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Memorandum M-1500

Digital Computer Laboratory
Massachusetts Institute of Technology
Cambridge, Massachusetts

SUBJECT: WHIRLWIND II MEETING OF MAY 16, 1952

To: Whirlwind II Planning Group

From: N. H. Taylor and W. Hosier

Date: May 23, 1952

Members Present:

I. Aronson	R. Horn	R. Pacl
P. Baltzer	W. Hosier	R. Pfaff
H. Boyd	R. Jeffrey	H. Rising
G. Briggs	A. Katz	R. Sims
D. Brown	W. Linvill	N. Taylor
D. Eckl	J. McCusker	R. von Buelow
R. Everett	J. Mitchell	B. Widrowitz
J. Forrester	W. Ogden	R. Wieser
A. Heineck		J. Woolf

N. Taylor began the meeting by reintroducing the question of building a prototype WWIA computer, which in the recent past has been regarded as impossible because of pressing time schedules. With three or four machines necessary at each air-defense site and anywhere from ten to fifty such sites distributed through the continental U. S. A., somewhere between thirty and two hundred computers of the WWII type will ultimately have to be built. It is therefore essential that we know after building the WWII prototype what sort of machine can feasibly be produced in such numbers and be expected to work. If our experience of the techniques involved is obtained solely from this WWII prototype, it is likely to be inadequate, for production will follow too closely on the heels of the prototype. This, N. Taylor feels, indicates the desirability of going back to our original intention and building a WWIA which will test memory and other components under something approaching operating conditions.

Certain minimum characteristics of WWII (e. g., reliability, speed, size of memory, time for completion, etc.) together with desirable improvements in those characteristics, were set forth in J. W. Forrester's note M-1468 of April 29th. N. Taylor listed these, commenting as follows:

The 24-month "most desirable" completion time listed in Forrester's note is close to an absolute minimum; the best we could hope to do in such a short time would be substantially to duplicate WWI, since no time would be available for development of new components. Possibly the time required for scheduled maintenance can be reduced from one hour (the "poorest acceptable" figure from Forrester's note) to one-quarter hour (the next preferable figure) by automatic marginal checking, but reduction of unpredicted down time from a half-hour to a quarter-hour probably will have to depend on the use of stand-by machines. The best combination of characteristics which would seem to be realizable, said N. Taylor, is probably: one hour of scheduled maintenance time, a half-hour of unpredicted down time, 30 microseconds per order, a 4,000-word memory and an order code one "degree" better than that of WWI (see discussion of additional orders in M-1468). Such a machine, he thought, could reasonably be built in 42 months. This figure should allow ample time for construction of a WWIA machine.

Here, J. Forrester pointed out that he regards 42 months as absolutely an outside figure; he mentioned that other interested parties outside the laboratory are thinking more in terms of 30 months and felt that we would have to justify our proposing to operate on a longer schedule. Of course, as N. Taylor remarked, there is some question as to just when the machine is to be regarded as completed. His concept of this is to have the machine actually in operation with terminal equipment. He thought that one thing we might gain from building WWIA would be a better estimate of how much improvement we could realize in WWII by taking longer to build it.

It was asked whether the figures on size of memory in M-1468 include external memory; the reply was that they do not: they represent only internal high-speed storage. The external memory of WWII, N. Taylor remarked, has been given very little thought so far. If no time is available to develop anything else, a magnetic drum can be used. However, it seems likely that if time is available, it will pay us to look into other forms such as an auxiliary memory of magnetic cores. Even if the drum is to be used, some improvement on the present techniques used in associated circuitry, such as the use of transistors, might be realized; but if this is to be done, development work will take about two years and should be started immediately.

Tentative specifications for WWIA were quoted by N. Taylor from the outline in the minutes of the WWII meeting of March 14th, as follows:

> Memory - Ferrite, 4 microseconds' access, 1024 registers
> Word length, 16 bits - Speed, not specified - Orders, probably 16

It probably would be desirable to build a small memory (16 x 16, say) into WWIA to test other components. Concurrently, a large (64 x 64) memory, approximating what is planned for WWII, should probably be built to investigate problems of driving larger numbers of cores. The time taken to complete WWIA is quite important, N. Taylor observed; at least 2,000 hours' running time is needed to give any sort of assessment of reliability of components. To log this much running time would take about six months. Any performance figures based on a shorter time than 2,000 hours, he thought, are likely to be over-optimistic; WWI storage tubes ran 1700 hours before developing significant faults. Therefore, 9 months is probably the maximum time we can allow ourselves to build WWIA.

