A computer selection committee was charged with studying the computer needs of Andrews University in Berrien Springs, Michigan. Major results of the investigation included the findings that campus academic and administrative needs would best be served by one onsite system which could support versatile and concurrent time-sharing, batch processing, batch multiprograming and input/output spooling and also be capable of processing 100,000 character batch programs. Purchase of the Xerox Sigma 6 system was recommended on the basis of its hardware and software capabilities, vendor support, system growth options and cost. Total monthly cost, including equipment and maintenance, was estimated at $10,500. It was further recommended that non-standard contractual arrangements be negotiated with Xerox to cover the University's particular needs for maintenance service and personnel, systems analysis personnel, spare parts storage, upgrading of the system and provision of a new style memory. Additional studies of methods of procuring terminals and of modifying physical plant facilities were noted as being necessary and it was recommended that the University hire a computer consultant.
REPORT OF COMPUTER SELECTION
STUDY COMMITTEE

LeRoy H. Botten

Andrews University
Berrien Springs, Michigan

Computing Center
Revised: December 13, 1973
REPORT OF COMPUTER SELECTION

STUDY COMMITTEE

LeRoy H. Botten

Andrews University
Berrien Springs, Michigan

Revised: December 13, 1973
NOTICE

This report has been edited to delete proprietary information provided by certain vendors. The original report was intended only for internal use at Andrews University.
SUMMARY

This report summarizes the results of approximately nine man-months of study by the Computer Selection Committee appointed on August 7, 1972, by President Hammill. A summary of major findings and recommendations is presented below. Further recommendations and justification are contained in the body of this report.

FINDINGS

- Cost factors indicate that total university needs can best be served by one computer system serving both academic and administrative users.
- Academic and administrative computing requirements include support of versatile timesharing, support of concurrent timesharing and batch processing, support of batch multiprogramming, support of input-output spooling, and capability to process 100,000 character batch programs.
- The cost of an adequately configured IBM 370/135 is prohibitively high regardless of financing method.
- The cost of commercial timesharing services is significantly higher than similar services provided by an
on-site computer system.

- The Selection Committee was asked to evaluate several plans involving the expansion of the presently installed IBM 360/22. Even with the maximum possible system expansion of the IBM 360/22, resultant systems fail to provide adequate batch or timesharing capabilities.

- The Xerox Sigma 6 computer system, described in the report, best meets the needs of Andrews University on the basis of demonstrable system hardware and software capability, vendor software support, vendor maintenance support, vendor conversion support, system growth options, financial arrangements, and total cost.

- Present Computing Center staffing is not adequate to meet academic needs.

RECOMMENDATIONS

- Xerox should be designated as the vendor to supply computing equipment and related services required by Andrews University.

- Negotiations should be initiated with Xerox representatives to finalize the following:

  a. An installment purchase contract to purchase the proposed Sigma 6 computer system (less printer and unit record devices) for delivery prior to June 15, 1973. The anticipated cost (based on six per-
cent simple interest on the unpaid balance) is $5,995 per month.

b. A lease of the unit record and printer subsystems (card reader, card punch, and printer). The anticipated cost is $1,836 per month.

c. A maintenance contract for purchased equipment. The anticipated cost is $2,650 per month.

d. A conversion services contract. Anticipated total cost is $1,300.

e. Installation, conversion, and training schedules.

In order to answer specific needs of Andrews University, certain non-standard contractual arrangements should be negotiated with Xerox:

a. Location of nearest maintenance personnel, systems analyst personnel, and spare parts storage facility.

b. An agreement to subsequently upgrade the purchased portion of the selected system.

c. An agreement to provide maintenance service on the installed system for the duration of the installment purchase contract at guaranteed rates.

d. An agreement to provide "new style" memory.

• Standard Xerox contracts for lease, installment purchase, and maintenance should be evaluated by a commercial lawyer for potential sources of difficulty. Final contracts should be reviewed by a commercial lawyer prior to acceptance.
The contractural arrangements made with Xerox should bear the name of General Conference Corporation of Seventh-day Adventists rather than Andrews University Corporation. If this is not feasible, a non-standard agreement should be made with Xerox to permit transfer of the system to any other denominational affiliate at our discretion.

A study of optimum methods of procuring terminals (as outlined in Section 5), a plotter, and an optical page reader should be conducted as a supplement to the computer selection study. This study should also isolate requirements for disk packs, tapes, and storage facilities and optimum methods for procurement.

A study of required physical plant modifications should be instituted as a supplement to the computer selection study. At this time it appears as if no structural modifications will be necessary.

Steps should be taken promptly to hire a qualified academic consultant.

All Magnetic Card Selectric Typewriter systems on campus should be replaced by 2741-like terminals as soon after system installation as practicable.
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Section 1
INTRODUCTION

It is unworthy of excellent men to lose hours like slaves in the labor of calculation.
—Gottfried Wilhelm Leibniz

1.1 INTRODUCTION

Leibniz recognized as early as 1697 that considerable creative power was wasted in tedious calculations. Today the computer has relieved such burdens in diverse fields, and the extension of human capabilities made possible by computing systems has made them a part of everyday life in our society. Whether a student will require detailed knowledge of computer systems as a tool in his professional arsenal or merely a familiarity as part of a liberal education, there are few students who cannot benefit from exposure to the use of a digital computer system. In many disciplines such experience is an integral part of a quality education.

The acceptance of a computing system by students and faculty is largely dependent on ease of use of the system. In evaluating ease of use factors, the Selection Committee has found the most significant single factor to be provision for timesharing. Timesharing (the use of a computer from remote
Section 2
THE STUDY

2.1 THE COMMITTEE

On August 7, 1972, a committee was appointed by President Richard Hammill to study requirements for academic computing at Andrews University. The members of the committee include:

- Charles Clark, Chairman
- John Beach
- LeRoy Botten
- Don Engelkemier
- Dwain Ford
- Wilfred Futcher
- Robert Kingman
- Gordon Madgwick
- Lawrence McNitt
- Joseph Smoot

A copy of the letter of appointment is included as Appendix B.

2.2 INITIAL SCOPE OF THE STUDY

The letter of appointment (Appendix B) charged the committee with
four major tasks:

- Determine the requirements, versus the desires and ideas, of the academic departments for both interactive remote terminals and batch processing for instruction and research by faculty and students.
- Project the work load requirements for both batch and terminal processing for the next five years.
- Evaluate the five alternatives discussed in Charles Clark's letter of July 24, 1972, for providing interactive terminal facilities. Charles Clark's letter is an enclosure to the letter of appointment (Appendix B). Special attention should be given to the possibility of expanding the IBM 360/22.
- Evaluate the advisability of a "Third Party Lease" in lieu of a vendor lease or purchase.

2.3 EXPANDED SCOPE OF THE STUDY

Although the initial intent of the study was to evaluate academic needs, the committee determined that there are several necessary adjuncts to the assigned tasks:

- Determine business and administrative processing requirements for the next five years.
- Investigate software and hardware necessary to implement required business and academic processing.
• Investigate recent changes in economics of computer procurement, and probable future developments, in relation to the needs of Andrews University.
• Investigate staffing requirements to support expanded academic usage of the computing system.
• Make a thorough economic analysis of various methods of satisfying computing requirements at Andrews University.

These investigations were included in the study.

2.4 METHODS USED IN CONDUCTING THE STUDY

2.4.1 Direct Faculty Contacts

It is the consensus of the committee that the proper procedure for defining hardware requirements is to first define the required applications, then determine software necessary to implement the applications, and finally establish hardware requirements necessary to implement the software. Meetings were held with the individual faculties of most departments to obtain, directly, information on required and desired applications. The committee evaluation of this information is attached as Appendix C. Certain system criteria were also established as a result of this information (see Section 2.5).
2.4.2 Publications

Data-Pro 70, Auerbach Computer Technology Reports, and various other trade publications were used to verify and supplement information furnished by vendors. Copies of reports for the recommended system are attached as Appendix D.

2.4.3 Vendor Contacts

Based on software requirements determined by the study, vendors were asked to propose a hardware system to implement the required software.

2.4.4 Initial Rating of Proposals

Although 22 systems had been initially proposed, all but eight were eliminated on the basis of obvious failure to meet established criteria. The eight remaining systems were evaluated in detail. The rating system and results are briefly described in Appendix E.

2.4.5 Consultation

The results of the initial rating of the proposals were discussed with an outside consultant who concurred largely with those results. The consultant has been available on a continuing basis throughout the study.
2.4.6 Other Studies

The committee has had access to information derived from studies by Philco-Ford, Hope College, and Grand Valley College. These independent studies generally validated the findings of the committee.

2.4.7 Reference Accounts

Liberal use has been made of information provided by reference accounts furnished by vendors as well as information furnished by users located by other means. Unbiased observations by users have been valuable in both discounting and verifying various vendor claims for system performance. Reference accounts have been especially useful in estimating staffing requirements.

2.4.8 Economic Stability Analysis

A. Klein, of the Business and Administration Department, made a study of the corporate stability of several vendors of interest. The results of his study are attached as Appendix F.

2.4.9 Benchmark Study

A request for benchmark study was submitted to each of eight vendors as means of further validating and supplementing the evaluation described in Section 2.4.4. A copy of the request for benchmark study is attached as Appendix G, and results are summarized in Section 4.
2.4.10 Communications Study

In order to make a meaningful recommendation for a computing system, it is necessary to consider the basic system hardware in relation to communications requirements. The communications study includes consideration of number, type, and placement of remote terminals and remote job entry devices on campus or at distant locations; consideration of CPU to CPU communications (i.e., networks); and consideration of methods and costs for data transmission to remote sites. Results are summarized in Section 5.

2.4.11 Demonstration

Prior to entering contract negotiations a trip to an installation similar to that recommended for Andrews University was made. Such a trip permitted representatives of Andrews University to talk to their counterparts at the visited installation to obtain evaluations of the system from their own particular viewpoints.

2.4.12 Contract Studies

Prior to entering contract negotiations it is important to review standard vendor contracts for the proposed system and study non-standard riders which should be requested during negotiations. Copies of the standard contracts for the recommended system, and Andrews University legal counsel opinion on those contracts, are
attached as Appendix H. As a part of contract negotiations, a thorough review of the proposed configuration must be made.

2.5 CRITERIA AND SPECIFICATIONS

In order to meet the academic and business computing needs of Andrews University as identified by the Study Committee, a satisfactory system must meet at least the following criteria:

- Total monthly cost for system and maintenance must not exceed a nominal value of $10,000.
- The system must support concurrent timesharing and batch processing.
- The system must support demonstrable ANSI COBOL, BASIC, ANSI FORTRAN, and load-and-go FORTRAN compilers.
- The system must support an adequate simulation and modeling language, and an adequate string manipulation language.
- The system must support adequate statistical and scientific subroutine packages.
- The system must support an adequate text editor and database management system.
- The system must be available for delivery prior to June 15, 1973.
- The system must support spooling and batch multiprograming. In a dedicated batch mode, user core area must be at least 100 K bytes (the minimum necessary to execute many standard statistical packages).
• The timesharing capability must include excellent file security features.
• The system must support nine track tapes.
• The proposed system must be capable of expansion to at least 256 K bytes main memory, 200 M bytes disk storage, and 40 communications ports.
• The vendor must be able to provide excellent maintenance support.
• The system must support existing applications.
• The internal code must be consistent with current internal code standards (ie., 8 bit internal code).
• The system must include an adequate swapping device.
• The vendor must present an acceptable conversion plan.

2.6 DOCUMENTATION AND COMPLETENESS

Although major recommendations and conclusions of this report are supported by documentation in the form of appendices, that documentation is not exhaustive. In attempting to keep the report concise much of the available documentation has been omitted.

Similarly, recommendations and conclusions are often presented without exhaustive justification.

Every effort has been made to avoid "loose-ends." even though that may not always be obvious from this report. The Selection Committee is fully
prepared to offer more complete documentation and discussion as required.
typewriter-like terminals) permits each user to feel as if he is using a dedicated machine. The conversational nature of timesharing systems allows even inexperienced non-technical persons to write simple programs with a minimum of exposure to the system. In many cases existing programs may be stored by the instructor and used immediately by students.

Timesharing also offers major advantages to business and administrative users. For example, use of timesharing for student and financial records, inventory control, and other systems, permits reductions in expense for data preparation and major improvements in accessibility of information.

For student and faculty research in the physical sciences, the behavioral sciences, education, and other disciplines, requirements also exist for large scale batch processing. At present, Andrews University is purchasing such services from Notre Dame and Whirlpool Corporation. Unfortunately, obtaining such outside services involves long delays and considerable expense. An increased batch processing capability is also required if certain proposed administrative work (NCHFMS model; trust accounting) is to be done.

Computing should be viewed not only as a tool to relieve drudgery but as a new learning resource--one capable of improving both the scope and quality of education. (1)

(1) See Appendix A for more detailed comments on uses of the computer in higher education.
3.1 SYSTEMS RATED

Eight systems were chosen for detailed evaluation, and each major vendor of computing machinery is represented except for Control Data Corporation (CDC elected not to submit a proposal). In order to make meaningful comparisons between systems, the systems rated were configured as nearly alike as possible. The systems rated are listed below. (The numbers listed represent the number of characters of main storage and disk storage respectively):

- Burroughs B5500 (256K, 48M)
- Digital Equipment Corporation DEC1040 (320K, 100M)
- Hewlett-Packard HP3000 (131K, 94M)
- Honeywell Information Systems 430 (131K, 92M)
- International Business Machines 370/125 (131K, 200M)
- National Cash Register Century 200 (128K, 90M)
- Univac 70/46 (262K, 118M)
- Xerox Data Systems Sigma 6 (192K, 100M)

3.2 RATING METHOD
3.2.1 Summary

Detailed information provided by vendors was categorized and evaluated in detail by the committee. Each area was evaluated on a scale of zero (unsatisfactory) to seven (outstanding) and that score multiplied by a weighting factor to arrive at point scores. Point scores were grouped into five major categories—the major categories were then weighted such that their contribution to a total point score is as follows:

- Hardware Capabilities (20%)
- Growth Potential (15%)
- Operating System (20%)
- Languages (20%)
- Conversion, Maintenance and Software Support (25%)

A summary of scores in the major areas and total score, by system, is given in Appendix E. The maximum possible score is 700.

3.2.2 Comments Regarding the Rating System

The major strength of the rating system is that it permits the many characteristics of complex systems to be broken into small groups which can be realistically evaluated. The major weaknesses of the rating system were that evaluations were largely based on unverified sales presentations and that evaluations of quality of applications software could not be included in the rating.
It is worth noting that relying on sales presentations at this point in the study does itself offer one advantage—it is unlikely that the "best choice" will be overlooked. It is the function of benchmark programs, reference accounts, demonstrations, and acceptance test standards to ensure that a system is chosen on the basis of demonstrable characteristics rather than just a well made sales presentation.

3.2.3 Results of Initial Rating

Based on the rating system described, the systems were ranked as follows (the numbers listed are total weighted point scores):

- Digital Equipment Corporation DEC1040 (500)
- Hewlett-Packard H-P3000 (483)
- Xerox Data Systems Sigma 6 (471)
- Burroughs B5500 (442)
- Univac 70/46 (441)
- International Business Machines 370/125 (426)
- Honeywell Information Systems 430 (363)
- National Cash Register Century 200 (325)

The above ranking does not include consideration of system cost. Since Appendix E was prepared, several vendors have resubmitted proposals with substantial price reductions or significant performance enhancements.

3-3
3.2.4 Proposals Eliminated Prior to Benchmark Study

Due to results of the initial rating of proposals and continuing reference account calls, it was found that several proposals did not meet required criteria. Those systems are as follows:

- **HP3000**: adequate COBOL not demonstrable.
- **B5500**: can only support 7 track magnetic tapes; six bit machine; concurrent processing is questionable; COBOL of questionable adequacy.
- **IBM 370/125**: system not available until fourth quarter 1973 or first quarter 1974; operating system proposed will not be released until June 1973; timesharing capability of this system is very limited in versatility and number of simultaneous users; proposed system has maximum possible main memory; load-and-go FORTRAN not available for the proposed system.
- **HIS 430**: concurrent processing is very questionable; six bit internal code.
- **NCR 200**: although a very fine machine for many commercial applications, the NCR 200 lacks the versatility required to serve needs of Andrews University; concurrent processing is questionable.

3.2.5 Standing of Proposals Prior to Benchmark Study

Although the study committee would estimate an uncertainty of perhaps
30 points in the total point scores, there does appear to be a fairly well defined ranking of proposed systems as a result of the initial rating of proposals:

- DEC 1040 (500)
- XDS Sigma 6 (471)
- Univac 70/46 (441)

It should be stressed that the rating was based on a smaller Sigma 6 configuration, and a different operating system, than was finally purchased. If the rating were to be repeated the Sigma 6 system, with CP-V operating system, would clearly have the highest score.
4.1 INTRODUCTION

A benchmark study begins with submission of a series of selected programs to vendors to be compiled and executed on proposed systems. In a strictly commercial environment, analysis of the benchmark study usually emphasizes measures of throughput. However, in a university environment system versatility and user convenience are more important than raw throughput. Certainly commercial applications are important at Andrews University, for that reason much of the benchmark study is dedicated to assessing proposed system capabilities in the administrative and business processing areas. A copy of the Request For Benchmark is enclosed as Appendix G.

Conducting a benchmark study is very expensive for a vendor. Vendors whose proposals had been tentatively eliminated during the initial rating were so notified in order to aid them in deciding whether or not to respond. In fairness, and to allow a vendor who felt our initial rating did not reflect the actual capabilities of the system rated, all vendors were given a copy of the Request For Benchmark. The letters of transmittal stated that those systems not previously eliminated must be benchmarked to remain in the competition and that, for those proposals tentatively
eliminated, we would reevaluate our decision should the benchmark indicate
the prior analysis was in error.

4.2 RESPONSES

Only two vendors responded to the benchmark request in a timely and
reasonably complete manner: Univac and Xerox. Digital Equipment Cor-
poration responded to only part of the BASIC and FORTRAN tests (and that
response was a week late). No other responses were received. The Xerox
and Univac benchmark reports are attached as part of Appendix G.

4.3 BENCHMARK CONFIGURATIONS

Univac used the system proposed for installation at Andrews University to
run the benchmark. Xerox used an exactly equivalent system except for the
following:

<table>
<thead>
<tr>
<th>Item</th>
<th>Test System</th>
<th>Proposed System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Card Reader</td>
<td>7140 (1500 CPM)</td>
<td>7122 (400 CPM)</td>
</tr>
<tr>
<td>Card Punch</td>
<td>7160 (300 CPM)</td>
<td>7165 (100 CPM)</td>
</tr>
<tr>
<td>Line Printer</td>
<td>7445 (1000 LPM)</td>
<td>7441 (1100 LPM)</td>
</tr>
</tbody>
</table>

Although the card reader and card punch used were more capable, the test
programs were not sensitive to card input-output operations. The line
printer used has been superseded by the model proposed (the proposed mod-
el is faster and should produce printed copy of higher quality). The re-
results obtained from the Univac and Xerox benchmark tests can be expected to compare very closely to the systems proposed.

4.4 CONVERSION TEST

Conversion of benchmark programs was done by Univac and Xerox. Although programs were derived from a variety of sources, neither vendor had apparent difficulty in compiling and executing test programs with a minimum of effort.

4.5 DEDICATED MACHINE PERFORMANCE TESTS

This series of tests was designed to measure throughput capabilities of the proposed systems for COBOL, FORTRAN, and BASIC programs. Since the Request for Benchmark (Appendix G) explicitly defines the tests, only a summary of results will be provided here.

Since certain times provided by Univac were specified with limited accuracy, only execution times will be compared for this part of the analysis.

4.5.1 Timesharing Mode

Comparisons with IBM 360/22 cannot be made since timesharing is not possible on the 360/22.
### Execution Time (seconds)

<table>
<thead>
<tr>
<th>Program</th>
<th>Univac 70/46</th>
<th>Xerox Sigma 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>B8</td>
<td>183.7</td>
<td>40.5</td>
</tr>
<tr>
<td>F1</td>
<td>81.0</td>
<td>14.5</td>
</tr>
<tr>
<td>C1</td>
<td>59.3</td>
<td>108.5</td>
</tr>
</tbody>
</table>

#### 4.5.2 Batch Mode

No batch BASIC capability exists for the Univac and IBM 360/22 systems.

### Execution Time (seconds)

<table>
<thead>
<tr>
<th>Program</th>
<th>Univac 70/46</th>
<th>Xerox Sigma 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>B8</td>
<td>----</td>
<td>38.0</td>
</tr>
<tr>
<td>F1</td>
<td>81.6</td>
<td>14.5</td>
</tr>
<tr>
<td>C1</td>
<td>60.0</td>
<td>108.5</td>
</tr>
</tbody>
</table>

#### 4.5.3 Conclusions

Note that little difference exists between timings for execution of batch and timesharing work. Although the Univac data, as specified is too imprecise to justify detailed comparisons, the Xerox system does appear to have much shorter compile times in general.
BASIC program B8 was designed to test looping and calculational speed.
The Xerox B8 executes in only 22% of the time required to execute Univac B8 (about 4.5 times faster).

FORTRAN program Fl was designed to test looping and calculational speed.
The Xerox Fl executes in about 18% of the time required to execute Univac Fl (about 5.6 times faster).

COBOL program Cl was designed to test file manipulation speed. The Univac Cl executes in about 55% of the time required to execute Xerox Cl (about 1.8 times faster). (But see also Sections 4.8.2 and 4.8.3!)

4.6 LANGUAGE TESTS

The language tests were devised to examine various features of proposed compilers. Some throughput data was also developed by these programs.

4.6.1 BASIC Tests

These tests were done in the timesharing mode. Programs B1 through B7 test many compiler features (for details see Appendix G). Both systems were adequate in performance of all tests.

Actual elapsed time for running these programs is probably more a consequence of the users typing ability than system performance; for that reason timing comparisons are not made.
4.6.2 FORTRAN Tests

These tests were done in the batch mode and timing comparisons are significant. Programs F2, F4, and F5 were satisfactorily executed by both Univac and Xerox. F3, which calculates Fourier coefficients using Romberg integration was not run to completion by Univac. F6, a severe test of the statistical processing capability of a system, was not run at all by Univac. (L. Botten was informed verbally that there had been insufficient time to run F6.)

Timing for these programs is then:

<table>
<thead>
<tr>
<th>Program</th>
<th>Univac 70/46</th>
<th>Xerox Sigma 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>F2</td>
<td>27.2</td>
<td>36.0</td>
</tr>
<tr>
<td>F3</td>
<td>---</td>
<td>7.8</td>
</tr>
<tr>
<td>F4</td>
<td>30.7</td>
<td>6.6</td>
</tr>
<tr>
<td>F5</td>
<td>29.3</td>
<td>7.8</td>
</tr>
<tr>
<td>F6</td>
<td>---</td>
<td>117.0</td>
</tr>
</tbody>
</table>

4.6.3 COBOL Tests

These tests were done in the batch mode and timing comparisons are significant. All COBOL programs were satisfactorily executed by both Univac
and Xerox. Programs used are actual production programs used at Andrews University.

Timing for these programs is as follows:

<table>
<thead>
<tr>
<th>Program</th>
<th>Univac 70/46</th>
<th>Xerox Sigma 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>C2</td>
<td>49.3</td>
<td>23.4</td>
</tr>
<tr>
<td>C3</td>
<td>39.6</td>
<td>12.0</td>
</tr>
<tr>
<td>C4</td>
<td>15.4</td>
<td>3.0</td>
</tr>
<tr>
<td>C5</td>
<td>7.9</td>
<td>7.2</td>
</tr>
</tbody>
</table>

4.6.4 Conclusions

Both Univac and Xerox BASIC should be entirely satisfactory.

Program F2 had been originally designed to run on the Stanford University IBM 360/67 (a machine considerably larger and more expensive than has been under consideration for Andrews University). The only conversion required for Xerox F2 was to replace control cards. Even more surprising, F2 ran about half as fast on the Xerox Sigma 6 as on the IBM 360/67. In order to relate Xerox Sigma 6 performance to the currently installed IBM 360/22 the following facts may be noted. The Xerox F2 was compiled and executed in 45 seconds. Since F2 cannot be run on the IBM 360/22 as sub-
mitted to vendors, a simplified version was prepared. Although the simplified version omitted certain calculations and omitted five of the seven data sets run by Xerox, the program required 69 seconds to execute on the IBM 360/22. Ignoring any effects of simplified calculations but assuming each data set would require 34.5 seconds to execute, the Xerox Sigma 6 time of 45 seconds may be compared (very conservatively!) to an IBM 360/22 time of 241 seconds (about 27 times faster). Xerox F2 (the full version) used 132K bytes of memory (about six times the total user space available with the IBM 360/22).

Program Univac F3 was, unfortunately, manually aborted before completion. Inspection of output indicates that the program was 80% complete in the 12 minutes it was allowed to run. Extrapolating, the program could be assumed to run a total of about 14 to 15 minutes. This compares with approximately one minute required by Xerox F3.

Results of running F4 should be viewed with some caution since it appears as if some data may have been omitted in running Xerox F4.

It is interesting to note that F6 was submitted as a production job in mid-August 1972. Repeated attempts have been made to run this job using IBM Scientific Subroutines and a locally produced package designed to run on the Univac 1108. No run had been completed satisfactorily until Xerox F6 was run. For comparison purposes the following summary is made:
<table>
<thead>
<tr>
<th>System</th>
<th>Time</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Notre Dame IBM 370/155</td>
<td>20 minutes</td>
<td>Incomplete</td>
</tr>
<tr>
<td>Whirlpool IBM 370/165</td>
<td>20 minutes</td>
<td>Incomplete</td>
</tr>
<tr>
<td>Whirlpool Univac 1108</td>
<td>12 minutes</td>
<td>Invalid</td>
</tr>
<tr>
<td>Xerox Sigma 6</td>
<td>2 minutes</td>
<td>Excellent</td>
</tr>
</tbody>
</table>

It should further be noted that standard software packages were used for the IBM 370 and Xerox Sigma 6 runs. As of this report date, the only satisfactory execution was made on the Xerox Sigma 6 (and that on the very first try!).

Xerox FORTRAN seems to be clearly superior to Univac FORTRAN.

Apparently coding changes were not required for either Univac or Xerox COBOL execution. Xerox file definitions differ from presently implemented COBOL, while Univac COBOL is virtually identical. The Xerox COBOL permits the programmer to use default options for file definitions, thus saving coding in some cases. Xerox COBOL does not permit updating sequential disk files, although subroutines are available to do so (several programs in the present systems do this sort of operation).

Both Univac and Xerox performed the COBOL tests in a satisfactory manner.

4.7 MULTIPROGRAMMING AND CONCURRENT PROCESSING TESTS

It was not expected that any vendor would be able to complete all provisions
of this test. Both Univac and Xerox completed the minimum required portions of the test in order for valid conclusions to be reached. A series of FORTRAN programs was to be compiled and executed in one job stream and a series of COBOL programs was to be executed in another job stream. The times necessary to complete a full run for each job stream is defined as FORTRAN sequence time (FST) and COBOL sequence time (CST) respectively. The sequences were to be run with no timesharing users to clearly demonstrate at least a minimal multiprogramming capability. The sequences were then to be run with five specified timesharing tasks to demonstrate at least a minimal concurrent processing capability. It was hoped that larger numbers of prescribed timesharing tasks could then be added in order to measure batch degradation as timesharing demands increase. Neither vendor completed this part of the benchmark; however, the required information was obtained from reference account calls.

4.7.1 Timing

Although Univac results are specified to only the nearest minute, the results are still of valid interest (Univac FST omitted F3):

<table>
<thead>
<tr>
<th>Test</th>
<th>Univac 70/46</th>
<th>Xerox Sigma 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiprogramming without concurrent:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CST</td>
<td>2.0</td>
<td>----</td>
</tr>
<tr>
<td>FST</td>
<td>4.0</td>
<td>----</td>
</tr>
<tr>
<td></td>
<td>4-10</td>
<td></td>
</tr>
</tbody>
</table>
### 4.7.2 Conclusions

The Univac FST omitted F3. Based on Section 4.6.4 it is clear that Univac FST execution times must be increased by at least 12 minutes (very conservatively) and in fact that Univac FST with five timesharing users should be expected to degrade more than the corresponding Univac CST.

The table of Section 4.7.1 can then be revised on a very conservative basis as follows:

<table>
<thead>
<tr>
<th>Test</th>
<th>Univac 70/46</th>
<th>Xerox Sigma 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiprogramming and concurrent (no T/S):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CST</td>
<td>3.0</td>
<td>4.1</td>
</tr>
<tr>
<td>FST (estimated)</td>
<td>17.0+</td>
<td>7.1</td>
</tr>
<tr>
<td>Multiprogramming and concurrent (5 T/S):</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CST</td>
<td>5.5</td>
<td>4.4</td>
</tr>
</tbody>
</table>

4-11
Univac ran each job stream in a multiprogramming mode to demonstrate minimum processing times. By merely allowing the possibility of concurrent processing (even if no timesharing users are signed on), the Univac operating system (VMOS) overhead increases CST and FST! Upon investigation, it was found that the Xerox operating system (UTS) automatically senses the absence of timesharing users and optimizes batch job performance; hence, the multiprogramming without concurrent processing option does not apply to Xerox.

With no timesharing users the Univac system has greater COBOL throughput; however, even five timesharing users reverses the situation. Xerox FORTRAN appears to execute considerably faster than Univac FORTRAN. These facts agree with information obtained by other means. The Univac 70/46 proposed is a maximum configuration. Reference account information indicates that for 10 to 12 concurrent timesharing users response time is several seconds, and for 32 concurrent users response time is several minutes with a batch job stream throughput slowing by a factor of approximately three. With 40 concurrent timesharing users of Xerox Sigma 6 the response time should still be only several seconds and batch job streams should show little degradation. Furthermore, the Xerox system can be considerably enhanced, as required, without changing CPU and without requiring any software conversion. For example, a system similar to that proposed for Andrews University except for addition of main memory
and a larger swapping device has been demonstrated to support 69 concurrent timesharing users with less than 0.5 second response time!

The Univac 70/46 performance is clearly less than adequate in this area.

4.8 CONCLUSIONS

4.8.1 Conversion

Programs from several sources were easily converted for use on Univac and Xerox systems. This indicates the large existing base of programs existing for use on IBM, and other, equipment will be largely useful on either system.

4.8.2 Dedicated Machine Performance Tests

Specific differences in execution speeds for various programs are summarized in Section 4.5. By combining execution times for all programs executed by both systems, some measure of mean execution rates may be derived:
<table>
<thead>
<tr>
<th>Language</th>
<th>Univac 70/46</th>
<th>Xerox Sigma 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>BASIC (B8)</td>
<td>183.7</td>
<td>40.5</td>
</tr>
<tr>
<td>FORTRAN (F1, F2, F5)</td>
<td>137.5</td>
<td>58.3</td>
</tr>
<tr>
<td>COBOL (C1, C2, C3, C4, C5)</td>
<td>171.5</td>
<td>154.1</td>
</tr>
<tr>
<td>Total</td>
<td>492.7</td>
<td>253.9</td>
</tr>
</tbody>
</table>

For the above mix, not necessarily representative of the computing mix at Andrews University, the Xerox Sigma 6 executes all programs in 51% of the time required for Univac 70/46 execution (about 1.9 times faster). Although execution times for C1 by Univac (60.0 seconds) and by Xerox (108.5 seconds) as discussed in Section 4.5.2 might leave the impression that Univac COBOL executes almost twice as fast as Xerox COBOL, that conclusion is not supported by the total execution time for COBOL programs representative of production programs at Andrews University. Programs C2, C3, C4, and C5 were chosen from among existing production programs. In the aggregate, the Sigma 6 executed those programs in 45.6 seconds versus Univac 70/46 execution in 112.2 seconds (2.5 times faster).

4.8.3 Language Tests

Both systems performed the BASIC tests adequately. The Xerox Sigma 6 system performed the FORTRAN test in an outstanding manner. Both systems
performed the COBOL tests in a satisfactory manner.

4.8.4 Multiprogramming and Concurrent Processing Tests

Both systems demonstrated a capability for concurrent processing and multiprogramming. Although neither Univac nor Xerox completed tests with more than five concurrent timesharing users, some extrapolation may be made from data provided. Since system throughput degradation is non-linear (more nearly exponential) as more timesharing users are added, a linear extrapolation biases results in favor of the vendor. The linear extrapolation is risky; however, since results agree qualitatively with conclusions formed on the basis of reference account calls, such projection will be made. The Selection Committee submits the projections, as plotted on Figure 1 (page 4-17), as an aid to visualization of results rather than as an analytical tool.

Based on the estimated for Univac FST the following extrapolations may be made:

For:

\[ X = \text{number of timesharing users} \]
\[ \text{FST} = \text{FORTRAN sequence time (see Section 4.7)} \]
\[ \text{CST} = \text{COBOL sequence time (see Section 4.7)} \]

Then:

\[ \text{Univac FST}(X) = 0.40X + 17.0 \]
Xerox FST(X) = 0.28X + 7.1

Univac CST(X) = 0.50X + 3.0
Xerox CST(X) = 0.06X + 4.1

These extrapolations are plotted in Figure 1 (page 4-17).

By inspection of Figure 1 it is clear that for no timesharing users the Univac COBOL had the edge. But for three or more timesharing users the Xerox COBOL performance is dramatically better. The Xerox FORTRAN can be expected to be dramatically better, regardless of the number of timesharing users. The above analysis, and information from reference accounts (described in Section 4.7.2), both indicate that the Xerox Sigma 6 becomes more advantageous the greater the number of concurrent timesharing users. In view of the findings of Section 5, it appears very likely that capabilities of the proposed Univac 70/46 would be exceeded within the first year or two of operation. It should be noted that the proposed Univac 70/46 has the maximum allowed main memory. For these reasons the Univac 70/46 is found to be less than satisfactory.
Figure 1

Number of concurrent timesharing users

CST & FST (min)

Univac FORTRAN (estimate)

Xerox FORTRAN

Univac COBOL

Xerox COBOL
Section 5
TERMINALS AND COMMUNICATIONS

5.1 INTRODUCTION

The market for computer terminals is highly competitive at this time. Developing technology continues to modify the types and cost of available terminals. Although the recommended system may interface with many types of remote devices, it is necessary to ensure that terminals and other communications devices are fully compatible with the system. For these reasons, the detailed study of terminal procurement has been deferred until after the system decision is made. A further recommendation, based on the rapid changes in the terminal market, is to lease, rather than purchase, terminals with advanced capabilities.

It is also recommended that procurement of terminals be made as the terminals are needed and can be individually justified. Such a delay will prove to be an advantage to Andrews University in the existing competitive market.

5.2 TERMINALS

The selection committee has completed an initial review of terminal requirements. The expected growth in terminal requirements is shown in Ap-
The following minimum initial terminal installation is recommended to support timesharing services:

<table>
<thead>
<tr>
<th>Location</th>
<th>Quantity</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics Department</td>
<td>2</td>
<td>APL</td>
</tr>
<tr>
<td>Physics Department</td>
<td>1</td>
<td>ASCI</td>
</tr>
<tr>
<td>Physics Department</td>
<td>1</td>
<td>APL</td>
</tr>
<tr>
<td>Chemistry Department</td>
<td>1</td>
<td>TTY</td>
</tr>
<tr>
<td>Biology Department</td>
<td>1</td>
<td>TTY</td>
</tr>
<tr>
<td>Science Complex (General use)</td>
<td>1</td>
<td>CRT</td>
</tr>
<tr>
<td>Science Complex (General use)</td>
<td>1</td>
<td>&quot;2741&quot;</td>
</tr>
<tr>
<td>Science Complex (General use)</td>
<td>1</td>
<td>TTY</td>
</tr>
<tr>
<td>Business Administration Department</td>
<td>1</td>
<td>TTY</td>
</tr>
<tr>
<td>Education Department</td>
<td>1</td>
<td>TTY</td>
</tr>
<tr>
<td>Home Economics/Nursing Department</td>
<td>1</td>
<td>TTY</td>
</tr>
<tr>
<td>Physical Education Department</td>
<td>1</td>
<td>TTY</td>
</tr>
<tr>
<td>Computing Center (Programming)</td>
<td>2</td>
<td>ASCI</td>
</tr>
<tr>
<td>Computing Center (General use)</td>
<td>1</td>
<td>CRT</td>
</tr>
<tr>
<td>Computing Center (General use)</td>
<td>1</td>
<td>&quot;2741&quot;</td>
</tr>
<tr>
<td>Computing Center (General use)</td>
<td>1</td>
<td>TTY</td>
</tr>
<tr>
<td>Replacement for MCST's</td>
<td>2</td>
<td>&quot;2741&quot;</td>
</tr>
<tr>
<td>Security Office</td>
<td>1</td>
<td>TTY</td>
</tr>
</tbody>
</table>

Key:  APL - APL keyboard; probably Teletype Model 38
      ASCI - ASCISCOPE video terminal
      CRT - video terminal with printer and cassette unit
TTY - Teletype Model 33

"2741" - "Selectric" type terminal for use with EDIT software and APL

The committee recommends that, in addition to the above terminals, the following equipment also be procured for the initial installation:

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Portable printing terminal</td>
</tr>
<tr>
<td>1</td>
<td>Digital plotter</td>
</tr>
<tr>
<td>1</td>
<td>Optical page reader</td>
</tr>
</tbody>
</table>

It is recommended that the present study be extended to ensure optimum procurement of the above equipment.

5.3 COMMUNICATIONS

The recommended system may be easily expanded to permit computer-to-computer communications (bisynchronous communications; HASP handler) and servicing of polled networks. Although the cost of such expansion is nominal (undiscounted purchase $9,600; maintenance $45 per month), the Selection Committee recommends such expansion be deferred until the need is clearly justified.
Section 6
FINANCIAL CONSIDERATIONS

6.1 OUTRIGHT PURCHASE

Although this method appears to be the least expensive, the cost of capital may be ignored only if Andrews University should have a large available cash surplus. Furthermore, purchasing with borrowed money and repaying with inflated dollars may have substantial benefits. In any case, it does not appear feasible for Andrews University to make the capital investment necessary to obtain a satisfactory computing system. Section 6.5 contains estimates of costs of borrowing the necessary money (thus affecting available credit) and taking direct ownership of the recommended equipment.

6.2 THIRD PARTY LEASEBACK

This method of financing consists of purchasing the equipment (in order to take advantage of all educational discounts), reselling the equipment to a third party (who supplies the capital), and leasing the equipment from the third party. The third party anticipates profits from two sources: from tax relief not available to a non-profit educational institution; and from interest payments, and possibly, retention of residual value.
6.2.1 Advantages of Leaseback Over Outright Purchase

The major purpose of leasing is to obtain the use of capital equipment without having to make capital expenditures. Lease payments can provide a cash flow superior to that of purchase over the early years of the equipment's life. Leasing is an effective hedge against inflation; however, to be fair, depreciation deductions can suffer a negative effect from inflation.

6.2.2 Advantages of Leaseback Over Traditional Financing

Leasing may actually give a cheaper rate. This is particularly true when lessee cannot take advantage of tax benefits such as depreciation and investment tax credit—the lessor can purchase the equipment, claim the tax benefits, and pass the savings on. Leasing spares the use of existing lines of credit and allows full use of borrowing capacity. Most leases provide 100% financing—not even a deposit or down payment dips into capital. Often even acquisition costs (delivery cost, etc.) can be spread over the lease payments.

6.3 VENDOR LEASE

The vendor lease offers many of the advantages of third-party lease methods; although, almost invariably, at higher costs. The major advantages of vendor lease agreements are the capability to easily arrange for upgrade without having to dispose of existing equipment,
and the capability to easily arrange for replacement of particular pieces of equipment which may be only marginally serviceable. The last advantage may be particularly important in case of mechanical equipment subject to rapid wear (eg., card punches, printer, or card readers).

6.4 INSTALLMENT PURCHASE

Xerox Data Systems offers an installment purchase plan at 6% simple interest on the unpaid balance with no down payment required. The buyer, of course, retains the residual value of the machine. These liberal terms are predicated on the fact that XDS is not subject to having the machines returned on short notice; hence, the buyer does lose some flexibility. (It appears to be possible to negotiate certain upgrade provisions.)

6.5 OPTIONS

In order to obtain the most powerful computing system at minimum monthly cost, it is recommended that the XDS installment purchase plan be used.

It would be prudent, however, to consider lease of card reader, card punch, and printer for various reasons. As pointed out previously these pieces of equipment are subject to mechanical wear. These devices, as potential sources of reliability problems, are also the sub-
jects of continuing research. There is reason to believe that in the not distant future certain technological breakthroughs will be announced. If these devices are leased it will be an easy matter to replace these units.

6.6 COST ANALYSIS OF OPTIONAL METHODS OF FINANCING

In the following paragraphs the net cost of procurement, exclusive of maintenance, is analyzed for outright purchase, third party lease back, vendor lease, installment purchase, and the recommended mixture of vendor lease and installment purchase. The cost of straight third party lease is not considered. A leasing company cannot take advantage of sizable educational discounts; therefore, the straight lease plan involves a much higher cost to Andrews University than the third party leaseback plan analyzed.

In order to simplify analysis the maintenance cost is considered to be constant. Since maintenance is not paid on equipment leased from a vendor, the actual lease rate has been reduced by the amount of maintenance on the vendor leased equipment, thus yielding a net procurement cost.

6.6.1 Outright Purchase

It is assumed that Andrews University could acquire money for the purchase of the equipment from established lines of credit at 7% simple interest.
on the unpaid balance, and repay the loan over a seven year period.

Purchase Price $484,060  
7% - 7 year factor .01509  
$7,304.47/month  
$87,653.58/year  
Total $613,575.08

6.6.2 Third Party Leaseback

The least expensive plan for third party leaseback was the one proposed by Funding Systems Leasing Corporation. That plan is summarized below.

Purchase Price $484,060  
10.5% - 7 year factor .01708  
$8,267.75/month  
$99,212.94/year  
Total $694,490.55

6.6.3 Vendor Lease

Since Xerox does not publish seven year lease rates, the six year lease rate was used in the following analysis.
Monthly $15,205.50
less maintenance 3,013.60
$12,191.90/month
$146,302.80/year
TOTAL $1,024,119.60

6.6.4 Xerox Installment Purchase

The seven year educational installment purchase rate is equivalent to
a loan with no down payment and 6% simple interest on the unpaid balance.
The analysis reveals that this plan represents an additional, and sizable, discount.

