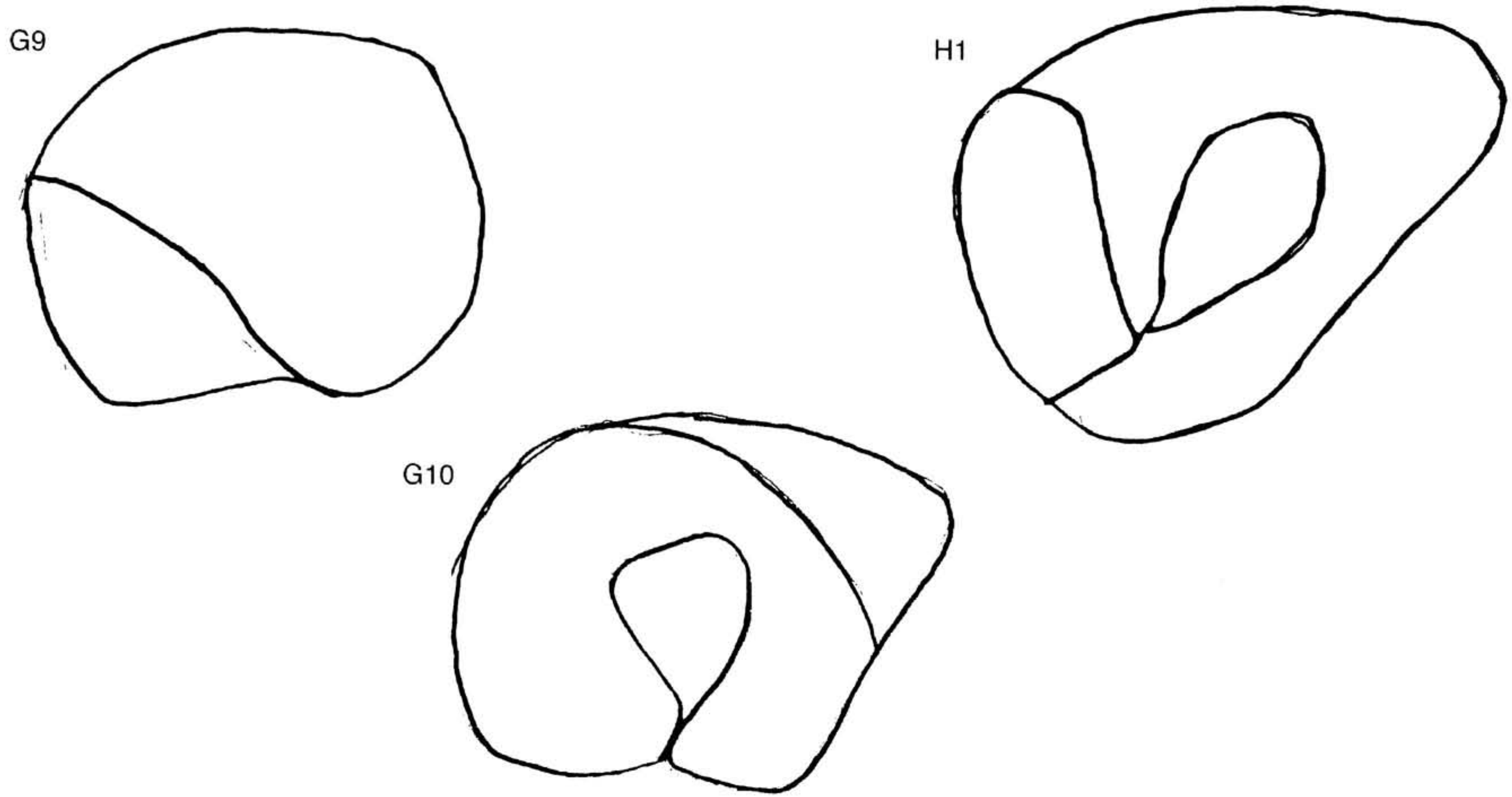


Fig. 36. Design concept G9, G10 and H1.

