Report No. CG-D-05-92

(2)

WORLDWIDE BUOY TECHNOLOGY SURVEY

John C. Daidola
Nedret S. Basar
Christopher J. Reyling
Fontain M. Johnson

M. ROSENBLATT & SON, INC.
and
Richard T. Walker

U.S. COAST GUARD RESEARCH AND DEVELOPMENT CENTER
AVERY POINT, GROTON, CONNECTICUT 06340-6096

FINAL REPORT
VOLUME I: REPORT

FEBRUARY 1991

Prepared for:

U.S. Department Of Transportation
United States Coast Guard
Office of Engineering, Logistics and Development
Washington, DC 20593-0001

NOTICE

This document is disseminated under the sponsorship of the Department of Transportation in the interest of information exchange. The United States Government assumes no liability for its contents or use thereof.

The United States Government does not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to the object of this report.

This report was directed and sponsored by the Coast Guard Research and Development Center. This report does not constitute a standard, specification or regulation.

SAMUEL F. POWEL, III
Technical Director
United States Coast Guard
Research & Development Center
1082 Shennecossett Road
Groton, CT 06340-6096

Technical Report Documentation Page

1. Report No. CG-D-05-92	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle BUOY TECHNOLOGY SURVEY WORLDWIDE BUOY TECHNOLOGY SURVEY		5. Report Date February 1991
		6. Performing Organization Code 15221-2
7. Author(s) J. C. DAIDOLA, N. S. BASAR, C. J. REYLING, F. M. JOHNSON & R. T. WALKER		8. Performing Organization Report No. R & DC 11/90
9. Performing Organization Name and Address M. ROSENBLATT & SON, INC. 350 BROADWAY NEW YORK, NY 10013 / USCG R & D CENTER AVERY POINT GROTON, CT 06340-6096		10. Work Unit No. (TRAIS)
		11. Contract or Grant No. DTCG39-89-C-E27E04
12. Sponsoring Agency Name and Address DEPARTMENT OF TRANSPORTATION U. S. COAST GUARD OFFICE OF ENGINEERING, LOGISTICS AND DEVELOPMENT WASHINGTON, DC 20593-0001		13. Type of Report and Period Covered FINAL
		14. Sponsoring Agency Code G-NSR

15. Supplementary Notes
REPORT CONSISTS OF THREE VOLUMES: VOLUME I CONTAINS MAIN TEXT OF REPORT PLUS APPENDICES A, D AND E: VOLUME II CONTAINS BUOY RECORDS IN TWO BOOKS: VOLUME III CONTAINS BUOY ILLUSTRATIONS.

16. Abstract
THIS REPORT PRESENTS THE RESULTS OF THE SECOND PART (TASK B) OF THE U.S.C.G. project "BUOY TECHNOLOGY SURVEY". PERSONAL INTERVIEWS WERE CONDUCTED WITH THE NAVIGATION AUTHORITIES AND BUOY MANUFACTURERS AND DESIGNERS IN CANADA, DENMARK, ENGLAND, FINLAND, FRANCE, GERMANY, JAPAN, THE NETHERLANDS AND NORWAY. NAVIGATION AUTHORITIES AND MANUFACTURERS FROM TWELVE ADDITIONAL COUNTRIES WERE ALSO CONTACTED DURING THE 12TH CONFERENCE OF THE INTERNATIONAL ASSOCIATION OF LIGHTHOUSE AUTHORITIES IN JUNE 1990. RELEVANT DATA WERE OBTAINED FROM THESE SOURCES ON THE PHYSICAL, OPERATIONAL AND PERFORMANCE CHARACTERISTICS OF THEIR FLOATING AIDS TO NAVIGATION. A COMPUTER DATABASE WAS DEVELOPED FOR STORING THE DATA FROM ALL SOURCES CITED AS WELL AS THE DATA RECEIVED DURING TASK A OF THIS PROJECT FROM THE U.S. COAST GUARD AND U.S. MANUFACTURERS. THE DATABASE (BUOY TECHNOLOGY INFORMATION SYSTEM - BTIS) IS BOTH RELATIONAL AND RETRIEVABLE AND IS INTENDED FOR USE BY THE U.S. COAST GUARD. A HARD COPY OF BTIS IS CONTAINED IN APPENDIX B OF THIS REPORT AND IS SUPPORTED BY ILLUSTRATIONS OF ALL BUOYS IN APPENDIX C.

THE RESULTS OF ALL INTERVIEWS AND THE DATA OBTAINED ARE ANALYZED AND TRENDS ARE NOTED WITH REGARD TO IDENTIFICATION OF SIGNIFICANT AREAS FOR DEVELOPMENT OF AID TO NAVIGATION BUOYS FOR USE IN THE NEXT TASK (TASK C: RECOMMENDATIONS FOR DEVELOPMENT OF BUOY TECHNOLOGIES).

17. Key Words FLOATING AIDS, BUOYS, ARTICULATED BEACONS, NAVIGATION AUTHORITIES, WORLDWIDE MFG., BTIS DATABASE	18. Distribution Statement DOCUMENT IS AVAILABLE TO THE U. S. PUBLIC THROUGH THE NATIONAL TECHNICAL INFORMATION SERVICE SPRINGFIELD, VA 22161

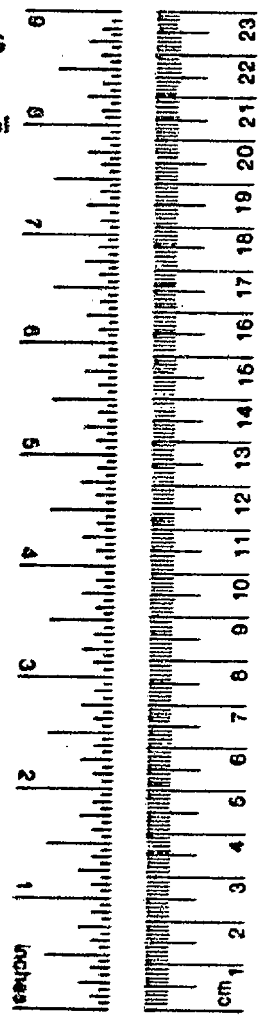
19. Security Classif. (of this report)	20. SECURITY CLASSIF. (of this page)	21. No. of Pages	22. Price
UNCLASSIFIED	UNCLASSIFIED	2231	

METRIC CONVERSION FACTORS

Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
		AREA		
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
		MASS (WEIGHT)		
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
		VOLUME		
tsp	teaspoons	5	milliliters	ml
tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
		TEMPERATURE (EXACT)		
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly).



Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
		AREA		
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
		MASS (WEIGHT)		
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
		VOLUME		
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	0.125	cups	c
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
		TEMPERATURE (EXACT)		
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F

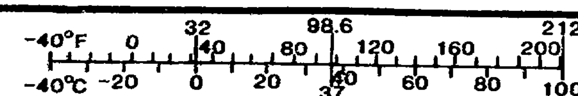


TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF FIGURES

LIST OF FIGURES

LIST OF FIGURES

LIST OF FIGURES

LIST OF TABLES

LIST OF TABLES

LIST OF PHOTOGRAPHS

LIST OF ABBREVIATIONS

AB	Articulated Beacon
ABS	Acrylonitrile-Butadiene-Styrene (Resin)
ADAR	Automatic Data Acquisition Radar
ADS	Automated Data Systems (USCG)
AISM	Association Internationale de Signalisation Maritime (IALA)
ALERP	Aluminum Lighted Emergency Reinforced Plastic
ANA	ANA Navaids Ltd. (India - Manufacturer)
ANBESS	Aids to Navigation Buoy Environmental Sensing System
ANT	Aid to Navigation Team
API	Automatic Power, Inc. (U.S. Manufacturer)
ATON	Aids to Navigation
B/C	Benefit/Cost Ratio
BMV	Bundesministerium fur Verkehr (Germany Ministry of Transport)
BTIS	Buoy Technolgy Information System
BTS	Buoy Technology Survey
CALM	Chain Anchor Leg Mooring
CAN	(Name given to cylindrically shaped buoy)
CANUN	(Name given a buoy with interchangeable CAN and NUN shapes)
CBB	Chiba Buoy Base (Japan)
CCG	Canadian Coast Guard
DECCA	A radio navigation system
DGSM	Netherlands Navigation Authority
DLL	Dept. of Lighthouses and Lightships (India)
DM	Deutsche Mark (Germany)
DTC	Dept. of Transportation and Communications (Australia)
DTIC	Defense Technical Information Center
DW	Deep Water
ECV	Office of Engineering, Logistics, and Development (USCG)
ELB	Exposed Location Buoy
FBN	Finnish Board of Navigation
FLTX	Floatex (Italy - Manufacturer)
FRG	Federal Republic of Germany
FRP	Fiber Reinforced Plastic (can be glass or other fibre)
FV	Farwandsvaesenet (Denmark's Nav. Authority)
FWA	Federal Waterways Authority (Germany)
GHT	Gloucester Harbor Trustees (UK)
GLA	General Lighthouse Authorities (UK)
GPS	Global Postitioning System
GRP	Glass Reinforced Plastic (FRP with glass fibre)
GTK	Gakuyo Toki Kogyo (Japan - Manufacturer)

<u>LIST OF ABBREVIATIONS</u> (cont'd)

HBD	Harwich Buoy Department (UK)
HMP	Hippo Marine Products (UK Manufacturer)
IALA	International Association of Lighthouse Authorities (AISM)
IEEE	Institute of Electrical and Electronic Engineers
KWH	KWH Pipe Ltd. (Finland Manufacturer)
LANBY/LNB	Large Navigation Buoy
LED	Light Emitting Diode
LORAN	Long Range Aids To Navigation
MBS	Maritime Buoyage System
MSA	Maritime Safety Agency (Japan)
MSEI	MIL Systems Engineering, Inc. (Canada)
MTS	Marine Technology Society
NBS	New Buoy Systems
NCD	Norwegian Coast Directorate
NDBC	National Data Buoy Center (USA)
NK	Norwegian Krones
NKK	Nippon Kogi Kogyo (Japan - Manufacturer)
NSR	Office of Navigation and Waterway Safety (USCG)
NTIS	National Technical Information Service
NUN	(Name given a conically shaped buoy)
PB	Pintsch Bamag (Germany - Manufacturer)
POD	Probability of Detection
POR	Probability of Recognition
PVC	Polyvinyl Chloride
QIC	Quarter Inch Cartridge
RACON	Radar transponder used as aid to navigation
RANDMARK	Fixed aid located at or near the edge of a navigation channel (used in Finland)
R&D	Research and Development
R&DC	Research & Development Center
RMS	Root Mean Square
RPS	Reinforced Plastic Structures (UK Manufacturer)
RS	Ryokuseisha Corp. (Japan - Manufacturer)
RSI	Racal Survey, Inc. (U.S. Manufacturer)
SALM	Single Anchor Leg Mooring
SANDS	Simplified Aids to Navigation Data System
SBM	Single Buoy Mooring
SNAF	Shanghai Navigation Aid Factory (China - Manufacturer)
SNAME	Society of Naval Architects and Marine Engineers

LIST OF ABBREVIATIONS (cont'd)

SOW	Statement of Work
SPA	Saudi Port Authority
SQL	Structured Query Language
SRA	Short Range Aids
STATO	(Name given a specific type of anchor)
STPB	Service Technique des Phares & Balises (France: Authority)
SW	Shallow Water
SWATH	Small Waterplane Area Twin Hull
SYLEDIS	A land based accurate radio positioning system
SZVF	Seezceichenversuchsfeld (Germany: ATON R&D Center)
TBTO	Tributyltin Oxide
TGC	The Gilman Corp. (U.S. Manufacturer)
THV	Trinity House Vessel (UK)
TICWAN	(Name given a small ATON servicing boat)
TOR	Tentative Operating Requirements
UHF	Ultra High Frequency
UK	United Kingdom
USCG	United States Coast Guard
UT	Urethane Technologies, Inc. (U.S. Manufacturer)
VTS	Vessel Traffic Services
WAMS	Waterway Analysis and Management Systems
WATG	Wave Activated Turbine Generator
WB	Weiseler Bojen (Germany - Manufacturer)
WGDB	Wine Glass Discrepancy Buoy
WHOI	Woods Hole Oceanographic Institution
ZLBC	Zeni Lite Buoy Co. (Japan - Manufacturer)

1.0 INTRODUCTION

1.1 Background

The Marine Aids to Navigation (ATON) System of the United States is an extensive and comprehensive array of devices external to a vessel. It is intended to assist a navigator in determining his position, plotting a safe course, identifying obstructions to navigation, and to promote safe and economic movement of commercial traffic. The United States Coast Guard (USCG) operates and administers this system which serves the needs of and benefits the maritime commerce, the general boating public and the armed forces. A subgroup of this system is the Short Range Aids (SRA) to navigation system including navigational devices within visual, audible, radar or low power radiobeacon range.

In order to research the potential technologies which could advance the state of the art in buoys as aids to navigation, the USCG has initiated the "New Buoy Systems" project. The Buoy Technology Survey is the first step in this new project with the purpose of conducting an overall technology assessment of buoy systems. This is to be accomplished by the following three tasks:

TASK A - Review of the research and development efforts by the USCG on aid to navigation buoy development since 1962.

TASK B - Worldwide survey of existing buoy technology and compilation of survey data in a computer database.

TASK C - Formulation of recommendations for the development of improved aid to navigation buoys for the USCG.

The first task, "USCG Buoy Development Review", has been completed and results presented in a final report.[1]

The current report is concerned with Task B of the project; it presents the results of a worldwide buoy technology survey and of the development of a computerized "Buoy Technology Information System (BTIS)".

1.2 Objective

The main concern of the overall project is the buoy platform and excludes the direct and detailed consideration of such related matters as mooring systems, signalling devices, and the much broader consideration of SRA type, arrangement and effectiveness. The fact that the mooring system and signalling devices are sometimes integrated with the platform has resulted in

[1] J. Daidola, N. Basar, M. Johnson and R. Walker, "Buoy Technology Survey - USCG Buoy Development Review." USCG R&D Center, Final Report, October 1990.

an indirect consideration of these features as will be evident in the material that follows. However, the larger question of type, arrangement and effectiveness of the complete system could not be addressed in detail within the constraints of this project. In an overall evaluation of the SRA system, such considerations should also be addressed. The USCG's Waterway Analysis and Management System (WAMS) is considering this matter as a separate investigation.

The objective of Task B, the subject of this report is to conduct surveys of foreign country navigation authorities responsible for buoys and the manufacturers of buoys, both domestic and foreign, and to develop a computer database of the information collected in this project. The task includes the screening of worldwide engineering and technical information on buoy systems, approaches to problem solving (particularly those that have been identified by the USCG), and development of a computer database for use by the USCG which is both relational and retrievable. The completed program is to be developed on a USCG supplied computer and software, and is then to be installed at the USCG R&D Center and at the USCG Headquarters (G-ECV and G-NSR).

In the next task of this project (Task C), buoy technologies will be evaluated in order to identify those that show the most promise for improving the SRA system. This will be accomplished by carrying out a matrix analysis of the technologies to rank them in accordance with their benefits as judged by three measures of merit: average annualized costs, operational effectiveness, and handling safety. The results of Task C will be presented in a separate report.

1.3 Approach

For accomplishing the goals of this task, two major efforts were undertaken:

(a) Conducting worldwide surveys

(b) Developing a relational and retrievable computer database.

Within the framework of worldwide surveys, personal interviews were conducted with the national navigation authorities and principal buoy manufacturers and/or designers of nine major countries as specified by the U.S. Coast Guard. In addition, interviews were held with representatives of national authorities and manufacturers from twelve additional countries during the Twelfth Conference of the International Association of Lighthouse Authorities in Veldhoven (the Netherlands) in June 1990. Information on buoy technology were also solicited and obtained by correspondance from other additional sources.

The efforts related to the "Buoy Technology Information Systems" included first the development of a "Database Design" in accordance with the USCG requirements. Upon approval of the Database Design by the USCG, a software package and BTIS Documentation were developed consisting of the database files and program routines as well as the Users Manual, the Computer Operations Manual, and the Program Maintenance Manual.

In the subsequent sections of this report, the findings and analysis results from all Task B efforts are presented as follows:

- In Section 2.0, the results of worldwide surveys are presented in separate subsections:
  - for the major countries' national navigation authorities,
  - for commercial institutions in the major navigation countries,
  - for the International Association of Lighthouse Authorities,
  - for the national authorities and manufacturers of other countries.
- Section 2.0 also includes, in subsection 2.5, a review of the findings and trends from all surveys.
- Section 3.0 describes the BTIS efforts and presents the results obtained.
- Detailed information to support the results cited in Sections 2.0 and 3.0 are presented in the five Appendices as follows:
  - Appendix A contains the summaries of all interviews held during the worldwide surveys as recorded.
  - Hard copies of all 381 U.S. and foreign buoy records included in the BTIS Database are contained in Appendix B along with curves of cumulative cross-sectional areas following the records of all buoys for which such curves could be developed.
  - In Appendix C, illustrations of all 381 buoys are presented.
  - Appendix D contains the methods used in computing cumulative area, nominal visual ranges, and radar ranges for individual buoys.
  - The contacts made and additional data obtained during the 1990 IALA Conference in Veldhoven, the Netherlands, are described in Appendix E.

Due to the voluminous nature of Appendices B and C, they are presented in separately bound volumes. Appendices A, D and E are found at the end of this report.

2.0 RESULTS OF WORLDWIDE SURVEYS

During the course of the first part of this task, the national navigation authorities and some of the commercial buoy manufacturers and designers in the nine countries (identified by the USCG as those operating more than 500 aid to navigation buoy stations) were visited and interviews conducted. Table 2-1A lists the countries and manufacturers /designers visited and persons interviewed in each country.

Prior to the interviews, letters were sent to each organization and it was suggested that the survey questionnaires attached to the letters be filled out and returned before the project investigators' visits. The form used as the survey questionnaire is shown in Table 2-2. Many of the addressees complied with this request, some others filled out the questionnaire during the interview and some others preferred to verbally provide the information needed to the extent they said they could. These questionnaires were used in preparing the "Summary Notes from Interview" contained in Appendix A as well as compiling the buoy records input into the BTIS database.

Appendix A contains only the "Summary Notes" and not the Exhibits referenced therein since the latter are too voluminous to include in this report. The originals and/or reproduced copies of these Exhibits are in the USCG R&D Center files.

The data obtained from all of these sources for each type of buoy used/ manufactured/designed by them were compiled, screened and recorded on specially prepared three-page formats shown in Table 2-3. Each hand-filled buoy record was then input into the BTIS computer database. Detailed information about the BTIS and the guidelines/conventions used in its preparation is provided in References 1, 2, 3, and 4. The database is further discussed in Section 3.0 of this report.

In addition to the personal interviews during survey visits, further contacts were made with these and some other country sources while in attendance at the 1990 IALA Conference in Eindhoven, the Netherlands. Such additional sources of information are listed separately in Table 2-1B and a Trip Report Summarizing the contacts made and the findings is included in Appendix E. Buoy records were compiled and input into the BTIS database for any new and/or different buoys that were identified during such contacts including those buoys which are in development stages and not yet manufactured or deployed.

Table 2-1A also lists the number of buoy records that are contained in the BTIS database for each country and each buoy manufacturer. As seen, there are a total of 381 buoy records in the database. At the bottom of the third page of each buoy record, there is a data field titled "Drawing Reference." The entry in this field corresponds to the number of the specific buoy's illustration which is contained in Appendix C. For easy cross-referencing, the listings of the national navigation authority and manufacturers' buoys and the corresponding illustration numbers are shown in Table 2-4.

TABLE 2-1A

LISTING OF WORLDWIDE SURVEYS AND INTERVIEWS

MAJOR NATIONAL NAVIGATION AUTHORITIES AND DESIGNERS/MANUFACTURERS

COUNTRY	AGENCY MANUFACTURER	LOCATION	PERSON(S)	No. of Buoys in BTIS
CANADA	Canadian Coast Guard Aids & Waterways Division	Ottawa, Ontario	Mr. Reiner Silberhorn	31
Authority	Canadian Coast Guard Base Prescott	Prescott, Ontario	Mr. Reiner Silberhorn Mr. Hugh Jones	-
	Canadian Coast Guard Base Charlottetown	Charlottetown, Prince Edward Island	Mr. Hillard MacLennan Mr. Charles McDonald	-
	Canadian Coast Guard Base Halifax	Dartmouth, Nova Scotia	Mr. David Smith Mr. Yves Leclerc	-
CANADA	MIL Systems Engineering, Limited	Ottawa, Ontario	Mr. Robert MacLaren Mr. Adil Ozdemir	-
Designer/ MFG.	KWH Pipe (Canada) Ltd.	Mississauga, Ontario	Mr. Pekka Maukola	-
	Georgetown Shipyard, Inc.	Georgetown, Prince Edward Island	Mr. Fred McConnell Mr. Tom Green Mr. John Perry	-
	Fairway Industries, Ltd.	Halifax, Nova Scotia	Mr. James Whiteway	-
	Orraids, Ltd.	Prescott, Ontario	Mr. Ron Bryenton	-
DENMARK Authority	Farvandsvaesenet Royal Danish Adm. of Navigation and Hydrography)	Copenhagen, Denmark	Mr. Nikolaj Hansen Mr. H.N. Svendsen Mr. H. Littau Jensen	24

TABLE 2-1 A-Cont'd

LISTING OF WORLDWIDE SURVEYS AND INTERVIEWS

MAJOR NATIONAL NAVIGATION AUTHORITIES AND DESIGNERS/MANUFACTURERS

COUNTRY	AGENCY MANUFACTURER	LOCATION	PERSON(S)	No. of Buoys in BTIS
DENMARK MFG	Electronic Supply Co.	Copenhagen, Denmark	Mr. Claus Jacobsen	-
ENGLAND Authority	Trinity House	London, England	Capt. Malcolm Edge Capt. John Barnes	34
	Trinity House - Harwich Depot	Harwich, England	Capt. Evans	-
	Gloucester Harbor Trustees	Gloucester, England	Mr. R. G. House Capt. Allen Boyer Mr. Gerard	-
	City of Bristol Conservancy and Pilotage Department	Bristol, England	LCDR. E.M. Bradley LCDR. W.J.M. Coles	-
ENGLAND	Nautical Institute	London, England	Mr. Michael Plummridge	-
Designer/ MFR.	Thorn EMI Electronics, Ltd.	Woking, England	Mr. John Irving	-
	Midar (Marine Systems) Ltd.	London, England	Vice-Admiral Sir Ian McGeoch	-
	Pharos Marine	Brentford, England	See U.S.-Automatic Power/Pharos	27
	Reinforced Plastic Structures (Lewes) Ltd.	Lancing, England	None	6

TABLE 2-1 A-Cont'd

LISTING OF WORLDWIDE SURVEYS AND INTERVIEWS

MAJOR NATIONAL NAVIGATION AUTHORITIES AND DESIGNERS/MANUFACTURERS

COUNTRY	AGENCY MANUFACTURER	LOCATION	PERSON(S)	No. of Buoys in BTIS
ENGLAND	HIPPO Marine Products	Tonebridge, England	Mr. John Wickham	1
Designer/ MFG.	Balmoral Nav-Aids	Aberdeen, Scotland	Mr. David Robertson Mr. Doug G. Marr	24
	Firdell Multiflectors Limited	London, England	Dr. Steve Bell	-
FINLAND Authority	Merenkulkuhallitus (Finnish National Board of Navigation)	Helsinki, Finland	Mr. Klaus Martonen Mr. Timo Rekonen	10
FINLAND MFG.	KHW Pipe, Ltd.	Vaasa, Finland	Mr. Jouko Hyttinen Mr. Keijo Malmberg	1
	Rencomarina, Ky	Porvoo, Finland	Mr. Raimo Niitynen Mr. Errki Viljakainen	-
FRANCE Authority	Service Technique des Phares et Balises Headquarters	Paris, France	Mr. Jean-Yves Chauviere Mr. Jacques Royer	15
	International Association of Lighthouse Authorities (IALA)	Paris, France	Mr. Norman Matthews	-
FRANCE MFG.	Gisman	Paris, France	Mr. Thierry Houchard	2
GERMANY Authority	Bundesministerium fur Verkehr (Ministry of Transport)	Bonn, Germany	Dr. Ing. H. Hartung	-

TABLE 2-1 A-Cont'd

LISTING OF WORLDWIDE SURVEYS AND INTERVIEWS

MAJOR NATIONAL NAVIGATION AUTHORITIES AND DESIGNERS/MANUFACTURERS

COUNTRY	AGENCY MANUFACTURER	LOCATION	PERSON(S)	No. of Buoys in BTIS
GERMANY Authority	Seezeichenversuchsfeld (ATON R&D Center)	Koblenz, Germany	Mr. Helmut Kuhlbrodt Mr. W. Gaschler	12
GERMANY Designer/ MFG.	Pintsch Bamag, GmbH	Dinslaken, Germany	Mr. Gerd Wiehe	12
	F. Hebold GmbH	Cuxhaven, Germany	Mr. Hartmut Hebold	-
	Compass GmbH	Koblenz, Germany	Mr. Gustav Hovermann	-
	Weiselerbojen und Maschinenbau oHG	Weisel, Germany	Mr. Ernst Knecht	-
ITALY MFG.	Resinex Offshore	Iseo (Brescia) Italy	Mr. Alex Valentines	2
	Floatex	Brescia, Italy	Mr. B.J.F. Zuurbier	1
JAPAN Authority	Maritime Safety Agency Headquarters	Tokyo, Japan	Mr. Hideki Noguchi Mr. Koujrou Katsume Mr. Shinozaki Masao Mr. Masato Sakai	15
	Maritime Safety Agency Chiba Buoy Base	Chiba, Japan	Mr. Hideki Noguchi Mr. Narita Mr. Tonami	-

TABLE 2-1 A-Cont'd

LISTING OF WORLDWIDE SURVEYS AND INTERVIEWS

MAJOR NATIONAL NAVIGATION AUTHORITIES AND DESIGNERS/MANUFACTURERS

COUNTRY	AGENCY MANUFACTURER	LOCATION	PERSON(S)	No. of Buoys in BTIS
JAPAN MFG.	Ryokuseisha Corporation	Tokyo, Japan	Mr. Hiroo Todoroki Mr. Mitsuo Horiguchi	19
	Gakuyo Tuki Kogyo Co., Ltd.	Tokyo, Japan	Mrs. S. Miyamura Mr. Eifumi Miyamura Mr. Hiroaki Noda Mr. Yasushi Okuyama Mr. Shoichiro Ohara Mr. Masahiro Kuramochi	-
	Nippon Koki Kogyo Co., Ltd.	Kawasaki, Japan	Mr. Naomura Kitamura Mr. Tsutomu Emura Mr. Katsuji Gotoh Mr. Shim Kato	5
	Zeni Lite Buoy	Osaka, Japan	None	21
THE NETHERLANDS Authority	Ministerie Van Verkeer en Waterstaat, Directoraat-General Scheepvaart en Maritieme Zuken (DGSM)	Schereningen, The Netherlands	Mr. G. H. van der Ent Mr. Hoekstra Ing. A. Verbaan Ing. J.W. Ockhurst Mr. A.P. Valstar	2
THE NETHERLANDS	Stromag N.V./Pintsch Bamag B.V.	Katwijk, The Netherlands	Mr. W.F.H. Scholten	5
Designer/ MFG.	Damen Shipyards	Gorinchem The Netherlands	Mr. Gerrit W. Ruyter	-
	Maritime Research Institute Netherlands MARIN	Wageningen The Netherlands	Capt. R. Tresfon Mr. Dallinga	-

TABLE 2-1 A-Cont'd

LISTING OF WORLDWIDE SURVEYS AND INTERVIEWS

MAJOR NATIONAL NAVIGATION AUTHORITIES AND DESIGNERS/MANUFACTURERS

COUNTRY	AGENCY MANUFACTURER	LOCATION	PERSON(S)	No. of Buoys in BTIS
THE NETHERLANDS	Marine Analytics, D.V.	Rotterdam The Netherlands	Mr. C.C. Glandsorg	-
Designer/ MFG. (Cont.)	All Marine	Rotterdam The Netherland	Ir. Henk Keers Capt. Ruud E. Behrend Capt. Ben Latooy	1
NORWAY Authority	Kystdirektoratet (Norwegian Coast Directorate)	Oslo, Norway	CDR. Svein Ording CDR. Eirik I. Sire	6
NORWAY MFG.	Ticon Plast A/S	Drammen, Norway	Mr. Svein Landaas	11
USA Authority	U.S. Coast Guard	Washington, D.C. & Groton, CT	See Ref: 29	51
USA	The Gilman Corporation	Gilman, Conn.	Mr. Richard L. Gilman Mr. George M. Greider	1
Designer/ MFG.	Racal Survey, Inc.	Houston, Texas	Dr. James E. Alexander	-
	Automatic Power	Houston, Texas	Mr. David Adams Mr. Inaki Garabieta	19
	Tideland Signals	Houston, Texas	Mr. Harry J. Saenger	11

TABLE 2-1 A-Cont'd

LISTING OF WORLDWIDE SURVEYS AND INTERVIEWS

MAJOR NATIONAL NAVIGATION AUTHORITIES AND DESIGNERS/MANUFACTURERS

COUNTRY	AGENCY MANUFACTURER	LOCATION	PERSON(S)	No. of Buoys in BTIS
USA	Urethane Technology	Port Allen, Louisiana	Mr. C. R. Dunbar	3
Designer/ MFG. (Cont.)	Benthos, Inc.	N. Falmouth, Massachusetts	Mr. Kevin McCarthy Mr. Joel Rezzo	-
	Woods Hole Oceanographic Institute	Woods Hole, Massachusetts	Mr. Henri O. Berteaux Mr. Peter Clay	-
	Heat Transfer Systems, Inc.	St. Louis, Missouri	Mr. David "Cau-Tu" Wong	
	Mooring Systems, Inc.	Monument Beach Massachusetts	Mr. Peter Clay	-
	Seaward International	Clearbrook, Virginia	Mr. John R. Hill	1
	Alu Power, Inc.	Warren, New Jersey	Mr. Robert P. Hamlen	-
	Rotocast Plastic Products, Inc.	Brownwood, Texas	Mr. David Fair	-

TABLE 2-1 B

LISTING OF CONTACTS WITH OTHER COUNTRIES'

NAVIGATION AUTHORITIES, MANUFACTURERS AND DESIGNERS

COUNTRY	AGENCY MANUFACTURER	LOCATION	PERSON(S)
Australia	Department of Transport and Communications	Canberra, Australia	Mr. D. Langford
Belgium	Administration de la Marine et de la Navigation Interieure	Brussels, Belgium	Mr. L. Van de Vel
Chile	Direccion General Territorio Maritimo Y Marina Mercante	Valparaiso, Chile	Capt. Estanislau Sabeckis Arre
	Technical Equipment International, Inc.	Vira Del Mar	Cmdr. (Ret) Gonzalo F. Ruiz
	Beacon Chile LTDA	Valparaiso	Mr. Carlos Patricio Arias
Equatorial Guinea	Direccion General De Puertos Y Senales	Malabo, Equatorial Guinea	Mr. F. Biahute Mateu
Hong Kong	Government Marine Department	Hong Kong	Mr. R.H. Parry
India	Department of Lighthouses and Lightships	New Delhi, India	Mr. K. Sriram Mr. K.V. Mohan Rao
	ANA Navaids, Ltd.	New Delhi, India	Mr. Harbans S. Grewal
Ireland	Commissioner of Irish Lights	Dublin, Ireland	Mr. J.J. Doyle Mr. M.B. McStay Mr. S.G.R. Ruttle

TABLE 2-1 B-Cont'd

LISTING OF CONTACTS WITH OTHER COUNTRIES'

NAVIGATION AUTHORITIES, MANUFACTURERS AND DESIGNERS

COUNTRY	MANUFACTURER	AGENCY LOCATION	PERSON(S)
Malawi	Ministry of Transport	Malawi	Mr. F.S. Chilalika
New Zealand	The Marine Division, Ministry of Transport	Wellington, New Zealand	Capt. D.W. Boyes
Nigeria	Nigerian Port Authority	Lagos, Nigeria	Capt. A.C. (Tony) Olugbode
Peoples Republic of China	Shanghai Navigation Aid Factory	Shanghai, PRC	----
Saudi Arabia	Saudi Ports Authority	Riyadh, Saudi Arabia	----
Scotland	Northern Lighthouse Board	Edinburgh, Scotland	Sh. Pr. R.R. Taylor
South Africa	South African Harbors	Braamfontein South Africa	Mr. J.H. Collocott
Sweden	The National Swedish Administration of Shipping and Navigation	Norrkoping, Sweden	Capt. Kjell-Ake Reslow Capt. T. Edenius Mr. Christer Wolinder Mr. Daniel Andersson Mr. Christian Lagorwall

QUESTIONNAIRE
NEW BUOY SYSTEMS
BUOY TECHNOLOGY SURVEY

Date:

Organization:
Full Name:
Address:

Tel No.:
Fax No.:

Person Responding:
Name:
Title:

Experience with Buoys (Note #1):
- Types of Buoys designed/Manufactured /or Used:

- Environments in Which Buoys are deployed:

Benefits of the Current Short Range Aids to Navigation (SRA):

Problems Experienced with the Current SRA:

Ideas for Improvements on the Current SRA:

Individuals Known to be Experts in Buoy Systems:

TABLE 2-2

Organizations Known to be Designers or Manufacturers of Buoy Systems:

Published Data Sources and References Available to the Respondee on Buoy Systems:

Recommendations on the Application of Advanced Technology to Buoy Systems:

The Extent and Impact of Conformance with IALA Buoy Regulations:

List of Attachments (Note #2):

Notes

#1. Please use additional sheets if the space provided in this questionnaire for individual entries is not sufficient for your response.

#2. Please list any attachments to the Questionnaire that you may wish to provide such as copies of papers on buoy systems, buoy specifications, brochures, catalogues, etc. under this entry.

#3. Please mail or FAX completed Questionnaire to:

M. Rosenblatt & Son, Inc.
350 Broadway
New York, NY 10013 - U.S.A.
Attention: Nedret S. Basar
Tel.: (212) 431-6900 FAX: (212) 334-0837

TABLE 2-2
Continued

BTIS Buoy Record

GENERAL INFORMATION

Name of Buoy: _

Country of Use: _

Function: ______________________________

____

____

____

____

____

PHYSICAL CHARACTERISTICS

Buoy Weight: _ _ _ _ _ Lbs.

Buoy Draft: _ _ _ . _ _ Ft.

Overall Buoy Length: _ _ _ . _ _ Ft.

Focal Height of Light: _ _ . _ _ Ft.

Buoy Beam or Diameter: _ _ . _ _ Ft.

Freeboard No Mooring: _ _ . _ _ Ft.
Minimum: _ _ . _ _ Ft.

Pounds Per Inch Immersion: _ _ _ _ _ Lbs.

Metacentric Height: _ _ . _ _ Ft.

Reserve Buoyancy: _ _ _ _ _ Lbs.

Wave Motion Response: _

Construction Material:
Hull Shell : _
Hull Filling : _
Tower : _
Topmark : _
Counterweight: _

Coating/Coloring System: _

Subdivision: _

Hull Type: _

Counterweight Type: _

TABLE 2-3

BTIS Buoy Record

RELATED EQUIPMENT

Number of Power Sources: _ _

Type of Power Sources:

_ _

Lighting Equipment:

_ _

Sound Equipment:

_ _

Other Payload:

_ _

Daymark Area: _ _ _ . _ Sq. Ft.

Bridle Size: Chain Size: _ . _ _ _ In.
Length : _ _ . _ Ft.

Mooring Line: Size: _ . _ _ _ In.
Type: _

Sinker Size: _ _ _ _ _ Lbs.

Topmark Type: _

Number of Padeyes: _ _

OPERATING CHARACTERISTICS

Operating Environment: _

Nominal Visual Range of Daymark: _ _ . _ Nmi.

Radar Range: _ _ . _ Nmi.

Maximum Current: _ _ . _ Kts.

Mooring Depth: Minimum: _ _ _ Ft.
Maximum: _ _ _ _ Ft.

Reflective Material Type:

_ _

TABLE 2-3
Continued

ADDITIONAL DATA

Cost: Replacement: $ _ _ _ _ _
Preparation: $ _ _ _ _ _
Monthly Servicing: $ _ _ _ _ _

Service Life: _ _ _ Yrs.

Maintenance Interval: _ _ Mos.

Maintenance Notes:

Special Features:

Stability Notes:

General Notes:

Manufacturers : _

Source of Design : _

Drawing Reference: _

TABLE 2-3
Continued

Country of Use	Buoy Name	Beam Ft.	Drawing Reference
Australia	8 x 28 LIGHTED BUOY	8.00	Aust-1
Canada	FA-1001 1.4M LR	4.59	Canada 1 & 4
Canada	FA-1004 1.8m LR	6.07	Canada 1 & 5
Canada	FA-1007 2.9m LBR	9.58	Canada 1 & 6
Canada	FA-1010 2.9m LWR	9.58	Canada 1 & 7
Canada	FA-1015 3.0m SCOW	5.00	Canada 1 & 8
Canada	FA-1017 1.8m LR	6.07	Canada 1 & 9
Canada	FA-1019 1.5m DISCUS	4.92	Canada 1 & 10
Canada	FA-2001 0.8m Coastal Can	2.62	Canada 2 & 11
Canada	FA-2002 0.8m Coastal Conical	2.62	Canada 2 & 12
Canada	FA-2003 1.2m Coastal Can	3.94	Canada 2 & 13
Canada	FA-2004 1.2m Coastal Conical	3.94	Canada 2
Canada	FA-2005 1.6m Coastal Can	5.25	Canada 2 & 14
Canada	FA-2006 1.6m Coastal Conical	5.25	Canada 2 & 15
Canada	FA-2007 2.0m Coastal Conical	6.56	Canada 2 & 16
Canada	FA-2008 0.9m River Conical	3.00	Canada 2 & 17
Canada	FA-2009 0.9m River Can	3.00	Canada 2 & 18
Canada	FA-2010 1.2m River Conical	4.00	Canada 2 & 19
Canada	FA-2011 1.2m River Can	4.00	Canada 2 & 20
Canada	FA-2012 0.6m Mackenzie River-C	2.00	Canada 2 & 21
Canada	FA-2013 0.6m Mackenzie River-N	2.00	Canada 2 & 22
Canada	FA-2014 Canol Type Boat	1.67	Canada 2 & 25
Canada	FA-2015 0.4m Mackenzie River-C	1.51	Canada 2 & 23
Canada	FA-2016 0.4m Mackenzie River-N	1.51	Canada 2 & 24
Canada	FA-3001 1.0m Ice, Can	3.31	Canada 3 & 26
Canada	FA-3002 1.0m Ice, Conical	3.31	Canada 3 & 27
Canada	FA-3003 0.7m Ice, Can	2.25	Canada 3 & 28
Canada	FA-3004 0.7m Ice, Conical	2.25	Canada 3 & 29
Canada	FA-3005 0.6m SPAR	2.04	Canada 3 & 30
Canada	FA-3006 0.6m SPAR, (Short)	2.04	Canada 3 & 31
Canada	FA-3007 0.3m SPAR, Ottawa Rvr	1.17	Canada 3 & 32
Canada	FA-3008 Vari.Buoyancy FRP SPAR	0.61	Canada 3 & 33
Denmark	Integrated Modular Buoy	4.92	Denmark - 24
Denmark	Jernvager I Type C Unlighted	0.00	Denmark 17
Denmark	Jernvager I Type K Unlighted	0.00	Denmark 18
Denmark	Jernvager Type S Unlighted	0.00	Denmark 19
Denmark	Lighted Racon Buoy Model 2	4.92	Denmark 16
Denmark	Type 11, Cylind. Top, Lighted	4.10	Denmark 10
Denmark	Type 12, Conical Top, Lighted	4.10	Denmark 1
Denmark	Type 13, Cylind. Top, Lighted	4.92	Denmark 11
Denmark	Type 14, Conical Top, Lighted	4.92	Denmark 2
Denmark	Type 15, Cylind. Top, Lighted	5.58	Denmark 15
Denmark	Type 16, Conical Top, Lighted	5.58	Denmark 8
Denmark	Type 21, Cylind. Top, Lighted	3.61	Denmark 12
Denmark	Type 22, Conical Top Lighted	3.61	Denmark 3
Denmark	Type 25, Cylind. Top, Lighted	3.61	Denmark 14
Denmark	Type 26, Conical Top, Lighted	3.61	Denmark 5
Denmark	Type 31, Cylind. Top, Lighted	3.61	Denmark 13
Denmark	Type 32 Conical Top, Lighted	3.61	Denmark 4
Denmark	Type 43 Ocean Conical, Lighted	9.43	Denmark 6
Denmark	Type 52 Ocean Conical, Lighted	6.56	Denmark 7
Denmark	Type 62 Conical, Lighted	4.92	Denmark 9

TABLE 2-4

LISTING OF WORLDWIDE BUOY RECORDS IN BTIS DATABASE

Country of Use	Buoy Name	Beam Ft.	Drawing Reference
Denmark	Vager I Unlighted	3.45	Denmark 20
Denmark	Vager II Unlighted	2.79	Denmark 21
Denmark	Vager III Unlighted	2.30	Denmark 22
Denmark	Vager IV Unlighted	1.64	Denmark 23
England	9'0" General Purpose Unlighted	9.00	England 12
England	Cardinal Class I, 10x50 LWBR	10.00	England 5
England	Cardinal Class I, 10x51 LWBR	10.00	England 4
England	Cardinal Class II Pillar Mk. I	10.00	England 7
England	Class 1 Can	12.00	England 15
England	Class 1 Conical	12.00	England 15
England	Class 1 Spherical	12.00	England 15
England	Class 2 Can	10.00	England 15
England	Class 2 Conical	10.00	England 15
England	Class 2 Spherical	10.00	England 15
England	Class 3 Can	8.00	England 15
England	Class 3 Conical	8.00	England 15
England	Class 3 Spherical	8.00	England 15
England	Class 4 Can	6.00	England 15
England	Class 4 Conical	6.00	England 15
England	Class 4 Spherical	6.00	England 15
England	Class 5 Can	5.00	England 15
England	Class 5 Conical	5.00	England 15
England	Class 5 Spherical	5.00	England 15
England	Class V conical, lighted	4.75	England 14
England	High Focal Plane, 10x39 LWR	10.00	England 3
England	High Focal Plane, 10x43 LWR	10.00	England 2
England	High Focal Plane, 10x44 LWR	10.00	England 1
England	Keel Type Auto CO2 Bell, Light	10.00	England 10
England	Keel Type Lighted Gas	10.00	England 8
England	Lighted Vessel Watch	6.00	England 16
England	Short Pillar Lighted Acetylene	10.00	England 6
England	Small Electric Lighted, "Bury"	5.00	England 13
England	Special Can	3.75	England 16
England	Spherical Mooring	5.50	England 16
England	Spherical Top	3.75	England 16
England	Standard GRP 3 Meter Lighted.	9.82	England 11
England	Std 4 Pocket Lighted Acetylene	10.00	England 9
England	Wreck/Nun	3.83	England 16
England MFG 1	950 Series Marker (3.1x5.8 L)	3.11	England MFG 1-1&1-15
England MFG 1	EF120L Marker Buoy (3.9x9 L)	3.94	England MFG 1-1& 1-2
England MFG 1	EF15L Class V (4.9x10 LR)	4.92	England MFG 1-1& 1-3
England MFG 1	EF15P Class V (4.9x14 LR)	4.92	England MFG 1-1&1-4
England MFG 1	EF18L Class IV (5.9x13 LR)	5.91	England MFG 1-1&1-5
England MFG 1	EF18P Class IV (5.9x18 LR)	5.91	England MFG 1-1&1-6
England MFG 1	EF20L (6.6x13 LR)	6.56	England MFG 1-1&1-7
England MFG 1	EF20P (6.6x18 LR)	6.56	England MFG 1-1& 1-8
England MFG 1	EF25L Class III (8.2x16 LR)	8.20	England MFG 1-1&1-9
England MFG 1	EF25P Class III (8.2x25 LR)	8.20	England MFG 1-1&1-10
England MFG 1	EF30L Class II (9.8x18 LR)	9.84	England MFG 1-1&1-11
England MFG 1	EF30P Class II (9.8x27 LR)	9.84	England MFG 1-1&1-12
England MFG 1	EF36L Class I (11.8x18 LR)	11.81	England MFG 1-1&1-13
England MFG 1	EF36P Class I (11.8x27 LR)	11.81	England MFG 1-1&1-14

TABLE 2-4 CONTINUED

Country of Use	Buoy Name	Beam Ft.	Drawing Reference
England MFG 1	L11 (3.6 x 6.7 LR)	3.61	England MFG 1-1&1-16
England MFG 1	L16 (5.3x9.2 LR)	5.25	England MFG 1-1&1-18
England MFG 1	L21 (6.9x12 LR)	6.89	England MFG 1-1&1-20
England MFG 1	L40 (13.1x18 LR)	13.12	England MFG 1-1&1-22
England MFG 1	P11 (3.6x10 LR)	3.61	England MFG 1-1&1-17
England MFG 1	P16 (5.3x13 LR)	5.25	England MFG 1-1&1-19
England MFG 1	P21 (6.9x17 LR)	6.89	England MFG 1-1&1-21
England MFG 1	P40 (13.1x30 LR)	13.12	England MFG 1-1&1-23
England MFG 1	SG2 Spar (1.3x20 LRS)	1.31	England MFG 1-1&1-24
England MFG 1	SG7 Spar (1.3x17 LRS)	1.31	England MFG 1-1&1-24
England MFG 2	Class II, Reinf. Plastic Struc	9.00	England MFG 2-1
England MFG 2	Class III, Reinf. Plastic Str.	7.00	England MFG 2-1
England MFG 2	Class V, Reinf. Plastic Struct	5.50	England MFG 2-1
England MFG 2	Class VI, Conical	3.50	England MFG 2-1
England MFG 2	Class VI, Dished	3.50	England MFG 2-1
England MFG 2	Reinforced Plastic Struct-SPAR	2.00	England MFG 2-1
England MFG 3	BC-21 Catamaran (6.6x9.8 LR)	6.60	England MFG 3-1 &3-2
England MFG 3	BC-22 Catamaran (9.0x16 LR)	9.02	England MFG 3-1 &3-2
England MFG 3	BS-13 (3.3x5.8 LR)	3.28	England MFG 3-1 &3-3
England MFG 3	BS-14 (3.6x5.7 LR)	3.61	England MFG 3-1 &3-3
England MFG 3	BS-16 (5.3x8.1 LR)	5.25	England MFG 3-1 &3-3
England MFG 3	BS-1830 (5.9x17 LR)	5.90	England MFG 3-1 &3-4
England MFG 3	BS-2230 (7.2x17 LR)	7.22	England MFG 3-1 &3-4
England MFG 3	BS-2240 (7.2x21 LR)	7.22	England MFG 3-1 &3-4
England MFG 3	BS-2630 (8.5x17 LR)	8.53	England MFG 3-1 &3-4
England MFG 3	BS-2640 (8.5x20 LR)	8.53	England MFG 3-1 &3-4
England MFG 3	BS-2650 (8.5x24 LR)	8.53	England MFG 3-1 &3-4
England MFG 3	BS-3030 (9.8x17 LR)	9.84	England MFG 3-1 &3-4
England MFG 3	BS-3040 (9.8x20 LR)	9.84	England MFG 3-1 &3-4
England MFG 3	BS-3050 (9.8x24 LR)	9.84	England MFG 3-1 &3-4
England MFG 3	BS-41 MKII (7.6x21 LR)	7.55	England MFG 3-1 &3-3
England MFG 3	BT-1115 (3.6x10 LR)	3.61	England MFG 3-1 &3-5
England MFG 3	BT-1125 (3.6x13 LR)	3.61	England MFG 3-1 &3-5
England MFG 3	BT-1830 (5.9x23 LR)	5.90	England MFG 3-1 &3-5
England MFG 3	BT-1840 (5.9x26 LR)	5.90	England MFG 3-1 &3-5
England MFG 3	BT-2240 (7.2x25 LR)	7.22	England MFG 3-1 &3-5
England MFG 3	BT-2250 (7.2x28 LR)	7.22	England MFG 3-1 &3-5
England MFG 3	BT-2640 (8.5x25 LR)	8.53	England MFG 3-1 &3-5
England MFG 3	BT-2650 (8.5x28 LR)	8.53	England MFG 3-1 &3-5
England MFG 3	BT-2665 (8.5x35 LR)	8.53	England MFG 3-1 &3-5
England MFG 3	BT-3040 (9.8x25 LR)	9.84	England MFG 3-1 &3-5
England MFG 3	BT-3050 (9.8x28 LR)	9.84	England MFG 3-1 &3-5
England MFG 3	BT-3065 (9.8x33 LR)	9.84	England MFG 3-1 &3-5
England Mfg-4	ELASTOMER "SOFT" BUOY	8.20	England Mfg 4-1
Finland	1.0m x 10m Plastic Pillar	3.28	Finland 1, 4 & 5
Finland	1.6m x 14m Plastic Pillar	5.25	Finland 1
Finland	160mm x 6m Plastic Spar	0.53	Finland 1, 5 & 6
Finland	225mm x 6 m Lighted Plast.Spar	0.74	Finland 1, 5 & 6
Finland	225mm x 7m Plastic Spar	0.74	Finland 1, 5 & 6
Finland	3m x 17m Steel Ice Buoy	9.84	Finland 1
Finland	50/120 Plastic Spar Unlighted	0.36	Finland 1 & 5
Finland	500mm x 6m Plastic Pillar	1.64	Finland 1, 4 & 5

TABLE 2-4 CONTINUED

Country of Use	Buoy Name	Beam Ft.	Drawing Reference
Finland	JPK 130-1050 Steel Ice Buoy	4.27	Finland 1,2 and 3
Finland	JPK 130-550 Steel Ice Buoy	4.27	Finland 1 & 2
Finland MFG-1	90/160 Plastic Spar	0.53	Finland 1 & 5
France	12 M3 Lighted Buoy With Tail	8.20	France - 12
France	18 M3 Lighted Buoy With Tail	9.84	France - 13
France	7.5 M3 Lighted Buoy With Tail	7.22	France - 11
France	DELPHINE Flat Bottom Lighted	8.20	France-14
France	DELPHINE Improved Stability	8.20	France-15
France	Flat Bottom Lighted 5 cu. m.	7.87	France - 2
France	Intermediate Buoy-Lighted	7.87	France - 1
France	Lighted Marina Buoy	4.59	France-10
France	Marina Buoy-Cardinal Unlighted	4.59	France-10
France	Marina Buoy-Lateral Unlighted	4.59	France-10
France	NOLWEN Flat Bottom Form Tower	7.87	France - 5
France	NOLWEN Flat Bottom Lattice Twr	7.87	France - 4
France	NOLWEN II Type Lighted Buoy	7.87	France - 6
France	NOLWEN Tail-Tube Solar	7.87	France - 3
France	Polyester Buoy	3.48	France-7, 8, 9
France MFG-1	ARTEMIS Lighted Buoy	9.00	France MFG 1-1
France MFG-1	DAPHNE Lighted Buoy	8.53	France MFG 1-2
Germany	Inland lighted STD steel	3.44	Germany-9
Germany	Inland Unlighted STD Steel	3.44	Germany-10
Germany	Leuchttonne 61	8.20	Germany-3
Germany	Leuchttonne 61 with reflector	8.20	Germany-4
Germany	Leuchttonne 72	8.20	German-5
Germany	Leuchttonne 81 Emden	8.20	Germany-11
Germany	Leuchttonne 81 standard	8.20	Germany-6
Germany	Leuchttonne 81-High Tower I	8.20	Germany-8
Germany	Leuchttonne 81-High Tower II	8.20	Germany-7
Germany	Modular Buoy	11.48	Germany - 12
Germany	T-86 Conical Buoy-Unlighted.	4.92	Germany-2
Germany	T-86 Spar Buoy-Unlighted	4.92	Germany-1
Germany MFG-1	Dpwtr Lt Buoy Type DW180G	5.91	Germany MFG 1-1
Germany MFG-1	Dpwtr Lt Buoy Type DW240G	7.87	Germany MFG 1-2
Germany MFG-1	Dpwtr Lt Buoy Type DW260G	8.53	Germany MFG 1-3
Germany MFG-1	Dpwtr Lt Buoy Type DW280G	9.19	Germany MFG 1-4
Germany MFG-1	Shalw Wtr LT Buoy Type SW160E	5.25	Germany MFG 1-9
Germany MFG-1	Shalw Wtr Lt Buoy Type SW200E	0.00	Germany MFG 1-10
Germany MFG-1	Shalw Wtr Lt Buoy Type SW220E	7.22	Germany MFG 1-11
Germany MFG-1	Shalw Wtr Lt Buoy Type SW220G	7.22	Germany MFG 1-5
Germany MFG-1	Shalw Wtr Lt Buoy Type SW240G	7.87	Germany MFG 1-6
Germany MFG-1	Shalw Wtr Lt Buoy Type SW260E	8.53	Germany MFG 1-12
Germany MFG-1	Shalw Wtr Lt Buoy Type SW260G	8.53	Germany MFG 1-7
Germany MFG-1	Shalw Wtr Lt Buoy Type SW300G	9.84	Germany MFG 1-8
India Mfg-1	CP-2800 CATAMARAN BUOY	4.59	India Mfg 1-3
India Mfg-1	SKP-1600 Nav. Buoy	5.25	India Mfg 1-1
India Mfg-1	SKP-2500 NAV BUOY	8.20	India Mfg 1-2
India Mfg-1	TT-2600 OPEN SEA NAV BUOY	8.53	India Mfg 1-4
Italy MFG 1	Deepwater Tension Beacon	0.00	Italy MFG 1
Italy MFG 1	Standard Elastic Beacon	0.00	Italy MFG 1
Italy MFG 2	Elastic Beacon	0.00	Italy MFG 2
Japan	L-1 (8.5x31 L) Battery Type	8.53	Japan 1 & 3

TABLE 2-4 CONTINUED

Country of Use	Buoy Name	Beam Ft.	Drawing Reference
Japan	L-1 (8.5x31 L) Wave Generator	8.53	Japan 1 & 2
Japan	L-2 (9.2x34 L) Battery Type	9.19	Japan 1 & 5
Japan	L-2 (9.2x34 L) Wave Generator	9.19	Japan 1 & 4
Japan	L-3 (10.5x38 L) Battery Type	10.50	Japan 1
Japan	L-3 (10.5x38 L) Wave Generator	10.50	Japan 1 & 6
Japan	L-4 (20x53 LR) Wave Generator	19.69	Japan 1 & 7
Japan	L-5 (13.1x23 LR)	13.12	Japan 1
Japan	L-6 (16x25 LR)	16.40	Japan 1 & 8
Japan	L-H (6.9x22 L)	6.89	Japan 1 & 9
Japan	L-U (7.9x20 L)	7.87	Japan 1 & 10
Japan	Segiyosetoho Resilient Becon	4.92	Japan 13
Japan	U-H Conical (NUN)	8.20	Japan 1 & 11
Japan	U-H Cylinder (CAN)	7.22	Japan 1 & 11
Japan	U-HP Plastic CAN	7.22	Japan 12
Japan MFG 1	LP-1A (7.2 x 27 LR)	7.22	Japan MFG 1-3
Japan MFG 1	NKK 1.5m (4.9 x 22 LR)	4.92	Japan MFG 1-2
Japan MFG 1	NLB-1000 (3.28 x 15 L)	3.28	Japan MFG 1-1
Japan MFG 1	NLB-600 (1.97 x 10 L)	1.97	Japan MFG 1-1
Japan MFG 1	NLB-800 (2.62 x 12 L)	2.62	Japan MFG 1-1
Japan MFG 2	AB-200 (3.0 x 15 L)	2.95	Japan MFG 2-11
Japan MFG 2	CB-100 (1.6 x 5.9 L)	1.64	Japan MFG 2-14
Japan MFG 2	CB-200 (1.6 x 9.3 L)	1.64	Japan MFG 2-13
Japan MFG 2	H-290 (4.9 x 19 LR)	4.92	Japan MFG 2-8
Japan MFG 2	M-250C (3.9 x 18 L)	3.94	Japan MFG 2-9
Japan MFG 2	M-350T (6.4 x 25 LR)	6.40	Japan MFG 2-7
Japan MFG 2	MLTV-10RA (5.9 x 57 LS)	5.91	Japan MFG 2-15
Japan MFG 2	MLTV-11S (6.6 x 56 LS)	6.56	Japan MFG 2-15
Japan MFG 2	MLTV-15RA (7.6 x 72 LS)	7.55	Japan MFG 2-15
Japan MFG 2	MLTV-19RA (8.2 x 92 LS)	8.20	Japan MFG 2-15
Japan MFG 2	MLTV-7S (4.6 x 36 LS)	4.59	Japan MFG 2-15
Japan MFG 2	MS-400 (7.9 x 20 L)	7.87	Japan MFG 2-6
Japan MFG 2	MS-500 (9.4 x 24 L)	9.84	Japan MFG 2-5
Japan MFG 2	SA-200 (1.6 x 13 L)	1.64	Japan MFG 2-12
Japan MFG 2	SAB-300 (3.6 x 18 L)	3.61	Japan MFG 2-10
Japan MFG 2	T-11 WAG (9.8 x 45 LR)	9.75	Japan MFG 2-1
Japan MFG 2	T-360S WAG (7.3 x 20 L)	7.25	Japan MFG 2-2
Japan MFG 2	T3-2 WAG (6.4 x 25 LR)	6.40	Japan MFG 2-3
Japan MFG 2	TS-300 WAG (4.5 x 21 L)	4.46	Japan MFG 2-4
Japan MFG 3	ZCB-160 (5.3 x 23 L)	5.25	Japan MFG 3-1 & 3-3
Japan MFG 3	ZCB-240D (7.9 x 13 L)	7.87	Japan MFG 3-1 & 3-3
Japan MFG 3	ZCB-350D (11.5 x 16 LR)	11.48	Japan MFG 3-1 & 3-3
Japan MFG 3	ZCB-603D (20x25 LR)	19.69	Japan MFG 3-1 & 3-3
Japan MFG 3	ZSB-100 (3.3 x 29 LS)	3.28	Japan MFG 3-1 & 3-4
Japan MFG 3	ZSB-120 (3.9 x 35 LS)	3.94	Japan MFG 3-1 & 3-4
Japan MFG 3	ZSB-140P (4.6 x 40 LS)	4.59	Japan MFG 3-1 & 3-4
Japan MFG 3	ZSB-160 (5.3 x 37 LS)	5.25	Japan MFG 3-1 & 3-4
Japan MFG 3	ZSB-210 (6.9 x 49 LS)	6.89	Japan MFG 3-1 & 3-4
Japan MFG 3	ZSB-220W (7.2 x 78 LS)	7.22	Japan MFG 3-1 & 3-4
Japan MFG 3	ZSB-240 (7.9 x 86 LSR)	7.87	Japan MFG 3-1 & 3-4
Japan MFG 3	ZSB-280 (9.2 x 95 LSR)	9.19	Japan MFG 3-1 & 3-4
Japan MFG 3	ZSB-300 (9.8 x 117 LSR)	9.84	Japan MFG 3-1 & 3-4
Japan MFG 3	ZSB-320 (10.5 x 133 LSR)	10.50	Japan MFG 3-1 & 3-4

TABLE 2-4 CONTINUED

Country of Use	Buoy Name	Beam Ft.	Drawing Reference
Japan MFG 3	ZSB-60 (2.0 x 24 LS)	1.97	Japan MFG 3-1 & 3-4
Japan MFG 3	ZSB-80 (2.6 x 24 LS)	2.62	Japan MFG 3-1 & 3-4
Japan MFG 3	ZWB-115 (3.7 x 18 L)	3.77	Japan MFG 3-1 & 3-2
Japan MFG 3	ZWB-120S (3.9 x 9 L)	3.94	Japan MFG 3-1 & 3-2
Japan MFG 3	ZWB-130 (4.3 x 15 L)	4.27	Japan MFG 3-1 & 3-2
Japan MFG 3	ZWB-160 (5.3 x 20 L)	5.25	Japan MFG 3-1 & 3-2
Japan MFG 3	ZWB-250 (8.2 x 30 L)	8.20	Japan MFG 3-1 & 3-2
Netherlands	12.5M3 Light buoy (10.5x19 LR)	10.50	Netherlands 1 & 3
Netherlands	6.5M3 Light buoy (8.4x17 LR)	8.40	Hol 2 & 3
Netherlands MFG-1	Solar Buoy Type SW160EZ	5.25	Netherlands MFG 1-1
Netherlands MFG-1	Solar Buoy Type SW180BZ	5.91	Netherlands MFG 1-2
Netherlands MFG-1	Solar Buoy Type SW200EZ	6.56	Netherlands MFG 1-3
Netherlands MFG-1	Solar Buoy Type SW220EZ	7.22	Netherlands MFG 1-4
Netherlands MFG-1	Solar Buoy Type SW260EZ	8.53	Netherlands MFG 1-5
Netherlands Mfg-2	ALL WEATHER DUTY BUOY	6.56	Netherlands Mfg 2-1
Norway	F-180/B-50 Lighted Steel Buoy	5.25	Norway - 5
Norway	Seawater Battery Powered Buoy	7.00	Norway - 6
Norway	Selco Type 26 Lighted Buoy	3.28	Norway - 4
Norway	Selco Type 5 Spar Buoy	1.38	Norway-1
Norway	SELCO Type 7 Spar Buoy	1.90	Norway - 2
Norway	SELCO Type 8 Spar Buoy	2.63	Norway - 3
Norway MFG-1	SELCO Marker Buoy Type 26A	3.28	Norway - MFG-1-11
Norway MFG-1	SELCO Marker Buoy Type 26B	3.28	Norway - MFG-1-10
Norway MFG-1	SELCO Type 10 Spherical Buoy	4.00	Norway MFG-1-4
Norway MFG-1	SELCO Type 11 Discus Buoy	7.55	Norway MFG-1-5
Norway MFG-1	SELCO Type 16 Spar Buoy	2.30	Norway MFG-1-6
Norway MFG-1	SELCO Type 23 Elliptical Buoy	2.00	Norway - MFG-1-7
Norway MFG-1	SELCO Type 24 Spherical Buoy	4.00	Norway - MFG-1-8
Norway MFG-1	SELCO Type 25 Spherical Buoy	4.00	Norway MFG-1-9
Norway MFG-1	SELCO Type 4 Spar Buoy	1.35	Norway - MFG-1-1
Norway MFG-1	SELCO Type 6 Spar Buoy	1.90	Norway MFG-1-2
Norway MFG-1	SELCO Type 9 Spherical Buoy	4.00	Norway MFG-1-3
Peoples Rep of China	HF 2.4 - D1 LIGHTED BUOY	8.00	China, Mfg 1-2
Peoples Rep of China	WAVE POWERED LIGHT BUOY	7.87	China Mfg 1-1
South Africa	DOUBLE HULL LIGHTED BUOY	6.46	S. Africa-1
USA	1 CR, 1952 Type Standard	5.00	USA-20
USA	1 NR, 1952 Type Standard	5.00	USA-21
USA	2 CFR	6.00	USA 42
USA	2 CR, 1952 Type Standard	4.00	USA-22
USA	2 NFR	6.00	USA 42
USA	2 NR, 1952 Type Standard	4.00	USA-23
USA	3 CFR	5.00	USA 43
USA	3 CI, 1982 Type Standard	2.30	USA-26
USA	3 CR, 1952 Type Standard	3.00	USA-24
USA	3 NFR	5.00	USA 43
USA	3 NI, 1982 Type Standard	2.30	USA-27
USA	3 NR, 1952 Type Standard	3.00	USA-25
USA	3-1/2x8 LR, 1965 Type Standard	3.50	USA-15
USA	4 CFR	4.00	USA 44
USA	4 CR, 1952 Type Standard	2.25	USA-28
USA	4NFR	4.00	USA 44
USA	4NR, 1952 Type Standard	2.25	USA-29

TABLE 2-4 CONTINUED

Country of Use	Buoy Name	Beam Ft.	Drawing Reference
USA	5 CFR	3.00	USA 45
USA	5 CI, 1981 Type Standard	2.30	USA-30
USA	5 CPR, 1972 Type Standard	2.33	USA-32
USA	5 NFR	3.00	USA 45
USA	5 NI, 1981 Type Standard	2.30	USA-31
USA	5 NPR, 1972 Type Standard	2.33	USA-33
USA	5X11 LR, 1965 Type Standard	5.00	USA-14
USA	6 CFR	2.00	USA 46
USA	6 CPR, 1972 Type Standard	2.33	USA-38
USA	6 CR, 1952 Type Standard	1.50	USA-34
USA	6 CT, 1952 Type Standard	1.50	USA-36
USA	6 NFR	2.00	USA 46
USA	6 NPR, 1972 Type Standard	2.33	USA-39
USA	6 NR, 1952 Type Standard	1.50	USA-35
USA	6 NT, 1952 Type Standard	1.50	USA-37
USA	6X20 LBR, 1962 Type Standard	6.00	USA-12
USA	6X20 LR, 1962 Type Standard	6.00	USA-11
USA	7X17 LR, 1962 Type Standard	7.00	USA-10
USA	7x20 LI, 1982 Type Standard	7.00	USA-13
USA	8X26 LBR, 1962 Type Standard	8.00	USA-7
USA	8X26 LGR, 1962 Type Standard	8.00	USA-8
USA	8X26 LR, 1962 Type Standard	8.00	USA-6
USA	8X26 LWR, 1962 Type Standard	8.00	USA-9
USA	8X26 WR, 1962 Type Standard	8.00	USA-19
USA	9x20 BR, 1962 Type Standard	9.00	USA-17
USA	9x20 GR, 1962 Type Standard	9.00	USA-18
USA	9X32 LBR, 1962 Type Standard	9.00	USA-2
USA	9X32 LGR, 1962 Type Standard	9.00	USA-3
USA	9X32 LR, 1962 Type Standard	9.00	USA-1
USA	9X32 LWR, 1962 Type Standard	9.00	USA-4
USA	9X35 LR, 1983 Type Standard	9.00	USA-5
USA	Discrepancy Buoy	4.00	USA-16
USA	FCPR Buoy	4.25	USA-40
USA	FNPR Buoy	4.25	USA-41
USA MFG 1	SAB-12 Sent. Articulated Buoy	6.00	USA MFG 1-9
USA MFG 1	SB-138 Sentinel	5.75	USA MFG 1-4
USA MFG 1	SB-510 Sentinel	5.67	USA MFG 1-3
USA MFG 1	SB-612 Sentinel	6.00	USA MFG 1-2
USA MFG 1	SB-826 Sentinel Series C	8.00	USA MFG 1-1
USA MFG 1	SB1M Buoy	3.28	USA MFG 1-8
USA MFG 1	SB2.5M Buoy	8.20	USA MFG 1-6
USA MFG 1	SB2M Buoy	6.56	USA MFG 1-5
USA MFG 1	SB3M Buoy	9.84	USA MFG 1-7
USA MFG 1	SF-5 Spar Buoy	0.50	USA MFG 1-10
USA MFG 1	UF-210 Spherical Buoy	2.00	USA MFG 1-11
USA MFG 2	BA-17C (1.7x6.7 C)	1.67	USA MFG 2-1 & 2-9
USA MFG 2	BA-17N (1.7x7.2 N)	1.67	USA MFG 2-1 & 2-9
USA MFG 2	BA-28C (2.3x7.3 C)	2.33	USA MFG 2-1 & 2-9
USA MFG 2	BA-28N (2.3x7.7 N)	2.33	USA MFG 2-1 & 2-9
USA MFG 2	BA-323C (1.7x5.5 C)	1.67	USA MFG 2-1 & 2-9
USA MFG 2	BA-323N (1.7x5.5 N)	1.67	USA MFG 2-1 & 2-9
USA MFG 2	BC-3, Class III (3X8 CR)	3.00	USA MFG 2-7

TABLE 2-4 CONTINUED

Country of Use	Buoy Name	Beam Ft.	Drawing Reference
USA MFG 2	BC-4, Class II (4X14 CR)	4.00	USA MFG 2-7
USA MFG 2	BC-5, Class I (5X18 CR)	5.00	USA MFG 2-7
USA MFG 2	BL-250 (2.5X12 L)	2.50	USA MFG 2-1 & 2-6
USA MFG 2	BL-358 (3.5X8.5 LR)	3.50	USA MFG 2-1 & 2-5
USA MFG 2	BL-511 (5X12 LR)	5.00	USA MFG 2-1 & 2-4
USA MFG 2	BL-620 (6X20 LR)	6.00	USA MFG 2-1 & 2-2
USA MFG 2	BL-717 (7X17 LR)	7.00	USA MFG 2-1 & 2-3
USA MFG 2	BL-826 (8X27 LR)	8.00	USA MFG 2-1 & 2-2
USA MFG 2	BN-3, Class III (3X9 NR)	3.00	USA MFG 2-8
USA MFG 2	BN-4, Class II (4X15 NR)	4.00	USA MFG 2-8
USA MFG 2	BN-5, Class I (5X20 NR)	5.00	USA MFG 2-8
USA MFG 2	Buoyant Beacon	0.00	USA MFG 2-1 & 2-10
USA MFG 3	5 CFLR	3.17	USA MFG 3
USA MFG 4	CM30	2.50	USA MFG 4-4
USA MFG 4	MBP-60	5.00	USA MFG 4-1 & 4-2
USA MFG 4	RM-30	2.50	USA MFG 4-1 & 4-3
USA MFG-5	ELASTOMER/FOAM SPAR BUOY	5.00	USA Mfg 5-1

TABLE 2-4 CONTINUED

Schematic representations of the largest steel ATON Buoys currently in use by each of the nine countries' navigation authorities and by the USCG in the United States are shown in Figures 2-1 through 2-10 in alphabetical order of the country names. As seen, the diameters of these largest buoys range
from approximately 8ft. to slightly more than 10ft. and all except one, i.e. that of Finland in Figure 2-4, are lighted offshore buoys. Finland's largest steel buoy is an offshore ice buoy.

Synopses of the surveys and interviews conducted in each country with the navigation authorities are presented in Section 2.1. More detailed records of the interviews are included in Appendix A.1. Similarly, the synopses of interviews with manufacturers/designers are given in Section 2.2 and detailed records in Appendix A.2.

Results obtained from interviews at the IALA headquarters in Paris, France are discussed in Section 2.3. Additional information received from contacts with representatives of other countries' navigation authorities and manufacturers are presented in Section 2.4 and synopses of interviews included in Appendix A.3.

In Section 2.5 an effort is made to screen the individual sources' data on buoy technology and to identify any innovative applications or designs, suggestions made by some of the sources for further research and development on ATON buoys, and any problem areas that have been identified by the specific sources with regard to buoy design, manufacture and operations. The results of this effort are to be utilized in Task C (Recommendations for Development) of this study.

In presenting the results and findings for each country and each manufacturer, notes are added at the end of the sections cross referencing the respective detail data sources for the appendices as follows:

Interview Summary: Appendix A, Sections____
Buoy Records : Appendix B, ____ Entries
Buoy Drawings : Appendix C, C- through C-_____

2.1 National Navigation Authorities

For each of the major navigation authorities interviewed in each country, as identified by the USCG, a brief discussion is included in the following subsections on the organization, functions and numbers/types of buoys that are in use within the system. Also included in the discussions are synopses of relevant buoy technology information obtained during the interviews and visits. Additionally, brief extracts are provided of the papers directly or indirectly related to ATON buoys presented to the IALA 90 Conference by each country.

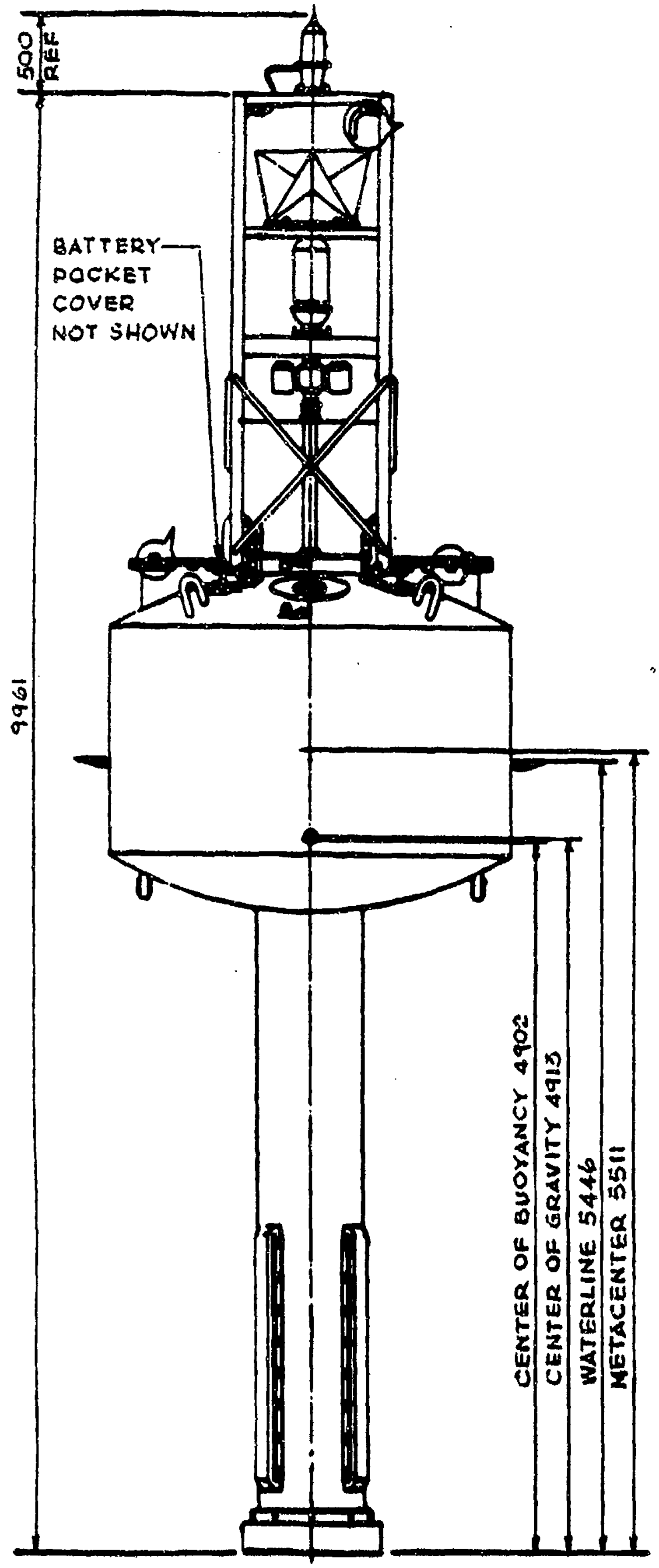


FIGURE 2-1
CANADA'S
FA 1010 (2.9 m. LWR)
LIGHTED BUOY

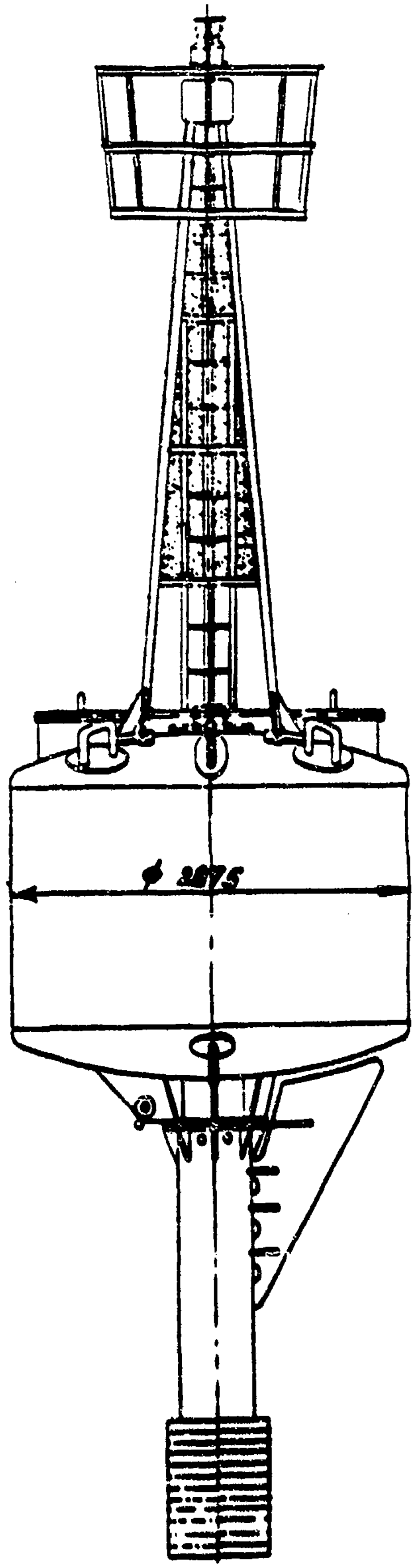


FIGURE 2-2
DENMARK'S
TYPE 43
LIGHTED BUOY

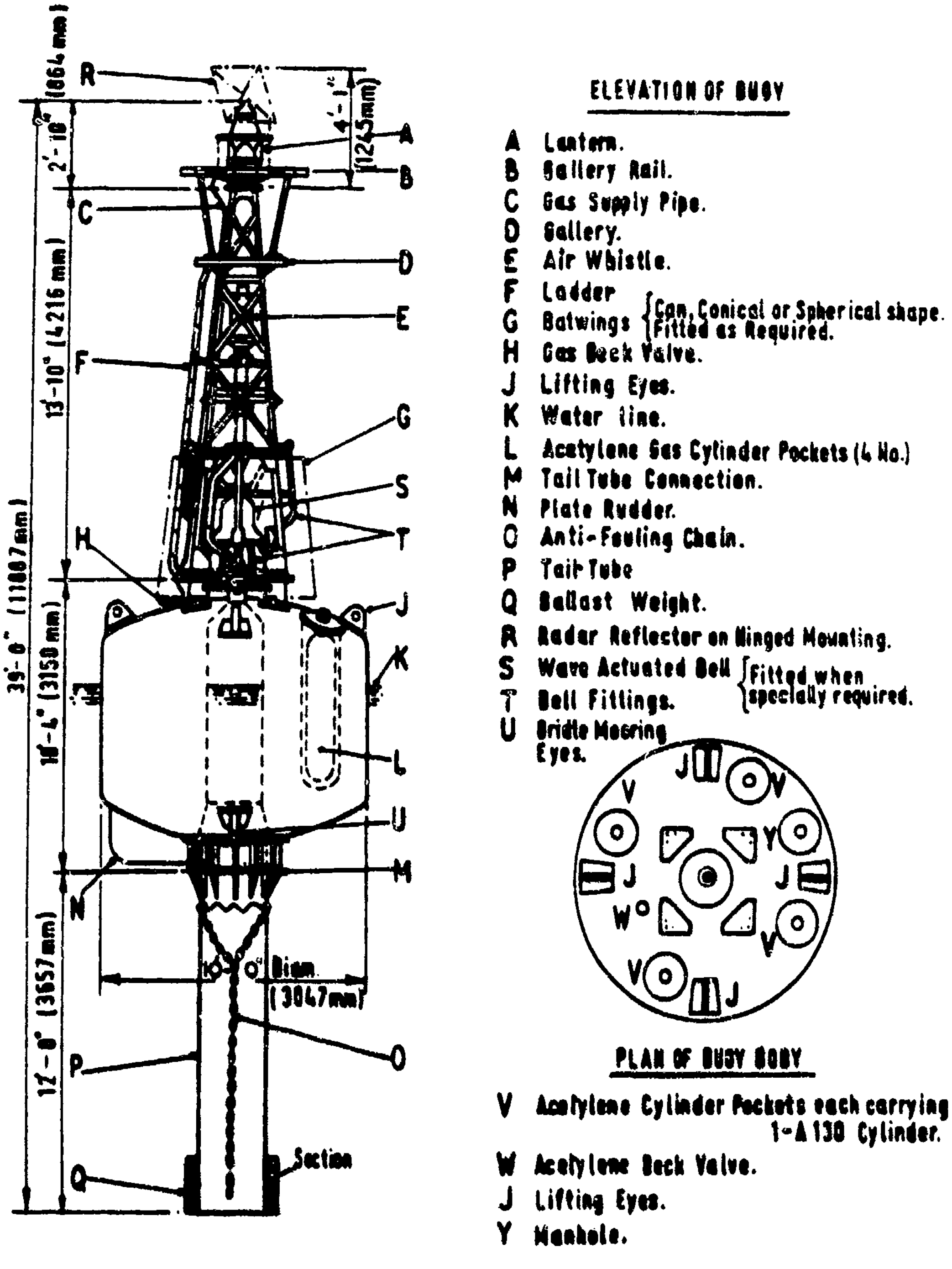


FIGURE 2-3
ENGLAND's HIGH
FOCAL PLANE BUOY

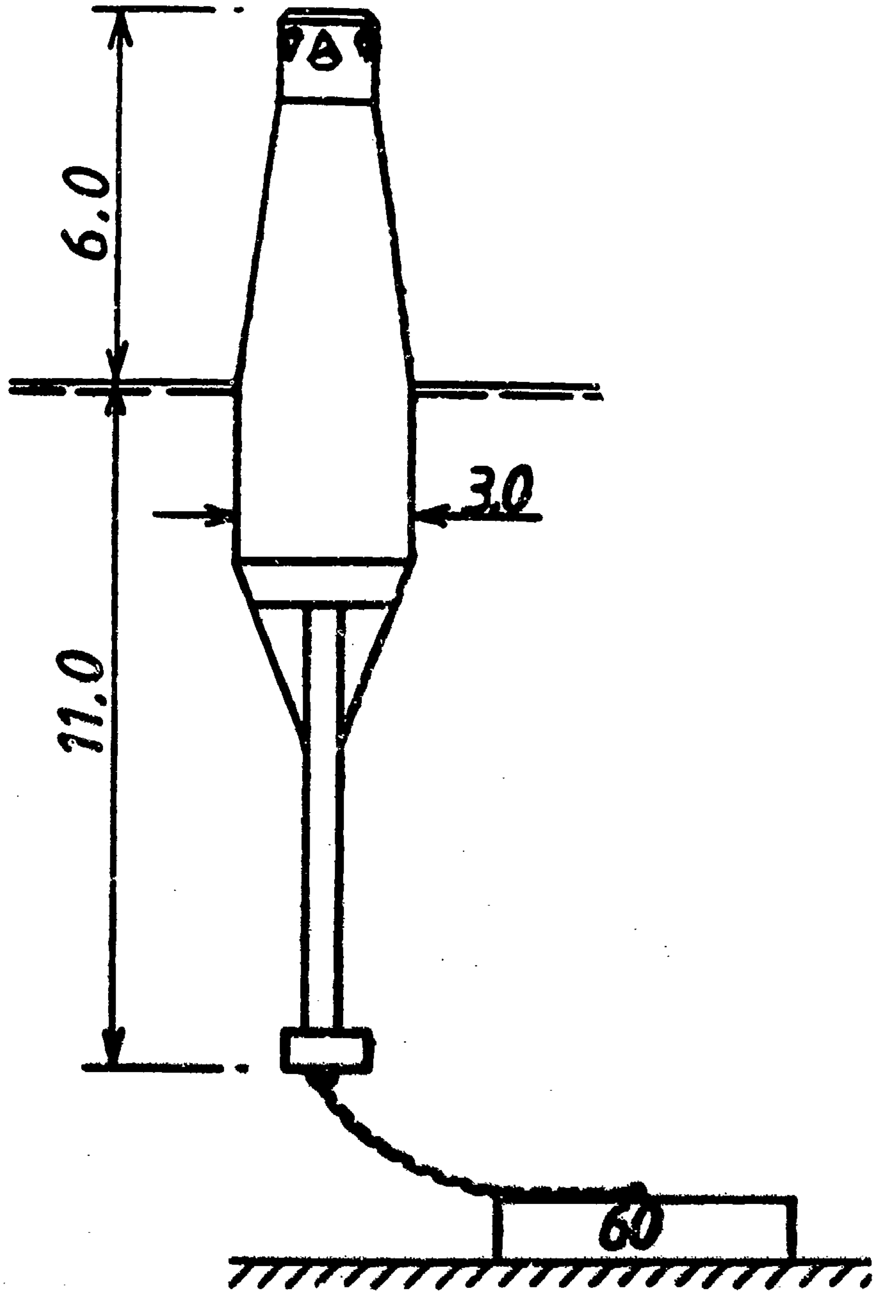


FIGURE 2-4
FINLAND'S
3m. x 17m.
OFFSHORE ICE BUOY

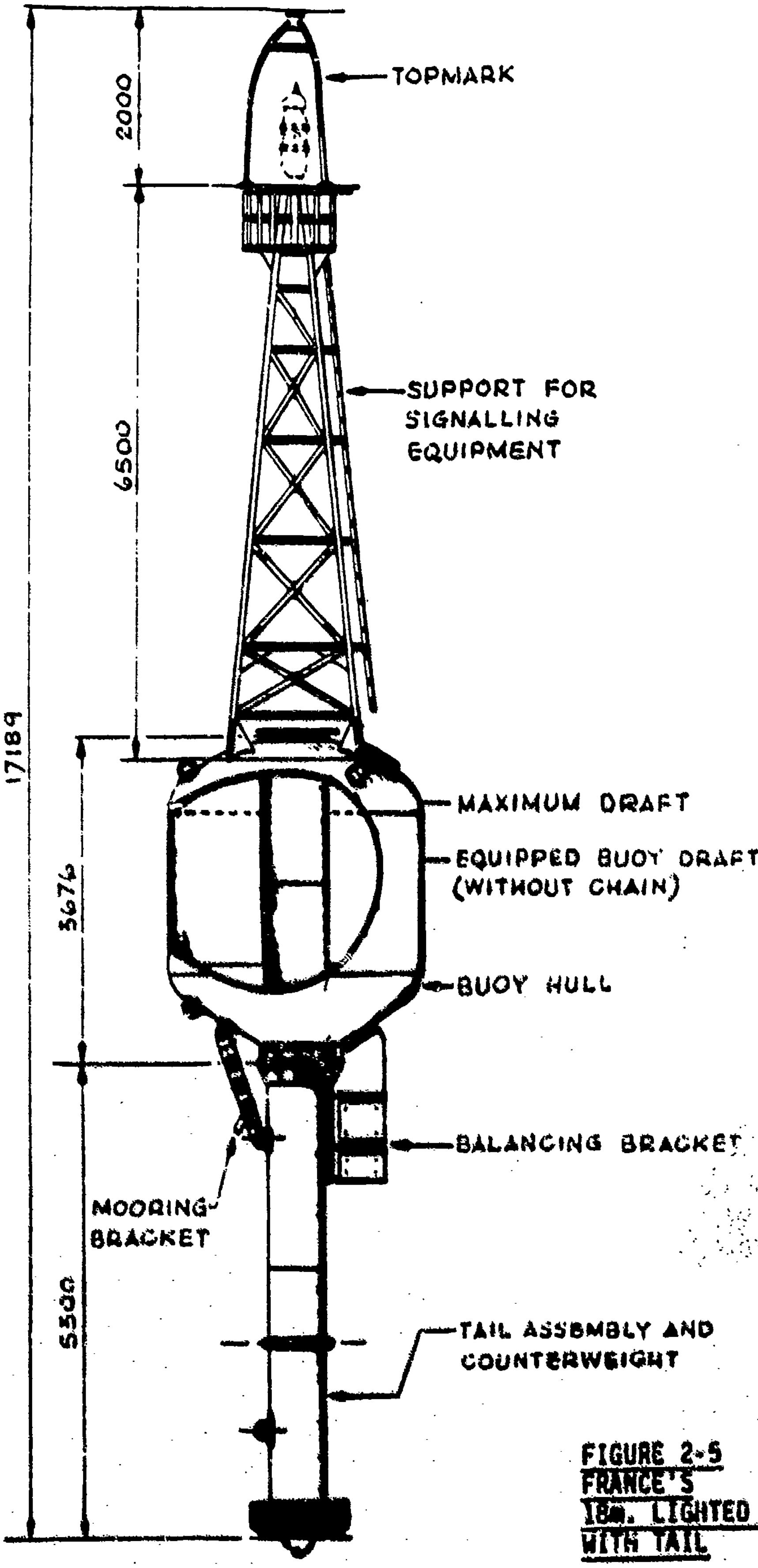


FIGURE 2-5
FRANCE'S
18m. LIGHTED BUOY
WITH TAIL

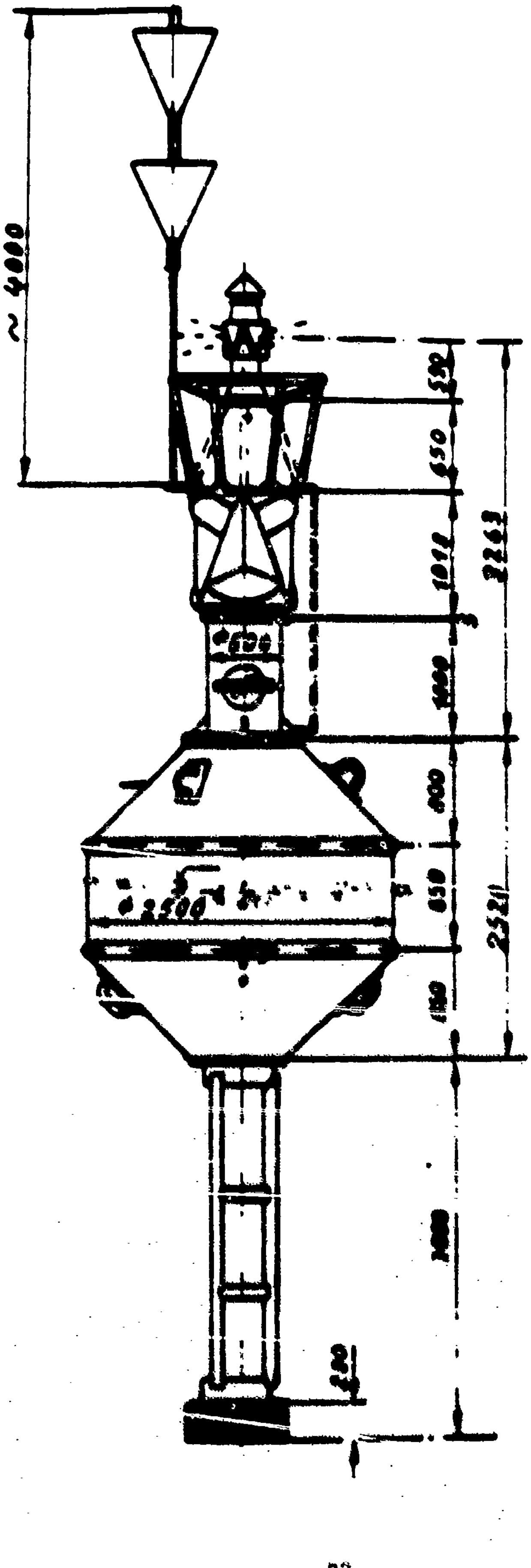


FIGURE 2-6
GERMANY'S
1981 STANDARD
LIGHT BUOY

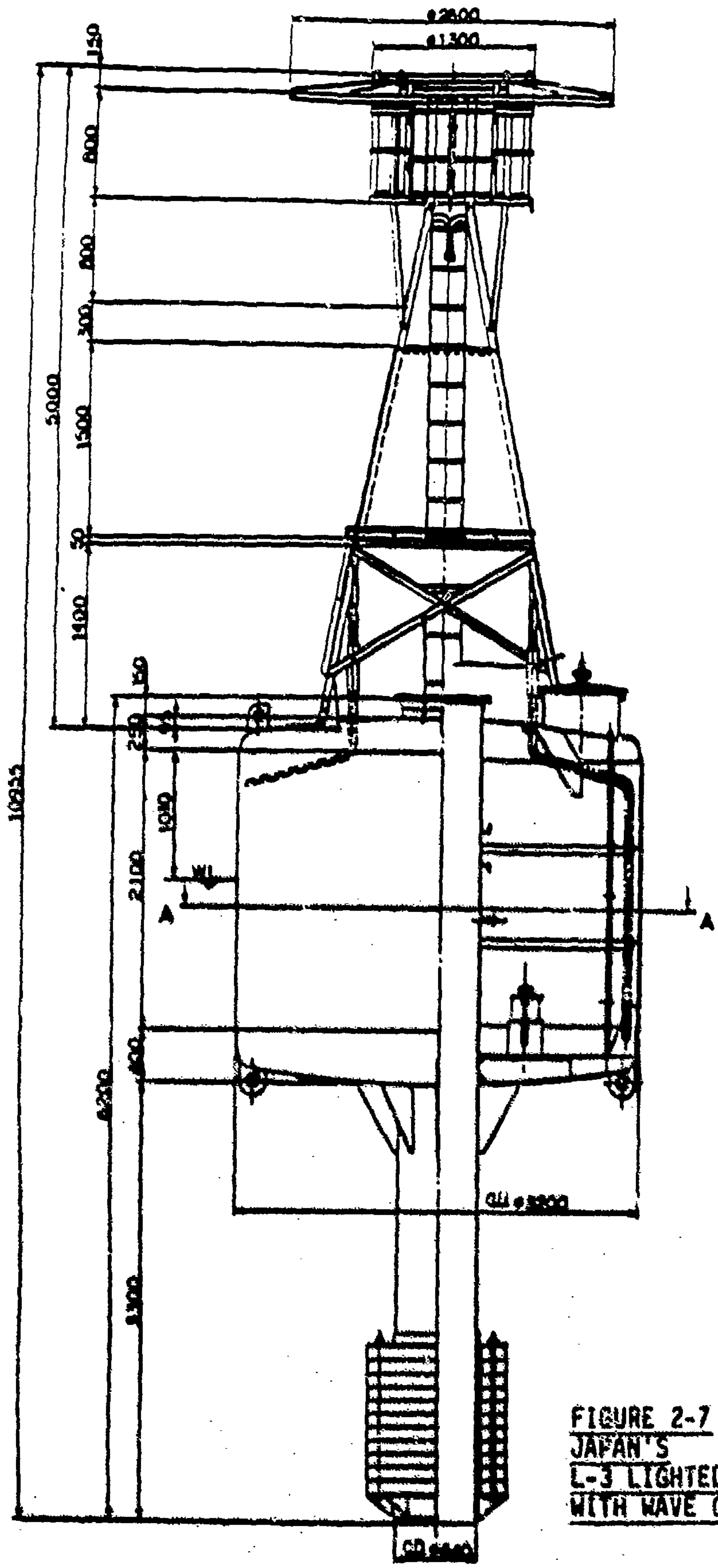


FIGURE 2-7
JAPAN'S
L-3 LIGHTED BUOY
WITH WAVE GENERATOR

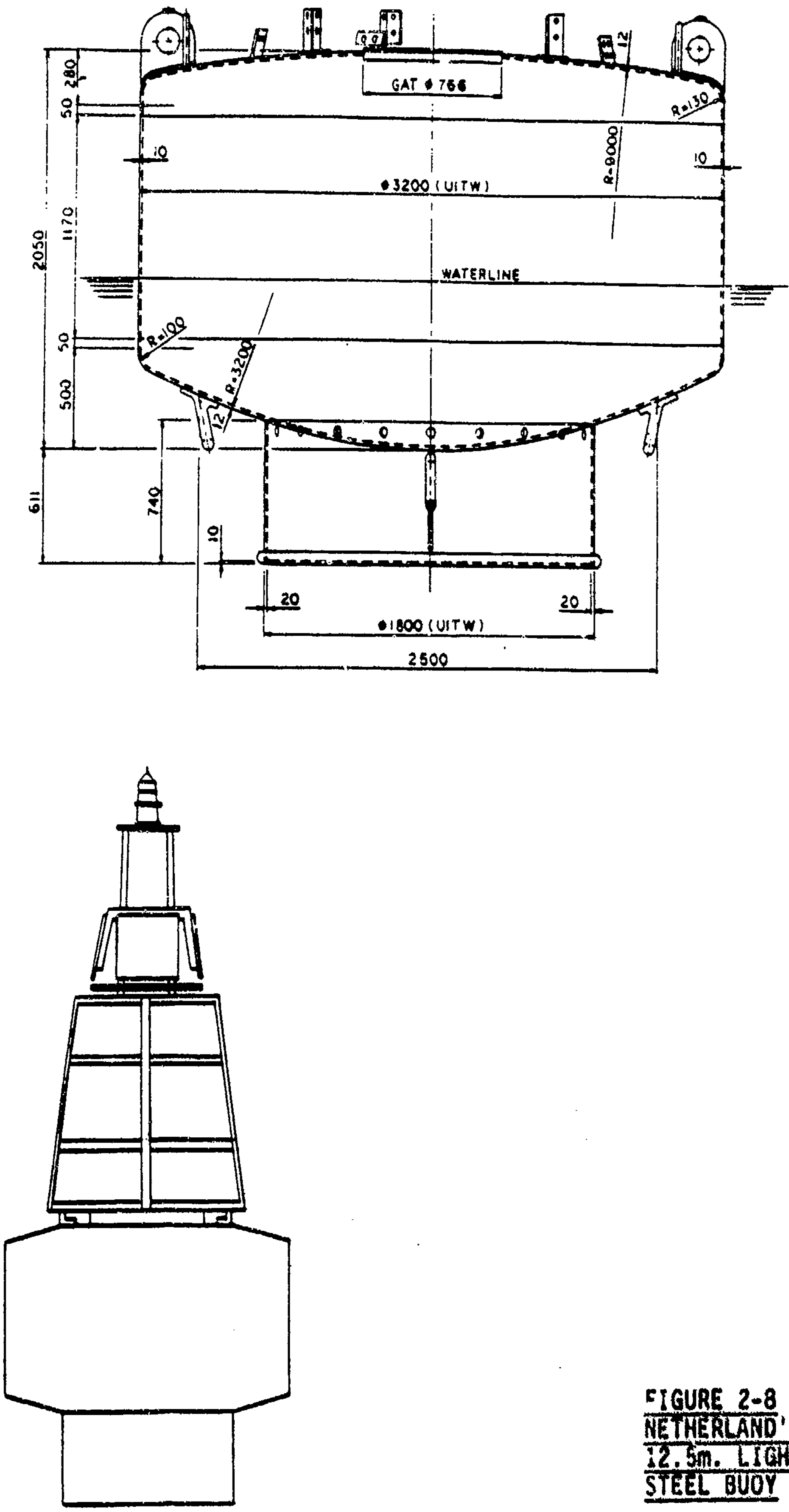


FIGURE 2-8
NETHERLAND'S
12.5m. LIGHTED
STEEL BUOY

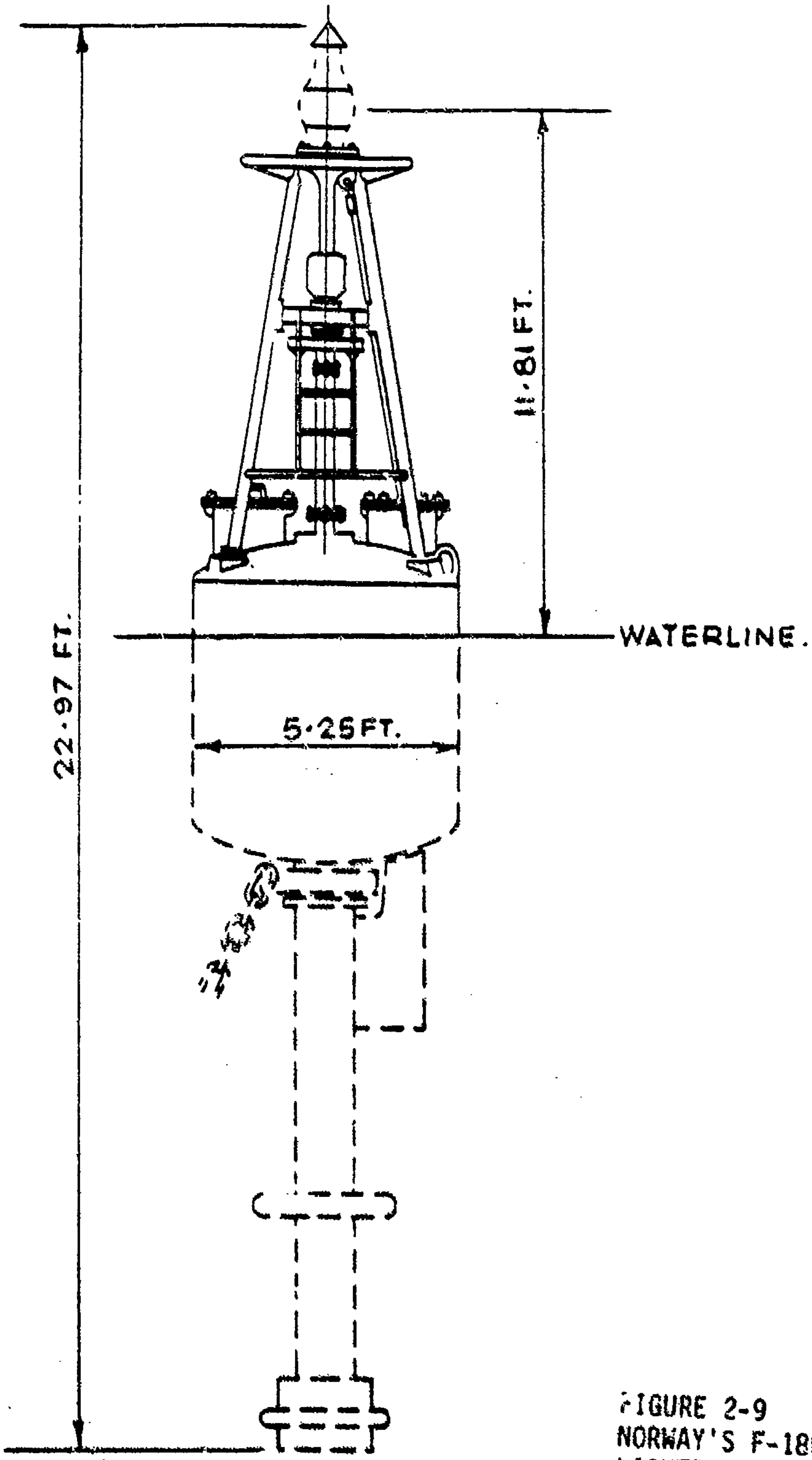


FIGURE 2-9
NORWAY'S F-180/B-50
LIGHTED STEEL BUOY

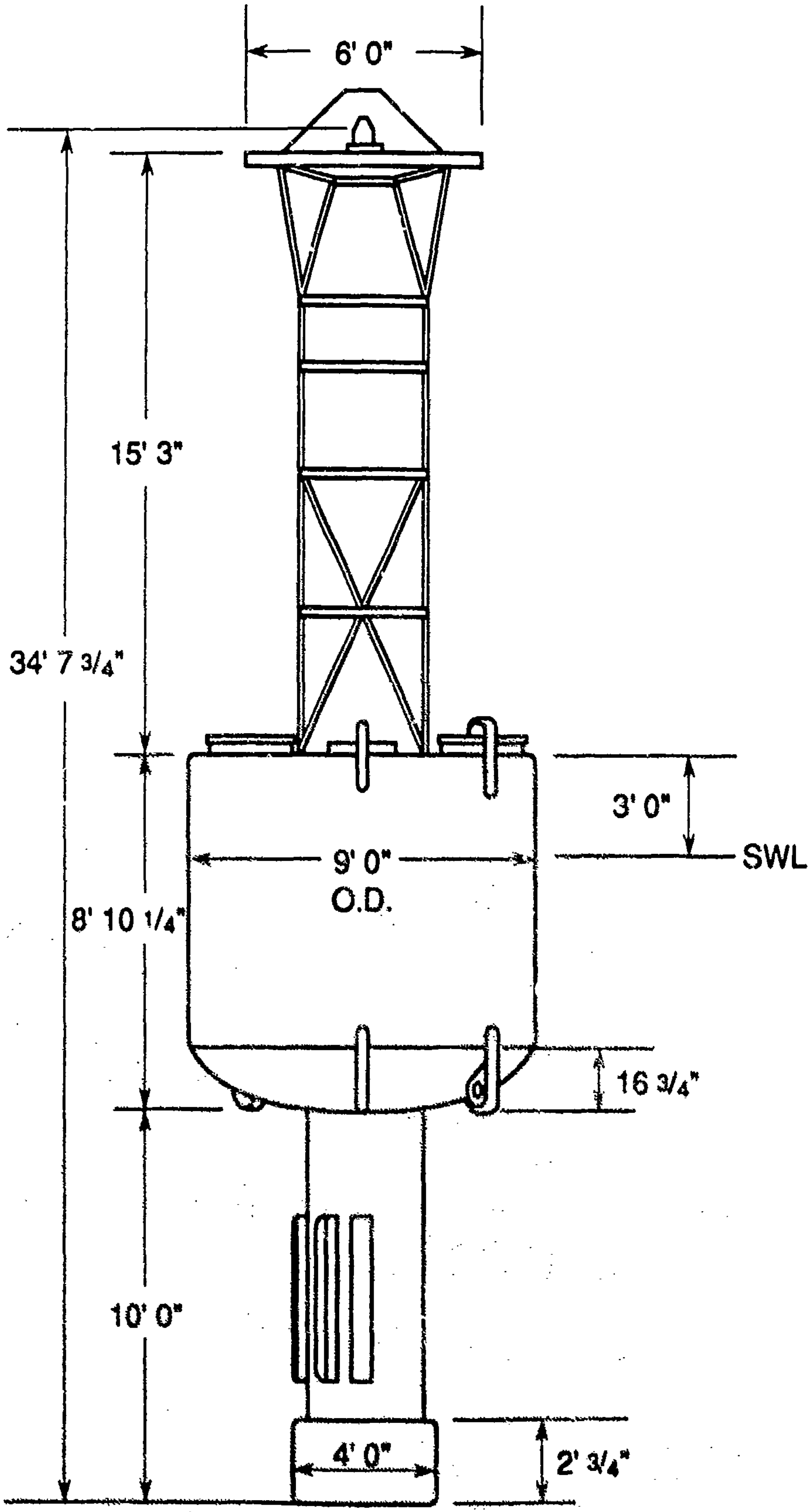


Figure 2-10 USCG 9 x 35 LR 1983 Type Standard Light Buoy

2.1.1 Canada

2.1.1.1 Canadian Coast Guard

In Canada the national navigation authority is the Canadian Coast Guard within the Ministry of Transport. CCG's "Aids and Waterways Division" oversees the design and construction of all aid to navigation systems including floating buoys as well as the overall administration of the nationwide ATON system. Actual operations control is accomplished by 10 different offices within five regions. The five regions are located in the west (in Vancouver, B.C.); central (Toronto, ONT); Laurentides (Quebec, Que.); Maritimes (Dartmouth N.S.); and Newfoundland (St. John's, NB). The district offices are at the following locations:

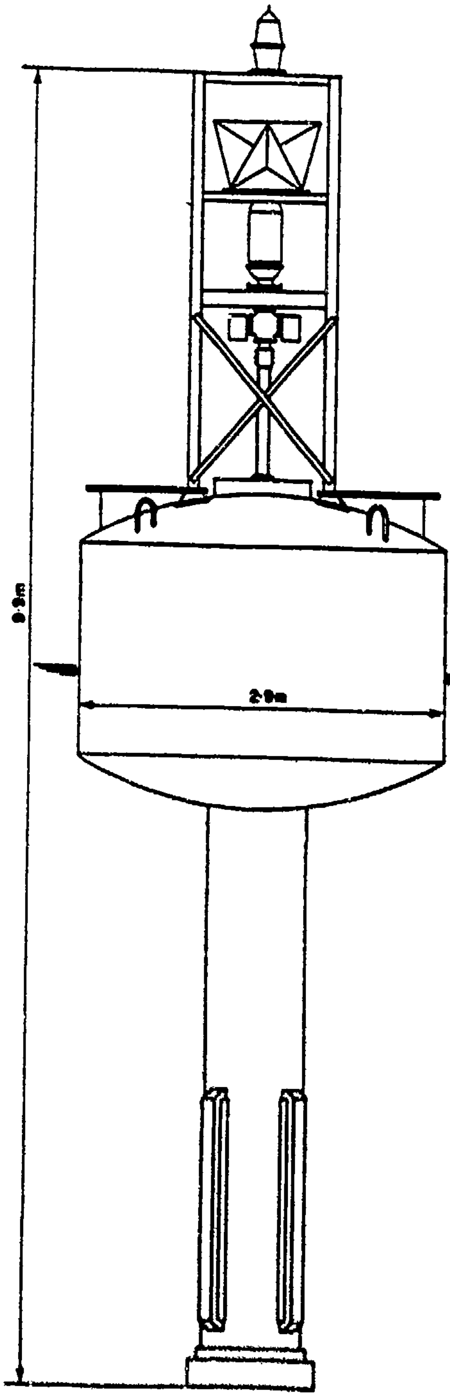
District 1:	Victoria, B.C.
District 2:	Prince Rupert, B.C.
District 3:	Hay River, N.W.T.
District 4:	Parry Sound, ONT.
District 5:	Prescott, ONT.
District 6	Montreal, QUE.
District 7:	Quebec, QUE.
District 8:	Charlottetown, P.E.I.
District 9:	Saint John, N.B.
District 10:	Dartmouth N.S.

Many different types of buoys are being used in the districts depending on their environment. Figures 2-11, 2-12 and 2-13 represent reduced-size illustrations of all ATON buoys currently used in the CCG system. They range from 2.9 m (9.5 ft.) to 1.4 m. (4.6 ft.) diameter steel buoys with tail or skirt to discus buoys, scow buoys, can/conical/spar type ice buoys, coastal and river buoys and CANOL type boat buoys. More detailed illustrations of each type of buoy, including physical and operational characteristics to the extent available, are contained in Appendix A-1. An inventory of the buoys in the CCG ATON system as of March, 1987, is shown in Table 2-5.

