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DEVELOPMENT AND EVALUATION OF EDUCATIONAL PROGRAMS IN BIO-MEDICAL EQUIPMENT TECHNOLOGY, PHASE I. FINAL REPORT.
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OFFICIALS OF A REPRESENTATIVE SAMPLE OF HOSPITALS, BIOMEDICAL EQUIPMENT MANUFACTURERS, AND MEDICAL RESEARCH INSTITUTES IN NEW ENGLAND AND THREE MIDDLE ATLANTIC STATES WERE INTERVIEWED TO DETERMINE THE NEED FOR TECHNICIANS TO SERVICE AND MAINTAIN EQUIPMENT FOUND IN HOSPITALS AND BIOMEDICAL RESEARCH INSTITUTIONS. RESPONSES INDICATED A NEED FOR BETWEEN 1,350 AND 1,450 TECHNICIANS ON CURRENT STAFFS AND BETWEEN 3,200 AND 3,700 BY 1970. FOUR TYPES OF TECHNICIANS WERE IDENTIFIED ACCORDING TO FUNCTIONS AND CAPABILITIES--(1) SERVICE AND MAINTENANCE ONLY, (2) OPERATION, INSTRUCTION IN USE, AND INSTALLATION, (3) DESIGN, MODIFICATION, AND ADAPTATION, AND (4) SALES-ORIENTED FUNCTIONS. ON THE BASIS OF THE INTERVIEW DATA AND DISCUSSIONS AT A CURRICULUM CONFERENCE, THE GENERAL STRUCTURE AND PRELIMINARY OUTLINE OF A 2-YEAR CURRICULUM WERE DEVELOPED TO FORM A TENTATIVE FOUNDATION FOR DETAILED DEVELOPMENT, PILOT TESTING, AND EVALUATION. THE CURRICULUM WAS ESSENTIALLY AN ELECTRONICS TECHNICIAN CURRICULUM WITH A STRONG EMPHASIS ON MEDICAL INSTRUMENTATION. IT CONTAINED A UNIQUE COMPONENT ON BIOMEDICAL EQUIPMENT TECHNIQUES, AS WELL AS ENGLISH, PHYSICS, AND MATHEMATICS. RECOMMENDATIONS WERE--(1) TO ESTABLISH A MINIMUM OF 50 PROGRAMS IN GEOGRAPHICALLY DISPERSED EDUCATIONAL INSTITUTIONS TO MEET THE DEMAND FOR 2,000 TECHNICIANS PER YEAR, (2) TO UNDERTAKE MAJOR CURRICULUM DEVELOPMENT RATHER THAN TO COMBINE EXISTING COURSES, AND (3) TO CONTINUE INTENSIVE RESEARCH TO DEVELOP AN ASSOCIATE DEGREE TYPE OF CURRICULUM ADAPTABLE TO NUMEROUS POST-SECONDARY INSTITUTIONS. (JK)

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PHASE I

July 1967

U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE

Office of Education
Bureau of Research

Development and Evaluation of Educational Programs in Bio-Medical Equipment Technology
Phase I

Project No. EO-366-65
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CONTENTS

LIST OF TABLES

Table		Page
XXXV.	Summary of Mean Number of BMET's Needed per Employer.	75
XXXVI.	Summary of Number of BMET's Needed by Employers in Population Studied.	
XXXVII.	Proportion of BMET's Needed Designated by General Job Types.	79
XXXVIII.	Number of BMET's Needed by Employers in Population Studied Designated by General Job Types.	80

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This research project has been carried on as a co-ordinated team effort and represents the contributions of many people in many ways. It represents not only the efforts of the staff members and consultants of Technical Education Research Center, Inc. (TERC), but of many individuals in hospitals, medical schools, research institutes, and equipment manufacturing concerns who have attended planning conferences and have in various ways assited the staff in planning and carrying out of this project. A list of both TERC staff members and other individuals who have assisted in this project is contained in Appendix E. Many other individuals including U.S. Government personnel in the U.S. Office of Education and other agencies who are not listed have also contributed to this project. Grateful acknowledgement is made of the contributions of all of these individuals.

Grateful acknowledgement is also made of the contributions of representatives from those hospitals, manufacturers, and research institutes who were interviewed during the Preliminary Survey and the Field Study. The names of these institutions (although not the individuals interviewed) are listed in Appendixes F and G.

INTRODUCTION

Recent advances in the fields of electronics and instrumentation have resulted both in the acceleration of medical technology in terms of equipment and procedures, and the creation of a need for people able to understand and effectively utilize these new gains. The proliferation of increasingly more complex and sophisticated instruments and methods in this area has created, among other things, a need for technicians capable of servicing and maintaining the bio-medical equipment used in hospitals and medical research institutes. The development of this technology has opened up a new area of employment--one which requires its personnel to be trained specifically to meet its needs.

The rapid growth of bio-medical equipment technology within the past few years has coincided with and has resulted largely from a rapid increase of expenditures in bio-medical research. As expenditures in bio-medical research have continued to grow,[1] there have been large increases in the numbers of research scientists[2] in the fields of biological and medical research. At the same time, manufacturers of bio-medical equipment have kept abreast of these trends. The volume of sales continues to expand as it reflects the rapid growth in the use of new bio-medical systems and instruments[3].

At present there are few educational programs in existence to prepare men specifically as Bio-Medical Equipment Technicians (BMET's). This lack of training opportunities has created an occupational vacuum; there is a lack of individuals able to fill the roles fostered by technological advances. There is evidence that the lack of educational programs for BMET's is adversely affecting many national health programs now underway and, unless corrected, may impair the quality and efficiency of our nation's health services.

The purpose of this project was three-fold. First, on the assumption that there _is_ a need for bio-medical equipment technicians, the extent of that need had to be determined. Secondly, once the need had been verified, it was necessary to determine the specifications of the need for bio-medical equipment technicians (location and extent of employment opportunities, specific job functions and characteristics). Finally once the specifications of the need had been determined it was necessary to design the preliminary framework or structure of a curriculum which will adequately prepare BMET's to fill these needs and to develop useful new careers in this rapidly emerging technology.

This research project as originally conceived had the final objective of developing a suggested two year post high school curriculum guide for bio-medical equipment technology. These objectives were reflected in the original title of the project--"Development of a Curriculum Guide for Bio-Medical Equipment Technology."

Research work was begun April 1, 1966 and was completed June 30, 1967. The first four months were devoted to a Preliminary Survey of the Field. This Preliminary Survey included a review of the literature and a series of unstructured interviews both with leading professionals in the field of bio-medical equipment technology and with officials of a number of prospective employers of BMET's. The categories of prospective employers interviewed included hospitals, medical schools, medical research institutes and bio-medical equipment manufacturers throughout the country.

The objectives of the Preliminary Survey were (1) to review any previous research programs or existing educational programs which might be relevant to this program; (2) to develop preliminary information about the prospective employers of BMET's and about the employment opportunities, functions, and characteristics of BMET's; and (3) to develop a preliminary proposed curriculum outline. This information was needed as a basis for developing the detailed research design for the project.

The Preliminary Survey strengthened previous impressions that little if any relevant occupational research has been done in the field of bio-medical equipment technology and that few if any formal educational programs exist for technicians in this field in the United States. Those technicians at work in the field typically have either electronic, electrical, or instrumentation backgrounds. They lack training to varying degrees in the basic educational subjects underlying this multidisciplinary technology. Their on-the-job training is usually restricted to providing them with proficiency in specific equipments of interest to their employers. Because of this lack of educational background their ability to develop and grow within this rapidly changing technology is limited. Furthermore many of the tasks and functions which might be performed by trained BMET's are now necessarily being performed by professionals with consequent expenditure of professional time. It was the general opinion of those interviewed in the Preliminary Survey that if a supply of systemmatically trained BMET's existed there would be substantial and growing employment opportunities for them particularly among three major categories of employers--hospitals, bio-medical equipment manufacturers, and medical research institutes.

The Preliminary Survey also considerably strengthened previous impressions that a BMET capable of meeting the present and developing needs of these employers would be a new type of technician. The need for such technicians has only recently been created by the development of this rapidly emerging technology. Understandably there exists virtually no educational experience to rely upon as a sound basis for the development of a curriculum for such a technician.

In view of the lack of existing occupational information in this field and the lack of tested instructional materials, it was concluded that it would be premature to publish a "curriculum guide" for bio-medical equipment technology until an actual curriculum for BMET's had been developed, pilot tested, and evaluated. It was felt that dissemination of an untested or "paper" curriculum guide could be a disservice both to schools, to prospective BMET's, and to their employers. It was also concluded that in a rapidly emerging technology such as this, where there is not yet a generally recognized occupational structure, any sound curriculum development effort must be preceded by a rather careful and intensive program of occupational research.

It was therefore decided, with the approval of the Project Officer, that in view of the budgetary limitations of the project, primary effort in this project should be focused on obtaining valid factual occupational information as to the developing employment opportunities, functions, and other characteristics of Bio-Medical Equipment Technicians. On the basis of this information, at least the general structure and a preliminary outline of a curriculum for BMET's would be developed. It was recognized that if the occupational research confirmed the preliminary indications of substantial employment opportunities for BMET's, it would be necessary, before actual educational programs for BMET's could be established in schools, to later carry out a carefully designed curriculum development and evaluation project in order to "flesh out" the curriculum and to develop and test the necessary instructional materials.

The objectives of the present project were therefore modified in August 1966 to comprise the following two specific objectives:

1. To determine by means of occupational research the employment opportunities for Bio-Medical Equipment Technicians and to identify the functions and other characteristics of such technicians; and

2. To develop a preliminary curriculum outline or structure for post high school educational programs in Bio-Medical Equipment Technology.

In order to achieve these two objectives a field study was designed based upon structured interviews with officials of a representative regional sample of the three major categories of prospective employers of BMET's--hospitals, bio-medical equipment manufacturers, and medical research institutes. The region studied included the six New England states (comprising Region I as defined by the American Hospital Association) and the three Mid-Atlantic states of New York, New Jersey and Pennsylvania (comprising Region 2 as defined by the AHA). It was believed, on the basis of the Preliminary Survey, that few if any regional differences exist in the pattern of employment opportunities and characteristics of BMET's within the United States so that the regional study would have national significance.

The Field Study was begun in October 1966 with the interviews being carried out during the period October 1966 through February 1967. The interview data were coded and analysed during the period March through June 1967. The preliminary curriculum outline for BMET's was developed in the months of May and June 1967 based upon the results of the occupational research as reviewed by a Curriculum Conference held in May 1967.

The results of the field study are reported in two parts: Part I entitled "Need for and Characteristics of BMET's" describes the statistical results of the occupational research. This part documents employment opportunities within the region and employer population studied. It identifies and describes the characteristics of four general types of jobs which BMET's will fill. The results of Part I imply a national need for the immediate development of educational programs for BMET's for a minimum of 2000 BMET's per year in fifty or more technical institutes and community/junior colleges.

Part II of the Results entitled "Preliminary Curriculum Outline for BMET's", outlines the general structure of a two year associate degree type curriculum in Bio-Medical Equipment Technology designed on the basis of the field study. It should be strongly emphasized that this curriculum outline is very preliminary and has not been tested. It is presented only to indicate the general requirements of such a curriculum and to form the basis for the detailed development, pilot-testing, and evaluation of such a curriculum in a Phase II research project.

The requirements of such a curriculum for BMET's are quite different from existing curricula in technical institutes and community/junior colleges. Many of the necessary instructional materials do not exist. In order to assist schools in establishing needed educational programs for BMET's it has been recommended that a broadly generalizeable curriculum development, testing and evaluation project be undertaken as a Phase II continuation of this program. TERC expects to begin such a Phase II curriculum development project with the cooperation of two pilot schools in September 1967. As soon as the tested instructional materials developed in Phase II are available, it will be possible for technical institutes, community/junior colleges and other post secondary schools to establish educational programs for BMET's with a minimum of local effort, cost, and time. Such programs can provide the basis for new careers in Bio-Medical Equipment Technology for thousands of young people. It is hoped that this intensive and coordinated research effort to develop and test educational programs for BMET's can provide a model for the systemmatic development of generalizeable educational programs in other emerging technologies.

The title of this Report has been changed from its original form both to reflect the modified objectives of this study and to identify it as the first phase of a broader coordinated research program to develop and evaluate educational programs in bio-medical equipment technology.

METHOD

I. Identifying the Populations and Sub-populations and Selecting Samples

The population of the field study (hospitals, bio-medical research institutes and bio-medical equipment manufacturers) was restricted to the New England and Middle Atlantic states on the premise that few, if any, regional differences exist in the pattern of employment opportunities and knowledge and skill requirements for BMET's. This restriction enabled TERC to carry on a sound statistical study within the budgetary limitations of the project. This decision was reinforced by the fact that the American Hospital Association Guide has a relatively detailed compilation of data that can be used to identify and compare the regional similarities and differences of hospitals.

As a result of conferences with hospital personnel it was decided to further limit the hospital sub-population by selecting only those hospitals offering general service, having at least 100 beds, and having either an accredited residency or internship program. It appeared evident that these criteria would be accurate indicators of hospitals which presently use, or which would use in the near future, substantial amounts of bio-medical equipment. The 1966 AHA Guide was used to identify hospitals meeting the above criteria.

These procedures yielded a sub-population of 318 hospitals. Three variables were used to stratify the hospital sub-population: medical school affiliation, cost per patient, and per cent of total expenses used for payroll. Cutting points for the latter two variables were determined on the basis of a two-dimensional matrix for each value of the first variable, i.e., a two-variable distribution for both hospitals with medical school affiliation and those lacking such affiliation. The cutting points were selected in such a way as to provide the most uniform distribution among the sub-groups. Once the hospitals had been assigned to sub-groups according to these three variables (see Table I) sampling quotas were set for each sub-group according to its relative size. An additional sub-group of 25 Veteran's Administration hospitals was identified. The decision to separate this sub-group from the others

TABLE I

DISTRIBUTION* OF HOSPITAL SUB-POPULATION ACCORDING TO THREE STRATIFYING VARIABLES**

Medical School Affiliation

		TOTAL EXPENSES PER PATIENT PER YEAR		
		Less than $18,000	More than $18,000	Total
Per cent of total expenses used for payroll	Less than 65%	14 (6)	31 (6)	45
	More than 65%	23 (6)	21 (6)	44
	Total	37	52	89

No Medical School Affiliation

		TOTAL EXPENSES PER PATIENT PER YEAR		
		Less than $18,000	More than $18,000	Total
Per cent of total expenses used for payroll	Less than 65%	60 (9)	28 (6)	88
	More than 65%	58 (9)	58 (9)	116
	Total	118	86	204

* Numbers in parentheses indicate sampling quotas

**From a sub-group of 25 Veteran's Administration hospitals a quota of 6 was assigned was based on the fact that they did not exhibit the characteristics of the other hospitals in the same proportions. It was felt that they would exert disproportionate influence on the results of one or two of the other sub-groups. Each sub-group was then randomly sampled to meet those quotas, yielding a sample of 63 hospitals. Additional hospitals were selected randonly to serve as alternates.

Four hundred thirty-five manufacturers of bio-medical equipment were identified in the New England and Mid-Atlantic regions from listings in the Medical Instrument Dictionary and Buyer's Guide, and Science magazine. Two variables were used to refine the population: type of equipment produced, and relative size as measured by asset data. Equipment was classified as either physiological (monitors, recorders, EKG's, etc.) or bio-chemical (laboratory equipment). Equipment of the first category generally has contact with the patient whereas equipment of the second category generally does not have contact with the patient. A third category designated "other" was required for those manufacturers who produced both types of equipment or who manufactured equipment not clearly of one type of the other.

On the basis of asset data obtained from the Dun and Bradstreet Million Dollar Market, the Dun and Bradstreet Middle Range Market, and the Thomas Register, three groups were identified: those companies worth $1,000,000 or more; those worth less than $1,000,000; and those manufacturers for which no asset data could be found. After discarding the "Other" category (leaving a total population of 380), quotas were set for each of the remaining six sub-groups. Random selections from each cell yielded a sample of 48 equipment manufacturers in the bio-medical equipment field (see Table II).

In the process of arranging interviews and randomly selecting alternates, it was found that 45 had been inappropriately identified for inclusion in the sample, i.e., they were not actually in the bio-medical equipment field, or were in the field only to a very small degree. There were five who either did not exist or who declined to participate in the study. Thirty-six were appropriate for the sample.

Thus, if one makes estimates on the basis of the total,

TABLE II

DISTRIBUTION* OF MANUFACTURER SUB-POPULATION ACCORDING TO TWO STRATIFYING VARIABLES

	Physiological		Laboratory		Other	Total
$1,000,000 or more	37	(6)	67	(9)	12	116
Less than $1,000,000	30	(6)	78	(9)	6	114
No asset data	59	(9)	109	(9)	37	204
	126	(21)	254	(27)	55	435

* Numbers in parentheses indicate sampling quotas.

but overinclusive, list of 380 manufacturers of bio-medical equipment, one could expect to find 182 inappropriately identified, 34 manufacturers either non-existent or not willing to participate, and 164 manufacturers both in the field and willing to participate.

Bowker Associates of New York provided TERC with two lists of research institutes in the two geographical areas being studied. Only one of the lists contained any supplementary data. Ninety-nine institutions from this list of 214 were selected as being in the field of bio-medical research. Forty-four of this smaller group were chosen as the sub-group to be studied, on the basis of the fact that more than 50% of their resources were devoted to research rather than to other types of activities. This group was designated "Research Laboratories" (RL).

As no data were available concerning the second list of 122 "Bio-Medical Institutes" (BMI) sub-group by Bowker Associates, it was decided to sample this sub-group without further qualification. Quotas of 6 and 9 were assigned to the two sub-groups; institutions and their alternates were drawn randomly within each group.

From the total sample to be studied it was found that 5 had been inappropriately identified. Eight institutions did not exist or declined to participate. Fifteen research institutions were appropriate to the study. On the basis of these figures it can be estimated that from the total population of research institutes, 28 would not belong in the sample, 52 might decline or be found not to exist, and 88 would be suitable for study.

In the course of conducting the interviews, suggestions were made by the respondents regarding the breadth of the field study. On the basis of these recommendations several supplementary interviews have been conducted, notably with hospital supply houses and local dealers of scientific instruments. However, since these types of organizations were not included in the original research design of this project, information from these sources were not included in the results of the field study.

II. Interview Procedures

Four interviewers were involved in conducting the interviews of the total field study population. In cases where there was more than one person interviewing a particular sub-population, interviews were assigned on a random basis within that sub-population.

Prior to the beginning of the interviews specialists in the areas of both technical and medical education devised a tentative two-year curriculum plan (Appendixes AI and AII). These charts were used not in a definitive manner, but rather as a basis for comments and reactions by the people being interviewed.

Loosely structured interview guides were used to record information gathered during the field study (Appendix AIII). The guide for each sub-population varied slightly in order to make it more applicable to that sub-population. These interview guides provided the basis for the data presently being analysed. The information was used to document the need for BMET's and his knowledge and skill requirements.

After selection of the hospitals, equipment manufacturers, and research institutes to be interviewed, arrangements were made to conduct the interviews. These arrangements were greatly facilitated in the case of the hospital sample by the generous cooperation of the New England Hospital Assembly and the Mid-Atlantic Hospital Assembly which wrote letters of introduction to the administrators of the hospitals to be interviewed within their respective regions. Similar letters of introduction were written by the Association for the Advancement of Medical Instrumentation to the manufacturers to be interviewed. Similar letters were written by the Bio-Medical Instrumentation Advisory Council of the American Institute of Biological Sciences to the research institutes to be interviewed. The cooperation of these professional organizations was very helpful in assuring the cooperation of the key officials of the institutions to be interviewed.

Following the letters of introduction the recipients were contacted by telephone, the field study was more fully described, and the date and time for the interviews were arranged. Among the hospitals the hospital administrator was usually interviewed first. In some cases additional interviews were conducted with other knowledgeable officials within the hospital. A similar pattern was followed in interviewing the manufacturers and research institutes. All interviews were conducted by experienced interviewers. Two interviewers were randomly assigned to conduct the hospital interviews. Two interviewers were randomly assigned to conduct the manufacturer interviews. One interviewer conducted all research institute interviews.

