Ken Olsen

digital INTEROFFICE MEMORANDUM

DATE: January 3, 1968

SUBJECT: SUMMARY OF SAFETY-SECURITY COMMITTEE ACTIVITY

TO: Bob Lassen
Safety Security Committee

FROM: John Holzer

cc: Operations Committee

1. Plant Safety and Fire Protection

| Item | Responsibility | Due Date | Expected Completion Date |
|---|---|---|---|
| **A. Recently Completed Projects** | | | |
| 1) "How to Report a Fire" (To Fire Marshals and Bulletin Boards) | Murphy | Completed | |
| 2) Fire Extinguishers-- 5-1, 5-2 | Hanson | Completed | |
| 3) New Fire Exit Signs Installed | Hanson | Completed | |
| 4) Submission of Fire Chief's Report (Mutual Aid Plan) to Op. Comm. | Lassen | Completed | |
| 5) Fire Bells Working in 4, 5, 7, 11, 12 | Hanson | Completed | |
| 6) Eye Safety (Report to Op. Comm. | Lassen | Completed | |
| **B. To Be Completed Projects** | | | |
| 1) Additional Egress Signs | Hanson | To be scheduled | |
| 2) Fire Bell Code Instruction (To Fire Marshals) | Murphy | 1/5 | 1/5 |
| 3) Central Control Check Sheet (Red Clip Board) | Murphy | 1/2 | 1/2 |

| | | | | |
|---|---|---|---|---|
| 4) | "How to Report a Fire" (Telephone Stickers) | Myers | 1/5 | 1/5 |
| *5) | Report to Op. Comm. ("Live" Testing of Alarm System) | Hanson | 1/5 | 1/5 |

*Note: The Operations Committee's recent review of the Fire Evacuation Plan and the Fire Chief's report brought forth the following questions which we feel should be reviewed with Mr. Lauffer (of Lethridge, Owens & Phillips):

a) Adequacy and Testing of Sprinkler System
b) Adequacy of Maynard Fire Department--Mutual Aid Plan
c) Fire Brigade (for laying of hose--volunteers to the Maynard Fire Department)
d) "Algorithm" of evacuation (who should evacuate in the event of fire in different buildings.

Al Hanson will arrange a meeting with Mr. Lauffer and the Safety Committee as soon as possible to review the above items. A final report on the Fire Evacuation Plan will then be submitted to the Operations Committee.

The Operations Committee has requested that a meeting be arranged with Harry Mann, Stan Olsen, Al Hanson and Bob Lassen and the Maynard Fire Chief to discuss the Mutual Aid Plan and the proposed Fire Brigade. This meeting will be arranged as soon as Chief Wilson's replacement has been named.

| | | | | |
|---|---|---|---|---|
| **6) | Status on Selection of a new Fire Chief | Murphy | Completed | |

** Chief Philip Wilson of the Maynard Fire Department passed away recently and John Murphy will make inquiry regarding the status of his replacement.

| | | | | |
|---|---|---|---|---|
| 7) | Area Evacuation Charts (To Fire Marshals) | Murphy | To be scheduled. | |
| 8) | Final Instructional Meeting with Fire Marshals | Murphy | To be scheduled. | |
| 9) | Meeting with Ken Olsen and Fire Marshals | Murphy | To be scheduled | |
| 10) | Fire Doors Repaired | Hanson | 2/1/68 | same |
| 11) | Major Worn Stairs Repaired | Hanson | 2/1/68 | same |

| | | | | |
|---|---|---|---|---|
| 12) | Egress Door--SW corner of 5-1 | Hanson | 3/1/68 | same |
| 13) | Fire Detection System (Maynard Industries) | Holzer | next meeting | |

jfr

**digital** INTEROFFICE MEMORANDUM

Memo #147

DATE: January 9, 1968

SUBJECT: HEATING REQUIREMENTS FOR BLDG. #11-1

TO: K. Olsen ✓
cc: H. Mann
P. Kaufmann

FROM: A. Hanson

In your memo dated November 17, 1967, "Heat for first floor of Building #11", you explained the heating problems caused by the use of triclorethylene in the Silk Screen Area. Actually, the problems are unrelated to one another. There is a small amount of air being exhausted (400 CFM) at the present time because of the use of tricolor, but after the new degreaser is installed that exhaust system will be eliminated. There is one other exhaust system over the Tin Plating Area. I don't think that there are any immediate plans to discontinue this system, but here again it is a small amount of air and it is not taxing the heat system to any significant degree.

The general heating problem is caused primarily because of the lease agreement with Maynard Industries and the heating system itself. I will try to explain:

1. The lease agreement states that Maynard Industries will supply enough heat to "warm" the buildings during an 8 hour period. They are not committed to supply heat after 5 o'clock, but they will supply the "extra" heat for $15.00 per hour. The lease does not mention any specific temperature but only states that the buildings will be kept "warm".
2. The reason for the "extra" heat charge of $15.00 per hour is because Building #11 together with all remaining buildings, except Building #5 and Building #1, are on one heating zone. As a result of this, when Maynard Industries supplies heat to Building #11, they also supply heat to Buildings 7, 12, 8, 8A, 6A, 6B, 10, etc.
3. Most of the heating problems arise in the spring and fall when the outside temperature varies from low temperatures at night to high temperatures during the day. The system is controlled manually based upon outside temperature and wind conditions, and the warm-up time of the system is probably 4 to 5 hours. As a result, it is virtually impossible to achieve good inside temperature control.

During the colder months, because of the long warm-up time of the system, Maynard Industries leaves the heat on 24 hours per day.

Conclusion: Because of the reasons stated above, I feel that the best way to solve the present problem is to install supplementary heat that can be automatically controlled. Electrical energy in this area costs three times more than #2 oil. Gas operation is 15% more than #2 oil. It has cost us approximately $1200.00 to install two gas-fired unit heaters in Building #11-1 which will satisfy all heat requirements there.

iea

# digital INTEROFFICE MEMORANDUM

DATE: January 12, 1968

SUBJECT: DECUS Statistics for Year 1967

TO: DECUS Executive Board

FROM: Angela J. Cossette

cc: Ken Olsen
Win Hindle
Nick Mazzarese
Larry Portner

Below are the statistics of DECUS activity for the year 1967 and a comparison to last year's statistics:

| MEMBERSHIP | 1967 | 1966 |
|---|---|---|
| New Applications | 1189 | 424 |
| Total Membership (Removed 31 in 1967) | 2008 | 850 |
| Delegates | 925 | 385 |
| Individuals | 1049 | 465 |
| Module Users (64) | 34 (not already members) | |
| Non-Members | 480 | 160 |
| Total on mailing list | 2488 | 1010 |

## DECUSCOPE

DECUSCOPE has now grown to a 36 page newsletter with approximately 28 pages of library catalog inserts.

| | 1967 | 1966 |
|---|---|---|
| Circulation | 2775 | 1975 |

Revised mailing procedure sending only one to an individual, thus cutting down on circulation. In the past, many were requesting several copies (in many cases not necessary).

## PROGRAM LIBRARY

| PROGRAM LIBRARY | 1967 | 1966 |
|---|---|---|
| Number of programs submitted (104-Accepted, 23-In process) | 127 | 58 |
| Total number of programs in library | 294 | 198 |
| Number obsoleted | 8 | none |
| Number of programs issued to requestors | 4655 | 1692 |
| Number of program tapes involved in requests: | 8815 | 3460 |
| Paper tapes | 8690 | |
| DECtapes | 124 | |
| Number of tapes reproduced (verified) | 9300 (approx.) | |

## PERCENTAGE OF INCREASES

135% Increase in membership growth

146% Increase in number on mailing list

125% Increase in size of DECUSCOPE (minus insert section)

40% Increase in DECUSCOPE circulation (affected by revising mailing procedure)

102% Increase in number of programs submitted

175% Increase in number of programs issued

170% Increase in tape reproduction

## BULK MATERIAL PRINTED

| Proceedings | Number Printed |
|---|---|
| Fall 1966 | 2,000 |
| Spring 1967 | 2,000 |
| Biomedical Symposium | 1,000 |
| Canadian Symposium | 1,000 |
| European Symposium | 1,000 |

| Other | Number Printed |
|---|---|
| Brochure reprinted | 3,000 |
| Library write-ups (125) | 100-200 each |
| LABCOM Manuals | 1,000 |
| DECUS notebooks issued | 550 |

We also completed many requests for reprints published in the Bibliography insert of the "Computers in the Life Sciences" brochure. These reprints consisted of both DECUS material published (DECUSCOPE and Proceedings) and reprints of articles published in other magazines provided by Digital's Advertising Department.

A.J.C.

/rmf

digital INTEROFFICE MEMORANDUM

DATE: January 16, 1968

SUBJECT: IBM 1130

TO: Operations Committee

FROM: George Rice

cc: D. Cotton
R. Collings
J. Jones
M. Ford
H. Painter
R. Savell
R. Lane

## I. INTRODUCTION

In the January issue of "Computers and Automation" it is estimated that IBM has installed over 2000 1130's and has a backlog in access of 4000. The purpose of this report is to examine the 1130 and its market to gain some insight as to why the tremendous success, and to see if DEC should consider the 1130 a threat or an opportunity.

## II. HISTORY

The small free standing scientific computer market has moved in cycles corresponding to the generations of the computers designed. Thus, the first cycle ran from about 1955 to about 1960 and was dominated by the IBM 650, Bendix (CDC) G-15, General Precision (CDC) LGP-30 and Recomp II. Scientific use of computers predominated in this phase. Since this was a purchase market, many of these computers are still in use today. Software and peripherals were limited during this stage.

The second cycle began about 1960 with the first deliveries of the CDC 160 and IBM 1620, followed more than two years later by the General Precision (CDC) LGP-21. Bendix dropped out. Autonetics tried unsuccessfully with its Recomp III in June, 1961. IBM dominated the market through its marketing coverage, low lease rates, easy-to-use system, peripherals, scientific and business software, and reputation for service. It first marketed the 1620 as a scientifically-oriented computer. But, over the years, the 1620 became a catch-all for various markets not conveniently serviced by other IBM systems. It even spawned the IBM 1700 control computer. The new entries in the market (i.e., DEC, 3C and SDS) offered high performance central processors aimed at the systems and OEM on-line, control markets. They did not pursue the off-line scientific market which required extensive peripherals, software and capital to support favorable lease rates . . . all the requirements needed to compete with IBM.

The third cycle of this market, beginning in late 1965, is dominated by the IBM 1130, a low-priced version of their small control computer, the 1800. CDC, IBM's strongest competitor in the second cycle, dropped out of this market, apparently to concentrate on larger systems. IBM has enjoyed an almost insurmountable price advantage in the 1130 because of a low-priced, ($9,000), high capacity (½ million words) disk and a low-priced ($11,700) line printer. As a result, the control computer manufacturers (i.e., DEC, 3C and SDS) are not price competitive with IBM in this market. The low lease rate of the IBM 1130 opened a new market which IBM has probably dominated more than any other market.

Just as the IBM 1620/1700 were IBM's catch-all computers in the second cycle, the 1800/1130 computers have temporarily served as IBM's catch-all computers in the third cycle to fill in the gaps left at the low end of the System/360. IBM's 1401H will serve the low-cost business system market. The 1401H consist of essentailly returned 1401's and run at a slow speed with considerable restrictions so they will not compete with the 360's.

III. <u>MARKET CHARACTERISTICS</u>

The characteristics of this market are essentially as follows:

A. <u>Lease Market</u>: From the information obtained from IDC, approximately 90% of the computers in this market are leased. For many of the IBM 1130 users, this is their first computer. Therefore, in addition to capital expenditure constraints, their hesitancy to buy a computer makes a lease plan, particularly a low cost one year plan, attractive. Moreover, the changeover from one scientific computer to another is simplified by the fact that these are free-standing off-line systems which use virtually standard languages, such as FORTRAN, and some specialized languages, such as COGO, STRESS, etc. In addition, most users in this market hedge by requiring a short term lease at the start in order to evaluate the computer and the software and give themselves the option of returning it, if they are dissatisfied. Generally, the smaller or lower cost a scientific system is, the more easily it is replaced.

Rentals offer computer centers to up and down grade their systems very easily. This is a very important characteristic of this market where one likes to typically start small and gradually upgrade the performance of their system. One might start with low performance peripherals to keep the initial rent low in the familiarization phase where the work load on the computer is low. At a later time when more work is put on the computer it can justify a larger rent; consequently, higher performance peripherals are added to give the machine capability to do more in less time. Of course, in order to obtain high performance peripherals, it is most attractive to be able to release from rent the low cost ones (most purchase plans do not allow for trade-ins). Rentals also allow one to upgrade the whole computer system when a new generation of machines come out.

Another reason for computers being successfully obtained via a lease is the fact that capital expenditures are much harder to justify than to bury rentals in operating expenses.

B. Price Conscious: When compared to larger computer systems, the principle advantage of the IBM 1130 (as well as its successful predecessor, the 1620) is price. As the lowest-priced scientific computer system ever offered, more IBM 1130 computers have been installed than the combined total of all its predecessors. Some users equate the cost of a small IBM 1130 with the cost of an intermediate level engineer, since it requires no programming staff. The PDP-8/S cannot even compete in the 1130 market because of high cost peripheral prices.

C. Applications: Information on 278 1130 installations was obtained from IDC. The data included such things as customer names, configuration, leased or purchased, and application. Plotting the applications in a market application chart which I had made for the PDP-8 showed that the 1130 sold primarily in five areas.

| | |
|---|---|
| Free Standing Scientific | 35% |
| Business | 30% |
| Education | 20% |
| Typesetting | 9% |
| Civil Engineering | 4% |
| | 98% |

Civil Engineering was an identifiable subset of Free Standing Scientific. The other 2% was spread out in many areas with no identifiable concentrations.

IDC's market intelligence methods may distort the analysis; therefore, the above percentages must be examined with caution. This market is heavily concentrated in higher educational institutions* where significant educational discounts are the rule rather than exception (i.e., 20% for the IBM 1130). IBM has been successful in developing this market through its 1620 with a large discount (at one time as high as 60%). About 500 or one-third of all 1620's were installed in universities and other educational establishments. This marketing technique is very effective in bringing the future decision makers into IBM's fold. Let's hope our efforts in the secondary school market will have an equal or better effect.

* See Addendum A for additional information

D. Open Shop Environment: The users are generally problem and applications oriented persons. They are engineers, scientists, mathematicians and students, rather than programmers, and are therefore looking for a computer which offers ease of operation and little to no software support. IBM offers a number of application software packages (programs for civil engineering, optical design, pattern cutting, etc.). It is felt that the availability of these packages is a prime reason for obtaining the 1130. The computer is in an open-shop, hands-on environment. IBM 1620's and 1130's are often located in establishments where there is also a large IBM system because some users will not tolerate, for their small problems, the relatively long turnaround time often associated with a computation center. There is also a growing trend, especially among very small companies, to use the 1130 (as they did with the 1620) for simple, small business applications. IBM and some software houses offer some standard business routines for the 1130.

E. Delivery: Long lead times have not ostensibly hurt IBM, but it is not likely that other manufacturers could quote the same long lead times. IBM still quotes lead times of about 12 months, except for key accounts and in competitive situations (3 months). IBM has the reputation for really turning on the pressure when competition gets into an account.

## IV. MARKET SIZE, POTENTIAL AND TREND

The current annual shipment rate is estimated at about $100 million, since IBM is delivering in excess of 1000 systems per year, and the average sell price is around $70K. On the other hand, the average system cost has decreased steadily from over $100K for the 1620 to the present average of about $70K, because of the low-cost basic 1130. The $70K average can be expected to increase because of add-on business.

Only a small segment of the IBM 1620 market is being replaced by the IBM 1130. Many of the 1620 users are stepping up to 360/44 or other larger machines. Computer center people tend to relate their job importance to the size of their budget. Therefore, few of them will switch to a lower cost system. This is a major reason why the PDP-6 failed to take any 7090 business. The 1130 users should be encouraged to consider the PDP-10 a logical machine to step up to, rather than trying to replace the 1130 with a basic PDP-8. There appears to be a potential threat to the small computer which is Multiple Access Computer Systems ("time-sharing"). The term, multiple-access, time-sharing systems, refers to systems which allow multiple users to enter, debug, compile and execute programs from multiple remote terminals, such that the response time is rapid enough that each user feels the computer is servicing only him.

Prior to 1966, there were only a few experimental time-shared systems. Currently, there are probably over one hundred. This application may be at a stage comparable to the computer industry in the second half of the 1950's. As such its full effect may not begin to be felt until the introduction of the fourth generation computers. It is very possible, however, that the use of time-sharing systems may spur the growth of the small scientific computer market because of the demand for small scientific computers as satellites or terminals with pre-processing capabilities, as well as with capabilities as free-standing open-shop computers. This capability is currently being offered with third generation equipment in a few cases, and should be even more attractive in the fourth generation through small, lower cost and high performance CPU's and peripherals. The TS-8 (time-shared PDP-8) concept may prove to be a very powerful tool in the future as a terminal to large time-shared computers.

## V. TYPICAL CONFIGURATION PRICE COMPARISONS

| Configuration A (IBM's Market) | Purchase | Monthly Lease |
|---|---|---|
| IBM 1130 (Typical) | | |
| Model 2B (typewriter, disk, 8K) | 44,080 | 980 |
| Line Printer | 11,700 | 260 |
| Card I/O | 14,575 | 265 |
| | 70,355 | 1,505 |
| DEC | | |
| Yesterday | | |
| PDP-8, 8K | 25,500 | |
| DECtape System | 12,100 | |
| Line Printer | 28,900 | |
| Paper tape I/O* | 4,800 | |
| | 71,300 | 2,852** |

* We offer no card I/O and the 1130 market is extremely card oriented.

** Based on the rates established for the 39 month lease plan for 8/S education market

| Configuration A | Purchase | Monthly Lease |
|---|---|---|
| Tomorrow | | |
| PDP-8/I, 8K | 18,500 | |
| Line Printer * | ≈ 8,000 | |
| Big Disk (not cartridge) | ≈ 14,000 | |
| P. T. I/O | 4,800 | |
| | 45,300 | 1,012 |

| Time Shared PDP-8** | | |
|---|---|---|
| PDP-8/I, 12K | 25,000 | |
| Big Disk | ≈ 14,000 | |
| 680 System | 7,000 | |
| 8/I T. S. mods | ≈ 1,000 | |
| DECtape System | 12,100 | |
| | 59,100 | 2,364 |

* Based on estimates of new products proposed for 1969 by several line printer companies.

** A multi-user system with extensive capabilities beyond the 1130. A PDP-XI system configured for T. S. applications would put us in an even more powerful position. The difference in C. P. cost between 8/I and Xl wouldn't be significant but the power would. The time shared PDP-8 system can be a reality prior to the end of calender 1968.

| Configuration B (DEC's Market) | Purchase | Monthly Lease |
|---|---|---|
| DEC | | |
| PDP-8/I, 4K | 13,500 | |
| Real Time I/O | ≈ 10,000 | |
| | 23,500 | |

One must remember to the OEM market, DEC offers considerable savings via various discount policies of which IBM presently has none.

| | | |
|---|---|---|
| IBM | | |
| 1130 Model 1B | 26,680 | |
| Real Time I/O | NA (>10K)* | |
| | >37,000 | |

* No real time capability available in the 1130. Some companies are developing/offering front-ends for the 1130 and it is quite conceivable that IBM will receive some additional business here. If IBM recognizes real time I/O as a market, they could successfully mount an attack (like DEC does by watching it's OEM market). IBM could put on front-end capability and enter many of our markets. Redcor, Real Time Systems, and others are presently offering real time I/O for the 1130.

## VI. OBSERVATIONS

A. DEC has been looked out of the free standing market because of:

1. Lack of adequate software
   a) operating load/go system
   b) applications software
   c) (business software?)
2. Lack of lease plan
3. Lack of desirable peripherals

B. The market has been growing (present size in excess of 100 million per year) with no noticeable let-up. Time sharing, some believe, will cut in; others feel it will stimulate even greater growth.

C. Many 1130 customers have this as their first or only machine. These are the ones most easily attacked since there is no significant reason why they wouldn't switch to a better machine except for IBM image (somewhat lowered by the many failures of the 360). The 1130 is not exciting anyone with its performance, there just isn't any alternative. IBM has a captive market.

D. Considering that software is a considerable portion of the sales decision, it is unclear whether our hardware oriented sales force would be very effective to sell to this market.

E. Selling with existing prices to the market that the 1130 is in should be considered carefully, since IBM works on a much higher sales price to factory cost ratio than we do, and this is partly because of the increased software field support force. Just like typesetting systems have some additional cost thrown in to cover extra support, any effort in this market may require likewise.

F. If we entered this market we would have to make time (equipment) available much like IBM does with their regional installations for pre-delivery software debug and development.

G. There is a potential replacement market here much like the 1401 market was attacked successfully with the H200 Liberator concept. However, it should be noted like the 1401, the 1130 is a clumsy machine and an equally successful attack on the 1130 may be made by a better performing computer, such as the 360 did to the 1401 market.

H. DEC has capability to offer real time I/O and offers black box interfacing, something which IBM has pretty much stayed away from so far. IBM does have an RPQ Special Systems Group, which is only used in prestige or new market efforts.

I. IBM's first deliveries of the 1130 models one and two were in November 1965, and model three started in early 1968. It appears unlikely that a replacement is forth coming.

J. The returned 1620's which are getting obsolete at the original prices might come back on the market at lower prices in a new configuration, much like the 1401H. A logical place to push the used 1620's is to practically give them away to the education market. This would help to capture more future buyer's into the IBM field.

VII. CONCLUSIONS

A. The probable reasons why IBM has sold 6000 1130's are:

1. The market need is there

2. They offer a system that satisfies the need

3. They have an excellent reputation and extensive sales force

4. There is no competition

B. The 1130 is potentially a threat to DEC because:

1. IBM is developing an extensive capability to manufacture and sell small computers.

2. Real Time I/O can be adapted to the 1130 and the computer may try to enter some of our markets.

C. The 1130 is potentially an opportunity for DEC because:

1. IBM has developed a large replacement market with the 1130

2. The 1130 will develop considerable interest in small computers and people with a knowledge of them .

Addendum A

Since 20% of the 1130 market is in education, and I have responsibilities in the education market, I made further analysis of the 55 1130 computers that were identified to this area.

Contrary to the 90% lease business of the 1130 as a whole, the education market was 75% lease and 25% purchase. This is probably because of government funded money (NSF Grants, etc.).

Only three out of the 55 systems in education institutions said they used their computers for business data processing as a secondary application. However, over half of them said they used the machine for educational data processing applications (i.e., scheduling, test scoring, school expenses, registration, etc.).

Eighty-eight 1130's are identifiable in the education market (IDC file, plus additional data); 100% of these are located in places of higher learning, not one in a high school. The prominent location is small colleges, probably schools without large computer centers. Realizing how IDC gathers its data may be a clue as to why there are no high schools listed. IDC sends out a questionnaire to all possible places where they feel a computer may be installed (Dave Packer gets one for DEC). The returned questionnaires are used as one source to update the files. It is possible that IDC hasn't been contacting high schools, since this is a relatively new market (IDC's file only contains formation on three PDP-8/S's).

The 1130 is a stripped down version of the 1800 (both manufactured in San Jose, California). The 1500 CAI system, which IBM has built 30 of, is presently using an 1800 as the central processor. Any fruitfull efforts with the 1500 system (it has been reported IBM is putting 30 million into the project) may be useful on 1130's at some later date. IBM stated that someday they hope to have a computer in every school.

digital INTEROFFICE MEMORANDUM

DATE: January 23, 1968

SUBJECT: Drafting Work Summary.

TO: Ken Olsen

FROM: Roger Melanson

The attached form, subject to change, will provide I believe, general information on the progress of major projects being drafted.

In our telephone conversation we discussed a single form having pertinent information about individual projects and a listing of all jobs being worked on. I think the one form arrived at combines the information that would appear on the two separate documents mentioned.

I believe the heading of each column is self-explanatory. The column "Estimated Hours Reworked" was divided into three major drafting catagories to show a more accurate account of rework. Under each category I sub-divided the hours into "Accrued" which will list all the rework hours to date on the projects, and the "New" will show the added hours since the last listing was issued.

If you prefer a different approach or wish to revise the form somewhat please let me know at your earliest convenience. In the meantime I will prepare a listing of projects being worked on by Drafting.

RM:tl
1 Atch.

Drafting Summary of Projects in Process

Page ____ of ____

Prepared By ____________________

Date ____________

| Project Name | Engineer | Total Estimated Hours | Total Actual Hours to Date | % Work Complete | Estimated Hours Reworked: Electrical | | Mechanical | | Wire List | | Reason(s) for "New" Rework Hours |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Acc'd | New | Acc'd | New | Acc'd | New | |
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DATE: January 24, 1968

SUBJECT: Large Modules for the PDP-X, Model 2

TO: Operations Committee

FROM: Roger Cady
Don White
J. A. Jones

cc: D. Knoll
E. deCastro

The purpose of this memo is to acquaint the members of the Operations Committee with the reasons behind the decision to partially implement the PDP-X, Model 2 in large boards. We would appreciate any suggestions that will help guarantee the success of this effort.

Many discussions have taken place concerning the physical-packaging concept of the PDP-X; whether it should be built of large or small modules. This question has been received again; therefore, we feel there are several points that have not been brought up that require clarification.

One of the biggest objections to large module construction is that it adds another "newness" to an already new machine. Our contention is that large modules are not really that new, if looked at in the proper prospective. Discussions with Ed deCastro and review of the logic structure to date, are quite revealing. It is anticipated that the PDP-X processor would require about twenty (20) large modules with a break-down as follows:

| Board | Quantity | Description | Comments | Type |
|---|---|---|---|---|
| 1 | 2 | Major Register | | A |
| 2 | 2 | Fast solid-state memory | | A |
| 3 | 1 | TTY in/out | ½ size board | B |
| 4 | 1 | Paper Tape in/out | ½ size board | B |
| 5 | 1 | Control Memory | same, regardless of module size on rest of machine | C |
| 6 | 1 | Control Memory S. A. & Buffer | | A |
| 7 | 1 | API | | E |
| 8 | 1 | Fast Memory Address Selector | | A |
| 9 | 1 | Rope Memory Address Selector | | A |
| 10 | 1 | IR, I/O Buffer Register | | A |
| 11 | 1 | Memory Control | | A |
| 12 | 1 | I/O Control | | E |
| 13 | 1 | Memory Bus Drivers | May be same as 14 | A |
| 14 | 1 | I/O Bus Drivers | May be same as 13 | A |
| 15 | 1 | Timing | | E |
| 16 | 1 | Indicator Register, Key filters, etc. | | D |
| 17 | 1 | ? | | ? |
| 18 | 1 | ? | | ? |

Type classification is the important thing on this list it reveals the problems of using this type construction. All boards of Type A are well organized logic structure that can be tested on existing test equipment by means of adapters and by testing in sections. These boards represent those areas of the processor least likely to change; thus, reducing scrap and ECO risks significantly.

Type B boards represent nothing more difficult than that which is used on the 8I. The only difference is that both in and out will be one board.

Type C is the control memory. It will be the same size regardless of the rest of the machine.

Types D and E represent the most difficult areas of the machine and those most likely to change. These modules represent a testing problem which can be met only with a large module tester capable of 144 pin-testing and diagnostic routines. Also, they represent a small percentage of the total processor and thereby can be built from small and medium sized modules (single and double size). This would place more logical points accessible to present test equipment, and more interconnection logic on the wired backboard.

When the subject, the large vs small module is approached, with the above in mind, it is evident, risks are much smaller than the first overall look may indicate. Manufacturing capability for large modules may be questioned, this indeed, is an important area.

At present, FLIP CHIP boards are manufactured four-high; essentially the same size as the proposed large module. Plans are being made to build 8I boards with plated-through holes the same way. The line widths and spacing are no more critical on the proposed, than on the 8I. In fact, improved layout techniques will make them more producible. Thus, if commitments to produce 8I boards are met, X boards can be produced.

Cost reduction is one of the key reasons for using large boards (about $1,000/system). It has been argued that this savings will be wiped out if the use of large boards makes the machine a few weeks late. Loss of Profit Before Tax that occurs if the X is in fact late (assuming that the Model 2 dies in 1972, regardless of when deliveries start), has been calculated. Result, it would require that deliveries start six-months late (due to large boards) before the large boards savings is wiped out for this computer.

Personnel committed to building, testing and programming the large-board approach, have flatly stated that it will be done on time.

Based upon the above information, plans to build the A, B, and C Types as large boards are in process. The D and E Types will be constructed on conventional boards. The 144 pin module tester will be implemented, as originally scheduled by the X project, to provide high speed - low cost testing of the large modules. However, the capability of testing these modules with existing testers will still exist as an alternate.

oh

# INTEROFFICE MEMORANDUM

DATE: January 25, 1968

SUBJECT: Mobil Oil Company

TO: √Ken Olsen
Nick Mazzarese
Jack Shields
Mike Ford
Gene Olsen

FROM: Brad Dewey

The purpose of this memo is to clarify DEC's position regarding the PDP-8 in their Torrence, California refinery.

As far as we are able to tell, it is not the PDP-8 which is causing the system to fail. The system certainly works well enough for Mobil to clean up their software, which is in extremely poor condition. We have offered them free time at night on our PDP-6 so that they may reassemble their program, the original assembly having been lost over a year ago. (The existing program has extensive octal patches in it.)

We would like very much to have Mobil call in Doctor Kipiniak of Real Time Systems, Inc. as a consultant. He has had experience with the PDP-8 in a similar process control gas chromatography application and should be able to help them locate the source of their problem. DEC would be willing to pay Doctor Kipiniak's way out to the West Coast to have him look at this system.

We would like to encourage Mobil to contract with Real Time Systems to have their software written. This would take the burden off our shoulders and should get the Mobil system operational in a fairly short time.

Frank Meers, the engineer in charge of the Mobil system will be on the East Coast some time in the next week or two, and will be stopping in to talk to Foxboro about their experience with DEC equipment. He is expected to take us up on our offer to reassemble his program. I will be in touch with him prior to that time and will advise him of our posture on this matter, as outlined above.

BD/dm

c - Ross Smart 2/1

# digital INTEROFFICE MEMORANDUM

DATE: January 30, 1968

SUBJECT: Atec Corporation

TO: Ken Olsen
cc Nick Mazzarese
Mike Ford

FROM: Marv Cothran

In reviewing the attached letter from Mr. Shober of Atec, I do not feel that we should enter into any agreement under the terms as outlined. Considering that they have no technical capability whatsoever, I am at present against any type of agreement.

The reasons for the above statement are as follows:

1. We should not enter into any exclusive agreement.

2. The six week Photon training course is not sufficient to make any non-electronic type person qualified to maintain a PDP-8. It does not meet the pre-requisite required for our current one week course. We are not at present willing to train technicians on a long-term basis.

3. We cannot maintain program support for systems sold in South America and Mexico. They do not have a qualified program staff to provide this capability.

4. All of our present OEM typesetting customers are purchasing hardware only systems and providing their programs and program support.

5. Mr. Shober's letter, in essence, is requesting authority as an agent or representative. This I do not find feasible for the above reasons.

6. Their financial statement is not strong.

I will answer Mr. Shober's letter, if you so desire.

MEC/dm

Enclosure

# ATEC CORPORATION

OFFICE OF THE PRESIDENT

1518 WALNUT STREET
PHILADELPHIA, PENNA. 19102 U.S.A.
TELEPHONE: (215) 546-1900
CABLE: ATECO
TELEX: 83-4362

January 5, 1968

Mr. Kenneth H. Alsin, President
Digital Equipment Corporation
Maynard, Massachusetts

Dear Mr. Alsin:

Permit me to apologize for not coming to Maynard to meet you and your associates on the past two Thursdays. Severe icing conditions were forecast for the Boston area on both days and we do not fly in such conditions.

My schedule for the immediate future is such that I will be unable to get up to Maynard and therefore this letter.

First, a brief description of ATEC, an export house, which I founded in 1957. We received the Presidential "E" for excellence in expanding U.S. exports in 1963. We are the exclusive export house for Fairchild Graphic's, Web Offset Presses, Web Press Engineering and for Photon products in Latin America the Caribbean, and Spain. We engineer, sell, finance, install and maintain complete printing systems in these areas. We maintain sales offices in Spain and Colombia and are establishing offices in Mexico and Argentina. ATEC purchases all equipment from its suppliers for cash.

We want to recommend a low cost computer to our Photon customers. The PDP 8 would fill our needs.

Would consider naming ATEC your exclusive export house for Spain, Latin America and the Caribbean for your computers used for typesetting only.

We would then actively promote their sale.

We would want you to develop and pay for the software for the Spanish language; the cost of which could be pro--rated acrosss the machines sold. We would also want to send you one or more of our Photon trained technicians for maintenance training and ask how long this training would take.

Looking forward to the favor of your reply, we are

ATEC CORPORATION

Wharton Shober

Wharton Shober

WS/jw

cc; Marvin Cothran

file

# INTEROFFICE MEMORANDUM

DATE January 31, 1968

SUBJECT SPROCKETS - LOW INERTIA TAPE AND READER

TO Ken Olsen
Henry Crouse
Pete Kaufmann

FROM Lee Goodbar

Lavezzi Machine Works is the supplier of above mentioned sprockets. The quality and workmanship is excellant with zero defects from this supplier. However, on a continuing effort to lower costs and shorten delivery time the following steps have been taken:

1. Local gear and sprocket houses have quoted "No" on these items because they do not have the necessary sprocket tooling.

2. Powder metal has been investigated through contact at trade shows and by request for quotation.

The following excerpt taken from a reply from Remington Arms Company, Inc., Hi-Dense Division sums up without exception the views of the powder metal sources on these sprockets.

> "Our process engineers indicate that a number of design revisions would be required to adopt these sprockets for the powder metal process. The undercuts and cross holes indicated along with the .043" thin wall condition and the root of the gear teeth below the outside diameter make it impractical for the powder metal process.
>
> The best possible shape we could offer you would require considerable secondary machining which in all liklihood would not compare favorably with your current method of manufacture."

Merriman, Inc., Hingham, Mass. and Reese Metal Products Corp., Lancaster, Pennsylvania were also on the bid list.

To pursue powder metal route further, redesign would appear to be in order.

Contacts with powder metal engineers can be arranged if so desired.

JD

# INTEROFFICE MEMORANDUM

DATE: February 9, 1968

SUBJECT: Office Copying Machines

TO: Ken Olsen

FROM: Jim Myers

Per your inquiry I have done a study of the usage over a 12-month period for each copier we have. The equipment we have on hand is as follows:

| NAME | BLDG. LOCATION | GROUPS SERVED |
|---|---|---|
| Dennison Standard | 12-2 | Programming (Bill Segal's section) Direct Mail Adv., Tech. Writers |
| Royfax 7 | 5-3 | Module Administration, PDP-9 Marketing, Sales Support |
| Xerox 330 | 5-3 | Computer Administration, also used by PDP-9 Marketing and Sales Support |
| Xerox 813 | 4-4 | Drafting, Mechanical Eng. |
| Xerox 813 | 5-4 | Temporary trial for Receiving Department - copying receiving reports, also used by Purchasing Dept. |
| Xerox 2400 | 5-4 | Personnel, Large Computer Group, Linc Group, Field Service |
| Xerox 914 | 12-2 | Programming, DECUS, Gen. Administration |
| Royfax 12 | 5-3 | Accounting, Advertising, Small Computer Marketing, Special Systems |

All these machines, save the Dennison, are under a lease agreement whereby we pay a charge per copy plus a small rental amount. The Dennison was purchased about 4 years ago.

To reduce the amount of time spent walking to the copiers as well as to reduce waiting time at the machines, I have ordered two additional copiers to be placed in administrative areas where the girls now have to contend with both distance and waiting. The additional copiers will relieve the load on existing machines and result in less down time. The copier which will best do the job for us as a satellite machine is the Xerox 660. It is a desk top model which offers 100% size reproduction and eliminates the undesirable cleaning jobs required in some of our existing equipment. While offering a better copier, we will also enjoy a cost savings with the "660" not available in some of our existing copiers. The machines I plan to replace with the "660" are Xerox types 330, 813 and 914.

We have experienced far too much down time on the high volume Xerox 2400 copier now located in the Purchasing Department. This is attributable to the numerous people who stock the copier with paper and toner. To allow us to enjoy more effective use of this machine and to relieve the secretaries of the bother of maintaining such a machine, I plan to place it in the office supply room where it will be under a controlled operator. This will coincide with my plan to have the office supply room manned throughout the workday by a full-time stockroom attendant. The 2400, in addition to its speed, is also capable of copying pages from books and magazines.

The lease plan for this type equipment is desirable because it allows us to improve our equipment and take advantage of advances in copying equipment with a minimum of inconvenience and no extra cost. In line with this, I have had on trial and have had demonstrated on our premises different makes of copiers.

The Log Books are checked by me regularly. I look to see who is using the copier (by cost center) to be sure they are properly located and to check on use of the copier which would have been done better by offset printing. The machines have not been locked nights and weekends up to now. I have ordered a supply of small locks which will fit into the plug of each machine to insure that this will be done.

JM/clw

# INTEROFFICE MEMORANDUM

DATE: February 12, 1968

SUBJECT: TU/79

TO: Phil Backholm

FROM: Loren Prentice

cc: Joe St. Amour, Ken Olsen, Dick Best, Dan Sullivan, Ken FitzGerald, Jim Jordan, Joe Godbout, Ron Denaro, Bob Antonuccio, Joe Sutton

Phil and I had a meeting on Thursday, February 9th, to review what could be done mechanically to cut costs. These are the items discussed. They all have some possibilities, and Phil is reviewing the feasibility at the present time.

1. Phil has already initiated simplification of the pressure manifold. It appears now that we could mount the reducing valve, the solenoid valve and the pressure gage along with the pump mount and this would either be mounted in the bottom of the cabinet or on top of the new larger power supply, if

memos Ken



MSG E-501 2/12/68

TO J C PETERSCHMITT
FROM NICK NAZZARESE
KEN OLSEN

TYPE 342 CHARACTER GENERATOR FOR USE ON 340 AVAILABLE NOW. PRICE 7,700 DOLLARS FOR 64 CHARACTER SET: 11,600 DOLLARS FOR 128 CHARACTER SET: MOCROSECONDS PER CHARACTER 30.

VC38 CHARACTER GENERATOR FOR USE ON 338 AND 339 AVAILABLE NOW. PRICE 6,000 DOLLARS: MICROSECONDS PER CHARACTER 50.

DOES THIS ANSWER YOUR QUESTIONS?

END MSGS TO PARIS

space enough, but this would eliminate the slides and all the framework for holding it which is quite considerable. This would mean some relocation of the vacuum pump and modifications to the present manifold, but should not substantially increase the cost.

3. There seems to be a chance to make considerable savings in the vacuum columns. Everybody seems to agree that we cannot make these out of an extrusion without machining them and Phil and I worked out a plan that looks like we should have an extruded eye section (an unbalanced eye cross section extruded). There is a good possibility that by working with Lapoint or some other company, we could broach this unit for a very reasonable price. The first tooling costs, of course, would be expensive for the extrusion and also for the broach. Another approach might be to set up and gang mill. Either by gang milling or broaching, all five critical areas would be machined at once. One of the reasons for suggesting broaching is that we believe the chances are better of getting straight extrusions after machining and also stay straight. That is, no residual stresses be built up due to machining. This should allow a very minimum of material to be relieved from the extrusion. The attachment point of the column to the main mounting plate would be premachined before broaching and all dimensions would be held between the mounting face of the column and the broach surface in one single operation.

Loren

bt

FEB 16 1968

digital INTEROFFICE MEMORANDUM

DATE: February 14, 1968

SUBJECT: VIBRATION AND TEMPERATURE SPECIFICATIONS ON THE DISC

TO: Mike Ford
Nick Mazzarese

FROM: Ken Olsen

CERCI, who is one of our best customers in France, is disappointed we don't have any vibration and temperature specifications on our disc. Will you let Jean-Claude know what we can give them in the way of specifications, or when we can give them. A possibility is to loan them a disc so they can work out the test and then give us the results.

Ken

ecc

Ken Fitzgerald
pl comment

This was something which we wanted to do but did not, due to pressing problems with paper tape and card readers. However, when we found that Jim O'Loughlin planned to do some RFI and power testing at Acton Labs, we decided to do the vibration and temperature testing at the same time.

DIGITAL EQUIPMENT CORPORATION • MAYNARD, MASSACHUSETTS

digital INTEROFFICE MEMORANDUM

DATE: February 19, 1968

SUBJECT: LABORATORY GUIDE TO INSTRUMENTS. . .

TO: Ken Olsen

FROM: Mark Nigberg

Reference: Letter dated 1/22/68

We have submitted the necessary information to the publisher as you requested.

