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FINAL REPORT FOR CONTRACT NUMBER N00014-76-C-0554, MOD. P00002,--ETC(U)

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N00014-76-C-0554

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MEMORANDUM REPORT

From: B. B. Rosenbaum
To: J. A. Satkowski, ONR, Code 473

Subj: Final Report for Contract Number N00014-76-C-0554, New Mod. P00002, Line Item 0001AB (AA, AB and AC), for the Twelve-Month Period Ending 30 September 1977.

12 13p.

1. Resume. This report summarizes and appraises the the technical and managerial aspects of the closed cycle Brayton turbomachinery research (CCBT) effort being sponsored by the ONR Power Program (Code 473). Specifically, it will consider the first year's CCBT contractual efforts at:

(a) Westinghouse Astronuclear Laboratory (WANL), Contract No. N00014-76-C-0706 entitled "Compact Closed Cycle Brayton System Feasibility Study;

(b) United Technologies Research Center (UTRC), Contract No. N00014-76-C-0542, "Lightweight Propulsion Systems for Advanced Naval Ship Application--System Studies."

In addition, the Gas Turbine Branch (Code 2721) of the Power Systems Division, Propulsion and Auxiliary Systems Department of David Taylor Naval Ship R&D Center, Annapolis (DTNSRDC/A) has been exploring the technological feasibility of CCBT as a main engine for ship propulsion and operationally evaluating a CCB laboratory engine. This work has been jointly sponsored by the Defense Advanced Research Projects Agency (DARPA) and the Naval Sea Systems Command (NAVSEA). There have been several other developmental efforts initiated in the past few years in the United States: by the Department of Energy (then ERDA), the Electric Power Research Institute (EPRI), the U. S. Maritime Administration (MARAD), the National Aeronautics and Space Agency (NASA), and the U. S. Army Mobility Equipment R&D Command (MERDC). Also, several Japanese maritime and engine manufacturing companies acting as a consortium, and a number of their European counterparts, acting independently, have all been deeply involved.

2. Westinghouse Electric Corporation Compact, Light Weight Closed Brayton Systems Feasibility Study. In appraising the contractor's performance under ONR contract N00014-76-C-0706 with the Westinghouse Advanced Energy Systems Division at the Westinghouse Astronuclear Laboratory (WANL), I am gratifyingly pleased. The project engineers conducting the Materials Testing effort are astute, serious professionals who plan and prepare their program with adequate care and consideration prior to embarking on the test bench. On three visits which I made to WANL over the past year, I was impressed with their candor and straightforward communication. The three gentlemen responsible for the metals characterization portion of the study: Messrs. Robert L. Ammon

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(Project Engineer), R. William Buckman, Jr. (Manager, Materials Science Section, Materials Department), and David C. Goldberg (Manager, Engineering and Materials Department) are all technologically quite competent and knowledgeable in both the science and the engineering of high temperature materials. I found technical discussions with them to be a pleasant and rewarding task.

3. Having defined the requirements of the system for which feasibility is being determined: 70,000 shaft horsepower output; 1700°F turbine inlet temperature; helium working fluid--the Westinghouse personnel selected five candidate alloys to be characterized for feasibility. These are named and defined in Table 1. Four of them are from the 45 or 50 superalloys presently on the market; the fifth is a refractory metall alloy. The selection displays the good judbement of the selectors, from the standpoint of variety and versatility.

Alloy 713LC - This is a nickel-base cast superalloy containing aluminum and titanium which permits the formation of gamma-prime phase of the intermetallic compound (Ni_3) (Al,Ti) that acts as a strengthener. This is a cast rotor alloy with low carbon (LC) to permit higher ductility than is obtained in the 713C alloy which contains 0.12% C vis-a-vis 0.05% C in this LC grade.

IN 100 - This is one of the commonest of the nickel-base cast superalloys of the eight alloys in this group (Udinet 500, Rene 77, 713C, IN 738, Rene 80, B-1900, IN 100, and NASA-TRW VI-A), only the NASA-TRW alloy has a higher temperature capability (1900 vs. 1850°F for IN-100) but it also has much higher content of expensive and embrittling (Mo+W), 7.8% vs. 3.0% in IN-100. The NASA-TRW alloy also contains hafnium (0.5%) and rhenium (0.3%) so that availability and price are factors. The tendency to form brittle sigma-phase and also to form an easily spotted cubic crystallization oxide scale require special precautions in handling IN-100, particularly in surface preparation.

