



LIBRARY  
TECHNICAL REPORT SECTION  
NAVAL POSTGRADUATE SCHOOL  
MONTEREY, CALIFORNIA 93940

Technical Report No. 44

SACLANT ASW  
RESEARCH CENTRE

AN INSTRUMENT FOR MEASURING EVAPORATION

by

Allen H. Schooley

1 SEPTEMBER 1965

NATO

VIALE SAN BARTOLOMEO, 92  
LA SPEZIA, ITALY



AD0472616

NATO UNCLASSIFIED

TECHNICAL REPORT NO. 44

SACLANT ASW RESEARCH CENTRE

Viale San Bartolomeo 92

La Spezia, Italy

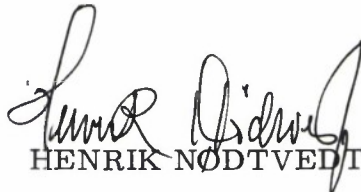
AN INSTRUMENT FOR MEASURING EVAPORATION

By

Allen H. Schooley

1 September 1965

APPROVED FOR DISTRIBUTION



HENRIK NØDTVEDT

Director

NATO UNCLASSIFIED

## TABLE OF CONTENTS

	<u>Page</u>
ABSTRACT	1
INTRODUCTION	2
1. PRINCIPLE OF OPERATION	3
2. WORKING MODEL	5
3. APPLICATIONS	6
REFERENCES	7
FIGURES	8

# AN INSTRUMENT FOR MEASURING EVAPORATION

By

A.H. Schooley

## ABSTRACT

An evaporation rate meter, or evaporimeter, has been devised that shows promise of directly measuring the rate of evaporation near the sea surface. The simplicity of the instrument indicates that it may be of interest to oceanographers, and possibly to meteorologists and climatologists.

## INTRODUCTION

According to von Arx (Ref. 1) the amount of water distilled into the atmosphere from the sea has been estimated by measuring the evaporation from pans of water on shipboard, by meteorological measurements of the upward flux of water vapour in the air above the sea, and by evaluating the successive terms in the steady-state heat budget for the oceans.

It appears that a simpler and more direct method of evaporation measurement is desirable. It is believed that the evaporimeter herein described may be a helpful tool in evaporation studies. The instrument described has only recently been devised and has not yet been used at sea. Early publication has been advised because of the instrument's simplicity and its possible application by others.

## 1. PRINCIPLE OF OPERATION

Figure 1 is a schematic, cross-sectional view of the instrument. The left-hand side of the plastic tube is filled with water contained between a porous filter and a thin cork disk. By wick action, the porous filter presents a continuously wet surface at the left-hand opening of the tube where evaporation occurs. The cork disk fits loosely in the plastic tubing. As its left-hand surface is wetted by the water, but its right-hand surface — being coated with beeswax — is not wetted, capillary forces tend to hold the disk at the water surface. A wire pointer attached to the disk serves both to hold the disk perpendicular to the axis of the tubing and to indicate — along the scale at the right — the position of the water surface.

Models of the evaporimeter have been made both with plastic tubes of 3 mm internal diameter and with those of 5 mm internal diameter. When the material of the tubing can not be wetted by the water, there is very little tendency for water to seep past a cork disk fitting loosely inside such sized tubes. The disk will recover to its stable position (to within about 0.1 mm) even when it is forced in either direction by as much as 0.5 mm. The disk's adherence to the water surface is sufficient for it to remain in position when the tubing is held either straight up or straight down. Even in these positions, moderate jarring will not break the disk away from the water surface. Although the device will work at any angle, it is thought that approximately horizontal operation is probably best, thereby minimizing any effect that the varying head of water in the tube might have as evaporation progresses.

For making measurements, the filter end of the tube is exposed to the environment in which evaporation is to be measured. The obstruction of the

cork disk impedes air circulation and minimizes evaporation loss from the other end of the water column. If the evaporation-surface area of the porous filter is assumed to be the same as the cross-sectional area of the water in the tube, differences with time of the scale readings will indicate the evaporation rate in unit scale length per unit time. The sensitivity of the instrument can be changed by changing the ratio between these two areas: greater sensitivity being obtained by proportionally increasing the evaporation-surface area of the filter. It is conceivable that a series of caps with various sized holes in their ends could be made to fit over the filter end of the tubing to give selected evaporation areas and, hence, various sensitivities.

