Steel Company of Wales /British Steel Corporation production system computer projects at Abbey Works, Port Talbot 1965-1973

A brief history

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Version 6

Introduction – this is a personal recollection by the author, written almost entirely from memory, over 2017-19. It's not a detailed technical specification of the systems designed and created at the time, but an overview of the shop-floor real-time transaction reporting system at the Abbey Works, Port Talbot, which was the first of its type in the world.

This paper is also intended as a tribute to the men and women who conceived, designed, wrote, tested and implemented this real-time system. The number of individuals involved in the projects described ran to some thirty or so over the period discussed, some of whose names I'm unable to recall, for which my apologies.

The systems analysis team included Brian Blandford, Doug Burns, Dr Lynn Davies, Cecil Evans, Ron Harwood, Geoff Henderson, Don Norman, Max Powell, Ralph Roath, Viv Snook, Geoff Stevens and Alan Windybank.

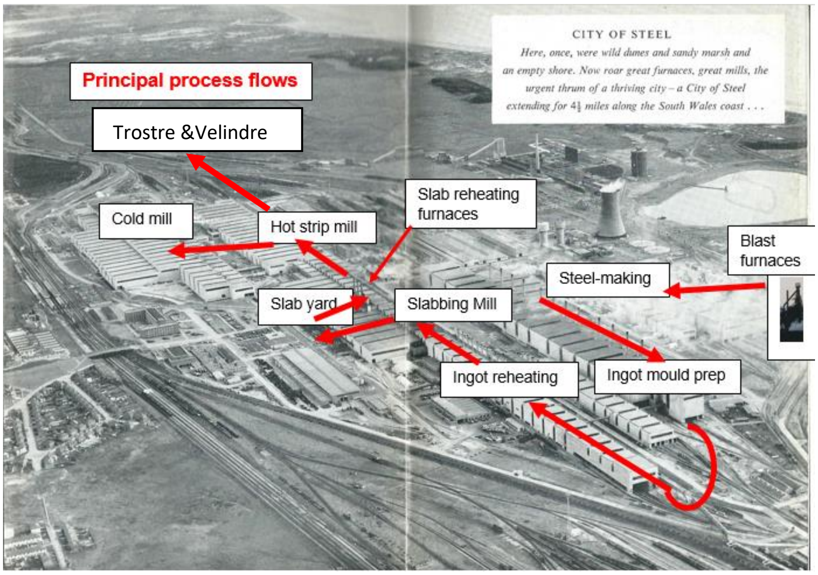
The software design and programming team included Joyce Bell, Marcus Benney, Mike Beynon, Eric Bragg, Mike Doyle, Mike Farrington of IBM, Tony George, Dilys Goacher, Phoebe Griffiths, Colin Heard, Diane Heggs, Tony Haworth, Mike Humphries, Alan Hutchinson, Gwyn Jenkins, Linda Jenkins, Brian Lord, Allan Morgan, Dai Parry, Les Powell, Gloria Puntan, Alwyn Rees, David Rees, Gordon Rees, Lyn Ash Thomas, Rowland Thomas and David Wanklyn.

More topical today, but at the time much less so, about 20% of our programming team were women. A high percentage of the total development team were graduates, from a wide variety of disciplines - maths, sciences, geography, music, languages and others. Many of our systems analysis team were recruited and trained internally, as was I; we especially sought people with experience of the parts of the plant targeted for the on-line systems. Amongst other benefits this strategy avoided accusations of the imposition of new ways of working created by 'outsiders'.

Our IT management sponsors were Dr Ken W Carr, Wesley Davies, John Hazell, Fred Hyatt, Gil Thomas and Jim Wackerbarth.

The Steel Company of Wales (SCoW).

The Steel Company of Wales, from its formation in 1947, had an ethos of innovation, clearly evident in the records and decisions of W F Cartwright Assistant Managing Director and General Manager at the time (later Managing Director), and documented since by Professor Louise Miskell of Swansea University[1]. The early adoption of leading-edge technologies was therefore a long-established practice by the mid-1960s. Senior management were habitually receptive to (good) new ideas, and change. The plant director at the time of which I'm writing, Dr Peter Roderick, a Havard MBA graduate, gave the ultimate approval for both the Slab Yard and Cold Mill projects. This was also the time when Harold Wilson, then Prime Minister, delivered his 'white heat of the technological revolution' speech. During this time one of our systems analysts left to work in the office of Wilson's Minister of Technology, Anthony Wedgwood Benn.



In the mid-60s to mid-70s the principal processing flows at the Abbey Works were – Blast furnace iron production, Steel-making Melting shop (Open hearth and VLN (highly innovative in its time) until late 1969, then Basic Oxygen Steelmaking (BOS)) – ingot production utilising ingot moulds – soaking pits to reheat ingots – slabbing mill to transform ingots into slabs – slab yard for cooling and cleaning - slab re-heating furnaces – hot strip mill to reduce slabs to hot-rolled coil strip – then into the Cold Mill - pickle line to clean – tandem mill to reduce the thickness of the strip – annealing to soften the steel – coil temper mill to apply the required surface finish – cut-up-line (for sheet orders) – packing and despatch. Much of the output, such as slab and hot rolled coil, was sold externally or transferred to other plants, particularly to SCoW's tinplate division plants at Trostre and Velindre. The process flows were largely continuous but because of the necessity to cool the product before the next stage, stocks equivalent to three or four days production of slab and annealed coil were maintained. Exceptionally, stocks were accumulated at other points in order, for instance, to permit process shut-downs for maintenance purposes. Annual production volumes were of the order of 2.5-3m tons. During the period covered by this paper, between a third and a half of the output was exported, and the principal uses of the Abbey Works finished product were in the automotive and domestic appliance industries.

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[1]Doing it for themselves: The Steel Company of Wales and the study of American Industrial Productivity, 1945-1955 Louise Miskell. https://cronfa.swan.ac.uk/Record/cronfa28929(Viewed 2 March 2018)

The major information problem throughout was that of accurate record-keeping. Orders were recorded manually by the Sales Department, details of which included physical properties and the required delivery date, a single-digit year and a two-digit week number.[2] Manually maintained order books were kept by the Sales Department, Order Control department and the Production Department, manually updated, Monday to Friday, from the hand-written shift production reports, generated by each process unit.

This required an army of clerical staff. There were constant and frequent differences between the records, due to time delays or clerical error. A customer seeking information about the progress of an order was not answered authoritatively, easily, or quickly. The works' ability to deliver on-time became a key performance measure, and performance was variable. As competition in the steel industry increased, delivery performance and product quality became key attributes of success, and therefore the ability to win business.

End-of-shift reports from each process unit were also used locally to maintain production records and stock inventories, which in turn became the input for scheduling the next process. These reports, from the slabbing mill onwards, were also batch-processed by the central production department to maintain progress of orders, by order number, and by the computer department, to maintain stock inventories, largely for accounting reasons. Central computing platforms until mid-1967 were an IBM1401[3] and an IBM1410[4] running 24/7 which provided the batch processing requirements of both the production and commercial systems, for the entire plant.

The sole means of data input to these systems was via 80 column punch cards produced from the handwritten production reports, by punch card machine operators. About fifty of these operators – all women[5] – worked day shifts Monday to Friday and were a key element in the entire IT infrastructure. Program input was performed the same way. Programs were written onto coding sheets, from which the 'punch room' produced the cards for input to the mainframe computer system and its compilers.

The only human-readable output from the systems was hard-copy, printed on IBM 1403 Line Printers at up to 1400 132-column lines per minute on 11-by-14 inch fanfold pin feed paper.

[2]As the process cycle rarely exceeded six weeks, it was explicit that week 01 for example was later than week 52 or 53. It also reduced the requirement for then very expensive computer system memory and disc storage space. Because we only allocated a single digit for the year the decade change caused a hiccup in 1980, but much later, and significantly, it eased the challenge of the Year 2000 project.

[3]See Appendix 1

[4]See Appendix 1

[5]See Appendix 15 *The role of women*

1965. The first shop floor data collection system – Hot Mill slab yard.

This system required very little by way of software development but it provided a great deal of experience and feedback about the design and implementation of 'computer' technology onto the shop-floor, including, critically, dealing with the personnel challenges relating to the introduction of new technology, of which there were more than a few. The hardware chosen was the IBM 357 Data Collection System.[6]This was an off-line, punched card-based terminal system for sending and receiving remote data, designed to operate in harsh industrial environments. The components used in the slab yard system were:

- IBM 357 Input station
- IBM 358 Input control unit
- IBM 372 Manual entry device
- IBM 029 Card punch [7]
- IBM 514 Reproducing punch

As slabs arrived at the slab yard the process recorder entered the slab identification number and stock location via the 372/357, which caused a punched card to be produced by the 029. When the slab was taken from the yard to the re-heat furnace, an updated card reproduced from the 514 was used as input to a 372/357 in the re-heat operator's pulpit. Remaining cards represented the slab yard stock, which were sent to the Computer Department for listing whenever a stock-take was required. Early operating challenges included suspected hardware sabotage of the 514, the role of which was not real-time critical for the operators, but the repair time needed to be within a few hours. I was part of a team of two dedicated to this system, the design of which was complete by the time I joined the development department. Interestingly, the suspected sabotage only ever occurred during the night shift, at around 3am. One of the two of us was always on call to handle problems and I still wonder about the motivations of the personnel involved. After some difficulties associated with using sensitive electro mechanical punch card equipment in a hot and very dirty industrial environment, matters settled down, and we learned some very important people and technical lessons.

