AUTOMATED DATA ACQUISITION and ANALYSIS SYSTEM

(ADAAS)

PHILIP MORRIS, INC.
RICHMOND, VIRGINIA

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November 1, 1968

Philip Morris, Inc.
Research Center
4201 Commerce Road
Richmond, Virginia 23206

Attention: Mr. Richard H. Talts

Subject: UNIVAC Preliminary Proposal
Data Acquisition and Analysis System

Reference: Philip Morris Inquiry/Specifications (9-19-68)

Gentlemen:

UNIVAC is pleased to submit a preliminary proposal in response to the referenced inquiry. The attached proposal includes budgetary pricing which will enable planning and appropriations request for the subject system.

The UNIVAC offering, developed jointly between the Data Processing and Federal Systems Division, presents two approaches to the digital subsystem requirement. One approach would provide a central site digital subsystem for both the data acquisition and data analysis function. The second approach offers a digital subsystem for data acquisition and remote transmission to a larger digital machine for analysis/reports. Identical analog subsystems have been configured for either the central site or the remote digital analysis approach.

A pricing summary is attached in table form. The digital subsystem pricing is presented with figures for purchase, lease and maintenance. The digital subsystem prices are catalogue items; therefore, prices are firm. The analog subsystem prices are best estimates based on assumptions made in lieu of specific technical data which will be needed to arrive at firm pricing. Software and systems engineering also are based on special software items which need further definition.

Several technical approaches are described in the technical discussion. An analog "hard wired" technique is recommended based on the close proximity of the various instruments to the proposed central computer site. The analog subsystem proposal covers the hardware system only with the assumption that all analog wiring will be provided by Philip Morris. The proposal further assumes that the analog wiring will meet minimum requirements for common mode rejection and grounding. Exception has been taken based on economic considerations for servicing Instrument No. 35 from a seven-mile distance. This exception is covered in the technical discussion.

UNIVAC's related experience in analog-digital systems similar to the Philip Morris requirement includes 50 to 100 installations. While many of these installations are performing government requirements, the digital subsystems and analog techniques are identical to those techniques recommended for the Philip Morris Laboratory Automation system. Specific installations of UNIVAC analog-digital systems are listed as follows:

USAF/Missile Procedures Trainer
UNIVAC 1218/A-D Interface

USN/Avionics Checkout Systems
UNIVAC 1218/A-D Interface

NASA/Worldwide Tracking Network
UNIVAC 1218/A-D Interface

USN/Simulation: Naval Underwater Weapons Laboratory
UNIVAC 1108/A-D/Analog System

*Note: UNIVAC 1218 is military version of UNIVAC 418

To further clarify specific details needed before a firm proposal can be prepared for the Philip Morris system, a brief survey by UNIVAC's Systems Engineering and Programming and a Redcor's Instrumentation representative is highly recommended. It is, in our opinion, very important not to underestimate the magnitude of the systems effort required in this kind of system. This survey could possibly be accomplished within a ten-day period. UNIVAC would like the opportunity to discuss any item in the proposed system, in particular, those items where there may be questions related to the estimated pricing and technical recommendations.

UNIVAC is looking forward to working with Philip Morris on the laboratory automation system and, in general, on Philip Morris' computer systems requirements.

Yours very truly,

Bryan G. Graham
Bryan G. Graham
Sales Representative

BGG/smm
Enclosure: Pricing Data

418-III COST SHEET SUMMARY

(1) 418-III Computer, .75 usec., 65K 18-bit words, 4 34KC Tape Drives, 1 9200 Computer Subsystem (I/O for reader, printer, punch), 1 FH 1782 Drum (4.19 Million words).

PURCHASE	MAINT.	ONE-YEAR	FIVE-YEAR
$730,725	$2,245	$16,770	$14,279

(2) DCT 2000, 128 Print Positions, 250 lpm printer, 200 cpm reader, 75-200 cpm punch, plus options.

PURCHASE	MAINT.	ONE-YEAR	FIVE-YEAR
$ 30,790	$140	$741	$634

(3) UNIVAC equipment summary:

$761,515	$2,385	$17,511	$14,913

(4) Analog/Digital Interface, Digital/Analog Interface, with the capability for 48-ADC lines and 12-DAC lines, with a growth capability of 1,928 Analog lines, including cabinet.

PURCHASE

$78,000

(5) Limited Function Communicator Boxes, with status lights for ON-OFF, used for communications between researcher, computer and analog or digital device (optional).

PURCHASE

$32,000

(6) Systems, technical and training support; from Redcor, Inc. (5 weeks).

CHARGE

$6,500

(7) Summary of 418-III charges:

Equipment (Computer, Analog/Digital Equipment, Communicators and Remote Terminal)

$871,515

Redcor Support: $6,500

(8) Third-party leasing would reduce monthly charges about 10% over our 5-year lease price. This applies to both computer systems.

9400/1108 COST SHEET SUMMARY

(1) 9400 Computer, 32K Bytes, 3 Discs, 2 Tape Drives, Reader, Printer, Punch, 1108 Communication Capability.

PURCHASE	MAINT.	ONE-YEAR	FIVE-YEAR
$358,890	$1,736	$8,269	$7,051

(2) DCT 2000

$ 30,790	140		

(3) UNIVAC Equipment Summary:

$389,680	$1,876	$9,010	$7,685

(4) A/D Equipment:

$ 78,000

(5) Communicators:

$ 32,000

(6) Redcor, Inc. Systems Support:

$ 6,500

(7) Estimate on Communications Costs:

Two Milgo Data Sets (4800 bps): $7-9000

Yearly Charge for Private and Leased Lines: $5-10,000.

(8) Estimate on 1108 Processing Time (Prime Shift):

$5-10,000 Monthly

(9) Summary of all equipment charges, both UNIVAC & Redcor:

$499,680

PROPOSAL FOR AUTOMATED DATA ACQUISITION AND ANALYSIS SYSTEM (ADAAS)

INDEX

I. GENERAL DESCRIPTION

A. Univac has responded to two requests from Philip Morris, Inc., with two different hybrid computer systems, both designed to achieve key Philip Morris objectives: the automation of the research laboratory and the furnishing of an efficient research tool, the scientific computer.

B. Our first response would place a computer at the Research Laboratory, together with associated data conversion equipment required in a laboratory environment. This computer, called a Univac 418 III, is a medium-scale, real-time computer that is designed to outperform the 360/40, the fully-optimized scientifically-oriented 360/44, and the 360/50, at 360/40 prices. This particular computer is the third in the 418 series, all of which have been specifically designed to operate in highly-critical, real-time environments. Therefore, this computer, in addition to having a very high cost/performance ratio, has already proved itself, from both a hardware and software standpoint, in scores of real-time installations.

1. As part of the process of further enhancing this computer to function well in a real-time, scientific environment, all of the mathematical and statistical programs from the Univac 1108, a remarkably successful and popular large-scale computer, will be available on the 418 III. There are at least 177 of these programs and they probably represent the largest and most sophisticated set of mathematical and statistical programs available in the computer industry.

2. A further enhancement to the 418 III has been in the input/output philosophy, whereby a very high data transfer can take place (far in excess of that available in even the fully-optimized 360/44), without any processor degradation. An input/output processor (maximum of two) control all I/O functions, thus greatly adding to total performance and very greatly reducing processor degradation. In addition, a UNIVAC development, call Externally Specified Index (ESI), allows data transfer to go directly to the computer memory, again without disturbing the central processor.

3. The third major enhancement has been the addition of the capability to accommodate the full range of 1108 Direct Access Storage Devices, the magnetic drum subsystems, that range from the leader in the computer industry (in terms of access times and transfer rates), to a high-performance, mass storage system.

4. All of the preceding are of truly major significance in a scientific environment.

5. The instrumentation (data conversion equipment) is furnished by Redcor, Inc., a company with wide experience in this area and one which is particularly well-qualified in accommodating signals of a very low level, the kinds of signals with which we'll be dealing in the Philip Morris environment.

6. The Main Street location will be accommodated by a UNIVAC terminal device, (a DCT 2000), allowing researchers at that location to send programs to the 418 II whenever they desire.

C. Our second response would place a high-speed computer, a UNIVAC 9400, at Philip Morris, with that computer being used only as a terminal to the UNIVAC 1108 previously described. This particular 1108, owned by Computer Response, Inc., is located in Washington, D. C.

1. In this case, all analysis and processing would be accomplished by the 1108, a computer that many independent analysts consider to be the best large-scale, general-purpose, time-sharing computer ever developed.

2. The Main Street terminal (the DCT 2000) would also communicate with the 1108, via dial-up phone lines.

3. Since a very good case can be made for the 1108 in terms of its cost/performance ratios and the way they will compare with <u>any</u> other large-scale computer, and since time is charged by the second and only for the time the processor is actually involved, the 1108 charges will be very reasonable.

4. A private line would probably be used to connect the 9400 to the 1108. In the event that the single private line becomes overloaded (which might happen if all the devices were on-line at one time and were being sampled at their

maximum rates - a worst-case condition), provisions can be made to easily send this data to the 1108 via a second line which can be automatically dialed by the computer.

5. Virtually the same Redcor equipment is involved with this approach.

D. All three of the computers discussed, the 418 III, the 9400 and the 1108, are very highly competitive in their environments and either configuration can meet Philip Morris' hybrid computational and off-line needs. The 418 III approach involves a computer, terminal and data conversion equipment valued at $450-525,000, with additional charges for communications and 1108 time estimated at from $60-120,000 annually. We cannot make a precise estimate on this particular aspect without further problem definition, but we certainly expect that this would be the range.

E. Details of the proposal, as well as significant appendixed items, follow. It is important to note the information contained in Appendix A, which contains a summary of major assumptions made in order to answer the specifications. We strongly urge that no decision be made on a system until these matters are clarified, since it would be definitely in the best interest of Philip Morris to do so. We will be happy to furnish competent technical advice to Philip Morris to help clarify these items. The personnel involved would examine these points from the viewpoint of hardware, software, and instrumentation, and would make suitable and final recommendations to Philip Morris.

