A HEAD RESTRAINT DEVICE FOR VESTIBULAR STUDIES

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SUMMARY PAGE

THE PROBLEM

To develop a head restraint system which would provide custom-fitted restraint of individual subjects with minimal preparation time.

FINDINGS

A restraint system based on a vacuum bladder technique was constructed from standard, commercially available materials. It provides a degree of restraint comparable to that available with permanent, rigid head/torso molds individually fitted to each subject without the attendant cost in preparation time and money.

INTRODUCTION

Of various methods used in vestibular experimentation to hold the head in some fixed orientation, the bite-bar for human subjects and tooth-clamp assembly for animal subjects have probably provided the highest degree of rigid constraint for the head. These methods are, however, unusable, or at least undesirable, in a variety of experimental situations, e.g., those in which continuous voice communications are essential, those in which severe motion sickness and the aspiration of vomitus may occur, and in linear oscillation in which device malfunction may produce impact. The bite-bar has additional disadvantages in that its efficacy is dependent upon the cooperation of the subject; inadequate pressure may permit head movement and excessive pressure may produce muscle noise or artifacts to contaminate the recording of corneo-retinal potentials or similar electrophysiological indices.

When such considerations have forbidden the use of the bite-bar method with our human subjects, we have sometimes resorted to standard U. S. Navy aviation helmets with adjustable head liners and chin straps or to individually fitted head and torso molds fabricated from plaster-of-paris or polyester impregnated glass cloth. The latter technique provides excellent restraint, but its usefulness is limited by the time and cost required for the development of a separate mold for each subject; it is not at all practical for single, brief tests and, even in long or repeated applications, restricted by the number of subjects which can be conveniently handled.

It is for such reasons as these, probably, that we have received numerous requests from vestibular investigators for a brief technical description of a simple vacuum bag restraint system developed for use with our rotating devices. The basic principle involves the use of atmospheric pressure to force a flexible, airtight bladder filled with solid particles to become rigid when evacuated. The flexibility permits the bladder to be molded to the configuration of any object, such as the head, which is to be secured in one position. The rigidity is maintained as long as the vacuum is intact. The principle is not original with us, however. Indeed, it is our understanding that similar procedures have had long-time industrial application in vacuum molding, although we are unable to cite any specific instance of such use. A brief description of the materials and methods used in the application of the system in our laboratory follows.

MATERIALS

The primary elements of the vacuum bag restraint system are two rubber bladders, an inflating needle and tubing, a vacuum pump, and 6 pounds of plastic granules (see list of materials). The bladders are standard ones of the type used in boxers' striking bags and are available in any sporting goods store. Their chief advantages are availability, low cost, and adequate flexibility for molding to shape, coupled with sturdiness to resist wear and handling.

The inflating needle is likewise available in any sporting goods store. The tubing is standard, 3/8-inch, gum-rubber laboratory tubing; actually the only requirement is that it be able to resist evacuation without collapsing. The vacuum pump is of the standard diaphragm type available in most laboratories.

The plastic granules are used to create a buffer to fill the bladders to facilitate molding and to increase rigidity. They are of the type called "cooking crystals," used by hobbyists for molding plastic objects and are readily available in most hobby supply stores. They appear to be made from a roughly formed plastic rod of about 1/16-inch average diameter and are broken into irregular 1/20-to-1/10-inch segments. Their small size lends itself to ready shaping of the bladder, and the irregularities in shape promote interlocking for rigidity when the bladder is evacuated.

METHOD

In the actual preparation of the restraint assembly, each bladder is filled with 3 pounds (approximately 1-1/2 quarts) of granules through a small, circular hole made in one side. After the filling is completed, the hole is sealed with an ordinary, automobile inner-tube cold patch. The bladder is then evacuated for about 30 seconds by means of the inflating needle connected by the tubing to a vacuum pump. With the inflating needle removed, the evacuated bladder is quite rigid and usually maintains its shape well for at least twelve hours. In this respect, leakage at the bladder valve may occur if a small granule becomes lodged within the valve mechanism. This problem can usually be corrected by applying a small positive pressure to the bladder, resulting in its partial inflation.

A photograph of a bladder before and after insertion of the plastic grains is shown in Figure 1. In Figure 2 a photograph of a bladder being manually shaped to the contours of a hand is shown at the left; the resulting contours being rigidly held after evacuation are shown at the right. The specific application of the method in one device is shown in the photographs presented in Figure 3. An angle-iron support for the bladder assembly was attached to the chair as shown at the upper left. The bladder assembly is then placed between this bracket and the head as shown at the upper right. The experimenter manually compresses and forms the bladder assembly between the head and the bracket as shown at the lower left and then evacuates the bladder by means of a foot-operated switch controlling the vacuum pump. After approximately sixty seconds, the bladders are rigid and the head restraint is complete as shown at the lower right.