III. Data Coding and Analysis

After completion of interviews, the interview data relating to the need for and characteristics of BMET's was coded and the coded data was punched into IBM cards. Data analysis was carried out in the form of frequency distributions.

Data gathered during the field study relating to the curriculum for BMET's was distributed to members of a Curriculum Conference consisting of representatives of hospitals, research institutes, manufacturers and technical educators. This data was used as the basis for the development by this Curriculum Conference of a preliminary outline for a two year associate degree type curriculum for BMET's.

RESULTS - PART I

THE NEED FOR AND CHARACTERISTICS OF BMET'S

I. Hospital Sub-Population

In many cases the coding of the data from the interview guides was designed to compensate for the roughness of the data. A second factor which affects the data is that in many instances the interviews were the first discussion which a respondent had on the topic of the need for bio-medical equipment technicians. This probable influence on the data could not be controlled in the analysis. On factor, however, could be readily controlled, i.e., the proportion of people who made no response to questions put to them during the interview. The data analysis is designed to carefully tabulate the proportion of respondents to each of the major questions and to report the findings only on the basis of those who responded.

The hospital sub-population was stratified on the basis of three variables: medical school affiliation (MSA), total expenses per patient per year (TE), and per cent of total expenses used for payroll (PR). Each variable was used to identify two groups of hospitals, producing a total of 8 sub-groups. Because of their specific characteristics, a ninth sub-group consisting only of VA hospitals was created. The cutting points used in this study were chosen to make the distribution of hospitals in the 8 sub-groups as even as possible. These cutting points are similar to the means established in the AHA Guide.

A. The Need for Bio-Medical Equipment Technicians

As a first approximation of the reaction to the respondents to this discussion, each interview report was coded to indicate whether the respondent at one time or another agreed that there was a need for bio-medical equipment technicians. This agreement could take several forms, ranging from a willingness to hire such a person immediately to simply stating that the service and maintenance of equipment was a pressing problem which could probably be resolved through the hiring of additional personnel. Eighty-four per cent of the respondents were in general agreement as to the need for BMET's. This indication was relatively uniform across the nine sub-groups. There is one notable exception. As may be seen in Tables BI and BII of the Appendix, in hospitals lacking MSA and having a below average TE and above average PC, 44% of the respondents indicated such a need. The finding is surprising in its deviation from other sub-groups, particularly among hospitals with relatively high payroll costs, for it was assumed that hospitals of this type would recognize the need for personnel and have budgets reflecting that concern.

1. Current Staff Needs

Each respondent was asked to specify a number of BMET's that he could use as members of his staff both now and by 1970. Tables BIII and BIV in the Appendix contain the proportion of respondents who specified a need for a number of BMET's on their present staff. There were respondents who clearly stated that there were no positions open on their current staffs for BMET's. There were others who did not respond to this question. Since an acceptable response in this regard was the number "o", the former group is included in these proportions and the latter group is excluded.

Tables III and IV contain the mean number of BMET's currently needed on hospital staffs. The standard deviations of these means are also included. The means and variances reported in this section were computed according to formulas presented in Chapter 5 of Sampling Techniques.[4] These data indicate that hospitals with MSA express a greater need than those without MSA. Hospitals with relatively low PC express a greater need for BMET's than those with a relatively higher PC, and hospitals with relatively high TE express a greater need for BMET's than those with relatively low TE. Only the finding with respect to payroll cost is surprising. As previously stated, it was assumed prior to the interviews that hospitals currently spending more in payroll would tend to recognize a greater need for BMET's. The data support just the opposite finding, i.e., those hospitals currently spending less in payroll recognize a greater need for BMET's.

The overall picture supported in Tables III and IV is far simpler than the complex interaction of these three variables. For example, in spite of the fact that hospitals with MSA have a higher mean need, two sub-groups with MSA have a lower mean need than that of hospitals lacking MSA. One of the non-MSA groups expresses a higher need than the mean of hospitals with MSA. One

TABLE III

Mean Number of BMET's Needed Now per Hospital

Medical School Affiliation

		Total expenses per patient per year	
		Less than $18,000	More than $18,000
Per cent of total expenses used for payroll	Less than 65%	2.0 /1.58*	1.0 / .82
	More than 65%	.75/ .43	2.50/1.06

Sub-total 1.34/ .25

No Medical School Affiliation

		Total expenses per patient per year	
		Less than $18,000	More than $18,000
Per cent of total expenses used for payroll	Less than 65%	1.50/ .71	1.33/ .47
	More than 65%	.50/ .50	1.14/.64

Sub-total 1.10/ .15

V.A. Hospitals

.80/.40

*Mean Number/Standard Deviation

Grand total 1.13/ .13

TABLE IV

Mean Number of BMET's Needed Now per Hospital
(Excluding V.A. Hospitals)

		TOTAL EXPENSES PER PATIENT PER YEAR		
		Less than $18,000	**More than $18,000**	**Total**
Per cent of total expenses used for payroll	**Less than 65%**	1.75/.33*	1.16/.31	1.50/.25
	More than 65%	.63/.21	1.44/.24	1.06/.16
	Total	1.19/.23	1.33/.19	1.26/.15

* Mean Number/Standard Deviation

can draw accurate conclusions only when the interaction of the three variables is taken into account.

Tables CI and CII in the Appendix contain the extrapolation of the means reported above to the hospital sub-population. The actual numbers do not necessarily closely reflect the means reported in Tables I and II because of the variations in the size of each sub-group. The grand total is reported, with 80% confidence limits, that there is a need for between 175 and 228 bio-medical equipment technicians in hospitals having the characteristics identified in the previous section.

2. Projected 1970 Need

The respondents were less able to specify a number of BMET's needed on their staffs by 1970. In fact, one sub-group could make no estimate at all. Tables BV and BVI in the Appendix contain the proportion of respondents who specified a need for BMET's in 1970.

Tables V and VI contain the mean number of BMET's specified by those respondents in each of the sub-groups. The overall results of the mean number of BMET's needed on current staffs is supported by the data on projected 1970 need, as is also the rather complex interaction of the variables. However, the pattern of interaction is somewhat different. This pattern is, of course, disrupted by the failure of the one sub-group to provide any estimate of their staff needs of 1970. One of the most interesting deviations from the pattern reported for current staffs is that the sub-group lacking MSA, but with a relatively high PC and low TE, for which there was the lowest mean number of BMET's needed on their current staffs, now has the second highest mean number for their 1970 staffs.

Tables CIII and CIV contain the extrapolations of the means reported above for the hospital sub-population. At an 80% confidence level there is a need for between 286 and 398 BMET's by 1970 in hospitals with the characteristics identified in the previous section.

3. Growth Estimate in the Need

There is a danger that one will infer a growth rate in reporting two estimates of need differing by an amount

TABLE V

Mean Number of BMET's Needed in 1970 per Hospital

Medical School Affiliation

		TOTAL EXPENSES PER PATIENT PER YEAR	
		Less than $18,000	More than $18,000
Per cent of total expenses used for payroll	Less than 65%	3.0/2.77 *	3.75/2.82
	More than 65%	1.50/.50	0

Sub-total 3.09/ .78

No Medical School Affiliation

		TOTAL EXPENSES PER PATIENT PER YEAR	
		Less than $18,000	More than $18,000
Per cent of total Expenses used for payroll	Less than 65%	1.0/0	2.5 / .50
	More than 65%	3.0/.82	2.33/1.05

Sub-total 2.19/.27

V.A. Hospitals

1.60/ .48

*Mean Number/Standard Deviation

Grand total 2.41/ .29

TABLE VI

Mean Number of BMET's Needed in 1970 per Hospital (Excludes V.A. Hospitals)

		TOTAL EXPENSES PER PATIENT PER YEAR		
		Less than $18,000	More than $18,000	Total
Per cent of total expenses used for payroll	Less than 65%	2.33/.75*	3.33/.95	2.73/.59
	More than 65%	2.40/.32	2.33/1.05	2.36/.28
	Total	2.36/.50	2.83/.77	2.58/.36

*Mean Number/Standard Deviation

of time. The report of each time period was independent of the other and many respondents were not able to provide an estimate for both points in time. In order to estimate the growth rate of the need for BMET's, it would be necessary to analyze the responses of those who provided data for both points in time. Tables VII and VIII contain the results of such an analysis. The numbers in parentheses indicate the proportion of respondents who provided estimates of both current and 1970 need. The statistics reported in Tables VII and VIII are the mean proportion increase in the number of BMET's between now and 1970. The most startling result contained in the tables is that those hospitals which reported the lowest need for BMET's report the greatest growth rate. The degree of interaction among the three variables is not as pronounced with respect to the growth rate as it is with respect to the need. In Table VII the comparison among sub-groups is about what would be expected on the basis of the overall findings. In Table VIII the interaction is opposite to the direction of the interaction reported in Table IV.

B. Variables Related to the Need for BMET's

The variables stratifying the hospital sub-population were chosen after consultations with persons familiar with hospital organization. The considerable interaction of these variables with regard to the current and projected needs for the BMET and to the growth rate of this need indicates their unsuitability; that is, the pattern established by the 9 sub-groups is independent of the three stratifying variables.

Using the need and growth rate data, the 9 sub-groups can be placed into the following five categories of need: above average, average, below average, decreasing, and increasing. This categorization contains one or two inconsistencies, but in general, it avoids the complexity of the interaction among the stratifying variables and the variation with respect to expressed needs on current staffs and projected 1970 staffs. One sub-group (having MSA and relatively low PC and TE) expressed an above average need for BMET's for both current and projected 1970 staffs. Two sub-groups (both lacking MSA and having relatively high TE but having opposite PC values) expressed a need for BMET's approximating the overall mean need. Two sub-groups (the VA

TABLE VII

Mean Proportion Increase in Need for BMET's per Hospital (1966-1970)

Medical School Affiliation

		Total expenses per patient per year	
		Less than $18,000	More than $18,000
Per cent of total expenses used for payroll	Less than 65%	1.87 (.69)*	2.33 (.5)
	More than 65%	2.0 (.33)	no estimate

Sub-total 2.06 (.37)

No Medical School Affiliation

		Total expenses per patient per year	
		Less than $18,000	More than $18,000
Per cent of total expenses used for payroll	Less than 65%	1.0 (.11)	2.5 (.33)
	More than 65%	3.0 (.22)	2.16 (.56)

Sub-total 2.27 (.33)

V.A. Hospitals

1.5 (.33)

Grand total 2.11 (.35)

* Mean Proportion Increase (Proportion of sample responding to this question.)

TABLE VIII

Mean Proportion Increase in Need for BMET's per Hospital (1966-1970)

		TOTAL EXPENSES PER PATIENT PER YEAR		
		Less than $18,000	More than $18,000	Total
Per cent of total expenses used for payroll	Less than 65%	1.73 (.33)*	2.39 (.42)	2.06 (.37)
	More than 65%	2.4 (.27)	2.16 (.40)	2.27 (.33)
	Total	2.03 (.30)	2.28 (.41)	2.16 (.35)

* Mean Proportion Increase (Proportion of sample responding to this question.)

sub-group, and one having MSA, relatively low TE and relatively high PC) expressed a below average need for BMET's for both the current and 1970 staffs. Two sub-groups (one having MSA and both relatively high TE and PC, the other lacking MSA and both relatively low PC and TE) expressed an average or above need for BMET's on the current staffs, but either could not estimate for the 1970 staffs or indicated a below average need for BMET's. Two sub-groups (one having MSA, a relatively high TE and relatively low PC, the other lacking MSA and having a relatively low TE and relatively high PC) expressed a need for BMET's opposite to that of the previous category; that is, a below average current need and an above average need for 1970.

1. Definition of Variables

Several variables may be used to study the relationship among the categories of sub-groups mentioned above. These variables can be placed into one of two general classifications. The data from one type of variable was gathered independent of the field study and is relatively objective and subject to little variation. Variables of this type are: number of beds, type of control, region in which the hospital is located, and type of city in which the hospital is located. Data for variables of the second type were collected as a part of the field study, and although the data are objective, they are not precise. These variables are: the amount of investment in bio-medical equipment, the yearly expenditure in bio-medical equipment, and the yearly expenditure in personnel and services associated with the equipment. Analysis of these variables was concerned with the distribution of the responses rather than the content of the responses; that is, the analysis was concerned not so much with specific figures, but rather with a respondent's relative position with respect to the other respondents. The distribution of the two variables concerning equipment were trichotimized, providing three groups: above average, average, and below average; the variable concerning personnel and services was dichotimized, providing an above and below average group. Appendix D contains a further exposition of this type of analysis.

Two variables need a brief explanation. Data on a hospital's type of control, taken from the AHA Guide, indicated that there were four types of control in the sub-population studied here. First was the governmental non-federal type of control, consisting primarily of city hospitals, although one of this group was a county hospital. Second was the church affiliated voluntary, non-profit type. VA hospitals and one US Public Health Service hospital comprised the third group of governmental federal hospitals. The final group, other voluntary, non-profit, consists primarily of community as distinguished from city hospitals.

There are two obvious classifications of the city type variable: large cities (New York, Philadelphia, Boston), and small cities (Bangor, Maine and Altoona, Pa.). A third category was used to include cities not clearly of either of the other two types; for example, Buffalo, New York, and Hartford, Conn. This category also includes suburbs such as Brockton, Mass. and East Orange, N.J., on the assumption that these cities are more akin to large cities in their thinking and outlook than to small towns isolated from large urban centers.

2. The Relationship Among the Variables and the Need for BMET's

Table IX contains the values of each variable for each category of sub-group. There are two sets of comparisons contained in Table IX: first, among the three columns in which the level of need is specified; and second, among the last two columns in which the change in the need for BMET's is indicated. The data with respect to the control variable is reported in proportions of three of the four control types identified in the previous section. In order, they are: governmental non-federal, church related voluntary non-profit, and other voluntary non-profit (community). The governmental federal control is not reported in the table, but one may infer its influence on the need for BMET's, since this type of control was largely in the VA subgroup which was categorized as below average. Data on the region variable is reported as the proportion of each category located in region 2. The last four variables reported in this table are distribution variables indicating the degree of skewness in the distribution of respondents on each of the variables.

Considering the data relative to the level of need con-

TABLE IX

Comparative Data on the Need for BMET's in Hospitals

Variable	Mean Need Relatively Constant (1966-70) Below Average N=12	Average N=15	Above Average N=6	Mean Need Changing (1966-70) Decreasing N=15	Increase N=15	Total N=63
Average Number beds	665	475	500	420	390	450
Type of Control[1]	.1/.2/.3	.2/.3/.5	0/.2/.8	.1/.1/.8	0/.3/.7	.1/.2/.6
Region[2]	.8	.7	.8	.9	.7	.7
City Type[3]	1.5	1.8	1.5	1.9	1.8	1.7
Investment in equipment[4]	2.2	2.0	2.4	1.9	1.9	2.0
Equipment Expenditure (Annual)[4]	1.7	1.8	3.0	2.0	1.8	2.0
Personnel and service Expenditure[5]	1.2	1.4	1.8	1.3	1.1	1.3

1. Proportion of hospitals controlled as follows: Governmental, non federal (primarily city)/Church related/ Other voluntary non-profit (primarily community hospitals)

2. Proportion of hospitals in Middle Atlantic region. Remainder in New England.

3. Index of city size: 1=Large city; 2=Middle sized or suburban city; 3=Small city

4. Measure of symmetry of distribution. See Appendix D. Perfect symmetry = 2.0

5. Measure of symmetry of distribution. Perfect symmetry =1.5

tained in the first three columns, the above average category has a high proportion of community hospitals, a relatively high investment in equipment, and in yearly expenditures on equipment and personnel and services associated with the equipment. The average category is characterized by mean values on each of the variables. The below average category has a high average number of beds, a high degree of federal control and a relatively low expenditure in equipment. The city type and investment variables are interesting in their pronounced U shaped relationship, in which the above and below average categories have similar values and the average category a different value. In the city type variable the above and below average categories have a distribution skewed toward the big city type, whereas the average category has a distribution skewed toward the middle city type. In the case of the investment variable the above and below average categories have distributions skewed toward high investment in equipment and the average category has a symmetrical distribution.

The data with respect to the change in the need for BMET's in the last two columns shows that there is little to suggest how these two categories might be different. There is some evidence that the category in which the need for BMET's will increase has a smaller average number of beds, has a greater degree of church related control, and is currently spending less on equipment. The category indicating a decrease in the need for BMET's has a rather high proportion of its respondents located in region 2. None of these differences is pronounced, but there is a consistency which is indicative of a trend in the findings.

Two of the variables used in Table IX provide a simple relationship for the level of needs for BMET's. These variables--the equipment and personnel and service expenditures--were therefore studied in greater detail in order to determine the characteristics of hospitals expressing a need for BMET's. Table X contains data relating expenditure in equipment to each of the other variables. As previously stated, expenditure in equipment is a distribution variable in which the distribution was trichotimized, providing groups of average, above average, and below average expenditures in equipment. There is also a proportion of respondents who

TABLE X

Comparative Data by Level of Annual Hospital Expenditure in Equipment:

Variable	Level of Expenditure: Below Aver. N=18	Average N=11	Above Aver. N=13	Total N=63	No Response N=21
Current Mean need for BMET's	1.00 (.5)[1]	1.00 (.5)	1.75 (.6)	1.13 (.6)	1.09 (.5)
Projected Mean need for BMET's 1970	2.81 (.6)[1]	1.67 (.3)	2.33 (.5)	2.41 (.5)	2.00 (.4)
Invest. in Equip.	1.7	2.1	2.4	2.0	2.1
Aver. Num. of beds	320	550	370	450	480
Type Control[2]	0/.22 /.56	.09/.18 /.73	.15/.23 /.46	.10/.21 /.59	.14/.19 /.62
City Type[2]	1.9	1.6	1.5	1.7	1.7
Region[2]	.5[illegible]	.64	.92	.71	.76
Propor.[3] MSA	.22	.45	.54	.38	.38
Propor.[4] High TE	.57	.82	.67	.53	.25
Propor.[5] Low PC	.43	.64	.42	.53	.60

1. Proportion responding to this question.
2. See footnotes Table IX for explanation.
3. Proportion of hospitals having Medical School affiliation.
4. Proportion of hospitals having relatively high total expenses per patient (over $18,000 per year).
5. Proportion of hospitals having relatively low per cent of payroll costs as related to Total Expenses (less than 65%).

made no response. The data for this latter group is included in the table in order to establish that they do not constitute a sub-set of responses which are not representative of the respondents in general.

Considering the relationship between the need for BMET's and the expenditure in equipment, the expected relationship is found with respect to current needs, namely that the greater the expenditure in equipment the greater the need for BMET's. An interesting reversal occurs when one considers the projected 1970 needs; the respondents with an above average expenditure in equipment indicate a below average need for BMET's, and those respondents having a relatively low expenditure in equipment express a high need for BMET's. There is a direct relationship between expenditure and investment in equipment, even though there is a U-shaped relationship between investment in equipment and the need for BMET's.

An inverse relationship was found to exist between city type and equipment expenditure. Hospitals having a relatively low equipment expenditure are, for the most part, suburban hospitals, whereas hospitals having a relatively high expenditure in equipment are primarily big city hospitals. This finding is corroborated in the control variable where the proportion of city type control is higher for those hospitals having a greater expenditure in equipment. The proportion of hospitals in region 2 increases as the value of the equipment expenditure variable increases. There are two U shaped relationships in these variables. Hospitals with a low or high expenditure in equipment have fewer beds than those with an average expenditure in equipment; hospitals with a low or high expenditure in equipment are to a lesser degree under the type of control typified by the community hospital.

The last three variables studied in relation to equipment expenditure are the stratifying variables. These data, shown in Table X, are the proportions of hospitals that according to their classification on each of the variables should express a higher need for BMET's. Using data of this form, one would expect a direct relationship between each of the stratifying variables and the equipment expenditure variable. This is the case only with regard to the MSA variable. In the other two cases there are U shaped relationships with the higher and lower equipment expenditure categories having lower values on the TE and PC proportions.

