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Limited Memorandum L-68

Digital Computer Laboratory
Massachusetts Institute of Technology
Cambridge, Massachusetts

Subject: COMMENTS ON THE IBM 701 COMPUTER

Date: November 4, 1952

To: J. W. Forrester

From: C. Corderman, N. Daggett, S. Dodd, R. Everett, J. O'Brien, N. Taylor and R. von Buelow.

Abstract: The above made a visit to IBM at Poughkeepsie October 13th through 15th for the purpose of studying and evaluating the 701 computer. Their resulting observations (given at a meeting in N. Taylor's office on October 16th) are presented in this memorandum.

(Note: Although J. Arnow and K. Olsen also made this trip, they were unable to be at the meeting; therefore no comments of theirs are given).

J. O'Brien began the meeting with a report on the 701 magnetic tape mechanism and added a few comments on the magnetic drum system and the tabulator, as follows:

The magnetic tape mechanism uses ½-inch magnetic tape (acetate base) in lengths up to about 1200 feet. The tape driving is accomplished by pinch rollers pressing the tape against constantly rotating capstans. The tape speed is 75 inches per second. There are two counter-rotating capstans, one on each side of the head assembly. There are also two pinch rollers and two eccentrically-mounted non-rotating brake drums against which the tape may be pressed for stopping. The motion of the pinch rollers is controlled through a mechanical linkage by a moving coil assembly. With the unit set ready to run in the forward direction, the left-hand pinch roller is pressed against the left-hand brake, and the right-hand pinch roller is held a very small distance away from the right-hand, or forward drive capstan. Upon receiving a start signal, the left-hand roller is moved away from the brake and the right-hand roller is pressed against the capstan. This situation is vice versa for ready and starting in the reverse direction. The direction is controlled by a solenoid or relay which acts upon the pinch roller control linkage so as to shift the motion limits of the pinch rollers to the left or right.

The action time of the pinch-roller clutch is about 4 milliseconds; however, the sudden acceleration of the tape produces a sudden stretching of the tape which in turn produces an oscillation in the tape which requires from 2 to 4 milliseconds to die out. The total time allotted for starting - with a safety factor - is 10 milliseconds. In order to reverse the tape it must be stopped, then the linkage changed, and then started again. During our visit one of the pins in the clutch linkage fell out, thus disabling the unit. This was apparently the first time that this had happened and it was soon fixed.

The tension on the tape is maintained by a vacuum system. On both sides of the head and drive assembly there is a chamber about 3 feet deep, 2½ inches wide and slightly thicker than the width of tape. The bottom of each chamber is connected to vacuum pump (a modified vacuum cleaner motor and fan). As the tape passes across the top of the chamber between the head-drive assembly to the take-up or supply reel, a loop of tape is drawn down into the vacuum chamber. In the back side of each vacuum chamber, or column, are two pressure-sensitive diaphragms, one about a foot above the other. The air pressure on these diaphragms controls dry-powder magnetic clutches connecting the reels to drive motors and brakes. The diaphragms in a chamber control the three clutches on the reel above the chamber. If both diaphragms sense atmospheric pressure, the take-up clutch is energized to reduce the length of tape in the chamber. If both diaphragms sense a partial vacuum, then the supply clutch is energized to increase the length of tape in the chamber, and if the top diaphragm is at atmospheric pressure and the lower diaphragm is under vacuum, then the brake clutch is energized.

This simple on-off servomechanism is capable of supplying or taking up tape much faster than 70 inches per second, and its action time is fast enough so that the tape never goes more than about 3 inches above or below the pair of sensing diaphragms. This take-up and supply system is definitely over-designed for the 701 application; it is a design that was borrowed as is from equipment that handles 3000-foot reels at higher speeds. The system works very well; it produces the required tension with a minimum of guide pulleys and tape wear.

