
National
Elliott

A. Cadete
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SOLID-STATE DIGITAL COMPUTER

GENERAL INFORMATION

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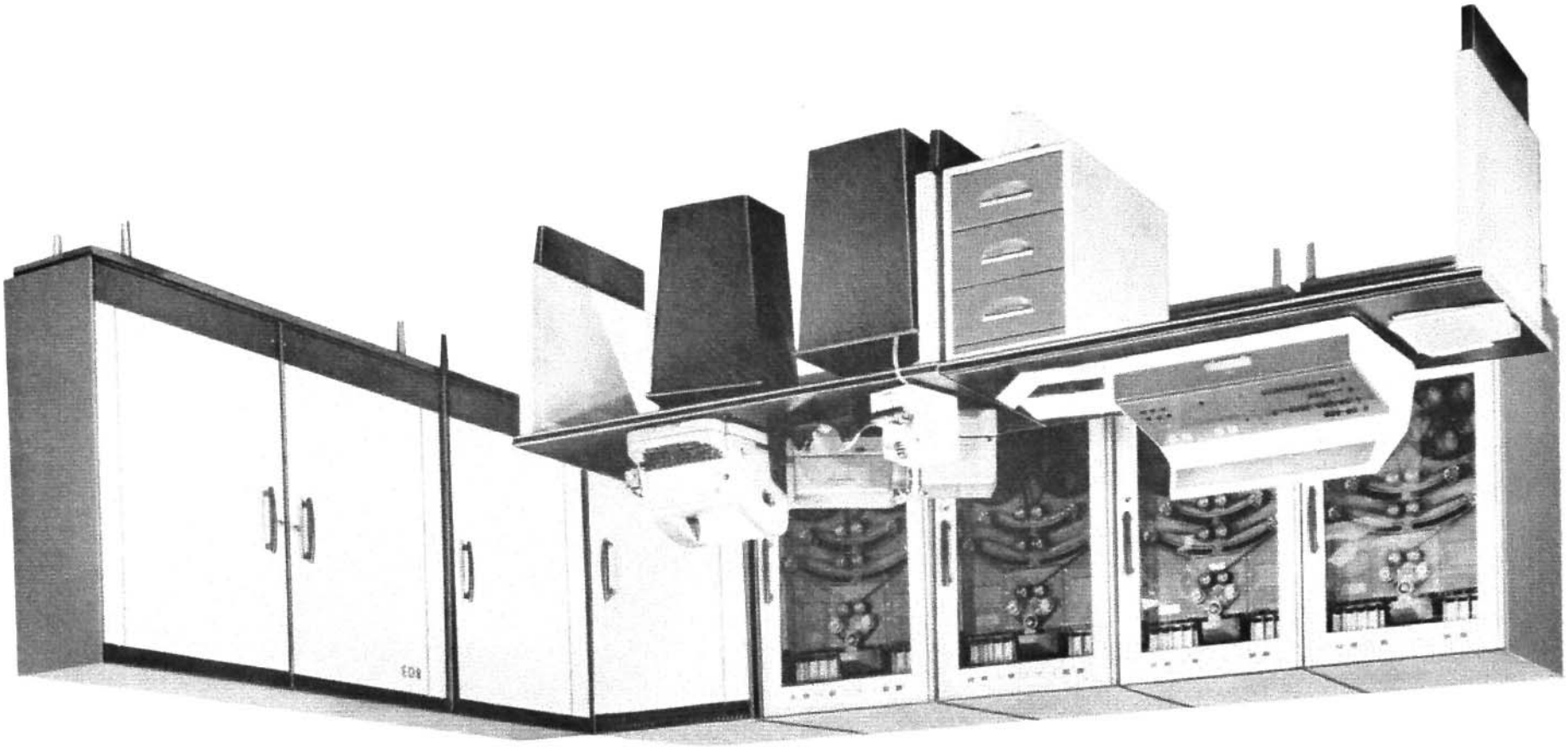

803

National Elliott

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SOLID-STATE DIGITAL COMPUTER

