POUGHKEEPSIE
Department 539
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7000 OPERATING TECHNIQUE MEMO NO. 2

SUBJECT: "Remote Control" Operation of the 704 at the IBM Research Computing Center

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During the week of July 21-25, I served as an apprentice 704 operator at the Research Computing Center. The main object of this tour of duty was to observe the "remote control" type of operation. This memorandum describes the operation, which has important implications for 7000 systems. Two conclusions are that we need programmable unloading of tapes and that proper disk facilities can assume a surprisingly large part of the task of tapes on the 704.

Physical Facilities

The Computing Center has a 704 with drums, a 32K memory and an on-line printer, reader and punch. This assemblage will collectively be called the computer. There are also a 714 peripheral card reader, a 722 peripheral card punch, and two 717 peripheral 150 lpm printers. The system also includes thirteen 727 tape mechanisms and a "United Aircraft" Tape Selector, manufactured by J. B. Lewis and Co.

The tape selector permits any of the physical tape units to be operated as any logical tape unit of the computer or to be connected to any of the peripheral units. The tape mechanisms are denoted by letters: A, B, C, D, E, F, G, H, L, M, N, P, Q. The machine room is arranged as shown in Figure 1.

The Tape Selector

The Tape Selector has a small panel on which the keys and lights of the on-line devices are repeated. This panel is physically adjacent to the 712 card reader. It also includes duplicates of the six sense switches, the clear, reset, load cards, and load tape keys, and lights which show when any tape or drum is being read or written, and the logical address of any selected tape.

The main panel of the device has controls for fifteen tape units.

For each tape there are:

a. an assignment knob

b. keys for Load-Rewind
Reset
Start
Reset Indicator
Write End of File

c. lights for tape status, viz.
Selected
Ready
File Protect (and Rewinding)
Tape Indicator (End of File)

d. lights for assignment status, viz.
Available
Hold
Connected

The assignment knob can be pushed, pulled, and turned. It has two stable in-out states and a inmost momentary contact state. In the out state, the tape is available, and the knob can be freely turned. In the in state, the tape is in hold status and cannot be turned. Further momentary depression causes the tape to become connected. The knob can be rotated to 18 positions:

logical tape 0-9
printer I-II
punch I-II
reader I-II
spare
blank.

As the knob rotates, a symbol showing its position appears in a window just above.

On each of the peripheral units is mounted a somewhat different knob and lights and keys for the tape. This knob can be rotated to any of lights A-Q, and can be momentarily depressed to connect the unit to the designated tape. This is only possible when the light for the tape is illuminated, indicating that the main assignment knob for that tape is set in hold status and rotated to the position for that particular unit. Momentarily raising the knob at the unit disconnects the tape and returns it to hold status.

A Typical Run

The people concerned with performing a typical machine run on a single program are the programmer, a clerk, a tape operator, a console operator, and one or both of the two peripheral operators. The console operator operates the tape selector and the 704. The tape operator mounts and dismounts all tapes. One peripheral operator operates the reader, punch, and one printer. The other operates the other printer and a transceiver.

When the programmer desires a debugging run, he brings his deck to the clerk with a remote control card, This is prepared as shown in Figure 2, indicating the sense switch settings, the account number, what to do for stops, and other pertinent information. Any tapes that are used are marked with the logical unit desired and the reel number to be mounted. If the tape is used only for external storage or output to be printed, MR is specified for the reel number, indicating that a "machine reel" is to be used.

The clerk stamps the front of the card with the time received, enters the time and programmer's name in a log, and puts the deck into a ready bin.

The tape operator picks up the deck and finds the time accounting card for that programmer and job number. If the program called for no tapes to be mounted, he would deliver the deck and time accounting card to the console operator. In the present case, however, he takes the deck to the tape file. Here he selects the needed tapes (29 and 46) and prepares them for mounting.

Few programs require more than two tapes to be mounted. (Although many programs use more than two tape mechanisms, most use several MR's.) Mechanisms E, F, G, and H are used for mounting all tapes. Mechanisms A-D, L-N, and P, Q generally are untouched. Occasionally an exceptional program will require more than four tapes to be mounted and some of mechanisms A-D are used.