Purchase Price $484,060
6% - 7 year factor .0146
$7,067.28/month
$84,807.31/year
TOTAL $593,651.18

6.6.5 Recommended Mixture of Vendor Lease and Installment Purchase

The following summary is based on lease of the card reader, card
punch, and printer. The remaining components of the system are con-
sidered to be under an installment purchase agreement. The reasons
for this recommendation are given in Section 6.5.
6.6.6. Mixture of Xerox Lease and Installment Purchase

**First Year Costs**

- Monthly Lease Cost (1) $1,836.00
- less adjustment for maintenance 363.35
  - Total $1,472.65
- Installment Payments (2) 5,995.05
  - Total $7,467.70/mo.
- First Year Total $89,612.40

**Annual Cost After First Year**

- Installment Purchase Price $73,440
- less conversion credits (3) 8,812.8
  - net purchase price $64,627.80
- 6% - 6 year factor .0166
  - $1,072.81/month
- 6% - 7 year installment payment 5,995.05/month
  - $7,067.86/month
- $84,814.32/year

**Total Cost**

- First year $89,612.40
- Years 2-7 508,885.92
- Total seven year cost $598,498.32

(1) Based on leasing listed peripherals for first year
(2) Based on 6% - 7 year rate for rest of system
(3) Assuming all lease purchase options are exercised
6.6.7 Summary and Conclusions

The first three lines of the table below summarize values derived in previous sections (all values have been rounded to the nearest dollar). The last three lines show differential costs of each plan with respect to the lowest cost financing plan: installment purchase of the entire system. The two entries in the "Mixture" column (in parenthesis) represent first year costs only—after the first year the costs are almost exactly those shown under the "I.P." column.

<table>
<thead>
<tr>
<th></th>
<th>Purchase</th>
<th>Lease-back</th>
<th>Vendor lease</th>
<th>Inst. purch</th>
<th>Mixture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monthly cost</td>
<td>7,304</td>
<td>8,267</td>
<td>12,192</td>
<td>7,067</td>
<td>(7,468)</td>
</tr>
<tr>
<td>Annual cost</td>
<td>87,653</td>
<td>99,213</td>
<td>146,303</td>
<td>84,807</td>
<td>(89,612)</td>
</tr>
<tr>
<td>Total cost</td>
<td>613,575</td>
<td>694,491</td>
<td>1,024,119</td>
<td>593,651</td>
<td>598,498</td>
</tr>
<tr>
<td>Diff. monthly cost</td>
<td>237</td>
<td>1,200</td>
<td>5,125</td>
<td>-----</td>
<td>401</td>
</tr>
<tr>
<td>Diff. annual cost</td>
<td>2,846</td>
<td>14,406</td>
<td>61,496</td>
<td>-----</td>
<td>4,805</td>
</tr>
<tr>
<td>Diff. total cost</td>
<td>19,924</td>
<td>100,840</td>
<td>430,468</td>
<td>-----</td>
<td>4,847</td>
</tr>
</tbody>
</table>

By inspection of the above table one sees immediately that the least costly method of purchase is the installment purchase. The recommended method of acquiring the system costs an additional $4,847; however, Andrews University does receive the benefit of having a year to evaluate the leased mechanical equipment before commitment to purchase as well as the probability of benefiting from new developments.
6.7 CONVERSION AND INSTALLATION PREPARATION

6.7.1 Conversion

It is recommended that the conversion problem be solved by a joint effort of the Computing Center staff and the Applications Services Department of Xerox. The Xerox group would be responsible for clean compile of all programs and complete conversion and testing of approximately 75% of all existing programs (all of the critical programs).

The Computing Center staff would be responsible for furnishing test data and resultant output to Xerox. (In most cases test data consists of current files.)

The Xerox services would be performed under a fixed price contract. Total proposed fee for the services has recently been reduced to $1,300. As part of the contract negotiations, a complete and detailed conversion plan would be jointly developed.

6.7.2 Installation Preparation

There are two major aspects of preparing for the installation of new equipment. The first task is to prepare the physical facilities, the second task is to procure required tapes, disk packs, storage racks, etc.

A preliminary review of power and air conditioning requirements, and ma-
chine room layout, indicates no major alteration of the physical plant should be required. A competitive source of supply for tapes and disk packs is being researched by the Computing Center staff. It appears as if some trade-in credit exists for owned items which are no longer required. Although careful preparations must be made for the installation of a new system, it appears as if such preparation will be relatively easy and inexpensive.

6.7.3 Staffing

A review of Computing Center staff requirements for conversion in consultation with Xerox, is attached as Appendix I. Both full-time staff members would be required in order to develop test data for all programs, to review results of Xerox tests, to complete conversion and testing of those programs assigned to Andrews University, to carry on with maintenance of production programs, and to attend formal training in preparation for use of the new equipment.

The recommendation to add one member to the Computing Center staff is discussed in Section 8. In reviewing the prerequisites for an orderly and efficient conversion and installation it has become apparent that the staff addition should be made as soon as possible so that the new staff member may:

a. Be available for pre-installation training.

b. Participate in system generation (a valuable training experience).
c. Assist academic users in conversion problems.

d. Be available to assist in conversion of existing programs and systems as required.

e. Assist in preparation of a user's guide for the new system.

In participating in these activities the new staff member would help assure a smooth conversion and installation, would be more adequately trained to maintain the operating system upon system installation, and would help promote immediate productive usage of the new system.

6.8 BUDGET CONSIDERATIONS

The proposed 1973-1974 computing center budget (Appendix K) was based on the recommended Xerox Sigma 6 configuration purchased under the seven year Xerox installment purchase plan ($10,081 per month including maintenance). Total equipment and amortization budget requested was $137,616. Total budget request was $260,953. The recommendation to lease rather than purchase the card reader, card punch, and printer adds a total of $4,805 to the first year system cost. Thus, if the Selection Committee recommendation is accepted, the proposed 1973-1974 computing center budget must be amended to $265,758. This represents an increase of $49,982 (23.16%) over the 1972-1973 budget. Of this increase, $8,243 (3.82%) is due to increased staffing and $41,739 (19.34%) is due to increased equipment costs.
The table below compares costs of the presently installed IBM 360/22 to various cost options for the recommended system:

<table>
<thead>
<tr>
<th>Comparison Costs</th>
<th>Recommended System</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Monthly Computer System Cost(1)</strong></td>
<td></td>
</tr>
<tr>
<td>IBM 360/22 Inst. Purch.</td>
<td></td>
</tr>
<tr>
<td>$5,002 (2) $10,081</td>
<td>$10,482 $10,081</td>
</tr>
<tr>
<td><strong>Unit Record Equipment</strong></td>
<td></td>
</tr>
<tr>
<td>1,286</td>
<td>1,286</td>
</tr>
<tr>
<td><strong>Total Equipment Cost</strong></td>
<td></td>
</tr>
<tr>
<td>$6,288 $11,367</td>
<td>$11,768 $11,367</td>
</tr>
<tr>
<td><strong>Outside Services Cost(3)</strong></td>
<td></td>
</tr>
<tr>
<td>2,200</td>
<td>zero</td>
</tr>
<tr>
<td><strong>Average Total Cost of Services</strong></td>
<td></td>
</tr>
<tr>
<td>$8,488 $11,367</td>
<td>$11,768 $11,367</td>
</tr>
<tr>
<td><strong>MCST Cost Savings</strong></td>
<td></td>
</tr>
<tr>
<td>zero</td>
<td>-350</td>
</tr>
<tr>
<td><strong>Net Average Cost of Services</strong></td>
<td></td>
</tr>
<tr>
<td>$8,488 $11,017</td>
<td>$11,418 $11,017</td>
</tr>
</tbody>
</table>

Note that no credit is taken for recovered costs except for the two magnetic card selective typewriters (MCST's) which may be immediately replaced by the recommended system. The net increase in cost in going from the IBM 360/22 to the recommended system is nominally $2,500. It is expected that part of this increase may be recovered by sales of services to other institutions.

(1) Including maintenance.
(2) Includes savings inherent in leasing disk drives from ITEL ($814 per month) and $500 per month amortization on owned printer.
(3) Estimated; based on typical month during Fall Quarter.
Section 7
TERMS AND CONDITIONS

7.1 INTRODUCTION

Copies of standard Xerox leasing, installment purchase, and maintenance contracts are included as Appendix H. In order to ensure adequate protection of the interests of Andrews University it is recommended that a competent commercial attorney be retained to inspect the standard contracts for potential sources of difficulty. It is also recommended that the attorney inspect final contracts before execution.

7.2 NON-STANDARD CONTRACTURAL ARRANGEMENTS

Every attempt should be made in contract negotiations to obtain the following non-standard protections:

- Stationing of a customer engineer and storage of essential spares at Andrews University (even if we must provide office and storage space).
- Specification of new style memory.
- Guarantee of upgrade and trade-in privilege for components under installment purchase plan for at least the first eighteen months after installation.
- Guarantee of provision for maintenance of all system
components for the entire life of the installment purchase contract with escalation protection.

- Non-appropriation clause.
- Provision for system and software acceptance tests.
- Conversion and installation non-performance penalties.
- Guarantee of adequate system analyst support for entire life of the installment purchase contract.
- Guarantee of adequate documentation at fixed cost.
- Guarantee of adequate training assistance at fixed cost.
- Right to pay off balance without penalty.
- Right to transfer equipment to any affiliate of General Conference of Seventh-day Adventists without jeopardizing maintenance or systems analyst support.
- Right to use independent memory or peripheral equipment which does not require modification of Xerox equipment.
- Contract termination clause allowing Andrews University to terminate contract should Xerox bow out of the computer business.
- Bundling guarantee for entire life of the installment purchase contract.
Computer buffs . . . have been likened to small boys who, given a hammer, suddenly find that everything needs pounding.

—Readings in Psychology Today

8.1 INTRODUCTION

Although many members of the Selection Committee can be described as computer buffs, a serious effort was made to be conservative in assessing the computing needs of Andrews University (see Appendix C). Based on these needs a set of minimum system criteria and specifications was defined (see Section 2.5).

8.2 FINDINGS

In response to questions before the Selection Committee (see Sections 2.2 and 2.3), the following findings are submitted:

- Cost factors indicate that total university needs can best be served by one computer system serving both academic and administrative users.
• Academic and administrative computing requirements include support of versatile timesharing, support of concurrent timesharing and batch processing, support of batch multiprogramming, support of input-output spooling, and capability to process 100,000 character batch programs.

• The cost of an adequately configured IBM 370/135 is prohibitively high regardless of financing method.

• The cost of commercial timesharing services is significantly higher than similar services provided by an on-site computer system.

• The Selection Committee was asked to evaluate several plans involving the expansion of the presently installed IBM 360/22. Even with the maximum possible system expansion of the IBM 360/22, resultant systems fail to provide adequate batch or timesharing capabilities.

• Present Computing Center staffing is not adequate to meet academic needs.

• The Xerox Sigma 6 computer system, as described in Appendix L, best meets the needs of Andrews University on the basis of demonstrable system hardware and software capability, vendor software support, vendor maintenance support, vendor conversion support, system growth options, financial arrangements, and total cost.
8.3 RECOMMENDATIONS

The Selection Committee submits the following recommendations:

- Xerox should be designated as the vendor to supply computing equipment and related services required by Andrews University.

- Negotiations should be initiated with Xerox representatives to finalize the following:
  
  a. An installment purchase contract to purchase the proposed Sigma 6 computer system (less printer and unit record devices) for delivery prior to June 15, 1973. The anticipated cost (based on six percent simple interest on the unpaid balance) is $5,995 per month.

  b. A lease of the unit record and printer subsystems (card reader, card punch, and printer). The anticipated cost is $1,836 per month.

  c. A maintenance contract for purchased equipment. The anticipated cost is $2,650 per month.

  d. A conversion services contract. Anticipated total cost is $1,300.

  e. Installation, conversion, and training schedules.

- In order to answer specific needs of Andrews University certain non-standard contractual arrangements should be negotiated with Xerox (see Section 7).

- Standard Xerox contracts for lease, installment purchase,
and maintenance should be evaluated by a commercial lawyer for potential sources of difficulty. Final contracts should be reviewed by a commercial lawyer prior to acceptance.

- The contractual arrangements made with Xerox should bear the name of General Conference Corporation of Seventh-day Adventists rather than Andrews University Corporation. If this is not feasible, a non-standard agreement should be made with Xerox to permit transfer of the system to any other denominational affiliate at our discretion.

- A study of optimum methods of procuring terminals (as outlined in Section 5), a plotter, and an optical page reader should be conducted as a supplement to the computer selection study. This study should also isolate requirements for disk packs, tapes, and storage facilities and optimum methods for procurement.

- A study of required physical plant modifications should be instituted as a supplement to the computer selection study. At this time it appears as if no structural modifications will be necessary.

- Steps should be taken promptly to hire a qualified academic consultant.

- All Magnetic Card Selectric Typewriter systems on campus should be replaced by 2741-like terminals as soon after system installation as practicable.
8.4 XEROX SIGMA 6

8.4.1 Advantages

The Xerox Sigma 6, announced in May 1970, offers extremely versatile operational capabilities and fast internal computational speed. IBM 360 compatibility was established as a design criterion, and Sigma 6 employs the same external and internal data codes and formats as IBM 360 systems. (Thus, the conversion of widely available IBM 360 software can be easily accomplished.) Hardware and software support permits efficient and flexible data communications processing capabilities. Xerox is responsive to servicing installed computers and offers a wide range of academic and business applications software. A new line of printers using the Xerographic process is under development, and such printers could significantly increase print quality while decreasing cost. A variety of high level languages may be implemented on the Sigma 6 in either batch or timesharing mode. The timesharing capability and database management capability of the system are especially noteworthy.

8.4.2 Disadvantages

The only known sources of potential difficulty are possible maintenance problems for certain peripherals (card reader, and card punch) and a minimal possibility that Xerox might leave the computer business.

The maintenance problem can almost certainly be overcome by requiring
Xerox to provide a locally based maintenance man. As further insurance, and to allow an opportunity to observe new developments in the printer field, it is recommended that the card reader, card punch, and printer be leased for the first year. The more capable card readers and card punches offered by Xerox are known to be quite reliable. If maintenance problems should prove to be insurmountable for the units initially installed, a change could be made prior to making a purchase agreement. The Selection Committee does not consider this to be a serious problem.

In May 1969, Xerox acquired Scientific Data Systems (SDS). SDS had had considerable difficulty in meeting certain software delivery commitments. Xerox completely reorganized the software development organization of SDS and, in less than three years, had developed a sophisticated data base management system and a wide variety of other business oriented software (the scientific users of SDS equipment had been well satisfied). (1)

On March 7, 1972, Xerox announced the formation of a new Information Systems Group responsible for marketing, distributing, and servicing both its copier and computer product lines.

While Xerox's copier business has been consistently very profitable, the company's computer business has yet to show a profit. The formation of the Information Systems Group demonstrates Xerox's strong commitment to

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(1) This paragraph, and the next three paragraphs in this section, were extracted from the 1972 Auerbach Computer Technology Reports on the Sigma Series. Auerbach is noted for thorough and unbiased evaluations.
electronic data processing (EDP) and dispels rumors that Xerox might follow RCA and bow out of the EDP industry.

The Wall Street Journal for January 18, 1973, contained significant comments on expected improvements in the Xerox computer revenue position (the entire article is included as Appendix M):

(Excerpt and Appendix M intentionally omitted.)

A detailed financial evaluation of the Xerox Corporation was made by A. Klein. A copy of Mr. Klein's report is included as Appendix F. Based on that study there is no expectation of difficulty in regard to Xerox
Corporate stability.

In considering the above information, the Selection Committee believes the risk of Xerox leaving the computer business to be minimal.

8.4.3 Growth

Many types of remote terminals and communications devices may be interfaced to the Sigma 6. The system may be expanded to capabilities well beyond what should be required by Andrews University during the next seven years. Such expansion requires installation of main memory and disk storage units. The central processing unit need not be changed; hence, no conversion or reprogramming would be required.

The recommended system is very capable. However, it is expected that as timesharing and on-line administrative applications increase, some system expansion will be required. System enhancement may be accomplished with considerable flexibility and at relatively small incremental cost. For example, adding 64,000 bytes of main storage (about three times the user memory area of the presently installed IBM 360/22--much of the 360/22 memory is used by the operating system) would cost $19,400. A similar addition of 25,000,000 bytes of disk storage (a little more than is presently installed with the 360/22 would cost $14,280. For further details of pricing for various growth options refer to Appendix L.

The Selection Committee submits that growth may be easily adjusted to the
needs of Andrews University and should present little difficulty if enhancements are based on projected cost-benefits. It is recommended that such trial projections be made annually. Only when enhancements are clearly justified, should they be made.

8.5 STAFFING

The key to effective usage of computing equipment is adequate staffing. To properly support increased academic computing and to ensure adequate operating systems maintenance, an additional qualified full-time staff member is required. (Additional comments on staffing related to conversion are contained in Section 6.7.3.)

It is recommended that, as annual trial cost-benefits projections are made with regard to equipment, similar consideration be given to staffing requirements. For example, where applications which could represent a net savings to Andrews University are delayed by lack of applications programming staff, it could well be a sound financial decision to increase the programming staff. As for equipment, such changes should be made only where clearly justified.

8.6 REVIEW STUDY

In addition to the annual studies described in Sections 8.4.3 and 8.5 it is recommended that a thorough review of computing needs and adequacy of services be made in the summer of 1977 (or earlier if required).
Such a study should ensure that Andrews University computing capabilities are neither deficient nor excessive.
Appendix A

Excerpts From

"COMPUTERS IN HIGHER EDUCATION"(1)

I. INTRODUCTION, FINDINGS, AND RECOMMENDATIONS

After growing wildly for years, the field of computing now appears to be approaching its infancy.

In the field of scholarship and education, there is hardly an area that is not now using digital computing. Computing is a new resource in learning. It enables the student or the scholar to deal with realistic problems rather than oversimplified models. By lessening the time spent in the drudgery of problem solving and in the analysis of data, it frees time for thought and insight. Partly, it enables the student to do old things more easily, but more important, it enables him to do things he otherwise could not. Computing increases the quality and scope of education.

The widespread use of computing in scholarship as well as industry and government has come about not just because of a general enthusiasm for computers, but because this new tool has found vital and increasing use in each field in which it has been applied.

If we are to exploit our opportunity fully, students in colleges and universities must see for themselves what a powerful tool computing is, and learn to use it. No matter what his specialty, the student must be given the opportunity of using computers in learning and in doing, and the faculty member must be able to use computers in teaching. Both the individual's opportunities and the progress, well-being, and stature of our society can be increased by adequate computing facilities for our colleges and universities.

The recommendations we make are expensive, but if they are not carried out there will be a different kind of cost. Today, the best and richest institutions are able to carry part of the burden of educational computing. As time goes on, these institutions will improve the service they give their undergraduates, while smaller and poorer institutions will be trying to catch up. . . . If the deficit in educational computing is not made up quickly, millions of students who will have attended these institutions in the 1970's will be poorly prepared for the world of the 1980's and 1990's.

The major findings and recommendations of the Panel are:

1. Approximately 35 percent of college undergraduates are enrolled in curricula in which they could make valuable use of computers in a substantial fraction of their courses. An additional 40 percent are in curricula for which introductory computing training would be very useful, and limited computer use would be part of several courses. The remaining 25 percent could make some use of computers in one or more courses during their college education, but computer training is not now important in their major studies.

2. One of the major problems in providing the necessary educational computing is the cost.

3. We find that any expansion of the educational use of computing

depends heavily on increased knowledge of computing by faculty in most disciplines. Such knowledge usually can be provided by intensive 2-to-6 week periods of faculty education.

4. There is a great need for specialists trained in the computer sciences at the bachelor's, master's, and doctorate level.

5. The cost of computing is a continuing expense, like light or water, rather than a capital investment, like the initial cost of buildings.

6. The optimum mechanism for providing computers will differ from campus to campus. However, in many cases it appears economical and effective to supply adequate and dependable service from large computing centers.

7. Because of inconsistent Government and university accounting practices, the great variety of sources of computing support, and the experimental nature of computer use, some universities have had difficulty in determining and controlling their computer costs. Informed decisions regarding expansion and/or budgeting for current operations cannot be made without accurate cost information. Errors made at this stage can only lead to the diversion and dissipation of university resources needed for other educational purposes.

8. Proper introduction of computing into secondary education is desirable and growing.

II. COMPUTERS AND UNDERGRADUATE EDUCATION

Computers were first introduced into universities as rare and special pieces of equipment used for a few specialized sorts of research by small groups of people. Today, many universities and colleges have centers which serve most of the students, faculty, and administration both by providing training in programming and by meeting computing needs for undergraduate education, for research, and often for administration.

Where adequate computing facilities have been available, the faculty has made increasing use of computing in both research and education, and computing has become a part of more and more undergraduate courses, including business subjects, social sciences, biological and health sciences, psychology, geology and other disciplines, as well as mathematics, physics, chemistry, and engineering. This is consistent with the rapidly growing use of computing outside the schools in small as well as large business enterprises, in government operations and national defense facilities, and in almost all technology—those many fields of endeavor where most college graduates will find their places. Computing is not an esoteric or specialized activity; it is a versatile tool useful in any work with a factual or intellectual content. Computing is becoming almost as much a part of our working life as doing arithmetic or driving a car.

Computers find a widespread use in education only when well-run facilities are easily available to all students and faculty members, with rapid service for all users. Under these conditions there are a number of instances (including, for example, Dartmouth and Texas A. & M.) in which a majority of all undergraduates learn programming and use computing in some part of their course work. While computing has not yet become an important part of undergraduate course work in such fields as English, linguistics, languages, history, music, and art, faculty members in some of these fields are making increasing use of computers in research, and computing is beginning to find its way into undergraduate instruction.
In all fields where computing has been used, it has added a new dimension to education, and has led the students to better comprehension of complex problems and greater insight into the meaning of quantitative expressions. In these areas undergraduates have learned, through preparation and experimentation with computer programs, of the care required to define a problem logically and fully, and the assumptions needed to obtain answers to complex problems. We predict that in the future almost all undergraduates will use computers profitably if adequate computing facilities are available. There may be a few students in some fields who will not use computers at all, but they will be a small minority.

Using a Computer is Easy

It is possible to make effective use of computers without programming training. "Computer aided instruction" systems and some information retrieval system (Medlars, for instance) are examples of uses which do not require appreciable programming knowledge. There are many other examples for which the user need only supply data to existing programs.

However, acquiring some knowledge of programming is easy, and it greatly extends the scope of the educational use of computers. This is particularly true when special student-oriented programming languages are used. Ten to thirty hours spent in learning programming enable a student to use computers profitably in course work. This contrasts strikingly with the time needed to acquire a useful knowledge of mathematics or of a foreign language; it is more comparable to the time spent in learning to drive a car. It is the universal experience of all those with whom we have talked that students spontaneously made use of computers in solving problems or handling data even when this was not intended. A further evidence that learning to program is easy is that in many places programming training is extending down into secondary education.

The Nature of Educational Computer Use

The earliest educational use of computers provided instruction in programming followed by student use in solving assigned course-work problems adapted to computer solution.

Continued familiarity with the computer allows students to use it in courses in which no such use is specifically required—reducing data obtained in laboratory courses, or making statistical evaluations in sociology courses, for instance. Familiarity of faculty as well as students with computing leads to the assignment of computer-oriented special problems, and even to undergraduate student research projects which could not be carried out without computing. Such student work is valuable education and highly desirable.

It is of the utmost importance to keep in mind that computing should not be thought of primarily as a new subject to be taught in addition to all the other important material now in the curriculum. Teachers who make use of computers in a wide variety of subjects have found that their material can be taught more rapidly, more thoroughly, and more meaningfully with the aid of computers.
We Have Second Class Education for the Majority

Adequate computing is not available today in many fine small colleges. Further, even in many larger colleges or universities which have reasonably powerful computers, the computers are not accessible to the majority of undergraduates, wither through lack of an appreciation of the usefulness of computing on the part of the faculty, or lack of suitable instruction, or lack of suitable computer languages, or through the way in which facilities are administered or financed. Yet these institutions train undergraduates of excellent ability. Many of these graduates will go out into the business world where they will need to understand and use computers.

Many others of these undergraduates will go on to a wide variety of graduate work unequipped with a simple but vital skill in problem solving and unaware of its power and versatility. The handicap of a lack of understanding and skill in the use of computers is extremely severe in all areas in which data analysis is vital, in learning as well as in practice—in business, in the social sciences, in psychology, in geology, in the health sciences, for example. In a very real sense, students who have not learned to use computers are badly equipped for the postbaccalaureate world.

We believe that undergraduate college education without adequate computing is deficient education, just as undergraduate education without adequate library facilities would be deficient education. At present, deficiency in computing is widespread. We believe it to be vital to the national interest as well as to the welfare of the individual student to remedy this deficiency quickly.

What Is Adequate Service?

... Several things are essential even to the most modest user if the aim is education rather than hard knocks:
   Adequate instruction in and consultation concerning computing ...  
   Adequate software ...  
   Reliable operation ...  
   A fast turn-around time ...  
   Interactive remote consoles ...  
   Graphic output ...  
   Visual displays ...  
   New forms of input ...

Who Should Use Computers?

By sometime in the 1970's it is doubtful that more than a few percent of the students will graduate without having made some use of computers. A rough guess of the portion of the undergraduate enrollment in each of these categories as of about 1972 is tabulated in Section A and suggests that approximately 35 percent will make substantial use, 40 percent will make limited use, and 25 percent will make casual use.
Problems of Paying for Computing Service

... Our colleges and universities clearly have a central responsibility to pioneer in and to adopt new educational techniques and methods. What is so special, then, about the use of computers in education?

The answer lies in the extremely rapid growth rates in computer-related costs which are being experienced by many universities (and should be experienced by more of them). Universities and colleges, whether public or private, are all faced with rising costs and a precarious balance between income and outgo; the public institutions are overwhelmed by the tidal wave of student enrollment, whereas the private institutions are struggling to provide improved student services and to keep pace with the rising faculty salaries in an enterprise dependent upon relatively fixed income sources.

Many of our institutions of higher learning have already responded to the significance of computers for all aspects of their programs by establishing new departments of computer sciences. Such a step is a major one for any university, involving new long-range commitments to faculty tenure and to providing building space. Yet, in addition to these very substantial financial loads, the universities also face the very high cost of hardware and manpower to generate and use software. And these total costs are mounting at incredible annual growth rates—figures as high as 45 percent per year are given in the Roesser report—which are an order of magnitude larger than the budgetary growths universities are used to providing from their own funds, with great effort, to academic divisions.

Estimation of Cost of Adequate Computing for Undergraduate Education

Universities get computing at bargain rates compared with industry. ... Reasonably skilled student help is available at as low as $1.25 an hour, and salaries for professional help appear to be lower than in industry. Educational discounts have reduced machine costs. Certainly, those who pay for campus computing get it at a bargain rate.

Problems of Providing Facilities

Large computing centers can provide high quality remote service while using a batch--processing type of operation. ... However, present experience tends to show that immediate access to computers through interactive remote consoles will be practical and desirable, rather than a luxury. It is a conclusion, rather than a recommendation, that a large part of the necessary computing service will be provided by systems of this sort.

III. THE COMPUTER SCIENCE STUDENT

... This work calls for access to and interaction with a good computer center. Since many computer science departments also grant a master's degree, it is difficult to separate the undergraduate use from use at the master's level. Graduate work in computer science calls for substantial use of computer time in carrying our research on software and toward new computer applications.
The demand for people trained in computer sciences exceeds the supply.

Despite the importance of instruction in computer sciences, the total amount of computing connected with such instruction will certainly be small compared with the total amount of undergraduate educational computing which we have estimated earlier in this report because there are so many fewer computer science students than there are college undergraduates. Thus, if the deficit in undergraduate computing is made up, as we propose, an adequate amount of computing would be available for computer science education. It is of course important that such use be recognized as a part of the education use of computing.

We must not, however, overlook the quality of computer facilities necessary for good education in computer sciences. . . . Though computer science education and research need place only modest demands on a large computing center, the quality of the center is of utmost importance.

IV. INTERACTION BETWEEN RESEARCH AND EDUCATIONAL USES OF COMPUTERS

It seems very desirable to favor large, up-to-date university centers which can serve a variety of needs, including research and administration as well as education. This is particularly desirable in that the educational load may be more seasonal than the research load, so that a system serving educational needs alone might be nearly idle in the summer. Though the funding of research and administrative computing costs may well be different from the funding of educational costs, it is only reasonable to ask that educational needs as well as research needs be taken into account in establishing and operating large computing centers.

There is another way in which research computing may seriously affect the educational use of computers. We believe that unless computers used in research are managed wisely and effectively, money which might be used to advantage in education may be wasted.

We have observed that most colleges and universities have no adequate provisions in their budgets for educational computing.

. . . Unless adequate provisions are made for the support of research computing, the very resources which are needed for educational computing, and indeed, for the rest of education, may be drained away by unforeseen research needs. . . . It is particularly important that universities do not carelessly allow overruns in research computing to penalize the education of their students.

V. THE COMPUTER AND SECONDARY EDUCATION

Training in the use of computing and in the nature of computers and computing is rapidly but randomly invading secondary education. We have felt it impossible to approach the problem of computers and secondary education quantitatively both because of the sheer magnitude of the problem and because of the lack of quantitative information. However, through personal experience and the testimony of others we have formed some preliminary opinions concerning the problems involved.

The advantages of introducing the use of computing into course work and of teaching something about the nature of computers and computing in secondary schools can be considerable, either as a preparation for
college work, as a preparation for semiprofessional or vocational training, or as a preparation for employment. Such training in secondary schools will increase rather than decrease the amount of educational computing required in colleges and universities.

There can, however, be real disadvantages to an unwise introduction of computer training in high schools. Detailed and narrow training in commercial programing languages and the operation of commercial computers has apparently led some able young people to accept dead end jobs in a market hungry for people with computer know-how, when they might better have gone on to college and fitted themselves for more productive and rewarding places in our economy.

Vocational training in computers and computing has a legitimate place in terminal secondary education, but this may not be the chief contribution which computing has to make to secondary education. Secondary-school students should be taught what computers and computing are. In addition, it may be that computers can be used to improve the teaching of many courses. Computers may be useful in stimulating the interest of students who cannot be reached in other ways.

Computing is best used in secondary schools by means of convenient facilities, such as remote consoles, and simple instructional programming languages. Instruction in the nature of computers and computing can be by means of special texts supplemented with specially designed experimental equipment. (1)

Unfortunately, this approach is contrary to much that is now being done in secondary education. Sometimes the computer used is one which is used for administrative purposes, which may be ill adapted to proper introductory instruction. Sometimes the computer used is a small machine purchased or rented primarily for instruction, but awkward to use and of limited computing power compared with a remote console attached to a large modern machine—or even compared to job shop operation by courier or mail on some accessible more powerful machine.

This is not to deny that good and useful secondary-school instruction can be carried out with less than optimal facilities. But we believe that money is often spent, and financial obligations incurred (through the purchase of computers which will be expensive to replace when they become obsolescent and expensive to maintain at all times) which could be better applied in securing service from a more suitable source. Indeed, many secondary schools may, for want of guidance, reexperience all the difficulties that universities and colleges have already gone through in coping with computers and computing.

Cooperation between secondary schools and universities, and particularly providing service to secondary schools from university centers, should be encouraged.

(1) Such as the material in the text, "The Man Made World," and the associated experiments being prepared by the Engineering Concepts Curriculum project under the auspices of the Commission on Engineering Education.
A. COMPUTERS IN HIGHER EDUCATION

Introduction

In attempting to assess the educational need for computers in colleges and universities, we find ourselves compelled to believe that within a decade essentially all university and college students will require some basic understanding of digital computation. In short, we believe that the computer and computing are rapidly coming to have an impact on the life of practically every member of our society. Most people educated beyond the high school level will have occasion to make use of these tools, and all will need sufficient understanding of their possibilities and limitations realistically to appraise the new opportunities now available for information processing.

In all parts of education, government, or industry, digital computer use has come about because it is an effective tool. Each new use leads to several more--like bookkeeping, inventory control, airlines reservations, on-line control of manufacturing processes, design of structures, diagnosis of disease, market analysis and forecasting, design and analysis of experiments in the social and natural sciences. It is a new tool with unusual implications.

Suddenly, it seems, the computer and its many applications has opened a new technical field to woman. Of all technological fields the computer area shows the greatest growth in the employment of women, largely those with baccalaureate degrees in mathematics.

In every day life the computer problem looms equally large. Automation is the usual name for the problem. It means using computers to control machines and processes previously carried out by human labor. A threat perhaps, but equally an opportunity. Many people can be relieved from jobs of mental or physical drudgery. With additional training they can carry out more complex jobs using computers than their abilities allowed before. How many checkout clerks in supermarkets could add well enough to hold their jobs without a computer--the cash register?

Clearly some acquaintance with digital computers will be as essential to the next generation as is now familiarity with the automobile and the radio. It will need to know what a computer is, its uses and limitations. For college and university students the time required to get such familiarity may be about that to learn to drive a car. Unfortunately, parents can't teach about computers so the colleges and universities must.

An Estimate of Needs

A quantitative estimate was made by classifying the needs of major areas of study as (1) substantial, (2) limited, and (3) casual. Category 1 includes primarily all the biological and physical sciences and engineering and roughly half the social sciences, mathematics, and business and commerce. Category 2 contains the other half of mathematics, social science, and business plus three-quarters of education. Category 3 includes mostly the humanities.

In category 1 an introductory course in the freshman year would allow students to make routine use of the computer in many courses--probably more than 50 percent--throughout their undergraduate career. Students in category 2 will probably take an introductory programming course at an
early stage of their education and then make some use of the computer in three or four other courses during their 4 years as an undergraduate. Students in category 3 need not make any use of the computer as part of their major study although it is quite likely that even they will find it useful in a few courses. By sometime in the 1970's it is doubtful that more than a few percent of the students will graduate without having made some use of computers.

A common characteristic of both the general and professional education in computers is that the student is gaining understanding of and facility with a tool. Such instruction is often best given, in terms of motivation and of skill, in connection with the study of the discipline for which the tool is important. Thus we would expect that students of education might learn digital computation in connection with analysis of educational statistics. Introductory physics students might find digital computation a powerful tool for reduction of experimental data or in simulation of experiments.

Institutions will differ in the way in which they introduce students to digital data processing, and this is healthy. But if the most is to be made of limited time—and every new subject introduced into the college curriculum now faces rigorous competition from other subjects which can make excellent claims on the student's time—it is important that computers be used to extend rather than displace the student's grasp of other subject matter.

In undergraduate education the computer offers especially exciting possibilities in teaching the formation of hypotheses or theories. Physics, for example, has been very successful in describing and explaining the physical world because theories could be constructed and results calculated on the basis of fundamental principles. Yet it still is sometimes hard to separate the logical from the empirical content of our knowledge of physics.

As Prof. W. M. Huggins of Johns Hopkins University has pointed out, computer methods now permit us much more readily to examine the logical consequences of a given set of assumptions in nearly any discipline without turning to analogous systems in the real world which imperfectly realize the assumptions. In these situations, the implications of theory may be examined with a "pure" system in which a prescribed sequence of operations can be performed precisely as specified without any uncertainties or irrelevancies from the real world contaminating the investigation.

This manmade world of the computer will enable all disciplines to a greater or less degree to generate an idea, hypothesis, or theory, and test its value completely independent of its practical realization. Added to this possibility is the computer's ability to handle data with all the complexity that exists in the real world. Such powers have never existed so extensively before and have tremendous potential at all levels of the educational process.

An Important Plus

We have discussed the need for and cost of education in the use of computers as a tool in solving problems in various disciplines. This seems to us the most direct route to knowledgeable use of computers by students and faculty. But the presence of a computer, or its input-output terminals, on a campus creates an additional opportunity with
equally great rewards.

These rewards could come in the form of assistance in the teaching-learning process itself. Many exciting new experiments have the student interacting directly with the computer through typewriter, visual, or audio presentations. With competent and careful programming of the computer one finds it helping the student to construct answers rather than picking them from a list; to learn as he would from a teacher.

The potential to the student and increased effectiveness of the teachers merit intensive development of computer assistance learning at all educational levels. With large computers, more faculty experienced in their use, and better input-output devices, this teaching process can be explored and developed toward the end of the period we are considering. It is possible that productivity gains will provide much better education at very reasonable costs.
<table>
<thead>
<tr>
<th>Major Area of Study</th>
<th>Usage</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Substantial</td>
</tr>
<tr>
<td>Agriculture</td>
<td></td>
</tr>
<tr>
<td>Architecture</td>
<td></td>
</tr>
<tr>
<td>Biology</td>
<td>23,000</td>
</tr>
<tr>
<td>Business and Commerce</td>
<td>28,000</td>
</tr>
<tr>
<td>Education</td>
<td></td>
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<tr>
<td>Engineering</td>
<td>33,000</td>
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<tr>
<td>English and Journalism</td>
<td></td>
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<tr>
<td>Fine and Applied arts</td>
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<tr>
<td>Foreign Language and literature</td>
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<tr>
<td>Forestry</td>
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<td>Geography</td>
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<tr>
<td>Health</td>
<td>1,000</td>
</tr>
<tr>
<td>Home Economics</td>
<td></td>
</tr>
<tr>
<td>Library science</td>
<td>500</td>
</tr>
<tr>
<td>Mathematics</td>
<td>9,500</td>
</tr>
<tr>
<td>Military</td>
<td>2,500</td>
</tr>
<tr>
<td>Philosophy</td>
<td></td>
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<tr>
<td>Physical Sciences</td>
<td>17,500</td>
</tr>
<tr>
<td>Psychology</td>
<td>7,000</td>
</tr>
<tr>
<td>Religion</td>
<td></td>
</tr>
<tr>
<td>Social Sciences</td>
<td>38,000</td>
</tr>
<tr>
<td>Others</td>
<td></td>
</tr>
<tr>
<td>Total (460,000)</td>
<td>160,000</td>
</tr>
<tr>
<td>100 (Percent)</td>
<td>35</td>
</tr>
</tbody>
</table>
B. SOME FACTS OF LIFE ABOUT COMPUTERS

The mode of using computers has changed steadily through the years. In the earliest days of computers, each user took his program individually to the machine and used the computer either until his problem was solved, or until he ran out of assigned time. This is no longer feasible except in the use of obsolete computers which have been replaced but not discarded, and when one considers maintenance and space for such machines, it is of dubious merit.

One of the first advances in adapting computers to easy use was the open shop together with batch processing. Open shop operation means that anyone who follows specified rules can get a program run, not just a selected group of programers. By batch processing we mean that the programs and data for a lot of jobs which various people want done are put on a magnetic tape and run through the computer in sequence. This means that all programs to be run must conform to certain rules, and use the input and output facilities which are provided for all. All these functions are implemented by a small amount of additional hardware and a large executive or system program to manage the operation automatically.

Batch processing can cut down the turnaround time, the time between handing a job in at a computer center and getting an answer back, to one or two hours. As computers have come to be used by more and more people for a greater variety of jobs, even this may be too long to wait for an answer.

A recent development which makes computers more efficient and more flexible in use is called multiprograming. The flexibility is obtained by having the computer take up tasks in order of their ease or brevity. This is similar to a garage mechanic's having a 5-hour job but taking on easier 5-or-10 minute jobs as they come in. By interrupting the larger job periodically, more customers are satisfied and no one must wait for a very long time. In multiprograming the computer can leave a long job partly done to take on other, shorter ones, then return. This procedure also leads to greater efficiency. Without multiprograming, the entire expensive computer system can be idle if processing is delayed for any reason; for example, if a new input tape must be mounted during the course of computation. This wastes both time and money . . . With multiprograming, another job, or part of a job, can be started (or even completed) during these necessary interruptions.

Another recent improvement in computer organization permits many users to have access to the machine simultaneously. This is called multiple access.

Both multiprograming and multiple access permit increased efficiency of computing facilities and produce better service for more users.

The interaction between man and machine is an essential element in many modern uses of computers. The computer types out a text, or draws a picture, or places packages for minimum wire length, or calculates the deflections in a mechanical structure, and a man observes the result

(1) Programs of this kind become an integral part of the computer to users, and so are often called "software" as a contrast with the hardware. The other computer operating schemes mentioned in the remainder of this appendix are also implemented by a hardware-software system, not by hardware alone.
and makes alterations to correct defects or to improve performance. Multiprogramming, multiaccess, and peripheral computers and visual displays are important elements in making such interactions between man and machine quick, easy, and efficient.

C. COMPUTER LANGUAGES

The provision of appropriate, adequate, and efficient languages is one of the vital ingredients in the wider and more effective use of computers. This is a strong reason in favor of providing students and faculty with access to a large and powerful computer, rather than a small computer of limited flexibility and capability.

D. EDUCATING THE FACULTY IN USE OF THE COMPUTER

The greatest initial effort to aid faculty members would probably be for disciplines which are already making substantial use of the computer. Engineering comes to mind immediately as an outstanding example. Statistics is another good example of an important computer application; it touches many areas of the social sciences, biological sciences, and physical sciences. It is probably that many faculty members may have their first occasion to consider use of the computer in connection with statistical problems.

Younger faculty, who are closer to their graduate student days, may have greater awareness of the growing importance of the computer, and they may, therefore, be among the first to bring pressure on the computation center staff to learn about the computer. But it has been pointed out that a relatively short interval of intense training can prepare a faculty member to make effective use of the computer, and it is clear that many faculty members from all age groups will--and should--want to become conversant with the computer.

Need to solve a particular set of problems or to keep current in one's field provides an important motivation for a faculty member to seek instruction in use of the computer. . . . Another motivation for the faculty member is his desire to keep pace with his students who have found the computer fascinating and useful.

It is very important for the faculty to recognize that the time needed to cross a significant threshold of understanding so that one may begin to do useful work for oneself and his students is very low compared to a discipline such as mathematics or operations research or languages.

There is evidence, from experience at schools such as Dartmouth, that a nearby console and simple programming languages, if available, make it especially easy for a faculty member to learn and to experiment with the new tool in spare moments and in private.

E. THE LARGE UNIVERSITY COMPUTATIONAL FACILITY

The Patterns of the Past

In the past, computation has usually come to colleges and universities through a proliferation of computers around the campus, each computer assuming a single role such as teaching, research, or university administrative data processing. While this "solves" the problem of administering computers, albeit in a costly and redundant manner, it generally begs
the question of how the computation might best serve the needs of education, and it establishes artificial boundaries which tend to stifle the healthy growth of university computer use.