The type of analysis that was carried on with respect to equipment expenditures was also applied to personnel expenditures. A direct relationship had been established between personnel and service expenditures and the level of need categories for the sub-groups. Table XI shows the relationships between personnel and service expenditures and the other variables. The expected direct relationships between the need for BMET's and personnel and service expenditures were obtained for both current and projected 1970 needs. There is also the expected direct relationship between the investment in equipment and personnel and service expenditures.

There is some support for the relationships reported between characteristics of hospitals and their expenditures in equipment. The two most pertinent variables were region and city type of control. With respect to some of the other variables, however, there are some interesting deviations from the relationships reported in Table X. The most pronounced of these deviations is with regard to the number of beds. The U shaped relationship established with regard to equipment investment is not present with regard to personnel expenditures and instead there is a strong positive relationship established. It is also interesting to note that the proportion of hospitals under church related control, which was rather evenly distributed with respect to the equipment expenditure variable, shows an uneven distribution on personnel and service expenditures (those hospitals spending the most having a very low proportion of church related control). The city type variable does not corroborate the relationship established with city type control as it did with respect to equipment expenditures. In the case of personnel and service expenditures there is some evidence to suggest that suburban hospitals spend more money in personnel and services than hospitals in other settings.

Considering the relationship between personnel and service expenditures and the stratifying variables, the direct relationships that would be expected are obtained with respect to the MSA variable and the PC variable. The very opposite relationship is obtained with respect

TABLE XI

Comparative Data by Level of Annual Hospital Expenditure in Personnel and Services:

Variable	Level of Expenditure Below Aver. N=24	Above Average N=11	Total N=63	No response N=28
Current mean Need for BMET's	.79 (.6)[1]	1.71 (.6)	1.13 (.6)	1.29 (.5)
Projected Mean need for BMET's 1970	2.36 (.5)[1]	2.25 (.4)	2.41 (.5)	2.07 (.5)
Invest. in Equip.[2]	1.8	2.6	2.0	2.0
Aver. numb. of beds	330	630	450	430
City type[2]	1.7	2.0	1.7	1.6
Type Control[2]	.00/.25 /.58	.18/.09 /.64	.10/.21 /.58	.14/.21 /.57
Region[2]	.67	.81	.71	.71
Proport.[3] MSA	.42	.55	.48	.37
Proport.[4] High TE	.65	.30	.53	.52
Proport.[5] Low PC	.55	.80	.53	.41

1. Proportion responding to this question.
2. See footnotes Table IX for explanation.
3. Proportion of hospitals having Medical School affiliation.
4. Proportion of hospitals having relatively high Total Expenses per patient (over $18,000 per year).
5. Proportion of hospitals having relatively low percent of payroll costs as related to Total Expenses (less than 65%).

to the TE variable.

There are two factors which might influence the data reported here--respondent and interviewer biases. Information about the position and background of the respondents was gathered and studied with respect to their expressed needs for BMET's. There were three types of respondents: the largest proportion being hospital administrators, a smaller proportion being medical staff personnel, a very small proportion being personnel from other departments, and a fourth category composed of interviews with more than one respondent. No relationship was found between the type of respondent or his background and his expressed needs for BMET's. The matter of interviewer bias was also examined and some evidence was obtained to suggest that one interviewer recorded a higher need for BMET's than the other. As may be seen in Tables BVII and BVIII of the Appendix, the distribution of the interviewers among the subgroups was such that the differential influence of the interviewer was evenly distributed among the sample, so that the results reported here are not unduly influenced by interviewer bias.

C. Characteristics of the BMET

Three questions were asked in each interview concerning the characteristics of the BMET: his salary, his supervisor, and his functions.

1. Salary

Table XII contains the salary data. There is considerable deviation not only within each sub-group, as shown by the standard deviations, but also among the sub-groups. This deviation becomes smaller when the sub-group is considered in conjunction with other sub-groups of the same type. The grand mean salary of $7,700 has an 80% confidence range of only $240. Once again, there is evidence of interaction among the three stratifying variables, so that although there are relatively clear relationships among each of the stratifying variables taken one at a time, one is unable to comment on the salary estimate of a particular sub-group without knowing what value that sub-group has on each of the three variables. When the salary figures are compared to the expressed needs of Tables III and IV there is also an

TABLE XII

Mean "Average" Salary of BMET in Hospitals
Medical School Affiliation

		TOTAL EXPENSES PER PATIENT PER YEAR	
		Less than $18,000	More than $18,000
Per cent of total expenses used for payroll	Less than 65%	6900/1970*	8200/1420
	More than 65%	6750/1860	9350/1650

Sub-total 7900/430

No Medical School Affiliation

		TOTAL EXPENSES PER PATIENT PER YEAR	
		Less than $18,000	More than $18,000
Per cent of total Expenses used for payroll	Less than 65%	9900/2130	6750/1680
	More than 65%	7100/615	6600/1300

Sub-total 7700/315

V.A. Hospitals

7600/1140

Grand total 7700 ± 240 **

* Mean "Average" annual salary/Standard Deviation

** Indicates 80% confidence range

interesting contrast where some sub-groups that express a relatively high need for BMET's also express a relatively high average salary, whereas other sub-groups do just the opposite. A case in point is the sub-group with MSA and relatively low PC and TE values. This sub-group reported a higher need on both current and projected 1970 staffs and yet cited one of the lower salary ranges.

2. Type of Supervisor

There were three general types of BMET supervisor identified by the respondents: the chief engineer, a medical staff member, and the administrator. The latter was named by only 7% of the respondents; the other two were evenly distributed among the remaining 93%. The distribution of these types of supervisors among the nine sub-groups was rather even, as may be seen in Table XIII. The administrator as a supervisor was identified in the sub-groups having relatively low PC and TE values, although evenly distributed among the MSA and non-MSA sub-groups. Only with the PC variable was there an uneven distribution between the remaining two types of supervisor. Sixty-seven per cent of those respondents with a relatively low PC value identified the chief engineer as the supervisor of the BMET, while 69% of those respondents having a relatively high PC value identified the medical staff member as the supervisor of the BMET.

3. Functions of the BMET

The respondents were allowed wide latitude with regard both to the functions and the number of types of BMET. Approximately 54% of the respondents who expressed a need for BMET's identified only one type, 24% identified two types, one respondent (2%) identified three types, and one respondent (2%) identified four types of BMET's. The distribution of the number of types of BMET's is relatively even among the nine sub-groups, as may be seen in Table XIV. The remaining 18% of the respondents suggested that they could best utilize the service of a BMET by engaging in cooperative efforts with other hospitals.

The responses concerning the BMET's functions were coded into five categories: service, maintenance and calibration;

TABLE XIII

Proportion of Hospitals Identifying Types of BMET Supervisors:
Medical School Affiliation

		Total expenses per patient per year	
		Less than $18,000	More than $18,000
Per cent of total expenses used for payroll	Less than 65%	.4/.4/.2 *	.7/.3/0
	More than 65%	.3/.7/0	.5/.5/0

No Medical School Affiliation

		Total expenses per patient per year	
		Less than $18,000	More than $18,000
Per cent of total expenses used for payroll	Less than 65%	.6/.2/.2	1.0/0/0
	More than 65%	.0/1.0/0	.3/.7/0

V.A. Hospitals

1.0/0/0

Grand total .46/.47/.07

* Chief Engineer/Medical Staff Member/Administrator

TABLE XIV

Proportion of Hospitals Identifying Only One Type of BMET Needed

Medical School Affiliation

		Total expenses per patient per year	
		Less than $18,000	More than $18,000
Per cent of total expenses used for payroll	Less than 65%	.5	.8
	More than 65%	.6 (.2)*	.8 (.2)

No Medical School Affiliation

		Total expenses per patient per year	
		Less than $18,000	More than $18,000
Per cent of total expenses used for payroll	Less than 65%	.6 (.3)	.4 (.4)
	More than 65%	.5	.8

V.A. Hospitals

.6 (.2)

Grand total .54 (.18)

* Proportion indicating cooperative effort

operation of equipment; instruction in the use and care of the equipment; design and modification of the equipment as a member of a research team; and supervision of hospital's equipment, i.e., generally overseeing all aspects of the equipment. Not all the functions suggested by the respondents could be coded under this scheme. The 9% of the functions termed "other" included such things as being a lab technician, assisting in purchasing, and taking over some of the nurses' duties. Since some of the respondents were unable to specify functions, there is a category of unspecified duties.

Half of the respondents identified only the first function of servicing, maintaining and calibrating equipment (Hospital job type 1). The combination of functions reported by the remaining respondents were examined and two additional types of BMET's were identified: first, the BMET capable not only of servicing and maintaining the equipment but also operating or instructing in the use and care of the equipment (Hospital job type 2). The other type of BMET would have considerable more responsibility and would be capable of more sophisticated duties, i.e., he would be the member of a research team who would assist in the design and modification of equipment, or he might be in charge of a department whose specific purpose would be all aspects of the bio-medical equipment within the hospital (Hospital job type 3).

The distribution of thre three types of BMET is not uniform for the two periods in time for which the respondents were asked to provide data. In Table XV the distribution of the current need for these job types is provided. Two sub-groups identified a need for type 3 BMET's. One sub-group having MSA and a relatively low PC and relatively high TE identified a need for type 3 BMET's in the same proportion as for types 1 and 2. The other sub-group lacks MSA, has a relatively high PC and relatively low TE. Fifty per cent of the technicians that they felt were needed now on their staffs were to be of type 3. In an overall sense the need for BMET's is evenly divided among types 1 and 2. A notable exception is in the case of MSA vs. non-MSA hospitals. In the former, it is clearly desirable to have type 1 BMET's, whereas in the latter it is clearly desirable to have type 2 BMET's. This relationship holds fairly evenly within each of the sub-groups.

TABLE XV

Proportion of Hospital~ Indicating Current Needs for BMET's by Job Types

Medical School Affiliation

		Total expenses per patient per year	
		Less than $18,000	More than $18,000
Per cent of total expenses used for payroll	Less than 65%	.50/0/0/.50*	.33/.33/.33/0
	More than 65%	.40/.20/0/.40	1.00/0/0/0

Sub-total .64/.14/.06/.16

No Medical School Affiliation

		Total expenses per patient per year	
		Less than $18,000	More than $18,000
Per cent of total expenses used for payroll	Less than 65%	.16/.33/0/.50	0/.75/0/.25
	More than 65%	0/0/.50/.50	.24/.64/.0/.12

Sub-total .15/.49/.05/.31

V.A. Hospitals

.50/.25/0/.25

Grand Total .33/.36/.06/.25

* Hospital Job Type 1/Job Type 2/ Job Type 3/Unspecified Job Type

As shown in Table XVI, the same general relations hold true for the needs of 1970, but the degree of the relationship is sharply reduced, and in fact it is not consistently held through all of the sub-groups. Two of the sub-groups having MSA declare a need for a greater proportion of Type 2 BMET's, whereas in sub-groups lacking MSA there are two instances of a declaration of greater need for Type 1 BMET's. The Type 3 BMET's are favored by the same two sub-groups as in current needs, but to a lesser degree in the sub-group without MSA. An additional sub-group with MSA, relatively low PC and relatively high TE, expresses a need for Type 3 BMET's.

There had been the expectation that the delineation of the various types of BMET's would help explain the wide deviation in the reported salaries for each of the sub-groups. There are one or two instances in which this is true, but as is true in most of the preceding analyses, there are interesting exceptions and contradictions which prevent a simple general statement relating salary to job type. Table XVII contains data relative to the type of supervisor and the salary for each job type.

The two most startling salary/job type comparisons are the two most contrasting sub-groups. One has MSA, relatively high PC and TE values; the other does not have MSA and has relatively low PC and TE values. The former sub-group expresses a need for Type 1 BMET's and provides no data for 1970; the latter sub-group indicates a need for predominately Type 2 BMET's, although with some Type 1, and indicates a need for only Type 2 in 1970. Yet the average salary for these two sub-groups is over $9,000 (in the latter case very close to $10,000). Neither of these salary figures is consistent with any of the other findings. Nor is there any hint of a particularly high regard for the need for BMET's. An inspection of the individual responses provides no clue as to why these two sub-groups should indicate such a high salary.

TABLE XVI

<u>Proportion of Hospitals Indicating 1970 Need for BMET's by Job Types</u>

<u>Medical School Affiliation</u>

		Total expenses per patient per year	
		Less than $18,000	More than $18,000
Per cent of total expenses used for payroll	Less than 65%	.54/0/.08/.38*	.14/.20/.11/.55
	More than 65%	0/.34/0/.66	0/0/0/0

Sub-total .26/.15/.09/.50

<u>No Medical School Affiliation</u>

		Total expenses per patient per year	
		Less than $18,000	More than $18,000
Per cent of total expenses used for payroll	Less than 65%	.33/0/0/.67	0/.60/0/.40
	More than 65%	0/.33/.23/.44	.50/.42/0/.08

Sub-total .25/.37/.07/.31

<u>V.A. Hospitals</u>

.60/0/0/.40

Grand total .28/.27/.05/.40

* Job Type 1/Job Type 2/Job Type 3/Unspecified Job Type

TABLE XVII

Proportion of Hospitals Indicating Combinations of BMET Job Types, Supervisors and Mean Salaries*

	Supervisors			
Hospital Job Type	Chief Engineer	Medical Staff Member	Hospital Administrator	Mean Salary
1	.37	.13	.04	$7300
2	.09	.18	-	$7400
3	.04	.13	-	$8500

* Reflects only hospitals who provided data on both Job Types and supervisors.

II. Manufacturer Sub-Population

The interview guide used in the hospital sub-population was modified slightly for use in the manufacturer sub-population (see Appendix A-IV). The purpose of the modifications was to delete the questions specific to hospitals, and to add instead questions pretaining to biomedical equipment manufacturers. The manufacturer sub-population is also different from the hospital sub-population in its sample design. As previously reported, two variables were used to stratify the sub-population: type of equipment manufactured, and the assets of the company. With regard to the latter variable, a large segment of the sub-population did not have any asset data available. This segment was too large to discard, but it was too amorphous to study in detail. For that reason alternates were not chosen for the two sub-groups lacking asset data when the sampled manufacturer of those two sub-groups was found to be inappropriate for interviewing. The sampling of these two sub-groups was essentially exploratory--to gain some information about their characteristics. The other four sub-groups were focused upon in the study of this sub-population.

A. The Need for BMET's

Procedures for coding responses concerning the need for BMET's were similar to those used in the hospital sub-population. Eighty-two percent of the respondents indicated that the training of BMET's was a worthwhile endeavor. The distribution of this agreement among the sub-groups is even (see Table BIX in Appendix), with the single exception of manufacturers of physiological equipment with assets under $1,000,000. One-third of these respondents saw no need for BMET's.

1. Need on Current Staffs

Each of the respondents was asked to indicate the number of BMET's needed by his company currently and projected to 1970. Seventy-one per cent of the respondents were able to indicate a current need, but only 54% were able to project that need to 1970. In general, these proportions were evenly distributed among the sub-groups, as may be seen in Tables BX and BXI in the Appendix.

Table XVIII contains the mean number of BMET's needed now (standard deviations are included). These data show that there is considerable difference between the

TABLE XVIII

Mean Number of BMET's Needed Now Per Manufacturer

Type of Manufacturer

Assets of Manufacturer	Physiological Equipment	Laboratory Equipment	Total
More than $1,000,000	16.75/ 23.17 *	10.33/ 7.11	11.90/ 2.90
Less than $1,000,000	1.75/ 1.26	16.00/ 30.03	10.3 / 6/58
Sub-total	8.97/ 2/63	12.27 5.07	11.26 2.08
No asset data	8.0/ 1.15	2.67/ 1.53	4.24/ .63
TOTAL	8.48/ 2.10	7.25/ 2.02	7.62/ 1.55

* Mean Number/Standard Deviation

sub-groups with and without asset data. This difference is not only with respect to the number of BMET's, but also with respect to the pattern of the need. The relationship of manufacturers of laboratory equipment to manufacturers of physiological equipment is the reverse of what one finds among sub-groups without asset data compared to what one finds with sub-groups with asset data.

For those sub-groups with asset data there is a striking difference between the sub-groups producing physiological equipment and having less than $1,000,000 assets and the other sub-groups having asset data. The effect of this sub-group is not as pronounced when one compares the two categories of asset data, but its impact is enough to lessen the average need for BMET's among manufacturers of physiological equipment when compared to manufacturers of laboratory equipment. This categorization is unfortunate, however, because the results reported in Table XVIII clearly establish that three sub-groups indicate a relatively high need and the fourth a markedly lower need.

One of the more disconcerting findings reported in Table XVIII is the magnitude of the standard deviations, especially in two of the sub-groups. This finding is particularly forceful when the means are expanded to actual numbers of BMET's needed on current staffs. These data are contained in Table CV in the Appendix. The effect of the standard deviation is noted in the 80% confidence level which is more than 25% of the total number needed.

The magnitude of the dispersion indicated in Table XVIII precludes considering each of the sub-groups as homogeneous. These dispersions indicate that each of the sub-groups (with one or two exceptions) contains elements of at least two contrasting groups of equipment manufacturers.

The most important variable studied in this report--the need for bio-medical equipment technicians--was used to identify the contrasting groups. Cutting points of 1 standard deviation above and below the overall mean of BMET's needed were used to identify two groups. One group expresses a relatively high need for BMET's (more than 9) and the other group expresses a relatively low need for BMET's (less than 6). Twenty-five per-cent of the respondents were in the high group, and they indicated a mean need of 25.5 BMET's with a range from 10 to 70. Forty-two per cent of the respondents were in the lower group and indicated a mean need of 1.5 BMET's with a range from 0 to 5. As indicated before 29% of the respondents gave no response to this question, leaving only 4% of the respondents that could be considered as having an average need for BMET's. This is a striking result which provides evidence for at least two modes in the distribution of the need for BMET's. The rather wide range in the high group may be indicative of one or more modes, but for the purposes of this study he analysis will be restricted to two modes.

Data in Table XIX indicate the proportion of each sub-group classified as a high need group. These data identified two sub-groups that are entirely of the low need classification and one sub-group which is predominantly of the high need classification. The latter sub-group (manufacturers of laboratory equipment with assets greater than $1,000,000) are relatively homogeneous and have a relatively high need for BMET's. The two sub-groups with the most interesting data are: one, manufacturers of physiological equipment with assets greater than $1,000,000; and two, manufacturers of laboratory equipment with assets less than $1,000,000. Both of these sub-groups expressed a relatively high mean need and yet they are evenly distributed among the high and low need classifications. These two sub-groups confirm the general polarity which was observed earlier. It is also of interest to note the difference in the proportion of the high need classification among the sub-groups for which asset data is known; yet this difference is not as wide in the mean need. For example, 60% of those sub-groups having assets greater than $1,000,000 are classified as a high need group as compared to 20% in those sub-groups having less than $1,000,000 in assets. However, the mean need for the high asset sub-groups is only 11.9 as compared to a mean need of 10.3 for sub-groups with low assets. This apparently contradictory finding is probably the result of the large range in the high need group. Even though there is a higher proportion of high need respondents

TABLE XIX

Proportion of Manufacturers Categorized in High* Current Need Group:

	Type of Manufacturer		
Assets of Manufacturer	Physiological Equipment	Laboratory Equipment	Total
More than $1,000,000	.5	.7	.6
Less than $1,000,000	.0	.4	.2
Sub-total	.3	.5	.4
No asset data	.5	.0	.2
TOTAL	.3	.4	.4

* Need more than nine BMET's.

in the sub-groups with more than $1,000,000 in assets, they are probably at the lower end of the range, whereas the small proportion of respondents in the low need category are at the higher end of the range, thereby giving means that are similar.

2. Projected 1970 Need

The mean number of BMET's needed in 1970 are indicated in Table XX. The pattern for the 1970 need is almost identical to that for current need, including a wide dispersion. Once again, the no asset data sub-groups differ from those having asset data both in the magnitude (though not to the same extent) and in the pattern. In addition, those manufacturers of physiological equipment with less than $1,000,000 assets are, once again, distinctly different from the other three in their need for BMET's. The expansion of the mean needs to actual numbers contained in Table CVI of the Appendix reflects this pattern and also indicates the impact of the dispersion in terms of the 80% confidence limit which, once again, is over 25% of the actual number needed.