Mark Nigberg
Applications Promotion Manager

tkw

**LABORATORY GUIDE** To Instruments, Equipment and Chemicals
1155 SIXTEENTH STREET, N.W., WASHINGTON, D.C. 20036 202-737-3337
ONE OF THE AMERICAN CHEMICAL SOCIETY PUBLICATIONS

January 22, 1968

President
Digital Equipment Corp.
146 Main St.
Maynard, Mass.

this WAS fwd from Ken's office /m

Dear Sir:

We are currently compiling our 1968-69 ACS LABORATORY GUIDE TO INSTRUMENTS, EQUIPMENT, AND CHEMICALS. In order that the products of your company be included in the new GUIDE, which will go to approximately 60,000 research scientists, we ask that you complete either or both of the two enclosed questionnaires and return to us by February 8. Including your products in this extensively used GUIDE involves no expense or obligation on your part.

The yellow questionnaire is for manufacturers of laboratory instruments and equipment. If your company also produces research chemicals or you offer research services, or if you are in the latter fields only, please complete the blue questionnaire.

For the first time, we have computerized the compiling of LAB GUIDE from the thousands of questionnaires returned. For this reason, carefully follow the instructions on the covers of the two questionnaires in order that we might list your products and services accurately.

Many of the new products and services included in the enclosed questionnaires are a result of suggestions made by companies we contacted last year. We will welcome suggestions for additional categories and will give careful consideration to them next year.

Very truly yours,

William Q. Hull

William Q. Hull

WQH:jm
enclosures

file

# digital INTEROFFICE MEMORANDUM

DATE: February 20, 1968

SUBJECT: YOUR MEMO DATED FEBRUARY 13, 1968, RE: SCHEDULE FOR INTEGRATING OPTIONS FOR PDP-8/I AND GOING TO POSITIVE BUS

TO: Ken Olsen

cc: Nick Mazzarese

FROM: Mike Ford

1. Jim O'Loughlin is currently about finished working on circuit design for positive bus.

2. Upon completion, we will immediately publish specs, schedule, etc.

3. My plans do not include converting data break options such as DECtape, etc., to positive bus. We will supply the PDP-8/I in one of two states:

    1. All positive bus - at little or no extra cost.

    2. Negative and positive bus - at some additional cost - via option panel.

Mike

eem

**digital** INTEROFFICE MEMORANDUM

DATE: February 22, 1968

SUBJECT: SALARY REVIEW PROCEDURE

TO: K. H. Olsen
Nick Mazzarese
Harry Mann
Ted Johnson
Win Hindle
Stan Olsen
Dick Best

FROM: Bob Lassen

At the next Salary Review Committee meeting, I would like to clarify the mechanics of administering monthly salary reviews through the Group Vice Presidents.

The procedure I would suggest is as follows:

## ALL EXCEPT SALES AND SERVICE

1. Personnel to send a Master (monthly) Review Sheet to each Group Vice President. The master sheet would list the names of all salaried people to be reviewed in each of his departments.

2. Separate Review Sheets would also be prepared for each department head. This list would include only those people reporting to the department head - (The departmental sheet could either be sent directly by Personnel to each department head or could be sent through the Group Vice President together with the Master Sheet).

3. Each Group Vice President would then meet with his department heads to discuss their recommendations. The Group Vice President would then indicate the approved recommendations on the Master Sheet (indicate his approval by signature) and forward the Master Sheet to Bob Lassen.

## SALES AND SERVICE

1. Master Review Sheets for both Sales and Field Service would be sent directly to Ted.

2. A Master Review Sheet would also be sent directly to Jack Shields for Field Service personnel.

3. Review Sheets would also be sent to each Regional Manager. This list would be in two parts: (a) Sales Personnel (b) Field Service Personnel.

4. The Regional Managers would then forward their recommendations for Sales personnel directly to Ted and would forward their Field Service

recommendations directly to Jack Shields.

5. Jack Shields would then review Field Service recommendations with Ted.

6. Ted would then forward approved (signed) Master Sheets for both Sales and Field Service directly to Bob Lassen.

The major problem seems to be that managers are confused about the mechanics of salary reviews and some of them send their recommendations directly to me and not through their boss.

Most importantly, I want to make sure that managers (department heads) carefully review and discuss their recommendations with the respective Vice President and that the Review Sheets (all recommendations) have been approved by the Vice President before they are sent to me.

As in the past, Paul Chambers (Field Service and Engineering Assistants), Graydon Thayer or Bob Lassen (Other Professional Categories) would be happy to provide managers with salary survey information to assist them in making their recommendations.

Graydon Thayer is actively collecting professional salary survey data which will provide us with more meaningful salary comparisons.

RTL/jh

digital INTEROFFICE MEMORANDUM

DATE: February 22, 1968

SUBJECT: Telegram Delivery

TO: Ken Olsen

FROM: Jim Myers Jim M.

This is in response to your inquiry to Bob Lassen concerning delivery of telegrams.

The following delivery procedure has been set up. A member of the Personnel Department monitors all incoming telegrams as they are received over the machine. Those messages addressed to a member of the Personnel Department are to be delivered immediately by the monitor. All other messages are to be delivered immediately to the Receptionist in the Building 5 Lobby. The Receptionist has been instructed to telephone the Addressee (or the Addressee's secretary) immediately and to forward the hard copy by interoffice mail. Should the Receptionist experience difficulty in determining who should receive the telegram, she will contact either the Communications Center or myself for assistance. We've had this system in operation since February 1, 1968 and are able to provide a quick flow of information.

The system outlined above is the best for the present service offered by the telegram company. By late March, 1968 Western Union's "Info-Com" system will be in effect. This will enable our Communications Room to send and receive telegrams from our existing Telex equipment. We will at that time make the telegram machine in Personnel a sattalite machine used to send their own telegram traffic (Personnel accounts for virtually all the outgoing telegrams). All other telegrams sent by the company (about ten per month average) will then go through the Communications Center.

CONFIDENTIAL

3/22/68

Copy to John Cohen

digital INTEROFFICE MEMORANDUM

DATE: 26 February 1968

SUBJECT: Visit to DEC 15 February 1968

TO: J. A. Jones
Stan Olsen
Nick Mazzarese
Ed deCastro
Mike Ford
Win Hindle
Ken Olsen

FROM: Gordon Bell

After spending a day talking about computers, I'm reacting by trying to write down my version of what transpired. I hope others will do the same, as I felt a tremendous need to try to put things into a framework. Also, since Mike Ford asked me what machines to build, I wanted to write an answer.

To begin with, I'm sorry to hear that the X has been killed, since it potentially could have formed the basis for a compatible series. However, since it implied a large number of compromises in each group, it probably is not possible
Ultimately, it would have removed the 9 and 10 as product lines and no one likes to be part of a vanishing product line.

In Summary

My favorite suggestions (although I'd like some other points looked at) now are:

1. Form a product-planning group.

2. Patent the Homogeneous Read-Only plus Read-Write Memory (described below).

3. Don't build a 24-bit computer, fast. If you have to, you might look at the PDP-X, which has both 16 and 32-bit instructions for an average of 24-bits only it's better than most 24-bit computers.

4. Build an 8/I around larger boards and lower cost and better cabinet fabrication (see Data Machines/and Mike Ford's suggestions). Incorporating options for:

   a. Lower basic cost.
   b. Use of Read-Only Memory.
   c. Not moving the computer on slides, drawers, or books.

5. ~~Build 10/I~~ Develop 10/I Memory for use in 9/I, 10/I.

6. A nice, modular, vast 9:

   a. Very lost cost.
   b. Modular memory system a la X in upper models.
   c. Multi-processor at high end.
   d. Use Read-Only Memory (either internal or main) to increase speed of arithmetic, so that it competes with 24-bit computers.
   e. Add XR's and some scratch pad, a la Ed deCastro's large 16 X 32 bits (18 X 32) or (18 X 16).
   f. Make a processor for interpreting PDP-10 instructions and handling PDP-10 I/O devices using Read-Only Memory internally.

7. Build the 9-bit controller. As a stand-alone computer, and a controller to 9, and 10 devices.

8. Try to build special, total systems, based on software packages for existing machines (e.g. TS8; TS9; Administrative Terminal System-like thing (IBM's Multi-terminal editor);)

9. Do something to consolidate market planning across product lines.

10. Data Communications can still be yours, don't drop it!

## Other Comments

Although my following arguments need to be based on cost/performance curves, I think our sales result from other factors, too: inertia, (IBM effect); lowest cost; and cost/performance.

The X group came up with some nice analytical relationships (e.g., instruction set utilization, performance of machines, checkout costs, etc.), especially when it was needed to back a decision. I would like to endorse their analysis and would hope the several machines that are being started could all be done on such underlying thoroughness. I'm suggesting a number of machines, and I'd really like to see cost/performance) memory size curves for each of them. I'm enclosing examples I did on the 360.

I'd like to put the following into a better framework then the linear list following, but think that's up to #1, below. The items are:

1. Set up a market-study group to try to consider the company as a whole, and have it connect with each product-marketing group. I would prefer to call and use the existing marketing groups for sales support, and sales, and information collection. Such a group would be more along the lines of product-planning group, doing market/cost analysis with a combination of design, production, and market inputs and would help guide product planning.

2. Try to increase the parts which are produced in common for all computers (for production, sales promotion, customer learning, and training reasons through some formal organizational body (maybe product planning)). (For example: parts of memories, peripherals, and peripheral controllers.) The structure of the 8, and 9 make it virtually idiotic not to have common controllers. The advent of the larger logic cards, then LSI, really necessitates this. Specifically Ed deCastro wound up with a 16 X 32 array, fast memory that could be used in the 9I+ and 10I. These parts include software (see 5 below). About a year ago (memo Feb 6, 1967), I suggested such a scheme for common peripherals, the arguments are still valid.

3. Start patent proceedings on the Homogeneous Read-Only, Read-Write Memory scheme, described below, which was developed on the 15 February meeting. It seems to be an effective way to get a nice local improvement in speed, in the case of simple processors like PDP-8, 9. I've looked at the PDP-8/I logic, and if you can wait long enough $\geqslant 1\frac{1}{2}$ years, I will make it go at .3 μsec/ read-only cycle, with only 15% more integrated circuits.

4. It is very difficult to measure the cost-benefit of another product in the line. I'm against any machine which is only incremental and does not try to better consolidate all DEC computers because I believe the cost of development and maintenance (especially software) is too high. For the same amount of development $'s, I believe system applications software has better payoff, i.e., a computer is converted to a particular device (a la typesetting, etc.).

5. Along the lines of 4, DEC could start collecting FORTRAN programs from places like SHARE, GUIDE, etc., which can be run on both the 9, and 10, and maybe 8. In fact, I think the generalized applications packages (e.g., a MATH-pak, or a STAT-pak, etc.) are the only reasons one would buy an IBM small 360 or 1130/1800 over DEC. This can be overcome by getting these packages into the DECUS library. A policy to use FORTRAN to code these packages seems like a good, long-range policy. Most such packages are available, free, now. (For example, all CALCOMP plotter programs exist in FORTRAN).

6. Investigate several design alternatives thoroughly. (The only implementation which traded-off cost for performance to come from DEC has been the PDP-8/S.) I'd like for these to be investigated.

8/I-1 (lower cost using larger boards, and different bus structure to lower cost).

8/I-2 (lower cost-lower performance - possibly a serial version to run at 2 μsec/word or so)

8/I-3 (a rope memory control which allows some small set of core or flip-flop memory to be added along the lines of the homogeneous rope-core below).

8/I-4 (8/I-1+ 8/I-B).

9/I-1 (lower cost 9 - may or may not use rope control like the 9).

9/I-2 (fancier 9 structure with local MB and MA in a memory). The memory options would be based on some X designs and include:

(1) Memory box with connection or port to one processor with 4K, 8K or 16K.

(2) Memory box with connection or ports to two processors or a processor and controller with 4K, 8K, or 16K.

(3) Box to allow multiple (4-8) processors or controllers to connect to a memory port. The processor might use rope control.

9/I-3 (processor with a homogeneous read-only core structure in which Read-Only structure might include programmed floating point or FORTRAN operating system interpreter to speed up numerical calculations. This structure could do numerical work faster than a single 24-bit machine). The main memory structure would be along lines of 9/I-2 in which some modules would be rope.

9/I-4 (A fancier processor with rope control, along the lines of the 9, but a larger rope so that floating point and other common ops could be sped up.) Such a structure would also allow control functions, such as DECtape, Magtape, 680-like teletypes, high speed line concentrator, to be included.

This feature would be sold to customers for their use.

9/I-5 ≡ Mini-processor 10-2

A processor which would connect to 9/I-2 Memories, and PDP-10 I/O bus, and interpret only PDP-10 code (using rope memory). 16K X 18-bits would be minimum memory size. Use 10/10 + software.

9/I-6 ≡ Mini-processor 10-2

A processor which would connect to PDP-10 Memories, and PDP-10 I/O bus and be 18-bits wide, and interpret PDP-10 code. 16K X 18-bits would be minimum. Use 10/10 + software.

9/I-7 A multi-processor 9 (where multi ≥ 2), this should not only out perform a 24-bit computer, but should be cheaper, and more reliable.

9/I Increments

From a future product planning point of view, the 9 can be spruced up a bit, e. g.

(1) Three-core index registers.

(2) Replacement of first 16-core register to speed up operations using index registers temporary, and auto-index registers.

(3) Investigate if MIT's (Lee), and Harvard's PDP-9 time-sharing system is marketable.

(4) Incorporate Edinburg's PDP-7 MACRO Assembler in software.

(5) See why the PDP-9 FORTRAN is so bulky, and slow.

| | |
|---|---|
| 10/I | Integration of processor, compatible with 10. Integrate other components, attempt to use 9/I sub-components. |
| X-1 | Smaller scale version of X. |
| 24 | Another computer. |
| 9-bit computer | A smaller than PDP-8 computer which would be part of a series of weakly, compatible machines of our 9, 18, 36-bit series. This would stand alone as a minimum computer. |

Also it would be specifically designed to serve as the controller for elaborate devices, or a group of devices which could be used on the 9 and 10, (also, 8 if desirable). It would be a front-end controller for communication lines for the 9 and 10 (scanning and buffering). This could be an important product, if it can be designed.

Note: This computer is along the lines of one we'd like built for here. I sent Mike Ford a copy of an 8-bit computer, along these lines which we thought could be built for $3K at Carnegie. I would like to remind people that the tasks which are done in 8-bit chunks, can be done nicely in a 9-bit computer. In fact, it may be a 'silly 1-bit longer'.

8-bit computer: Although this is also minimum, it doesn't look very good as a controller to an 18 or 36-bit machine. I've never felt that 8 is an especially good base, and base $(2^9)$'s has 100% more states than an 8-bit base.

7. Do something about Data Communications Market (product) planning, before it's too late! Although it still isn't too late, waiting another year before starting to plan may be. (See memos of about 1½ years back). This is just right for DEC as a market (especially with the new $9 \times 10^6$ bit disk). This includes both telegraph message switching, and display (text-keyboard) at 2400-bits/sec concentration. Respond positively, creatively, and correctly to ARPA's RFQ for their network switching computers. This job may take a PDP-9, and the present DEC organizational structure precludes thinking of the problem this way.

   Right now IBM has just announced an option to connect to the 360/25 to give 64 telegraph lines in and two high speed lines out in a concentrator and the price isn't awfully unreasonable, especially since they rent.

The proposed 24-bit machine

I think this machine isn't especially good as it's a compromise between a medium computer (16/18-bits) and a reasonably large one (32/36-bits). Although a 24-bit machine will out perform an 18-bit machine (for the same level of technology - i.e., memory speed) due to added index register and extra instructions. I don't give one (e.g., 910-920-like) more than a factor of 2 over a PDP-9 for the same memory speed, although one can build a 24-bit computer that performs like a large computer (e.g. CDC 3200).

Mostly, I don't like the idea of another product which has no chance of bringing the other product's production, programming, or sales training any closer together. (I can show you a real mess at IBM prior to the 360 in which slightly better, non-computible products kept getting stuck in cost/performance, cost, or performance holes.)

I agree that thereis a significant hole between the 9 and 10. This hole can be filled with existing product parts rather than introduce another incompatible series. In both the 9 and 10, there exists the possibilities for a nice filler. There is a discussion of the 360 as an example of filling.

The issue of whether a multi-processor 9 is better than a mini-processor 10 (9/I-5 or 9/I-6) should be based on cost/performance comparing say space/time for FORTRAN in the two machines, peripheral costs, instruction set power, and the fact that 10 software is already pretty far advanced. (Such a machine would use a memory of 16K words). I dont believe that the PDP-10 group is capable of making such a design or evaluating thefeasability.

Again, I think $'s should be spent on support software instead of basic software like maintenance routines, compilers, etc. A three or four year extensive effort to get DEC to the level of the SDS 900 series. Also, I believe that if any present 24-bit manufacturers want to, they could wipe you out! On the other hand, with a dual processor 18-bit machine, you could make things rougher on them.

I looked at some sample SDS 900 series programs, and though admittedly not typical, in 100 instructions I counted, an 8-bit address was sufficient 75% of the time. This compares favorably with the statistics in the instructions measured by the X group. I don't believe the small address hack is a hack, but rather an efficient use of bits.

## 360 Lessons

Enclosed are some notes on a talk given by Fred Brooks, one of the IBM 360 designers at a talk at IBM Poughkeepsie. I have also enclosed my IBM 360 cost/performance graphs, as I believe this kind of analysis is necessary to find a filler between the 9 and 10. The issue of ROS and multi-processors can be seen from the 360. For example, the utilization of memory

$$= \frac{\text{number of memory cycles used}}{\text{number of memory cycles available}}$$

| Model | Memory Utilization |
|---|---|
| 30 | .2 |
| 40 | .4 |
| 44 | .55 |
| 50 | .5 |
| 65 | .37 - .18 |
| 75 | .54 - .27 |

This is low compared to the PDP-8,9 machines, but on the other hand, the complex 360 instructions do move. Their 1130 and 1800 are like .75. ROS causes part of the problem, but the complex instructions do too. The 10 would probably be pretty low too, due to floating point, and multiple memories (in fact, a 32K system would put it below .5).

I proposed a smaller set of 360 processor primitives which would give better cost/performance in the 360, and I think these also apply to the 9+, 10-, 24-bit issue. These are given below.

An Alternative Series of Processors to Cover the Range of Computing Power.

Graph 4 indicates that an alternative approach based on multiple Pc's is feasible. Suppose the following Pc's are chosen as primitives:

| Model | Power |
|---|---|
| C(20) | 1 |
| C(30') | 4 |
| C(44) | 30 |

Then by combining primitives, the performance values of the present computer line can be obtained, as shown below:

| Model | Power | Pc Cost |
|---|---|---|
| C(20) | 1 | .00049 |
| 2-C(20) | 2 | .00098 |
| C(30) | 2 | .00125 |
| C(30') | 4 | .00125 |
| C(40) | 6 | .00295 |
| 2-C(30') | 8 | .00250 |
| C(50) | 15 | .011 |
| 4-C(30') | 16 | .005 |
| C(44) | 30 | .004 |
| 2-C(44) | 60 | .008 |
| C(65) | 60 | .022 |
| C(75) | 80 | .0365 |
| 3-C(44) | 90 | .012 |
| 16-C(44) | 480 | .064 |
| C(91) | 500 | .09 |

Note that in every case, the multiple Pc approach performs significantly better than the uni-processor, at a lower cost. (The multiple Pc interconnection cost with Mp, and the problem of breaking the task apart has been ignored.)

<u>The Interdata Machine</u>

## Interdata Appeal

CONFIDENTIAL

1. Read-Only Memory (ROM) is safe.

2. ROM gains about a factor of 10 over a PDP-8 in speed (.3 μsec/instruction). Although the instructions aren't as powerful for general use, they are good for local and small state modifications.

3. The ROM word size is equal to the system word size, and using a certain option, can be made to run from primary (core) memory.

4. Proprietary control programs can be written in ROM for particular applications.

5. ROM can be 1K X 16-bit or go up to 2K X 16 bits.

6. ROM instruction set is easy to understand.

## PDP-8/I Relevance

0. Find out why it's so much cheaper!

1. For many applications, the ROM change rate will be too high to allow anything being fixed.

2. A certain region of memory which is protected against every Write, except JMS, would be lovely, and give one most of the ROM benefits. (See my memo to Ed deCastro, and Nick Mazzarese - re: a protected region of Memory.)

3. It's hard to believe that the Interdata structure (Core Memory, Rope Memory, 16 X 8-bits of Integrated Circuit Memory) can ever cost the same as a 12-bit machine. In fact, the cost difference should be =

   4 X 4096 core bits + (4 X 4 + 4 X 16) hardware bits + 1K X 16-bits Read-Only Memory + more extensive order code logic.

4. Hope that CDC doesn't buy them.

I believe you should try to project the cost of the Interdata approach into the future and see if from a lower price basis, an 8-like machine is justifyable. My bet, is that it always is (the software is just getting good). I feel that a much better implementation will have to take place than was done on the 8/I, for example:

a. Memory Protection (to compete with dedicated ROM Controllers) to get effect of ROM.

b. Mechanical packaging in line with the technology.

c. An (I/O bus, Memory bus, and Direct Data Bus) structure in line with technology and reason to cut the inter-connections down between all parts of the machine. (As a holder of a large PDP-8, the cabling problem is beginning to be reminiscent of PDP-6 cabling problems.) Never build a computer on slides, or drawers or hinges. "If von Neuman had meant computers to live in drawers, he wouldn't have given them hardware."

d. A single machine which is capable of running with several speed memories, serial if cost merits, but certainly capable of present operating speeds.

<u>Comparison with the X</u>

1. Generally the X is heavy-footed internally, following IBM 360/30 style implementation in order to gain speed.

2. The X should be faster internally because of: 16-bit paths; twice the raw circuit speed; more commands encoded simultaneous in a single word, though I'd estimate a speed difference of (2 X 2 X 3/2) for the above factors, the cost difference might only be (2 X 1 X 1), or a worthwhile trade-off for the X.

3. The X has few of the advantages of the Interdata appeal. Though they don't market to people to whom it would appeal, it's possible they could (e.g., Peake at Western Electric; Applied Logic, people who want to design special consoles, etc).

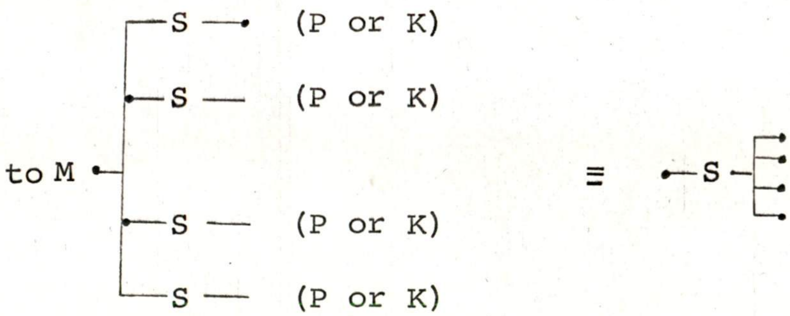
# Memory Boxes for PDP-9/I

Using PMS notation (where P = processor, M = memory, K K = controller, S = switch), the X group proposed some primitives, to which I've added #3 below, I suggest the varifications of the structures be looked at carefully.

1.


A two-port memory module. Where M doesn't necessarily imply an MA and MB - although a good case can be made for them. M might range over 4, 8, 16K due to overhead of S's.

2.



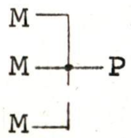

A four-port arbiter module. To expand the number of ports into an M module, this module makes decisions about the P or

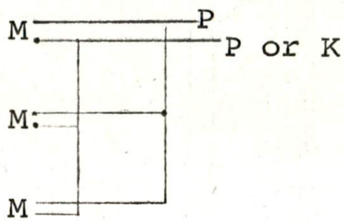
3.

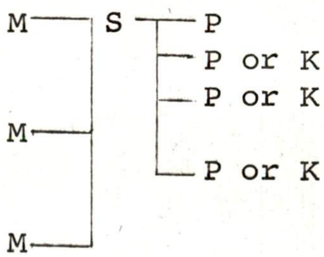

A one-port memory module. Note, this is considerably simple than 1. above, although it may be possible to design it as an option to 1. For example, the PDP-10 memory does not gracefully degenerate to this.

The above primitives yield the following configurations:

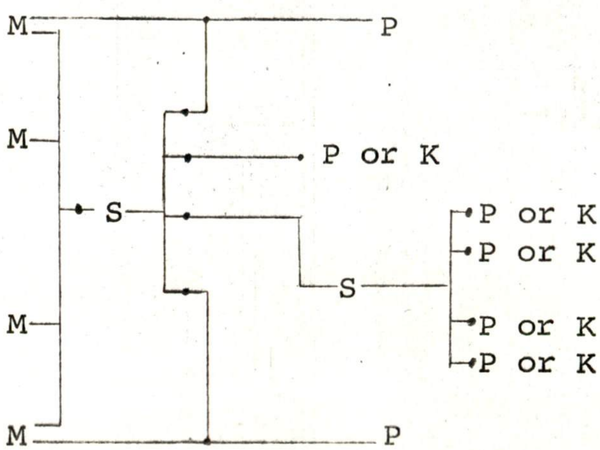
a. 


b. 


c. 


(Alternative) (Note: the performance is probably less than 3, although the structure is cheaper.)

d. 


Compound switching

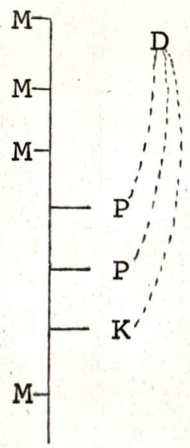
5. If each P or K has some local switching, then a common <u>single</u> bus can be used for everything. This scheme requires some form of master arbiter to decide on bus utilization; thus each P, or K is really:

S — P —

S — K —

and

a configuration looks like




etc.

where D is a decision maker who decided the P or K who is allowed to broadcast its address call

Note: this is cheap, but a fault anywhere puts the system down.

Also, with a 1 μsec memory, and ½ μsec access, and "lucky" Programs with overlapped addresses you'll probably not be able to get more than 3/4 μsec effective memory cycles.

Appendix

## A Homogeneous Read-Only plus Read-Write Memory

Wilkes originally suggested* the use of Read-Only Memories for the control unit or the sequential decoding and enactment of instructions within the processor of a computer - the scheme is called Micro-programming. In fact, this scheme is used in many computers. Other computers use a protection mechanism on a normal read-write memory which protects a block of words or a single word.

Early military computers and some aerospace computers use a scheme which is not really the micro-programming structure outlined above, but is based on a heterogamous, two-memory system consisting of instructions and data. In these computers, the instructions reside in the read-only part of memory and the data in the read-write part of memory. Thus, instructions in the read-only part refer generally to specific locations in either memory depending on the address. As such instruction cannot be built-in which refer to data locations which are inherently local to the read-only part (for example, subroutine calling). In the case of existing computers, the memory organization is a homogeneous structure which the processor assumes can either be read or written. This in effect means that instructions can be included which would have to write in what would naturally

*M. V. Wilkes "The Best Way to Design an Automatic Calculating Machine" - Manchester University Inaugural Confeim. Manchester England p 16-18 July 1951 be a read-only part. This is apparent in the case of the common instructions, branch to subroutine and store the link at the head of the subroutine. Here the only place for the link is at the head of the read-only subroutine, and we are forced to find a method of linking the address to a place where the link can be written.

In the read-only memories above, there is a heterogeneous structure to the organization such that the machine has an internal structure which is programmed in read-only memory and an external structure which is programmed in read-write memory. Similarly in the aerospace computers, there is a heterogeneous structure composed of both data and program. We suggest a homogeneous address space which can be either read-only or read-write memory. The principal reasons we suggest such a storage arrangement is based on the reasoning applied to other structures which use read-only memory, namely:

1. The read-only structure allows faults to occur which completely change the current state of the process, without changing the program. Thus, while momentary failures occur, there does not have to be an extra copy of the program on some other memory device local to the computer, which has to be read into a read-write memory after failure.

2. Conventionally a read-only memory ranges from 2 to 5 times faster than a read-write memory, thus, for program access, and constant storage accesses, we can gain a significant factor of speed. We admit that the price paid is to commit ourselves to a permanent program.

3. For systems which might be constructed for a particular use, we can organize the computer so that proprietary processes can be written in the read-only part and thus this added-on part can be part of the structure which he sells.

4. Most read-only structured computers use a different read-only instruction set from that which is externally available for the programmers or user. It would be desirable to use the same set instruction set, to avoid having to know the two structures, and also because a program could run in either read-only or read-write memory, facilitating check-out of read-only programs.

5. In the case of proprietary software, such as very high performance compilers or similar packages, it provides a method to give an increase in level of performance for a cost. For example, it could be the vehicle by which compilers are installed and maintained.

6. For most computers, using the following scheme the method which we suggest to allow the attachment of read-only memory is so trivial that it most certainly can be easily incorporated on existing computer structure with only minor or no modifications to a processor. (No modifications are required provided a read-write memory is associated with the read-only memory.)

7. Read-only memory is less expensive than read-write memory. In all computers there must be some amount of state which can be changed, otherwise, we would have a very

small, finite state machine. In some cases this state could be as small as the state of the processor itself (that is, just an accumulator, the index registers, flags, and the instruction location counter). If however, the state of the processor is very small (e.g., an instruction counter and a single accumulator), then more than likely a read-write memory would be needed to solve any useful problems.

8. The suggested scheme allows any amount of read-only and read-write memory to be intermixed, and to cover a homogeneous addressing space.

9. The scheme allows for complete and single program debugging in a read-write memory before being fixed in read-only memory.

10. For the computer manufacturer, the scheme provides a method for incorporating software options which will both run faster, and which might eventually be hardware in upward compatible models.

The scheme is organized about a computer primary (or program) memory space of m, w digit words.

a. A read-only memory of w digits per word and r words require a special additional bit, the indirect write-bit, i.

b. A read-write memory of w digits per word and n words.

c. The largest total computer memory space of m words may consist of $m = r + n$.

d. It may be necessary or desirable to have some additional, temporary memory space, t, of read-write memory, such that the total memory in the system $= t + r + n$.

Normally, however, the space we refer to as t, could be included in an unused portion of read-write memory, n.

e. The meaning of the bit, i, in the read-only memory is as follows:

   (1) Anytime the bit is off (e.g. = 0), the word is taken to mean: use this word as datum for either the instruction or datum for the instruction.

   (2) When the bit is on, (e.g. = 1) then the word is taken to mean: use the word this word addresses, or points to as the instruction or datum for the instruction.

   Normally, all read-only references will be off, if reading occurs in the word, and a one, if write occurs in the word. Also, on writing the read-only addresses should eventually address a read-write memory address, so that writing takes place and the instruction is executed properly. Note that several words with indirect "on" may all point to a single read-write word.

FRED BROOKS    THE PROOF OF THE PUDDING ....    1/18/68

(Notes taken by an IBMer)

At Triangle they installed a cheap Model 40 just to get communications experience before installing the expensive Model 75.

In 1961 there were several major objectives for the System/360:

- o Carrier of the new hybrid technology
- o Upwards, downwards, and sidewise compatibility
- o System to be communications and DASD file oriented
- o Impliment new software concepts (e.g. software varies by memory size, not CPU)
- o Provide for the attachment of a wide variety of I/O devices
- o Do all the old established applications well and be able to do new applications

The hybrid technology proved to be a wise move. We could build it. Only in '67 have integrated circuit machines appeared economically on the market. At the time the decision was made they were scarred stiff that the technology of System/360 would be leap-frogged too soon.

Ahmdal and Brooks at first thought that you could not maintain downward compatibility and still be economically competitive. However, after resolving the hurdle of address length, they found it to be fairly easy. There were many more problems in sidewise compativbility/.

Up until three months before the announcement they had not ~~decinds~~ decided to NOT extend the 1401 concept. The decision for a Model 20 was "ify" down to this time. It turned out to be a wise decision.

English pointed the way to using ROS. In order to give the designers incentive to use ROS, they decreed that anything in conventional hardware must be at least 25% better than ROS.

LIKES: CPU (in general); base registers not bad; large addressing range; LCS good; 2311 cheap enough to"emulate" tapes and thus make introduction to DASD easier; likes PL/I; large character set good.

Says core is the universal aid. Only it can be added to a system on the floor to cure any system fault such as speed, function, or capacity. Also these capabilities can be varied by the minute.

The standard I/O interface makes for easy reconfiguration.

Feels that the 1403 is the most important product IBM has developed. Error tolerance in a horizontal plane results in letters being bunched together or spread apart. The eye accepts this better thanvariance in the vertical plane. Thus, the 1403 better even with the same mechanical tolerances. This also goes to show that the CPU is not necessarily the most important part of the total system.

IBM's growth is constrained by the amount of systems support we can supply.

WRONG:

Although the system design was the broadest up to that time, it was not broad enough. For instan they neglected the concept of the system residence device. It turns out that the second level of change is the most important problem for our large machines.

there was no strong effort to maintain compatibility between similar I/O devices for example, look at System/360 card readers.

Software was not considered early enough in the game, nor hard enough. The software was split off from the hardware at an early stage. Both of these points were bad.

Poughkeepsie is very ingrown. People there do not know enough about other systems. For instance, the 1108, and 6600 and some British machines have excellent operating systems. In addition, because CPU's are built at Poughkeepsie; they tend to be too CPU oriented. For instance, the 360 software was not designed to allow for an economy of effort in use or maintenance; and the I/O devices were not matched to the CPU (e.g. 2301 drum).

Brooks himself is responsible for seeing the Operating System as a collection of pieces. They did not look at system aspects like Operator protocol. Operator protocol should have been part of the initial planning. They decided not to develop Remote Job Entry, but they should have had a picture of how RJE would look to the user. Job Control Language is an especial problem in connection with RJE. They knew by late '64 that JCL was bad.

They were too conservative. OS/360 does well what the 1410 Operating System and IBSYS did well; but it is not matched to the System/360. This is problem even with universities - you fight the last war over again.

Thinks the second system that a designer works on is the most dangerous. In the first system he makes mistakes beacause he is ignorant. On the second system, he knows the mistakes he made on the first system and he over-elaborates function - oblivious to the dangers in this direction. For instance, in hardware, the STRETCH was absolutely Roccoco - it had gargoyles. It had two indexing systems because Ahmdal and Brooks could not agree. OS/360 is the STRETCH of the software area.

Nothing was done in '63 by DPD in connection with marketing until three months before announcemnent. They did an excellent preparation for announcement. However, their late start was soon felt in the lack of preparation in education, documentation, etc.

Why was DPD not ready? In both DPD and SDD there were still large committments in the second generation area.

Another general problem was the slowness of the IBM Corporation to face the consequences and corrolaries of the System/360 decision. Later in the game, there was an unwillingness to see the decisions through - that is they didn't live with the consequences and corrolaries.

Brooks doesn't think that the 360 will ever be replaced in one fell swoop. It will be like George Washington's ax. The man said it had been in contincious use since GW's day. The handle had been replaced 7 times, the head - 5. We will replace the head; then the handle; then the head, etc.

In '62 they found out that they would have too wait 6 weeks to get the cards for the I/O design as specified. So they couldn't wait. They designed so that the outermost unit needs a power supply (3v ground - not zero). Thus, the meter is running even when not in use. In '64 they could have corrected this for approx. 100,000 dollars. Too expensive. In '66 they finally were forced to correct it at perhaps $1,000,000. This ties in with an example in the software. Brooks decided to take some short-cuts under the pressures of time. Marty Jossky said that if you do it right you will get there just as soon as if you do it wrong. Brooks did it wrong - and Jossky was right.
1130 could have been compatible with the System/360 - we just didn't follow through.

Another example of lack of follow thru. In '66 you couldn't get disk packs. We still don't support LCS. You must ask whether an application program runs on BOS or OS.

TSS/360 is a split off from System/360 just like BOS is a split off from OS/360. He feels that the ultimate answer will be in an OS/TS type of system.

Thinks that you need two compilers and two loaders on any system. One compiler - fast compile. The other - tight execution code. We don't want to use the Linkage Editor for simple load-and-go type of jobs. We recognize this; but time after time we sit between the two stools.

He feels that areas like a match between secondary storage speeds and CPU; and data flow are more important to the system than new instructions.

Very much likes the library management concepts in OS/360 - the idea of managing data sets when user is off the system.

He would like to see more time spent in planning before implimentation and a strong interface specification set up. In OS/360 the let the interfaces ~~f~~get fuzzy and they never cleared up.

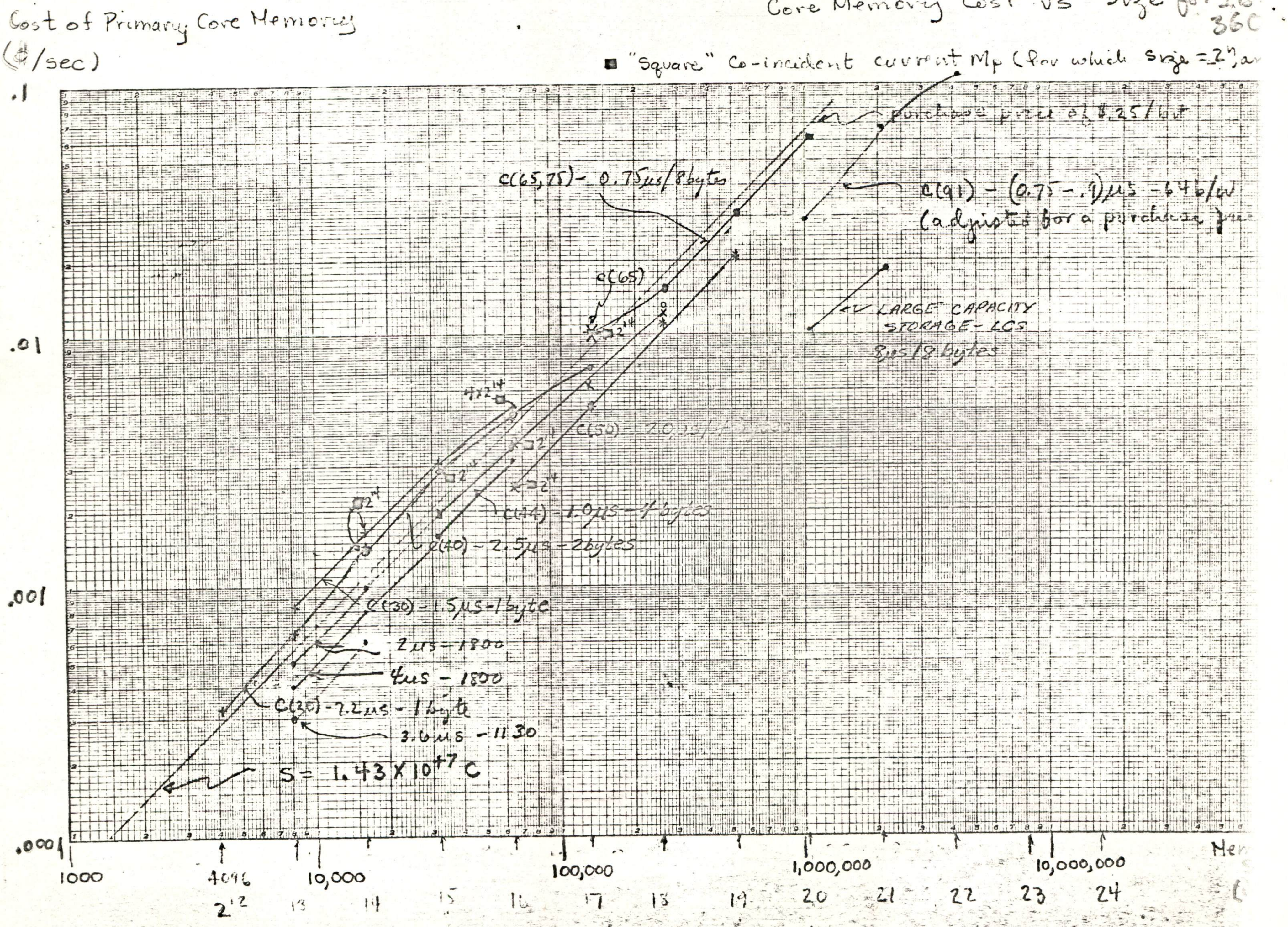
Bothe the OS/360 code and documents are a mized bag - some very good - some horrible. PL/1 PLM (first part) good. Documentation more comprehensive than our competitors.

The way in which people use computers and a shift in the economic balance between components of the system make for changes in system architecture - not changes in technology per se.

The decision to truncate as opposed to round off in FP arithmetic was a bad decision. It can be fixed currently thru an RPQ. Example problem: $\prod \frac{i}{i+1} \cdot \frac{i+1}{i}$ let i from 1 to 100,000.

If a complex function has too many storage addresses generated (say 4 or more) there is little reason to place it in hardware as opposed to firmware or software.

