

AccessionIndex: TCD-SCSS-T.20121208.018

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Accession By: Prof.J.G.Byrne

Object name: IBM 360/44 console and subsystems

Vintage: c.1965

Synopsis: Control panel, CPU logic, core memory from IBM 360/44 installed in Trinity College Dublin to provide a service to all sectors of College, including the Dept.Computer Science, from 1969.

Description:

The IBM System/360 was a mainframe computer system family announced by IBM on 7-Apr-1964 and delivered between 1965 and 1978 [1]. It is said to be the first family of computers designed to cover the complete range of applications, small to large, commercial and scientific. Development of the IBM 360 family was overseen by Thomas Watson Jnr, son of the founder, in the transition period between father and son running the company. It was entirely financed from company funds, the most expensive gamble in company history thus far, and nearly bought IBM to its knees. However, it was extremely successful in the market, allowing customers to purchase a smaller system and be able to migrate upward if needed without reprogramming of application software or replacing peripheral devices. Many consider the design one of the most successful computers in history, influencing computer design for years to come. But others consider it was a backward step from the high-level language machines like Manchester University's Atlas and the Burroughs 5000 series to a focus on low-level machine code and assembly-language.

The design (by Gene Amdahl) made a clear distinction between architecture and implementation, allowing IBM to release a suite of compatible designs at different prices. All but the incompatible model 44 and the most expensive systems used microcode to implement the instruction set, which featured big-endian byte addressing and binary, decimal and (hexadecimal) floating-point instructions, 32-bit general purpose registers (R0-15), 64-bit program status word (PSW), and manual control operations for reset, boot (called Initial Program Load or IPL), operator-initiated interrupts, basic debugging and changing the system state. Virtual memory and an MMU were added in Aug-1965 with the Model 67.

Rather than use integrated circuits, IBM designed custom hybrid circuits using discrete flip-chip-mounted glass encapsulated transistors and diodes with silk screened resistors on a ceramic substrate. This substrate was then either encapsulated in plastic or covered with a metal lid to create a "Solid Logic Technology" (SLT) module, multiple of which were mounted on small multi-layer printed circuit "SLT cards" that were plugged into a logic chassis.

IBM introduced the IBM 360/44 as a specialized model for scientific and real-time computing and process control on 16-Aug-1965 and withdrew it on 24-Sep-1973 [2]. It had a subset of the IBM 360 instruction set, but an "extended instruction set" was available to provide the missing instructions and it had variable-length precision for faster floating point arithmetic, with a rotary switch on the front panel to set the precision to 32, 40, 48 or 56 bits (although long floating-point numbers still occupied 64 bits in memory). It could be said to perform about 0.1MIPS.

Extra *Read Direct Word* (RDDW) and *Write Direct Word* (WRDW) instructions transferred 32-bit words to/from an external device and memory (c/f standard IBM 360 8-bit transfers). Extra *Change Priority Mask* (CHPM) and *Load PSW Special* (LPSX) instructions enabled masking and indexing via a table for entering and exiting interrupt handlers according to data sent by the device. It had 37 interrupt levels (c/f standard 5).

Trinity College Dublin installed an IBM 360/44 in 1968/69, as described below by John Moriarty, the first Director of the Computer Laboratory [3]:

I joined Trinity in March 1968 as a lecturer in systems engineering but was immediately charged with setting up the “Computer Laboratory” – a new central service department to run the IBM System/360 Model 44 which was due for delivery later that year. This became my main job with the title of director although I continued to do some teaching for several years to come.

Recruitment of programming and operations staff and the organising of accommodation for the new department’s staff and equipment continued through the spring and summer of 1968 so that everything was ready for the arrival of the machine before the year-end.

A prefabricated “Terrapin” building was constructed in the Fellows Garden between the old library and Nassau Street. Part of the standard Terrapin [the *Computer Room*] was modified with the installation of air-conditioning, a raised floor to accommodate cabling, and an automatic fire protection system. In addition to the Computer Laboratory this building also provided staff accommodation for the departments of Computer Science and Statistics and a second Terrapin was located nearby for use as a lecture theatre by these departments. The accommodation was ready and the core staff appointed when the machine was delivered in November 1968 and the Laboratory was officially opened by the then Minister for Education, Brian Lenihan, senior, on 9th January 1969.