A classification scheme based on the data with respect to 1970 was used to identify contrasting groups of equipment manufacturers. Cutting points of 1 standard deviation above and below the overall mean need were used to create two groups: the first, a high need group, indicating a mean need of 34 or more BMET's; and the second, a low need group, indicating a mean need of 22 or less. Twenty per cent of the respondents were in the high need group which had a mean need of 65.9 and a range of 36 to 170. Thirty-one per cent of the respondents were in the low need group which had a mean need of 8.5 and a range of 0 to 20. As indicated previously, 46% of the respondents did not provide data for this question, leaving 3% of the respondents who could be considered of average need. Once again, the range of the high need group is considerable and is indicative of the possibility of more than one high need group.

Table XXI contains the proportion of respondents who were classified as high need. Three pure sub-groups were identified; however, two of those had no asset

TABLE XX

Mean Number of BMET's Needed in 1970 per Manufacturer

Assets of Manufacturer	Physiological Equipment	Laboratory Equipment	Total
More than $1,000,000	23.33/ 27.09*	30.8/ 13.07	29.11/ 11.28
Less than $1,000,000	5.33/ 4.16	45.67/ 62.84	33.81/ 44.38
Sub-total	14.01/ 10.84	37.11/ 25.36	31.73/ 7.31
No asset data	59/0	5/0	20.88/0
TOTAL	28.18/ 9.02	28.89/ 23.82	28.26/ 6.04

* Mean Number/Standard Deviation

TABLE XXI

Proportion of Manufacturers Categorized in High* 1970 Need Group:

Assets of Manufacturer	Type of Manufacturer: Physiological	Type of Manufacturer: Laboratory	Total
More than $1,000,000	.3	.5	.4
Less than $1,000,000	.0	.5	.3
Sub-total	.2	.5	.4
No asset data	1.0	.0	.5
Total	.3	.5	.4

* Need more than thirty-four BMET's.

data and contained such a low proportion of respondents that they were not considered for analysis. The sub-group of manufacturers producing physiological equipment with assets lower than $1,000,000 is, once again, a low need group. The other three sub-groups for which asset data were available are relatively uniform in their proportions of high need classification.

Since two different criteria were used for identifying high and low need groups of manufacturers it is of interest to note the degree of overlap in the two categorizations. Sixty-four per cent of the respondents were classified the same way under both criteria. Twenty-four per cent of those who were classified differently gave no response in reply to a 1970 need. Of the remaining 12% only 4% were classified high need for current staffs and low need for the 1970 staff. The remaining 8% went from high to middle or middle to high. The proportion of respondents classified the same way is not evenly distributed among high and low classifications. Forty per cent of the respondents classified the same way were in the high group; the remaining 60% were in the low group.

3. Growth in the Need for BMET's

As stated in the analysis of the hospital sub-population data the comparison between the need for BMET's in current staffs and 1970 staffs should not be construed to indicate the growth of the need for BMET's, since these are two independent estimates of need and are not necessarily related. The data provided by those respondents who gave estimates for both current and 1970 needs were analysed with respect to the relationship implied. Table XXII contains the mean proportion between BMET's needed in 1970 compared to BMET's needed now. These data indicate that the sub-groups which manufacture physiological equipment perceive a greater growth rate than those who produce laboratory equipment. The overall growth rate of 2.2, when applied to the actual number indicated as a current need for BMET's, yields an estimate of 2,195 BMET's needed in 1970. This figure compares quite favorably with the estimate of 2,235 BMET's derived previously. The data of those respondents categorized into high and low need groups using both criteria were analysed to give an indication

TABLE XXII

Mean Proportion Increase in Need for BMET's per Manufacturer (1966-1970)

Assets of Manufacturer	Physiological	Laboratory	Total
More than $1,000,000	3.5 (.5)*	2.5 (.6)	2.7 (.5)
Less than $1,000,000	3.2 (.5)	2.6 (.6)	2.6 (.5)
Sub-total	3.4 (.5)	2.6 (.6)	2.7 (.5)
No asset data	3.7 (.3)	1.3 (.3)	2.5 (.3)
TOTAL	3.5 (.5)	1.9 (.6)	2.2 (.5)

* Mean proportion increase (Proportion of sample responding to question.)

of the growth for those two sub-groups. The respondents indicating a relatively high need provided a growth rate of 2.8 BMET's, whereas the respondents who indicated a relatively low need provided a growth rate of 4.6 BMET's.

B. Variables Related to the Need for BMET's

The considerable variance and its relative independence from the stratifying variables suggests that they are not useful in studying the relationships concerning the need for BMET's in this sub-population. Instead, the categorizations formed on the basis of expressed need data (both current and projected) will be used. In spite of the 64% overlap between the two characterizations, there was some deviation in the comparison between high and low need groups that suggested each categorization should be reported separately.

1. Definition of the Variables

Four variables were used to study the need for BMET's: the per cent of "resources" in the bio-medical field, the per cent of a company's resources in the service and maintenance of equipment, the number of men used to service and maintain equipment, and the ratio between the number of men needed for service and $100,000 in sales. The latter three are distribution variables. The resources variable was used to identify four groups of equipment manufacturers, but the identification was on the basis of the percentages and not on the basis of the distribution. This variable was not treated as a distribution variable because it was felt that the responses were not sufficiently reliable. The variable representing the ratio of BMET's to sales served the dual purpose of providing data both with respect to the need for BMET's and for the possible conversion of independently gathered sales data to the need for BMET's.

Comparative data between the high and low need groups defined on the basis of current need for BMET's is contained in Table XXIII. There is a column for those respondents who failed to express a need for BMET's to establish the characteristics of that sub-group. There is some evidence to support the expected differences between the high and low need groups: the high need

TABLE XXIII

Comparative Data Between Manufacturers Having High and Low Current Need for BMET's (1)

Variable	Low need N=15	High need N=9	Total N=35	No response N=10
Current mean need for BMET's	1.5 (.4)(2)	25.5 (.3)	7.6 (.7)	-- (.3)
Proport. of resources in-vested in bio-medical equip. mfg.	.41	.48	.43	.41
Resources(3) in service	1.7	2.3	2.0	2.0
Men used in service of bio-medical equipment(3)	1.7	2.1	2.0	3.0
BMET's needed per $100,000 in sales(4)	1.3	1.3	1.3	1.5
Proportion producing physiologi-cal equip.	.5	.3	.4	.5
Proportion with $1,000,000 or more assets	.3	.7	.4	.4

(1) One manufacturer having average current need not included.

(2) Mean Need (Proportion responding to this question).

(3) Measure of Symmetry of Distribution. See Appendix D Perfect symmetry = 2.0

(4) Measure of Symmetry of Distribution. See Appendix D Perfect symmetry = 1.5

group is in the bio-medical field to a larger degree, has a higher percentage of its resources in service, and uses a greater number of men with regard to service and maintenance. It is of interest to note that the ratio between BMET's and sales does not distinguish the high from the low need group, nor is there a pronounced distinction between the proportion of manufacturers in physiological equipment. The proportion of manufacturers having $1,000,000 or more in assets does serve as a distinguishing characteristic between the two groups. With regard to the sub-group that failed to express a need for BMET's, there is evidence to suggest that they are representative of the sub-population in general, the most notable exception being with respect to the variable of the number of men used in service. In this instance they exhibit a distribution that is skewed greatly toward the higher number of men. This finding is remarkedly inconsistent with the conception of a sub-group that failed to express a need for BMET's.

Comparative data on the high and low need groups of manufacturers for projected 1970 needs are contained in Table XXIV. The expected relationships with regard to per cent of resources in the bio-medical field and the resources in service and maintenance were obtained in the same manner as for the current need for BMET's. The extent of the relationship is slightly greater than that reported for the current need. With regard to the ratio of BMET's to sales there is a slight distinction indicating that the group of manufacturers expressing a low need for BMET's sees a relatively higher ratio of BMET's to sales. This is not a pronounced distinction in view of its inconsistency with the previous finding, and it should not be regarded seriously. The most pronounced deviation from the results of the comparison on the basis of current needs is with regard to the proportion of manufacturers having $1,000,000 or more in assets. On the basis of their expressed needs for projected 1970 needs, there is no distinction between high and low need groups.

When the possibility of interviewer bias was investigated, there was evidence to suggest that there was a considerable difference in the responses recorded by the interviewers. The assignment of interviews had

TABLE XXIV

Comparative Data Between Manufacturers Having High and Low Projected 1970 Needs for BMET's[1]

Variable	Low need N=11	High need N=7	Total N=35	No response N=16
Projected mean need for BMET's	8.5 (.3)[2]	65.9 (.2)	28.3 (.5)	-- (.5)
Proport. of resources invested in bio-medical equip. mfg.	.38	.46	.43	.51
Resources in service[3]	1.8	2.6	2.0	1.9
Men used in service of bio-medical equipment[3]	1.9	2.5	2.0	1.6
BMET's needed per $100,000 in sales[4]	1.4	1.2	1.3	1.2
Proportion producing physiological equip.	.5	.3	.4	.3
Proportion having $1,000,000 or more in assets	.4	.4	.4	.4

(1) One manufacturer having average current need not included.

(2) Mean Need (Proportion responding to this question).

(3) Measure of Symmetry of Distribution. See Appendix D Perfect symmetry = 2.0

(4) Measure of Symmetry of Distribution. See Appendix D Perfect symmetry = 1.5

been designed to distribute whatever interviewer bias might have existed among the sub-groups. As may be seen in Table BXII in the Appendix, the distribution of interviewers is rather uniform among the sub-groups. With regard to the high and low need categorization the distribution is not uniform, but is such that the relationships reported with regard to the need for BMET's are not disproportionately influenced by interviewer bias.

C. Characteristics of the BMET

The manufacturer respondents were asked to characterize the BMET in terms of his average salary, his supervisor, and his functions. Table XXV contains the mean salary of each of the sub-groups. In general, the deviation of the mean salary among the sub-groups is considerably less than that found in the hospital sub-population, but the individual sub-groups had about as much variance in their responses with respect to salary as did the hospitals. Only one of the sub-groups for which complete data were available deviated noticeably from the overall mean of $7000--those manufacturers producing physiological equipment with assets more than $1,000,000 perceive an average salary of $8800. This is a particularly high value when one considers that this was the sub-group that indicated a higher ratio of BMET's per $100,000 sales of equipment. These two findings would indicate that manufacturers of this type are heavily committed to the service and maintenance of their equipment.

Four types of supervisor for the BMET were identified by the manufacturer respondents: a professional or research person, a sales staff person, the service manager, and a production or plant manager. These four types were evenly distributed among the respondents, as may be seen in Table XXVI. There were, however, some notable exceptions. The sales supervisor was primarily in the sub-group producing physiological materials and having assets less than $1,000,000. (This is the sub-group that has consistently been uncommitted to the service and maintenance of its equipment and has expressed a relatively low need for BMET's.) Conversely, the service manager type of supervisor was

TABLE XXV

Mean "Average" Salary of BMET's Among Manufacturers

Assets of Manufacturer	Type of Manufacturer: Physiological Equipment	Laboratory Equipment	Total
More than $1,000,000	8800/* 1600	7100/ 1020	7700/ 230
Less than $1,000,000	6900/ 700	7100/ 1680	7000/ 270
Sub-total	7800/ 250	7100/ 510	7300/ 220
No asset data	7100/ 700	6400/ 2000	6700/ 810
TOTAL	7300/ 210	6700/ 440	7000/ 310

* Mean "Average" Annual Salary/Standard Deviation

TABLE XXVI

Proportion of Manufacturers Identifying Types of BMET Supervisors

Type of Manufacturer

Assets of Manufacturer	Physiological Equipment	Laboratory Equipment	Total
More than $1,000,000	2/.1/.6/.1*	.2/.2/.3/.3	.2/.2/.4/.2
Less than $1,000,000	3/.5/.2/.0	.3/.1/.3/.3	.3/.3/.2/.2
Sub-total	.3/.3/.4/.1	.2/.3/0/.5	.3/.2/.3/.2
No asset data	0/0/.5/.5	.2/.3/0/.5	.1/.2/.2/.5
TOTAL	.2/.2/.4/.2	.2/.3/.1/.4	.2/.2/.3/.3

* Professional/ Sales/ Service/ Production Supervisors

evenly distributed among the three sub-groups strongly committed to service of their equipment and expressing a higher need for BMET's. The production or plant manager type of supervisor was found almost totally in sub-groups producing laboratory equipment.

The manufacturer respondents were permitted wide latitude in listing functions that the BMET would perform. It was anticipated that the manufacturer respondents would identify more types of BMET's since they are involved with more aspects of the bio-medical equipment. This proved to be the case, as 25% of the respondents identified three or four types of BMET's, whereas no hospital respondents had identified more than two types of BMET. It should be pointed out that the distinctions among the types of BMET's reported here are distinctions made by the respondents. (In some instances when the functions provided by the respondents were coded, our analysis did not always make the distinctions the respondents did.)

Six types of functions were identified on the basis of information given by the respondents: service, operation, sales, teaching, installation, and production. These function types were often reported in combination by the respondents, although 76% of the respondents identified either the service type or the production type alone. There is a function type missing in the analysis of the manufacturer sub-population which was present in the hospital sub-population, namely the function of design and modification of equipment. There were a few isolated instances in which these functions were mentioned, but they were always mentioned in connection with production. In fact, the production type of function was construed as an umbrella which included such specific functions as quality control, assembly, and calibration.

Four types of BMET jobs among manufacturers were identified on the basis of the combination of types of functions. The first two types are service only (job type 1) and production (job type 2); they constitute 76% of the functions identified. There is an assumption made with respect to the service which is not entirely borne out by the data. In most cases where service was mentioned as a function, field service was included in the description. There were other cases in which the service was not further specified. The assumption is that unless service is qualified in some other way, the intent of the reply is field service. This is an important assumption because both of the other two types of BMET's have service as a component of their overall duties. In one case not only does the BMET provide field service but he is also called upon to assist in operation, teaching, installing and production matters.(job type 3). In other words, this third type of BMET has a wide range of responsibilities and must be competent enough to handle a variety of jobs. The fourth type of BMET is characterized by a sales orientation (job type 4). This combination of functions was identified in only 4% of the cases, but it is reported here because it was anticipated as an option for the BMET. Not all of the respondents provided data with regard to the functions of the BMET, nor were all the combinations of functions included in the four types given. Thus, a category of unspecified type which constitutes about 18% of the number of BMET's needed. The distribution of the types of BMET's was remarkedly even among the sub-groups with only slight deviations. Table XXVII contains the distribution of the job types among the sub-groups and also indicates the proportion of BMET's for whom job type is unspecified. The most notable exception from an even distribution occurs with respect to the production type of BMET, which consistently was cited more frequently among respondents from sub-groups producing laboratory equipment.

The general service type of BMET (Type 3) is identified primarily by sub-groups having more than $1,000,000 in assets, and the overall distribution between the sub-groups producing physiological equipment vs. those producing laboratory equipment is even. The sales type of BMET is evenly distributed among three of the sub-groups--the two sub-groups producing physiological equipment and the one laboratory sub-group having more than $1,000,000. It is interesting to note that although the sub-group with less than $1,000,000 in assets producing physiological equipment identified the sales type of supervisor to a higher degree, it does not identify the sales type of BMET to a disproportionately high degree.

TABLE XXVII

Proportion of Manufacturers Indicating Needs for BMET's by Job Types

Assets of Manufacturer	Type of Manufacturer: Physiological Equipment	Type of Manufacturer: Laboratory Equipment	Total
More than $1,000,000	.18/.18/.27 .09/.28 *	.31/.38/.15 .08/.08	.25/.29/.21 .08/.17
Less than $1,000,000	.33/.33/0 0/.33	.27/.47/.07 0/.19	.29/.42/.04 0/.25
Sub-total	.25/.25/.15 .05/.30	.29/.43/.11 .04/.13	.27/.35/.13 .04/.21
No asset data	.25/.50/0 0/.25	.25/.50/.25 0/0	.25/.50/.12 0/.13
Total	.25/.29/.13 .04/.29	.28/.44/.13 .03/.12	.27/.38/.13 .04/.18

* Manufacturer Job Type 1/ Job Type 2/ Job Type 3/ Job Type 4/ Unspecified

TABLE XXVIII*

Proportions of Manufacturers Indicating Combinations of BMET Job Types, Supervisors and Mean Salaries

	SUPERVISOR				
Manufacturers Job Type	Professional	Sales	Service	Production	Mean Salary
1 - Service Only	.05	.07	.15		7600
2 - Production	.17		.07	.25	6800
3 - General Service	.02	.02	.07	.02	8000
4 - Sales		.07			9000

*Reflects only manufacturers who provided data on both Job Types and Supervisors.

Further characterization of the BMET is possible by comparing the distribution of the supervisor types among the function types. Table XXVIII contains data relative to those comparisons. The data reported with regard to the supervisor type vs. function type are the proportions of each particular combination to all of the combinations. The more obvious combinations that one would expect are supported by the data, i.e., the field service technician is supervised by the service manager and the sales oriented technician is supervised totally by the sales manager. The most interesting finding is with respect to the supervisor of the production technician. There appear to be two distinct types of supervisors for this technician: the production manager and the professional person. This dichotomy probably reflects the fact that the definition of the production BMET included some of the more sophisticated functions, for example, design and modification, in addition to those functions strictly identified with production. The salary data indicate that production is the position into which a newly trained technician most likely would enter, although the need for other types of BMET's may create a situation where the more successful graduate of a technical institute could assume other duties.

III. Research Institute Sub-Population

Procedures used with the research institute sub-population were similar to those used with the other two sub-populations. The only major difference was that just one interviewer was used to report on the small number in the sample.

A. The Need for BMET's

All of the respondents in the sample agreed that the service and maintenance of bio-medical equipment was a pressing problem that could probably be lessened through a training program to supply the needed technicians.

1. Current Needs

Every respondent was also able to indicate a number of BMET's who would be employed at present if they were available. Table XXIX contains the mean number of

TABLE XXIX

Mean Number of BMET's Needed Now per Research Institute

Type of Institute	Need
Research Laboratory	1.17/.98*
Bio-Medical Institute	2.78/5.56
Total	2.34/1.25

*Mean Number/Standard Deviation

BMET's needed by each of the two sub-groups. The extrapolation of these means to the actual numbers of BMET's needed in the sub-population is contained in Table CVII in the Appendix.

Tl large standard deviation and its concomitant large confidence levels indicate heterogeneity in the respondents. An inspection of the raw data indicates that the variance in the responses is caused by one respondent who felt that there was a need for 17 BMET's. If this respondent is removed from that sub-group and the remaining data are analysed, the mean number of BMET's is reduced from 2.78 to 1.0 with a standard deviation of 1.36, which is still relatively large. If these findings are extrapolated to the sub-population, the 80% confidence levels are reduced from ± 141 to ± 44. This reduction depends upon an estimation of the variance of the deviant respondent based on the other respondents and on the assumption that the deviant respondent was randomly selected from a third sub-group. These procedures are, of course, on tenuous ground and prohibit the substitution of the reduced findings for the original findings.

2. Projected 1970 Need

The research institute respondents were not as capable of projecting the need for 1970 as they were for specifying needs on their current staffs. Table BXIII of the Appendix contains proportions of people who were able to provide data with respect to the projected 1970 need for BMET's. The mean number of BMET's needed is contained in Table XXX with the respective standard deviations. Extrapolation of these means to the subpopulation are contained in Table CVIII of the Appendix.

Once again, there is evidence of the lack of homogeneity in the research institute sub-population. In the case of the 1970 needs the variance is explained by two respondents: one who needed 20 BMET's, and the other who needed 106 BMET's. When these two deviant cases are removed from the research institute sub-group the mean number of BMET's is 2.6 and its standard deviation is 1.38. When these data are extrapolated to the subpopulation the 80% confidence levels are reduced from ± 774 to ± 40. The same procedures and assumptions

TABLE XXX

Mean Number of BMET's Needed in 1970 per Research Institute

Type of Institute	Need
Research Laboratory	2.0/1.41*
Bio-Medical Institute	17.13/33.12
Total	15.26/10.35

* Mean Number/Standard Deviation

are associated with this reduction as with the reduction in the current staff needs and are equally tenuous. Both analyses, however, indicate that the institute sub-group is not homogeneous and that future investigation in this sub-population should take this finding into account.