Chief amongst these was the need to design the application from the point of view of the user. This involved spending large amounts of time with the people who would be using the equipment, observing and understanding process and information flows and seeking wherever possible to simplify and reduce the recording effort required, and, as a by-product, improve data accuracy. Operator time was generally at a premium and the pressures to maintain 24/7 production were at all times intense. Avoiding the scope for error was key. Suspicion of change was endemic and constant explanation of our intentions became essential. The unions were fearful that technological development would have a negative effect on both jobs and wages[8]. It was also our first exposure to trade union negotiation. For any change in working practices the unions demanded additional pay, whether they were 'staff' employees or process workers, two branches of the same union, requiring two separate sets of negotiations. Our role in these

[6] See Appendix 2
[7]See Appendix 2
[8]Issues substantiated in a study at RTB and in three Parliamentary enquiries into SCoW/trade union negotiations.

negotiations was purely informational, responsibility lay with the management of the mill and their labour relations team. Another of the lessons we drew was the necessity to recruit people with detailed knowledge of the plant and its processes that we could train as systems analysts and systems implementers, and who could rapidly gain credibility and acceptance from those operators who would be using the new systems and technologies.

1967. The Cold Mill on-line real-time data collection system.

The experience gained implementing the off-line slab yard system was an invaluable step in judging the industrial relations implications of introducing such technology onto the shop floor, and in particular the need for 24/7 terminal operator support.

With the exception of the annealing process which required stocks to be held post-process for 36-72 hours to permit cooling, cold mill processes quickly followed one another. Traditional batch-processing of process production reports achieved little other than historically; by the time a coil temper mill report had been batch-processed the product could easily have been through two further processes and despatched to the customer. Therefore, for the data to be of any value, reporting had to be real-time. Happily, developments in computer hardware and software made this a possibility. IBM's new System /360 range offered an operating system, MFT (Multiprogramming with a Fixed number of Tasks) in which the highest priority partition could be dedicated to handling on-line messages, large (relatively) and cheap (relatively) direct access storage devices to hold the on-line files and a telecommunications facility to handle remotely attached terminals.

Technical expertise was drawn from IBM's Paris-based Steel Industry Centre. The newly formed and named Computer Projects Department was charged with the responsibility for the development and its implementation. The decision was taken to develop, for the Cold Mill, what proved to be the first on-line real-time computer system, with full restart/recovery, in the world, which had to operate 24/365. This presented some real challenges, for technology, application systems design, and of labour relations. The budget sought was of the order of £3m with a project delivery timescale of eighteen months, ie January 1969. The deadline was missed by just under a month, but within the budget.

Technology - hardware.

The new central processing hardware was a pair of IBM System/360/40[9] processors running under OS/360 MFT[10]with IBM 2311 disc drives, IBM 2400 series tape drives, IBM 1403 Printers and other peripherals.[11] These peripherals were attached directly to the mainframes by a high-speed channel. The 360s 'enjoyed' 131k of main memory, compared with 8k for the IBM1401 and 16k for the IBM1410, the mainframes they replaced.(Even mobile phones today 'enjoy' Gigabytes of RAM, mainframes 'enjoy' Terabytes)[12]. Each 2311 disc drive had a removable

[9]See Appendix 3

[10]https://en.wikipedia.org/wiki/OS/360_and_successors (Retrieved 19 February 2019)

[11] See Appendix 4

[12]See Appendix 3.1

7.25mb capacity disc pack. Our design studies had convinced us that a sub five-second response to a shop-floor operator input was crucial, and that even quicker was obviously better. System availability was equally crucial so key components had to be duplicated. Normally, one 360/40 was designated to production systems, the other to commercial systems. In the event of the production systems processor failing, the on-line system was to be switched to the 'commercial' 360/40, a process which took up to twenty minutes.

The cold mill was a harsh environment and input terminals were, all but one, to operate 'in the open' with no protection. There was no standard commercially available input terminal on the market so we needed a technology supplier who could not only handle high-speed communications between the terminals and the System/360 complex, but could custom-build terminals to our design. We chose hardware and associated software from Elliott Automation[13] with golf-ball typewriters from IBM[14].

This set of computer initiatives was announced to the press in May 1967 and picked up by *The Times*[15] which highlighted them as 'one of the most ambitious projects undertaken by heavy industry' in the planned provision of 'immediate information' to the systems users. SCoW were described as 'most advanced users of computing…. using 13 digital computers' Also highlighted was the fact that the computers replaced an '….an ICT Pegasus…used by Operational Research 120 hours a week' The coverage continued with possibly the first mention of *real-time,* reporting that '….2 X Arch 102 computers and 24 terminals…were a first step towards a comprehensive ***real-time*** production control system'

See Appendix 7 for examples of training initiatives taken during 1966 and 1967.

The Elliott Automation hardware consisted of two identical ARCH 102[16] computers with 8K of storage, and two communication controllers which mimicked a high-speed channel-attached IBM 2848control unit.[17] Connection between the ARCH 102 computers and the two '2848' control units was by heavy multi-core cables, necessary to obtain the required transfer speed. Similar cables connected each input terminal to the Arch 102 via a local switching unit. In the event of an Arch 102 failure, the terminals were switched en-masse, to the second machine. The cabling was a significant element of the total cost of the system[18]

The design criteria for the input terminals were:-
1. Usable by shop-floor operators wearing heavy often oil-soaked protective gloves.
2. Resistant to oil, dust, dirt, and a wide range of temperatures and vibration.
3. Resistant to corrosion - and contain no complex electronics.
3. Robust – 'rough handling' is the norm in steel mills.
4. Require no maintenance and to be quickly repairable in the event of any failure or damage.

[13]https://en.wikipedia.org/wiki/Elliott_Brothers_(computer_company) (Retrieved 19 February 2019)
[14]See appendix 10
[15]See Appendices 5 and 6 for *The Times* and *The Dragon* articles.
[16] ARCH (the *Articulated Control Hierarchy*)http://www.ourcomputerheritage.org/eli_co.pdf (Viewed 2 March 2018)
[17]http://www.columbia.edu/cu/computinghistory/2260.html (Viewed 2 March 2018)
[18] See Appendix 8

See Appendix 9for the terminal design, a device we christened the IMIC (Industrial Manual Input Console[19]). In the event no terminal failure occurred between going 'live' in early 1969 and the author leaving BSC in June 1973. Notably, on one occasion, an IMIC was hit by a twenty ton coil of steel suspended from an overhead crane, and knocked over and out of its bolted foundation - 'flat on its face'. It was restored to its foundation with nothing other than cosmetic damage. To protect the golf-ball typewriters from the environment, low-pressure compressed air was pumped into the protective steel enclosure[20]. Considering these typewriters were designed to be used in pristine offices such as by the chairman's secretary, they proved remarkably reliable.

The Arch 102 software, written by Elliott Automation, simply transferred terminal messages to the IBM mainframe and routed the replies back to the terminal and the Golf-ball typewriter. Loading of the Arch 102 software was via punched paper tape. An air-conditioned computer room was built in the basement of the cold mill to house the equipment and to provide a training environment.

Technology – software.

IBM's IMS[21] was first released in 1966 but we judged it to be too CPU-intensive (ie slow) and over-complex for the relatively simple file structures we were using. (IBM's CICS[22]was released in 1968;too late for our development schedule, but it also lacked real-time restart/recovery). Instead IBM's telecommunications access methods BTAM[23] and BATS[24] were chosen to run in conjunction with our own, in-house designed, BDAM-based[25]file structures, in a package we christened STACA (Steel Telecommunications and Control Application). This was written using S/360 Assembler language, with some early technical assistance from IBM system engineers and developers. Two IBM developers were with us for some months; they were inseparable and were christened by us the 'Midwich cuckoos'[26]. In addition, the STACA development team had to design the package to operate within the constraints of the available S/360 hardware and operating system (limited physical computer memory of only 131k and limited support for "virtual" storage, with its ability to page applications and data in and out of memory). Consequently, a mechanism to overlay inactive code with that necessary to run the next transaction was implemented, thus allowing a much more complex and comprehensive system to be developed, but with minimal impact on overall performance and responsiveness.

STACA thus became the single platform for our entire message processing from all the shop floor terminals across the plant, the process control computers and those from the sales and order processing systems.

[19]Sadly, no photograph exists of this ground-breaking device.

