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A BIBLIOGRAPHY OF THE ROLE OF THE VESTIBULAR APPARATUS UNDER WATER AND PRESSURE: CONTENT-ORIENTED AND ANNOTATED

Robert S. Kennedy

**Naval Medical Research Institute
Bethesda, Maryland**

10 August 1972

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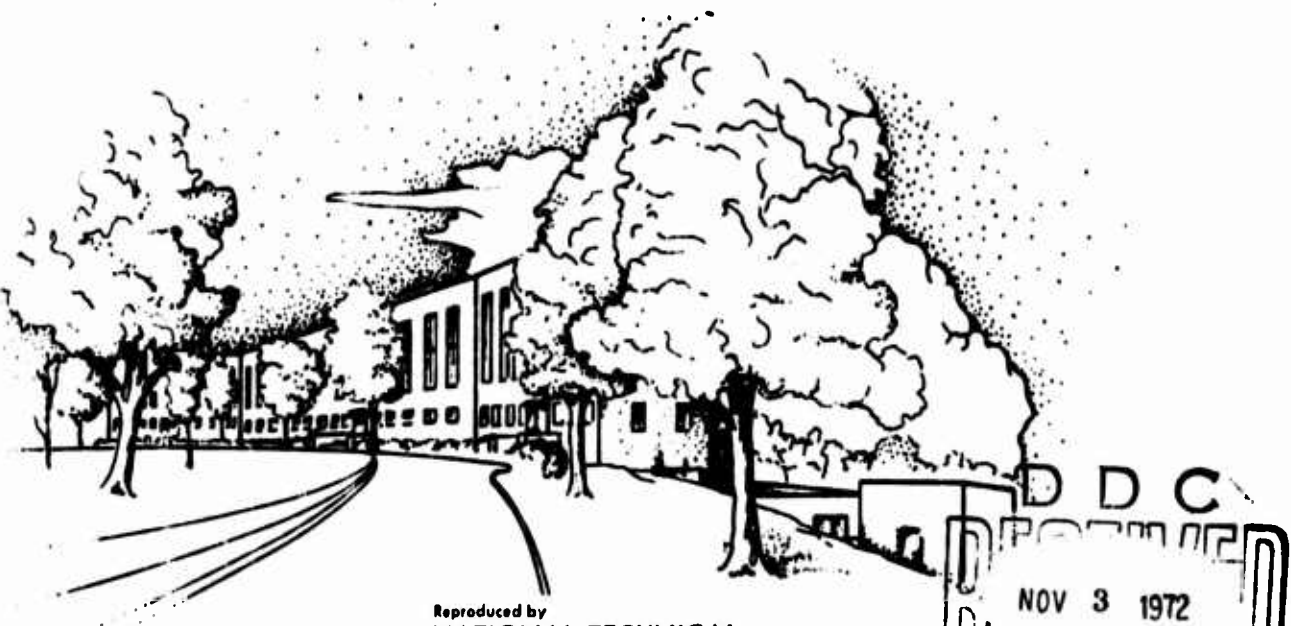
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**A BIBLIOGRAPHY OF THE ROLE OF THE VESTIBULAR APPARATUS
 UNDER WATER AND PRESSURE: CONTENT-ORIENTED AND ANNOTATED**

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| 13. ABSTRACT This report contains about 965 references dealing with the role of the vestibular apparatus in compressed air work. The sources for this bibliography include the diving medicine reference works as well as the literature dealing with vestibular functions. In addition, there are many items in the bibliography which would not typically be seen when consulting the standard reference works in diving medicine or vestibular physiology. These include obscure references and/or translations of articles not previously translated. The references are sorted by subject matter into six categories: <ul style="list-style-type: none"> Category I. Vestibular Symptomatology as a Sign of Decompression Sickness (Compression Effects; Isobaric?) Category II. Clinical Investigation of Vestibular Symptomatology Category III. Tests of Positive Function of Vestibular Apparatus Category IV. Perceptual Illusions Occasioned by the Environment Some of Which May be of Vestibular Origin Category V. The Use of the Vestibular System as an Inertial Guidance System Category VI. Auditory Studies which Have Relevance for Understanding Vestibular Function Underwater. The major category is Category I (293 references). Most of the citations are annotated and many are cross-referenced between and within categories. It is felt that the role of the vestigular system in compressed air work is presently under- estimated. This bibliography calls attention to the incident of vestibular involvement in compressed air work and provides reference to the background material essential for understanding and future study of vestibular problems. | | | |

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| 5. Vestibular Symptoms | | | | | | |
| 6. Diving Medicine | | | | | | |
| 7. Compressed Air Sickness | | | | | | |
| 8. Decompression Sickness | | | | | | |
| 9. Diver Navigation | | | | | | |
| 10. Navigation | | | | | | |
| 11. Disorientation | | | | | | |
| 12. Orientation | | | | | | |
| 13. Diver Disorientation | | | | | | |
| 14. Diver Selection | | | | | | |
| 15. Neurological Deficits-Diver | | | | | | |
| 16. Vestigular Hits | | | | | | |
| 17. Diver Auditory Problems | | | | | | |
| 18. Perceptual Disorientation | | | | | | |
| 19. Diving History | | | | | | |
| 20. Vestibular Diagnosis | | | | | | |
| 21. Vestibular Pathology | | | | | | |
| 22. Caisson Disease | | | | | | |

A BIBLIOGRAPHY OF THE ROLE OF THE VESTIBULAR APPARATUS
UNDER WATER AND PRESSURE: CONTENT-ORIENTED AND ANNOTATED

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10 August 1972

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the private ones of the writer and are not to be construed as official or
reflecting the views of the Navy Department or the Naval service at large.

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ABSTRACT

This report contains about 965 references dealing with the role of the vestibular apparatus in compressed air work. The sources for this bibliography include the diving medicine reference works as well as the literature dealing with vestibular functions. In addition, there are many items in the bibliography which would not typically be seen when consulting the standard reference works in diving medicine or vestibular physiology. These include obscure references and/or translations of articles not previously translated. The references are sorted by subject matter into six categories:

- Category I. Vestibular Symptomatology as a Sign of Decompression Sickness (Compression Effects: Isobaric?)
- Category II. Clinical Investigation of Vestibular Symptomatology
- Category III. Tests of Positive Function of Vestibular Apparatus
- Category IV. Perceptual Illusions Occasioned by the Environment Some of Which May be of Vestibular Origin
- Category V. The Use of the Vestibular System as an Inertial Guidance System
- Category VI. Auditory Studies Which Have Relevance for Understanding Vestibular Function Underwater

The major category is Category I (293 references). Most of the citations are annotated and many are cross-referenced between and within categories. It is felt that the role of the vestibular system in compressed air work is presently underestimated. This bibliography calls attention to the incidence of vestibular involvement in compressed air work and provides reference to the background material essential for understanding and future study of vestibular problems.

KEY WORDS

Diving

Compressed Air Work

Bibliography: Content-Oriented, Annotated

Vestibular Function

Vestibular Symptoms

Diving Medicine

Compressed Air Sickness

Decompression Sickness

Diver Navigation

Navigation

Orientation

Disorientation

Diver Disorientation

Diver Selection

Neurological Deficits-Diver

Vestibular Hits

Diver Auditory Problems

Perceptual Disorientation

Diving History

Vestibular Diagnosis

Vestibular Pathology

Caisson Disease

CONTENTS

| | <u>Page No.</u> |
|---|-----------------|
| ABSTRACT..... | i |
| KEY WORDS..... | ii |
| CONTENTS..... | iii |
| ACKNOWLEDGMENTS..... | iv |
| PROLOGUE..... | v |
| CATEGORY I. Vestibular Symptomatology as a Sign of Decompression Sickness (Compression Effects: Isobaric?)..... | 1 |
| CATEGORY II. Clinical Investigation of Vestibular Symptomatology..... | 38 |
| CATEGORY III. Tests of Positive Function of Vestibular Apparatus..... | 62 |
| CATEGORY IV. Perceptual Illusions Occasioned by the Environment Some of Which May be of Vestibular Origin..... | 73 |
| CATEGORY V. The Use of the Vestibular System as an Inertial Guidance System..... | 92 |
| CATEGORY VI. Auditory Studies Which Have Relevance for Understanding Vestibular Function Underwater..... | 105 |
| AUTHOR INDEX..... | 112 |

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PROLOGUE

In reading the literature on compressed air work as related to Navy diving, I was prepared to see vestibular implications if they were present since my previous work in aviation medicine dealt mainly with vestibular functions. However, I became impressed with the frequency with which aspects of that sensory system were mentioned throughout the research literature: as a symptom of decompression sickness, ancillary to auditory problems, or in connection with disorientation, etc. Yet general reference works (Hoff, 1948; Greenbaum and Hoff, 1954; Greenbaum and Hoff, 1966) and manuals (e.g., Navy Diving Manual, 1970*) did not appear to deal in any formal way with problems which may center around this organ complex, and general textbooks often merely indicated that additional work is needed in this area.

A file of over 1,000 general references on "vestibular functions" was consulted and it appeared that only about a dozen articles dealt specifically with vestibular functions under water and pressure. Many more articles were probably important to an understanding of the role of the vestibular apparatus under water and compressed air, and these references do not generally appear in the diving literature. Furthermore, I knew of no "vestibular scientist" actively engaged in compressed air study and there is evidence that a correspondence

*Cited in bibliography.

between the two exists and is increasing (cf. Rubenstein and Summitt, 1970*). I therefore decided to merge studies of vestibular function which I felt were applicable to work in a compressed air environment with studies of compressed air work involving the vestibular apparatus in some way.

I decided to organize the studies into subject matter categories, so I "forced" each citation into one of six bins. When an article had broader application it was placed into the most appropriate category and cross-referenced at the end of the other categories to which it applied. Occasionally such a study had been published as a government report and as a journal article as well, or similarly in two journals, or was one of a series; in these cases an entry was made in two categories.

The available literature was searched in several ways: (a) modern sources were consulted and references which were cited therein were backtracked, (b) the overall vestibular literature was surveyed, (c) the "Sourcebooks" (Hoff, 1944; Greenbaum and Hoff, 1957; Greenbaum and Hoff, 1966; Shilling and Werts, 1971) were consulted and articles were skimmed or read as needed. Occasionally, when it was not possible to "see" hard copy of an article for one reason or another, the notation "N.V." (not viewed, therefore not verified) appears. In those instances, unless the source of the reference is specified, the source was one of

*Cited in bibliography.

the "Sourcebooks" previously listed, (d) experienced workers were consulted for leads. These people were either "vestibular scientists" or "hyperbaric scientists", (e) since studies of vestibular functions have historically enjoyed more popularity outside the United States than in it, particular attention was paid to articles which were not published in English. When titles, abstracts, or entire articles were translated by others this information is included in the text.

The implication of a particular article is carried sometimes in the title; when it isn't, the results are also listed in the text. For the most part, however, it was felt that an interpretation of the meaningfulness of the findings would be more useful for the reader and so most articles are annotated. Generally, I introduced my own opinions and interpretations regarding the application or implication of a reference. When this was done, I usually indicated I had taken this liberty by the notation "(RK)." Sometimes it was felt that a reference would be more meaningful in connection with another. When this was the case, the other article(s) were cross-referenced in the annotation.

In the course of assembling this bibliography, it was apparent that many of the vestibular findings reported in the earlier literature were not always known to later writers. To point this out, the literature throughout this bibliography is listed chronologically within each category. An author index also appears at the end of the bibliography. Each article has a unique identification number. Journal title abbreviations used were taken from the List of Journals Indexed in Index Medicus,

1972, or from ACCESS, Key to the Source Literature of the Chemical Sciences, 1969 edition.

As mentioned above, each article was placed into what was considered the most appropriate category. Six categories were employed:

1. Vestibular symptomatology reported in connection with compressed air work.
2. Clinical diagnosis of vestibular symptoms with relevance to hyperbaria.
3. Provocative tests of the positive function of the vestibular apparatus to be used as pre-post measurements of normal functioning.
4. Illusory phenomena occasioned by water and similar environments which may involve or interact with vestibular functions.
5. The potential use of the vestibular system as a navigation aid under water.
6. Relevant auditory studies.

Category I generally contains articles which report vestibular symptoms in connection with decompression sickness. Occasionally a methodology paper which would be useful in studying this problem is included. If an article appeared more diagnostic than descriptive it would be included in Category II. For example, some reports of aerotitis media report vestibular symptoms, are diagnostic, but also report auditory problems. These therefore may appear in Categories I, II or VI.

Compression also produces problems and while articles reporting decompression sickness symptoms make up the largest part of this section, compression and isobaric studies are also included.

When pathology is discussed the article may appear in Categories I or II.

Category II contains papers which it is felt would be useful in the diagnosis of involvement of the vestibular system or its central pathways, although most of the citations are to papers which do not mention hyperbaria per se. Some overlap exists between Category II and Categories I and III and, to a lesser extent, Category IV. An effort was made to include modern, representative studies in this category, and the earlier literature which may contain similar studies is not always included since it is felt that new diagnostic approaches would supercede older ones and provide reference to the earlier, if the latter were of interest.

Category III lists the many methods for measuring the integrity of the vestibular apparatus for the primary purpose of describing normal function, or what is normal for that individual. Papers contained within this category can be used to assemble a battery of tests for specific or general purposes. Thus, if pretesting is performed prior to a dive (or to a career in diving) post-testing can then be employed to show deficits if they occur. Some of these tests reported may also be used to indicate whether this organ system and its pathways is being affected by the experimental condition whilst the condition is on-going (e.g., during an extended dive).

Category IV includes papers which discuss perception in general as well as those which discuss aspects of the kinds of perceptual environments that may be encountered under water and pressure.

In this section, for example, there are reports describing submersibles and there are reports of the effects of motion on perception. Also, because water immersion was used to simulate the weightlessness of space flights, and because perceptual problems were mentioned in these reports, some articles from this literature are included. Motion sickness as a diving problem may be of importance only indirectly (viz., a diver is often transported to his dive site and tended by a boat). However, the consequences of sea sickness to a diver who later dove could be fatal, thus a recent review of motion sickness is included (Money, 1971*).

Category V includes representative and general works regarding animal orientation, navigation, homing and migration as well as the few studies which dealt directly with human abilities to perform these operations. Several studies of importance for this category may also be found in Categories III or IV.

The list of animal navigation studies is not meant to be exhaustive but rather representative of the kind of cues that are being studied in that literature. The studies referenced generally are: a major conference with many articles, by a significant person in the field, contain a good bibliography, or are recent articles.

Category VI includes articles dealing with auditory problems. These articles were obtained during the course of obtaining the

*Cited in bibliography.

references cited in Categories I to V above. These articles are included because of the similarities of vestibular and auditory systems, but the list is not meant to be complete or representative. The auditory articles are concerned mainly with barotrauma of the tympanic membrane, Eustachian tube, etc., or hearing loss or "sudden deafness."

Generally, tests of these injuries involve auditory tests and auditory symptoms (e.g., tinnitus), although vestibular involvement (e.g., vertigo) and tests (e.g., caloric) may be included.

The overall purpose of this bibliography is to call attention to the incidence of vestibular involvement in compressed air work, and to provide reference to the background material essential for understanding and future study of these problems.

References

Hoff, E. C.

A bibliographical sourcebook of compressed air, diving and submarine medicine. Vol. I. NAVMED 1191.

Wash., D. C.: Department of the Navy, ONR/BUMED, Feb. 1948.
(Available from U. S. Gov't. Printing Office)

Greenbaum, L. J., Jr. and E. C. Hoff.

A bibliographical sourcebook of compressed air, diving and submarine medicine. Vol. II.

Wash., D. C.: Department of the Navy, ONR/BUMED, Nov. 1954.
(Available from U. S. Gov't Printing Office)

Greenbaum, L. J., Jr., and E. C. Hoff.

A bibliographical sourcebook of compressed air, diving and submarine medicine. Vol. III.

Wash., D. C.: Department of the Navy, ONR/BUMED, Dec. 1966.
(Available from U. S. Gov't. Printing Office)

Shilling, C. W., and M. F. Werts.

An annotated bibliography on diving and submarine medicine.
New York: Gordon and Breach, Science Publishers, Inc., 1971.

CATEGORY I. VESTIBULAR SYMPTOMATOLOGY AS A SIGN OF DECOMPRESSION
SICKNESS (COMPRESSION EFFECTS: ISOBARIC?)

1870-1899

1. BAUER, L.
Pathological effects upon the brain and spinal cord of men exposed to the action of a largely atmospheric pressure.
The Saint Louis Medical and Surgical Journal, R. P. Studley & Co., 1870.

A report of the Mississippi Bridge works in St. Louis; historically interesting.
2. SMITH, A. H.
The effects of high atmospheric pressure, including the caisson disease.
pp. 1-53. Brooklyn: Eagle Print, 1873.

The book describes experiences connected with building the Brooklyn Bridge. This is an excellent and little referenced study. It contains early references to animal studies (pp. 23, 24); use of pressure to treat illness (pp. 23, 24); adaptation effects (pp. 20, 34); constitutional factors (p. 37); and cardiovascular effects (p. 20). Vestibular and auditory difficulties are mentioned throughout (particularly p. 27 ff.). Smith feels a first-order problem in compressed air work is on "effect on hearing (p. 17)." He coined the term, "Caisson Disease (p. 25)."
3. TREITEL.
Die rupturen des trommelfalles mit besonderer berucksichtigung ihrer forensichen bedeutung.
Zeitsch. f. Ohr., Bd. XIX:115, 1880. (Cited by Lestienne, 1932; cited by A. Pagano, 1959.)
4. VAN RENSSELAER, H.
The pathology of the caisson disease.
Trans. N.Y. State Med. Soc. pp. 408-444, 1891.

One of the earliest articles written in America. Historically, very interesting with an exhaustive bibliography, particularly of the French literature. Vestibular symptoms as prodromal signs (p. 414), obesity (p. 438), adaptation (p. 439), and cerebellar implications (p. 440), as well as case histories, are included.
5. BOBINGTON, T. H., and A. CUTHBERT.
Paralysis caused by working under compressed air in sinking the Foundation of Londonderry New Bridge.
Dublin J. Med. & Sci. (N.S.) 36:312-318, 1893. N.V.
6. CURNOW, J.
Auditory vertigo caused by working in compressed air.
Lancet 11:1088-1089, 1894.

One of the earliest and certainly the most descriptive report of vertigo in compressed air. An excellent paper.
7. HELLER, R., W. MACER, and H. von SCHROTTER.
Vorlaufige Mittheilung uber Caissonarbeiter. (Introductory report on caisson workers. Trans. by Mrs. A. Woke, NMRI, 1972.)
Wien Klin. Wochenschr. 8:475-476, 1895.

An early report of decompression sickness which refers to Meniere-like symptoms. Describes the early experience of the authors with the caisson at Nussdorf. The entire report later appeared as a book.

8. SILBERSTEIN.
 Sur kasuistik des caissonkrankheiten.
Wien Med. Woch. N:31, 1895. (Cited by Lestienne, 1932; cited by A. Pagano, 1959.) N.V.
9. ALT, F.
 Ueber apoplectiforme Labyrinthkrankunge bei Caissonarbeitern. (Concerning apoplectic-form labyrinth diseases in caisson workers. Trans. by Mrs. A. Woke, NMRI, 1971.)
Monatsschrift fur Ohrenheilkunde 30:341-349, 1896.

Reviews the early literature on ear (labyrinthine) problems from pressure, and although the author considered the previous literature small, he offers about 20 references. He calls attention to the large number of ear diseases that von Shrotter was discovering at the Nussdorfer Spitz floodgate, reports cases, and offers theories regarding etiology. He also reports on animal tests and performed ear sections, but shows no slides in the printed version of his talk.

10. SNELL, E. H.
 Compressed air illness (or so-called caisson disease).
 London: H. K. Lewis, 1896.

The author claims this article to be one of the first reviews in English (but see Smith, 1873, #2). It is excellent for its description of disorders involving the auditory and vestibular systems. In reports on vertigo (pp. 29, 30) and vomiting (p. 57) in tunnel workers Snell claims that "...cases of auditory vertigo...have not previously been met with and recognized by writers on the subject (p. 74)." He mentions thickening of the tympanic membrane due to constant "accommodation of the ear (p. 116, 117)." Case histories of vestibular involvement begin on p. 98.

11. ALT, F., R. HELLER, W. MAGER, and H. von Schrotter.
 Pathologie der Luftdruckerkrankungen der Gehororgans. (Pathology of air pressure diseases of the auditory organs. Trans. by Mrs. A. Woke, NMRI, 1972.)
Monatsschrift fur Ohrenheilkunde 31:229-242, 1897.

Auditory problems occasioned by pressure changes in general are discussed; also labyrinthine diseases caused by gas emboli after rapid decompression, with figures which show lesions in the cochlea and semicircular canals (p. 239). The authors describe the symptoms reported by workers as including dizziness, tinnitus, vomiting, "reeling like drunkards (p. 240)," inability to stand on one foot (Romberg). They also report cases described by previous workers: Moos, Gruber, Ekert, Pol and Wattle, Gal, Gerard, Catsaras, and Snell, plus twelve of their own. Animal studies of rapid decompression from 5 ata showed hemorrhages in various places within the labyrinth particularly in the semicircular canals.

12. HOCHÉ, A.
 Ueber die Luftdruckerkrankungen des Centralnervensystems. (Air pressure diseases of the central nervous system. Trans. by Mrs. A. Woke, NMRI, 1972.)
Berlin. Klin. Wochenschr. 22:464-469, 1897.

A very good early paper. Spontaneous nystagmus (p. 465), dizziness, etc., are mentioned.

1900-1909

13. BARATOUX, J.
 Des accidents survenante du cote de l'oreille dans l'air comprime.
Indipend. Med. VI:114, 1900. (Cited by Lestienne; cited by A. Pagano, 1959.) N.V.

14. HELLER, R., W. MAGER, and H. von SCHROTTER.
Luftdruck-Erkrankungen, mit besonderer Berücksichtigung der
sogenannten Caissonkrankheit. Vols. 1 and 2
Vienna: A. Holder, 1900.

Many authors (e.g., Keays, 1909, #22; Hill, 1912, #25; Behnke, 1951, #85; 1969, #225) have used these volumes for basic data regarding vestibular symptomatology and decompression sickness, but the works themselves have not been formally translated. Reporting similar data, articles by Alt (1896, #9; 1897, #11), Heller, et al. (1895, #7), and von Schrotter (1904, #16) are found elsewhere in this bibliography.

15. ROPKE.
Die berufskrankheiten des ohres und der oberen Luftwege.
J. r. Bergmann. Wiesbaden, 1902. (Cited by Philip; Cited by A. Pagano, 1959.) N.V.

16. VON SCHROTTER, H.
Zur Pathogenese der sogenannten Taucherlahmung.
(The pathogenesis of so-called diver paralysis. Trans. by Mrs. A. Woke, NMRI, 1972.)
Verhandlungen der deutschen pathologischen Gesellschaft 8:136-138, 1904.

A report of post-mortem spinal cord observations (with 2 figures) in 3 divers, one of whom had disziness.

17. PHILIP, M.
Des accidents auriculaires dans les travailleurs des caissons.
Ann. Mal. Or. 140, 1907. (Cited by A. Pagano, 1959.) N.V.

18. TORRETTA.
Lesioni del labirinto non acustico.
Il Policlinico, 1907. (Cited by A. Pagano, 1959.) N.V.

19. BERRUYER, G.
Les accidents auriculaires chez les Travailleurs des caissons.
Bull. de Laryng. Otol. Rhin., 199, 1908. (Cited by A. Pagano, 1959.) N.V.

20. BOYCOTT, A. E., G. C. C. DAMANT, and J. S. HALDANE.
The prevention of compressed-air illness.
J. Hyg. (Camb) 8:342-443, 1908.

They indicate that as far as "mechanical symptoms (p. 388)" are concerned, goats do not appear to suffer from ear problems as men do. However, behavioral measures of VIIIth nerve involvement are difficult to accomplish. They describe that a "fair number of cases have occurred when the animal is obviously ill (p. 387)." It may be that vertigo or other vestibular symptoms were present. See Brauer, et al., (1971, #266).

21. BLICK, G.
Notes on diver's paralysis.
Br. Med. J. 2:1796-1798, Dec. 25, 1909.

An early paper.

22. KEAYS, F. L.
Compressed air illness, with a report of 3,692 cases.
Cornell University Medical College, Ithaca, New York, Researches
from the Department of Medicine 2, October 1909.

One of the most quoted works on the epidemiology of decompression sickness. A good paper. The author claims that 5% of all cases had vertigo as the "most characteristic symptom (p. 38)"; he suggests labyrinthine hemorrhage was the cause. Perhaps more cases of vertigo occurred, but as accessory symptoms to joint pain (See Hill, 1912, p. 78 ff., #25; Adler, 1964, p. 74 ff., #154.) The author appears to suggest saturation diving (p. 50). Good references to the earlier literature.

23. POLI, C.
Resultati dell'esame preventive dell'orecchio nei lavoratori in aria compressa.
Policlinico. Sez. Prat. XVI:210, 1900. (Cited by A. Pagano, 1959.) N.V.

1910-1919

24. BRYANT, W. S.
Occupational diseases of the ear, nose and throat.
J. M. New York, XII:295, 1912. (Cited by A. Pagano, 1959.) N.V.

25. HILL, L.
Caisson sickness, and the physiology of work in compressed air.
London: Edward Arnold, 1912.

A very important review of the earlier work includes slides (fig. 36, p. 83) from von Schrotter (1904, #16) of lesions in semicircular canals. Reviews work of Heller, Mager, & von Schrotter (1900, #14), (Danube caisson works), where involvement of the auditory and non-auditory labyrinth may have been as high as 28% of all cases.

26. BASSOE, P.
The late manifestations of compressed-air disease.
Am. J. Med. Sci. 145:526-542, 1913.

Should be read with Boot's (1913, #27) paper. Bassoe reports "ear affections," in "87 of the 161 men (p. 541)"; "33 complained of dizziness," "6 of vomiting" (p. 527); "6 had blind staggers, that is, labyrinthine vertigo, with nystagmus (p. 527)."

27. BOOT, G. W.
Caisson workers' deafness.
Ann. Otol. Rhinol. Laryngol. 22:1121-1132, 1913.

Boot mentions vestibular problems (p. 1131) and also indicates that the vestibular system often continues to function even though hearing losses occur. However, his index of vestibular function is probably an ice water caloric, which may not be a sensitive enough test for showing graded amounts of hypofunction (yet ice water calorics are often used in modern times). (RK)

28. BERRUYER, G.
Les accidents auriculaires chez les travailleurs des caisson.
Bull. de Laryngol. St. Louis, XXII:1121, 1913. (Cited by A. Pagano, 1959.)
N.V.

29. ERDMAN, S.
The acute effects of caisson disease or aeropathy.
Am. J. Med. Sci. 145:520-526, 1913.

Describes somewhat differently the same data reported by Kaays (1909, #22). Considers vertigo to possibly "...be due to cerebellar gas embolism" or bubbles in labyrinth (p. 523). Shows 88% of cases had pain "either as the only symptom or associated with others (p. 523)." [Underlining mine (RK)] Because percent incidences sum to 100, one wonders if vertigo (for example) appeared in "more than 5% (p. 523) as reported, or if vertigo was a prominent symptom in >5% but was an accessory symptom in some of the 88% who reported pain. (RK)

30. ANDREWS, A. H., L. W. ROTH, and A. C. IVY.
On the use of reduced atmospheric pressure in the treatment of paranasal sinusitis.
Quart. Bull. North. W. Med. Univ. School 46:41, 1915.

1920-1929

31. LEVY, E.
Compressed-air illness and its engineering importance (with a report of cases at the East River Tunnels).
Bureau of Mines Technical Papers No. 285, Washington, D.C., 1922.
- A report of 680 cases of DCS. Vertigo as a major symptom occurred in 6.5%; localized pain in 91.8%. In this report, as in Keays (1909, #22), there is no record of whether vertigo appeared as an accessory symptom or as a premonitory sign of pain (although it probably did). Therefore, the true incidence of vertigo is probably undetermined.
32. GORDON, L.
Die Bempfkrankherten der Gehororgans.
Zbl. Habs. Nas. n. Ohrenheilk 9:433-461, 1926. N.V.
33. VAIL, H. H.
Traumatic conditions of the ear in workers in an atmosphere of compressed air.
Arch. Otolaryngol. 10(2):113-126, 1929.
- This paper reviews the earlier work of Alt (1896, #9), Keays (1909, #22), etc., and calls attention to the fact that the U.S. Navy had no record of "admission to the sick list for damage to the ears considered due to diving activity (p. 114)." Reasons are given and two cases histories are reported.

1930-1939

34. OTANI, N.
Beitrag Zn. Caisson Krauheit.
Zb. Habs. Nas. u. Ohrenheilk 16:460, 1930. N.V.
35. HILL, L.
Deep-sea diving.
J. R. Nav. Med. Serv. 18(8):157-173, 1932.
- A good paper of historical interest mentions "giddiness" (p. 165) and alludes to perceptual difficulties attendant upon the environment.
36. LESTIENNE, J.
Des accidents labyrinthiques chez les ouvriers des chantiers de travail a l'air comprins (maladie de caissons). (Labyrinthine accidents occurring in workers performing jobs in compressed air. Caisson disease. Summary Trans. by F. Russo, NMRI, 1972.)
Ann. oto-laryng. (Paris) 2:200-217, 1933.
- Following a brief historical review, the author discusses case histories from compression and decompression accidents. He states compression accidents often resulted in functional damage which recovered; decompression accidents affected the nerve and were not recoverable. State-of-the-art and methods of treatment (e.g., recompression) are discussed. A good biophysical reference for decompression sickness.
37. BERTOIN, R.
Pronostic eloigne des accidents labyrinthiques par decompression.
Ann. oto-laryng. (Paris) 407, 1934. (Cited by A. Pagano, 1959.) N.V.
38. MAGNOTTI, T.
Alterazioni del naso, laringe ed orecchio in animali sottoposti compressione e decompressione di aria (aviatori e lavoratori dei cassoni).
Otorinolaringol. Ital. 6, 1936. N.V.
39. SHILLING, C. W., and J. A. HAWKINS.
Hazard of caisson disease in individual submarine escape.
U.S. Navy Med. Bull. 34:47-52, 1936.

40. SINGSTAD, O.
Industrial operations in compressed air.
J. Ind. Hyg. 18:497-523, 1936.
- Describes theories of compressed air illness and in particular, vertigo (p. 513).
41. WILLHELMY, G. E.
Ear symptoms incidental to sudden altitude changes, and the factor of over-closure of the mandible-preliminary report.
U.S. Nav. Med. Bull. 34(4):533-541, 1936.
- See also Costen (1934, #302), Pinto (1966, #446), and Kelly and Langheins (1946, #69).
42. ARMSTRONG, H. G.
The effect of flight on the middle ear.
J.A.M.A. 109(6):417-421, 1937.
- Early reference to aero-otitis media with inclusion of reference to vertigo as a symptom.
43. SHILLING, C. W.
Quantitative study of mental and neuromuscular reactions as influenced by increased air pressure.
U.S. Nav. Med. Bull. 35:373-380, 1937.
- Mentions among other things, dizziness on compression (p. 379).
44. BERTOIN, R.
A propos des accidents labyrinthiques par decompression.
J. de med. de lyon 19:457-460, 1938. N.V.
45. SHILLING, C. W.
Compressed air illness.
U.S. Nav. Med. Bull. 36:9-17, 1938.
- A very good earlier review of the literature, "cause, symptoms, treatment prognosis, prophylaxis (p. 9)" of decompression sickness.
46. CHIAPPE, E.
Lesioni dell'orecchio interno da decompressione. (Riliev, Istopatologici)
Otorinolaringol. Ital. 9:149-178, 1939. (Cited by A. Pagano, 1959.) N.V.
47. CRESPI REGHIZZI, A.
Contributo clinico alle malattie professionali dei cassoni.
Arch. ital. otol. 51:408-420, 1939. N.V.
48. MANIGAN, T. P.
Otologic aspect of caisson disease.
Memphis Med. J. 14:81-84, 1939.
- Mentions labyrinthine involvement.

1940-1949

49. GANDINO, D.
La malattia dei cassoni dal punto di vista otiatrico.
Rassegna di med. indust. 11:142-148, 1940. N.V.
50. REQUARTH, W. H., and R. E. BENSON.
Compressed air illness with special reference to the middle ear.
Indust. Med. 9:115-121, 1940. N.V.

51. **REQUARTH, W. W.**
Aero-Otitis media in compressed air workers; treatment with helium-oxygen mixtures.
J.A.M.A. 116:1766-1769, 1941.

52. **SHILLING, C. W.**
Compressed air illness. III through VI.
U.S. Nav. Med. Bull. 39:235-259, 1941a.

A continuation of a previous paper with special mention of the fact that "Meniere's symptom complex is relatively common and vertigo, either alone or associated with other symptoms, is frequently noted (p. 237)," but no reference is given. The reference list is otherwise very complete, much of it not often reviewed by modern authors.

53. **SHILLING, C. W.**
Compressed air illness.
U.S. Navy Med. Bull. 39:367-376, 1941b.
(Review of literature 1936-1940 incl.)

An update of the previous paper where "joint pathology" and "otological effect(s)" are considered the two special problems, i.e., "given more notice than before" (p. 309). Four references to the latter problem are given, and nine to the former. This paper probably dates a turning point in DCS studies toward an increased emphasis on joint pathology. (RM)

54. **ALMOUR, R.**
Industrial otology in caisson workers.
N.Y. State J. Med. 42:779-785, 1942a.

Mentions a Meniere-type syndrome and gives a good review. A good discussion follows.

55. **BLINKE, A. R.**
Physiologic studies pertaining to deep sea diving and aviation, especially in relation to the fat content and composition of the body.
The Harvey Lectures 37:198-226, 1942a.

A good description of bubble formation and fat. The central nervous system and vestibular system may have a relatively high fat content compared to other structures.

56. **CAMPBELL, P. A.**
Aerosinusitis.
Arch. otolaryngol. 35:107-114, 1942.

57. **SHILLING, C. W., and EVERLEY, I. A.**
Auditory acuity in submarine personnel. Part III.
U.S. Navy Med. Bull. 40(3):664-686, 1942.

This article contains a good bibliography of earlier work plus case histories of the authors. The distinction is made between barotrauma-type problems which result in vestibular and auditory problems versus Meniere-like syndromes most likely due to nitrogen bubbles causing "aural lesions (p. 669)." Vertigo as an accompanying symptom is mentioned (p. 675).

58. **BERT, P.**
Increased pressure. In Barometric pressure. Researches in experimental physiology, 1878. Trans. by M. A. Hitchcock, and F. A. Hitchcock. Chapter I, 353 ff. Columbus, Ohio: College Book Co., 1943.

In this classic, case histories of Bert's and others are reported. Vertigo, "dizziness," "vomiting" (p. 363) are mentioned frequently. For example, the author had the bends and vomited. "...reflex movements [of the eyes] caused by the slightest stimulus (p. 381)" may be an example of nystagmus. "...sight was affected, and I saw my arm moving much as one perceives objects after he has whirled about several times (p. 385)," may be an example

of the oculogyral illusion (Graybiel & Hupp, 1946, #536) (RK) "I was dazed and my eyes refused to serve me at all. I saw only at long intervals, and for a second at the most, then everything disappeared to reappear only after a few moments in the same way (p. 385)." It may have been nystagmus. (RK)

59. DICKSON, E. D. D., J. E. G. MCGIBBON, and A. C. P. CASTRELL.
Acute otitic barotrauma-clinical findings, mechanism and relationship to the pathological changes produced experimentally in the middle ears of cats by variations of pressure.
J. Laryngol. 58:456, 1943. N.Y.
60. OGDEN, F. W.
A study of altitude chamber aero-otitis media.
U.S. AAF School of Aviation Medicine, Randolph, Field, Tex., Report No. 1, Project 147, 3 May 1943. N.Y.
61. ENGEL, G. L., J. P. WEBB, E. B. FERRIS, J. ROMANO, H. RYDER, and M. BLANKENHORN.
A migraine-like syndrome complicating decompression sickness.
War Med. 5:304, 1944.
62. SHILLING, C. W.
Aero otitis media and auditory acuity loss in submarine escape training.
Trans. Am. Acad. Ophthalmol. Otolaryngol. 49:97-102, 1944-45.
63. BEHNKE, A. R.
Physiologic effect of pressure changes with reference to otolaryngology.
Arch. Otolaryngol. 42:110-116, 1945.

Deals mainly with barotrauma as a middle ear problem.
64. BROWN, G. A., C. H. CRONICK, H. L. HOTLEY, E. J. KOCOUR, and W. O. KLINGMAN.
Nervous system dysfunction in adaptation to high altitude and as postflight reactions.
War Med. 7:157-161, 1945.

The article provides case histories of altitude decompression sickness. The first diagnostic category employed is "Disturbances of equilibrium and coordination (p. 157)." Case No. 1 (p. 158) shows dizziness, ataxia, and nystagmus.
65. STEWART, C. B., O. N. WARWICK, and G. L. BATEMAN.
Acute otitic barotrauma resulting from low pressure chamber tests.
J. Aviat. Med. 16:385, 1945. N.Y.
66. ANON.
Barotrauma.
Roy. Nav. Med. Bull. 22:53-57, 1946. N.Y.
67. GRAY, J. S., S. C. F. MAHADY, R. L. MASLAND, and H. S. WIGODSKY.
Studies on altitude decompression sickness. I. Symptomatology.
J. Aviat. Med. 17:333-342, 1946.

Nausea, vomiting, pallor, sweating, faintness (p. 339) are considered circulatory reactions in this report.
68. HAINES, H. L., and J. D. HARRIS.
Aerotitis media in submariners.
Ann. Otol. Rhinol. Laryngol. 55:347-371, 1946.

A good review of the problem, mentions vertigo as one of the symptoms.
69. KELLY, W. J., and H. W. LANGHEINZ.
Dental treatment for the prevention of aerotitis media.
Ann. Otol. Rhinol. Laryngol. 55(1):13-28, 1946.

The authors report a successful dental treatment in 46 of 50 cases of persons diagnosed with aerotitis media in submarine training. A similar

effort could perhaps be made in diver training where a careful dental examination might be performed after tests for ability to clear the ears are conducted. This might: (a) return to training persons who fail; (b) identify persons who could develop chronic problems later in their diving careers. Behnke (1969, #225) reports that in "...5 to 25% of all compressions to 50 psi (about 150,000 compressions) applied to American submarine personnel...[the personnel] have been unable to accommodate readily to the excess pressure (p. 261)." See other articles by the senior author.

70. LENTINE, J.
A review of one hundred cases of acute auro-otitis.
Arch. Otolaryngol. 43:293-297, 1946.
71. LUND, D. W., J. H. LAWRENCE, and L. B. LAWRENCE.
Latent neurologic manifestations following decompression.
J. Occup. Med. 1:75-80, 1946.
- Dizziness and vomiting are reported, among other findings.
72. BEHNKE, A. R.
A review of physiologic and clinical data pertaining to decompression sickness.
Naval Medical Research Institute, Bethesda, Md., Report No. 4,
Project No. X-443, 13 May 1947.
- An excellent review of DCS and one of the few works to review directly (see Table 4) the studies of Heller, Mager, and von Schrotter (1895, #7). Of those with DCS: they report 70% bends, 8% vertigo and Meniere's, 6% "chokes," 4% sensory disturbances, and 12% motor paralysis; the latter two may also contain vestibular involvement. (RK) Although not widely available, this is a very good report. See also Behnke (1971a, #261) for a similar updated report.
73. DICKSON, E. D. D., J. E. G. MCGIBBONS, and A. C. P. CAMPBELL.
Acute otitic barotrauma--clinical findings mechanisms and relationship to the pathological changes produced experimentally in the middle ears of cats by variations of pressure.
In E. D. D. Dickson (Ed.) Contributions to aviation otolaryngology.
pp. 60-83. London: Headley Brothers, 1947. N.V.
74. SHILLING, C. W., H. L. HAINES, J. D. HARRIS, and W. J. KELLY.
Aerotitis media. A brief presentation of its symptomatology, prevention and treatment.
J. Aviat. Med. 18:48-55, 1947.
- In a discussion following the paper the influence of the mandible (p. 55) was mentioned and should be compared to Pinto (1966, #436).
75. ASCHAN, G. K.
Aerotitis media and aerosinusitis.
Acta Otolaryngol. (Stockh) Suppl. 69:1-93, 1948. N.V.
76. HARVEY, W.
Investigation and survey of malocclusion and ear symptoms, with particular reference to otitic barotrauma (pain in ears due to change in altitude).
Br. Dent. J. 85(10):219-225, 1948.
- This article should be considered along with Costen (1934, #302) and Pinto (1966, #436).
77. KEREKES, G.
Contributions oto-rhinologiques a la connaissance de la maladie des caissons.
Ann. oto-laryng. (Paris) 65:762-766, 1948.
78. ORTIZ, R. B.
Barotrauma otico.
Rev. Otorhinolaring. 8:41-66, 1948. (English summary.) N.V.

