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Evaluation of High Temperature Superconductive Thermal Bridges for Space-Borne Cryogenic Infrared Detectors

by

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ABSTRACT

The focus of this research is on the reduction of the refrigeration requirements for infrared sensors operating in space through the use of high temperature superconductive (HTS) materials as electronic leads between the cooled sensors and the relatively warmer data acquisition components. Specifically, this initial study was directed towards the design of an experiment to quantify the thermal performance of these materials in the space environment. First, an intensive review of relevant literature was undertaken, and then design requirements were formulated. From this background information, a preliminary experimental design was developed. Additional studies will involve a thermal analysis of the experiment and further modifications of the experimental design.

INTRODUCTION

Infrared sensors are currently being used to monitor the concentration of various chemical radicals in the upper atmosphere in an overall effort to study the condition of and changes in the earth's environment. Liquid helium cryogenic refrigeration systems are used to provide cooling for the sensors, and consequently, cryogenic evaporation is the primary limiting factor in the lifetime of these satellite systems. One area in which thermal losses can be reduced is within the electrical connections between the cryogenically cooled infrared sensors and the relatively warmer data acquisition system.

This study is focused on the use of high temperature superconductive (HTS) electronic leads in place of the commonly used manganin leads as a means of reducing the refrigeration load. The overall goal of this ongoing research effort is to quantitatively compare the thermal performance of HTS materials with manganin wires for use in space. The initial objective was to develop a preliminary experimental design which satisfies the primary requirements for the experiment. The research strategy was to design an experiment which allowed for the direct comparison of the cooling requirements of the HTS and the manganin leads and also allowed for the determination of the thermal conductivity of the HTS material in the space environment.

The research plan for these initial studies first involved an intensive review of relevant literature, and in addition, the finite element software to be used in future thermal analysis of the experimental design was determined and studied. This background information was then used to formulate a list of requirements and constraints for the proposed experiment. Commercial vendors were then contacted to determine the feasibility of certain design components and the availability of equipment items. Finally, based on requirements and constraints and on commercial vendors' recommendations, a preliminary experimental design was formulated.

EXPERIMENTAL REQUIREMENTS AND CONSTRAINTS

Based on the stated objectives and relevant background information, the experimental requirements include 1) identical systems for the HTS materials and the manganin wires, 2) thermal isolation of these systems, 3) minimum non-conductive heat losses, 4) maximum and minimum source temperatures at approximately 80K and 4K, 5) isolated measurement of refrigerant consumption at cold tips for each system, 6) structural supports to withstand vibrational loads during launching, 7) a minimum of 100 detector leads to simulate the electrical requirements of typical infrared detectors, 8) 6" long leads, and 9) a measurable heat flux at the warmer temperature source to determine thermal conductivity. Some of the design objectives are limited by the constraints of the spaceflight mission. These constraints include 1) payload size, 2) available power and current, 3) weight constraints, 4) maximum vibrational loads during lift-off, 5) mission lifetime, and 7) experimental budget.

PRELIMINARY EXPERIMENTAL DESIGN

The preliminary experimental plan is shown in Figure 1. It features three identical systems differing only in the electronic lead material. Two of these systems are comprised of two different types of superconductor/substrate combinations and the other system is composed of manganin wires. As indicated in Detail B, each of the three test materials is clamped between three identical cold tips at 4K, while a heating element is used at the other end to supply a heat flux condition at approximately 80K. Temperature sensors are located along the test materials and at each end. A single cryogenic cooler equipped with three cold tips is used to supply the refrigeration effect. A single dewar system with three separate flow meters to the three cold tips will allow for the measurement of the required heat flow for each test sample. The three test samples are encased in a single vacuum environment to minimize convective losses. To reduce vibrational problems, an ionic vacuum pump will be used. Radiation losses and interactions will be minimized through the use of separate radiation shields around each sample. Finally, structural supports (not shown), made from a material such as a fiberglass composite, are to be included.

The electronic leads will consist of 100 individual leads for each type of material. In the case of the manganin leads, 40 AWG wires encased in a thin layer of Kapton will be used. The HTS materials will be printed on one side of the substrate material, as shown in Figure 2.

FUTURE STUDIES

Continuation of this work will include the development and analysis of a thermal model of the experimental design, the identification of sources for the experimental components, an analysis of the support requirements for the test leads, and the modification of the design as warranted with the acquisition of new information. The completion of the design is targeted towards a 1996 Space Shuttle mission.

