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1.0. INTRODUCTION

This paper describes an experimental, computer-oriented management information system, LBL-MIS, currently under development within the Physics Division of the Lawrence Berkeley Laboratory. This system has been designed to aid the management primarily of the Physics Division, but potentially of other LBL Divisions as well. (Several sub-systems are already in lab-wide use.)

The LBL-MIS system was begun in fiscal year 1972 under the general direction of the Laboratory's Operations Engineer, who had lab-wide responsibility for improving management reports. For a discussion of the historical background to this system, the reader is referred to Appendix A.

The approach taken was to integrate the many pieces of available machine-readable management data and to heuristically approach a general management system, using the high speed CRT display as a basic I/O device. The resulting system differs from most other management information systems in a number of ways. It operates variously in both batch and interactive mode, taking advantage of the relative powers of both the computer and the user to balance the trade-offs between computer resources and management's time. Large volume, systematic procedures are done in batch mode, while the interactive mode offers extreme flexibility for exception processing. The on-line programs offer two distinct modes of operation, which are effectively in simultaneous use. In the response mode, the computer prompts succeeding procedures; in the command mode, the manager can spontaneously redirect his attention to other aspects of the task at hand.

Two points need to be stressed at the outset. First, LBL-MIS is not a substitute for an accounting system. In fact, without LBL's relatively accurate and timely accounting system to provide the raw input to LBL-MIS, our efforts would not have progressed as far as they have. The accounting system and LBL-MIS complement each other. Whereas the accounting system measures, aggregates, and reports past transactions, LBL-MIS is a facility that allows management to retrieve, manipulate, and compute using not only past accounting data but also projections of future transactions. Without the reliable record of where one has been (provided by the accounting system), it is much more difficult to plan where one should go in the future.

The second point that should be stressed is that the computer programs by themselves do not fully constitute the management system. Especially in the context of heuristic development, the close cooperation between management and programmers in the use of the programs has been vital. We also feel that similarly close cooperation will prove valuable in the maintenance of the system through changes both in administrative policy and in computing environment. It is hoped that this development can be used throughout the Laboratory and that the experience can be conceptually extended to other government agency management problems.

Section 2, The Problem, describes the problem that confronted the Physics Division management before the installation of LBL-MIS. Section 3, The Solution, presents an overview of the solution and presents the major benefits and costs of LBL-MIS. Section 4, Technical Aspects of LBL-MIS, outlines the major components LBL-MIS including the purpose of each sub-system, the data sources, and the output. Our Conclusions and Recommendations are presented in Section 5. This paper is intended as a general introduction to LBL-MIS; more specific information on this system may be found in the documents described in Appendix C.

2.0. THE PROBLEM

LBL-MIS was initially designed to serve the needs of the Physics Division Office and of the Operations Engineer for lab-wide support effort management. The management functions in these areas are described here to acquaint the reader with the underlying environment in which LBL-MIS was to operate. This may prove useful to a fuller understanding of the system.

2.1. Management Functions

Until 1973 the Physics Division Office managed over half the research program dollars that were spent at the Berkeley Laboratory (approximately $20 out of $38 million per year). The Division, composed of roughly 23 decentralized research groups, was managed under the direction of the Associate Director, by the Managing Engineer,[1] the Business Manager, and the Personnel Administrator.

Aside from management of the general direction of the research undertaken within the Division, the Physics Division Office presently also performs the following functions.

2.1.1. Budget Control. Control over the expenditures of the individual research groups of the Physics Division. The Division Office works with each group and helps the group leader to plan his expenditures so that the group's budget will balance at the end of the year. If, in the middle of the year, a group wants to change staff size, increase its computer usage, or decrease its support utilization, the Division Office helps the group to forecast the effect of these changes on its ability to meet the year-end budget constraint. The Division Office, in effect, interacts with the research groups.

2.1.2. Coordination Among Groups. Coordination among groups within the division. The Division Office must balance the Division's budget across all groups at year-end; therefore it coordinates the expenditures of all those groups that do not meet their end-of-year budget constraints. It also coordinates the utilization and arrangement of buildings occupied by the various groups, and coordinates the support effort requirements. The Division Office facilitates the interaction among the research groups on budget, space and support utilization throughout the year, and especially at year end on the budget fit.

2.1.3. Communication Within Division. Communication to the research groups of any changes made by the LBL administration that might affect expenditures of the group. This is accomplished by the preparation of impact studies. For example, if the overhead rate were changed from 35% to 40%, impact studies in the form of projected expense statements would be prepared for each research group, incorporating the new overhead rate. In this way the effect of the change could be illustrated and the research groups would be better prepared to alter their research programs. Thus, the Division Office facilitates the interaction between the research groups and the Laboratory administration.

2.1.4. Communication With Higher Management. Communication to the LBL Budget Office and the AEC, not only on past expenditures but also on planned expenditures. The Budget Office and the AEC require updated projections on research plans in order to coordinate inter- and intra-Laboratory expenditures. The Division Office prepares routine reports of the Division's research plans, and thereby interacts with the Budget Office and the AEC.

2.1.5. Personnel Administration. Administration of all Physics Division payroll groups. This includes administering all wage and salary adjustments, Affirmative Action programs, and domestic and foreign travel of Division personnel. In addition, the Division Office maintains a personnel file, including current and past salary adjustments, that is used for statistical studies and is useful for forecasting future payroll expense. In this case the Division Office interacts primarily with the Personnel Department.

2.1.6. Plan Preparation. Preparation of annual plans and Five Year Plans for the Division, based on the projections of the research groups. These documents are the primary source records used by the AEC and the Congress in determining funding allocations. In this case the Division Office interacts with the Budget Office and the Director with respect to the future direction of the research program within the Division.

2.1.7. Equipment Purchase and Control. All major equipment purchases are made through the Division Office. The subsequent control of the equipment, including the annual and biannual property inventories, are also the responsibility of this office. Thus the Division Office interacts with both Purchasing and Property Accounting.

2.2. Promoting Interaction by Communicating Information

Clearly, one important theme of the Physics Division Office operation is facilitating interaction, both within the Division, and between the Division and the Laboratory and/or the AEC. By interaction we mean the channeling of the flows of information from data source to relevant decision maker such that the various research activities can be coordinated and the overall operating efficiency of the Laboratory can be maintained. In a decentralized organization such as LBL these information flows are crucial if fixed or nondivisible resources are to be used in an efficient manner.[2] The Division Office is a critical point in a set of interconnected nodes comprising the formal communication network of LBL.

Information is transmitted within this network among decision makers of the Laboratory. The research groups receive information on the amount of resources consumed, the expected future prices for various input factors (support rates, computer rates, etc.), the accounting parameters (e.g., the overhead rate), and the plans of other research groups insofar as these affect the availability of limited resources (accelerator schedules, shop schedules, etc.). This information is required by the research groups in order to arrive at decisions regarding the best use of remaining resources or regarding future experiments. The Budget Office receives information on future expenditures of the research groups in order to coordinate the overall spending of the Laboratory's various budgets,[3] and various administrative departments receive information coordinated on a Division-wide basis.

Not only does the Division Office accumulate and relay information, it also assists the Laboratory's administration in evaluating the financial plans of the research groups and assists the groups in evaluating any options open to them. But while the Division Office participates in the decision making processes at various levels of the Laboratory, its role in channeling information flows and as a communications node is central to LBL-MIS.

2.3. The Role of Information

LBL-MIS is a computer oriented system designed to improve the interactive, and thus communicative, capabilities of LBL management. In essence, data is received from numerous sources (the research groups, Accounting, the Budget Office, the support groups), then the Division Office filters, aggregates, projects and transmits information to the proper destination. The computer programs of LBL-MIS assist in this process. Crucial to understanding this process is the difference between data and information.[4] A datum is a specific fact or number to some naturally bounded precision. For example, M. Smith's gross earnings of $12,441.25 in 1974 is a datum. Information, on the other hand, is complexes of related data used in arriving at a decision. For example, that in 1974, M. Smith earned $12,441.25 and that other employees performing the same function earned $14,421.50, is information useful in adjusting M. Smith's salary in 1975. Usually the actual decision maker performs the data conversion since this individual is most knowledgeable of the informational needs of the decision process. Still it might be advantageous in many cases for the decision maker to receive data already partially coordinated into information. But the ultimate use of the data must be known, at least implicitly, or the conversion to information is meaningless.

For example, suppose a scientist must make a decision, say, on the number of mechanical engineers to use next month. The accounting system provides great quantities of data pertaining to past transactions, including effort use and expenses. The scientist also knows his year-end budget constraint and, for simplicity, there is one month remaining. By balancing his various commitments and needs, the scientist may arrive at an amount expendible for mechanical engineers. From past effort and expense data he could calculate past effort rates (in dollars/man-month, say). After adjusting such figures by any factors that might cause next month's rate to differ (salary adjustments, terminations, etc.), he could calculate an effort level corresponding to his available money. In supplying the scientist with information, the manager must recognize and display all of the interrelationships among the data: in this case not only among the year-end constraint and any commitments and/or needs, but also among expenses, effort, and personnel changes.

If these interrelationships were stable over time and all the factors were known, then, hypothetically at least, a computer could make the conversion. However the interrelationships are constantly changing, and management learns of the interrelationships in the data, which are surrogates for the interrelationships in the real world, by working with the data, making estimates of future amounts, and receiving feedback as to whether the estimates are right or wrong. It is this very aspect of management that is difficult, if not impossible, to capture in a prescribed computer code. The manager's mind is much better suited than the computer's binary logic for exploring complex interrelationships and for discovering implications from one set of data to another. However, the computer possesses the capabilities to perform rapid calculations on large data bases. Thus, the crux of what LBL-MIS attempts to accomplish is to place the computer's serial processing capabilities at the call of the manager's heuristic, although often difficult to define, data coordinating capabilities.

2.4. The Problem Becomes Critical: Processing Overload

As long as the actual physical volume of data the manager must operate on is small and/or the amount of manual data processing required is not terribly time consuming, then the conversion of data into information can be performed by manual procedures. However, if the volume of data rises or the number of requests for information rises to a very cumbersome level, then management does not have the facility to meet all of the requests with available personnel. This was the situation in which the Physics Division Office found itself during the period 1969 to 1971.

The Division Office received roughly 50 computer prepared reports each month, with a cumulative length of around 13,000 pages. The vast majority of these data are produced by Accounting and provide the historic record of past transactions made by the research groups. The data is expressed in dollars or man-months expended on the various research programs. This data base is required to produce various types of information, including information regarding the projected total expenditures for each research group; and these projections are used by each group to adjust their expenditures in order to meet their budget constraints.

In order for the Division Office to accurately[5] project the future expenditures of a particular research group, the past mix of effort must be scanned to determine the stability of the mix. Payroll rates for the various categories of effort must be determined in order to convert projected effort by category into projected dollars. Before LBL-MIS, this calculation was performed after wrestling with two-inch thick computer printout reports containing the historic figures (quantity of effort, expenses, and the mix of effort) upon which the future projections were based. This was required in order to arrive at the projected expenditures, from which the groups could adjust their spending patterns. When this had to be done for up to 26 research groups, a great deal of management's time was devoted to adjusting the historic accounting data.

The individual groups could perform these detailed calculations if, 1) there were incentives to expending valuable research talent in performing these calculations instead of in conducting research, or 2) each research group was willing to expend the resources to train and maintain at least one member of their group in the intricacies of the accounting system. There are non-trivial costs associated with having each research group perform the required calculations necessary to generate accurate forecasts of its future spending levels. It is certainly better to carry out most of the processing from data to information within the Division Office.

The problem became critical during 1970-71 when reduced funding levels, compounded by inflation, required even more accurate spending forecasts in order to prevent excessive layoffs.

In addition, several other events increased the work load.

a. Affirmative Action and Equal Opportunity studies required detailed (and costly) data regarding the number and distribution of minorities within the Division.

b. The responsibility for managing and coordinating the Laboratory's shop priority loads and mix of support groups' effort was delegated to the Operations Engineer whose only staff was the Physics Division Office. The Laboratory's total utilization of its support groups had to be accurately forecasted, the annual quantity of support the Laboratory was to provide had to be set, and peaks and troughs in the support utilization had to be smoothed out. This added to the Physics Division Office data processing overload.

c. In 1970 the LBL Business Manager eliminated the inventory clerks and placed the responsibility for conducting the biannual inventory with the research programs. This policy change gave further responsibility for roughly half of the Laboratory's property items (10,000 items with a value of approximately $34 million) to the Physics Division Office.

d. During the period 1969-1971, the size of the groups within the Physics Division changed relative to each other, thus prompting a continual reevaluation and reallocation of buildings and rooms among the research groups. This required the maintenance of a current space data base with details of the existing allocation.

While the conversion of data to information useful to various decision makers in LBL and the AEC had always been a Division Office responsibility, various external events during the period

1969-71 caused the volume of the processing to increase substantially. The management of the Physics Division Office, under the direction of the Laboratory Operations Engineer, chose to automate much of the repetitive data processing by using the extensive computer facilities at LBL (both batch and interactive). However, the resulting set of computer programs needed to provide more than just automatic data processing. An important requirement was that the interactive programs would allow the use of the computer to do exception processing, retrieving data and performing calculations selectively. This might be called interactive information management.

3.0. THE SOLUTION

This section discusses the general systems approaches that we found appropriate for the development and use of LBL-MIS. There is both a discussion of the team effort approach and a general overview of the computing procedures. The section concludes with a summary evaluation of LBL-MIS.

3.1. The Team Effort Approach

In order to design and implement any system, especially a fairly complicated one, a number of specialized capabilities must be brought together and integrated into the solution; this was the technique used in LBL-MIS. And, as is often the case, these various capabilities were furnished by different members of a team. The management staff provided the technical knowledge regarding the existing data bases and the interrelationships among the distinct data elements within each data base. In addition, these individuals were performing manual tasks that were to be automated, and thus also possessed the technical knowledge regarding the algorithms required to process the data into information. The programmer provided the technical expertise for structuring the data bases in ways that were efficiently accessible to the computer programs, for reformulating the processing algorithms into precise language acceptable for computation, and for expressing information in a readily usable fashion in both on-line displays and printed reports. Finally, one team member served in a consulting capacity. As a doctoral student in the Graduate School of Business, University of California, with a broad knowledge of computer systems outside the Laboratory, the consultant served both to facilitate understanding between management and programming members and to bring a broader perspective to bear on both management and computing procedures. More detailed descriptions of the team members may be found in Appendix B.

A very important aspect of the team effort approach, we have found, is to have the team members working closely together on a regular basis. What is critical to the development of a computer oriented system is that the users provide detailed specifications of data sources, needed processing algorithms, and informative presentations for output. Systems typically must also be revised after the users find that the first version "is not exactly what we had in mind". In order to make the most of such feedback, our approach was to locate the programmer and consultant in the Physics Division Office and to make them members of the office team. This led to a much more dynamic development than one where the team members work in isolation. The transfer of specifications was not limited to occasional meetings, a procedure that has previously inhibited such development.

Whenever the management staff needed some information, often their first impulse was to ask the programmer for it. Sometimes the problem could not be handled by computer techniques, sometimes the information could be gotten surprisingly easily (to the management staff) from existing data bases. There were also occasions when the programmer developed the techniques to produce the information while the manager proceeded to obtain it manually. This was done in parallel primarily to meet management deadlines, but also provided a valuable cross-check, lending confidence to subsequent use of the computer procedure. This concern with the solution of "brush fire" problems might appear to have delayed the development of LBL-MIS, but it was the mode of operation chosen to avoid an abstractly well conceived but less than useful system. As described below, we have tried to develop facilities and programs that conformed to the user's cognitive pattern, rather than have users conform to processing patterns more natural to the computer. By trying to develop the various computational procedures when needed for solving real problems, we tended to build in healthy emphasis on those most often needed. Doing this efficiently required the occasional tearing apart and reintegration of large amounts of computer code, but we felt that the more natural usability of the results was worth this effort.

By having the users come to the programmer and/or consultant with problems and by tackling daily problems as an integrated team, we experienced a rapid transfer of knowledge and feedback of information. The programmer quickly learned how the user approached problems. The management staff quickly gained an appreciation of the limits of the computer and of the effort and calendar time required to solve various types of problems. In addition to this educational advantage, there were large motivational inducements derived from working in this integrated fashion. The entire team was greatly encouraged by seeing positive results of design and development in the shortest possible time scale; and any approaches for which the value of the results was negative could be quickly redirected. The usefulness of feedback, both positive and negative, was enhanced by minimizing the delay between attempt and results (in line with the psychological principle of reinforcement).

One factor that proved advantageous to the development of LBL-MIS should be considered for its limiting aspect. Because the system was developed for a small number of users, the programmer could concentrate on specifically useful facilities rather than developing general (but not naturally useful) facilities conceived in compromise. This probably means that the system must be gradually expanded to accommodate other management styles, needs or constraints.