3. Growth in the Need for BMET's

Following the procedures outlined in the other two sub-populations the mean proportion of BMET's needed in 1970 compared to BMET's needed now were derived. These data are contained in Table XXXI. If the deviant respondents are set aside from the analysis the mean proportion of growth for the institute sub-group is 2.8, and the mean proportion of growth for the deviant cases is 7.4. The overall proportion of 6.13, when applied to the current need for BMET's, yields an expected need for 1970 of 1263; this is considerably higher than the need established on the projected 1970 data, although it is within the 80% confidence level reported (deviant cases not considered).

B. Variables Related to the Need for BMET's

The analysis of the data reported in this section is divided into two cases: one in which the original sampling design is considered, and the other in which the two deviant cases are studied apart from their original sub-group. Data on four variables are available for studying the need for BMET's: size of the research institute, investment and expenditure in biomedical equipment, and expenditure in the personnel and services associated with the equipment.

1. Definition of the Variables

The size of the research institute was defined on the basis of the number of people on the research staff. Two categories of size were identified: one with 50 or fewer people, and the other with more than 50 people. The remaining three variables are distribution variables, each of which was dichotimized.

TABLE XXXI

Mean Proportion Increase in Need for BMET's per Research Institute (1966-1970)

Type of Institute	Proportion Increase
Research Institute	2.0
Bio-Medical Institute	6.5
Total	6.13

2. Relationships Among the Variables and Need for BMET's

Table XXXII contains comparative data of sub-groups, with and without deviant cases separated, on the four variables mentioned above. Current and projected 1970 need data are also included. There are no clearcut relationships contained in the data of Table XXXII. The non-deviant bio-medical institutes and the research laboratories express approximately the same need, and for the most part share common characteristics, the most notable exception being with regard to the investment variable in which the bio-medical institutes have a distribution skewed toward higher investment. The deviant cases identified on the basis of their expressed needs also deviate from the other respondents with respect to their characteristics, with the exception of the investment variable in which they reflect the overall mean.

C. Characteristics of the BMET

The respondents in this sub-population suggested fewer alternatives with regard to the characteristics of the BMET. For example, only two types of supervisor were identified: the chief of maintenance, and a professional or research staff member. One respondent in the research laboratory sub-group suggested that the BMET would work without a supervisor.

The research institute respondents were similar to the hospital respondents in that they identified either one or two types of BMET (one respondent identified 3 types), and they suggested the same functions that the BMET would perform, namely, service and maintenance, operation, design/adaptation, and instruction. There was also the small proportion (.13) of research institutes who agreed with a small proportion of hospital respondents that their need for a BMET could be best utilized through cooperative efforts. The research institute respondents differed from the hospital respondents in that they combined the functions more frequently and therefore no one function can characterize the job types identified on the basis of the responses. Two job types were identified: service and maintenance combined with operation (job type 1), and design/

TABLE XXXII

Comparative Data Between Types of Research Institutes

	RESEARCH LABORATORY N=6	BIO-MEDICAL INSTITUTES Deviant Cases Removed N=7	Deviant Cases N=2	Sub-Total N=9	TOTAL N=15
Mean Current need for BMET's	1.17	1.14	8.5	2.78	2.34
Mean need for BMET's in 1970	2.00	2.6	63.00	17.13	15.25
Size of Institute(1)	.3	.4	1.0	.6	.5
Investment (2)	1.3	1.6	1.5	1.6	1.5
Equipment(2)	1.3	1.2	1.5	1.3	1.3
Pers. and Service Expend. (2)	1.4	1.6	2.0	1.7	1.6

(1) Proportion of institutes having more than 50 employees.

(2) Measure of symmetry of distribution. See Appendix D Perfect symmetry = 1.5

adaptation and instruction (job type 2). The data with respect to the characteristics of the BMET are contained in Table XXXIII.

One of the most interesting findings that result from the data in Table XXXIII is that the research laboratory sub-group proposes an average salary of $8200, largely for one type of BMET (service and operate) who would be supervised to a greater degree by a maintenance personnel than in any other sub-group. By way of contrast the deviant cases who expressed the greater need for BMET's suggest a much lower salary for a greater number of types of BMET's.

Table XXXIV contains some comparative data with regard to the characteristics of the BMET. The disparate salaries between the two types of BMET is the most pronounced finding. The expected relationship between the maintenance supervisor and the lower level BMET is obtained, but it is interesting to note that about twice the proportion of the lower level BMET will be supervised by the research staff.

TABLE XXXIII

Data Relative to Characteristics of the BMET in Research Institutes

	Res. Labs N=6	Bio-Medical Institutes Dev. Rem. N=7	Dev. Cases N=2	Sub-total N=9	Total N=15
Salary	8200	7300	6700	7100	7400± 660
Proportion Specifying Types of Supervisor(1)	.4/.6	.2/.8	.3/.7	.2/.8	.3/.7
Proportion of Types of BMET's (2)	.7/.3	.2/.8	.4/.6	.3/.7	.4/.6

(1) Maintenance Supervisor/ Professional Supervisors
(2) Job Type 1/ Job Type 2

TABLE XXXIV

Proportions of Research Institutes Indicating C binations of BMET Job Types, Supervisors and Salaries

	Supervisor		
Research Job Type	Maintenance	Professional	Mean Salary
1	.06	.19	6500
2	.31	.38	9100

IV. Discussion of Combined Data from Hospitals, Manufacturers, and Research Institutes

The data presented in the preceding sections clearly establish a need for BMET's. This need is the most pronounced in the manufacturer sub-population, which not only expressed the greatest mean need, but also identified the greatest number of job types. The research institute sub-population expressed the second greatest mean need, but they identified only two job types, each of which was a combination of functions, thus indicating that service and maintenance alone was not sufficient to warrant a need for personnel in this area. The hospital sub-population expressed the lowest mean need for BMET's, although they suggested the highest average salary. In terms of actual numbers of BMET's needed, the hospital and research institution sub-populations were essentially identical. The projected needs of these two sub-populations, however, are quite different; the research institute sub-population sees a much greater need for BMET's in 1970. Table XXXV contains a summary of the mean need data for each of the sub-populations and the total population. The extrapolation of these means to the population is contained in Table XXXVI.

Each sub-population provided evidence that the most pertinent variable related to the need for BMET's is current involvement in the service and maintenance of bio-medical equipment. The most important variables in the manufactuer sub-population were the proportion of a company's resources devoted to service and maintenance and the number of men currently used in the service and maintenance of equipment. In the hospital and research institute sub-populations the variables were expenditure in personnel and service with respect to the equipment. In the same two sub-populations there was also evidence to suggest that there was a relationship between current expenditure for bio-medical equipment and the need for BMET's. The analogous relationship in the manufacturer sub-population, the sales of equipment compared to the need for BMET's, was not as strongly supported. Two relationships to the need for BMET's that had been anticipated were not supported by the data: investment in bio-medical equipment in hospitals and research institutes; and the ratio between the number of BMET's needed and per $100,000 in sales in the manufacturer sub-population.

TABLE XXXV

Summary of Mean Number of BMET's Needed per Employer

Sub-Population	Current Staff	Projected 1970
Hospital	1.13/.13*	2.41/.29
Manufacturer	7.62/1.55	28.26/6.04
Research Institute	2.34/1.25	15.26/10.35
Total	3.37/.11	12.74/.69

* Mean Number/ Standard Deviation

TABLE XXXVI

Summary of Number of BMET's Needed by Employers in Population Studied

Sub-population	Current staff	Projected 1970
Hospital	202 ± 27*	342 ± 58
Manufacturer	998 ± 260	2235 ± 612
Research Institute	206 ± 141	891 ± 774
Total	1406 ± 53	3468 ± 254

* 80% confidence range

Taken together, these findings add strength to the relationships between current expenditures in service and maintenance of equipment and the need for BMET's by suggesting that neither past investment in equipment nor number of BMET's needed to service equipment are related to the need for BMET's.

The sampling procedures employed in this study were designed to utilize objective data that were readily available in studying the need for BMET's in each of the sub-populations. The results of these procedures were, to some extent, disappointing. There were relatively weak relationships observed with respect to medical school affiliation and payroll costs in the hospital sub-population, and in the type of equipment produced and relative assets in the manufacturer sub-population. When these variables are considered in combination, however, the observed relationships are somewhat disrupted by the interaction of the variables. The stratifying variables, therefore, apparently do not serve the complete purpose of providing objective data to characterize those respondents who express a greater need for BMET's. Only the hospital sub-population had further objective data available. These data were with regard to the control of the hospital, the type of city and region in which it was located, and the number of beds contained by the hospital. On the basis of these data the greater need for BMET's seems to be among hospitals in the relatively larger cities of region 2 which are under city type control.

There was disagreement among the respondents concerning the immediacy of the need for BMET's. One segment of the respondents indicated a pressing need to be resolved as soon as possible. The other segment, however, indicated that the need for BMET's would occur in the future. This latter group consisted of the smaller manufacturers of physiological and the smaller hospitals with community control located in the suburban areas of region 1. This particular segment has the lowest current expenditures in bio-medical equipment.

The data with regard to the characteristics of the BMET suggest that the three sub-populations have jointly defined four types of BMET. The first type of BMET would be found in hospitals or manufacturers and his duties would be restricted to the service and maintenance of equipment (General job type 1). The second general type is characterized by the ability to assume a wider range of responsibilities with respect to the equipment (General job type 2). This category was identified by the hospital sub-population as their second type. The manufacturer sub-population indicated that this type would be their field service man. The research institute population identified this type as their lower level technician. The third general type must have the ability to design and modify equipment in addition to being able to service, maintain, and operate the equipment (General job type 3). This was the most sophisticated type, and was identified to a much greater degree by the research institute sub-population. The fourth general type would be oriented to the sales of bio-medical equipment, and logically was identified only by the manufacturer sub-population (General job type 4). Table XXXVII contains the proportions of each type of BMET needed now and in 1970. Table XXXVIII contains the extrapolation of these proportions to the actual number of each type of BMET needed both on current and 1970 staffs among the population of employers studied.

TABLE XXXVII

Proportion of BMET's Needed Designated by General Job Types

	Category of Employer				
General Job Type	Hospital	Manufacturer	Res. Institute		Total
1	.33	.32	0	.28*	.24**
2	.36	.38	.40	.38	.38
3	.06	.03	.60	.12	.18
4	.00	.07	.00	.04	.04
Unspec.	.25	.20	.00	.18	.16
Total	1.0	1.0	1.0	1.0	1.0

* Using current need data

** Using projected 1970 data

TABLE XXXVIII

Number of BMET's Needed by Employers in Population Studied Designated by General Job Types

	SUB-POPULATION			
Job Type	Hospital	Manufacturer	Res. Institute	Total
1	67/113*	319/715	0/0	476/828
2	73/123	379/849	82/356	534/1328
3	12/21	30/67	124/535	166/623
4	0/0	70/157	0/0	70/157
Unspec.	50/85	200/447	0/0	250/532
Total	202/342	998/2235	206/891	1406/3468

* Current Number/ Number 1970

RESULTS - PART II

PRELIMINARY CURRICULUM OUTLINE FOR BMET'S

The second major objective of this coordinated research project was to develop the general structure and a preliminary outline of a post high school curriculum for BMET's based upon the needs of prospective employers of BMET's as determined from the Field Study.

The first approach to developing a curriculum outline was made at the beginning of the Project. As a part of the Preliminary Survey a series of unstructured interviews were conducted with representatives of a few hospitals, medical schools, and bio-medical equipment manufacturers throughout the country during which the educational requirements for BMET's were discussed (Appendix G). Based on these preliminary interviews a first draft of an "ideal" curriculum outline was prepared.

Following these preliminary interviews two planning conferences were held in Cambridge, Massachusetts in July 1966 to review and refine this curriculum outline. The first conference was attended primarily by hospital administrators and leading technical educators and the second conference was attended primarily by representatives of bio-medical equipment manufacturers and leading technical educators. It was generally agreed at these conferences that an approximately two year associate degree level type of curriculum would be required for adequate preparation of BMET's and a draft of a tentative two year curriculum was prepared. This curriculum outlined in Appendix AI and AII was used during the Field Study interviews as an initiator of conversation relative to BMET's and as a point of departure for soliciting suggested modifications.

The modified and expanded curriculum outline presented in this Report was developed on the basis of data gathered during the Field Study. The interview data were comments and reactions to the preliminary curriculum proposal, including such topics as the length of the program, the extent to which particular subjects should be taught, the need for an internship, the necessity of accreditation, and the types of equipment with which the technician should be familiar. On the basis of these data, recommendations were prepared for the modification of the preliminary curriculum proposal and a conference was held to act on these recommendations. Conference participants included representatives of hospitals, research institutes and manufacturing concerns. In addition, there were several members from TERC's staff and faculty members from a technical institute. The present curriculum proposal is the result of efforts to balance the implications of the interview data with the results of the conference discussions in the context of experience in technical education.

I. Guidelines Derived from Interview Data

Data concerning the need for BMET's clearly indicate that employment opportunities are greatest with manufacturers of equipment. For that reason the data from manufacturers' interviews were accorded greater weight in determining the curriculum than the data from hospitals and research institutes, although there was relatively little variation in the responses of the three groups.

All respondents identified electronics as the most important aspect of the curriculum, followed closely by instrumentation. The coupling of instrumentation with electronics is the strongest indication that the BMET is not considered synonymous with the electronics technician; rather, he may at the least be a particular kind of electronics technician.

Many respondents (especially manufacturers) indicated that communicative skills should receive emphasis in the curriculum. These respondents felt that a BMET would be hampered if he were unable to express himself and to understand the problems of others.

Mathematics and physics were generally agreed to be worthwhile and even necessary, but the consensus was that they are of secondary importance. Biology, physiology, chemistry and medical sciences received the most uneven attention from the respondents. The overall impression provided by the data is that the technician must be conversant in these areas, but that this knowledge can be attained in an internship program or in a small number of courses with the narrow objective of familiarizing the student with broad concepts and terminology.

The overwhelming majority of respondents agreed that two years was about the proper length for the program. One respondent, however, felt that the job of training a BMET could only be accomplished in four years; a few others felt that on-the-job training was sufficient.

The comments and reactions of respondents with respect to the accreditation of the BMET were fairly evenly divided between those who felt that it was of little use and those who felt that it was necessary. There is a possibility of some ambiguity with regard to accreditation. There is professional accreditation which is accorded to people who meet certain standards within a given profession, and there is the accreditation given to schools that meet certain standards; this ambiguity may have been operating in the responses. It was decided that the curriculum should attempt to meet the educational standards that go into the accreditation of a school.

II. Curriculum Conference

The preceding guidelines were discussed at considerable length at a curriculum conference held at TERC in May. Each guideline was discussed in detail from several points of view; the implication of the discussion was left to the authors of the curriculum. In general, the conference participants approved of the guidelines presented to them, but there were differences in the degree to which they emphasized certain aspects of the guidelines.

The curriculum conference added insight into the problem of constructing a curriculum for BMET's by highlighting three areas of the guidelines: the breadth of the curriculum, inclusion of communicative skills, and the need for accreditation. With regard to the breadth of the curriculum, the participants were concerned with the future of an individual who had been trained as a BMET. There was general agreement that as bio-medical equipment becomes more sophisticated, an increasing degree of competence in the technician will be required. Therefore, the technician must receive a broad education focusing on fundamental concepts. On the other hand, the educational program should not become too abstract for the type of student likely to enter it. It was felt that the success of the program would depend on an early introduction to the type of equipment that the technician would be expected to service and maintain. This introduction would have to be reinforced throughout the educational experience by explicitly demonstrating the relevance of any given phase of the curriculum to the projected needs of a bio-medical equipment technician. Thus, the needed curriculum must meet with the somewhat contrasting objectives of being broadly based on fundamental concepts and avoiding over-abstraction.

The technician's ability to communicate effectively with others concerning the use of bio-medical equipment was strongly emphasized by all the participants in the conference. The general feeling was that the technician, in order to achieve a high level of effectiveness, must be attuned to the various ways in which other people conceptualize the workings of bio-medical equipment. The technician must have the ability to utilize another's explanation within the context of his own understanding and competence. It was suggested that whereas certain aspects of these communicative skills could be taught formally, the best source of experience would be on the job; thus, the internship program could focus on the problems of communication.

The problem of accreditation was discussed at length by the conference participants. Two concerns prompted this discussion: the future growth and development of the technician, and the quality of student that would matriculate into the program. It was felt that in order for the BMET to further his education, an appreciable percentage of his course work should be transferable to institutions of higher learning, thereby encouraging those with the motivation and capability to complete a bachelor's degree in bio-medical engineering. In conjunction with the second concern, it was felt that unless a program could offer a high proportion of college credits, the student who would be attracted to the program would of necessity have lower standards and the effect of the training would be immediately diluted. These concerns, therefore, were expressed in terms suggesting that the construction of the curriculum be sensitive to providing the type of course that would be acceptable for college credit. Consequently, the emphasis of accreditation was more on the educational characteristics of the institution and less on professional accreditation.

III. Special Requirements of the BMET Curriculum

The construction of the BMET curriculum necessitates coordinating the technologies of electronics and instrumentation and applying this coordinated technology to bio-medical equipment. Programs in both electronics technology and instrumentation technology require two years for completion. Assuming an overlap of not more than 50% between these two technologies, it would take three years of a conventional curriculum designed to educate an electronics/instrumentation technician. To apply this technology to bio-medical equipment would take from one to two additional semesters. Clearly, then, a curriculum that attempts to coordinate electronics and instrumentation and seeks the application to bio-medical equipment within a period of two years must be designed in such a way that the goal of bio-medical equipment technology is directly served by each component of the curriculum. This requires both the integration of courses and the coordination of faculty effort to a degree generally unknown at present in higher education. Both the integration of the course work and the coordination of faculty effort must be specified and the mechanism for effecting them established.

The integration of the course work is accomplished in a course titled "Bio-Medical Techniques." This course is taught every semester, beginning with some rudimentary biology, physiology and medical science and eventually considering bio-medical instrumentation. This course is designed to serve as a focus for all of the other courses taught in the curriculum. The sequence and emphasis of the topics within this course will depend on the level of competence acquired by the student from the other components of the curriculum, but bio-medical equipment will always be the focal point of topics covered in this course. For example, as soon as the concepts of electrical resistance and potential have been established in the electrical/electronics part of the curriculum, the EKG machine can be used in the "Bio-Medical Techniques" course to stimulate dis=

cussion on heart-beat, heart diseases and the use of the EKG.

The design of the "Bio-Medical Techniques" course is not restricted to merely reflecting the skills and competencies developed in the other aspects of the curriculum. Rather, it can play an active role in determining the sequence and emphasis of topics covered by the other components. For example, the use of a spectrophotometer may be a logical outcome of discussion in a bio-medical techniques class, but the physics and electricity of the spectrophotometer may not have been covered. The design of this course is such that the instructor can approach the instructors in physics and electronics and encourage them to alter their plans so that he might discuss the spectrophotometer. Thus, the bio-medical techniques course serves as the mechanism by which the electronics and instrumentation technologies can be applied to bio-medical equipment, and indeed it is the course which can guarantee that the necessary electronics and instrumentation are included for the particular application of bio-medical equipment.

The design of the curriculum assumes that faculty members both can and will be aware of students' progress in other areas of the curriculum, and so adjust their own specific areas of instruction. This implies that discussion among faculty members will influence the sequence and emphasis of topics within any of the components of the curriculum. Members of the faculty of bio-medical equipment technology must have the ability to adapt and modify their knowledge to meet the needs of the curriculum in bio-medical equipment technology, thus implying that the instructor is capable of producing new materials or new variations to old materials. It requires that he be aware of the demands of bio-medical equipment technology, and above all it requires that he be capable of working with others toward a common goal while maintaining his own general goals. Perhaps no other special requirement of a BMET curriculum is more crucial than that of gathering a faculty that meet these requirements. The integration of the course work is an ideal which can be realized only through the coordination of the efforts of the faculty.