MAR-M-509. This is a cast cobalt-base alloy along with X-45, FSX-414 XFS-31 (X-40), W1-52, MARM-509, arranged in increasing temperature capability. Its strength capability is 1720°F vs. 1800°F for the MAR-M.322. The co-base MAR-M-509 alloys require greater care in handling than Ni-base to avoid loss in strength due to instability of the complex carbides formed.

B. B. Rosenbaum

CANDIDATE ALLOYS

Alloy	Composition (wt. %)	Density (lbs/in^3)	Stress Rupture at 1800^{0}F	
			1000 Hrs.	10,000 Hrs.
1. Alloy 713LC	Ni-12Cr-4.5Mo-2Cb-5.9Al-0.6Ti-0.05C	0.289	15	6
2. IN 100	Ni-10Cr-15Co-3Mo-4.7Ti-5.5Al-0.9V-0.18C	0.280	15	9
3. MAR-M-509	Co-23.5Cr-10Ni-7.0W-3.5Ta-0.2Ti-0.5Zr-0.6C	0.320	13	8.5
4. MA-754	Ni-20Cr-0.5Ti-0.3Al-0.6Y_2O_3-0.05C	0.300	17.9	16.6
5. TZM	Mo-0.5Ti-0.08Zr-0.02C	0.368	35	30

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30 June 1977

MEMORANDUM REPORT

From: B. B. Rosenbaum
To: J. A. Satkowski, ONR, Code 473

Subj: Progress Report for Period Ending 30 June 1977 (Line Item 0001AF, Contract Number N00019-76-C-0554, Mod. P00002)

1. Resume: Previous reports under this contract have dealt with:

(a) Solar Energy Research, particularly the broad program being conducted by ERDA and its interrelationship with the ONR Power Program (Reports 0001AA, 31 March 1976 and 0001AC, 31 August 1976). In particular, these covered photoconductor conversion and Ocean Thermal Energy Conversion (OTEC) Programs, respectively.

(b) ONR-sponsored Fuel Research at the Naval Research Laboratory (Report 0001AD, 31 December 1976.

(c) Closed Cycle Brayton Turbomachinery (CCBT) research, particularly high-temperature materials research in that area (Report No. 0001AE, 31 March 1977).

This current report (No. 0001AF, 30 June 1977) defines and summarizes the more pertinent of the broad miscellany of divergent--and previously unreported--technical matters that have been participated in under the one-day-a-week consulting arrangement of the subject contract. The next, and Final Report, under the present Contract No. N00019-76-C-0554, Report No. 0001AB, Mod. P00002, is due no later than 30 September 1977. It will abridge and assess the first year's CCBT contractual efforts at Westinghouse Astronuclear Laboratory (WANL), at United Technology Research Center (UTRC), and at David Taylor Naval Ship R&D Center, Annapolis (DTNSRDC/A), in addition to peripheral discussions with producers of relevant materials, e.g., International Nickel Co. (INCO), Molycorp, and FMI (Fiber Materials Inc.).

2. Inventory of "Energy Farm Hand" Chores Performed for the ONR Power Program. The self-designation of this contractor/consultant as a farm-hand is in no way proffered as a pejorative reflection on the assignments involved nor on my capability as a deductive logician in technological matters dealing with materials or energy conversion. Within the Navy's System Commands, the sobriquet is used to denote a technical person--usually highly capable professionally and gifted with adaptability--whose services have been commandeered from a field activity on a temporary loan basis to fill a personnel breach in the Command. As used herein, the "farm hand" designation is meant to reflect the broad scope and the many-sidedness of the topics which arise in conducting a versatile energy program and which must be considered. A partial list of such matters, dealt with in the past year, follows:

a. Iron-Silver Battery - A new, high energy density power source,

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proposed for DSV's (deep submergence vehicles, Seacliff/Turth).

b. Tribology in Energy Technology - A workshop sponsored by ASME, ERDA and ONR to assess critical tribological R&D needs in the development of Energy Technology, 7-9 February 1977, Capitol Hilton Hotel, Washington, DC.