[20]See Appendix 10

[21]http://www-03.ibm.com/ibm/history/ibm100/us/en/icons/ibmims/ (not named IMS until 1969) (Viewed 2 March 2018)

[22]https://en.wikipedia.org/wiki/CICS (Viewed 2 March 2018)

[23]https://en.wikipedia.org/wiki/Basic_telecommunications_access_method (Viewed 2 March 2018)

[24]BATS - British Additional Telecommunications Support

[25] BDAM https://en.wikipedia.org/wiki/Basic_direct_access_method.(Viewed 2 March 2018)

[26]The **Midwich Cuckoos** is a 1957 science fiction novel written by the English author John Wyndham. The cuckoos in the novel, were very alike, and inseparable.

I've mentioned the importance of response times: equally important was the question of restart/recovery. Our judgement was that any terminal operator needed a positive response to sending a message, and we particularly did not want to be in the situation when for the lack of one, a message would be resent and duplicated, or not resent. A message from a shop-floor terminal updated the stock and order files in real-time. Each process message required the input message to be logged, a read and delete from one stock file to an update and write in a new stock file, plus a read, update and write of the order file and a write to the output log. Should a failure in this sequence occur before a transaction completed, the software was designed to back out the transaction and re-process it to completion before sending the operator an acknowledgement, lighting the 'OK' lamp on the IMIC, and printing the record on the Golf-ball typewriter. If the message was resent, the message-processing application would recognise that fact and reject it. Alongside each IMIC, in a protective steel enclosure[27] the Golf-ball typewriter printed a record of all transactions and error messages, and also served as a paper-trail for the operators. The printed format was a duplicate of the previously manually completed shift report – this was a crucial document as bonus payments were throughput related. Whilst it was very important in the early days of the system, it became less so over time as confidence grew.
Towards the end of the first week of 'live' running we started to hit order file update errors and discovered that between reading the order file for one transaction, updating it and writing it back, a second transaction[28] for the same order could also have read the record. It would complete its update then write it back, overwriting the effect of the earlier transaction's update. We took the system off the air for a few days while we corrected an oversight in our file handling routines. Each application needed to reserve (enqueue) a record after reading it and before writing an updated version.

Application design.
The key elements of design centred on the unique identification (rolling number) of the material processed together with the NEW information generated by the process itself. Analysis showed that twenty-two characters would be sufficient to perform this reporting, hence a key element of the IMIC design. For some processes, the rolling number only, plus a check digit[29]was sufficient. This contrasted markedly with the manual reporting method which required some hundred or so characters of information to be recorded – with much scope therefore for error. The design of the message flows mirrored the way that the processes worked, and each step in the process was reported by an appropriately designed message format. Other messages types included the reporting of the start and end of shifts, crew identification, process delays and equipment changes.

Another crucial design decision was that if a message was judged to contain a data error, the software would point this out by lighting an error lamp on the IMIC and printing an explanatory error message, requesting the message be corrected and resent. The most frequent error was of

[27] See Appendix 10
[28]Most orders required ten or more stock items to fulfil the order, many required a hundred or more. As the batch moved through the process cycle, generally quite closely together, it was inevitable that an order record would receive many update messages in a short period of time.
[29]The standard identification was a five digit 'rolling number' The check digit was calculated and applied at hot rolled coil production, to guard against transposition errors in subsequent 'rolling number' reporting.

a rolling number/check digit mis-match, and easily rectified. We took the view though that the operators weren't going to deliberately make mistakes and that getting into an 'error, send again' loop with an operator would simply lead to frustration, and decided that we would seek only one resend of a message. If the resent message was still judged to be in error we passed it to the person who was the shift *system controller*. This was a new position, one of the results of our slab yard experience, established specifically to handle transaction reporting errors, but also with the responsibility of handling top-up training and any other system problems such as Elliott Arch switchover in the event of a failure. The four system controllers, who covered 24/7 operation, were selected from amongst the most senior shift staff, totally versed in the manual reporting systems and processes, and were a key part of the operator training conducted jointly with the systems implementers. The quality of the operator training and the co-operation of the operators never gave rise to an unmanageable situation. The system controller's terminal[30] was another unique variant, described by some as resembling the bomb-aimer's console from a Vulcan bomber. The system controller had to able to mimic every single message type, from any terminal and had extensive file enquiry facilities.

The application logic for the updating of the order and stock records was specified using decision tables, which for the time was a relatively new technique.

Application testing.

This was performed by computer projects development systems analysts and programmers initially, before passing to a test phase run by the system controllers. To some extent of course the training sessions for the process operators performed a third and final phase of testing. No system-based testing aids were available, so testing consisted of sitting at an IMIC, entering transactions and deliberately introducing errors. Testing was further complicated by the fact that the IBM360 complex was very heavily loaded during the day and at shift-ends – 0600-1700 & 2200-2400 – therefore much of our development activity and testing took place mid-evening or in the wee small hours. Sleep, and family life, became for many, a poor second. A failure of STACA itself invariably required a full core dump and inches-high stacks of continuous stationery print-out to pore over.

Shop floor implementation.

It became very clear early on in the project that the unions involved, principally BISAKTA, were going to insist on being paid for using the new input terminals, even though the volume of recording required was far lower and therefore quicker. Whilst there were a few tense moments during the negotiations – which had to be conducted process unit by process unit - agreement on the level of payment was reached and implementation went well. Training of the operators took place in the basement computer room initially and all parties proved quick and adept learners particularly the process workers, a number of whom boasted to their families that they were now 'using computers' which put them a cut above most other steelworkers. Training itself was carried out during the working shifts, process crew by process crew, for which they were paid an average tonnage throughput. A major issue arose at one point. We had programmed the

[30]Sadly, no photograph exists of this device either.

message processing applications to reject the input of any new data which contradicted what the system already 'knew'. Because the manual system had no mechanism to spot 'over-reporting' of tonnage, on occasions, operators reporting throughput at one stage of the process disagreed with a previously reported lighter weight. They felt they would lose out on tonnage-based payments. To obtain agreement to the implementation of the system, the mill management agreed not only to pay for the change to on-line reporting but also to 'buy-out' the opportunity, now lost, for 'earning' extra tonnage payments. On another occasion, during one late-night training session the author was asked if the basement computer room could be rented by the night shift film club – "it's ideal, hidden away from prying foremen and with the lights out, completely dark" – a polite refusal was graciously accepted.

By mid-1971 the system collected all process information from the annealing bay, three coil temper mills and four cut-up-lines. All of the previously manually-produced production reports were batch-generated from the data collected, at the end of each shift, for distribution to the user departments. These programs were written in COBOL[31], and were complimented by a wide variety of routine and exception reporting analyses. On-line scheduling of the coil temper mills had also been implemented. The next on-line reporting stages planned were the despatch bays, galvanising line and hot sheet finishing.

Data volumes.

The typical number of orders processed per annum numbered some 30,000 and each required around 5-10 stock items, on average. Some, obviously, required many more, hundreds even. During the life-cycle of an order, typically six weeks, each stock item would pass through an average of 10-12 processes. Process transaction volumes were not therefore very high, of the order of 1,000-1,500/shift. Disc storage was both limited and very expensive, requiring a number of steps to be taken to economise on it – the most obvious of which was to abbreviate the customer name on the order file for internal use. A separate but linked file containing the full name and associated address information was maintained on magnetic tape for invoicing and external use.

Postscript

In September 2017 I sought a visit to the Cold Mill to assess what, if any, of STACA remained in use. The short answer is a lot. The online reporting of steel processing is now almost entirely real-time from process control computers directly connected to STACA processors, message content and message handling being relatively unchanged. Two Cold Mill exceptions to this direct process control connection are batch annealing and #1 coil temper mill, where the manual entry formats are instantly recognisable as 1969 vintage, albeit they operate under some wonderful application names such as RUMBA, BAME and BELGRAVIUM. This otherwise mostly direct connection, coupled with the largely continuous nature of processing has also eliminated the need for the IMIC/Golf-ball hardware and the system controllers. PCs now rule, displays being protected still, from what remains a relatively hostile physical environment. STACA also continues to handle all the process reporting messages coming from process control computers and terminals from the

[31] A high-level programming language https://en.wikipedia.org/wiki/COBOL (retrieved 19 February 2019)

BOS Plant through to despatch, and has itself has been extended to collate and provide real-time data for scheduling and management purposes together with much historical data on unit performance for example, all in 1960s 'green screen' formats[32]*. As I write serious thought is being given to replacing STACA; it is after all, half a century old.*

I'd like to express my sincere thanks to Rebecca Baird of HR for enabling my visit and Nigel Bowden, John Martin and Tim Rutter for their time, interest and the friendliness with I was welcomed. When Nigel took me into the Cold Mill, even had I been blind, I'd have known where I was. Whilst much had changed, the smell had not – and it's rightly said that smell is a most powerful stimulant of memory.