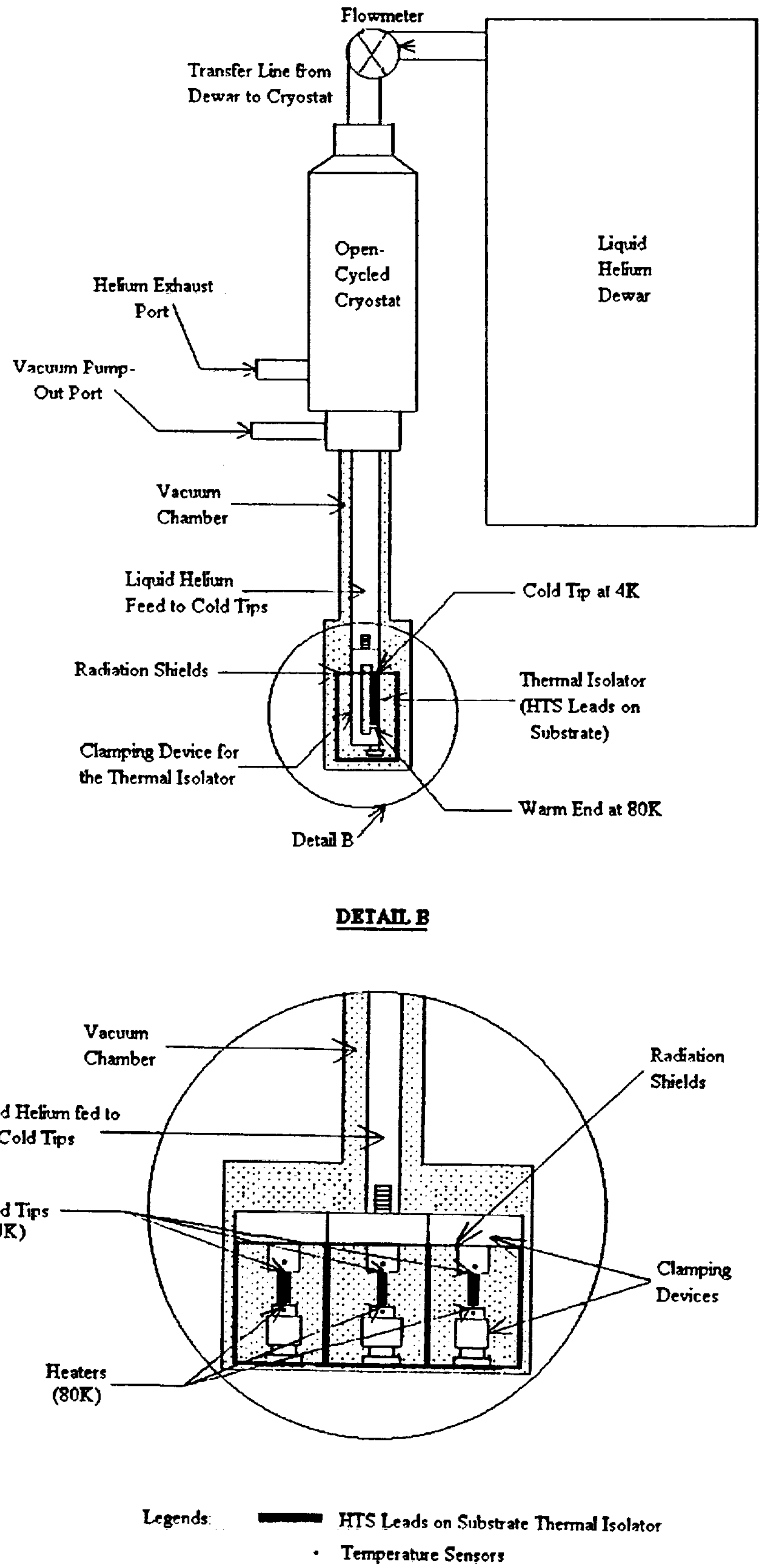

Figure 1. Preliminary Design of Experiment for the Thermal Comparison of Electronic Lead Materials