II. TECHNICAL DESCRIPTION

A. Analog Subsystem

1. System Requirements

a. The primary use of this system will be for data collection from analog and digital devices on a real-time basis, with this data to be transferred to a digit computer for analysis and processing. The computer must be able to process the data and return the results of the processing to a station near the data producing analytic device. The computer also must be able to operate batch programs in a multiprogramming environment.

b. The system cannot be experimental in nature and must be based upon established techniques as much as possible.

c. The digital computer requirements and peripherals are defined in the system specification and will be discussed in the digital system section.

d. The real-time devices are described in the system specification. The specification calls out their prime characteristics, anticipated use, and installation schedule.

e. All instruments, with two exceptions, are analog output devices having a voltage output of between 0-10 millivolts full scale or between 0-1000 millivolts full scale. The sample rates range between 1 sample per second and 3000 samples per second.

f. The two exceptions include instrument 9 and instrument 21. Instrument 9 produces digital pulses with a

35-to-60 millisecond duration. These pulses are counted to produce a digital number proportional to the quantity measured. Instrument 21 produces an unspecified digital output. The sample rates of these digital outputs are not specified.

g. The distance of these devices from the computer ranges from a minimum of 75 feet to a maximum of 625 feet, with one exception. The exception is instrument 35 which is located approximately 7 miles from point B.

h. The system must be designed to accommodate 40 real-time devices with the capability of being upwardly expanded with minimum additional cost. The input/output devices must be of a type that are easily expandable.

i. The number of output devices to be accommodated requiring digital-to-analog conversion capability is not specified. Using ratios common to other installations it is assumed that one digital to analog communication channel will be required for each four real time devices. A requirement of 10 digital to analog conversion channels is, therefore, assumed with the same capability of being upwardly expandable with minimum additional cost.

j. The software requirements are described in the specification and will be discussed in the digital software section.

k. Information on the physical requirements, expansion capability and manufacturers support is required in the specifications and will be described in later sections under those titles.

2. Alternate System Approaches

There are a variety of possible system approaches which could be used to input the data from the devices. In general one can convert the analog data at each location to digital data and transmit the information, or; one can send the analog data to a site adjacent to the computer for conversion at this single location. A further choice in the first scheme is in the method of transmission whether that be a hardwired method or ratio telemetry. These three possibilities will be discussed and the recommended approach given.

a. Analog/Digital Conversion at Each Location With Hardwired Communication

In general, it is easier to transmit digital information without information degradation. The very nature of digital data makes it more immune to noise. The least significant bit of a digital number has the same voltage swing as the most significant bit and further parity checks, redundant transmissions and other schemes are readily applied to such information. Analog information is much more difficult to send any distance with accuracy, because it lacks the characteristics just described. The appendix covers some of the techniques for preventing degradation of analog data.

There is a complication which is important in using such a scheme and that is the duplication of equipment. Analog-to-digital conversion equipment is expensive, in addition, sending parallel digital data requires a pair of lines, or the equivalent, for each bit in the number. To send digital data down a single line requires a serializer on the transmitter end and a storage shift register on the other.

b. Analog/Digital Conversion at Each Location With Telemetry Communication

The same discussion with respect to the first system applies here, with the exception of the transmission link. Here, a serial mode of transmission must be used, because of the sheer complexity of the transmitter and receivers required to send a digital word in parallel rules out such an approach. The advantage of such a system is the freedom of location of the instruments, including the ability to move a group of devices with little impact upon the system. One can even collect the data from the instrument seven miles away from point B using this scheme.

c. Analog/Digital Conversion at a Central Location With Hardwired Analog Communication

(1) This approach minimizes the conversion and transmission equipment required in the hardwired analog data transmission.

(2) This approach also avoids any redundancy in the electronic equipment itself, but requires one twisted pair of shielded wires per instrument. The discussion in Appendix B as to the precautions to observe and techniques to apply must be followed in this system.

d. Recommended System

(1) Considering the trade-offs presented, the number of instruments involved, and the distance of these instruments from the computer, the latter system (hardwired control data conversion) is recommended.

(2) With the exception of the instrument seven miles distant, all distances are well within the state of the art for analog data transmission. While care must be exercised with this approach, the additional cost of the redundant conversion and data transmission and collection equipment overrides this cost considerably. It is assumed in this system that the data be sent out analog links provided by Philip Morris and that the system provided by UNIVAC begins at the central collection site.

(3) An exception is taken in the proposed system to the collection of data from Main Street location. Conversion equipment, digital serializing and transmission equipment and digital shift registers, as well as connecting lines, must be provided for this one instrument. This represents a considerable cost for only one device, particularly for one with such a low data collection rate. While such a system for this one device can be provided, and will be, if necessary, it is recommended that alternative schemes be investigated, such as using a remote analog recording of the signal for conversion and processing at the central site.

(4) Therefore, with one exception, a central site, adjacent to the computer (that is to say, within two hundred feet of the computer) using analog links in each direction is the

recommended system.

3. Operating Philosophy

a. It is assumed that communication with the digital computer from the analytical devices, other than the data flow, will be by teletype. Further, that the data flow itself will be an analog signal in each direction. The digital devices will communicate with the central site using parallel digital words to a collection register in the interface. The data flow from the digital computer will be analog. Other than these links, the only communication will be an ON-OFF switch at each device which will enable the flow of data from that one device directly into the digital computer memory. When the switch is in the ON position, a light adjacent to the switch will be activated by the interface, indicating that the switch has been answered.

b. The method of operation would require that the operator first teletype the request for the operating programs which he requires for his data, along with the identification of the device to be used. The computer will collect these programs and make them available to the analytic device and when all is in readiness, teletype the ready status to the operator. At this time the only additional act by the operator is to turn the ON-OFF switch at the instrument from OFF to ON. The interface will receive this request and will <u>immediately</u> start receiving the data and sending it automatically into the computer memory, while lighting a light at the switch, informing the operator of that operational status.

c. Upon completion of the run, the switch would be returned to OFF, thus stopping the data flow and changing the status light condition. This same process is applied whether the data input is analog or digital.

d. The computer operates upon the data, using the specified program and, if required, will transmit analog data, using analog-to-digital converters in the interface to the appropriate line. Comments on the data can be sent over the teletype link to the appropriate instrument site.

e. This approach is a very simple, straightforward procedure which is the most economical to implement, while still providing the essential features. If more features are desired they can be readily added with an attendant increase in cost.

4. ANALOG SYSTEM BLOCK DIAGRAM

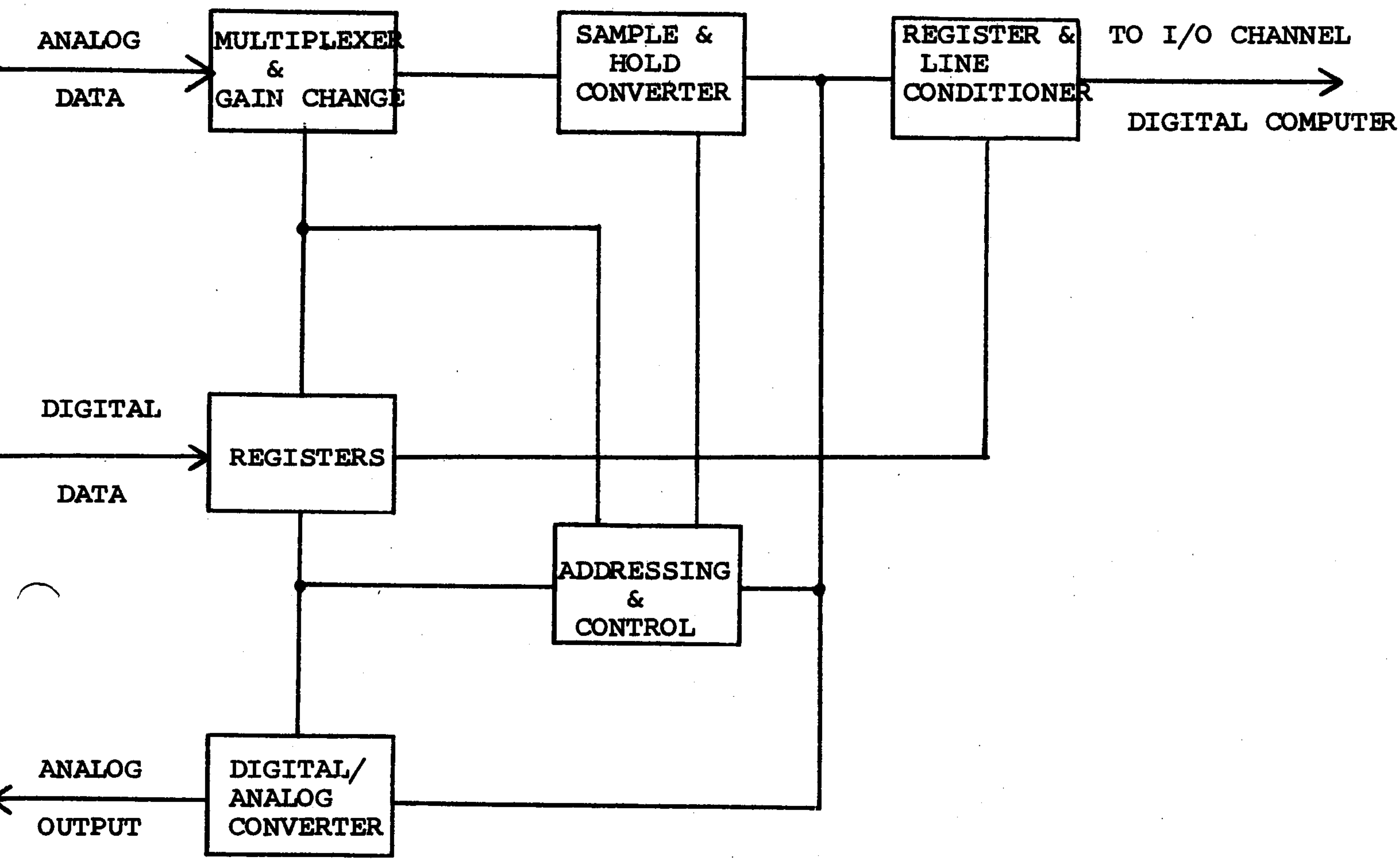


Figure 1

5. Analog System

a. The following description follows the Analog System Block Diagram. Provision is made for 48 analog channels and 2 digital inputs although, as shown, up to 2, 048 analog channels can be accommodated in groups of 16. In like manner the number of digital channels can be expanded. Essentially each digital channel substitutes for 10 analog channels; thus, if digital channels are added the number of total channels would be reduced correspondingly. For example, if 12 digital channels are added, the 2,048 analog channel capacity would be reduced by 120 to 1,928, still many times in excess of Philip Morris' present or planned needs.

b. Selection is under the control of a multiplexer in the interface, which samples each line in turn and converts data from each line, while also generating an address corresponding to the sampled line. This address will be utilized by the I/O portion of the digital computer to receive the data with no intervention by the 418 III Central Processor Unit (CPU). This automatic I/O feature, called ESI (External Specified Index), will be described in detail later both as to its hardware and software impact. This feature is a very powerful, sophisticated feature of the UNIVAC line of computers which was developed expressly for the real-world, real-time interface environment.

c. When a line has been sampled and converted, the end of conversion signal initiates the data transfer automatically.