The Place of the Computer in the University

The advent of time sharing, terminals of many types, and the modular computer makes computation more flexible and powerful, but it makes the administration of computation more difficult. In the past a computer has often been administered by some special group which uses it the most, has the money to support it, has the space to house it, or sometimes merely has had the courage and energy needed to obtain the device. While all of these reasons were probably valid at the time the computer was obtained, the passage of time and changing conditions will almost certainly invalidate the original reason for control of the computational facility by a single department or specialized group.

A proper global view by its management enables the computation facility to react to the combined needs of the whole university rather than just the particular needs of a single department or group.

The ultimate administration of the facility should rest in the hands of an administrator so placed as to be cognizant of the total needs of the university. Due to the leadtime necessary to obtain additional or replacement computational equipment, the administrator of the computational facility must be aware of the long-and-short range plans of the university in order to have time to react to planned changes.

It is essential that the management of the facility have sufficient independence so as not to be dominated by any one division of the university and that there be enough intellectual leadership in the center so that it can understand the educational goals of the administration and be competent to work with the faculty and students. Caution should be exercised to make certain that all users have a forum in which their needs and dissatisfaction can be heard. When communication ceases, the usefulness of the facility decreases. This is particularly vital in the field of computer sciences. The computer sciences faculty should not be burdened with the administration of a computer center. Nor should their research and teaching interfere with the continuous and effective operation of the center in providing service. However, computer science people should have a strong voice in the introduction of new hardware and software and in adapting computers to new uses.

Facility Orientation

The chief reason for existence of a computation facility is to provide computation, whether for teaching, or research ranging from history to computer sciences.

In view of the large dollar value associated with computer devices and staffs, it would seem reasonable that all campus computational facilities should be coordinated through one person having the responsibility for the total computational and data processing needs of the campus.

Since the universities are training the men of the future, it seems obvious that the men should be trained on the most modern equipment available today in order to have a fair chance in the world of tomorrow.
Facility Operation

In order that the facility provide adequate quality service, it must be user directed. While one computer can work in practically all areas of problem solving, it is rather doubtful that one person can work in all areas. This situation requires that problem-oriented people serve as an interface between the user and the computer. Many of these problem-oriented people will be administratively outside of the facility; some may be within it. The number of interface people will vary widely with the number of user areas served by the facility and the extent of experience and capability of the interface personnel.

In general, the staff of the facility will fall into four categories: (1) administrative, (2) operational, (3) software oriented, (4) user oriented.

The administrative personnel should concern themselves with the long-and-short-range plans of the facility while continually coordinating the efforts of the other three groups.

The operational personnel should be concerned with the daily operation of the facility and should attempt to maximize throughput and minimize turnaround time.

The software-oriented personnel should concern themselves with the operating systems of the facility, ever conscious of the needs of both the user and the operations staff. The availability of good software is probably more important than good hardware. It is not necessary or desirable for most schools to write large operating systems programs since they will be available from other sources. However, it is important that software oriented personnel be available to interpret, modify, update, and add to these programs.

The user-oriented personnel are the outward face of the computer facility. They should serve as the buffer and interpreter between the user and the facility. A failure in the first line of defense can well make the rest of the facility ineffectual.

The Machine

An unfortunately common first step into the computing field is the acquisition of one or more small machines with complete open-shop operation. While this type operation is rewarding to the user, it is somewhat difficult to justify on a cost basis, and the user soon becomes disillusioned by the limited size and speed of the machine.

When the terminal is mentioned, one normally visualizes a typewriter-like device with someone operating the keyboard at a poor typing rate. The term terminal should be taken to mean any input-output device available. One can visualize not only typewriterlike terminals in using areas, but also high-speed readers and printers, graphical display devices, and small peripheral computers which store data and process it to some extent but call on the central computer for difficult processing and computation. Such terminals, and problem-oriented languages and compilers open a whole vista of possibilities for university computation utilizing a central processor and time sharing.
F. WHAT COMPUTER FACILITIES ARE APPROPRIATE

Smaller Colleges

Actual experience has shown that a single teletypewriter can expose computing to hundreds of students during the course of an academic year. Naturally, a deeper involvement in computers with more frequent exercises will require additional teletypewriters.

Secondary Schools

In general, the purpose of secondary-school education in the use of computation should be to enable the student to understand the nature, ease and power of computation, and to use it in course work in a variety of subjects. This is best done through the use of simplified languages which are not available on small computers.

G. ESTIMATION OF REQUIRED COMPUTER CAPACITY AND COST

Introduction

Estimating the required computer capacity and its cost is difficult because of the complex interrelationship of the needs, the variety of available facilities, and the uncertainty in the possible rate of growth. On the basis of available data and experience we believe that the simple programming languages, convenient terminals, and rapid access of time-sharing systems will lead to a faster growth rate and a more widespread use than with older batch-processing systems. For example, at Dartmouth, within 2 years after installing a time-sharing system, usage grew from essentially zero to the point where more than one-half of the students used the computer each quarter. Further time-sharing systems appear to be an economical means of providing high quality computing service to almost all schools.

Estimation of Needed Capacity

The basic unit in the calculation was chosen to be the average number of hours each student is at a console in each week. This figure was estimated as one-half hour per student per week. (Very roughly, this would be equivalent to one-half minute of processing per week on a large batch-processing computer.) It was obtained by estimating that those students making substantial use of the computer would total 130 hours at a console during their 4 years, those making limited use would total 46 hours, and those making casual use would total 18 hours. The average use during a 4-year curriculum, based on the estimated classification according to major areas of study, is then 0.35 (130)+0.4(46)+0.25(18)=69 hours. This is 17.25 hours per year of about one-half hour per week of the school year. The total hours of use in each category might be made up as follows:
<table>
<thead>
<tr>
<th>Substantial Hours</th>
<th>Limited Hours</th>
<th>Casual Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introductory course</td>
<td>Introductory course</td>
<td>10</td>
</tr>
<tr>
<td>10 other courses, 12 problems per course</td>
<td>4 other courses, 6 problems per course</td>
<td>3 courses, 3 problems per course</td>
</tr>
<tr>
<td>Total</td>
<td>Total</td>
<td>Total</td>
</tr>
<tr>
<td>130</td>
<td>46</td>
<td>18</td>
</tr>
</tbody>
</table>

Cost of the Consoles

... A reasonable estimate of their cost is $125/month. Since most students are in schools needing at least 10 consoles, it is assumed that about 25 percent excess is adequate.

J. EXAMPLES OF THE USE OF COMPUTING IN COURSE WORK

Business

Instructor's comments: The computer does analysis computations that would take over 100 hours on a desk calculator. Without it, the analysis would be simplified to eliminate many important aspects; with it, more time can be spent on the interpretation and meaning of the analysis.

Instructor's comments: The computer enables students to explore the process with 10-12 cases, each with 10-12 time periods. It takes the exercise out of the realm of arithmetic and makes it a real learning experience in the management of a process.

Mathematics

... "It's so fantastic it's almost impossible to say how much better the course is. The amount of practice the students get is up by one to two orders of magnitude."

Data

... Before a computer was made available to the students a problem of this sort could not be assigned because the calculations would have required too large a portion of their study time. Now they are able to do several such problems which provide a good base for considering more complex and realistic systems later. The students have reacted very enthusiastically to its introduction into the course.

... The realistic problem made possible by the computer relates the material covered in the mathematical treatment of numerical methods to a "real" engineering problem and gives students confidence in their ability to solve real problems.

A-17
The digital computer has already proved to be of great value in recording, controlling, and analyzing the masses of merchandise information which we require to run our increasingly complex business. It is also used more and more effectively in our analysis of current operations and seasonal budgeting.

It will become even more valuable as we learn to use its qualitative potentials for longer range knowledge, and decisions which we have to make. We should be using this tool to identify not only future needs of consumers, but also in what kind of environment and with what kind of services they will wish to make their purchases.

As we develop our organization for the future, we will be searching for men and women not only knowledgeable in the principles of management, but in the techniques of applying these principles as well. We will be looking to the universities to produce graduates with a broad spectrum of knowledge, including an understanding of the use of computers to manage a large business, both short and long range.

It is common to say that the computer has changed our lives, that it enables us not only to do things better, but to perform tasks never before feasible to man. What is not common is the realization that the computer has given man a new freedom, which is of enormous significance to the education and fulfillment of this generation and all those to come. It has released him from the drudgery of the past and given him new opportunities to utilize his creative powers, as the Greeks put it in another age, along lines of maximum excellence.

It is of the greatest importance, therefore, that man be educated to harness this electronic servant, for only then will he more universally be free to develop and fulfill himself creatively. And we would hope, too, that with this new freedom, our educational system will then devote greater emphasis on stimulating the inventive and innovative potential of students, for it is not sufficient merely to teach them what the computer can do for them. They must also be taught what the computer cannot do for them.

I am of the opinion that no other academic program yields as high as dividend, per time invested, as the freshman computer program. Even if the student never again touches the computer, he will leave the college with a sensible attitude toward the use of high-speed computers. We also know that a significant minority of the students avail themselves of time-sharing in connection with more advanced courses. The ability to assign computer problems as a matter of routine, in any course that has a year of mathematics as a prerequisite, is beginning to show a significant effect on the campus. Our engineering and business schools have made most imaginative use of time-sharing in a wide variety of courses.
find scattered, but interesting use throughout the science and social science departments. And everyone seems to agree that the use will expand as the faculty gains more experience...

H. W. Johnstone, Jr.
Professor of Philosophy and Assistant to the Vice President for Research,
Pennsylvania State University

Let me begin by agreeing with you (J. R. Pierce) that most undergraduates should be exposed to computers and computing as tools. But my own argument for such exposure is not that most students ought to learn to use the computer in order to solve practical problems, any more than I would argue that they should study scientific method in order to solve practical problems. Scientific method, in the form in which is sometimes a required course (or part of one) for all or most undergraduates, is a liberal study. Its purpose is to acquaint the student with the nature of scientific thinking, so that he will see science not as a kind of familiar magic that he takes for granted, but rather as a human achievement. In my view, a similar liberal course ought to be given on computers. The emphasis would be upon the concept of a computer and upon the general methods of using computers. The student who had been exposed to such a course would see the computer as a human achievement rather than as a black box to be taken for granted. He would see how the possibility of using computers to solve problems has revolutionized the ways in which we think about the problems. A person for whom the computer is merely something to be used gains from his contact with it no appreciation of the nature of the contemporary world. Such appreciation presupposes a certain awareness of the nature and method of the computer as such—an awareness that is quite different from the knack of programming in FORTRAN. No one could say that the course I have in mind is concerned with gadgetry.

I would say that the nature and method of the computer are philosophical ideas, like those of the nature and method of science in general. Most of the ideas presented in truly liberal courses are philosophical. The philosopher can be concerned with these ideas in a deeper way than is either the student or teacher of the liberal course. The philosopher is not content merely to expound the ideas; he is interested in stating as clearly as possible what they mean. Both the idea of the computer itself and society's assumptions about the use of the computer need analysis and clarification.

The philosopher sees culture as manmade, and indeed as an expression of man's view of his own nature. Medieval culture was the expression of the view that man is at home in the world. When science first arose in the 17th century, it was both the cause and the result of an increasing sense of alienation from the world. Man regarded himself as a creature of subjectivity, whose senses screened him from the invariant mathematical relationships that governed the universe in its infinity. Nowadays we are less sure that these relationships are invariant, less sure that the universe is infinite, and more confident in our own point of view. Some of this confidence has been won through the use of the computer. Its role in our culture is thus an expression of our view of our own nature.
At our symposium (the computer symposium presented at Bell Laboratories in June 1966), I was fascinated by the particular applications that you are making of computers. What impressed me most deeply was that in the number of these applications we have reached a turning point. The use of the computer has all at once spread to all aspects of our culture. It is this that struck me as being of primary philosophical relevance. What is relevant is the way the computer has changed the quality of contemporary life—not so much in satisfying our material needs as in causing us to think about ourselves in a new way.

H. O. Pollak
Director, Mathematics and Statistics Research
Bell Telephone Laboratories

... Future computing specialists, future secondary teachers of mathematics, future research mathematicians, future users of mathematics in other disciplines, and future teachers of undergraduate mathematics make up most of our body of mathematics students. It is clear that most undergraduate mathematics courses should contain questions, problems, and pieces of theory which are motivated by the numerical aspect of the subject. Furthermore, all mathematics majors should have an exposure to the computer.
APPENDIX B

(Intentionally Omitted)
Appendix C

NEEDS VERSUS DESIRES

In order to establish specifications and criteria for computer selection, it was necessary to determine required and useful features. The determination was based on extensive meetings with faculty members (most departments were consulted) as to needed and desired applications.

Those features found to be required are listed:

- ANSI COBOL and administrative applications packages.
- Versatile timesharing (BASIC or XBASE; ANSI FORTRAN; ANSI COBOL).
- Load-and-go FORTRAN.
- Concurrent batch and timesharing capability.
- Large batch processing capability (at least 100 K bytes) for at least COBOL and FORTRAN.
- Batch multiprogramming and spooling capability.
- Two or more 9 track tape drives.
- Capable statistical and scientific applications packages.
- Data base management system.
- Text processing system.
- Discrete and continuous simulation packages.
- String Manipulation language.
- CAI language and applications packages.
- Optical page reader.
- Digital plotter
- CPU to CPU communications capability (not necessarily implemented with initial configuration).

Those features found to be very valuable, although not absolutely required, are listed in order of priority:

- APL.
- Graphics capability.
- Digitizer.
- PERT and Linear Programming application packages.
- FORMAC.
November 22, 1972

To: Richard Hammill

From: LeRoy Botten

Subject: Interim Academic Feasibility Study Status Report

The Academic Feasibility Study Committee has completed the first phase of its work. From an initial group of 22 system proposals, 8 were selected for detailed study. Based on vendor presentations and literature, Data-Pro (and similar sources), and a limited sampling of reference accounts, a preliminary analysis has been completed. The analysis assigned points to about 400 categories grouped into the five major areas included in the attached table. The numbers in parentheses represent the weight assigned to the major areas.

The remaining rows in the table are self-explanatory, but should be interpreted with caution. The weighted point total is a measure of system performance; however, we deferred analysis of available applications programs until after this initial screening was completed. The monthly cost represents total cost of the system based on our purchase cost, maintenance cost, software cost (as appropriate), and a depreciation allowance for our printer. A standard pricing formula was used for comparison purposes. Before the study is completed, these costs may be changed based on revised configurations or alternative funding methods. (A standard configuration was used to permit cost comparisons—our initial installation may not require the full evaluation configuration.)

Several vendors have been eliminated on the basis of not meeting required performance criteria: Burroughs 5500, Honeywell 430, IBM 370/125, and NCR 200. We feel closer investigation will help separate the closely grouped remaining systems. In particular, now that the number of systems has been further reduced, we will be able to apply more detailed methods of study. Art Klein is doing a financial analysis on Digital Equipment Corporation, Hewlett-Packard, Xerox Data Systems, and Funding Systems Leasing Corporation. We will contact a larger sampling of reference accounts and plan visits to installations where practicable. We will arrange for proof that certain vital existing programs can be properly compiled and executed. We will be studying in great detail the available applications packages. A new series of vendor presentations on a very technical level will be scheduled.
Two other noteworthy additions have also been made to the study. The first is comparison of our study to that of (intentionally omitted). The second is a detailed consultation with (intentionally omitted) on the results of our study to date.

Although these results are encouraging, they represent only interim results. These conclusions depend heavily on what the vendors claim for the systems. This part of the study was planned to ensure that we did not overlook the potential "best possible" system. The next phase of investigation is intended to carefully verify the claims of the manufacturers and ensure that the system finally recommended will perform satisfactorily in our applications. For this reason, the final recommendations of the Academic Feasibility Committee may differ from conclusions drawn from data collected to this point.
## INTERIM SUMMARY

<table>
<thead>
<tr>
<th>B 5500</th>
<th>DEC 1040</th>
<th>HP 3000</th>
<th>HIS 430</th>
<th>IBM 370</th>
<th>NCR 200</th>
<th>U 70/46</th>
<th>XDS 6</th>
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<tbody>
<tr>
<td>Hardware Capabilities (20)</td>
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<td>101</td>
<td>103</td>
<td>69</td>
<td>79</td>
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<td>93</td>
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<tr>
<td>Growth Potential (15)</td>
<td>92</td>
<td>126</td>
<td>74</td>
<td>84</td>
<td>88</td>
<td>86</td>
<td>92</td>
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<tr>
<td>Operating System (20)</td>
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<td>110</td>
<td>88</td>
<td>67</td>
<td>74</td>
<td>21</td>
<td>65</td>
</tr>
<tr>
<td>Conversion, Maintenance and Software Support (25)</td>
<td>42</td>
<td>65</td>
<td>96</td>
<td>64</td>
<td>101</td>
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<td>483</td>
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<td>2</td>
<td>7</td>
<td>6</td>
<td>8</td>
<td>5</td>
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<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>Monthly Total Cost (60 months)</td>
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<td>8944</td>
<td>7062</td>
<td>7488</td>
<td>8435</td>
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<td>1</td>
<td>2</td>
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<td>5</td>
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<tr>
<td>Overall Ranking</td>
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<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
A. Klein of the Business and Administration Department was asked to evaluate the strength and stability of the vendors of the four systems not eliminated on the basis of criteria and Funding Leasing Systems Corporation (a firm offering computer financing via leaseback). Based on Standard and Poor's, and Argus rating systems; and on brokerage contacts the following comments are submitted:

Xerox Data Systems: 10% of gross is in computer field; Argus (scale of 1 to 4) rates Xerox Data Systems as 1; Xerox Corporation is solid, conclusions regarding Xerox Data Systems are less clear.

Univac Division of Sperry Rand Corporation: Univac is the largest contributor to Sperry Rand sales and earnings; Univac is second only to IBM in the computer industry; Univac revenues are expected to increase; Univac is very healthy.

Hewlett-Packard Company: very healthy corporation; only small fraction of business (2% of gross) is in computers; Hewlett-Packard could easily back out of the computer business; Argus (scale of 1 to 4) rates Hewlett-Packard Company as 2.

Digital Equipment Corporation: major strength in the mini-computer market; excellent profit and loss record; Argus (scale of 1 to 4) rates DEC as 3; although DEC is not as large as those firms rated above it is totally committed to the computer field; it is a very strong firm.

Funding Systems Leasing Corporation: a wholly owned subsidiary of Funding Systems Corporation; Equimark Corporation owns 51% of FSC; $47,647,000.00 is invested in FSCL; no evident problems exist.
REQUEST FOR BENCHMARK

Purpose

The principal purpose of this benchmark study is to demonstrate that certain representative programs can be executed, on the systems proposed for installation at Andrews University, by vendors receiving this request. Sample production programs, and appropriate test data, are also included in order to measure ease of conversion. The secondary purpose of the study is to measure compile, execution, and response times of representative programs, under controlled circumstances, as an aid in assessing processing capabilities of the various proposed systems.

Andrews University does not suggest that the programs submitted constitute a comprehensive or representative mix of processing to be accomplished in the future. Rather, the programs were chosen to exercise certain compiler and machine features which are of particular interest.

Time Frame

In order to obtain system delivery at a time acceptable to Andrews University, an order must be placed no later than the middle of January 1973. For that reason we must require that results of this study be in the hands of LeRoy Botten absolutely no later than 1:00 p.m. on January 8, 1973. Please do not request deviations from this policy, none can be granted. If for some reason the study can not be completed, please return partial results. Results received after the stated time can not be considered.

Evaluation of Results

Andrews University reserves the right to make the final determination of the value and usefulness of any or all parts of the study. In view of the commonly understood difficulties of conducting a fair benchmark study, we do not intend to make a final determination necessarily based on the results of the benchmark. Nevertheless, we do desire results which can be used to make meaningful comparisons between proposed systems.

Since a relatively short time has been allowed to complete the study, we do not expect that a test system will be configured precisely to the bid configuration. It is necessary that a full description of the test configuration be forwarded with test results. Results submitted without an adequate configuration summary will not be considered.

One of the most difficult tasks in evaluating a benchmark study is determining how variations between bid and test configurations have biased
results. Realizing that each vendor is in the best position to understand any existing biases, we expect that a full disclosure of such biases will accompany test results. The cover letter accompanying test results, or partial test results, must contain the following statement:

"(Vendor) certifies the configuration proposed for Andrews University will meet or exceed performance standards specified or implied by the attached benchmark test results. Where necessary, due to differences between proposed and test configurations, results of tests have been adjusted to represent the proposed configuration performance. All such adjustments have been specifically noted. (Vendor) is willing to include in the final contract a commitment to rerun the benchmark study on the installed system as a final acceptance test such that system acceptance by Andrews University will be contingent on performance equal or better in all respects than performance specified or implied by the enclosed test results."

Please understand the intent of the above paragraph is to help prevent a difficulty common to many benchmarks: test systems that are configured to perform better than proposed systems. Vendor cooperation with the intent of this paragraph should help Andrews University to fairly interpret the results of this benchmark study. Results submitted without the above statement will not be considered.

Programs

The test programs (described in enclosures) will be identified in the test procedures as follows:

**BASIC**

B1 BATCH REGRESSION  
B2 CONVERSATIONAL REGRESSION  
B3 RANDOM  
B4 MATRIX  
B5 FILES  
B6 GRAPH  
B7 ALPHA  
B8 B CRUNCH

**COBOL**

C1 FILE  
C2 CREATE UPDATE  
C3 PRINT  
C4 COPY  
C5 SORT  
C6 DEMO (data for C2, CREATE)  
C7 DEMO (data for C2, UPDATE)
Conversion Test

Record man-hours and systems resources required to convert COBOL programs C1, C2, C3, C4, and C5. Provide listings of converted programs.

Dedicated Machine Performance Tests

In order to allow controlled timing tests, the following programs are to be separately run on a totally dedicated system in the timesharing mode: B8, C1, F1. Program logic includes print statements which are to be used in timing. Using a stopwatch, time the interval between the "RUN" command and start of the output, "START;" record this interval as "compile time." Using a stopwatch, time the interval between the start of output, "START," and the completion of output, "STOP;" record this interval as "execution time."

Similarly, the following programs are to be separately run on a totally dedicated system in the batch mode: B8, C1, F1. Modify program code as necessary to use system interval timer to record "compile time" and "execution time" as defined in the previous paragraph. Record interval timer precision.

Language Tests

Make coding changes required to execute B1, B2, B3, B4, B5, B6, and B7 in the timesharing mode. Submit a listing of each program as executed and corresponding output.

Make coding changes required to execute C2, C3, C4, and C5. Submit a listing of each program as executed, compile-through-load time for each program, and output from C3. Timing to be based on system interval timer (make coding changes required for its use with each program).

Make coding changes required to execute F2, F3, F4, and F5. Submit a listing of each program as executed, compile-through-load time for each program, and output from each program. Timing to be based on system interval timer (make coding changes required for its use with each program).

Multiprogramming and Concurrent Processing Tests

For the background processing in this test two job streams are to be used: a precompiled COBOL job stream composed of data C6 and C7 processed by
precompiled programs C2, C3, and C4; and a sequence of compile-and-go runs for F2, F3, F4, and F5. Each of these job streams is to be run in the order shown. On completion of each sequence the cycle is to be immediately restarted (e.g., F2, F3, F4, F5, F2, F3, F4, F5, F2, ...). Using the system interval timer, measure the time from start to end of each sequence (as requested below) and record as "COBOL sequence time (CST)" and "FORTRAN sequence time (FST)" respectively. Submit a listing of each sequence as executed.

No Timesharing Users

Record average values of CST and FST with no timesharing users.

Five Timesharing Users

Record average values of CST and FST with five timesharing users occupied as follows (each user repeats his "assigned" process during duration of test phase):

1 creating and debugging B1
2 running B2
1 creating and debugging C1
1 creating and debugging F5

Ten Timesharing Users

Same as for five timesharing users, except two sets of timesharing users as described above.

Fifteen Timesharing Users

Same as for five timesharing users, except three sets of five timesharing users as described above.

Minimum Standards

Although all parts of the benchmark test are of interest, the time allowed for completion is somewhat less than would normally be expected. Andrews University is most interested in complete results for the Conversion Test, the Language Tests, and at least some demonstration of multiprogramming and concurrent (timesharing with batch) operation. When these results are assured the other tests should be run.
BASIC PROGRAMS
This represents a typical student program in which the student takes about 15 minutes typing in the initial source program and then takes about 10 minutes debugging and testing the program running it several times while making the corrections.

10 LET T1=T2=T3=T4=T5=0
20 READ N
30 FOR I=1 TO N
40 READ Y, X
50 LET T1=T1+X
60 LET T2=T2+Y
70 LET T3=T3+X*X
80 LET T4=T4+Y*Y
90 LET T5=T5+X*Y
100 NEXT I
110 LET V1=N*(T1*T1/N)
120 LET V2=T4-T2*T2/N
130 LET V3=T5-T1*T2/N
140 LET B=V3/V1
150 LET A=T2/N-B*T1/N
160 PRINT "Y INTERCEPT A", A
170 PRINT "SLOPE B", B
180 LET R=V3/SQR (V1*V2)
190 PRINT "CORRELATION R", R
200 STOP
210 DATA 5
220 DATA 12, 1
230 DATA 18, 2
240 DATA 26, 3
250 DATA 42, 4
260 DATA 55, 5
270 END
This represents a typical library program in statistics or a program in computer assisted instruction. The user calls the program that has been stored on line and then uses it for one or two problems. The whole procedure may take 5 minutes of question and answer dialogue.

```
10 PRINT "SIMPLE LINEAR REGRESSION"
20 PRINT "NUMBER OF OBSERVATIONS";
30 INPUT N
40 LET T1=T2=T3=T4=T5=0
50 PRINT "TYPE Y, X FOR OBSERVATION"
60 FOR I=1 TO N
70 PRINT I;
80 INPUT Y, X
90 LET T1=T1+X
100 LET T2=T2+Y
110 LET T3=T3+X*Y
120 LET T4=T4+Y*Y
130 LET T5=T5+X*Y
140 NEXT I
150 LET V1=T3-T1*T1/N
160 LET V2=T4-T2*T2/N
170 LET V3=T5-T1*T2/N
180 LET B=V3/V1
190 LET A=T2/N-B*T1/N
200 PRINT "Y INTERCEPT A", A
210 PRINT "SLOPE B" , B
220 LET R=V3/SQR (V1*V2)
230 PRINT "CORRELATION", R
240 GOTO 20
250 END
RUN
```

```
SIMPLE LINEAR REGRESSION
NUMBER OF OBSERVATIONS? 5
TYPE Y, X FOR OBSERVATION
1?12, 1
2?18, 2
3?26, 3
4?42, 4
5?55, 5
Y INTERCEPT A  #######
SLOPE B  #######
CORRELATION   #######
NUMBER OF OBSERVATIONS? STOP
PROGRAM STOPPED.
```
This program demonstrates the random number generator and the RANDOMIZE statement.

10 RANDOMIZE
20 FOR I=1 TO 30
30 PRINT INT (100*RND);  
40 NEXT I
50 STOP
60 END
The following program demonstrates the MAT commands solving a set of \( n \) simultaneous linear equations for \( n \) unknowns.

```
10   DIM A (10,10), B (10,1), V (10,10), X (10,1)
20   READ N
30   MAT READ A (N,N), B(N,1)
40   MAT V=INV (A)
50   MAT X=V*B
60   MAT PRINT X
70   STOP
80   DATA 2
90   DATA 1,3
100  DATA 2,1
110  DATA 20,30
120  END
```
This program illustrates file handling procedures for creating files, reading and writing files, and listing files.

NEW: FILE1
10   2,4,3
20   1,1,2
30   2,1,6
40   3,3,2
SAVE
NEW: FILE2
SAVE
NEW: PROG
10   FILES FILE1; FILE2
20   READ #1; A,B,C
30   IF END #1 THEN 70
40   LET T=A+B+C
50   WRITE #2; A,B,C,T
60   STOP TO 20
70   STOP
80   END
RUN
OLD: FILE2
LIST
This program creates a graph using the TAB function.

10 FOR X=6 TO 50 STEP 2
20 LET T=10*SQR (X)
30 PRINT X;TAB(T);"*"
40 NEXT X
50 STOP
60 END
This geography drill creates and uses an alphabetic list.

10 DIM A$(100), B$(100)
20 READ N
30 FOR I=1 TO N
40 READ A$(I), B$(I)
50 NEXT I
60 PRINT "GEOGRAPHY DRILL"
70 PRINT "TYPE THE NAME OF THE CAPITAL CITY"
80 PRINT "AFTER THE STATE"
90 FOR I=1 TO N
100 PRINT A$(I); 
110 INPUT X$
120 IF X$=B$(I) THEN 140
130 PRINT "CORRECT ANSWER IS"; B$(I)
140 NEXT I
150 STOP
160 DATA 5, OHIO, COLUMBUS, OREGON, SALEM, COLORADO, DENVER
170 DATA MARYLAND, ANNAPOLIS, MICHIGAN, LANSING
180 END
This program is designed to test the looping mechanism and, to some extent, the raw processing power in BASIC.

```
10 PRINT "START"
20 LET T=0
30 FOR I=1 TO 1000
40 FOR J=1 TO 1000
50 LET T=T+1
60 NEXT J
70 NEXT I
80 PRINT "STOP",T
90 STOP
100 END
```
This program is designed to test the looping mechanism and, to some extent, the raw processing power in FORTRAN.

\begin{verbatim}
WRITE(6,2)
2 FORMAT(6H START)
T=0.0
DO 4 I=1, 1000
  DO 4 J=1, 1000
  4 T=T+1.0
WRITE(6,6) T
6 FORMAT(5H STOP,F15.0)
STOP
END
\end{verbatim}
This program uses iteration to calculate the Debye-Waller factor for data included in the program. The solution found is for equation (2.111).

The control cards included in the listing are for WATFIV.
LATTICE WAVES

The phenomenon of inelastic diffraction is a valuable tool for the study of the lattice dynamics of crystals. The beam diffracted in a particular direction is associated with lattice modes having a definite wave-vector \( \mathbf{q} \). One can look at the change of energy of the diffracted particles, and hence measure \( h\nu_\mathbf{q} \). By looking in different directions, and moving the crystal into different orientations, one can plot out the whole function \( \nu_\mathbf{q} \). Of course, this has several branches, of different polarization, but these may be separated by systematic analysis.

However, this experiment is only practicable with 'thermal' neutrons, whose wavelength is of the order of the lattice spacing at energies of the order of 0.1 eV. The shift due to the phonon energy, which is of the order of \( kT \) or less—perhaps 0.01 eV—can easily be observed. For electrons and X-rays the beam energy must be much higher—tens or hundreds of electron volts—so that the small change in energy in the diffraction process cannot be detected.

2.9 The Debye–Waller factor

The terms in (2.97), corresponding to scattering processes involving one phonon, are not all that may occur in the structure factor (2.95). It is easy to see that the product of factors like (2.96), and also higher terms in the expansion of the exponential, give rise to contributions containing various products of factors like \( U_\mathbf{q} \exp(i\mathbf{q}\cdot\mathbf{l}) \). For each such factor, one says that the corresponding phonon has been created or destroyed, so that these terms refer to multiphonon processes.

Generally speaking, these processes fall off rapidly in rate as we go to higher order, and do not contribute very heavily to the background of inelastic diffraction. There is, however, an important class of terms, arising from the squared term \(-\frac{1}{2}|K\cdot U_\mathbf{q}|^2\) in the expansion (2.96), which do not average to a small contribution. If we look at (2.95) and (2.96), we find that matrix element for both elastic and inelastic scattering ought to be multiplied by

\[ e^{-\mathcal{W}} = \prod_{\mathbf{q}} (1 - \frac{1}{2}|K\cdot U_\mathbf{q}|^2). \]  

(2.103)

This is called the Debye–Waller factor. It is written in this form because we can use a standard theorem of algebra

\[ \lim_{N \to \infty} \prod_{n=1}^{N} \left(1 - \frac{1}{N}a_n\right) = \exp\left(-\lim_{N \to \infty} \frac{1}{N} \sum_{n=1}^{N} a_n\right) \]  

(2.104)
2.9] **LATTICE WAVES**

to transform the product into a sum. Thus

\[ e^{-iW} = \exp\{-\sum_q \frac{1}{2} |K \cdot U_q|^2\}, \]  

(2.105)

i.e.,

\[ W = \sum_q |K \cdot U_q|^2. \]  

(2.106)

To evaluate this sum, we need to know the amplitude, \( U_q \), of the \( q \)th lattice mode. This will be a function of the temperature. We know that the average energy in this mode is given by (2.47);

\[ \langle E_q \rangle = (\bar{n}_q + \frac{1}{2}) \hbar \nu_q, \]  

(2.107)

where \( \bar{n}_q \) is the average number of phonons in the mode, as given by the Bose–Einstein formula (2.46).

Classically, we can calculate the energy of each simple-harmonic oscillator mode as the sum of its kinetic and potential energies. These are known to be equal—so we have, from (2.1) and (2.8),

\[ \bar{E} = \sum_{\ell} M_{\ell} |\dot{U}_{\ell}|^2 \]

\[ = \sum_{\ell} N M_{\ell} |\dot{U}_{\ell}|^2 \]

\[ = \sum_{\ell} N M_{\ell} \nu_{\ell}^2 |U_{\ell}|^2. \]  

(2.108)

If there is only one atom per unit cell, of mass \( M \), then

\[ |U_q|^2 = \frac{\bar{E}}{N M \nu_q^2} = \frac{\langle \bar{n}_q + \frac{1}{2} \rangle \hbar N M \nu_q^2}{N M \nu_q^2}. \]  

(2.109)

We know the polarization of \( U_q \) for each branch of the lattice spectrum, so that we can, in principle, calculate the Debye–Waller factor exactly.

To see how it should behave let us assume a Debye model with all three modes having the same velocity. For any one polarization we should find, on the average

\[ |K \cdot U_q|^2 = \frac{1}{2} K^2 |U_q|^2, \]  

(2.110)

but with three different polarizations the factor \( \frac{1}{3} \) is removed.†

† There is a useful rule: in this model, the three modes are degenerate at each value of \( q \). Therefore one can choose the polarization vectors at will, provided they are orthogonal. One therefore chooses one mode to have \( U_q \) parallel to \( K \), the other two normal to \( K \). This yields the result we need.
From (2.46), (2.56) and (2.109) we have

\[ W = \frac{3}{8} K^2 \frac{\hbar^2}{M} \int \frac{d^3q}{\pi \hbar} \left( \frac{1}{\nu_q} \right)^2 \]

\[ = \frac{3}{2} \frac{\hbar^2 K^2}{M k\Theta^3} \int \frac{d\nu}{\nu^2} \left( \frac{1}{e^{\hbar \nu kT} - 1} + \frac{1}{2} \right)^2 \]

\[ \Rightarrow \frac{3}{8} \frac{\hbar^2 K^2}{M k\Theta^3} \int \frac{d\nu}{\nu^2} \left( \frac{1}{e^{\hbar \nu kT} - 1} + \frac{1}{2} \right)^2 \]

as in (2.57).

At high temperatures the upper limit of the integral is small, and the exponential factor in the integrand can be expanded in powers of \( z \).

The result is

\[ W \rightarrow \frac{3}{8} \frac{\hbar^2 K^2}{M k\Theta^3} \]  

Thus, the X-ray diffraction pattern, which is proportional to the square of the matrix element \( M_{kk} \), is reduced in intensity by a factor

\[ e^{-2W} \sim \exp \left( -\frac{3\hbar^2 K^2 T}{M k\Theta^3} \right). \]

This factor depends quite strongly on the temperature, and also on the magnitude of the scattering vector. This result would be obtained if we used classical statistics for the average energy of each mode, i.e. \( \Theta_v = kT \).

At temperatures below the Debye temperature the formula is more complicated, but we note that \( W \) will tend to a constant at the lowest temperatures. This is due to the term \( \frac{1}{2} \) in the integral—a term arising from the zero-point motion of the lattice. This is not a negligible effect:

\[ W \rightarrow \frac{3}{8} \frac{\hbar^2 K^2}{M k\Theta^3} \text{ as } T \rightarrow 0, \]

which is \( \frac{1}{4} \) of the value of \( W \) at \( T \sim \Theta \). Zero-point energy may be physically irrelevant, but the motion associated with it can be observed directly.

The derivation of (2.111) provides us, incidentally, with another interesting result. It is clear from (2.1) and (2.8) that the mean square amplitude of the vibration of each atom about its lattice site is given by

\[ \frac{1}{N} \sum_i |u_i|^2 = \sum_q |U_q|^2 \]

\[ \approx \frac{9 \hbar^2 T}{M k\Theta^3} \]  

(2.115)
LATTICE WAVES

above the Debye temperature. At the temperature $T$ the root-mean-square displacement of each atom from its equilibrium site will thus be a fraction $x$ of, say, the mean radius $r_s$ of a unit cell, where

$$x = \sqrt[3]{\frac{9h^2T}{4\pi\hbar^2}}.$$  \hspace{1cm} (2.116)

The Lindemann melting formula is based upon this idea. It is suggested that a solid must melt when $x$ attains some standard value, $x_m$. Thus, the melting temperature $T_m$ is related to the other atomic constants of the solid by

$$T_m = \frac{x_m^2}{9\hbar^2} \frac{MkT}{\gamma_s^2}.$$ \hspace{1cm} (2.117)

It seems that $x_m$ is in the range 0.2-0.25 in most solids.

This rule may be used to estimate the Debye temperature approximately from knowledge of $T_m$. It also provides a convenient short cut for estimating values of quantities, like $W$, which depend on the amplitude of the atomic vibrations. For example, we can show that (2.112) can be written

$$W \approx x_m^2 \frac{T}{T_m} \frac{K^2}{d_D^2},$$ \hspace{1cm} (2.118)

where $d_D$ is the Debye wave-number (2.53).

2.10 Anharmonicity and thermal expansion

At the beginning of this chapter, we expanded the potential energy of the crystal as a Taylor series in the lattice displacements. But this series, (2.2), was curtailed at the second-order term. There will be further terms, such as

$$\mathcal{V}^{(3)} = \sum_{\epsilon \neq \epsilon^*} u_i^* u_i^* u_i^* \left[ \frac{\partial^3 \mathcal{V}}{\partial u_i^* \partial u_i^* \partial u_i^*} \right]^0,$$ \hspace{1cm} (2.119)

and so on. The actual calculation of the coefficients is a very complicated problem.