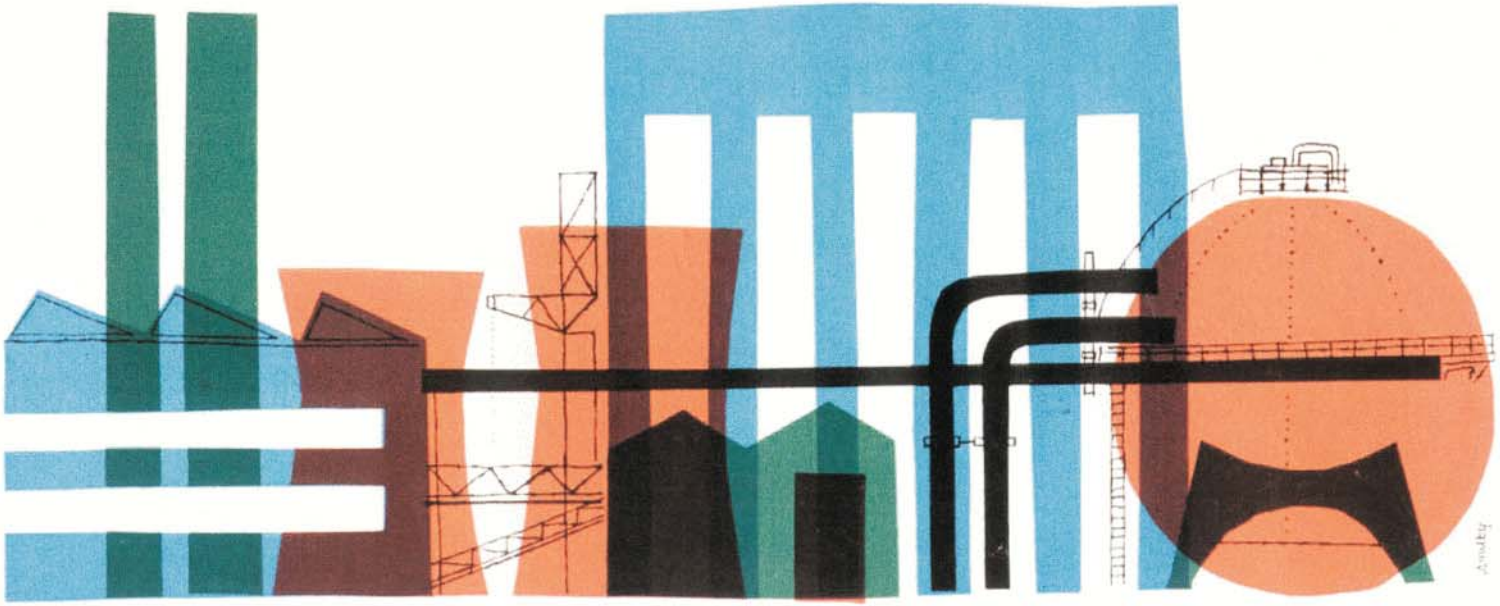
INTRODUCTION

Inexpensive. Efficient. Versatile. The 803 general purpose digital computer is all three. This is why so many people in science, industry, business, and commerce, not only in Britain but all over the world, have already found in the 803 the perfect answer to their particular problem.

On computer standards the 803 is undeniably very cheap. There are three good reasons for this surprising affordability. Small physical size. Mass production of the standard logic units. And the least tangible but most important factor of all—National-Elliott "know-how"

This also accounts of course, basically, for its amazing efficiency. The 803 is a fully automatic stored-programme electronic digital computer with a store of over 8,000 words, each equivalent to a 12 digit decimal number, and all immediately accessible. For capacity and speed it can be favourably compared with computers several times its price.

Versatility? This derives from the wide range of ancillary equipment which enables the 803 to be adapted to all kinds of applications in all kinds of fields. To give you some small idea of this versatility let us consider a few of the many different functions the 803 can perform in science, industry, business, and commerce.



