T-M

INTERNATIONAL MARINE AIDS TO NAVIGATION

3rd Edition

Brian Clearman

Mount Angel Abbey

2010

INTERNATIONAL

MARINE

AIDS TO NAVIGATION

TRANSPORTATION-MARKINGS A STUDY IN COMMUNICATION
MONOGRAPH SERIES

Alternate Series Title: An Inter-modal Study of Safety Aids

Alternate T-M Titles: Transport [ation] Mark [ing]s/Transport Marks/
Waymarks/Transportation Control Devices

T-M Foundations, 5th edition, 2008 (Part A, Volume I, First Studies in T-M) (2nd ed, 1991; 3rd ed, 1999, 4th ed, 2005)

A First Study in T-M: The US, 2nd ed, 1993 (Part B, Vol I)

International Marine Aids to Navigation, 3rd ed, 2010 (Parts C & D, Vol I) (2nd ed, 1988)

[Unified lst Edition of Parts A-D, 1981, University Press of America]

International Traffic Control Devices, 2nd ed, 2004 (Part E, Vol II, Further Studies in T-M) (1st ed, 1984)

International Railway Signals, 1991 (Part F, Vol II)

International Aero Navigation, 1994 (Part G, Vol II)

T-M General Classification, 2nd ed, 2003 (Part H, Vol II) (lst ed, 1995), [3rd ed, Projected]

Transportation-Markings Database:
Marine, 2nd ed, 2007 (Part Ii, Vol III, Additional Studies in T-M) (1st ed, 1997)
TCD, 2nd ed, 2008 (Part Iii, Vol III) (1st ed, 1998)
Railway, 2nd ed, 2009 (Part Iiii, Vol III) (lst ed, 2000)
Aero, 2nd ed, 2009 (Part Iiv) (lst ed, 2001)
Composite Categories Classification & Index, 1st ed, 2006 [2nd ed, Projected]

Transportation-Markings: A Historical Survey, 1750-2000, 2002 (Part J, Vol IV, Final Studies in T-M)

Transportation Markings as an Information/Communication System [Part K, Vol IV, Projected]

Transportation-Markings General Table of Contents with Index, 7th ed, 2010 (lst ed, 2002; 2nd edition, 2003; 3rd ed, 2004, 4th ed, 2005, 5th ed, 2006, 6th ed, 2008) [8th ed, Projected]

INTERNATIONAL MARINE AIDS TO NAVIGATION

Parts C & D, 3rd Edition

Volume I, First Studies

Brian Clearman

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2010

Dedication:
To my parents:
Dad (1909-1980) Mom (1910-1973)
My Step-mother Jennie (1911-1977)
My Step-Mother Mary (1912-2001)

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Library of Congress Cataloging-in-Publication Data

Clearman, Brian.
International marine aids to navigation
Updated ed. of Transportation markings, , v. 1,
parts C & D. 1981.
Bibliography: p.
Includes index.
1. Signals and signaling. 2. Aids to navigation.
I. Clearman, Brian. Transportation-markings.
II. Title.
VK381.C53 1988 623.8'561 88-8960
ISBN: 978-0-918941-33-6

Classification for lst ed: TA 1245.C56 1981
629.04'2 80-6184

Note: TA 1245.C56 employed for all monographs in the Transportation-Markings monograph series

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PREFACE

This monograph is the third edition of *International Marine Aids to Navigation.* The original edition was under the heading of Parts C and D of Volume I, *Transportation-Markings: A Study in Communication.* That volume was published by University Press of America in 1981. It also contained Parts A and B. Those parts were originally a unified monograph that was intended to be published by a small European publisher. That publisher went out of business before completing a semiotics monograph series which included the Transportation-Markings study.

Part A included introductory and foundational materials. Part B reviewed Transportion-Markings in one nation: the US. Parts C & D was the initial study in a series of studies of transportation modes safety aids. The marine materials became all but buried in a volume containing many other materials. Hence, the need to produce an independent monograph. Part A and Part B eventually became independent studies as well.

The second edition in 1988 included updating of statistics, rearrangement of materials, expansion of some topics and replacement of buoy and topmark illustrations. Those topics were joined by illustrations of light phase characterstics and of daybeacons.

This third edition is marked by substantial changes. The general introduction has been merged with the separate introduction for fixed visual markings and expanded. Separate chapters on buoy classification and buoy descriptions have been merged as well. The radio aids chapter has been altered because of the decline of older aids and the growth of GPS. Some changes have been made in the fog signal coverage as those aids decline. This ediition has fewer brief sub-chapters and more sections and segments. Internet resources have a role in this edition that was absent in past editions.

The title of the original volume now serves as the title of the monograph series: Transportation-Markings: A Study in Communication. The heading for the original Parts C and D is the now the title for the monograph: *International Marine Aids to Navigation.*

Acknowledgements are those of previous editions.

ABBREVIATIONS

AN	Aids to Navigation
AN, USCG	*Aids to Navigation Manual*, USCG
BA	*Britannica Atlas*, 1974
BC	British Columbia
Bowditch	Original author of *American Practical Navigator (APN).* Publication often referred to by Bowditch alone (USNOO)
CANS	*Canadian Aids to Navigation System,* 1975
DGPS	Differential GPS
DMA	Defense Mapping Agency
DNSS	Defense Navigation Satellite System
Dutton	See Maloney
EB	*Encyclopedia Britannica*, 1911 edition
EQ	East Quadrant
ESA	European Space Agency
ESNA	Elastic Stop Nut of America
F & O	Fisheries & Oceans ministry, Canada

ESNA	Elastic Stop Nut of America
F & O	Fisheries & Oceans ministry, Canada
FRP	Féderal Radionavigation Plan, US DOD
GPS	Global Positioning System
Hz	Herz
IALA	International Association of Lighthouse Authorities/Association Internationale de Signalisation Maritime
IALA BCR	IALA *Buoy Conference Report*
IDAMN	*International Dictionary of Aids to Maritime Navigation,* IALA
IHB	International Hydrographic Bureau
IMC	International Marine Conference, Washington, D.C., 1889, US State Dept.
IMC/CIM	International Maritime Conference, St. Petersburg, 1912. CIM refers to French-language title. Not to be confused with International Marine Conference, 1889 (Russia)
IMCO	International Maritime Consultative Organisation
Kc	Kilocycle
Khz	Kiloherz

Light Phase Characteristics:

AL	Alternating Light
F	Fixed Light
FFL	Fixed and Flashing Light
FL	Flashing Light
FL (3)	Group-Flashing light (3 is given as an example)
FL (3+1)	Composite Group-Flashing Light (3+1 is given as an example)
IQ	Interrupted Quick Flashing Light
ISO	Isophase Light

IUQ	Interrupted Ultra Quick Light
IVQ	Interrupted Very Quick Light
LFL	Long-flashing
Mo (U)	Morse Code Light (U is an example)
Oc	Occulting
Oc (2)	Composite Group Occulting (2+1 is an example
Q	Quick Light
Q (3)	Group Quick Light (3 is an example)
Q (6)+LFL	Group Quick with Long-Flashing Light (6 is an example)
UQ	Continuous Ultra Quick Light
VLF	Very Low Frequency
VQ	Continuous Very Quick Light
VQ (3)	Group Very Quick (3 is an example)
VQ (6)+LFL	Group Very Quick with Long-Flashing Light (6 is an example)

LF	Low Frequency
LL	Light List
LN	League of Nations
LNB/LANBY	Large Navigational Buoy
LNB	Locan Notices to Mariners
LOP	Line of Position
MBS	*Marine Buoyage Systems*, IHB 1956
Navsat	US Navy Satellite System (it can also have a more general meaning)
NCMH	*New Cambridge Modern History*
NE	Northeast
NGIA	(US) National Geospatial-Intelligence Agency
NQ	North Quadrant
NW	Northwest
Norvan	Buoyage System Answers
ODAS	Ocean Data Acquistion System
OED	*Oxford English Dictionary*

OMEGA	See US Navy
PCPI	Pacific Coast & Pacific Islands LL
PNT	National Space-Based Positioning, Navigation, and Time Coordination Office
RHDEL	*Random House Dictionary of the English Language*
SE	Southeast
SMBB	*Systems of Marine Buoyage & Beaconage* IHB, 1971
SQ	South Quadrant
SW	Southwest
UK 1846	Report of Buoyage Practices
UK 1883	UK Uniform System of Buoyage
UK USB	See UK 1883
USB	Uniform System of Buoyage
USCG	US Coast Guard
USN	US Navy
USNOO	US Naval Oceanographic Office
WLB	*World's Lighthouse Before 1820*
WQ	West Quadrant
WNID	*Webster's New International Dictionary*
WNID 2nd ed	*Webster's New International Dictionary* 2nd edition
WTNID	*Webster's Third New International Dictionary*

CHAPTER ONE

INTRODUCTION TO MARINE AIDS TO NAVIGATION

A Introduction and Overview

1 Introduction

International Marine Aids to Navigation is a short introduction to Transportation-Markings forms that provide a safe passage for marine transportation. It bears resemblance to previous editions though changes have been. These include a merger of the general introduction with the special introduction to fixed marine aids. Chapters dealing with buoys have been reduced by merging some chapters. The original classification has been joined by a variant classification. Sources have been updated and expanded.

Some 40 years ago an initial edition of a T-M classification was composed and assembled. That early work included written materials in a descriptive form as well as charts. Over time both alphanumeric and visual taxonomies were produced.

The exigencies of the chart required (or at least strongly suggested) dividing Marine Aids to Navigation into Floating and Fixed forms. As a result these became quasi-autonomous parts. Marine Aids to Navigation should have retained a unitary character with subordinate sub-divisions (e.g. Part Ci and Part Cii) instead of separate units (Part C and Part D).

That historical anomaly (if that is the correct phrase) has become embedded in the T-M project.. The original decision to divide a single entity is continued in this 2nd edition more than 20 years after the lst edition. The writer acknowledges that earlier decision was an error. However, it cannot be entirely overturned after 40 years of work based on the original decision.

There is a second problem to consider. The original classification was based on two "platforms": land and water. However, there is now a spaced-based platform as well. That requires a third basic subdivision. That has not taken place to date. Most Radio Aids are fixed in nature and the newer spaced-based forms have simply been attached to the land-based forms. This is a matter that needs to be addressed and resolved.

The coverage of this edition will therefore be predicated on the two-part structure of Floating Aids and Fixed Aids. That is generally workable though the previous mentioned shortcomings are present. All of the Marine T-M forms manifest an integral unity though often widely spaced and of diverse characteristics. Unity draws the floating and fixed dimensions together. That dimension is increased for many forms that are elements of formal systems (e.g. IALA system of 1980). The divided coverage is not intended to separate the various forms of Aids.

Finally, it may appear that all marine aids to navigation are divided into either fixed or floating locations. That may seem to be the only practical division. However, a problem arises in that fixed aids can be further divided into marine sites and into land sites. As a result, the difference between a fixed marine light in the water, and a buoy may not be quite as great as their fastenings might indicate. Nonetheless, the fastenings of an aid can serve as a distinguishing point between floating and fixed markings. An interesting blurring of the distinction is found in Finland where the "edgemark," a "fixed aid" operates as a buoy. The functional dimension of the aid is overtaken by the physical dimension despite the contrary appearance (Rolf Backstrom letter, 11-07-83, Board of Navigation, Helsinki).

Fixed and floating markings have distinguishing characteristics within the respective markings beyond the matter of fastenings. These distinguishing characteristics include the structures supporting the light and the intensity of the light. Historically there are more variations in fixed aids than in buoys. The fact that systems of buoys are long-established is an indicator of the standardization to be found among buoys and messages. Fixed aids are somewhat less standardized (though standardization is increasing) and frequently they are numerically smaller than floating aids (according to IALA; however, are many very simple forms reported to the survey?). The following overview will further summarize the characteristics of major forms of aids.

2 Overview

The first major segment of this study focusses on floating aids. Buoys overwhelmingly make up these Aids. Other forms have declined in use. Lightships are extinct or nearly so. A newer aid, Large Navigational Buoy, has apparently declined significantly. There are also automated floats including newer versions. Buoys have been affected by regulation through the use of national and international systems. That provides an overarching structure and direction for buoys and for a study of buoys. Buoys share a common platform so that divergencies in buoys are mitigated to some degree by that commonality. That is less the case with fixed aids. This coverage includes history, systems, classifications, and descriptive treatments.

In past times many nations made use of only parts of one or other agreed-upon system of buoyage; in other instances variations were built into a basic system of buoyage. This resulted in a broad and chaotic spectrum of systems and messages. The IALA system seemingly eliminates much of the chaos, and also individuality; in the past that was a keynote of buoyage systems. Some measure of distinctiveness may well continue in systems with special-shaped buoys. For example, Norway and Germany make use of substantial numbers of a design unique to those systems. A chart of Norwegian aids clearly follows IALA but numerous aids are traditional in design. It would be necessary to examine national systems to see which conform to stylized illustrations of IALA and which follow national patterns. Different shape for some buoy forms may not violate IALA standards.

US and Canada have long employed separate types of buoys for lighted purposes and unlighted purposes. Many nations seemingly have adopted identical shapes for both lighted and unlighted forms. This is also the practice for the Uniform System and IALA. Formerly the US employed special-shaped buoys for sound signals. But increasingly sound buoys utilize a light buoy without the light support structure and mechanism. Special sound buoys are apparently still in service.

The second segment of this study is more diverse and complex. The elements of it include fixed light aids (both major and minor), unlighted fixed aids, radio aids, and a very shrunken fog signal element. There can be significant differences not only between types of aids but also within a type of aid. Methodological grappling with those differences was a notable feature of the first edition. A revised examination of method is present in this edition.

It is a common practice to divide fixed lights into major aids (distinctive towers on headlands and outlying rocks often known as lighthouses) and minor aids (smaller structures in harbors, bays, and rivers). Major lights have been the subject of books and photographs and require few details here. In brief, most traditional towers are enclosed. Smaller towers are found on headlands and promotories; more lofty structures are at low elevations. Massive towers with enormous lanterns and optics are a signature of past lights. Newer towers are relatively rare and unpretentious in the extreme.

Many minor lights on marine sites are found atop a single or multiple-pile structure. The light may be placed directly on the structure or a small house or box may be added. Skeleton (open) towers are a common design for land sites. A single beam or pole is often employed as a structure. Increasingly daymarks or dayboards are attached to the structure that display letters and/or numbers along with distinctive colors. These symbols are often part of the buoyage system message schema.

Many fixed markings do display lights. Such aids are known as daybeacons or simply beacons. They have been a long enduring aid. They are often a pole or column atop rock or at a channel edge. Elaborate structures have also been used. Trees and branches represent extremely simply aids that continue to mark channel limits.

Electronic aids to navigation continue to grow in importance. While visual aids and certainly acoustic aids have lost ground in significance. Visual markings cannot produce long-distance messages and can be handicapped even at short range. That is even more true of fog signals. The previous edition spoke of Loran, radiobeacons and radar reflectors. The last-name continues to have use but other older radio forms have lost importance as global positioning systems move toward dominance for marine aids to navigation.

3 Classification & Semiotics

Classification is a basic element of all T-M studies. Each of the modes includes a classification. And for road, rail, aero studies that is in a unitary form. However, the classification for the oldest study, marine aids, was originally divided into segments and attached to the floating, fixed lights, fog signals, radio aids. That arrangement is continued in this edition. However, there is a unitary classification in Appendix II. The General Classification (Part H) includes the material of this study as well. Essential information is also present in Foundations (Part A) including the nomenclature for the classification.

Semiotics is also a basic element of T-M studies. Information on concepts and the working of semiotics is found in Foundations (Part A). Foundations of messages, communications is also included.. This study is primarily descriptive. Core concerns include: apparatus for creating messages, messages in themselves and their meaning.

B Methodology

a) Introduction

Methodology has a simple meaning in T-M studies. It refers to the framework of information that undergirds the studies and guides the direction and interconnections of those studies. T-M method also incorporates semiotic and communication dimensions. They generally serve as a backdrop to the study.

Railway Signals and Aero Nav Aids studies included a section on methodology and how it was assembled. The material outlined sources that undergirded the classification (the backbone of the study) and also influenced the study throughout. Marine Aids to Navigation in previous editions lacked such a segment but it did follow a method. The omisson of a section on methology is now corrected.

The previous editions of marine a/n included an admittedly idiosyncratic statement on method that focussed on the special needs of localized fixed visual markings. The statement attempted to explain how forms of T-M that were significant yet found only in limited regions of the world could be incorporated into the larger schema. That statement has been substantially eliminated though portions have been reworked and included in this edition.

The foundation of Marine T-Ms is the classification which is built up on historic practices as found in governmental and nongovernmental organizations and meetings dealing with navigation safety. Historic practices also stem from individuals engaged in design and construction of aids. Corporate entities are also included. These sources directly influence other parts of the study as well as through the classification.

The United Kingdom played a multifaceted role in the forming of aids to navigation systems: design and building of aids especially lighthouses, design of optical systems as well as message systems. The families of Stevenson and Douglass not only built many lighthouses but also designed the towers as well as the optical systems. Message systems are a result of their work. Manufacturing firms such as Chance Brothers designed and produced optical systems over a long span of time of time along with physical structures. An agreed upon system of messages may not have been present in the work of individual and firms yet those systems are greatly influenced by that work. Note: sources for this coverage are included with more detailed coverage in other chapters.

Aids to navigation were greatly influenced by the UK in other ways. The buoyage system of Mersey and a survey report of the Admiralty (1846) influenced buoy messages down to the present. What began as the Liverpool System became known as the Washington system. Buoyage and beaconage messages in the Western Hemisphere reflect that older system and in turn influenced IALA. A second UK document, the 1883 British buoyage system, was to have an impact well beyond the British Isles.

The decision to mark ships with red to port and green to starboard in about 1847 by the House of Commons and the Admiralty also affected buoyage systems by creating an opposing arrangement to the Liverpool system and that has continued to the present.

The 1889 International Marine Conference in Washington, D.C. promulgated the first international system. The system was somewhat limited in scope but it was an important early stage. And it "cemented" one of the basic trajectories: red to starboard.

The 20th century has been marked by numerous systems of bouyage. Among the earliest was that of St. Petersburg (1912). While only a limited number of nations attended that Conference it had widespread repercussions since it promoted the green to starboard idea. The League of Nations worked on buoyage systems in the 1930s. Their efforts reflected the green to starboard approach The most important of the systems, IALA, has created a system with two approaches: green to starboard for much of the Eastern Hemisphere, and red to starboard for the Western Hemisphere (and a part of east central Asia). This may represent the maximum degree of cooperation possible among maritime nations. The various systems and the documentation are found throughout T-M. and they provide a sense of direction for this study. Further information on the systems are found in this study and the T-M history (Part J).

Sources for fixed visual markings are different from numerous buoyage sources. Floating Aids are often represented in system publications. Fixed aids may be found in government sources often times but much less of a systems character. System sources are more likely to give more information on messages and meanings and less on physical apparatus. Though both kinds of information may be found to a degree in all forms of safety aid publications. The shape of the buoy may be included in sources but the primary focus is often on morphology (function) more than physical. Fixed markings constitute a message system in their physical state. Increasingly though systems include smaller lighted aids. And light phase information is often present. Sources for fixed aids often include a taxonomy of types of structures. And the classification foundations in this study are often based on that information.

Major sources for an outline of major lights came from diverse sources. The references for traditional lighthouses include older materials. A perhaps curious source is that of Douglass and Gedye who authored a lengthly account of lighthouses for EB 1911. Their writings remain important since they were both experienced in the subject and it was still a time when traditional lighthouses were a critical element in safety. An older edition of USCG's A/N manual (1964) provides information on the types of lighthouses when lighthouses were still in a somewhat healthy state.

Various publications of IALA also provided some information on both major fixed aids and more dimunutive forms. USNOO (this organisation has undergone numerous organizational and name changes) produces global aids to navigation lists and a survey of forms based on them provides considerable information. Other nations including Sweden, Norway and Canada contributed data on forms including minor aids. A reasonably coherent and comprehensive sketch of the forms of fixed aids resulted from these and other sources.

b) The Problem of Methodology for Fixed Visual Markings

This segment is a revision and contraction of Ch 16 in the previous edition as well as similar coverage in the original monograph (UPA 1981. It provides an admittedly atypical approach to explaining and building up a methodology.

This study of T-M is intended to be world-wide in scope and integrative in method and integrative in method. The monograph could have been global minus an integrative basis, but its value would have been substantially reduced if it was only a nation-by-nation survey of markings. The method employed in this study has often proved workable since marine markings have much in common even with national and regional differences. The integrative method of the work has not meant that divergent systems and markings have been forced into a rigid framework that suppresses uniqueness. This system has also proved to be sufficiently flexible and open that variations can be included without obscuring the international and integrative foundations.

The goals of the study have been realized for many of the topics in the study including the treatment of buoys, electronic, and acoustical signals which have portrayed the internationally shared character of T-M. But upon turning to fixed visual markings -- and especially unlighted markings -- it became apparent that these markings were apart from previously studied areas and did not fit an overarching approach to markings. Fixed visual markings undermined the writer's effort to precisely create a methodology and system of markings that could encompass all types of marine by a single and simple approach. If the proposed methodological approach were followed inflexibly those markings of limited numerical significance would be slighted.

The principal problem with a fixed visual markings -- in the context of this study -- stemmed from the fact that a small number of nation dominated various areas of such markings. This fact in itself does not affect the character of the study and the method of that research. A nation could dominate a component of markings without that marking losing its universality. For example, conical buoys are found in nearly every maritime nation. Even if one nation owned half of the world's conical buoys that would not, in itself, elimate the global nature of those buoys.

The difficulty arises with those aids to navigation which are distinctly local, or at best, regional. A comprehensive study can not ignore a significant number of markings even if these are found in only one nation. (and older IALA survey notes that Norway maintained 40% of all structural day-beacons of surveyed nations). The study would not be complete with such omissions. A method needs to be found for special markings within a study primarily focusses on widely-used markings of an international character.

No actual method grew out of these considerations. But the resulting methodology was at least subtly shaped by the special situation of aids dominated by a few nations. General guidelines for the methodology would include:

1. Taxonomy and descriptive treatments must be couched in more general and less preciseterms because of diverse aids including regional and local forms. UN 1968 (TCD) and ICAO (Aero) provide more precision because of international systems. But that is less true of marine. Admittedly even more standardized systems can have divergencies.

2. Overall, the study with its multi-faceted characteristics does achieve a global comprehensiveness with its -- hopefully -- coherent mingling of universal elements along with regional and local elements.

3. What may appear to be an undue emphasis on North America, Western Europe and Scandinavia is not generated so much by cultural factors as it is by the predominance of many specialized markings in those areas. The long-enduring nature of major sea lanes and merchant fleets has largely brought about the situation rather than some notion of superiority.

What are the nations and marking types that are numerically large? They include the US for minor lights (not a primary aid but perhaps more significant); Germany and Canada for non-structural day beacons (perches, poles, and small trees); Finland for edgemarks; Norway and the US for structural beacons (France, Canada, Finland, the Netherlands also have substantial quantities of beacons).

CHAPTER TWO

HISTORICAL SURVEY OF BUOYS & BUOYAGE SYSTEMS

2A Development of the Buoy & the Impact of Technology

2A1 The Impact of the Industrial Revolution on Buoys

A study of present-day buoys and buoyage systems can be enhanced by a historical review. More attention is given to buoyage history and the development of messages than to fixed aids in this study. Fixed aids -- especially that of traditional lighthouses -- receives considerable attention in numerous sources while floating aids has received much less. Hence the focus on floating aids. However, in this edition historical coverage was expanded for fixed aids. The brief history sketch in this chapter is augmented by longer coverage in *T-M History* (2002).

While buoys and lightships extend back in time for several centuries, the principal era of this history is that of the Industrial Revolution including the Victorian and Edwardian periods. The Industrial Revolution can be viewed in a somewhat precise and limited span of time that includes 1750-1825. Growth in mechanical means for manufacturing and economic changes in UK are hallmarks of that narrower definition (Hughes, IESS 1968, 7, 253). The term can be applied in a more general sense that includes large portions of the 18th, 19th, and some of the 20th centuries (Langer 1968, 603).

There is considerable agreement that the Industrial Revolution began in mid-to-late18th century. But the end of it is less agreed upon. For some it ends in about 1830, for others about 1870. It can be viewed as an unified period or as containing subdivisions or phases. (Bruun 1972, 138; Derry 1961, 275 ff; Hayes 1953, 514). If the Industrial Revolution ends as such in about 1870 what would industrial development be termed beyond that era? Possibly a second or new industrial revolution, a scientific revolution, or an age of technology (Gollwitzer 1966, 24; Bruun 1972, 138). What is the place of the development of the buoy in these various segments of time and events? The buoy is in its "pre-history" in the early years of the 19th c. that fall within a strict sense of the Industrial Revolution. 1820-1870 is significant for industry but not marine floating aids though change has begun. Major changes occur from 1870 to about 1900. A second industrial revolution or age of technology is more significant.

The years from 1870 to 1900 are distinguished by several characteristics: the time of amateur craft people producing technical advances has declined; the emphasis on coal and iron is past its prime; much the same can be said of a few basic industries dominating industrial production (Gollwitzer 1966, 243; NCMH 1962, XI, 94-5). After 1870 there is more focus on scientific and theoretical processes, more organization is employed, and older industries give birth to new and more diverse offerings. Change has spread beyond the sites of heavy industry (NCMH 1972, X, 3, 76ff).

Advances in late Victorian technology include electrotechnics, transportation, chemistry and biology . Electrotechnics include diverse offerings such as electric locomotives, studies in high and low voltage, the incandescent light globe and electric power plants. Transportation changes include not only expansion of railway trackage but new inventions including the internal combustion engine, the diesel engine, automobiles and improved steam-propelled ships . Chemistry provided new processes and technology including applications encompassing even lighthouses and buoys (Gollwitzer 1966, 26).

Much of the growth and advances in buoyage stems from changes in electrical and chemical industries and advances in metal technology processes and practices (Derry 1961, 475). Transportation changes in seaways and harbors and in modes of transport created the need for more buoys. Bruun, who views the later 19th c. as a "technological age," notes that the years from 1867 to 1881 produced "many new instruments of power and precision." (Bruun 1972, 139). This frame of reference can encompass the specialized world of the buoy.

2A2 The Buoy & Its Development in the 19th Century

The progression and expansion of the buoy during (and before) the Industrial Revolution(s) may be divided into three parts. The first period -- which may be termed the "pre-history" period -- began in perhaps the 15th or 16th century OED indicates that the buoy began in the 16th century (OED II, 1180). The first period ended in about 1820. The idea that 1820 is a juncture point is promoted by Alan Stevenson (*The World's Lighthouses Before 1820,* (1959). His comments are more directed to lighthouses than to buoys though they may be applied to buoys. Stevenson notes that 1820 marks the end of simple lighthouses employing primitive lenses and using crude and unprocessed fuels (Stevenson 1959, v ff). Earlier lights were built with the aid of sailing ships and primitive construction methods. After 1820 coal-fired construction and transportation systems began to be available and, more significantly, the means of production of message improves dramatically; (Stevenson 1959, v ff). Augustin Fresnel developed in 1823 a lens that was capable of throwing more light more efficiently and farther than any previous lens system. This lens continues in use (Dudley 1975, 21).

The period from about 1820 to 1870 sees increasing changes in buoys though the most notable changes are still in the future. The Industrial Revolution, during the mid-years of the century, offered new technologies and materials that effected a major change in buoy construction and design through the use of iron (Weiss 1926, 39). While buoys would be predominantly of wood construction for decades more, the increasing number of iron buoys allowed flexibility and versatility that led to the addition of audio and/or acoustical capabilities (Conway 1916, 28; that source notes that 28% of the buoys were of iron, 30-31).

It is not until about 1870 that the modern era of buoys can be said to have begun. Bruun notes that the 1870s are a "decade of unparelled expansion" and this can be applied to buoys as well (Bruun 1972, 39). Many of the advances in buoys are in the field of lighting. Gas-powered buoys with fixed or occulting lights began operation in 1878 (EB 1910, XIV, 808). The English introduced the incandescent oil-vapor light in 1893 (Putnam 1-13-13, 31). The US began experiments with a gas-lighted buoy in 1881 and finally added the new buoy to the "fleet" in 1884. Experiments with electrically lighted buoys were conducted between 1888 and 1903. These experiments ended in failure because the power cables to the buoys were affected by water and weather conditions (Conway 1916, 51). They also engaged in experiments centering on various forms of acetylene gas in the first decade of the 20th c. (Gibbs 1955, 99). Dalen', the Swedish Nobel Prize winner in physics, also worked to advance the use of acetylene gas during this time (AGA).

Dalen' also invented the first automated light control mechanism. This device, known as a "sun valve," activated the light when the sun set and deactivated it when the sun rose (Scott 1977, 453). It was this invention that won him the Nobel Prize in 1906. Despite various forms of photo-electric cells, the "sun valve" is still a useful device for operating lights and also for saving fuel (ESNA 1965, 34).

The iron that permitted lighted buoys also permitted the introduction of sound buoys and mechanisms. The US introduced the whistle buoy in 1876; gong buoys were introduced in the second half of the 19th c. Sea-activated bell buoys followed in 1885 (Weiss 1926, 40).

Other inventions and advances, though not originally designed for buoys, found applications -- or at the least influenced -- for buoy systems. For example, the French extended the range of possible light phase characteristics in 1892 by the introduction of quick-flashing lights (Putnam NGM, 1-13-13). England contributed an "automatic occulter" in 1883 (Douglass & Gedye 1910, XVI, 446). Supporting systems, including Kitson's incandescent oil-burner, also improved the quality and range of buoy and other lights (Douglass & Gedye1910, XVI, 654). Not only were inventions occurring during this time but manufacturing processes meant that more lighthouses and buoyage equipment were being manufactured more efficiently as well as more cheaply (Hayes 1953, 92).

In summary, by the turn of the 20th c. the basic types of buoys were established. This was also true of the major forms of sound signals. A variety of light-phase character--istics were already in use though fixed lights would continue to dominate for some time to come. What was available in buoys during the late 19th c. materially shaped the form of British and IMC systems of the 1880s. It also influenced the

1912 St. Petersburg and the 1930 League of Nations buoyage systems. This in turn made a discernible impact on the IALA system of the 1970s and 1980s. Components of buoyage systems, and in many respects the buoys themselves, are to a considerable degree the same today. Lights are more often electric, sound signals are increasingly electric, some "monster buoys" have been added, buoys are welded rather than riveted. But the shapes, colors, numbers, and their patterns and arrangements can be substantially traced to the late Victorian period. That same era can be said to be the sum total of changes in transportation, manufacturing, illumination and acoustics throughout the 19th century.

2B The Development of International Buoyage Systems

2B1 International Buoyage Systems, 1846-1936

Buoyage systems that have transcended national boundaries need to be considered as well as developments in the types of buoys and equipment for buoys. There were four buoyage systems before IALA: The British "Union System of Buoyage" (1883), the International Marine Conference buoyage system (1889), the League of Nations "Uniform System of Buoyage" (1930/1936), and the International Maritime Conference at St. Petersburg (1912).

One might also include a government report of UK of 1846 that described buoyage practices in that nation (Putnam LN 1930, 60). Those practices, especially that of red to starboard for buoyage, influenced US practice and greatly helped to establish red in the starboard position. The first named system (UK 1883) may appear to be that of a single nation. However, this system encompassed three independent aids to navigation agencies as well as several smaller lighthouse and buoyage authorities in the British Isles . These included Trinity House, Irish Lights, Northern Lighthouses; smaller agencies including Mersey Docks & Harbour Board; Clyde River Trustees, and the Admiralty. Even smaller agencies included the River Tyne, River Tay, the Thames, and the Hull. In addition, British dependencies employed this system to a substantial degree for many years.

The British system of 1883 focusses on several principles. The most important principle is the shape of the buoy (UK USB, Points 3-7). This contrasts with IMC which placed significance on color, letters and numbers (USB Points 9-11). Basic forms of buoys included can (port-hand), conical (starboard), and spherical ("end of the middle grounds,") (USB Points 3-7). Other types of buoys included pillar, spar, and sound buoys (USB Points 3-7). While color had importance, specific colors for certain functions were not included in the nomenclature.

The British system is significant not only because it covered many of the principal ports and shipping lanes. It also influenced the IMC system. Obviously it is unlikely that the buoyage system of the principal maritime nation of the 1880s could have failed to influence international navigation of that period.

The International Marine Conference (IMC, 1889) has an unique place in buoyage and beaconage systems since it represents the first truly international attempt at uniformity. The system continued to exercise an important role in the buoyage systems of many nations until the 1980s and even to the present. This has been especially true in the Western Hemisphere. IMC was organized under the auspices of the US State Department. While the US played a major role, other nations were also involved in bringing about the meeting. Some 28 nations were represented at the Conference

(UK Protocol, Vol. I, v-vi). That number, though small by a late 20th century perspective, represented a large majority of independent states in the late 19th century (Palmer 1965, 557-559).

It may be an overstatement to say that the IMC deliberations constituted a system since the provisions of the conference on buoys were limited. This brevity may have been necessary since, as the first international effort toward buoyage uniformity, it would not have been feasible to create a full-scale global system. The term system can have many definitions. Nöth offers a frequently employed definition from Hall and Fagan 1956: "A system is a set of objects together with relationships between the object and between their attributes." (Nöth 1990, 198). Greater uniformity was theoretically possible except for the fact that any change meant great expense and a more elaborate -- even if a superior system -- would not have met with approval by many governments.

Color and numbers/letters were given preference over buoy shape in IMC (IMC Protocols, III, 331-332). Paint and stencils caused fewer problems and less expense than redesigning entire fleets of buoys. The issue of shape surfaced and heatedly during the conference. The US system then in use employed shape. The British and German delegates (especially the latter) maintained that shape was not a basic and integral dimension of the US system. The US statutes on buoys appeared to support the European contention (Protocols, II, 1326-28). The IMC proposal was adopted so as to include shape but stated that the signatories would not be obliged to include shape in their respective systems (IMC Protocols, II, 1389).

The discussion of development in buoyage focussed on lateral buoyage. There were fewer problems with cardinal systems. The cardinal system found in IMC was established previous to the conference. Several northern European nations had worked out the cardinal system and IMC largely took over what already existed. A similar system is found in the USB (Protocols, II, 1321).

The 1912 conference in St. Petersburg overturned the meaning of color of IMC. The problem engendered by that move is considered in the final segment of this chapter (CIM Actes; see also Bury 1978).

2B2 Red/Green to Port-----Red/Green to Starboard: A Special Problem in International Buoyage

An ongoing problem in buoyage and beaconage systems has been the question of which side are the red buoys on, and which side are the green buoys on? While that may over-simplify the problem it sums up the core issue. The IMC system did not provide a long-lasting solution to the future crisis. In time the foundations that IMC had laid down would become an element in the divergent approaches to buoyage messages. Divergent practices continue to this day and very likely is permanent. An entirely logical pattern of buoyage has not existed either in the inception of systems in the 19th c., or in the development of systems in the 20th c. After nearly a century of illogical and contradictory practices it would not be easy to overcome the problems. IALA may have come as far as possible in bridging the gap.

It is not altogether clear how the problem of red and green and their use came about. Nonetheless, enough of the salient features are known to permit a review of the problem. An early development in the green/red imbroglio is a government report of the UK noting the placement of red buoys on the starboard side of channels in 1846, and the commencement of red to port, and green to starboard for ship lighting in 1847. It is curious that the government report noting the red to starboard buoy practice, and the beginning of ship lighting, occurred almost simultaneously. A related development was the practice of harbor lights in the later 19th c. in Europe. This utilized red to port and is possibly based on shipboard lighting practice (Putnam LN 1930, 60; O'Dea 1958, 86).

It is true that IMC in 1889 did not face a great number of lighted aids to navigation. There were few lights, other than the major landfall lights, of a complex and sophisticated nature. During the late 19th c. there were some lighted buoys in operation. These were either in an experimental state or little removed from it. And it is unlikely that heavy usage of various colors of lights were in use. IMC, following UK 1846 and other usages, adopted red for starboard, not green for starboard. Black continued as a primary marking color until the implementation of IALA.