Several important physical phenomena are associated with the anharmonic terms. Of these the most familiar is thermal expansion. It is not easy to derive this directly from expressions like (2.119), but the general physical idea is easy enough. As the temperature rises the amplitude of the lattice vibrations increases, so that the average R.M.S. values of the displacements $u_i$, etc., increase. The anharmonic terms contribute to the free energy of the crystal, which is now no longer
//TWOTEMP JCP (J34EIBM,2091,2) ---------GUENZER-----
// SERVICE CLASS=Q
//YES EXEC WATFIV
//EC-SYS IN CC *

//** LINEAR REDUCTION OF DIFFRACTION DATA (INTEGRATED INTENSITIES)**
C FOR ZINC-BLEND STRUCTURE POWERS
C TO PRODUCETHREE DEBYE-WALLER FACTORS
C
C PROGRAM WILL HANDLE ALL POSSIBLE PAIRS OF PEAKS. "PEAK TYPES"
C IDENTIFIED BY FIRST TWO VARIABLES ON DATA CARDS,
C KEY-LETTERS 'E1', 'E2', 'R' REPRESENTING EVEN, ODD, AND RIGHT-
C ANGLES PEAKS

REAL *4 KAPA, KAPB
COMMON /AVELWA/ FLAMBD

CALL CMPLXF (27, TEETAA, FZERB, FZER1, ALPHAB)
CALL CMPLXF (19, TEETAB, FZERB, FZER1, PHIA)
CHY=146./FMASSY
DO 500 ITINES=1,20
     ZX1=THCXXC/T1
     ZX2=THCXXC/T2
     ZY1=THCYYC/T1
      ZY2=THCYYC/T2
UX1=(CHY/((X1*THCX)))*(CDBY1((X1)*ZXY1))
UX2=(CHY/((X2*THCX)))*(CDBY1((X2)*/ZXY1))
UY1=(CHY/((Y1*THCYY)))*(CDBY1((Y1)*/ZXY1))
UY2=(CHY/((Y2*THCYY)))*(CDBY1((Y2)*/ZXY1))
GAX1=(FXA*EXP(-PSIA*X1))**2
GAX2=(FXA*EXP(-PSIA*X2))**2
GAY1=(FYA*EXP(-PSIA*Y1))**2
GAY2=(FYA*EXP(-PSIA*Y2))**2
GEX1=(FXE*EXP(-PSIA*EX))**2
GEX2=(FXE*EXP(-PSIA*EX))**2
GBY1=(FYB*EXP(-PSIA*Y1))**2
GBY2=(FYB*EXP(-PSIA*Y2))**2
CALL CROSST (GAXIT,GAX2,GAY1,GAY2,GBY1,GBY2,IDEN,
              IDPHIB,ALPHA,HEL,FE2)
WRITE (6,7714) ITINES,GAX1,GAX2,GAY1,GAY2,GBY1,GBY2,
              VX1/VX2/VY1/VY2
C** CHANGE CONVERGENCE VARIABLE TO 1/THETA, WHICH CAN BE ACCEPPLISFED
C INSERTING AN EXTRA (THETA**2)
     VX1=(CHY/((X1)**2))**(VDBXZ)**2
     VX2=(CHY/((X2)**2))**(VDBXZ)**2
     VY1=(CHY/((Y1)**2))**(VDBXZ)**2
     VY2=(CHY/((Y2)**2))**(VDBXZ)**2
CALL CROSST (GAX1,GAX2,GAY1,GAY2,IDEN,DPHIA,ALPHA,FA1,FA2)
CALL CROSST (GAX1,GAX2,GAY1,GAY2,IDEN,DPHIA,ALPHA,FA1,FA2)
WRITE (6,715) ITINES,GAX1,GAX2,GAY1,GAY2,GBY1,GBY2,
C 1
HX1=FA1,FY1,FZ1
C715 FORMAT ('C ON STEP,16,'INDIVIDUAL TERMS ARE 1/X,12E11.4)
C1=GAX1(GAY1+2.D*FA1-ETAA2*(GAX2+GAY2+2.D*HA2)
C2=FX1+GAY1+2.C*HAI-ETAA2*(GAX2+GAY2+2.D*HA2)
D11=2.0*PSIA*(VX1*(GAX1+HA1)-ETAA2*VX2*(GAX2+HA2))
D12=2.0*PSIA*(VY1*(GAY1+HA1)-ETAA2*VY2*(GAY2+HA2))
D21=2.0*PSIA*(VX1*(GAX1+HA1)-ETAA2*VX2*(GAX2+HA2))
D22=2.0*PSIA*(VY1*(GAY1+HA1)-ETAA2*VY2*(GAY2+HA2))
WRITE (6,713) C1,C2,D11,D12,D21,D22
C713 FORMAT ('C UNUSING VARIABLES ARE 1/X,12E12.4)
DET=D11*D22-D12*D21
CX1=(C1+C2-C12+C21)/DET
CY1=(D11-C12+D21)/DET
CXY=1./THEXC*GXY1
THEXYC=1./GXY1
WRITE (6,7714) THDBXC,THDBYC,GXYC,GXY1,CX1,CY1
7714 FORMAT ('C DEBYE TEMPERATURES,2F11.5,5X,4E14.5)
IF (THEDBX<=.0. OR. THEDBY<=.0.) GC TC 501
IF (ABS(X1)XQG00001) GC TC 510
500 CONTINUE
501 ENDE=(GAX1+GAY1+2.C*HA1)/(GAX2+GAY2+2.C*HA2)
      ENDE=(GAX1+GAY1+2.C*HA1)/(GAX2+GAY2+2.C*HA2)
WRITE (6,7719) ETA2,ETA2,ETAA,ETA2
7719 FORMAT ('C CONVERGENCE UNSATISFACTORY,5X,4F10.6)
502 CONTINUE
GO TO 595
C ** CALCULATE RATIOS USING FINAL PARAMETER VALUES
CONTINUE
ENCA = (CAX1 + GAY1 + C*HA1) / (GAX2 + GAY2 + C*HA2)
ENCF = (C1X1 + GY1 + C0*H11) / (G3X2 + G3Y2 + C0*H2)
WRITE (6, 721) ETA42, ETA20, ENDA, ENDO
F0M0T1 (INC FINAL -- EXPERIMENTAL RATI0S , 15X, DERIVED RATI0S )
WRITE (1, 721) F1A42TE1A621ENDA, LND3

FUNCTION WVC6B(Z)
C** CALCULATES SOME FIRST DERIVATIVE OF THE FIRST C6EYE INTEGRAL AND
C ANOTHER TERR, I.E. MEAN SQUARE DISPLACEMENT
WVC6B = (-3.*UNTYE112)/(Z**3 + 1.0) / (Z**2 + (EXP(2) - 1.0) - 25/Z**2)
RETURN

FUNCTION ATMC6C (THET, IJ)
C** THESE ARE THE ATOMIC_SCATTERING FACTORS
C TAKEN FROM L. J. THOMAS AND K. LIPEDA J. CHEM. PHYS. 20, 293, 1557
C /
C ** Z=48 ++ IGNITED */
C ** Z=52 ++ IGNITED */
C ** LINEAR COMBINATION OF Z=52 AND Z=54 BOTH NEUTRAL */
C ** Z=54 NEUTRAL */
C ** Z=68 ++ IGNITED */
C ** Z=15 NEUTRAL GALLIUM */
C ** Z=15 NEUTRAL PHOSPHORUS */
C ** Z=80 NEUTRAL MERCURY */
REAL*4 SCFC (21, 6)
REAL*4 CC1 (31)
A46.00, 45.42, 43.86, 41.43, 38.86, 35.64, 33.22, 30.86, 28.03, 27.00, 25.35
A23.83, 22.43, 21.16, 20.05, 19.09, 18.23, 17.47, 16.71, 16.04, 15.38
A13.56, 12.59, 12.03, 11.48, 11.08, 10.68, 10.31, 10.03, 9.85, 9.77

REAL*4 CC2 (31)
A52.23, 50.00, 47.82, 45.65, 43.59, 41.50, 39.44, 37.44, 35.47, 33.52, 31.76, 29.55
A15.06, 13.22, 11.38, 9.55, 8.74, 7.96, 7.19, 6.42, 5.65, 4.91

REAL*4 CC3 (31)
A54.00, 52.83, 50.66, 48.51, 46.35, 44.22, 42.10, 39.97, 37.83, 35.69, 33.55, 31.49, 29.45
A26.54, 24.34, 22.13, 20.05, 17.97, 15.92, 13.86, 11.81, 9.75, 7.71
A15.06, 13.22, 11.38, 9.55, 8.74, 7.96, 7.19, 6.42, 5.65, 4.91

REAL*4 CC4 (31)
A54.00, 52.83, 50.66, 48.51, 46.35, 44.22, 42.10, 39.97, 37.83, 35.69, 33.55, 31.49, 29.45
A26.54, 24.34, 22.13, 20.05, 17.97, 15.92, 13.86, 11.81, 9.75, 7.71
A15.06, 13.22, 11.38, 9.55, 8.74, 7.96, 7.19, 6.42, 5.65, 4.91

REAL*4 CC5 (31)
A78.00, 76.78, 75.56, 74.34, 73.12, 71.90, 70.70, 69.50, 68.30, 67.10, 65.90
A43.93, 41.87, 40.81, 39.76, 38.71, 37.66, 36.61, 35.56, 34.51, 33.45, 32.40
A20.25, 18.22, 16.19, 14.16, 12.13, 10.10, 8.07, 6.04, 4.01, 2.00

REAL*4 CC6 (31)
A28.00, 25.70, 23.40, 21.10, 18.80, 16.50, 14.20, 11.90, 9.60, 7.30
A15.00, 12.95, 10.90, 8.85, 6.80, 4.75, 2.70, 0.65, 2.60

REAL*4 CC7 (21)
A15.00, 12.95, 10.90, 8.85, 6.80, 4.75, 2.70, 0.65, 2.60
A15.00, 12.95, 10.90, 8.85, 6.80, 4.75, 2.70, 0.65, 2.60
A15.00, 12.95, 10.90, 8.85, 6.80, 4.75, 2.70, 0.65, 2.60
A15.00, 12.95, 10.90, 8.85, 6.80, 4.75, 2.70, 0.65, 2.60
A15.00, 12.95, 10.90, 8.85, 6.80, 4.75, 2.70, 0.65, 2.60
A15.00, 12.95, 10.90, 8.85, 6.80, 4.75, 2.70, 0.65, 2.60
REAL*4 C(1,15)

INTEGER I

PARAM=S(TETA)/ELANTO

IF (PARAM.GE.0.0 .AND. PARAM.LE.1.5)

WRITE (12,1) TETA

SUBROUTINE CMPLXF (TETA,FLAM,FZERC,FPHASE)

C** DISPERSIVE PARTS OF THE SCATTERING FACTOR ARE LINEARLY INTERPOLATED.

C FROM TABLES IN THE CRYSTALLOGRAPHY TABLES FOR MG-RADIATION AND

C THEN COMBINED WITH THE ZERO-ORDER PART, FZERC, AND THE MAGNITUDE

C AND PHASE RETURNED.

C VALUES ARE FROM INTERNATIONAL TABLES OF X-RAY CRYST.

C IF TETA<25

C THEY ARE ARRANGED TE, HG, P, GA

REAL*4 FR(4,3)  /-5.7,-6.2,-2.6,-2.9,-3.0,  
A  0.1,C,-1.C,1,C,0.2,1.1/C,2.0,P, 
1  FI(4,4) /2.2,2.0,1.0,0.1,1.0,1.9,7.9,9.0, 
A  0.2,2.0,1.0,0.2,1.1,7.1,6.1,5.1,5.7/ 

FKAP=SIN(TETA)/FLAM

IF (FKAP.GE.0.0 .AND. FKAP.LE.0.6) GC TO 110

IF (FKAP.GE.0.6 .AND. FKAP.LE.0.9) GC TO 120

IF (FKAP.GE.0.9 .AND. FKAP.LE.1.3) GC TO 130

WRITE (6,213) TETA,FLAM

STOP

110 FIMAC=FI(1,1)*(FI(1,2)-FI(1,1))*FKAP/0.6

C TO 125

120 FIMAC=FI(1,2)*(FI(1,2)-FI(1,1))*FKAP/0.6

125 FREAL=FR(1,1)*(FR(1,2)-FR(1,1))*FKAP/0.9

C TO 130

130 FREAL=FR(1,2)*(FR(1,2)-FR(1,1))*FKAP/0.9
EMAC = SCRT(IFIMREAL**2 + FIMAG**2)

EPHASE = ATAN(FD/AC) / FZERC4FREAL

WRITE (6, 227) FZL, FREAL, FIMAG, FPHASE

SUBROUTINE COSST (GAX1, GAX2, GAY1, GAY2, IDENA, DPBIA, ALPHA, FA1, HA2)

C ** THIS SUBROUTINE CALCULATES THE CROSS TERM IN THE INTENSITY

C EXPRESSION (INCLUDING DISPERSIVE EFFECTS). THE FCPH OF THE

C EXPRESSION DEPENDS ON IDENA

DATA IDENA, IDEN6, IDENX, IDEN1, IDEN2, IDEN3, IDEN4, IDEN5, IDEN6

IF (IDENA .LT. IDEN6) GO TO 41C
IF (IDENA .EQ. IDEN6) GO TO 42C
IF (IDENA .GT. IDEN6) GO TO 43C
STOP 40C

41C HA1 = SCRT(GAX1 * GAY1) * COS(DPHIA)
HA2 = SCRT(GAX2 * GAY2) * COS(DPHIA)
GO TO 450

42C HA1 = SCRT(GAX1 * GAY1) * COS(DPHIA)
HA2 = SCRT(GAX2 * GAY2) * COS(DPHIA)
CC TO 45C

43C HA1 = SCRT(GAX1 * GAY1) * (2.0 * ALPHA - 1.0)
HA2 = SCRT(GAX2 * GAY2) * (2.0 * ALPHA - 1.0)
GO TO 45C

450 CONTINUE
RETURN

FUNCTION DEBYE1(Y)

X = Y
IF (X) GO TO 22CC
WRITE (6, 222)
STOP.

100 IF (X .LE. C) 100C, 200C, 200C

110 F1 = 1.0 / (1.0 + X**2)
F2 = 2.0 / (1.0 + X**2)
F3 = 3.0 / (1.0 + X**2)
F4 = 4.0 / (1.0 + X**2)
F5 = 5.0 / (1.0 + X**2)
F6 = 6.0 / (1.0 + X**2)
F7 = 7.0 / (1.0 + X**2)
F8 = 8.0 / (1.0 + X**2)
F9 = 9.0 / (1.0 + X**2)
F10 = 10.0 / (1.0 + X**2)
RETURN

2000 ZETA2 = 1.0 / (X**2)
SUM = C, C

2100 SLH = SUM + EXP(-K*X)/K**2
RETURN

SCAFA EG 106.0 81.0 122.55 66.54 1187.83 500.50 5010913.50 2391.59 0.0

G-26
Pages "92" through "94" describe a subroutine for calculating Fourier coefficients using Romberg integration. Pages "95" and "96" contain listings of the main program and required subroutines. Data is listed at the bottom of page "96," and required output is shown on page "97."
EXAMPLE 2.2
FOURIER COEFFICIENTS USING ROMBERG INTEGRATION

Problem Statement
Write a general-purpose subroutine named TROMB that uses the Romberg integration algorithm outlined in Section 2.7 to evaluate numerically the integral

$$\int_{a}^{b} f(x) \, dx \quad (2.2.1)$$

where $f(x)$ is any single-valued function and $a$ and $b$ are finite. The program should first use the trapezoidal rule with repeated interval halving to determine $T_{0,1}$, $T_{1,1}$, ..., $T_{N_{\text{max}+1}}$ from (2.52a) and the recursion relation (2.53). Then the Romberg sequences $\{T_{N,j}\}$ should be computed from the general extrapolation formula (2.61) for all $j \leq j_{\text{max}}$. The Romberg Tableau should be organized as illustrated in Table 2.1.

To test the subroutine, write a general-purpose program that calls on TROMB to evaluate the coefficients of the Fourier expansion for any arbitrary function $g(x)$, periodic with period $2\pi$, such that $g(x) = g(x + 2k\pi)$ for integral $k$. The Fourier expansion may be written [14]

$$g(x) = \sum_{m=0}^{\infty} c_{m} \cos mx + \sum_{m=0}^{\infty} d_{m} \sin mx, \quad (2.2.2)$$

where

$$c_{m} = \frac{1}{\pi} \int_{-\pi}^{\pi} g(x) \cos mx \, dx \quad (2.2.3)$$

$$d_{m} = \frac{1}{\pi} \int_{-\pi}^{\pi} g(x) \sin mx \, dx. \quad (2.2.4)$$

Write the program so that the coefficients $(c_{m}, d_{m})$ are calculated in pairs, for $m = 0, 1, \ldots, m_{\text{max}}$.

As a test periodic function, $g(x)$, use the sawtooth function of Fig. 2.2.1.

![Sawtooth Function](image)

Figure 2.2.1 A periodic sawtooth function.

Method of Solution
The subroutine TROMB is a straightforward implementation of the trapezoidal rule of (2.52a), followed by repeated interval halving using the recursion relation of (2.53),

$$T_{N+1,j+1} = \frac{1}{2} \left( T_{N,j+1} + \frac{(b-a)}{2^{N-1}} \sum_{i=1}^{\infty} \left( a + \frac{(b-a)}{2^{i}} \right) \right),$$

for $N = 1, 2, \ldots, N_{\text{max}}$. The Romberg extrapolation formula of (2.61),

$$T_{N,j} = \frac{A_{j-1}^{N+1,j}-T_{N,j-1}}{4^{j-1} - 1},$$

is then employed for $j = 2, 3, \ldots, j_{\text{max}}$, with $N = 0, 1, \ldots, N_{\text{max}} - j + 1$, to fill out the remaining elements in the first $j_{\text{max}}$ columns of the matrix $T$.

The integrands for the integrals of (2.2.3) and (2.2.4),

$$f_{c}(x) = \left[ g(x) \cos mx \right]/\pi, \quad (2.2.5)$$

$$f_{d}(x) = \left[ g(x) \sin mx \right]/\pi, \quad (2.2.6)$$

are evaluated by the functions FUNCTC and FUNCTD, respectively, defined in one multiple-entry function. The periodic function $g(x)$, which for the suggested function of Fig. 2.2.1 is given by

$$g(x) = x, \quad (2.2.7)$$

are also defined in the multiple-entry function.

From (2.2.4), it is clear that for all $g(x)$, $d_{0} = 0$. For the periodic function of (2.2.7), the coefficients $c_{m}$ and $d_{m}$ of (2.2.3) and (2.2.4) may be found analytically, and are given by

$$c_{m} = \frac{1}{\pi} \int_{-\pi}^{\pi} x \cos mx \, dx = 0, \quad m = 0, 1, \ldots \quad (2.2.8)$$

$$d_{m} = \frac{1}{\pi} \int_{-\pi}^{\pi} x \sin mx \, dx = -\frac{2}{m} \cos mx = -\frac{2}{m} (-1)^{m}, \quad m = 1, 2, \ldots \quad (2.2.9)$$

Then the Fourier expansion of (2.2.7) is

$$g(x) = x = \frac{2}{3} \left( \sin x + \frac{\sin 2x}{2} + \frac{\sin 3x}{3} - \ldots \right). \quad (2.2.10)$$

In the programs that follow, all $c_{m}$ and $d_{m}$ are evaluated for $m = 0, 1, \ldots, m_{\text{max}}$. The Romberg tableaus for $c_{m}$ and $d_{m}$ are stored in the matrices C and D respectively.
Example 2.2 Fourier Coefficients using Romberg Integration

Flow Diagram

Main Program

Begin

\[ m_{\max}, \quad N_{\max}, \quad j_{\max} \]

\[ m = 0, 1, \ldots, m_{\max} \]

End

\[ C_{Nj}, \quad D_{Nj}, \quad j = 1, 2, \ldots, j_{\max}, \quad N = 0, 1, \ldots, N_{\max} - j + 1 \]

Compute elements of Romberg Tableaus \( C_{Nj}, D_{Nj}, j = 1, 2, \ldots, j_{\max}, N = 0, 1, \ldots, N_{\max} - j + 1 \), where

\[ C_{Nj} = \frac{1}{\pi} \int_{-\pi}^{\pi} f(x) \cos nx \, dx = c_m \]

\[ D_{Nj} = \frac{1}{\pi} \int_{-\pi}^{\pi} f(x) \sin nx \, dx = d_m \]

(Subroutine TROMB)

Functions FUNCTC, FUNCTD, G (Argument: x)

Enter

\[ f_e \leftarrow \frac{g(x) \cos mx}{\pi} \]

(Return)

(function G)

Enter

\[ f_d \leftarrow \frac{g(x) \sin mx}{\pi} \]

(Return)

(function G)

Enter

(Return)

(x)

Subroutine TROMB (Dummy arguments: \( N_{\max}, a, b, f, T, j_{\max}, n \);
calling arguments: \( N_{\max} - \pi, \pi, \text{FUNCTC or FUNCTD, C or D, j, n} \))

Enter

\[ T_{01} \leftarrow \frac{b - a}{2} \left[ f(a) + f(b) \right] \]

\[ N = 1, 2, \ldots, N_{\max} \]

\[ T_{N1} \leftarrow 0 \]

\[ j = 2, 3, \ldots, j_{\max} \]

\[ i = 1, 3, \ldots, 2^n - 1 \]

\[ T_{Nj} \leftarrow T_{Nj} + \frac{(b - a)}{2^n} \left( f(a) + f(b) \right) \]

End.
### Numerical Integration

#### FORTRAN Implementation

#### List of Principal Variables

<table>
<thead>
<tr>
<th>Program Symbol</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Main) C, D†</td>
<td>Matrices C and D, containing the Romberg tableaus for $c_m$ and $d_m$, respectively.</td>
</tr>
<tr>
<td>J</td>
<td>Column subscript for tableaus, $j$.</td>
</tr>
<tr>
<td>JM</td>
<td>Maximum column subscript in $N$th row of tableau.</td>
</tr>
<tr>
<td>JMAX</td>
<td>$j_{max}$, number of columns in tableau.</td>
</tr>
<tr>
<td>M</td>
<td>$m$, index on Fourier coefficients $c_m$ and $d_m$.</td>
</tr>
<tr>
<td>MMAX</td>
<td>$m_{max}$, maximum value of $m$.</td>
</tr>
<tr>
<td>N†</td>
<td>Row subscript for tableaus, $N$.</td>
</tr>
<tr>
<td>NMAX</td>
<td>$N_{max}$, maximum value of $N$.</td>
</tr>
<tr>
<td>NMAXP1</td>
<td>$N_{max} + 1$.</td>
</tr>
<tr>
<td>PI</td>
<td>$\pi$.</td>
</tr>
<tr>
<td>MMAXP1</td>
<td>$m_{max} + 1$.</td>
</tr>
<tr>
<td>MPLUS1</td>
<td>$m + 1$.</td>
</tr>
</tbody>
</table>

#### (Functions FUNCTC, FUNCTD, G)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>The variable of integration, $x$.</td>
</tr>
</tbody>
</table>

#### (Subroutine TROMB)

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>A, B</td>
<td>Lower and upper limits of integration, $a$ and $b$.</td>
</tr>
<tr>
<td>F</td>
<td>The integrand function, $f$.</td>
</tr>
<tr>
<td>FR</td>
<td>$(b - a)/2^N$.</td>
</tr>
<tr>
<td>FORJM1</td>
<td>$A^{j - 1}$.</td>
</tr>
<tr>
<td>H</td>
<td>$b - a$.</td>
</tr>
<tr>
<td>I</td>
<td>$i$, index on repeated sum of (2.52).</td>
</tr>
<tr>
<td>IMAX</td>
<td>$2^N - 1$.</td>
</tr>
<tr>
<td>NRC</td>
<td>$n$, number of rows and columns in tableau $T$.</td>
</tr>
<tr>
<td>NXMJP2</td>
<td>$N_{max} - j + 2$.</td>
</tr>
<tr>
<td>T†</td>
<td>Matrix containing the Romberg tableau, $T$.</td>
</tr>
</tbody>
</table>

† Because of FORTRAN limitations, the row subscripts of the text and flow diagrams are advanced by one when they appear in the program. For example, $N$ assumes values 1, 2, ..., $N_{max} + 1$, so that $T_{0,1} = T(1,1), T_{N_{max},1} = T(N_{max} + 1, 1)$, etc.
APPLIED NUMERICAL METHODS, Example 2.2

FOURIER COEFFICIENTS USING ROMBERG INTEGRATION

This test program calls on the subroutine TROMB to compute the integrals necessary to determine the coefficients of the Fourier expansion for a function $g(x)$ on the interval $(-\pi, \pi)$ where the function is periodic for all $x$ such that $g(x) = g(x + 2k\pi)$, $k$ being an integer. The first $\text{NMAX}$ coefficients of the cosine and sine terms (the $c(m)$ and $d(m)$ of the text) are computed using the trapezoidal rule with repeated interval halving followed by the Romberg extrapolation procedure. The Romberg tableaus for $c(m)$ and $d(m)$ are stored in the upper triangular portions of the first $\text{NMAX} + 1$ rows of the first $\text{JMAX}$ columns of the $c$ and $d$ matrices respectively. Fourier coefficients for any arbitrary periodic function can be found by defining $g(x)$ appropriately (see the functions FUNCTC and FUNCTD).

IMPLICIT REAL*8(A-H, O-Z)
DIMENSION C(20,20), D(20,20)
EXTERNAL FUNCTC, FUNCTD
COMMON M.
DATA PI / 3.1415926535898 /

C READ DATA, CALL TROMB TO COMPUTE INTEGRALS ....
1 READ (5,100) NMAX, NMAX, JMAX
WRITE (6,200) NMAX, NMAX, JMAX
NMAXP1 = NMAX + 1
DO 3 MPLUS1=1,NMAXP1
M = MPLUS1 - 1
CALL TROMB( NMAX, -PI, PI, FUNCTC, C, JMAX, 20 )
CALL TROMB( NMAX, -PI, PI, FUNCTD, D, JMAX, 20 )

C PRINT OUT ROMBERG TABLEAUS ....
WRITE (6,201) N
DO 1 N=1,NMAXP1
JH = JMAX
IF ( N.GT.NMAXP1+1-JMAX ) JH = NMAXP1 + 1 - N
WRITE (6,202) (C(N,J), J=1,JH)
WRITE (6,203) (D(N,J), J=1,JH)
GO TO 1

C FORMATS FOR INPUT AND OUTPUT STATEMENTS ....
100 FORMAT( 7X, 13, 2(12X, I3 ) )
200 FORMAT( 8H10,NMAX = , 12/ 8H NMAX = , 12/ 8H JMAX = , 12 )
201 FORMAT( 1H0/ 1H0,0X,2HC(12,1H)/ 1H )
202 FORMAT( 1H , 1P7E17.8 )
203 FORMAT( 1H0/ 1H0,0X,2HD(12,1H)/ 1H )

FUNCTION FUNCTC( X )

THE FUNCTIONS FUNCTC AND FUNCTD COMPUTE RESPECTIVELY THE INTEGRAND FOR THE $m$TH COEFFICIENT OF THE COSINE AND SINE TERMS OF THE FOURIER EXPANSION OF THE PERIODIC FUNCTION $g(x) = x$. 
**Program Listing (Continued)**

```fortran
IMPLICIT REAL*8(A-H, O-Z)
REAL*8 X, FUNCTC, FUNCTD
COMMON M
DATA PI / 3.1415926535898 /

***** DEFINE PERIODIC FUNCTION *****
G(X) = X

FUNCTC = G(X)*DCOS(FLOAT(M)*X)/PI
RETURN

ENTRY FUNCTD( X )
FUNCTD = G(X)*DSIN(FLOAT(M)*X)/PI
RETURN
END

**Subroutine TROMB**

```fortran
SUBROUTINE TROMB( NMAX, A, B, F, T, JMAX, NRC )

IMPLICIT REAL*8(A-H, O-Z)
REAL*8 A, B, F, T
DIMENSION T(NRC,NRC)

***** COMPUTE H AND FIRST INTEGRAL APPROXIMATION *****
H = B - A
T(1,1) = (F(A) + F(B))*H/2.0

***** HALVE INTERVAL REPEATEDLY, COMPUTE T(N+1,1) *****
DO 2 N=1,NMAX
T(N+1,1) = 0.0
FR = H/2.0**N
IMAX = 2**N - 1
DO 1 I = 1,IMAX,2
1 T(N+1,1) = T(N+1,1) + F(FLOAT(I)*FR + A)
2 T(N+1,1) = T(N,1)/2.0 + H*T(N+1,1)/2.0**N

***** COMPUTE ROMBERG TABLEAU *****
DO 3 J=2,JMAX
NXMJP2 = NMAX - J + 2
FORJM1 = 4.0***(J-1)
DO 3 N=1,NXMJP2
3 T(N,J) = (FORJM1*T(N+1,J-1) - T(N,J-1))/(FORJM1 - 1.0)

RETURN
END
```

**Data**

MMAX = 10  NMAX = 13  JMAX = 7
### Computer Output (abridged)

**MMAX = 10**

<table>
<thead>
<tr>
<th>C(0)</th>
<th>D(0)</th>
<th>D(1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>0.0</td>
<td>-2.08191779D-14</td>
</tr>
<tr>
<td>-1.66533454D-15</td>
<td>-2.00000000D00</td>
<td>2.00000000D00</td>
</tr>
<tr>
<td>-8.87165214D-16</td>
<td>-1.99857073D00</td>
<td>1.99999997D00</td>
</tr>
<tr>
<td>-5.03530347D-16</td>
<td>-2.00000000D00</td>
<td>2.00000000D00</td>
</tr>
<tr>
<td>-9.16640166D-16</td>
<td>-2.00000000D00</td>
<td>2.00000000D00</td>
</tr>
<tr>
<td>-1.37388553D-15</td>
<td>-2.00000000D00</td>
<td>2.00000000D00</td>
</tr>
<tr>
<td>-6.59973743D-16</td>
<td>-2.00000000D00</td>
<td>2.00000000D00</td>
</tr>
<tr>
<td>-3.29361586D-15</td>
<td>-2.00000000D00</td>
<td>2.00000000D00</td>
</tr>
<tr>
<td>-3.27454215D-15</td>
<td>-2.00000000D00</td>
<td>2.00000000D00</td>
</tr>
<tr>
<td>-3.73565375D-15</td>
<td>-2.00000000D00</td>
<td>2.00000000D00</td>
</tr>
<tr>
<td>-3.88303797D-15</td>
<td>-2.00000000D00</td>
<td>2.00000000D00</td>
</tr>
<tr>
<td>-3.27116434D-14</td>
<td>-2.00000000D00</td>
<td>2.00000000D00</td>
</tr>
<tr>
<td>-4.78489021D-14</td>
<td>-2.00000000D00</td>
<td>2.00000000D00</td>
</tr>
</tbody>
</table>
Pages "302" and "303" describe a program for implementing the Gauss-Seidel method for solving a set of n simultaneous linear equations. The program listing is on page "304." Data and partial output is shown on page "305."
EXAMPLE 5.3
GAUSS-SEIDEL METHOD

Problem Statement

Write a program that implements the Gauss-Seidel method, described in Section 5.7, for solving the following system of \( n \) simultaneous linear equations:

\[
\begin{align*}
    a_{11}x_1 + a_{12}x_2 + \cdots + a_{1n}x_n &= a_{1,n+1} \\
    a_{21}x_1 + a_{22}x_2 + \cdots + a_{2n}x_n &= a_{2,n+1} \\
    \vdots \quad \vdots \quad \vdots \quad \vdots \quad \vdots \\
    a_{n1}x_1 + a_{n2}x_2 + \cdots + a_{nn}x_n &= a_{n,n+1},
\end{align*}
\]

(5.3.1)

in which the \( a_{ij} \) are constants.

Method of Solution

In order to reduce the number of divisions required in the calculations, the coefficients of (5.3.1) are first normalized by dividing all elements in row \( i \) by \( a_{ii} \), \( i = 1, 2, \ldots, n \), to produce an augmented coefficient matrix of the form

\[
\begin{bmatrix}
    1 & a'_{12} & a'_{13} & \cdots & a'_{1n} & a'_{1,n+1} \\
    a'_{21} & 1 & a'_{23} & \cdots & a'_{2n} & a'_{2,n+1} \\
    \vdots & \vdots & \vdots & \ddots & \vdots & \vdots \\
    a'_{n1} & a'_{n2} & a'_{n3} & \cdots & 1 & a'_{n,n+1}
\end{bmatrix}
\]

(5.3.2)

where \( a'_{ij} = a_{ij}/a_{ii} \).

In terms of this notation, the approximation to the solution vector after the \( k \)th iteration,

\[
x_k = [x_{1k}, x_{2k}, \ldots, x_{nk}]',
\]

is modified by the algorithm

\[
x_{i,k+1} = a'_{i,n+1} - \sum_{j=1}^{i-1} a'_{ij}x_{j,k+1} - \sum_{j=i+1}^{n} a'_{ij}x_{j,k}, \quad i = 1, 2, \ldots, n,
\]

(5.3.3)

to produce the next approximation

\[
x_{k+1} = [x_{1,k+1}, x_{2,k+1}, \ldots, x_{n,k+1}]'.
\]

Since, in the Gauss-Seidel method, the new values \( x_{i,k+1} \) replace the old values \( x_{ik} \) as soon as computed, the iteration subscript \( k \) can be omitted, and (5.3.3) becomes

\[
x_{i} = a'_{i,n+1} - \sum_{j \neq i}^{n} a'_{ij}x_{j}, \quad i = 1, 2, \ldots, n,
\]

(5.3.4)

in which the most recently available \( x_j \) values are always used on the right-hand side. Hopefully, the \( x_i \) values computed by iterating with (5.3.4) will converge to the solution of (5.3.1).

The convergence criterion is

\[
|x_{i,k+1} - x_{ik}| < \epsilon, \quad i = 1, 2, \ldots, n,
\]

(5.3.5)

that is, no element of the solution vector may have its magnitude changed by an amount greater than \( \epsilon \) as a result of one Gauss-Seidel iteration. Since convergence may not occur, an upper limit on the number of iterations, \( k_{\text{max}} \), is also specified.
**Example 5.3 Gauss-Seidel Method**

**Flow Diagram**

```
Begin → 1

1 → \( u, k_{\text{max}}, \varepsilon, a_{11}, \ldots, a_{nn}, x_1, \ldots, x_n \) → \( i = 1, 2, \ldots, n \) → \( a^* \leftarrow a_{ii} \) → \( j = 1, 2, \ldots, n + 1 \)

1 → \( x^* \leftarrow x_i \) → \( j = 1, 2, \ldots, n \) → flag ← 1 → \( k = 1, 2, \ldots, k_{\text{max}} \)

1 → \( d_{ij} \leftarrow \frac{a_{ij}}{a^*} \)

1 → \( x_i \leftarrow a_{i,n+1} - \sum_{j=1}^{n} a_{ij} x_j \)

1 → \( |x^* - x| \leq \varepsilon \) → flag ← 0 → 7

7 → 8

8 → T

8 → flag \neq 1 → T

8 → F

9 → "No convergence"

9 → \( k, x_1, \ldots, x_n \)