INDUSTRY

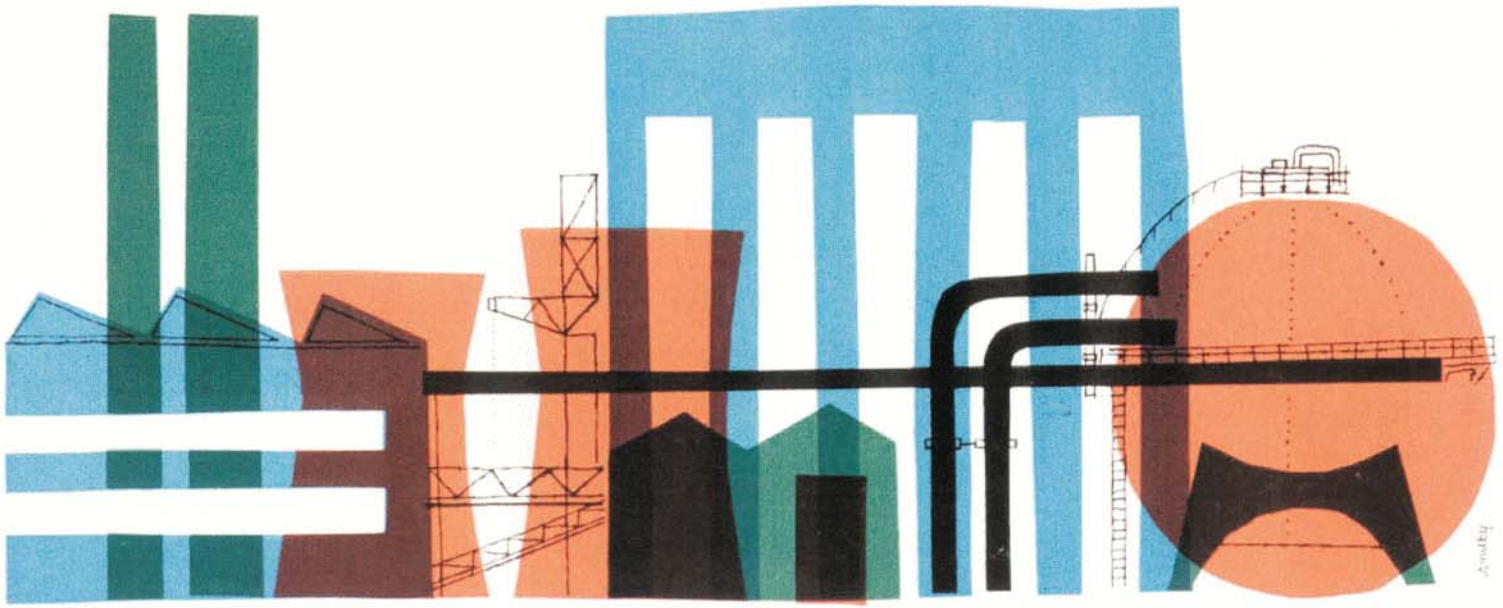
PLANNING AND PRODUCTION

Traditionally, advanced mechanisation techniques were developed in order to increase the efficiency or productivity of industrial processes. One might imagine, therefore, that automatic computing techniques would have fairly widespread use in industry. The truth is, however, that only with the introduction of the 803 has any marked advance towards full automation become economically feasible. There are several reasons for this.

For one thing, the nature of many industrial processes is such that the demands on reliability are extremely high and can only be met by the 803.

Furthermore, these processes often entail the performance of a number of concurrent operations; the design of the 803 has been specially chosen with this requirement in view. Process control information systems based on the 803 include a wide range of commutator switches and analogue-to-digital converters, together with other special purpose peripheral and terminal equipment.

On the planning and administrative side of industrial production, many data-processing problems demand much flexibility in the organisation of the system, whether the processing is done manually or automatically. The 803 has all the flexibility, plus much more, to suit it to this type of application. Peripheral equipment is so easily installed that one system can readily be changed to another as circumstances dictate.