The head assembly of the tape unit consists of seven heads each about 32 mils thick stacked together with spacers and shielding between them. This head assembly allows them to record seven channels across the ½-inch tape. The seventh channel is used as a parity, or redundancy, check on the information recorded in the other six channels. The head has a very small wrap angle (about 12°), and the radius of curvature of the head at the gap is about 1/16 of an inch. The tape suffers quite a bit of acceleration in going around this corner and perhaps some deformation. A spring-loaded felt pressure-pad is used to press the tape against the head. The pad and the tape wear, producing lint and small acetate flakes. Twice we found errors due to lint on the oxide side of the tape.

The type of recording used in the tape mechanism is a form of the non-return-to-zero or the NRZ type in which, during the recording process, the tape is magnetized to saturation in one direction or the other and the direction of magnetization is changed every time a "one" is recorded. The recording of a "zero" does not change the direction of magnetization. Information is recorded in this way on six of the seven channels. In order for this type of information to be read back there must be at least 1 "one" recorded in each line of seven bits across the tape, and that is the reason for the seventh channel. Rather than use the seventh channel as a pure index channel, it is used as a parity channel in which a "one" is recorded or not so as to make the total number of "one's" recorded in a single line an odd number. In this way a check can be made on each line during the reading operation, and the output of all channels can be mixed to obtain an index mark.

IBM uses a recording density of 100 lines per inch, as we do, but by using the NRZ recording they obtain a maximum flux change density one-half as great as ours. Presumably they could record at a density of 200 lines per inch and still be no closer to the resolution limits of the tape than we are now.

The fact that the IBM machine uses seven channels on the ½-inch tape requires that the individual heads be narrower than ours. Their heads are only 32 mils wide, and this narrow channel width has resulted in an additional problem for them. They have found that if they record over a tape that has been recorded on several days previously, dimensional changes in the tape sometimes cause the new tracks to be out of line with the old tracks. This misalignment allows only partial erasure of the old recording, and the unerased information may be picked up as errors on subsequent readings. In order to eliminate this problem, IBM has added a separate erasing head which erases the entire width of the tape before it passes over the recording head.

Because of the erase head, the unit can record in only the forward direction. In addition to this limitation they cannot perform selected alteration of blocks, or rerecording, nor do they allow recording beyond the end of a previous recording, if there has been any intervening reading. All recordings must start from the beginning of the tape.

Detection of the beginning or end of the tape is done by means of stainless steel leaders on both ends of the tape, at the center of each reel. These steel leaders are attached to the tape with ordinary splicing tape, and they are sensed by the electrical contact they make with two guide rollers. This feature is used in the automatic rewind, and as a limit control.

The reading amplifiers used are straightforward difference amplifiers with the last stage feeding a pair of normally off cathode followers in order to get full wave rectification of the signal. They seem to have quite a bit of trouble due to noise from these circuits. The noise may be power line noise, since they use very little decoupling, and the difference amplifiers are not designed to attenuate common-mode signals, as they could be. There were no provisions for marginal checking of the circuits, nor apparently any record of the amplifier gain settings. The engineer showing the writer the equipment changed the adjustments with no hesitation.

Most of the observations on the tape unit were made as it operated from a special piece of test equipment built for testing the tape units. The tape unit would not run for more than a few minutes without error, some errors due to dust and others due to noise. The units appeared to run a little better with the computer; occasionally we could get runs of 15 or 20 minutes, more or less.

Conclusions

This writer feels that, other things being equal, their tape units are much better than ours. If they could get rid of electronic noise and extra pulses from the tape, then they could take very great advantage of our redundant recording scheme. They should have much less trouble than we do from the dispersion in time of the reading pulses from the bits of a single line across the tape. The signal that they get from the output flip-flop exists relatively for a much longer time, and therefore the signals from all seven channels are much more likely to overlap in time. With their system we could get a gate width of about 300 microseconds, whereas ours at present is about 100 microseconds.