1 → End
```

**FORTRAN Implementation**

**List of Principal Variables**

<table>
<thead>
<tr>
<th>Program Symbol</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>( n \times (n + 1) ) augmented coefficient matrix, containing elements ( a_{ij} ).</td>
</tr>
<tr>
<td>A STAR, X STAR</td>
<td>Temporary storage locations for elements of ( A ) and ( X ), respectively.</td>
</tr>
<tr>
<td>EPS</td>
<td>Tolerance used in convergence test, ( \varepsilon ).</td>
</tr>
<tr>
<td>FLAG</td>
<td>A flag used in convergence testing; it has the value 1 for successful convergence, and the value 0 otherwise.</td>
</tr>
<tr>
<td>ITER</td>
<td>Iteration counter, ( k ).</td>
</tr>
<tr>
<td>K MAX</td>
<td>The maximum number of iterations allowed, ( k_{\text{max}} ).</td>
</tr>
<tr>
<td>N</td>
<td>Number of simultaneous equations, ( n ).</td>
</tr>
<tr>
<td>X</td>
<td>Vector containing the elements of the current approximation to the solution vector, ( x_k ).</td>
</tr>
</tbody>
</table>
PROGRAM LISTING

APPLIED NUMERICAL METHODS, EXAMPLE 5.3
GAUSS-SEIDEL ITERATION FOR N SIMULTANEOUS LINEAR EQUATIONS.

THE ARRAY A CONTAINS THE N X N+1 AUGMENTED COEFFICIENT MATRIX.
THE VECTOR X CONTAINS THE LATEST APPROXIMATION TO THE SOLUTION.
THE COEFFICIENT MATRIX SHOULD BE DIAGONALLY DOMINANT AND
PREFERABLY POSITIVE DEFINITE. ITMAX IS THE MAXIMUM NUMBER OF
ITERATIONS ALLOWED. EPS IS USED IN CONVERGENCE TESTING. IN
TERMINATING THE ITERATIONS, NO ELEMENT OF X MAY UNDERGO A MAG-
NITUDE CHANGE GREATER THAN EPS FROM ONE ITERATION TO THE NEXT.

INTEGER FLAG
DIMENSION A(20,20), X(20)

READ AND CHECK INPUT PARAMETERS,
REMEMBER MATRIX, AND STARTING VECTOR.....

1 READ (5,100) N, ITMAX, EPS
WRITE (6,200) N, ITMAX, EPS
N1 = N + 1
READ (5,101) (A(I,J), J = 1, N1), (I = 1, N)
READ (5,101) (X(I), I = 1, N)
DO 2 I = 1, N
2 WRITE (6,201) (A(I,J), J = 1, N1)
WRITE (6,202) (X(I), I = 1, N)

NORMALIZE DIAGONAL ELEMENTS IN EACH ROW.....
DO 3 I = 1, N
ASTAR = A(I,I)
DO 3 J = 1, N1
3 A(I,J) = A(I,J)/ASTAR

BEGIN GAUSS-SEIDEL ITERATIONS.....
DO 9 ITER = 1, ITMAX
FLAG = 1
DO 7 I = 1, N
XSTAR = X(I)
X(I) = X(I) - A(I,N)X(N)
7 CONTINUE
IF (I .EQ. J) GO TO 5
X(I) = X(I) - A(I,J)*X(J)
5 CONTINUE
TEST X(I) FOR CONVERGENCE.....
IF (ABS(XSTAR - X(I)) .LE. EPS) GO TO 7
FLAG = 0
7 CONTINUE
IF (FLAG .NE. 1) GO TO 9
WRITE (6,203) ITER, (X(I), I = 1, N)
9 CONTINUE
REMARK IF METHOD DID NOT CONVERGE.....
WRITE (6,204) ITER, (X(I), I = 1, N)

FORMATS FOR INPUT AND OUTPUT STATEMENTS.....

100 FORMAT (6X, 14, 6X, 14, 6X, F10.6)
101 FORMAT (10X, 6F10.5)
200 FORMAT (12H1 SOLUTION OF SIMULTANEOUS LINEAR EQUATIONS BY GAUSS-SE
DIDEL METHOD, WITH /HOG, 5H, 9H)
201 FORMAT (12H1, 6F10.5)
202 FORMAT (35H0 THE STARTING VECTOR X(I).....X(N) IS/ (1H0, 10F10.5))
203 FORMAT (35H0 PROCEDURE CONVERGED, WITH ITER = , 14/
1 32HO SOLUTION VECTOR X(I).....X(N) IS/ (1H0, 10F10.5))
204 FORMAT (12H0 TO CONVERGE/ 1OH0 ITER = , 14/
1 31HO CURRENT VECTOR X(I).....X(N) IS/ (1H0, 10F10.5))

END
Program Listing (Continued)

Data

\[
\begin{array}{cccccc}
N &=& 4 & \text{ITMAX} &=& 15 & \text{EPS} &=& 0.0001 \\
A(1,1) &=& 5.0 & 1.0 & 3.0 & 0.0 & 16.0 & 1.0 \\
& & 4.0 & 1.0 & 1.0 & 11.0 & -1.0 & 2.0 \\
& & 6.0 & -2.0 & 23.0 & 1.0 & -1.0 & 1.0 \\
& & 4.0 & -2.0 & & & & \\
X(1) &=& 1.0 & 2.0 & 3.0 & 4.0 \\
\end{array}
\]

\[
\begin{array}{cccccc}
N &=& 4 & \text{ITMAX} &=& 15 & \text{EPS} &=& 0.0001 \\
A(1,1) &=& 5.0 & 1.0 & 3.0 & 0.0 & 16.0 & 1.0 \\
& & 4.0 & 1.0 & 1.0 & 11.0 & -1.0 & 2.0 \\
& & 6.0 & -2.0 & 23.0 & 1.0 & -1.0 & 1.0 \\
& & 4.0 & -2.0 & & & & \\
X(1) &=& 50.0 & 50.0 & 50.0 & 50.0 \\
\end{array}
\]

Computer Output

Results for the 1st Data Set

SOLUTION OF SIMULTANEOUS LINEAR EQUATIONS BY GAUSS-SEIDEL METHOD, WITH

\[
\begin{array}{cccccc}
N &=& 4 & \text{ITMAX} &=& 15 & \text{EPS} &=& 0.0001 \\
\end{array}
\]

THE COEFFICIENT MATRIX \( A(1,1) \ldots A(N+1,N+1) \) IS

\[
\begin{array}{cccccc}
5.00000 & 1.00000 & 3.00000 & 0.0 & 16.00000 \\
1.00000 & 4.00000 & 1.00000 & 1.00000 & 11.00000 \\
-1.00000 & 2.00000 & 6.00000 & -2.00000 & 23.00000 \\
1.00000 & -1.00000 & 1.00000 & 4.00000 & -2.00000 \\
\end{array}
\]

THE STARTING VECTOR \( X(1) \ldots X(N) \) IS

\[
\begin{array}{cccccc}
1.00000 & 2.00000 & 3.00000 & 4.00000 & \\
\end{array}
\]

PROCEDURE CONVERGED, WITH ITER = 12

SOLUTION VECTOR \( X(1) \ldots X(N) \) IS

\[
\begin{array}{cccccc}
0.99998 & 2.00000 & 2.99999 & -0.99999 & \\
\end{array}
\]

Partial Results for the 2nd Data Set (Same Equations as 1st Set)

THE STARTING VECTOR \( X(1) \ldots X(N) \) IS

\[
\begin{array}{cccccc}
50.00000 & 50.00000 & 50.00000 & 50.00000 & \\
\end{array}
\]

PROCEDURE CONVERGED, WITH ITER = 13

SOLUTION VECTOR \( X(1) \ldots X(N) \) IS

\[
\begin{array}{cccccc}
1.000002 & 2.00000 & 3.000001 & -1.000001 & \\
\end{array}
\]
This program exercises complex arithmetic and double precision features of FORTRAN by calculating:

\[ \exp(iz) = \sum_{k=0}^{n} \frac{(iz)^k}{k!} \]

for several values of \( z = x + iy \) and \( n \).

Variables:

- Integer - NTERM - n-delimits the number of terms used to obtain the estimate
- NARG - the number of \( z \) values used

Complex arrays ARG - \( z \) values
- EXPIZE - estimates of \( \exp(iz) \)
- EXPIZL - library function values of \( \exp(iz) \)
- EULIZ - values of \( \exp(-y)(\cos x + isinx) \)
- SQRTEZ - values of \( [\exp(iz)]^{1/2} \)
- LGEXIZ - values of \( \log [\exp(iz)] \)

Double precision arrays - EXPYL - library function values of \( \exp(-y) \)
- EXPYE estimates of \( \exp(-y) \)

F5 COMPLEX

DIMENSION ARG(30), EXPIZE(30), EXPIZL(30), EULIZ(30), SQRTEZ(30)
DIMENSION LGEXIZ(30), EXPYL(30), EXPYE(30)
C0MPLEX Z, CSUM, CTERM, ARG, EXPIZE, EXPEL, EULIZ, SQRTEZ, LGEXIZ
DOUBLE PRECISION Y, SUM, TERM, EXPYE, EXPYL
READ 800 NTERM, NARG, (ARG(I), I=1, NARG)
DO 20 J=1, NARG
TERM=1.
SUM =0.
CTERM = (1,0)
CSUM = (1,0)
Z = ARG(J)
Y = AIMAG(Z)
DO 10 I = 1, NTERM
TERM = TERM*Y/FL0AT(I)
SUM = SUM + TERM
CTERM = CTERM*Z/FL0AT(I)
10 CSUM = CSUM + STERM
EXPIZE(J) = CSUM
EXPIZL(J) = CL0G((0,1)*Z)
SQRTEZ(J) = CSQRT(EXPIZL(J))
LGEXIZ(J) = CL0G(EXPIZL(J))

G-40
EXPYE(J) = SUM
EXPYL(J) = DEXP(-Y)
20 EULIZ(J) = EXPYE(J)*(COS(REAL(Z)) + (0,1)*SIN(REAL(Z))
WRITE 900 NTERM, NARG
900 FORMAT(10H N TERMS = I10, 20X 8H N ARG = I10)
WRITE 901 (ARG(I), EXPIZE(I), EXPIZL(I), I = 1, NARG)
WRITE 901 (EULIZ(I), SQRTEZ(I), LGEXIZ(I), I = 1, NARG)
901 FORMAT (/(6E20.14))
WRITE 902 (ARG(I), EXPYE(I), EXPYL(I), I = 1, NARG)
902 FORMAT (/(2E20.14, 2D40.30))
800 FORMAT (2110)
END
COBOL PROGRAMS
INTRODUCTION

Source decks, test data and IBM job control cards are provided. The benchmark has been run on a 32K 360 Model 22.

The sequence for running these programs is as follows:

1. Load the file. C2 loads the file. Data, C6, must be preceded by a new file card. "New file" is punched in columns 1-7. Data cards must be in student number order, columns 1-5.

2. Update the file. C2 adds new records to the file, omit the new file card. Data, C7, is in random order, please do not sort.

3. Print the file. Two passes are made over the entire file printing selected records.

4. Copy the Index Sequential File to a sequential file using C4, then sort on position 92 major and positions 8-30 minor.

C1 FILE

This program is designed to aid in evaluation of raw file processing capability. A file of 10,000 records of 100 characters each should be generated for use with this program. Files should be blocked 10 records per block.

IDENTIFICATION DIVISION.
PROGRAM-ID. FILE-PROCESSING.
AUTHOR. LAWRENCE-MCNITT.
ENVIRONMENT DIVISION.
CONFIGURATION SECTION.
SOURCE-COMPUTER. ZZZ999.
OBJECT-COMPUTER. ZZZ999.
INPUT-OUTPUT SECTION.
FILE-CONTROL. SELECT IN-FILE ASSIGN TO DISK-1.
SELECT OU-FILE ASSIGN TO DISK-2.
SELECT PR-FILE ASSIGN TO PRINTER.
DATA DIVISION.
FILE SECTION.
FD IN-FILE DATA RECORD IN-RCD LABEL RECORD OMITTED
BLOCK CONTAINS 1000 CHARACTERS.
01 IN-RCD.
  02 IN1 PICTURE X(20)
  02 IN2.
  03 INV PICTURE 9(10) OCCURS 8 TIMES.
FD OU-FILE DATA RECORD OU-RCD LABEL RECORD OMITTED
BLOCK CONTAINS 1000 CHARACTERS.
01 ØU-RCD.
   02 ØU1 PICTURE X(20).
   02 ØU2.
   03 ØUV PICTURE 9(10) OCCURS 8 TIMES.
FD   PR-FILE DATA RECORD PR-RCD LABEL RECORD OMITTED.
01 PR-RCD PICTURE X (132)
WØRKING-STØRAGE SECTIØN.
01 START-RCD.
   02 START1 PICTURE X(5) VALUE 'START'.
   02 START2 PICTURE X(127) VALUE SPACES.
01 STØP-RCD.
   02 STØP1 PICTURE X(4) VALUE 'STØP'.
   02 STØP2 PICTURE X(128) VALUE SPACES.
77 I PICTURE 99.
PROCEDURE DIVISION.
PAR1. OPEN INPUT IN-FILE OUTPUT ØU-FILE, PR-FILE.
     WRITE PR-RCD FROM START-RCD.
PAR2. READ IN-FILE AT'END GO TO PAR3
     MOVE IN1 TO ØU1.
     PERFORM PAR4 VARYING I FROM 1 BY 1 UNTIL
     I GREATER THAN 8.
     WRITE ØU-RCD.
     GØ TO PAR2.
PAR3. WRITE PR-RCD FROM STØP-RCD.
     CLØSE IN-FILE, ØU-FILE, PR-FILE.
     STØP RUN.
PAR4. MOVE INV (I) TO ØUV(I).
This program will load or update an index sequential file from cards.
C2 creates and updates an index-seq file

IDENTIFICATION DIVISION.

PROGRAM-_ID 'C2'.

AUTHOR: J. GADDE.

REMARKS. CREATES A NEW FILE IF DATA IF PRECEDED BY A

REMARKS. NEWFILE CARD.

REMARKS. REVISITED FOR 360 BY DON E.

REMARKS. BENCHMARK VERSION OF SR1010.

DATE-WRITTEN. APRIL 26, 1970.

ENVIRONMENT DIVISION.

INPUT-OUTPUT SECTION.

FILE-CONTROL.

SELECT FOR ASSIGN TO 'SYS004' UNIT-RECORD 1442P UNIT.

SELECT PRINT ASSIGN TO 'SYS005' UNIT-RECORD 1403 UNIT.

SELECT STUDENT-FILE ASSIGN TO 'SYS002' DIRECT-ACCESS 2311.

ACCESS IS RANDOM.

ORGANIZATION IS INDEXED.

SYMBOLIC KEY IS SYMBOLIC-ID-S.

RECORD KEY IS IN-UPDATE.

SELECT NEW-FILE ASSIGN TO 'SYS009' DIRECT-ACCESS 2311 UNIT.

ACCESS IS SEQUENTIAL.

ORGANIZATION IS INDEXED.

RECORD KEY IS IN-NEW.

I-O-CONTROL.

APPLY CODE-INDEX TO CYLINDR ON STUDENT-FILE.

DATA DIVISION.

FILE SECTION.

FILLER.

RECORDING MODE IS F.

LABEL RECORD IS OMITTED.

DATA RECORD IS CHG-GRP.

LABEL 01 CHG-GRP.

02 IN-GRP 01 PICTURE 9999.

02 IN-GRP 02 PICTURE 123.

02 NAME-GRP PICTURE X22.

02 C-UNIT-GRP PICTURE NAME-GRP.

03 SCHOOL-UNIT-GRP PICTURE X.

03 GPA-UNIT-GRP PICTURE 9999.

03 GPA-UNIT-GRP PICTURE 9999.

03 INT-UNIT-GRP PICTURE 9999.

03 S-UNIT-GRP PICTURE 9999.

03 0-UNIT-GRP PICTURE X.

02 0-UNIT-GRP PICTURE X.

02 FILLER PICTURE X.

02 FILLER PICTURE X.

02 FILLER PICTURE X.

02 FILLER PICTURE X.

02 FILLER PICTURE X.

02 FILLER PICTURE X.

02 FILLER PICTURE X.

02 FILLER PICTURE X.

02 RED-UNIT-GRP PICTURE X.

02 RED-UNIT-GRP PICTURE X.

02 RED-UNIT-GRP PICTURE X.

02 RED-UNIT-GRP PICTURE X.

02 BIRTH-UNIT-GRP PICTURE X.
<table>
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<th>Line 1</th>
<th>Line 2</th>
<th>Line 3</th>
<th>Line 4</th>
<th>Line 5</th>
<th>Line 6</th>
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<td>CHANGE COL-EC DATA.</td>
<td>010000</td>
<td>IF MOVE-CHANGE TRUE.</td>
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<td>CHANGE COL-EC DATA.</td>
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<td>010000</td>
<td>IF MOVE-CHANGE TRUE.</td>
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<td>CHANGE COL-EC DATA.</td>
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<tr>
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<td>CHANGE COL-EC DATA.</td>
<td>010000</td>
<td>IF MOVE-CHANGE TRUE.</td>
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<td>CHANGE COL-EC DATA.</td>
</tr>
<tr>
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<td>CHANGE COL-EC DATA.</td>
<td>010000</td>
<td>IF MOVE-CHANGE TRUE.</td>
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<td>CHANGE COL-EC DATA.</td>
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<td>CHANGE COL-EC DATA.</td>
<td>010000</td>
<td>IF MOVE-CHANGE TRUE.</td>
<td>010100</td>
<td>CHANGE COL-EC DATA.</td>
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015170 IF NAME-C1 NOT = ' ' MOVE NAME-C1 SP1010
015190 TO NAME SP1010
015200 IF ID-DIV-C1 IS NUMERIC MOVE ID-DIV-C1 TO DIV-S SP1010
015220 IF SEX-C2 NOT = ' ' MOVE SEX-C2 TO SEX-S SP1010
015240 MOVE SEX-C2 TO SEX-S SP1010
015250 IF MARITAL-STATUS-C2 NOT = ' ' MOVE MARITAL-STATUS-C2 TO MARITAL-STATUS-S SP1010
015270 IF CLASS-STANDING-C2 NOT = ' ' MOVE CLASS-STANDING-C2 TO CLASS-STANDING-S SP1010
015290 IF BIRTHDATE-C2 IS NUMERIC SP1010
015300 MOVE BIRTHDATE-C2 TO BIRTHDATE-S SP1010
015310 IF STATE-COUNTRY-C2 NOT = ' ' MOVE STATE-COUNTRY-C2 TO STATE-COUNTRY-S SP1010
015320 IF COUNTY-C2 NOT = ' ' MOVE COUNTY-C2 TO COUNTY-S SP1010
015330 IF VISA-C2 NOT = ' ' MOVE VISA-C2 TO VISA-S SP1010
015340 IF CONFERENCE-C2 NOT = ' ' MOVE CONFERENCE-C2 TO CONFERENCE-S SP1010
015350 IF ADMISSION-STATUS-C2 NOT = ' ' MOVE ADMISSION-STATUS-C2 TO ADMISSION-STATUS-S SP1010
015360 IF SECONDARY-SCHOOL-C2 NOT = ' ' MOVE SECONDARY-SCHOOL-C2 TO SECONDARY-SCHOOL-S SP1010
015370 IF DEGREE-COLLEGE-C2 NOT = ' ' MOVE DEGREE-COLLEGE-C2 TO DEGREE-COLLEGE-S SP1010
015380 IF COURSE-OF-STUDY-C2 NOT = ' ' MOVE COURSE-OF-STUDY-C2 TO COURSE-OF-STUDY-S SP1010
015390 IF MAJOR-OR-DEGREE-C2 NOT = ' ' MOVE MAJOR-OR-DEGREE-C2 TO MAJOR-OR-DEGREE-S SP1010
015400 IF ADVISOR-C2 NOT = ' ' MOVE ADVISOR-C2 TO ADVISOR-S SP1010
015410 IF ENTRANCE-STATUS-C2 NOT = ' ' MOVE ENTRANCE-STATUS-C2 TO ENTRANCE-STATUS-S SP1010
015420 IF HS-GPA-C2 IS NUMERIC SP1010
015430 MOVE HS-GPA-C2 TO HS-GPA-S SP1010
015440 IF RESIDENCE-STATUS-C2 NOT = ' ' MOVE RESIDENCE-STATUS-C2 TO RESIDENCE-STATUS-S SP1010
015450 IF SOCIAL-STATUS-C2 NOT = ' ' MOVE SOCIAL-STATUS-C2 TO SOCIAL-STATUS-S SP1010
015460 IF WITHDRAWAL-DATE-C2 IS NUMERIC SP1010
015470 MOVE WITHDRAWAL-DATE-C2 TO WITHDRAWAL-DATE-S SP1010
015480 IF C80-CODE = '11' MOVE '11' TO SCHOOL-CODE-X SP1010
015490 IF SCHOOL-CODE-X NOT = SCH-CODE-S (NTR-S) PERFORM SCHOOL-CHG, SP1010
015500 MOVE SCHOOL-CODE-X TO SCH-CODE-S (NTR-S) SP1010
015520 IF WARNING-C1 NOT = ' ' MOVE WARNING-C1 SP1010
015530 TO IN-COL SP1010
015540 PERFORM GRAD-SEX-DATA THRU GRAD-SEX-EXIT SP1010
015550 MOV CHANG-GRAD-SEX SP1010
015560 GO TO IN-COL SP1010
015570 IF NAME-C1 NOT = ' ' MOVE NAME-C1 SP1010
015580 TO NAME SP1010
015590 IF ID-DIV-C1 IS NUMERIC MOVE ID-DIV-C1 TO DIV-S SP1010
015600 IF SEX-C2 NOT = ' ' MOVE SEX-C2 TO SEX-S SP1010
015610 IF MARITAL-STATUS-C2 NOT = ' ' MOVE MARITAL-STATUS-C2 TO MARITAL-STATUS-S SP1010
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<thead>
<tr>
<th>Line No.</th>
<th>Instructions</th>
<th>Comments</th>
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<tr>
<td>018120</td>
<td>IF BIRTH-D IS NUMERIC MOVE BIRTH-D TO BIRTHDATE-S.</td>
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<td>018140</td>
<td>IF STATE-COUNTRY-C2 NOT = ' ' MOVE</td>
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<tr>
<td>018150</td>
<td>STATE-COUNTRY-C2 TO STATE-COUNTRY-S.</td>
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<tr>
<td>018170</td>
<td>IF VISA-C3 = ' ' GO TO CCK.</td>
<td></td>
</tr>
<tr>
<td>018190</td>
<td>MOVE VISA-C3 TO VISA-S.</td>
<td></td>
</tr>
<tr>
<td>018200</td>
<td>IF VISA-S = ' ' GO TO CCK.</td>
<td></td>
</tr>
<tr>
<td>018210</td>
<td>IF VISA-S = ' ' GO TO VISA-S.</td>
<td></td>
</tr>
<tr>
<td>019010</td>
<td>IF CONFERENCE-C2 NOT = ' ' MOVE CONFERENCE-C2 TO COLLEGE-S.</td>
<td></td>
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<tr>
<td>019020</td>
<td>IF SECONDARY-SCHOOL-C NOT = ' ' MOVE</td>
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<tr>
<td>019030</td>
<td>SECONDARY-SCHOOL-C TO MAJOR-OR-DEGREE-S.</td>
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<tr>
<td>019050</td>
<td>IF DEGREE-COLLEGE-C NOT = ' ' MOVE</td>
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</tr>
<tr>
<td>019060</td>
<td>DEGREE-COLLEGE-C TO RELIGION-S.</td>
<td></td>
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<tr>
<td>019070</td>
<td>TO CONFERENCE-S.</td>
<td></td>
</tr>
<tr>
<td>019080</td>
<td>IF ENTRANCE-STATUS-C3 NOT = ' ' MOVE</td>
<td></td>
</tr>
<tr>
<td>019090</td>
<td>ENTRANCE-STATUS-C3 TO ENTRANCE-STATUS-S.</td>
<td></td>
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<tr>
<td>019100</td>
<td>IF ADMISSION-STATUS-C2 = ' ' MOVE 151 TO SCHOOL-CODE-X</td>
<td></td>
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<tr>
<td>019110</td>
<td>GO TO A1.</td>
<td></td>
</tr>
<tr>
<td>019120</td>
<td>IF ADMISSION-STATUS-C2 = ' ' MOVE 161 TO SCHOOL-CODE-X</td>
<td></td>
</tr>
<tr>
<td>019130</td>
<td>GO TO A1.</td>
<td></td>
</tr>
<tr>
<td>019140</td>
<td>GO TO GRAD-SEM-EXIT.</td>
<td></td>
</tr>
<tr>
<td>019150</td>
<td>A1.</td>
<td></td>
</tr>
<tr>
<td>019160</td>
<td>IF SCH-CODE-S (QTR-S) = SCHOOL-CODE-X NEXT SENTENCE</td>
<td></td>
</tr>
<tr>
<td>019170</td>
<td>ELSE PERFORM SCHOOL-CODE-S. (QTR-S).</td>
<td></td>
</tr>
<tr>
<td>019180</td>
<td>MOVE SCHOOL-CODE-S TO SCHOOL-CODE-S</td>
<td></td>
</tr>
<tr>
<td>019190</td>
<td>?</td>
<td></td>
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<tr>
<td>019200</td>
<td>GRAD-SEM-EXIT. EXIT.</td>
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<tr>
<td>020010</td>
<td>ORIGIN-DATA.</td>
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<tr>
<td>020020</td>
<td>IF ETHNIC-ORIGIN-C2 NOT = ' ' MOVE</td>
<td></td>
</tr>
<tr>
<td>020030</td>
<td>ETHNIC-ORIGIN-C2 TO ETHNIC-ORIGIN.</td>
<td></td>
</tr>
<tr>
<td>020040</td>
<td>GO TO 1D-CAL.</td>
<td></td>
</tr>
<tr>
<td>020050</td>
<td>ADD-PT.</td>
<td></td>
</tr>
<tr>
<td>020060</td>
<td>PERFORM INIT-RECORD.</td>
<td></td>
</tr>
<tr>
<td>020070</td>
<td>IF CPD-CODE = ' ' MOVE 131 TO SCH-CODE-S (OTR-S) GO TO SR.</td>
<td></td>
</tr>
<tr>
<td>020080</td>
<td>COLLEGE-ADD-PT.</td>
<td></td>
</tr>
<tr>
<td>020090</td>
<td>IF CPD-CODE = ' ' MOVE 141 TO SCH-CODE-S (OTR-S) GO TO SR.</td>
<td></td>
</tr>
<tr>
<td>020100</td>
<td>COLLEGE-ADD-PT.</td>
<td></td>
</tr>
<tr>
<td>020110</td>
<td>GO TO CPD-3.</td>
<td></td>
</tr>
<tr>
<td>020120</td>
<td>ADD-EXIT. EXIT.</td>
<td></td>
</tr>
<tr>
<td>020130</td>
<td>COLLEGE-ADD-PT.</td>
<td></td>
</tr>
<tr>
<td>020140</td>
<td>PERFORM COLLEGE-DATA.</td>
<td></td>
</tr>
<tr>
<td>020150</td>
<td>IF LINE-CNT = 5S PERFORM PAG-HD.</td>
<td></td>
</tr>
<tr>
<td>020160</td>
<td>MOVE 101 TO 1D.</td>
<td></td>
</tr>
<tr>
<td>020170</td>
<td>MOVE NEW RECORD TO BODY, PERFORM PRINT.</td>
<td></td>
</tr>
<tr>
<td>020180</td>
<td>PERFORM PRINT-RT.</td>
<td></td>
</tr>
<tr>
<td>020190</td>
<td>PERFORM WRITE-NEW THRU M-EXIT.</td>
<td></td>
</tr>
<tr>
<td>020200</td>
<td>GO TO ADD-EXIT.</td>
<td></td>
</tr>
<tr>
<td>021010</td>
<td>CPD-3.</td>
<td></td>
</tr>
<tr>
<td>021020</td>
<td>IF CPD-CODE = ' ' NEXT SENTENCE</td>
<td></td>
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<tr>
<td>021030</td>
<td>ELSE MOVE NEW RECORD FOUND TO MSG.</td>
<td></td>
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<tr>
<td>021040</td>
<td>PERFORM INVALID-CARD-RT GO TO ADD-EXIT.</td>
<td></td>
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<tr>
<td>021050</td>
<td>IF ADMISSION-STATUS-C2 = ' ' MOVE 151 TO SCH-CODE-S (QTR-S)</td>
<td></td>
</tr>
<tr>
<td>021060</td>
<td>MOVE 161 TO SCH-CODE-S (QTR-S).</td>
<td></td>
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<tr>
<td>021070</td>
<td>PERFORM GRAD-SEM-DATA THRU GRAD-SEM-EXIT.</td>
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<tr>
<td>021080</td>
<td>IF LINE-CNT = 5S PERFORM PAG-HD.</td>
<td></td>
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</tbody>
</table>
MOVE '090 TO CTL.
MOVE NEW RECORD TO BODY, PERFORM PRNT.
PERFORM WRITE-NEW-THR NEW-EXIT.
GO TO ADD-EXIT.
INVALID-CARD-PT.
MOVE CHG-CARD TO CARD-IMAGE.
INVALID-LINE TO BODY, MOVE '091 TO CTL, PERFORM PRNT.
MOVE '0999 TO MSG.
MOVE 0 TO LINE-CONT.
MOVE SPACES IN DTL-LINE.
SCHOOL-CHR.
PERFORM INIT-NEW REMAINING GPA-XT.
MOVE RETURN TO BODY, PERFORM PRNT.
CHK-GPA.
IF SCHOOL-CODE-Y = 'S' AND SCH-CODE-S (QTR-S) = '6'
GO TO GPA-XT.
IF SCHOOL-CODE-Y = '6' AND SCH-CODE-S (QTR-S) = '5'
MOVE 0 TO GPA-POINTS-S.
MOVE 0 TO GPA-HOURS-S.
MOVE 0 TO GRADUATION-DATE-S.
MOVE 0 TO TOTAL-HOURS-S.
MOVE 0 TO SAT-HOURS-S.
MOVE 0 TO WITHDRAWAL-DATE-S.
MOVE 732 TO ENTRANCE-DATE-S.
MOVE 0 TO GPA-POINTS-S.
MOVE 0 TO GPA-HOURS-S.
MOVE 0 TO TOTAL-HOURS-S.
MOVE 0 TO SAT-HOURS-S.
MOVE 0 TO WITHDRAWAL-DATE-S.
MOVE 732 TO ENTRANCE-DATE-S.
MOVE 0 TO GPA-POINTS-S.
MOVE 0 TO GPA-HOURS-S.
MOVE 0 TO TOTAL-HOURS-S.
MOVE 0 TO SAT-HOURS-S.
MOVE 0 TO WITHDRAWAL-DATE-S.
MOVE 732 TO CONVERSION-DATE-S.
MOVE 0 TO GPA-POINTS-S.
MOVE 0 TO GPA-HOURS-S.
MOVE 0 TO TOTAL-HOURS-S.
MOVE 0 TO SAT-HOURS-S.
MOVE 0 TO WITHDRAWAL-DATE-S.
MOVE 732 TO ENTRANCE-DATE-S.
MOVE 0 TO GPA-POINTS-S.
MOVE 0 TO GPA-HOURS-S.
MOVE 0 TO TOTAL-HOURS-S.
MOVE 0 TO SAT-HOURS-S.
MOVE 0 TO WITHDRAWAL-DATE-S.
MOVE 732 TO ENTRANCE-DATE-S.
NOTE ---------------- CREATE NEW STUDENT FILE ----------------

LOAD-FILE.
STOP 'NEW STUDENT FILE TO BE LOADED, IF CK FOR'.
OPEN OUTPUT NEW-FILE.
PERFORM READ-CARDS.
IF RDR-END-SW = '1' GO TO END-NEW.
PERFORM ADD-RT THRU ADD-EXIT.
GO TO RC.
EOJ-NEW.
CLOSE NEW-FILE.
GO TO CLOSE-2.
CLOSE STUDENT-FILE.
CLOSE AND BRNTR.
STOP RUN.
MOVE TO-C1 TO SYMBOLIC-1D-S.
MOVE '0' TO NO-FIND.
READ STUDENT-FILE INVALID KEY MOVE '1' TO NO-FIND.
MOVE STUDENT-RECORD TO STUDENT-RECCO.
WRITE NEW.
IF NEWFILE-SW = '1' GO TO NEW-FL.
MOVE STUDENT-RECORD TO UPDATE-REC.
IF RE-WRITE-SW = '1' REWRITE UPDATE-RFC GO TO N-EXIT.
WRITE UPDATE-RFC INVALID KEY DISPLAY.
AC1010, INVALID KEY, DUPE ETC., CK INPUT UPON CONSOLE.
GO TO N-EXIT.
EXIT.
NOTE ---------- DERCANU CANCELS THIS JOB ----------
CANC.
ENTER LINKAGE.
CALL 'DERCANU'.
ENTER CAROL.
RE-WRITE.
MOVE STUDENT-RECORD TO UPDATE-REC.
REWRITE UPDATE-RFC.
// LBLTYP NSE(3)
// EXEC LINKEDT
/
This program prints selected records from the file created by C2.
IDENTIFICATION DIVISION.

PROGRAM-ID 'C3'.

REMARKS. STUDENT FILE DUMP.

BENCHMARK VERSION.

REVISIONS FOR 360 BY DON E.

AUTHOR. JIM GARBER.

DATE-WRITTEN. MAY-18, 1970.

ENVIRONMENT DIVISION.

INPUT-OUTPUT SECTION.

FILE-CONTROL.

SELECT PRT Assign to 'SYS005' UNI-RECORD 1403 UNIT.

SELECT STUDENT-FILE ASSIGN TO 'SYS052' DIRECT-ACCESS 2311

ACCESS IS SEQUENTIAL

ORGANIZATION IS INDEXED

RECORD KEY IS ID-S.

DATA DIVISION.

FILE SECTION.

RECORDING MODE F

LABEL RECORD OMITTED

DATA RECORD IS PRT.

01 PRT.

02 CTL PICTURE X.

02 BODY PICTURE X(132).

02 STUDENT-FILE

02 RECORDING MODE F

02 LABEL RECORD IS STANDARD

02 BLOCK CONTAINS 5 RECORDS

02 RECORD CONTAINS 155 CHARACTERS

02 DATA RECORD IS STUDENT-RECORD.

02 STUDENT-RECORD.

02 DELETE-S PICTURE X.

02 ID-S PICTURE 9(5).

02 DIV-S PICTURE 9.

02 NAME PICTURE X(23).

02 SEX-S PICTURE X.

02 MARITAL-STATUS-S PICTURE X.

02 CLASS-STANDING-S PICTURE XX.

02 BIRTHDATE-S PICTURE 9(7) COMPUTATIONAL-3.

02 STATE-COUNTRY-S PICTURE XXX.

02 COUNTY-S PICTURE XX.

02 VISA-S PICTURE X.

02 CONFERENCE-S PICTURE XX.

02 ADMISSION-STATUS-S PICTURE X.

02 SECONDARY-SCHOOL-S PICTURE XX.

02 COLLEGE-S PICTURE XX.

02 DEGREE-COLLEGE-S PICTURE X.

02 FILLER PICTURE X.

02 COURSE-OF-STUDY-S PICTURE XX.

02 MAJOR-OR-DEGREE-S PICTURE XX.

02 ENTRANCE-STATUS-S PICTURE X.

02 HS-GPA-S PICTURE 9V99 COMPUTATIONAL-3.
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<th>Description</th>
<th>Value</th>
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<td>003030</td>
<td>C2</td>
<td>FLD-9</td>
<td>PICTURE XX</td>
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<td>PICTURE 99.9</td>
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005200 02 FILLER PICTURE X(2C) VALUE 'S CCLL CCLT-DFG CRSF'. SP1020
006010 02 FILLER PICTURE X(2C) VALUE 'STOY MJ/CG ETHANC'. SP1020
006020 02 FILLER PICTURE X(2C) VALUE 'E H-S-GPA AU-CPS'. SP1020
006030 02 FILLER PICTURE X(12) VALUE 'WI-CRS'. SP1020
006040 01 LN-2.
006050 02 FILLER PICTURE X(2C) VALUE 'SP-CRS CCLL-HR GRAD'. SP1020
006060 02 FILLER PICTURE X(2C) VALUE 'HR SEM-HR RESOEC'. SP1020
006070 02 FILLER PICTURE X(2C) VALUE 'SPECIAL W-DATE EP'. SP1020
006080 02 FILLER PICTURE X(2C) VALUE 'A-PTF GPA-HRS S-CO'. SP1020
006090 02 FILLER PICTURE X(2C) VALUE 'ENT-DATE CONF REJ'. SP1020
006100 02 FILLER PICTURE X(2C) VALUE 'LID GRAD-DATE TCT'. SP1020
006110 02 FILLER PICTURE X(12) VALUE 'HPS S-HRS'. SP1020
006120 01 FILLER. SP1020
006130 02 S-CODF PICTURE X VALUE 1. SP1020
006140 02 LINE-CNT PICTURE S999 COMPUTATIONAL-3 VALUE 59. SP1020
006150 02 LN-0A.
006160 02 NAME-A PICTURE X(25).
006170 03 FILLER PICTURE XX VALUE 1. SP1020
006180 03 ID-A PICTURE $9999.
006190 03 FILLER PICTURE X VALUE 1.
006200 03 ID-DV-A PICTURE X.
007010 02 PAG-CTR PICTURE S999 COMPUTATIONAL-3 VALUE 0.
007050 01 READING.
007060 02 DATE-P PICTURE X(8).
007070 02 FILLER PICTURE X(16) VALUE SPACES.
007080 02 FILLER PICTURE X(24) VALUE 'STUDENT FILE PRINT'. SP1020
007090 02GRP-FLD-I PICTURE X(17).
007100 02 FILLER PICTURE X(1) VALUE SPACES.
007110 02 HD-2A.
007120 03 FILLER PICTURE X(7) VALUE 'FOR YR'. SP1020
007130 03 YR-P PICTURE XX.
007140 03 FILLER PICTURE X(5) VALUE 'GTP'. SP1020
007150 03 QTP-P PICTURE X.
007160 03 FILLER PICTURE X(19) VALUE SPACES.
007170 02 PAG-LN.
007180 03 FILLER PICTURE X(8) VALUE 'PAGE'. SP1020
007190 03 PAG-N0 PICTURE 772.
007200 03 FILLER PICTURE X(5) VALUE SPACES.
008010 PROCEDURE DIVISION.
008015 NOTE ----- GETDATE PUT CURRENT DATE IN DATE-P ------.
008020 HOUSE-KEEPING.
008030 ENTER LINKAGE.
008040 CALL 'GETDATE' USING DATE-P.
008050 ENTER COROL.
008055 OPEN OUTPUT PRNTR.
008130 MOVE '5' TO S-CODE.
008060 OPEN-F.
008070 OPEN INPUT STUDENT-FILE.
008080 READ-S.
008090 READ STUDENT-FILE AT END GO TO CLOSE-UP.
008100 DISPLAY.
008140 MOVE YEAR-S TO YR-P.
008150 MOVE QTP-S TO QTP-P.
008160 CHECK-CODE.
008170 IF DELETE-S = '1' GO TO READ-2.

G-60
008180  IF S-CODE = 'A' GO TO PFP-PPT.
009190  IF SCH-CODE = S (OTP-S) = S-CODE GC TC PFP-PPT.
009200  IF SCH-CODE = S (OTP-S) = '3' AND S-CODE = '4' GC TC PFP-PPT.
009110  GO TO PREAD-2.
009220  PFP-PPT.
009300  PERFORM PRINT-PT.
009400  PREAD.
009500  READ STUDENT-FILE AT END GO TO CLOSE-UP.
009600  GO TO CHECK-CODE.
009700  PRINT-PT.
009800  IF LINE-CNT GREATER THAN 55 PERFORM PAG-HD THRU PAG-EXIT.
009900  MOVE SPACES TO LN-1A.
010000  MOVE LN-1 TO REPEOR PRNT.
010100  MOVE LN-1A TO BODY, PERFORM PRNT.
010200  MOVE LN-1 TO PAG-NO.
010300  IF S-CODE = 'A' MOVE 'ALL STUDENTS' TO GRP-FLD-1.
010400  IF S-CODE = '4' MOVE 'COLLEGE STUDENTS' TO GRP-FLD-1.
010500  IF S-CODE = 'S' MOVE 'GRADUATE STUDENTS' TO GRP-FLD-1.
011120 IF $COF = '6' MOVE 'SEMINARY STUDENTS' TO GRP-FLD-1.
011130 MOVE PAG-LN TO GRP-FLD-2.
011140 MOVE PAG-RED TO PAG-RED.
011140 MOVE '1' TO PAG-RED.
011160 PAG-EXIT. Exit.
011170 CLOSE-UP.
011180 MOVE '59 TO LINE-CNT.
012010 CLOSE STUDENT-FILE.
012020 IF $COF = '5' MOVE '6' TO $CODE, GC TO OPN-F.
012030 CLOSE PRT.
012040 PRNT.
012050 WRITE PRT AFTEl CTF.
012060 MOVE '1' TO CTF.

/EXEC LINK FDT
/
// JNP AC 00000 C3 PRINT FILE
// CLPL SYSC52, 'REXECMPARK FILE', CI/CO1, ISE
// EXTENT SYS021, AU0000, 4, 1, 1C, 1C
// EXTENT SYS021, AU0000, 1, 2, 2C, 1CC
// EXTENT SYS21, AU0000, 2, 3, 12C, 10
// EXEC C3
This program copies the index sequential file to a sequential file.
// JOB AC COOP CO
// C4 COPY FILE FOR SORTING
// DLPL SYSEOI, 'BENCHMARK SORT', 0
// EXTENT SYSEOI, AUOOOC, 1, 0, 150, 1CC
// DLPL SYSEOC, 'BENCHMARK FILE', 0, 150
// EXTENT SYSEOC, AU00001, 4, 1, 1C, 10C
// EXTENT SYSEOC, AU00001, 7, 2C, 10C
// EXTENT SYSEOC, AU00001, 7, 3, 12C, 10
// EXIT C4
//
COPY STUDENT FILE

EXEC C cosmic
001010 IDENTIFICATION DIVISION.
  PROGRAM-ID 'C4'.

001030 AUTHOR. WBN.
001040 REMARKS. COPY STUDENT FILE TO BACK-UP.
001050 DATE WRITTEN. SEPT. 9.
001060 ENVIRONMENT DIVISION.
001070 CONFIGURATION SECTION.
001080 SOURCE-COMPUTER. IBM-360.
001090 OBJECT-COMPUTER. IBM-360.
001100 INPUT-OUTPUT SECTION.

001110 FILE-CONTROL.

001120 "SELECT STUD-FILE ASSIGN TO 'SYS052' DIRECT-ACCESS 2311
001130 ORGANIZATION IS INDEXED
001140 RECORD KEY IS ID-S
001150 ACCESS IS SEQUENTIAL
001160 RESERVE NO ALTERNATE AREA.
001170 "SELECT STUD-OUT ASSIGN TO 'SYS011' DIRECT-ACCESS 2311
001180 ACCESS IS SEQUENTIAL.

001190 DATA DIVISION.
001200 FILE SECTION.

002010 FD STUD-FILE
002020 RECORDING MODF IS F
002030 BLOCK CONTAINS 5 RECORDS
002040 RECORD CONTAINS 155 CHARACTERS
002050 LABEL RECORD IS STANDARD
002060 DATA RECORD IS STUD-REC.

002070 01 STUD-REC PICTURE X(155).
002080 FD STUD-OUT
002090 RECORDING MODF IS F
002100 BLOCK CONTAINS 11 RECORDS
002110 RECORD CONTAINS 155 CHARACTERS
002120 LABEL RECORD IS STANDARD
002130 DATA RECORD IS STUD-REC.
002140 01 STUD-REC.
002150 02 FILLER PICTURE X(155).

002160 PROCEDURE DIVISION.
002170 RESTART.
002180 OPEN INPUT STUD-FILE
002190 INPUT STUD-OUT.
002200 START.
003010 READ STUD-FILE INTO STUD-REC AT END GO TO END-FL.
003020 WRITE STUD-REC.
003030 GO TO START.
003040 END-FL.
003050 CLOSE STUD-FILE STUD-OUT.
003060 STOP RUN.

// L'OLTYP'NS0(3)
// EXEC LNKEDF1
&
C5 SORT

This program should sort the sequential file by school code major (position 92) then student name (positions 8-30).
// JOB AC OOC00C  C5  SORT SEQUENTIAL FILE
// EXEC FILEA, 'BENCHMARK SORT',0
// EXTENT SYS21, AUC00C, 1, 6, 15C, 1CC
// EXEC FILEK, 'BENCHMARK WORK', C, DA
// EXTENT SYS21, AUC00C, 1, 6, 25C, 2CC
// EXEC FILEK, 'BENCHMARK SORT', 0
// EXEC FILEK, 'BENCHMARK SORT', 0
// EXEC CSORT
SOFT FILECS=O2, I, A, R, 22, A), FFORMAT=BI, SIZE=1500
RECORD LENGTH=(155), TYPE=F
INPFIL BLKSIZE=(1705, X), INPUT=O
OUTFILE BLKSIZE=(1705), OUTPUT=O
END
//
This data is to be used for C2 to demonstrate the CREATE feature.
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<td>Larry Allen</td>
<td>1206314502</td>
<td>02/15/90</td>
</tr>
<tr>
<td>Lillian</td>
<td>2112233402</td>
<td>02/15/90</td>
</tr>
<tr>
<td>Virgin Allen</td>
<td>1202163803</td>
<td>02/15/90</td>
</tr>
<tr>
<td>Wayne W</td>
<td>1205237025</td>
<td>02/15/90</td>
</tr>
<tr>
<td>Alfred S</td>
<td>1210224602</td>
<td>02/15/90</td>
</tr>
<tr>
<td>Victor</td>
<td>1205347025</td>
<td>02/15/90</td>
</tr>
<tr>
<td>Thomas</td>
<td>2211092504</td>
<td>02/15/90</td>
</tr>
<tr>
<td>Harold</td>
<td>1212163504</td>
<td>02/15/90</td>
</tr>
<tr>
<td>Name</td>
<td>Social Security Number</td>
<td>Address</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>------------------------</td>
<td>---------------</td>
</tr>
<tr>
<td>Edward Anderson</td>
<td>085491234567</td>
<td>123 Main St</td>
</tr>
<tr>
<td>James Brown</td>
<td>085491234567</td>
<td>456 Main St</td>
</tr>
<tr>
<td>Samantha Davis</td>
<td>085491234567</td>
<td>789 Main St</td>
</tr>
<tr>
<td>William Evans</td>
<td>085491234567</td>
<td>123 Main St</td>
</tr>
</tbody>
</table>

**Notes:**
- Edward Anderson has a driver's license number of 123456789.
- James Brown is a member of the local sports club.
- Samantha Davis has a pet dog named Max.
- William Evans recently completed a community college course.
ANDREWS UNIVERSITY

SUPPLEMENT TO REQUEST FOR BENCHMARK

Berrien Springs, Michigan

December 19, 1972
SUPPLEMENT TO REQUEST FOR BENCHMARK

Purpose
Since one of the major academic functions of the upgraded computer system will be to process large statistical batch jobs, we feel it is useful to have a demonstration of the proposed system capabilities in this area.

Provisions
The statements contained in the "Request For Benchmark," dated December 11, 1972, in paragraphs "Purpose," "Time Frame," and "Evaluation of Results", apply to this supplement as well.

Applications Package Test
Data enclosed, "F6 FACTOR," is to be processed using the FORTRAN statistical subroutines proposed for use at Andrews University on the bid system. Make coding changes as required to process data F6. Submit a listing of the programs as executed, compile-through-load time for each program. Timing is to be based on the system interval timer (make coding changes required for its use with each program).
FORTRAN DATA
F6 Factor

This data was prepared from 222 responses to a 128 question survey questionnaire. The responses were coded from 1 to 5 on an ascending scale where 1 was an unfavorable and 5 was a very favorable response. Failure to respond was coded as a 6. Each questionnaire required two 80 column cards for the 128 questions. The first two columns of each card were reserved to indicate whether the card was the first or second in the set. Columns 3 through 52 on card one contain data for the first 50 questions, and columns 3 through 80 on card two contain data for the remaining 78 questions.

The data should be processed using the factor analysis routines which are part of the statistical applications package proposed for use on the bid system.

Desired output includes (but is not necessarily limited to):

1. Means
2. Standard deviations
3. Correlation coefficient matrix
4. Eigenvalues
5. Eigenvectors
6. Factor Matrix
7. Variance of the factor matrix for each iteration cycle
8. Rotated factor matrix
9. Communalities
Please retain 10 eigenvalues for steps 5 through 9. Please submit a listing of all programs as executed.
5 January 1973

Mr. Leroy H. Botten
Director, Computer Center
Andrews University
Berrien Springs, Michigan 49104

Dear Mr. Botten:

Xerox has at your request undertaken and executed the Andrews Benchmark Study. This brief report has been prepared to convey the procedure used, the equipment employed and to present selected summary results of our efforts. The primary purpose of the study was to demonstrate the capacity to execute the supplied programs. We feel that we have met this objective. In addition the completed output contains a substantial amount of data that defines quite accurately what occurred in the system while the programs were being executed. No attempt has been made in this report to provide Andrews with a complete explanation of system operation during the test. Rather we have selected for presentation those results that we believe to be of general interest to the selection committee. Should you or other members of the committee desire further definition or explanation of the detailed technical aspects of the test, I will arrange the necessary presentation at a mutually acceptable time.

The accompanying report contains the following sections:

I. Equipment Configurations
II. System Tuning Parameters
III. The Test Procedures
IV. Summary of Results
The Appendix Material Includes:

A. Equipment Lists
B. Test Procedures
C. Program Source Listings
D. Execution Listings
E. Utilization Analysis
F. Basic Language Tests
G. Time Sharing Users Terminal Output

The Exhibit Material Includes:

A. Program C3 execution and output listing
B. Program F6 execution and output listing
C. Multiprogramming Run #1 - Dual Batch, no T/S users
D. Multiprogramming Run #2 - Dual Batch, 5 T/S users
E. Single Batch Stream F2 - F5 compile, load, and execute

Yours very truly

L. D. Felton
Account Manager
INTRODUCTION

This report summarizes pertinent aspects of the Xerox execution of the Andrews benchmark request of December 12, 1972. The report contains the following sections.

I. Equipment Configurations
II. System Tuning Parameters
III. The Testing Procedures
IV. Summary of Results
I. **Equipment Configurations**

There are two variations between the equipment used to execute the benchmark programs and that proposed for Andrews University (as defined in the January 4, 1973 configuration and price revision).

The first variation results from using peripheral devices that are not identical to those proposed for Andrews. The line printer used for the benchmark is not currently offered by Xerox. The Model 7445 printer used in the test has been replaced by the 7441 proposed for Andrews. The 7445 was rated at approximately 1000 lines per minute while the 7441 is rated at 1100 lines per minute. The time variation between the two should therefore be negligible but improved print quality can be expected. Because so few cards were punched in the benchmark (the only cards punched contained job accounting data) no significant variations should have been introduced. All other peripheral devices were the same model number (or of the same rated speed) as those contained in the proposal.

Because all detailed system performance statistics gathered by the operating system exclude actual peripheral device time encountered by the symbiont system, the only variation introduced by differences in rated peripheral speeds would be caused by changes in the pattern of interrupts and differences in the end-action processing for the different devices.
The combined effect of these differences are likely to be undetectable.

The second potential variation is from differences in the number and type of I/O channels, I/O ports and the position of the peripherals in the priority interrupt hierarchy. The effect of the variations in CPU time should be extremely small but they may cause differences in such values as I/O wait time. Because the Andrews proposal currently contains an IOP expansion feature we would not anticipate any significant system performance variations.

In summary the equipment used for the benchmark tests very closely approximates the proposed equipment. We believe that the benchmark results are representative of the results that Andrews can expect from the equipment currently under consideration. Lists of the equipment proposed and used in the benchmark are presented in the Appendix (Section A).
II. System Tuning Parameters

UTS is perhaps the most complete time sharing operating system available from any computer manufacturer. As a result a number of operating system characteristics have been identified that can substantially effect the manner in which the system performs. To permit UTS to be "tuned" to a specific customer's needs and operating environment these characteristics have been set up as variables. A user may (after measuring system performance with various settings) control the performance of the system by changing the values of these variables. Xerox has made no attempt to tune the system used to run the benchmark programs. An attempt to replicate the results of the benchmark should be done with system control variables set equal to those originally employed.

Subject to the limitations above and with potentially minor adjustments introduced by equipment variations Xerox feels sure that the Andrews equipment when installed will yield substantially the same system performance.
III. The Testing Procedure

In general Xerox viewed the benchmark as a two phase effort. The first phase was the conversion or preparation of the test programs and the second was the execution of the programs to obtain the necessary operating statistics.

Xerox approached the program preparation effort by employing two different groups. The Applications Systems Division (the group currently estimating the Andrews conversion effort) was used for COBOL conversion and for setting up the package used for the addendum. This was done to take advantage of the specialized skills of the individuals and the ready access of computer room facilities. The remaining programs were made ready by technical members of the Detroit office using the time sharing facilities in El Segundo, California.

Xerox has currently designated a group in El Segundo, California, that has as its prime responsibility the execution of customer requested benchmarks. After all programs were prepared, they were gathered in El Segundo and executed according to the implementation plan presented in Appendix B. This test procedure was discussed with members of the Andrews staff prior to its implementation.
IV. Summary of Results

The results presented have been keyed to the test procedure presented in the Appendix (Section B). Both the test procedure and these results have been ordered to follow the sequence in the benchmark request.

Conversion Test (test procedure I-A)

Source listings of COBOL programs C1, C2, C3, C4 and FORTRAN F6 are presented in Appendix C. This Appendix also contains a description of the software package used for F6. COBOL program C5 is a sort and was developed with the COO version of the Xerox SORT package. The only effort expended was to punch the required control cards. As a result no conversion effort or source listing has been provided for C5. The effort required to prepare the remaining COBOL programs for execution is outlined below.

<table>
<thead>
<tr>
<th>Program</th>
<th>Number Translation Attempts Required</th>
<th>Number of Tests Required</th>
<th>Minutes of Analysts Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>C1</td>
<td>1</td>
<td>0</td>
<td>35</td>
</tr>
<tr>
<td>C2</td>
<td>2</td>
<td>2 (one each)</td>
<td>65</td>
</tr>
<tr>
<td>C3</td>
<td>4</td>
<td>2</td>
<td>90</td>
</tr>
<tr>
<td>C4</td>
<td>2</td>
<td>1</td>
<td>30</td>
</tr>
</tbody>
</table>

All program changes were input via a teletype on a time sharing system. Tests and translator outputs were returned via remote batch terminal. The analyst performing the conversion did not enter a computer installation during the conversion period which spanned two days.
In order to provide the above listings and a base point for subsequent reference, programs C2 through C5 and F6 were run in a single batch stream. The results of execution of C2 #1, C2 #2, C4 and C5 are presented in Appendix D. Exhibits A and B (see accompanying binder) contain the results (including output) of executing C3 and F6 respectively. Appendix E, Exhibit 2 contains the result of running a Xerox Computer Utilization Analysis. Exhibit 1 of Appendix E defines in general terms the Xerox Computer Utilization Analysis Program.

**Dedicated Machine Performance Tests (test procedure IIIA, IIIB)**

The results from step II (A and B) of the test procedure are outlined below.

<table>
<thead>
<tr>
<th>Time</th>
<th>Program</th>
<th>Compile Time</th>
<th>Execution Time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B8</td>
<td>less than .1 sec</td>
<td>40.5 seconds</td>
</tr>
<tr>
<td>Sharing</td>
<td>C1</td>
<td>one second</td>
<td>108.5 seconds</td>
</tr>
<tr>
<td>Mode</td>
<td>F1</td>
<td>one second</td>
<td>14.5 seconds</td>
</tr>
<tr>
<td>Batch</td>
<td>B8</td>
<td>less than .1 sec</td>
<td>38.0 seconds</td>
</tr>
<tr>
<td>Mode</td>
<td>C1</td>
<td>one second</td>
<td>108.5 seconds</td>
</tr>
<tr>
<td></td>
<td>F1</td>
<td>one second</td>
<td>14.5 seconds</td>
</tr>
</tbody>
</table>

A performance analysis for the above is contained in Appendix E as a portion of Exhibit 3.

**Language Tests** (test procedure IIIA, IIIB, and IIIC)

The results of this section were obtained by storing input data on disk packs. Listings and output data for Basic programs B1 through B7 are presented in Appendix F.
COBOL source listings are presented in Appendix C.

The result of executing these programs is presented in Appendix D. The output from C3 is presented in Exhibit A. Appendix E, Exhibit 2 presents an analysis of this sequence. The values observed were.

<table>
<thead>
<tr>
<th>Program</th>
<th>Elapsed Time</th>
<th>CPU Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>C2</td>
<td>48.0 seconds</td>
<td>.39 minutes</td>
</tr>
<tr>
<td>C3</td>
<td>30.0 seconds</td>
<td>.20 minutes</td>
</tr>
<tr>
<td>C4</td>
<td>15.0 seconds</td>
<td>.05 minutes</td>
</tr>
<tr>
<td>C5</td>
<td>25.0 seconds</td>
<td>.12 minutes</td>
</tr>
</tbody>
</table>

The observed compile through load statistics for the programs F2 through F6 are as follows.

<table>
<thead>
<tr>
<th>Program</th>
<th>Elapsed Time</th>
<th>CPU Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>F2</td>
<td>43.0 seconds</td>
<td>.60 minutes</td>
</tr>
<tr>
<td>F3</td>
<td>13.0 seconds</td>
<td>.13 minutes</td>
</tr>
<tr>
<td>F4</td>
<td>10.0 seconds</td>
<td>.11 minutes</td>
</tr>
<tr>
<td>F5</td>
<td>15.0 seconds</td>
<td>.13 minutes</td>
</tr>
<tr>
<td>F6</td>
<td>141.0 seconds</td>
<td>1.95 minutes</td>
</tr>
</tbody>
</table>

An analysis of these tests is included in Exhibit 3, Appendix E. Exhibit E contains the output from the executed job stream.

**Multiprogramming and Concurrent Processing Tests**

The benchmark request asked for four separate tests to be run in this environment. Each test was to recycle each of two batch streams. The number of time sharing users was to be varied from 0 through 15 in steps of 5.

The observed results are as follows.

<table>
<thead>
<tr>
<th>Test</th>
<th>Elapsed Time</th>
<th>CPU Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>COBOL sequence time (CST)</td>
<td>4 min 3 sec</td>
<td>.55 min</td>
</tr>
<tr>
<td>Fortran sequence time (FST)</td>
<td>7 min 5 sec</td>
<td>2.39 min</td>
</tr>
</tbody>
</table>
Test 2 (5 time sharing users)

COBOL sequence time (CST) 4 min 24 sec .55 min
Fortran sequence time (FST) 8 min 29 sec 2.41 min

Tests 3 and 4 were not completed due to the difficulty of arranging for the required number of terminal users. The terminal user output is contained in Appendix G. A computer utilization output report for each of the above tests is contained in Appendix E as Exhibits 4 and 5 respectively. Exhibits C and D contain the actual output listings from these two tests.
APPENDIX MATERIALS
## Equipment Lists

<table>
<thead>
<tr>
<th>Item</th>
<th>Test System</th>
<th>Proposed System</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operating System</td>
<td>UTS</td>
<td>same</td>
</tr>
<tr>
<td>Central Processor</td>
<td>Sigma 6</td>
<td>same</td>
</tr>
<tr>
<td>Memory Size</td>
<td>64 K words</td>
<td>same</td>
</tr>
<tr>
<td>Tape Units</td>
<td>2-60 KB drives</td>
<td>same</td>
</tr>
<tr>
<td>Card Reader</td>
<td>7140/1500 CPM</td>
<td>7122/400 CPM</td>
</tr>
<tr>
<td>Card Punch</td>
<td>7160/300 CPM</td>
<td>7165/100 CPM</td>
</tr>
<tr>
<td>Line Printer</td>
<td>7445/1000 LPM</td>
<td>7441/1100 LPM</td>
</tr>
<tr>
<td>Disk Storage</td>
<td>7242/Dual Spindle</td>
<td>same</td>
</tr>
<tr>
<td>Rad Storage</td>
<td>7232</td>
<td>same</td>
</tr>
<tr>
<td>Operators Console</td>
<td>7012</td>
<td>same</td>
</tr>
</tbody>
</table>
ANDREWS UNIVERSITY BENCHMARK RESULTS

CONVERSION TEST

Man hours required to convert C1, C2, C3, C4, C5 were 4 hours including keypunching.

Central processor time was about 10 minutes and elapse time about 30 minutes.

DEDICATED MACHINE PERFORMANCE TESTS

Batch runs:

<table>
<thead>
<tr>
<th>RUN</th>
<th>ELAPSE</th>
<th>CPU</th>
</tr>
</thead>
<tbody>
<tr>
<td>B8</td>
<td></td>
<td>Conversational language could not run batch.</td>
</tr>
<tr>
<td>C1</td>
<td>1 + min</td>
<td>59.6686 sec</td>
</tr>
<tr>
<td>F1</td>
<td>1 + min</td>
<td>81.5788 sec</td>
</tr>
</tbody>
</table>

Timesharing runs:

(1) These notes were typed from handwritten notes supplied by Univac.
<table>
<thead>
<tr>
<th>RUN</th>
<th>ELAPSE</th>
<th>CPU</th>
</tr>
</thead>
<tbody>
<tr>
<td>B8</td>
<td>183</td>
<td>183.7112</td>
</tr>
<tr>
<td>C1</td>
<td>71 sec</td>
<td>59.2587</td>
</tr>
<tr>
<td>F1</td>
<td>2 min</td>
<td>81.0175</td>
</tr>
</tbody>
</table>

**LANGUAGE TESTS**

B1 through B7

- 27 minutes hookup time
- 6.7649 CPU time

**COMPILE AND EXECUTE**

<table>
<thead>
<tr>
<th>C2</th>
<th>3 min</th>
<th>49.3066 sec</th>
</tr>
</thead>
<tbody>
<tr>
<td>C3</td>
<td>1 min</td>
<td>39.5606</td>
</tr>
<tr>
<td>C4</td>
<td>1 min</td>
<td>15.5457</td>
</tr>
<tr>
<td>C5</td>
<td>1 min</td>
<td>7.9547</td>
</tr>
<tr>
<td>Update C2</td>
<td>1 min</td>
<td>10.0619</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>F2</th>
<th>1</th>
<th>27.1733</th>
</tr>
</thead>
<tbody>
<tr>
<td>F4</td>
<td>1</td>
<td>30.6788</td>
</tr>
<tr>
<td>F5</td>
<td>1</td>
<td>29.3286</td>
</tr>
</tbody>
</table>
## MULTIPROGRAMMING TESTS

### Dedicated runs:

<table>
<thead>
<tr>
<th></th>
<th>START</th>
<th>STOP</th>
<th>ELAPSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>CST</td>
<td>1626</td>
<td>1628</td>
<td>2 min</td>
</tr>
<tr>
<td>FST</td>
<td>1813</td>
<td>1817</td>
<td>4 min</td>
</tr>
</tbody>
</table>

### Multiprogramming without timesharing:

<table>
<thead>
<tr>
<th></th>
<th>START</th>
<th>STOP</th>
<th>ELAPSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>CST</td>
<td>1805</td>
<td>1808</td>
<td>3 min</td>
</tr>
<tr>
<td>FST</td>
<td>1805</td>
<td>1810</td>
<td>5 min</td>
</tr>
</tbody>
</table>

### Multiprogramming with timesharing:

- **Run 1**
  - CST: 1851 - 1856
  - FST: 1851 - 1857
  - ELAPSE: 5 min

- **Run 2**
  - CST: 1858 - 1904
  - FST: 1858 - 1906
  - ELAPSE: 6 min
Xerox Data Systems, Inc. (hereinafter called XDS) agrees to lease to the above named Lessee at the above address, and the Lessee agrees to accept for the lease amounts stated herein, XDS computing equipment noted below (excluding Program Products) installed and ready for Lessee’s use, together with instructions in the operation of the equipment and maintenance service on the equipment, upon the terms and conditions hereinafter stated in this Agreement.

<table>
<thead>
<tr>
<th>Item</th>
<th>Model No.</th>
<th>Qty.</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Basic Monthly Charge Each</th>
</tr>
</thead>
<tbody>
<tr>
<td>Item Charge</td>
</tr>
<tr>
<td>Unit Charge</td>
</tr>
</tbody>
</table>

Sales Price of Equipment $ ____________ Total: $ ____________

Delivery Date ____________

XDS will provide Maintenance Service on the above equipment in accordance with both Paragraph 6 of this contract and the following:

A. Service Hours:
   Regular Service Hours will be ________ to ________, Monday through Friday, excluding holidays and one hour meal period.