No international standards for lights had been established by the time of the preliminary work of the League of Nations's Technical Committee for Buoyage and the Lighting of Coasts during the 1920s. But the practice of the US and other nations was to place red lights with red to starboard (Putnam, "Statement", 4, 8). But not in Europe. Europe followed the strange practice of red buoys to starboard (as in IMC) but red lights to port. This practice apparently came from the practice of harbor lights in Europe which, in turn, was presumably based on ship lighting practices (green to starboard, red to port (Putnam, "Statement," 9).

The 1912 conference seems odd in the retelling. The conference did not send out invitations to all maritime nations (including the UK, and Canada) and the invitation received by the US was presented not long before the convening of the conference (Putnam, G.R. 10, APC). St. Petersburg 1912 was short in duration and was supposedly only a preliminary meeting. In fact only three nations adopted the conclusions of the conference: to correct the problem of red buoys on one side and red lights on the other. But that problem was only in Europe (and possibly colonies of those nations).

France became very much concerned during the 1920s over the problem and the resulting confusion of the non-existence of uniformity. France requested action from the LN. (Garrett, International ... 3). The Technical Committee began work on a new system in 1925, a system that was an attempt to overturn IMC and to adopt the conclusions of St. Petersburg. Putnam notes what can be termed the myopic vision of Europe: they represented a minority yet they promoted their regional needs over the majority; perhaps they saw themselves as the majority (Putnam G.R., 6-7). Positive support for the Technical Committee came from European nations. The same nations were represented on that committee, and the same nations were represented at the 1912 conference. Perhaps Bury's "political intrigue" (discussed later in this segment) has reference to this situation (Bury 1978, 136).

Work on the Technical Committee led to the League of Nations conference at Lisbon in 1930, and Geneva in 1936. Those efforts expanded and extended the 1912 effort (Putnam, G.R., 1). The League of Nations report and system, while followed to varying degrees, never gained official status. Bury's comment that the 1889 conference "fell afoul of political intrigue and two world wars" may have reference to the League of Nations system which was the final outcome of what had begun in St. Petersburg (Bury 1978, 136). The upheaval of war ended any official system, and IALA's work did not come about until more than four decades later. War was also to block completion of a system of markings in a different sphere: that of traffic control devices (see Vol. IIE for discussion of the problems reaching accord in that area). A conservative dynamic seems to be at work in T-M (and possibly other systems of symbols as well): people, nations, and cultural groupings can become wedded to a specific approach to (e.g., buoyage messages) meanings and it becomes of little consequence if those symbols are illogical, arbitrary or accidental in execution.

The buoyage situation, prior to IALA, presented this pattern of messages: all European nations (including Russia) followed the red to port rule. Seemingly all Western Hemisphere nations obeyed red to starboard. A variety of African and Asian nations conformed to the European practice. Yet other nations, including some in the Northwest Pacific, employ the red to starboard pattern of the Western Hemisphere. As a result of these long-standing policies, IALA was not able to establish a single color-code for the world. Originally IALA contemplated two systems of buoyage, but a further movement toward consensus altered this to one system with two regional variants (Bury 1978, 137-143 & IALA BCR 1980).

2B3 IALA Buoyage Systems

The various buoyage efforts before IALA -- each in its turn -- further splintered efforts toward uniformity and simultaneously compounded the confusion. The Uniform System of Buoyage, despite its official appearing character, was "never ratified and officially introduced." (Bury 1978, 136; IALA 1975 Supplement #6; DMA 1977 Pilot Chart). It was the victim not only of politics and war but of its inherent problems and less than world-wide application.

This mingling of multiple conferences, politics and strife suggest the massive difficulties in working toward a universal system. Perhaps the most significant component of the problem was the abandoning of the "red to starboard" of IMC and its replacement, at least in Europe and selected other nations, by the diametrically opposed green to starboard of the St. Petersburg and later League of Nations approaches (Bury 1978, 136; IMC Conference Papers; LN 1930, 36; DMA Pilot Chart 1977).

Any solution to the problem of disunity would presumably have to come through the one organization that has universal status: the International Association of Lighthouse Authorities/Association Internationale de Signalization Maritime (IALA/AISM) founded in Paris (1957). IALA had signficance because of the many maritime nations belonging to it. It began with a limited objective, broadened its goal and finally established a new system which combined what was usable from the past with new thinking and research (Bury 1978, 135-136).

The first stage of IALA's effort consisted of examing and improving upon existing harbor lighting (Bury 1978, 136) But this proved to be too narrow a study, and a new study group was formed and mandated to supplement and update the Lisbon and Geneva system. The broader study was required because of new aids to navigation, systems and problems.

The second stage was successful in introducing new rules for "ocean data acquisition systems" (ODAS) and for setting up a system (in Europe) for dividing recreational waters into boating and bathing zones by the use of buoys (Bury 1978, 136). But then a series of major shipping disasters involving supertankers occurred and IALA was asked by the Inter-Maritime Consultative Organization (IMCO) to take up a much-needed project of unifying the various buoyage systems with special attention to marking wrecks (Bury 1978, 136). The membership of the committee that took up this more basic challenge overlapped with that of the earlier group. Stumbling blocks to unification of existing systems soon arose. The US refused to change from the red to starboard pattern of 1889, and both the US and Canada noted that North America was already unified to the point of a lateral systems without a cardinal system. Both employed systems lacking the complexities of the League of Nations approach (Bury 1978, 137).

But, in turn, abandonment of the cardinal system, which is largely European in usage, met opposition by many European nations (Bury 1978, 137: note for paragraph save last reference). The previously mentioned committee established a cardinal system for wreck marking but this limited system "would be overtaken by further work on overall problems" and was never employed. A basic working plan was assembled in 1971 that called for placing green to starboard and red to port in various combinations. But this proposal proved unworkable since it would be unrealistic to expect the US and Canada to reverse their already simple system. And it was thought equally unrealistic for the Europeans to adopt the North American pattern. It should be noted that various nations neither European nor North American follow either the green to port or green to starboard as well (IALA Supl. #6 1975, 1).

The realization of the incompatibility of the two regions led to the significant, and at that time necessary, decision to split the world into two regions. This decision excluded the special danger buoy, which was to be universal in scope (IALA 1975, #6). It is not known how the IALA group saw the problem of areas such as Asia where both red to port and red to starboard systems were in use. It may have been presumed that individual nations would choose the system most akin to the current practice of the nation (IALA 1975, Supl. #6).

At some point after adoption of the two-zone resolution the committee came to the conclusion of not using the North American approach, a simpler Geneva system, or a lateral system based on zones (Bury 1978, 137-138). By 1973 the IALA group had not reached a solution (Bury 1978, 138). It was at that juncture that a new director of the buoyage group was selected and "new terms of reference for the project were established" (Bury 1978, 138). J.E. Bury, the new director, came to the conclusion that a more fundamental change was needed. Namely, that establishing a new system "upon the wreckage of Washington and Geneva was not feasible (Bury 1978, 138). The beginnings of progress date from that fundamental decision. In the next three to four years what was known, until 1980, as "System A" was established. (Bury 1978, 138). System A was approved by members of IALA at the IX Conference in Ottawa in 1975 (Garrett, International...).

A key difference between Geneva and System A was the combining of lateral and cardinal systems thereby extending the use of the cardinal approach. (IALA Supple. #6, 1-2; Bury 1978, 138). Green became an exclusively lateral color thereby ending its long-established function of wreck marking (Bury 1978, 139). No mention of ogival or spindle buoys was made in System A. Those buoys apparently have been eliminated from usage. System A includes various standards for buoyage sizes and light phase characteristics. A variety of other issues were also resolved. (Bury 1978, 138ff). Finally, in March of 1977, Northwest Europe lighthouse authorities signed the agreement implementing the use of System A. System B was to follow later (Bury 1978, 143).

In 1975 IALA members agreed to harmonize what was to become Systems A and B while simultaneously admitting that the contradictory notions of the meaning of red and green could not be bridged (Garrett International, 1, 5, 6). System A would include both cardinal and lateral approach with red to port. System B would be exclusively lateral with red to starboard. "A" would be found substantially in the Eastern Hemisphere and "B" would be largely in the Western Hemisphere.

The nations that were following red to starboard then began to construct rules for an eventual System B. These rules would meet their specific needs "which would be compatible to the extent possible, with System A rules." (Garrett, International, 1, 5, 6). System A nations, through USB, had more points of commonality than potential System B members. And, in fact, red to starboard was often times the only point the B nations had in common. Captain L.W. Garrett, USCG notes that on remaining issues "the diversity was rich, indeed." (Garrett, International, 5). The meetings of B committee went on for four years, and the result was a series of rules very close to those of System A except for the position of red and green. Inclusion of a cardinal system at one point permitted similar rules.

Originally a single system may have seemed impossible but the end result was nearly a single system though with variant forms on one key issue: the use of red and green. This became evident by the end of the committee's work on

System B. In Toyko (Nov. 1980) the single system was approved; instead of System A and System B it became one system with Region A and Region B (Garrett letter, 12-17, 1980). A key point in bringing together the two systems together was the matter of cardinal markings. Captain Garrett notes that without the common cardinal system the possibility of divergence rather than convergence would have been quite strong (Garrett International, 8). However, the use of cardinal markings remains optional for IALA members.

Other points in the merged systems that affect Western Hemisphere nations center on topmarks and color patterns. (Garrett International, 6-8). Topmarks are strongly recommended though optional. The US -- until IALA -- never employed topmarks though any use of cardinal markings would require such supplemental marks (Garrett International, 6-7). The US has employed black and white colors for mid-channel marks (termed safe water marks by IALA). However, it has been found that the black and white pattern appears gray in certain lights. That problem has been resolved by a new scheme of red and white. The US, as well as many other nations, employed black buoys for port but these are being phased out in favor of green. Green has been found to be at least equal to black in visual appearance (Garrett, International, 7). This change is the most vivid of any change brought about by IALA. The US has employed green for daymarks and these have performed satisfactorily. Black and red horizontally banded buoys for junctions and other purposes have been replaced by buoys with a red and green pattern (Garrett International, 7).

Regional variations do not pertain to cardinal marks, isolated dangers markings, safe water marks, special marks or new danger markings (Proposed ... adden. Garrett). The differences come in the lateral system: the use of green and red. Differences in buoy types, light phase characteristics and other matters are limited in scope (Proposed IALA Buoyage System addendum to Garrett). Region A and Region B -- where differences -- are virtually mirror images of each other.

The two regions generally follow the respective hemispheres. However, geography only infrequently follows precise limits, and some artificial adjustments are necessary to fully define the limits of the regions. The international dateline is the primary boundary in the Northern Hemisphere. But at 10 degrees north latitude the regional boundary travels east until reaching 120 degrees west longitude. The boundary then moves south along that line. This division of the Pacific places most of the islands within Region A while Hawaii and islands in the far Eastern Pacific are in Region B. A significant exception is the placement of Japan, South Korea and the Philippines with Region B (IALA BCR 1980, An. 3, Sec 2). Those nations have historically followed red to starboard. The remaining boundary, that between Africa and South America, moves north along 20 degrees west longitude. It then jogs west to 35 degrees west longitude and follows that line until reaching 55 degrees north latitude. The remaining boundary then proceeds in a northwesterly direction between Canada and Greenland (IALA BCR 1980, An. 3, Sec 2).

CHAPTER THREE

CLASSIFICATION & DESCRIPTION OF BUOYS IN INTERNATIONAL USAGE

3A Classification

3A1 Introduction

This chapter has two themes: the classification of buoys in international usage, and description of buoy types based on the classification. The classification includes a main form and a variant form; earlier editions lacked the second form. Changes in names and types of buoys have occurred as well as changes in numeration. Illustrations of basic types of buoy are included accompanied by classification names and numbers.

The description of buoy types is divided into the types of buoys and the types each have two components: the derivation of the name of buoy (at least in its English-language form), and an examination of the function of the specific form of the buoy. The classification and illustrations of the chapter are integral to the descriptions.

The earlier edition provided separate chapters for classifications and for descriptions. The two themes are interconnected and in this edition they occupy a single chapter. The former edition employed end-notes.

3A2 The Classification

12 Lighted Buoys
  120 Standard Single Types

1200 Can
1201 Spherical
1202 Conical
1203 Pillar
13 Unlighted Buoys
130 Standard Single Forms
1300 Ogival
1301 Spindle
1302 Spherical
1303 Pillar
131 Forms with Variant Versions
1310 Conical
1311 Can/Cylindrical
1312 Spar
14 Sound Buoys
140 Single Types
1400 Bell
1401 Whistle
1402 Gong
16 Multi-Message Floating Aids
160 Large Floating Aids Single Types
1600 Light Vessel
1601 Large Navigational Buoy/LANBY Buoy
161 Lighted Sound Buoys
1610 Lighted Bell Buoy
1611 Lighted Whistle Buoy
1612 Lighted Gong Buoy

Variant Forms:

12 Lighted Buoys; 13 Unlighted Buoys; 14 Sound Buoys; 16 Combination Buoys

.1 Floating Aids
.10 Lighted Buoys-National Models

- .100 Canada
- .101 US
- .102 Greece A/Thailand A
- .103 Russia
- .104 Thailand B
- .105 Greece B
- .106 Norway
- .107 Germany (Beacon Buoy, Lateral & Cardinal Forms)
- .108 All-lighted High Intensity Forms

.11 Unlighted Buoys: Conical

- .110 US (Nun Form)
- .111 Denmark A
- .112 Denmark B
- .113 Italy
- .114 Poland & France
- .115 Canada

.12 Unlighted Buoys: Can/Cylindrical

- .120 US
- .121 Denmark
- .122 Germany
- .123 Taiwan
- .124 Sweden, Russia
- .125 Canada

.13 Unlighted Buoys: Spars

- .130 Modified Standard, US
- .131 Modified Standard, Norway
- .132 Modified Standard, Canada
- .133 Special, Spar on Can Base, Iceland, et al.
- .134 Special, Spar on Modified Can Base, The Netherlands, Poland
- .135 Special, Spar on Conical Base-A & B, Iceland, Germany

.14 Miscellaneous Unlighted Buoys

.140 Beacon Buoy, Germany
(Lateral & Cardinal Forms)
.141 Barrel Buoys, Sweden, Russia
.142 Oil Drum Buoys, US
.143 Casks
.15 Sound Buoys
.150 Bell Buoy, US
.151 Whistle Buoy, US
.152 Gong Buoy, US
.153 Carrillon, France
.154 Bell Buoy, France
.155 Siren
.16 Combination Buoys: Lighted Sound
.160 Lighted Bell Buoy, Canada
.161 Lighted Whistle Buoy, Canada
.162 Lighted Bell Buoy, US
.163 Lighted Whistle Buoy, US
.164 Lighted Gong Buoy, US
.165 Lighted Horn Buoy, US
.166 Lighted Bell Buoy--Can, USB
.167 Lighted Bell Buoy--Conical, USB
.168 Lighted Bell Buoy--Spherical, USB
.17 Electronic Buoys
.170 Radar Beacon Buoy
.171 Radio Beacon Buoy
.18 Multi-Message Floating Aids
.180 Lightfloats
.181 Lighted Catamarans

3A3 Notes on Classification

This classification does not achieve as much precision as is found in the US classification (Part B, 1992). That classification focussed on a single nation thereby allowing for more detail within a smaller body of information. The

Special illustrations are included when provided (e.g. IHB MBS1971) edition includes a Norwegian light buoy that is distinct from those of other nations with a separate light buoy). Admittedly the shape of a buoy is only one dimension of a marine aid to navigation. The size of a buoy is a possible dimension though a less important one. The colors and other message systems are at least as important as the shape and may be more so. It is the hope of this compiler that a precise T-M classification may eventually be possible; however this simpler version is a necessary prologue to that possibility.

Detailed notes on the individual buoy types are found in Chapter 3B. The following explanatory notes provide general information on the buoy type divisions that can assist the reader in using the classification chart.

Lighted buoys are divided into two sections: 120, Standard Single types, and .100, variant forms. The first segment includes buoys that are found in official international agreements and have both lighted and unlighted counterparts. The variant segment includes buoys that are found in a variety of nations, have a shape peculiar to that buoy, or lack unlighted counterparts. At least one nation, the US, makes use of lighted buoys, but without the light apparatus, for sound buoys (USCG 1964, Amd #2). Some of the second group may be used for combination light and sound buoys. For example, Canada has entries under .160 and .161 in .16 category (Lighted bell and lighted whistle buoys).

Unlighted buoys, 13, come in a great many sizes and shapes. They can be divided into two standard single forms (130) and forms with variant versions (131). The older classification had several three-digit sections for those with variations as well as one standard single group. Many unlighted buoys are of variant forms. These are divided into four segments: Unlighted buoys-Conical (.11), Can/Conical (.12), Spars (.13), Miscellaneous forms (.14). Many of these forms are national forms.

Conical buoys cover a range of shapes including the USB conical buoy which is a cone above the water line (1310). Other versions include cones of steeper or shallower slope, and conical-shaped buoys ranging from slightly to severely truncated variations (Variants, .11; IHB MBS 1971, 7, 10). The notably truncated cone of Germany is included with can buoys (.122) since it more closely resembles a can buoy than a conical buoy (IHB MBS 1971). It is not clear if there is an actual difference between USB and IALA conical buoys. However, visual appearances suggest a difference and are listed separately.

USB has labelled buoys for lateral services as can and the same buoy for cardinal use as cylindrical (1310). This dual appellation is retained. Earlier comments about uncertainty of differences and their significance apply to these buoys as well. There are less variations in the shape of can buoys then of conical though some differences are present. Some cans have a sloping appearance, and others are varying sizes.

Spar buoys in this classification encompass a range of buoys that lack a more suitable general term. Any buoy with a narrow, elongated appearance is regarded as a spar in this study (e.g., Netherlands, Poland; IHB MBS 1971). These will include basic spar buoys as well as spars with an extension above the water that are of a variant form. Further complexities in classifying these buoys occur in national systems where the term spar is not used for spar or near-spar larger classification faces differences in national approaches to marine safety, design and manufacture as well as the sheer number of systems. As a result details need to be limited in the main classification. The earlier classification lacked a variant classification. The addition of that form allows for a leaner main form well allowing for greater variations in the second form.

What are the criteria for including buoys in the classification? All buoys listed in IHB SMBB 1956 and MB 1971 and in IALA (IALA 1980; IDAMN 1970) will be regarded as standard if they visually and descriptively conform to the Uniform System of Buoyage (1936), the US System (Bowditch 1966) (term employed for red to starboard navigation); antecedents are Liverpool 1846 (Putnam LN 1930, 60 and IMC 1889), or the IALA System (1980). IHB 1926 and 2004 may also have some bearing on buoys as well. Differences will be classified as either modifications or variants.

Buoys which are slightly larger or smaller, or vary slightly in shape from the standard models, will be classified under the appropriate standard or variant heading. This should result in a workable classification that neither glosses over significant differences or overemphasizes miniscule distinctions. It appears that IHB uses a stylized form of illustrations for its publications. If a national marine agency does not provide illustrations contrary to the stylized form then stylized forms are used. For example, IHB (SMBB 1956) shows the can buoy for the US as identical to can buoys of European countries even though there are visual differences. IHB may have determined that if the basic form is present -- and that the failure to given nuanced differences will not present problems -- then the basic pictorial form is sufficient for safe navigation.

buoys.

Miscellaneous buoys include several buoys that do not fit other classification categories. These include the German beacon-buoy or bake (.140). This is a general purpose for Germany (IHB MBS 1971, 13-17; IDAMN, 2-6-220, Fig. #60). Barrels (.141), oil-drums (.142), and casks (.143) are not infrequently employed by marine safety agencies as buoys though they are not always regarded as "official." The barrel buoy pictured in IHB publications appears to be a stylized illustration (MBS 1971, 20; e.g., Sweden). In the past the US has augmented its buoyage with oil drums which are the equivalent of barrel and cask buoys (USCG 1964, Ch. 2).

Standard unlighted single types (ogival, spindle, spherical and pillar, 1440-1443) along with the spar buoy are the only buoys to have official status. IALA has added the spar and the ogival forms (IALA 1975 Supl. #6). Because of the presence of those buoys in USB they are retained here even if a gradual phasing out was undertaken.

Sound buoys (14/.15) are not listed or illustrated in IHB works. But they are included in IALA and USB publications. IDAMN has representations of sound-only buoys while USB refers only to sound-light combination buoys (161/.16). IDAMN 1970 rather than IALA buoyage documents includes sound buoys (IDAMN 1970, Fig. 56 and Fig 57). Formerly, the US used special sound buoys while light buoys minus the light apparatus are currently employed. As a result there is an overlap with some buoys though they remain distinct types. The LANBY(UK) and Large Navigational Buoys (1601) are similar buoys and are classified together. Other buoys of similar proportions and equipment can also fit this classification. DMA refers to "Superbuoys" (Older name for agency now known as US NGIA 2004, xvi). Sweden includes a "Superboj" (Sweden 1985, 24).

Combination buoys for this classification are large light and sound buoys. Many buoys contain radar reflectors but since this is a nearly ubiquitous feature it does not warrant referring to nearly all of the buoys in some system as being combination by nature. The large navigational buoys are light-sound-electronic combination buoys. A final element is that of Multi-message Floating Aids (.18). These include Light Floats (.180), and Lighted Catamarans (.181).

3B Description of Buoy Types

The description of buoy types will be based on the classification. Each of the sections of this chapter includes two components: The derivation of the name of the buoy at least in its English-language form, and an examination of the function of the type of buoy. The classification and illustrations of this chapter are integral to the descriptions.

3B1 Lighted & Lighted-Sound Buoys

There is no buoy of an exclusively lighted nature in IALA or in USB. However, the US, Canada, Norway and several other nations have such a buoy. Lighted buoys for USB, and presumably for IALA as well, share the same shapes as the unlighted buoys. The buoys for lighted purposes are modified to carry out that function while having the same basic physical appearance. For nations with a separate light buoy the buoy includes a tank base with a tower-like superstructure; such buoys may be further equipped with radar reflector (USCG 1977, 4). The US light buoy has undergone several design changes. The "wasp-waist" look of another era has given way to straight-line shape in the current era (See older editions of USCG LL for illustrations).

The Canadian light buoy is not shown in the 1971 edition of IHB. However, there is a distinct light buoy for that system which is of a squared-off design and a slightly sloping appearance (CANS 1975 centerfold sheet). Norway makes extensive usage of light buoys in both lateral and cardinal systems; that light buoy is retained in post-IALA publications. It is mounted on a tank that is apparently smaller than US and Canadian counterparts . The superstructure angles in steeply from its base and a second structure is mounted athwart the top of the underlying structure and, in effect, surrounds the light apparatus (MBS 1971, 57-59).

IHB provides what appears to be a stylised light buoy for Greece and Thailand. This buoy has the typical shape of a tank surmounted by sloping structure (MBS 1971, 39, 72, 74). Thailand has a second light buoy but with a smaller tank. The light buoy, termed a Pillar buoy, is a simple vertical cylinder topped by a light (MBS 1971, 72). Germany's Bake buoy also comes in lighted forms and has two variant froms: cardinal and lateral usage (MBS 1971, 36-37).

Non-standard buoys still exist in IALA-sanctioned systems by shapes. Even if the shape is non-standard the color and other messages systems will have been altered to fit IALA rules.

Combination buoys include those with light and sound mechanisms. Radar reflectors are very common -- as well as serving as a peripheral electronic aid -- and are not included as a component of the combination buoy. Combination buoys include same range of sound devices that sound-only buoys contain. Detailed coverage in international publications is not available so that only an approximation of the types of lighted sound buoys is possible. Bell and whistle are common forms with or without a light. In all likelihood electronic horns are more common. Seemingly only the US makes use of the gong buoy. And apparently only France employs a carillon buoy.

3B2 Unlighted Buoys: Conical and Can/Cylindrical Buoys

Conical-shaped buoys (141) include a diversity of standard and variant forms. In the classification there are two "standard" conical buoys. One is the USB conical buoy, the second is that of IALA. The nun buoy of the US, seemingly influenced by IMC, may arguably be a third "standard." The basic term of cone may refer to either a perfect geometric cone or "anything shaped more or less like a mathematical cone." (WNID 1934, 563). A conical structure may include either of the forms and can be found in buoyage systems. Cone refers to the above-water part of the buoy. Many buoys out of water will present a double cone or possibly other shape. Conical buoys, and other buoys as well, are analogous to icebergs since much of the mass is under water.

The stylised IHB conical buoy exhibits a perfect cone shape while the IALA presents a cone with a more pronounced curvature (IALA BCR 1980). The IDAMN defines a conical buoy (and this includes the nun buoy) as "a buoy of which the upper part of the body (above the water line), or the larger part of the superstructure, has approximately the shape of a cone with vertex upwards." (IDAMN 1970, 2-6-230). This definition allows for a measure of latitude in buoy shape.

Conical buoys, and can buoys as well, are more frequently employed in USB lateral and cardinal systems than any other forms of buoys. They are also the most common in IALA lateral usage but not in cardinal (SMB 1956, 7-11; IALA BCR, Annex 3). Conical buoys are used as wreck buoys in USB but not for isolated dangers in IALA or any usage except lateral purposes. USB also employed conical and can for lateral positions of sides of channels (SMB 1956, 7-11; MBS 1971, 2). Some nations, which otherwise follow

IMC, have opted for the conical buoy rather than the nun buoy; Canada is an example of this practice though the buoy in question seemingly rides closer to the waterline than other conical buoys (MBS 1971, 16).

The origin of the term "nun" (as in nun buoy) stems from the term "nun-gigge" which can be defined as having small ends with a larger middle (OED III, 262) A contemporary definition describes a nun buoy as a "red metal buoy made up of two cones joined at the base." (WTNID II, 1551). The buoy in modern usage is conical in shape rather than a perfect cone shape. The definition from IDAMN of conical buoys encompasses the nun buoy as well (IDAMN 2-6-230). Modern nun buoys are actually can-shaped with a nun-shaped radar reflector added on. (MBS, 136; USCG AN, 4; see also WTNID reference).

Denmark, in IHB, had two forms of conical buoys both of which were at variance with the basic IHB model. One form appears to be an ogival buoy except for a slightly less pronounced curvature; Denmark classifies this buoy as a conical buoy. The second form is of a straight-line design but steeply elongated in shape (MBS, 31).

The Italian buoyage system includes a variant conical buoy in addition to the standard form. The former displays a cone atop a cylindrical base. The appearance is of a cone attached to a shallow cylinder above the water line. In contrast to many other systems, the Italian uses both of the conical buoys on both sides of the channel (MBS, 31). Other message factors are at work which vary the purpose and message of the buoy.

A final variant form is found in France. This buoy is a standard conical buoy that is moderately truncated but slopes to such a degree that the buoy may be regarded as a sloping cylinder or can buoy (MBS, 31). The buoy was used only in limited situations. Poland at one time made use of an identical buoy but it was apparently discontinued (MBS, 117).

Can and Cylindrical buoy terms seem to be self-explanatory and not requiring explication. However, examination of the terms suggests less clarity. OED, normally an accurate source for word origins, seemingly adds to the confusion by describing a can buoy as a "large cone-shaped buoy." (OED, X, 57-58). This seems to be more of a definition of a conical or nun buoy. The "cone-shaped" may be greatly truncated but the definition has limited value. OED defines a "cylindrical" as having the "form of a cylinder," and that is certainly the case (OED, X, 57-58). A cylinder can be a geometric shape or an object with that shape. More precisely, a can buoy can be described as N"truncated with a flat top" or as "truncated or flat." (WTID, 325).

IDAMN defines can and cylinder as those buoys "of which the upper part of the (above the waterline), or the larger part of the superstructure, has the shape of a cylinder or nearly so." (IDAMN 2-6-225). That definition seems to be more adequate than the previous one. In USB the term can buoy refers to lateral, and cylindrical to cardinal. Seemingly they are physically the same but different names for separate functions. IALA and various national systems make reference exclusively to can buoy (SMBB 7-10; 13, 15).

Can buoys, along with nun/conical buoys, are the most common buoys in USB and IMC systems; the "mix" of major buoy types is somewhat different in IALA. A number of nations with simple message systems opted exclusively for can and conical buoys in the older systems (e.g. Mexico, Argentina). The US can is a taller version than that of IALA and USB; at least when judging by stylized illustrations though it is possible that the ratio of width to height is greater in non-US forms. The US can is equipped with the ubiquitous radar reflector (MBS; cp US with European nations, 68, 79).

In the first edition of IHB Denmark maintained a can buoy similar to the stylized type except for an appearance that is both narrower and taller. The new edition of IHB does not list any type of can buoy for Denmark. Presumably, IALA norms may cause the addition of a can buoy to that system (SMB, 41).

The German system has, in addition to standard can buoys, a conical buoy that is severely truncated and bears a greater resemblance to a can buoy than to a conical buoy. IALA notes in a footnote to its definition of can/cylindrical buoys that the "German term 'Stumpftone' also includes buoys of truncated cone shape," which supports the view that the truncated conical buoy is by appearance a can rather than a conical buoy. (IDAMN 2-6-225).

Taiwan has a single type of buoy for its entire system. This buoy is a moderately truncated buoy which suggests a conical buoy though of a very muted cone shape. Its shape is sufficiently can-like to be considered more as belonging to that category. (MBS, 19). The can buoy of Canada appears to be somewhat smaller in visual representation, and somewhat closer to the waterline than other can buoys. It is a variant form of the basic form. (CANS 1975 centerfold). A final can buoy is that of Sweden and of the USSR. It has a definite can shape but of a more bulky and squat form and is also to be regarded as a variant form of the can buoy (MBS 71, 76). The previous described US can buoy may be regarded as a variant form, but the great masses of that buoy may justify it being regarded as a second "standard" buoy along with the US nun buoy (See Classification, 3A).

3B3 Unlighted Buoys: Spar, Standard & Miscellaneous

The word "Spar" can be defined as "a general term for any mast, yard, boom or gaff ... ". (WNID, 2nd ed, 1934, 2410; see also WTNID; OED, Vol X, 511). It has reference primarily to maritime usage during the era of sailing ships; more precisely it refers to ship masts. Spar buoys can be an upright mast or spar or has that appearance. IDAMN defines spar buoys in similar terms: "a buoy in the shape of a spar floating nearly vertically." (IDAMN 2-6-235). At an earlier stage of development spars used for purposes were of wood rather than of iron or steel construction. It is possible that some older spars may have come from the same yards as those that produced ship masts. (OED, X, 511). More modern versions are more likely to be of metal construction.

The standard spar may have more functions than any other buoy in either USB or IALA. In USB the spar has several exclusive roles and also serves as an alternative to one or other of the remaining standard buoys (MBS, 7, 10). In IALA the spar is an option in lateral systems and -- though the cardinal system does not call for a precise shape of buoy -- the spar is one of two normally used in those situations. It is also an option for miscellaneous situations in IALA. (IALA BCR, An. 3).

The Finnish system, at least before IALA, employed only spar buoys (MBS, 28-29). The spar buoy was heavily used at one time in the US but is no longer listed in newer USCG Manuals. However, it is listed in the classification since it had major significance in the not too distant past.

Since the US and IDAMN both present a spar with a slightly tapered appearance they are included together in the classification (USCG 1964, Amd #2, 8-3). The spar of Norway is both severely tapered and pointed as well. It represents a separate listing in the classification. (USCG 1964, Ch 3, 8-3; IDAMN 2-6-040 and Fig. 49).

Canada continues to include spar buoys in its operations (CANS 1975; Norvan 2008; Canada F&O 2008). Canada employs a slight varying form of the spar along with the standard version. A flat-topped model provides an alternative to the can buoy (CANS centerfold). The variant form is pointed and can provide an alternate to the conical buoy. In other nations the spar buoy is the same shape for both can and conical functions. Belgium formerly used the flat and pointed top spars, but this feature has been dropped in the second edition of IHB (SMBB 24). The buoy may suggest a spindle buoy but the spar resemblance seems stronger.

An additional variant form is the spar buoy on can. Denmark, Norway, and Iceland all have this buoy. (MBS, 23, 41, 58).The local name of the buoy varies, but the appearance remains the same. In Denmark the buoy is termed a perch. A perch can be either a buoy or a fixed aid. Supposedly the perch is not the same as a spar from the view of a dictionary. However, a perch on a buoy, and a spar buoy on a can base, are visually the same. It is not known if a separate term describes this buoy type in Iceland. The Netherlands also uses this buoy where it is referred to as a "floating beacon," a term applied to a previously described buoy (MBS, 52). In Norway this buoy is termed a spar; Norway also includes the standard spar (SMBB, 108).

The final variant form of these buoys are those mounted on a base with a conical shape. Iceland includes this buoy while Germany has a buoy consisting of a conical base and a slightly sloping spar buoy (MBS, 41, 43). The buoy may suggest a spindle buoy though the spar resemblance seems stronger.

The Netherlands and Poland exhibit a buoy attached to a base that is both can and conical in shape. The Netherlands terms this buoy a "floating beacon," though this beacon is much like other variant spars. (MBS, 52, 53). Iceland's "fleet" of spar buoys also includes a can-shaped spar with a rounded top base. The spar itself is standard in appearance MBS, 41).

It is possible that all buoys with a base and spar combination should be a separate classification. But at this phase of the study it would seem that these buoys belong to the class of spar despite distinctive shapes.

Standard single types of buoys include the ogival, spindle, spherical, and pillar buoys. There are seemingly no recognized variant forms and these types are included within a "singles" category. These buoys are found within USB. They are classified as standard though not all are found in IALA. They are not found in IMC. The pillar buoy, which is an optional shape in IHB, becomes a major buoy in IALA. These buoys are also included within lighted buoys, but the primary coverage is in this unlighted segment.

The pillar buoy is illustrated in IHB publications but not named. It does not have a regular function in the IHB (SMB, 14). EB includes the buoy. It seems to have been regarded as having some importance and even a regular status (EB 1911, IV, 806-808). For IALA it is one of five official buoys. This buoy is made up of a large tank and is topped with a superstructure of lattice work construction. It is an acceptable option for all buoys in lateral and special position. It is one of two buoys for IALA cardinal usage (IALA BCR, 4-5-7).

The term "ogival" is not found in common English-language marine parlance. According to OED the term refers to objects with the "form or outline of an ogive or pointed ('Gothic') arch." An ogival buoy is one that has the appearance of such an arch (OED, VII, 90).

Ogival buoys are included in USB publications of the IHB (SMB, 10). IDAMN does not include the buoy. It found use in the eastern quadrant of the USB cardinal system, and also for wreck marking (SMB 10-11). France was apparently the only nation that specifically included the buoy under USB and in IHB publications (SMB, 31). Other nations included it for optional use. The buoy was the least familiar among standard USB buoys. The Danish system contained a buoy somewhat like an ogival though it bore greater resemblance to a conical buoy (SMB, 31). The stylised illustration of an IALA conical buoy has a modest curvature reminiscent of an ogival buoy. But it is not included in IALA.

Various dictionaries, including OED, WTID and RHDEL, make mention of a marine marking known as a spindle (OED, X, 605; WTNID II 1961, 1971). But in all of these cases the spindle is a fixed aid to navigation, not a floating one. The use of fixed spindles, at least by that name, appears to be confined to the US judging by available literature (USCG 1985, Atlantic, Volume I). Spindles, outside of aids to navigation, are found in spinning, and also as the upper section of wooden ship masts. The source of the term presumably comes from ship usage though speculation might suggest spinning spindles as well. IDAMN speaks of the spindle as having a "spindle-like shape" which offers little aid in determining the derivation of the term (IDAMN, 2-6-340).

The spindle buoy is found in the USB cardinal system; it is not found in the lateral system of USB or IMC. It is not found at all in IALA. The spindle buoy has had a variety of functions in individual buoyage systems; France, Spain, and the Netherlands all employed it (MBS, 31, 53, 69). Various nations, including Egypt, Turkey and Portugal were listed in IHB as having adopted the cardinal system, and this includes a possible use of the spindle. Spain used the spindle, though the USB cardinal system was not in use in that country (MBS, 69).