It should be noted that this special requirement is the point upon which the concern for college credit rests. The coordination of the efforts of the faculty can have two extreme possibilities. There can be little or no coordination, in which case each faculty member teaches his course as he sees fit. In this context college credit is relatively easy to establish, but the success of the program to educate a BMET rests upon the ability of the student to integrate the various components of the curriculum. The other extreme possibility for the coordination of the faculty is that the content of each course is subordinated to the need to train a BMET; unless a particular topic can be shown to have direct and explicit relevance to the service and maintenance of bio-medical equipment, the topic is not taught. Within this context, it would be very difficult to establish college credit for any of the courses taught, but the student would be well prepared to assume the role of a bio-medical equipment technician. If he wished to further his education, however, he would be limited in the amount of coursework that he could transfer to an institution of higher learning. The faculty, therefore, must integrate the curriculum in such a way as to serve the dual obligation of providing the framework upon which further education is possible, and assisting the student in integrating that framework into the context of bio-medical equipment technology.

There are few instructional materials presently available for use in a curriculum of this design. Of course, materials relating the fundamental concepts of electronics, instrumentation, mathematics, physics and communicative skills are available from several sources. The important link that is missing is the application of these concepts to bio-medical equipment technology. This link must be established by the faculty. The resource upon which they will draw is knowledge in their respective subject fields and a list of equipment which has been compiled from the interview data. This list consists of equipment that the bio-medical equipment technician must be prepared to service and maintain and also equipment that he will use as tools for that purpose. The instructional materials, therefore, will be developed from the knowledge and skill requirements associated with that list of equipment. In general, the task is to identify classes of equipment which are related to certain fundamental concepts in each of the curriculum areas, then to devise instructional materials which will exemplify these fundamental concepts within the context of the classes of equipment.

One of the more important aspects of the curriculum which thus far has received little attention is that of the emphasis of laboratory work. It is through laboratory work that the goal of avoiding abstraction is achieved and the concept of integration of course work can be effected. In the laboratory the student can see first-hand how the topics covered in the various components of the curriculum bear directly on the role of a bio-medical equipment technician. Furthermore, the laboratory can be a situation in which more than one instructor can play a part in devising materials so that a particular experience can be connected to more than one component of the curriculum. In this context the laboratory need not be a physics laboratory; rather, it can be a laboratory in which the concepts of mathematics, instrumentation, and bio-medical equipment technology are extracted together with the physics. The laboratory component of the BMET curriculum is, therefore, a special requirement which goes beyond the requirement of most laboratory experiences in other curricula.

IV. Preliminary Curriculum Outline

The following pages contain a preliminary curriculum outline for an associate degree level curriculum in bio-medical equipment technology designed on the basis of the Field Study. It includes: Preliminary Curriculum Chart, Preliminary BMET Curriculum, and Preliminary Curriculum Content.

It should be strongly emphasized that this curriculum outline is very preliminary and has not been tested. It is presented only to indicate the general requirements of such a curriculum and to form a tentative basis for the detailed development, pilot testing, and evaluation of such a curriculum in a continuing research project.

V. Curriculum Development Planning Conference

In order to explore some of the problems of systematically developing and evaluating curricula in a rapidly emerging technology such as bio-medical equipment technology, a curriculum development planning conference was held in Waco, Texas on January 20-21, 1967 at the James Connally Technical Institute of Texas A&M University. Participants in this conference included several nationally leading technical educators. The guidelines laid down at this conference will be very useful in the development, testing, and evaluation of a new broadly generalizeable curriculum for BMET's.

PRELIMINARY CURRICULUM CHART
BIO-MEDICAL EQUIPMENT TECHNICIAN

13th and 14th GRADE LEVEL

English	Physics	Mathematics	Electronics	Electricity	Bio-Medical Equipment Techniques
Vocabulary Word usage Composition Effective Writing	Units of measure Kinematics Heat Light Modern Physics	College Algebra Analytic Geometry	Principles of Electronics Basic Electronic Circuits	Electrical Fundamentals AC and DC circuits	Including: Concepts of Medical Science Bio-Medical Instrumentation Field Experience in Hospitals, Research Institutes and Equipment Manufacturers
Report Writing	Psychology I Principles of Human Behavior	Introduction to Calculus	Basic Pulse Circuits	Bio-Medical Electronics Application of electronics to bio-medical instrumentation including trouble-shooting & equipment modification	
Speech	Psychology II Principles of Human Adjustment	Basics of Computers	Construction & Design Individual Projects in building specialized equipment		

Horizontal Distance represents distribution of time in a typical day.
Vertical Distance represents distribution of time within four semester program.

Prerequisites: High School Mathematics through Trigonometry, two semesters of High School Physics.

PRELIMINARY BMET CURRICULUM

First Semester	Class	Lab	Credit
Bio-Medical Techniques I	2	3	3
Electrical Fundamentals	2	3	3
Principles of Electronics	2	3	3
Physics I (Mechanics)	3	3	4
Mathematics I	3	0	3
English I	3	0	3
	15	12	19

Second Semester			
Bio-Medical Techniques II	2	3	3
AC and DC Circuits	2	3	3
Basic Electronic Circuits	2	3	3
Physics II (Heat, Light, Sound)	3	3	4
Mathematics II	3	0	3
English II	3	0	3
	15	12	19

Third Semester			
Bio-Medical Techniques III	3	3	4
Bio-Med. Electronic Systems I	2	3	3
Basic Pulse Circuits	2	3	3
Mathematics III	3	0	3
Psychology I	3	0	3
Report Writing	2	0	2
	15	9	18

Fourth Semester			
Bio-Medical Techniques IV	3	3	4
Bio-Med. Electronic Systems II	3	3	4
Bio-Med. Equip. Construction & Design	1	3	2
Basics of Computers	2	3	3
Psychology II	3	0	3
Speech	2	0	2
	14	12	18

Total			
Bio-Medical Component	16	21	23
Electrical/Electronic Component	10	15	15
Physics/Mathematics Component	17	9	20
General Education Component	16	0	16
	54	45	74

PRELIMINARY CURRICULUM CONTENT

First Semester

Bio-Medical Techniques I	Class 2 Lab 3 Credits 3
Concepts of Medical Science	Introduction to cell structure & physiology as the basic unit of the human body. Course designed to give a concise survey of human anatomy & physiology emphasizing structures and function of each system. Structural anomalies and functional disorders are studied in their relation to bio-medical instrumentation.
Bio-Med. Instrumentation	Introduction, defined by competence and background of student, beginning with monitoring equipment: EKG, EEG.
Field Experience	Limited experience in actual bio-medical settings.
Electrical Fundamentals	Class 2 Lab 3 Credit 3
Properties & Behavior of Electricity	Electron theory, electrostatics, magnetism, introduction to measuring devices.
DC Characteristics of Electrical Components	Resistance, inductance, capacitance, electromagnetism, Ohm's Law.
Alternating Current Principles	Electromagnetic induction, phase, inductive and capacitive reactance and impedance, transformers.
Principles of Electronics	Class 2 Lab 3 Credit 3
Vacuum Tubes & Semiconductors	Electron emission, physics of semiconductors, diodes, static and dynamic curves, Zener diodes, voltage regulators.

Three-element Devices	Triode vacuum tubes, transistors, parameters, unijunction transistors; silicon controll rectifiers, characteristic curves.
Multi-element Devices	Tetrodes, pentodes, beam power vacuum tubes, special-purpose transistors.
<u>Physics I (Mechanics)</u>	Class 3 Lab 3 Credit 4
Fundamental Concepts	Time and space, precision measurements, forces and force systems, rectilinear and angular motion.
Kinematics	Velocity and acceleration, projectiles.
Dynamics	Force and motion, momentum and collisions, work, power, and energy.
Objects in Equilibrium	Statics
<u>Mathematics I</u>	Class 3 Lab 0 Credit 3
Slide Rule	Scope, description, accuracy. Location of decimal point. Relation of logarithms to slide rule.
Basic Algebra	Linear equations, functions and graphs, simultaneous equations, exponents and radicals.
Introduction to Advanced Algebra	Solution of quadratic equations in one unknown by plotting, factoring, completing the square, and by formula. The discriminant.
<u>English I</u>	Class 3 Lab 0 Credit 3
Problems in Mechanics	Construction of effective sentences and paragraphs, functional grammar usage and organization. Emphasis upon proper spelling.
Word Usage & Vocabulary Building	Exercises in expansion of vocabulary and proper identification and use of words. Persistent problems in mechanics.

Principles of Composition	Instruction and practice in the different types of writing including informative evaluative and persuasive. Abstract and short papers studied as models of expression and stimulation for expository writing.

Second Semester

<u>Bio-Medical Techniques II</u>	Class 2 Lab 3 Credit 3
Concepts of Medical Science	Review of basic chemistry emphasizing redox, chemical equilibrium and ionization. Introduction to physiological chemistry, integrating concepts with related electronic laboratory apparatus.
Bio-Med. Instrumentation	Experience in the operation and purpose of laboratory equipment: pH meter, spectrophotometer, colorimeter, flame photometer, blood analyzers.
Field Experience	Regularly scheduled experience in hospital laboratories
<u>AC and DC Circuits</u>	Class 2 Lab 3 Credit 3
DC Circuit Analysis	Kirchhoff's Laws, superposition theorem, Thevenin's and Norton's theorems.
AC Circuit Analysis	Simple circuits, series circuits, parallel circuits, combination circuits.
Resonant Circuits	Series and parallel resonand circuits and their characteristics.
<u>Basic Electronic Circuits</u>	Class 2 Lab 3 Credit 3
Rectification	Principles of rectification, types, filtering,

	voltage dividers, for vacuum tubes and semiconductors.
Amplification	Classification of circuits, audio-frequency amplifiers for vacuum tubes and semiconductors.
Oscillation	Uniform wave oscillators, phase shifting, resonant circuit, crystal controlled oscillators for vacuum tubes and semi-conductors.
<u>Physics II (Heat, Light, Sound)</u>	Class 3 Lab 3 Credit 4
Temperature, Heat, Thermodynamics	Temperature and ideal gases, thermal expansion and stress, heat and laws of thermodynamics.
Wave Motion	Transverse and longitudinal waves, polarization and photoelectric effect. Sound waves.
Light	Geometrical optics, interference and diffraction.
Introduction to Modern Physics	Nuclear structure, atomic molecular structure, nuclear disintegration.
<u>Mathematics II</u>	Class 3 Lab 0 Credit 3
Advanced Algebra	Simultaneous quadratic equations, solution of systems of equations, reduction to simpler systems. Binomial Theorem.
Logarithms	Definition, properties, relation to exponents, tables, interpolation, computation.
Trigonometry	Trigonometric functions, the right triangle, the oblique triangle, trigonometric identities. Vectors.
<u>English II</u>	Class 3 Lab 0 Credit 3
Development of Concepts	To cultivate analytical

	and critical thought. Introduction to semantics, levels of usage and applications. Practice in developing and expressing ideas.
Literary Forms	Critical reading of related essays and their applications. Literature is approached through a study of the short story, the novel, drama and poetry with emphasis on reading for comprehension of idea and structure.
Effective Writing	Long and short, unified, coherent and purposeful compositions, research papers, critical reviews and business letters.

Third Semester

Bio-Medical Techniques III	Class 3 Lab 3 Credit 4
Concepts of Medical Service	Terminology and specialized techniques and procedures: electrophorisus, ultra-violet spectrophotometry.
Bio-Med. Instrumentation	Activities and experiences designed to direct the student's attention to the service and maintenance of bio-medical equipment. Procedures in trouble-shooting.
Field Experience	Formally established cooperative endeavors with bio-medical equipment manufacturers.
Bio-Med. Electronic Systems I	Class 2 Lab 3 Credit 3 Applications of principles and concepts previously developed to bio-medical electronic equipment

Basic Pulse Circuits	Class 2 Lab 3 Credit 3
Nonsinusoidal Wave shapes	Fourier analysis, square, rectangular, sawtooth, triangular and peaked waves, transients.
Waveshaping Circuits	Operation, R-C differentiator, integration, differentiated and integrated voltage waveshapes.
Multivibrators	Types of multivibrators, astable, monostable, and bistable.
Mathematics III	Class 3 Lab 0 Credit 3
Analytic Geometry	Slope, equations of a straight line, equations and graphs of the conics.
Differentiation	Functions and the limit concept, derivatives of algebraic functions, maxima and minima, the differential.
Integration	Integration as the inverse of differentiation, the concept of summation, the definite integral, the integral as an area, integration of algebraic functions.
Psychology I (Principles of Human Behavior)	Class 3 Lab 0 Credit 3
Basic Concepts	Definition, description, and growth of psychology as a science. Explanation of methodology and techniques.
Structure and Function of Human Nervous System	The nature of the brain and neural system. Sensory reception and perceptual development.
Behavioral Processes	Motivation, learning, thinking, emotion, and personality. Reaction to frustration and conflict.

<u>Report Writing</u>		Class 2 Lab 0 Credit 2
	Guiding Principles	Selection and scope of topic, abstract and exposition, interpretation of facts, proper integration and chronological presentation of argument.
	Writing the Report	Techniques of analysis, methods of investigation, functional organization, refinement of rough draft to final copy.

<u>Fourth Semester</u>

<u>Bio-Med. Techniques IV</u>		Class 3 Lab 3 Credit 4
	Concepts of Med. Science	Review of theory and applications directly related to bio-medical equipment.
	Bio-Med. Instrumentation	Activities and experiences designed to direct the student's attention to the modification and adaptation of fundamental components to meet specialized requirements.
	Field Experience	Regularly scheduled experience in research institutes.
<u>Bio-Med. Electronic Systems II</u>		Class 3 Lab 3 Credit 4 Investigation of specialized topics and exploration of unique problem solving experiences
<u>Bio-Med. Equipment Construction and Design</u>		Class 1 Lab 3 Credit 2 Individualized instruction permitting the development and completion of projects interrelating the competencies previously attained, the basic tools and techniques of a machine shop and those ancillary resources required by the

	project.
Basics of Computers	Class 2 Lab 3 Credit 3
Number Systems	Decimal to any base, any base to decimal conversions.
Boolean Algebra	Propositions, Venn diagrams, Boolean algebra functions, switching circuit theory, map technique, synthesis.
Basic Logic Units	AND gates, OR gates, NOR and NAND, inverters, diode matrix, logical operations.
Psychology II (Principles of Human Adjustment)	Class 3 Lab 0 Credit 3
Personality Dynamics	Defining and differentiating between the normal and abnormal personality patterns.
Atypical Behavior and Adjustment	Recognition and avoidance of maladjustment. Principles of mental hygiene.
Group Interaction and adjustment	Emphasis on the development of individuals and groups in present day cultures and principles of adjustment.
Elements of Speech	Class 3 Lab 0 Credit 3
Basic Fundamentals	Fundamental concepts, content, organization, voice and diction. Types of public speeches including formal discussions, speeches of persuasion and information, speeches using visual aids.
Techniques of Delivery	Platform behavior including posture and bodily action. Constructive criticism through interview sessions and tape recording analysis. Development of listening skills.

CONCLUSIONS AND IMPLICATIONS

The first objective of this study was to determine the need for individuals to service and maintain equipment found in hospitals and bio-medical research institutes. This documentation was to take the form of specifying the number of such individuals needed, characterizing the employment opportunities that would be open to them, and gathering information that can assist in the formulation of a curriculum to train these technicians. On the basis of these data the following conclusions can be drawn:

1. There is a current need for between 1350 and 1450 technicians to service and maintain bio-medical equipment in the New England and Mid-Atlantic regions;

2. This need, projected to 1970, increases to between 3200 and 3700 BMET's;

3. The greatest opportunity for employment is with manufacturers of bio-medical equipment, although the more sophisticated jobs are found in hospitals and research institutes;

4. There are four general job types that a BMET will fill:

   a. Rudimentary service and maintenance under close supervision by the production manager in the manufacturer setting or the chief engineer in the hospital setting, and providing an average salary of $6800;

   b. General service and maintenance requiring greater competencies not only with respect to the quality of his work, but also with respect to the number of tasks expected of him, and supervised to a greater degree by professional people and providing an average salary of $7400;

   c. Sophisticated service and maintenance that would involve design and modification of equipment almost exclusively under the supervision of professional people and providing an average salary of $8400.

d. Sales oriented service under the supervision of the sales manager, and providing an average salary of $9000;

5. At the present time, there are people currently engaged in the service and maintenance of bio-medical equipment. However, the following impressions resulted from the discussions on this aspect that were a part of the interviews.

   a. The demand for technicians greatly exceeds the supply and the situation will get more pronounced with time.
   b. Those technicians now servicing and maintaining bio-medical equipment have typically been drawn from a variety of backgrounds, primarily either electrical, electronic, or instrumentation. Virtually none have been formally trained in the service and maintenance of bio-medical equipment and therefore a considerable period of on-the-job training is typically required. Such on-the-job training seldom includes adequate preparation in the basic educational subjects and is usually restricted to providing proficiency in specific equipments of interest to the employer. These technicians typically, therefore, have limited capability to perform many of the tasks and functions which might be performed by trained BMET's. The rapidly changing nature of this technology will make it increasingly difficult for these technicians to meet the demands of employers without further basic education.

6. The technician capable of filling the existing and developing employment opportunities for BMET's identified by this Field Study will be a new type of technician. His preparation will require a new type of interdisciplinary curriculum.

The implications of this information is clear. There is a need for the development of a number of new educational programs which will systematically prepare individuals to fill the existing and developing opportunities identified in this study.

Although the Field Study was specifically focused on the New England and Middle Atlantic regions it is believed that the needs for and basic characteristics for BMET's throughout the United States will not vary greatly from those in the regions studied.

Very conservatively there is estimated to be a national need for educational programs to provide at least 2000 BMET's per year in the United States utilizing a curriculum such as outlined preliminarily in this Report. Although this number will not fill all of the employment opportunities for BMET's it will provide a hard core of well trained technicians. Since the need for BMET's is distributed throughout the United States this requirement implies a need for at least fifty geographically distributed educational institutions such as technical institutes and community/junior colleges to establish educational programs for BMET's as quickly as possible.

The second objective of this study was to develop a preliminary structure or outline of a curriculum designed to form the basis for the development of such new educational programs for BMET's. On the basis of the Field Study the following conclusions can be drawn about such a curriculum. An adequate curriculum for BMET's is unique in several important aspects. First it represents a new kind of curriculum--one which extracts from existing curricula in the natural and physical sciences, integrates them and uses this as a basis for a program in bio-medical equipment technology. This interdisciplinary approach must be made for the specific purpose of applying it to bio-medical equipment. Thus, a curriculum new both in format and purpose is being designed.

Such an educational program makes new kinds of demands upon the faculty members. Knowledgeable in their own respective fields, they must acquire some degree of competence in the other areas of the bio-medical equipment technology field if they are to foster and carry out the integration of the subject areas required by this interdisciplinary approach. There must be a high degree of interaction among faculty members in order to accomplish the goals of this new education program. Teaching goals in any one course must be in accord with the learning goals of the entire program.

The design of the curriculum must meet at least two specific needs. It must give the student a competency as a bio-medical technician. But the program must also enable the student to further his formal education if he so chooses. Thus, the curriculum which is designed to meet specific needs in terms of employment opportunities must also meet the requirements of four-year degree granting technical institutes to which the student might apply. The curriculum for bio-medical equipment technicians must be narrow enough to train an individual for a specific job, but at the same time be sufficiently broad and flexible to fulfill the student's own needs and objectives.

RECOMMENDATIONS

Recommendation No. 1

Educational programs in Bio-Medical Equipment Technology should be planned and implemented to provide a minimum of 2000 BMET's per year beginning as soon as possible.

It is recommended that educational programs be established in a minimum of fifty geographically dispersed educational institutions such as technical institutes, and community/junior colleges graduating an average of forty BMET's per year.

Recommendation No. 2

Because of the unique curriculum requirements of this emerging technology, schools cannot expect to develop adequate programs for BMET's by utilizing combinations of existing courses and instructional materials without major modifications and additions.

Major curriculum development is required in order both to interrelate the academic courses in this multi-disciplinary technology and to relate the academic courses to the required laboratory and clinical experience.