3.2. An Overview of the Computing Procedures

From the start this team adopted the approach of trying to use the computer's capabilities to organize, retrieve, and calculate in order to relieve management of time-consuming, repetitive manual tasks. The use of flexible interactive programs to facilitate exception processing greatly extended the degree to which this could be done. This use allowed management more time to analyze information and to interact with other members of the Laboratory, communicating information.

In Section 4 there will be specific discussions of the sub-systems of LBL-MIS. However, a separate discussion on general techniques and guiding principles is appropriate here. Four general techniques can be distinguished: 1) maintaining as much data as possible in machine readable form, 2) maintaining those data in as compact a form as possible, 3) using "warehousing" access to the data, and 4) making very careful separation of procedures appropriate to interactive or batch processing.

(1) The development of LBL-MIS has been greatly facilitated by the availability of the Laboratory's established data bases -- accounting, personnel, purchasing, and so on. The Physics Division has been able to obtain data from most departments not only in printed form but also in machine readable form. LBL-MIS uses nine different magnetic tapes as input. As a passing note, the system, in using Accounting's transactional data base for several types of detail, closely parallels the approach suggested by Sorter.[6] Much data valuable to management, however, is not appropriate to such factual data bases. Therefore the management files have been set up to accommodate many forms of anticipatory data and plan figures (all of which are entered interactively).

With such extensive maintenance of data in the machine readable form, LBL-MIS has provided management with flexible, mechanical methods of preparing various types of reports and of providing different segments of the Laboratory -- the Division Office, Budget Office, research groups, support groups, top management, and the AEC -- with various levels of information. This computerized facility allows the Division Office to respond rapidly to a changing environment where accurate, reliable information is required if good interaction is to be maintained.

(2) The second general technique has been to maintain the data in as compact a form as possible. This included treating all numerical values as integers (with effort expressed in hundredths of man-months, for example), and not using sixty bits (a CDC computer word) when thirty or even ten would do. This technique was followed to allow storage on the IBM data cells, which are quickly accessible to interactive users, and required extensive packing and unpacking facilities. (Both of these aspects were dictated by the specific computing environment, see below.) This technique occasionally resulted in discrepancies in the least significant digits between comparable values in management and accounting reports. However, as long as reasonable accuracy is maintained, such extreme precision is not as important to the management function.

(3) The third technique used in LBL-MIS has been to adopt the "warehouseman" notion for data access. Early in the design of LBL-MIS we anticipated a continually evolving data base structure and a changing computer system. In order to minimize the amount of recoding as data files and computer systems change, only one subroutine or program module contained the I/O communications for each type of data. This module is the warehouseman and any file change meant only changing its I/O module, not all of the program segments which communicated with the file.

(4) We have been careful to distinguish what computing procedures were appropriate to interactive or to batch processing. In general, procedures involving large amounts of systematic processing, such as data reduction and report generation, are carried out in batch programs. Data reduction includes the more figurative aspect of aggregating data into subsets of primary interest to management, as well as the more literal aspect of minimizing storage requirements by packing. The procedures appropriate to interactive processing are those involving detailed or exceptional considerations, or those where the immediate feedback of information is extremely valuable. These include the updating of personnel records, where the program is prepared to catch many types of errors, and the entering or adjusting of plan figures where the observed implications may lead to immediate readjustment.

There have been three guiding principles in the development of the computing techniques used in LBL-MIS. The primary principle has been, insofar as possible, to develop the computer facilities to accommodate the user's natural mode of functioning, rather than to require the user to conform to restrictive and inflexible procedures more natural to computer processing. The other two principles are part of the first but more specific, namely to maximize user control and to minimize the cognitive load on the user.

(1) There are two types of reasons for making the computing facilities conform to the user rather than vice versa. The technical reason is the likelihood that computing costs will continue to drop relative to personnel costs. Therefore there is a financial premium on carrying out the reexpression between the two processing modes, mental and computer, within the less costly mode. More important in management functions, however, is the recognition that the user is the creative element in this symbiosis. The computer is very fast and exact in maintaining organizational details, retrieving and replacing data, and calculating. The user must somehow communicate the spontaneous requirements. While an airline reservations clerk may be reasonably trained to conform to computing procedures, management's time is far too valuable to spend in translating general ideas into specific notations acceptable to an unsophisticated computer program. LBL-MIS has attempted to shift the burden of translation onto the computer programs, both in accepting input in the natural expression of the user and in expressing results in forms readily comprehended.

(2) Of course the computer programs cannot process natural language, but they do not require highly formatted input. The programs process input in a flexible fashion and reject uninterpretable input with helpful feedback. For the interactive programs, this includes reminders of interpretable forms. More important in on-line use, however, the user can normally enter a processing sequence in which the program makes sequential queries and the user responds with values. This prompting processing not only saves the user the effort of specifying what a value represents, it also saves him the need to remember the details of particular procedures. This makes it a powerful technique for minimizing the cognitive load on the user.

(3) The trouble with prompting processing, however, is that it locks the user into the computer program's inflexible sequence. The interactive programs in LBL-MIS actually give precedence to command processing, the technique for giving the user maximum control over the flow of execution. This allows the user to redirect his attention to many different aspects of the task at hand, usually with spontaneous discretion. Sometimes the program may suggest that a move is unwise, particularly if it may harm the data base or result in abortive processing. And while the user is often most grateful for the reminder, he can usually override the program's objection and proceed. The programs are also written so that when attention is redirected, any parameters under prior consideration are left in the state of any effectively completed process. Also there are classes of commands that are momentary; the user may spontaneously use them and return to the preceding considerations. In many ways the prompting processing and the command processing are woven into an integrated but dynamic fiber.

We do not wish to give the impression that maximizing user control and minimizing cognitive load are principles only for interactive procedures. The flexibility of input and the legibility of reports are as important in batch processing. The management staff also has a great deal of control over batch processing through the facility to instigate most of the normal data reduction and report generation whenever needed and without the programmer's involvement. Some of the commands to the interactive programs call in the batch processing programs.

3.3. The Costs of LBL-MIS

We wish to give some indication of the costs involved in the computing aspects of LBL-MIS. They cannot be definitively established since the development of computing procedures was intentionally interwoven with day to day management. Also, since the system is still undergoing development, there are no clearly established costs for maintenance. The costs of fixing bugs in programs and adjusting LBL-MIS to changes in the accounting and computing environments are so far considered part of development. We do have rough estimates, however, of development and operational costs.

Development costs include approximately three man-years of effort, designing and programming the system to the current state. This includes just the programmer's and consultant's time, since the management staff's time may best be assigned to day to day management. In addition the programmer (an unlimited time professional) devoted approximately one man-year of uncharged time due to his research interests. Of course, this is not technically a cost; and besides, much of the general development will have far broader application. (Note that one man-year of development costs have been underwritten by Math and Computing.) The completion of development is projected at one man-year of effort, primarily in generalization and in bringing the documentation to a level needed for maintenance.

Computer time used for development has cost about $7,000 based on LBL's recharge structure and operating efficiency. If an equivalent amount of time had to be purchased from an outside vendor, the cost would have been $14,000 or more.

During the first complete year of operations, the computer costs consumed operationally, by the three users combined, averaged around $400 per month. This cost includes computing (central processing and input/output), data storage, and interactive line connect time charges. It does not include any amortization of the terminals, which is small. In addition to the computer operating costs, the programmer expends approximately two man-days per month on organizing and submitting standard jobs. This effort is little affected by the addition of users, as shown when Math and Computing began using major parts of the system.

3.4. The Benefits of LBL-MIS

LBL-MIS has produced a number of changes: the Division Office has improved its capability to interact by increasing its information processing capacity; more accurate, timely, relevant information is being produced for use by a number of decision makers; and the LBL-MIS user has been able to expand the types of information he can provide. All three of these changes produce a single benefit: by providing the decentralized decision makers of LBL with better information[7] their decision-making behavior is enhanced. The Laboratory as a whole is better off for having decisions made more rapidly and based on more reliable information.

To make this point clearer, consider the following situation, which actually occurred. The fiscal year is half over and $17 million has been spent of the Laboratory's budgeted $32 million. The budget is cut to $30 million; layoffs must occur. But how many and where? If there are too many staffing cuts, the Laboratory loses a very valuable resource: trained, essential personnel. If the initial staff cut is not large enough to offset the projected budget overrun, additional personnel must be terminated. This second cut raises in the minds of the remaining staff the possibility of further cuts, with the ensuing consequence of debilitated morale. Additionally, if there are two cuts, the combined layoff is usually larger than if only one cut is made, the later date requiring termination of more persons to save the same dollars. Thus management needs to make the correct cut the first time. The more accurately management can forecast existing spending needs for the remainder of the year and estimate the total savings (salary plus fringe costs) of each termination, the less likely it is that either too few or too many employees will be terminated. Thus, better information produces better decisions and the Laboratory uses its scarce resources more wisely.

3.4.1. Benefits of increased information processing capacity. By automating much of the routine data retrieval, calculation, and report preparation functions, the management of the Division Office can spend more time on non-routine information requests and more time interacting with group leaders. This shift in the work load can be seen in an organization change that occurred in 1974, in which the Operations Engineer moved to a new assignment. Before LBL-MIS the LBL Operations Engineer and the Physics Division Business Manager could barely keep up with the data conversion process and were fortunate if detailed reassessments came out quarterly. With LBL-MIS, the Business Manager by himself handles two-thirds[8] of the conversion process and does a reassessment monthly. Without LBL-MIS, it would have been impossible for the Business Manager to assume all of these duties without added staff.

3.4.2. Benefits of more accurate, timely, and relevant information. Detailed assessments are now made monthly that before LBL-MIS were possible either irregularly or at best quarterly. Over- or under-spending is detected earlier and the research group and the Division are better able to plan research programs. In addition, Laboratory-wide support effort management is more easily accomplished through an historic comparison report, with actual use updated monthly and plan values revised periodically. Personnel management reports are available at need.

One very important benefit is that the individual research group leader in the Physics Division is now spending less time on routine calculations in the forecasting process. It also appears that more reliable information presented in a clear, concise format that details the underlying assumptions (overhead rate, payroll burden, etc.) increases the researcher's confidence in the information and his willingness to accept any conclusions based on the report. Thus, the researcher spends less time on the purely mechanical aspects of administration and can spend more time on research.

More accurate information regarding future spending reduces the uncertainty regarding the final budget overrun or underrun. For example, if a researcher has a budget of, say, \$100,000 for the year and there is some uncertainty regarding what the plans conceived in terms of effort and equipment will mean in terms of expenses, he will typically commit \$85,000 to be spent and will withhold the remaining \$15,000 as a contingency reserve. However, if the researcher has very good information, the contingency funds are usually reduced. In fact, since LBL-MIS has been in use, several groups have voluntarily reduced their budgets and funds have been shifted to other programs. Primarily this is because the probability of the research group exceeding its budget due to forecast errors has been reduced. Since the research group feels the estimated expenditures are more accurate, a smaller contingency fund is built into their forecasts. The groups can either expand their activities during the year or else allow their contingency funds to be used by other research groups.

3.4.3. Benefits of Expanded Types of Information

3.4.3.1. Project funding reports, which detail the amount of resources flowing into various projects, can now be prepared. A project may involve resources from a number of research groups, or one research group may have a number of projects. LBL-MIS has the capability of creating hypothetical entities defined as aggregations of the Accounting Department's account number structure. This is the facility used for reporting plans to the Budget Office by budget category.

3.4.3.2. Detailed impact studies can be routinely prepared. Since the accounting system has been parameterized into a computer system it is an easy task to prepare "what-if" reports. For example, what is the impact on the various groups in the Physics Division if the overhead rate fell 4%, average salaries rose 6%, and support burden rose 1%? Such evaluations can be easily done in a general fashion, but LBL-MIS allows doing so in detail, with potential group-specific reactions taken into account. (Such impact studies can be carried out without affecting the regular data bases.)

Thus, the major benefit derived from LBL-MIS is an improved decision making capability due to LBL-MIS's superior data handling and report preparation. Although the benefits have not been quantified, in the opinion of the management of the Physics Division Office, the combined benefits accruing from LBL-MIS have far exceeded the costs of LBL-MIS. In fact, the authors feel that the development costs have already been recovered.

4.0. TECHNICAL ASPECTS OF LBL-MIS

This section describes the technical aspects of LBL-MIS. The first part briefly outlines LBL's computing facility, which supports LBL-MIS, and the considerations underlying LBL-MIS due to the type of computing center LBL maintains. The remainder of the section outlines the purposes and techniques of the seven subsystems of LBL-MIS.

4.1. The Computing Environment at LBL

The Physics Division of LBL maintains a national computing center for the AEC consisting principally of three Control Data machines (6400, 6600, 7600) plus a large complex of peripheral equipment. These systems are interconnected and support the basic research needs of LBL. These machines were originally designed by CDC as large scale scientific batch processors. However, LBL has developed software and hardware that allows limited timeshare capabilities on the 6000 machines; and the Math and Computing Systems group is constantly upgrading the system in response to user's needs. This computing environment creates two primary considerations which had to be taken into account as LBL-MIS was being built.

A timeshare program occupies one of the 64 control points in the 6000 system and the system automatically rolls the user's entire field length in and out depending on the total demand for resources. Large timeshare codes cannot be run effectively during peak loads unless the timeshare user converts the code to an overlay structure in order to shorten the field length and thus minimize waiting time as the field length is moved in and out of memory. Thus, the programmer must manually handle overlays and keep the field length to at most 20K (octal) if response time is to be minimized.

Secondly, the system provides only minimal back-up procedures for data files. Thus, a major concern in LBL-MIS was the design of a back-up system to ensure the integrity of the data bases if the system crashed while the user had been updating files interactively.

The LBL computing system is tremendously powerful, but it is not designed primarily to support interactive computing. Thus, we had to develop many of the system techniques that are commonly found on timeshare systems. As much as a quarter of the effort expended in the development of the interactive programs could have been saved in such an environment. This in no way is meant as a criticism of the LBL computing center for whom we have the utmost respect. The computer center was designed primarily to serve the "number crunching" needs of scientists. Tradeoffs had to be weighed, and it was our considered decision to go with the efficiency and general sophistication of LBL's computer system, rather than use a commercial vendor.

4.2. The Computer Subsystems of LBL-MIS

The computer programs in themselves do not constitute LBL-MIS. As discussed earlier, the teamwork between management and programmers in the use of these programs fully constitute the functional system. This is especially true because the need, at least in management functions, for interactive exception processing. But the system as such is dynamic and difficult to describe. In this section we shall discuss the individual computer subsystems and their isolated use. Later we shall discuss the communication among these subsystems, whether mediated by the computer or by the users, to fill out what will here be somewhat artificial.

A few general comments are in order before describing the individual subsystems. We shall try to follow the same general organization in every case -- with systematic descriptions of the data involved, of the procedures available, and of the displays or reports generated by each of the subsystems. Also we shall follow a common pattern in the presentation of figures and exhibits.

For each of the subsystems we present a figure briefly outlining the execution of the subsystem. The various symbols used to indicate the storage or processing units are presented in Fig. 1. These figures are only in the vaguest sense flow charts and the symbols only represent general aspects of the subsystems. While more detailed representations are available elsewhere (see Appendix C), only a broad overview is offered here.

A brief description is presented with each figure, outlining the development and use of each subsystem. This includes the current users and the monthly computing costs. (The operational effort on the part of the programmer is not easily divisible, but also minimal.) The development effort depicted in the figures indicates past effort and projected effort to completion, the latter given in parentheses. The past effort does not add up to the total of about four man-years, which was mentioned in Section 3.3. The remainder of approximately 8.7 man-months is best accounted to the development of general techniques, such as a standard terminal interface, fail safe file maintenance, and so on.

There are in general two types of exhibits, recordings of interactive sessions and representative examples of regular reports. The reports were generated directly from active files. However, in some cases the identification was suppressed -- not so much to avoid embarrassment to the groups involved as to avoid distraction to the readers who might know the reference. We hope that the readers will concentrate their attention on the form of presentation. One general feature to note is the line of demarcation between the actual data, as received from Accounting, and the projected "data", as derived from the plan figures and anticipated patterns stored on the management files. This feature is also found in the major terminal displays. Exhibits 1, 2 and 5 were taken from actual on-line sessions, a continuous session for each. A non-standard interface module was used to dump all transactions to a card file -- the users' input flagged as bold face. Again, these card images were edited to remove recognizable identification.

The interactive protocols will be briefly discussed for each case. However, generally we might comment here on its telegraphic nature. The term "telegraphic" describes the brevity of commonly used referents ("O" in place of "overhead" and "S" in place of "specify", for example). While this is somewhat obscure during the learning phase, it is very important for the long term pattern of daily use (a well known psychological phenomenon exemplified, for example, by the use of acronyms). Some commands, however, require typing out a relatively lengthy phase, primarily those that directly alter the stored data (REPLACE BUDGET, REPLACE RECORD, etc.). This serves to prevent inadvertent alteration of the files due to mistyping.