79. UFFENORDE, H.
Otolological experience with "Schnorchel"-equipped submarines.
Monograph on Submarine-Medicine, Folio VII. U.S. Naval Forces,
Germany. (Technical Section, Medical.) Date uncertain, 1948.
- Discusses the barotraumatic effect of Snorkel submarines, particularly
in heavy seas. Reports that the symptomatology in some cases included
thickened ear drums, upper range hearing loss (p. D-III-5), balance
disturbance and dizziness (p. D-III-6), spontaneous nystagmus (p. D-III-7).
80. VAN DER AUE, O. E.
Caisson disease--in the case of Ferguson, Charles P., GMI, 250-54-57.
U.S. Navy. Naval gun factory, EDU. (aboard U.S.S. Chanticleer ASR-7),
Report to Chief, BuMed, 6 November 1948. N.V.
81. WEERSMA.
Barotrauma dei seni e dell'orecchio.
Nederl. Med. Geneesk. Tijdsch. X, 1948. (Cited by Hyde; cited by A. Pagano,
1959.) N.V.
82. BOIES, L. R.
Acute otitis media.
In L. R. Boies, J. A. Hilger, and R. A. Priest Fundamentals of otolaryngology.
pp. 61-69. Philadelphia: W. B. Saunders Co., 1949. N.V.
83. FLANAGAN, J. C.
Techniques for developing critical requirements from critical incidents.
Am. Psychol. 4:236, 1949.
- An excellent methodology for problem definition. Of potential utility
in surveys of diver accidents.

1950-1959

84. FILIPPI, P.
Sui rapporti fra pressione del liquor e pressione endolabirintica nel gatto.
Boll. Soc. Ital. Biol. Sper. 26:661, 1950. N.V.
85. BEHNKE, A. R.
Decompression sickness following exposure to high pressures.
In J. F. Fulton (Ed.) Decompression sickness. Caisson sickness,
diver's and flier's bends and related syndromes. p. 53-89.
Philadelphia: W. B. Saunders Co., 1951.
- A good review paper with a summary of 1,361,461 decompressions.
86. FERRIS, E. B., and G. L. ENGEL.
The clinical nature of high altitude decompression sickness.
In J. F. Fulton (Ed.) Decompression sickness. Caisson sickness,
diver's and flier's bends and related syndromes. pp. 4-52.
Philadelphia: W. B. Saunders Co., 1951.
87. FULTON, J. F. (Ed.)
Decompression sickness, caisson sickness, diver's and flier's bends
and related syndromes.
Philadelphia: W. B. Saunders, 1951.
- There are many good articles in this book. The ones considered most
important are referenced individually.
88. GERSH, I., and H. CATCHPOLE.
Decompression sickness: physical factors and pathologic consequences.
In J. F. Fulton (Ed.) Decompression sickness. Caisson sickness,
diver's and flier's bends and related syndromes. pp. 165-181.
Philadelphia: W. B. Saunders Co., 1951.

See especially pages 165-171.

89. PAGANO, A.
Sinusopatie da barotrauma.
Arch. ital. laring. 59:257-268, 1951.

90. WAITE, C. L.
Medical problems of an underwater demolition team.
U.S. Armed Forces Med. J. 2:1317-1326, 1951.

Aerotitis media and external ear infections are discussed.

91. DESPONS, M.
Labyrintho-traumatisme chez un ouvrier de caissons. (Labyrintho-trauma
in a caisson worker.)
Arch. Mal. Prof. 13(10):615-616, 1952.

Two other papers dealing with neurological/labyrinthine problems of
caisson workers are also listed (p. 616).

92. MEDA, E.
A research on the threshold for the Coriolis and Purkinje's phenomena
of excitation of the semicircular canals.
Archivo di Fisiologia 52(2):116-134, 1952. Trans. by E. R. Hope,
Defense Scientific Information Service, D.R.B. Canada, 1-5 Sept. 1954.
(Cited by Stewart & Clark, 1965, #692.) N.V.

93. PASHALIAN, S., W. J. E. CRISSY, A. I. SIEGEL, and E. P. BUCKLEY.
The interview: I. A selectively abstracted bibliography.
U.S. Navy Submarine Medical Center, New London, Conn., Report No. 1,
Project NM 002 016.01, 2 June 1952.

If vestibular problems are increasing in incidence, techniques described
in this article will be useful in studying the true base rate in diver
population.

94. PORTMANN, M., and G. PORTMANN.
Auricular disorders due to a brutal decompression.
Med. J. (Bordeaux) 129(11):1055, 1952. N.V.

95. BERTOIN, R.
Evolution clinique des accidents labyrinthiques survenant chez les ouvriers
travaillant en air comprimé. (Clinical evolution of labyrinth accidents
in the ears of compressed air workers.)
Arch. Mal. Prof. 14:221-224, 1953.

The author asks for better diagnostic categorization of these maladies.
He also feels that some chronic cases of VIIIth nerve disorder (balance
problems, etc.) worsen with time.

96. CHOSSEGROS, H., L. ROCHE, and L. MIGEON.
Les Atteintes vestibulaires graves dans la maladie des caissons.
(Grave vestibular hits in decompression sickness. Partial translation
by F. Russo, NMRI, 1972.)
Arch. Mal. Prof. 14:211-220, 1953.

The author differentiates between vestibular hits in dam workers due
to compression and those due to decompression. It is his opinion
that the latter are more traumatic and are more likely to be chronic.

97. McCALLUM, R. I., and D. N. WALDER.
Compressed-air illness on Tyneside.
Lancet 1:464-467, 1953.

Vomiting is reported in 1 of 2 cases, but is most likely due to causes
other than vestibular.

98. PAGANO, A.
Ricerche audiometriche nei barotraumi da caissoni.
Arch. ital. laring. 61:254-265, 1953.

99. CLARK, B., and M. A. NICHOLSON.
Aviator's vertigo: A cause of pilot error in naval aviation students.
J. Aviat. Med. 25:171-179, 1954.
100. PATON, W. D. M., and D. N. WALDER.
Compressed air illness. An investigation during the construction of the
Tyne Tunnel, 1948-50.
Medical Research Council Special Report Series No. 281. London: Her
Majesty's Stationery Office, 1954.
- The main symptoms recorded were: "Pain, aching, burning, gripping,
stabbing, tingling (p. 10)," and perhaps for this reason vestibular
symptomatology is being underestimated, since there is no category for recording
it.
101. ROGER.
Variations de l'EEG chez l'homme en fonction de la pression.
Rev. de Neurol. 51:6, 1954. (Cited by A. Pagano, 1959.) N.V.
102. AMBROSIO, L., V. MAZZA, and C. SERRA.
Comportamento della attivita elettrica corticale e dell equilibrio
elettrolitico in operai affetti da mal dei cassoni.
(Status of the cortical electric activity and of the electrolyte
equilibrium [balance?] in workers affected by caisson sickness.)
Acta Neurol. (Napoli) 10(6):879-906, 1955.
- Electrolyte imbalances relative to EEG changes in connection with compressed
air work are reported. There is a relationship of EEG changes to the high
pressure nervous system syndrome (Bennett & Towse, 1971g, #264) possible
relationships of fluid balance to decompression sickness (Warwick, 1942,
#309; 1943, #311) and Meniere's disease (Simpson, 1965, #424) elsewhere
in this bibliography. Also numerous labyrinthine symptoms in case
histories are reported (pp. 883-893).
103. BEHNKE, A. R.
Decompression sickness.
Milit. Med. 117:257-271, 1955.
- A review paper with minor mention of vestibular involvement as a symptom
of DCS, although dizziness and nausea are included in several case histories.
104. HAYMAKER, W., and A. D. JOHNSTON.
Pathology of decompression sickness. A comparison of the lesions of airmen
with those in caisson workers and divers.
Milit. Med. 117:285-306, 1955.
- The authors describe their own findings in relation to a very large literature.
A good bibliography is included.
105. KOMENDANTOV, G. L.
Vestibular nystagmus in conditions of lowering barometric pressure.
In The functioning of organisms under conditions of changing gaseous
environments. p. 53. Moscow, Leningrad: Academy of Sciences, USSR, 1955.
(In Russian, trans. by J. Diachenko, NMRI, 1972.)
- Changes in post rotational nystagmus (induced by rotation) were noted
as a function of altitude. In general, changes begin to occur above
5,000 meters.
106. KRATOCHVIL, C. H.
The contributions of Alphonse Jaminet to an understanding of decompression
sickness.
J. Aviat. Med. 27:59-63, 1956.
- Of historical interest, and indicates Jaminet himself suffered dizziness
after decompression.

107. ADES, H. W., A. GRAYBIEL, S. N. MORRILL, G. C. TOLMURST, and J. A. MERRIN.
Nystagmus elicited by high intensity sound.
U.S. Naval School of Aviation Medicine, Pensacola, Fla., Joint Project
NM 13 01 99, Subtask 2, Report No. 6, 15 February 1957.

Because vestibular responses are obtained in deaf persons by noise and because compression chambers are noisy, vestibular testing at depth must take this relationship into account.

108. BOZZI, E.
Il comportamento dell'Orecchio interno nel' Esercizio del nuoto subacqueo con auto-respiratore ad aria.
Minerva Otorinolaringol. (Torino) 7:376, 1957. N.V.
109. CROSS, E. R.
Prevention of diving disease.
Water World 2:30, 44-45; May/June 1957. N.V.
110. KOOPERSTEIN, S. I., and B. J. SCHUMAN.
Acute decompression illness. A report of forty-four cases.
Ind. Med. Surg. 26(11):492-496, 1957.

Preselection on the basis of: (a) ability to equalize pressure, (b) ear drum inspection, and (c) no untoward effects with the expiration of the first work shift (p. 493) may have contributed to the low base rate (.0318%). (RK)
111. LANPHIER, E. H.
Diving medicine.
N. Engl. J. Med. 256(3):122-128, 1957.

Calls attention to the vestibular reaction of caloric irrigation from cold water (p. 122) and equilibrium disorder with spinal lesion (p. 128).
112. MELVILLE-JONES, G.
Review of current problems associated with disorientation in man-controlled flight.
Flying Personnel Research Committee, Royal Air Force, Farnborough, England, October 1957.

A good review paper with reference to pressure vertigo (p. 22 ff.). Also describes a possible mechanism.
113. ARSLAN, M., and V. BOTNER.
Orecchio e sistema nervose vegetative.
XII Conv. Soc. Oto-Rhino-Laryng. Latina/Roma 1958. N.V.
114. BACKUS, J.
Tinnitus.
Skin Diver 7:25, Dec. 1958. N.V.
115. BRUZZI, B.
Sindromie otorinoliatriche nella malattia dei cassoni.
Folia Med. Napoli 41(8):780-783, 1958. N.V.
116. BUSCAINO, V. M.
Sindromi neurologiche nella malattia dei cassoni.
Folia Med. Napoli 41(8):773-779, 1958. N.V.
117. FIELDS, J. A.
Skin Diving: Its physiological and otolaryngological aspects.
A.M.A. Arch. Otolaryngol. 68:531-541, 1958.

An important but short paper. Mentions how during descent underwater, the stomach contents reorient themselves which can lead to problems, particularly as the stomach gas bubble expands with compression, and gastric secretion can be forced into the esophagus (p. 537). In addition, the contribution of a "plug of cerumen" (p. 539) to vertigo is mentioned.

118. DE VITA, C.
Contributo allo studio delle sinusiti barotraumatiche.
Folia Med., Napoli 42:781-793, 1959. N.V.
119. NOURRIT, P.
Barotrauma of inner ear. Experimental clinical study. Contribution
to prevent auricular accidents in workers performing jobs in
compressed air. (65 references.)
Thesis, Marseille, 1959. N.V.
120. PAGANO, A.
Otopatie e sinusopatie da barotrauma nei lavoratori dei cassoni.
Napoli: Casa Editrice V. Idelson di e Guocchi, 1959.

This text deals specifically with inner ear and sinus problems in
caisson workers. Early literature is reviewed and case histories are
given. A very good and complete book (more than 250 pp.).

121. PICARD, D., A. APPAIX, and P. NOURRIT.
Lesions histologiques de l'oreille interne consecutives a des
barotraumatismes experimentaux chez le Cobaye.
Comptes Rendus Soc. Biol. Paris 153:1230-1232, 1959.
122. ROZSAHEGYI, I.
Late consequences of the neurological forms of decompression sickness.
Br. J. Ind. Med. 16:311-317, 1959.

This paper is a report of a follow-up of the cases first seen and reported
in a previous report (Rozsahegyi & Soos, 1956, #122a). Relative to the
vestibular system and its central connections is a "pseudo Meniere's
syndrome" which is central rather than peripheral and is probably caused
by a lesion of the medullary vestibular nuclei. It is often associated
with paraplegia and signs of syncope or parasympathetic disturbances.
From the author's description one is reminded of the report by Simpson
(1965, #424) that prior to his death, Meniere was attempting to relate
the disease which bears his name to forms of migraine and was suggesting
fluid retention as a similar mechanism for both. The paper by Engal,
(1944, #61) on migraine-like symptoms in DCS is also worth noting. Further,
the comment often made (cf. van Rensselaer, 1891, #4) that diuresis occurs
in compressed air workers and high fluid exchange rates as part of a
person's habit afford some protection from DCS. The fact that sodium
excretion is reduced by compression (Radomski & Bennett, 1970b, #505)
and ADH is released during unusual vestibular stimulation (Taylor, et. al.,
1957, #363) may all be connected.

- 122a. ROZSAHEGYI, I., and I. SOOS.
Caissonkrankheit and Zentralnervensystem.
Arbeitsmedizin, Heft 30. Barth, Leipzig, 1956. N.V.

1960-1969

123. CAMPBELL, P. A.
Aero-otology.
In G. Coates and H. Schenck (Eds.) Otolaryngology. Vol. 2, Chapter 28.
Hagerstown, Md.: W.F. Prior, Co., Inc. 1960a.
124. DONNELL, A. M., Jr., and C. P. NORTON.
Successful use of the recompression chamber in severe decompression
sickness with neurocirculatory collapse.
Aerosp. Med. 31:1004-1009, 1960.

Dizziness, nausea, and vomiting (p. 1006) were reported; perhaps they were
syncopal rather than vestibular.

125. FLOTTES, L., and R. RIU.
The ear and the Navy.
Rev. Corps. Sante Armees 1-2:183-260, 1960. N.V.
126. GOLDING, F. C., P. GRIFFITHS, M. V. HEMPLEMEN, W. D. M. PATON,
and D. N. WALDER.
Decompression sickness during construction of the Dartford Tunnel.
Br. J. Ind. Med. 17:167-180, 1960.

This paper points out the difficulty in adequately assessing the incidence of decompression sickness of vestibular origin. First, only cases severe enough "for the man to bring himself back for treatment are included (p. 168)." Second, it would appear that pain as a symptom (perhaps accompanied by dizziness) would still be classed as type I. Nonetheless, after pain, vertigo is the next largest symptom category. The authors also report that type II symptoms when they appear, do so with shorter latency than type I, and so, if compressed air workers were alert for their appearance, it is possible mild, type II symptoms could be used as an early sign of type I, and recompression could begin sooner.

127. HELLER, M. F.
Skin diving injury.
Arch. Otolaryngol. 72:358-360, 1960.
- A hearing loss post-dive occurred, but vestibular problems are also mentioned (viz., dizziness and gaze nystagmus).
128. APPAIX, A., D. PICARD, and P. NOURRIT.
Les barotraumatismes cochléaires. Données expérimentales. (Cochlear barotraumas, experimental data.)
Ann. oto-laryng. (Paris) 78(4-5):232-245, 1961.
- Histological sections are shown.
129. BOUCHE, J., J. SIARDET, and M. HANNEQUIN.
A propos de deux cas de surdité cochléaire à l'occasion de plongée sous-marine.
Ann. oto-laryng. (Paris) 78(12):829-833, 1961.
130. COLES, R. R. A., and J. J. KNIGHT.
Aural and audiometric survey of qualified divers and submarine escape training tank instructors.
Medical Research Council, Great Britain, Royal Personnel Command 61/1011, 1961.

The authors attempt to distinguish vertigo due to syncope from that due to vestibular involvement. Report hypo function from caloric stimulation in older divers. A good review and excellent bibliography of auditory and vestibular studies.

131. JARRETT, A. S.
Ear injuries in divers.
J. R. Nav. Med. Serv. 47(1):13-19, 1961a.
132. LAMBERTSEN, C. J.
Harmful effects of oxygen, nitrogen, carbon dioxide and carbon monoxide. Decompression sickness.
In P. Bard (Ed.) Medical physiology. pp. 720-721. St. Louis: C. V. Mosby Co., 1961. N.V.
133. MALETTE, W. G., J. B. FITZGERALD, and A. T. K. COCKETT.
Dysbarism. A review of 35 cases with suggestions for therapy.
USAF, Aerospace Medical Center (ATC), School of Aviation Medicine, Brooks AFB, Texas, 1961. N.V.
134. NICOLET, L., P. MERER, and R. JAFFRES.
De l'existence des manifestations neurologiques chez les travailleurs en caisson présentant des lésions ostéo-articulaires barotraumatiques. (On the existence of neurological manifestations in caisson workers presenting barotraumatic osteo-articular lesions).
Rev. Rhum. 28:241-245, 1961. N.V.

135. NOURRIT, P.
Clinical study of barotrauma of the inner ear.
Mars. Med. 98(8):823-828, 1961. N.V.
136. PAGANO, A.
Les Barotraumatismes de l'oreille et des sinus. (Pressure trauma of the ears and sinuses.)
Mars. Med. 98:803-810, 1961.
- The author emphasized the importance of diving medicine. He speaks of the mechanics of pressure upon the ear and sinuses and how it creates lesions through increased blood pressure. He also delineates the difference between compression and decompression sickness, and their different treatments. He states the prognosis of compression to be much more favorable than that of decompression.
137. PICARD, D., and P. NOURRIT.
Histologic lesion of experimental barotraumas of the middle and inner ear.
Mars. Med. 98(8):819, 1961. N.V.
138. ROWE, B.
Medical hazards of skin diving.
Med. J. Aust. 30:1038, 1961. (Cited in Edmonds, 1971.)
- In this article it is stated that vertigo occurs in divers and is probably due to caloric irrigation.
139. ROZSAHEGYI, I., and B. GOMORI.
Otologische Untersuchungen bei Caissonarbeitern. (Otolological investigations on caisson workers. Trans. by Mrs. A. Woke, NMRI, 1972.)
Arch. Gerwerbepathol. Gewerbehyg. 18:384-393, 1961.
- The article reviews well the literature of labyrinth problems in compressed air work. It shows that evidence of auditory (hearing) and vestibular (caloric) loss is greater in a group of workers who had had acute caisson disease than in a group of workers who hadn't; the latter also had larger deficits than would be expected although a normal (control) group was not studied. Etiology is discussed.
140. SERRA, C. and L. AMBORSIO.
Malattia dei cassoni e male delle altitudini.
Acta Neurol. (Napoli) 16:239-250, 1961.
141. SHELBY, R. W.
Prevention and minimization of barotraumatic injuries associated with scuba diving.
J. Am. Osteopath. Assoc. 60:896-902, 1961. N.V.
142. SIMS, R. O. S., and S. WATSON.
Otitic barotrauma in divers.
Med. J. Aust. 48(2):1040-1041, 1961. N.V.
143. DAVIES, W.
The medical hazards of underwater swimming.
Practitioner 188:656-660, May 1962. N.V.
144. GRINDA, M., and R. CANAVESE.
New observation of barotrauma in the inner ear.
J. Franc. O.R.L. 114:536-539, 1962. N.V.

145. HIDALGO, F. C.
 Síndrome de descompresión. (Decompression syndrome.)
Revista Med. Mex. 27:360-365, 1962. N.V.
146. LANG, J.
 L'évocation du nystagmus opto-cinétique à l'aide d'un nouvel appareil
 et l'importance diagnostique de la méthode.
Acta Otorinolaryngol. Belg. 16:5, 1962. N.V.
147. ERDE, A.
 Experience with moderate hypothermia in the treatment of nervous system
 symptoms of decompression sickness.
 In Proceedings Second symposium on underwater physiology, February 25-26,
 1963, Wash., D. C. pp. 66-73. Wash., D. C.: National Academy of
 Sciences--National Research Council Publication 1181, 1963.
- Feels greater concern should be given to CNS symptoms of DCS. Reports
 7 case histories, 5 of which show sensory neurological residual deficits.
 Dizziness and disconjugate eye movements are reported in two case
 histories.
148. GRAYBIEL, A.
 Significance of vestibular organs in problems of weightlessness.
 In R. B. Livingston, A. A. Imshenetsky, and G. A. Derbyshire (Eds.)
Life sciences and space research. A session of the Third Inter-
 national Space Science Symposium, Wash. D.C., April 30-May 9, 1962.
 Amsterdam: North-Holland Publ. Co., 1963.
- The similarity of motion sickness symptomatology to symptoms from other
 "functional disorders resulting from a disturbance of the normal
 pattern of central nervous system integration (p. 26) are discussed.
 To the author's list might be added "decompression sickness." (RK)
149. GWOZDIEWICZ, J., and L. LABA.
 Nietypowy obraz neurologiczny w przypadku choroby kesonowej u nurka.
 (An atypical neurological picture of a case of caisson disease in a
 diver.)
Bull. Inst. Mar. Med. Gdansk 14:175-179, 1963. N.V.
150. HARDACRE, L. E., and R. S. KENNEDY.
 Some issues in the development of a motion sickness questionnaire for
 flight students.
Aerosp. Med. 34(5):401-402, 1963.
- A questionnaire similar to this could be constructed in order to assess
 past history of vestibular involvement in compressed air work.
151. LABA, L.
 Późne następstwa choroby kesonowej u nurków. (Late consequences of
 the decompression sickness in divers.)
Bull. Inst. Mar. Med. Gdansk 14:209-214, 1963.
- Written in Polish, but the English summary indicates the author dis-
 cusses pathology in divers.
152. MACKAY, D. E.
 Comments on therapeutic recompression.
 In Proceedings Second symposium on underwater physiology, February 25-26,
 1963, Wash., D.C. pp. 57-65. Wash., D.C.: National Academy of Sciences--
 National Research Council Publication 1181, 1963.
- The author reports that most persons had pain only (62%). The remainder
 had other symptoms with or without pain. Many of these other symptoms

could have a vestibular basis. If a liberal criterion of what constitutes vestibular involvement is employed, 50% might involve the vestibular system (e.g., nausea, vertigo, disorder of sensations, etc.).

153. RIVERA, J. C.

Decompression sickness among divers: an analysis of 935 cases. U.S. Navy Experimental Diving Unit, Wash. D.C., Report No. 1-63, 1 February 1963.

One of the very best epidemiologic studies of DCS. Table 14 (p. 12) shows the frequency of signs and symptoms. Those individual symptoms which could be due to vestibular involvement are reasonably prominent. It is felt that vestibular symptoms when reported occur often enough as initial manifestation and should be emphasized more to divers as possible premonitory signs of more painful or serious DCS.

154. ADLER, H. F.

Aeromedical reviews: Dysbarism. USAF School of Aerospace Medicine, Brooks AFB, Texas, Report No. 1-64, AD 601600, February 1964.

This is a very important but little referenced review of studies of compressed air. The accompanying bibliography is excellent. Of particular importance for this bibliography are the following: (1) reference to high fluid intake (p. 60) and tolerance for decompression sickness (cf. studies of Meniere's hydrops); (2) vestibular problems with reference to "bubbles in the labyrinth or cerebellum: (p. 76) as a likely locus; (3) "effects on the ear... (are considered) one of the most common manifestations of altitude dysbarism" (p. 117-125); and (4) the relationship of "barodontalgia" (p. 125) to sinus problems (p. 129), and "mal position of the jaws" (p. 119).

155. ALNOR, P. C., R. HERGET, and J. SENSING.

Drucklufferkrankungen. (Air compression sickness.) Munich, Barth, 1964.

156. ANDERSON, B., Jr., R. E. WHALEN, and H. A. SALTZMAN.

Dysbarism among hyperbaric personnel. J.A.M.A. 190(12):87-89, 1964.

157. SEEMANN, K.

Vorschlag zur Klassifizierung von Trommelfellbefunden beim Barotrauma des Mittelohrs. (Proposal for classification of tympanic membrane findings in barotrauma of the middle ear.) HNO 12:227-228, 1964.

158. SIIRDE, E. K., and V. A. SYARGAVA.

Osnostoyanii lorarganov u skvalangistov i. vodolagov. (Some otorhinological observations in frogmen and divers.) Vestn. Otorinolaringol. 26:86-89, Nov./Dec. 1964. N.V.

Probably the same as #159.

159. SIIRDE, E. K., and V. A. SARGAVA.

(Some otorhinological observations in frogmen and divers.) English abstract trans. from Russian article. Vestn. Otorinolaringol. 26(6):86-89, 1964.

160. ANDERSON, B., Jr., A. HEYMAN, R. E. WHALEN, and H. A. SALTZMAN.
Migraine-like phenomena after decompression from hyperbaric
environment.
Neurology 15(11):1035-1040, 1965.

The similarities of syncope, migraine, Meniere's disease, decompression sickness, and motion sickness should be studied for possible common etiologies. All occur in connection with diving. Simpson (1965, #424) (p. 751) claims that Meniere was working on a paper which called attention to the similar etiologies of certain forms of migraine and Meniere's disease when he died.

161. ANON.
Underwater neurology.
J.A.M.A. 193(7):611-612, 1965.

A one-page review.

162. BENSON, A. J.
Spatial disorientation in flight.
In J. A. Gilles (Ed.) A textbook of aviation medicine. pp. 1086-1129.
New York: Pergamon Press, Inc., 1965.

A GOOD REVIEW, especially with regard to pressure vertigo (p. 1101), vestibular function, and vestibular illusions/disorientation. A very good bibliography. Main thrust of the chapter is in regard to aviation, but many problems are common in diving. (RK)

163. DOLL, R. E.
Decompression sickness among U.S. Navy operational divers: an estimate
of incidence using decompression tables.
U.S. Navy Experimental Diving Unit, Wash., D.C., Report No. 4-64,
15 February 1965.

The base rate for decompression sickness in U.S. Navy diving is reported as < 1%.

164. FENN, W. O.
Inert gas narcosis.
In Hyperbaric oxygenation. Ann. N.Y. Acad. Sci. 117:760-767, 1965.

A good paper on nitrogen narcosis.

165. GWOZDZIEWICZ, J.
Izmeneniya v slinnoy mozg-u vodolazov, svyazannye s khronicheskoi formoi
kessonnoi bolezni. (Changes in the spinal cord of divers resulting
from chronic form of caisson disease.)
Bull. Inst. Mar. Med. Gdansk 16:171-185, 1965. N.V.

166. LUNDGREN, C. E. G.
Alternobaric vertigo--a diving hazard.
Brit. Med. J. 2:511-513, 1965.

An epidemiological paper and the one that focused attention on the problem. See also Terry and Dennison (1966, #190), and Voroswanti and Bradley (1970, #252) for American studies.

167. MASPETIOL, R., R. RODDIER, and J. GUTTIERES.
Barotraumatismes affectant les fonctions cochleo-vestibulaires chez les travailleurs dans l'air comprimé. (Scaphandriers-Caissons). (Barotrauma affecting cochleo-vestibular function in workers under compressed air. Divers-Caisson workers.)
Arch. Mal. Prof. 26(3):164-166, 1965.
168. MASPETIOL, R., and R. RODDIER.
Barotraumas affecting the cochlear vestibular functions occurring in workers performing jobs in compressed air.
Arch. Mal. Prof. 26(3):164-166, 1965. N.V.

Probably the same as #167.
169. MULHOLLAND, T., and C. R. EVANS.
An unexpected artefact in the human electroencephalogram concerning the alpha rhythm and the orientation of the eyes.
Nature 207(4992):36-37, 1965.

Changes in EEG are symptoms of the HPNS syndrome and this study suggests that eye movements are related to EEG changes. The relationship of eye movements to vestibular stimulation is well known (cf. Robinson, 1968, #565).
170. PAULEY, P.
Decompression sickness following repeated breath-hold dives.
J. Appl. Physiol. 20(5):1028-1031, 1965.

See "dizziness and nausea" (pp. 1028-1029).
171. POMPEIANO, O., and A. R. MORRISON.
Vestibular influences during sleep.
Arch. Ital. Biol. 103:569-595, 1965.

This paper, plus Morrison and Pompeiano (1965, #421), does not discuss vestibular symptomatology due to decompression, but may suggest mechanisms and connections of EEG microsleep as a HPNS symptom and vestibular function.
172. VOTH, A. C.
Autokinesis and alcoholism.
Q. J. Stud. Alcohol 26(3):412-422, 1965.

Anecdotal evidence suggests Navy divers are heavy drinkers and Van Rensselaer (1891, #4) comments on the "fullness of habit" of compressed air workers. Perhaps a correlation exists between drinking and inhibition of apparent movement. This might suggest that the incidence of subjective vertigo is less in Navy divers than in other diving groups (e.g., SCUBA). (RK)
173. WALDER, D. N.
Some dangers of a hyperbaric environment.
In I. McA. Ledingham, (Ed.) Hyperbaric oxygenation. pp. 5-11.
Proceedings of the Second International Congress, Glasgow, September 1964. Edinburgh: E. & S. Livingstone, Ltd., 1965. N.V.
174. BARNARD, E. E. P.
Aspects of underwater medicine.
Postgrad. Med. J. 42:636-642, 1966.

A short review paper. Labyrinthine problems mentioned (p. 638).

175. BARNARD, E. E. F., and D. H. ELLIOTT.
Decompression sickness: paradoxical response to recompression therapy.
Br. Med. J. 2:809-810, 1966.
Vomiting was reported but was more likely due to other complications than to vestibular involvement.
176. BOND, G. F.
Effects of new and artificial environments on human physiology.
Arch. Environ. Health 12:85-90, 1966.
There were no ear problems reported in this paper on SEA-LAB I.
177. CABARROU, P.
Schema clinique et therapeutique.
La Presse Medicale 74(4):169-171, 1966a.
Vertigo as a serious symptom of DCS is mentioned.
178. CABARROU, P., H. HARTMANN, K. H. WEINER, P. ALINAT, and H. D. FUST.
Introduction a la physiologie de homo aquaticus.
La Presse Medicale 74(53):2771-2773, 1966.
Otoneurologic changes in deep diving are described.
179. GWOZDZIEWICZ, J.
Mielopatia na tle przewleklej postaci choroby kesonowej u nurkow.
(Mylepathy in correlation with a chronic form of caisson disease in divers.)
Bull. Inst. Mar. Med. Gdansk 17:329-333, 1966. N.V.
180. HAMILTON, R. W., J. B. MACINNIS, A. D. NOBLE, and H. B. SCHREINER.
Saturation diving at 650 feet.
Ocean Systems Inc., Tonawanda, N. Y., Technical Memorandum B-411, March 1966.
Vestibular problems reported during compression (High Pressure Nervous System Syndrome).
181. KIDD, D. J.
Decompression sickness. Current trends in prophylaxis and treatment.
Med. Serv. J. Can. 22:79-86, 1966.
In addition to mention of dizziness, etc., as a type II symptom, the author suggests that "careful clinical (neurological) examination under pressure is the only reliable way of assessing the effect of treatment (p. 83)." [Underlining mine-RK]
182. KING, P. F.
Otitic barotrauma.
Proc. R. Soc. Med. 59:543-554, 1966.
A good paper--describes how vertigo can result, and in the discussion the suggestion was made that this malady should be termed "barotraumatic otitis media (p. 551)."

183. LANPHER, E. H.
Decompression sickness.
In Committee on Hyperbaric Oxygenation Fundamentals of hyperbaric medicine, pp. 89-94. Wash., D. C.: National Academy of Sciences--National Research Council, 1966.
184. LUNDGREN, C. E. G., and L. U. MALM.
Clinical aviation and aerospace medicine: Alternobaric vertigo among pilots.
Aerosp. Med. 37(2):178-180, 1966.

Replicated their previous study (1965) in pilots and showed an even higher incidence for a problem that has gone largely ignored for divers and pilots.
185. MACINNIS, J. B.
The medical and human performance problems of living under the sea.
Can. Med. Assoc. J. 95(5):191-200, 1966.

Vestibular problems are reported (p. 199) and a large bibliography is presented.
186. OTTOBONI, A., G. PERFUMO, and G. SPERATI.
La patologia auricolare nei sommozzatori. (Ear pathology in skin divers.)
Arch. Ital. Otol. 77 (Suppl. 49):1-74, 1966. N.V.
187. ROZSAHEGYI, I.
O neurologických formách dekompresivní nemoci (kesonové a potápačské nemoci). (The neurological form of caisson disease.)
Cesk. Neurol. 29(6):391-395, 1966.

ENGLISH SUMMARY (from the journal article)
The author gives a survey of his experience with caisson disease. He distinguishes 4 types of the disease: diffuse focal lesions of the CNS, a syndrome of multiple lesions of the cerebral hemispheres and the upper brain stem, a syndrome of affection of the rhombencephalon and a spinal cord syndrome. He further deals with the acute and the primary and secondary chronic form of the disease. He stresses the frequency of vegetative and mental changes as well as the variability of the clinical picture of this affection.
188. ROZSAHEGYI, I., and B. ROTH.
EEG studie dekompresivní nemoci. (EEG study of caisson disease.)
Cesk. Neurol. 29(6):386-390, 1966a.

Where labyrinthine forms of caisson disease had occurred, 50% had EEG abnormalities; where CNS forms of caisson disease had occurred, 67% had abnormal EEG'S.
189. ROZSAHEGYI, I., and B. ROTH.
Participation of the central nervous system in decompression.
Ind. Med. Surg. 35:101-110, 1966b.

This and other papers by this author describe residual neurological deficits in compressed air workers and of particular interest are involvements of vestibular apparatus and its central connections. These deficits even occur in caisson workers without a history of decompression sickness episodes (although the latter difference is small). The highest "sleep activity (p. 104)" disturbances

occurred in the group "touched by labyrinthopathy (p. 104)."
Divers should be encouraged to be more candid about symptoms
of DCS, particularly when the symptom is of a vestibular or
central nature. (RK)

190. TERRY, L., and W. L. DENNISON.
Vertigo among divers.
U. S. Naval Submarine Medical Center, Groton, Conn., Special
Report No. 66-2, 8 April 1966.

A lower rate than found by Lundgran (1965, #166) but still substantial.
The authors differentiate alternobaric vertigo from other
etiologies.

191. WAGEMANN, W.
Barotrauma und Taucherkrankheiten. (Barotrauma and diseases of
divers.)
Z. Laryngol. Rhinol. Otol. 45:379-383, June 1966.

Compression problems involving the ear are discussed.

192. WALDER, D. N.
Some problems of working in an hyperbaric environment.
Ann. R. Coll. Surg. Engl. 38:228-307, 1966. N.Y.

193. BARNARD, E. E. P.
The treatment of decompression sickness developing at extreme
pressures.
In C. J. Lambertsen (Ed.) Proceedings of the third symposium
on underwater physiology. pp. 156-164. Baltimore: The
Williams & Wilkins Co., 1967.

Case histories of decompression sickness occurring during ascent
to the surface are presented and their treatment discussed.
Unlike cases that occur at the surface, relief from symptoms
occurred at a pressure difference of only 60 feet. Very small
pressure fluctuations (one foot out of eighty) were sufficient
to cause noticeable changes in symptoms. Further, pain occurred
immediately and acutely after pressure drops.

194. BENNETT, P. B.
Performance impairment in deep diving due to nitrogen, helium,
neon and oxygen.
In C. J. Lambertsen (Ed.) Proceedings of the third symposium on
underwater physiology. pp. 327-340. Baltimore: The Williams
& Wilkins Co., 1967.

In connection with a study on performance, the author reported
that at 600 feet "dizziness and nausea and very occasionally...
vomiting" occurred "during the latter part of the exposure or at
the initial stops during decompression (p. 334)."

195. BORASI, G., and G. SPERATI.
I. Ipoacusie improvvisate nei sommozzatori. (Summary in English.)
Ann. Lar. Ot. Rin. Far. 66:897-905, 1967.

Two of three divers reported vertigo; one had "ipo-reflessia
vestibulare sempre a destra (p. 898)," that is, suppressed
response in the right ear.

196. BUHLMANN, A. A., and W. WALDVOGEL.
The treatment of decompression accidents.
Helv. Med. Acta 33:487-491, 1967. (In English)

The authors report that from their experiences approximately 1 in 8 accidents from deep chamber exposures (11-23 ata) involved the labyrinth and nearly all (9 of 11) of these required treatment. Of the remaining accidents (71), 22 did not require treatment. The only case of permanent damage involved the labyrinth (hearing).

197. DOLL, R. E., and T. E. BERGHAGE.
Interrelationships of several parameters of decompression sickness.
U. S. Navy Experimental Diving Unit, Wash., D. C., Report No. 7-65,
1 March 1967.

The coding of DCS symptomatology is shown in an appendix to this paper. The codes for different symptoms which could be a reflection of vestibular involvement tend to have high numbers (e.g., 12 and 20 for "dizziness/vertigo," and "equilibrium disturbance" (p.28), and tend not to be grouped together. Both of these factors could cause underestimation in reporting and data analysis.

198. GOULON, M.
Resultats de l'oxygenotherapie hyperbare dans 13 cas de'embolie gazeuze cerebrale et dans 10 cas d'accident de decompression chez des tubistes. (Results of hyperbaric oxygen therapy in 13 cases of cerebral gaseous emboli and 10 cases of decompression accidents in pipe workers.)
Anesth. Analg. (Paris) 24(4):431-438, 1967. N.V.

199. GREGG, J. B., and M. R. FERRELL.
Cochlear and vestibular damage from middle ear pressure change.
Eye Ear Nose Throat Mon. 46:464-470, 1967.

Although most of the references are "Personal Communication" this article is a good source for additional cases of vestibular involvement due to pressure.

200. MCCALLUM, R. I.
Decompression of compressed air workers in civil engineering.
Great Britain: Oriel Press, 1967.

Many good articles appear in this collection. The entire book should be perused. An item in the Introduction is of interest: if a joint pain (bends) occurs in about 1% of all decompressions (cf. Doll, 1965, #163; Keays, 1909, #22; Patton and Walder, 1954, #100; and articles in this book), but 19% of "tunnellers in compressed air who were symptomless...had bone lesions (p. vii)," then perhaps a similar relationship exists between vestibular/neurological symptoms and subsequent permanent deficit. Stated differently, the incidence of symptoms may underestimate by a good deal the ultimate identifiable damage done to an organism.

201. MILES, S.
Medical hazards of diving.
In C. N. Davies, P. R. Davis, and F. H. Tyrer (Eds.) The effects of abnormal physical conditions at work. pp. 111-120. Edinburgh: E. & S. Livingstone, Ltd., 1967.

Of 200 diving accidents (SCUBA) reported, 22 died of asphyxia and of these, two inhaled vomit. "...a situation may occur where

ill-fitting hoods block the ears so that though the middle ear equalizes with the nasopharynx the external meatus may remain at a lower pressure and the drum is drawn outwards (p. 119)." More importantly, perhaps, if the hood has been moved for pressure equalization, some very cold water may be let in.
(RK)

202. NICHOLSON, A. N., and J. ERNSTING.
Neurological sequelae of prolonged decompression.
Aerosp. Med. 38(4):389-39A, 1967.
Concerns altitude decompression.
203. PANOV, A. G., and M. P. ELINSKY.
Steryte formy lorazheniya nervnoi sistemy dekompressionnoi etiologii u vodoiazov. (Atypical forms of nervous system disorders from decompression in divers.)
Zh. Nevropatolog. Psikhiat. 67:1791-1795, 1967.
204. ROZSAHEGYI, I.
Decompression tables in civil engineering in Hungary.
In R. I. McCallum, (Ed.) Decompression of compressed air workers in civil engineering. pp. 41-45. Proceedings of an international working party held at the Ciba Foundation, London, October, 1965. Newcastle upon Tyne: Oriel Press, 1967a.
205. ROZSAHEGYI, I.
Decompression sickness and the Hungarian schedules.
In R. I. McCallum, (Ed.) Decompression of compressed air workers in civil engineering. pp. 99-113. Proceedings of an international working party held at the Ciba Foundation, London, October, 1965. Newcastle upon Tyne: Oriel Press, 1967b.
206. ROZSAHEGYI, I.
Neurological damage following decompression.
In R. I. McCallum (Ed.) Decompression of compressed air workers in civil engineering. pp. 127-137. Proceedings of an international working party held at the Ciba Foundation, London, October, 1965. Newcastle upon Tyne: Oriel Press, 1967c.
- This article is a narrative version of Rozsahegyi and Roth (1966b, #189), with somewhat more speculations, plus a good discussion by symposium participants.
207. WALDER, D. N.
Adaptation to decompression sickness in caisson work.
Biometeorology 2 (pt. 1):350-359, 1967a. N.V.
208. WALDER, D. N.
The effectiveness of the British decompression table.
In R. I. McCallum (Ed.) Decompression of compressed air workers in civil engineering. pp. 65-70. Proceedings of an international working party held at the Ciba Foundation, London, October, 1965. Newcastle upon Tyne: Oriel Press, 1967b. N.V.
209. WALDER, D. N.
Aetiological factors in decompression sickness.
In R. I. McCallum (Ed.) Decompression of compressed air workers in civil engineering. pp. 114-126. Proceedings of an international working party held at the Ciba Foundation, London, October, 1965. Newcastle upon Tyne: Oriel Press, 1967c. N.V.