The spherical buoy derives its name from the notion of sphere; possibly in a mathematical context. There does not appear to be a non-marking usage of that term that directly leads to a maritime adoption of it as is the case with spindle and ogival. Dictionaries, whether general or specialized, do not give a background for the term that has a marine connection. According to the 1882 Conference at London, a distinction was made between buoys with flat tops (can buoys) and those with domed tops (spherical buoys) (UK 1883). Spheres are a basic geometric form and may have been perceived as a suitable candidate for buoyage systems. IDAMN defines a spherical buoy as a "buoy of which the upper part of the body (above the waterline), or the larger part of the superstructure, is spherical." (IDAMN 1970, 2-6-215).

In USB the spherical buoy is primarily found in lateral usage; it is applied to bifurcation and junction marks, and for wreck marking (SMB, 7-9). There is no use of it in the USB cardinal system, though the buoy is employed for uses "common to both systems" including isolated danger markings and for limited optional situations (SMB, 11). IALA uses it for safe water marks and for special marks needs (IALA BCR, 6).

Miscellaneous buoys include the barrel and oil-drum buoys, and the two forms of the German Bake buoy. The Bake buoy was the most important buoy for Germany under USB; it is not known if that buoy has retained its significance under IALA (other special buoys of several nations continue to exercise their roles under IALA after necessary message modifications). In many instances the Bake buoy replaces both can and conical buoys (SMB, 92, 104, 105). The buoy has two forms. The first has a conical shape that is built up of slats rather than of a solid form. The second version is used for the cardinal system, and the slats in this case are bowed or concave rather than flat. The first version is for lateral usage and is used for both port and starboard sides of channels. The second edition of IHB indicates that there is increased usage of standard forms of buoys; nonetheless, the Bake continued to find substantial employment in the system (SMB, 92, 104, 105).

A rather informal buoy type is that of the barrel buoy. It is not mentioned in USB, IMC, or IALA, but it is frequently found in many national systems. The functions that it carries out are largely peripheral. For example, it marks quarantine moorings and general moorings. But in some instances the barrel is an integral and significant buoy. Sweden is probably the best example of heavy usage of the barrel (MBS, 70). IHB offers a stylized form of the barrel but there are varying sizes and shapes of barrels. The name for it can also vary greatly. In some systems it is a tun buoy or a ton buoy; in at least one nation it is a cask buoy (SMB, 32, 104, 145). But despite the different names, various forms of it share a substantial similarity in shape.

At one time the US included an oil-drum buoy in its system. It was used for marking channels in rivers of shallow depth (Enclosure to O'Connell 1974). It bears some resemblance to a barrel though it is probably more of a cylindrical shape. The previously described ton buoy can be defined as a "large wine-vessel, a cask; hence a measure of capacity used for; now spelt Tun" (OED, X, 121, 464). Tun can be seen as a cask or barrel which is now "less common than cask." (see previous note).

3B4 Sound Buoys

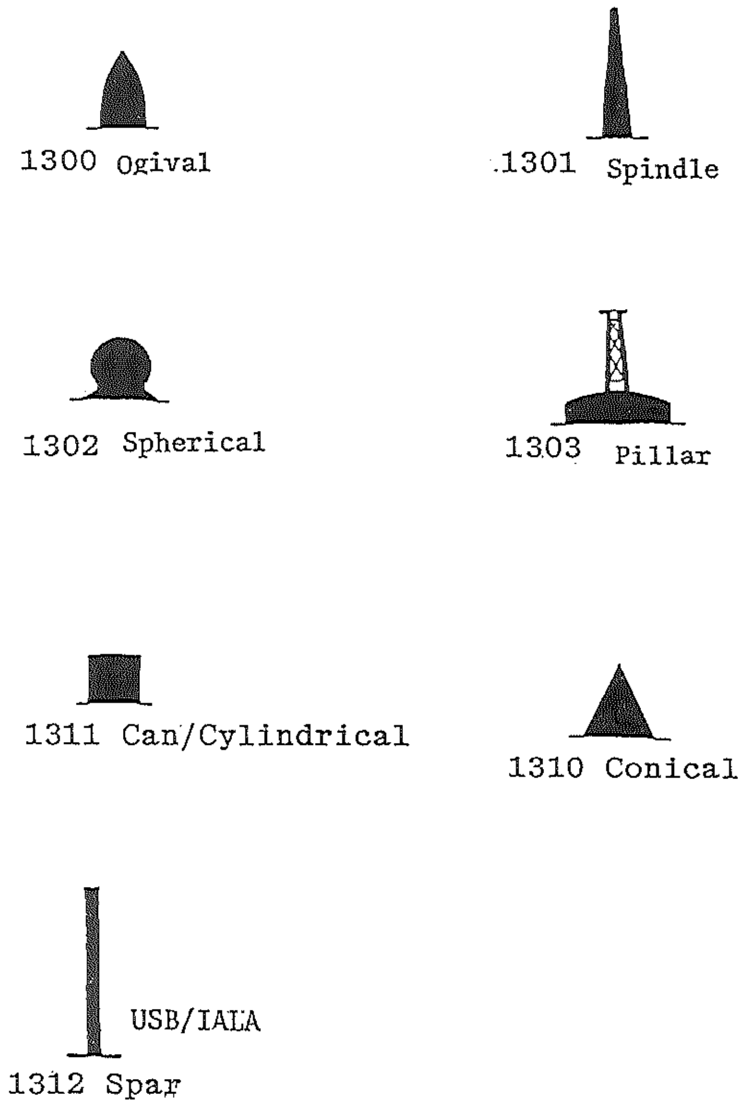
Sound buoys constitute the smallest portion of international buoyage systems. IHB does not mention sound buoys, and this may suggest that they were not a major aid to navigation. Admittedly, on a global basis they do not rank very high. However, a number of nations have operated sound buoys in substantial numbers. These buoys have at least regional importance (IALA Survey, 1984/3, 16-19). IDAMN lists three types of sound buoys, and one variant form. The Secretary-General of IALA notes an additional type: the electric horn. (IDAMN 2-6-180, 2-6-185, 2-6-190; Prunieras, 12-30 letter, 1977).

The shape of these buoys is often not significant though they follow the color message systems of buoys. These buoy maintain a visual value as well as an acoustical one. USB and IALA sound buoys maintain the same shapes common to light and unlighted buoys. Other nations make use of special sound buoys which are a cutdown version of a lighted buoy. (IDAMN 2-6-180). Germany has employed the Bake buoy for sound purposes. (IDAMN 1970, 2-6-220).

The four traditional types of buoy signals are the gong, the whistle, the bell, and the horn. France has a variant of the bell buoy known as a carillon buoy (IDAMN 2-6-180). This last named buoy refers to a buoy "bearing a group of bells." (IDAMN 2-6-185). A gong buoy, which is found only in the US, is "fitted with a group of saucer-shaped bells of different tones." (IDAMN 3-2-310). The resulting sound approximates that of chimes. The French carillon and the US gong buoys are notably similar. The US buoy has three special shaped bells with a clapper for each; the French has four saucer-shaped bells to strike two of the bells ("Bouee A Carillon; USCG A/N 1979, 2-21). The 1964 edition speaks of 3-gong and 4-gong models). Bell buoys usually have a single bell and presumably several clappers which is the reverse of the carillon/gong models (Prunieras, 1977). Whistle buoys contain a whistle mounted upright on the buoy tank and activated by the motion of the sea; horn buoys are electrically activated. Bell buoys have tappers or hammers, and these are mounted on the outside of the bell rather than on the inside (USCG 1979, 2-23, 2-19). Presumably the number of activators and their location increases the noise-producing ability of the buoy.

The traditional means of activating these buoys has been by the motion of the sea. This has been a problem in that the sea is frequently calm, or nearly so, during foggy weather when the sound signal is most needed. Hence, the sea-activated forms of buoys are somewhat declining in numbers while there is a corresponding increase in electric-activated versions. The use of consistent power also means that a fixed and unvarying message is also possible.

UNLIGHTED BUOYS: STANDARD FORMS



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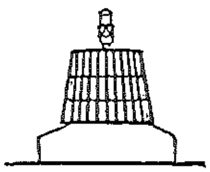
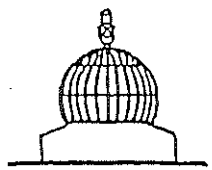
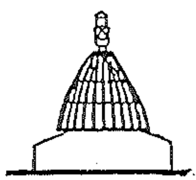
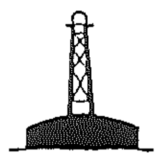
BUOYS & OTHER FLOATING AIDS

LIGHTED BUOYS: STANDARD SINGLE TYPES


1200 Can

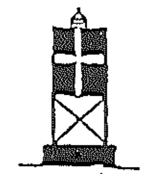

1201 Spherical


1202 Conical

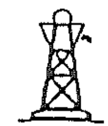

1203 Pillar

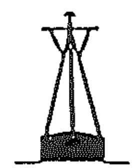
LIGHTED BUOYS: VARIANT FORMS


.100
Canadian

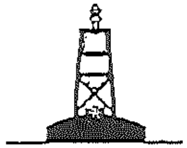

.101
USA


.104
Thailand B

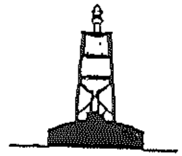

.103
USSR


.106
Norway

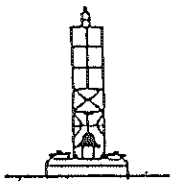
LIGHTED SOUND BUOYS



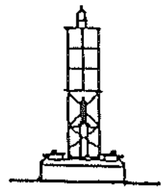
.160 Bell
Canada



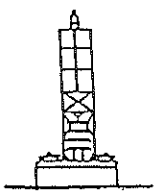
.161 Whistle
Canada



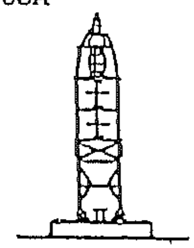
.162 Bell
USA



.163 Whistle
USA

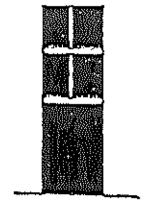


.164 Gong
USA



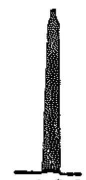
.165 Horn
USA

UNLIGHTED BUOYS: VARIANT FORMS

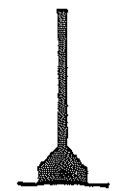


.120 Can
USA

.100 Nun
USA



Norway
.131 Modified
Spar



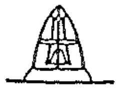
Iceland
.135
Modified
Spar on
Can Base

.140 Beacon-buoy
Lateral,
W. Germany

.141 Barrel
Sweden, USSR

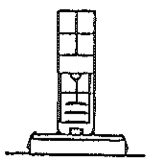
.142 Oil-drum
USA

SOUND BUOYS

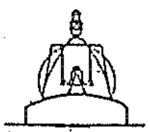


1400 Bell
IALA

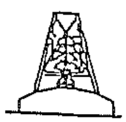
1401 Whistle
IALA



1402 Gong
USA

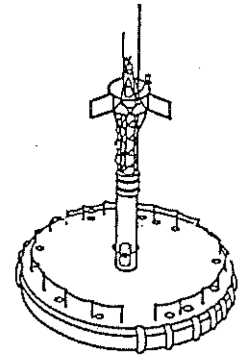


.166/.167/.168
Bell/Conical/
Spherical/Can
USB

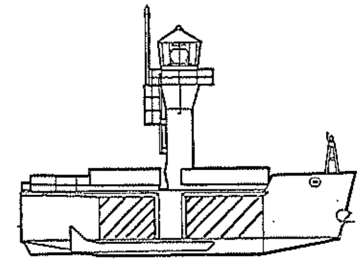


.153 Carillon
France

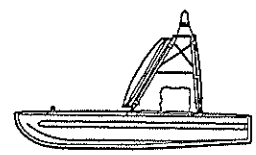
LARGE FLOATING AIDS



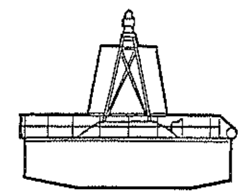
1601 Large Naviga-
tional Buoy., USA,UK



1600 Lightship



.180 GRP Catamaran



.181 Lightfloat

Notes for Buoy Illustrations

Earlier editions of Marine A/N included only a main classification; the General Classification (1994, 2003) added a variant classification. The addition of a variant classification creates a more complex situation for a pictorial buoy classification: there are too many forms to include. Buoy pictures in this classification are divided into two segments: main category (it includes primary forms) and a variant category with a sample of forms.

page 70. Lighted Buoys. Standard forms are included. These are stylized designs and reflect international usage. They probably represent European buoys more than they do western hemisphere buoys.

page 71. These lighted forms are listed in the variant classification; they suggest diverse national designs. While there are other designs these are notably striking. Canada (.100); US (.101); Thailand (.104); Russia (.103); Norway (.106).

page 72. The upper portion include buoys with a single form (1300-03). The lower portion includes buoys with variant forms (1310-1312).

page 73. These variant unlighted forms are an ecclectic mix of US can, US nun (truncated conical), a variant shaped spar, and one of several spars set on a second form. The Beacon-buoy in Germany has a variety of forms including a lighted buoy. Barrels, and oil-drum are a simple and common form.

page 74. Standard buoys include bell and whistle forms. The main classification also includes the US gong buoy though less often employed. The 2003 classification lists the French carillon buoy as a variant form. This may be correct since the carillon it is a form of bell buoy though of a distinctive appearance and sound. The USB bell buoy has three shapes. It is in variants.

page 75. Lighted Sound Buoys are listed in the variant classification. It includes both national and sound models.

page 76. Large Floating aids are divided into main and variant. The decision that placed Light Vessels and Large Navigation Buoys into main, and Light Floats and Lighted Catamarans into variant can be debated. It may have been thought that the former aids were more significant than the latter ones. However, Light vessels (or ships) are obsolete and LNBs may be at least obsolescent; the other Aids are more often in use. Illustrations include a Large Navigational Buoy (1601) and a Lightship (1600). However, the later is a product of Pharos Marine and therefore a modern and automated unit. Pictures of Lightfloat (.180) and Lighted Catamaran (.181) are also Pharos Marine products.

References:
Page 70, 1200-1202, LN; 1203, USB (IHB)
Page 71, CANS; USCG; USB; Norway
Page 72, USB (IHB); IDAMN
Page 73, USCG; USB (IHB)
Page 74, IDAMN; USCG; USB (IHB)
Page 75, CANS; USCG
Page 76, USCG; Pharos Marine (print catalogue, ca. 1990; under new ownership; digital catalogue does not include those aids)

CHAPTER FOUR

MESSAGE SYSTEMS FOR

FLOATING AIDS TO NAVIGATION

4A Introduction & USB

4A1 Introduction

A simple description of the types of buoys is not sufficient for this study. It is also necessary to examine the ways in which buoys exhibit their messages of information, of warning, or of guidance. The shape of a buoy while it can be an important part of the message system is not the complete message. The color of the buoy, letters, the arrangement of colors are also significant. The buoy and its messages are also arranged into patterns in relation to geographical features, points of the compass, or other buoys. These elements are also part of the message system.

The systems of buoys display variety and diversity as influenced by sponsoring nations. International conferences have narrowed -- at least to some extent -- the range of diversity. This conformity can be reduced by national systems that only partially follow the tone set by such conferences. Other nations may ignore in a more substantial way the international attempts at uniformity. Nonetheless, some degree of order exists and probably increases with time. This chapter will follow the provisions of the international systems with necessary notation on qualifications of implementations created by divergencies. The chapter begins with what had been the most frequently utilized system -- until the early 1980s -- that of the Uniform System of Buoyage.

Coverage of USB includes a review of the abstract provisions, how the system was treated by nations subscribing to it either fully or partly. This Chapter also includes a review of IMC and supporting nations, the newer system of IALA, and a summation of provisions of selected buoyage systems. Most references in this sub-chapter are from IHB publications including *Systems of Maritime Buoyage* [MB] (1956) and *Maritime Buoyage & Beaconage* [SMBB] (1971; see also: IHB *Buoys & Buoyage* ... 1926). Limited sources include Canada, IALA, US Coast Guard.

4A2 Full USB System

USB contains both a lateral system and a cardinal system. The lateral system is a more frequently adopted system. The starboard side -- of side channels -- is marked by either conical or spar buoys. Black or black/white check buoys (for spar buoys the upper half is white and the lower half is black) are the colors and color combinations permitted. Lights, if any, are white and can exhibit either a flashing or an occulting pattern; one or three flashes or occults per period are prescribed. Green lights are permitted if they do not interfere with light characteristics for wrecks. Green/white combinations are permitted. Topmarks, if added, are to be black cones or diamonds for conical buoys, and cone-shaped brooms for spars. Odd numbers are permitted when required. Topmark can be defined as: "One or more relatively small objects of characteristic shape or colour (or both), placed on top of a navigation mark (or buoy) to identify it." (IDAMN 1970, 2-6-255).

The port side of channels require spar and can buoys. Can buoys are painted in red/white checks; spars present red or red/white combination patterns. Numbers, if used, are even. Topmarks for can buoys are red cans with red "Ts".

Spar topmarks are inverted cone-shaped brooms. Lights are red in color and can have either a flashing or occulting pattern with one of several characteristics. White lights exhibit variant characteristics; white/red combinations follow these same patterns. Yellow checks can be substituted for the white checks in secondary channel for both starboard and port positions.

Spherical buoys with red and white horizontal bands are required in middle-ground situations if the main channel is to right (outer end). Topmarks are to be a red can; lights are to be distinctive. Spars are also to display red and white bands, and topmarks are to be a "red can over a red sphere." (SMB, 8). The inner end of the channel calls for the same pattern except for a red T topmark for spherical buoys, and a "red T over a red sphere" for spar buoys (SMBB, 8). Main channel to port requires buoys and light characteristics similar to those listed under the instructions for main channel to starboard. Spherical buoys are to exhibit a black cone with the point up for the outer end topmark, and a black diamond at the inner end. Spar buoys display a black cone (with vertical point up) over black sphere at the outer end and a black diamond over black sphere at the inner end.

"Channels of equal importance" follow the injunction for middle grounds main channel to the right, except for the topmarks (SMBB, 9). Spherical buoys have red sphere topmarks for the outer end and red St. George's Crosses for the inner end. USB specifications for mid-channel markings are very general. The shape of buoys must be easily distinguished and at variance with conical, can or sphere-shaped buoys. Lights are also to be easily distinguished from side of channel markings.

Wreck markings require special colors and other characteristics call for odd or uneven variations.

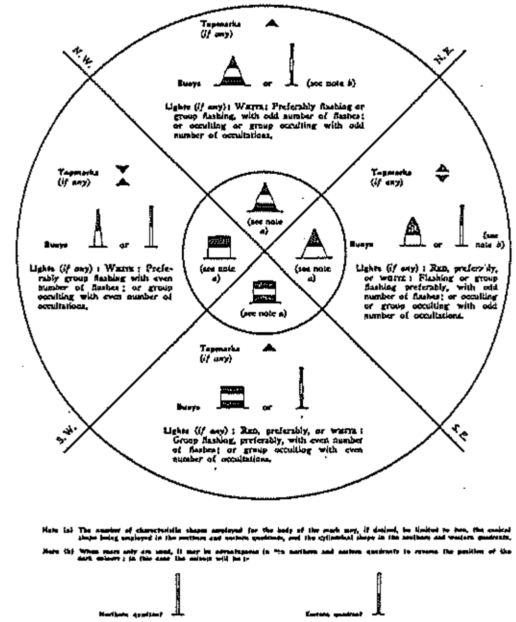
The cardinal system requires spindle or spar buoys for the WQ (SW to NW). The upper portions of WQ buoys are painted black, the lower parts white. Topmark are "two black cones point to point;" (SMBB, 10). USB offers a simplified alternative for the previously described cardinal system. This alternative has conical buoys in both the north and east quadrants. It is also permissible, according to the standard cardinal system, to have a single buoy type; that buoy is to be a spar buoy. This option is followed by Finland. In this last variation it is recommended that the dark colors be reversed. This would result in a white buoy with a broad black middle band in the NQ and in the EQ a buoy with a white upper and red lower patterns.

Wreck marking rules complete the cardinal system. These markings are found in the EQ and WQ. In the EQ ("NE to SE from wreck") buoys are to be conical, ogival or spar and, as with lateral wreck buoys, these are to be green with a white "W" (SMB, 10). Topmarks are two green diamonds. Any light on a wreck buoy is to exhibit an interrupted flashing green pattern. WQ buoys are cylindrical, spindle, or spar. Color and letters are to match wreck buoys of the EQ (SMBB, 10). Topmarks are "two green cones point to point." Green lights are exhibited with a flash rate similar to that of WQ buoys; the light is a regular flash, not an interrupted flash. There are also some buoy message patterns common to both USB systems.

USB also contains a limited range of miscellaneous markings. A principal buoy of this category is the isolated danger buoy. This is a spherical or spar buoy banded with broad black and red bands divided by a slender white band. Topmarks are red or black spheres with black/red horizontal

characteristics. If the wreck is "[to] be passed on the Star-boardhand..." the buoy should be a green conical or spar buoy; lights are to have a group flashing combination. Top-marks are to be green cones. If the wreck is "[to] be passed on the Port Hand ... ." The buoys should be a can or spar buoy with letters as previously described (SMBB, 9). The light should have a green group flashing indication. Top-topmarks are to be green cans. A spherical or spar buoy is standard if either side of the wreck is acceptable for passage. Topmarks in that case would be sphere-shaped and a light would be an occulting green indication with a single flash. There are also USB rulings for situations in which the wreck itself can be used as a marking.

The cardinal system of buoyage for USB can be viewed under three headings: danger markings, simplified cardinal system markings, and wreck markings. Spar buoys can be employed in any or all of the quadrants for danger markings. Each of the quadrants has, in addition, a specific buoy type assigned to it.



(IHB SMBB 1956, LN USB, 14)

Spar topmarks are inverted cone-shaped brooms. Lights are red in color and can have either a flashing or occulting pattern with one of several characteristics. White lights exhibit variant characteristics; white/red combinations follow these same patterns. Yellow checks can be substituted for the white checks in secondary channel for both starboard and port positions.

Spherical buoys with red and white horizontal bands are required in middle-ground situations if the main channel is to right (outer end). Topmarks are to be a red can; lights are to be distinctive. Spars are also to display red and white bands, and topmarks are to be a "red can over a red sphere." (SMB, 8). The inner end of the channel calls for the same pattern except for a red T topmark for spherical buoys, and a "red T over a red sphere" for spar buoys (SMBB, 8). Main channel to port requires buoys and light characteristics similar to those listed under the instructions for main channel to starboard. Spherical buoys are to exhibit a black cone with the point up for the outer end topmark, and a black diamond at the inner end. Spar buoys display a black cone (with vertical point up) over black sphere at the outer end and a black diamond over black sphere at the inner end.

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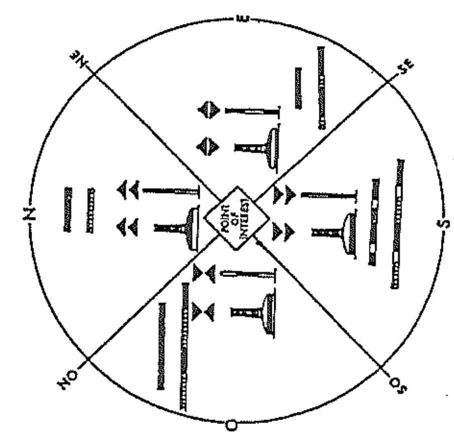
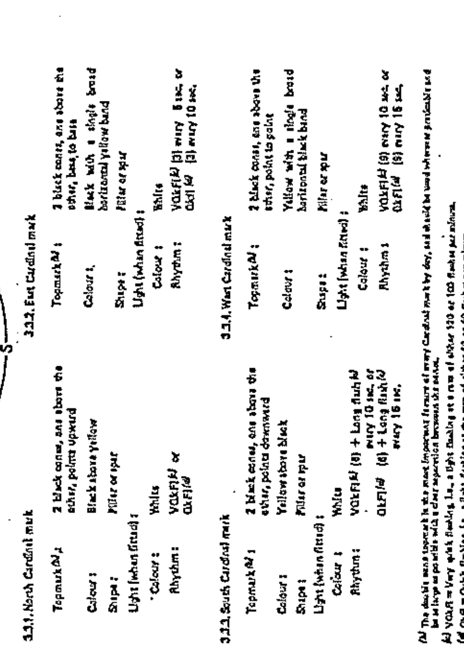
Wreck markings require special colors and other





IALA 1980 BCR, An 3, 4)

In the NQ (NW to NE from a point of danger) conical or spar buoys are adopted. These buoys are black with a broad white middle band. Topmarks, if used, are to be a black cone with the point up. White lights with an odd number of flashes can be added to the buoy.

In the SQ (SE to SW) the buoys are either cylindrical or spar. These buoys exhibit a broad white middle band but are otherwise red. Topmarks are to be inverted red. Light periods contain an even number of flashes, and red lights are permissable. Ogival or spar buoys are found in the EQ (NE to SE). The upper part of these buoys are to be red and the lower half are to be white. Topmarks are to be red diamonds ("two cones base to base") (SMBB, 10). Red lights are preferable, though again white is acceptable; the light characteristics call for odd or uneven variations.

characteristics call for odd or uneven variations.

The cardinal system requires spindle or spar buoys for the WQ (SW to NW). The upper portions of WQ buoys are painted black, the lower parts white. Topmark are "two black cones point to point;" (SMBB, 10). USB offers a simplified alternative for the previously described cardinal system. This alternative has conical buoys in both the north and east quadrants. It is also permissible, according to the standard cardinal system, to have a single buoy type; that buoy is to be a spar buoy. This option is followed by Finland. In this last variation it is recommended that the dark colors be reversed. This would result in a white buoy with a broad black middle band in the NQ and in the EQ a buoy with a white upper and red lower patterns.

Wreck marking rules complete the cardinal system. These markings are found in the EQ and WQ. In the EQ ("NE to SE from wreck") buoys are to be conical, ogival or spar and, as with lateral wreck buoys, these are to be green with a white "W" (SMB, 10). Topmarks are two green diamonds. Any light on a wreck buoy is to exhibit an interrupted flashing green pattern. WQ buoys are cylindrical, spindle, or spar. Color and letters are to match wreck buoys of the EQ (SMBB, 10). Topmarks are "two green cones point to point." Green lights are exhibited with a flash rate similar to that of WQ buoys; the light is a regular flash, not an interrupted flash. There are also some buoy message patterns common to both USB systems.

USB also contains a limited range of miscellaneous markings. A principal buoy of this category is the isolated danger buoy. This is a spherical or spar buoy banded with broad black and red bands divided by a slender white band. Topmarks are red or black spheres with black/red horizontal stripes. White or red lights flash a "rhythmic" pattern (Defined: "A light showing intermittently with a regular periodicity"; IDAMN 1970, 2-5-105). Landfall buoys require no specific shape or topmarks providing they do not give misleading messages that can cause confusion with other buoys. Landfall buoy colors consist of black/white vertical stripes or red/white vertical stripes; any light is to be "rhythmic" in character. Transition buoys follow the optional shape and topmark rules. Colors are to form red/white or black/white spiral band patterns.

Quarantine buoys are yellow in color; outfall and spoil-ground buoys are yellow (for the upper part) and black (lower part). Any other characteristics employed are not to create confusion with similar banded buoys. Military practice area buoys are optional in shape. The color code is at variance. The buoys are to "white with two blue stripes intersecting at right angles at the upper extremity of the mark and extending to the water line, thus representing a cross when observed from above, in combination ... with letters indicating in the national language a dangerous area" (SMB, 1).

In retrospect, the USB rules for buoyage are only that: a listing of rules. Only a minority of nations adopting USB included all of the lateral and/or cardinal systems. The attitudes toward the system take several forms. Some nations have adopted the system in its entirety, others made slight changes, while others were influenced by USB only to a limited extent.

According to the International Hydrographic Bureau, Belgium, India, Iran, New Zealand, Portugal, Spain, Turkey, Indonesia and Yugoslavia indicated that they had adopted the lateral system -- or simply the USB -- in all of its points.

France, Poland, the Netherlands, South Africa, the United Kingdom, Australia, and Pakistan made limited changes.

4A3 USB Users With Limited Changes

France offers a truncated conical buoy as an option for wrecks. Poland includes a modified conical-based spar buoy for the port-hand position in fairways and channels. Poland has included a standard spar buoy for the port-hand position whose markings, white uppers and red lowers, are contrary to USB norms (red-only markings). Poland has also adopted several special and miscellaneous buoys not found in the standard regulations. Australia has accepted the USB cardinal system but not the entire lateral system; Australia does not list specific buoy types for fairways and channels. Wreck situations also allow for optional shape buoys.

Pakistan substitutes a solid red landfall buoy for the standard striped models; wreck buoys include a checkered buoy option. South Africa follows the USB in large part except that certain starboard-hand buoys are painted white. UK has adopted the USB norms but certain exceptions are to be noted. For example, in Scotland there are exceptions for wreck buoys. These are to be spherical buoys which "may be passed on either side and carries an interrupted quick flashing green light instead of an occulting green light." (MB, 78). Interrupted quick flashing lights are also used when a distinctive light is deemed necessary. Normally, topmarks are not found on either lighted or unlighted buoys in Scotland. English and Welsh wreck buoys have WRECK spelled out on the buoys instead of the abbreviation W. Interrupted quick flashing green lights are substituted for occulting lights. Eire and Ulster, which share the Commissioners of Irish Lights aids to navigation agency, follow USB rulings except for wreck buoys, which emulate UK practice.

The Netherlands is in conformity with USB with one exception in color markings. The Netherlands lack a green/ red spar buoy for wrecks in which mariners are to pass on the left of the wreck. There are considerably more variations in Dutch buoy shapes. For example, the Netherlands' aids to navigation agency has special variants of spar buoys and expands the usage of the standard spindle buoy into uses where USB calls for notable uniformity. Nevertheless, the color patterns and banding designs of the Netherlands are identical to USB except for the previously mentioned differences (SMBB 1956, 92ff).

4A4 Special USB-Compliant Systems

Two unique buoyage systems are those of Sweden and Finland. Perhaps paradoxically, the two systems are standard since they comply with USB norms. The Finnish system is exclusively cardinal. There are no lateral marks, unless the "dangers of small extent" buoy can be regarded as lateral (MB, 28). The standard spar buoy is virtually the only buoy in the Finnish system; the use of the spar follows USB guidelines. There are differences in the topmarks of the system from those of USB. The NQ requires a single black cone with point up over a black sphere. The WQ allows one inverted, or the same topmark over a black sphere. A single inverted red cone or a single red cone or a single red cone inverted over a red sphere is the hallmark of the SQ. Finally, the EQ topmark is either two red cones point to point or two red cones point to point over a red sphere.

The Finnish wreck markings are at variance with the USB cardinal system. The Finnish system has a north to south and east to west arrangement instead of a northwest to southeast and northeast to southwest orientation. The topmarks are flags instead of the USB arrangement of cones. All Scandinavian nations substitute flags for regular topmarks in wreck markings.

The Swedish system combines the lateral and the cardinal systems of USB. This system has three primary characteristics: a) the merging of cardinal and lateral into one unit; b) the extensive use of barrel buoys, which are often peripheral; c) the wide spectrum of topmark options for most buoy positions.

For fairways and channels, red spar or barrel buoys are employed for north and west positions. N and W spar buoys have an inverted cone, an inverted cone/sphere, or two inverted cone for the topmark. S and E locations have black buoys and the exact reverse of topmarks. N and W barrel buoys have a single inverted cone topmark. S and E have a black/white spar topmark for ton or barrel buoys. The spar buoy for S and E is identical to the topmark color pattern for barrel buoys.

Swedish middle-ground buoys are similar to the USB middle-ground buoy except for a two-sphere topmark option that is available. A ton buoy with a single sphere topmark offers an additional option. The barrel buoy in this situation is banded with a vertical black and red pattern.

The arrangement of danger buoys is complex. The color markings, except for the SQ, follow the USB pattern; the SQ has a solid red motif instead of the red/white pattern. In each case either a spar or a ton buoy can be adopted. The Swedish NQ topmarks are a single verted cone, an inverted cone, and a single sphere over a single vertical (point up) cone and two spheres. The SQ is the exact opposite. The WQ has either two cones joined at the base with the addition of a single sphere, or two cones joined at the base and two spheres. The color is black in all of these cases. The EQ is identifical in regard to the spheres; however, the cones are joined at the points and all are red.

Wreck markings resemble those of Finland. In addition, Sweden provides for the marking of the wreck itself. The vessel markings are two lights or balls to the left of the masthead in the SW square and one to the right; the NE square has the reverse position. Bells can be added when wrecks are directly marked. For the NE the bell is struck in "groups of two over ten" every two minutes; (MB 1971, 7). The SW position calls for a single ringing in the same pattern. Quarantine buoys are yellow and in variant can buoy form.

4A5 Partial USB Systems

Iceland incorporates the meaning that black and white have for USB, but that is the end of the resemblance to USB norms. Icelandic buoys for fairways, channels, and middle-grounds are ogival buoys and three forms of spar buoys. Wreck and spoil-ground buoys are also ogival; danger and submarine cable buoys are either ogival or a special spar. Red/black bandings and the green of wreck buoys are two additional areas in which USB norms are followed.

Topmark, in Iceland, for port-hand fairways and channel buoys are one, two, or three inverted cones. Middle ground buoys have one, two or three red spheres with a black horizontal stripe. Danger area buoys have a single yellow sphere with a black horizontal stripe.

Malaysia has adopted the USB practice in most instances but there are several exceptions. Wreck buoys are green but the light phase characteristics are of Malaysian design, and outside the lateral system. Light buoys are red; fairway buoys, in some instances, are all white with can or conical daymarks. There are a selected number of other buoys outside the lateral system described in detail in IHB.

Thailand's system partially resembles the USB pattern. Fairway and channel buoys are red and black in accordance with USB. Major buoy types include a light buoy, the standard spar buoy, and an optional choice buoy. The topmark is a square for the starboard side and a black cone for port. Landfall buoys conform to USB. Wreck buoys are green, and they may be a special light buoy, a spherical buoy, or a spar buoy. The topmarks -- except for the light buoy -- are cone over square. Spoil ground and quarantine buoys conform to USB. Isolated danger buoys are either a light buoy or an optional choice that is not described. This last form is white with a horizontal black band; topmarks are sphere-shaped or a cone over square. Thailand conforms to USB markings for military practice buoys, but the buoy is yellow, not blue. Submarine buoys are black with a white "T".

Italy conforms to color, pattern, and topmarks of USB with few exceptions. However, the buoy types or shapes and their positioning are at variance with the established norms. Italy uses a variant conical buoy, a standard conical buoy, and a spar buoy for all positions in fairways, channels, and middle grounds. In all other positions, lateral and cardinal, only the special conical and the standard conical buoys are employed save for optional choice in quarantine and sewer outfall situations. The same buoys are found in both port and starboard positions; shape is generally not a major factor for these buoys and their messages.

Norway has a modified lateral system and a standard cardinal system. There are only three buoys in use: the Norwegian light buoy and two special spar buoys. Topmarks are limited. Black buoys, lateral or cardinal, have vertical (point up) black cones; red buoys have inverted red cones. Most buoys are in a solid color, but there are instances in which buoys with a white horizontal band are offered as an option. Middle-ground buoys are black and red in a horizontally-banded pattern with a matching sphere.

Greece included a modified conical buoy and two light buoys for port-hand positions. These are solid in color. The conical buoy has a cone-shaped topmark. Starboard-hand buoys employ the same two light buoy types and a slightly modified can buoy with a square topmark. Middle-ground conical buoys are banded white and red with a diamond topmark for bifurcation purposes, and a white and red banded buoy with two cones point to point for junction topmarks. Dangers in channels are marked by white and red banded spherical buoys for navigation to port and black and white banded spherical buoys for starboard navigation. Wreck buoys are green conical buoys, and isolated danger buoys are banded in horizontal black and red stripes with red sphere topmarks.