In the typical case, though, mechanisms E-H are used for mounting tapes, and of these, two, say E and F, will be connected to the computer for the run in progress. If no other program is waiting for tape mounting, the tape operator then mounts tape reel 29 on mechanism G and reel 45 on mechanism H. He marks this on the card as shown in Figure 3, and passes the deck to the console operator, together with the time accounting card. Mechanisms G and H are set to the blank position and are in hold status.

When preceding programs are done, the console operator logs this program in by punching its card in his clock. He turns the knob for mechanism G to logical tape 1 and fully depresses it to connect it. Similarly, he connects H as tape 3. He connects two other mechanisms, say L and M, as logical tapes 2 and 8. He depresses load-rewind for all four mechanisms. He then places the deck in the reader and depresses the clear memory and load cards keys. The program runs a little, printing some on-line, and stops at 453_8. According to instructions, the console operator wishes to dump memory on the output tape. The dump program uses logical tape 10, so he reconnects mechanism M as tape 10. He notes the stop on the control card, and depresses the load cards key. At the next stop he knows the program is finished. He returns mechanism L to available status. He returns mechanisms G and H to hold status, and tells the tape operator that they are free. The console operator turns mechanism M to PR1 (printer 1) and places it in hold status. He marks the output facts on the control card, and puts the deck in the drawer of decks awaiting off-line print. He tears the pages of on-line print-out from the printer and puts them in a slot marked "incomplete prints". He stamps the time accounting card for this program out, and that for the next program in.

The tape operator dismounts tapes 29 and 45 and returns them to the file. He then uses mechanisms G and H to mount tapes for any waiting programs.

The peripheral operator at printer 1 sees that the light for mechanism M is illuminated, indicating that it is awaiting printing. When his preceding jobs are done, he gets the deck from the bin to see if there are special printing instructions. There are none. He turns his control knob to mechanism M and depresses it, connecting the tape to the printer. He then depresses the rewind key, and when the tape returns to ready status, he depresses the start key on the printer. When the tape reaches end of file, the printer stops. He restores the carriage. The notations on the reverse side of the card indicate both output and dump are on mechanism M, so he depresses start again. This is repeated until the distinctive dump format appears. The end of this is the end of the material to be printed. It is probably marked by several end of file indications, generated by the console operator when he dismissed the problem. The peripheral operator rewinds the tape and pulls out his knob to disconnect it. He then notifies the console operator that mechanism M is free. The console operator sets it to available status.

The peripheral operator picks out the earlier on-line print from the incomplete prints bin and takes the deck and the prints to the clerk. She stamps the time on the back of the deck and logs it out. The prints are placed in the file folder of the programmer in a file at the clerk's location. The typical run is complete. The total elapsed time in this case would have a mean of one-hour with a standard deviation of about a half-hour.

Schedule

The Computing Center ordinarily operates two shifts. The day shift is reserved for debugging runs and assemblies. One hour of the night shift is similarly reserved. The rest of the night shift is used for production runs, generally in blocks of one hour.

The daytime schedule is further complicated by the fact that decks whose programmers are at the Lamb Estate arrive at noon. They must be run and printed in time for the results to return to Lamb on the 2:00 P.M. shuttle. These programs thus have a priority during these two hours, and little local work gets done at this time.

In the typical day, the machine is received from the customer engineers at 9:00 A.M. Several decks are already waiting and many others arrive before 9:30 . These are processed and printed. Meanwhile, BCD cards for SAP assembly have been put on a MR tape by the second peripheral operator. About ten or ten-thirty, the main frame is caught up with the debugging runs, so the SAP tape is mounted and all assemblies are run.

Meanwhile the printed results from the first round of debugging runs are trickling out. Some bugs are easy, and a small second round of debugging runs is ready by eleven or so when assemblies are finished. These are done, and things are apt to get slack about 11:30 . Generally, standby or idle-time programs which have little printed output and can be arbitrarily started and stopped are waiting, and these may be run some until noon.

The assemblies have generated a lot of print, so the printers are generally fully operating at this time. They usually get the morning work done before the Lamb work is ready for printing, however. The Lamb work usually fills the computer time from noon to one or one-thirty. When it is complete, another round of local debugging runs has piled up. This keeps things hopping until three-thirty or so, when another round of assemblies is done. Things may then be slack until four-thirty, when a final burst of debugging runs appear. Any of these not completed by the end of the shift at five are run during the night shift.