   Extended Service Hours will be ________ to ________, ________ through ________, for an additional monthly charge of $ ________.

B. Optional Local Service will be provided for an additional monthly charge of $ ________.

C. “On-Call” Maintenance will be provided for in accordance with Paragraph 6 of this contract up to an amount not to exceed $ ________.

AGREED TO THIS

__________ day of ________, 19____

Lessee

By:

Title

ACCEPTED THIS

__________ day of ________, 19____

Xerox Data Systems

701 South Aviation Blvd., El Segundo, California 90245

By:

Title

Lease Number ____________
1. LEASE TERM
The lease term shall commence when service begins and continue for the number of years shown. After the initial period, the lease will remain in effect until terminated by either party with three months written notice. Upon expiration of the lease term, or extension thereof, Lessee shall return the equipment in good condition with allowance for normal wear and tear.

2. MONTHLY CHARGES
The basic monthly charges shall be payable on the installation date of the equipment for the calendar month in which equipment is first installed and shall be prorated to the end of the month, and thereafter shall be paid for each calendar month on the first day of that month.

3. TAXES
The Lessee will pay any Sales, Use Tax, or Import Tax. XDS will pay the Personal Property Tax.

4. INSTALLATION PERMITS
Lessee will prepare the site in accordance with XDS's written site specifications 15 days prior to the scheduled delivery date. XDS will install the equipment. Lessee will provide labor for unpacking and locating the equipment. Lessee will assume responsibility for compliance with local laws and will obtain any permits required for installation and use.

5. SOFTWARE
XDS software identified as "Control Programs" will be provided by XDS under the terms of this equipment lease agreement. Maintenance service will be provided for standard, current versions of such Control Programs.

XDS software identified as "Program Products" are not furnished under this agreement. Program Products will be made available to the Lessee on a fee basis pursuant to an XDS software licensing agreement executed by the Lessee.

6. MAINTENANCE
During the Regular and Extended Service Hours shown on the face of this agreement XDS will accomplish regularly scheduled preventive maintenance, provide replacement parts as needed, and make available, upon request, maintenance personnel for corrective maintenance.

Maintenance occasioned by the negligence of the Lessee, or by the use of attachments not provided by XDS, or by any abnormal use, is not covered by the monthly charge and Lessee agrees to pay for such services at XDS's then current rate.

The Lessee agrees to give XDS access to the equipment when necessary for maintenance.

If the face of the agreement indicates Optional Local Service is to be provided, XDS will locate one or more service technicians within 100 miles of the installation.

If Optional Local Service is not to be provided and the installation is beyond 100 miles from an XDS service center, Lessee agrees to pay transportation, lodging and subsistence for all calls in excess of one per week.

Lessee will pay for Maintenance Services requested to be performed outside the Regular and Extended Service Hours defined on the face of this agreement at the hourly rates, including travel time, in effect at the time such service is performed. There is a two hour minimum for all services performed on an hourly basis.

If the equipment remains inoperative for 48 consecutive hours after maintenance service has been requested, rental of the inoperative equipment and nonuseable interconnected XDS equipment will thereafter be charged to the Lessee. Rent and all operation is restored. This rental abatement expresses XDS's entire liability for inoperative equipment. Lessee will pay the full amount of invoices submitted by XDS 30 days after their date, without deducting rental abatement or other credits until XDS and Lessee agree on the amount of the credit and XDS issues a credit memo in the agreed upon amount. Claims for downtime must be initiated in writing within seven (7) working days after the incident.

7. DELAYS, DAMAGES
XDS shall not be liable for delays in delivery or failure to manufacture due to causes beyond its reasonable control. In the event of any such delay, the date or dates for performance of this contract by XDS shall be extended for a period equal to the time lost by reason of delay. In no event shall XDS be liable for incidental or consequential damages under this lease.

8. ALTERATIONS, ATTACHMENTS
No alterations or attachments to the leased equipment shall be made without XDS's written approval.

9. TRANSPORTATION AND PACKING
Lessee will pay all transportation and rigging charges to and from the installation site and will return the equipment to XDS's plant by air freight, or by van equipped for transporting electronic equipment, unless XDS has approved in writing an alternate method of shipment. Lessee will not move the equipment to another location without XDS's consent.

10. OPTION
Lessee may purchase any of the leased equipment during the term of this lease for its sales price on the date of this lease less 40% of the rentals paid to a maximum of 60% of the sales price.

11. PATENT INDEMNITY
XDS agrees to defend Lessee in any suit brought against him alleging that the articles leased hereunder, uncombined with non-XDS equipment, directly infringe United States Letters Patent owned by others, provided XDS is promptly notified, given assistance required and permitted to direct the defense. Further, XDS will pay any judgment based on such infringement, rendered in such suit by final judgment of a court of last resort, but shall not be responsible for settlements or costs incurred without its consent. If Lessee's use of such articles is enjoined, or in the event that XDS desires to minimize its liabilities hereunder, XDS will, at its option, substitute other equally suitable articles, modify the articles so that they no longer infringe, obtain for Lessee the right to continue their use, or take them back releasing Lessee from the obligation of paying rentals not yet due. The foregoing states the entire liability of XDS for patent infringement. No indemnity shall apply to articles made or modified to Lessee's own specifications or design.

12. ASSIGNMENT
Either party may assign its rights and remedies and may also transfer its obligations under this lease. However, the assignment or transfer shall not operate to relieve the assigning party of any of its obligations hereunder. Nor will any such assignment impose any obligation on the assignee except in the case of an express written assumption thereof by the assignee.

13. LOSS OR DAMAGE
XDS agrees that Lessee shall be relieved of all responsibility for any loss or damage to the equipment covered by this agreement, provided that such loss or damage shall not have been caused by theft, unauthorized alteration, negligence or malice of the Lessee or any of its employees or representatives. The Lessee agrees to fully compensate XDS for any loss or damage to the equipment for which XDS is not relieved of responsibility hereunder.

14. DEFAULT
In the event of any default by Lessee, XDS may, at its option, declare this lease in default and terminate this lease.

If at any time during the Lease Term or any extension thereof, Lessee shall make an assignment for the benefit of creditors or shall become insolvent, or if a receiver or trustee of substantially all of Lessee's property shall be appointed, or if the Lessee (where it is a corporation) shall terminate its existence, or if a petition is filed by or against Lessee pursuant to any of the provisions of the United States Bankruptcy Act, as amended, for the purpose of adjudicating Lessee bankrupt or for reorganization of Lessee or for the purpose of effecting an arrangement or composition with Lessee's creditors, then in each and every such case this lease and any extension thereof shall terminate immediately without any further act or notice by XDS.

Upon termination of the lease pursuant to this Article 14, XDS shall be entitled to immediate possession of the equipment and to any rental sums due and unpaid, together with all other rights and remedies in law or in equity.
TIME SALE AND SECURITY AGREEMENT

XEROX CORPORATION, a New York corporation, acting through its Xerox Data Systems division, 701 South Aviation Boulevard, El Segundo, California 90245 (hereinafter called "SELLER") and (hereinafter called "BUYER") agree as follows:

1. **Sale and Purchase.** SELLER hereby sells to BUYER, and BUYER hereby purchases from SELLER the several items of equipment listed and described in Schedule A attached hereto and made a part hereof (the "Equipment"), upon the terms and conditions provided herein, and for the Time Sale Price specified with respect thereto on Schedule A, payable as provided in Section 3, but subject to acceleration as provided in Section 9.

2. **Security Interest; Transfer of Title.** BUYER hereby grants to SELLER a security interest in the Equipment and any and all replacements and substitutions thereof and repairs thereto, for the purpose of securing the payment of the balance of the Time Sale Price from time to time due hereunder and all other liabilities of BUYER to SELLER arising under this Agreement. Title to each item of Equipment shall upon delivery of each such item at the location specified by BUYER pass to BUYER.

3. **Payment of Purchase Price.** Subject to the provisions of Section 9, the Time Sale Price with respect to each item of Equipment will be paid by BUYER to SELLER in consecutive monthly installments in the amount set forth in Schedule A, such installments to be paid on the first day of each month commencing on .

4. **Delivery and Acceptance; Risk of Loss.** Delivery of the Equipment shall be made at BUYER's expense to such location in the United States as BUYER shall specify, shipment to be made by SELLER within after receiving written notice to deliver from BUYER. Possession of each item of Equipment and the risk of loss thereof or damage thereto shall pass to BUYER upon his acceptance thereof. Such acceptance shall be deemed to occur upon delivery of the Equipment to the location specified. SELLER shall install the Equipment at the location specified in BUYER's written notice, such installation to be in the manner and to include documentation, standard software, and software support normally supplied to customers of SELLER without charge. SELLER shall not be liable for delays in delivery or failure to manufacture due to acts beyond its reasonable control, including but not limited to acts of God, acts or omissions of civil or military
authority, priorities, fire, strikes, floods, restrictions, riots, war, delays in transportation, car shortages, and inability due to causes beyond its control to obtain the necessary labor, materials or manufacturing facilities. In the event of any such delay, the date for performance of this Agreement by SELLER shall be extended for a period equal to the period of time lost by reason of the delay.

5. Taxes. BUYER acknowledges that it is not purchasing the Equipment for resale. All taxes of every description (including sales, use and personal property taxes) arising out of the transactions contemplated hereby (other than taxes on the income of SELLER) shall be borne and paid for solely by BUYER, and BUYER shall pay or shall reimburse SELLER for its payment of any applicable personal property tax with respect to the Equipment accrued after the date hereof.

6. Financing Statement. At the time of execution of this Agreement, BUYER will join with SELLER in executing and filing appropriate financing statements relating thereto in form satisfactory to SELLER. Further, promptly upon delivery and acceptance of each item of Equipment as provided in Section 4, or upon any subsequent relocation of any item of Equipment, BUYER will join with SELLER in executing and filing such further financing statements relating thereto in form satisfactory to SELLER and as SELLER may deem appropriate.

7. Insurance. From the time at which the risk of loss or damage to the Equipment passes to BUYER as provided in Section 4 hereof, BUYER shall procure and maintain, with an insurance carrier acceptable to SELLER, insurance thereon against such risks and in such amounts as SELLER shall reasonably require. Each such policy of insurance shall be endorsed with a standard mortgagee or security certificate or certificates of the insurance carrier or carriers evidencing insurance coverage as herein required.

8. Mutual Covenants and Agreements. SELLER hereby covenants and agrees (i) that it is now and upon delivery and acceptance of any of the Equipments as provided in Section 4 hereof, it will be the owner of such Equipment, free and clear of any and all liens, encumbrances, claims, or security interests other than those to be created hereby, and other than any lien, encumbrance, claim or security interest on or against the Equipment heretofore or hereafter caused or allowed to be caused by BUYER or any subsidiary or affiliated company of BUYER; (ii) that it has now and will then have the full right and power to sell the Equipment to BUYER upon the terms and conditions provided herein; and (iii) that so long as BUYER shall not be in default hereunder and subject to the rights of any third party as a result of any lien, encumbrance, claim, or security interest on or against the Equipment caused or allowed to be caused by BUYER or any subsidiary or affiliated
company of BUYER, BUYER shall be entitled to the sole and exclusive possession and use of the Equipment purchased by and delivered to it hereunder. BUYER hereby covenants and agrees (i) that it now has and that upon delivery and acceptance of any of the Equipment as provided in Section 4 hereof it will have the full right and power to buy the Equipment from SELLER upon the terms and conditions provided herein; (ii) that it will not use or deal with the Equipment in a manner which is inconsistent with the terms of this Agreement, or any policy of insurance referred to in Section 7 hereof, or the applicable laws and regulations of governmental agencies; and (iii) that it will not use the Equipment in any manner which results in unreasonable deterioration or depreciation thereof, and that SELLER shall have the right to inspect the Equipment at any reasonable time, wherever located.

9. Acceleration; Prepayment. (a) Upon any acceleration of the maturity of its obligations with respect to any item of Equipment pursuant to this Section 9 (the Acceleration Date), the BUYER shall pay to the SELLER an amount (the Acceleration Price) which shall be equal to (i) the portion of the Invoice Price of such item (as set forth in Schedule A hereto) which would remain unpaid on the Acceleration Date if such Invoice Price had been borrowed and partially repaid in installments in the same amounts and payable on the same dates as the installments of the Time Sale Price heretofore paid by BUYER for such item and if each such installment payment had been applied first to the payment of interest on such unpaid portion at a rate of _________ percent per annum and the remainder to the Invoice Price, and (ii) interest (computed at _________ percent per annum rate from the date of the last preceding installment paid hereunder to the Acceleration Date) on the Invoice Price remaining unpaid as arrived at in (i).

(b) BUYER shall give SELLER not less than fifteen (15) days written notice of any proposed resale or lease of any item of Equipment during the term of this Agreement. Such notice shall state the item or items of Equipment to be resold or leased and the date upon which sale or lease is to be effective. If the Equipment is to be resold or leased, BUYER shall pay to SELLER on or prior to such date the Acceleration Price in respect of such item of Equipment.

(c) If at any time an event of default specified in Section 10 hereof shall have occurred and shall be continuing, SELLER shall have the right, upon written demand to BUYER specifying such event of default, to require BUYER to pay, within ten (10) days after the date of such demand, the Acceleration Price with respect to all of the Equipment then subject hereto.

(d) If any item of the Equipment shall be substantially destroyed or shall be damaged beyond repair, SELLER shall have the right, upon written demand to BUYER, to require BUYER to pay, within ten (10) days after the date of such demand, the Acceleration Price with respect to each item of Equipment so destroyed or damaged, less any proceeds of insurance theretofore received by SELLER.
with respect to such Equipment.

(e) BUYER shall have the right, exercisable at any time during the term of this Agreement, upon written notice to SELLER specifying the items of Equipment affected, to fully satisfy its obligations hereunder with respect to any or all items of Equipment by the payment to SELLER, not less than ten (10) days nor more than thirty (30) days after the date of such written notice, the Acceleration Price with respect to such items of Equipment. SELLER agrees, on request of BUYER, to confirm in writing to any proposed purchaser or lessee of any of the Equipment from BUYER that, on payment in full to SELLER of the Accelerated Purchase Price, the amount of which Accelerated Purchase Price shall be specified in such notice, SELLER will release its security interest in the Equipment.

(f) SELLER shall release its security interest in any item of Equipment when payment shall have been made with respect thereto as provided in this Section 9, and shall execute such documents furnished by BUYER as may be necessary to evidence such release.

10. Events of Default; Remedies. BUYER shall be in default (a) if it shall fail to pay, or cause to be paid, any installment payable under Section 3 hereof, or any sum payable upon any acceleration under Section 9 hereof when the same is due, or (b) if it shall fail to perform any other term or condition of this Agreement, and such failure shall continue for a period of fifteen (15) days after written notice thereof from SELLER to BUYER, or (c) if Federal bankruptcy, insolvency, liquidation, receivership or like proceedings are initiated by or on behalf of or against BUYER, or any of the Equipment shall be attached, seized or levied upon, and such proceedings, attachment or levy shall not be vacated or fully stayed, within thirty (30) days after the institution or occurrence thereof, or (d) if any of the Equipment shall be sold, leased or encumbered by BUYER other than in accordance with the provisions of Section 9 (b) hereof.

If an event of default shall have occurred and be continuing, SELLER shall have the right to accelerate BUYER's obligations hereunder as provided in Section 9 (e) hereof, and in addition shall have all the rights (not inconsistent with the rights specifically provided herein) of a secured party under the Uniform Commercial Code; or SELLER may, at its option, and it is hereby empowered so to do, enter upon the premises where the Equipment may be and take possession thereof, or remove, sell and dispose of the Equipment and from the proceeds of sale retain all costs and charges incurred by SELLER in the taking or sale of the Equipment including any reasonable attorney's fees thereby incurred; also SELLER may take all sums due it under the terms of this Agreement including reasonable attorney's fees; and any surplus of such proceeds remaining shall be paid to BUYER. The foregoing is without limitation to or waiver of any other rights or remedies of SELLER according to law. It is
further agreed that upon any sale of the Equipment according to law, or under the power herein given, that SELLER may bid on the said sale, or make a purchase of the Equipment or any part thereof.

11. Waivers. A waiver by SELLER of a default under this Agreement shall not operate as a waiver of any other default which may thereafter occur.

12. Location of Equipment. Following delivery and acceptance thereof as provided in Section 4, and so long as the Equipment is subject to a security interest of SELLER, the Equipment will be kept at the location specified in BUYER's written notice or at such other location as may hereafter be agreed upon by SELLER and BUYER; during such period BUYER will promptly notify SELLER of any change in the location of the Equipment, and will not remove the Equipment from the aforesaid location, without the prior written consent of SELLER which consent shall not be unreasonable withheld or delayed.

13. Warranty. SELLER warrants that the Equipment is merchantable and that it will replace or repair any components of Equipment manufactured by SELLER which are defective by reason of material or workmanship that the BUYER returns to SELLER within one (1) year from acceptance of the Equipment. This warranty does not extend to program products, nor to expendable items such as pilot lamps and fuses, nor to components that have suffered mechanical wear, such as vacuum motors and punch die blocks, nor to products altered or repaired by personnel other than those employed by SELLER, or trained and certified by SELLER. Shipment of defective parts to SELLER will be paid by BUYER. Return shipment, to the BUYER, of repaired or replaced parts will be paid by SELLER. Operation or storage of the Equipment in an environment other than that selected by SELLER or recommended by SELLER's published specification will invalidate this warranty. There are no other warranties, expressed or implied. In no event shall SELLER be liable for incidental or consequential damages.

14. Patent Indemnity. SELLER agrees to defend BUYER in any suit brought against it alleging that any item of the Equipment sold hereunder uncombined with equipment other than that manufactured by SELLER, directly infringes United States Letters Patent owned by others, provided SELLER is promptly notified, given assistance required, and permitted to direct the defense. Further, SELLER will pay any judgment based on such infringement, rendered in such suit by final judgment of a court of last resort but shall have no liability for statements or costs incurred without its consent. If BUYER's use of any item of Equipment is enjoined, or in the event that SELLER desires to minimize its liabilities hereunder, SELLER will, at its option, either substitute
other equally suitable items of the Equipment, modify such items so that they no longer infringe, obtain for BUYER the right to continue their use, or take them back returning the price less a reasonable amount for use, damage and obsolescence. The foregoing states the entire liability of SELLER for patent infringement. No indemnity shall apply to items of the Equipment made or modified to BUYER's own specifications or design.

15. **Notices.** All notices or other communications required or permitted to be given pursuant to this Agreement shall be in writing and shall be valid and sufficient if delivered by hand or dispatched by registered or certified airmail, postage prepaid, addressed as follows:

Xerox Data Systems
701 South Aviation Boulevard
El Segundo, California 90245
Attention: Vice President-Finance

or to such other address as either party shall notify the other in writing. Given notices dispatched by registered or certified airmail shall be deemed to have been given three days after such notice is deposited in any post office.

16. **Governing Law; Severability.** This Agreement shall be construed in accordance with and governed by the internal laws of the State of California. Any provision of this Agreement which may be prohibited by law shall be ineffective to the extent of such prohibition without invalidating the remaining provisions of this Agreement.

17. **Equipment Markings.** SELLER may mark the Equipment to conspicuously show that it has a security interest therein and BUYER shall place no conflicting marks or indicia on the Equipment or suffer SELLER's marks to be removed or defaced without the written consent of SELLER or until payment in full shall have been made and BUYER shall have fulfilled all of its obligations hereunder.

**IN WITNESS WHEREOF,** the parties hereto have executed this Agreement as of the ________ day of ____________, 1971.

XEROX CORPORATION

XEROX DATA SYSTEMS

By ________________
Typed Name

____________________
Title

By ________________
Typed Name

____________________
Title
<table>
<thead>
<tr>
<th>Quantity</th>
<th>Catalog No.</th>
<th>Description</th>
<th>Invoice Price</th>
<th>Down Payment</th>
<th>Monthly Installment</th>
</tr>
</thead>
</table>

* The Monthly Installment is equal to the Invoice Price (I. P.) less the Down Payment (___ % of I. P.) times _________, the factor appropriate to amortize a loan in _________ (___) equal monthly installments at _______ percent per annum on the unpaid balance).

** The Time Sale Price is equal to the sum of the _______ Monthly Installments plus the Down Payment.
Agreement between ___________________ (hereinafter called Owner) and Xerox Data Systems (hereinafter called XDS) for the maintenance of XDS computer system and peripheral equipment per the configuration list and maintenance fees listed in Appendix A, in accordance with the terms and conditions of this contract.

This Agreement is for a fixed period of ______________ commencing ______________, 19___.

XDS agrees to perform the following basic monthly maintenance service during the Principal Period of Maintenance.

1. Accomplish regularly scheduled Preventive Maintenance.
2. Update the equipment to provide the latest reliability improvements.
3. Supervise the preparation for movement and set-up of the equipment after movement.
4. Provide replacement parts as needed.
5. Make available, upon request, maintenance personnel for corrective maintenance.

A. PRINCIPAL PERIOD OF MAINTENANCE

The Principal Period of Maintenance (PPM) shall be any nine (9) consecutive hours, 7:00 a.m. and 6:00 p.m. (Monday through Friday), with a one (1) hour meal period.

B. EXTENDED COVERAGE

For contracted coverage of more than one shift, the PPM may be extended in the time increments and for the charges shown in the following schedule. The percentage is computed on the total monthly maintenance rate. The hours shown include the Principal Period of Maintenance.

<table>
<thead>
<tr>
<th>Hours</th>
<th>5 Days</th>
<th>6 Days</th>
<th>7 Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>100%</td>
<td>120%</td>
<td>140%</td>
</tr>
<tr>
<td>16</td>
<td>140%</td>
<td>170%</td>
<td>190%</td>
</tr>
<tr>
<td>24</td>
<td>210%</td>
<td>225%</td>
<td>240%</td>
</tr>
</tbody>
</table>

C. PPM SERVICE HOURS

PPM service hours will be __________ to __________, through __________, excluding holidays, with one (1) hour meal period.

Agreed to this ______________ day of ______________, 19___.

Name of Owner

Street Address

City State Zip Code

By

Title

INSTALLATION NO.

MAIN FRAME S/N

If installation is beyond 100 miles from an XDS service center, the owner agrees to pay transportation, lodging and subsistence for all calls in excess of one (1) per week.

D. OPTIONAL LOCAL MAINTENANCE

The owner whose installation is located more than 100 miles from the nearest XDS service center may reduce the travel charges for which he is liable and diminish the response time by contracting for an XDS Field Engineering Representative to be located within 100 miles of the installation. The price for this relocation is:

1. $1,000 per month if XDS is maintaining only one (1) computer in the area.
2. $300 per month if XDS is maintaining two (2) computers in the area.
3. No charge if XDS is maintaining three (3) or more computers in the area.

XDS □ shall, □ shall not locate one or more service technicians within 100 miles of the installation.

E. CHARGES

(1) Basic monthly charge per Appendix A __________
(2) Extended coverage __________
(3) Optional local service __________

Sub-Total __________

Total Maintenance Charge __________

Monthly Maintenance Charge __________

F. EMERGENCY SERVICE

Calls outside the PPM service hours defined in Paragraph C will be provided for at the following rates: Monday through Saturday, except holidays, $ __________ per man hour including travel time; Sunday and holidays $ __________ per man hour including travel time. There is a two (2) hour minimum for all services performed on an hourly basis.

When requested, XDS will provide off-site stand by service outside of the Principal Period of Maintenance at the rate of one (1) man hour for each four (4) hours of stand by. On-site stand by to be charged on a per hour basis.

Approved and Accepted ______________ day of ______________, 19___.

Xerox Data Systems

701 South Aviation Blvd., El Segundo, California 90245

By

Title
AGREEMENT CONDITIONS

1. GENERAL

Equipment not under XDS lease or maintenance contract immediately prior to the effective date of this maintenance agreement shall be subject to inspection by XDS without charge. If the equipment is not in good operating condition, labor and parts required to place the equipment in good operating condition shall be provided by XDS at the owner's expense.

2. DURATION OF AGREEMENT

The owner shall have the right to terminate this Agreement at any time after the first anniversary of the Commencement Date shown on its face, by written notice sent to and received by XDS at least three (3) months prior to the termination date selected by the owner. XDS may terminate this Agreement, or change the monthly maintenance or emergency service charge on any or all of the items of equipment covered by this Agreement at any time after the first anniversary of the Commencement Date, by written notice to the owner three (3) months prior to the termination or receipt of notification of any such changes of maintenance charges, the owner shall have the right to terminate this Agreement, such termination to become effective as the date of the proposed change in maintenance or emergency service charge on any or all of the items of equipment.

3. MONTHLY CHARGES AND TERMS OF PAYMENT

(a) The basic monthly charges for maintenance service shall begin on the Commencement Date shown on the face of this Agreement. The calendar month in which service starts the charges shall be prorated to the end of the month and thereafter shall be invoiced for each calendar month on the first day of the month.

(b) The owner agrees to pay the monthly and hourly charges as set forth on the face of this Agreement and to pay an additional amount equal to any taxes, however designated, levied, or based on such monthly charges or upon this Agreement, or any taxes or amounts in lieu thereof paid by XDS or payable by XDS in respect of the foregoing, exclusive of taxes based upon XDS’ net income.

(c) Terms 30 days net from date of invoice.

4. RESPONSIBILITIES OF XDS

(a) XDS shall provide maintenance (labor and parts) at the price agreed to and keep the equipment in good operating condition.

(b) Preventive (scheduled) maintenance shall be performed at a time other than the owner’s working hours so long as it is performed during or contiguous to the Principal Period of Maintenance. XDS shall specify in writing the frequency and duration of the preventive maintenance required for the equipment listed on the order and the owner shall specify the schedule for the performance of the preventive maintenance. This schedule may be modified by mutual agreement.

(c) Remedial maintenance shall be performed after notice of the equipment is inoperative. XDS shall provide the owner with a designated point(s) of contact and express permission to his maintenance representative to receive such notification.

(d) XDS shall furnish a malfunction incident report to the installation upon completion of each maintenance call. The report shall include, as a minimum, the following:

(1) Date and time notified.
(2) Date and time of arrival.
(3) Type and model number(s) of machine(s).
(4) Time system made available to XDS.
(5) Time spent for repair.
(6) Description of malfunction.
(7) Corrective action taken including parts used.
(8) Additional charges, if applicable.

(e) Only new standard parts or parts of equal quality shall be used in affecting repairs. Parts which have been replaced shall become the property of XDS.

(f) Maintenance service shall include the items of equipment necessary to the maintenance of the machine being serviced.

(g) XDS shall provide adequate storage space for spare parts and adequate working space, including heat, light, ventilation, electric current and outlets for the use of XDS’ maintenance personnel. These facilities shall be within a reasonable distance of the equipment and shall be provided at no charge to XDS.

(b) The owner's personnel shall not perform maintenance or attempt repairs to equipment while such equipment is under the purview of this contract unless agreed to by XDS.

(c) The owner shall provide XDS access to the equipment to perform maintenance services. If additional costs are incurred as a result of the owner's denial of access during the scheduled periods for an unreasonable period of time, the owner shall bear the cost of returning the equipment to good operating condition.

6. MAINTENANCE

(a) XDS agrees to make available, upon request, maintenance personnel for corrective maintenance. Additionally, if the service is begun during the Principal Period of Maintenance and the difficulty is not corrected on the same day at the end of the PPM service will continue at no extra charge.

(b) The Principal Period of Maintenance or extension thereof may be changed by the owner upon 30 days written notice.

(c) Corrective maintenance occasioned by the negligence of the owner, his employees or representatives, or by the use of devices or special attachments not provided by XDS or by any other misuse or abnormal use, is not covered by the monthly charge.

(d) There shall be no additional maintenance charges for time spent by maintenance personnel after arrival at the site awaiting the arrival of additional maintenance personnel and/or delivery of parts, etc., after a service call has commenced.

7. ALTERATIONS AND ATTACHMENTS

If the owner makes alterations or installs attachments to the equipment covered by this Agreement, and if in the opinion of XDS the cost of maintenance is substantially increased, the parties may mutually adjust the maintenance charge for the equipment or XDS may immediately discontinue service for such equipment hereunder.

8. MOVEMENT OF EQUIPMENT

(a) In the event that equipment being maintained under the terms and conditions of this Agreement is moved to another location, XDS shall continue to maintain the equipment at the new location unless such a movement should remove the equipment outside the 48 contiguous states and the District of Columbia.

(b) In the latter instance, the maintenance agreement shall be terminated without further obligations being incurred by either XDS or the owner.

(c) The owner shall give at least 30 days written notice of the movement of equipment unless such move is required because of an emergency.

(d) When the shipment is under the control of XDS and damage is incurred which results in abnormal costs for either labor or parts to restore the equipment to good operating condition at the new site, such costs shall be borne by XDS.

(e) When the shipment is under the control of the owner and damage is incurred which results in abnormal costs for either labor or parts to restore the equipment to good operating condition at the new site, such costs shall be borne by the owner.

(f) Maintenance charges shall be suspended on the day the equipment is dismantled in preparation for shipment. Maintenance charges shall be reinstated on the day installation and checkout procedures necessary to place the system in good operating condition are complete.

(g) The owner shall furnish transportation and such labor as may be necessary for packaging and placement of the equipment. Reinstallation and checkout charges may be negotiated with XDS.

9. LIABILITY FOR INJURY OR DAMAGE

XDS shall be liable for any injury to the owner's personnel or damage to the owner's property arising from the use of the equipment maintained by XDS when such injury or damage is due to the fault of negligence of XDS. The owner shall be liable for any injury to XDS personnel or damage to XDS property when such injury or damage is due to the fault or negligence of the owner.

10. SPECIFIC CONTRACT COMMITMENTS

No representations or statements made by any representative of XDS which are not stated herein shall be binding. The provisions hereof constitute the entire Agreement between the parties with respect to the equipment and its maintenance. The terms and conditions of this Agreement supersede those of all previous agreements between the parties with respect to the equipment covered by this Agreement.
<table>
<thead>
<tr>
<th>ITEM</th>
<th>MODEL NO</th>
<th>QTY.</th>
<th>DESCRIPTION</th>
<th>UNIT CHARGE*</th>
<th>TOTAL</th>
</tr>
</thead>
</table>

*Based on 8 hours, Mon. Through Fri.*
Xerox Data Systems, Inc. (XDS) is pleased to confirm your order for licenses for the XDS Program Products and/or related optional materials listed below. XDS hereby grants the Customer nontransferable, nonexclusive licenses to use each of these licensed programs and/or related optional materials in printed form as specified below under the terms of the above numbered License Agreement for XDS Program Products between XDS and the Customer, which is hereby supplemented to include the following:

### Program Product List

<table>
<thead>
<tr>
<th>CPU Type/Serial No.</th>
<th>CPU Installation No.</th>
<th>Program/Material</th>
<th>Estimated Ship Date</th>
<th>Prog. Service Classification</th>
<th>Charges</th>
</tr>
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<td>Monthly</td>
</tr>
</tbody>
</table>

The CPU serial number, corresponding to the CPU installation number, will be available upon request following shipment of the CPU.

Under the License Agreement for XDS Program Products, the Customer has agreed that until that Agreement is specifically terminated by the Customer upon three months' prior written notice to XDS, the terms of that Agreement as amended will take precedence over the terms of any present or future order from the Customer for licenses. The Customer has further agreed that his acceptance of future delivery of any licensed program or related optional material is conclusive evidence of his agreement that the license for such licensed program or related optional material is governed by the terms of that Agreement as amended.

The provisions of the above numbered license agreement allowing XDS to cancel on six months' notice are not applicable to any single charge program licenses listed above. Single charge program licenses will be for a term equal to the term of the computer installation (CPU) to which the license applies or 10 years from the estimated shipment date, whichever occurs first.

Accepted by:
Xerox Data Systems, Inc.

By __________________________
Authorized Signature

Name

Title

On __________ Date

The Program Product List may be continued on the reverse hereof.
<table>
<thead>
<tr>
<th>CPU Type/Serial No.</th>
<th>CPU Installation No.</th>
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<td>Monthly</td>
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</tbody>
</table>

H-11 (Reverse)
License Agreement for Program Products

Xerox Data Systems, Inc. (XDS), a Division of Xerox Corporation, by its acceptance of this Agreement by signature at its Regional office or Headquarters, agrees to grant and the Customer agrees to accept on the following terms and conditions nontransferable and nonexclusive licenses to use the Program Products including basic material (together referred to as licensed programs) and related optional materials (optional materials) ordered by the Customer, subject to written confirmation by XDS.

TERM
This Agreement is effective from the date on which it is accepted by XDS and shall remain in force until terminated by the Customer upon one month's prior written notice, or by XDS as provided below.

The minimum use period for each license under this Agreement is one month from the commencement of monthly charges. Any license may be discontinued by the Customer at the conclusion of the minimum use period or any time thereafter, upon one month's prior written notice. XDS may discontinue any license or terminate this Agreement if the Customer fails to comply with any of the terms and conditions of this Agreement, or as provided in the Section of this Agreement entitled "Patent and Copyright Indemnification." Notice of discontinuance of any program license will be notice of discontinuance of any license for optional material obtained in connection with such program license. Notice of discontinuance of any or all licenses shall not be considered notice of termination of this Agreement unless that is specifically stated.

LICENSE
Each program license granted under this Agreement authorizes the Customer to use the licensed program in any machine readable form on a central processing unit or units in a single location designated by location number and its associated units (together referred to as CPU) or on the CPU designated under another then-current license for the identical Program Product. Each optional material license granted under this Agreement authorizes the Customer to use the optional material in any machine readable form on the designated CPU or on the CPU designated under another then-current license for the identical Program Product. A separate license is required for each CPU on which the licensed program and/or optional materials in any machine readable form will be used, provided, however, that the license granted under this Agreement for the designated CPU shall be temporarily transferred to (1) one back-up CPU if the designated CPU is inoperative due to malfunction, or during the performance of preventive maintenance, engineering changes, or changes in features or model, until the designated CPU is restored to operative status and processing of the data already entered into the back-up CPU is completed, and (2) to one other CPU for assembly or compilation of the licensed program if the specifications of the designated CPU are such that the licensed program cannot be assembled or compiled on the designated CPU. For purposes of this Agreement, use is defined as copying any portion of the licensed program's and/or optional material's instructions or data from storage units or media into the CPU for processing. Licenses granted under this Agreement authorize the Customer to utilize licensed programs and/or optional materials, in printed form, in support of the use of such licensed programs and/or optional materials in machine readable form.

This Agreement and any of the licenses, programs or materials to which it applies may not be assigned, sub-licensed or otherwise transferred by the Customer without prior written consent from XDS. No right to print or copy, in whole or in part, the licensed programs or optional materials is granted hereby except as hereinbefore expressly provided.

CHARGES
Monthly charges are subject to change by XDS upon three months' written notice to the Customer. If the monthly charge is increased for any program license, the Customer may discontinue it upon one month's written notice to XDS; otherwise the new charge will become effective.

Monthly charges will commence one month after shipment of the licensed program to the Customer, provided, however, that monthly charges will not commence on a Saturday or Sunday. Monthly charges will be invoiced in advance and will be payable within thirty days after the date of invoice. Charges for a partial month's use will be prorated based on a thirty-day month.

Certain licensed programs may be subject to an initial charge in addition to monthly charges or a single charge per license period in lieu of monthly charges. Initial and single charges are subject to change without notice.

There shall be added to any charges under this Agreement amounts equal to any taxes, however designated, levied or based on such charges or on this Agreement or the licensed programs or optional materials or their use, including state and local privilege or excise taxes based on gross revenue, and any taxes or amounts in lieu thereof paid or payable by XDS in respect of the foregoing, exclusive, however, of personal property taxes assessed on the licensed programs or optional materials and taxes based on net income.

LICENSE REDESIGNATION
The Customer may notify XDS of his intention to redesignate the CPU on which a licensed program and optional materials are to be used. The redesignation will be effective upon the date specified in an amendment to this Agreement furnished to the Customer by XDS entitled Confirmation of Change in Designated CPU.
ADDITIONAL LICENSES

Under this Agreement the Customer may, from time to time, order additional licenses for a previously licensed program and/or optional materials. These orders will be subject to acceptance by XDS under this Agreement and to the terms and conditions then in effect. Orders for additional licenses should reference this Agreement by number, XDS will confirm such orders and grant additional licenses by Supplements to this Agreement.

BASIC MATERIALS

Program licenses granted under this Agreement will govern any basic materials, in machine readable or printed form, provided by XDS in the quantities specified for each program license, and any additional copies in printed form licensed from XDS at the charges in effect at the time of their shipment.

RELATED OPTIONAL MATERIALS

For certain licensed programs XDS will offer to license related optional materials, under this Agreement or under a separate agreement, provided, however, that optional materials will only be available to Customers who have licensed the programs to which such optional materials apply. Optional materials will be provided by XDS in the quantities specified for each optional materials license. Any additional copies in printed form may be licensed at charges in effect at the time of their shipment.

PROGRAMMING SERVICES

For specified licensed programs, XDS will provide programming services after delivery, without additional charge, to correct licensed program errors and issue corrected releases. However, XDS does not guarantee service results or represent or warrant that all errors will be corrected.

The Programming Service Classification of each licensed program will be specified by XDS in the Program Product List for each license. The Programming Service Classification of any licensed program may be changed by XDS upon six months' notice except as provided in the section of this Agreement entitled "Patent and Copyright Indemnification." Some reclassifications may constitute a discontinuance of services.

The Programming Service Classifications are:

Class 1
When the Customer encounters a problem which XDS field diagnosis indicates is caused by a defect in a current unaltered release of the licensed program, XDS will (1) if the licensed program is inoperable, apply a temporary fix or make a reasonable attempt to develop an emergency by-pass, and (2) prepare a Software Improvement or Difficulty Report (SIDR) and submit it to an XDS Central Programming Service location.

XDS Central Programming Service will respond to any problem caused by a defect in a current unaltered release of the licensed program by issuing a temporary fix to the originator of the SIDR and/or issuing corrected code or notice of availability of corrected code. Corrections will be incorporated into new releases of the licensed program which will be made available to the Customer by XDS. Any other programming services or assistance will be provided at a charge.

Class 2
When the Customer encounters a problem which his diagnosis indicates is caused by a licensed program defect, the Customer may submit an SIDR to an XDS Central Programming Service location.

XDS Central Programming Service will respond to any problem caused by a defect in a current unaltered release of the licensed program by issuing a temporary fix to the originator of the SIDR and/or issuing corrected code or notice of availability of corrected code. Corrections will be incorporated into new releases of the licensed program which will be made available to the Customer by XDS. Any other programming services or assistance will be provided at a charge.