Contact was established with other organisations with similar interests and problems. The Laboratory became an active member of the Share European Association (SEAS), an association of scientific users of IBM systems, and I attended their meetings in Schevingen and Grenoble in 1968 and 1969. Trinity also participated in the “Forty Forum”, a group of UK universities which also used 360 Model 44 machines and met in Glasgow and Trinity during 1969.

Fig.1 below shows the official opening of the Computer Laboratory (now IT Services) by Minister Lenihan. It was a new central College service department, independent of academic and administrative structures, established to provide a service to all sectors of College, as recalled by John Moriarty [4]:

The 360/44 went straight into the Computer Laboratory which had just been set up as a central service department, rather like the Library but not as prestigious a unit, of course! I believe that the Computer Science Department was set up at the same time. Trinity was organised into Schools up to that time and was just setting up a faculty structure, possibly as a result of the “merger” proposals which were current then. I had been a part-time Lecturer in Computer Science in the Engineering School since 1963

and in 1967/8 applied for a full-time Lectureship in Electrical Engineering arising from the resignation of the late Percy McCormack. On joining College full-time on 1st March, 1968, I was "rebadged" either Lecturer in Computer Science or Lecturer in Systems Engineering, I do not recall which, and was immediately relieved of most teaching work and charged with preparing, on a full-time basis, for the arrival of the 360 which had been ordered earlier. This involved recruiting staff, organising accommodation, etc. I do not recall exactly when the Dept. Computer Science and Computer Laboratory were formally set up but the Lab was certainly in existence as an independent unit when the 360/44 arrived in late 1968. The Engineering School had replaced the original 1620 by an IBM 1130 in September 1967. The 360/44 remained in the Terrapin in the Fellows Garden until the imminent building of the Arts block forced it's evacuation to Pearse Street in September 1972.

Trivia: March 2018 may mark the 50th anniversary of the founding of the Computer Laboratory, the Dept. Computer Science (and perhaps the Dept. Statistics too)

The 360/44 was chosen rather the 360/40 because 128kB of memory would be provided rather than 64kB. The original configuration had:

Qty	Item	Description
1	IBM 2044 Model H CPU	IBM 360/44 CPU
1	128kB memory	1uS Core memory
1	Console	
1	IBM 1053 printer/keyboard	console printer/keyboard
1	IBM 2941 storage controller	
1	IBM 2315 disk drive	1MB capacity internal "biscuit" disk
2	IBM 2311 disk drives	7.25MB capacity each
2	IBM 2415 magtape drives	9-track 800/1600-BPI
1	IBM 2501 card reader	
1	IBM 1442 card punch	
1	IBM 2921 printer controller	
1	IBM 1403 line printer	
8	IBM 2260 display terminals	

This was later expanded to four IBM 2311 disk drives. Later again the system was upgraded by adding four 29MB IBM 2314 disk drives and the core memory was increased to 256kB at a cost of about IR£140,000.

The Model 44 Programming System (M44PS) included a supervisor, utility programs, assembler, FORTRAN IV compiler, and a library of scientific subroutines, and used the internal "biscuit" drive as a systems residence device.

This was the first time-sharing system in Ireland, with eight local IBM 2260 user terminals directly connected via multicore or coax cables to an IBM 2848 controller (i.e. not networked), see elsewhere in this catalog. The IBM 2260 display terminals initially ran RAX, then an IBM product called ITF (not a success), then GUTS (Gothenburg University Terminal System). An IBM 3704 16-bit programmable terminal adapter was added c.1975 to connect ASCII screens and printers.

For administration applications (mainly payroll and the Trinity College Library) the PCP (Primary Control Program) application was used. Later these applications were moved to MFT with HASP.

The IBM 1403 printer was provided with two chains, one a QN2 chain with just uppercase and a TN chain with lowercase for the Trinity College Library, which was much slower as there were more letters and they had to travel further. It is possible that the TN chain was specifically built for the Library.

Registers R1-16 were usually located in a non-addressable (i.e. invisible) portion of core storage termed "bump storage". Optionally, faster (0.25uS) registers could be provided in SLT hardware. Another "floating point option" provided a 64-bit hardware Ax reg. It is not known whether these options were installed at TCD.