Germany has what may be the most complex system of buoyage and beaconage of any nation. There is, nonetheless, some influence from the USB in the use of colors for the lateral and cardinal systems. Approaches to channels include only the German Bake-buoy (translated as Beacon-buoy in IHB). For the port-hand the buoy is red, for mid-channel it is black and red vertically striped, and for the starboard it is black. The topmark for port is two cones point to point, for mid-channel it is a modified Cross of Lorraine, and the starboard is an ellipsoid. Lights are white or red for port, red for mid-channel, and white for starboard. A complex of light characteristics accompanies these colors.

The port-hand sides of channels allow for a special spar, a Bake buoy, or a special can. The topmarks include a red can, a "T", two spheres point to point or an inverted broom. The starboard permits either a standard cone, or a Bake buoy. Letters and numbers are in white for both sides. The port-hand allows for white or red lights, but white only is permitted for the starboard side. Again, various light characteristics are given. Mid-channel buoys are described under "approaches to channels." (MB, 33).

Additional rules apply to "junctions and bifurcations not caused by middle grounds." (MB, 34). If the main channel is to the left, the port hand buoy will be a Bake buoy in black with a red band. The starboard is a solid black buoy. Both have white lights, black cone topmarks and white lettering. If the main channel is to starboard the buoy will be a red buoy with can topmark and white or red light and white lettering. The starboard position is a red buoy with black band and similar lettering, lighting and topmark. Channels of equal importance have black and red vertically striped buoys with undetermined light characteristics. Lettering is optional. Topmarks are matching spheres.

If the main channel is to right -- and if a middle ground -- the buoy is red with black band and a red can topmark over a sphere; if the main channel is to left the buoy is black with a red band, and a cone over sphere topmark for bifurcation, and diamond over sphere topmark for junction. A topmark for the junction position is a red "T" over sphere if channel is to right. Main channel to right has white or red lights, and a junction buoy has only white lights. Lettering is in white. For channels of equal importance the buoy is striped vertically in red and black. In this last instance the topmarks are two red spheres with a black vertical stripe; for junctions, a black cross of Saint George over a single black and red vertically striped sphere. Lettering is not required and lighting is undetermined.

The buoy for "shoals and isolated dangers within the channel which may be passed on either hand" is a bake buoy with the upper half red and the lower half black." (MB, 35). A black sphere constitutes the topmark. Lettering is to be white, and the lighting is to be red in an isophase characteristic.

The German cardinal system offers a choice of a concave bake buoy, a special spar buoy, or a standard spar buoy for each quadrant. The name of the shoal is lettered on the buoys, followed by the first letter of the quadrant. NQ and WQ have white lights and a variety of characteristics; EQ and WQ have white lights and also a variety of characteristics; EQ and SQ have red or white lights and accompanying characteristics. In the NQ the buoys are black with a white middle band; in the WQ the upper halves are black and the lower halves are white. EQ has upper half in red and lower half in white. The SQ have solid red buoys with white bands across the middle. Topmarks are two vertical (point up) black cones for the NQ, and two black cones point to point for the WQ. The EQ has two red cones base to base, and the SQ has two inverted red cones. Buoys actually on the shoal would be banded in red, white, and black. The topmark would be a black ball. Lighting is in red or white isophases, and the lettering follows the previous injunctions.

For lateral wreck markings, bake buoys or spar buoys can be used for wrecks whether for port passage, either side passage, or starboard passage. For port passage the special spar and special can buoys are also permissable; for either side navigation the spherical buoy is a third option, and for starboard use the standard conical buoy is permitted. The lights are green, and light characterstics permitted include short, long flashing and isophase.

Wreck marking in cardinal buoyage permits one of three buoys: the cardinal bake buoy, the special spar, and the standard spar. Green is the color for all of these buoys. Topmarks are identical with those for shoals and isolated dangers. The lighting varies according to quadrant: group occulting (3) in NQ, interrupted quick flashing in EQ, group occulting (4) in SQ, and quick flashing in WQ. Shoal buoys exhibit fixed green lights. Buoys for roadstead limits are to be black barrels for starboard and red barrels for port. The starboard displays a black cone topmark and the port -hand has a red can. The lights are white or red for port, and white for starboard. Characteristics of lights can vary.

Germany has about 15 special buoy patterns. In many instances they utilize barrel buoys. Some special buoy patterns, such as those of military practice areas, resemble the markings of USB; others are unique to Germany.

Denmark's buoyage system follows the USB to a considerable extent in color markings but less so in the shape of buoys. Fairways, channels, and middle grounds employ two special conical buoys and a special spar. Port-hand buoys are red except for the special spar, which is red on a black base. Topmarks are one, two, or three inverted brooms. Starboard buoys are solid black with one, two, or three brooms. Middle-ground buoys are horizontally banded in black and red, and the topmark is a red ellipsoid.

Danish "mineswept or recommended routes" (MB 23) use one of three special conical buoys. The topmark is an ellipsoid that is vertically red with black stripes. These buoys have a white light. Middle-ground buoys have red or white lights, and fairways have red for port and white for starboard. Wreck buoys are of the same types as those found on fairways. These are green except for the base of the spar buoy which is black. The topmarks are flags, as is the case in all Scandinavian nations. Lights for wreck buoys are green and flashing. Military practice areas are marked with buoys painted in black and yellow bands with yellow ellipsoid topmarks with black bands. Spoil grounds and submarine cable areas employ special conical buoys in solid colors of yellow; submarine cable buoys have green quick flashing lights.

Russia relies heavily on a few buoys for its system. These are a standard spar buoy, and a light buoy similar to that of Thailand; an optional buoy that is not described is listed for nearly all positions. Fairways and channels buoys are red for port and black for starboard. On bend sections of fairways and channels there is a white band across the buoy. Port positions have inverted black cones, while the starboard has vertical (point up) black cones. A variety of light characteristics are available.

Middle-ground buoys of the spar type are horizontally banded black and red with sphere topmark that is black for upper part and white for the lower part. Light buoys are vertically banded in red and black as are other shape buoys. Lights are white and flashing. Mid-channel buoys are banded black and white horizontally for straight sections, and red and white for bend sections. The spar topmark is black for the former and red for the latter. Lights are white for some straight sections and red for bends. Wreck buoys have the same shape and topmark but are solid green in color. The light is also green.

Cardinal buoys are all white in the NQ with white flashing lights and black cone topmarks. In the EQ they are vertically striped red and white except for the spar, which is white (upper portion) and red (lower part) with a two-cone point to point topmark. The light is red and flashing. WQ buoys are striped black and white with spars painted in an upper black and exhibit base to base cones. The WQ light is white. The SQ buoys are completely red with red flashing lights and inverted red cones. Fishing zones are the same except for using only spar buoys and for different light patterns. The NQ has a fixed white light, the EQ has two fixed red lights, SQ has one red light, and WQ has two fixed white lights.

Submarine cable areas have banded spar or striped buoys in black and orange. The spar has a flag-shaped topmark and the light is orange in an isophase pattern. Anchorage areas include the standard buoys, a barrel buoy, and a special can buoy; the optional-choice buoy is also available. These are -- except for the banded spar -- striped in red and orange. Lights are orange and flashing. The spar topmark is flag-shaped with diagonal swatches of orange and red. Quarantine areas include the above buoys except for the barrel buoy. Quarantine buoys are solid orange with an orange flashing light.

4B International Marine Conference Influenced Buoyage System

There are no current publications outlining a complete IMC buoyage system. But there are a number of nations that follow or, at the least, are influenced to some degree by it. IALA has altered that situation though core values of IMC remain. Major sources for this sub-chapter include IHB, Canada, USCG, and IMC publications. The most striking differences between USB amd IMC are the meaning given to black (and later green) and red. USB regarded black as the starboard day color of channels, while IMC perceives red as the starboard-hand color. And, of course, port-hand colors had the reverse meaning. Green accompanies black in both USB and IMC but with opposite meanings. Red lights and markings mirror this phenomenon of opposite meanings. Most nations in the Western Hemisphere follow in some manner or other the IMC provisions of 1889. Most other maritime nations follow the lead of USB, though there are exceptions, especially in East Asia.

Argentina stated in the 1956 editon of IHB that its system is in conformity with IMC. Argentine fairways and channels have black port-hand buoys that are can buoys with flashing lights in white; starboard buoys are red conicals with red flashing lights. Can buoys can be augmented or replaced by a "buoy surmounted by a cylindrical shape." (MB, 11). Conical buoys can be replaced by "a truncated cone buoy with a sharp point or a buoy surmounted by a conical shape." (MB, 11). There are no topmarks for these buoys.

Middle-ground buoys are of optional-choice shape and banded black and white. Bifurcation buoys have a black sphere topmark; junction buoys have a half-sphere in black. Mid-channel buoys have a vertically stripped motif with "a black cage in the form of an inverted/truncated cone of pyramid" topmark (when a topmark is included) (MB, 11). Middle-ground buoys are optional-choice buoys with white and red horizontal bands. The topmark is a black sphere. Wreck buoys are green with lights in the same color. Wreck buoy, in some instances, have an inscription. A ship marking would be painted green with two balls on the left mast and one on the right; three green lights can serve as an substitute. WRECK is painted on the ship in white.

Buoys are in use in Costa Rica and Peru, but there are no standard rules or systems governing the buoyage in those jurisdictions (at least as listed in the 1971 edition of IHB). Guatemala has black can buoys with odd numbers on the port-hand side of channels with fixed green lights. The starboard side has red can buoys with even numbers and fixed red lights. There is no further buoyage in Guatemala according to IHB 1971.

Ecuador has black can buoys with odd numbers and green or white lights of varying characteristics on the port side. Starboard buoys are conical or can, and red in color. Red lights and even numbers complete the starboard messages. Middle-ground buoys are cans -- if the principal channel is to right -- with horizontal black and white bands. Lights are green or white and exhibit a group flashing characteristics. If the main channel is to left the conical or can buoys are banded with horizontal red and white colors. Lights are group flashing and red. Landfall and mid-channel buoys are can or conical. These buoys exhibit vertical black and white bands with green group occulting lights.

Miscellaneous buoys are optional shape in all cases. Mooring and related purpose buoys are yellow with a blue isophase light. Fishing zone buoys are white; leading mark buoys are painted in black and white checks and have a white isophase lights. Special purpose buoys are banded in yellow and white. They have isophase lights.

The Chilean buoyage system consists of black and white banded can buoys for the port-hand of fairways and conical buoys of white and red banding in both cases are in white. Mid-channel buoys are spherical and banded in vertical white and black stripes. Wreck buoys are conical or spherical in green with a white horizontal band. WRECK is painted on the white band. Yellow barrel buoys mark quarantine areas and red barrels indicate mooring buoys for explosives.

Cuban fairway buoys are cans and spars for port, and conicals and spars for starboard. A black topmark in spherical shape is attached to port buoys. Lights are white or green, numbers are odd. A white or red cone topmark (point up) is found with starboard buoys. Lights are white or green, and numbers are even. Middle-ground buoys are of the same patterns; all are horizontally banded in red and black. Lights are white and group flashing for both port and starboard. Mid-channel buoys are of optional shape and are vertically banded in black and white. Lights follow the middle- ground pattern.

Japan and South Korea have identical buoyage systems (IHB 1971). All buoys are conical. Black is used for port and red for starboard. Numbers follow the IMC patterns in fairways. Middle-ground bifurcation buoys are banded in horizontal black and white stripes. Junction buoys are solid red or in bands of white and red. Topmarks for port fairways are in the shape of black cans and red cones for starboard. Bifurcation topmarks are diamond-shaped and junction topmarks are two cones point to point in black. Mid-channel buoys are conical with black and white stripes and a white can topmark. Isolated danger buoys are conical with black and red bands and a red sphere topmark. Wreck buoys are green conicals with WRECK written in English and Japanese or Korean.

The Brazilian buoyage system has only one type of buoy, the conical. Port-hand buoys on fairways are black with even numbers and white flashing lights. Starboard buoys are conical and red with odd numbers. Lights are red and either flashing or occulting. Middle-ground buoys for bifurcation are banded with white and black markings. Lights are white and group flashing or group occulting. Junction buoys are red and white banded with red group flashing or group occulting lights. Mid-channel buoys are vertically striped in white and black with the same light characteristics as bifurcation buoys. Isolated danger buoys are horizontally band in black and red with junction buoy light characteristics. Submarine cables and pipelines are marked by white buoys with flashing or occulting lights. Wreck buoys have green coloring with green flashing or occulting lights.

Mexico has the familar pattern of black port can buoys and red conical starboard buoys. Black buoys have odd numbers and green or white flashing or occulting lights. Red buoys have even numbers and red or white flashing or occulting lights. Middle grounds have can buoys with red and horizontal bands -- if the channel is to starboard -- and green or white interrupted quick flashing lights; if to port, a conical buoy with the same markings and red or white interrupted quick flashing lights.

Mid-channel buoys are conical with white and black stripes. The light characteristic is Morse Code "A". All special buoys are of optional shape. These include special purpose buoys, which are horizontally banded in white and yellow with light patterns that do not create confusion with other buoys. Landfall buoys are black and yellow vertically striped and white with the same injunctions on lighting. Both of these buoys may be lettered. Quarantine buoys are solid yellow in color; anchorage buoys are solid white. Fish-net buoys are white and black in horizontal bands. Dredging buoys are painted in green for the upper portion with white for the lower part. The restrictions on lighting that pertain to special purpose buoys includes all of these buoys.

Port buoys in the Congo are black "with a flourescent white cylindrical topmark numbered in green," and the light is either white or green, with an occulting pattern (MB, 11). Starboard buoys are red with a fluorescent red topmark in the form of a triangle with red numbers. Starboard lights are red and occulting.

The Canadian buoyage system is only partially covered by IHB. That system is described in *The Canadian Aids to Navigation System* (1975) (and updated by F & O 2008). Fairways, channels, and middle grounds adopt one of three buoys: can, light, or spar. Port spars are flat topped, while the starboard counterpart is pointed. Port fairway buoys have green reflectors or lights. The lights exhibit flashing or quick flashing characteristics. Starboard buoys have red reflectors and lights with the same basic characteristics. Middle-ground buoys are banded horizontally with the top band of port buoys in black and of starboard buoys in red. Reflectors and lights follow standard patterns. Light characteristics are interrupted quick flashing for both sides.

Mid-channel light buoys are marked in vertical white and black stripes. Can and conical buoys as well. Reflectors are white and the lights are green with interrupted quick flashing for downstream direction and red in the same pattern for upstream movement. Special purpose buoys are outside the lateral system and have no specific shape. Letters may be present on these buoys but not numbers. Special purpose buoys include white for anchorage, orange for cautionary, and vertically striped yellow and orange buoys for scientific work.

In the US black buoys indicated the port or left side of channels or wrecks; red marks the starboard-hand side (USCG LL, Pacific, Vol. III, 1979 for this paragraph). Junction and bifurcation are marked by the buoys with red and black horizontal bands; the channel of preference is indicated by the color of the top band. Vertically striped buoys of black and white mark mid-channel or fairway buoys, and the mariner is strongly advised to navigate close to either side of the buoy. Conical-shaped buoys, known as nun buoys, are starboard and red; cylindrical buoys are either can or nun. Shape does not pertain to light and sound buoys. The color and other characteristics will indicate the channel to be followed for those buoys. Buoys of one color are always numbered: red buoys have even numbers, black buoys have odd numbers. The buoy at the seaward end of a channel has the smallest number. Buoys which are not red, or are multi-colored with black, do not have numbers. Red buoys have red lights, while black (in pre-IALA terms) buoys have green lights. White lights can be used on buoys of any color.

Red and black buoys exhibit flashing or occulting lights, though fixed patterns are allowed. These buoys usually display a slow flashing pattern, though special situations allow for a quick flashing characteristic. Buoys that are banded black and red have interrupted quick flashing messages. Vertical striped buoys -- in black and white -- give forth a Morse Code A message in white. Some buoys -- as well as some fixed aids -- exhibit reflectors. Reflector messages duplicate lighted messages. Reflectors may be composed of reflective material rather than a reflector in the strict sense.

4C IALA Buoyage System

Provisions of IALA require, whenever possible, can buoys for port-hand, and conical buoys for starboard-hand positions for lateral markings (IALA Supl. # 6, 4-5, 7 for paragraph). If pillar or spar buoys are used as substitutes, An appropriately shaped topmark is added to the substitute buoy if pillar or spar buoys are used as substitutes. The topmarks are can-shaped for port, and cone-shaped for starboard. If a light is added to buoys in lateral service it will be red for port and green for starboard; the light phase characteristic or rhythm, can be of any type. Black buoys can be substituted for green buoys where it is deemed necessary, but this substitution is not to be widely employed. Since green/red lights have a limited range, a buoy agency may employ a cardinal buoy -- which exhibits white lights of greater range -- in such locations as a turning point in a lateral channel.

Buoys in the cardinal part of the system mark the four quadrants (north, west, south, and east) (IALA Supl. #6, 4-5, 7). The quadrants are divided by north-east to south-west and north- west to south-east lines of bearing. If, for example, a cardinal buoy is in the north position then the mariner should pass to the north of it. Cardinal buoys indicate the deepest water for the area of the buoys by their position and markings, if the buoy marks a danger, it indicates the safe side on which to pass. Cardinal buoys also indicate junctions, bifurcations, shoal perimeters, and channel turnings; many of these functions were formerly allocated to the lateral systems. A specific shape is not mandatory for cardinal buoys, but usually they are pillars or spars.

The buoys in a cardinal position follows a distinctive yet complementing pattern that is easy to follow and remember (IALA Supl. #6, 5, 7 and next two paragraphs).

North and South buoys --N upper structure is painted black while the lower part is in yellow; S pattern is the reverse. Topmarks have black cones (point up) for N and inverted black cones for S. When lighted the N buoy has a white light in very quick flashing pattern (VQkFl) or quick flashing arrangement (QkFl). S has a VQkFl supplemented by a long flash every ten seconds and a QkFl with a long flash every 15 seconds.

West and East buoys --E buoy is in black with a single yellow band (horizontal); the W buoy is the opposite. Topmarks for the E buoy contains two black cones base to base while the W has the same topmark but point to point. The E buoy has a VQkFl characteristic every five seconds or QkFl every ten seconds; for the W buoy it is every 10 seconds in a VQkFl pattern of QkFl every 15 seconds.

No other buoys in the system employ QkFl or VQkFl characteristic and white lights (IALA System #6, 5-7). Therefore the simple existence of a pattern indicates a cardinal buoy without further investigation by the mariner through time measurement. VQkFl phase flashes at a rate of either 120 or 100 flashes per minute; QkFl is either 60 or 50 flashes per minute. Bury notes that propane-fueled lights can not flash more than 90 flashes per minute though the flash rates are given as 120 or 100 flashes per minute (VQkFl) (Bury 1978, 99). Long flashes are at least two seconds. The characteristics have been so arranged that they are easily memorized: the E buoy three per period, the S six times, and the W buoy nine times; the N buoy flashes but a single time. This creates, if a clock face is kept in mind, a three-six-nine pattern of flashes whether QkFl or simple QkFl. The added long flash is added to prevent confusion over counting six or nine rapid flashes from a buoy.

Isolated danger is defined as "a mark erected on, or moored on or above, and isolated danger which has navigable water all around it." (IALA 1978, Supl. #6, 5-6). This buoy is either a pillar or a spar. The marks are black with broad bands in red displayed in a horizontal arrangement. Topmarks are two black spheres arranged vertically. If lighted, the color will be white and emitting a group flashing motif of two groups of flashes per period. According to IALA, the message systems of marks "serve to associate isolated danger marks close to cardinal marks." (IALA Supl. #6, 5-6). Safe water marks exhibit the reverse indications of isolated danger marks; they indicate safe water all around the marking. The desired shape for these buoys is spherical though a pillar or spar buoy can be substituted. The daymarkings are red and white vertical stripes. Pillar and spars in this instance include a single red sphere topmark. The light is white with a choice of isophase, occulting or long flash (one per 10 seconds) patterns. They can also substitute for cardinal or lateral markings to "indicate a landfall." (IALA Supl. #6, 5-6).

Special marks are "not primarily intended to assist navigation but ... indicate a special area or feature." (IALA Supl.#6, 5-6 and paragraph). In a variety of instances they serve to maintain a keep out or keep away function. Primary areas of use include ODAS marks, Traffic Separation Zones, spoil grounds, military activities areas, cables and pipelines, and recreation zones. They are always yellow. Their shape is of optional design and may include can, spherical, conical, pillar, or spar buoys. Any topmark would be a yellow X. Lights of yellow hue are permitted and can follow any rhythm that is not used by cardinal, isolated danger, and safe water marks.

New danger marks includes those not listed in nautical publications to date (IALA Supl. #6, 7). They would include a recent ship wreck or newly found underwater obstacles. If lighted they exhibit "an appropriate cardinal or lateral VQkFl or QkFl light character." (IALA Supl. #6, 7). If a duplicate mark is installed it will be identical to the first. A racon with the code letter D may be added to the mark. A new danger mark may be a cardinal mark in no way different from established cardinal marks except for lacking a listing in nautical publications due to the freshness of the installation.

Even though some comments comparing IALA with past buoyage efforts have been made, there is value in directly comparing IALA with USB and IMC. The comparison with IMC contains a prologue to the comparison as well as the comparison. The prologue comprises a review of two major systems that consitute a working out of IMC principles: the buoyage and beaconage of Canada and of the US. A brief summary of the view of J.E. Bury earlier in this chapter also affords a comparative view of this topic.

In USB there were eight standard topmarks and combinations in the official system; this does not include variant forms by the nations subscribing to USB (IHB, SMBB, 1956). The new system has just four types and combinations of topmarks (IALA Supl. #6, 4-6). Seemingly, widespread variations are not found in IALA. At least a strong implication is found here and in the underlying philosophy of IALA buoyage system that it greatly simplifies the buoyage system in use (IALA Supl. #6, 7). Ogival and spindle buoys have been eliminated from IALA. At least there is no reference to them in the existing literature. They may possibly have some optional value but specific inclusion of them is absent. Some options are available in the IALA buoyage system but they are limited. Pillar buoys, which were unnamed and secondary in USB, are now primary. A buoy unnamed but listed as a possible option in IHB publications is identified in the IALA system as a pillar buoy. It and the spar are listed more frequently than other buoys. The pillar buoy would seem to have an edge over the spar because of its greater visibility. DMA, extracting from British hydrographic literature, describes the buoy as being one of several shapes. (2nd ed., 1988; DMA 1983).

Cardinal and lateral systems now form a single buoyage network (though a system may center on lateral and make little use of cardinal markings) (Garrett, 8). Black, which was one of the two primary colors for non-light functions in USB, is relegated to a substitute role; green now becomes a basic color -- along with red -- for both day and night use (See Supl.#6, 7; North American systems continued to include black as a primary color along with red until the implementation of IALA). Wreck markings no longer form a special category; they are subject to regular danger markings: isolated dangers and new dangers (Bury 1978, 139). Fixed beacons become a definite and integral part of IALA; they are not a peripheral marking (IALA Supl.#6, 1 and fold-out). Middle-ground and mid-channel subdivisions of USB are not found in IALA; however, lateral and cardinal messages are available to fulfill the functioning formerly carried out by those types of buoys. The wide spectrum of lighted messages with accompanying imprecise characteristics has been replaced by a much more coherent and precise system. The isolated danger buoy which existed in USB as a minor category develops a major role in IALA (IALA Supl. #6, 6-7). The use of white buoys is now restricted to recreational boating and bathing zones (IHB, SMBB, 11-16).

The principles of IMC can be reduced to a few general norms. Those principles are sufficiently broad that a host of national systems could be adduced from them. Essentially, IMC called for red to starboard and black to port; this practice was established before the widespread usage of port and harbor lights, and before lighted buoys were common (IMC 1889, General Division 12). Buoy shapes -- when required -- used cylindrical buoys for starboard and can for port; topmarks, if any, were cone-shaped for starboard, and cylinder-shaped for port. Numbers and letters were optional. Wrecks were marked with green buoys with white inscriptions. Both Canada and the US conform to the guidelines of IMC rather closely. Port-hand buoys for the US include can for unlighted, and a specially designed buoy for light positions; Canada follows a similar pattern except that it has retained the spar (CANS centerfold; USCG A/N, 13). For starboard positions, Canada includes the lighted buoy, conical buoys and spar with pointed top; the US includes a nun buoy and the light buoy but no spars as a regular and standard buoy.

For light colors, Canada applies green exclusively for port and red for starboard; the US exhibits green or white on port and red or white on starboard (CANS, centerfold; USCG A/N, 13 and for the paragraph). Canada is more specific in the spectrum of light phase characteristics and allows for color options on each side. White may have been retained for lateral usage in the US because of its greater range. Mid-channel buoys are near-identical for both countries; the only appreciable difference is in the exact message of the Morse Code character. Junction buoy message symbols are also close in appearance for the two nations; one exception in this component is the red-only meaning and green-only regulations in Canada, and the color option in the US. The US system can, in crowded waters, establish specific message characteristics so as to eliminate confusion in light messages. Neither nation employed green buoys on a regular basis before IALA. Both have established standards for daybeacons and daymarks, and these correspond to buoyage requirement for message.

The long-standing and deeply-rooted difference on whether red is to starboard or to port will in all likelihood continue and never be resolved. IALA recognizes and clarifies that distinction on placement of color in a manner more rational and -- more or less -- agreeable or tolerable by all parties. But IALA has not eliminated the problem. IALA elevates the cardinal buoyage concept to a higher and more equal footing with lateral. IMC included a cardinal system as well, but it was based on existing European practices and was unknown in the Western Hemisphere (IMC, III, 333-335). This historic difference may continue but at a reduced level since cardinal buoys come into play in many nations at least for specific usage.

Topmarks, though provided in IMC, have been rare in the Western Hemisphere. They may be more common in the future in the Eastern Hemisphere than in the Western, but an increase of topmarks is coming about in many nations under IALA (e.g., US isolated danger buoys). Topmarks have become rational and easier to understand than in the past when individual systems and a complex official systems were both in operation (see provisions in IALA Supl. #6). IALA does not address the large system of daymarks found in some IMC nations, but that practice grew up independently of IMC as well (e.g., Norway).

A striking resonance between IMC-derived systems and that of IALA is simplicity. The official and not so official options USB are being phased out, and a system more easily comprehended has resulted. The North American systems have long exhibited a basic simplicity, and they are now joined -- and strengthened -- by the work of IALA.

CHAPTER FIVE

FIXED LIGHTED MARKINGS

5A Introduction, Criteria for Major & Minor Forms, & History

5A1 Introduction

Previous editions of this chapter lacked both an introduction and a historical sketch. The reason for omitting an introduction is unclear. History was omitted because the traditional lighthouse has been amply chronicled in many tomes and articles and such coverage was deemed unnecessary. However, a brief historical sketch now seems to be an essential element. That sketch is largely a summary of material in the T-M history (2002).

The primary elements of the chapter include a classification of both major and minor forms. Necessary explanatory notes are included. Descriptions of physical forms and a review of messages complete the coverage. A major issue is deciding how to categorize major (large aids which are often traditional lighthouses) and minor (including river, harbor, bay lights) forms. The criteria for those categories is part of the introduction. An added component attempts to provide correlation between classification entries with the marine study in the T-M database. Both topics share the same information yet the drawing together of types in the classification is often at variance with the expansive nature of the database as it gathers together diverse and numerous terms.

5A2 Criteria for Major & Minor Forms

It is a common practice to divide fixed lights into major and minor divisions. This is true of IALA, various maritime agencies, and other marine interests. While the meaning of "major" and of "minor" may be understood in practice (people generally know a major light when they see one, and the same is true of a minor light), there is considerable difficulty in stating with some precision the distinction between them.

For the IALA survey, minor lights are those with a candlepower intensity of under 100, and major lights are all those 100cp (IALA 1984/3, 17, 10). This criteria does not include structures or locations. But the IALA buoyage system has a much more expansive criteria. That system includes all marine markings except lighthouses, lightships, large navigational buoys, and the special categories of sector lights and leading lights/daymarkings (IALA Sup. #6 1976, 3). While those terms do not employ the terms major and minor, those aforementioned types would be considered as major aids (except for leading lights and daymarks; see previous notes). These criteria include locational and structural factors, and when combined them with the division proposed by the survey it provides a substantial basis for determining the classification of various aids to navigation.

Is it possible to be more complete about what constitutes a major aid and a minor aid? If a marking in question is a lighthouse then some degree of precision is possible. IDAMN describes a lighthouse simply as major, but that proves to be rather circular. (IDAMN, 2-5-005). Traditionally lighthouses have been imposing structures, usually a tower on an island, rock, or headland. More important, a lighthouse has a powerful light which can be perhaps 20 miles or more away. Some lights of especially great power can be seen that far in daylight (e.g. Tiri Tiri Light, Aukland, NZ; *Dock & Harbor Authority*, Vol. XLVI, #537, 7-65 via Stone-Chance). Usually the location is on, or off, a coastline and not inland. One can also say that a light of the major category may represent a major geographical feature rather than a restricted object or channel. Some nations, including Canada and the US, designate major lights by the type of style in light list publications (USCG LL, Pacific, III, 1985; it also includes BC). These lights are nearly always coastal, though some of a reduced variety may be in major harbors and bays (e.g., Fort Cornwallis Light, Penang, Malaysia, Stone-Chance).

Lightships have traditionally been floating lighthouses in areas where fixed markings would not be practical (for example, Sevenstones LS on an off-shore location in UK would not be feasible for a lighthouse, Bowen 1947, 37). Hence, they are clearly major in function are not found in sheltered waters, and do not perform a limited function. Large navigation buoys and LANBYS(referred to as "Lighthouse Buoys" in DMA Pilot Chart, 1977 [extracted from UK Hydrographic Office, NP 735] Publ #37) were replacements for lightships and can be classified as major aids. Though they may have faded out as well.

Conversely, minor aids are of much lower light intensity and are less physically imposing and of a less permanent character. They are more often of a standardized design and construction. Few are classified as coastal, though many are at the approaches of harbors and bays. In those nations which divide light lists into seacoasts, and harbor, river and bay sections, it is quite easy to distinguish major and minor categories.

The terms major and minor are not affixed to many navigation aids. Instead, a variety of terms are used which may create confusion as to the level of an aid. In some nations major lights are divided into two types: primary and secondary. The primary lights include lightships as well, and these are the landfall lights and most significant markings on a coastline. A secondary designation indicates lights still classified as major though of somewhat reduced significance. In the US the secondary major lights are a limited group (USCG LL Pacific, III, 1985, x-xi). IDAMN refers to landfall lights, and that is what the term implies: those lights first seen when coming in from the open sea (IDAMN 1970, 2-5-050). They are equipped with powerful lights and can be seen at a great distance (IDAMN 1970, 2-5-050). Other terms include "Feu de Jalonnement," which is a coastal light marking much akin to landfall lights. It is "particularly used with reference to marks placed on a long straight coastline devoid of many natural landmarks." (IDAMN 1970, 2-6-020). France also employs "Phare" for major lights.

Minor lights go to by a variety of terms. Channel, river, and, harbor lights are the most common terms (USCG LL Pacific, III, v). France refers to an unlighted beacon as a balise, and channel lights -- the most common minor lights -- as a "Feu de Rive." (IDAMN 1970, 2-5-060). The French also apply the phrase "Amer Remarquable" to certain aids though this is more often related to a major aid; it "is particularly easily seen, by virture of its form, size or colour." (IDAMN 1970, 2-6-000).

In summary, large imposing structures with a powerful light along the approaches to a coast or major off-coast body of water are generally major. They represent a significant geographical point, and they are largely independent of other markings. Minor markings are smaller, lower-powered, often standardized and affiliated with similar markings. They represent a small and restricted danger or channel or other object to the mariner. Buoys are associated with the minor category; lightships and large navigational buoys are "stand-ins" for large fixed markings.

5A3 History

a) Introduction & Early History

T-M History (2002) includes a sketch of Fixed Lights history. That survey is in increments: Before 1750, 1750-1870, 1870- 1920, and 1920-2000. A summary of that material is included here. It reveals several uneven chronological and technological dimensions. A long span of human history before 1750 includes only a small number of lighted aids. And these aids were simple, even primitive in nature. Some were towers with open flames. While others were beacons with braziers. A shorter period of time roughly corresponding to the original Industrial Revolution followed. New technology and construction methods permitted building towers in rough terrain and rough water. Lighting also gradually became more sophisticated. A third and shorter era (1870-1920) expanded and perfected construction, lighting and messages that began in the previous era. But even as that was taking place a seminal shift in marine safety was underway: radio waves. The pinacle of visual aids reached its zenith only to find it undermined at an accelerating rate.

Lighthouses extend far back into the ancient world. The most notable lighthouse is that of Alexandria, one of the "wonders of the ancient world." In time other lighthouses in the Mediterranean world were built and lit. Gradually lighthouses also expanded into other parts of Europe. The number of lighthouses was small. They were perhaps fewer than three dozen in the early 1600s (Stevenson 1959, 87). Many lighted aids in the Middle Ages were maintained by monasteries, chapels and churches (Naish 1985, 81-83). There may have been one light (Vera Cruz, Mexico) in the Western Hemisphere in the 17th century. And two in North America in the early 18th century (Boston and Louisbourg NS) (Witney 1975, 17).

Early lights were simple in the extreme. Lights were very dim. They could be seen in large part because nights were very dark and "visual pollution" was unknown (Spotts *CSM*, 2002, 11; Tyson *NH* 2002, 34). It is an apparent commonplace to lump all sea and harbor lights together as lighthouses especially in early times. Not all observers agree. Naish speaks of early towers as "fire towers" because of their dim fires atop a tower. He also refers to Fire Beacons which were open fires in a brazier. (Naish 1985, 18, 79-81). "True" lighthouses displayed a light that consisted of a few dozen candles and that was also dim. The first tower on a truly exposed location was that of Eddystone I (late 17th/early 18th c.). Corduan in France was the first wave-exposed tower. It was on a small island rather than on precarious sea rocks. (Langmaid 1966, 14, 76ff). Oil lamps with wicks were known in the 18th century but candles were also in use. And open fires were not unknown even into the 19th century. (Douglass & Gedye EB 1910, XVI, 640).

b) 1750-1870

Many of the sea-swept towers were built during this time. Rock towers were a signature of the original Industrial Revolution. Building towers on precarious sites became a virtual art form. These towers manifested three qualities: form, weight, rigidity. This meant they had a low center of gravity, massive weight which brought about stability and a monolithic character (akin to a large stone from a quarry).

(Edwards 1884, 23-24) The foundations for the tower were dug deep into the rock. (Witney 1975, 37). The stones were cut with great precision on land (Sutton-Jones 1885, 29; Naish 1985).

A second form of lighthouse surrounded by water was the screw-pile lighthouse. The process was developed about 1830. It consisted of driving iron piling into the sea and harbor beds as a foundation for the superstructure. The procedure was used where rock formations were not available. Many such lights were built in relatively shallow and often less-exposed locations in Europe and the US. More than 40 such structures were built in the Chesapeake. Later on caisson structures were often employed. (Naish 1975, 130; Kettle/Findley 1896, 4; de Gast 1973, 4). Land-based lighthouses were also increasingly prominent.

Developments in the Industrial Revolution included steam engines for construction work. Then the addition of oil lamps, reflectors, lenses required an enclosed lantern house. Lantern houses gradually increased in size which, in turn, required more glass and iron. Construction materials included stone, brick (especially in the US). Wood structures were becoming less common as well as less enduring. They were, of course, commonplace in pre-Industrial Revolution times. Wood structures on occasion did survive for quite some time as noted by Hague & Christie (1971, 100). A Pacific Northwest Lighthouse, Yaquina Bay Light (Newport, Oregon), was built in 1871 and remains to this day despite a long period of abandonment. Only the foundations of that structure are of stone (Leffingwell & Welty 2000, 169). Lighthouses entirely of iron also were developed as industrial products became more common. A series of such lights were cast and then shipped to the West Indies (Langston-Jones 1944, 193). North American iron towers included Cape

Mendocino in California, and Race Rock in Newfoundland (Gibbs 1955, 56; Beaver 1973, 63).