Graph 1.
Core Memory Cost vs Size for IBM 360

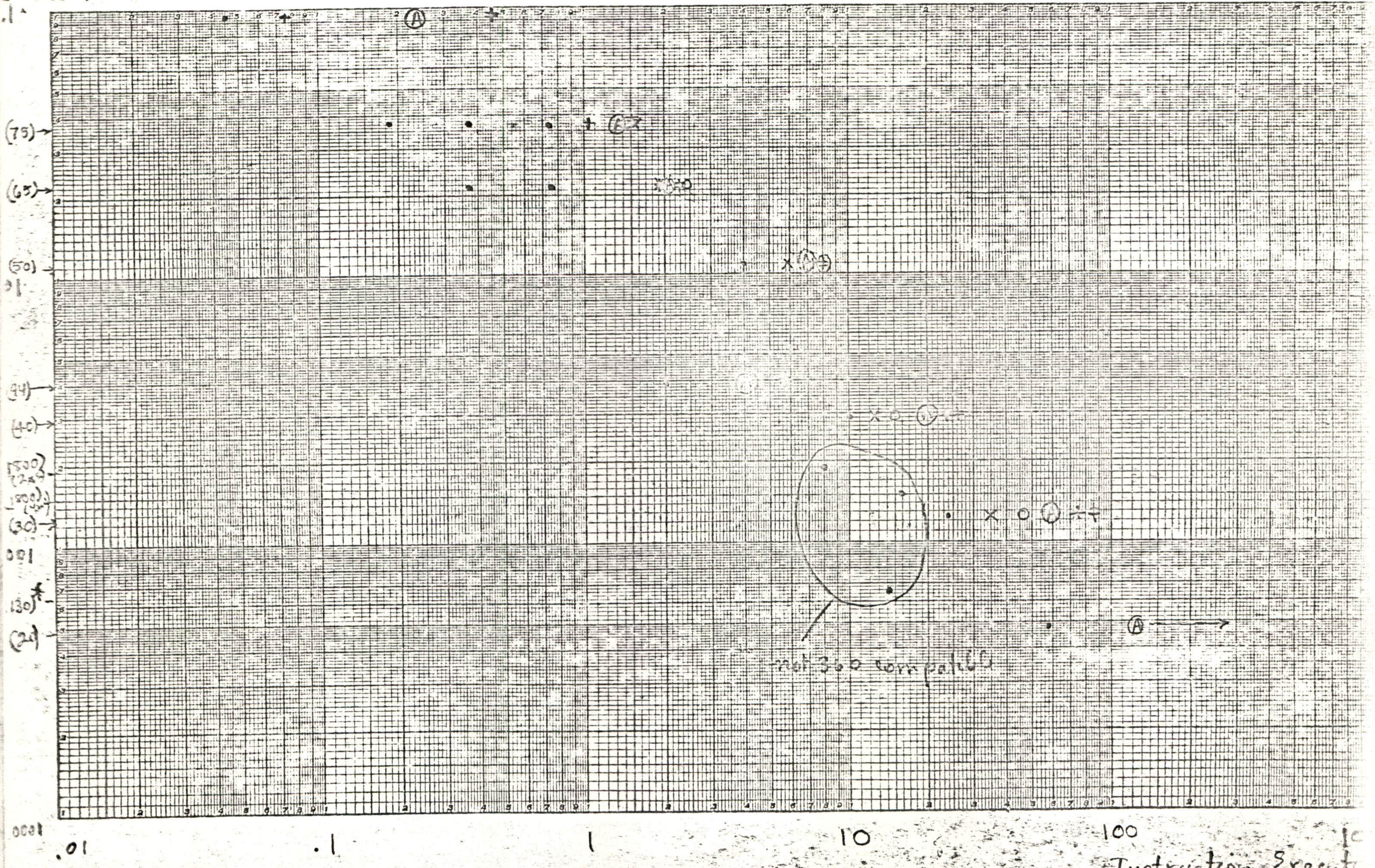


Graph 2.

Instruction execution times (Average) versus Processor Cost for I 36

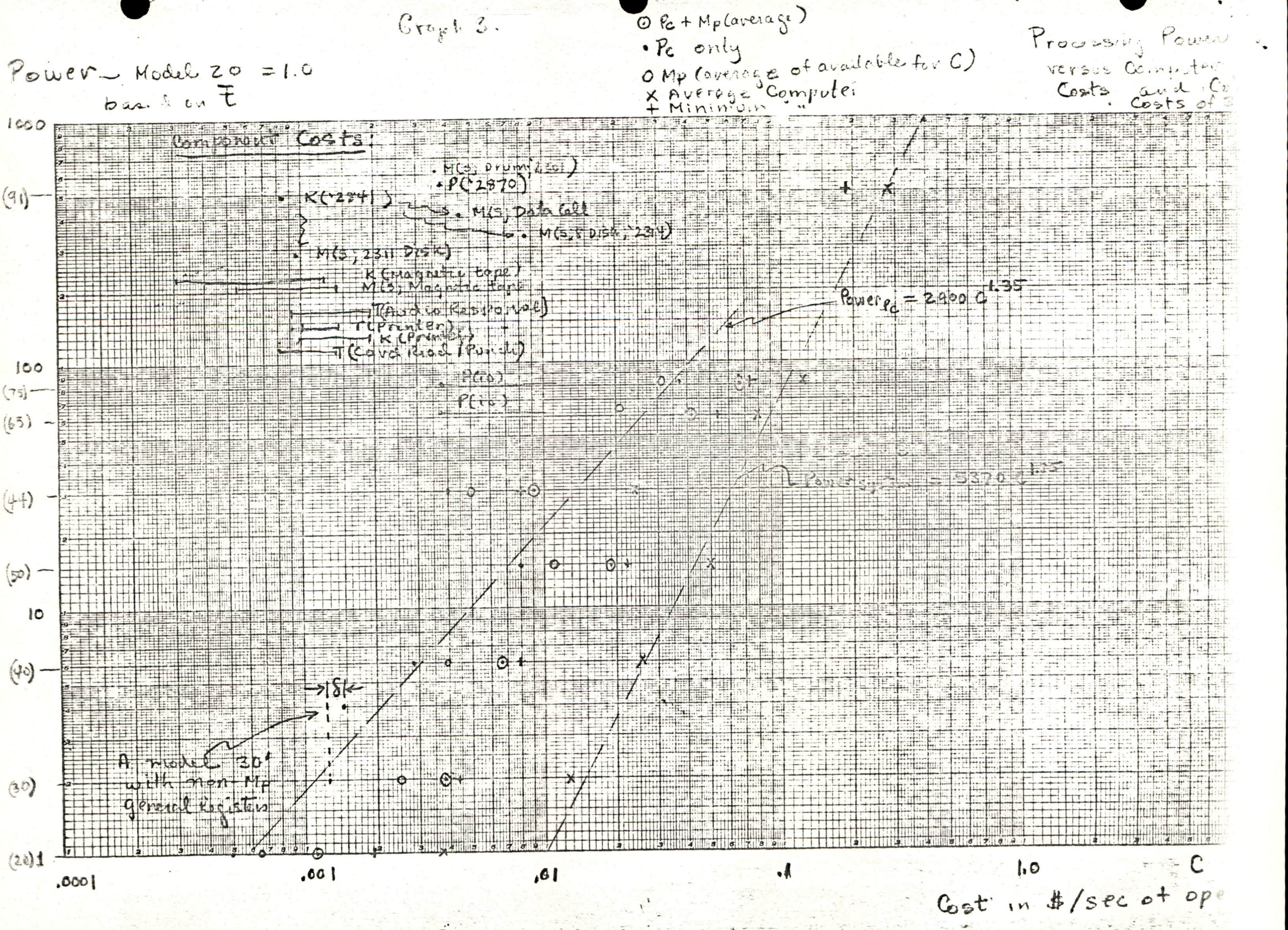
A $\bar{t}$
≠ set
+ matrix multiply
x field scan
o scientific mix
• max

Processor cost in $/sec (millions)




Instruction Execut Times (in micros

≠ not 360 compatible

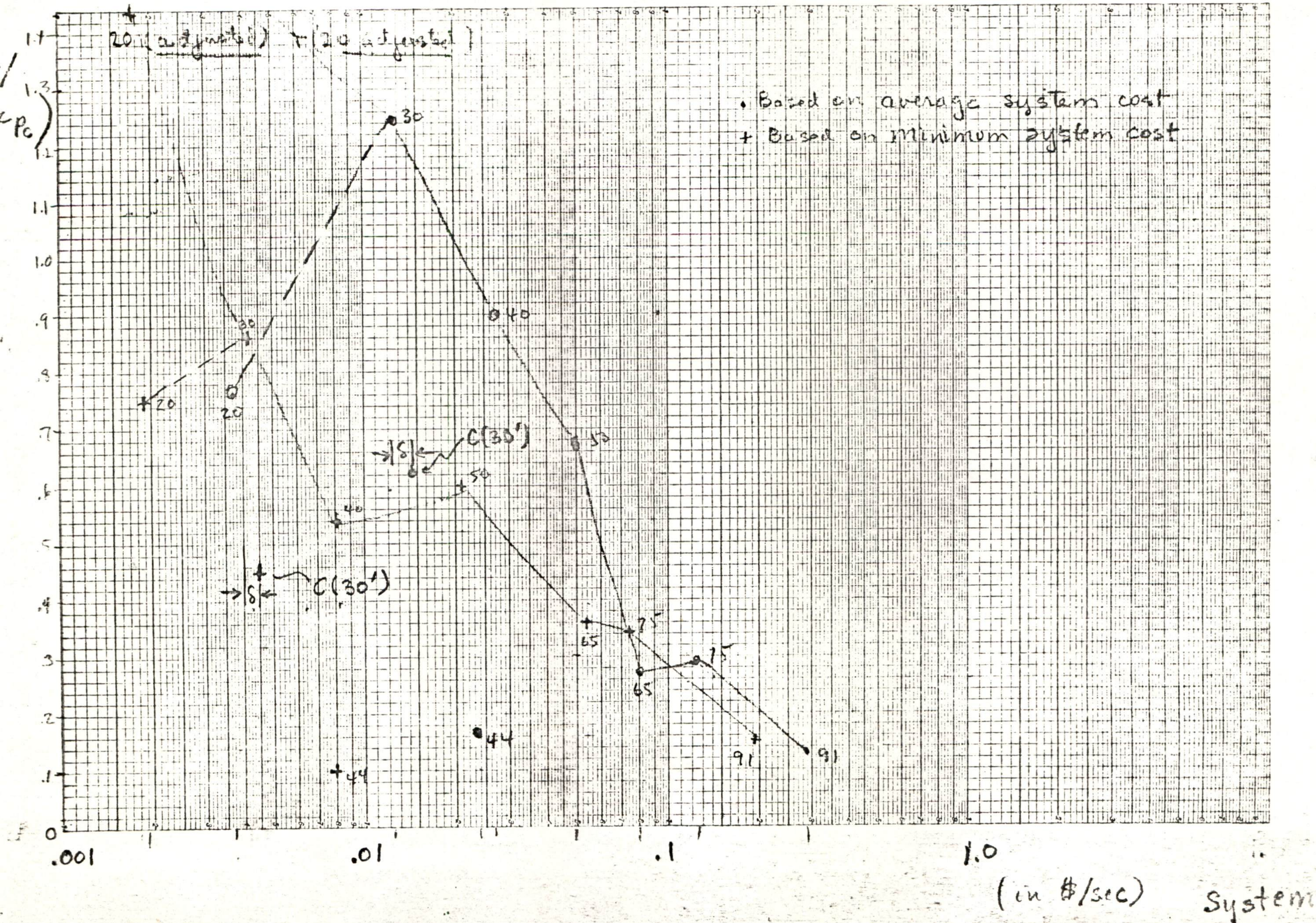


Graph 3.
⊙ Pc + Mp (average)
• Pc only
o Mp (average of available for C)
× Average Computer
+ Minimum "
Processing Power versus Computer Costs and Costs of
Power – Model 20 = 1.0
based on E
Component Costs:
K(2741)
M(5; Drum; 2301)
P(2870)
M(5; Data Cell
M(5, 5 Disk, 2314)
M(5; 2311 Disk)
K(Magnetic tape)
M(5; Magnetic tape)
T(Audio Response)
T(Printer)
K(Printer)
T(Card Read/Punch)
P(10)
P(16)
$Power_{Pc} = 2960\ C^{1.35}$
$Power_{system} = 5370\ C^{1.35}$
18
A model 30' with non-Mp general registers
1000
(91)
100
(75)
(65)
(44)
(50)
10
(40)
(30)
(20) 1
.0001
.001
.01
.1
1.0
C
Cost in $/sec of op

Graph 4

Cost for a task versus configuration for 360

Cost for fixed task using $\bar{I}$ instructions



# INTEROFFICE MEMORANDUM

DATE: February 27, 1968

SUBJECT: PDP-9 Power Supply currents.

TO: Ken Olsen

FROM: Don Zereski

Enclosed, please find a list of the PDP-9 power supply current measurements. All measurements were made at the power supplies. The PDP-9 measured did not have the following internal options: MP09 (Memory Parity), 34H display, KP09 (Power fail). The currents for those devices not included in the system were estimated by module types and are included in the totals.

The ripple measurements were made at the power supplies with the machine stopped and with programs running. The basic 60 cycle ripple has a 25 to 30 megacycle high frequency noise component of about twice the magnitude of the 60 cycle ripple while programs are running.

DZ/nam
enclosure

+10 Volts ABS Voltage 10.50volts.

measured current 9.85

estimated current 1.07

total current 10.92 amps

Ripple measured with the machine stopped 220MV

Ripple measured with a program running,

high frequency (25 - 30 meg) and 60 400MV

-15 Volts ABS Voltage 16.0volts

measured current 31.20

estimated current 5.57

total current 36.77 amps

Ripple measured with the machine stopped 300MV

Ripple measured with a program running. 500MV

-30 Memory voltage ABS Voltage 29.75volts

measured current 5.6 amps (program of all ones in 8K)

Ripple measured with the program running: 4.0volts.

-30 Punch voltage ABS Voltage 31.0volts

measured current 1.6 amps (punching all ones)

Ripple measured with the program stopped 120MV

Ripple measured with the program running 300MV

-15 Volt marginal check

measured current 3.6 amps (Processor SW 1 and 2 on margins)

measured ripple with program stopped 400MV

measured ripple with program running 800MV

... 2

The marginal check supply is voltage limited.

Maximum current available is approximately 5.0 amps.

digital INTEROFFICE MEMORANDUM

DATE: February 29, 1968

SUBJECT: Results of a one hour telephone conversation regarding displays with Chuck Missler, Director, Ford Motor Company Scientific Computer Center

TO: Ken Olsen
Bob Collings
Ted Johnson
Nick Mazzarese
Dave Cotton
Bill Sewalk
Pat Green
Hank Spencer
Murry Reuben
Lowell Henize
Jack Dumser

FROM: Bob Fronk - Ann Arbor

RWF

Ford Motor Company is now using a CDC-1700 Digigraphic System valued at $300,000 after they decided not to buy our equipment last year.

CDC has a programming team at Ford Motor developing software on the large tube Digigraphics System. As you are aware, it is a 4096 x 4096 matrix, and they can get 10 - 20 thousand inches of vector on the screen at one time. Lettering can be slightly larger than 1/8 inch.

Ford also has an Ambilog 200, but the new display is not on it yet. The system selling price is about $90,000.

For general information about the Ford Scientific Center, see COMPUTERS IN AUTOMATION, January issue.

Ford wants economic applications now, NOT R&D display systems. Within the next six months they will have two (2) CDC-1700 systems. One in the Scientific Center now, and a second at the Styling Center, both time-sharing on the Philco 212's. (A bare 1700 was recently installed in Styling.)

General Motors, especially the Chevrolet Engineering group, are quite interested in seeing Ford's system, along with a group from Chrysler.

Serious estimates of display systems for these three companies are as follows:

FORD - Four (4) more within the next year

CHRYSLER - Two (2) within the next year

GENERAL MOTORS - Two (2) within the next year. Our competition at GM is IBM, ADAGE, and CDC.

CDC has taken the Ford programming team back home for a few days to prepare a special demonstration program for GM Chevrolet. They have six (6) "master programs" (whatever they are) already developed in this area, mostly machine independent on a FORTRAN basis.

Ford feels they can double the number of machines they need if we are able to provide $100,000 systems to do their basic work. They feel that the large tube is almost a necessity.

DATE: 29 February 1968

SUBJECT: ROS Revisited

TO: S. Olsen

FROM: L. Seligman

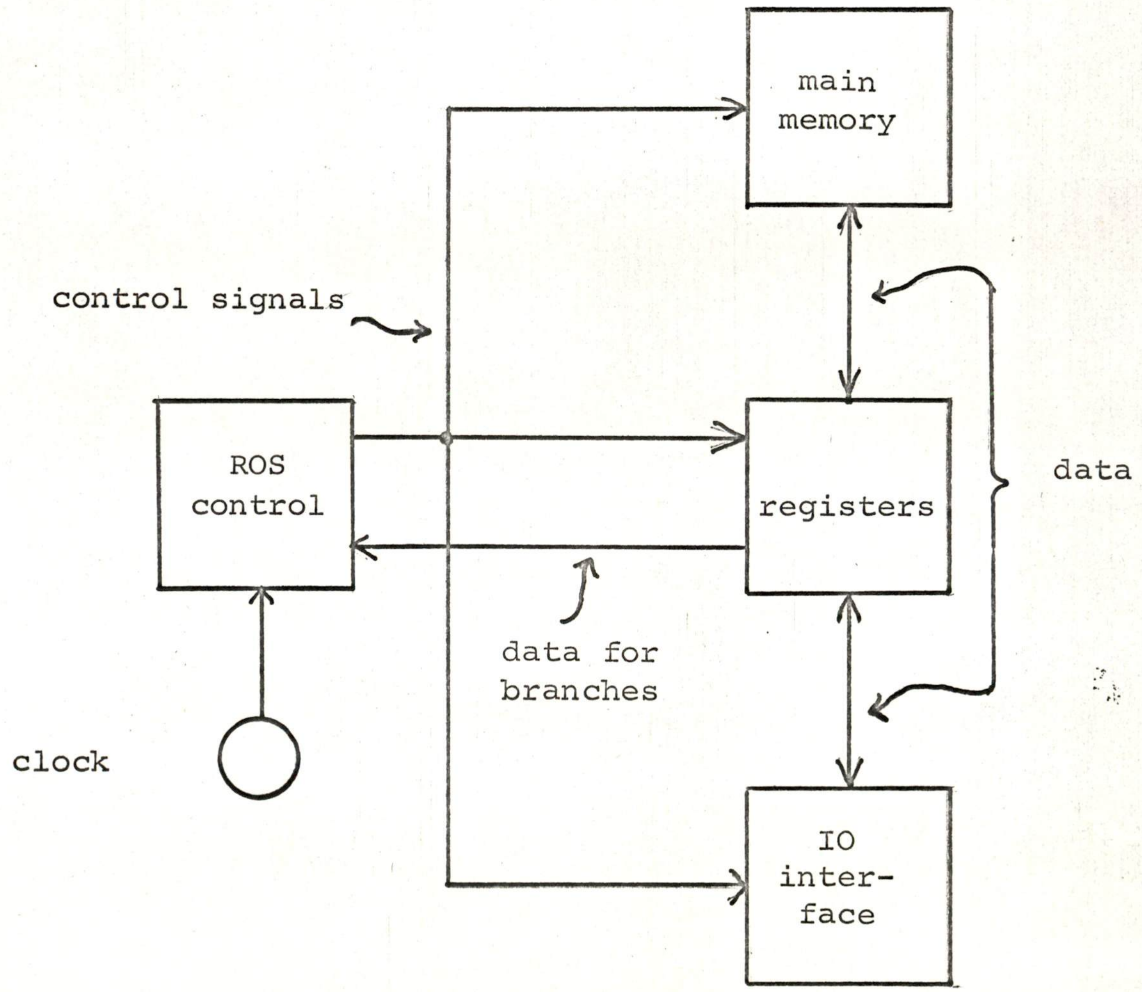
CC: K. Olsen
J. Jones
On Request

The purpose of this memo is to present some considerations on the design of a new ROS-controlled version of the PDP-9. As an introduction, let me point out the major advantages of such a control structure which permits both ease of modification of the order code and inclusion of special functions. As other manufacturers are beginning to realize, the emphasis in small computer applications is shifting from general arithmetic computation toward "production" tasks where the computer is imbedded in OEM products. This shift will certainly increase for machines in the PDP-9 class and will probably dwarf current markets. What is needed in these cases is an inexpensive, flexible computer structure which can be made to behave as efficiently as any specially-designed digital hardware.

The sections below present a brief review of general ROS design and lessons from the PDP-9 ROS design, and make some estimates about a new design. Since we have already built both an ROS computer and an IC computer, we should be able to develop a particularly clean design that is both inexpensive and easy to manufacture.

Brief Review of ROS Design

An ROS-controlled computer structure is sketched below*; the only section requiring explanation is the ROS control section. Absorbed into the ROS control are the conventional functions performed by the major state generator, the minor states, much of the timing chain, and the control signal generating logic (e.g., PC+1⟶PC). During each core memory cycle, several ROS cycles occur, directing the flow of data through the registers as required for instruction fetch, defer, or execution. Each micro-instruction word read from the ROS specifies one elementary operation; the sequences of micro-instructions required to direct the behavior of the computer are called its microprogram. In a well-designed ROS computer, changes need be made only to the microprogram and not to the hardware when changing the instruction set or adding new functions.




*There are a number of potentially messy details, one should not be misled by the apparent simplicity of the diagram.

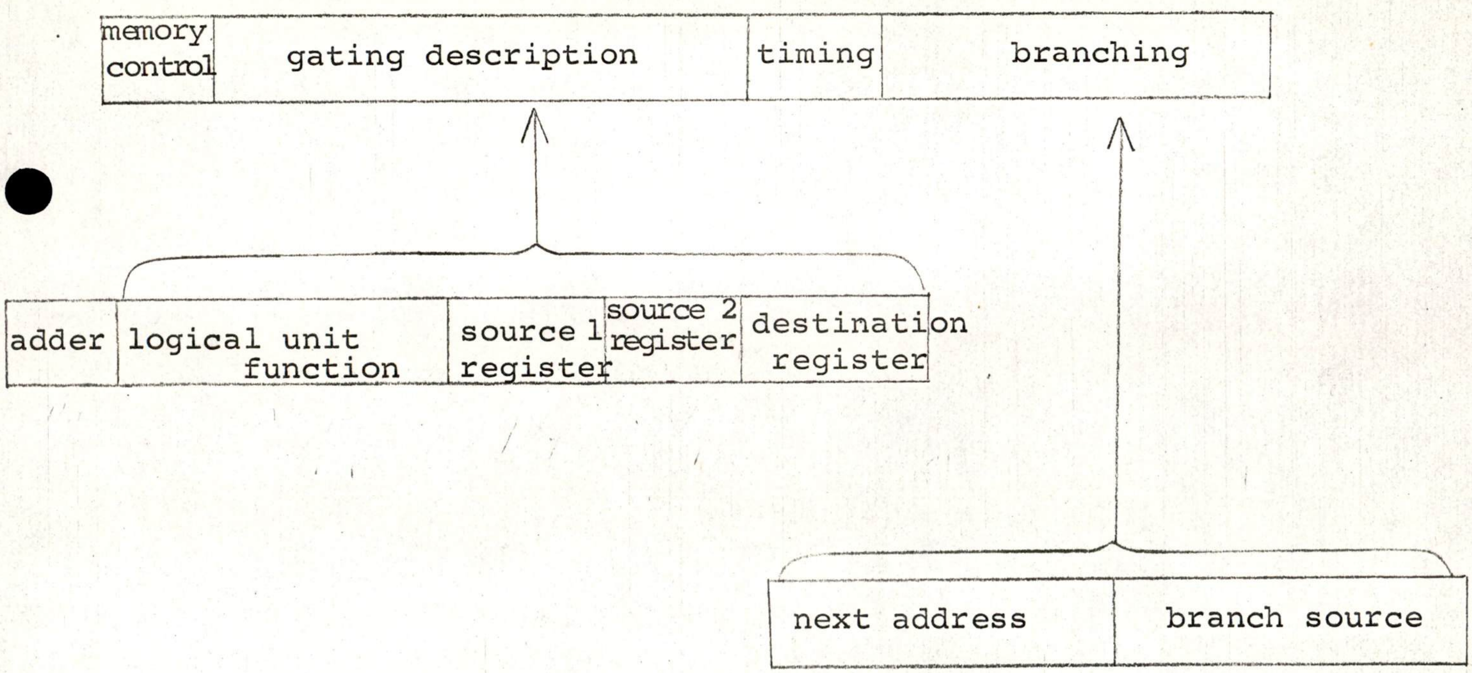
The micro-instruction format consists of 4 basic fields as shown below. These include:

1. core memory control - e.g., start, pause

2. gating description - e.g., data path enable, control operations

3. timing - e.g., wait for IO, wait for memory strobe

4. ROS branching - address of next micro-instruction, branches due to contents of IR, type of interrupt, etc.



Problems in PDP-9 ROS Structure

Most of the problems with the PDP-9 ROS structure are due to its small size; the larger ROS assemblies now possible should alleviate these problems.

1. PDP-9 ROS word too short - several bits had to have multiple meanings, depending upon other conditions detectable in the control. This led to additional control logic. In addition, several bits were simply omitted (e.g., shiftright or shiftleft) and their generation required special additional control hardware.

2. PDP-9 ROS had too few words - the EAE, which really needed 7 separate control loops had to make do with only 2 loops since there was not sufficient space in the ROS for them.

3. The match between the logical functions specified in the micro-instruction and the physical functions formed was not close enough (e.g., the EAE-R and EAE-P bits), making the computer hard to microprogram.

4. The IO section was very independent of the central processor; if more of it could be absorbed into the ROS control, its cost would be considerable decreased and its flexibility increased.

Good Ideas in PDP-9 ROS Structure

Several aspects of the PDP-9 ROS structure are worth retaining in a future design since they worked out so well. I might point out that even though I have made an extensive search of the literature, I have been unable to find anything useful concerning ROS structure. IBM has kept their designs secret (we do know that the ROS in the 360/30 contains 8192 words of 100 bits each, making it larger than the maximum available core memory) and the published papers contain complicated solutions to nonexistent problems.

1. branching scheme - the branching scheme, basically "oring" in the next ROS address of bits from the instruction register, IO section, keys and switches, etc., should be retained.

2. unary control - the main register controls, e.g., lead MB, are not encoded; one bit specifically controls this action. This leads to speed and simplicity.

3. maintenance loop - the idea of a wired-in microprogram capable of exercising the hard core of the machine should be expanded to do automatic checking. Such a microprogram insures that the basic hardware is working and that a diagnostic program can be run.

4. certain specific bits in the ROS - certain details of the current PDP-9 design are particularly good compromise solutions and probably want to be retained in a redesign (e.g., the SKIP flip-flop).

## Conclusions

I hope that I have not made the impression that design of an ROS-controlled computer is simple; like any engineering project, it requires a great deal of hard work and compromise. It is particularly important to insure the generality of the ROS structure so that customers or the DEC special systems group will be able to add any special functions required without hardware changes, and that the internal maintenance microprogram can diagnose the basic hardware. The project is certainly feasible since, based upon PDP-9, I would estimate that a 128-word ROS (expandable to perhaps 256 if special functions or additional instructions are to be added) with 48 bits per word would be sufficient; this is certainly within reach. Decisions on main core memory speed and multiply/divide time will have a significant impact on the structure and will, in fact directly determine the cost of building the product.

digital INTEROFFICE MEMORANDUM

DATE: March 4, 1968

SUBJECT: THE COMPUTER LAB WORKBOOK, ITS CONTENT AND SCHEDULE

TO: Ad Hoc Meeting Participants
Ken Olsen
Stan Olsen
Al Devault
Gabe Del Rossi
Joan Fine
John Hughes

FROM: John Holzer

Here is a tentative agenda for our meeting:

1. The Name "Computer Lab "; Canada wants a clarification of the rationale for using it.

2. The Technical Level of the Workbook: How high should it be? What markets do we aim to serve best?

3. Organization of the material

   a. Alternative #1: ascending complexity in each chapter
   b. Alternative #2: keeping circuitry Boolean equations, misc. hairy topics in appendices.

4. Revision methodology

   a. For first printing

      (1) Course in Canada for teachers
      (2) Gabe DelRossi for grammatical and organizational aid
      (3) Technical re-reading

   b. For 2nd printing

      (1) How do we organize the feedback process?
      (2) If we expect major feedback, should we limit size of first printing?

5. Schedule to first printing

   Is it both challenging and realistic?

6. Non-subject matter content

What?

<u>Ideas</u>

a. Order blanks

(1) For Computer Lab itself
(2) Logic Handbook
(3) Small Computer Handbook
(4) Request for an 8/S demonstration
(5) For accessories

b. How computers are finding their way into all parts of life.

Overview of the operation of a computer. How the Computer Lab teaches understanding on which computer organization is based.

Levels of computer understanding.

(1) Circuitry
(2) Logic
(3) Assembly language
(4) Compiler language (FORTRAN, FUCAL)

Computer Lab gives an understanding of (2). The 8/S education package gives understanding of (3) and (4).

c. The 8/S education package

(1) Uses
(2) Configurations
(3) Prices
(4) Applications

d. The foreword to the teacher: how to integrate Computer Lab into his curiculum.

e. Accessories List and description

f. DEC's experience in education

g. Our line of computer products

h. Index

i. How to use Computer Lab Workbook with other math, binary & logic texts.

7. Number of pages in Workbook

mdo

# DIGITAL INTEROFFICE MEMORANDUM

DATE March 6, 1968

SUBJECT

TO Ken Olsen

FROM Jean-Claude Peterschmitt

Names of persons whom you met in Paris:

CERCI

Kaufmant, President
Faure, Assistant to the President
Sahut d'Izarn, Technical Manager
Jeannin, Head of Systems Projects

CGA

Turpin, Technical Manager
Vandenbroeck, Head of Electronic Systems

At Arnaud de Vitry's apartment:

Allegre, Assistant of Galley, Administrator of Plan Calcul.

Jean Claude

digital INTEROFFICE MEMORANDUM

DATE: 6 March 1968

SUBJECT: Towards PDP-9I

TO: S. Olsen FROM: L. Seligman

In this memo I would like to present my suggestions for the re-implementation of PDP-9. My primary assumption is that it is more important to be able to produce the 9I in high volume, at low cost, and quickly than it is to provide such frills as a souped-up instruction set or customer-alterable Read Only Memory.

The suggested approach is to build the 9I from parts and ideas stolen from the PDP-8I with as little alteration as possible. This means specifically:

1. don't change the architecture at all, any changes will greatly increase development time and require major software changes.

2. use PDP-8I parts without modification wherever possible. This includes the modules, especially the registers, the cabinetry, the power supply, if possible, and the wired-in option modules. Since the architecture of the two machines is so similar, this should be easily accomplished. A 4K machine with a few IO options ought to fit into the 8I cabinet.

3. use the PDP-8 flow chart; that is, implement the various functions exactly as the PDP-8 does wherever possible, although certain functions will have to be added. Whenever such functions are added, they should follow PDP-9 practice as closely as possible. The intent here is to facilitate training of technicians, ease the shock of introducing the machine into the production line, and generally reduce the production engineering effort required. It should be possible to use technicians from one line on another; right now, this can't be done at all and the number of machines lost in the early days of production strongly affects total profit.

4. keep the negative IO bus as did the 8I. This will permit PDP-9 options to be used without change.

5. use the new 3-wire memory; it runs at less than a microsecond, is inexpensive, and matches the internal speeds possible with the PDP-8I modules. Design a new memory bus with positive signals using the PDP-9 IO bus connector which has the property that the DM09 replacement can attach to it instead of requiring a second port on the memory. True cycle stealing must still be possible.

The implication is the PDP-9I engineering effort should concentrate on building the most easily manufacturable machine rather than the most technically sophisticated machine. By building on the engineering foundation laid in PDP-8I, it should be possible to minimize development time and effort, simplify the production phase-in effort, and, generally, concentrate on polishing current practice rather than inventing new technology and new problems. Had it not been for the speed goals of PDP-9, we could have done exactly the above by stealing from the PDP-8 two years ago.

If such an approach is taken, any new development work designed to make the 8I less expensive will automatically carry over to the new PDP-9. In particular, a large module version of PDP-8 could be built in 6-bit sections so that 3 such sections could be used in PDP-9 (and perhaps 4 such sections in . . .). While the control logic of the machines is sufficiently different that boards could not be shared, a good portion besides the registers is indeed common or could be made so.

The rather serious question does arise, however, as to how much of the company's engineering resources should be allocated toward continuing PDP-8, PDP-9 type machines; I suspect that competition will eventually force us to change to more modern computer architectures and a wider performance and cost range of the products.

The design of such a wide range of products is a difficult task, especially if all are to neatly fit together in order to take maximum advantage of shared engineering and production facilities. This task is becoming increasingly important as our major sources of value added to the purchased parts becomes system design, software, and production capability. If any small computer is going to outsell PDP-8 or 9, it ought to be one of our own.

digital INTEROFFICE MEMORANDUM

DATE: 6 March 1968

SUBJECT: Attached Memo

TO: J. Jones
K. Olsen ✓
P. Kaufmann
N. Mazzarese

FROM: L. Seligman

Stan Olsen has asked me to present my suggestions in regard to the PDP-9I. I hope you may also find some of the ideas useful.

Attachment
jeh

digital INTEROFFICE MEMORANDUM

DATE: March 11, 1968

SUBJECT: TU-79 MECHANICAL DESIGN REVIEW

TO: R. Antonuccio
cc: R. Best
R. Denaro
K. Fitzgerald
Distribution
J. Godbout
J. Jordan
D. Sullivan

FROM: Joe Sutton

Thank you for your report on the mechanics of the TU-79. I agree with your conclusion that the TU-79 will be a good selling and reliable unit which will make money at the $21K price.

I have reviewed your suggestions and cost saving proposals. Seven out of twelve of these suggestions are being worked on to be introduced before production. The total cost saving of these items is $633.

I have checked your arithmetic and estimates on the other proposals. I have evidence (quotes) and reason to believe that the possible savings would amount to less than $150. Please see list following for specifics. These suggested changes are also the hardest to put in. We plan to reconsider these after production starts.

A foul blow was found on the last page of your report where you added 10% to our present costs for oversights but adjudged yourselves (the committee) as above oversights and did not add 10% to your estimates before totalizing.

Distribution:

K. Olsen
B. Savell
P. Backholm
P. Kaufmann
D. Knoll
J. St. Amour
L. Prentice

1. Vacuum Column Assembly

Please see attached quote for complete machined and assembled columns. Better purchase these soon before the wild inflation you envision sets in. See that Phil's estimate of $140 a pair is substantiated. Your proposed saving is then $60. We will review extrusion after production release.

2. Power Supply Assembly

In your calculation of present power supply costs you showed power supplies for both a 50 cps and 60 cps version combined (twice as many supplies as one machine needs). The proper sum for a 60 cps machine is $256.

You have shown the cost of a different supply made in much larger volume than TU-79. I judge the most we might save to be:

$256
-225
$ 31

We will look into this after production.

3. Cabinet Assembly

We have not yet discarded this idea of a door. We are still considering it.

4. Logic Assembly

Redoing the logic to fit on different panels takes effort which is best used in other ways. A recount of modules shows more than 128,so it won't fit on two (2) 1943 bars anyway.

5. Harness Assembly

We will be simplifying this as you have suggested.

6. Vacuum Assembly

This is a change to the tape handling vacuum system and changes will invalidate completed tests. It only saves $35 if that.

7. Tape Deck

We are incorporating your suggestion.

8. <u>Write Lockout Switch Assembly</u>

We are looking into this as you suggested.

9. <u>Fixed Reel Assembly</u>

We are doing as your suggested.

10. <u>Pivot Arm Assembly</u>

We will do what you suggested.

11. <u>Manifold Assembly</u>

Our earlier policy statment on changes to air or vacuum system and the small cost saving (if any) leads us to reject this at this time. Possible saving - $10.

12. <u>Unit Assembly</u>

With all the changes we have agreed to we should save money here, too.

We are trying to incorporate suggestions 3, 5, 7, 8, 9, 10, 12. Possible savings - $633.

We do not intend to put in before production suggestions 1, 2, 4, 6, 11.

<u>Revised Estimates of Savings for these Suggestions</u>

| Item | |
|---|---|
| 1 | $60 |
| 2 | 31 |
| 6 | 35 |
| 11 | 10 |
| | $136 |

ARTISAN

ARTISAN INDUSTRIES INC.

73 POND STREET, WALTHAM, MASSACHUSETTS 02154 • TELEPHONE: (617) 893-6800

Mr. Lee Goodbar
Digital Equipment Co.
Maynard, Mass.

DATE: March 6, 1968

ATTENTION: Mr. Phil Backholm / Mr. Lee Goodbar

OUR NO.: 68-8580

SUBJECT: Vacuum Column Assembly

*Gentlemen:*

*Thank you for your inquiry. We are pleased to submit this quotation for your consideration:*

| ITEM | DESCRIPTION | PRICE |
|---|---|---|
| | *All Quotations, Contracts and Sales Subject to Conditions on back of this Sheet* | |
| A | 1 - R.H 7005579-1 (Lots of 25) | $70.00 each |
| B | 1 - L.H. 7005579-2 (Lots of 25) | 70.00 each |
| C | 1 - Retainer Vacuum Column 7406228-0-0 (lots of 50) | 10.00 each |
| D | 1 - Clip, Glass Retainer 7406225-0-0 (lots of 50) | 2.00 each |
| E | 1 - BOT-EOT Sense Block - 7406216-0-0 (lots of 25) | 8.00 each + $200.00 for tooling |
| F | 1 - Vacuum Tank - 7406128 (lots of 25) | 39.60 ea |

☐ *Confirming Verbal Quotation*

☒ F.O.B. ~~WALTHAM FACTORY~~ Maynard, Mass.

TERMS: ½% 10 DAYS NET 30 DAYS

WEIGHT:

DELIVERY:

*This opportunity of quoting is appreciated. Your order will receive prompt attention.*

*Very truly yours,*

ARTISAN INDUSTRIES INC.

Anthony W. Citro

vg

digital INTEROFFICE MEMORANDUM

DATE: March 12, 1968

SUBJECT: LIGHT PENS

TO: Ken Olsen

FROM: Len Halio

CC: Pat Greene
Nick Mazzarese

Re: Your Memo of March 1st Concerning Light Pens

I have checked various semiconductor photodiodes and to date only one looks at all promising. This is the PIN photodiode manufactured by Hewlett-Packard. The response time is quoted at less than 1 nanosecond. Cost is about $13.00 in the quantities we would use.

Furthermore, very flexible light pipes using plastic fibers are available with wires placed within the bundle. These pipes are extremely flexible (I have tied five knots in a sample pipe with no problems), cost less than glass, and have only slightly less light transmissibility.

I would envision a pen using a combination of both a PIN diode and a plastic fiber light guide. The pen itself would consist of a slim holder with a sensitive micro-switch (I have a model now) where the index finger normally falls. The pen would have a removable lens with a focal length of about one inch to both restrict the field of view and to allow the pen to be used without blocking the screen.

The light guide itself will be both an incoherent center bundle and a coherent coaxial bundle. These sections will be broken out separately. A light bulb will shine into the coaxial bundle causing a circle of light to appear on the screen indicating both the field of view and when the pen is in focus. I believe this "feedback" is important to the operator. The dual bundle costs about the same as a single bundle.

The diode will be mounted on a FLIP-CHIP card along with its associated amplifiers. Since the photodiode is shock sensitive, I believe the controlled environment of the display is better suited than mounting the diode in the pen where it would be subject to falls, etc.

Design of the electronics of the pen would overcome present problems in the Type 370; namely false triggering on noise and after-glow. By keeping the gain and signal lines separate, noise induced on the lines running to the gain control will not give false pulses. Furthermore, the pen will be made sensitive to fast rise time light pulses only, and the longer after-glow will not cause a problem.

Both +5V and -3V pulses will be brought out allowing the pen to interface directly with existing and new equipment.

Selling cost of the pen would be approximately $900.00. Manufacturing cost would be approximately $250.00.

Len

/ds

c- Ken Larsen 4/23

COMPANY CONFIDENTIAL

digital INTEROFFICE MEMORANDUM

DATE: March 19, 1968

SUBJECT: ARPA CONTRACTORS' MEETING, MARCH 13-15, SALT LAKE CITY

TO: ✓Ken Olsen
cc: Nick Mazzarese
Stan Olsen
Win Hindle
Ted Johnson

FROM: Gordon Bell

The above meeting is the second one I have attended. I don't believe there is conflict in conveying my impressions of this meeting to you in this unsolicited fashion, but I'd just as soon not be quoted.

To begin with, "the group" was initially formed by Leih Aider, was run by Ivan Sutherland, and now has Larry Roberts. Actually, the control at this point is under Bob Taylor, a techno-politico-administrator. The present club is:

BBN - Elkind - (Have SDS 940, getting a PDP-10).
UC (Berkeley) - Pirtle, Lampson - (SDS 940 inventors, now working on a super 940 - (5 - 10) x 940, the 6700).
UCLA - Kleinrock (Queing theory) and Estein - (SN00 per computer).
UC (Santa Barbara) - Culler
Case - Glaser - (to get a PDP-10?)
Dartmouth - Kurtz - (GE Basic Time-Sharing System).
Carnegie-Mellon University - Perlin - Newell
Harvard - Oettinger, Ivan Sutherland (Ivan's going to Utah).
Illinois - Slothick - (ILLIAC IV) - Bruce McCormick - (ILLIAC III).
Michigan - Westervelt, Herzog - (Have 8's, 9's, 360/67, Interdata).
Lincoln - Stockham, Bert Sutherland
MIT - MAC - Licklider, Corbato
MIT - MAC-AI Group - Minsly, Papert - (PDP-6)
RAND - Uncapher, Ellis - (committed to IBM).
SDC - Schwartz
SRI - Englebart, Raphael, Shapiro - (Information Retrieval, Robots, Network).
Washington University - Clark - (MACRO modules).
Utah - Dave Evans - (graphics).
Stanford - McCarthy
ARPA Office - Taylor, LuKasik, Roberts, Barry Wessler.