c. Arctic OTEC (Ocean Thermal Energy Conversion) - State of the Art; prognoses.

d. Liquid-Metal Current Collectors (Brushes) - Wetting and cleanup studies of NaK; new quinquenary alloys.

e. Trip to Fiber Materials, Inc., Biddeford, Maine (19-20 October 1976) - valuation of woven composites (e.g., for re-entry vehicles) for turbomachinery applications.

f. Manufacturing Technology in Lieu of R&D in Improving the Fleet - Possibilities of joint ventures with the Army and Air Force; NAVAIR & NAVSEA programs for FY 78.

g. Literature Search - This probe was for relatively elementary and clearly expressed tutorial dissertations to briefly and swiftly nstruct our ONR associates in highly specialized technical areas which are pertinent to the subject at hand. Thus, the two metallurgical texts recommended by this study for any understanding of state-of-the art in materials for advanced energy conversion have been purchased by the ONR library and are a vital addition for the subject.

h. Ship Construction from HY-130 Steel - Germaine questions based on procedures at the Electric Boat Shipyard, Groton, Connecticut; prepared at the request of former ASN(R&D) Marcy, prior to a visit to the Yard by him.

i. Mechanized Narrow-Gap Welding Technology - for fabricating heavy steel sections (i.e., ships' hulls); state-of-the art; advantages and constraints; prognosis for practical utility in the Fleet of the relatively near future.

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31 March 1977

MEMORANDUM REPORT

From: B. B. Rosenbaum
To: J. A. Satkowski, ONR, Code 473

Subj: Progress Report for Period Ending 31 March 1977 (Line Item 0001AE, Contract Number N00019-76-C-0554, Mod P00002)

1. This report succinctly summarizes the materials-related portion of the current ONR research effort in compact light weight closed cycle Brayton turbomachinery (CCBT) for ultimate use as more efficient ship propulsion systems. In addition to ONR contractual efforts in CCBT systems feasibility studies, reference is made to Westinghouse Advanced Energy Systems Division, Westinghouse Astronuclear Laboratory (WANL)--ONR Contract N00014-76-C-0706 and United Technologies Research Center (UTRC)--ONR Contract N00014-76-C-0542). By title, these two efforts are tersely defined, respectively, as: "Compact Light Weight Closed Brayton Feasibility Study" and "Lightweight Propulsion Systems for Advanced Naval Ship Applications--Part I - System Studies." At WANL, the materials research is under the direction of Messrs. David C. Goldberg, Manager, Engineering and Materials Department; R. William Buckman, Jr., Manager, Materials Science Section; and Robert L. Ammon, Materials Science Section, the cognizant project engineer. The UTRC work is directed by Dr. Simion C. Kuo, a capable and brilliant systems analyst. He has developed computer models reflecting the various parameters involved, but to date the contract has not dealt with any materials characterization under simulated or presumed operational conditions.

2. In addition to ONR's participation in fundamental energy conversion research, the quest for economic and practical means to alleviate the energy crisis and the petroleum shortage, at least in some small measure, is widespread. In the engineering and scientific disciplines many of the professional societies have entered into the thick of things. The government, via ERDA, NASA, the three services within DOD, has a very significantly substantial investment. Within the Navy, in addition to ONR, each of the Systems Commands (and possibly the Laboratories--independently) appears to be involved. This writer is concerned that, despite an obvious effort within the Interagency Advanced Power Group (Army, Navy, Air Force, NASA, ERDA, et al) to coordinate efforts and to implement communication, there are still ultrazealous aspirants to fame and glory who are pursuing experimentally parochial will-of-the wisps.