<u>1969. The Basic Oxygen Steel (BOS) Plant, mould bay and soaking pit systems.</u>

By March 1969 it became clear that the process control system[33] planned for the new BOS Plant would not be completed in time for its commissioning in October 1969. The computer projects team was tasked with the design and implementation of a real-time data collection system such that the plant could start up and operate, no manual systems having been planned. The timescale was very tight, but STACA had been running successfully for some months and confidence levels were high in our ability to design an easy-to-operate message handling application for the two key information generators - the laboratory and the BOS plant operator's pulpit. The key challenge was to select and acquire suitable terminal hardware which could be delivered in time and be suitable for roll-out further down the 'heavy-end' production processes.

Being late was not an option. The Elliott Arch/IMIC combination would have been ideal, but Elliott Automation could not meet the delivery timescale. A different solution was therefore required and IBM's 1070 Process Communication system[34] was selected. The 1070 design permitted a variety of operator input devices and we, of course, designed our own, based on a 1077 and christened it SCWT (Steel Company of Wales Terminal)[35]. It could be configured for up to 24 digits, with a facility for constructing a variety of formats to suit the circumstances. An IBM 1053 golf-ball printer was attached to each SCWT to provide a hard-copy record of all transactions. The laboratory terminal selected was an IBM 2741, an un-buffered golf-ball-based typewriter input device, necessary because the spectrographic laboratory analysis for each 'blow' ran to some one hundred characters. The 'live' date was met and the system was quickly extended into the mould bay, soaking pits and slabbing mill, joining up with and replacing the earlier slab yard/reheat furnace IBM 357 system. The 1070/2741 combination, running at 70cps, connected to the IBM System/360 complex via channel-attached IBM 2701, later IBM 2702/3 transmission control units.

[32]See Appendix 11 for examples of these.
[33] See Appendix 12 for *TheDragon* report.
[34] See Appendix 13
[35]See appendix 13

1971. The computerisation of the order entry system[36]

The next logical step was to speed up the order entry process and we chose a visual display unit (VDU) as the ideal data entry device. These, new technology 'office-friendly' CRT (Cathode Ray Tube) devices were very new to us, but had clear attractions, in particular, screen layouts could be designed which resembled the existing order entry processes and documentation. As much of our business was of a repeat nature we held most of the required customer data in our order data-base. Even in the heaviest case where no prior customer record existed we could reduce data entry to a single screen's worth of input data. We could even, particularly from existing customers, take orders over the phone. The VDU we chose was bought from Sanders Associates[37] whose terminals and controllers mimicked IBM's 2260 system[38]of which we had prior experience in building the Elliott Arch/IBM System/360 connection.

1969-1973 Cost/benefit.

Once the on-line collection of data had proved itself, the challenge moved to maximising the use of it. Some departments were reluctant to drop manual record-keeping until 'they were certain' the on-line systems outputs could be 'trusted' The routine of regular stock-takes soon proved that, and bravely, Grove Martin the Production Manager at the time, later took the decision to 'burn' the hard-copy order books which had entailed laborious manual updating, relying subsequently of the computer system records for plant process scheduling, order tracking and customer service, which was dramatically improved by the on-line enquiry facilities and in turn led to the achievement of the project's key objectives. Over the next few years the few hundred or so clerical staff employed in maintaining the stock and order records were reduced by over 90% with a not dis-similar reduction in the number of punch card machine operators required.

Whilst the manual record-keeping was an obvious cost and an equally obvious potential benefit opportunity, it was more difficult to persuade the less senior operational line managers to understand the value of the data. To attempt to overcome this reluctance the author was, for a time, seconded by senior management to the Cold Mill management team and became therefore a member of the daily production meetings which reviewed the previous twenty-four hours operations, and discussed the next twenty-four. Early on, the management team were contemplating a major piece of capital investment. They were really persuaded of the value of the system when a series of simple analyses demonstrated that the investment they were about to make was going to cost substantially more than was needed to handle the vast majority of the throughput of the mill. The analysis showed that for about 65% of the cost they could handle almost 90% of the job. The 'reluctance dam' was breached. There were later countless other examples of the use of the data for management, budgetary and investment decision-making purposes. An unanticipated and major benefit came from the heavy end mould tracking system, which proved able to improve mould usage performance and to identify under-performing mould suppliers.

[36]See Appendix 14 for *Steel News* report.
[37]http://bitsavers.trailing-edge.com/pdf/sandersAssociates/Sanders_720_Technical_Description_Mar67.pdf
[38]http://www.columbia.edu/cu/computinghistory/2260.html - (Both retrieved 19 February 2019)

Analysis of the order book also strongly and positively influenced pricing policies after computer models were built of BSC and overseas competitor price lists. In a later case the models avoided severe embarrassment for BSC after a botched price increase was announced.

An independent audit of the cost benefit case for the on-line systems was conducted and published in 1972/3. It identified the significant benefits achieved, which offset the expenditure by a factor of three, per annum, and led to the identified savings being incorporated by executive management into the budgets and operating plans for the process units.

At the time I left BSC in mid-1973 we had clearly and convincingly proved that STACA and real-time transaction processing paid, and that capital funding for the next stage of the roll-out of both the Hot and Cold Mill systems would prove highly beneficial. Shop-floor employee acceptance was high, the plant's delivery performance was outstanding and customer confidence was high.

However, BSC's new strategy ran counter to individual plants competing for business – the corporation wanted to 'load-balance' across the various steel plants and therefore needed to discourage customer preference. At the same time the new centralised Management Services function wasn't strong enough to impose either development standards or the cross-corporation deployment of successful systems; each plant was left relatively free to do its own thing. The result was development waste and re-invention, loss of competitive edge and deep frustration.

Fifty years on, the record shows that sound design can endure regardless of technological developments. A lesson might be to avoid chasing the latest technological whimsy.

Acknowledgments.

My particular thanks to Dai Parry, Mike Farrington and Dr Maurice Perks who corrected and enhanced some of the more technical aspects of the paper and to Allan Morgan for some additional and very useful insights. Thanks are also due to Professor John V. Tucker of Swansea University for stimulating my interest in even thinking about recording this time in my life, and commenting on my efforts throughout, and to Jennifer Protheroe-Jones, Principal Curator – Industry, at the National Waterfront Museum, Swansea for her meticulous attention to detail, both large and small, which massively contributed to the final result. Thanks too, are due to Paul Martynenko for his incisive suggestions. At TATA Steel, thanks are due to Rebecca Baird, John Martin, Nigel Bowden and Tim Rutter.

Chief amongst user management supporters of our efforts during the time covered by this paper were Norman Behenna, Arthur Bowden, Bill Harrison, Grove Martin, Frank Murdoch, W Kerry Phillips, Ross Ramsay, Dr Peter Roderick, Doug Short, S O Lyn Thomas, Peter Truscott and Arthur Tucker.

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1965-1973. From 1967 led the Computer Projects production systems design team.
1973-2000. IBM UK Ltd, retiring as Director, Finance Sector, Region North, EMEA
geoffhenderson@btopenworld.com

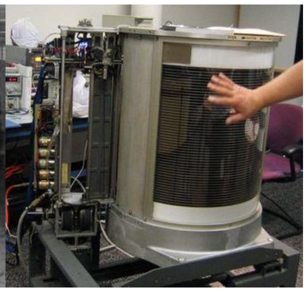
Appendix 1

IBM 1401 - under restoration at Computer History Museum, California

From IBM library

IBM 1410

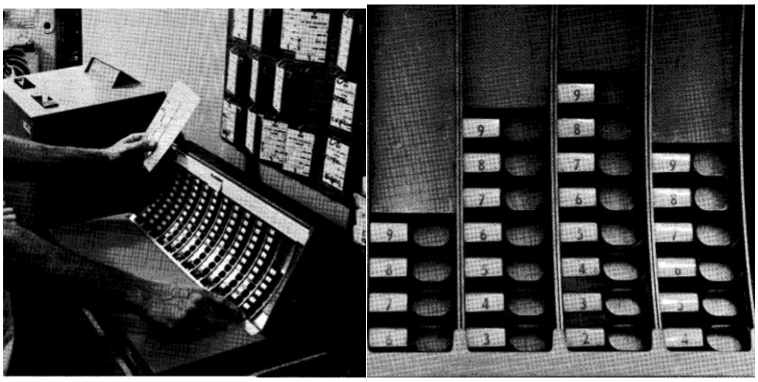
IBM RAMAC



https://en.wikipedia.org/wiki/IBM_1401
http://www.computerhistory.org/atchm/about-the-computer-history-museums-ibm-1401-machines/
https://www.ibm.com/ibm/history/ibm100/us/en/icons/mainframe/
https://en.wikipedia.org/wiki/IBM_1410
http://www.bitsavers.org/pdf/ibm/1401/C24-3258-2_Disk_Autocoder_Specifications_Apr66.pdf
(All retrieved 19 February 2019)

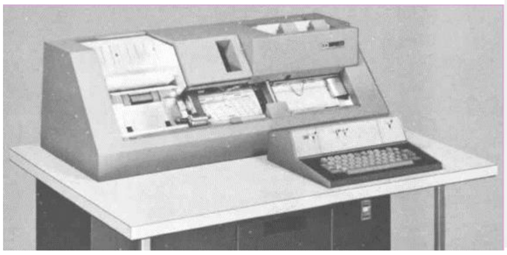
Appendix 2

IBM 372 manual entry device. The IBM 357 input station with card reader is in the top left of the first illustration.