The number of registers in the machine is not important except as it might necessitate qualitative changes in components; the number of orders desirable was agreed to be at least four and probably eight. Several problems can be thought of even now in which WWIA would be able to give us much-needed data. For example: the question of magnetic stepping registers versus crystal matrices for control purposes; the problem of mixing the outputs of two or more magnetic cores; possible interference troubles in the magnetic memory analogous to difficulties encountered in electrostatic storage. More important, however, WWIA is likely to give us a better idea of what the problems are, and to raise questions that we cannot now anticipate. W. Ogden remarked at this point that building a large memory, or even one plane of it, may be difficult at the moment for want of sufficient uniform cores. P. Baltzer gave figures on the wide dispersion of output voltage for one thousand metallic cores recently tested. With a uniform input pulse of 2.6 ampere-turns, the output voltage on a single-turn sensing coil varied from .24 volts to .80 volts, with a mode of .56 volts. Of the original one thousand cores, 250 were within 5% of the mode and 500 were within 10%.

R. Jeffrey suggested that the WWIA memory might profitably incorporate a bank of metallic-core memory along with a bank of ferrite cores, both to compare performance of the two types of cores and to investigate the desirability of the two-bank memory.

With regard to the 4-bit transistor accumulator that D. Eckl is building, he said that work has been slowed somewhat by the difficulty of matching transistors for two-transistor "static" flip-flops. He hopes that the carry flip-flops, which do not need to be complemented, can be of the single-transistor type, thus avoiding the matching problem. Even when transistors can be matched and made to work in these circuits, there is difficulty in correlating their performance with previously-measured parameters, so that matching transistors in the present state of the art is in large measure guesswork. N. Taylor suggested here that we need to look at greater length into the design of SEAC, particularly the dynamic delay-line flip-flop. R. Jeffrey asked if it were not possible to combine a single-transistor flip-flop, either with an inverter or with another single-transistor flip-flop and suitable gates, so that the resulting "static" flip-flop would be complementable, but less sensitive to transistor characteristics. D. Eckl replied that such a combination is, in fact, under consideration and probably will be tried shortly. He mentioned incidentally that the two 1734 transistors tried have both performed well. Whether this is because they are 1734's or merely coincidence is not known.

It is possible, thought J. Forrester, that research effort in the nation as a whole is not well-balanced from the standpoint of achieving maximum reliability in electronic components. That is to say, much of the facilities and talent being currently expended on transistors might yield greater gains in the near future if some of it were directed toward effecting certain minor improvements in vacuum tubes, (e. g., better welds, double leads, ruggedization in general). He wondered whether reliability would improve if we were to use lower-performance tubes (triodes) for the most part. This question, said N. Taylor, is difficult to answer. For example, one of our best tubes in WWI is the 7AK7, a high-performance pentode. One must remember, however, that the 7AK7 was produced especially for our purposes at a higher price and presumably with more care than the run-of-the-mill tube. Actually, the 7AD7, a Sylvania production tube, has turned out about as well as the 7AK7 in comparable applications, but this is in many respects a ruggedized tube. N. Taylor also quoted George Hoberg of Burroughs as recommending the use of 6AN5's, if proper attention is given to the relation between plate and screen voltage. Flip-flop service, it was pointed out, has been harder on tubes than most other applications. R. Everett suggested that a redesign of the flip-flop might be in order, even using more tubes, if need be, so that the life of tubes in this service can be lengthened. He stated further that if we are, in fact, going to have to use vacuum tubes in considerable numbers in WWII, we should be putting more effort into testing and improving them to make them more reliable. Transistors, he believes, are at best somewhat of a gamble, whereas there is little doubt that satisfactory reliability could be achieved with vacuum tubes if the necessary effort were put into improving them.