Recommendation No. 3

A continuing intensive research project can and should be carried out, based upon the occupational information developed in this project, to systematically develop, pilot test, and evaluate an associate degree type of curriculum for BMET's which can be broadly generalized to be applicable to numerous post secondary institutions.

It is not economical nor feasible for individual schools to attempt to develop such a curriculum independently with limited resources. The results of an intensive research program in this area can be used by many schools as the basis for establishing educational programs for BMET's with minimum local effort, time, and cost.

SUMMARY

The purpose of this study was to document the need for individuals to service and maintain equipment found in hospitals and bio-medical research institutions. This documentation took the form of specifying the number of such technicians needed, establishing the characteristics of the potential employers of this technician, and gathering data that would assist in formulating a curriculum to train such a technician. The three obvious sub-populations of hospitals, manufacturers, and research institutes were independently sampled according to a stratified random design. A loosely structured interview guide, constructed to organize the interview, but to provide the freedom to explore open-ended questions, was used with the selected participants.

The data gathered from the interviews established a need within the population of employers studied in the New England and Middle Atlantic regions for between 1350 and 1450 BMET's to be utilized on current staffs, and for between 3200-3700 BMET's for use on 1970 staffs. The greatest proportions of these needs are expressed by the manufacturer sub-population, with the lowest proportion being expressed by the hospital sub-population. In each of the sub-populations the need was most directly related to the current involvement in bio-medical equipment, in regard to both direct expenditure and to expenditures for personnel and services associated with the equipment. There were few substantial relationships established between readily available objective data and the need for BMET's. There was some evidence to suggest that hospitals with medical school affiliation and lower payroll costs who were under a city type control and located in metropolitan areas of region 2 would employ the BMET to a greater degree than any other type of hospital. In the manufacturer sub-population there was evidence to suggest that manufacturers of physiological equipment having assets less than $1,000,000 would utilize BMET's to a lesser degree than any other type of manufacturer. In the case of the research institute sub-population, the rather obvious relationship between the size of the institute and the need for BMET's was supported.

The need for BMET's was distributed among four types of technician. Three of the four types were levels of service and maintenance, and the fourth was a sales-oriented technician identified by the manufacturer

sub-population with an estimated average salary of $9000. The first two levels of the service and maintenance technician constitute the greatest proportion of BMET's needed. The levels are distinguished by a sophistication of functions expected of the BMET. The lowest level identified by the hospital and manufacturer sub-populations would be a service and maintenance only technician supervised by the production manager in the manufacturer sub-population and by the chief engineer in the hospital sub-population. The average salary for this type is $6800. The second level of technician would be capable of a wider range of functions, including operation of the equipment, instruction in its use, and installation of the equipment. The second level technician would be supervised to a greater degree by research and professional staff members, and the average salary would be $7400. The third level of technician performs the most sophisticated tasks, namely the design, modification and adaptation of the equipment. This type of technician was identified to a greater degree by the hospital and research institute sub-populations, would be supervised almost exclusively by research and professional staff members, and would receive an average salary of $8400.

Using the data with respect to the employment opportunities for the BMET as a basis, the informal information gathered in the interviews with regard to the skill and knowledge requirements of the BMET was combined with the experience of consultants in the fields of bio-medical engineering and technical education to devise a curriculum for training the BMET. The essential character of the curriculum is that it is largely an electronics technician curriculum with a strong emphasis on medical instrumentation. The aspect of the curriculum that makes it uniquely suited for bio-medical equipment technology is a component titled "Bio-Medical Equipment Techniques." This component is the focal point of the entire curriculum. It serves as the mechanism by which the several other components of the curriculum may be integrated and their application to bio-medical equipment established. It is through the student's experience in the bio-medical equipment techniques course that he becomes familiar with the concepts, terminology and procedures unique to the bio-medical field. The necessary integration requires the faculty to devise ways by which the goals and objectives of the curriculum can most effectively be reached.

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LIST OF APPENDIXES

APPENDIXES AI AND AII

PRELIMINARY CURRICULUM PROPOSAL FORMS USED IN FIELD STUDY

EXPLANATION OF CURRICULUM FORMS

The attached sheets are representative of our general thoughts in regard to a curriculum for the bio-medical equipment technician. The circle chart depicts the distribution of credit hours among the several major areas of the curriculum. There is also an indication of the time that is devoted to the laboratory aspects of some courses.

The block chart has implied time factors in its horizontal and vertical dimensions. Distances in the horizontal direction are representative of the distribution of time in a typical day. Distances in the vertical direction are representative of the distribution of time within the four semester tenure of the program. For example, the Electricity & Electronics areas receive considerable time in the first two semesters but in the third semestester the time is halved and it is not taught in the fourth semester.

An aspect of our curriculum proposal that is not clearly shown in either chart is a high degree of integration among the several areas. The major component of the integration is the bio-medical area. It is our plan to begin the familiarization of bio-medical equipment and techniques in the first semester and to expand this area as the students develop competence in the other areas. The expansion takes place not only as courses are added (one in the third semester and two more in the fourth semester) but also by considering bio-medical applications in other areas (telemetry in electricity & electronics, and transducers in physics). Our model for the curriculum is a core of bio-medical equipment techniques that is gradually expanded and in addition is "served" by the other areas. Mathematics acts as a service to electricity & electronics and physics.

Our feeling is that the accomplishment of the broad background that is required of the technician necessitates a highly integrated program that stresses the relationship of fundamental subjects to bio-medical techniques.

APPENDIX AI-CHART USED IN FIELD STUDY

BIO-MEDICAL EQUIPMENT TECHNICIAN
COURSE OUTLINE
13th and 14th GRADE LEVEL

General 20%	Electricity & Electronics 20%	Mathematics 15%	Physics 15%	Bio-Medical 30%
English Composition	AC & DC Circuits	Trigonometry	Mechanics	Bio-Medical Equipment Techniques
Tech Report Writing	Amplifiers	Vector Analysis	Heat	including
Humanities Electives	Vacuum Tubes	Algebra	Heat Transfer	Clinical Experience
	Transistors	Number Systems	Optics	
	Telemetry	Analytic Geometry	Fluid Mechanics	
	Practicum -Trouble Shooting -Preventive Maintenance	Graphical 'lculus	Bio-Medical Transducers	
	Sociology of Bio-Medical Professions & Occupations	Specialization Electives	Design and Equipment Selection	
	Computer Applications to Bio-Medical Systems			

Prerequisites: High School Mathematics through Trigonomet-
Two-semesters School Physics

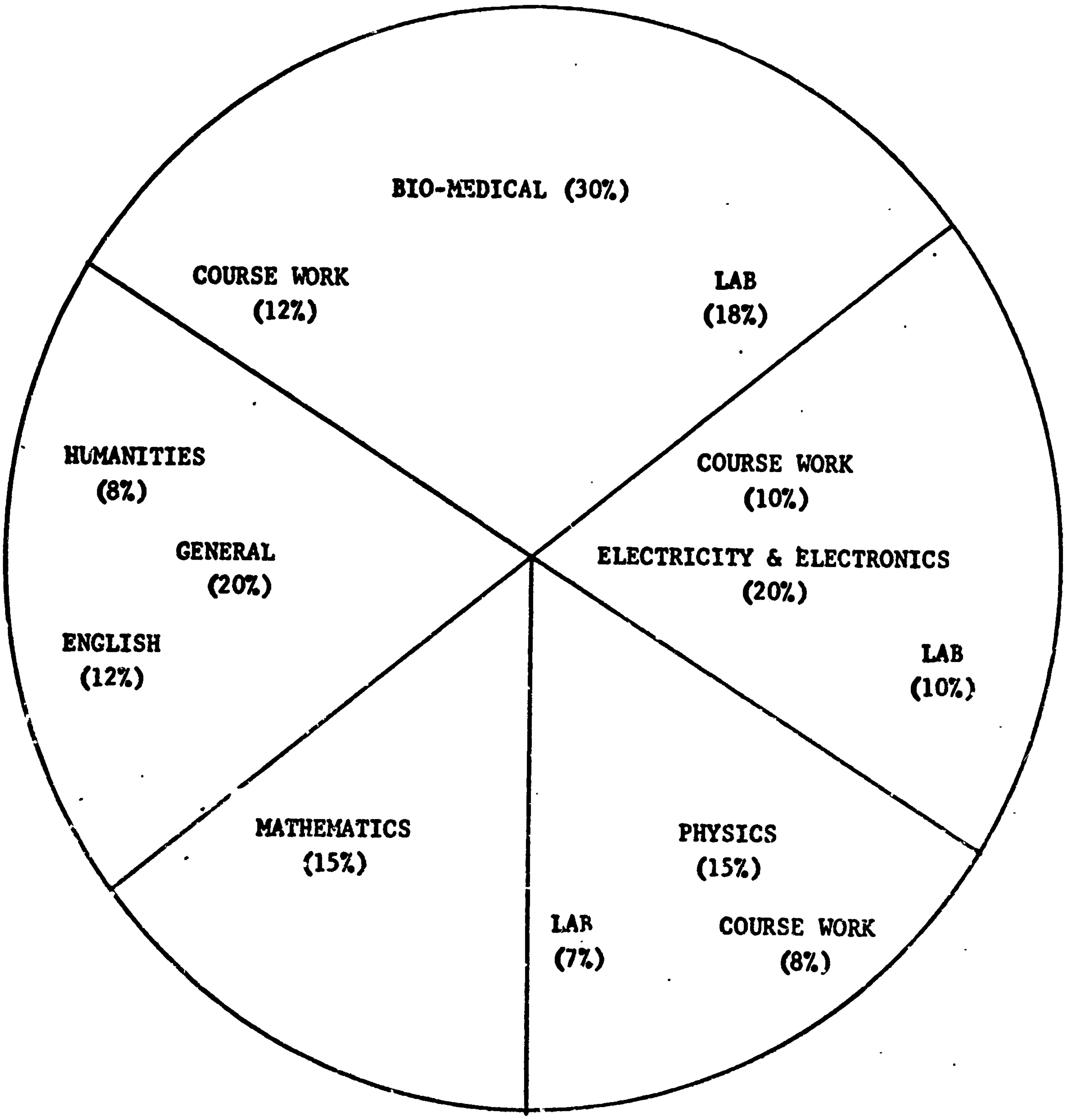
APPENDIX AII-CHART USED IN FIELD STUDY

CURRICULUM REQUIREMENTS

FOR

TRAINING BIO-MEDICAL EQUIPMENT TECHNICIANS

13th and 14th GRADE LEVEL



APPENDIX AIII

INTERVIEW GUIDE
for
Hospital Sample
of
Bio-Medical Equipment Technician
Field Study

Name______________________________ Date______________________

Position____

Institution______________________ Interviewer________________

IA. Do you have any recommendations for employing the curriculum on the attached sheet?

Specifically:

a. What should be the length of such a training program?

b. To what extent would the technician require the following subjects?

Biology	Physics
Physiology	Mathematics
Chemistry	Electronics
Instrumentation	Communication

c. Could medical specialization be taught in an internship program which follows the training program?

d. Do the courses seem to prepare individuals for the functions you feel are needed?

e. Does the scope of training seem appropriate?

f. What equipment should receive high priority for inclusion in the bio-medical techniques course?

g. Is there a need for accreditation of the BMET?

IB. How many types of jobs that you administer do you foresee a BMET engaged in? What are the functions of each type? What is the salary range of each type? How many BMET's of each type do you need? Who will supervise each job type?

Job Type I	Salary Range ____________	Job Type II	Salary Range ____________
Number Now____	1970________	Number Now______	1970________
Functions	Supervisor	Functions	Supervisor

Is there a requirement for skilled maintenance personnel? Superintendent of grounds?

IIA. What is your estimate of the hospital's investment in Bio-Medical Equipment?

Could you break that estimate down into several categories of equipment?

What is your estimate of the hospital's yearly expenditure in purchase and/or leasing of bio-medical equipment now?

1970?

How would that expenditure be distributed among your categories?

What is your estimate of the hospital's yearly expenditure in personnel and services associated with the maintenance of the equipment?

Now________________ 1970__________________

How would that expenditure be distributed both among your categories and also among the following service organizations?

Hospital			
Manufacturer			
Local Dealer or Distributer			
Independent Service Organizations			
Other			

Do you maintain property records of your bio-medical equipment?

Do you maintain service and maintenance records on your bio-medical equipment?

Would it be possible for us to analyze these records?

IIB. What functions are performed by personnel on your staff in relation to bio-medical equipment? What is their training history? What is their salary range? Who supervises these personnel?

Functions	Supervisor	Salary	Training

What functions are performed by outside personnel?

What factors influence the selection of inside vs. outside personnel?

APPENDIX AIV
Modifications for Industry Sample

A. 1. Do you maintain and service bio-medical equipment?

a. If you do not, who does service your equipment?

b. If you do maintain and service bio-medical equipment, please answer the following questions.

1. How many employees do you have for servicing bio-medical equipment?

2. What is the educational background of your personnel in this area?

3. Is the maintenance and service restricted to your products?

4. What portion of your resources is devoted to maintenance and service?

5. Do you expect to expand your maintenance and service program?

6. If you do expand, will the expansion increase the portion of your resources devoted to maintenance and service, or will the expansion be in proportion to the total expansion of the company?

7. If you do expand your maintenance and service program, what will be the rate of expansion through the period from the present to 1970?

8. What proportion of the maintenance and service of bio-medical equipment is shared by each of the following:

   a. Manufacturer

   b. Hospital staff

   c. Local dealer

   d. Independent service agency

   e. Other

9. Do you expect the above proportions to change by 1970? If so, please indicate above.

10. How many BMET's do you estimate are needed to servic and maintain $100,000 of your type of equipment

   a. Do you expect this ratio to change by 1970?

TABLE BI

Proportion of Hospitals Recognizing a Need for BMET's

Medical School Affiliation

		TOTAL EXPENSES PER PATIENT PER YEAR	
		Less than $18,000	More than $18,000
Per cent of total expenses used for payroll	Less than 65%	1.00	.83
	More than 65%	.83 (.17)*	.67 (.17)

Sub-total .83 (.08)

No Medical School Affiliation

		TOTAL EXPENSES PER PATIENT PER YEAR	
		Less than $18,000	More than $18,000
Per cent of total Expenses used for payroll	Less than 65%	.89 (.11)	1.00
	More than 65%	.44 (.12)	1.00

Sub-total .82 (.06)

V.A. Hospitals

1.00

* Non-respondents

Grand total .84(.07)

TABLE BII

Proportion of Hospitals Recognizing a Need for BMET's

		TOTAL EXPENSES PER PATIENT PER YEAR		
		Less than $18,000	More than $18,000	Total
Per cent of total expenses used for payroll	Less than 65%	.93	.92	.93
	More than 65%	.60	.87	.73
	Total	.77	.89	.82

TABLE BIII

Proportion of Hospitals Indicating a Need for a Specific Number of BMET's for Current Staffs:

Medical School Affiliation

		TOTAL EXPENSES PER PATIENT PER YEAR	
		Less than $18,000	More than $18,000
Per cent of total expenses used for payroll	Less than 65%	.67	.50
	More than 65%	.67	.33

Sub-total .54

No Medical School Affiliation

		TOTAL EXPENSES PER PATIENT PER YEAR	
		Less than $18,000	More than $18,000
Per cent of total Expenses used for payroll	Less than 65%	.44	.50
	More than 65%	.44	.78

Sub-total .55

V.A. Hospitals

.83

Grand total .57

TABLE BIV

Proportion of Hospitals Indicating a Need for a Specific Number of BMET's for their Current Staffs:

		TOTAL EXPENSES PER PATIENT PER YEAR		
		Less than $18,000	More than $18,000	Total
Per cent of total expenses used for payroll	Less than 65%	.53	.50	.52
	More than 65%	.53	.60	.57
	Total	.53	.56	.54

TABLE BV

Proportion of Hospitals Indicating a Need for a Specific Number of BMET's for 1970:

Medical School Affiliation

		TOTAL EXPENSES PER PATIENT PER YEAR	
		Less than $18,000	More than $18,000
Per cent of total expenses used for payroll	Less than 65%	1.00	.67
	More than 65%	.33	.00

Sub-total .50

No Medical School Affiliation

		TOTAL EXPENSES PER PATIENT PER YEAR	
		Less than $18,000	More than $18,000
Per cent of total Expenses used for payroll	Less than 65%	.33	.33
	More than 65%	.33	.67

Sub-total .42

V.A. Hospitals

.50

Grand total .46

TABLE BVI

Proportion of Hospitals Indicating a Need for a Specific Number of BMET's for 1970:

		TOTAL EXPENSES PER PATIENT PER YEAR		
		Less than $18,000	More than $18,000	Total
Per cent of total expenses used for payroll	Less than 65%	.60	.50	.56
	More than 65%	.33	.40	.37
	Total	.47	.44	.46

TABLE BVII

Proportion of Hospitals Interviewed by Interviewer 1*

Medical School Affiliation

		TOTAL EXPENSES PER PATIENT PER YEAR	
		Less than $18,000	More than $18,000
Per cent of total expenses used for payroll	Less than 65%	.5	.5
	More than 65%	0	.5

Sub-total .4

No Medical School Affiliation

		TOTAL EXPENSES PER PATIENT PER YEAR	
		Less than $18,000	More than $18,000
Per cent of total Expenses used for payroll	Less than 65%	.5	0
	More than 65%	.5	.3

Sub-total .4

V.A. Hospitals

.5

Grand total .4

* Remaining hospitals were interviewed by Interviewer 2.

TABLE BVIII

Proportion of Hospitals Interviewed by Interviewer 1*

		TOTAL EXPENSES PER PATIENT PER YEAR		
		Less than $18,000	More than $18,000	Total
Per cent of total expenses used for payroll	Less than 65%	.5	.3	.4
	More than 65%	.3	.3	.3
	Total	.4	.3	.4

* Remaining hospitals were interviewed by Interviewer 2.