Magnetic Drum System

Relatively little information was obtained on the drum system. The drum operated very satisfactorily with tester. The recording surface is composed of a helix of wire wrapped on a drum. Speed ≈ 10 microseconds between pulses. One of the IBM engineers stated that the density of the recording could be increased by 100%, still getting satisfactory operation (using half the surface of the drum). S. Dodd stated here that Ross had told him the drums were the most unreliable part of the system. It appears that the design of the drums was completely isolated from the rest of the system. Production of the 701 drum frames is lagging behind that of the other constituent frames; the first 701 computer is now approximately complete from a production standpoint, but the first drum system is still very far from finished. They can't find electro-plated tanks big enough to handle the drums they have and they don't know how to plate them; they are well behind MIT on this.

TABULATOR

Concerning the difficulty of connecting an IBM tabulator to WWI:

It would require 72 thyratrons to store one line of card information. These tubes would have to read 12 such lines of information into the tabulator in less than a second in such a way as to make it appear to the tabulator that it is receiving information from a card reader.

This tabulator is a device about the size of an office desk - (about a foot higher) - almost completely filled with relays of IBM wire contact type and standard telephone type. In addition to this, there are many large cast gears, much grease, oil, small pipe lines, etc., etc. It is very noisy. It functions well and is apparently extremely flexible in its operation.

A plug board enables the programmer to have stored at his convenience any number of arrangements which permit various sorts of tabulation and automatic features that might fit various programs. All-in-all, the tabulator looked like a very good device. They had no figures on its reliability.

Thyratrons are located in the computer and serve to operate both the tabulator and the card punch.

N. H. Taylor recommended that a study be made of the possible uses and value of a tabulator in WWI.

The tabulator is essentially a much more impressive device to watch in operation than an electrical typewriter and might be of more value for demonstrating the output capabilities of the computer.

The tabulator sends back to the computer signals called "print echoes;" these are essentially a check to see that proper print wheels were selected in accordance with the information received from the computer.

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N. H. Taylor then discussed the over-all system:

<u>General Impressions</u>

Reliability of the 701 is from 10 to 50 times poorer than present WWI reliability figures. Its state of development is similar to that of WWI 18 to 24 months ago; it will take about a year of continuous polishing of their circuitry to bring their machine up to a performance comparable with WWI's.

IBM puts a high premium on keeping the machine running as much of the time as possible, as they want it available for study and demonstration purposes. This is accomplished at the cost of a great deal of time that could be spent on much-needed engineering study. Only 4 to 8 hours a week are now spent in study for improving the system; 40 to 60 hours a week (of engineering study) would be needed to bring the machine to its highest reliability. As soon as more than one system is available, IBM feels that this will be possible.

Each part of the system had random errors which seemed to recur at 15-to-25-minute intervals, and no part of the system had ever worked any better than this, as far as I could gather. In spite of this, there was no hesitation about putting these building blocks together into an overall system because of the IBM emphasis on the importance of keeping the machine running. Engineers on the project seemed very conscious of this situation and not at all happy about it; they are under constant administrative pressure to keep the 701 "on the air."

During our stay, we were exposed to the machine about 24 hours. About 10 or 12 of these hours were spent in looking for trouble other than the strictly random errors which were experienced continuously throughout our study of the machine.

Comments on the Williams memory rack

For about $3\frac{1}{2}$ hours, we watched the Williams memory rack running a spill problem, which is similar to our read-around problem. The average time between errors was 25 minutes, according to IBM, and the longest run on the 72-tube element was $1\frac{1}{2}$ hours. Our observations were nearer 10 minutes between errors. Since random errors now are more of an obstacle than the spill problem, no attempt to improve the spill has been made for several months. Various attempts to improve the system have been unsuccessful because of the lack of time available and the lack of test equipment which would give the engineers knowledge of where these random errors originate. A parity check, or some similar device, is badly needed at this point. Indications that the trouble may be in the circuitry instead of the tubes themselves are rather strong at present.