4.2.1. Budget Management. By comparison with other figures, the Budgeting subsystem depicted in Fig. 2 seems relatively simple. Although this subsystem is by far the most detailed and sophisticated, the depiction in Fig. 2. is not in reality false. The budgeting subsystem has had the most development and is by far the most thoroughly integrated. Most of its facilities are directly accessible to management through the on-line terminal, with direct intervention of the programmer thus minimized. In this sense of its superficial aspect, it is the simplest and most readily used. The mark of highest development is to appear simple and natural.

There is a great variety of data carried on the Budget Management file; for indeed, except for detailed data from past years, all data are carried on one file. These data may be distinguished as general or specific, actual or anticipated, as follows.

- General Constants
  - Overhead, Payroll Burden, Average Raise
  - General Leave Patterns
  - Average Salaries by Payroll Group
- Data for Each Group Budgeted
  - Current Budget by Line Item
  - Projected Support Use (man-months) and Expected Rate
  - Projected Scientific Payroll (full-time equivalents)
  - Several Years' Total Expenses by Line Item
  - Monthly Expenses
    - Actual for Year-to-Date
    - Expected Irregularities
  - Monthly Effort
    - Actual for Year-to-Date
    - Expected Patterns
  - Comments (up to 50 characters per line item)

A technical note on the data storage: due to our packing procedures, all of the data for one group can be packed in only 15,000 bits. This allows ready storage in on-line storage devices. At present, in fact, each user is allowed two independent versions of the file, allowing maintenance of firmer and more tentative plans or, toward the end of a fiscal year, initial planning for the following year.

A wide variety of processes are available directly at the on-line terminal, as listed below. The batch processing in the budgeting subsystem serves primarily to funnel the accounting data into the management file or to generate detailed or summary reports for distribution. The procedures available interactively are distinguished primarily as yearly or monthly considerations. Such procedures are accessible in the two facilities of the program -- the Budgetor and the Monitor, respectively. External processing can be called in at all times, and jumping from one facility to the other is easily done.

General Interactive Processes

- Instigate Data Reduction or Report Generation
- Fetch and Replace Budgets
- Sum Budget Sets
- Control File Management
- Change General Constants

Processes Specific to the Budgetor

- Change Average Salaries (Scientific)
- Distribute Total Budget to Line Items by Historical Pattern
- Specify Plan as Expenses
- Specify Plan as Effort (Man-months for support, full-time equivalents for Scientific)
- Convert Effort to Expense and vice versa

Processes Specific to the Monitor

- Specify Plan as Yearly Total or as Average Monthly Expense for Remaining Months
- Enter Anticipated Irregularities in Monthly Expensing Patterns
- Enter Anticipated Patterns (general or in detail) of Effort Charging

As an important feature, in both saving effort and minimizing distraction, is that the program automatically applies any necessary effort-to-expense conversion and/or application of burden or overhead rates. And if any general constant is changed, all subsequent displays dependent on that constant are given with the new evaluation.

The examination of Exhibit 1 may clarify some of these points. In general terms, this terminal session involves shifting some funding away from scientific effort into support effort due to the receival of a major purchase. The yearly budget is fetched in Exhibit 1.A, and in Exhibit 1.B the effort in Mechanical Shops is increased. In Exhibit 1.C it seems reasonable to decrease the planned effort in one of the scientific payroll accounts. (The distinction of academic and non-academic periods is due to the important flux of faculty during the summer.) Note that the conversion of full-time equivalents to effort (by a standard leave factor) and to expense (with the addition of payroll burden) is automatic. In Exhibit 1.D, after jumping into the Monitor facility, the display shows actual data through April; the values in the multiple month columns are average values for ready comparison. The total planned expense, shown in Exhibit 1.D after the major purchase has been anticipated, reflects the alterations in expected support burden and overhead due to the change of the base.

The session depicted in Exhibit 2 was obtained after the end of the fiscal year and compares the actual values to the planned values. This exhibit primarily exemplifies another facility, available in both the Budgetor and the Monitor, namely the summing of a group of (presumably related) budgets. This is very handy just to get an overview. After revising some number of budgets for individual groups, the manager can sum all budgets in the division, for example, to see the overall effect. But also, since a sum of budgets can be treated internally to the program just as any separate budget, the manager can do quick, summary impact studies in complete analogy to more detailed impact studies.

Much of the 'output' from the Budgeting subsystem, therefore, comes directly to the manager at the on-line terminal. However, there is one report, organized by payroll account rather than budgeted group, that is generated during the course of data reduction. An example of this report is given in Exhibit 3. This report isolates the various leave charges (or burden charges, since they are covered by the payroll burden) and gives some percentages for comparisons. We draw the reader's attention to the line "Non-burden as a Percent of Total". This is the man-months to full-time equivalents pattern referred to above.

The other reports generated by the Budgeting subsystem are partly for historical record but primarily for distribution, either to the research groups themselves or to other relevant decision makers throughout the Laboratory. These reports include the following.

Detailed Reports of Yearly Budget Plans

Summary Reports of Yearly Budget Plans

Reports of Effort and Expense Plans by Budget Category

Projections of Expenses based on Year-to-Date Expenses and Historical Patterns

Expenses to Date as a Fraction Plan, Compared to Fractions in the Same Period in Previous Years

Distribution of Plans over Remainder of Year, Showing Expected Irregularities

The projections of expenses are somewhat useful early in the year; but as actually expected patterns become known and entered into the Management file, the Remainder Distributed Reports are much more meaningful. Such a report is exemplified in Exhibit 4, based on Expense Plans. The values up to the line of demarcation are actual expenses; the plan as well as irregularities in expensing are taken from the Management file. Similar reports are generated for scientific effort and for support rates and effort.

4.2.2. Personnel Management. The Personnel Management subsystem is not nearly as well integrated as the Budget Management subsystem, as can be seen in Fig. 3. There are primarily two interactive programs and one batch program. One of the interactive programs is entirely oriented to the individual employee, updating records and retrieving information on this basis. The other interactive program is oriented toward analysis on classes of employees; it presently acts on the more compact file derived from the payroll tape. The major batch program compares these two data bases. The payroll tape, received from Accounting at the beginning of each month, usually lags the personnel records; but this redundancy check has occasionally revealed errors in both data bases. This batch program also cleans up dead space created in the personnel records by certain types of corrections.

There are also a scattering of specialized report generating programs using both data bases. The projected development work includes building a general report generator out of these. We have not presented any examples of reports, both because of their currently ad hoc character and because of the sensitivity of the data. Future development also includes integrating the two interactive programs so that the analysis of classes of employees can be carried out on the more extensive personnel records.

Since these personnel data bases are kept in generally accessible on-line storage, all sensitive data items are maintained in the data bases in encrypted form. To gain access to the data through the interactive programs, the user must supply an access code. The program uses the code to decode some encrypted item, and allows access only if it finds a characteristic pattern in the result. The code is stored in the data base only in this functional form, the form which must be presented to the program is committed to memory by the few valid users. Of course any encoding of a finite data item can be broken; however we feel that, even after obtaining the encrypting algorithm, the cost of computing time to break any given code would be prohibitive.

The two data bases, the personnel records and the payroll file, contain essentially the same data items. However, the payroll data base contains only current values, whereas the personnel records contain not only the employee's history but also any anticipated changes as well. The latter are not entered into the employee's record, but are stored in a separate part of the file. At the beginning of any session the program checks if any of these changes are dated on or before the date of that session, allowing the user to transfer the data into the employee's record if it still applies. This facility is useful, for example, if an employee goes on leave with an expected return date. The expected return can be entered, so that a reminder is given by the system. The other use, for projecting scientific effort levels, is discussed in Section 4.3.

The data items carried in the personnel records include

Personal Data

- Name
- Employee Number
- Birthday and Start Day
- Minority and Sex Codes

Educational Data

- Degree and Year
- Major
- School

Job Data Sets (Updatable)

- Salary and Raises
- Payroll Account
- Job Classification
- Time Status

The updatable sets include date, values, and descriptive items. This is shown in Exhibit 5. The descriptive items are not stored directly in each employee's record but on separate lists. The employee's record points to the list item. This not only saves space but reduces the chance of differentiating specifications intended to be the same. (The user can also save typing by entering list numbers instead of the full expression.)

We will discuss only those processes, listed below, that are available in the interactive programs. The data reduction and report generating are presently done by the programmer.

Record Oriented Processes

- Creating New Records
- Fetching and Replacing Records
- Updating Records
- Anticipating Future Updates
- Displaying Entire Status (Current or as of some past date)
- Displaying Histories of Updatable Items
- Correcting Records

Class Analysis Processes

- Selecting a List of Employees
- Ordering the List

Stepping through the List
Totaling the List
Saving and Restoring Selection Criteria

The record-oriented processes are essentially data entry and information retrieval; it is unlikely that the information on file would change the user's mind about what to enter. The program does interact with the user, however, in regard to format errors and mistyping. Exhibit 5 gives an on-line session with this program. There are two examples of the updating process: after the user selects the card to be updated, the program prompts for individual items. One feature not shown is that, if the user leaves the salary unchanged and enters the salary in place of the raise (a raise larger than the old salary is noted), the program actually resets the salary and calculates the raise. Exhibit 5.A also shows a display of the salary history (a conversion from salary to wage rate can be noted).

The class analysis processes are for global information retrieval. This program has been used, however, for truly interactive information management in the case of allocating raises. The program was modified to allow changing an employee's raise while going through the list. The totaling process was made to specify the average raise for the list, expressed as a percent. This greatly facilitated adjusting raises on an individual basis while trying to meet the Laboratory policy governing the average raise for classes of employees. Note that the four simple processes: selecting, ordering, listing and totaling -- can all be done completely independently and spontaneously. This includes continuing through a list, starting at the same employee, after it has been re-ordered or even re-defined. The spontaneous, discretionary use of a small set of simple processes can be a powerful, flexible analysis tool.

The Personnel Management subsystem is not oriented toward generating reports for distribution. With all information accessible on the terminal (a CRT), there is no need for internal reports (and much less paper needs shredding in this system). Periodically a complete listing of the current status of all employees is generated to help minimize use of the terminal. Other reports have been generated when needed, the most frequent being the analysis of average salary by payroll account. These reports are written to tape and printed off-line.

4.2.3. Support Effort. The Operations Engineer (now Assistant to the Associate Director for the Engineering and Technical Services Division) is responsible for projections, review and management of the use of Support personnel by all research undertaken at LBL. The Support Effort Subsystem of LBL-MIS is used to facilitate this management responsibility. This subsystem consists primarily of an interactive program, for updating the plan figures, and a batch program, for monitoring actual use. This is shown in Fig. 4.

The data maintained in the on-line management file include several sets of historical data and several types of plans:

Historical Data

Total Effort Used, each of two previous fiscal years
Effort Used, year-to-date
Effort Used in Most Recent Month

Plan Figures

Most Recent Two Sets of Plan Figures, obtained from Program Managers and stored on Accounting's Effort Description Tape
Working Figures of the Operations Engineer, firmer and more tentative

A complete set of data is maintained for each of some 70 separate Laboratory programs in relation to each of 12 support departments.

In the Support Effort subsystem the processes in the main batch program and in the interactive program are equally important.

Processes in Interactive Planning

- Displaying Data Selectively
- Updating the Working Figures
- Estimating Vacation and Leave Values

Processes in Batch Monitoring

- Updating Historical Data
- Preparing Detailed Reports

In addition there are batch programs that pick up the plan figures from the Effort Descriptor tape and print summary reports. The two sets of reports are as follows.

Summary Reports

- Listings of Account Assignments to Programs
- Listing of Program Assignments to Summary Categories
- Listing of Data on File

Detailed Reports

- Distribution of Plan over Remainder of Year
- Usage as Percentage of Totals

The summary reports of data on the management file are given in two forms, one ordered primarily by data type to facilitate comparison among programs, the other ordered primarily by program to facilitate analysis of a given program's usage. An example of the latter is given in Exhibit 6, showing some of the summary categories. In these summary reports the usage of each support department is given in succeeding columns and summed in a total column, in order to gauge the overall stance of the program with regard to support use.

The detailed reports are also given in two orderings, the columnar structure reserved of course for the monthly values. One set is ordered primarily by support department, the other primarily by program. An example of the former type is given in Exhibit 7. Two separate analogies to reports in the Budgeting subsystem can be noted. Like the report in Exhibit 4, the line of demarcation separates actual from anticipate values. In this case the fluctuations in anticipated months are simply historically based leave patterns (note that Total Direct FTE, a summary category in Exhibit 7.B, has a flat distribution). This facilitates evaluating the significance of fluctuations in actual months. The second comparison is that, like the report in Exhibit 3, the usage is also reported as percentages of relevant totals. In the Support Department reports, these percentages are given only for the summary categories (Exhibit 7.B). These percentages are also given in the report ordered with one individual program per page.

All numerical values in these reports are normalized -- man-months per month or man-years per year.

4.2.4. Procurements. The Procurements subsystem, consisting of the batch program COSTAL2, was designed to merge the relevant data in the Purchasing and Accounting data bases. This is done so as to obtain management information on outstanding purchase order commitments. This subsystem, shown in Fig. 5, is used throughout the Laboratory. We should mention that the development effort does not include the original COSTAL (see Appendix A), and that the monthly costs do not include the development and maintenance of the source data bases. The Procurements subsystem is entirely dependent on the quality of the Purchasing and Accounting data bases, which has been excellent.

The data maintained on the commitments file include

General Identifiers

- Purchase Order Number
- Account Charged

Data from Purchasing

- Requisition Number
- Dates: Needed, Placed, Expected
- Amounts: Ordered, Received

Data from Accounting

- Lien Outstanding
- Amounts Paid (charged to account)

The data from Accounting takes precedence in management considerations, since it is taken directly from the expense processing stream. For purchase orders missing on PAR (i.e., the Purchase Analysis Report) the accounting date is picked up and carried for its indicative value.

The processes performed by COSTAL2 include

Data Processing

- Accumulating the Amounts Paid
- Updating All Other Data by Replacement
- Calculating the Outstanding Commitment

Report Generating

- Flagging where Receivals Exceed Payments
- Flagging Completions
- Distributing Commitments According to Expected Delivery Date
- Summing Over Purchase Orders for a Program
- Summing Over Related Programs

There are two procedures for calculating the outstanding commitment on a particular purchase order. Where ever a lien is available from the accounting data base, the commitment is

outstanding lien - current payments.

The outstanding lien is available only on the monthly accounting tape, so the commitments file is updated only when processing this tape. The payments and charges to accounts come out on weekly tapes (accumulated on the monthly tape); and between monthly update runs these constitute the current payments (i.e., payments since the lien was last recorded). When no lien is carried, the commitment for a given purchase order is

amount ordered - all known payments.

The amount received is basically for information only, although a separate column in the summary report lists the excess of receivals over payments as rather firmer commitments.

The reports generated by COSTAL2 are of two distinct forms, the detailed and the summary. The detailed reports are grouped by program, ordered by account and (within an account) by purchase order number. All dates and amounts are listed in this report, and special conditions are noted: completions in bold face, receivals in excess of payments by underlining. Exhibit 8.A is a page lifted out of such a detailed report (the program listed at the top of the page is not in its entirety). Note that any words listed in the commitments column are treated as zero in all sums.

The summary report, a page of which is shown in Exhibit 8.B, is ordered in columns according to the expected delivery date. Certain exceptional values are accumulated in special columns -- any order not on PAR may or may not be expensed within the current fiscal year. The same is true of orders falling in "PAST DUE", where the expected delivery date has passed: this could mean that the date is incorrect and has not been updated. The fiscal year columns "float" across the page as the end of the fiscal year approaches. Exhibit 8 is taken from the last week of a fiscal year, when the discretionary control of purchases is most critical for balancing fixed budgets.[9] The total fiscal year column is the sum of all preceding columns, which include the current payments. It represents a normally worst case value, directly additive to the prior month's year-to-date procurements expense.