The transfer is on a locked communication basis. This means that the data is transmitted and the sequence awaits a receipt signal from the digital computer. This scheme permits the input device to operate at its maximum speed on an asynchronous basis.

d. The digital channels are sampled in the same manner as the analog lines and a corresponding address generated. The difference is that the numbers are sent directly to the input register, because no conversion is necessary.

e. The status of each line appears in the switch status register as to whether the line is active or inactive. As each line is sampled, its status is also determined and sent to the digital computer as part of the input word. This bit is used by the computer to determine whether the program should use the data or not. This determination is entirely automatic and does not involve the 418 III Central Processor. Essentially, if the data is being inputted this bit will turn on the data stream into the computer and if the data is not being inputted this bit will inhibit the data flow.

f. The sequence and address control will test all lines and all digital input registers in turn, while generating the corresponding ESI address. The line being sampled will be held in the sample-and-hold section and converted into a 12-bit number in the analog-to-digital converter. The conversion will be made twice. The first conversion will be used to determine if one of the first four bits are zero;

if so the gain will be increased by a factor of 2, 4, 8 or 16 depending upon the number of zeros. If this were not done, each leading zero in the gain field would reduce the resolution in the digital field.

g. After the gain is changed, a second conversion is made which will now have no leading zeros and will have a high resolution. The total number comprising the gain and the data is sent to the digital computer. This approach gives dynamic ranges well in excess of one million, the range required for this type of data. The input data word format following illustrates the process.

The input data word format shown below consists of the 12-bit converted signal and a 4-bit gain identifier, used in the automatic gain ranging.

Gain	Digital Data
15——12	11——0

Input Data Word

h. If a digital word is sampled, then the number is merely transferred from the digital channel register to the input register.

i. The ESI register receives the address of the quantity being read and has a bias number appended to it. The I/O module in the digital computer accepts this number as the address of a pointer within its memory. The I/O module goes to this address and obtains instructions as to where to place the first data word on the channel, whether to increment or decrement the memory location for subsequent numbers and whether to interrupt the CPU when the memory block specified has been filled. This automatic feature, called External Specified Index, permits the data to be loaded directly into the digital computer memory, involving the processing unit only if the data is active.

j. Data output is sent to the analog interface system by using a command and address as to which register (computer line status or digital to analog converter) to load and the number to be inserted.

6. Expansion Capabilities

a. There are two primary ways to increase the capability of this system. One is to increase the speed and the number of channels in the input equipment. The second is to increase the power of the digital computation capability.

b. This system provides both capabilities. The number of channels can readily be increased due to the modular design of the interface equipment. The submultiplexer approach is readily expandable in modules of the submultiplexer input. The equipment can be operated much faster than required for the present system which permits a second dimension of expansion capability. In addition to merely speeding up the input equipment, changes in organization are possible.

B. DIGITAL SUBSYSTEM

1. Two-Response Description

As our letter of transmittal indicated, we are making two responses:

a. The first, and the one which answers the written specifications, involves the medium-scale, real-time UNIVAC 418-III computer. It is our understanding that this computer will perform all data acquisition and distribution tasks and will, in addition, perform all necessary background and real-time processing.

b. The second response, and the one which answers a verbal request, involves using a smaller medium-scale, real-time processor, the UNIVAC 9400, as a terminal connected to a large-scale computer, in this case the UNIVAC 1108. This particular configuration involves the 9400's being involved with data acquisition and distribution and communications to the large-scale UNIVAC 1108. The 1108 will perform <u>all</u> analysis and computation.

c. The remote location (Main Street) will be handled in either case by a UNIVAC DCT 2000; in case of the 418-III, the Data-Phone link will be to the Research Center. With the 9400, the Data-Phone link will be to the 1108 in Washington, D. C.

d. The 418-III is wholly a UNIVAC venture, except for the analog/digital interface. The 9400/1108 approach involves UNIVAC's cooperating with a time-sharing company, Computer Response, Inc. in Washington, D. C. In both cases, the analog/digital equipment will be furnished by Redcor, Inc., one of the most experienced and qualified instrumentation firms in the nation.

2. 418 III Performance

As we have noted in several discussions with you, the 418-III has been specifically designed to out-perform the 360/40, 360/44, and 360/50 at 360/40 prices. It is the third computer in a series designed, initially, for message switching. The second issue of this series, the 418-II was enhanced by a Fortran compiler. Virtually every 418 computer is being used in a real-time environment, and has been, dating to 418-I experience in 1961. This means that the software and real-time executive systems are highly refined. A real-time evaluation of the 418-III and the 418-II is included in Appendix 1. The third issue (the 418-III) has been considerably enhanced in several ways:

a. The full range of Mathematical and Statistical routines on the highly successful 1108 have been added to the standard NASA FORTRAN subroutines. There are at least 177 of these programs, a full listing of which is included in the 1108 manual. This gives the user a very wide range of routines which to use and makes the 418-III, in this respect, an extremely flexible tool.

b. The input/output philosophy has been modified in a fashion similar to the 1108. This involves the use of I/O control units, called Input/Output Modules (IOM's) to control all I/O functions. In this way, memory can be accessed in three different banks simultaneously, with one access being by the processor and two being by the IOM's. This enables a transfer rate of 2.67 million, 18-bit words to take place, without any processor degradation, and very considerably aids total cost/performance.

c. The 1108 peripheral devices have been added to the 418-III. This gives the user several important advantages:

(1) All three drum units (FH 432, FH 1782, and FASTRAND) can be used with the 418-III. These range from the 4.25 millisecond 432 drum to the 87 millisecond, mass storage FASTRAND;

(2) Up to eight drums of each type can be added, giving the user a very wide range of flexibility, growth, storage and performance;

(3) All the devices are, and have been, operational in many installations throughout the country.

d. The 418-III is many times faster than the 418-II, so much so, in fact, that it is more than seven times as fast as the 360/40, more than two and one-half times as fast as the 360/50, and up to one-third to one-half again as fast as even the much more expensive, fully-optimized 360/44, in a scientific, Gibson mix of instructions.

e. The system software performs many tasks that helps to optimize the programmer's time. The executive performs the program function necessary to reference files, protect programs, load programs, initialize and start equipment, and other tasks previously written as part of each program.

f. Multiprogramming in the 418-III imposes no constraints whatsoever upon positioning the program in memory. The only constraints imposed are the actual, physical constraints of memory size. No partitioning is necessary.

g. A list of major advantages of the 418-III over the 360/40, 360/44 and the 360/50 is included in Appendix 2.

3. The UNIVAC 1108

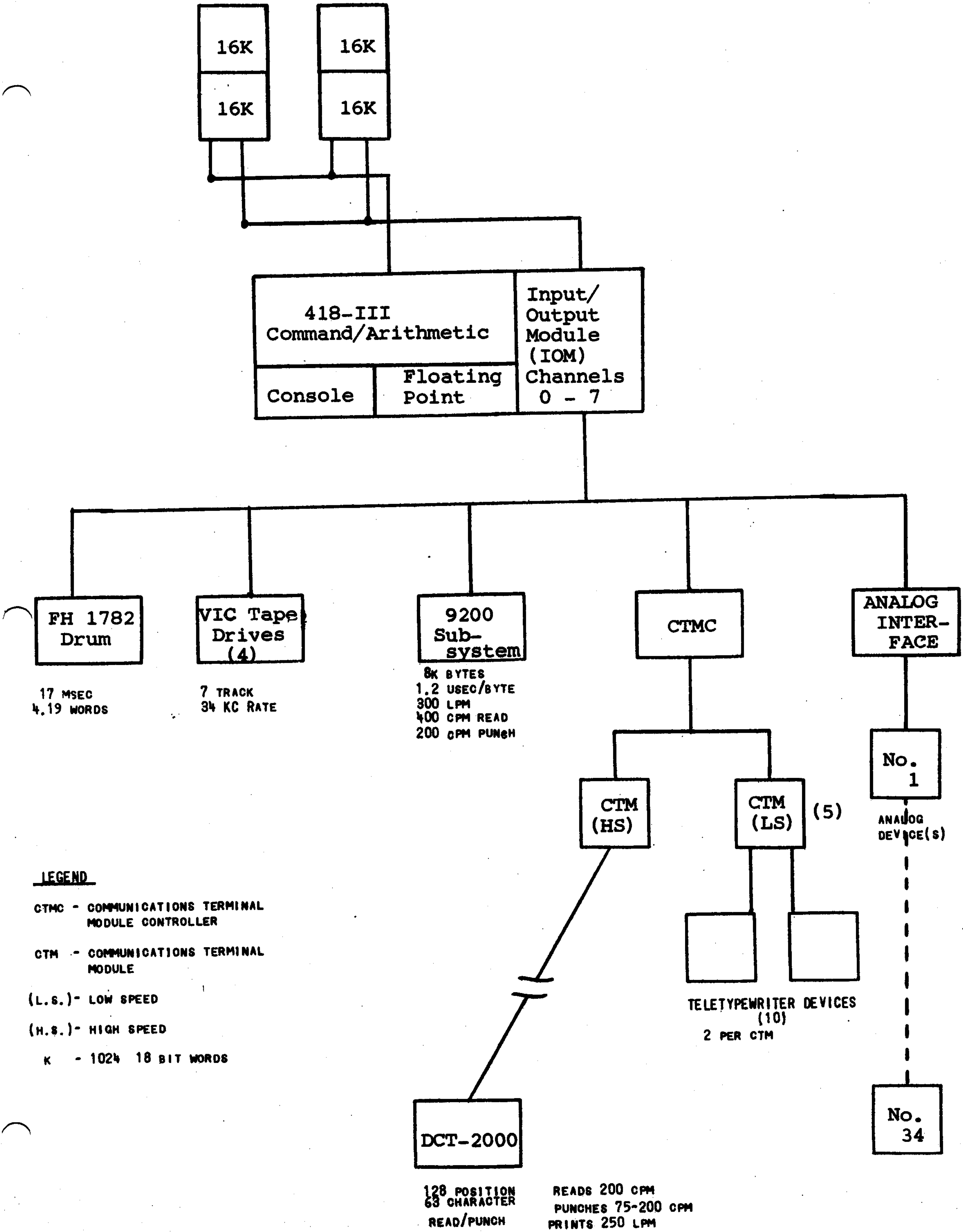
The UNIVAC 1108, one of the most popular and successful large-scale computers ever developed, will be the computational unit involved in the second proposal. The 1108, for example, in independent tests by a user who also owned the IBM 360/75 and the CDC 6600, rated the 1108 at a 3:1 advantage over the 360/75 and equal to the CDC 6600. The environment included the running of a large number of FORTRAN programs. Another major user who owns both the UNIVAC 1108 and CDC 6600 rated them equal overall, with the UNIVAC FORTRAN compiler being rated so highly that a rewriting of that compiler in machine language would not have significantly improved its performance. It should be noted that the 360/75 typically rents for 15-50 percent. Thus, in terms of the very critical cost/performance ratios, the UNIVAC 1108 is an extremely formidable competitor.