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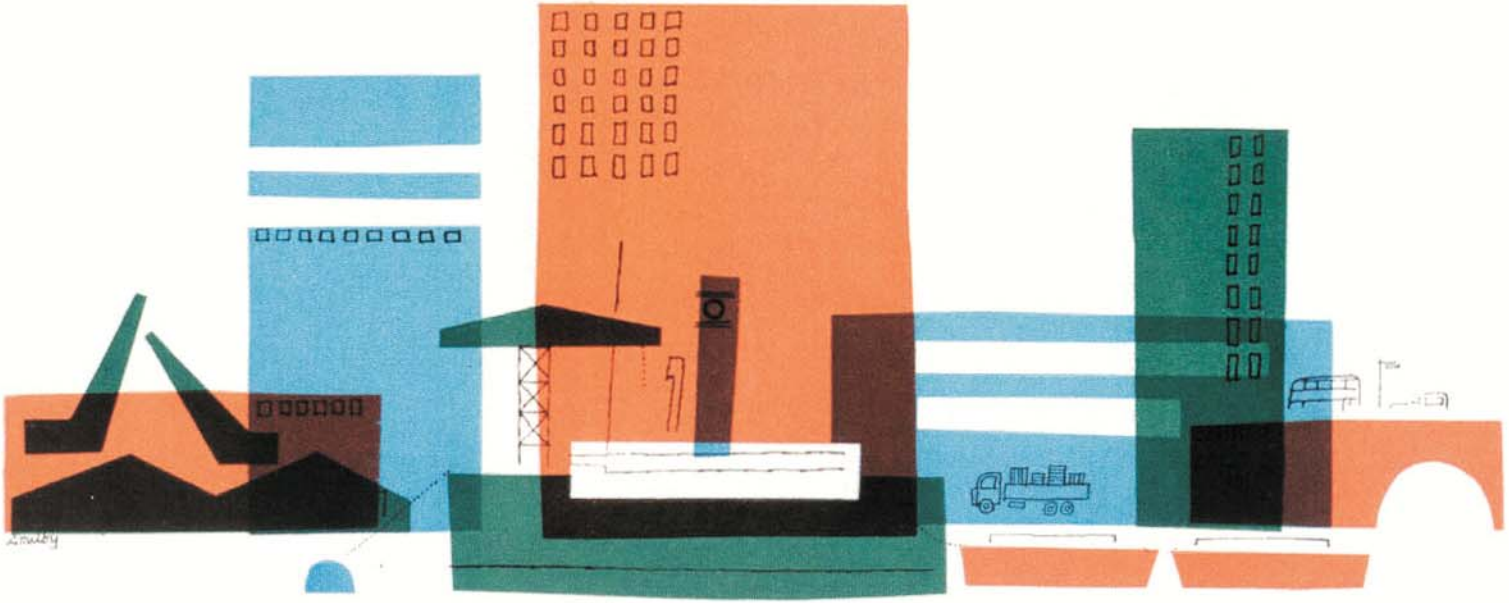
BUSINESS

FINANCE AND ADMINISTRATION

The characteristics that make it so attractive a proposition to mathematicians and engineers—its versatility, simplicity of operation, its low-cost and inherent reliability—are equally important to the businessman. Indeed, in much the same way that the laboratory computer speeds development and aids research, the 803 in the office strides its way through paper-work routines and, at the same time, provides a most efficient means of obtaining the kind of information so essential to creative management.

By the variations of its peripherals—card or tape readers, card or tape punches, information files and output printers—the 803 is adaptable to the measured requirements of any situation. In a large and complex organisation, separate branches or departments can be individually equipped with machines exactly suited to their actual needs. In others, the 803 can be operated as a single-machine installation serving all needs from a central point.



COMMERCE

MARKETING AND DISTRIBUTION

Analysis is the key to successful marketing and all that that involves. Analysis of sales, carried out with actuarial logic, answers questions far beyond "Who bought what?—and how much?" It also tells you *why*; not only in respect of single products but product groups and entire brands. And, moreover, it senses trends—away from and towards—*before* they gather force; in time for creative action.

In product planning and launching too, the 803 computes the way as only computers can. On the basis of things known—data assembled from experience, market researches and pilot trials—scientific analysis will appraise the product, predict its appeal and suggest the way to sell it.

With an unlimited number of locations available for the dissection of data under selected headings (or composite groupings), 803 is ideal for extraction of significant information—quickly, accurately and automatically, in accordance with *any* need.

FEATURES OF THE 803

SEVEN GOOD REASONS

The advantages of the 803 compared with other computers on the market are almost as manifold as its range of possible applications. The following seven, however, seem to us to be the most important ones.

SURPRISINGLY AFFORDABLE

Nobody expects an article of this nature to be downright cheap. Indeed, a six-figure sum is by no means an unusual price to pay for a good quality digital computer. The price of the 803, however, will give you a very pleasant surprise.

A basic machine with paper tape input and output costs only £29,000 including installation, supply of library programmes, and six months' free maintenance.

SIMPLE TO USE

In any general purpose computer, a programme of instructions must be prepared, coded, and fed in, before the machine is ready to solve any particular problem. The 803 library programmes are adaptable to all routine tasks, and the 803 Autocode Programme makes the compiling of a master routine, and incorporating standard sub-routines both easy and straightforward.

Operation of the 803 is equally simple. Only a few keys are required in addition to the number generator. This, combined with careful logical design, makes the 803 virtually foolproof.