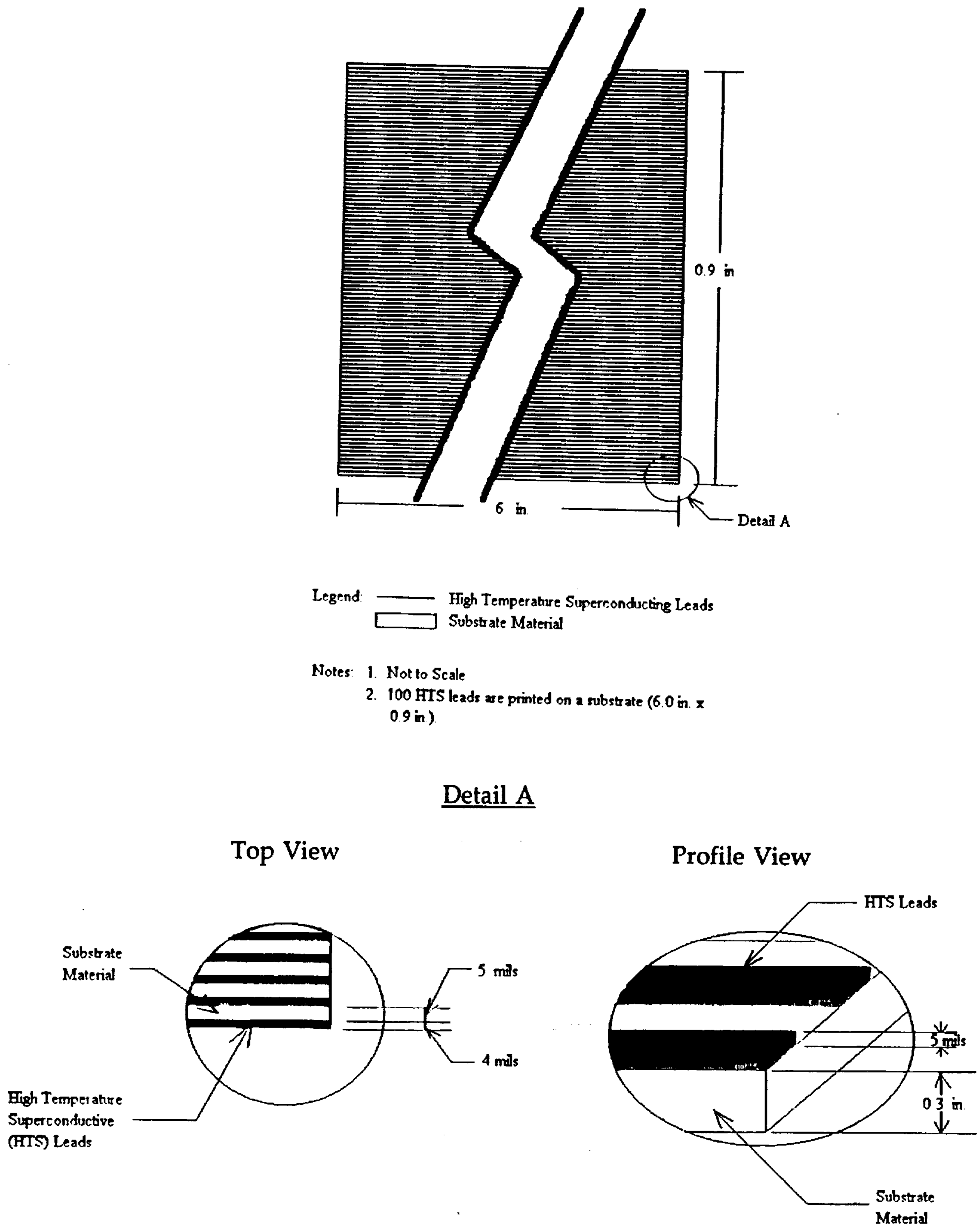

Figure 2. High Temperature Superconductive Leads Printed on the Substrate

ORGANIZATIONAL DEVELOPMENT: A PLANNED CHANGE EFFORT IN THE MANAGEMENT SUPPORT DIVISION AT NASA LANGLEY RESEARCH CENTER

by

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ABSTRACT

This abstract describes an organizational development project which was initiated at NASA Langley Research Center in the Management Support Division (MSD). Organization development (OD) is a planned change effort which involves "the application of a *system approach* to the functional, structural, technical, and personal relationships in an organization."[1] The purpose of the project was to identify key problems that existed in the Division, to develop feasible solutions to the problems, to implement these solutions, and ultimately, to improve "the effectiveness of the organization and its members."[2]

MSD consists of a Division Office, and three Branches: Logistics Management, Security Services, and Institutional Support (see Figure 1). The MSD currently employs 50 civil servants and is supported by 160 man years of effort under its current contractor, Mason & Hanger Services, Inc. The MSD civil servants and contractors are housed in 17 different buildings throughout the Center, which has reportedly contributed to a breakdown in communication. This OD effort was limited to the 50 MSD civil servants. Over the past 4 months, major changes have taken place within MSD, including retirements, promotions, transfers, and temporary details.