210. WALDER, D. N.
Decompression sickness in tunnel workers.
In C. M. Davies, P. R. Davis, and F. H. Tyrer (Eds.) The effects of abnormal physical conditions at work. Edinburgh: E. & S. Livingstone, Ltd., 1967d.
- He points out that while <1% of all dives result in accidents, >20% of the divers appear to have necrosis. Perhaps similar relationships can be demonstrated regarding vestibular symptomatology in diving and permanent vestibular/neurological effects. (RK) In addition, he feels that probably everyone experiences DCS, but most don't report it because it isn't manly. Perhaps vertigo, or a similar symptom, could be used to screen persons who may profit by extra decompression time. (RK)
211. BAYLISS, G. J. A.
Aural barotrauma in naval divers.
Arch. Otolaryngol. 88:49-55, 1968.
- This report is mainly of interest as an auditory study. However, the author's speculation (p. 146) regarding selection procedures as a possible influence on the low incidence of vertigo in his population vs. others is important. Shilling and Everley (1942, #57) make a similar point in another context. These factors could result in an underestimation of the problem of vertigo in populations with less vigorous selection procedures.
212. DAVIS, G. D.
A review of skin diving hazards.
Med. J. Aust. 55(6):230-235, 1968. N.V.
213. ELINSKII, M. P., and I. V. ROGOZINA.
Tserebral'nye rasstroistva pri dekompressionnoi Bolesni. (Cerebral disorders in decompression sickness.)
Gig. Tr. Prof. Zabol. 12:16-20, 1968. N.V.
214. FRYER, D. I.
Evolution of concepts in the etiology of bends.
Aerosp. Med. 39(10):1058-1061, 1968.
- A good historical treatment.
215. GILLEN, H. W.
Symptomatology of cerebral gas embolism.
Neurology 18:507-512, 1968.
- The author states the symptoms of cerebral gas embolism (dizziness, nausea, and visual disturbances reported in 20% of the cases investigated) is similar to, and should be compared with, reports of vestibular symptoms of DCS.
216. KELLEY, J. S., T. E. BERGHAGE, and J. K. SUMMITT.
Review of diving accident reports, 1967.
U. S. Navy Experimental Diving Unit, Wash., D. C., Research Report 10-68, 1968.
217. LABA, L.
Przypadek choroby kesonowej z zespolem Meniera u Nurka, leczony recompresja z zastosowaniem tlenu pod cisnieniem, 3,4 atn. (A case of decompression sickness with Meniere's syndrome, in diver treated by recompression with pure oxygen under 3.4 atn. pressure.)
Bull. Inst. Mar. Med. Gdansk 19:191-195, 1968.
- The English summary indicates that dizziness and vomiting occurred, as well as pain in lumbar-sacral region.

218. LAMBERTSEN, C. J.
Modern aspects of treatment of decompression sickness.
Symposium on Undersea-Aerospace Medicine, Miami, Florida, May 9, 1968.
Aerosp. Med. 39(10):1055-1093, 1968.
219. MCCALLUM, R. I.
Decompression sickness: A review.
Br. J. Ind. Med. 25:4-21, 1968.
- Table I (pp. 6, 7) shows that type II ranges from 2 to 17% in a review of 13 major caisson works between 1914 and 1966. It appears that type I and type II are mutually exclusive, and the former category is used in preference to the latter. This would underestimate the incidence of type II cases.
220. PARKER, D. E., H. E. VON GIERKE, and M. RESCHKE.
Studies of acoustical stimulation of the vestibular system.
Aerosp. Med. 39(12):1321-1325, 1968.
- This study and references in the author's bibliography show that noise can result in vestibular stimulation and should be considered in connection with noise levels in pressure chambers (Murry, 1970, #956).
221. RICCIO, D. C., and J. S. THACH.
Response suppression produced by vestibular stimulation in the rat.
J. Exp. Anal. Behav. 11(4):479-488, 1968.
- A "behavioral approach [providing] a sensitive and quantifiable technique for assessing the effects of vestibular stimulation in animals (p. 479)" is described using FR, VR, VI, and FI schedules.
222. U. S. NAVY.
U. S. Naval flight surgeon's manual. Wash., D. C.: U. S. Govt. Printing Office, 1968.
- "The danger of pressure vertigo is that it occurs suddenly, may persist for 10 to 60 seconds, and is apt to occur at a critical time in flight when the plane is either gaining or losing altitude rapidly."
223. WALTREGNY, A., M. LAMEY, and J. MAWET.
Surveillance continue electroencephalographique et electrocardiographique de la plongee a l'air en caisson (4 ATA). (Continuous electroencephalographic and electrocardiographic surveillance of submergence in caisson (4 ATA).
Acta Neurol. Belg. 68:851-861, 1968. N.V.
224. BAYLISS, G. J. A.
Civilian diving deaths in Australia.
J. Forensic Med. 16:39-44, 1969.
- The author reports the cause of death in 71 drownings: Decompression sickness was a factor in 9 ("neurological involvement was responsible for most deaths from decompression sickness [pp. 42, 43]"); 30 were cause unknown. Not mentioned but possibly a factor in the cause unknown category is disorientation.
225. BEHNKE, A. R.
New approaches to medical aspects of work in compressed air.
J. Occup. Med. 11:259-272, 1969.
- Dizziness and ataxia were reported, in some cases exposed only to 9-16 psi. The author feels that type I DCS should be called "mild (p. 263)" and

type II DCS "serious (p. 264)." He feels also that residual impairment is likely with serious DCS. Other studies are reviewed where the ratio of type I to type II is between 6:1 and 24:1. The importance of the patency of auditory tubes, and auditory acuity as a concern are mentioned (p. 261).

226. BENNETT, P. B.
Hazards of inner space.
Sci. J. pp. 64-69, April, 1969.

"Sometimes the tremors were accompanied by dizziness, nausea, and even vomiting [to depths between 90 and 240 meters] during the latter part of the exposure or during decompression (p. 66)."

227. BRIERLEY, J. B., and A. N. NICHOLSON.
Neuropathological correlates of neurological impairment following prolonged decompression.
Aerosp. Med. 40:148-152, 1969.

In addition to a report of cerebellar and other CNS pathology this paper contains a useful bibliography. For connection of cerebellum and vestibular system see Wang and Chinn (1956, #361); Brodal, et al. (1962, #383); and Brodal (1966, #427). For bubbles in the cerebellum, see Erdman (1913, #29).

228. COCKETT, A. T. K., R. T. KADO, and R. M. NAKAMURA.
The patho-physiology of decompression sickness.
Rev. Physiol. Subaquatique Med. Hyperbare 1:199-202, Jan./Mar. 1969. N.V.

229. FRUCTUS, X., and J. C. RICCI.
Reflexions sur deux cas de maladie de la decompression (M.D.D.)
In Bulletin Medsubhyp 1, pp. 10-12, French Association for Subaquatic and Hyperbaric Medicine Service, 13 Marseille, December, 1969.

230. GRIFFITHS, P. D.
Clinical manifestations and treatment of decompression sickness in compressed air workers.
In P. B. Bennett and D. H. Elliott (Eds.) The physiology and medicine of diving. pp. 451-463. Baltimore: Williams and Wilkins Co., 1969.

The author distinguishes between type I (e.g., pain) and type II (e.g., chokes, CNS) symptoms. Claims the latter are more traumatic and appear earlier post-dive. It may follow that: (a) type II could be a useful premonitory sign of type I if workers could be encouraged to be candid; (b) some type II symptoms may appear more benign than type I and the worker may ignore them unless type I symptoms occur, with the result that the incidence of type II symptoms is underestimated.

231. KIDD, D. J., and D. H. ELLIOTT.
Clinical manifestations and treatment of decompression sickness in divers.
In P. B. Bennett and D. H. Elliott (Eds.) The physiology and medicine of diving. pp. 464-490. Baltimore: Williams & Wilkins, 1969.

A good review of diagnostic classification with data. They consider that 'the staggers' "...is a disturbance of labyrinthine function with vertigo, nystagmus, nausea and vomiting (p. 471)."

232. LANG, J., I. ROZSAHEGYI, and T. TARNOCZY.
Investigations of the hearing loss of caisson-workers.
Proceedings of the III. Conference against noise and vibrations. Bucur-esti, 1969. N.V.

233. MORRISON, L. E.
The ears, the nose, and the diver.
Eye Ear Nose Throat Mon. 48:508-511, September 1969. N.V.

234. SUMMITT, J. K., J. S. KELLEY, J. M. HERRON, and H. A. SALTZMAN.
Joint U. S. Navy--Duke University 1000-foot saturation dive.
U. S. Navy Experimental Diving Unit, Wash. D. C., Research Report 3-69,
41 p. May, 1969. N.V.

1970-1972

235. ADOLFSON, J., K. BJERVER, E. FLUUR, and L. GOLDBERG.
Vestibular reactions during hyperbaric conditions.
Forsvarsmedicin (Stockh) 6:234-238, 1970.

The authors found no difference in the vestibular ocular reflex at 10 ata induced by head (relative to neck) displacement--but see Hinoki and Terayama (1966, #431). This study should be repeated with whole body stimulation to minimize cervical inputs, then characteristics of the fast phase and slow phase velocity should be studied (RK), in addition to slow phase displacement. See also Kotaskova (1970, #751).

236. THE ATHLETIC INSTITUTE.
Human performance and scuba diving.
Proceedings of the Symposium on Underwater Physiology, La Jolla, Calif.,
April 10-11, 1970. Chicago: The Athletic Institute, 1970.

237. BENNETT, P. B., J. MORRISON, J. BEVAN, P. SHARPHOUSE, and J. EATON.
Interim report on some physiological studies during 1500 foot simulated
dive.
Royal Naval Physiological Laboratory Report IR 1/70, Alverstoke, England,
1970.

Authors state that during the compression phase: "Rapid movements of the head were followed by a slightly delayed sense of re-orientation (p. 23)."
"Decompression. One subject (P.S.) developed symptoms indicating loss of sense of balance including nausea and vomiting, especially whilst the eyes were open (p. 24)." Lying motionless helped. Decompression was attempted and helped somewhat, but caused syncopal symptoms in the other subject.

238. BUEHLMANN, A. A., H. MATTHYS, H. G. OVERRATH, P. B. BENNETT, D. H. ELLIOTT,
and S. P. GRAY.
Saturation exposures at 31 ata in an oxygen-helium atmosphere with excursions
to 36 ata.
Aerosp. Med. 41(4):394-402, 1970.

The authors report: In a 2-hour exposure to 31 ata, 2 subjects were symptom free; in a four-hour dive to 31 ata, vertigo, tremor, and tachycardia appeared in one subject and nausea in the other; in a third group of 2 subjects, both had tremor, 1 had tachycardia and the other vertigo and nausea; of 3 subjects exposed to 31 ata with excursions to 36 ata, 1 had nausea and vertigo.

239. CHAPMAN, R. M., C. P. CAVONIUS, and J. T. EPNEST.
Alpha and kappa electroencephalogram activity in eyeless subjects.
Science 171:1159-1161, 1970.

This study questions the results of Lippold (1970, #247) and Mulholland and Evans (1965, #169) regarding eye movements and EEG.

240. DEMARD, F., P. FREDENUCCI, and A. APPAIX.
Traitement hyperbare des surdités brusques et des surdités de l'oreille-interne
par barotraumatisme. (Hyperbaric treatment of sudden deafness and of deaf-
ness of the inner ear caused by barotrauma.)
In Bulletin Medsubhyp No. 1, French Association for Subaquatic and Hyperbaric
Medicine, pp. 13-14. Salvator Hospital, 13 Marseille (9e), December, 1969.
Trans. from French, NIC Trans. No. 3070, Naval Intelligence Command Hdqtrs.,
Wash. D. C., 22 June 1970.

241. EICHEL, B. S., and LANDES, B. S.
Sensorineural hearing loss caused by skin diving.
Arch. Otolaryngol. 92:128-131, 1970.
- Of two cases of unilateral hearing loss one person had dizziness and balance problems.
242. ELINSKII, M. P.
Decompression disorders after exposures to a "safe pressure" or a "safe altitude."
Milit. Med. J. 7:87-92, 1970.
- Describes some neurological disturbances and provides the translated title of Russian literature appearing within the past twenty years.
243. ENDERS, L. J., and E. RODRIGUEZ-LOPEZ.
Aeromedical consultation service case report: Alternobaric vertigo.
Aerosp. Med. 41(2):200-202, 1970.
- Claims alternobaric vertigo incidence may be underestimated. Contributing factors and differential diagnoses are discussed.
244. GRAYBIEL, A. (Ed.)
Fourth symposium on the role of the vestibular organs in space exploration. Naval Aerospace Medical Institute, Pensacola, Fla., September 24-26, 1968. Report No. NASA SP-187, 1970.
- This volume plus Graybiel (1965, #417; 1966, #576; 1967, #450) are the best collection of studies of the vestibular apparatus. See also Camis (1930, #299).
245. KREPS, E. M., et al.
Hyperbaric epilepsy and narcosis.
Joint Publications Research Service, Wash., D. C., JPRS-51714, 4 November 1970.
- Several articles which deal with CNS effects (in man and animals) from hyperbaria are contained in this translation.
246. LEHMANN, H. J., K. HELD, and G. WERNER.
Neurologische Folgezustände der Taucherkrankheit. (Neurological conditions resulting from diver's disease. Trans. by Mrs. A. Woke, NMRI, 1972.)
Nervenarzt 41:189-193, 1970.
- This study shows that neurological deficits involving the vestibular apparatus and its connections occur in connection with a career in compressed air work (see also Lang, 1971, #278).
247. LIPPOLD, O.
Origin of the alpha rhythm.
Nature 226:616-618, 1970.
- Changes in EEG are symptoms of the HPNS syndrome, and this study suggests that eye movements are related to EEG changes. The relationship of eye movements to vestibular stimulation is well known (cf. Robinson, 1968, #595).
248. OVERRATH, G., H. MATTHYS, and A. A. BUILMANN.
Saturation experiment at 31 ata in an oxygen-helium atmosphere.
Helv. Med. Acta 35(3): 180-200, 1970.
- Mentions vestibular symptomatology as part of the high pressure nervous system syndrome.

249. PLANTE-LANGCHAMP, G., P. MAESTRACCI, and H. NICOLAI-HARTER.
Deux cas de destruction labyrinthique après plongées.
In Bulletin Medsubhyp No. 4, Edite par la Comex B. P. 143 Mazargues, 13
Marseille, December 1970.

This article describes two instances of labyrinthine damage. In addition,
other articles in this Bulletin contain mention of vestibular difficulties.

250. STANG, P. R., and E. L. WIENER.
Diver performance in cold water.
Hum. Factors 12(4):391-399, 1970.

A good bibliography on cold water performance. Data showed also that one
of 14 people were nauseated (p. 393)--perhaps due to caloric irrigation of
the vestibular system. (RK)

251. U. S. NAVY.
U. S. Navy diving manual.
NAVSHIPS 0994-001-9010. Wash., D. C.: U. S. Govt. Printing Office, 1970.

Very small mention of vestibular functions is made in this publication.

252. VOROSMARTI, J., and M. E. BRADLEY.
Alternobaric vertigo in military divers.
Milit. Med. 135:182-185, 1970.

253. ZAL'TSMAN, G. L.
Initial manifestations of hyperbaric epilepsy in man.
In Giperbaricheskiye epilepsiya i narkos. pp. 155-162. Leningrad: 1968.
Trans. in Kreps, E. M., et al., Hyperbaric epilepsy and narcosis. pp. 26-43.
Wash. D. C.: Joint Publications Research Service, 4 November 1970.

This compilation (90 pp.) contains chapters from a book of about 300 pages.
Most of the articles deal with the CNS effects of compressed air and gas
mixtures (e.g., helium and argon), are excellent, and will repay careful
reading. (RK) Symptoms of the high pressure nervous system syndrome are
reported, particularly with regard to performance and EEG changes. Few
references to subjective symptoms "heaviness in the head (p. 49)" and
"nausea (p. 50)" are mentioned. Reports of "fullness of the head" are re-
ported (cf. e.g., Wendt, 1951, #345), often in connection with motion sickness.

254. ZINKOWSKI, N.
No air and bad air.
Undercurrents pp. 19-23, May 1970.

255. ADOLFSON, J. A.
Inert gas narcosis--A review.
Lecture presented at the Symposium on "Man in the Sea," University of Florida,
Communication Sciences Laboratory, Gainesville, Fla., 29 April 1971.

Some of the symptoms mentioned are, most likely, of vestibular origin. A
good bibliography.

256. ALVIS, H. J. (Ed.)
Hazards of valsalva maneuver. (Editor's Note.)
Hyperbaric Medicine Newsletter 7(5):6, 1971.

Describes the hazards of valsalva when used to clear the ears.

257. ANON.
Unique diving mask reduces jaw fatigue.
Oceanol. Int. 6(3):34, 1971.

Announcement of a new mask by General Aquadyne, Inc., to minimize jaw
fatigue. (cf. Pinto, 1966, #436; Costen, 1934, #302; Fields, 1958, #117.)

258. ANON.
OPNAV Form 9940/1(4-70) Combined diving log--accident injury report.
10, 19 September 1971.
- A case of vertigo is reported.
259. ANON.
Four divers to try for 5,000 foot "dry" dive. (Man in the Sea.)
Oceanol. Int. 11-12 August 1971.
- This is a report of the same dive described by Sundmaker (1972, #291) where vestibular problems occurred.
260. ANON.
"Dry" dive to 5,025 feet yields valuable data.
Oceanol. Int. 16-17, September 1971.
- Describes the vestibular symptomatology of the University of Pennsylvania Institute for Environmental Medicine dive.
261. BEHNKE, A. R.
Decompression sickness: Advances and interpretations.
Aerosp. Med. 42(3):255-267, 1971a.
- An excellent review and modern version of a previous paper by Behnke (1947, #72), but with less discussion of the earlier investigators (e.g., von Schrotter).
262. BEHNKE, A. R.
Personal communication regarding diving physiological decrements (e.g., labyrinthine fluid volume, bone marrow squeeze, and problems of the inner ear). 16 December 1971b.
263. BENNETT, P. B.
Psychological, physiological, and biophysical studies of narcosis.
In C. J. Lambertsen (Ed.) Underwater physiology. pp. 457-469. New York: Academic Press, 1971.
- Reporting on the work of others in helium diving, Bennett mentions... "dizziness and nausea during compression (p. 465)."
264. BENNETT, P. B., and E. J. TOWSE.
The high pressure nervous syndrome during a simulated oxygen-helium dive to 1500 feet.
Electroencephalogr. Clin. Neurophysiol. 31:383-393, 1971a.
- A good review of the literature precedes a report of "vestibular decompression sickness, resulting in vertigo, nausea, vomiting and photophobia (p. 387)" from 1500 feet in one of two subjects. The remainder of the paper deals mainly with a study of other aspects of the HPNS.
265. BENNETT, P. B., and E. J. TOWSE.
Performance efficiency of men breathing oxygen-helium at depths between 100 feet and 1500 feet.
Aerosp. Med. 42(11):1147-1156, 1971b.
- "Dizziness" and "nausea" reported by both divers (p. 1154).

266. BRAUER, R. W., R. O. WAY, M. R. JORDAN, and D. E. PARRISH.
Experimental studies on the high pressure hyperexcitability syndrome
in various mammalian species.
In C. J. Lambertsen (Ed.) Underwater physiology. pp. 487-500. New York:
Academic Press, 1971.
- Behavioral measures of vestibular stimulation in animals are difficult to
assess (e.g., dizziness, nausea), but perhaps are present in connection
with the high pressure hyperexcitability syndrome (see p. 498) as they are
in man (cf. Bennett, 1971, #263).
267. BROWN, F. M.
Vertigo due to increased middle ear pressure: Six-year experience of the
Aeromedical Consultation Service.
Aerosp. Med. 42(9):999-1001, 1971a.
- Case histories of alternobaric vertigo are described.
268. CAVE, F. M.
Some comments on a skin-diving death.
Med. J. Aust. 1(15):803-804, 1971.
- This paper should be read in conjunction with Fields (1958, p. 537, #117)
since the latter offers a mechanism by which the death might be explained.
Cave offers a different explanation.
269. CHOUTEAU, J., J. M. OCANA de SENTUARY, and L. PIRONTY.
Theoretical, experimental and comparative study of compression as applied
to intervention dives and saturation dives at great depths.
Physiological Studies Report N. 1.71 CEMA, March 25, 1971. (Trans. from
French by M. E. M. Hashmall, ONR contract N0014-67-A-0214-0009 with the
Biological Sciences Communication Project Medical Center, The George
Washington University, Wash. D. C.)
- Describes deep dives where symptoms of the high pressure nervous system
(HPNS) syndrome have been observed and includes as part of the syndrome
"nausea, vertigo...(p. 1)." Considers HPNS resembles neurovegetative
symptoms of the vagotonic type (p. 35), and it is known that vagotonic
effects tend to adapt, as in motion sickness.
270. COVEY, C. W.
Simulated dives indicated man can work down to 5,000-foot depths.
Undersea Technology 12(9):19-20, 1971.
- The vestibular problems of the 1200 foot University of Pennsylvania,
Institute for Environmental Medicine dive are reported.
271. DEMARD, F.
Hyperbarie et oxygénothérapie hyperbare en oto-rhino-laryngologie.
Doctoral thesis, 1968. 185 p. (Hyperbaria [life under high pressure]
and therapy with oxygen at high pressure in otorhinolaryngology.)
NAVSHIPS Trans. No. 1292, Wash., D. C., June 1971.
- The latter portion of this thesis deals with barotrauma. It has an ex-
haustive bibliography, and case histories and epidemiology are included.
Of particular interest is the section on "Barotrauma of the Internal Ear"
(p. 211 of the NAVSHIPS Translation).

272. EDMONDS, C.
Vertigo in diving.
Royal Australian Navy School of Underwater Medicine, Balmoral, N. S. W.
2091, Report No. 1/71, 1971.

An outstanding review article--probably the best single source regarding the medical implications of the vestibular apparatus in compressed air work. A nosology for differential diagnosis of vertigo in diving is offered (p. 7), and this or a similar classification should be adopted. Case histories are included; etiologies and countermeasures are suggested.

273. FRUCTUS, X., and P. FRUCTUS.
Research program on using various gaseous mixtures for very deep dives.
Trans. from French by L. J. Robbins. NAVSHIPS Translation No. 1276, 58.
Dept. of Navy, Wash., D. C., May 1971.

Vertigo, disorientation, and vomiting mentioned throughout. Additionally, the high pressure nervous system syndrome is described, and symptoms of drowsiness are emphasized. The soporific effect of vestibular stimulation is well known and should be considered.

274. FRUCTUS, X. R., R. W. BRAUER, and R. NAQUET.
Physiological effects observed in the course of simulated deep chamber dives to a maximum of 36.5 atmospheres in a helium-oxygen atmosphere.
In C. J. Lambertsen (Ed.) Underwater physiology. pp. 545-550. New York: Academic Press, 1971.

Vestibular problems during decompression (p. 546) are mentioned. Also the "somnia" (p. 547) mentioned may be of similar etiology to "drowsiness" in motion sickness (Graybiel, 1966, #576).

275. HEMPLEMAN, H. V., W. J. EATON, J. M. MORRISON, P. B. BENNETT, and R. M. BARNARD.
Experimental observations on men at pressures between 4 bars (100 ft.) and 47 bars (1500 ft.).
Royal Naval Physiological Laboratory, Alverstoke, England. Report No. 1-71, 1971.

Vestibular problems reported.

276. JOHNSTON, D. G., and W. D. BURGER.
Injury and disease of scuba and skin divers.
Postgrad. Med. pp. 134-139, April 1971.

A good section on ear injury.

277. KENNEDY, R. S., W. F. MORONEY, R. M. BALE, H. G. GREGOIRE, and D. G. SMITH.
Comparative motion sickness symptomatology and performance decrements occasioned by hurricane penetrations in C-121, C-130, and P-3 Navy aircraft.
Naval Aerospace Medical Research Laboratory, Pensacola, Fla., NAMRL-1139, July 1971.

278. LANGE, J., I. ROZSAHEGYI, and T. TARNOCZY.
Kochleovestibulare Befunde bei Caissonarbeitern. (Cochleovestibular conditions in caisson workers. Trans. by Mrs. A. Woke, NMRI, 1971.)
Monatsschr. Ohrenheilkd. Laryngorhinol. Reprint 1, 1971.
(Available from Verlag URBAN & SCHWARZENBERG, Kommanditgesellschaft, A-1096, Wien, Frankgasse 4.)

Shows that residual vestibular problems exist in a population of "432, predominantly under 40, trouble free caisson workers (p. 9)." Refers to a larger report (100 pp.) of the author and contains a few other references to their own work.

279. MCCORMICK, J. G., T. L. HIGGINS, R. M. CLAYTON, and R. W. BRAUER.
Auditory and vestibular effects of helium-oxygen hyperbaric chamber dives to convulsion depths.
82nd Meeting of the Acoustical Society of America, Denver, Colorado, 19-22 October 1971.
- Vestibular post-dive disorders were obtained in guinea pigs similar to vestibular loss found in a previous study of squirrel monkeys.
280. PEGG, J.
Five hundred sixteen ft. (16.6 ATA) five-day ocean saturation dive using a mobile habitat.
Aerosp. Med. 42(12):1257-1262, 1971.
- Vestibular problems (nystagmus and vertigo) in a dive two weeks previous (p. 1259) did not recur. Some mention of auditory problems.
281. REUTER, S. H.
Medical problems of the sport diver. (Also Editor's note.)
Hyperbaric Medicine Newsletter 7(6):3, 1971.
- Reports that "90% of the medical problems of the sport diver are centered around the middle ear (p. 3)."
282. RUBENSTEIN, C. J., and J. K. SUMMITT.
Vestibular derangement in decompression.
In C. J. Lambertsen (Ed.) Underwater physiology. pp. 287-292. New York: Academic Press, 1971.
- Even though a conservative criterion was employed, vestibular derangement incidence appears to be increasing. A very good discussion of possible etiologies is included.
283. SMITH, R. W.
Application of the critical incident technique to accident research in skin and scuba diving.
Presented at the Human Factors Society Meetings, New York, 1971.
- The use of this technique should be explored, particularly if one wishes to establish the base rate of vestibular symptomatology (vertigo, staxia, etc.).
284. SUMMITT, J. K., and S. D. REIMEPS.
Noise: A hazard to divers and hyperbaric chamber personnel.
Aerosp. Med. 42(11):1173-1177, 1971.
- This article reports, among other things, right mandibular numbness. It should be compared with Pinto (1966, #436) and Costen (1934, #302):
285. UDDIN, D. E., T. L. SALLEE, R. E. DANZIGER, E. M. NEPTUNE, J. M. ALEXANDER, E. T. FLYNN, and J. K. SUMMITT.
Biochemical studies during saturation diving: Two exposures at 19.2 ATA with excursions to 23.7 ATA.
Aerosp. Med. 42(7):756-762, 1971.
286. ADOLFSON, J., K. BJERVER, E. FLUUR, and L. GOLDBERG.
Balance disturbances in divers at 10 ATA ambient air pressure.
Manuscript (1970) cited in J. Adolfson, and T. Berghage. Man's sensory processes in the undersea environment. In press.

287. ALVIS, H. J. (Ed.)
Simulated dives to 5,000 feet.
Hyperbaric Medicine Newsletter 8(1):7, 1972a.

Mentions the vestibular disturbances in the dive conducted at the University of Pennsylvania, Institute for Environmental Medicine.

288. ALVIS, H. J. (Ed.)
Aseptic bone necrosis.
Hyperbaric Medicine Newsletter 8(3):1f, 1972b.

Reporting on a symposium at USN Submarine Base, New London, it was described that 5 to 20% of compressed air workers have aseptic bone necrosis even though they experience no symptoms and may not have experienced decompression sickness. The possibility exists that vestibular deficits are present in the same way in a diver population. (RK)

289. KENNEDY, R. S., and A. R. FREGLY.
Depressed vestibular function in Navy divers as reflected by caloric irrigation thresholds.
In press.

290. KENNEDY, R. S., and J. A. DIACHENKO.
A review of diver vestibular accidents.
In press.

291. SUNDMAKER, W. K. H.
Vestibular function.
Presented at the Special Summary Program-Predictive Studies III, University of Pennsylvania, State College, Pa., 5-7 April 1972.

Of four men exposed to a simulated depth of 1200 FSW, three experienced several vestibular problems (nausea, dizziness, nystagmus) with residual effects apparent post-dive. The problems did not appear to coincide with changes in pressure. The symptoms were somewhat similar to those of cupulolithiasis (Schuknecht, 1969, #493), although other diagnoses e.g., Costen's syndrome (1934, #302), epidemic vertigo, bubble formation, etc., are possible.

See also:

References 295, 297, 302, 306, 315, 338, 339, 345, 349, 354, 359, 362, 367, 369, 370, 390, 393, 403, 408, 411, 421, 424, 429, 431, 433, 436, 443, 444, 455, 458, 464, 472, 473, 474, 483, 490, 495, 496, 505, 511, 512, 521, 524, 552, 555, 558, 562, 577, 596, 610, 612, 626, 716, 734, 762, 773, 774, 824, 878, 895, 899, 900, 901, 902, 907, 914, 917, 918, 925, 926, 928, 947, 951, 956.

ADDENDUM TO Category I

- 291a. KORNHUBER, H. II.
Neurologie des Kleinhirns. (Neurology of the cerebellum. Trans. and summarized by Mrs. A. Woke, NMRI, 1972.)*
Z. Gesamte Neurol. Psychiat. 191:13, 1968.

The old structure in archi- or vestibulo-, paleo- or spino- and neo- or pontocerebellum is still useful for clinical orientation. Superior- and inferior vermiform processes belong to the spinocerebellum. Both work together to maintain equilibrium and body posture. Lesions produce disturbances in equilibrium. The inferior vermiform process is also connected with position nystagmus. The middle vermiform parts, especially folium and tuber, have a special function: apparently they serve the sight motor field. The anatomically found somatotopic structure of the superior vermiform process is clinically relevant--.*

- 291b. VYSLONZIL, E.
Über eine umschriebene Ansammlung von Otolonien im hinteren hautigen Bogengang.
(A transcribed accumulation of otoconia at the posterior membranous semicircular canal. Trans. and summarized by Mrs. A. Woke, NMRI, 1972.)*
Monatsschr. Ohrenheilkd. Laryngorhinol. 97:63-68, 1963.

The occurrence of a globular formation at the posterior semicircular canal, near the common pillar is reported. The author found this change in three cases of severe nephrogenous hypertonia and in one case of lupus erythematosus. It was found that large masses of otoconia build up this globe, whereby layers of albumin traverse this formation and simultaneously appear to represent the connective mass. The pathogenesis of otoconia migration and masses of albumin is discussed, and the apparently glandular formation at this location of the semicircular canal. This article should be compared with one on cupulolithiasis (Schuknecht, 1969, #493).*

CATEGORY II. CLINICAL INVESTIGATION OF VESTIBULAR SYMPTOMATOLOGY.

1900-1909

292. BARANY, R.
Untersuchungen über den vom Vestibular-apparat des Ohres reflektorisch ausgelosten rhythmischen Nystagmus und seine Begleiterscheinungen. (Investigations on vestibular apparatus of the ear, reflectively released rhythmic nystagmus and its accompanying symptoms. Summary [pp. 91-95] trans. by Mrs. A. Woke, NMRI, 1970.)
Berlin: Verlag Von Oscar Coblenz, 1906.

An early report of diagnostic tests.

293. GRAY, A. A.
The labyrinth of animals. Vol. I.
London: J. & A. Churchill, 1907.

The source for the anatomy of the labyrinth for many animals. The auditory and vestibular portions are described and the dimensions of all the parts are listed. In man, the caliber of a canal is about 1.4 mm; in mouse, about .25 mm.

1910-1919

294. WILSON, J. G., and F. H. PIKE.
IV. The effects of stimulation and extirpation of the labyrinth of the ear and their relation to the motor system.
Philos. Trans. R. Soc. Lond; B 203:121-159, 1912. N.V.

295. SCOTT, S.
Vertigo and nystagmus associated with inflation of the Eustachian tube.
J. Laryngol. Rhinol. Otol. 34:51-52, 1919.

It occurs.

1920-1929

296. CHAROUSEK, H.
Zur mechanik des Drucksymptoms. (The mechanics of pressure symptoms. Trans. by Mrs. A. Woke, NMRI, 1972.)
Z. Hals, Nasen Ohrenheik. 15:225-227, 1926.

297. GUILD, S. R.
Observations upon the structure and normal contents of the ductus and saccus endolymphaticus in the guinea-pig (*cavia cobaya*).
Am. J. Anat. 39(1):1-56, 1927a.

The circulation of the labyrinth is described. The article provides important leads in the diagnosis of vestibular symptoms of decompression sickness. (RK)
Good bibliography, long article.

298. GUILD, S. R.
The circulation of the endolymph.
Am. J. Anat. 39:57, 1927b. N.V.

1930-1939

299. CAMIS, M.
The physiology of the vestibular apparatus.
Oxford, England: Clarendon Press, 1930.

An old, excellent, and only formal text of the vestibular system. It is largely not out of date. (RK)

300. HUGHSON, W.
A note on the relationship of cerebrospinal and intralabyrinthine pressures.
Am. J. Physiol. 101:396-407, 1932.
301. HUGHSON, W., and S. J. CROWE.
Experimental investigation of the physiology of the ear.
Acta Otolaryngol. (Stockh) 18:291-339, 1932-33.
- The section on methods for measuring the relationship of cerebrospinal fluid pressures and intralabyrinthine pressures is interesting. (RK)
302. COSTEN, J. B.
A syndrome of ear and sinus symptoms dependent upon disturbed function of the temporomandibular joint.
Ann. Otol. Rhinol. Laryngol. 43(1):1-15, 1934.
- Following removal of the posterior teeth temporomandibular joint problems can occur and vertigo, among other symptoms, has been reported. Long-term mouthpiece use could produce similar problems. (RK)
303. SPIEGEL, E. A.
Vertigo in brain tumors, with special reference to the results of labyrinth examination.
Ann. Otol. Rhinol. Laryngol. 45:979-998, 1936.
- A good article with good references by a person long concerned with the central connections of the vestibular apparatus.
304. MCINTYRE, A. K.
The quick component of nystagmus.
Am. J. Physiol. 91:8-16, 1939.
305. SPIEGEL, E. A., and J. B. PRICE.
Origin of the quick component of labyrinthine nystagmus.
Arch. Otolaryngol. 30:576-588, 1939.
- The relationship of the fast phase of nystagmus to central arousal centers is discussed.

1940-1949

306. JOHNSON, F. H., D. E. S. BROWN, and D. A. MARSLAND.
Pressure reversal of the action of certain narcotics.
J. cell. comp. Physiol. 20:269-276, 1942.
- Perhaps a clue to the etiology of some symptoms associated with protracted exposures to high pressures will be found in this and related studies.
307. MCNALLY, W. J., and E. A. STUART.
Physiology of the labyrinth reviewed in relation to seasickness and other forms of motion sickness.
War Med. 2:683-771, 1942.
- A good review paper for vestibular physiology as well as motion sickness.
308. SMITH, H. W., and G. W. MANNING.
The relationship between daily urinary output and the incidence of decompression sickness.
No. 2 Clinical Investigation Unit, RCAF, August 1942. (Cited in Adler, 1964)
- See Warwick (1942, #309; 1943, #311).

309. WARWICK, O. H.
The apparent relationship of fluid balance to the incidence of decompression sickness.
No. 2 Clinical Investigation Unit, RCAF, Regina. Report to NRC, April 1942.
(Cited in Adler, 1964)
- High fluid excretion rates appear to afford some protection from DCS Contrast with hydrops in Meniere's disease.
310. WEVER, E. G., C. M. BRAY, and M. J. LAWRENCE.
Effects of pressure in the middle ear.
J. Exp. Psychol. 30:40, 1942. (Cited by A. Pagano, 1959) N.V.
311. WARWICK, O. H.
Further studies on the relationship of fluid intake and output to the incidence of decompression sickness.
Flying Personnel Medical Section. No. 1 "Y" Depot, RCAF, Halifax. Report to NRC, Feb. 1943.
(Cited by Adler, 1964)
- See Warwick (1942, #309).
312. KOS, C. M., and H. D. SMITH.
Aviation otolaryngology.
Handbook AAF School of Aviation Medicine, Randolph Field, Tex., 1944.
- A good handbook. It would be useful if modified for high pressure and underwater otolaryngological examination.
313. MORALES, M. F., E. N. RATHBUN, R. E. SMITH, and N. PACE.
Studies on body composition. II. Theoretical considerations regarding the major body tissue components, with suggestions for application to man. 8p.
U. S. Naval Medical Research Institute, Bethesda, Md., Report No. 2, Project X-191, 7 August 1944. N.V.
314. OGDEN, F. W.
Tubal resistance and sero-otitis media.
U. S. AAF School of Aviation Medicine, Randolph Field, Tex.
Report No. 1, Project 268, 24 June 1944. N.V.
315. TEED, R. W.
Factors producing obstruction of the auditory tube in submarine personnel.
U. S. Nav. Med. Bull. 42(2):293-306, 1944.
316. BATEMAN, G. H.
The effect of sinusitis on flying personnel.
J. Laryngol. Otol. 60:110, 1945. N.V.
317. NIELSEN, J. C.
Studies of the aetiology of acute otitis media. 191 pp.
Copenhagen: Ejnar Munksgaard, 1945. N.V.
318. SENTURIA, B. H.
Etiology of externa otitis.
U. S. AAF School of Aviation Medicine, Randolph Field, Tex., Project 349,
Report No. 1, 15 pp., 15 January 1945. N.V.
319. BIERMAN, H. R., and I. W. BRICKMAN.
The relationship of dental malocclusion to vacuum-otitis media and the use of dental splints during descent from altitudes.
Ann. Otol. Rhinol. Laryngol. 55(1):5-12, 1946.

This paper should be considered with Pinto (1966, #436) and Costen (1934, #302).

320. BROWN, B. R.
The incidence and relation of syncope to decompression sickness.
J. Aviat. Med. 17:257-264, 1946.
- Syncopal reactions and vestibular symptomatology are very similar and may be confused in decompression sickness.
321. EAGLE, W. W.
Secretory otitis media.
Ann. Otol. Rhinol. Laryngol. 55:55-67, 1946.
322. KELLY, W. J.
The results of dental therapy in 50 cases of aerotitis media in submarine personnel based upon a new functional concept of Eustachian tube blockage.
U. S. Navy Submarine Base, New London, Conn. Medical Research Dept. Project X-434 (Sub. No. 89), Interval Report No. 1, 21 January 1946a. N.V.
323. KELLY, W. J.
Dental treatment of trismus, tinnitus, otalgia and obscure neuralgias.
U. S. Navy Submarine Base, New London, Conn. Medical Research Dept. Project X-434 (Sub. No. 90), Interval Report 2, 31 January 1946b. N.V.
324. KELLY, W. J.
A rapid dental treatment for the prevention of aerotitis media.
U. S. Navy Submarine Base, New London, Conn. Medical Research Dept. Project X-434 (Sub. No. 90), Interval Report No. 3, 1 February 1946c. N.V.
325. KELLY, W. J.
An evaluation of a dynamic concept of dental treatment based upon a functional classification of malocclusion.
U. S. Navy Submarine Base, New London, Conn. Medical Research Dept. Project X-434 (Sub. No. 90), Interval Report No. 4, 15 February 1946d. N.V.
326. STERNSTEIN, H. J.
Management of common eye, ear, nose, and throat conditions in naval practice.
U. S. Nav. Med. Bull. 1041-1052, 1946. N.V.
327. AHLEN, G.
On the connection between cerebrospinal and intra-labyrinthine pressure and pressure variation in the inner ear.
Acta Otolaryngol. (Stockh) 35:251-257, 1947.
328. BALLENGER, W. L., H. C. BALLENGER, and J. J. BALLENGER.
Injuries and diseases of the tympanic membrane.
In Diseases of the nose, throat and ear. pp. 637-641. Philadelphia: Lea & Febiger, 1947a. N.V.
329. BALLENGER, W. L., H. C. BALLENGER, and J. J. BALLENGER.
Diseases of the Eustachian tubes.
In Diseases of the nose, throat and ear. pp. 642-651. Philadelphia: Lea & Febiger, 1947b. N.V.
330. CATCHPOLE, H. R., and I. GERSH.
Pathogenic factors and pathological consequences of decompression sickness.
Physiol. Rev. 27:360-397, 1947.

An excellent review paper and of particular use when considered along with what is known about vestibular physiology in making a differential diagnosis for the most likely source of a "bubble" with regard to vestibular symptoms, although the latter are not described as such. They claim that bubbles are about .025 mm in diameter and plug up arterioles of the same order of magnitude. Semicircular canals in humans are about 1 mm in diameter (Gray, 1907, #293; 1908, #782). A good review of the pathology regarding the central nervous system (pp. 373 ff.), and an exhaustive bibliography.