4. The UNIVAC 9400

The UNIVAC 9400 computer which will be used as a terminal, is a very high-speed, byte-oriented, real-time processor. Its operating system is specifically designed to function in a real-time environment. This computer will help to control the instruments and will send data to and receive data from the 1108, in addition to accommodating the output devices and two magnetic tape drives.

5. Figure 2, 418-III Analog System Diagram and Operational Discussion

The general configurations will be diagrammed as noted in Figures 2 and 3. We will briefly discuss Figure 2 (418-III) first.



LEGEND

CTMC - COMMUNICATIONS TERMINAL MODULE CONTROLLER

CTM - COMMUNICATIONS TERMINAL MODULE

(L.S.)- LOW SPEED

(H.S.)- HIGH SPEED

K - 1024 18 BIT WORDS

a. Note that Figure 2, in a simplified form, relates the total environment to the 418-III. The remote terminal at Main Street would communicate, when necessary, to the 418-III. In the absence of more specific information, we have assumed that this communication can be accommodated via a dial-up telephone line (a Data-Phone link).

b. The specifications called for from 8-12 remote printers of the teletypewriter variety. Therefore, we have included arrangements for 10 of these devices.

c. Specifications called for at least two tape drives but further discussions seemed to indicate that, for programs requiring less frequent runs and lower response times, the program and data files could be furnished to the system for processing, updated and taken back out for storage until the program is run again. Thus, we have suggested using tape drives for this purpose, in addition to its stated purpose of accommodating occasional programs that already exist on tape. This would accomplish two things. One, it would keep the cost of on-line storage to a minimum and; two, it would allow for the updating of program and data files without the inefficiencies of operator intervention required in a two-tape environment. This approach still visualizes the 1782 drum as the high-performance storage unit in the system and all processing would involve that unit. The tapes would be used to copy the program and data file updates. We had assumed that program and data file updating would be a normal operational requirement.

d. UNIVAC's FH (Flying Head) 1782 drum is another unit in the system that meets a major specification requirement, that of having a high-speed direct-access storage device to be used for the executive, the most frequently used data files, and the most frequently used FORTRAN programs.

e. Thus, a summary of the 418-III approach is:

(1) Test initiation;

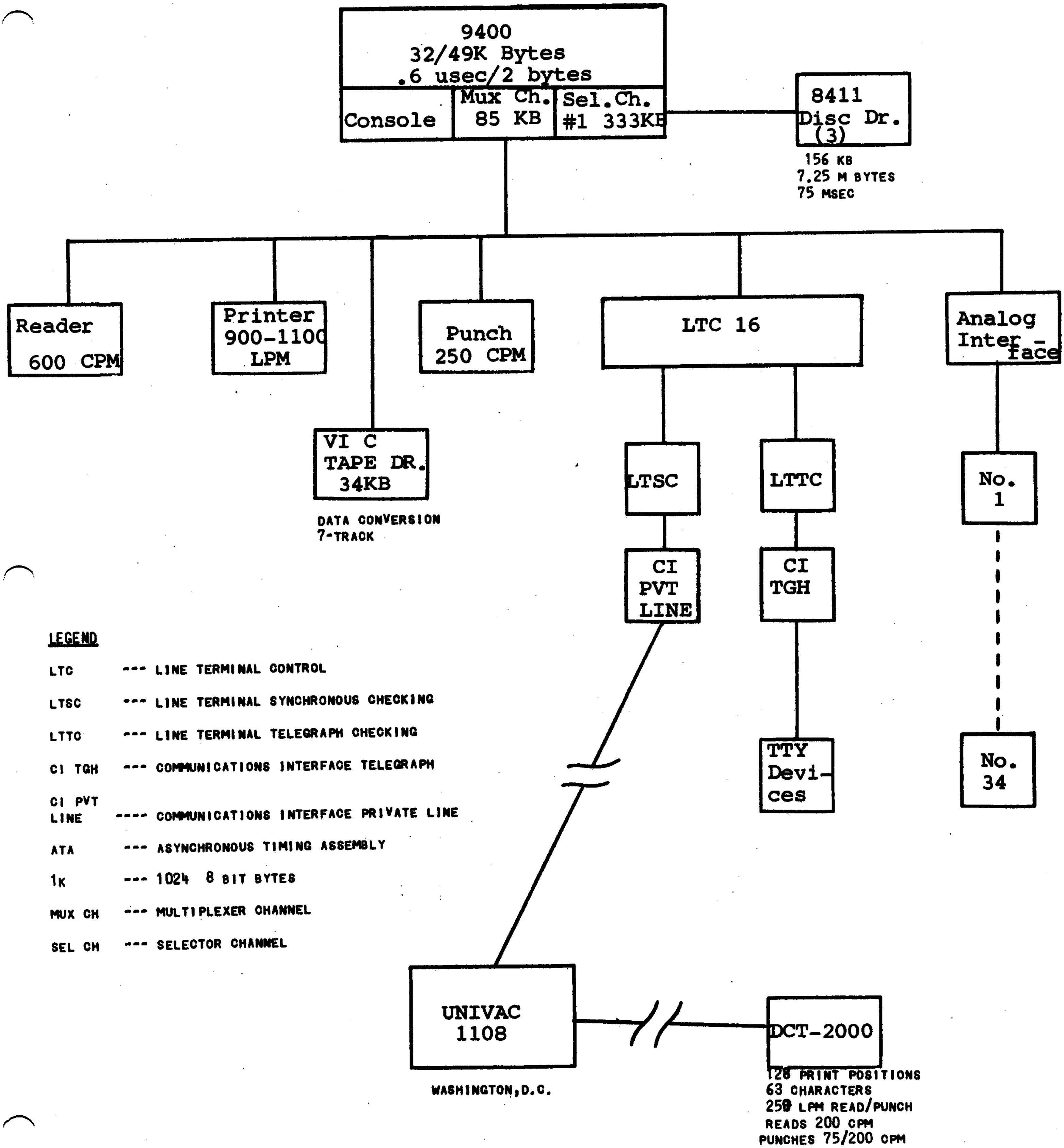
(2) Data conversion;

(3) Processing by the 418-III;

(4) Teletype or analog reports back to testing locations, and;

(5) Main Street's terminal connected to the 418-III.

f. The 9400/1108 configuration follows.



LEGEND

LTC	--- LINE TERMINAL CONTROL
LTSC	--- LINE TERMINAL SYNCHRONOUS CHECKING
LTTC	--- LINE TERMINAL TELEGRAPH CHECKING
CI TGH	--- COMMUNICATIONS INTERFACE TELEGRAPH
CI PVT LINE	---- COMMUNICATIONS INTERFACE PRIVATE LINE
ATA	--- ASYNCHRONOUS TIMING ASSEMBLY
1K	--- 1024 8 BIT BYTES
MUX CH	--- MULTIPLEXER CHANNEL
SEL CH	--- SELECTOR CHANNEL

FIGURE 3

6. Figure 3, 9400/1108-Analog System Diagram and Operational Discussion

Figure 3 is a diagram of the 9400/1108 configuration. This is, conceptually very similar to the 418-III approach, except that the UNIVAC 9400 computer gathers the data for processing by the 1108.

a. Note that this system has two tapes, instead of the four on the 418-III. All program and data updates will be accomplished at the 1108, instead of at the 418-III.

b. The 9400 computer will poll all the devices, in order to collect the data. This contrasts with the 418-III, which uses a different technique (ESI) to collect the data.

c. After the 9400 receives information from a researcher via the teletype, it will notify the researcher to start the test, begin polling the device, receive the data and start a data file on discs; the 9400 will maintain control of that data file until the test is complete, sending blocks of data intermittently to the 1108 for analysis.

d. Following the 1108 analysis, the 9400 will receive the report and send it to the teletypes, and if needed, to the conversion equipment for an analog output on strip charts near the testing devices.

e. To summarize, then, the 9400 will:

(1) Receive pertinent information from the researchers;

(2) Notify the researcher to start the test;

(3) Poll the device at the appropriate speed;

(4) Build the data file;

(5) Send the data to the 1108 and receive reports from the 1108, and;

(6) Send reports back to the researcher in printed and, if desired, in analog formats.

C. Software

1. 418-III Discussion and Diagram

a. The monitoring capability that will be provided on the 418-III will operate in the externally specified index mode. The standard communications I/O handler can be used to control the software environment needed for this type of operation.

b. When data or discrete signals are received by the analog interface, the assigned number of the device currently being sampled by the multiplexer is added to a hard wired bias to generate the ESI address and passed to the I/O module of the 418-III along with the data. The input data request line is raised and the normal hardware communication takes place.