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3. <u>NAVSEA Gas Turbine Materials Program</u>. This writer has canvassed NAVAIR, NAVSEA and NAVFAC regarding their participation in the materials aspects of the current Energy Conversion R&D program. In ships' main propulsion gas turbines (e. g., General Electric's LM 2500) hot section components are only achieving 4,000 hour lives. The group is seeking to operate at consistently higher turbine inlet temperatures of 1600-1700°F whereas today's marine gas turbine inlet temperature may get as low as 1300°F, with the blades even cooler. The metallurgy group at NSRDC Annapolis has designed protective coatings to permit the engine to operate at 1500°F (constant), but the rate of attack at the lower temperature cited is equal to or exceeds the rate of attack at the higher temperatures. Thus, presently, the major thrust of the NSRDC/A group is to provide a coating that will withstand the lower temperature operation. Their current effort is directed to developing an experimental burner rig that will reproduce (or simulate) the lower temperature attack. From that point they (NSRDC/A) will begin to screen the available superalloys and coatings. The types to be examined are: one directionally solidified superalloy; Inconel 939; coatings: aluminides; cobalt-chromium-aluminum-yttrium, with and without precious metals; also, means for processing these alloys. The priorities of the NAVSEA program in decreasing sequence are: (1) improvement of the metal-CrAlY coating systems (NiCrAlY; CoCrAlY); (2) develop ceramic coatings: (a) zirconium on a nickel-chrome alloy, stabilized to ZrO_2; (b) with magnesium, known as thermal barrier coatings by the airframe people; (3) work with superalloys themselves (e.g., single crystals of DS - directionally solidified - alloys). N.B. D.S. eutectics do not work too well in the marine environment; (4) studies of the mechanisms of the "lower temperature" attack, cited previously. This effort in FY 77 was $415K; $180K was in house at NSRDC/A; $235K was contracted at UTRC (Pratt & Whitney) and at General Electric Co. Research Laboratory, Schenectady. This total NAVSEA program amounted to $2M in FY 77, with 25% of the effort being in-house. It is under the guidance of R&D Program Manager, Mr. Charles Miller of NAVSEA 0331G. He has established excellent coordination on Gas Turbine research with the British since 1972, when a meeting was held at NAVSEC in Hyattsville, Maryland. A second meeting in 1974, at Castine, Maine, considered Hot Corrosion Problems in Marine Gas Turbines. A third (1976) conference at the Admiralty Laboratory and at Imperial College considered coating developments. Reports from the attendees indicate that a significant exchange of valuable information is effected. The gentlemen involved with the program at NSRDC/A are with the Metal Physics Branch (Code 2812). Mr. George A. Wacker is Branch Head and Mr. Louis F. Aprigliano is the Project Engineer.

4. <u>NAVAIR Gas Turbine Materials Program</u>. NAVAIR's R&D program in materials for gas turbines for aircraft propulsion is directed to allowable operation times ranging from ten minutes to several thousand hours. Mr. Irving Machlin, the Air Systems Command's Project Engineer in High Temperature Materials (Code 52031) speaks of making trade-offs in which the realism of economic costs are "quite" important, so that, for example, a minimum life of 1,000 hours could be acceptable if a relatively small increase in longevity would engender exorbitant increases in cost. Machlin's prognosis for an acceptable "new" alloy for aircraft machinery would require a total of around $10

million over 10 to 15 years of R&D. NAVAIR's overall meterials R&D involves: metals; composites; ceramics. In the case of metals, the present T_{max} of 1800°F would be improved, presumably, ingradual steps to 1950°F. Currently, this NAVAIR Elevated Temperature R&D effort appears to be concentrated largely on increasing the present limiting temperature (T_{max} = 1800°F) of such materials to ultimately as high as 1950°F. The generic technique employed in this effort is known as "directional solidification" (DS) of eutectics or of superalloys. The Command will be engine testing such cast materials and believes that, within the next year, there will be evidence of whether an anticipated improvement of 50 to 65°F has been realistically achieved. This phenomenon in cast structures is discussed in pp. 495 et ff of Sims and Hagel: The Superalloys (John Wiley and Sons, Inc., 1972). Another important materials strengthening technique, widely used in today's superalloy metallurgy, is Dispersion Strengthening (another, but completely dissimilar, DS!) wherein fine, chemically inert particles (e.g., oxides) increase an alloy's strength by providing resistance to slippage, much as sand on an icy street inhibits skidding. This DS technology in superalloys is discussed at some length in Sims and Hagel (op. cit., Chapter 7). With it, NAVAIR's objective is a 2,000°F superalloy. Admittedly, this is a "long term" ambition and its achievement is still problematical. The key personnel involved with these Navy aircraft-oriented efforts are: Mr. Thomas F. Kearns (NAVAIR-320), Technology Administrator (Materials), Research and Technology Directorate; and Mr. Irving Machlin (NAVAIR 52031B), Project Engineer, HIgh Temperature Materials, Metals Section, Technical Support Branch, Engineering Division, Materials Acquisition Directorate.

