ENGINEERING EXPERIMENT STATION
Georgia Institute of Technology

PROJECT INITIATION

Date: 12-1-60

PROJECT TITLE: Mine Hunting

PROJECT NO: A-531

PROJECT DIRECTOR: L. A. Woodward

SPONSOR: Dept. of the Navy, Bureau of Ships

EFFECTIVE: 8-1-60 ESTIMATED TO RUN UNTIL: 7-31-61

TYPE AGREEMENT: Contract No. NBS 04237

Amount: $55,032.00

Reports: Monthly Progress Letter Summary Report (after completion of each assigned task)

Contract provides for Anticipatory Costs in an amount not to exceed $9,172.00 during the period 8-1-60 to 10-30-60

Assigned to: Physics Branch, Physical Sciences Division

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GEORGIA INSTITUTE OF TECHNOLOGY
Engineering Experiment Station

PROJECT TERMINATION

DATE: July 1, 1968

PROJECT TITLE: Mine Hunting
PROJECT NO.: A-531
PROJECT DIRECTOR: L. C. Young
SPONSOR: Dept. of the Navy
TERMINATION EFFECTIVE: June 30, 1968

CHARGES SHOULD CLEAR ACCOUNTING BY: All charges have cleared

PSD

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Form EES 402 (R10-62)
U. S. Mine Defense Laboratory  
Panama City,  
Florida

Attention: Dr. Hogge, Code 712

Subject: Project A-531, Progress Report  
Corrosion of Underwater Vessels  
Contract N600(24)59885

Gentlemen:

Purpose

Our report of October 2, 1964 listed as studies for future work the following:

(1) To obtain a more precise measurement of the rate of the corrosion process.

(2) To determine the effect on rate of exposure of larger areas of metal to the palladium chloride solid.

During the period of this report, attention has been directed primarily to the second item. No precise determinations of reaction rates has been attempted, and such rate effects as have been observed have been by inference from the results of Item 2 experiments.

Specimens

Specimen tablets were prepared as before, except that areas of ca. 1/2 inch x 1/2 inch were stripped of paint and burnished to expose bare metal.

Immersion Vessel

Exposures to reconstituted sea water were conducted in the same vessel under the same conditions previously used.

Experimental Procedures and Results

(1) Palladium Chloride Solution

A saturated solution of palladium chloride in water was introduced into the sea water directly above the bare metal spots. As it came into contact with the tablet, the metal darkened immediately, then gradually acquired a silvery luster as metallic palladium was deposited by chemical replacement.
The circulation of water in the aquarium washed the palladium chloride solution away too quickly for the effects of prolonged reaction to be observed, and it was necessary that these experiments be supplemented by observations in still water.

Very slight corrosion pitting was observed over a period of two months with this type of exposure.

(2) Palladium Chloride Solid

A crystal of palladium chloride, introduced above the bare spot, fell to the metal surface. As it slowly dissolved, a gradually widening area of metallic palladium formed around it. Since the solid material was not so easily dissipated, a more substantial deposit of palladium was eventually formed than in the case of the palladium chloride solution.

Corrosion pitting occurred as before; however, the deeper penetration which was experienced in scratch exposure (Oct. 2 Report) did not occur in this instance. Penetration was broader and shallower. Thus, while the corrosion rate was apparently as great or possibly greater, it was spread over a wider area and did not reach as great a depth.

(3) Palladium Stearate Solid

Since deeper penetration was obtained with the slowly dissolving solid, a further similar experiment was conducted utilizing palladium stearate solid, a very slightly soluble compound. This material releases palladium ions to its surroundings very slowly; consequently, it has a very long residence time as compared to palladium chloride.

At the conclusion of a two-month exposure period, the area of corrosion was found to be restricted almost entirely to the underside of the deposit of palladium stearate, indicating that ions released outside this area generally escaped. At least, no accumulation of solution, giving rise to a broad area of attack, was evident.

Depth of penetration was virtually the same as that observed with solid palladium chloride in this series of studies.

Conclusions

Two series of studies have been completed, examining various methods of exposing mine casing to sea water in the presence of palladium salts.

The most rapid penetration rate was observed in the instance of a crystal of solid palladium chloride resting on the bare metal of the mine casing at a scratch mark in the paint coating of the casing.
On larger areas of bare metal, the total corrosion rate appeared to be unchanged, but penetration was much shallower, as the corrosion was spread over a wider area.

On larger bare areas, the area of attack is reduced by the use of a less soluble compound of palladium, such as palladium stearate.