Critical to the value of a lighthouse is the lighting system. Candles, open fires, primitive lamps offered only dim light. Between the mid-18th and late 19th centuries a revolution in lighting took place that created strong, clear lights. A. Argand in the 1780s developed the first effective oil burner. The device featured a tubular wick that drew an air current through the center. It resulted in bright light with little smoke. Addition of a chimney greatly improved the burner. But the burner alone lacked reflectors or lenses. Early reflectors were made of shards of mirror glass set in plaster of paris followed by parabolic reflectors employing copper bowls coated with silver. (Williams 1992, 151).

A great advance in lighting was created by Augustin Fresnel who developed complex lenses that captured and projected light at great differences. Fresnel lenses became a global phenomenon and are still employed. (Sutton-Jones 1985, 96-97). Illuminants took many directions. A welter of fuels were experimented with including fish, animal and vegetable sources in the 19th century. (Kettle/Findley 1896, 10; Conway 1915, 32). "Earth oil" (petroleum) was also employed in the 19th century. (Johnson 1890, 55). Mineral oils were to eventually dominate lighthouse illuminants. This occurred largely after 1870. The primary illuminant was keosene or paraffin in UK. Bathurst refers to the post-1870 as the "Paraffin Age" (Bathurst 1999, 252).

Light phase characteristics are now a commonplace of marine lights. But at an earlier time all lights were fixed; in the early 19th century over 85% were fixed. One means of distinguishing lights was by adding more towers. Casquet Light in the Channel Islands) for example had three towers.

(Chadwick 1971, 59). Mechanical advances led to a more economical means of creating separate characteristics. Clockwork mechanisms were experimented with that moved the apparatus thereby alternating light with dark periods. (Chadwick 1971, 59).

c) 1870-2000: Lighthouse Zenith & Decline

The 1870-1920 era is the high point of marine visual aids. While great improvements in lighting apparatus and in design, and construction occurred before 1870, and major aids were built after 1920, the nearest to perfection and dominance of visual aids, especially great coastal lighthouses, occurred during this time.

The role of the Industrial Revolution is especially important in this time. Wiedemann in discussing the development of lighthouses notes the beginning of steam ships, the growth of routes requiring new aids (Wiedemann 1982, 9). Improved technology and increased travel and trade fed each other and generated new aids. Many of which were developed in the later 19th and early 20th centuries.

A great expansion of lighthouses was underway and some new projects presented difficult challenges. However, what might be termed the pioneer era was substantially over. The hard-earned lessons of building on sea-sweep rocks and reefs established the how of difficult tower construction which was applied and refined in this era (Sutton-Jones 1985, 106-107; Naish 1985, 133).

Even before the perfected state had been reached the first tremors of a revolution that would eclipse and even overthrow many visual (and acoustical) aids was afoot. Early work in electro-magnetic studies and early radio research were taking place at the same time as new fuels, lamps, lens technology were underway. Practical radio aids were decades away yet there were hints that visual and acoustical could become peripheral if not obsolete all too soon.

Kerosene remained a vital source of energy for the Lights. And it would do so for most of the first half of the 20th century. A new fuel, Acetylene, began to be used about the beginning of the 20th century. However, it was not often employed for major lights. A. Kitson devised a system for vaporizing the fuel which then became gaseous before ignitition. This fuel and an incandescent mantle invented by Welsbach in 1885 created a very brilliant light. A limited number of electrified lighthouses existed in the later 19th century. But the electricity had to be produced onsite which required "magneto-electric machine[s]" and coal. (see Part J and sources, pgs 79-80).

Caisson lighthouses appeared in the 1880s. This required towing the tub or caisson to the site where it was positioned and water was pumped out of the caisson until it reached bottom. Crews then dug out sand in the structure until it rested firmly on the bottom. A structure for the light and living quarters was built on top of the caisson. The first was at Rothersand at the mouth of the Weser River in Germany. Structures in the US included Delaware Bay and Chesapeake Bay. Most lights still displayed a fixed message even into the 20th century. Faster moving optics permitted a variety of characteristics. Some red lights were added to the established white message. (Part J, pg 81).

The 20th century saw a lighthouse establishment that reached a high point then became increasingly eroded. Few lights were built. And "robot lights" became commonplace. The first US light of that sort was at Long Beach CA in 1949.

Automation eliminated nearly all keepers by the 1990s and many were automatic before that decade. A second change can be seen in the T-M history. More coverage was given to buoys and harbor lights of a small size. And systems of buoyage and beaconage became more of the focus of maritime agencies and international meetings. Building vast towers and installing complex light apparatus (and also fog signals) became nearly extinct long before most radio aids were in use. Long-term automatic devices as well as acrylic and other forms of plastic were increasingly used as well. Electronic aids with a secondary visual component now heavily mark aids to navigation. (Part J, pg 81).

5B Classification of Fixed Marine Lights With Explanatory Notes

5B1 The Classification

210 Single Forms
- 2100 Traffic Control Signals
- 2101 Sector Lights
- 2102 High-intensity Marine Lights

221 Major Structures (Lighthouses): Sea-Girt
- 2210 Towers on Rocks
- 2211 Towers on Skeleton Structures
- 2212 Towers on Special Marine Foundations
- 2213 Houses on Special Marine Foundations

222 Major Structures: Land-Based Towers
- 2220 Tall Coastal Towers
- 2221 Towers on Promontories & Headlands
- 2222 Open Towers

223 Major Structures: Non-Towers
- 2230 Houses
- 2231 Skeleton Structures
- 2232 Buildings
- 2233 Composite Structures

224 Minor Structures
- 2240 Single Vertical Members (Narrow)
- 2241 Single Vertical Members (Broader)
- 2242 Multi-members Open Structures
- 2243 Enclosed Structures
- 2244 Composite Forms
- 2245 Single Forms

Variant Classification:

.2 Fixed Aids
- .20 Major Lights (Lighthouses)
  - .200 Towers on Skeleton Structures:

Screw-Pile Towers

.201 Towers on Skeleton Structures

.202 Skeleton Towers

.203 Framework Towers

.204 Composite: House on Structure

.205 Composite: Tower Attached to House/ Building

.206 All-Lighted High Intensity Forms

.21 Minor Lights: Multi-Member Structures

.210 Tripod

.211 Pyramid

.212 Pile Structure: Marine Site

.213 Pile Structure: Land-based Site

.214 Skeleton Structure

.215 Dolphin

.216 Tripodal Tower

.217 Tubular Tower

.218 Skeleton Tower

.22 Minor Lights: Single Member Structure I (Narrow Configurations)

.220 Spindle

.221 Spar

.222 Pipe

.223 Post

.224 Pole

.225 Single Pile

.226 Stake

.227 Mast

.228 Buoyant Beacon

.23 Minor Lights: Single-Member Structures II (Wide Configurations)

.230 Column

.231 Pedestal

.232 Pillar

.233 Pylon
.234 Obelisk
.24 Minor Lights: Enclosed & Solid Constructions II & Composite Structures
.240 Hut
.241 Small House
.242 Cairn
.243 "Beacon"
.244 Cylinders
.245 House/Hut on Structure
.246 House/Hut on Pile Structure
.247 House/Hut on Tripod
.25 Minor Lights: Single Types of Structures
.250 Stand
.251 Arm
.252 Lighted Bank
.253 All-Lighted High Intensity Forms
.254 All-Lighted Range/Leading Lights

5B2 Explanatory Notes

a) Overview

Parts of this chapter are devoted to message systems and structural types. That affords a substantial review of fixed and lighted markings. There is also a need for notes explaining terms and the relationships of the classification of Lighted Aids.

21, All-lighted Marine Aids. While most marine aids are not continuously lighted there are some aids of more recent vintage that has such capability. The lst ed of this study included one such aid and two more were added in the 2nd ed. Pharos Marine provided the information which partially reflects IALA/IALP guidelines.

The first 3-digit segment, 221, for Major Structures, is similar to that of the same category in the 1988 edition. One change is the merger of the two open structure entries (Towers on screw-piles and on off-shore platforms). The detailed forms are now in the variant classification. All entries refer to open-water aids.

The three-digit category, 222, for land-based aids is also similar to the previous version. One change is the merger of skeleton towers and frameworks into an open tower entity. The detailed forms are in the variant classification.

The final 3-digit category for non-towers, 223, also bears close resemblance to the previous edition. Once more, two entries were merged; a single entry was added, 2232, for composite structures. The variant classification includes the detailed forms.

There were six three-digit categories for minor lights in the 1988 edition. They contained 32 four-digit entries. The current version has a single three-digit category. There are six four-digit entries. They encompass basic groups rather than individual entries. The large number of specific forms are found in the variant classification.

The variant classification has one 3-digit category for Major Lights. All variant forms from the 3-digit categories are listed here.

Minor Lights are represented by five 3-digit categories in the variant classification. Most were in the former main classification. .21 includes Multi-member structures of which there are currently nine forms. .22 and .23 include single member forms; the former for narrow forms; the latter for wide forms. .24 includes enclosed, solid and composite forms of aids. Finally, .25 includes single types, and two forms of all-lighted aids.

b) Detailed Observations

Towers on Rocks, 2210. Rocks, submerged and above water, are not to be equated with islands. By rock is meant a solid object large enough for a structure to be built upon it. Often there would little additional rock or other remaining surface. In some instances the rock may be altogether submerged; even the lower portion of the light tower may be underwater at all times; in other situations the rock may be showing at low tides.

Towers on Skeleton Structures, 2211, include older screw-pile forms and newer offshore platforms. Both forms are in the variant classification.

Special marine foundations for towers and houses, 2212, 2213, include caisson and cribs forms. Differences in superstructures created two main entries.

Tall Coastal Towers, 2220, is a catch-all term which includes towers of varying heights, construction materials and designs. The term as used here includes only enclosed towers.Towers on Promontories and Headlands is a “blanket” term for shorter towers on headlands and other elevations. These markings are designated 2221.

Open Towers, 2222, includes two former main entries. Those entries with details are in the variant classification.

Houses, 2230, is a vague term. Perhaps, at most, it can be said that this refers to buildings with a house or near-house appearance which have a tower or raised portion exhibiting a light. A structure with a distinctly tower-like form or a composite form would be excluded.

2231, Skeleton Structures, is a yet more vague and uncertain expression. It indicates those structures that are not distinct design types whether tower, house, or other forms. It includes objects that are not enclosed and which lack an image of an enclosed building. It may be only a semantic usage that indicates an undifferentiated structure. It may also suggest a small or bulky construction lacking a sufficient height to be designated a tower.

Buildings, 2232, approaches the ultimate in vagueness. In marine parlance building suggests a non-tower, a non-house, a non-skeleton structure. It can include various forms of buildings whether square or rectangular or other shape. Only a small number of light supports are listed as buildings without further clarification or qualification. Identification of such a structure by color and daymark makes immediate and precise identification a more certain prospect.

Composite Structures, 2233, is a "catch-all" term which includes various types of houses constructed upon unspecified kinds of structures. The structures in question may be an integral part of the light or they may have existed before the establishment of a given light. Structures may include piers, pilings, pile structures, and other under-pinnings. It also includes Towers Attached to House/ Buildings. "Attached"can include various ways that towers are linked to various structures.

The category of Minor/Lesser Structures: Multi-member, 224, is a loose amalgam of diverse elements. The connecting links are the several members that each of these is composed of, and the lack of enclosures as found in many major light structures. The problem of determining whether overlapping terms are semantic or structural differences is not easily resolved. *Canadian Aids to Navigation System* (1975) provides an outline of types of structures including design features that helps to outline many forms.

.21, Minor Lights: Multi-Members Structures includes many aids formerly in the main classification. Among the specific problems in this segment are the possible differences between Tripod and Tripodal Towers (.210, .216). Tripod may be a three-legged structure with a "true" tripod shape. Tripodal may be of much larger dimensions that only suggest a tripod appearance. Pyramids (.211) can be of rock, rubble, or timber frame-work; they may be either an openwork structure or an enclosed form. Skeleton Structures (2244) are also considered under Major Structures, and Tubular Towers (.214) suggesting similar constructions though one may be of piping or tubing; the other of flat steel or wood construction. Skeleton Towers (.218) are perhaps much like those of major lights though of reduced stature. A dolphin (.215), in many definitions, is a series of several pilings in a tapered arrangement fastened together at the top by cables or other bindings. Pile Structures (.212, .213) are of piling or timbers in a roughly rectangular or square form; pile structures on land may be similar to marine forms though adapted to materials and construction techniques of land foundations.

If semantic ambiquities are latently present with other portions of this classification they are rampant in .22 and .23. (Single Members with narrow, wide configurations). A lengthly study could be made of the single-member forms alone. This compiler has located more than a dozen single-member markings, and this list is not definitive. It is possible that the division into more slender and less slender may help to distinguish between various forms of Single-Member Markings. This has been done in this classification though the dividing line is at best uncertain and possibly arbitrary. Obelisks, Pylons, Pillars, Pedestals, and Columns represent bulkier parts of the sections while Stake, Spindle, Spar, Post, Pile, and Pipe are the more lean types of Single-Member Markings. Cylinders can either be of this category, or among the enclosed markings types, since Cylinders can be hollow and equipped with a door; that makes them more akin to a small Hut than to a Post . However, cylinders are included only with the enclosed markings in the present classification (.244 within enclosed and solid configurations, .24). Further research may clarify the status of the cylinder and expand its presence in the study.

Enclosed minor structures should perhaps be subdivided as well. A possible point of demarcation may be between dwelling-like or hollow forms versus solid and bulky or filled varieties. However, the classification remains at an early stage and only a single category is provided. Huts (.240) are presumably small house-like structures; the term is commonly associated with Australia. Small house, .241, a term found in the US, is not necessarily a house at all. Many of these traditional "houses" are three to four feet (about one meter) square and perhaps 10 to 15 feet (3-5 m.) high. The expression hut might be more acceptable than house. Cairns (.242) are heaps of rubble or of masonry; in some instances Pyramids (.211) is in multi-members; it can belong to both classifications. Pyramids may be similar to cairns in materials though it is more shaped than cairns.

Beacons (.243) is a more troublesome term and yet it is necessary to include it. Beacon can include many of the components of this classification and it may also be a general term merely indicating the supporting structures, of whatever form, of a minor or lesser light. It can also represent a specific type of marking; for example, in IHB and IALA publications, it is a spindle, spar or perch. It is included in this classification to satisfy any need for it as a marking that may exist in some nations. It is possible that Beacon is a blanket term or it may simply refer to undifferentiated aids to navigation lacking a distinct form.

Many minor lights are found on composite structures (.24 includes composite as well as enclosed and solid constructions). These combinations include various supports already found in this classification. Major forms include Small Houses (.241), House/Huts (.245-.247). Structures can include Pile Structures, Dolphins, or Tripods. The variety of possible combinations proves difficult to chart.

Finally, there are isolated markings (.25, Single types) that fall outside the above described categories despite the broadness of these categories. Two such markings are the Stand (.250) and the Arm (.251). The Stand is difficult to define; it may be akin to Single-Member markings or to composite forms. For the present classification it seems best to classify it as a special and separate form. The Arm is probably attached to some other structures though this may be, for example, a port building, not an aid to navigation structure. It can also be viewed as a composite structure. The last marking in this category is that of the French Lighted Bank (.252). This aid consists of multiple lights set in a metal railing (in some instances it resembles a US guard rail) and are found in harbor areas. The final entries are an anomaly for marine aids: all lighted forms. They appear in variant classification for both major and minor aids.

5C Descriptive Treatment of Structures Types

A study of types of towers for structures of marine lights is not easily accomplished. There are seemingly no international agreements on sizes and shapes. The diverse needs, designs, cultures results in a nearly bewildering spectrum of structures. Though there are some general principles and guidelines that can lead to some understanding of the types of structures. One such guideline was proposed by a pair of lighthouse engineers writing in the first years of the 20th century. The engineers in question, W.T. Douglass and N.G. Gedye, wrote an essay for the *Encyclopedia Britannica* (1910-11 edition, XVI, 627, 651). The publication in question and the age of the essay may appear to be questionable for this study, but this is not necessarily the case. The early 20th century represents the late stage of major lighthouse development. Britain represented a significant center for lighthouse design and construction and the article in question is authoritative in a time when lighthouse phenomena was of considerable interest. The general interest in things maritime and especially in lighthouses, can be seen in the exhibits at the Centennial Exposition in Philadelphia in 1876 and the Panama-Pacific Exposition in San Francisco in 1915 (2nd edition of this study). Even the awarding of the Nobel Prize for physics for Dalen's sun valve in 1906 suggests the more central position in public awareness of this area of endeavor.

Douglass and Gedye divided all lighthouses into two sections: wave-swept towers and land structures. The sea-girt towers, though a minority, provide the more spectacular and even romantic portion; the land counterparts, though somewhat resembling the exposed versions, provided less of a challenge in design, construction, and building techniques. The "front-line" towers are either enclosed or openwork structures. The former are built up of masonry or cast-iron panels. The later represent a Victorian-era version of the more modern oil-well influenced offshore platforms. Remaining are caisson-based structures that allow for more conventional superstructures (USCG 1964, Ch. 4, 4-9, 4-10).

There are greater difficulties in dividing land towers into subcategories. US Coast Guard provides an approach in their 1964 *Aids to Navigation Manual* (Ch 4, 4-1).That approach divides land towers into those on islands and headlands, and those on low-lying elevations. This is not a precise differentiation and may easily degenerate into arbitrariness. At the least it can suggest the massive soaring towers on the one hand, and the short and even squat towers on headlands on the other. In turning from major towers to minor light structures one finds yet more uncertainty. Some of these structures display lights that are very much minor with reduced light intensity but similar structures may support a light defined as major by IALA though of lesser importance and not a landfall light. Despite the difficulties it is possible to make some progress toward defining and classifying structures (See *Foundations*, Ch 2).

There is a limited range of design possibilities for towers exposed to direct action of waves. Among enclosed wave-exposed or sea-girt towers many are of a cylindrical or conical shape with a tapered base. Conical towers, which are probably the most common, are cylinders with a slight to moderate upward slope. Cylindrical towers are of a more straight design though they frequently, as in the case of the great landfall lights of Britain, have a very pronounced taper in the lower section. Most of these installations were built in the 19th century. A few were constructed in the 18th century and a small number in the 20th century. These towers are almost uniformly of stone construction without coverings of stucco, paint, or other substances; the action of the sea would prevent anything beyond the solid unadorned surface to survive. Towers fastened to larger outcroppings or small islands are more akin to land installations than to sea-battered towers.

There are other forms of exposed in addition to solid towers. Two of these are skeleton structures or towers. The older versions of this type consist of a tower on iron pilings; the ill-fated Maplin Light in the Thames is one such example (Bowen 1947, 7). The "popular" lantern house on a "square pyramidal skeleton tower on pile foundation" is a familar feature of the US Florida Keys, and it bears a substantial resemblance to the Maplin type (USCG LL Atlantic (south) 1970, II, 9; USCG 1964, 4-3). In both instances, iron piles were driven into the sub-surface terrain upon which the tower, dwelling, and lantern house were built (USCG 1964, 4-10, 4-11). Several smaller versions of this type were built in the early years of this century in the Florida Keys (USCG A/N, 1965, 1977, 4-9; IALA 1979-2, 37).

More recently a new form of skeleton structure has been placed at sea. The modern version is designed after offshore oil platforms. It is usually located in shallow waters and serves as a replacement for lightships. It consists of a tower or house on a superstructure which is in turn mounted on four massive pilings. The elevation of the light can be as much as 100 feet (30.5m) above the surface of the water. A final type of exposed structure is the caisson-based light. The caisson -- of which there are several varieties -- is assembled on land, towed to its site and then sunk. This presents a firm foundation which allows for a more conventional tower or tower/house structure. While some caisson-based structures are in exposed waters, they are more generally found near the coastline and do not necessarily belong to the first line of landfall lights (USCG 1964 Manual, 4-10).

Douglass and Gedye note that land towers are of normal design character. This may be true, when compared to exposed towers. However, Tall Coastal Towers represent a special category and bear at least limited relationships to marine locations. It is not possible to speak of a specific range of heights for these towers. But USCG in 1964 gave examples of various forms of Tall Coastal Towers. And the heights ranged from nearly 140 to just under 200 feet (USCG 1964, 4-9). Tall Coastal Towers are likely to be 100 feet as a general minimum. Towers on promontories are shorter and in some cases they do not exceed 50 feet and some may fall short of 25 feet (information from USCG LL).

The range of possible shapes for land towers is obviously greater than for sea-girt towers, though design and construction limitations are still operative. Many or most of the towers are conical or cylindrical in shape; conical are probably the most common form. Other designs include octagonal, pyramidal and hexagonal towers (Design information comes from a survey of USCG publications). Composite shapes are in use though relatively rare. Composite shapes are in use though relatively rare. Composite forms include truncated-pyramidal-octagonal, which may be the ultimate in combining independent designs (USNOO LL 1967-72 including HO Publ. #111A). Nearly all tall towers are enclosed though a somewhat rare skeleton tower can be found in use (USNOO including HO #111B). Despite differences in shape and construction materials, these towers present a quickly identified mark from the sea; hence their value as primary landfall markings.

The types of towers common to low elevations are also found at other locations. Tall coastal towers include a restricted range of forms, but at lower elevations designs include a broad range of shapes. These include shapes associated with tall towers (admittedly there is a significant difference in height). Towers for other land-based lighthouses include hexagonal, circular, cylindrical, triangular, square, octagonal, rectangular, quadrangular, and conical (USNOO including HO # 113). Some other forms are truncated: conical, pyramidal, and octagonal. While others are composite. These include truncated-octagonal-pyramidal. Again, many towers are enclosed though some are skeletal in form. Skeleton towers come in square, pyramidal, and triangular forms. Many are in some way or other attached to other buildings. These other buildings often take the form of houses and other dwellings. Tower-house combinations include a simple attachment of house to tower; in other cases towers are found growing out of the house or other structures. Yet other composite forms include towers on foundation bases, on piers, and on other forms of building construction (Statistical summation from USNOO publications includes remainder of sub-chapter).

Some light supports are listed in light lists simply as structures. This does not provide very much information as to shape and other dimensions of the supporting structure. Nonetheless, more data can be gained from these barely described, undifferentiated structures than the word "structures" first indicates. For one thing, structures are outside of clearly defined types of architecture: they are neither houses or towers nor buildings. Many are presumably rectangular or square and of various conventional construction materials. In sum, the supporting structures are an assemblage of materials put into a recognizable form which has some type of simple shape but are outside the standard categories. The building materials would conceivably include wooden beams, pilings, planks. Great height is presumably not a keynote of undifferentiated light supports. It is possible that any dividing line between structures and skeleton towers may well be arbitrary; nevertheless structures in this sense, and skeleton assemblages, suggest a lighter, more open appearance, while structures suggest a bulkier, less "airy" appearance. The shapes of structures include octagonals, pyramidals and quadrangulars; rectangular and hexagonal shapes are also in use. Confusion in differentiating between types is heightened by such terms as "skeleton structures."

Land structures beyond these somewhat distinct types quickly descend into a disorderly mixture of near-countless kinds of light supports. Some of these may well be major structures while others are part of the IALA-defined major structures though they may be similar to river and harbor types; yet others are definitely in the minor category without regard to what definition is followed. The casual and even the knowledgeable observer will not be able to say that a given light is in this or that category without also considering the intensity of the light, daymarkings and inclusion/exclusion in a buoyage-beaconage system. These structures, upon examination, wend their way in and out of categories that are imposed upon them. A hasty glance at what this compiler terms "single-member" supports will churn up pipes, posts, piles, columns, piling, single piles, masts, stakes, pedestals, pylons, pillars, obelisks. Supports of multiple members become mind numbing as one reads off frames, pipe towers, tripods, dolphins, tripodal towers, stands, trellis-towers, skeleton masts, lattice masts. Yet other supports are more solid in girth: pyramids, pile-structures, cylinders, huts; small houses on tripods, on piles, on dolphins, on piers, huts on piles and other foundations; and columns on towers.

This lengthly spectrum of supports still does not exhaust the possibilities. Some nations simply list minor supports as "beacons." It is not easy to determine what these are. It may suggest that the support is not significant to the light; it may suggest that only the daybeacon or marking dimensions are to be considered by the mariner, or that the beacons follows the shapes outlined in international agreements. In some instances detail are given, and this at least suggests a form. Some are listed as square beacons or quadrangular or rectangular beacons. This may represent a cairn or a slatted wooden structure as in the case of Norway. The beacon forms known as perches and spars are only infrequently found in light lists, though they are the most common terms for beacons in international publications on buoyage and beaconage systems. The expressions stake, pile, pole may encompass what are termed perches and spars.

The classification preceding this segment attempts to at least outline and suggest the vast range of types of supporting structures. Despite the diversity and scope of these supports, the listing in this study can not pretend to be exhaustive or definitive.

5D Messages Systems for Lighted Aids

5D1 Light Phase Characteristics

This sub-chapter includes two sections: light phase characteristics, and an amalgam of topics including the use of color, day messages for major lights, and diverse message information for minor lights.

Marine lighted markings, of all types, do not have the controlled message indications familiar to road and rail system. There is not a narrow number of message possibilities and patterns for marine markings with nothing beyond that. Marine messages generally fall into broad general categories, and the specific message for each marking is determined on a case-by-case basis. Though some classes of characteristics may be reserved for specific functions. Marine markings present an unchanging message to the user even though that message may be complex; this is contrary to the changing messages of road and rail situations. Some measure of guidelines and norms for the types of light characteristics are available for buoyage and beaconage areas, but there is little in the way of guidelines for major lights and minor lights of an isolated version. Perhaps paradoxically, a numerically small portion of marine aids to navigation -- that of the major lights -- manifests the greatest degree of complexity and diversity for this study.

This coverage of messages consists of a review of categories of light phase characteristics. Statistics are not available on how much different patterns are employed. Flashing patterns are obviously the most common. Information is not readily available on characteristics more likely in use for major lights and minor lights. Message characteristics also include some mention of the role of color. All of the characteristics provide identification of a given light, define specific functions, and prevent confusion where a great many lights are in close proximity.

The basic sources for light phase characteristics are IALA-prepared publications including its study of lighting, IDAMN, publications on the buoyage systems (IDAMN, Visual Aids and IALA Supl. #6, 1976). A variety of publications from UK Admiralty, US DMA (and past and future names for that agency), Canada (CANS and F & O), and USCG over 30-40 years also provides information. IHB publications can also have a bearing on data as well.

A strong consensus has been established over the past

30-40 years in regard to light phase characteristics. The IALA buoyage and beaconage system has been a major factor in building that consensus. Older names and some characteristics have faded out of use. However, many of these older names and characteristics can be found in maritime literature. This study has bypassed most of the non-current terms. However, *T-M Database: Marine* includes a broad selection of past and present terms as well as variations of basic terms. That volume can be consulted by those readers wanting a more complete coverage of the subject.

The fixed light characteristic can be described as a light of a single color of an unvarying, steady and continuing nature (IDAMN, 2-5-105).

Occulting lights are those in which the light is of longer duration than the darkness for each period. This is the opposite pattern of flashing. It is also known as a single occulting light (IDAMN, 2-5-170).

Group-occulting lights place the occultations together. The amount of light within the group is more than the duration of darkness. However, the light period is shorter than the spaces between the groups (IDAMN, 2-5-180).

Composite Group-occulting characteristics follow the previously described patterns except that the groups are of different numbers of occult-units. For example, an occulting light may have a group of three occults, and a group of four occults (IDAMN, 2-5-185).

Isophase, or equal-interval, consists of dark and light sections of equal duration (IDAMN, 2-5-165). At one time some nations included this type of characteristic under the occulting heading; in those cases occulting included all flashes in which the light was at least equal to the duration of the darkness element. This appears to be no longer the case (Bowen 1947, pl. 7, 9, 10; fig. 3).

Flashing lights, of single-flashing in IALA parlance, can be variously described variously as a brief showing of light in relation to the accompanying period of darkness, and a light in which the light occupies less time in the period than the time of darkness. The flashes would have to be less than 50 or 60 per minute or they would be classified as Quick Flashing (IDAMN, 2-5-145).

Long-flashing light is comprised of a single-flashing light whose flashes are at least two seconds long. Long-flashes are occasionally found in tandem with other light phase characteristics (DMA 1983, viii).

Group Flashing includes light phase characteristics in which two or more flashes are combined per period. IALA defines this as two or more groups, but DMA and USCG require a minimum of one group (IDAMN, 2-5-155; USCG, LL, Atlantic, I, 1979, viii).

Composite Group Flashing is a variation of the above. It includes groups of varying numbers of flashes in a period; for example, a group of two flashes followed by a group of three flashes which, in turn, is followed by a group of two flashes (IDAMN, 2-5-160).

Quick-Flashing Lights consist, in IALA's definition, of flashes of "rapid alteration." (IDAMN, 2-5-140). IALA does not give a precise figure. Both DMA and USCG state that this light will exhibit 50-79 flashes per minute (USCG LL Atlantic, I 1979, viii; see DMA lists; USCG list: 50-80). IALA buoyage system states that Quick-flashing lights are either 50 flashes per minute or 60 flashes per minute; the difference in flash rates depends on the type of equipment in use (IALA Supl. #6, 1976, "System A", 7).

Group Quick lights in DMA nomenclature consist of groups of flashes at regular intervals. Group Quick can be combined with Long Flashing characterstic described earlier. (DMA 1983, viii).

IALA describes the Interrupted Quick Flashing characteristic in terms similar to that of Quick Flashing except that the interrupted form flashes are separated at set intervals by lengthly eclipses of darkness (IDAMN, 2-5-195). DMA gives the interupted interval as four seconds while the USCG indicates they are five seconds in duration (USCG LL, Atlantic, Vol. I, 1979, viii; also DMA). It would not be possible for a light so defined to flash 50 or 60 times per minute but the rate of flashing is in that ratio.

The IALA buoyage system has developed a new characteristic termed the Very Quick Flashing. It consists of a steady flashing light of either 100 or 120 flashes per minute (80-159 in DMA). The difference in IALA publications of the flash rate is due to the differening capabilities of flash-producig mechanisms. (IALA MBS, Preface). The characteristic was developed for cardinal messages. DMA terms this characteristic as the continuous Very Quick characteristic. (DMA 1983, ix; Bury 1978, 142-143).

DMA lists three variant forms of the Very Quick: the Group Very Quick includes a series of flashes per period; the Group Very Quick with Long-Flash; and the Interrupted Very Quick which is composed of groups of flashes separated by regular and lengthly eclipses (DMA 1983, ix).

DMA also includes two forms of Ultra Quick characteristics. The continuous form consists of a series of flashes with a rate of at least 160 per minute. The interrupted version contains flashes separated by lengthly eclipses of darkness. (DMA 1983, ix).

The final characteristics are long-established light patterns. The Morse code characteristic is made up of flashes of various durations that form a chain of letters emulating Morse code communications (IDAMN 2-5-200).

USCG and DMA include a Fixed and Flashing characteristic but this is not found with IALA. This signal consists of a fixed and steady light punctuated at regular intervals by a flash of greater intensity (USCG LL, Atlantic I, 1985, ix; see DMA introductory section). The Fixed and Group Flashing characteristic formerly employed by the USCG appears to be defunct (USCG LL Pacific, III, 1962).

So far, this discussion of characteristics has referred only to single-color lights. Lights of more than one color are referred to as Alternating which IDAMN defines as a "rhythmic light showing light of alternating colours." (IDAMN, 2-5-205). But no further details are given. DMA notes that alternating lights can be used in tandem with many of the other characteristics. This then can be regarded as a final characteristic in itself (DMA 1983, viii-ix).

Germany has developed several characteristics which approximate more commonly known types of lights. The firsts of these is known as the Blitze. It is defined as an "appearance of light of duration of not more than one second;" (IDAMN, 2-5-125 and par.). This suggests the Quick Flashing type since both are operated at a rate of 60 flashes per minute. Secondly, the Schein calls for "an appearance of light between two darkness segments; the duration of darkness being not longer than the duration of light." At least some forms of the Schein are similar to the isophase characteristic. Finally, the Blink is of a minimum of two seconds duration and it would appear to give flash patterns. IDAMN regards the Blitz and Blink as flashing characteristics.

The IALA buoyage system provide norms on the use of various types of characteristics for many situation. The new Very Quick Flashing pattern was designed for cardinal buoys and presumably is not used elsewhere (IALA 1976, "System A," 3, 7). The Morse code characteristics in North America is reserved for buoys at entrances to harbors and bays and is not usually found with fixed markings (CANS fold out; USCG LL). Fixed lights, which were once the only characteristic, are a relatively rare pattern, and probably few major lights exhibit such a characteristic (based on an examination of LL). Flashing lights of one color are the most common pattern found in marine lights.

In summary, light phase characteristics are complex in the abstract and seemingly shrouded in mystery for the unitiated. The actual encounter with marine lights is much simpler. The mariner is coping with one or at most a half-dozen lights at a given time. When equipped with charts, light lists, and theoretical knowledge honed by experience, the navigator can quickly and accurately identify the correct light.

5D2 Special Lights Messages, Major Lights Day Messages, & Minor Lights Messages

White, red and green are nearly universal colors for marine markings. For major lights white is the most commonly employed color by a wide margin (based on examination of light lists). This practice exists in large part because of the greatly reduced range of red and green. Some high intensity lights (e.g., Xenon flashing lights) exhibit a slightly different white "color" but one that is within an accepted definition of white. Infrequently other colors are in use for coastal and other significant lights. Canada, for example, occasionally uses yellow for designated lights (USCG LL, Pacific, III, 1985 includes BC). And for minor aids yellow has become a standard color for cardinal buoys in the IALA system.

One special type of light within the major category is the sector light (IALA Supl. #6 1976, 5). This light "presents different characters (usually different colors) over various parts of the horizon of interest to marine navigation." (IDAMN, 2-5-215). A major reason for the sector light is to point out special features such as dangers to navigation; red, of course, represents dangers. An example of a sector light -- and a three-part one at that -- is the Walter Rock Light in British Columbia. The main light of Walter Rock is a group flashing white light. In addition there are sector lights in a fixed color pattern: the white, red, and green sectors each cover from four to seven degrees of the compass (USCG LL, Pacific, III, 1979, 178). In some nations the sector light is known as a light with sector (s) (see French-language side of CANS, 6). The directional light -- which can be seen to be at least distantly related to the sector light -- points out multiple channels rather than specific danger points.

There are two -- and three possible ingredients -- for a lighted marine marking: the light and its characteristics, the structure supporting the light, and the day message systems applied or attached to the structure. Day message systems can be a formal, design method of creating a message. But the structure in itself can constitute a message. The structure can support a message system or it can be both support and message. There are no hard and fast rules for daymarks in aids to navigation which are not part of a buoyage/beaconage system. The daymarks on fixed lights and certainly on major lights vary from nation to nation and even from light to light; nonetheless, some general remarks can be made.