Until we can get some indication that these random errors are not a basic problem, it will be difficult for us to consider the Williams memory in any future computer. If, however, this trouble could be cleaned up by paying attention to circuit details, there might be a very good case for the Williams memory. The tubes themselves cause little trouble - that is, it is not often necessary to replace them (only 4 or 5 tubes have been changed in the last few months). (This point is debatable; see Corderman's remarks). In any event, a very thorough study should be made of this memory frame so that it can be evaluated in terms of its own ability to remember information without error. During one marginal checking routine which they performed, a pulse on the number one grid of the storage tube varied 10% in level, and this was enough to cause an error. IBM engineers are not happy with the margins in this system and hope that time will be made available to improve this situation. Indications are that other margins are not as good as this 10%.

Arithmetic and Control Element

The situation here is at present complicated by the program to change from the original tubes designed for the machine to a new improved type now available to IBM (i. e., the 5965 replacing the 12AV7). Characteristics are somewhat different from those of the original design, so most of the margins originally designed into the circuitry were washed out by the improved tube and it is now necessary to go over all the circuitry and make changes so that margins will again exist. Consequently, the present margins (in the arithmetic and control element) are very poor. An ambitious program for cleaning up this margin situation is under way, but here again, time is very inadequate. No one has any feeling that the arithmetic or control circuits are any better, if as good, as the memory bank. In discussing this circuitry with members of IBM, it appears that their approach to the arithmetic problem can be made quite satisfactory and comparable to our own. However, in its present state their work on marginal checking and reliability is several years behind the art as we know it, mostly due to the large amount of work and study that has gone into our arithmetic element.

It should be pointed out that the lack of a check register or a parity check on the memory makes it difficult to decide whether a given error comes from the memory frame or from the arithmetic frame. The ensuing dilemma is rather difficult, if not impossible, to analyze.

Magnetic Drum

There is discontent among the 701 engineers, both as to the component circuitry and the logical arrangement of the magnetic drum. The present logical arrangement allows such slow access to the drum that it would be just as well to have serial shift registers as parallel reigsters in the circuitry. All the circuitry has been redesigned, as its original design was so poor. In the production model, it has been necessary to redesign heads in order to make it possible to adjust these heads without damaging the drum. An amplitude system of detection is being used which makes it possible to get errors when continuous writing on one track is undertaken, and some sort of phasing, similar to the ERA system, would probably be better. One would have to compare the two systems in more detail to know exactly what to recommend here. IBM feels that the system is not as good as it should be, and everyone agreed that it would have to be polished up considerably before these drums could be used in an air defense system. No provision exists for a dual head to be used on a single track, and this would be a basic need in handling very much data as we get it from MITE.

Terminal Equipment

The punch card equipment and high-speed printer were very favorably received by our engineers, mostly because of the novelty of never having seen them before. Since we know very little about them, they seem very wonderful, but we should proceed carefully (in estimating their value). However, they did not break down during our visit, and the reliability of these units seems to be excellent to the uninitiated.

Power Supplies

Power supplies of the system were designed and constructed by the Power Equipment Company, in consultation with certain IBM engineers. The general feeling of the men I talked to on this point was that they were working with Power Equipment Company merely because no other company was available to do the job. Trouble has developed with power line transients. No attempt has been made to isolate these errors, and it is hard to understand how IBM feels they can get around these transients without knowing exactly what they are.

General Conclusions

While I do not feel that the 701 computer is at this time in such condition as to be very usable in a control system, I do feel that the basic attitude of the engineers on the job is correct (they themselves are worried about all these errors and about improving the design margins of the system). If they could be given sufficient time to clean it up (nine months to a year), and barring any basic troubles, I feel that the system would be useful in a control problem.

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This was followed by a report by C. Corderman on the 701 memory:

The memory frame houses seventy-two 3-inch Williams tubes, two of which are placed together in each of thirty-six plug-in memory drawers. Each drawer has three adjustments for each tube, and one adjustment which is common to the two tubes.Two of the adjustments allow variation of the grid bias and focus voltage. The third adjustment varies the timing between the read-out signal and the sensing pulse at the read-out gate tube and is used to give optimum timing between these two signals. The adjustment which is common to the two tubes is that of the video amplifier gain. The time required to install one of these drawers and the subsequent set-up time for two of the tubes is in the order of five minutes. During this adjustment process, the read-out signals are monitored on an oscilloscope, and all adjustments are made on an empirical basis.