The evaporimeter is refilled, when necessary, by letting it soak in distilled water of the required depth, filter end down. It can also be filled by the use of a thin hypodermic needle inserted through the filter, or by removing the cork disk and filling through a long hypodermic needle.

## 2. WORKING MODEL

Figure 2 shows one embodiment of the evaporimeter. In this case the scale is mounted below the water-filled tube so that the position of the cork disk can be read directly at any time. A further 5 cm of the plastic tubing on the right-hand side has had approximately a quarter of its diameter removed to leave a channel in which a narrow strip of pressure-sensitive recorder paper can be placed.

Riding lightly on top of this recording paper is a black epoxy bead formed on one end of a wire that is attached at its other end to the cork disk. Just above the bead is a 3 mm diam, 4.5 cm long, brass tube that may be pressed down on the bead by activating an electromagnet attached to the back of the instrument. This action causes the epoxy bead to make a round mark or point on the recording paper below.

By activating the electromagnet at suitable time intervals and noting the distance between the points on the paper, the rate of evaporation may be determined. It is expected that for most work it would be desirable to activate the magnet at fixed time intervals, the length of which would be adjusted for the experiment being made. The electromagnet could be replaced with a mechanical clockwork system if desired.

Figure 3 shows a strip record of evaporation in the laboratory over a 63 hr time period. The small divisions are approximately 1 mm. The total evaporation rate in this case is slightly greater than 0.5 mm/hr.



### 3. APPLICATIONS

The author has been making measurements at sea of the temperature gradients in the first 10 cm of water below the surface and, simultaneously, in the first 10 cm of air above the surface (Refs. 2 & 3). A small plastic float has been used as the instrument platform. It is intended to augment these measurements with the addition of a more refined version of the evaporimeter. Experience has shown that there is a considerable amount of time in the Mediterranean during which such an instrument could be mounted about 10 cm above the sea surface without it becoming appreciably affected by spray. For such use the evaporimeter will be shielded from radiation heating and mounted in such a way as to minimize the effect of spray without impeding the air flow.

It is also visualized that several evaporimeters at various heights above the sea (or land) may give information that would be of interest to meteorologists and climatologists.

## REFERENCES

1. W.S. von Arx, "An Introduction to Physical Oceanography", Addison-Wesley Publ. Co., 1962, p. 187.
2. A.H. Schooley, "Simple Instrumentation for Measuring Temperature Gradients at the Sea-Air Interface", Proc. Ocean Science & Ocean Eng. Conf., Washington D.C., 1965.
3. A.H. Schooley, "Simple Instrumentation for Measuring Temperature Gradients at the Sea-Air Interface", SACLANTCEN T.R. 35, 1965, NATO UNCLASSIFIED.