4.2.5. Inventory. The Inventory subsystem of LBL-MIS is also in use by several divisions. It was developed to put the management of equipment under the individual most responsible for each particular piece of equipment. In 1970 the inventory clerks who spent full time surveying the equipment were eliminated and the responsibility to inventory all property (items costing over $300 or sensitive) was shifted to the research programs. The Operations Engineer initiated a program which placed each piece of equipment under the control and responsibility of the user of the equipment or the user's supervisor. Currently each of the approximately 10,000 equipment items is tagged with the name of one of the 60 equipment managers. Each equipment manager is selected based on his familiarity with the equipment and program management responsibility for specific equipment. Figure 6 summarizes this subsystem. The data carried for each piece of equipment include

Property Number
Descriptive Nomenclature
Accounts of Purchase and Use
Original Cost
Manufacturer and Serial Number
Codes for Sensitivity and Mobility
Present Location
Comments
Responsibility Center Number

The Physics Division Office maintains a list of all equipment belonging to the equipment managers who have elected to use the system on magnetic tape. This tape is periodically compared to the Master Property Tape of all equipment at LBL for any changes (additions, deletions, location changes). The Master Property Tape is produced by Property Accounting. In addition, the Inventory Tape is updated by punched cards from data received from either the equipment managers or from maintenance records. Each equipment manager is given a deck of prepunched computer cards, one card for each piece of equipment which he is responsible for and a listing of the equipment.

Whenever an item changes status, the equipment manager can use the equipment decks to maintain a convenient record of the change. All transactions are maintained by the Physics Division Office on an easily indexed microfiche for future reference.

The Inventory subsystem is a tool to implement the concept of equipment managers and to aid these individuals in the performance of their task.[10]

4.2.6. Affirmative Action. When the Data Processing department was unable to develop programs for Affirmative Action reports, the Physics Division developed the program MINSEX for this type of analysis. The program is also being used by the Affirmative Action department. The data used by MINSEX are

Payroll Account
Job Classification
Minority Code
Sex Code
Base Salary

Note that identification of individuals is not necessary in the analysis by MINSEX.

The processing flow in the Affirmative Action subsystem in indicated in Fig. 7. The Physics Division does its analysis from the Payroll File (see Fig. 3), while an alternate read module allows the Affirmative Action department to analyze its own Personnel tape. MINSEX reads input card decks for definitions of departments (groupings of payroll accounts) and classification groupings. Within these groupings, and in a comparative fashion, the program analyzes the distribution among the various minority and sex categories.

There are two types of reports generated by MINSEX. The classifications analysis lists for each job classification and grouping of classifications, the number and percentage of total in each minority/sex category. Reports are generated for each department and overall. This facilitates evaluating a given department's stance. The salary analysis reports the average salaries by minority/sex category for each job classification and for groupings of classifications. This report is not broken down by department (although limiting a report to dealing only with the restricted set of payroll accounts will obtain such information). A second salary analysis report calculates median salaries for the lower, middle, and upper thirds (by count of employees in each minority/sex category). This report is not broken down either by department or by classification; although such detailed information can again be obtained by restrictive passes over the data base.

4.2.7. Space. The Space utilization management subsystem of LBL-MIS was originally developed for use within the division. More recently it has been used by the Laboratory Space Committee. This subsystem is depicted in Fig. 8.

There are two distinct parts of the Space data base, one describing the locations and another describing occupants.

Data on Occupants

Name and Employee Number
Payroll Account
Location Occupied (Building/Room)
Type (Senior Staff, Professional, Technical, Clerical, and Visitor)

Data on Locations

Building/Room
Area (square feet)
Type of Use (office, lab, etc.)
Nominal Assignment to a Payroll Account
Comments

The card decks are maintained by hand. However, the occupant cards can be initialized from the personnel tape and then modified (for senior staff, or cases where a mail address is used for location, etc.).

The SPACE program does little actual analysis. Primarily it orders and groups the data in the most informative fashion. The program does give a summary of number of occupants and average space occupied for each of the five types of occupant and for each payroll account.

Two types of detailed listings are generated by SPACE. One is ordered by building and room, and grouped within a region. The occupants are listed in the same column as the payroll account assignment, and noted where not included in the "hosting group". The other type of listing is also ordered by building and room, but grouped by payroll account assignment. Again, employees from other payroll accounts are so noted.

4.3. Intra-System Transfers

All phases of management are essentially interrelated; budgeting decisions affect personnel decisions and vice versa, procurement commitments affect the usage of support effort, and so on. It is therefore necessary that the management information system reflect these interrelationships as closely as possible. LBL-MIS satisfies this need in various ways. There are a few direct data transfers from one computing subsystem's data base to another, and more such machine links are under development. For the most part, however, the users must carry out this transfer, aided as much as possible by the programs.

Let us disregard the cases where different subsystems read the same data bases, as can be noted in the figures. There is one machine link in regular use. After the Division Business Manager is satisfied with his budgets, the planned support effort can be transferred to the Support Effort management file. Another link involves the calculation of the average salaries by payroll account from the personnel records for entry into the budget management file. A facility yet to be developed involves the gleening of the anticipated changes (for example, the departure from and return of faculty members to the Laboratory payroll) from the personnel records; these would be distributed among budgeted groups according to typical recharge patterns, giving some detailed scientific effort patterns. The personnel data base could be used to furnish information on major vacation and other leave effects (sick leave is fairly statistical). None of this information binds the budget manager however, since he can modify it or convert it to expensing patterns if desirable.

Another clearly defined intra-system transfer is from procurements analysis to budget monitoring. The COSTAL2 commitments information cannot very reasonably be transferred directly to the budget management file by a programmed link. This is because the bulk of small purchases run through the system too quickly to be anticipated in advance. Major procurements tend to move more slowly, and the commitments reports point up such effects. These can be entered into the budget monitor as is shown in Exhibit 1.D. The plan is adjusted so that there are sufficient funds spread on top of the major fluctuations to cover small purchases. The algorithms for such a procedure are not sufficiently well defined to allow a program to do this. LBL-MIS depends on the budget manager to make this transfer.

Certainly information from the Affirmative Action subsystem affects decisions regarding personnel, and many other such information transfers can be imagined. It is important to recognize that most of these transfers must be mediated by the users -- who are the most capable, if not the fastest, elements of the system. Direct transfers mediated by programs are developed only as they can usefully reflect reality; implementation of such machine links out of a misguided desire for a comprehensive set of computing procedures can not only waste programmer's efforts and computing resources, but also distract the users from their own superior capabilities.

5.0. CONCLUSIONS AND RECOMMENDATIONS

The development of LBL-MIS is not yet complete, but it seems appropriate at this time to present our conclusions and make some recommendations to the management community -- both within and outside the Laboratory. Although LBL-MIS has been under development for somewhat over two years, it is still an experimental system in two senses. First, the development has been heuristic: the revision of programs in response to the feedback from the user was considered a viable, even important, option. Some work therefore remains in fully documenting the more or less stabilized system. Second, the system has been adjusted to the management style of only a few users; we intentionally avoided the development of a general system that was not particularly useful. Since all management within the Laboratory is based on a common accounting structure, and since most subsystems of LBL-MIS have been successfully used by other divisions, the system can further develop to accommodate general needs.

Still, on the basis of our experience we have been able to draw the following three general conclusions:

(1) Computer systems can be used very effectively in purely management functions. By this we do not refer to automatic data processing -- the aggregating and calculating procedures that are more properly accounting functions. Daily management usually deals too much with exceptions for automatic procedures to be applicable. However, LBL-MIS allows the manager to apply processes selectively to functional aggregates of data. Computer-aided exception processing is entirely appropriate with dynamic interactive programs, giving rise to interactive information management.

When a manager has sufficient flexibility in the use of a computer system, with all appropriate options not only discretionary but also spontaneously available, the computer system can very effectively and very efficiently augment his capabilities. This allows management to shift attention away from the basic tasks of bookkeeping and calculating so as to devote more attention to improving the communication of information and to enhancing the interaction among various parties both internal and external to the Division.

(2) The team approach to the development of computer oriented systems is very effective. By this we mean more than just bringing together a group of individuals of complementing expertise for the design and implementation of the system. Our experience suggests that having the team work in an integrated fashion on an essentially daily basis can greatly facilitate the development of an effective system.

(3) Finally, and perhaps most important in a research laboratory, supplying scientists with timely, accurate, and relevant information can lead to better research. Prior to LBL-MIS the group leaders of the Physics Division tended to react in a skeptical, at times negative manner to the reports manually prepared by the Physics Division Office. These manually prepared reports were not only untimely but many times relatively inaccurate. However, LBL-MIS has reversed the situation and research group leaders have reacted in a strong, positive manner when they are given accurate, reliable, easily used reports which clearly outline the underlying assumptions. These scientists are spending less time performing routine calculations, yet, we feel, are making better decisions. With a better source of information and with less time devoted to accounting, the individual researchers have been able not only to allocate their resources more effectively but also to devote more time to research.

Finally, we feel that it is appropriate to make the following three recommendations.

(1) We both recommend and are encouraged to find that other divisions within the Laboratory are now trying LBL-MIS in their management functions. We recommend this for the following reasons. First, the broad effectiveness of the system would certainly carry over to such similar management situations: other divisions could well share the benefits found within the Physics Division. Second, we would certainly like to see LBL-MIS continue to evolve in response to other management situations.

(2) We recommend that LBL-MIS be seriously regarded as a first step in the development of a Laboratory-wide management information system. Certainly the basic decisions of the Laboratory can be facilitated by improved information communication among the decentralized decision makers, and by the rapid aggregation of such information for the use of top management. We believe that the eventual system will allow all managers to interact on a regular basis with an integrated management file, the computer carrying out all organizing, retrieving and calculating for them. The management file would contain not only the relevant accounting data, but also firm plans and working figures. The firm plans could be available instantaneously to anyone with valid access, enhancing the flow of information. We by no means present LBL-MIS as a fait accompli, but it certainly represents a great deal of thought in this direction.

In particular, LBL-MIS starts with basic policy as given (e.g., the overhead rate and application, average raise by class of employee, etc.). The determination of such policy (that is, evaluating the best constants to use) is a cybernetic problem of a higher order, but this problem is undoubtedly capable of solution with techniques used in LBL-MIS. Since doing impact studies is severely limited when much manual effort is required, and since our experience within the Physics Division could undoubtedly be duplicated at the higher level, the adoption of interactive information management within the area of policy determination deserves serious consideration.

(3) To our broader audience we would certainly recommend for consideration not only our general conceptual approach to management information systems but also the team effort approach to the development of such systems. There may be some possibility that the computer programs, which are very modular, may be used with relatively minor modifications at other, similarly organized laboratories. However, it is certainly true that concepts are more easily transported than computer code. We hope that, at this conceptual level, our work will prove useful, not only to other research laboratories, but also to other Government agencies, on a broad spectrum of management problems.

APPENDIX A

HISTORICAL BACKGROUND: DEVELOPMENT OF DATA BASES AND REPORT STRUCTURES

The following historic background shows the development of Management Reports at Berkeley and outlines the evolution of the data base and report structures. This is the background against which LBL-MIS was developed.

The development of this interactive Management Information System is a logical outcome of the evolution of management reporting at Berkeley. It is a culmination of report design and development at LBL that started for R. L. Hinckley when he began working in E. O. Lawrence's Director's Office in 1957. At that time the only computer was the IBM 650, on which Bill McNaughton programmed the original Budget Run Program Schedule 92. There was tab equipment that was used for the General Ledger, Expense Statements and other basic accounting reports, but the majority of management reporting was typewritten summary or data plotted on graph paper.

In 1959 Hinckley worked with Ardith Kenney of Math and Computing in the Budget Office to expand the Schedule 92 program with which he was calculating Berkeley Budget Submission data.

Later in 1959 Hinckley was on active duty with the Air Force as a Personnel Officer. Having had experience on the Berkeley IBM 650 computer, he was involved in the conversion of all USAF Personnel records to an IBM 650 computer data system. There he obtained some outside experience in handling large complex data base problems requiring rapid access via key word inquiry. Later that year, back at Berkeley, he initiated and worked with Accounting to design Berkeley's first computer-produced Construction and Equipment Status Report (No. 517). In a parallel effort at Livermore, Bill Shanahan designed the Livermore Construction Status Report.

In 1961 Hinckley helped design the first computer-produced Man Months Effort Report (No. 410). The same year he worked with Warren Chupp in setting up a reporting system for the Major Bevatron Improvement Program that used the critical path and analysis system and a PERT cost type program PROLOG, described by Bill Bagot in UCRL-10491.

In 1962 Hinckley became Managing Engineer for the Physics Division and during the next 11 years developed management reports in order to carry out the fiscal management responsibility for over half of the dollars spent at Berkeley.

In 1963 he requested the establishment of a weekly effort report and worked with the Management Information Reports Committee in designing the first Weekly Effort Report (No. 412) and the original Job Order Cost Reports for which Tom Lewis has carried the major responsibility.

In 1964 Hinckley set the primary requirements for Berkeley's first computer produced Space report and worked with the Plant Engineering Department to design Span-I (first run Oct. 16, 1964). The same year he made requests to get major changes in the Berkeley inventory information system.

In 1965 he worked with the Budget Office and the Accounting Office to make a major change in the Expense Statement format so that 12 months cost would show on a single page for each account or subaccount. This current report was first printed in August of 1965. In November of the same year he was involved in the Administrative Data Processing Committee review of the total ADP status and requirements of the Berkeley Personnel Department. He co-authored a December 8, 1965 report to the Director's Office that had the primary purpose of "obtaining an Integrated Management Reporting System that would meet the requirements of Berkeley Program Management".

On February 11, 1966, Hinckley initiated and designed the 480 Monthly Effort Report which matched the Berkeley Operating Cost Statement reporting levels and added one month's data each month on a 12-month format. At the same time he designed the Weekly Effort Report that collected and printed 13 weeks' data with a sliding picture frame format and also requested reports on detail Effort by Payroll Account, Effort by Cost Account or subaccount, and hours charged by each individual. These reports were later the basic framework of the current E-500 series Effort Reports. On February 20, 1966, Hinckley initiated and helped design the first Weekly Cost Report (No. 352). The same year he chaired the Ad Hoc Committee on Printing and Photographic Equipment which reviewed the inventory report structure and initiated major changes in that data base and reporting process. In addition, he and Warren Chupp made numerous attempts to get the PAR purchase order status report modified to provide purchase order projection data. Later that year he worked with Marjorie Simmons of Math and Computing to design a Purchase Order Projection Report (COASTAL-I) that combined the Purchasing Department's PAR data and Accounting ledger data to project weekly best estimates of what and when each purchase order would cost against each account.

In 1967, working with D. L. Judd and R. L. Thornton, Hinckley initiated the formation of the Data Processing Planning Committee that was to review and set priorities on all administrative program and report development for Berkeley and Livermore.

In 1968 Hinckley worked with Marjorie Simmons to design the weekly Shop Priority Effort Projection Report (SHUFL), which was in use until 1971. The same year he designed the first Cumulative Operating Cost Report (F-393-1), which took the Berkeley operating cost data and put it into a 12-month format to compare costs at the summary level with the 480 Effort Report Summary. In concept, this was an identifiable forerunner of LBL-MIS. In the Data Processing Planning Committee he initiated the appointment and was a member of an Effort Report Subcommittee which expanded the 480 monthly and weekly cumulative reports into LBL's current E-500 series integrated effort report. He was also on the subcommittee which reviewed the Laboratory's procurement information system including Berkeley's LAPSE and PAR and Livermore's PIC system.

In 1969 Hinckley was appointed Operations Engineer for LBL reporting to the Director with specific responsibility for "improving the system of reports and other information required for better scientific program management and support scheduling at the Berkeley site". During that year he initiated weekly Stores Issues reporting to program and project managers. He also suggested PROLOG be rewritten in COBOL language for the CDC-6600 computer in view of the HILAC major improvement program.

In 1970 he requested and helped design the Berkeley Monthly Blanket Order Summary Report. In July of that year J. Zimmerman and Hinckley began development of the Physics Division Equipment Management System, the preliminary working version of one of the LBL-MIS Management Systems.

In 1971 Hinckley initiated modification of the Berkeley Operating Cost Statement to provide a more uniform format between that monthly dollar summary report and the summary level of the E-560-1 Effort Report. He also began working with Bob Harvey and Fran Permar of Math and Computing to develop weekly and monthly computer usage reports.

APPENDIX B
THE TEAM MEMBERS

In 1972 under the general direction of R. L. Hinckley, then Operations Engineer for the Lawrence Berkeley Laboratory, a staff team was brought together and agreed to jointly undertake the development of an interactive Management Information System to be executed on-line to a CDC-6600 computer. The members of this team project were each selected to complement one another in the systems development. Selection was based on their experience, knowledge, interest in management theory and practice, and/or interest in the cognitive processes involved in man-machine interactions and on their potential ability to selectively share in the joint efforts in a complementary manner.

There were five primary team members. Bob Hinckley, a Management Engineer, was to provide the basic management structure, having initiated and designed many of the Berkeley Laboratory ADP reports. Dan Kane, a Math Programmer who had used interactive computing techniques while completing his Ph.D. in high energy physics, was to provide programming design and implementation. Julia Kearney Wright, having the background in maintaining personnel records, would supervise the development of the personnel system. Wes Weber, the Physics Division Business Manager, with a previous scientific background including man-machine interaction in data acquisition, would supervise the major financial management system as well as the space management system. Jerry Zimmerman, a Ph.D. candidate at the University of California Graduate School of Business, would provide the latest applicable knowledge on business theory and practice and on related management systems.