331. SIMPSON, W. L. and J. E. WITCHER.
A study of the eustachian tubes and their orifices and lumens in patients with large operative defects giving direct visualization.
Ann. Otol. Rhinol. Laryngol. 56:357-367, 1947. N.V.
332. CARRUTHERS, D. G.
Diseases of the middle ear.
In Diseases of the ear, nose, and throat. pp. 201-210. Baltimore: The Williams & Wilkins Co., 1948a. N.V.
333. CARRUTHERS, D. G.
The complications of suppurative otitis media.
In Diseases of the ear, nose, and throat. pp. 211-238. Baltimore: The Williams & Wilkins Co., 1948b. N.V.
334. FARRIOR, J. B.
Lymphoid eustachian salpingitis: its effect on tubal patency.
Arch. Otolaryngol. 48:212-232, 1948. N.V.
335. LEWIS, R. S.
Common accidents to the ears and their treatment.
Med. Pr. 219:579-582, 1948. N.V.
336. WEVER, E. G., M. LAWRENCE, and K. R. SMITH.
Effects of negative air pressure in the middle ear.
Ann. Otol. Rhinol. Laryngol. 57:418-428, 1948. N.V.
337. JONES, M. F., and F. C. EDMONDS.
Acoustic and vestibular barometry: air pressure effects on hearing and equilibrium on unoperated and fenestrated ears.
Ann. Otol. Rhinol. Laryngol. 58(2):323-344, 1949.
338. LEMPERT, J., E. G. WEVER, M. LAWRENCE, and P. E. MELTZER.
Perilymph: Its relation to the improvement of hearing which follows fenestration of the vestibular labyrinth in clinical otosclerosis.
Arch. Otolaryngol. 50:377-387, 1949.
- Discusses effects of pressure changes within the vestibular labyrinth occasioned by surgery. There may be leads here for understanding vestibular problems which occur at high pressure. (RK)

1950-1959

339. CHANG, H. T., R. MARGARIA, and S. GELFAN.
Pressure changes and barotrauma resulting from decompression and recompression in the middle ear of monkeys.
Arch. Otolaryngol. 51:378-399, 1950.
- The mechanism of barotraumatic otitis media is described and studied.
340. ENGSTROM, H., and S. HJORTH.
On the distribution and localization of injected dyes in the labyrinth of the guinea pig.
Acta Otolaryngol. (Stockh) Suppl. 95:149, 1950. N.V.
341. HOOPLE, G. D.
Otitis media with effusion--a challenge to otolaryngology.
Laryngoscope 60(4):315-329, 1950.
342. HALLPIKE, C. S., M. S. HARRISON, and E. SALTER.
Abnormalities of the caloric test results in certain varieties of mental disorder.
Acta Otolaryngol. (Stockh) 39:151-159, 1951.

343. HAYASHI, S.
Statistic study of mastoid cell development in cases of chronic otis media,
as observed in X-ray pictures.
J. Oto-rhinolaryng. Soc. (Tokyo) 54(6):28-29, 1951. (English text pagination.)
N.V.
344. MCCANCE, R. A., and E. M. WIDDOWSON.
Composition of the body.
Br. Med. Bull. 7:297-306, 1951. N.V.
345. WENDT, G. R.
Vestibular functions.
In S. S. Stevens (Ed.) Handbook of experimental psychology. pp. 1191-1223.
New York: Wiley, 1951.

Probably the best single heuristic, descriptive and concise source for
VESTIBULAR FUNCTIONS (in the fewest number of pages). The anatomy, physiology,
neurology, psychology, etc., of the vestibular apparatus is described. (RK)
346. DIX, M. R., and C. S. HALLPIKE.
The pathology, symptomatology and diagnosis of certain common disorders of the
vestibular system.
Ann. Oto-laryng. (Paris) 61:987-1016, 1952.
Proc. R. Soc. Med. 45:341-354, 1952.

Reviews the original works of Meniere regarding diagnosis of Meniere's disease.
Includes also a discussion of other vestibular disorders.
347. HYDE, R. W.
Aerotitis media. A critical review.
Ann. Otol. Rhinol. Laryngol. 61:937, 1952. (Cited by A. Pagano, 1959.) N.V.
348. BORISON, H. L., and S. C. WANG.
Physiology and pharmacology of vomiting.
Pharmacol. Rev. 5:193-230, 1953.

This pathway can be involved in DCS from vestibular or other stimulation.
349. CROSBY, E. C.
Nystagmus as a sign of central nervous system involvement.
Ann. Otol. Rhinol. Laryngol. 62:1117-1126, 1953.
350. ANDERSEN, H. C., O. JEPSEN, and F. KRISTIANSEN.
The occurrence of directional preponderance in some intracranial disorders.
Acta Otolaryngol. (Stockh) Suppl. 118:19-31, 1954.
351. LEE, G., J. M. B. MATTHEWS, and E. P. SHARPEY.
The effects of the valsalva manoeuvre on the systemic and pulmonary arterial
pressure in man.
Br. Heart J. 61:311, 1954. N.V.
352. MILLER-GUERRA.
Le syndrome cerebelleux et le syndrome vestibulaire.
Masson et G. Parigi, 1954.
(Cited by A. Pagano, 1959.) N.V.
353. SEYMOUR, J. C.
Observations on the circulation in the cochlea.
J. Laryngol. Otol. 68:689, 1954.

354. U. S. DEPARTMENT OF THE NAVY.
Instructor's manual for high altitude physiology training in low pressure chambers. Device 9-A series.
Department of the Navy, Special Devices Center, Port Washington, N. Y.,
NAVEXOS P-1260, April 1954.
- A very good and simple description (with figures) of the mechanism of barotrauma is offered (pp. 7-9). It also is interesting that vestibular symptoms of DCS are not mentioned as such (pp. 10-12).
355. IRWIN, J. W., F. L. WEILLE, and W. S. BURRAGE.
Small blood vessels during allergic reactions.
Ann. Otol. Rhinol. Laryngol. 64:1164-1175, 1955.
356. PERLMAN, H. B., and R. S. KIMURA.
Observations of the living blood vessels of the cochlea.
Ann. Otol. Rhinol. Laryngol. 64:1176-1192, 1955.
- This article is of use for mapping potential bubble transport. (RK)
357. RYAN, G. M. S., and S. COPE.
Cervical vertigo.
Lancet 2:1355-1358, 1955.
358. WHITE, C. S., J. E. ROBERT, and H. W. MEREDITH.
The relation between dental overbite and aerotitis media.
J. Aviat. Med. 252:180, 1954; Exc. Med. 23, 1955. N.V.
359. GRAY, L. P.
Extra labyrinthine vertigo due to cervical muscle lesions.
J. Laryngol. Otol. 70:352-361, 1956.
- Shows that a combination of vertigo, nausea, and tinnitus can result from localized cervical lesions.
360. VAN EGMOND, A. A. J., and W. F. B. BRINKMAN.
On the function of the saccus endolymphaticus.
Acta Otolaryngol. (Stockh) 46:285-289, 1956.
- Suggests that the function of the saccus is a suction to provide protection within the labyrinth. Pressure changes might perturb function.
361. WANG, S. C., and H. I. CHINN.
Experimental motion sickness in dogs. Importance of labyrinth and vestibular cerebellum.
Am. J. Physiol. 185:617-623, 1956.
- The connections of the vestibular system with the cerebellum are reported.
362. DEWITT, G.
Acquired sensitivity to sea sickness after an influenza infection.
Pract. Otorhinolaryngol. (Basel) 19:579-586, 1957.
- Perhaps vestibular symptomatology in general is potentiated by illness of flu type. This may be an additional reason not to dive when ill, since decompression sickness type II symptoms often resemble motion sickness symptoms and other similar syndromes have been connected with decompression sickness (e.g., migraine, syncope).
363. TAYLOR, N. B. G., J. HUNTER, and W. H. JOHNSON.
Antidiuresis as a measurement of laboratory-induced motion sickness.
Can. J. Biochem. 35:1017-1027, 1957.
- This article shows that a vestibular stimulus (which results in motion sickness) also produces a release of ADH. The antidiuresis which occurs in connection with DCS may also be related to vestibular or vagal stimulation. (RK)

364. ALPERS, B. J.
Symptoms and signs associated with vertigo.
Mod. Med. Monogr. 15:27-40, 1958.
365. CAWTHORNE, T.
Vertigo. (President's address)
Proc. R. Soc. Med. 52:529-536, 1958.
- A very good description of the phenomenon.
366. FREEBERG, N. E.
Environmental and pilot aspects of the vertigo accident.
U. S. Naval Aviation Safety Center, Norfolk, Va., Report No. AM 1-58, 1958.
- Vertigo cases which resulted in aviation accidents are reported.
367. SNYDER, J. F.
Dive reaction scale study. Project NS185-005 Subtask 5, Test 10.
U. S. Navy Experimental Diving Unit, Wash., D. C. Research Report 5-58,
13 March 1958.
- A scale such as this should be re-introduced to diving medicine for many reasons: (a) diagnoses can be made more reliably; (b) saturation diving forms of DCS are less clear cut and probably more serious than previously (see Rubenstein & Summitt, 1971, #282), and a rating scale such as this would be useful; (c) a similar approach would be useful for diagnostic classification of perceptual distortions which occur under water. (RK)
368. GERNANDT, B.
Vestibular mechanisms.
In Field & Magoun (Eds.) Handbook of physiology. Vol. I. Neurophysiology.
pp. 549-564. Philadelphia: Williams & Wilkins, 1959.
369. KUILMAN, J.
The importance of the cervical syndrome in otorhinolaryngology.
Pract. Otorhinolaryngol. (Basel) 21(2):174-185, 1959.
- The relationship of vestibular and cervical systems should be considered in the diagnoses of decompression sickness symptomatology. (RK)
370. WING, K. G.
Studies of basic cochlear physiology and the energy-metabolism of the cochlear response in the cat.
Acta Otolaryngol. (Stockh) Suppl. 148:1-97, 1959.
- A good and long paper (94 pp.), which utilized oxygen and nitrogen to study various responses of the ear in the cat. A large reference list.

1960-1969

371. CODY, D. T. R., and H. L. WILLIAMS.
Cogan's Syndrome.
Laryngoscope 70:447-478, 1960.
- A review of previous literature with the addition of four new case histories of "nonsyphilitic interstitial keratitis" (p. 447). Symptoms include vertigo, ataxia, tinnitus, nystagmus, and bilateral sensory neural deafness. Complaints referable to eyes or ears may be premonitory signs. "From the available evidence it would seem that this systemic disease is periarteritis nodosa (p. 473)."
372. FERNANDEZ, C., R. ALZATE, and J. R. LINDSAY.
Experimental observations on postural nystagmus.
USAF Aerospace Medical Center, Brooks AFB, Tex., 60-23, January 1960.

373. JERGER, J., and T. TILLMAN.
A new method for the clinical determination of sensorineural acuity level (SAL).
A. M. A. Arch. Otolaryngol. 71:948-955, 1960.
374. KROL, Ya. M., and LA. KUDEL'SKIY.
Characteristics of inflammatory diseases of the nasal sinuses in submariners.
Voen. Med. Zh. 3:92-98, 1960. N.V.
375. LABA, L., and J. RUSZEL.
About permanent injury of the ear in divers.
Bull. Inst. Mar. Med. Gdansk 11:165-172, 1960. N.V.
376. BERGSTEDT, M.
Studies of positional nystagmus in the human centrifuge.
Acta Otolaryngol. (Stockh) Suppl. 165, 1961.

The most complete reference to the influence of alcohol on vestibular functioning.
377. COLLINS, W. E., W. E. CRAMPTON, and J. B. POSNER.
Effects of mental activity on vestibular nystagmus and the electroencephalogram.
Nature 190:194-195, 1961.

The implication of nystagmus and arousal is discussed and should be considered with reports of lowered arousal in the HPNS syndrome.
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Pressure changes in the middle ear after altering the composition of contained gas.
Acta Otolaryngol. (Stockh) 53:1-11, 1961.

Studied the "normal" steady state partial pressure of oxygen in the middle ear (ca. 55 mm Hg).
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Early diagnosis of hydrops of the labyrinth.
USAF Aerospace Medical Center, Brooks AFB, Tex., Review 1-61, February 1961.

Hearing losses appear to precede vertigo in Meniere's disease.
380. WEILLE, F. L., J. W. IRWIN, G. JAKO, L. HOLSCHULL, A. S. WEILLE, C. A. STANLEY,
and M. G. RAPPAPORT.
Pressure of the labyrinthine fluids.
Ann. Otol. Rhinol. Laryngol. 67:528-540, 1961. N.V.
381. ALLEN, G. W., and M. HABIBI.
The effect of increasing the cerebrospinal fluid pressure upon the cochlear microphonics.
Laryngoscope 72(4):423-434, 1962.
382. BERNSTEIN, L.
The otology and diagnosis of vertigo.
Arch. Otolaryngol. 76:329-337, 1962.

Discusses epidemiology and methods of differential diagnosis of vertigo (vestibular versus central nervous system origin).
383. BRODAL, A., O. POMPEIANO, and F. WALBERG.
The vestibular nuclei and their connections, anatomy and functional correlations.
Edinburgh: Oliver & Boyd, 1962.

384. BURGER, D., and J. W. VAN DEN BERG.
Experimental huskiness. (Hoarseness.)
Pract. Otorhinolaryngol. (Basel) 24:193-202, 1962. N.V.
385. DAVEY, L. M., and W. J. GERMAN.
The vestibular system and its disorders.
Ann. Rev. Med. 13:431-446, 1962.
- An excellent article with a very complete bibliography.
386. FLUUR, E.
The mechanism of nystagmus.
Acta Otolaryngol. (Stockh) 54:181-188, 1962.
- Different control centers for vertical and horizontal nystagmus are reported.
387. FUREY, J. A., and R. N. KRAUS.
A clinical classification of vertigo.
School of Aerospace Medicine Review No. 7-61, U. S. A. F. Aerospace Medical
Division (AFSC), Brooks AFB, Tex., AD287069, April 1962.
- An excellent treatment of description and differential diagnosis. Of more than
passing interest are the sections on epidemic vertigo (p. 1316) vestibular
neuritis (p. 1320) and pseudo (p. 1321) and atypical (p. 1322) Meniere's
syndrome.
388. JERGER, J.
Hearing tests in otologic diagnosis.
Asha 4(5)139-145, 1962.
389. PHILIPSZON, A. J.
Compensatory eye movements and nystagmus provoked by stimulation of the vestibular
organ and the cervical nerve roots.
Pract. Otorhinolaryngol. (Basel) 24:193-202, 1962.
- This study should be compared with the study of Adolfson, Bjerver, Fluur, and
Goldberg (1970, #235). In the latter, head and neck movements were made in
hyperbaric air.
390. PINTO, O. F.
A new structure related to the temporomandibular joint and middle ear.
J. Prosthetics & Dentistry 12(1):95-103, 1962.
- If some vestibular problems under water and pressure are shown to be related
to Costen's (1934, #302) syndrome, then this article is important. See also
Pinto (1966, #436).
391. SANDSTROM, J.
Cervical syndrome with vestibular symptoms.
Acta Otolaryngol. (Stockh) 54:207-226, 1962.
- A good paper which points out that the locus for some so-called vestibular
symptoms is the cervical region.
392. SCHUKNECHT, H. F.
Positional vertigo: Clinical and experimental observations.
Trans. Am. Acad. Ophthalmol. Otolaryngol. 66:319-331, 1962.
- An early paper describing the symptoms which were later (Schuknecht, 1969, #493)
called "cupulolithiasis."

393. ARNVIG, J.
Transitory decrease of hearing after lumbar puncture.
Acta Otolaryngol. (Stockh) 56:699-705, 1963.
- The author shows that changes in lumbar region can result in functions associated with nerve VIII (nausea and hearing loss).
394. COLES, R. R. A.
Ears and their after effects.
R. Nav. Diving Magazine 10(3):5-11, 1963.
395. COLLINS, W. E., and J. B. POSNER.
Electroencephalogram alpha activity during mild vestibular stimulation.
Nature 199:933-934, 1963.
- See Collins, et al. (1961, #377).
396. ELIA, J. C.
Practical treatment of otitis externa.
Maryland Med. J. 12:501-503, 1963. N.V.
397. FLINN, D. E., and G. J. WOMACK.
Neurological manifestations of dysbarism: a review and report of a case with multiple episodes.
Aerosp. Med. 34:956-962, 1963.
- Because the symptoms of migraine and vestibular involvement are similar, particularly in connection with decompression sickness, this report is useful.
398. FLISBERG, K., S. INGELSTEDT, and U. ORTEGREN.
The valve and "locking" mechanisms of the Eustachian tube.
Acta Otolaryngol. (Stockh) Suppl. 182, 57-68, 1963.
399. HARRISON, M. S., and I. NAFTALIN.
Meniere's disease.
J. Laryngol. Otol. 77:832-833, 1963.
- Shows a relationship between fluid retention and vertigo in Meniere's disease.
400. NOZUT, M.
Title and article in Japanese.
Otolaryngology (Tokyo) 35:901-907, 1963.
- English Abstract: Observations were made on 51 patients with sudden onset of deafness that was combined with some vestibular disturbances at the Out-patient Department of Otolaryngology at the Tokyo University Medical School Hospital; attentions in these examinations were particularly focused on the types of nystagmuses and the conditions to which the vestibular organs may be disturbed. Directions of the nystagmus varied from simple horizontal to rotatory, direction changing and vertical. From the nature of nystagmus manifested in this way in cases of sudden deafness, the authors believe that, the pathology of this disease is extremely complicated depending upon the degree and the location of the lesion which may be localized in the cochlea or the vestibule; that it may be the influence of some disturbances in the central region particularly the brain stem should also be seriously considered.
401. PHILIPSZON, A. J., and J. H. BOS.
Neck torsion nystagmus.
Pract. Otorhinolaryngol. (Basel) 25:339-344, 1963.
- Vertigo and nystagmus are generally, but not always, of vestibular origin. Because spinal lesions in DCS can occur, this factor should be considered. (RK)

402. SERRINS, A. J., R. HARRISON, AND J. R. CHANDLER.
Cogan's syndrome. An audiologic evaluation and review of current concepts.
Arch. Otolaryngol. 78:785-789, 1963.
- A disease entity where neurological deficits other than those which involve nerve VIII appear absent. The symptoms have some communalities with studies of otological deficits in caisson workers. (RK)
403. STEARNS, P. E., and C. F. KASPAREK.
Catalog of scientific publications, 1942-Present.
U. S. Naval School of Aviation Medicine, Pensacola, Fla., 31 December 1963.
(Original publication date; updated periodically.)
- This catalog of scientific publications contains more citations of studies regarding the vestibular apparatus than any other.
404. SZEKELY, E. G., and A. A. SPIEGEL.
Vertical nystagmus induced by injection of stimulating substances into the striatum, third, or lateral ventricle.
Neurology 13(4):306-314, 1963.
405. THOMAS, J. J.
Chemical mechanisms in oxygen toxicity.
Proceedings, Second Symposium on Underwater Physiology. Office of Naval Research, February 25-26, 1963. pp. 139-151. Wash., D. C.: National Academy of Sciences-National Research Council, 1963.
406. ALLEN, G. W.
Endolymphatic sac and cochlear aqueduct.
Arch. Otolaryngol. 79:322-327, 1964. N.V.
407. ANSON, J. B., J. A. DONALDSON, R. L. WARPEHA, and T. R. WINCH.
Surgical anatomy of the endolymphatic sac and perilymphatic duct.
Laryngoscope 74:480-497, 1964. N.V.
408. COLES, R. R. A.
Eustachian tube function.
J. R. Nav. Med. Serv. 50:23-29, 1964.
- Inability to equalize a standard pressure level is cause for rejection from diver training. It might be interesting to determine whether a negative linear relationship exists between hyperbaric vestibular involvement and the magnitude of pressure equalization beyond the standard minimum. (RK)
409. JONGKHEZS, L. B. W., and A. J. PHILIPSZOOM.
Electronystagmography.
Acta Otolaryngol. (Stockh) Suppl. 189, 1-111, 1964. N.V.
410. LUNDQUIST, P. G., P. S. KIMURA, and J. WERSALL.
Experiments in endolymph circulation.
Acta Otolaryngol. (Stockh) Suppl. 188, 1964. N.V.
411. MACFIE, W. C. D. D.
E. N. T. problems of diving.
Med. Serv. J. Can. 20:845-861, 1964.
- The embryology of the ears, nose, and throat is discussed. The author indicates that the mechanical reasons for 94% of the separation from diving training "lay in the ear, nose, and throat (p. 851)." Barotrauma to parts of the ear is discussed. Case histories which also include vestibular difficulties are discussed.

412. ANSON, B. J., J. A. DONALDSON, R. L. WARPERA, and T. R. WINCH.
The vestibular and cochlear aqueducts: their variational anatomy in the adult human ear.
Laryngoscope 75:8, 1965. N.Y.

413. BERNSTEIN, L.
Simplification of clinical caloric test.
Arch. Otolaryngol. 81:347-349, 1965.

414. DAVISON, R. A.
Ventilation of the normal and blocked middle ear. A review of mechanisms.
Ann. Otol. Rhinol. Laryngol. 74:162-173, 1965. N.Y.

415. EDWARDS, C. H.
The differential diagnosis of vertigo.
In W. G. Scott-Brown, J. Ballantyne, and J. Groves (Eds.) Diseases of the ear, nose, and throat. Vol. II. Wash., D. C.: Butterworths, 1965.

416. GERNANDT, B. E., M. IGARASHI, and H. W. ADES.
Effects of prolonged caloric stimulation upon oculomotor, vestibulospinal, and segmental spinal activity.
U. S. School of Aviation Medicine, Pensacola, Fla., and National Aeronautics and Space Administration, NSAM-934, NASA Order No. R-93, 24 June 1965.

417. GRAYBIEL, A. (Ed.)
Symposium on The Role of the Vestibular Organs in the Exploration of Space.
U. S. Naval School of Aviation Medicine, Pensacola, Fla., Report No. NASA SP-77, January 20-22, 1965.

This volume plus Graybiel (1966, #576; 1967, #450; 1968, #588) are the best collection of studies on the vestibular apparatus. See also Camis (1930, #299).

418. GRAYBIEL, A., R. S. KENNEDY, E. C. KNOBLOCK, F. E. GUEDRY, JR., W. MERTZ, M. E. MCLEOD, J. K. COLEHOUR, E. F. MILLER, II, and A. R. FREGLY.
Effects of exposure to a rotating environment (10 RPM) on four aviators for a period of twelve days.
Aerosp. Med. 36(8):733-754, 1965.

Decreased urinary output in connection with a bizarre vestibular stimulus (p. 742) is reported. Radomski and Bennett (1970a, #504) show increased sodium retention with pressure, and Warwick (1942, #309; 1943, #311) shows that high fluid exchange rates afford some protection from altitude decompression sickness.

419. GUEDRY, F. E.
Psychophysiological studies of vestibular function.
In W. D. Neff (Ed.) Contributions to sensory physiology, Vol. I. pp. 63-135.
New York: Academic Press, 1965.

A very good review paper.

420. MONTANDON, A., P. MONTANDON, G. KAPHAN, and J. LIBOIS.
Nystagmus central et nystagmus peripherique. (English summary.)
Acta Otolaryngol. (Stockh) 59:320-328, Feb.-Apr., 1965.

421. MORRISON, A. R., and O. POMPEIANO.
Vestibular influences on vegetative functions during the rapid eye movement periods of desynchronized sleep.
Experientia 21(11):667-668, 1965.

This paper, and Pompeiano and Morrison (1965, #171) show a relationship between the vestibular nuclei and REM sleep and should be consulted for leads regarding the relationship of their findings to the microsleep reported as a symptom of the High Pressure Nervous [system] Syndrome by Fructus and Fructus (trans. 1971, #273) and Bennett and Towse (1971a, #264). (RK)

422. PICKARD, B.
Physiology of equilibration.
In W. G. Scott-Brown, J. Ballantyne, and J. Groves (Eds.) Diseases of the ear, nose, and throat. Vol. II. Wash., D. C.: Butterworths, 1965a.
423. SCOTT-BROWN, W. G., J. BALLANTYNE, and J. GROVES. (Eds.)
Diseases of the ear, nose and throat. Vol. II.
Wash., D. C.: Butterworths, 1965.

There are many excellent chapters in this book.

424. SIMPSON, J. F.
Meniere's disease.
In W. G. Scott-Brown, J. Ballantyne, and J. Groves (Eds.) Diseases of the ear, nose and throat. Vol. II. p. 737f. Wash., D. C.: Butterworths, 1965.

This excellent chapter reviews the description of the disease by Meniere and indicates that Meniere was planning to relate the disease to certain forms of migraine--also a symptom seen in connection with DCS (see Engel, 1944, #61). Further, the analogy of the disease to glaucoma and too much fluid and the findings in fluid exchange in caisson workers (Adler, 1964, #154; Warwick, 1942, #309; 1943, #311) is interesting.

425. WOLFSON, R. J., D. MEYERS, W. D. SCHLOSSER, and R. A. WINCHESTER.
Vertigo.
Clin. Symp. 17(4):99-133, 1965.

An excellent paper which discusses the provocative clinical tests to use as well as differential diagnoses from the results. Figures are by Netter.

426. WUSTROW, F., and M. WESTHUES-KOELN.
Druckmessungen im perilymphraum des horizontalen bogengangs des menschen bei der rotation. (Pressure measurements in the perilymphspace of the horizontal semicircular canal of man at rotation. Trans. by Mrs. Anna Woke, NMRI.)
Arch. Ohren. Nasen. Kehlkopfheilk. 185:652-655, 1965.

The author shows that pressure changes in the perilymph accompany changes in rotation, therefore, other factors which change pressure in the perilymph could perturb vestibular function.

427. BRODAL, A.
Anatomical aspects of functional organization of the vestibular nuclei.
In A. Graybiel (Ed.) Second symposium on the role of the vestibular organs in space exploration. NAC-NRC Committee on Hearing, Bioacoustics, and Biomechanics, Ames Research Center, Moffett Field, Calif., January 25-27, 1966. NASA SP-115, Wash., D. C., 1966.

428. FLUUR, E., and L. MENDEL.
Relation between strength of stimulus and duration of latency time in vestibular rotatory nystagmus.
Acta Otolaryngol. (Stockh) 61:463-474, 1966.

429. HENRIKSSON, N. G., and L. GLEISNER.
Vestibular activity at experimental variation of labyrinthine pressure.
Acta Otolaryngol. (Stockh) 61:380-386, 1966.

Changes in pressure within the labyrinth caused by the introduction of fluid to the posterior canal resulted in variable activity in the horizontal ampullary nerve. See also Schuknecht (1962, #392; 1969, #493).

430. HENRIKSSON, N. G., L. GLEISNER, and G. JOHANSSON.
Experimental pressure variations in the membranous labyrinth of the frog.
Acta Otolaryngol. (Stockh) 61:281-291, 1966.

If a bubble is suspected at the end organ this article should be consulted for pro and con evidence. (RK)

431. HINOKI, M., and K. TERAYAMA.
Physiological role of neck muscles in the occurrence of optic eye nystagmus.
Acta Otolaryngol. (Stockh) 62:157-170, 1966.
- This influence of neck muscle stimulation on nystagmus is discussed (cf. Adolfsen, et al., 1970, #235).
432. ISHII, T., H. SILVERSTEIN, and K. BALOGH.
Metabolic activities of the endolymphatic sac.
Acta Otolaryngol. (Stockh) 62(1):61-73, 1966. N.V.
433. KLOCKHOFF, I., G. ANGGARD, and L. ANGGARD.
Recording of cranio-labyrinthine pressure transmission in man by acoustic impedance method.
Acta Otolaryngol. (Stockh) 61:361-370, 1966.
434. LAWRENCE, M.
Effects of interference with terminal blood supply on organ of corti.
Laryngoscope 76:1318-1337, 1966.
- Emphasizes the importance of adequate blood supply for structures within the labyrinth.
435. MCCABE, B. F.
The quick component of nystagmus.
Trans. Pac. Coast Otophthalmol. Soc. 47:91-95, 1966.
436. PINTO, O. F.
Temporomandibular joint problems in underwater activities.
J. Prosth. Dent. 16:772-784, 1966.
- The strain placed on the temporomandibular joint from protracted mouthpiece use is similar to the strain which can occur following removal of posterior teeth. The latter results in problems termed Costen's Syndrome (1934, #302), one of the symptoms of which is dizziness and vertigo. See Pinto (1962, #390).
437. RIVERA, J. C., and W. L. DENNISON.
Gas embolism and related accidents.
In Diving Medicine Notebook, p. 208. U. S. Naval Submarine Medical Center, Groton, Conn., 1966. N.V.
438. SILVERSTEIN, H.
Biochemical and physiologic studies of the endolymphatic sac in the cat.
Laryngoscope 76:498, 1966. N.V.
439. WOLFE, J. W.
Evidence for cerebellar control over habituation of vestibular nystagmus.
Unpublished doctoral dissertation, University of Rochester, N. Y., 1966.
- A relationship of the cerebellum to vestibular function is reported. Other relationships are described in the Introduction and Discussion.
440. YULES, R. B., C. Q. KREBS, and F. P. GAULT.
Reticular formation control of vestibular system.
Exp. Neurol. 16:349-358, 1966.
- Because of arousal changes with deep dives (high pressure nervous system syndrome) this article should be consulted for possible vestibular implications. See also Morrison and Pompeiano (1965, #421).
441. ANSON, B. J., D. G. HARPER, and T. R. WINCH.
The vestibular system: Anatomic considerations.
Arch. Otolaryngol. 85:497-514, 1967.
- An excellent description of the gross anatomy.

442. BERGAN, J. J., J. S. LEVY, O. H. TRIPPEL, and M. JURAYJ.
Vascular implications of vertigo.
Arch. Otolaryngol. 85:182-187, 1967.
443. BUCY, P. O.
Vertigo with diseases of the central nervous system.
Arch. Otolaryngol. 85:535-536, 1967.
- A short definition of vertigo. An introductory paper to the symposium on vertigo, all of which is reported in this volume of the journal.
444. CARPENTER, M. B.
Central connections of the vestibular system.
Arch. Otolaryngol. 85:517-520, 1967.
- A very good paper from a symposium on vertigo (Vol. 85).
445. DUVALL, A. J., and V. T. RHODES.
Ultrastructure of the organ of corti following intermixing of cochlear fluids.
Ann. Otol. Rhinol. Laryngol. 76:3, 1967. N.V.
446. FIELDS, W. S.
Arteriography in the differential diagnosis of vertigo.
Arch. Otolaryngol. 85:555-556, 1967.
447. FIELDS, W. S., W. RUBIN, and R. J. WOLFSON.
Essentials of the examination and evaluation of the patient with vertigo.
Philadelphia, Pa.: Smith, Kline & French Laboratories, 1967.
448. FISHER, C.M.
Vertigo in cerebrovascular disease.
Arch. Otolaryngol. 85(5):529-534, 1967.
449. GERNANDT, B. E.
Central regulation of the vestibular system.
Arch. Otolaryngol. 85:521-528, 1967.
450. GRAYBIEL, A., H. F. SCHUKNECHT, A. R. FREGLY, E. F. MILLER, and M. E. MCLEOD.
Streptomycin in Meniere's disease.
Arch. Otolaryngol. 85:156-170, 1967.
451. HARKINS, W. B., and H. M. YANOF.
Current exploratory work on pressure measurements in the inner ear.
Laryngoscope 77(5):701-716, 1967. N.V.
452. HILGER, J. A.
The vertigo of endolymphatic hydrops,
Arch. Otolaryngol. (Stockh) 85:542-543, 1967.
453. HINCHCLIFFE, R.
Validity of measures of caloric test response.
Acta Otolaryngol. (Stockh) 65:69-73, 1967. N.V.
454. HITSELBERGER, W. E.
Tumors of the cerebellopontine angle in relation to vertigo.
Arch. Otolaryngol. 85:539-541, 1967.
455. INGELSTEDT, S., A. IVARSSON, and Bjorn JONSON.
Mechanics of the human middle ear.
Acta Otolaryngol. (Stockh) Suppl. 228:1-60, 1967.

"Pressure Regulation in Aviation and Diving, a Nontraumatic Method" is the subtitle of this long article.

456. JERGER, J.
The audiological examination as an aid in diagnosis.
Arch. Otolaryngol. 85:552-554, 1967.
457. JONGKEES, L. B. W.
Vestibular tests.
Arch. Otolaryngol. 85:548-551, 1967.

Good description of vertigo and differential diagnoses.
458. KAWAMOTO, K.
The atypical epithelial formations of the utricle.
Arch. Otolaryngol. 85:561-571, 1967.

Possible cite for bubble formation? (RK)
459. KIMURA, R. S.
Experimental blockage of the endolymphatic duct and sac; its effect
on the inner ear of the guinea pig. A study on endolymphatic hydrops.
Ann. Otol. Rhinol. Laryngol. 76(3):664-687, 1967. N.V.
460. KOBURG, E., J. HAUBRICH, and B. KERBARCH.
Autoradiographische Untersuchungen Zum Stoffwechsel des Ductus und saccus
endolymphaticus.
Acta Otolaryngol. (Stockh) 64:146-156, 1967. N.V.
461. LINDSAY, J. R.
Paroxysmal postural vertigo and vestibular neuronitis.
Arch. Otolaryngol. 85:544-547, 1967.
462. LITTON, W. B., and B. F. MCCABE.
Thermal vestibulometry: Technique and clinical aspects.
In A. B. Graham (Ed.) Sensori-neural hearing processes and disorders. pp. 263-281.
Boston: Little, Brown and Co., 1967. N.V.
463. NORRIS, C., and W. RUBIN.
Notes on nystagmography.
Arch. Otolaryngol. 85:265-268, 1967.
464. SCHUMACHER, G. A.
Demyelinating diseases a cause for vertigo.
Arch. Otolaryngol. 85:537-538, 1967.

Myelin has a high fat content and could be a locus for bubble formation. (RK)
465. SHAMBAUGH, G. E.
The symptoms of vertigo.
Arch. Otolaryngol. 85:515-516, 1967.
466. SIMMONS-BLAIR, F., and C. J. MONGEON.
Endolymphatic duct pressure produces cochlear damage.
Arch. Otolaryngol. 85(2):143, 1967. N.V.
467. WALKER, A. E.
Summation of the symposium on the vertiginous patient.
Arch. Otolaryngol. 85:558-560, 1967.
468. WŁODYKA, J.
Neuronitis vestibularis.
Arch. Otolaryngol. 85:298-302, 1967.

469. WOLF, S.
The bradycardia of the dive reflex: a possible mechanism of sudden death.
Cond. Reflex 2:88-95, 1967. N.V.
470. ALTMANN, F.
Diagnostic significance of vertigo.
In R. J. Wolfson (Ed.) The vestibular system and its diseases. pp. 353-371.
Philadelphia: University of Pennsylvania Press, 1968.
471. ANSON, B. J., D. G. HARPER, and T. R. WINCH.
Developmental and adult anatomy of the membranous labyrinth in man.
In R. J. Wolfson (Ed.) The vestibular system and its diseases. pp. 19-38.
Philadelphia: University of Pennsylvania Press, 1968.
472. ARSLAN, M.
Experimental Meniere's disease.
In R. J. Wolfson (Ed.) The vestibular system and its diseases. pp. 180-206.
Philadelphia: University of Pennsylvania Press, 1968.
473. BENSEL, C. K., E. DZENDOLET, and H. L. MEISELMAN.
Body sway during long-term standing and as affected by pure tones.
Perception & Psychophysics 4(3):171-174, 1968.
- This study contains a good reference list to the early studies of postural equilibrium. The application to "staggers" and body sway at depth is great. Also because of noise in chambers, this paper (which deals with the so-called "Tullio effect") is of methodological interest. (RK)
474. COCKETT, A. T. K., N. L. MANGELSON, L. E. SWANSON, and R. T. KADO.
The diagnosis of experimental pulmonary aero-emboli following decompression by radio-isotopic lung scanning.
Am. Surg. 34(2):109-113, 1968.
- Perhaps this procedure could be modified for vestibular studies. (RK)
475. FIELDS, W. S.
Vertigo related to alteration in arterial blood flow.
In R. J. Wolfson (Ed.) The vestibular system and its diseases. pp. 472-483.
Philadelphia: University of Pennsylvania Press, 1968.
476. FREGLY, A. R., and A. GRAYBIEL.
Acute alcohol ataxia in persons with loss of labyrinthine function.
Acta Otolaryngol. (Stockh) 65:468-478, 1968a.
- It is axiomatic that divers are heavy drinkers, and the relationship reported here should be considered. See also Voth (1965, #172).
477. HALLPIKE, C. S.
The Caloric Test: A review of its principles and practice with especial reference to the phenomenon of directional preponderance.
In R. J. Wolfson (Ed.) The vestibular system and its diseases. pp. 207-217.
Philadelphia: University of Pennsylvania Press, 1968.
478. HARRISON, M. S.
Benign positional vertigo.
In R. J. Wolfson (Ed.) The vestibular system and its diseases. pp. 404-427.
Philadelphia: University of Pennsylvania Press, 1968.
- See also Schuknecht (1962, #392).
479. LINDSAY, J. R.
Meniere's Disease: Pathology and manifestations.
In R. J. Wolfson (Ed.) The vestibular system and its diseases. pp. 375-389.
Philadelphia: University of Pennsylvania Press, 1968a.

480. LINDSAY, J. R.
Pathology of vestibular disorders vertigo of peripheral origin: Histopathology.
Ann. Otol. Rhinol. Laryngol. 77(2):203, 1968b.
- A good description (re: differential diagnoses) of episodic vertigo, postural vertigo, and distortion of one or both labyrinths. (RK)
481. MCCABE, B. F.
Clinical aspects of the differential diagnosis of end-organ vertigo.
Ann. Otol. Rhinol. Laryngol. 77(2):193, 1968.
- A very good paper.
482. NAFTALIN, I., and M. S. HARRISON.
Biochemistry of the labyrinthine fluids.
In R. J. Wolfson (Ed.) The vestibular system and its diseases. pp. 159-179.
Philadelphia: University of Pennsylvania Press, 1968.
483. PARKER, D. E., W. P. COVELL, and H. E. von GIERKE.
Exploration of vestibular damage in guinea pigs following mechanical stimulation.
Acta Otolaryngol. (Stockh) Suppl. 239:1-59, 1968.
- Describes the effects on swimming ability and the righting reflex in guinea pigs whose otoconia (maculae) are lost due to mechanical (acceleration) stimulation. No regeneration of lost otoconia appeared to occur. Noise was without effect. Vibration produced a transient loss in behavior.
484. STAHL, J.
Electronystagmography--its value as a diagnostic tool.
In R. J. Wolfson (Ed.) The vestibular system and its diseases. pp. 267-280.
Philadelphia: University of Pennsylvania Press, 1968a.
485. STAHL, J.
Vestibular neuritis.
In R. J. Wolfson (Ed.) The vestibular system and its diseases. pp. 459-470.
Philadelphia: University of Pennsylvania Press, 1968b.
486. WEISS, A. D.
Neurological aspects of the differential diagnosis of vertigo.
Ann. Otol. Rhinol. Laryngol. 77(2):216, 1968.
- Various pitfalls in the diagnosis of neurological involvement when a patient presents with vertigo are discussed. (RK)
487. WOLFSON, R. J.
Labyrinthine surgery for vertigo.
In R. J. Wolfson (Ed.) The vestibular system and its diseases. pp. 527-544.
Philadelphia: University of Pennsylvania Press, 1968a.
488. WOLFSON, R. J. (Ed.)
The vestibular system and its diseases. (Second printing.)
Philadelphia: University of Pennsylvania Press, 1968b.
- A textbook of vestibular function and otoneurology. Many chapters are important sources. "...the program falls naturally into categories...anatomical studies and research; diagnostic methods...; pathophysiology; and therapy. (p. 550)."
489. FREDRICKSON, J. M., H. H. KORNHUBER, and R. L. GOODE.
Nystagmus: Diagnostic significance of recent observations.
Arch. Otolaryngol. 89:88-95, 1969.
- A good paper for differential diagnosis.

490. JONGKEES, L. B. W.
Cervical vertigo.
Laryngoscope 79:1473-1483, 1969a.

The possibility of vertigo resulting from stimuli (e.g., bubbles) in "neck structures (p. 1482)" should be considered. (RK) Jongkees offers probable etiologies (p. 1482). "...nystagmus, homolateral past pointing, and a tendency to fall toward the injected [cervical fissure] side (p. 1474)" can also occur.