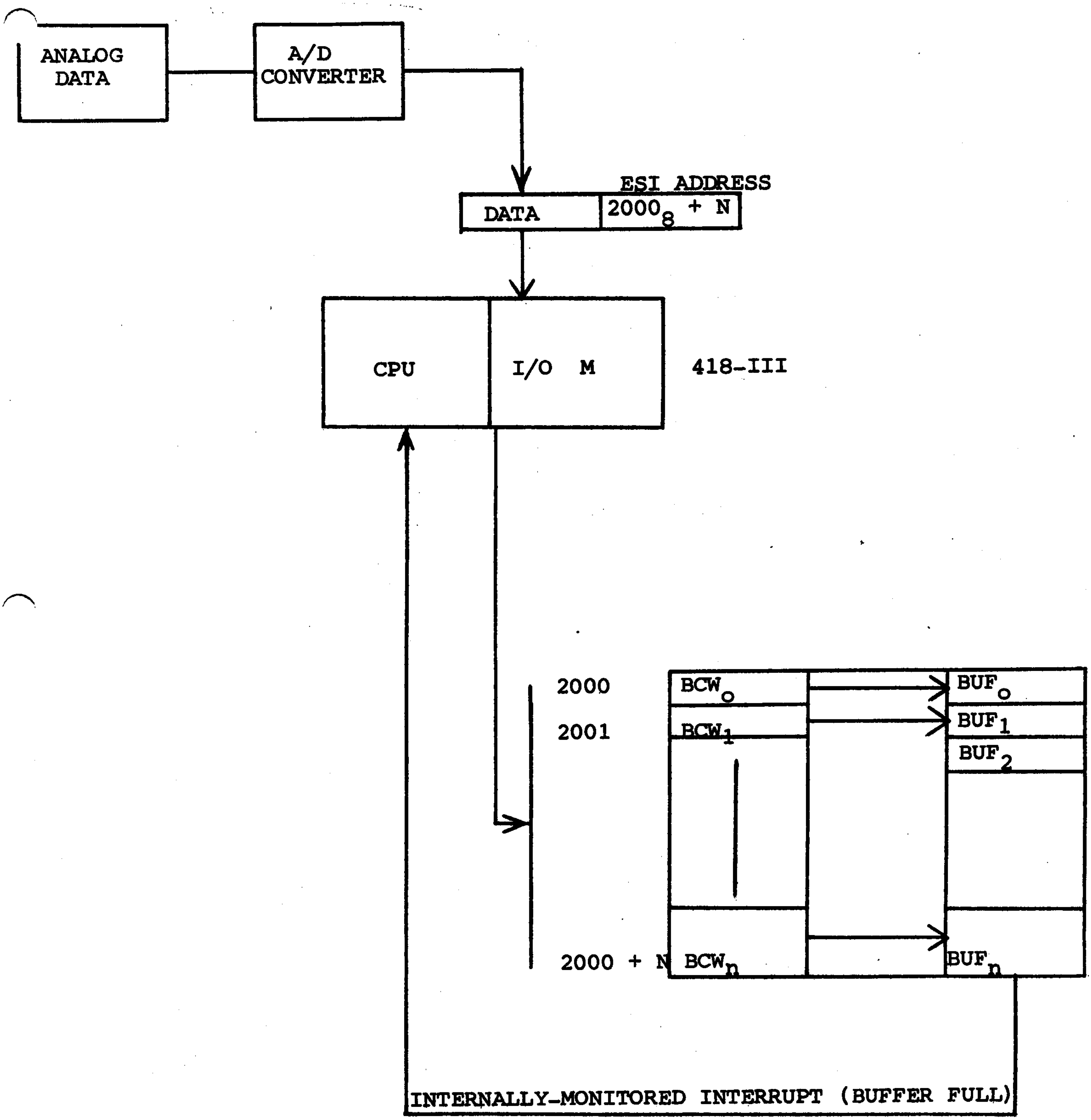
c. Beginning at the address indicated by the hard wired bias in the interface, the user program will cause storage of a series of buffer control words. One control word will be associated with each device that is capable of transferring information to the digital computer. The number of buffers that may be assigned is limited only by the memory available.

d. When the I/O module of the 418 receives the data and buffer control word address, it will store the data (packed or unpacked) in the buffer indicated, without alarming the central processing unit. This data can be entered in any random manner with devices emitting data at various speeds and collection may be in various buffer sizes.

e. When any of the buffers are filled, an internally-monitored interrupt will be generated that will cause the central processor to be alerted. The CPU will then set an alternate buffer for the data from the particular device and then can analyze, format or transfer the data, as fits the problem.

f. The I/O module has an independent path to memory, and it should be noted that the CPU is operating independently of all data acquisition from the analog devices. At the same time, the CPU has full control of what data has entered, and where and when the processor should be notified.

418-III SOFTWARE SCHEMATIC



2. Software Discussion and Diagram

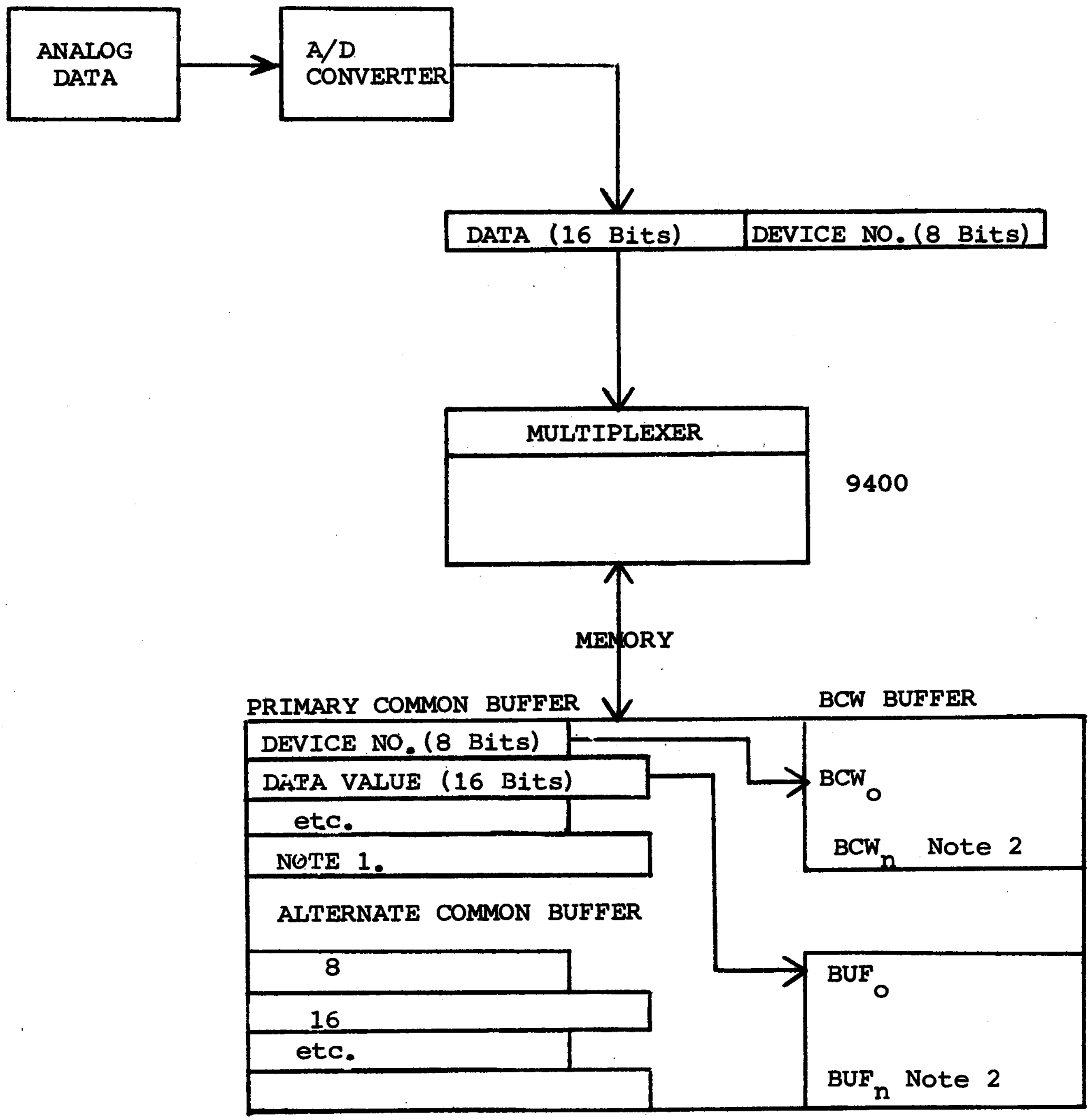
a. All activity between the CPU and the analog interface will be controlled through the channel scheduler routines which provide queuing, dispatching, posting and error detection. A high level routine will be provided that will have the responsibility of activating the analog channel and setting a common buffer where data will be automatically stored. Each word of data stored will have a corresponding device number. When the variable length common buffer is full, an interrupt will cause the CPU to set an alternate common buffer for the continuous data flow. It will then store each data value in the proper buffer associated with the device as indicated by a preset table of buffer control words (BCW). When the BCW indicates that a buffer is full, an alternate buffer will be indicated in the BCW table and the data will be transferred to the applications program. This routine will also block and deblock records, validate data, swap buffer areas and execute periodic test transfers to check the reliability of the interface.

b. The high level routine will provide a common software interface between the applications program and the channel scheduler. The application program will request data from a particular device and will provide the location and length of the data buffers (two buffers if continuous data flow is desired), and an entry location for normal and error completion. Verification and reformatting of the data may also be done at this level.

c. After the applications program receives the data, it will a) format the data, b) store the data on an intermediate storage device, and; c) transmit the data to the large-scale UNIVAC 1108.

d. A full description of supporting 1108 software is given in the 1108 manual.

9400 SOFTWARE SCHEMATIC



Note 1. CPU is alerted when one common buffer is full. It then begins filling the alternate and continues flip-flopping back and forth.

Note 2. When BCW buffer is full, CPU transfers data to applications program.

Figure 5

III. MANUFACTURER'S SUPPORT

A. Education: UNIVAC runs a large, nationwide network of schools that are available for training; these schools involve hardware, software, and concept courses, and range from one-half day executive sessions to sixteen-week comprehensive training courses.

B. Systems Support: UNIVAC has local systems support available and additional support available from Charlottesville and Washington, D. C. The proposed installation might, in addition, require the assistance of specialized personnel from other areas. These will be available.

C. Field Engineering Support: UNIVAC also has local, on-call engineering support available and will keep a small supply of parts and maintenance items on premises. This is detailed in the appendix describing environmental conditions. Engineering support is included within the standard maintenance contract and covers any nine-hour, contiguous period specified by the customer between 7:00 a.m. and 6:00 p.m. Additional charges are made for 12 and 24 hour coverage, or the customer can simply pay an hourly rate for charges that exceed prime shift coverage. This is of no particular concern at this point, since we are concerned primarily with prime shift operation at Philip Morris.