There was little noticeable change in status from last year. There are some specific points which may be in DEC's interests:

1. Taylor would like an explanation as to why DEC is not in the GSA catalog. It would be much easier to buy computers.

2. DEC seems to be the most favored manufacturer. The PDP-8's and 10's are favored machines. People would like some paging hardware on the PDP-10. With the exception of SRI, UC (SB), Lincoln, and SDC, all have some DEC machines. I hope the trend continues.

3. The group who designed the Berkeley time-sharing system based on an SDS 930 (the SDS 940) is working on a computer called the 6700. It will be fabricated by SCC, Bryant, and UC (Berkeley). Though it will be two years before it runs, the machine looks to be the most promising time-sharing computer being designed. SCC undoubtedly can't pull it off. UC has been talking to CDC (at about the Norris level) of possible interest. UC isn't happy with SDS's botching of the 940 system.

4. Wes Clark feels he's about one year away from having a reasonable inventory of MACRO modules. They look good to me. Wes, LuKasik, and Taylor are all interested in the transfer problem (ethics and problems of moving a design to a company). Apparently, IBM is also interested, and there is no doubt that DEC is interested. A very soft sell involving the above three and L. Roberts would be a nice gesture. This is more complicated since NIH owns part, too.

5. ILLIAC IV is a wild machine, and though I don't consider it buildable, it will help push the technology. A year ago, I felt Dan Slotnick was too paranoiac to pull the machine off. Now I feel that if it comes off, it will be because of his personality. (I am beginning to be rather fond of him.) It's slipped from a full machine in January of 1970 to one-quarter of the machine then. It has to slip more because of Burroughs (Paoli). (I recently worked with USS to have a look at the two-year overdue Burroughs Paoli B8500 and don't find them an exciting group.) Needless to say, Dan doesn't appreciate my saying, "ILLIAC IV in 1974."

6. The ARPA Network project is being carried out by Roberts, though UCLA, SRI, UC (SB) are also helping. (If we are ever forced to lose part of the club, I'm prepared for this set to go.) DEC has a chance of supplying either an 8/I or 9 for the Network now up to about 15+ computers. They may rule out the 8/I, and there's a bit of a bias against 18 bits (as opposed to 16 bits). The building is going to be on a total system's basis with a vendor supplying both hardware and software. It is important to stay clear of the impossible software here, I suspect. Western Union may bid on the whole thing, too.

7. Hendricks Electronics (somewhere in New Hampshire) is building a display for UC (Berkeley) that looks quite interesting. I don't know if DEC is thinking about the terminal business, but this company might be worth looking at. Everyone there was very interested in graphic terminals. I believe this to eventually be a significant market, and it seems worth building up a group in the area.

8. RAND has been working with IBM, using an 1800, video disc, and standard 800 line TV. Their console, which can handle RAND tablet, printer, etc., looks pretty good. I'm sure you could get some arrangement with MIT, us, or anyone else for an order for a first few terminals so that users get in on the design of the terminal. (A display

group should contact Uncapher or Ellis at Rand.)

9. I'm impressed with Dave Evans (Utah), and hope that some of the V-P's can stop by and talk with him sometime. He's got a reasonable grasp on where we're headed and when. Ivan is going there. Their inputs on graphic terminals will be valuable.

10. There is a chance of a significant sale to UC (Berkeley) of a pile of PDP-9's. Butler Lampson, of the crew who developed the 940 system, believes, as I do, that small time-sharing systems have a lot to recommend themselves around these environments. He likes the idea of the PDP-8 time-sharing system, which may or may not be connected with a larger system. He would rather have a PDP-9 though, because of not too much more dollars and more power.

    Therefore, I recommend that he be approached immediately with the possibility of buying such systems for UC (Berkeley). He is now very enthusiastic, and can be sold, particularly if he thinks DEC is interested in making lots of these and pushing them. I would hope that he might possibly consult for DEC in this regard. Possibly, DEC might farm development out to UC in return for a large order. Lampson, I believe, would like to see DEC get on a bit at Berkeley. He's young and competent (I won't make that statement about all ARPA contractors). I doubt if he can be gotten away from UC (Berkeley) or a university, but it might be worth trying. I'm going to try to get him at CMU.

11. The communications market is just beginning. The Network contract would be very valuable to get. I would like to see some brainstorming on the problem of communications processing for: typewriter (100 - 200 bits/second), scopes (2,000 - 4,000 bits/second), and high-speed computer (50,000 bits/second).

    I now am not convinced the PDP-8 680 approach is right for the technology. There is also a problem of what to put on the 9 and 10, especially at the higher speeds.

    Therefore, I would like to see an inter-product line group (like tape group) to work on general problems for all machines, and also marketing for systems in this area. The UC (Berkeley) 940 group is interested in some kind of a communications processor for their 6700. It would be worthwhile talking with Lampson and Pirtle in regard to it because they just might want to buy it from DEC.

12. LRL-Livermore (Conn, a programmer) was there and is programming an SDS Sigma 7 for time-sharing (one of many such attempts, including UCLA). He says their paging hardware ("made by Livermore") on PDP-6 isn't too reliable.

13. Multics (Corbato) reported for the first time. They have problems, but Corbato thinks they're under control. The hardware isn't the greatest ever.

14. Dartmouth (Kurtz) has another GE kludge (GE-635). I can't see why he persists in buying them... or why a 10 won't do, as he complains about GE's hardware, software, etc.

Gordon Bell

ecc

# INTEROFFICE MEMORANDUM

DATE: 19 March 1968

SUBJECT: PDP-9I Memory Bus

TO: G. Butler

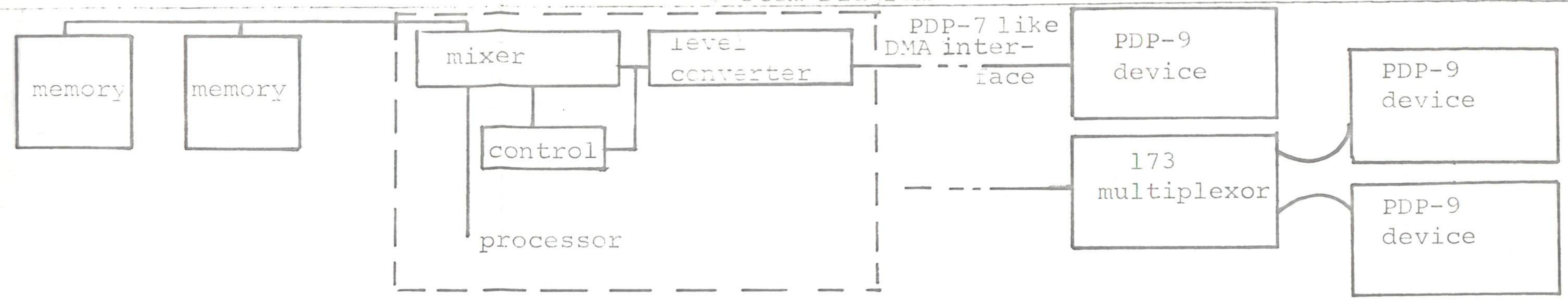
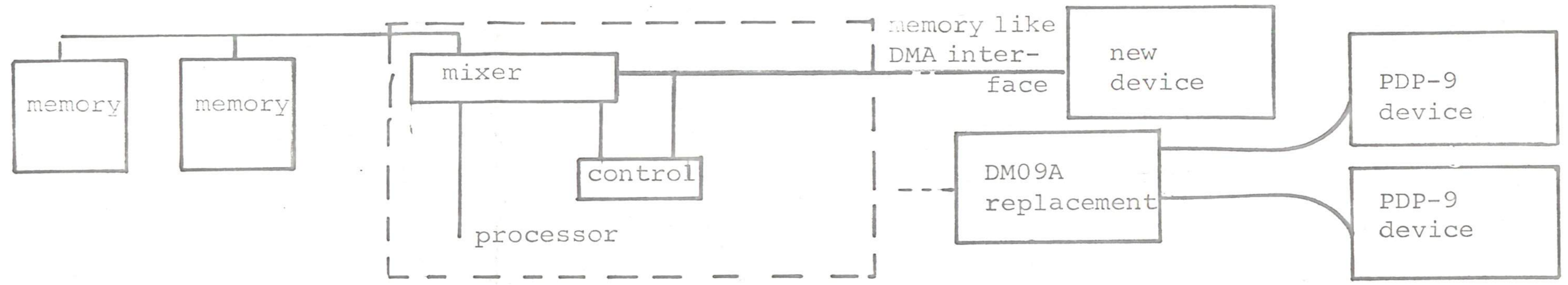
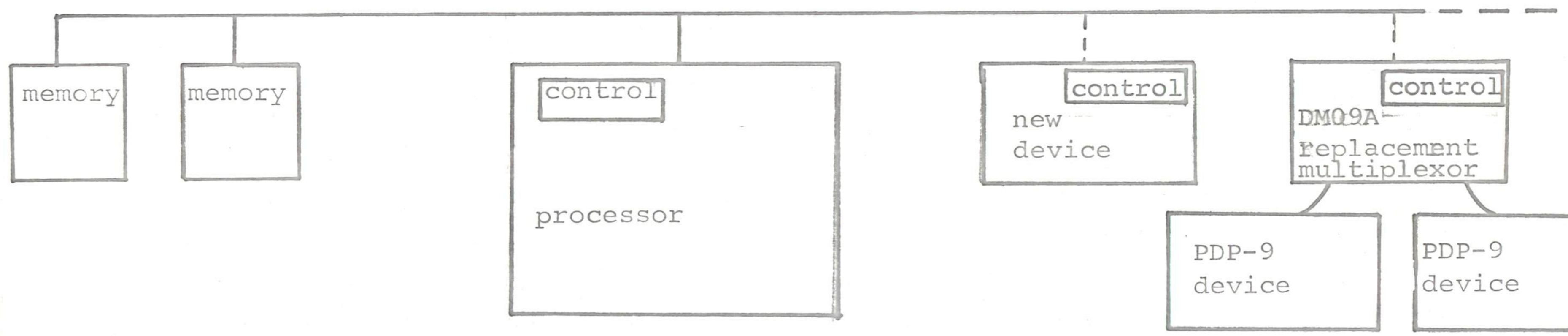
FROM: L. Seligman

CC: K. Olsen ✓
S. Olsen
J. Jones
R. Sogge
D. Vonada

In an earlier memo to S. Olsen, I suggested that one way to reduce the cost of the PDP-9I was to design a new memory/processor interconnection scheme that would retain the advantages of true cycle stealing while eliminating the cost of having two ports in each memory. I have done further work along these lines and have come up with the three ideas outlined in the chart on the next page. I omitted all ideas which would not permit true cycle stealing (e.g., sharing the IO bus lines) since the disk requires it.

You ought to look this over carefully and if you think my choice is reasonable, we can work out the details together.

Attachments
jeh

| # | Scheme | Advantages | Disadvantages | System Diagram |
|---|---|---|---|---|
| 1. | Build DMA port into processor as in PDP-7 except make true cycle stealing | Simple control; accepts current PDP-9 options; use type 173 multiplexor; simplest interface | Multiplexor required when more than 1 device; radial system with expensive cabling; considerable logic required in processor, including level converters for negative logic bus |   |
| 2. | Add a port to the processor that makes it look like a memory | Devices could hook directly to memories or through processor; simplified cabling; simpler interface than the one below | Adapter required to interconnect current PDP-9 devices; multiplexor required when more than 1 device; radial system with many cables in large configurations; considerable logic required in processor |   |
| 3. | Continue memory bus out to the devices; multiplexor distributed among devices | Devices could hook directly to memories or through processor; simplified cabling; requires least hardware; no multiplexor required | Adapter required to interconnect current PDP-9 devices; fairly complex control logic required in each device |   |

Of the three alternatives, I would choose the last for the following reasons:

1. the cabling is simple and the total amount of logic required is the least of all the alternatives

2. no multiplexor is required for new-device designs

3. compatibility is not a real problem since there are only three DMA devices offered with the PDP-9: the disk, the 340 display, and the 338 display. Since both the 340 and 338 already have interface units to connect them to the PDP-9, these interfaces could be easily converted to the new scheme without changing either display itself. The current disk is quite expensive and we would probably do well to redesign it to use IC's and an in-house mechanism.

4. the other alternatives have distinct disadvantages. It seems pointless to continue a negative logic DMA interface in the light of the positive logic components with which we will be building devices and processors. The second alternative has all the disadvantages of the other two.

5. with IC's and larger boards, it should be possible to package the whole interface logic for the third scheme on one card much as we did for the PDP-8 in building the W103 or for the PDP-9 in building the W104.

When large board versions of the PDP-8 and PDP-9 are built, they can <u>both</u> use this memory interface scheme, making it possible to share memories (the standard DEC memory?), certain IO devices such as the 338 replacement, and certainly a great many module types. If it proves sufficiently inexpensive, we may be able to use it for the positive IO bus. If all our products used similar interfaces, it would be far easier for customers, technicians, salesmen, and field servicemen to understand the operation and design of all our computers.

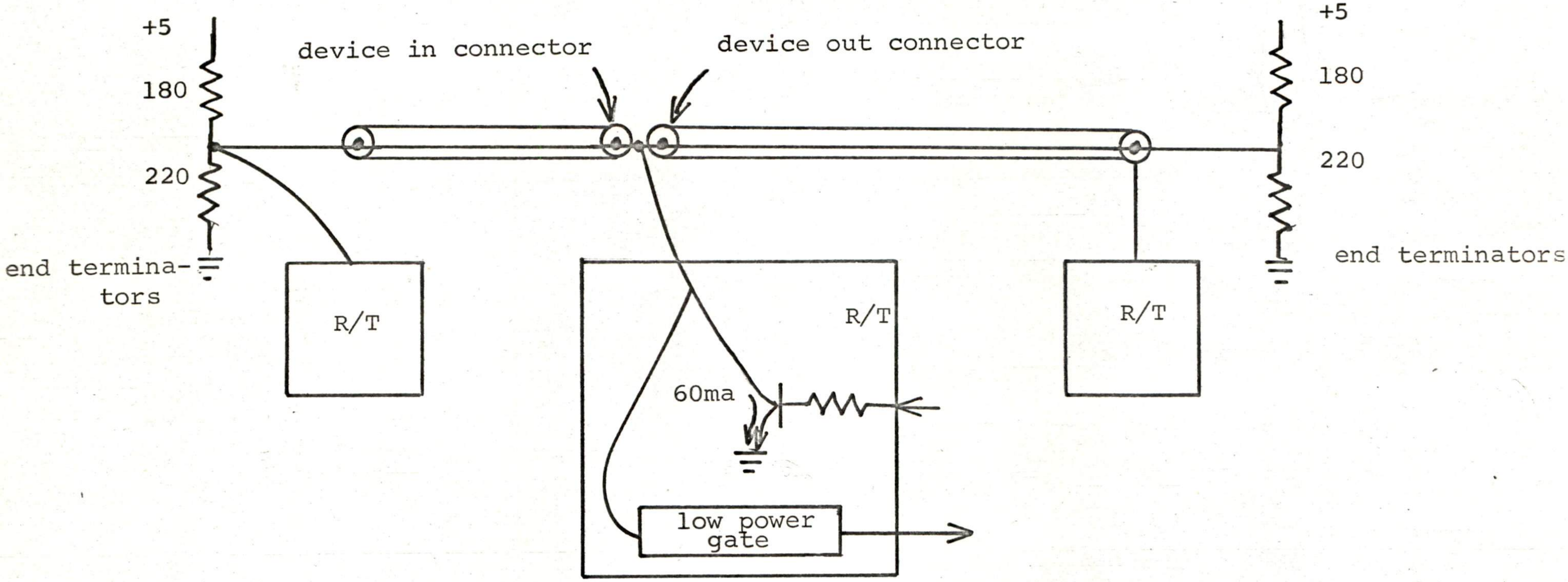
## Logical Properties of the Memory Bus

We have designed a great many such busses in the past and any reasonable scheme can form the basis of this new one. The additional complexity involved in this scheme is that during memory re-write, the system must determine which one of the several devices and processor that require use of the memory is to be selected. The problem is similar to determining which of several devices is requesting service on the PDP-9 data channel.

The solution can also be similar; use of a signal with the properties of the "priority" signal on the PDP-9 bus. Operation would be as follows. After each memory loaded its MB and began re-writing, it would send a signal down the bus to the first device (or processor); this device would either forward it or block it depending upon whether it required service or not. The device so selected would then send its address and control signals to the memory; the memory would start the requested new cycle as soon as it finished the old one. Several schemes are possible to circumvent the problem of physical ordering determining priority; the one used by IBM on their channel busses is a reasonable alternative for us to use; it is both simple and efficient.

## Electrical Properties of the Bus

For this scheme to work well, the bus must be reasonably clean; that is, there should not be reflections or steps in the signals due to impedance mismatches. Dick Sogge has suggested a good system using a single transistor as driver and a simple receiver, perhaps a low current gate, as pictured on the next page. Since there will be fewer than 36 wires on the bus (18 are bi-directional data/address, the rest are control) either PDP-8 W021-coax-W021 cables or one PDP-9 twisted-pair cable (without the clamps) may be used.


+5
180
220
end termina-
tors
device in connector
device out connector
+5
180
220
end terminators
R/T
R/T
R/T
60ma
low power
gate

# INTEROFFICE MEMORANDUM

DATE: March 21, 1968

SUBJECT: "FOOTS"

TO: Ken Olsen

FROM: Tom Stockebrand

cc: Joe the Saint
Bill Owens

I asked Norm to lay out some boards with the various techniques:

1. I.C. rigid layout as for plastic module
2. Eyelets as through connectors
3. Plated Through Holes as through connectors (no wires between tear-drop pads)
4. "Foots" for top soldering

Conclusions:

1. The best scheme is PTH with tear-drop pads. It gives .018" copper around the holes rather than .009" in the I.C. board case. In the high density boards, double drilling (in which drilling is accomplished for only the holes which need be plated through) followed by a second drilling step after plating, will considerably increase the density by avoiding the worries about plating "collars" around the through holes.

2. The "foot" does save drilling holes and is no worse for layout (I was wrong), but it uses a lot more area and is second in our judgment.

3. Forget eyelets

4. Forget rigid I.C. layout unless the plastic module comes along. It is already wasting us considerable drilling money.

Details:

The 4 layouts enclosed are layouts of a simple (M113) board to illustrate some of the points made above. There is no question that we have not learned everything until we have laid out an extremely complicated board, but most of the extensions of our ideas seem perfectly straight forward. It's plain to see that the top-soldered I.C. with "foots" uses very considerably more area than the other scheme. It does use the fewest holes (31 versus 47 versus 58 versus 72), but the ratio is like one-half rather than one-fifth or one-tenth the number of holes. Insertion will be much slower with this scheme, though removal, repair, and replacement is obviously considerably easier. I was surprised to find that Norm feels that, with the tear-drop shaped eyelets, he could probably get away from wires in between lands anyway in most boards. A more complete discussion of this problem will follow as more data turns up and the dialogue continues.

Tom

bt

Enc.

digital INTEROFFICE MEMORANDUM

DATE: March 25, 1968

SUBJECT: DR. WEID, CYTOLOGIST - UNIVERSITY OF CHICAGO

TO: Ken Olsen

FROM: Mort Ruderman

cc: Win Hindle
Bill Sewalk
Bill Karavatos
Tom Quinn

I visited with Dr. Weid on March 7th to extend our customer relations and learn more about the use of computers in cytology. Dr. Weid was given his computer by Bausch & Lomb, and they hope to eventually market a computer controlled microscope system. Dr. Weid has two of these systems operating, one by Zeis and one home-made. He has made significant advances in the diagnosis of cancer cells with these systems and is, therefore, amply funded and much sought after by manufacturers of microscopes and other associated equipment, such as IBM.

He is quite happy with DEC and especially with local support by field service and sales. However, he is quite status conscious and needs more recognition from top management at DEC (and I am sure eventually will need more equipment, loans and discounts). He has asked for a direct line to Maynard for support and preferred delivery when required.

He is not asking for any of this now, and might be setting us up for the hill. However, I suggested that we would cooperate with him. I told him if top management was in Chicago they would drop by to see what he was doing, and if he should be in Boston he could visit with them. I also promised to listen to any request he may have of us, and agreed to do all we could to assist him.

I am asking you to cooperate since he is both Bausch & Lomb's and Zeis's key to offering DEC's computers as OEM. He is a highly respected cytologist and is sponsoring a two-week Tutorial next August for 200 cytologists. He will demonstrate his work, at this Tutorial, on the LINC-8 and is allowing us to participate in any way we wish. To boot, he will be spending in the vicinity of 30-50K immediately.

digital INTEROFFICE MEMORANDUM

DATE: 3-25-68

SUBJECT: G. E. Tempo
Santa Barbara

TO: K. Olsen

FROM: J. Lessard

Have written software to identify numerical characters with light pen as writing media. Believe they can develop photo electric character recognition device?? with some financial assistance. Claim character rate of 1200/minute, (dependent on character size). Claim character recognition is independent of "slant", write jitter, embellishments or position.

Both individuals seem to be very vague about what an association with DEC would be?? May be looking for financial backing or contract with DEC to complete development?? G.E. could have a vested interest. They are unsure of G.E. interest or release of interest?? Market possibilities of reading zip codes for P.C. Reading account numbers and charges on credit cards, etc.

Does DEC wish to pursue this situation - primarily accounting - or show no further interest.

encl

Jerry

digital INTEROFFICE MEMORANDUM

DATE: 28 March 1968

SUBJECT: A 16-bit PDP-8

TO: K. Olsen ✓
S. Olsen
N. Mazzarese
J. Jones

FROM: L. Seligman

See attached.

jeh

L. Seligman
3/28/68

## Introduction

I have recently read some papers describing the techniques of emulation as they have been applied to ease the problems of the introduction of new computer systems that are incompatible with older systems. An example is the 7094 emulator package available on the 360 Model 65 which is currently in use at MIT to run all 7094 batch jobs. Although there is considerable difficulty in emulating a 7094 with a 360, both because of the vast structure differences and the longer word length of the 7094, the ROS structure of the 360 coupled with the introduction of a small amount of special hardware makes emulation practical.

This memo proposes the application of an emulation technique to small computers; in particular, it describes a 16-bit computer (to be called PDP-?) derived directly from PDP-8 which can emulate the latter. Since the structures of the two machines are so similar and the word length of the machine to be emulated is shorter, emulation will not <u>require</u> either ROS control or a great deal of complex hardware.

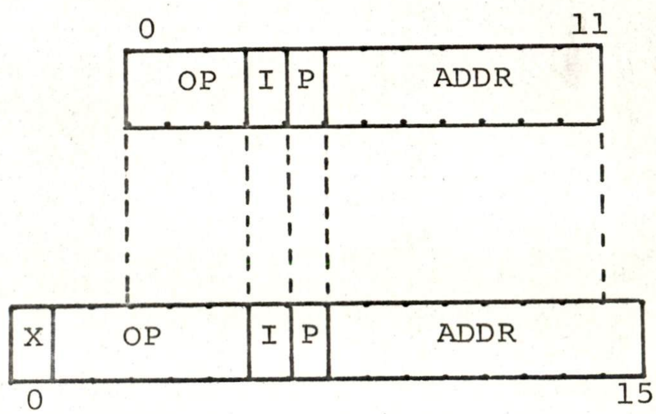
## PDP-? Architecture

The architecture of the PDP-? is a straightforward extension of the PDP-8. The opcode bits are increased as is the page size; indexing is added. The IO system remains basically the same; the word length is lengthened to 16 bits, but it remains a parallel transfer system with IOP pulses, rather than a byte bus. (The goal there is to insure that Digital's customers and salesmen will have no difficulty designing their special IO devices.) The instruction set is chosen so that it includes the PDP-8 instructions as a subset.

The rest of the instruction set I leave to its designer. Clearly, LAC and DAC instructions should be added, as well as Load Index, Store Index, and Increment Index; SUBtract and decrement memory would be useful if they could be economically implemented. Sixteen opcodes would then still be open, certainly they are enough to satisfy complaints about the PDP-9 instruction set.

PDP-8 instruction

PDP-? instruction



## Emulation Goals

By emulation of the PDP-8 I mean the ability of the 16-bit computer to run binary PDP-8 programs directly, including most IO, at speeds approximating actual operation of the 8. EAE instructions, extended memory, and IO devices like DECtape would probably have to be simulated rather than emulated because of the complexities involved; other instructions would proceed at the full memory rate of the 16-bit computer.

Since all basic PDP-8 programs will run without change, the PDP-? can be introduced into applications currently using the 8, but requiring, ultimately, a larger machine. Since the non-data break devices also connect directly, many applications packages currently available for the PDP-8 would be usable on the larger machine and could be supplied until newer programs were developed. New 16-bit software for the 16-bit machine must be developed, however.

I chose to emulate the PDP-8 rather than the PDP-9 because of the aforementioned difficulties with longer word length and structure differences. To match the speed of the PDP-9, the 16-bit machine would need a 32-bit memory system, considerable instruction decode hardware, about a 25% faster internal operation speed (adder and transfer bus), and certainly ROS control. It would be particularly fast when running normally, perhaps it could achieve a 750 ns effective cycle with two basic 16-bit 1 μs memories. Such a machine could be program compatible with the PDP-8 emulating machine and, therefore, could be the largest member in a 16-bit family. The smallest member of the family would be a bare minimum, yet program compatible, 16-bit machine lacking emulation hardware.

## Emulation Method

The design of an emulator package requires the solution to two highly-related problems. The first relates to the image of the emulated machine within the emulating machine, the second to the ratio of hardware simulation to software simulation of the emulated machine.

A PDP-8 data word or instruction is stored in bit positions 3-14 of the PDP-? word. Data words are kept in sign extended format, that is, bits 0, 1, 2, 3 are all the same, bit 15 is set to zero. Such a storage format requires the least additional hardware for PDP-8 instructions to execute properly. The PDP-8 rotate instructions will be troublesome. When inputting IO data, a left shift and sign extension are required, when outputting IO, a right shift is required; since the transfer bus organization provides the shifting hardware anyway, such operations will not be expensive.

In order to achieve highest speed, almost all of the PDP-8 operation will be accomplished by hardware. That is, when in "emulation" mode, the PDP-? program counter represents the position in the PDP-8 program the machine is emulating; essentially all instructions are implemented in hardware. This technique insures that the PDP-? can execute PDP-8 code at the same rate as the PDP-8 does. Since the structures of the two machines is so similar, little additional hardware is required; bits 0, 1, 2 of the instruction word are ignored; and certain instructions, such as EAE, will cause traps. During address generation, the processor will have to shift the generated address right one bit position to keep it consistent with the address generated when not emulating.

## Conclusion

PDP-? as described above can stand on its own as a reasonably simple, yet sufficiently powerful, computer to replace PDP-9. Its ability to emulate PDP-8 and PDP-8 IO devices make it a particularly attractive product; with good systems design it can form the basis for a family of program compatible 16-bit computers. The design problems are not simple, however, if a good, inexpensive design is to be achieved; the above description can only be construed as a general approach which is subject to many troublesome details as the design proceeds.

→ Jerry

# digital INTEROFFICE MEMORANDUM

DATE: March 12, 1968

SUBJECT: General Electric Tempo

TO: Gene Olson
cc: Nick Mazzarese
Ted Johnson

FROM: Ken Olsen

Dr. Harry P. Kramer, Post Office Drawer Q Q, of General Electric Tempo, Santa Barbara, California 93102, called to tell me about a character recognition system they have developed. He uses a PDP-8 and light pen display, makes a thousand of each character, and can read 20 characters per second. This work is developed on the D. A. funds of Tempo.

He is going to be in this area in March, and would like to demonstrate the system to me. I mentioned, however, that I plan to be in California during the next couple months and will probably stop in to visit him.

Will you have someone visit him soon to develop an idea of whether the system is worthwhile and whether they are offering the system for us to exploit commercially. These are Government funds and the work may belong to the public domain or to G.E. He is very definitely academically inclined.

He asked if we had any equipment to lock the characters on a printed page that he may use in his system. I suggested that he call John Busby at Optical Scanning.

He says that Westinghouse has a PDP-8-driven TV camera which he would like to use for his project but is not able to afford it.

Ken

ecc

Moore

DAVID KARPELES
1169 Summit Rd.
Santa Barbara, California
969-3983

Telephone: Area Code 805 - 965-0551 ext. 415

HENRY KRAMER
1503 Mission Canyon Rd.
Santa Barbara, California
965-5374

Telephone: Area Code 805 - 965-0551 ext 481

KRAMER

# New IBM Machine Reads Hand Printing To Feed to Computer

* * *

## Firm Unveils First Commercial Model of Scanner Accepting 15 Hand-Written Characters

*By a* WALL STREET JOURNAL *Staff Reporter*

NEW YORK—International Business Machines Corp. introduced its first commercial model of a machine that reads 15 hand-printed characters—the 10 digits and the letters C, S, T, X and Z.

IBM and others have been working for several years on experimental optical scanners that can accept hand-printed characters for processing by a computer. IBM tried out one version of the machine last year in its pavilion at the New York World's Fair.

Now, after field-testing by a department store and a utility, IBM is offering the commercial model for delivery in the first quarter of 1968. The new IBM 1287, which also reads machine-printed and credit-card printed numbers, is priced at $162,000 and up, or may be leased for $3,600 a month and up, not including the computer.

IBM and others make optical scanners that recognize a wide variety of machine-printed characters. IBM's top model of this type, the 1428, can be leased for about $3,200 a month.

The new machine is aimed at processing sales checks, meter readings, and other documents without having a clerk translate them into punched cards or some other "machine-language" form. The IBM 1287-II, priced at $180,000, accepts cash-register and adding-machine rolls, as well as individual documents.

The new machine uses a curve-following beam that traces around the outline of a character in order to identify it. Some restriction is placed on the shape and size of the charcter to be printed, but this isn't a handicap, IBM said. The five letters were chosen because they were commonly used for coding on documents, and are relatively easy for the machine to identify.

# INTEROFFICE MEMORANDUM

DATE: April 8, 1968

SUBJECT: Board Master Display

TO: Ken Olsen

CC: John Jones
Henry Crouse
Lon Beaupre

FROM: Paul McGaunn

Per your request for information on the Science Associates Message Board, I have received the following information. The unit displayed at the IEEE Show was a 6 line 43 character unit developed for Dow Jones news service and selling for 5 to 6 thousand dollars including the electronics to run directly from a teletype. A system with 8 lines and 72 characters per line would take approximately 4 months and sell for roughly $10,000.00. They inform me that a brochure describing their capabilities was mailed to your attention on April 2.

They have 2, 6 line 43 character units that we may be able to borrow on a short-term consignment. The individual I contacted was Mr. Donald Green.

341

Paul

Ken
It would seem as though we used 15-20 lines for most programs (43 characters should be O.K.) therefore 3 - 6x43 units = $18,000 - this seems too expensive

Nick

DIGITAL EQUIPMENT CORPORATION • MAYNARD, MASSACHUSETTS

K. Olsen

digital INTEROFFICE MEMORANDUM

DATE: April 9, 1968

SUBJECT: DIL INTEGRATED CIRCUITS, REFLOW SOLDER VS INSERTION

TO: Distribution List

FROM: J. St. Amour

Modules with DIL integrated circuits should be assembled by a common method. Within DEC there are two schools of thought regarding the better method and we must reach agreement by April 15, 1968 in order not to delay planned new product schedules. My comments are listed below followed by a summation of difference between the two methods.

Please review and prepare comments. A meeting will be scheduled before Monday, April 15, 1968 to reach a common agreement.

The only items assigned a cost value are those easily measured and for which a minimum difference of opinion should exist. These show reflow soldering techniques .0124 per IC more expensive than inserted IC's.

Solder plate and solderability (item 3) and touch-up (item 7) are factors which can account for considerable cost difference in the two methods. The needs for greater control over solderability, control over the amount of solder used, control over machine settings and tip cleanliness and the visual inspection problems with reflowed joints indicate greater expense with reflowed joints.

Circuit layout problems (item 5) give a slight advantage to the reflowed technique. Two drilling setups for the insertion technique will allow the majority of cases to have similar line widths and spacing as for reflowed construction. The loss in top side layout area for reflowed technique should affect only a small number of modules.

The same tool will allow repair of a module without damage to printed circuit board or IC. The tool is probably more expensive than required if our only concern was reflowed construction.

Information previously distributed on this topic is also attached.

| | | Equip. Cost | Cost |
|---|---|---|---|
| **A.** | **REFLOW SOLDER** | | |
| 1. | Solder leads on IC--necessary to insure solder at assembly. | | |
| 2. | Reform and trim IC leads (might be available in this form from vendor). | 15K | .002/1 =.012/mod[2] |
| 3. | Solder plate PC board--thickness .0015 to .002--solderability is critical. | -- | -- |
| 4. | Drilling PC board (requires 50% less holes) Avg 150/module. | -- <br> -- | (save) .03 mod. |
| 5. | Circuit layout problems--requires more space per component on component side, have more available space on etch side. Must be sure pad sizes are similar for consistant heat sink and thereby good soldering. | -- | -- |
| 6. | Repairability--easier than inserted IC. | -- | -- |
| 7. | Touch-up--more expensive due to problems with control-solderability and solder thickness. | -- | -- |
| 8. | Assembly rate--300 per hour maximum cost each machine 12,000. <br><br> FY1969[1] requirements need 5 machines for equipment investment of 60,000. | -- | .020 eachIC =.12/mod. |
| **B.** | **INSERTION TECHNIQUE** | | |
| 1. | Solder leads on IC--not required. | -- | -- |
| 2. | Reform or trim IC leads--probably required to raise height of IC on board for ease of removal | 10K | .002/IC =.012/IC |
| 3. | Solder plate--not required (any savings minimum as solder plate .001 is part of PTH process). | -- | -- |
| 4. | Drilling--2X as many holes, extra drilling setup preferred after etch to allow for larger pad size. | -- | .005 extra/ mod. |
| 5. | Circuit layout problems--see drilling comment under item 4. | -- | -- |
| 6. | Repairability--tool developed by DEC will do job. | -- | -- |

---

1. Base on 300,000 IC per month.
2. Base on Avg of 6 IC's per module.

7. Touchup--joint inspection simpler, all joints at once in solder wave. -- --

8. Assembly rate 1000 per hour. .006 each IC = .036/mod.

   Cost each machine 15,000.
   FY1969 requirements need 2 machines for investment of 30,000.

C. COST DIFFERENCE

1. Operations

   Reflow = .132
   Insertion = .083
   Difference= .049 per module = .0082

2. Equipment

   Cost per IC, reflowed = .0067
   Cost per IC. inserted = .0025

3. Total--reflow .0124 greater per IC.

Distribution List:

| | |
|---|---|
| K. Olsen ✓ | G. Geralds |
| P. Kaufmann | T. Stockebrand |
| S. Olsen | W. Owens |
| C. Kendrick | G. Wood |

/kb
Attachments (2)

# INTEROFFICE MEMORANDUM

DATE: March 13, 1968

SUBJECT: DIL INTEGRATED CIRCUIT ASSEMBLY TECHNIQUE

TO: K. Olsen
P. Kaufmann
T. Stockebrand

FROM: J. St. Amour

The most economical technique for assembly of DIL packages is a function of both repair and engineering change technique. Our goal is to be able to remove and replace IC's in house and in the field with a simple, inexpensive tool that will not damage the PC board or the IC. Some consideration will be given to the number of changes possible without PC board damage.

Assembly is less expensive with the insertion technique. (Approx. .04 per unit).

The re-flow technique allows the use of wider conductors between pads, possibly reducing board shrinkage. It requires no plated thru holes except as feed thru connections.

Development of tooling for repair and change should be easier with the re-flow technique.

Prototype tooling for removal and repair of inserted IC's is being developed. We will know how practical our approach is particularly from a field service standpoint, within the next two weeks.

Fortunately, a similar tool will work for the re-flowed assembly. A tool which will not quite make it for the inserted IC could be ideal for the re-flowed IC.

/kb

K. Olsen

digital INTEROFFICE MEMORANDUM

DATE: April 15, 1968

SUBJECT: ROPE MEMORY PLAN

TO: Joe St. Amour
Pete Kaufmann
Dick Sogge

FROM: Tom Stockebrand
Dave Estabrooks

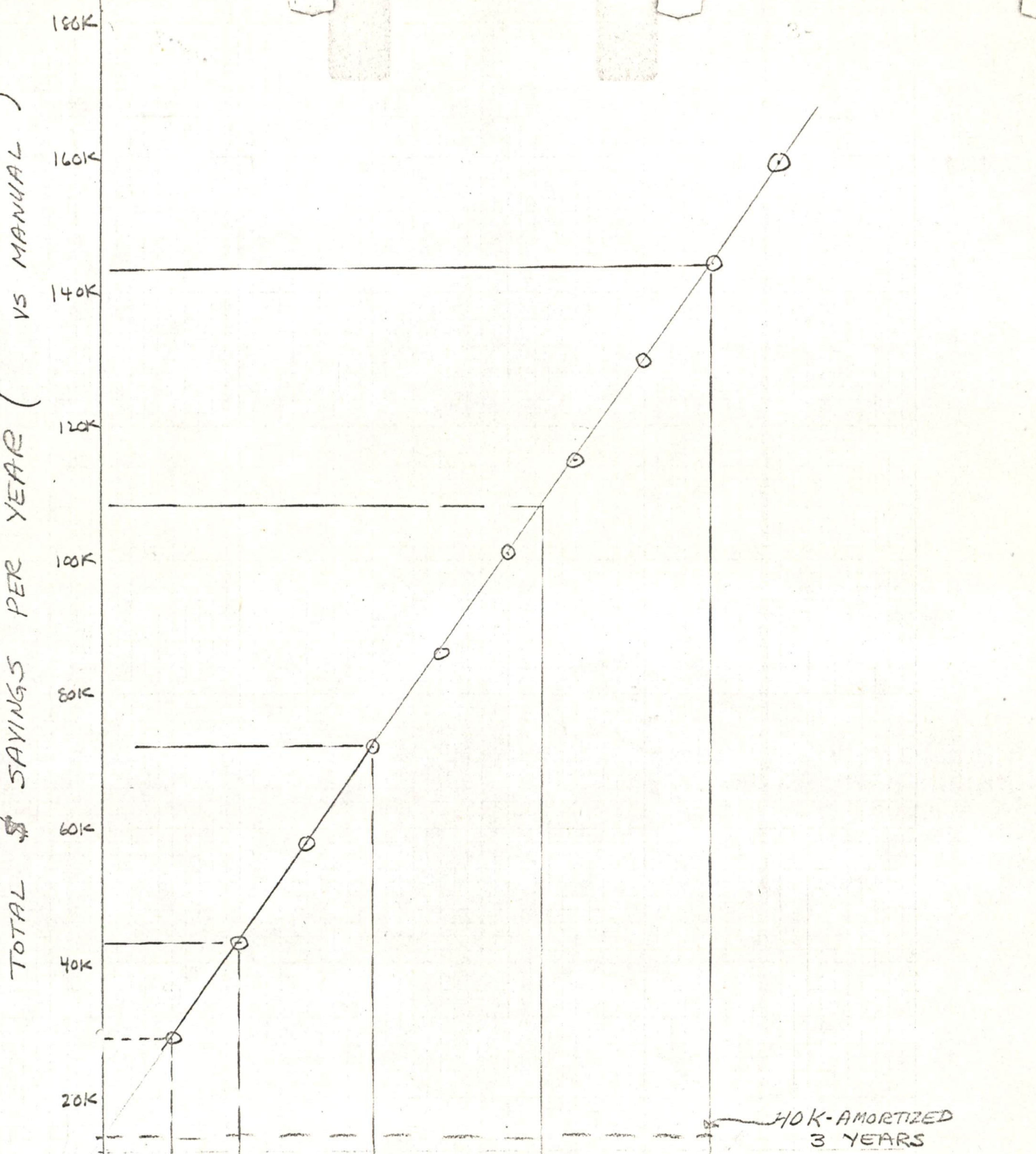
I recommend that the rope memory project be tabled until June 1st and be reconsidered about that time. If the volume estimates have changed or if the date of first need is not June of 1969 the picture will be different.

This study shows that, at 20 memories per month, return on investment will be 140% before taxes if the machine-aided project is started now (18 months ahead of need) and 200% if it is started 8 months before actual need.

We are following engineering's activities in this area: Two prototypes will be built by hand by outside vendors to get the design proven (we have already slanted the design toward machine wiring). When these are achieved and tested, a firm figure of cost to wire by hand will be available. Then we will look again.

Tom

jaf


TOTAL $ SAVINGS PER YEAR (SEMI-AUTOMATIC VS MANUAL)
180K
160K
140K
120K
100K
80K
60K
40K
20K
20
30
40
50
60
70
80
90
100
110
120
AVG. UNITS PER MONTH
40K-AMORTIZED 3 YEARS
3-13-68

Tom Stockebrand
April 15, 1968

# ROPE MEMORY

## VOLUME

PDP-9 is sole user. A redesigned nine would need 20-30/month in 18 months.