IBM 029 card punch

IBM 514 card reproducer



http://bitsavers.org/pdf/ibm/generalInfo/E20-8076_IBM_Data_Collection_at_the_Factory_1961.pdf
https://en.wikipedia.org/wiki/IBM_357
http://www.columbia.edu/cu/computinghistory/029.html
https://www.ibm.com/ibm/history/exhibits/rochester/rochester_4011.html (IBM 514)
(All retrieved 19 February 2019)

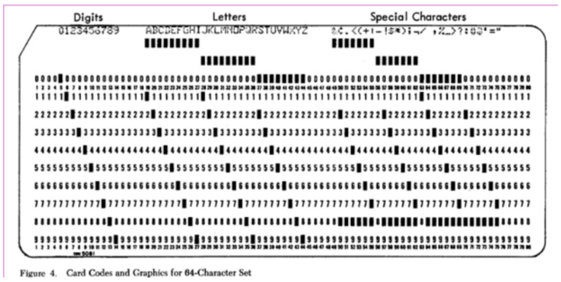


Figure 4. Card Codes and Graphics for 64-Character Set

Standard 80 column punch card.

Appendix 3

IBM System /360/40

IBM 2311 Disc drive

https://www.ibm.com/support/knowledgecenter/zosbasics/com.ibm.zos.zmainframe/zconc_s360history.htm

https://en.wikipedia.org/wiki/IBM_System/360_Model_40

https://ipfs.io/ipfs/QmXoypizjW3WknFiJnKLwHCnL72vedxjQkDDP1mXWo6uco/wiki/IBM_System_360_Model_40.html

http://www.bitsavers.org/pdf/ibm/360/funcChar/A22-6881-2_360-40_funcChar.pdf

http://www-03.ibm.com/ibm/history/ibm100/us/en/icons/system360/

http://s3.computerhistory.org/groups/ibm-1311-2311.pdf

(All retrieved 19 February 2019)

Appendix 3.1

The evolution of removable storage IBM 2311 to 128GB SD card.

The 2311removable disc pack stored 7.25MB of data. Had it been possible (it wasn't) 128GB of 2311 storage would have required a floor area approximately the size of the Principality Stadium, and probably have required a hundred tons or more of heavy multi-core cable and a dedicated power station.

$1m to 2 cents/GB

Appendix 4

The conversion from IBM 1401/1410 to IBM S/360.

Most of the production system's application programs written for the IBM 1401 & 1410 were written, by us, in *Autocoder* (https://en.wikipedia.org/wiki/Autocoder) as was the author's first (and only) program in 1965, the *Slab Yard Stock listing*. COBOL was the dominant programming language for the commercial systems. Operating systems, access methods and compilers were supplied by the computer manufacturers, but little else. There was no third party software package industry. If an application was required, it was designed and written in-house. The biggest commercial application for example, the payroll system, was designed and written by SCoW systems analysts (recruited from the Wages Department), and programmers.

Although S/360 and DOS/360 included 1400 compatibility hardware and software to allow 1400 programs to run on S/360 in emulation mode[39], this was only ever going to be a temporary option for the production systems. *Autocoder* was not compatible with the S/360 so every *Autocoder* program which was required to run on the S/360 had to be re-written, this time in *IBM Assembler Language.*

(https://en.wikipedia.org/wiki/IBM_Basic_assembly_language_and_successors). (Retrieved 19 February 2019)

There were no language conversion tools; every program had to be *re-written* – compiled and tested as if it were new. For the best part of twelve months the programming teams did little else, critical maintenance aside. Neither users, developers, nor programmers were happy about this but IBM committed that the new assembler language would be upwards compatible with the entire S/360 range and its successors. This remains true today, a fundamental reason STACA is able to remain in use.

[39] For S/360 model 40: https://en.wikipedia.org/wiki/IBM_System/360_Model_40#IBM_1400_series_emulation
For a full description of the emulator: http://bitsavers.org/pdf/ibm/360/dos/C27-6940-2_14xx_Emulator_Feb69.pdf
(Retrieved 19 February 2019)

Appendix 5

*The Times*May 1967

£1.4m computer link for SCOW

By PEARCE WRIGHT, Science Reporter

The steel industry is becoming one of the biggest users of advanced computer systems.

In one of the most ambitious single projects undertaken by heavy industry, the Steel Company of Wales is embarking on a £1,400,000 scheme involving six computers.

These will form part of a data-communications network linking production plants centred on Port Talbot, Velindre (Swansea) and Trostre (Llanelly). For this purpose I.B.M. is providing two 360 model-40 computers valued at £630,000, Elliott Automation is supplying two Arch 102 systems worth £120,000, and English Electric Computers is providing a system 4-50 and 4-10 valued at £280,000.

The I.B.M. and Elliott Automation computers will be used at Port Talbot as part of a management information and communication system. It will provide a direct link between production shops and a central production control department. The Elliott Arch machines will act as message-handling exchanges. Information will pass from 24 data-gathering units in the steel mill via one-mile-long transmission cables into the I.B.M. computers.

In a two-way communication system, the central production control department will have immediate information of the situation in the works; the mill operators will receive information about the material they are processing.

The two English Electric machines will be for tinplate mills at Velindre and Trostre. They will be linked over a distance of 10 miles by leased telephone line.

The English Electric systems replace two I.B.M. machines that were installed two years ago.

Appendix 6

The Dragon May 1967

BE ALERT —DON'T GET HURT

The Dragon

2,000 DAYS IN SAFETY See Page 4

THE MONTHLY PUBLICATION OF THE STEEL COMPANY OF WALES LIMITED

MAY 1967

£1.4m. COMPUTER SCHEME

Company embarks on big development programme

OUR Company, which has long been amongst the most advanced users of computing equipment in this country, particularly for production control and process control applications, has now embarked on a new phase of development in this field.

Together with the new computer centre now under construction, the expansion scheme will cost £1.4 million.

The Company currently operates 13 electronic digital computers of various types. Several new projects have recently been initiated.

The new computer centre will cost £400,000 and is being built adjacent to the head office at Abbey Works.

The Company has already taken delivery of one IBM 360 Model 40 computer and will install a second machine of the same type at the end of this year, when the new computer centre will be completed. One of these machines will be used for production control work and the other for accounting and technical applications.

Each 360 computer will have 131,000 bytes of core memory and 7 magnetic disk drives and are together worth £630,000. They will replace an IBM 1401 and an IBM 1410 computer currently in use at Port Talbot.

The Company also operates an ICT Pegasus computer which is used for operational research work. This work will be carried out on the IBM 360 computers in future and the Pegasus has been offered to the Llandaff Technical College, Cardiff.

Telephone link

The Tinplate Division will acquire from English Electric Computers Limited, for installation in May, 1968. two System 4 computers worth £280,000 for use in production control and accounting applications. The equipment will comprise a System 4/50 computer with 65,000 bytes of core memory and four disk files at Velindre Works and a System 4/10 computer with 8,000 bytes of core memory at Trostre Works. The two computers will be about 10 miles apart and are to be directly connected by a leased telephone line capable of transmitting information at the rate of 200 characters per second.

The computer at Trostre will act as an input and output unit of the main machine for data relating to the operations at the works.

These two English Electric computers will replace two IBM 1440 computers which were installed in 1965 and are now in use for more than 120 hours a week.

The Company has ordered from Elliott Automation a set of 24 plant data terminals and two Arch 102 computers worth £120,000 for direct connection to the Company's IBM 360/40 computers. These terminals will be situated in the cold mills at Abbey works and will provide an on-line data collection facility. The equipment forms the first step towards a comprehensive real-time production control system in the Port Talbot Divisions.

Three IBM 1050 data communication terminals have been ordered. These terminals will be situated at the computer centres at Port Talbot, Velindre and Trostre and will be connected by telephone lines. They will be used for rapid communication of orders and notification of deliveries of hot rolled coil which is produced at Port Talbot and used at Trostre and Velindre for making tinplate.

Appendix 7

The Dragon, 1965 and 1966

NOVEMBER 1966 THE DRAGON

12-WEEK COMPUTER COURSE FOR PRODUCTION DEPARTMENT STAFF

Mr. Fred Hyatt, chief systems analyst, scheduling development department, lecturing at the opening session of the course.

AS a result of requests from members of the staff of the department, a 12-week course is now in full swing for personnel of the production department at Abbey Works.

The course has been organised by Mr. W. Grove Martin, manager of the production department, and Mr. Fred Hyatt, chief systems analyst in the scheduling development department. The lectures are being given by Mr. Hyatt.