Respectfully submitted:

W. H. Burrows
Project Director

Approved:

Frederick Bellinger, Chief
Chemical Sciences and Materials Division
U. S. Navy Mine Defense Laboratory
Panama City, Florida

Attention: Code 700

Subject: Quarterly Letter Progress Report No. 10
Contract No. N600(24)-59885, Index SF011-02-33, Task 2392

Gentlemen:

This report covers work on the captioned contract for the period from 1 April 1964 to 30 June 1964.

During this period an advanced summary of the study that has been made on induction locators was forwarded to the MDL. In addition, arrangements have been made for Dr. J. E. Rhodes, who made the study here, to make an early visit to the MDL and confer with Dr. Hogge and others who have an active interest in this instrumentation. The detailed report on this study will be completed this summer.

A short informal report on the Wellhoner Two Gradiometer-Angle Approach to Mine Location was forwarded to the MDL. In addition, a copy of the original computer data that was used in the study was supplied to the MDL for further study.

As a result of discussions held during a recent visit to the MDL, certain additional matters will be looked into during the summer. These include the preparation of some theoretical total field contour plots of typical sources, a report on an extension of the analysis of the MTG type instrumentation, and an account of how to prepare the various equations to be found in the series of Special Reports for computer runs.

In answer to a question raised during my visit, our computer capabilities include the possibilities of feeding data in analog form to the digital computer for analysis. It should be understood that this involves a considerable amount of programming but can be done when the need demands.

Respectfully submitted

Henry H. Woodward
Project Director
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U. S. Navy Mine Defense Laboratory
Panama City, Florida
Attention: Code 700

Subject: Quarterly Letter Progress Report No. 11
Contract No. N600(24)-59885, Index SFO11-02-33, Task 2392

Gentlemen:

This report covers work on the captioned contract for the period from 1 July 1964 to 30 September 1964.

During this period Special Report No. 6, entitled "Simulating Mine Hunting Magnetometer Data by Digital Computers" (U) was completed and forwarded to the USNMDL. Two additional reports, one on magnetic anomaly contour plots and the other on induction type locators, are ready in draft form and will be forwarded when processing is completed.

Teaching duties for both Dr. Rhodes and myself begin this month so, as happened last year, work on the project will be at a reduced rate for the next periods. Efforts are continuing to get additional personnel on the project.

Planned work for the next periods include a report on an extension of the analysis of the MIG type equipment and continued classification studies.

Respectfully submitted,

LeRoy A. Woodward
Project Director
U. S. Navy Mine Defense Laboratory
Panama City, Florida

Attention: Code 700

Subject: Quarterly Letter Progress Report No. 12
Contract No. N600(24)-59885, Index SP011-02-33, Task 2392

Gentlemen:

This report covers work on the captioned contract for the period from 1 October 1964 to 31 December 1964.

During the period, Special Report No. 7, entitled "Theoretical Total-Field Magnetic Anomaly Contour Plots for Ground Mines (u) was completed and forwarded. Due to confusion apparently still existing because of the shifting of the contract from BuShips to USNMDL, the reports were apparently sent to Washington, at least indirect word has been received to this effect. Careful measures have been taken to insure that this will not happen again, and if the Defense Lab cannot arrange for the reports to be reshipped to Panama City, we would appreciate advice as to the proper procedure to accomplish this.

During the period arrangements were made for Dr. Rhodes to attend a USNMDL conference on the subject of induction locators early in the new year. Work continues on a report of a component magnetometer analysis.

Respectfully submitted,

LeRoy A. Woodward
Project Director
U. S. Navy Mine Defense Laboratory  
Panama City, Florida

Attention:  Code 700

Subject:  Quarterly Letter Progress Report No. 13  
Contract No. N600(24)-59885, Index SP011-02-33, Task 2392

Gentlemen:

This report covers work on the captioned contract for the period from 1 January 1965 to 31 March 1965.

Early in the period, Dr. J. Elmer Rhodes, Jr. attended a conference at the USNMDL on the general subject of induction type locators. Some of the ideas there discussed were further developed upon his return and an additional conference with Dr. Hogge from USNMDL was held here at Tech, and a classified letter confirming several of these matters was sent on 22 February 1965.

Work continues on several reports. One on an analysis method based on component type magnetometers and component type gradiometers has reached the final rough draft stage and should be issued soon. Another on induction type locators and added matters is also taking shape. The various visits of Dr. Rhodes to USNMDL has resulted in several revisions of this report aimed at greater usefulness. This report started as an essentially independent study and as additional information has become available as to the specific interests of the Navy, it has been enlarged from time to time.

Scheduled work for the next period is mainly finishing up the reports mentioned.