A steadily-increasing quantity of FORTRAN work is being run. At present, it seems that about one-fifth of all debugging runs are FORTRAN. Each such compilation requires from ten to twenty minutes, so these provide a break in the ordinarily hectic routine of short problems. FORTRAN compilations also generate a good bit of printed output, most of which consists of the compiled program in SAP language. It would be interesting to know how often this is used in subsequent debugging runs.

Evaluation of the 704 Operation

The 704 is operated on a production-line basis under a system which does a good job of keeping the main frame busy. This type of operation is immensely facilitated by the Tape Selector. Insofar as we expect any future system to be operated under the same type of conditions, we must make provisions for solving the problems that are solved by the Tape Selector.

The operating results at the Computing Center range from fair to good. Elapsed time on decks ranges from one to two hours, except for those that are elbowed aside by Lamb work. Average users remark that they can easily get from two to four runs per day on a single deck. In extreme cases, this may go up to six, but this takes vigilance and strategy.

Most of the elapsed time is spent awaiting prints of output and especially dumps on magnetic tape. One feels that a reliable 500 lpm printer would replace both 150 lpm printers, release an operator, and significantly improve service. Also, abandonment of the practice of putting several dumps on a single tape would noticeably improve service. This would be possible in the 704 system only by adding tape mechanisms, but the general problem has other solutions, which will be discussed below. Finally, a lot of unnecessary printing is done. It would be more useful to have the programmer present during print-out than at any other time.

The Tape Selector works well and is well designed. It does not include facilities for enough communication between operating stations, so the operators must talk to each other. This can lead to errors.

The signalling facilities do not permit the peripheral operator to request a tape mechanism for loading cards. The console can, however, notify him when a tape is assigned and which tape. The peripheral operator cannot signal when the tape is ready for use, but this is not much needed, since the operating instructions must change hands at this time, anyhow.

So far as the tape operator is concerned, he would be aided by a signal that mechanisms are free. This could be most conveniently accomplished by giving the console operator a duplicate of the unload key.

The console operator can signal the peripheral operator as to when and which tapes are to be printed. The peripheral operator cannot signal that he is through with a tape and that it is thus ready to be reassigned.

Conclusions

When a system of operation such as that used at the Computing Center succeeds in attaining a very high utilization rate for the equipment, this seems to demonstrate its desirability.

Against this must be placed the conclusion of many programmers that they get better service from the PDL 704, which does not have remote control procedures. In the PDL center, each programmer has the machine for a 15 minute block. He then tends his off-line prints. The 704 is undoubtedly in actual automatic operation a lower percentage of the time than at the Research Center.

What is the explanation for the impression of better service from the "less efficiently" operated installation? There are several possible explanations.

1. The impression might be an illusion. When a programmer is present and participating in the time-consuming activities he may accept the amount of elapsed time more readily than when he waits blindly for things to be done.

2. The service may be better for reasons that are independent of the mode of operation. If there are fewer total users, each will naturally tend to get better service. This may completely mask the effect of the operating mode. It should be observed that this depends upon the number of different high-density users rather than upon the total amount of computing work they impose on the system.

3. The service may be better for some users and poorer for others. The remote control operation tends to spread service deficiencies uniformly among all users. This can be seen by considering the overloaded installation in each mode of operation. In the remote-control installation, the lag of things waiting to be run or printed would build up, and the average throughput time would appreciably increase for all programs. In the other installation, those programs which were run at all would be completed with maximum efficiency, but some work would have quite long delays.

4. The impression may be accurate. One mode of operation may in fact give significantly better service than another for the same true workload. This can be true in spite of the fact that the other method uses a higher percentage of available machine time.

This paradox can be explained by the fact that remote control operation very often requires more computing and printing to be done for the same useful output. Very frequently, programs are run for several minutes after the useful point, because the programmer is not on the scene. In even more cases, page after page of unnecessary printing is done because the programmer is not present to stop it. I believe that this unnecessary printing, which includes a lot of unnecessary memory dump, is the biggest source of delays, and poor service in the Research Computing Center. In short, the very nature of the remote control operation generates a lot of extra computing and printing work, which the system handles with blind efficiency. The net effect of remote control operation is not necessarily greater efficiency in solving problems. I believe this fourth explanation to be the true cause of the impression that the PDCC philosophy gives better service.