IV. PHYSICAL ENVIRONMENTAL FACTORS

A. 418-III System

		BTU/HR	CFM	KVA
1.	Approx.	71,059	8,175	27.0

2. Approx. sq. ft. 25 x 38 = 950 sq. ft.

3. Maintenance sq. ft. 15 x 15 = 225 sq. ft.

4. Add for each:

	Unit	Sq. Ft.	BTU/HR	CFM	KVA
a.	Fastrand	157	19,500	1000	7.0
b.	1782 Drum	55	4,000	200	1.8
c.	432 Drum	28	7,480	420	2.3

B. 9400 System

	BTU/HR	CFM	KVA
Approx.	62,640	6,345	21.4

APPENDIX A - MAJOR ASSUMPTIONS

We made the following assumptions in answering the written and verbal specifications.

1. Philip Morris will furnish wiring and shielding that will yield the appropriate signals at the analog/digital interface. The criteria are covered in detail in Appendix B.

2. We have assumed that, typically, about one-half the devices will be on-line at one time, even though the analog/digital equipment and both digital computer arrangements can accommodate all devices, present and planned, simultaneously. The number of devices that are typically on-line at one time has been determined, based on other laboratory environments. It is important, however, to clarify the ratio of active to idle instruments, since this can help to optimize the digital computer configuration.

3. Since there are no detailed figures available for the amount of data to be entered from the Main Street terminal, we have assumed that a dial-up, Data-Phone link will be adequate. If, however, the work load is high and the stimulation factor is also high (as we suspect), a private line link might be economically justified.

4. No estimates have been given for the size of the output report. Thus, we have estimated that a typical report

will be about 3,000 characters. This is based upon estimates from other laboratories. Assuming an <u>effective</u> printing speed of 8 - 13 characters/second, this would result in about a 4 - 6 minute output report per test.

5. Typically, in a laboratory environment, a certain ratio is maintained between the analog/digital lines and digital/analog lines. Often, a researcher will still desire an analogically varying strip-chart recording, in addition to the printed report. We have assumed a 1:4 ratio of D/A to A/D lines, and the analog interface includes this capability.

6. No estimates on data and program file storage are available by each machine type. The only information given is that each different type of device will require storage approximating that of an 1130 disc. This would be .5 - 1.0 million bytes. Thus, we have estimated that our 17 msec., FH 1782 drum, with a storage of over 4 million words or more than 12 million characters, will be sufficient, particularly since several of the devices (13) do not require an "immediate" response. It is anticipated that some data and program files can enter the system from tape and be transferred to the drum for processing. It is our understanding that an arrangement of this type has already been envisioned, except that disc packs were mentioned for the inputting of programs and data. The highly time critical data and program files, as well as executive routines, will be continuously resident on the high-performance drum.

7. It appears that, in the case of the 9400's communicating to the 1108, a single voice grade line (4,000 cycles per second bandwidth) will be adequate. However, assumptions that are critical here are worst case situations involving not only having all devices on line, but also involving a maximum sampling rate on all instruments. Other laboratory experience indicates that the sampling rate on the slower devices (the 10-20 times/second type) will, in about 80 percent of the cases, be samples at 10 times/second. Pending further clarification of this, we are planning on a single voice grade line. For worst-case situations, a Data-Phone link (automatically dialable by the computer) could be established to the 1108 as a kind of "safety" valve. This would negligibly add to the system.

8. A further assumption, related to No. 7 preceding is that the voice grade link to the 1108 will be a private line. This would appear to have two major advantages:

(a) It is very economical, and;

(b) Very high speed data-sets (non-Bell System) could be used, thus minimizing any leased-line charges incurred as a result of using the "safety" valve, dial-up arrangement.

9. We have included four tape drives (34KC) in the system, instead of two. We assumed that if programs and data files (particularly those of a historical nature) are entered for some devices, Philip Morris would also want to update both the program and data files periodically. The four tape units will

enable these two events to occur simultaneously and reduce the disefficiencies of operator intervention required in a two-tape environment.

10. No mention has been made of a continuous audit of data with that data to be collected on tape and stored for a period of time. This might be desirable, but we have assumed that it is not wanted. If it is, another tape drive would have to be added to the configuration.

11. Another major assumption is that the application software routines desired need further definition before we can determine the magnitude of the software effort. It is our intention to be highly competitive in this respect, and we are already adding handlers to the 418-III and 9400 executive systems to accommodate all devices.

An examination of laboratory environments indicates that there exists a wide discrepancy in approaches to developing the supporting software routines. In short, "standard" software is not, because of highly distinctive software approaches in different laboratories, very standard.

We hope to clarify this issue, as well as others, by having a competent team of men (hardware, software, and instrumentation) spend some time with the appropriate Philip Morris representatives.

Appendix B
TECHNICAL DISCUSSION OF ANALOG INPUT FACTORS

1. GENERAL. There are many factors which influence the final accuracy and reproducibility of the proposed system. Many potential problems can be overcome by proper handling of analog inputs. The input wiring of the system is the most sensitive portion of the entire wiring complex. Not only is the power level of the system at its lowest, but common mode noise sources are present.

2. NOISE SOURCES

a. The input cables, another very important part of the system, are intended to deliver the output of the transducer to the input terminals of the system without alternation. This goal requires careful attention to all noise sources including the lowest level types such as thermal or photoelectric voltages. Larger noise sources, such as magnetic or electrostatic pickup must be treated with even greater care. Proper treatment of the entire input section of the system, including the transducer, its power supply, the cable, and the input amplifier, is required to provide sufficient common mode injection and/or isolation against injection of normal mode voltages. This requires careful attention to all sources of impedance and capacitive degradation and none must be neglected.

b. Ignoring common mode for the moment, first consider the requirements for bringing the transducer voltage to the amplifier terminals. The amplifier must have a high stable input impedance to prevent much current being drawn through the cable impedance. The cable in turn must not produce noise through flexing or through thermal changes, that is, thermal gradients which quite often are not recognized even when their presence is extreme. If the frequencies to be transmitted cover any appreciable band, the cable capacity per foot and the cable length become important. The cable length is also significant due to leakage resistance. Effective grounding techniques are probably the most often abused.

3. MAGNETIC SHIELDING: The pair of wires in the cable must be close together and twisted to prevent pickup from magnetic fields. This is required to prevent large effective areas being generated thereby allowing differentail magnetic fields to be coupled in one cable and not the other. This technique of twisting inherently produces high cable capacitance and may not be permissible if high frequency signals are to be carried. If wide spaced wires are dictated by capacitance or other considerations, the cables must be shielded from magnectic fields. This can be done by running them in a magnetic shield cable trough, by using distances as a shield, or by twisted pair coaxial cable. In any case, it is important to note the location of every source of change in magnetic field in the vicinity of the cable run.

4. ELECTROSTATIC SHIELDING: To prevent pickup from electrostatic fields, the pairs of wires must be surrounded by an efficient shield. This usually takes the form of a braid around the cable structure under the outer insulation. This type of shield has proved adequate for many applications and former specifications when properly connected. However, the leakage capacity from the shield to ground is one of the most significant factors of common mode rejection. The connections of the cable shield will be discussed later, but the basic principle is the same as any other shield. It must be at a fixed potential with respect to the circuit being protected.

This last statement infers, of course, that if the circuit being protected has dynamic voltages, then of course, the shield also must be driven at the same dynamic voltage.

5. SYSTEM DESIGN AND CONCEPT.

a. The previous requirements clearly mean that the system's responsibility should not end at the termination point of the data handling equipment. The cable to the transducer, its routing and cable ways, and connection at both ends a are as important to the system as anything inside the rack. In the discussion of the common mode it will be seen that this extension of the system's responsibility includes the transducer, its power supply and their connections. it is not enough to build a system capable of measuring small voltage at its input to a required degree of accuracy. Scientists invariably want to measure small voltages referred to a transducer to a required degree of accuracy. This is by no means the same thing. By way of an example, consider the case of a typical braided shield cable.

b. Here we have two inner conductors surrounded by a copper braid. We have two capacitances, C 1/c and D 2/c to the actual shield and then two leakage capacitors C 2/L and C 1/L through the cable to ground. If the braid were perfect, then these two leakage capacitances will be zero. However, because of the nature of the braid, the shielding effectively is typically only 90 percent, which means to say, then that 10 percent of internal cable capacity can be reflected to an outside ground placed in near proximity to the cable.

c. The type of cable which would circumvent this problem would be a foil-wrapped cable with a solid guard wire running through the foil to make sure that each point of the foil was connected. This, then, would prove to be a near-perfect, guarded shield and would thus almost eliminate the two leakage capacitors.