Respectfully submitted,

LeRoy A. Woodward  
Project Director
U. S. Navy Mine Defense Laboratory  
Panama City, Florida  

Attention: Code 700  

Subject: Quarterly Letter Progress Report No. 14  
Contract No. N600(24)-59885, Index SFOII-02-33, Task 2392  

Gentlemen:  

This report covers work on the captioned contract for the period from 1 April 1965 to 30 June 1965.  

Special Report No. 8, entitled "Magnetic Source Evaluation by Component Magnetometer and Gradiometers" has been issued and should be received. Work continues on another report on induction type locators. This report, in addition to providing a basis for the evaluation of devices of this general class, also illustrates in some detail the application of the principles involved so that future developments can be approached along these same lines.  

Conferences are planned with the USNMDL to schedule future work when this report is completed.  

Respectfully submitted,  

LeRoy A. Woodward  
Project Director
1 October 1965

U. S. Navy Mine Defense Laboratory
Panama City, Florida

Attention: Code 700

Subject: Quarterly Letter Progress Report No. 15
Contract No. N600(24)-59885, Index SF011-02-33, Task 2392

Gentlemen:

This report covers work on the captioned contract for the period from 1 July 1965 to 30 September 1965.

The most significant results from the technical point of view during the period was the verification, through the comparison of magnetic field measurements on a model and computations through theoretical equations, that the method outlined in Special Report No. 6 did, in fact, have significant physical meaning. While this verification should continue to be investigated, by looking at similar measurements on actual targets, including the effects of rods and perm, it certainly seems to open up to us all the powers of analysis available through the use of digital computers. Since much of the work done here has been directed toward this end, this is very gratifying and encouraging. I feel that considerable effort should be made at this time to further coordinate our mutual efforts, so that this approach can be exploited to produce the maximum results.

The Induction Locator Report is being put on plates and should be available in due time.

As of this date, Mr. Richard E. Bryan assumes the responsibilities as Project Director for the contract. He can be reached by phone at the same number 404-873-4211, Ext. 268, or by mail directed to his name at the address on the letterhead. Dr. Rhodes and myself will continue to be available to him on a consulting basis, although the start of the teaching season will limit the time we have available. It will provide better coordination if all contacts with Tech are made through Mr. Bryan.

Consideration will be given during the next period as to ways and means of exploiting the computer approach to the analysis of mine hunting problems.

Respectfully submitted,

LeRoy A. Woodward
Project Director
U. S. Navy Mine Defense Laboratory
Panama City, Florida

Attention: Code 700

Subject: Quarterly Letter Progress Report No. 16
Contract No. N600(24)-59885, Index SF011-02-33, Task 2392

Gentlemen:

This report covers work on the captioned contract for the period 1 October 1965 to 31 December 1965.

The major portion of the work during this period involved the implementation of a digital computer model simulating search patterns using total field magnetometers. This work was planned to fulfill two purposes:

(1) To provide a basic model which might be expanded to accommodate future studies, and

(2) To familiarize the author with the technical developments previously accomplished under this contract.

Also, a new classification technique was investigated.

The Inductor Locator Report was completed during this period and should be available during the next report period.

A conference has been scheduled for the first week in January to discuss future work in the area of digital computer simulations and evaluation of several classification techniques.

Respectfully submitted,

Richard Bryan
Project Director
U. S. Navy Mine Defense Laboratory
Panama City, Florida

Attention: Quarterly Progress Report No. 17
Contract No. N600(24)-59885, Index SF011-02-33, Task 2392

Gentlemen:

This report covers work on the captioned contract for the period 1 January 1966 to 31 March 1966.

On 6 January 1966 the author visited the Mine Defense Laboratory to discuss specific technical problems to be considered by Georgia Tech for the remainder of the fiscal year. The following problems were considered to be most pertinent at that time.

1. Construction of a statistical decision theory model to be used to evaluate various classification schemes.

2. Evaluation of method for calculating CPA as proposed by Walter Maine.

3. Evaluation of a neutralization vehicle directional mechanism.

Considerable progress has been made on all three problems. In particular, a rather general computer model being used in conjunction with (1) has been designed and proven to be satisfactory; an equation for CPA calculation based on Maine's previous studies has been devised empirically and is being checked using computer data; a mathematical model is being designed to aid in considering (3).

Also of importance during this report period, the services of Mr. Lou Young, Senior Research Engineer, have been made available to the project on a consulting basis. Mr. Young is a specialist in the areas of digital computation and statistical analysis. He is currently involved with problem (1) as described above.

The Induction Locator Report, Special Report No. 9, was published February 1966.

A conference has been scheduled for 15 April 1966 to discuss completion of problems under investigation during the present fiscal year and possible new areas of investigation for the coming fiscal year.