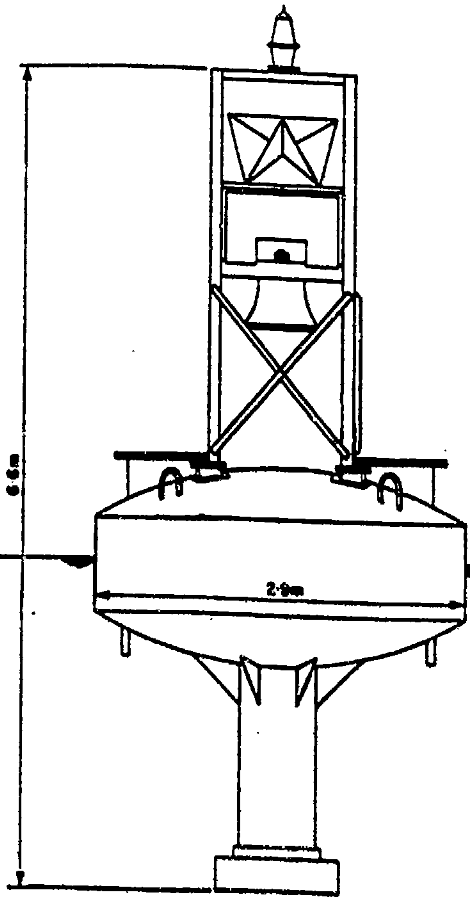
In addition to the steel buoys, Canada also has in use plastic and foam buoys and some wooden spars. Plastic buoys are of Finnish manufacture (KWH Pipe) and are manufactured in Canada. Foam buoys are made of Surlyn and manufactured by Gilman Corp. in the U.S.A.

CCG is slowly solarizing many of their lighted buoys to eliminate the need for battery changes. As of the date of the interview, solarization had reached 30% of the lighted buoy population.

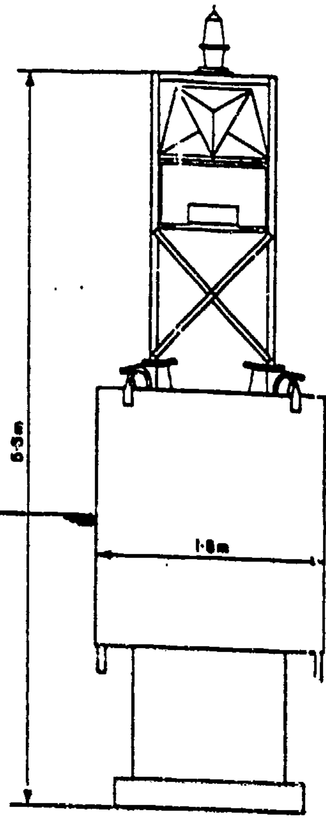
CCG contracts out all design and construction work for buoys to the private sector. Aside from buoy construction in accordance with technical specifications prepared by the CCG Headquarters and District Offices, some R&D work had also been contracted. One design firm (See Section 2.2.1.2) was developing design criteria for the buoys deployed by CCG. The study has since been completed and a preliminary copy of the results entitled "Navigational Buoy Design Manual" was made available to the project investigators by the CCG.



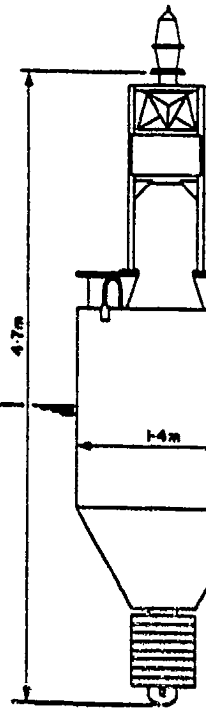
FA-1010
2·9m WHISTLE BUOY



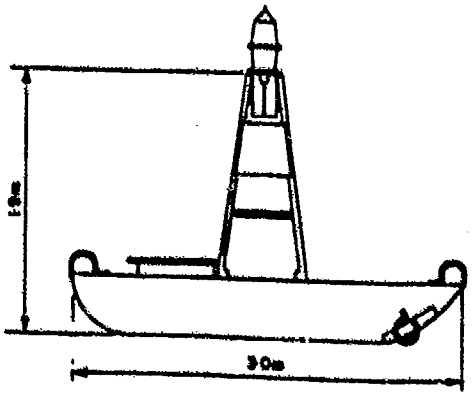
FA-1007
2·9m BELL BUOY



FA-1004
1·8m BUOY



FA-1001
1·4m BUO



FA-1015
3·0m SCOW BUOY

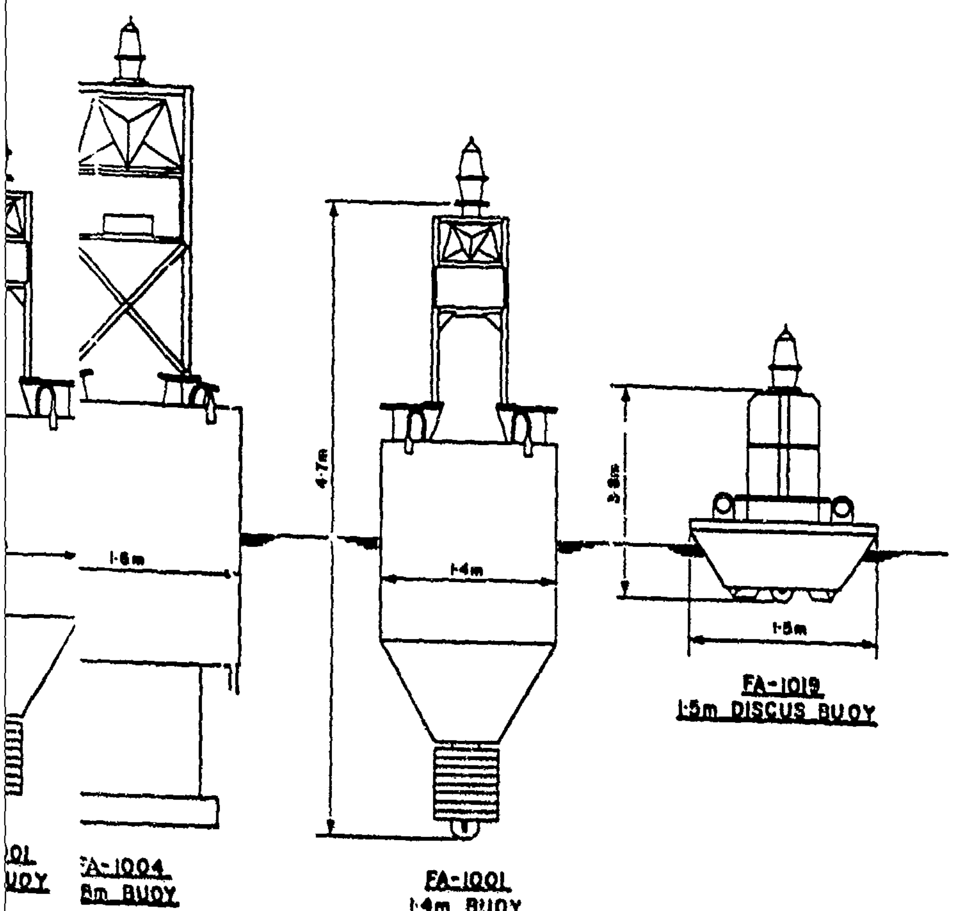
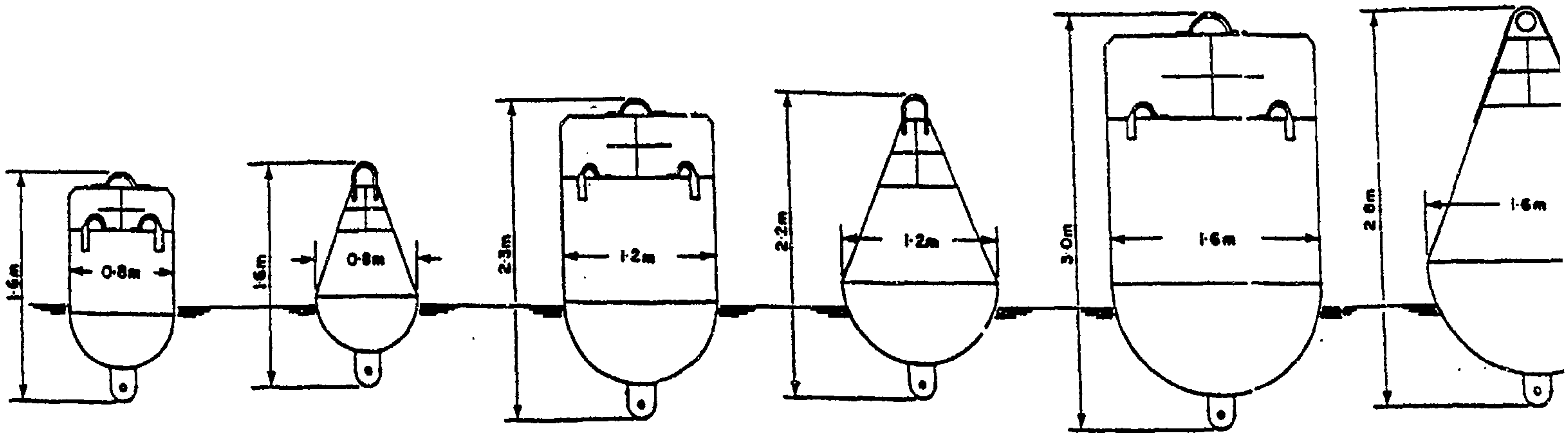


FIGURE 2-11
CANADIAN COAST GUARD BUOYS



FA-2001
0·8m COASTAL BUOY
CAN VERSION

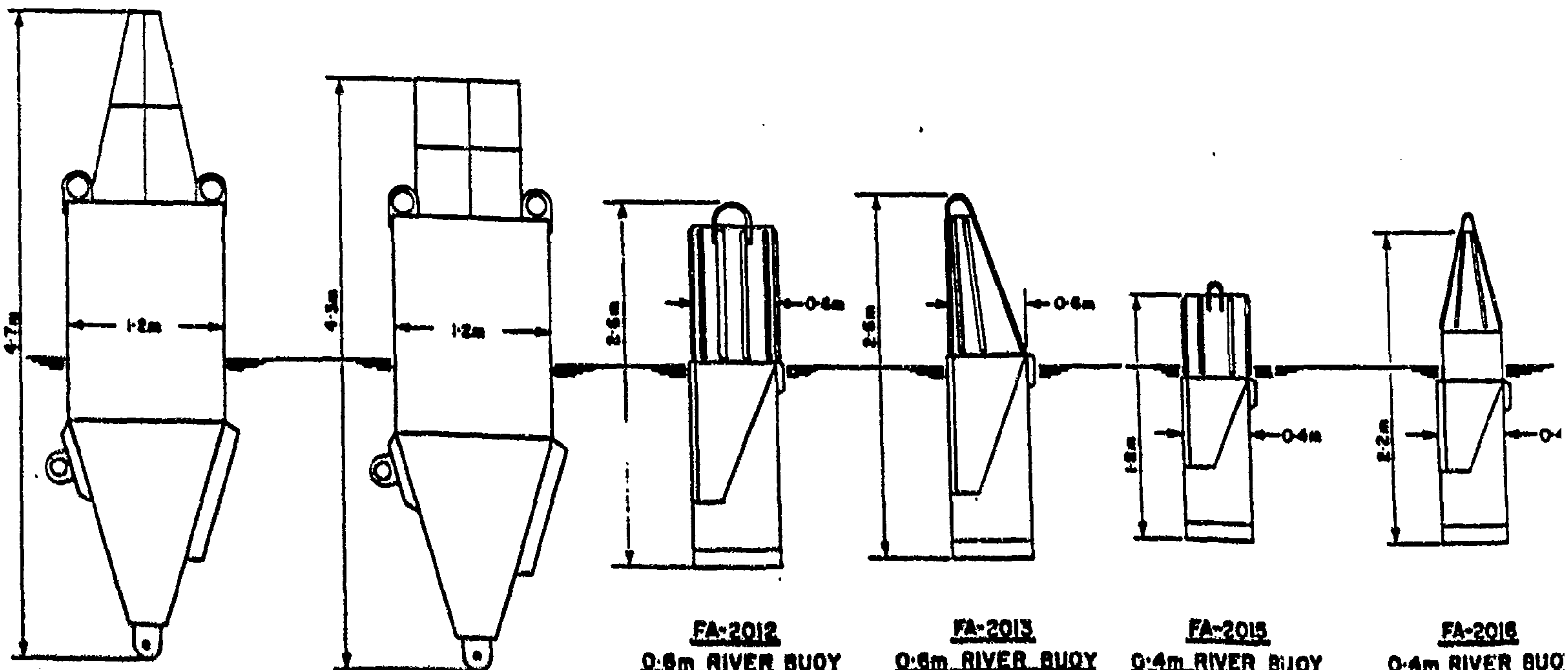
FA-2002
0·8m COASTAL BUOY
CONICAL VERSION

FA-2003
1·2m COASTAL BUOY
CAN VERSION

FA-2004
1·2m COASTAL BUOY
CONICAL VERSION

FA-2005
1·6m COASTAL BUOY
CAN VERSION

FA-20[...]
1·6m COASTA[...]
CONICAL VE[...]



FA-2012
0·6m RIVER BUOY
MACKENZIE TYPE
CAN VERSION

FA-2013
0·6m RIVER BUOY
MACKENZIE TYPE
CONICAL VERSION

FA-2015
0·4m RIVER BUOY
MACKENZIE TYPE
CAN VERSION

FA-2016
0·4m RIVER BUO[...]
MACKENZIE TYP[...]
CONICAL VERSIO[...]

FA-2010
1·2m RIVER BUOY
CONICAL VERSION

FA-2011
1·2m RIVER BUOY
CAN VERSION

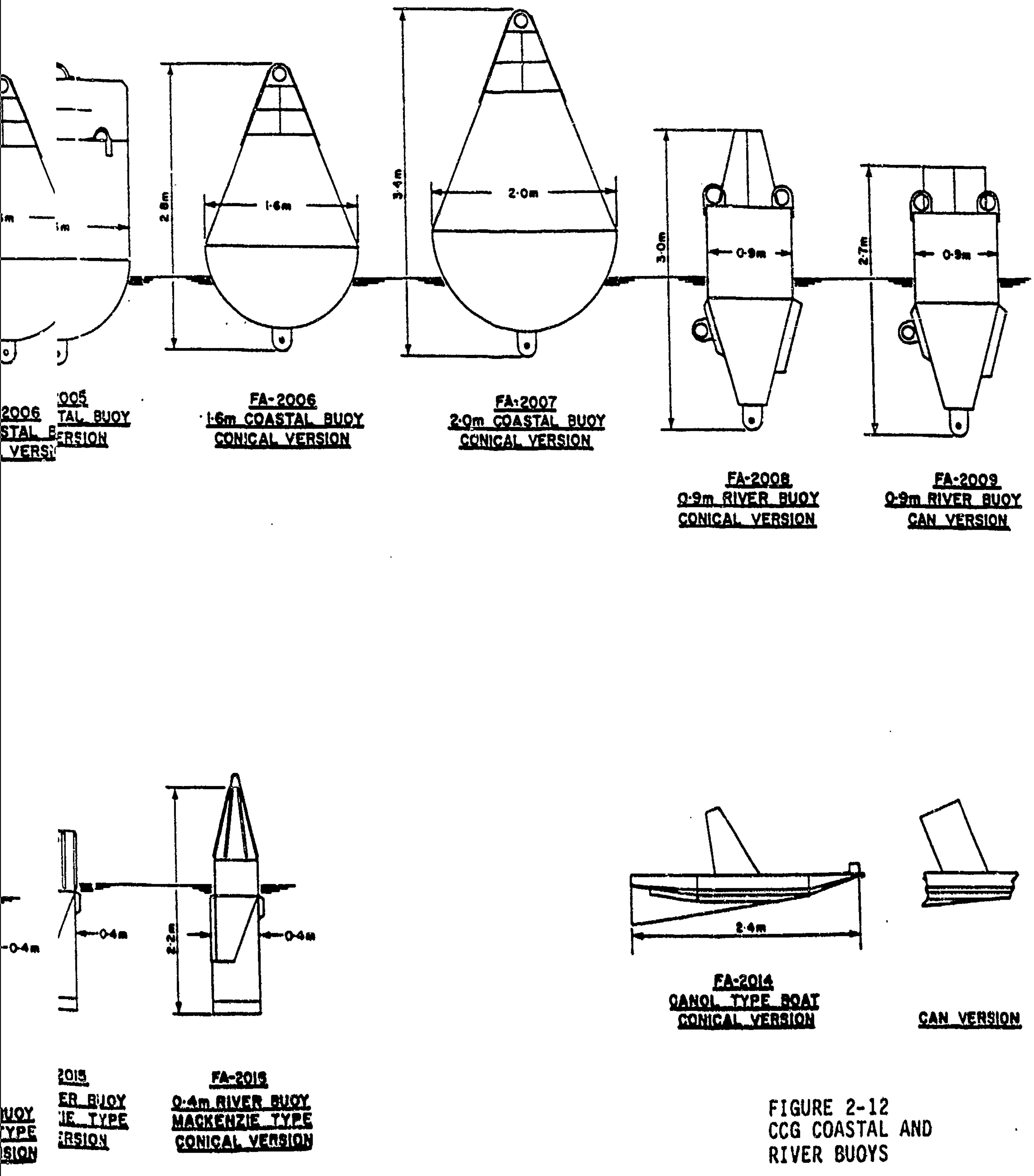
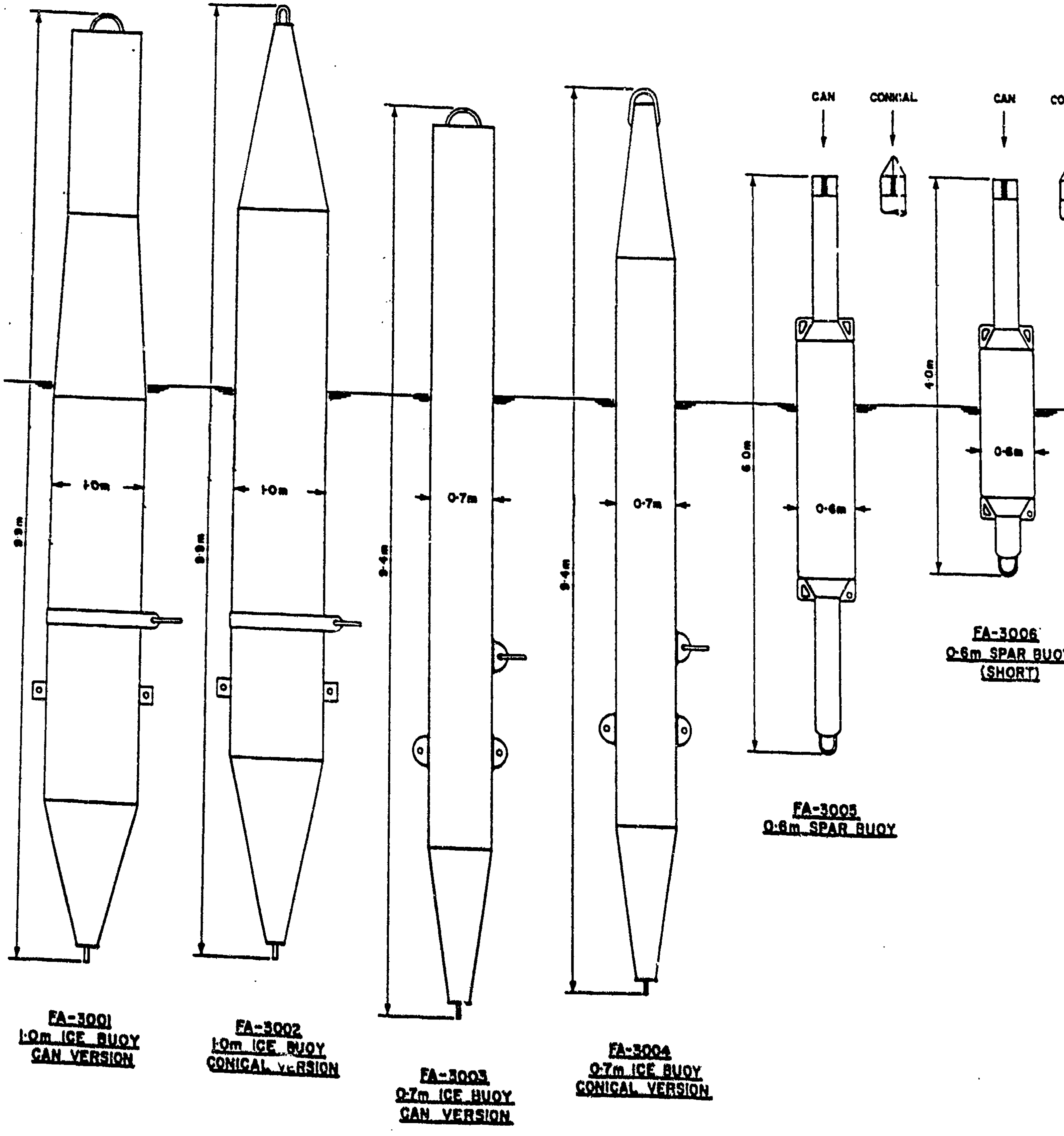


FIGURE 2-12
CCG COASTAL AND
RIVER BUOYS



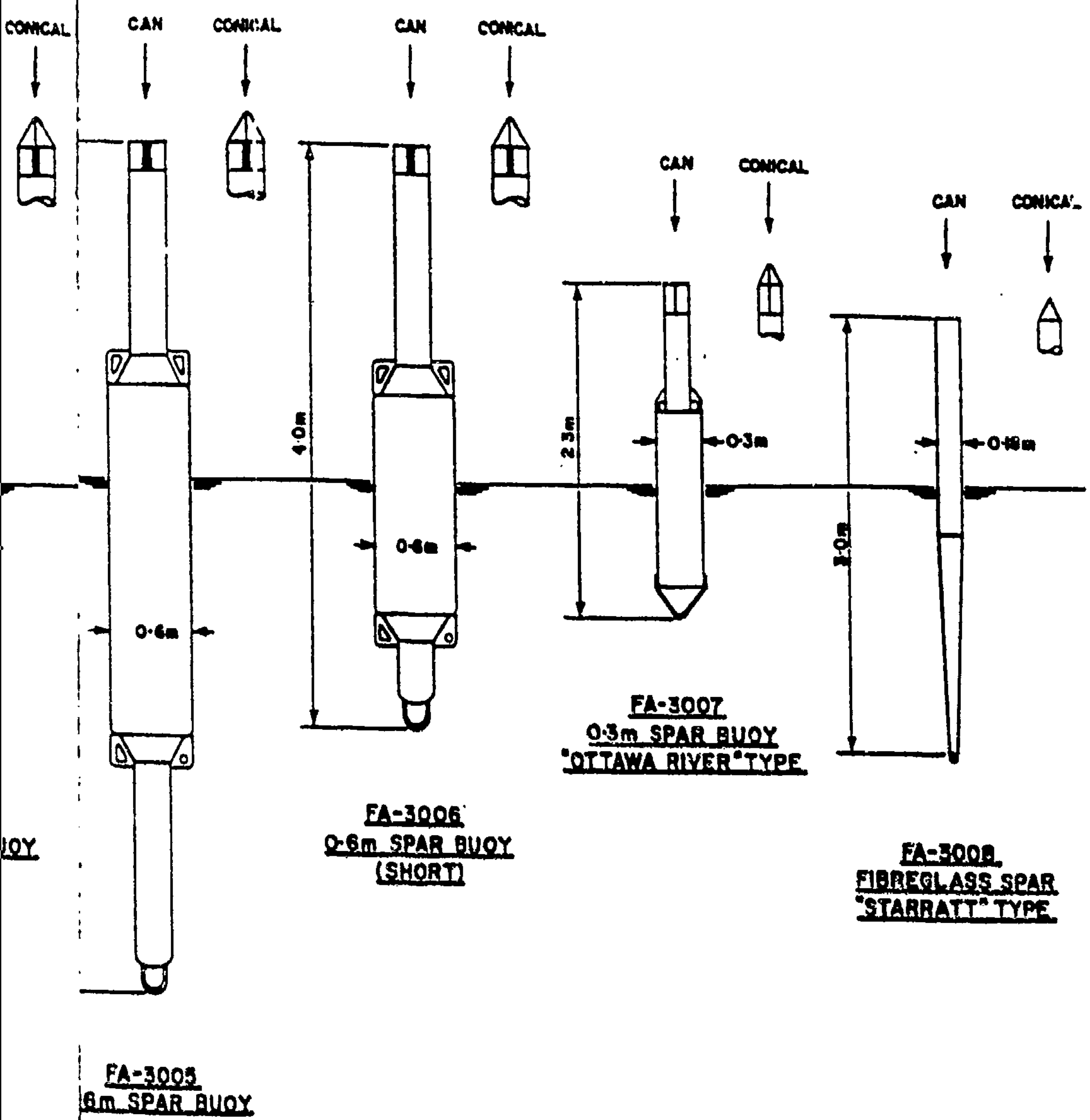


FIGURE 2-13
CCG SPAR BUOYS

BUOY INVENTORY as of March 1987 - ALL REGIONS

	DRAWING No.	DESCRIPTION	IN USE	SPARE		FISCAL YEAR WRITE OFF	
				NO.		NO.	Value
STANDARD LIGHT BUOYS	AR-15517	3' Electric (Gannet)	182	28	-----	-----	-----
	CR-15158	3'6" Electric Spar	248	27	-----	-----	-----
	CR-15006	4'6" Electric (River)	708	201	-----	-----	-----
	CR-15005	6' Electric	657	64	-----	-----	-----
	CR-15004	9'6" Gas & Bell	-	1	-----	-----	-----
	CR-15004	9'6" Electric	313	28	-----	-----	-----
	CR-15004	9'6" Electric & Bell	392	107	-----	-----	-----
	CR-15003	9'6" Electric & Whistle	133	32	-----	-----	-----
	CR-15003	9'6" El. Whistle & Racon	17	1	-----	-----	-----
	CR-14521	7'5" Boat Type	57	29	-----	-----	-----
	CR-14777	14'8" Boat Type	-	3	-----	-----	-----
	CR-15284	Scow Type	191	29	-----	-----	-----
		Total	2590	579			
STANDARD CAN & CONICAL BUOYS	CR-15002	3' Conical - Coastal Type	31	46	-----	-----	-----
	CR-15002	4' Conical - Coastal Type	66	40	-----	-----	-----
	CR-15002	5'6" Conical - Coastal Type	92	101	-----	-----	-----
	CR-15002	7' Conical - Coastal Type	66	23	-----	-----	-----
	CR-15001	2'6" Can - Coastal Type	1	8	-----	-----	-----
	CR-15001	3' Can - Coastal Type	31	33	-----	-----	-----
	CR-15001	4' Can - Coastal Type	60	22	-----	-----	-----
	CR-15001	5' Can - Coastal Type	61	82	-----	-----	-----
	CR-14765B	3' Conical - River Type	50	83	-----	-----	-----
	CR-14765A	4' Conical - River Type	28	4	-----	-----	-----
	CR-14765B	3' Can - River Type	31	63	-----	-----	-----
	CR-14765A	4' Can - River Type	7	4	-----	-----	-----
	CR-15160	18" Can - Mississippi	8	233	-----	-----	-----
	CR-15160	18" Conical - Mississippi	13	161	-----	-----	-----
	CR-15356	30" Can - Mississippi	13	32	-----	-----	-----
	CR-15356	30" Conical - Mississippi	18	30	-----	-----	-----
	CR-15291	Can - Swift Current (Camel)	122	200	-----	-----	-----
	CR-15291	Conical - Swift Current (Camel)	124	176	-----	-----	-----
	CR-15457	Can - Fast Current FRP Boat	-	-----	-----	-----	-----
	CR-15457	Conical - Fast Current FRP Boat	-	-----	-----	-----	-----
		Total	1302	1312			
STANDARD SPAR & ICE BUOYS	AR-13010	Ottawa River Spar	3372	1318	-----	-----	-----
	CR-13253	Steel Can Spar	1132	307	-----	-----	-----
	CR-13009	3'6" Conical - Winter Type	91	19	-----	-----	-----
	CR-13009	3'6" Can - Winter Type	37	-----	-----	-----	-----
	CR-13153	3'3" Conical Swift Current Type	87	17	-----	-----	-----
	CR-13153	3'3" Can - Swift Current Type	32	36	-----	-----	-----
	CR-14764	3'3" Conical - Swift Current Type	7	1	-----	-----	-----
	CR-14764	3'3" Can - Swift Current Type	28	1	-----	-----	-----
	CR-13150	3'6" Spar (Steel)	223	131	-----	-----	-----
		Total	5139	3134			
MISCELLANEOUS ITEMS		Wood Spar	170	146	-----	-----	-----
		Kegs	8	1	-----	-----	-----
		Fibreglass Spar	312	28	-----	-----	-----
		Naolite	1538	83	-----	-----	-----
		Styrofoam	1318	763	-----	-----	-----
		3' Electric Steel	32	13	-----	-----	-----
		4'6" Electric Boat Type	-	1	-----	-----	-----
		6' El. ABA & Pintsch	38	13	-----	-----	-----
		7' Electric (ABA)	4	18	-----	-----	-----
		8' Electric Steel	3	-	-----	-----	-----
	Other	------------------------	2335	331	-----	-----	-----
		------------------------	-----	-----	-----	-----	-----
		------------------------	-----	-----	-----	-----	-----
		Total	4374	2088			
	TOTAL		----	----	----	----	----

TABLE 2-5
LISTING OF CANADIAN CG BUOYS

Another engineering consulting firm (Advanced Materials Engineering Center in Halifax, N.S.) is studying the use of composite materials for buoy construction under a CCG contract. This study will, according to CCG, be completed by the end of 1990. Also to be completed in 1991 is the final version of the "Floating Aids to Navigation Manual" which will include physical and operational data on scow, canol and boat buoys as well as buoyancy data for the conical buoys in addition to all data existing in the preliminary edition cited above.

Two of the CCG district offices were visited during this project: CCG Base Prescott, ONT and CCG Base Charlottetown, PEI, and a telephone interview was conducted with CCG Base Halifax in Dartmouth, NS. The results of the Base Prescott interview are discussed below in Section 2.1.1.2, Base Charlottetown in 2.1.1.3, and the results of a telephone interview with Base Halifax in 2.1.1.4.

<u>References for Additional Information</u>:

Interview Summary	:	Appendix A, Section A.1.1.1
Buoy Records	:	Appendix B, 31 Entries, Pages B-4 through B-124
Buoy Drawings	:	Appendix C, Pages C-3 through C-35

Eight papers were presented to the IALA conference by authors from Canada. Only three of these were directly or indirectly related to ATON buoys; others discussed topics such as lighthouses, LORAN - C applications, VTS systems, etc. Extracts from the three papers relevant to buoy technology are presented below:

1. <u>Paper No. 1.2.4</u>, Reference 5, presents (in French language) the methodology used, the recommendations developed, and the action plan which followed as well as comments on its implementation in a study to evaluate the "Marine Aids Organization" and the service it provides. Included in the investigations carried out for this project are the floating aid to navigation buoys.

2. <u>Paper No. 2.4.1</u>, Reference 6, deals with the development of a set of standard procedures to ensure the consistent and equitable application of national policies and guidelines to the selection of appropriate aids to navigation in response to user requests. The procedures developed also include the preparation of "Level of Service" statements covering efforts for review and design of marine aids as well as for costing of designs for decision making purposes.

3. <u>Paper No. 3.2.5</u>, Reference 7, describes the buoy paint systems and facilities upgrading efforts undertaken by the Canadian Coast Guard with the objective of achieving a total buoy system which is capable of extended service without major maintenance. Extensive testing of buoy paint systems has been carried out and it was found that extending the maintenance or service period to three years is easily achievable. It is reported that CCG is planning to improve the buoy maintenance facilities in all of its bases on the basis of information gained from the evaluation of a prototype facility constructed at the CCG Base in Prescott, Ontario.

2.1.1.2 CCG Base Prescott

The CCG Base in Prescott, Ontario is a modern installation with complete facilities needed for constructing, outfitting, testing and servicing buoys. Included among the facilities are separate shot-blasting and spray-painting rooms, waterwash areas, buoy storage and curing areas and workshop equipment including steel and aluminum welding capability.

During the Lakes' navigation season, the Prescott District has approximately 1,400 buoys in place. The buoys are not repaired on site except for minor replacement of parts when necessary. They are picked up by buoy tenders and brought back to the base for repairs.

The following are a few of the more important points recorded during the interview:

- Buoys used in the Lakes region are considered long-term investments. Some of the current buoys are more than 40 years old and the number of buoy losses per year is very small. Consequently, if a new buoy design is accomplished with integral daymarks, solar panels, etc., it may prove to be more cost effective in the long run despite the higher initial acquisition cost.

- Since buoy tender operations are very expensive, about $6 to $7,000 Canadian per day, any improvements in buoy design and manufacture to ease the maintenance requirements should result in considerable savings. Impact of the initial acquisition cost on the life cycle cost of buoys is small.

- A complete listing of the buoy painting systems used by the CCG is referenced in Appendix A Section A.1.1.1. The Lakes region uses the Epoxy coating system of AMERCOAT and also applies AMERSHIELD for protection against ultraviolet rays.

- The following suggestions were made by CCG Base Prescott for consideration as improvements on buoy hull designs:

  - Solid superstructures instead of latticework.
  - Improving the venting of battery pockets for better air circulation.
  - Compartmentation of buoy hulls to improve damage stability.

<u>References for Additional Information</u>

Interview Summary : Appendix A, Section A.1.1.2

2.1.1.3 CCG Base Charlottetown

A brief visit was made to the CCG Base in Charlottetown, Prince Edward Island, and a tour of the base facilities was afforded to the project investigator. It was observed that Base Charlottetown facilities were not nearly as developed as the Base Prescott facilities, e.g. there were no automatic blasting and painting equipment. However, as referred to in an IALA

90 paper, Reference #7, plans are currently underway by the CCG to improve the buoy paint systems and facilities at all CCG bases including Base Charlottetown on the basis of experience gained from the Prescott prototype facility.

Base Charlottetown handles most types of steel, aluminum, foam, and plastic buoys of the Canadian Coast Guard. Tests were conducted for several years on plastic lighted winter spars, and reportedly additional spars will be deployed this year. The intention is to leave the buoys on station for two years with battery changes once a year. Also underway is a project to replace small steel can and conical buoys.

References for Additional Information

Interview Summary : Appendix A, Section A.1.1.3

2.1.1.4 CCG Base Halifax

The types of buoys handled in this CCG Base include 24" and 48" styrofoam buoys, disc buoys of one meter diameter, and steel buoys up to 9'-6' diameter. The buoys are deployed in small rivers, harbor entrances, sheltered waters, and in open sea environments.

References for Additional Information

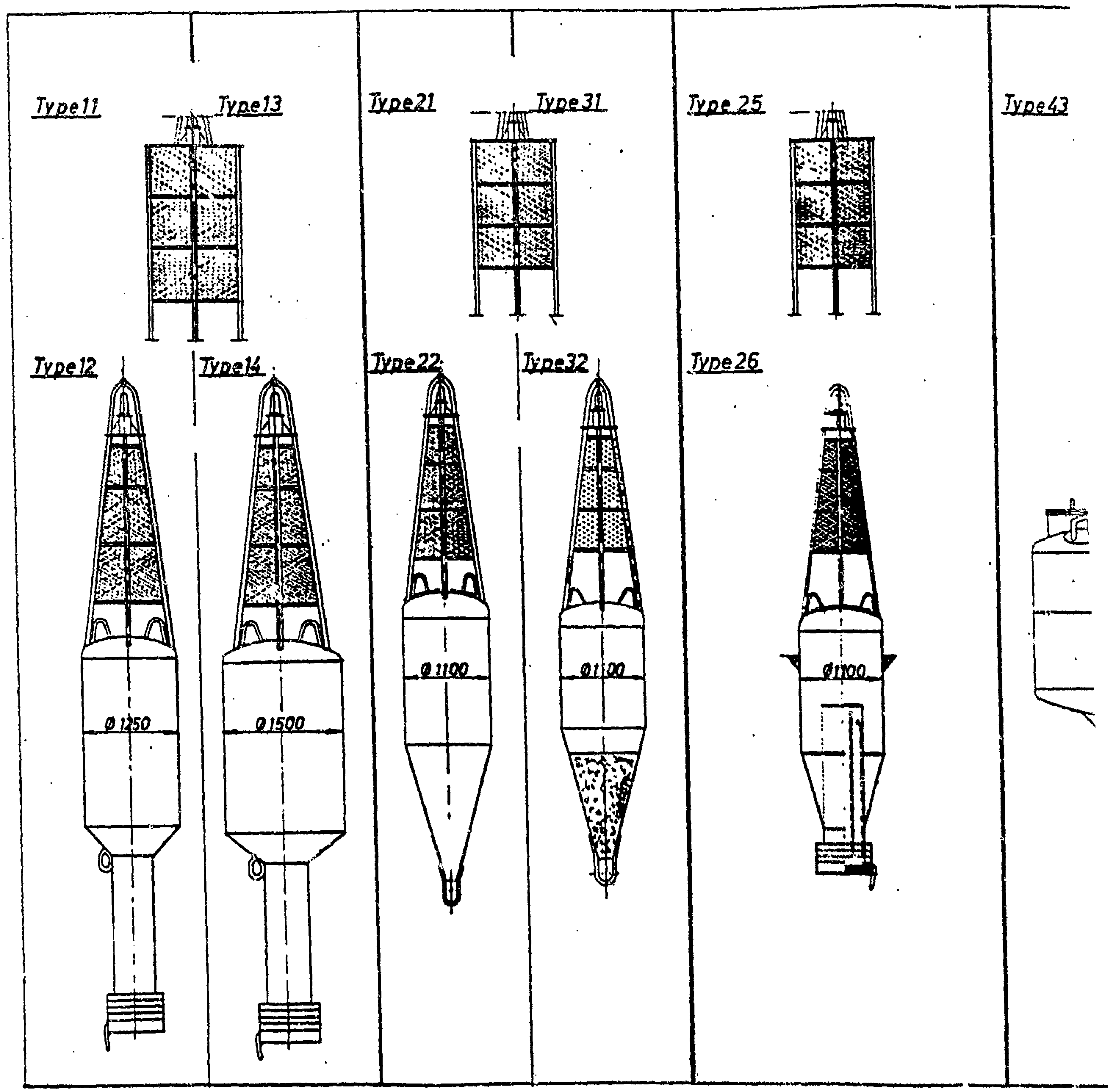
Interview Summary : Appendix A, Section A.1.1.4

2.1.2 Denmark

The name of Denmark's national navigation authority is "FARVANDSVAESENET" (FV) which roughly translates as "Seaway Administration" and refers to the "Royal Danish Administration of Navigation and Hydrography". The nationwide ATON system includes 1,500 unlighted and 400 lighted buoys as well as 1,000 spare unlighted and 200 spare lighted buoys. Schematic representations of Denmark's buoys are shown in Figure 2-14.

FV has experimented with GRP buoys in recent years and they have found that the GRP buoys were not suitable for Denmark's ATON buoy needs. Consequently, only steel buoys are being used in marking the waterways. As it can be seen in Figure 2-14, the diameters of buoy hulls range from 1.10 m (3.6 ft) to 2.87 m (9.4 ft) and the length from 6.2 m (20 ft) to 10.55 m (35 ft). All of the steel buoys used in Denmark are of their own designs. FV stated that these buoys represent the result of many years of experience and that they are tailored to the marine environment in Denmark.

For powering lighted buoys, gas or batteries are used. Manganese or lithium primary batteries are replaced every 18 months. However when only used between 7% and 50% of the time, the replacement cycle may extend from 2 to 3-1/2 years. "Kirk" type lanterns (MLF 325) are used on the lighted buoys; these have been in service for over 25 years and have provided 40 candle power.



Type 11
Type 13
Type 21
Type 31
Type 25
Type 43
Type 12
Type 14
Type 22
Type 32
Type 26
Ø 1250
Ø 1500
Ø 1100
Ø 1100
Ø 1100

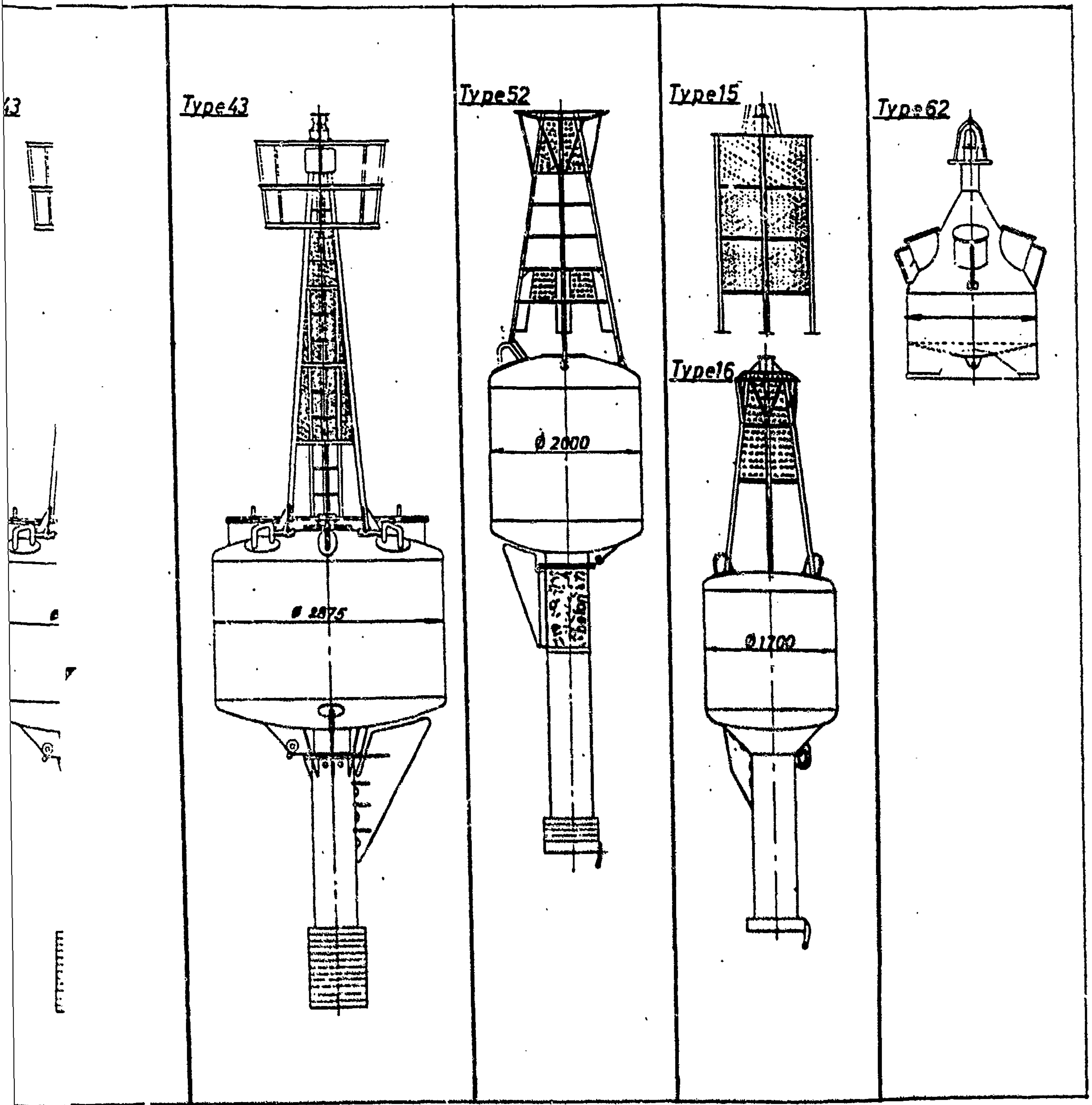


FIGURE 2-14
DENMARK'S ATON BUOYS

No solar power application has been undertaken for ATON buoys in Denmark yet. They have, however, conducted tests with wave generators on one of the 1.7 m diameter (about 5.6 ft) Type 16 buoys. They feel that their wave generator research has been quite successful. (See discussion on wave generators as applied to a new design buoy below.)

FV stated that they are also using wind generators for illuminating the superstructure of lighted beacons in connection with the Ocean Data Acquisition System.

The number of buoys lost per year in Denmark does not exceed 20 on the average. Losses are mostly due to damage from collisions. Even though the losses are small in number, the costs are high, especially when RACON and large lighted buoys are lost. The loss of one RACON buoy costs approximately half a million Danish Krons ($78,000).

Buoy locations are not currently monitored and off-station buoys are normally reported by mariners and users. However, FV stated that Denmark is currently experimenting with the remote monitoring of buoys. A paper presented to the IALA 90 Conference, Reference 8, includes a discussion of the remote monitoring of buoy's status as applied to the design of a new "Integrated Modular Buoy" which the Royal Danish Authority (FV) has been developing since 1988. As reported therein, the buoy status data to be monitored include the condition of the light beacon, the power supply, the electronic equipment and the actual position of the buoy. The objective is to make the installed electronic equipment in the buoy intelligent, so that they can communicate by means of a radio link to a land-based computer in a "Buoy Monitoring Center". This will enable the FV to maintain a real-time, round-the-clock control of the buoys and take immediate precautions in case of a failure. FV foresees that additional payload may be installed on the "intelligent buoy" to also allow its use as an environmental data buoy.

3-knot currents are common in Danish waterways and the depth of water generally ranges from 20 m to 50 m (approximately 165 ft). Inland and between islands, the depth of water is only up to 20 m. (66 ft.). FV does not design new buoys to meet the needs of differing environmental conditions in various locations but modifies the existing buoy designs to suit the intended service.

Minor maintenance of buoys is accomplished by buoy tenders, but servicing such as painting and repairs are done in "Buoy Depots". One such Buoy Depot (in Korsor, Denmark) was visited by the project investigator and one of Denmark's two large (70 m i.e., 230 ft. long) buoy tenders, M/V ARGUS, was also toured. Denmark also has two smaller buoy tenders of approximately 130 ft. length and about 30 ANT boats. A new 164-ft. long buoy tender is currently under construction. The Korsor buoy depot has the facilities to service, repair, overhaul all existing buoys and to modify them for any new application.

As stated by FV, the buoy tenders are expensive to operate. The annual cost of maintaining a lighted buoy runs approximately to 100,000 Danish Krons (about $16,000).

It is reported in Reference 8 that the design of the new lighted "Integral Modular Buoy" was based on new principles. The development project called "PRO UDLYST" by the Danish (meaning the Lighted Beacon Project) had the following objectives (as quoted from the paper):

- To develop a floating ATON buoy which can remain on location for longer periods of operation without inspection, service and maintenance.

- To reduce the acquisition and maintenance costs during the buoy's lifetime.

- To establish the possibility of monitoring the status of the buoy by means of radio communication.

- To establish the possibility of monitoring the marine environment.

In order to accomplish these objectives, the project has been investigating buoy materials, preservation and non-toxic anti-fouling methods, buoy design criteria, mooring systems and materials, radar reflectors, light beacons, renewable power sources, protection against ice damage, remote monitoring and facilities for environmental data collection.

An illustration of the "Integrated Modular Buoy" is shown in Figure 2-15 as reproduced from Reference 8. Among the materials considered for the body of this buoy were stainless steel and reinforced plastics. The former was found to be too expensive and the latter vulnerable to ice.

The following were considered or experimented with for use on this buoy:

- Non-polluting, anti-fouling systems including sound-emitting transducers.

- Mooring materials with specific gravities less than water or those provided with floats.

- A modular system of daymarks to enable the use of any type of daymark only by changing the top.

- A radar reflector design that is integrated in the light buoy structure.

- A new low-energy light beacon.

- A new prototype wave-powered generator. This unit is in final development stages; final tests, as reported, will be made in 1990.

- Precautions to reduce damage due to ice, including:

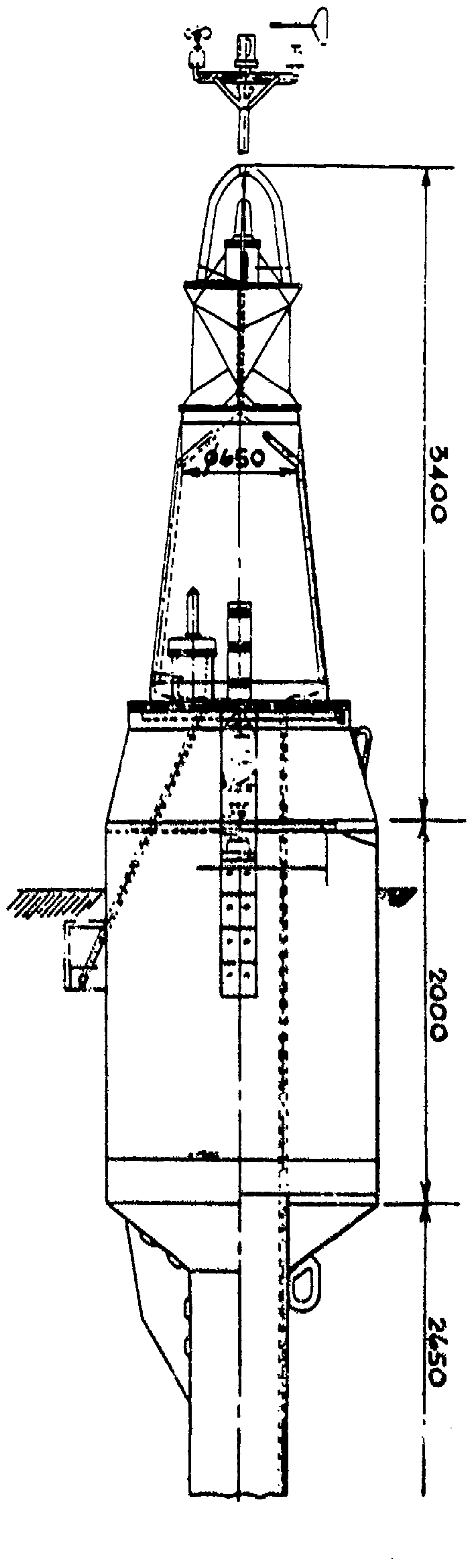


FIGURE 2-15
DENMARK'S
INTEGRATED
MODULAR BUOY

- Reinforcing the buoy structure as well as encapsulating the beacon and other equipment.

- Designing the buoy to slide under the drifting ice.

- Withdrawing the buoy when ice is expected to occur.

o Remote monitoring and environmental data collection (as briefly discussed above).

The referenced paper discuses all of the above in greater detail and provides further illustrations.

References for Additional Information:

Interview Summary	:	Appendix A, Section A.1.2
Buoy Records	:	Appendix B, 24 Entries, Pages B-131 through B-219
Buoy Drawings	:	Appendix C, Pages C-39 through C- 52

2.1.3 England

The aids to navigation in the United Kingdom and Ireland are provided by the lighthouse services administered by the Corporation of Trinity House, the Northern Lighthouse Board, and the Commissioners of Irish Lights. These lighthouse services are financed from light dues which are levied on vessels loading or discharging at ports in the United Kingdom and Ireland and are based on net or net registered tonnage. The dues are paid into the General Lighthouse Fund which is under the trusteeship of the Department of Transport.

The Corporation of Trinity House is the General Lighthouse Authority for England, Wales and the Channel Islands, providing lighthouses, light vessels, buoys and beacons. Personnel from Trinity House were interviewed during the surveys and the findings are discussed in this section.

The Northern Lighthouse Board is responsible for the waters of Scotland and the Isle of Man. The Commissioner of Irish Lights is responsible for the waters of both Northern Ireland and the Republic of Ireland. Discussions with some of their personnel were held during the 1990 IALA Conference and are reported in Section 2.4.

Local harbor authorities have cognizance over activities in their areas but must obtain approval from the three major lighthouse authorities for additions to or changes in aids to navigation in their systems. Few of these, the Gloucester Harbor Trustees and the City of Bristol Conservancy and Pilotage Department, both under the authority of Trinity House, were visited during the surveys and the results are presented later in this section.

Twelve papers were presented to the IALA '90 conference by authors from England. Five of these were directly related to ATON buoys and extracts of these are presented below:

1. Paper No. 1.4.4, Reference 9, by the Nautical Institute (see Section 2.2.3.5) discusses how to meet the navigational requirements of the mariner based on a systems approach. The system described is an overall system which includes as its elements the mariner himself, the presentation of navigational information and the Navaids used in the system. The standpoint is that of the mariner: how he sees himself working within the system, what he requires of the system and finally what is to the user an ideal system. The various major equipments available, or likely to be in the foreseeable future, are considered as possible components of the system. The paper concludes by stating the mix of Navaids that appear best-suited to meet the mariner's requirements. They state that clearly no one system can meet all the requirements of the various phases of navigation and there is a requirement for various aids. The UK Department of Transport in its consultative document remarks that "Radionavigation aids are complemented by visual aids of lights and buoys, of which a basic system will continue to be necessary to mark hazards and navigable channels and give visual confirmation of a ship's position." Visual marks will remain therefore.

2. Paper No. 2.4.5, Reference 10, by Trinity House, presents a computer database system to aid Trinity House in discharging its responsibility to make periodic inspections of all the aids to navigation within its area which are maintained by local authorities, which includes major ports and harbors. There are some 8,000 local aids which range from major lighthouses to unlighted beacons. The database can be used to ascertain what authority is responsible for a known aid or aids in a particular location, what aids are maintained by a known authority, or the characteristics of a particular aid.

3. Paper No. 2.4.8, Reference 11, by Trinity House, discusses the power required of an aid to navigation as an important consideration in deciding its range. The objectives are to categorize aids to navigation by power requirements and secondly to assess the most economical power source for these categories. The conclusions are that the requirements for long-range lights and fog signals can have a disproportionate effect on costs because of the power needed, and solar energy is the most economical source of power for requirements of a few Watts, wind or wave energy for tens of Watts, and cycle - charge diesel for hundreds of Watts.

4. Paper No. 3.6.6, Reference 12, by AB Pharos Marine, Ltd., United Kingdom, presents a new wave powered generator system for buoys. In this system, shown in Figure 2-16, the motion of the buoy is sent to stretch and relax a special hose contained within the mooring system. The resulting pumping action drives a small turbine. The system can be installed in both new and existing skirt keel buoys and useful power is generated 24 hours a day, even in relatively sheltered waters. The paper summarizes the results of development work and trial activities and outlines the wide areas of application of this technique.

5. Paper No. 1.2.3, Reference 13, by the General Lighthouse Authorities (GLA) of the UK and Ireland describes the review criteria which have been formally adopted by GLA for assessing the requirements for aids to navigation. The consultation process from which they arose is also described and reference is made to the common ground which exists with the IALA NAVGUIDE. With regard to floating aids to navigation they note the future

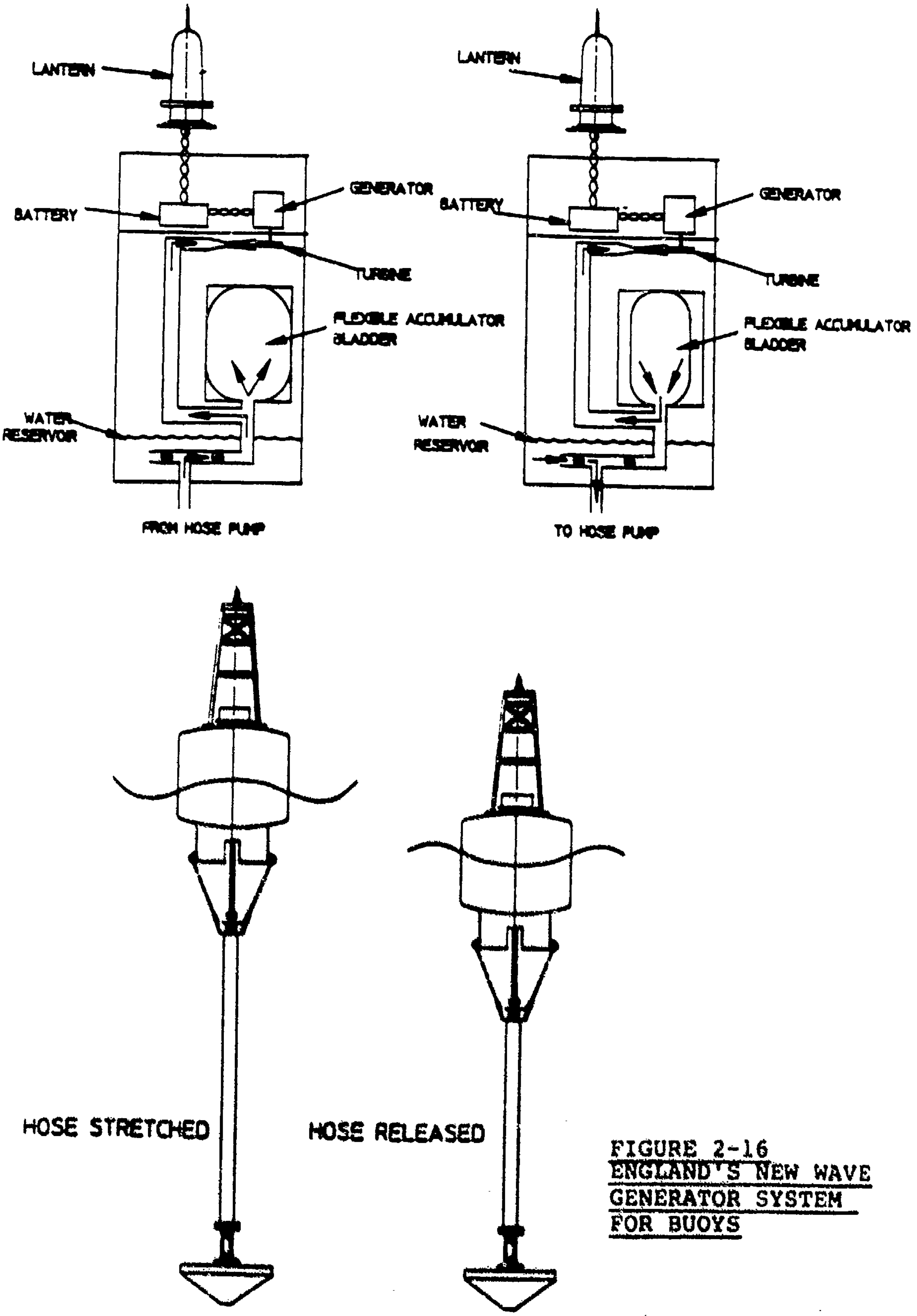


FIGURE 2-16
ENGLAND'S NEW WAVE GENERATOR SYSTEM FOR BUOYS

prospects and critical factors are that a continuing demand is expected and that the introduction of retro-reflective surfaces would be valuable on unlighted buoys.

2.1.3.1 The Corporation of Trinity House Lighthouse Services

The Corporation of Trinity House Lighthouse Service, London, is a unique maritime organization which throughout its long history has had as its prime objective the safety of shipping and the welfare of seafarers. In addition to its ATON activities it provides a charitable organization for relief of mariners and their dependents who are in financial distress and a deep sea pilotage authority. It is not a governmental organization but it was created by an act of Parliament.

Trinity House headquarters are in London. Buoy tending and maintenance operations are carried out from buoy depots at Harwich, Great Farmouth, East Cowes, Isle of Wright, Penzance and Swansea. The Harwich depot was visited during the surveys and the findings are reported below.

Trinity House is responsible for approximately 600 buoys, which are located in exposed waters, not harbors. Their largest class of buoy is 4 meters in diameter, 50' high, weighs 12 tons and has a 7 mile light. All of their deep water buoys are 9 ft. to 10 ft. in diameter and of Class I, high focal plane tail tube type as shown in Figure 2-3, or Class II skirt type as shown in Photograph 2-1. The buoys are of their own design, in steel which they believe is more resistant to the collision damage their buoys are exposed to. Their latest steel buoy design, the Class II shown in Photograph 2-1, has a standard hull on which different superstructures can be mounted. Note also the use of a slat covered frame superstructure to obtain shape significance. They have very few fiberglass buoys but a standard 3 meter GRP buoy is shown in Figure 2-17.

Trinity House is currently more concerned with the power sources than with the buoy itself. For many years, until recently, they utilized acetylene gas lights. Now their buoys are solar powered with batteries.

Trinity House operates two lighthouse tenders, THV PATRICIA AND THV MERMAID, which are purpose-built vessels constantly employed at sea to support and maintain floating aids to navigation. These tenders are described in Reference 14 and their operating cost is 296 pounds/hour on a 24 hour basis. Buoys are visited once each year, hauled and cleaned. They are returned to base every 4 years, blasted, primed and covered with three coats of epoxy.

<u>References for Additional Information</u>:

Interview Summary	:	Appendix A, Section A.1.3.1
Buoy Records	:	Appendix B, 34 Entries, Pages B-220 through B-344
Buoy Drawings	:	Appendix C, Pages C-53 through C-68

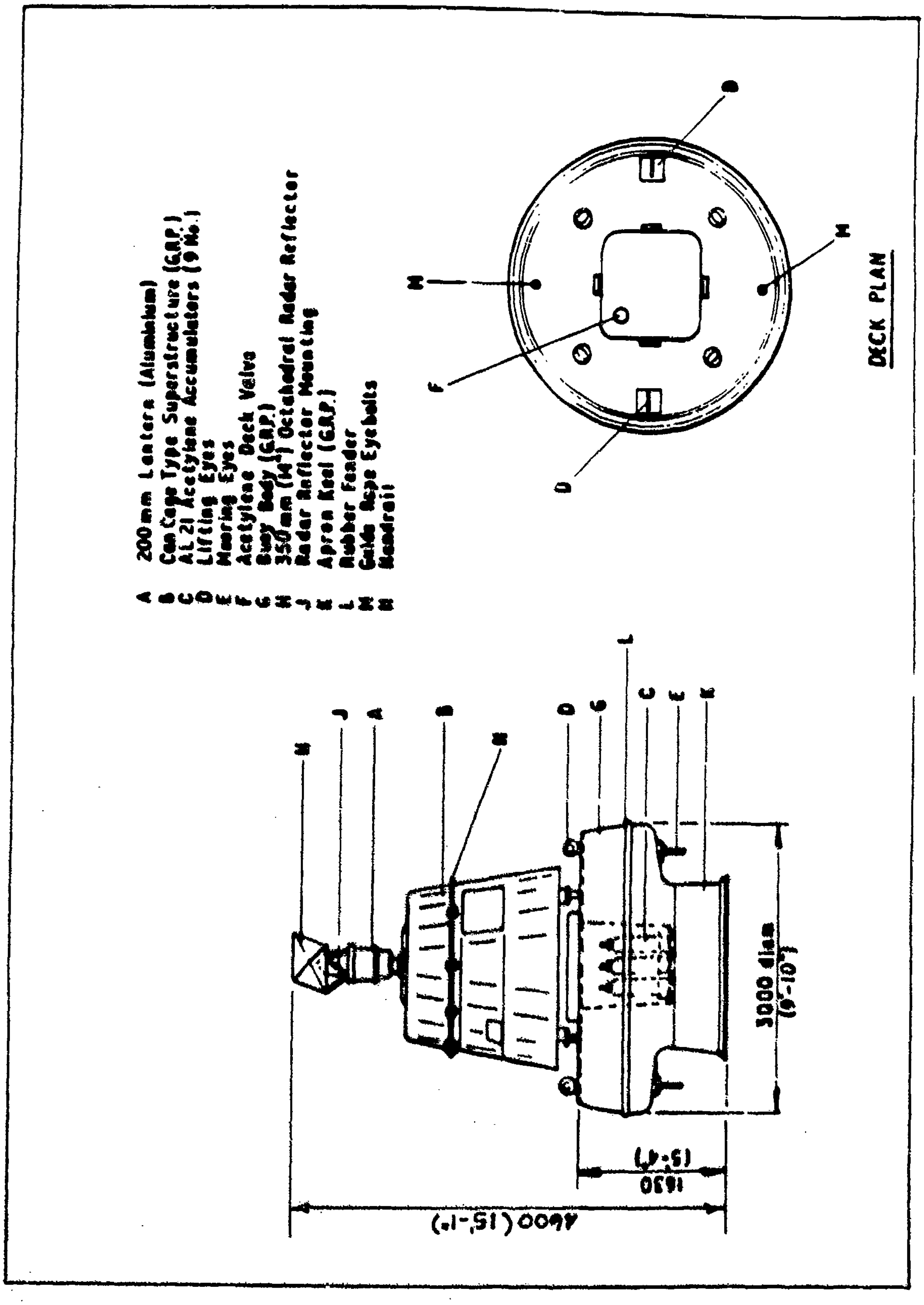


FIGURE 2-17
ENGLAND'S 3m.
GRP LIGHTED BUOY

2.1.3.2 Trinity House Harwich Buoy Department

The Harwich Buoy Department (HBD) is located northeast of London and serves the English North Sea buoys. The North Sea conditions are shallow water with shifting sand whereas the coast conditions are deep ocean with rocky bottom.

In the 1970's, the Trinity House tried a fiberglass Class II buoy which did not work well. They had problems with the moorings, disintegration of fiberglass, and fading of color. A number of smaller harbors in England use Balmoral buoys which are available in a range of sizes from one to five meters in diameter. Balmoral buoys had traditionally been constructed of foam filled GRP but their newest buoys are of foam with an elastomer exterior (see Section 2.2.3.1).

Trinity House maintains an average level of spare buoys of 25%.

References for Additional Information:

Interview Summary : Appendix A, Section A.1.3.2

2.1.3.3 Gloucester Harbor Trustees

The Gloucester Harbor Trustees (GHT) are responsible for the river Severn, at the headwaters of the Bristol Channel of the Southwestern portion of England. They have 30 navigation aids of which 5 are buoys.

Whatever buoy the GHT installs must be approved by the Trinity House.

Their buoys are of typical steel construction. The GHT had found that steel corrodes quickly in their estuarine environment and accordingly, they have incorporated GRP superstructures on their buoys.

References for Additional Information:

Interview Summary : Appendix A, Section A.1.3.3

2.1.3.4 City of Bristol Conservancy and Pilotage Department

The port of Bristol is in the Southwestern portion of England. The tidal range is 38 ft. and the current ranges up to 4-5 knots. Like the GHT, they must obtain Trinity House approval for their actions.

They have two 2.5 meter diameter Hippo Marine (see Section 2.2.3.6) polyurethane elastomer skin buoys with polyethylene foam interiors. These buoys have solar panels and a battery compartment at the top of the superstructure. Reportedly, they work very well in current and survive collisions. They have found that older GRP buoys crack in collisions with ships.

References for Additional Information:

Interview Summary : Appendix A, Section A.1.3.4

2.1.4 Finland

In Finland, the aids to navigation are administered by the "Waterways Department" within the Finnish Board of Navigation (FBN). The Waterways Department consists of three divisions, i.e.: the "Waterways Division", the "Harbor Division" and the "Division of Aids to Navigation" the Finnish name of which is "Merenkulkuhallitus". The responsibilities of the ATON Division include the design, manufacture, installation and maintenance of all buoys used in marking and maintaining the 12,700 kilometers (approximately 8,000 nautical miles) of Finnish navigation channels. Steel, plastic and wooden spar buoys and pillar buoys are used in addition to fixed structures in marking the channels. Shown in Figure 2-18 are schematic representations of standard navigation buoys. There were a total of 12,472 buoys in use at the end of 1983; this number has increased to approximately 13,400 as of the end of 1987. The breakdown of the 1983 buoy count by types is given in Appendix A, Section A.1.4.

Figure 2-19 shows the dimensions, materials and equipment of the typical plastic pillar buoy.

FBN had developed a standard design for a steel ice buoy in 1970. In 1989 a newer steel ice buoy was developed. The 1970 design 130 cm. by 1,050 cm. (4.27 ft. by 34.44 ft.) standard steel ice buoy is shown in Figure 2-20 and the 1989 design in Figure 2-21. Table 2-6 shows a comparison of the characteristics for the old and the new designs. As seen, the new design has five compartments instead of the old design's four in order to provide more protection against Finland's severe ice environment. The maximum thicknesses of level ice along Finland's coast are shown in Figure 2-22 as recorded during the period from 1920 to 1980. It can be seen that the thickness may reach a maximum of 120 cm. (nearly 4 ft.) along the northern coast. FBN's experience is that floating buoys, spar or pillar type, will only function properly in ice thicknesses up to 30 cm. (1.0 ft.) and therefore, outside of areas where the ice thickness is greater than 30 cm., fixed structures are used. Steel buoys are more resistant to wear and impact from the ice. Plastic buoys are subject to damage from ice ridges and drifting ice. Still however, the life expectancy of plastic buoys is estimated to be about 10 years, while wooden buoys have to be discarded after one year.

The wave height criteria used in designing buoys in Finland is shown in Table 2-7 (Tables 2-6 through 2-10 are reproduced from Exhibit 1 of the Summary Notes for Finland in Appendix A, Section A.1.4).

The FBN had conducted some tests on buoy motions and measured the maximum tilts of standard ice buoys. Table 2-8 shows the results. They are contemplating the development of a computer program to calculate the motions of a floating buoy in the future.

The lighted buoys are powered by primary batteries only. FBN had not used solar panels or wave generators for powering buoy lights even though

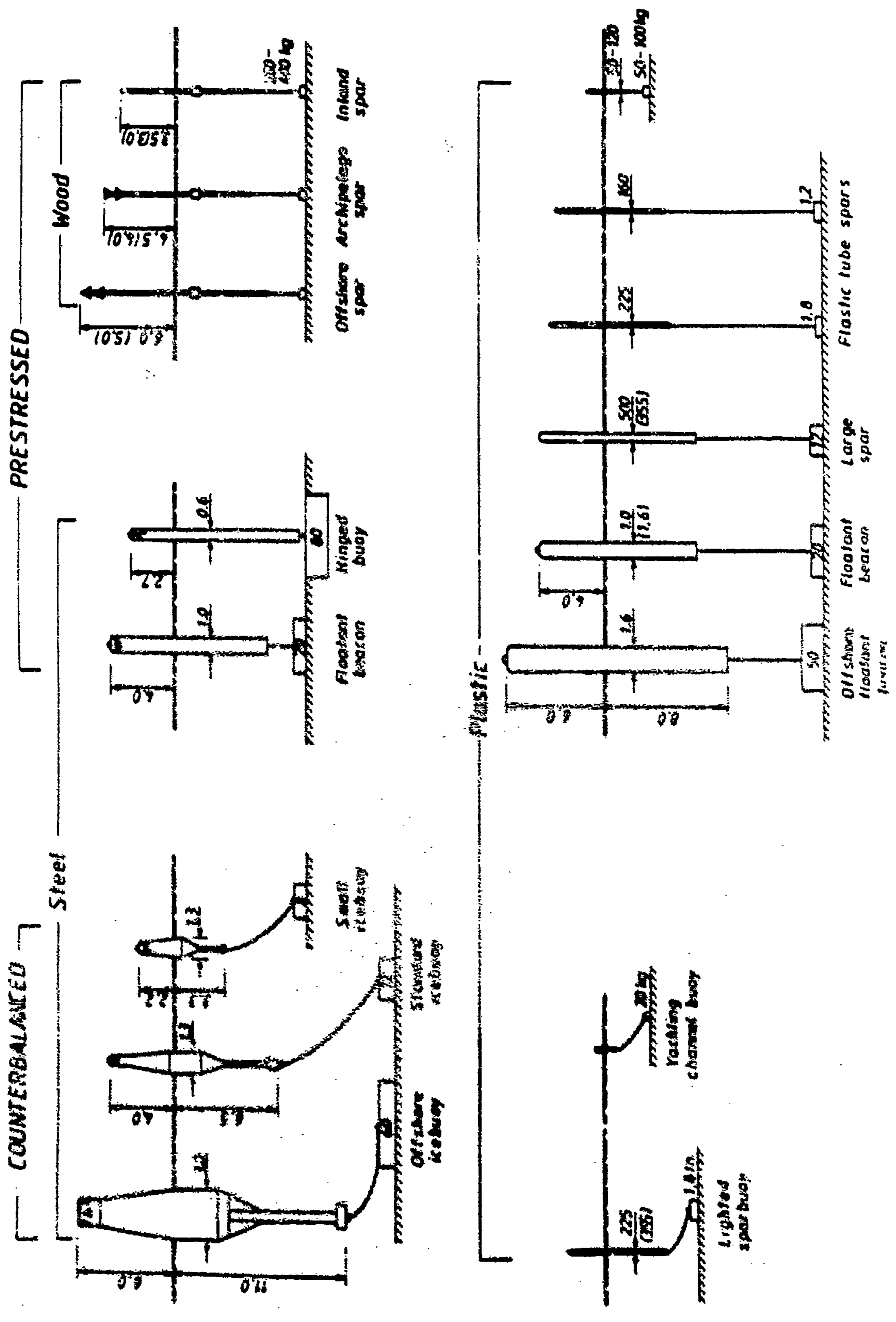


FIGURE 2-18
FINLAND'S
ATON BUOYS

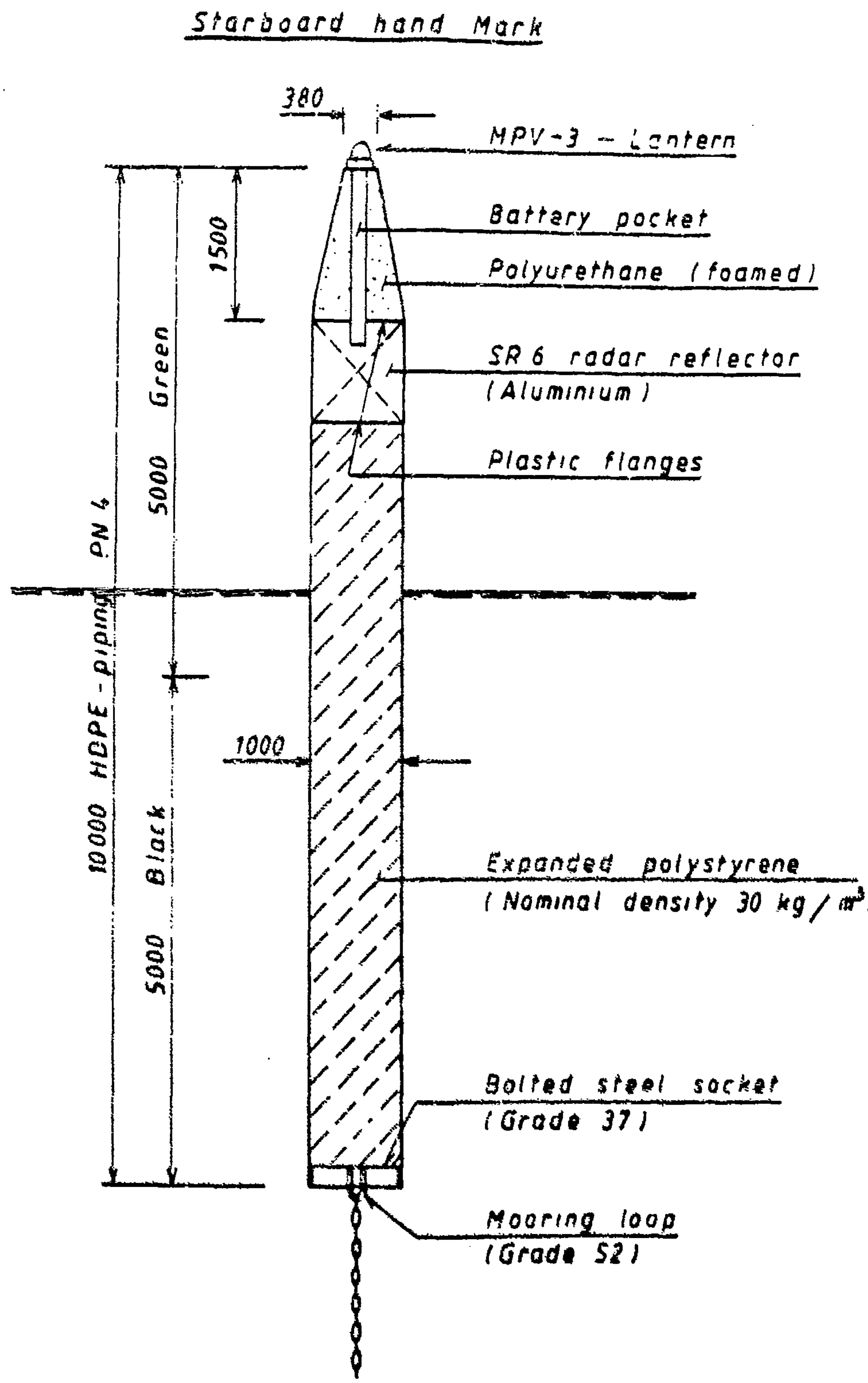


FIGURE 2-19
FINLAND'S TYPICAL
SPAR BUOY

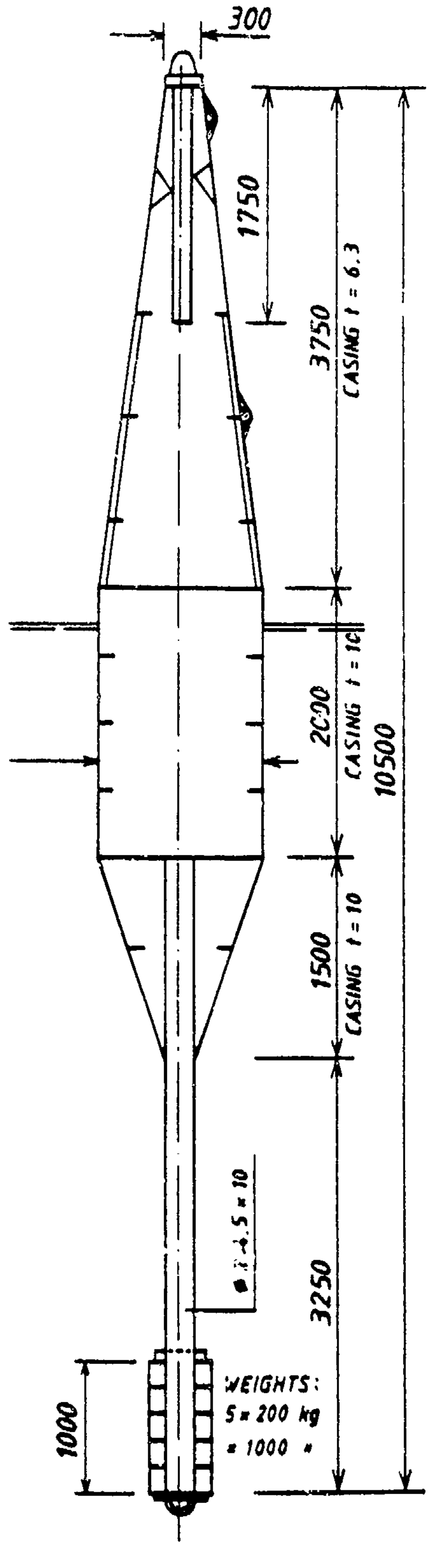


FIGURE 2-20
FINLAND'S 1970
DESIGN STEEL ICE
BUOY

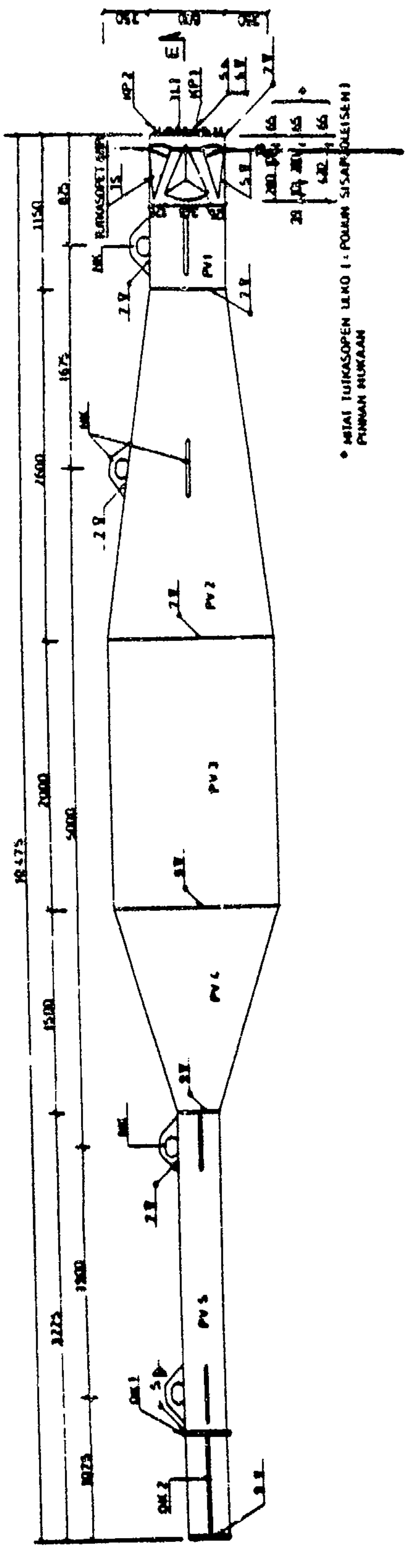


FIGURE 2-21
FINLAND'S 1989
DESIGN STEEL
ICE BUOY

STANDARD STEEL ICE BUOY

NORMAL ISBOJ AV STÅL

	New Type **Ny typ (1989)**	Old Type **Gammal typ**
Dimensions **Mått**	**1300 x 10 500**	Same **samma**
Focal Height **Ljushöjd**	**4200**	**samma**
Weight **Vikt**	**2466 + 1043 = 3.509 kg**	**2200 + 1000 = 3.200 kg**
Radarreflektor	**6st hörnreflektorer t = 270 mm A_x = 24 m^2**	**samma**
Steel Grade **Stål**	**RAEX 490**	**Fe 37 B**
Svetsar	**WB**	**WC**
Q.C. **Kvalitetsprov**	**Ultraljudkontroll: 25 % av manteln och radarreflektorer, 5 % övrigt**	**Okulär kontroll och punktvis röntgen kontroll**
	Tryckprovning 3 ... 5 kN/m^2	-
	Svetsarens initialer	
Preservation **Ytbehandling**	**Sandblästnings Sa 2 1/2 o. lösningsfri epoxi INERTA 165 2 x 200 mμ**	**samma**
Zinc Anodes **Galvaniskt skydd**	**Sinkanoder 4 x 1 kg**	-
Compartments **Avdelningar**	**5 st**	**4 st**

TABLE 2-6
FINLAND'S 1970
VS. 1989 BUOY DESIGNS

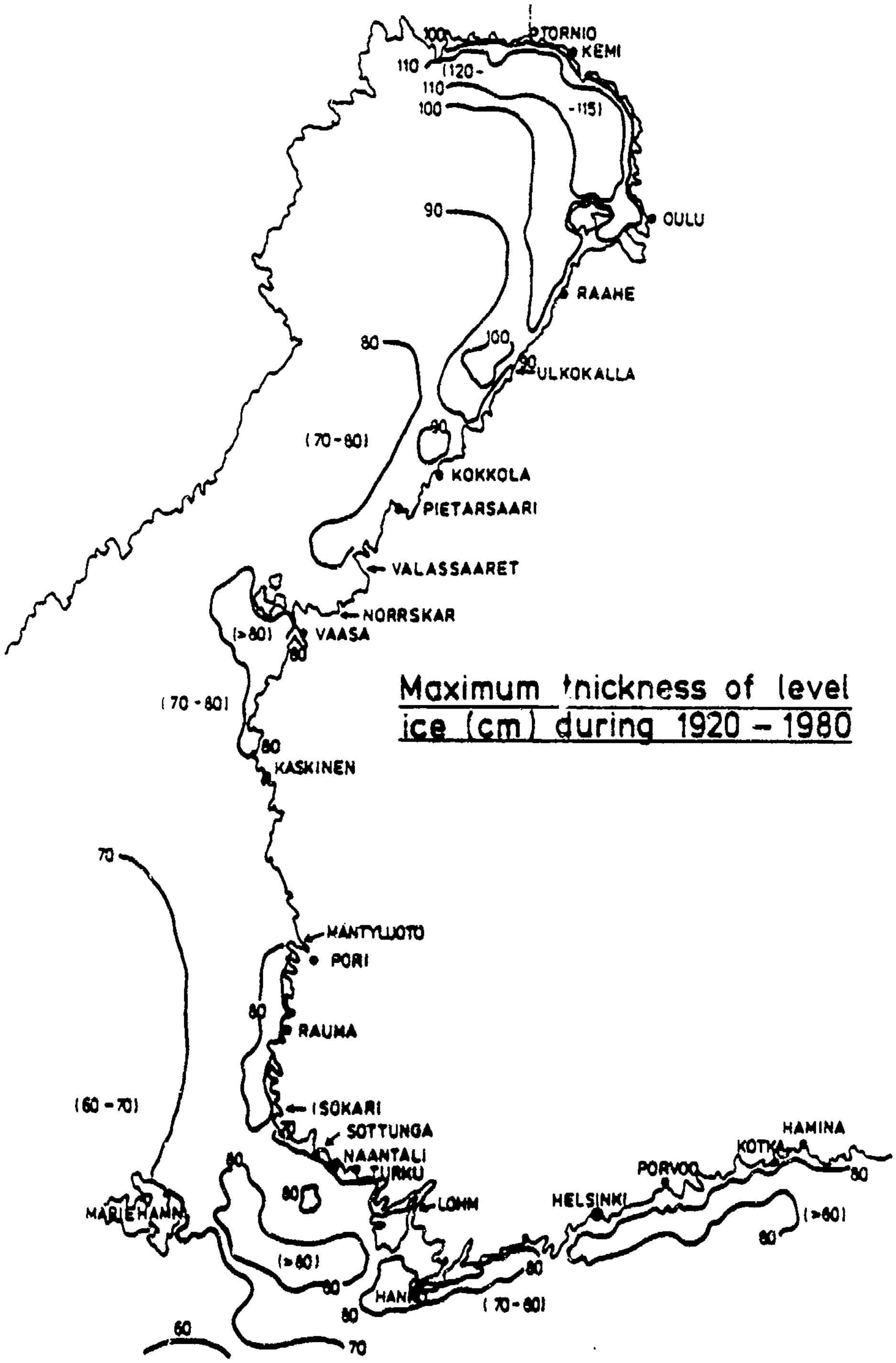


FIGURE 2-22
LEVEL ICE THICKNESSES
IN FINLAND'S COAST

SUUNNITTELUKRITEERIT
DESIGN CRITERIA
PROJEKTERINGSKRITERIER

Kestävyysrajatila **Survival Condition** **Hållbarhetsgräns**	H_{max}
Myrskymitoitus **Storm Design** **Stormdimensionering**	$H_{99,99\%}$
Ylempi käyttörajatila **Max operating Condition** **Övre brukstillstånd**	$H_{90\%}$
Normaali käyttörajatila **Normal Operating Condition** **Övre brukstillstånd**	$H_{70\%}$

TABLE 2-7:
FINLAND'S WAVE HEIGHT CRITERIA

TEST RESULTS

TESTRESULTAT

FOR STANDARD ICE BUOY

AV NORMAL ISBOJ

Depth **Djup** **m**	**Våghöjd** **m**	Chainlength **Kätting-längd** **m**	Maximum Tilt **Maximum lutning**
25	**3,5**	**27**	**20°**
25	**5,0**	**"**	**23°**
25	**7,0**	**"**	**26°**
15	**3,5**	**20**	**25°**
15	**5,0**	**"**	**32°**
10	**2,0**	**10**	**33°**
10	**3,5**	**"**	**45°**

TABLE 2-8
FINLAND'S MEASURED
MAXIMUM TILT ANGLES

solar power is currently being considered for future use. A possible configuration of solar panels being studied is shown in Figure 2-23.

A systematic position control/monitoring procedure does not exist in Finland. Position control is maintained by means of reports from users and buoy tender crews. Various position control systems such as SYLEDIS, mini-DECCA and GPS are being considered for future use.

The number of buoy losses vary depending on the hull material. The biggest casualty is among the wooden spars. About half of these are lost or heavily damaged each year. Only between 10% and 20% of the plastic spars and lighted buoys are lost annually. Steel buoy losses are negligible; however, approximately 10% of the steel buoys need repairs or repainting every year. The average repainting period is 2.8 years.

The "Helsinki Buoy Depot" is an FBN facility that stores buoys and buoy parts/equipment and also performs necessary minor repairs on damaged buoys. Major repairs or modifications as well as new construction of plastic spars with diameters less than 50 cm. (1.64 ft.) are accomplished in the FBN's own manufacturing plant in Joensuu, Finland. Spars and buoys with larger diameters are manufactured in Vaasa, Finland by KWH Pipe, Ltd. (See Section 2.2.4.1.)

Finland has three buoy tenders of 43 m. (141 ft.) length and approximately 30 small ANT boats. The tenders are operated with a crew of 15 and are mainly used for servicing and maintaining the buoys. The small boats are also used in performing other services such as pollution prevention.

Maintenance costs for buoys were not available from the FBN. However, the acquisition costs for buoys of different types and for buoy equipment were made available and are shown respectively in Tables 2-9 and 2-10.

An interesting project, similar to the BTIS of this study, is currently underway at the FBN to develop a computer database for storing reliable buoy statistics with the objective of improving the designs or redesigns of future buoys. The work is reportedly not yet complete.

A paper was presented to the IALA '90 Conference by Mr. Klaus Martonen of the Finnish Board of Navigation, Reference #15. The paper, on the most part, deals with the planning and execution of a 120 km. (approximately 75 mile) long channel in the southern part of Finland leading to the port of Naantali. The application of the plan includes a study of the ATON needs for the channel. As a result, the paper reports on the various navigation aids considered and eventually deployed in the channel. These include 74 buoys in addition to the rand marks and leading lights. 62 of the 74 buoys come under the jurisdiction of the Finnish Board of Navigation. The numbers and types of buoys used, and the costs of the buoys and buoy equipment as well as maintenance procedures are also discussed.

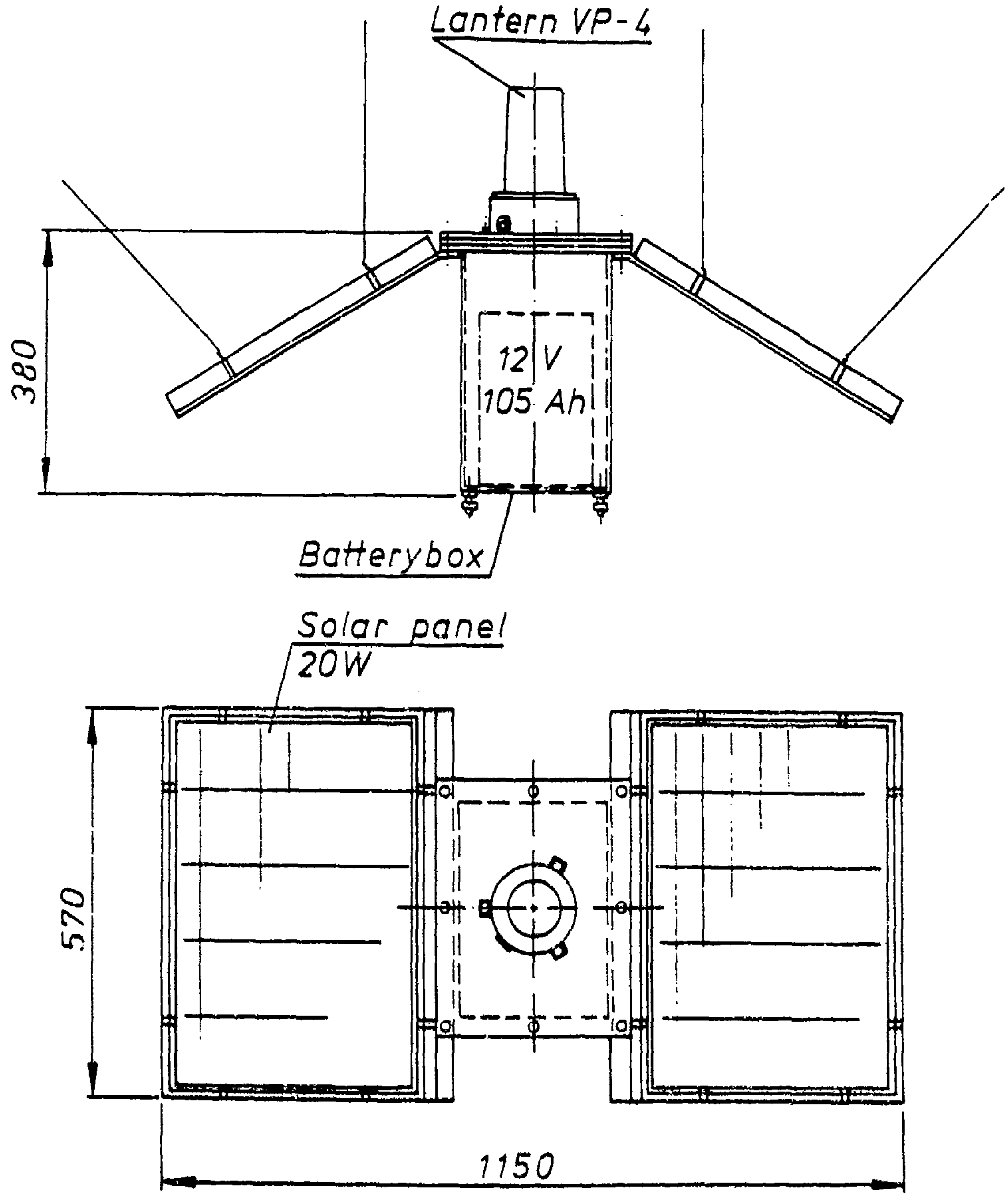


FIGURE 2-23
FINLAND'S SOLAR
PANEL STUDY

PRICES

PRISLISTA

(ALL PRICES CONVERTED TO 1989 DOLLAR EQUIVALENTS)

PLASTPRICKAR: PLASTIC SPARS

- priser 1.1.1988 fritt fabrik
- med reflexband och radarreflektor

D160	* 6000	lateral	1.420 mk	($ 346)
	* 7000	kardinal	1.665 "	($ 406)
D225	* 7000	lateral	2.535 "	($ 618)
	* 8000	kardinal	2.830 "	($ 690)
D500	* 10 000	lateral	16.215 "	($3,955)
		kardinal	16.155 "	($3,940)

PLASTBOJAR: PLASTIC PILLARS

1985 Unit Costs for a total cost of 5.1 Million F. Marks

- enhetspriser i en leverans på 5,1 milj.mk 1985

D1000	* 10 000	45.105 mk	($10,023)
D1600	* 11 000	126.850 "	($28,189)

STÅLBOJAR: STEEL BUOYS

Unit Costs within a total cost of 2.8 Million F. Marks

1989: - enhetspriser i en leverans på 2,8 milj.mk

Standard Ice Buoy

Normal isboj	33 st D1300 * 10 500	á 46.646 mk	($11,857)
Sträckförankr. boj	41 st D1000 * 10 000	á 29.350 mk	($ 7,460)

1987:

Normal isboj (D1300 * 10 500)	29.950 mk	($6,933)
Sträckförankr. boj (D1000 * 10 000)	22.200 "	($5,139)

TABLE 2-9
FINLAND'S BUOY
COST DATA

TILLBEHÖR EQUIPMENT (ALL PRICES CONVERTED TO 1989 DOLLAR EQUIVALENT)

Ljusapparat: Lanterns

Renco MPV-3 komplett med klipp och polykarbonat kupa (15.2.1989)	**6.900 mk**	($1,754)
Renco VP-3 komplett med klipp och stålskydd (15.2.1989)	**5.692 mk**	($1,447)

Batteri: Battery

60 Ah + 20°C, 30 Ah - 30°C, 10,7 - 8,0 V 147 • 147 • 470 mm^2 (1989)	**365 mk**	($ 93)

Bojkätting Chain

D32 mm 1988, priser CIF Hfors (1988), totalleveverans 704.000 mk

1 längd (27,5 m)	**4.396 mk**	($1,072)	**(159,90 mk/m)**	($ 39 per m.)
1 ankarschackel	**346 "**	($ 84)		
1 skarvschackel	**336 "**	($ 82)		

Kätting för prickar Chain for Spars

D16 • 96 • 22 (1988) Chain -	**34,60 mk/m**	($ 8.40 per m.)
ankarschackel för dito Shackle	**7,20 mk/st**	($ 1.75 ea.)

Förankringsrep för prickar flätat 20 mm polypropylenline	**3,20 mk/m**	($0.78 per m.)

Concrete Sinkers

Prickankare av betong (1988) 1,2 ton á	**500 mk**	($ 122)
Bojankare av betong (1988) 10 ton á	**4.800 mk**	($1,170)
Bojankare av betong (1988) 20 ton á	**10.400 mk**	($2,534)

TABLE 2-10
FINLAND'S BUOY
EQUIPMENT COST DATA

References for Additional Information:

Interview Summary	:	Appendix A, Section A.1.4
Buoy Records	:	Appendix B, 10 Entries, Pages B-571through B-610
Buoy Drawings	:	Appendix C, Pages C-103 through C-108

2.1.5 France

The "Service Technique Des Phares Et Balises" (STPB) is responsible for all aids to navigation on the mainland of France and in some overseas locations, except those for inland navigation on small rivers and canals which do not have many buoys. The STPB is composed of a headquarters office in Paris and six port Directors: Port Autonome de Dunkerque, Port Autonome deRouen, Port Autonome du Havre, Port Autonome de Nantes - St. Nazaire, Port Autonome de Bordeaux, and Port Autonome de Marseille. Overseas locations also include Antigua and St. Frias in the Indian Ocean with buoy departments there paid by France. Overseas locations also include Martinique, Guadaloupe, Canada, and Malaysia but in these locations others are in charge and funds for support of the ATON systems come from the local governments.

The STPB is responsible for about 8,000 aids to navigation, 1,000 lighted aids including lighthouses, and 2,000 buoys, 1,000 with lights. Except for a new plastic buoy, all STPB buoys are of older designs which have not been altered except for changes in signalling devices. Their large buoys are constructed of steel and are very robust. The buoy body is actually a steel pressure gas tank and inspected by Bureau Veritas as a pressure hull. They have some GRP foam filled buoys, a 2 meter diameter being the largest. Other plastic buoys have been used around France.

Their new GRP buoy is the Delphine shown in Figure 2-24. The same buoy can be configured with a shallow base or provided with a tail tube for greater stability to support higher topside weight and center of gravity and to tune motion characteristics.

The highest currents in France are found in the Straits of Dover area and some rivers. The straits have 4 knot current, but between an island in that location and the coast of France the current can reach 12 knots. In rivers with high current, stationary marks have been utilized. The STPB has built a special 10 knot buoy for Polynesia in the Pacific utilizing a boat hull, however no information was made available for this buoy.

The STPB does not have any specific pro iems to solve except adequate funding to replace tenders and purchase buoy . They will consider smaller buoys and tenders in an effort to reduce the r quired funding. They have tried a smaller buoy tending vessel in the Medi ranean. It must drag the buoys rather than lift them due to its smaller siz nd lesser capability. This was the first new vessel built in 40 years. The principal characteristics of this vessel and others are given in Table 2-11. Their newest buoy tender, 38 meter length overall, shown in Figure 2-25, has Voith Schneider cycloidal propeller propulsion. Each of the port districts under the STPB has a buoy tender and maintenance facilities. They inspect the

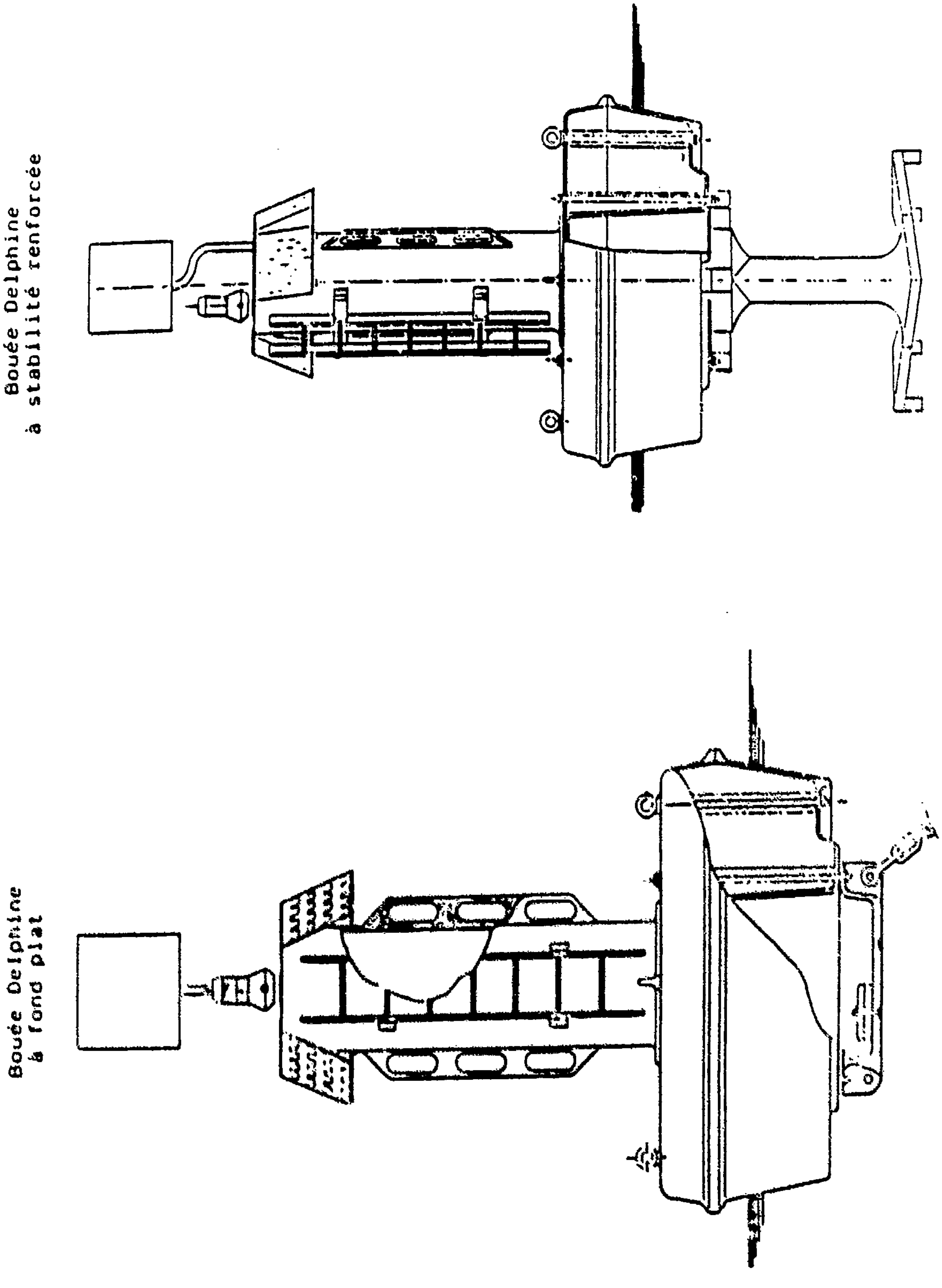


FIGURE 2-24
FRANCE'S DELPHINE
TYPE BUOY

André BLONDEL 1933 Acier	LE VERDON	L = 51,80 m l = 9,32 m C = 4,10 m D = 738 T
A. FRESNEL 1949 Acier	MARSEILLE	L = 54,00 m l = 9,75 m C = 3,96 m D = 790 T
Emile ALLARD 1949 Acier	DUNKERQUE	L = 54,00 m l = 9,30 m C = 4,10 m D = 730 T
Quinette de ROCHEMONT II 1949 Acier	LE HAVRE	L = 54,00 m l = 9,75 m C = 3,96 m D = 790 T
Georges de JOLY 1929 Acier	BREST	L = 55,00 m l = 9,50 m C = 4,15 m D = 750 T
Charles BABIN 1949 Acier	ST NAZAIRE	L = 54,00 m l = 9,30 m C = 4,10 m D = 730 T
Marius MOUTET 1947 Acier	PTE A PITRE	L = 47,50 m l = 8,50 m C = 3,50 m D = 525 T
Paul VEILLON 1951 Bois.	ST PIERRE ET MIQUELON	L = 23,25 m l = 5,30 m C = 2,50 m D = 110 T
ILES SANGUINAIRES 1958 Bois.	AJACCIO	L = 23,25 m l = 5,30 m C = 2,50 m D = 110 T
ROI GRADLON 1948 Acier.	LORIENT	L = 34,85 m l = 6,80 m C = 1,55 m D = 280 T
GALIBI 1965 Acier	NOUMEA	L = 27,60 m l = 6,50 m C = 3,00 m D = 150 T

TABLE 2-11
FRANCE'S BUOY TENDERS: PRINCIPAL DIMENSIONS

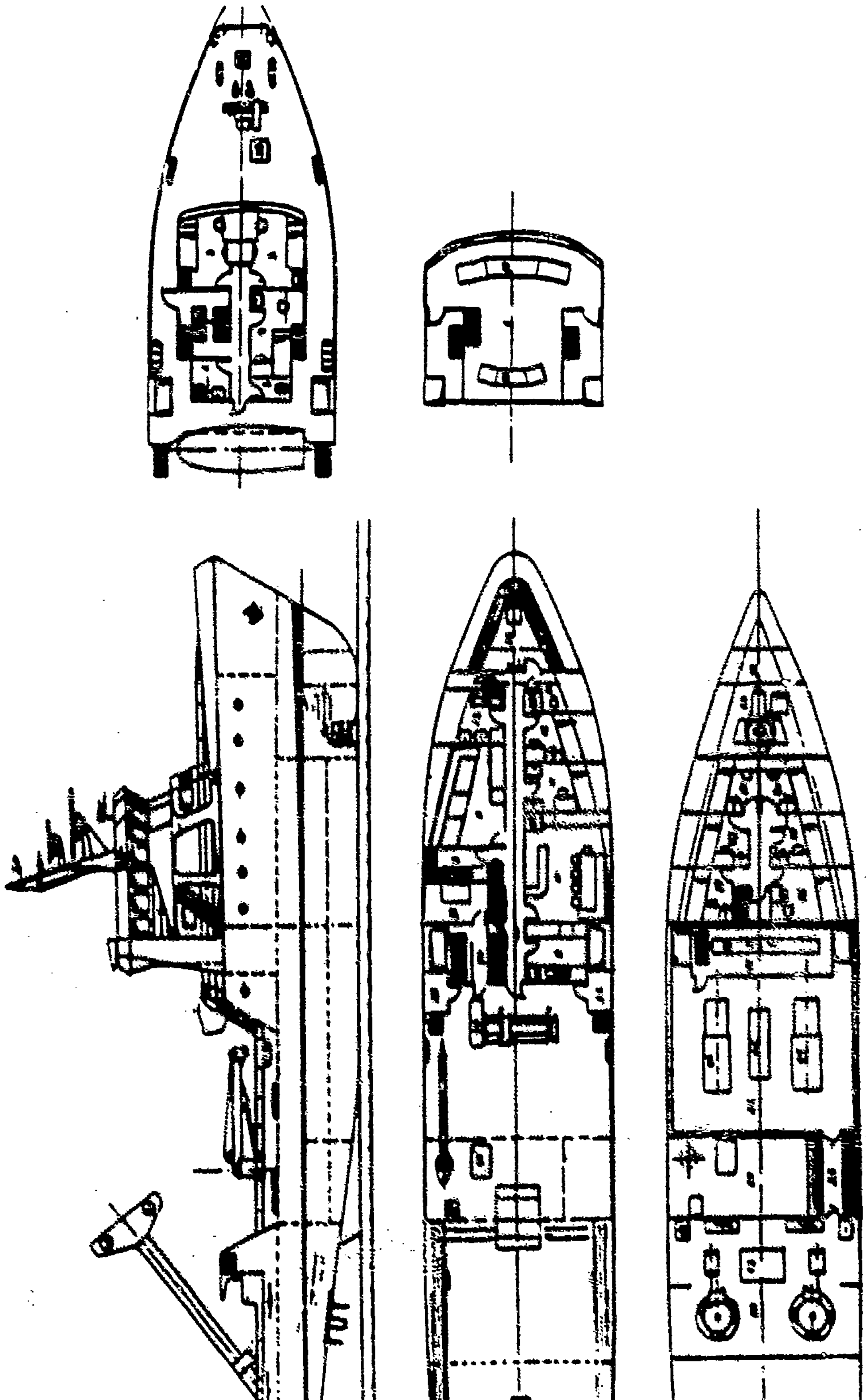


FIGURE 2-25
FRANCE'S NEW BUOY TENDER

mooring chains every 12 or 24 months and change the buoy out every 3 or 5 years.

Ten papers were presented to the IALA '90 Conference by authors from France. Two of these were directly related to ATON buoys, and extracts from these are presented below:

1. Paper No. 3.6.5, Reference 17, describes the technical evaluation and equipment used since 1983 for powering navaids, mainly floating types, with solar generators. The evolution and failure statistics of France's 800 solar-powered navaids are presented. A theoretical calculation of navaid solar power requirements are given as well as a survey of 10 buoys located in different latitudes.

2. Paper No. 2.4.9, Reference 18, describes the conversion of more than 90 gas operated buoys to solar photovoltaic operation, including costs. The modifications needed to the buoys are described (at the IALA '90 Conference photographs exhibited during the presentation showed batteries located in boxes within the superstructure cage).

References for Additional Information:

Interview Summary	:	Appendix A, Section A.1.5
Buoy Records	:	Appendix B, 15 Entries, Pages B-615 through B-675
Buoy Drawings	:	Appendix C, Pages C-109 through C-123

2.1.6 Germany

The ultimate responsibility for the waterways and aids to navigation in Germany belongs to the Ministry of Transport, "Bundesministerium fur Verkehr" (BMV). Within the ministry, Department "BW25" refers to "Ship Navigation Marks Directorate" and reporting to BW25 are 6 districts and a total of 32 land offices. Every district has a buoy yard which includes a repair facility and a buoy depot. With a few exceptions, the local offices do not have buoy handling and maintenance capability. They do, however, have complete procurement and some engineering capability. Figure 2-26 shows all coastal and inland waterways in West Germany.

Also under BW25 is the ATON research and development branch of the Federal Waterways Administration, the "Seezeichenversuchfeld" in Koblenz on the river Rhein.

2.1.6.1 Federal Ministry of Transport

The Federal Waterways Authority (FWA) within the Ministry of Transport is responsible for the construction, operation and maintenance of the entire buoyage system including open sea, coastal and inland waterways. The aids to navigation of all types which have been placed on FRG's coastline are shown in Figure 2-27. It can be seen that there are three unmanned lightships and many fixed aids in addition to floating buoys.