The management members of the team all had previous experience with automatic data processing systems. Much of Hinckley's involvement is described in Appendix A. Julie Kearney Wright had prior experience with several of the report generating programs there described. Weber was familiar with interactive systems from his years of working with the Powell-Birge research group. In 1966 he had initiated as well as co-designed the COBWEB system.[11] This system combined data collection, equipment control, information feedback, and time-sharing capacity in putting multiple scan tables and Frankenstein Measuring Projectors on-line to an IBM 7044.

The other members of the team also brought a range of experience to the effort. Jerry Zimmerman had prior experience in the development of computer systems, especially in the area of accounting systems and inventory control. That Dan Kane had obtained his doctorate[12] within the Physics Division provided him a direct appreciation for the intended use of LBL-MIS, the management of basic science. Dr. Kane also had a long standing interest in and broad knowledge of cognitive psychology, which proved very valuable for the development of computer systems responsive to the user's thought patterns. Dr. Zimmerman has completed his thesis, based in part on this work,[13] and may now seek to apply his management theories to other types of management structures.

In addition to the five primary members of the team, many others have played significant roles. Mary Holloway, the Physics Division Office secretary, has provided constant and most helpful support, including some running of both batch and interactive programs. Ev Magnuson, of the Math and Computing group, has been using the financial management and procurements subsystems. Jane Kennedy, who recently joined the Division Office, took over the use of the personnel management subsystem. Both of these individuals helped establish the ease of use of the interactive programs, but also made valuable suggestions. Howard L. Smith, of the Technical Information Department, was an initial user of the inventory subsystem and provided valuable direction and support in the debugging

and implementation process. Miriam Machlis, of the Affirmative Action Department, provided the initial guidance for the affirmative action subsystem. Eddie Reed provided programming support to both the financial management and the affirmative action subsystems.

Finally, although they did not participate in the development, the successive Associate Directors of the Physics Division, Dr. William A. Wenzel and Dr. Robert W. Birge, provided invaluable guidance and encouragement.

APPENDIX C

BRIEF DESCRIPTION OF AVAILABLE MANUALS

A variety of manuals listed below, are available covering different aspects of LBL-MIS. These manuals are revised as the system changes; the latest versions are available from the Physics Division Office. Other manuals may be developed as broader use warrants.

An Overview of the Management Information System - UCID-3673.

Orientation - User
Coverage - General
Remarks - This manual gives an overall introduction to the system, describes the data flows, and explains the batched reports.

The Budget Management Facility - UCID-3670.

Orientation - User
Coverage - The Budget Management Subsystem
Remarks - This is the user's manual for the interactive budgeting/monitoring program. It also refers to the data reduction and report generation batch processors which are called in by interactive commands.

The Personnel Management Facility - UCID-3669.

Orientation - User
Coverage - The Personnel Management Subsystem
Remarks - This is the user's manual for the interactive personnel program.

COSTAL2 - UCID-3672.

Orientation - User
Coverage - The Procurements Subsystem
Remarks - This manual describes in detail the relationships among the data in the determination of purchase order commitments. It also describes the reports generated by COSTAL2.

MINSEX - UCID-3671.

Orientation - User
Coverage - The Affirmative Action Subsystem
Remarks - This manual describes the input formats to the program MINSEX, as well as the reports generated.

The Batch Programs in the Management Information System - UCID-3674.

Orientation - Programmer
Coverage - General
Remarks - This manual describes the batch programs for data reduction, report generation, and interfile transfers. It also describes file structures and the data access modules.

The Interactive Programs in the Management Information System - UCID-3675.

Orientation - Programmer

Coverage - Primarily the Budget and Personnel Management Subsystems

Remarks - This manual describes the structure and processes of the interactive programs: the overlay structures, the subprograms and common blocks, and the call and return sequences.

Subsets on the PSS Library NTR-ACT - UCID-3668.

Orientation - Programmer

Coverage - General

Remarks - This manual discusses the basic modules of the system. These modules are primarily oriented to the interactive programs but are used by the batch processors as well. These modules are intended to be used as "black boxes" so they are discussed in terms of common block transfers and call sequences.

REFERENCES AND FOOTNOTES

1. In 1974 the Physics Division Office general fiscal management responsibilities became the sole responsibility of the Division Business Manager, when the Physics Division Business Managing Engineer/LBL Operations Engineer assumed new responsibilities in the Engineering and Technical Services Division.

2. Marschak and Radner, The Economic Theory of Teams discusses the tradeoffs between centralized vs. decentralized organizations. Also, Mason Haire, Modern Organization Theory discusses the importance of communication in maintaining the viability of organizations.

3. The Laboratory does not receive a single budget allocation from the AEC but rather, the activities of LBL are funded from a number of AEC programs (e.g., High Energy Physics, Low Energy Physics, Math and Computing Research, etc.) as well as a number of non-AEC grants (e.g., NASA, Energy and Environment, etc.).

4. G. Feltham, Information Evaluation, American Accounting Association, Sarasota, Florida (1972), Chapter 2.

5. Our cumulative experience has led to the conclusion that accurate forecasts of spending are required and that accurate forecasts can only be generated by forecasting each line item in the budget. We call this process micro planning, in contrast to a macro approach, which takes total dollars spent to date and adjusts this figure by the number of months remaining in the fiscal year. This procedure is less complicated and cheaper to perform, but it suffers from one major drawback, it assumes the remainder of the fiscal year will be similar to the first part of the fiscal year. For some research groups that do not have large summer research programs and maintain a constant research program over time, macro planning is adequate. But for those research groups where these two conditions do not hold, macro planning results in inaccurate, distorted forecasts.

6. G. Sorter, "Events Theory", Accounting Review (January 1969).

7. By "better information" we mean timelier or more accurate information. The literature suggests that one information system is better than another if the decision from the first produces a higher payoff than the second. See McGuire and Radner, Decisions and Organizations, North Holland Publishing (1972).

8. After the Physics Division was reorganized into the Physics Division and the Accelerator Division, the responsibilities of the new Physics Division (with two thirds of the groups and three fourths of the staff) were assumed by the Business Manager and the Personnel Administrator. The position of Managing Engineer was vacated.

9. As a passing note, although the Federal budget system prohibits agencies from carrying over unspent allocations from one fiscal year to the next, devices such as the above accomplish the same thing; but instead of the agency holding a liquid asset (cash), they hold durable goods.

10. For further information on INVENTORY the reader may consult J. Zimmerman and R. L. Hinckley, "LBL Physics Division Equipment Management System", (September 1971).

11. H. C. Albrecht, E. P. Binnall, R. W. Birge, M. H. Myers, and P. W. Weber, The COBWEB Data Reduction System, Lawrence Berkeley Laboratory Report UCRL-18528, Rev. (October 1968).

12. D. F. Kane, Jr., A Study of the Reactions $K^{-}p \rightarrow \Sigma^{\pm}\pi^{\pm}(\pi^{\circ})$ Between 1.1 and 1.7 GeV/c, (Ph.D. Thesis), Lawrence Berkeley Laboratory Report UCRL-20682 (April 1971).

13. J. L. Zimmerman, Individual Financial Decision Making in Basic Science: A Normative and Descriptive Study, (Ph.D. Thesis), Lawrence Berkeley Laboratory Report LBL-3025 (May 1974). This gives a theoretical treatment of the relationships between uncertainty and spending.

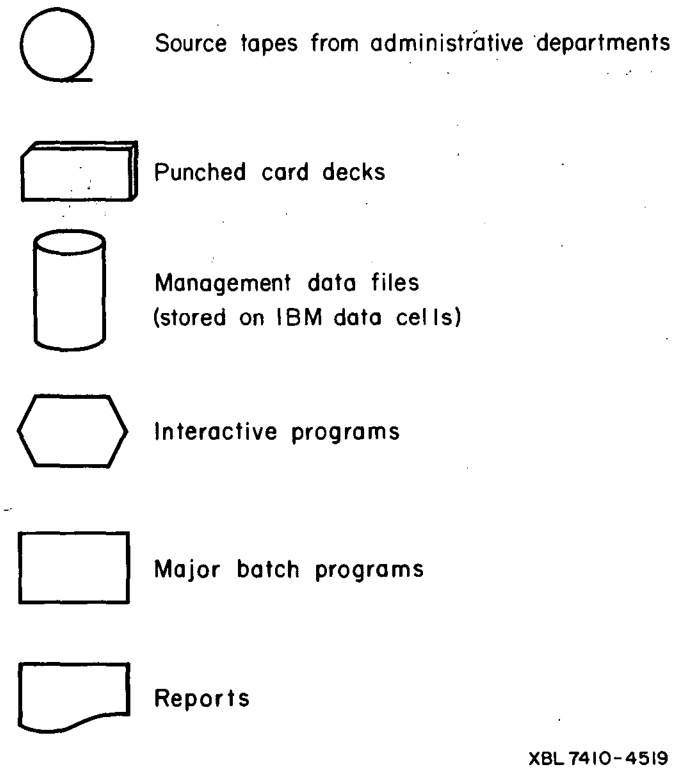

Fig. 1. Symbols for system components.

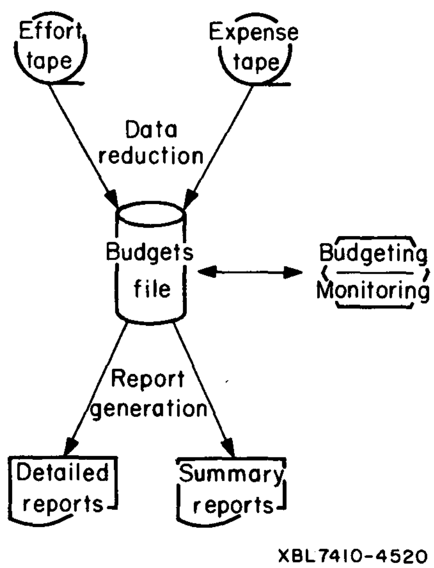

Fig. 2. Budgeting sub-system.

Users:	Physics Division Chemistry Division Math and Computing
Development effort:	17.7 man months
Monthly computing cost:	$200 per user

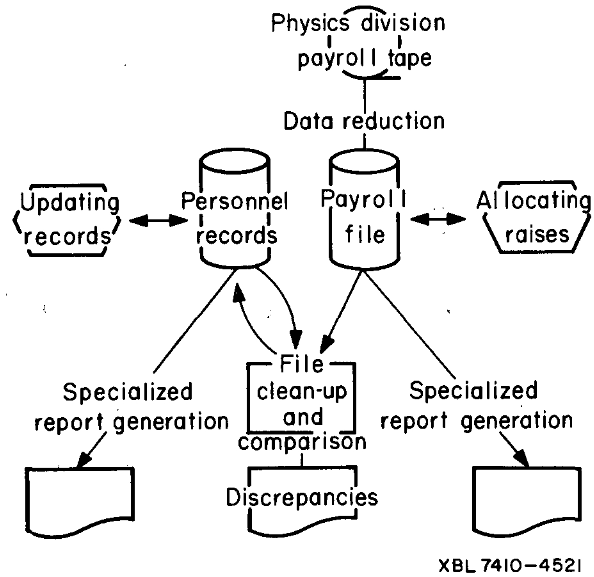

Fig. 3. Personnel sub-system.

User:	Physics Division
Development effort:	6.0 man months
Monthly computing cost:	$150

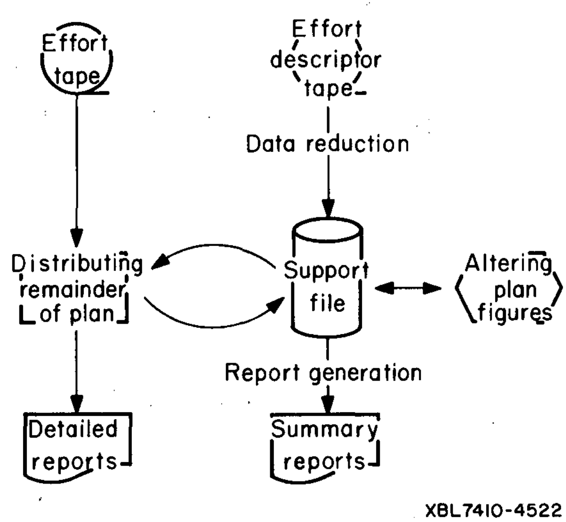

Fig. 4. Support sub-system.

User:	Engineering and Technical Services Division
Development effort:	4.4 man months
Monthly computing cost:	$20

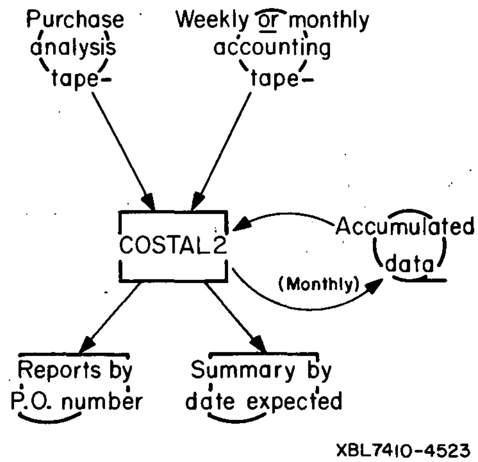

Fig. 5. Procurements sub-system.

Users:	Physics Division Math and Computing Other Divisions
Development effort:	2.1 man months
Monthly computing cost:	$20

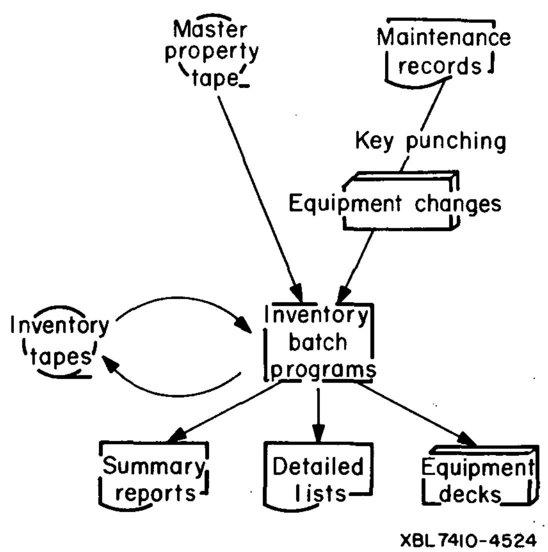

Fig. 6. Inventory sub-system.

Users:	Physics Division Technical Information Department
Development effort:	6.7 man months
Monthly computing cost:	Periodic

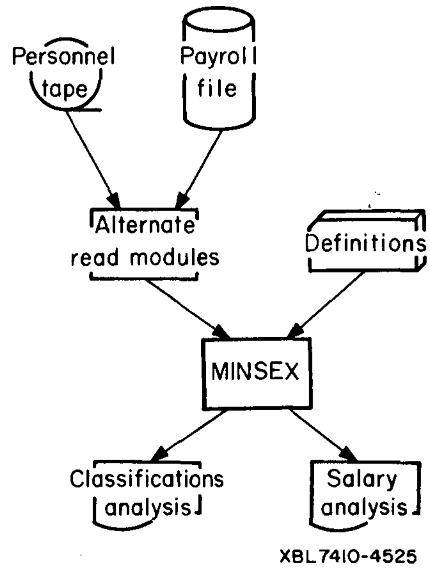

Fig. 7. Affirmative Action sub-system.

Users:	Physics Division Affirmative Action Department
Development effort:	0.7 man months
Monthly computing cost:	$10

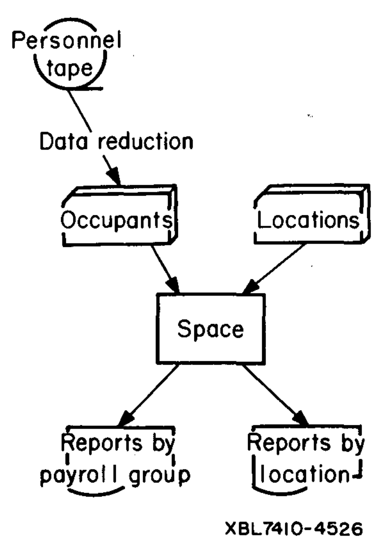

Fig. 8. Space Allocation sub-system.