The 360/44 had a subset of the IBM 360 instruction set that did not include the commercial instructions such as decimal arithmetic and character instructions such as MVC (move character, for moving variable length strings) or CLC (compare logical character). The "extended instruction set" option that retored the missing instructions was implemented by an exception handler, also invisible in bump storage, that was invoked by invalid OP-CODE interrupts (software traps) to emulate the instructions. Execution was returned to real storage via a special form of the LPSW instruction. The emulator was a deck of binary punched cards which had to be loaded every time the machine was turned on. The emulation was very slow, so a TCD maths student, David McQuillan, disassembled the emulator punched card deck and transformed it into assembly language source code, recoded some of the commercial instructions, especially MVC and CLC, using the native instructions of the 360/44, and re-assembled the revised source code to produce a new binary deck. For example, if 4 bytes were to be moved by an MVC and were on a word boundary then native load and store instructions were used instead. This improved the emulation speed by about 40%. Another TCD student, John McFerran, added significantly to this effort.

Within the Terrapin Hut in the Fellows Garden (now Fellows Square) that housed the system, a large room was reserved for the IBM engineers, who kept all sorts of spares there. The whole machine was offline for preventive maintenance every Monday morning. After that it was very important that the TCD Emulator be loaded.

Following one such preventive maintenance a user (David West) alerted Mike Nowlan that the results of his calculations were different from previous weeks, potentially a very serious problem. After some digging Mike realised that the IBM engineers would routinely set the "precision" rotary switch on the 360/44 front panel to some known figure, whereas the real users wanted it set to maximum!

This collection retains (in the display cases in the foyer of the ORI) some subsystems from the department's IBM 360/44. The standalone IBM Card Reader Model 29C punched card reader was also retained, see elsewhere in this collection.

Many thanks to John Moriarty, first Director of the Computer Laboratory, and Mike Nowlan, his successor (and previously Systems Manager for the Dept. Computer Science), and *Techarchives* for details and photographs relating to this item.

The homepage for this catalog is at: <https://www.scss.tcd.ie/SCSSTreasuresCatalog/>
 Click '*Accession Index*' (1st column listed) for related folder, or '*About*' for further guidance. Some of the items below may be more properly part of other categories of this catalog, but are listed here for convenience.

Accession Index	Object with Identification
TCD-SCSS-T.20121208.018.01	IBM 360/44 console, with an elaborate set of switches and indicators
TCD-SCSS-T.20121208.018.02	IBM 360/44 CPU logic chassis with some of its hybrid logic modules
TCD-SCSS-T.20121208.018.03	IBM 360/44 high-density stacked core memory array
TCD-SCSS-T.20121208.018.04	Chain from the IBM 1403 line printer
TCD-SCSS-T.20121208.018.05	IBM 1316 7.25MB 14-inch disk cartridge for IBM 2311 drive Marked 'Backup Spool 1 initialised 19.11.1976'
TCD-SCSS-T.20121208.018.06	McQuillan & McFerran's revised emulator punched card deck

References:

1. Wikipedia, *IBM System/360*, see:
https://en.wikipedia.org/wiki/IBM_System/360
 Last browsed to on 17-Nov-2016.
2. Wikipedia, *IBM System/360 Model 44*, see:
https://en.wikipedia.org/wiki/IBM_System/360_Model_44
 Last browsed to on 17-Nov-2016.
3. John Moriarty, *John Moriarty: IBM Ireland customer engineer / systems engineer 1957-68*, TechArchives, 2016, see:
<http://techarchives.irish/irelands-first-computers-1956-69/john-moriarty/>
 Last browsed to on 17-Nov-2016.
4. John Moriarty, *email communications*, Nov-2016.