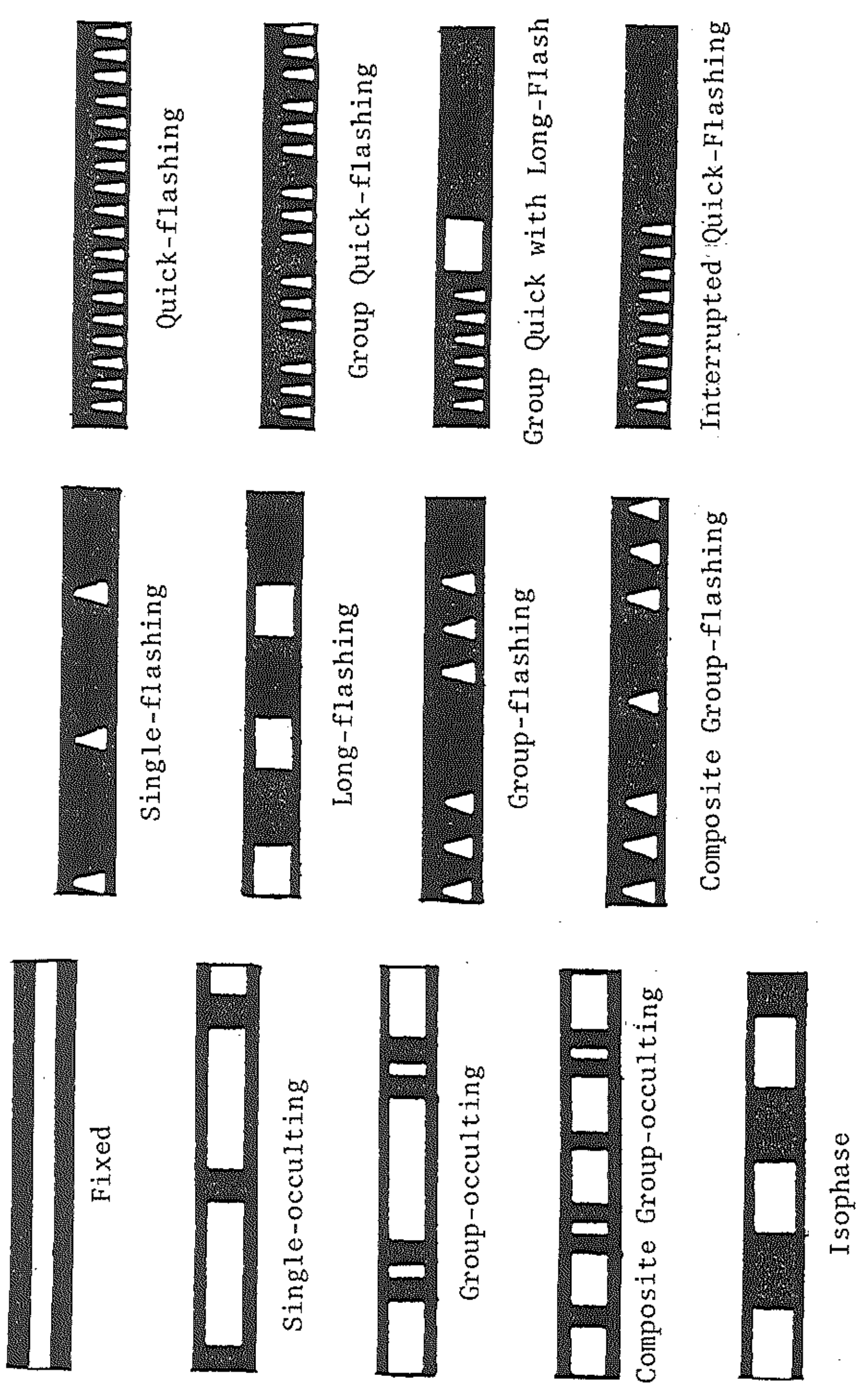
The great sea-girt towers need not have message characteristics other than the light and tower. The massive visibility of such towers needs few, if any, extra aids. Some of these towers may have the lantern house, gallery, trim and ancillary buildings painted in different hues from the tower; for example, Peggy's Point Light in Nova Scotia, and North Point Light in the Netherlands Antilles, illustrate some uses of alternate color schemes (SF 1971, Nov-Dec, back cover; SF 1973, May-April, back cover). Of those towers that are painted, stuccoed or otherwise altered, the greatest number are painted; this seems to be true of lights around the world (based on examination of USNOO publications). In a great many instances the towers are solid white without additonal stripes, bands or other designs. Painting the upper portion of a light tower may well be a common practice, but it is not known how common, since a number of nations do not always indicate in light lists some of the more limited markings on towers. For example, in the US some lights exhibiting a black, red, or other color lantern are not so indicated in the light list, yet other similarly marked towers are so listed (e.g., Yaquina Head Light, USCG Pacific, LL 1979, 9).

For lighted towers that are not white, what other colors are in use? It would appear, based on various sources, that red is the second most common color (based on USNOO publications). Red can provide a contrast to a white background; for example, Longstone Light in Scotland is painted red because of the surrounding terrain (Bowen 1947, 23). Other light tower colors include black, and yellow; chrome yellow is the most common color in Iceland; presumably to create contrasting background hues (USNOO publications; Iceland LL 1968). However, the most common color scheme for lighthouses, after white, is not a second color but a composite pattern.

A diverse and numerous grouping of worldwide lights exhibit stripes, bands, checks, diamond or two-color patterns. Stripes, which are vertical, are often single, though multiple stripes are not unknown. Black or red stripes on white towers seem to be more common than any other arrangement. Stripes can distinguish one tower from another, and they can provide needed contrast with natural terrain; for example, at least one Canadian tower is painted red with a single white stripe. The red provides contrast with the snow and the white stripe distinguishes the tower from surrounding autumnal patterns of colors. (from survey of USNOO publications).

Some nations also paint bands on towers; the colors of these are likely to be those colors used in the painting of towers, and colors used in painting stripes on towers (e.g. Beachy Head Light, UK in Bowen 1947, 23). Bands also include brown, orange, and blue. Some bands are horizontal, some spiral, others diagonal; the last type presenting a diamond-shaped appearance. Checker patterns are occasionally used; black and white patterns seem to be the most common design. Yet other towers are in two colors; one color for the upper tower, a second shade for the lower section; an example would be Saint Davids Lighthouse in Bermuda. A second two-color arrangement would have the middle section in one color and a second for the top and bottom sections. The range of colors for these designs includes black and

LIGHT PHASE CHARACTERISTICS



white, red and white, red and yellow, aluminum and green, and gray and orange.

To sum up, it is necessary to quickly identify a tower, and to distinguish it from neighboring lights. Buoyage and beaconage follow agreed-upon message systems, but more significant lights do not have a system of day messages readily at hand. Hence, an easy means of locally identifying each unit is needed. Stripes, bands, checks, multi-colors as well as a welter of solid hues provide a major means of daytime identification.

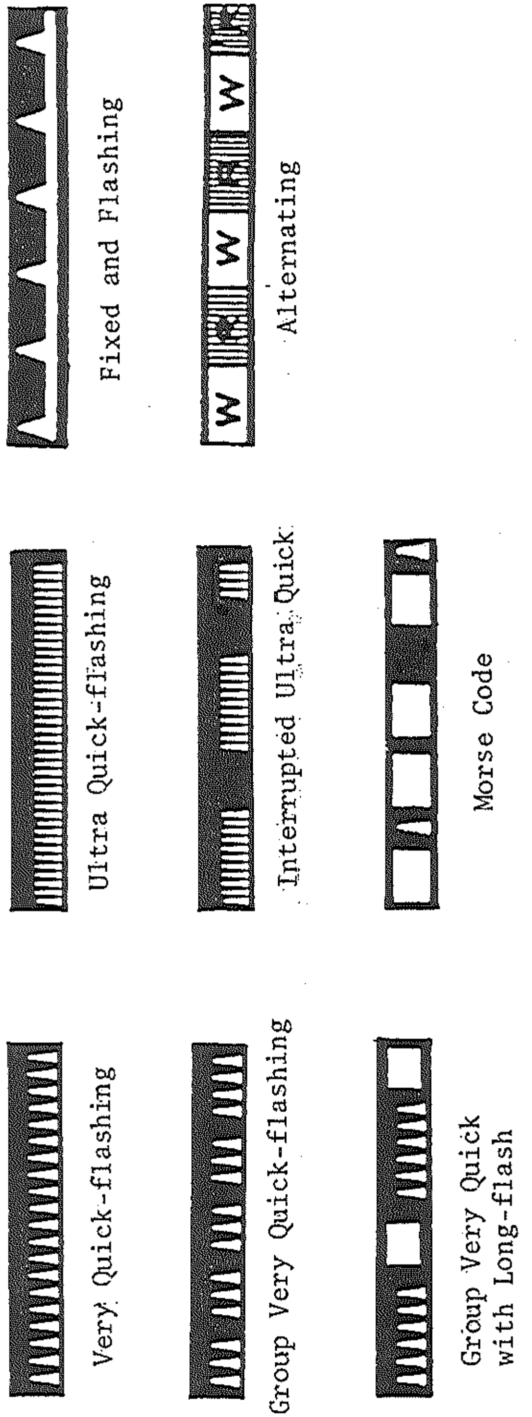
A review of messages for minor lights requires a different approach: only a limited portion of the material for minor lights will appear in this segment. Most of the materials are found in other parts of the monograph and can be located by using the index of such materials found at the end of this section. This format stems from the fact that various parts of light message systems for minor aids are found not ony with major aids, but also with buoyage/beaconage materials. There is no need to reprint that information here.

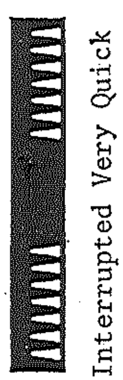
While much of the message systems for minor lights can be found in buoyage agreements, it may be asked if minor markings messages are thereby complete. This is not an easily answered question. According to the IALA system, all minor lights are included except for certain stated exceptions: the category of major aids to navigation, and also range and sector lights (IALA, Supl. #6, 3). According to the USB, minor markings are included, though one cannot say with certainty that all are (Conference papers, LN, 1930, 1936). IMC was couched in more general language, and therefore it is more difficult to say what was included (IMC POP 1889). But it does seem that all aids to navigation in proximity to buoys were not included. In the US minor lights were not formerly marked to the degree that buoys were; however, of late all minor markings are in the lateral systems for directional and range lights (cp 1962 Pacific LL with a current listing). In Canada, which also stemmed from IMC, it would appear that minor lights were included, especially with the advent of IALA (if the writer understands the change in that system). Lights of various national outside of IALA are in the process of being integrated into IALA in many instances.

In general terms, one might say that harbor and river and non-coastal aids to navigation follow the local pattern of messages or at least do not contradict it explicitly. Some attention will need be given to isolates which are more minor than major though they are outside the appropriate message system.

Index of materials for messages of minor lights:

Unlighted Messages	Chapter 6C
Structures (Daybeacons)	Chapter 6B
Message Systems (Buoyage)	Chapter 4A-B-C
Light Phase Characterstics	Chapter 5C





Illustrations include those of DMA and USCG. Other illustrations are influenced by IALA while others are alterations and assemblies of existing light lists.

markings" exemplifies the problem. Other terms (beacon, daybeacon, unlighted and/or fixed beacon) compound the problem. Terminology seems especially difficult in English-language publications though perhaps it is no less a problem in other languages. It becomes necessary to examine various terms in order to decide what may provide a more adequate term to describe unlighted and fixed marine markings.

The most likely term may appear to be that of beacon. It is true that frequently the term beacon refers to small marine aids to navigation that lack lights. IALA reserves that term for unlighted fixed marks in surveys of marine marking. However, beacon can also include lighted markings and even buoys. And to compound the confusion, the word can be used to include all types of Transportatation-Markings (WTNID 1961, Vol. 1, 189). What alternatives to beacon are available? In Canada and the US the word for fixed, unlighted markings is daybeacon. This usage reduces confusion with beacon and leaves that term as a general designation for all marine aids to navigation (USCG LL Pacific, III, 1985, x). In the UK the term beacon is employed for unlighted markings though IDAMN adds "unlighted" in parentheses to eliminate confusion in the definition (IDAMN 2-6-030).

In France the expression "balise" is generally applied to unlighted beacons though IALA adds the qualifying term of fixed (IALA 199/3, 3, 16, 18). In the German language the word "bake" includes unlighted fixed beacons (Dietal & Lehmans 1964, 57). IHB definition of beacon appears to be all-encompassing in some instances but confined to day-usage in many other situations. IHB uses the term beacon at times for both lighted and unlighted types; at other times this applies only to unlighted, or only to lighted. (IHB 1956, 1971).

CHAPTER SIX

DAYBEACONS

6A Introduction, Terms, & History

6A1 Introduction & Terms

A study of fixed, unlighted marine Transportation-Markings can prove to be a difficult matter. Obviously, such markings suffer a marked degree of anonymity and this, in itself, can be a problem in a study of markings. Many persons may have some awareness of lighthouses, fog signals, and harbor lights but they may have no awareness of unlighted, fixed beacons. This anonymity is not due to their small numbers, since they constitute a large category of marine markings (IALA 1979/2, 23), but rather to their often small, simple form and unpretenious message systems. A cairn or perch may be noticed only by the actual user, while a coastal lighthouse will receive a great amount of attention from tourists, painters, and photographers. Bob Trapani in his website spoke of the daybeacon as having "no shining light, dutiful bell or raucous horn; nor do they possess a beautiful superstructure, but make no mistake about it, the daybeacon is a lifesaver just like its aids to navigation cousins, the lighthouse, light tower and buoy" (Trapani 2008). Yet this anonymity may not be the primary problem in itself though it does mean less documentation for the researcher.

A more basic problem with unlighted fixed markings is one of terminology: what to call these markings. There is little if any terminology problem with buoys, fixed lights, and fog signals (at least not until recent years). The long and awkward term "fixed, unlighted marine transportation

Daybeacon, even though its choice might engender some controversy, appears to be the best possibility for a term for fixed and unlighted markings. It is descriptive of the aids to navigation in question, and it eliminates at least some of the confusion and uncertainty of other possibilities. Use of the French balise and of the German bake may be utilized in appropriate situations in the monograph.

A final term that may increase an understanding of markings (though it may also add additional confusion to terminology) is that of daymark. This term finds it predominant usage in Canada and the US, though nations outside North America have employed the term. In a broad sense it refers to "a distinctive structure serving as an aid to navigation during the day whether or not the structure has a light." (Bowditch 1966, 920; see also USCG LL). In both the US and Canada it has a more specific meaning: an object which is an addition to the structure of an aid to navigation and which adds an additional message capability. Both lighted and unlighted aids frequently include a daymark. However, daymarks can be either a specific device attached to a structure or it can have a broader meaning of the day dimension of a structure. Major coastal lights are usually sufficiently distinctive so as to not to require further identification but the structure serves as a daymark. Many daymarks for minor lights are of wood construction and come in various shapes including rectangles, triangles, diamonds, and squares. Daymarks are often required to fit into a message pattern dictated by a given buoyage and beaconage.

IDAMN notes that "in the U.S. the word daymark is often used for a topmark." (IDAMN 2-6-030). This is only partially true. Topmarks are frequently small in dimension while daymarks are considerably larger. Though there are instances in which topmarks are about the size of daymarks. This is especially true of topmarks for some types of Norwegian daybeacons (IHB 1971, 57). Topmarks are more often associated with buoys, and daymarks with fixed aids to navigation.

6A2 History

A history of beacons or daybeacons can prove to be an elusive topic. Very simple forms (such as tree branches) are not accompanied by many records. Nonetheless, there are source materials available for this topic. A primary source for this is John Naish's 25-year old *Seamarks* (1985). It is not a lighthouse treatise with some add-ons for related topics. Rather, he explores a wide range of marine aids to navigation with a notable emphasis on the less known seamarks of unlighted (or day) beacons.

A welter of daybeacons forms grew up over many centuries. The development was often local or at most regional. Major types of beacons include tree branches, slender constructions (pole beacons), more complex structures (large tripods, wooden constructions), large complex structures (Kapen) and structures that are solid or enclosed structures of brick or stone. Comments about these aids can be detailed if local though brief if in an overarching perspective.

The "planting" of tree branches as channel markers may go back to early human history. (Naish 1985, 28). The use of tree branches has continued as illustrated in IHB 1956. Rivers flowing through a complex terrain and channels such as that of Frisia created a challenging waterways requiring channel markers of trees and tree branches. (Naish 1985, 28)

They have gone by many names including Pricken (Dutch and German). The English equivalent is Withy. (Naish 1985, 28). The French Petit Arbres is seemingly similar in meaning. (IALA 1983 Survey footnote). Naish notes that this simple aid was also used in Scandinavia for land navigation. (Naish 1985, 28).

Pole beacons are more of a human construct though the term can have several meanings. They were in use in UK in late 17th century, and possibly earlier on the northern European coast. Topmarks of birch branch besoms (brooms) were attached to Pole Beacons in Denmark at an early date. Placing the besoms with point up for one side of the channel and point down for the other side marked off the north side from the south side. (Naish 1985, 31-33, 40). Some forms are more substantial and of a tripodal design (Naish 1985, 44). Large Beacons in a tripod form date back a thousand years or more at Venice. (Naish 1985, 29, 40). Some tripod beacons, known as dolphins, were installed on marine sites in UK (Naish 1985, 47).

A more complex structure known as a Kapen was employed on low elevations in northern Europe. The term comes from the word Cape and the human-built version was a kind of artificial headland on low level elevations in northern Europe. They date back to the early 18th century. (Naish 1985, 29, 40). Constructions more complex than pole beacons yet simpler than Kapens were also in use. Examples of this form are employed in Norway down to the present. One notable form is a moderately large wood construction of timbers and slats. It is termed a bake (Norway NS-NS). Landfall Beacons in 18th and 19th century UK resembled Kapens (Naish 1985, 47).

Enclosed structures were also employed in various locations and employed several forms of building material. Stone beacons in a tower shape were employed on the French coast and in a variety of places cairns of stones were built up at key points. Towers of pyramid or cylindrical shape were constructed by Vikings and by Romans in France and Spain. These suggest great age. (Naish 1985, 47). Masonry beacons were constructed in 18th and 19th century UK (Naish 1985 45-46).

In addition to channel markers there were two other specific functions carried out by beacons: Recognition Beacons and Leading Marks. Recognition Beacons were prominent aids clearly visible and identified by mariners. (Naish 1985, 68). In some instances they could be noticed miles out to sea. Kapen were notable examples for both leading marks and recognition beacons (Naish 1985, 29). Leading Marks (or range marks) date back to the late 16th century. Such marks consisted of two paired marks. When lined up by a ship's crew it provided a safe passage through a confused and unclear body of water (Naish 1985, 37).

The long-lasting character of even simple beacons is illustrated in IHB 1956: trees and trees with branches continue in use down to the present. In addition to official aids there are probably many informal simple aids that exist locally and not infrequently they may not be listed in any buoyage or beaconage system.

6B Classification & Description of Daybeacons

6B1 Introduction, Classification & Explanatory Notes

a) Introduction & Classification

This sub-chapter has two themes: a classification of daybeacons in international usage, and description of those aids based on the classification. The classification includes both a main and variant versions. Earlier editions lacked the variant form. Changes in names and types of daybeacons have also taken place as well as changes in nomenclature. Illustrations of daybeacon forms accompanies the text.

The description of daybeacons are divided into types. Types, in turn, contain two components: derivation of the name (at least in its English-language form) and an examination of the function of the specific form.

The earlier edition had separate sub-chapters for classification and for descriptions. The two themes are similar and are therefore placed together in this edition.

Main Forms:

231 Natural Marks
- 2310 Cairns
- 2311 Trees
- 2312 Stone Construction

232 "Artificial" Marks
- 2320 Unidimensional Forms
- 2321 Open Structural Forms
- 2322 Enclosed & Solid Construction Forms

233 Morphological/Physical Forms
  2330 Daymarks
  2331 Daymarks & Structures

Variant Forms:

.26 Daybeacons: Natural Marks
  .260 Cairn
  .261 Small Tree/Petite Arbres
  .262 Tree Branch: Natural State
  .263 Tree Branch: Tied-Down Branch
.27 Daybeacons: Uni-Dimensional Marks
  .270 Spindle
  .271 Perch/Pole
  .272 Pile
  .273 Post
  .274 Stake
  .275 Edgemark
.28 Daybeacons: Open Structure
  .280 Dolphin/Multiple Pile
  .281 Tripod
  .282 Latticework
  .283 Skeleton Tower
  .284 Wooden Framework
  .285 Beacon/Bake, Germany
  .286 Pyramidal Structure
  .287 Triangular Structure
.29 Enclosed & Solid Structures
  .290 Small House
  .291 Enclosed Structure
  .292 Stone/Masonry Structure

b) Explanatory Notes

The 1988 marine classification lacked a variant aspect. forms; that has been added here. The main classification was comprised of five 3-digit categories. There are now three 3-digit categories. Natural Marks and Daymarks were retained. Daymarks now appear under Morphological/Physical forms.

The Simpler Structures and More Complex Structures category was replaced by "Artificial" Marks. The 4-digit entries in that category do not refer to specific aids. Instead, they refer to categories of objects (2320, Unidimensional, 2321, Open Structures, 2322, Enclosed and Solid Construction forms).

Basic forms of aids (e.g. Trees, 2311) remain in the main classification but variations are assigned to the variant classification (e.g., Small Tree, .261, Tree Branches (2), .262, .263).

Basic categories in variant classification are 2-digit preceded by a decimal point (e.g. Natural marks are .26). Fixed aids to navigation are subsumed under .2. Other 2-digit categories include Uni-dimensional (.27) and Open Structures (.28), and Enclosed & Solid Structures (.29). .26 includes cairns and three versions of trees. .27 includes a diverse group of terms whose membership may overlap (e.g. Perch/Pile may be very similar to Spindles and Posts. Though there may be significant differences as well. .28 encompasses a wide range of multi-dimensional forms. Some are simple in design while others are complex constructions.. .29, Enclosed and Solid Structures were absent in 1988. Not only the category but the aids within it were omitted. Many of the 4-digit entries in the previous edition are now 3-digit entries preceded by decimal points in the variant classification.

6B2 Description of Types of Daybeacons

There is a welter of terms describing markings with a single vertical dimension (uni-dimensional markings). As a result it becomes difficult to sum up those markings briefly and with some precison. The various terms may seem to be no more than semantic quibblings with the actual differences only miniscule. The most frequently employed term for uni-dimensional mark is that of Perch. This may suggest that Perch refers to a narrowly defined object. However, IHB uses the term for a variety of national markings, and national markings are not always identical, or nearly so, to one another. It would appear that the various terms are broad in meaning rather than narrowly focussed on a given meaning; if this is not the case then there is a possible, or probable, misuse of many terms. Possibly this is due to the fact that IALA perceives the expression as a French word, and thereby translates the term perch as pole for English language usage (IALA Survey 1979/2, 2). *Navigation Dictionary* includes perch as an English language term. (USNOO 1969, 186). *The International Maritime Dictionary* lists perch as English and perche as French (De Kerchone 1961, 577).

Poles, Perches, Posts may often be much the same in outward appearance and the terms may be interchangeable. IDAMN notes that the Pole Beacon is also referred to as a Spindle and Single-Pile Beacon. However, IDAMN does not include the term perch. The spindle and single-pile beacon can probably be regarded as perches despite the omission of IDAMN. The US has installed a few markings known as Stakes and perhaps they too can be included with Perches and similar markings. (O'Connell with enclosure, 1974). The classification, however, lists the various terms as separate items so as to avoid forcing possibly separate marking types into an incorrect category. It is difficult to determine the correct measure of details in a classification. John Fowles comments in a 1979 essay that it was a regretable habit of Victorian science to minutely dissect living organisms into categories and subcategories (Fowles 11-1979, 49-56 & later pages). In the 20th century the tendency of science is to classify less minutely and to present the larger situation in a given study. The purpose of this classification -- which, obviously, does not deal with living organisms -- is not to create minute classification for the sake of near-microscopic precision but to allow for eventual and more accurate study of the subject. It seems preferable to tentatively subdivide excessively than to create a few categories which may be inadequate, or worse, overshadow and obscure necessary distinctions which may be later lost from sight altogether.

Topmarks, as already mentioned, are primarily part of the message systems. Daybeacons, because of their size and impact, must be considered as part of both the daybeacon structure and message system. Daymarks, in the Canadian and US sense, often require a structure not so much to accompany them or provide extra support but in order to support the daybeacon. Canadian daybeacons are listed, in mot instances, by the daymark portion. The light list usually does not include support structures which are presumably obscured from the mariner's view. Daymarks are frequently of wood construction and of varying shapes. Daymarks can measure as much as seven feet per side though others are much smaller (USCG 1964, Chapter 4, 4-18-19). Some of the traditional forms of unlighted markings in the US, such as small houses, are obscured by the daymark so that the original marking is no longer included in the light list describing the aid. For example, Waterford (Columbia River, Washington state) is listed as a small house in the 1962 Pacific LL but after the addition of a daymark it was relisted as a daymark only since the house was then largely obscured.

A composite daybeacon type includes the daybeacons in which the daymark is attached to the supporting structure in such a manner that both daymark and structure are integral parts of the marking; a variety of US markings are of this form. An example of a composite daymark/structure would be that of the Honga River daybeacon on Tangier Sound in Maryland (Atlantic LL, I, 1979, 411). The aid is a "square green on black slatted pile structure." Since the painted surface is an integral part of the marking there is no way of separating daymark and underlying structure.

The Small Tree, or Petit Arbre, is a very simple form of marking, and a very traditional one. This marking continues to be frequently used despite the development of more complex and sophisticated aids to navigation. In many instances this marking consists of a tree branch in its natural state. In other instances tree branches are tied down, or a single tree branch serves as a mark. For example, this is the practice in the Netherlands according to IHB 1971, 52).

Cairns are not mentioned in IHB publications though they are included in IDAMN (IDAMN 2-6-055). Cairns are piles of stones heaped into a distinctive form at needed navigation points. It is difficult to know how common such markings are since there are limited statistics on the subject. Many may not be found in any list, since local authorities or individuals could pile up such stones at harbor entrances on their volition; many may not have any official standing. (USNOO Sailing Directions, Soenda ..., 1975, 9-10).

Not all daybeacons are as simple as those previously described. There are two major subdivisions among the more complex types. There are the less complex which may be composed of several posts or pilings bound together into a simple framework or construction, and the more complex of multi-dimension shape and of more substantial construction. The major types in the less complex category can be encompassed under the umbrella a term of multiple-piling. This phrase is a frequently used term in the US. IDAMN, however, notes that this type of aid -- of which there are two forms -- has no name in English (IDAMN 2-6-055). Norway includes a variety of iron tripods for daybeacons; many of these include a separate topmark; a limited number of US markings are also tripodal in shape. For example, Craig Point Daybeacon, Alaska. (USCG Pacific LL 1979, 204).

More complex structures include the US Skeleton Tower, the German Bake, the Latticework structure of Norway, and the Wooden framework of Russia. The US Skeleton Tower is a single type of aid though it is capable of varying heights and widths. The German Bake is of two types: one a skeleton pyramidal structure, and the other is a rectangular construction made up of vertical corner posts and interspersed with a series of three diamond-shaped panels (IHB 1971, 36). The Norwegian structure is of a bulky shape and in a latticework pattern; it also has a slightly pyramidal appearance (IHB 1971, 37).

6C Message Systems

6C1 Introduction & Systems

Daybeacons, even though they lack sophisticated capabilities, are more than pieces of wood or metal posts, pilings, perches, or structures. In many instances they have a message system of some distinctiveness: stripes, bands, patterns. These may be as important as the basic daybeacon construction. Formal daymarks or topmarks may also be included in the aid.

A discussion of message systems includes three topics: What systems (or partial systems) provide messages for daymarks? What non-daybeacon message systems can be applied to daybeacons? And what national message systems have been developed for daybeacons? Available international maritime publications suggest that efforts at standardization of marine markings have not seriously focussed on beacons whether lighted or unlighted. However, occasional references have been made to messages for fixed marks. For example, IMC in 1889 included the term beacon in its official documents, though IMC centered on buoyage to a considerable extent. There is also a brief reference to "marks." (IMC Vol. II, 1388-1389).

A system for fixed markings on a par with that of buoys is not to be found in IMC. Though there are references to fixed markings in IMC sections that consider the cardinal system. Messages for beacons are to conform to those for buoys (Previous reference and Vol. I, xii). That is, painted messages are to adopt the standards for buoys: colors are to conform to, or at least not contradict, buoy message patterns. A committee report spoke of the need for uniformity in shape and color for marks and buoys. Topmarks are described by shape and marks, and buoys by color only. The committee remarks did not become part of the final act but they do suggest some correlation between buoy and beacon messages (IMC II, 1322).

The Uniform System of Buoyage established by the League of Nations conference (1930 and 1936) did not include the term beacon or beaconage in the titles of the conference papers. Nonetheless, some mention of beacon is made. The USB calls for conformity of beacon light messages to those of buoys by implication, and presumably day messages are to follow suit. (LN 1930, 1936).

The most recent international buoyage system gives more direct and complete consideration of messages for fixed marks. That system, IALA, specifically applies to "all fixed and floating marks" except "major aids" and certain special markings (DMA, Pilot Chart ... 1977). And unlike previous international systems "most lighted and unlighted beacons, other than leading marks, are included in the system" (DMA, Pilot Chart ... 1977). Topmarks for fixed markings normally follow the shape and color of buoyage topmarks.

The diagrams in publications describing the system include only buoyage types. The omission is caused by "the variety of beacon structures." (DMA Pilot Chart ... 1977). Some revision of fixed aids will probably take place in order to meet the norms of IALA. One nation, The Netherlands, has already done so. It may be noted that the injunction indicating fixed marks should follow the messages of floating markings is found in nearly all international marine message systems though frequently nothing beyond the injunction is given.

In summary, despite the brief documentation that refers to fixed beacons, some general norms can be inferred and a national maritime agency -- by extrapolating from those norms -- could construct a message system for fixed beacons including lighted as well as unlighted forms. These norms include guidance on selecting lights as well as providing some ideas on the shapes and colors for topmarks and daymarks. But there is little illustrated information which describes the types and shapes of lighted and/or unlighted beacons. The existence of vague and uncertain coverage in this monograph maybe partially explained by the lack of international conferences and organizations efforts to construct a coherent system for fixed markings.

6C2 National Daybeacon Agencies

There are eight major systems of daybeacons and their messages based on existing data. These include Canada, Norway, Germany and the US. Other notable users of daybeacons include Finland, Sweden, France and the former Yugoslavia (IALA 1979, 37). Coverage of many of the major users will be complemented by a brief review of other nations that make limited usage of daybeacons. Older figures have been given priority in this coverage. New statistics (2008) include only 24 nations (IALA Survey 2008). This is less than half of older figures.

Daybeacons in Canada are listed by shape and message content, not by structure. In many instances there is no visible structure other than the daymark. Port-hand marks are square with a red border, white inset, and black square center. Starboard daybeacons are triangles with a red border, white inset, and flourescent red triangle centerpiece. Junction daybeacons are diamond-shaped; if the principal channel is to the right the daybeacon has a flourescent red border with a small red triangle in three of the points; the fourth and top point is a green triangle. The center exhibits a flourescent red triangle point downward with a green rectangle atop it. The channel to left beacon is identical except that the center designation is the reverse of the channel to right marking. Contrary to the practice of many European nations, daybeacon messages parallel buoyage message only to a limited degree. (CANS 1975, Canada F & O [2010]]

Norway has about 40% of the structural daybeacons listed in the IALA survey; Norway also maintains a variety of perch beacons (IALA Survey 1984/3, 17; IHB 1971, 57. All references in this section save the first are from IHB). For many daybeacons in Norway the message system diverges from the commonly accepted definition of both daymark and topmark. Special messages consist of arms attached to the daybeacon that point to the fairway indicated by the marking. In some instances there are two arms since the channel in question has two directions of travel; these pointers are usually omitted for markings in heavy and open seas. Norway also makes use of red, green, and white reflectors. These reflectors follow the color scheme of the buoyage system. A white reflector is added when a longer distance from mark to mariner is a problem and when confusion with other messages will result.. In some instances a white/red or a white/green reflector system is added to the marking. At least some portions of the Norwegian beaconage messages are direct extensions of the lateral system of buoyage.

Germany ranks among the largest users of unlighted users of unlighted beacons (IHB 1971, 33-38 and reference for this paragraph and next two) There are six types of beacons in the system, two of which are structural, and the remaining four are either simple constructions or have a natural character. The later four include two variations of multiple pilings, the small tree or petit arbre, and the perch or pole beacon. Each of these daybeacons can be found on either the starboard or port-hand sides for channel edges. The message characteristics of color and topmark are identical to those of buoys in parallel positions.

Structural beacons are found in junction and bifurcation, middle ground, and shoal and danger situations. Buoys lack topmarks though some of the corresponding daybeacons have them; at least that was the case before IALA. Structural marking topmarks -- in junction and bifurcation locations --

include a black triangle with the apex up when the "main channel is to the left" and a red rectangle, with the long dimension vertical, when to the right. The mark has a red and black vertical striped oval "when channels are of equal importance then it is a black cross over a black and red vertically striped oval." Shoals and isolated dangers within the channel may be passed on either hand" and these have a single type of topmark consisting of a black oval atop the structural mark.

This pattern diverges for "shoals and isolated dangers outside the channel" in the cardinal system. In these instances, the structural beacons are joined by perch or pole beacons. The color messages follow the buoy pattern, but the topmark symbols are different. For the northern quadrant the structural mark topmark (and in all cases only this type has topmarks) is a double triangle with the point up; the western quadrant has two triangles, both black with one point up and one inverted inwardly. In the eastern quadrant the two triangles are arranged with the bases in parallel, while in the southern quadrant there are two red triangles facing downward. The same marking, when on the shoal, exhibits the black oval.

US lateral markings (for general usage) include square boards with "flourescent green film" for the major color; green reflector material for the border and reflective numbers for port are added (USCG, 1979, Ch 5 and par). Starboard side uses the same materials but in red and the board is a triangle. Junction markers employ the same shapes with the agreed-upon meanings. If the preferred channel is to port the triangle includes a letter in reflective red and the upper part of the triangle "filling" is red while the lower portion is green. If the preferred channel is to starboard the letter is green and the upper part of the marking is green, the lower portion red. Borders are green or red depending on the shape of the marking. Mid-channel markers are eight-sided with white reflector border and letter. The filling is half white film and half black film. Range markers are rectangular in shape with the long dimension vertical. They include three panels. The panels are of one color and the center panel of the other. Intracoastal waterway and western rivers markings follow the basic patterns but with variant identifying message configurations.

While the coverage of daybeacons of other nations is not extensive it can present some tentative remarks on the range and universality of daybeacons and of the spectrum of visual appearances of daybeacons. IHB publications include the message pattern of markings for Argentina but does not include illustrations. Argentine daybeacons can be found in fairways and channels and in middle grounds. Color codes emulate the buoyage pattern which was based on that of IMC before IALA. (IHB 1971, 11).