THIS

PAGE

IS

MISSING

IN

ORIGINAL

DOCUMENT

FIG 2-26

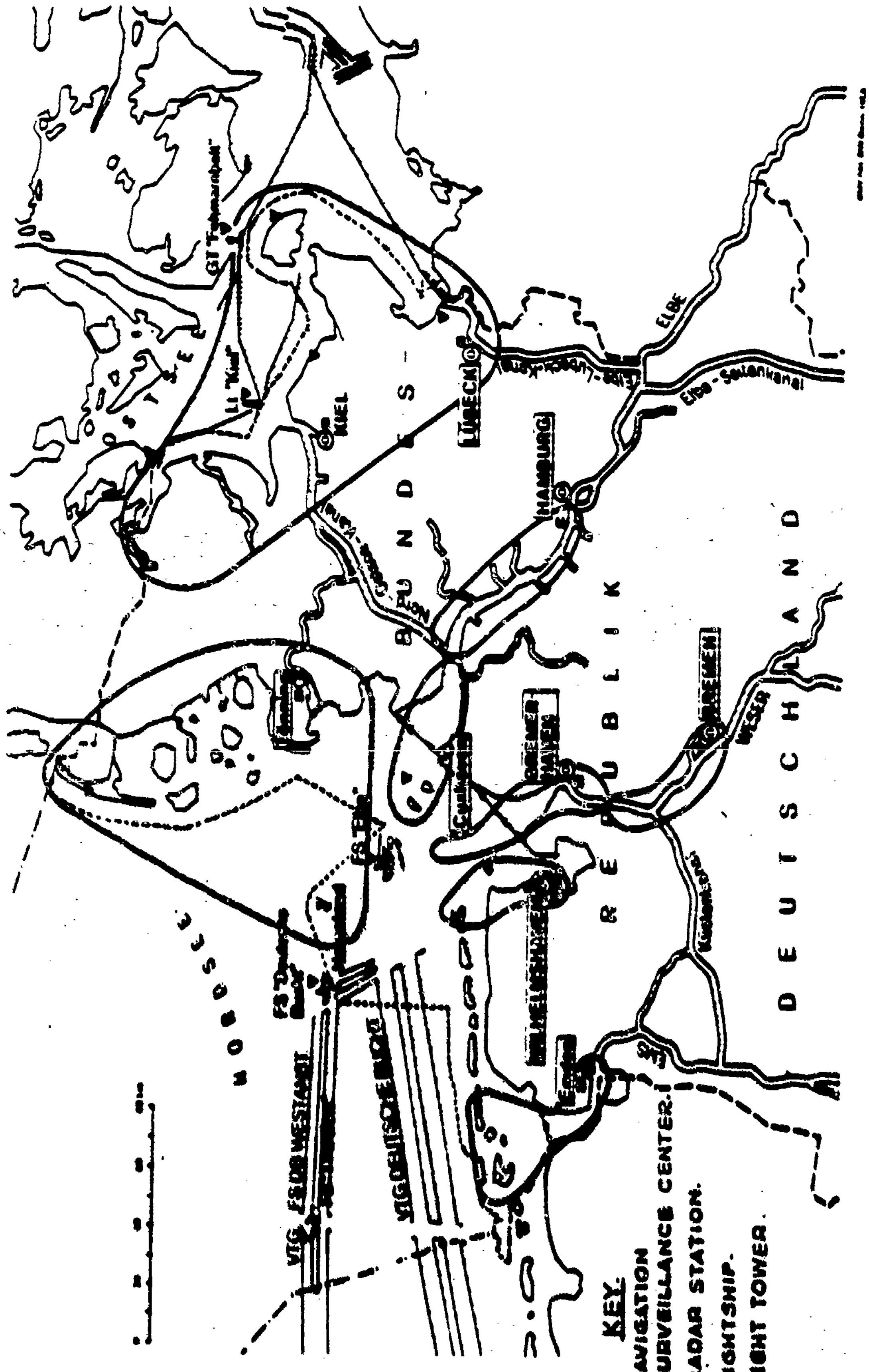


FIGURE 2-27
NAVIGATION AIDS ON
GERMANY'S COASTLINE

On the river Rhein and other inland waterways, only unlighted steel buoys are used.

The power supply used for nearly all lighted buoys is propane gas. Batteries or solar electric power are used on some small lighted buoys. The use of wave-activated generators was also considered but abandoned for economic reasons.

The buoys positioned in the North Sea are found to be subject to excessive abrasion and wear on their mooring chains, especially on the parts that are lying on the bottom.

In general, Germany prefers steel buoys over buoys made with other materials. Steel buoys can be, and are, easily maintained in good condition by also painting them every two or three years to keep their colors bright.

In the coastal areas, the local offices are well prepared to pick up the buoys before ice arrives so that no buoys are lost. The only losses that cannot be prevented are those of the lanterns on the buoys.

Germany had made an effort to standardize the buoys used in the systems some 50 years ago. This effort was interrupted by World War II but was restarted in the 1950's. The reason for the standardization is that there was a large variety of buoys in use and it was difficult to stock parts for all of them. The standard lighted buoy and the standard inland waterways buoy were developed for this purpose (see Section 2.1.6.2 for detailed information on these and other German buoys).

The designs of all buoys are developed by the R&D center (Seezeichenversuchsfeld). The procurement of coastal buoys is accomplished by the local offices within the districts. However, the sole procurement agency for river buoys and equipment is the R&D center. Construction contracts for buoys are placed with private contractors.

Germany has several buoy tenders ranging in size from 40 m. (approximately 130 ft.) to 70 m. (230 ft.) Since the coastal waterways in Germany are very short compared to other European countries, the tenders can get to the navigation aids at any location along the coastline quickly and easily.

<u>References for Additional Information</u>:

Interview Summary : Appendix A, Section A.1.6.1

2.1.6.2 <u>Seezeichenversuchsfeld (SZVF)</u>

Located in Koblenz, this facility is the R&D center of the German Waterways Authority. It contains a "Paint Quality Testing Facility", an electrical shop/test area and a chemical/mechanical test laboratory which conduct R&D work as well as testing of commercial buoy materials and equipment.

SZVF is responsible for the development and design of all floating and fixed aids to navigation in Germany. In general, the ATON buoys are categorized according to the environment that they are deployed in. In coastal waterways, one standard lighted buoy and two standard unlighted buoys, all of steel construction, are used. There are still some older buoys in use as well. The total number of coastal buoys is approximately 2,700 out of which only 700 are lighted buoys. Eleven of the lighted buoys also have sound equipment installed. Their distribution to various regions along the coast is shown in Table 2-12.

The current standard lighted buoy for use in coastal regions shown in Figure 2-28 is named "Leuchttonne 81." It was developed in 1981 by improving the older 1961 and 1972 lighted buoy designs.

For the inland waterways use, only one type of standard buoy is currently being constructed even though approximately 1,500 of the total of 3,500 inland buoys on the waterways are of the older designs. They are being replaced by the new standard inland buoy at the rate of about 300 per year including losses due to various reasons. The standard inland waterways buoy "Einheits - Binnenfahrwassertonne" is shown schematically in Figure 2-29. This SZVF design was arrived at (after experimenting with aluminum, PVC, and GRP buoys) as being the most economical and efficient buoy for inland use. It has a thin steel shell, is constructed in two pieces (top and bottom) and welded at the middle annular seam. It is filled with rigid polyurethane foam. A photograph showing both the unlighted and the lighted versions of this buoy as manufactured by the firm "Weiselerbojen" can be seen in Section 2.2.6.2, Photo No. 2-6.

Buoy repairs and maintenance is accomplished by the local offices in a very efficient manner. For repairing the inland buoys, welding of the thin shell plate is avoided except for closing very small holes and cracks since when the polyurethane foam inside starts burning, it releases toxic gases. For larger welds, the foam packing must first be removed from the vicinity of the area to be welded.

The service life for steel buoys is quite long - up to 30 years for the 1972 design lighted buoy built with 6 mm. thick steel which has already completed nearly 20 years and is still going strong. Had it been constructed with 12 mm. steel plate, it would probably have lasted 50 to 70 years. The inland buoys, however, have service lives of 7 to 10 years on the average.

SZVF was not able to provide costs for maintaining the buoys used in the system since it is understood that maintenance and repair work is mostly accomplished by the buoy yards in various regions without job orders. The cost of operating buoy tenders is reported to be approximately 1,300 DM (more than $800) per hour in 1990 rates.

The SZVF representative while attending the IALA 90 Conference provided the following additional information:

- No minimum freeboard is specified for the German buoys. However, as much freeboard as possible is assessed in all cases. While on station, the buoys' freeboard decreases with increasing current velocity. The standard inland waterways buoy, for

REGIONS / BUOY TYPES	LUBECK	TONNING	BRUNS-BUTTEL	KIEL-HOLTENAU	HAMBURG	CUXHAVEN	TOTAL FAIRWAY NORD	TOTAL FAIRWAY NORDWEST	GRAND TOTAL
Fairway Length, nm	76.1	328.1	26.7	26.5	62.7	76.5	586.6	362.3	
Lateral Marks	257	533	12	11	153	120	1086	742	1828
Lighted Buoys	45	65	12	11	51	72	256	259	515
Unlighted Buoys	212	488	–	–	102	48	830	483	1313
Open Sea, n.m	158	–	–	–	–	120	276		
Lateral Marks	26	–	–	–	–	15	40	21	61
Unlighted Buoys	26	–	–	–	–	15	40	20	60
Lighted Buoys	–	–	–	–	–	–	–	1	1
Cardinal Marks	35	33	–	–	26	23	117	204	321
Lights	3	10	–	–	–	10	23	15	38
Unlighted	32	23	–	–	26	13	94	189	283
Special Marks	49	12	3	8	10	35	117	100	217
Lighted	6	1	–	–	10	24	41	7	48
Unlighted	43	11	3	8	–	11	76	93	169
Other Buoys	249	20		–	6	6	281	–	281
Lighted	31	2	–	–	–	6	39	–	39
Unlighted	218	18	–	–	6	–	242	–	242
Total Operational	615	598	15	19	196	199	1641	1067	2708
Lighted	110	78	12	11	61	127	399	301	700
Unlighted	506	520	3	8	134	72	1242	766	2008
Sound Buoys	6	6	–	–	–	–	11	–	11
Spare Buoys	500	493	15	10	162	155	1336		
Lighted	61	63	16	10	28	51	229		
Unlighted	439	430			134	104	1107		

TABLE 2-12
GERMANY'S BUOY DISTRIBUTION BY REGIONS

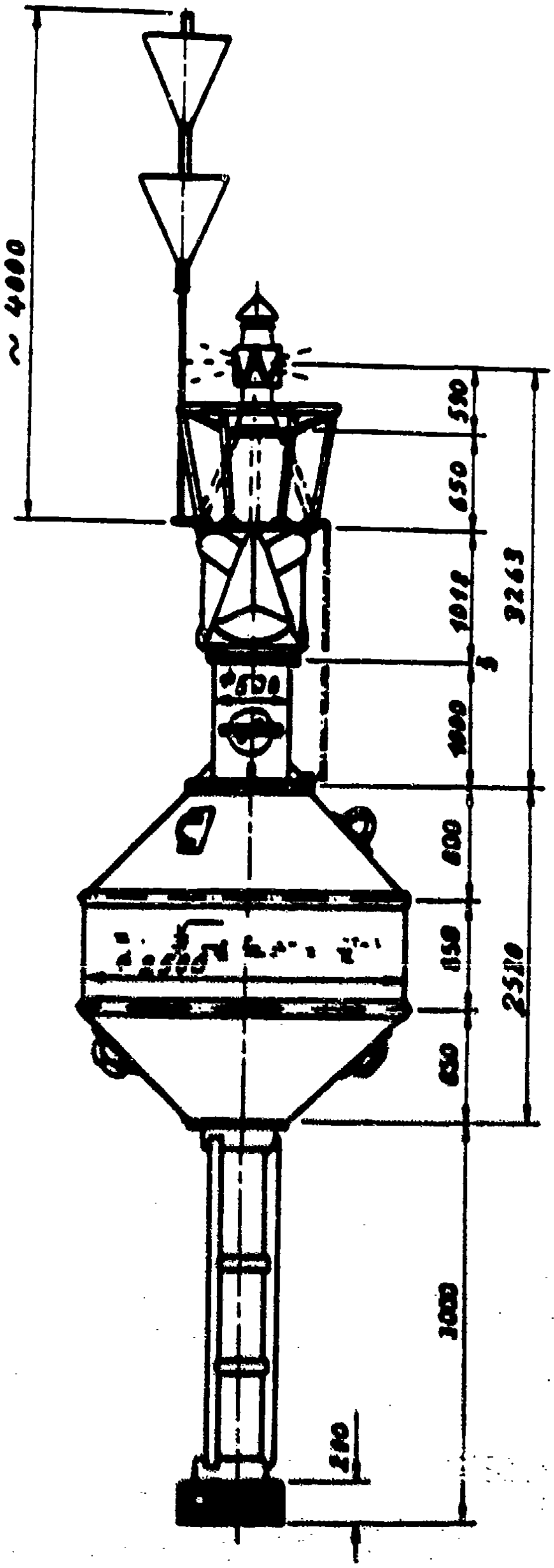


FIGURE 2-28
GERMANY'S 1981
DESIGN STANDARD
LIGHT BUOY

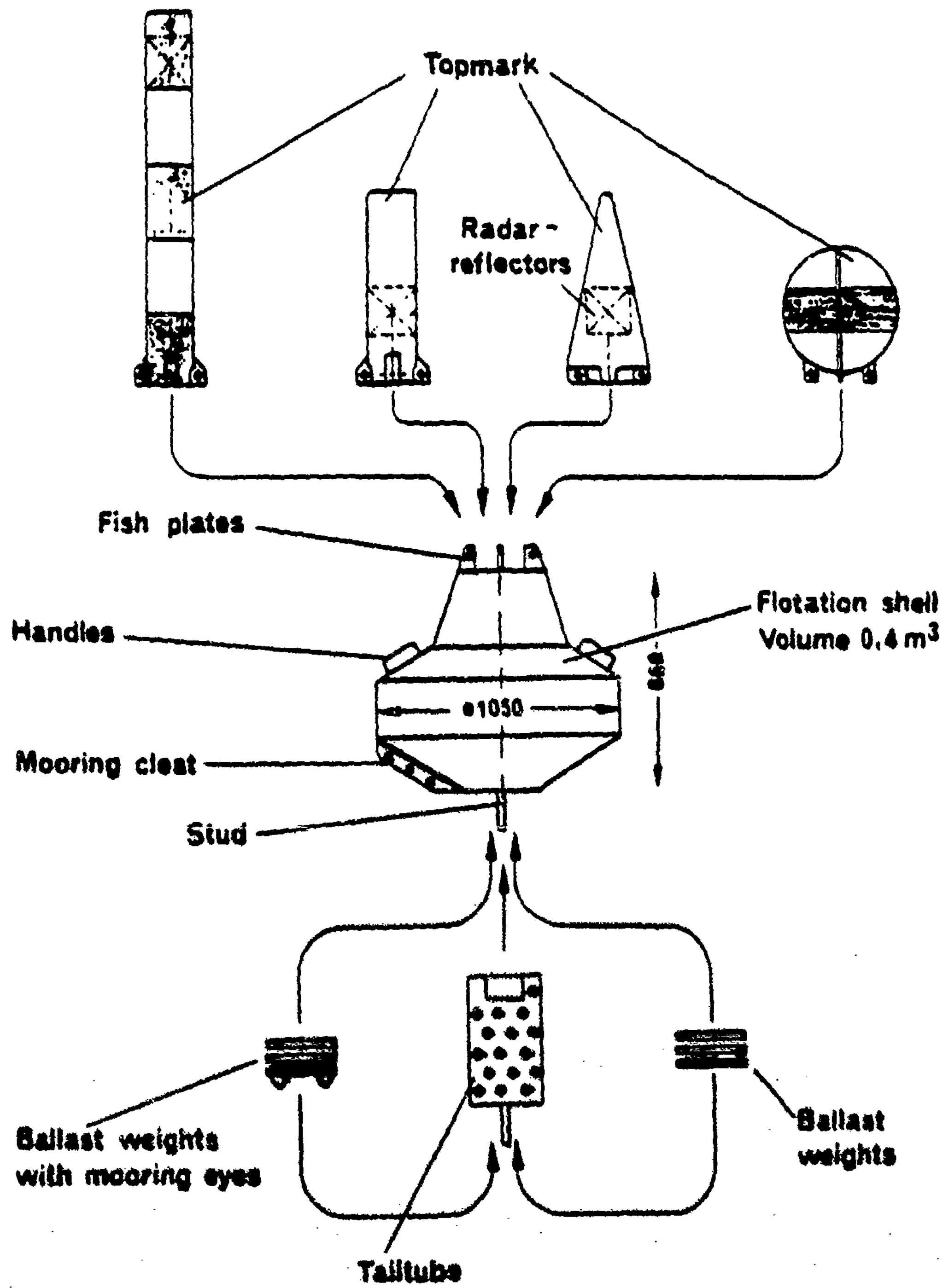


FIGURE 2-29
GERMANY'S STANDARD
INLAND WATERWAYS BUOY

example, cuts underwater when the current velocity exceeds 3.0 to 3.5 m/sec. (approximately 7 knots). Under these conditions, only the buoy superstructure sticks out of the water.

- The tidal currents in German maritime waters may go up to 5 knots at certain locations. However, at the locations where they are positioned, Germany's coastal buoys are not subjected to much more than 3 to 3.5 knots. In inland waterways, current velocities may reach 7 knots as mentioned above.

- Depth of water on the continental shelf of the North Sea does not exceed 40 m. (130 ft.). Depths of 6 to 20 m. (20 to 65 ft.) are more common in coastal areas and harbor approaches. The minimum mooring depth for 1981 design lighted buoy may be on the order of 5 to 6 m. (about 16 to 20 ft.).

- The detection range of the standard lighted buoy (Leuchtonne 81) is on the order of 3,300 m. (1.8 nautical mile) and that of the standard inland waterway buoy is 1,100 m. (0.6 nm). With regard to the identification and recognition of top marks of buoys, the ranges are 800 m. (0.43 nm) for coastal buoys and 700 m. (0.38nm) for inland waterways buoys.

- The following types of retro-reflective materials are used in German buoys:

  - Small Striped Material: 3M Scotchlite Signal Foil, Series 6870

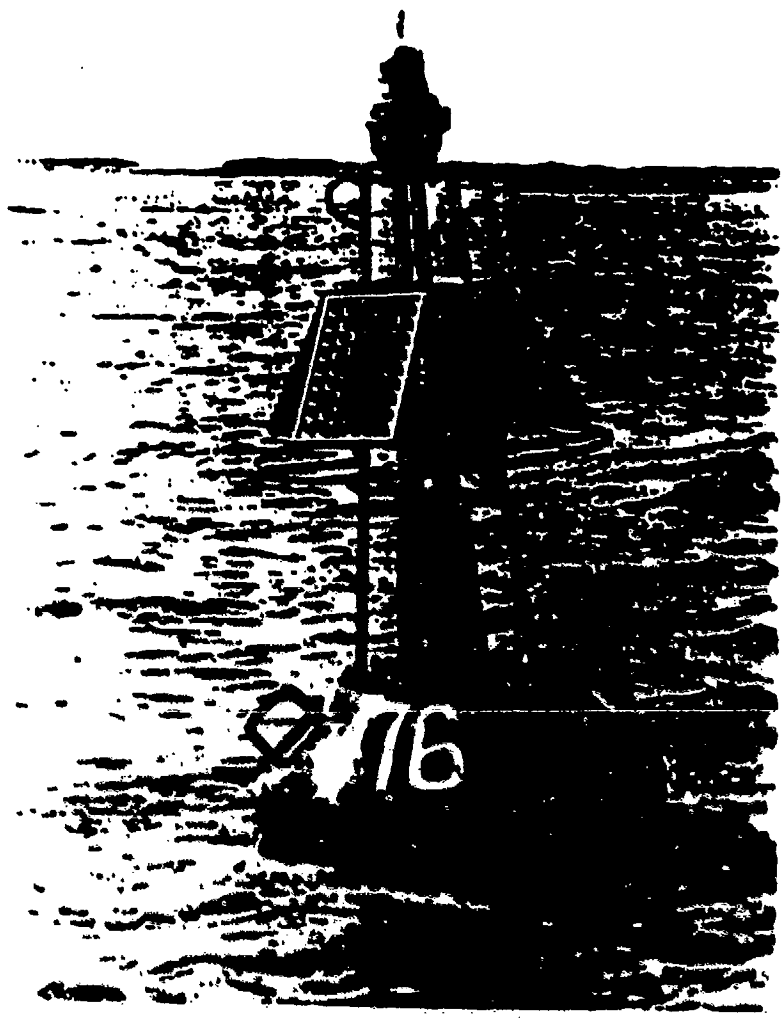
  - Rolled Material: 3M Scotchlite, Engineer Grade, Series 3270.

<u>References for Additional Information</u>:

Interview Summary	:	Appendix A, Section A.1.6.2
Buoy Records	:	Appendix B, 12 Entries, Pages B-683 through B-730
Buoy Drawings	:	Appendix C, Pages C-127 through C-139

Personnel from the West German Federal Waterways Authority have presented several papers during the IALA 1990 Conference. Three papers discussed specific subjects on ATON buoys:

1. <u>Paper No. 2.4.7</u>, Reference 18, discusses an investigation carried out by the FWA on the economics of marking the Ems River estuary between Emden and Leer with solar-powered lighted buoys. The results have shown that the implementation of the new marking systems would provide a minimum benefit-to-cost (B/C) ratio of 1.5 and perhaps even up to 3.0. Since a B/C ratio greater than 1.0 is considered enough justification for realizing the project, the decision was made and the project is now underway. Figure 2-30 shows the small solar buoy which is being contemplated for use in this project. Reportedly, this waterway was already marked with lighted buoys using propane gas as power supply pending development and procurement of solar powered buoys.



Small lighted buoy
with four 18 W solar panels
and electric lantern

FIGURE 2-30
GERMANY'S SMALL
SOLAR POWERED BUOY

2. Paper No. 3.2.2, Reference 19, describes the development of and the experience gained with floating aids to navigation in West Germany. For the most part, this paper deals with the development of a Lanby (Large Navigation Buoy) and unmanned lightships to replace the manned lightships. In its second part however, the paper also describes the development of a special light buoy for use in closing the gap between the standard light buoy (Leuchttonne 81) and the Lanby. The important feature of this buoy is that despite its large size, 3.50 m. (11.5 ft.) diameter and 16.22 m. (53 ft.) length, which makes it impossible for existing buoy tenders to handle, it can be both assembled and disassembled while afloat. This enables the buoy tenders to launch and retrieve parts of the buoy separately. A representation of the 3.50 m. version of the modular buoy is shown in Figure 2-31; the individual components are as shown in Figure 2-32; Photographs 2-2 show the disassembly and lifting of buoy components.

3. Paper No. 3.1.3, Reference 20, reports the results of quality testing of ATON buoy paints conducted at SZVF. It also describes the preparation, procedures and evaluation of photometric, colorimetric, and accelerated weather testing of commercially available paints.

2.1.7 Japan

The Maritime Safety Agency (MSA) is responsible for all navigation buoyage is Japan.

The MSA, headquartered in Tokyo is instituted as an extra-ministerial board of the Ministry of Transport. The whole country and coastal waters of Japan are divided into 11 regions and each of these has one Regional Maritime Safety Headquarters with authority to carry out certain MSA functions.

2.1.7.1 MSA Tokyo Headquarters

MSA Headquarters are responsible for every facet of the ATON. Japan adopted the International Association of Lighthouse Authorities (IALA) B region system and recommendations in 1983. Since then it has been carrying out a 7-year program necessary to change the shape, surface color, character of light, etc., of about 2,000 visual aids, mainly navigation buoys. In December of 1989 Japan completed the change to IALA B.

Most Japanese buoys are large steel buoys which originally evolved from U.S. Coast Guard designs. These earlier designs were modified for incorporation of wave-activated generators more than anything else. The latest buoy designs are about 15 years old. Figure 2-33 shows the current line of Japanese steel buoys. There are a few unlighted foam-filled GRP buoys of their own design. The Japanese have limited the use of plastic buoys because they have found them vulnerable to physical damage and not easily repairable as compared to steel.

At this time, the MSA must reduce cost of navigation buoys because of shrinking government budgets. Paper No. 2.4.2 presented at the IALA '90 Conference and summarized below describes this matter in detail. Future buoy designs must be simplified to cut costs.

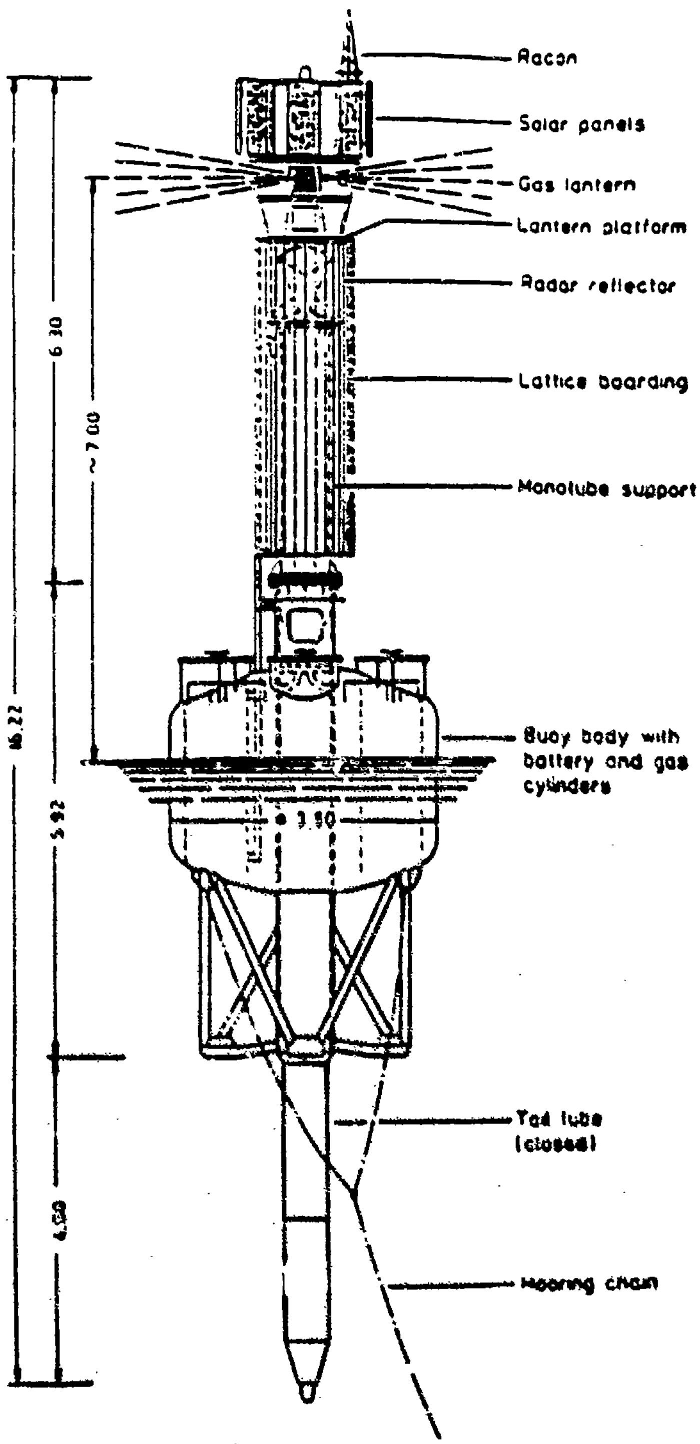


FIGURE 2-31
GERMANY'S 3.5m
MODULAR BUOY

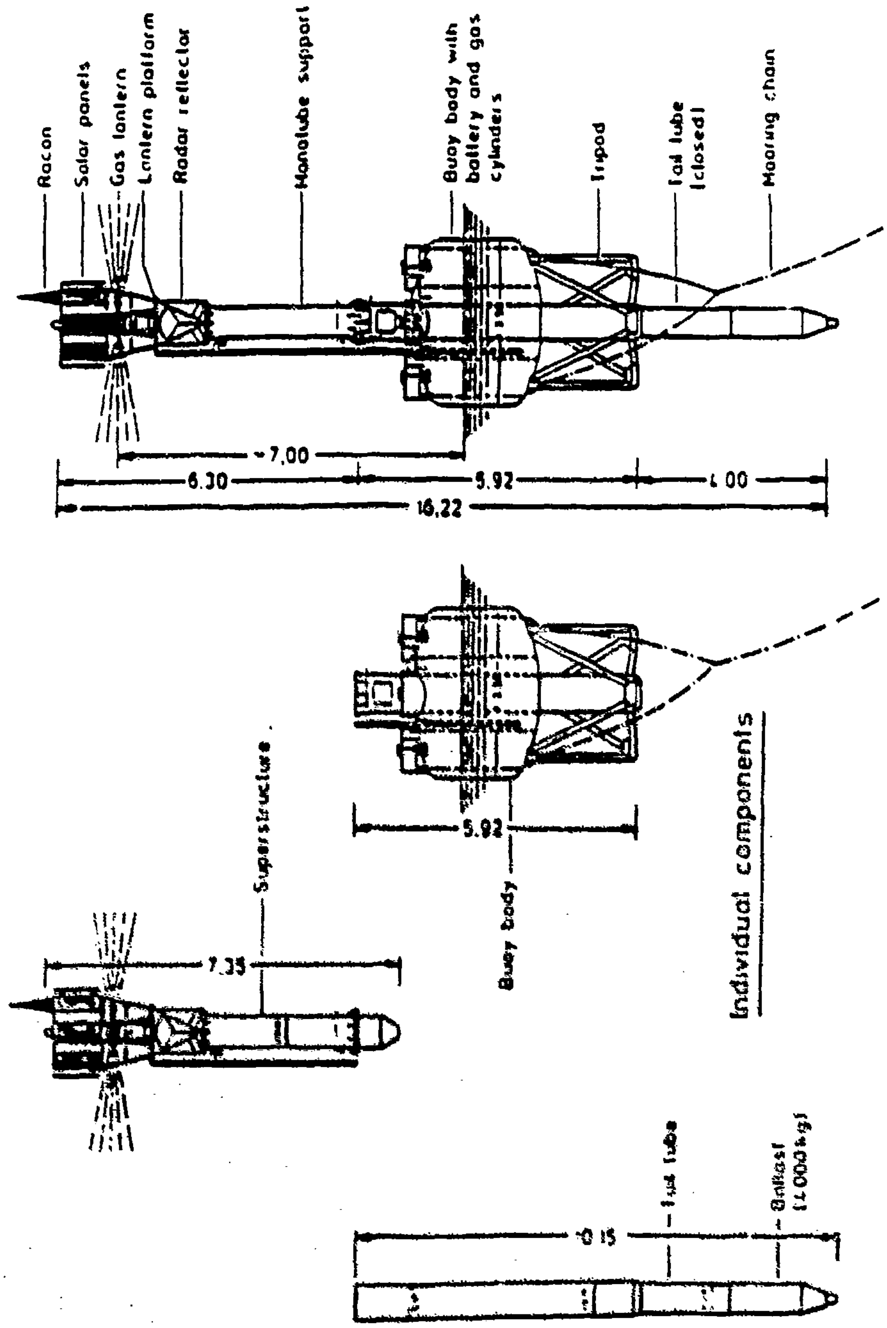
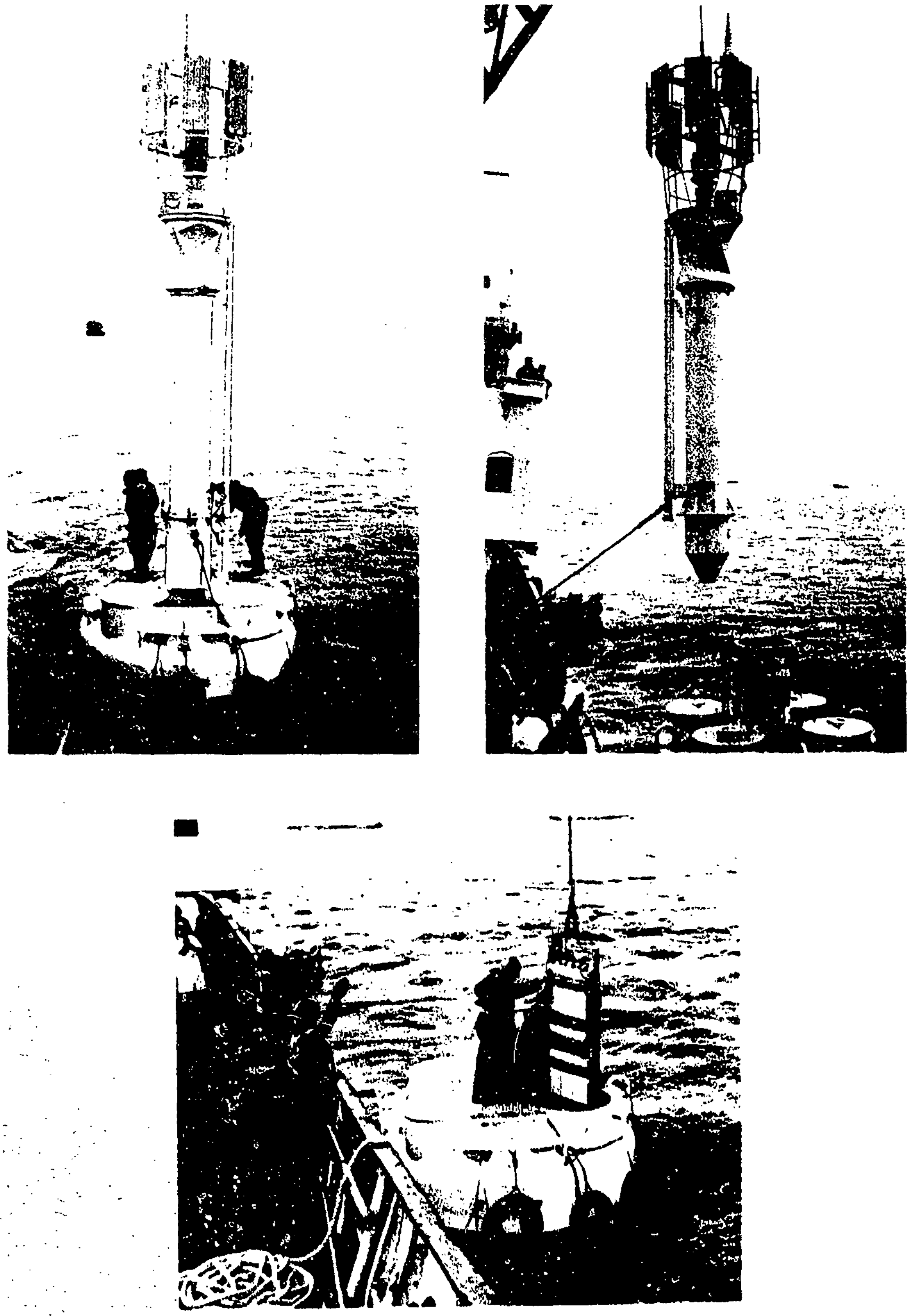


FIGURE 2-32
COMPONENTS OF
MODULAR BUOY



PHOTOGRAPH 2-2
GERMAN MODULAR BUOY - DISASSEMBLY
LIFTING WHILE AFFLOAT

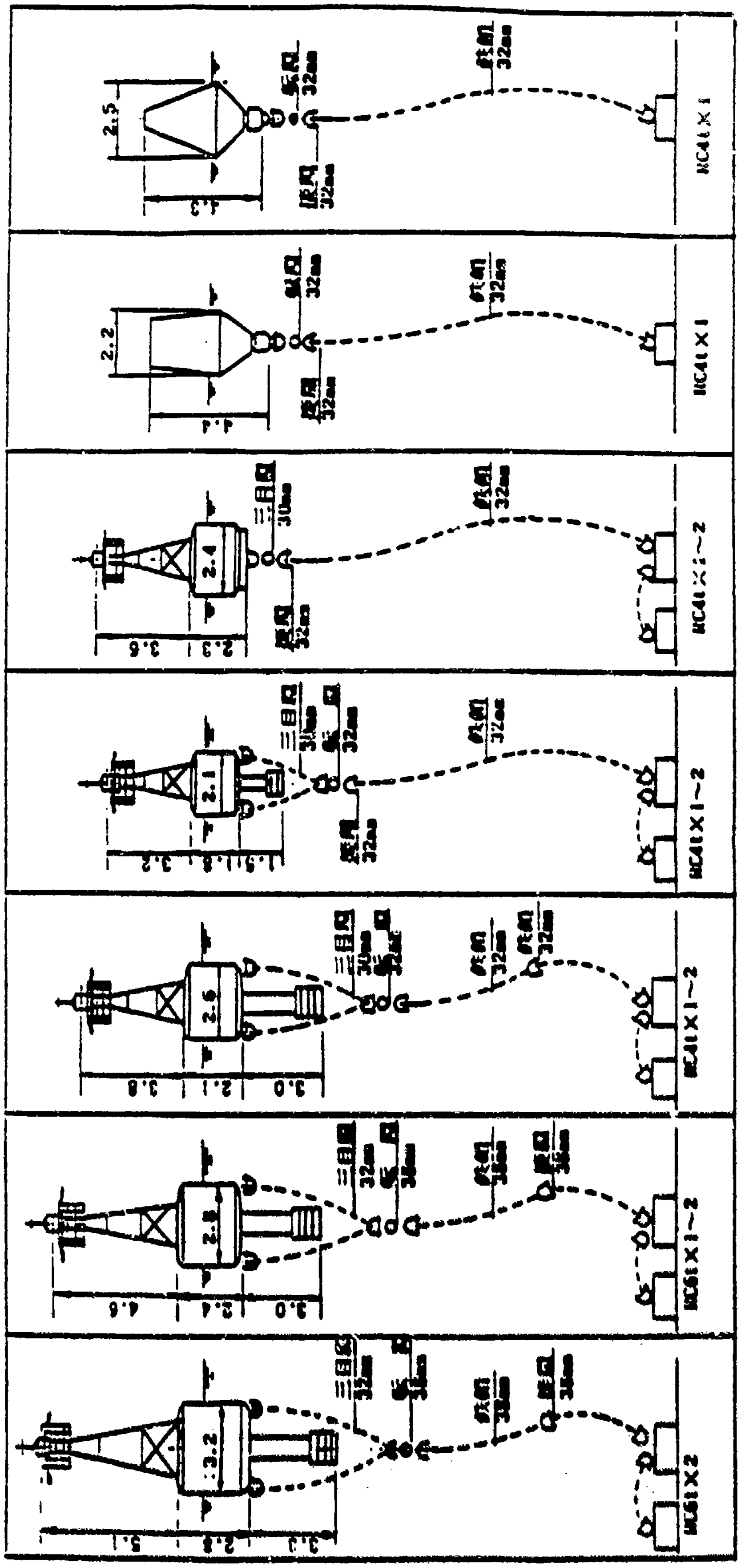


FIGURE 2-33
JAPAN'S LINE
OF ATON BUOYS

The MSA utilizes L-5 and L-6 buoys shown in Figure 2-33 for deployment in currents of 5 to 7 knot range which occur in the Inland Sea and Hurushimi Straits. They have no mechanical sound buoys, only 6 buoys with electric horns, and intend to eliminate buoy sound signals in accordance with IALA recommendations. Japan has begun solarizing their buoys placing the solar panels more or less horizontally at the very top of the buoy. They have favored wave-activated generators but feel the solar panels will be useful in bolstering the generated power even in these applications. In areas of strong current, iron sinkers are used as they are smaller than concrete and less affected by strong currents.

The MSA is utilizing three floating beacons of their own design in areas where wave action is too heavy for regular buoys with an average wave height of 9 meters. These beacons are much more expensive than buoys, and were built by the Zeni Lite Buoy Company (also see Section 2.2.8.3).

The Japanese have experienced significant damage to their buoys as a result of collisions with ships. As a result they have developed the paint marking and radio transmission system shown in Figure 2-34. This system sprays paint on a colliding ship and sends out a radio signal to the vessel traffic center advising of the mishap. A patrol boat is dispatched to intercept the colliding ship. This has resulted in the identification of the colliding ship increasing from zero instances to 30% of all collisions.)Also see comments from the Japanese manufacturer NKK regarding this subject in Section 2.2.8.1.).

Japan has two buoy tender designs as shown in Figure 2-35: three mono-hulls and one catamaran. These vessels are utilized for the maintenance of 80% of all buoys in Japan. The MSA brings buoys in for maintenance every two years. They visit a buoy every month, but are considering increasing this interval. They are currently considering contracting out all buoy tender services to commercial companies.

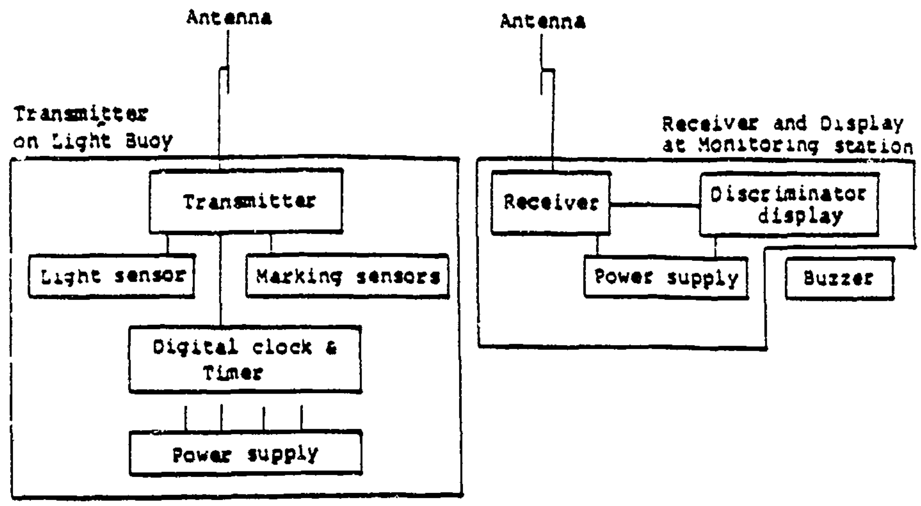
The MSA has prepared a manual on all aspects of navigation buoys and have provided a copy. They also utilize this as a textbook in instructing third world countries in Southeast Asia coming to Japan to learn about navigation buoys.

<u>References for Additional Information</u>:

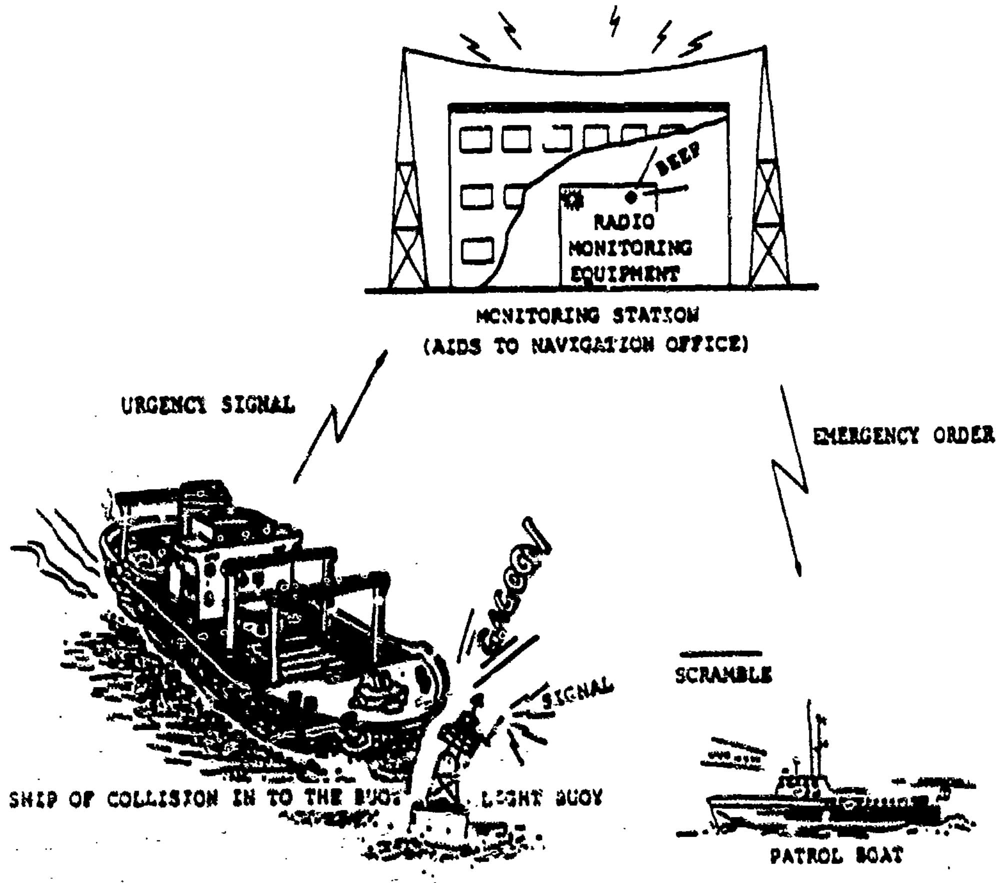
Interview Summary	:	Appendix A, Section A.1.7.1
Buoy Records	:	Appendix B, 15 Entries, Pages B-800 through B-855
Buoy Drawings	:	Appendix C, Pages C-160 through C-172

Six papers were presented to the IALA '90 conference by authors from Japan. Two of these were directly or indirectly related to ATON buoys and extracts from these are presented below:

1. <u>Paper No. 2.4.2</u>, Reference 22, "Present Situation and Difficulties in Administration of Aids to Navigation Services" by M. Suzuki of the Maritime Safety Agency, presents the current situation at the MSA which is confronted with management problems, environment requirements, efficiency



Block Diagram of Light Buoy Monitor



System for Light Monitoring and Collision Informing

FIGURE 2-34
JAPAN'S PAINT
MARKING AND RADIO
TRANSMISSION SYSTEM

Performance of buoy tenders

item \ name of ship	Kaiou	Hokuto	Ginga	Myojyo
gross tonnage (t)	619.0	600.0	617.0	260.0
total length (m)	55.0	55.0	55.0	27.0
breadth (m)	10.6	10.6	10.6	12.0
draft (m)	4.8	4.8	4.8	3.9
speed (kt)	13.0	12.0	14.2	10.5
hoisting power (t)	15.0	15.0	15.0	15.0

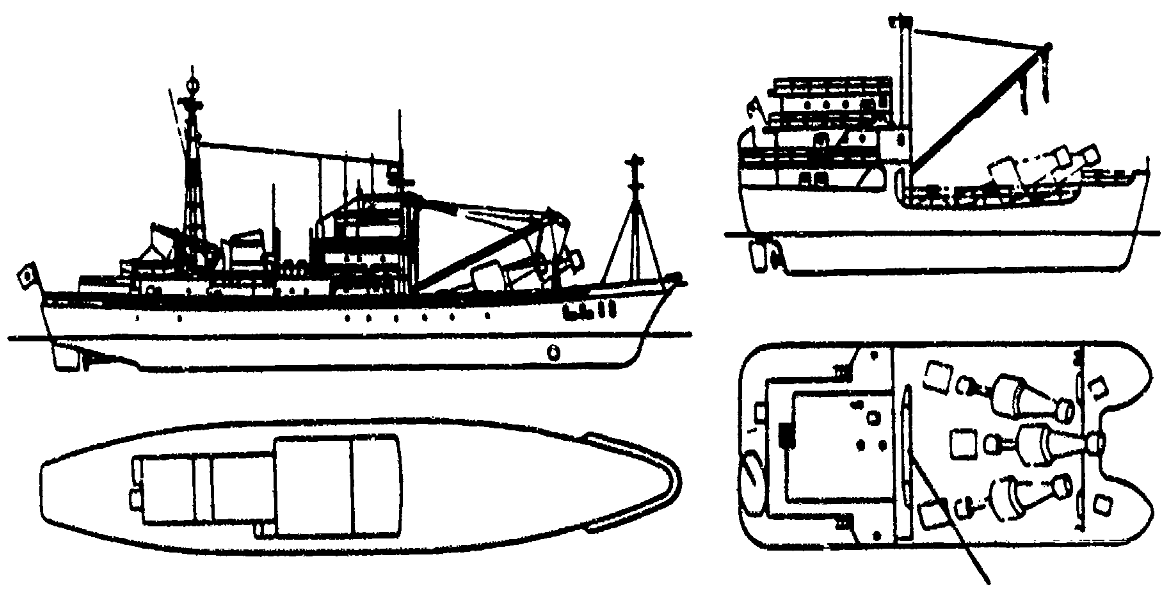


FIGURE 2-35
JAPAN'S BUOY
TENDER DESIGNS

objectives, financial cutbacks, etc. which is impacting their services. Among the countermeasures they have taken are: reorganization of the MSA, review of service visit intervals, improvement of quality and reliability of equipment, development of maintenance-free equipment and development of a small, light and movable fixed light. The paper contains a complete description of the organization including manpower levels and monetary budget.

2. Paper No. 3.1.5, Reference 23, by various individuals from the MSA and Japanese ATON industry describes the development of a LED (light emitting diode) light for short range ATON. The outstanding characteristics of the LED are the very long lifetime (more than 100,000 hours) and the excellent switching response. The LED has weak luminous intensity, one-directional emittance and widely varying characteristics among elements however, thanks to the recent availability of highly intensified light and the rapid development of quality management technology, interest has been rekindled.

2.1.7.2 MSA Chiba Buoy Base

The Chiba Buoy Base (CBB) is responsible for 195 buoys. Half of these buoys are brought back to the CBB each year. The largest buoy base in Hiroshima is responsible for 300 buoys.

Inspection, sandblasting, and painting of buoys are all done at the buoy bases. Concrete sinkers are manufactured at the base. Minor welding repair is accomplished but serious damage repair is subcontracted to an ironwork factory.

The most difficult problem is marine growth. One-half of the buoys handled by the CBB are the wave-generator type and marine growth seriously impedes operations after 2 years on station. They are experimenting with new paints.

L-4 and L-7 are the only buoys which have compartmentation. The L-7 uses an outside toroid (4 compartments) for ballasting with water.

L-4 buoys are filled with foam in outside compartments.

References for Additional Information:

Interview Summary : Appendix A, Section A.1.7.2

2.1.8 The Netherlands

The Ministry of Transport and Public Works, Directorate - General Shipping and Maritime Affairs (DGSM) is responsible for the safety of waterborne traffic throughout the Netherlands. This includes the North Sea and all inland waters.

The DGSM has two principal buoys of their own design, the 12 1/2 m^3 and 6 1/2 m^3 steel buoy shown in Figures 2-8 and 2-36 respectively, which have been improved over the years and are used for all sea, estuary, river and wide

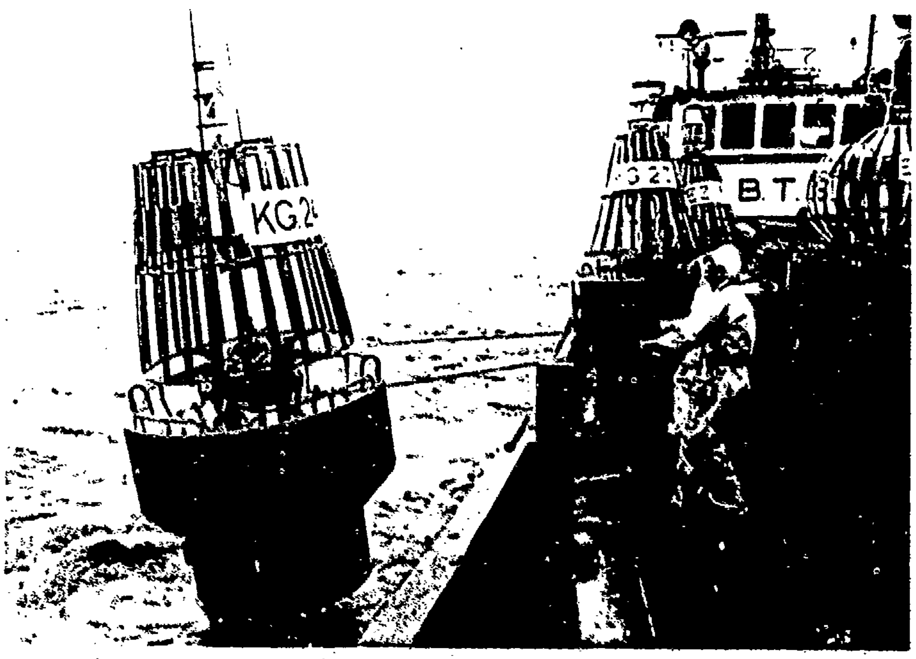


FIGURE 2-36
NETHERLAND'S 6.5 M^3
STEEL BUOY

inland waterway locations. These buoys have interchangeable day and topmarks. There are approximately 800 light buoys of the 12 $1/2m^3$ and 6 $1/2m^3$ variety, 300 in the open sea and the remainder in estuaries. There are approximately 2,500 unlighted buoys located in less important waterways, occasionally supplemented with small light buoys. Floating pillar beacons are used in shallow waters.

Figure 2-37 shows mooring configurations for the Netherland buoys.

They believe that steel buoys had proven their reliability and should be continued for open sea and dense traffic locations. Some of their steel buoys have lasted 50 years. Synthetic material buoys can be used for other applications. They have utilized some smaller plastic buoys for inland waters and are now doing some tests of a polyethylene foam filled buoy of their own design.

Shape significance on their buoys is achieved with an open slat type structure of wood or plastic like Trinity House in England uses. Their buoys have a central battery pocket. They are solarizing their buoys and have plans to change 50 buoys per year, with 100 buoy completions to date. DGSM buoys have no horns or whistles. They have had an ice buoy designed for them by "All Marine" (see Section 2.2.9.2) which has been in place for two years but there has been no ice during this period.

The most significant problems the DGSM has with floating aids are not specifically related to the buoys themselves but instead are:

- Mari-culture growth on the buoy hulls in certain shallow water areas where anti-fouling paint is prohibited.

- Removing and destroying almost 5,000 long-life dry batteries yearly. It is expected that due to increasing environmental considerations the cost of this will become increasingly unacceptable in the future.

Damage to buoys by collisions has been a problem for the DGSM in terms of cost. They can identify who has damaged a buoy since most ships have pilots who would report the occurrence and additionally, there is the water police. An insurance company then pays the cost of damage which usually ranges from 10,000 to 50,000 Guilders ($1,700. - $8,400. U.S.).

The DGSM has a number of vessels utilized for tending aids to navigation as shown in Table 2-13. Their two newest buoy tenders are the 44.12 meter long "ROTTERDAM" Class and the 38.17 meter "NIEUWE DIEP" class. The DGSM prepared the design specifications of both vessels which have bow and stern thrusters and a dynamic positioning system.

The Netherlands believes that efforts for the improvement of safety of navigation in the North Sea must consider the total system of ATON including short range aids, radio navigation systems, RACONS, etc. rather than concentrating on improving individual components. This is elaborated upon in the IALA '90 Conference paper No. 1.4.3 discussed below. They now have a definite proposed plan to change navigation aids in the North Sea which would require ratification by the North Sea countries. They believe a reduction in

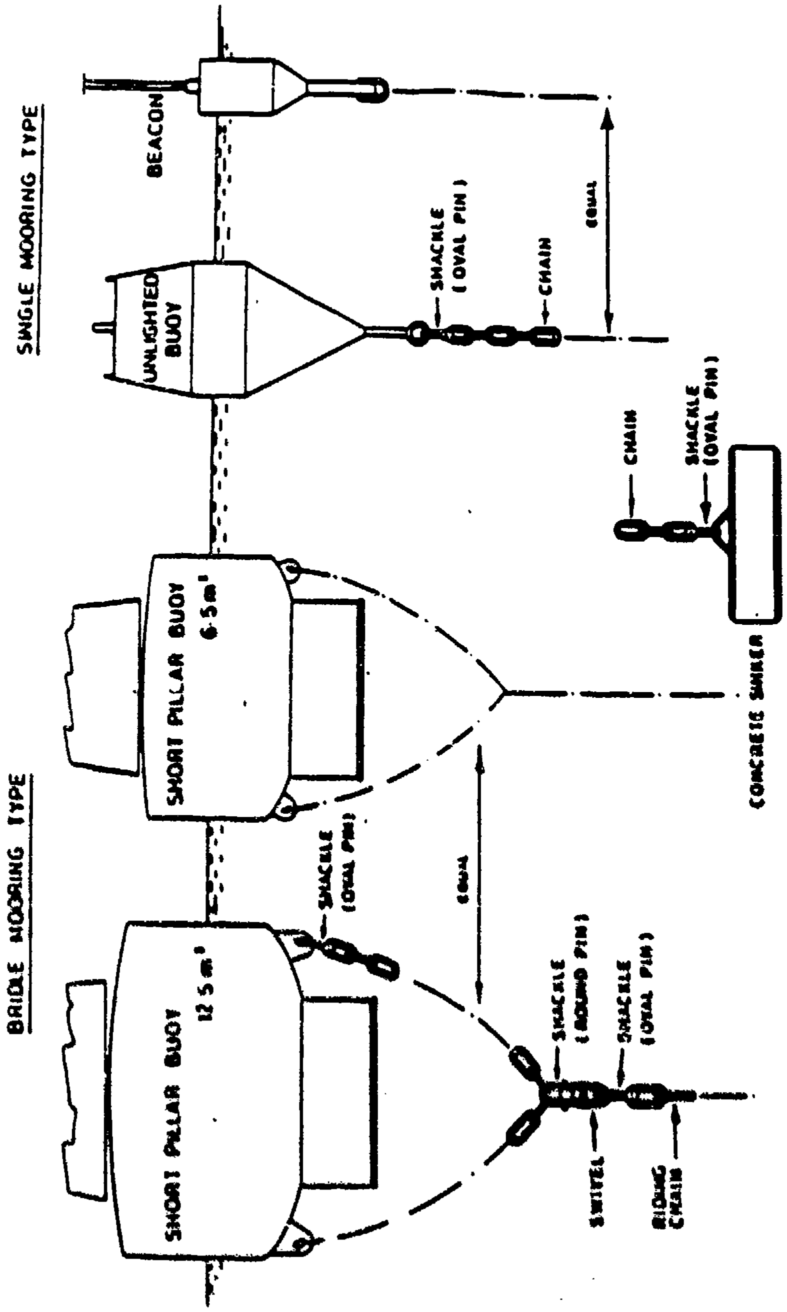


FIGURE 2-37
MOORING CONFIGURATIONS
FOR THE NETHERLAND'S
BUOYS

TABLE 2-13
CHARACTERISTICS OF THE NETHERLAND'S BUOY TENDERS

name	year of build	length overall (m)	breadth (m)	depth (m)	tonnage (depl.)	working load (tons)	crew	buoys carried
Breeveertien	1972	61.25	11.30	4.70	1010	15	11	8 (a 12,5 m3)
Zeus	1961	28.80	5.86	2.68	146	5	7	3 (a 6,5 m3)
Nieuwe Diep	1990	38.17	8.70	2.75	420	7.5	6	6 (a 6,5 m3)
Terschelling	1988	44.22	10.25	4.00	680	10	9	6 (a 12,5 m3)
Vliestroom	1988	38.17	8.70	2.75	420	7.5	6	6 (a 6,5 m3)
Waddenzee	1959	28.80	5.96	2.64	129	5	7	3 (a 6,5 m3)
Grevelingen	1958	30.63	6.43	2.50	182	7,5	7	4 (a 6,5 m3)
Krammer	1958	30.63	6.43	2.50	182	7,5	7	4 (a 6,5 m3)
Rotterdam	1987	44.12	10.50	4.00	680	10	9	6 (a 12,5 m3)
Frans Naerebout	1989	44.22	10.25	4.00	680	10	9	6 (a 12,5 m3)
Vlissingen	1989	40.50	7.96	3.75	410	10	11	3 (a 12,5 m3)

* heli landing pads : none
* bow thrusters : Breeveertien, Rotterdam, Terschelling, Frans Naerebout, Vliestroom, Nieuwe Diep, Vlissingen
* DPS : Rotterdam, Terschelling, Frans Naerebout

sea buoys by one-third can be achieved, including those set for oil company platforms and for marking subsea standpipes.

References for Additional Information:

Interview Summary	:	Appendix A, Section A.1.8
Buoy Records	:	Appendix B, 2 Entries, Pages B-1030 through B-1035
Buoy Drawings	:	Appendix C, Pages C-198 through C-200

Ten papers were presented at the IALA '90 Conference by authors from the Netherlands. Four of these were directly related to ATON buoys and extracts of these are presented below:

1. Paper No. 1.1.2, Reference 24, discusses the development of an assessment and design method for ATON systems. This method is meant to provide lighthouse authorities with a tool to assess their present ATON systems and if required to design a new system. The method is based on an assessment involving different ATON functions such as redundancy, position accuracy, hazard warning and confirmation. This has been applied by the DGSM in the assessment of ATON in the North Sea, Paper No. 1.4.3 below. This is a computer based system.

2. Paper No. 1.4.3, Reference 25, discusses the improvement of navigation on the North Sea by considering the coherence of the total system rather than by improvement of the several individual components. Using this approach of considering the whole system in the North Sea, it is possible to reduce the total number of markings by a large extent. Cost benefit and cost effectiveness studies play a large part in this procedure and indicate a relatively large financial saving could be achieved in the North Sea.

3. Paper No. 2.4.3, Reference 26, describes the method used for a study of a national buoyage service, the study results and the implementation and functioning of the new organization. Attention is given to the new buoy tenders of the Service and the automation of the operational and logistic data. Figure 2-38 shows the new organization with the dashed lines representing functional relationships and the solid lines the hierarchical relationships.

4. Paper No. 3.6.4, Reference 27, describes the development of autonomous photovoltaic systems for use with ATON, particularly in the Netherlands. It goes on to describe the use of such systems in developing countries. In particular the paper deals with the rehabilitation of aids to navigation in Guinea Bisseau, improvements to aids in Hartelkanaal in the Rotterdam region, modernization of ATON in Honduras and the development of a deep water buoy as a light vessel replacement, powered by solar energy.

2.1.9 Norway

The Norwegian Coast Directorate (NCD - Kystdirektoratet) is the authority responsible for all coastal service in Norway. The fields of responsibility are distributed to three separate divisions:

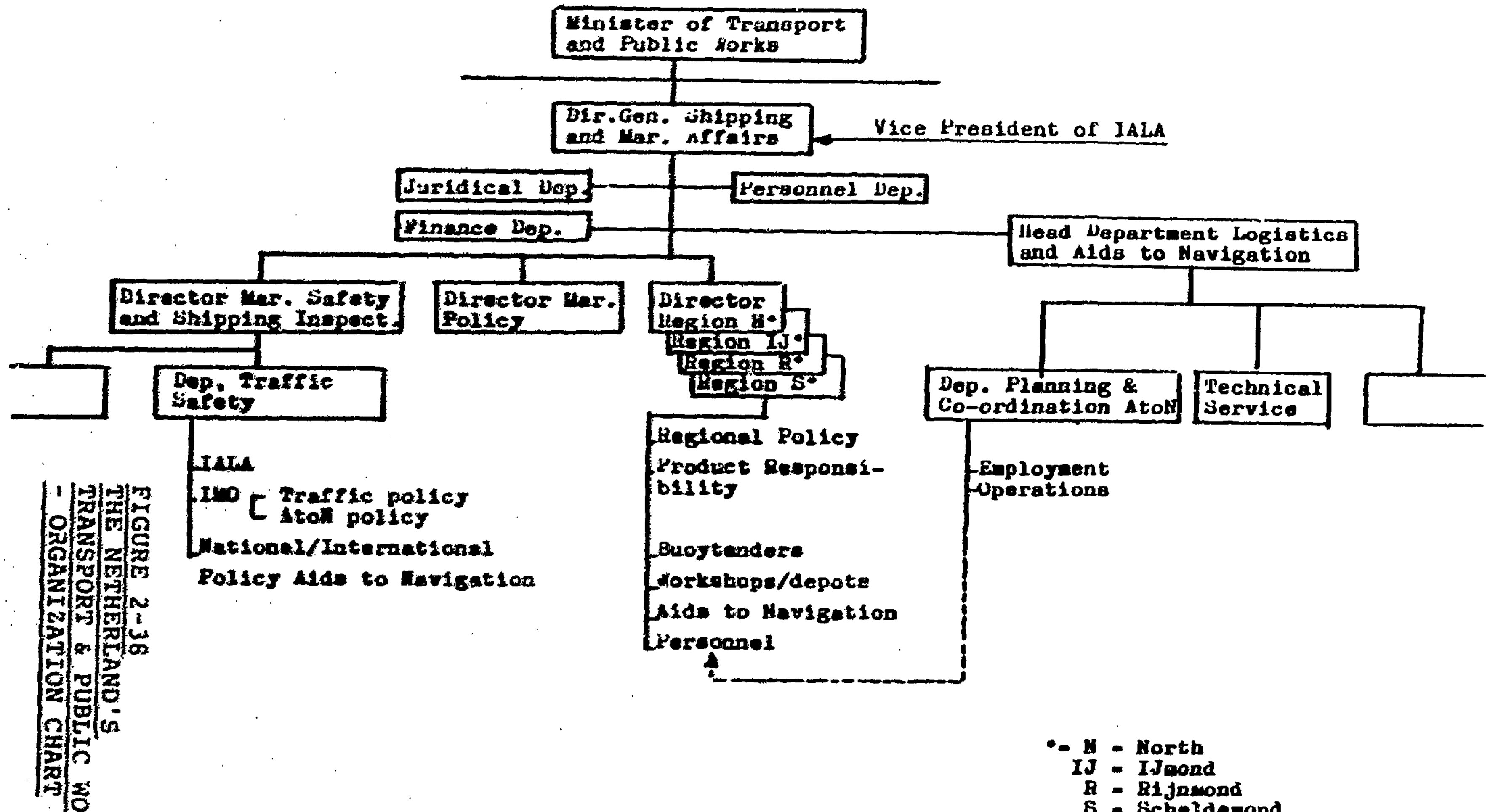


FIGURE 2-36
THE NETHERLAND'S
TRANSPORT & PUBLIC WORKS
- ORGANIZATION CHART

- Aids to Navigation Division
- Waterway Administration
- Pilot Service

The ATON division is responsible for the development, establishment and maintenance of all aids to navigation.

The navigation aids used along the Norwegian coast are tailored to the needs of the specific geographic and climatic conditions prevailing at the locations. A mixture of floating and fixed aids, large and small lights, and electronic aids are used in marking the fairways. Figure 2-39 is a chart which shows a typical sector lighting situation along the Norwegian coast. The use of sector lights has been highly developed and proven to be, for the Norwegians, an economical and effective lighting system for their waterways.

In addition to the sector lights, the NCD uses fixed lighted and unlighted aids and floating aids. Norway's waters are mostly shoal and the depth of water in a majority of waterways is less than 10 m. (30 ft.) This makes it suitable for using fixed lights instead of floating aids and this is the direction Norway has headed. (See discussion under IALA Paper No. 2.4.6 below). They have been using fixed lights since the 1890's and they currently have about 15,000 fixed aids as opposed to approximately 2,200 floating, only 120 of which are lighted buoys. NCD stated that 110 of these lighted buoys are stationed in waters of less than 10 m. depth and that they too will soon be replaced with fixed lights. Most of the lighted buoys are made of steel. There are only 20 lighted plastic buoys.

More than 2,000 of the floating aids are unlighted buoys, and 80% of them are made of plastic. The number of steel unlighted buoys is about 400. Figure 2-40 shows the standard steel lighted buoy and in Figure 2-41 a typical unlighted plastic buoy (Type 5 Spar) is shown. In addition to the Type 5 unlighted spar shown in Figure 2-41, NCD also uses Type 7 and Type 8 light plastic spars and Type 26 lighted plastic buoys.

The NCD had experimented with some aluminum buoys but the results were not found to be satisfactory. The service life afforded by aluminum buoys was inferior to that of plastic and steel buoys.

The lighted buoys used in Norway have been converted from using gas as the power source to using dry cell batteries. Lithium batteries were found to be the most convenient for ATON buoy applications in that they provide high energy density and excellent storability and service life. However, since the cost of energy from these batteries is very high, the NCD is currently developing a novel seawater primary battery. (See discussion below on this subject as extracted from a paper presented to the IALA 90 Conference). The NCD had also considered the use of solar panels and wave generators as power sources for lighted buoys but both were found to have undesirable limitations for use in their waterways. Solarization of fixed lights, however, has been initiated in 1990.

There are very few sound buoys in use in Norway. They are phasing out the sound buoys and replacing them with RACON's installed on fixed shore lights.

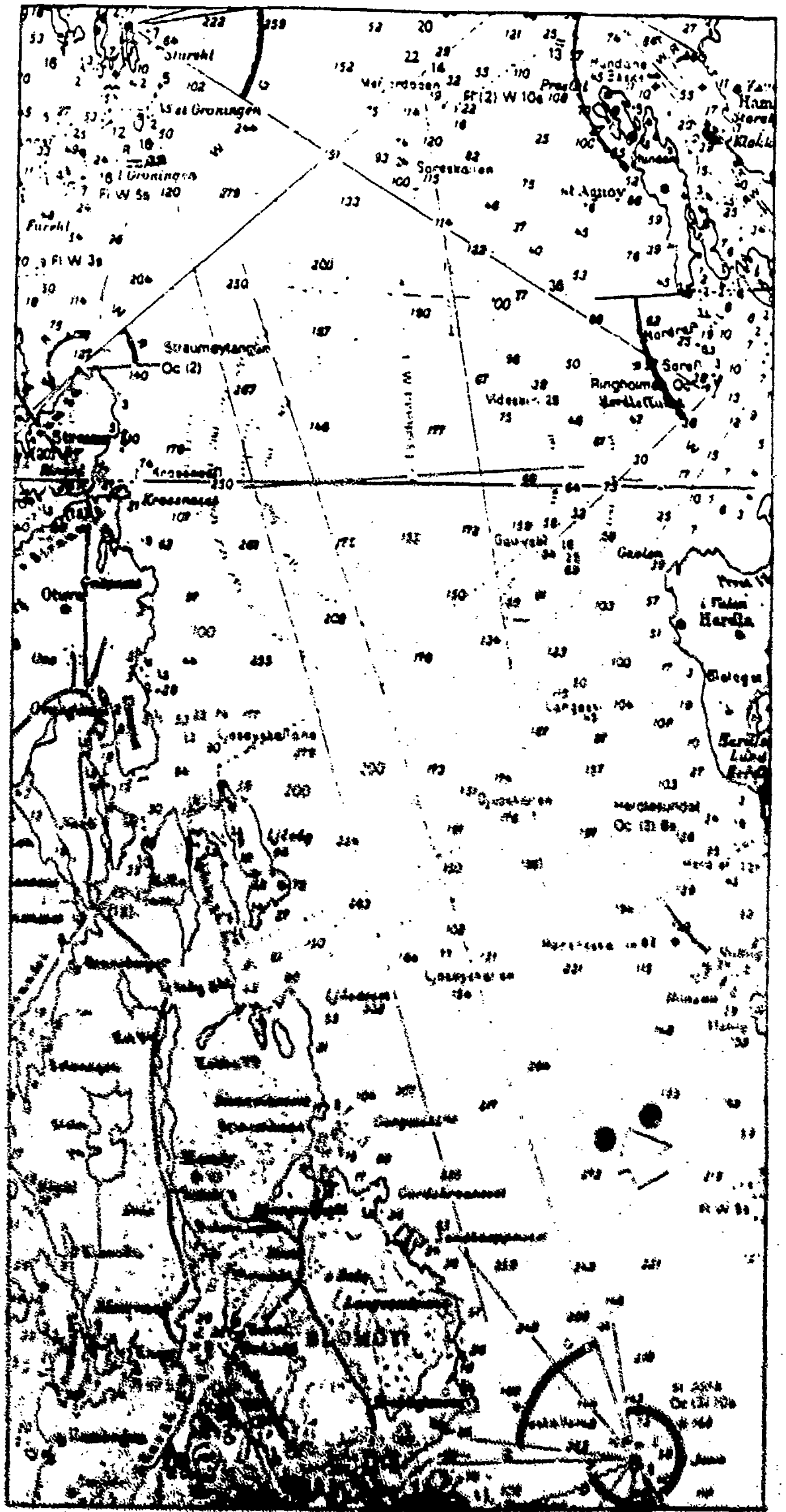


FIGURE 2-39
SECTOR LIGHTING CHART
FOR NORWAYS COAST

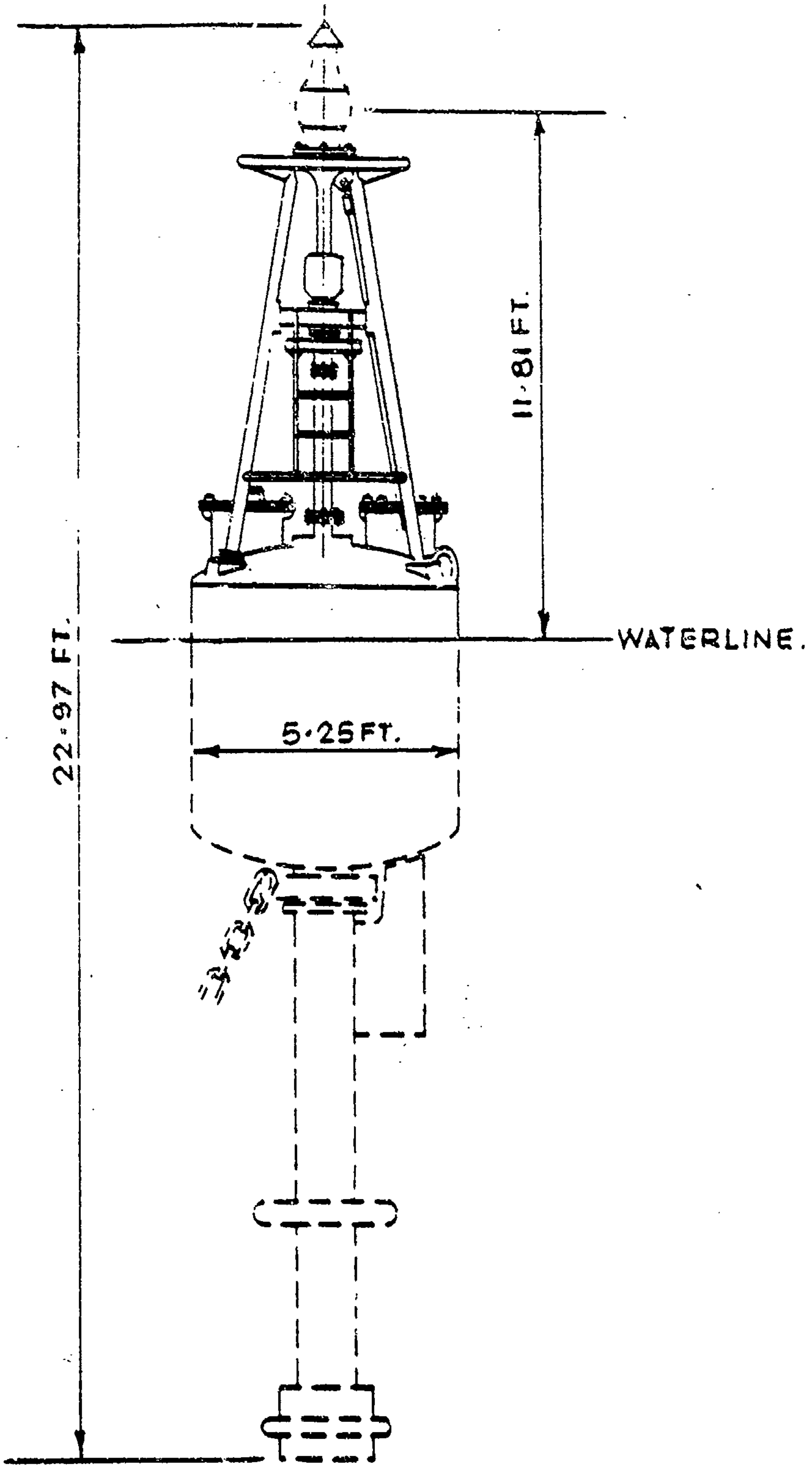
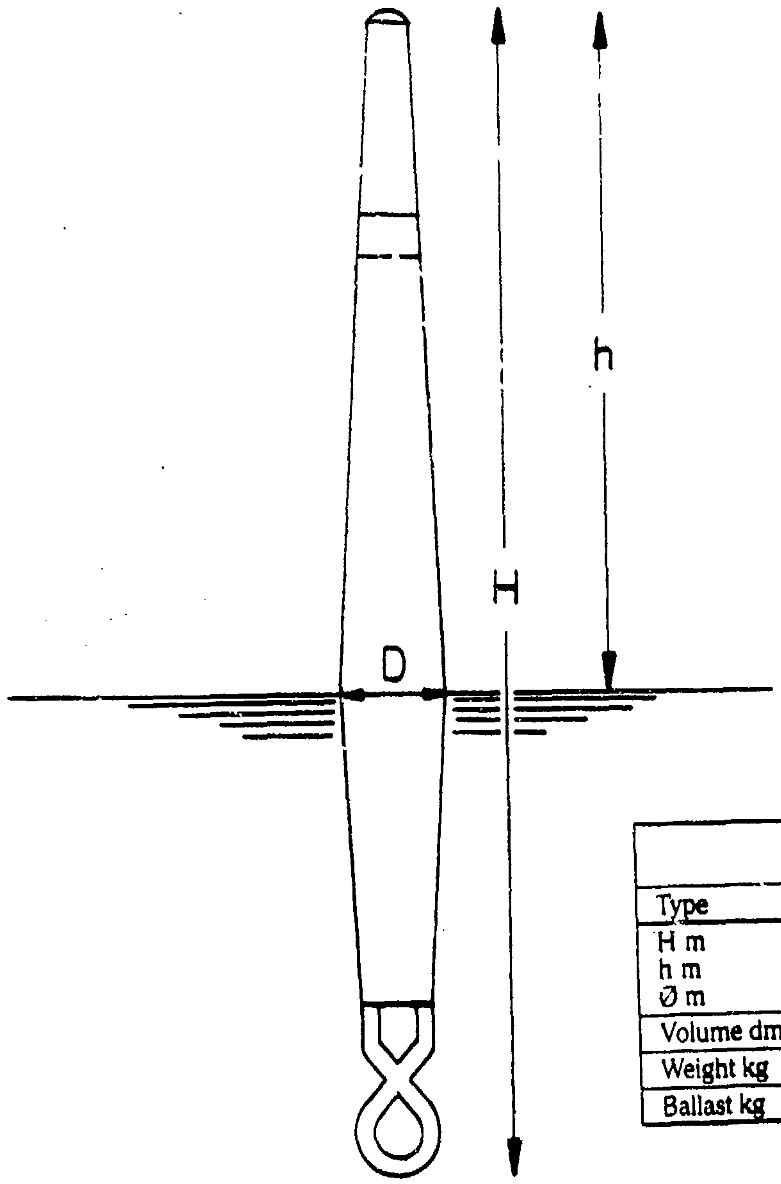


FIGURE 2-40
NORWAYS STANDARD
STEEL LIGHTING BUOY



	Rigid Plastic	
Type	4	5
H m	7.65	4.30
h m	5.00	2.80
Ø m	0.41	0.42
Volume dm³	175	300
Weight kg	45	50
Ballast kg	65	100

FIUGRE 2-41
NORWAY'S TYPE 5
UNLIGHTED SPAR

The buoys are serviced and maintained by the buoy tenders except for major repairs which are contracted out to private yards. Photograph 2-3 shows the cleaning by high-pressure water of a plastic spar aboard the buoy tender M/V VILLA. Buoy tender crews accomplish painting, scraping, light changing and other servicing on site. Servicing of mooring chains is accomplished every one or two years for buoys located in open sea areas. For buoys located in protected waters, service periods are extended to ten years.

Buoy losses in Norway are minimal; there were no losses in the 1989-1990 winter season during which very little ice occurred; but on the average with normal ice occurrence, about 40 to 50 buoys are lost per year.

The normal service life expected from the steel buoys is 20 to 25 years. However, the real service life is closer to 30 years and only 100 new buoys are acquired every year to maintain the total number after losses. The steel buoys are manufactured by local steel fabricating shops and plastic buoys by the Norwegian manufacturer TICON PLAST A/S (See Section 2.2.10.1 for a discussion on this manufacturer).

Norway had five large buoy tenders of about 44 m. (144 ft.) length. Two of these have been put out of service as a result of reduced buoy maintenance needs because of replacing buoys with fixed lights. The NCD stated that when additional lighted buoys are replaced with fixed lights in the near future, it will be possible to decommission one more buoy tender and to realize savings of 10 million NK (approximately $1.7 million) per year in operating costs.

The three buoy tenders currently in service have lifting capacities of 12 tons each and they are operated with crews of 9 each. Their operating costs are 8 million NK ($1.2 million) per year without depreciation and 10 million NK ($1.5 million) when depreciation is added.

The high operating costs, in NCD's opinion, make floating buoys undesirable in spite of their lower initial acquisition costs as compared to fixed aids.

<u>References for Additional Information</u>:

Interview Summary	:	Appendix A, Section A.1.9
Buoy Records	:	Appendix B, 6 Entries, Pages B-1059 through B-1082
Buoy Drawings	:	Appendix C, Pages C-210 through C-215

A number of papers were presented by Norway to the 1990 IALA Conference. Those found relevant to the Buoy Technology Survey project were the following:

1. <u>Paper No. 1.3.1</u>, Reference 26, discusses a comprehensive coordin-ated database system for fairways and aids to navigation. As part of this integrated system, the "Fairway Database" contains information for individual aids to navigation including data on equipment specifications, responsible agencies and malfunctions or breakdowns.

2. Paper No. 3.6.9, Reference 27, gives a description of the novel seawater battery systems and reports on tests of prototype batteries installed in lighted buoys to replace the dry cell lithium batteries. Norwegian government, in cooperation with private manufacturers, had started a development program in 1985 for an underwater battery for defense and oil industry applications. The NCD in 1989 has established a project group to adapt this new battery for light buoy applications. A description of the principles of operation and design approach for this battery is given in Reference 27. Figure 2-42 shows the seawater battery powered lighted buoy which is reported to be presently undergoing tests. Preliminary results indicate, according to Reference 27, that the new battery will provide long-term operational capability, excellent shelf life, low operating costs and will present no environmental or safety hazards. Consequently, the paper claims, it may find wide-ranging application in the future lighted buoys. With regard to lifetime of the battery the Norwegians have stated the battery can be used for more than two years of maintenance-free continuous operation., At that time the only requirement will be to replace the anode material. Further, the battery has a virtually infinite storability and can be taken out of the water for an indefinite amount of time and put back to sea for continuing operation.

It should be noted that another manufacturer of seawater batteries (Alu Power of U.S.A., see Section 2.2.11.13) states that their ALDOS batteries have long shelf life and their service life is dependent on the amount of aluminum anode present.

3. Paper No. 2.4.6, Reference 28, as briefly cited above, describes a systematic approach for substituting floating aids to navigation with fixed aids as used in Norway. The paper also discusses the current status of substitutions, the experience gained from fixed aids and the impact of more substitutions on the number and size of future buoy tenders and the added benefits resulting therefrom.

2.1.10 United States

The responsibility for operating and maintaining the ATON system in the United States was given to the U.S. Coast Guard in 1939 when the U.S. Lighthouse Service was merged into the Coast Guard. The area of jurisdiction covers the United States, its territories and possessions, and the Trust Territories of the Pacific Islands.

The U.S. Coast Guard, as of the end of 1989, has the following operational floating marine aids to navigation:

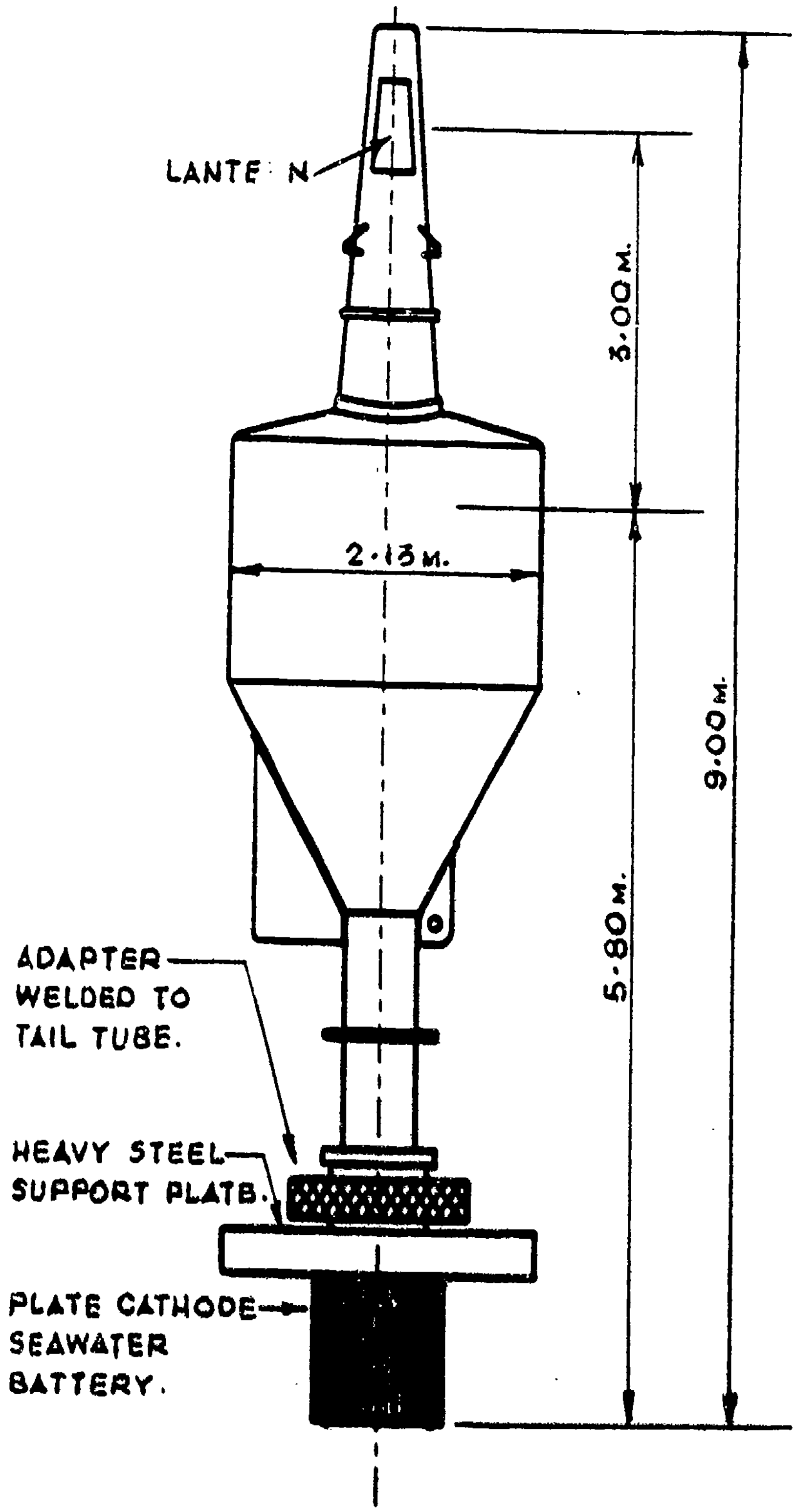


FIGURE 2-42
NORWAY'S SEAWATER
BATTERY POWERED BUOY

8	Lighted Buoys over 9m. diameter
4,346	Lighted Buoys less than 9m. diameter
21	Lighted Buoys less than 9m diameter (Along the Mississippi River and the Western Rivers)
4,375	Total Lighted Buoys
10,446	Unlighted Buoys
11,524	Unlighted Buoys (Miss. & Western Rivers)
21,970	Total Unlighted Buoys
26,345	Total Floating Aids

In Task A of this study, the research and development efforts undertaken by the USCG since 1962 on buoy developments were reviewed, interviews were held with the USCG ATON personnel at the Headquarters, the R&D Center, and several District aid to navigation offices (oan), and the results were reported in the final task report, Reference #29.

References for Additional Information:

Interview Summary	: Appendix A, Section A.1
Buoy Records	: Appendix B, 51 Entries, Pages B-1128 through B-1329
Buoy Drawings	: Appendix C, Pages C-230 through C-275

During the IALA 90 conference, authors from the United States have presented 16 papers seven of which are directly or indirectly related to floating short range aids to navigation. Brief extracts from these papers are given below:

1. Paper No. 2.1.1, Reference #31, describes the USCG's primary aids to navigation training facility, the National Aids to Navigation School. It also addresses training concepts and management, provides brief course descriptions, discusses resident and on-site training and presents the benefits of exportable training.

2. Paper No. 2.2.1, Reference #32, reports on the separate privatization efforts for servicing navigation marks and presents the USCG Short Range Aids Program's evaluation of the contractors' performance on a total number of 800 navigation marks in three trial areas.

3. Paper No. 3.1.6, Reference #33, discusses the field measurements and laboratory experiments to assess the effects of signal size and background lighting density on a mariner's ability to find a navigation light. The time required for the observers to correctly locate the signal was used as the measure of conspicuity of the point and extended sources. The paper reports the results and provides methods for aiding design engineers in the sizing and selection of extended sources.

4. Paper No. 3.1.7, Reference #34, summarizes the result of studies on the extent of degradation of the effectiveness of a buoy's signal light due

to the motions of a buoy. It concludes that increased lantern divergence will reduce the degradation and increase the buoy detection range.

5. Paper No. 3.2.1., Reference #35, describes the latest developments in floating aids to navigation. Included are discussions of modifications to the Exposed Location Buoy, Articulated Lights, Foam Buoys, and Synthetic Line Buoy Moorings as well as a presentation on improvements on Large Navigation Buoy (LNB) power consumption and efficiency.

6. Paper No. 3.5.2, Reference #36, discusses the U.S. Coast Guard's acquisition program to replace its aging fleet of buoy tenders with modern effective ships which will operate well into the next century.

7. Paper No. 4.1.1, Reference #37, reports on a recent USCG project to purchase a frequency-agile racon for use in the ATON system. The paper summarizes the efforts involved in the development, the anticipated deployment, and the testing philosophy for the use of radar transponders as aids to navigation.

2.2 Commercial Manufacturers/Designers/Institutions

In each country visited during this task, buoy manufacturers and designers as well as private institutions involved in aid to navigation systems were identified. Many of these sources were visited, personal interviews held, and facilities toured by the project investigators. Additionally, other manufacturers and institutions were contacted either in writing or in person during the 1990 IALA Conference and appropriate information on buoys was requested and received to the extent possible. In the following subsections, synopses of these interviews are presented along with discussions of findings from other sources by correspondence and/or by contacts during the IALA Conference.

2.2.1 Canada

2.2.1.1 Orraide, Ltd.

As an exclusive agent in Canada for Pharos Marine, Ltd. of England, Orraide, Ltd. is essentially offers consulting services and markets buoys manufactured in Europe not only by Pharos Marine, but also by other sources including the Balmoral Group, Ltd.

One project that Orraids, Ltd. is currently working on in conjunction with the CCG Base Prescott is a fast-water buoy designed by Janko & Associates of England and manufactured in Canada, after some modifications by the Prescott Machine and Welding Co. Figure 2-43 shows a schematic arrangement of this buoy. Photograph 2-4 shows the original Janko buoy as deployed for tests and Photograph 2-5 as it was being lifted for launching.

According to Orraids, and as verbally confirmed by Base Prescott, the results obtained from the tests so far are very promising. The buoy has successfully withstood 10 knot currents. The goal is to deploy these buoys on a project in the Niagara Falls region.

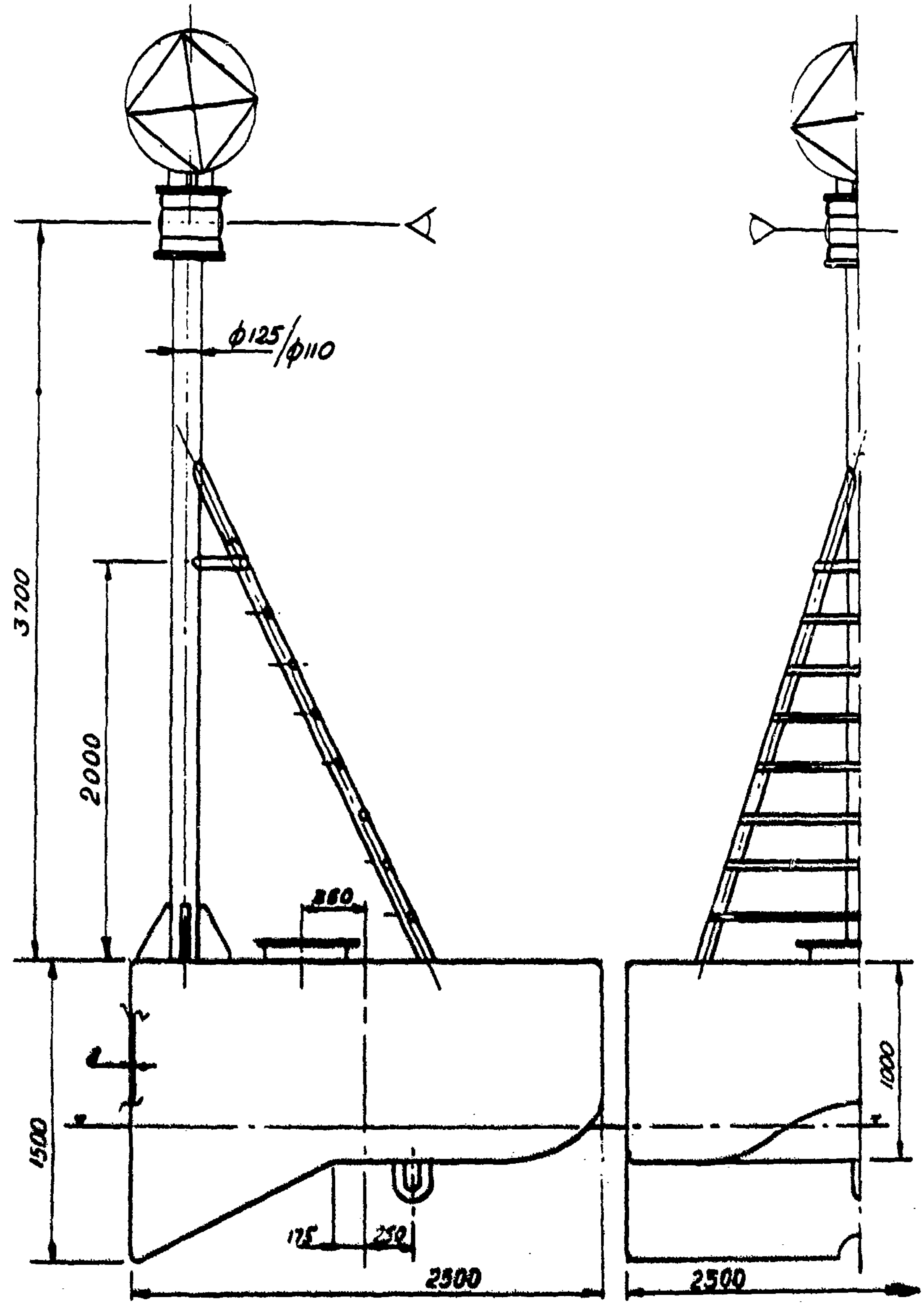


FIGURE 2-43
CANADIAN
FASTWATER BUOY

References for Additional Information:

Interview Summary : Appendix A, Section A.2.1.1

2.2.1.2 MIL Systems Engineering, Inc.

MIL Systems Engineering, Inc. (MSEI), a member of the MIL Group, has completed, in March 1990, a contract for the Canadian Coast Guard to develop design criteria for the aid to navigation buoys used by the CCG. The criteria considered included environmental conditions, structural design, buoyancy, stability, etc., as well as updating of the drawings of ATON buoys used throughout Canada. The manual is being currently revised and finalized and will probably be completed next year in the form of a "Floating Aids Technical Manual".

In their response to the survey questionnaire, MSEI stated in general that:

- The current short range aids were developed on the basis of operational experience over the last fifty years and in general they seem to work fairly well;
- Buoyancy problems are experienced in high current and icing conditions;
- Lifting points are hard to use and have occasionally failed;
- There is an ever-increasing need for space in the buoy superstructures;
- Battery life is a problem in some areas of operation.

References for Additional Information:

Interview Summary : Appendix A, Section A.2.1.2

2.2.1.3 KWH Pipe (Canada) Ltd.

This company is the Canadian subsidiary of KWH Pipe, Ltd. of Finland and is engaged in consulting for and marketing of KWH spar buoys. It does not currently have any manufacturing facilities in Canada.

(For a discussion of the interview held with KWH Finland, see Section 2.2.4.1.).

References for Additional Information:

Interview Summary : Appendix A, Section A.2.1.3

2.2.1.4 Georgetown Shipyards, Inc.

Located in Georgetown, Prince Edward Island, this shipyard had been constructing steel and aluminum buoys for the CCG. They have recently completed and delivered a series of 4'-6" diameter lighted river buoys and 9'-6" diameter sound buoys in accordance with the construction specifications and drawings supplied by the Dartmouth CCG Base. As requested by the specifications, the shipyard delivers the buoys with only the prime coat applied. The final painting, and outfitting are accomplished at the CCG Base.

References for Additional Information:

Interview Summary : Appendix A, Section A.2.1.4

2.2.1.5 Fairview Industries Ltd.

This company is located in Halifax, Nova Scotia and essentially is involved in fabrication of steel and aluminum structures. They had manufactured both steel and aluminum buoys of the conical and discus types for the CCG in 1988 and 1989 and are currently submitting a proposal for the construction of a new series of buoys. At the time of the brief visit to their facilities, they had no buoys under construction or in storage. The fabrication shop is equipped with all types of buoy construction equipment including aluminum and steel welding, blasting and painting and testing facilities.

Mr. Whiteway of Fairview Industries commented that having constructed many aluminum discus buoys, he found them to be over designed.

References for Additional Information:

Interview Summary : Appendix A, Section A.2.1.5

2.2.2 Denmark

2.2.2.1 Electronic Supply Co.

The Electronic Supply Company is a source of electronic equipment for buoys. However, they are currently also involved in developing a wave generator capable of operating in small waves and free from direct exposure to the seawater environment.

A buoy fitted with a prototype of this new type of wave powered generator was the subject of an IALA '90 Conference paper previously discussed in Section 2.1.2 and is shown in Figure 2-15.

The wave generator is driven by the acceleration of the buoy caused by wave action as low as 30 cm in height. It is a completely mechanical device with no exposure to sea water, thereby being exempt from marine growth build-up, fouling and corrosion. The anticipated maintenance interval for this new wave powered generator is expected to be three years when internal springs and bearings may need to be replaced.

References for Additional Information:

Interview Summary : Appendix A, Section A.2.2.1

2.2.3 England

2.2.3.1 Balmoral Group Ltd.

Balmoral is a part of the Balmoral Group of marine companies and is located in Aberdeen, Scotland. They manufacture a series of plastic navigation buoys in sizes ranging from one to five meters in diameter. Their navigation buoys had traditionally been constructed of foam filled GRP. Their newest buoys are manufactured of foam with a Belthane Elastomer exterior.

Balmoral believes foam buoys with elastomer exteriors hold a great deal of promise for being the navigation buoy of the future. They originally developed their elastomer/foam buoys in response to the marking needs in the harsh environment of the North Sea oil fields. They have already replaced some large steel sea buoys up to approximately 10 ft. in diameter with these. An example of a Balmoral elastomer/foam buoy is shown in Figure 2-44. The EF20L buoy shown is 2 meters in diameter with a focal plane of 2.55 meters and a weight of 1650 kg.

The purchase cost of the foam/elastomer buoys is comparable to steel in Europe but not in "third world" countries. The material for their buoys is Balmoral's own and the buoys can only be constructed at their facilities in the United Kingdom. They believe the operational costs of their buoys are drastically reduced as these buoys will survive high impact forces without sustaining deformation or damage, require minimum maintenance, and there are no expensive paint treatment or welding repairs.

The design of elastomer/foam buoys has resulted in some comparisons to steel buoy characteristics. Foam/elastomer buoys are lighter than steel and additional weight must be added to achieve a working waterline. Motion characteristics of the plastic synthetic buoys have been equilibrated to those of steel buoys by matching the GMs and the weights have been added accordingly. Generally speaking, funds are not available for motion studies of buoys, which are very expensive.

References for Additional Information:

Interview Summary : Appendix A, Section A.2.3.1
Buoy Records : Appendix B, 24 Entries, Pages B-345 through B-441
Buoy Drawings : Appendix C, Pages C-69 through C-92

2.2.3.2 Reinforced Plastic Structures

Reinforced Plastic Structures (Lewes) Ltd. (RPS) was introduced to MR&S by the Gloucester Harbor Trustees. There was no direct contact with them.

THIS

PAGE

IS

MISSING

IN

ORIGINAL

DOCUMENT

FiG 2-44

RPS manufactures a variety of marking and navigational buoys of foam filled glass reinforced plastic as shown in Figure 2-45. Their Class II navigation buoys have hull diameters of 9 ft. Their support buoys for anti-pollution oil booms (not shown) have diameters of 15 ft.

References for Additional Information:

Interview Summary	:	Appendix A, Section A.2.3.2
Buoy Records	:	Appendix B, 6 Entries, Pages B-442 through B-459
Buoy Drawings	:	Appendix C, Page C-93

2.2.3.3 Pharos Marine, Ltd.

Pharos products were presented by Automatic Power, Inc. during the U.S. surveys. See the U.S. Section of this report (Section 2.2.11.2) for details.

As summarized in Section 2.1.3 of this report, Pharos personnel from the United Kingdom presented a paper on a new wave powered generator system for buoys, at the IALA '90 Conference. The system utilizes a special flexible hose within the mooring system driven by buoy motion to pump water to a power turbine. The paper summarizes the results of development work and trial activities. Pharos does supply equipment for more conventional power sources as well as a full range of other ATON equipment. Figure 2-46 shows the available systems. Their commentary on the two types of systems are as follows:

Gas

This well-proven method of lighting is still regarded as being the most reliable and experience has shown that gas equipment is the least affected by the marine environment.

Electric

There are three main systems of providing electric power to buoys:

- Batteries, primary (disposable) or secondary (rechargeable).
- Solar generator with secondary battery.
- Wave activated generator with secondary battery.

References for Additional Information:

Interview Summary	:	Appendix A, Section A.2.3.3
Buoy Records	:	Appendix B, 27 Entries, Pages B-460 through B-567
Buoy Drawings	:	Appendix C, Pages C-95 through C-99

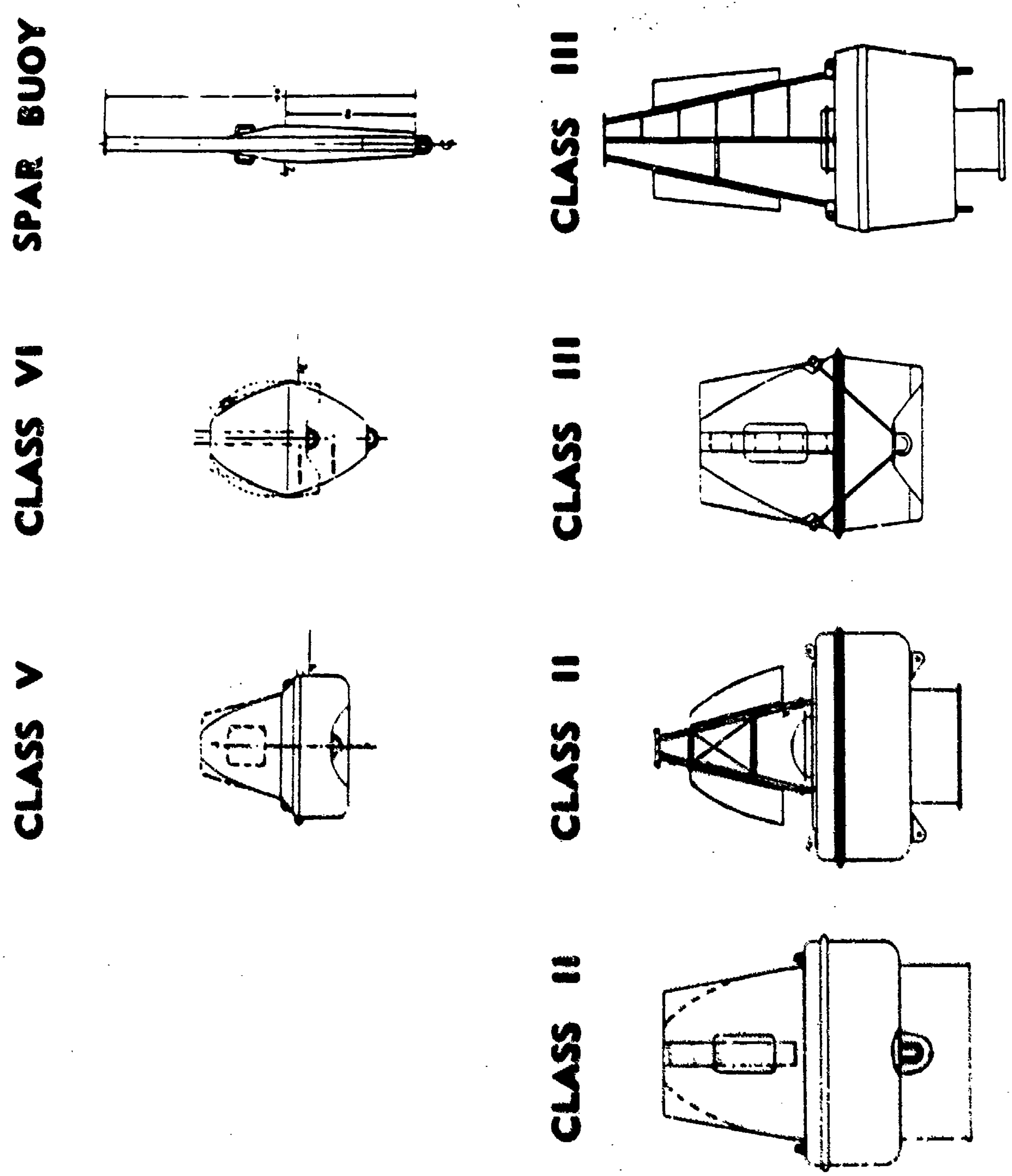
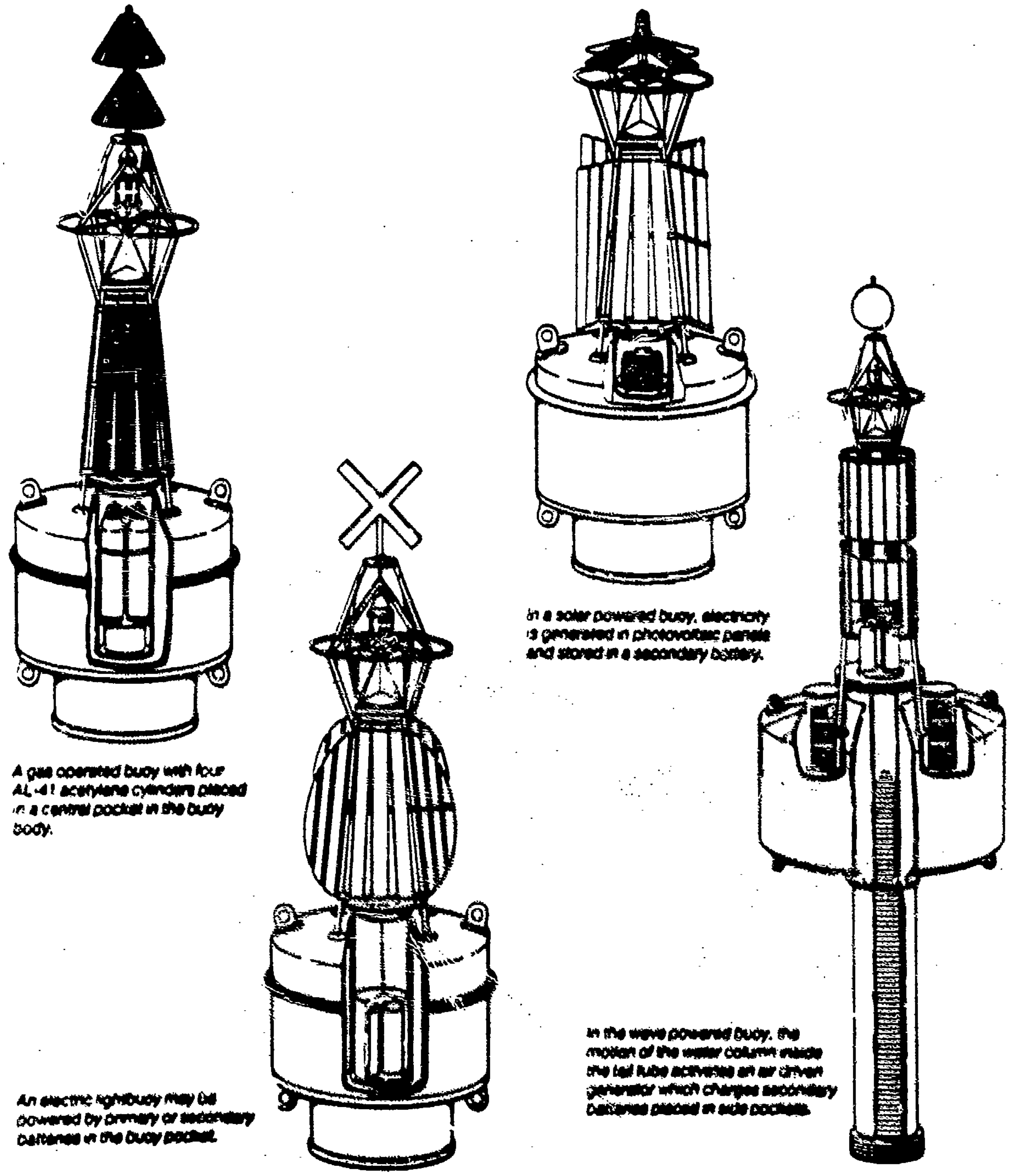


FIGURE 2-45
REINFORCED PLASTIC
STRUCTURE'S LINE
OF BUOYS



<u>FIGURE 2-46</u>
<u>PHAROS MARINE"S</u>
<u>BUOY POWERING SYSTEMS</u>

2.2.3.4 Midar Systems

Midar is an acronym for "Microwave Identification Data Automatic Response". It is an add-on secondary radar system designed to give an identity to a "radar blip". The system consists of an interrogator and receiver/transponder which automatically transmits a response indicating a unique identity. In the example shown in Figure 2-47, the Midar system is being used by Ship A to recognize radar contact. Pulses from the ship's radar and Midar interrogator are received simultaneously in Ship B by her Midar receiver, which automatically transmits a response, consisting of number of digits which indicate her unique identity suitably coded for transmission. On receipt by Ship A, this message is automatically decoded enabling the ships international radio call sign to be displayed and used, if required, to initiate UHF radio communication. Although this system was originally developed for ships as just described, it could in principle be utilized to identify buoys by a ship.