User:	Laboratory Space Committee
Development effort:	1.7 man months
Monthly computing cost:	Periodic

ENTERING THE BUDGETOR

```
FY74,FILE 1 WAS LAST UPDATED    05/23/74. 12.50.19.
IS THIS THE MOST RECENT FILE?
Y
   YEARLY DATA LAST UPDATED -- 09/09/73.
  EXPENSE DATA LAST UPDATED -- 05/16/74.
   EFFORT DATA LAST UPDATED -- 05/11/74.
SUPPLY WRITE ACCESS CODE
XXXXXXXXXXXXXXXXXXXX
BUDGETOR      OR      MONITOR
BUDGETOR
AT YOUR COMMAND.
USE=3
USING  3 HIST. YEARS
AT YOUR COMMAND.
```

FETCHING A GROUP'S BUDGET

```
BUDGET=GROUP ID
4XXX GROUP IDENTIFIER
                4XXX.DATA ON FILE
   ITEM     )...FY71..)...FY72..)...FY73..)...FY74..
STORES      )$   12.7K)$    8.0K)$   15.8K)$    8.1K$
PURCHASES  )    20.7 )      9.1 )    36.0 )      5.3 $
OTH EXPN   ).....0.3.)....10.0.).....9.3.)....15.0.$
TRAVEL     )    11.6 )     11.1 )     5.8 )      7.0 $
CONSULTANT)           )          )     0.1 )      1.7 $
ACCL RECHR)..........)..........)..........)..........$
COMP RECHR)   140.0 )    136.2 )    44.4 )     28.2 $
SCIENTIFIC)   259.6 )    272.0 )   269.6 )    237.5 $
ADMIN      )..........)..........)..........)..........$
TECH SRVCS)      0.3 )           )     0.2 )           $
CNST/MAINT)      0.4 )      0.2 )     0.2 )      0.5 $
MECH SHOPS)....12.3.).....4.7.)....20.2.)....14.9.$ 50IN MAGNET DEVELUP
ELEC ENG   )      2.9 )      9.0 )    15.1 )      0.4 $
ELEC SHOPS)      7.0 )      5.1 )    13.7 )      5.4 $
MECH ENG   ).....5.6.).....0.4.)....15.2.)....10.5.$ 50IN MAGNET DESIGN
MECH TECH )      6.6 )      2.0 )     2.9 )      3.5 $
SUPP BURDN)      5.9 )      4.6 )    15.7 )      9.1 0
OVERHEAD   )...131.6.)...111.7.)...141.3.)...121.9.
  TOTAL     )$  618.0K)$  584.1K)$  605.5K)$  469.0K
BUDGETED   )           )          )   577.0 )   469.0
```

REVISING SUPPORT EFFORT

```
LI=MS
MECH SHOPS)$    12.8K)$     4.7K)$    20.2K)$    14.9K$ 50IN MAGNET DEVELOP
MECH SHOPS)      2.1%)      0.8%)      3.3%)      3.2%$
GIVE $ FIXED AMT?
N
D(ISPLAY),P(ROJECT),OR C(ALCULATE)
D
        (    1.82 MM IN OCT-APR 74    $ 1624/MM
PRIOR USE<   2.34 MM IN HALF1 FY74    $ 1659/MM
        (   12.84 MM IN TOTAL FY73    $ 1570/MM
SPECIFY DD FOR DIVISION AVERAGE.
C
                   MECH SHOPS            CURRENTLY BUDGETED $   14.9 K
PROJECTING   8.88 MAN MO.S EFFORT AT $ 1678/MM GIVES TOTAL $   14.9 K
USE TOTAL (IN BUDGET) OR N
N
D(ISPLAY),P(ROJECT),OR C(ALCULATE)
10MM
  10.00 MM
C
                   MECH SHOPS            CURRENTLY BUDGETED $   14.9 K
PROJECTING  10.00 MAN MO.S EFFORT AT $ 1678/MM GIVES TOTAL $   16.8 K
USE TOTAL (IN BUDGET) OR N
USE TOTAL
SPECIFY LI=LINE ITEM
```

CHECKING PARAMETERS

```
WHAT ARE B,O
OVERHEAD= 44.7%
SUPPORT BURDEN=25.9 PERCENT,    BASED ON LAST 0 YRS
SPECIFY LI=LINE ITEM
```

Exhibit 1.

(A) Interactive session with the budgeting/monitoring sub-system (continued through Exhibit 1(D)).

(B) Interactive session with the budgeting/monitoring sub-system (continued).

REVISING SCIENTIFIC EFFORT

```
LI=SCI
SCIENTIFIC)$  259.6K)$  272.0K)$  269.6K)$  237.5K$
SCIENTIFIC)    42.0%)     46.6%)     44.5%)     50.3%$
GIVE $ FIXED AMT?
N
D(ISPLAY),P(ROJECT),OR C(ALCULATE)
D
USE SPECS (9XXX)(,)(HIST N,HIST A,PROJ N,PROJ A,OR AV.SAL)
9903
9903     15.0 FTE  39.15 MM   NON-ACAD.  9903 RESEARCH 3
9903     13.0 FTE 101.79 MM   ACADEMIC.  9903 RESEARCH 3
9903     15.2 FTE  26.42 MM  JUL-AUG 73  9903 RESEARCH 3
9903     11.4 FTE  79.20 MM  SEP-APR 74  9903 RESEARCH 3
WHAT IS R
RATIO MM/FTE=0.870
P
USE 9XXX=FTES (MAY APPEND N OR A)
9903=12A
    NON-ACAD.          ACADEMIC            PAYROLL GROUP
9903 $1205             $1212               9903 RESEARCH 3
9903     15.0 FTE  39.15 MM   NON-ACAD.       9903  $  60668
9903     12.0 FTE  93.96 MM   ACADEMIC.       9903  $ 146449
C
    NON-ACAD.          ACADEMIC            PAYROLL GROUP
9903 $1205             $1212               9903 RESEARCH 3
9907 $1825              SAME               9907 RESEARCH 7
9918 $ 706              SAME               9918 TECHNICAL 8
   PROJECTED USE OF PERSONNEL              EXPENSE (INC.PAY BURDEN
9903     15.0 FTE  39.15 MM   NON-ACAD.       9903  $  60668
9903     12.0 FTE  93.96 MM   ACADEMIC.       9903  $ 146449
9907      0.1 FTE   1.04 MM   FULL YEAR       9907  $   2441
9918      2.8 FTE  21.00 MM   FULL YEAR       9918  $  15716
         12.9 MY =155.15 MM                  TOTAL  $ 225.3 K
                                  CURRENTLY BUDGETED $ 237.5 K
USE TOTAL (IN BUDGET) OR N
WHAT IS P
PAYROLL BURDEN=28.6%
USE TOTAL (IN BUDGET) OR N
USE TOTAL
SPECIFY LI=LINE ITEM
```

JUMPING TO MONITOR THE SAME BUDGET

```
RETAIN JUMP
4XXX GROUP IDENTIFIER
                          4XXX DATA ON FILE
          )JUL-OCT)NOV-FEB)  MAR  )  APR  )  MAY  )  JUN  )  PLAN
STORES    )    534.    440.    754.    667)  1390.   1390)    8100
PURCHASES )    224.    297.    619.   1994)   301.    301)    5300
OTH EXPN  )...1183...-1047....6948....1948)...2779....2779)....15000
TRAVEL    )    570.       .    -44.   1075)  1845.   1845)    7000
CONSULTANT)    412.       .       .       )    25.     25)    1700
ACCL RECHR)...............................)...............).........
COMP RECHR)   1845.   1190.   1816.   2563)  5840.   5840)   28200
SCIENTIFIC)  23673.  16937.  18099.  19687) 12537.  12537)  225300
ADMIN     )...............................)...............).........
TECH SRVCS)       .       .       .       )      .       )
CNST/MAINT)     54.      7.     77.     16)    82.     82)     500
MECH SHOPS)....855.....344.....596.....196)...3206....8006)....16800
ELEC ENG  )     14.       .       .       )   171.    171)     400
ELEC SHOPS)    392.     72.     14.     87)  1720.   1720)    5400
MECH ENG  )....128......35....1342....1430)...5937....1137)....10500
MECH TECH )    469.     72.    270.    141)   463.    463)    3500
SUPP BURDN)    494.    133.    590.    439)  3031.   3031)    9600
OVERHEAD  )..10848....7818....9546...10089)..11286...11712)...117300
  TOTAL   )  41697.  26299.  40627.  40332)  50615.  51041)  454600
                                      BUDGETED               469000
```

ANTICIPATING A LARGE PURCHASE

```
LI=2
          )JUL-OCT)NOV-FEB)  MAR  )  APR  )  MAY  )  JUN  )  PLAN
PURCHASES )    224.    297.    619.   1994)   301.    301)    5300
PLAN
15300
PURCHASES )    224.    297.    619.   1994)  5301.   5301)   15300
AVG.REM.
N
JUNE
10300
PURCHASES )    224.    297.    619.   1994)   302.  10300)   15300
MAY
LI=TOT
          )JUL-OCT)NOV-FEB)  MAR  )  APR  )  MAY  )  JUN  )  PLAN
  TOTAL   )  41697.  26299.  40627.  40332)  50616.  61040)  464600
                                      BUDGETED               469000
REPLACE BUDGET
AT YOUR COMMAND.
```

Exhibit 1.

(C) Interactive session with the budgeting/monitoring sub-system (continued).

(D) Interactive session with the budgeting/monitoring sub-system (concluded).

ENTERING THE MONITOR

```
FY74,FILE 1 WAS LAST UPDATED   07/12/74. 21.46.06.
IS THIS THE MOST RECENT FILE?
Y
   YEARLY DATA LAST UPDATED -- 09/09/73.
  EXPENSE DATA LAST UPDATED -- 07/12/74.
   EFFORT DATA LAST UPDATED -- 07/08/74.
SUPPLY WRITE ACCESS CODE
XXXXXXXXXXXXXXXXXXXX
BUDGETOR     OR     MONITOR
MONITOR
SPECIFY BUDGET=4NNN
```

AGGREGATING RELATED BUDGETS

```
SUM BUDGET SET=SET ID
4AAA IDENTIFIER FOR FIRST
  I    LIST OF THE
  V  GROUPS IN THE SET
4ZZZ IDENTIFIER FOR LAST
                         SUMMED FROM FILE
          )JUL-OCT)NOV-FEB)MAR-APR)  MAY  )  JUN  )  YTD   ) PLAN
STORES    )    683.    895.   1615.   1969.   3849)  15363)   12500
PURCHASES )    212.    510.   3006.   1201.   1267)  11369)   12700
OTH EXPN  )..15519...13749...20663...19842...21310)..199551)..202900
TRAVEL    )    224.    521.    952.   2075.   1130)   8091)    7300
CONSULTANT)      .      40.      .    1200.       )   1362)    1400
ACCL RECHR)..-2101...-3839...-7745...-4185...-7864)..-51300)..-48500
COMP RECHR)   3088.   1274.    798.    535.    662)  20241)   20700
SCIENTIFIC)  27468.  23468.  28772.  24915.  22674) 308881)  314500
ADMIN     )..................................15)......15)........
TECH SRVCS)     47.     15.    141.    107.     27)    665)     800
CNST/MAINT)   2017.   1682.   2064.   1151.   1418)  21495)   21800
MECH SHOPS)....514.....284....1099.....323.....187)....5902)....6300
ELEC ENG  )   1888.   2086.   1498.    781.    607)  20282)   20100
ELEC SHOPS)   4777.   5069.   5809.   4775.   5136)  60913)   61500
MECH ENG  )....538.....946....1079.....553.....172)....8817)....8900
MECH TECH )   1448.   1695.   2525.   1846.   2933)  22402)   21500
SUPP BURDN)   2428.   2549.   2753.   1609.   1864)  28889)   28800
OVERHEAD  )..16408...15809...20119...16123...18673)..203903)..206600
  TOTAL   )  75160.  66754.  85151.  74820.  74060) 886841)  899800
                                       BUDGETED           894000
WHAT ARE O,B
      JUL  AUG  SEP  OCT  NOV  DEC  JAN  FEB  MAR  APR  MAY  JUN  PLAN
OVERHEAD
     42.4 ---> ---> ---> ---> ---> 46.8 ---> ---> ---> --->       45.4%
SUPP BURDN
     21.5 22.2 21.6 21.2 21.7 21.8 21.6 21.5 22.1 16.0 16.9 17.8 20.6%
```

Exhibit 2. Interactive session with the budget monitor.

9205 COMP. OPS. CLERICAL						SCIENTIFIC EFFORT							07/08/74.
	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	TOT
MAN-MONTHS													
1232 HOLIDAYS	.39		.33		.77	1.36	.41	.53	.51	.09	.49		4.88
1815 VACATION	.71	.47	-.11	.06	.35	.93	.23	.07	.40	.21	.41	.20	3.93
3560 SICK LEAVE	.18	.34	.21	.34	.64	.59	.13	.56	.24	.31	.33	.83	4.70
0 NON-BURDEN	6.75	6.14	6.10	8.44	6.02	6.64	8.33	10.37	10.27	11.35	11.12	10.53	102.06
0 OTHER	3.68	2.35	2.12	2.78	2.09	1.91	2.32	3.31	3.50	3.85	3.50	4.07	36.48
4370 GROUP R/CROWE	.02							.03	-.02	.02			.05
4380 GROUP R/VPM	.05												.05
4100 GROUP A					.46	.91	1.53	1.61	.79	.63	.85	.74	7.52
4130 KENNEY-HELMHOLZ				.10	.05		.02						.17
4150 ELY				.01									.01
4160 SEGRE-CHAMBERLAIN	.01		.04	.08	.01	.01		.01	.04	.01	.01	.01	.23
4180 TRILLING-GOLDHABER												.01	.01
4220 PHYSICS DIV. OFFICE	.01	.02		.03	.03	.06	.03	.03	.02		.02	.04	.29
4271 NUCLEAR INSTRUMENTS	.02	.02	.01	.08	.01				.04	.01			.19
4290 MATH/COMPUTER RSRCH	.06		.01		.01	.03	.04		.01	.01	.01	.01	.19
4240 MATH/COMPUTING SRV	2.51	3.70	3.87	4.36	3.36	3.70	4.76	5.38	5.87	6.82	6.72	5.60	56.65
4960 COMPUTER OPERATIONS	.37						-.37						0.
4170 PEP						.01							.01
4300 ERA STUDY	.02	.05	.03						.02				.12
4900 BEVATRON OPERATIONS			.02			.01					.01	.05	.09
-0 TOTAL	8.03	6.95	6.53	8.84	7.78	9.52	9.10	11.53	11.42	11.96	12.35	11.56	115.57
PERCENT OF TOTAL													
1232 HOLIDAYS	4.9		5.1		9.9	14.3	4.5	4.6	4.5	.8	4.0		4.2
1815 VACATION	8.8	6.8	-1.7	.7	4.5	9.8	2.5	.6	3.5	1.8	3.3	1.7	3.4
3560 SICK LEAVE	2.2	4.9	3.2	3.8	8.2	5.2	1.4	4.9	2.1	2.6	2.7	7.2	4.1
0 NON-BURDEN	84.1	88.3	93.4	95.5	77.4	69.7	91.5	89.9	89.9	94.9	90.0	91.1	88.3
PERCENT OF NON-BURDEN													
0 OTHER	54.5	38.3	34.8	44.8	34.7	28.8	27.9	31.9	34.1	33.9	31.5	38.7	35.7
4370 GROUP R/CROWE	.3							.3	-.2	.2			.0
4380 GROUP R/VPM	.7												.0
4100 GROUP A					7.6	13.7	18.4	15.5	7.7	5.6	7.6	7.0	7.4
4130 KENNEY-HELMHOLZ				1.2	.8		.2						.2
4150 ELY				.1									.0
4160 SEGRE-CHAMBERLAIN	.1		.7	.9	.2	.2		.1	.4	.1	.1	.1	.2
4180 TRILLING-GOLDHABER												.1	.0
4220 PHYSICS DIV. OFFICE	.1	.3		.4	.5	.9	.4	.3	.2		.2	.4	.3
4271 NUCLEAR INSTRUMENTS	.3	.3	.2	.9	.2				.4	.1			.2
4290 MATH/COMPUTER RSRCH	.9		.2		.2	.5	.5		.1	.1	.1	.1	.2
4240 MATH/COMPUTING SRV	37.2	60.3	63.4	51.7	55.8	55.7	57.1	51.9	57.2	60.1	60.4	53.2	55.5
4960 COMPUTER OPERATIONS	5.5						-4.4						0.
4170 PEP						.2							.0
4300 ERA STUDY	.3	.8	.5						.2				.1
4900 BEVATRON OPERATIONS			.3			.2					.1	.5	.1

Exhibit 3. Sample page from Scientific Effort Report.

GROUP IDENTIFIER LISTED HERE — REMAINDER OF PLAN DISTRIBUTED (DOLLARS) — 05/23/74.