OUTSTANDINGLY DEPENDABLE

Solid-state components which are used throughout the 803 ensure far greater reliability than the now out-dated valves.

With a valve computer it was necessary to maintain a strict regular schedule of checking and testing. Because of the greater reliability of transistors and magnetic cores, this routine maintenance has now been eliminated.

EASILY EXTENDABLE

The 803 is specially designed so that the system can be extended at any later date. There is a wide range of ancillary equipment which can be added to the basic 803 system as new and diversified applications arise, and as the volume of work expands with increasing productivity.

The range of equipment includes punched paper tape readers and punches, punched card readers and punches, magnetic film backing stores, an automatic floating-point arithmetic unit, and a direct input/output typewriter. Many applications, particularly in the process control field, require specialised input and output devices, and provision has been made in the design of the 803 to allow the simultaneous operation of several such devices. Analogue-to-digital converters and commutator switching systems are used in the ISI 609—another product of the Elliott-Automation Group.

SIMPLE TO INSTALL

The main cabinet of the superbly styled 803 system weighs only 500 lb. It measures 5 ft. 6 in. by 1 ft. 4 in. and is only 4 ft. 8 in. high. So you can see that for a computer the 803 is remarkably compact and will take up a surprisingly small amount of office, laboratory or factory space. Floors need not be specially strengthened and no additional ventilation or temperature control is required.

SURPRISINGLY FAST

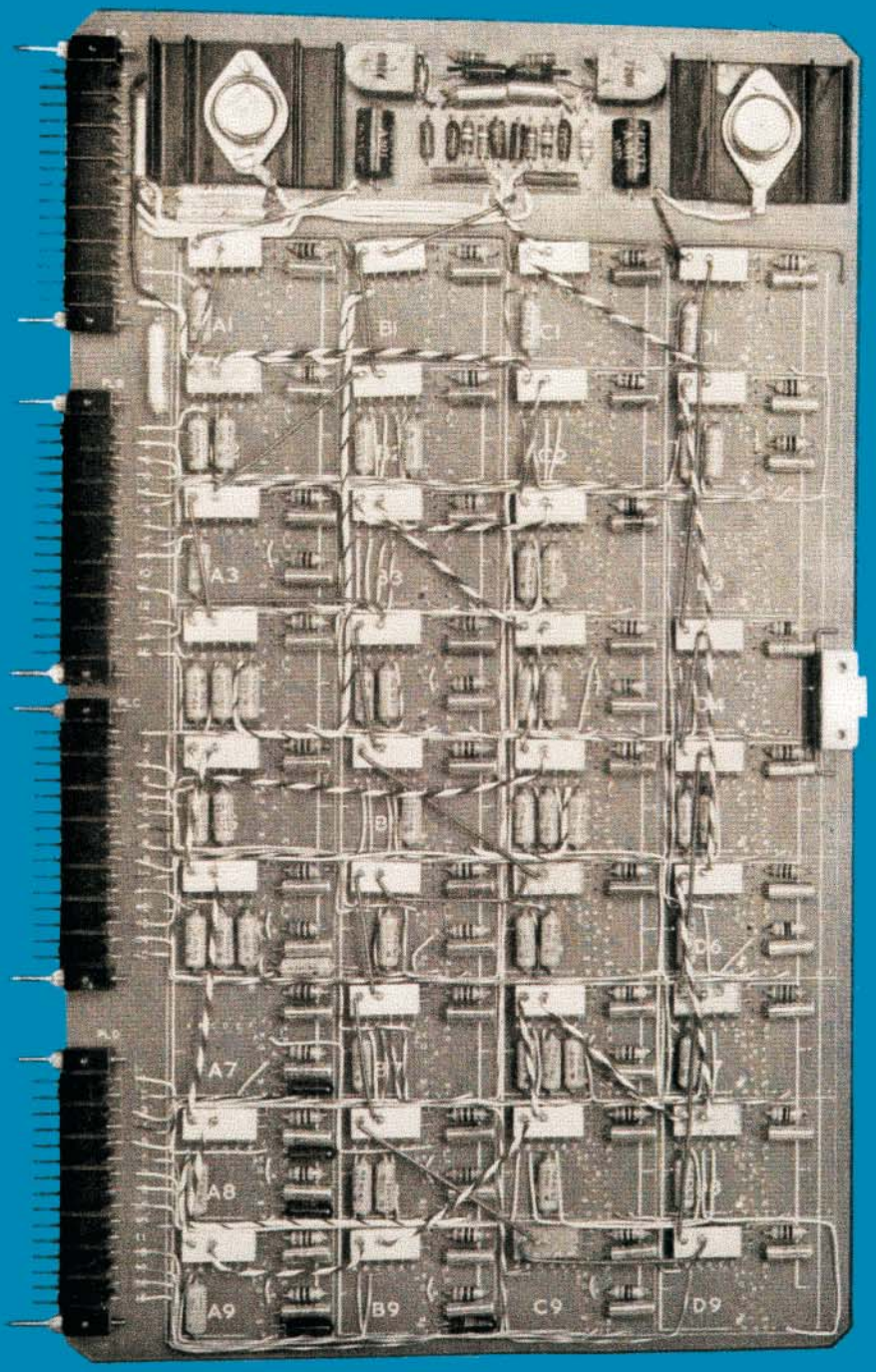
The 803 is a stored-programme machine which operates from a single-level fast access store, from which all data and instructions are available as soon as they are required, wherever they are situated in the store. Thus minimum access coding is not necessary and the computer is always working at full speed. The simple and flexible machine instruction code makes provision for a great deal of multiple data transfer operations: wasted time is cut to an absolute minimum.