Figure 1: Official opening of the TCD Computer Laboratory, 9-Jan-1969

(Photo courtesy: John Moriarty, source: "Terrapin of Ireland News" June 1969)

Front row: John Moriarty (TCD), Minister of Education Brian Lenihan, Rosemary Murphy (TCD)

Middle row: Ian Roberts (TCD architect), Prof. John Byrne (TCD), Prof. William Wright (TCD)

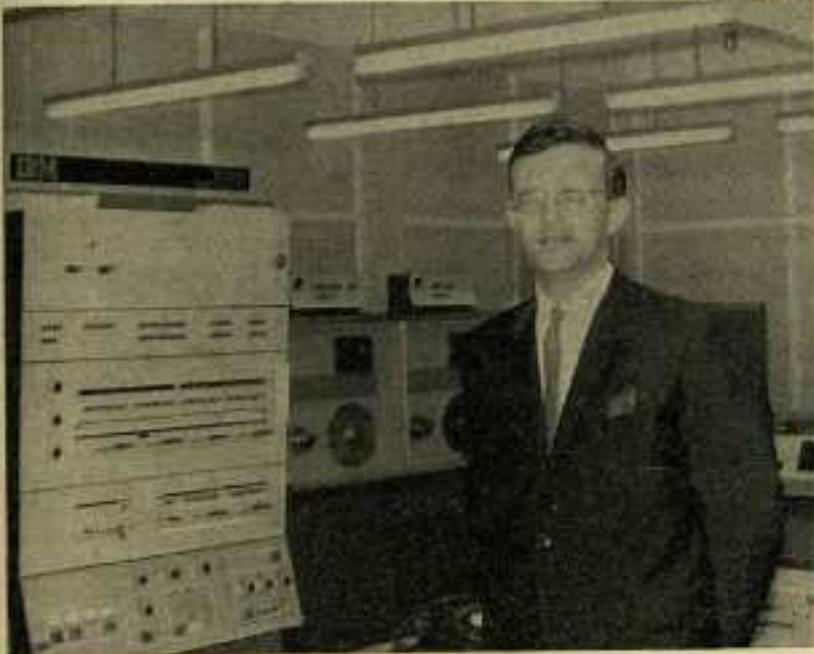
Rear row: ???, ???, Brian Bond (Cramptons), Dr. A.J. McConnell (TCD Provost)

£1¼M COMPUTER AIDS COLLEGE WORK

The Minister for Education, Mr. Lenihan, speaking at the opening of the new computer laboratory last Thursday, said that the work to be done by the College's I.B.M. 360/44 computer would help to "bridge the gap in a practical way between the humanities and the services."

Valued at a quarter of a million pounds, the I.B.M. 360/44 is the third computer to be acquired by Trinity. It is the only one of its kind in Ireland and has an unusually wide range of application.

—Pat Moriarty



John Moriarty with I.B.M. 360/44.

Professor W. Wright, Chairman of the Computer Management Committee, said: "The installation has been designed to cope with the mix of jobs appropriate to an academic environment."

The Manager of the Computer Laboratory, Mr. John Moriarty, has directed the installation and programming of the new computer with the aid of a staff of 13 analysts, programmers and operators. He said that "the need for computer power had grown to such an extent that it could no longer be satisfied by the previous systems."

The purchase of the 360/44 represented a "much bigger step" than the former acquisitions," he said, "because the smaller computers were used for the most part in the engineering field, whereas the new computer not only will facilitate engineering teaching and research, but will have special application to library and administrative needs."

Its ability "to retain large files of data," Mr. Moriarty continued, "makes it feasible to enter areas of activity not possible with earlier equipment." He cited the organisation of the library's some 30,000 volumes annually received under the Copyright Act. He said it would be an aim of the computer to "harness" these new acquisitions and perhaps maintain a "profile of interests of academic staff," so that new material in their particular fields would be brought to their attention.

Teaching with the computer is also facilitated as it is a multi-access, time sharing computer, "to which many students can have simultaneous access through terminals located outside the computer room."

The work of the computer is now in full swing. It is making analyses based upon 1968 student registrations, and has been busy in the teaching and research field since November.