LINE ITEM	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	PLAN
STORES	304	161	139	164	118	247	113	144	98	93	1534	184	3300
PURCHASES	25	341	44	295	500	4	916	456	589	503	513	8313	12500
OTH EXPN	435	1079	987	1095	1250	470	643	435	469	777	1080	1080	9800
TRAVEL	1052		228		400	450	535	92		578	847	847	5000
CONSULTANT													
ACCL RECHR													
COMP RECHR	28	4	4	146	165	39	91	43	118	129	166	166	1100
	======	======	======	======	======	======	======	======	======	======	======	======	======
SUPPLY/EXP	1844	1585	1402	1700	2433	1210	2268	1170	1273	2080	4142	10592	31700
SCIENTIFIC	16211	22778	15888	12960	10705	11511	9910	11834	11180	11043	11091	13091	158200
ADMIN													
TECH SRVCS					15				15	15	27	27	100
CNST/MAINT											100	100	200
MECH SHOPS	159	307	217	615	133	96	18	240	81	115	10	10	2000
ELEC ENG		19			134				38		154	154	500
ELEC SHOPS	56	82	138	46	118				100	87	186	186	1000
MECH ENG	20						20				30	30	100
MECH TECH					241	206	448	489	79	31	53	53	1600
	======	======	======	======	======	======	======	======	======	======	======	======	======
SUPPORT	235	408	355	661	641	302	486	729	313	248	561	561	5500
SUPP BURDN	63	111	91	168	148	79	128	191	69	31	160	160	1400
	======	======	======	======	======	======	======	======	======	======	======	======	======
TOTAL WAGE	16446	23186	16243	13621	11344	11813	10396	12563	11493	11291	11652	13652	163700
OVERHEAD	6973	9831	6887	5775	4810	5009	4865	5879	5379	5284	5453	7054	73200
	======	======	======	======	======	======	======	======	======	======	======	======	======
TOTAL	25326	34713	24623	21264	18735	18111	17657	19803	18214	18686	21408	31459	270000
											ACTUAL BUDGET IS		270000

PERCENT	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	PLAN
SUPP BURDN	26.8	27.2	25.6	25.4	23.1	26.2	26.3	26.2	22.0	12.5	28.6	28.6	25.5
OVERHEAD	42.4	42.4	42.4	42.4	42.4	42.4	46.8	46.8	46.8	46.8	46.8	51.7	44.7

(OVERHEAD RATES THRU MAY ARE AS COLLECTED. ADJUSTMENT TO YEARLY RATE IS MADE IN JUNE.)

Exhibit 4. Sample page from Expense Report showing remainder of plan distributed (accounting data up to the line of demarcation).

GAINING ACCESS TO FILE

```
THIS FILE WAS LAST UPDATED     08/05/74. 17.51.20.
IS THIS THE MOST RECENT FILE?
Y
SUPPLY SALARY ACCESS CODE.
XXXXXXXXXXXXXXXXXXXX
       NO ANTICIPATED CHANGES DATED BEFORE TODAY.
SPECIFY N=LAST NAME
```

FETCHING THE EMPLOYEE S RECORD

```
N=LAST NAME
↑LAST NAME      ↑OTHER NAME      ↑NUMBER
1 07/07/40  ↑08/15/67  ↑TM   ↑
2 BS    67  ↑GEOLOGY          ↑UNIV OF CALIF
3 03/01/74  $   4.14   $  0.00   $  0.00
4 07/01/74  ↑9911-01          ↑TECHNICAL 1
5 07/01/72  ↑759.4            ↑COMP TECH SR
6 03/03/74  ↑LBL        ↑H040      ↑E000
SPECIFY S=CARD #
```

UPDATING THE SALARY

```
S=3
SAL DATE
7/1/74
3 07/01/74  $    4.14   $  0.00   $  0.00
SALARY
4.55
3 07/01/74  $    4.55   $  0.00   $  0.00
GEN INC
N
MERIT INC
0.41
3 07/01/74  $    4.55   $  0.00   $  0.41
IS THIS OK TO STORE?
YES
DISPLAY DATA?
```

AND DISPLAYING SALARY HISTORY

```
D=3
  HOW MANY
4
3 07/01/74  $    4.55   $  0.00   $  0.41
3 03/01/74  $    4.14   $  0.00   $  0.00
3 07/01/73  $ 720.00    $  0.00   $ 50.00
3 07/01/72  $ 670.00    $  0.00   $ 41.00
  HOW MANY MORE
```

UPDATING JOB CLASSIFICATION

```
S=5
JOB DATE
7174
5 07/01/74  ↑759.4           ↑COMP TECH SR
JOB CODE
782.2
5 07/01/74  ↑782.2           ↑COMP TECH SR
JOB TITLE
SCI ANALYST SR
THATS NOT ON THE    JOB TITLES LIST.
TRY AGAIN,OR TYPE N TO ADD IT.
17
5 07/01/74  ↑782.2           ↑SCI DATA ANAL SR
IS THIS OK TO STORE?
Y
DISPLAY DATA?
```

DISPLAYING UPDATED RECORD

```
Y
↑LAST NAME      ↑OTHER NAME      ↑NUMBER
1 07/07/40  ↑08/15/67  ↑TM    ↑
2 BS    67  ↑GEOLOGY          ↑UNIV OF CALIF
3 07/01/74  $   4.55   $  0.00   $  0.41
4 07/01/74  ↑9911-01          ↑TECHNICAL 1
5 07/01/74  ↑782.2            ↑SCI DATA ANAL SR
6 03/03/74  ↑LBL        ↑H040      ↑E000
AT YOUR COMMAND.
REPLACE RECORD
SPECIFY N=LAST NAME
```

Exhibit 5.

(A) Interactive session with the personnel management sub-system (continued on Exhibit 5(B)).

(B) Interactive session with the personnel management sub-system (concluded).

TOTAL BIO-MED

BIOMT	CON	MNT	ME	MT	MS	EE	ES	PE	CUS	MD	HP	SS	TOT		
PFY	0.4	0.8	1.0	3.4	4.9	5.2	8.3	0.1				2.3	26.4	FPRIOR FY	11/01/72.
LFY		1.1	1.1	1.6	4.0	4.7	5.8	0.1			0.1	2.4	20.9	LAST FY	73/07/07.
YTD		0.9	0.8	0.9	3.7	3.9	6.0	0.1			0.1	1.5	17.9	YR TO DATE	74/06/07.
LMO		1.2	1.0	1.2	2.7	4.1	5.8	0.2				1.4	17.6	LAST MONTH	74/06/07.
OPL		0.9	0.8	1.5	4.0	5.3	7.2					2.1	21.8	OLD PLAN	73/08/22.
CPL		0.9	0.8	1.5	4.0	5.3	7.2					2.1	21.8	CURR PLAN	73/10/18.
PRJ		0.9	0.8	1.5	4.0	5.3	7.2					2.1	21.8	PROJ FIGS	10/18/73.
WF		0.9	0.6	0.9	3.9	4.2	6.2					2.1	18.8	WORK FIGS	05/16/74.

TOTAL ENERGY

ENERT	CON	MNT	ME	MT	MS	EE	ES	PE	CUS	MD	HP	SS	TOT	
PFY	0.1		1.6	2.6	5.2	1.7	8.4	0.1			1.1	0.1	20.9	FPRIOR FY
LFY		0.2	1.3	3.2	7.2	2.6	8.9						23.4	LAST FY
YTD		0.7	3.7	5.6	8.1	2.8	15.3	0.5			0.3		37.0	YR TO DATE
LMO		1.5	10.3	6.9	16.2	6.8	22.6	2.3			0.7	0.3	67.6	LAST MONTH
OPL		0.2	0.5	3.7	1.2	3.8	9.6						19.0	OLD PLAN
CPL		0.2	0.5	3.7	1.2	3.8	9.6						19.0	CURR PLAN
PRJ		0.2	0.5	3.7	1.2	3.8	9.6						19.0	PROJ FIGS
WF		0.2	3.2	5.8	4.9	5.8	11.1	0.5			0.7		32.2	WORK FIGS

TOTAL RESEARCH

TOTLR	CON	MNT	ME	MT	MS	EE	ES	PE	CUS	MD	HP	SS	TOT	
PFY	19.5	21.9	50.3	54.8	58.9	74.1	140.7	2.2			1.1	14.2	437.7	FPRIOR FY
LFY	1.4	38.8	42.0	49.9	49.2	71.0	136.6	1.6			0.1	8.2	398.8	LAST FY
YTD	1.3	32.5	35.3	42.3	39.9	60.9	123.5	1.8			0.4	5.4	345.3	YR TO DATE
LMO	2.6	32.7	41.5	44.4	50.6	64.0	129.0	4.2			0.7	8.2	377.9	LAST MONTH
OPL	0.9	35.2	36.2	42.8	36.0	64.8	125.7	1.5				7.4	350.5	OLD PLAN
CPL	0.9	35.2	36.2	42.8	36.0	64.8	125.7	1.5				7.4	350.5	CURR PLAN
PRJ	0.9	35.4	33.8	42.0	34.5	64.1	128.1	2.8				7.4	348.9	PROJ FIGS
WF	0.6	34.6	34.9	45.0	34.9	66.7	124.2	2.1			0.7	7.4	351.1	WORK FIGS

TOTAL DEPARTMENTS

TDEPT	CON	MNT	ME	MT	MS	EE	ES	PE	CUS	MD	HP	SS	TOT	
PFY	12.8	15.4	0.7	1.1	2.4	1.8	4.6	2.0	32.0			0.6	73.4	FPRIOR FY
LFY	0.8	35.7	2.4	1.5	3.1	2.6	5.4	2.3	30.3			0.2	84.3	LAST FY
YTD	0.5	36.4	3.9	3.3	1.8	3.2	5.0	2.5	30.4		0.3		87.3	YR TO DATE
LMO	0.6	42.7	3.2	1.6	1.6	2.3	3.2	4.7	31.8				91.7	LAST MONTH
OPL	1.0	36.0	3.6	1.8	3.1	2.4	4.9	2.1	31.0			1.8	87.7	OLD PLAN
CPL	1.0	36.0	3.6	1.8	3.1	2.4	4.9	2.1	31.0			1.8	87.7	CURR PLAN
PRJ	1.0	36.0	3.6	1.8	3.1	2.4	4.9	2.1	31.0			1.8	87.7	PROJ FIGS
WF	0.6	35.6	1.9	2.3	1.7	2.9	5.6	2.0	31.0		0.4	1.8	85.8	WORK FIGS

TOTAL WFO

TWFO	CON	MNT	ME	MT	MS	EE	ES	PE	CUS	MD	HP	SS	TOT	
PFY	0.1	1.6	4.7	4.1	2.2	4.2	3.6	0.6	0.1		0.9	0.2	22.3	FPRIOR FY
LFY		0.7	6.8	6.2	5.7	5.7	7.1				0.4	0.2	32.8	LAST FY
YTD		0.6	6.8	6.0	4.9	8.5	7.1				0.3	0.2	34.4	YR TO DATE
LMO		0.5	5.1	7.7	8.7	9.7	10.9				0.3	0.1	42.0	LAST MONTH
OPL		1.3	12.0	9.4	7.0	18.2	14.1	0.2			0.4	0.2	62.8	OLD PLAN
CPL		1.3	12.0	9.4	7.0	18.2	14.1	0.2			0.4	0.2	62.8	CURR PLAN
PRJ		1.3	12.0	9.4	7.0	18.2	14.1	0.2			0.4	0.2	62.8	PROJ FIGS
WF		0.4	8.3	7.8	4.9	9.8	9.0	0.1			0.2	0.2	40.7	WORK FIGS

Exhibit 6. Sample page from Support Effort Summary.

MECH ENGINEERING — EFFORT IN MAN MONTHS — 02/07/74.

	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	YTD	PLAN
GROUP A	.14				.05	.20	.59	.28	.28	.29	.28	.28	.14	.20
NUCLEAR EMULSION	.07	.01	.01	.06			.01	-.03	-.03	-.03	-.03	-.03	.02	
LOFGREN		.01	.11	.13				.90	.90	.94	.90	.91	.04	.40
KENNEY-HELMHOLZ	.01	.03			.02	.01		.22	.22	.23	.22	.23	.01	.10
BIRGE	.01					.07		-.02	-.02	-.02	-.02	-.02	.01	
SEGRE-CHAMBERLAIN	.12	.41	.22	.53	.51	.33	.50	.19	.19	.20	.19	.20	.37	.30
GROUP B/CROWE	.14	.15	.06	.03	.32	.02	.09	.31	.32	.33	.31	.32	.12	.20
GROUP P/VPM				.01				-.00	-.00	-.00	-.00	-.00	.00	
TRILLING-GOLDHABER		.01						.24	.24	.25	.24	.24	.00	.10
ATOMIC BEAMS GROUP	.01						.01	-.00	-.00	-.00	-.00	-.00	.00	
PEP	.92	1.75	1.26	1.34	1.22	.93	1.90	1.24	1.24	1.29	1.24	1.25	1.33	1.30
PHYSICS DIVISION OF								.48	.48	.50	.48	.48		.20
SPEC PROJ DEVELOPMT		.04						-.01	-.01	-.01	-.01	-.01	.01	
MATH/COMPUTING SRV	.42	.04	.56	.16			.15	.21	.21	.22	.21	.21	.19	.20
NUCLEAR INSTRUMENT		.01				.01		-.00	-.00	-.00	-.00	-.00	.00	
BEVATRON OPERATIONS	14.29	15.87	13.30	14.88	12.24	11.31	18.81	13.40	13.44	13.97	13.40	13.49	14.67	14.20
184 INCH CYCLOTRON	.05	.04	.29	.28	.28	.34	.16	-.05	-.05	-.05	-.05	-.05	.21	.10
SUPERCONDUCTING	1.16	.98	1.62	1.83	1.78	1.48	2.16	3.52	3.53	3.67	3.52	3.54	1.57	2.40
ERA STUDY	1.71	1.04	1.65	1.85	1.72	1.72	1.74	1.54	1.54	1.60	1.54	1.55	1.63	1.60
NUCLEAR CHEM RSRCH	2.85	2.80	2.93	4.20	3.51	2.84	3.46	5.03	5.04	5.24	5.03	5.06	3.23	4.00
HILAC OPERATIONS	1.49	2.01	2.68	2.38	2.13	1.70	4.09	5.05	5.07	5.27	5.05	5.08	2.35	3.50
88 INCH CYCLOTRON	3.97	2.62	2.85	3.09	2.14	1.54	2.30	1.09	1.09	1.13	1.09	1.09	2.64	2.00
INORGANIC CHEMISTRY	.02	.02		.02	.06	.05	.06	.19	.19	.20	.19	.19	.03	.10
METALLURGY	.03		.12	.12	.05		.03	.41	.41	.42	.41	.41	.05	.20
BIO-MED RESEARCH	.91	.43	.16	.12	.28	.43	.68	.12	.12	.12	.12	.12	.43	.30
CHEM BIODYNAMICS	.23	.29	.24	.22	.27	.18	.32	.37	.37	.38	.37	.37	.25	.30
CTR BERKELEY	.43	.33	.30	1.44	.83	.69	.77	-.47	-.47	-.49	-.47	-.48	.68	.20
OTHER CTR					.08	.04	.04	1.87	1.87	1.95	1.87	1.88	.02	.80
LIVERMORE PROGRAMS	.34	.05	.10	.07			.07	.35	.35	.37	.35	.35	.09	.20
GEOTHERMAL							3.71	4.02	4.03	4.19	4.02	4.04	.53	2.00
TECH SERV SUPPORT	.01	.11	.10	.06	.06	.02	.07	-.09	-.09	-.09	-.09	-.09	.06	
ADMIN SUPPORT	.09	.41		.03	.01	.01		.13	.13	.13	.13	.13	.08	.10
STORES FABS/MISC SU	3.41	2.73	2.47	4.17	5.40	5.08	2.22	-4.33	-4.34	-4.52	-4.33	-4.36	3.64	.30
EE/MECH TECH/DEVEL	.61	.91	1.22	1.11	.71	.34	1.19	2.36	2.36	2.46	2.36	2.37	.87	1.50
MAINTENANCE	.02	.02	.02	.02	.07	.01	.09	-.05	-.05	-.05	-.05	-.05	.04	
NON-CAPITAL ALTER.					.02	.01		-.01	-.01	-.01	-.01	-.01	.00	
NASA BIO-MED BIO-SA						.20		-.04	-.04	-.04	-.04	-.04	.03	
ALL OTHER REIMBURS	2.63	2.74	1.82	2.41	2.64	1.71	2.02	4.68	4.69	4.88	4.68	4.71	2.28	3.30
HAPPE/HEAD	.82	.26	.64	1.09	1.06	.88	.95	.77	.77	.80	.77	.78	.81	.80
WORK FOR OTHERS	3.65	3.61	5.89	4.12	4.32	3.05	3.73	3.97	3.98	4.13	3.96	3.99	4.34	4.20
BEVATRON ACCEL IMPR	1.10	.35	.23	.25	.13	.08	.02	.76	.76	.79	.76	.76	.31	.50
184 IN CYC ACC IMPR	1.09	.41	1.25	.92	.41	.22	.18	.30	.30	.31	.30	.30	.64	.50
HILAC ACCEL IMPROV						.05		1.18	1.18	1.23	1.18	1.19	.01	.50
88 IN CYC ACC IMPR					.40	.63	.79	.35	.35	.37	.35	.35	.26	.30
OTHER CONSTRUCTION	.26	.14	.01	.06	.03		.01	.14	.14	.14	.14	.14	.07	.10
BEVALAC	10.20	12.59	14.67	14.01	14.52	10.02	5.07	6.04	6.06	6.30	6.04	6.08	11.58	9.30
PHYS. EQUIP FABS.	3.21	1.23	.24	.04	.01	.05	.06	2.61	2.61	2.72	2.60	2.62	.69	1.50
CHEM. EQUIP FABS.	1.49	1.30	1.06	1.53	1.43	.88	1.63	-.66	-.66	-.69	-.66	-.66	1.33	.50
BIO-MED EQUIP FABS.	.53	.60	1.23	1.77	.76	.39	.38	1.49	1.50	1.56	1.49	1.50	.81	1.10
CHEM-BIO EQUIP.FABS	.01	.03					.01	-.01	-.01	-.01	-.01	-.01	.01	
DEPT ADMINISTRATION	11.34	10.33	8.81	11.44	11.25	7.17	10.49	14.01	14.05	14.61	14.01	14.10	10.12	11.80
DIRECT VACATION	8.01	13.79	8.25	3.43	1.92	13.14	2.23	.55	1.05	.80	.95	4.67	7.25	4.90
DIRECT SICK LEAVE	2.84	3.00	2.31	3.87	3.06	2.99	2.59	4.56	3.50	4.66	3.92	3.50	2.95	3.40
DIRECT HOLIDAYS	3.99		4.24		7.61	11.98	2.36	3.77	3.62		3.24		4.48	3.50
DIRECT OTHER LEAVE	.77	.02	.05	.11	.39	.38	.04		.53	.26	.79	.26	.25	.30

Exhibit 7. (A) Sample page from Detailed Support Effort Report, showing remainder of plan distributed (accounting data up to line of demarcation).