TABLE BIX

Proportion of Manufacturers Recognizing a Need for BMET's

	Phys.	Lab.	Total
More than $1,000,000	.8	.9	.9
Less than $1,000,000	.7	.8	.7
Sub-total	.8	.8	.8
No asset data	1.0	1.0	1.0
TOTAL	.8	.9	.8

TABLE BX

Proportion of Manufacturers Indicating a Need for a Specific Number of BMET's for Current Staffs:

	Phys.	Lab.	Total
More than $1,000,000	.7	.7	.7
Less than $1,000,000	.7	.6	.6
Sub-total	.7	.6	.7
No asset data	1.0	1.0	1.0
TOTAL	.7	.7	.7

TABLE BXI

Proportion of Manufacturers Indicating a Need for a Specific Number of BMET's for 1970:

	Phys.	Lab.	Total
More than $1,000,000	.5	.6	.5
Less than $1,000,000	.5	.8	.6
Sub-total	.5	.7	.6
No asset data	.3	.3	.3
TOTAL	.5	.6	.5

TABLE BXII

Proportion of Manufacturers Interviewed by Interviewer 1

	Phys.	Lab.	Total
More than $1,000,000	.3 (.17*)	.4	.4 (.06)
Less than $1,000,000	.5	.4 (.13)	.4 (.07)
Sub-total	.4 (.08)	.4 (.06)	.4 (.07)
No asset data	.7	.3	.5
TOTAL	.5 (.06)	.4 (.05)	.4 (.06)

* Indicates proportion interviewed by third interviewer

TABLE BXIII

Proportion of Research Institutes Indicating a Need for a Specific Number of BMET's for 1970:

Type of Institute	Need
Research Laboratories	.3
Bio-Medical Institutes	.8
Total	.6

TABLE C-I

Number of BMET's Needed on Current Staffs: Hospital Sub-Population

Medical School Affiliation

		TOTAL EXPENSES PER PATIENT PER YEAR	
		Less than $18,000	More than $18,000
Per cent of total expenses used for payroll	Less than 65%	19 (14)*	15 (31)
	More than 65%	11 (23)	17 (21)

Sub-total 63 (89)

No Medical School Affiliation

		TOTAL EXPENSES PER PATIENT PER YEAR	
		Less than $18,000	More than $18,000
Per cent of total Expenses used for payroll	Less than 65%	40 (60)	19 (28)
	More than 65%	13 (58)	51 (58)

Sub-total 122 (204)

V.A. Hospitals

17 (25)

Grand total 202 ± 26.8 (318)

* Sub-group size

TABLE CII

Number of BMET's Needed on Current Staffs: Hospital Sub-Population

		TOTAL EXPENSES PER PATIENT PER YEAR		
		Less than $18,000	More than $18,000	Total
Per cent of total expenses used for payroll	Less than 65%	59 (74)*	34 (59)	93 (133)
	More than 65%	24 (81)	68 (70)	92 (160)
	Total	83 (155)	102 (138)	185 (293)

* Cell size

TABLE C-III

Number of BMET's Needed in 1970: Hospital Sub-Population

Medical School Affiliation

		TOTAL EXPENSES PER PATIENT PER YEAR	
		Less than $18,000	More than $18,000
Per cent of total expenses used for payroll	Less than 65%	42 (14)*	77 (31)
	More than 65%	11 (23)	0 (21)

Sub-total 131 (89)

No Medical School Affiliation

		TOTAL EXPENSES PER PATIENT PER YEAR	
		Less than $18,000	More than $18,000
Per cent of total Expenses used for payroll	Less than 65%	20 (60)	23 (28)
	More than 65%	58 (58)	90 (58)

Sub-total 191 (204)

V.A. Hospitals

21 (25)

Grand total 342 ± 57.8 (318)

* Sub-group size

TABLE CIV

Number of BMET's Needed in 1970: Hospital Sub-Population

		TOTAL EXPENSES PER PATIENT PER YEAR		
		Less than $18,000	More than $18,000	Total
Per cent of total expenses used for payroll	Less than 65%	62 (74)*	100 (59)	162 (133)
	More than 65%	69 (71)	90 (79)	159 (160)
	Total	131 (155)	190 (138)	321 (293)

* Cell size

TABLE GV

Number of BMET's Needed on Current Staffs: Manufacturer Sub-Population

	Phys.	Lab.	Total
More than $1,000,000	156 (14)*	296 (43)	452 (57)
Less than $1,000,000	17 (15)	241 (24)	258 (39)
Sub-total	173 (29)	537 (67)	710 (96)
No asset data	160 (20)	128 (48)	288 (68)
TOTAL	333 (49)	665 (115)	998 ± 259.9 (164)

* Sub-group size

TABLE CVI

Number of BMET's Needed in 1970:
Manufacturer Sub-Population

	Phys.	Lab.	Total
More than $1,000,000	164 (14)*	736 (43)	900 (57)
Less than $1,000,000	40 (15)	822 (24)	862 (39)
Sub-total	204 (29)	1558 (67)	1762 (96)
No asset data	393 (20)	80 (148)	473 (68)
TOTAL	597 (49)	1638 (115)	2235 ± 611.8 (164)

* Sub-group size

TABLE CVII

Number of BMET's Needed on Current Staffs: Research Institute Sub-Population

Type of Institute	Need
Research Laboratory	28 (24)
Bio-Medical Institute	178 (64)
Total	206 (88) ± 141.2

TABLE CVIII

Number of BMET's Needed in 1970: Research Institute Sub-Population

Type of Institute	Need
Research Laboratory	14 (24)
Bio-Medical Institute	877 (64)
Total	891 ± 773.9

APPENDIX D

PROCEDURES USED TO EXPLAIN DISTRIBUTION OF MONEY VARIABLES

The data with regard to the investment and expenditures in bio-medical equipment were coded to indicate the distribution of the respondents. This procedure was employed because the respondents were uncertain about the figures they gave. The coded data were analysed on the basis of the assumption that they represented the distribution of the respondents on the variable rather than any actual dollar amounts. In order to demonstrate what this analysis means, the distribution of respondents on the coded investment variable is presented in this appendix and the indicators derived from it are included so that the reader may compare them. Tables I and II of this appendix contain the distribution on the three coded categories of the investment variable for each of the nine sub-groups and their combinations. The number in parentheses is the distribution indicator reported in the text. These figures were derived by assigning values of 1, 2, and 3 to the three categories and taking the mean of each of the distributions. For each of the three sub-groups having an indicator of 2.0 there is symmetry in their distributions even though the actual distributions are somewhat different especially in the case of the sub-group having no respondents in the high or low group. (Certain deviations from the symmetry are permitted when the frequency of each of the three categories increases.) The most notable exception is in the grand total where there is a slight skewness to the higher category, but the indicator is still 2.0.

The two MSA sub-groups with a relatively low PC value have indicators that are reasonably similar even though their distributions are quite different. The common aspect of the distributions is their skewness to the higher category. The sub-group with a relatively high TE value has a lower indicator even though a greater proportion of the respondents are in the higher investment category. This is caused by one respondent in that sub-group being in the lower investment category. If one were to remove that compensating effect, the indicator would be 2.6. In Table II there is an interesting result that one may follow by looking across either row. As the frequency of the distribution increases a greater absolute skewness results in an indicator which is equal to the indicator of distribution having less absolute skewness. For example, in the row that contains the distributions for hospitals having a relatively low PC, in the first entry the difference between those in the high and low categories is only two respondents. The same is true for those in the second entry. In the total column for that row there are four more respondents in the higher level than in the lower level, but the same indication of skewness is obtained. This result points out the fact that the indicator is a proportional indication of skewness and not an absolute indication.

TABLE DI

Comparison Between Distribution of Hospital Investment Data and Investment Distribution Indicator

Medical School Affiliation

		TOTAL EXPENSES PER PATIENT PER YEAR	
		Less than $18,000	More than $18,000
Per cent of total expenses used for payroll	Less than 65%	0/3/2* (2.4)**	1/2/3 (2.3)
	More than 65%	0/5/1 (2.2)	1/5/0 (1.8)

Sub-total 2/15/6 (2.2)

No Medical School Affiliation

		TOTAL EXPENSES PER PATIENT PER YEAR	
		Less than $18,000	More than $18,000
Per cent of total Expenses used for payroll	Less than 65%	2/3/2 (2.0)	0/5/0 (2.0)
	More than 65%	4/3/1 (1.4)	2/4/2 (2.0)

Sub-total 8/15/5 (1.9)

V.A. Hospitals

2/1/3
(2.2)

Grand total 12/31/14 (2.0)

* Number of hospitals: Below average/ Average/ Above average

** Investment distribution indicator
Perfect symmetry = 2.0

TABLE DII

Comparison Between Distribution of Hospital Investment Data and Investment Distribution Indicator

		TOTAL EXPENSES PER PATIENT PER YEAR		
		Less than $18,000	More than $18,000	Total
Per cent of total expenses used for payroll	Less than 65%	2/6/4* (2.2)**	1/7/3 (2.2)	3/13/7 (2.2)
	More than 65%	4/8/2 (1.9)	3/9/2 (1.9)	7/17/4 (1.9)
	Total	6/14/6 (2.0)	4/16/5 (2.0)	10/30/11 (2.0)

* Number of hospitals: Below average/ Average/ Above average

** Investment distribution indicator
Perfect symmetry = 2.0

APPENDIX E

LIST OF INDIVIDUALS WHO ASSISTED IN PLANNING AND CARRYING OUT PROJECT

Abele, John	Vice President and General Manager, Advanced Instruments, Inc. Newton; Chairman, Manufacturer's Advisory Board, Association for the Advancement of Medical Instrumentation.
Austen, W. Gerald, M.D.	Chairman, Sub-Committee on Biological and Medical Engineering, Massachusetts General Hospital, Boston.
Ayers, John, M.D.	Director, Springfield Municipal Hospital, Springfield, Massachusetts.
Balasz, Endre	President, Retina Foundation, Boston, Massachusetts.
Berkley, Carl	Scientific Director, Foundation for Medical Technology, New York, New York.
Boal, Bruce	President, Hickok Teaching Systems, Inc., Cambridge, Massachusetts
Buchanan, William W.	Vice President, Bowker Associates, Washington, D. C.
Bugby, John	Faculty, Springfield Technical Institute, Springfield, Massachusetts.
Busser, John H.	Executive Secretary, Bioinstrumentation Advisory Council, American Institute of Biological Sciences, Washington, D. C.
Cooke, Lot H., Jr.	Senior Supervisor for Research, Division of Vocational Education, Massachusetts Department of Education, Boston, Massachusetts.
Croll, Millard, M.D.	Department of Radio Therapy; Hahnemann Hospital, Hahnemann Medical College, Philadelphia, Pennsylvania.

Cronkhite, Leonard W., Jr., M.D.	Administrator, Children's Hospital Medical Center, Boston, Massachusetts.
Davis, Julie	Cambridge School Department Planning Staff, Cambridge, Massachusetts.
Dobrovolny, Jerry	Head, Department of General Engineering, University of Illinois, Urbana, Illinois
Dugger, Roy W.	Vice President and Director, James Connally Technical Institute of Texas, A & M University, Waco, Texas.
Fine, Samuel	Chairman, Department of Bio-Physics and Bio-Medical Engineering, Northeastern University, Boston, Massachusetts.
Frank, Nathaniel H.	Massachusetts Institute of Technology, Cambridge, Massachusetts.
Fribance, Austin E.	Technical Education Research Center, Cambridge, Massachusetts.
Garvey, Edmond P.	President, Springfield Technical Institute, Springfield, Massachusetts.
Giddings, Frank	Faculty, Springfield Technical Institute, Springfield, Massachusetts.
Herbert, Achille C.	Head of Applied Physics and Technical Mathematics Department, James Connally Technical Institute, Waco, Texas.
Herron, Earl H., Jr.	Bioinstrumentation Advisory Council, American Institute of Biological Sciences, Washington, D.C.
Hubbard, Donald	Technical Education Research Center, Cambridge, Massachusetts

Husman, Don	Vice President, Manufacturing Instrumentation Laboratory, Watertown, Massachusetts.
Klein, Herbert	Chief Engineer, Boston University Medical Center and University Hospital, Boston, Mass.
Knowles, John H., M.D.	General Director, Massachusetts General Hospital, Boston, Mass.
Krueger, Cynthia	Technical Education Research Center, Cambridge, Massachusetts.
Markham, Walter J.	Director, Division of Vocational Education, Massachusetts Department of Education, Boston, Massachusetts.
Martin, Josephine	Editor, Medical Electronic News, Pittsburg, Pennsylvania.
McLaughlin, Bette	Education Development Center, Cambridge, Massachusetts
McNary, William	Director of the Teaching Laboratory, Boston University School of Medicine, Boston, Massachusetts.
Miller, A. J.	Center for Vocational and Technical Education, Ohio State University, Columbus, Ohio.
Nangle, Grace L.	Supervisor, Health Occupations Training, Massachusetts Division of Vocational Education, Massachusetts Department of Education.
Nelson, Arthur H.	Technical Education Research Center, Cambridge, Massachusetts.
Owen, Jack W.	Secretary, Middle Atlantic Hospital Assembly.
Post, John	Executive Secretary, Association for the Advancement of Medical Instrumentation.
Quigley, John	Secretary, New England Hospital Association.

Ratner, Muriel	Community College Health Careers Project, New York State Education Department, New York, New York.
Roney, Maurice W.	Director of the School of Industrial Education, Oklahoma State University; President American Technical Education Association.
Scofield, Robert	Professor of Psychology and Management, University of Houston, Houston, Texas.
Skaggs, Kenneth G.	American Association of Junior Colleges, Washington, D.C.
Slater, Lloyd E.	Associated Universities, Inc. Washington, D.C.
Soule, A. Bradley, M.D.	Chairman, Department of Radiology, College of Medicine, University of Vermont, Burlington, Vermont.
Sussman, Patricia	Director, Health Careers Program, American Hospital Association, Chicago, Ill.
Sweeney, Robert S.	Director, Technical Institute, Cambridge School Department, Cambridge, Massachusetts.
Taylor, A.N.	Council on Medical Education, American Medical Association, Chicago, Illinois.
Thompson, John	Arthur D. Little, Inc. Cambridge, Massachusetts.
Tischler, Morris	Baltimore, Maryland
Twyman, J. Paschal	Vice President, Tulsa University, Tulsa, Oklahma.

Van Dusen, Edward B.	Director of the Evening Division, Lowell Technological Institute, Lowell, Massachusetts.
Weimer, Edward W.	Assistant Secretary, American Hospital Association, Chicago, Illinois.
Wilde, Evelyn	Technical Education Research Center, Cambridge, Massachusetts.

APPENDIX F

List of Hospitals, Manufacturers, and Research Institutes Interviewed in Field Study

Participants

Hospitals

Beverly Hospital
Beverly, Mass.

Malden Hospital
Malden, Mass.

Brockton Hospital
Brockton, Mass.

Union Hospital
Fall River, Mass.

New Britain General Hosp.
New Britain, Conn.

University Hospital
Boston, Mass.

VA Hospital
West Haven, Conn.

Memorial Hospital
Pawtucket, R.I.

Chester County Hospital
West Chester, Pa.

VA Hospital
Providence, R.I.

VA Hospital
Philadelphia, Pa.

Presbyterian Hospital
New York, N.Y.

Pascack Hospital
Westwood, N.J.

St. Mary's Hospital
Passaic, N.J.

Pittsburgh Hospital
Pittsburgh, Pa.

Mercy Hospital
Buffalo, N.Y.

Christ Hospital
Jersey City, N.J.

St. Elizabeth Hospital
Elizabeth, N.J.

U.S. Public Health Service Hosp.
Boston, Mass.

St. Elizabeth's Hospital
Brighton, Mass.

Mt. Sinai Hospital
Hartford, Conn.

Cambridge City Hospital
Cambridge, Mass.

Carney Hospital
Boston, Mass.

Morristown Memorial Hosp.
Morristown, N.J.

St. Luke's Hospital
New Bedford, Mass.

VA Hospital
East Orange, N.J.

Bronx Municipal Hosp. Center
Bronx, N.Y.

Presbyterian-University Hosp.
Pittsburgh, Pa.

St. Francis General Hosp.
Pittsburgh, Pa.

St. Vincent's Hospital
Bridgeport, Conn.

Williamsport Hospital
Willaimsport, Pa.

French Hospital
New York, N.Y.

East Orange General Hospital
East Orange, N.J.

Bellevue Hospital center
New York, N.Y.

Bridgeport Hospital
Bridgeport, Conn.

Englewood Hospital
Englewood, N.J.

Flushing Hosp. & Med. Center
Flushing, N.Y.

Misericordia Hospital
Bronx, N.Y.

St. Vincent's Hospital
Staten Island, N.Y.

Meadowbrook Hosp.
East Meadow, N.Y.

Long Island Jewish Hospital
New Hyde Park, N.Y.

Harlem Hospital
New York, N.Y.

Mary Immaculate Hospital
Jamaica, N.Y.

Atlantic City Hospital
Atlantic City, N.J.

Presbyterian-U. of Pa. Med. Center
Philadelphia, Pa.

Cumberland Hospital
Brooklyn, N.Y.

Hahnemann Medical College & Hospital
Philadelphia, Pa.

St. Barnabas Medical Center
Livingston, N.J.

Altoona Hospital
Altoona, Pa.

Kingston Hospital
Kingston, N.Y.

St. Mary's Hospital
Hoboken, N.J.

Brooklyn Hospital
Brooklyn, N.Y.

Genesee Hospital
Rochester, N.Y.

Emergency Hospital
Buffalo, N.Y.

Binghamton General Hospital
Binghamton, N.Y.

VA Hospital
Newington, Conn.

Meriden Hospital
Meriden, Conn.

VA Hospital
Wilkes-Barre, Pa.

Allentown Hosp.
Allentown, Pa.

Mercer Hospital
Trenton, N.J.

Hackensack Hosp
Hackensack, N.J.

Mercy-Douglass Hospital
Philadelphia, Pa.

Harrisburg Hospital
Harrisburg, Pa.

Jefferson Med. College Hosp.
Philadelphia, Pa.

Manufacturers

Virtis Co.
Gardiner , N.Y.

Cambridge Instruments
New York, N.Y.

Sperry Products
Danbury, Conn.

Medcraft Electronics
Skippack, Pa.

Telemedics-Vector Div.
Southampton, Pa.

F&M Scientific
Avondale, Pa.

Hydor Therme Corp.
Pennsauken, N.J.

Jordan Com Refrig Co
Philadelphia, Pa.

Air Products & Chemical Corp.
Natick, Mass.

Carl Zeiss Inc.
New York, N.Y.

Teca Corp
White Plains, N.Y.

U.S. Catheter & Instr. Corp.
Glens Falls, N.Y.

Linde Div
New York, N.Y.

Brinkmann Instr. Inc.
Westbury, N.Y.

Standard Scientific Supply
New York, N.Y.

Lehigh Valley Electronics Inc.
Fogelsville, Pa.

American Electr. Labs Inc.
Lansdale, Pa.

Perkin-Elmer Corp
Norwalk, Conn.

Brookline Instrument Co.
White Plains, N.Y.

Tenney Engineering Inc.
Union, N.J.

Modern Lab Equipment
New York, N.Y.

Manostat
New York, N.Y.

Electro-Medical Lab
Windsor, Vermont

Baird-Atomic
Cambridge, Mass.

Neslab Instrs. Inc.
Durham, N.H.

Elgeet Opitcal
Rochester, N.Y.

Bausch & Lomg
Rochester, N.Y.

Internation Equipment
Needham Heights, Mass.

Waters Associates
Framingham, Mass.

Gifford Wood
New York, N.Y.

American Opitcal
Bedford, Mass.

RCA
Camden, N.J.

Warren E. Collins
Braintree, Mass.

Hewlett Packard
Waltham, Mass.

Research Institutes

Electronics Branch
U.S. Army Natick Lab
Natick, Mass.

Hypertension & Atherosclerosis
Research Unit, Boston U. Hosp.
Boston, Mass.

Phio. Coll. of Pharmacology & Sci.
Philadelphia, Pa.

Pharmacology Research, Inc.
Darby, Pa.

Bristol Labs, Inc.
Syracuse, N.Y.

NYS Dept of Health
Div. of Labs & Research
Albany, N.Y.

Cancer Research Institute
New England Deaconess Hosp
Boston, Mass.

Brooklyn Testing Lab
Brooklyn, N.Y.

Biochemex Labs
Elmont, N.Y.

Institute for Steroid Research
Montefiore Hosp & Med Center
Bronx, N.Y.

Mellon Institute
Pittsburgh, Pa.

Cardiovascular Lab
Columbia-Presbyterian Med. Center
New York City

Sterling-Winthrop Res. Inst.
Rensselear, N.Y.

O'Donnell Mem. Res. Labs
Saranac Lake, N.Y.

Retina Foundation
Boston, Mass.

APPENDIX G

LIST OF INSTITUTIONS INTERVIEWED IN PRELIMINARY SURVEY

Southwest Medical Center
Dallas, Texas

University of California at Los Angeles
White Memorial Hospital
Los Angeles, California

Stanford Medical School
Stanford, California

Cutter Laboratory
Berkeley, California

University of California Medical Center
San Francisco, California

Monroe County Laboratories
Rochester, New York

Springfield Municipal Hospital
Springfield, Massachusetts

Massachusetts General Hospital
Boston, Massachusetts

* A number of other institutions represented by individuals listed in Appendix E were also consulted during the Preliminary Survey.

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Bio-Medical Equipment technician

IDENTIFIERS

ABSTRACT

The need for and characteristics of bio-medical equipment technicians (BMET's) were studied as a first step in the development and evaluation of generalizeable educational programs for BMET's. The objectives were: (1) to determine the employment opportunities for BMET's and to identify their functions and other characteristics; and (2) to develop a preliminary curriculum outline for post high school educational programs for BMET's. A Field Study (based upon structured interviews) was designed to elicit information from officials of a representative regional sample of the three major categories of prospective employers of BMET's--hospitals, bio-medical equipment manufacturers, and medical research institutes. The region studied comprised New England and three Middle Atlantic states. The results document substantial and growing employment opportunities for BMET's and identify and describe the characteristics of four general job types which BMET's will fill. The general structure and preliminary outline of a two year associate degree type curriculum in bio-medical equipment technology designed to prepare technicians who will be broadly employable within this new technology was developed on the basis of Field Study Data.

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