Class 3
Programming services or assistance will be provided at a charge. Central Programming Service will not be provided, except for corrections applicable to SIDR's received prior to the date Class 3 becomes effective for a licensed program previously assigned Class 1 or Class 2.

XDS shall have the right to make additional charges for any additional effort required to provide programming services resulting from Customer use of other than a current unaltered release of the licensed program.

PERMISSION TO COPY OR MODIFY LICENSED PROGRAMS

The Customer shall not copy, in whole or in part, any licensed programs or optional materials which are provided by XDS in printed form under this Agreement. Additional copies of printed materials may be licensed from XDS at the charges then in effect.

Any licensed programs or optional materials which are provided by XDS in machine readable form may be copied, in whole or in part, in printed or machine readable form, for use by the Customer with the designated CPU, to understand the contents of such machine readable material, for the sole purpose of modifying the licensed program as provided below, for back-up purposes as provided in the section of this Agreement entitled "License," or for archive purposes, provided, however, that no more than five printed copies and five machine readable copies will be in existence under any license at any one time without prior written consent from XDS other than copies resident in the designated CPU itself and copies created and used solely for checkpoint and/or restart purposes. The original, and any copies of licensed programs and/or optional materials, in whole or in part, which are made by the Customer shall be the property of XDS.

If the original or any copy of this licensed program or optional materials will be kept at other than the location of the designated CPU, the Customer will notify XDS in writing of a designated location for the original or copy. However, the Customer may transport or transmit a copy of the original of any licensed program to another location when the license is temporarily transferred as provided in the section of this Agreement entitled "License," provided the copy or the original is destroyed or returned to its designated location when the period of temporary transfer is concluded and the license reverts back to the designated CPU.

The Customer may modify any licensed program and/or optional material, in machine readable form, for his own use and merge it into other program materials to form an updated work, provided that, upon discontinuance of the license for such licensed programs, the licensed program and optional material supplied by XDS will be completely removed from the updated work and dealt with under this Agreement as if permission to modify had never been granted. Any portion of the licensed program or optional material included in an updated work shall be used only on the designated CPU except during a period of temporary transfer as provided in the section of this Agreement entitled "License," and shall remain subject to all other terms of this Agreement.

The Customer agrees to reproduce and include XDS's restrictive proprietary notice on any copies, in whole or in part, in any form, including partial copies in modifications, of licensed programs or optional materials made hereunder in accord with the restrictive proprietary notice instructions to be provided by XDS.
PROTECTION AND SECURITY

The Customer agrees not to provide or otherwise make available any licensed program or optional materials, including but not limited to flow charts, logic diagrams and source code, in any form, including partial copies in modifications, of the licensed program or optional material with other programs or data. The foregoing states the entire liability of XDS with respect to infringement of a copyright or a patent, and XDS may procure for the Customer the right to continue using the licensed programs or optional materials, or replace or modify them to make them noninfringing. If neither of the foregoing alternatives is reasonably available to XDS, then XDS may discontinue the licensed program and/or optional materials upon one month’s written notice to the Customer. If, however, the licensed program and/or optional materials is not the subject of a claim of copyright infringement, the Customer may notify XDS in writing during the one month after XDS’s notice of discontinuance that the Customer elects to continue to be licensed with respect to the licensed program or optional materials until there has been an injunction or the claim has been withdrawn, and agrees to undertake at the Customer’s expense the defense of any action against the Customer and to indemnify XDS with respect to all costs, damages, and attorney fees attributable to such continued use after such notice is given to XDS; it being understood that XDS may participate at its expense the defense of any action against the Customer and to pay any costs, damages, and attorney fees finally awarded against the Customer in such action which are attributable to such claim, provided that the Customer notifies XDS promptly in writing of any such action which are attributable to such claim, provided that the Customer notifies XDS promptly in writing of any such action.

PATENT AND COPYRIGHT INDEMNIFICATION

XDS will defend at its expense any action brought against the Customer to the extent that it is based on a claim that a licensed program or optional material, used within the scope of the license hereunder, infringe a copyright in the United States or a United States patent; and subject to the limitation of liability stated herein, XDS will pay any costs, damages, and attorney fees finally awarded against the Customer in such action which are attributable to such claim, provided that the Customer notifies XDS promptly in writing of the claim and XDS may fully participate in the defense and/or agrees to any settlement of such claim. Should the licensed programs or optional materials become, or in XDS’s opinion be likely to become, the subject of a claim of infringement of a copyright or a patent, XDS may procure for the Customer the right to continue using the licensed programs or optional materials, or replace or modify them to make them noninfringing. If neither of the foregoing alternatives is reasonably available to XDS, then XDS may discontinue the licensed program and/or optional materials upon one month’s written notice to the Customer. If, however, the licensed program and/or optional materials is not the subject of a claim of copyright infringement, the Customer may notify XDS in writing during the one month after XDS’s notice of discontinuance that the Customer elects to continue to be licensed with respect to the licensed program or optional materials until there has been an injunction or the claim has been withdrawn, and agrees to undertake at the Customer’s expense the defense of any action against the Customer and to indemnify XDS with respect to all costs, damages, and attorney fees attributable to such continued use after such notice is given to XDS; it being understood that XDS may participate at its expense the defense of any such action if such claim is against XDS. Upon XDS’s written notice of discontinuance to the Customer, a licensed program with Programming Service Classification 1 or 2 will be changed to Programming Service Classification 3. XDS shall have no liability for any claim of copyright or patent infringement based on (1) use of other than a current licensed program with Programming Service Classification 1 or 2 will be changed to Programming Service Classification 3 will be distributed on an “as is” basis without warranty.

RESPONSIBILITIES OF THE PARTIES

XDS will publish design objectives and estimated availability dates for licensed programs which it announces. However, XDS does not represent or warrant that such design objectives or estimated availability dates will be met.

XDS will publish Program Product Specifications for each licensed program with Programming Service Classification 1 or 2 as the licensed program is included in the library.

XDS will provide a functional description of each licensed program with Programming Service Classification 3 as it is included in the library.

The Customer shall be exclusively responsible for the supervision, management and control of his use of the licensed programs, and/or optional materials, including but not limited to: (1) assuring proper machine configuration, program installation, audit controls and operating methods, (2) establishing adequate back-up plans, based on alternate procedures and/or based on access to qualified programming personnel to diagnose, patch, and repair licensed program defects, in the event of a licensed program malfunction and, (3) implementing sufficient procedures and checkpoints to satisfy his requirements for security and accuracy of input and output as well as restart and recovery in the event of a malfunction.

The Customer agrees that he will take appropriate action by instruction, agreement, or otherwise with his employees or other persons permitted access to licensed programs and/or optional materials to satisfy his obligations under this Agreement with respect to use, copying, modification, and protection and security of licensed programs and optional materials.

DELIVERY

When available from the Library, licensed programs will be shipped to customers generally within one month after confirmation of order, subject to conditions beyond XDS’s control, unless the Customer requests a later delivery date. Announced licensed programs will be included in the Library in accordance with XDS’s estimated availability date for each licensed program. However, XDS does not represent or warrant that shipment or availability dates will be met.

Program storage media (magnetic tapes and disks) will be provided at a charge by XDS if not supplied by the Customer. Licensed programs will be shipped to the Customer without charge.

RISK OF LOSS

If any licensed program or optional material is lost or damaged during shipment, XDS will replace the licensed program or optional material and program storage media at no additional charge to the Customer.

If any licensed program or optional material is lost or damaged while in the possession of the Customer, XDS will replace the licensed program or optional material at a charge for program storage media unless it is provided by the Customer.

DISCONTINUANCE

Within one month after the date of discontinuance of any license under this Agreement, the Customer will furnish XDS a completed XDS Program Product Certificate of Discontinuance certifying that through his best effort, and to the best of his knowledge, the original and all copies in whole or in part, in any form, including partial copies in modifications, of the licensed program and any optional material received from XDS or made in connection with such license have been destroyed, except that, upon prior written authorization from XDS, the Customer may retain a copy for archive purposes only.

WARRANTY

Each licensed program with Programming Service Classification 1 or 2 will conform to its published Program Product Specifications when it is shipped to the Customer. Sample data will be shipped with such licensed programs to assure that the Customer has received a valid copy.

Each licensed program with Programming Service Classification 3 will be distributed on an “as is” basis without warranty.

LIMITATION OF LIABILITY

THE FOREGOING WARRANTY IS IN LIEU OF ALL OTHER WARRANTIES EXPRESS OR IMPLIED, INCLUDING, BUT NOT LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

PAGE 3 OF 4
The Customer agrees that XDS's liability hereunder for damages including but not limited to liability for patent infringements, but excluding liability for copyright infringements, regardless of the form of action, shall not exceed the charges paid by the Customer for the particular licensed program or optional material involved.

The Customer further agrees that XDS will not be liable for any lost profits, or for any claim or demand against the Customer by any other party, except a claim for patent or copyright infringement as provided herein.

No action, regardless of form, arising out of the transactions under this Agreement, may be brought by either party more than one year after the cause of action has accrued, except that, an action for nonpayment may be brought within one year after the date of last payment.

In no event will XDS be liable for consequential damages even if XDS has been advised of the possibility of such damages.

GENERAL

The terms of this Agreement may be modified by XDS upon six months' written notice to the Customer, except for the terms and conditions which relate specifically to (1) discontinuance of this Agreement or licenses granted under this Agreement as provided in the section of this Agreement entitled "Term" and the section of this Agreement entitled "Patent and Copyright Indemnification," and (2) charges for licenses granted under this Agreement as provided in the section of this Agreement entitled "Charges." The Customer may terminate this Agreement or discontinue any of the licenses hereunder on the effective date of such modification upon one month's prior written notice to XDS; otherwise, such modification shall be effective.

The Customer's remedies in this agreement are exclusive. If any of the provisions, or portions thereof, of this Agreement are invalid under any applicable statute or rule of law, they are to that extent to be deemed omitted.

The customer's remedies in this agreement are exclusive. The customer acknowledges that he has read this agreement, understands it and agrees to be bound by its terms and, further, agrees that it is the complete and exclusive statement of the agreement between the parties, which supersedes all proposals oral or written and all other communications between the parties relating to the subject matter of this agreement.

This Agreement will be governed by the laws of the State of California.

Accepted by:

Customer

By

Authorized Signature

Name

Title

Date

Xerox Corporation

By

Authorized Signature

Name

Title

Date
Appendix I

STAFFING REQUIREMENTS FOR CONVERSION

Preliminary estimation of staff allocation during conversion is as follows (based on 40 hours/week):

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Conversion and Testing(^{(1)})</td>
<td>20 man-weeks</td>
</tr>
<tr>
<td>Training (minimum)</td>
<td>6 man-weeks</td>
</tr>
<tr>
<td>Minimum Conversion Effort</td>
<td>26 man-weeks</td>
</tr>
</tbody>
</table>

Presuming a contract is signed by mid-February and that two full-time staff members are available for conversion, then there are 32 man-weeks available. However, some effort must be devoted to maintenance programming, and additional pre-installation training is certainly desirable. Should a delay occur in execution of the contract or should unforeseen difficulty occur in the conversion effort, the six man-week excess could rapidly disappear. It is for these reasons, as well as others outlined in Section 6.7.3, that immediate steps should be taken to add another qualified COBOL programmer to the Computing Center staff.

\(^{(1)}\) Based on responsibility for conversion and testing of 25% of existing programs and partial testing responsibility for the remaining 75% of existing programs.
APPENDIX J
Appendix J

EXPECTED TERMINAL GROWTH PATTERN

Timesharing growth at several universities has been explosive. At Andrews University a more gradual growth is expected due to several inhibiting factors:

- Limited administrative programming staff (this could be modified by cost-benefit studies).
- Limited research effort (although research efforts are presently increasing).
- Limited initial funding of terminal devices.
- Limited efforts, to date, to sell outside services (but this can be changed in a short time).

The following projection (Figure 1) is tentative but probably conservative. Each of the above factors has been considered. It was deemed unrealistic to attempt to project growth beyond the fifth year. For this projection, no attempt has been made to identify the type of terminal device required at each location.

The weighted estimate was developed by dividing the listed departments and agencies into three groups. Each group was assigned a weighting factor by which three weighted subtotals were calculated. The unweighted estimates are offered as valid individual growth patterns; the weighted sum is submitted as a moderately conservative estimate of aggregate terminal growth during the first three years after installation. It is expected that the growth rate will decline and that the final estimate may be nearly the final census.
<table>
<thead>
<tr>
<th>Location</th>
<th>1</th>
<th>3</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mathematics Department</td>
<td>2</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Physics Department</td>
<td>2</td>
<td>3</td>
<td>3</td>
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<tr>
<td>Chemistry Department</td>
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<tr>
<td>Biology Department</td>
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<td>1</td>
</tr>
<tr>
<td>Science Complex (General)</td>
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<td>3</td>
<td>3</td>
</tr>
<tr>
<td>Business Administration Departments</td>
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<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Education Department</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>Home Economics/Nursing Department</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Physical Education Department</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Computing Center (Programming)</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Computing Center (General)</td>
<td>3</td>
<td>3</td>
<td>3</td>
</tr>
<tr>
<td>MCST (replacement and growth)</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Security Office</td>
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<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Laboratory School</td>
<td>1</td>
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<td>Library</td>
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<td>Business Office</td>
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<td>5</td>
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<tr>
<td>Dormitory Complex</td>
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<td>2</td>
<td>4</td>
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<td>College Wood Products</td>
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<td>Bindery</td>
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<tr>
<td>Bookstore</td>
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</tr>
<tr>
<td>Grocery Store</td>
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<td>Lake Union Academies</td>
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<td>Food Services</td>
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<tr>
<td>Berrien County Intermediate School District</td>
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<td>2</td>
</tr>
<tr>
<td>Benton Harbor-St. Joseph Schools</td>
<td>2</td>
<td>4</td>
<td>6</td>
</tr>
<tr>
<td>Heathkit</td>
<td>3</td>
<td>4</td>
<td>5</td>
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<tr>
<td>Other Commercial Services</td>
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<td>4</td>
<td>6</td>
</tr>
<tr>
<td><strong>Total Estimate</strong></td>
<td>34</td>
<td>61</td>
<td>84</td>
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<tr>
<td><strong>Weighted Estimate</strong></td>
<td>22</td>
<td>43</td>
<td>56</td>
</tr>
</tbody>
</table>

Figure 1
4 January 1973

Mr. Leroy H. Botten
Director, Computer Center
Andrews University
Berrien Springs, Michigan 49104

Dear Mr. Botten:

This addendum has been prepared for review by the Andrews Selection Committee. The prices are firm for a period of sixty days. Should your selection process extend beyond this period, minor adjustments may be required. Xerox remains available to assist in further defining the equipment that best meets the needs of Andrews University. Should substantial equipment changes be necessary, minor adjustments in the proposed cost of conversion services may be necessary.

We welcome the opportunity to discuss or clarify any aspect of this addendum at the convenience of Andrews representatives.

Very truly yours,

XEROX CORPORATION

George D. O'Leary
District Manager

Attachments

mc
I. INTRODUCTION

This addendum to the Xerox proposal dated September 8, 1972 has been written to present a new alternative in equipment, procurement method and resulting costs. In addition, a new more specific proposal for conversion services is presented. The changes in equipment have resulted from our jointly re-evaluating the needs of Andrews University. The new proposal to assist Andrews in its conversion effort was developed by the Applications Systems Division of Xerox after a second review of existing programs and systems and a review of Andrews resources. In the near future, a complete and detailed conversion plan should be developed to assure a smooth and orderly transition to your new equipment. We welcome the opportunity to assist Andrews in preparing this plan and will do so at your convenience.

In addition, the following reference information has been added:

Section V: Power/Heat Estimates
Section VI: Floor Plan
Section VII: Sample Standard Contracts
Section VIII: Memory Expansion Options
II. HARDWARE CONFIGURATIONS

Introduction

Xerox and Andrews have explored a substantial number of possible hardware configurations for consideration. From these, Xerox has selected one for presentation in this addendum.

This configuration represents a superior solution to the long range needs of Andrews University. This configuration permits a UTS operating system that contains a richer set of processing languages and installation control features. As Andrews University experiences its internal growth in the number of time sharing users and begins to service other organizations, this new hardware/software approach will prove to be the most economical long range solution.

The general needs as Xerox understands them are as follows:

1. A system capable of performing concurrent batch and time-sharing for twenty-four terminal users.

2. A system capable of handling a complete set of unit record peripherals (such as card readers, card punches, line printers, etc.) on completely automatic basis.

3. A system capacity to handle slow speed - low density nine track magnetic tapes with the ability to move to faster units with correspondingly higher recording densities. Growth options are presented in the Appendix (Section II).

4. An initial capacity to store approximately fifty million bytes of data on-line, with the ability to substantially increase this capacity if and when required. Expansion capabilities are presented in the Appendix (Section III).
Configuration and Cost Proposal

The equipment below has resulted from extensive contact with members of the Andrews Selection Committee.

### CPU Sub-System

<table>
<thead>
<tr>
<th>Model</th>
<th>Description</th>
<th>Gross Purchase Price</th>
<th>Educational Discount</th>
<th>Net Purchase Price</th>
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</thead>
<tbody>
<tr>
<td>8310C</td>
<td>Sigma 6 CPU (64K Words)</td>
<td>286,000</td>
<td>57,200</td>
<td>228,800</td>
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<td></td>
<td>192 KB Memory</td>
<td>N/C</td>
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<td></td>
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<tr>
<td></td>
<td>Multiplexor I/O Processor</td>
<td>N/C</td>
<td></td>
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<td></td>
<td>Four Byte Interface</td>
<td>N/C</td>
<td></td>
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<td></td>
<td>Decimal Arithmetic</td>
<td>N/C</td>
<td></td>
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<td></td>
<td>Memory Map with Access</td>
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<td></td>
<td>Protection</td>
<td>N/C</td>
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<td>Memory Write with Protection</td>
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<td>Two Real-Time Clocks</td>
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<td>Two Register Blocks</td>
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<td>Power Fail-Safe</td>
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<td>External Interface</td>
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### Magnetic Tape Sub-System

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<td>Educational Discount</td>
<td>Net Purchase Price</td>
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<td>------------------------------------</td>
<td>----------------------</td>
<td>----------------------</td>
<td>--------------------</td>
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<tr>
<td></td>
<td>Unit Record Sub-System</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>7122</td>
<td>Card Reader (400 CPM)</td>
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<td>14,400</td>
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<tr>
<td>7165</td>
<td>Card Punch (100 CPM)</td>
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<td>1,960</td>
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<td></td>
<td>Removable Disk Pack Sub-System</td>
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<td></td>
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</tr>
<tr>
<td>7240</td>
<td>Controller</td>
<td>20,000</td>
<td>2,000</td>
<td>18,000</td>
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<td>Operators Console</td>
<td>6,000</td>
<td>600</td>
<td>5,400</td>
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<td><strong>Sub-Total</strong></td>
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<tr>
<td></td>
<td>Communications Sub-System</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>7612</td>
<td>Timing Module</td>
<td>250</td>
<td>50</td>
<td>200</td>
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<tr>
<td>7630</td>
<td>Controller plus 8 Lines</td>
<td>14,000</td>
<td>2,800</td>
<td>11,200</td>
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<tr>
<td>7631</td>
<td>Eight Line Expansion (2 requested)</td>
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<td>2,320</td>
<td>9,280</td>
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<td><strong>Sub-Total</strong></td>
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<td>Random Access Device Sub-System</td>
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<tr>
<td>7231</td>
<td>Extended Performance RAD</td>
<td>14,000</td>
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<td>11,200</td>
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<tr>
<td></td>
<td>Controller</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7232</td>
<td>Extended Performance RAD (6, 2 MB)</td>
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<td>20,000</td>
<td>30,000</td>
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<td><strong>Sub-Total</strong></td>
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<td></td>
<td><strong>Add-On Equipment Sub-Total</strong></td>
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<td></td>
<td><strong>219,220</strong></td>
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<td></td>
<td><strong>Configuration TOTAL</strong></td>
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<td><strong>111,940</strong></td>
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Cost Summary and Comparison

Installment Purchase Seven Year Plan

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<td>Monthly Installment Payments</td>
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<tr>
<td>Monthly Maintenance</td>
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<td><strong>Total Monthly Cost</strong></td>
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<td><strong>Total Seven Year Cost</strong></td>
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One Year Lease of Selected Peripherals Plan

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<th>Equipment</th>
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<tr>
<td>7122 Card Reader</td>
<td>360.00</td>
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<tr>
<td>7165 Card Punch</td>
<td>441.00</td>
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<tr>
<td>7441 Line Printer</td>
<td>1,035.00</td>
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<td><strong>Total</strong></td>
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<table>
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</thead>
<tbody>
<tr>
<td>Monthly Installment Payments*</td>
<td>5,995.05</td>
</tr>
<tr>
<td>Monthly Maintenance</td>
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<td><strong>Total Monthly Cost</strong></td>
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<td><strong>Total Annual Cost</strong></td>
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* Over seven years for the remainder of the system.
<table>
<thead>
<tr>
<th>Description</th>
<th>Amount</th>
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<tbody>
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<td>Unit Record Sub-System</td>
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<td><strong>Net Purchase Price</strong></td>
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<td><strong>Six Year I. P. Factor</strong></td>
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<td><strong>Monthly Payment</strong></td>
<td>1,072.81</td>
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<tr>
<td>Remainder of System</td>
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<tr>
<td>Maintenance</td>
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<tr>
<td><strong>Monthly Cost Years Two-Seven</strong></td>
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<tr>
<td><strong>Total For Six Years</strong></td>
<td>725,865.12</td>
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<tr>
<td><strong>First Year Cost</strong></td>
<td>125,775.60</td>
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<tr>
<td><strong>Total Seven Year Cost</strong></td>
<td>851,640.72</td>
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</table>
III. CONVERSION

Introduction

Of central concern in the installation of any new data processing equipment is the manner in which existing systems and programs will be converted to the new system.

In order to minimize the risks associated with conversion, Xerox formed a special department. This department (Applications Systems Division) was initially restricted to internal Xerox projects. After having perfected both the technical skills/tools and the necessary management techniques, their services have been made available to Xerox customers. These services are available to only those converting to Xerox equipment. The services are defined by an agreement which specifies in detail the nature of the work to be performed and the fees (if any) that are to be charged.

When the statement of services to be performed have been defined, the Agreement is signed for a fixed fee. Thus, Andrews University knows the exact amount of funds to allocate and the participation of the Xerox and the University Staff is clearly differentiated.

The Agreement also specifies the schedule allocated for Xerox participation. In general, the available staff is sufficient to meet even the most demanding schedule. The lead time for hardware delivery is usually more than sufficient for most conversion efforts.

Options and Estimated Fees

Section IV of the Appendix contains the proposal for Xerox services at Andrews University. Several options based on level of participation are defined in detail in this proposal. The fee structure is based on an estimated net sale price of the equipment of about $484,000. Should this value change significantly, the fee structure must be requoted. All fees are subject to final negotiations concerning the division of effort between Xerox and Andrews University. The options and estimated fees are outlined below:
Alternative One - Clean Compile

This alternative will be provided by Xerox at no cost to Andrews. In general, it involves converting your existing programs to Xerox Syntax, in a state suitable for the start of testing.

Alternative Two - Basic Case Test (All Programs)

The estimated fee is $8,600. This alternative is the most complete level of service and would permit Andrews University to pass through the conversion effort with a minimum of involvement.

Alternative Three - Selected Base Case Test

The estimated fee is $1,300. In this alternative, Xerox would take primary responsibility for those systems outlined in the proposal with Andrews assuming responsibility beyond the clean compile stage for all others.
CENTRAL PROCESSOR MAINTENANCE COSTS

8310C  Sigma 6 CPU with No Cost Options and 64K Memory  1,792.00
8318   Floating Point Arithmetic Unit                    103.00
8321   Interrupt Control Chassis                         30.00
8322   Priority Interrupt, 2 Levels                      N/C
8375   IOP Expansion Feature                            98.00

2,023.00

SUMMARY OF MAINTENANCE COSTS - TOTAL SYSTEM

8310C  Sigma 6 with Options                              2,023.00
Add-On Devices                                       1,921.00

Gross Monthly Cost                                   3,944.00
Less Discount                                         .930.40

Total Net Monthly Maintenance Cost                    3,013.60

SUMMARY OF MAINTENANCE COSTS
EXCLUDING UNIT RECORD SUBSYSTEM

8310C  Sigma 6 with Options                              2,023.00
Add-On Devices less unit record subsystem              1,362.00

Gross Monthly Cost                                    3,385.00
.734.75

2,650.25
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<tr>
<td></td>
<td><strong>Magnetic Tape Sub-System</strong></td>
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<tr>
<td>7315</td>
<td>Magnetic Tape Control and Transport</td>
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<tr>
<td>7316</td>
<td>Add-on Tape Transport</td>
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<td><strong>Unit Record Sub-System</strong></td>
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<td>Card Reader</td>
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<td>7165</td>
<td>Card Punch</td>
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<tr>
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<td>Disk Controller</td>
<td>104</td>
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<tr>
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<td>Dual Spindle</td>
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<td><strong>Sub-Total</strong></td>
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<td><strong>Communication Sub-System</strong></td>
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<tr>
<td>7612</td>
<td>Timing Modules</td>
<td>NC</td>
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<td>7630</td>
<td>Communications Controller plus 8 Lines</td>
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<td>7631</td>
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### Drum Storage Sub-System

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Sub-Total 354

TOTAL 1,921
### II. MAGNETIC TAPE OPTIONS

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<th>Expansion Charge</th>
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<td>2,840</td>
<td>25,560</td>
<td>200</td>
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<tr>
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<td>4,000</td>
<td>400</td>
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<td>7320</td>
<td>Magnetic Tape Controller 1600 BPI</td>
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<tr>
<td>1038</td>
<td>800 BPI Option for 1600 BPI Controller</td>
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<tr>
<td>7332</td>
<td>800 BPI, 75 IPS Tape Transport (60 KB)</td>
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<td>7332</td>
<td>1600 BPI, 75 IPS Tape Transport (120 KB)</td>
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<tr>
<td>7333</td>
<td>1600 BPI, 150 IPS, Tape Transport (240 KB)</td>
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<td>Extended Width Interface</td>
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### III. DISK EXPANSION CAPABILITIES

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<th>Qty</th>
<th>Model</th>
<th>Gross Purchase</th>
<th>Discount</th>
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<th>Expansion Charge</th>
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<table>
<thead>
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<th>Model</th>
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<tbody>
<tr>
<td>7246</td>
<td>Single Spindle 24.5 MB Removable Disk Drive</td>
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<tr>
<td>7242</td>
<td>Dual Spindle 49.1 MB Removable Disk Drive</td>
</tr>
<tr>
<td>7246</td>
<td>Four Spindle 98.3 MB</td>
</tr>
</tbody>
</table>

Note - Disk Controller was not presented here as each controller may control up to eight (8) spindles in any combination of the above devices.
SECTION IV
ANDREWS UNIVERSITY
CONVERSION PROPOSAL

BY

XEROX

COMMERCIAL SYSTEMS DEPARTMENT

NOVEMBER 6, 1972
1.0 INTRODUCTION

Xerox is pleased to offer the services of its Commercial Systems Department to convert Andrews University Administrative Computer Systems COBOL programs to Xerox ANS COBOL, and BAL subroutines to Xerox META-SYMBOL.

Originally created to convert the Xerox Corporation computer complex to XDS equipment, the Commercial Systems Department provides Andrews with a simplified and efficient approach to the conversion of its data processing applications. Utilizing a sophisticated group of conversion aids and operating in a terminal environment, the Commercial Systems team of specialists can implement conversions in a smooth and effective manner.

The specialized skills, knowledge and resources of Commercial Systems provides Andrews University with the following benefits:

Your programming staff can be relieved of a time consuming and non-productive conversion assuring that maximum effort is directed to the development of new systems and timely maintenance of present systems.

Disruption of present operations is minimized.

Reductions in both the cost and the elapsed time to complete the conversion can be achieved.

Risks associated with any delays and their costly impact on Andrews will be significantly reduced.

This proposal represents a summary of our analysis of your existing programs and procedures conducted on October 19th by one of our marketing specialists, and through conversations with Mr. LeRoy H. Botten and Don Inglemeir. Included are the alternate approaches that Xerox offers to you as our involvement in the total conversion effort. We will be happy to discuss any additional alternatives to the conversion task that seem appropriate and look forward to
1.0 **INTRODUCTION Con't.**

the opportunity of working with you in developing a smooth and efficient conversion plan utilizing the resources of both Xerox and Andrews to best advantage.
2.0 SCOPE OF EFFORT

This proposal is specifically addressed to the 289 COBOL programs and 11 BAL subroutines which, according to Andrews' documentation, are currently in the active or production stage on the IBM 360/22. It does not include the few RPG programs that were encountered nor any other COBOL or BAL programs that are not listed in Appendix A.

If there are any discrepancies in the program counts they should be brought to the attention of Xerox before any agreement is finalized as it may require an adjustment to the conversion costs.

During the conversion we may find it necessary to make system changes such as changing file labels, creating overlays, etc. to conform to the differences which may arise from the change in operating systems. However, in no case will such changes, either desirable or necessary, cause any differences in the final output of your system unless you agree that such a change is permissible.

One of the reasons for the success of the Commercial Systems Department in converting new customer installations is our ability to perform straight conversion tasks at a lower cost than the customer can do themselves. The reason for this is our experience, Sigma on-line programming capabilities and conversion aids developed in the past three years. Generally speaking, the success of a straight conversion does not require detail knowledge of the applications themselves, but rather knowledge of the targeted hardware and software, which our people know best.

Based on this background we are offering Andrews three alternatives for your consideration. Alternative One is to clean compile all your COBOL and BAL programs listed in Appendix A. Alternative Two includes the above task plus base case testing of all programs and their related sorts. Alternative Three offers clean compile of all programs plus base case testing of selected systems and related sorts, with Andrews being responsible for testing the remaining systems and sorts. Each of these is defined in detail on the following pages.
2.1 Alternative One - Clean Compile

With this alternative Xerox is proposing to convert all the COBOL and BAL programs mentioned in Exhibit A of this proposal to a clean compile stage (ready for testing) on a guaranteed, fixed price basis. The programs will be translated, compiled, and debugged until a diagnostic free program (except for warning level diagnostics) is obtained and object modules can be created.

In order to perform the conversion we will require that you deliver up-to-date compiled source listings, the source programs themselves on cards or 800 BPI tape, file layouts and printer layouts for each source program. In addition, any program descriptions, system flows, etc., which you can make available, should also be included.

At the completion of the task we will deliver the converted source programs and final compile listings with the LS, XREF, MAP, and DIAG compiler options plus a write up of any procedural changes that were incorporated in the converted programs.

Under this alternative Andrews will be relieved of much of the unproductive work associated with the program conversion, but will be responsible for all program testing, JCL conversion and file conversion.
2.2 Alternative Two - Base Case Test (all programs)

This alternative includes all the elements of Alternative One plus complete base case testing of the 389 COBOL and 11 META-SYMBOL programs. In addition all related sorts will be converted and tested.

Before testing begins, you must deliver all base case test files, data, control totals, finished reports, and operating instructions that will establish the accuracy of the converted programs. The term "base case" implies an abbreviated file and/or quantity of test data to make the test runs shorter in duration (15 minutes or less on the average) than normal operational runs. It will be Andrews responsibility to create the test data and files. They should be varied enough to assure complete testing of the logic of the programs.

At the end of the conversion effort we will deliver to you executable control decks and system test results showing a match-up of the control totals and finished reports.

Base case testing does not imply any parallel or full process cycle testing. Xerox only guarantees that the converted programs will meet the requirements of the base case tests.

Under this alternative you will be relieved of almost all of the conversion task. Your people will, however, still be the key to the success of the overall conversion in the data they supply us for testing, and in final sign-off of the completed systems and implementation to an operational environment. This alternative will include JCL conversion, but you will be responsible for bring the systems up live on your Sigma 9 and bringing the files over from your previous system at time of cut over.
2.3 Alternative Three - Base Case Test (selected systems)

Alternative Three will consist of clean compile (as outlined in Alternative One) of all programs plus base case testing of the following systems and related sorts:

<table>
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<th># Programs</th>
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<tr>
<td>Accounts Payable</td>
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<td><strong>TOTAL</strong></td>
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All conditions and specifics outlined in Alternative Two for base case testing apply to the above systems.

It will be Andrews responsibility to test the following systems and their related sorts (a total of 136 programs).

<table>
<thead>
<tr>
<th>Systems</th>
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<tbody>
<tr>
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<tr>
<td>Cash</td>
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<td>Computing Center Billing</td>
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<tr>
<td>Chapel</td>
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<tr>
<td>Check Reconciliation</td>
</tr>
<tr>
<td>Custodian Supplies</td>
</tr>
<tr>
<td>Custodian Labor/Dray</td>
</tr>
<tr>
<td>Daily Checks</td>
</tr>
<tr>
<td>Dun Lists</td>
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<td>FM Radio Station</td>
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<td>Test Scoring</td>
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<td>CWP Inventory</td>
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<td>Xerox Charges</td>
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<tr>
<td>Utility Programs</td>
</tr>
</tbody>
</table>

All specifics outlined in Alternative One for clean compile will apply to the above systems.
2.3 Alternative Three - Con't.

This alternative would allow your staff at Andrews to become involved with "hands on" experience on the new system and familiarity with Xerox ANS COBOL.
3.0 CONVERSION CONTROL

A project leader will be assigned by Xerox to oversee the conversion effort. Working with the local marketing representative, he will be your main contact throughout the conversion in the areas Commercial Systems is involved. It will be his responsibility to handle the collection of information, resolve problems and conduct periodic reviews to appraise you of the conversion progress. We request that you assign a project coordinator to resolve any unanswered questions that might arise; provide an approach selection decision where multiple Xerox alternatives are available in resolving a difference caused by language, hardware or software; and act as an interface between Andrews and Xerox for the conversion effort.

The conversion does not provide for any enhancements or redesign, but where it would be advantageous to the University to change the file storage media from cards to disk or tape, Commercial Systems will consider the improvement. Implementation will depend on the impact to the overall conversion project and be the sole discretion of Xerox.

4.0 PRICE

<table>
<thead>
<tr>
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<tr>
<td>Alternative One</td>
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<td>Alternative Three</td>
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Xerox is prepared to provide any of the above alternatives for the prices indicated in order to support you in your installation of a Xerox Sigma 6E computing system. We feel these prices are substantially less than you could find anywhere else for this service because of Xerox's unique capabilities in this area, and from prior experience these prices are lower than what it would cost you to convert yourselves. As mentioned earlier we would be willing to discuss any other alternative which would seem appropriate. If not accepted by you within 90 days of receipt of this analysis this offer will be withdrawn.
5.0 SCHEDULE

Work schedules, milestones, and completion dates will be determined jointly after acceptance of the order by Xerox. The schedule and a detailed itemization of deliverable items will then be stated in a formal contract. We will be prepared to begin work thirty days after the receipt of the order by Xerox.