MECH ENGINEERING — EFFORT IN MAN MONTHS — 02/07/74.

	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	YTD	PLAN
PHYSICS W/O BEVATRON	4.76	4.52	5.78	6.22	5.91	5.11	7.31	9.03	9.05	9.41	9.02	9.08	5.66	7.10
BEVATRON	14.29	15.87	15.30	14.88	12.24	11.31	18.81	13.40	13.44	13.97	13.40	13.49	14.67	14.20
TOTAL PHYSICS	19.05	20.39	21.08	21.10	18.15	16.42	26.12	22.43	22.49	23.38	22.42	22.57	20.33	21.30
CHEMISTRY W/O HILAC	6.82	5.42	5.78	7.29	5.65	4.38	5.76	6.12	6.13	6.38	6.12	6.16	5.87	6.00
HILAC	1.49	2.01	2.68	2.38	2.13	1.70	4.09	5.05	5.07	5.27	5.05	5.08	2.35	3.50
TOTAL CHEMISTRY	8.31	7.43	8.46	9.67	7.78	6.08	9.85	11.17	11.20	11.65	11.17	11.24	8.23	9.50
TOTAL IMRD	.05	.02	.12	.14	.11	.05	.09	.60	.60	.62	.60	.60	.08	.30
TOTAL BIO-MED	1.14	.72	.40	.34	.55	.61	1.00	.48	.48	.50	.48	.49	.68	.60
TOTAL CTR,LIV	.77	.38	.40	1.51	.91	.73	4.59	5.76	5.78	6.01	5.76	5.80	1.33	3.20
TOTAL DEPARTMENTS	4.14	4.18	3.81	5.39	6.27	5.47	3.57	-1.99	-1.99	-2.07	-1.99	-2.00	4.69	1.90
TOTAL WFO	7.10	6.61	8.35	7.62	8.02	5.84	8.70	9.38	9.40	9.78	9.37	9.43	7.46	8.30
BEVATRON IMPROVMENT	1.10	.35	.23	.25	.13	.08	.02	.76	.76	.79	.76	.76	.31	.50
OTH ACCL IMPROVMENT	1.09	.41	1.25	.92	.81	.90	.97	1.82	1.84	1.91	1.83	1.84	.91	1.30
BEVALAC	10.20	12.59	14.67	14.01	14.52	10.02	5.07	6.04	6.06	6.30	6.04	6.08	11.58	9.30
OTHER CONSTRUCTION	.26	.14	.01	.06	.03		.01	.14	.14	.14	.14	.14	.07	.10
PHYS. EQUIP FABS	3.21	1.23	.24	.04	.01	.05	.06	2.61	2.61	2.72	2.60	2.62	.69	1.50
OTHER EQUIP FABS	2.03	1.93	2.29	3.30	2.19	1.27	2.02	.83	.83	.86	.83	.83	2.15	1.60
TOTAL DIR EFFORT	58.45	56.38	61.31	64.35	59.48	47.52	62.07	60.04	60.19	62.59	60.02	60.40	58.51	59.40
DEPT.ADMINISTRATION	11.34	10.33	8.81	11.44	11.25	7.17	10.49	14.01	14.05	14.61	14.01	14.10	10.12	11.80
TOTAL NON-BURDEN	69.79	66.71	70.12	75.79	70.73	54.69	72.56	74.05	74.24	77.20	74.03	74.50	68.63	71.20
TOTAL BURDEN	15.61	16.81	14.85	7.41	12.98	28.49	8.42	8.88	8.69	5.73	8.90	8.43	14.94	12.10
TOTAL DIR. FTE	85.40	83.52	84.97	83.20	83.71	83.18	80.98	82.93	82.93	82.93	82.93	82.93	83.57	83.30

PERCENT OF TOTAL DIRECT EFFORT

	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	YTD	PLAN
PHYSICS W/O BEVATRON	8.1	8.0	9.4	9.7	9.9	10.8	11.8	15.0	15.0	15.0	15.0	15.0	9.7	12.0
BEVATRON	24.4	28.1	25.0	23.1	20.6	23.8	30.3	22.3	22.3	22.3	22.3	22.3	25.1	23.9
TOTAL PHYSICS	32.6	36.2	34.4	32.8	30.5	34.6	42.1	37.4	37.4	37.4	37.4	37.4	34.7	35.9
CHEMISTRY W/O HILAC	11.7	9.6	9.4	11.3	9.5	9.2	9.3	10.2	10.2	10.2	10.2	10.2	10.0	10.1
HILAC	2.5	3.6	4.4	3.7	3.6	3.6	6.6	8.4	8.4	8.4	8.4	8.4	4.0	5.9
TOTAL CHEMISTRY	14.2	13.2	13.8	15.0	13.1	12.8	15.9	18.6	18.6	18.6	18.6	18.6	14.1	16.0
TOTAL IMRD	.1	.0	.2	.2	.2	.1	.1	1.0	1.0	1.0	1.0	1.0	.1	.5
TOTAL BIO-MED	2.0	1.3	.7	.5	.9	1.3	1.6	.8	.8	.8	.8	.8	1.2	1.0
TOTAL CTR.LIV	1.3	.7	.7	2.3	1.5	1.5	7.4	9.6	9.6	9.5	9.6	9.6	2.3	5.4
TOTAL DEPARTMENTS	7.1	7.4	6.2	8.4	10.5	11.5	5.8	-3.3	-3.3	-3.3	-3.3	-3.3	8.0	3.2
TOTAL WFO	12.1	11.7	13.6	11.8	13.5	12.3	14.0	15.6	15.6	15.6	15.6	15.6	12.8	14.0
BEVATRON IMPROVMENT	1.9	.6	.4	.4	.2	.2	.0	1.3	1.3	1.3	1.3	1.3	.5	.8
OTH ACCL IMPROVMENT	1.9	.7	2.0	1.4	1.4	1.9	1.6	3.1	3.1	3.1	3.1	3.1	1.6	2.2
BEVALAC	17.5	22.3	23.9	21.8	24.4	21.1	8.2	10.1	10.1	10.1	10.1	10.1	19.8	15.7
OTHER CONSTRUCTION	.4	.2	.0	.1	.1		.0	.2	.2	.2	.2	.2	.1	.2
PHYS. EQUIP FABS	5.5	2.2	.4	.1	.0	.1	.1	4.3	4.3	4.3	4.3	4.3	1.2	2.5
OTHER EQUIP FABS	3.5	3.4	3.7	5.1	3.7	2.7	3.3	1.4	1.4	1.4	1.4	1.4	3.7	2.7

PERCENT OF TOTAL NON-BURDEN

	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	YTD	PLAN
TOTAL DIR EFFORT	83.8	84.5	87.4	84.9	84.1	86.9	85.5	81.1	81.1	81.1	81.1	81.1	85.3	83.4
DEPT.ADMINISTRATION	16.2	15.5	12.6	15.1	15.9	13.1	14.5	18.9	18.9	18.9	18.9	18.9	14.7	16.6

PERCENT OF TOTAL DIRECT FTE

	JUL	AUG	SEP	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	YTD	PLAN
TOTAL NON-BURDEN	81.7	79.9	82.5	91.1	84.5	65.7	89.6	89.3	89.5	93.1	89.3	89.8	82.1	85.5
TOTAL BURDEN	18.3	20.1	17.5	8.9	15.5	34.3	10.4	10.7	10.5	6.9	10.7	10.2	17.9	14.5

Exhibit 7. (B) Sample page from Detailed Support Effort Report, showing analysis of the groupings of programs.

DETAILS OF OUTSTANDING COMMITMENTS FOR NORMAL PROGRAM PURCHASE ORDERS
MERGING INFORMATION FROM PURCHASING AND ACCOUNTING

06/27/74

ACCOUNT	P.O.NUM	RQ.NUM	NEEDED	PLACED	ORDERED	RECEIVED	OLD PAYMNT	MAY LIEN	JUN PAYMNT	EXPECTED	COMMITTED
SHUGART											
4140-09	7180206	974871	06/20/74	06/07/74	13.20	**13.20**			13.20	06/12/74	NEGLIGIBLE
4140-09	7180406	974869	06/17/74		20.00					(NEEDED)	20.00
4140-09	7180216	974871	06/20/74	06/07/74	45.54	**45.54**			45.54	06/19/74	NEGLIGIBLE
4140-09	71804A6	974869	06/17/74	06/12/74	11.64	**11.64**			11.64	06/18/74	NEGLIGIBLE
					==========	==========	==========	==========	==========		==========
					5844.60	733.55	64.05	1065.65	662.65		5147.65
GROUP R/CROWE											
4370-01	72290A6	121422	07/01/74	06/17/74	38.23					06/30/74	38.23
4373-01	6793506	250048	03/26/74	03/19/74	1214.76	**1214.76** >>**>>**>>		1214.76		04/15/74	1214.76
4373-01	7085706	233053	05/24/74		75.00			1992.32		(NEEDED)	1992.32
4373-02	6747706	248561	03/15/74	03/14/74	3428.84	**3428.84** >>**>>**>>	3401.65	27.19		03/15/74	27.19
4376-24	71009A6		06/20/74						**97.65**	(NO PAR)	**COMPLETE**
					==========	==========	==========	==========	==========		==========
					4756.83	4643.60	3401.65	3234.27	97.65		3272.50
GROUP R/VPM											
4380-01	63984A6	67002	11/27/73	11/14/73	9.95	9.95 >>**>>**>>	8.95			11/27/73	1.00
4390-01	6341206	67004	04/09/74	04/02/74	189.00	**189.00**		247.80	247.80	06/14/74	NEGLIGIBLE
4381-01	6918006	248864	05/06/74	04/19/74	678.10	**678.10**	610.24		**77.00**	04/23/74	**COMPLETE**
4381-01	72269A6	232056	06/21/74	06/17/74	28.05					06/20/74	28.05
4381-01	72297A6	200788	06/20/74	06/17/74	19.40					06/20/74	19.40
4381-01	72331A6	235754	06/20/74	06/18/74	50.00					06/18/74	50.00
4381-02	58621A6	132875	06/25/73	06/22/73	39.75	39.75 >>**>>**>>	37.76			06/28/73	1.99
4381-02	68494A6		06/18/74						31.76	(NO PAR)	UNKNOWN
4385-12	71884A6	249766	06/12/74	06/07/74	58.50	**58.50**			58.50	06/11/74	NEGLIGIBLE
					==========	==========	==========	==========	==========		==========
					1072.75	975.30	656.95	247.80	415.06		100.44

Exhibit 8. (A) Sample page from Detailed Report of Purchase Commitments.

SUMMARY OF OUTSTANDING COMMITMENTS FOR NORMAL PROGRAM PURCHASE ORDERS
MERGING INFORMATION FROM PURCHASING AND ACCOUNTING

06/27/74

	JUNE PAYMNTS	NOT ON PAR	RECVD GT PAYMNTS	PAST DUE 06/22	06/29	REM FY	TOT FY	07/13	07/20	07/27	08/10	08/24	NEXT FY
				EXPECTED DELIVERY DURING SUBSEQUENT PERIOD ENDING ON GIVEN DATE									
SHUGART	663		37	1768	160		2628				36		3147
GROUP R/CROWE	98		1242	1992		38	3370						
GROUP R/VPM	415		3	97			515						
GROUP R/KAPLAN	286	170					456						
184 INCH CYCLOTRON													
ELY			75				75						
TRILLING-GOLDHABER	26			125			151						
VIS. TECH. M/I	1478		3366	3821	1372		10037	199	226	649	85	8	372
DATA HANDLING			12				12						
GROUP A	1096	311	1008	1552	259	620	4846	1915	43				48
HECKMAN	635		1056	250	560		2501						
KERTH	538		330	100			968		257				
KENNEY-HELMHOLZ	3005		1507	5688	166	2286	12652	55	3297		2294		
SEGRE-CHAMBERLAIN	267		1992	1059	1344	53	4715	214	229		465		
ASTROPHYSICS	1292		1015	15419	17096	243	35065	1355					
THEORETICAL PHYSICS	496			390			886	95					
NUCLEAR INSTRUMENTS	864		703	301	468		2336	506					22
MATH/COMPUTER RSRCH													
MATH/COMPUTING SRV	5652	14150	1981	97577	17365		136725	24126	1777	3267	2427	417	777
COMPUTER OPERATIONS													
DIVISION ONE OFFICE	639						639						
PHYSICS	17450	14631	14327	130139	38790	3240	218577	28465	5629	3916	5307	425	4366
TECHNICAL PHOTOG													
CRYO. TARGET													
PHYSICS SHARED													
MAGNET TESTING			12	1			13						
PEP STUDY			139				139						
SUPERCONDUCTING	202		537	25813	324	20445	47321	28	127				
ERA STUDY	320		2136	1060			3516						
BEVATRON OPERATIONS	2256		3360	5206	635	10	11467	4510	15071	31	5888	40950	83
ACCELLERATOR	2778		6184	32080	959	20455	62456	4538	15198	31	5888	40950	83
TOTAL PHYSICS	20228	14631	20511	162219	39749	23695	281033	33003	21027	3947	11195	41375	4449
NUCLEAR CHEM RSRCH	20954	40218	18441	39029	14666	2834	136142	5859	19996	2635	4833	1756	6368
HILAC OPERATIONS	4559	5	3387	8525	576	252	17304	5253	386	780	286	186	91
88 INCH CYCLOTRON	1150		451	668	363	26	2658	327	105		33	74	
TOTAL NUCLEAR CHM	26663	40223	22279	48222	15605	3112	156104	11439	20487	3415	5152	2016	6459
INORGANIC CHEMISTRY	1761		1631	4826	3753	57	12028	6702	5720	154			
METALLURGY	6198	351	12052	36928	12	1012	56553	2443	254	499	4492		498
TOTAL IMRD	7959	351	13683	41754	3765	1069	68581	9145	5974	653	4492		498
BIO-MED RESEARCH	3293	55	3971	9062	876	1696	18953	2885	341	110	119		100
CHEM BIODYNAMICS	3168	1933	2780	14381	1196	622	24080	2599	701	27		329	
TOTAL BIO-MED	6461	1988	6751	23443	2072	2318	43033	5484	1042	137	119	329	100
CTR BERKELEY	5896	977	13585	2968	1806	64	25296	6870		167			20019
GEOTHERMAL	2515		3382	16897		78	22872	746	205		848		10540
TOTAL RESEARCH	69722	58170	80191	295503	62997	30336	596919	66687	48735	8319	21806	43720	42065

Exhibit 8. (B) Sample page from Summary Report of Purchase Commitments.

TECHNICAL INFORMATION DIVISION
LAWRENCE BERKELEY LABORATORY
UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA 94720