5. NAVFAC Involvement in Energy Conversion R&D. Within the scope of RDT&E enveloped by this report, the Research Directorate of Facilities Engineering Command is essentially inactive. As previously noted in this contract's Report No. 0001AC of 2 July 1976, the Ocean Facilities Program personnel of NAVFAC have been providing managerial and technological consulting services on the Ocean Thermal Energy Conversion (OTEC) program to ERDA. This effort is well supported by Congress and the NAVFAC participation continues. Although Commander Lawrence K. Donovan, then Director of the Ocean Facility Program, has been reassigned, Dr. Eugene A. Silva, the Assistant Director is fully familiar with the OTEC effort and the Navy's participation is continuing smoothly under his aegis, without interruption.

6. Other Pertinent Developments in Elevated Temperature Structural Materials. 1974 Figures for the Closed Cycle Helium Gas Turbine (50 MWe) operated at Oberhausen in West Germany,* operating at a Turbine Inlet Temperature (TIT) of 750°C (1380°F) exhibit an efficience of 33%. Since overall cycle efficiency increases about 1% for each 50°F temperature rise in such systems, the advantage of a TIT of 1700°F in fuel saving is apparent. The problem involves the inherent properties of the materials available. Ceramics have been proposed, particularly SiC (silicon carbide) and Si_3N_4 (silicon nitride);

*Kuo, S. C.: Recent Developments of Closed-Cycle Gas Turbines and Gas-Cooled Nuclear Reactors in West Germany and Switzerland. United Technologies Research Center (UTRC) Report R76-952566-2, October 1976. (ONR Contract N000k476-C-0542)

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but ceramics are inherently brittle and the problems of adapting them to dynamic machinery are truly great. Fiber reinforced composites, as used in Re-entry Vehicles, are economically frightening to the builders of prosaic hardware. The nickel- and cobalt-base alloys generically known as Superalloys have been improved very significantly, particularly over the past decade. At this writer's recommendation, the ONR library has purchased two volumes: "The Superalloys," edited by Chester T. Sims and William C. Hagel, John Wiley and Sons, Inc. (1972) and "Superalloys: Metallurgy and Manufacture," Proceedings of the Third International Symposium, September 12-15, 1976, Seven Springs, Pennsylvania, Claitor's Publishing Division, Baton Rouge, Louisiana 70821. To the neophyte in Superalloys for Advanced Energy Systems, I strongly recommend the opening paper (Sims: Superalloys: Their Use and Requirements in Advanced Energy Systems) on pp. 1-23 of the latter volume.

The many authors and organizations involved in the search for better, more heat resistant superalloys is an engrossing list of people actively involved, which include, but is in no way limited to: alloy producers (INCO, Cabot Corp. (Stellite), Allegheny-Ludlum Steel, Universal-Cyclops Steel, Howmet, Climax Molybdenum, and Union Carbide); turbine producers (Westinghouse, General Electric, Pratt & Whitney, Eaton Corp.); non-DOD government agencies (NASA, ERDA, Oak Ridge National Laboratory); academe (Purdue, Columbia, UCLA, University of Pittsburgh); foreign sources (Canada, France, Great Britain, Italy, Japan). These texts should offer an engrossing challenge to materials scientists.

In these disciplines enterprising engineers/scientists/managers have an opportunity to participate professionally in an effort analagous with Superbowl Game importance. They may develop and utilize original and aring concepts to solve high temperature problems. If the athletic contest metaphor is carried further, then at this point so early in the Energy Crisis season, the bolder--more venturesome--players on the Materials (special) Team have an opportunity to establish and highlight their professional reputations in an area of tremendous importance in the field of Energy Conversion. In the event the ONR materials specialists should elect to attain specialized expertise and to pursue a higher temperature capability tenaciously enough, they may well bring professional honor and recognition to themselves, distinction to ONR, beneficial culmination of a vexing Fleet problem, and, at least, a partial solution to the Energy enigma which is a threat to our civilization. Such an effort will require militant diligence, intellectual integrity, fortitude, stamina, and integrity; but the recompense will be rewarding!