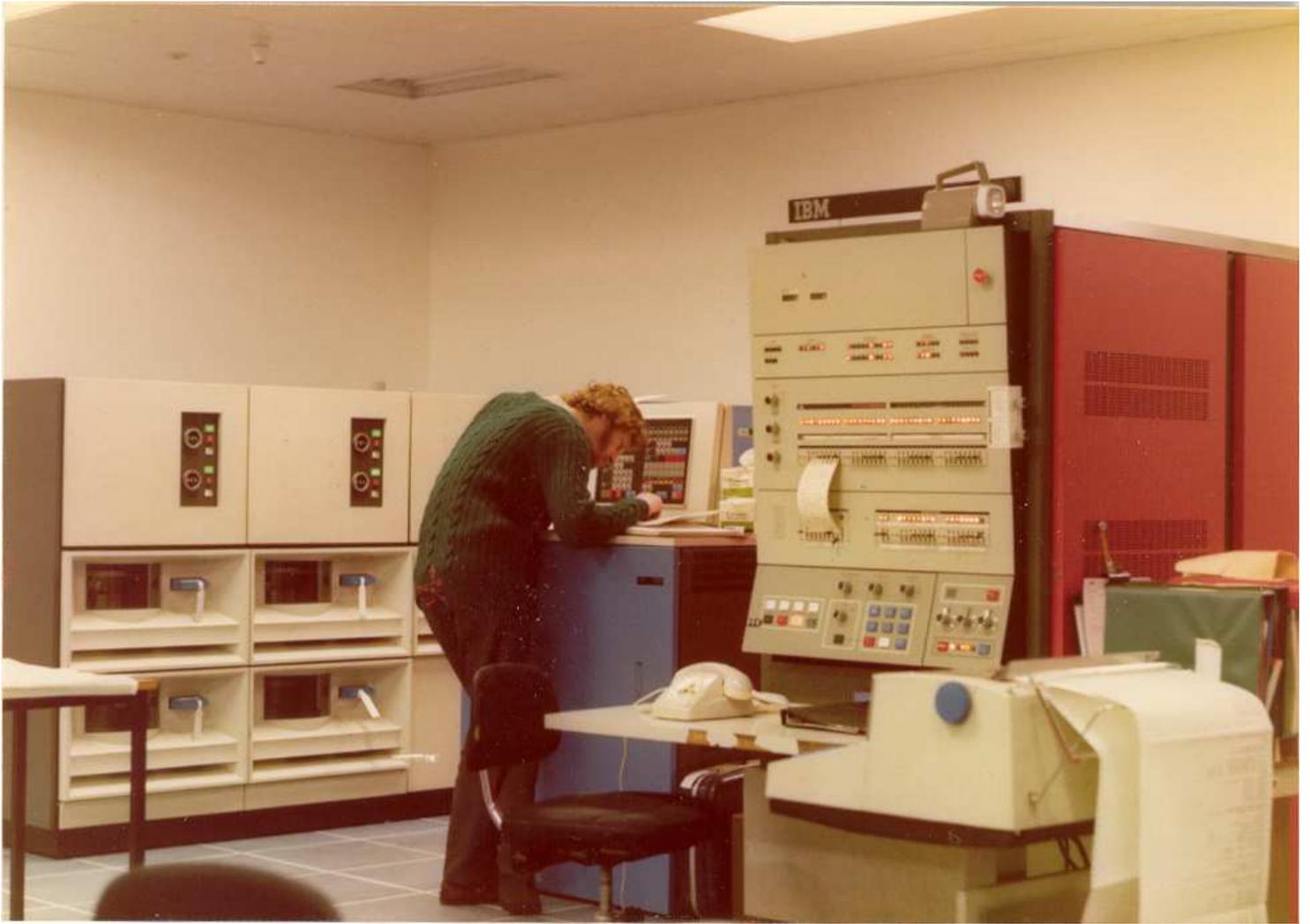
Figure 2:
Article about IBM 360/44 in "TCD News",
the Trinity College Dublin student paper,
16-Jan-1969



*Figure 5: IBM 360/44 in action c.1974, image courtesy Prof.J.G.Byrne
The verso carries the printed inscription 'IBM 360/44 Computer Laboratory, Trinity College Dublin
(L to R) Majella Ryan, Jack Grace, Tony Flynn September 1974'*



*Figure 3: IBM 360/44 in action c.1976, image courtesy Mike Nowlan
Console at left, IBM 1052 console printer/keyboard in foreground
4 x IBM 2311 7.25MB disk drives, 2 x IBM 2400 magtape drives at rear*



*Figure 4: IBM 360/44 in action c.1976, image courtesy Mike Nowlan
Ken Gordon deep in thought over IBM 3704, 4 x IBM 2314 29MB disk drives at rear*