The OD planned change effort was based upon the action research model, which consists of eight major steps.[3] "Action research involves collecting information about the organization, feeding this information back to the client system, and developing and implementing action programs to improve system performance."[4]

Initially, this researcher met with the MSD Chief and Assistant Chief to determine their goals for the OD effort, visited various MSD offices, and became familiar with the organization's structure, functions, leadership, employees, and culture. These management officials provided visible support for the OD effort, which greatly enhanced the success of the project. An MSD Organizational Assessment Questionnaire (OAQ) consisting of five open-ended questions (see Figure 2) was subsequently developed and administered to each of the MSD civil servants to gather information needed to diagnose the organizational functioning of the Division. The employees were requested to respond anonymously to the questions.

Twenty-four MSD employees returned their completed OAQ's, yielding a 48 percent rate of return. Narrative comments from the completed OAQ's were compiled for each question, and major themes were derived. The survey was effective in eliciting employee perceptions and attitudes toward their jobs, leaders and supervisors, co-workers, opportunities for advancement, rewards and recognition, work environment, equipment, communications, morale, motivation, training, staffing, funding, and organizational structure. Due to space limitations, only the key findings of the MSD OAQ's will be reported.

MSD OAQ results revealed that the work itself was the most preferred aspect of working in MSD, followed by the employees within the Division, and supervision/leadership mentioned third. Lack of communication, and supervision/leadership were equally cited as being the least preferred aspects of working in MSD, followed by organizational structure. The discrepancy in viewpoints on supervision/leadership could be largely attributed to the fact that MSD employees report to different Branch managers or supervisors. Poor funding and lack of training were viewed as the greatest job impediments. The perceived lack of training was frequently attributed to poor funding, especially for travel. Employees cited increased funding and improved communications within MSD as the two major areas where improvements could be made to help them perform their jobs more effectively, and to increase their job satisfaction. Additional areas cited included leadership, work, attitudes, rewards, and teamwork. Seven of the 24 OAQ respondents provided additional comments on the OAQ for question number 5, with the most frequent comments pertaining to leadership, employee morale/motivation, comments about the survey, and communication.

Each employee was provided with a copy of the narrative comments that were compiled from the completed MSD OAQ's, and a Follow-Up MSD Organizational Assessment Questionnaire (OAQ) to answer (see Figure 3). The purpose of the Follow-Up OAQ was to elicit feedback on the original MSD OAQ responses. There was a 30 percent response rate on the second questionnaire. Employees generally agreed that the OAQ responses were accurate, although some indicated that they were not necessarily true for the entire organization. Perceptions that were noted by employees which were not covered in the original OAQ results typically involved comments about the survey, or survey expectations. The overwhelming majority of the respondents indicated that lack of communication was the "number one" problem in MSD. Additional problems noted in the Follow-Up OAQ included poor morale, lack of confidentiality, favoritism, inadequate staff, and insufficient funding. Employees provided solutions for some of the problems, particularly communication. Communication breakdowns are often "a precipitant factor behind many other problems,"[5] such as poor morale.

In keeping with the intent of the Total Quality Management effort at the Center, a Quality Action Team consisting of eight volunteers was formed. The team was established to help identify the two or three major problems to address in MSD, based on OAQ results; to identify and analyze root causes; and to develop a course of action for resolving, or at least improving, these problems. Spin-off benefits from team participation, such as bolstered employee morale, enhanced competence, and increased motivation, are expected.[6] Two meetings have been held to date, and additional meetings are scheduled until the action plan is finalized and submitted by the team. This researcher will return to MSD throughout the year to assist the team, implement OD interventions that are needed, and develop a proposal to evaluate the outcome and impact of the change effort 1 year from now. Additional interventions may be implemented following the evaluation procedure.

References

[1]Donald F. Harvey, and Donald R. Brown, *An Experiential Approach to Organizational Development*, 4th ed. (Englewood Cliffs, NJ: Prentice Hall, 1992), 59.

[2]Ibid., 5.

[3]Thomas G. Cummings, and Edgar Huse, *Organizational Development and Change*, 4th ed. (St. Paul, MN: West Publishing, 1989), 48.

[4]Harvey, *An Experiential Approach*, 60-61.

[5]Kenneth R. Gilberg, "Open Communications Provide Key to Good Employee Relations," *Supervision* 54 (April): 8-9.

[6]Henry L. Lefevre, *Quality Service Pays: Six Keys to Success* (Milwaukee, WI: Quality Press, 1989), 294.