A redesigned display *might* use it - 5/month in 12 months.

A retrofit to present 9 is not in the cards.

Any other use (none planned) will be at least 16 months off - e.g., PDP-10, PDP-X+.

## LABOR COST (Parts are about $85)

1. Hand wired prototypes have taken a week to string. Assuming 3 days to string, 1 day to test and 1 day for diode assembly and the like (@ $5.00/hour) — $200 labor

2. One outside quote says $350 @ 40/month; $400 @ 15/month.

3. Another outside quote says $260 @ 30/month depending on experience with a prototype order of 2 in the next month or so. Estimates of stringing time, by machine similar to back panel wiring machine fitted with a stringing head - 5 hours

   Welding with a similar or simpler X-Y table and a welding head - 3 hours

   Diode assembly, insertion, testing, repair - 8 hours

   TOTAL: - - - 16 hours = $80

   Labor savings per memory by machine: $200 -$80 = $120

Tom Stockebrand
April 15, 1968

# ROPE MEMORY PLAN

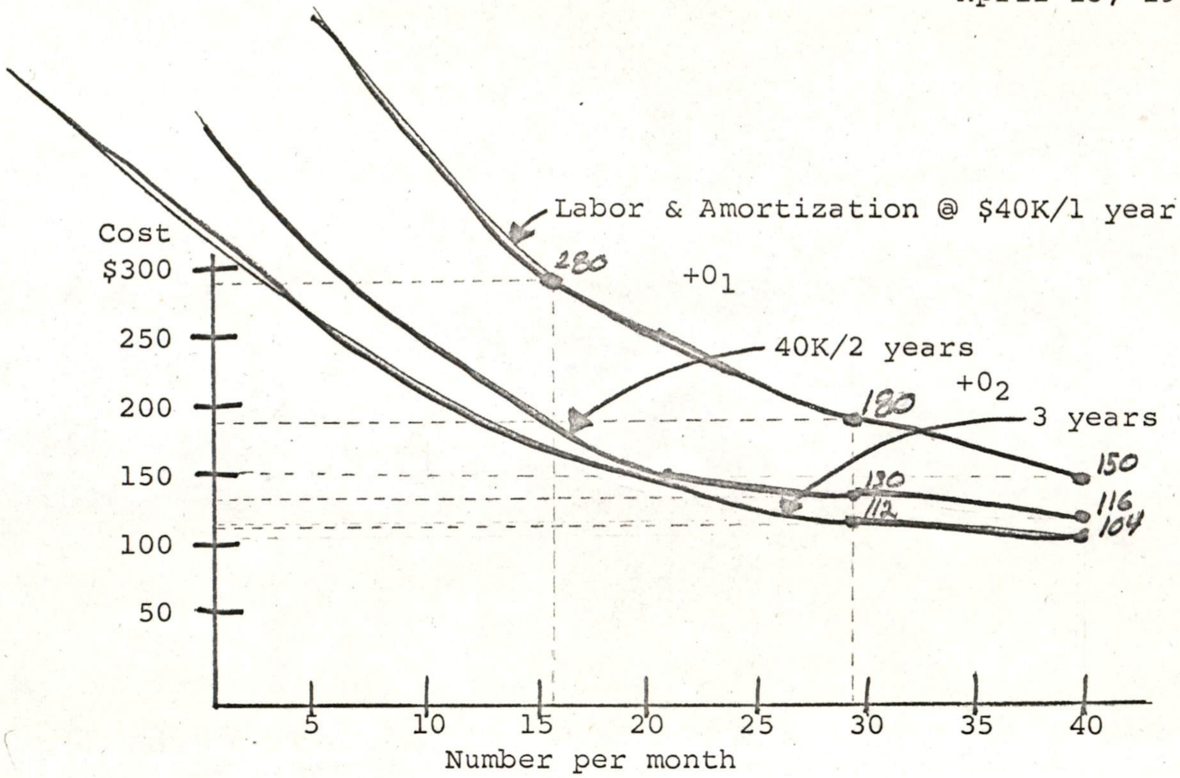
## MACHINE COST

| | |
|---|---|
| Work to develop first head for stringing to be mounted on wire wrap X-Y table now | $20,000 |
| Separate X-Y table with welder machine (bought or built) | 10,000 |
| Diode loading fixtures, mold costs, jigs, etc. | 5,000 |
| Programming | 5,000 |
| TOTAL . . . . . . . . . . . . . . . . . . . . . . . . . . | $40,000 |

Project life - 3 years before redesign.

Computer (if present 8 to Canada) - $20,000

Tom Stockebrand
April 15, 1968




$+0_1$ & $+0_2$ are outside quotes, current RFQ.

Another way "saves $120K in 3 years"

APR 17 1968

K. Olsen
T. Johnson
N. Mazzarese
M. Ford
B. Landis

# digital INTEROFFICE MEMORANDUM

DATE: 15 April 1968

SUBJECT: PDP-8/S AT AMERICAN HOIST

TO: JACK SHIELDS

FROM: JIM McPHERSON

cc: KEN LARSEN

The PDP-8/S we have had on loan to American Hoist, Oakland, California for the past six months caused some problems during the latter part of February and into March. It had suffered from morning sickness problems even after the memory tracking modification and all pending ECO's were installed into the machine. The machine was located in a barn-type environment and the temperature would vary through a large range. During the first two or three minutes in the morning the machine would not function. A temporary replacement machine was shipped from Maynard, so that the customer could continue with his interfacing and we could take time to troubleshoot the machine. Since the temporary replacement machine arrived, the temperature has become warmer and the machine has not failed in the past three to four weeks, therefore, we find it almost impossible to troubleshoot this machine in that environment. I attempted to rent a refigeration truck to serve as a portable environmental chamber to test the machine, but I find it almost impossible to rent one of these. I have made arrangements with a local chain store to use their meat locker for a few days during the early part of the week of April 8th. I feel sure we will find the problem when we get the machine cold enough.

We were able to gain access to the meat locker in the Safeway store on the 9th of April and Larry Reeves installed the PDP-8/S on a scope dolly in the meat locker at that time. The temperature in the meat locker varies from 28° to 33° Fahrenheit. Within a short period of time the machine failed and Larry had the problem isolated and repaired within a period of approximately six hours. I feel that Larry would have fixed the problem sooner, however, he was hampered by the following problems:

1) He is a native Californian and is not accustomed to the cold.
2) Working among hanging sides of beef is not an ideal environment to be troubleshooting computers.
3) A combination of frozen water and blood on the floor made footing somewhat treacherous.

After replacing the defective sense amplifier he could induce no further failures. He further checked the ability of the memory to track by wheeling the computer in and out of the locker and monitored the memory voltages to see that they tracked evenly. The temporary replacement 8/S at American Hoist will be removed Monday, April 15th and this original PDP-8/S will be installed at that time.

There will be a charge of approximately five dollars for the usage of the meat locker in the Safeway store.

Jim

JM:vlb

R. Olsen

digital INTEROFFICE MEMORANDUM

DATE: 15 April 1968

SUBJECT:

TO: J. Jones

FROM: L. Seligman

Towards an Ultra-Repairable,
Extremely-Fast PDP-9I - Part 1 (Hardware)

jeh

## Introduction

My discussion last week with Stan Booth concerning the proposed data path structures for PDP-9I led me to consider the implications of redundancy in achieving an ultra-repairable system. I concluded that such a substantial reliability increase is practical without significant increase in system costs. The basic method used is to so design the PDP-9I that it can be partitioned into two identical subsystems, each separately capable of performing all the basic operations. When both subsystems are operable, the system proceeds at very high speed due to parallel data flow in the two sections (e.g., address calculation or MQ shift simultaneous with accumulator operation). When only one subsystem is operable, the system remains in operation albeit at reduced speed; maintenance personnel perform repairs on the failing subsystem with the aid of a working central processor and diagnostic program.

A study of these methods as used by the Bell System in their electronic switching systems indicate that such techniques work even for real-time systems. Designs for use in small computers like the PDP-9I require far more cost consciousness, however; thus, while the design below is extravagant for the minimal cost version of PDP-9I, it is appropriate for PDP-9I systems approximately the size of typical PDP-9's sold today.

Areas of Redundancy

If the computer system is to exhibit a significant reliability increase, redundancy is required in all parts of the system where troubles are likely to arise. Fortunately, in larger systems, much of the redundancy is already present and, in real-time systems, the problems of redundancy in the IO areas can be legitimately passed along to the customer who supplies the special hardware. I will assume, therefore, that the IO system works properly beginning with the connector at the processor and that the memory system contains at least two independent 4K word sections. This leaves the central processor, the buses, and the power supply. The latter, I assume is provided in two halves so that if one section fails, the other is capable of supplying sufficient power to run one processor subsystem and at least part of the memory system at reduced cycle rate.* The buses, in particular, and the circuitry, in general, must be designed fail-safe in the sense that removal of power from a module electrically isolates it from the remainder of the circuitry.

The problems of integrating diagnostic software into a control or system program warrants further discussion, but I must postpone it to a future memo; the sections below deal with the details of partitionable design of the central processor hardware. Design techniques to validate the above assumptions are fairly well-known and are not discussed.

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*In this regard, it would be important to calculate the power requirements for the PDP-9L. I suspect that <u>one</u> of the 709 supplies used in the PDP-9 might suffice for a 4K, no options system. In larger systems, the two supplies connected through relays might be able to maintain partial system operation if one failed; and together with a current sensing device, one might replace the fuses now used.

<u>Basis for Design</u>

Figure 1 shows a potential PDP-9I register structure designed to operate with a 800 ns memory system. The extreme speed requires address calculation separate from data movement in such common instructions as OPR (16%) and the other instructions that can cause skips (11%). In keeping with these speeds, a separate path is provided for shifting the MQ register, although it is not justified by the frequency of EAE instructions (1%). As an example of data flow, consider the execute phase of an OPR instruction. As in PDP-8I, the event times are accomplished spatially with the AC data flowing out past the skip condition detector, through the true/complement gates, the adder, the shifter, and, thence, back into the AC. Simultaneously, the PC contents flow through the adder which increments it if the skip conditions are met; the normal PC increment occurred previously during instruction access.

While the hardware shown in Figure 1 is probably not optimal, it does have pretentions of being so. That is, the gating structure shown does realize the PDP-9 instruction set and is economical in terms of hardware currently available. As a control element, I assume a read-only memory system of the form described in an earlier memo. Here, since there are additional data paths to control, the number of bits per word would have to be increased from 48 to, say, 60.

Redundant Design

The redundant system is derived from the nonredundant design by replacing the special MQ and address calculation paths with a copy of the main data path as shown in Figure 2. The MQ register is the AC of the second section; the extra PC and MB registers will be wasted unless some scheme is adopted to use them in connection with the data channel facilities. Such use to speed up data channel device processing will be consistent with the degraded-performance-in-case-of-failure philosophy. Without such use, approximately 30% of the hardware would be redundant. In addition, hardware is required for Link control, Instruction Register, and the Interrupt System. This hardware, while minimized by use of ROS would also have to be duplicated. The basic portion of the ROS itself, inclusing address drivers and magnetics (and sense amplifiers if needed) would not be duplicated. Figure 3 is a processor subsystem block diagram.

Some additional hardware is required to multiplex the two basic processor systems out to the memory, IO, and ROS; this is also indicated in Figure 3. Normally, the ROS controls the right and left processor subsystems simultaneously, the left requiring a much shorter control word. In case of failure, power is removed from the offending processor subsystem and associated selector. The ROS program then controls the operable subsystem with its right control words, taking special branches to permit sequential occurrence of data transfers normally occurring simultaneously (e.g., the OPR instruction previously described).

Costs and Extensions

To estimate the costs of this system, one could simply calculate the percentage of the cost of an 8K PDP-8I with EAE that a 50% increase in processor modules represents. Since I do not have PDP-8I manufacturing costs in front of me, I can only guess that this would only increase system costs by perhaps 10%. This would seem a low price indeed for the marketing advantages that would accrue; but it needs to be evaluated further. Similarly, further details of the design must be worked out to insure that no unforeseen problems arise to adversely affect the cost of the system.

Since additional registers an an adder are available in the normally operating redundant design, we can consider additional features that might be added to the system to take better advantage of the redundant hardware. The use of hardware registers to augment data channel operation has already been mentioned; other possibilities include a base register for relocation when running normally in a background/foreground environment and, since at least two independent memories are required, we can consider overlapped operation to further speed processing. I would estimate that the processor could operate with a 650 ns effective cycle memory system.

More complex system designs with additional selectors are also possible along the lines of the Bell System's ESS. Such designs would tolerate multiple failures before shutting down, but would greatly increase costs. Similarly, the ROS could also be duplicated; failure records on PDP-9 ROS as well as the frequency of multiple failures should be investigated before such elaborate designs are begun.

## Conclusion

The computer structure descirbed herein permits significantly increased PDP-9I reliability in moderately-sized systems without a corresponding increase in system cost. In applications using a background/foreground monitor system to multiplex computer resources between a critical real-time process and other programs, the system will be able to withstand most hardware failures and continue controlling the real-time process until repair is effected. Diagnosis of failures is facilitated through the ability of one processor subsystem to run diagnostic tests on the other.

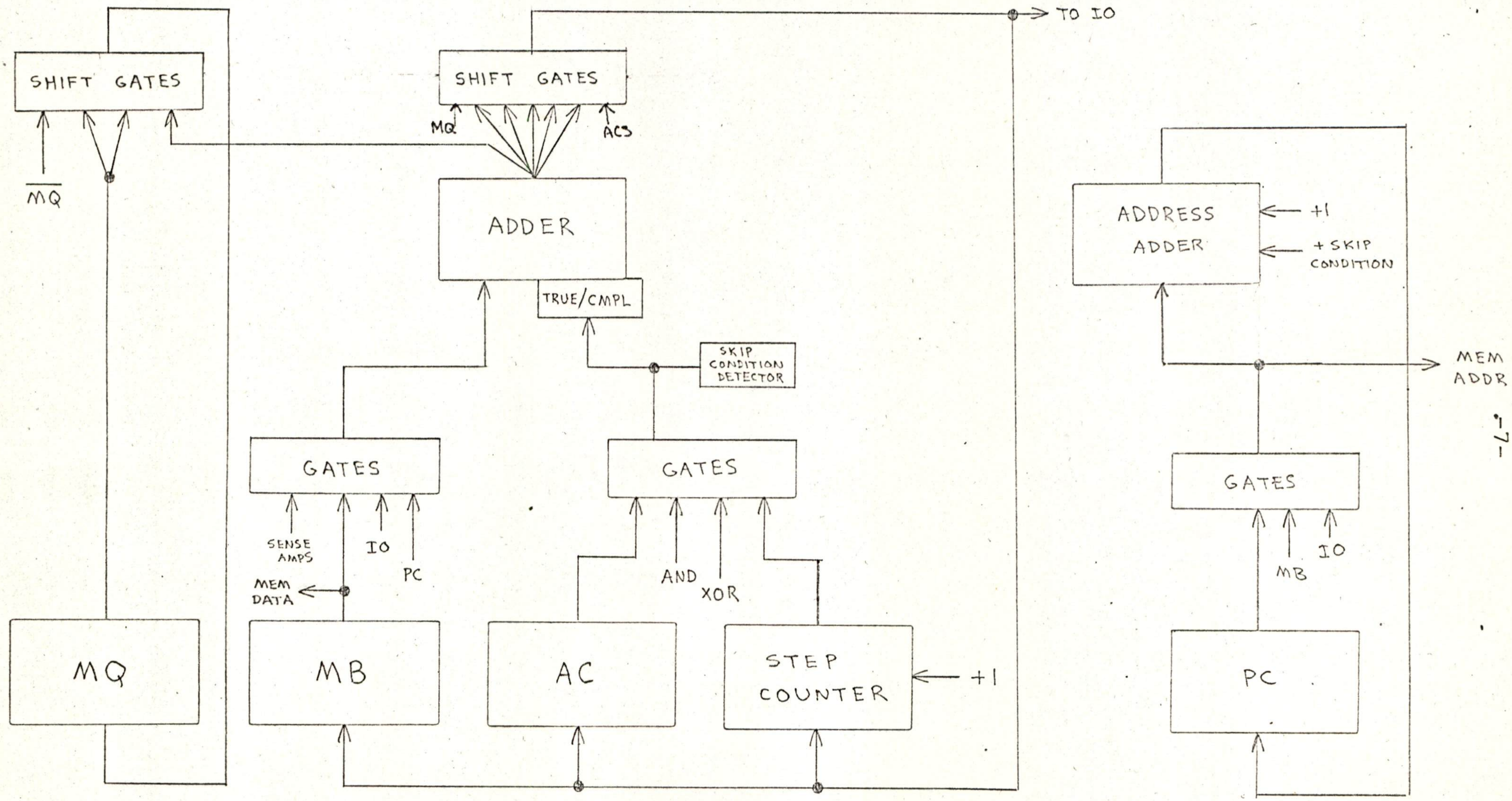



FIGURE 1

NON-REDUNDANT PDP-9 REGISTER CONFIGURATION

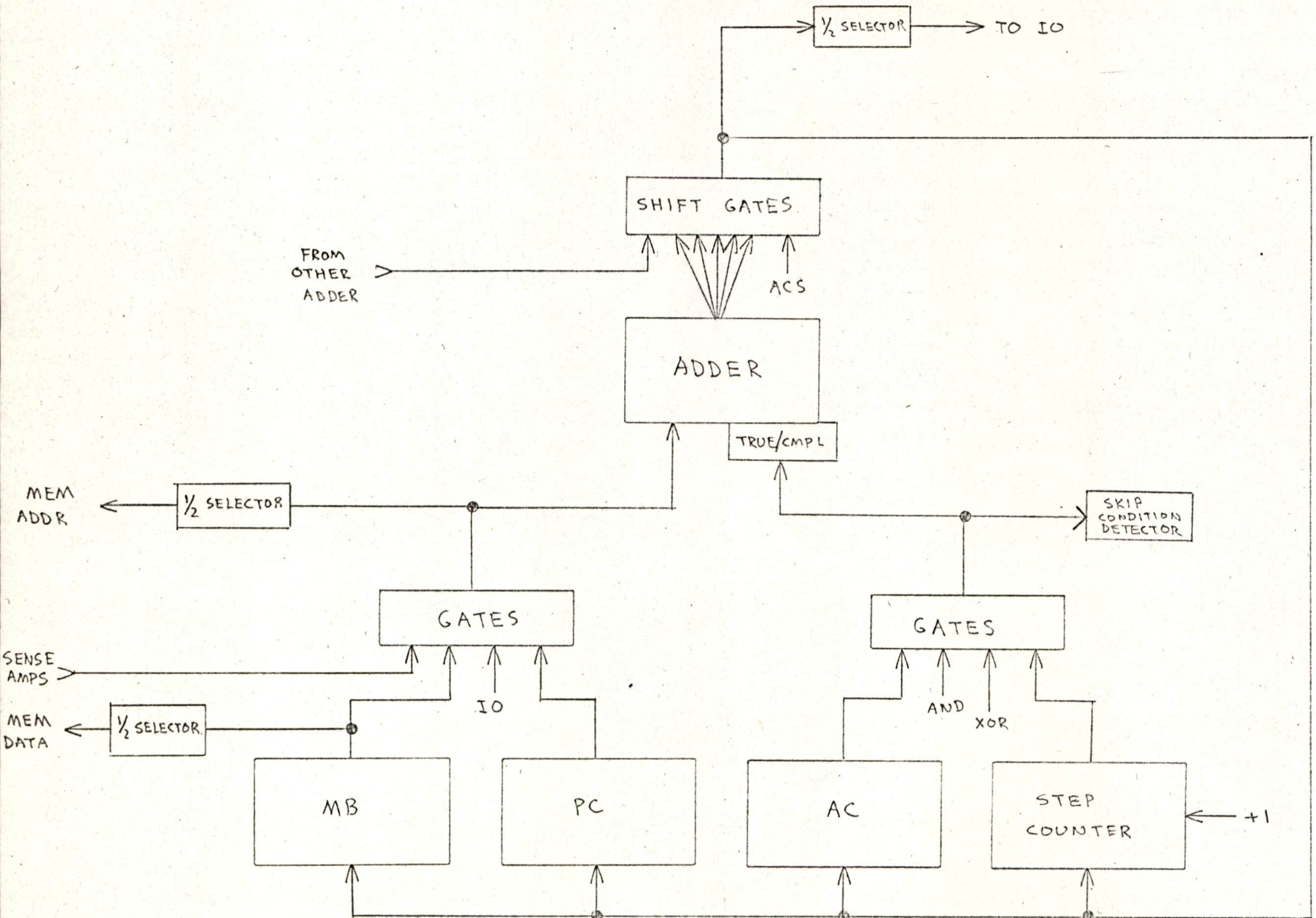





FIGURE 2

½ OF REDUNDANT PDP-9 REGISTER CONFIGURATION

4-16-68

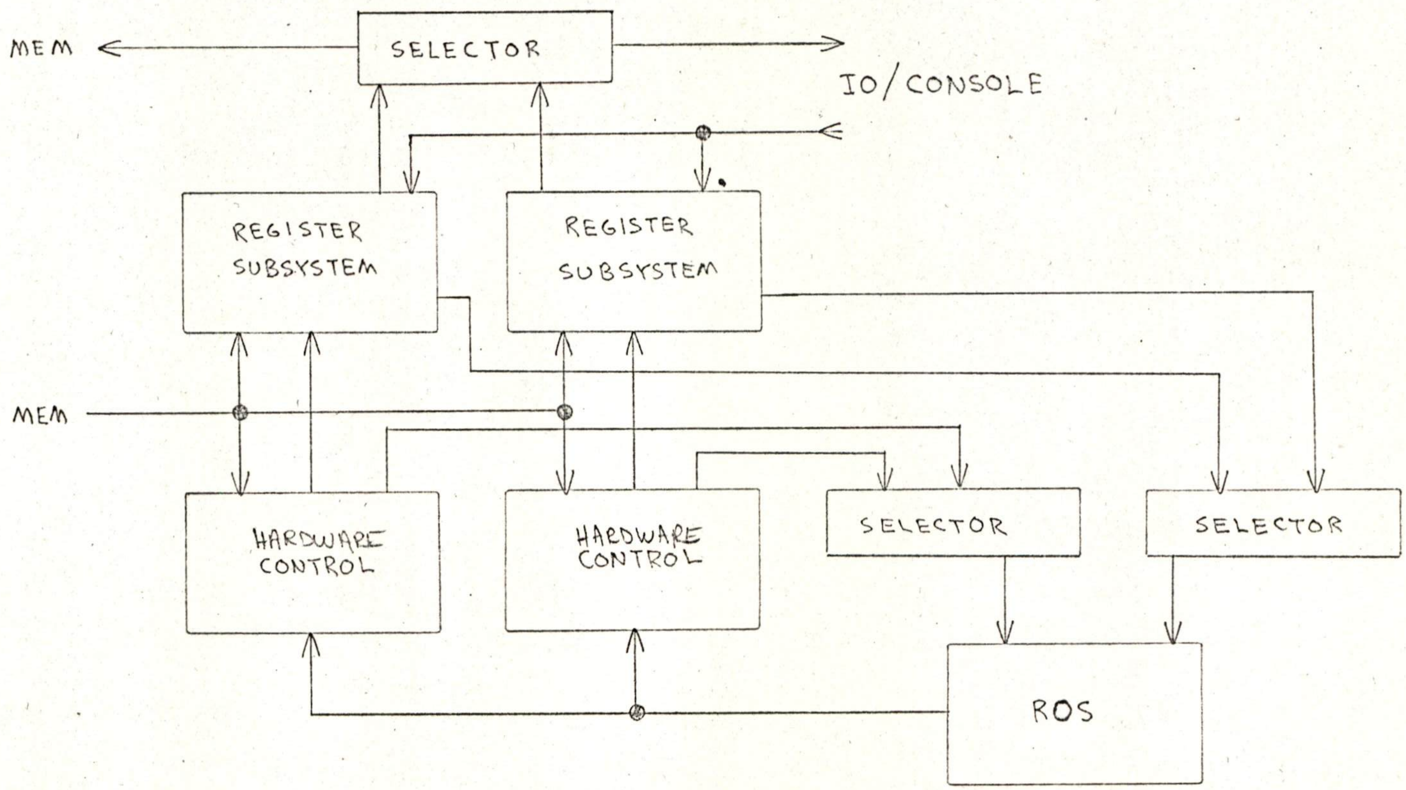
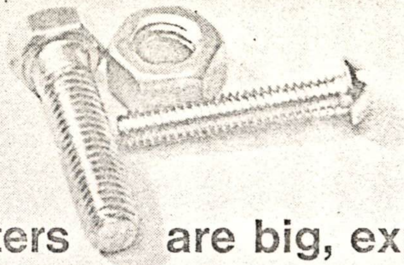
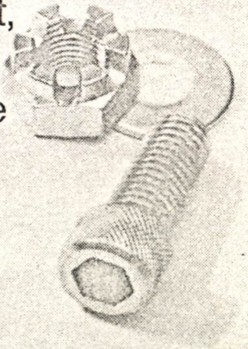



FIGURE 3

REDUNDANT SYSTEM CONFIGURATION



# Computers are big, expensive components. Bit for bit, ounce for ounce, some are a bargain.



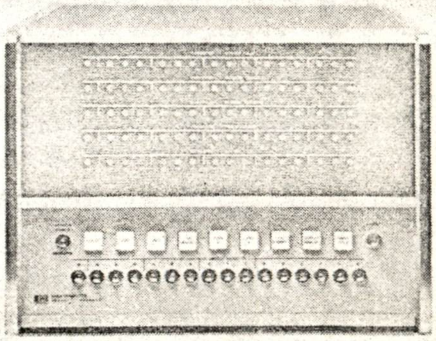
When you tie another man's computer into your product, you're staking your reputation on his equipment. Your reputation is worth shopping for. Naturally you want the most for your dollar. Like reliability at 130° F. Hewlett-Packard computers are designed for rugged dependability—as well as high performance. All things considered, they're something of a bargain.

We've been selling quality instruments to original equipment manufacturers for years. We know the problems. So we back our computers with excellent training, complete service and our traditional warranty. We'll train your people or your customer's people in maintaining the computer and in using the software.

We supply plug-in I/O interfaces and the software drivers for peripheral devices. You buy only the equipment you need for interfacing your system. And you tie it in with minimum engineering time because both hardware and software are operational and fully documented.

The 2115A pictured here measures 16¾"x 12"x 24⅜" (its power supply is a bit smaller). It uses 16-bit words, operates with 4K or 8K memory, and has a two microsecond cycle time. Price: $14,500.

For more information about a computer that will live up to your reputation, call your local HP field engineer. Or write Hewlett-Packard, Palo Alto, California 94304; Europe: 54 Route des Acacias, Geneva.



HEWLETT hp PACKARD

DIGITAL COMPUTERS

06807

J. St. Amour
Copy G. Wood 4/22/68

# digital INTEROFFICE MEMORANDUM

DATE: April 16, 1968

SUBJECT: GOLD PLATING THICKNESS

TO: Engineering Committee FROM: J. St. Amour

FY1968 expenditures for gold will be $184,000 (based on gold price of $35.00 per ounce). Savings of one third or $61,000 per year are possible within two weeks by a reduction of plating thickness from .000150 inches to .000100 inches.

This change could even result in improved reliability since implementation is recommended only if adequate controls are installed for both thickness and porosity.

Porosity is the critical item. Proper control could require a decrease in current density, thereby increasing processing time. Capacity is available and, if required, the cost of increased processing time will be less than $10,000 per year.

Present specification is .000150 inches minimum. Tolerance variations of ±.000020 mean that we average .000170 inches thick. A new value of .000100 inches minimum would probably mean average thickness of .000120 inches.

Reference articles attached are:

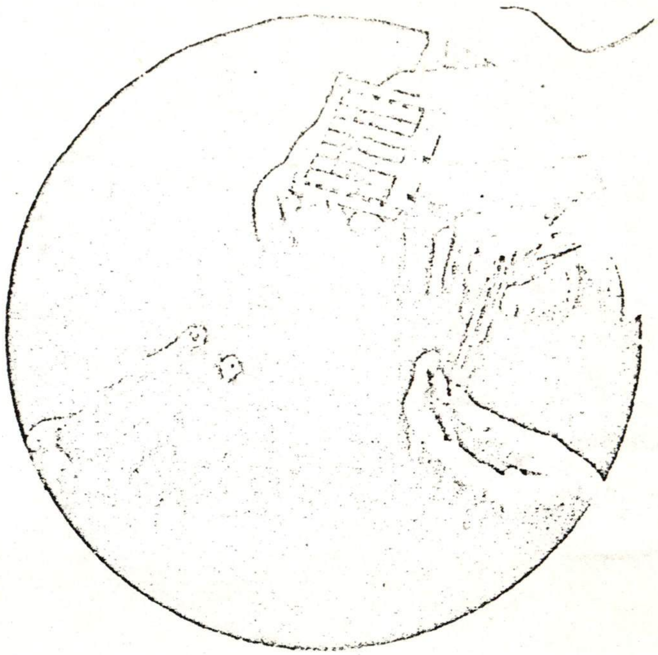
1. M. Ball, F. H. Hardie & E. J. Struckus, IBM, Owego N.Y., "Increase Connector Contact Reliability," The Electronics Engineer, March 1968--see underlined page 84 and graph figure 4, page 85.
2. Pages 21 and 25 from The Use of Electroplated Metals in Static Contacts by K.G. Compton & R. G. Baker, Bell Labs, Murray Hill, N.J. (Entire 19-page article is available if required.)
3. Page 7 from Factors Affecting Reliability of Electrical Contacts For Space Application by Wilfred E. Campbell, Bell Labs. (Entire 33-page article is available if required.)

Additional savings can be made immediately by lowering the height of the plating on the fingers. Selective plating (by an automatic plastic or RTV rubber mask, etc.) of the lower part of the fingers to .000030 inches could probably eliminate another one thid off gold cost.



/kb
Attachments

# Increase connector contact reliability



For aerospace applications the authors recommend gold on nickel as the contact material with an increase in thickness of the gold plating from the standard 50 mils to about 150 mils.

By M. Ball, F. H. Hardie and E. J. Struckus
IBM Corp., Federal Systems Div., Electronics Systems Center, Owego, N. Y.

One of the penalties of modularizing a digital system is that more external connectors are needed, since every module requires its own connector. These connectors severely limit the attainable reliability.

Recently, we conducted environmental tests to determine which properties of electrical contact materials could adversely affect reliability. The tests were performed for over a year at several test sites. Relative humidity at these sites varied from around 10% to over 80%. Measured airborne contaminants included various amounts of $NO_2$, HF, $NH_3$, $SO_2$, $O_3$, $CL_2$ and $H_2S$. Ambient temperatures varied over a range from 60° to 100°F.

## Connector contact materials

Original values of contact resistance for the contact materials tested and the values after one year of environmental exposure are shown in Table 1. We averaged the data from several test sites to obtain these values. Since the table indicates resistance rather than resistivity, the values are of comparative value only.

Copper alloys or other of the high-resistance materials listed in Table 1 would not be suitable for contact materials in aerospace applications. Some of the data indicates almost infinite resistance after one year's exposure to the most adverse environments. Caution should be exercised with palladium or palladium alloys containing copper where high concentrations of organic materials may be encountered. Because of the catalytic nature of palladium, polymers may form in a high organic atmosphere.

The films that form on the surface of silver tend to be highly resistive, coherent and tenacious if the major ingredient is silver sulfide. However, if appreciable amounts of silver chloride are present the film may be non-adherent and of moderately low resistance. Although the average contact resistance after one year was indicated in Table 1 as 0.01 to 100 Ω, the measured values at the various sites varied from 0.001 to over 100 Ω. Since silver is only applicable in controlled environments, we will not consider it further.

Contact resistance of 10, 14 and 18 karat green-gold alloys (simple solid solutions of gold and silver) also varied widely with environment. Although the variations were less extreme (than with silver) because the films were thinner in proportion to the gold content, be cautious in the use of green-gold alloys for aerospace applications. Red-gold alloys (solid solutions of gold and copper) compared generally with green-gold and the same conclusions apply.

The oxide films of tin, lead and other soft metals tend to be coherent, self-limiting and thin. These films are easily penetrated under pressure as the soft bulk material yields. Despite the apparent attractions of tin, lead, indium, etc., we don't recommend them for low-load separable-contact applications, especially in sliding situations where wear debris can build up.

Gold and gold alloys seem to be the best connector contact materials. The excellent behavior of gold and gold alloy with exposure time is shown in Fig. 1. The higher platinum content alloy (6% platinum, 25% silver, 69% gold) is probably best although more test data is needed for a firm decision. Visible films do exist on exposed gold surfaces but consist of absorbed material rather than tarnish products. SMS gold and 24 karat gold showed similar properties during the tests.

### Lubricants

We are continually studying the characteristics of thin-film lubricants to reduce contact wear. As we often need connectors with many pins, we should consider lubricants for reducing connector insertion forces. Lubricants should also be considered as a possible protective coating for contact surfaces in adverse environments.

Since gold is "technically" the best contact surface material for aerospace applications, only lubricants especially adaptable to gold surfaces are reported. The U.S. Army Electronics Laboratories and Stanford Research Institute studied lubricants and recommended octadecylamine-hydrochloride (ODA-HCL) for gold contact surfaces. Our tests have verified this lubricant's excellent properties.

Left to right are authors F. Hardie, E. Struckus and M. Ball.

ODA-HCL forms a stable and tenacious film on gold surfaces. These properties are probably due to the gold surface's physical absorption of the lubricant, and perhaps also due to electrostatic attraction between the lubricant and the gold. The thin film doesn't affect the electrical resistance of the gold contact while it does decrease the coefficient of friction up to 75%. The film is stable with time, contaminants and hard vacuum. During our tests it maintained its lubricating properties and its low resistance characteristics after several weeks' exposure to atmospheres containing sulphur dioxide, hydrogen sulfide and water vapor.

Since the test results on ODA-HCL were so consistently encouraging, we highly recommend it as a connector lubrication for aerospace applications.

### CONTACT RESISTANCE

Table 1 (Average of Several Test Sites)

| Metal | Initial Resistance (ohms) | Resistance After One Year (ohms) |
|---|---|---|
| Aluminum | 0.01 to 100 | >100 |
| Nickel-Silver | 0.01 to 100 | >100 |
| Phosphor Bronze | 0.01 to 100 | >100 |
| Brass | 0.01 to 100 | >100 |
| Nickel | 0.01 to 100 | >100 |
| Beryllium Copper | 0.001 to 0.01 | >100 |
| Copper | 0.001 to 0.01 | >100 |
| Red Gold | 0.001 to 0.01 | 0.01 to 100 |
| Green Gold | 0.001 to 0.01 | 0.01 to 100 |
| Silver | <0.001 | 0.01 to 100 |
| Silver-Cadmium Oxide | <0.001 | >100 |
| Tin | <0.001 | 0.001 to 0.01 |
| Tin-Lead | <0.001 | 0.001 to 0.01 |
| Rhodium | <0.001 | 0.001 to 0.01 |
| Platinum | <0.001 | 0.001 to 0.01 |
| Platinum-Iridium | <0.001 | 0.001 to 0.01 |
| Gold* | <0.001 | <0.001 |

* From this table it can be seen that only gold maintained its resistance value of <0.001.

### Contact resistance

Resistance of a contact consists of:

(1) constriction resistance due to the convergence of current flow lines to points of contact.

(2) film resistance due to impedance of electron flow by the surface films.

Constriction resistance varies primarily with the resistivity of the contact material, the contact load and the contact geometry. Figure 2 shows the constriction resistance of several contact materials. The curves indicate the manner in which constriction resistance varies with contact load for given contact geometry and material. Note that some of the curves cross, suggesting that the choice of contact material for a given connector design may be made on the basis of the contact load of that connector. However, we must first consider film resistance.

Contact films are the result of the contact material's reaction with one or more contaminants in the environment or an absorption of impurities by the contact surface. In general, all metals except pure gold will form reactant films. Gold alloys will form reactant films in

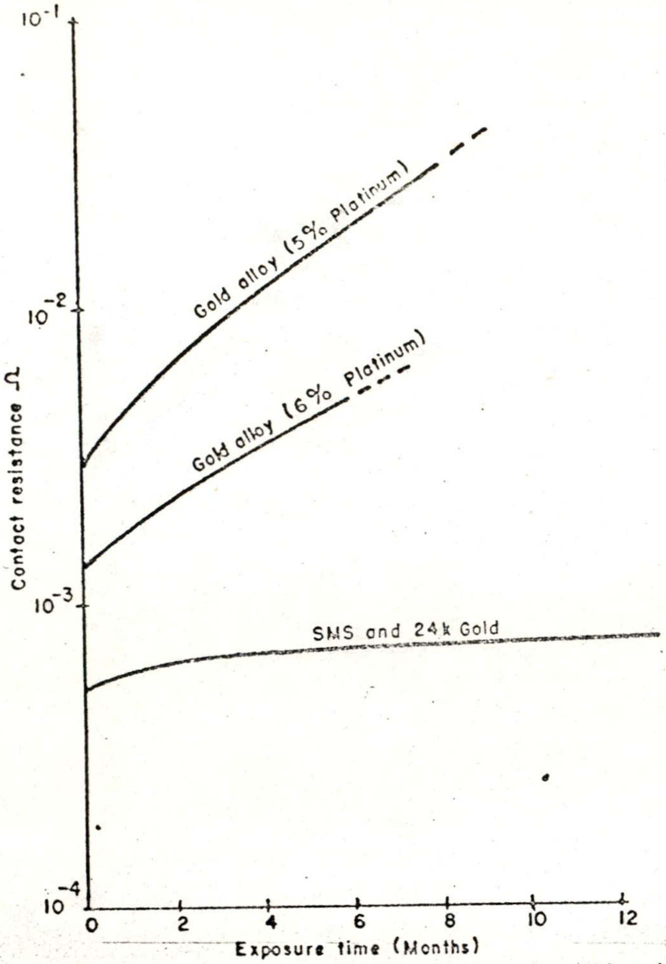



Fig. 1: Change in contact resistance with time for gold and gold alloy.

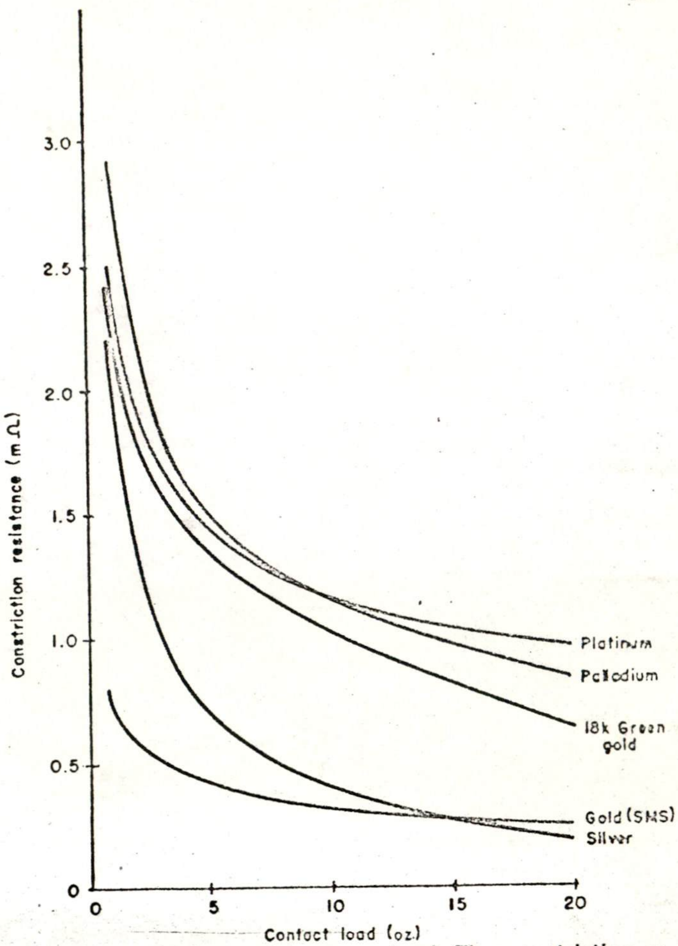



Fig. 2: Constriction resistance vs load. The constriction resistance was measured with a 1/8 in. diameter, spherically shaped gold probe tip against a flat surface.

## Connector contacts (Concluded)

proportion to the amount of alloying material, as indicated in Fig. 3. (The curves were derived from field test data.) Gold alloys may be needed in aerospace applications to provide enough hardness and wear resistance.

### Porosity

Since gold and low resistance gold alloys are soft materials, their primary use as contact materials has been in the form of gold plating over base materials such as nickel or copper. The major problem in this application is that the porosity of the plating leaves the porous areas of the basic materials exposed to contamination. Resulting degradation of the contact surface can occur in the following two ways:

(1) When the base material exposed under the pores in the gold plating is attacked by contaminants such as sulfur, chlorine and nitrous oxide, the resulting sulfides, chlorides and nitrates will migrate through the gold pores and spread out over the contact's surface, forming high resistance films. Although we can control these creeping films by surface lubricants or choice of base material, the primary solution is to control porosity.