The course got off to a good start in the conference room at Abbey general offices on October 12, with 30 people enrolled.

The course covers the use of computers in production planning and control as applied to meeting customers' orders at Abbey. This embraces order acceptance, keeping a file of customers' orders on the computer, a progress file showing the locations of all material held against orders, a stock file showing the stocks ahead of each process in the cold mills, and a proposed network of keyboards and typewriters on the mills through which information (such as production reports) will be sent to and received from the IBM computer installation.

Powerful agent

The purpose of the course is to illustrate the ways in which computers can assess in production planning and control, and to show that the pay-off from the substantial expenditure involved lies in management and staff being given the power to do things with the aid of a computer that would be impossible without it.

The computer is already a powerful agent and will become increasingly so in the battle for better delivery and higher profits.

JULY, 1965 THE DRAGON

Computer courses planned for school-leavers

WITH an eye to the future the Company have decided to launch a computer course in the Port Talbot Divisions.

It will start in September and will be open to a fixed number of 16 to 18-year-old school-leavers who have obtained "O" level of the G.C.E. in mathematics, English and any two of the following subjects:— geography, history, science, commerce and another language.

During the first two years of training, students will spend periods in major departments of the two divisions. Time will also be spent in the operations and development sections of the data processing department, and visits made to the Tinplate Division.

When training is complete they will be transferred to permanent positions in the operations sections of either the Tinplate or Port Talbot Divisions' data processing departments. Some of these positions will be on a shift basis.

Day release

All trainees will be given day release to attend the College of Further Education at Margam to study for the City and Guilds' certificate for computer personnel.

Promotion will depend on proficiency in the job and selection for further specialised training, such as the international business machines programming course or the City and Guilds computer personnel advanced certificate.

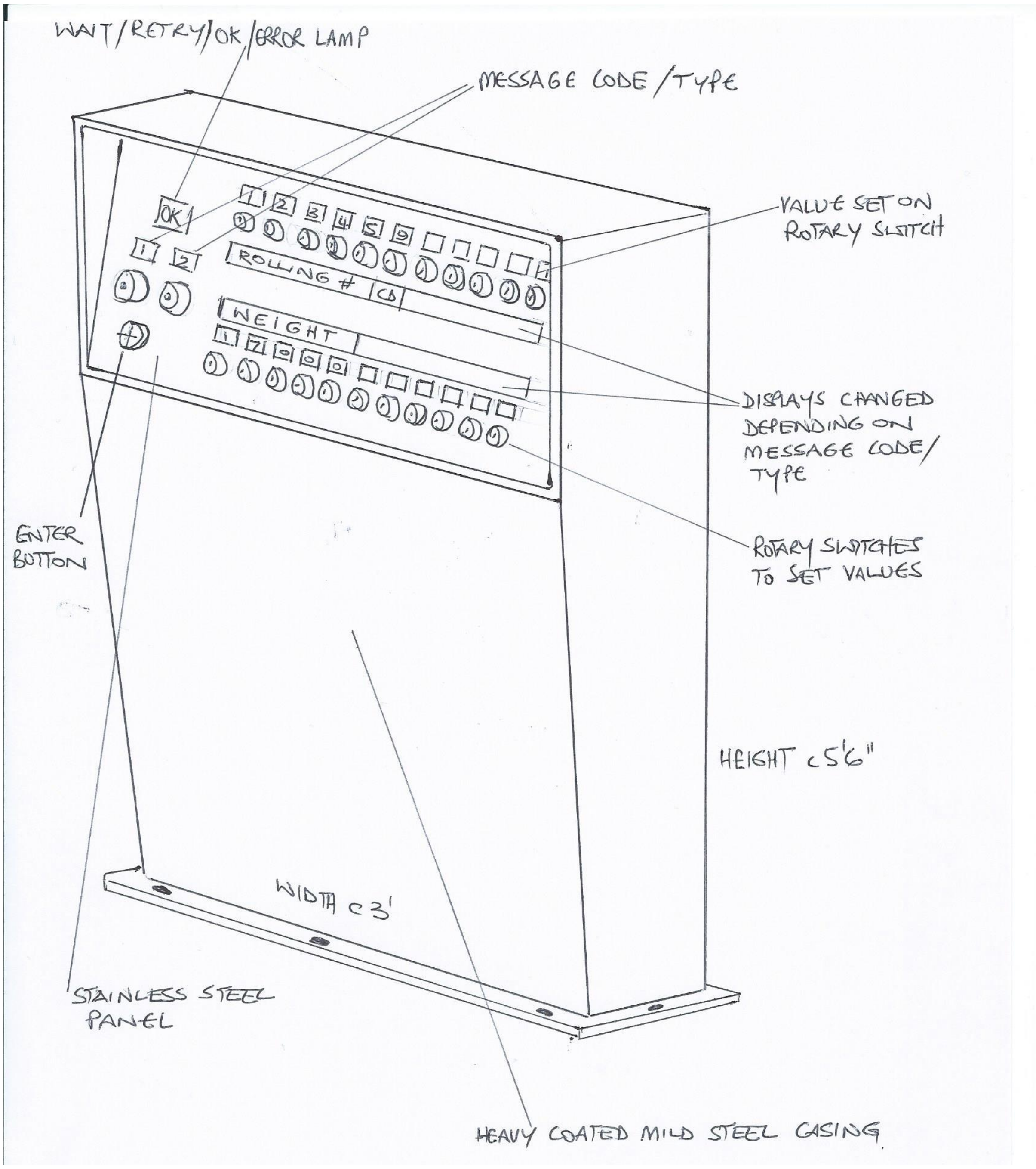
Students are engaged annually, usually during the second week of September, so that academic studies and practical work may commence at the same time.

Appendix 8

The multi-core cable from each IMIC and the smaller cable from each Golf-ball typewriter was routed through the Cold Mill cellar to a termination block in the basement computer room.

Photographed November 2017

Appendix 9 Cold Mill IMIC terminal



Above each rotary switch was a window which displayed the switch setting. The two switches on the left of the panel were the *message type.* The right hand switch rotated two horizontal bars on which were engraved the data required for each *message type.* In the example above two of the data fields required are *rolling number, check digit* and *weight.*

Sadly no photograph exists, that I have been able to trace, and the last IMIC was scrapped it's thought, in 2015.

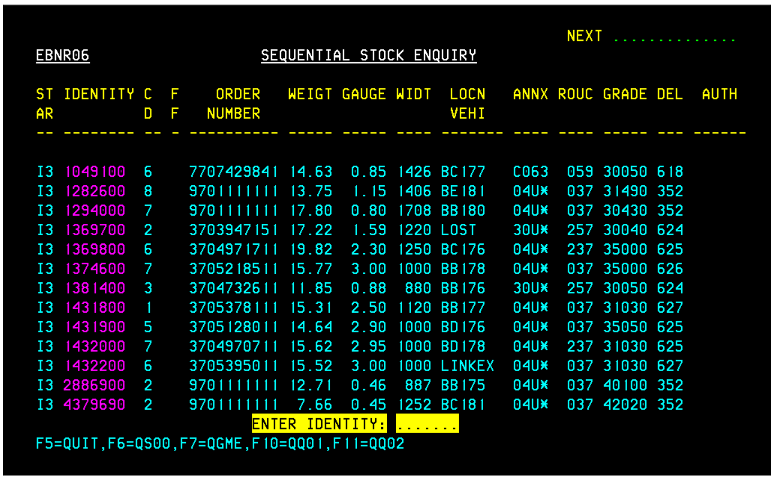
Appendix 10

A Golf-ball typewriter and the remains of a protective casing. The shelf below the typewriter held the large supply of continuous feed stationery. Compressed air at low pressure was piped into the casing to minimise ingress of dust and other potentially damaging particulates or chemicals.

Casing photographed November 2017

https://www.ibm.com/ibm/history/ibm100/us/en/icons/selectric/

Appendix 11 STACA Green Screens still in use in 2019



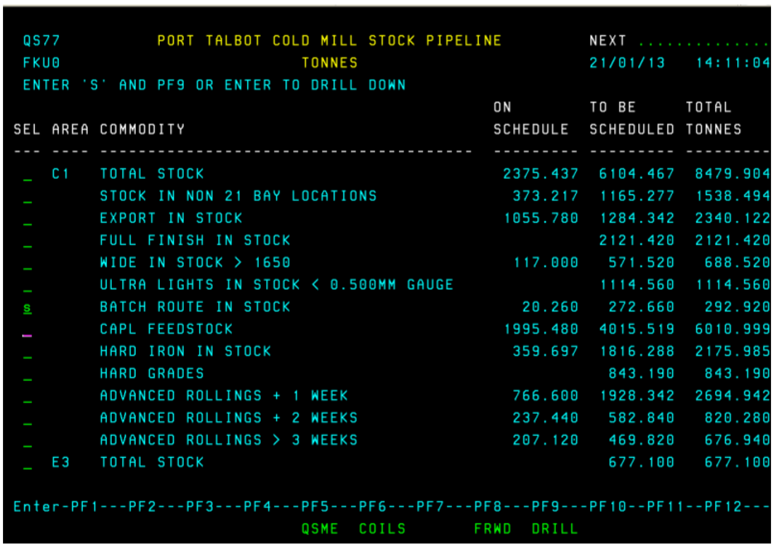
NEXT ....