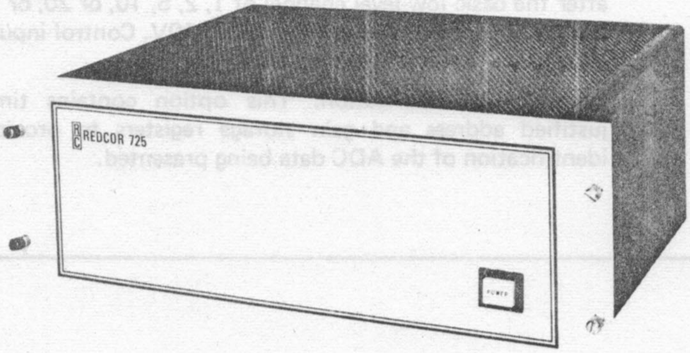
APPENDIX C. DETAILED PRICING, 418-III

ITEM	QTY.	PURCHASE	MAINT.	1 Yr. RENTAL	5 Yr. LEASE
3020-00 Processor	1	$92,875	$275	$2,135	$1,815
F1084-01 I/O Channel Expansion	1	4,785	10	110	95
F1083-00 Floating Pt.	1	5,220	5	120	100
4010-00 Console	1	11,310	20	260	220
7009-00 16K	1	76,995	180	1,770	1,505
F1087-00 16K	1	50,895	120	1,170	995
7009-02 16K	1	54,595	145	1,255	1,065
F1087-01 16K	1	50,895	120	1,170	995
5012-00 432/1782 Control	1	82,515	260	1,885	1,600
6015-00 1782 Drum	1	117,210	260	2,680	2,280
5008-00 Uniservo VIC Control	1	31,070	35	710	605
0858-00 VIC Master	1	17,350	115	400	340
0858-01 VIC Slave	3	31,410	210	720	615
F1097-00 Multi-Strobe Read	1	1,090	5	25	20
3030-00 9200 Processor	1	12,200	65	280	240
F0869-98 Multiplexer	1	2,070	5	50	45
F0868-01 132 Pos.	1	7,360	20	170	145
F0969-00 8 LPI	1	220	-	5	5
7007-00 8K	1	15,870	30	365	310
F0963-00 300 LPM	1	2,070	-	50	45
F1130-00 Form Align.	1	410	-	10	9
0711-00 Card Reader	1	4,735	30	110	95

APPENDIX C. (continued)

ITEM		QTY	PURCHASE	MAINT.	1 Yr. RENTAL	5 Yr. LEASE
0604-00	Card Punch	1	$ 9,920	$ 90	$ 230	$ 195
F1095-00	418/9000 ICCU	1	8,050	20	185	155
F0900-06	C.T.M.C.	1	24,700	135	570	485
F0901-04	CTM (LS)	5	(2,255 ea)	(15 ea)	(50 ea)	(45 ea
			11,275	75	250	225
F0903-02	CTM (HS)	1	3,630	15	85	75
8560-00	DCT 2000 ASC II	1	16,170	45	390	335
0603-00	Read/Punch	1	7,350	60	175	150
F0835-00	Punch Check	1	1,545	10	37	31
F0836-00	128 Print Positions	1	2,695	17	65	55
F0847-00	Telephone Alert	1	470	2	12	10
F0848-00	Error/Detect Retransmit	1	1,620	3	39	33
F0849-00	Forms Control	1	940	3	23	20
TOTAL, 418-III and DCT 2000			$761,515	$2,385	$17,511	$14,613
	Maintenance				2,385	2,385
	GRAND TOTAL				$19,896	$16,998

DATA SHEET



MODEL 725
LOW-LEVEL MULTIPLEXER/A-D CONVERTER

A real solution to the high cost multi-channel data acquisition problem, the 725 can handle low-level signals directly at high speeds. It includes a low-level multiplexer, sample-and-hold, A-D converter and sequence control unit. Channels may be randomly or sequentially selected and a programmable gain feature permits the handling of a variety of analog sources.

Redcor's 725 is a completely solid-state instrument which features high performance along with user-tailored options. Options are available to provide programmable gain ranging, low-pass filters, and address/gain verification. All digital signals are DTL/TTL compatible.

Field expandability and ease of maintenance is ensured by extensive use of standard Redcor 770 Series functional modules. The instrument is completely self-contained with mating I/O connectors included.

FEATURES

- ☐ 128 channel system including A-D converter for less than $10,000
- ☐ Expandable in groups of 16 channels to a total of 2,048 channels
- ☐ Full scale input ranges of ±5mv to ±200 mv
- ☐ Up to 15,000 12-bit samples per second
- ☐ Individual channel programmable gain option in decimal or binary steps
- ☐ Automatic gain ranging option to simplify data acquisition programs
- ☐ ±5μV channel-to-channel offset
- ☐ Isolated 16 channel modules to minimize crosstalk

FEATURES (Continued)

- ☐ Driven shield option for improved common mode applications
- ☐ DTL/TTL compatible data and control logic levels

SPECIFICATIONS

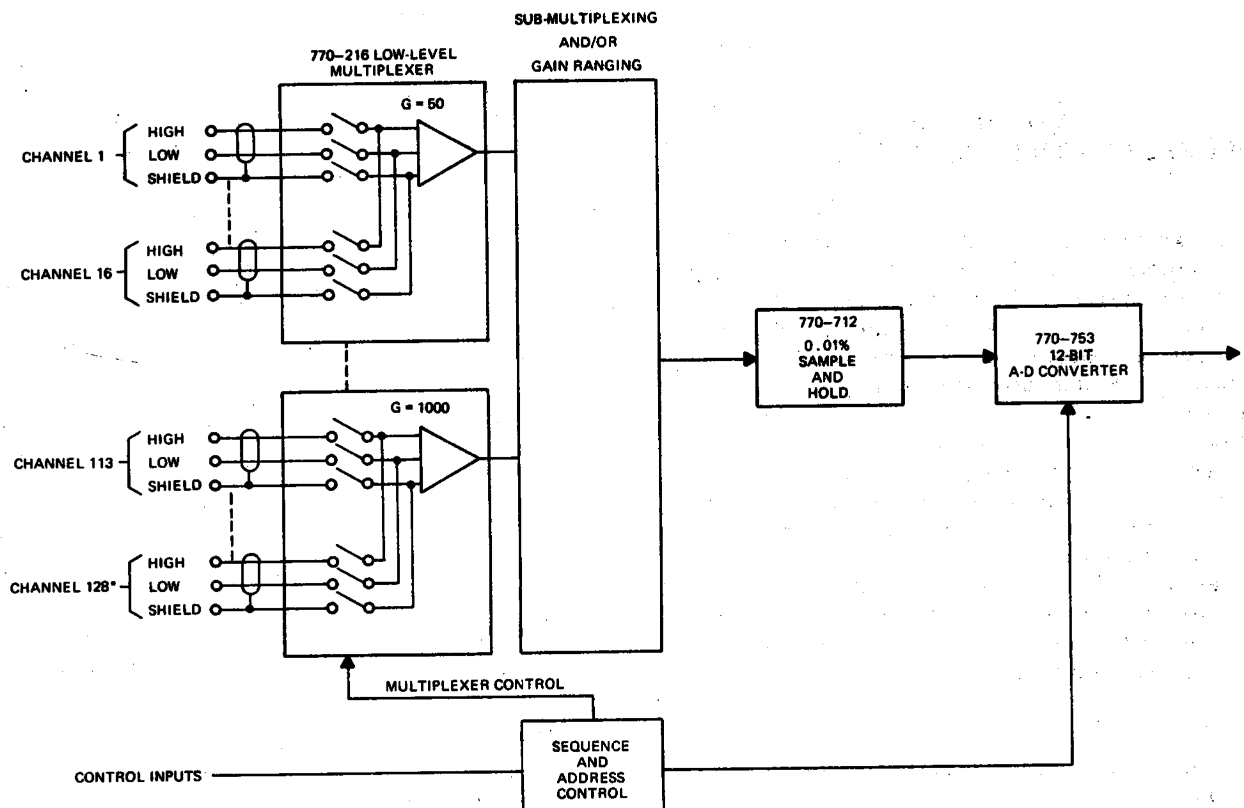
Number of Channels	Up to 128 channels in the basic unit. Logically expandable to 2,048 channels.
Input	Differential ±5mv to ±200mv full scale.
Common Mode	±10V
Nominal Overrange	±1V
Maximum Allowable Input Without Damage	±15V common mode; ±5V normal mode with zero source resistance, ±15V normal mode with >400 Ω source resistance
Channel-to-Channel Offset	±5μV RTI
Input Resistance	Greater than 10 megohms shunted by less than 0.0015μfd
Common Mode Rejection	100db with 350 ohm source unbalance; 120db with filters.
Crosstalk (60Hz)	(RS/1000 + 0.1) 200/F.S. (.01%) RTI per channel or 0.02% RTI per channel whichever is greater, with ±10 Volts, 60 Hz common mode signal applied to unselected channels.
Gain Accuracy	0.05% of full scale range.
Pump Out Current	5 nanoamperes maximum.
Common Mode Source Resistance	1 megohm or less; larger when shunted by suitable capacitance.
Gain Stability	
Time	±0.01% for eight hours ±0.05% for 90 days
Temperature	±0.003%/°C
Linearity	±0.01%
Drift (RTI)	
Time	±10μV per week
Temperature	±1.5μV per °C for ±5mv full scale: ±3μV per °C for ±200mv full scale.

SPECIFICATIONS (Continued)

Control	Octal decoded DTL levels
Aperture Time	50 nanoseconds
A-D Resolution	12 bits including sign
A-D Output	12 bits parallel offset binary, one's complement or two's complement
Throughput Rate	Up to 15,000 samples per second
Channel Addressing	Random or Sequential
Power Required	115VAC, 50-60Hz, 50 watts
Physical Size	19" pack mounting chassis, 7" high, 14" deep

OPTIONS

- ☐ Expandable in groups of 16 channels to 128 channels. Logically expandable to 2,048 channels.
- ☐ Individual channel low-pass filters. Factory installed at time of purchase. 6db/octave with nominal break-points of 5, 10, 20, 50 or 100Hz. Other frequencies available on special order (5Hz filter improves 60Hz CMR to 120db.)
- ☐ Third wire switching and driving. Individual switches for signal shields and active drive with common mode signal.
- ☐ Programmable gain. Provides a second level gain stage after the basic low-level channel of 1, 2, 5, 10, or 20; or 1, 2, 4, 8, 16, or 32. Full scale output ±10V. Control input: 3-bit binary code DTL compatible.
- ☐ Address/Gain verification. This option contains time justified address and gain storage registers to provide identification of the ADC data being presented.



*EXPANDABLE IN GROUPS OF 16 CHANNELS TO 2,048 CHANNELS

MODEL 725
LOW-LEVEL MULTIPLEXER/A-D CONVERTER

AUGUST 1968

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APPENDIX E: Computer Response, Inc. and the 1108 Configuration

1. Computer Response Corporation.

a. Computer Response was incorporated in May of 1968 as a small business concern to provide a full complement of data processing services to both the federal government and private industry. We are a privately-held company financed by the Small Business Investment Corporation of New York, which is a federal licensee under the Small Business Investment Act of 1958. The management of the company averages over ten years experience in both large and small systems data processing. In addition, Computer Response maintains a professional staff of Systems Analysts, Programmers, and Marketing Specialists, all of whom provide customer support.

b. Our Univac 1108 computing system is very conveniently located at our home office, 1100 17th Street, Washington, D. C., 20036. The system provides for maximum capability and versatility through its reliable hardware/software combination.

c. Configuration. Univac 1108.