Midar believes that the general system of lights and buoyage can be improved and number of marks reduced by the two following implementations:

1. Enhanced radar conspicuity through better reflectors.

2. Fitting of every mark with an identification transponder known to mariners and which could be selectively interrogated by radar.

Midar believes that radar and satellite systems are here to stay, so that a buoy system tailored to radar should be useful into the foreseeable future. In such a system buoys would be set for the best radar navigation rather than navigation by sight. Racons of various kind and navmarks, D/F stations and "UHF stations" have inherent limitations which diminish their potential for universal use. Racons are not so good for they blot out other radar signals and with two or more, the radar screen can become completely confused.

With the Midar system a Midar transponder would be mounted on the buoy. Ships would have a Midar interrogator connected to their general radar. Buoys marking hazard areas are essential and would be made non-selective, i.e. they would respond to any radar. Other buoys would be equipped with a selective radar signal so that the navigator can interrogate to find the one he is looking for.

Currently the Midar system is in a prototype state. Sperry has a similar system: Marine Interrogator Responder System. IALA has discussed Midar but has not tested it, whereas they did try ADAR (Automatic Data Acquisition Radar) which requires ship position data to be transmitted to shore stations.

<u>References for Additional Information</u>:

Interview Summary : Appendix A, Section A.2.3.4

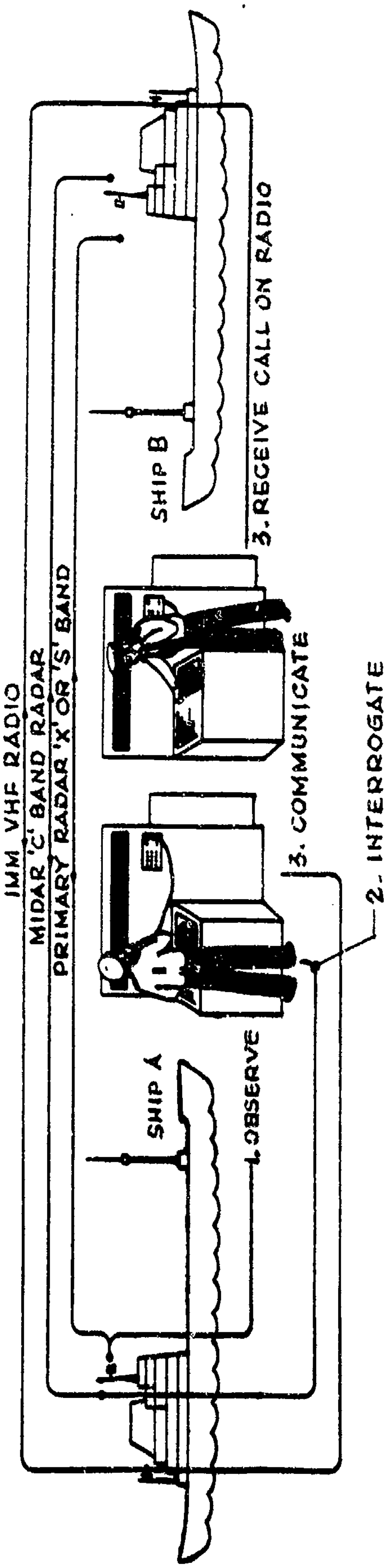


FIGURE 2-47
MIDAR"S NAVIGATION
COMMUNICATION SYSTEM

2.2.3.5 Nautical Society

The Nautical Society, with 5000 members in 70 countries, is an independent international professional body whose principal aim is to encourage a high standard of knowledge, competence and qualification amongst those in control of seagoing craft.

In the past they have been asked by IALA to provide input as to the requirements for aids to navigation desired by its members, the mariners. As discussed in Section 2.1.3, they were responsible for Paper No. 1.4.4 presented at the IALA '90 Conference. Previous publications authored by their members have indicated that:

- Buoys work well.

- Fog signals are not required.

- Future navigation systems could consist of only fairway buoys with Racons.

- Satellite navigation will supersede the need for buoys.

- Install transponders on ships and buoys to identify them.

References for Additional Information:

Interview Summary : Appendix A, Section A.2.3.5

2.2.3.6 Hippo Marine Products

HMP is primarily involved in the manufacture of moorings and marker buoys, but they have utilized technology in the manufacture of some navigation buoys. They have provided buoys around the world.

This year they were constructing two 2.5 meter diameter lighted buoys for the Bristol Haven Authority as shown in Figure 2-48. This buoy as well as other HMP buoys are said to have the following characteristics:

- Fabricated using polyurethane elastomer exterior and light weight foam interior.

- Polyurethane elastomer is extremely hard wearing but resilient.

- The buoy is unsinkable unless severely damaged.

- Any shape buoy is possible by hot wire cutting of the polyethylene foam with subsequent spraying of the polyurethane elastomer.

- Sea buoys can be made by adding a tail tube.

HMP originally manufactured GRP buoys. They found the buoys to be satisfactory in calm estuaries, but in the open sea they were stable but too

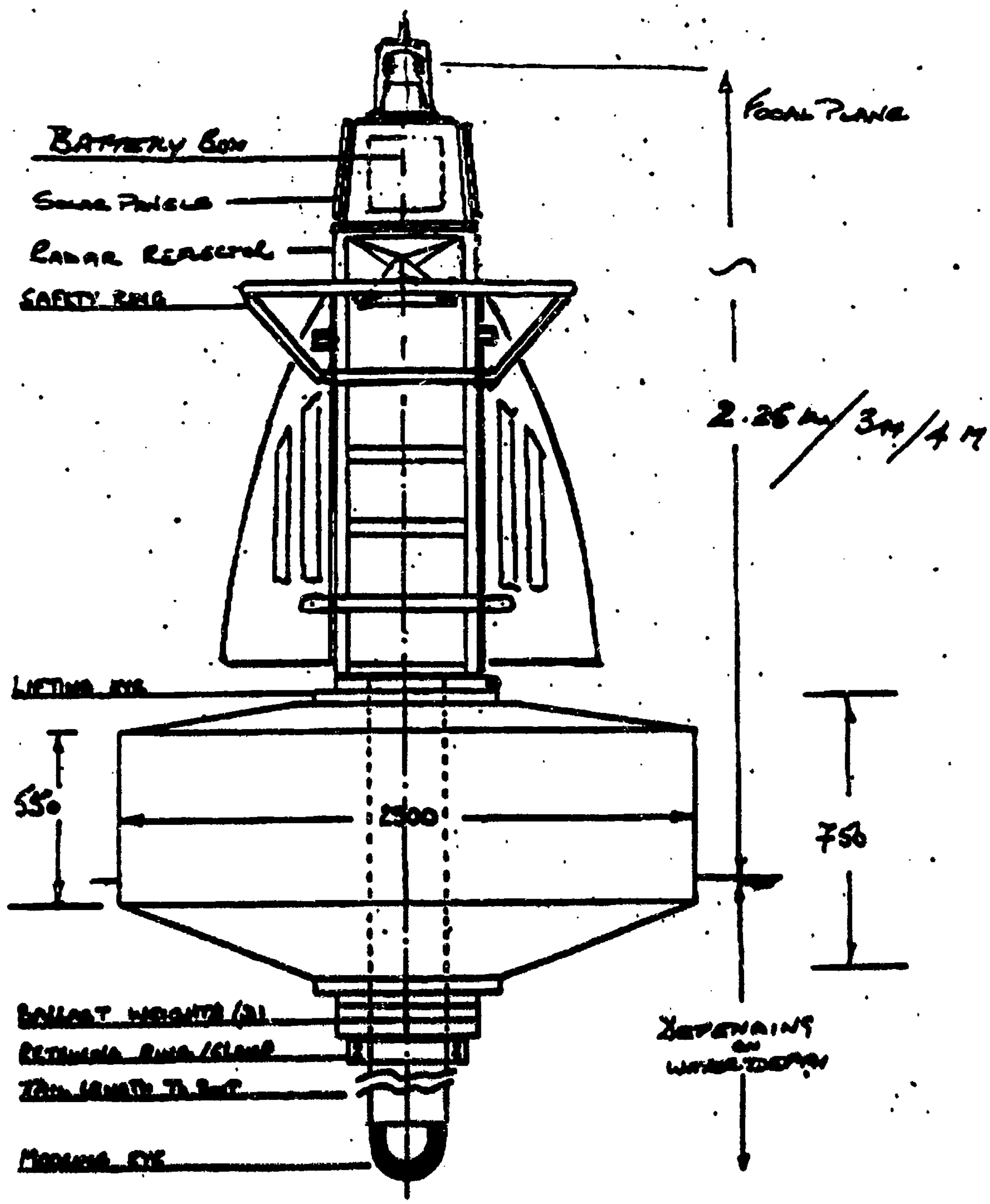


FIGURE 2-48
HIPPO MARINE"S
ELASTOMER "SOFT" BUOY

"lively" resulting in reduced visibility of the light due to their motion. By counterbalancing the elastomer/foam lightweight buoy with extra heavy chain they have obtained a lightweight buoy that has a seakeeping response identical to a larger or heavier buoy.

References for Additional Information:

Interview Summary	:	Appendix A, Section A.2.3.6
Buoy Record	:	Appendix B, 1 Entry, Page B-568
Buoy Drawings	:	Appendix C, Page C101

2.2.3.7 Firdell Multiflectors, Ltd.

Firdell Multiflectors, Ltd. (Firdell) has developed products that improve radar reflectivity. They were not visited during the surveys but they did supply MR&S with written material.

Firdell defines an effective radar reflector as one that gives a consistent radar return through a 360° azimuth and through at least plus or minus 20° of heel of the buoy. The mean "Radar Cross Section" throughout this 360° x 40° band should not be less than 2.5 m^2 and there should be no "gap" in the band more than 10° in azimuth and plus and minus 2° in the vertical.

Firdell manufactures a number of radar reflectors. From the literature it appears they have used their Blipper 200 and 300 series on floating buoyage. The Blipper 210-7 is shown in Figure 2-49 and has dimensions of 595 x 225 mm with a weight of 1.8 kg. These radar reflectors appear to consist of a reflective structure of aluminum encased in seamless UV-stabilized rotationally molded polyethylene.

References for Additional Information:

Interview Summary : Appendix A, Section A.2.3.7

2.2.3.8 Thorn, EMI

Thorn, EMI Electronics Ltd. manufactures high integrity monitoring systems for marine applications. Their "Oceanmaster Data Acquisition System" is the latest version of a complete marine weather station which can relay both meteorological and oceanographic data directly by radio from a buoy to a base station.

References for Additional Information:

Interview Summary : Appendix A, Section A.2.3.8

2.2.4 Finland

2.2.4.1 KWH Pipe, Ltd.

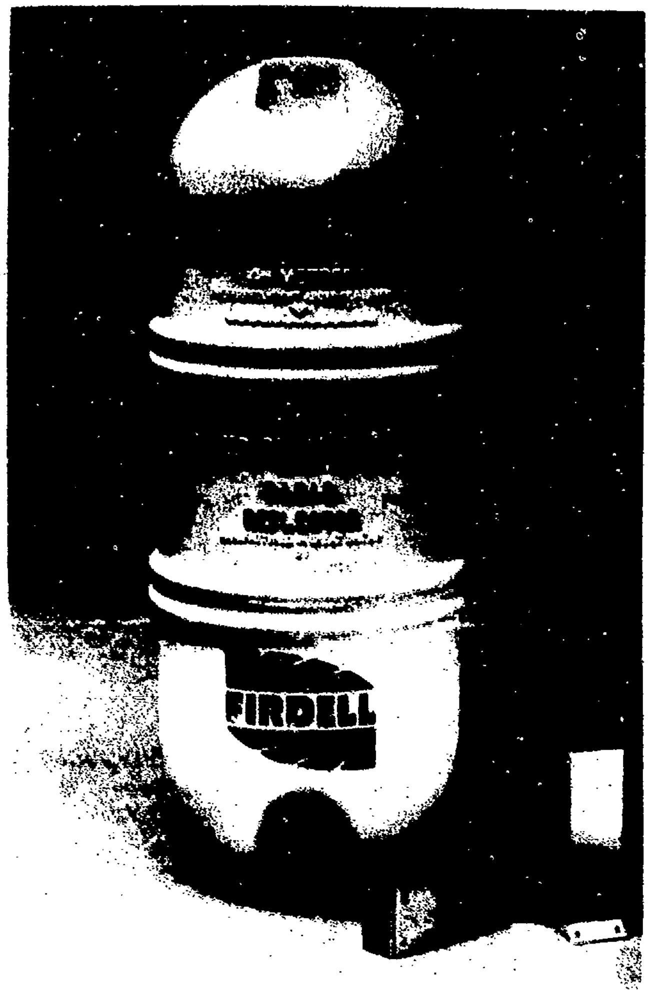


FIGURE 2-49
FIRDELL'S BLIPPER 210-7
RADAR REFLECTOR

This company manufactures, in its plant in Vaasa, Finland, a series of plastic spars and pillar type buoys ranging in diameter from 110 mm to 1,600 mm (5.25 ft) and in length from 3 m to 14 m (45.93 ft). All of the plastic pillars of 500 mm (1.64 ft) diameter and above that are used within the Finnish Board of Navigation's ATON system are supplied by KWH Pipe. The smaller spars manufactured by KWH Pipe are sold to other governments' navigation administrations, port authorities, and private companies. (Finnish Board of Navigation constructs its spars up to 225 mm diameter at its own manufacturing plant.)

The KWH plastic spars are manufactured by a fully automatic extrusion process. Extrusion production lines of varying size and capacity manufacture pipes to given specifications and lengths. The spars are made from appropriate lengths of pipe (of high density polyethylene) and filled with expanded polystyrene. Coloring of the spars is accomplished by pigmenting the plastic material and for this reason, the color does not fade or wear off. A single spar may consist of several pipes of different color in which case the ends of pipe segments are joined by welding. The welding process consists of heating the pipes and pressing them together. The end piece is also joined to the cylindrical pipe sections by welding in a similar manner. A metallic base is bolted to the bottom end by steel fixing plates. An illustration for the 1,000 mm diameter pillar type buoy as manufactured by KWH is shown in Figure 2-19 of Section 2.1.4. Shown in Figure 2-50 is the construction details of a plastic KWH spar. Figure 2-51 shows the line of KWH spars and pillars up to 1,000 mm diameter and Figure 2-52 provides mooring details for the 500 mm and 1,000 mm pillars.

Radar reflectors are fitted on all spars and pillars of 225 mm diameter and above as well as on some of the 160 mm spars. In order to provide resistance to wear from debris and ice, retro-reflecting strips are placed in grooves on the outside surface of pipes.

As seen in Figure 2-51, spars and pillars above 225 mm diameter may also be, and those used in Finland mostly are, equipped with lanterns. The batteries are installed within the pipe.

KWH Pipe Ltd. facilities in Vaasa include a "Mechanical/Chemical Testing and Research Laboratory" and a "Paint Weather Testing Laboratory".

<u>References for Additional Information</u>:

Interview Summary	:	Appendix A, Section A.2.4.1
Buoy Records	:	Appendix B, 8 Entries, Pages B-571 to B-590, B-595 to B-602 and 611
Buoy Drawings	:	Appendix C, Pages C-103, 106, 107, 108

2.2.4.2 Renco Marine Oy

This company, located in Porvoo, Finland, manufactures traffic regulating equipment and signals including those used by the Finnish Board of Navigation on their lighted buoys, articulated beacons, landmarks, etc.

PAGES 125, 126

ARE

MISSING

IN

ORIGINAL

DOCUMENT

FIG 250, 251

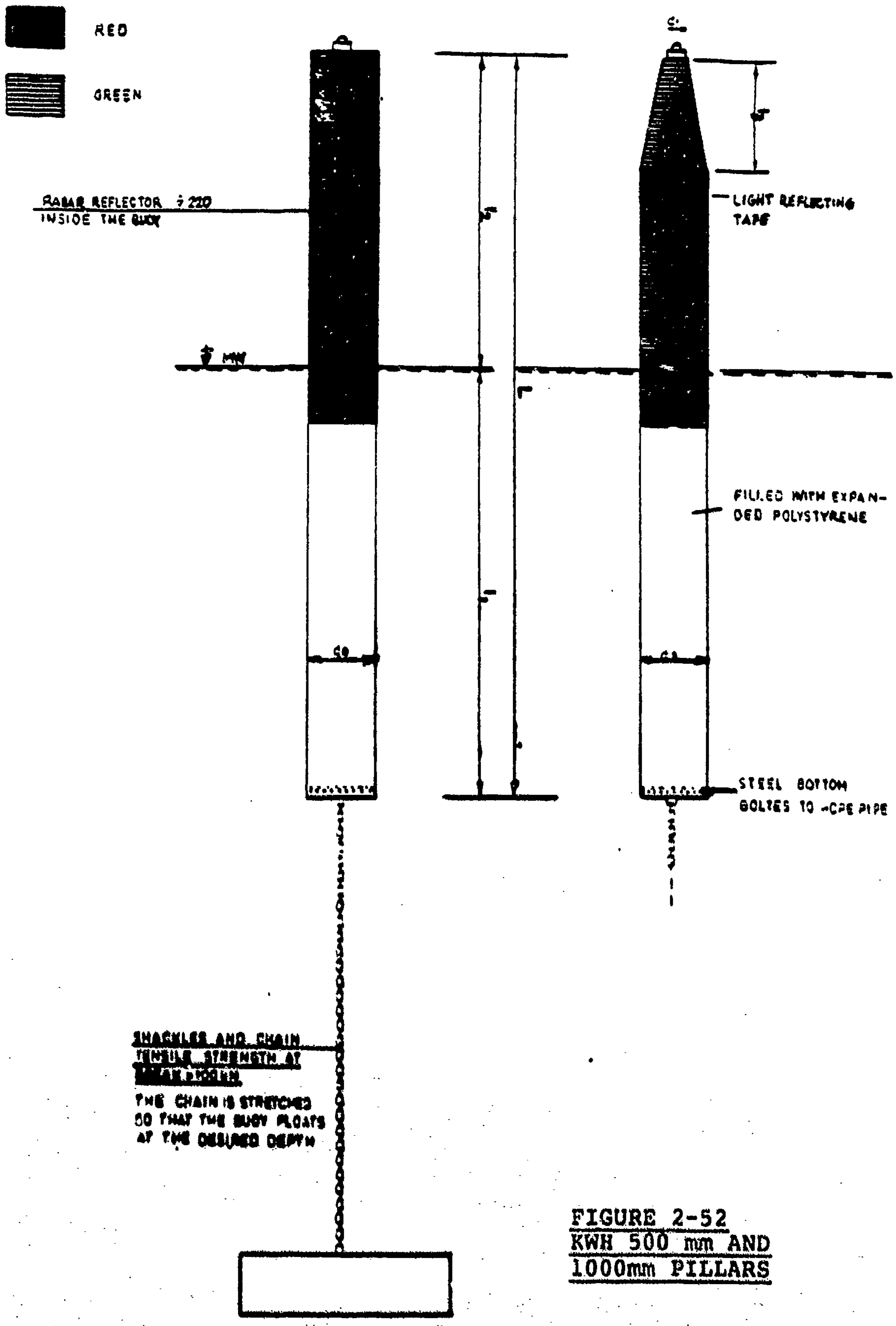


FIGURE 2-52
KWH 500 mm AND
1000mm PILLARS

Included in their manufacturing line are the following types of equipment:

- Buoy lanterns of Type VP-3, MVP-3
- Range lights of Type LO-1, LO-2
- Rand Mark lanterns of Type RV-10, RV-20
- "Renpulssi" 10-25 flasher
- Renco Photocell VIC-3
- Photovoltaic Power systems
- Daytime leading lights
- "Renprocessor 10-28" Microprocessor based flasher
- "Renprogrammer" (portable programmer for use with the "Renprocessor")

"Renco Marine" is a supplier of navigation signals and equipment to the Finnish Board of Navigation and to KWH Pipe, Ltd. for use on their aids to navigation.

References for Additional Information:

Interview Summary : Appendix A, Section A.2.4.2

2.2.5 France

2.2.5.1 Gisman

Gisman is made up of a group of companies manufacturing a wide variety of products. As a manufacturer of buoys, they have delivered a number of buoy types although at this time they are not manufacturing any. 85% of their buoy business had been outside France.

As examples of their buoy construction they have noted the following:

- The Delphine and Marina GRP buoys are shown in Figures 2-53 and 2-54. The Delphine is manufactured with a flat bottom however a tail tube can be added as shown in the figure. It is 2.5 meters in diameter including the built-in fender. It comes with various daymarks, topmarks and signalling devices. The French lighthouse authority has 30 of the Delphine type buoys along the French coast, replacing larger steel buoys. The 1.4 meter diameter Marina buoy is similar and is intended for beaconing channels and port entrances.
- A large underwater gas wellhead marker in the North Sea with a steel body for ruggedness and a GRP tower for reduced maintenance.

PAGES 129, 130

ARE

MISSING

IN

ORIGINAL

DOCUMENT

FIG 253, 254

- A floating beacon for 8 meter wave heights for the Spanish coast.

- Floating beacons for 20-30 meter water depth. These all had a universal joint at the mooring connection.

For the design of buoys Gisman has access to a computer based mooring response program giving mooring line response. The program can handle articulated beacons and is available at the "Institut National D'Essais et de Recordes Nautiques," a semi-governmental organization.

Gisman believes the following are current constraints and potential beneficial characteristics for buoy design/construction:

- Cost of buoy maintenance operations should be less than current.

- Specific buoy motion characteristics should be designed for the intended sea conditions.

- With GRP buoys homogeneity of material must be achieved for best results.

- Unless a light is marking a danger point the continuity of a light signal is not important.

Although Gisman's market share of the world navigation buoy business is small, they believe 60% of the world buoy business belongs to Pharos and 10% to Automatic Power.

<u>References for Additional Information</u>:

Interview Summary	:	Appendix A, Section A.2.5.1
Buoy Records	:	Appendix B, 2 Entries, Pages B-676 through B-682
Buoy Drawings	:	Appendix C, Pages C-125 and 126

2.2.6 Germany

2.2.6.1 Pintsch Bamag AG

As one of the leading German and worldwide manufacturers of navigation aids equipment, this company currently offers marine lanterns, headlights, range lights, rotary beacons, and road traffic engineering devices and signals as produced in its plant in Dinslaken, West Germany. Not too many years ago, the company also offered completely outfitted navigation buoys to the German Ministry of Transport. The buoys would be designed by a German consulting firm (e.g. Compass GmbH) in cooperation with the Federal Waterways Authority's R&D branch (Seezeichenversuchsfeld), constructed by a German steel manufacturer such as Franz Hebold GmbH, and outfitted by PB Dinslaken for delivery to the FWA.

However, the buoy operations have recently been transferred to PB's subsidiary in the Netherlands (Stromag AG) and Dinslaken now only manufactures and supplies the equipment cited above. They can still offer a complete line of steel aid to navigation buoys for the world market when necessary and have the buoy hulls built in the Netherlands or in England.

The PB standard light buoys fall into two major categories: the DW series of deep water buoys with tail tubes and counterweights and the SW series of shallow water buoys with skirt keels. Typical examples of both types are shown in Figures 2-55 and 2-56 respectively for the DW and SW series buoys.

Among other navigation aids equipment manufactured by PB are gas lanterns. According to PB, the German ATON System prefers to use propane gas in steel lighted buoys since they are very economical. A 200 Kg. cylinder of liquid propane reportedly lasts more than a year on a lighted buoy. The character of the light obtained from propane gas is electronically programmed on most buoys.

References for Additional Information:

Interview Summary	:	Appendix A, Section A.2.6.1
Buoy Records	:	Appendix B, 12 Entries, Pages B-731 through B-778
Buoy Drawings	:	Appendix C, Pages C-140 through C-151

2.2.6.2 Weiselerbojen und Maschinenbau oHG

This firm manufactures steel and plastic inland waterways buoys for the German Federal Waterways Administration in accordance with the drawings and specifications prepared by the "Seezeichenversuchsfeld". The firm has been able to consistently bid the lowest prices for the construction of steel river buoys within the last 15-20 years. Its success has been attributed to the fact that a patented special mold was being used in forming the top and bottom halves of the thin steel buoy body which were then welded together along their overlapped annuli in a simple production operation. The completed buoy hulls are then shot-blasted to clean metal, the interiors are filled with plastic foam, outfitted, and painted in accordance with the specifications.

Photograph 2-6 shows typical red and green inland buoys, as manufactured by WB, on display at an exhibition.

References for Additional Information:

Interview Summary	:	Appendix A, Section A.2.6.2
Buoy Records	:	Appendix B, 2 Entries, Pages B-683 through B-690
Buoy Drawings	:	Appendix C, Pages C-136 and C-137

2.2.6.3. Compass GmbH

This is an engineering and consulting company which offers services to the German Federal Ministry of Transport for engineering and planning of the maritime traffic systems. Being located within one block of the

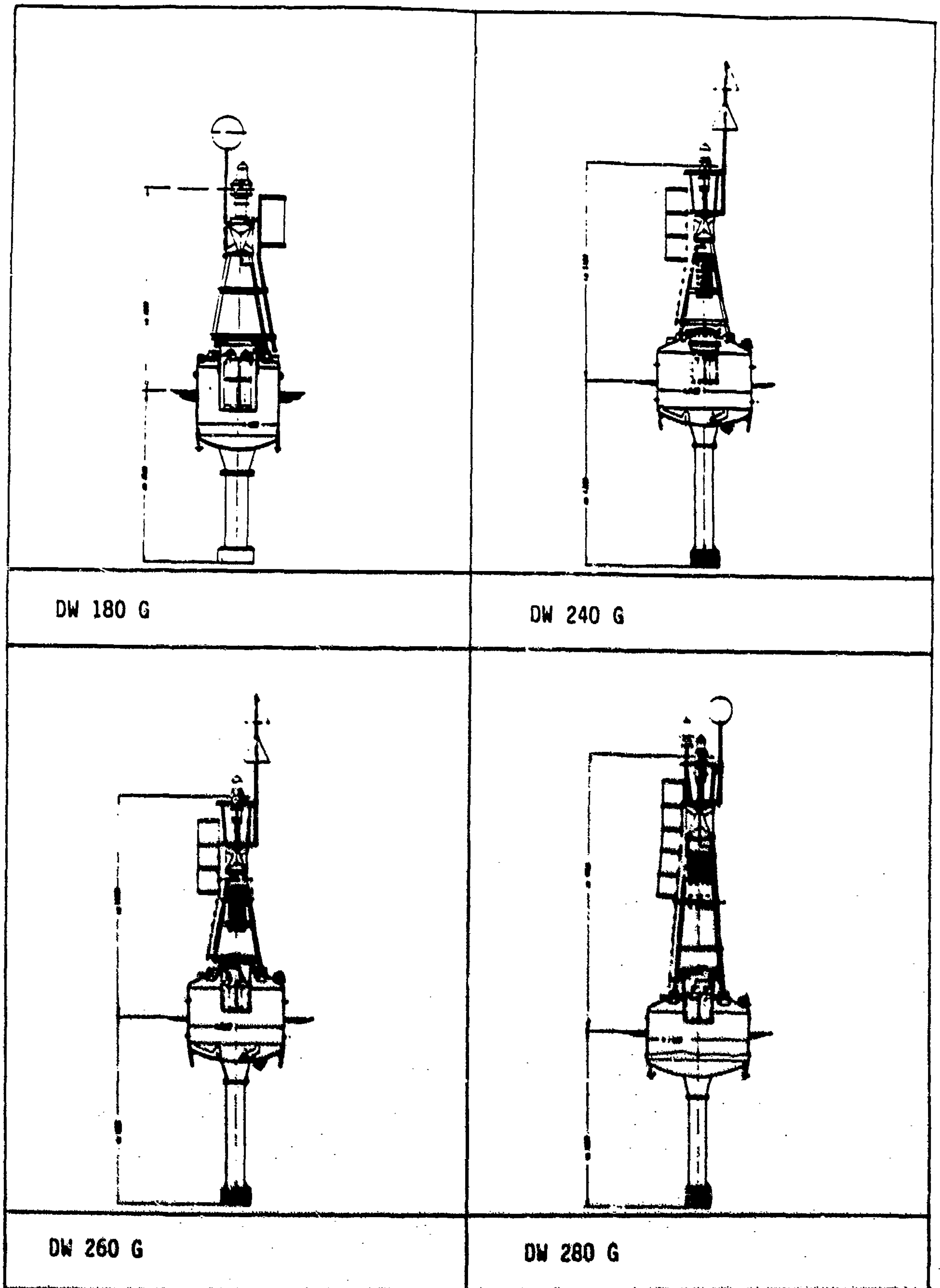


FIGURE 2-55
PINTSCH BAMAG DW
SERIES BUOYS

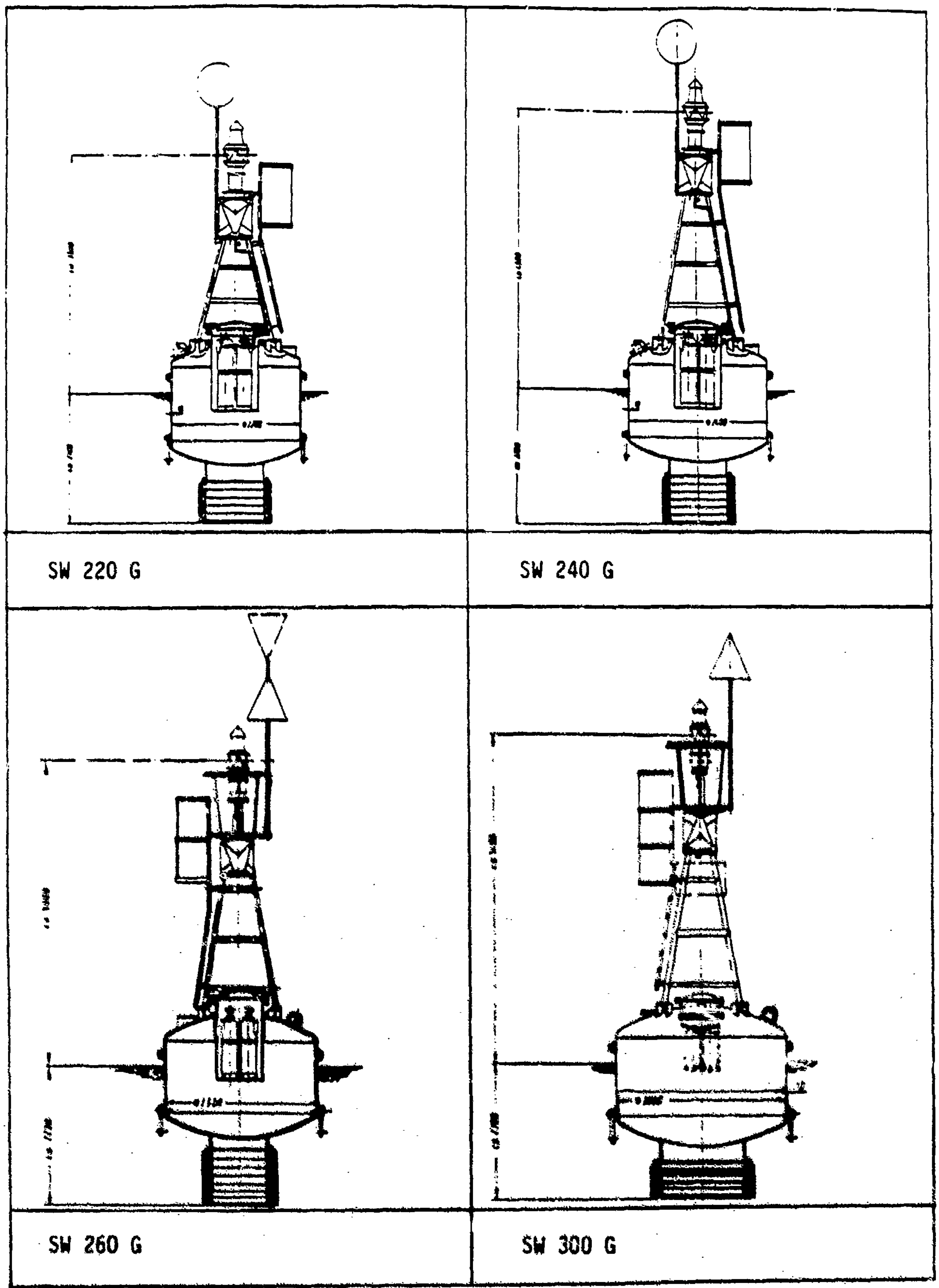


FIGURE 2-56
PINTSCH BAMAG SW
SERIES BUOYS

"Seezeichenversuchsfeld" facilities in Koblenz, Compass works for and in cooperation with SZVF in the development of ATON systems. Specific functions that they perform include the preparation of specifications, development of software, carrying out of necessary calculations for buoys, and conductance of optimization studies for new buoy designs.

References for Additional Information:

Interview Summary : Appendix A, Section A.2.6.3

2.2.6.4. Hebold Apparatebau and Maschinenfabrik GmbH

"Hebold" is an established steel buoy manufacturer according to the German Federal Ministry of Transport. However, it was not possible to secure a personal interview with this company. In response to the written survey questionnaire, "Hebold" stated that they do not wish to participate in this study. When in Germany to visit the German federal navigation authorities and other manufacturers, another request was made to Hebold. The managing director of the company stated again that they had not constructed any buoys for the German government during the past several years and that they did not have any buoys under construction presently. He added that for this reason, it would not be productive to visit their facilities in Cuxhaven.

It is known however that Hebold had constructed many types of steel aid to navigation buoys in the past which are still in use in the German waterways. Figures 2-57 and 2-58 show several types of lighted and unlighted steel buoys of Hebold manufacture.

References for Additional Information:

Interview Summary : Appendix A, Section A.2.6.4

2.2.6.5 Wilhelm Weule A/G

This company is located in Goslar, Germany and responded to the survey questionnaire. The response stated that the firm has no experience in the manufacturing of complete buoys and that they only deliver cut and polished glass drum lenses of 200 mm., 300 mm., 375 mm., and 500 mm. diameter.

References for Additional Information:

Interview Summary : Appendix A, Section A.2.6.5

2.2.7 Italy

Italy has a relatively small buoyage system but it is home to Resinex Offshore, S.r.l., which is one of the well known manufacturers of articulated beacons. Some data as well as a response to the survey questionnaire was received from Resinex.

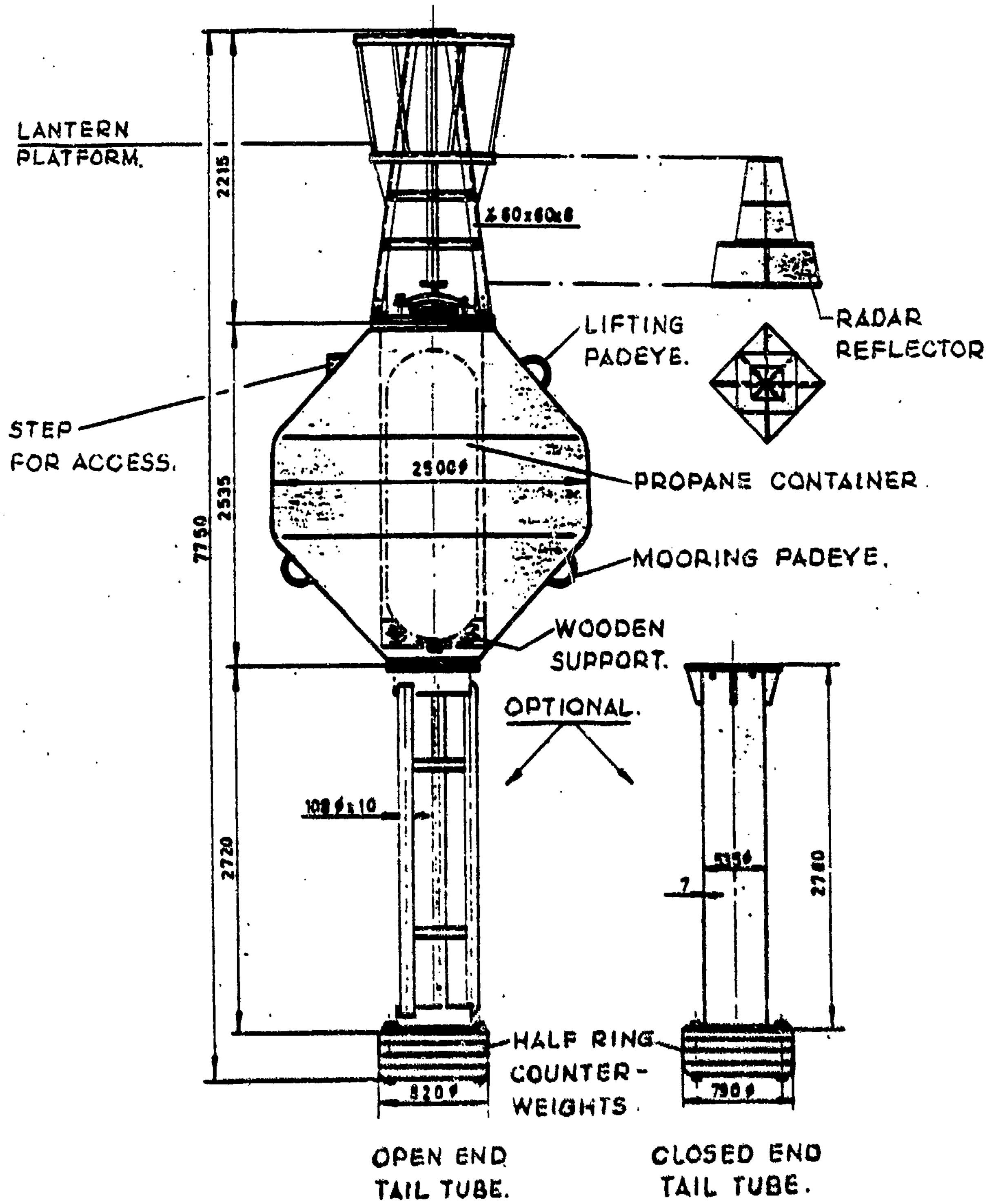


FIGURE 2-57
F. HEBOLD MANUFACTURE
STANDARD LIGHT BUOY

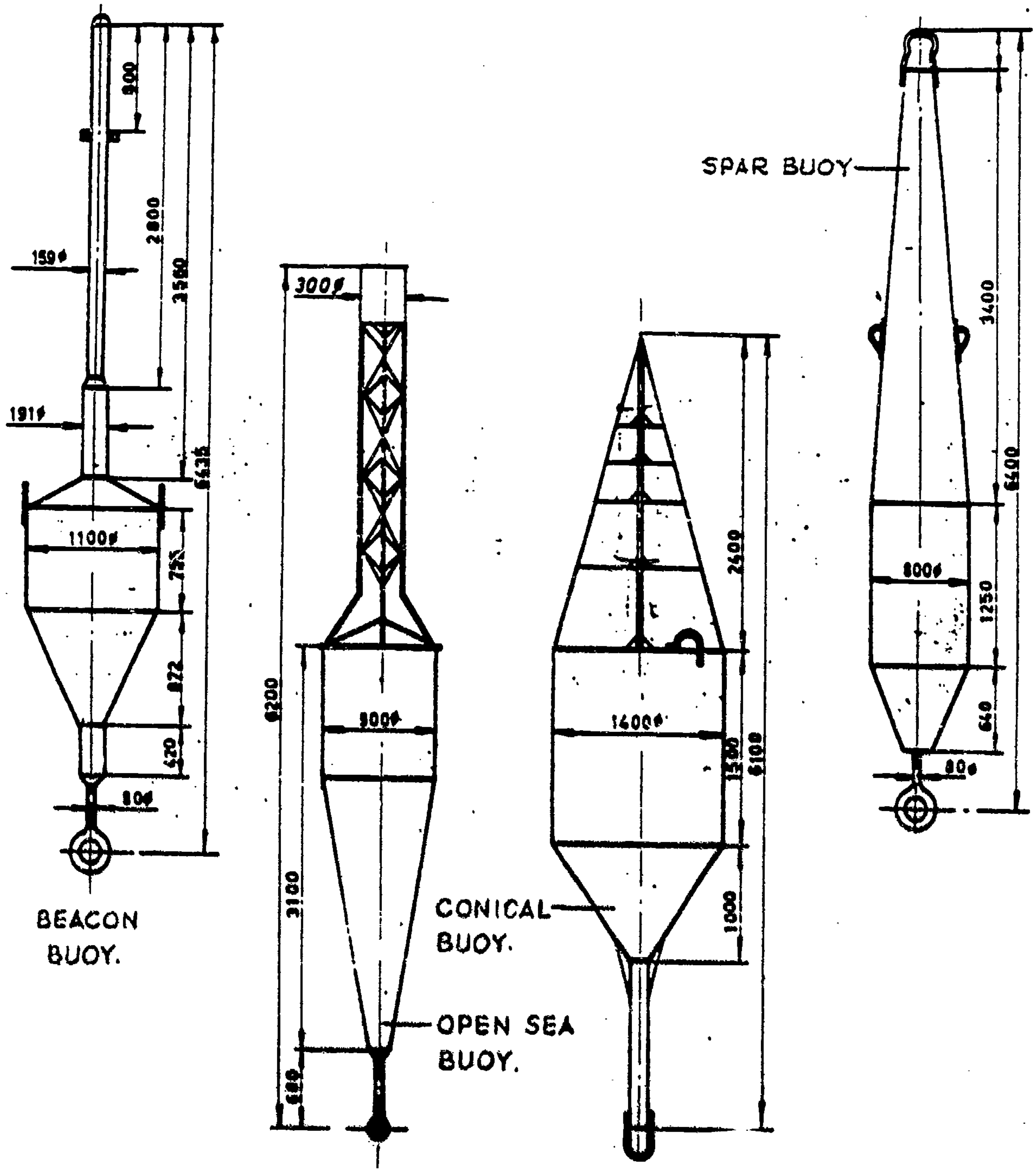


FIGURE 2-58
F. HEBOLD MANUFACTURE
UNLIGHTED BUOYS

Contacts were also made during the IALA 90 conference in the Netherlands with Resinex representatives and those of another Italian manufacturer, Floatex S.r.l.

2.2.7.1 Resinex Offshore S.r.l.

Resinex was established in 1961 and its facilities are located on the shores of Lake Iseo, North of Milan, in Italy. This firm has developed and realized the elastic beacon (an articulated navigation light) as a new signalling system to replace the traditional light buoys moored with chains.

According to the survey response, Resinex manufactures articulated beacons of their own design for use in water depths up to and more than 100 meters and with surface currents of 5-6 knots as well as subsurface currents of more than 2 knots. These beacons provide a very accurate signalling function. They have a high focal plane for optimum visibility; they exhibit less motion than buoys; they require less maintenance; and they serve as a stable platform for easy access during maintenance operations. The beacon does not rotate around its axis and thus provides an excellent possibility for the ideal arrangement of solar panels.

Possible configurations of the Resinex beacons are shown in Figure 2-59. The "Standard Beacon" functions as an elastic tension pile held vertical by a large fully submerged buoyancy chamber. A single mooring shackle and tension riser allows the pile restricted freedom to move under the effects of wind, wave, and current. This restricted movement assures that the beacon accurately marks the dredged channel, fairway, or obstacle.

The beacons can be provided with power sources such as solar photovoltaic panels, batteries, or gas containers.

Throughout its development, Resinex states, the articulated beacon has been subjected to significant improvements with regard to the float (buoyancy chamber) configuration and the connection joint of tension riser to sinker. They hold two patents on the design and shape of the float (one for open sea applications and one for fast currents) and one patent concerning the joint connecting the riser to the sinker.

<u>References for Additional Information</u>:

Interview Summary	:	Appendix A, Section A.2.7.1
Buoy Records	:	Appendix B, 2 Entries, Pages B-791 through B-796
Buoy Drawings	:	Appendix C, Page C-156

2.2.7.2 Floatex S.r.l.

Floatex (FLTX) is a manufacturer and supplier of buoys, elastic beacons (floating beacons), navigation aid signalling equipment, and additional non-ATON marine equipment.

THIS

PAGE

IS

MISSING

IN

ORIGINAL

DOCUMENT

FIGURE 259

140

Their buoys are constructed of steel and range in diameter from 1.3 meters to 2.6 meters. Each of six models come in either a skirt design or tail tube design. All except the smallest have a detachable cage which is bolted to the buoy body on welded stools. All tail tube buoys except the smallest have a detachable tail tube.

FLTX elastic beacons, shown schematically in Figure 2-60 are manufactured with a tubular steel structure which is sandblasted and galvanized, a foam filled plastic or metal subsurface float, a tower for signalling, a sinker and an elastic joint for mooring to the sinker. The elastic joint has been patented by FLTX.

They believe that their floating beacons have the following advantages:

- o Significantly enhanced position marking as compared to the traditional mooring chain as demonstrated in Figure 2-61.
- o High focal plane.
- o High stability which is also advantageous for maintenance operations as the platform is easier to approach and board than a buoy.
- o Reduced maintenance as a result of the absence of chain sections and significant structure at the waterline exposed to wave action.
- o The elastic tubular rubber joint connecting the beacon to the sinker provides the elasticity to absorb shock.

References for Additional Information:

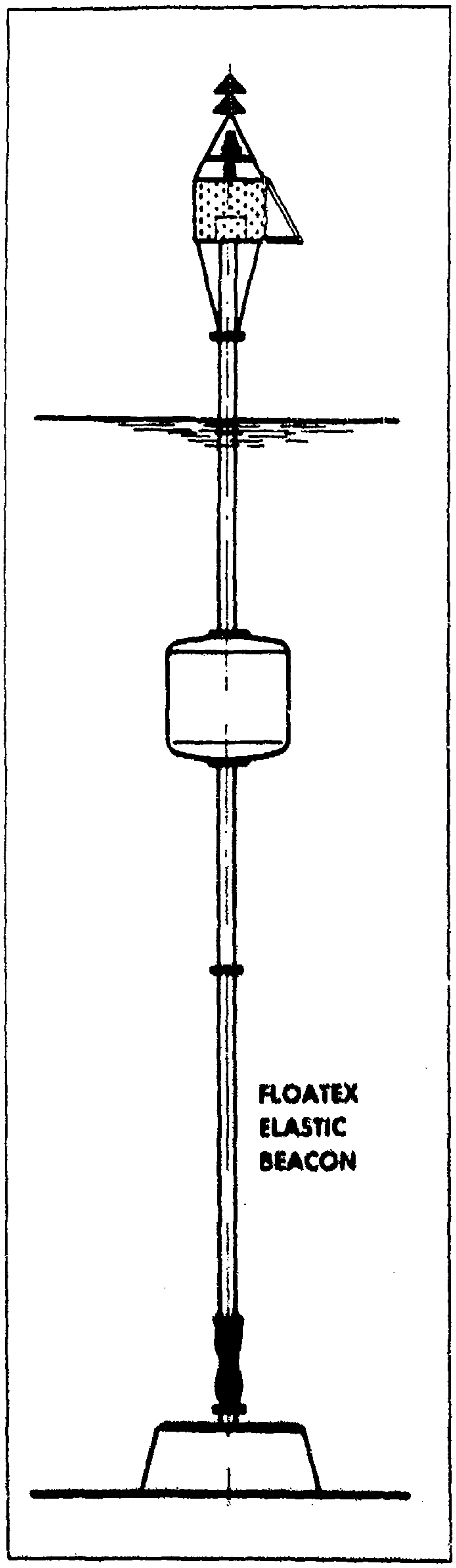
Interview Summary	:	Appendix A, Section A.2.7.2
Buoy Records	:	Appendix B, 1 Entry, Pages B-797 through B-799
Buoy Drawings	:	Appendix C, Page C-158

2.2.8 Japan

2.2.8.1 Nippon Kogi Kogyo Co., Ltd.

The Nippon Kogi Kogyo Co., Ltd. (NKK) manufactures buoys and buoy equipment of various types. The Japanese authority type L-3, L-2 and L-1 steel buoys were designed in conjunction with MSA by NKK. The last design was completed 8 years ago.

NKK believes a steel buoy with FRP superstructure may be an optimum configuration providing a lighter aid with lower maintenance requirements. The elimination of the requirement to have an upper platform for light changing, and therefore stiffer structure, would help this development as would changes in the buoy tender requirements.



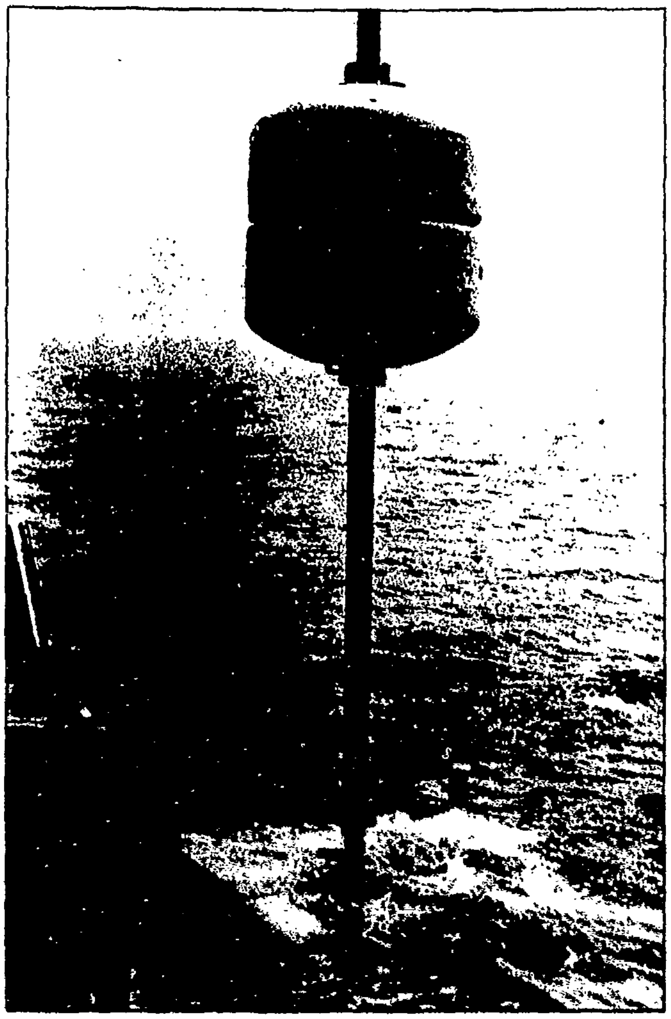


FIGURE 2-60
FLOATEX ELASTIC
BEACON

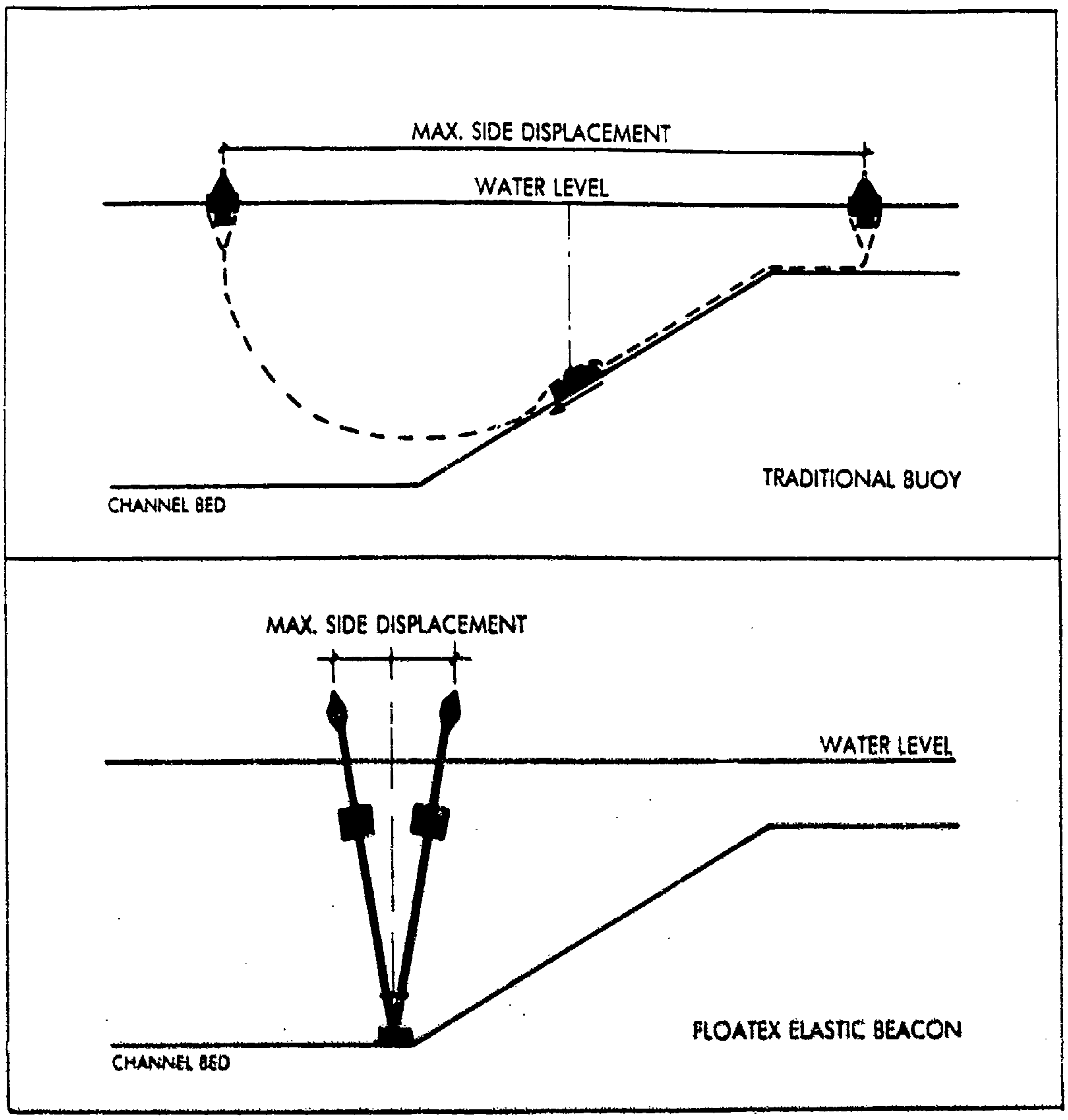


FIGURE 2-61
BUOY VS. FLOATING
BEACON MARKING
ACCURACY

To overcome the effects of buoy motion on light visibility they believe a broader beam light is necessary. One possible solution is the NKK LED light shown in Figure 2-62 and discussed earlier in Section 2.1.7.1 in the summary to the IALA '90 Conference paper 3.1.5. The light intensity is lower but broad and it can be seen for a few miles. The reasons for developing this light included this characteristic and the low power consumption. The wide beam is an outfall of the LED light concept.

NKK has also developed a paint marking system to help detect ships striking buoys, shown in Figure 2-63. They believe the success of this system is such that 50% of all ships striking and damaging buoys are identified.

References for Additional Information:

Interview Summary	:	Appendix A, Section A.2.8.1
Buoy Records	:	Appendix B, 5 Entries, Pages B-856 through B-875
Buoy Drawings	:	Appendix C, Pages C-174 through C-176

2.2.8.2 Ryokuseisha Corporation

The Ryokuseisha Corporation (RS) manufactures a wide range of buoys, articulated beacons, power supplies (including wave-generators), and various signalling equipment for buoys.

The beacons manufactured by RS intended for the open sea are constructed of steel and are of both the tail tube and skirt type ranging in diameter from 1.2 to 3.0 meters. They also have a series of open sea steel buoys specially designed and fitted with wave generators ranging in size from 1.36 to 6.0 meters in diameter. Their smaller range of buoys, used for location marking in harbors and rivers or in designating dangerous areas and working areas for dredging and reclaiming are manufactured of various plastics including polyurethane foam, FRP with polyurethane foam filling and ABS resins. Figure 2-64 shows three of these plastic buoys.

The buoys with wave-activated generators are also configured with solar panels and batteries to supplement the wave generator where necessary. RS has provided a comparison of purely wave-activated generator buoys and solar/battery powered buoys with results shown in Table 2-14. It is indicated that the initial cost of the wave generator system is higher but the semi-total costs of over a 10 year period are 6-7% less, with any damage or repair to solar panels neglected.

RS also has a standard series of floating beacons which they call Light Tower Buoys as shown in Figure 2-65. In early February they installed 13 of the MITV-10RA types in Tokyo Bay and 31 in Osaka Bay. The RS floating beacons have both the floatation chamber and the buoy body constructed of steel. The connection to the mooring is by a patented universal joint developed in Australia. As required by the Japanese authority all the beacons in Tokyo and Osaka Bays had synchronized flashing systems.

RS also has a ship paint marking system for identifying ships colliding with buoys.

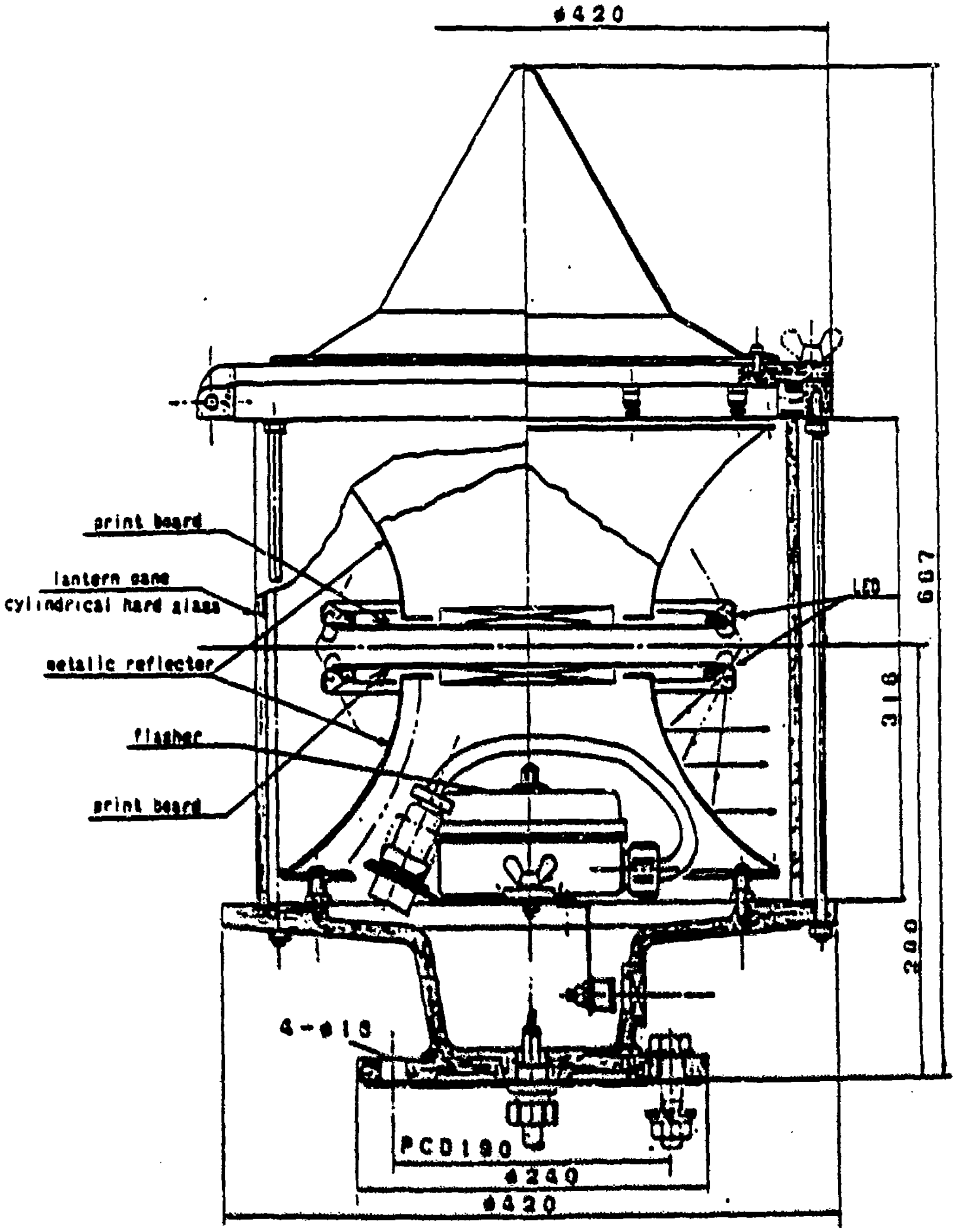


FIGURE 2-62
NIPPON KOGI KOGYO'S
LED LIGHT

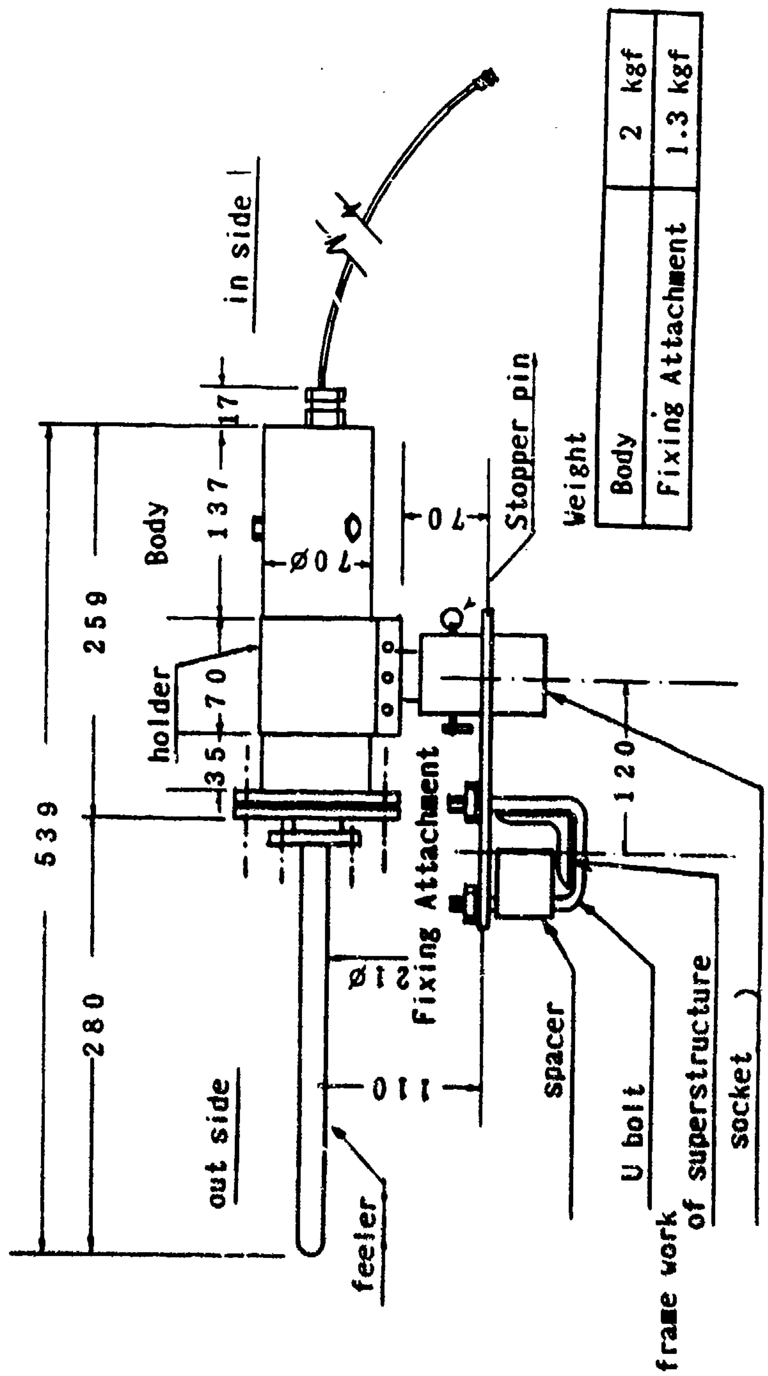


FIGURE 2-63
NIPPON KOGI KOGYO'S
COLLISION MARKER

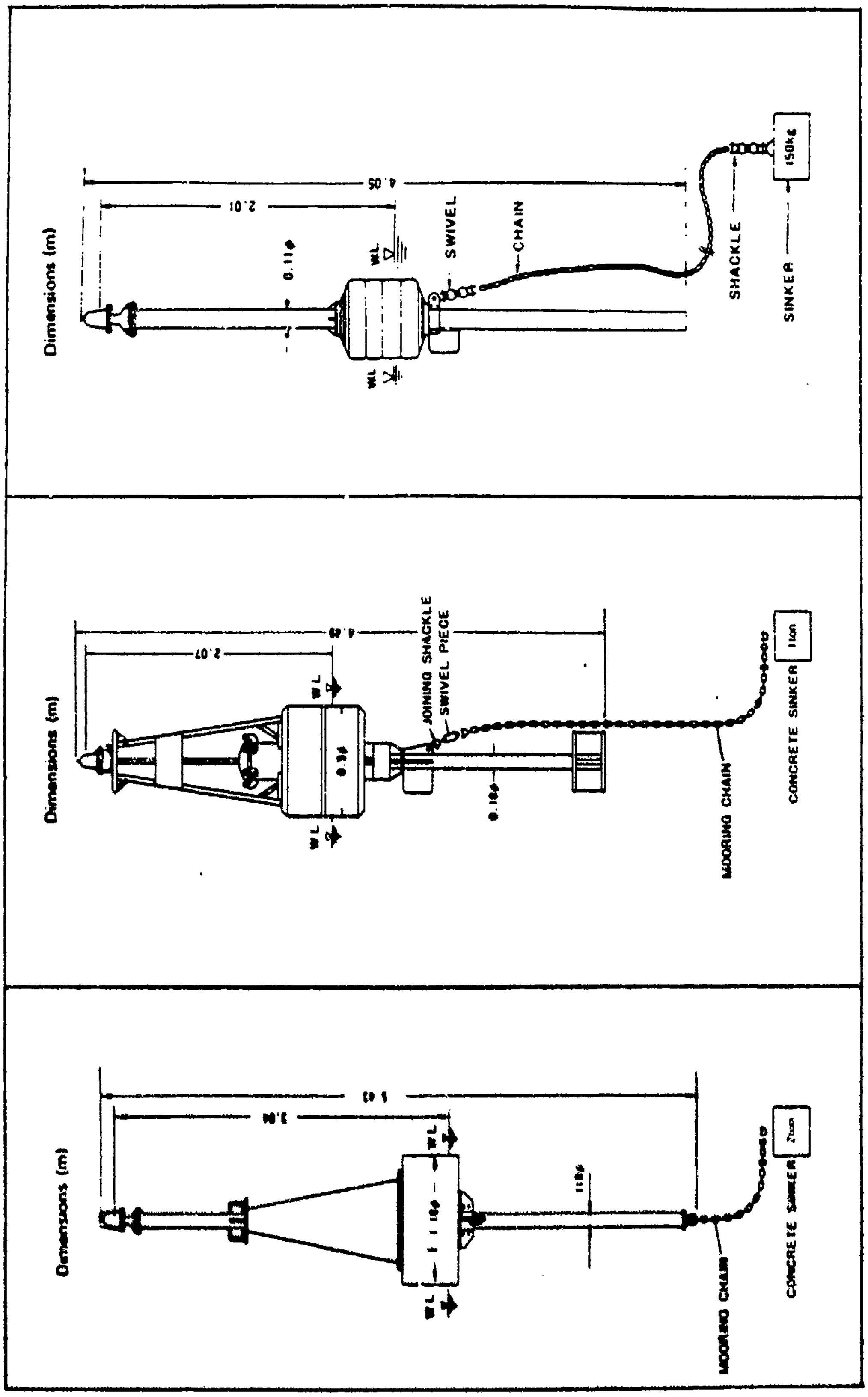


FIGURE 2-64
RYOKUSEISHA'S
PLASTIC BUOYS

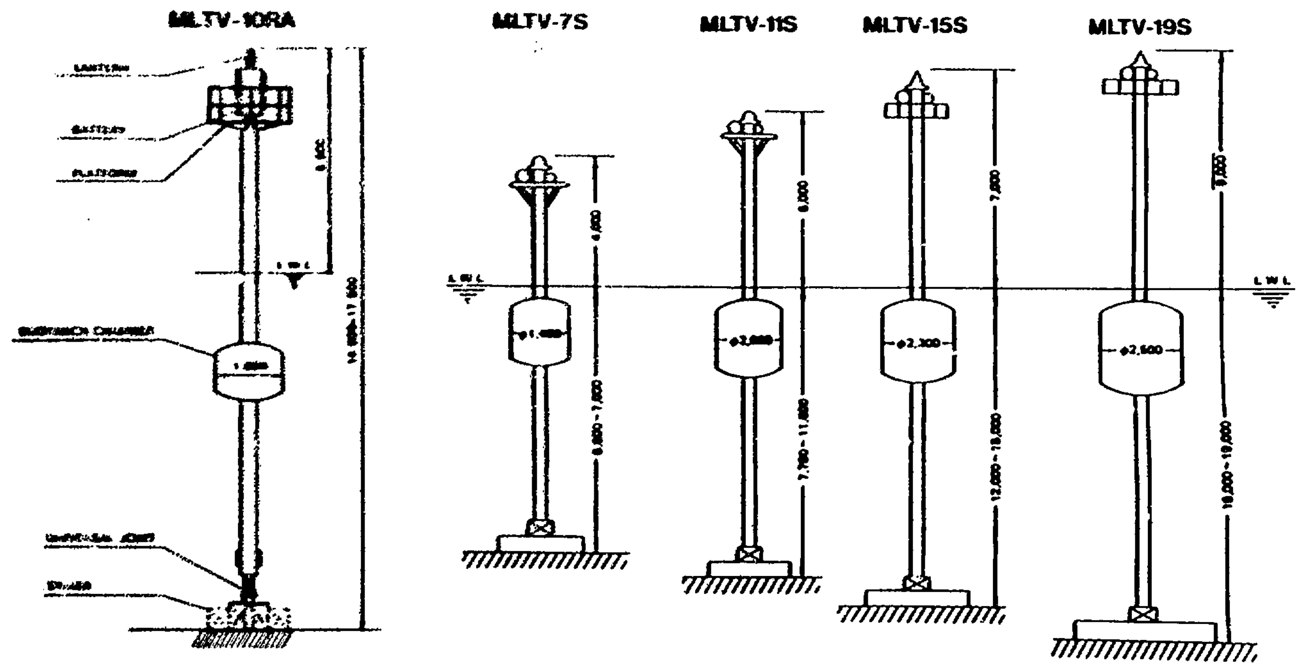
	Wave-activated Generator System	Solar Battery Power Supply System
Cost of whole unit	100.0	79.2
Cost per output unit	100.0	155.3
Cost per weight unit	100.0	64.3
Cost per area unit (required for power generation)	100.0	56.8
Maintenance Cost: 0-2 years 2-4 years 4-6 years	 100.0 215.0 391.0	 150.0 300.0 525.0

The aggregate cost for 10 years can be assessed as follows for each system:

	Wave-activated Generator System	Solar Battery Power Supply System
Cost of Power Generator	US$5,570.00	US$3,889.00
Cost of Maintenance for 10 years	US$10,548.00	US$13,363.00
Total : (@¥135/$)	US$16,118.00	US$17,252.00

Note: 1) In case of Solar Battery Power Supply System, where solar panels are often broken, the above cost does not include such expenses for repairs and changes of solar panels. In case of Wave-activated Generator System, its turbine, generator and valves scarcely break down.

TABLE 2-14
RYOKUSEISHA COSTS -
SOLAR VS. WAG
COMPARISON



ITEM / DESIGNATION	MLTV 7S	MLTV 11S	MLTV-[illegible]RA	MLTV-15RA	MLTV 19RA
DEPTH (m)	6m–7m	8m–11m	10m–14m	12m–15m	16m–19m
MAIN MATERIAL	SS41	SS41	SS41	SS41	SS41
LANTERN	L 123 123mm/mLENS	L 123 123mm/mLENS	ML-156 156mm/mLENS	ML 156 156mm/mLENS	ML 156 156mm/mLENS
INTENSITY (cd)	12V6W 60cd	12V6W 60cd	12V12, 8W 300cd	12V13, 8W 240cd	12V13, 8W 240cd
LUMINOUS RANGE	[illegible]	[illegible]	10.8km	16.8km	16.8km
POWER SOURCE	SOLAR SYSTEM or BATTERY	SOLAR SYSTEM or BATTERY	SOLAR SYSTEM or BATTERY	SOLAR SYSTEM or BATTERY	SOLAR SYSTEM or BATTERY
CURRENT (knot)	LESS THAN 2	LESS THAN 2	LESS THAN 2-4	LESS THAN 2-4	LESS THAN 2-4
RADAR REFLECTOR	OPTION	OPTION	OPTION	OPTION	OPTION
SINKER	CONCRETE SINKER 6ton	CONCRETE SINKER 6ton	CONCRETE SINKER 11ton	CONCRETE SINKER 10ton	CONCRETE SINKER 20ton

* Figures of concrete sinker weight are just standard. Please refer these figures.

FIGURE 2-65
RYOKUSEISHA'S MLTV
SERIES LIGHT TOWER
BUOYS

References for Additional Information:

Interview Summary	:	Appendix A, Section A.2.8.2
Buoy Records	:	Appendix B, 19 Entries, Pages B-876 through B-951
Buoy Drawings	:	Appendix C, Pages C-178 through C-182

2.2.8.3 Zeni Lite Buoy Co., Ltd.

Information on Zeni Lite Buoy Co., Ltd. (ZLBC) buoys was forwarded by the Japanese and Australian authorities and was also obtained from ZLBC at the IALA '90 Conference.

ZLBC manufactures a wide range of navigation buoys and floating beacons. The buoys include lighted steel and tail tube types, unlighted polyurethane foam filled steel types, swift current steel or aluminum buoys with tail tube or disc type hulls, and severe sea condition foam filled steel and aluminum hull/superstructure types and some smaller GRP light buoys.

ZLBC manufactures a line of resilient light beacons. These are available for water depths from 10 meters to 25 meters and currents up to 3.0 knots. The construction is predominantly of steel for strength and rigidity with an aluminum superstructure to increase stability and lessen heeling presumably due to the lighter weight. The connection to the mooring is by a short chain although other connections will be considered as shown in Figure 2-66.

References for Additional Information:

Interview Summary	:	Appendix A, Section A.2.8.3
Buoy Records	:	Appendix B, 21 Entries, Pages B-952 through B-1029
Buoy Drawings	:	Appendix C, Pages C-194 through C-197

2.2.8.4 Gakuyo Toki Kogyo Co., Ltd.

Gakuyo Toki Kogyo Co., Ltd. (GTK) is a manufacturer/supplier of various electronics and equipment for aids to navigation buoys. GTK does not design or manufacture the buoy themselves, but they do supply the topmarks for aid to navigation buoys.

GTK has found that buoy lighting systems worldwide do not have the best reliability. On the other hand, GTK has a lighting system that can last 10 years as opposed to others only lasting 3 years. The cost of the 10-year system is approximately 150% of the cost of the 3 year system. This high reliability system is the GT-200S which incorporates a lamp changer, flasher and a molded glass lens. The lamps themselves have a life of 500 hours.

GTK is currently developing a Global Positioning System (GPS) driven unit which periodically checks the position of the buoys on which it is carried.

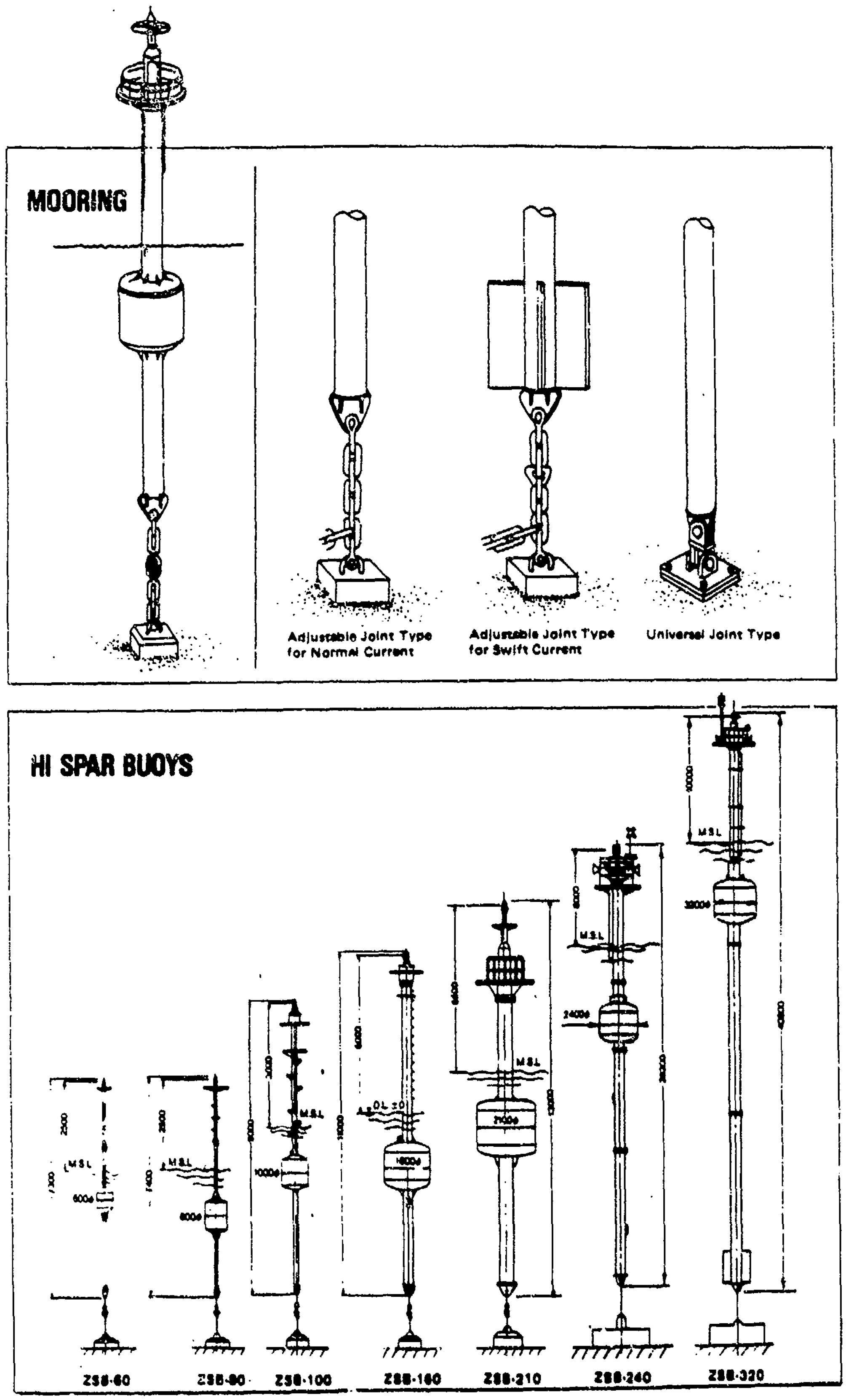


FIGURE 2-66
ZENI LITE'S BEACONS
AND MOORING OPTIONS

References for Additional Information:

Interview Summary : Appendix A, Section A.2.8.4

2.2.9 The Netherlands

2.2.9.1 Stromag N.V./Pintsch Bamag N.V.

In the Netherlands Pintsch Bamag works within the firm Stromag N.V. (Stromag), who is the largest supplier of ATON in this country. (Also see Pintsch Bamag in Section 2.2.6.1.)

Stromag delivers 50-100 buoys per year, the principal types being their 2.2 meter (SW 220 EZ) and 2.6 meter (SW 260 EZ) steel buoys which are shown in Figure 2-67. Construction is subcontracted to a Dutch fabricator but all work is done in accordance with Stromag designs. Most of Stromag's buoy hull business is in third world countries.

Stromag believes that the topmark approach to lateral identification is better than buoy body shape significance as it allows for provision of a reasonable access to the signalling devices atop the buoy. They fit rubber fenders to the upper part of the buoy body to offer some protection from collision and have found that utilizing 10 mm thick plate results in buoys lasting 25-30 years.

Powering of Stromag buoys is by solar charging of batteries. In tropical areas they change batteries between 2-5 years. In the Netherlands, battery changes occur at 7-8 year intervals. To maintain long life of a battery, a good solar regulator is most important. Direct and constant charging of batteries is not good.

It is important to see a light at 4 to 5 miles. Wider angle light is more effective even though the light may be less powerful.

References for Additional Information:

Interview Summary : Appendix A, Section A.2.9.1
Buoy Records : Appendix B, 5 Entries, Pages B-1036 through B-1055
Buoy Drawings : Appendix C, Pages C-202 through C-206

2.2.9.2 All Marine

All Marine services range from procurement/installation of buoys and other navigational aids to the completion of detailed port surveys and the provision of pilotage services.

Recently they did have an opportunity to design a buoy for ice conditions, which they call the All Weather Duty Buoy which is shown in Figure 2-68. This project was initiated based on their experience with The Netherlands authority on damage to buoys in ice during 1987. This buoy was modeled after the U.S. Coast Guard 7 x 20 LI lighted Steel Navigational Ice

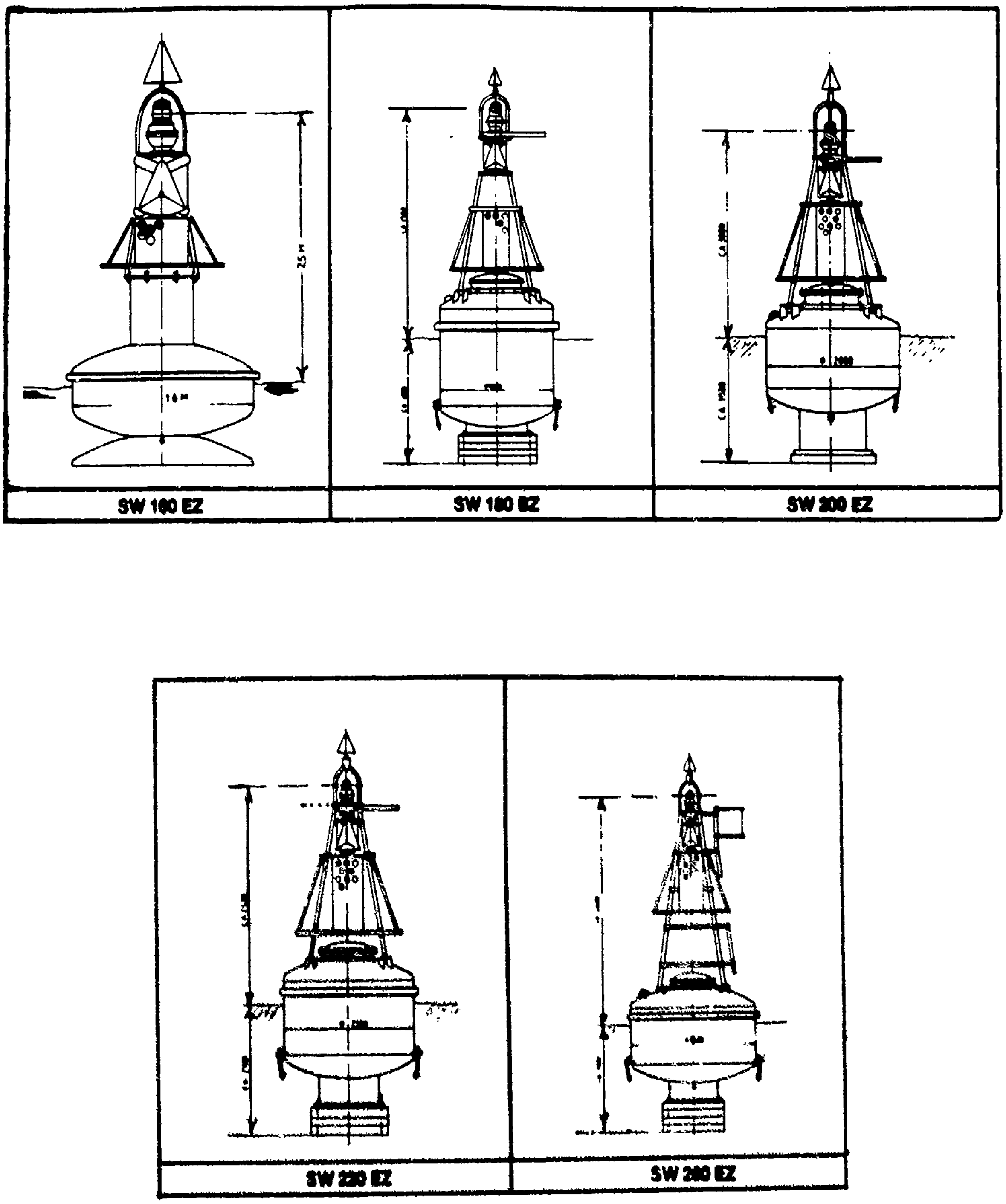


FIGURE 2-67
STROMAG/P. BAMAG
STEEL BUOYS

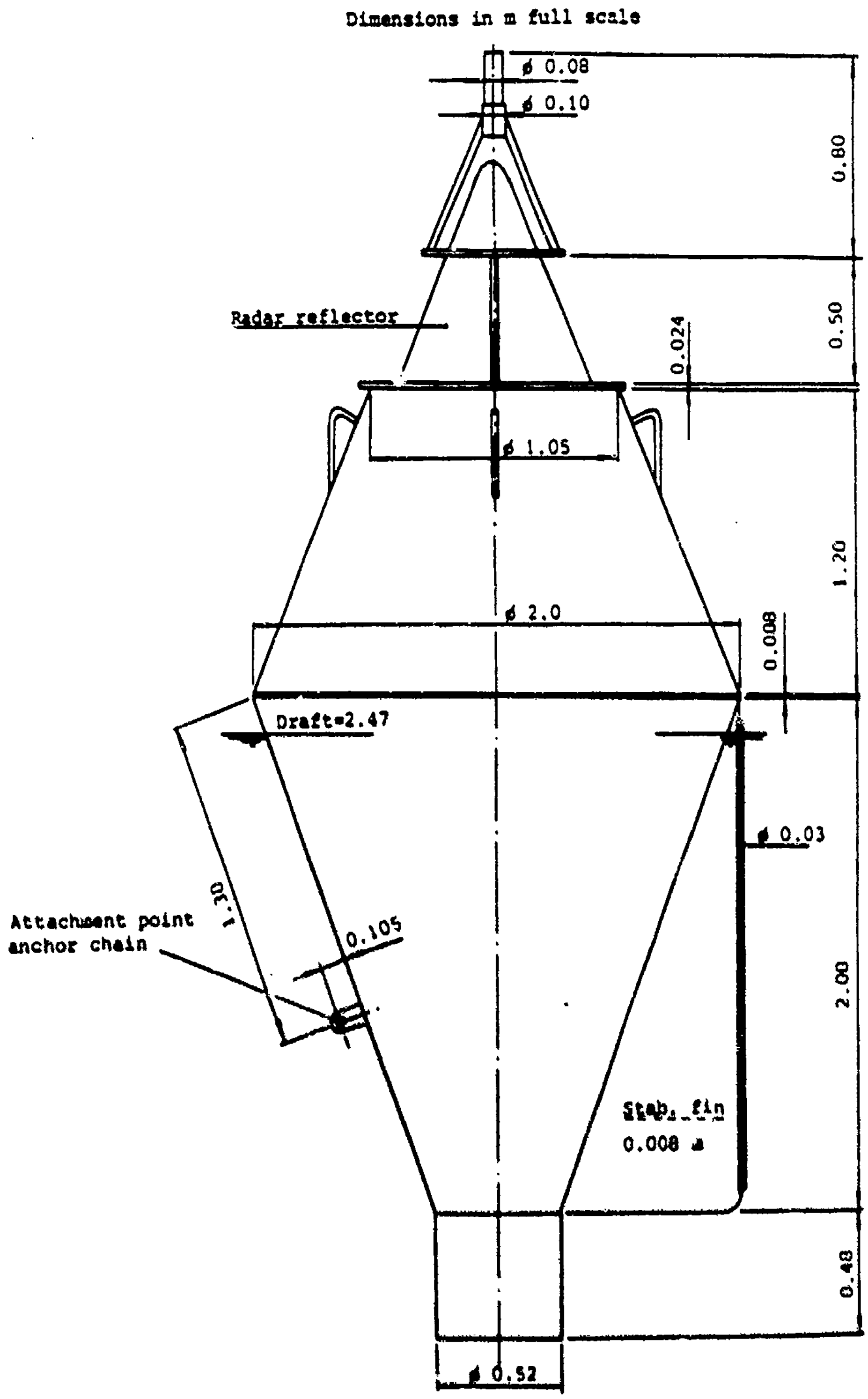


FIGURE 2-68
ALL MARINE'S
HEAVY DUTY LIGHTED
BUOYS

Buoy. It is constructed of steel with three watertight compartments and was model tested at MARIN (see Section 2.2.9.3 below) to verify its performance characteristics. There has been no ice in the Netherlands since the buoy's placement and hence the success of their efforts is not known.

References for Additional Information:

Interview Summary : Appendix A, Section A.2.9.2
Buoy Records : Appendix B, 1 Entry, Pages B-1056 through B-1058
Buoy Drawings : Appendix C, Page C-208

2.2.9.3 The Research Institute Netherlands (MARIN)

The Maritime Research Institute Netherlands (MARIN) performs research and development, comprising of consultative assistance, mathematical modeling and model experiments for the shipbuilding, shipping and offshore industry and for Governmental and Inter-Governmental bodies. MARIN has at times developed mathematical modeling for buoys and has conducted model testing. The buoys have usually been larger mooring buoys of companies such as SBM, IMODCO, SOFAC. Their personnel have published some work on buoy hydromechanics.

MARIN has carried out testing for All Marine on a navigation buoy intended for use in extreme environmental conditions including ice. Ice tests were carried out utilizing paraffin to model ice as shown in Figure 2-69. They note that in conducting tests it is more cost effective to test several buoy models simultaneously as the greatest cost is for rental of the tank which can accommodate several buoy tests simultaneously.

MARIN has been active in the field of training pilots and ship officers in ship handling with their real-time simulators. They have also been involved in sea traffic and accident analyses and have a Vessel Traffic Services (VTS) simulator for training of VTS operators.

References for Additional Information:

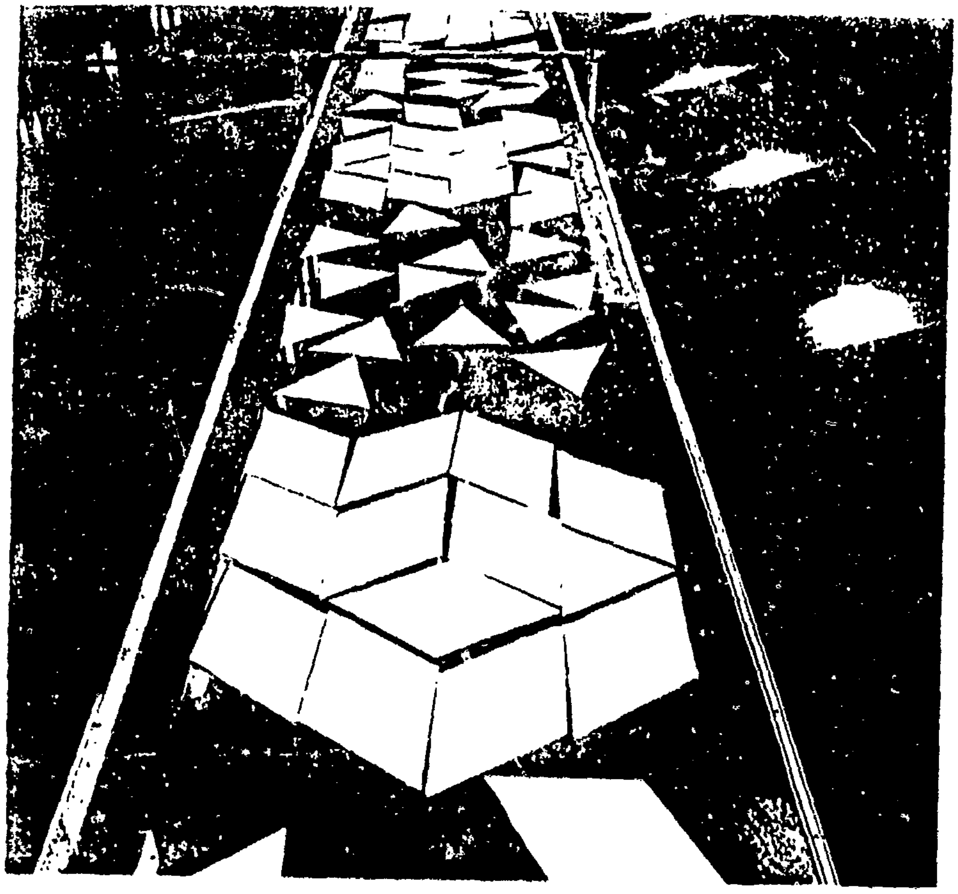
Interview Summary : Appendix A, Section A.2.9.3

2.2.9.4 Marine Analytics B.V.

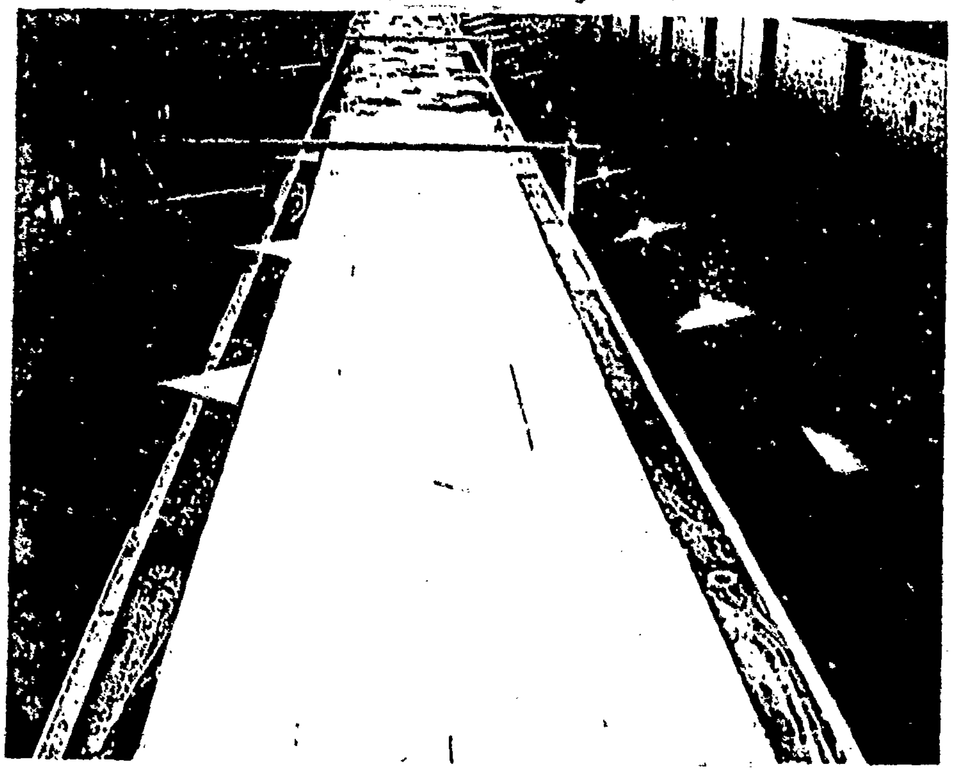
Marine Analytics B.V. is a consultant involved in marine traffic and navigation investigations.

They were involved in a study by the Netherlands authority to consider the improvement of navigation on the North Sea considering the coherence of the total system rather than by improvement of the several individual components, reported on at the IALA '90 Conference and summarized in Section 2.1.8.

This study was based on the fact that the use of radars is widespread on board ships. They have assumed 90% of all vessels will have a



Ice clogged coverage 60%



Ice clogged coverage 100%

FIGURE 2-69
MARIN: PARAFFIN/ICE SIMULATION IN TANK

radar and 75% of all others will have two radars. Within 6 or 7 miles of shore, all ships will need the visual aids and pleasure boaters will need it the most when close to shore. Farther offshore, RACONS or selected lighthouses should provide adequate markings to be identified by ship's radar. Therefore, the amount of offshore buoyage can be reduced from today's levels. Figure 2-70 demonstrates the buoyage reductions off the coast of the Netherlands.

References for Additional Information:

Interview Summary : Appendix A, Section A.2.9.4

2.2.9.5 Damen Shipyards

Damen Shipyards have a number of yards throughout the world producing small to medium sized vessels of all types.

They have built a number of buoy tenders. Figure 2-71 demonstrates the six classes of tenders for which data were obtained during the IALA '90 Conference.

References for Additional Information:

Interview Summary : Appendix A, Section A.2.9.5

2.2.10 Norway

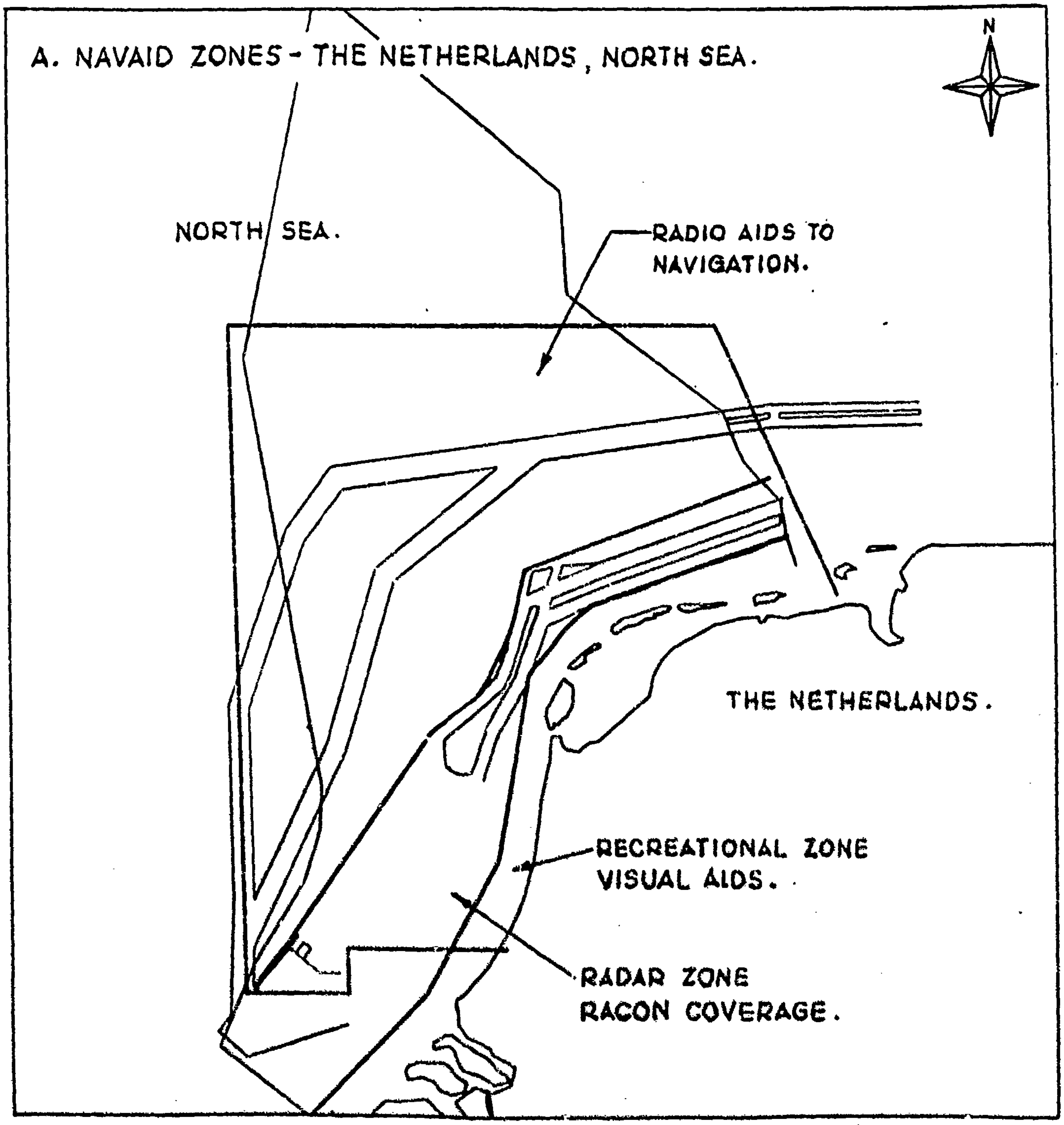
2.2.10.1 Ticon Plast Industries A/S

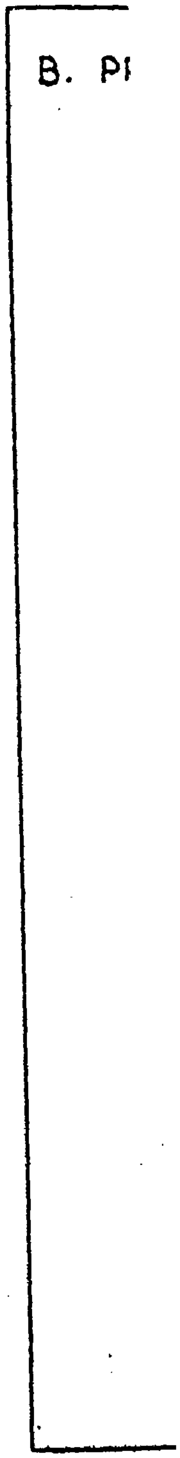
Ticon Plast (TP) manufactures the line of ATON buoys known by the trade name of "SELCO MARITIME SYSTEMS". Its plant is in Drammen, Norway where these plastic buoys are manufactured manually by a hand lay-up process. TP stated that the number of buoys procured per year by the Norwegian Coast Directorate does not justify investing in an automatic production line for ATON buoys. The company does have mold and pattern shops and employs other types of production processes including vacuum injection, wet-vacuum molding, and press-molding when and if required by the customer's specifications.

SELCO MARITIME buoys are identified by type numbers. Table 2-15 lists the principal characteristics of various types and Figure 2-72 is an illustration of the Type 7 lighted buoy which is being used by the Norwegian Coast Directorate.

References for Additional Information:

Interview Summary : Appendix A, Section A.2.10.1
Buoy Records : Appendix B, 11 Entries, Pages B-1083 through B-1124
Buoy Drawings : Appendix C, Pages C-210 to C-213 and C-216 to C-226


A. NAVAID ZONES - THE NETHERLANDS, NORTH SEA.
N
NORTH SEA.
RADIO AIDS TO NAVIGATION.
THE NETHERLANDS.
RECREATIONAL ZONE VISUAL AIDS.
RADAR ZONE RACON COVERAGE.