EBNR06 SEQUENTIAL STOCK ENQUIRY

ST AR	IDENTITY	C D	F F	ORDER NUMBER	WEIGT	GAUGE	WIDT	LOCN VEHI	ANNX	ROUC	GRADE	DEL	AUTH
I3	1049100	6		7707429841	14.63	0.85	1426	BC177	C063	059	30050	618	
I3	1282600	8		9701111111	13.75	1.15	1406	BE181	04U*	037	31490	352	
I3	1294000	7		9701111111	17.80	0.80	1708	BB180	04U*	037	30430	352	
I3	1369700	2		3703947151	17.22	1.59	1220	LOST	30U*	257	30040	624	
I3	1369800	6		3704971711	19.82	2.30	1250	BC176	04U*	237	35000	625	
I3	1374600	7		3705218511	15.77	3.00	1000	BB178	04U*	037	35000	626	
I3	1381400	3		3704732611	11.85	0.88	880	BB176	30U*	257	30050	624	
I3	1431800	1		3705378111	15.31	2.50	1120	BB177	04U*	037	31030	627	
I3	1431900	5		3705128011	14.64	2.90	1000	BD176	04U*	037	35050	625	
I3	1432000	7		3704970711	15.62	2.95	1000	BD178	04U*	237	31030	625	
I3	1432200	6		3705395011	15.52	3.00	1000	LINKEX	04U*	037	31030	627	
I3	2886900	2		9701111111	12.71	0.46	887	BB175	04U*	037	40100	352	
I3	4379690	2		9701111111	7.66	0.45	1252	BC181	04U*	037	42020	352	

ENTER IDENTITY: ....

F5=QUIT,F6=QS00,F7=QGME,F10=QQ01,F11=QQ02



QS77 PORT TALBOT COLD MILL STOCK PIPELINE NEXT ....

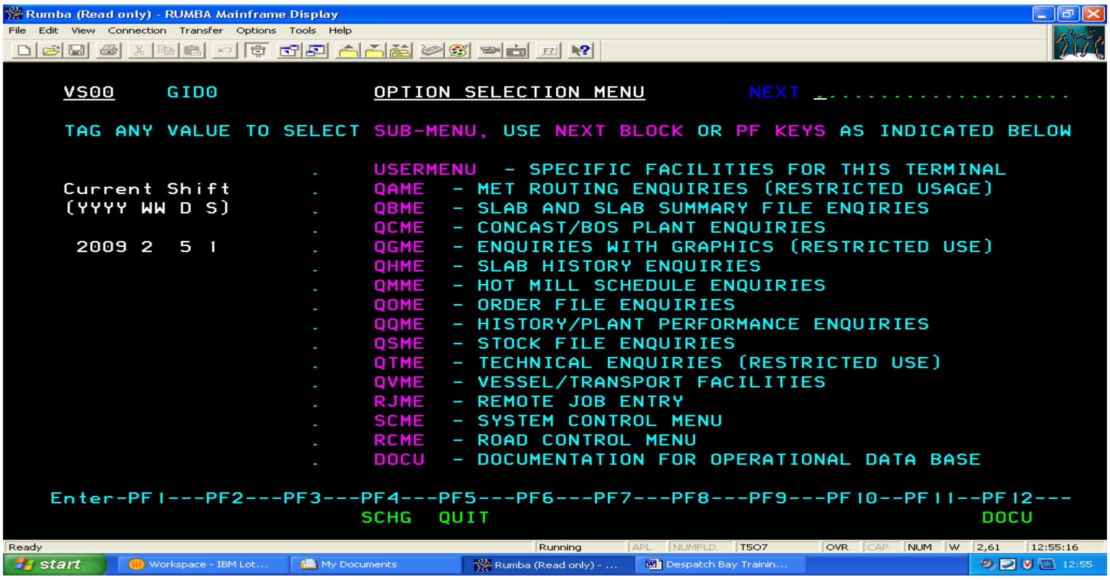
FKU0 TONNES 21/01/13 14:11:04

ENTER 'S' AND PF9 OR ENTER TO DRILL DOWN

SEL	AREA	COMMODITY	ON SCHEDULE	TO BE SCHEDULED	TOTAL TONNES
_	C1	TOTAL STOCK	2375.437	6104.467	8479.904
_		STOCK IN NON 21 BAY LOCATIONS	373.217	1165.277	1538.494
_		EXPORT IN STOCK	1055.780	1284.342	2340.122
_		FULL FINISH IN STOCK		2121.420	2121.420
_		WIDE IN STOCK > 1650	117.000	571.520	688.520
_		ULTRA LIGHTS IN STOCK < 0.500MM GAUGE		1114.560	1114.560
s		BATCH ROUTE IN STOCK	20.260	272.660	292.920
_		CAPL FEEDSTOCK	1995.480	4015.519	6010.999
_		HARD IRON IN STOCK	359.697	1816.288	2175.985
_		HARD GRADES		843.190	843.190
_		ADVANCED ROLLINGS + 1 WEEK	766.600	1928.342	2694.942
_		ADVANCED ROLLINGS + 2 WEEKS	237.440	582.840	820.280
_		ADVANCED ROLLINGS > 3 WEEKS	207.120	469.820	676.940
_	E3	TOTAL STOCK		677.100	677.100

Enter-PF1---PF2---PF3---PF4---PF5---PF6---PF7---PF8---PF9---PF10--PF11--PF12---

QSME COILS FRWD DRILL



Rumba (Read only) - RUMBA Mainframe Display

File Edit View Connection Transfer Options Tools Help

VS00 GID0 OPTION SELECTION MENU NEXT _...................

TAG ANY VALUE TO SELECT SUB-MENU, USE NEXT BLOCK OR PF KEYS AS INDICATED BELOW

Current Shift
(YYYY WW D S)

2009 2 5 1

. USERMENU - SPECIFIC FACILITIES FOR THIS TERMINAL
. QAME - MET ROUTING ENQUIRIES (RESTRICTED USAGE)
. QBME - SLAB AND SLAB SUMMARY FILE ENQIRIES
. QCME - CONCAST/BOS PLANT ENQUIRIES
. QGME - ENQUIRIES WITH GRAPHICS (RESTRICTED USE)
. QHME - SLAB HISTORY ENQUIRIES
. QMME - HOT MILL SCHEDULE ENQUIRIES
. QOME - ORDER FILE ENQUIRIES
. QQME - HISTORY/PLANT PERFORMANCE ENQUIRIES
. QSME - STOCK FILE ENQUIRIES
. QTME - TECHNICAL ENQUIRIES (RESTRICTED USE)
. QVME - VESSEL/TRANSPORT FACILITIES
. RJME - REMOTE JOB ENTRY
. SCME - SYSTEM CONTROL MENU
. RCME - ROAD CONTROL MENU
. DOCU - DOCUMENTATION FOR OPERATIONAL DATA BASE

Enter-PF1---PF2---PF3---PF4---PF5---PF6---PF7---PF8---PF9---PF10--PF11--PF12---

SCHG QUIT DOCU

Ready Running APL NUMFLD TS07 OVR CAP NUM W 2,61 12:55:16

start Workspace - IBM Lot... My Documents Rumba (Read only) - ... Despatch Bay Trainin... 12:55

Appendix 12

The Dragon, November 1967

Myriad will speed things up in new steel plant

1967 SEPTEMBER THE DRAGON

THE process control computer to be installed in our new basic oxygen steel plant will help to speed up the plant operation, reduce process losses and almost eliminate paper work.

The computer's calculating power, memory and ability to collect information quickly will also assist in the production of better quality steel faster, safer and cheaper.

The plant is due to start up in mid-1969 and the computer system will have facilities for automating almost every aspect of the steelmaking process from charging the converter to analysing steel samples.

In a second

The centre to control activities will be a large air-conditioned room, set well back from the vessels, in which the computer is to be located and from where the operators will get an unobstructed view of the process.

The computer control system will use an English Electric Myriad II, one of the fastest micro-miniature process computers in the world. For example, if all the employees of our Company bought two dozen articles at a supermarket, the computer could total all their bills, in under one second.

The latest techniques are used in the Myriad, which will be built from thousands of tiny integrated circuits each one the size of a pinhead. A large magnetic disc store will hold data on all the steel grades, together with the standard practice for making them.

Myriad's task

The computer is linked to all the 17 weigh scales. Besides reading in weights from these for use in calculation and records, the computer will ease their maintenance by checking the weighbridge electronics every shift and printing out an alarm if a fault occurs. Similarly the computer will keep an eye on over 200 instruments on the plant which are measuring temperatures, pressures, flows and levels. If any dangerous conditions do arise a warning message is flashed on a display screen, similar to a T.V. screen, which is situated in front of the melter.