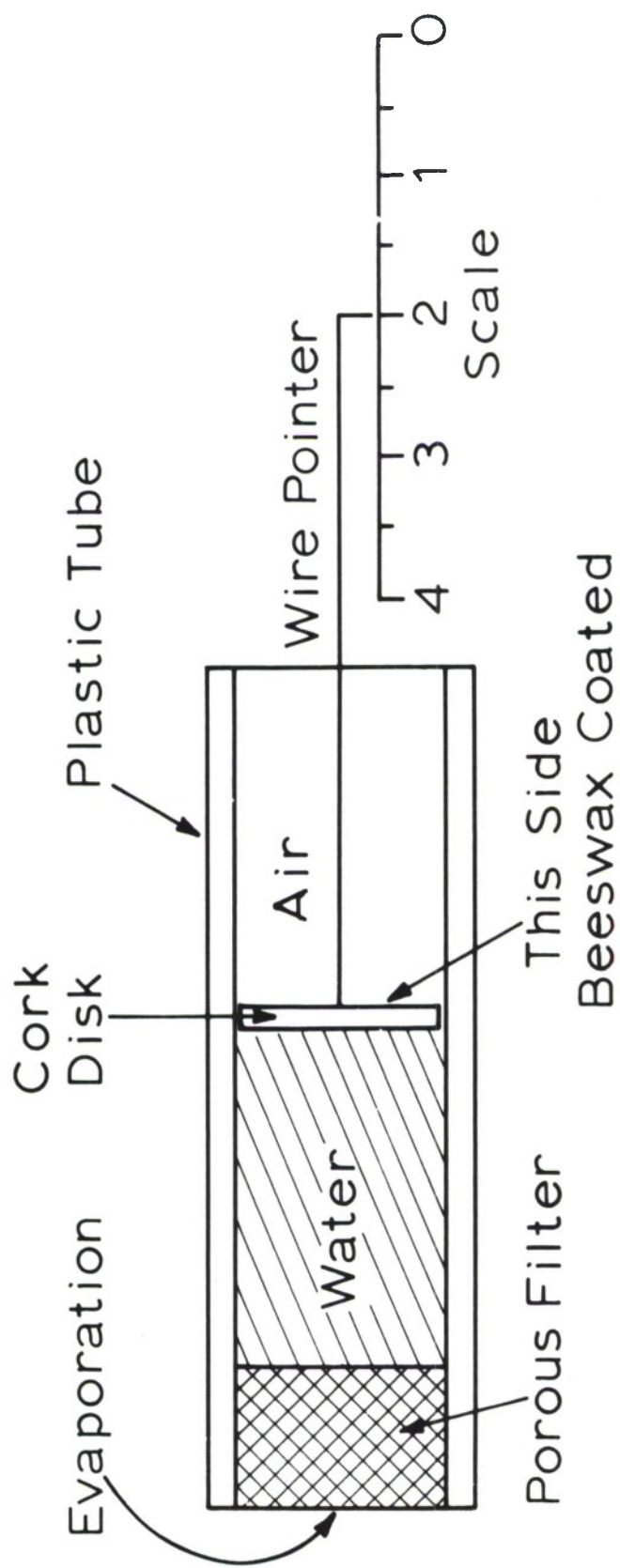


Fig. 1 - SECTIONAL SKETCH OF THE EVAPORIMETER

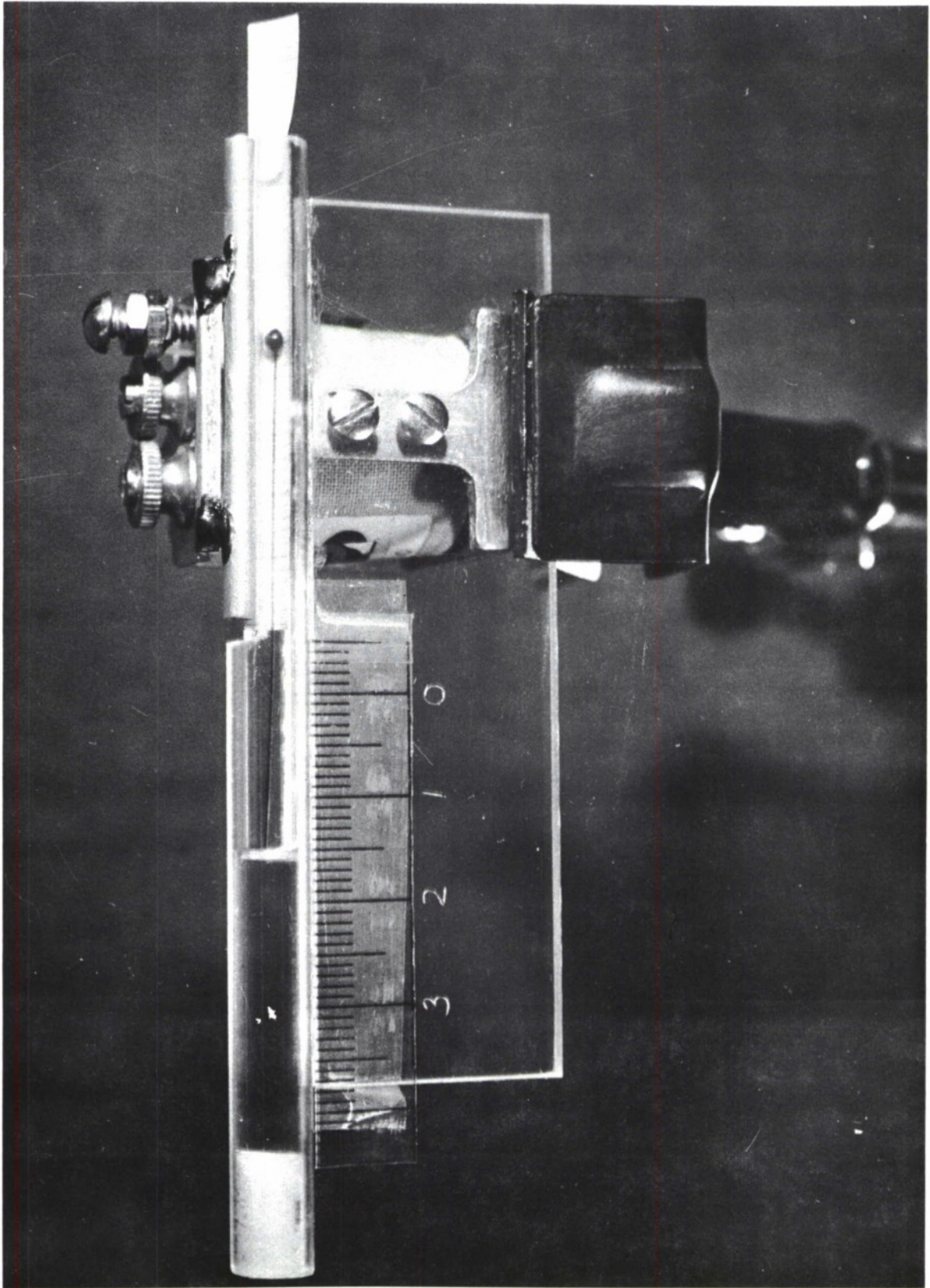


Fig. 2 — WORKING MODEL OF THE EVAPORIMETER

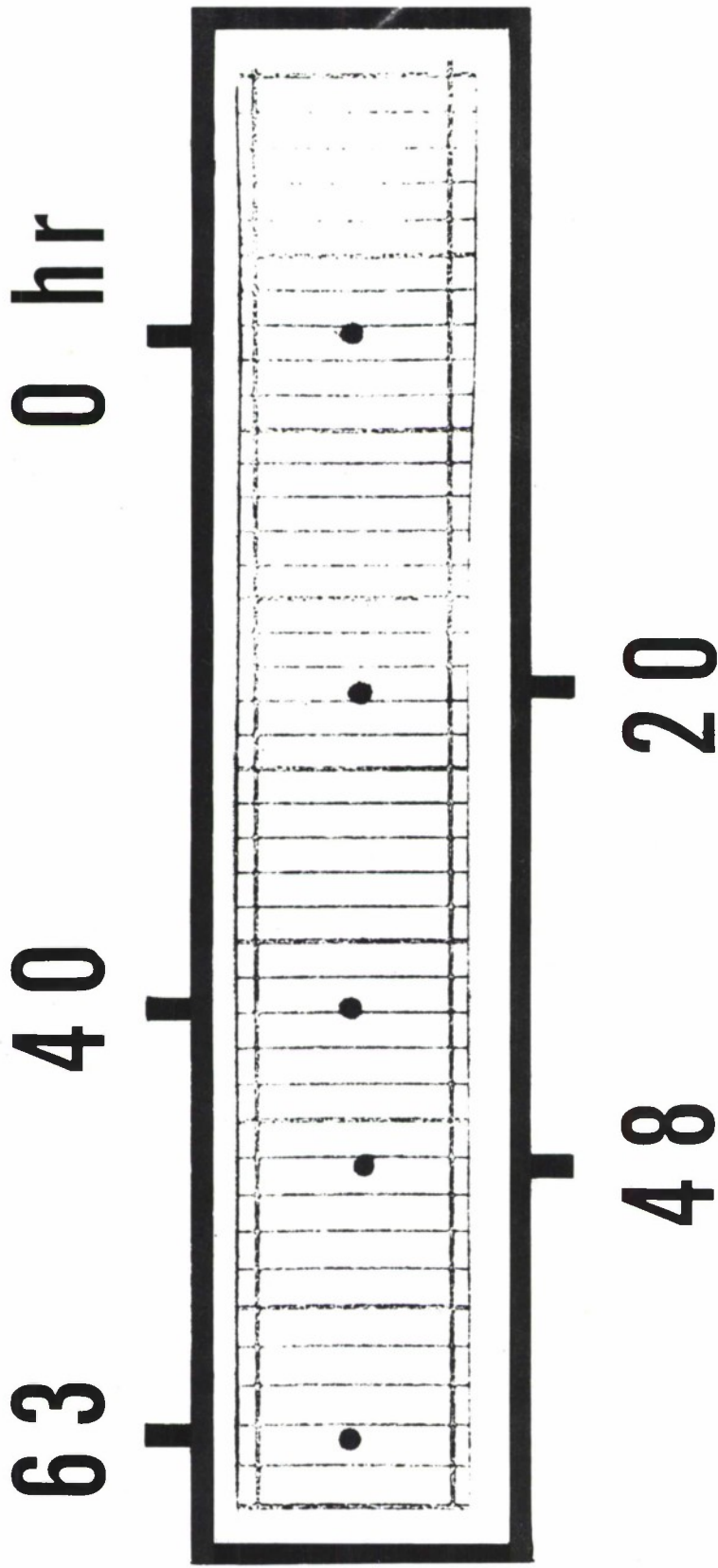


FIG. 3 - A SAMPLE EVAPORIMETER RECORD

# DISTRIBUTION LIST

Minister of Defense Brussels, Belgium	10 copies	Commander in Chief Western Atlantic Area (CINCWESTLANT) Norfolk 23511, Virginia	1 copy
Minister of National Defense Department of National Defense Ottawa, Canada	10 copies	Commander in Chief Eastern Atlantic Area (CINCEASTLANT) Eastbury Park, Northwood Middlesex, England	1 copy
Chief of Defense, Denmark Kastellet Copenhagen Ø, Denmark	10 copies	Maritime Air Commander Eastern Atlantic Area (COMAIREASTLANT) R. A. F. Northwood Middlesex, England	1 copy