B. P

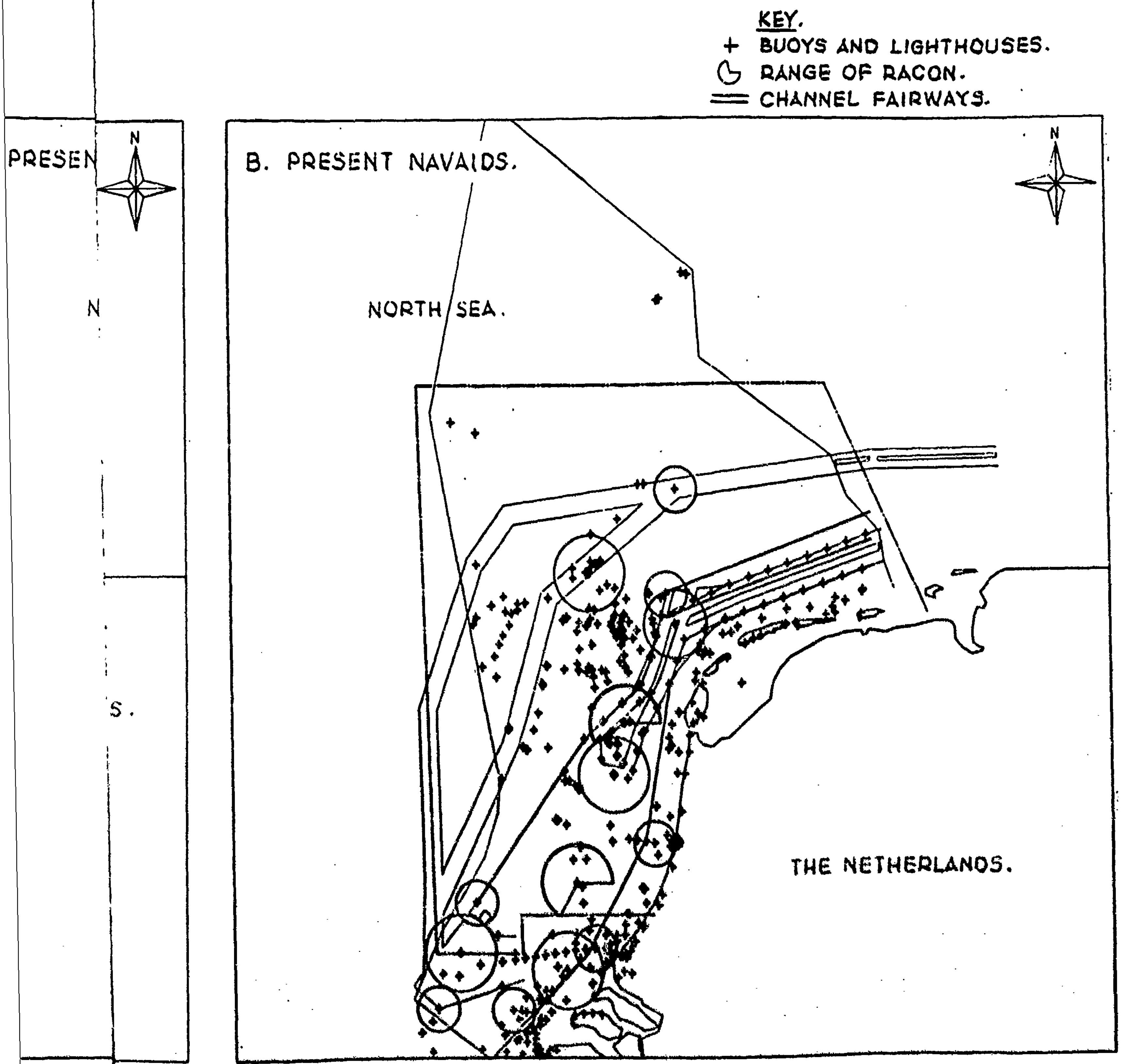
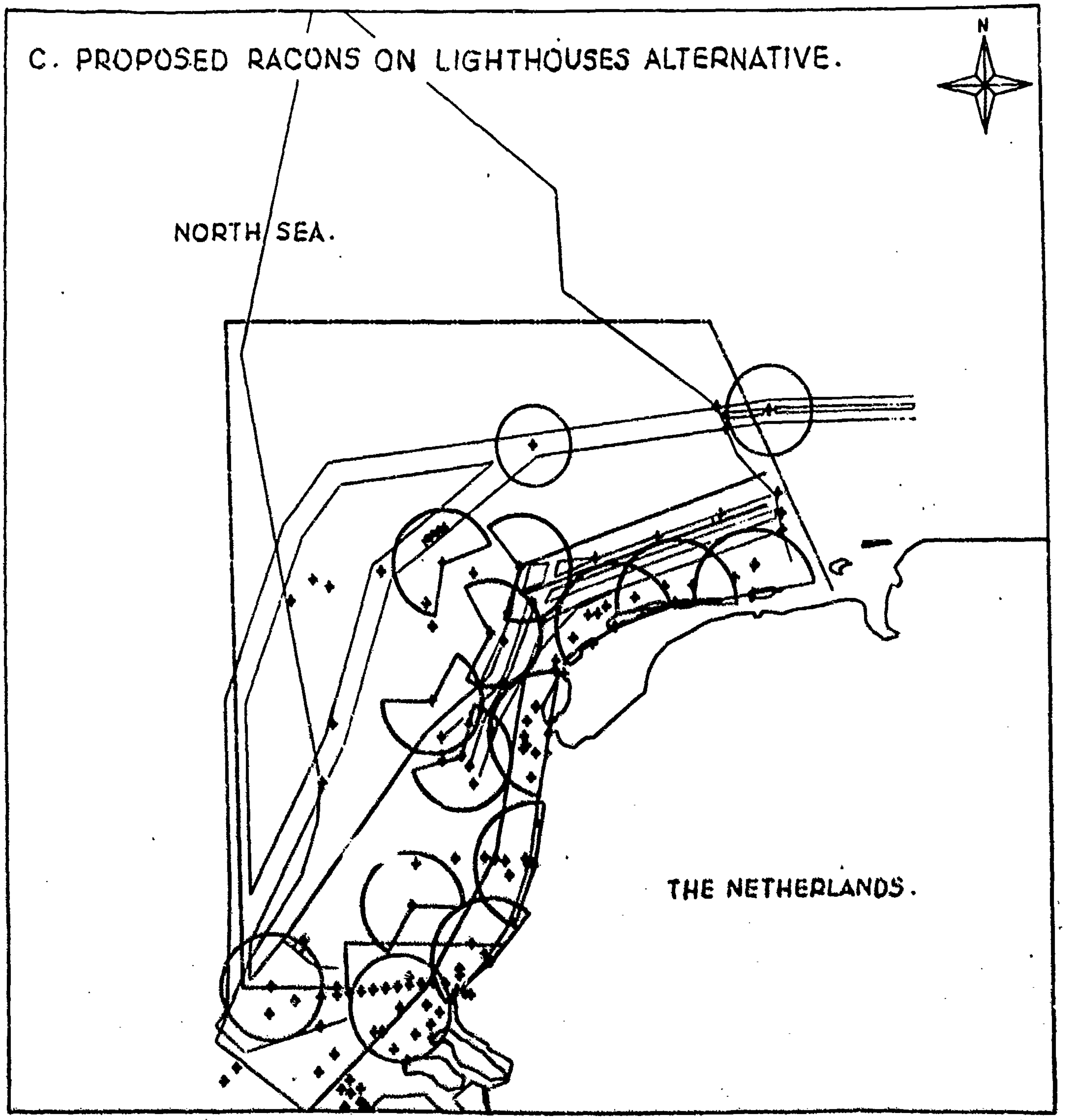
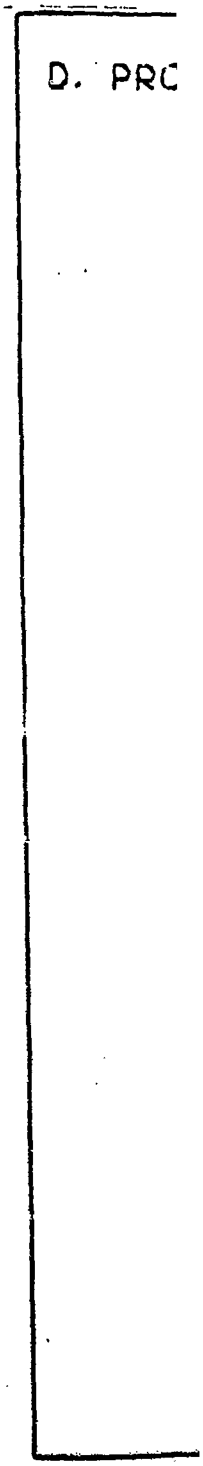


FIGURE 2-70-A
MARINE ANALYTICS:
NORTH SEA COASTLINE
MARKING


C. PROPOSED RACONS ON LIGHTHOUSES ALTERNATIVE.
N
NORTH SEA.
THE NETHERLANDS.


D. PRC

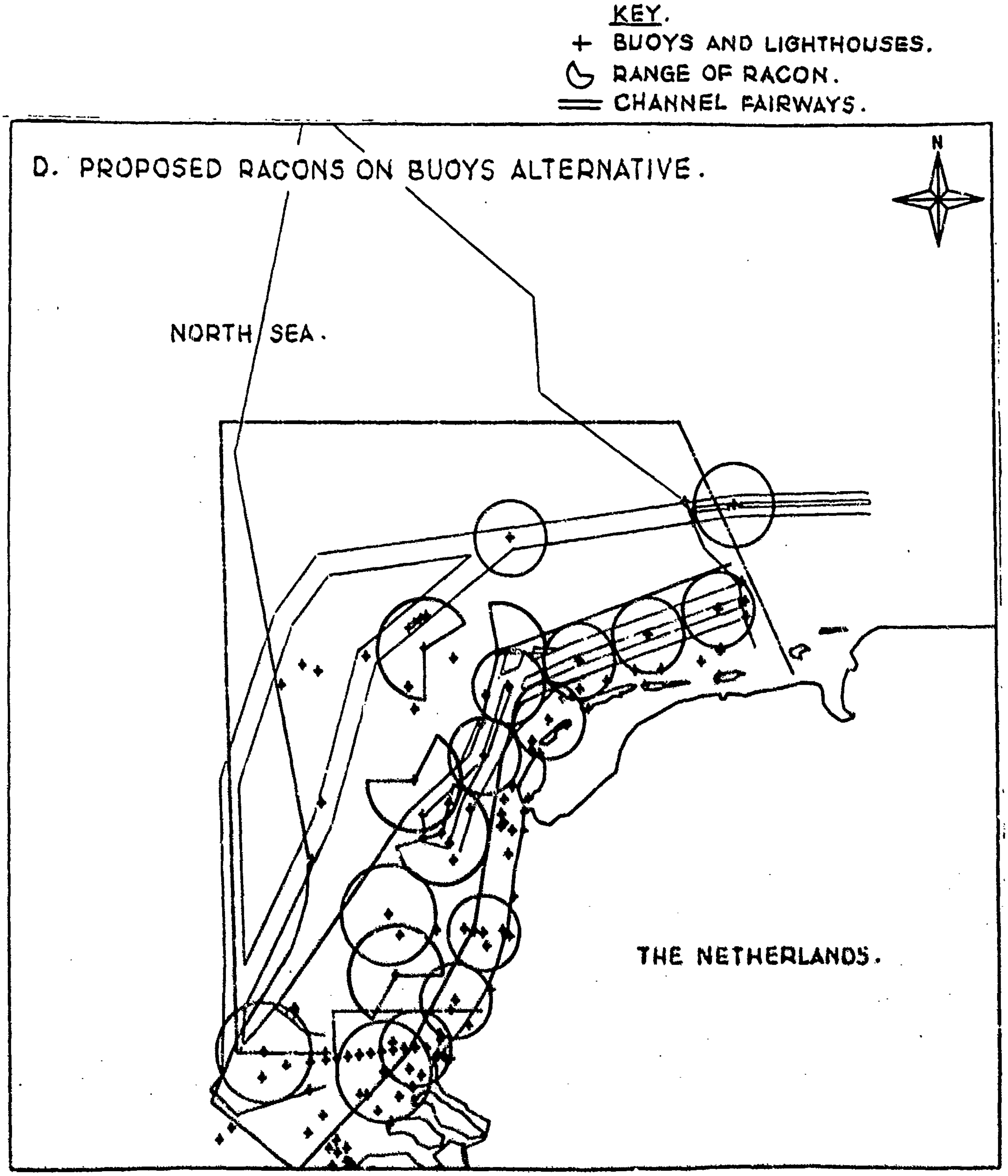
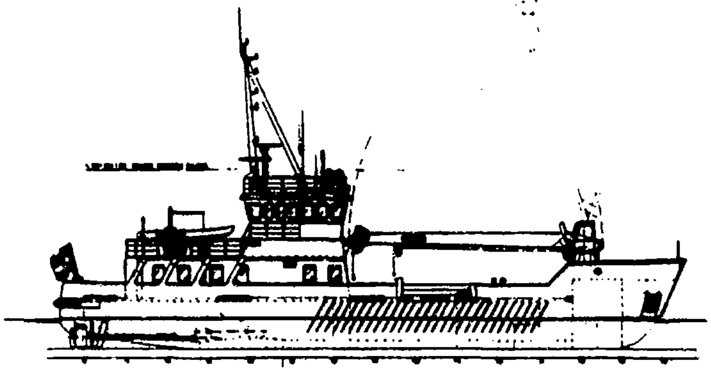
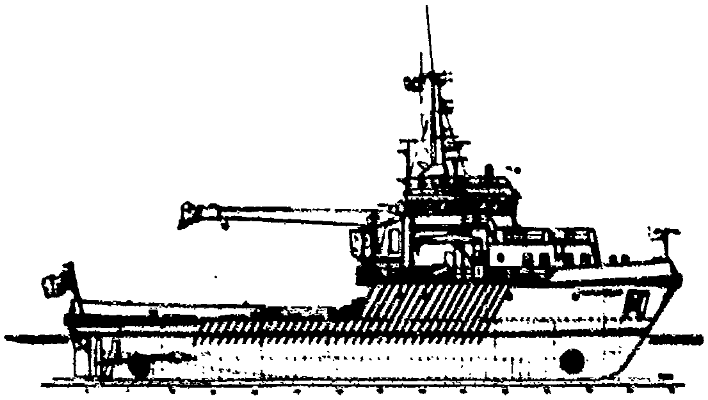


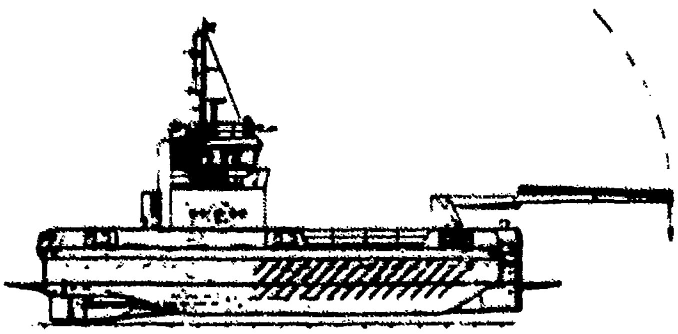
FIGURE 2-70-B
MARINE ANALYTICS:
NORTH SEA COASTLINE
MARKING



1. M.V. NIEUWE DIEP - LOA 38.00m

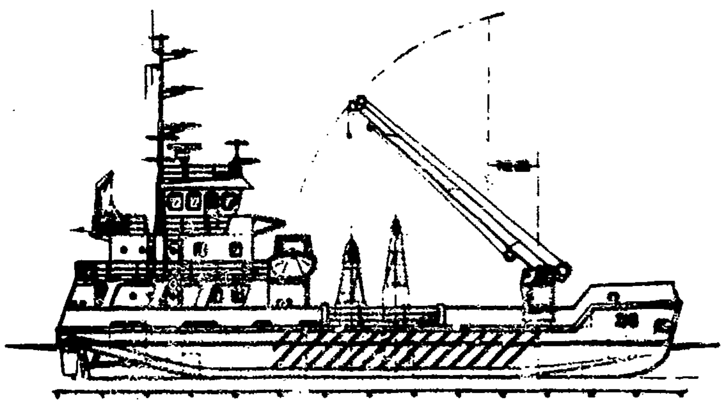


2. M.V. ROTTERDAM - LOA 44.40m

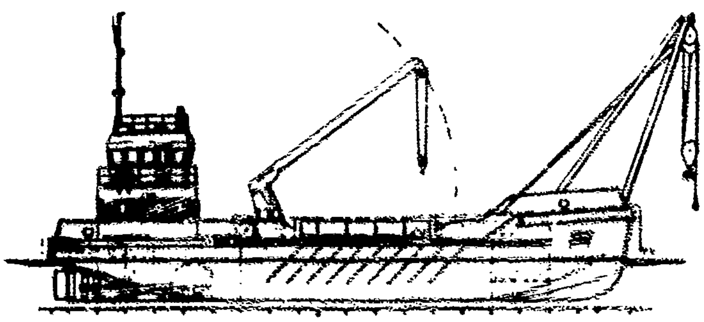


3. DAMEN MULTI CAT 25x10 - LOA 24.96m

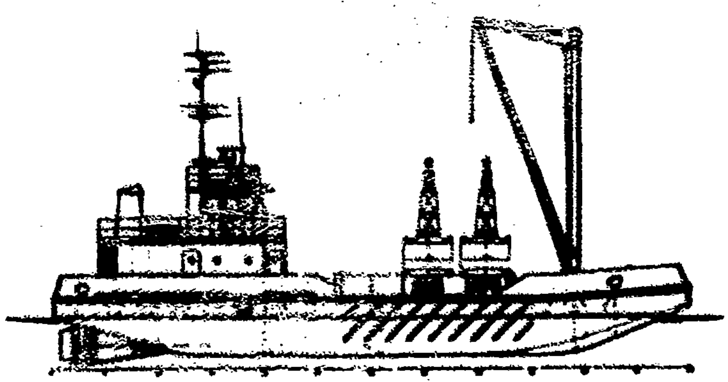
FIGURE 2-71
DAMEN SHIPYARD:
BUOY TENDER DESIGNS



4. M.V. MONTEVIDEO - LOA 35.06m



5. M.V. DIVING - POT 1 - LOA 30.00m



6. M.V. SAMBUIA - LOA 30.00m

FIGURE 2-71
Continued

KEY.

H - BUOY LENGTH (HEIGHT).

h - FOCAL HEIGHT.

Ø - DIAMETER.

m - METERS.

	Rigid Plastic						
Type	4	5	6	7	8	9	10
H m h m Ø m	7.65 5.00 0.41	4.30 2.80 0.42	3.80 1.85 0.58	6.10 4.05 0.58	5.00 2.25 0.80	2.85 1.80 1.22	3.15 2.10 1.22
Volume dm^3	175	300	500	600	1400	900	2050
Weight kg	45	50	110	140	130	145	185
Ballast kg	65	100	150	200	600	350	350

						Resilient Plastic	
Type	11	16	23	24	25	26A	26B
H m h m Ø m	4.60 3.00 2.30	7.15 4.40 0.70	1.20 0.60 0.61	2.00 1.35 1.22	1.75 1.10 1.22	3.95 2.35 1.00[3]	5.60 3.30 1.00[2]
Volume dm^3	1950	1100	180	2050	900	1760	2460
Weight kg	365	245	40	150	105	480	600
Ballast kg	575	500	40	400	395	450	600

TABLE 2-15
TICON PLAST BUOYS

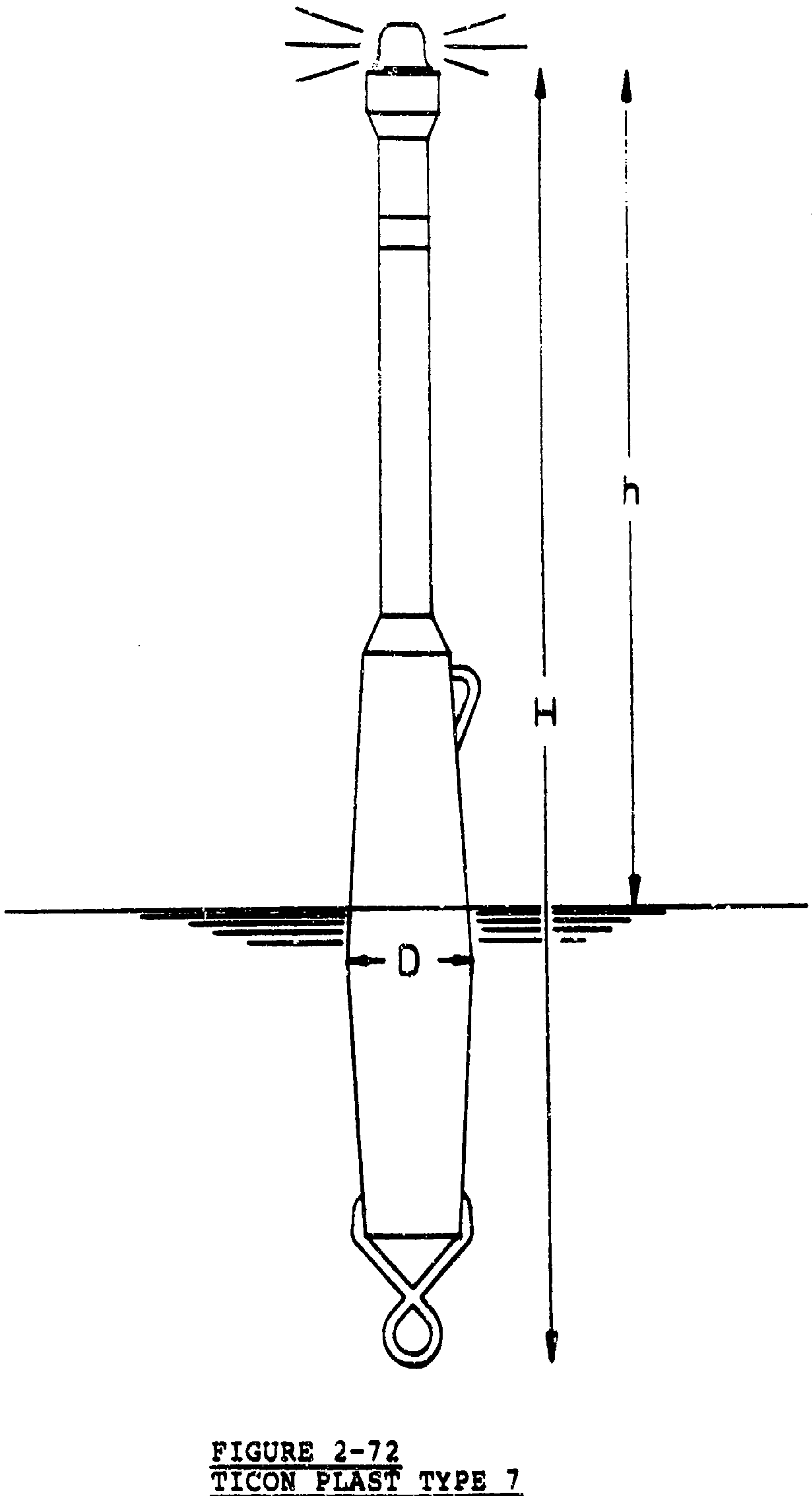


FIGURE 2-72
TICON PLAST TYPE 7
LIGHTED BUOY

2.2.11 United States

2.2.11.1 Tideland Signal Corporation

Tideland Signal Corporation (Tideland) carries out research, engineering and production of navigational aids and solar electric generators including lanterns, fog signals, buoys and electric monitoring systems. At one time Tideland maintained a large number of aids and marks for the oil industry in the Gulf of Mexico which were maintained with 90 ft. boats.

Tideland stated that they were pioneers in GRP buoys. These were developed for countries having limited equipment to maintain buoys. Two of their earliest GRP buoys purchased by the City of Cleveland, Ohio 20 years ago are still in use. These were derived from an early USCG design.

Tideland has carried out extensive testing with plastic to determine the best materials for buoy applications. They believe that some plastic buoys have suffered from being developed without a well thought out design or quality construction.

Their latest plastic buoy design, the 5'-9" diameter SB-138 Sentinel Navigation Buoy shown in Figure 2-73, was developed on a systems basis. It has a fiberglass core. The outside of the buoy body is shielded by a 4" thick elastomer skin to absorb impacts. The solar panels are integrated into the hull and it has an internally fitted Luneberg lens.

They have built some very different types of GRP buoys. The Sentinel SB-826 Series C sea buoy shown in Figure 2-74 is constructed of flat fiberglass panels with spiral wound filament. These buoys are filled with polyurethane foam and have been repaired on site. Their 8 ft. diameter hull is fitted with deck-mounted battery boxes and a ladder leading to the signalling devices mounted atop the radar reflector. Some features noted for this buoy are: easier servicing and prolonged on-station life, 50% weight reduction over similar steel buoys, and the bulkheads in the foam-filled floatation compartments.

Tideland manufactures the SAB-12 Sentinel Articulated Buoy shown in Figure 2-75. This has been a successful design with the use of a taut moor between the sinker and the hull which avoids the buildup of structural loads that can occur in more rigid connections like universal joint. The taut moor is pre-tensioned by the use of a buoyancy chamber constructed of Surlyn foam.

Tideland believes that in order to reduce the cost of buoys, it would be prudent to consider manufacturing and inventory economics. For example, if buoy size could be scaled down to a more unified and standardized basis perhaps different type and size buoys could be assembled from identical components. This would provide an assembly system from limited inventory components of any size and type buoy. They also believe that procurement policies based on purchasing buoy components separately inhibits an integrated system design approach.

Tideland believes that as RACON technology advances it may be used to determine whether a buoy is on station or not, and if not, its RACON code could change automatically to warn mariners.

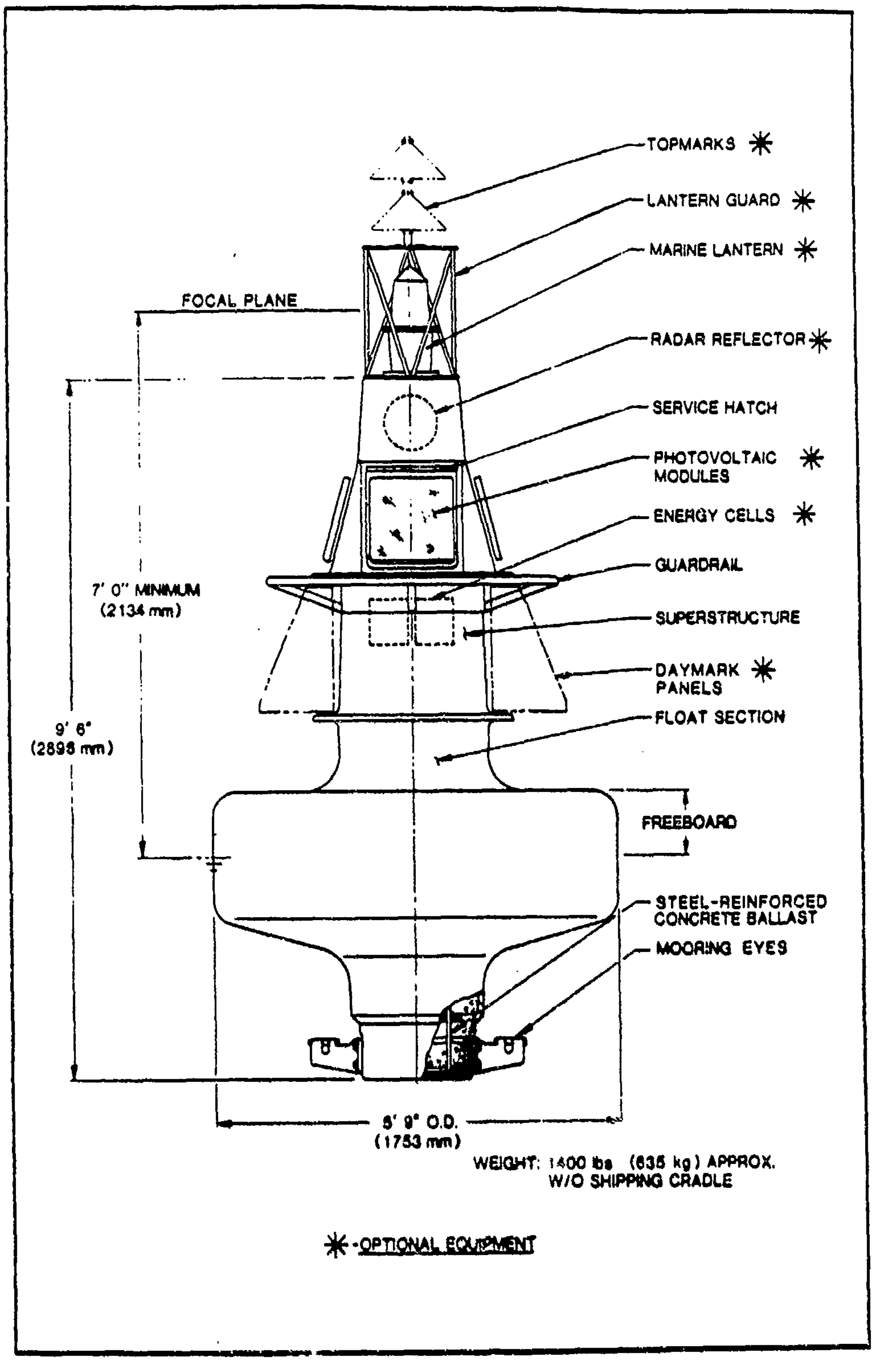


FIGURE 2-73
TIDELAND'S SB-138
SENTINEL ELASTOMER
SKIN GRP BUOY

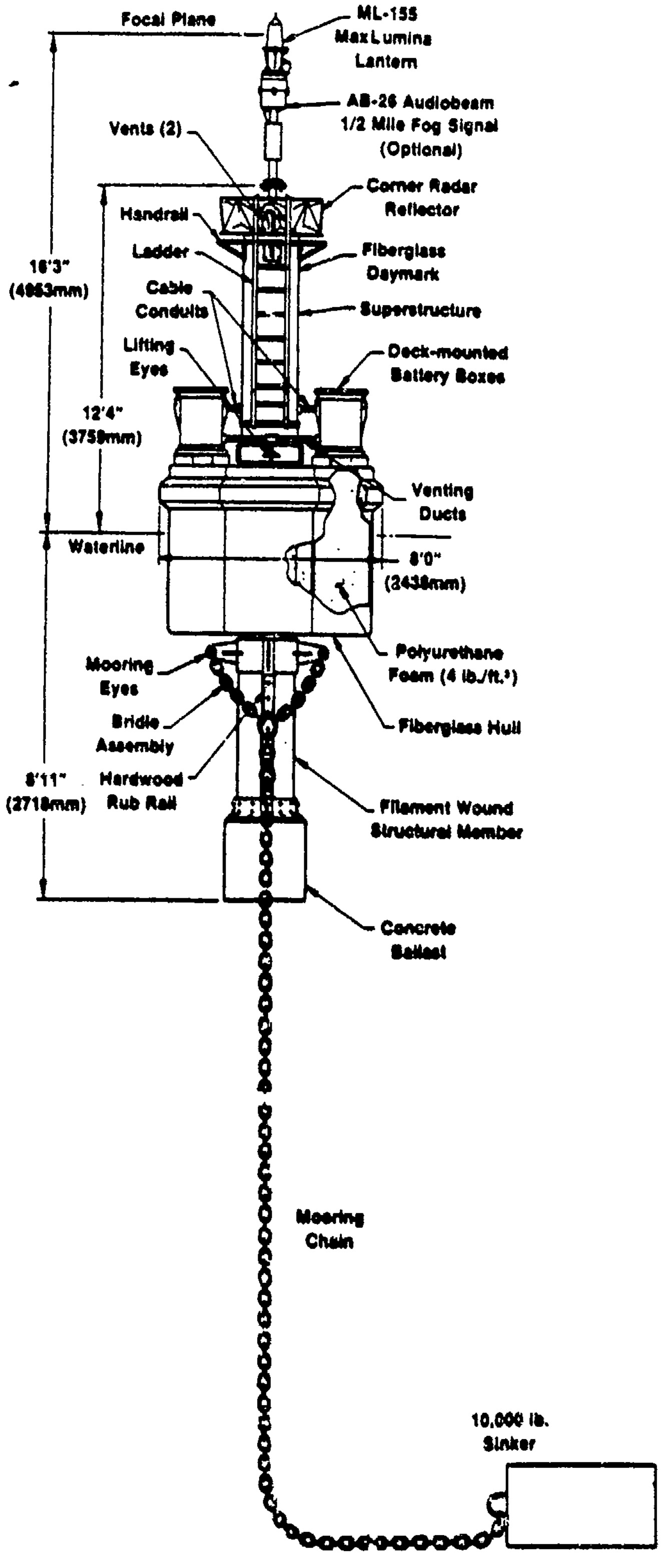


FIGURE 2-74
TIDELAND'S SB-826
SENTINEL GRP
SEA BUOY

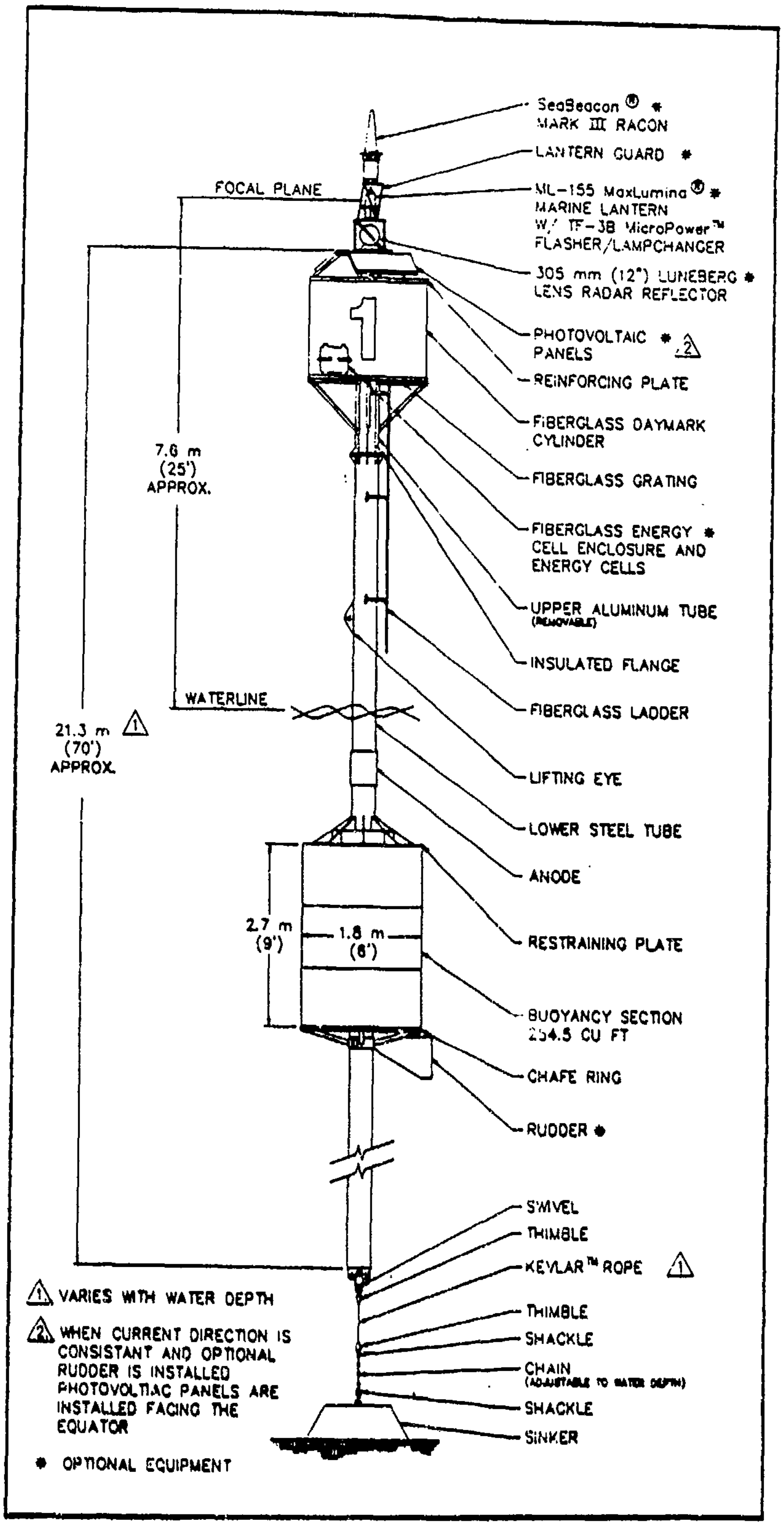


FIGURE 2-75
TIDELAND'S SAB-12
SENTINEL ARTICULATED
BUOY

References for Additional Information:

Interview Summary	:	Appendix A, Section A.2.11.1
Buoy Records	:	Appendix B, 11 Entries, Pages B-1330 through B-1371
Buoy Drawings	:	Appendix C, Pages C-276 through C-286

2.2.11.2 Automatic Power, Inc.

Automatic Power, Inc. (API) entered buoy design in the late 1960's and at that time most of their buoys were sold to oil companies. Now API is part of the Pharos Group of companies which have their headquarters offices in Sweden. In addition to buoys, API has a full line of buoy equipment including signalling devices, power supplies and moorings.

API designs its own buoys. Pharos has its own designers in England. API sells buoys all over the world except in South America where their designs are built in steel, fiberglass and combined steel and fiberglass.

API manufactures a buoyant beacon of steel with foam filled steel floating chamber and a shackled connection to the sinker as shown in Figure 2-76. Three to four of these are manufactured per year.

All offshore buoys manufactured by API are constructed of steel. They feel that this material has demonstrated its superiority over the years as there are steel buoys which have been in service for more than 40 years. The buoys shown in Figures 2-77 and 2-78 are examples of models for unprotected deep water. They do manufacture a series of small GRP buoys mostly used in calm waters such as lakes and rivers.

The range of floating markers manufactured by Pharos Marine are shown in Figures 2-79 and 2-80.

References for Additional Information:

Interview Summary	:	Appendix A, Section A.2.11.2
Buoy Records	:	Appendix B, 19 Entries, Pages B-1372 through B-1446
Buoy Drawings	:	Appendix C, Pages C-288 through C-297

2.2.11.3 The Gilman Corporation

The Gilman Corporation (TGC) has been manufacturing foam buoys for about 12 years. Their buoys are constructed of Surlyn (a DuPont chemical) ionomer resins and metal hardware. These foam buoys are concentrically wrapped, continuously heat sealed and then densified to produce a tough outer skin. The foam mass from which the buoys are made can be shaped to any exterior contour by heat cutting.

TGC has used this technology to manufacture navigational aids for the U.S. and Canadian Coast Guards. Currently they are manufacturing second through sixth class foam unlighted buoys for the USCG shown in Figure 2-81.

PAGES 169, 170

ARE

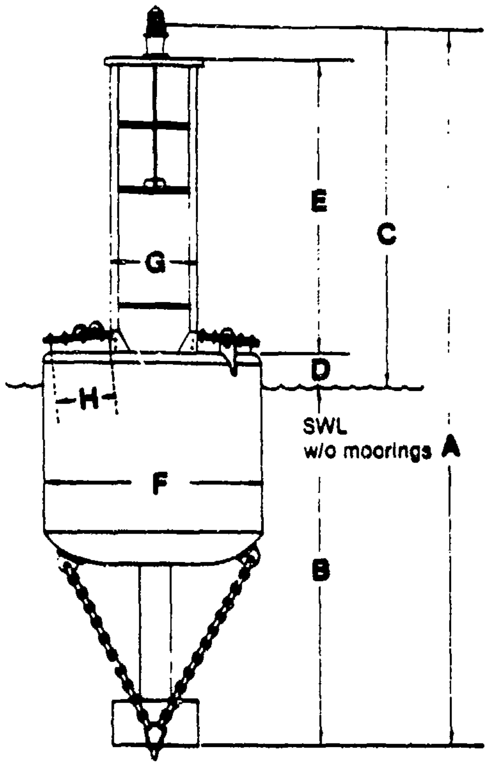
MISSING

IN

ORIGINAL

DOCUMENT

FIGURES 2-76, 2-77



Specifications	BL-620	BL-826
Dimensions		
A	19'7"	26'0"
B	9'2"	10'11"
C	10'5"	15'1"
D	2'0"	2'6"
E	7'6"	11'8"
F	6'0"	8'0"
G	2'4"	3'6"
H	1'10"	2'0"
Bridle (size)	1 1/8"	1½"
Recommended Moorings		
Sinker, concrete	5,000 lbs.	7,000 lbs.
Chain size	1 1/8"	1¼"
Chain length	2 — 4 times water depth	2 — 4 times water depth
Body Material	¼" steel	5/16" steel
Pounds/inch immersion	150 lbs./in.	270 lbs./in.
Reserve Buoyancy		
(without moorings)	3,600 lbs.	8,100 lbs.
Weight, less mooring	6,000 lbs.	13,150 lbs.
Day Mark height	7'9"	11'7"
Day Mark area	8 ft.²	19 ft.²
Recommended optional equipment		
Lantern	FA-249	FA-249
Batteries		
Dry primary	12v 2,400 ah	12v, 4,800 ah
Wet primary	12v, 6,000 ah	12v, 6,000 ah
Rechargeable	12v, 1,000 ah	12v, 2,000 ah
Sound Signal	SA-850/1A	SA-850/1A

FIGURE 2-78
AUTOMATIC POWER'S
BL-826/620 OPEN
WATER TAIL TUBE BUOYS

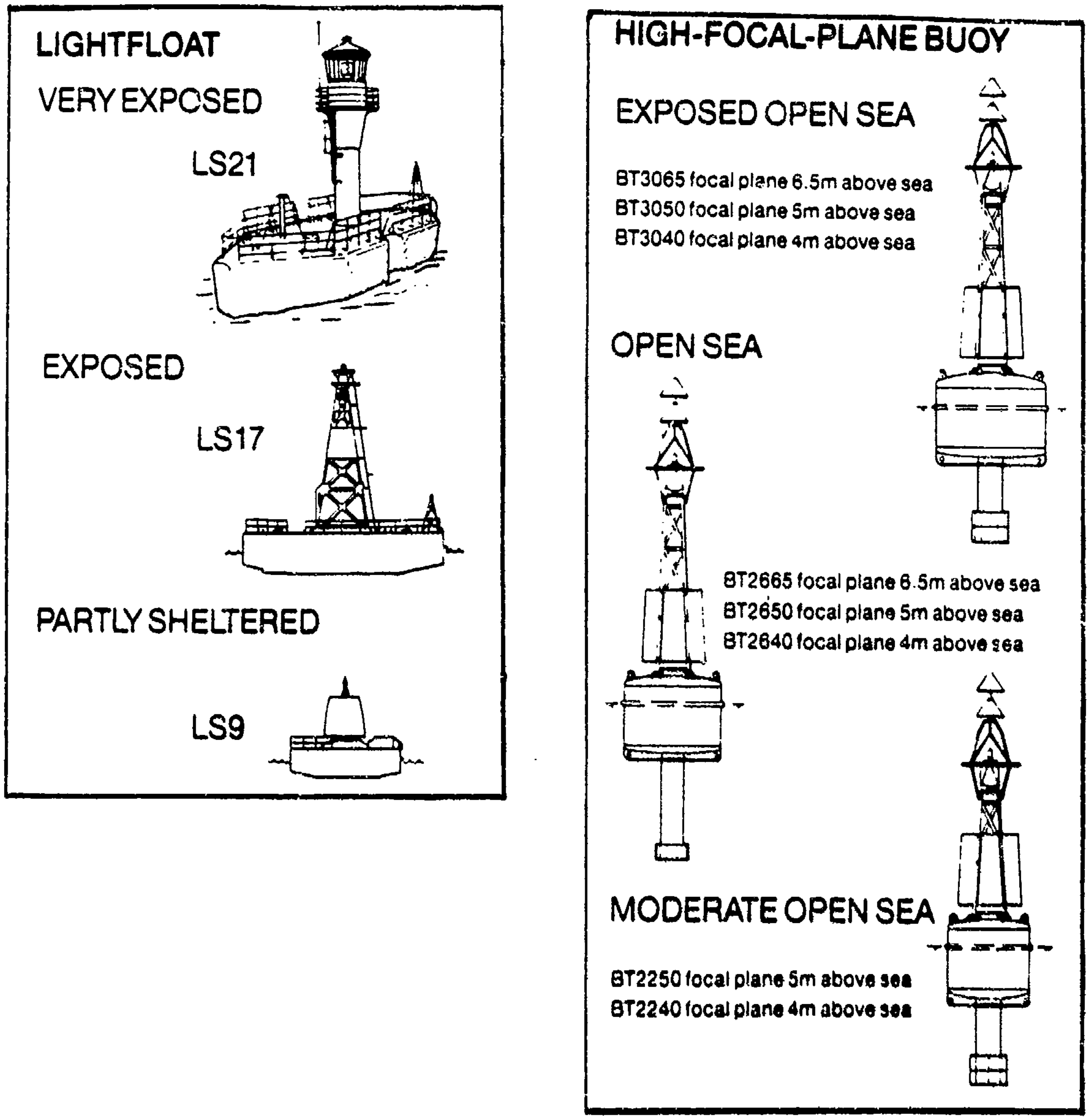


FIGURE 2-79
PHAROS' OPEN SEA
MAJOR PORT FAIRWAY
FLOATING MARKERS

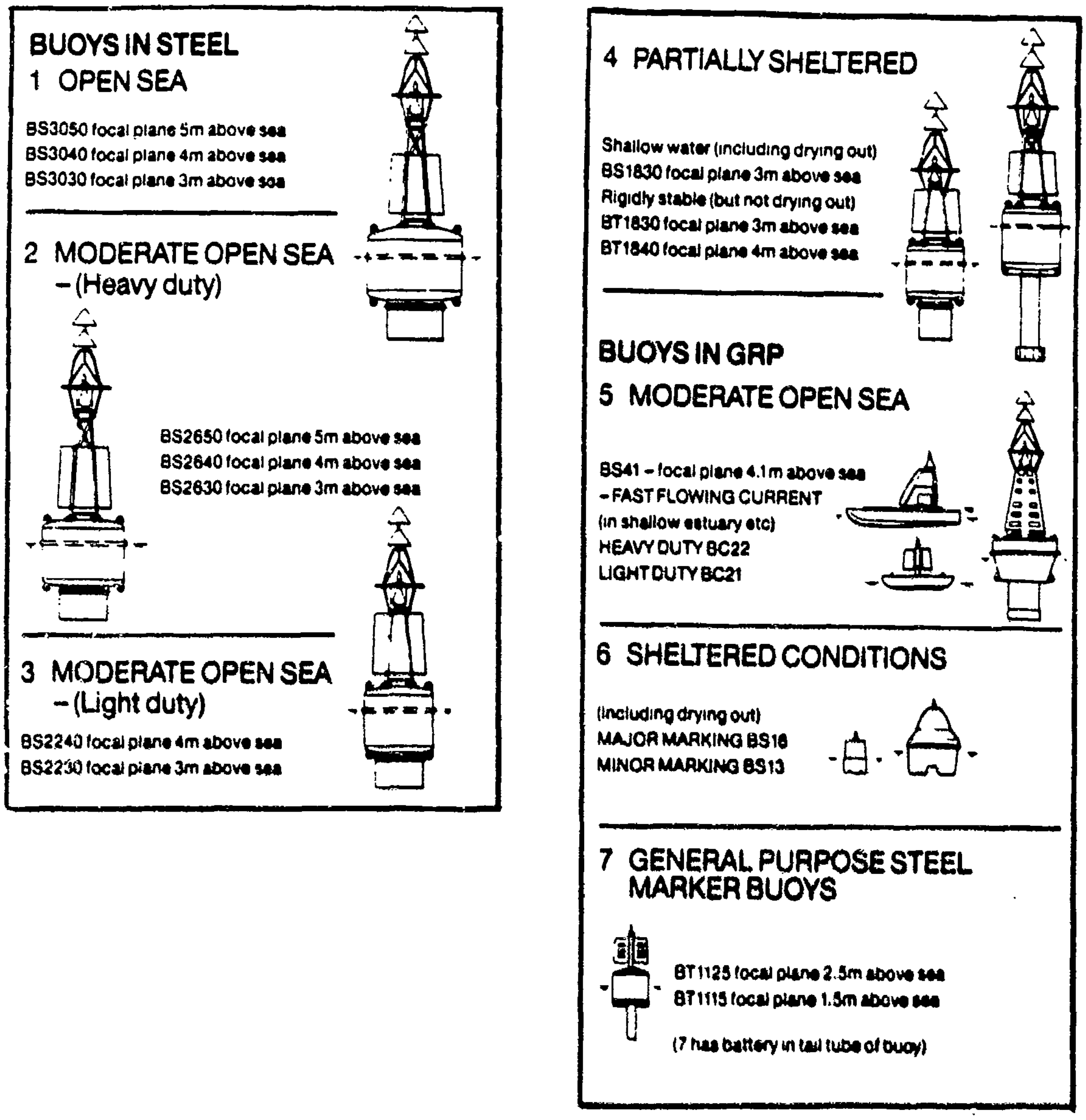


FIGURE 2-80
PHAROS' CHANNELS
AND HARBORS FLOATING
MARKERS

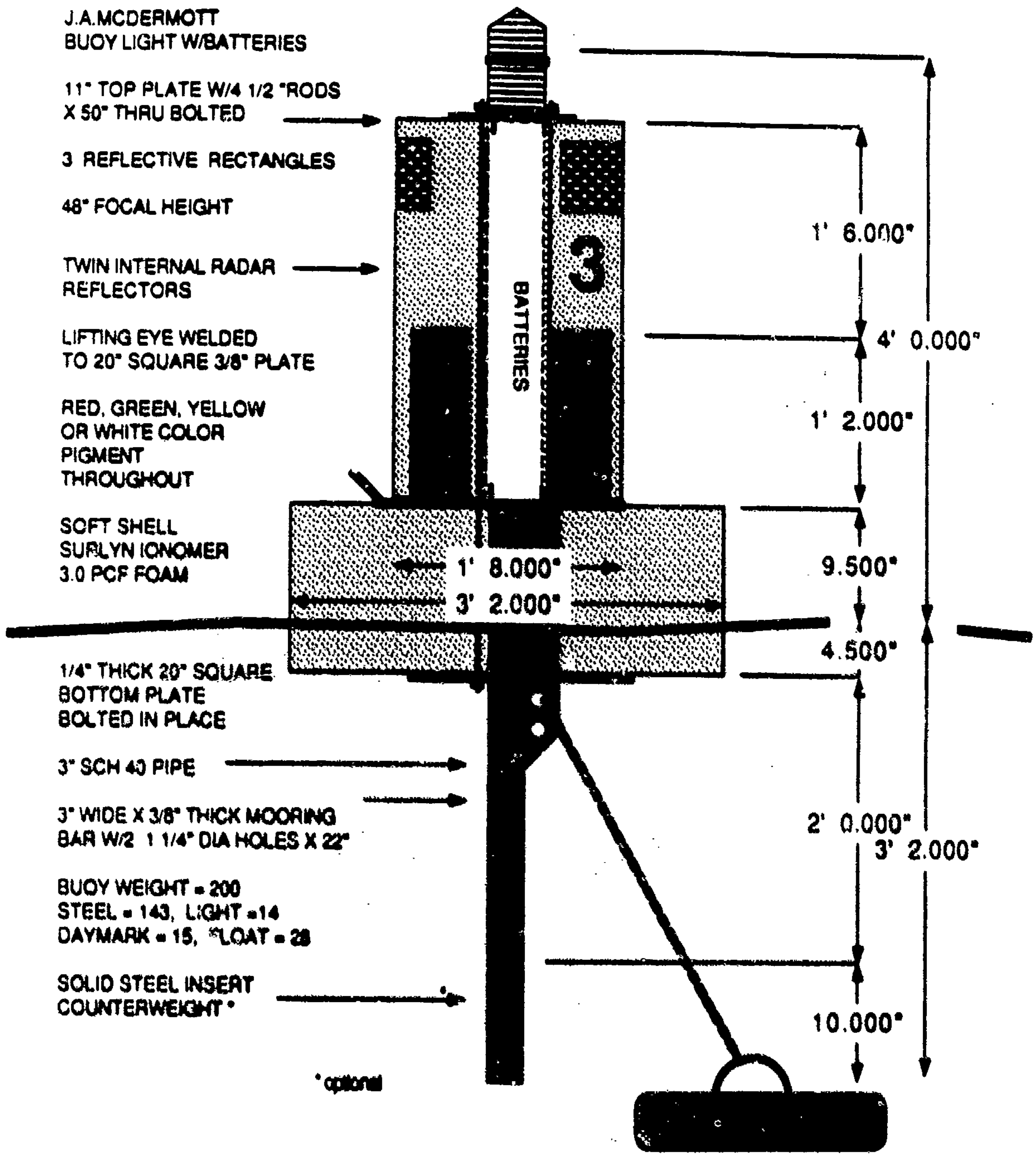


FIGURE 2-81
GILMAN'S SOFTLITE
5 CFLR

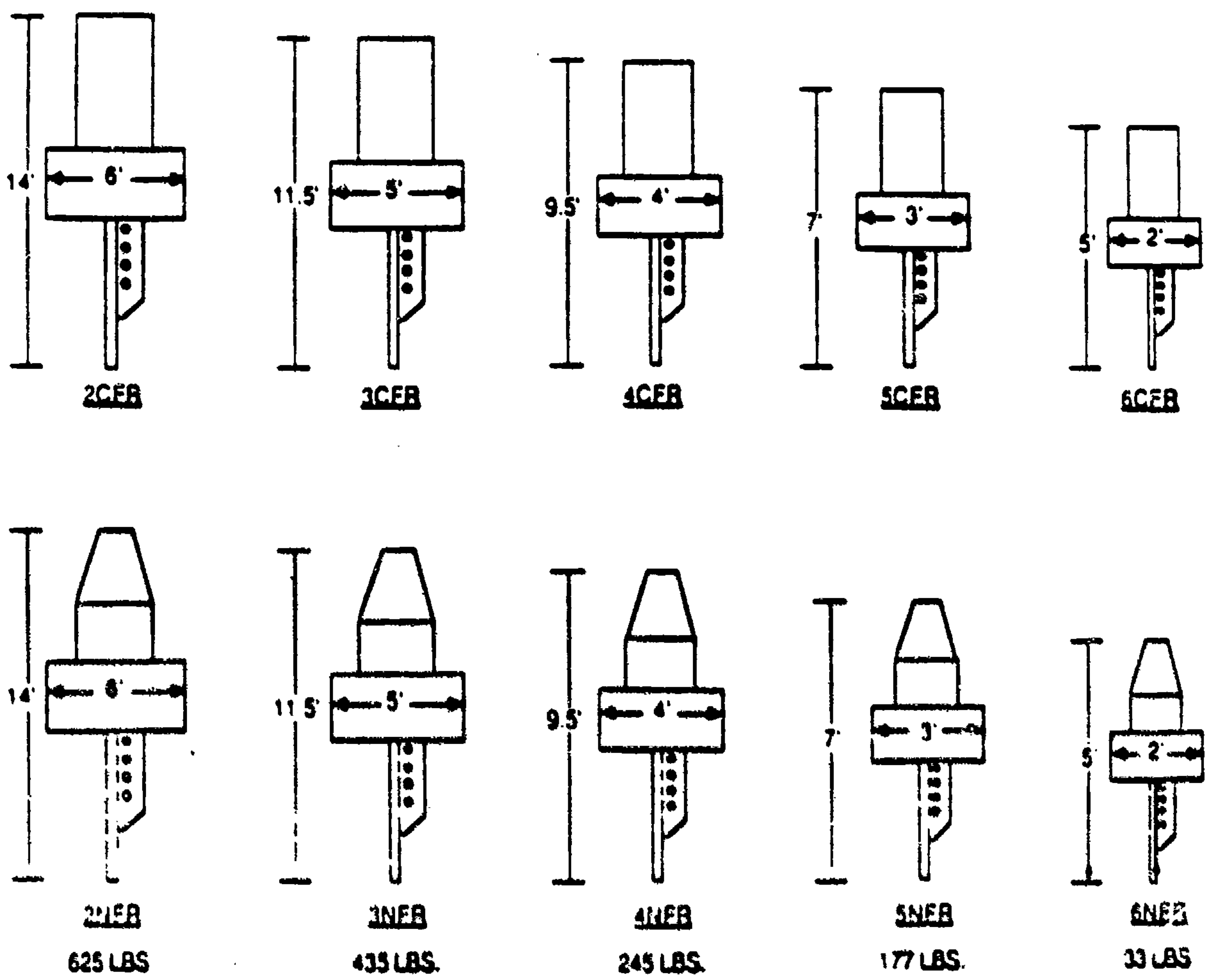


FIGURE 2-82
GILMAN'S FOAM BUOY
FAMILY

Figure 2-82 indicates the construction of a fifth class buoy which, for the case in the figure, has been fitted with a light. TGC has recently constructed the log shedding and fast water buoys shown in Figure 2-83.

The Surlyn foam used to construct the buoys is intended to remain tough and effective even when subjected to repeated impact, low temperatures and chemical attack. It is reportedly well suited for marine applications since it offers low weight, low density, toughness, durability and excellent resistance to environmental agents, such as radiation, salt, fuels and chemicals.

TGC has also constructed float sections for Tidelands articulated beacons as well as for buoys utilized for oceanographic purposes (also see Woods Hole Oceanographic Institution and Mooring Systems Inc. in Sections 2.2.11.5 and 2.2.11.12, respectively).

References for Additional Information:

Interview Summary	:	Appendix A, Section A.2.11.3
Buoy Records	:	Appendix B, 11 Entries, Pages 1136, 1144, 1152, 1164, 1180, 1188, 1196, 1207, 1222, 1238 and 1447-1450
Buoy Drawings	:	Appendix C, Pages C-271 through C-275 and Page C-298

2.2.11.4 Urethane Technologies, Inc.

Information including a response to the survey questionnaire was obtained from this firm through written and verbal correspondence. According to the Company Brochure and other documents Urethane Technologies (UT) manufactures collision survivable buoys of one of the following types of construction:

a. Closed Cell Crosslined Polyethylene foam buoy with a tough polyurethane skin. Larger units of this type have Spectra fabric reinforcement in the poly-urethane skin.

b. Surlyn foam body with a densified Surlyn foam skin.

UT states that construction (a) is "tougher and more attractive than construction (b) but it is also more expensive than (b)". Figure 2-84 and Photograph 7 show UT's Fast Water Channel Marker buoys of CAN and NUN types.

References for Additional Information:

Interview Summary	:	Appendix A, Section A.2.11.4
Buoy Records	:	Appendix B, 13 Entries, Pages 1136, 1144, 1152, 1164, 1180, 1188, 1196, 1207, 122, 1238 and 1451-1462
Buoy Drawings	:	Appendix C, Pages C-271 to C-275 and C-300 to C-303

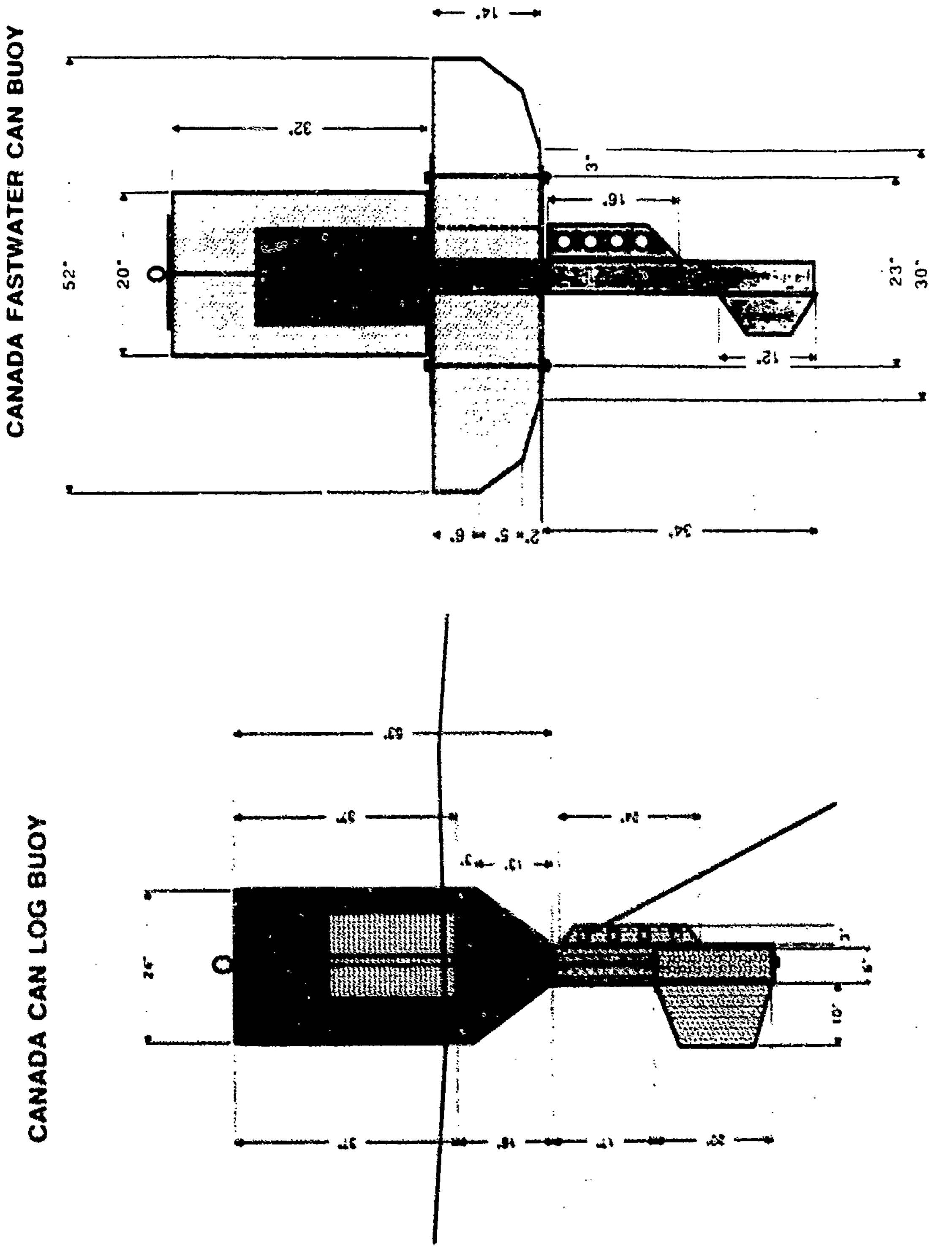
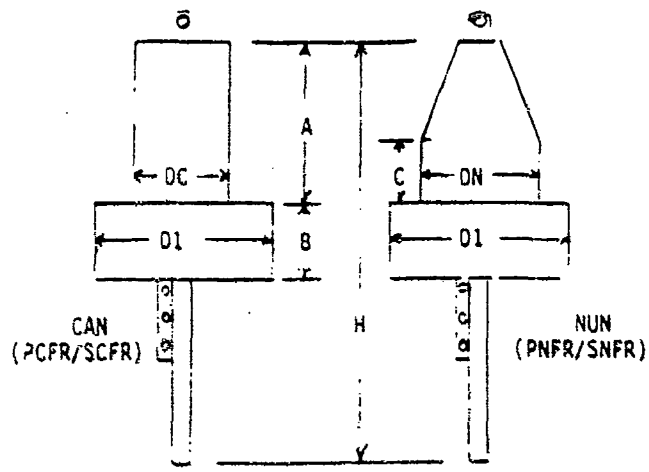


FIGURE 2-83
GILMAN'S BUOYS
FOR CANADA

FAST WATER CHANNEL MARKERS
(U.S. COAST GUARD STYLE)



Primarily used in moving water as a channel marker.

Steel Components - Hot dip galvanized.

Standard Colors - Green or Red- other colors optional

Available in two types of construction:
Type 1: PCFR and PNFR series are made of crosslinked closed cell polyethylene foam with a Seathane® polyurethane skin.
Type 2: SCFR and SNFR series are made of closed cell Surlyn® foam with a densified Surlyn® skin for milder duty.
These buoys do not require external counterweighting. All have radar reflectors embedded in the foam.

MODEL NUMBER									APPROXIMATE	
TYPE 1	TYPE 2	A	B	C	H	D1	DC	DN	NET WT.	NET BUOYANCY
PCFR 2	SCFR 2	66"	27"	---	165"	72"	36"	--	075 lbs	4850 lbs
PNFR 2	SNFR 2	66"	27"	27"	165"	72"	---	43"	375 lbs	4050 lbs
PCFR 3	SCFR 3	58"	22"	---	140"	60"	30"	--	615 lbs	2880 lbs
PNFR 3	SNFR 3	58"	22"	24"	140"	60"	---	36"	615 lbs	2880 lbs
PCFR 4	SCFR 4	47"	18"	---	113"	48"	25"	--	275 lbs	1650 lbs
PNFR 4	SNFR 4	47"	13"	19"	113"	48"	---	30"	275 lbs	1650 lbs
PCFR 5	SCFR 5	34"	14"	---	84"	38"	20"	--	150 lbs	770 lbs
PNFR 5	SNFR 5	34"	14"	14"	84"	38"	---	23"	150 lbs	770 lbs
PCFR 6	SCFR 6	21"	10"	---	55"	24"	13"	--	55 lbs	200 lbs
PNFR 6	SNFR 6	21"	10"	9"	55"	24"	---	16"	55 lbs	200 lbs

FIGURE 2-84
URETHANE TECHNOLOGIES
FAST WATER CHANNEL
MARKER

2.2.11.5 Woods Hole Oceanographic Institution

The Systems and Mooring Department of the Woods Hole Oceanographic Institution (WHOI) serves the needs of the other WHOI departments for buoys to carry their systems. The WHOI buoys are primarily open sea data buoys for deep water and of either the surface or subsurface type.

They believe that a buoy utilizing Surlyn foam as a peripheral collar providing the means of floatation and with steel or aluminum cages and underbody mooring structure and central core is a good alternative offering improvement over previous designs. Use of Surlyn supersedes painting requirements and cuts buoys' weight in half. Figure 2-85 shows the ESOM buoy they have constructed of Surlyn foam/aluminum.

WHOI is constantly testing new material applications at their test site offshore Bermuda. The Office of Naval Research is also supporting this effort. They have investigated Surlyn foam at this site and conclude in Reference 44 that it:

- Offers many advantages as a buoyancy material for surface buoys.
- Has low weight/volume ratio.
- Is a tough material which is resistant to the marine environment.
- Needs no painting.

WHOI has their own deep water mooring analysis computer program named SURFMOOR.

References for Additional Information:

Interview Summary : Appendix A, Section A.2.11.5

2.2.11.6 Benthos, Inc.

Benthos, Inc. is a manufacturer of equipment for underwater imaging, hydrospheres, acoustics, remotely operated submersible vehicles and glass spheres for underwater floatation in deep water moorings. They are not, nor have they ever been, involved directly with navigation buoys.

References for Additional Information:

Interview Summary : Appendix A, Section A.2.11.6

2.2.11.7 Heat Transfer Systems, Inc.

This is a steel and aluminum fabricating company located in St. Louis, MO which manufactures, under contract to the USCG and in accordance with the USCG drawings and specifications, several types of aid to navigation buoys. A brief visit was made to this facility during the interview held with

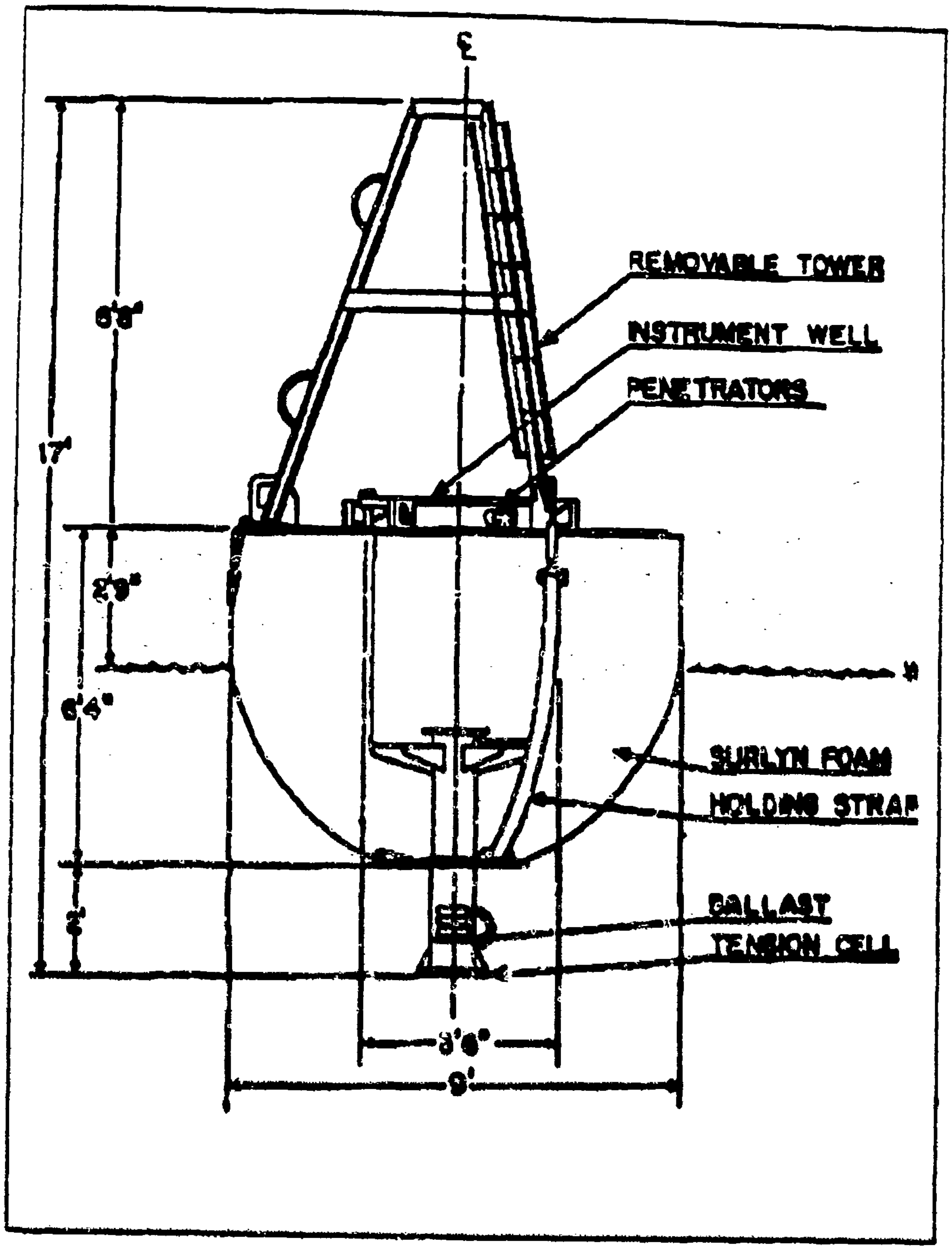


FIGURE 2-85
WOODS HOLE:
HEMISPHERICAL BUOY

USCG Base St. Louis in the course of Task A efforts. The following types of buoys were observed to be in production during the visit:

- 4th and 6th class unlighted steel, foam filled river buoys of can and nun types.
- 8'x20' and 9'x35' steel buoys.
- Aluminum data buoys.
- Aluminum NOMAD buoys.

References for Additional Information:

Interview Summary : Appendix A, Section A.2.11.7

2.2.11.8 Bahr Technologies, Inc. (LocUS)

This firm, which has since changed its name to "LocUS Navigation, Inc.," is a designer and developer of state-of-the-art microprocessor based products. Its facility is in Madison, WI.

LocUS has a patented new LORAN receiver which they claim is a self-reliant piece of equipment using standard power. It is a miniature receiver which can broadcast and identify the buoy's position with accuracy and can therefore be very helpful in locating buoys that frequently drift off-station.

Basically, LocUS states that they are able to provide the highest performance battery-powered LORAN system available. Such a system, they add, is ideal for use in buoys and can tremendously enhance the navigational function of any buoy regardless of its primary application (e.g. channel navigation, oceanography, or search and rescue).

References for Additional Information:

Interview Summary : Appendix A, Section A.2.11.8

2.2.11.9 Rotocast Plastic Products, Inc.

Rotocast has been manufacturing a line of commercial buoys since 1978 and has also manufactured, under contract, fast water buoys for the U.S. Coast Guard. The commercial buoy line is intended primarily for use in inland waterways.

References for Additional Information:

Interview Summary : Appendix A, Section A.2.11.9

2.2.11.10 Seaward International, Inc.

Reportedly, Seaward International, Inc. (Seaward) originated the resilient foam filled marine fender. They have extended this technology and experience into the field of buoy design and manufacture.

The Seaward "Sea Float" style buoy, a spar buoy version shown in Figure 2-86, incorporates a steel core surrounded by rigid closed cell foam which is itself covered with a resilient urethane elastomer skin. This composition reportedly gives them the flexibility to manufacture buoys of almost any shape, buoyancy, color and serviceability. Advantages of these buoys cited by Seaward are resiliency, unsinkability, little or no maintenance and indefinite life expectancy.

References for Additional Information:

Interview Summary	:	Appendix A, Section A.2.11.10
Buoy Records	:	Appendix B, 1 Entry, Pages 1463 through 1465
Buoy Drawings	:	Appendix C, Page C-304

2.2.11.11 Racal Survey, Inc.

Racal Survey, Inc. (RSI) is a division of Racal Data Communications, Inc. Currently they supply surface positioning systems to the Mine Counter Measures group of the U.S. Navy. RSI has also gained additional positioning experience with hydrographic surveys, ship trials, drilling rig positioning, seismic surveys, dredging, etc.

Few of their standard systems are the Micro-Fix short range microwave interrogation technique position fixing systems utilizing user provided shore based remote stations; and the Hyper-Fix microprocessor based medium frequency phase comparison technique positioning system, also requiring user provided shore based remote stations.

References for Additional Information:

Interview Summary : Appendix A, Section A.2.11.11

2.2.11.12 Mooring Systems, Inc.

Mooring Systems, Inc. provides a number of buoys and mooring components. Their buoys as exhibited during the Marine Technology Society '90 Conference and Exposition (some in conjunction with the Gilman Corporation, see Section 2.2.11.3) are designed with metallic superstructure, central core and mooring linkage with a Surlyn foam flotation collar.

Figure 2-87 shows their Lighted Guard Buoy which has the appearance of a lighted navigation buoy with light atop a cage structure.

References for Additional Information:

Interview Summary : Appendix A, Section A.2.11.12

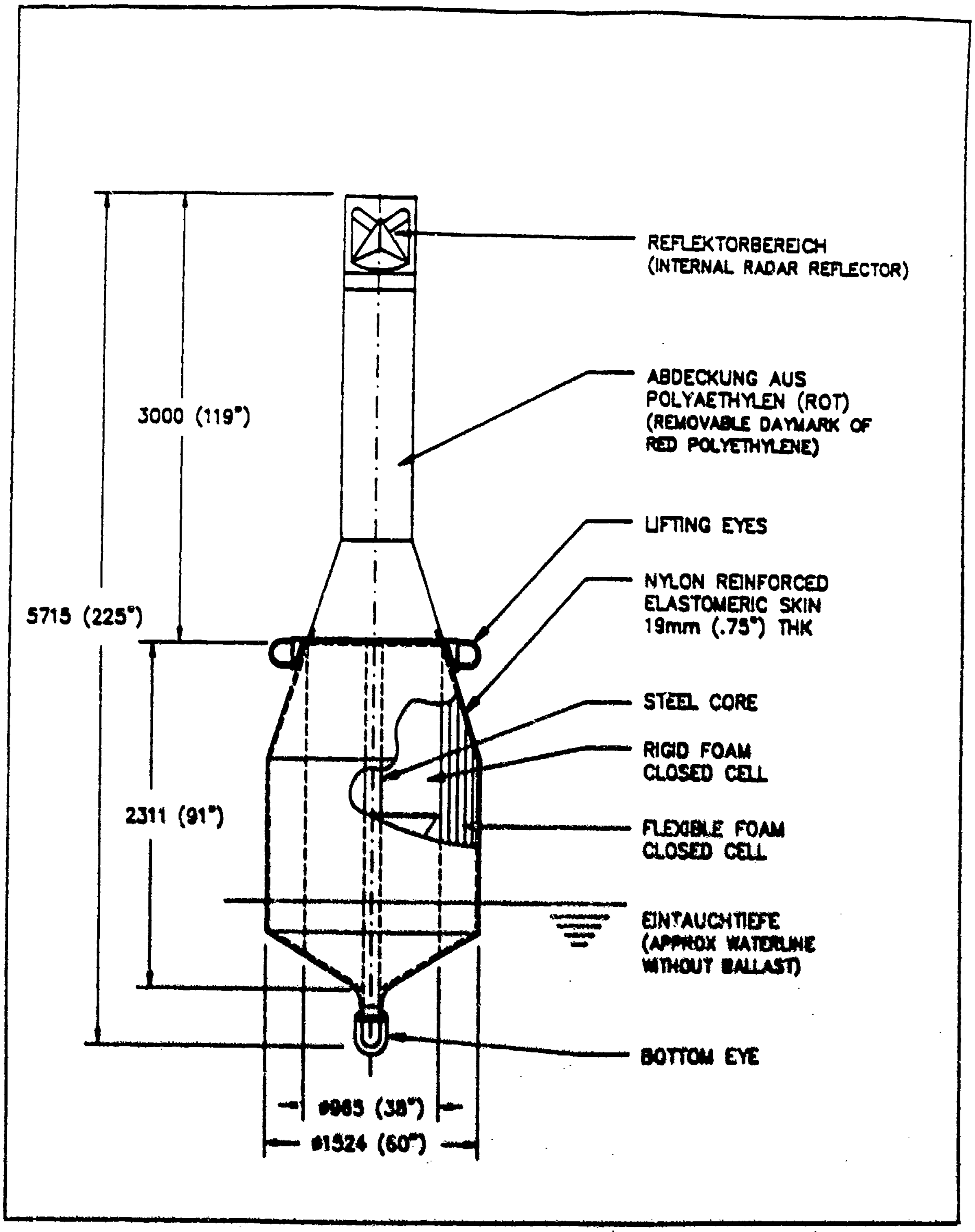


FIGURE 2-86
SEAWARD'S ELASTOMER/
FOAM SPAR BUOY

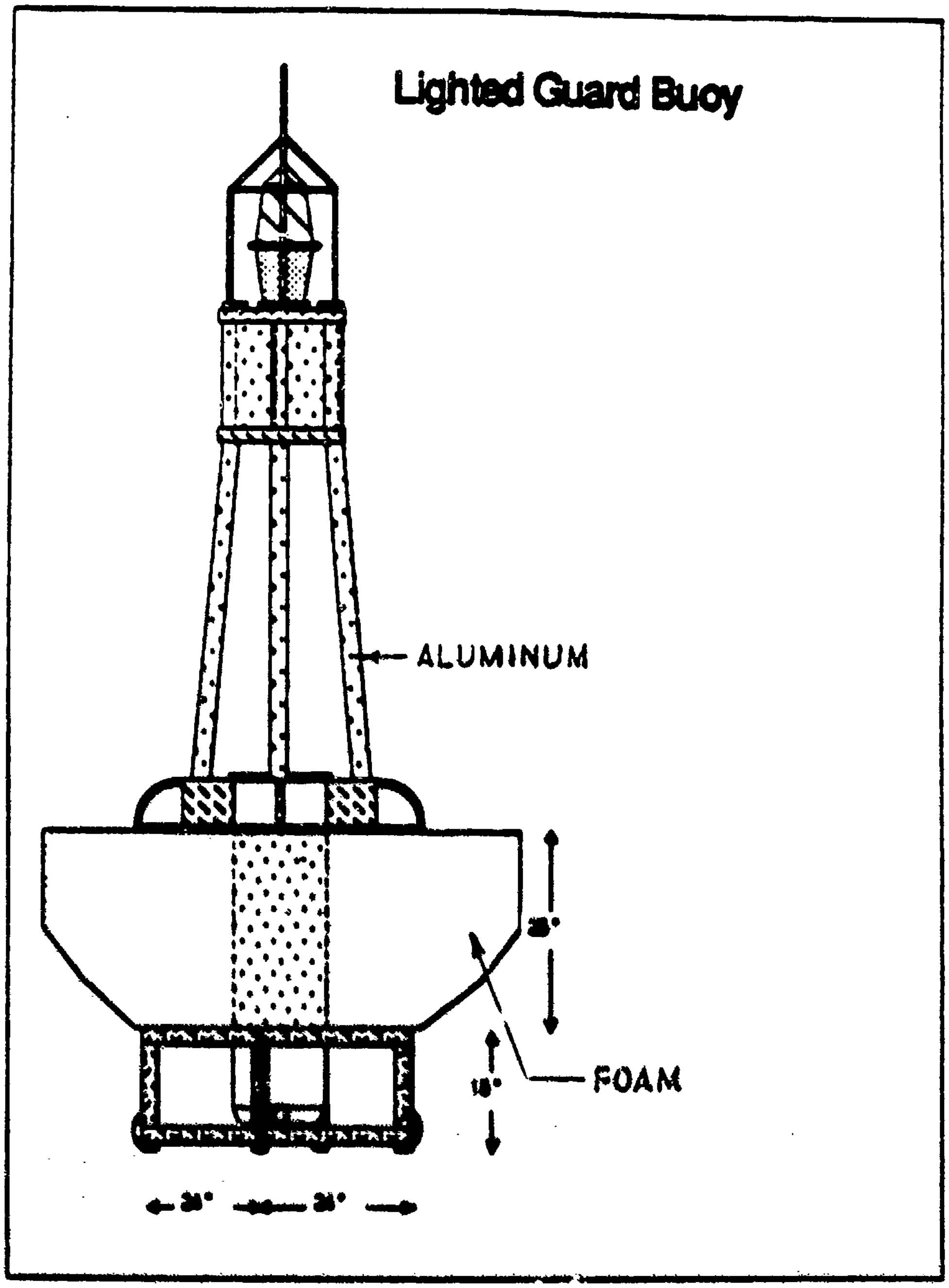


FIGURE 2-87
MOORING SYSTEM'S
GUARDIAN SERIES
BUOYS

2.2.11.13 Alu-Power, Inc.

Alu Power, Inc. has developed an aluminum-dissolved oxygen (ALDOS) seawater battery. The cells are an open system with inlets and outlets for seawater entry and exit. It consists of an aluminum alloy anode and an inert cathode substrate at which the dissolved oxygen discharges and an electrolyte gap. The cell reaction product, aluminum hydroxide, exits from the cell as an environmentally innocuous precipitate which is then dissipated in the ocean current. In buoy applications they believe such a battery can be used either directly or as a recharger for a lead-acid or similar battery.

Alu-Power has other seawater batteries as well. Table 2-16 lists physical characteristics and other information pertinent to each available type.

References for Additional Information:

Interview Summary : Appendix A, Section A.2.11.13

2.3 International Association of Lighthouse Authorities (IALA)

The ground work for the "Association Internationale de Signalisation Maritime (AISM)", International Association of Lighthouse Authorities (IALA) can be traced back to 1889. During the World Exhibition in Paris, France during that year the first of a series of international conferences dealing with aids to navigation was held. This first meeting had an attendance of 243 delegates and there were two technical contributors on aids to navigation:

- Fleischer, Inspector and Engineer-in-Chief of the Lighthouses of Denmark: "The characteristics of the Lights and Fog Signals Associated with Them."

- Charles Ribiere, Lighthouse Engineer, Paris: "Note on Floating Lights."

In the decades that followed representatives of nations interested in ATON were able to arrange a number of meetings in conjunction with those of other organizations. During the Fifth International Conference on Lighthouses and other Aids to Navigation held in 1955 in Scheveningen, The Netherlands, it was noted that there is clearly great importance in the interchange of views in the field of technical development of marine signals and that it seemed appropriate to consider the question of a permanent secretariat to carry on the work of such an organization. As a result, IALA was founded on July 1, 1957 with twenty Lighthouse Authorities as initial members. Reference 39 describes the historical aspects in detail. The IALA members are the navigation authority administrations of nations belonging to IALA. Associate members and industrial members are also admitted. The Commandant, the U.S. Coast Guard is the authority member for the United States. A complete list of members is given in Reference 40.

The primary aim of the IALA is to meet the needs of the mariner, by providing ATON that will enable him to determine his position reliably, warn him of dangers and ensure his safety. As part of this goal, they have

Types & Customers	Power Watts	Service Months	Energy kWh	Weight kg	Volume liter	Wh/kg	WH/l	Use
Al/DOS (1 Volt)								
NOSC	1.6	12	14	18	70	770	200	Arctic
WHOI	2	3	10	14	600	714	17	Experimental
Customer	2	6	10	15	57	650	175	Experimental
	20	24	100	110	250	900	400	Well-head
Al/MnO_2 (1.2 Volt)								
NOSC/NUSC	2	12	18	67.5	113	266	158	Deep Array
NOSC-Chain	0.1	?	0.5	4.5	4.5	110	110	Towed Array
ALWATT		V, Hours						
ALWATT	7.5	6V,30	0.25	1.3	1.8	190	138	Experimental
ALWATT	12	6V,30	4.1	8.2	4.4	500	930	Experimental
NOSC-ALWATT	24	24V,24	0.73	6.4	25	117	30	?
DND Canada	128	12V,50	9	93	3.2	143	63	SDL-1

Wh/kg = WATT-HOURS PER KILOGRAM.

WH/l = WATT-HOURS PER LITER.

TABLE 2-16
ALU-POWER SEAWATER BATTERY DATA

developed the IALA Maritime Buoyage System (MBS), Reference 41, to provide a single set of recommendations which apply world-wide to all fixed and floating marks, lightships and large navigational buoys. Associated with the MBS they have published a series of other guidelines and recommendations listed in Appendix A.1.10 and the IALA NAVGUIDE, Reference 42.

The IALA MBS recommendations provide for the world to be divided into two buoyage regions: Region A where the surface and light colors of lateral marks are green to starboard on approaching a harbor, river, estuary or other waterway from seaward and red to port, and Region B where red color is to starboard and green color to port. In all other respects the recommendations are identical for both regions. The United States subscribes to Region B. Although the recommendations of the IALA MBS were not agreed to in their final form until November 1980 in Tokyo, many administrations had already begun to implement the new system in their waters as early as mid-1977. By the beginning of 1982, large areas of the world's coastal waters had been completely converted to the new system.

Within the IALA MBS there are 5 types of marks which may be used in any combination: Lateral Marks, Cardinal Marks, Isolated Danger Marks, Safe Water Marks, and Special Marks. Lateral marks differ between Buoyage Regions A and B as described above, whereas the other 4 types of marks are common to both regions.

The Mariner can readily distinguish between these marks by the shape and surface colors or at night by the color and rhythm of the lights. An administration can choose whether it wishes to make use of all or only some of the 5 types available. The choice will depend upon the configuration of the coastline, the type of sea bed, depth of water and type of traffic. As an example, the U.S. has opted not to use the Cardinal marks. Reportedly these are very useful and cost effective tools although not always popular with pleasure boaters who are more partial to explicitly marked channels.

Table 2-17 which is reproduced from Reference 43 lists the IALA member administrations and the number of their ATONs at the end of the year 1988. Table 2-18 from the same reference lists the staff and service transport vehicles.

The IALA view is that well-constructed, simple equipment, if carefully maintained, can often be more valuable to the mariner than sophisticated equipment not operating properly.

IALA has observed that a number of countries, including the United States, had introduced the use of GRP for their buoys with enthusiasm which had over the years waned.

Regarding buoy tenders, multi-purpose vessels are not specifically as good as dedicated buoy tenders.

Vessel Traffic Service (VTS) systems have a high profile in IALA. The U.S. Coast Guard had dropped consideration of VTS but with the EXXON VALDEZ disaster it has regained consideration. As an example of VTS in North America, Canada has extensive VTS including in remote areas where ship traffic

DISPOSITIFS D'AIDES A LA NAVIGATION EN SERVICE AU 31 DECEMBRE 1988 / *AIDS TO NAVIGATION IN USE ON 31st DECEMBER, 1988*	FEUX/*LIGHTS* – Sur supports fixes *on fixed structures* – > 100cd – Gardés/*Watched*	> 100cd – Non gardés/*Unwatched*	> 100cd – Télécommandés/*Remotely controlled*	< 100 cd	Sur marques flottantes *on floating marks* – Bateaux-feux/*Lightvessels* – Gardés/*Manned*	Bateaux-feux/*Lightvessels* – Non gardés/*Unmanned*	Lanbys/*Lanbys*	Bouées lumineuses < 9m dia *Lighted Buoys < 9m dia*	Autres marques lumineuses/*Other lighted aids*	MARQUES NON LUMINEUSES/*UNLIGHTED AIDS* – Balises fixes/*Unlighted beacons*	Bouées ordinaires/*Unlighted buoys*	Autres marques/*Other aids*	AVERTISSEURS SONORES/*SOUND SIGNALS* – Sur supports fixes/*On fixed structures*	Sur bateaux-feux/*On light vessels*	Sur bouées/*On buoys*	Radioph… et radioalign… *Radiobeaco… radio leadin…* – Radiophares circulaires *Non-directional radiobeacons* – > 10 milles/*miles*	< 10 milles/*miles*	Radiophares directionnels/*Directional radiobeacons*
Australia/*Australie**, Dept. of Transport	30	288	—	.	.	2	—	15	—	8	—	—	—	—	—	8	—	—
Australia/*Australie**, Dept. of Harbours, Brisbane	—	208	7	1132	—	—	—	143	—	805	64	—	—	—	—	—	—	—
Australia/*Australie**, Port of Melbourne	1	121	—	22	—	—	—	70	—	3	19	1	1	—	—	—	—	—
Barbados/*Barbades**	—	10	—	—	—	—	—	4	—	—	—	—	—	—	—	—	—	—
Belgium/*Belgique*, Pilotage de la Coté et des Embouchures de l'Escaut*	16	—	—	21	1	—	—	70	8	—	22	—	7	1	21	—	4	—
Belgium/*Belgique*, Groupe Maritime de l'Escaut*	—	35	—	—	—	—	—	36	—	—	—	7	—	—	—	—	—	—
Benin/*Bénin**	1	6	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—
Bermuda/*Bermudes*	9	—	—	30	—	—	—	11	2	66	18	—	—	—	—	2	—	—
Brazil/*Brésil**	30	277	—	190	—	3	—	469	—	334	288	—	—	—	—	—	14	—
Cameroon/*Cameroun**	2	2	—	—	—	—	—	23	—	—	2	—	—	—	—	—	—	—
Canada*	148	4081	15	41	—	—	—	2899	—	4964	9946	—	380	—	568	84	1	—
Chile/*Chili**	21	172	—	234	—	—	—	24	1	340	45	—	10	—	—	—	6	—
China/*Chine**	101	703	6	418	—	8	1	876	14	140	96	54	9	6	2	15	—	—
Cuba	17	118	17	279	—	—	—	333	—	96	132	18	—	—	—	—	4	—
Cyprus/*Chypre*	—	19	—	16	—	—	—	10	—	3	10	—	—	—	—	—	—	—
Denmark/*Danemark*	17	241	29	18	—	—	—	372	242	65	1163	83	15	—	—	26	1	—
England & Wales/*Angleterre & Pays de Galles*, Trinity House*	28	33	25	2	3	15	6	443	—	34	153	—	44	18	124	27	5	—
England/*Angleterre*, Gloucester Harbour Trustees*	—	23	—	—	—	—	—	4	—	2	—	—	1	—	—	—	—	—
Equatorial Guinea/*Guinée Equatoriale**	4	4	—	7	—	—	—	—	—	—	6	2	—	—	—	—	—	—
Ethiopia/*Ethiopie*	2	—	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Finland/*Finlande*	—	1452	3	168	—	—	—	417	34	20	185	7215	1	—	—	15	—	—
France* (1)	116	1256	105	573	1	—	3	1053	66	2614	1272	187	77	1	128	31	1	1
The Gambia	—	4	—	1	—	—	—	12	—	—	—	—	—	—	—	—	—	—
German Dem Rep/*Rép Dém Allemande**	—	7	206	21	—	—	—	282	—	4	1509	—	1	—	—	1	—	—
German Fed Rep of/*Rép Féd d'Allemande**	1	584	443	293	—	3	1	697	80	74	2127	9164	17	3	24	11	3	—
Greece/*Grèce**	41	161	15	689	—	—	—	118	2	—	—	—	3	—	—	—	2	—
Haiti	15	—	—	11	—	—	—	2	—	—	—	—	—	—	—	—	—	—
Hong Kong*	2	65	—	90	—	—	—	85	2	15	4	1	3	—	—	—	—	—
Iceland/*Islande**	58	58	5	3	—	—	—	11	2	36	2	12	2	—	—	13	—	—
India/*Inde*	130	25	—	—	—	1	—	12	—	—	—	—	6	—	—	16	—	—
Indonesia/*Indonésie**	184	583	—	163	—	—	—	467	—	572	403	—	—	—	—	—	—	—
Ireland/*Irlande**	17	46	32	—	—	2	2	185	—	22	34	29	20	2	23	13	—	—

* Avait rempli le même questionnaire pour 1987/*Completed the same questionnaire for 1987.*

(1) Y compris les Départements et les Territoires d'Outre-Mer/*including Overseas Territories.*

STICS OF

1. STATISTICS OF AIDS TO NAVIGATION AS AT THE 31ST DECEMBER 1988

...ophares ...lignements/ ...eacons and ...ading lines: Radiophares directionnels/ *Directional radiobeacons*	Radioalignements/ *Radio leading lines*	Other aids	AVERTISSEURS SONORES/ *SOUND SIGNALS*: Sur supports fixes/ *On fixed structures*	Sur bateaux-feux/ *On light vessels*	Sur bouées/ *On buoys*	AIDES RADIO ELECTRIQUES/*RADIO AIDS* — Radiophares et radioalignements/ *Radiobeacons and radio leading lines*: Radiophares circulaires/ *Non-directional radiobeacons* > 10 milles/ *miles*	Radiophares circulaires/ *Non-directional radiobeacons* < 10 milles/ *miles*	Radiophares directionnels/ *Directional radiobeacons*	Radioalignements/ *Radio leading lines*	Autres radiophares/ *Other radiobeacons*	Systèmes de radionavigation/ *Radionavigation systems*: Chaînes Decca/ *Decca chains*	Stations Loran A/ *Loran A stations*	Stations Loran C/ *Loran C stations*	Chaînes Toran/ Toran chains	Stations Oméga Différentiel/ *Differential Omega stations*	Balises radar/ *Radar beacons*: Balises répondeuses radar/ *Racons* > 500 mW	Balises répondeuses radar/ *Racons* < 500 mW	Ramarks/ *Ramarks*	Radars de surveillance/ *Surveillance radars*: Stations portuaires/ *Harbour stations*	Stations côtières/ *Coastal stations*	Autres aides/ *Other aids*	REFLECTEURS RADAR/ *RADAR REFLECTORS*
—	—		—	—	—	8	—	—	—	—	1	—	—	—	1	9	16	—	—	—	4	30
—	—		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	—	—	—
—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	—	1	—	1	—	—	—	1
—	—		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—		7	1	21	—	4	—	—	—	—	—	—	—	—	—	—	1	1	3	—	92
—	—		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4	—	—	—
—	—		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	1
—	—		—	—	—	2	—	—	—	—	—	—	—	—	—	2	—	—	1	—	—	—
—	—		—	—	—	—	14	—	—	23	—	—	—	—	1	23	—	—	—	—	—	757
—	—		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
—	—		380	—	568	84	1	—	—	—	—	—	4	—	—	75	32	—	3	15	—	2864
—	—		10	—	—	—	6	—	—	—	—	—	—	—	—	15	—	—	—	2	—	77
—	—	6	9	6	2	15	—	—	—	—	—	10	—	—	—	17	—	—	1	8	—	7
—	—	8	—	—	—	—	4	—	—	—	—	—	—	—	—	3	—	—	—	—	—	13
—	—		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	3	15	—	—	26	1	—	—	—	—	1	2	—	—	—	—	—	—	—	—	—
—	—		44	18	124	27	5	—	—	—	4	—	—	—	—	26	21	—	—	—	2	463
—	—		1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	8
—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—
—	—		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
1	—	5	1	—	—	15	—	—	—	—	—	—	—	—	—	7	35	—	15	—	—	190
—	—	7	77	1	128	31	1	1	—	11	1	—	2	7	—	6	18	—	13	5	—	409
—	—		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—		1	—	—	1	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	290
—	—	6	17	3	24	11	3	—	—	—	1	—	—	—	—	—	14	14	5	24	15	18
—	—		3	—	—	—	2	—	—	—	—	—	—	—	—	2	—	—	—	—	—	—
—	—		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	1	3	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—
—	—	2	2	—	—	13	—	—	—	—	—	—	—	—	—	14	—	—	—	—	—	—
—	—		6	—	—	14	—	—	—	—	3	—	—	—	—	—	12	—	—	—	—	5
—	—		—	—	—	—	—	—	—	—	—	—	—	—	—	2	4	—	—	—	—	—
		29	20	2	23	13	—	—	—	3	2	—	—	—	—	5	5	—	—	—	—	133

TABLE 2-17
WORLD ATON STATISTICS -
31 DECEMBER 1988

DISPOSITIFS D'AIDES A LA NAVIGATION EN SERVICE AU 31 DECEMBRE 1988 / *AIDS TO NAVIGATION IN USE ON 31st DECEMBER, 1988*	FEUX/*LIGHTS* Sur supports fixes *on fixed structures* > 100cd Gardés/*Watched*	Non gardés/*Unwatched*	Télécommandés/*Remotely controlled*	< 100 cd	FEUX/*LIGHTS* Sur marques flottantes *on floating marks* Bateaux-feux/*Lightvessels* Gardés/*Manned*	Non gardés/*Unmanned*	Lanbys/*Lanbys*	Bouées lumineuses < 9m dia *Lighted Buoys < 9m dia*	Autres marques lumineuses/*Other lighted aids*	MARQUES NON LUMINEUSES/*UNLIGHTED AIDS* Balises fixes/*Unlighted beacons*	Bouées ordinaires/*Unlighted buoys*	Autres marques/*Other aids*	AVERTISSEURS SONORES/*SOUND SIGNALS* Sur supports fixes/*On fixed structures*	Sur bateaux-feux/*On light vessels*	Sur bouées/*On buoys*	Radiophares circulaires/*Non-directional radiobeacons* > 10 milles/*miles*	< 10 milles/
Israel*	—	5	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—
Italy/*Italie**	137	278	—	746	—	—	—	82	75	—	64	—	65	—	2	19	—
Ivory Coast/*Côte d'Ivoire*, Port Abidjan*	4	16	—	—	—	—	—	23	2	1	1	—	1	—	1	1	—
Ivory Coast/*Côte d'Ivoire*, Port San Pedro	—	4	—	2	—	—	—	—	—	41	16	—	—	—	—	—	—
Japan/*Japon**	72	2603	553	97	—	—	1	1386	—	130	81	—	42	—	6	11	—
Korea, Dem Rep of/*Corée Rép Dem de*	23	42	2	18	—	—	—	38	—	6	48	—	8	—	—	3	—
Malaysia/*Malaisie**	10	105	—	49	—	1	—	111	—	—	4	—	—	—	—	—	—
Mexico/*Mexique*	110	602	—	—	—	—	—	258	—	—	—	—	—	—	1	—	—
Morocco/*Maroc*	33	72	—	10	—	—	—	16	—	2	—	4	6	—	—	3	—
Netherlands/*Pays Bas**	15	290	6	271	—	2	—	693	—	884	369	—	25	2	—	7	—
Nigeria	4	1	—	20	—	—	—	—	—	41	16	—	—	—	2	—	—
Norway/*Norvege**	55	3057	3	822	—	—	—	127	—	13420	1995	—	24	—	17	32	—
Oman*	1	24	—	—	—	—	—	37	5	—	—	2	—	—	—	—	—
Panama*	—	78	—	—	—	—	—	65	—	—	3	—	—	—	—	—	—
Peru/*Perou**	1	57	—	7	—	—	—	5	—	—	—	—	—	—	—	—	—
Poland/*Pologne**	15	72	2	240	—	—	—	118	—	7	285	—	23	—	—	7	—
Portugal*	34	222	18	49	—	—	—	69	—	—	—	8	28	—	1	4	—
Romania/*Roumanie**	16	4	—	2	—	—	—	32	—	—	18	—	4	—	—	2	—
Saudi Arabia/*Arabie Saoudite*	—	44	4	59	—	—	—	307	—	2	34	2	2	—	—	—	—
Scotland/*Ecosse*, Commissioners of Northern Lighthouses	29	124	35	5	—	—	—	127	—	43	44	—	21	—	—	18	
Scotland/*Ecosse*, Clyde Port Authority	—	73	—	—	—	—	—	118	—	11	16	—	3	—	—	—	—
Senegal	3	9	—	—	—	—	—	9	—	62	153	—	1	—	3	—	—
Singapore/*Singapour**	—	14	5	49	—	—	—	83	14	15	7	—	—	—	—	—	—
South Africa/*Afrique du Sud*	18	28	85	91	—	—	—	189	—	14	39	—	15	—	6	24	—
Spain/*Espagne*	89	160	10	705	—	—	—	265	—	—	—	—	40	—	4	27	—
Sudan/*Soudan**	1	4	7	12	—	—	—	—	—	107	2	—	—	—	—	1	
Sweden/*Suède*, Lake Vänern Navigation and Lighthouse Board*	4	62	—	28	—	—	—	30	—	810	16	153	—	—	—	—	—
Thailand/*Thaïlande*, Hydrographic Dept*	11	56	—	14	—	—	—	15	—	—	21	—	—	—	—	—	—
Thailand/*Thaïlande*, Port Authority*	—	20	—	—	—	—	—	39	—	14	—	—	—	—	—	—	—
Tunisia/*Tunisie**	21	45	—	20	—	—	—	85	—	36	56	—	—	—	2	3	—
United States of America/*Etats-Unis d'Amerique**	18	3518	107	6151	—	—	8	4143	—	9866	11302	—	397	—	1695	186	—
Viet Nam*	19	21	—	36	—	—	—	50	—	24	54	1	—	—	—	—	—
Yemen, Peoples Dem Rep/*Rep P de**	3	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Yugoslavia/*Yougoslavie**	33	154	—	426	—	—	—	56	1	253	59	—	15	—	—	3	—
MENAS	1	43	—	—	—	13	—	285	—	—	1	—	1	—	—	—	—

* Avait rempli le même questionnaire pour 1987/*Completed the same questionnaire for 1987.*

(1) Y compris les Départements et les Territoires d'Outre-Mer/including *Overseas Territories.*

1. STATISTICS OF AIDS TO NAVIGATION AS AT THE 31ST DECEMBER 1988

	AVERTISSEURS SONORES/ *SOUND SIGNALS*			AIDES RADIO ELECTRIQUES/*RADIO AIDS*																REFLECTEURS RADAR/ *RADAR REFLECTORS*
				Radiophares et radioalignements/ *Radiobeacons and radio leading lines*					Systèmes de radionavigation/ *Radionavigation systems*					Balises radar/ *Radar beacons*			Radars de surveillance/ *Surveillance radars*			
				Radiophares circulaires / *Non-directional radiobeacons*										Balises répondeuses radar/ *Racons*						
Autres marques/ *Other aids*	Sur supports fixes/ *On fixed structures*	Sur bateaux-feux/ *On light vessels*	Sur bouées/ *On buoys*	> 10 milles/ *miles*	< 10 milles/ *miles*	Radiophares directionnels/ *Directional radiobeacons*	Radioalignements/ *Radio leading lines*	Autres radiophares/ *Other radiobeacons*	Chaînes Decca/ *Decca chains*	Stations Loran A/ *Loran A stations*	Stations Loran C/ *Loran C stations*	Chaînes Toran/ Toran chains	Stations Oméga Différentiel/ *Differential Omega stations*	> 500 mW	< 500 mW	Ramarks/ *Ramarks*	Stations portuaires/ *Harbour stations*	Stations côtières/ *Coastal stations*	Autres aides/ *Other aids*	
—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	65	—	2	19	—	—	—	—	—	—	—	—	—	13	—	—	—	—	—	144
—	1	—	1	1	—	—	—	—	—	—	—	—	1	—	—	—	—	—	—	10
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2	—	—	—
—	42	—	6	11	—	36	4	—	6	11	—	—	1	1	19	44	10	—	—	265
—	8	—	—	3	—	—	—	—	—	—	—	1	—	—	—	—	—	—	—	8
—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	1	—	—	—	—	6
—	—	—	1	—	—	—	—	—	—	—	—	—	—	14	—	—	—	—	—	—
4	6	—	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	5
—	25	2	—	7	—	—	—	—	2	—	—	—	—	7	6	—	5	4	—	1948
—	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—
—	24	—	17	32	—	—	—	—	4	—	1	—	—	34	—	—	1	—	1	—
2	—	—	—	—	—	—	—	—	—	—	—	—	—	3	—	—	—	—	3	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	23	—	—	7	—	—	—	5	—	—	—	—	—	1	3	—	—	—	—	218
8	28	—	1	4	—	—	—	—	—	—	—	—	3	—	1	—	—	1	—	62
—	4	—	—	2	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2	2	—	—	—	—	—	—	—	—	—	7	—	—	7	4	—	—	1	—	271
—	21	—	—	18	2	—	—	—	6	—	—	—	—	25	1	—	—	—	—	78
—	3	—	—	—	—	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—
—	1	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	2
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	4	—	—	—	—	—
—	15	—	6	24	—	—	—	—	—	—	—	—	—	7	—	—	7	—	2	—
—	40	—	4	27	—	1	—	—	2	—	—	—	3	9	—	—	—	—	—	300
—	—	—	—	1	1	—	—	—	—	—	—	—	—	—	—	—	1	1	—	5
152	—	—	—	—	—	—	—	—	—	—	—	—	—	3	6	—	—	—	—	36
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1
—	—	—	2	3	—	—	—	—	—	—	—	—	1	1	—	—	—	—	—	19
—	397	—	1695	186	—	—	—	—	—	—	44	—	8	—	70	—	17	—	24	29000
1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—		—	—	—	—	1	—	—	—
—	15	—	—	3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	11
—	1	—	—	—	—	—	—	—	1	—	—	—	—	23	—	—	—	—	—	179

TABLE 2-17
Continued

DISPOSITIFS AU 31 DECEMBRE 1988 *POSITION AT THE 31ST DECEMBER 1988*	II. PERSONNEL/*STAFF*											Baliseurs *Buoy and lighthouse tenders*	
	Employés pour le fonctionnement des phares et feux à terre et sur les bateaux-feux gardés *Employed for the operation of lighthouses and lights on land and manned vessels*				Employé pour l'entretien des phares, feux à terre, bouées et balises en mer *Employed for the maintenance of lighthouses, lights, on land, buoys and beacons at sea*			Effectifs des équipages des baliseurs et vedettes de balisage *Crew in buoy tenders and servicing craft*		Effectifs des équipages des autres moyens de service *Crew in other servicing units*			
	Personnel titulaire *Established staff*		Temporaire et auxiliaire *Temporary and Auxiliary*										
	Hommes/*Men*	Femmes/*Women*	Hommes/*Men*	Femmes/*Women*	Hommes/*Men*	Femmes/*Women*	Parcs de balisage/*Depots*	Hommes/*Men*	Femmes/*Women*	Hommes/*Men*	Femmes/*Women*	> 30m	< 30m
Australia/*Australie*, Dept. of Transport*	54	—	4	2	174	11	11	72	—	—	—	2	—
Australia/*Australie*, Dept. of Harbours, Brisbane*	—	—	—	—	55	1	15	36	1	—	—	—	13
Australia/*Australie*, Port of Melbourne	—	—	—	—	14	—	6	17	—	—	—	1	—
Barbados/*Barbades*	—	—	—	—	6	1	2	—	—	—	—	—	—
Belgium/*Belgique*, Pilotage de la Coté et des Embouchures de l'Escaut*	21	—	—	—	5	—	—	22	—	—	—	2	—
Belgium/*Belgique*, Groupe Maritime de l'Escaut*	4	—	—	—	—	—	—	—	—	—	—	1	1
Benin/*Bénin**	7	—	—	—	7	—	1	—	—	2	—	—	1
Bermuda/*Bermudes*	11	3	1	—	11	3	2	10	—	—	—	—	3
Brazil/*Brésil**	206	11	—	—	520	41	6	142	—	—	—	5	5
Cameroon/*Cameroun**	8	—	—	—	28	1	1	15	—	5	—	1	2
Canada*	273	3	30	3	390	3	16	1018	76	60	2	25	14
Chile/*Chili**	—	—	—	—	155	—	16	—	—	—	—	—	—
China/*Chine**	1027	—	12	3	1818	286	32	1550	—	—	—	—	—
Cuba	12	2	—	—	60	—	28	98	—	—	—	4	1
Cyprus/*Chypre*	—	—	—	—	5	—	5	—	—	—	—	—	—
Denmark/*Danemark*	217	6	53	2	36	—	—	49	—	—	—	3	2
England & Wales/*Angleterre & Pays de Galles*, Trinity House*	189	4	32	—	281	76	6	147	—	—	—	3	2
England/*Angleterre*, Gloucester Harbour Trustees*	—	—	—	—	2	—	1	—	—	—	—	—	1
Equatorial Guinea/*Guinée Equatoriale**	2	—	8	—	10	—	—	2	—	—	—	—	1
Ethiopia/*Ethiopie*	3	—	6	—	—	—	—	—	—	—	—	—	—
Finland/*Finlande*	41	—	71	—	112	—	10	23	2	—	—	5	5
France* (2)	—	—	—	—	—	—	—	—	—	—	—	7	4
The Gambia	5	—	—	—	5	—	—	6	—	—	—	1	—
German Dem Rep/*Rép Dém Allemande**	—	—	—	—	—	—	—	—		—	—	2	10
German Fed Rep of/*Rép Féd d'Allemande**	78	—	2	—	354	6	19	—	—	—	—	11	12

MOY					MOYENS DE SERVICE/*SERVICE TRANSPORT*					
		...fectifs des ...ipages des ...liseurs et ...dettes de balisage *...ew in buoy ...nders and ...vicing craft*	Effectifs des équipages des autres moyens de service *Crew in other servicing units*		Baliseurs *Buoy and lighthouse tenders*			(1)	(1)	
< 30m	Autres bateaux/ *Oth...*	Femmes/ *Women*	Hommes/ *Men*	Femmes/ *Women*	> 30m	< 30m	Autres bateaux/ *Other vessels*	Avions/ *Fixed wing aircraft*	Hélicoptères/ *Helicopters*	Autres moyens/ *Other transport*
—	—	—	—	—	2	—	—	—	—	70 land vehicles + 6 LARC ampnibians
13	1	1	—	—	—	13	19	—	6	16 land vehicles
—		—	—	—	1	—	3	—	—	2 + 3 land vehicles
—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	2	—	—	—	—	—
1	—	—	—	—	1	1	—	—	—	—
1		—	2	—	—	1	1	—	—	2 land vehicles
3	—	—	—	—	—	3	—	—	—	—
5	2	—	—	—	5	5	24	—	—	45 land vehicles
2	—	—	5	—	1	2	—	—	—	1 land vehicle
14	2	76	60	2	25	14	26	6	28	235 land vehicles + 82 other units
—	—	—	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—
1	—	—	—	—	4	1	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—
2	—	—	—	—	3	2	—	—	—	—
2	,	—	—	—	3	2	5	—	2	27 vehicles, various, 6 cranes
1		—	—	—	—	1	—	—	—	—
1	-	—	—	—	—	1	—	—	—	—
—		—	—	—	—	—	1	—	—	1 land vehicle
5	5	2	—	—	5	3	55	—	2	12 + 40 snowcopters, 16 hydrocopters
4	4	—	—	—	7	4	48	—	—	—
—	—	—	—	—	1	—	—	—	—	—
10	—		—	—	2	10	—	—	—	12 land vehicles
12	1	—	—	—	11	12	13	—	—	26 land vehicles

* Avait rempli le même questionnaire pour 1987/ *Completed the same questionnaire for 1987.*

** Y compris le personnel employé pour l'entretien/ *including maintenance staff.*

(1) Y compris les appareils loués/*including hired aircraft.*

(2) Y compris les Départements et les Territoires d'Outre-Mer/*including overseas Territories.*

TABLE 2-18
WORLD STAFF AND
TRANSPORT VEHICLE STATISTICS

DISPOSITIFS AU 31 DECEMBRE 1988 / *POSITION AT THE 31ST DECEMBER 1988*	LE PERSONNEL/*STAFF* — Employés pour le fonctionnement des phares et feux à terre et sur les bateaux-feux gardés / *Employed for the operation of lighthouses and lights on land and manned vessels* — Personnel titulaire / *Established staff* — Hommes/*Men*	Femmes/*Women*	Temporaire et auxiliaire / *Temporary and Auxiliary* — Hommes/*Men*	Femmes/*Women*	Employé pour l'entretien des phares, feux à terre, bouées et balises en mer / *Employed for the maintenance of lighthouses, lights, on land, buoys and beacons at sea* — Hommes/*Men*	Femmes/*Women*	Parcs de balisage/*Depots*	Effectifs des équipages des baliseurs et vedettes de balisage / *Crew in buoy tenders and servicing craft* — Hommes/*Men*	Femmes/*Women*	Effectifs des équipages des autres moyens de service / *Crew in other servicing units* — Hommes/*Men*	Femmes/*Women*	Balis... *Buoy... lighth... tend...* > 30m
Greece/*Grèce**	—	—	—	—	—	—	—	—	—	—	—	2
Haiti	2	—	—	—	2	—	1	—	—	—	—	—
Hong Kong*	24	—	—	—	30	—	—	12	—	—	—	—
Iceland/*Islande**	19	8	70	1	—	—	—	12	—	—	—	1
India/*Inde*	332	—	285	—	106	—	6	139	—	—	—	2
Indonesia/*Indonésie**	20		1304	—	—	—	—	128	—	—	—	23
Ireland/*Irlande**	108	—	57	2	72	—	—	94	—	—	—	2
Israel*	—	—	—	—	—	—	—	—	—	—	—	—
Italy/*Italie**	260	3	—	—	164	20	7	100	—	—	—	4
Ivory Coast/*Côte d'Ivoire*, Port Abidjan	3	—	3	—	19	—	1	3	—	—	—	—
Ivory Coast/*Côte d'Ivoire*, Port San Pedro	2	—	2	—	4	—	1	—	—	—	—	—
Japan/*Japon**	1039	—	—	—	—	—	150	281	—	—	—	5
Korea, Dem Rep of/*Corée Rép Dem de*	—	—	—	—	121	3	5	52	—	—	—	—
Malaysia/*Malaisie**	44	13	—	—	127	—	4	61	—	—	—	3
Mexico/*Mexique*	281	—	—	—	—	—	24	54	—	—	—	1
Morocco/*Maroc**	27	—	37	—	64	—	1	8	—	—	—	—
Netherlands/*Pays Bas**	—	—	—	—	—	—	7	—	—	—	—	8
Nigeria	18	—	—	—	31	—	—	70	—	—	—	—
Norway/*Norvège**	208	—	1392	—	117	—	—	106	—	—	—	8
Oman*	—	—	—	—	—	—	—	—	—	—	—	—
Panama*	17	1	—	—	8	—	—	—	—	—	—	1
Peru/*Pérou**	—	—	—	—	—	—	—	—	—	—	—	—
Poland/*Pologne**	—	—	—	—	—	—	—	—	—	—	—	3
Portugal*	220	—	—	—	136	13	1	51	—	—	—	1
Romania/*Roumanie**	—	—	—	—	—	—	—	—	—	—	—	—
Saudi Arabia/Arabie Saoudite	—	—	—	—	—	—	6	34	—	—	—	4
Scotland/*Ecosse*, Commissioners of N. Lighthouses*	156	—	199	7	123	20	4	104	—	—	—	2
Scotland/*Ecosse*, Clyde Port Authority	—	—	—	—	11	—	1	6	—	—	—	1
Senegal	14	—	—	—	14	—	1	19	—	—	—	1
Singapore/*Singapour**	44	1	3	—	44	1	1	23	—	—	—	—
South Africa/*Afrique du Sud*	34	—	9	—	78	—	7	—	—	—	—	—
Spain/*Espagne*	506	30	5	7	310	[illegible]	—	—	—	—	—	—
Sudan/*Soudan**	2	—	3	—	8	—	—	—	—	—	—	1
Sweden/*Suède*, Lake Vänern Navigation and Lighthouse Board*	2	1	—	—	2	1	—	13	—	4	—	1
Thailand/*Thaïlande*, Hydrographic Dept*	78	2	—	—	78	2	1	67	—	—	—	1
Thailand/*Thaïlande*, Port Authority*	—	—	—	—	12	1	1	14	—	—	—	1
Tunisia/*Tunisie*	—	—	—	—	—	—	—	—	—	—	—	1
United States of America/*Etats-Unis d'Amérique**	—	—	—	—	—	—	—	2278	45	543	22	50
Viet Nam*	268	5	18	—	239	53	4	92	—	—	—	1
Yemen, Peoples Dem Rep/*Rép P de**	14	—	9	—	24	—	—	22	1	—	—	1
Yugoslavia/*Yougoslavie**	30	—	—	—	40	—	8	17	—	—	—	3
MENAS	7	—	—	—	22	—	1	30	—	—	—	1

* Avait rempli le même questionnaire pour 1987/*Completed same questionnaire for 1987.*

(1) Y compris les Départements et les Territoires d'Outre-Mer/*including Overseas Territories.*

...lliseurs / ...oy and ...hthouse ...nders < 30m
—
—
2
—
6
—
1
—
—
—
1
—
73
15
—
7
—
3
2
6
—
—
12
8
1
1
1
—
1
—
2
— 3
14
5
5
—
—
—
29
—
—
11
—

Effectifs des équipages des autres moyens de service *Crew in other servicing units*		MOYENS DE SERVICE/*SERVICE TRANSPORT*					
		Baliseurs *Buoy and lighthouse tenders*			(1)	(1)	
Hommes/ *Men*	Femmes/ *Women*	> 30m	< 30m	Autres bateaux/ *Other vessels*	Avions/ *Fixed wing aircraft*	Hélicoptères/ *Helicopters*	Autres moyens/ *Other transport*
—	—	2	—	—	—	—	3 land vehicles
—	—	—	—	—	—	—	1 land vehicle
—	—	—	2	—	—	—	1 land vehicle
—	—	1	—	—	—	—	5 land vehicles
—	—	2	6	1	—	—	27 land vehicles
—	—	23	—	44	—	—	2 horses
—	—	2	1	19	—	1	—
—	—	—	—	—	—	—	—
—	—	4	—	79	—	—	100
—	—	—	1	1	—	—	6 land vehicles + 4 M/C
—	—	—	—	—	—	—	1 land vehicle + 1 M/C
—	—	5	73	1	—	—	267 land vehicles
—	—	—	15	—	—	1	3 land vehicles
—	—	3	—	—	—	—	9 land vehicles
—	—	1	7	75	—	4	121 land vehicles
—	—	—	—	2	—	—	5 land vehicles
—	—	8	3	2	—	—	4 land vehicles
—	—	—	2	—	—	—	—
—	—	8	6	5	—	—	—
—	—	—	—	—	—	—	—
—	—	1	—	—	—	1	1 2 land vehicles
—	—	—	12	—	—	—	—
—	—	3	8	6	—	—	2 6 land vehicles
—	—	1	1	5	—	—	14 land vehicles
—	—	—	1	—	—	—	2 land vehicles
—	—	4	1	—	—	—	—
—	—	2	—	5	—	1	22 land vehicles
—	—	1	1	1	—	—	1 land vehicle
—	—	1	—	—	—	—	—
—	—	—	2	1	—	—	—
—	—	—	— 3	—	—	—	29 land vehicles
—	—	—	14	—	—	—	3 40 land vehicles
—	—	1	5	—	—	—	—
4	—	1	5	—	—	—	1 + 2 hydrocoptars
—	—	1	—	10	—	—	1 land vehicle
—	—	1	—	—	—	—	—
—	—	1	—	3	—	—	—
543	22	50	29	145	Coast Guard units		
—	—	1	—	10	—	—	13 land vehicles
—	—	1	—	—	—	—	—
—	—	3	11	57	—	—	13 land vehicles
—	—	1	—	—	1	—	4 land vehicles

* Avait rempli le même questionnaire pour 1987/ *Completed the same questionnaire for 1987.*

** Y compris le personnel employé pour l'entretien/ *including maintenance staff.*

(1) Y compris les appareils loués/*including hired aircraft.*

(2) Y compris les Départements et les Territoires d'Outre-Mer/*including overseas Territories.*

TABLE 2-18
Continued

is infrequent. With VTS systems, fewer aids to navigation are necessary since mariners have another means to keep them in position.