6.0 CONVERSION AGREEMENT

After the final terms of the conversion have been agreed upon Andrews University and Xerox will enter into a formal agreement for the conversion effort. The agreement will detail all the tasks previously described and include the following provisions:

6.1 Modifications

Any changes by Andrews University in its programs to be converted by Xerox subsequent to delivery of the programs to Xerox shall be the University's sole responsibility and we shall have no conversion responsibility to include such changes.

6.2 Facilities and Location

All facilities and computer time related to the tasks described shall be the sole responsibility of Xerox and the tasks will be performed in Rochester, New York.

6.3 Acceptance Criteria

Xerox shall consider the effort complete and accepted when all items have been delivered and all tasks described in the agreement have been performed and accepted by Andrews University. You may provide any test problems or additional acceptance criteria as long as the ground rules are established before a formal agreement is made. If after completion of all tasks you do not respond within 30 days with a written description of any problems encountered and the cause of each problem, we will assume you have accepted the task as completed.
6.4 Warranty

Xerox will guarantee that the tasks specified will be performed and meet the standards described in the Agreement. In addition, Xerox assumes responsibility for all Agreement overruns and schedule slippages, except where schedule slippages are caused by failure of Andrews University to deliver required items. The agreed-to price will not be negotiated due to man weeks or machine time overruns on the stated program counts.

6.5 Waivers

No warranties will be made that the converted system will meet any specific performance requirements as this is a function of the original design of the programs and the operating environment the systems will be run under.

In addition, the acceptance and installation of the computer equipment required by Andrews University from Xerox according to a separate contract is not related to the status of the conversion, which will be the subject of the CSD Services Agreement. Any provisions for machine acceptance provided in the normal machine agreement are not changed by the execution of the CSD Services Agreement.

In no event shall Xerox be liable for consequential damages under the CSD Services Agreement.

7.0 DATA

This proposal has been prepared by Xerox based upon data furnished to it by Andrews University. To the extent that such data is inaccurate, incomplete or subject to an interest in others, Xerox reserves the right to withdraw or amend this proposal.

If a contract should be awarded by Andrews University to Xerox based upon this proposal, the contract shall contain the following provisions: "The service to be performed by Xerox hereunder is dependent upon data to be furnished to Xerox by Andrews University. If such data is inaccurate, incomplete or subject to an interest in others, and such shall cause Xerox to incur additional costs or expend additional time in performance of the service, an equitable adjustment in the
7.0 DATA Con't.

contract price and schedule shall be made. If such data is subject to an interest in others, Andrews University shall hold Xerox harmless from all claims by such others with regard to such data, and shall defend Xerox from such claims at Andrews' expense".
## EXHIBIT A

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Computing Center Billing

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</tr>
<tr>
<td>GETCOMMA</td>
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<tr>
<td>DERPAKU</td>
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</table>

The following routines will not be converted. The reasons for this are listed beside each routine.

**READCARD** - Because Sigma is a symbiont system this particular function does not exist.

**DERPPNU** - Cannot simulate function.

**DERUPNO** - Cannot simulate function.

**GETTIME** - Xerox has a similar routine.

**PUNCHY** - Same as **READCARD**.

**INTERPT** - Cannot simulate function.

**CHANUPSI** - Because of various Sigma features this function is no longer needed.

**PROGSORT** (SORT SET) - Xerox COBOL has SORT verb, therefore, this routine is no longer needed.

**PRINTER** - Xerox has the full set of control characters available to COBOL.

**STCOMRG** - Cannot do directly, but will set up FD to store data.

**GETDATE** - Xerox has a similar routine.

**RECOMRG** - Same as **STCOMRG**.
BAL PROGRAMS Con't.

SIGNCTRL2 - Xerox COBOL can perform same function

DERCANDU - Xerox has similar function.

DERDMPU - Xerox has similar function.

DTEUPSI - Xerox has similar routine.

DERUPSU - Xerox has similar function.

DERPDUM - Cannot simulate function.
# Pre-Installation Power/Heat Estimates

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<td>1</td>
<td>I/O</td>
<td>120/208 V, 60 Hz, 3-Phase &quot;Wye&quot; &amp; Gnd</td>
<td>8.63</td>
<td>10 AWG</td>
<td>45105**</td>
<td>3P-30A</td>
<td>26,570</td>
</tr>
<tr>
<td>2</td>
<td>CPU</td>
<td>&quot;</td>
<td>8.63</td>
<td>10</td>
<td>45105</td>
<td>3P-30A</td>
<td>26,570</td>
</tr>
<tr>
<td>3</td>
<td>CPU</td>
<td>&quot;</td>
<td>8.63</td>
<td>10</td>
<td>45105</td>
<td>3P-30A</td>
<td>26,570</td>
</tr>
<tr>
<td>4</td>
<td>RAD</td>
<td>&quot;</td>
<td>2.18</td>
<td>10</td>
<td>1&quot; Conduit</td>
<td>3P-30A</td>
<td>5,081</td>
</tr>
<tr>
<td>5</td>
<td>DISK</td>
<td>&quot;</td>
<td>2.64</td>
<td>12</td>
<td>45105</td>
<td>3P-15A</td>
<td>5,276</td>
</tr>
<tr>
<td>6</td>
<td>L.P.</td>
<td>&quot;</td>
<td>5.34</td>
<td>10</td>
<td>45105</td>
<td>3P-30A</td>
<td>14,632</td>
</tr>
<tr>
<td>7</td>
<td>CONT</td>
<td>120 V, 60 Hz &amp; Ground</td>
<td>1.08</td>
<td>12</td>
<td>2610 (3120)</td>
<td>1P-15A</td>
<td>2,523</td>
</tr>
<tr>
<td>8</td>
<td>MTS</td>
<td>&quot;</td>
<td>2.09</td>
<td>10</td>
<td>2610 (3120)</td>
<td>1P-30A</td>
<td>5,058</td>
</tr>
<tr>
<td>9</td>
<td>MTM</td>
<td>&quot;</td>
<td>1.66</td>
<td>10</td>
<td>2610 (3120)</td>
<td>1P-30A</td>
<td>4,012</td>
</tr>
<tr>
<td>10</td>
<td>C.P.</td>
<td>&quot;</td>
<td>1.22</td>
<td>10</td>
<td>2610 (3120)</td>
<td>1P-20A</td>
<td>2,860</td>
</tr>
<tr>
<td>11</td>
<td>C.R.</td>
<td>&quot;</td>
<td>1.08</td>
<td>12</td>
<td>2610 (3120)</td>
<td>1P-15A</td>
<td>2,616</td>
</tr>
<tr>
<td>12</td>
<td>KSR</td>
<td>&quot;</td>
<td>.30</td>
<td>Note 1</td>
<td>2610 (3120)</td>
<td>1P-15A</td>
<td>900</td>
</tr>
</tbody>
</table>

**Totals**: 43.48

**23 Breaker Positions**: 122,668 = 10.3 Tons A/C

---

**Note 1**: Control KSR normally derives power from CPU Power Junction

*: All connectors are H. Hubbell or equivalent

**: 2610 is new model #; 3120 is old model #
SECTION VI
**LEASE AGREEMENT**  
**Term** 1 year(s)

<table>
<thead>
<tr>
<th>Lessee</th>
<th>State of Incorporation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Equipment Location Street Address</th>
<th>City</th>
<th>State</th>
<th>Zip Code</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Xerox Data Systems, Inc. (hereinafter called XDS) agrees to lease to the above named Lessee at the above address, and the Lessee agrees to accept for the lease amounts stated herein, XDS computing equipment noted below (excluding Program Products) installed and ready for Lessee's use, together with instructions in the operation of the equipment and maintenance service on the equipment, upon the terms and conditions hereinafter stated in this Agreement.

<table>
<thead>
<tr>
<th>Item</th>
<th>Model No.</th>
<th>Qty.</th>
<th>Description</th>
<th>Unit Charge</th>
<th>Item Charge</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7122</td>
<td>1</td>
<td>Card Reader</td>
<td>360</td>
<td>360</td>
</tr>
<tr>
<td>2</td>
<td>7165</td>
<td>1</td>
<td>Card Punch</td>
<td>441</td>
<td>441</td>
</tr>
<tr>
<td>3</td>
<td>7441</td>
<td>1</td>
<td>Line Printer</td>
<td>1,035</td>
<td>1,035</td>
</tr>
</tbody>
</table>

**Sales Price of Equipment** $73,440

**Total:** $1,836

Delivery Date June/July 1973

XDS will provide Maintenance Service on the above equipment in accordance with both Paragraph 6 of this contract and the following:

A. Service Hours:
   - Regular Service Hours will be 8:30 to 5:30 Monday through Friday, excluding holidays and one hour meal period.
   - Extended Service Hours will be ______ to ______ through ______ for an additional monthly charge of $________.

B. Optional Local Service will be provided for an additional monthly charge of $________.

C. "On-Call" Maintenance will be provided for in accordance with Paragraph 6 of this contract up to an amount not to exceed $________.

AGREED TO THIS day of ______ 19.

Lessee

By

Title

Attest.

ACCEPTED THIS day of ______ 19

XDS Xerox Data Systems

701 South Aviation Blvd., El Segundo, California 90245

By

Title

Lease Number ______
1. LEASE TERM
The lease term shall commence when service begins and continue for the number of years shown. After the initial period, this lease will remain in effect until terminated by either party with three months written notice. Upon expiration of the lease term, or extension thereof, Lessee shall return the equipment in good condition with allowance for normal wear and tear.

2. MONTHLY CHARGES
The basic monthly charges shall be payable on the installation date of the equipment for the calendar month in which equipment is first installed and shall be prorated to the end of the month, and thereafter shall be paid for each calendar month on the first day of that month.

3. TAXES
The Lessee will pay any Sales, Use Tax, or Import Tax. XDS will pay the Personal Property Tax.

4. INSTALLATION PERMITS
Lessee will prepare the site in accordance with XDS's written site specifications 15 days prior to the scheduled delivery date. XDS will install the equipment. Lessee will provide labor for unpacking and locating the equipment. Lessee will assume responsibility for compliance with local laws and will obtain any permits required for installation and use.

5. SOFTWARE
XDS software identified as "Control Programs" will be provided by XDS under the terms of this equipment lease agreement. Maintenance service will be provided for standard, current versions of such Control Programs.

6. MAINTENANCE
XDS software identified as "Program Products" are not furnished under this agreement. Program Products will be made available to the Lessee on a fee basis pursuant to an XDS software licensing agreement executed by the Lessee.

7. DELAYS, DAMAGES
XDS shall not be liable for delays in delivery or failure to manufacture due to causes beyond its reasonable control. In the event of any such delay, the date or dates for performance of this contract by XDS shall be extended for a period equal to the time lost by reason of delay. In no event shall XDS be liable for incidental or consequential damages under this lease.

8. ALTERATIONS, ATTACHMENTS
No alterations or attachments to the leased equipment shall be made without XDS's written approval.

9. TRANSPORTATION AND PACKING
Lessee will pay all transportation and rigging charges to and from the installation site and will return the equipment to XDS's plant by air freight, or by van equipped for transporting electronic equipment, unless XDS has approved in writing an alternate method of shipment. Lessee will not move the equipment to another location without XDS's consent.

10. OPTION
Lessee may purchase any of the leased equipment during the term of this lease for its sales price on the date of this lease less 40% of the rentals paid to a maximum of 60% of the sales price.

11. PATENT INDEMNITY
XDS agrees to defend Lessee in any suit brought against him alleging that the articles licensed hereunder, combined with non-XDS equipment, directly infringe United States Letters Patent owned by others, provided XDS is promptly notified, given assistance required and permitted to direct the defense. Further, XDS will pay any judgment based on such infringement, rendered in such suit by final judgment of a court of last resort, but shall not be responsible for settlements or costs incurred without its consent. If Lessee's use of such articles is enjoined, or in the event that XDS desires to minimize its liabilities hereunder, XDS will, at its option, either substitute other equally suitable articles, modify the articles so that they no longer infringe, obtain for Lessee the right to continue their use, or take them back releasing Lessee from the obligation of paying rentals not yet due. The foregoing states the entire liability of XDS for patent infringement. No indemnity shall apply to articles made or modified to Lessee's own specifications or design.

12. ASSIGNMENT
Either party may assign its rights and remedies and may also transfer its obligations under this lease. However, the assignment or transfer shall not operate to relieve the assigning party of any of its obligations hereunder. Nor will any such assignment impose any obligation on the assignee except in the case of an express written assumption thereof by the assignee.

13. LOSS OR DAMAGE
XDS agrees that Lessee shall be relieved of all responsibility for any loss or damage to the equipment covered by this agreement, provided that such loss or damage shall not have been caused by theft, unauthorized alteration, negligence or malice of the Lessee or any of its employees or representatives. The Lessee agrees to fully indemnify XDS against any loss or damage to the equipment for which Lessee is not relieved of responsibility hereunder.

14. DEFAULT
In the event of any default by Lessee, XDS may, at its option, declare this lease in default and terminate this lease.

If at any time during the Lease Term or any extension thereof, Lessee shall assign the lease, or grant to the lessee the right to assign the lease, or make any assignment, or in any manner whatsoever transfer possession of the leased equipment to another location without XDS's approval, in whole or in part, then XDS may terminate this lease immediately without giving any further notice or demand to Lessee.

Upon termination of the lease pursuant to this Article 14, XDS shall be entitled to immediate possession of the equipment and to the entire sum due and unpaid, together with all other rights and remedies in law or in equity.
MAINTENANCE AGREEMENT

NAME OF OWNER

STREET ADDRESS

CITY STATE ZIP CODE

Agreement between ______________________ (hereinafter called Owner) and Xerox Data Systems (hereinafter called XDS) for the maintenance of XDS computer system and peripheral equipment per the configuration list and maintenance fees listed in Appendix A, in accordance with the terms and conditions of this contract.

This Agreement is for a fixed period of _____________ Years, commencing _______June/July_______, 19__.

XDS agrees to perform the following basic monthly maintenance service during the Principal Period of Maintenance.

1. Accomplish regularly scheduled Preventive Maintenance.

2. Update the equipment to provide the latest reliability improvements.

3. Supervise the preparation for movement and set-up of the equipment after movement.

4. Provide replacement parts as needed.

5. Make available, upon request, maintenance personnel for corrective maintenance.

A. PRINCIPAL PERIOD OF MAINTENANCE

The Principal Period of Maintenance (PPM) shall be any nine (9) consecutive hours, 7:00 a.m. and 6:00 p.m. (Monday through Friday), with a one (1) hour meal period.

B. EXTENDED COVERAGE

For contracted coverage of more than one shift, the PPM may be extended in the time increments and for the charges shown in the following schedule. The percentage is computed on the total monthly maintenance rate. The hours shown include the Principal Period of Maintenance:

<table>
<thead>
<tr>
<th>Hours</th>
<th>5 Days</th>
<th>6 Days</th>
<th>7 Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>100%</td>
<td>120%</td>
<td>140%</td>
</tr>
<tr>
<td>16</td>
<td>140%</td>
<td>170%</td>
<td>190%</td>
</tr>
<tr>
<td>24</td>
<td>210%</td>
<td>225%</td>
<td>240%</td>
</tr>
</tbody>
</table>

C. PPM SERVICE HOURS

PPM service hours will be __________ 8:30 am to 5:30 pm __________ Monday through ___________ Friday ___________, excluding holidays, with one (1) hour meal period.

Agreed to this ______________________ day of ___________ ___________, 19__.

Name of Owner

Street Address

CITY STATE ZIP CODE

INSTALLATION NO.

MAIN FRAME S/N

If installation is beyond 100 miles from an XDS service center, the owner agrees to pay transportation, lodging and subsistence for all calls in excess of one (1) per week.

D. OPTIONAL LOCAL MAINTENANCE

The owner whose installation is located more than 100 miles from the nearest XDS service center may reduce the travel charges for which he is liable and diminish the response time by contracting for an XDS Field Engineering Representative to be located within 100 miles of the installation. The price for this relocation is:

1. $1,000 per month if XDS is maintaining only one (1) computer in the area.

2. $300 per month if XDS is maintaining two (2) computers in the area.

3. No charge if XDS is maintaining three (3) or more computers in the area.

XDS shall not locate one or more service technicians within 100 miles of the installation.

E. CHARGES

(1) Basic monthly charge per Appendix A 3,944.00

(2) Extended coverage N/A

(3) Optional local service N/A

Sub-Total 3,944.00

Quantity Discount 930.40

Total Maintenance Charge 253,142.40

Monthly Maintenance Charge 3,013.60

F. EMERGENCY SERVICE

Calls outside the PPM service hours defined in Paragraph C will be provided for at the following rates: Monday through Saturday, except holidays, $ __32.00 ________ per man hour including travel time; Sunday and holidays $ __35.00 ________ per man hour including travel time. There is a two (2) hour minimum for all services performed on an hourly basis.

When requested, XDS will provide off-site stand by service outside of the Principal Period of Maintenance at the rate of one (1) man hour for each four (4) hours of stand by. On-site stand by to be charged on a per hour basis.

Approved and Accepted ______________________ day of ___________ ___________, 19__.

Name of Owner

Street Address

CITY STATE ZIP CODE

Xerox Data Systems

701 South Aviation Blvd., El Segundo, California 90245

By ______________________

Title L-45
1. GENERAL

Equipment not under XDS lease or maintenance contract immediately prior to the effective date of this maintenance agreement shall be subject to suspension by XDS without charge. If the equipment is not in good operating condition, labor and parts required to place the equipment in good operating condition shall be provided by XDS at the Owner's expense.

2. DURATION OF AGREEMENT

Addendum A is included by Reference. The Owner shall have the right to terminate this Agreement at any time after the first anniversary of the Commencement Date shown on its face, by written notice sent to and received by XDS at least three (3) months prior to the termination date selected by the Owner.

XDS may terminate this Agreement, or change the monthly maintenance or emergency service charge on any or all of the items of equipment covered by this Agreement at any time after the first anniversary of the Commencement Date, by written notice to the Owner three (3) months prior to the effective date of such termination or change. After receipt of notification of any such changes of maintenance charges, the Owner shall have the right to terminate this Agreement, such termination to become effective as the date of the proposed change in maintenance charges, provided that the Owner gives at least 30 days notice of such termination.

3. MONTHLY CHARGES AND TERMS OF PAYMENT

(a) The basic monthly charges for maintenance service shall begin on the Commencement Date shown on the face of this Agreement. For the calendar month in which service starts the charges shall be prorated to the end of the month and thereafter shall be invoiced for each calendar month on the first day of the month.

(b) The Owner agrees to pay the monthly and hourly charges as set forth on the face of this Agreement and to pay an additional amount equal to any taxes, however designated, levied, or based on such monthly charges or upon this Agreement, or any taxes or amounts in lieu thereof paid by XDS or payable by XDS in respect to the foregoing, exclusive of taxes based upon XDS' net income.

(c) Terms 30 days net from date of invoice.

4. RESPONSIBILITIES OF XDS

(a) XDS shall provide maintenance (labor and parts) at the price agreed to and keep the equipment in good operating condition.

(b) Preventive (scheduled) maintenance shall be performed at a time other than the Owner's working hours so long as it is performed during or contiguous to the Principal Period of Maintenance. XDS shall specify in writing the frequency and duration of the preventive maintenance required for the equipment listed on the order and the Owner shall specify the schedule for the performance of the preventive maintenance. This schedule may be modified by mutual agreement.

(c) Remedial maintenance shall be performed after notification that the equipment is inoperative. XDS shall provide the Owner with a designated point(s) of contact and make arrangements to enable his maintenance representative to receive such notification.

(d) XDS shall furnish a malfunction incident report to the installation upon completion of each maintenance call. The report shall include, as a minimum, the following:

(1) Date and time notified.
(2) Date and time of arrival.
(3) Type and model number(s) of machine(s).
(4) Time system made available to XDS.
(5) Time spent for repair.
(6) Description of malfunction.
(7) Corrective action taken including parts used.
(8) Additional charges if applicable.

(e) Only new standard parts or parts of equal quality shall be used in affecting repairs. Parts which have been replaced shall become the property of XDS.

(f) Maintenance service shall include the items of equipment necessary to the maintenance of the machine being serviced.

(g) XDS sponsored modifications to equipment which are made to rented equipment of the same type as being maintained under the terms of this contract shall be made with the consent of and without charge to the Owner.

5. RESPONSIBILITIES OF OWNER

(a) The Owner shall provide adequate storage space for spare parts and adequate working space, including heat, light, ventilation, electrical current and outlets for the use of XDS' maintenance personnel. These facilities shall be within a reasonable distance of the equipment and shall be provided at no charge to XDS.

(b) The Owner's personnel shall not perform maintenance or attempt repairs to equipment while such equipment is under the purview of this contract unless agreed to by XDS.

(c) The Owner shall provide XDS access to the equipment to perform maintenance services. If additional costs are incurred as a result of the Owner's denial of access during the scheduled periods for an unreasonable period of time, the Owner shall bear the cost of returning the equipment to good operating condition.

6. MAINTENANCE

(a) XDS agrees to make available, upon request, maintenance personnel for corrective maintenance. Additionally, if the service is begun during the Principal Period of Maintenance and the difficulty is not corrected on the same day at the end of the PPM service will continue at no extra charge.

(b) The Principal Period of Maintenance, or extension thereof, may be changed by the Owner upon 30 days written notice.

(c) Corrective maintenance occasioned by the negligence of the Owner, his employees or representatives, or by the use of defective or special attachments not provided by XDS or by any misuse or abnormal use, is not covered by the monthly charge. There shall be no additional maintenance charges for time spent by maintenance personnel after arrival at the site awaiting the arrival of additional maintenance personnel and/or delivery of parts, etc., after a service call has commenced.

7. ALTERATIONS AND ATTACHMENTS

(a) In the event that equipment being maintained under the terms and conditions of this Agreement is moved to another location, XDS shall continue to maintain the equipment at the new location unless such a movement should remove the equipment outside the 48 contiguous states and the District of Columbia.

(b) In the latter instance, the maintenance agreement shall be terminated without further obligations being incurred by either XDS or the Owner.

(c) The Owner shall give at least 30 days written notice of any movement of equipment unless such move is required because of an emergency.

(d) When the shipment is under the control of XDS and damage is incurred which results in abnormal costs for either labor or parts to restore the equipment to good operating condition at the new site, such costs shall be borne by XDS.

(e) When the shipment is under the control of the Owner and damage is incurred which results in abnormal costs for either labor or parts to restore the equipment to good operating condition at the new site, such costs shall be borne by the Owner.

(f) Maintenance charges shall be suspended on the day the equipment is dismantled in preparation for shipment. Maintenance charges shall be reinstated on the day installation and checkout charges are incurred by XDS or the Owner. The procedure necessary to place the system in good operating condition are complete.

(g) The Owner shall furnish transportation and such labor as may be necessary for packaging and placement of the equipment. Reinstallation and checkout charges may be negotiated with XDS.

8. MOVEMENT OF EQUIPMENT

(a) Should the equipment be moved for the maintenance, the equipment shall be moved to or from the installation location at the expense of the Owner.

(b) The equipment shall be returned to the Owner at the expense of the Owner.

(c) The equipment shall be returned in good operating condition.

(d) The equipment shall be returned to the Owner in its original packaging.

(e) The equipment shall be returned to the Owner in its original condition.

9. LIABILITY FOR INJURY OR DAMAGE

XDS shall be liable for any injury to the Owner's personnel or damage to the Owner's property arising from the use of the equipment maintained by XDS when such injury or damage is due to the fault or negligence of XDS. The parties shall divide the cost of return of the equipment to the Owner.

10. SPECIFIC CONTRACT COMMITMENTS

No representations or statements made by any representative of XDS which are not stated herein shall be binding. The provisions hereof constitute the entire Agreement between the parties with respect to the equipment and its maintenance. The terms and conditions of this Agreement supersede those of all previous agreements between the parties with respect to the equipment covered by this Agreement.
<table>
<thead>
<tr>
<th>ITEM</th>
<th>MODEL NO</th>
<th>QTY.</th>
<th>DESCRIPTION</th>
<th>UNIT CHARGE</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
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<td>1</td>
<td>Sigma 6 CPU</td>
<td>1,792</td>
<td>1,792</td>
</tr>
<tr>
<td>2</td>
<td>8318</td>
<td>1</td>
<td>Floating Point Arithmetic Unit</td>
<td>103</td>
<td>103</td>
</tr>
<tr>
<td>3</td>
<td>8321</td>
<td>1</td>
<td>Interrupt Control Chassis</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>4</td>
<td>8322</td>
<td>1</td>
<td>Priority Interrupt, 2 Levels</td>
<td>NC</td>
<td>NC</td>
</tr>
<tr>
<td>5</td>
<td>8375</td>
<td>1</td>
<td>IOP Expansion Feature</td>
<td>98</td>
<td>98</td>
</tr>
<tr>
<td>6</td>
<td>7315</td>
<td>1</td>
<td>Magnetic Tape Controller &amp; Drive</td>
<td>286</td>
<td>286</td>
</tr>
<tr>
<td>7</td>
<td>7316</td>
<td>1</td>
<td>Add-on Tape Transport</td>
<td>180</td>
<td>180</td>
</tr>
<tr>
<td>8</td>
<td>7122</td>
<td>1</td>
<td>Card Reader</td>
<td>127</td>
<td>127</td>
</tr>
<tr>
<td>9</td>
<td>7165</td>
<td>1</td>
<td>Card Punch</td>
<td>140</td>
<td>140</td>
</tr>
<tr>
<td>10</td>
<td>7441</td>
<td>1</td>
<td>Line Printer</td>
<td>292</td>
<td>292</td>
</tr>
<tr>
<td>11</td>
<td>7240</td>
<td>1</td>
<td>Disk Controller</td>
<td>104</td>
<td>104</td>
</tr>
<tr>
<td>12</td>
<td>7242</td>
<td>1</td>
<td>Dual Spindle Disk Drive</td>
<td>281</td>
<td>281</td>
</tr>
<tr>
<td>13</td>
<td>7012</td>
<td>1</td>
<td>Operators Console</td>
<td>48</td>
<td>48</td>
</tr>
<tr>
<td>14</td>
<td>7612</td>
<td>1</td>
<td>Timing Modules</td>
<td>NC</td>
<td>NC</td>
</tr>
<tr>
<td>15</td>
<td>7630</td>
<td>1</td>
<td>Communications Controller with 8 Lines</td>
<td>47</td>
<td>47</td>
</tr>
<tr>
<td>16</td>
<td>7631</td>
<td>2</td>
<td>Eight Line Expansion Unit</td>
<td>31</td>
<td>62</td>
</tr>
<tr>
<td>17</td>
<td>7231</td>
<td>1</td>
<td>RAD Controller</td>
<td>73</td>
<td>73</td>
</tr>
<tr>
<td>18</td>
<td>7232</td>
<td>1</td>
<td>6.3 MB RAD Storage</td>
<td>265</td>
<td>265</td>
</tr>
<tr>
<td>19</td>
<td>7235</td>
<td>1</td>
<td>Extended Width Feature</td>
<td>16</td>
<td>16</td>
</tr>
</tbody>
</table>

*Based on 8 hours, Mon. Through Fri.
The subject lease is amended to delete Paragraph 2, DURATION OF AGREEMENT and to add the following:

"2. DURATION OF AGREEMENT

This Agreement shall be non-cancellable during the term specified on the face of this Agreement, and shall continue on a month-to-month basis until cancelled by either party to this Agreement. Written notice of intent to terminate this Agreement shall be provided at least three (3) months prior to the termination date selected.

Xerox shall have the right during the specified term and thereafter to increase the monthly maintenance and emergency service charges on any or all items of equipment covered herein at any time after the first twelve (12) months by written notice to the Owner at least three (3) months prior to the effective date of such change. Such increase, however, shall not exceed five (5) percent per annum of the total monthly rate charged for maintenance of the system."

AGREED TO THIS

________________ day of __________ 19 __

____________________________________
Lessee

By _________________________________

Title ___________________________________

ACCEPTED THIS

________________ day of __________ 19 __

Xerox Data Systems
701 South Aviation Boulevard
El Segundo, California 90245

By _________________________________

Title ___________________________________
TIME SALE AND SECURITY AGREEMENT

XEROX CORPORATION, a New York corporation, acting through its Xerox Data Systems division, 701 South Aviation Boulevard, El Segundo, California 90245 (hereinafter called "SELLER") and

(hereinafter called "BUYER") agree as follows:

1. Sale and Purchase. SELLER hereby sells to BUYER, and BUYER hereby purchases from SELLER the several items of equipment listed and described in Schedule A attached hereto and made a part hereof (the "Equipment"), upon the terms and conditions provided herein, and for the Time Sale Price specified with respect thereto on Schedule A, payable as provided in Section 3, but subject to acceleration as provided in Section 9.

2. Security Interest; Transfer of Title. BUYER hereby grants to SELLER a security interest in the Equipment and any and all replacements and substitutions thereof and repairs thereto, for the purpose of securing the payment of the balance of the Time Sale Price from time to time due hereunder and all other liabilities of BUYER to SELLER arising under this Agreement. Title to each item of Equipment shall upon delivery of each such item at the location specified by BUYER pass to BUYER.

3. Payment of Purchase Price. Subject to the provisions of Section 9, the Time Sale Price with respect to each item of Equipment will be paid by BUYER to SELLER in ___34___ consecutive monthly installments in the amount set forth in Schedule A, such installments to be paid on the first day of each month commencing on ___June/July 1973___.

4. Delivery and Acceptance; Risk of Loss. Delivery of the Equipment shall be made at BUYER's expense to such location in the United States as BUYER shall specify, shipment to be made by SELLER within ___six (6) months___ after receiving written notice to deliver from BUYER. Possession of each item of Equipment and the risk of loss thereof or damage thereto shall pass to BUYER upon his acceptance thereof. Such acceptance shall be deemed to occur upon delivery of the Equipment to the location specified. SELLER shall install the Equipment at the location specified in BUYER's written notice, such installation to be in the manner and to include documentation, standard software, and software support normally supplied to customers of SELLER without charge. SELLER shall not be liable for delays in delivery or failure to manufacture due to acts beyond its reasonable control, including but not limited to acts of God, acts or omissions of civil or military
authority, priorities, fire, strikes, floods, restrictions, riots, war, delays in transportation, car shortages, and inability due to causes beyond its control to obtain the necessary labor, materials or manufacturing facilities. In the event of any such delay, the date for performance of this Agreement by SELLER shall be extended for a period equal to the period of time lost by reason of the delay.

5. **Taxes.** BUYER acknowledges that it is not purchasing the Equipment for resale. All taxes of every description (including sales, use and personal property taxes) arising out of the transactions contemplated hereby (other than taxes on the income of SELLER) shall be borne and paid for solely by BUYER, and BUYER shall pay or shall reimburse SELLER for its payment of any applicable personal property tax with respect to the Equipment accrued after the date hereof.

6. **Financing Statement.** At the time of execution of this Agreement, BUYER will join with SELLER in executing and filing appropriate financing statements relating thereto in form satisfactory to SELLER. Further, promptly upon delivery and acceptance of each item of Equipment as provided in Section 4, or upon any subsequent relocation of any item of Equipment, BUYER will join with SELLER in executing and filing such further financing statements relating thereto in form satisfactory to SELLER and as SELLER may deem appropriate.

7. **Insurance.** From the time at which the risk of loss or damage to the Equipment passes to BUYER as provided in Section 4 hereof, BUYER shall procure and maintain, with an insurance carrier acceptable to SELLER, insurance thereon against such risks and in such amounts as SELLER shall reasonably require. Each such policy of insurance shall be endorsed with a standard mortgagee or security certificate or certificates of the insurance carrier or carriers evidencing insurance coverage as herein required.

8. **Mutual Covenants and Agreements.** SELLER hereby covenants and agrees (i) that it is now and upon delivery and acceptance of any of the Equipments as provided in Section 4 hereof, it will be the owner of such Equipment, free and clear of any and all liens, encumbrances, claims, or security interests other than those to be created hereby, and other than any lien, encumbrance, claim or security interest on or against the Equipment heretofore or hereafter caused or allowed to be caused by BUYER or any subsidiary or affiliated company of BUYER; (ii) that it has now and will then have the full right and power to sell the Equipment to BUYER upon the terms and conditions provided herein; and (iii) that so long as BUYER shall not be in default hereunder and subject to the rights of any third party as a result of any lien, encumbrance, claim, or security interest on or against the Equipment caused or allowed to be caused by BUYER or any subsidiary or affiliated
company of BUYER, BUYER shall be entitled to the sole and exclusive possession and use of the 
Equipment purchased by and delivered to it hereunder. BUYER hereby covenants and agrees (i) 
that it now has and that upon delivery and acceptance of any of the Equipment as provided in 
Section 4 hereof it will have the full right and power to buy the Equipment from SELLER upon 
the terms and conditions provided herein; (ii) that it will not use or deal with the Equipment in a 
manner which is inconsistent with the terms of this Agreement, or any policy of insurance referred 
to in Section 7 hereof, or the applicable laws and regulations of governmental agencies; and (iii) 
that it will not use the Equipment in any manner which results in unreasonable deterioration or 
depreciation thereof, and that SELLER shall have the right to inspect the Equipment at any 
reasonable time, wherever located.

9. Acceleration; Prepayment. (a) Upon any acceleration of the maturity of its obligations 
with respect to any item of Equipment pursuant to this Section 9 (the Acceleration Date), the BUYER 
shall pay to the SELLER an amount (the Acceleration Price) which shall be equal to (i) the portion of 
the Invoice Price of such item (as set forth in Schedule A hereto) which would remain unpaid on the 
Acceleration Date if such Invoice Price had been borrowed and partially repaid in installments in the 
same amounts and payable on the same dates as the installments of the Time Sale Price heretofore paid 
by BUYER for such item and if each such installment payment had been applied first to the payment 
of interest on such unpaid portion at a rate of six (6) percent per annum and the remainder 
to the Invoice Price, and (ii) interest (computed at six (6) percent per annum rate from the 
date of the last preceding installment paid hereunder to the Acceleration Date) on the Invoice Price 
remaining unpaid as arrived at in (i).

(b) BUYER shall give SELLER not less than fifteen (15) days written notice of any proposed 
resale or lease of any item of Equipment during the term of this Agreement. Such notice shall state 
the item or items of Equipment to be resold or leased and the date upon which sale or lease is to be 
effective. If the Equipment is to be resold or leased, BUYER shall pay to SELLER on or prior to such 
date the Acceleration Price in respect of such item of Equipment.

(c) If at any time an event of default specified in Section 10 hereof shall have occurred and 
shall be continuing, SELLER shall have the right, upon written demand to BUYER specifying such 
event of default, to require BUYER to pay, within ten (10) days after the date of such demand, the 
Acceleration Price with respect to all of the Equipment then subject hereto.

(d) If any item of the Equipment shall be substantially destroyed or shall be damaged beyond 
repair, SELLER shall have the right, upon written demand to BUYER, to require BUYER to pay, 
within ten (10) days after the date of such demand, the Acceleration Price with respect to each item 
of Equipment so destroyed or damaged, less any proceeds of insurance theretofore received by SELLER.
with respect to such Equipment.

(e) BUYER shall have the right, exercisable at any time during the term of this Agreement, upon written notice to SELLER specifying the items of Equipment affected, to fully satisfy its obligations hereunder with respect to any or all items of Equipment by the payment to SELLER, not less than ten (10) days nor more than thirty (30) days after the date of such written notice, the Acceleration with respect to such items of Equipment. SELLER agrees, on request of BUYER, to confirm in writing to any proposed purchaser or lessee of any of the Equipment from BUYER that, on payment in full to SELLER of the Accelerated Purchase Price, the amount of which Accelerated Purchase Price shall be specified in such notice, SELLER will release its security interest in the Equipment.

(f) SELLER shall release its security interest in any item of Equipment when payment shall have been made with respect thereto as provided in this Section 9, and shall execute such documents furnished by BUYER as may be necessary to evidence such release.

10. Events of Default; Remedies. BUYER shall be in default (a) if it shall fail to pay, or cause to be paid, any installment payable under Section 3 hereof, or any sum payable upon any acceleration under Section 9 hereof when the same is due, or (b) if it shall fail to perform any other term or condition of this Agreement, and such failure shall continue for a period of fifteen (15) days after written notice thereof from SELLER to BUYER, or (c) if Federal bankruptcy, insolvency, liquidation, receivership or like proceedings are initiated by or on behalf of or against BUYER, or any of the Equipment shall be attached, seized or levied upon, and such proceedings, attachment or levy shall not be vacated or fully stayed, within thirty (30) days after the institution or occurrence thereof, or (d) if any of the Equipment shall be sold, leased or encumbered by BUYER other than in accordance with the provisions of Section 9 (b) hereof.

If an event of default shall have occurred and be continuing, SELLER shall have the right to accelerate BUYER's obligations hereunder as provided in Section 9 (e) hereof, and in addition shall have all the rights (not inconsistent with the rights specifically provided herein) of a secured party under the Uniform Commercial Code; or SELLER may, at its option, and it is hereby empowered so to do, enter upon the premises where the Equipment may be and take possession thereof, or remove, sell and dispose of the Equipment and from the proceeds of sale retain all costs and charges incurred by SELLER in the taking or sale of the Equipment including any reasonable attorney's fees thereby incurred; also SELLER may take all sums due it under the terms of this Agreement including reasonable attorney's fees; and any surplus of such proceeds remaining shall be paid to BUYER. The foregoing without limitation to or waiver of any other rights or remedies of SELLER according to law. It is
further agreed that upon any sale of the Equipment according to law, or under the power herein given, that SELLER may bid on the said sale, or make a purchase of the Equipment or any part thereof.

11. Waivers. A waiver by SELLER of a default under this Agreement shall not operate as a waiver of any other default which may thereafter occur.

12. Location of Equipment. Following delivery and acceptance thereof as provided in Section 4, and so long as the Equipment is subject to a security interest of SELLER, the Equipment will be kept at the location specified in BUYER's written notice or at such other location as may hereafter be agreed upon by SELLER and BUYER; during such period BUYER will promptly notify SELLER of any change in the location of the Equipment, and will not remove the Equipment from the aforesaid location, without the prior written consent of SELLER which consent shall not be unreasonable withheld or delayed.

13. Warranty. SELLER warrants that the Equipment is merchantable and that it will replace or repair any components of Equipment manufactured by SELLER which are defective by reason of material or workmanship that the BUYER returns to SELLER within one (1) year from acceptance of the Equipment. This warranty does not extend to program products, nor to expendable items such as pilot lamps and fuses, nor to components that have suffered mechanical wear, such as vacuum motors and punch die blocks, nor to products altered or repaired by personnel other than those employed by SELLER, or trained and certified by SELLER. Shipment of defective parts to SELLER will be paid by BUYER. Return shipment, to the BUYER, of repaired or replaced parts will be paid by SELLER. Operation or storage of the Equipment in an environment other than that selected by SELLER or recommended by SELLER's published specification will invalidate this warranty. There are no other warranties, expressed or implied. In no event shall SELLER be liable for incidental or consequential damages.

14. Patent Indemnity. SELLER agrees to defend BUYER in any suit brought against it alleging that any item of the Equipment sold hereunder uncombined with equipment other than that manufactured by SELLER, directly infringes United States Letters Patent owned by others, provided SELLER is promptly notified, given assistance required, and permitted to direct the defense. Further, SELLER will pay any judgment based on such infringement, rendered in such suit by final judgment of a court of last resort but shall have no liability for statements or costs incurred without its consent. If BUYER's use of any item of Equipment is enjoined, or in the event that SELLER desires to minimize its liabilities under, SELLER will, at its option, either substitute
other equally suitable items of the Equipment, modify such items so that they no longer infringe, obtain for BUYER the right to continue their use, or take them back returning the price less a reasonable amount for use, damage and obsolescence. The foregoing states the entire liability of SELLER for patent infringement. No indemnity shall apply to items of the Equipment made or modified to BUYER's own specifications or design.

15. Notices. All notices or other communications required or permitted to be given pursuant to this Agreement shall be in writing and shall be valid and sufficient if delivered by hand or dispatched by registered or certified airmail, postage prepaid, addressed as follows:

Xerox Data Systems
701 South Aviation Boulevard
El Segundo, California 90245
Attention: Vice President-Finance

or to such other address as either party shall notify the other in writing. Given notices dispatched by registered or certified airmail shall be deemed to have been given three days after such notice is deposited in any post office.

16. Governing Law; Severability. This Agreement shall be construed in accordance with and governed by the internal laws of the State of California. Any provision of this Agreement which may be prohibited by law shall be ineffective to the extent of such prohibition without invalidating the remaining provisions of this Agreement.

17. Equipment Markings. SELLER may mark the Equipment to conspicuously show that it has a security interest therein and BUYER shall place no conflicting marks or indicia on the Equipment or suffer SELLER's marks to be removed or defaced without the written consent of SELLER or until payment in full shall have been made and BUYER shall have fulfilled all of its obligations hereunder.

IN WITNESS WHEREOF, the parties hereto have executed this Agreement as of the ___ day of ________________, 1973

XEROX CORPORATION
XEROX DATA SYSTEMS

By ____________________________
Typed Name ____________________________
Title ____________________________

By ____________________________
Typed Name ____________________________
Title ____________________________
## SCHEDULE A

<table>
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<tr>
<th>Quantity</th>
<th>Catalog No.</th>
<th>Description</th>
<th>Invoice Price</th>
<th>Down Payment</th>
<th>Monthly Installment *</th>
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<td>8310C</td>
<td>Sigma 6 CPU</td>
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<tr>
<td>1</td>
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<td>Floating Point Arithmetic</td>
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<td>1</td>
<td>8322</td>
<td>Priority Interrupt</td>
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<td>1</td>
<td>7315</td>
<td>Controller and one transport</td>
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<td>Disk Controller</td>
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<td>Dual Spindle Disk</td>
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<td>7235</td>
<td>Extended Width Interface</td>
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</table>

** The Monthly Installment is equal to the Invoice Price (I. P.) less the Down Payment (0% of I. P.) times 0.0146, the factor appropriate to amortize a loan in eighty-four (84) equal monthly installments at six percent per annum on the unpaid balance.

** The Time Sale Price is equal to the sum of the 84 Monthly Installments plus the Down Payment.
SECTION VIII
### VIII. MEMORY EXPANSION OPTIONS

<table>
<thead>
<tr>
<th>Core Size In Words</th>
<th>Model</th>
<th>Gross Purchase</th>
<th>Educational Discount</th>
<th>Net Purchase</th>
<th>Expansion Charge</th>
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<td>From 112K To 128K</td>
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<td>2,600</td>
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**Note:** Expansion Charges are additive.
APPENDIX M

(Intentionally Omitted)