Minister of National Defense Division Transmissions-Ecoute-Radar 51 Latour Maubourg Paris 7 <sup>e</sup> , France	10 copies	Commander Submarine Force Eastern Atlantic (COMSUBEASTLANT) Fort Blockhouse Go'sport, Hants, England	1 copy
Minister of Defense Federal Republic of Germany Bonn, Germany	10 copies	Commander, Canadian Atlantic (COMCANLANT) H. M. C. Dockyard Halifax, Nova Scotia	1 copy
Minister of Defense Athens, Greece	10 copies	Commander Ocean Sub-Area (COMOCEANLANT) Norfolk 23511, Virginia	1 copy
Ministero della Difesa Stato Maggiore Marina Roma, Italy	10 copies	Supreme Allied Commander Europe (SACEUR) Paris, France	7 copies
Minister of National Defense Plein 4, The Hague, Netherlands	10 copies	SHAPE Technical Center P. O. Box 174 Stadhouders Plantsoen 15 The Hague, Netherlands	1 copy
Minister of National Defense Storgaten 33, Oslo, Norway	10 copies	Allied Commander in Chief Channel (CINCCHAN) Fort Southwick, Fareham Hampshire, England	1 copy
Minister of National Defense Lisboa, Portugal	10 copies	Commander Allied Maritime Air Force Channel (COMAIRCHAN) Northwood, England	1 copy
Minister of National Defense Ankara, Turkey	10 copies	Commander in Chief Allied Forces Mediterranean (CINCAFMED) Malta, G. C.	1 copy
Minister of Defense London, England	20 copies	Commander South East Mediterranean (COMEDSOU EAST) Malta, G. C.	1 copy
Supreme Allied Commander Atlantic (SACLANT) Norfolk 23511, Virginia	3 copies		
SACLANT Representative in Europe (SACLANTREPEUR) Place du Marechal de Lattre de Tassigny Paris 16 <sup>e</sup> , France	1 copy		