491. JONGKEES, L. B. W.
Vestibular physiology and tests.
Arch. Otolaryngol. 89:37-44, 1969b.

492. MCNALLY, W. J.
An evaluation of vestibular testing.
Arch. Otolaryngol. 89:57-63, 1969.

A very good treatment of the kinds of tests which can be used for diagnosis and positive vestibular function. Many are adaptable for clinical use and expensive, complicated apparatus is not always required. (RK)

493. SCHUKNECHT, H. F.
Cupulolithiasis.
Arch. Otolaryngol. 90:765-778, 1969.

The symptoms of this disease bear a strong resemblance to those experienced in the deep dive reported by Sundmaker (1972, #291). Perhaps a similar mechanism is involved whereby the effects of pressure cause otocoma (as do other substances with high specific gravity) to accumulate in the ampulla of the posterior semicircular canal. (RK)

494. STEGEMANN, J., and U. TIBES.
Die Veränderung der Herzfrequenz beim Tauchen und atemenhalten nach körperlicher anstrengung. (Changes of heart rate during diving and breath-hold after exercise. Trans. by Mrs. Anna Woke, NMRI, 1971.)
Pfleugers Arch. 308:16-24, 1969.

The vagal influence on diving is discussed.

1970-1972

495. BARLOW, J. S.
Vestibular and non-dominant parietal lobe disorders.
Dis. Nerv. Syst. 31:674-679, 1970.

Describes the relationship of neurological deficits to spatial disorientation. Similar symptoms may occur in connection with compressed air work. (RK)

496. BRUNER, A., and T. W. NORRIS.
Lateralization of hearing loss and vestibular nystagmus in test pilots.
Aerosp. Med. 41(6):684-687, 1970.

Shows that vestibular and auditory deficits are correlated.

497. CLARK, B.
The vestibular system.
Annu. Rev. Psychol. 21:273, 1970.

A good modern review of vestibular studies. No studies of diving are included.

498. FLUUR, E., and L. MENDEL.
Crescendo time for per-rotatorily elicited nystagmus.
Acta Otolaryngol. (Stockh) 69:239-246, 1970.

499. FLUUR, E., and A. MELLSTROM.
Vestibular bidirectional sensitivity.
Acta Otolaryngol. (Stockh) 69:363-365, 1970.
- Shows that "it is not possible to cause a nystagmus in both directions from only one semicircular canal (p. 363)" with galvanic stimulation.
500. FREGLY, A. R., and A. GRAYBIEL.
Labyrinthine defects as shown by ataxia and caloric tests.
Acta Otolaryngol. (Stockh) 69:216-222, 1970.
- Shows the validity and reliability (with caloric) of ataxia testing.
501. FRUCTUS, X., and J. C. RICCI.
Reflections on two cases of caisson disease.
Bulletin Mesubhyp No. 1, December 1969. French Association for Subaquatic and Hyperbaric Medicine, Salvator Hospital, 13 Marseille (9e) Trans. from French, NIC Trans. No. 3070, Naval Intelligence Command Hdqtrs., Wash., D. C., 22 June 1970.
- Points out the danger of the Valsalva maneuver when resurfacing.
502. IGARASHI, M., B. R. ALFORD, T. WATANABE, and P. M. MAXIAN.
Direction of ataxic gait after unilateral partial destruction of the vestibular system in squirrel monkeys.
Laryngoscope 80(6):896-914, 1970.
- Provides validity and diagnostic utility of ataxia tests.
503. MAN, A., and G. LEVENTON.
On vestibular response to mechanical irritation.
Acta Otolaryngol. (Stockh) 69:443-444, 1970.
- A negative finding, but of some importance. Should be replicated with a more sensitive indicator like the oculoogyral illusion. (RK)
504. RADOMSKI, M. W., and P. B. BENNETT.
Electrolyte changes in humans under hyperbaric conditions.
Aerosp. Med. 41(12):309-313, 1970a.
- Sodium and calcium retention are reported in connection with hyperbaric air, but not hyperbaric helium.
505. RADOMSKI, M. W., and P. B. BENNETT.
Metabolic changes in man during short exposure to high pressure.
Aerosp. Med. 41(3):309-313, 1970b.
- The authors state the otoliths of the utricle are calcium carbonate concretions. If decreases in calcium excretion can occur with high pressure perhaps increases in calcium deposits within the body can also occur. If so, perhaps these changes might perturb normal vestibular function. (RK)
506. RESCHKE, M. F., and D. E. PARKER.
Stimulation of the vestibular apparatus in the guinea pig by static pressure changes: head and eye movements.
J. Acoust. Soc. Am. 48(4):913-923, 1970.
507. STAHL, J.
Vestibular function on earth and in space.
New York: Pergamon Press, 1970.
- A good collection of papers concerning many aspects of vestibular function.

508. TIBBLING, L.
Observations on central mechanisms common to vestibular and optokinetic nystagmus.
Acta Otolaryngol. (Stockh) 69:434-442, 1970.
509. UDO DE HAES, H. A., and H. SCHONE.
Interaction between statolith organs and semicircular canals on apparent vertical and nystagmus.
Acta Otolaryngol. (Stockh) 69:25-31, 1970.
510. WADA, J. A., A. TERAOKA, H. SCHOLTMAYER, and W. C. TRAPP.
Reversible audiogenic seizure susceptibility induced by hyperbaric oxygenation.
Exp. Neurol. 29:400-404, 1970.
511. ANDERSON, J. R.
Case report of student aviator with unusual psychosomatic symptoms.
Aerosp. Med. 42(11):1212-1218, 1971.
- Vestibular symptoms were considered to be precipitated by fear. The application to diving may be direct.
512. ANON.
Carbon monoxide in the Corvair.
Consumer Reports 36(9):572-574, 1971.
- The vestibular symptoms reported here are very similar to the "staggers" and other vestibular derangements seen in DCS.
513. BENNETT, P. B., and S. P. GRAY.
Changes in human urine and blood chemistry during a simulated oxygen-helium dive to 1500 ft.
Aerosp. Med. 42(8):868-874, 1971.
- Among other changes recorded, it was shown that at 1500 feet there was retention of calcium. Otoliths are calcium carbonate concretions; perhaps there is a connection so that changes in otolith crystallization can occur.
514. BROWN, F. M.
Vertiginous flyer: A review of 6 years' experience of the Aeromedical Consultation Service.
Aerosp. Med. 42(8):891-893, 1971b.
- A good epidemiologic study with a citation of 6 cases of alternobaric vertigo.
515. BRUNER, A., and T. W. NORRIS.
Age-related changes in caloric nystagmus.
Acta Otolaryngol. (Stockh) Suppl. 282:1-24, 1971. N.V.
516. GRAYBIEL, A., C. R. SMITH, F. E. GUEDRY, JR., E. F. MILLER, II, A. R. FREGLY, and D. B. CRAMER.
Idiopathic progressive vestibular degeneration in a young man: loss of vestibular sensation not the basis for detection.
Naval Aerospace Medical Research Laboratory, Pensacola, Fla., Report NAMRL-1128, March 1971.
517. GUEDRY, F. E., JR., and A. J. BENSON.
Nystagmus and visual performance during sinusoidal stimulation of the vertical semicircular canals.
Naval Aerospace Medical Research Laboratory, Pensacola, Fla., NAMRL Report No. 1131, USAARL Report No. 71-16, 10 March 1971.

Because of the difference between fast phase-up and fast phase-down nystagmus responses, this approach may provide a way of measuring differentially superior vs. inferior canal function by mechanical means.

518. HAWKINS, J. E., JR.
The role of vasoconstriction in noise-induced hearing loss.
Ann. Otol. Rhinol. Laryngol. 80(6):903-1003, 1971.
Shows the influence of oxygen on cochlear function.
519. HIGGINS, L. L., C. KNOX, and W. W. SIMMONS.
Acoustic-optical imaging techniques for decompression studies.
TRW Systems, Redondo Beach, Calif., ONR Report No. 12833-6006-RO-00, 31 March 1971.
520. HILLS, B. A.
Concepts of inert gas exchange in tissues during decompression.
In C. J. Lambertsen (Ed.) Underwater physiology. pp. 115-122. New York and London: Academic Press, 1971a.
521. HILLS, B. A.
Decompression sickness: a fundamental study of "surface excursion" diving and the selection of limb bends versus C.N.S. symptoms.
Aerosp. Med. 42:833-836, 1971b.
Limb bends (type I) generally outnumber (NS type II) bends. This paper suggests a way to study the latter.
522. ISHIYAMA, E., and E. W. KEELS.
Preliminary results on intralabyrinthine temperature changes in the vestibular labyrinth during caloric stimulation.
Pract. Otorhinolaryngol. (Basel) 32(4):231-239, 1971.
523. LANDAU, J. V.
Hydrostatic effects on cellular function.
In C. J. Lambertsen (Ed.) Underwater physiology. pp. 85-93. New York: Academic Press, 1971.
This report may be relevant if cellular changes within the vestibular apparatus are shown to occur under pressure. (RK)
524. LANGER, P. H., and F. T. MANSURE.
Hazards of valsalva maneuver.
Hyperbaric Medicine Newsletter 7(5):6, 1971.
525. MATHOG, R. H., and R. L. CRAMER.
Testing of the vestibular system.
Aerosp. Med. 42(7):741-745, 1971.
The title is self explanatory but the article also calls attention to the fact that cerumin (p. 744) in an ear can modify a caloric response in the laboratory. This factor should be considered as a possibility in deep-sea diving where water has access to the ear and if there is a plug of wax in one ear it could result in a differential stimulus to the semicircular canals. (RK)
526. MONEY, K. E., L. BONEN, J. D. BEATTY, L. A. KUEHN, M. SOKOLOFF, and R. S. WEAVER.
Physical properties of fluids and structures of vestibular apparatus of the pigeon.
Am. J. Psychol. 220(1):140-147, 1971.
527. SHAPPELL, S. O.
Hemoglobin affinity for oxygen during angina pectoris.
Cited in: New England J. Med. 282:1219, 1970; Hyperbaric Medicine Newsletter 8(3):4, 1971.

528. VAIL, E. G.
Hyperbaric respiratory mechanics.
Aerosp. Med. 42(5):536-546, 197.
529. COMEX (Hyperbaric Research Center), Versailles, France.
100 hours at 500 meters. Chamber saturation dive at 1640 ft (50.68 ATA).
Unpublished paper, February/March 1972.

Vestibular symptoms are not mentioned in this report but "incoordination" and lessening of awareness (p. 6)" as a part of the HPNS syndrome is. See also Morrison and Pompeiano (1965, #421), and Yules, et al., (1966, #440).

See also:

References 29, 67, 76, 79, 95, 102, 117, 130, 131, 148, 159, 160, 162, 171, 181, 182,
227, 235, 246, 247, 256, 271, 272, 282, 530, 531, 532, 534, 539, 542, 544, 546, 551, 556,
557, 564, 566, 567, 568, 573, 574, 575, 577, 582, 584, 586, 591, 595, 596, 597, 598, 608,
614, 616, 618, 622, 668, 730, 755, 777, 782, 797, 824, 835, 874, 878, 905, 919, 926, 947.

CATEGORY III. TESTS OF POSITIVE FUNCTION OF VESTIBULAR APPARATUS.

1920-1929

530. ROORDA, P.
Der Einflub der Drehung auf den Zeigerversuch von Barany. (The influence of turning on the pointing test of Barany. Trans. by Mrs. A. Woke, NMRI, 1971.) Archives Fur Ohren, Hals-und Kehlkopfheilkunde 113:97-103, 1925.
Describes the effects of a rotatory (i.e., vestibular) stimulus on past pointing.
531. TULLIO, P.
I riflessi sonori.
Amer. J. Physiol. 90:542, 1929. (In Italian. Abstract of communications from International Physiological Congress.)
An early reference to the adequacy of sound serving as a vestibular stimulus. Since pressure chambers can have high noise levels, one should control (or at least be cognizant of) this relationship in provocative vestibular testing performed in the presence of noise. (RK)

1930-1939

532. CATTELL, M.
The physiological effect of pressure.
Biol. Rev. 11:441-476, 1936.
A good source for the preparation of a battery of tests constructed to measure vestibular function (in particular) or CNS functions (in general) at or after pressure. (RK)
533. MOWRER, O.H.
A comparison of the reaction mechanism mediating optokinetic nystagmus in human beings and in pigeons.
Psychol. Monogr. 47(212):294-305, 1936.
Species differences and baseline data are presented. Mechanisms are discussed.
534. WENDT, G. R.
The form of the vestibular eye movement response in man.
Psychol. Monogr. 47:311-328, 1936.
This paper should be consulted if eye movements of suspected vestibular origin during (or pre-post) a dive are to be studied. (RK)
535. DOHLMAN, G.
On the mechanism of transformation into nystagmus on stimulation of the semi-circular canals.
Acta Otolaryngol. (Stockh) 26:425-442, 1938.
Describes the origin of the CNS pathways of the slow phase. The mechanics of the vestibular apparatus are discussed.

1940-1949

536. GRAYBIEL, A. and D. HUPP.
The oculogyral illusion: A form of apparent movement which may be observed following stimulation of the semicircular canals.
J. Aviat. Med. 3:1-12, 1946.
This paper describes a sensitive measure of semicircular canal function. It shows also that illusory responses can occur for angular velocities which could be experienced in a submersible. (RK)

537. GRAYBIEL, A., B. CLARK, and K. MACCORQUODALE.
The illusory perception of movement caused by angular acceleration and by centrifugal force during flight. I. Methodology and preliminary results. J. Exp. Psychol. 37(2):170-177, 1947.
- "The method is adaptable to a number of types of studies concerned with the influence of angular acceleration and g on visual perception (p. 177)," for example, submersibles. (RK)
538. FENN, W. O., R. GALAMBOS, A. B. OTIS, and H. RAHN.
Corneoretinal potential in anoxia and acapnia. J. Appl. Physiol. 1:710-716, 1949.
- Because the gas mixture can influence the standing potential in the eye this factor must be considered when recording vestibular eye movements under pressure and with different gas mixtures. (See Kennedy, 1972, Appendix B, #622, for a bibliographic review.) On the other hand, this measurement may be a useful index of the change. See also Dolatkowski, et al. (1966, #572), and Adolfsen, et al. (1970, #235), who recorded eye movements.
539. JONGKEES, L. B. W.
Which is the preferable method of performing the caloric test? Arch. Otolaryngol. 49:594-608, 1949.

1950-1959

540. WORCHEL, P., and K. M. DALLENBACH.
Vestibular sensitivity in the deaf. Am. J. Psychol. 63:161-175, 1950.
- Correlation between tasks are reported.
541. MOORE, E. W., and R. L. CRAMER.
Perception of postural verticality: effects of flying experience upon reduction of error. U. S. School of Aerospace Medicine, Brooks AFB, Texas, Report No. TDR-62-72, June 1952.
542. THOMSEN, K. A.
The caloric test a. m. Hallpike, et al. in a normal material. Acta Otolaryngol. (Stockh) Suppl. 109:189-196, 1953.
543. BEKESY, G. V.
Subjective cupulometry. Threshold, adaptation, and sensation intensity of the vestibular organ for rotations in the horizontal plane. Arch. Otolaryngol. 61:16-28, 1955.
- A good test of vestibular function.
544. MCNALLY, W. J.
Some facts and fancies about the utricle. Ann. Otol. Rhinol. Laryngol. 65:355-363, 1955.
- The other paper by McNally (1969, #492) should also be consulted.
545. ASCHAN, G., M. BERGSTEDT, and J. STAHL.
Nystagmography: Recording in clinical neuro-otological examinations. Acta Otolaryngol. (Stockh) Suppl. 129, 1956. N.V.
546. HENRIKSSON, N. G.
Speed of slow component and duration in caloric nystagmus. Acta Otolaryngol. (Stockh) Suppl. 125: 1-29, 1956.

547. MANN, C. W., and C. J. CANELLA.
An examination of the technique of cupulometry.
U. S. Naval School of Aviation Medicine, Pensacola, Fla., Joint Report No. 42,
30 May 1956.

A good test of vestibular function.

548. STAHLE, J.
Electro-nystagmography in the caloric and rotatory tests.
Acta Otolaryngol. (Stockh) Suppl. 137, 1958. N.V.

549. de RIVERA, J.
The postural sway test and its correlations.
U. S. Naval School of Aviation Medicine Report No. 3, Pensacola, Fla., 12 November
1959.

This test measures suggestibility in addition to being a measure of postural equilibrium. It might be a good test as part of a battery for use in compressed air experiments for both reasons. (RK)

1960-1969

550. CRAWFORD, W. A.
False perception of the horizontal and vertical planes in a dynamic setting.
Flying Personnel Research Committee, Farnborough, England, October 1960.

551. CAVACNA, G., F. SAIBENE, and R. MARGARIA.
A three-directional accelerometer for analyzing body movements.
J. Appl. Physiol. 16:191, 1961.

A useful paper for building apparatus to measure postural equilibrium either as an indicator of vestibular/CNS symptomatology under pressure, or to measure pre-, post-changes, or to evaluate symptoms. (RK)

552. JONSSON, B., and B. STEEN.
Function of the hip and thigh muscles in Romberg's test and "standing at ease."
An electromyographic study.
Acta Morphol. Neer. Scand. 5(3):269-276, 1962.

Of interest for testing postural equilibrium during or after a dive. (RK)

553. KENNEDY, R. S., and A. BRAYBIEL.
Validity of tests of canal sickness in predicting susceptibility to airsickness and seasickness.
Aerosp. Med. 33:935-938, 1962a.

The relationship of caloric responsivity to motion sickness susceptibility is shown.

554. MCLEOD, M. E., and J. C. MEEK.
A threshold caloric test: results in normal subjects.
U. S. Naval School of Aviation Medicine, Pensacola, Fla., and National Aeronautics and Space Administration, Report No. 72, NASA Order No. R-47, 9 July 1962.

Threshold responses can occur to as little as 1.5°C either side of body temperature. This could be a source of problems in cold water or gas. (RK)

555. CANTRELL, R. P.
Body balance activity and perception.
Percept. Mot. Skills, 17:431-437, 1963.

556. DAVEY, L. M.
Evaluation of bicaloric test of vestibular function.
U. S. Naval Medical Research Report No. 411, Groton, Conn., 12 September 1963.

Probably the best normative data published for the caloric test ($N > 400$)--the procedure is well described. Notes regarding differential diagnosis are given.
(RK)
557. GUEDRY, F. E., and C. S. HARRIS.
Labyrinthine function related to experiments on the parallel swing.
U. S. Naval School of Aviation Medicine, Pensacola, Fla., BuMed Project
MRO05.13-6001 Subtask 1, Report No. 86, 25 September 1963.

Validation of parallel swing studies by showing normals and persons with labyrinthine defects produce different responses.
558. HARRIS, C. S., R. K. AMBLER, and F. E. GUEDRY.
A brief vestibular disorientation test.
U. S. Naval School of Aviation Medicine, Pensacola, Fla., BuMed Project
MRO05.13-6001, Report No. 82, 1 May 1963.

This test may be useful in selecting persons who are insusceptible to vertigo, or training persons to be more tolerant of vertigo. Transfer of training could occur to vertigo which was induced by pressure, cold water, submersible motion, etc., from that induced mechanically. (RK) This transfer could be in the form of increased physiologic tolerance or improved perceptual awareness.
559. HINOKI, M., and M. KITAHARA.
An application of strain-gage-type instruments to the analysis of the equilibrium function in human subjects and animals.
Acta Otolaryngol. (Stockh) Suppl. 179:110-121, 1963.

Describes apparatus construction for measuring postural equilibrium.
560. MILLER, E. F., and A. GRAYBIEL.
Role of the otolith organs in the perception of horizontality.
U. S. Naval School of Aviation Medicine, Pensacola, Fla., Report No. 80,
19 March 1963a.

A good paper for constructing behavioral tests which measure normal otolith function. (RK)
561. BROWN, J. H., and G. H. CRAMPTON.
Quantification of the human nystagmic response to angular acceleration.
Prediction formulae and nomograph.
Acta Otolaryngol. (Stockh) 58:555-564, 1964.

A transfer function for semicircular canal function and input is presented.
562. DZENDOLET, E.
Effect of dramamine on the objective electric vestibulogram.
Percept. Mot. Skills 18(2):465-468, 1964.

Used sway as a provocative test. Showed threshold changed (higher) with drug.
563. GUEDRY, F. E., JR., R. S. KENNEDY, C. S. HARRIS, and A. GRAYBIEL.
Human performance during two weeks in a room rotating at three RPM.
Aerosp. Med. 35(11):1071-1082, 1964.

Describes the results of the use of tests of vestibular function (postural equilibrium, past pointing) before, during, and after bizarre vestibular stimulation.

564. MCLEOD, M. E., and M. J. CORREIA.
Use of caloric test in evaluating the effects of gravity on cupula displacement.
U. S. Naval School of Aviation Medicine, Pensacola, Fla., Report No. 94, and
NASA, 2 April 1964.

A technique which can be used in diagnosis and possibly as part of a test battery during compressed air work. (RK)

565. MILLER, E. F., and A. GRAYBIEL.
Magnitude of gravito-inertial force, an independent variable in egocentric visual localization of the horizontal.
U. S. Naval School of Aviation Medicine, Pensacola, Fla., Report No. 98,
31 July 1964.

A good paper for study of vertical and horizontal spatial orientation. Many other papers by these authors appear in Stearns and Kasperek (1963, #403).

566. FLUUR, E., L. MENDEL, and L. LAGERSTROM.
Reproducibility of duration of latency time in unidirectional per-rotatory nystagmus.
Acta Otolaryngol. (Stockh) 62:118-124, 1965.

567. FREGLY, A. R., and R. S. KENNEDY.
Comparative effects of prolonged rotation at 10 RPM on postural equilibrium in vestibular normal and vestibular defective human subjects.
Aerosp. Med. 36(12):1160-1167, 1965.

Validity of ataxia testing.

568. PICKARD, B.
Methods of examination of the ear.
In W. G. Scott-Brown, J. Ballantyne, and J. Groves (Eds.) Diseases of the ear, nose, and throat. Vol. II. Wash., D. C.: Butterworths, 1965b.

569. WOLFSON, R. J., W. D. SCHLOSSER, and R. A. WINCHESTER.
Vertigo.
Summit, N.J.: CIBA Pharmaceutical Company, 1965.

A reissue of Wolfson, et al. (1965, #425).

570. CABARROU, P.
Etude electro-encephalographique de l'ivresse des grandes profondeurs.
Maroc Med. 45:529-536, July 1966b.

571. CRAMPTON, G. H.
Does linear acceleration modify cupular deflection?
From the Second Symposium on The Role of the Vestibular Organ in Space Exploration.
Ames Research Center, Moffett Field, Calif., January 1966.

572. DOLATKOWSKI, A., J. TORBUS, K. DEGA, and S. KLAJMAN.
Hibarii Naczas Odruchu Wzrokowo-'fiesiowego u Kurkow. (The influence of hyperbaria on the eye-muscle reflex period in divers.)
Bull. Inst. Mar. Med. Gdansk 17:303-309, 1966.

The connections of the oculomotor system (III, IV, and VI nerve nuclei) with the vestibular system are well known (cf. Wendt, 1951, #345; Robinson, 1968, #595), and should be considered relative to the findings here of increased eye muscle reflex latency with increased pressure. Of relevance also are changes in eye muscle potential with luminance and with gas mixture (Kennedy, 1972, Appendix B, #622, for review). Since electronystamography is used in provocative tests of vestibular function, if vestibular tasks are performed at pressure using eye muscle potential as a measure, then the data of Dolatkowski are relevant. (See Fenn, et al., 1949, #538). (RK)

573. ESKIN, A., and D. C. RICCIO.
The effects of vestibular stimulation on spontaneous activity in the rat.
The Psychological Record 16(4):523-527, 1966.
- This study showed that behavioral indicators of vestibular stimulation in animals could be reliably obtained. A similar methodology for study of vestibular problems in animals due to decompression could be followed. (RK)
574. FREGLY, A. R., and A. GRAYBIEL.
An ataxia test battery not requiring the use of rails.
U. S. Naval Aerospace Medical Institute, Pensacola, Fla., Report No. 985,
6 December 1966.
- This well standardized test is a good model to follow if one wished to have an entire neurological battery of tests which could be administered prior to entrance into a diving career or even before exposure to a specific environment. It should be considered with other papers by Fregly in this review. (RK)
575. FREGLY, A. R., A. OBERMAN, A. GRAYBIEL, and R. E. MITCHELL.
Thousand aviator study: non vestibular contributions to postural equilibrium functions.
U. S. Naval Aerospace Medical Institute, Pensacola, Fla., Report No. 956,
17 March 1966.
- Correlation of ataxia and other variables (e.g., body build) are shown.
576. GRAYBIEL, A. (Ed.)
Second symposium on the role of the vestibular organs in space exploration.
NAC-NRC Committee on Hearing, Bioacoustics, and Biomechanics, Ames Research Center, Moffett Field, Calif., January 25-27, 1966. NASA SP-115, Washington, D. C., 1966.
- This document and others in the series (I, III & IV) are the modern analogues of a textbook of vestibular functions. (cf. Camis, 1930, #299.)
577. GRIGOR'EV, Y. G., and Y. V. FARBER.
Vestibular function in man during a 120-day period in a hermetically sealed chamber.
Fed. Proc. (Trans. Suppl) 25:966-968, 1966.
- Confinement per se appeared to affect a change in vestibular function. This could be a factor in long-term submergence studies. (RK)
578. NIXON, C. W., C. S. HARRIS, and H. E. von GIERKE.
Rail test to evaluate equilibrium in low-level wideband noise.
Aerospace Medical Research Laboratories, Wright-Patterson AFB, Ohio, Report No. TR-66-85, July 1966.
- The authors demonstrate the use of this test to measure performance in an exotic environment.
579. GRAYBIEL, A., E. F. MILLER, II, B. D. NEWSOM, and R. S. KENNEDY.
The effect of water immersion on perception of the oculogravic illusion in normal and labyrinthine-defective subjects.
U. S. Naval Aerospace Medical Institute, Pensacola, Fla., NAMI-1016, NASA-93,
September 1967.
- Individual differences in normals on this test suggest that it might be useful in monitoring vestibular-connected perception during (or pre- post-) compressed air work. It may also be useful as a selection device. (RK)

580. NAPIER, J.
The antiquity of human walking.
Sci. Am. 216(4):56-66, 1967.
- Of some importance for studies of postural equilibrium.
581. NELSON, J. G.
The effect of water immersion and body position upon perception of the gravitational vertical.
U. S. Naval Air Development Center, Johnsville, Pa., Report No. MR-6709,
18 July 1967.
- Because of the difficulties in determining body position under water, perhaps individual performances could be related to success in diving careers, and so used as a selection test. (RK)
582. PEITERSEN, E.
Vestibulospinal reflexes.
Arch. Otolaryngol. 85:192-198, 1967.
- Good references to his earlier work. A simple test for monitoring suspected vestibular involvement as well as for diagnosis post hoc of residual damage.
583. RICCIO, D. C., M. IGARASHI, and A. ESKIN.
Modification of vestibular sensitivity in the rat.
Ann. Otol. Rhinol. Laryngol. 76(1):179-188, 1967.
- Because the rat is often the animal of choice in studies of the experimental analysis of behavior, this reference to vestibular responsivity is included. (RK)
584. BENSEL, C. K., and E. DZENOLET.
Power spectral density analysis of the standing sway of males.
Perception & Psychophysics 4(5):285-288, 1968.
- Because of "staggers" and increasing body sway at increasing depths (Adolfson, et al., 1970, #235) tests of this type would be useful for monitoring subjects during a dive, as well as for pre- and post-dive (permanent and temporary) changes. (RK)
585. CLARK, B., and J. D. STEWART.
Magnitude estimates of rotational velocity during and following prolonged increasing, constant, and zero angular acceleration.
J. Exp. Psychol. 78(2):329-339, 1968a.
- Shows the sensitivity of the semi-circular canals to turning.
586. FODOR, F.
Electronystagmography: Its perspective, advantages, and limitations in routine vestibular testing.
In R. J. Wolfson (Ed.) The vestibular system and its diseases. pp. 309-321.
Philadelphia: University of Pennsylvania Press, 1968.
587. FREGLY, A. R., and A. GRAYBIEL.
Labyrinthine defects as shown by ataxia and caloric tests.
U. S. Naval Aerospace Medical Institute, Pensacola, Fla., NAMI-994, NASA Order R-93, 22 August 1968b.
588. GRAYBIEL, A.
Vestibular mechanisms in human behavior.
Ann. Otol. Rhinol. Laryngol. 77(4):772-786, 1968.
- A summary of provocative tests.

589. HINCHCLIFFE, R.
Nystagmus rate as an index of caloric test response.
Acta Otolaryngol. (Stockh) 65:311-315, 1968.
590. HUMPHREYS, L. G.
Comparison of three methods to determine thresholds for perception of angular acceleration.
Am. J. Psychol. 81:207-216, 1968.
591. IGARASHI, M., A. GRAYBIEL, and F. R. DEANE.
Screening of squirrel monkeys (Saimiri sciureus) for vestibular function studies.
U. S. Naval Aerospace Medical Institute, Pensacola, Fla., Report No. 1042, 9 May 1968.

Also see Igarashi, et al. (1970, #502).
592. JONGKEES, L. B. W.
Parallel swing test.
In R. J. Wolfson (Ed.) The vestibular system and its diseases. pp. 218-228.
Philadelphia: University of Pennsylvania Press, 1968.
593. MILLER, E. F.
Ocular counterrolling.
In R. J. Wolfson (Ed.) The vestibular system and its diseases. pp. 229-241.
Philadelphia: University of Pennsylvania Press, 1968.
594. MILLER, E. F., A. R. FREGLY, and A. GRAYBIEL.
Visual horizontal-perception in relation to otolith function.
Am. J. Psychol. 81:488-496, 1968.
595. ROBINSON, D. A.
The oculomotor control system: A review.
Trans. IEEE. 56:1032-1049, 1968.

If eye movements of vestibular (or other) origin are studied during (or pre-post) compressed air work this paper is useful. (RK)
596. CLARK, B.
Factors influencing the perception of angular acceleration in man.
San Jose State College, Department of Psychology, San Jose, Calif., August 1969.

A review of the author's recent book.
597. FLUUR, E., and L. MENDEL.
Relation between strength of acceleration and duration of postacceleratory nystagmus.
Acta Otolaryngol. (Stockh) 68:127-136, 1969a.
598. FLUUR, E., and L. MENDEL.
Reproducibility of duration of postacceleratory nystagmus.
Acta Otolaryngol. (Stockh) 68:201-214, 1969b.
599. MILLER, E. F., II.
Evaluation of otolith organ function by means of ocular counterrolling measurements.
U. S. Naval Aerospace Medical Institute, Pensacola, Fla., NAMI-1063, and NASA, 20 March 1969.
600. YUGANOV, Y. M., S. S. MARKARYAN, E. V. LAPAYEV, and I. A. SIDEL'NIKOV.
Outlook for the development of vestibular selection methods in aviation.
Voyenno Meditsinskiy Zhurnal 12:57-61, 1969.

1970-1972

601. AMBLER, R. K., and F. E. GUEDRY, JR.
Reliability and validity of the brief vestibular disorientation test compared under 10-RPM and 15-RPM conditioning.
U. S. Naval Aerospace Medical Research Laboratory, Pensacola, Fla., Report No. 1115, USAARL Ser. No. 71-7, 14 August 1970.
- This disorientation test could be used to determine susceptibility to vertigo in divers. It could also show pre-post changes due to a career in diving, if a control group was available. (RK)
602. APPAIX, A., and F. DEMARD.
L'examen d'aptitude a la plongee sous-marine. (In French.)
J. Fr. Otorhinolaryngol. 19:391-394, 1970.
- The authors suggest ENT testing (among other things) for divers, and describe results which counterindicate diving.
603. COHEN, M.
Hand-eye coordination in altered gravitational fields.
Naval Air Development Center, Johnsville, Pa., Report No. NADC-AC-7007, June 1970. Also Aerosp. Med. 41(6):647-649, 1970.
- This test is similar to the pointing test of Barany (See Roorda, 1925, #530), and could be used as part of a battery which measures this function pre-, per-, post-compressed air work. The intended application was aviation and space, but it is relevant to underwater investigation. (RK)
604. FLUUR, E.
The interaction between the utricli and the saccule.
Acta Otolaryngol. (Stockh) 69:17-24, 1970a.
605. FLUUR, E.
Multiple choice rotation chair.
Aerosp. Med. 41(8):921-924, 1970b.
606. GRAYBIEL, A., C. W. STOCKWELL, and F. E. GUEDRY, JR.
Evidence for a test of dynamic otolith function considered in relation to responses from a patient with idiopathic progressive vestibular degeneration.
U. S. Naval Aerospace Medical Research Laboratory, Pensacola, Fla., NAMRL-1119, October 1970.
607. NASHNER, L. M.
Sensory feedback in human posture control.
Massachusetts Institute of Technology Thesis No. MVT-70-3, Cambridge, Mass., June 1970.
608. OOSTERVELD, W. J., J. B. JANEKE, and L. B. W. JONGKEES.
On the vestibular threshold.
Adv. Otorhinolaryngol. 17:180-190, 1970.
609. PARIN, V. V., and M. D. YEMEL'YANOV.
Physiology of vestibular analyzer.
NASA Technical Translation No. TT F-616, Wash., D. C., June 1970.
610. SOMMER, H. C., and C. S. HARRIS.
Comparative effects of auditory and extra-auditory acoustic stimulation on human equilibrium and motor performance.
Aerospace Medical Research Laboratory, Wright-Patterson AFB, Ohio, Report No. AMRL-TR-70-26, June 1970.

Because of the interaction of balance changes due to vestibular and auditory stimulation (e.g., in pressure chambers), this article should be consulted. (RK)

611. BARNES, D. J., G. C. BROWN, and Z. M. FRACTOR.
Differential effects of multiple and single irradiations upon the primate equilibrium function.
USAF School of Aerospace Medicine, Brooks AFB, Texas, SAM-TR-71-7, AD 722058.
March 1971.
- Describes an indicator methodology which could be used to study vestibular problems of compression in animals.
612. BLACKWOOD, F., and C. EDMONDS.
Some otological investigations in divers.
Royal Australian Navy School of Underwater Medicine, Balmoral, N. S. W., Report No. 2/71, 1971. (Cited in Edmonds, 1971)
- Discusses vestibular testing under water and pressure.
613. ELSNER, W.
Power laws for the perception of rotation and the oculogyral illusion.
Perception & Psychophysics 9(5):418-420, 1971.
- Provides human transfer functions for graded, single angular acceleration stimuli.
614. HILL, J. C.
A dynamic model of the human postural control system.
Presented at the Joint National Conference on Major Systems, Anaheim, Calif., October 25-29, 1971.
- Of importance if changes in postural equilibrium due to pressure occur or are being studied.
615. SCHROEDER, D. J.
Alcohol and disorientation-related responses. I. Nystagmus and "vertigo" during caloric and optokinetic stimulation.
Federal Aviation Administration, Wash., D. C. Report No. FAA-AM-71-6, February 1971.
616. CLARK, B., and J. D. STEWART.
Comparison of the sensitivity of rotation of pilots and nonpilots.
Aerosp. Med. 43(1):8-12, 1972.
- Shows that vestibular sensitivity does not change appreciably with exposure, history, or age and thus is a good and relatively invariant index of function. A test of this type would be useful to check for vestibular damage due to a career in diving. Also shows overall sensitivity of vestibular apparatus to turning stimuli. (RK)
617. FREGLY, A. R.
Vestibular ataxia and its measurement in man.
In H. H. Kornhuber (Ed.) Handbook of sensory physiology. Vol. VI. Vestibular system. Berlin-Heidelberg-New York: Springer-Verlag, in press.
- Probably the best single source for measurement of postural equilibrium in man. An extensive bibliography. (RK)
618. FREGLY, A. R., A. GRAYBIEL, and M. J. SMITH.
Walk on floor eyes closed (WOFEC): A new addition to an ataxia test battery.
Aerosp. Med. 43(4):395-399, 1972.
- See other articles by senior author. This paper is also related to the question of swimmer navigation. (RK)

619. FREGLY, A. R., and M. J. SMITH.
Chronological age influences on ataxia test battery intercorrelations.
U. S. Naval Aerospace Medical Research Laboratory Report, Pensacola, Fla., in press.
See other papers by senior author.
620. FREGLY, A. R., M. J. SMITH, and A. GRAYBIEL.
Revised normative standards of performance of men on a quantitative ataxia test battery.
U. S. Naval Aerospace Medical Research Laboratory, Pensacola, Fla., Report No. NAML-1160. (Submitted to Acta Otolaryngol. (Stockh), in press.)
See other references by the senior author.
621. FREGLY, A. R., M. J. SMITH, C. D. WOOD, D. B. CRAMER, and A. GRAYBIEL.
Effects of some antinotion sickness drugs and secobarbital on postural equilibrium at ground level and at 12,000 feet (simulated).
U. S. Naval Aerospace Medical Research Laboratory Report, Pensacola, Fla., in press.
See other papers by senior author.
622. KENNEDY, R. S.
The relationship between habituation to vestibular stimulation and vigilance: individual differences and subsidiary problems.
Ph.D. thesis, University of Rochester, New York, 1972.

See also:

References 14, 130, 150, 162, 235, 246, 250, 272, 288, 305, 337, 345, 403, 428, 441, 447, 463, 473, 477, 484, 488, 492, 496, 498, 499, 500, 502, 507, 508, 525, 627, 635, 638, 639, 640, 651, 652, 653, 660, 662, 678, 698, 701, 702, 703, 707, 708, 718, 732, 742, 745, 747, 755, 758, 764, 801, 808, 824, 827, 835, 842, 844, 857, 858, 870, 872, 873, 874, 941, 960.

ADDENDUM--CATEGORY III

- 622a. CLARK, B., and M. A. NICHOLSON.
Aviator's vertigo: A cause of pilot error in naval aviation students.
Aviat. Med. 25:171-179, April 1954.
- 622b. MOTTRAM, J., and G. SINGER.
Judgments of body and object verticality in the presence of discordant visual information.
Psychon. Sci. 22(6):265-367, 1971.

CATEGORY IV. PERCEPTUAL ILLUSIONS OCCASIONED BY THE ENVIRONMENT
SOME OF WHICH MAY BE OF VESTIBULAR ORIGIN.

1910-1919

623. STIGLEP, R.
Versuche über die Beteiligung der Schwereempfindung an der Orientierung des Menschen im Raume. (Experiments dealing with the participation of the sensation of gravity in the orientation of man in space. Trans. by Mrs. A. Woke, NERI, 1972.)
Archiv. für die gesamte Physiologie 148:573-584, 1912.

An early paper which describes the existence of a "special spatial sense organ (p. 575)" which the author studied under water. He used the best swimmers of the Vienna Row Club "DONAU" as subjects (p. 575). He dipped the subjects under water and rotated them for 1 to 1 1/2 minutes, then had Ss indicate which way was up. Gross errors were made, and the subjects were frightened. These data differed from those reported by Exner, therefore, additional tests were made with subjects under water for longer periods, strapped to a board rotating vertically or as a spit. The Ss (Hungarian divers) were able to respond to the upright correctly, although accuracy was not perfect. Mentions also that fear and apprehension contributed to errors. (PK)

1920-1929

624. KOCH, H. L., and J. UFKESS.
A comparative study of stylus maze learning by blind and seeing subjects.
J. Exp. Psychol. 9:118-131, 1926.

Stylus maze performance is generally poorer in blind than blindfolded subjects, although having "some visual experience before the onset of blindness" helps. Similar relationships may be applicable under water. (PK)

625. WEBER, C. O., and K. M. DALLENBACH.
The properties of space in kinaesthetic fields of force.
Am. J. Psychol. 41:95-105, 1929.

1930-1939

626. MACCURDY, J. T.
Disorientation and vertigo, with special reference to aviation.
The introductory contribution to a discussion of disorientation and vertigo at the joint meeting of the Physiological and Psychological Sections of the British Association for the Advancement of Science, Leicester, England, 1933.
627. GIBSON, J. J., and O. H. MOWRER.
Determinants of the perceived vertical and horizontal.
Psychol. Rev. 45:300-323, 1938.

An excellent early reference on the perception of the upright with complete bibliography.

1940-1949

628. GRAYBIEL, A., and B. CLARK.
The autokinetic illusion and its significance in night flying.
U. S. Naval School of Aviation Medicine, Pensacola, Fla., Report No. 3, Project X-148(AV-V4-3), 7 February 1945.

A significant paper which reviews visual effects which occur in unarticulated visual environments. The thrust of the paper is aviation, but diving environments have much commonality. (PK)

629. VINACKE, W. E.
The concept of aviator's "vertigo."
U. S. Naval School of Aviation Medicine, Pensacola, Fla., Report No. 7, 8 May 1946a.
630. VINACKE, W. E.
Illusions experienced by aircraft pilots.
U. S. Naval School of Aviation Medicine, Pensacola, Fla., Report No. 9, 31 May 1946b.
631. VINACKE, W. E.
Predicting the susceptibility of aviators to "vertigo". A preliminary study.
U. S. Naval School of Aviation Medicine, Pensacola, Fla., Report No. 10,
21 June 1946c.
632. VINACKE, W. E.
"Vertigo" as experienced by naval aviators.
U. S. Naval School of Aviation Medicine, Pensacola, Fla., Report No. 12, 3 July 1946d.