The vacuum bag restraint system is adaptable to fixing the orientation of the head, torso, and/or limbs of any human or animal subject. Obviously improvements could be made in materials, e.g., more flexible casing and technique, e.g., precision cutting and assembly of patterns to improve the basic fit of the bladder or to leave access openings where desired. The above description is meant only to show how commercially available materials of low cost and simple modification procedures can be used to provide a restraint system equal to or better than most of the methods currently in use.

LIST OF MATERIALS

1. Striking bag bladder, two Kantleek Model SR 1545-R (Seamless Rubber Company, New Haven, Connecticut)

2. Plastic Cooking Crystals, 6 pounds (available in hobby supply stores or from Southwest Hobbies Inc., Wichita Falls, Texas)

3. Air Pump, pressure-vacuum, motor driven, 0-30 inches of mercury (Model 1-093-5V1, Fisher Scientific Co., U. S. A.)

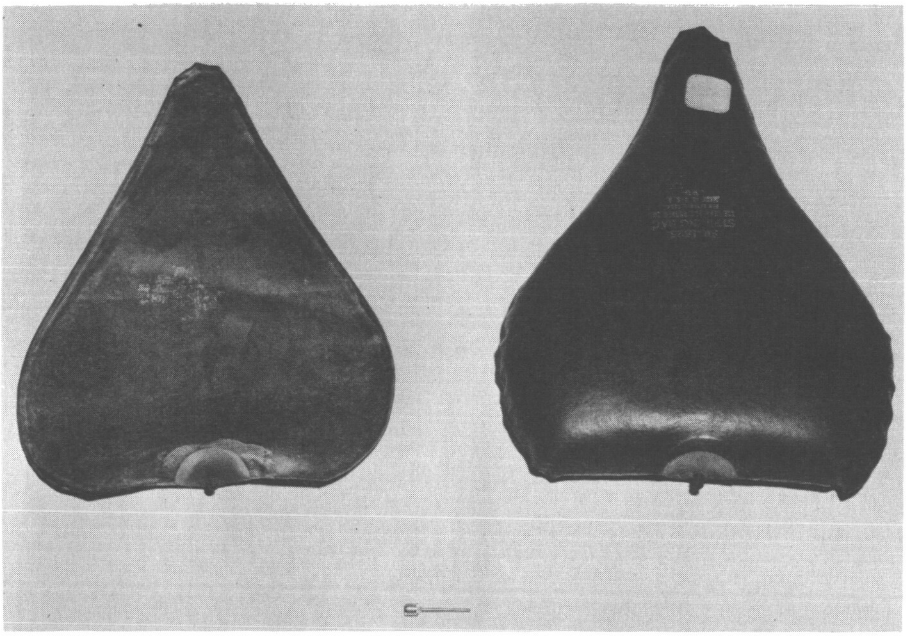

Figure 1

Striking bag bladder before and after insertion of plastic grains.