(2) The second phenomenon created by porous plating is electrolytic activity at the base material in the presence of moisture and active atmospheric contaminants. The gold plating itself can flake, and corrosion products migrating to the contact surface can form resistant films.

Both types of degradation dictate that the porosity of the gold plating be minimized. The obvious approach is to increase the thickness of the plating. However, Fig. 4 shows that, although the porosity does decrease as plating thickness increases, the curve levels off at the higher thicknesses. This curve represents an average of data, and is plotted relative to the plating porosity at 50 mils plating thickness as standard (or unity). To be practical, we will not consider plating thicknesses over 150 mils.

Other factors such as production and testing methods tend to predominate over actual plating thickness in determining porosity at the higher thicknesses. For example, an increase in thickness from 50 to 150 mils was obtained in one case by increasing current density rather than increasing processing time, and the resulting thick plating had higher porosity than the thin plate. The degree to which porosity can be minimized is very sensitive to the cleaning and handling techniques used on the base material.

We can control the final product's porosity by adequately testing the plating to screen out samples which exceed a predetermined limit. For critical applications we can set the limit much more stringently than we can for commercial grade platings. We use sensitive electrographic testing methods in which an electrolyte-

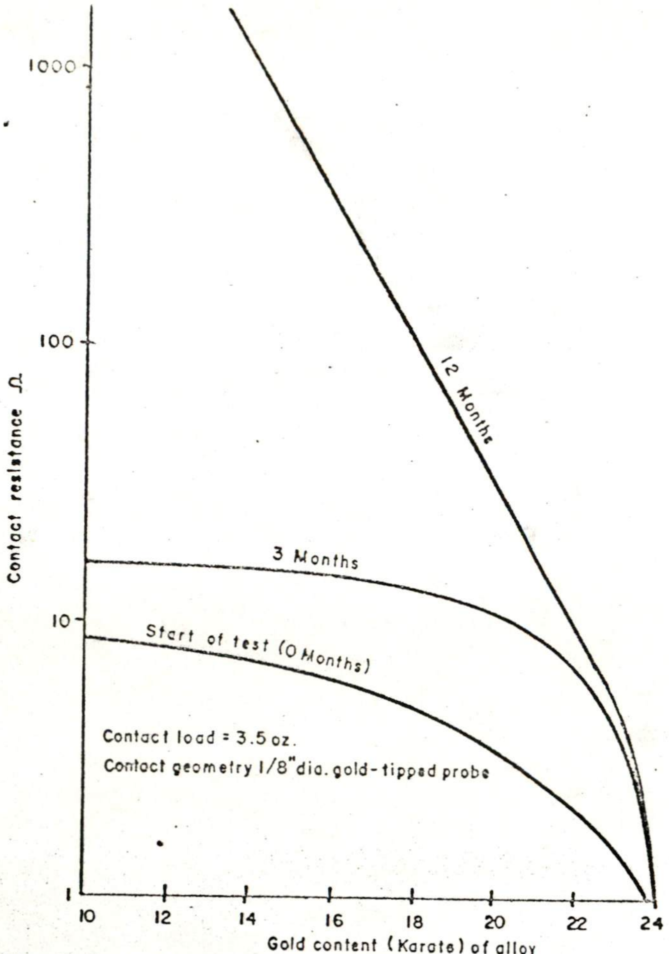



Fig. 3: Contact resistance vs alloy gold contact. The curves were derived from IBM field test data.

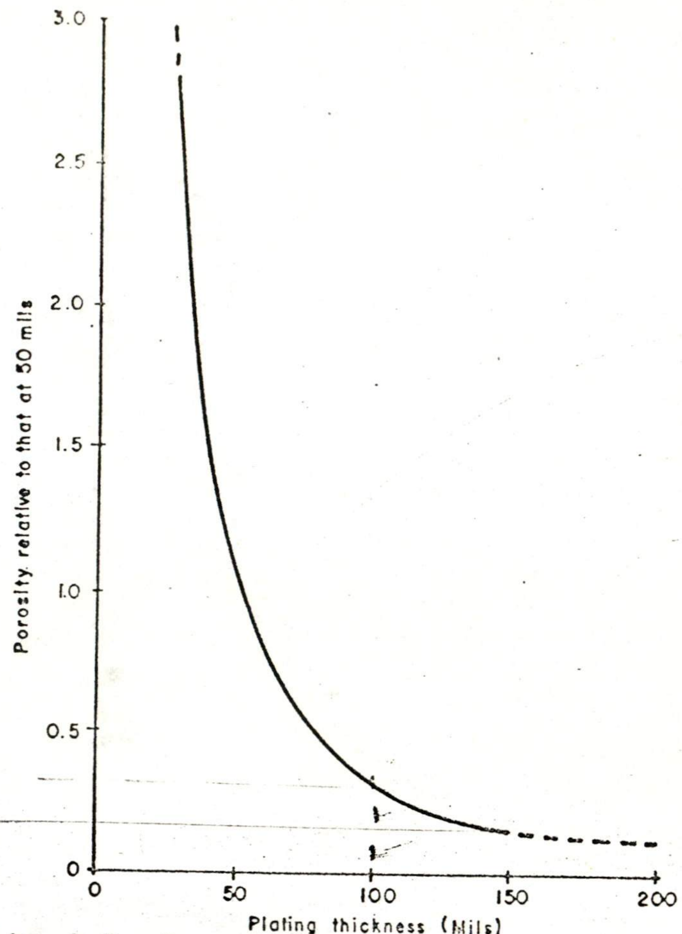



Fig. 4: Porosity vs thickness of gold plating. Note that although porosity decreases as plating thickness increases, the curve levels off at the higher thicknesses.

saturated filter pad is wrapped around each contact and a small current is made to flow from the contact through the pad. After a fixed period a reagent applied to the pad indicates the porosity by color test.

Protective contact coatings have been produced by welding gold foil onto the base contact material rather than by plating. This method has essentially eliminated the porosity problem associated with plating methods. However, it has not proven suitable to commercial applications because of the process's inherent cost and because it's difficult to produce uniform coating thickness. This method should not be overlooked, however, for low quantity highly critical applications.

Since multilayer platings are generally more expensive than single layer platings of the same total thickness, they are not favored for high production commercial uses. However, when a contact surface is built up from several layers of gold plating, there will be some misalignment of the porosity of the individual layers. Result is a decrease in effective porosity over that of a thick coating deposited as a single layer.

Even if the porosity problem is solved by pursuing methods which have been rejected for commercial applications because of cost or difficulties in mass production, a diffusion problem may exist. Diffusion is the migration of base contact material or impurities through the plating material itself rather than through the pores. The transferred materials form resistive films on the gold plating's surface in the same manner as those caused by porosity. Some commercial applications use an intermediate barrier layer of nickel between a base material of copper and the gold plating to retard diffusion. Although rhodium has the highest retardation capability as a barrier layer, it is too expensive, too difficult to process and too brittle for commercial use.

Before choosing the plating and base contact materials you must also consider the possibility of galvanic corrosion. To prevent galvanic action, metals relatively close in the electromotive series should be selected for these materials.

The choice of nickel as the base material with gold as a thick-film surface material is best suited for aerospace applications in view of all the above factors. The thick film should be built up by several successive electrodeposits or, preferably, by welding gold foil on the nickel contact pins. Stringent process and testing methods must be applied, which will surely result in high rejection rates. Although the resulting connector costs will be much higher than those of commercial connectors now used, the pin corrosion problem will be minimized and the costs seem to be justified for low quantity, highly critical uses.

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This "sliding" or "wiped" value was lower in all cases than the nonwiped value, unless some particulate matter was introduced into the contact area.

It is evident from an inspection of Table 4 and Fig. 11 that the copper-tin-zinc alloy is the least desirable coating from the standpoint of the initial nonslid contact resistance, being several orders of magnitude worse than the remainder of the coatings. Even when covered with a flash of either gold or rhodium it still remained relatively high. With the exception of these three coatings and different thicknesses of palladium, all the other platings on copper wire had resistance values of approximately 7 milliohms or less at 25 grams contact force. The values shown in Table 4 show the dependency of contact resistance on the contact force.

After six months' exposure the contact resistance of specimens with various coatings was measured as previously described, using the apparatus shown in Fig. 9. The values obtained were plotted as cumulative frequency curves. Figures 12-17 are graphic representations of the resistance values obtained at the end of a six-month exposure at the three locations. Duplex coatings have been used because of the supposed economic advantages in plating a very thin noble metal on top of a thicker, less expensive metal. This upper coating is usually quite porous, however, and atmospheric contaminants are able to attack the underlying metallic coating at the base of the pores, with a resulting buildup of corrosion products.

Figures 12, 13, and 14 show that the use of a thin coating of a noble metal such as gold or rhodium over copper or nickel is not satisfactory. Since the corrosion of silver is limited by the availability of sulfur at the silver surface, plating a thin noble metal such as gold or rhodium over a silver substrate should have the advantage of limiting the silver area that can be sulfided. However, because of the tendency of silver sulfide to creep and adhere to a gold surface (3), a duplex coating of silver plus a thin gold is not satisfactory for static contacts. To work satisfactorily the upper gold coating must be pore-free, or there must be a protectant on the surface which will close up any existing pores and prevent the formation of silver sulfide.

(a) .000030 Au over Cu
(b) .000030 of Gold over .000300 Nickel
(c) .000020 Rhodium over .000300 Nickel

Silver sulfide does not have this tendency to creep over rhodium (3), indicating that a duplex coating of silver plus rhodium may possibly be a good compromise if the excellent wear properties of rhodium are needed. Figure 15 shows that the contact resistance values for this duplex coating are, in fact, generally satisfactory. At this point it is necessary to inject a word of caution concerning the use of rhodium in any rotating contact system where organic vapors are present. Rhodium in the presence of organic vapors has been observed to form a film on its surface, which can build up to a thickness sufficient to interfere with the maintenance of a low, stable contact resistance.

The 0.0001 in. soft gold contact resistance values shown in Fig. 16 are typical of pore-free soft gold. The few nonwiped values that showed open circuit resulted from particulate matter being between the wires as the force was applied. The wiped values are all quite low, and the spread of values is greatly reduced.

The 0.0002 in. 50/50 solder (Fig. 17) shows that a base metal may be a good contact material provided that it has two very important characteristics. It should form a relatively thin, brittle corrosion film. The metal itself must be soft so that the act of sliding will cause the thin corrosion film to rupture. The soft metal can then cold-flow at those ruptures, and metallic bridges will be formed.

In general those coatings that exhibited high contact resistance values after exposure were also unsatisfactory from the standpoint of solderability. The actual solderability ratings after a six-month exposure are shown in Table 5.

After the first six months' exposure it was apparent that there was a definite difference in the resistance of the four copper alloy basis metals to the corrosive action of all three atmospheres. Yellow brass was the most heavily corroded. This was followed by 12% nickel brass. Copper and phosphor bronze exhibited the maximum corrosion resistance in these atmospheres. Table 6 shows the results of a visual examination after a six-month exposure. The Group I metals exposed in Steubenville were arbitrarily assigned a rating of 100, since these were the least affected by the exposure. All other groups were rated according to general appearance when compared to this group. Examination of these data again showed the superiority of gold finishes 0.0001 in. thick, or thicker. Tin and 50% Sn-50% Pb solder also fall within Group I in all locations. As previously mentioned, the outer layers of the duplex coatings are relatively porous, permitting corrosion of the underlying metal, and these coatings were in the lower two groups in all three locations.

From the initial study, the following conclusions were reached: (1) soft 24 carat gold coatings at least 0.0001 in. thick were the best plated contact material tested; (2) 0.0002 in. electroplated 50/50 tin-lead solder showed promise, even though the wear characteristics of this coating were poor.

While the initial program answered general questions about individual finishes and indicated how they might behave if exposed to corrosive environments before assembly, it was not designed to answer specifically how actual contacts already assembled would behave under similar conditions of exposure, nor did it attempt to establish the effect of contact load on the behavior of assembled contacts. To answer these questions actual connectors and printed circuit boards with selected metallic finishes were assembled and exposed in the louvered aluminum shelter in New York City. Table 7 lists the metallic coatings applied to the boards and connectors. Contact resistance measurements were taken periodically. Figure 18 shows the connectors and boards with all the necessary wiring for measurement. Although the circuitry was designed to include a minimum of external resistance, some was still included. For this reason the change in resistance from the initial values can be assumed to be the increase in resistance in the actual

Factors Affecting Reliability of Electrical Contacts For Space Application
Wilfred E. Campbell, Bell Labs.


The most important single cause of unreliability of low-level contacts is tarnishing or corrosion while in use or in storage. This problem is new outside the communications industry, and relatively little study of the effect of tarnishing on static contacts has been published.

An obvious method of improving the behavior of base material at tolerable cost is to use electroplated coatings of precious metals or soft metals forming thin protective films which can be readily penetrated. Work of this kind is described in references 18 and 19. This work, which was carried out on crossed wire contacts at 25 gr. load in natural atmospheres, showed that gold plate at least 0.0001" thick maintained low contact resistance most effectively. Solder films .0002" thick were also very effective. Films thinner than .0001", of several precious metals, accelerated corrosion of the anodic underlying metal. The common practice of using duplex coatings consisting of a very thin noble metal over a thicker, less expensive undercoat, such as nickel, proved unsatisfactory - only .00002" rhodium over .00003" silver showed any promise.

The effect of wipe on make was also studied and it was found that length of wipe path approximately equal to the diameter of the gross contact area was sufficient to reduce a high resistance caused by corrosion of solder to that of the freshly prepared surfaces. The improvement was achieved at the expense of wear - solder coatings .0002" to .0005" thick were often worn through in 5 to 20 operations.

More recent studies, initiated by ASTM B4, Subcommittee IV, Section G, and still in an early stage, show that tarnishing can cause high resistance and opening in closed contacts of unprotected base metals. These studies promise to supply useful data on a number of contact materials, and deserve more active support than they have been receiving. Data on ageing of crossed-wire, made contacts in an accelerated indoor atmosphere are given in reference (20). The best results were obtained with silver, gold, platinum, and nickel, the worst with copper and high copper alloys. Increasing load, as would be expected, reduced failure incidence in all cases.

Lubrication of soft coatings like solder and gold reduces the wear rate appreciably (19). An effective lubricant film will also prevent corrosion during inactive periods but may act as a dust collector. No published studies of these factors are available. In outer space, most organic lubricants will evaporate rapidly (21).

Contacts exposed in outer space are not likely to corrode and the soft coatings typified by solder should be very effective. Their wear characteristics may even be better, because oxide formation is a likely accelerating cause of wear. Inside space vehicles corrosion can also be minimized, so that metals like nickel, which corrode rapidly in humid industrial atmosphere, can be used as undercoats.

digital INTEROFFICE MEMORANDUM

DATE: 16 April 1968

SUBJECT: Educational Computers

TO: D. Best
J. Holzer
J. Hughes (Canada)
J. Jones
N. Mazzarese
K. Olsen ✓
S. Olsen

FROM: J. Godbout

It is apparent from the advertising campaign that the educational computer-training market is a relatively high-volume and profitable venture. The Computer Lab and Logic Lab offers a complete digital experience for the student. If we are to complete the market, I feel that we should consider developing an analog computer which would sell for less than \$500 and would be of sufficient potential to solve complex linear second order differential equations. Such a computer would be the same size as the Computer Lab. It would have low power requirements ($\pm$10 volt range) with meter output built in and trunk lines for scope or plotter results. Some preliminary cost estimates are given below.

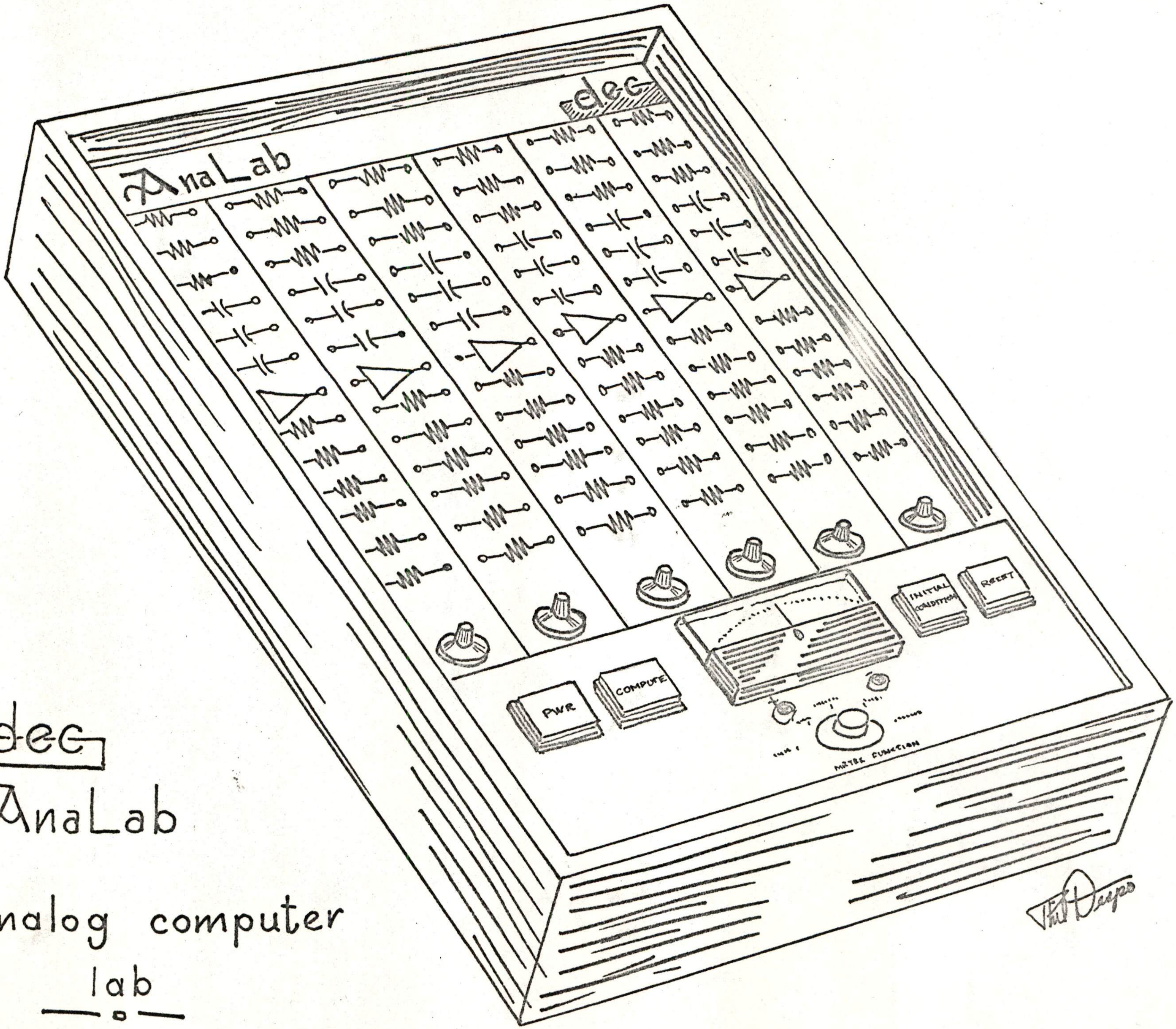
| | | |
|---|---|---|
| 1. | Motorola 10-volt Operational Amplifiers<br>Minimum Number Required - 6 @ \$5 ea. | \$ 30 |
| 2. | Coefficient Pots - 6<br>10 Turn Dial Type | \$ 60 |
| 3. | Resistors, Integrator Capacitors | \$ 1 |
| 4. | Power Supply and Voltage Regulator | \$ 10 |
| 5. | Frame and Racks | \$ 10 |
| | TOTAL | \$111 |

The computer itself is rather easy to design and construct (primarily through the use of IC operational amplifiers). The time-consuming part of the program is the technical, instructive, and advertising literature necessary to reach the secondary school system. This computer could serve as a useful training tool in understanding analog computer operation and could be used to solve distance, velocity, and acceleration (projectile) problems in physics. Other secondary school applications are in mathematics, chemistry, and electrical circuits. The manuals must give many sample problem solutions and explain the computer's solutions in relation to those now being taught in the school system.

Thank you,

Joseph Godbout

Attachment
jeh




dec

AnaLab

analog computer

lab

Ken Olsen

digital INTEROFFICE MEMORANDUM

DATE: April 18, 1968

SUBJECT: NEW CABINET DESIGN REVIEWS

TO: Design Review Committee and Designers

FROM: Secretary

After a fairly thorough descussion the committee feels that the following points should be answered by the designers of the cabinets. In general, each point should be answered by building a model of the desired features (hopefully in two different ways) so that at a future go-around, instant decisions can be made and the project sent to production. Please reply giving the date that the objections will be answered.

1. Please show how a table will be added to this design. If short skin doors are to be used with the table, show models and list all the standard sizes which are allowable in the various designs.

2. Show results of a test in which a doublely loaded pair of cabinets is progressively rolled off a skid to demonstrate that no stortions in the frame will occur because of the unusual moments. Similarly support only the outer two rows of casters on a block to show that no permanent sagging occurs in the center.

3. Show at least photographs of the drop test from various heights of the cabinet loaded in a nominal way mounted on a skid and shoved off an edge so as to land on one corner.

4. Build several versions of the cabinet fan and filter mounting including the cover arrangement and the edge arrangement. Be sure to include filters in the models.

5. Build at least one bussing arrangement suitable for shipping sixty amperes from a power supply on the back of the plenem doors around to a distribution system in one bay. Bob Wyman to be satisfied here.

6. Fill a cabinet full of at least a DEC tape, an AD converter, a scope, a PCO/1 and an 8/I with its power supply to show

accessibility in cabling in the finished product.

7. Why can't the rear plenem door be reversed? Show a model with indicators along the top such as are available in the PDP/10 configuration. Show how the skin doors interact with the indicator system.

8. Put about 1 kilowatt of heat into the cabinet distributed in some defined way and make actual measurements of the temperature rise and the hot spots in the cabinet with one and two fans running to prove at least one point in the temperature dissipation curve. Publish the data.

9. Demonstrate means of grounding panels to the frame. Construct some end panels with hot sections to demonstrate their stiffness.

Tom

bn

# digital INTEROFFICE MEMORANDUM

Memo #221

DATE: April 18, 1968

SUBJECT: Miscellaneous Problems

TO: Ken Olsen
cc: Harry Mann

FROM: Al Hanson

1). Subject: Security
Having received approval from the Operations Committee on my Entrance & Exit Proposal, we have secured all the inside doors in Building 4 and 6D and all others described on the proposal.

2). Subject: Flood Prevention
I think your idea of preventing the flow of water by using inflatable devices is worth consideration. Most contractors use dunnage bags to stop the flow of water in large pipes and culverts. The dunnage bag conforms and makes a tight seal to any shape. I have presented a proposal to Maynard Industries to do three things;
   a). Install a wall on the South bank of the river to prevent overflow, under flooding conditions.
   b). Install a sluice gate at the raceway opening to prevent water from entering the raceway.
   c). Install manholes in the raceway between the river and the sluice gate. Manholes will be used to pump water from the raceway back into the river.

3). Subject: Yard Housekeeping
Maynard Industries has initiated a clean-up program.

4). Subject: Seal Concrete Floor Building #7
George Wood has completed the "Urethane Project" in Building 7-1.

5). Subject: Plant Cleanliness
I will initiate a plant tour by this department on a monthly basis and will report all unsightly areas to the appropriate Vice-president.

6). Subject: Conduct

Two of my Millwrights were chaining saw horses to fixed objects on the Thompson Street parking area ramp, when an engineer who works for Win Hindle, took one of the saw horses and threw it into the woods, thus allowing himself to drive up the ramp. I notified Win Hindle personally, upon positive identification.

7). Subject: Best Key System

We are presently revising the entire key system for the plant. Each key will be coded by using letters and digits. I will describe the system to you when we have finished.

8). Subject: Company Signs

There is a question as to whether or not we have done enough work on informing employees of certain facets of the plant and its operation. This past year we did install signs in every building and every floor identifying the area. All exit doors were marked with "EXIT" signs and given numbers. Most of the parking lots were also given signs.

I have been talking with the new Silk-screening man and anticipate doing business with him in the future.

iea

# digital INTEROFFICE MEMORANDUM

DATE: April 22, 1968

SUBJECT: THE FUTURE OF MEMORIES AT DIGITAL

TO: ✓Ken Olsen
Joe St. Amour
Pete Kaufman

FROM: Tom Stockebrand

With the loss of Deric Chin, Dick Sogge and Tom Hughes we have pretty well lost our memory engineering. This makes it somewhat important that we precede solidly. In particular, around the 10th of May, Dick Heaton has arranged for us to NCR to see about their glass rod memory. It's very possible that we should consider licensing them for our bulk memories under the present circumstances. I'm not suggesting that we do this, but data needs to be obtained.

The question is "Who should go?" me?, Dick Best?, Bill Owens? or who? Maybe there are some people that you expect to put into the memory business that I don't know anything about. Maybe we should hire somebody.

Tom

bn

COMPANY CONFIDENTIAL

digital INTEROFFICE MEMORANDUM

DATE: April 23, 1968

SUBJECT: ENGINEERING/MANAGERIAL EMPLOYEES THAT HAVE TERMINATED SINCE June 1, 1967

TO: Ken Olsen

FROM: Bob Collings

| NAME | NOW EMPLOYED BY | REPLACED | POSITION ELIMINATED | WOULD REHIRE |
|---|---|---|---|---|
| (N. Mazzarese) | | | | |
| Stu Ogden | Harvard | | yes | no |
| Irv Doucette | Saul Dinman | yes | | yes |
| Dave Brown | Beta | | yes | no |
| Sherwood Kidder | Raytheon | yes | | no |
| Lou Illingsworth | Own Business | no | | no |
| Jack MacKeen | R.C.A. | no | | no |
| Barry Wessler | Civil Service | yes | | yes |
| Ed DeCastro | Own Business | no | | yes |
| Henry Burkhart | Own Business | no | | yes |
| (W. Hindle) | | | | |
| Derrick Chin | S.E.L. | no | | yes |
| Dexter Pehle | ? | yes | | no |
| Don McNutt | Brecks | yes | | yes |
| Roland Boisvert | Own Business | yes | | no |
| Bob Bowering | ? | yes | | no |
| Bill Keyworth | ? | yes | | no |
| Andy McGill | ? | yes | | no |
| Martin French | Raytheon | yes | | no |
| Carol Worden | ? | yes | | yes |

COMPANY CONFIDENTIAL

(S. Olsen)

| NAME | NOW EMPLOYED BY | REPLACED | POSITION ELIMINATED | WOULD REHIRE |
|---|---|---|---|---|
| Saul Dinman | Own Company | yes | | ? |
| Tom Hughes | S.E.L. | yes | | yes |
| Dick Bank | S.E.L. | yes | | yes |
| Jim Green | H.P. | no | | yes |
| Larry Hess | C.C.C. | yes | | no |
| Larry White | Data Tek | yes | | no |
| Eric Hokans | Service | | yes | no |
| Dick Sogge | Own Company | no | | yes |

8

7

Stan has one to go to ..ch 9

/mac

digital INTEROFFICE MEMORANDUM

DATE: April 24, 1968

SUBJECT: FY 68 Engineering Hires

TO: K. Olsen

FROM: G. Thayer

Attached per our recent conversation are lists of hardware/design type engineers which we have hired to date this fiscal year.

I have not included engineers hired right from college.

GAT/lw

WIN HINDLE

| NAME | SUPERVISOR | DEPARTMENT | DATE HIRED | TERMINATED FROM |
|---|---|---|---|---|
| Menno Koning | B. Savell | PDP-10 Elec. Eng. | 8/21/67 | Electrograph Corp. |
| James Young | B. Savell | PDP-10 Desn. Eng. | 9/1/67 | Honeywell, Inc. |
| David Ives | B. Wyman | Lg. Comp. Eng. | 10/2/67 | Hamilton Standard |
| Lorrin Gale | M. Ruderman | Linc 8 Engr. Des. Eng. | 10/25/67 | Ford Motor Company |
| Ernest Luttig | R. Savell | Lg. Comp. Eng. Engr. | 1/8/68 | Tech. Measurements Co. |

STAN OLSEN

| NAME | SUPERVISOR | DEPARTMENT | DATE HIRED | TERMINATED FROM |
|---|---|---|---|---|
| J. Beverly Young | E. DeCastro | Med. Comp. Eng. | 8/28/67 | ARMA/NASA |
| Donald Chace | R. Doane | Module Eng. Engr. | 1/24/68 | Itek Corporation |
| Jonathan Browne | J. Jones | PDP-9 Eng. Des. Engr. | 4/1/68 | Raytheon Company |

NICK MAZZARESE

| NAME | SUPERVISOR | DEPARTMENT | DATE HIRED | TERMINATED FROM |
|---|---|---|---|---|
| John Holland | B. Long | Sm. Comp. Spec. Sys. | 7/31/67 | Canadian Armament Research & Develop. Establishment |
| Roger Dow | C. Crocker | Sm. Comp. Eng. | 8/14/67 | Acton Labs |
| Roger Wells | B. Long | Sm. Comp. Spec. Sys. | 10/23/67 | General Dynamics |
| Murray Ruben | P. Greene | Graphic Display | 11/6/67 | Tyco Laboratories |
| David Peterson | B. Long | Sm. Comp. Spec. Sys. | 2/26/68 | Bell Telephone Labs |

PETE KAUFMANN

| NAME | SUPERVISOR | DEPARTMENT | DATE HIRED | TERMINATED FROM |
|---|---|---|---|---|
| John Gannon | L. Prentice | Mech. Eng. Engr. | 8/1/67 | Rex Chain Belt |
| Robert Antonuccio | R. Cady | Comp. Test Eng. | 8/28/67 | Raytheon - Power Tube |
| Richard Heaton | H. Crouse | Purchasing | 9/25/67 | Texas Instruments |
| David Estabrooks | L. Prentice | Mech. Eng. Engr. | 11/6/67 | Western Electric |
| Walter Belecki | H. Crouse | Purchasing | 11/13/67 | Northern Electric |
| Roger Cady | D. Knoll | Comp. Test Eng. | 11/20/67 | Honeywell EDP |
| Warren Garlick | R. Cady | Comp. Test Engr. | 11/28/67 | Raytheon Company |
| Ira Morris | L. Prentice | Mech. Eng. Engr. | 3/11/68 | Bell Telephone Labs |

# digital INTEROFFICE MEMORANDUM

DATE: April 24, 1968

SUBJECT: KEYBOARDS

TO: Dick Clayton

FROM: Lorrin Gale

cc: Mort Ruderman

This memo is a summary of my investigation of keyboard manufacturers and general state-of-the-art survey of these companies. I have requested and received literature along with "ball park" figures from the following companies: Controls Research Corporation, Garden, California; Invac Corporation, Waltham, Massachusetts; Icor Corporation, Burlington, Massachusetts; Kleinschmidt Corporation, Deerfield, Illinois; Navcor Corporation, Norristown, Pennsylvania; Teletype Corporation, Skokie, Illinois; Micro Switch (Division of Honeywell), Freeport, Illinois.

I have also visited Icor and Invac to see keyboards being manufactured and to assess their capabilities as potential suppliers. The techniques used to generate codes from a keyboard are suprisingly varied. One method employs a reed switch actuated by a permanent magnet upon depression of a key. The output from each switch is fed into a diode encoding matrix to produce the desired code. The reed switch is usually housed in a plastic enclosure and attached to a PC board along with any additional electronic components; such as, diodes (for the diode matrix), IC's (for output buffer, strobe signal generation), etc. Navcor, Micro Switch, and Controls Research use this general method.

I personally found this technique to offer the most impressive advantage along with good economy. Specifically, these keyboards are simple in construction, rugged, require no field service for adjusting and can be easily repaired in case of catastrophic failure. They have only one moving part per key and should last the lifetime of our machine. Their principle of operation is simple; thus, field service, production, and our sales people could be quickly trained. This keyboard can be purchased in lots of 50 for approximately $250.

Other features that are most common available with this type of keyboard are error detection circuits, strobe, ready/busy flags, and one character buffered outputs with the logic for these features being mounted on the PC board within the keyboard housing. The one serious problem with this design is the matter of error detection. As the keys are mechanically independent from each other, it is impossible to physically prevent two keys from being struck simultaneously. It, therefore, requires logic not normally found in mechanical arrangements such as offered by Teletype. However, there are a number of methods available to electronically perform this interlocking.

As part of my investigation, I simulated a keyboard interface with a program on the LINC-8 computer to clearly define which parameters effected this function and what logic would be required to incorporate an electrical interlock. It turns out that the simpliest and cheapest method is to detect when two keys are struck simultaneously and block the resulting erroneous code. This is readily achievable with logic design and is a good compromise between cost versus performance.

Invac, Teletype, and Kleinschmidt use coding key levers which perform the coding function. The main difference in these three keyboards is only in the way the code is transferred from the key levers to the output buffers. Invac uses a light beam and photoresistor detector - one pair for each bit. Teletype and Kleinschmidt uses metal bars to transmit the codes to a set of contacts. Teletype uses an exposed set of contacts and Kleinschmidt uses a glass envelope in the dry reed switch.

Icor offers a completely different approach to the problem. A code is contained within each key and the code is transmitted via capacitive coupling between the key and a detector circuit (operating frequency approx. 4 KHz). I have looked at their keyboard, visited their plant in Burlington, Massachusetts and have come to the conclusion that their keyboard is not yet sufficiently developed for our purposes. I do not believe they possess adequate capability in building printed circuit PC boards with a high density of electronic components. I also feel that their design does not offer good reliability nor does it have the capability to withstand abuse in the field.

We now know that our code requirements are ASCII and that the device must be capable of generating the entire ASCII code set including shift and control functions. This leads us to one of three choices:

(a) Use a Teletype keyboard - solenoid reset - cost $138.

(b) Use a keyboard manufactured by either Micro Switch, Navcor, or Control Research (approx. $275).

(c) Build our own which would be in design very similar to one of the above keyboard manufacturers - cost $120 approx. to manufacture.

There are two further facts which we should consider in our selection:

1. There appears to be a keyboard requirement from Pat Greene's display group. I believe it is in the best interest of the company for us to select a keyboard which can be used by us as well as them.

2. I believe that remote display terminals are becoming more common and will be specified by our customers in the near future. Such systems as LABCOM, patient monitoring, patient interviewing, etc., will require keyboards along with a scope display.

We should, therefore, decide if we want to meet these requirements in a keyboard design along with the requirements for our immediate needs.

Lorrin

Lorrin

bjw

digital INTEROFFICE MEMORANDUM

DATE: April 25, 1968

SUBJECT: Institute for Educational Services - PDP-8/S's - Negro Colleges

TO: Ken Olsen
Nick Mazzarese

FROM: Norm Doelling

1. Conrad Snowden is out of town. I'll call him again Monday and provide you with the follow-up.

2. I'm glad we obtained this lead in the manner we did. I am very familiar with the project as I originally worked with them on GE's Time-Sharing (for which they pay).

They are funded by the Office of Education and should be considered a prime prospect. PDP-8/S's would be more worthwhile and consistent with their objectives.

I'll see how we can tie in with their summer program in Boston.

cmp

Norm

digital INTEROFFICE MEMORANDUM

DATE: April 26, 1968

SUBJECT:

TO: Ken Olsen

FROM: George Arnold
Programming

About a year ago I briefly surveyed the literature to try to determine which spelling, disc or disk, appeared most likely to become most popular in the future. I was not aware of your preference for disc.

I found that IBM had switched to disk, as the attached bibliographies, and the current IBM ad in Communications of the ACM show.

The spelling "disc" is also losing ground in the new general dictionaries, such as the new Random House Dictionary of the English Language, which does not define "disc". This is probably because "disc" is not phonetic.

Assuming that IBM still has 70% of the market, and the remainder of the industry is split, it would seem to me that about 85% of the computer industry is using "disk". If the trend in the general dictionaries continues, "disc" will soon be archaic.

In order to conform, I recommend that we at Digital should switch to "disk".

gab

# digital INTEROFFICE MEMORANDUM

DATE: April 26, 1968

SUBJECT: COMPUTER OPERATION -- PRODUCTION EQUIPMENT

TO: K. Olsen ✓ FROM: J. St. Amour

CC: P. Kaufmann
T. Stockebrand

Your comment on make instead of buy NC drill interests me. I would like your comments on the following building proposal:

1. Build must be accomplished with standard mechanical components, standard shop measuring equipment, drill press, Bridgeport and lathe.

2. Simple plan, probably with building block concept to be developed so anyone could build this type of mechanical unit for any application.

3. Electronic interface to be by DEC. (This needs to be two axis only, should it be three axis to demonstrate this capability?)

For complex application, I would like your thoughts on a transfer machine where each station has multi-positions controlled by computer. Suggested operation would be four-station component insertion. Plan would be to use existing Universal machines, maybe make new X-Y table under each head, operate each X-Y table independently by single computer, transfer from station to station with standard pallet and pallet mechanism.

If we are clever enough, maybe we can convince every small shop that a single computer can take care of the majority of their handling and fixturing operations faster and more economically than air cylinder, valves, etc.

Could we also help the small shop justify a computer by having a package that would allow payroll, etc. processing in parallel with control. Would this not be less expensive than their present alternative or manual or contract with computer specialist.



/kb

# digital INTEROFFICE MEMORANDUM

DATE: April 30, 1968

SUBJECT: Corporate Anti-Trust Policy

TO: Ken Olsen

FROM: Ed Schwartz

"A Guide to the Observance of Corporate Antitrust and Conflict of Interest Policies" – in "Conflict of Interest" file "Articles"

The attached is excellent. It is something that I believe each publicly-held company should distribute to its management team.

By this I mean to say that each company should publish its own Corporate Anti-Trust Policy so that the management team, and to a certain extent, its employees, are fully aware of the corporate position. Such a course of action also gives the company "mileage" in the event of an anti-trust suit. It serves to eliminate an improper intent on the part of corporate individuals.

May I suggest that this pamphlet be distributed to Stan Olsen, Win Hindle, Nick Mazzarese, Bob Savell & John Jones. I would also appreciate having one sent to me for my files.

Mike Ford

Done 6/14/68

6/10 Asked Pat Clark for 10 more copies

EAS:o

5/3 - Ted to handle
lc

digital

April 30, 1968

Mr. Ken Olsen
Digital Equipment Corporation
146 Main Street
Maynard, Massachusetts 10754

Dear Mr. Olsen:

I have just notified Mr. Gene Olson of my resignation as a junior secretary at Digital Equipment. During the past year, seven others have done the same. One of them, Mrs. Anne Christopher, felt she could not endure the humility long enough to give proper notice. Another secretary, Sherry Hamersky, was not even given the chance to resign, but was fired.

Sherry tried very hard and, in my opinion, did extremely well in her work. I found her most cooperative. It seems the reason she was fired was because she was continually tardy and was ill two days in the past two months.

First of all, Ken, Sherry was never tardy. She was almost always at work before I arrived, and many times she was five or ten minutes early. Secondly, Sherry was very ill the two days she was gone. Upon my inquiry to Gene Olson about why Sherry was fired, I was told she had called the office Thursday morning, April 25, and told Mrs. Hall she was too tired to come to work and that she might try to make it in that afternoon. Also, he was under the impression Sherry had been out the night before. None of Mr. Olson's information was true.

Last week I went on vacation to Wyoming to visit my family. I thought perhaps some time to get a way and think things over would help me with my job. Upon returning to work Monday morning, the first thing said to me was, "I guess you know what happened to Sherry, and I don't want to have to go through it again with you." Needless to say, this upset me very much. Mrs. Hall's negative attitude didn't allow me much hope for fulfillment of my desire to try even harder than before to be especially cooperative.

There are countless examples which could be illustrated as evidence of poor leadership, but I will not go into detail as I know you are a very busy man. In essence, what I am trying to express in this letter is the common knowledge that leaders must work with their people, not against them, in order to attain successful ends. Gene Olson is a spineless man who has hired a domineering, vindictive woman to make up for his shortcomings in character.

Ken, you have founded one of the greatest corporations in our United States. I feel it is one of the greatest because I feel at ease enough to call you Ken and to have the freedon to write this letter and know both sides will be heard.

This letter is not born of a hateful mind, but of a great respect for Digital Equipment and its people. But, primarily, I am hoping it will help my friends at DEC; many of whom share my feelings, but have families to provide for and cannot jeoperdize that responsibility.

My last day with Digital will be May 10, 1968. If you should wish to contact me, I will be glad to help in any way I can. I can be reached at Area Code 714-636-0904. My address is 1911 South Haster Apartment No. 51, City of Anaheim, California 92802.

Very Sincerely,

Kathleen L. Seaton

Kathleen L. Seaton

:kls

cc: Ted Johnson

# INTEROFFICE MEMORANDUM

DATE: May 1, 1968

SUBJECT: LINC-8 ENGINEERING

TO: Distribution

FROM: Dick Clayton

Because of several needs for stand alone keyboards in the LINC-8 product area, we have recently investigated a number of manufacturers. The summary report of this investigation is attached for your possible reference. If you have questions about our findings, please feel free to call Lorrin Gale and discuss them.