This and other papers by the author report a questionnaire approach that could well be modified for underwater studies of vertigo. (RK)

633. VINACKE, W. E.
"Fascination" in flight.
U. S. Naval School of Aviation Medicine, Pensacola, Fla., Report No. 13, 1946e.
634. CLARK, B., and A. GRAYBIEL.
The effect of angular acceleration on sound localization: the audiogyral illusion.
J. Psychol. 28:235-244, 1949a.
- Under certain conditions this effect can lead to disorientation; particularly when using sound localization for navigation. (RK)
635. CLARK, B., and A. GRAYBIEL.
Studies of human adaptation to centrifugal force. I. Visual perception of the horizontal.
U. S. Naval School of Aviation Medicine, Pensacola, Fla., Research Report No.
NM 001.059.01.22, November 15, 1949b.

Indicates that the vestibular system is useful in orientation but also describes an illusion (oculogravie) which could occur in submersibles and lead to disorientation. (RK)

636. WITKIN, H. A.
Perception of body position and of the position of the visual field.
Psychol. Monogr. 73(7):302, 1949.
- A good source for studies of perception of the upright under water.

1950-1959

637. PASSEY, G. E.
The perception of the vertical: IX. Adjustment of the visual vertical from various magnitudes of body tilt.
U. S. Naval School of Aviation Medicine, Pensacola, Fla., Joint Project Report No. 15, NM 001 063.01.15 (formerly NM 001 037), March 10, 1950.
- This whole series of studies is of importance for underwater perception. About thirty studies from these two authors have appeared. See Stearns and Kasperek (1963, #403) for additional titles.
638. MANN, C. W., and G. E. PASSEY.
The perception of the vertical: V. Adjustment to the postural vertical as a function of the magnitude of postural tilt and duration of exposure.
J. Exp. Psychol. 41:108-113, 1951.
- Shows influence of tilt on perception of upright.

639. GIBSON, J. J.
The relation between visual and postural determinants of the phenomenal vertical.
Psychol. Rev. 59:370-375, 1952.
640. BITTERMAN, D. E., and P. WORCHEL.
The phenomenal vertical and horizontal in blind and sighted subjects.
Am. J. Psychol. 66:598-602, 1953.

Shows the dependence of vision in orientation but also shows that blindfolded sighted subjects are more disrupted than blind subjects when they are tilted.
641. CLARK, B., and A. GRAYBIEL.
"Fascination": A cause of pilot error.
U. S. Naval School of Aviation Medicine, Pensacola, Fla., Report No. NM 001.059.01.35, 15 May 1953.

The similarities of a pilot flying into a target/tow banner (which occur with some frequency in aviation training) and "perceptual narrowing in novice divers" (Weltman & Egstrom, 1966, #705) are strong enough to suspect a similar mechanism. (RK) This study used over 500 subjects.
642. WITKIN, H. A., H. B. LEWIS, M. HERTZMAN, K. MACHOVER, P. B. MEISSNER, and S. WAPNER.
Personality through perception. New York: Harper, 1954.

This and Witkin (1949, #636) and Witkin et al. (1962, #674), report individual differences in perception of the upright which may have important applications for diver selection and training. (RK)
643. ASHER, H. M.
Off effect giving rise to a sensation of blackness.
J. Physiol. 134:18, 1956.

Demonstrates that "perceptual narrowing" or "tunnel vision" can be of neural origin and can occur when a person stares fixedly. This could also occur if attention is fixed. (RK) (cf. Weltman & Egstrom, 1966, #705.)
644. CLARK, B., and A. GRAYBIEL.
Vertigo as a cause of pilot error in jet aircraft.
U. S. Naval School of Aviation Medicine, Pensacola, Fla., Report No. 44, 15 August 1956.

This paper should also be consulted because of the possibility of vertigo in submersibles. (RK) Additionally, it describes a useful technique for questionnaire construction which could be used to study vertigo as symptomatology of DCS. (RK)
645. FEENY, B.
Buffalo divers use underwater sled.
Skin Diver 5-21, Sept. 1956. N.V.
646. MANN, C. W.
Final Technical Report, Joint Project Report No. 43.
U. S. Naval School of Aviation Medicine, Pensacola, Fla., 30 June 1956.

The report lists all 43 studies in this series, many of which deal with orientation to vertical and horizontal.
647. CLARK, B., and A. GRAYBIEL.
The break-off phenomenon.
J. Aviat. Med. 28:121-126, 1957a.

Divers should be interviewed to determine whether a similar phenomenon also occurs at depth. (RK)

648. CLARK, B., and A. GRAYBIEL.
Vertigo as a cause of pilot error in jet aircraft.
J. Aviat. Med. 28:469-478, 1957b.
- See Clark and Graybiel (1956, #644) for a more complete explanation of questionnaire construction.
649. KOHL, O. A., and F. SEARLE, JR.
Subjective and articulation tests of deep and shallow water divers communication.
U. S. Navy Experimental Diving Unit, Wash., D. C. Report on Project NS185-005,
Subtask 2, Test 10, 19 August 1957.
- Because underwater sound communication is poor, perhaps vestibular and/or cutaneous communication should be explored. (RK)
650. WOELLNER, R. C.
The perception of vertical in the presence of increased accelerative forces.
U. S. Naval School of Aviation Medicine, Pensacola, Fla., Report No. 45,
31 October 1957.
651. MARGARIA, R.
Wide range investigations of acceleration in man and animals.
J. Aviat. Med. 29(12):855-871, 1958.
- This is a significant paper--not often referenced in the compressed air literature (probably because it was intended to apply to aviation and space flight). (RK)
It contains information of interest in several categories, e.g., (a) sense of position under water (p. 860), and (b) evoked cerebellar responses have lower thresholds in migratory than non-migratory birds (p. 863 ff).
652. MARGARIA, R., T. GUALTIEROTTI, and D. SPINELLI.
Protection against acceleration forces in animals by immersion in water.
J. Aviat. Med. 29(6):433-437, 1958.
- See also Margaria (1958, #651).
653. MELVILL JONES, G.
Disorientation in flight.
Presented at the First International Congress of Aeronautical Sciences, Madrid,
Spain, 8-13 September, 1958.
- A good discussion of the problem relative to aviation, and applicable to diving.
654. NUTTALL, J. B.
The problem of spatial disorientation.
J. A. M. A. 166(5):431-438, 1958.
- There are many similarities between diving and aviation. Because of a relatively larger research effort in the latter, important leads for the former can often be found. This paper and others deal with disorientation (e.g., Melville Jones, 1957, #112; 1958, #653; and Lundgren, 1965, #166; 1966, #184).
655. PIRENNE, M. H., H. C. MARRIOTT, and E. F. O'DOHERTY.
Individual differences in night-vision efficiency.
Medical Research Council, Special Report Series No. 294, London: Her Majesty's Stationery Office, 1958.
- Offers a neural explanation for an effect similar to "perceptual narrowing" (Weltman & Egstrom, 1966, #705).
656. BECKMANN, E. L.
Escape from ditched aircraft.
Institute of Aviation Medicine, R. A. F., Farnborough, England, 1959. N.V.

657. PADDEN, D. A.
Ability of deaf swimmers to orient themselves when submerged in water.
Res. Q. Am. Assoc. Health Phys. Educ. 30:214-226, 1959.

Clearly shows the importance of vestibular organs for orientation underwater. In addition, since individual differences are reported, tests of this orientation ability in normal individuals could be employed as a selection device for diving training. (RK)

1960-1969

658. CLARK, B., and A. GRAYBIEL.
Visual perception of the horizontal during prolonged exposure to radial acceleration on a centrifuge.
U. S. Naval School of Aviation Medicine, Pensacola, Fla., Report No. 54, 18 August 1960.

Same as Clark and Graybiel (1957, #647).
659. GRAYBIEL, A., B. CLARK, and J. J. ZAPRIELLO.
Observations on human subjects living in a "slow rotation room" for periods of two days.
A. M. A. Arch. Neurol. 3:55-73, 1960.

Findings of dizziness, etc., at low rates of angular velocity (1 & 2 RPM) suggest this may be an area of concern in submersibles if the latter turn at comparable rates. (RK)
660. SCHOCK, G. J. D.
Perception of the horizontal and vertical in simulated subgravity conditions.
U. S. Armed Forces Med. J. 2(7):786-793, 1960.

Most of this paper contains raw data. The purpose of the study was connected with space flight; however, the tests were carried out underwater.
661. WHITESIDE, T. C. D.
The effect of weightlessness on some postural mechanism.
Aerosp. Med. 31:324, 1960.

The author describes past pointing errors in zero gravity. Neutral buoyancy may produce similar problems. (RK)
662. BROWN, J. L.
Orientation to the vertical during water immersion.
U. S. Naval Medical Research Laboratory, Groton, Conn., Report No. 355, 10 May 1961.

This very significant study shows that orientation underwater is sometimes very poor. It contains suggestions for improvement of perception, and further research needed.
663. CHAMBERS, R. M., D. A. MORWAY, E. L. BECKMAN, R. DEFOREST, and K. R. COBURN.
The effects of water immersion on performance proficiency.
U. S. Naval Air Development Center, Johnsville, Pa., Report No. MA-6133, 1961.
664. GRAVELINE, D. E., B. BALKE, R. E. MCKENZIE, and B. HARTMAN.
Psychobiologic effects of water-immersion-induced hypodynamics.
Aerosp. Med. 32:387-400, 1961.

Mainly shows cardiovascular effects, but a good source for other water immersion studies. (RK)

665. GRAYBIEL, A., and CLARK, B.
Perception of the horizontal or vertical with head upright, on the side, and inverted under static conditions and during exposure to centripetal force. U. S. Naval School of Aviation Medicine, Pensacola, Fla., and National Aeronautics and Space Administration, NASA Order No. R-1, 15 August 1961a.
666. GRAYBIEL, A., and B. CLARK.
Symptoms resulting from prolonged immersion in water: The problem of zero G asthenia.
Aerosp. Med. 32(3):181-196, 1961b.
Describes some psychological effects from enforced prolonged water immersion.
667. GUENRY, F. E., JR., and E. K. MONTAGUE.
Quantitative evaluation of the vestibular Coriolis reaction.
Aerosp. Med. 32:487-500, 1961.
Of importance if the angular velocity of submersibles reaches threshold values.
668. BLEGVAD, B.
Caloric vestibular reaction in unconscious patients.
Arch. Otolaryngol. 75:506-514, 1962.
Suggests that arousal can potentiate the caloric vestibular reaction and so a diver in panic may be more susceptible to caloric induced vertigo. Also shows the diagnostic use of the test. (RK)
669. CORSO, J. F.
Bodily position and auditory thresholds.
Percept. Mot. Skills 14:499-507, 1962. N.V.
670. DAVSON, H. (Ed.)
The eye.
New York & London: Academic Press, 1962.
The Troxler phenomenon is described, which is behaviorally similar to "greying out," "tunnel vision," or "perceptual narrowing," and occurs when one gazes fixedly (cf. Weltman & Egstrom, 1966, #705).
671. HAMMER, L. R.
Perception of the visual vertical under reduced gravity.
Aerospace Medical Division, 6570th Aerospace Medical Research Laboratories, Wright-Patterson AFB, Ohio. Report No. MRL-TDR-62-55, May 1962.
A good review paper with some reference to mutual buoyancy studies.
672. KENNEDY, R. S., and A. GRAYBIEL.
Symptomatology during prolonged exposure in a constantly rotating environment at a velocity of one revolution per minute.
Aerosp. Med. 33:817-825, 1962b.
Shows that disorientation and motion sickness are minimal or absent at this angular velocity except for extremely susceptible persons. Perhaps submersibles should use this as an upper limit unless countermeasures are employed. (RK)
673. PIPEPNE, M. H.
Light-adaptation.
In H. Davson (Ed.) The eye. Vol. 2. New York: Academic Press, 1962.
The Troxler phenomenon reported here has much in common with "perceptual narrowing" (Weltman & Egstrom, 1966, #705).

674. WITKIN, H. A., R. B. DYK, H. F. FATEPSON, D. R. GOODENOUGH, and S. A. KAPP.
Psychological differentiation: Studies of development.
New York: Wiley, 1962.
- See Witkin et al. (1954, #642), and Witkin (1949, #636).
675. ANON.
Handbook of instructions for aerospace systems design. Vol. III. Reduced gravity.
AFSON 80-9, HDQTRS AFSC, Andrews AFB, Wash., D. C., September 1963.
- Many studies are reported where water immersion was used to simulate zero gravity. These studies are also of interest for their application to underwater studies, but are not often referenced in underwater reviews. (FK) They include studies of perceptual, cardiovascular, and performance problems.
676. CHAMBERS, R. M.
Psychological problems in disorientation.
U. S. Naval Air Development Center, Johnsville, Pa., NADC-MA-6321, AD 432968,
31 December 1963.
- A good review paper with well-described mechanisms and nomenclature.
677. FERGUSON, J. C., and R. M. CHAMBERS.
Psychological aspects of water immersion studies.
U. S. Naval Air Development Center, Johnsville, Pa., Report No. MA-6328,
30 December 1963.
- Shows "a considerable disorientation in the water, especially in the head down and back position (p. iii)." These studies were concerned with effects of weightlessness in space flight but many used water immersion to simulate sub-gravity and as such have application for underwater physiology and psychology. (FK)
678. MILLER, E. F., and A. GRAYBIEL.
Rotary autokinesis and displacement of the visual horizontal associated with head (body) position.
Aerosp. Med. 34(10):915-919, 1963b.
679. NORWAY, D. A., R. G. LATHROP, R. M. CHAMBERS, and L. HITCHCOCK.
The effects of prolonged water immersion on the ability of human subjects to make position and force estimates.
U. S. Naval Air Development Center, Johnsville, Pa., Report No. MA-6115, 24 July 1963.
- Shows that past pointing is in error underwater, but adapts.
680. WHITESIDE, T. C. D., A. GRAYBIEL, and J. I. NIVEN.
Visual illusions of movement.
U. S. Naval School of Aviation Medicine, Pensacola, Fla., and National Aeronautics and Space Administration, NSAM-877, NASA R-93, 21 October 1963.
- A review paper which also speculates on mechanisms and implications.
681. BAUERWEISTER, M.
Effect of body tilt on apparent verticality, apparent body position, and their relation.
J. Exp. Psychol. 67(2):142-147, 1964.
682. FLETCHER, J. L., G. D. ROBERSON, and M. LOEB.
Effects of high intensity impulse noise and rapid changes in pressure upon stapedectomized monkeys.
U. S. Army Medical Research Laboratory, Fort Knox, Ky., Report No. 610, August 21, 1964.

683. GUEDRY, F. E., JR., R. S. KENNEDY, C. S. HARRIS, and A. GRAYBIEL.
Human performance during two weeks in a room rotating at three RPM.
Aerosp. Med. 35(11):1071-1082, 1964.
- This report shows that some difficulties exist with an angular velocity as low as 3 RPM and should be considered in connection with submarines. (Same as #563, Category III.)
684. KATZ, M. S., W. METLAY, and P. A. CIRINCIONE.
The effects of stimulus and field size on the accuracy of orientation in the homogeneous environment.
Communications Psychology Division, Human Factors Laboratory, Orlando, Fla.,
NAVTRADEVCEM IH-13, AD 607739, July 1964.
- See Metlay, et al. (1964, #685).
685. METLAY, W., M. S. KATZ, P. A. CIRINCIONE, and G. C. TOLHURST.
Vertical orientation in a homogeneous environment.
U. S. Naval Training Device Center, Port Washington, N. Y., NAVTRADEVCEM IH-19,
AD 603568, 12 October 1964.
- Empty or near-empty fields are experienced by divers.
686. SCHONE, H.
On the role of gravity in human spatial orientation.
Aerosp. Med. 35(8):764-772, 1964.
687. SZIKLAI, C., S. WAPNER, J. H. MCFARLAND, and H. WEPNER.
Effect of tonus changes on perceived location of visual stimuli.
Aerosp. Med. 35(6):519-523, 1964.
- Interaction of postural and visual systems is reported.
688. AVANT, L. L.
Vision in the Ganzfeld.
Psychol. Bull. 64(1):246-258, 1965.
- Empty or near empty fields are experienced by divers.
689. MACKWORTH, N. H.
Visual noise causes tunnel vision.
Psychon. Sci. 3:67-68, 1965.
- This paper is relevant to any study where amorphous visual environments exist. It is particularly relevant to the "perceptual narrowing" finding (Weltman & Egstrom, 1966, #705).
690. PROPST, A. S.
A preliminary study of man in the sea, diver personnel and training implications.
Naval Personnel Program Support Activity, Personnel Research Laboratory, Wash.,
D. C., Report No. WRM 66-5, July 1965.
- Describes a "depth disorientation phenomenon" (pp. 18, 19, and 22) in connection with Sealab II.
691. STEPHENS, W. M.
Research submarines.
Sea Frontiers 11:228-241, July/Aug. 1965. N.V.

692. STEWART, J. D., and B. CLARK.
Coriolis effects during pitch and roll maneuvers in a piloted flight simulator.
Aerosp. Med. 36(2):106-112, 1965.
- Applicable to submersibles.
693. WYKE, M.
Comparative analysis of proprioception in left and right arms.
Q. J. Exp. Psychol. 17(2):149-157, 1965.
- Pointing accuracy a function of target position and head movement. The influence of neutral buoyancy on these results should also be studied. (RK)
694. CONTICELLI, M., and E. M. GLORIA.
Visual performance in the empty field and in partially structured fields. III.
Task involving Vernier acuity.
Atti Fond. G. Ronchi 21(3):605-614, 1966.
- See Conticelli and Zoli (1966, #695).
695. CONTICELLI, M., and M. T. ZOLI.
Visual operating characteristic in the empty field.
Atti Fond. G. Ronchi 21(3):307-314, 1966.
- Visibility underwater can be analogous to an empty field.
696. DAY, R. H., and N. J. WADE.
Visual spatial aftereffect from prolonged head-tilt.
Science 154(3735):1201-1202, 1966.
697. DOWD, P. J., E. W. MOORE, and R. L. CRAMER.
Effects of flying experience on the vestibular system: A comparison between pilots and non-pilots to Coriolis stimulation.
Aerosp. Med. 37(1):45-47, 1966.
- The differences in susceptibility to Coriolis stimulation between experienced and inexperienced aviation personnel may be applied to submersible training and selection of divers. (RK)
698. HOWARD, I. P., and W. B. TEMPLETON.
Human spatial orientation.
New York: John Wiley & Sons, 1966.
- An excellent text which describes the interrelationships of vestibular and visual stimulations. Tests of vestibular function are included. The chapter on orientation (p. 419 ff.) on weightlessness is particularly relevant for diving medicine.
699. MARGARIA, R.
Human locomotion on the earth and in subgravity.
Schweizerische Zeitschrift fur Sportmedizin 14:159-167, 1966.
- See other papers by Margaria.
700. MILLER, E. F., and A. GRAYBIEL.
Magnitude of gravito-inertial force, an independent variable in egocentric visual localization of the horizontal.
J. Exp. Psychol. 71(3):452-460, 1966a.

701. MILLER, E. F., and A. GRAYBIEL.
Role of the otolith organs in the perception of horizontality.
Am. J. Psychol. 79:24-37, 1966b.

- This paper and others by these authors should be consulted for the mechanism of orientation to the vertical and horizontal in humans, as well as for an understanding of the disorientation problems which may occur in this capacity under neutral buoyancy. (RK)

702. MILLER, E. F., A. R. FREGLY, and A. GRAYBIEL.
Visual horizontal perception in relation to otolith function.
U. S. Naval Aerospace Medical Institute, Pensacola, Fla., Report No. 989,
23 December 1966.

703. MOORE, E. W.
Responses to Coriolis stimulation in flying personnel with different levels of proficiency.
USAF School of Aerospace Medicine, Brooks AFB, Texas, SAM-TR-66-36, AD 634406,
April 1966.

The author reports increased tolerance with flying experience and similar effects may occur in similar environments (e.g., submersibles). Flying experience was correlated with age, and although not mentioned as such, may also have been a factor. (RK)

704. WEENE, P., and R. HELD.
Changes in perceived size of angle as a function of orientation in the frontal plane.
J. Exp. Psychol. 71(1):55-59, 1966.

705. WELTMAN, G., and G. H. EGSTROM.
Perceptual narrowing in novice divers.
Hum. Factors 499-506, December 1966.

These effects can influence orientation whether to the upright or in terms of a direction sense. (RK)

706. ARNOLD, H. A.
Manned submersibles for research.
Science 158(3779):84-95, 1967.

The addition of motion to the other attributes of the underwater sensory environment may increase the perceptual problems.

707. CLARK, B., and A. GRAYBIEL.
The egocentric localization of the visual horizontal in normal and labyrinthine-defective observers as a function of head and body tilt.
U. S. Naval Aerospace Medical Institute, Pensacola, Fla., Report No. 991,
17 January 1967a.

Shows the importance of the vestibular system in orientation (as in Clark & Graybiel, 1967b, #708).

708. CLARK, B., and A. GRAYBIEL.
Egocentric visual localization in normals and partially blind during a change in direction of gravito-inertial force.
U. S. Naval Aerospace Medical Institute, Pensacola, Fla., Report No. 1006,
2 May 1967b. Also in Am. J. Psychol. 81:314-318, 1968.

Shows the importance of the vestibular system in orientation.

709. GRAYBIEL, A. (Ed.)
Third symposium on the role of the vestibular organs in space exploration.
U. S. Naval Aerospace Medical Institute, Pensacola, Fla., NASA SP-152, 24-26
January 1967.
- This volume, plus Graybiel (1965, #417; 1967, #450; 1968, #588), are the best collection of studies of the vestibular apparatus. See also Camis (1930, #299).(RK)
710. GRAYBIEL, A., E. F. MILLER, II, B. D. NEWSOM, and R. S. KENNEDY.
The effect of water immersion on perception of the oculogravic illusion in normal and labyrinthine-defective subjects.
U. S. Naval Aerospace Medical Institute, Pensacola, Fla., Report No. 1016, September 1967.
- One "normal" subject had more difficulty in orientation underwater than did the other three. (Same as #579.)
711. GUEDRY, F. E., JR.
Relations between vestibular nystagmus and visual performance.
U. S. Army Aeromedical Research Unit, and U. S. Naval Aerospace Medical Institute, Pensacola, Fla., NAMI-1008, 24 May 1967.
- Nystagmus elicited by rotation degrades visual performance. It is felt that if vertigo and nystagmus occur in divers from pressure, bubbles or other means, a similar outcome can be expected. (RK)
712. PESCH, A., and R. TOHER.
Analysis of star boat performance and characteristic response.
General Dynamics Electric Boat Division, Groton, Conn., P417-67-060, October 30, 1967.
- Figures 18, 19, and 20 suggest that in a 30-second 180° turn, the angular velocity in the last 10 seconds approaches the threshold for Coriolis stimulation of the semicircular canals (Meda, 1952, #92) which could in turn produce vertigo. (RK)
713. STEEDMAN, W. C.
Absolute judgments of size in a restricted visual environment.
Percept. Mot. Skills 24:731-736, 1967.
714. ANON.
Rotational extravagance.
Approach 14-15, June 1968.
- Describes how fear, information overload, and a vestibular stimulus can summate and interact with hazardous consequences.
715. ANON.
Research submersibles; A report from General Dynamics.
Undersea Technol. 9:77, May 1968. N.V.
716. BARNUM, F.
The epidemiology of USAF spatial disorientation aircraft accidents.
Presented at the 1971 Aerospace Medical Association Meeting in Houston, Texas, 1 January 1958-1 December 1968.
- Although present-generation submersibles do not approach the aerobic freedom of high performance aircraft, this report suggests that a violent maneuver is not always necessary for disorientation. Leads and potential problem areas for underwater vehicles can be found here. (RK)

717. CLARK, B., and J. D. STEWART.
Comparison of sensitivity for the perception of bodily rotation and the oculogyral illusion.
Perception and Psychophysics 3(4A):253-256, 1968b.

The fact that two indicators of rotation sensitivity have different thresholds can result in disorientation in moving vehicles, particularly when cues are altered or absent (e.g., underwater). (RK)

718. HARRIS, C. S., and H. C. SOMMER.
Human equilibrium during acoustic stimulation by discrete frequencies.
Aerospace Medical Research Laboratories, Wright-Patterson AFB, Ohio, Report No. ATRL-TR-68-7, May 1968.

Because noise can produce changes in equilibrium, and because pressure chambers are noisy, one must control the effects of noise in order to measure the effects of pressure on equilibrium. (RK)

719. IWANE, M., H. ONO, and M. SAWADA.
Effects of Coriolis stimulus during mild centrifugal G-load upon stick performance.
Med. Experiment Report 8(4):135-141, 1968. (Trans. by Civilian Aeromedical Institute Library, AC-922, Federal Aviation Administration, Oklahoma City, Okla., 1969.)

This paper shows that head movements incident to angular velocity (not very different from the rate of turn in submersibles--RK) can influence tracking.

720. LETKO, W., and A. A. SPADY, JR.
Walking in simulated lunar gravity.
Presented at the Fourth Symposium on the Role of the Vestibular Organs in Space Exploration, Pensacola, Fla., September 24-26, 1968.

721. MILTICH, A. J.
Human auditory threshold shifts following changes between upright, supine and inverted bodily positions.
J. Auditory Res. 8:367-377, 1968.

Auditory thresholds are higher in the inverted position--a position not uncommon in diving. The influence of the vestibular system was not ruled out satisfactorily. (RK)

722. NELSON, J. G.
Effect of water immersion and body position upon perception of the gravitational vertical.
Aerosp. Med. 39(8):806-811, 1968.

Demonstrates the difficulties in orientation to which way is up when immersed in water. A good bibliography.

723. PESCH, A. J.
Human factors research and simulation in the design of small submersibles.
General Dynamics Electric Boat Division, Groton, Conn., May 7, 1968.

See Pesch and Toher (1967, #712).

724. RADLOFF, R., and R. HELMREICH.
Marine life.
In R. Radloff and R. Helmreich Groups under stress: Psychological research in SEALAB II. Century Psychology Series. New York: Appleton-Century-Crofts, 1968.

Reports on disorientation in SEALAB II, pp. 62, 63.

725. ROSS, H. E., and P. LENNIE.
Visual stability during bodily movement underwater.
Underwater Association Report 504:55-57, 1968.

726. ANON.
Cepter 1 submersible.
Oceanol. Int. 4:14, Jan./Feb. 1969. N.V.

727. ANON.
Sub-surface ocean vehicle.
Oceanol. Int. 4:26, May/June 1969. N.V.

728. BARRETT, G. V., P. A. CABE, C. L. THORNTON, and H. E. KERBER.
Evaluation of a motion simulator not requiring cockpit motion.
Hum. Factors 11(3):239-244, 1969.

Because motion sickness and vertigo might occur in submersibles, and on barges before a dive with dire consequences, a training or screening device may be useful for diving medicine. (RK)

729. BROSGOLE, L., and K. H. HANSEN.
The effect of change in body orientation upon the perceived direction of autokinesis.
Psychon. Sci. 15(4):204, 1969.

Because a swimmer's attitude underwater with respect to gravity is different than when under terrestrial conditions, this paper is of interest. (RK)

730. BYNUM, J. A., and J. A. STEPH.
Painted helicopter main rotor blades and flicker-induced vertigo.
Aerosp. Med. 40(6):622-626, 1969.

The authors indicate that under special conditions "vertigo" can be induced by flicker.

731. CONTICELLI, M., and R. BRANCATO.
Autokinesis in the empty field.
Atti Fond. G. Ronchi 24(3):375-386, 1969.

See Conticelli and Zoli (1966, #695).

732. DOTY, R. L.
Effect of duration of stimulus presentation on the angular acceleration threshold.
J. Exp. Psychol. 80(2):317-321, 1969.

Results should be compared to angular velocity of submersibles for purposes of design criteria and perhaps selection of crew members. (RK)

733. MCCOY, D. F., and K. C. LANGE.
Stimulus generalization of gravity.
J. Exp. Anal. Behav. 12:111-118, 1969. N.V.

734. MILES, S.
Underwater medicine (3rd ed.).
Philadelphia: J. B. Lippincott Co., 1969.

Discusses the effect of neutral buoyancy on perception, and other perceptual illusions occasioned in water. Mentions "interest in dizziness has in recent years subsided," but "cannot be lightly dismissed," and "is worthy of future consideration" (p. 94). A very good book. (RK)

735. MOSER, R., JR.
Spatial disorientation as a factor in accidents in an operational command.
Aerosp. Med. 40(2):174-176, 1969.

A similar effort might be undertaken for divers.

736. PETERS, R. A.
Dynamics of the vestibular system and their relation to motion perception,
spatial disorientation, and illusions.
NASA Contractor Report No. CR-1309, Wash., D. C., April 1969.

737. PICK, H. L., JR., D. H. WARREN, and J. C. HAY.
Sensory conflict in judgments of spatial direction.
Perception & Psychophysics 6(4):203-205, 1969.

The hierarchy of sensory modalities is shown in this study and as expected, vision is very important. However, the influence of proprioception over audition has application for underwater where the influence of the former is minimized. (RK)

738. RAINNIE, W. O., JR.
Adventures of Alvin.
Ocean Ind. 3:22-28, May 1969. Also published as Woods Hole Oceanogr. Inst.
Report 69-48, AD 692 346, May 1969. N.V.

739. REASON, J. T., and A. GRAYBIEL.
Magnitude estimations of Coriolis sensations.
U. S. Naval Aerospace Medical Institute, Pensacola, Fla., and National Aeronautics
and Space Administration, NAMA-1082, NASA Order R-93, 18 July 1969.

One of a series of studies on this phenomenon by these authors.

740. ROSS, H. E., S. D. CRICKMAR, N. V. SILLS, and E. P. OWEN.
Orientation to the vertical in free divers.
Aerosp. Med. 40(7):728-732, 1969.

The authors report inverted (relative to gravity) performances are poorer than upright. Their findings are essentially supportive of the studies by Nelson (1968, #722), Brown (1961, #662), and others.

741. TROUT, O. F., JR., and W. J. BRUCHEY, JR.
Water immersion reduced-gravity simulation.
Hum. Factors 11(5):473-488, 1969.

A very good review. Although intended for an aerospace audience, it is directly applicable to diving. (RK)

742. YESSENOW, M. D.
A study of the relationship between nystagmus eye movements and the oculogyral illusion.
Submitted in partial fulfillment of the requirements for the degree of Doctor
of Philosophy, University of Rochester, New York, 1969.

1970-1972

743. ANON. (Staff - Deep Vehicles Branch of the U. S. Naval Oceanographic Office.)
Manned submersibles and underwater surveying.
U. S. Naval Oceanographic Office, Wash., D. C., 1970.

Illustrates the characteristics of submersibles. In addition to possible problems from Coriolis stimulation due to head movements incidental to angular velocities (e.g., during turns), the presence or absence of ports may also lead to illusory disturbances connected to the vestibular apparatus. (RK)

744. BERNOTAT, R. K.
Rotation of visual reference systems and its influence on control quality.
IEEE Trans. on Man-Machine Systems, MMS-11 (2):129-131, 1970.
- There could be an application of the findings to instrument design in submersibles and perhaps for free swimming divers. (RK)
745. CLARK, B., and J. D. STEWART.
Thresholds for the perception of angular acceleration about the three major body axes.
Acta Otolaryngol. (Stockh) 69:231-236, 1970.
- See Clark and Stewart (1968b, #717).
746. COLLINS, W. E.
Effective approaches to disorientation familiarization for aviation personnel.
Department of Transportation, Federal Aviation Administration, Oklahoma City, Okla., Report No. A-70-17, November 1970.
- The training program reported here may be useful in connection with duty in submersibles. (RK)
747. EBENHOLTZ, S. M.
Perception of the vertical with body tilt in the median plane.
J. Exp. Psychol. 83(Part 1):1-6, 1970.
- Shows data regarding egocentric horizontality and variables which influence this ability.
748. FRANKLIN, S. S., H. E. ROSS, and G. WELTMAN.
Size-distance invariance in perceptual adaptation.
Psychon. Sci. 21(4):229-231, 1970.
- Adaptation to perceptual distortion is related to water and face mask distortion.
749. GRIGOR'EV IU, G., IU V. FARBER, and N. A. VOLOKHOVA.
Vestibuliarnye reaktsii. (Vestibular reactions. A71-28672.) 195 pp.
Moscow, Izdatel'stvo Meditsina, 1970.
- Of some interest regarding Coriolis forces and submersibles. (Abstract only seen.)
750. KENNEDY, R. S.
Visual distortion: a point of view.
U. S. Naval Aerospace Medical Institute, Pensacola, Fla., Report No. 7600,
Monograph #15, 6 January 1970.
- A review of the literature on visual distortion with references to vestibular distortions also. Speculations on mechanisms and counter-measures are made.
751. KOTASKOVA, J.
Some psychological aspects of isolation in hyperbaric conditions.
Revue De Physiologie Subaquatique 2(1), 1970.
- Mentions disorientation.
752. MCKAY, C. L.
Decrease in perceived distortion with repeated exposure: application for Naval diver training.
U. S. Naval Submarine Medical Center, Groton, Conn., Report No. 613, 16 February 1970.

753. MELVILL JONES, G.
Dynamic cross-coupling in the semicircular canals.
In D. E. Busby (Ed.) Recent advances in aerospace medicine. pp. 235-248.
Dordrecht-Holland: D.Reidel Publishing Co., 1970a.
- If vertigo occurs in future generations of submersibles this report will aid in explaining the mechanisms. (RK)
754. MELVILL JONES, G.
Origin significance and amelioration of Coriolis illusions from the semicircular canals: A non-mathematical appraisal.
Aerosp. Med. 41(5):483-490, 1970b.
- Countermeasures are suggested.
755. OOSTERVELD, W. J.
Threshold value for stimulation of the horizontal semicircular canals.
Aerosp. Med. 41(4):386-389, 1970.
- This experiment showed that laboratory threshold values are not very different from those obtained in flight. The threshold given is lower than the turn rate for some operational submersibles. (PI)
756. STOCKWELL, C. W., and F. E. GUEDRY, JR.
The effect of semicircular canal stimulation during tilting on the subsequent perception of the visual vertical.
Acta Otolaryngol. (Stockh) 70:170-175, 1970.
- This factor should be considered in underwater experiments investigating perception of the upright where subjects are often tumbled.
757. WADE, N. J.
Effect of prolonged tilt on visual orientation.
Q. J. Exp. Psychol. 22(3):423-439, 1970a.
- One of many studies by this author with a good review and explanation of the mechanisms.
758. WADE, N. J.
The effect of different psychophysical methods on visual orientation during tilt.
Psychon. Sci. 19(4):201-203, 1970b.
759. WATERLAND, J. C., and G. M. SHANDES.
Biplane center of gravity procedures.
Percept. Mot. Skills 30:511-514, 1970.
760. WHITESIDE, T. C. D.
Blur zone.
Nature 225(5227):94-95, 1970.
- An interesting review and theoretical paper which raises a question about what is available for "seeing" when a subject is in motion. Although written for aviation, the slower speeds (but poorer visibility) of divers may make this a diving problem also. (RK)
761. BENSON, A. J., and F. E. GUEDRY, JR.
Comparison of tracking-task performance and nystagmus during sinusoidal oscillation in yaw and pitch.
U. S. Army Aeromedical Research Laboratory, Pensacola, Fla., Report No. 1123,
29 October 1970. Also Aerosp. Med. 42(6):593-601, 1971.
- Insofar as submersibles will occasion stimuli such as these, degraded performance might be expected. (RK)

762. CLARK, B.
Pilot reports of disorientation across 14 years of flight.
Aerosp. Med. 42(7):708-712, 1971.

A reference list of review articles on this problem is in the paper, as is a reference to the construction of a questionnaire which could be modified to study similar problems in divers. (RK)

763. DZENDOLET, E.
Comments on Sjoberg's hypothesis for the mechanism of the inversion illusion under zero-gravity conditions.
Aerosp. Med. 42(11):1211-1213, 1971.

The mechanism underlying the "inversion illusion under zero-gravity" may have direct relevance for the difficulties experienced by divers in judging the upright. Perhaps the otoliths only signal the plane of the gravity vector and not its direction. (RK)

764. GALLE, R. R., B. V. USTIUSHIN, L. N. GAVRILOVA, and E. I. KHELETSKII.
K voprosu ob otsenke vestibuliarnoi ustoiichivosti. (The problem of estimating vestibular stability. A71-28414.)
Kosm. Biol. Med. 5:65-71, 1971.

Different human tolerances to Coriolis stimuli (as might be encountered in a submersible) are discussed.

765. KELLOGG, R. S.
Vestibular influences on orientation on zero gravity, produced by parabolic flight. In H. E. Adler (Ed.) Orientation: Sensory basis. Ann. N. Y. Acad. Sci. 188:217-223, 1971.

There is application of his findings to underwater environments.

766. LEIBOWITZ, H.
Size constancy and visual space. In H. E. Adler (Ed.) Orientation: Sensory basis. Ann. N. Y. Acad. Sci. 188, 1971.

767. MILLER, E. F., II, and A. GRAYBIEL.
Goggle device for measuring the visually perceived direction of space. U. S. Naval Aerospace Medical Research Laboratory, Pensacola, Fla., Report No. 1151, November 1971.

This device, modified for water and pressure, would be useful for investigating spatial orientation. (RK)

768. SEIREG, A., A. BAZ, and D. PATEL.
Supportive forces on the human body during underwater activities.
J. Biomech. 4:23-30, 1971.

769. STEWART, J. D.
Human perception of angular acceleration and implications in motion simulation.
J. Aircraft 8(4):248-253, 1971.

Of application for design of underwater vehicles.

770. WEERTS, T. C., and W. R. THURLOW.
The effects of eye position and expectation on sound localization.
Perception & Psychophysics 9(1A):35-39, 1971.

The influence of sound position versus eye and head position on localization are reported.

771. WELTMAN, G., J. E. SMITH, and G. H. EGSTROM.
Perceptual narrowing during simulated pressure-chamber exposure.
Hum. Factors 13(2):99-107, 1971.

See also Weltman and Egstrom (1966, #705).

772. WOODS, J. D., and J. N. LYTCHGOE (Eds.)
Underwater science.
New York: Oxford University Press, 1971. N.V.

773. ADOLFSON, J., and T. BERGHAGE.
Man's sensory processes in the undersea environment.
New York: John Wiley & Sons, in press.

The chapter on spatial orientation underwater discusses the influences of the vestibular system. A chapter on somethesis contains reference to vestibular function underwater and pressure (body sway, vertically), as well as some examples of disorientation.

774. ADOLFSON, J. A., T. BERGHAGE, and L. GOLDBERG.
Effects of increased ambient air pressures on standing steadiness in man.
Aerosp. Med., in press.

Changes in balance as a function of ata occurred. Because noise affects balance (Tullio, 1929, #531; Bensei, et al., 1968, #584), the influence of chamber noise (Murry, 1970, #956; Summit and Reimers, 1971, #964) on equilibrium (Harris, et al., 1968, #718) should be ascertained also. (RK)

775. E. C. O. R., INC.
Underwater propulsion systems. Specification sheet, ECOR-1.
Melbourne, Fla., 1972.

This announcement describing the ECOR-1 suggests that turning rates higher than 2 RPM can occur in submersibles and should be compared with threshold data for producing Coriolis vestibular illusion (Meda, 1952, #92; Stewart and Clark, 1965, #692).

776. MORANT, R. B., and J. ARONOFF.
Starting position, adaptation and visual framework as influencing the perception of verticality.
J. Exp. Psychol., in press.

Because of the relationship of this ability to certain personality variables (e.g., field independence) there may also be application for diver selection. (RK)

777. SCHROEDER, D. J.
Some effects of alcohol on nystagmus and vertigo during caloric and optokinetic stimulation.
Ann. Otol. Rhinol. Laryngol. 81(2):218-230, 1972.

Divers as a group tend to drink heavily and because alcohol can influence vestibular reaction (at times inhibiting and at times facilitating), this should be considered.

778. SHENTON, E. H.
The story of the deep submersible.
New York: Norton, 1972.

779. VAUGHAN, W. S., JR., and A. S. MAVOR.
Diver performance in controlling a wet submersible during four-hour exposure
to cold water.
Hum. Factors 14(2):173-180, 1972.

See also:

References 35, 69, 72, 112, 117, 162, 224, 235, 250, 272, 273, 302, 345, 365, 367,
403, 488, 495, 507, 531, 536, 537, 550, 552, 553, 554, 555, 558, 573, 585, 590, 596,
603, 610, 622, 708, 725, 740, 773, 781, 788, 790, 799, 801, 802, 810, 824, 832, 835,
842, 848, 855, 857, 858, 861, 941, 955, 960.

CATEGORY V. THE USE OF THE VESTIBULAR SYSTEM AS AN INERTIAL GUIDANCE SYSTEM.

1850-1900

780. GALTON, F.

The art of travel: or, Shifts and contrivances available in wild countries.
London: John Murray, Albermarle Street, 1856.

Early reference to methods of navigation in humans and animals, e.g., moss on trees (p. 126), etc.

781. GULDBERG, F. O.

Die Cirkularbewegung als thierische Grundbewegung, ihre Ursache, Phenomenalität und Bedeutung. (The circular movement as the basic movement of animals, its cause, phenomenon and importance. Trans. by Mrs. A. Woke, NMI, 1972.)
Z. Biol. (Munich) 35:419-458, 1897.