Commander Central Mediterranean (COMEDCENT) Naples, Italy	1 copy	NLR Netherlands Netherlands Joint Staff Mission 4200 Linneau Avenue Washington, D.C. 20008	1 copy
Commander Submarine Allied Command Atlantic (COMSUBACLANT) Norfolk 23511, Virginia	1 copy	NLR Norway Norwegian Military Mission 2720 34th Street, N.W. Washington, D.C.	1 copy
Commander Submarine Mediterranean (COMSUBMED) Malta, G.C.	1 copy	NLR Portugal Portuguese Military Mission 2310 Tracy Place, N.W. Washington, D.C.	1 copy
Standing Group, NATO (SGN) Room 2C256, The Pentagon Washington 25, D.C.	3 copies	NLR Turkey Turkish Joint Staff Mission 2125 LeRoy Place, N.W. Washington, D.C.	1 copy
Standing Group Representative (SGREP) Place du Marechal de Lattre de Tassigny Paris 16 <sup>e</sup> , France	5 copies	NLR United Kingdom British Defence Staffs, Washington 3100 Massachusetts Avenue, N.W. Washington, D.C.	1 copy
ASG for Scientific Affairs NATO Porte Dauphine Paris 16e, France	1 copy	NLR United States SACLANT Norfolk 23511, Virginia	40 copies
<u>National Liaison Representatives</u>			
NLR Belgium Belgian Military Mission 3330 Garfield Street, N.W. Washington, D.C.	1 copy	<u>Scientific Committee of National Representatives</u>	
NLR Canada Canadian Joint Staff 2450 Massachusetts Avenue, N.W. Washington, D.C.	1 copy	Dr. W. Petrie Defence Research Board Department of National Defence Ottawa, Canada	1 copy
NLR Denmark Danish Military Mission 3200 Massachusetts Avenue, N.W. Washington, D.C.	1 copy	G. Meunier Ingenieur en Chef des Genie Maritime Services Technique des Constructions et Armes Navales 8 Boulevard Victor Paris 15 <sup>e</sup> , France	1 copy
NLR France French Military Mission 1759 "R" Street, N.W. Washington, D.C.	1 copy	Dr. E. Schulze Bundesministerium der Verteidigung ABT H ROMAN 2/3 Bonn, Germany	1 copy
NLR Germany German Military Mission 3215 Cathedral Avenue, N.W. Washington, D.C.	1 copy	Commander A. Pettas Ministry of National Defense Athens, Greece	1 copy
NLR Greece Greek Military Mission 2228 Massachusetts Avenue, N.W. Washington, D.C.	1 copy	Professor Dr. M. Federici Segreteria NATO MARIPERMAN La Spezia	1 copy
NLR Italy Italian Military Mission 3221 Garfield Street, N.W. Washington, D.C.	1 copy	Dr. M.W. Van Batenburg Physisch Laboratorium RVO-TNO Waaltdorpplakke The Hague, Netherlands	1 copy

Mr. A. W. Ross  
Director of Naval Physical Research  
Ministry of Defence (Naval)  
Bank Block  
Old Admiralty Building  
Whitehall, London S. W. 1 1 copy

Dr. J. E. Henderson  
Applied Physics Laboratory  
University of Washington  
1013 Northeast 40th Street  
Seattle 5, Washington 1 copy

Capitaine de Fregate R. C. Lambert  
Etat Major Général Force Navale  
Caserne Prince Baudouin  
Place Dailly  
Bruxelles, Belgique 1 copy

CAPT H. L. Prause  
Søvaernets Televaesen  
Lergravsvej 55  
Copenhagen S', Denmark 1 copy

Mr. F. Lied  
Norwegian Defense Research  
Establishment  
Kjeller, Norway 1 copy

Ing. CAPT N. Berkay  
Seyir Ve HDR D  
CUBUKLU  
Istanbul, Turkey 1 copy

National Liaison Officers

Mr. Sv. F. Larsen  
Danish Defense Research Board  
Østerbrogades Kaserne  
Copenhagen Ø, Denmark 1 copy

CDR R. J. M. Sabatier  
EMM/TER  
2 Rue Royale  
Paris 8e, France 1 copy

Capitano di Fregata U. Gilli  
Stato Maggiore della Marina  
Roma, Italia 1 copy

LCDR J. W. Davis, USN  
Office of Naval Research  
Branch Office, London  
Box 39, Fleet Post Office  
New York, N. Y. 09510 1 copy

CDR Jose E. E. C. de Ataide  
Instituto Hydrografico  
Rua Do Arsenal Porta H-1  
Lisboa 2, Portugal 1 copy