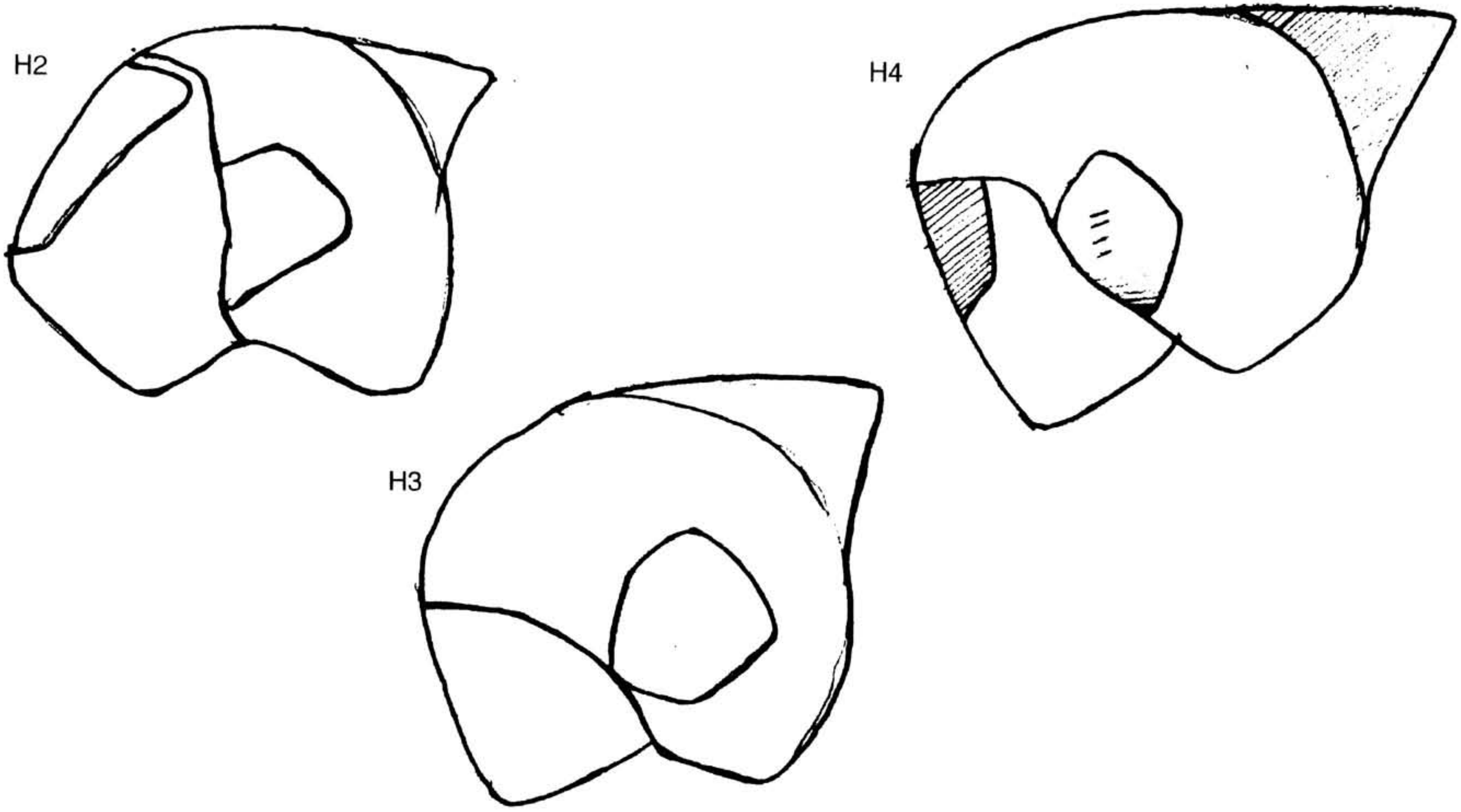


Fig. 37. Design concept H2, H3 and H4.

H5

Fig. 38. Design concept H5.

H6

Fig. 39. Design concept H6.