A modern student using the University's I.B.M. computer

*Figure 6: IBM 360/44 in action c.1976, image of unknown provenance
Caption is: "A modern student using the University's I.B.M. computer"*



Figure 7: Combined exhibit of retained IBM 360/44 subsystems on public display in this collection (also VAX 11/780 control panel in foreground)

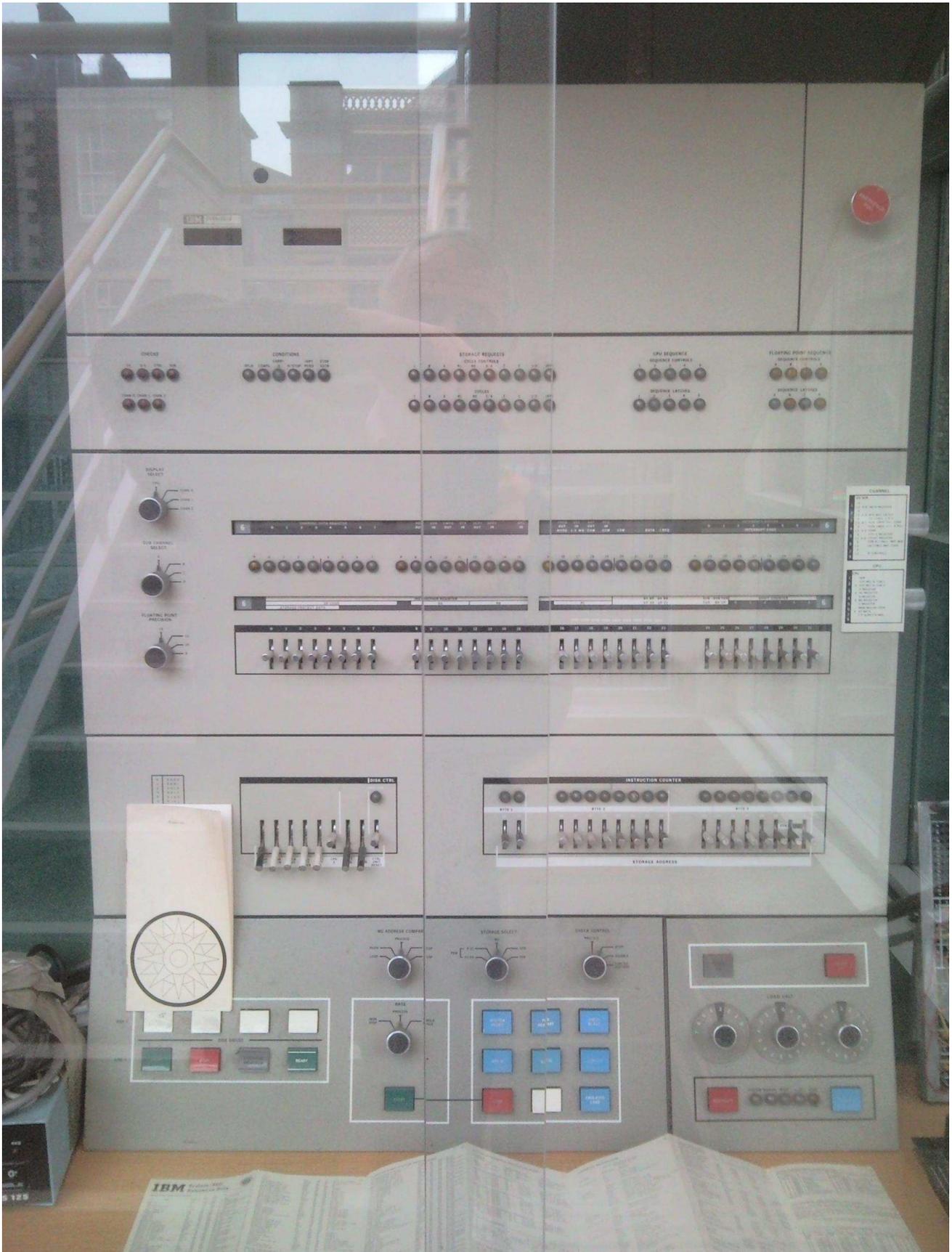


Figure 8: IBM 360/44 Console front view



Figure 9: IBM 360/44 CPU logic chassis and hybrid logic modules

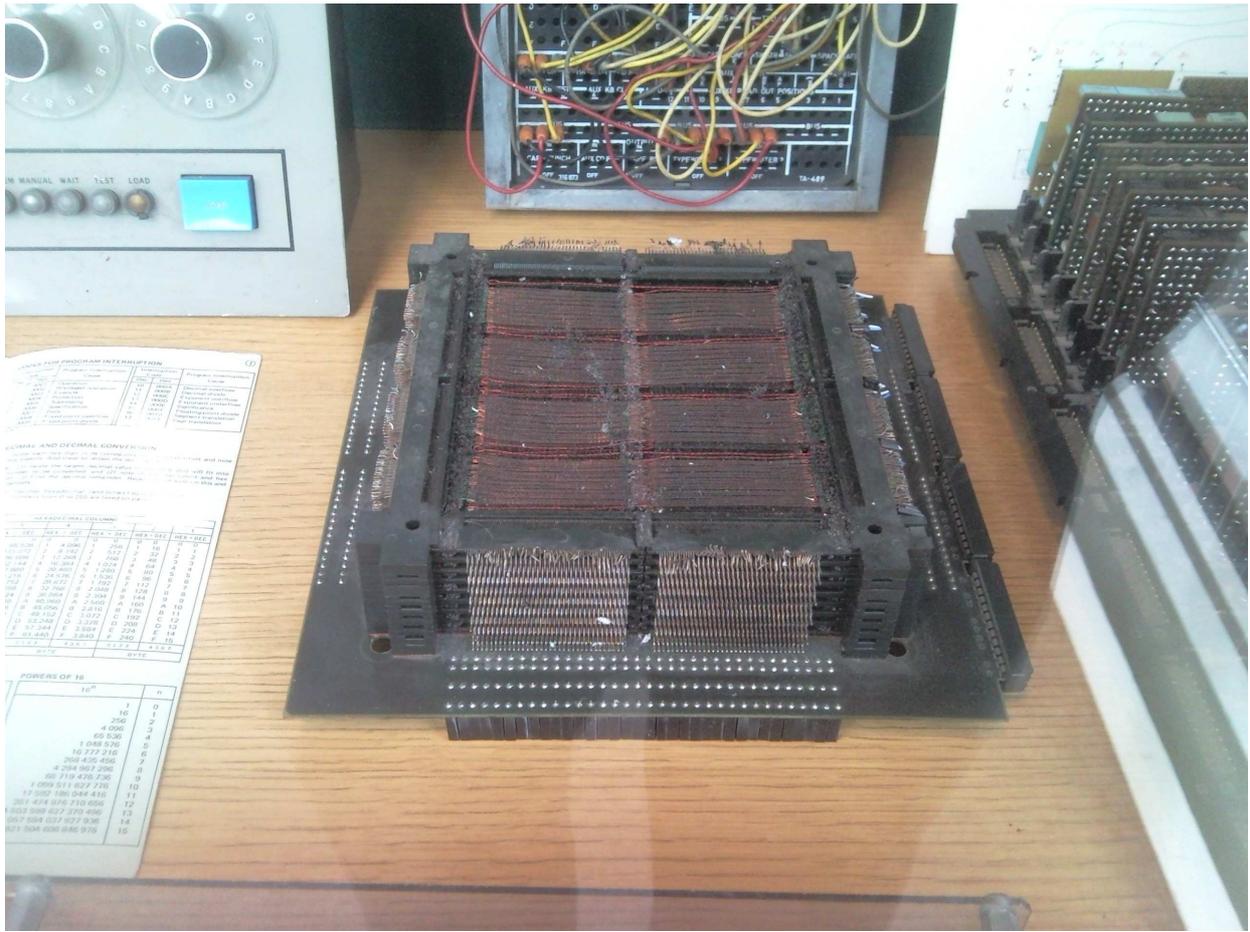


Figure 10: IBM 360/44 core memory plane



Figure 11: IBM 1316 7.25MB 14-inch Disk Pack for use on an IBM 2311 drive
Marked 'Backup Spool 1 initialised 19.11.1976'