Unit(s)	Quantity
1108A CPU	1
I/O Channel Expansion	1
131 K, 36-bit memory	1
FH 432/1782 Drum Control	1
FH 432 (4.25 msec.) Drums	5
FH 1782 Drum	1

APPENDIX E (CONTINUED)

Unit(s)	Quantity
Uniservo VIII C Control	1
Translate option	1
Uniservo VIII C's (96 KC) Tape Drives	8
Fastrand (Mass Storage) Control	1
Fastrand II (133,000,000 chars.)	1
CTMC's	2
CTM - HS's	12
CTM - LS's	20
Printer Control	1
Printer Control Capability	1
Printer, 1200-1600 lpm	1
Card Control	1
Card Reader, 900 cpm	1

TIME-SHARING IS COST-SAVING . . .

Fees are calculated according to:

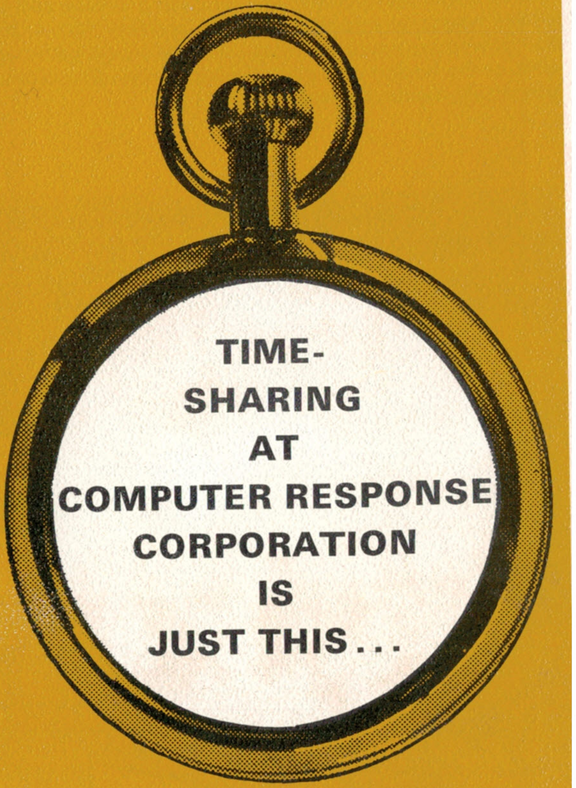
- the time the terminal is connected to the system by telephone circuit;
- the amount of actual computer time to process the work;
- the amount of data storage required to house programs and data files.

"Block time" is available at an hourly rate for customers who desire to come to the computing facility to use the entire system.

COMPUTER RESPONSE CORPORATION . . .

Computer Response Corporation brings together the diversified backgrounds of professionals who have comprehensive understanding of business and government computational requirements and thorough knowledge of all phases of the computer industry. Computer Response is a young, aggressive company with goals set high and the wisdom to know that reaching those goals can be accomplished only one way—by providing to its customers the best possible service with the finest and most advanced software/hardware combination in the industry.

COMPUTER RESPONSE CORPORATION
1100 17th Street, N.W.
Washington, D.C. 20036
202/659-4630



APPENDIX E.

. . . immediate and continuous use of a large-scale computer for maximum efficiency of time, money and manpower—for the smallest and the largest jobs—with complete confidence that your material is secure.

ALL PURPOSE . . .

Whether your business encompasses simple or highly-technical, complex problems in:

- large- or small-scale commercial endeavors
- government research and development
- scientific or technical calculations
- programming
- engineering analyses

Computer Response Corporation offers you all the benefits of participating in a computer time-sharing environment—savings of both time and money.

FLEXIBLE . . .

The installation of a low-speed or high-speed terminal in your office and the use of dial telephone circuits are all you need to make contact with the computing system and to receive computer response for every problem from a 20-man payroll system to the most elaborate critical path network or the design of a part utilizing a three-dimensional numerically-controlled machine tool.

IDEAL TIME-SHARING SYSTEM . . .

The Univac 1108 Computing System offered by CRC is an impressive hardware/software combination providing maximum capability and versatility. A powerful CPU plus a hierarchy of high-speed magnetic drums ensures you fast compile and execution speeds as well as optimized response time.

The Univac 1108 is the first time-sharing system that allows conversational and remote batch to coexist in one environment. This multi-purpose system gives the remote user the same facilities as if he had an on-site batch system.

The low-speed terminal is desirable for low volume jobs and for testing programs and routines. These typewriter-like terminals print 10 to 15 characters per second, and will respond to the user almost instantaneously.

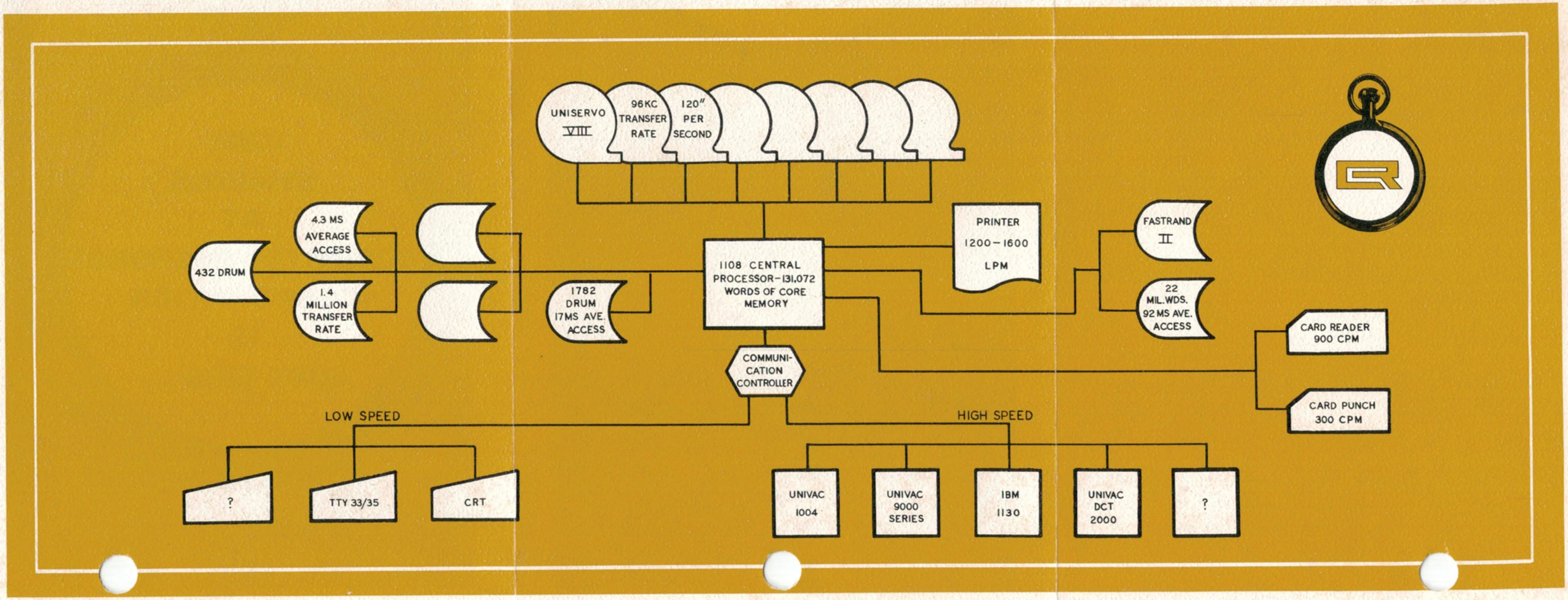
The high-speed terminal is used for programs and computations which require large amounts of input data and volume response. The high-speed terminal operates at speeds of several hundred cards or several hundred lines per minute.

COMPREHENSIVE . . .

Computer Response Corporation makes available to you:

- a variety of languages to meet your programming needs
  FORTRAN V, BASIC, COBOL, ALGOL, ASSEMBLER
- a variety of terminals to satisfy your application requirements
  TTY 33, TTY 35, Univac 9000 Series, Univac 1004, DCT 2000, IBM 1130; other terminals such as CRTs will be added
- these libraries
  SORT/MERGE, MATH PACK, STAT PACK
- these application programs
  PERT/COST, GPSSII, LINEAR PROGRAMMING, SIMULA, APT III
- the responsive and personal service that successfully brings together man and machine to produce meaningful results for you
- competitive price performance
- complete consulting and contract programming services
- complete systems management contracting for development of requirements, implementation and operation of a total data processing package
- the technical and systems competence that assures you of complete understanding and total assistance in your data processing needs

Computer Response Corporation
Time-Sharing System



APPENDIX F. DETAILED PRICING 9400

ITEM		QTY.	PURCHASE	MAINT.	1 Yr. RENTAL	5-Yr. LEASE
3019-00	9400 Processor	1	$ 33,280	$ 135	$ 765	$ 650
F1092-00	Sel. Chan. 1	1	7,830	30	180	155
F1093-00	Comm. Adapter	1	1,960	5	45	40
7010-95	32K	1	79,390	325	1,825	1,550
0711-05	Card Reader	1	8,265	75	190	160
0768-00	Printer	1	40,765	315	935	795
0604-99	Card Punch	1	15,660	90	360	305
5024-00	Disc Control	1	20,010	80	460	390
8411-00	Disc Drives	3	65,250	270	1,500	1,275
F1211-00	Disc Packs	6	2,940	-	90	90
F1098-00	Record Overflow	1	435	-	10	10
F1099-00	File Scan	1	1,525	-	36	30
0858-98	VIC Master Control & Slave	1	30,655	195	700	595
F0827-00	Data Conversion	1	2,030	5	50	45
8575-01	LTC-16	1	22,185	90	510	435
F1008-00	Long Record Ck	1	1,650	7	38	32
F1003-98	Line Term TGA Checking	10	18,300	80	420	360
F1005-98	Line Term. Synch Checking	1	2,260	10	52	44
F1002-01	CI TGH Interface	10	3,500	20	80	70
F1002-03	CI Pvt. Line	1	565	2	13	11
F1010-99	Asyn.Timing Assembly	1	435	2	10	9
9400 Subtotal			(358,890)	(1736)	(8269)	(7051)

APPENDIX F. (continued)

ITEM	QTY	PURCHASE	MAINT.	1 Yr. RENTAL	5-Yr. LEASE
DCT 2000		$30,790	$ 140	$ 741	$ 634
TOTAL, 9400 & DCT 2000		$389,680	$1,876	$9,010	$7,685
Maintenance				1,876	1,876
GRAND TOTAL				$10,886	$9,561