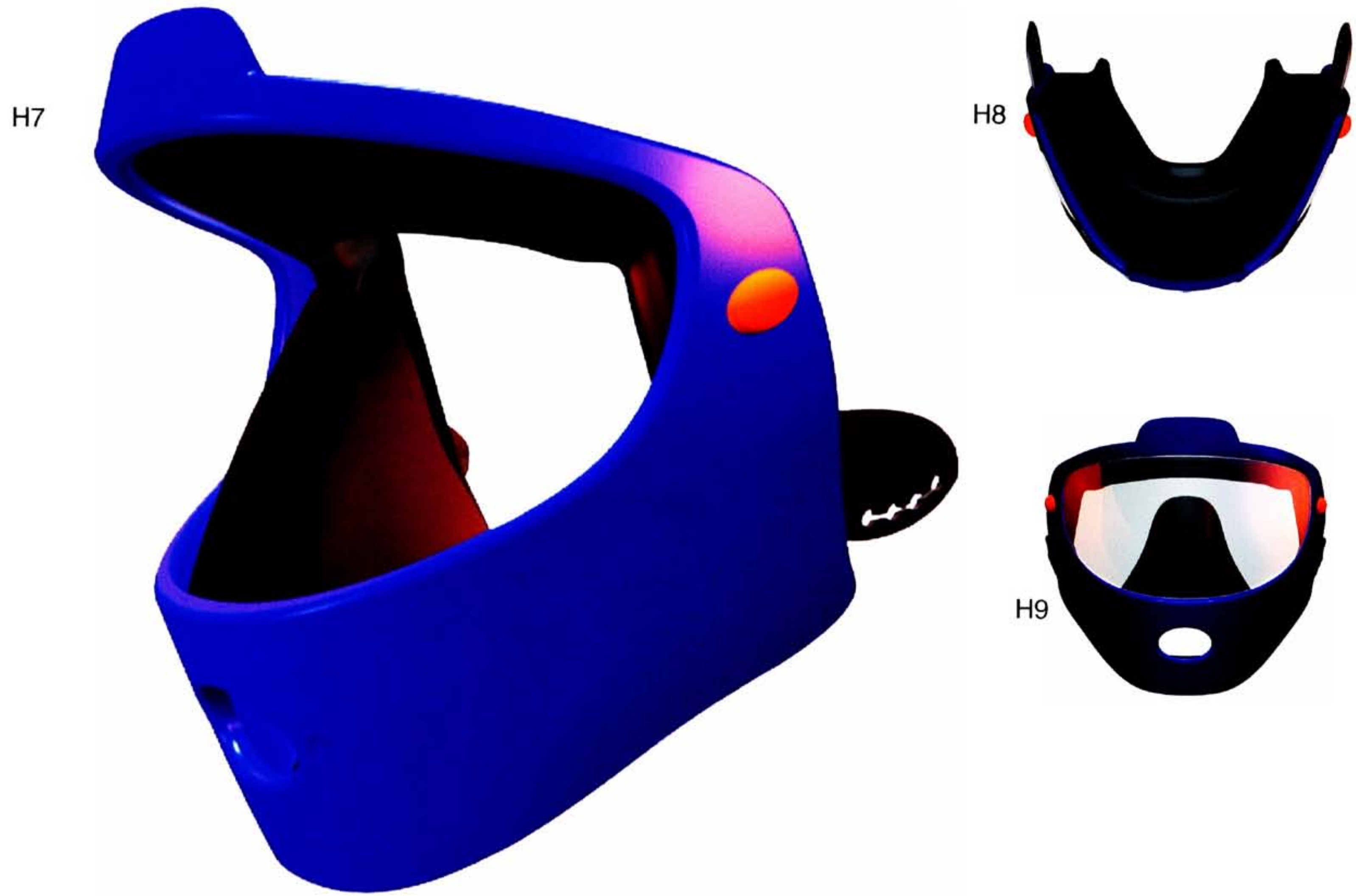


Fig. 40. Design concept H7, H8 and H9.

APPENDIX