The IALA '90 Conference was held in Veldhoven, The Netherlands in June of 1990. An overview of the Conference is given in Appendix E. The major topics addressed in separate sessions were: Systems Approach; Management Issues; Navigation Guide; Fixed and Floating Aids; Radionavigation; Exhibition of Manufacturer Equipment; Aspects of VTS and Civil Engineering.

Of particular interest is the general report made by Mr. Martonen of Finland, Chairman of the Committee on Floating and Fixed Aids. He summarized the state of affairs since the last IALA Conference 5 years ago as follows:

- Today the performance of buoys is increasingly described by mathematical models.
- General trends with floating aids are:
  - Design based on tank tests
  - Performance data collected from buoy stations
  - Longer service periods
  - Better materials
  - Conversion of buoy stations to fixed aids to navigation stations.
- The community should report on unsuccessful as well as successful buoy designs so that all may learn.
- Control Microprocessors are increasing in application.
- General trends with servicing craft:
  - Smaller units needed to service new energy sources.
  - Increased automation and crew reduction.
  - Better position keeping capabilities.
- Energy Sources.
  - Increased Solarization.
  - Solarization being applied to larger and larger lights.
  - New power sources making a breakthrough.
  - Reduction in prevalent light ranges.
  - Wind energy still being considered.

- Wave Energy generators are maturing.

- Some new breakthroughs like the seawater power cell developed in Norway (See Section 2.1.9).

Many voluminous and important publications were unveiled at the Meeting inluding "The NAVGUIDE" and the "IALA Guide to the Availability and Reliability of Aids to Navigation", References 42 and 44 respectively.

A session of the Conference was devoted to reviewing the NAVGUIDE. It is noted in its Foreword that the NAVGUIDE will assist those planning for the future as it deals with the needs, required accuracies and the selection of a suitable mix of navaids to meet particular circumstances. It is noted that the following are some of the changes that have taken place that have caused Lighthouse Authorities to reconsider the needs of the mariner and the aids to navigation he requires:

- The changing economic and social climate requires savings in capital and maintenance costs, and thus the need to reduce manning levels. In many countries personnel are no longer willing to endure long periods of isolation or discomfort.

- The increasing use of radar and radar devices requiring the introduction of radar reflectors, racons, etc. either instead of or supplementary to lights and daymarks.

- A changing pattern of sea trade, the establishment of routing systems and a greater management of traffic via Vessel Traffic Services (VTS) or radio communications. The shifting of traffic to developing countries away from former trading areas. In some cases reduction of skill levels for those manning the ships, and in other increased awareness of and reliance upon electronic rather than traditional aids to navigation.

- An enormous increase in the number of pleasure craft in many countries.

- The need to standardize equipment; to simplify maintenance; ensure economies and possibly reduce the numbers of vessels used for maintenance purposes.

- An enhanced need for short range navigational accuracy. Ships are now larger and the safety margins in terms of depth and width of channels are smaller.

A summary of the NAVGUIDE Chapters follows:

CHAPTER 1: Background

gives an overview of what navigation is and the considerations involved in the determination of policy by Lighthouse Authorities.

CHAPTER 2: Navigation Requirements for Accuracy

discusses accuracy; the general conceptions of what accuracy is and means to the mariner. The need for accuracy is covered and the chapter includes notes on hydrographic accuracy related to surveying. Comment is made on the relationship between the accuracy of any aid to navigation system or mix and the scale of accuracy of the navigational chart. A philosophy on accuracy leads to recommendations on the level of accuracy being used. It concludes that in IALA documents the stated accuracy of a two dimensional fixing system should, in principle, be the radius of a circle in which a fix had a 95% probability of being found. The center of the circle is the true position in the case of absolute and predictable accuracies. In the case of a repeatable accuracy, it is the mean value of a number of measurements.

CHAPTER 3: Availability/Reliability of Aids to Navigation Failure Response Time

uses extracts from the IALA Guide to Reliability to discuss the performance standards of aids to navigation. It includes recommendations on the desired levels of performance of aids to navigation to be achieved.

It is noted that the large amount of data gathered by IALA shows that as a general rule light buoys have an availability ranging from 99.9% to 97% depending on local conditions and the type of power supply. It is suggested that the absolute minimum level of availability should be set at 95% but that it should be possible to provide a system of aid that gives an overall acceptable level of availability even though individual units of the system may on occasions fall below 95%

CHAPTER 4: Standardization of Aids to Navigation

briefly assesses the advantages to be accrued from the standardization of equipment. The benefits of standardization are summarized as:

- fewer different types of equipment in use means that fewer maintenance personnel are required.

- less spares need to be stored leading to

  a. Less space being utilized for spares reducing rents or releasing space for more productive use.

  b. Less capital being tied up as an investment in spares.

- it can lead to better liaison between authorities and manufacturers of equipment and may lead to economies through larger orders of certain types of equipment.

- it allows greater flexibility and certainty in the replacement of parts on station. This coupled with the greater familiarity of technicians with the equipment can lead to less downtime following a failure of an aid to navigation.

CHAPTER 5: Training of Maintenance Personnel

discusses the desirability and benefits to be gained from adequate training of personnel involved in the maintenance of aids to navigation. Examples of subjects that might be covered in training schemes are given.

CHAPTER 6: The Use of Databases

comments on the developments in modern technology that have resulted n the provision of computer based records by Lighthouse Authorities. It gives examples of the type of data that can be processed. There is a cautionary statement on the dangers of being overambitious in the development of computerized databases.

CHAPTER 7: Economic Factors and Planning

will be particularly interesting to those authorities which are, for one reason or another, attempting to economize and to be more cost effective. The overriding principle of safety of the mariner must remain but the economic facts of life are becoming more relevant.

CHAPTER 8: Waterways Considerations

covers the planning, design, marking and management of a waterway. Consideration is given to the calculations involved in assessing the size of vessel capable of using a waterway and also to other principles involved in the determination of requirements.

CHAPTER 9: Evaluation of the Needs for Aids to Navigation

discusses the evaluation of the need for aids to navigation. It details the factors involved in the evaluation, tabulates the accuracies obtainable at certain ranges of different types of aids and provides an easy guide to the advantages and disadvantages to both the user and the provider of aids to navigation.

CHAPTER 10: Information to the Mariner

highlights the importance of informing the mariner of the operational status of aids to navigation. The World Wide Navigational Warning Service is described.

CHAPTER 11: Aids to Navigation Systems

provides descriptions of all types of aids to navigation, visual, fixed and floating, radar and radio. In addition the value of each type of aid is given together with performance criteria. This chapter is a collection of facts which will enable the reader to assess the relevance of an aid.

CHAPTER 12: Nav-Plan Layout

considers the development of an Aids to Navigation Plan which should actually be the aim of all Lighthouse Authorities. The factors to be considered are listed.

CHAPTER 13: IALA Recommendations, Guideline and Manuals

schedules the relevant IALA Recommendations, Guidelines and Manuals.

CHAPTER 14: References

is a list of the references used in the compilation of the NAVGUIDE.

CHAPTER 15: Definitions

consists of definitions of technical expressions used in the NAVGUIDE.

CHAPTER 16: Abbreviations

is an alphabetical list of the meaning of all abbreviations used in the NAVGUIDE.

CHAPTER 17: Annexes

contains annexes of a technical nature which provide more detail covering some subjects discussed in the main text of the book. These include Hydrographic Requirements of Nautical Charts, the Methods of Calculation of Accuracy, Technical Description of Radio Aids to Navigation, a Data Sheet on Leading Lines or Ranges and information on the members of the Working Group which has produced the NAVGUIDE.

CHAPTER 18: Index

is a detailed index of the chapters of the book and their contents.

The IALA Guide to the Availability and Reliability of Aids to Navigation considers reliability and availability techniques as management tools to assist in the decision making process, arising from the reassessment of established policies, and the rationalization of the approach to the inevitable and unavoidable failure of existing and new types of ATON. It gives guidance and advice on the application of the techniques. Quality assurance and maintenance management are also considered in this context. The

Part II Applications Guide specifically considers signalling devices, power sources and moorings but not the buoy hull.

2.4 Other Countries' National Authorities and Manufacturers

2.4.1 Australia

The Department of Transportation and Communications (DTC) is responsible for Australia's coastal marine navigation aids. Various state governments provide the navigation aids within port limits and those for fishing and pleasure craft.

In recent years, the highest number of buoys operated by the DTC has been about 40. Currently, there are 32 buoy stations. Eighteen are of their own 8 ft. x 28 ft. shown in Figure 2-88 which is similar to U.S. Coast Guard 8 ft. x 26 ft. except that the tail tube is 2 ft. longer to improve stability and the tower and tail tube are bolted to the buoy hull to make them easier to transport.

The remaining buoys are Zeni Lite ZWB-250 types (See Buoy Drawing No. Japan MFG 3-2 in Appendix C).

There are no specialty manufacturers of buoys in Australia.

References for Additional Information:

Interview Summary	:	Appendix A, Section A.3.1
Buoy Records	:	Appendix B, 1 Entry, Pages B-1 through B-3
Buoy Drawings	:	Appendix C, Page C-1

2.4.2 Belgium

The "Administration de la Marine et de la Navigation Interieure" is responsible for 80 buoys covering 5 harbors with 8 entrances. All these buoys have been purchased from Balmoral. They are in the process of converting these buoys from propane to solar/battery power.

References for Additional Information:

Interview Summary : Appendix A, Section A.3.2

2.4.3 Chile

The "Direccion General Territorio Maritimo y Marina Mercante" is responsible for aids to navigation in Chile. Chile with its long coastline has several hundreds of fixed marks and buoys. IALA lists 24 lights on floating marks.

The authority has recently developed the new buoy design shown in Figure 2-89. They have had this new design built in plastic as well as steel.

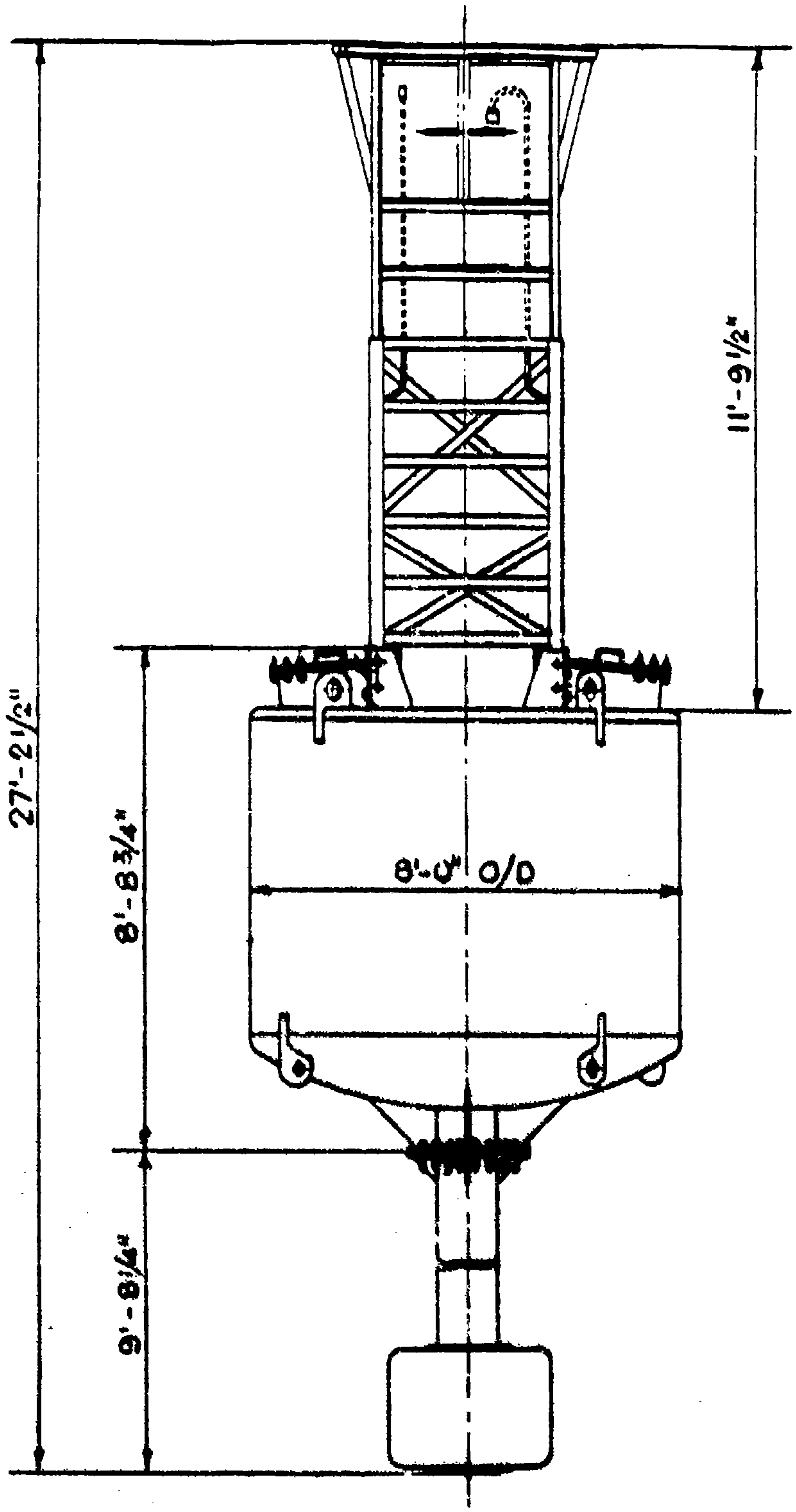


FIGURE 2-88
AUSTRALIA'S 8x28 BUOY

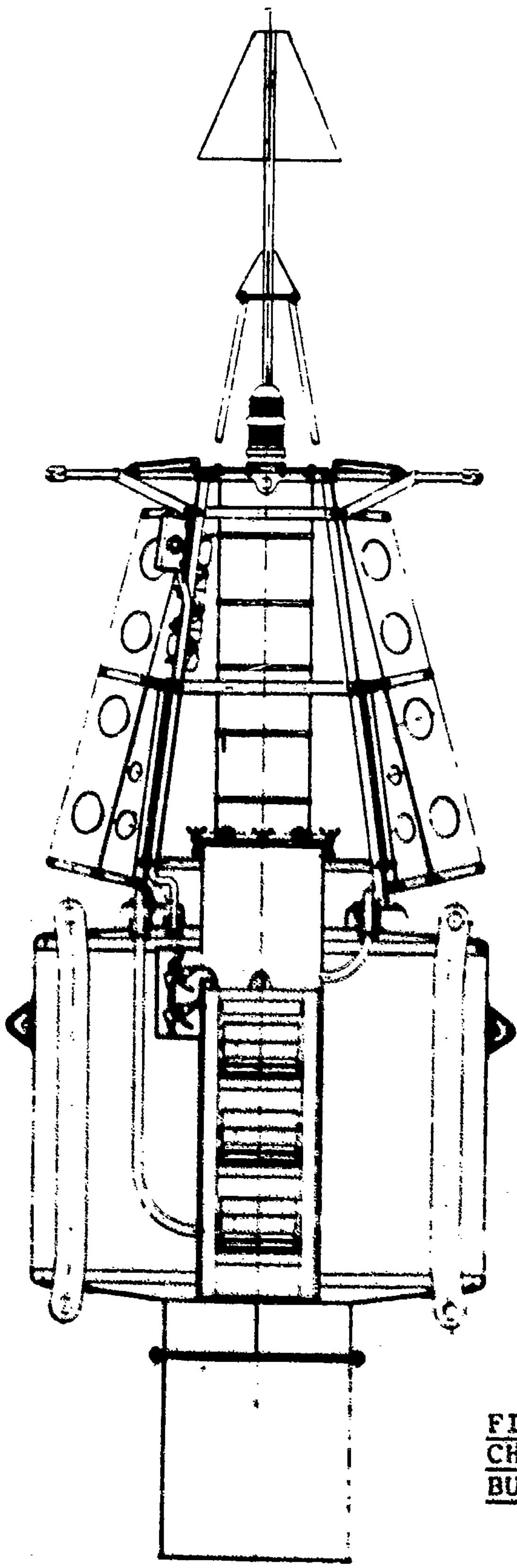


FIGURE 2-89
CHILE'S NEW DESIGN
BUOY

They have found that the plastic tends to be damaged during buoy tender operations.

References for Additional Information:

Interview Summary : Appendix A, Section A.3.3

2.4.4 Equatorial Guinea

The "Direccion General De Puertos y Senales" is responsible for aids to navigation. They purchase all their equipment and buoys from Gisman (see Section 2.2.5.1) in France. According to the IALA tables in Section 2.5, they have few buoys.

References for Additional Information:

Interview Summary : Appendix A, Section A.3.4

2.4.5 Hong Kong

The "Government Marine Department" is responsible for aids to navigation in Hong Kong. According to IALA listings they have in the order of 45 lighted buoys and 4 unlighted buoys.

Hong Kong's principal means of facilitating the safe and expeditious execution of port calls made by commercial shipping and of voyages undertaken by the multifarious passenger-carrying ferries operating on scheduled services to and from Hong Kong and a number of ports on the Pearl River between Guangzhou (Canton) and Macau is its new Vessel Traffic Service (VTS). Secondary allied purposes of the Hong Kong VTS are the maintenance of port call records and the automation of certain related invoicing processes.

References for Additional Information:

Interview Summary : Appendix A, Section A.3.5

2.4.6 India

2.4.6.1 Department of Lighthouses and Lightships

The "Department of Lighthouses and Lightships (DLL)" is entrusted with maintaining aids to navigation along India's large coastline of about 7200 km., including the Islands of Andaman and Nicolas in the Bay of Bengal and Lakshadweep Islands in the Arabian Sea. There are ten district authorities responsible for various regions. Their navigational aids consist of lighthouses, light vessels, radio beacons and Decca navigator chains all dispersed over the entire coastline. These include 300 ATON buoys.

India's nagivation buoys are of steel and GRP, some of which are described in Section 2.4.6.2 below, with the largest buoy having a diameter of 3.66 meters. Power sources include gas, batteries and solar panels.

There were four papers spresented at the IALA '90 Conference by authors from India and these are summarized below:

1. **Replacement of Lighthouse Tender M.V. SAGARDEEP**, by K. Sriram, Paper No. 3.5.1: A description of the DLL's 100.9 meters in length lighthouse tender built in 1964 and the development of specifications and drawings for its replacement by a vessel of 82.6 meters in length.

2. **Training of Lighthouse Personnel and Facilities Available in India and Maintenance Objectives of Aids to Navigation**, by K.V. Mohan Rao, Paper No. 2.1.3: The first part of the paper deals with the necessity of the comprehensive training of lightkeepers and other operational and maintenance personnel; indicating the present training facilities available in the country as well as the future program of revamping the Training Center at Calcutta. The second part of the paper, which addresses floating aids to navigation as well, describes preventive and corrective maintenance, their objectives, functions and corrective measures to be adopted to make the aid reliable and to have a high availability factor.

3. **Replacement of Existing Bombay and Calcutta DECCA Navigator Chains by Loran C Chains**, by K. Sriram, Paper No. 4.3.2: Describes the replacement noted in the title.

4. **Application of Polymer Impregnated Ferrocement and Fiber Reinforced Concrete Construction Techniques on Lighthouses and Construction of a New Reinforced Concrete Lighthouse at Paradip**, by E.U. Rao, Paper No. 6.1.2: Part I of the paper describes the properties and potential of these new materials for the construction of lighthouse towers while Part II outlines the salient features of design and construction of a reinforced concrete lighthouse tower at the Paradip Port.

<u>References for Additional Information</u>:

Interview Summary : Appendix A, Section A.3.6.1

2.4.6.2 <u>ANA Navaids, Ltd.</u>

ANA Navaids Ltd. (ANA) provides a range of aids to navigation equipment including electric equipment, gas equipment, lantern houses, towers, radar reflectors, navigation buoys, mooring buoys, light floats, light vessels, buoy tenders and mooring gear.

ANA manufactures small GRP buoys for harbors, rivers and estuaries; medium size GRP buoys for moderate sea conditions; GRP Catamaran buoys for harbors, rivers and estuaries; skirt and tail tube steel buoys for environments from moderate sea to deep sea. All their buoys can be gas or solar/battery powered.

Figure 2-90 shows a small size GRP buoy with two pockets. The body is filled with polyurethane foam which makes it rigid and virtually unsinkable in case of accident. The color is impregnated and can or cone type daymarks can be fitted. Its bottom design has been configured for shallow water and high current application. Figure 2-91 shows a medium large size GRP buoy with one central pocket and mild steel angle superstructure. The body is filled with polyurethane foam. The buoy has a diameter of 2.5 meters and weighs 2400 kilograms. Figure 2-92 shows a small size GRP buoy with one pocket. The catamaran has two hulls which are joined at the front to make a single hull so that no floating debris gets entangled in the small gap between the hulls. This catamaran buoy has proven to be very suitable for river applications where current speed may reach 8 knots. Figure 2-93 depicts a medium size mild steel tail tube buoy.

ANA has found that GRP buoys require three times the counterweight to match the motion response of steel buoys.

References for Additional Information:

Interview Summary	:	Appendix A, Section A.3.6.2
Buoy Records	:	Appendix B, 4 Entries, Pages B-779 through B-790
Buoy Drawings	:	Appendix C, Pages C-152 through C-155

2.4.7 Ireland

The "Commissioner of Irish Lights" is responsible for aids to navigation in the waters of both Nortnern Ireland and the Republic of Ireland. From IALA listings they appear to have 105 lights on floating buoys.

In the recent past they have been standardizing their buoys which are of thair own design. They had too many types. It is believed their buoys are of steel and similar to those of the Trinity House of England.

References for Additional Information:

Interview Summary : Appendix A, Section A.3.7

2.4.8 Malawi

Malawi is inland from Mozambique in eastern Africa and does not have a seacoast. Their buoyage which is the responsibility of the "Ministry of Transport", is used on a major lake. In total they have 11 fixed marks and 7 buoys, all from Pharos.

References for Additional Information:

Interview Summary : Appendix A, Section A.3.8

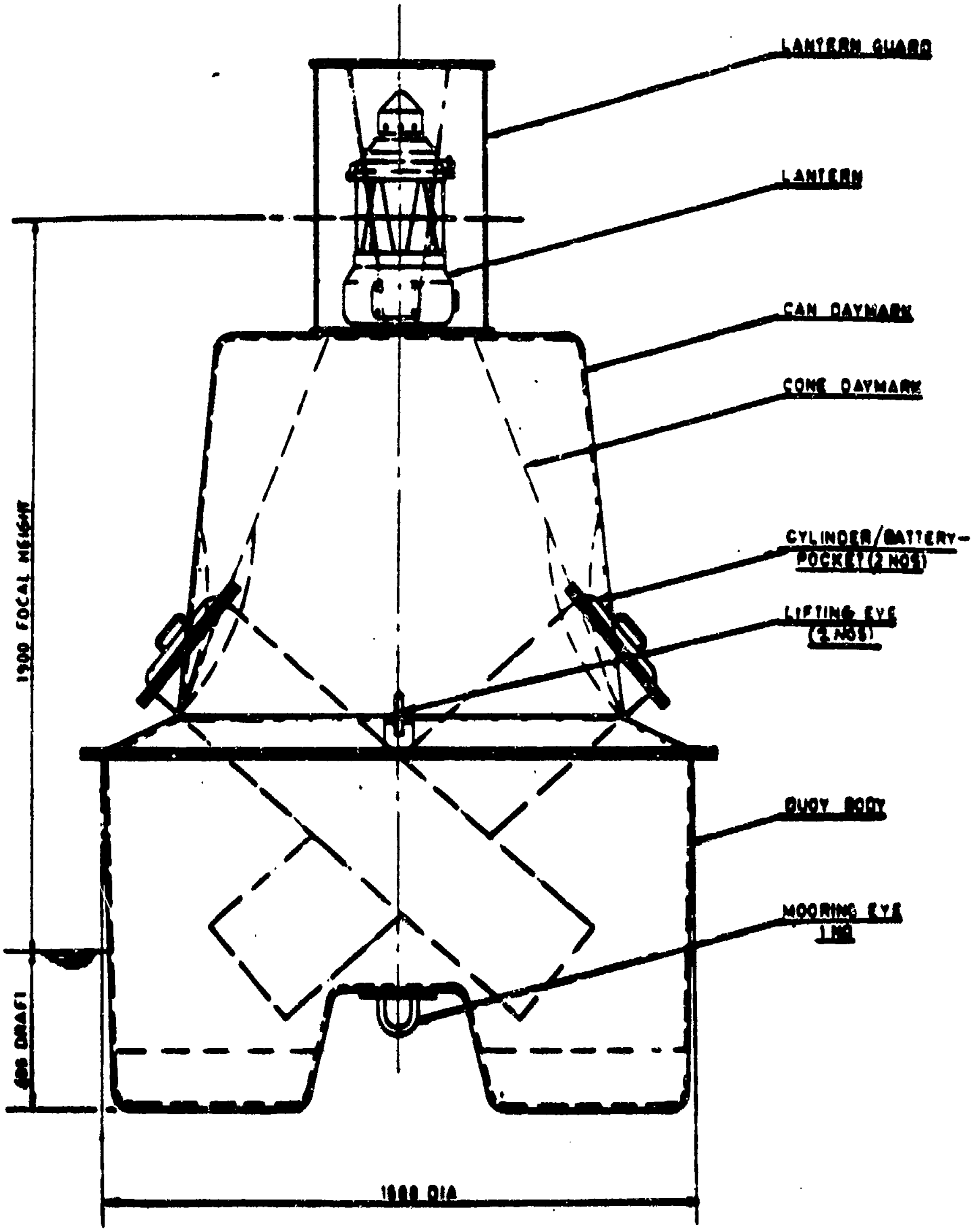


FIGURE 2-90
INDIA'S SMALL
SIZE GRP BUOY

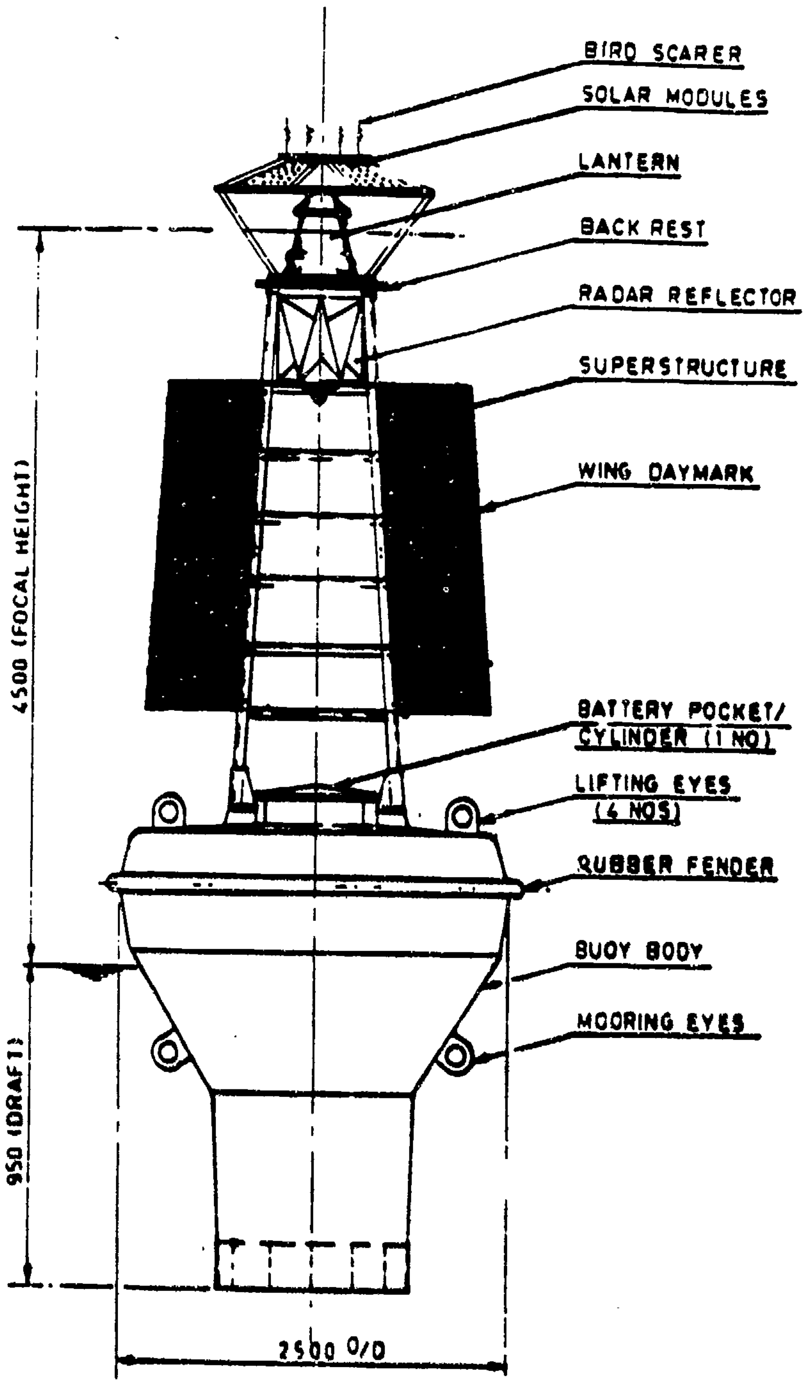


FIGURE 2-91
INDIA'S MEDIUM
SIZE GRP BUOY

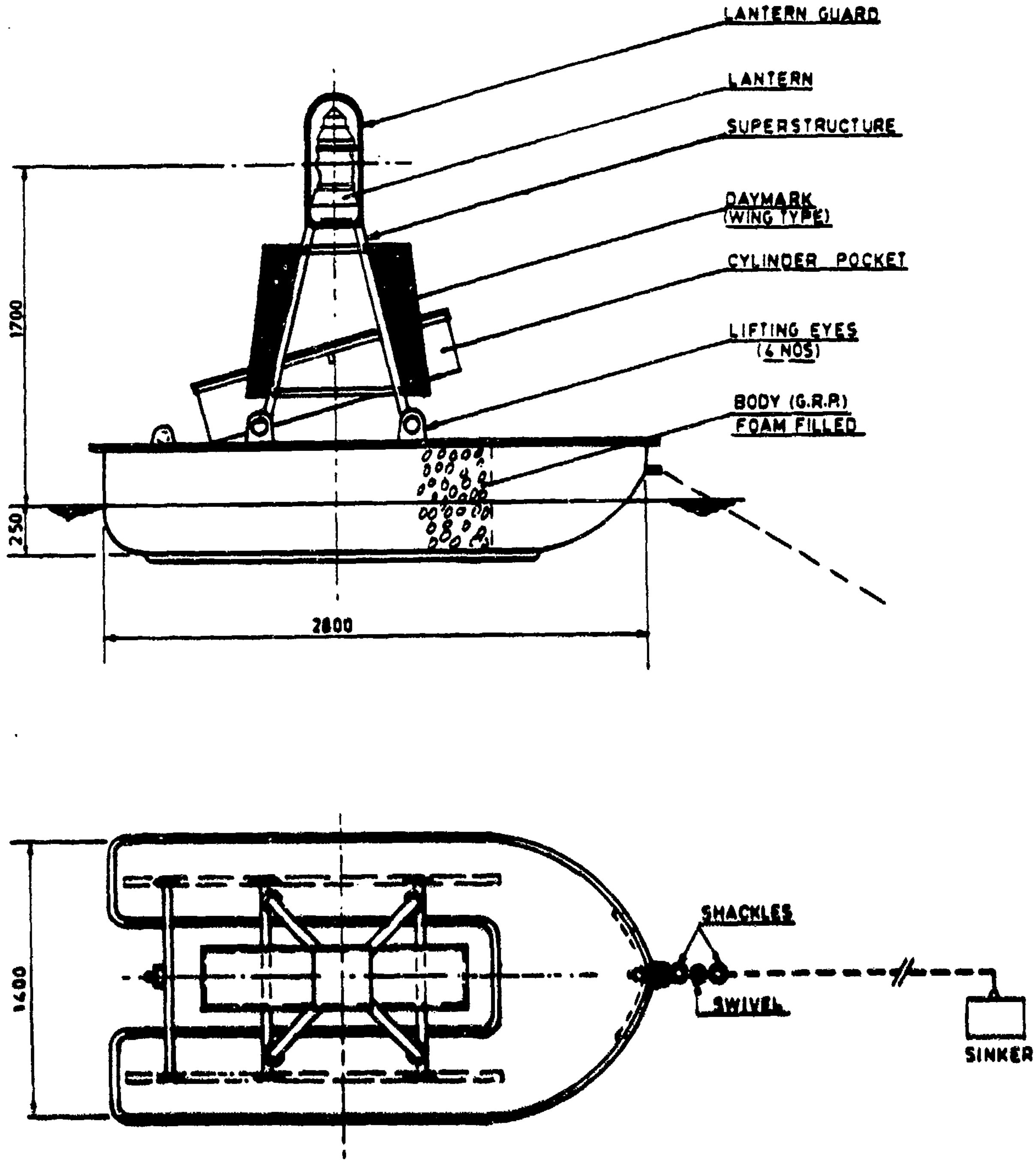


FIGURE 2-92
SMALL SIZE BUOY
WITH ONE POCKET

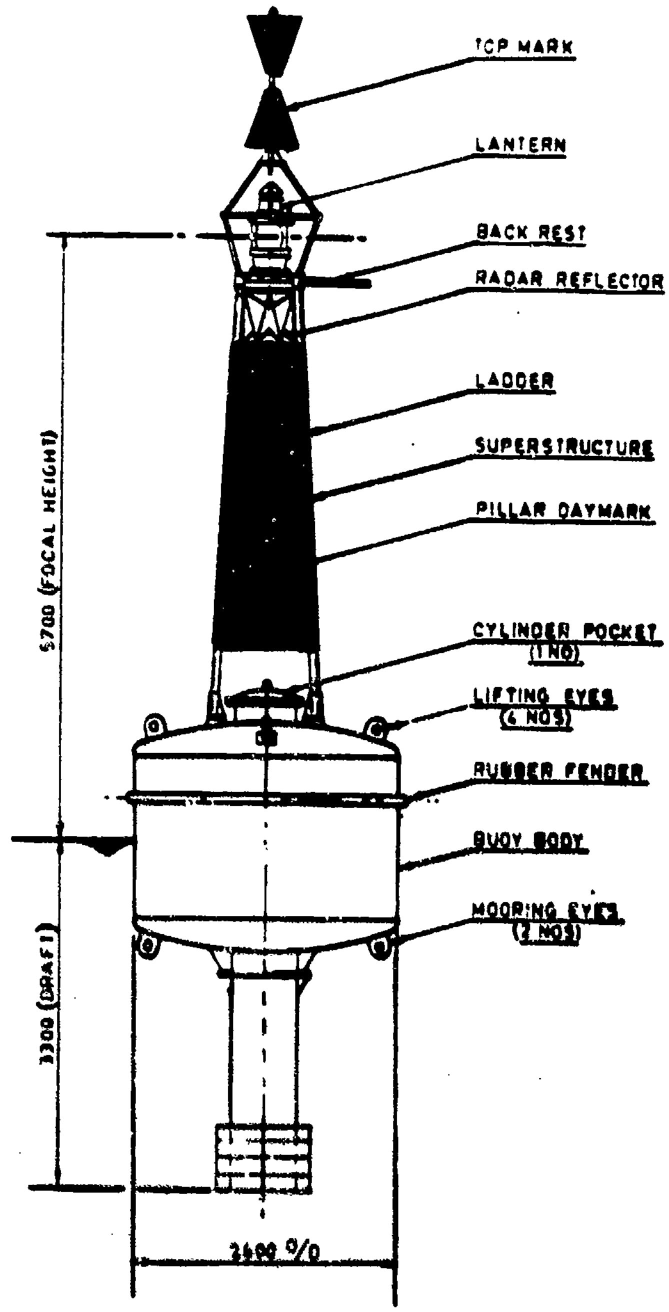


FIGURE 2-93
INDIA'S MEDIUM SIZE
STEEL TAIL TUBE BUOY

2.4.9 New Zealand

The Marine Division of the Ministry of Transport is responsible for aids to navigation in New Zealand, except within harbors where the responsibility is that of local authorities.

As a result of there being deep water all around the island, there are only seven offshore buoys which they have purchased from manufacturers.

Vegas Industries of New Zealand is an industrial member of IALA but it was not possible to make contact with them at the IALA' 90 Conference.

References for Additional Information:

Interview Summary : Appendix A, Section A.3.9

2.4.10 Nigeria

The Nigerian Port Authority is responsible for aids to navigation in Nigeria. As a third world country they believe their ATON system is more advanced, particularly in Africa. They have a total of 300 buoys purchased from manufacturers outside their country including Tidelands, Automatic Power, and Balmoral.

Maintenance is currently their most significant consideration and it is expensive for them. Every two years buoys are hauled and moorings checked. The warm water in their area is particularly hard on equipment due to corrosion and marine growth. They service these buoys with two buoys tenders, one for offshore work and one for rivers.

They have found that GRP is hard to repair and, as a result, has not worked out favorably for them. They have ordered a Balmoral foam buoy with elastomer to try this concept.

They have found that the claims of manufacturers are always impressive, but not always borne out in practice. Manufacturers, whom they are dependent upon, should place more emphasis on the reliability and maintainability of their buoys and equipment.

References for Additional Information:

Interview Summary : Appendix A, Section A.3.10

2.4.11 Peoples Republic of China

The Shanghai Navigation Aid Factory (SNAF) was an industrial exhibitor at the IALA '90 Conference. They have a history of more than 100 years in design, manufacture and maintenance of aids to navigation and have been engaged in developing and manufacturing buoys for forty years.

Reportedly SNAF buoys can be found in every harbor and channel of the Peoples Republic of China. In recent years they have produced buoys for America, England, Mexico and Mauritania.

Their navigation buoys, shown in Figure 2-94, consist of steel tail tube buoys from 1.15 to 3.83 meters in diameter, steel skirt buoys of from 1.5 to 2.4 meters in diameter, and smaller inland buoys of steel with tail tube and skirts.

References for Additional Information:

Interview Summary	:	Appendix A, Section A.3.11
Buoy Records	:	Appendix B, 2 Entries, Pages B-125 through B-130
Buoy Drawings	:	Appendix C, Pages C-37 and C-38

2.4.12 Saudi Arabia

Fifteen years ago very few marine aids to navigation existed in Saudi Arabia remote from the oil exportation terminals and their approaches. Since then a rapid expansion in port facilities has seen an equally rapid improvement of aids to navigation, which are the responsibility of the Saudi Port Authority (SPA).

More than 400 light buoys have been installed in approaches to the Saudi ports. Surveillance radar equipment has been installed at the ports of Yanbu, Jeddah, Ras Tanara and Jubail. Longer range navigation have been aided by the deployment of a Loran-C Radio Navigation System which covers all the coastal waters.

It is likely that the SPA floating aids are standard buoys of manufacturers like Pintsch Bamag (see Section 2.2.6.1). These are maintained by five buoy tenders ranging in size from a small buoy maintenance catamaran to two sea-going maintenance vessels.

During the IALA '90 Conference the SPA presented Paper No. 3.6.2 "Solar Energy in the Red Sea" by A.A. Jehaiman where it was noted that Gulf buoys have solar panels on top of the cage like Japanese buoys and they orient the panels at a 10° incline to the horizontal. Dust collection and bird droppings have a severe impact on the solar panel operation and as a result the solar panels are not performing at anywhere near the level suggested by the manufacturers/suppliers. In response the SPA has had to increase maintenance activities to provide more frequent cleaning and replacing of panels and changing of batteries. Solarization has actually been more expensive for them than utilizing gas and they feel the industrial members of IALA should address this. The SPA has no intentions of installing additional solar panels until they believe the situation will improve.

References for Additional Information:

Interview Summary	:	Appendix A, Section A.3.12

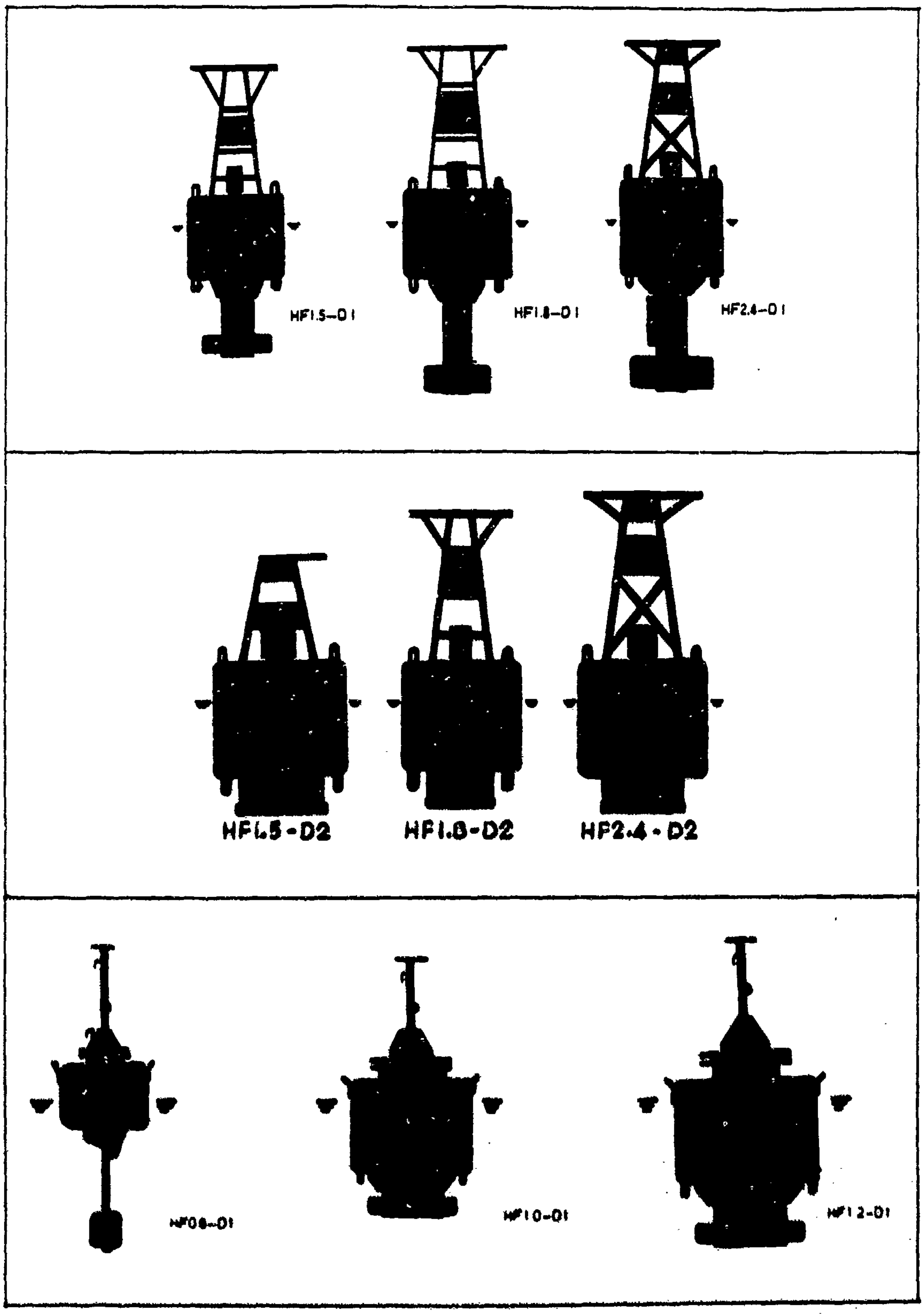


FIGURE 2-94
CHINA'S STEEL
OFFSHORE AND
INLAND BUOYS

2.4.13 Scotland

The "Northern Lighthouse Board" of Scotland is responsible for all navigation buoys in the waterways of Scotland and the Isle of Mann except for those of the Clyde Port Authority. This includes more than 300 buoys. They are of a design similar to those of the Trinity House of England (see Section 2.1.3.1).

Approximately 100 of their buoys are lighted by acetylene gas, although they are converting to solar/battery power.

References for Additional Information:

Interview Summary : Appendix A, Section A.3.13

2.4.14 South Africa

The South African Harbors Authority maintains 300 buoys at 5 major and 3 minor harbor entrances.

These buoys are of several designs and have been purchased from established manufacturers. They have a Resinex (see Section 2.2.7.1) buoyant beacon and this same company indicated they expect tc have available a telescoping buoyant beacon to adjust to changes in tide. They also utilize a double hull buoy made from hemispherical heads manufactured in a boiler factory.

References for Additional Information:

Interview Summary	:	Appendix A, Section A.3.14
Buoy Record	:	Appendix B, 1 Entry, B-1125
Buoy Drawing	:	Appendix C, Page C-228

2.4.15 Sweden

The National Swedish Administration of Shipping and Navigation is responsible for navigation buoys in Sweden which reportedly has up to 10,000 buoys including private aids.

They utilize steel offshore buoys and plastic in-shore buoys. Their buoy tenders operate in ice up to 20 cm in thickness.

References for Additional Information:

Interview Summary : Appendix A, Section A.3.15

2.5 Review of Findings and Trends

2.5.1 General

The results of the surveys and findings have been included in various parts of this report. Sections 2.1 through 2.4 review the results of interviews and data gathering efforts from the navigation authorities and manufacturers throughout the world. Section 3.0 presents the Buoy Technical Information System (BTIS) and its database, which includes technical data and graphic representations of all the buoys identified. The present section identifies innovations identified.

Task C will concern the formulation of recommendations for the development of improved aids to navigation buoys for the USCG. For this reason this section has been divided into general topic areas that are believed to have significance as key areas for future consideration. In Section 2.5.2 those specific areas and problems identified by the USCG in its "Statement of Work" for this project are addressed. Section 2.5.3 considers topics that are deemed to be fruitful areas for future research and development promising to offer improvement for the USCG navigation buoyage.

The areas identified by the USCG and expanded on the basis of survey findings are river and fast water buoys, large lightweight buoys, articulated beacons, ice buoy design, exposed location buoys, unlighted sound buoy design, correlation of tender size to buoy characteristics and measure of buoy effectiveness. Other topics that are deemed to be fruitful areas for future research include general buoy hull design, construction methods and materials, payload and signal equipment impacts, buoy maintenance in support systems and buoy design methods and procedures.

2.5.2 Specific Problem Areas Identified

2.5.2.1 River and Fast Water Buoys

The USCG has not yet been able to develop a survivable, low cost, lightweight buoy for use in fast water environments. A lightweight plastic, fast water buoy with a spherical, foam filled hull has been developed which rides very well and meets its weight requirements, but its susceptibility to damage and high initial cost has relegated it to only limited use. Collision and debris accumulation appear to be the most troublesome areas in this type of service, and so far no Coast Guard effort has been able to overcome them. Foam buoys appear to be attractive for this type of service, but the problems of cost and debris accumulation still exist. As manufacturing processes and materials have improved, the cost for these buoys has steadily declined, but there is currently no solution for the debris problem. As it stands now the USCG uses small steel, foam-filled buoys on a throw-away basis for most of its river applications.

Some of the findings during the surveys that may impact this situation include:

- The Canadians (Orraids, Ltd.) have a design (developed by Janko & Associates, England), for a fast water buoy capable of withstanding 10 knots of current. It is currently being tested on the Niagara River.

- Zeni Lite Buoy Co. of Japan has a design for several sizes of a large fast water discus buoy.

- Pharos Marine, Ltd. of England has Catamaran hulls for fast water buoys. ANA Navaids of India has GRP catamaran buoys for high currents (to 8 knots) and debris shedding.

- Korea has developed a finned tail tube buoy that will maintain a maximum 10 degree list in 5 knot current, (see IALA '90 Conference Paper 3.2.3).

- The Gilman Corporation of USA has developed a Surlyn foam fast water buoy for Canada.

2.5.2.2 Large Lightweight Buoys

Numerous USCG attempts have been made to apply the use of plastic materials to large buoy applications with only partial success. Large, plastic-hulled, foam-filled buoys were found to be unacceptable as lighted aids, and only marginally acceptable as unlighted aids. This was due to a lack of strength in the plastic design and the very high cost of these buoys. Foam buoys have been produced in large sizes and have even been successfully fitted with solar panels and lighting sets on a test basis. Historically, the major drawback has been the high initial cost of the buoys, which has forced them to be used only in small sizes and in areas where high steel buoys' maintenance costs would offset the initial cost of the foam buoy. As in the case of river buoys, declining manufacturing costs are making foam a more attractive option.

Some of the findings during the surveys that may impact this situation include:

- The Japanese have substituted GRP for steel superstructure on a large unlighted buoy.

- The French have lightweight GRP buoys tuned to the local sea conditions that have replaced much larger steel buoys.

- Denmark is developing an "Integrated Modular Buoy" design for which fiber reinforced plastics as well as steel are being considered as buoy hull materials.

- Balmoral of England has utilized foam/elastomer buoys for various applications including elastomer belt for shock absorption.

- It is suggested by the English plastic buoy manufacturers that the motion characteristics of a much heavier buoy can be achieved using underwater weights on lightweight plastic buoys, possibly by simply increasing the chain size.

- The Gilman Corporation has fitted lights to large foam buoys and has built large oceanographic buoys with lights.

- Tidelands has developed several medium and large GRP/foam filled GRP buoys.

2.5.2.3 Articulated Beacons

Although significant strides have been made in the development of articulated structures, those that have been developed so far have limitations and deficiencies which preclude their use in many cases. The most troublesome problems are in the areas of hardware strength. Originally these types of structures were thought to be able to withstand collisions better than buoys. In practice, however, the beacons have proven to be much less damage-resistant than expected. Much of this problem has been traced to inadequate strength in connecting flanges and the hinge. Redesign has strengthened these components, but the lower hinge is still subject to excessive wear. Furthermore, current USCG designs provide an inadequate signal in high currents because of excessive tilt. Lastly, these structures can only be used on up to 60 foot water depths and 5 foot tides. The working depth will have to be increased if there is any hope with articulated structures. The USCG's latest effort is to design another generation of these beacons which are extremely effective in protected harbors, semi-exposed locations and open seas.

Some of the findings during the surveys that may impact this situation include:

- "Resinex Offshore" of Italy claims that their elastic beacons are deployed in water depths up to and more than 100 meters.

- The Japanese have several variations in the design of articulated beacons. Also Tideland, Inc. in USA, and Floatex, S.r.l. in Italy have elastic beacons which they state are in use throughout the world.

- Joint designs have varied. Tension-leg type joints are touted as those that may best absorb shocks and vibrations.

- Float designs include foam and steel chambers both with and without foam filling.

2.5.2.4 Unlighted Sound Buoys

The two major flaws of the current wave-activated sound buoys are that they are relatively heavy and that their sound signals have a range of only about 1/4 mile.

A new unlighted sound buoy is needed with an increased range. A reduction in weight of the buoy structure itself should aid this cause as a more potent and heavier sounding device can be fitted to the buoy.

Other IALA countries are not particularly interested in this type of buoy, especially since IALA has recommended the elimination of sound signals. However, the utilization of lighter structural materials as incorporated in other buoys identified may help the overall design. Additionally, consideration may be given to the use of improved wave generated power systems for better sound signals on unlighted buoys.

2.5.2.5 Measure of Buoy Effectiveness

A USCG does not have a set measure of effectiveness for its buoys. A series of studies were performed in the early 80's using a simulator to measure the effectiveness of buoy systems and positional configurations, but not for buoy platforms themselves. Some studies have been made on rolling buoy light recognition, but still no measure of merit has been developed. One approach that has been proposed is to measure a buoy's effectiveness in terms of how many days the aid is functioning properly out of a year. This is, in effect, a measure of how well the aid performs as a guide to mariners. It therefore appears that the USCG still needs to develop a measure of effectiveness which takes into account both aid availability and performance, so that new buoy designs may be compared to existing ones.

Some of the findings during the surveys that may impact this situation include:

- o IALA has published a "Guide to the Availability and Reliability of Aid to Navigation" in 1989, Reference 43.
- o Also, the IALA NavGuide published in February 1990, addresses all aspects of buoy performance, Reference 41.
- o The USCG has presented an IALA paper on buoy light detection, Reference 34.
- o The Dutch have carried out extensive studies of aids to navigation in the North Sea to reduce the number of buoys through greater effectiveness.

2.5.2.6 Correlation of Tender Size to Buoy Characteristics

A prevalent factor in support of lighter weight buoys is the effect on the servicing vessel size which, it is presumed, will decrease. Although it is true that lighter weight buoys would require less lifting capacity, whether this would translate into a smaller vessel is another question. For example, transporting of the lightweight or heavier buoys may require the same deck area but lighter weight buoys might have livelier motions thereby necessitating a more stable vessel to service them. Also, seagoing tenders may have to retain their dimensions because of the need to operate in an exposed seaway or to carry out other functions and missions in addition to buoy tending. Before any conclusions can be drawn, the effects of buoy characteristics on buoy tender design have to be evaluated.

Some of the findings during the surveys that may impact this situation include:

- The French are proposing lighter buoys matched to smaller buoy tenders.

- Germany has developed a large lighted buoy which consists of 4 parts that can be assembled and disassembled while afloat so that the existing fleet of small buoy tenders can handle them, see IALA Paper No. 3.2.2, Reference 19.

2.5.3 Technologies for Future Improvement

As a result of the surveys, the technical areas discussed below have been deemed to offer potential for fruitful research in the future resulting in improved buoy systems for the USCG.

2.5.3.1 General Buoy Hull Design

- Some large steel Japanese buoys are compartmented for damage stability.

- The Japanese have proposed reducing the strength/stiffness requirements of the superstructure to reduce the weight of the buoy and thereby simplify buoy tending procedures.

- The Japanese are proposing buoy stabilization procedures to counteract wave motion.

- The French are designing buoys to match the motion characteristics of local wave systems. They propose that unless a buoy is marking a danger area, it is not important to have continuity of its light signal, implying that motion of the buoy is acceptable.

- The Germans have a standard unlighted inland waterways buoy of simple and cost effective design with up to 10 years service life.

- The Canadians suggest solid superstructures instead of latticework.

- The Danish are developing an Integrated Modular Buoy, see IALA Paper 3.6.7, Reference 8.

- Pharos Marine, Ltd. (and others) have a series of buoy bodies that have interchangeable tail tubes or skirts and signal platforms, i.e. high focal plane or short pillar. The English and other authorities have a standardized set of buoys with interchangeable parts.

2.5.3.2 Construction Methods and Materials

- o In general, the use of new or improved construction materials such as composites, new grades of aluminum, and other corrosion resistant and durable materials have been investigated. Canada has carried out a study on the "Use of Composite Materials for Buoy Construction".

- o Foam buoys have been considered for a greater number of lighted buoy applications.

- o Surlyn foam buoys are currently being used in unlighted and some lighted buoy applications.

- o The use of sectional Surlyn type foam as the main buoy hull with a cage of either Surlyn or a more conventional metallic material could be considered. Woods Hole Oceanographic Institution uses data buoys of this type of construction. If "building block" sections could be utilized to make more than one class of buoy then a situation would exist where buoys as needed could be made from stock/inventory material. This should result in a significant economy in manufacturing and inventory costs.

- o Surlyn foam technology is continually advancing and already provides the ability to construct a wide variety of buoys. The basic building block is a cylindrical roll of Surlyn which can be made in varying diameters and can later be shaped to any configuration. The central core is usually steel and this may be the weakest link since it will corrode.

- o Buoys with foam inside and a tire-like rubber outside to absorb impact may be more resistant to damage from ships and debris. Balmoral of England has several plastic buoys with elastomer fenders.

- o The use of Poly-vinyl-chloride (PVC) and fiber or glass reinforced plastic (FRP/GRP) materials in buoy construction is continuing.

- o New paint systems may provide coatings for buoys and buoy elements such as solar panels, solving the problems of bird droppings and buildup of marine growth.

- o Cages could be constructed out of aluminum alloys to reduce weight.

- o Counterweights could be fabricated in pieces rather than casting as a single piece.

- o The Japanese have used GRP for superstructures (of larger cross sectional area) for buoys to increase daymark area and reduce weight. (France also).

- Zeni Lite Buoy Co. of Japan is using aluminum to fabricate the superstructures on some of their buoys to reduce the weight.

- The Japanese have developed a quick acting buoy hatch cover.

- The Danish have experimented with non-polluting anti-fouling systems, including sound emitting transducers.

- Canada is testing paint systems to extend the maintenance period.

- ANA Navaids, India has GRP high focal plane buoys. These and Tideland's buoys are the only application of GRP, found by this study, to match steel equivalents.

2.5.3.3 Payload, Signal and Power Equipment Impacts

- Solar Panels and topmarks (for lighted solar powered buoys) have been made integral with the buoy hull in some applications.

- Means of improving the solar panel design, fabrication and installation to provide better protection against the environment have been investigated.

- In order to increase radar reflector discernibility, some commercially available reflectors have been utilized.

- Placing of homing devices on buoys in high loss areas have been considered to facilitate search and recovery operations. Similarly, the installation of radar transponders or Loran receivers on buoys in critical areas to accurately monitor their position has been studied.

- The use of electronic bells and gongs (to eliminate possible damage due to shock and vibration) in lieu of current mechanical equipment has been studied.

- The use of an external battery box installed in the cage to withstand the environment has been tested to result in the eventual elimination of battery pockets. The French have placed the battery box at the top of the cage on steel buoys. Also British (Balmoral solar), USA (Tideland solar), Japan (Zeni solar) have used this approach.

- The Japanese have widespread experience with wave activated generators as the primary buoy power source. In some areas they are using solar power as a back-up or secondary source. Also, Denmark has an inertial wave generator design in their Integrated Modular Buoy.

- In ports with bright background lights, the Japanese have found the synchronization of flashing lights to be beneficial in buoy identification.

- The Norwegians are developing a primary battery with sea water as electrolyte. A U.S. company (Alupower) has also developed such a battery.

- The Japanese have developed interchangeable daymarks. Also Danish use modular daymarks on their Integrated Buoy design.

- The Japanese (NKK & GTK) are developing an LED light that could mitigate the problem of buoy motion by displaying a broader beam.

- The Germans have carried out extensive colorimetric, photometric and accelerated weather testing of buoy paint materials.

- The Danish have developed an integrated radar reflector. (Also England, Finland, Germany, Japan). It is also suggested by several commercial manufacturers that purchasing radar reflectors may be cheaper than building them into the superstructure, and these (e.g. SR-6 type) will offer more omnidirectional reflection compared to the standard USCG bi-plane type.

- The British (Gloucester Harbor Authority) suggest designing an indicator to show if the battery is low. The indicator may be seen with binoculars.

- The British are working on a current driven generator.

- Germany has studied the "Recognizability of Symbols and Lettering on Aids to Navigation".

- Automatic Power, Inc. and Micro-Design, Inc. of USA have developed "Microprocessor Designs for Low and High Intensity Lights".

- IALA has indicated cardinal marks can be used to reduce the number of buoys in a system. However, it should be noted that the US pleasure boating lobby is against this idea - they want channel boundaries to continue to be marked.

- It was suggested by the Dutch that wider angle lights could be more easily seen. This would make the effect of buoy motion less critical.

- Stromag/P. Bamag of Holland states that utilization of topmarks rather than buoy body structure for shape significance allows for providing easier access to the signalling devices atop the buoy.

2.5.3.4 <u>Buoy Maintenance and Support Systems</u>

- Increased floatation and damage stability: Some buoy tenders spend a large amount of time on damage repairs. Improved damage stability was found to reduce such activities.

- Prevention of bird droppings: The use of such preventers have eliminated the discoloration of buoy paints and provided better protection for solar panels, if fitted.

- Increase protection of steel buoys from corrosion: Through the use of new improved paints and other coatings, better materials, and/or heavier scantlings, effects of corrosion damage have been reduced.

- Better anti-fouling protection: This has helped reduce buoy sinkage through marine growth buildup. Possibly, new ablative paints and coatings could help shed marine growth. Current paints may be more effective on vessels that move through the water, which will aid shedding of marine growth.

- Japanese are developing a GPS system for monitoring buoy position, with a fail-safe signal generator. The Dutch suggest a central alarm panel to keep monitoring the status of all systems on the buoy.

- The Japanese have a collision marking and signalling device to assist in the identification of ships striking and damaging a buoy.

- The Norwegians are systematically replacing most of their floating SRAs with fixed lights. The fixed lights offer easier maintenance, especially in heavy ice areas. Along with this, they have made extensive use of sector lights.

- The Japanese have found the use of cast iron sinkers to be advantageous in strong currents.

- A Japanese manufacturer has increased the reliability of light systems (10 years vs. 3 years) to extend the relief/maintenance cycles. In general, the Japanese propose utilizing more reliable electronic flashing systems requiring less maintenance and repairs.

- The Dutch have attained a reduction in the number of offshore buoys through the use of RACONs.

- The British have developed a buoy that can be deployed by helicopter in an emergency.

- The British use free hanging pieces of chain inside the tail tubes of their high focal plane buoys to prevent fouling.

- The British propose using open link chain moorings to reduce weight and cost.

2.5.3.5 <u>Buoy Design Methods and Procedures</u>

- It was observed that some buoys have been designed at the outset for solar power systems incorporating features for solar panel protection (from bird droppings and from theft), improved battery arrangement for protection, ease of maintenance, and optimum relational location and arrangement of signalling devices, battery, and solar panel. These could be value engineered against existing buoys which have been modified to accept these components.

- In some applications, buoy motions were analyzed to determine the effects of shape, mass, and mooring forces. It has been reported that Surlyn buoys have motions in waves which may allow them to be more visible than steel buoys when both are fitted with a light. They can also be designed and easily built to behave in different ways, such as riding on the water in fast current areas and absorbing impact from debris.

- In developing new designs, life cycle cost analyses have been carried out in some cases to identify the most cost effective options.

- The buoy design process should follow a systems approach covering all elements of the system including the buoy hull, signals, power sources, and mooring.

- Canada has compiled a standard procedure for the review and design of marine aids to navigation.

- Consideration should be given to designing entirely new buoy systems for certain applications. An example which has been considered but never applied by the Canadian Coast Guard was deploying lightweight buoys by simply dropping them from the deck of a catamaran buoy tender through cartridge type storage racks on the tender's deck.

- A Korean paper, Reference #45, presented to the 1990 IALA Conference suggest setting aids to navigation in accordance with probability-of-danger analysis.

- The following countries have presented papers to the 1990 IALA Conference on their experiences and design recommendations for VTS and channel layout: Germany, England, Scotland, Ireland, Finland, France and Norway.

- Performance of buoys could be optimized through the use of model tests, as proposed by MARIN of the Netherlands.

- The 1990 IALA NAVGUIDE contains the following chapters which may be helpful in buoy design:

  Chapter 2, Navigational Requirements for Accuracy.
  Chapter 3, Availability/Reliability of ATONs.
  Chapter 4, Standardization of ATONs.
  Chapter 7, Economic Factors and Planning.
  Chapter 9, Evaluation of Needs for ATONs.
  Chapter 11, ATON Systems.
  Chapter 13, IALA Recommendation, Guidelines and Manuals.

2.5.3.6 Ice Buoy Design

- The Finnish have made extensive use of spar buoys with taut moorings in ice environments. These buoys have the added benefit of providing a negligible watch circle since they are essentially a variation of the articulated beacon.

- The Finnish have a new (1989) design for steel ice buoy with 5 compartments having 2 compartment damage stability.

- The Finnish have successfully used foam filled rigid plastic spar buoys in ice environments with 10 year service life. Canada is now using some of the same KWH manufactured plastic spar buoys.

- The Dutch have developed a method of tank testing ice buoys using paraffin to model the ice. They have also designed and built an ice buoy after utilizing this technique.

3.0 BUOY TECHNOLOGY INFORMATION SYSTEM (BTIS)

3.1 General

The technical data collected during the worldwide surveys were compiled in the form of a computerized database designated as the Buoy Technology Information System (BTIS). This database is intended to be used by the USCG engineering personnel as an information and design reference tool in support of aid to navigation buoy research and development efforts. The database contains technical information on 381 individual buoy platform designs in use worldwide by both government authorities and private manufacturers. The data cover a wide variety of buoy design aspects including physical characteristics, related equipment, operational characteristics, cost information and maintenance notes. A listing of the data fields contained in the database is presented in Table 3-1. The BTIS system is designed to run with standard USCG equipment and software. The software package also includes extensive documentation relating to system use and operation.

3.2 Database Design

At the beginning of the design process for the BTIS system, a set of required overall system characteristics developed by the U.S. Coast Guard was received. These characteristics included the following:

- The system is to be run on standard USCG work stations and software.
- The system is to be developed using the PROGRESS database software language.
- The program should utilize a menu-driven user interface.
- The program should utilize the Structured Query Language (SQL) protocol in defining the database files in order to enhance portability.

In addition, a set of formalized user requirements was developed as a result of consultation with the intended user groups. These requirements defined the formats for the database buoy records, query criteria, and output and security/access levels.

In light of these established requirements and a review of programming software capabilities, a database system was developed, coded and tested. The proposed database design approach was reviewed and approved by the USCG. Reference #4 contains the details of this approach. As completed, the BTIS database design incorporates the following features:

- A user-friendly program structure consisting of a menu "tree" through which all program functions may be accessed.

Name of Buoy	
Country of Use	
Function	
Date of Last Record Update	

PHYSICAL CHARACTERISTICS

Buoy Weight	
Buoy Draft	
Overall Buoy Length	
Focal Height of Light	
Buoy Beam or Diameter	
Freeboard:	No Mooring
	Minimum
Pounds Per Inch Immersion	
Metacentric Height	
Reserve Buoyancy	
Wave Motion Response	
Construction Material:	Hull Shell
	Hull Filling
	Tower
	Topmark
	Counterweight
Coating/Coloring System	
Subdivision	
Hull Type	
Counterweight Type	

RELATED EQUIPMENT

Power Sources:	Number
	Type
Lighting Equipment	
Sound Equipment	
Other Payload	
Daymark Area	
Bridle Size:	Chain Size
	Length
Mooring Line:	Size
	Type
Sinker Size	
Topmark Type	
Number of Pad Eyes	

OPERATIONAL CHARACTERISTICS

Operating Environment	
Nominal Visual Range of Daymark	
Radar Range	
Maximum Current	
Mooring Depth	Minimum
	Maximum
Reflective Material Type	

ADDITIONAL DATA

Cost:	Replacement
	Preparation
	Monthly Servicing
Service Life	
Maintenance Interval	
Maintenance Notes	
Special Features	
Stability Notes	
General Notes	
Manufacturers	
Source of Design	
Drawing Reference	

TABLE 3-1
DATA FIELDS IN BTIS

- Program routines written exclusively in the PROGRESS programming language.

- Database files created and maintained using the SQL protocol.

- Buoy records containing 56 fields of technical information each, arranged within a single buoy record file.

- Database queries which may be carried out based on user-specified criteria for seven principal fields or as ad hoc queries.

- An iterative query sequence whereby a large number of records can be narrowed quickly, using successive queries.

- Query criteria which can be saved to a disk and recalled for later use.

- Query output which can take the form of complete buoy records or tables composed of user-specified fields.

- Output functions which allow results to be sent to the terminal screen, printer or hard disk file.

- An on-screen editing facility which allows new records to be added or existing records to be modified.

- Database archiving and restoring functions.

- Three levels of user access privileges to insure database security and integrity.

- Error warning and recovery.

These features resulted in a database system that meets all USCG requirements and is extremely easy to use, even for those with very limited computer experience.

3.3 BTIS Software

The software package developed for the BTIS system consists of the database files and a library of PROGRESS program routines which carry out all of the database access and administration functions. This software package runs from within the PROGRESS database environment (Version 5.0 or higher) which must be installed on the standard work station. The software is designed to be run on a Unisys B28 or B38 work station equipped with a hard disk, 4 Mb of RAM, a Canon Laser Beam Printer and the BTOS II operating system.

3.4 BTIS Documentation

Documentation for the BTIS system was developed according to the U.S. Coast Guard's Automated Data Systems (ADS) standards. The documentation takes the form of three manuals: the Users Manual (UM), the Computer Operations Manual (OM) and the Program Maintenance Manual (PM).

The Users Manual, Reference #1, is intended for the day-to-day users of the BTIS system who may have very little computer experience. The manual provides an overview of the BTIS system and detailed instructions for using the program functions. An introductory tutorial session is also provided as an appendix.

The Computer Operations Manual, Reference #2 is intended for system operations personnel (system operators, schedulers, etc.) who are familiar with the computer system but not necessarily knowledgeable about PROGRESS. The information contained in this manual pertains to the operation of BTIS within a computer system. This information includes a listing of the JCL commands used with the program and system configuration guidelines.

The Program Maintenance Manual, Reference #3 is intended for the System Manager and program personnel who are familiar with both the computer system and PROGRESS software. The manual provides detailed descriptions of the BTIS system, database files and individual program routines. General flow-charts of program logic are provided along with a full source code listing for each routine. This manual also provides instruction for the BTIS System Manager in the use of system administration and backup functions.

3.5 Population of the Database

All information and data obtained from worldwide national navigation authorities and designers/manufacturers of ATON buoys were first compiled by country names. The compilations included data contained in the filled out survey questionnaires (if any), the forwarding letters and subsequent written correspondence, notes recorded during individual surveys/interviews, and the documents supplied by the interviewees during the project investigators' visits and while in attendance at IALA 90 Conference in Veldhoven, the Netherlands.

Emphasis was placed primarily in including in the BTIS Database those ATON buoys identified by the respective national navigation authorities to be their standard line of floating aids. Additionally, other floating aids in development or testing stages were also included.

The blank format used in recording the data for each individual buoy was shown in Table 2-3 of Section 2.0.

A sample hand-filled BTIS Buoy Record is shown in Table 3-2. As seen, it contains all the data fields listed in Table 3-1. The approach used in filling out each data field and the organization of the information associated with buoys into characteristic groups common to all are described in detail in Reference #4, the Interim Report for Task B-2 of this project. Reference #4 also presents the Database Design (approved by the USCG), the

BTIS Buoy Record

System Location: G-ECV
Project Number : 15221

Sheet 1 of 3
Prepared By: [illegible]
Approved By:

GENERAL INFORMATION

Name of Buoy: 5X11-LR--1962-TYPE-STANDARD

Country of Use: USA

Function: THE 5X11 LR BUOY IS DESIGNED AND CONSTRUCTED FOR PROTECTED LOCATIONS. THIS BUOY CONFIGURATION CANNOT HAVE A SOUND SIGNAL INSTALLED.

PHYSICAL CHARACTERISTICS

Buoy Weight:	2004	Lbs.
Buoy Draft:	4.05	Ft.
Overall Buoy Length:	11.67	Ft.
Focal Height of Light:	7.43	Ft.
Buoy Beam or Diameter:	5.00	Ft.
Freeboard No Mooring:	2.17	Ft.
Minimum:	0.35	Ft.
Pounds Per Inch Immersion:	105	Lbs.
Metacentric Height:	.	Ft.
Reserve Buoyancy:	945	Lbs.

Wave Motion Response: WAVE FOLLOWING

Construction Material:
- Hull Shell : STEEL
- Hull Filling : NONE
- Tower : STEEL
- Topmark : NONE
- Counterweight: CAST IRON

Coating/Coloring System:
EPOXY-PRIMER/VINYL-ALKYD-[illegible]

Subdivision: NONE

Hull Type: CYLINDRICAL

Counterweight Type: EXTERNAL TUBE

TABLE 3-2
HAND-FILLED
BTIS BUOY RECORD

BTIS Buoy Record

Sheet 3 of 3

ADDITIONAL DATA

Cost: Replacement: $ 6900
Preparation: $ -----
Monthly Servicing: $ -----

Service Life: 6.0 Yrs.

Maintenance Interval: 6 Mos.

Maintenance Notes:

Special Features:

THIS BUOY FEATURES A SHORT COUNTERWEIGHT TUBE WITH A FLAT BOTTOM TO FACILITATE STOWAGE ON DECK

Stability Notes:

General Notes:

Manufacturers : USCG-YARD

Source of Design : USCG

Drawing Reference: USCG

TABLE 3-2
Continued

RELATED EQUIPMENT

Number of Power Sources: 1

Type of Power Sources:
ELECTRIC BATTERY 012

Lighting Equipment:
155MM ELECTRIC LANTERN

Sound Equipment:
NONE

Other Payload:
RADAR REFLECTOR

Daymark Area: 11.0 Sq. Ft.

Bridle Size: Chain Size: 1.000 In.
Length : 14.0 Ft.

Mooring Line: Size: 0.750 In.
Type: STEEL CHAIN

Sinker Size: 4000 Lbs.

Topmark Type: NONE

Number of Padeyes: 1

OPERATING CHARACTERISTICS

Operating Environment: PM

Nominal Visual Range of Daymark: 1.4 Nmi.

Radar Range: 1.7 Nmi.

Maximum Current: 3.0 Kts.

Mooring Depth: Minimum: 10 Ft.
Maximum: 770 Ft.

Reflective Material Type:
ALUMINUM SHEET

TABLE 3-2
Continued

definitions used, the file structure, the user interface/menu structure, the query process, etc. Table 3-3, reproduced from the cited reference, gives the detailed descriptions for all data fields in the Database.

In filling out the entries for individual data fields, the specific approach used was to enter the exact data supplied by the source agency or manufacturers (if such is indeed supplied) or to enter the data established by a thorough screening of all compilations for the buoy in question as described above.

For all data fields except two, entries were made only if the data for an entry were supplied by the source or if it was possible to extract the data from the documents, notes, or correspondence with the source. If no data were made available or if it could not be extracted from available documents, the data field was left blank. The two data fields mentioned above are the "Nominal Visual Range of Daymark" and the "Radar Range". For these data fields, calculations were performed to obtain the desired value as explained in detail, complete with sample calculations and references used, in Appendix D.

Calculations were also performed to obtain plots of cumulative cross sectional areas for buoys as a function of height above water. The steps required in constructing the cumulative area curves are also described in detail in Appendix D. As a matter of fact, cumulative area calculations constituted the first step in determining the nominal visual range of buoys.

The populated BTIS Database contains records for a total of 381 buoys. The distribution of buoy records by countries and by manufacturers is shown in Table 3-4. A full set of buoy records are included in Appendix B. Also included in Appendix B are plots of cumulative areas vs. height above water for each buoy (for which such areas could be calculated) immediately following the buoy's three page record. The nominal visual range and radar range values, as calculated for those buoys that had sufficient data to enable calculations, are entered into the appropriate data fields in the buoy record.

Out of a total of 381 buoys in the BTIS Database, sufficient information was available to:

- Calculate and plot cumulative areas for all USCG buoys and 276 foreign buoys. Consequently Appendix B contains cumulative area curves for a total of 327 buoys.

- Calculate and input to BTIS the nominal visual ranges for all USCG buoys and 274 foreign buoys. The BTIS Database (and the buoy records in Appendix B) contains visual range data for a total of 325 buoys.

- Calculate and input to BTIS the radar range values for 37 USCG buoys and 141 foreign buoys so that the BTIS Database (and Appendix B) contain radar range data for a total of 178 buoys.

A typical "populated" BTIS Database Buoy Record is shown in Table 3-5. This specific Buoy Record is for the U.S. Coast Guard's 9x32 LR (Steel Lighted Buoy with Reflector). The "Nominal Visual Range" and "Radar Range"

Detailed Description of Data Fields		
Field	**Description**	**Format**
Name of Buoy	Commonly used designation for the buoy design, such as"8 x26 LWR, 1962 type."	30 Characters
Country of use	Country currently using the buoy as an aid to navigation.	20 Characters
Function	Short description of the use or purpose of the buoy.	6 Lines x 40 Characters
Date of Last Record Update	Date of the last time the record was modified This field is automatically updated when the record is entered or altered.	Date Format mm/dd/yy
Buoy Weight	Weight of the buoy in pounds without moorings or power units. See definition in Ref [1].	Numeric Format #####
Buoy Draft	Distance in feet from the buoy waterline to its lowest underwater part with no moorings or power units installed. See definition in Ref [1].	Numeric Format ###.##
Overall Buoy Length	Overall length of the buoy in feet along a line at a right angle to its defined perpendiculars. For axisymmetric buoys, this line is generally the vertical centerline. For boat-shaped hulls, this line is generally the fore-aft centerline.	Numeric Format ###.##
Focal Height of Light	Vertical height in feet from the waterline to the focal plane of the light for the buoy with no mooring or power units. See definition in Ref [1].	Numeric Format ##.##
Buoy Beam or Diameter	Extreme transverse width or diameter of the buoy in feet.	Numeric Format ##.##
Freeboard:		
- No Mooring	Vertical distance in feet from the waterline to the deck for the buoy without moorings or power units. For unlighted buoys with no sound signal the distance is measured from the waterline to the base of the radar reflector. See definition in Ref [1].	Numeric Format ##.##
- Minimum	Minimum recommended freeboard in feet for the buoy to resist current and wave loads. See definition in Ref [1].	Numeric Format ##.##
Pounds Per Inch Immersion	Force in pounds required to submerge the buoy an additional inch. See definition in Ref [1].	Numeric Format #####

TABLE 3-3
DESCRIPTION OF BTIS DATA FIELDS

Detailed Description of Data Fields (cont'd)		
Field	Description	Format
Metacentric Height	Distance in feet from the center of gravity to the transverse metacenter for the buoy without moorings or power units.	Numeric Format ##.##
Reserve Buoyancy	Force in pounds required to submerge the buoy to the deck (for lighted buoys and unlighted sound buoys) or to the base of the radar reflector (unlighted buoys). In both cases, the buoy is assumed to be initially floating at its minimum freeboard.	Numeric Format ######
Wave Motion	Indication of whether the buoy is primarily wave following or decoupled.	20 Characters
Construction Materials		
-Hull Shell	Material used in the construction of the hull shell, e.g., steel, aluminum, GRP, foam, etc.	20 Characters
-Hull Filling	Material used for the hull filling, if any, e.g., foam.	20 Characters
-Tower	For lighted and unlighted sound buoys, the materials used in the construction of the above-deck tower.	20 Characters
-Topmark	Material used in the construction of the buoy topmark (if installed).	20 Characters
-Counterweight	Material used for counterweight, e.g., concrete, steel, water, etc.	20 Characters
Coating/ Coloring System	Description of any special hull coating normally used with the buoy, such as rust inhibiting primers or abrasion resistant coatings. For foam or plastic buoys, any color impregnation should be noted.	30 Characters
Subdivision	Description of any subdivision incorporated into the buoy hull for the purpose of damage survival. Note "Hull Filled" if this is the method of damage floatation.	20 Characters
Hull Type	General hull type, such as CAN, NUN, Ice, Articulated Light, etc.	20 Characters
Counterweight Type	Description of the counterweight, such as "Internal," "External Tube," "External Ball," etc.	20 Characters

TABLE 3-3 CONTINUED

Detailed Description of Data Fields (cont'd)		
Field	Description	Format
Power Sources:		
- Number	Maximum number of power source units that the buoy can accommodate. See definition in Ref [1].	Integer Format ##
- Type	Type of power source(s) used on the buoy, e.g., dry-cell batteries, solar panels, WATG, etc.	30 Characters
Lighting Equipment	Description of any lighting equipment installed on the buoy.	30 Characters
Sound Equipment	Description of any sound equipment installed on the buoy.	30 Characters
Other Payload	Description of any other payload installed on the buoy, such as a radar reflector, Racon, weather package, navigation instruments, etc.	30 Characters
Daymark Area	Area, in square feet, of the daymark for the purpose of calculating nominal visual range.	Number Format ###.#
Bridle Size		
-Chain Size	Size of chain, in inches, used on the buoy bridle, if so equipped. See definition in Ref [1].	Numeric Format #.##
-Length	Total length of the bridle in feet. See definition in Ref [1].	Numeric Format ##.#
Mooring Line:		
- Size	Diameter of chain or line, in inches, recommended for use under normal conditions. See definition in Ref [1].	Numeric Format #.##
- Type	Type of mooring line used on the buoy under normal conditions such as, steel chain, synthetic line, etc.	20 Characters
Sinker Size	Weight of the sinker, in pounds, recommended for use under normal conditions. See definition in Ref [1].	Numeric Format #####
Topmark Type	Description of the topmark type used on the buoy, such as 'Isolated Danger.' 'Safe Water,' etc. If no topmark is used, any shape significance should be noted.	20 Characters
Number of Pad Eyes	Number of lifting eyes installed on the buoy.	Integer Format ##

TABLE 3-3 CONTINUED

Detailed Description of Data Fields (cont'd)		
Field	Description	Format
Operating Environment	Description of the operating environment(s) where the buoy is normally used. Abbreviations used in this field will be in accordance with Appendix B of Ref [2].	20 Characters
Nominal Visual Range of Daymark	Nominal Visual range of the buoy daymark in nautical miles if the visibility is 10 nmi. See definition in Ref. [1].	Numeric Format ##.#
Radar Range	Radar Range of the buoy in nautical miles determined using a stereotypical radar set. See definition in Ref [1].	Numeric Format ##.#
Reflective Material	Description of any retroreflective material installed on the buoy, such as high intensity or low intensity light reflective tapes, flourescent films or paints, or other means intended to enhance buoy visibility, particularly at night.	30 Characters
Maximum Current	Maximum surface current, in knots, in which the buoy will stand upright with adequate freeboard. See definition in Ref [1].	Numeric Format ##.#
Mooring Depth:		
- Minimum	The depth of water, in feet, needed to float the buoy with its counterweight or chain bridle clear of the bottom. See definition in Ref [1].	Numeric Format ###
-Maximum	The maximum mooring depth, if any, determined for the buoy. See definition in Ref [1].	Numeric Format ####
Cost:		
-Replacement	Total cost of establishing a fully outfitted buoy on station in 1989 U.S. dollars. See definition in Ref [3].	Numeric Format #####
-Preparation	Cost, in 1989 U.S. dollars, of preparing, adapting, and placing the buoy. See definition in Ref [3].	Numeric Format ####
- Monthly Servicing	Average Annual servicing costs in 1989 U.S. dollars converted to a monthly basis.	Numeric Format ###
Service Life	Estimated service life for the buoy in years.	Numeric Format ##.#
Maintenance Interval	Approximate time period between required maintenance visits in months.	Numeric Format ##
Maintenance	Short narrative describing any pertinent maintenance features or considerations.	4 Lines x 60 Characters

TABLE 3-3 CONTINUED

Detailed Description of Data Fields (cont d)		
Field	Description	Format
Special Features	Short narrative describing any special features or construction methods employed with the buoy.	4 Lines x 60 Characters
Stability Notes	Short narrative outlining any special stability characteristics such as whether a man can safely stand on the buoy deck.	4 Lines x 60 Characters
General Notes	Short narrative detailing any general information about the buoy which may be useful to the designer.	4 Lines x 60 Characters
Manufacturer	Name of the buoy manufacturer.	20 Characters
Source of Design	Name of company or government agency which designed the buoy.	20 Characters
Drawing Reference	Reference to the buoy drawings which appear in the hardcopy technical report.	20 Characters

TABLE 3-3 CONTINUED

TABLE 3-4

DISTRIBUTION OF BUOY RECORDS IN BTIS DATABASE

BY COUNTRIES AND MANUFACTURERS

Country	Authority/Mfg.	No. of Records	Name of Source
Australia	Authority	1	Dept. of Trans. & Comm'cn
Canada	Authority	31	Canadian Coast Guard
China (P.R. of)	Manufacturer 1	2	Shanghai Nav Aids Fact.
Denmark	Authority	24	Farvandsvaesenet
England	Authority	34	Trinity House
	Manufacturer 1	24	Balmoral
	Manufacturer 2	6	Reinforced Plastic Str.
	Manufacturer 3	27	Pharos Marine
	Manufacturer 4	1	Hippo Marine
Finland	Authority	10	Merenkulkuhallitus
	Manufacturer 1	1	KWH Pipe
France	Authority	15	Phares & Balises
	Manufacturer 1	2	Gisman
Germany	Authority	12	Seezeichenversuchsfeld
	Manufacturer 1	12	Pintsch Bamag
India	Manufacturer 1	4	ANA Nav Aids
Italy	Manufacturer 1	2	Resinex Offshore
	Manufacturer 2	1	Floatex

TABLE 3-4 Cont'd

DISTRIBUTION OF BUOY RECORDS IN BTIS DATABASE

BY COUNTRIES AND MANUFACTURERS

Country	Authority/Mfg.	No. of Records	Name of Source
Japan	Authority	15	Maritime Safety Agency
	Manufacturer 1	5	Nippon Kogi Kogyo
	Manufacturer 2	19	Ryoskuseisha
	Manufacturer 3	21	Zeni Lite Buoy
The Netherlands	Authority	2	DGSM
	Manufacturer 1	5	Stromag/P. Bamag
	Manufacturer 2	1	All Marine
Norway	Authority	6	Kystdirektoratet
	Manufacturer 1	11	Ticon Plast
South Africa	Authority	1	S.A. Harbors Authority
U.S.A.	Authority	51	U.S. Coast Guard
	Manufacturer 1	11	Tideland Signals
	Manufacturer 2	19	Automatic Power
	Manufacturer 3	1	Gilman Corp.
	Manufacturer 4	3	Urethane Technologies
	Manufacturer 5	1	Seaward International
Total Number of Records in BTIS Database		381	

BTIS Buoy Record

GENERAL INFORMATION

Name of Buoy: 9X32 LWR, 1962 Type Standard

Country of Use: USA

Function: Designed and constructed for the most exposed locations, this buoy is used with a four-ball whistle and whistle valve for the wave-actuated sound signal. The buoy body has an open tube running thru it to activate

Date Of Last Update For This Record: 11/01/90

PHYSICAL CHARACTERISTICS

Buoy Weight:		18,616 Lbs.
Buoy Draft:		12.92 Ft.
Overall Buoy Length:		31.96 Ft.
Focal Height of Light:		19.00 Ft.
Buoy Beam or Diameter:		9.00 Ft.
Freeboard:	No Mooring:	3.25 Ft.
	Minimum:	1.33 Ft.
Pounds Per Inch Immersion:		300 Lbs.
Metacentric Height:		1.73 Ft.
Reserve Buoyancy:		9,096 Lbs.
Wave Motion Response:		Wave Following
Construction Material:	Hull Shell	Steel
	Hull Filling	
	Tower	Steel
	Topmark	
	Counterweight	Cast Iron
Coating/Coloring System:		Epoxy, Anti-Fouling, Vinyl
Subdivision:		Two Compartment
Hull Type:		Cylindrical
Counterweight Type:		External Tube

TABLE 3-5
TYPICAL "POPULATED"
BTIS BUOY RECORD

RELATED EQUIPMENT

Number of Power Sources:		2
Type of Power Sources:		Electric Batteries B30
Lighting Equipment:		Electric Lantern, 155mm
Sound Equipment:		4-Ball Whistle
Other Payload:		Radar Reflector
Daymark Area:		53.0 Sq. Ft.
Bridle Size:	Chain Size:	1.500 In.
	Length :	18.0 Ft.
Mooring Line:	Size:	1.500 In.
	Type:	Steel Chain
Sinker Size:		12,750 Lbs.
Topmark Type:		Lateral
Number of Padeyes:		2

OPERATING CHARACTERISTICS

Operating Environment:		EM
Nominal Visual Range of Daymark:		3.1 Nmi.
Radar Range:		8.1 Nmi.
Maximum Current:		5.0 Kts.
Mooring Depth:	Minimum:	30 Ft.
	Maximum:	155 Ft.
Reflective Material Type:		Retroreflective pnls &numerals

TABLE 3-5
CONTINUED

ADDITIONAL DATA

Cost:	Replacement:	$0
	Preparation:	$0
	Monthly Servicing:	$0

Service Life: 30.0 Yrs.

Maintenance Interval: 12 Mos.

Maintenance Notes:

Special Features:

Stability Notes:
The values obtained for metacentric height and reserve buoyancy include bridle and US3010 Power Unit.

General Notes

Manufacturers:

Source of Design: USCG

Drawing Reference: USA-4

TABLE 3-5
CONTINUED

values are entered in their respective data fields on Page 2 of the record. The "Cumulative Area Curve" for this buoy is shown in Figure 3-1. Appendix B contains the records and curves for all of the 381 buoys. The BTIS computerized Database contains only the buoy records.

3.6 Installation and Training

The BTIS System has been installed at three U.S. Coast Guard sites. The first two sites are G-ECV-3B and G-NSR-1 at the USCG Headquarters in Washington, D.C. The third site is at the U.S. Coast Guard Research and Development Center in Groton, CT. The software was delivered to each site on a single quarter-inch cartridge (QIC) magnetic tape containing the database, program source code, run files and associated submit files.

Training was conducted at all sites at the time of installation. Training consisted of a single session at each site in which the overall BTIS system capabilities and contents were described and instruction was provided in the procedures for running the program and its functions. In the course of the sessions, the full range of BTIS user functions was demonstrated to the trainees using a portable computer system on which BTIS had been installed.

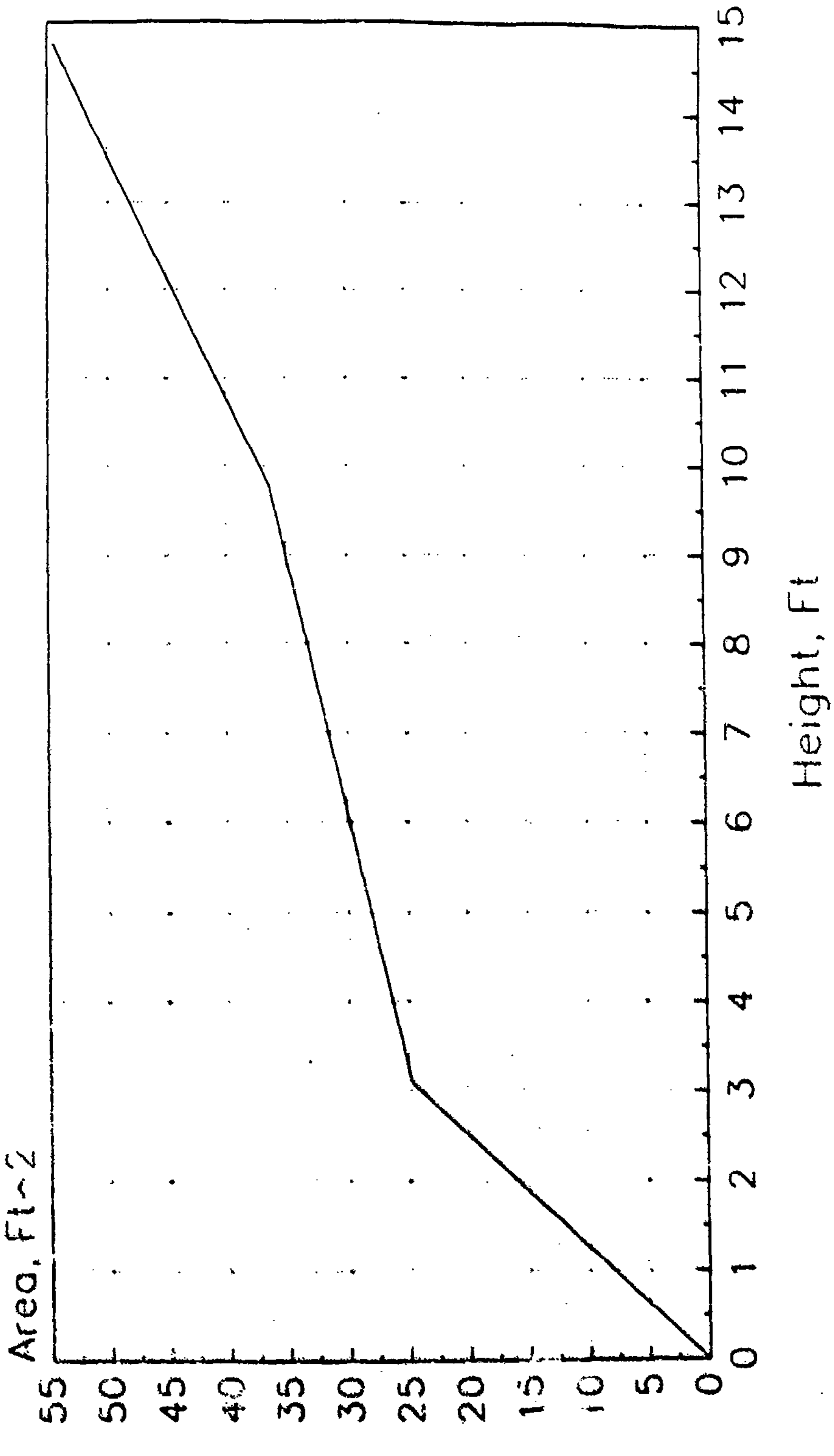


FIGURE 3-1
CUMULATIVE AREA
FOR USCG'S 9x32'
LR BUOY

REFERENCES

1. Users Manual for The Buoy Technology Information System (BTIS) U.S. Coast Guard, Washington, D.C.: August 1990

2. Computer Operations Manual for The Buoy Technology Information System (BTIS) U.S. Coast Guard, Washington, D.C.: August 1990

3. Program Maintenance Manual for The Buoy Technology Information System (BTIS) U.S. Coast Guard, Washington, D.C.: August 1990

4. Task B-2: Worldwide Buoy Technology Survey: Proposed Buoy Technology Information System (BTIS) Database Design U.S. Coast Guard Interim Report, New London CT: January 26, 1990

5. IALA 90 Paper No. 1.2.4, "Etude Sur L'Analyse des Taches Relatives Aux Aides Maritimes", by R. Cote, Canada

6. IALA 90 Paper No. 2.4.1, "Levels of Service-Marine Short Range Aids to Navigation", by E.T. Muller, Canada

7. IALA 90 Paper No. 3.2.5, "Buoy Paint Systems and Facilities Upgrading", by D.A. Long, Canada

8. IALA 90 Paper No. 3.6.7, "The Integrated Modular Buoy", by N. Hansen, H. Littau, and C. Jacobsen - Denmark

9. IALA 90 Paper No. 1.4.4, "A Systems Approach to NAVAIDS Based on the Mariner's Requirements", by Commander D. Bell, The Nautical Institute, England.

10. IALA 90 Paper No. 2.4.5, "The Development of a Computerized Database In the Trinity House Lighthouse Service, In Particular Its Application to the Aids to Navigation Maintained by Local Authorities by S.J.W. Dunning, Trinity House Lighthouse Service, England.

11. IALA 90 Paper No. 2.4.8, "Categorisation of Navaid Power Requirements," by N. Ward, Trinity Lighthouse Service, England.

12. IALA 90 Paper No. 3.6.6, "Wave Power For Buoys, A Practical Solution With Wide Application, " by T.D. Hewitt, AB Pharos Marine Ltd.

13. IALA 90 Paper No. 1.2.3, "The Requirement for Aids to Navigation," by Capt. D.J. Orr (Trinity House), Cdr. J.H. Mackay (Northern Lighthouse Board) and Capt. D.A. Gray (Commissioner of Irish Lights).

REFERENCES

14. S. Allen (Editor), et al., "Survey of Technology With Possible Applications to United States Coast Guard Buoy Tenders", Report No. CG-D-06-88, U.S.C.G. R&D Center, September 1987.

15. IALA 90 Paper No. 3.4.1, "The Navigation Plan of the Channel to Port of Naantali," by K. Martonen, Finland

16. IALA 90 Paper No. 3.6.5, "Electric Buoys Powered By Photovoltaic Solar Generators: Generator and Battery Optimisation," by G. Cunty, STPB, France.

17. IALA 90 Paper No. 2.4.9, "Economic Aspects of Change from Gas to Solar Power For Buoys," by J.M. Calbet and J. Granboulan, STPB, France.

18. IALA 90 Paper No. 2.4.7, "Investigation of the Economy for Aids to Navigation", by Wittneben & Murdel, F.R. of Germany

19. IALA 90 Paper No. 3.2.2, "Development and Experience Gained with Floating Aids to Navigation", by Alker, et al., F.R. of Germany

20. IALA 90 Paper No. 3.1.3, "Quality Testing of Paint Coats for Aids to Navigation", by Gaschler, & Volkel, F.R. of Germany

21. IALA 90 Paper No. 2.4.2, "Present Situation and Difficulties in Administration of Aids to Navigation Services" by M. Suzuki, Japan.

22. IALA 90 Paper No. 3.1.5, "Development of LED Light For Short Range Lighted Aid," by S. Tanaka, N. Kitamura and E. Miyamura, Japan.

23. IALA 90 Paper No. 1.1.2, "A Computer Assessment and Design Method of Systems of Aids to Navigation," by C. Deutch, C.C. Glandsdorp, P.M. Stuurman, J. Bakker, The Netherlands and France.

24. IALA 90 Paper No. 1.4.3, "The Optimal Mix of Aids to Navigation in the North Sea," by P.M. Stuurman, The Netherlands.

25. IALA 90 Paper No. 2.4.3, "Re-Organised Buoyage Service in the Netherlands", by A. Verbaan, The Netherlands.

26. IALA 90 Paper No. 1.3.1, "A Coordinated Data Base System for Fairways and Aids to Navigation", by Cdr. Ording & N. Lund, Norway

27. IALA 90 Paper No. 3.6.9 "Sea Water Primary Battery", by Kjennbakken & Storkensen, Norway

28. IALA 90 Paper No. 2.4.6, "A Systematic Approach to Substitute Floating Aids to Navigation by Fixed Aids", by Cdr. E. Sire, Norway

REFERENCES

29. "Buoy Technology Survey: USCG Buoy Development Review", by Daidola, Basar, Johnson, and Walker. Final Report, October 1990, U.S. Coast Guard

30. "Aids to Navigation-Technical," U.S. Coast Guard, COMDTINST M16500.3, "Washington, D.C., 1979.

31. IALA 90 Paper No. 2.1.1, "Training Aids to Navigation Technicians and Their Supervisors in the United States Coast Guard", by J.R. Perry and J.H. Clarke, U.S.A.

32. IALA 90 Paper No. 2.2.1, "Preliminary Results of Privatization within the USCG Short Range Aids to Navigation Program", by LCDR J.R. Thacker, U.S.A.

33. IALA Paper No. 3.1.6, "Conspicuity of Aids to Navigation: Extended Light Sources", by M.B. Mandler, U.S.A.

34. IALA Paper No. 3.1.7, "Detecting Buoy Lights: Effects of Motion and Lantern Divergence", by Wroblewski and Mandler, U.S.A.

35. IALA 90 Paper No. 3.2.1, "Developments in Floating Aids to Navigation", by Walker, Boy, Strahl, and Davis, U.S.A.

36. IALA 90 Paper No. 3.5.2, "United States Coast Guard Buoy Tender Fleet Modernization/Replacement", by CDR Jones, U.S.A.

37. IALA 90 Paper No. 4.1.1, "Development and Use of Frequency-Agile Radar Transponders (RACON) in the U.S. Aids to Navigation System", by C.B. Mosher, U.S.A.

38. International Co-operation in Aids to Navigation 1889-1955, IALA, Paris, 1982.

39. List of Members, IALA, 1989.

40. IALA Maritime Buoyage System, September 1983.

41. IALA Aids to Navigation Guide (NAVGUIDE), IALA, February 1990.

42. The Development of Aids to Navigation during the year 1988, Supplement to IALA Bulletin 1989/3.

43. IALA Guide To the Availability and Reliability of Aids to Navigation, IALA, 1990.

44. Berteaux et al., "Testing and Evaluation of SURLYN Foram and SPECTRA Fiber Ropes for Buoy Systems Applications", WHOI Report 88-23, August 1988.

45. IALA 90 Paper No. 1.2.1, "Allocation of Navigation Marks Along the Approach Channel to the West Sea Barrage of Korea", by Chong Si Muk, Maritime Transport Research Institute of Korea.

ACKNOWLEDGEMENTS

The information and illustrations on worldwide buoys presented in this report have mostly been obtained from the sources cited in the text either during visits to their offices or by correspondence. The authors are indebted to the British, Canadian, Finnish, French, German, Japanese, Dutch and Norwegian national navigation authorities and their personnel as listed in the report for the time and kindness afforded to them during survey visits. Thanks and gratitude are also due to many other national navigation authority personnel and numerous worldwide buoy manufacturers and designers for their contributions in filling out the survey questionnaires and providing detailed data for their buoys.

The guidance provided by the U.S. Coast Guard Headquarters and by the USCG Research & Development Center during performance of this task is also greatly appreciated.

(THIS PAGE INTENTIONALLY LEFT BLANK)

APPENDIX A

WORLDWIDE BUOY TECHNOLOGY SURVEY
SUMMARY NOTES FROM INTERVIEWS

A.1 Major Countries' Navigation Authorities
A.2 Major Countries' Commercial Organizations
A.3 Other Countries' Authorities and Manufacturers

(THIS PAGE INTENTIONALLY LEFT BLANK)

APPENDIX A

WORLDWIDE BUOY TECHNOLOGY SURVEY

SUMMARY NOTES FROM INTERVIEWS

TABLE OF CONTENTS

Appendix A.2 MAJOR COUNTRIES' COMMERCIAL ORGANIZATIONS

A.2.1 Canada

A.2.1.1 Orraids, Ltd.

A.2.1.2 MIL Systems Engineering, Inc.

A.2.1.3 KWH Pipe (Canada) Ltd.

A.2.1.4 Georgetown Shipyard, Inc.

A.2.1.5 Fairview Industries, Ltd.

A.2.2 Denmark

A.2.2.1 Electronics Supply Co.

A.2.3 England

A.2.3.1 Balmoral Group Ltd.

A.2.3.2 Reinforced Plastic Structures

A.2.3.3 Pharos Marine, Ltd.

A.2.3.4 Midar Systems

A.2.3.5 Nautical Society

A.2.3.6 Hippo Marine Products

A.2.3.7 Firdell Multiflectors, Ltd.

A.2.3.8 Thorn EMI

A.2.4 Finland

A.2.4.1 KWH Pipe, Ltd.

A.2.4.2 Renco Marine

A.2.5 France

A.2.5.1 Gisman Co.

A.2.6 Germany

A.2.6.1 Pintsch Bamag

A.2.6.2 Weiselerbojen

A.2.6.3 Compass

A.2.6.4 F. Hebold

A.2.6.5 Wilhelm Weule

A.2.7 Italy

A.2.7.1 Resinex S.r.l.

A.2.7.2 Floatex S.r.l.

A.2.8 Japan

A.2.8.1 Nippon Kogi Kogyo Co.

A.2.8.2 Ryokuseisha Corp.

A.2.8.3 Zeni Lite Buoy Co.

A.2.8.4 Gakuyo Toki Kogyo Co., Ltd.

A.2.9 Netherlands

A.2.9.1 Stromag/Pintsch Bamag

A.2.9.2 All Marine

A.2.9.3 The Research Institue Netherlands (MARIN)

A.2.9.4 Marine Analytics

A.2.9.5 Damen Shipyards

A.2.10 Norway

A.2.10.1 Ticon Plast A/S

A.2.11 United States

A.2.11.1 Tideland Signal Corp.

A.2.11.2 Automatic Power, Inc.

A.2.11.3 Gilman Corp.

A.2.11.4 Urethane Technologies, Inc.

A.2.11.5 Woods Hole Oceanographic Institution

A.2.11.6 Benthos, Inc.

A.2.11.7 Heat Transfer Systems, Inc.

A.2.11.8 Bahr Technologies (Loc US) Inc.

A.2.11.9 Rotocast Plastic Products, Inc.

A.2.11.10 Seaward International, Inc.

A.2.11.11 Racal Survey, Inc.

A.2.11.12 Mooring Systems, Inc.

A.2.11.13 Alu Power, Inc.

Appendix A.3 OTHER COUNTRIES' NATIONAL AUTHORITIES AND MANUFACTURERS

A.3.1 Australia

A.3.2 Belgium

A.3.3 Chile

A.3.4 Equatorial Guinea

A.3.5 Hong Kong

A.3.6 India

A.3.7 Ireland

A.3.8 Malawi

A.3.9 New Zealand

A.3.10 Nigeria

A.3.11 Peoples Republic of China

A.3.12 Saudi Arabia

A.3.13 Scotland

A.3.14 South Africa

A.3.15 Sweden

SUMMARY NOTES FROM INTERVIEW
CANADIAN COAST GUARD
AIDS AND WATERWAYS
OTTAWA, ONTARIO, CANADA

PERSON INTERVIEWED: Mr. Reiner Silberhorn

SUMMARY

Mr. Silberhorn oversees the design and construction contracts given out to various buoy designers and manufacturers within all Canadian Coast Guard districts.

He referred to the completed questionnaire already sent to us by mail (Attachment #1) and added that he was the one who prepared it for Mr. Hodgson.

Following random comments by Mr. Silberhorn were recorded during the interview:

- o Solarization of the lighted buoys in the Canadian Coast Guard (CCG) buoy system has been initiated and is now only about 30% complete.

- o CCG personnel have problems with aluminum as a buoy hull material, (crew dislike). No facilities for welding on site exist.

- o CCG had purchased some plastic buoys (poly-ethylene ice buoys) of 18 ft. length and 630 mm. diameter. The manufacturer is KWH. (Dwg. WH-0083-3 sheets). Three of these buoys are now in the Prince Edward Island coast. 7 more are on order.

- o They have some Gilman foam buoys in the system. Tests done on them for the last three years are favorable. A design firm (Advanced Materials Engineering Center in Halifax) is studying the use of composite materials for buoy construction under a CCG award. The study is to be completed around Christmas 1990. For further information, Dr. Gordon Murphy (VP Technical) or Mel Walker can be contacted at (902) 425-4500.

- o MIL Systems Engineering Ltd. of Ottawa is also conducting a study on buoy design criteria for the CCG.

- o Mr. Silberhorn gave copies of reduced size drawings for CCG standard buoys and a one page listing of ATON buoys in the CCG system. He also promised to send by mail, copies of references cited in their completed questionnaire.

- o Mr. Silberhorn accompanied the interviewer during visits to the CCG Prescott Base and to ORRAIDS, Ltd.

Interviewer: N. Basar
Date: February 14, 1990

A.1.1.1

(THIS PAGE INTENTIONALLY LEFT BLANK)

SUMMARY NOTES FROM INTERVIEW
CANADIAN COAST GUARD
COAST GUARD BASE
PRESCOTT, ONTARIO, CANADA

PERSON INTERVIEWED: Mr. Hugh Jones
Also Present: Mr. Reiner Silberhorn

SUMMARY
General

A lengthy verbal interview was held with Mr. Jones and a tour of the base facilities was made. The base is a modern installation with fully automatic buoy shot-blasting, painting, steel and aluminum welding, and other facilities.

Normally two busy tenders would be stationed in this base but in winter time, they are laid up elsewhere. Mr. Jones was given a copy of the survey questionnaire and requested to complete and return it to us.