> "Why should a man, whose blood is warm within,
> Sit like his grandsire cut in alabaster?"
>
> W. Shakespeare: The Merchant of Venice
> Act I, Sc 7, line 83

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31 December 1976

MEMORANDUM

From: B. B. Rosenbaum
To: J. A. Satkowski, ONR, Code 473

Subj: Progress Report for Period Ending 31 December 1976 (Line Item 001AD, Contract Number N00014-76-C-0554, Mod P00002)

Encl: (1) Memo, ONR Boston (L. H. Peebles, Jr.) to ONR (Code 473) dtd 6 Oct 76

This report is an assessment of R&D efforts in Fuel Research at the Naval Research Laboratory, SR 024-02-03 (Flammability and Autoignition; Biocides for Sulfate-Reducing Bacteria). The material which follows was assembled by B. B. Rosenbaum from several sources including a visit to NRL by the author in company with Dr. L. H. Peebles, Jr., ONR/Boston.

DATE	SITE	PERSONS CONSULTED
		Flammability & Autoignition (Morning)
29 Sep 1976	Naval Research Laboratory Washington, D.C. 20390	* Affens, Wilbur A. Dr. (NRL 6180)
		Carhart, Homer W. Dr. (NRL 6180)
		Hazlett, Robert N. Dr. (NRL 6180)
		McLaren, George W. Dr. (NRL 6180)
		Neihof, Rex A. Dr. (NRL 8353)
		Davis, Eugene C. Mr. (NAVSEC 6101F), (Tech. Agent)
		Biocides (Afternoon)
		Bailey, Carmela A. Mrs. (NRL 8353)
		Linnenbom, Victor J. Dr. (NRL 8300)
		May, Marian E. Mrs. (NRL 8353)
		* Neihof, Rex A. Dr. (NRL 8353)
		Strasburg, Donald W. Dr. (NRL 8350)
		Davis, Eugene C. Mr. (NAVSEC 6101F), (Tech, Agent)

* Principal participant

1. PURPOSE: Since the ONR Power Program (Code 473) has been directed to broaden its emphasis in special new areas--with no compensatory increase in available resources--Dr. Larry Peebles (ONR Boston) and I (as contractor-consultant) were tasked with objectively assessing the subject ONR/NAVSEC/NRL efforts: their current utility and relative priority vis-a-vis other research needs of the fleet.

2. BACKGROUND:

a. Enclosure (1) is an excellent perceptive review of these NRL efforts. From its References 1-13, it is significant that Dr. Affens' work on Fuels (flash points; autoignition; flammability index; et al) extends back to 1965, if not earlier. Similarly, the ONR-NAVSEC funding of the microbial contamination effort started in 1968. Before that, it had been supported entirely by the laboratory. In conjunction with president-elect Carter's resurrection of "zero-base-funding" as a management technique for governmental operations, the chronological age and relative maturity of such research exercises assume special importance in the bureaucratic arena.

b. The publicity accompanying: the BELKNAP incident; earlier carrier conflagrations and the attendant casualties; the burning, melting, or catastrophic softening of aluminum hardware by shipboard fires--all have sharply focussed public scrutiny (frequently unfavorable) on the likelihood of Navy traumas from recurrence of such incidents. I have been informed that NAVSEA 03 currently has active 6.2 and 6.3 programs related to Survivability during fire, fire retardation, fire prevention, etc. Further, Fire Protection is one of the Technical Strategies formulated with ASN (R&D) Marcy's concurrence for the current 6.2 program. Dr. Carhart, as the Navy's outstanding strategist in this field, properly heads the team. Outside the R&D area, the Navy's Damage Control personnel, the appropriate Ship Logistics engineers, and relevant Ship Acquisition Project Managers (PMS's) are all concerned in some degree with protection from shipboard fires.

c. Regarding Dr. Niehof's microorganic studies, the bacterial culprit, Sporovibrio desulfuricans, and its disastrous corrosive effect on metals has long been recognized--at least, since 1923. It has been charged with degradation of transatlantic lead cable sheathing and of underground pipe lines, as well as the fuel tank erosion and fuel perversion cited in Enclosure (1) (paragraph 4.a.). The interrelation of sulfate reducing bacteria and corrosion has been succinctly summarized in Uhlig's Corrosion Handbook, 1948 ed., pp 469-477. An unusual and premature corrosive decompostion manifested in the cupronickel sea water tubes of USS CALIFORNIA and USS SOUTH CAROLINA (DLGN 36 and 37, respectively) at the time of their commissioning in 1974 has also been attributed to similar microbes in the James River. Thus, the fundamental linkage between sea water corrosion and control of these organisms is of much broader significance in the fleet than the degradation of fuel tanks solely.