A second type of conclusion concerns the equipment itself. In the system as it is usually operated, only four (maximum six) of the tape mechanisms are used as tapes. The other nine are used as external storage media, and the number of mechanisms is much more important than their capacity. It seems to be quite rare for more than 400 feet of an MR tape to be used. One program required 1000 feet while I was there; this was considered proof positive that there was a bug, and the problem was dumped. (It was a bug.)

In short, nine of the thirteen tapes could be replaced by nine disk areas of no more than 15-20 thousand words each.

This confirms the importance of making available a suitable disk unit with all levels of 7000 machines as a standard item. The economies in equipment and in Exchange channel utilization are large when a disk unit can be used in place of tapes in this manner.

Another inescapable conclusion is that the program should be able to unload tape mechanisms. Such action saves operator time and saves separate signalling equipment which would otherwise be required in a system to notify the tape operator to dismount tapes. Furthermore, provision of this facility is equivalent to furnishing an UNLOAD key at the operating console, and this is desirable in some modes of operation.

FPB/pkb

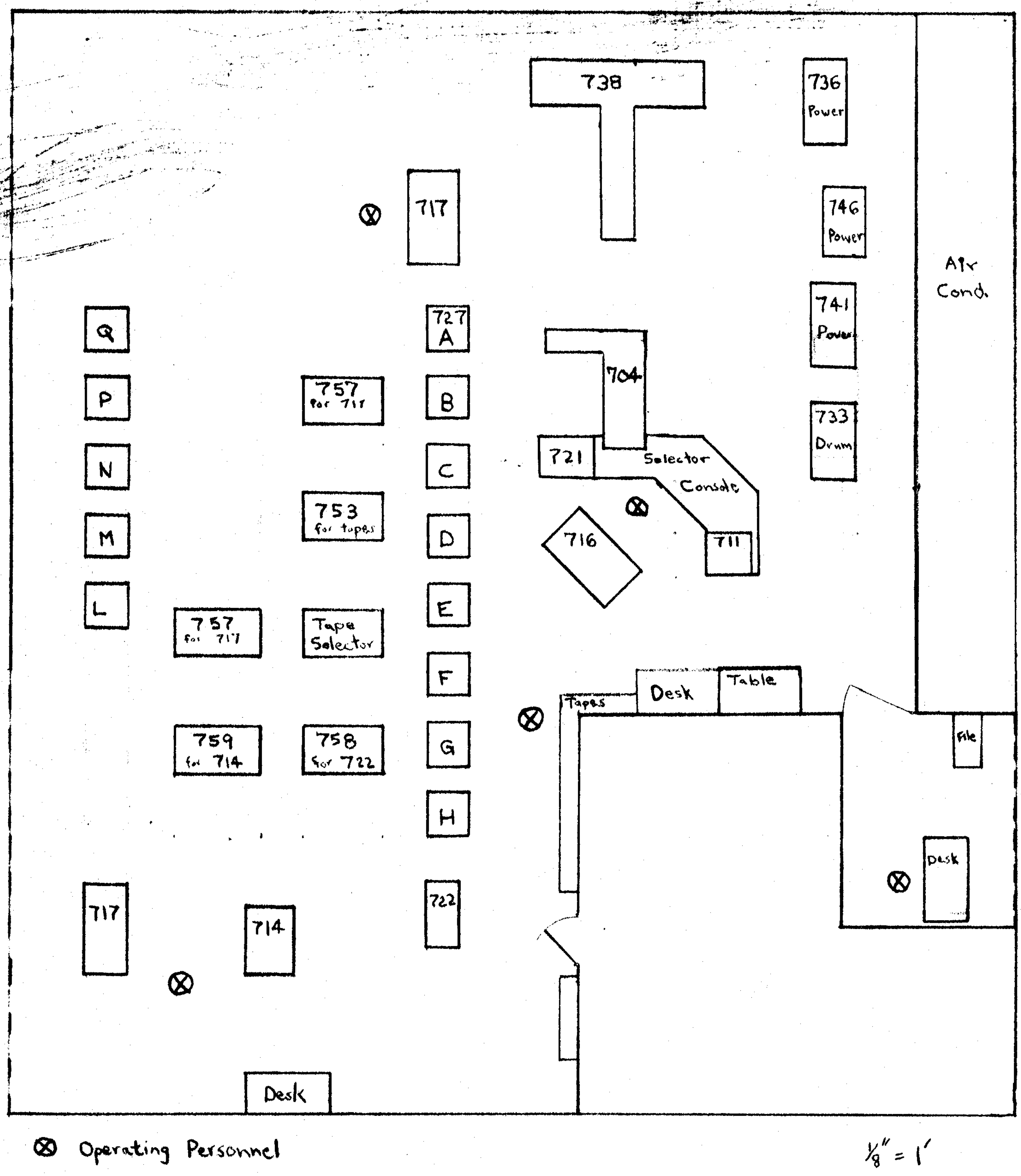

Fig 1. 704 Layout

PK

DATE 8-14	SENSE SWITCH 1 (2) 3 4 (5) 6		INPUT		INTERMEDIATE	OUTPUT
JOB# 4292	EST RUNNING TIME 3 MIN	TAPE UNIT	1	3	2	9
	DRUM 1 2 3 4	TAPE NO	29	45	MR	MR

TYPE STOP	AT	WHAT TO DO
PS	7Kz	end
R/W CHECK		Any other stop, press load cards
DIV CHECK		to dump memory
LOOP		

COMMENTS:

FORMAT OF DECK: 1 2 3 4 5 6 7 8 9 10