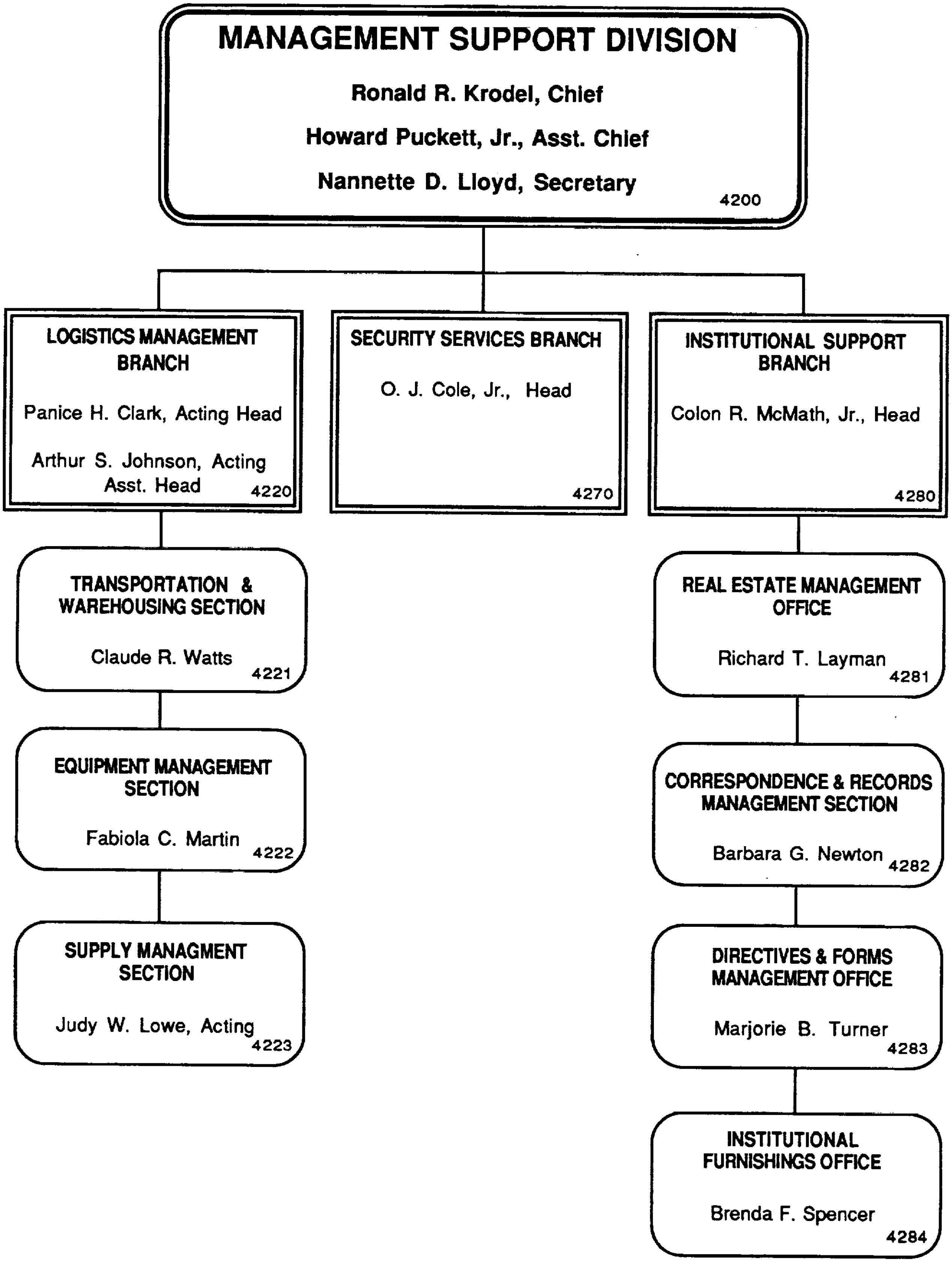

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Figure 1

MSD Organizational Assessment Questionnaire (OAQ)
1. What do you like most about working in the Management Support Division?
2. What do you like least about working in the Management Support Division, and why?
3. What do you see as the greatest impediment in preventing you from performing your job as well as you would like?
4. What do you believe can be done within the system to help make you a more satisfied employee?
5. Are there any additional comments that you would like to make?

Figure 2

Follow-Up MSD Organizational Assessment Questionnaire (OAQ)
1. Are the comments an accurate reflection of the employee perceptions concerning the Management Support Division?
2. Identify and elaborate on any perceptions that you have, both positive and negative, which are not covered in the comments.
3. What do you feel is the "number one" problem in the Management Support Division? What solution(s) do you propose for the problem?

Figure 3