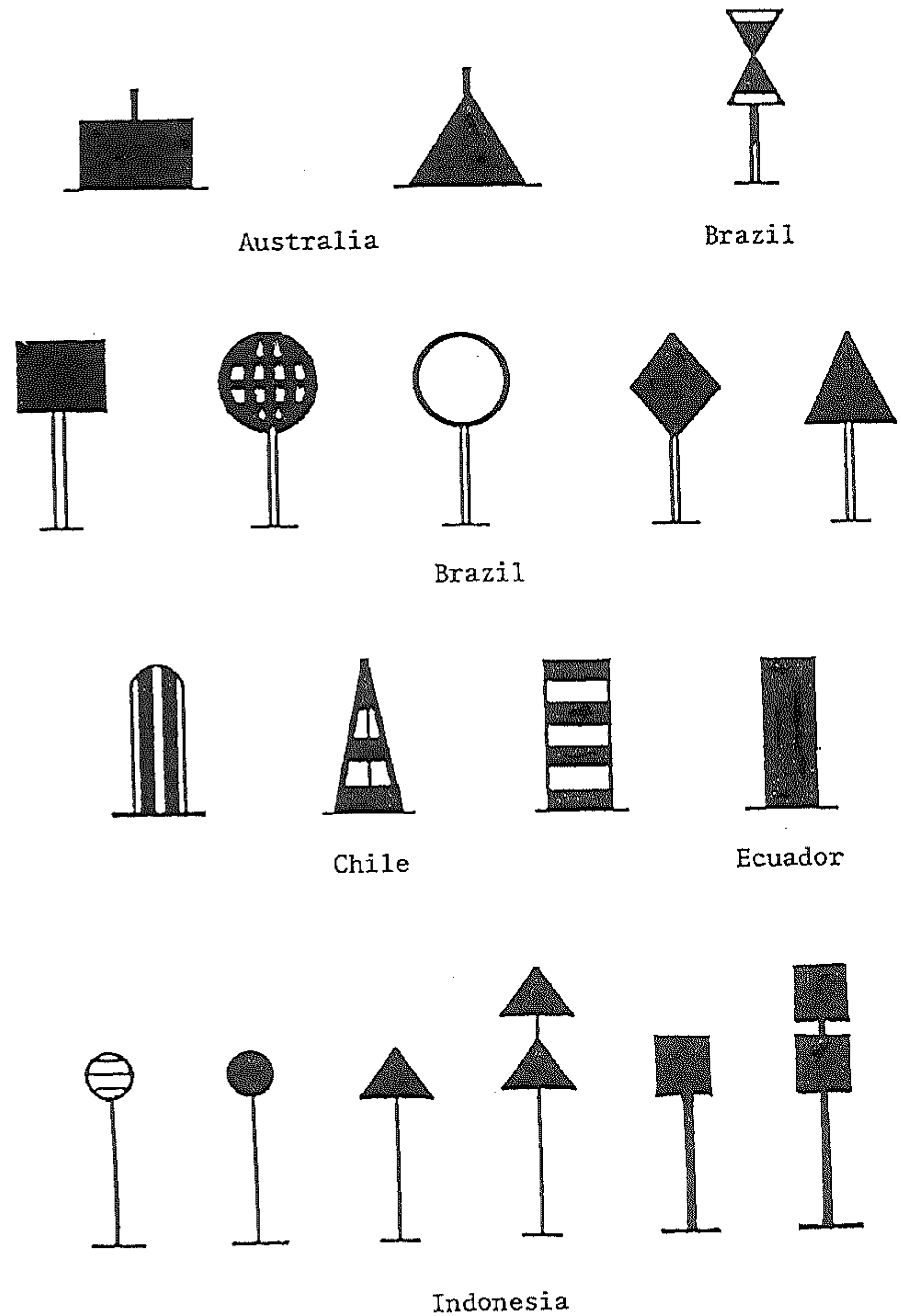
Australia also maintains daybeacons but IHB (1971, 11) did not include illustrations. Daybeacons are found in fair-ways and channels, middle grounds and danger situations; topmarks resemble those of buoys. Brazilian daymarks include perches or pole beacons (IHB 1971, 15). These include topmarks though the specific term topmark is not used. Buoys and daybeacons share the same messages. Topmarks for fairways and channels include triangles for port-hand, and waffle-patterned spheres for starboard-hand. An inverted double-cone topmark will be found on middle-ground markings. Miscellaneous topmarks include a square for isolated dangers, oval for submarine locations, and diamond-shaped for wrecks. Chilean beaconage is one of three types: rectangles for port-hand; fairway and channel locations; elongated conical beacons for starboard positions;

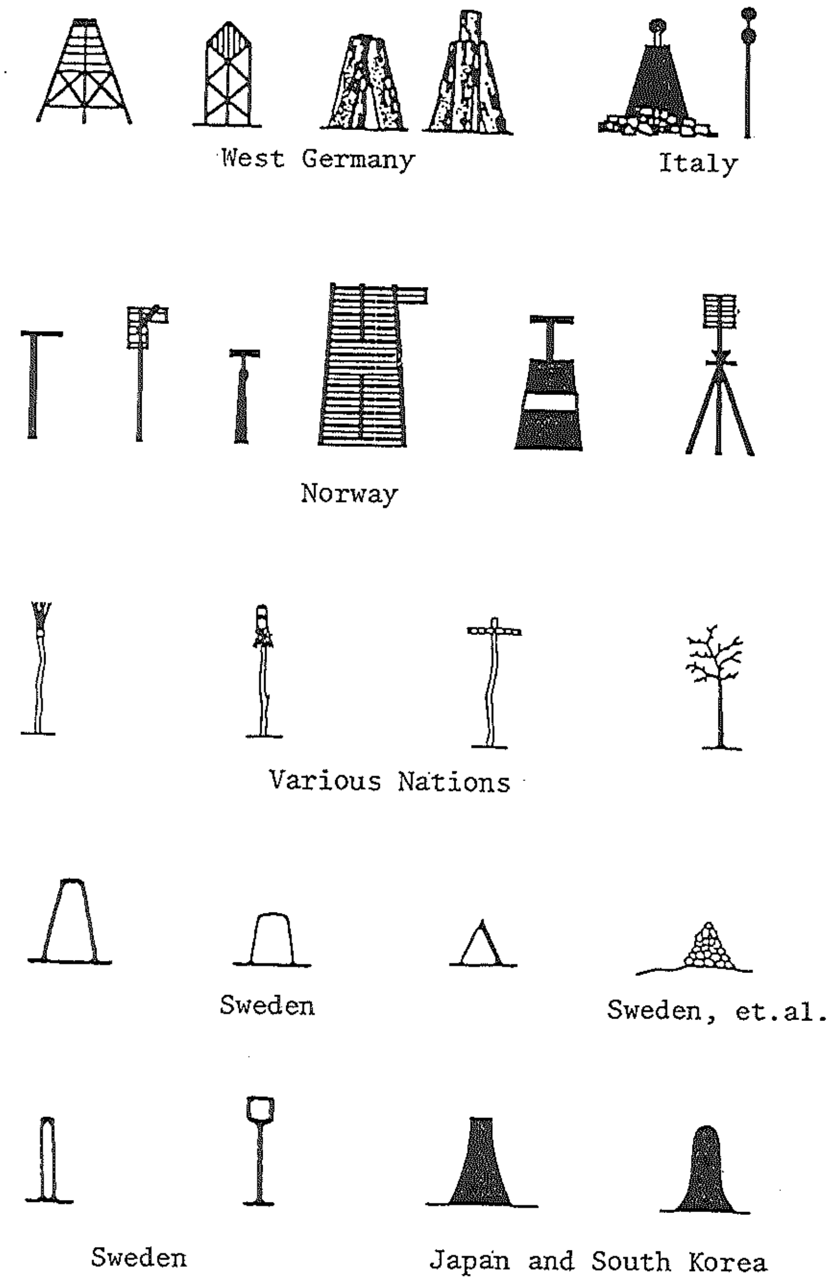
and rectangles with rounded tops for mid-channels (IHB 1971, 19). Color messages follow the buoyage regulations.

USNOO describes daybeacons for China but shapes are not given (USNOO, Sailing ... 1976, 11 and par). Colors for beacons can be white, red, or black. Apparently colors can be added to red or black marks. White can be either added to the topmark color or used exclusively. Shapes for topmarks are also absent from IHB for China.

Ecuador's single type of beacon is an elongated rectangle; the message of buoys applies to daybeacons (IHB 1971, 26). France, according to IALA, has one of the more significant systems of beaconage, but neither the 1956 or the 1971 edition of the IHB buoyage publication includes any beacons for France (IHB 1956, 26; IHB 1971, 49). According to the 1983 IALA survey, France has 2900 markings (IALA Survey 1984, 3, 16). Finland has developed a daymark known as an "edgemark" and this an important aid to navigation for Finland; the name clearly indicates its function.

Indonesian beaconage includes a feature possibly unique to that nation (IHB 1971, 44). The perches or spars employed include reflectors but not those found in other nations. The reflectors consist of mirrors arranged in vertical groups of three. By holding a light on the reflector the light will be "bounced" back to the ship. According to DMA *Sailing Directions* "to prevent being dazzle, it is recommended that only ordinary flashlight batteries, with a high concentrated light be used." (Soenda Strait, 9-10 and par). It is estimated that the mirrors can be picked up as much as a half-mile away. Indonesian daybeacons follow the buoyage color pattern as determined for fairways and channels. According to DMA, the fixed beacons are spars not perches; the

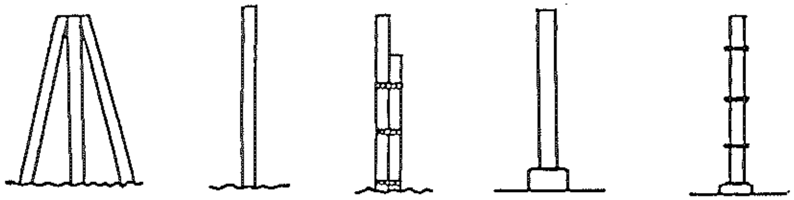




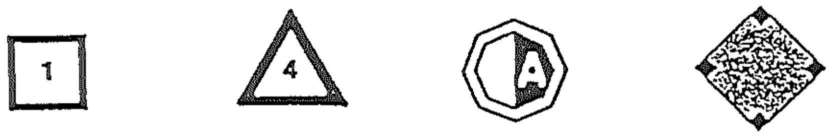
differences with the IHB may be one of semantics. Port-hand beacons are painted black with one or two black cones. (point-up). Port-hand beacons with mirrors reflectors emit a "white or green glow." For starboard beacons the glow is red or white; these also have a cylinder shape for the daybeacon.

Japan and South Korea have identical buoyage and beaconage systems according to IHB (1971, 48-49). Their single type of daybeacon is illustrated but not named in IHB. This marking is found in channels, fairways, mid-channel, and isolated dangers. It follows the buoyage message descriptions. IHB lists no daybeacon for Malaysia though DMA does so (USNOO Sailing Directions, Soenda Strait, 9-10). The daybeacons are not described, though possibly they occupy pile structures as do lighted aids for Malaysia. Day messages possibly emulate lighted messages of red to port and white to starboard.

Daybeacons of the Netherlands are exclusively perch in form (IHB 1971, 52). The perch takes the shape of a small tree. Starboard perches follow the parallel buoy message and the perch in that position has the branches tied down. Port-hand perches exhibit tree branches in the natural mode. They are found only in fairways and channels. IHB does not list daybeacons for Russia though DMA does so (USNOO Sailing Directions for Northern USSR. Rev. ed. 1975, II, 13-14, 17-22). These are of a wooden framework structure and presumably follow buoyage message patterns. An older DMA publication lists luminous and non-luminous signs instead of the framework (Vol III, Revised 1976, 14).

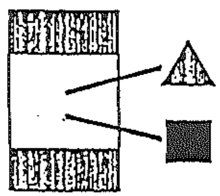


U.S. Coast Guard: Daybeacon Supports

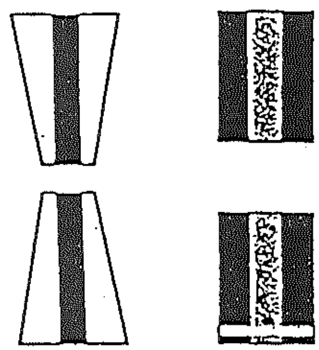


U.S. Coast Guard: Daymark Forms

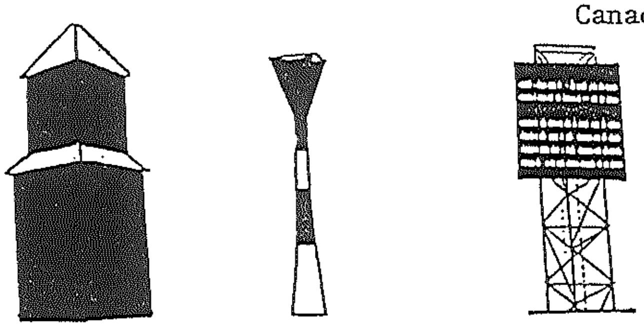
U.S. Daymark



Canadian Daymark



Range Daymarks:
Canada U.S.



Finnish Daybeacons

CHAPTER SEVEN

RADIO AIDS TO NAVIGATION

7A Introduction, History & Classification

7A1 Introduction

Radio Aids constitute a small but vital part of marine aids to navigation. Their significance is far greater than the limited number of devices in use. The previous edition of this study presented a complex picture of aids that ranged from traditonal radiobeacons to hyperbolic systems, radar and the early stages of satellite navigation. The current picture of these aids has greatly changed. Many forms are obsolete or obsolescent. It is common knowledge that radio aids have greatly affected visual and acoustical signals. But the transformation of radio aids by new radio aids is perhaps less noticeable. The lose of significance by visual aids and acoustical aids has been matched and, in some instances, eclipsed by changes within radio aids.

Perhaps ironically this chapter has undergone greater change than those for visual and acoustic aids. Visual aids are diminished though the coverage is intact; fog signals are more historical than current but the coverage is similar. An embryonic aid, GPS, was only partially in operation in the 1980s and was eclipsed by a host of other radio aids. But GPS now dominates radio aids as well as visual and acoustic forms. This chapter has been reformulated to accommodate that change. Older forms are retained though they are now minor or non-operational. Much of the former chapter is retained as are visual, and especially, acoustic aids since obsolete forms retain value as message systems.

Notes for Daybeacon Ilustrations

Page 171	Computer graphics based on IHB
Page 172	Row I, Left two, computer graphics as above
	Row II, Middle two, IHB
	Row III, Computer graphics based on IHB, and Norwegian seamarks
	Row IV, IHB
	Row V, Left three, Svenska Sjokert, Right, IDAMN
	Row VI, Left two, Svenska Sjokort Right two, IHB
Page 173	Row I, USCG Manual, 1979
	Row II, USCG Manual, 1979
	Row III, Left, USCG Manual, 1979 Left-center, CANS Right-center, CANS Right, USCG Light List
	Row IV, Board of Navigation, Helsinki

There is sufficient standardization within buoyage that a classification incorporating buoy forms is feasible. However, diversity within daybeacons is such that a classification of shapes would be difficult to produce. One can speak of general shapes with a sampling of classification examples but little more than that. The accompanying illustrations from international and national sources can suggest some of the diversity in the subject as well as reflect the classification.

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Other changes have occurred in the chapter as well. The earlier edition omitted a discussion of terminology. That is now included. A brief coverage of history has been augmented with material from the *Transportation-Markings: A Historical Survey*. The older classification included a main form without a variant version. Both versions are now included.

Earlier editions employed the term Electronic Marine Aids to Navigation as the basic term. That may have been a somewhat adequate practice though Electronic can also refer to shipboard devices that are not aids to navigation. However, the term Radio Aids and Radio Aids to Navigation (or to Marine Navigation) are employed by many sources including other studies in this monograph series (e.g., the history study as well as the database employ Radio Aids). That term and variant forms seems to be more adequate and precise than Electronic Aids. Radio Aids, a short form of Radio Aids to Marine Navigation, will be the common parlance in this study. Substantial coverage of overarching terms appears in the *T-M Database: Marine* and offers further elucidation on this topic.

7A2 History

Radio Aids has a relatively short history when compared to other aids. Early work on radio began in the late 19th century. Experiments and embryonic radio systems were underway in the first decade of the 20th century. Marconi's Wireless Lighthouse engaged in transmissions during 1916-1921 though apparently it was not a fully actualized system. (Kendal 1990, 318; Williams 1992, 87). US Bureau of Standards experimented with direction finding in 1917 and again in 1919 and 1920. The equipment evolved into the first operational units of the US Marine Radio Beacon Service in 1921 (O'Brien 1983, 4-5). Originally radio beacons were termed radio fog signals and wireless fog signal. This suggests an aid to navigation for low visibility and not a full-time aid. But gradually it became full-time and the names referring to fog signals faded out (O'Brien 1983, 4-5). The system grew in size with various classes ranging from short-distance to relatively long-distance. Radio Beacons remained a significant aid well into the 1980s and 1990s. But gradually various hyperbolic aids were established and the use of Radio Beacons waned. By the late 1990s they had evolved into DGPS components and their independent service largely ended. (FRP 1999, 1-9).

A variety of aids were developed under the heading of Hyperbolic. These aids became a major dimension in marine navigation for several decades. However that term usually does not include satellite aids though it is viewed as hyperbolic by at least by one source. Fifield in his *Navigation for Watch-keepers* views GPS as hyperbolic though in a three-dimensional configuration (Fifield 1980, 176-77). Others may not so view it in that light because of the lack of conventional hyperbolae. GPS does share a sub-chapter though in separate segments. Space-based aids are often usually referred to as satellite navigation and increasingly that means GPS.

An early form of hyperbolic aids is that of Consol. Though it remains uncertain whether Consol can be viewed as hyperbolic in a functional sense. Consol had at least two antecedents. German researchers reworked the US radio range system and created a version known as Elektra. That aid was capable of emitting multiple equisignals thereby creating multiple routes. A second version added directional data between the equisignals. This was termed Sonne or Sun in German. (Blanchard 1991, 311).

Sonne was a primary aid in Germany during World War II. A variety of aids precede and succeed Sonne; at least one alternate name (Consol) grew out of Sonne (Beck 1971, 113). Consol is listed as a hyperbolic aid because its signals created lines that are hyperbolic in nature. But the lines are short causing it to be termed a "collapsed" hyperbolic system. As a result it has been regarded as primarily a directional radio beacon. Fully hyperbolic systems began with GEE and continued with Loran. The latter is -- in some sense -- a descendent of GEE. They can be considered together because of that shared commonality.

Early stages of GEE can be traced to the 1930s in UK. A proposal in 1937 for a navigation system employing pulse transmitters and cathode-ray tubes did not immediately materialize. Earlier studies leading to radar research included both pulse transmitters and cathode-ray tubes. Development and trials did not occur until 1940. It was the most important navaid in the war. Its uses including guidance for bombing raids in Germany. A planned expansion after the war did not occur. However, GEE was still in operation in Europe into the late 1950s. (Blanchard 1991, 297-98).

Beginnings in the late 1930s a group of hyperbolic aids grew up under the acronym Loran (LOng RAnge Navigation). They were known as "radio position fixing systems." The core principle is based on measurement of time differences of pulse signals from several transmitting stations. The Lines of Position (LOPS) are hyperbolaes and signals are long range in nature. (Williams 1992, 234).

Loran was the early US effort to create a hyperbolic radio navigation system of a pulsed nature. Achieving accurate time-delay measurements was a major problem in its development. The original project was abandoned because of the GEE program. A new effort focussed on long range over water navigation was then pursued. However, a researcher on GEE became involved in Loran thereby adding GEE ideas to Loran. Loran-A became operational in 1943. It continued in the Pacific into the 1990s though it ended operations in the Atlantic in 1980. (Blanchard 1991, 306).

Work on a system based on low frequency began in 1946. Earlier work on a longer-distance aid requiring accurate long pulse measurements had been suspended; it was originally known as Cyclan. US Air Force then became involved in the project and named it Cytac. That work was also suspended. However, USAF and Sperry (who worked on Cyclan) worked on a LF system from 1952-57. That system employed a frequency of 90-100 mHz and included two distance-measuring methods (pulse time difference measurements and phase difference measurements). The US Navy developed an interest in the suspended project and ran tests on the old Cytac transmitters. The accuracy was sufficient and transmitters were set up under a new name, Loran-C. (Blanchard 1991, 309; Kramer 1963, 119).

Other forms of Loran are mentioned in the literature including Loran-B, Loran-D and a Loran-SS. Loran-B can be viewed as a developmental step to Loran-C. Loran-D was a tactical system (bombing aid). Loran-SS referred to Skywave-Synchronized Loran. It utilized skywaves available at night thereby increasing accuracy and distance. (Casabona 1959, 26-34; Blanchard 1991, 307-308, 310).

Decca is an US invention though largely developed in UK and associated with UK. Early work took place in the 1930s in California. A prototype system was carried out with a master and one slave station. A phase comparison technique was employed that did not require modulation. UK Admiralty took an interest in it by 1942 and carried out trials in 1943. An early version, under the name of QM, was found to be superior to GEE. Decca was employed for "Overlord." Decca was a private-owned system that included several derivatives including Delrac and Dectra. (Blanchard 1991, 301, 302, 307).

Early work on Omega can be traced back to World War II. Omega itself was established in the 1950s. Antecedents of Omega included Radux followed by a second form known as Radux-Omega. The second form included transmissions on LF and VLF. LF was dropped from Omega. (Omega NS 1975). It was developed by US Navy with US Coast Guard assistance. It operated at a lower frequency than Loran; it also maintained wider coverage. Omega needed fewer transmitters and its signal matching required a difference process than Loran. Omega substantially superseded Loran-C for long distance uses. However, the advent of GPS greatly altered the navaid situation and it was superseded by that system. It ended in 1997. (Blanchard 1991, 310; FRP 1999, 1-10).

Satellite Navigation began in the 1950s. That term is perhaps overly succinct, but it is generally known to include aids for navigation. US Navy began a satellite navigation program in the 1960s. Operational status began in 1964 with the first Transit satellite. The term Transit was employed outside of the Navy while Navsat (Navsat = US Navy Satellite System) was used in the Navy (Hobbs 1990, 572). USSR began Cicada not long after Transit. (Parkinson 1995 NJIN, 109-110). During the 1960s the Navy began a second system called Timation. It was in a concept status and possibly in a prototype state. (French 1996, 15). US Air Force also began a system called System 631b. The Defense Department called for a merger of the two systems that became known as Defense Navigation Satellite System (DNSS). A concept known as Navstar was the result. It was three-dimensional and of continuous operation. The system provided latitude, longitudinal and altitude data. (French 1996, 5). Timation and 621b are the predecessors of GPS. (Parkinson NJIN 1995, 110)

The older and separate efforts of the Navy and Airforce became known as the GPS Joint Program. (Runkle IEEE 1988, 1). The first phase (1973-79) was a time of "Concept Validation." The initial launch was in 1977 and in the following year the first Navstar GPS satellite was launched. The second phase (1979-85) undertaken was a major development and testing endeavor. The third phase began in 1985, and in 1989 the initial "Block II Navstar GPS SV was launched. By 1993 "Initial Operational Capability" was achieved with a minimum of Block I and II satellites. In 1995 the "Full Operational Capability" was achieved with a full complement of 24 Block II satellites. (French 1996, 15, 17).

The relative brevity of the classification, and especially that of the main classification, is easily explained. Most of the complexity is found with the messages themselves rather than in the structural and physical dimensions. And messages are generally not in the classified objects. Visual aids, especially with traffic signs, can proliferate individual entries. The earlier edition of this study lacked a variant classification. This resulted in a somewhat long main classification. Many of the entries are now in the variant classification.

a) The Classification

25 Marine Radio Aids
 250 Radio Aids, Single Form with Variants
  2500 Radiobeacon
 251 Radar Aids
  2510 Racon
  2511 Ramark
  2512 Radar Reflectors
 252 Hyperbolic Radionavigation Systems
  2520 Loran
  2521 Decca
  2522 Omega
 253 Satellite Navigation Aids
  2530 Global Positioning System
  2531 Differential GPS

.4 Electronic Aids
 .40 Radiobeacons
  .400 Non-Directional: Circular, Omni-Directional
  .401 Non-Directional: Sequence, Group
  .402 Non-Directional: Continuous

.403 Directional: Sequence, Group
.404 Directional: Continuous
.41 Radar Aids, Passive Forms, Reflectors
.410 Corner Reflector, Trihedral
.411 Corner Reflector, Pentagonal
.412 Dielectric
.414 Dihedral
.415 Luneberg
.42 Hyperbolic Systems
.420 Loran-A
.421 Dectra
.422 Toran
.43 Satellite Aids
.430 Transit
.44 Radio Buoys
.440 Radar Beacon Buoys
.441 Radio Beacons
Dual Classification (with Buoyage)
.17 Radio Buoys
.170 Radar Beacon Buoys
.171 Radio Beacon Buoys

b) Explanatory Notes

The title of the classification was Electronic Transportation-Markings in the previous edition of this study. And it was Marine Electronic Aids in the 2nd edition of the Classification. It is altered to Marine Radio Aids in alignment with the chapter heading. The two-digit designation is 25.

The first component is that of Radio Aids, Single Form with Variants, 250. There is one entry, 2500, Radiobeacon. The previous edition had a three-digit category for Radio beacons and it contained all forms of that aid. The other forms are now in the variant classification. Radar had two three-digit categories in the previous editon. That is reduced to one (251) with entries for primary, secondary active forms and radar reflectors. The last-named is amply represented in the variant classification (.41). Hyperbolic Aids, 252, contains four basic forms while the previous classification had seven. The remainder are now in the variant classification. Satellite Navigation, 253, has two entries in both editions. However, Transit moves to the variant classification. And Differential GPS is added. That Aid is ground-based and an entity in its own right.

The variant classification has three 2-digit categories: radiobeacons, radar reflectors. The 2nd edition of the Classification includes two buoys with electronic capability. They are a Radar Beacon Buoy, .170, and a Radio Beacon Buoy, .171. They have a dual classification: one within the context of buoyage and one within the type of aid classification.

7B1 Satellite-Based Navigation & Hyperbolic Aids

1) Satellite-Based Navigation

Contemporary Satellite Navigation aids can be summed up as the Four Gs: GPS, Galileo, Glonass and GNSS. GPS has become a familiar system for transportation of all kinds including walking and hiking. The next two terms are somewhat familiar. GNSS is a more complex entity. It can have three possible meanings. It can refer to any system that provides Navigation Aid data by satellite. It can also refer to existing systems such as GPS and Glonass. Or it can refer to a system in development by ICAO that goes beyond existing Satellite Navaids. GPS is perceived as not fully supplying the level and breadth of navigation needs and therefore not fully adequate in some respects. GNSS is intended to be a civil system that measures up for all users. (*T-M Database: Marine* 2007, ICAO 1997).

Global Positioning System (GPS) includes orbiting satellites, earth stations for control and monitoring functions, and receivers. The system includes 24 satellites that follow a correct orbit. GPS satellites transmit signal on two frequencies (1575.52 MHz and 1227.6 MHz). GPS employs a pseudo-range and time measurement approach rather than a hyperbolic one. The frequencies carry information codes and a navigation data message. The transmited information includes positioning, navigation and time (PNT) data. Receivers display a three-dimension package of latitude, longitude and altitude information. Time data is also included. (Thompson 1985; National S-B PNT Coordination Office; see also *T-M Database: Marine*).

A key element is that of augmentation through

Differential GPS. It is an overarching term that encompasses the means for correcting and improving GPS messages. These systems aid accurate and reliable signals. US Nationwide Differential GPS System (NDGPS) is a system operated by agencies for several forms of transportation. Traditional radiobeacons have taken on a new lease on life by providing differential corrections. Other means for the corrections process are also in use. (National S-B PNT Aug.)

European Space Agency is responsible for the Galileo system. It is currently involved in launching initial satellites for Galileo system. Galileo carries out several functions including basic navigation information as well as search and rescue and other services. (ESA 2009). Glonass, a product developed by the former USSR is similar to GPS.

2) Hyperbolic Aids

This coverage includes Loran, Decca and Omega. All are obsolete or nearly so. Loran is an acronym constructed from the words Long Range Navigation. (IHB 1965, II.2-01). It is the oldest of the major hyperbolic systems of navigation, and one of two such systems that had trans-regional capabilities. Loran coverages extended over most of the hemispheres including the North Pacific, North Atlantic, the Artic Ocean basin and the Mediterranean Sea areas. (USCG LL, Atlantic, I, 1985, xxx; Pacific, III, 1985, xxx). While only a few nations maintained Loran stations, the character and range of Loran did not preclude wide coverage. The US maintained over 80% of Loran-C while Japan had nearly 75% of Loran-A. Canada and Denmark operated both Loran-A and Loran-C stations. (IALA Survey 1984/3, 17, 19). In the 1980s the US was actively increasing Loran-C stations while phasing out Loran-A.

Loran forms employed pulsed wave transmissions. This contrasts with continous wave transmissions in other systems including Omega and Decca. Loran was based on a time measuring approach while Omega and Decca determined position through measurement of phases. Loran-A and -C, along with other hyperbolic systems, operated on a master/ slave station arrangement or some form of multiple- station or multiple transmissions. (IHB 1965, IHB, 2, II.2-01, II.3-01; USN Omega).

A type of Loran known as Loran-B was developed but never placed in practical navigation systems. It employed the same frequency as "A" but achieved greater accuracy through matching cycles as well as matching "envelopes." It had potential for application in coastal and restricted waters because of high accuracy. GPS ended other navigation possibilities. (IHB 1965, Radio Aids, II.2-02). Loran-C has the capability for that specialized usage may have eliminated the possibility of "B" gaining practical usage. Of course, Loran-C was also superseded.

Loran uses short-pulse radio broadcasts from two stations that are paired. Ships require special receivers to benefit from Loran. Radiobeacons, by contrast, needed only standard equipment. An indicator in the shipboard receiving set indicates the "difference in time of arrival of the signals" from the transmitting unit that permits the receiving operator to calculate a "Line of Position" (LOP). The calculation of two such LOPs is "crossed to obtain a loran fix." The Loran fix was the location of the ship. (IHB 1965, Radio Aids, II.2-02).

Loran-A operated on a frequency of 2000 kc. Each station consisted of a master and slave unit; in some instances one station served two pairs. The multiple-use stations directly transmit different signals for each pair. MF employed included ground waves and sky waves. The use of ground waves is a factor in the lower accuracy of "A". "A" was capable of reliable reception up 1400 nautical miles at night and during the day 600 to 900 nautical miles. The station equipment included a transmitter, amplifier and a timer. The timer supplied timing or trigger impulses that in turn activated the transmitter's pulse emissions. The pulse was set by the master station according to established practices; the slave unit adjusted its transmissions to the master unit as necessary. The reception of the signals aboard ship was through a radio somewhat similar to standard receivers though modified. (IHB 1965, Radio Aids, II.2.-01, 02, 07-09, -17, -19).

The Loran-C system extendeds and improved the other "A" system. It differed in transmission frequencies and in the measurement of time differences resulting in a greater range and accuracy. "C" operated on the low frequency of 90 to 110 kc contrasting Loran-A's MF. Each installation comprises a master station and two or three slave stations. (IHB 1965, Radio Aids, II.2-31).

Measurement of Loran-C signals was by two methods. Time measurement of the differences in the arrival of signals is augmented by time measurement of the carrier frequency. (IHB 1965, Radio Aids, II.2-31). The master and slave stations emitted eight pulses per transmisson; Loran-A emitted a single pulse per transmission. (USCG LL, I, 1985, xxvii-xxviii). The master station had a ninth pulse for station identification of the station. (IHB 1965, Radio Aids, II. 2-33).

The use of LF brought about transmission synchronization thereby expanding coverage but with the same amount of radiated power. Expanding the area covered meant that more of the position line crossing angles were nearer to 90 degrees thereby this increasing geometric accuracy. (IHB 1965, II.2-31).

Decca, a separate hyperbolic system, was based on continous wave transmission, and on phase comparison measurement. It operated at approximately 100 Khz with a daytime range of about 250 miles; the night-time rate is somewhat less. (IHB 1965, Radio Aids, II.3-05). Each station consists of a master station and two or three slave stations. The slave stations are 70 to 100 miles from the master unit. (CANS 1975, 8). Individual stations emitted had continous wave transmissions on a different frequency. "The four frequencies for a chain being in the ratio of five, six, eight, ten and the entire group in the 70 to 100 and thirty Kc band." (Bowditch 1966, 345)

Measurement consists in determining the difference in wave-length received. The receiver is at variance with standard receivers and even hyperbolic receivers of other types. The receivers which receive the chain's signals on difference frequencies and these are then "brought to a common comparison frequency within the receiver." The receiver not only indicated incoming data to be processed, but also aided in assembling the data which is then interpreted. The incoming data created "three intersecting hyperbolic patterns;" all three patterns were not required for determing a position. The two patterns providing the best data for determing position were used. (IHB 1965, Radio Aids, II.3). The system was extensively used though it was not global in scope. Major areas of usage include western Europe, South Africa, India and Japan. (IHB 1965, Radio Aids, II.2024; IALA Survey 1984/3, 17, 19).

Omega had worldwide capabilities that transmitted on a very low frequency channel of 10 to 14 Khz. Contrary to Loran. It emitted a "phase-difference measure technique" instead of the time-difference technique of Loran-A and -C. (Omega Navigation Systems, 1-3). Through the utilization of VLF frequencies it gained reliable transmissions for many thousands of miles; transmissions were. The stations time-share frequencies thereby allowing for a high quality fix in any location. (Omega NS, 1-3).

Hyperbolic systems normally employ a master-slave station format, and early Omega followed this pattern through the use of a "bank of celsium frequency standards" which generates the vast range of Omega; there is no need for specific pairing of any of the eight worldwide stations. A mariner could pair any two stations in the world to gain a locational fix for the ship. The system, however, remained hyperbolic-based positioning navigation. The fact that a system composed of little more than a dozen stations could encompass the entire globe suggests the immense range and possibilities that Omega represented. (Omega NS, 1-3).

7C Radio, Radar and Miscellaneous Systems

Radiobeacons are the oldest portion of radio aids. They became operative in 1921 (at least in the US) and shortly after the beginnings of commercial radio. The first stations began in May of 1921 and more than a dozen were operating by 1925. In the earlier history of radiobeacons they were often referred to as "radio fog signals." This indicated an important function though not the only one. (Weiss 1926, 38-39).

Bowditch defines the radiobeacon as a "radio transmitter emitting a characteristic signal to permit a craft with suitable equipment to determine its direction, distance or position relative to the beacon." (Bowditch 1966, 942). IDAMN concurs except for omitting a position determining capability (IDAMN, 4-2-000). The radiobeacon lacks the intersecting lines of a hyperbolic system. It can be noted that the radiobeacon was intended to aid the mariner in locating position in relation to a fixed object rather than locating the exact position of the ship in relation to geographical position. The radiobeacon is a single-unit station in its operation in contrast to multi-station patterns of hyperbolic systems. However, one English source suggested that cross-bearings can be gained though placing a fix on two radiobeacon stations. (Bowen 1947, 43-44).

The radiobeacon clearly indicated its function by its title. This contrasts with many other aids that have opaque names. The radiobeacon is a radio transmitter with a specialized function. It is also a beacon: it sends out impulses by a single station to mariners though through a different form of wave. Radiobeacons can provided three kinds of navigation services. Some have served as regular beacons and providing an ongoing message. A second type transmitted in all weather but increased its transmissions in fog conditions. The final version emitted messages only during times of fog. (IDAMN, 4-2-025).

Canada and the US, which were the largest operators of radiobeacons, normally operated radiobeacons according to the beacon service pattern. Clear weather beacons include those stations that function less frequently than beacon service but whose transmissions are expanded when there periods of fog or when visibility. is restricted (IDAMN, 4-2-025). The third type is exclusively a fog signal service. Calibration radiobeacons provide a service for mariners wishing to improve the accuracy of direction-finding equipment aboard ship. (IDAMN, 4-2-025).

While some radiobeacons operated alone, many operated in groups. Dutton suggested a group sequence pattern of three radio beacons per group, but in the US and Canada the stations were arranged in groups of six; each unit employed one frequency and each maintained a one-minute transmission in sequence. (Dutton 1958, 235, USCG LL, Atlantic 1979, xvi). Low-power marker radiobeacons functioned singly for local use at entrance to bays, harbors, and rivers. (USCG LL, Pacific, III, 1979, xvi). An European agreement reached in 1933 established a pattern of regional control and organization for radiobeacons that had the goal to ending confusion of overlapping stations. (Bowen 1947, 45). Some North American radiobeacons were synchronized across national boundaries as well. (CANS 1975, 7).

Station identification was accomplished through dot and dash patterns that were frequently outside the Morse code system though some did follow that system. (USCG LL, Pacific, xvi, 1979). In some countries special combined radiobeacons and fog signals were maintained. These radio direction finding stations syncronized the radio beacon message with that of sound signal. (IDAMN, 4-2-055).

According to an older IALA survey there were about 790 radiobeacons in operation. Eight nations were responsible for over 70% of the surveyed radiobeacons. The US had nearly 30% of that number and Canada 15%. (IALA 1984/3, 17, 19).

Most radiobeacons were either omni-directional or non-directional. This means that they could be picked up by shipboard receivers in all directions. A small number of radiobeacons were directional indicating they could be received only in specific directions. All of these beacons are operated by Japan, and they are a combination of directional and non-directional types.

Dutton and other sources classified radiobeacons by range of signals. According to Dutton, "A" range is 200 miles; "B" is 100 miles; "C" transmit up to 20 miles; "D" a modest 10 miles. That classification strongly suggested the short-to-medium-range character of radiobeacons. (Dutton 1958, 25).

Radiobeacons continued to occupy an important role in navigation until the advent of GPS. They maintained a major role even in the era of hyperbolic aids. Some are retained as augmentations to GPS operations.