Since the video amplifier is common to the two tubes, they are read out at different times during the regeneration period. The read-outs from the two tubes are stored in two separate triggers; and, after the read-out has been completed in both tubes, the dash signal is written simultaneously in the tubes as may be required. In computer operation, only one tube will be giving an output on any storage access so that all the tubes are sensed at the same time in the action cycle.

For demonstration,the memory frame was operated with its tester. In this case, running a "spill" test, the average interval between errors was in the order of 10 to 15 minutes. These errors were more or less evenly divided between "spill" errors, which occurred in a single tube and could be repeated; and the other type of error, which was more or less of a random nature, which occurred in a number of tubes at once and was not repeatable. Regarding these random errors, in addition to the fact that they occurred in a number of tubes and were not repeatable, it was even more significant that they occurred at storage addresses different from the one at which the "spill" test was being performed. These random errors always occurred in the left-hand tube, which is the first tube read out in the regeneration cycle. Generally, the errors occur only in two of the corners of the array.

Many experiments have been performed on the deflection circuits. Finally, the whole deflection system was changed, which reduced, but did not eliminate, random errors. The engineers working on the memory unit have also tried monitoring supply voltages for transients and have run experiments with Tesla coils to note the effects of static interference.

(N. H. Taylor mentioned here that he had talked with an engineer associated with another IBM project who stated that he had been using Williams' tubes in a serial fashion with no trouble from random errors.)

The frequency of error seemed to be lower when the tubes were operated with the computer than when they were operated with the memory tester. The tester shows two types of error, one "spill," one "forget." The "spill" designation indicates a dot which has failed and turned into a dash, "forget" means the reverse -- a dash which has changed into a dot. With the tester, we varied the amplitude of the writing gate which is common to all seventy-two tubes in the rack. The gate is normally fixed at 37½ volts; upon being reduced to thirty-six volts, one of the tubes lost a dash. When the amplitude was raised to forty-two volts (maximum supply voltage), all the tubes continued to run, which indicates that their set-up procedure gives them operating conditions such that the tubes operate on the low side of making "spill" errors. It was also noted during this test that the gate amplitude changed by approximately four volts between conditions of all dots and dashes in all seventy-two tubes. This was thought to be due to a bad crystal in one of the units, and we removed combinations of the thirty-six units until the faulty crystal was finally isolated. The need for marginal checking is obvious in the 701 computer, since it took about ten minutes to isolate the bad unit.

In the 701, 512 spots are stored in each tube in an array consisting of two interleaved 256-spot arrays. Consecutive computer addresses are obtained by further subdividing each of the 256-spot arrays into sixteen 4 x 4 arrays. They feel that this arrangement helps them somewhat in cases of extreme "spill" which might be encountered in a short program loop.

It would appear that a 100% turnover of memory units has taken place in the past six months. (This estimate was based on a rough count of the number of changes of memory units entered in the Memory Test log, and is not meant to imply that this many storage tubes failed in service.)

A very slight amount of data recording is done. Instead of studying units, the computer engineer merely replaces a bad unit with a new one. (S. H. Dodd mentioned here that very inadequate record-keeping was done on the whole computer.)

Memory Program

There was a good correlation between two different opinions proffered, both of which stated that the acceptance rate of tubes to be used in the computer is in the order of 25% of the Williams tubes received. Most of the rejects were due to blemishes on the surfaces and tubes which exhibit the "mud hole" effect. This "mud hole" effect is the name given to the phenomenon which occurs when too many references to a dot in quick succession cause that dot to disappear after a short delay. When this occurs, the spot no longer holds the dot but reads out as a dash. This loss is attributed to induced conductivity of the phosphor, caused by repeated readouts. People who are responsible for keeping tubes in the computer seem to feel that the research group does not have a 100% solution to the problem of how to handle this "mud hole" effect. They simply observe that some tubes show it and some do not. Since about 25% of the tubes received do not show this effect and are otherwise satisfactory, they are eligible for use in the computer. No intensive research program to investigate the causes of this effect is underway. Willemite phosphor shows this effect to a much greater degree than P5 phosphor, and the effect also varies with different binders. No correlations have been made with respect to the spot size as it might affect the amount of heat in the vicinity which is bombarded many times. The engineers on the 701 have been somewhat hampered by lack of enough tubes which did not have this "mud hole" effect. They are now planning to increase production of 3-inch Williams tubes at the factory to approximately 50 tubes a day. They are also building experimental tubes with a 1-inch diameter screen and have installed several of these in the 701 for short periods. These tubes seem to have a lower read-around ratio than the 3-inch model.