Synopsis of Discussions (As Recorded)

- Lighted ice buoys currently in use in the CCG system need improvements. The plastic buoys did not stand up to ice. Two of the polyethylene buoys were crushed.

- Steel buoy hull designs are ok - but they are heavy. Aluminum buoys are lighter but they may not withstand stresses.

- Improvements are needed in the mooring systems. Kevlar was tried but was given up. It was too tough.

- In general, buoys stationed in the Lakes region are considered long term investments. There are buoys in the CCG ATON system currently in use which are more than 40 years old. Therefore, if new buoy designs can be developed with integral solar panels, daymarks, etc., they may prove to be more economical in the long run even though the initial acquisition costs may be higher.

- There are about 1400 buoys in the district in season. The number of buoys lost per year average about 12 or less. However, this winter season (especially during December due to severe ice and also due to the CCG personnel strike) a larger number of buoys were lost and heavy damage (especially to superstructures) was witnessed on many others. Some of the buoys lost in Quebec and New Brunswick are reportedly being picked up in Newfoundland.

A.1.1.2

- The buoy tender operations are costly. Currently, they cost approximately 6 to 7,000 $ CAN. per year. Accordingly, any measures introduced to ease buoy maintenance requirements should result in considerable savings.

- The approximate cost of a 6 ft. buoy is $CAN 12,000 on the average. Considering that it lasts a minimum of 30 years, it is easy to see that the impact of initial acquisition cost on the life cycle cost is small.

- The current designs for solar panel installation are not good. One design has the panel located on top of the lantern positioned laterally. This obscures the visibility of the lantern. The other design positions the panel below the lantern on the sides. This is no good either. The panels should be integral with the hull.

- Aluminum discus buoys hold out very well in shallow water areas and in rivers.

- The buoys are not repaired on site. Instead, they are picked up by the tender and brought back to base for repairs. Each buoy is partially blasted and touched up as necessary every year. Every 10 years however, they are blasted to bare metal and two coats of paint applied. Epoxy coating is used (AMERCOAT) and for protection against ultraviolet rays AMERSHIELD is applied. This coating also has good resistance to ice. However, it is very expensive. The price of one gallon of it is approximately $150.- CAN in some colors. This coating system is peculiar to this district. A different coating system is used in the Maritimes.

- The new paint gets slippery when wet. It was necessary to use non-slip materials.

- Following comments were made by Mr. Jones on the buoy hull designs:
  - Use of solid superstructure should be considered in lieu of lattice work.
  - Venting of battery pockets need improvement.
  - Compartmentation of the buoy hull will improve damage stability.

- The positions of buoys in the CCG ATON system are not remotely monitored.

Interviewer: N. Basar
Date: February 14, 1990

A.1.1.2

SUMMARY NOTES FROM INTERVIEW
CANADIAN COAST GUARD BASE
CHARLOTTETOWN, PRINCE EDWARD ISLAND, CANADA

PERSON INTERVIEWED: Mr. Charles McDonald

Summary

A half hour tour of the base facilities was made with Mr. McDonald and photographs of the buoys were taken.

Base Charlottetown is not as fully developed as Base Prescott, e.g. the automatic blasting and painting facilities do not exist. However, the system is reportedly in the planning stage and installation will be completed in the near future.

A copy of MR&S Survey Questionnaire was left with Mr. McDonald. He promised he will have his supervisor (who was not at the Base during this visit) complete it and mail back to us.

Interviewer: N. Basar
Date: February 16, 1990

SUMMARY NOTES FROM TELEPHONE INTERVIEW
CANADIAN COAST GUARD BASE HALIFAX
DARTMOUTH, NOVA SCOTIA, CANADA

PERSON INTERVIEWED: Mr. David Smith

Summary

Mr. Smith was recently assigned to his current position where he is responsible for overseeing the buoy design and construction activity within the district. He suggested that Mr. Yves Leclerc of his staff would be the more knowledgeable person to answer our questionnaire.

MR&S will mail a copy of the questionnaire to Mr. Smith's attention and he will in turn have Mr. Leclerc complete it and mail back to MR&S.

Interviewer: N. Basar
Date of Conversation: February 16, 1990

SUMMARY NOTES FROM INTERVIEW

ROYAL DANISH ADMINISTRATION OF NAVIGATION AND HYDROGRAPHY

(FARVANDSVAESENET)

COPENHAGEN, DENMARK

Persons Interviewed: Mr. Nikolaj Hansen
Mr. Svendsen
Mr. Littau

SUMMARY:

Mr. Anker Nielsen, who is the head of Navigation and Hydrography Administration (Farvandsvaesenet), was out of town on the day of the interview. Of the above-named three persons, Mr. N. Hansen is the chief of Technical Division within the Administration. Mr. Svendsen is an ex-buoy tender Captain and Mr. Littau is a buoy design engineer.

The following are notes taken at random during the interview:

- Denmark uses only steel buoys in marking the waterways. They have experimented with some GRP buoys but found out that they are not suitable for their purposes. The plastic buoys used were of Norwegian manufacture (Ticon Plast). The standard lighted buoys currently in use are shown in Figure 1 which is a reduced copy of Drawing #0375-460A. As seen, the buoy hull diameters vary from 1,100 mm. to 2,875 mm. maximum and the lengths range from 6.2 meters to a maximum of 10.55 meters. The following Farvandsvaesenet (Navigation Adm.) drawings (in reduced Xerox reproductions) were made available:

  0375-460A: Dimensions & Weights of Standard Buoys (lighted)
  0375-441: Type 16 (1,700 x 7,600) Lighted Buoy
  0375-538: Type 14 (1,500 x 7,400) Lighted Buoy
  0375-557A: Type 14 Lighted Buoy with Fiberglass Superstructure

  The unlighted steel buoys are shown in the following drawings:

  0376-300: Type I - IV Unlighted Buoys
  0376-301: Type C-K-S Steel Unlighted Buoys

  All of the steel buoys in Denmark are built to their own designs.

- There is no serious ice problem in Danish waters. They do experience drifting ice at times.

- For lighted buoys, they use gas and battery power. The lithium batteries are made in Denmark with the "Kirk" lantern which has 40 candle power. When used 7% to 50% of the time these batteries will last 2 to 3-1/2 years. Alkaline batteries are also used in other locations.

A.1.2

- No monitoring is done of the buoy locations. Off-station buoys are reported by mariners and users. The Danish Authority, however, is currently experimenting with the monitoring idea.

- In connection with a project called ODAS (Ocean Data Acquisition System) they are also using wind generators to provide power for illuminating the superstructure of lighted beacons. However, they were not willing to provide specific information on this subject. They said they will present a paper to the IALA conference in June and give the details and progress to date.

- The Danish ATON Systems has 1,500 unlighted and 400 lighted buoys. About 1,000 unlighted plus 200 lighted buoys also exist as spares.

- They are experimenting with a double armored plastic cable for use in the mooring of buoys. The manufacturer is a U.S. company (PMI Industries of Cleveland, OH). Its breaking strength is 11 tons and, at 125 Danish Krones (DK) per meter length, it is only a little more expensive than chain. It has been a month and a half since it was installed - and the results of this experimental application are not yet determined.

- Denmark has not used solar power on any buoys yet.

- Superstructures of lighted buoys are made of steel or plastic only. An aluminum radar reflector and a plastic superstructure (integral) is used with Type 25 and Type 26 buoys.

- Type 12 is a major buoy type. About 200 of these buoys exist (some are type 14 with 1,500 mm diameter instead of 1,250 mm). Type 26 and Type 22 use the same buoy hull of 1,100 mm diameter. 50 of Type 26 are being built using hulls for Type 22.

- Type 52 Buoy is used mostly for RACON applications. There are approximately 20 of these buoys.

- The largest buoy is Type 43; there are only nine of this type - they replace the lightships of which there were 12, but none are left now.

- In Danish waterways, 3 knot current is common. Type 12 buoy (with 1,250 mm diameter) goes under in this current. This is why Type 14 was developed by increasing the diameter to 1,500 mm. Type 14 can stay on the surface at up to 4 knot currents. It can be moored at the bottom or on the side according to the currents at the location.

- The Danish Navigation Administration has been conducting tests with Wave Generators on the 1,700 mm buoys. One of these buoys, it was stated by Mr. Hansen, would be installed in water in about 2 weeks. The wave generator will produce 20 watts continuously. The Danish feel their wave generator research has been quite successful. It is being carried out in cooperation with a commercial manufacturer and when the development is complete, the wave generator will be available for sale commercially. A paper describing the research and development effort in this area will be presented to the IALA Conference in June.

A.1.2

- The Danish waterways generally have depths of 20 to 50 meters. Inland, between islands, the depth is only up to to 20 meters. In meeting the needs of specific depths or locations, they do not go into designing all new buoys, but modify existing buoy hulls to make them suitable for the new service.

  About 20 buoys may be lost per year on the average. Losses are due mostly to collision damages If the buoys get drifted off station due to collision or any other cause, they mostly get picked up in Germany or Sweden. Buoy losses, especially those with RACON, are very expensive proposals. The loss of one of these costs approximately half a million DK. The Tideland beacons on these buoys only cost $2,500 apiece.

- Denmark has 2 large (70 m long) and 2 small (40 m long) buoy tenders, and 25 to 30 small ANT boats. A new buoy tender with 50 meter length is currently under construction.

- Among the buoys serviced by the buoy tenders are approximately 207 lighted buoys in Denmark proper, about 25 in the islands, and 64 in Greenland. The main port for one of the big tenders is Korsor and for the other one is Greno-Esbjerg in Jutland. The tenders are operated with two shift crews. Shifts are changed every 2 weeks. One shift consists of 19 crew members on the big tender and 17 on the smaller tender.

- The cost of operating the buoy tenders is high. The price for maintaining a lighted buoy is approximately 100,000 DK in one year.

The "Farvandsvaesenet" personnel offered to provide a field trip to Korsor where one of the big buoy tenders is stationed and also where a Government Buoy Depot is located.

The M/V ARGUS is an offshore Buoy Tender of approximately 70 feet in length with icebreaking capability. She was built in 1971 primarily to service the LORAN stations in Greenland She has a 15 ton derrick type crane and a large (approximately 10 x 15 meter) well deck forward for servicing the buoys. The Korsor Buoy Depot is capable of replacing and servicing all existing buoys as well as modifying any existing buoy for any new application. Also stored in the depot are spares for all buoy equipment, including lanterns, batteries, flashers and mooring system spares. The Depot personnel gave copies of data on the following equipment:

- High Energy Lithium Thronyl Chloride Battery
- MLF 325 Multiflash Unit
- DIN 40 859 for Dry Primary Cells R40 and AR 40, Dimensions and Tests.

Interview conducted: March 26, 1990
at: Copenhagen and Korsor, Denmark
by: Nedret S. Basar

A.1.2

(THIS PAGE INTENTIONALLY LEFT BLANK)

SUMMARY NOTES FROM INTERVIEW

TRINITY HOUSE

LONDON, ENGLAND

PERSON INTERVIEWED:

Capt. Malcolm Edge
Deputy Master of Trinity House
President of IALA

Capt. John Barnes
Head of Engineering and Maintenance

SUMMARY

- The Corporation of Trinity House, London, is a unique maritime organization which throughout its long distinguished history has had as its prime objective the safety of shipping and the welfare of seafarers. The Corporation is the General Lighthouse Authority for England, Wales and the Channel Islands, providing such aids to general navigation as lighthouses, light vessels, buoys and beacons, a charitable Organization for relief of Mariners and their dependants who are in financial distress, and a Deep Sea Pilotage Authority. It is not a government organization but it was created by an act of Parliament.

- The Trinity House Lighthouse Service is financed from light dues which are levied on vessels loading or discharging at ports in the United Kingdom and Ireland and are based on net, or net registered tonnage. The dues are paid into the General Lighthouse Fund which is under the trusteeship of the Department of Transport and is used to finance the lighthouse services provided by Trinity House and the other two General Lighthouse Authorities, the Northern Lighthouse Board (responsible for the waters of Scotland and the Isle of Man) and the Commissioners of Irish Lights (responsible for the waters of both Northern Ireland and the Republic of Ireland).

- Trinity House operates two Lighthouse tenders which are purpose-built vessels constantly employed at sea to support and maintain floating aids to navigation. The vessels perform such duties as towing, fueling and mooring light vessels, laying or lifting buoys, surveying newly reported shoals and searching for and marking wrecks. At the end of 1988 a third vessel CTHV STELLA, built 1953) was withdrawn from service and is held in reserve pending expereince of operating a two vessel fleet which is composed of the modern vessels THV PATRICIA (1982) and THV MERMAID (1987).

- The number of buoys they are responsible for is approximately 600.

A.1.3.1

- o The buoys of Trinity House are in very exposed waters, not harbors.
- o For many years until recently they utilized acetylene gas lights. Now their buoys are solar powered with batteries.
- o Their largest class one buoy is 4 meters in diameter, 50' high, weighs 12 tons and has a 7 mile light.
- o They have a boat type hull for fast water. It is of their own design. Have 2 of these and need 2 more.
- o They have very few fiberglass buoys.
- o The exposed locations of the buoys results in a significant amount of collision damage, so steel is better. Can be retrieved more easily. Exhibit #1, page 16, gives an account of an occurrence.
- o All their deep water buoys are 9ft. to 10ft. in diameter and of Trinity design. They are still using some buoys build 90 years ago.
- o Their latest steel buoy has a standard hull on which they can mount different superstructures. Therefore they are all interchangeable.
- o Balmoral in Scotland builds fiberglass buoys.
- o Maintenance of the buoys is carried out from Harwich, Great Yarmouth, East Cowes, Isle of Wight, Penzance and Swansea.
- o Maintenance schedule:
  - Visit buoy once each year. Clean buoy and return to position.
  - Return buoy to base every 4 years. Sandblast, prime (baked) and apply 3 coats of epoxy.
- o Cost data:

-	Tender Costs:	296 L/hr. on 24 hr. basis
-	Buoy:	15000. L 1st Class
		6700. L 2nd Class
-	Racon:	35,000. L

- o Trinity House is currently more concerned with power sources than the buoy itself.
- o Harbor buoyage is handled by a number of local authorities.

Interview Conducted: March 5, 1980
At: Trinity House
London, England
By: John C. Daidola

A.1.3.1

TRINITY HOUSE

EXHIBITS

1. The Trinity House Flash, September 1989.
2. The Trinity House Flash, December, 1989.
3. Description of The Corporation of Trinity House.

(THIS PAGE INTENTIONALLY LEFT BLANK)

SUMMARY NOTES FROM INTERVIEW

TRINITY HOUSE

HARWICH, ENGLAND

PERSON INTERVIEWED: Capt. Evans
Marine Superintendent

SUMMARY

- Buoy Depots are located at Great Yarmouth, Harwich and Swansea.

- Lighted Buoys utilized by Trinity House are the Class I and II Steel buoys. All their buoys are in export locations.

- In the 1970's they tried a fiberglass Class II buoy. It was probably built by Balmoral. It didn't work as they had problems with moorings, disintegration of fiberglass, fading of color.

- A number of smaller harbors in England use Balmoral fiberglass buoys. The responsibility for those buoys is under the local harbormaster.

- Local harbor authorities must obtain Trinity House approvals for aids to navigation changes and installations. Once the buoys are installed Trinity inspects the installation.

- Have not purchased any buoys in the last 5 years.

- Trinity House maintains an inventory of 25% in spares.

- Until recently they were also responsible for the marking of drill rigs.

- Collision of ships with buoys is a problem. The buoys do not have any damaged stability provisions.

- On the west coast of England the conditions are deep ocean with rocky bottom whereas on the east they are shallow water with shifting sand.

Interview Conducted: March 7, 1990
At: Trinity House - Harwich Depot
Harwich, England
By: John C. Daidola

TRINITY HOUSE - HARWICH DEPOT

EXHIBITS

1. Data on: Methods of Mooring, Buoy Chain, Sinkers, Cardinal System, Radar, Reflector, Daymark Superstructures, Top Marks, Fog Signals and Electric Lanterns.
2. Drawing and data Cardinal Class I 10x50 LWBR
3. Drawing and data for Cardinal Class II 10x26 Mk II
4. Drawing and data for Cardinal Class II Std. Solar
5. Drawing and data for Cardinal Class I Solar (Large)
6. Photo: Tender Patricia with Class II Buoy on Deck.
7. Photo: Buoy Tender Buoy Tube.
8. Photo: Buoy Tender Foredeck.
9. Photo: LANBY and Old Lightship at Anchor.
10. Photo: Buoy Tender Foredeck Buoy Tube and Hold.
11. Photo: Floating Beacon Collar.
12. Photo: Class II Buoys and Interchangeable Cages.
13. Photo: Racon atop a Class I Buoy.
14. Photo: Cardinal Topmarks.
15. Photo: Class II Buoy Tube Appendages.
16. Photo: Buoy Tube Appendages.
17. Photo: Buoy Showing Acetylene Gas Pockets.
18. Photo: 9ft. Diameter/General Purpose utilized Buoys Demonstrating Cage Interchangeability.
19. Photo: 9ft. Diameter General Purpose Unlighted Buoys.
20. Manual illustrations of all Trinity House Buoys:
    - o High Focal Plane Steel Buoy
    - o Short Pillar Steel Buoy
    - o Small Lighted Steel Buoy
    - o Fiberglass Buoy, 4'-9" DIAMETER

A.1.3.2

- Standard GRP 3 meter diameter lighted buoy
- Cardinal Class I Steel Buoy
- Cardinal Class II Steel Pillar Buoy
- Steel Keel Type Buoy
- 9'-0" Diameter Steel General Purpose Unlighted Buoy
- Standard Steel unlighted buoys

A.1.3.2

(THIS PAGE INTENTIONALLY LEFT BLANK)

SUMMARY NOTES FROM INTERVIEW

GLOUCESTER HARBOR TRUSTEES

GLOUCESTER, ENGLAND

PERSONS INTERVIEWED:

Mr. R.G. House
Honorary Engineer

Capt. Allen Boyer
Port Captain

Mr. Gerard
Superintendent

SUMMARY

- The Gloucester Harbor Trustees (GHT) are responsible for the river Severn, at the headwaters of the Bristol Channel. They have 30 lights and buoys, 5 buoys.
- Whatever buoyage they install must be approved by Trinity House.
- The significant tidal action (10 meters) in this area sometimes leaves their 5 buoys aground at low tide.
- They have considered various power sources for their buoys. Up to 10 years ago all English buoys were acetylene gas driven. Now they are battery solar powered. The GHT had looked at wind generators (nothing adequately safe or commercial found) and current generators (never got beyond idea stage).
- Their fixed lights have hydraulic arms to raise and lower lights.
- Photos of their buoy types are shown in Exhibits 2-4.
- Steel rusts quickly in an estuarine environment so they have gone to fiberglass superstructures on their buoys. They don't rust and they're lighter. Hippo Marine Products built them. Hippo also builds small mooring and navigation buoys, Exhibit 7 Brochure on Hippo was turned over to MR&S.
- 4 of their buoys have spike anchors. One has a weight.
- One of their buoys is a boat buoy. They gave no specific reason for its selection.
- Have a Pharos gimballed mast which has been in place 20 years, Exhibit 6. Average water is 5ft. at low tide and 35ft. at high water.

- **Ideas For Research and Development:**

  - Indicator to show if a battery is low. Something that can be seen with binoculars.
  - Current driven generator.
  - Installation of battery boxes outside buoy hull.

Interview Conducted: March 6, 1990
At: Gloucester Harbor Trustees, Gloucester, England
By: John C. Daidola

GLOUCESTER AUTHORITY

EXHIBITS

1. Photo: Buoy, Type 1 and Type 2
2. Photo: Buoy, Boat and Type 2
3. Photo: Buoy, Type 3
4. Photo: Fixed Towers
5. Photo: Pharos Gimballed Mast
6. Brochure on Hippo Marine Products (see its separate file).
7. Brochure on Reinforced Plastic Structures (LEWES) Ltd. (see it's separate file).

A.1.3.3

SUMMARY NOTES FROM INTERVIEW

CITY OF BRISTOL CONSERVANCY AND PILOTAGE DEPARTMENT

BRISTOL, ENGLAND

PERSONS INTERVIEWED:

LT. CDR. E.M. Bradley
Haven Master

LT. CDR. W.J.M. Coles
Conservancy Officer

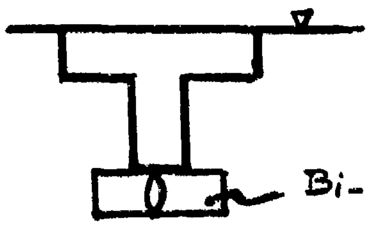
SUMMARY

- The port of Bristol is in the Southwestern portion of England. The tidal range in this area is 38ft.

- Currents can reach the 4-5 knot range.

- Have 2 large (2.5 meter diameter and 850Kg HIPPO buoys constructed of a polyurethane elastomer skin and a polyethylene foam interior. It has solar panels and a battery compartment on top. It works very well in current.

- On these same HIPPO buoys it is intended to install a current generator with a bi-polar vane mounted at the bottom. Lt. (Cdr. Coles to supply further information.



- Have some older GRP buoys made by one of the larger manufacturers. Although it was indicated that these buoys were not favored, the complete details were not noted. In general it is found that GRP cracks when ships collide with the buoys and this is a problem.

- Have one Tideland 2 meter diameter light buoy. This buoy tends to tip easily enough that it is very difficult for a man to board it.

- Feel that HIPPO has the best up to date technology. Their elastomer foam buoys survive ship collisions, however, the above noted new 2.5 meter buoys will be the first foam buoys in the most exposed locations. They are hopeful they will work well.

Interview Conducted: March 6, 1990
At: Bristol Haven Master
Bristol, England
By: John C. Daidola

A.1.3.4

(THIS PAGE INTENTIONALLY LEFT BLANK)

SUMMARY NOTES FROM INTERVIEW

FINNISH BOARD OF NAVIGATION
(MERENKULKUHALLITUS)

HELSINKI - FINLAND

PERSONS INTERVIEWED: Mr. Klaus Martonen
Mr. Timo Rekonen

SUMMARY

The organization of the Finnish Navigation Authority was changed in early March, 1990. Previously, the "Waterways Department" and the "Board of Navigation" were two separate agencies. Under the new organization, both agencies are now in the Board of Navigation as the "Waterways Division" and the "Aids to Navigation" division. Mr. Kimmo Mannola is the director of the "Waterways Department" and under him are the two aforementioned divisions.

Mr. Martonen is the Chief Design Engineer of the ATON division and Mr. Rekonen is in the Waterways Division.

Messrs. Mannola and Kostiainen (Head of Waterways Division) were out of town the day of the MR&S visit and could not be interviewed.

Messrs. Martonen and Rekonen gave a briefing-type presentation to the interviewer. A summary of the presentation as well as discussions that took place during the interview is given below as recorded at random:

- The maximum ice thickness experienced in the Finnish waterways is more than 1.0 meter. The coast is charted by 40 maps, each covering a 25-mile long area. The thicknesses have been measured and recorded for each area since the early 1900's. Figure 1 (from a paper by Mr. Klaus Martonen entitled "Buoy Engineering in Finland", 1984, a copy of which is attached as Exhibit 1) shows the maximum thicknesses of level ice along the coast of Finland from 1920 to 1980.

- Buoys will function only in ice up to 30 cm. thick. Therefore, outside the 30 cm. thick areas, fixed structures are used. The approximate cost of a fixed structure is close to 1 million Finnish Marks (FM). The weight of the superstructure for these fixed lights is about 4 tons and the height is 12 meters. The fixed pile foundation weighs about 70 tons. Typically, it is stationed in 18 meter deep waters and the pile is driven 17 meters into the bottom. A minimum of five and an average of ten of these structures are built each year.

- The criteria used by the Board of Navigation in buoy designs with regard to wave heights are based on the the environment in four different regions. The largest wave experienced is 13.7 meters high in Area #1 which is the North Baltic region - the worst area. The second largest wave is 8 meters high. The survival maximum wave height (used mainly for mooring design) is 19 meters. This wave height does not present a problem for the buoy hulls. The Finnish Wave Design Criteria is shown in Table 1 which is in three languages (Finnish/English/Swedish) - the middle line is the English version for all entries.

- It is difficult to calculate the movements of a floating buoy. The Finns have not developed a computer program for this purpose. However, Mr. Martonen stated that it should be possible to do so. For the time being, the only reliable way is to conduct model tests. Mr. Rekonen had conducted such tests and the measured maximum tilts found are shown in Table 2. (English equivalents of Swedish entries are hand lettered.)

- The Finnish coast is subject to extreme ice conditions. Maximum ice thicknesses of 130 cm. are recorded. The ice season lasts seven months in the extreme north, 6 months in the middle regions and 4 months in the south. Ice ridges and drifting ice due to water between ice layers cause damage to plastic buoys. Still, the life expectancy of plastic buoys is estimated to be about 10 years. Wooden spar buoys are discarded after one season.

- The Finnish Board of Navigation is responsible for marking and maintaining navigation channels with a total length of 12,700 kilometers. In addition to fixed structures, these channels are marked using spar buoys and pillar buoys. In Exhibit #1 a spar buoy is defined as "a buoy whose visible part has a small cross-section with a height of more than 5 times its width" and a pillar buoy is defined as having a more solid tower. Figure 2 is a schematic representation of the standard navigation buoys of the spar and pillar type used in Finland.

- As of the end of 1983, as reported in Exhibit #1, a total of 12,472 buoys were in place for marking the channels. The number, as of the end of 1987, has increased to 13,389. The breakdown of different types of buoys for 1983 is as shown below:

Wooden Spar Buoys	4,342
Plastic Spar Buoys	
-lighted	217
-unlighted	7,451
Pillar Buoys	
-lighted	289
-unlighted	173
TOTAL	12,472

- By the end of 1987, there were only a total of 1,681 wooden spars in the system with an annual loss of 50% and about half of the damaged buoys being repairable. The total number of plastic spar buoys has increased to 11,444 with an annual loss of 100 to 200 buoys. There are also 264 lighted plastic buoys for inland use in diameters ranging from 160 to 500 mm. max. About 50 of these are found off-station, recovered and replaced annually; 20 are found to be damaged and 5 totally demolished.

- 133 plastic buoys of sizes ranging from 1 m. to 1.6 m. (some with H/D ratios greater than 5, i.e. spars, some others smaller than 5, i.e. pillars or buoys) have been in use since 1980. 14 of these buoys have had to be repaired due to ice damage. The correct place for these buoys is where the ice thickness is less than 30 cm.

- There are 442 standard steel buoys in the system 250 of which are lighted steel buoys for use in rougher sea conditions. 10% of the steel buoys have to be repaired every year. The needed repairs may consist of weld repairs, fixing of dents, and painting. The paint may last anywhere from one to five years; exceptionally, it may last 7 years in some locations, but the average period for repainting is 2.8 years.

- The Board of Navigation has three large buoy tenders of maximum 43 meter length and lifting capability of 12 tons with 6 meter outreach. These tenders are operated with a crew of 15 each. There are also small boats (similar to US Coast Guard's ANT teams) which have crews of 3 each. The buoy tenders are mainly used in buoy servicing and maintenance, while ANT boats are also used in other services such as pollution prevention, etc. There were a maximum of 40 ANT boats at one time; currently the number is about 30.

- No solar panels nor wave generators are used in Finland. All lighted buoys are equipped with primary batteries only. The batteries are charged every 8 to 9 months, and they are thrown away after use. Solar power, however, is being considered for future applications. Figure 3 shows a possible configuration of solar panels on a light buoy that is currently under study.

- Work is currently underway in the Board of Navigation to develop a computer database for storing reliable buoy statistics. The purpose is to be able to improve the weak points of the existing buoys in any redesign effort. This development is not yet complete.

- Position control of buoys is done by reports form pilots, tender crews,and users (tugboat personnel, etc.). A systematic position control procedure does not exist. A position control system (Syledis) giving an accuracy of 3 meters as well as a mini DECCA system (French) and GPS are being considered for future application. GPS may be installed in November 1990 in the southern region. No collisions have been reported in Finland, but a high density of grounding cases exists. A degree of VTS (Vessel Traffic Systems) operation exists in the Coastal regions of East Finland.

- The Board of Navigation has a total design budget of slightly more than one million FM (Approximately $250,000).

- The spar buoys with diameters less than 50 cm. are manufactured in the Board of Navigation's own plant in Joensuu, Finland. Larger buoys are manufactured by KWH Pipe (ex: Wiik & Hoglund) at their plant in Vaasa, Finland.

- Steel buoys are more resistant to wear and impacts from ice. Finland has developed standard steel buoy designs for ice use in 1970 (the old type) and in 1989 (the new type). Table 3 gives a summary of the 1989 design improvements compared to the 1970 designs. In Finnish waters, there is no need for anti-fouling paint on steel buoys. For protection against galvanic action, however, zinc anodes are used.

- The old steel buoys had four compartments. The new design has five as shown in Table 3. This is needed as protection against the severe ice environment in Finland. The buoys are capable of withstanding two compartment damage.

- The cost data for the buoys used in Finland are shown in Table 4 (English translations written in long hand on Swedish text). Typical costs for buoy equipment are likewise shown in Table 5.

- The following additional documents were received from Mr. Martonen:

  Exhibit 2: Brochure "For Channel Marking - The Plastic Spar Buoy" Roads and Waterways Administration, Finland, 1984.

  Exhibit 3: Board of Navigation Buoy 3 TR 912-674. Detailed construction drawing for Standard Steel Ice Buoy 130x1050.

  Exhibit 4: "Horizontal Divergence and Stationary Intensity", test results plots for LO-1 Range Light, 10.3 v and 2 w through 100w.

- After the interview, Mr. Martonen accompanied the interviewer for brief visits to the Board of Navigation's Buoy Depot and to the "Navigation Aids Test Laboratory" in Helsinki. Exhibit #5 contains photographs taken during the visit to the Helsinki Buoy Depot as follows:

  Photo A: A new (1989) Steel Buoy type JPK-130-550 for shallow water use.

  Photo B: Marking numerals on Buoys in Photo A.

  Photo C: A new "KWH Pipe" Plastic Buoy.

  Photo D: The weld seam at end of Plastic Buoy.

  Photo E: A damaged Plastic Buoy showing the polythene shell and the polystyrene foam inside.

  Photo F: Steel Buoys of old (1970) design.

  Photo G: Dents in the shell of a Steel Buoy.

  Photo H: Small Plastic Spars in storage at the Buoy Depot.

  Photo I: Concrete sinkers at the Buoy Depot.

Interview conducted: March 21, 1990
At: Board of Navigation
Helsinki, Finland
By: Nedret S. Basar

SUMMARY NOTES FROM INTERVIEW

DIRECTEUR DES PORTS ET DE LA NAVIGATION MARITIMES

SERVICE TECHNIQUE DES PHARES ET BALISES (STPB)

PARIS, FRANCE

PERSON INTERVIEWED: Mr. Jean-Yves Chauviere, Director of Maritime Navigation

Mr. Jacques Royer, Secretary-General

SUMMARY

- The Service Technique Des Phares Et Balises is responsible for all aids to navigation on the mainland of France and other locations overseas as described below. In France the STPB is composed of a Headquarters office in Paris and six port Directorates: Port Autonome de Dunkerque, Port Autonome de Rouen, Port Autonome du Havre, Port Autonome de Nantes-St. Nazaire, Port Autonome de Bordeaux, and Port Autonome de Marseille.

- Mr. Royer used to be the manager at the port of Dunkerque for the Strait of Dover. Now he is the overall Technical Manager.

- Responsible for about 6000 aids to navigation. 1000 lighted aids including lighthouses, 2000 buoys (1000 with lights).

- Buoys are on the mainland of France and in some overseas locations.

- STPB is not responsible for inland navigation on small rivers and canals. The latter do not have many buoys. Canals are narrow and therefore there is not much to mark--navigators know they have to be careful.

- Overseas locations include Antigua and St. Frias in the Indian Ocean with buoy departments there paid by France. Others include Martinique, Guadaloupe, Canada and Malaysia, but in these locations others are in charge and funds come from the local government.

- STPB has about 10 types of buoys. Except for the new plastic buoys they all have been designed a long time ago. Although they have changed signals, the buoy hulls have been unaltered.

- France is now solarizing (note that a paper on these efforts was given at the IALA '90 Conference).

- Problem with buoys is that they are large and heavy. The ships to service them are old. STPB needs new ships and may consider changing the ship and buoy together to reduce ship requirements.

- In the Mediterranean the STPB has gone to a smaller buoy tending vessel which must drag the buoys rather than lift, due to its smaller size and lesser capability. This was done because of fewer funds available to support the operation. This vessel is the first new ship in 40 years. They will send MR&S data on this vessel (Note: data was received in June of 1990). This vessel is driven by cycloidal propellers.

- The STPB doesn't have information on buoy motions. A few years ago they had proposed a study to do this but didn't have enough funds. They would like more information on the motions of their buoys. All they have to go on is what mariners offer on the visibility of the buoy and its signalling devices.

- The Mediterranean is calm compared to the Atlantic.

- The STPB's large buoys are constructed of steel and are very robust. The buoy body is actually a steel pressure gas tank and is inspected by Bureau Veritas as a pressure vessel.

- The STPB has tried GRP buoys.

- Buoy losses due to collisions with ships and storms total 6 per year.

- The EGAR 2500 (actually seems to be the 3500?) type was specifically designed to lay on the ground at low tide.

- The STPB has now gone ten years without building a large buoy. They expect that when their stockpile of buoys is depleted in the future they will simultaneously be at a point of low funding for buoy construction.

- '84-'85 cost of constructing buoys are available and will be sent to MR&S (note that cost data, some more recent, was forwarded to MR&S in June of 1990).

- A new large steel buoy would be 90,000 Francs. This includes all steel work but not solar panels, batteries and signalling devices.

- STPB has not identified the cost of buoy tending alone so that no data can be offered on this subject.

- Hurricane Hugo damaged their buoy tender in Guadaloupe. This vessel had been built in 1948. They are looking for a replacement.

- The 2-meter (GRP) plastic buoy is the largest. Other plastic buoys have been used around France.

- All buoys used by the STPB are of their design. They don't believe any of their buoys have been imported. Currently there are no buoy manufacturers in France. They have used general steel fabrication shops to manufacture steel buoys. (After visiting Gisman it seemed that some GRP buoys manufactured by them are used by the STPB).

- Most large steel buoy bodies are pressure tanks with no compartmentation. One steel buoy does have compartmentation. Plastic buoys are foam filled.

- Every STPB District port (6) has a buoy tender and maintenance facility. All work on the buoys is accomplished by the STPB.

- The service period for buoys includes inspecting chains every 12 or 24 months and changing the buoy every 3 or 5 years, depending on location.

- The highest currents in France are found in the Straits of Dover area. The Straits have a 4-knot current, but between an island in that location and the coast of France the current can reach 12 knots.

- In some harbors and rivers there are high currents, but instead of trying to develop a buoy for this, stationary marks have been utilized. Sailors in these areas also know the conditions.

- STPB has built a special 10-knot buoy for Polynesia in the Pacific. Believe this was a boat hull type buoy and that resulted in a buoy better able to operate in the current.

- STPB has not utilized any floating beacons, but they are aware of the concept.

- Whenever ship collisions with buoys have occurred, the STPB has usually not been able to identify the vessel.

- Funding level for STPB is low relative to the work that needs to be done.

- The STPB does not have any specific problems to solve except adequate funding to replace tenders and buy more buoys. They will consider smaller buoys and tenders in an effort to reduce the required funding.

- The STPB would like to obtain the results of the USCG study. Advised them this was up to the USCG.

Interview Conducted: March, 1990
At: STPB
Paris, France

By: John C. Daidola

SERVICE TECHNIQUE DES PHARES ET BALISES

EXHIBITS

1. Boue Marine, Notice D'appareil, Egar 5001, May 1988.

2. Boue Intermediare, Notice D'appareil, Egar 2501, March 1979.

3. Boue Lumineuse de type Delphine, Notice D'appareil.

4. Boue Lumineuse, Type Nolwen, Notice Descriptive, February 1987.

5. Boue Lumineuse Mixte, Type Nolwen, Specifications Techniques, March 1987.

6. Boues Lumineuses en Polyester (modele 1973), Boue du Systeme Lateral et de Danger Isol, Egar 3000 and 3500, Notice D'appareil, Egar 3001, September 1987.

7. Boue Lumineuse Font Plat, de $5m^3$, Egui 5300, Notice D'appareil, Egui 5301, April 1970.

8. Boues Lumineuses Queue (modele 1965), de 7.5 m^3 Egui 5000, de 12 m^3 Egui 5100, de 18 m^3, Notice D'appareil, Egui 5100, March 1968.

9. Article giving number and types of French buoys.

10. List of characteristics of French buoy tenders.

11. Prices of French Buoys, June 15, 1990.

12. Quantities of French Buoys, June 15, 1990.

13. Article on the New French Buoy Tender, Revue Technique des Phares et Balises No. 85.

SUMMARY NOTES FROM INTERVIEW

MINISTRY OF TRANSPORT

(DER BUNDESMINISTER FUR VERKEHR - BMV)

BONN, WEST GERMANY (FRG)

Person Interviewed: Dr. Ing. H. Hartung

SUMMARY

Dr. Hartung is a "Ministerialrat" (i.e. a Director) in the Ministry of Transport, which also contains the Federal Waterways Authority (FWA). An organization chart for BMV was given by Dr. Hartung and is attached, Exhibit 1. All Aids to Naviga- tion Service in West Germany is integrated into the FWA and therefore the responsibility for the construction, operation and maintenance of the entire buoyage system, including open sea, coastal and inland waterways, rests on FWA's shoulders. During the interview, Dr. Hartung gave the following information:

- FWA also administers inner-waterways traffic and waterways construction. A major project currently in progress and to be completed in 1992 is the Main/Danube canal which will connect the Black Sea to the North Sea by joining the two rivers. A map showing all coastal and inland waterways is attached, Exhibit 2.

- Exhibit 3 shows all aids to navigation on the coastline of Germany (FRG). Exhibit 4 illustrates the shore-based radar installations.

- FWA's Aids to Navigation division (BW 25) has 6 districts and a total of 32 local offices in all of these districts. Every district has a buoy yard which includes a repair facility and buoy depot. Local offices maintain only spare parts. Only three or four of the 32 local offices have small shops doing maintenance and handling of buoys. Personnel-wise, the local offices are quite strong; they employ 500 to 600 persons and they have engineering capability as well.

- There are, as seen in Exhibit 3, three specially-constructed unmanned lightships and many fixed aids on FRG's coastline. Both the lightships and the fixed lights are remotely controlled. The remote control for lightships includes fully automatic operation which is programmed and self correcting. The data are transmitted to the local office. To avoid transmittal of unnecessary or unimportant information, about 50% of the data collected is eliminated.

- In order to control the floating aids (buoys), two buoy tenders operate around the clock in the North Sea. The buoy tenders' mission also includes oil pollution fighting and vessel traffic control and monitoring. In this effort, ships and aircraft exchange information.

- For all ships of 50 meter length or longer, pilots are mandatory, especially in the coastal areas. In the Federal Republic of Germany, (FRG) all pilots are private, but their rates are established and/or approved by the Ministry of Transport (BMV).

- On the river Rhine, only unlighted buoys are used. They are made of steel and of one type only. Some plastic buoys were tried but did not work.

- There are no buoy losses in the coastal areas. Local offices are well prepared to pick up the buoys before ice arrives. Of course, some lanterns are being lost.

- For river buoys and buoy equipment, the sole procurement agency is the "Seczeichenversuchsfeld" (SZVF) in Koblenz. However, coastal region buoys are all procured by the local offices. The specifications and drawings for all coastal buoys are on the basis of designs prepared by SZVF. FRG has an "Aid to Navigation Booklet" (The German name is "Schiffsfahrtzeichenweisung") which consists of 2 volumes. Its use is restricted to MBV personnel involved in ATON operations only.

- Buoy construction contracts are placed with private contractors. Among the contractors currently doing work for the BMV are Pintsch Bamag, Richard Totzke GmbH in Neumunster and Weiseler Bojen und Maschinenbau in Weisel.

- The buoys used in FRG have long service lives and traditionally the FWA has been operating a large variety of buoys. An effort to standardize the buoys they made some 50 years ago; it was interrupted by World War II, and started anew in the 1950's.

- In general, steel buoys are preferred in FRG. They are maintained in good condition, their colors are kept bright by painting every two or three years.

- One or two light towers were made of plastic materials with the colors pigmented into the plastic material during production. However, the pigment was not stable; the red color turned into rose, and consequently, these lights are now being painted.

- The coastal waterways in FRG are very short (compared to other European countries) and the buoy tenders can therefore get to the aids at any location along the coastline very quickly and easily. There is a defined division of work among the buoy servicing vessels. Any work regarding heavy lifts is carried out by the big buoy tenders and simpler work such as lantern changes, etc., is accomplished by small boats. Both the buoy tenders and the small boats used in servicing aids to navigation also take on other missions such as oil pollution control operations and hydrographic data collection.

- The buoy tenders range in size from about 40 meters long to about 70 meters long. Some were converted for their current multi-mission service from offshore supply vessels and some were specifically constructed for the multi-mission service including tending of buoys.

- The mooring chains of steel buoys in the North Sea, especially the parts that are lying on the bottom, are subject to excessive abrasion and wear.

- With regard to the costs and service lives of buoys and equipment, Dr. Hartung suggested to inquire from Mr. Kuhlbrodt at the SZVF in Koblenz when interviewing with him the next day.

- In FRG, nearly all lighted buoys are run on propane gas. Electric power sources (battery or solar) do not provide enough energy for longer flashes. Some smaller buoys may run on electric. In the rivers area, some fixed lights on shore are powered with solar panels.

- The propane containers have a capacity of 350 kg. One cylinder of propane lasts about one year or longer.

- Wave generators were also considered but abandoned because of the propane's advantages of high intensity and longer duration flashes. The cost of operating lighted buoys with propane gas amounts to only 1/40 of the cost of running them with batteries. The system works well for FRG since the distances are short and the buoys are close together.

- In closing, Dr. Hartung stated that Mr. Kuhlbrodt at SZFV in Koblenz has prepared a set of documents on buoys used in FRG for us. He also said that West Germany will report no ATON changes and no new developments to the IALA Conference in June. However, there will be a paper on unmanned lightbuoys.

Interview conducted: March 28, 1990
At: Bundesminister fur Verkehr
Bonn, FRG
By: Nedret S. Basar

(THIS PAGE INTENTIONALLY LEFT BLANK)

SUMMARY NOTES FROM INTERVIEW

GERMAN FEDERAL WATERWAYS AUTHORITY (FWA)

SEEZEICHENVERSUCHSFELD (SZVF)

KOBLENZ, WEST GERMANY (FRG)

PERSON(S) INTERVIEWED: Mr. Helmut Kuhlbrodt
Mr. A. Alfter
Mr. R. Pohle
Mr. W. Gaschler

SUMMARY

SZVF is the Federal Ministry of Transport's buoy design, research and testing agency. Mr. Kuhlbrodt is the Director of the agency, which contains a Paint Quality Testing Facility equipped with photometric testing devices as well as an "accelerated weather tester". Also within the SZVF grounds in Koblenz are an electrical shop and a mechanical/chemical testing facility where R&D work and tests on buoy materials are carried out.

During the interview with Mr. Kuhlbrodt and his assistant Mr. Pohle, the following were noted at random:

- In coastal waterways, FRG currently has a total of slightly more than 2,700 buoys. Out of these, approximately 2,000 are unlighted and 700 are lighted buoys; 11 of the lighted buoys are sound buoys as well. The distribution of these buoys in various regions of the coastal waterways in the north and northwest is said to be as shown in Exhibit 1 (Annual Report on Aids to Navigation for the Year 1989).

- One standard lighted buoy and two standard unlighted buoys are currently in use in the coastal waterways. Exhibit 2 shows the standard lighted buoy (Leuchttonne 81) of the latest design. This standard lighted buoy is the culmination of design efforts by SZVF since the 1960's. The evolution of the standard lighted buoy is described in a paper by Mr. Kulhbrodt entitled "A New Lighted Buoy", a copy of which was made available to the interviewer and is attached, Exhibit 3. Some of the older lighted buoys are shown in Exhibit 4 (Lighted Buoy 1961) and 5 (Lighted Buoy 1972).

- Inland waterways were marked by wooden or plastic rods with "Bober", in the early days. They have since been replaced with buoys using SR-6 Type radar reflectors (which were invented by Dr. Speckter of SZVF).

- The standard unlighted buoys are shown in Exhibits 6 and 7 respectively, for the conical (Spitztonne T86) and the Spar (Spierentonne T86) versions.

- For Inland waterways, only one standard buoy is being constructed currently in quantities of about 300 per year. This quantity includes all new buoy orders for replacements of both the older types and the losses due to collisions or high water. This is the 1,050 mm. diameter buoy shown in Exhibit 8 (Einheits-Binnenfahrwassertonne) designed by SZVF. Altogether, there are approximately 3,500 inland waterways buoys, about 2,000 of which are of the new standard type. The remainder are of the older type.

- The evolution of the inland waterways buoy is described in an IALA 1980 paper (by Messrs. Kuhlbrodt and Elschner) entitled "Experience Acquired with Inland Waterways Buoys". A copy of the English version of this paper is attached, Exhibit 9. In summary, the development of inland buoys has passed through several stages including construction of aluminum, polyvinylchloride (PVC) and glass-reinforced plastic (GRP) buoys in addition to steel. The aluminum and PVC buoys were not very successful and were abandoned because of high cost and susceptibility to damage, respectively. The GRP and steel buoys were both found to be feasible for use in inland waterways on a long-term basis. Both buoys are filled with rigid polyurethane foam.

- The shell of the steel buoy is made of thin steel plate (of 1.75 mm thickness) in two halves (top and bottom) and the two halves are then joined together by welding the annular seam. Exhibit 10 is a schematic illustration of all elements and variations of this buoy for different applications.

- A small manufacturing firm in Weisel (a city 50 km southeast of Koblenz) has consistently been able to bid the lowest price for the construction of the standard steel inland buoy for the past 15-20 years and has more or less become a sole source for procurement. It is understood that this firm has manufactured a mold onto which the buoy halves are pressed and then joined together, outfitted, and painted.

- This steel buoy has proven to have adequate strength and durability for inland waterways application. Its service lifetime is 7 to 10 years and even more than 10 years when not subjected to collisions. One type of buoy, LT72, which had a steel shell thickness of 6 mm. lasted about 20 years and will probably last another 10 years for a total of 30 years service life. Those built with 12 mm. steel plate may probably last 50 to 70 years.

- The buoys are maintained in good condition. They are painted once every two years and sometimes every year. Every 5 to 6 years, they are blasted to clean metal and then painted over completely.

- Its weight is less than 50 kg. and can be handled by 2 people with small boats and therefore needs no buoy tenders. Some of the boats used for this purpose may have small davits with enough capacity to lift the buoys rather than handle them manually.

- These buoys can be repaired without problems. However, welding of the thin shell plate presents environmental problems due to toxic gases being released when the polyurethane foam inside starts burning during repair welds. Consequently, only very small holes and cracks can be welded without removing the foam packing from the vicinity of the weld.

- The paint/coating system applied includes a final coating of "Tagesleuchtfarbe", i.e. fluorescent daylight colors. Fluorescent colored buoys are widely preferred by mariners and nearly all buoys will eventually be flurorescent.

- The acquisition cost of a coastal buoy is approximately 18,080 DM (approximately $11,000) exclusive of the chain and sinker, at 1990 exchange rates. The acquisition costs for the inland waterways buoys are (in 1985 rates) 510 DM for the steel buoy and 665 DM for the GRP buoy.

- The maintenance costs cannot be precisely determined according to Mr. Kuhlbrodt, since most minor maintenance and repair work is performed without job orders by FWA shops.

- The operating costs for buoy tenders are reported by Mr. Kuhlbrodt to be as follows:

  - o For M/V GUSTAV MEYER (typical) with a crew of 14 in 1980, the hourly cost was 1,520 DM.

  - o In 1990, with a crew of 11, the cost is 1,300 DM/hr.

  - o Cost of operating a tugboat is about 250 DM/hr.

- After the interview, Mr. Kuhlbrodt accompanied the interviewer for a brief tour of the SZVF facilities including the "Paint Quality Testing Laboratory", the "Buoy Electrical Equipment Shop" and the "Materials Laboratory".

  - o The Paint Testing Laboratory has facilities for testing the quality of paints/coatings offered by vendors for use on navigational aids, including photometric test devices and accelerated weather testing equipment. The test methods and equipment used as well as a description of results obtained are given in a paper by Gaschler and Volkel, Exhibit 17. (Mr. Gaschler is the Director of the Paint Testing Laboratory). Exhibits 18, 19 and 20 were also provided by Mr. Gaschler. They are papers by the "Q-Panel Company" on weathering tests of paints. The "Q-Panel Company" of Cleveland, OH is the manufacturer of accelerated weathering testers being used in SZVF. The tester is named the "Q-U-V Accelerated Weathering Tester" and it has been designed, according to its manufacturer, to meet the following requirements:

    (1) To simulate the effects of sunlight.
    (2) To simulate the outdoor wetness attacks.
    (3) To accelerate the effects of ultraviolet rays and condensation by elevating the test temperatures.

    Exhibit 21 is a sample coupon which has been subjected to accelerated weather testing in SZVF's Q-U-V equipment. The coupon was submitted for testing by a paint manufacturer which had applied three 40-micron coats of ordinary color, two 60-micron coats of fluorescent color and one 25-micron coat of special paint for protection against ultraviolet rays.

- In the electrical shop, various electrical components of navigational aids such as batteries, lanterns, flashers, lamp changers, etc. are tested, evlauated and reported upon as to quality and acceptability. Also tested and evaluated herein are the propane gas bottles ad associated parts.

- The Materials Laboraory is equipped to conduct mechanical as well as some chemical tests.

- A complete listing of all data/documents made available to the interviewer by Mr. Kuhlbrodt is given in Attachment A .

Interview Conducted: March 29, 1990
At: Koblenz, W. Germany
By: Nedret S. Basar

ATTACHMENT A

SZVF Koblenz

List of Exhibits

No. Description/Title

1 "Annual Report on Aids to Navigation for the Year 1989"

2 "Einheits Leuchttonne 81"
(Standard Light Buoy 81)

3 "A New Lighted Buoy" Paper by H. Kuhlbrodt

4 Lighted Buoy 1961

5 Lighted Buoy 1972

6 Spitztonne T86
(Unlighted Conical Buoy)

7 Spierentonne T86
(Unlighted Spar Buoy)

8 Einheits-Binnenfahrwassertonne
(Standard Inland Waterways Buoy)

9 "Experience Acquired with Inland Waterways Buoys" Paper by H. Kuhlbrodt and Elschner

10 Schematic Illustration of Standard Inland Buoy

11 German Language Version of "Inland Waterways Buoy Development" (Entwicklungarbeiten an Binnenfahrwassertonnen)

12 Inland Waterways Buoy Details Drawings:
A - S1019 "Radarreflektor(spitz)"
B - S1018 "Radarreflektor(stumpf)"
C - S1034 "Schwanzrohr" (Tail Tube)
D - S778 Standard Buoy Assembly & Details

13 Drawings for Various Buoy Components:
A - S992 "Befestigungsring für Toppzeichen (Topmark Fastener)
B - S1035 "Scheibe für Schwanzrohr" (Tail Tube Disc)
C - S978 "Gegengewicht 15 mm" (Counterweight)
D - S977 "Gegengewicht mit Osen" (Counterweight with Eyebolts)
E - S991 "Befestigungskrenz für Toppzeichen" (Cross for Topmark)
F - 1153 "Zylindertoppzeichen" (Cylindrical Topmark)
G - 1154 "Kegeltoppzeichen" (Conical Topmark)
H - S995 "Toppzeichen" (stumpf)"
I - S1017 "Sperrzeichen"

14 Design Package for "Leuchtonne 81" consisting of drawings and Documents listed in Attachment 2 (Most in German language).

15 Mooring Details

16 Paper by Kuhlbrodt and Vogt "Buoy Tender - Manning and Utilization" IALA 1980.

17 Paper by W. Gaschler and L. Völkel, "Quality Testing of Paint Coats for Aids to Navigation"

18 George W. Grossman, "Correlation of Laboratory to Natural Weathering" Paper to Coatings Technology Symposium, Cleveland, 1977

19 Q-Panel Company Brochure "Know Your Enemy: The Weather and How to Reproduce it in the Laboratory" by Douglas M. Grossman

20 Q-Panel Company Brochure "Q.C.T. Condensation Tester"

21 Sample Coated Metal Coupon Weather Tested in Q.C.T.

SUMMARY NOTES FROM INTERVIEW

MARITIME SAFETY AGENCY - JAPAN

TOKYO, JAPAN

PERSONS INTERVIEWED:

Mr. Hideki Noguchi
Mr. Shinozaki Masao
Mr. Masato Sakai
Mr. Koujirou Katsume

SYNOPSIS:

- The Maritime Safety (MSA) is responsible for all navigation buoyage in Japan.

- Japan adopted the IALA B region rule in 1983. Since then it has been carrying out a 7-year program necessary to change the shape, surface color, character of light, etc., of about 2,000 visual aids, mainly navigation buoys.

- Exhibit 8 gives a complete summary of the situation with buoys in the 1986-88 time frame and discusses all aspects of their navigation buoyage. Much of what was discussed during our meeting is contained therein and will not be repeated here.

- Most Japanese buoys are large steel buoys which originally evolved from USCG designs. There are a few unlighted foam-filled GRP buoys, photographs of which are in the file on the Japanese buoy yard in Chiba. The Japanese have avoided plastic buoys because they found them vulnerable to physical damage and not easily repairable as compared with steel.

- Latest steel buoy designs are about 15 years old. Earlier designs, which were derived from USCG buoys were modified for incorporation of wave-activated generators more than anything else.

- Now the Japanese must reduce the cost of navigation buoyage because of shrinking government budgets. Future designs must be simplified to cut costs.

- MSA uses small manufacturers to construct steel buoys to MSA designs.

- Highest currents in Japan are in the Inland Sea. Kurushimi Straits experience 7-knot currents. L-5 and L-6 buoys are used for high current areas, L-5 in currents of less than 5 knots and L-6 for higher currents.

- L-1, L-2 and L-3 buoys are for the Inland Sea and in-port only: no current considerations.

- Japan has no mechanical sound buoys and only 6 buoys with electric horns. They will eliminate buoy sound signals in accordance with IALA recommendations.

A.1.7.1

- Capital cost of buoys:

  L-6: 7,200,000 yen
  L-4: 18,000,000 yen
  L-3: 4,778.000 yen
  L-2: 3,586,000 yen
  L-1: 3,112,000 yen ($18,750.00 US)
  L-0: 2,764.000 yen

- Maintenance cost of Buoys:

  The Japanese bring buoys in for maintenance every two years. The work done costs about $3,000 U.S. at the buoy yard alone. No buoy tender costs are available.

- In December of 1989 Japan completed change to IALA B.

- MSA is using articulated tower for three lighted beacons. Their design as shown in Exhibit 6 was built by Zeni Light Buoy Company. Zeni also has a number of articulated light towers as shown in Exhibit 7.

- MSA design as shown in Exhibit 6 has a body providing floatation. It is used only in areas where wave action is too heavy for regular buoys. Average wave height is 9 meters. These towers are much more expensive than buoys.

- Nippon Koki Kogyo Co. in Japan is now marketing small plastic buoys.
- Japan has two buoy tender designs:

  3 - 700-ton. 55 mm in length Monohulls
  1 - 303-ton. 27 mm in length Catamaran

  Details and photos are given in Exhibit 4. Also see Chiba buoy base data.

- In areas of strong current, iron sinkers are used. These are smaller than concrete and less affected by strong currents.

- Japan has begun solarizing their buoys. They place their solar panels more or less horizontally at the very top of the buoy.

- Japanese experience significant damage to their buoys as a result of ship collisions. As a result they have developed a paint marking and radio transmission system described in Exhibit 8. This system sprays paint on a colliding ship and sends out a radio signal to the vessel traffic center advising of the mishap. A patrol boat is dispatched to intercept the colliding ship. This has resulted in the identification of the colliding ship increasing from 0% to 30% of all damage sustained.

- Japan has favored wave-activated generators and has developed a number of their buoy designs around these. Solar panels are being mounted on these buoys as well and it is expected they will be useful in bolstering the output provided by the wave-activated generators.

A.1.7.1

- o The maintenance carried out on their articulated towers is a check of the universal joint every five years.

- o MSA brings in buoys for maintenance every 2 years. They visit a buoy every month, but are considering increasing this interval. At one month they check the lantern and battery. They are currently considering contracting out of all buoy tender services to commercial companies.

- o The MSA has provided a manual on all aspects of navigation buoys including mooring design and buoy stability analysis, Exhibit 12. They use this as a textbook in instructing third world countries in Southeast Asia coming to Japan to learn about navigation buoys. Highlights of interest include:

  - A unique shackle to facilitate connecting and disconnecting.
  - A number of wave-activated generator details and performance tables.
  - Marker systems for spraying paint on a colliding ship.
  - Topmarks, designs, dimensions and installation.
  - Procedure for setting a buoy and maintaining it.
  - Buoy stability calculations.
  - Buoy mooring calculations.

- o Additional details are contained in the Chiba Buoy Base summary. Photographs are contained therein.

Interview conducted: April 18, 1990
At: MSA Headquarters
Tokyo, Japan
By: John C. Daidola

MARITIME SAFETY AGENCY - JAPAN

EXHIBITS

MATERIAL OBTAINED

1. Completed Questionnaire
2. Buoy Types and Numbers
3. Summary Sheet of All Japanese Buoys and Principal Characteristics
4. Buoy Tender Characteristics
6. Drawing of Resilient Light Beacon
7. Zeni Light Buoy Articulated Beacons
8. Summary of Status of Buoyage in Japan
9. Detailed Drawing Blueprints of all Buoys
10. Blueprint of Radar Reflector
11. Blueprint of Marking System
12. Buoy Calculation Procedures (Volume of Machineries Part II - Lighted Buoy)

SUMMARY NOTES FROM INTERVIEW

JAPAN MARITIME SAFETY AGENCY

CHIBA BUOY BASE

AND TOKYO HARBOR TOUR

PERSONS INTERVIEWED: Mr. Hideki Noguchi, MSA, Tokyo
Mr. Tonami, MSA Chiba Buoy Base
Mr. Narita, MSA Chiba Buoy Base

SUMMARY

- This base is responsible for 195 buoys. It actually maintains one half or about 90 buoys per year in accordance with Japanese two-year maintenance cycle.
- The largest buoy base is on Hiroshima. It is responsible for 300 buoys.
- Inspection, sandblasting and painting of buoys are all done at the buoy bases.
- The most difficult problem is marine growth. One half the buoys here are the wave-generator type and marine growth impedes operation after 2 years on station.
- Trying new paints for marine growth. New paint is a smooth-surface type. See Exhibit 2.
- Now they make concrete sinkers at base.
- Concrete sinkers do not sink straight in high current due to lower weight/volume and large surface area. The cast iron compact sinkers sink quickly and in place.
- Some welding repair done at base. Where damage is serious, they send the buoy hull to an ironwork factory.
- Most buoys are 15-18 years old.
- Counterweights are iron castings.
- Steel buoy plates are of 9 mm. thickness.
- Two L-1 buoys have bottom with deadrise to reduce effect of wave slamming.
- L-4 and L-7 are only buoys which have compartmentation. On L-7 use outside torroid (4 compartments) for ballast with water. L-4 buoys are filled with foam in outside compartments. Batteries in center compartment.

A.1.7.2

- Vent pipes have screw type connections to hull side.
- Yokohama and Kobe are the largest Japanese ports.
- Two-way turnstile controlled channel into and out of Tokyo Bay.

Interview conducted: April 19, 1990
At: MSA Chiba Buoy Base
Chiba, Japan

By: John C. Daidola

CHIBA BUOY BASE AND TOKYO HARBOR

EXHIBITS AND PHOTOGRAPHS

EXHIBITS

1. Map of Tokyo Harbor area

2. Paint Specifications

PHOTOS

Buoy Base:

1. Top foam filled GRP unlighted can buoy.

2. Foam filled GRP can buoy.

3. Can and nun steel unlighted buoys. Maintenance shed in background.

4. Nun steel unlighted buoy.

5. Large offshore buoy for largest wave generator.

6. East end of buoy yard.

7. Southeast end of buoy yard showing maintenance shed.

8. Topmark and Solar Panel rack.

9. Wave generator and hatch securing arrangement.

TOKYO HARBOR

10. Unlighted tributary channel marker.

11. Articulated light tower in construction area. Believe these are of Ryokusesha Corp. design and manufacture.

12. Articulated light tower marking main channel.

13. Articulated towers marking congested construction site area.

14. Top of articulated tower.

15. Lighted buoy in harbor. Note topmark. This buoy fitted with a spray paint marking system.

16. Lighted buoy. As per 15.

A.1.7.2

(THIS PAGE INTENTIONALLY LEFT BLANK)

SUMMARY NOTES FROM INTERVIEW

MINISTERIE VAN VERKEER EN WATERSTAAT

DIRECTORAAT - GENERAAL SCHEEPVAART EN MARITIEME ZAKEN (DGSM)

SCHEVENINGEN, THE NETHERLANDS

PERSONS INTERVIEWED:

Mr. G.H. van der Ent
Head, Traffic Safety
Department

Mr. Hoekstra
Marine Signalling
Department

ing. A. Verbaan
Hoofd afdeling
Planning & Coordinateie
Vaarwegmarking

ing. J.W. Ockhorst
Senior Engineer
Department of Aids
of Navigation and
Logistics

Mr. A.P. Valstar
Traffic Safety
Department

SUMMARY

- The DGSM, Ministry of Transport and Public Works, Directorate-General Shipping and Maritime Affairs, is responsible for the Safety of Waterborne traffic throughout the Netherlands. This includes the North Sea and all inland waters.

- They have two buoy designs of their own which have been improved over the years and are used for all sea, estuary, river and wide inland waterway locations. These are their $12^{1/2}$ m^3 buoys and $6^{1/2}$ m^3 buoys. These buoys have interchangeable day and topmarks.

- There are approximately 800 light buoys of the $12^{1/2}$ m^3 and $6^{1/2}$ m^3 variety, 300 in the open sea and the remainder in estuaries.

- There are approximately 2500 unlighted buoys. These are located in less important waterways, occasionally supplemented with small light buoys. Floating pillar beacons are used in shallow water.

- The configuration of the smaller buoys is given in IALA papers. Those of the $12^{1/2}$ m^3 and $6^{1/2}$ m^3 buoys are included in the Exhibits.

- Buoys are utilized for up to 20-30 meter water depth and 2 knot current maximum.

- They have had the company All Marine design an ice buoy for them. It has been in place for two years but there has been no ice during this period. See the All Marine summaries for details.

- They have retained steel buoys and have utilized some smaller plastic buoys for inland waters. They are now doing some tests of a polyethylene foam filled buoy of their own design.

- Their buoy hulls may last 50 years. Shape significance is achieved with an open slat type structure of wood or plastic like Trinity House in England uses.

- They are solarizing their buoys. Have plans to change 50 buoys per year to solar panels. Each will have four panels which have a 10 year guaranteed life and 6 Delco 2000 batteries of 150 amp hours guaranteed for 5 years. 100 buoys have been completed to date.

- Their buoys have a central battery pocket.

- Their buoys have no horns or whistles. Light vessels and platforms have these.

- The most significant problems are not specifically with the buoys themselves. They are:

  - Mari-culture growth on the buoy hull in certain shallow water areas where anti-fouling paint is prohibited.

  - Removing and destroying about 5000 long-life dry batteries yearly. It is expected that due to increasing environmental considerations the cost of this will become increasingly unacceptable in the future.

- Damage to buoys by collision is not a problem for them in terms of cost. They can tell who damaged the buoy since most ships have pilots and there are water police. The insurance company then pays. A surveyor inspects and determines cost. Usually damage ranges from 10,000.- 50,000. Guilders.

- Their two newest buoy tenders are a 45 meter long vessel with a 9 man crew and an aft buoy deck (The ROTTERDAM) and a 38 meter vessel with a 6 man crew and forward buoy deck. See the Exhibits for photographs. A complete listing of vessels used for tending aids to navigation is given in Exhibit 9.

A.1.8

- The newest is the 45 meter vessel. The design specification was prepared by the DGSM. It has bow and stern thrusters and a dynamic positioning system.

- They believe that steel buoys have proven their reliability and should be continued for open sea and dense traffic areas. Synthetic material buoys can be used for other applications.

- The Netherlands consider the improvement of the safety of navigation on the North Sea in relation with the coherence of the total system, including Short range aids, Radio Navigation Systems (RNS) and RACONS, rather than by improvement of individual components. Using a coherent approach to the whole system may make it possible to reduce the total number of markings by a large extent without degrading the capability. The results of a study on this is to be presented at the IALA '90 meeting. They now have a definite proposed plan to change navigation aids to suit the intended navigation. This will require ratification by other North Sea countries. They believe a reduction in sea buoys by $^{1}/_{3}$ can be achieved, including those set for oil company platforms and for marking subsea standpipes.

Interview Conducted: March 8, 1990
At: DGSM
Schaveningen, The Netherlands

By: John C. Daidola

DGSM

EXHIBITS

1. Completed Questionnaire, 28 February 1990.
2. Data and Sketches for $12^{1/2}$ m^3 light buoy.
3. Data and Sketches for $6^{1/2}$ m^3 light buoy.
4. Buoy Tender ROTTERDAM (45m) underway.
5. Buoy Tender ROTTERDAM (45m) underway.
6. Buoy Tender NIEUWE DIEP (30m) underway.
7. ROTTERDAM hauling a steel light buoy.
8. NIEWE DIEP hauling a plastic buoy.
9. Aids to Navigation-Tenders, DGSM - The Netherlands

A.1.8

(THIS PAGE INTENTIONALLY LEFT BLANK)

SUMMARY NOTES FROM INTERVIEW

NORWEGIAN COAST DIRECTORATE (NCD)

(KYSTDIREKTORATET)

OSLO, NORWAY

PERSONS INTERVIEWED: CDR. Svein Ording (R)
CDR. Eirik I. Sire (R)

SUMMARY:

CDR Ording is the Director of the Norwegian Harbor, Lighthouse, and Pilotage Service.

CDR. Sire is the Head of Aids to Navigation Division of the Directorate.

Through previous correspondence, CDR Ording had already sent a response to the Interview Questionnaire. The filled-out questionnaire is attached, (Exhibit #1).

The discussions that took place during the interview are summarized below at random and as recorded:

- Norway is trying to get rid of floating navigation buoys. Norwegian waters are nearly all shoal, and most areas are less than 10 meters deep. Due to this particular coast configuration, NCD marks most fairways with fixed lighted and unlighted aids in addition to sector lights.

- The use of sector lights has been highly developed in Norway. NCD states that they have been able to operate a cheap and effective lighting system of their waterways. (A chart was provided, Exhibit #2, which shows a typical sector lighting situation along the Norwegian Coast).

- Norway had been using fixed lights since the 1890's. There are currently about 15,000 fixed and only 2,200 floating aids to navigation. There are a total of only 120 lighted buoys 110 of which are stationed in areas with less than 10 meters water depth and they too will soon be replaced with fixed lights.

- Solarization of fixed lights, instead of using oil or gas, has been initiated this year.

- Solarization has been directed to fixed lights; no floating buoys have yet been solarized.

- Mr. Sire has prepared a paper in 1989 which describes the approach to substituting fixed aids in place of floating aids. A copy of the paper was made available and is attached (Exhibit 3). This paper was based on the results of an earlier study, the report for which (in Norwegian) is also attached as Exhibit 4. In summary, Exhibit 3 discusses the history of developments with regard to fixed lights, reports on the advantages and economics of this system and concludes that, by the use of this system, they will be able to eliminate two buoy tenders, thus saving 10 million Norwegian Krones (NK) per year in operating costs only, exclusive of the tender replacements. Already, the original number of 5 large buoy tenders has been reduced to 3, and one more will be out of service in the near future.

- In general, floating buoys are cheaper to build, but the tender and maintenance costs are high.

- In Norway, sound buoys are being phased out; no new equipment is purchased for sound buoys. Instead of sound buoys, RACON's are being installed on fixed shore lights. Of course, for small boats which have no receiving equipment, RACON's are of no use, and the problem still remains for such craft.

- The buoy servicing and maintenance is done on the buoy tenders. If any major repairs become necessary, then these are accomplished at private commercial yards. The Coast Directorate also has 3 service facilities but no permanent manpower exists for these facilities.

- The three buoy tenders currently in service are of 44 meters length with a lifting capacity of 12 tons. They have a crew of only 9 and their operating costs are about 8 million NK per year excluding depreciation. When the 2 million NK depreciation is added, the operating costs become 10 million NK per year.

- Of the approximately 2,200 floating aids to navigation in Norway, more than 2,000 are unlighted buoys. Unlighted buoys are mostly made of GRP. Only 20%, i.e. approximately 400, are steel buoys.

- Of the lighted buoys, most are made of steel; there are only about 20 lighted buoys made of GRP.

- Some aluminum buoys were tried, but not very successfully. When used as buoy hull material, aluminum alloys did not provide as good a service life as plastic buoys. The steel chain used with the aluminum buoys caused electrolytic action.

- Exhibit 5 is a report, in Norwegian, summarizing the status of Norwegian ATON facilities from the early 1900's through 1989. "BILAG 2" on page 19 of this report lists the fixed navigation lights and lighted beacons and is reproduced in Table 1 on the following page. As seen, there were a total of 111 lighthouses, 1889 fixed lights, and 1939 lighted beacons in Norway in 1988.

- "BILAG 3" of the aforementioned report, reproduced in Table 2, lists the numbers of fixed navigation marks and floating marks in service in Norway to 1988. The number of fixed marks then was 13,420, but as of today it is approximately 15,000. The number of floating aids were 1,995 in that year, but today is over 2,000.

- Norwegian buoys are built for a service life of 20 to 25 years. However, in actual usage, only about 100 new buoys are being purchased per year to maintain the number after losses. The real service life is closer to 30 years.

- The standard Norwegian buoys are as shown in Exhibits 6 and 7, attached. Exhibit 6 is a Coast Directorate sketch showing the lighted steel buoys. Exhibit 7 shows the plastic buoys manufactured by TICON-Plast. The steel buoys are manufactured by local workshops. Norway also uses spar buoys made of GRP and polyethylene.

- The costs for typical standard buoys shown in Exhibit 7 are as follows:

  No. 5 = 4.30 m long x 0.42 m diameter Rigid Plastic Unlighted Spar = 6,000 NK.

  Nos. 7 & 8 = 6.10 x 0.58 and 5.00 x 0.80 Rigid Plastic Lighted Spars = approximately 30,000 NK.

  No. 26B = 5.60 x 1.00 Resilient Plastic Lighted Spar with Topmark = 50,000 NK.

- The last spar shown above, No. 26B, is not used in Norway. Especially on lighted buoys, topmarks are never used.

NOTES FROM VISIT TO AND SHORT CRUISE ON BUOY TENDER "VILLA"

The Norwegian Buoy Tender M/V VILLA was visited when berthed in Moss approximately 60 km south of Oslo; a 3-hour cruise was attended, during which the VILLA proceeded further south along the coast and replaced a spar buoy which was reported off-station by mariners. The off-station buoy was picked up, separated from its mooring and a new buoy from the tender's stock was connected to the mooring after correctly locating the sinker. The salvaged buoy was brought alongside the tender (see Photo A in Exhibit 8), lifted aboard the tender's deck (photo B), scraped clean (photo C), and finish-cleaned with high-pressure water spray (photo D).

It was explained by the tender's crew and Mr. Sire that servicing of buoys including painting, scraping, changing lights are all done on site. Chain maintenance is done every 1 or 2 years on buoys located in open sea areas, but once in up to 10 years on buoys located in protected waters. The most frequent damage experienced is to the mooring system such as ice cutting the chain. Three years ago 180 marks were damaged in one season due to heavy ice. There were no buoy losses this year (the winter of 1989/1990) but on the average, with normal ice, buoy losses range between 40 and 50 per year.

The current availability of floating marks in this district is about 95%, which is not good. The availability should be better than 99%. The district is responsible for about 1,000 buoys out of which only about 40 are lighted buoys. They have nearly 200 spar buoys of Finnish manufacture. The radar reflectors used on the Finnish spars are especially good.

Interview conducted: March 19, 1990
at: The Norwegian Coast Directorate
and aboard M/V VILLA off Moss, Norway
by: Nedret S. Basar

(THIS PAGE INTENTIONALLY LEFT BLANK)

SUMMARY NOTES FROM INTERVIEW

INTERNATIONAL ASSOCIATION OF LIGHTHOUSE AUTHORITIES (IALA)

PERSON INTERVIEWED: Mr. Norman F. Matthews
Secretary General

SUMMARY

- IALA was started in 1890.

- The United States, the Commandant, U.S. Coast Guard is a type A member of IALA and fully subscribes to its determinations. The IALA Maritime Buoyage System provide a single set of rules which apply world-wide to all fixed and floating marks, lightships and large navigational buoys. The recommendations provide for the world to be divided into two buoyage regions: Region A where the surface and light colors of lateral washes are green to starboard on approaching a harbor river, estuary or other waterway from seaward and red to port; and Region B where red color is to starboard and green color to port. In all other respects the recommendations are identical for both regions, which are very well detailed (the U.S. in the Region B).

- Although the recommendations of the IALA Maritime Buoyage System were not agreed to in their final form until November 1980 in Tokyo, many administrations had already begun to implement the new system in their waters as early as mid 1977. By the beginning of 1982, large areas of the world's coastal waters had been completely converted to the new system.

- Within the IALA Buoy System there are 5 types of marks which may be used in any combination. The marine can readily distinguish between these marks by the shape and surface colors or at night by the color and rhythm of the light. An administration can choose whether it wishes to make use of all or only some of the 5 types available. The choice will depend upon the configuration of the coastline, the type of sea bed, depth of water and type of traffic.

- The first aim of IALA is to meet the needs of the mariner, by providing aids to navigation that will enable him to fix his position reliably warn him of dangers and ensure his safety. Therefore, economy can be practiced but these requirements must be met. On the other hand and as a general statement, it can be said that well-constructed, simple equipment, carefully maintained, can often be more valuable to the mariner than sophisticated equipment operating badly.

- IALA carries on a yearly survey of the numbers of buoys its members have Exhibits 5 and 9 contain these for the years 1988 and 1987 respectfully. Besides the U.S. and Canada, Norway has a large number of buoys.

A.1.10

- The perception as to the U.S. move into GRP buoys was that in 1965 they were trying to convert the rest of the world, in 1970 they were still high on it, in 1975 not so sure, and in 1980 they were back to steel. This full cycle has been the same for a number of countries.

- Aluminum was tried as a buoy material in France and was a failure.

- Trinity House in England developed a boat buoy for fast water. Pharos, the largest manufacturer of buoys in the world, has developed a catamaran buoy for fast water.

- Multi-purpose vessels as buoys tenders are not specifically as good as dedicated buoy tenders.

- The U.S. has opted not to use the Cardinal buoys. These are a very useful tool although not always popular with pleasure boaters who are more partial to explicitly marked channels. Cardinal marks are particularly useful for making offshore dangers of dangerous obstructions of significant size, e.g. sandbanks, rocks, or wrecks. They are also very useful for marking route in areas where the direction of buoyage cannot easily be defined. The latest System of buoyage depends on direction, and since the cardinal mark has SWNE designation it can give a better description.

- European countries and Japan had to rationalize using cardinal marks and they found there is a cost savings. This was due to a need for fewer buoys. As an example, telling a mariner to stay to the north for example was sufficient whereas working the spot with two buoys was not necessary.

- Canada has a fast water buoy under development to be available at the end of 1989.

- Exhibits 3 and 4 give the latest recommendations for lights and retro reflective material.

- USCG had dropped consideration of Vessel Traffic System (VTS) but with the EXXON Valdez this has re-gained consideration. VTS has a high profile in IALA.

- Canada has extensive VTS including remote areas where ship traffic is infrequent. They shift operators from place to place to keep them from becoming bored.

- With VTS systems fewer aids to navigation are necessary since mariners have another means to keep them in position.

- VTS does not replace the pilot. It is an aid for the pilot.

- In future buoys will be used more for vision than for signalling because of electronics. Therefore smaller buoys may be possible.

A.1.10

- Finland has a 5 to 10 year plan to remove buoys and replace them by fixed marks in rivers that don't change course. As a note the Mississippi constantly changes course.

- The Suez Canal may go to buoys since the periodic dredging required in the Canal requires the markers to be moved.

- Norway and Finland have rocky bottoms and ice problems. They have found fixed marks work better in these conditions.

- MR&S was extended an invitation to attend the 1990 IALA meeting.

Interview conducted: March 13, 1990
At: IALA Headquarters
Paris, France
By: John C. Daidola

(THIS PAGE INTENTIONALLY LEFT BLANK)

SUMMARY OF INTERVIEW
ORRAIDS, LTD.
PRESCOTT, ONTARIO, CANADA

PERSON INTERVIEWED: Mr. Ron Bryenton, Technical Manager
Also Present: Mr. Reiner Silberhorn (CCG)

Summary

- ORRAIDS is essentially a consulting and marketing firm. They offer buoys manufactured in Europe from sources such as Balmoral in Aberdeen, Pharos Marine etc. They are exclusive agents (in Canada) for Pharos Marine. They also have buoys manufactured in Canada by a small machine shop (Prescott Machine and Welding Co.).

- The buoys manufactured in Prescott are fast water buoys. CCG Base Prescott is currently experimenting with these buoys. The results obtained so far are favorable. They have withstood 10 knot currents. Some of the buoys are currently in use in Quebec with good results. Mr. Bryenton gave MR&S copies of sketches and photographs of these buoys.

- The Canadian Coast Guard's experience with these buoys is that they are good but difficult to handle..

- These fast water buoys will be deployed in a project in the Niagara Falls region. They are not yet deployed, however, since the project is not yet completed.

- Mr. Bryenton had earlier worked for Pharos Marine in England where he was involved in buoy designs. The fast water buoys now being manufactured in Canada are basically of the original British design.

- Mr. David Harris of Pharos Marine in England is a very knowledgeable and experienced buoy designer. Mr. Bryenton suggested that MR&S, when in England, should contact Mr. Harris.

- He also recommended that we write to Vega Industries of New Zealand. They are designers and manufacturers of lighted navigational aids.

Interviewer: N. Basar
Date: February 14, 1990

SUMMARY NOTES FROM INTERVIEW
MIL SYSTEMS ENGINEERING, LTD.
OTTAWA, ONTARIO, CANADA

PERSONS INTERVIEWED: Mr. Robert MacLaren
(General Manager, Advanced Eng.)

Mr. Adil Ozdemir
(Project Engineer)

Summary

- MIL System Engineering Ltd. (MSEL) is currently conducting a study for the Canadian Coast Guard (CCG) under Mr. Reiner Silberhorn's guidance. A draft report for the first phase of the study has just been submitted to CCG, and MSEL is now awaiting comments.
- The study involves revising and updating drawings for standard CCG buoys, developing design and operational requirements criteria, and preparing a design manual.
- The study will probably be completed by the end of March 1990. MSEL suggested that MR&S contact Mr. Silberhorn of the CCG to obtain a copy of their final report.
- Mr. Ozdemir made following general remarks about buoy technology (as recorded):
  - Ice build-up on buoy hulls and cages may create a stability problem.
  - Large buoys do not get lost in Canada. Not one loss was recorded in the last 70 years. Accordingly, MSEL does not think that further compartmentation of buoy hulls is necessary.
  - Rubber buoys manufactured by Seaward International Inc. (of USA) are in use in Canada. Seaward is in Falls Church, VA, and their telephone number is (703) 534-3500.
  - They also know of sinkable/retrievable buoys of British design which they suggested MR&S could follow-up.
  - MSEL recommended Mr. Dave Smith in the Dartmouth, NS Coast Guard Base for a possible interview candidate.

Interviewer: M. Basar
Date: February 15, 1990

SUMMARY NOTES FROM TELEPHONE INTERVIEW
KWH PIPE (CANADA) LTD.
MISSISAUGA, ONTARIO, CANADA

PERSON INTERVIEWED: Mr. Pekka Maukola, President

Summary

- KWH PIPE (CANADA) LTD. (KWH) is the Canadian Subsidiary of KWH PIPE of Finland who are the well known buoy designers and manufacturers previously known by the name of WIIK & HOGLUND. They have recently changed the company name to KWH PIPE.

- Mr. Maukola said that they do not manufacture buoys in Canada. All manufacturing is done in Finland at the KWH Pipe plant in Vaasa. For this reason he recommended that if MR&S is to visit Finland, KWH Pipe should definitely be one of the stops. When told that the interviewer would visit Finland sometime in March, Mr. Maukola offered to telefax a message to Mr. Ralph Stoor (who he said is the person we should interview) to ask their cooperation.

- Mr. Maukola also said that he would have our questionnaire completed and sent to us along with some brochures for KWH buoys.

Interviewer: N. Basar
Date: February 15, 1990

Note

Later, the following were received from KWH Pipe Canada:

- Completed Questionnaire (dated Feb. 16, 1990)
- Brochures:
  - The Plastic Spar Buoy
  - WH Aids to Marine Navigation
- Drawing No. 3Q 1271-10 "WH Buoys 500 and 1000"
- Copy of Telefax message to Mr. R. Stoor dated Feb. 15, 1990.

SUMMARY NOTES FROM INTERVIEW
GEORGETOWN SHIPYARD, INC.
GEORGETOWN, PRINCE EDWARD ISLAND, CANADA

PERSONS INTERVIEWED: Mr. Fred McConnell-Technical Manager
Mr. Tom Green-Marketing
Mr. John Perry-Production

SUMMARY
General

Georgetown Shipyard had just completed the construction and shipment of some all steel and all aluminum buoys for the Canadian Coast Guard. They did not have any buoys under construction or still in the shipyard at the time of the interview visit. They are presently preparing a proposal for an upcoming series of buoys for the Dartmouth CG Base.

Discussions (as recorded)

- o Some of the buoys manufactured at GS were all steel 4'-6" dia. lighted river buoys. They had internal concrete counterweights. Some others were 9'-6" dia. "Gas and Bell" and "Gas and Whistle" buoys with cast iron counterweights.

- o The manufactured buoy hulls are delivered to the Coast Guard with only the prime coating applied. The final painting and outfitting are accomplished at the CG Base.

- o A copy of the specifications to which they had worked was made available to MR&S. These specs are entitled "Specification for Buoys for Aids to Navigation" dated February 1988 by CCG Maritimes Region Navigational Aids Division in Dartmouth, Nova Scotia.

- o Drawings to which the buoys were constructed were reviewed jointly with Mr. Perry. It was suggested that copies of these detail drawings could be requested from the CCG Headquarters in Ottawa.

- o Mr. Green offered to send MR&S copies of photographs of recently completed buoys.

- o Mr. McConnell promised to complete and mail to MR&S the survey questionnaire which was left with him.

Interviewer: Y. Basar
Date: February 16, 1990

SUMMARY NOTES FROM INTERVIEW
FAIRVIEW INDUSTRIES, LTD.
HALIFAX, NOVA SCOTIA, CANADA

PERSON INTERVIEWED: Mr. James Whiteway
Technical Manager

General

Fairview Industries, Ltd. (FIL) is essentially a steel and aluminum fabrication shop. They had however manufactured steel and aluminum buoys for the Canadian Coast Guard (and other customers) in 1988 and in July and October 1989. There were no buoys in the shop at the time of the interview visit.

Summary

- FIL had built 30 buoys in October 1989. They were can and conical type steel buoys and aluminum discus buoys for the Canadian CG.
- Also for the CCG, they had built twelve 2.9 meter diameter steel buoys about 1 1/2 years ago.
- In July 1989, they had constructed data buoys for the Canadian Department of Fisheries and Environment.
- The specification they have worked to was numbered AQUP-146 (Mr. Whiteway suggested that we could obtain a copy from the CCG HQ in Ottawa).
- The following random comments were offered by Mr. Whiteway:
  - The design of the aluminum discus buoy is, in his opinion, an overkill.
  - The coatings applied on buoy hulls consist of vinyl primer, zinc chromate, coal tar epoxy. Also used is alkalide color (trade name "Blue Shield"). For protection against fading BAR RUST 235 is applied. Anti-fouling coating is epoxy based.
  - Fairway Ind. is equipped with all types of steel and aluminum fabrication and welding equipment as well as blasting/painting and testing facilities.
  - FIL is currently preparing a proposal in response to a CCG solicitation for a new series of buoys to be awarded to a Maritimes manufacturer by the Dartmouth Base.
- A copy of MR&S Survey Questionnaire was left with Mr. Whiteway for completion and forwarding later.

Interviewer: N. Basar
Date: February 16, 1990

SUMMARY NOTES OF INTERVIEW

ELECTRONIC SUPPLY COMPANY

COPENHAGEN, DENMARK

PERSON INTERVIEWED: Mr. Claus Jacobsen
Managing Director

SUMMARY

- The Electronics Supply Company is developing a wave generator than can operate in 30 cm wave heights as the wave heights around Denmark are only in the order of one meter.

- The low wave height makes other wave turbines like those manufactured in Japan unsuitable.

- A prototype of a buoy fitted with a prototype of this new type of wave powered generator was the subject of the IALA '90 Conference paper 3.6.7, "The Integrated Modular Buoy (Development of a New Light Buoy & Data Acquisition Platform)."

- The generator is driven by the acceleration of the buoy caused by wave action. It is a completely mechanical device with no exposure to sea water, thereby being exempt from marine growth build-up, fouling and corrosion.

- The anticipated maintenance interval for this new wave powered generator is expected to be 3 years, when internal springs and bearings may need to be replaced.

Interview Conducted: June, 1990
At: IALA '90 Conference
Veldhoven, The Netherlands

By: John C. Daidola

SUMMARY NOTES FROM INTERVIEW

BALMORAL NAV-AIDS

ABERDEEN, SCOTLAND

PERSONS INTERVIEWED:

Mr. David Robertson
Group Naval Architect
Balmoral Group Ltd.

Mr. Doug G. Marr
Sales Manager
Balmoral Nav-Aids

SUMMARY

- Balmoral was not actually visited during MR&S Surveys. However, discussions with their personnel noted above took pace during the IALA '90 Conference in Veldhoven, The Netherlands.

- Balmoral is an industrial member of IALA.

- Balmoral manufactures a range of plastic navigation buoys in sizes from one to five meters in diameter.

- Their navigation buoys had traditionally been constructed of foam filled GRP. Their newest buoys are of foam with a Balthane Elastomer exterior.

- Balmoral originally developed the elastomer/foam buoy in response to the needs in the harsh environment of the North Sea Oil fields.

- They believe the operational cost of buoys is drastically reduced with the elastomer/foam concept in that they will survive high impact force without sustaining deformation or damage, require minimum maintenance, no expensive paint treatment or welding repairs.

- They believe the foam/elastomer is the material of the future. The first anchor buoys they made of this material for the North Sea are now 10 years old. The lighted 2.5 meter diameter special marks shown on page 7 of Exhibit 1 has been in place in Turkey for 5 years and is like new.

- Cost of the foam/elastomer is comparable to steel in Europe but not to steel construction in "third world countries". Material for foam/elastomer buoys are Balmoral's development and can only be constructed at their facilities in the U.K.

- Balmoral believes life cycle cost of foam/elastomers should be much better than steel.

- Foam/elastomer buoys are lower in weight than steel and additional weight must be added to achieve a working waterline.

- Foam buoys with elastomer exterior (sprayed on 3/8" thick) hold a lot of promise. They have already replaced some large steel sea buoys up to approximately 10ft. in diameter with these.

- Motion characteristics of synthetic buoys have been equilibrated to those of steel buoys by matching the GMs. Weights have been added accordingly.

- Generally speaking funds are not available for motion studies of buoys, which are too expensive.

Interview Conducted: June 27, 1990
At: IALA 90
Veldhoven, The Netherlands
By: John C. Daidola

BALMORAL NAV-AIDS

EXHIBITS

1. Catalogue of Nav-Aids
2. Balmoral Group News, Issue 6, Spring '90
3. Balmoral Marine Equipment
4. Balmoral Group - A Corporate Profile
5. Balmoral Nav-Aids: Brochure

SUMMARY NOTES OF INFORMATION OBTAINED

REINFORCED PLASTIC STRUCTURES (LEWES) LTD.

LANCING, ENGLAND

PERSON INTERVIEWED: NONE

SUMMARY

- Reinforced Plastic Structures (Lewes) Ltd. was introduced by the Gloucester Harbor Trustees. There was no direct contact with them.
- They manufacture a variety of marking and navigation buoys of foam filled glass reinforced plastic.
- Their Class II navigation buoys have hull diameters of 9ft. Their support buoys for anti pollution oil booms have diameters of 15ft.

EXHIBITS

1. Buoys in Glass Fibre by Reinforced Plastic Structures (Lewes) Ltd.

SUMMARY NOTES FROM INTERVIEW

PHAROS MARINE

BRENTFORD, ENGLAND

PERSON INTERVIEWED: NONE

SUMMARY

o Although an interview could not be arranged, Pharos products were presented by Automatic Power, Inc. during the U.S. Surveys. See the U.S. Section of this report for details.

SUMMARY NOTES FROM INTERVIEW

MIDAR (MARINE SYSTEMS) LTD.

LONDON ENGLAND

PERSON INTERVIEWED: Vice - Admiral Sir Ian McGeoch

SUMMARY

- Midar is an acronym for "microwave identification data automatic response." It is an add-on secondary radar system designed to give an identity to a "radar blip". The system consists of an interrogator and receiver/transponder which automatically transmits a response indicating a unique identity. Although this system was originally developed for identification of a ship by a ship it could also be applied to identification of a navigational buoy by a ship.

- Midar believes that the general system of lights and buoyage can be improved and the number of marks reduced by the two following implementations:

  1. Enhanced radar conspicuity though better reflectors. Believes Firdell Multiflectors Limited can be help in this area.

  2. Fitting of every mark with an identification transponder known to mariners and which can be selectively interrogated by radar. The Midar system could accomplish this.

- With the Midar system a Midar transponder would be mounted on the buoy. The ship would have a Midar interrogator connected to its general radar.

- Midar believes that radar and satellite systems are here to stay so that a buoy system tailored to radar should be useful into the foreseeable future. In such a system buoys would be set for the best radar navigation rather than navigation by sight.

- Racons of various kinds, and ramarks, D/F stations and "VHF lighthouses" have inherent limitations which diminish their potential for universal use. Racons are not so good for they blot out other radar signals and with two or more the screen is completely confused.

- Buoys marking hazard areas are essential and would be made non-selective, i.e. they would respond to any radar.

- For other buoys (non hazard) it seems reasonable to Midar to equip them with a selective radar signal so that the navigator can interrogate to find the one he is looking for.

A.2.3.4

- Sperry has a system similar to Midar: Marine Interrogator Responder System.
- Firdell radar reflectors have been sold to Trinity House and possibly the UCSG.
- Solar power is acceptable for powering Midar's system.
- Currently they only have a prototype system which measures 400 mm x 500 mm x 210 mm and weighs 40 kg. This has been tested at a lifeboat station on the Isle of Wight. It has been working perfectly for about 3 months. Cost about $30k. In a quantity of 200 could be reduced to $15k. Presumably a smaller less expensive system could be devised.
- The Midar approach has been discussed at IALA in the working group on Identification.
- IALA has not tested Midar. They tried ADAR: Automatic Data Acquisition Radar. This requires ship position data to be transmitted to shore stations. Would be very expensive to develop.

Interview Conducted: March 7, 1990
At: London, England
By: John C. Daidola

MIDAR

EXHIBITS

1. Midar - A new system which takes the guesswork out of radar interpretation.
2. Identification - The Missing Link, January 1985 "Seaways" (a publication of the Nautical Institute and provided by them).
3. Firdell, Catalogue of Radar Reflectors for Buoyage and Beacon Systems with Performance Notes, Firdell Multiflectors Limited (See Firdell File).

SUMMARY NOTES FROM INTERVIEW

NAUTICAL INSTITUTE

LONDON ENGLAND

PERSON INTERVIEWED: Mr. Michael Plummridge

SUMMARY

- o The Nautical Institute is an independent international professional body for qualified mariners whose principal aim is to encourage a high standard of knowledge, competence and qualification amongst those in control of seagoing craft. The Institute is a registered charity and is directed by a Council of whom the majority must by actively employed at sea. The Institute publishes a monthly journal, 'Seaways", which has a circulation of 5,000 in 70 countries.

- o In the past The Nautical Institute has been asked by IALA to input as to the requirements for aids to navigation devised by its members, the mariners.

- o Papers appearing in Institute publications have indicated:

  - Buoys work well
  - Fog signals are not required
  - Future navigation systems could consist of only fairway buoys with Racons.
  - Satellite navigation will supersede the need for buoys
  - Install transponders on ships and buoys to identify them.

- o The British Hydrographer in Tornton keeps track of buoys that have been reported out of position. This phone 08-23-33-7900, Navigation Warnings Department.

Interview Conducted: March 5, 1990
At: Nautical Institute
London, England
By: John C. Daidola

A.2.3.5

NAUTICAL INSTITUTE

EXHIBITS

1. Identification - The Missing Link, January 1985 "Seaways", Nautical Institute (see Midar (Marine Systems) Ltd. File)

2. Nautical Institute Publications

3. The Nautical Institute Plans For The Future

4. SEAWAYS, January, February and March 1990

A.2.3.5

SUMMARY NOTES OF INFORMATION OBTAINED

HIPPO MARINE PRODUCTS

TONEBRIDGE, ENGLAND

PERSON INTERVIEWED (CORRESPONDENCE): John Wickham
Partner

SUMMARY

o HIPPO Marine Products (HMP) was introduced by the Gloucester Harbor Trustees and the Bristol Haven Authority. On October 16, 1990 FAX communication took place between MR&S and HMP.

o An HMP brochure was obtained from the Gloucester Harbor Trustees.

o It appears HMP is primarily involved in the manufacture of mooring and marker buoys, but they have utilized their technology in the manufacture of some navigation buoys. This year they were constructing two 2.5 meters diameter lighted buoys for the Bristol Haven Authority.

o They advertise their buoys have the following characteristics:

- Fabricated using polyurethane elastomer exterior and light weight foam interior.

- Polyurethane Elastomer is extremely hard wearing but resilient.

- The buoy is completely unsinkable unless severely damaged.

- The central trunk to take the chain is of hard wearing polypropylene.

o They originally manufactured GRP buoys. They found the buoys to be satisfactory in calm estuaries, but in the open sea they were stable but too "lively" resulting in an affected visibility of the light due to their motion.

o The only good GRP sea buoy they produced was a 19ft. long spar buoy for the English Channel and North Sea (purpose unknown).

o The polyurethane elastomer is sprayed over polyethylene foam. It has the added advantage of enabling them to tailor a buoy to a custom configuration without making molds for the floatation unit. The foam is fabricated to the required size, hot wire cut into shape, and then sprayed. They have made sea buoys of these by adding a tail tube.

- By counter balancing with extra heavy chain they have created an elastomer/foam lightweight buoy that responds motion-wise as a much larger or heavier buoy, and by using extra heavy chain, the service period of the chain is extended.

- They have provided buoys around the world.

HIPPO MARINE PRODUCTS

EXHIBITS

1. Brochure - Received from Gloucester Harbor Trustees, England.

2. Fax letter with photographs from HMP, 16 October 1990.

SUMMARY NOTES FROM DATA OBTAINED

FIRDELL MULTIFLECTORS LIMITED

LONDON, ENGLAND

PERSON INTERVIEWED: Dr. Steve Bell

SUMMARY

- Firdell was recommended by Midar (Marine System), LTD. as a company that has developed products to improve radar reflectivity.

- Firdell defines an effective radar reflector as one that gives a consistent radar return through a 360° azimuth and through at least plus and minus 20° of heel. The mean "Radar Cross Section" throughout this 360° x 40° band should not be less than 2.5m² and there should be no "gap" in the band more than 10° in azimuth and plus and minus 2° in the vertical.

- Firdell manufactures a number of radar reflectors. From the literature it appears they have used their Blipper 200 and 300 series on floating bouyage. These appear to consist of a reflective structure of aluminum encased in seamless UV-stabilized rotationally molded polyethylene.

- The Blipper 210-7 is 595 x 225 mm and weights 1.8 kg. For an order of over fifty it costs L57.75 each. It has a mean radar Cross Section at 9.4 GHz, 360° x ± 20° of 2.5m².

- The Blipper 300-5 660 x 235 mm weights 3.2 kg. For an order of over fifty it costs L69.20 each. It has a mean radar Cross Section at 9.4 GHz, 360° x ± 20° of 8m².

FIRDELL MULTIFLECTORS LIMITED

EXHIBITS

1. **Catalogue of Radar Reflectors for Buoyage and Beacon Systems with Performance Notes (received from Midar Ltd. and later from Firdell), January 1990. Includes some prices.**
2. **Firdell Tables of Radar Extinction (Fresnel) Zones.**
3. **Radar Reflectors, Firdell.**

A.2.3.7

SUMMARY NOTES FROM DATA

THORN EMI ELECTRONICS LIMITED

WOKING, SURREY, ENGLAND

PERSON INTERVIEWED: John Irving

SUMMARY

- They are involved in delivering high integrity remote monitoring systems for marine applications.
- Their Oceanmaster Data Acquisition System is the latest version of a complete marine weather station which can relay both meteorological and oceanographic data directly by radio to a base station.
- Their Seawatch Databuoy has a diameter of 3 meters. Details are given in Exhibit #1.

THORN EMI ELECTRONICS LIMITED

EXHIBITS

1. Oceanmaster Data Acquisition.

SUMMARY NOTES FROM INTERVIEW

KWH PIPE, LTD.

VAASA, FINLAND

Persons Interviewed: Mr. Jouko Hyttinen
Mr. Keijo Malmberg

Summary

KWH Pipe, Ltd. is a continuation of the well known Wiik & Hoglund Company. Its plant is in Vaasa, Finland approximately 400 miles northwest of Helsinki.

Mr. Hyttinen is a Product Manager/Special Products for KWH and he currently operates out of KWH Pipe's Helsinki Office. Mr. Malmberg is the Plant Production Manager in Vaasa.

The Navigation Aids products by KWH comprise a series of plastic spars and buoys ranging in diameter from 50/110 mm. to 1000 mm. and in length from 3 to 10 meters. Exhibit #1 gives a description of KWH ATON operations and products as well as overall dimensions of the 50/110, 90/160, 160, and 225 mm. diameter spars and 500 and 1000 mm. diameter buoys. Exhibit #2 is a KWH drawing (No. 3Q1271-10B) showing dimensional details of the WH 500 and WH 1000 buoys. In addition, the following brochures were given:

Exhibit #3:	Brochure: "The Pipe Specialist" giving descriptions of KWH Pipe products other than buoys.
Exhibit #4:	Brochure: "Thermotite" describing insulation systems for flowlines.
Exhibit #5:	KWH Group (Parent of KWH Pipe) 1988 Annual Report.

Messrs. Hyttinen and Malmberg took the interviewer through a tour of KWH facilities. The first stop was the extrusion plant. This was a large workshop with more than two dozen extrusion lines of varying capacity. The operation was fully automatic from the supply of raw materials into the ducts through to the end of the extrusion line at which point desired lengths of ready-to-use pipe are cut.

Navigation buoys represent only a very small portion of the production. Most of the pipes produced are for use in underground sewage systems, as pressure pipes for water supply systems, as cable jacketing pipes, as drainage pipes, and for many other industrial operations. Also manufactured are thermostatic pipe insulation materials, piping system valves and fittings, storage tanks, process tanks, and pressure vessels.

The second stop was the Paint Weather Testing Laboratory. Using special equipment, the paint samples are subjected to accelerated testing representing a probable 10 year life or longer, in order to establish their resistance to wear in a salt water environment and ultraviolet rays of sun. The paint systems offered by vendors for use in pigmenting the polyethylene material in buoy manufacture are applied on industrial coupons and tested for a predetermined length of time to correspond to the desired number of years of exposure to actual weather conditions. The equipment, reportedly, does not give an accurate measurement of the durability of paints. However, it provides a dependable tool in comparing the quality and effectiveness of one paint system over another. Furthermore, the predictions with regard to paint system life with this equipment in later tests have been verified to be near correct by actual observation over a number of years of some applications.

The last stop of the tour was the Mechanical/Chemical Testing and Research Laboratory. Several types of test equipment for measuring the physical and mechanical properties of plastic material samples along with specialized mixing and heating instruments used for developing and verifying compositions of plastics were in use.

Photo "A" in Exhibit #6, shows two of the "just completed" Navigation Spar Buoys ready for shipment. In Photo "B", a few of the same type of buoys can be seen in the icy waters of the Vaasa Bay. A red buoy is visible on the right side of the photo and a green one is just off the bow of the boat on the left. Photo "C" shows a number of KWH Spar Buoys in storage at the Helsinki Buoy Depot of the Board of Navigation.

Interview Conducted: March 23, 1990
By: Nedret S. Basar

SUMMARY NOTES FROM INTERVIEW

RENCOMARINE KY
PORVOO, FINLAND

Persons Interviewed: Mr. Raimo Niitynen
Mr. Errki Viljakainen

Summary

Rencomarine (Rencotuote Oy) is a manufacturer of traffic regulating equipment and signs located near Helsinki in Porvoo, Finland. Included in their manufacturing line are signals that are being used by the Finnish Board of Navigation on their lighted buoys and articulated beacons.

Mr. Niitynen is the President of the company and the Manager of the plant in Porvoo. Mr. Viljakainen is the Chief Engineer for design and production.

A briefing was given by Mr. Niitynen which covered the products marketed by Rencomarine:

- Buoy Lanterns of type VP-3, MVP-3
- Range Lights of type LO-1, LO-2
- Round Mark Lanterns of type RV-10, RV-20
- Renpulssi 10-25 Flasher
- Renco Photocell VIC-3
- Photovoltage Power Systems
- Daytime Leading Lights

Rencomarine also manufactures and is currently promoting an innovative micro-processor based flasher with the trade name "Renprocessor 10-28". This flasher can be programmed by the use of a pocket size portable programmer called "Renprogrammer". Exhibit #1 is a copy of the User's Manual for the Renprogrammer and Exhibit #2 describes the characteristics and technical data for Renprocessor 10-28 type flasher.

In Exhibit #3, brief descriptions of the lanterns, range lights and other Renco products are given, and more detailed data is given as follows:

- In Exhibit #4 for LO-1 Range Lights
- In Exhibit #5 for VP-4 Lanterns
- In Exhibit #6 for Photovoltage Power Systems.

Messr. Niitynen and Viljakainen expressed their desire to market their products, especially the lanterns, range lights, and the Renprocessor/Renprogrammer, in the United States.

Interview Conducted: March 22, 1990
By: Nedret S. Basar

(THIS PAGE INTENTIONALLY LEFT BLANK)

SUMMARY NOTES FROM INTERVIEW

GISMAN

PARIS, FRANCE

PERSON INTERVIEWED: Mr. Thierry Houchard
Directeur de L'Exploitation

SUMMARY

o Gisman consists of a group of companies manufacturing a wide variety of products. As a manufacturer of buoys they have delivered all types. Apparently at this time they are not manufacturing any buoys, however. 85% of their buoy business is outside France.

o In a more recent project they were asked to design a buoy for Norwegian waters to mark underwater gas wellheads between Norway and the Shetland Islands. Environmental conditions consisted of 25 meter waves, 115 knot winds and 150 meter water depth. In this design they had a steel body for ruggedness and a GRP tower for reduced maintenance.

o Gisman has access to a computer based mooring response program giving mooring line response. The program can handle articulated beacons.

o In the past Gisman designed and delivered to a client for the Spanish coast a floating beacon for 8 meter wave heights. They guaranteed the metallic structure and the float.

o Gisman has built floating beacons for 20-30 meter water depth. These all have a universal joint at the bottom.

o One of the Gisman group partners is the Nautical Research Institute of France which carries out buoy motion and GRP analyses. This is a semi-governmental organization:

Institut National D'Essais
et de Recordes Nautiques
Inern Rue Didier Bestin
56100 Lorient
France
Attn: Christoff Baley and Mr. Connan
Tel: 97 21 05 93

o In terms of new ideas Gisman had proposed the following buoy for development to the French lighthouse authority. These would replace existing steel offshore buoys:

- Cost of buoy and maintenance operations should be lower than current buoys.

A.2.5.1

- Study various materials and energy-producing devices.

- Standardize 3.5 meter focal plane.

- Maximum weight 5 tons.

- Freeboard 60 cm.

- Draft 2-3 meters.

- Specific motion characteristics designed for sea conditions.

o This project was not pursued by the French authority but data as developed by Gisman was made available. Drawings are on a Company Confidential basis. This buoy has been named the Artémis.

o Gisman believes lack of homogeneity of material has been the problem with GRP buoys.

o They do not believe that the continuity of a light signal (in terms of being seen) is all important unless the light is marking a danger point.

o A second idea presented to the French authority involved a similar buoy with longer roll period and holes at its base. Data on this was also provided on a Company Confidential basis. This buoy has been named the Daphné.

o Buoy ballast used by Gisman is heavy reinforced concrete due to expense of cast iron.

o Gisman believes that GRP is 50% cost of steel for equivalent capability.

o Gisman has several GRP buoys in production. The Delphine comes with a flat bottom or a tail can be added. It is 2.5 meters in diameter including the built-in fender. It comes with various daymarks, topmarks and signaling devices. The 1.4 m diameter Marina buoy is similar and is intended for beaconing channels and port entrances. The Delphine is about 15,000 Francs for tail or skirt type w/o signalling devices.

o The French lighthouse authority has 30 of the Delphine type buoys along the French coast. These replaced larger steel buoys.

o 60% of the world buoy business belongs to Pharos and 10% to Automatic Power.

Interview conducted: March 13, 1990
At: Gisman
Paris, France
By: John C. Daidola

GISMAN

EXHIBITS

1. Description and photos of the buoy "Delphine".

2. Description of the "Marina" buoy.

3. Description of the "Artémis" buoy, Company Confidential.

4. Desirable characteristics of a buoy.

5. Description of the "Daphné" buoy, Company Confidential.

6. Drawing of the "Artémis" buoy, Company Confidential.

7. Drawing of the "Daphné" buoy, Company Confidential.

(THIS PAGE INTENTIONALLY LEFT BLANK)

SUMMARY NOTES FROM INTERVIEW

PINTSCH BAMAG GmbH

DINSLAKEN, WEST GERMANY (FRG)

PERSON INTERVIEWED: Mr. Gerd Wiehe

SUMMARY

Mr. Wieh· is the Sales Engineer for the Aids to Navigation Department of Pintsch Bamag (PB) which is known as one of the world's leading manufacturers of Navigation aids. The following are notes recorded during the interview.

- PB currently manufactures marine lanterns, headlights, range lights, rotary beacons and road traffic engineering equipment in its plant in Dinslaken. Previously, steel navigation buoys were handled in this plant. However, the buoy operations have now been transferred to PB's Netherlands operation (STROMAG) in Katwijk.

- In meeting West Germany's domestic aid to navigation requirements, PB in the past offered complete buoy systems witn firms like Compass GmbH preparing the design and F. Hebold GmbH constructing the steel buoy hulls. These years, however, PB has not supplied any buoys to the German Ministry of Transport. They still offer complete buoy systems to the international market but have the hulls built in the Netherlands or in England.

- In West Germany, a branch of the Transport Ministry called "Seezeichenversuchsfeld" (SZVF) in Koblenz manufactures small buoys for rivers. SZVF is, however, responsible for the designs and modifications of, as well as research and development on, all aid to navigation buoys. In procuring the buoys, SZVF may (and does) specify PB equipment and award the buoy construction contracts to private manufacturers on the basis of competitive bids.

- SZVF also uses some plastic buoys but in general the plastic buoys are not well liked in Germany because of their relative weakness as far as ice resistance is concerned.

- PB also manufactures gas lanterns since in Germany, especially in the North Sea and in the Baltic, only gas-powered lighted buoys are used. Gas- burning marine lanterns are very economical to use. They keep burning day and night, and a 200 kg. barrel of liquid propane is good for more than a year. The character of the light from propane gas can be and is electronic- ally programmed. PB can also manufacture gas lanterns that use acetylene.

- West Germany's ATON system has two peculiar characters:

  1. Only steel buoys are used.
  2. Only propane gas us used in lighted buoys.

A.2.6.1

The reasons for these, according to Mr. Wiehe, are that the Germans do not trust plastic or GRP buoys and they don't want to fool around with changing batteries every six months or so.

- Pintsch Bamag's electric marine lanterns are preferred by SZVF in combination with glass lenses. They have a wide vertical divergence. The base is made of GRP but it can also be made of cast aluminum. Lenses are acrylic or glass. PB does not manufacture lenses. For the most popular 155-mm. diameter lantern, PB uses a lens manufactured by Automatic Power (Pharos). For the 250-mm. lantern, a lens manufactured by Tideland is used.

- PB makes range lanterns as well. The base is the same for various types; only the top changes.

- Other products made by PB include a 6-bulb automatic lamp changer with programmable flasher and a double filament lamp which has a service lifetime of 1,500 hours. The designer/manufacturer of the double filament lamp is Dr. Fisher, who belongs to the "Phillips" concern and supplies all major buoy firms.

- Mr. Wiehe gave copies of the following brochures/catalogues describing PB products:

  - o Pintsch Bamag "Aids to Navigation"
  - o Pintsch Bamag "Products and Services"
  - o Pintsch Bamag "Gas Operated Marine Lanterns"
  - o Pintsch Bamag "Electric Marine Lanterns, Types EE/55N, EE 155, EE 155S, EE250 and EER 130.
  - o Sector Direction Light Type SLF 138
  - o Marine Rotary Beacon, Type DLL 6-300, DSL 4 and Airport Rotary Beacon Type DL 150.
  - o Pintsch Bamag Solar Powered Systems
  - o Pintsch Bamag Hazard Warning Beacon, WF 220, WF 300 and GF 300.
  - o Solid State Flasher, NK 2000
  - o Standard Steel Light Buoys
  - o Shallow Water Light Buoys Type SW 160E, SW 200E, SW 220E, SW 260E
  - o Mooring of Light Buoys Including Chains, Sinkers, Shackles, etc.
  - o Radar Reflector SR 6-500
  - o PB Acetylene Accumulators and Propane Bottles
  - o Rotating Beacons

Interview conducted: March 27, 1990
in: Dinslaken, W. Germany
by: Nedret S. Basar

A.2.6.1

SUMMARY NOTES FROM INTERVIEW

WEISELER BOJEN UND MASCHINENBAU oHG

WEISEL, WEST GERMANY

Person Interviewed: Mr. Ernst Knecht

SUMMARY:

"Weiselerbojen" is a family-owned small "bicycle shop" type company atop hills on the eastern shore of the river Rhine south of Koblenz in the small town of Weisel.