3. BRIEF: The technological aspect of the conference (s) is guite adequately reviewed in enclosure (1). The quality of these specific NRL studies, conducted and reported during the past ten years, appears, in my opinion, to have been excellent. Nor can one forthrightly dispute their relevance to important fleet

needs. However, at this late date, characterizing these efforts as 6.1 Research is a misnomer, if not a gross exaggeration. At best, as R&D, they are more properly included in Categories 6.2 or 6.3. For brevity, significant points pertinent in arriving at the decision for which this conference was conducted, are condensed in the next Paragraph.

4. CONCLUSIONS:

a. The 10-year period (1966-1976) during which the flammability properties of hydrocarbon fuels were characterized has been adequate to bring the program to fruition.

b. The current work on autoignition of fuels, directed to inclusion in purchase specifications, would more properly be supported by the procurement-involved segment of the appropriate Systems Command.

c. On the basis of return-on-the-investment, there is valid guestion whether the Fuel studies have been carried too far beyond maturity.

d. The current investigation of biocides for anaerobic bacteria has been improperly defined as 6.1 Research.

e. NAVSEC has been remiss in using 6.1 funds to establish specification limits for the selection of commerical biocides; also, for diverting the laboratory investigators' efforts to examination of contaminated hydrocarbons and recommendations for correction.

f. Although portions of the studies being considered here may be vital in the fleet, their NRL proponents should seek support in the appropriate segments of the Navy and under the proper budget category.

5. RECOMMENDATIONS:

a. In the event it is decided to abrogate ONR 6.1 funding support of the NRL studies being considered here, the Laboratory and the principal investigators should be so informed, as promptly as possible, to permit an attempt to realign sponsorship of any fleet-essential studies, or pertinent parochial portions thereof.

b. Within the Navy R&D community, NAVMAT 034 should be in the best position to advise on the status of Fuel Research in the concerned Systems Commands (NAVAIR or NAVSEA).

c. In the Ship Logistic Area (NAVSEA 934), the cognizant project engineers for the various ship classes should be interested in these studies. Thus, William R. Bartow (NAVSEA 9345) heads the DLGN/DLG branch; Fred A. Joest (NAVSEA 944B) is Deputy Director of the Amphibious/Auxiliary Ship Logistic Division.

d. The various Ship Acquisition Project Offices (e.g., PMS 303, 304, 378, 383, 396) also have a necessary involvement in Damage Control and in service impairment via corrosive attack.

e. Under the headings of Standardization and of Inspection and Qualification, NAVSEC--for example, NAVSEC 6101F---should be of assistance in providing direction to the proper sources of such support. Also, NAVSEC 6105E (Arthur J. Marchand) is involved with Ship Safety and Damage Control policy, standards, and coordination with RDT&E.

f. In the context of possibly having hypercritically implied that laboatories tenaciously cling to research projects too long after their fruits have ripened, a recommendation in re Manufacturing Technology (Man Tech) is apropos. During the past year, ODDI&L (Mr. Clements) has stressed the importance of each service expanding its efforts in this area. For Navy, the projected fiqures are $50M/yr. by FY 1980. Man-Tech evokes the engineering methodology to pragmatically achieve the necessary equipment or procedures for more economical, more reliable, and/or better performing hardware. Man-Tech is in category 7.8 of the Federal budget. In fact, the initials R&D are "out-of-bounds" in requests for Man-Tech support. Within the Navy, it is under the jurisdiction of NAVMAT 042, (CAPT. Louis C. Dittmar); within NAVSEA, applications must be approved by NAVSEA 0354 (Thomas E. Draschil).

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