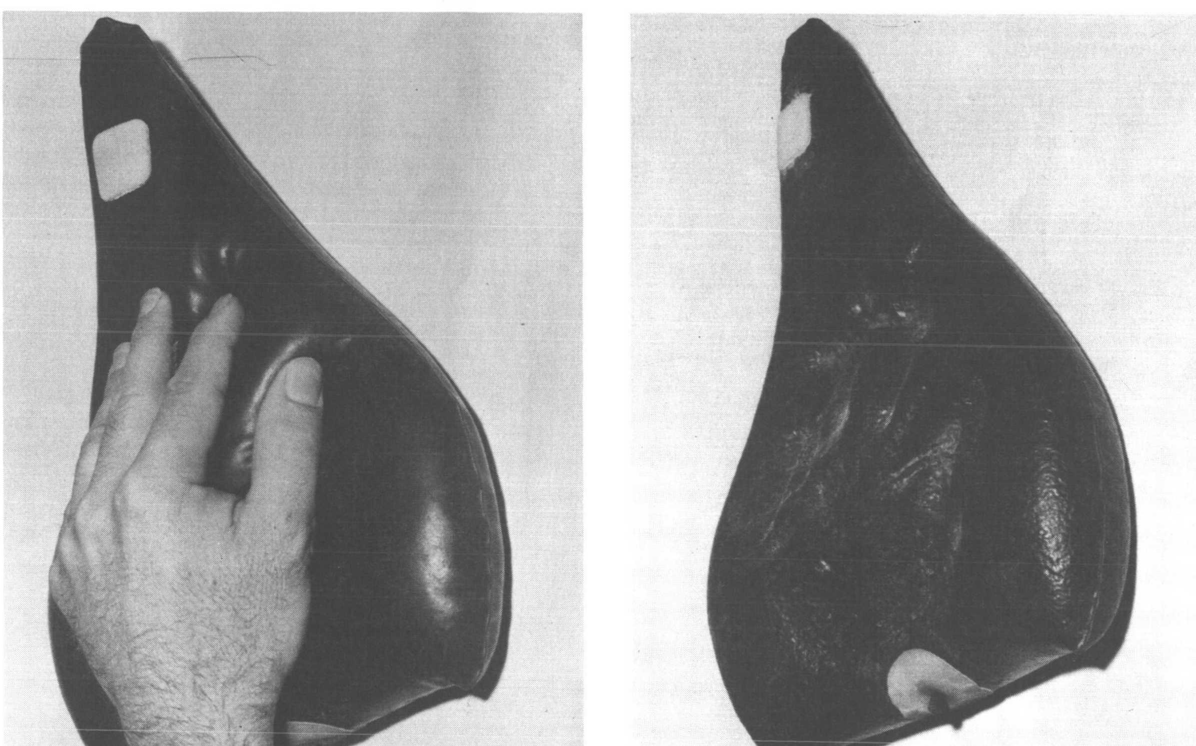

Figure 2

Plastic-filled bladder is manually shaped to the hand to illustrate its flexibility (left) and the fidelity and rigidity of the resulting contours after evacuation (right).

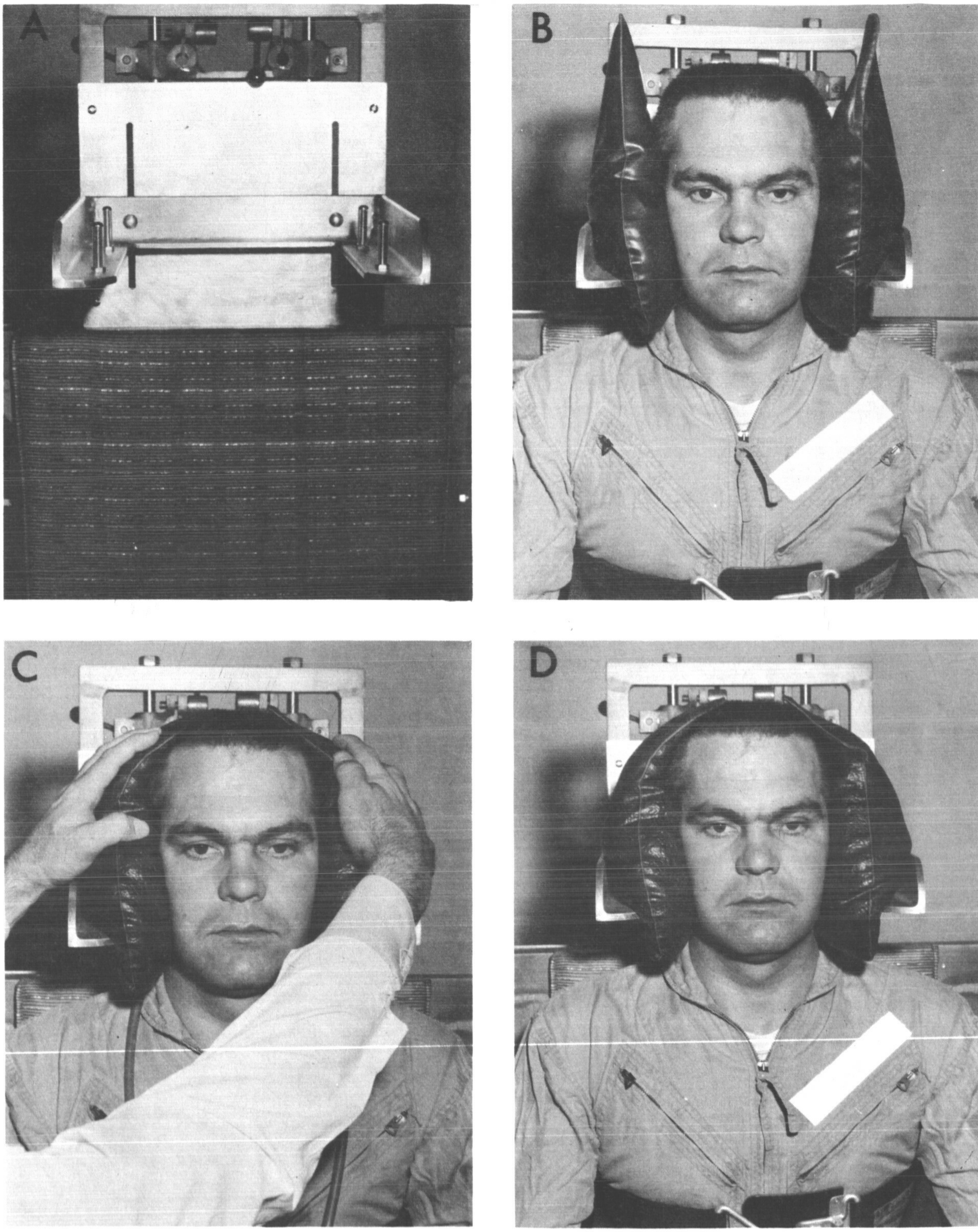

Figure 3

Typical application of the head restraint system. A simple aluminum frame (A) provides support for the bladder units placed at each side of the subject's head (B). The bladders are easily shaped to the head for a snug fit before evacuation (C) and hold their contoured shape rigidly after evacuation (D).

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