Shows that organisms travel in a circle and suggests the functional importance of such a tendency is to permit them (in the case of certain animals) to rejoin the herd. Mentions (p. 438) that deep sea divers see fishes swimming in circles in response to illumination by diver's lanterns.

1900-1909

782. GRAY, A. A.

The labyrinth of animals. Vol. II.
London: J. & A. Churchill, 1908.

See Gray (1907, Vol. I. #283).

1910-1919

783. TOLBRIDGE, C. C.

Fundamental methods of orientation & "imaginary maps."
Science 38:888-897, 1913.

Discusses the different methods employed in navigation in humans. Some methods are better (e.g., imaginary maps) for some functions and poorer for others. Application for free swimming and reconnaissance divers may be found. (PK)

784. ABBERWALDEN, E.

Beobachtungen zur Frage der morphologischen und funktionellen Asymmetrie des menschlichen Körpers. (Observations concerning the question of the morphological and functional asymmetry of the human body. Trans. by Mrs. A. Woke, NMI, 1971.)

Pflügers archiv für die gesammte physiologie 177:213-216, 1910.

An early study showing directional preponderances and preferences in humans. In particular the tendency within individuals to ascend different stairways is used to launch a discussion of the basis of this response preference.

1920-1929

785. BULLINGTON, W. E.

A study of spiral movement in the Ciliate Infusoria.
Arch. Protistenk. 50(5) 219-274, 1925.

The author reports most of the one-celled organisms studied (164 ciliates) tend to spiral movement in a leftward (counterclockwise) direction. The ratio is about 2:1. This study was performed in the Northern Hemisphere (largely at Cold Spring Harbor). The author does not mention that the rotation of the earth could be a factor, but if ciliates in the Southern Hemisphere turn mostly rightward this would suggest that organisms are capable of responding to very low levels of Coriolis force. Future study appears warranted and if positive findings are obtained, there may be practical application for navigation in humans. (PK)

786. WEBER, C. O.
The properties of space and time in kinesthetic fields of force.
Am. J. Psychol. 38:597-606, 1927.
787. RABAUD, E.
How animals find their way about.
New York: Harcourt, Brace and Co., 1928.
788. SCHAEFFER, A. A.
Spiral movement in man.
J. Morph. Physiol. 45:293-398, 1928.

In this long and significant article the author reviews the functional significance of directional preponderance (turning) in man and animals. In addition to discussing spiral movements across phylla (amoeba to man), the author also discusses experiments on blindfolded persons walking and swimming. An excellent bibliography is presented; many articles are in German. Experiments in man on turning during swimming and rowing are reported, mechanisms are discussed. (PK)

789. KNOTTS, J. R., and W. R. MILES.
The maze-learning ability of blind compared with sighted children.
J. Genet. Psychol. 36(1):21-50, 1929.

Better performance was obtained by blind than blindfolded persons, and recently blind persons appeared to learn better than blind prior to age five.

1930-1939

790. LUND, F. H.
Physical asymmetries and disorientation.
Am. J. Psychol. 42:51-62, 1930.

An important paper applicable to diver navigation and orientation. For example, one interesting finding: right turning predominates in walking, but left turning in swimming is due most likely to the fact that left legs are longer and right arms are stronger (p. 59), although the relationship is not perfect (also see Schaeffer, 1928, #788; and others).

791. DESILVA, H. R.
A case of a boy possessing an automatic directional orientation.
Science 73:393-394, 1931.

Although the ability was not as good as claimed, it shows how one's "sense of direction" can profit by use of the ability.

792. DUNCAN, B. K.
A comparative study of finger-maze learning by blind and sighted subjects.
J. Genet. Psychol. 44(1):69-95, 1934.

1940-1949

793. GREGG, F. H.
Overcoming geographical disorientation.
J. Consult. Psychol. 4:66-68, 1940.

Shows the influence of the vestibular system when "intently thinking (p. 66)" of a "geographic direction (p. 66)."

794. RYAN, T. A., and M. S. RYAN.
Geographical orientation.
Am. J. Psychol. 53:204-215, 1940.

A study on humans.

795. LORD, F. E.
A study of spatial orientation of children.
J. Educ. Res. 34(7):481-505, 1941.
A good paper for future studies of navigation in free swimming divers. (PK)
Several additional references.

796. GRIFFIN, D. R.
The sensory basis of bird navigation.
Q. Rev. Biol. 19:15-31, 1944.
Evaluates kinesthetic and other theories of homing. Excellent bibliography.

1950-1959

797. MENZIO, P.
Labyrinthine reactions induced in man by means of minimal thermal stimuli and the influence of previous modification of temperature in the external auditory canal.
Arch. Physiol. 51:154, 1951. N.V.

798. WORCHEL, P.
Space perception and orientation in the blind.
Psychol. Monogr. 65(15):1-28, 1951.
Among other findings the author suggests that time estimation is the method employed in navigation.

799. CLARK, B., and P. D. MALONE.
Topographical orientation in naval aviation cadets.
U. S. Naval Air Station, Pensacola, Fla., Report No. 001 059.01.30, 2 June 1952.
A test is reported which purports to measure a personality or life style trait "sense of direction." The hypothesis was that high scores could be related to success in aviation training. No relationship was found. However the trait, if it exists, may be more critical for divers than pilots since the latter have more navigation aids and therefore can depend less on their sense of direction. (PK)

800. WORCHEL, P.
The role of the vestibular organs in space orientation.
J. Exp. Psychol. 44(1):4-10, 1952.

801. DALLENBACH, K. H.
The phenomenal vertical and horizontal in blind and sighted subjects.
Am. J. Psychol. 66:598-602, 1953.

802. McREYNOLDS, J., and P. WORCHEL.
Geographical orientation in the blind.
J. Gen. Psychol. 51:221-236, 1955.
Because divers are often rendered effectively blind by the poor visibility of some water, there is much to be learned regarding navigation from this literature. (RK) This study and others by Worchel have good bibliographies.

803. ROUSE, D. L. and P. WORCHEL.
Veering tendency in the blind.
New Outlook for the Blind 49(4):115-118, 1955.

There is a directional tendency to veer even in blind persons and this tendency is relatively consistent within a subject. Perhaps a "personal equation" identified in a diver could improve the diver's ability to navigate. (PK)

804. BERG, J., and P. WORCHEL.
Sensory contributions to human maze learning: a comparison of matched blind, deaf, and normals.
J. Gen. Psychol. 54:81-93, 1956.

There is application for underwater swimmer navigation, as well as for the training of blind divers. (RK)

805. GUEDRY, F. E., and G. RICHMOND.
Differences in response latency with different magnitude angular acceleration.
U. S. Army Medical Research Laboratory, Pensacola, Fla., Report No. 301,
2 November 1957.

Shows response of subject to various magnitudes of turning (angular acceleration) stimuli.

806. MARGARIA, R.
Prolonged after-effect of centripetal and tangential accelerations on cerebellar potentials.
Final Report, Contract AF 61(514)-968, AF Air Research & Development Command,
AD 152 246, Summary of work from 1 June 1956 to 30 September 1957.

"Rotatory and post-rotatory cerebellar activity in birds [is] investigated (p. 1)" and reported. Responses are obtained in cerebellar cortex as low as .01-.02 g.

807. GRIFFIN, D. R.
Listening in the dark: The acoustic orientation of bats and men.
New Haven: Yale University Press, 1958.

See Chapter 12, "Echolocation in the Blind."

808. GUEDRY, F. E., and S. J. CEPAN.
Derivation of 'subjective velocity' from angular-displacement estimates made during prolonged angular accelerations: adaptation effects.
U. S. Army Medical Research Laboratory, Fort Knox, Ky., Report No. 376, 21 November 1958.

The accuracy of subjective stimuli of turning is given.

1960-1969

809. FRAENKEL, G., and D. L. GUNN.
The orientation of animals.
New York: Dover Books, 1960.

810. DIFFENBACH, W. S.
The ability of submerged subjects to sense the gravitational vertical.
Cornell Aeronautical Laboratory, Inc., Buffalo, N.Y., Report No. CM 1355 V-1,
2 September 1961.

Shows how poor is orientation to the vertical when subjects are immersed in water and tilted.

811. FRAENKEL, G. S., and D. L. GUNN.
The orientation of animals: Kineses, taxes, and compass reactions.
New York: Dover Publications, Inc., 1961.

Probably the best single reference work for a basic understanding of the problem and for implication to human navigation. Excellent references.

812. BERITOFF, J. S.
Spatial orientation of man and animals.
XXII Inter. Congr. Physiol. Sci., Leiden, 1-17 September 1962.
Inter. Congr. Series 1(47):3-4, 1962.
- Shows (in a film) the importance of a functioning labyrinth (human and dog) for traversing a route.
813. HOWLAND, C. H., and B. HOWLAND.
The reaction of blinded goldfish to rotation in a centrifuge.
J. Exp. Biol. 39:491-502, 1962.
814. MENALDT, L. R.
Displacement of migratory birds.
San Jose State College, Calif., NWRP Report No. (7)-00030-62, 26 December 1962.
815. PPATT, J. G.
Research on animal orientation, with emphasis upon the phenomenon of homing in pigeons.
Duke University, Raleigh, N. C., ONR Research Project No. 301-244, 18 October 1962.
816. ADLER, H. E.
Sensory factors in migration.
Anim. Behav. 11(4):566-577, 1963.
- A review of the sensory system involved in animal migration. An excellent bibliography. His reports of time estimation (i.e., internal clocks) are useful in theoretical formulations regarding the use of the vestibular system as an initial guidance system. (OK)
817. AUTPUN, H., et al. (Eds.)
Orientierung der Tiere Animal Orientation.
Berlin, Göttingen, Heidelberg: Springer-Verlag, 1963.
- All papers in this symposium have English summaries although some articles are in German. There are several very good papers.
818. BERITACHVILI, I. S. (BERITOV)
Les mecanismes nerveux de l'orientation spatiale chez l'homme.
Neuropsychologia 1:233-249, 1963.
- The English summary describes how deaf-mutes with bilateral labyrinthine defects were unable "to walk along the route along which they were led or carried (p. 248)." However, otherwise normal deaf-mutes could (i.e., not labyrinthine defective). Same author as Beritoff (1962, #812).
819. BARLOW, J. S.
Inertial navigation as a basis for animal navigation.
J. Theor. Biol. 6:76-117, 1964.
- Offers a theory and model regarding the use of the vestibular system in animal migration and navigation.
820. MARGARIA, R., and G. A. CAVAGNA.
Human locomotion in subgravity.
Aerosp. Med. 35:1140-1146, 1964.
- See other papers by Margaria.
821. SCHMIDT-KOENIG, K.
Sun compass orientation of pigeons upon displacement north of the Arctic Circle.
Biol. Bull. 127(1):154-158, 1964.

822. BARLOW, J. S.
Inertial navigation and animal navigation.
N. Engl. J. Med. 273(20):1090-1092, 1965.

Similar to Barlow (1964, #819).
823. BATSCHIELET, E.
Statistical methods for the analysis of problems in animal orientation and certain biological rhythms.
Wash., D. C.: The American Institute of Biological Sciences, 1965.

Some of these methods can be applied to studies of navigation in free swimming divers.
824. CRATTY, B. J.
Perceptual alterations of veer by interpolated movement experience.
Res. Q. Am. Assoc. Health Phys. Educ. 35:22-28, 1965.

This report is short but has many applications for diving mediums. It suggests important leads for research, particularly for aiding navigation in free swimming reconnaissance divers. (PK)
825. SHOOP, C. R.
Orientation of *ambystoma maculatum*: Movements to and from breeding ponds.
Science 149(3683):558-559, 1965.
826. BARLOW, J. S.
Inertial navigation in relation to animal navigation.
J. Inst. Navigation 19(3):302-316, 1966.

Similar to Barlow (1964, #819).
827. BROWN, J. H.
Magnitude estimation of angular velocity during passive rotation.
J. Exp. Psychol. 72(2):169-172, 1966.

Brown's article shows that the subjects' reports of a vestibular stimulus (i.e., turning) is proportional to the stimulus, and the error of the estimate is small. This report and others in this section suggest that the ability to navigate by "direction sense" is better than the use made of it in practical situations. (PK)
828. EPLEN, J. T., and R. L. PENNEY.
The navigation of penguins.
Sci. Am. 215(4):105-113, 1966.

Although a sun compass is used when available during long dark winter nights another mechanism may be involved at other times. (PK)
829. STORV, R. M. (Ed.)
Animal orientation and navigation.
Corvallis: Oregon State University Press, 1966.

Some very excellent papers appear in this book and the bibliographies are good. Inertial theories are discussed occasionally (cf. pp. 35-37; especially p. 54).
830. CARR, A. F.
So excellent a fishe. (A natural history of sea turtles.)
Garden City, N.Y.: The Natural History Press, 1967.

Describes the various theories of navigation/migration in green turtles. Speculates on how the animals find Ascension Island--a "small crumb out in the sea between Africa and South America (p. 159)" and near the equator. One of the theories offered uses the vestibular system.

831. GENTRY, R. L.
Underwater auditory localization in the California sea lion.
J. Auditory Res. 7:187-193, 1967.
832. LOCKLEY, R. M.
Animal navigation.
New York: Hart Publishing Co., 1967.

The chapters on "A sense of balance (p. 66)" and "A sense of time (p. 72)" are most important for a study of human navigation. (RK)
833. TOLSTOY, L.
Master and man.
In Great Short Works of Leo Tolstoy, pp. 453-500. New York: Harper & Row, 1967.

Circular movement in humans was well enough known to Tolstoy that it served as the theme of this story.
834. ANDERSEN, B. G.
Diver performance measurement: Underwater navigation, depth maintenance, weight carrying capabilities.
General Dynamics Electric Boat Division, Groton, Conn. Human Factors Section Report No. U-417-68-030, AD 674 528, March 1968.

Navigation accuracy averaged 5.21° over a 780-foot course. If bias was constant within a diver perhaps a knowledge of a "personal equation" could improve accuracy. Further, if cause of error could be attributed to relative strength of the legs, perhaps a diver could be trained to modify his headings. (TK)
835. GRAYBIEL, A., E. F. MILLER, B. D. NEWSOM, and R. S. KENNEDY.
The effect of water immersion on perception of the oculogravic illusion in normal and labyrinthine-defective subjects.
Acta Otolaryngol. (Stockh) 65:599-610, 1968.

Shows that orientation to the upright in water is better in normal than in persons with labyrinthine defects.
836. HIXSON, W. C., and J. I. NIVEN.
Instrumentation for measurement of vestibular-significant forces in helicopters.
U. S. Naval Aerospace Medical Institute, Pensacola, Fla., Report No. 1043, USAARU Serial No. 68-10, 21 May 1968.

This system might be adapted for underwater use and could then serve as a navigation aid.
837. JANDER, R.
Über die Ethometrie von Schlüsselreizen, die Theorie der telotaktischen Wahlhandlung und das Potenzprinzip der terminalen Cumulation bei Arthropoden. (On the ethometry of sign stimuli, the theory of telotactic choice, and the power principle of the terminal cumulation in Arthropoda.)
Z. Verö. Physiol. 59:319-356, 1968.
838. KAVANAU, J. L., and C. E. BISCHEP.
Program clocks in small mammals.
Science 161:1256-1259, 1968.

For the vestibular system to be able to serve as a useful inertial guidance system it must respond to the linear and angular forces and must also have an accurate timing device. This paper shows how accurate some clocks in animals can be. (TK)
839. MCDONALD, D. L.
Bird orientation: A method of study.
Science 161:486-487, 1968.

840. ANDERSEN, B. G., P. L. ALLEN, and J. C. LAWB.
Diver performance measurement: transporting neutrally buoyant objects, manual movement by heavy objects.
General Dynamics Electric Boat Division, Groton, Conn. Prepared for the Office of Naval Research, Wash., D. C., Report No. U-417-69-066, July 1969.

Effects of weight-carrying on navigation is reported.
841. BERTHAR, G., and R. TOFT.
Sensory mechanisms of homing in salmonid fish. I. Introductory experiments on the olfactory sense in grilse of Baltic salmon (*Salmo Salar*).
Behaviour 35(3-4):235-241, 1969.
842. CLARK, D., and J. D. STEWART.
Effects of angular acceleration on man: Thresholds for the perception of rotation and the oculogyral illusion.
Presented at the Annual Meetings of the Aerospace Medical Society, San Francisco, Calif., May 5-8, 1969.

See Clark and Stewart (1968b, #717).
843. PROSCHER, V. B.
The magic of the senses.
New York: E. P. Dutton & Co., Inc., 1969.

Chapters 8 and 9 on Migration and Navigation, respectively, are of interest.
844. GUEBRY, F. E., JR., G. C. OWENS, and J. W. NORMAN.
Assessment of semicircular canal function: I. Measurements of subjective effects produced by triangular waveforms of angular velocity.
U. S. Naval Aerospace Medical Institute, Pensacola, Fla., NAMI-1073, USAARL 69-7, AD 695368, June 1969.

A useful method for studying the analogue of the vestibular apparatus as an inertial guidance system.
845. HOLUBAR, J.
The sense of time: An electrophysiological study of its mechanisms in man. 1961.
Trans. from the Czech by John S. Barlow. Cambridge, Mass.: Mass. Institute of Technology, 1969.

This recently translated work reports on the accuracy of timing behavior in man and animals. A supplemental bibliography is appended. An important source for studies of navigation by vestibular cues. (RK)
846. MAYNE, R.
The analogy of the vestibular organs to an inertial guidance system.
Oto-Rhino-Laryngology Excerpta Medica International Congress Series No. 206:407-415, 1969a.

This excellent paper makes the point that this analogy has not been discussed much in vestibular physiology. It follows and should be added that the application of these findings to problems of diver navigation could have important implications and applications. (RK)
847. MAYNE, R.
The analogy of the vestibular organs to an inertial guidance system.
Presented at the World Congress of Oto-Rhino-Laryngology, Mexico City, August 1969b.

Essentially the same as Mayne (1969a, #846), however an updated version of both will appear in Handbook of sensory physiology. VI. Vestibular system.
Berlin: Springer-Verlag, in press.

848. OWENS, G. G. and F. E. GUENDY, JR.
Assessment of semicircular canal functions: II. Individual differences in subjective angular displacement produced by triangular waveforms of angular displacement.
U. S. Army Aeromedical Research Laboratory, Pensacola, Fla., Report No. 1074, 17 June 1969.

Adaptation of this method using trains of stimuli could be worthwhile in studying information processing with vestibular stimulation relative to navigation by "dead reckoning" or "direction sense." Individual differences could be useful for purposes of selection. (RK)

849. PARTRIDGE, I. D., and J. H. KIM,
Dynamic characteristics of response in a vestibulomotor reflex.
J. Neurophysiol. 32(4):485-495, 1969.

1970-1972

850. GOULD, J. L., M. HENEFY, and M. C. MACLEOD.
Communication of direction by the honey bee.
Science 169:544-554, 1970.
851. HASLER, A. D., R. M. HERRALL, A. B. SASKO, and A. E. DIZON.
Orientation cues and tracking of migrating salmonid fishes.
Proc. Natl. Acad. Sci. USA 66(1):13-14, 1970.
852. JANDER, R.
Ein Ansatz zur modernen Elementarbeschreibung der Orientierungshandlung. (An attempt at a modern elementary description of orientation activities.)
Z. Tierpsychol. 27:771-778, 1970.
853. JANDER, R., Michael FABRITIUS, and Monika FABRITIUS.
Die Bedeutung von Gilederung und Kantenrichtung für die visuelle Formunterscheidung der Wespe *Dolichovespula saxonica* am Flugloch. (The significance of disruption and contour-direction for visual form discrimination near the nest entrance in the wasp [*Dolichovespula saxonica*].)
Z. Tierpsychol. 27:881-893, 1970.
854. JANDER, R., and I. VOLK-HEINRICH.
Das straub-spezifische visuelle Perceptor-system der Stabheuschrecke (*Carausius morosus*). (The straub-specific visual perceptor-system of the stick insect [*Carausius morosus*].)
Z. Vergl. Physiol. 70:425-447, 1970.
855. LEGGIERE, T., J. MCANIFF, H. SCHENCK, and J. VAN RYZIN.
Sound localization and homing of scuba divers.
MTS J. 4(2):27-34, 1970.

A useful model for future studies of vestibular orientation and navigation capabilities.

856. LISSA'IAN, P. B. S., and C. A. SHOLLJENBERGER.
Formation flight of birds.
Science 168:1003-1005, 1970.
857. PARKER, D. E.
Interactions between electrical and mechanical vestibular stimulation: observations on rabbits and men.
J. Exp. Psychol. 84(1):96-104, 1970.

Because mechanical (physiologic) and electrical stimulation of the vestibular apparatus is possible, and because the response tends to be proportional to the stimulus, water adaptable (e.g., ELF) stimuli may be useful to human divers as a navigation aid. (RK)

858. PARSONS, R. D.
Magnitude estimates of the oculogyral illusion during and following angular accelerations.
J. Exp. Psychol. 84(2):230-238, 1970.

The accuracy of the human vestibular system to respond to turning stimuli is good and the system should be studied as a navigation aid. (PK)

859. PROTEUS, S. D.
Possible effects of rate of global spin.
Percent. Mot. Skills 30:503-509, 1970.

If he is correct about differential responses to global spin, then perhaps such mechanisms could aid in human geographic orientation and navigation. (PK)

860. ROBERTSON, D. G.
A self-contained underwater swimmer guidance system.
In Proc. First Western Space Congress, I. pp. 332-338. North Hollywood, Calif.: Western Periodicals Co., 1970.

This is a good article concerning a self-contained swimmer guidance system using sound localization which could be modified to study the ability of the vestibular system to do similar or redundant work, or to add another dimension. Remote transmission might also be attempted. (PK)

861. ROSS, H. E., D. J. DICKINSON, and B. P. JIPP.
Geographical orientation under water.
Hum. Factors 12(1):13-23, 1970.

Although errors occur in geographical orientation under water, it would be interesting to repeat this study with the purpose of studying ways to improve performance, e.g., training in time estimation, advice on personal veering tendencies, etc. (PK)

862. SMITH, A.
The seasons. Rhythms of life: Cycles of change.
London: Weidenfeld and Nicholson, 1970.

Chapter 4 on Migration is interesting.

863. SOLIDAY, S. M.
Navigation in terrain-following flight.
Hum. Factors 12(5):425-433, 1970.

864. WILLIAMS, T. C., and J. M. WILLIAMS.
Radio tracking of homing and feeding flights of a neotropical bat,
Phyllostomus hastatus.
Anim. Behav. 18:302-309, 1970.

865. ADLER, H. E. (Ed.)
Orientation: Sensory basis.
Conference, New York Academy of Sciences-American Museum of Natural History,
New York, February 8-10, 1971. Ann. N. Y. Acad. Sci. 188, 1971.

866. ANON.
Bird navigation during distorted vision (contact lens).
New Scientist and Science Journal, 29 July 1971.

Describes the ability of birds to navigate even when vision is disrupted.

867. BROWN, F. A.
Some orientational influences of nonvisual, terrestrial electromagnetic fields.
In H. E. Adler (Ed.) Orientation: Sensory basis. Ann. N.Y. Acad. Sci. 188:224-241, 1971.

868. CORY, C. H.
A comparison of the porteus and Navy maze tests.
Naval Personnel and Training Research Laboratory, San Diego, Calif., Tech. Bull.
STB 71 11, June 1971.
- This test, plus tests of geographical orientation (Clark, 1971, #762), may be useful selection devices for divers. (PK)
869. DIZON, A. E., R. M. HERRALL, and A. D. HASLER.
The homing salmon and EEG responses to homestream water.
Presented at the New York Academy of Sciences Conference on Orientation: Sensory Basis, New York City, February 3-10, 1971.
870. DOCKSTADER, S. L.
Comparison of cupulometric and psychophysical thresholds for perception of rotation and the oculogyral illusion.
Perception & Psychophysics 9(3A):299-302, 1971.
- Shows that the vestibular system (semicircular canals) is very sensitive to turning. This study has application for diving as: (1) a provocative test of vestibular function which pressure could perturb; (2) to show that vestibular sensitivity might be useful for navigation under water. (PK)
871. FERGUSON, D. E.
The sensory basis of orientation in amphibians.
In H. E. Adler (Ed.) Orientation: Sensory basis.
Ann. N.Y. Acad. Sci. 188:3036, 1971.
- A good bibliography.
872. GILSON, R. D., C. W. STOCKWELL, and F. E. GUEDRY, JR.
Nystagmus responses during triangular waveforms of angular velocity about the Y- and Z-axes.
U. S. Naval Aerospace Medical Research Laboratory, Pensacola., Fla., Report No. 1138, USAARL Serial No. 72-1, 22 July 1971.
- Shows the accuracy of vestibular apparatus to angular velocity stimuli.
873. GUEDRY, F. E., JR., C. W. STOCKWELL, and R. D. GILSON.
Comparison of subjective responses to semicircular canal stimulation produced by rotation about different axes.
Acta Otolaryngol. (Stockh) 72:101-106, 1971.
- Demonstrates the reliability of human responses to angular acceleration stimuli.
874. GUEDRY, F. E., JR., C. W. STOCKWELL, J. W. NORMAN, and G. G. OWENS.
Use of triangular waveforms of angular velocity in the study of vestibular function.
Acta Otolaryngol. (Stockh) 71:439-448, 1971.
875. HODGSON, E. S., and R. F. MATHEWSON.
Chemosensory orientation in sharks.
Ann. N.Y. Acad. Sci. 188:175-182, 1971.
876. HOWLAND, H. C.
The role of the semicircular canals in the angular orientation of fish.
In H. E. Adler (Ed.) Orientation: Sensory basis.
Ann. N.Y. Acad. Sci. 188:202-216, 1971.
877. JANDER, R.
Visual pattern recognition and directional orientation in insects.
In H. E. Adler (Ed.) Orientation: Sensory basis.
Ann. N.Y. Acad. Sci. 188:5-11, 1971.

878. LEIDNER, P. N. and D. S. DENNIS.
Preliminary research on the ability of ducks to discriminate atmospheric pressure changes.
Ann. N.Y. Acad. Sci. 188:98-109, 1971.
- Ducks responded to .4 psi of pressure. This has implications for learning but perhaps also for barotraumatic otitis media. (RK)
879. PAYNE, R., and D. WEBB.
Orientation by means of long-range acoustic signaling in Baleen whales.
In H. E. Adler (Ed.) Orientation: Sensory basis.
Ann. N.Y. Acad. Sci. 188:110-141, 1971.
- A good bibliography.
880. SCHLICHTE, H. J., and K. SCHMIDT-KOENIG.
Zum Heimfindevermogen der Brieftaube. (The home-recall ability of the carrier pigeon. Trans. by Mrs. A. Woke, NMRI, 1971.) =
Naturwissenschaften 58(6):329-330, 1971.
- The article points out the importance of vision in bird navigation.
881. SCHMIDT-KOENIG, K.
Session on "Photoreceptors."
In H. E. Adler (Ed.) Orientation: Sensory Basis.
Ann. N.Y. Acad. Sci. 188, 1971.
882. SCHUSTERMAN, R. J., and R. F. BAILLET.
Aerial and underwater visual acuity in the California sea lion (*Zalophus Californianus*) as a function of luminance.
In H. E. Adler (Ed.) Orientation: Sensory basis.
Ann. N.Y. Acad. Sci. 188:37-46, 1971.
883. SIMMONS, J. A.
Echolocation in bats: Signal processing of echoes for target range.
Science 171:925-928, 1971.
884. SIMMONS, J. A., and J. A. VERNON.
Echolocation: Discrimination of targets by the bat, *Eptesicus fuscus*.
J. Exp. Zool. 176(3):315-328, 1971.
885. SIMMONS, J. A., E. G. WEVER, and J. M. PYLKA.
Periodical cicada: Sound production and hearing.
Science 171:212-213, 1971.
886. SOUTHERN, W. E.
Gull orientation by magnetic cues: A hypothesis revisited.
In H. E. Adler (Ed.) Orientation: Sensory basis.
Ann. N.Y. Acad. Sci. 188:224-241, 1971.
- A good bibliography.
887. STASKO, A. B.
Review of field studies on fish orientation.
In H. E. Adler (Ed.) Orientation: Sensory basis.
Ann. N.Y. Acad. Sci. 188:12-29, 1971.
- A good bibliography.
888. TAVOLGA, W. N.
Acoustic orientation in the sea catfish, *Galeichthys felis*.
In H. E. Adler (Ed.) Orientation: Sensory basis.
Ann. N.Y. Acad. Sci. 188:80-97, 1971.

889. WARD, R. R.
The living clocks.
New York: Alfred A. Knopf, 1971.

An accurate inertial guidance system is only as accurate as the timer. (RK) This discusses various timers in organisms.

890. ANON.
(A question and answer regarding vestibular system in flounders.)
Sea Secrets 16(1), 1972.

The response to a question regarding the directional specificity of the migration of the eye and optic nerve in flounders is of interest (p. 14).

891. BLAKESLEE, E.
Sensitivity of pigeons to direction of movement considered in relation to inertial guidance theories of animal navigation.
Unpublished Ph.D. dissertation, University of Indiana, Bloomington, 1972.

892. EMLEN, S. T.
Birds. Their migration is at least as complex as human navigation and probably no more mysterious.
Psychol. Today 5(11):52-56, f. 94, 1972.

Mentions the importance of celestial cues in navigation but agrees that other cues (e.g., vestibular) could be important.

893. GALLER, S. R., K. SCHMIDT-KOENIG, G. J. JACOBS, and R. E. BELLEVILLE.
Animal orientation and navigation.
National Aeronautics and Space Administration, Wash., D. C. 1972.

In this long report (600 pp.) studies of virtually all forms of navigation and orientation of homing and migratory animals are discussed. No reports deal specifically with man.

894. WILTSCHKO, W., and R. WILTSCHKO.
Magnetic compass of European robins.
Science 176:62-64, 1972.

The magnetic compass of European robins does not use the polarity of the magnetic field for detecting the north direction. The birds derive their north direction from interpreting the inclination of the axial direction of the magnetic field lines in space, and they take the direction on the magnetic north-south axis for "north" where field lines and gravity vector form the smaller angle. (Author's abstract.)

See also:

References 139, 162, 345, 403, 488, 495, 550, 561, 585, 596, 613, 616, 618, 624, 649, 651, 652, 662, 698, 701, 707, 708, 737, 745, 773, 946, 955, 961.

CATEGORY VI. AUDITORY STUDIES WHICH HAVE RELEVANCE
FOR UNDERSTANDING VESTIBULAR FUNCTION UNDERWATER.

1800-1899

895. LESTER, J. C., and V. GOMEZ.
Observations made in the caisson of the new East River bridge as to the effects of compressed air upon the human ear.
Arch. Otol. 27(1):1-19, 1898.

ENT examinations were performed in a caisson with persons previously examined at normal pressure. Labyrinthine disturbances are mentioned (pp. 17-18).

1900-1909

896. POLI, C.
Risultati dell'esame preventivo nei lavoratori sotto pressione.
Atti XII Congr. Soc. Ital. ORL., 1908. (Cited by A. Pagano, 1959.) N.V.

1910-1919 None.

1920-1929

897. POHLMAN, A. G., and F. W. KRANZ.
The effect of pressure changes in the external auditory canal on acuity of hearing.
Ann. Otol. Rhinol. Laryngol. 32:545-553, 1923.

1930-1939

898. MITCHELL, J. H.
Streptococcic dermatoses of the ears.
J.A.M.A. 108:361-366, 1930.
899. THOMPSON, E., H. A. HOWE, and W. HUGHSON.
Middle ear pressure and auditory acuity.
Am. J. Physiol. 110:312-319, 1934.

Increased or decreased pressure can impair one's functional ability to about the same extent.

900. BEHNKE, A. R.
Medical problems relating to diving, underwater construction, and submarines.
Pacific Scientific Congress 6:85-89, 1939.
- The effects of pressure change on air spaces (specifically, auditory tubes and sinus passages) are discussed.
901. LOVELACE, W. R., and C. W. MAYO.
Aero-otitis media: its alleviation or prevention by the inhalation of helium and oxygen.
Proceedings of the Staff Meetings of the Mayo Clinic 14:91-96, 1939.

1940-1949

902. HALL, J. F., JR.
The use of helium-oxygen mixtures in aviation for the prevention of painful ear symptoms.
J. Aviat. Med. 11:81-86, 1940.
903. ALMOUR, R.
The "blocked ear" of the caisson worker.
Laryngoscope 52:75-81, 1942b.

904. BEHNKE, A. R.
Investigations concerned with problems of high altitude flying and deep diving; application of certain findings pertaining to physical fitness to the general military service.
The Military Surgeon 40:9-29, 1942b.
- A review paper; of more importance for auditory than vestibular problems. (RK)
905. LOCH, W. E.
Effect of experimentally altered air pressure in middle ear on hearing acuity in man.
Ann. Otol. Rhinol. Laryngol. 51:1006, 1942a. N.Y.
906. LOCH, W. E.
The effect on hearing of experimental occlusion of the Eustachian tube in man.
Ann. Otol. Rhinol. Laryngol. 51:396-405, 1942b.
907. ANON.
Diver's ear (otitic barotrauma).
R. Nav. Med. Bull. 5:13-14, 1943.
- This article suggests that tympanic changes occur in persons exposed to compressed air who do not have the "knack of ear clearing (p. 14)." For inexperienced persons following a descent of about 10 feet or more, "100 percent...will show drum changes [and the] common appearance is that of acute otitis media (p. 13)."
908. KOS, C. M.
Effect of barometric pressure changes on hearing.
Tr. Am. Acad. Opht. 49:75-81, 1944. (Cited by Fulton: cited by Pagano, 1959.)
909. MITCHELL, D. F.
Aerodontalgia.
Bull. U. S. Army Med. Dept. 73:62-67, 1944.
910. KENNON, R. H., and C. M. OSBORN.
Relation of aerodontalgia to aerosinusitis.
Air Surgeons Bulletin 2:434-435, 1945.
- A possible contributing factor in cases of DCS. (RK)
911. SANDLER, H. C.
Toothaches at low atmospheric pressure.
The Military Surgeon pp. 475-477, December 1945.
912. LIEBERMAN, A. T.
Aero-titis media in pressure chamber "flights."
Arch. Otolaryngol. 43:500-508, 1946.
913. PATTON, R. A.
Purulent otitis media in albino rats susceptible to sound-induced seizures.
J. Psychol. 24:313-317, 1947.
914. CHANG, H. T., R. MARGARIA, and S. GELFAN.
Pressure changes and hemorrhage in the middle ear of monkeys resulting from decompression and recompression.
Fed. Proc. Amer. Soc. Exp. Biol. 8:23, 1949.
915. HITSCHLER, W. J.
The relationship of swimming and diving to sinusitis and hearing loss.
Laryngoscope 59:799-819, 1949.

916. THULLIER, A.
Sinusite barotraumatique. *Medecine aeronautique*.
B. S. S. Air 4:130, 1949. (Cited by Bertrand, 1954; cited by A. Pagano, 1959.)
N.V.

1950-1959

917. KUROZUMI, S.
What influences on the hearing acuity were found when the pressure in the tympanic cavity was changed experimentally?
Nippon zibinkoka gakkai kaiho 53: Japanese text pagination 331-335; English text pagination 35-36, 1950. (In Japanese with English summary.) N.V.
918. ADAMS, W. S.
The aetiology of swimmer's exostoses of the external auditory canals and of associated changes in hearing. Part I.
J. Laryngol. Otol. 65:133-153, 1951a.

In addition to perceptive loss of hearing there are also reports of vertigo.
919. ADAMS, W. S.
The aetiology of swimmer's exostoses of the external auditory canals and of associated changes in hearing. Part II.
J. Laryngol. Otol. 65:232-250, 1951b.

See also Adams (1951a, #918).
920. TONNDORF, J.
The influence of service on submarines on the auditory organ.
In Symposium on submarine medicine, Folio VII, U. S. Naval Forces, Germany.
(Technical Section, Medical). Date uncertain, 1951.
921. COLEMAN, J.
Auditive disorders in the compressed air illness.
Arch. Mal. Prof. 14(3):211-220, 1953. N.V.
922. BERTRAND, M.
Contribution a l'etude des sinusites barotraumatiques.
Rev. de Laryngol. (Paris) 75:784-813, 1954. N.V.
923. PAGANO, A.
Ulteriori ricerche audiometriche nei barotraumi da cassoni.
Arch. ital. laring. 63:269-275, 1955.
924. HALLBERG, O. E.
Sudden deafness of obscure origin.
Laryngoscope 66:1237-1267, 1956. N.V.
925. BURKE, D. T.
Barotrauma.
Med. J. Aust. Section of Oto-Rhino-Laryng. 867, June 21, 1958.
926. TAYLOR, G. E.
The otolaryngologic aspects of skin and scuba diving.
Laryngoscope 69(7):809-859, 1959.

Although mainly concerned with the auditory portion of nerve VIII function, this is a very significant and complete article and there is much of interest regarding the vestibular system, particularly effects of barotrauma. Over 60 references and case histories are reported. (RK)

1960-1961

927. CAMPBELL, P. A.
Sinus barotrauma.
In Otolaryngology. Vol. 3, Ch. XII. Hagerstown, Md.: W. F. Prior Co., Inc.,
1960b. N.V.
928. APPAIX, A., M. GRINDA, J. HENIN, and P. NOURRIT.
Les barotraumatismes cochléaires. Données cliniques. (Cochlear barotraumas,
clinical data.)
Ann. oto-laryngol. (Paris) 78(6):359-371, 1961.
929. BOSATRA, A. B., and G. B. STAFANI.
Endolymphatic sudden deafness: clinical study.
Acta Otolaryngol. (Stockh) Suppl. 169:1-62, 1961. N.V.
930. JARRETT, A. S.
Reversed-ear syndrome and the mechanism of barotrauma.
Br. Med. J. 483-486, Aug. 19, 1961b.
931. MONTAGUE, W. E., and J. F. STRICKLAND.
Sensitivity of the water-immersed ear to high- and low-level tones.
J. Acoust. Soc. Am. 33(10):1376, 1961.
932. BOND, G. F.
Clinical problems of SCUBA diving.
Conn. Med. 27(6):312-314, 1963.

The author briefly mentions the importance of the ear in diving.
933. BUSNELL, R. G. (Ed.)
Acoustic behavior of animals. 933 pp.
New York: Elsevier Publishing Co., 1963. N.V.
934. SERGEANT, R. L.
Speech during respiration of a mixture of helium and oxygen.
U. S. Naval Medical Research Laboratory, Groton, Conn., Report No. 412, 14 October
1963.
935. ALFANDRE, H. J.
Aerotitis media in submarine recruits.
U. S. Naval Submarine Medical Center, Groton, Conn., Report No. 450, 29 May 1965.

Reports the epidemiology study of 432 cases.
936. SMITH, P. F.
Bone conduction, air conduction, and underwater hearing.
U. S. Naval Submarine Medical Center, Groton, Conn., Report No. 65-12, 8 October
1965.
937. WILKE, V. M., and M. STEFEL.
Hörstörungen bei tauchsportlern. (Disturbances in hearing of sport divers.)
Dtsch. Gesundheitsw. 20:1149-1156, 1965.
938. ADOLFSON, J., and E. FLUUR.
Hearing discrimination in hyperbaric air.
Aerosp. Med. 38(2):174-175, 1967.

The authors did speech discrimination at 4, 7, and 11 ata. They found a difference
at 7 and 11 ata.

939. BEAL, D. D., W. G. HEMENWAY, and J. R. LINDSAY.
Inner ear pathology of sudden deafness.
Arch. Otolaryngol. 85:591-598, 1967.
940. DUBS, R.
ORL-probleme beim Tauchsport. (ENT problems in diving sport.)
Z. Unfallmed. Berufskr. 60:251-255, 1967.
941. HARRIS, C. S., and H. E. von GIERKE.
The effects of high intensity noise on human equilibrium.
Paper presented at the Annual Convention of Aerospace Medical Association, Wash.,
D. C., April 1967.

The influence of noise on equilibrium is discussed.
942. SPERATI, G., and G. PEFUMI.
L'otite esterna die Sommazatori. (Otitis externa of skin divers.)
Arch. ital. otol. 78:443-459, July/Aug. 1967. N.V.
943. NIXON, C. W., W. E. MABSON, F. TRIMBOLI, J. E. ENDICOTT, and B. E. WELCH.
Observations on man in an oxygen-helium environment at 380 Mf. HG total pressure:
IV. Communications.
USAF School of Aerospace Medicine, Brooks AFB, Texas, SAM TR 67-205, 1968.
944. SERGEANT, R. L.
Limitations in voice communications during deep submergence-helium dives.
Mar. Sci. Instrum. 4:405-411, 1968a.
945. SERGEANT, R. L.
Voice communication problems in spacecraft and underwater operations.
Ann. N.Y. Acad. Sci. 155(1):342-350, 1968b.
946. HARDACRE, L. E., and J. HALPERN.
The evaluation of a dynamic visual display of transient underwater acoustic signals.
Computer Image Corporation and University of Denver, Denver, Colo., Technical
Report No. 2, September 1969.
947. HARRIS, J. D.
Hearing loss in decompression.
U. S. Naval Submarine Center, Groton, Conn., Report No. 591, 1969.