The new steel plant process is similar to the present VLN except that the bath is blown from above with pure oxygen through a single lance. At the beginning of each shift the process computer will receive a schedule of steel grades to be made. This will come direct from the IBM 360 scheduling computer via an electrical link like a telephone line. Knowing the grade required the computer will calculate the best "ingredients", i.e. the weights of molten iron, scrap, and other additions, to be charged.

These will be displayed to the appropriate operators and the actual amounts weighed out will be recorded by the computer and used for further calculations. The lime, limestone, fluorspar, millscale and ore additions will be weighed out automatically under the control of the computer.

Ending blow

Once all these materials are charged into the converter, oxygen blown on to the bath converts the iron into steel in less than 20 minutes. The problem is to end the blow with the correct steel analysis and temperature. In order to do this the computer calculates the analysis and temperature of the bath at every instant during the blow. To help it to follow the blow, measurements of bath temperature and exhaust gas composition and flow are fed automatically into it. With this information the computer will be able, by varying oxygen flow, lance height and additions, to steer the process to the required end point conditions. At the end of the blow the computer records the actual temperature from the dip thermocouple and also the steel bath analysis from the laboratory equipment.

The computer will form a major part of the laboratory equipment complex. It will read in the voltages from the laboratory instruments and store the spectrometer calibration curves. From these it will calculate the percentage element composition of the steel sample, displaying the results directly to the melter on the display screen in the control pulpit. Thus speeding the sample analysis time.

The computer will be connected to the teeming bay crane weighing equipment and each ingot weight will be recorded as it is teemed.

Operators helped

Eventually when vacuum degassing equipment is installed into the steel plant, the computer will assist the operators by calculating the composition of the metal in the ladle and the required additions to be made.

At the end of a complete heat cycle a log sheet giving all the details of the charge, blow and teem will be printed out in the control pulpit. This data will be sent to the central IBM 360 which will produce daily the specialised log sheets required by quality control, the laboratory, management, accounts and cost department.

Appendix 13

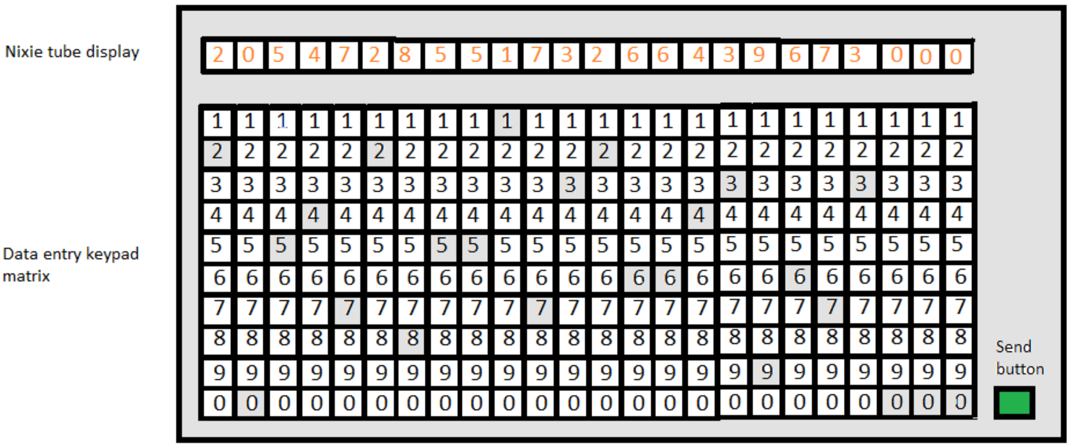
http://ed-thelen.org/comp-hist/IBM-ProdAnn/1070.pdf (retrieved 19 February 2019)

https://en.wikipedia.org/wiki/IBM_1070 (retrieved 19 February 2019)

https://www.computerhistory.org/collections/catalog/102634909 (retrieved 7 March 2019)

SCWT

There was also a method of indicating the inputs required for different transaction types



Schematic of Steel Company of Wales Terminal or SCWT

IBM 1053 Printer

Appendix 14

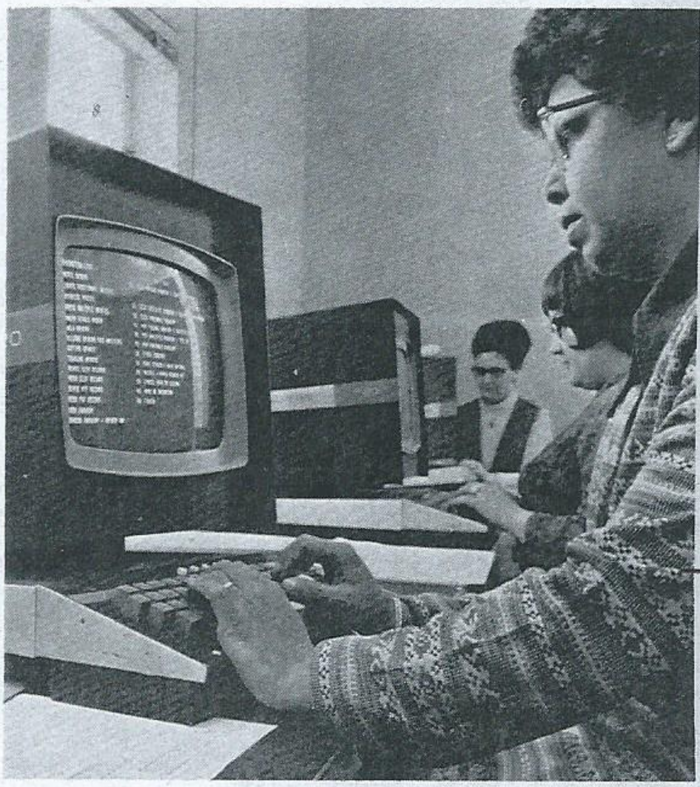
Steel News 6 May 1971 '……..among the most advanced in the world'

Customers' orders: Computer takes over at Port Talbot

STEEL NEWS 6 MAY 1971

A COMPUTERISED method of order acceptance has been introduced in the commercial department at Port Talbot Works, and is among the most advanced in the world.

The system, designed and implemented by computer projects at Port Talbot, uses five visual display units (VDU) into which customers' order information is entered and passed immediately into a computer. The computer, in turn, checks the information and makes a response to the VDU terminal operator within three seconds.



Big advantage

An obvious advantage of the system is the fact that the information can be checked immediately, and if errors are spotted the operator is on hand to correct them.

In addition, amendments to orders, which can be critical from a time standpoint, are handled equally quickly and with the same safeguards.

As well as providing a simple method of entering information into the computer, facilities are provided for getting information out of it. Staff may make enquiries of all the computer's records relating to orders, material in stock, customer information and product information, and because information on material movement is fed into the computer – the majority using terminals installed in the cold mill – the situation of a customer's order can be obtained at any time and displayed on the VDU screen.

At the moment, the system handles all prime home trade orders but will shortly be extended to include order for corrugated galvanised sheets. Other developments are in hand to expand the use of VDU's to cover other aspects of the commercial department's functions.

Appendix 15 The role of women (at the time)

During my time at SCoW/BSC there were no women in senior management positions, nor can I recall one in any management position. Women were employed in their hundreds in secretarial, clerical and administrative roles, and particularly in those which required some degree of keyboard dexterity such as typing and operating accounting machines such as comptometers, the bed-rock of the accounting system ledgers. Typists in 'pools' typically numbered in the dozens. It was also the case that women were only generally employed in the head office and the nearby cluster of buildings, very few were based in the smaller offices distributed around the huge plant. In these smaller offices only the senior manager would have a secretary or typist, the other clerical or administrative roles would be filled by men. The major exception was, of course, catering. Traditionally, and still, the reserve of women, whether staffing the smaller canteens across the plant or the main canteen and dining rooms near the head office.

When punch card machines arrived as the principal input medium for computers, women were the obvious candidates, especially given the *qwerty* keyboards, as operators and some fifty or more staffed our 'punch room', many of whom we ex-typists or comptometer operators.

In every case above, the supervisors of these groups were also women, whose desks were in the same open plan area, sometimes 'protected' from the rest of the group by a low partition. These were very noisy places, particularly the 'punch room'. The supervisors not only shared the space, they shared the work. Managers, to whom the supervisors reported, and who carried other responsibilities, had offices of their own, generally a little way away.

A key distinction for all day-staff was the frequency with which one was paid. The majority of the staff were paid weekly. Professional and management grades were paid monthly i.e. salaried. Computer development staff were salaried and in 1973 about 20% of our programming team were women, but women were not represented in the higher professional grades, either in systems design and analysis or in management.

In the early 1970s a beauty contest was held to choose and crown Miss BOS Plant, and for some years the SCoW newspaper *The Dragon*, and later, the BSC version *Steel News*, featured a women's page, dedicated to fashion and (largely steel) domestic goods and appliances.