They are also doing work on a redundant type of Williams memory system in which two tubes are operated in parallel, one storing dots, the the other dashes for a given bit of information. The read-out signals are added algebraically after one of them has been inverted. They feel this will give the system reliability, independent of "spill" and of bad spots, and that they will be able to use tubes which previously have been rejected for use in the 701. (The cost of the 3-inch tubes is $85).

In general, the memory appeared to be operating better than had been anticipated; however, the possibility of working with 1024 spots per tube seems to have been abandoned. IBM appears to be satisfied with 512 spots per tube for the 701 computer.

They run their "spill" tests with the maximum number of repetitive reads which a tube can ever encounter in computer operation. Under these conditions, their margins of operation would appear to be considerably narrower than we experience here. However, it must be realized that we do not test our tubes under the worst conditions which could ever be encountered.

(N. L. Daggett stated in response to a question from R. R. Everett that WWI makes parity alarms on an average of two or three a day. However, this figure is subject to fluctuation.) The error rate for the 701 memory appears to be about two to three an hour.

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N. Daggett gave his comments, which were interspersed with some remarks of S. Dodd's and N. Taylor's, as follows:

The two most obvious weaknesses in the 701 system seem to be:

1) That, although the circuits themselves are basically sound, an insufficient amount of engineering time is spent on debugging them. This situation has led to -

2) Their working with the philosophy of run-a-check-program-and-if-it-works,-fine. Since they have no marginal checking system, they operate at all times with no idea of when or where trouble is about to appear.

(One specific example of the above is the failure in the shift order which was seen several times. This again, is capable of being eliminated if more engineering time could be expended on it).

IBM engineers seem to have a more comprehensive set of diagnostic programs than do we. This is partly because their printer is capable of such fast output and partly because they must rely on these techniques to get the information that we get by marginal checking and built-in checks, which they (see above) lack.

Their punch card system presents some substantial advantages from the point of view of handling, as it is simpler to put a program on the machine with it than it is with our paper tape.

Another advantage is the speed with which they can replace their memory drawer, which is considerably greater than in our system.

The circuitry used in the arithmetic element is fairly impressive. Rather extensive use of diode logic gives them substantial advantages from the point of view of packaging. Information flows as pulses in the order of 1 microsecond or more in width, enabling them to use open-wire cabling pre-fabricated on a frame. For relatively short distances, they could use our circuitry with their type of wiring, but the fast rise times that we use would probably preclude any extensive use of this wiring where the information has to flow for relatively long distances. In a number of places in our computer, information flows at 1/10-microsecond pulses through channels that are used only once - every several microseconds or so.

(A discussion of diode gates between N. H. Taylor and J. O'Brien, which is not covered here, then took place).

N. Taylor then mentioned that IBM uses no decoupling in some of their circuitry. N. Daggett stated he feels some of our methods seem ridiculously brute force at times, compared to theirs, and that some of their ideas present substantial advantages. N. Taylor felt that the cascading of levels was a serious weakness in their system, but Daggett thought that there was sufficient clipping in the system to prevent any such difficulty. Taylor considered this clipping a brute force measure. Daggett pointed out that to obtain stability in WWI it had been necessary to abandon the philosophy of only driving grids to zero bias and instead to drive grids well positive in order to obtain appreciable grid clipping. In general, both think that if the amount of engineering time spent on our system were spent on IBM's, they would probably end up with as good a system. The fact that this time is not available is due to IBM administrative policy of keeping the maching running and available for demonstration at the sacrifice of time-to-investigate-trouble. N. Taylor said he did feel that, considering the small amount of time spent on the circuitry, it was amazing how well it worked.