A very good review of the effects of pressure on hearing. More than 80 references,
many of which are of interest for vestibular functions. (RK)
948. HOLLIEN, H., and J. F. BRANDT.
Effect of air bubbles in the external auditory meatus on underwater hearing
thresholds.
J. Acoust. Soc. Am. 46:384-387, 1969.
949. MURTY, V. S. N.
Otitic barotrauma with bilateral perforations (a case report).
J. Aero. Med. Soc. India 12(1):62-66, 1969.
950. RIU, R., L. FLOTES, R. GUILLERM, R. BADRE, and R. LEDEN.
La trompe d'eustache dans la plongee. (Eustachian tube during diving.)
Rev. Physiol. Subaquatique Med. Hyperbare 1:194-198, Jan./Mar. 1969.
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Barotraumatisko ostecenje slusnog organa u ronilaca. (Barotraumatic damage of
hearing organ in divers.)
Vojnosanit. Pregl. 26:75-77, Feb. 1969. N.V.

No English abstract available.

952. SMITH, P. F.
Underwater hearing in man: I. Sensitivity.
U. S. Naval Submarine Medical Center, Groton, Conn., Report No. 569, 28 February 1969.

953. WEBSTER, J. C.
Sil-past, present, and future.
Sound and Vibration 3(8):22-26, 1969.

1970-1972

954. BAUER, B. B.
Comments on "Effect of air bubbles in the external auditory meatus on underwater hearing thresholds."
J. Acoust. Soc. Am. 47(2):1465-1467, 1970.

Failed to replicate the finding of Hollien and Brandt (1969, #948). The latter "measured no significant difference in underwater threshold (p. 1465)."

955. HARRIS, J. D., and R. L. SERGEANT.
Sensory behavior of naval personnel: Monaural/binaural minimum audible angle of auditory response.
U. S. Naval Submarine Medical Center, Groton, Conn., Report No. 607, 14 January 1970.

956. MURRY, T.
Noise levels inside Navy diving chambers during compression and decompression.
U. S. Naval Submarine Medical Center, Groton, Conn., Report No. 643, 21 October 1970.

Very high noise levels were obtained in diving chambers (they can be more than 100 db, A-scale), and noise does affect vestibular functions (cf. Harris and von Gierke, 1967, #941).

957. SMITH, P. F.; R. HOWARD, M. HARRIS, and D. WATERMAN.
Underwater hearing in man: II. A comparison of temporary threshold shifts induced by 3500 hertz tones in air and underwater.
U. S. Naval Submarine Medical Center, Groton, Conn., Report No. 608, 15 January 1970.

958. SUMMITT, J. K., J. M. ALEXANDER, E. T. FLYNN, and J. M. HERRON.
Repetitive excursion dives from saturated depths on helium-oxygen mixtures.
Phase II: Saturation depth 200 feet, saturation depth 150 feet.
U. S. Navy Experimental Diving Unit, Wash., D. C., Report No. 6-70, 23 September 1970.

959. WATERMAN, D., and P. F. SMITH.
An investigation of the effects of a helium-oxygen breathing mixture on hearing in naval personnel.
U. S. Naval Submarine Medical Center, Groton, Conn., Memo Report 70-7, 1970.

960. HARRIS, C. S.
Effects of acoustic stimuli on the vestibular system.
Aerospace Medical Research Laboratory, Wright-Patterson AFB, Ohio, Report No. A7-1, 1971.

Harris' findings showed that nystagmus and egocentric verticality were not disrupted by noise, but postural equilibrium was.

961. HOLLIEN, H., and H. ROTHMAN.
Underwater sound localization in humans.
Communication Sciences Laboratory, University of Florida, Gainesville, Fla., Progress Report No. 23, 1 March 1971.

962. MCCORMICK, J. G., T. L. HIGGINS, H. S. DAUGHERTY, and P. E. JOHNSON.
Cochlear dysfunction associated with decompression from 300-ft. hyperbaric chamber dives.
82nd Meeting of the Acoustical Society of America, Denver, Colorado, 19-22 October 1971.

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Cochlear potentials at 11 atmospheres.
Laryngoscope 81(6):979-988, 1971.

A good bibliography. Losses of 15 to 20 db are reported.

964. SUMMITT, J. D., and S. D. REIMERS.
Noise: A hazard to divers and hyperbaric chamber personnel.
U. S. Navy Experimental Diving Unit, Wash., D. C., Report No. 5-71, 15 May 1971.

Noise levels in chambers and helmets are high (> 90 db), and result in temporary threshold shifts.

See also

References 10, 14, 19, 27, 28, 33, 42, 48, 51, 54, 57, 59, 62, 63, 65, 66, 68, 69,
73, 74, 81, 110, 114, 127, 128, 129, 130, 131, 154, 157, 178, 182, 315, 359, 394, 398,
403, 518, 718, 721, 855.

ADDENDUM--CATEGORY VI

965. DELONCA, G.
Considerations sur les manoeuvres dites d'equilibration de l'oreille chez le plongeur.
Part of a longer COMEX--CIEEXO report. (Unable to identify title; probably after 1966. Ed. Note.)

The article stresses the importance of the patency of the Eustachian tube in diving operations and the dangers of Valsalva to the ear (barotrauma) and the cardiovascular system (generation of syncope). They counsel their divers in other methods.

AUTHOR INDEX

- Abderhalden, E. 784
 Adams, W. S. 918, 919
 Aden, H. W. 107, 416
 Adler, H. E. 816, 865
 Adler, H. F. 154
 Adolfson, J. A. 235, 255, 286, 773, 774, 938
 Ahlen, G. 327
 Alexander, J. M. 285, 958
 Alfandre, H. J. 935
 Alford, B. R. 502
 Alinat, P. 178
 Allen, F. L. 840
 Allen, G. W. 381, 406
 Almour, R. 54, 903
 Alnor, P. C. 155
 Alpers, B. J. 364
 Alt, F. 9, 11
 Altmann, F. 470
 Alvis, H. J. 256, 287, 288
 Alzate, R. 372
 Ambler, R. K. 558, 601
 Ambrosio, L. 102, 140
 Andersen, B. G. 834, 840
 Andersen, H. C. 350
 Anderson, B., Jr. 156, 160
 Anderson, J. R. 511
 Andrews, A. H. 30
 Anggard, G. 433
 Anggard, L. 433
 Anson, B. J. 407, 412, 441, 471
 Appaix, A. 121, 128, 240, 602, 928
 Armstrong, H. G. 42
 Arnold, H. A. 706
 Arnvig, J. 393
 Aronoff, J. 776
 Arslan, M. 113, 472
 Aschan, G. K. 75, 545
 Asher, H. M. 643
 Athletic Institute, The, 236
 Autrum, H. 817
 Avant, L. L. 688

 Backus, J. 114
 Badre, R. 950
 Bale, R. M. 277
 Balke, B. 664
 Ballantyne, J. 423
 Ballenger, H. C. 328, 329
 Ballenger, J. J. 328, 329
 Ballenger, W. L. 328, 329
 Balliet, R. F. 882
 Balogh, K. 432
 Barany, R. 292
 Baratoux, J. 13
 Barlow, J. S. 495, 819, 822, 826
 Barnard, E. E. P. 174, 175, 193
 Barnard, R. N. 275
 Barnes, D. J. 611

 Barnum, F. 716
 Barrett, G. V. 728
 Bascoe, P. 26
 Bateman, G. H. 316
 Bateman, G. L. 65
 Batachelet, E. 823
 Bauer, B. B. 954
 Bauer, L. 1
 Bauermeister, M. 681
 Bayliss, G. J. A. 211, 224
 Baz, A. 768
 Beal, D. D. 939
 Beatty, J. D. 526
 Beckmann, E. L. 656, 663
 Behnke, A. P. 55, 63, 72, 85, 103, 225, 261, 262, 900, 904
 Bekesy, G. V. 543
 Belleville, R. E. 893
 Bennett, P. B. 194, 226, 237, 238, 263, 264, 265, 275, 504, 505, 513
 Bensel, C. K. 473, 584
 Benson, A. J. 162, 516, 761
 Benson, R. E. 50
 Berg, J. 804
 Berghage, T. E. 107, 216, 773, 774
 Bergan, J. J. 442
 Bergstedt, M. 376, 545
 Beritachvili, I. S. (Beritoff, J. S.) 812, 818
 Bernotat, R. K. 744
 Bernstein, L. 382, 413
 Berruyer, G. 19, 28
 Bert, P. 58
 Bertmar, G. 841
 Bertoin, R. 37, 44, 95
 Bertrand, M. 922
 Bevan, J. 237
 Bierman, H. R. 319
 Bjerver, K. 235, 286
 Blackwood, F. 612
 Blakeslee, E. 891
 Blankenhorn, M. 61
 Bleck, G. 21
 Blegvad, B. 668
 Bitterman, K. E. 640
 Bobington, T. H. 5
 Boies, L. R. 82
 Bond, G. F. 176, 932
 Bonen, L. 526
 Boot, G. W. 27
 Borasi, G. 195
 Borison, H. L. 348
 Bos, J. H. 401
 Bosatra, A. B. 929
 Botner, V. 113
 Bouche, J. 129
 Bovcott, A. E. 20
 Bozzi, E. 108
 Bradley, M. E. 252
 Brancoto, P. 731

Brandt, J. F. 948
 Brauer, R. W. 266, 274, 279
 Bray, C. M. 310
 Brickman, I. W. 319
 Brierley, J. B. 227
 Brinkman, W. P. B. 360
 Brodal, A. 383, 427
 Brosdale, L. 729
 Brown, B. R. 320
 Brown, D. E. S. 306
 Brown, F. A. 867
 Brown, F. M. 267, 514
 Brown, G. A. 64
 Brown, G. C. 611
 Brown, J. H. 561, 827
 Brown, J. L. 662
 Bruchey, W. J., Jr. 741
 Bruner, A. 496, 515
 Bruzzi, B. 115
 Bryant, W. S. 24
 Bucy, P. O. 443
 Buhlmann, A. A. 196, 238, 248
 Bullington, W. E. 785
 Burger, D. 384
 Burger, W. D. 276
 Burke, D. T. 925
 Burrage, W. S. 355
 Buscaino, V. M. 116
 Busnell, R. G. 933
 Bynum, J. A. 730

 Cabarro, P. 177, 178, 570
 Cabe, P. A. 728
 Camis, M. 299
 Campbell, A. C. P. 59, 73
 Campbell, P. A. 56, 123, 927
 Canavese, R. 144
 Canella, C. J. 547
 Cantrell, R. P. 555
 Carpenter, M. B. 444
 Carr, A. F. 830
 Carruthers, D. G. 332, 333
 Catchpole, H. R. 88, 330
 Cattell, M. 532
 Cavagna, G. A. 551, 820
 Cave, F. M. 268
 Cavonius, C. R. 239
 Cawthorne, T. 365
 Ceran, S. J. 808
 Chambers, R. M. 663, 676, 677, 679
 Chandler, J. R. 402
 Chang, H. T. 339, 914
 Chapman, R. M. 239
 Charousek, H. 296
 Chiappe, E. 46
 Chinn, H. I. 361
 Chossegras, H. 96
 Chouteau, J. 269
 Cirincione, P. A. 684, 685
 Clark, B. 99, 497, 537, 585, 596,
 616, 622a, 628, 634, 635, 641, 644,
 647, 648, 658, 659, 665, 666, 692,
 707, 708, 717, 745, 762, 799, 842

Clayton, R. M. 279
 Coburn, K. R. 663
 Cockett, A. T. K. 133, 228, 474
 Cody, D. T. R. 371
 Cohen, M. 603
 Colehour, J. K. 418
 Coleman, J. 921
 Coles, R. R. A. 130, 394, 408
 Collins, W. E. 377, 395, 746
 Comex, 529
 Conticelli, M. 694, 695, 731
 Cope, S. 357
 Correia, M. J. 564
 Corao, J. F. 669
 Corv, C. H. 868
 Costen, J. B. 302
 Covell, W. P. 483
 Covey, C. W. 270
 Cramer, D. B. 516, 621
 Cramer, R. L. 525, 541, 697
 Crampton, G. H. 561, 571
 Crampton, W. E. 377
 Crawford, W. A. 550
 Cratty, B. J. 824
 Crespi Rephizzi, A. 47
 Crickmar, S. D. 740
 Crissy, W. J. E. 93
 Cronick, C. H. 64
 Crosby, E. C. 349
 Cross, E. R. 109
 Crowe, S. J. 301
 Curnow, J. 6
 Cuthbert, A. 5

 Dallenbach, K. M. 540, 625, 801
 Damant, G. C. C. 20
 Danziger, R. E. 285
 Daugherty, H. S. 962
 Davey, L. M. 385, 556
 Davies, W. 143
 Davis, G. D. 212
 Davison, R. A. 414
 Davson, H. 670
 Dav. R. H. 696
 Deane, F. R. 591
 DeForest, R. 663
 Dega, K. 572
 Demard, F. 240, 271, 602
 Dennis, D. S. 878
 Dennison, W. L. 190, 437
 de Rivera, J. 549
 De Silva, H. R. 791
 Despons, M. 91
 De Stafani, G. B. 929
 De Vita, C. 118
 De Witt, G. 362
 Diachenko, J. A. 290
 Dickinson, D. J. 861
 Dickson, E. D. D. 59, 73
 Diffenbach, W. S. 810
 Dix, M. R. 346
 Dizon, A. E. 851, 869
 Dockstader, S. L. 870

Dohlman, G. 535
 Dolatkowski, A. 572
 Doll, R. E. 163, 197
 Donaldson, J. A. 407, 412
 Donnell, A. M., Jr. 124
 Doty, R. L. 732
 Dowd, P. J. 697
 Droscher, V. B. 843
 Dubs, R. 940
 Duncan, B. K. 792
 Duvall, A. J. 445
 Dyk, R. B. 674
 Dzendolet, E. 473, 562, 584, 763

Eagle, W. W. 321
 Eaton, J. (W. J.) 237, 275
 Ebenholtz, S. M. 747
 E. C. O. P., Inc. 775
 Edmonds, C. 272, 612
 Edmonds, F. C. 337
 Edwards, C. H. 415
 Egstrom, G. H. 705, 771
 Eichel, B. S. 241
 Elin, J. C. 396
 Elinskii (Elinsky), M. P. 203, 213, 242
 Elliott, D. H. 175, 231, 238
 Elsner, W. 613
 Emlen, J. T. 828, 892
 Enders, L. J. 243
 Endicott, J. E. 943
 Engel, G. L. 61, 86
 Engstrom, H. 340
 Erde, A. 147
 Erdman, S. 29
 Ernest, J. T. 239
 Ernsting, J. 202
 Eskin, A. 573, 583
 Evans, C. R. 169
 Everley, J. A. 57

Fabritius, Michael 853
 Fabritius, Monika 853
 Farber, Iu. V. (Farber, Y. V.) 749, 577
 Farrior, J. B. 334
 Faterson, H. F. 674
 Feeny, B. 645
 Fenn, W. O. 164, 538
 Ferguson, D. E. 871
 Ferguson, J. C. 677
 Fernandez, C. 372
 Ferrell, M. R. 199
 Ferris, E. B. 61, 86
 Fields, J. A. 117
 Fields, W. S. 446, 447, 475
 Filippi, P. 84
 Fisher, C. M. 448
 Fitzgerald, J. B. 133
 Flanagan, J. C. 83
 Fletcher, J. L. 682
 Flinn, D. E. 397
 Flisberg, K. 398
 Flottes, L. 125, 950

Fluor, E. 235, 286, 386, 428, 498, 499, 566, 597, 598, 604, 605, 938
 Flvnn, F. T. 285, 958
 Fodor, F. 586
 Fractor, Z. M. 611
 Fraenkel, G. S. 809, 811
 Franklin, S. S. 748
 Fredenucci, P. 240
 Fredrickson, J. M. 489
 Freeberg, N. E. 366
 Fregly, A. R. 289, 418, 450, 476, 500, 516, 567, 574, 575, 587, 594, 617, 618, 619, 620, 621, 702
 Fructus, C. 273
 Fructus, X. P. 229, 273, 274, 501
 Fryer, D. I. 214
 Fulton, J. F. 87
 Furey, J. A. 387
 Fust, H. D. 178

Galambos, R. 538
 Galle, R. R. 764
 Galler, S. R. 893
 Galton, F. 780
 Gandino, D. 49
 Gault, P. P. 440
 Gavrilova, L. N. 764
 Gelfan, S. 339, 914
 Gentry, R. L. 831
 German, W. J. 385
 Gernandt, B. E. 368, 416, 449
 Gersh, J. 88, 330
 Gillen, H. W. 215
 Gilson, J. J. 627, 639
 Gilson, R. D. 872, 873
 Gleisner, L. 429, 430
 Gloria, E. M. 694
 Goldberg, L. 235, 286, 774
 Golding, F. C. 126
 Gomez, V. 895
 Comori, B. 139
 Goode, P. L. 489
 Goodenough, D. R. 674
 Gordon, L. 32
 Gould, J. L. 850
 Goulon, M. 198
 Grav, A. A. 293, 782
 Grav, J. S. 67
 Gray, L. P. 359
 Grav, S. P. 238, 513
 Graybiel, A. 107, 148, 244, 417, 418, 450, 476, 500, 516, 536, 537, 553, 560, 563, 565, 574, 575, 576, 579, 587, 588, 591, 594, 606, 618, 620, 621, 628, 634, 635, 641, 644, 647, 648, 658, 659, 665, 666, 672, 678, 680, 683, 700, 701, 702, 707, 708, 709, 710, 739, 767, 835
 Graveline, D. E. 664
 Gregg, F. M. 793
 Gregg, J. B. 199
 Gregoire, H. G. 277
 Griffin, D. R. 796, 807

Griffiths, P. D. 126, 230
 Grisor'Ev, Y. G. 577, 749
 Grinda, M. 144, 928
 Groven, J. 423
 Gualtierotti, T. 652
 Guedry, F. E., Jr. 418, 419, 516, 517,
 557, 558, 563, 601, 606, 667, 683,
 711, 756, 761, 805, 808, 844, 848,
 872, 873, 874
 Guild, S. R. 297, 298
 Guillerm, R. 950
 Guldberg, F. O. 781
 Gunn, D. L. 809, 811
 Gutierrez, J. 167
 Gwozdiewicz, J. 149, 165, 179

 Habibi, M. 381
 Haines, H. L. 68, 74
 Haldane, J. S. 20
 Hall, J. F., Jr. 902
 Hallberg, O. E. 924
 Hallpike, C. S. 342, 346, 477
 Halpern, J. 946
 Hamilton, R. W. 180
 Hammer, L. R. 671
 Hannequin, M. 129
 Hansen, K. H. 729
 Hardacre, L. E. 150, 946
 Harper, D. G. 441, 471
 Harris, C. S. 557, 558, 563, 578, 610,
 683, 718, 941, 960
 Harris, J. D. 68, 74, 947, 955
 Harris, M. 957
 Harrison, M. S. 342, 399, 478, 482
 Harrison, R. 402
 Hartman, B. 664
 Hartmann, H. 178
 Harvey, W. 76
 Hasler, A. D. 851, 869
 Haubrich, J. 460
 Hawkins, J. A. 39
 Hawkins, J. E., Jr. 518
 Hawkins, W. B. 451
 Hay, J. C. 737
 Hayashi, S. 343
 Haymaker, W. 104
 Held, K. 246
 Held, R. 704
 Heller, M. F. 127
 Heller, R. 7, 11, 14
 Helmreich, R. 724
 Hemenway, W. G. 939
 Hempleman, H. V. 126, 275
 Henerey, M. 850
 Henin, J. 928
 Henriksson, N. G. 429, 430, 546
 Herget, R. 155
 Herron, J. M. 234, 958
 Hertzman, M. 642
 Heyman, A. 160
 Hidalgo, F. C. 145
 Higgins, L. L. 519

 Higgins, T. L. 279, 962
 Hilger, J. A. 452
 Hill, J. C. 614
 Hill, L. 25, 35
 Hills, B. A. 520, 521
 Hinchcliffe, R. 453, 589
 Hinoki, M. 431, 559
 Hitchcock, L. 679
 Hirschler, W. J. 915
 Hitzelberger, W. E. 454
 Hixson, W. C. 836
 Hjorth, S. 340
 Hoche, A. 12
 Hodgson, E. S. 875
 Hollien, H. 948, 961
 Holschull, L. 380
 Holubar, J. 845
 Hoople, G. D. 341
 Horrall, R. M. 851, 869
 Howard, I. P. 698
 Howard, R. 957
 Howe, H. A. 899
 Howland, B. 813
 Howland, H. C. 813, 876
 Hughson, W. 300, 301, 899
 Humphreys, L. G. 590
 Hunter, J. 363
 Hupp, D. 536
 Hyde, P. W. 347

 Igarashi, M. 416, 502, 583, 591
 Ingelstedt, S. 308, 455
 Irwin, J. W. 355, 380
 Ishii, T. 432
 Ishiyama, E. 522
 Ivarsson, A. 455
 Ivv, A. C. 30
 Iwane, M. 719

 Jacobs, G. J. 893
 Jako, G. 380
 Jander, R. 837, 852, 853, 854, 877
 Janeke, J. B. 608
 Jarrett, A. S. 131, 930
 Jepsen, O. 350
 Jerger, J. 373, 388, 456
 Jaffres, R. 134
 Johansson, G. 430
 Johnson, F. H. 306
 Johnson, P. E. 962
 Johnson, W. H. 363
 Johnston, A. D. 104
 Johnston, D. G. 276
 Jones, G. M. 378
 Jones, M. F. 337
 Jongkees, L. B. W. 409, 457, 490, 491,
 530, 592, 608
 Jonson, Bjorn 455
 Jonsson, B. 552
 Jordan, M. P. 266
 Jupp, B. P. 861
 Juravj, M. 442

Kado, R. T. 228, 474
 Kaphan, G. 420
 Karp, S. A. 674
 Kasparek, C. F. 403
 Katz, M. S. 684, 685
 Kavanau, J. L. 838
 Kawamoto, K. 458
 Keays, F. L. 22
 Keels, K. W. 522
 Kelley, J. S. 216, 234
 Kellogg, R. S. 765
 Kelly, W. J. 69, 74, 322, 323, 324, 325
 Kennedy, R. S. 277, 289, 290, 418, 553, 563, 567, 579, 622, 672, 683, 710, 750, 835
 Kennon, R. H. 910
 Kerharch, B. 460
 Kerber, H. E. 728
 Kerekes, G. 77
 Khelemkii, E. I. 764
 Kidd, D. J. 181, 231
 Kim, J. H. 849
 Kimura, R. S. 356, 410, 459
 King, P. F. 182
 Kitahara, M. 559
 Klafman, S. 572
 Klinzman, W. O. 64
 Klockhoff, I. 433
 Knight, J. J. 130
 Knoblock, E. C. 418
 Knotts, J. R. 789
 Knox, C. 519
 Koburg, E. 460
 Koch, H. L. 624
 Kocour, E. J. 64
 Kohl, O. A. 649
 Komendantov, G. L. 105
 Kooperstein, S. I. 110
 Kornhuber, H. H. 291a, 489
 Kos, C. M. 312, 908
 Kotaskova, J. 751
 Kranz, F. W. 897
 Kratochvil, C. H. 106
 Kraus, R. N. 379, 387
 Krebs, C. Q. 440
 Krepis, E. M. 245
 Krol, Ya. M. 374
 Kristiansen, F. 350
 Kudel'skiy, LA. 374
 Kuehn, L. A. 526
 Kuilman, J. 369
 Kurozumi, S. 917

 Laba, L. 149, 151, 217, 375
 Lagerstrom, L. 566
 Lamb, J. C. 840
 Lambertsen, C. J. 132, 218
 Lamey, M. 223
 Landau, J. V. 523
 Landes, B. S. 241
 Lang, J. 146, 232, 278

 Lange, K. O. 733
 Langer, P. H. 524
 Langheinz, H. W. 69
 Lanphior, E. H. 111, 183
 Lapayev, E. V. 600
 Lathrop, R. G. 679
 Lawrence, J. H. 71
 Lawrence, L. B. 71
 Lawrence, M. (M. J.) 310, 336, 338, 434
 Le Den, R. 950
 Lee, G. 351
 Leggiere, T. 855
 Lehmann, H. J. 246
 Lehner, P. N. 878
 Leibowitz, H. 766
 Lempert, J. 338
 Lennie, P. 725
 Lentine, J. 70
 Lester, J. C. 895
 Lestienne, J. 36
 Letko, W. 720
 Leventon, G. 503
 Levv, E. 31
 Levy, J. S. 442
 Lewis, H. B. 642
 Lewis, R. S. 335
 Libois, J. 420
 Lieberman, A. T. 912
 Lindsay, J. R. 372, 461, 479, 480, 939
 Lippold, O. 247
 Lissaman, P. B. S. 856
 Litton, W. B. 462
 Lock, W. E. 905, 906
 Lockley, F. M. 832
 Loeb, M. 682
 Lord, F. E. 795
 Lovelace, W. R. 901
 Lund, D. W. 71
 Lund, F. H. 790
 Lundgren, C. E. G. 166, 184
 Lundquist, P. G. 410
 Lythgoe, J. N. 772

 Mabson, W. E. 943
 MacCorquodale, K. 537
 MacCurdy, J. T. 626
 Machover, K. 642
 MacFie, W. C. D. D. 411
 MacInnis, J. B. 180, 185
 Mackay, D. E. 152
 Mackworth, N. H. 689
 MacLeod, M. C. 850
 Maestracci, P. 249
 Mager, W. 7, 11, 14
 Magnotti, T. 38
 Mahady, S. C. F. 67
 Maletti, W. G. 133
 Malm, L. V. 184
 Malone, R. D. 799
 Man, A. 503
 Manselton, N. L. 474
 Manigan, T. P. 48

Mann, C. W. 547, 638, 646
 Manning, G. W. 308
 Mansure, F. T. 524
 Marparia, R. 339, 551, 651, 652,
 699, 806, 820, 914
 Markaryan, S. S. 600
 Marriott, H. C. 655
 Marsland, D. A. 306
 Masland, R. L. 67
 Maspetiol, R. 167, 168
 Mathewson, R. F. 875
 Mathog, R. H. 525
 Matthews, J. M. B. 351
 Matthys, H. 238, 248
 Mavor, A. S. 779
 Maxian, P. M. 502
 Mawet, J. 223
 Mayne, R. 846, 847
 Mayo, C. W. 901
 Mazza, V. 102
 McAniff, J. 855
 McCabe, B. F. 435, 462, 481
 McCallum, R. I. 97, 200, 219
 McCance, R. A. 344
 McCormick, J. G. 279, 962
 McCoy, D. F. 733
 McDonald, D. L. 839
 McFarland, J. H. 687
 McGibbons, J. E. G. 59, 73
 McIntyre, A. K. 304
 McKay, C. L. 752
 McKenzie, R. E. 664
 McLeod, M. E. 418, 450, 554, 564
 McNally, W. J. 307, 492, 544
 McReynolds, J. 802
 Meda, E. 92
 Meek, J. C. 554
 Meiselman, H. L. 473
 Meissner, P. B. 642
 Mellstrom, A. 499
 Melvill Jones, G. 112, 653,
 753, 754
 Meltzer, P. E. 338
 Mendel, L. 428, 498, 566, 597, 598
 Menzio, P. 797
 Meredith, H. W. 358
 Merer, P. 134
 Mertz, W. 418
 Metlay, W. 684, 685
 Mewaldt, L. R. 814
 Mevers, D. 425
 Migeon, L. 96
 Miller, E. F., II 418, 450, 516, 560,
 565, 579, 593, 594, 599, 678, 700,
 701, 702, 710, 767, 835
 Miller-Guerra 352
 Miller, H. E. 963
 Miles, S. 201, 734
 Miles, W. R. 789
 Miltich, A. J. 721
 Mitchell, D. R. 909

Mitchell, J. H. 898
 Mitchell, R. E. 575
 Money, K. E. 526
 Monjeon, C. J. 466
 Montague, E. K. 667
 Montague, W. E. 931
 Montandon, A. 420
 Montandon, P. 420
 Moore, E. W. 541, 697, 703
 Morales, M. F. 313
 Morant, R. B. 776
 Moroney, W. F. 277
 Morrill, S. N. 107
 Morris, T. W. 515
 Morrison, A. P. 171, 421
 Morrison, L. E. 233
 Morrison, J. (J. M.) 237, 275
 Morvav, D. A. 663, 679
 Moser, R., Jr. 735
 Motley, H. L. 64
 Mottram, J. 622b
 Mowrer, O. H. 573, 627
 Mullholland, T. 169
 Murry, T. 956
 Murty, V. S. N. 949

 Naftalin, I. 309, 482
 Nakamura, R. M. 228
 Napier, J. 580
 Nashner, L. M. 607
 Naquet, R. 274
 Nelson, J. G. 581, 722
 Neptune, E. M. 285
 Newson, B. D. 579, 710, 835
 Nicholson, A. H. 202, 227
 Nicholson, M. A. 99, 622a
 Nicolai-Harter, H. 249
 Nicolet, L. 134
 Nielsen, J. C. 317
 Niven, J. I. 107, 680, 836
 Nixon, C. W. 578, 943
 Noble, A. D. 180
 Norman, J. W. 844, 874
 Norris, C. 463
 Norris, T. W. 406
 Norton, C. P. 124
 Nourrit, P. 110, 121, 128, 135,
 137, 928
 Nozut, M. 400
 Nuttall, J. B. 654

 Oberman, A. 575
 Ocana de Sentuarv, J. M. 269
 O'Doherty, E. F. 655
 Ogden, F. W. 60, 314
 Ono, M. 719
 Oosterveld, W. J. 608, 755
 Ortesaren, U. 308
 Ortiz, R. B. 78
 Osborn, C. M. 919
 Otani, N. 34

Otis, A. G. 538
 Ottoboni, A. 186
 Ovrath, G. 238, 248
 Owen, E. P. 740
 Owens, G. G. 844, 848, 874

 Pace, N. 313
 Padden, D. A. 657
 Pagano, A. 89, 98, 120, 136, 923
 Panov, A. G. 203
 Parker, D. E. 220, 483, 506, 857
 Parin, V. V. 609
 Parrish, D. E. 266
 Parsons, R. D. 858
 Partridge, L. D. 849
 Pashalian, S. 93
 Passey, G. E. 637, 638
 Patel, D. 768
 Paton, W. D. M. 100, 126
 Patton, R. A. 913
 Pauley, P. 170
 Payne, R. 879
 Pege, J. 280
 Peitersen, E. 582
 Penny, R. L. 828
 Perfumo, G. 186, 942
 Perlman, H. B. 356
 Pesch, A. J. 712, 723
 Peters, R. A. 736
 Philip, M. 17
 Philipszoon, A. J. 389, 401, 409
 Picard, D. 121, 128, 137
 Pick, H. L. 737
 Pickard, B. 422, 568
 Pike, F. H. 294
 Pinto, O. F. 390, 436
 Pirene, M. H. 655, 673
 Pironty, L. 269
 Plante-Lanpchamp, G. 249
 Pohlman, A. G. 897
 Poli, C. 23, 896
 Pompeiano, O. 171, 383, 421
 Porteus, S. D. 859
 Portmann, G. 94
 Portmann, M. 94
 Posner, J. B. 377, 395
 Pratt, J. G. 815
 Price, J. B. 305
 Propst, A. S. 690
 Pylka, J. M. 885

 Rabaud, E. 787
 Radloff, R. 724
 Radomski, M. W. 504, 505
 Rainnie, W. O., Jr. 738
 Rahn, H. 538
 Rappaport, M. G. 380
 Rathbun, E. N. 313
 Reason, J. T. 739
 Reimers, S. D. 284, 964
 Requarth, W. H. 50, 51

 Reschke, M. F. 220, 506
 Reuter, S. H. 281
 Rhodes, V. T. 445
 Ricci, J. C. 229, 501
 Riccio, D. C. 221, 573, 583
 Richmond, G. 805
 Rischer, C. E. 838
 Riu, R. 125, 950
 Rivera, J. C. 153, 437
 Roberson, G. D. 682
 Robert, J. E. 358
 Robertson, D. G. 860
 Robinson, D. A. 595
 Roche, L. 96
 Roddier, R. 167, 168
 Rodriguez-Lopez, E. 243
 Roger 101
 Rogozina, I. V. 213
 Romano, J. 61
 Roorda, P. 530
 Ropke 15
 Ross, H. E. 725, 740, 748, 861
 Roth, B. 188, 189
 Roth, L. W. 30
 Rouse, D. L. 803
 Rowe, B. 138
 Rozsahgyi, I. 122, 122a, 139, 187,
 188, 189, 204, 205, 206, 232, 278
 Rubenstein, C. J. 282
 Rubin, W. 447, 463
 Runzel, J. 375
 Ryan, G. M. S. 357
 Ryan, M. S. 794
 Ryan, T. A. 794
 Ryder, H. 61

 Saibene, F. 551
 Sallee, T. L. 285
 Salter, E. 342
 Saltzman, H. A. 156, 160, 234
 Sandler, H. C. 911
 Sandstrom, J. 391
 Sasko, A. B. 851
 Sawada, M. 719
 Schaeffer, A. A. 788
 Schenck, H. 855
 Schlichte, H. J. 880
 Schlosser, W. D. 425, 569
 Schmidt-Koenig, K. 821, 880, 881, 893
 Schock, G. J. D. 660
 Scholtmeyer, H. 510
 Schone, H. 509, 686
 Schreiner, H. B. 180
 Schroeder, D. J. 615, 777
 Schuknecht, H. F. 392, 450, 493
 Schuman, B. J. 110
 Schumcher, G. A. 464
 Schusterman, R. J. 882
 Scott-Brown, W. G. 423
 Scott, S. 295
 Searle, F., Jr. 649

Seaman, K. 157
 Seireg, A. 768
 Sensing, J. 155
 Senturia, B. H. 318
 Sergeant, R. L. 934, 944, 945, 955
 Serra, C. 102, 140
 Serrins, A. J. 402
 Seymour, J. C. 353
 Shambaugh, G. E. 465
 Shambes, G. M. 759
 Shappell, S. O. 527
 Sharpey, E. P. 351
 Sharpouse, P. 237
 Shelby, R. W. 141
 Shenton, E. H. 778
 Shilling, C. W. 39, 43, 45, 52, 53,
 57, 62, 74
 Shollenberger, C. A. 856
 Shoop, C. R. 825
 Siardet, J. 129
 Sidel'nikov, I. A. 600
 Siegel, A. I. 93
 Sierde, E. K. 158, 159
 Silberstein 8
 Sills, N. V. 740
 Silverstein, H. 432, 438
 Simpson, J. F. 424
 Simpson, W. L. 331
 Simmons-Blair, F. 466
 Simmons, J. A. 883, 884, 885
 Simmons, W. W. 519
 Sims, R. O. S. 142
 Singer, G. 622b
 Singstad, O. 40
 Sleskovic, Z. 951
 Smith, A. 862
 Smith, A. H. 2
 Smith, C. R. 516
 Smith, D. G. 277
 Smith, H. D. 312
 Smith, H. W. 308
 Smith, J. E. 771
 Smith, K. R. 336
 Smith, M. J. 618, 619, 620, 621
 Smith, P. F. 936, 952, 957, 959
 Smith, R. E. 313
 Smith, R. W. 283
 Snell, E. H. 10
 Snyder, J. F. 367
 Sokoloff, M. 526
 Soliday, S. M. 863
 Sommer, H. C. 610, 718
 Soos, I. 122a
 Southern, W. E. 886
 Spady, A. A., Jr. 720
 Sperati, G. 186, 195, 942
 Spiegel, E. A. 303, 305, 404
 Spinelli, D. 652
 Stahle, J. 484, 485, 507, 545, 548
 Stang, P. R. 250
 Stanley, C. A. 380
 Stasko, A. B. 887
 Stearns, P. E. 403
 Steedman, W. C. 713
 Steen, B. 552
 Stefel, M. 937
 Stegemann, J. 494
 Stephens, W. M. 691
 Stern, J. A. 730
 Sternstein, H. J. 326
 Stewart, C. B. 65
 Stewart, J. D. 585, 616, 692, 717,
 745, 769, 842
 Stigler, R. 623
 Stockwell, C. W. 606, 756, 872, 873,
 874
 Storm, R. M. 829
 Strickland, J. F. 931
 Stuart, E. A. 307
 Summitt, J. K. 216, 234, 282, 284,
 285, 958, 964
 Sundmaker, W. K. H. 291
 Swanson, L. E. 474
 Syargave, V. A. 158, 159
 Szekely, E. G. 404
 Sziklai, C. 687
 Tarnoczy, T. 232, 278
 Tavalpa, W. N. 833
 Taylor, G. D. 926
 Taylor, N. B. G. 363
 Teed, R. W. 315
 Templeton, W. B. 698
 Terao, A. 510
 Terayama, K. 431
 Terry, L. 190
 Thach, J. S. 221
 Thomas, J. J. 405
 Thompson, E. 899
 Thomsen, K. A. 542
 Thornton, C. L. 728
 Thuillier, A. 916
 Thurlow, W. R. 770
 Tibbling, L. 508
 Tibes, V. 494
 Tillman, T. 373
 Toft, R. 841
 Toher, R. 712
 Tolhurst, G. C. 107, 685
 Tolstoy, L. 833
 Tonndorf, J. 920
 Torbus, J. 572
 Torretta 18
 Towse, E. J. 264, 265
 Trapp, W. C. 510
 Treitel 3
 Trimboli, P. 943
 Trippel, H. 442
 Trout, O. F., Jr. 741
 Trowbridge, C. C. 783
 Tullio, P. 531

Uddin, D. E. 285
 Udo de Haes, H. A. 509
 Uffenorde, H. 79
 Ufkess, J. 624
 U. S. Navy 222, 251, 354
 Ustiushin, B. V. 764

 Vail, E. G. 528
 Vail, H. H. 33
 Van Der Aue, O. E. 80
 Van Der Berg, J. W. 384
 Van Edmond, A. A. J. 360
 Van Rensselaer, H. 4
 Van Ryzin, J. 855
 Vaughan, W. S., Jr. 779
 Vernon, J. A. 884
 Vinacke, W. E. 629, 630, 631,
 632, 633
 Volk-Heinrichs, I. 854
 Volokhova, N. A. 749
 von Gierke, H. E. 220, 483, 578, 941
 von Schrotter, H. 7, 11, 14, 16
 Vorosmarti, J. 252
 Voth, A. C. 172
 Vyslonzif, E. 291b

 Wada, J. A. 510
 Wade, N. J. 696, 757, 758
 Walberg, F. 383
 Walder, D. N. 97, 100, 126, 173, 192,
 207, 208, 209, 210
 Waldvogel, W. 196
 Walker, A. E. 467
 Waltregny, A. 223
 Wagemann, W. 191
 Waite, C. L. 90
 Wang, S. C. 348, 361
 Wapner, S. 642, 687
 Ward, R. R. 889
 Warpeha, R. L. 407, 412
 Warren, D. H. 737
 Warwick, O. H. 65, 309, 311
 Watanabe, T. 502
 Waterland, J. C. 759
 Waterman, D. 957
 Watson, S. 142
 Way, R. O. 266
 Weaver, R. S. 526
 Webb, D. 879
 Webb, J. P. 61
 Weber, C. O. 625, 786
 Webster, J. C. 953
 Weene, P. 704
 Weersma 81
 Weerts, T. C. 770
 Welle, A. S. 380
 Welle, F. L. 355
 Weiner, K. H. 178
 Weiss, A. D. 486
 Welch, B. E. 943
 Weltman, G. 705, 748, 771

 Wendt, G. R. 345, 534
 Werner, G. 246
 Werner, H. 687
 Wersall, J. 410
 Westhues-Koeln, M. 426
 Wever, E. G. 310, 336, 338, 885
 Whalen, R. E. 156, 160
 White, C. S. 358
 Whiteside, T. C. D. 661, 680, 760
 Widdowson, E. M. 344
 Wiener, E. L. 250
 Wigodsky, H. S. 67
 Wilke, V. M. 937
 Willhelmy, G. E. 41
 Williams, H. L. 371
 Williams, J. M. 864
 Williams, T. C. 864
 Wilson, J. G. 294
 Wiltchko, R. 894
 Wiltchko, W. 894
 Winch, T. R. 407, 412, 441, 471
 Winchester, R. A. 425, 569
 Wing, K. G. 370
 Witcher, J. E. 331
 Witkin, H. A. 636, 642, 674
 Wlodyka, J. 468
 Woellner, R. C. 650
 Wolf, S. 469
 Wolfe, J. W. 439
 Wolfson, R. J. 425, 447, 487, 488, 569
 Womack, G. J. 397
 Wood, C. D. 621
 Woods, J. D. 772
 Worchel, P. 540, 640, 798, 800, 802,
 803, 804
 Wustrow, F. 426
 Wyke, M. 693

 Yanof, A. M. 451
 Yemel'yanov, M. D. 609
 Yessenow, M. D. 742
 Yugenov 600
 Yules, R. B. 440

 Zal'tsman, G. L. 253
 Zariello, J. J. 659
 Zinkowski, N. 254
 Zoli, M. T. 695