PRODUCTION — ASSEMBLY — Smith

IBM FORM NUMBER 93-4589-0 REMOTE CONTROL CARD

Obverse

LOCATION

OUTPUT CHECK CARD

OPERATOR:			PROG.	MACH. OPR.
P/S	SENSE SWITCH 1 2 3 4 5 6	PRINT OUTS - ON LINE	✓	
R/W CHECK	TAPE UNIT	PRINT OUTS - OFF LINE	9	
DIV. CHECK	TAPE NO.	MEMORY DUMP - ON LINE		
LOOP AT:	PRINTED OUT TAPE	MEMORY DUMP - OFF LINE		
OPERATOR COMMENTS:		PUNCHED CARDS - ON LINE		
		PUNCHED CARDS - OFF LINE		
		ASSEMBLY LISTING		
		OTHER ( )		
		USE A NEW CARD FOR EACH RUN		
		IDENTIFY ALL ON LINE AND OFF LINE OUTPUT		
		WRITE YOUR LOCATION ON THE TAB. (PK, LAMB, SPRING)		

IBM - W.E.R.

Reverse

Fig. 2
Remote Control Card as Prepared by the Programmer

PK

DATE 7-28	SENSE SWITCH 1 (2) 3 4 (5) 6	TAPE UNIT	INPUT 1	3	INTERMEDIATE 2	OUTPUT 8
JOB # 4392	EST RUNNING TIME 3 MIN	TAPE NO	29 (G)	45 (H)	MR	MR
DRUM 1 2 3 4						

TYPE STOP	AT	WHAT TO DO
PX	%x	end
R/W CHECK		Any other stop, press load cards to dump memory.
DIV CHECK		
LOOP		

COMMENTS:

FORMAT OF DECK: 1 2 3 4 5 6 7 8 9 10

PRODUCTION · ASSEMBLY · DEBUG · TAPE — Smith

IBM FORM NUMBER 95-6663-0 REMOTE CONTROL CARD

Figure 3

Remote Control Card as Marked by Tape Operator

LOCATION

OUTPUT CHECK CARD

OPERATOR			PROG	MACH OPR
P/S 453₆	SENSE SWITCH 1 2 3 4 5 6	PRINT OUTS - ON LINE	✓	✓
R/W CHECK	TAPE UNIT	PRINT OUTS - OFF LINE (M)	8	✓
DIV. CHECK	TAPE NO	MEMORY DUMP - ON LINE		
LOOP AT	PRINTED OUT TAPE	MEMORY DUMP - OFF LINE (M)		✓
OPERATOR COMMENTS		PUNCHED CARDS - ON LINE		
		PUNCHED CARDS - OFF LINE		
		ASSEMBLY LISTING		
		OTHER ( )		
		USE A NEW CARD FOR EACH RUN		
		IDENTIFY ALL ON LINE AND OFF LINE OUTPUT		
		WRITE YOUR LOCATION ON THE TAB. (PK, LAMB, SPRING)		

IBM - WEK

Figure 4

Remote Control Card as Marked by Console Operator