Respectfully submitted,

Richard Bryan
Project Director
U. S. Navy Mine Defense Laboratory
Panama City, Florida

Attention: Code 700

Subject: Quarterly Letter Progress Report No. 18
Contract No. N600(24)-59885, Index SF011-02-33, Task 2392

Gentlemen:

This report covers work on the subject contract for the period 1 April 1966 to 30 June 1966.

At the beginning of this period investigations were being conducted in three major areas: classification, CPA identification, and neutralization. Results of these investigations through 1 May 1966 were summarized in a letter of 4 May 1966 proposing an extension of current work into the 1966-67 fiscal year. The summary indicated that the signature length classification scheme and the CPA identification method proposed by Maine are inadequate. However, the summary also included description of a modified classification scheme which gives better results.

At a conference held at the Mine Defense Laboratory on 15 April 1966, it was decided to temporarily neglect the localization and neutralization problems in an attempt to complete current work on classification with existing contract funds since additional funding was not expected for the fiscal year 1966-67. Since that time, research efforts have been focused on classification from a probabilistic viewpoint. Results of this work will be published in a formal report to be written during the next quarterly period. Hopefully, this report will be available to the sponsor before 1 August 1966.

Also, during the coming quarterly period, a final report covering all investigations undertaken during fiscal years 1965-66 and 1966-67 will be drafted. This report should be received by the sponsor shortly after 1 October 1966.

Dr. Elmer Rhodes has recently finished the initial draft on a report which covers his research on induction locators conducted since the publication of Special Report No. 9. This report will be available around 1 September 1966.

Respectfully submitted

[Signature]

Project Director
U. S. Navy Mine Defense Laboratory  
Panama City, Florida  
Attention: Code 700  
Subject: Quarterly Progress Report No. 19  
Contract No. N600(24)-59885-A-531  
Index SF011-02-33, Task 2392  

Gentlemen:  

This report covers work on the subject contract for the period 1 July 1966 through 30 September 1966.  

During the first month of this period, work was continued on determining an appropriate classification system. A Special Report No. 10 summarizing results of this work was issued and transmitted by August 1.  

Following a conference at the Mine Defense Laboratory on 8 August 1966, recommendations based on agreement reached there were made by the undersigned on 12 August and approved by letter on 9 September 1966; these concerned six areas of work to be undertaken at Georgia Tech during the remainder of the fiscal year. The first of these required re-examination of the proposed classification system under different ground rules.  

The classification system was reviewed and again evaluated as required, and found somewhat deficient, by the October 1 deadline set. It was therefore agreed that further work would be performed here during that month toward improvement of the classification system under the new ground rules. This performance will be covered in the next quarterly report.  

Respectfully submitted,  

Louis Young  
Project Director  

LY:srt  

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U. S. Navy Mine Defense Laboratory
Panama City, Florida

Attention: Code 700

Subject: Quarterly Progress Report No. 22
Contract No. N600(24)-59885-A-531
Index SF011-02-33, Task 2392


Gentlemen:

This report covers work on the subject contract for the period 1 April 1967 through 30 June 1967.

L. C. Young visited the Mine Defense Laboratory on 24 April 1967 to become acquainted with new technical developments there, to learn of new requirements and to discuss work which had been completed at Georgia Tech and reported in letter reports.

During this quarter, work was completed on item IV of the reference letter, and was reported on 19 April, by letter report code 722.

Work on item V of the reference schedule has just been completed. Work on item VI has been in progress for four months and results have been obtained but these have not lived up to our initial hopes. Of three basically different approaches, one was unsuccessful, one has been untrustworthy, and one has not yet shown promise of sufficient precision. Research work will end with the fiscal year, and next month will be given to reporting the foregoing two items and summarizing work done during the previous year, for general distribution.

Respectfully submitted,

[Signature]

Project Director, A-531

LCY:brj
29 September 1967

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U.S. Navy Mine Defense Laboratory
Panama City, Florida

Attention: Code 700

Subject: Quarterly Progress Report No. 23
Contract No. N600(24)-59885-A-531
Index SF011-02-33, Task 2392

Gentlemen:

This report covers work on the subject contract for the period 1 July 1967 through 30 September 1967.

Special Report No. 12 was issued during July and transmitted; it detailed all those results of contract work performed during the year which had not already been forwarded in letter reports.

L. C. Young visited the Mine Defense Laboratory on September 11, 1967, to discuss work previously reported and to learn what the prospects were, of keeping the project active during this fiscal year. Recommendations made during the year were discussed, as well as some further areas of potential investigation.

In as much as the previously defined mission for the past year has been completed and funds have been exhausted, no further work will be done on this project until further negotiation.

Respectfully submitted,

Louis C. Young
Project Director, A-531

LCY:srt