Radar aids by contrast continue to have a diverse and current role in navigation. Radar aids are of three forms: ramarks, a form of primary radar; racon, a type of secondary radar; and radar reflectors which are a form of passive radar (Bowditch 1966, 323). Ramark is from "ra" in radar plus mark. Primary radar reflects signals without being "ignited" by the radar capabilities of shipboard installations. Ramark broadcasts are continuous and omni-directional (IDAMN, 4-3-450). They indicate bearings for a ship but do not provide distance or range information; a shipboard radar unit attuned to a ramark unit receives a "radial line at the bearing of the beacon." (USCG LL, III, Pacific 1979, xiv). An older IALA survey found that Japan had about 60% of these aids and Canada 40%. (IALA Survey 1979-2, 37).

Racon, a secondary radar system, needs to be triggered before they transmit the desired pulse (IDAMN, 4-3-010). The shipboard radar set serves as the trigger. Racons can transmit either a individualized code signal, or an unvarying signal. Racons provide both bearing and distance information. Coded racons also provide identification of the transmitting racon unit. (IDAMN, 4-3-445; see also USCG LL).

Radar reflectors are designed to provide enhanced radar reflective quality. Radar signals "bounce" off the reflector more effectively than non-designed structures. Many, if not most buoys, have the reflectors as well as some fixed aids. (IDAMN, 4-3-525; USCG LL, Pacific, III, 1985, xix). An older IALA survey found that over 2/3 of the reflectors were maintained by the US. (IALA, Survey, 1984/3, 17, 19).

Consol and Toran represent two final systems of radio aids. Neither is of major significance whether regionally or globally. In the 1980s Consol existed as a single station in France, and Toran consisted of six stations in France and one in The Netherlands. (IALA Survey, 1984/3, 17, 19). Consol is a derivative of the German Sonne system of World War II and a close companion of that system. It has been classified as hyperbolic by one source, and azimuthal by another; effectively it can be regarded as a radiobeacon system though it is of great range and of more precise accuracy than conventional radiobecons. Consol had a range of 500 nautical miles in daylight and 900-1550 nautical miles at night. It transmited on a medium frequency. (IHB 1965, Radio Aids, II.4-01).

In essence, a Consol installation consisted of one transmission station providing both directional and rotating radiobeacon characteristics. The transmissions are of medium frequency and these were emitted from three antennae. (IHB 1965, II. 4-01). The surface of the earth was divided into sectors made up of dots and dashes. A transmission had three components: the equisignal which was preceded by alternating dots and dash and followed by dots and dashes as well. Angular position is determined by sign count for the sector. No special receiver is required with the Consol system. Any standard receiver which could receive medium-frequency waves of a continuous character sufficed. If the receiver lacked "automatic gain control" then it only required only a "narrow band-pass." (IHB 1965, II. 4-01; II. 4-26; II. 4-29). In 1960 there were functioning Consol stations in Western and Southern Europe and a similar version, termed Consolan, on the Eastern coast of the US. Only the French station may have remained by the 1960s. (IHB 1965, II.4-26, II. 4-29). However, A.F. Blanchard notes the existence of stations in Spain in 1970 (Blanchard in Proc 2008).

Toran is listed as a hydrographic aid in IHB publications. (IHB 1965, table of contents). However, both IDAMN and IALA listed it as an radio aid to navigation. (IALA, Survey, 1984/3, 17, 19; IDAMN, 4-4-430). It was a hyperbolic system capable of precise information. The ship "[could] obtain its position by the determination of the phase differences between the HF waves emitted by a pair of confocal transmitters and the transmission from a fixed reference transmitter." It had a range of about 300 miles. The emissions come from a frequency of about 2 MHz. (IDAMN, 4-4-430). IHB speaks of several applications, but none are specifically for general navigation. IHB saw Toran as aiding harbor works such as dredging and surveying. (IHB 1965, Radio Aids, III.12-02).

There are a variety of hyperbolic systems in use that are outside the T-M spectrum. They found use in surveying and other hydrographic projects. They are not strictly speaking T-M but they are related to, and at least touch upon Transportation-Markings and maritime matters. Many publications on T-M include references, and sometimes extensive treatments, of hydrographic hyperbolic electronics. IDAMN does not distinguish between hydrographic and aids to navigation types, and IHB includes both in one volume though in separate sections. Delineation between aids to navigation and hydrographic forms is necessary in this study. There are instances in which a variation of a hyperbolic aid to navigation is employed for hydrographic purposes; the reverse may also be true. Hyperbolic systems that refer to hydrographic usage include Lambda, Hi-Fix, Raydist, and Shoran.

Lambda, an acronym formed from Low Ambiguity Decca, followed the basic features of Decca. (IHB, Radio Aids, 2; IDAMN, 4-4-225). However, the master station is aboard ship and the system is designed for hydrographic purposes. A second "phase comparison position fixing system" is that of Hi-Fix. It operates at a higher frequency than Lambda and has a shorter range; it is also a derivative of Decca. (IDAMN, 4-4-230).

Raydist employed a continuous wave phase comparison process. It was used primarily for determining location of ships employed in survey work. (IDAMN, 4-4-270). There were four types: M, N, DM, and F. Raydist operates in medium- to high-frequency channels. Raydist M and N are hyperbolic, while DM and F employ a variant approach for gaining the needed coordinates for determining position. (IDAMN, 4-4--285 ff). Shoran, a separate system from Raydist, also employed "circular co-ordinates systems" for determining position and that too found usage in survey work. (IDAMN, 4-4-305).

Other systems to consider are Lorac and Rana. Lorac, a hydrographic system, is similar to the Raydist system. A Lorac chain consisting of a main station and two side units. IHB refers to three versions: Lorac A, B, and LM. The first two focus on position-fixing while LM measures distance. It can be viewed simply as Lorac (IDAMN, 4-4-380; IHB 1965 III.6-01ff). Rana varies from most hyperbolic systems in that each of three units of the system can serve as a master unit for a frequency and also serve for the remaining frequencies. The result is an approach that creates lines of position of great precision and without ambiguity. It employs continuous wave system using phase comparison methods. (IDAMN 4-4-390).

CHAPTER EIGHT

FOG SIGNALS

8A Introduction, & Classification

8A1 Introduction

a) Revisited: Fog Signals and T-M Studies

Earlier editions of this study project an image of Fog Signals as a viable means of communication though in decline. However, the last decades have witnessed a precipitate decline that has resulted in a state of near-extinction. A graphic picture of what has taken place is to be seen in Renton's *Lost Signals* (2001). This edition reflects the older studies more than the actual state of Fog Signals. The decision to do so is based less on nostalgia than a perspective that views communication as a broad range of possible sounds with distinct messages and meanings that can have a timeless significance. The extinction of Fog Signals does not eliminate a communication and semiotic system of note. History, contemporary navigation systems, antiquarian and semiotic perspectives become interwoven in this edition.

Changes in this edition also include a historical addition and a revised classification. A number of modal studies had included historical coverage but Fog Signals lacked that dimension in previous editions. Perhaps the entire study of Fog Signals has become history. The T-M historical study (2002) provides source material as does Renton's treatise.

The classification in the 1988 edition requires substantial reworking. And the 2003 edition, while offering an updated perspective, also needs further work. A primary change will be the addition of a variant classification. Buoy sound aids also need to be included in the Fog Signal classification though the primary coverage remains in Buoys. A new edition of Dana's system of mineralology also needs to be considered for the classification (Gaines, *Dana's New Mineralology*, 1997). Explanatory notes which were very brief in the previous edition have been expanded in this edition.

b) Introduction

Fog Signals had been a vital though restricted form of Transportation-Marking. They were not global but were significant in specific regions. Fog Signals can be divided into three broad categories: floating, fixed, and electronic. This chapter will focus primarily on fixed sound signals, though some mention of Buoy sound mechanisms is included.

Fog signals have manifested diverse forms and messages. Nonetheless, some general characteristics can be noted. These include directional forms, energy sources, acoustic vagaries, and terms. Fog signals can be uni-directional or omni-directional. Uni-directional may not be entirely accurate since some signals include more than one trumpet without achieving full horizontal coverage though increasing degrees of coverage are involved. The omni-directional form experienced usage as technology of acoustics and the need for longer-distance signals merged. This allowed for massive-emitter units to be produced and positioned (USCG 1979, 7-3, 7-4). Renton notes the increased use of those units but also noted the gradual fading away even of those machines. Renton's study of Fog Signals also includes references to some older omni-directional forms (Renton 2001, 162, 165).

Fog signals can be powered by the action of the sea, compressed air, steam, electronics or electricity. Signals became increasingly electric-powered (more precisely, electro-magnetic) in propulsion; electronic type signals became more common. Fog signals can be heard from a few hundred yards for traditional gongs, bells, and whistles to several miles for more sophisticated models so designed for long-range service.

Terminology remains stable and largely permanent for most T-M forms. That is not true for Fog Signals. Along with the vanishing of fog signals has been the very term. In the 1960s (or early 1970s) the use of the term went into a steep decline. IALA has employed Sound Signal and Audible Signal (though the term fog signal was employed in the Audible Signal chapter of IDAMN) (IDAMN 1970, 3-1-030).

US Coast Guard dropped the term Fog Signal during the 1970s and switched to Sound Signals [cp LL PCPI 1962 and 1967]. The remaining signals continued to issue acoustic warnings as before. Yet the new term lacked much of the meaning of the older term. It seemed to suggest a limited, even a very restricted aid that carried out a minor role. And very likely that was the role of the remaining Fog Signals. In a late 1990s publication USCG termed the sound signal as a "generic term" producing "an audible signal ... ." (USCG LL PCPI 1997, xxi). But the name of Fog Signal and the traditional aids it designated was largely eliminated. Wayne Wheeler also notes that Sound Signal is more accurate than Fog Signal (Wheeler S-1990, 20). Secondary terms long were employed though Fog Signal was primary. But the recent situation sees Fog Signal in retreat and new or older terms supplanting it.

Other general terms found in T-M include Acoustic Aids, Acoustical Aids and Audible Aids . There are a few other terms that serve as sub-overarching terms though only of restricted usage. IHB 2004 includes the term Membrane Horn which is seemingly not found anywhere else (IHB 2000, A-6). It encompasses all Fog Signals employing a membrane including Nautophone, Reed and Typhon. It is potentially a primary term though seemingly rarely used. A second term is that of Percussion Aids and Percussion Devices. Renton employs the second as an overarching term for Bells and Gongs (Renton 2001, 191). USCG 1953 offered a tripartite devision of air, electric and percussion units (USCG 1953, 25-2/-3; see also T-M Database: Marine 2007, 250). This compiler may have coined Percussion Aids from the USCG schema. That term like Membrane Signal offers an overarching term for many forms of Aids.

Regions that required Fog signals were relatively clear-cut in location. The underlying factors were latitude and climate. All areas were north of 30 degrees north latitude and nearly all were north of 45 degrees north latitude (BA 1974, 2-3). The North Atlantic rim was the primary realm of fog signals with the North Pacific as a secondary region. Many shipping areas in those regions were marked by heavy fog and heavy shipping. Statistics of the 1970s and 1980s reflect the dominance of regions. An IALA survey in early 1980s (IALA 1984/3) gives an approximate sense of Fog Signals at a time when such Aids were relatively common. The survey listed 3,700 signals. This included slightly less than 1500 fixed signals or just over 40%. Floating signals were near 2,200 or slightly under 60%. US had slightly over one-half. Canada had 25% and Trinity House and France had a little more than 10%. Four organizations maintained 90% of the signals. Fixed Fog Signals were more diffuse. Canada and the US each had about 25% of the total. Six other nations had a third quarter.

A late 1970s survey indicated that fixed signals were stable. A situation that was not to continue for many more years. A letter from J Prunieras noted a significant change in that time period: many of the existing signals were electric horns while older forms were taken out of service (gong, bell, whistles, older horns) (Prunieras 12-30 1977). Sea-activated, manually-operated, steam- or -airpowered forms were on the wane.

8A2 Classification of Fog Signals With Note [Including Buoy Sound Signals]

a) The Classification

24 Fixed Fog Signals
- 240 Signals with Single Forms
  - 2400 Whistle
  - 2401 Bell
  - 2402 Gong
  - 2403 Reed Horn
  - 2404 Siren
- 241 Signals with Variant Forms
  - 2410 Diaphone
  - 2411 Diaphragm Horn
  - 2412 Explosives

Variant Classification:

24 Acoustical Signals
- .3 Fog Signals

.30 Diaphone
    .300 Regular
    .301 Two-Tone
.31 Diaphragm
    .310 Compressed Air
    .311 Oscillator
    .312 Nautophone
    .313 Chime
.32 Explosive Signals
    .320 Explosives
    .321 Gun
.33 Submarine Signals
    .330 Submarine Bells
    .331 Submarine Oscillator

14 Sound Buoy
  140 Single Types
    1400 Bell
    1401 Whistle
    1402 Gong

16 Multi-Message Marine Floating Aids, Single Types
  160 Large Floating Aids, Single Types
    1600 Light Vessels
    1601 Large Navigational Buoys
  161 Lighted Sound Buoy
    1610 Lighted Bell Buoy
    1611 Lighted Whistle Buoy
    1612 Lighted Gong Buoy

.15 Sound Buoys
    .150 Bell, US
    .151 Whistle, US
    .152 Carillon, France
    .153 Bell, France

.154 Horn Buoy
.155 Siren Buoy
.16 Combination Buoys: Lighted Sound
.160 Lighted Bell, Canada
.161 Lighted Whistle, Canada
.162 Lighted Bell, US
.163 Lighted Whistle, US
.164 Lighted Gong, US
.165 Lighted Horn, US
.166 Lighted Bell--Can, USB
.167 Lighted Bell-Conical, USB
.168 Lighted Bell-Spherical, USB
.17 Electronic Buoys
.170 Radar Beacon Buoy
.171 Radio Beacon Buoy
.18 Multi-Message Floating Aids
.180 Lightfloats
.181 Lighted Catamarans

b) Explanatory Notes

Explanatory information was limited to a single unitary note in the previous edition. Notes appearing in Part H have been added to this edition. (with some modification). The greatest number of distinct fog signal types is to be found in the single types category. No doubt differences in specific bells, whistles, and gongs can be present. Nonetheless, each of these forms represent a specific sound emission system in its own right. And, based on the literature of the field, none can be easily subdivided into variant forms.

Marine Aids included a unitary classification in 1981 and 1988 editions. There was no variant form of the classification until the first edition of Part H in 1994. Separating the core from the variant form has proven to be difficult since the available international standards, largely those of IALA, pertain almost entirely to buoys. The compiler had thought that summing up local and non-standard forms would not be difficult. However, that task proved to be difficult. That first attempted solution was admittedly imprecise and uncertain: forms of aids that were traditionally commonplace to marine aids were assigned to the main classification but only in their core form. Other forms were assigned to the variant classification. Guidelines for this process have included the references to fixed aids in the IALA system, the IALA dictionary, and IHB publications. An additional reference is a survey by the writer of structural forms in Defense Mapping Agency (now National Geospatial-Intelligence Agency; several names preceded DMA as well) aids to navigation publications for the first edition of Parts C & D in 1981.

Two-digit numbers in the classification underwent some changes between 1994 and 2003. 15 designation has become 14 and 25 has become 24. Changes were caused by revisions of the classification nomenclature.

8B History, Types, and Messages

8B1 History & Types

The previous editions of this study included types of Fog Signals but not history as such. This edition first attempted coverage of both history and types. That proved to be a problem since the topics overlap. This is especially true now with many fog signals gone; types and history thereby become virtually one topic. This section has become primarily history though materials on types from the previous editions has been added. References for this coverage are largely from Part J (2002) and its sources.

Before 1750 Fog Signals were limited in variety and numbers. Signals were largely cannons and bells. Gongs were possibly an additional form. More diverse and complex forms developed as the Industrial Revolution developed. Industrial events became intertwined with economic and transportation growth.

1750 to 1870 marked the first Industrial Revolution as well as many developments in marine aids. Fog Bells became more commonplace and early versions of clock-work mechanism for operating bells were invented.

An early invention was the Reed Horn. It employed a reed placed in a large trumpet that was activated by steam or compressed air blowing through the trumpet thereby activating the reed. At times it was termed a trumpet because of its most distinctive feature (Part J and its sources).

Sirens became a focus of development in the second half of the 19th century. Steam or compressed air was directed through discs and later slotted cylinders in earlier forms. The end result was a long-distance, loud and piercing sound. Electricity was employed at a later time (IDAMN 1970, 3-2-70).

Whistle technology began in mid-19th century. They became common in North America but did not catch on in Europe. A concern about confusing ship fog signals, and ship whistles surfaced in Europe.

Floating signals developments were active as well in mid-19th century. They included Bell Buoys and Bell floats. See Buoy chapters in this study.

Two marine writers, Wayne Wheeler, and Kenneth

Sutton-Jones (Wheeler, F-1990, 11; S-J 1985, 107-114) provide a demarcation between the older era of fog signals and a more recent time. Wheeler notes that by 1870 the four new forms (mechanical bells, reed horns, whistles, siren) had reached a perfect state and were established signals. The initial phase of the Industrial Revolution came to completion at about the same time. Sutton-Jones writes of the "Age of Magnificence" which refers to the high point of the traditional lighthouse. The dates of that zenith were approximately 1890-1912.

Sutton-Jones included a subset termed the "Gargantuan Sound" which perhaps occupies a similar span of time. He specifically mentioned a Scottish diaphone whose sound was "...seismic--the gargantuan sound." (Sutton-Jones 1985, 107-114). The decline of fog signals was on the verge of beginning even in the first years of the 20th century. The next fifty or so years (1870-1920 were a very active time for fog signal changes even as the fog signal moved into its autumn.

Explosive signals in the form of cannon were a long established aid. Yet tests on the type of cannon to be used were tested even in later 19th century. Other forms of explosive signals were also employed. Rockets or signal rockets were employed that used a tonite charge with detonator. Acetylene gas guns were also employed.

Many of the signals of 1870-1920 were developed before 1870. These included whistles, sirens, bells, reed horns. Much of their usage occurred in the 1870-1920 era.

Propulsion systems were greatly affected by industrial developments. Coal-fired steam boilers grew in use and power. Gradually air compressors eclipsed steam use. By the early 20th century electricity came into frequent play. Air compressors were electrically-powered and electricity directly activated bells and sirens.

An important signal of the early 20th century was the Diaphone. It was a Canadian invention of about 1900 and found its initial use in the US. The technical name was that of a reciprocating siren. It was high in volume, reliable in emissions and notable for its harmonic quality.

New floating aids included whistle or whistling buoy. This aid dates back to the 1870s. The original form with tube extending through the buoy float with sea-action pushing air up the tube thereby activating a whistle. Gong buoys were introduced in the early 1920s. The sound mechanism consisted of several nearly saucer-like discs and activated by tapers attached to the superstructure of the buoy.

Underwater signals were added in the early 20th century. The signals addressed the problem of erratic emission receptions by air transmitted signals. A submarine bell was the first version of these signals. Other versions were attached to lightships and buoys. One form was mounted from a tripod on the sea bottom. Some years later a submarine oscillator was introduced that employed an underwater diaphragm fog horn. This was an improvement over earlier forms. They may have lasted until the 1950s though their decline began in the World War II era.

More recent years were marked by decline of many fog signal types though an increase in various kinds of diaphragm signals also occurred. The early 21st century continues to chronicle the end of the remnants of fixed Fog Signals. The reason usually given is their lack of importance for safe navigation: "Due to new/improved navigation technology (DGPS), no longer considered necessary for the safe navigation in the waterway." That phrase was applied to the long enduring fog signal at Lime Kiln Light in Washington State (LNM, District 13, 10-05-04). A similar statement (without reference to DGPS) has been added to a proposed removal of fog signals on the Tacoma (WA) Narrows Bridge. (LNM, District 13, 9-29-09).

USCG 1953 provides information on many fog signals and more rare new forms for the years 1920s-1950. The 1920s-1940s includes the addition of an electric air oscillator and four forms of diaphragm signals. While hand-operated bells, cannon-guns, submarine bells, submarine oscillator and acetylene gun became obsolete. Other forms were declining in usage or were regarded as obsolescent. Diaphones were regarded as "extensive" but not current. (USCG 1953, 25-2).

Wheeler noted the ending of sirens and whistles before 1970. By 1990 "pure tone signals" and a few traditional diaphragm signals were about all that remained. Pure tone refers to new form of diaphragm signal of an oscillator type. Pure tone signals are unmodulated. A simulation of horn, gong, or bell is feasible though it is debatable whether it can fully emulate traditional fog signals. (Wheeler F-1990, 14).

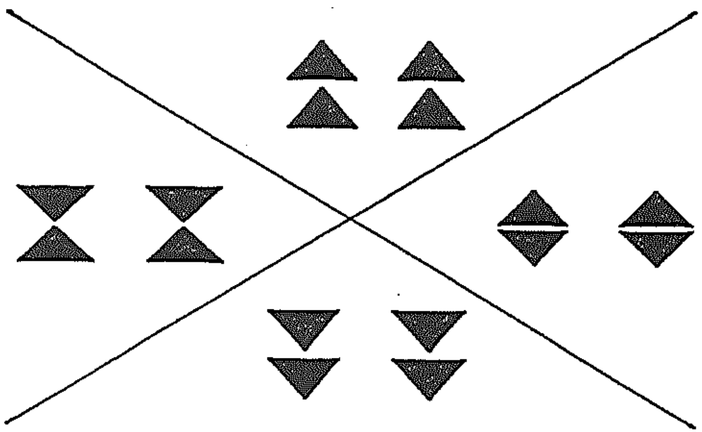
8B2 Messages

Messages for fog signals are composed of two elements: the character of the sound wave produced (the sound tone), and the length of the signal period (signal blast/accompanying segment of silence) that makes up a signal emission unit. A possible third element is the period of operation. Some signals operated during fog while others operated continuously through the year. There were other units that

Topmarks: Types and Usages in IALA

Lateral marks: Location and color of can and cone dependent on region. Colors: red and green

Cardinal Marks:

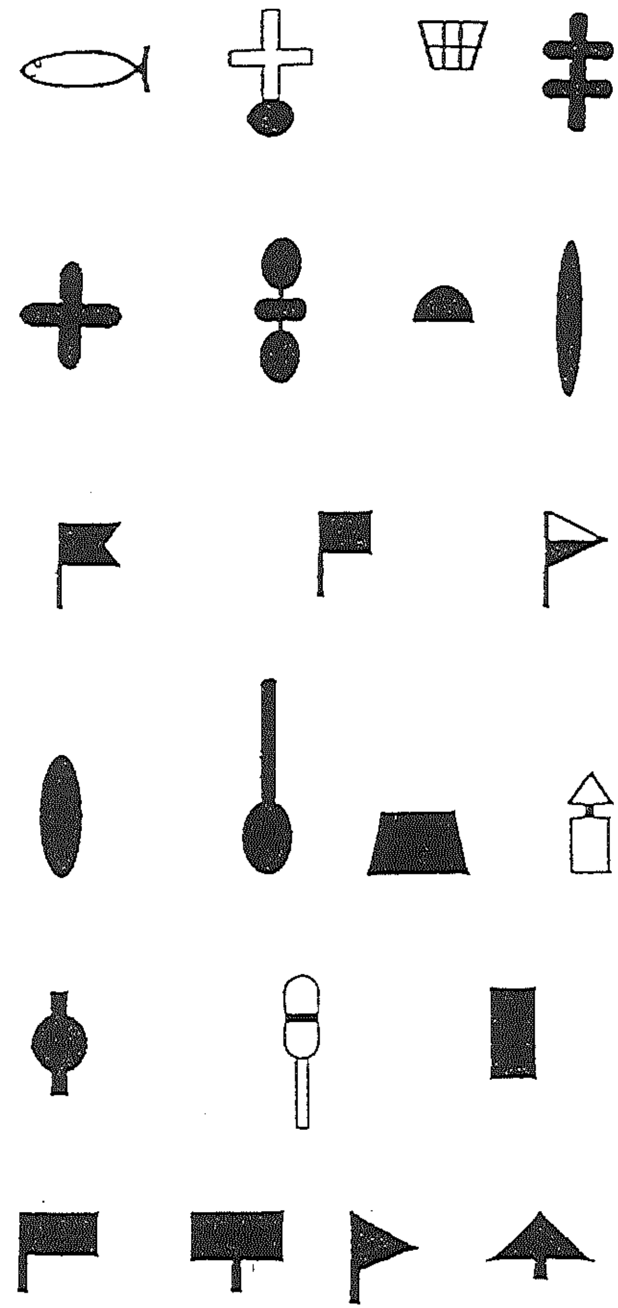


Isolated Dangers: Two Black Spheres:

Safe Waters: One Red Sphere:

Special Marks: One Yellow “X”:

APPENDIX I: SELECTED TOPMARK PATTERNS



Selected National Topmarks: MBS/SMBB

operated seasonally.

International agreements on buoyage and beaconage give little attention to fog signals. Fog signals were warning signals and lacked a broad range of functions. For example, fog or sound signals did not have messages for noting the sides of channels and other basic roles. But fog signals frequently had an assigned characteristic which would be printed in list of navigation aids for a country or for a larger region. With increasing standardization of sound tones the specific message characteristic assumed greater importance. Wave-actuated signals are classified as random. With increasing standardization of sound tones the specific message characteristic assumes greater significance

USCG produced a system of standardized messages. These ranged from a one-second blast/nine-second silence (1 bl-9 si) to two three-second blasts separated by three seconds of silence followed by a three-second blast and finished with 51 seconds of silence (3 bl-3 si-3 bl-51s) (USCG 1979, 7-1).

Fog Signal transmissions are subject to many vagaries. The distance of a signal's range can vary greatly. And the transmission can be affected by the signal's bearing. Quite often, atmospheric conditions are a major fact in the erratic transmissions. Other anomalies include a signal with two-tones that can be heard on one tone in certain conditions but not on both tones. And in other situations a signal can be heard at a considerable range but not near the signal transmitter. The uncertainties of Fog Signals was very much a part of that aid even when sound signals were important. Cautionary and warning information on erratic fog signal behavior was found in older editions of Light Lists but that is no longer included, or only infrequently included.

APPENDIX II
A UNIFIED CLASSIFICATION OF INTERNATIONAL MARINE AIDS TO NAVIGATION

FOG SIGNALS (Including Buoy Sound Signals)

Main Classification:

- 24 Fixed Fog Signals
  - 240 Signals with Single Forms
    - 2400 Whistle
    - 2401 Bell
    - 2402 Gong
    - 2403 Reed Horn
    - 2404 Siren
  - 241 Signals with Variant Forms
    - 2410 Diaphone
    - 2411 Diaphragm Horn
    - 2412 Explosives

Variant Classification:

- 24 Acoustical Signals

- .3 Fog Signals
  - .30 Diaphone
    - .300 Regular
    - .301 Two-Tone
  - .31 Diaphragm
    - .310 Compressed Air
    - .311 Oscillator
    - .312 Nautophone
    - .313 Chime
  - .32 Explosive Signals

.320 Explosives
.321 Gun
.33 Submarine Signals
.330 Submarine Bells
.331 Submarine Oscillator

Exerpts from Buoy Classification:

14 Sound Buoy
140 Single Types
1400 Bell
1401 Whistle
1402 Gong
16 Multi-Message Marine Floating Aids, Single Types
160 Large Floating Aids, Single Types
1600 Light Vessels
1601 Large Navigational Buoys
161 Lighted Sound Buoy
1610 Lighted Bell Buoy
1611 Lighted Whistle Buoy
1612 Lighted Gong Buoy

.15 Sound Buoys
.150 Bell, US
.151 Whistle, US
.152 Carillon, France
.153 Bell, France
.154 Horn Buoy
.155 Siren Buoy
.16 Combination Buoys: Lighted Sound
.160 Lighted Bell, Canada
.161 Lighted Whistle, Canada
.162 Lighted Bell, US
.163 Lighted Whistle, US
.164 Lighted Gong, US

.165 Lighted Horn, US
.166 Lighted Bell--Can, USB
.167 Lighted Bell-Conical, USB
.168 Lighted Bell-Spherical, USB
.18 Multi-Message Floating Aids
.180 Lightfloats
.181 Lighted Catamarans

BUOYS & OTHER FLOATING AIDS

Main Classification:

12 Lighted Buoys
120 Standard Single Types
1200 Can
1201 Spherical
1202 Conical
1203 Pillar
13 Unlighted Buoys
130 Standard Single Forms
1300 Ogival
1301 Spindle
1302 Spherical
1303 Pillar
131 Forms with Variant Versions
1310 Conical
1311 Can/Cylindrical
1312 Spar
14 Sound Buoys
140 Single Types
1400 Bell
1401 Whistle
1402 Gong
16 Multi-Message Floating Aids

160 Large Floating Aids Single Types
  1600 Light Vessel
  1601 Large Navigational Buoy/LANBY Buoy
161 Lighted Sound Buoys
  1610 Lighted Bell Buoy
  1611 Lighted Whistle Buoy
  1612 Lighted Gong Buoy

Variant Classification:

12 Lighted Buoys; 13 Unlighted Buoys; 14 Sound Buoys; 16 Combination Buoys

.1 Floating Aids
  .10 Lighted Buoys-National Models
    .100 Canada
    .101 US
    .102 Greece A/Thailand A
    .103 Russia
    .104 Thailand B
    .105 Greece B
    .106 Norway
    .107 Germany (Beacon Buoy, Lateral & Cardinal Forms)
    .108 All-lighted High Intensity Forms
  .11 Unlighted Buoys: Conical
    .110 US (Nun Form)
    .111 Denmark A
    .112 Denmark B
    .113 Italy
    .114 Poland & France
    .115 Canada
  .12 Unlighted Buoys: Can/Cylindrical
    .120 US
    .121 Denmark

- .122 Germany
- .123 Taiwan
- .124 Sweden, Russia
- .125 Canada

.13 Unlighted Buoys: Spars

- .130 Modified Standard, US
- .131 Modified Standard, Norway
- .132 Modified Standard, Canada
- .133 Special, Spar on Can Base, Iceland, et al.
- .134 Special, Spar on Modified Can Base,
  The Netherlands, Poland
- .135 Special, Spar on Conical Base-A, Iceland

.14 Miscellaneous Unlighted Buoys

- .140 Beacon Buoy, Germany
  (Lateral & Cardinal Forms)
- .141 Barrel Buoys, Sweden, Russia
- .142 Oil Drum Buoys, US
- .143 Casks

.15 Sound Buoys

- .150 Bell Buoy, US
- .151 Whistle Buoy, US
- .152 Gong Buoy, US
- .153 Carrillon, France
- .154 Bell Buoy, France
- .155 Siren

.16 Combination Buoys: Lighted Sound

- .160 Lighted Bell Buoy, Canada
- .161 Lighted Whistle Buoy, Canada
- .162 Lighted Bell Buoy, US
- .163 Lighted Whistle Buoy, US
- .164 Lighted Gong Buoy, US
- .165 Lighted Horn Buoy, US
- .166 Lighted Bell Buoy--Can, USB
- .167 Lighted Bell Buoy--Conical, USB
- .168 Lighted Bell Buoy--Spherical, USB

.17 Electronic Buoys
.170 Radar Beacon Buoy
.171 Radio Beacon Buoy
.18 Multi-Message Floating Aids
.180 Lightfloats
.181 Lighted Catamarans

DAYBEACONS

Main Classification:

231 Natural Marks
2310 Cairns
2311 Trees
2312 Stone Construction
232 "Artificial" Marks
2320 Unidimensional Forms
2321 Open Structural Forms
2322 Enclosed & Solid Construction Forms

233 Morphological/Physical Forms
2330 Daymarks
2331 Daymarks & Structures

Variant Classification:

23 Daybeacons

.26 Daybeacons: Natural Marks
.260 Cairn
.261 Small Tree/Petite Arbres
.262 Tree Branch: Natural State
.263 Tree Branch: Tied-Down Branch
.27 Daybeacons: Uni-Dimensional Marks

.270 Spindle
.271 Perch/Pole
.272 Pile
.273 Post
.274 Stake
.275 Edgemark
.28 Daybeacons: Open Structure
.280 Dolphin/Multiple Pile
.281 Tripod
.282 Latticework
.283 Skeleton Tower
.284 Wooden Framework
.285 Beacon/Bake, Germany
.286 Pyramidal Structure
.287 Triangular Structure
.29 Enclosed & Solid Structures
.290 Small House
.291 Enclosed Structure
.292 Stone/Masonry Structure

RADIO AIDS

Main Classification:

25 Marine Radio Aids
250 Radio Aids, Single Form with Variants
2500 Radiobeacon
251 Radar Aids
2510 Racon
2511 Ramark
2512 Radar Reflectors
252 Hyperbolic Radionavigation Systems
2520 Loran
2521 Decca

2522 Omega
253 Satellite Navigation Aids
2530 Global Positioning System
2531 Differential GPS

Variant Classification:

25 Electronic Aids

.4 Electronic Aids
.40 Radiobeacons
.400 Non-Directional: Circular, Omni-Directional
.401 Non-Directional: Sequence, Group
.402 Non-Directional: Continuous
.403 Directional: Sequence, Group
.404 Directional: Continuous
.41 Radar Aids, Passive Forms, Reflectors
.410 Corner Reflector, Trihedral
.411 Corner Reflector, Pentagonal
.412 Dielectric
.414 Dihedral
.415 Luneberg
.42 Hyperbolic Systems
.420 Loran-A
.421 Dectra
.422 Toran
.43 Satellite Aids
.430 Transit
.44 Radio Buoys
.440 Radar Beacon Buoys
.441 Radio Beacons
Dual Classification (with Buoyage)
.17 Radio Buoys
.170 Radar Beacon Buoys
.171 Radio Beacon Buoys

FIXED LIGHTS

Main Classification:

- 210 Single Forms (All-lighted Marine Aids)
  - 2100 Traffic Control Signals
  - 2101 Sector Lights
  - 2102 High-intensity Marine Lights
- 221 Major Structures (Lighthouses): Sea-Girt
  - 2210 Towers on Rocks
  - 2211 Towers on Skeleton Structures
  - 2212 Towers on Special Marine Foundations
  - 2213 Houses on Special Marine Foundations
- 222 Major Structures: Land-Based Towers
  - 2220 Tall Coastal Towers
  - 2221 Towers on Promotories & Headlands
  - 2222 Open Towers
- 223 Major Structures: Non-Towers
  - 2230 Houses
  - 2231 Buildings
  - 2232 Composite: House
- 224 Minor Structures
  - 2240 Single Vertical Members (Narrow)
  - 2241 Single Vertical Members (Broader)
  - 2242 Multi-members Open Structures
  - 2243 Enclosed Structures
  - 2244 Composite Forms
  - 2245 Single Forms
  - 2246 Tripodal Tower
  - 2247 Tubular Tower
  - 2248 Skeleton Tower

Variant Classification:

- 22 Fixed Lights

.2 Fixed Aids
.20 Major Lights (Lighthouses)
.200 Towers on Skeleton Structures:
Screw-Pile Towers
.201 Towers on Skeleton Structures
.202 Skeleton Towers
.203 Framework Towers
.204 Composite: House on Structure
.205 Composite: Tower Attached to House/
Building
.206 All-Lighted High Intensity Forms

.21 Minor Lights: Multi-Member Structures
.210 Tripod
.211 Pyramid
.212 Pile Structure: Marine Site
.213 Pile Structure: Land-based Site
.214 Skeleton Structure
.215 Dolphin
.216 Tripodal Tower
.217 Tubular Tower
.218 Skeleton Tower
.22 Minor Lights: Single Member Structure I
(Narrow Configurations)
.220 Spindle
.221 Spar
.222 Pipe
.223 Post
.224 Pole
.225 Single Pile
.226 Stake
.227 Mast
.228 Buoyant Beacon
.23 Minor Lights: Single-Member Structures II

(Wide Configurations)
.230 Column
.231 Pedestal
.232 Pillar
.233 Pylon
.234 Obelisk
.24 Minor Lights: Enclosed & Solid Constructions II & Composite Structures
.240 Hut
.241 Small House
.242 Cairn
.243 "Beacon"
.244 Cylinders
.245 House/Hut on Structure
.246 House/Hut on Pile Structure
.247 House/Hut on Tripod
.25 Minor Lights: Single Types of Structures
.250 Stand
.251 Arm
.252 Lighted Bank
.253 All-Lighted High Intensity Forms
.254 All-Lighted Range/Leading Lights

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978-0-918941-33-6