Dick

Distribution

Ken Olsen
Dick Best
Mike Ford
Gerry Butler
Don White
Pat Greene
Bob Savell
Henry Crouse

digital INTEROFFICE MEMORANDUM

COMPANY CONFIDENTIAL

DATE: May 6, 1968

CONFIDENTIAL

SUBJECT: Quantity Discount Agreements

TO: Ken Olsen

FROM: Ed Schwartz

I am getting more and more concerned about the way our company is handling the Quantity Discount Agreement in the area of customers requesting that their divisions or subsidiaries be brought within the parent's Quantity Discount Agreement.

Although we employ the term "Quantity Discount Agreement" we are in effect using a "Volume Discount Agreement." The former term is generally used when several items are purchased at one time and the latter term is generally used when several items are purchased over a given period of time.

The more I read on the development of litigation under volume discount agreements, and the application of the Robinson-Patman Act, the more I find that even the most commonly used defense of cost justification is not being proved to the courts satisfaction. I realize that this is a case by case analysis on the part of the court and therefore few generalizations can be made. However, I do not think it takes an individual with a great deal of foresight to conclude that in most instances when we extend our Quantity Discount Agreement to subsidiaries and divisions we are not able (with the degree of certainty I would like to see) to cost justify this move.

I appreciate the fact that the Operations Committee, after considering my presentation, concluded that divisions or subsidiaries can only be brought under a parent's Quantity Discount Agreement after vice-presidential and Operations Committee approval are secured. One of the purposes of this memo is to again impart to you my apprehension in extending our Quantity Discount Agreement in this fashion.

In my opinion, as DEC grows larger, the chances of being sued by a competitor of DEC's or a competitor of one of DEC's customers, also becomes more possible. I realize that being able to bring divisions and subsidiaries within the scope of a parent's Quantity Discount Agreement places DEC in the desirable position of increasing its sales. I am sure that the Congress of the United States was aware of this fact when it passed the Robinson-Patman Act, probably concluding, at that time, that the interest of the small purchaser and the isolation of this purchaser from discriminatory practices outweighs the benefit which a potential seller might derive from being able to conduct a volume business.

The main purpose of this memo is to emphasize my concern in this area and my hope that the company does not extend itself unnecessarily.

THIS IS THE ONLY COPY OF THIS MEMO. I HAVE NOT RETAINED ONE FOR MYSELF. WOULD YOU PLEASE DESTROY THIS AFTER YOU HAVE READ IT.

EAS:o

Ken Olsen

May 5, 1968
553 Briar Cliff Rd.
Pittsburg, Pa. 15221

Dear Win;

Thanks for putting my application for credit cards into the mill.

I just filled out and enclosed the travel vouchers and expensed for the trip. It would be nice if the traveler's vouchers and the summary trip travel voucher for the week in someway corresponded to one another. It takes at least 15 minutes to compute the weekly one whereas it should just be a matter of writing it down. — having done the other one

In regard to the management of PDP-10 engineering, its unfortunate you cant hire Savell for it. On the other hand, a rotating manager taken from the group might be the answer, so that the indivuals all got experience in this regard, and don't end up losing their competence. The manager would not / engagp in any designd during the period. I've read at the layman level of groups or projects run in thei fashion, and it appeams to have some advantages, particularly when the people get along welll, and are at about the same level, as it doesn't stress the individuals or put them into an overly competitive state. At any rate it might be worth reading a littel about such an organization, and talking it over with the company psKychologist before throwing it out as a bad idea. I'm sorry I don't know of a reference, but I think the system is used enough to have been studied and reported.

Interesting

In regard to the Memory Engineer, I believe a fellow, who married a friend of Gwen's, by the name of Jim Schott is working at RCA Memory interviewed DEC at one time, but I don't know the outcome. I think he might be pretty average in this area, but again, how much creative talent do you need here? ...There's always big Jim McKalip who I'll gladly recommend as long as I never have to rely on any o. memories he designs, or have to listen to him.

Thayer

I hope you can get someone, and I'll pass along any hints I have. DEC is interviewing one of my Ph D's, Adrian van der Goor who will hopefully finish in Septe/mber, and he would be w quite good at this kind of work since he is good at circuitry. It's too bad that schools aren't turning out these kind of engineers, as I feel that circuitry alond with power engineering seems to be vanishing from our curricula. We turn out the big, but useless big picture man. If Ted Johnson who went to VRC is available, he would be a good Memory guy.

I'm still fond of the idea of an xø or something-or-another employees discount plan for DEC equipment cause my son needs a computer lab, and I eventually want an 8 or one of its friends.

In listening to president Olsen's report to somebody as reported in one of the DEC publications, I find that DEC has 2/// 2-1/2 x the number of computers installed as SDS. It seems to me that any model of computer marketing has got to be based on the number of c machines in the field, and as such puts DEC in an ///// and enviable position-provided that it can take advantage of the effect. As I talk with the small C guys, I feel their stmategy is based on continued bottom prices. The 10 strategy is clearly on a service and computation/$ basis. The place what i think is ignored is th//e intermddiate, general purpose market which I believe is characterized by the IBM 1620, and now 1130. 7/ Both the 8 (with all its software, including Algol ) and the 9 ( with not quite so exotic software) seem great machines for this large, general purpose area. Now with teh existence of the new , large disc, DEC can be very strong here, if it proceeds to market as a general purpose machine. This entails a marketing effort similar in nature to the tysetting or laboratory or data communications area. Of course a line printer would be nice to have in this area, but not mandatory if one used et either th//e Motorola or the Teletype Inktronic printers, ...and there is also the card reader problem, although Teletypes might be sold as Keypunchers....Of course, the 8 Time Shared system obviates the need for Keypunchers.

Gordon

digital INTEROFFICE MEMORANDUM

DATE: May 6, 1968

SUBJECT: PARKING VIOLATIONS

TO: Ken Olsen FROM: Harry S. Mann

I have discussed the problems involving the three people covered in your memo of April 24. Frankly, I was not entirely satisfied with the attitudes involved but we are not sitting still. As a result, we are working with these people and believe that they are worth taking some effort to correct rather than to replace.

Nancy Egan is the switchboard supervisor and she had indicated that she realized that she was parking illegally but felt everyone did it and it was so much easier for her than having to walk a great distance from an alternative lot. Her general attitude toward the Company is excellent and I believe we will not experience any further violations. There have been none since your memo of April 24.

Bob Graham points out that these violations all occurred when he was asked to run errands for the Company. Since he would return at odd hours, it frequently resulted in his finding no place to park in the area to which he had been assigned. He did what he felt was the next best thing of parking in an improper manner. Here again, his attitude appeared to be satisfactory and we have had no violations since we spoke with him.

Charles Manchester received his violations during the middle of the Winter when snow in the parking lot on Main Street resulted in a number of parking problems. In consultation with the Personnel Department, two of the three violations were rescinded, being minor in nature and somewhat controversial. His attitude is excellent and we have had no further problems.

It is apparent that all three of these violations related to people who use the area in the mill yard off Main Street. A number of people who have been moved out of that part of the building to building 5 and other places, appear to still be using the area which should be reserved for people in buildings 12 and 3 particularly. We will look into this problem a little further.

HSM/ml

digital INTEROFFICE MEMORANDUM

DATE: April 24, 1968

SUBJECT: PARKING VIOLATIONS

TO: Harry Mann

FROM: Ken Olsen

In a memo dated April 10th from Wallace Skilling in Personnel, the following people in your cost center were reported as having received three or more parking violations during the month of March:

Nancy Egan

Robert Graham

Charles Manchester

I would like to know what their reaction was when advised of these violations, and if they have had any more violations since that time.

Ken

ecc

digital INTEROFFICE MEMORANDUM

DATE: April 10, 1968

SUBJECT: Parking Violations

TO: Harry Mann

FROM: Wallace Skilling - Personnel

The following people have received three or more parking violations in the past month:

Nancy Egan, (Dept. 641, Jim Myers). Parked in the No Parking area of the Main Street Lot March 12, March 14, March 15, and March 28.

Robert Graham, (Dept. 549, George Lord). Parked in the No Parking area of the Main Street Lot March 5, March 7, March 11, March 22, and March 28.

Charles Manchester, (Dept. 552, Elliot Hendrickson). Occuping two parking spaces in the Main Street Lot March 7; Parked in the No Parking area of the Main Street Lot March 21. and March 22.

cc: Ken Olsen
Bob Lassen
Al Hanson
John Murphy

WS

# INTEROFFICE MEMORANDUM

cc: W. Hindle
K. Olsen

DATE: April 17, 1968

SUBJECT:

TO: P. Kaufmann ✓ FROM: J. Smith

The following action has been initiated on the below reported violations:

Doris Larrabee, Department 433, George Wood

Final warning has been issued; additional violation will warrant a suspension or discharge.

Ronald Miller, Department 436, Jack Smith

Was working nights; parked in Visitors' Lot. Car broke down; could not remove that night. Removed the following day but was reported as a violation.

Carl Pearson, Department 435, Jim Cudmore

Final warning has been issued; additional violation will warrant a suspension or discharge.

Edward Dart, Department 435, Jim Cudmore

Parked by guard; not considered a violation per John Murphy, Personnel Department.

Jack

sm

Attachment

Jy [illegible] [illegible]

# INTEROFFICE MEMORANDUM

DATE: April 10, 1968

SUBJECT: Parking Violations

TO: Pete Kaufmann

FROM: Wallace Skilling - Personnel

The following people have received three or more parking violations in the past month:

Doris Larrabee, (Dept. 433, George Wood). Parked in the No Parking area of the Main Street Lot March 25, March 26, and March 27.

Ronald Miller, (Dept. 436, Jack Smith). Parked in the Visitor's Parking Lot March 4th; Parked on the Thompson Street ramp March 22, and March 23.

Carl Pearson, (Dept. 435, Jim Cudmore). Parked in the Visitor's Lot March 14th; Parked on the Thompson Street ramp March 18, and March 21.

Edward Dart, (Dept. 435, Jim Cudmore). Parked outside the lines in the Walnut Street Lot March 6, March 28, and March 29.

cc: Ken Olsen
Bob Lassen
Al Hanson
John Murphy

WS

digital INTEROFFICE MEMORANDUM

DATE: April 24, 1968

SUBJECT: PARKING VIOLATIONS

TO: Win Hindle FROM: Ken Olsen

In a memo dated April 10th from Wallace Skilling in Personnel, the following people in your cost center were reported as having received three or more parking violations during the month of March:

David Friesen

Thomas Walsh

I would like to know what their reaction was when advised of these violations, and if they have had any more violations since that time.

Ken

ecc

digital INTEROFFICE MEMORANDUM

DATE: April 10, 1968

SUBJECT: Parking Violations

TO: Win Hindle

FROM: Wallace Skilling - Personnel

The following people have received three or more parking violations in the past month:

David Friesen, (Dept. 258, Bob Lane). Parked in the Visitor's Parking Lot March 25, March 26, and March 27.

Thomas Walsh, (Dept. 461, Steve Mikulski). Parked on the Thompson Street ramp March 26, March 27, and March 28.

cc: Ken Olsen
Bob Lassen
Al Hanson
John Murphy

WS

digital INTEROFFICE MEMORANDUM

DATE: April 26, 1968

SUBJECT: Parking

TO: Ken Olsen

FROM: Win Hindle

Friesen and Walsh stopped parking illegally immediately after being spoken to the first time. As it happened, both men were spoken to on the day of their third violation, so they had accumulated three violations at that point. Both were reasonable and agreed willingly to park legally.

bwf

# digital INTEROFFICE MEMORANDUM

DATE: May 7, 1968

SUBJECT: Programmable Controller

TO:

FROM: Jack Dumser - Ann Arbor

The Programmable Controller has been conceived to be a replacement for relay and solid state control panels (sequencing panels) commonly used on machine tools, special machines, and in process control.

A study recently made at Hydramatic Division, General Motors, Willow Run, Michigan, indicated that of the 5,000 or so machines in their plant roughly 95% of them have control panels falling into easily defined categories. The cost of these panels typically falls into the $2500 - $3000 range. The ratio of digital inputs to outputs is 2:1 over the entire range of machines, and the mean is 22 inputs and 12 outputs.

The controller currently being specified by Hydramatic must have the following:

1. 115 vac inputs and outputs;
2. A non-destructive read out form of memory;
3. Modularity;
4. Provisions for simplified trouble shooting by present plant maintenance personnel.

Present plans at Hydramatic call for a prototype to be delivered within 9 months, 5 - 10 preproduction models shortly thereafter, followed by approximately 1000 units over the next three (3) years.

Dow Chemical, Midland, Michigan, has also shown intense interest in these controllers. They expressed a need for 450 units over the next 12 months.

digital INTEROFFICE MEMORANDUM

DATE: April 30, 1968

SUBJECT: Programmable Controller

TO: Stan Olsen
Al Devault
Russ Doane
Bob Fronk

FROM: Jack Dumser - Ann Arbor

It is suggested that the Programmable Controller might have provisions for eight (8) devices addressable by the ninth (9) instruction of the proposed instruction set. Each of the 8 devices would be essentially an 8-bit counter with an over-flow flag and each would be capable of being loaded by the 9th proposed instruction with an 8-bit binary number. Inputs to the individual counter could be from any one of four sources:

1. Jumpered to a selected input line;
2. Jumpered to a 60 cycle pulse source;
3. Jumpered to a selected output line;
4. Jumpered to the logic such that the counter can be incremented by a machine instruction.

The over-flow flags with the counters will automatically be cleared when the counters are loaded. The over-flow flag can be jumpered to any selected input line. The program will detect the end of a timed interval by periodically sampling that input line.

Another feature that appears necessary is the capability of doing single level subroutining in which case an additional register must be provided and a return instruction implemented. Any jump instruction would automatically cause the current program counter to be loaded into the subroutine register.

Dow Chemical, Midland, Michigan, has shown intense interest in these programmable controllers. Their feeling is that they need hundreds of them, but that they need them now.

JMD/sbs

digital INTEROFFICE MEMORANDUM

RECEIVED
APR 12 1968
DIGITAL EQUIP. CORP.

DATE: April 9, 1968

SUBJECT: PROGRAMMED CONTROLLER

TO: Al Devault
cc: Stan Olsen

FROM: Russ Doane, Jack Dumser.

office copy

INSTRUCTION SET

00XXXXXX Set Test FF if Specified Input Zero

01XXXXXX Set Test FF if Specified Input One

100XXXXX Clear Specified Output Control FF

101XXXXX Set Specified Output Control FF

1100XXXX, XXXXXXXX Jump* if Test FF Zero

1101XXXX,XXXXXXXX Jump* if Test FF One

1110XXXX, XXXXXXXX Jump* unconditional

11110XXX Delay Using Specified K303 Timer

11111XXX,XXXXXXXX Delay* By Specified Cycles (120 Hz)

*These instructions use word following; if no jump, operation begins from second address after jump instruction. All jumps clear Test FF. Jump instructions use last 8 bits to address up to 256 8-bit words directly, with last bit in first word available for expansion to 512. Jump bits 4, 5, and 6 are available for incrementing event counters, addressing other processors, or microprogrammed options added by user. Programmed time delay has 11 bit resolution to obtain times from 8 ms to 16 sec.

CAPABILITIES

INPUTS TESTED: up to 128 in increments of 32
OUTPUTS CONTROLLED: up to 64 in increments of 16
Directly Addressable Memory: up to 512 words normally; 4096 words maximum
HARDWARE OPTIONS: up to 8 event counters; up to 8 RC timers; one or more live registers (addressed as memory extension)

MEMORY

Basic machine has 128 8-bit words. All memory is normally read-only.

COST TARGETS, Preliminary

128 word memory, $100 production cost
Basic Logic $200 production cost

EXPANSION

Capability for inputs and outputs rises in direct proportion to memory capacity. The 16,32,128 proportion between outputs, inputs, and memory appears to be near optimum for a wide variety of machine sizes. Input and output interfaces plug into prewired sockets, so only those actually required need be purchased.

cc

digital INTEROFFICE MEMORANDUM

DATE: May 7, 1968

SUBJECT:

TO: Ken Olsen

FROM: Jack Dumser - Ann Arbor

Thank you very much for sharing your room with me on Tuesday night at the Spring Joint Computer Conference.

Attached are the memos relating to the Programmable Controller currently being proposed to Hydramatic Division of General Motors. Copies of these memos are also being sent to John Cohen as per your request.

Enclosed also is a pen which I believe you left in the room.

Again, my thanks.

Regards,

Jack

digital INTEROFFICE MEMORANDUM

DATE: May 8, 1968

SUBJECT: SUPERIOR ELECTRIC COMPANY

TO: Ken Olsen
Ken Fitzgerald
Lon Beaupre

FROM: Henry Crouse

I expressed "concern" to Mr. Burr Denning, the National Sales Manager, of their performance in supplying us the oil damped motor for our paper tape reader. And more "concern" that they were selling a paper tape reader.

His response was that they felt badly the results were not as good as they expected them to be. They had tooling problems with our motors but are now in production. They had extended their efforts considerably to the point of hand producing, in the laboratory production level, units at production prices.

He felt this reader was not competitive with ours. The motor is not oil damped. The motor is not available for sale.

He said candidly, "we are not about to play games" with us, since we are customers. The problems with our motor were not related to the development of their paper tape reader.

The reader was developed for their N/C equipment, since they were having problems with the reader supplied to them.

ams

Hary

Copy sent to Vern Alden 5/14

digital INTEROFFICE MEMORANDUM

DATE: May 10, 1968

SUBJECT: Follow-up on 13 Negro Colleges

TO: Ken Olsen
Nick Mazzarese

FROM: Norm Doelling

On Wednesday morning I met with Dr. Conrad Snowden and Mr. Jack Alexander, who are in the Curriculum Development Group of the 13 college program. We discussed the potentialities of computers to replace time sharing, and the PDP-8/S in particular. They are interested in the one-year lease program for a maximum of 12 machines, if they can obtain the funding. Evidently they had some budget problems this year with the Office of Education. However, they were optimistic about going back to O.E. for funds. If they do, I think we have a very good chance of leasing PDP-8/S's to them.

I took Mr. Alexander over to the Cambridge office so that he could get a demonstration and so that we could pick up some specific price information which he needed before going on a trip of one week's duration. In the interim they will compare our one-year lease prices with their cost experience with time sharing. When Jack returns from his trip he will come out to DEC to play with an 8/I and to test some of the programs he has already written (in BASIC) in the FOCAL language to compare his experience and to compare the languages. I find FOCAL is difficult to adapt to after extensive use of both BASIC and JOSS. I hope Mr. Alexander does not. I will apprise you of future developments.

Norm

cmp

digital INTEROFFICE MEMORANDUM

DATE: May 13, 1968

SUBJECT: Quantity Discount Policy

TO: Harry S. Mann
cc: Ken Olsen ✓

FROM: Ed Schwartz

I was most interested to review the memo of the Marketing Review Committee to the Operations Committee dated April 22, 1968, especially the last page thereof, which compares the policies in detail of several of our competitors in this area.

The one thing that struck me was that Honeywell, a rather sophisticated, knowledgable company, does in fact give discounts on a quantity basis, but probably justifies them by not having any service, documentation or warranty period. I rather think that our Quantity Discount Agreement leaves us open to attack on a cost justification basis because we do not cut back on the services which we give to Quantity Discount customers to the extent that we probably should.

This is just an observation and something that should be kept in mind when this matter is reviewed.

Ed

EAS:o

digital INTEROFFICE MEMORANDUM

DATE: May 13, 1968

SUBJECT: Dr. Kramer's Character Recognition System

TO: Ken Olsen

FROM: Gene Olson

cc: Ted Johnson
Nick Mazzarese

Since our conversation regarding the character recognition system of Dr. Henry P. Kramer, I have met with him to discuss his plans.

Now that he has demonstrated machine recognition of handwritten characters without the usual constraints on character size, orientation, and style, he would like to develop his concept into a commercial system. (The demonstration consists of showing that any Arabic numeral written on the display of a 338 will subsequently be printed on its teletypewriter.)

This development will probably be directed toward the most immediate application, check handling (becuase it requires only numeral recognition plus a few symbols). The system configuration: a paper feed device, an optical reader, a PDP-8/I, and an interface to a magnetic ink marker. Dr. Kramer intends to use available equipment to the maximum possible extent, and do only that development work which is absolutely necessary. Thus, most of the effort will go into the optical reader and further software development.

Hardware development is, of course, beyond the scope of General Electric Tempo. Although various groups throughout GE have witnessed the 338 demonstration, no one has expressed a strong interest in supporting further effort. Therefore, Dr. Kramer is looking for an arrangement outside GE. (His work in character recognition has been funded by the two percent discretionary portion of his Navy contracts, which does not, he feels, put it in the public domain; however, he has a legal opinion that since his work is strictly conceptual, it is not patentable, and GE has no proprietary interest.)

Dr. Kramer is seeking support for a two-year effort to develop a prototype check handling system. His projected costs for the first year total $110,000 plus the rental of a 338. This included salaries for himself, his assistant (Dave Karpeles), and a secretary, office rental, and all equipment needed to fabricate an optical reader. The 338 will serve as a flying spot scanner in simulating a photocell matrix. He is much less precise about second-year costs, estimating them to be between $200,000 and $300,000. The fabrication of several optical readers accounts for the increase. The prototype paper feed devices is also included here, as well as the interface to a magnetic ink marker. He envisions a system having the following cost of manufacture:

| | |
|---|---|
| Paper Feed Device | $1,000 |
| Optics | 500 |
| Transducer (36 x 2 photodiode matrix) | 1,000 |
| Interface to computer | 1,000 |
| Computer | 3,000 |
| | $6,500 |

(Not included: interface to magnetic ink marker)

As for the form of the relationship that he would like to have with Digital, Dr. Kramer suggested the formation of a small company, partly owned by Digital and partly by himself. This company could undertake other research and development work for Digital. (Voice recognition, for example, is an area in which Dr. Kramer has special interest.) He would also like to take his Navy contracts with him. Alternatively, he would be willing to become an employee of Digital -- provided this included stock ownership. In either case he prefers to remain in Santa Barbara.

It is worth noting that the Chase Manhatten Bank and also the First National City Bank of New York were very receptive to Dr. Kramer's presentation of a system that reads ordinary handwriting. Both offerred financing on favorable terms.

Dr. Kramer is very anxious to learn of your reaction to his proposal; first, because he feels that Digital is where he wants to be, and second, because he must proceed before anyone at GE takes an interest in his creation -- at which point things become very much more difficult.

GMO:bh

# INTEROFFICE MEMORANDUM

DATE: May 15, 1968

SUBJECT: MODULE 222

TO: Distribution

FROM: J. St. Amour

The LINC 8I has some interesting boards. M222 with 20 integrated circuits on a double size board, M221[1] with 22 integrated circuits on a double size board and M212 with 10 integrated circuits on a single size board.

These will provide a good sample for layout evaluation of surface mounted versus inserted components. We should look at both the M212 single circuit and the more complex of the double circuits. It is possible the double circuit could be less complex due to the additional space between circuits.

A surface mounted IC can fit within a .500 X .650 inch PAD area which will allow mounting the required components on the same size board for either technique. In addition, there is no reason why the center space on a double board cannot be used for component mounting if it gives an advantage.

Norm stated he could start this evaluation by Monday, May 20. This information is needed fast, as a number of board layouts should be re-worked with the better technique to reduce delivery time and cost.

Either way will certainly give a less complex board than the present layout.

1 The present M221 is subject to change; however, evaluation of the present configuration can provide needed data on layout technique.

Distribution:

| | | |
|---|---|---|
| K. Olsen ✓ | N. Perryman | G. Wood |
| P. Kaufmann | T. Stockebrand | G. Geralds |
| | | R. Clayton |

/kb
Attachment

MAY 1 3 1968

digital INTEROFFICE MEMORANDUM

DATE: May 6, 1968

SUBJECT: MODULE M222

TO: Joe St. Amour

FROM: Ken Olsen

425

I was visiting with Dick Clayton recently and he showed me a new module of his. It is not officially into the system because he is a little afraid of it being so hard to make. Looking over this module, it seems to me that all its problems would be solved if we laid the individual circuits on the surface. (It's a module he calls M222.)

Ken

ecc

Jim Scanlon

MAY 17 1968

digital INTEROFFICE MEMORANDUM

DATE: May 16, 1968

SUBJECT: PDP-8 at Trade Shows

TO: Ken Olsen

FROM: Richard M. Merrill

CC: Nick Mazzarese
Mike Ford
George Rice
Roy Gould

Let's have a meeting to consider some improvements in showing the PDP-8/I and family at the trade shows. Several people have expressed disappointment with our showmanship at the SJCC, and I would like to make some suggestions, beginning with the least:

1. Modify the antiquated false floors. We don't need them to hide cables, and few exhibitors now have that problem. But it is good to elevate the machine somewhat so that they may be viewed better. However, the salesmen are not on exhibit and should be on the same plane as the customers. In fact, the salesmen, customers, and programmers up there sometimes obscure the machine!

2. Pre-show briefings should take place the evening before the show with salesmen present. This would be the time to present new information and leave plenty of time to answer all questions. The meeting on the opening morning could be more of a pep-rally thing. People need time to assimilate the many new fliers, brochures, program manuals, etc. This lack of basic information on the part of all personnel was one of the weak points in our exhibit. The people there should know something about all product lines.

3. New literature, especially about new products and programs should be distributed to the sales offices at least a week in advance of the show. This would disseminate information through the proper channels and avoid the embarassment when customers who attend the shows have more data than the salesmen.

4. The following is plagerized from Jim Murphy's memo:

"A remarkable amount of knowledgeable interest was expressed towards the software and the hardware and in most instances the impression created was a healthy one.

"The following points were noted during the course of the conference and are itemized below in hope to realize the old adage that 'experience is the best teacher'.

"I believe that these problems are company wide and should be the subject of extensive research ASAP. Adequate solutions would improve DEC's image commensurate with that deserved by the software that has been developed.

a) Adequate showmanship to attract passerby - the PDP-8 booth was drab and caused questions such as, "What's going on here?" Much explanation could have been avoided with descriptive signs and diagrams to stir the interest of the spectators.

b) Adequate supply of brochures and manuals.

c) Marketing and sales people should be informed of the strong points of the demo and leave the answering of detailed questions to those equipped to answer them correctly."

5. The PDP-8 group did seem to have good coordination between Marketing and Programming, and most were enthusiastic. However, the booth often seemed "dead" especially without working computers at all times. And there could still be stronger adherence to the booth duty schedule.

6. According to some observers we were "outdone at every turn": H.P. had time-sharing, C.D.C. had motion pictures, Varian had handbooks, A.D.R. had audio output via interactive language, and Techtronics had a conversational and inexpensive graphics terminal that offers complete program compatibility. (It is also modularly interchangeable with the ASR-33, i.e. 33 input and scope output and with the 34D control.)

Our only innovation was the new disc (the "Maxi-disc") and its sign was seldom more than three feet off the ground.

Let's make more noise by having more peripherals (DECtape, scope, A to D and D to A, and remote control teddy bears!) and some short, simple and graphic signs to get our message across better and faster. A dynamic character display would be a great help here.

7. One page <u>graphic fliers</u> that carried the booth theme in some fashion (a picture of the PDP-8/I, or disc, or a miniature of some work of art) would do wonders for reinforcing their impression of the DEC exhibit.

8. With all the buttons being passed out we should distribute a <u>Button Banner</u>. This would be worn over the shoulder and across the chest and would protect good suits from myriad pinpricks. Although the front would be covered by other people's buttons, the back would proclaim:

"Digital Equipment Corporation"

PDP-8/I, PDP-9, PDP-10

9. Specifically I would propose for the Fall Joint Computer Conference that we demonstrate time-sharing on each computer in the product line:

| | |
|---|---|
| PDP-8/I | (General purpose or one language dedicated system) |
| | Features Disc, display, FOCAL, Basic |
| PDP-9 | (Multi-forground/background) |
| | Features Disc, dectape, A/D, Fortran |
| PDP-10 | (Advanced programming systems) Features multi-lingual capabilities |

Each system would have at least three terminals, at least one of which should be graphic. Another on each system could be tied to a data phone!

Rick

RM/mc

## SUMMARY

1. Have something artistic for the booth itself.
2. Get the literature out early.
3. Keep salesmen informed in advance.
4. Have more peripheral equipment.
5. Have a unifing theme for all product lines.

digital INTEROFFICE MEMORANDUM

DATE: May 17, 1968

SUBJECT: MEMORY CORES

TO: Ken Olsen ✓
Pete Kaufmann

FROM: Henry Crouse

We are surveying vendors for current core pricing.

Ferroxcube offered the following budgetary price for a 30FC01, 30 mil core.

| QUANTITY | | PRICE PER M |
|---|---|---|
| 100 million | @ | \$2.50/M |
| 250 million | @ | \$2.25/M |
| 500 million | @ | \$2.00/M |

Wide temperature, lithium material is approximately 20% higher.

A year ago the pricing would be \$6.00 to \$7.00 per M.

There is a general over capacity situation in core production and pricing has deteriorated accordingly.

Harry

ams

5/23

cc: Nick Mazzarese
Mike Lord
Roger Cady
John Holzer

May 18, 1968
553 Briar Cliff Rd.
Pittsburgh, Pa. 15221

Dear Ken,

You had ask for a reading on this proposal, and moreover these guys or perhaps one of them.

I read the proposal and think it was a nice public relations kind of job suitable to sell even the hardest heart of manager types ( of the non-computer oriented variety so typical to the GE computer division). Unfortunately the thing doesn't say how their scheme is different, nor does it say exactly what it is.

I've never been able to quite figure out why the character recognition equipment business is the way it is. Recognition Inc. appeard to be always on the forefront of a breakthrough, but has never quite made it as a company, which I suspect is because the people are always trying to build something harder than they can do, rather than just selling something that will work....This ~~seems~~ is probably an over simplification of all failures in new technologies, but probably accounts for a large number.

If the people are good in both the mechanics, and the recognition part, then it would be worth getting them, if not for recognition stuff, but for other reasons. If there aren't good mechanical people, then I don't think it is a very saleable group, because the mechanism seems the most difficult part to me, ie. moving all that crumpled paper, that fast, seems a real problem.

All in all, although I am easy to ~~be~~ persuade, any form of character recognition device is among the lowest priorities of things I would try to develop, because of the technical and marketing problems. (How about the little company that ARD owns as a better starting point?)

An area that may be equally difficult, and perhaps has the same problems is the mechanical robot and manipulator market. Servomation (somewhere in Connecticut) seems like a more ~~likely~~ interesting area, and has as much or more need for computers.

Sincerely,

Gordon Bell

PS. I've just come from looking at the Hewlett-Packard Desk Calculator that has been recently announced. I'm currently TRying to get E M Williams to write a programmed text for the FOCAL package for the PDP-8, since he is using it on the PDP-8s here. This would be quite a coup, since Williams is head of the EE department, has wirtten several programmed texts, (and the other kind too), but is also on the board of directors of EAI. The department is currently tring to decide between the PDP-8i, with FOCAl , and a desk calculator. I am rambling on abotu DESK Calculators, because I think they present a very interesting Marketing and production challenge to DEC. The market is estimated to be quite large, and I would like to see some real brainstorming about the market psossibility of such and item. I think it would be q good practice for the forthcoming years and technology, where comptuers end up in homes. I estimeate it would be woth while having a PDP-8' with large disc, and several consoles in our own home when the price gets into the $10k region (about 2 years away?). At any rate, I feel this program is quite an interesting device, but feel it isn't going anywhere now. at DEC The EE department compared the 8 with a Wang LOCI calculator, but ~~through~~ threw out the Wang. If it wins the Hewlett Packard Battle, it will be solely on its own...and not a marketing effect. The HP Calculator is quite cute, DEC engineering/production would do well to have a perusal. It uses a rope memory for its control, and a resistor/diode character generator for the tube, not to mention a tape recorder for storing programs.

digital INTEROFFICE MEMORANDUM

DATE: May 22, 1968

SUBJECT: Technograph Printed Circuits Limited and Technograph, Inc. - Patent Infringements Suits

TO: Ken Olsen

FROM: Ed Schwartz

The same day I received the newspaper clipping from you, concerning the above matter, I also received the notices from the United States District Court with regard to this matter.

It is my understanding that this company did sue DEC several years ago on certain patent infringements, which I do not think are the subject of the suits, and a settlement was reached. Bob Cesari informs me that even if Technograph is successful in the subject suits, it could well be that the patents that concern DEC have already expired and therefore the damages would be minimum. However, he felt it would be necessary to review the memorandum which I received from the court to ascertain whether or not DEC is, in fact, a potential infringer.

If my understanding of patent litigation is correct, and I must admit that a Class Action is not the most common way of enforcing patent rights, even if Technograph were successful in this Class Action it would then have to sue each and every infringer to ascertain if, in fact, damages were due.

EAS:o

**digital** INTEROFFICE MEMORANDUM

DATE: May 23, 1968

SUBJECT: Bryant Computer Products; Division of Ex-Cell-O Corporation
850 Ladd Road, Walled Lake, Michigan 48088 Phone 313/965-7880
or 624-4571 Ext. 243

TO: Ken Olsen, Stan Olsen, Pete Kaufmann, Ted Johnson, Al Devault, Bill Landis, Bob Lane, Fred Gould, Bill McNamara

FROM: Bob Fronk - Ann Arbor

THIS MEETING IS BEING RE-SCHEDULED AT
BRYANT'S REQUEST TO MONDAY

8:30 a.m., MONDAY, MAY 27, STRATEGY DISCUSSION MEETING
9:30 a.m., MONDAY, MAY 27, MEETING WITH BRYANT PERSONNEL

Primary Purpose:

To discuss manufacturing of modules for Bryant Computer. They use about 20,000 boards per year including read/write amplifiers, etc.

They have made the decision to buy modules made outside. They are in the process of choosing a vendor.

Secondary Purpose:

To discuss small computers for use as terminals. They are now involved in a terminal research project (using INTERDATA 3) at the University of Michigan. This is supposedly a secret project.

Visitors from Bryant, Walled Lake, Michigan

Mr. Robert Wilson, Vice-President and General Manager
Mr. Belanger, Materials Manager
Mr. Strehl, Research-Development and Engineering Group Manager

Visitors from Ex-Cell-O Corporation Systems Group (formed one year ago)

Mr. Elliott, Manager Systems Group
Mr. A. Kritz
Mr. D. Ridenour

Other persons previously contacted at Bryant (old information):

Mr. Bitterle, Product Assurance
George Roach, Engineer (now in Englewood, New Jersey)
Scott Weaver, Engineer - user of PDP-8 for drum testing (purchased through S. Sterling)

Jack Lockery
W. W. Grodin, Purchasing Agent
John Labby
Don Biondo
Jim Jessup
Don McIntosh (transferred to Englewood, New Jersey, to help set up the systems group and then left the company)

General background information:

1. In January, 1965, Bob Oakley discussed a disk tester with their engineering group.

2. In May, 1965, Roger Buiten discussed construction of modules for Bryant with George Roach. At that time they said that they were not yet ready to present their ideas to management.

3. In September, 1966, they purchased a PDP-8 through S. Sterling to build into their own disk tester. Scott Weaver seems to be the prime engineer for this project.

4. In the winter of 67-68, a contract was signed with the University of Michigan Institute of Science and Technology to construct a computer terminal using Bryant drums, keyboards, and displays. Frank Westervelt, Assistant Director, Computing Center, University of Michigan, is in charge of this system.

   Fred Coury, Engineer at the University of Michigan, is working out details of the system. They are using an INTERDATA 3 computer despite our efforts to talk them out of it (they wanted 8 bit byte orientation and read-only storage.)

5. May 20, 1968 - Bob Lane was contacted by General Manager, Robert Wilson, Bryant, Walled Lake, Michigan, regarding possibility of DEC manufacturing modules for Bryant.

Ex-Cell-O

1. Very large manufacturer of machine tool systems. They use GE N. C. Controllers. They have a division which manufactures weapons for the government.

2. Bryant Computer Products are noted for their drums and disks which have unique hydraulic binary actuators for head positioning.

llp

**digital** INTEROFFICE MEMORANDUM 6/10

Copies to: Win Hindle
Stan Olsen
Dave Cotton
John Jones

DATE: May 24, 1968

SUBJECT: PDP-10 COMPARABLE WITH SIGMA 5

TO: Gordon Bell

FROM: Ken Olsen

SDS seems to have outsmarted us when they came out with their Sigma 5. They now have the lowest priced computer of this size, and are taking many orders away from our PDP-10.

What can we cut out of the PDP-10 to make a useful, low-priced computer?

Ken

*...I'm glad you ask that question. On February 26 1968 I wrote a number of possible solutions which came out of my visit on 15 February, and on 21 of February 1968 Seligman wrote a memo on PDP-9 which said roughly the same thing.*

*Namely, we say: The Sigma 5 came out because of the PDP-10 and is presumably selling better because of lower cost, or 32 bits or people not able to sell the 10 IO structure or the 10 IO structure may not be as good. The 10 people probably aren't interested in any compatibility with the 9, or are interested in a scaled down version of the 10. I expect future plans for the 10 to be more extensive in its ability to time share, with better (more exotic) program mapping to cut down on the monitor overhead.///... All of these take the machine up the price scale, but make it more useful or better for timesharing. I don't think the 10 designers are particularly interested in the problem...or should they be? One thing that Seleigman and I agree on in this regard, is that a very useful, PDP-10 compatible Processor could be made which is probably based on a Read Only Store to interpret the PDP-10 order code. It would be slow by 10 standards, but on the other hand could maybe exist for as little as 20-30 k$....and be only 1/4 as fsst. Just integrating might help on the cost question.*

*In regard to the stuff taht John Cohen is doing we are obtaining very interesting results by coding various problems, and intend to find the best machines for various problem classes. I am asking John to add coding for the PDP-10 to see how it s fares, .. or am trying to find just what it is the large machine is good at. Several weeks ago, I started examining the possibility of connecting many of these computers together, to see if it helps the power problem, with the hopes of wiping out large machines for most problems, and it appears as if this may just be possible. Therefore, in the 8 bit machine, that sells for $2k I want to put some escape mechanism so that it can exist in a high performance version with 32 or more bits, and floating point. As of now, the problem seems easy, but may not look so good as we get closer to the solution. So far the 8 bit (cough) $2k machine is better than and x, a 9, the 8, (10) all 16 bitters, and maybe the 10, now maybe we ought to look at a problem it doesnt do so well on..*

How About putting Seligman on this problem this summer? gordon

# digital INTEROFFICE MEMORANDUM

DATE: May 24, 1968

SUBJECT: POWER SUPPLY POWER CONTROL CABINET DESIGN

eng. committee

TO: ~~Ken Olsen~~

FROM: George Gerelds

cc: Operations Committee

In an organization expanding as rapidly as DEC, I believe the Mechanical Engineering Department (or the responsible group), should take a good look at what is happening in our computer cabinet design. By this I mean, power supply's power controls not just logic and design. If we use cabinets that we can lay out the power supply and power control together on a flat panel, we would save thousands of dollars in assembly time alone.

My previous experience has been, that once everything is built, then engineering decides on a power supply for one corner and a power control in the other because there is only room at the bottom or on the side. In most cases, there is so much material in this power supply or control that it is put in a box that is 14" x 14" x 5" deep. Some of the components have to be wired in subassembly, some wires can't be attached or components can't be secured. Good examples of this are the 844, 845 power controls; 844 is the "in-out" equipment MA10 memory, the 845 is the KA10 PDP-10. Both of these power controls are going to be a definite manufacturing "headache."

Some engineers argue that power controls must be put in boxes for safety reasons - always afraid that someone will get a shock. Who goes around looking for a shock? People in electronics, like electricians, work with power every day and they should respect it - not be afraid of it.

My point is, that even though we are in a big hurry for the prototype, we should make the changes in the initial stages despite a possible time delay. Production is only interested in getting them out the door (the past and present is no different). Production people will complain among themselves but not to the right people - the people who could correct the situation.

mdo

**digital** INTEROFFICE MEMORANDUM

DATE: May 27, 1968

SUBJECT: SMALL COMPUTERS EMPLOYING READ-ONLY MEMORIES

TO: Ken Olsen FROM: John Holzer

It turns out that Franz Jerfy, a sales trainee from Munich, is the most knowledgeable observer of Nixdorff.

Nixdorff's product incorporates a pluggable Read-Only memory that contains the entire "program," a Read-Write memory, a processor, and several standardized interfaces.

Of course, developing a Read-Only memory for one application appears to offer lowest cost for many applications, but I don't know:

1. who develops the application program--Nixdorff or the customer,
2. how the program is debugged (e.g. is it debugged in a general-purpose computer first?),
3. if the customer develops a specialized program and wants to buy corresponding Read-Only memories;
    a. what the pricing policy is,
    b. how Nixdorff tests the specialized Read-Only memories.

Franz is telexing Munich and Cologne to try to obtain information to answer these questions and to pin down what hardware Nixdorff employs.

John Cohen has already started the 8-bit in earnest. I do not know if I should be involved with it or not. Please advise.