S. Dodd mentioned here again that, whereas we keep fairly extensive records on what goes on in our computer, they keep practically none.

N. Taylor said that, while he felt the 701's present reliability was sufficient for the computations being done now, it was definitely not good enough for use in a future air defense system. S. Dodd said that apparently, according to Ross, there is little chance of it improving substantially (as it is being maintained and run almost exclusively now for demonstration and training purposes, etc., see above).

N. Taylor stated the specifications were that tubes must last more than 10,000 hours. Goetz is getting this now.

N. Taylor felt that, in order to get good reliability out of their circuits, IBM would have to pound at their circuit engineers to make them work harder and more steadily at debugging.

S. Dodd remarked that the 701's lack of trouble-location equipment, parity checks, etc., was a great handicap during the present phase of development of the machine, as they can't find out where errors are. (N. Taylor assured him that our prototype units would have built-in checks.) Presumably, however, this lack of built-in checks would not present such a difficulty in the final system. N. Daggett said that, since the 701's units are removable and therefore replaceable, they (IBM engineers) don't have the need to localize trouble that we do, and therefore this lack of built-in checking facilities is not as serious as it might be. S. Dodd feels, however, that while this policy of simply replacing faulty units would be all right on a production machine, it is not good on a testing, or experimental machine.

S. Dodd also said that T. A. Burke had told him that recently they have had trouble with a so-called "morning sickness" in the computer. This was particularly noted as incorrect operation of the computer on Monday mornings. This trouble disappeared after the first of September, and he felt that the reduction of humidity at about this time of year might be a partial explanation of the disappearance of this "morning sickness." He said, however, that they have much trouble with soldered joints in the plug-in units and that this might be another explanation of the "morning sickness" problem. Frequently when they installed a new plug-in unit, they found that the unit did not operate satisfactorily, and the difficulty would be tracked down to trouble in a soldered joint. This difficulty appeared to occur because of stressing of the soldered joint when the unit was clamped into place, due to the fact that the plug-in unit was not completely rigid. In their production machine they are using a new type of plug-in unit, which has a slide contact plug and is supposed to prevent the stress on the plug-in unit from developing. The evidence they had, however, could indicate that the troubles they encountered were actually caused by stressing of the plug-in units, and the modified production design did not make him (S. Dodd) certain that they would solve this problem in the production machine.

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R. von Buelow felt that most of his own observations were already fairly well covered by the above but added the following comments:

Though their diagnostic programs are fairly impressive, they don't go far enough to permit them to isolate trouble completely. After completing a diagnostic program, they have to replace an entire plug-in unit or interchange tubes in plug-in units almost at random, as they have no evidence of exactly where the trouble lies. There is a serious need for marginal checking. They can run a program with an error; this doesn't stop the machine. They are trying varying voltage, but this varies not only the voltage in which they are interested but also the voltage in the whole computer and so still fails to isolate the error. One good feature of their diagnostic-program system was the tabulator; (N. Taylor mentioned here that he, too, felt their methods of record keeping were better and less cumbersome than ours. (See C. Corderman and S. Dodd, pages 9 and 12 above).

Test storage consists of two banks of push buttons. This clearly is not enough, as it limits the output to set-up test programs.

The crystal gating also made a favorable impression; this might prove advantageous if incorporated into our Memory Test Computer.

There are four sense switches on the console which are somewhat similar to our "cp" in that they permit deviation during programs. These sense switches permit skipping an order during a program. This seems to be a very valuable gadget.

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Limited Memorandum L-68 UNCLASSIFIED

The elimination of delay lines and use of the Havens delay unit seems to be a step in the right direction.

Approved: Robert R. Everett
R. R. Everett

CC:ND:SD:RE:JO:NT:RVB/bs

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