Mr. Knecht is the proprietor and manager. The firm manufactures steel and plastic inland waterways buoys for the German Federal Waterways Administration in accordance with the drawings and specifications prepared by "Seczeichenversuchsfeld". (Mr. Helmut Kuhlbrodt, who is the Director of SZVF was also present during the interview with Mr. Knecht).

According to information given by both Mr. Kuhlbrodt and by Dr. Hartung at the Federal Transport Ministry during their respective interviews, Weiselerbojen has consistently bid the lowest prices for the construction of steel river buoys during the last 15-20 years. They attributed this to the fact that "Weiselerbojen" (WB) was using a special mold and manufacturing the steel buoys by forming the thin steel plates in presses over the mold in two halves and by welding the two halves with an annular seam.

Upon questioning by the interviewer, Mr. Knecht declined to give any information on this mold except to say that it is a protected patent and that it belongs to another firm who forms the two halves of buoys at its own facility and delivers them to WB ready to weld together. Mr. Knecht said he could not give the name or the location of this other firm. (Mr. Kuhlbrodt confirmed that this is what they had been officially told by WB on earlier occasions upon request by Dr. Hartung).

Mr. Knecht gave some information and a few brochures on the line of packaging machinery that WB also manufactures. He also showed, and upon request gave copies of, the following photographs:

Photo 1: Typical Inland Waterways Buoys (Red and Green)

Photo 2: "Weiselerbojen" Stand in a Recent Industrial Fair Showing a Historical Buoy and Three Different Applications of the Standard Buoy

Mr. Knecht was asked if it was possible to tour the buoy workshop areas. He responded that it was after working hours of the firm and that he would be happy to show us around but that there would not be any employees working.

A.2.6.2

The buoy workshop was an old single building which must have been used, in earlier years, as a barn. It did, however, contain all the necessary facilities to accomplish the following work:

- receipt, quality control and storage of already-formed buoy halves. (Approximately 10 or 12 sets of buoy halves apparently awaiting their turn to be worked on were stored in one part of the workshop.)

- Joining of the two halves by an annular welding seam and welding of the lifting lugs.

- Shot blasting of the complete buoy to clean metal. (There was a self-contained shot blasting machine sufficiently large to hold and shot blast a complete 1,050 mm buoy hull.)

- Foam filling of the buoy interior.

- Outfitting of the buoy in accordance with the specifications (i.e. addition of counterweights, tail-tubes, lanterns, reflectors, etc. if and as required by the specifications.

- Application of various coats of paint as required by the specifications.

The opinion formed by the interviewer and shared by Mr. Kuhlbrodt, as a result of the interview and the tour was that WB was running a very efficient organization with a minimum number of employees, and that the key to its consistent low bidding was this efficiency as well as the "Secret!" mold used in forming the buoy halves.

Interview conducted: March 30, 1990
at: Weisel, West Germany
by: Nedret S. Basar
Accompanied by: Mr. Helmut Kuhlbrodt

A.2.6.2

SUMMARY NOTES FROM INTERVIEW

COMPASS GMBH

KOBLENZ, WEST GERMANY

Person Interviewed: Mr. Gustav Hovermann

SUMMARY:

COMPASS is an engineering consulting organization offering services for engineering and planning of German Maritime Traffic Systems. They are located in Koblenz, within a block of the Seczeichenversuchsfeld. Mr. Hovermann is the Managing Director of the Company.

Currently, about 90% of their work is for foreign concerns, mostly for Saudi Arabia. However, according to Mr. Hovermann, they do work for and with Mr. Kuhlbrodt's organization (Seczeichenversuchsfeld) in developing specifications and performing calculations for buoys as well as preparing software and optimization studies for new buoy designs. Detailed construction drawings for the buoys are prepared by the Contractors.

In performing its functions, Compass GmbH uses a nucleus of 5 to 10 engineers in the Koblenz office and has access to many consultants whom it can call in to work on any specific projects. Exhibit 1 is a brochure describing the types of services Compass offers. Mr. Hovermann said he would send more descriptive information later.

Interview conducted: March 29, 1990
at: Koblenz, West Germany
by: Nedret S. Basar

SUMMARY NOTES FROM INTERVIEW

F. HEBOLD GmbH

CUXHAVEN, WEST GERMANY

NOTE:

"Hebold Apparatebau und Maschinenfabrik GmbH & Co." had responded to the Project Investigator's initial request by their letter dated March 5th, 1990, copy attached as Exhibit 1, which in effect states that they do not wish to participate in this study and recommends contacting the German Navigation Authority in Koblenz.

Having been earlier informed by Dr. Hartung of the Bundesministerium fur Verkehr (Ministry of Transport) that "Hebold" is an established German buoy manufacturer, the project team sent another fax message to Hebold, but no response was received prior to departure for the European trip.

A telephone call was made to the Hebold Company upon arrival in Hamburg, West Germany by train from Copenhagen, Denmark and the visit request was repeated.

Mr. Hartmut Hebold, the Managing Director of the company, stated again that Hebold does not have any buoys presently, and furthermore, has not had any buoys constructed for the past several years for the German government. Accordingly, he said, a visit to Cuxhaven would not be of any use to this project.

Exhibit 2 contains reproductions of two drawings which were obtained in the very early stages of this project from the Bundesverkehrs Ministerium, courtesy of Dr. Hartung and represents the configurations of a 2,500 mm. diameter lighted buoy on Dwg. 4-8000-3-1 and several types of unlighted buoys on Dwg. 4-8000-3-2 of Franz Hebold Manufacture.

It was not possible to obtain any additional information on Hebold products.

Telephone interview conducted: March 27, 1990
with: Mr. Hartmut Hebold
by: Nedret S. Basar

SUMMARY NOTES FROM INTERVIEW BY CORRESPONDENCE

WILHELM WEULE GmbH

GOSLAR, GERMANY

PERSON RESPONDING: Dipl. Eng. Rainer Muller

SUMMARY

- o As evidenced by the filled-out survey questionnaire (Exhibit 1), this firm has no experience in the manufacturing of complete buoys.
- o The firm manufactures and delivers cut and polished glass drum lenses of 200 mm., 300 mm., and 500 mm. diameter.
- o Exhibit 2 is a leaflet in German which lists the various glass lenses and other optical glass products, including mirrors, that the company manufactures.

Reference: Wilhelm Weule GmbH Correspondence dated Feb. 2, 1990

A.2.6.5

(THIS PAGE INTENTIONALLY LEFT BLANK)

SUMMARY NOTES FROM INTERVIEW BY CORRESPONDENCE

RESINEX OFFSHORE S.r.l.

ISEO (BRESCIA), ITALY

PERSON RESPONDING: Mr. Alex Valentines

SUMMARY

o RESINEX has responded to the project investigator's inquiry by returning a filled-out survey questionnaire (Exhibit 1) as well as a company brochure (Exhibit 2) describing the company's background, products and services, and another brochure entitled "Introduction to Resinex Elastic Beacons" (Exhibit 3).

o As described in detail in Exhibit 2, this manufacturer is situated on the shores of Lake Iseo which is north of Milano. It has been established in 1961 and has pioneered the use of plastics in offshore and navigation aids industries. According to this brochure, in the field of aids to navigation "the best result obtained by Resinex" is the development of "a new signalling system that replaces the traditional signalling buoys with chain", i.e. the Elastic Beacon.

The Elastic Beacon, patented by Resinex, is described and illustrated in Exhibit 3. It is stated that this specific aid, which is essentially an articulated beacon, has been installed in large numbers throughout the world, notably in the Suez Canal. It functions as an elastic tension pile which is held vertical by a large, fully submerged floating body of spherical or elliptical shape. "When combined with the slim structure," this floating body (buoyancy chamber) "reduces the form coefficients to a minimum."

> "A single mooring shackle and tension riser allows the pile restricted freedom to move under the actions of wind, wave and current. This restricted movement, a function of the rigidity, inertia and buoyancy of the structure, ensures that the beacon accurately marks the dredged channel, fareway or obstacle to a degree impossible to achieve with any form of catenary moored buoy arrangement. . . [The] precision marking improves considerably the safety of the navigational system.
>
> The restricted motion of the Elastic Beacon ensures that the navigation aids, such as lights and daymarks, are held steadily at the required focal height and within lens divergence requirements. . . .
>
> Power sources, such as Solar Photovoltaic Panels, Batteries, Mains Power and Gas, can be readily fitted

A.2.7.1

to the Resinex Elastic Beacon, to provide long maintenance free intervals.

The limited torque of the Beacon about its vertical riser axis allows Solar Panels, for example, to be optimized by placing them on one side and at a fixed angle to the tower, hence obtaining the maximum insulation--combined with maintenance intervals of 7 to 10 years for the beacon structure, this feature insures a highly cost-effective installation."

- Additional information is provided by Resinex on the filled-out survey questionnaire, Exhibit 1, as follows:

  - The beacons are deployed in water depths up to and more than 100 meters, in surface currents of 5-6 knots and sub-surface currents of 2 knots.

  - Resinex' computerized design methods coupled with multiple size and shape of floats has made it possible to overcome most traditional problems.

- The most significant improvements on this system were those relative to the float configuration to enable it to adopt to and perform well in all environments, as well as those relative to the materials of metallic parts such as the shackle connecting the riser to the sinker.

- Resinex holds the following patents:

  - Patent 5159 A/88 concerns the design and shape of floats for open sea application which reduces stress on structure due to better dynamic performance.

  - Patent 6934 B/72 concerns the joint connecting the riser to the sinker.

  - Patent 5218 A/79 concerns the design and shape of a float for fast current applications which helps reduce some of the drag.

Reference: "Resinex Offshore" letter dated 01/03/90

SUMMARY NOTES OF INTERVIEW

FLOATEX S.R.L.

BRESCIA, ITALY

PERSON INTERVIEWED: Mr. B. J. F. Zuurbier
President

SUMMARY

- o Floatex S.R.L. (FLTX) is a manufacturer and supplier of buoys, elastic beacons (floating beacons), navigation aid signalling equipment, and additional non-navaid marine equipment.
- o Their buoys are constructed of steel and range in diameter from 1.3 meters to 2.6 meters. Each of six models come in either a skirt design or tail tube design. All except the smallest have a detachable cage which is bolted to the buoy body on welded stools. All tail tube buoys except the smallest have a detachable tail tube.
- o Features of their buoys noted by them include;
  - Dismountable components for easy handling and transportation.
  - The counterweight on tail tube buoys is made up of sections which can be dismounted allowing the weight to be adjusted to chain characteristics and depth of the mooring. This system makes it possible to re-position the buoy in several sites with different waterdepths.
  - The buoy body is given fendering protection by a circumferentially fixed hard rubber fender.
  - The single circular pocket can hold both the battery pack and, if needed, the charging regulator.
- o FLTX elastic beacons are manufactured with a tubular steel structure which is sandblasted and galvanized, a foam filled plastic or metal subsurface float, a tower for signalling, a sinker and an elastic joint for mooring to the sinker. The elastic joint design has been patented by FLTX.
- o FLTX indicates the following advantageous characteristics for its elastic beacons:
  - Significantly enhanced position marking as compared to the traditional chain mooring system.
  - High focal plane.

A.2.7.2

- High stability which is also advantageous for maintenance operations as the platform is easier to approach and board than a buoy.

- Reduced maintenance as a result of the absence of chain sections and significant structure at the waterline exposed to wave action.

- The elastic tubular rubber joint connecting the beacon to the sinker provides the elasticity to ensure the absorption of any vibrations which may arise in the system.

FLOATEX S.R.L.

EXHIBITS

1. Floatex, General Catalogue.

A.2.7.2

SUMMARY NOTES FROM INTERVIEW

NIPPON KOKI KOGYO CO., LTD.

KAWASAKI, JAPAN

Persons Interviewed:

Mr. Naomasa Kitamura, Executive Director, Chief of Engineering Dept.
Mr. Tsutomu Emura, Chief of Business Department
Mr. Katsuji Gotoh, Asst. Chief of Business Department
Mr. Shim Kato

SUMMARY

- NIPPON KOKI KOGYO CO., LTD. (NKK) manufactures buoys and buoy equipment of various types.
- The Japanese Maritime Safety Agency (MSA) type L-3, L-2 and L-1 buoys were designed in conjunction with MSA by NKK. Last design was completed about 8 years ago.
- They also manufacture lanterns, flashes and lamp changers. Basically, all types of short range aids equipment.
- Their design work on buoys has included buoyancy and stability calculations. They have some dynamic motion analysis capability.
- To overcome buoy motion, they believe a broader beam light is needed. One possible solution to this is the NKK LED light. Light intensity is lower but it can be seen for a few miles. Reason for developing this light is that it is clear and power consumption low. Wide beam is outfall of its characteristics. It will be on display at the IALA meeting and Mr. Kitamura will present a paper on it. (Paper 3.1.5).
- NKK believes that cost of current MSA buoys could be reduced since they have generally been overdesigned. The requirement to have an upper platform for light changing results in a stiff and therefore heavier structure than otherwise needed. Perhaps buoy tending procedures can be altered so this requirement can be reduced.
- NKK sales are mostly domestic. However they are delivering a single 3.2m diameter buoy weighing 10 tons to the Japan Arabian Oil Co. on a yearly basis.
- Mr. Kitamura is the principal designer for NKK.

- NKK has a paint marking system to mark a ship striking a buoy. They believe the success of this system in Japan is 50%.

- The new Japanese Maritime Safety Agency (MSA) GRP buoy is of NKK design. It will be used in an area 1,000 mi. south of Tokyo and therefore needs to be light for transportation. The radar reflector (SR-6) is contained in the body.

- NKK is only manufacturer of SR-6 type radar reflector.

- The MSA uses corner cast aluminum radar reflectors, 8 pieces fastened to the superstructure. NKK is manufacturing this for them. NKK believes a radar reflector like the SR-6 is better, small and light and free from wind load. Both are about the same cost.

- NKK is thinking about how to develop a buoy stabilized against wave motion. A very diffcult problem.

- NKK believes a steel buoy with FRP superstructure may be an optimum configuration. Could use a cage type superstructure which would be much more visible yet light. The buoy would weigh less and maintenance to superstructure would be minimal since there would be no peeling paint.

- NKK was asked for cost data. They said they could not provide any, since they quote on a case-to-case basis.

Inteview conducted: April 20, 1990
At: NKK
Kawasaki, Japan
By: John C. Daidola

NIPPON KOKI KOGYO CO., LTD.

EXHIBITS

1. Copy of IALA paper 3.1.5, "Development of LED Light for Short Range Lighted Aids", 1990.
2. Data sheets on collision marker for buoys.
3. Company brochure.
4. Catalogue of lanterns and electronics for visual aids to marine navigation.
5. Various brochures on lanterns, radar reflectors, topmarks.
6. Brochure on LED light beacons.

A.2.8.1

SUMMARY NOTES FROM INTERVIEW

RYOKUSEISHA CORPORATION

TOKYO, JAPAN

Persons Interviewed: Mr. Hiroo Todoroki, General Manager - Export Sales Division

Mr. Mitsuo Horiguchi, Export Sales Division

SUMMARY

- Ryokuseisha (RS) manufactures a wide range of buoys, articulated beacons, power systems (including wave-generators), and various signaling equipment for buoys.

- RS buoys intended for the open sea are constructed of steel and are of both the tail tube and skirt type ranging in diameter from 1.2 to 3.0 meters. They also have a series of open sea buoys specially designed and fitted with wave generators ranging in size from 1.36 to 6.0 meters in diameter. Their smaller range of buoys, used for location marking in harbors and rivers or in designating dangerous areas for dredging and reclaiming, are manufactured of various plastics including polyurethane foam, FRP with polyurethane foam filling and ABS resins.

- This past February (1990) they installed a number of articulated beacons, 13 in Tokyo Bay and 31 in Osaka Bay (See MSA Chiba Buoy Base file for photographs). These towers were of the MLTV-10RA type and were set in a mud bottom. All had a synchronized flashing system.

- The RS articulated beacons have both floatation and buoy body made of steel. They have a patented universal joint at the bottom. They can accommodate a 2 meter variation in tide in Tokyo Bay.

- The 31 articulated beacons in Osaka Bay were to mark the construction site of an airport. The 13 for Tokyo Bay were to mark the construction site for a trans Tokyo Bay road.

- The patented universal joint for the articulated beacons was developed in Australia and the Japanese bought the patent.

- The RS wave-activated generators can be fitted to any existing buoy.

- Synchronized flashing is easy to see. The Japanese Maritime Safety Agency (MSA) requires synchronized flashing on its buoys.

- RS has a nozzle spray paint system for identifying ships that collide with a buoy.

- RS provides wave-activated generators which can also be coupled with solar panels and solar batteries. They provided an analysis included in the

Exhibits showing that a purely wave-activated generator system is more cost effective than a purely solar battery power supply system.

- o RS said they could not give buoy cost. All buoys are a little different in terms of their signaling devices.
- o A completed questionnaire was provided and is included herewith as an exhibit.

Interview conducted: April 18, 1990
At: RS
Tokyo, Japan
By: John C. Daidola

RYOKUSEISHA CORPORATION

EXHIBITS

1. "Comparable Merits and Demerits of Wave-activated Generator System and Solar Battery Power System"
2. Completed Questionnaire.
3. Catalogue of RS floating buoys, batteries and lanterns.
4. Catalogue of RS wave-activated generators and wave-activated generator buoys.
5. Brochure on RS synchronized flashing system.
6. Catalogue on RS light towers (articulated beacons).
7. Brochures on radio buoy and sel-call system.

INFORMATION OBTAINED

ZENI LITE BUOY CO., LTD.

OSAKA, JAPAN

PERSONS FORWARDING: None directly

SUMMARY

- o An appointment at Zeni Lite Buoy Co. (ZLBC) offices could not be arranged; however, information on their buoys was forwarded by The Japanese and Australian Authorities and was obtained from ZLBC at the IALA '90 Conference.

- o ZLBC manufactures a wide range of navigation buoys and floating beacons.

- o The buoys include the following

  - ZLB Series with tail tube or skirt with body diameters ranging from 1.8 meters to 3.2 meters. They are all manufactured of steel.

  - The ZUB Series unlighted buoys of polyurethane foam filled steel. Reportedly they perform well against collisions by ships.

  - The ZCB Series for swift currents. One is a tail tube type of 1.6 meter diameter constructed of steel with an aluminum cage and capable for currents to 5 knots. The others, from 3.5 to 6.0 meters in diameter, are of the shallow draft disc type, constructed of steel or aluminum and capable in currents of 5 to 9 knots.

  - The ZWB Series are buoys for severe sea conditions. They are constructed of foam-filled steel and aluminum hulls/ superstructures.

  - The ZGB Series are GRP and steel light buoys. They range from 1 meter to 2.4 meters in diameter. Some designs can handle currents up to 5 knots.

- o The original ZLBC navigational lighted buoys were the so-called resilient light beacons. These are available for water depths from 10 meters to 25 meters and currents up to 3.0 knots. They have the following characteristics:

  - Main structure is made of steel for strength and rigidity with an aluminum superstructure to increase stability and lessen heeling (presumably due to the lighter weight).

  - The connection between the beacon and the sinker is a short chain mooring. Upon a customer's request, other mooring procedures can be utilized including a universal joint or articulated link.

ZENI LITE BUOY CO., LTD.

EXHIBITS

1. Zeni Lite, Aids to Navigation, Catalogue, Zeni Lite Buoy Co., Ltd.
2. Marine Aids to Navigation, Zeni Lite Buoy Co., Ltd.

SUMMARY NOTES FROM INTERVIEW

GAKUYO TOKI KOGYO CO., LTD.

TOKYO, JAPAN

PERSONS INTERVIEWED: Mrs. S. Miyamura, President
Mr. Eifumi Miyamura, Executive Director
Mr. Hiroaki Noda, Managing Director
Mr. Yasushi Okuyama, Manager of Foreign Division
Mr. Shoichiro Ohara, Director
Mr. Masahiro Kuramochi, Director of Engineering

SUMMARY

o Gakuyo Toki Kogyo Co., Ltd. (GTK) is a manufacturer/supplier of various electronics and equipment for aids to navigation buoys.

o GTK does not design or manufacture the buoys themselves. They do, however, supply topmarks for aid to navigation buoys.

o They are currently developing a Global Positioning System (GPS) driven system which periodically checks the position of the buoy on which it is carried. The Marine Safety Agency of Japan is very interested in the completion of this project.

o They supply a radio transmission/paint spray system to identify/mark ships colliding with navigation buoys. They feel 90% of the colliding ships are found with this system.

o GTK (Mr. Miyamura) have found that buoy lighting systems worldwide do not have the best reliability. On the other hand, GTK has a lighting system that can last 10 years as opposed to others only lasting 3 years. The cost of the 10-year system is approximately 1.5 times the cost of a 3-year system.

c The GTK lamp charger and flasher (GT-2005) features a molded glass lens as opposed to a plastic lens which may be flawed. Also, they can add a small flash synchronizer.

o GTK believes it is very important to have synchronization in ports with bright background.

o GTK specializes in working with clients to optimize solutions for their situation. It also takes responsibility for the long-term performance of its products.

o GTK has about 50 employees.

Interview conducted: April 20, 1990
At: GTK
Tokyo, Japan
By: John C. Daidola

GAKUYO TOKI KOGYO CO., LTD.

EXHIBITS

1 Brochure on Automatic Lighthouse Control System.

2. Various brochures on lighting equipment and control systems.

3. Catalogue on lights and electronics for Aids to Navigation Systems.

4. Brochure on topmarks for navigation buoys.

5. Two catalogues on chain.

6. Brochure on Luneburg radar lens.

SUMMARY NOTES FROM INTERVIEW

STROMAG N.V./ PINTSCH BAMAG B.V.

KATWIJK, THE NETHERLANDS

PERSON INTERVIEWED: Mr. W.F.H. Scholten
Sales Manager

SUMMARY

- In The Netherlands Pintsch Bamag works within the firm STROMAG N.V. (Stromag) Katwijk, The Netherlands. STROMAG is the largest supplier of aids to navigation equipment in The Netherlands.

- Pintsch Bamag B.V. (PB) is one of the oldest manufacturers of Aids to navigation in the world. They have been in business for 100 years.

- A catalogue available in their office dated 1912 showed a very complete line of floating navigation buoys manufactured by them was available at that time.

- They currently offer a complete line of steel aid to navigation buoys for the world marketplace as shown in the Exhibits.

- 50-100 buoys are manufactured per year. They sub-contract the construction of their larger buoys to a fabricator. All work is done in accordance with their designs.

- Their main buoys are the 2.2 meter and 2.6 meter diameter steel buoys.

- Most of their buoy hull business is in third world countries. After installation of the buoys PB trains local navigation authorities to maintain the buoys. Stromag comes back one year later to see how the operation is working.

- They find mooring chain lasts 5 years.

- Powering of buoys is by solar charging of batteries. In tropical areas they change batteries between 2-5 years. In Holland battery changes occur at 7-8 years. To maintain long life of a battery a good solar regulator is most important. Direct and constant charging of batteries is no good.

- As far as light visibility is concerned it is important to see 4 or 5 miles. Wider angle light is more effective even though the light may be less powerful. See Figure 13 of Exhibit 1.

- They have their own radar reflectors and solar power systems.

- They have built a large buoy with a 5 meter diameter body for the center of a traffic lane.

A.2.9.1

- 10 mm thick steel plate is used to build buoys. They last 25-30 years.
- Today there is the possibility to develop a system where you could check all systems aboard a buoy from a central "alarm" panel which could be read by standing on the buoy or even from a helicopter.
- Consideration could be given to a back-up emergency light system to provide signalling capability when the main system breaks down.
- In ship collisions with buoys 80% of the time the offending vessel leaves the scene of the collision. A way to identify ships so that they can be tracked down is to note their position at a VTS station and maintain a track on them.
- Believe topmark approach to lateral identification is better than buoy body shape significance as it allows for provision of a reasonable access to the signalling devices atop the buoy. See the cage standing system provided on their buoys, which is possible with a tall cage and flat surfaces on the cage exterior. As opposed to this, look at Trinity and DGSM slat designs, where it is difficult to get to the light at the top of the buoy.
- PB worldwide territory is divided between Stromag and the Dinslaken, Germany PB group.
- They fit rubber fenders to the upper part of the buoy body to offer some protection from collision.

Interview Conducted: March 9, 1990
At: Stromg N.V.
Katwijk, The Netherlands

By: John C. Daidola

STROMAG N.V./PINTSCH BAMAG B.V.

EXHIBITS

1. Aids to Navigation, Stromag.
2. Solar Power systems, Stromag.

SUMMARY NOTES FROM INTERVIEW

ALL MARINE

ROTTERDAM, HOLLAND

PERSONS INTERVIEWED:

Ir. Henk Keers
Senior Consultant

Captain Ruud E. Behrend
Managing Director

Captain Ben Latooy
Senior Consultant

SUMMARY

- All Marine services range from procurement/installation of buoys and other navigational aids to the completion of detailed port surveys and the provision of pilotage services.

- Recently executed Aids to Navigation projects have included a turnkey planning and installation of 40 fairway buoys and 22 lighthouses in Guinee Bissau, buoy-handling assistance in inland ice conditions for the Dutch lighthouse authority, installation of solar powered units on existing Dutch beacons, maintenance of fairway buoys for a certain part of Holland's inland waterways for the Dutch authority (DGSM), installation of non NAVAID buoys, NAVAID support to several countries abroad and development of a special lighted navigation buoy for operation in ice conditions.

- The ice buoy developed by them is called an All Weather Heavy Duty Buoy (AWHDB). This was initiated based on their experience with the DGSM and damage to buoys in ice during 1987. The DGSM then decided it should remove lighted buoys in inland waters during the winter but this is very costly. This led to their program of developing a buoy which could remain on station during the anticipated ice conditions.

- Their AWHDB was modelled after the U.S. Coast Guard 7x20 LI lighted Steel Navigational Ice Buoy. The environmental conditions defined were:

  - Fresh water river ice buildup, 10cm thick

  - Ice Floes passing by the buoy, 10cm thick

  - Currents to 4 Knots (but buoy Spec. indicates a maximum of 6 Knots)

  The AWHDB has three watertight compartments.

The AWHDB design was model tested (scale 1:10) at the Maritime Research Institute Netherlands (MARIN) in ice fields (a novel paraffin ice modeling technique--also see MARIN file), current and waves. Forces in the mooring chain were measured and the behavior of the buoy was monitored and filmed. Excerpts from the model basin report are in Exhibit 6.

One of these buoys has been in place for the past two years but no ice conditions have developed during this period.

- They have heard that a Dutch Company is investigating energy production on a buoy from its wave induced motion.

Interview Conducted: March 8, 1990
At: ALL MARINE
ROTTERDAM, THE NETHERLANDS

By: John C. Daidola

ALL MARINE

EXHIBITS

1. ALL MARINE, General Presentation
2. ALL MARINE, Brochure
3. Completed MR&S New Buoy Systems Questionnaire.
4. Chammar Light buoy 12.5 Type, Specification.
5. All Weather Heavy Duty Lighted Buoy, Presentation and Drawing.
6. Model Tests on Light Buoys in Ice, excerpts from MARIN Report No. 08528-1-BT.

SUMMARY NOTES FROM INTERVIEW

MARITIME RESEARCH INSTITUTE NETHERLANDS

WAGENINGEN, THE NETHERLANDS

PERSON INTERVIEWED:

Captain R. Tresfon
Project Manager,
Maritime Operations Division

Mr. Dallinga
Project Manager,
Ocean Engineering Department
Industrial Project Division

SUMMARY

- The Maritime Research Institute Netherlands (MARIN) performs research and development, comprising of consultative assistance, mathematical modelling and model experiments for the shipbuilding, shipping and offshore industry and for Governmental and Inter-Governmental bodies.

- MARIN has at times developed mathematical modelling for buoys and has conducted model testing. The buoys have usually been larger mooring buoys of companies such as SBM, IMODCO, and Sofac.

- SPM has built some of these large mooring buoys Contact: SPM, P.O. BOX 199, MC 98007, MONACO CEDEX, ATTN: C. VOGT

- They believe that SPM has built navigation buoys.

- They have carried out testing for All Marine on a navigation buoy for ice conditions (See All Marine file for details). During this testing they were able to correlate buoyancy with ice reactions.

- MARIN personnel have published some work on buoy hydromechanics.

- An ice test for a buoy encompassing 3 or 4 ice conditions and including the buoy model may cost $30K U.S. Seakeeping tests would also cost approximately this much. They suggested that when carrying out seakeeping tests on buoys it is more cost effective to test several possible buoys at once since the greatest cost is for tank rental and several buoy tests can be conducted simultaneously.

- They recommend testing of buoys. They have not yet correlated test results to full scale measurements.

- For many years MARIN has been active in the field of training pilots and ship officers in ship handling with the MARIN real-time simulators. MARTIN has also been involved in sea traffic and accident analysis including route structures and traffic patterns, sea lane design, and offshore vessel traffic services.

- They have utilized the position information provided by buoys in the decision making process of the navigator in relation to ship controllability. Both in real-time and fast-time simulations.

- They have advised on restructuring of buoyage patterns in relation to their functions and operational use by various user groups. This work was in collaboration with Marine Analytics for the DGSM in regard to reducing the amount of navigation buoyage in the North Sea (See Marine Analytics file).

- MARIN'S Vessel Traffic Services Simulator is a facility for adequate, realistic and controlled operational training of VTS-operators, independent of all factors that influence on-the-job training i.e. work-load, weather conditions, traffic situations etc. The simulator can also be used for research. Problems related to work-load, communication procedures, remote piloting and traffic planning are among the many matters that can be studied.

Interview Conducted March 9, 1990
At: MARIN
Wageningen, The Netherlands

By: John C. Daidola

MARIN

EXHIBITS

1. A description of MARIN.

2. MARIN Report No. 33, September 1988. Various articles on marine navigation and traffic analysis by MARIN.

3. VTS-Simulator (1986), data sheet.

4. DPSIM - Simulation of low frequency behavior of DP vessels, software documentation sheet 10.

5. MARIN'S SHIP MANEUVERING SIMULATORS, data sheet.

SUMMARY NOTES FROM INTERVIEW

MARINE ANALYTICS B.V.

ROTTERDAM, HOLLAND

PERSON INTERVIEWED: Mr. C.C. Glandsorp
Managing Director

SUMMARY

o Marine Analytics is a consultancy composed of Mr. Glansdorp. He can obtain the services of other consultants and experts in the field of this endeavors which include:

- Marine traffic engineering
- Marine traffic safety
- Vessel traffic services and vessel traffic management
- Aids to navigation
- Vessel navigation process
- Vessel maneuvering qualities/properties
- Marine simulation techniques

o Among its past projects are cost-benefit analyses of traffic measures: VTS and aids to navigation; marine traffic planning studies for the port of Amsterdam; cost-benefit analyses of traffic measures in the approaches to Amsterdam and studies on optimal aids to navigation system North Sea (in close cooperation with Opeform and Marin). See Marin summary for description. Opeform is located in France: Opeform, 1 rue de la Tour, Malakoff, France; attention Mr. C. Deutsch, Director.

The above-mentioned study on the North Sea was presented at the IALA '90 conference. It is based on the fact that radar is widespread on board ships. They have assumed 90% of all vessels will have radar and 75% of all others will have two radars. Within 6 or 7 miles of shore, all will need visual aids and pleasure boaters will need the most close to shore. Farther offshore RACONS or selected lighthouses should provide adequate markings to be identified by ship's radar. Therefore, the amount of offshore buoyage can be reduced from today's levels.

Interview Conducted: March 9, 1990
At: Marine Analytics B.V.
Rotterdam, The Netherlands

By: John C. Daidola A.2.9.4

MARINE ANALYTICS B.V.

EXHIBITS

1. Company Profile
2. Graphs of Buoyage Alternatives.

SUMMARY NOTES FROM INTERVIEW

DAMEN SHIPYARDS

GORINCHEM, THE NETHERLANDS

PERSON INTERVIEWED: Mr. Gerrit W. de Ruyter
Sales Manager

SUMMARY

- Damen Shipyards has a number of yards throughout the world producing small to medium sized vessels of all types.

- They have built a number of buoy tenders:

  - 38 meter in length M.V. NIEUWE DIEP caps class with forward buoy deck.

  - 44.40 meter in length M.V. ROTTERDAM class with aft buoy deck.

  - 24.96 meter in length Multi Cat Class with forward buoy check.

  - 35.06 meter in length M.V. MONTEVIDEO Class with forward buoy deck.

  - 30. meter in length M.V. DIVING - POT 1 class with forward buoy deck and over the bow handling davit.

  - 30 meter in length M.V. SAMBUIA Class.

- Their U.S. representative is Mr. Peter Kalis.

Interview Conducted: June , 1990
At: IALA Meeting
Veldhoven, The Netherlands

By: John C. Daidola

DAMEN SHIPYARDS

EXHIBITS

1. General information M.V. NIEUWE DIEP
2. General information M.V. ROTTERDAM
3. General information Damen Multi Cat 25 x 10
4. General information M.V. MONTEVIDEO
5. General information M.V. DIVING - POT 1
6. General information M.V. SAMBUIA

SUMMARY NOTES FROM INTERVIEW

TICON PLAST INDUSTRIER A/S

DRAMMEN, NORWAY

PERSON INTERVIEWED: Mr. Svein Landaas
Managing Director

Summary

TICON PLAST is part of TICON INDUSTRIER Group which comprises 10 production subsidiaries with activities in offshore, industry, building and construction equipment manufacture and in real estate.

With its plant in Drammen, Norway (near Oslo) TICON PLAST is a major producer of reinforced plastics and composites. Some of their products are sandwich panels, radomes and defense and industrial products in addition to navigational aids.

The main line of aid to navigation buoys they manufacture is known by the trade name "SELCO MARITIME SYSTEMS". They range in size from Type 4 spar buoys of 41 cm. diameter and 7.65 meters length to Type 16 with 70 cm. diameter and 7.5 meter length to Type 26 marker buoys with 100 cm. diameter and overall lengths varying from 3.95 to 5.60 meters.

Ticon plast is the supplier for nearly all the plastic buoys in use by the Norwegian Coast Directorate. However, this does not constitute a major part of its business. The number of buoys procured per year is small and does not justify automating the production process. Consequently, the buoys are currently produced manually by a hand lay-up process. The company does have its own mold and pattern shop and employs other types of production such as vacuum injection, wet-vacuum molding and press molding depending on the requirements for specific orders.

The following brochures were made available during the interview and the tour of TICON-PLAST facilities:

Exhibit 1: "Selco Maritime Systems" Data on Navigational Aids
Exhibit 2: TICON Companies Brochure
Exhibit 3: TICON PLAST A.S. Brochure
Exhibit 4: Selco "Beacon Program"
Exhibit 5: Selco "Ticon Tower"
Exhibit 6: Selco "Marker Buoy - Type 26"
Exhibit 7: TICON RADOMES
Exhibit 8: Selco "Off-Shore Cladding"

Interview Conducted: March 20, 1990
at: Ticon Plast, Drammen, Norway
by: Nedret S. Basar

(THIS PAGE INTENTIONALLY LEFT BLANK)

SUMMARY NOTES FROM INTERVIEW

TIDELAND SIGNAL CORPORATION

HOUSTON, TEXAS

PERSON INTERVIEWED: Mr. Harry J. Saenger
President

SUMMARY

- Tideland Signal Corporation (Tideland) carries out research, engineering and production of navigational aids and solar electric generators including lanterns, fog signals, buoys and electric monitoring systems.

- At one time Tideland maintained a large number of aids and marks for the oil industry in the Gulf of Mexico. The total number may have exceeded the U.S. Coast Guard's. For tending purposes they used 90' boats.

- Today their business activity is 80% for ports and harbors and only 20% for oil area applications.

- Tideland pioneered GRP buoys. These were developed for countries having limited equipment to maintain buoys. Two of their earliest GRP buoys purchased by the City of Cleveland, Ohio 20 years ago are still in use. These buoys were a take-off from an early USCG design.

- Until about 1967, Tideland manufactured steel buoys. Because of the advantages of GRP, they now manufacture only fiberglass buoys.

- Tideland believes that some plastic buoys have suffered from being developed without a well thought out design or quality construction.

- Tideland has carried out extensive testing with plastic to determine the best for buoy applications. Their latest plastic buoy design, the 5'-9" diameter SB-138 Sentinel Navigation Buoy, was developed on a system basis. It has a fiberglass hull with a central foam-filled fiberglass core. The outside of the buoy body is shielded by a 4" thick elastomer skin to absorb impacts. The mooring shackle has been replaced with a mooring eye with bolt cap. The solar panels are integrated into the hull and it has an internally fitted Luneberg lens. They also build the smaller SB-510 buoy.

- Tideland believes the Luneberg lens radar reflector is best for positive radar reflection.

- They have built some very different types of GRP buoys. The Sentinel SB-826 Series C sea buoy is constructed of flat fiberglass panels fiberglassed over with spiral wound filament. These buoys are filled with polyurethane foam and have been repaired on site. Their 8' diameter hull is fitted with deck-mounted battery boxes and a ladder leading to the signalling devices mounted atop the radar reflector (cornertype). Some features noted for this buoy are: easier servicing and prolonged on-station life, 50% weight reduction over similar steel buoys, and the foam-filled flotation compartments are bulkheaded.

- The English division of Tideland has had YARD design the SB steel buoy series they build. They are 1000 mm and 3000 mm diameter designs.

- Tideland manufacturers the SAB-12 Sentinel Articulated Buoy. This has been a successful design with the use of a taut line moor between the sinker and the hull which avoids the buildup of structural loads that can occur in more rigid connections like a universal joint. The taut moor is pre-tensioned by the use of a buoyancy chamber constructed of foam.

- Tideland believes that a procurement policy aimed at purchasing buoy components separately inhibits an integrated system design approach.

- In order to reduce the cost of buoys, it would be prudent to consider manufacturing and inventory economics. For example, if buoy size could be scaled down to a more unified basis, then float sections of Surlyn foam protected by an elastomer skin could be constructed which could be stacked on each other to make different buoys and articulated beacons. This would provide an assembly system from inventory of any buoy size and type.

- Ice buoy technology should consider a cone buoy with the hull extending well below the ice line. This may improve the buoy's ability to remain upright and when the ice becomes significant enough it should drive the buoy down under the ice as pressure forces are exerted on its skin.

- Most use UV stabilized plastic to preclude fading of color.

- The design of buoys to avoid resonances with the environment still represents the most significant problem.

- Tideland has a wide range of navigational aid equipment as shown in the exhibits including signal light systems, fog signals, RACONS, power sources and other auxiliary equipment.

- Tideland's newest RACON, Sea Beacon 2, was developed under USCG Contract.

- Tideland believes that as RACON technology advances it may be used to determine whether a buoy is on station or not, and if not, its RACON Code could change automatically to warn mariners.

- The cost of a complete articulated tower as installed in the Gulf of Mexico at the LOOP facility was $80-90,000.

- Compliant foams do suffer some from abrasion.

A.2.11.1

- They understand that Malaca Straits floating beacons, not Tidelands, had problems with the universal joint connecting the beacon to the mooring.

Interview Conducted:
At: Tideland Signal Corp.
Houston, Texas

By: John C. Daidola

TIDELAND SIGNALS CORPORATION

EXHIBITS

1. SB-138 Sentinel Navigational Buoy
2. SB-510 Sentinel Navigational Buoy
3. SB-612 Sentinel Navigational Buoy
4. SB-826 Sentinel Series C Navigational Buoy
5. SAB-12 Sentinel Articulated Buoy
6. SB Series Steel Navigation Buoys
7. SF-5 and UF-210 Location Buoy System
8. Catalogue data on signal light systems
9. Catalogue data on fog signals (Audio Beam)
10. Catalogue data on RACONS (Sea Beacon)
11. Catalogue data on Power Sources
12. Catalogue data on Auxiliary Equipment

(THIS PAGE INTENTIONALLY LEFT BLANK)

SUMMARY NOTES FROM INTERVIEW

AUTOMATIC POWER, INC.

HOUSTON, TEXAS.

PERSON INTERVIEWED:

Mr. David Adams
Electrical Department

Mr. Inaki Garabieta
Mechanical Engineer

SUMMARY

- Automatic Power, Inc. (API) entered buoy design in the late 1960's and at that time most of their buoys were sold to oil companies. Now API is part of the Pharos Group of companies which have their headquarters offices in Sweden.

- API sells buoys all over the world except in South America where their designs are built in steel, fiberglass and combined steel and fiberglass.

- API designs its own buoys. Pharos has its own designers in England.

- In addition to buoys API has a full line of buoy equipment including signalling devices, power supplies and moorings.

- All offshore buoys manufactured by API are constructed of steel, with an 8ft. x 26ft. being the largest. They feel steel has demonstrated its superiority over the years as there are steel buoys which have been in service for more than 40 years. 50% of the steel buoys they sell are foam filled.

- As an example API's wide range of buoys its BL-826, BL-620 and BL-717 steel buoys can serve in unprotected deep water; the B-511 steel buoy surpasses requirements in semi-protected harbors and bays; and the small BA series fiberglass buoys are mostly used in calm waters such as lakes and rivers.

- API believes that in environments with high current a deep draft buoy is better than a short shirt which tends to pick-up floating debris. Debris slides off the tail tube of deep draft buoys.

- Some considerations for buoy design and selection include:

  - Electronic bells can replace gongs.

  - A buoy that performs well in calm water may not behave well in rough water.

- Must be very careful with GRP. As examples, if a component is not finished with a gel coat it will absorb water and in a cold region ice could form and the buoy would crack.

- A fender around a buoy protects it to some degree.

- Counterweights assembled in pieces are less expensive than single pour counterweights.

- Can utilize a gimballed light for maintaining the optical lens level.

- Greater stability will be needed in buoys to support RACONS.

o API manufacturers a buoyant beacon constructed of steel with a foam filled steel floating chamber and a shackled connection to the sinker. The deepest water depth for which they have manufactured a beacon is 44ft. but have looked at designs for water depths as much as 150ft. They manufacture 3 or 4 per year.

o Pharos Marine (PM) is the world's leading supplier of aids to navigation dating back 80 years.

o For the open sea and major port fairways PM has high-focal-plane steel tail tube buoys. The BT-3000 series is for the exposed open sea, the BT-2600 series is for the open sea and the BT-2200 series is for the moderate open sea.

o For Channels and Harbors PM has steel skirt keel buoys and GRP buoys. The BS-3000 series steel buoys are for open sea locations, the BS-2600 and BS-2200 series for moderate open sea, and the BS-1000 series for partially sheltered conditions. The BS-41 MKII GRP buoy is for the open sea whereas the BS-13 thru BS-16 GRP buoys are for harbors and sheltered conditions. The BC-21 and BC-22 GRP catamarans are intended for estuaries, shallow and fast flowing water.

o PM finds that the BS series skirt steel buoys are usually preferred by marine authorities because they can be stood upright on the deck of a buoy to make handling procedures easier. The BT series tail tube design gives maximum stability.

o The GRP buoys are foam filled and color impregnated.

Interview Conducted:

At: Automatic Power, Inc.
Houston, Texas

By: John C. Daidola

AUTOMATIC POWER, INC.

EXHIBITS

1. Data Sheet on Buoyant Beacon.

2. Data Sheets on Buoys: BL-620, BL-826, BL-717, BL-511, BL-358, BL-250, Unlighted Steel Buoys - Can Type, Molded Fiberglass Buoys.

3. Data Sheets on buoy equipment.

4. Pharos Marine Aids to Navigation Catalogue.

(THIS PAGE INTENTIONALLY LEFT BLANK)

SUMMARY NOTES FROM INTERVIEW

THE GILMAN CORPORATION

GILMAN, CONNECTICUT

PERSONS INTERVIEWED:

Mr. Richard L. Gilman
President

Mr. George M. Greider
Director of Marketing
& Development

SUMMARY

- The Gilman Corporation (TGC) has been manufacturing foam buoys for approximately 12 years.
- Their foam buoys are constructed of Surlyn ionomer resins and metal hardware. These foam buoys are concentrically wrapped, continuously heat sealed and then densified to produce a tough outer skin. Smaller buoy metal parts are hot-dipped galvanized while for the larger buoys, they are sand blasted and coated with epoxy primer.
- Surlyn ionomer resins are thermoplastic polymers from DuPont. The material is intended to remain tough and effective even when subjected to repeated impact, low temperatures and chemical attack. It is reportedly well suited for marine applications since it offers low weight, low density, toughness, durablity, and excellent resistance to environmental agents, such as radiation, salt, fuels and chemicals.
- TGC has developed its own basic extrusion and fabrication technology for all its products which it produces under the name Softlite Ionomer Foam. The Softlite foam mass can be shaped to any exterior contour by heat-cutting. The two horizontal surfaces are then "end-capped with additional sheets of Surlyn heat-welded to the body, after which all surfaces are densified by heat and pressure to form a strong, integral outer skin.
- TGC has used this technology to manufacture navigational aids for the U.S. and Canadian Coast Guards, nuclear weapon floats and fenders for the U.S. Navy, and scientific platforms and buoys for research groups including the Woods Hold Oceanographic Institution, Battelle Ocean Sciences, and the National Data Buoy Center.
- Currently TGC is manufacturing to USCG specifications second through sixth class unlighted buoys. These buoys were designed by the USCG.
- TGC had constructed an experimental lighted buoy for the USCG. Since then they have built some lighted buoys for other clients.

- The Seattle District of the USCG has indicated that chain wear is less with foam buoys.

- Foam buoys become cheaper as size increases. 4th class and larger buoys are believed to be cheaper than steel.

- When struck, a Surlyn foam buoy does not break apart. It absorbs impacts by locally crushing or slicing. As an example, if repeatedly hit with an ax it may begin to resemble "shredded wheat."

- TGC has recently constructed log shedding and fastwater buoys for an organization in Canada.

- TGC has constructed float sections for Tideland articulated beacon buoys.

- Exhibit 10 contains data sheets on a number of buoy systems using ionomer foam floatation in connection with aluminum and/or steel support structure and superstructure.

- The Lighted Guard Buoy and Coastal Discuss Buoy shown in Exhibit 10 has the appearance of a lighted navigation buoy with light atop a cage structure. The Bio Spar Buoy shows an application with a long tail tube.

Interview Conducted: January 10, 1990
At: The Gilman Corporation
Gilman, Connecticut

By: John C. Daidola

Also: September 27, 28
At: MTS '90 Conference
Washington, D.C.

By: John C. Daidola

A.2.11.3

THE GILMAN CORPORATION

EXHIBITS

1. Gilman Softlite Marine Products.

2. Gilman Softlite Ship Fenders.

3. Greider, G. and Gilman, R., "Summary of Experience with Surlyn Buoys," MTS 1989.

4. Berteaux, H. et. al., "Testing and Evaluation of SURLYN Foam and SPECTRA Fiber Ropes for Buoy System Applications," Woods Hole Oceanographic Institution Report WHO1-88-32, 1988.

5. SURLYN Ionomer Resins, Products Guide, DuPont.

6. SURLYN Ionomer Resins, Technical Information, DuPont.

7 Gilman Corporation Navigational Aids & Fenders Catalogue, 1990.

8. TGC marine products sales, January 1990.

9. Section C Statement of Work, Sol,# DTCG23-89-B-20003, Section C for requirements for ionomer foam buoys, floats, and fenders for use in the navigable waters of the United States.

10. Recent Advances in Off the Shelf Low Cost Surface Buoy Technology, MTS '90 Poster Session by P. Clay and G.M. Greider.

11. Sketches of Canadian Log and Fastwater Buoys.

12. Photo of Canadian Log and Fastwater Buoys manufactured by Gilman.

13. Photo of Lighted Foam Buoy Manufactured by Gilman.

14. Price data for foam buoys.

A.2.11.3

(THIS PAGE INTENTIONALLY LEFT BLANK)

SUMMARY NOTES FROM INTERVIEW BY CORRESPONDENCE

URETHANE TECHNOLOGIES, INC.

PORT ALLEN, LOUISIANA

PERSON RESPONDING: Mr. C. R. Dunbar

SUMMARY

Urethane Technologies, Inc. (UT) manufactures collision survivable buoys, According to the Survey Questionnaire, Exhibit 1, filled out and returned by UT, the buoys are manufactured by one of the following types of construction:

a. Closed Cell Crosslined Polyethylene foam body with a tough polyurethane skin. Larger units of this type have Spectra fabric reinforcement in the polyurethane skin.

b. Surlyn foam body with a densified Surlyn foam skin.

UT stated that the type (a) Construction is tougher and more attractive than the type (b) construction but also more expensive.

Their product lime includes primary surface floatation equipment, lighted and unlighted buoys, and some sub-sea riser buoys.

Exhibit 1 contains the following comments on aids to navigation buoys:

- Some of the problems normally experienced with short range aids are damage due to collisions, corrosion effects, and vandalism.

- Improvements to buoys are desirable by increasing thair collision survivability and resistance to corrosion. Buoys should be designed to reduce damage from rifle fire from vandals.

- Application of advanced technologies such as buoy monitoring systems will make it possible to detect when a buoy is off-station and to determine its current location.

Also provided by UT were a brochure entitled "Floatation Devices Catalog" (Exhibit 2), photographs of their foam buoys (Exhibit 3), and price lists (Exhibit 4) for their products.

Exhibit 2 gives a more detailed description of the "Seathane" (a registered trademark of UT) polyurethane skin, discusses the advantages of UT's floatation devices, and presents illustrations of buoys, fast water channel markers, and their attachments.

Reference: Urethane Technologies, Inc. letter dated February 26, 1990 and Questionnaire (Exhibit 1) dated 4/9/1990

A.2.11.4

(THIS PAGE INTENTIONALLY LEFT BLANK)

SUMMARY NOTES FROM INTERVIEW

WOODS HOLE OCEANOGRAPHIC INSTITUTION

WOODS HOLE, MASSACHUSETTS

PERSONS INTERVIEWED:

Mr. Henri O. Berteaux
Head, Systems and Mooring

Mr. Peter Clay
Systems and Moorings

SUMMARY

- The Systems and Moorings Department is the former Buoy Group at Woods Hole Oceanographic Institution (WHOI).
- All five departments at WHOI use buoys which are developed by Systems and Moorings.
- The WHOI buoys are primarily open sea data buoys for deep water. They are of the surface and sub-surface type.
- They have had no problems with sub-surface buoys which have been in place 2-3 years whereas their surface buoys rarely last for more than 1 year.
- The USCG buoy motion and model testing work carried out by Lt. R. Foy and the University of Oregon was utilized by WHOI in the development of a buoy with reduced roll characteristics, the ESOM, built by The Gimman Corporation (see Exhibits 1, and 2). It has a Surlyn foam floatation body with aluminum support structure and superstructure.
- WHOI has some foam filled GRP data buoys (7' O.D., 3' I.D., 26" toroid. 2#/ft³ foam and 1/4" GRP) which are 20 years old. However, they have found GRP shatters on impact with a ship. Surlyn foam does not seem to be damaged in this way.
- They believe that a buoy utilizing Surlyn foam as a peripheral means of floatation and with steel or aluminum cages and underbody mooring structure is a good alternative offering improvement over previous designs. Use of Surlyn also supersedes painting requirements. The Surlyn foam will also cut buoy weight by half.
- WHOI believes that the system approach to the design of the buoy and payload as a combined unit is important.
- Fairing of buoys to reduce drag in high current areas is important.

- WHOI is constantly testing new material applications at their testsite offshore Bermuda. The Office of Naval Research is also supporting this effort. They have investigated Surlyn foam and Spectra mooring lines at this site, Exhibit #3. The conclusions on the Surlyn foam were:

  - Offers many advantages as a buoyancy material for surface buoys.
  - Low weight/volume ratio.
  - Tough material which is resistant to the marine environment.
  - No painting needed.

- WHOI has a deep water mooring analysis computer program called SURFMOOR.

Interview Conducted: November 28, 1989
At: WHOI
Woods Hole, Mass.

By: John C. Daidola, MR&S
Richard Walker, USCG

WOODS HOLE OCEANOGRAPHIC INSTITUTION

EXHIBITS

1. Sea Technology ad on TOUGH BUOY.
2. Gilman data sheet on ESOM BUOY.
3. Berteaux et al. "Testing and Evaluation of SURLYN Foam and SPECTRA Fiber Ropes for Buoy Systems Applications." WHOI-88-32, August 1988.

SUMMARY NOTES FROM INTERVIEW

BENTHOS, INC.

N. FALMOUTH, MASSACHUSETTS

PERSONS INTERVIEWED: Mr. Kevin McCarthy
Sales Manager

Mr. Joel Rezzo

SUMMARY

- Benthos is not and has not been involved with navigation buoys.
- They are the principal suppliers of glass spheres for deep water moorings floatation.
- They are involved with underwater imaging, hydrospheres, acoustics and submersible remotely operated vehicles.

Interview Conducted: November 28, 1989
At: Benthos, Inc.
N. Falmouth, Mass.

By: Richard Walker, USCG
John C. Daidola, MR&S

SUMMARY NOTES FROM INTERVIEW

HEAT TRANSFER SYSTEMS, INC.

ST. LOUIS, MISSOURI

PERSON INTERVIEWED: Mr. David "Cau-Tu" Wong

ALSO PRESENT: Lt. Daniel R. May, USCG

SUMMARY

At the time of project investigator's visit to their facilities, Heat Transfer Systems, Inc. (HTS) had a current contract with the U.S. Coast Guard for the construction of standard 4th and 6th Class unlighted steel, foam-filled river buoys for use in USCG's Second District.

HTS are essentially a local steel and aluminum fabrication shop. They are equipped with heavy metal-working machinery as well as blasting, painting, foam-filling, and testing facilities.

The number of river buoys (for can and nun types) amounted to, as reported, more than 400 for the current order.

The buoy manufacturing process consisted of steps including cutting, forming, welding, proof testing, blasting, painting, and foam-filling stages. It was not an assembly-line type operation.

HTS also had under construction a number of 8 x 20' and 9 x 35' steel buoys for the USCG as well as several aluminum data buoys and aluminum NOMAD buoys.

Interview Conducted: December 6, 1989
At: St. Louis, MO

By: Nedret S. Basar

Jointly with: Lt. Daniel R. May, USCG
Commander, USCG Base St. Louis

SUMMARY OF INTERVIEW
AT BAHR TECHNOLOGIES, INC.
MADISON, WISCONSIN

INTRODUCTION

"Bahr Technologies, Inc." (BTI) is currently a designer and developer of state-of-the-art microprocessor-based products. The firm until now had been involved essentially in design functions, but had also developed and manufactured prototypes of designed products using the facilities of a larger associated firm. According to Dr. Linn Roth, Vice President Sales and Marketing, they have since found the needed funding and are planning to get into the series production of their patented new Loran receivers (*).

The U.S. Coast Guard Research and Development Center had recommended that MR & S conduct an interview with Bahr Technologies to obtain information on this advanced Loran receiver with regard to its possible application to "Smart Buoys". These miniature receivers could broadcast and identify the buoy's position with accuracy and would be helpful if installed on buoys that frequently drift offstation.

SUMMARY

The firm's new Loran receiver is a self reliant piece of equipment and uses standard power.

According to Dr. Roth, the U.S.C.G. R&D Center is currently procuring two prototypes from BTI. The unit is a single board LORAN receiver originally developed for automated vehicle location systems. BTI claims that it is much smaller than current conventional equipment and will cost much less when it gets into series production.

Dr. Roth showed the interviewer both the current conventional equipment and the new BTI receiver. He claimed that the BTI unit can perform the same functions (and much more) as the conventional unit without the use of an additional controller board and can therefore reduce the space needed as well as the cost of the unit.

MR&S had earlier sent BTI a blank Survey Questionnaire which was then filled in by BTI and returned. A copy of the BTI response is included as Attachment #1. As can be seen therein, their response discusses the following major topics specifically with regard to their receiver:

(*) The name of the Company has since been changed to "Loc US Navigation, Inc."

- Benefits of Current SRA:
  - Positioning Accuracy
  - Fast Acquisition Time
  - Greatest Geographic Coverage
  - Most Reliable Operation

- Problems with current SRA
  - Compares BTI receiver with conventional units.

- Ideas for Improvement:
  - Discusses the improvements to be gained by the use of BTI receivers.

During the interview, BTI also provided MR&S with additional proprietary data on their products including:

Attachment #2: Presentation by Dr. Roth entitled "Linear Averaging Digital (LAD-LORAN).

Describes the product (LAD-LORAN); discusses the benefits provided by the product for "over-the-road" applications and for "urban" applications; presents examples of data recorded during actual tests for both applications; and compares the advantages of LAD-LORAN with several conventional competitive units.

Attachment #3: Vehicle Location Prototype
LORAN Specifications

Presents the physical, electrical requirements for the units and summarizes the operational characteristics plus the receiver specifications for the Vehicle Location Prototype.

Attachment #4: Handheld Prototype
LORAN Specifications

Presents the same type of information for the Handheld Prototype.

Attachment #5: Competitive Analysis I

Describes the assumptions made and the approach used during tests and presents data analyses of results obtained by the Vehicle Location Prototype.

Attachment #6: Competitive Analysis II

Presents the same type of information and results for the Handheld Prototype.

Attachment #7: BTI Brochures and Data Sheets for Products.

A.2.11.8

SUMMARY NOTES FROM INTERVIEW BY CORRESPONDENCE

ROTOCAST PLASTIC PRODUCTS, INC.

BROWNWOOD, TEXAS

PERSON RESPONDING: Mr. David Fair

SUMMARY

ROTOCAST have been manufacturing, according to the filled-out Survey Questionnaire (Exhibit 1), a line of commercial buoys since 1978. They have also manufactured fast water buoys under contract to the U.S. Coast Guard.

Their commercial buoy line is primarily intended for inland waterways. They are used for applications in shallow waters and swift currents.

ROTOCAST stated that they are not aware of any developments since 1962 other than their experience with the USCG Fast Water Buoy.

Reference: Survey Questionnaire, Received 1/22/1990

SUMMARY OF DATA OBTAINED

SEAWARD INTERNATIONAL, INC.

CLEARBROOK, VIRGINIA

PERSON FORWARDING: Mr. John R. Hill
Sales Administrator

SUMMARY

- o Reportedly Seaward International, Inc. (Seaward) originated the resilient foam filled marine fender and has extended that technology and experience into the field of buoy design and manufacture.

- o The Seaward Sea Float style buoy, which is their primary design, incorporates a steel core surrounded by closed cell foam which is covered with a resilient urethane elastomer skin. This approach reportedly gives them the flexibility to manufacture buoys of almost any shape, buoyancy, color and serviceability.

- o Advantages of their buoys cited by Seaward are resiliency, unsinkability, little or no maintenance and indefinite life expectancy.

- o Seaward has recently delivered a series of Lighted Marker Buoys (LMB) to the Salina Cruz region of Mexico. In addition to mooring buoys their literature includes sketches of an unlighted 5 ft. diameter "Nunbuoy" and a 5 ft. diameter "Sparbuoy," both with internal radar reflectors.

SUMMARY NOTES FROM INFORMATION OBTAINED

RACAL SURVEY, INC.

HOUSTON, TEXAS, USA

PERSON FORWARDING: Dr. James E. Alexander, General Manager

SUMMARY

- Racal Survey, Inc. (RSI) is a division of Racal Data Communications Inc.
- Currently RSI supplies surface positioning systems to the Mine Counter measures group of the United States Navy. RSI has also gained additional positioning experience with hydrographic surveys, ship trials, drilling rig positioning, seismic surveys, dredging etc.
- Data was provided pertaining to their line-of-sight (Micro-Fix) and over-the-horizon (Hyper-Fix) positioning systems.
- Micro-Fix is a short range position fixing system utilizing a microwave interrogation technique to achieve a repeatable accuracy of typically, ± 1 meter. The system utilizes a low power solid state transmitter operating in the 5 GHz board providing a working range of 80km with line of sight. It requires user provided shore based remote stations.
- Hyper-Fix is a microprocessor based medium frequency (1600 KHz to 3400 KHz) phase comparison positioning system. It requires user provided shore based remote stations.

RACAL SURVEY, INC.

EXHIBITS

1. Racal Marine Systems - Brochure.
2. Hyper - Fix descriptive data.
3. Micro - Fix descriptive data.

A.2.11.11

(THIS PAGE INTENTIONALLY LEFT BLANK)

SUMMARY NOTES OF INFORMATION OBTAINED

MOORING SYSTEMS INC.

MONUMENT BEACH, MASSACHUSETTS

CONTACT: Mr. Peter Clay

SUMMARY

- Mooring System, Inc. (MSI) provides a number of buoys and mooring components.
- Their Guardian Series Model - G2000 incorporates a cylindrical hull with one or more chines, a central well, a base, and a tower. It is the midline product in the Guardian Series and is shown in the Exhibits. The floatation collar or body is constructed of Surlyn foam.
- The MSI Guardian Series was developed to replace high cost conventionally constructed buoys to provide a wide range of features and options to meet the needs of the oceanographic community.
- MSI has been involved with The Gilman Corporation (see their separate file) on composite buoys with Surlyn floatation.
- The MTS '90 poster session by MSI and Gilman depicts a number of buoys with Surlyn floatation collars and metallic superstructures and mooring bases.
- The Lighted Guard Buoy and Coastal Discuss Buoy shown in Exhibit 1 have the appearance of a lighted navigation buoy with light atop a cage structure. The Bio Spar Buoy shows an application with a long tail tube.

Conducted: September 28, 1990
At: MTS '90
Washington, D.C.
(See Woods Hole Oceanographic Institution file for Mr. P. Clay)

By: John C. Daidola

A.2.11.12

MOORING SYSTEMS, INC.

EXHIBITS

1. Clay, P. (MSI) and Greider G.M (The Gilman Corporation), MTS `90 Poster Session entitled, "Recent Advances in Off the Shelf Low Cost Surface Buoy Technology."

2. Guardian Series Model G2000, Mooring Systems, Inc.

A.2.11.12

SUMMARY NOTES FROM INTERVIEW

ALU POWER, INC.

WARREN, NEW JERSEY

PERSONS INTERVIEWED: Mr. Robert P. Hamlen

SUMMARY

- They have developed an aluminum-dissolved oxygen (ALDOS) seawater battery.
- The ALDOS cell is an open system with inlets and outlets for seawater entry and exit. It consists of an aluminum alloy anode and an inert cathode substrate at which the dissolved oxygen discharges and an electrolyte gap.
- The cell reaction product, aluminum hydroxide, exits from the cell as an environmentally innocuous precipitate which is then dissipated by the ocean current.
- For use in buoy applications they believe such a battery can be used either directly, or as a recharger for a lead-acid or similar battery.

Interview Conducted: APPROXIMATELY October 9, 1990 (By phone)
At: New York/New Jersey

By: Nedret Basar

ALU POWER, INC.

EXHIBITS

1. Letter of October 9, 1990 describing seawater batteries.
2. Aluminum - Manganese Dioxide Seawater Battery Data Sheet.
3. Aluminum - Water Battery Data Sheet.
4. Aluminum - Dissolved Oxygen Seawater Battery Data Sheet.

A.2.11.13

(THIS PAGE INTENTIONALLY LEFT BLANK)

INFORMATION OBTAINED

DEPARTMENT OF TRANSPORT AND COMMUNICATIONS

CANBERRA, AUSTRALIA

PERSON FORWARDING: Mr. D. Langford
Director Engineering
Marine Navigation Aids Branch

SUMMARY

- The Department (DTC) operates a total of 32 buoys of which 18 are of the 8 ft. x 28 ft. type of steel and 14 are Zeni Lite (see their separate file) Type ZWB-250 of steel and aluminum. All buoys are fitted with solar powered beacons.

- Drawings of the 8 ft. x 28 ft. type are contained in the Exhibits. This type is similar to the U.S. Coast Guard design with the following modifications:

  - The tower and tail tube assemblies are bolded to the hull to make them easier to transport.

  - The tail tube is extended by 2 ft. from the USCG standard to improve stability.

- The ZWB-250 is a 2.5 meter diameter buoy with tail tube and focal plane height of 5.7 meters. These buoys are intended for severe open sea conditions. They are constructed of steel and aluminum with a polyurethane foam filled body.

- To their knowledge, there are no firms in Australia specializing in either buoy design or manufacture. However, many general engineering firms are capable of constructing buoys to supplied drawings.

Information Received: October 1990
At: USCG R&D Center

By: Richard T. Walker

A.3.1

DEPARTMENT OF TRANSPORT AND COMMUNICATIONS

EXHIBITS

1. Lighted Buoy, 8' x 28' with Radar Reflector, General Assembly, Drawing No. 32-83, DTC.

2. Mooring For Large Light Buoys, Drawing No. 32-55, DTC.

3. Buoy Mooring Shackles, Sinker, Swivel and Bridle, Drawing No. CN-32-62, DTC.

4. Sinker, Cast Iron, 38 CWT. Approx., Drawing No. 32-82, DTC.

5. Light Buoys Moorings, 10 ton 15 CWT. SWL-HTS, Small Dee Swivel Shackle, Drawing No. CN-32-167, DTC.

6. Light Buoys Moorings, 13 ton SWL-HTS Large Dee, Bridle Shackle, Drawing No. CN-32-166, DTC.

7. Adaptation of 8' x 28' Lighted Buoy to Acetylene, General Assembly, Drawing No.CN-32-132, DTC.

8. Miscellaneous drawings for 8' x 28' Buoy, DTC.

9. 7 photographs of 8' x 28' Buoy.

SUMMARY NOTES FROM INTERVIEW

ADMINISTRATION DE LA MARINE ET DE LA NAVIGATION INTERIEURE

BRUSSELS, BELGIUM

PERSON INTERVIEWED: Mr. L. Van de Vel

SUMMARY

- o They have 80 buoys covering 5 harbors with 8 entrances.
- o All their buoys have been purchased from Balmoral.
- o Are in the process of converting their buoys from solar/battery power to propane.
- o They have one buoy tender which operates from 9:00 A.M. to 5:00 P.M. in emergencies a tug relieves the buoy tender.

Interview Conducted: June, 1990
At: IALA '90 Meeting
Veldhoven, The Netherlands

By: John C. Daidola

SUMMARY NOTES FROM INTERVIEW

DIRECCION GENERAL TERRITORIO MARITIMO Y MARINA MERCANTE

VALPARAISO, CHILE

PERSON INTERVIEWED: Capt. Estanislau Sebeckis Arce
Capitan de Corbeta Lt. Sn.

SUMMARY

- There are several hundreds of fixed marks and buoys in Chile which has a long coastline. The IALA listings indicate 24 lights on floating marks.
- They have recently developed a new buoy design of their own, a drawing of which was provided.
- They have built this new design in plastic as well as steel. Plastic tends to be damaged during buoy tender operations.
- They have had the best experience with NiCad batteries as opposed to lead acid batteries. They have found these are only 35% more expensive than lead acid when purchased in Sweden.
- The following designers/manufacturers/suppliers were also introduced:
  - CMDR (Ret.) Gonzalo F. Ruiz
    Honorary Member of IALA
    Technical Equipment International Inc.
    Vina Del Mar, Chile
  - Mr. Carlos Patricio Arias
    Beacon Chile LTDA.
    Valparaiso, Chile

Interview Conducted: June, 1990
At: IALA '90 Meeting
Veldhoven, The Netherlands

By: John C. Daidola

SUMMARY NOTES FROM INTERVIEW

DIRECCION GENERAL DE PUERTOS Y SENALES

MALABO EQUATORIAL GUINEA

PERSON INTERVIEWED: Mr. F. Biahute Mateu

SUMMARY

- According to IALA data they have very few buoys.
- They purchase all their equipment and buoys from GISMAN (see their separate file) in France.

Interview Conducted: June, 1990
At: IALA '90 Meeting
Veldhoven, The Netherlands

By: John C. Daidola

(THIS PAGE INTENTIONALLY LEFT BLANK)

SUMMARY NOTES FROM INTERVIEW

GOVERNMENT MARINE DEPARTMENT

HONG KONG

PERSON INTERVIEWED: Mr. R.H. Parry
Marine Department

SUMMARY

- According to IALA listings Hong Kong (HK) has in the order of 85 lighted buoys and 4 unlighted buoys.

- However, HK's principal means of facilitating the safe and expeditious execution of port calls made by commercial shipping and of voyages undertaken by the multifarious passenger-carrying ferries operating on scheduled services to and from HK and a number of ports on the Pearl River between Guangzhuo (Canton) and Macau in its new Vessel Traffic Service (VTS). Secondary allied purposes of the HK VTS are the maintenance of port call records and the automation of certain related invoicing processes.

- There are two principal functions of the HK VTS:

  - surveillance of the waters of Hong Kong and approaches thereto, with highly developed exploitation of the data derived by such surveillance; and

  - ancillary data collection, processing, display and exploitation in support of the purposes of the HK VTS.

- Surveillance data acquisition and exploitation is carried out utilizing seven radars. One is located at the Vessel Travel Center (VTC) and the others are dispersed around the HK geographic area.

- The principal element of ancillary data acquisition and exploitation is a major database (known as the "Informatics System"). A large element within this base is information derived from Lloyd's Maritime Information Service (LMIS) relating to particulars of individual vessels. Associated with the VTC is the Informatics Centre (IC) where information received from external sources (e.g., local ships' agents) is input to the database; other sources in addition to the Marine Department have the capability of inputting directly data related to their routine operation -- Port Health, Immigration, Customs and Excise and the Hong Kong Pilots Association. Through the use of customized software the input data is distributed by the system to a number of terminals for display (read only) and, to a designed extent, for manipulation (read and write). These terminals have access to a number of pre-designed screens and reports which may be printed out on demand, or automatically in certain cases, (watchlists, etc.). A link has been established directly between the Informatics and the surveillance systems such that major trip milestones registered by the latter system are automatically recorded by the former. The extension of this facility enables automatic production of invoices relating to port and light dues, anchorage and government mooring buoy dues and the production of receipts against payment of the many and various fees associated with ship activity provided for in law.

- A paper presented at the IALA '90 Conference described this new and novel system: 5.2.3 The Hong Kong (HK) Vessel Traffic Service (VTS) by R.H. Parry.

Interview Conducted: June, 1990
At: IALA '90 Conference
Veldhoven, The Netherlands

By: John C. Daidola

SUMMARY NOTES FROM INTERVIEW

DEPARTMENT OF LIGHTHOUSES AND LIGHTSHIPS

NEW DELHI, INDIA

PERSONS INTERVIEWED:

Mr. K. Sriram
Deputy Director General

Mr. K. V. Mohan Rao
Deputy Director General

and also

Mr. Harbans S. Grewal*
Managing Director
ANA Navaids Ltd.
New Delhi

(*included here in description of India navigation buoys, but also see ANA Navaids, Ltd.)

SUMMARY

- India has a vast coastline of about 7200 km. including the Islands of Andaman and Nicobar in the Bay of Bengal and Lakshadweep Islands in the Arabian Sea.
- Their navigational aids consist of lighthouses, light vessels, radio beacons and Decca navigator chains all dispersed over the entire coastline.
- The Department of Lighthouses & Lightships is responsible for 300 navigation buoys around India. There are ten district authorities responsible for various regions.
- They use steel and GRP buoys.
- The maximum size buoy that can be handled by their newest buoy tender is:

buoy diameter	- 3.66 m
overall height	- 6.423 m
depth of tail tube	- 3.5 m
diameter of tail tube	- 0.8 m
mooring chain	- 42 mm x 150 m
weight if sinker	- 7 tons

- Power sources include gas, batteries and solar panels.

A.3.6 [1]

Interview Conducted: June 17 and 18, 1990
At: IALA '90 Meeting
Veldhoven, The Netherlands

By: John C. Daidola

A.3.6 [1]

SUMMARY NOTES FROM INTERVIEW

ANA NAVAIDS LTD.

NEW DELHI, INDIA

PERSONS INTERVIEWED: Mr. Harbans S. Grewal
Managing Director

SUMMARY

o ANA Navaids Ltd. (ANA) provides a range of aids to navigation equipment including electric equipment, gas equipment, lantern houses, towers, radar reflectors, navigation buoys, moorings buoys, light floats, light vessels, buoy tenders and mooring gear.

o The range of buoys manufactured by ANA is as follows:

- Small GRP buoys for harbors, rivers and estuaries. These are up to 1.6 meters in diameter and filled with polyurethane foam. Lights are driven by either gas or solar/batteries.

- Medium size GRP buoys for moderate sea conditions. These buoys are up to 2.5 meters in diameter and 6.45 meters in height, with a focal plane of 4.5 meters. They have skirts and resemble USCG cage buoys. They have one central pocket and mild steel angle superstructure. The body is foam fitted with polyurethane foam and color impregnated. The buoys are for general purpose channel marking and can be filled with Lateral or Cardinal Daymarks, Topmarks and Radar Reflectors. Lights can be gas or solar/battery operated. The largest buoy weighs 2400 Kgs and, therefore, can be handled by light craft.

- GRP Catamaran buoys for harbors, rivers and estuaries. The smaller 2.8 x 1.4 x .25 meter buoy with 1.7 meter focal height has two hulls joined at the bow to form a single hull bow so that no floating debris gets entangled in the small gap between the hulls. The catamaran is reportedly very suitable where water depth may vary from a dry river bed to 15 meters depth and the current may reach 8 knots, wherein the buoy remains upright and stable. The larger catamaran buoy of 4.3 x 2.6 x .27 meters with 3.3 meter focal height is suitable for water depths up to 20 meters and currents to 8 knots. The two hulls have enough separation to let floating debris pass between them. Both buoys are foam filled and either gas or solar/battery powered.

- Skirt and tail tube steel buoys for from moderate sea to deep sea, with diameters from 2.2 meters to 3.6 meters and focal plane heights from 3.6 meters to 6.7 meters. These buoys are constructed of mild steel and have a single center pocket for gas

A.3.6 [2]

cylinders or batteries. These buoys may be fitted with rubber fenders.

- Light floats of overall length of 10 meters, 18 meters and an unattended light vessel of 23 meters.

o GRP buoys require 3 times the counterweight to achieve the same motion response as steel buoys. GRP is harder to repair.

o ANA has a contract to maintain navigation buoys.

o Birds dropping fish on solar panels on buoys close to shore is more of a problem than droppings. Panels have to be cleaned every two months.

o Believe gas driven lights are more dependable than batteries and solar. Gas lights are also brighter. Believe people left gas so as to not be left out of new devices and the electronics of the electronic age.

o NiCad batteries are supposed to last 5 years, but will probably last 3. They are using completely sealed batteries.

o Radar range is not normally checked, but was done in a case by test (10 km for sea buoy). Don't make visibility checks, but can see them at 7 km

o A completed steel buoy in India costs about US$ 2/kilogram.

Interview Conducted: June 17 and 18, 1990
At: IALA '90 Meeting
Veldhoven, The Netherlands

By: John C. Daidola

ANA NAVAIDS LTD.

EXHIBITS

1. Aids to Navigation Catalogue, ANA Navaids Ltd.

SUMMARY NOTES FROM INTERVIEW

COMMISSIONER OF IRISH LIGHTS

DUBLIN, IRELAND

PERSONS INTERVIEWED:

Mr. J.J. Doyle

Mr. M.B. McStay
Engineer-in-Chief

Dr. S.G.R. Ruttle
Deputy Engineer-in-Chief

SUMMARY

- They have been trying to standardize their buoys. Had too many types.
- They have also centralized operations.
- They bring all buoys to be positioned to a location convenient to their buoy tender for pick-up. Since Ireland is only 200 miles across, this is not so difficult.
- Have installed buoy pockets in their buoy tender to afford better stacking of buoys on the buoy deck.
- From IALA summaries it appears they have 105 lights on floating buoys, 2 buoy tenders longer than 30 meters in length and 1 less than 30 meters.
- They have buoys of their own design and had hoped to deliver drawings but apparently were unable to do so.

Interview Conducted: June, 1990
At: IALA '90 Meeting
Veldhoven, The Netherlands

By: John C. Daidola

SUMMARY NOTES FROM INTERVIEW

MINISTRY OF TRANSPORT

MALAWI

PERSON INTERVIEWED: Mr. F. S. Chilalika

SUMMARY

- Malawi is inland from Mozambique and does not have a seacoast.
- Their buoyage is used on a major lake.
- They have 11 fixed marks and 7 buoys--all from Pharos (see their separate file).

Interview Conducted: June, 1990
At: IALA '90 Meeting
Veldhoven, The Netherlands

By: John C. Daidola

SUMMARY NOTES FROM INTERVIEW

THE MARINE DIVISION, MINISTRY OF TRANSPORT

WELLINGTON, NEW ZEALAND

PERSONS INTERVIEWED: Capt. D.W. Boyes

SUMMARY

- There is deep water all around the island. As a result they only have seven offshore buoys which they purchase from manufacturers.
- Harbor buoys are handled locally.
- An Industrial Member from New Zealand was present at the IALA '90 Conference. Vega Industries did not have a display nor was there an opportunity to speak to their representative Mr. J.P. Rochfort.

Interview Conducted: June 1990
At: IALA '90 Meeting
Veldhoven, The Netherlands

By: John C. Daidola

SUMMARY NOTES FROM INTERVIEW

NIGERIAN PORT AUTHORITY

LAGOS, NIGERIA

PERSON INTERVIEWED: Capt. A.O. (Tony) Olugbode
Ag. Deputy Director Harbors

SUMMARY

- Nigeria is more developed than other third world countries, particularly in Africa.
- The Nigerian Port Authority (NPA) has a total of 300 buoys made up of those from Tidelands, Automatic Power, Balmoral and some others (see separate files on these companies).
- The NPA services these buoys with two buoy tenders, one for offshore work and one for rivers.
- Every two years buoys are hauled and the moorings checked. The warm water in their area is particularly hard on equipment.
- They have found GRP is hard to repair and, as a result, has not worked out favorably for them.
- Maintenance is their most significant consideration and it is expensive.
- They have ordered a Balmoral GRP buoy with elastomer.
- They have found that the claims of manufacturers are always good, but are not always borne out in practice.
- They feel that manufacturers, whom they are dependant upon, should place more emphasis on the reliability and maintainability of their buoys and equipment.

Interview Conducted: June, 1990
At: IALA '90 Meeting
Veldhoven, The Netherlands

By: John C. Daidola

SUMMARY NOTES OF DATA OBTAINED

SHANGHAI NAVIGATION AID FACTORY

SHANGHAI, PEOPLES REPUBLIC OF CHINA

AGENT:	Hei Tung Marine Machinery Suppliers, Ltd. Hong Kong
DATE OBTAINED:	IALA '90 Conference

SUMMARY

- The Shanghai Navigation Aid Factory (SNAF) has a history of more than 100 years in design, manufacture, and maintenance of aids to navigation. They have been engaged in developing and manufacturing buoys for forty years.
- Their buoys can be found in every harbor and channel of the Peoples Republic of China (PRC). In recent years they have produced buoys for America, England, Mexico and Mauritania.
- Their navigation buoys appear to consist of steel tail tube buoys from 1.15 to 3.83 meters in diameter, steel skirt buoys of from 1.5 to 2.4 meters in diameter, and smaller inland buoys of steel with tail tube and skirts.
- The above information was obtained from their catalogue.

SHANGHAI NAVIGATION AID FACTORY

<u>EXHIBITS</u>

1. SNA, Aids to Navigation Catalogue.

(THIS PAGE INTENTIONALLY LEFT BLANK)

INFORMATION OBTAINED

SAUDI PORTS AUTHORITY

RIYADH, SAUDI ARABIA

OBTAINED: IALA '90 Conference

SUMMARY

- Fifteen years ago very few marine aids to navigation existed in Saudi Arabia remote from the oil exporting terminals and their approaches. Since then a rapid expansion in port facilities has seen an equally rapid improvement of aids to navigation.

- More than 400 light buoys have been laid in approaches to the ports and significant advances have been made in marking the coral reefs with beacons.

- Longer range navigation has been made safer by the deployment of a Loran-C Radio Navigation System, which covers all the coastal waters.

- In the continuing efforts to increase navigational safety in the approaches to the ports, surveillance radar equipment has been installed at Yanba, Jeddah, Ras Tanara and Jubail.

- Five buoy tenders ranging from a small buoy maintenance catamaran to two sea-going maintenance vessels are employed in service.

- Believe Saudi buoys are standard buoys purchased from manufacturers like Pintsch-Bamag (see their separate file) who confirmed they did have contracts with the Saudis.

- During presentations at the IALA '90 Conference the Saudis noted:

  - The Gulf buoys have solar panels on top like Japanese buoys and they are set at a 10o incline to the horizontal.

  - Dust collection and bird droppings have a severe impact on the solar panel operation.

  - As a result the solar panels are not performing at anywhere near the level suggested by the manufacturer/supplier. As a result they have increased maintenance to clean and replace panels and change batteries.

- Solarization is actually more expensive for them and they feel the industrial members of IALA should address this. They will not install any more solar panels until they believe the situation will improve.

Interview Conducted: June, 1990
At: IALA '90 Meeting
Veldhoven, The Netherlands

By: John C. Daidola

SUMMARY NOTES FROM INTERVIEW

NORTHERN LIGHTHOUSE BOARD

EDINBURGH, SCOTLAND

PERSONS INTERVIEWED: Sh. Pr. R.R. Taylor

SUMMARY

- Responsible for all navigation buoys around Scotland except for those of the Clyde Port Authority.
- No more than 300 buoys.
- In the order of 100 are lighted; the power source is acetylene, although they are converting to solar/battery power.

Interview Conducted: June 1990
At: IALA '90 Meeting
Veldhoven, The Netherlands

By: John C. Daidola

SUMMARY NOTES FROM INTERVIEW

SOUTH AFRICAN HARBORS AUTHORITY

BRAAMFONTEIN, SOUTH AFRICA

PERSON INTERVIEWED: Mr. J. H. Collocott

SUMMARY

- The South African Harbors Authority (SAH) maintains 300 buoys at 5 major and 3 minor harbor entrances.
- The have been purchasing buoys from established manufacturers.
- Their 300 buoys are of various designs.
- They have a Resinex (see their separate file) buoyant beacon. In the future, Resinex has said they will have a telescoping buoyant beacon with telescoping mast for the tide changes.
- They have a double hull buoy made from pressed hemispherical heads made in a boiler factory.

Interview Conducted: June, 1990
At: IALA '90 Meeting
Veldhoven, The Netherlands

By: John C. Daidola

SUMMARY NOTES FROM INTERVIEW

THE NATIONAL SWEDISH ADMINISTRATION OF SHIPPING AND NAVIGATION

NORRKOPING, SWEDEN

PERSONS INTERVIEWED:

Capt. Kjell-Ake Reslow
Head of Department

Capt. T. Edenius
Head of Section,
Aids to Navigation

Mr. Christer Wolinder
Project Engineer,
Aids to Navigation

Mr. Daniel Andersson
Engineer Aids to Navigation

Mr. Christian Lagorwall
Engineer Aids to Navigation

SUMMARY

- Have up to 10,000 buoys including private aids.
- They utilize steel offshore buoys and plastic in-shore.
- Their buoy tenders operate in ice up to 20 cm in thickness.
- A buoy data requirements list was given to the NSA which they intended to respond to.

Interview Conducted: June 20, 1990
At: IALA '90 Meeting
Veldhoven, The Netherlands

By: John C. Daidola

A.3.15

(THIS PAGE INTENTIONALLY LEFT BLANK)

APPENDIX D

Cumulative Area, Visual Range, and Radar Range Calculations

D.1 Introduction

This Appendix is intended to describe the methods and assumptions used in determining the cumulative areas, nominal visual ranges, and radar ranges for buoys contained in the Buoy Technology Information System (BTIS) database. Values for each of these data items were not readily available from data collected during the buoy survey; however, there was enough data to calculate them for a significant portion of the buoys. Calculations for these values were carried out in accordance with procedures outlined in USCG Memo 10500 of 6/7/90 re: New Buoy Systems Detection Ranges. These calculations were performed for all buoys for which sufficient data was available. The total number of buoys for which each calculation was performed is given in the table below:

Item	USCG	Non-USCG	Total
Cumulative Area	51	275	326
Visual Range	51	273	324
Radar Range	37	141	178

There are a total of 370 buoys in the BTIS database.

D.2. Cumulative Area Calculation

D.2.1. General

Curves of cumulative area vs. height above waterline were calculated for each buoy in the databases for which sufficient data exists. Cumulative area is defined as the total lateral projected area of the buoy between the waterline and a prescribed height above the waterline. For buoys which have openings in the above-water profile (i.e. lattice towers, crow's nests, etc.), a correction factor was applied to the calculated silhouette area to obtain the effective lateral area of the buoy. These correction factors were determined by calculating actual net areas for representative buoys which have similar above-waterline structure and equipment. The plotted curves which resulted from these calculations are provided along with the hardcopy database records presented in Appendix B.

D.2.2. Assumptions and Requirements

In order to carry out the cumulative area calculation, certain assumptions were made and some basic information was required. These assumptions and requirements are as follows:

- o The reference waterline is taken as the "no-mooring" waterline for the buoy.

- A scalable drawing or photograph is required so that height and width ordinates can be measured.

- No-mooring draft or freeboard information must be available. In some instances, where the underwater buoy shape was relatively simple and the buoy weight was known, an estimate of the no-mooring waterline was calculated and used for the area curve calculation in the absence of any other information.

D.2.3. Calculation Method

The procedure used for calculating the cumulative area consisted of first breaking the above-water buoy profile into height divisions according to breaks in shape. The shape of each section dictated how many division points were required. Sections with straight sides required divisions at the top and bottom only, whereas sections with tapered sides required an additional division at the midpoint. Sections with curved sides were assigned additional divisions as required to sufficiently define the shape of the cumulative area curve. A sample height division scheme is presented as Figure D-1.

The width of the buoy silhouette was measured at each height division and the areas of the trapezoids between each division were calculated. The resulting incremental areas were then multiplied by the appropriate correction factor to account for openings in the superstructure and then summed as a running total from the waterline to each height division. A sample of this calculation is shown on Figure D-2. The resulting values were then plotted as a curve of cumulative area vs. height using straight lines to connect the points. A sample cumulative area curve is presented as Figure D-3.

D.3. Nominal Visual Range Calculation

D.3.1. General

The nominal visual range was calculated as a function of above-water projected area for each buoy for which sufficient data exists. The calculations were performed in accordance with the procedure outlined in USCG Memo 10500. The visual range which results from this calculation is a relative measure of detectability and <u>not</u> an intrinsic property of the buoy. Actual detection range is often much less than these determined values. The calculated visual ranges have been incorporated into the BTIS buoy database records.

D.3.2. Assumptions and Requirements

In order to carry out the nominal visual range calculation, certain assumptions were made and some basic information was required. These assumptions and requirements are as follows:

- The cumulative area curve for the buoy must be obtained as described in Section D.2. above.

- The minimum freeboard waterline is taken as the reference waterline for the calculation. If no minimum freeboard information is available, it may be estimated as 16% of the depth of the main buoy hull.

- Meteorological range is taken as 10 nautical miles and effective contrast is taken as 0.7.

D.3.3 Calculation Method

The nominal visual range calculation is accomplished by first obtaining the total cumulative area from the no-mooring waterline to the highest point on the buoy. Next, the minimum freeboard is subtracted from the no-mooring freeboard and the cumulative area to the minimum freeboard line is read from the curve at this height difference. This area is then subtracted from the total buoy area to obtain the net cumulative area. Next, the visual range (in yards) is read by entering Duntley's Nomogram (Enclosure (2) to Memo 10500 at the appropriate net area curve. Finally, the range is converted to nautical miles with a resolution of 0.1 NM. A sample of this calculation is shown in Figure D-2.

D.4. Radar Range Calculations

D.4.1. General

Radar ranges were calculated for those buoys fitted with radar reflectors for which sufficient data exists. The calculations were performed in accordance with the procedure outlined in USCG Memo 10500. The resulting radar range is a relative measure of detectability and not an intrinsic property of the buoy. Actual radar ranges are often much less than the calculated values. Radar ranges thus calculated have been entered into the BTIS database records for the appropriate buoys.

D.4.2. Assumptions and Requirements

In calculating the radar range of buoys, the following assumptions were made and basic information required:

- The radar set is assumed to operate with a 3 cm. wavelength and a radar constant of 135. The antenna height is assumed to be 50 feet.

- Reflector height is referenced to the minimum freeboard waterline.

- The radar reflector must be shown on a scalable drawing or photograph so that reflector dimensions and/or height may be measured.

D.4.3. Calculation Method

The radar range calculation is performed by first obtaining the echo area for the radar reflector. The echo area may be calculated using scaled reflector dimensions and applying them to the echo area formulas provided in Enclosure (4) of Memo 10500. Alternatively, echo areas may be obtained from manufacturers' data provided they are calculated for a radar wavelength of approximately 3 cm. Once the echo area (@) is calculated, the reflector constant (Y) is calculated using the relation:

$$Y = -10 \log (1/@).$$

The reflector constant is then added to the radar constant and this value is used to enter the radar range curves (Enclosure (3) of Memo 10500). The radar range is then read from the curve (in yards) and converted to nautical miles with a resolution of 0.1 NM. A sample of this calculation is included in Figure D-2.

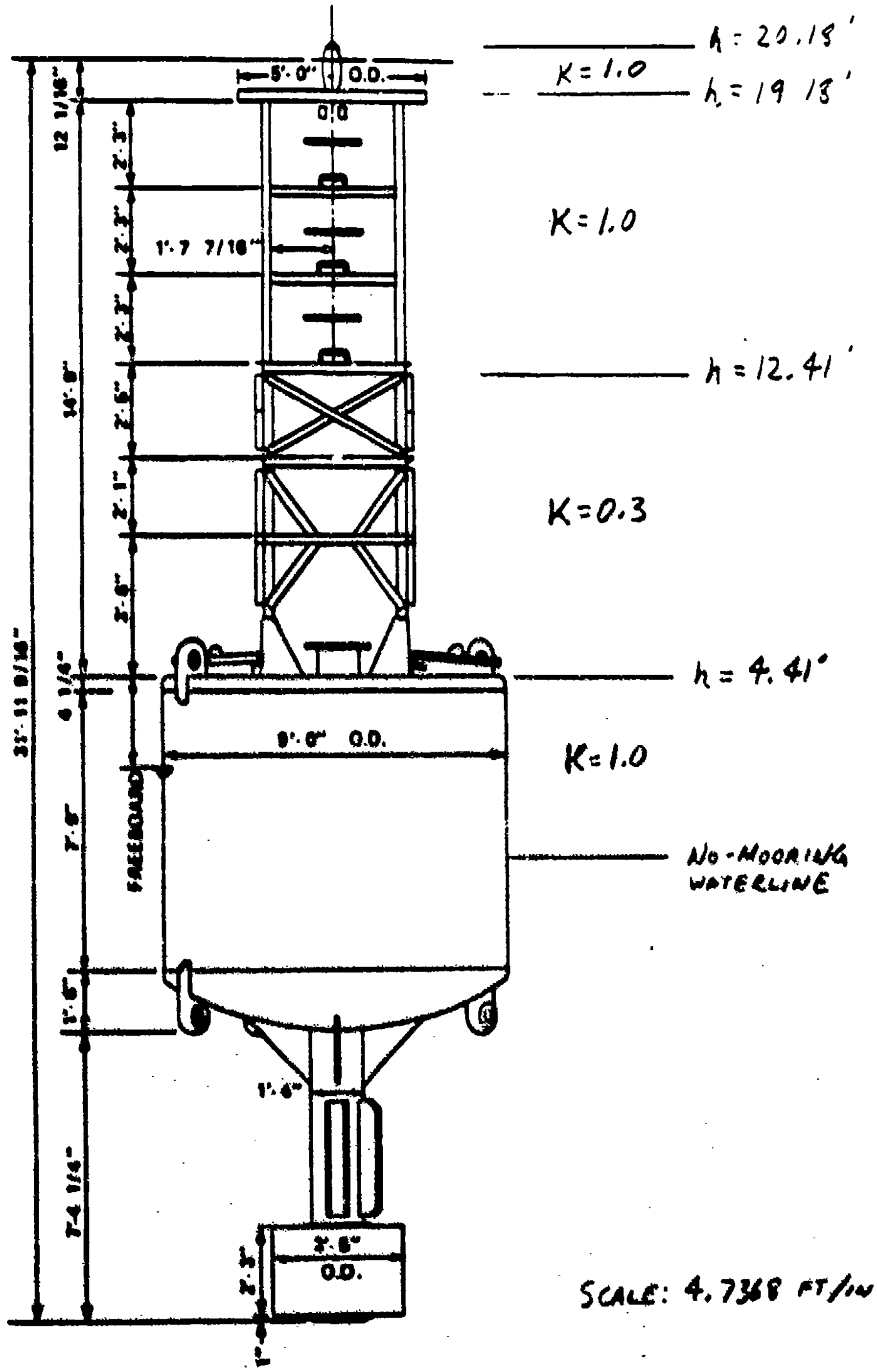


Figure D-1. Sample Height Division Scheme.

				9X32 LR		
Scale	4.7368 ft/in			Cumulative Area Calculation		
Height Ord	Width Ord	Coeff		Height, Ft	dArea	Cumulative Area
0	1.9	1		0.00	0.00	0.00
0.93	1.9	1		4.41	39.65	39.65
0.93	0.83	1		4.41	0.00	39.65
2.62	0.83	0.3		12.41	9.44	49.09
4.05	0.83	1		19.18	26.63	75.72
4.05	0.08	1		19.18	0.00	75.72
4.26	0.08	1		20.18	0.38	76.10

Visual Range Calculation

Max. Fbd.	4.42	Ft
Min. Fbd.	1.33	Ft
Fbd Diff.	3.09	Ft
Tot. Area	76	Ft^2
Net Area	49	Ft^2
Contrast	0.7	
Met. Range	20000	Yds
Vis. Range	6000	Yds
	3.0	Nmi

Radar Range Calculation

Echo Area	11493	Yds^2
Ref. Const	41	
Rec. Const	135	
'Z'	176	
Ref. Ht	12.71	Ft
Rad. Range	16500	Yds
	8.1	Nmi

Figure D-2. Sample Calculations.

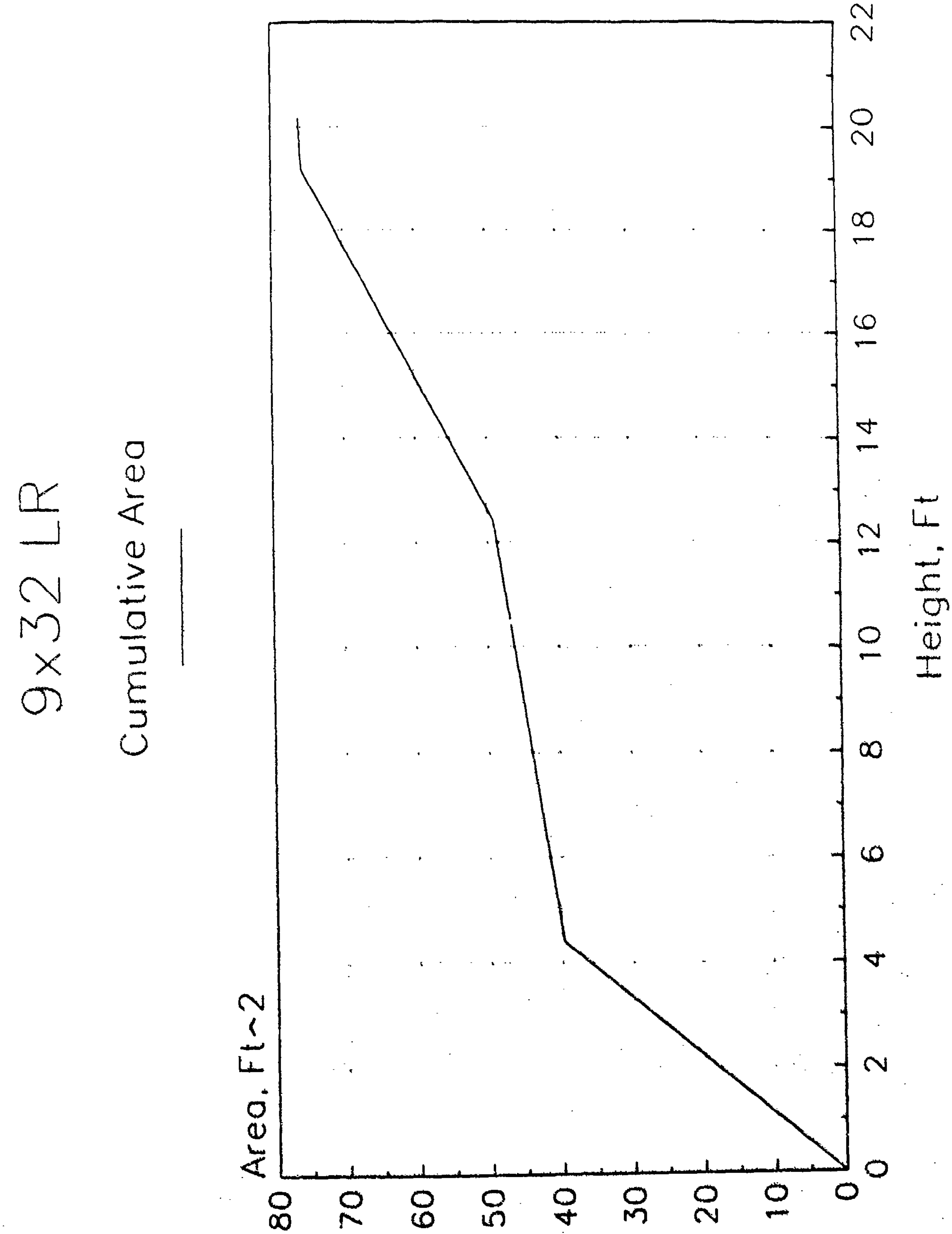


Figure D-3. Sample Cumulative Area Curve.

(THIS PAGE INTENTIONALLY LEFT BLANK)

Appendix E

Trip Report

of

The 1990 IALA CONFERENCE

Veldhoven,

The Netherlands

Prepared For:
U.S. Coast Guard
Research and Development Center
Avery Point
Groton, CT 06340

Prepared by:
M. ROSENBLATT & SON, INC.
NAVAL ARCHITECTS & MARINE ENGINEERS
350 BROADWAY
NEW YORK, NY 10013

Report #15221-3

July 11, 1990

TABLE OF CONTENTS

1. INTRODUCTION

As part of the workscope of the U.S. Coast Guard (USCG) contract DTCG39-89-C-E27E04, New Buoy Systems, Buoy Technology Survey, M. Rosenblatt & Son, Inc. personnel attended the 1990 IALA Conference in Veldhoven, The Netherlands. Dr. John C. Daidola, Project Manager, attended during the period June 17 through June 27 and Mr. F. Martin Johnson, Project Engineer, attended during the period June 20 through June 27.

The principal objectives of MR&S participation were as follows:

- Attend presentation of technical papers and technical show exhibits relevant to floating short range aids to navigation and navigation systems, as well as any other topics pertinent to the New Buoy Systems Project.

- Augment the data collected to date during performance of the Task B Worldwide Buoy Technology Survey. This was to be accomplished by endeavoring to meet the sources during the conference and secure the data.

- Obtain conference proceedings and any other significant hard copy information for the USCG R&D Center, to be delivered at the conclusion of the contract Task B.

The sections that follow this Introduction summarize the results of MR&S efforts at the Conference. A hard copy of all proceedings and other materials collected will be delivered with other hard copy material at the conclusion of Task B.

2. SESSION SUMMARIES

2.1 General

The Conference was arranged so as to consider the following topics on the dates noted:

System Approach -	June 18
Management Issues -	June 19
Navigation Guide -	June 20
Fixed and Floating Aids -	June 21-22
Radionavigation, Remote Control and Electronics -	June 23
Radio Aids to Navigation -	June 24
Exhibition -	June 24 - June 29
Aspects of VTS -	June 27-28
Civil Engineering -	June 28-29

Herein a brief summary statement is given of the content of the sessions.

2.2 Systems Approach

An overview of the subjects covered in this area indicated that most reports (there were twelve papers in all) questioned the viability of certain aids to navigation. Specifically, it was noted that visual aids appear to be reducing in importance whereas radar detection through RACONS is increasing in importance. The following three presenations were cited as being particularly interesting and thought provoking:

- o The Dutch paper proposing the marking of the North Sea by RACONS with a drastic reduction in the number of floating buoys.
- o The Korean paper suggesting the setting of aids to navigation in accordance with a probability-of-danger analysis.
- o The English (Nautical Institute) report identifying the needs of the mariner.

These three presentations and possibly some others serve to indicate potentially impending implementation schemes for floating buoyage. These will be considered during the selection of R&D projects during Task C.

2.3 Management Issues

The principal topics covered during this session were: Training of ATON personnel; privatization of buoy tending for servicing of aids to navigation; automation of aids to navigation (particularly lighthouses); reduction in manpower levels of ATON authorities; computerization of data handling; and cost effectiveness of aids to navigation systems.

In the latter category papers were presented that may be of use in Task C in identifying R&D projects. These papers covered fixed structures versus floating aids, cost benefit analysis of traffic safety programs, life cycles cost analysis of power supply systems for buoys and a French paper giving buoy cost data for the district handling about 200 buoys in the Bordeaux area (input to Task B).

2.4 Navigation Guide

An IALA Navigation Guide was distributed at the meeting (which will be provided to the R&D Center) and the panel of the chairmen responsible for its development were present to summarize each of the chapters which include:

- Policy
- Navigational Requirements for Accuracy
- Availability/Reliability of Aids
- Standardization of Aids
- Waterway Design Considerations
- Evaluation of the Need for Aids to Navigation
- Information to the Mariner
- Aids to Navigation Systems
- Aids to Navigation Plan

The requirements for floating aids to navigation stated in the Navigation Guide will be considered in identifying R&D projects for Task C.

2.5 Fixed and Floating Aids to Navigation

The topics covered during this session can be grouped into five basic categories: visual studies, floating aids, control, servicing vessels and equipment. The visual studies topics centered mainly on methods of improving conspicuity through the use of extended light sources and better marking practices. The effects of rolling buoy motion on light detection were also discussed. The floating aids topics covered the latest USCG experience with ELB's, articulated lights and foam buoys; German experience with a modular buoy concept; and the results of an extensive Canadian test program on buoy corrosion and coating systems. The control topics mainly centered on microprocessor monitor and control installations for large navigational buoys. The servicing vessel discussions covered a new design for an Indian offshore buoy tender and the USCG expectations for their upcoming offshore and coastal buoy tender procurement. Lastly, the topics on equipment covered lighting equipment for fixed and floating aids such as new rotating beacons and LED light sources.

During the remaining portion of this session it was stated that the trends in floating aids to navigation are: designs based on mathematical models or model tests, performance data is collected from buoy stations, longer service periods, better materials and conversion of buoy stations to fixed aids to navigation.

Of the topics discussed above, those which show significant applicability to the New Buoy Systems project are: 1) the probability of detection studies on rolling buoys; 2) the USCG experience with floating aids; 3) the German modular buoy concept; and 4) the Canadian buoy coating system study.

2.6 Special Session: Energy Sources

The topics covered in this session related to power sources for both fixed and floating aids to navigation. The types of power sources discussed in the presentation were: solar panels, primary batteries, wave-activated generators and seawater primary batteries. Solar power still appears to be the predominant replacement for primary batteries in floating aids to navigation, although experiences among nations which have converted their aids suggests that fouling due to bird droppings is still a significant problem. The main efforts with regard to primary batteries have been to make them more environmentally compatible by reducing or eliminating the content of mercury and other hazardous compounds. Two novel concepts (initial studies and testing) for wave-activated generators were also presented in this session, both of which eliminated the admission of seawater into the working mechanism. A new type of seawater primary battery was introduced, which shows promise for application to lighted buoys. The results of wind generator use in fixed aids and utilization of batteries and solar panels with varying arrangements were also addressed.

This current thinking in energy sources and new forms of energy generation could impact buoy design and will be considered in Task C.

2.7 Radionavigation, Remote Control and Electronics

The topics covered in this session related mainly to electronic navigational aids and control and monitoring systems for aids to navigation. The first portion of the session dealt primarily with satellite and terrestrial electronic navigation with particular emphasis on Loran C, GPS, and Differential GPS. The control and monitoring topics focused on data and communication links between inland and remote navigational aid stations. The most popular methods for maintaining such links appear to be radio transmissions from offshore navaid locations to inland stations and public phone links between inland stations. Additionally, there was some discussion on the use of RACONS with floating aids. Navigation authorities in Sweden are looking to expand the use of RACONS on their floating aids while the U.S. is not looking to expand the relatively small number in service.

Overall, it does not appear that radionavigation methods will supplant maritime buoyage for coastal areas in the foreseeable future due to deficiencies in accuracy and availability. As monitoring and control devices become more compact and reliable, their application to minor floating aids may become more frequent. Finally, the use of RACONS in the U.S. aid to navigation system does not appear to be expanding.

2.8 Aspects of VTS

During the introduction to this session it was noted that Vessel Traffic Services (VTS) are becoming more widespread and an IALA manual for shipboard use while operating under such a system has been developed for all ships. IMO has adopted IALA recommendations. Canada's system is maturing and expanding. Hong Kong and Singapore systems are now in place. China is currently introducing VTS in some of their rivers.

The content of this session during the period of MR&S attendance focused mainly on applications of VTS in busy harbor areas of specific countries, most notably Canada and Germany. The methods employed in VTS do not appear to vary greatly from country to country and consist mainly of correlating VHF radio communications from ships with shore-based radar monitoring. Significant new efforts include Canada's experiments in extending VTS beyond their territorial waters and Germany's efforts to establish a ship identification system using VHF DF technology.

Based on the presentations given during this session, it does not appear that VTS technology is advancing in a way that is aimed at the elimination of maritime buoyage or to impact buoy design. However, the certainty of an increasing presence of such systems in the future will be considered in developing topics for R&D in Task C.

3. BUOYAGE AUTHORITY CONTACTS

The presence of buoyage authorities from a large number of countries afforded the opportunity to make follow-on requests for data from the countries originally visited during Task B. These requests were made verbally and the contact was given a hard-copy listing of the data desired. Additionally, it was possible to learn about the floating buoyage of a number of other countries. The followng listing indicates the contacts and status:

Country (Originally Contacted During Task B)	Status	Persons	Additional Data Expected
France	Sending info and will review data list.	Mr. Chauviere Mr. Cunty	Yes
England	Have data list.	Capt. Edge	Yes
Netherlands	Have data list.	Mr. Van der Ent	Yes
Japan	Have data list.	Mr. Moriyama (but forwarded to Mr. Noguchi)	Possibly
Denmark	Have data list.	Mr. Nissen	Possibly
Germany (FRG)	Have data list.	Mr. Kuhlbrodt	Yes
Finland	Returned marked-up data list.	Mr. Martonen	No
Norway	Have data list.	Mr. Ording	Yes
Canada	Have data list.	Mr. Lorquet	Possibly

Additional Countries	Status	Persons	Data Expected
Nigeria	Discussed.	Capt. Olugbode	No
Sweden	Have BTIS Info Sheet.	Mr. T. Edenius, et al.	Yes
Belgium	Discussed.	Mr. Van de Vel	No
South Africa	Discussed.	Mr. Collocott	Yes
Equat. Guinea	Discussed.	Mr. Mateu	No

Additional Countries	Status	Persons	Additional Data Expected
Chile	Discussed and received info.	Lt. Cdr. E. Arce	No
Saudi Arabia	Some general data obtained.	----	No
Ireland	Have BTIS Info. Sheet	Mr. Doyle	Yes
New Zealand	Discussed.	Capt. Boyes	No
Malawi	Discussed.	Mr. Chilalika	No
Hong Kong	Discussion on VTS.	Mr. Hunt (?)	No
India	Discussed.	Messrs. Rao and Sriram and Mr. Grewal of ANA aids	No
Scotland	Discussion.		No

4. MANUFACTURER CONTACTS

The IALA Industrial Members' Exhibition provided an opportunity to contact buoy manufacturers and fill in any gaps in the buoy data obtained from the earlier survey. It also proved to be an excellent opportunity to contact and obtain data from other manufacturers who had not responded or had not been contacted during the earlier effort. A list of the manufacturers contacted by MR&S at this exhibition is as follows:

- All Marine, Inc. (Netherlands)
- Gisman, Inc. (France)
- Floatex, Inc. (Italy)
- Balmoral Nav Aids, Ltd. (Scotland)
- Ryokuseisha Corp. (Japan)
- Zeni Light Buoy Co., Ltd. (Japan)
- Shanghai Navigation Aids (People's Republic of China)
- Resinex, Inc. (Italy)
- ANA Navaids Ltd. (India)
- Electronic Supply Company (Denmark)
- Technical Equipment International Inc. (Chile)
- Automatic Power Inc. (USA)
- Japan Association for Aids to Navigation
- RACAL Marine Group Limited (England)
- Nippon Kuki Kugyo Co., Ltd. (Japan)
- Damen Shipyards (The Netherlands)
- Beacon Chile Ltd. (Chile)
- Gakyo Tokikogyo Co., Ltd. (Japan)
- Pintsch Bamag (The Netherlands and FRG)

5. LISTING OF DATA OBTAINED

- Transactions of IALA 1990 Conference
- IALA Aids to Navigation Guide (NAVGUIDE)
- IALA Guide to the Availability and Reliability of Aids to Navigation
- Balmoral Nav - Aids Catalogue
- Vessel Traffic Management in the Port of Rotterdam
- Floatex Catalogue
- Ryokuseisha Catalogue
- Zeni Light Buoy Co. Catalogue
- ANA Navaids Catalogue
- Saudi Ports Authority Aids to Navigation
- Comments from the Buoy Authority of Finland
- Drawing of New Chilean Buoy
- Buoy Paint Systems Approved for Use by the Canadian Government
- Resinex Catalogue
- Drawing of the All Marine All Weather Heavy Duty Light Buoy