Incidentally, I contracted with J. A. Jones to engineer a PDP-9 Card-Reader Control. I am supposed to complete my assignment by July 1. My sole motivation is to work with DEC Logic before it goes the sabre-toothed tiger route.

llp

John

DIGITAL EQUIPMENT CORPORATION • MAYNARD, MASSACHUSETTS

digital INTEROFFICE MEMORANDUM

DATE: May 27, 1968

SUBJECT: PDP-9 MEMORY STACK FAILURES

TO: Henry Crouse
CC: Ken Olsen
Pete Kaufmann
Lon Beaupre
Bob Hughes
Bill Burns

FROM: Dick Heaton

Between November of 1967 and April 15, of 1968 we received 342 PDP-9 memory stacks from Data Products, Inc. and Electronic Memories. Of this total, 82 stacks or 24% have failed on the PDP-9 production line and in the field. These naturally were returned to the respective vendors and repaired at no charge. Failure rates were 30% and 20% for Data Products and Electronic Memories respectively.

A cooperative effort has been under way since January between DEC personnel and representatives of Data Products and Electronic Memories. The attack has been to define problem areas and make specific design changes to correct their reoccurance in future stacks manufactured and stacks returned for repair.

Lou Lueders, General Manager of Data Products, the prime reject offender, has pledged on April 23, his support to reduce failures to below 10%. This is acceptable based on our experience with the PDP-8 and PDP-8S.

Electronic Memories has made several design and manufacturing changes within the month of May which are aimed at correcting 50% of the reported failures.

The type of corrective actions taken involve closer QC inspection of diodes at the component state and preassembled state, methods of relieving strain on the magnet wires at the PC board terminations, and test fixtures to prevent upper and lower sense lines from being reversed.

With specific corrective steps taken we will continue to monitor with the vendor the results of his changes.

Dick

Dick Heaton

atl

digital INTEROFFICE MEMORANDUM

DATE: May 10, 1968

SUBJECT: MEMORY STACK FAILURES IN THE PDP-9

TO: Henry Crouse

FROM: Ken Olsen

I have been hearing a lot about trouble from memory stack failures in the PDP-9. Are we keeping good records of this, and is someone watching it to see if we should change vendors or if we should make wholesale changes of those computers in the field?

Could you send me a note listing what our failure situation has been.

Ken

ecc

SALES CALL REPORT NO. 47496

- [ ] INITIAL CONTACT
- [x] FOLLOW-UP
- [ ] ADD TO MAILING LIST
- [ ] ADD TO FORECAST

% $ ORDER MONTH

PRODUCT: PDP-10

FIRM: LINK Group, General Precision Inc.

ADDRESS: Systems Division
Binghamton, New York 13902

PHONE AC 607-772-3516

SALESMAN: Rod Belden

DATE: 5-1-68

OFFICE: Rochester

CONTACT: [X] MV [ ] TV [ ] MT [ ] TT
SJCC

| PERSONS CONTACTED | (✓) | KEY(✓) | POSITION | EXT. |
|---|---|---|---|---|
| Daniel G. O'Connor | | X | Technical Dir. | |
| also key persons: | | | | |
| James M. McGowan | | X | V.P. & Gen. Mgr. | |

SOURCE OF FUNDS: Internal

WHEN:

| (✓) | EVAL. | (✓) | YEARLY POT'L. | PRO | INFLUENCED BY | CON |
|---|---|---|---|---|---|---|
| | URGENT | X | >150K | X | PRICE | |
| X | HI | | >50K | | DELIVERY | |
| | MED. | | >20K | | QUALITY | |
| | LO | | <20K | | SERVICE | |
| | FORGET | | | | OTHER (DETAIL) | |

COMPETITION: (MFR./EQUIP.) SDS Sigma 5/7

SPECIAL COMMENTS: LINK will review this project during the week of May 6 and decide which manufacturers they will continue with.

APPLICATION:

LINK has changed their approach from wanting a full license to purchasing processors at a discount from a manufacturer and installing either their own or a purchased memory system. Average of 64K memory per system.

At the SJCC with Bob Savell we proposed the possibility of a contract price to pmoduce 25-50 PDP@10 processors with minimum memory and I/O.

ACTION TO BE TAKEN:

FOLLOW-UP DATE 5-7-68 BY R. Belden

SPECIAL COPIES TO

Bob Savell

DIGITAL EQUIPMENT CORP. [redacted]

KO re keeping in
touch with
production people

SALES CALL REPORT NO. 47497

| | |
|---|---|
| INITIAL CONTACT | |
| FOLLOW-UP | X |
| ADD TO MAILING LIST | |
| ADD TO FORECAST | |

% $ ORDER MONTH

PRODUCT: PDP-10

FIRM: LINK Group, General Precision Inc.
Systems Division

ADDRESS: Binghamton, New York 13902

PHONE AC: 607-772-3011

SALESMAN: Rod Belden

DATE: 5/28/68

OFFICE: Rochester

CONTACT: MV [ ] TV [ ] MT [X] TT [X]

| PERSONS CONTACTED | (✓) | KEY (✓) | POSITION | EXT. |
|---|---|---|---|---|
| Daniel O'Connor | | X | | |

SOURCE OF FUNDS: Internal

WHEN:

| (✓) | EVAL. | (✓) | YEARLY POT'L. | PRO | INFLUENCED BY | CON |
|---|---|---|---|---|---|---|
| | URGENT | | >150K | | PRICE | |
| | HI | | > 50K | | DELIVERY | |
| | MED. | | > 20K | | QUALITY | |
| | LO | | < 20K | | SERVICE | |
| | FORGET | | | | OTHER (DETAIL) | |

COMPETITION: (MFR./EQUIP.)

SPECIAL COMMENTS: See Sales Call Report from May 1, 1968, #16576

APPLICATION:

The LINK Group has decided not to solicit a detailed technical proposal from DEC for their hybrid simulation controller. The PDP-10 does not match the requirements for the low cost processor needed by LINK:

1 LINK will manufacture memory systems either to their specification or under license.

2. The KA10 is a more powerful processor than is needed, and would not be competitive unless it was supplied under special contract at a price of approximately $40,000. (List price of a SIGMA-5 processor is $50,000.)

At this time it if not clear that the SIGMA-5 will be the chosen processor for the next phase of this project.

ACTION TO BE TAKEN:

1. Keep Dan O'Connor informed of all new DEC products.
2. Follow progress of the project and equipment selection.

FOLLOW-UP DATE

BY R. Belden

SPECIAL COPIES TO

Ken Olsen, Win Hindle, Bob Savell

DIGITAL EQUIPMENT CORP.

SPECIAL ACTION

# INTEROFFICE MEMORANDUM

DATE: June 3, 1968

SUBJECT: PROJECT SCHEDULING SYSTEM

TO: John Leng

cc: Ken Olsen ✓

FROM: Bob Collings

Ken Olsen has indicated that he would like to include the development of Reading's manufacturing facilities in the Project Scheduling System. I have enclosed DEC STD 008 and a couple of typical schedules in order to familiarize you with the system.

Initially, it may be somewhat difficult to coordinate efforts so that the Schedule Review Committee can effectively follow the progress of your program, but over the long term, this should provide valuable communication in both directions.

I would like to add your project to those we review on the fourth Friday of the month, so please arrange the mailing of the schedule so it arrives a day or so prior to that meeting.

Bob

mac

Enc.

File - Xerox

digital INTERPOFFICE MEMORANDUM

DATE: June 3, 1968

SUBJECT: Xerox R & D Reorganization

TO: Ken Olsen
John Cohen

FROM: Rod Belden

"Significant organizational changes have been made in Xerox' research and development activities, to enable the company to diversify more effectively and increase its ability to meet short and long term goals."

The attached article from "The Xerox World" outlines the new organization and the responsibilities of men such as J. Dessauer, R. Hay, G. White, R. Potter and J. Glavin. I hope you find this useful background information.

RB:msf

Att.

Ken Olsen

# Research, Development Are Realigned

Significant organizational changes have been made in Xerox' research and development activities, to enable the company to diversify more effectively and increase its ability to meet short and long term goals.

The changes were disclosed April 19 in a joint announcement by Archie R. McCardell, executive vice president of operations, and John H. Dessauer, vice chairman of the board and executive vice president of the Research and Engineering Sciences Division.

Following are the new technological responsibilities of the various Xerox divisions:

• The former Research and Advanced Engineering Division now becomes the *Research and Engineering Sciences Division* (RESD), a title that better defines its new role. It will investigate and develop new or advanced sciences and technologies that could provide diversification opportunities for the company. In addition, it will conduct innovative research in technological areas assigned to the business divisions, but upstream from current business division efforts.

RESD also will continue fundamental research, coordinate all Rochester-originated research and development work sub-contracted outside the company, consult with the business divisions and recruit and develop top level research scientists and engineers. It will be a

See 'Research,' Page 4

## 5 Reasons For Changes

In making the recent announcement of the organizational changes in Xerox' research and development activities, Xerox officers cited five basic reasons for making the changes.

The primary purposes of the moves were:

• To broaden the role of corporate research and advanced engineering to give the group a key

See 'Reorganization,' Page 3

# Reorganization Is Made For 5 Primary Reasons

Continued from Page 1

long term role for innovative research in areas of support for all divisions and to increase its responsibility for research in completely new areas.

"We thus expect to safeguard the primary mission of this group to develop and make available the technologies, inventions and devices needed for the future, rather than to be engrossed in important, but shorter term product activities," said Archie R. McCardell, executive vice president of operations, and John H. Dessauer, vice chairman of the board and executive vice president of the Research and Engineering Sciences Division.

- To continue the decentralization trend and to insure that the operating divisions become fully responsible for their own areas of activity and interest.

- To establish an important new staff review function in line with moves recently made in other areas, so as to provide complete corporate staff capabilities for the corporation.

- To move additional trained and capable people into certain key management positions.

- To initiate what will be a continuing program of job rotation in all research and development areas, recognizing that this is an effective device for the development of individual skills and progression in management careers in technical or other areas.

"The realignment of research and development responsibilities provides more precise objectives," McCardell and Dessauer added. "It allows Research and Engineering Sciences to place greater emphasis on the future and eliminates unnecessary duplication of technological effort.

"As a result, we are confident the realignment will enable Xerox to increase its technological capabilities and thus assist us in attaining our ambitious growth and diversification objectives for the future," they concluded.

# Research, Development Aligned

Continued from Page 1

source of such people for eventual placement in business divisions. The division will have a budget based on a percentage of total research and development expenditures in a given year, thus eliminating it from competition for funds and assuring objectivity.

• Business Products and Systems Division Development Departments. Technical groups in the division will have primary assignment for the development, exploitation and utilization of xerography, optical systems design and paper and document handling. They will be the *primary source* for the design and development of those portions of all products involving these technologies.

• Information Systems Division Development Department. ISD will be the *primary source* for the development and exploitation of several non-xerographic technologies such as electrography, character generation and display technology, whose development had been under way in the Advanced Engineering Department.

"To implement these new objectives has required a new structure for RESD and for the development departments in BPSD and ISD," McCardell and Dessauer said. "The accompanying organization charts indicate a number of significant moves for key people. Many have moved from one division to another. Inter-divisional and intra-divisional moves of technical people, as well as of others, will become much more common in the future in an attempt to broaden the experience of people."

Department managers who have new assignments under the reorganization include:

• Clyde Mayo, formerly vice president and manager of the BPSD Development Department. Mayo now becomes vice president in charge of technical evaluation and review in RESD.

• Robert Potter, formerly vice president and manager of the Advanced Engineering Department in R&AED. He becomes vice president and manager of the Development and Engineering Department of ISD.

• Paul Catan, formerly manager of the technical program management section in BPSD. He becomes manager of the new Product Design and Engineering Department in BPSD.

• George White, formerly manager of ISD's Development Department. He is now manager of the Advanced Development Department of BPSD.

• Peter Warter, formerly manager of the Advanced Materials Technology Laboratory. He now becomes manager of the Engineering Sciences Department in RESD.

## *Mayo: Engineer's Engineer*

Clyde R. Mayo, 47, the new vice president in charge of technical evaluation and review for the Research and Engineering Sciences Division, has gained a reputation among his colleagues as an engineer's engineer during his 19 years with Xerox.

Mayo, a native of Providence, R.I., joined Xerox in 1949 as a development engineer for the first commercial xerographic products. In [illegible]6, he was named manager of machine development and it was his organization that developed all the company's xerographic products on the market today.

Clyde Mayo

Mayo received his B.S. degree from Brown University in 1942. He was a mechanical engineer with the U.S. Naval Ordnance Laboratory from 1942 to 1945, and worked with the Chefford-Master Manufacturing Co. for three years before joining Xerox.

Mayo became a vice president and assumed the duties of manager of the Business Products and Systems Development Department in January, 1966.

## Review Committee Formed

As part of the realignment of research and development activities, a corporate-wide technical review committee has been established to prevent overlapping and duplication of effort among divisions. Its chairman is Clyde Mayo.

The committee will have the responsibility for recommending approvals or changes to technical program plans, assignment of divisional responsibility for new specific plans, assignment of divisional responsibility for new specific technologies and various technical department policies.

Besides Mayo, other members of the committee are Robert Potter; George White; Paul Catan; Peter Warter; Winfield W. Tyler, vice president and manager of the Research Department of RESD; Eugene Goldberg, manager of materials science and engineering; and Robert Bussard, chief scientist at Electro-Optical Systems, Inc., in Pasadena, Calif.

Ellis Slack, corporate planning will be secretary of the committee.

## *Four Department Managers Get New Assignments*

Robert Potter

Paul Catan

George White

Peter Warter

Dr. Robert J. Potter, the new vice president and manager of the Development and Engineering Department for the Information Systems Division, is one of Xerox' youngest vice presidents at the age of 35.

Potter joined Xerox in 1965 as associate director of the applied research laboratory, where he established the Xerox information technology research group.

Potter received his doctorate in optics in 1960 from the University of Rochester. He held managerial posts in the areas of optics, pattern recognition and image processing at IBM's Thomas J. Watson Research Center prior to joining Xerox.

Paul Catan, 40, now the manager of the Product Design and Engineering Department for the Business Products and Systems Division, joined Xerox in 1957 as a product engineer on the 914 program.

The native of Brooklyn was a U.S. Army technician before going to college. He earned his B.S. degree in mechanical engineering from Rensselaer Polytechnic Institute in 1950 and did work for his MBA at the City College of New York.

Prior to joining Xerox, Catan served the Merganthaler Linotype Corp. as a product engineer on new product programs.

Dr. George White, 39, newly-named manager of the Advanced Development Department for the Business Products and Systems Division, came to Xerox less than a year ago from the post of chief scientist at Electro-Optical Systems, Inc., a Xerox subsidiary in Pasadena, Calif.

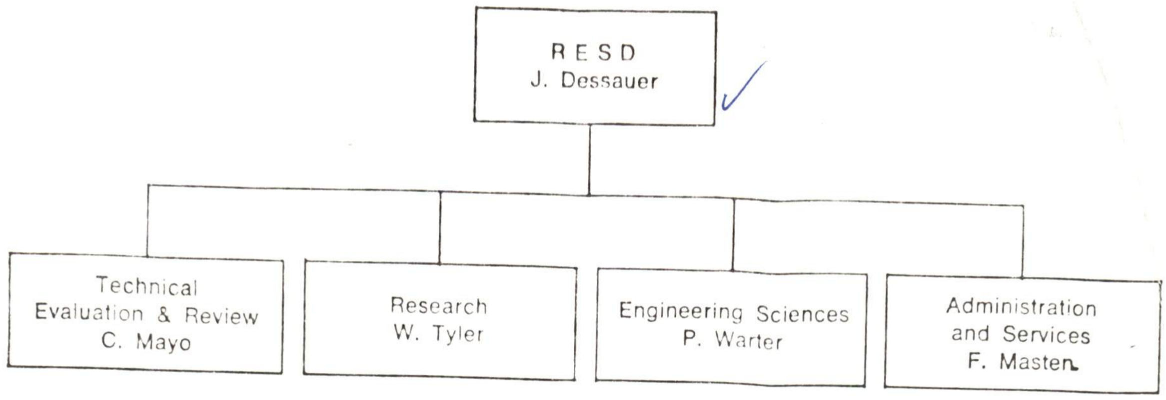
White joined Xerox last September as manager of the Engineering Department for the Information Systems Division. At EOS, he had held several positions including manager of the Quantum Products Division, manager of the Optical Electronics Division and technical director prior to assuming the post of chief scientist in 1967.

Dr. Peter J. Warter, 35, th[e] new manager of the Engineerin[g] Sciences Department for the Re[-] search and Engineering Science[s] Division, joined Xerox in 1965 a[s] manager of the photoconducto[r] research branch of the former Re[-] search and Advanced Engineer[-] ing Division.

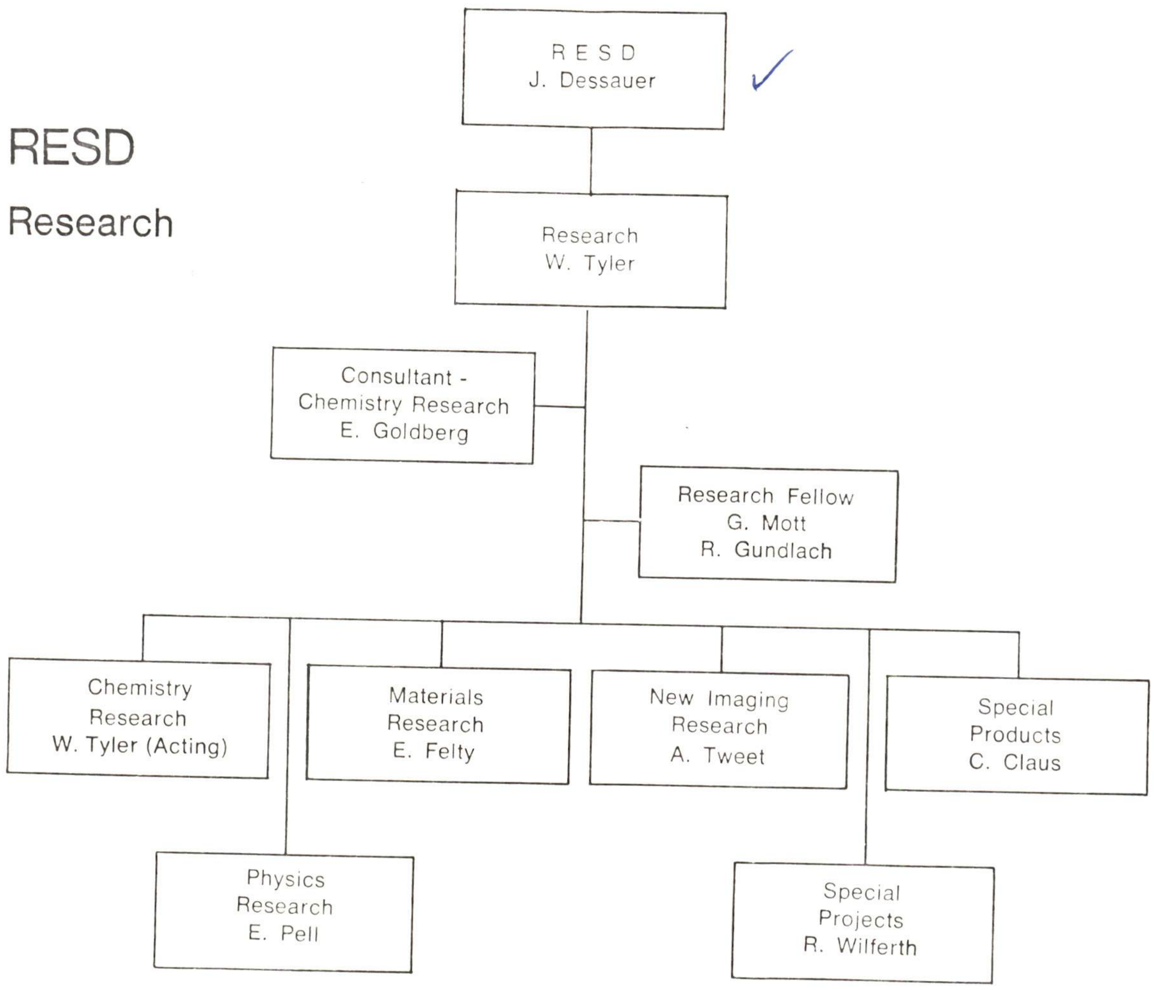
Warter earned his B.S. in physics and electrical engineerin[g] from Princeton University i[n] 1954. He obtained his master' degree in electrical engineerin[g] from Princeton in 1956 and hi[s] doctoral degree in solid state elec[-] trical engineering from Princeto[n] in 1962.

He was an assistant professo[r] of electrical engineering a[t] Princeton from 1962 to 196[?].

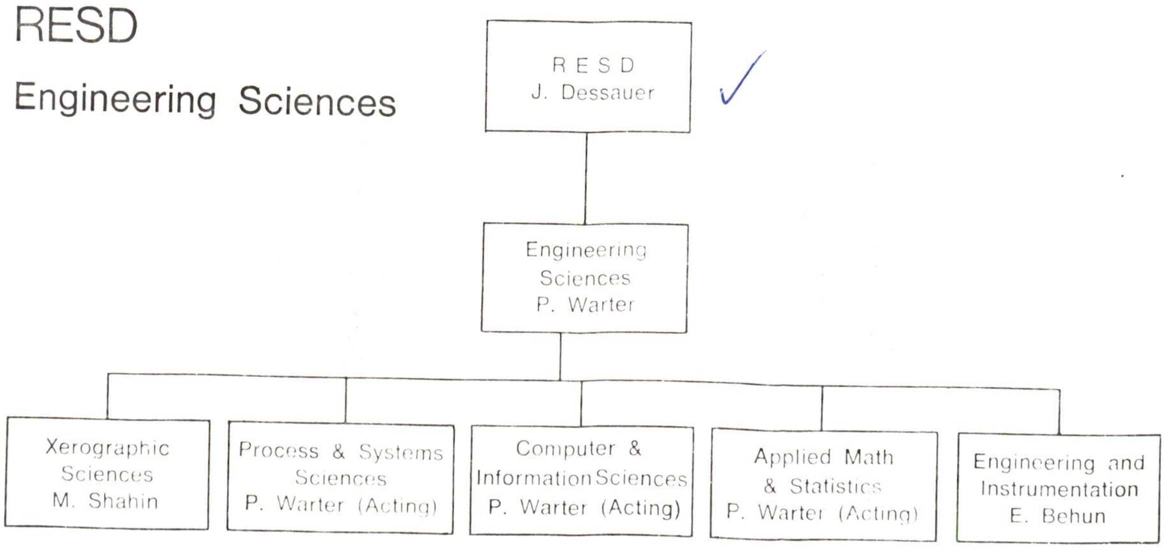
# RESD




# RESD
## Research

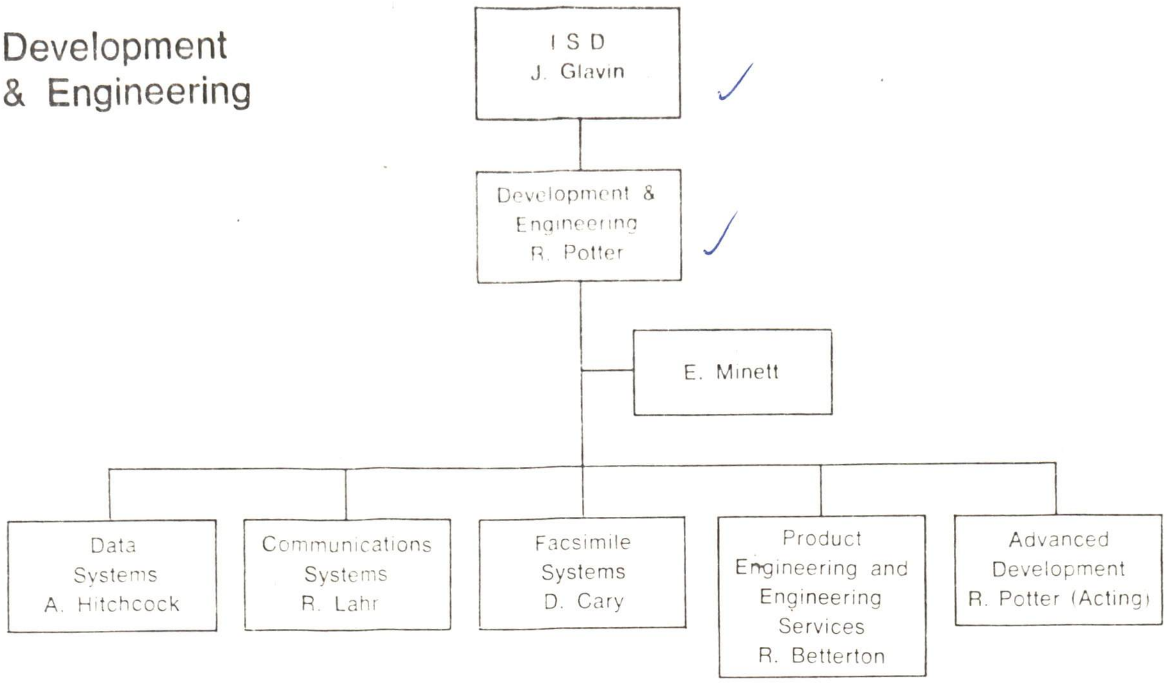



# RESD
## Engineering Sciences



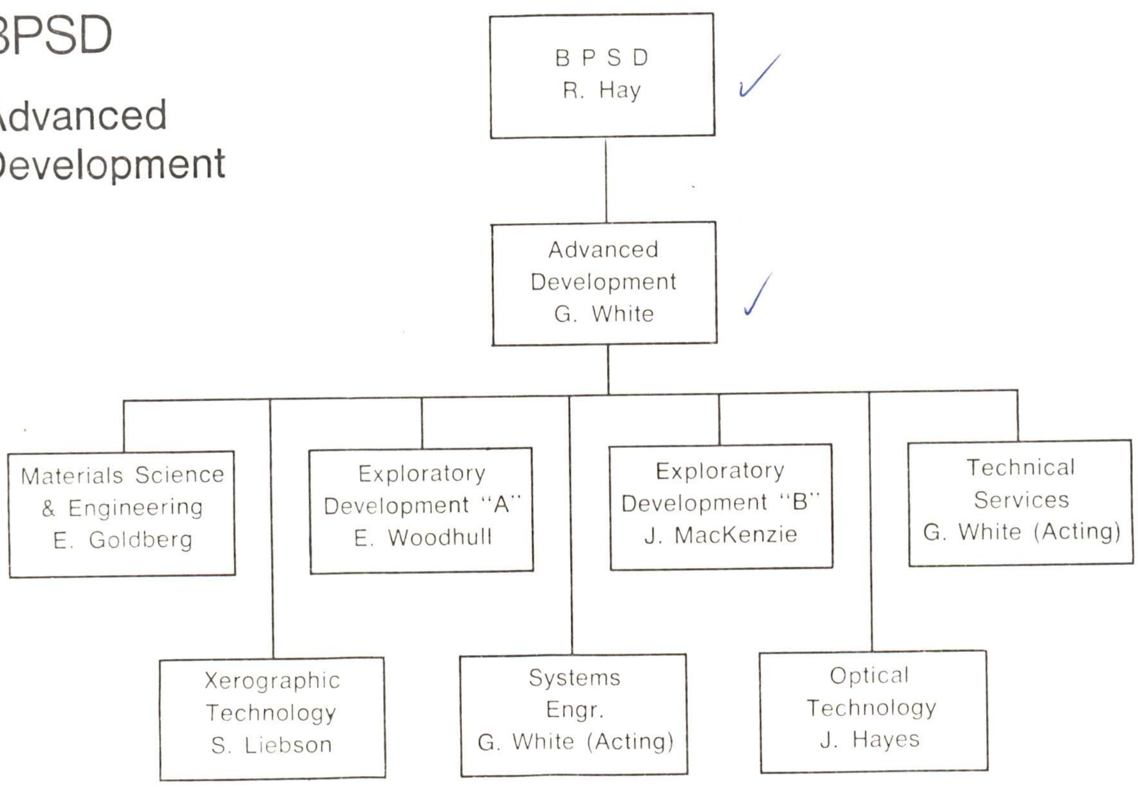
# ISD

## Development & Engineering



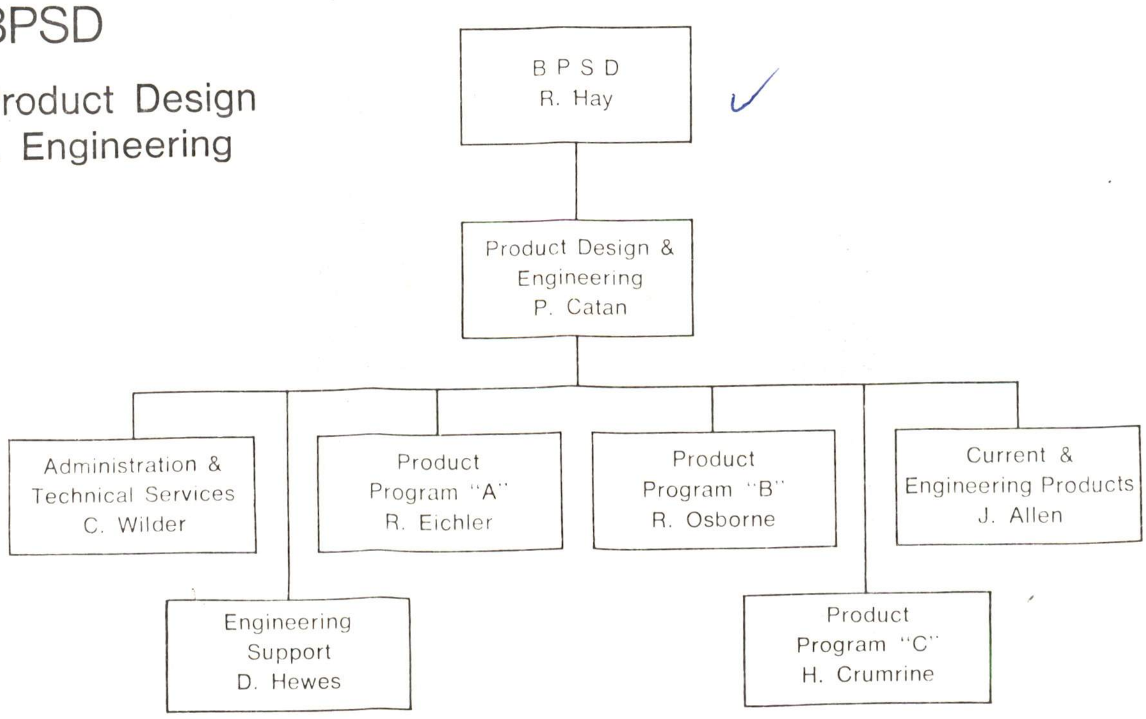

# BPSD

## Advanced Development




# BPSD

## Product Design & Engineering



digital INTEROFFICE MEMORANDUM

Memo #268

DATE: June 17, 1968

SUBJECT: Requested Drawing and Diagram

TO: K. Olsen

FROM: J. Pinder

Enclosed you will find a diagram of the new paging system, now located on the second floor of building five, and a schematic drawing of the present fire alarm system.

Jon
Ted
Gordon
Johnson

Enclosure (2)

JP/iea

dec

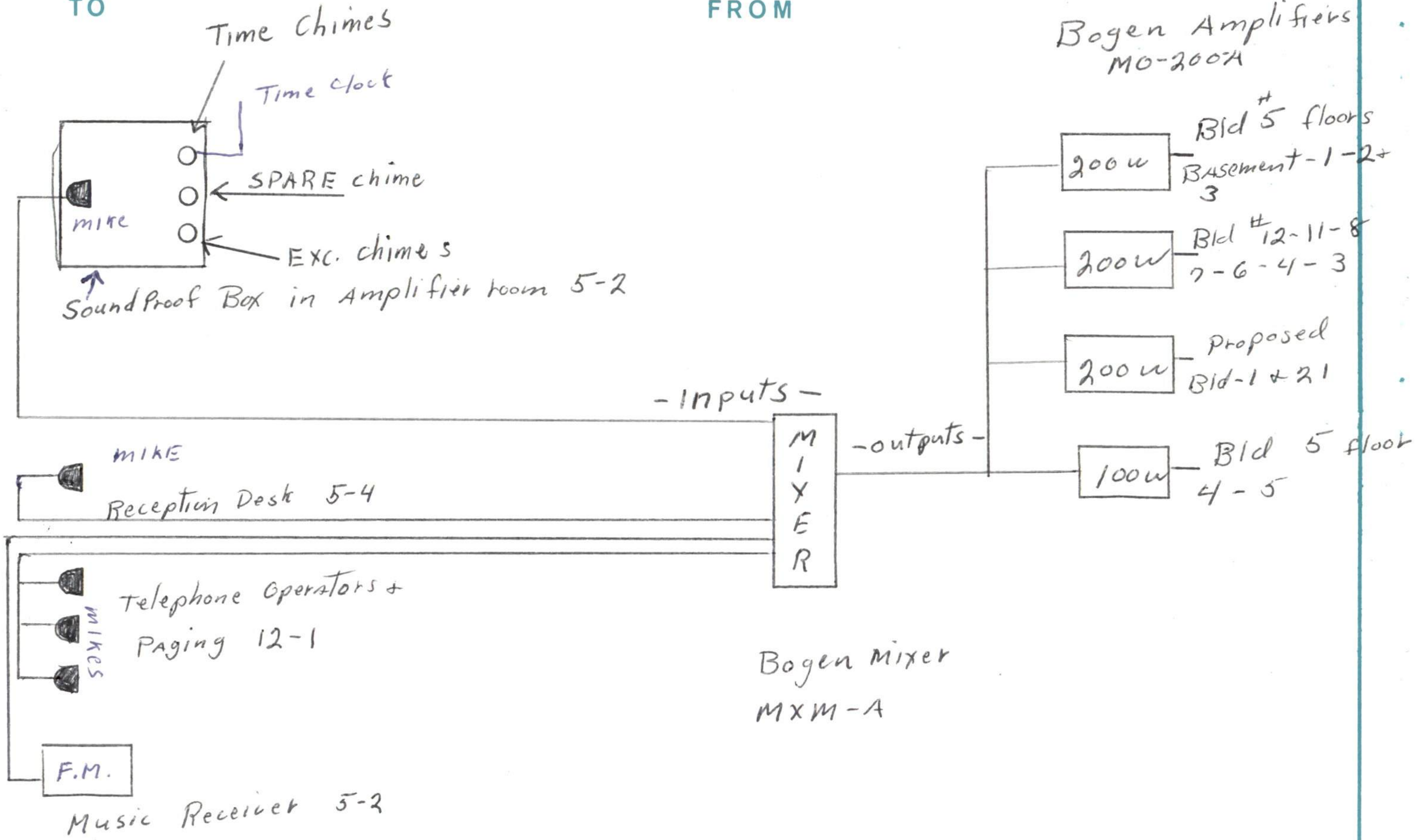
# INTEROFFICE MEMORANDUM

DATE

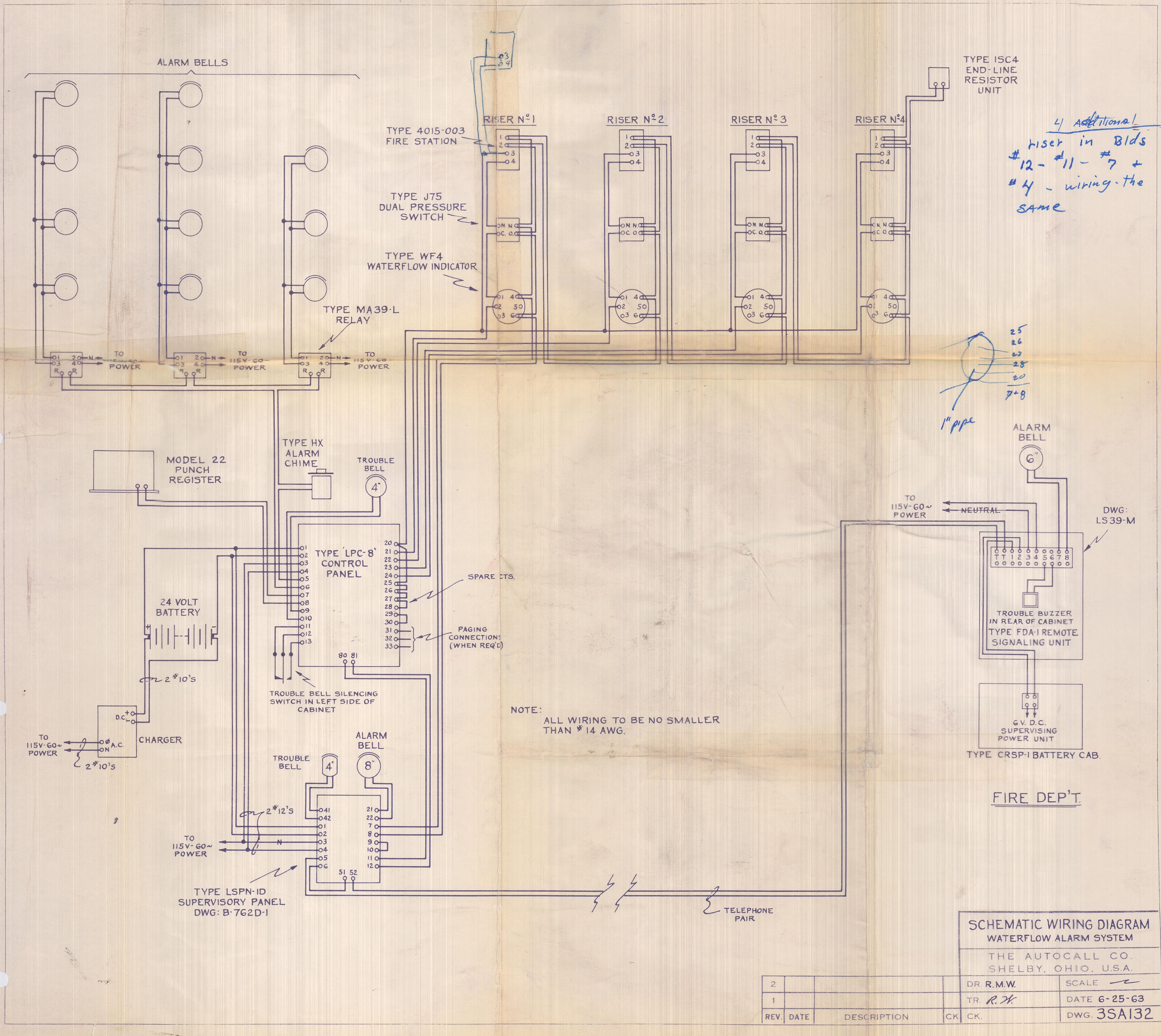
SUBJECT

TO

FROM




Entire Paging System is now Located on second floor of Bld 5



ALARM BELLS
TYPE 4015-003 FIRE STATION
RISER Nº1
RISER Nº2
RISER Nº3
RISER Nº4
TYPE ISC4 END-LINE RESISTOR UNIT
4 Additional riser in Blds #12 - #11 - #7 + #4 - wiring the same
TYPE J75 DUAL PRESSURE SWITCH
TYPE WF4 WATERFLOW INDICATOR
TYPE MA39-L RELAY
TO POWER
TO 115V-60~ POWER
TO 115V-60~ POWER
25
26
27
28
20
7+8
1" pipe
ALARM BELL
6"
TYPE HX ALARM CHIME
MODEL 22 PUNCH REGISTER
TROUBLE BELL
4"
TYPE 'LPC-8' CONTROL PANEL
SPARE CTS.
PAGING CONNECTIONS (WHEN REQ'D)
24 VOLT BATTERY
2 #10's
TROUBLE BELL SILENCING SWITCH IN LEFT SIDE OF CABINET
TO 115V-60~ POWER
NEUTRAL
DWG: LS39-M
TROUBLE BUZZER IN REAR OF CABINET
TYPE FDA-1 REMOTE SIGNALING UNIT
6V. D.C. SUPERVISING POWER UNIT
TYPE CRSP-1 BATTERY CAB.
FIRE DEP'T.
NOTE: ALL WIRING TO BE NO SMALLER THAN #14 AWG.
TO 115V-60~ POWER
CHARGER
2 #10's
TROUBLE BELL
4"
ALARM BELL
8"
2 #12's
TO 115V-60~ POWER
TYPE LSPN-1D SUPERVISORY PANEL DWG: B-762D-1
TELEPHONE PAIR
SCHEMATIC WIRING DIAGRAM
WATERFLOW ALARM SYSTEM
THE AUTOCALL CO.
SHELBY, OHIO, U.S.A.
DR R.M.W.
TR R.W.
SCALE —
DATE 6-25-63
DWG. 3SA132
REV. DATE DESCRIPTION CK. CK.

digital INTEROFFICE MEMORANDUM

DATE: June 20, 1968

SUBJECT: CHEAP TAPE INFORMATION FROM LOU ILLINGWORTH

TO: Ken Olsen
cc: Nick Mazzarese

FROM: Mike Ford

Now that we are doing the PDP-8/L, the cheap tape has come into clearer focus and I have included $ in my engineering budget for this project. Roger Cady is seeking the personnel to do it right now; programming is making available personnel for diagnostic and utility programming within several months. In short, I have redecided to do the project starting in July. Do you still want the materials you requested in your memo of June 17?

Mike

eem