EASILY MAINTAINABLE

There is no need to employ special staff to look after the 803. Elliotts operate a comprehensive maintenance service which provides for quarterly routine visits, replacement of any components which might become defective, provision of spare mechanisms for peripheral equipment, and emergency visits if necessary.

The annual cost of this service is only about 2½ per cent of the initial cost of the 803, and is free for the first six months after installation.

The logic boards of the 803 are simply constructed, using semi-conductor elements and magnetic cores.



803 SPECIFICATION

BASIC COMPUTER CONSTRUCTION

The complete computer, comprising arithmetic and control logic and store, is housed in a single steel cabinet measuring 66 in. long by 16 in. deep by 56 in. high (168 cm. by 41 cm. by 144 cm.) and weighing less than 500 lb (230 kg).

A second cabinet of half this length contains the battery power supplies, and is connected to the main cabinet by a cable which may be up to 5 ft. (152 cm.) long.

The operator's keyboard is mounted on a steel pedestal desk generally sited adjacent to the paper tape station, which is specially built to carry tape readers and tape punches, as well as a paper tape reproducer. The local control equipment for these units is built into the paper tape station, which is connected to the computer cabinet by a cable of maximum length 25 feet (762 cm.).

The entire system is provided with fully automatic temperature control, permitting operation under any ambient conditions of temperature from 50°F. to 110°F. (10°C. to 43°C.).

INPUT AND OUTPUT

5-track paper tape reading, punching and reproducing facilities are embodied in a paper tape station, which includes all necessary power supplies, control equipment, and local manual control switches.

The Elliott tape reader provides input speeds up to 500 characters a second. The Teletype punch produces tape at a maximum of 100 characters a second.

Two alternative designs of paper tape station are available. Type 1 includes one paper tape input/output channel, and measures 80 in. long by 30 in. wide (203 cm. by 76 cm.). Type 2 includes two channels.

OPERATORS CONTROL

Two alternative designs of keyboard may be used to control the 803. In the standard design used in the basic machine, the word generator section operates directly in the binary mode, and contains 39 push-button switches corresponding to the 39 bits of the 803 word.

The other design incorporates a decimal word generator having 13 columns of push-button switches, complete with decimal-to-binary conversion facilities, but is in all other respects the same. Data set on the word generator may be read into the 803 either by programme or by use of other manual controls.

The keyboard stands on a desk measuring 60 in. long by 30 in. wide (152 cm. by 76 cm.), and is connected to the computer by a cable of maximum length 20 ft. (610 cm.).

STORAGE

The single-level immediate access magnetic core store has a maximum capacity of 8,192 words, each comprising 39 bits. The first four locations are reserved for fixed initial instructions.

A 4,096-word store is normally fitted, but other capacities can be provided for special applications.

NUMBER REPRESENTATION

Numbers in the 803 are held in binary form, ranging from -1 to $(1 - 2^{-38})$, negative numbers being represented by their twos complement.

The Elliott tape reader

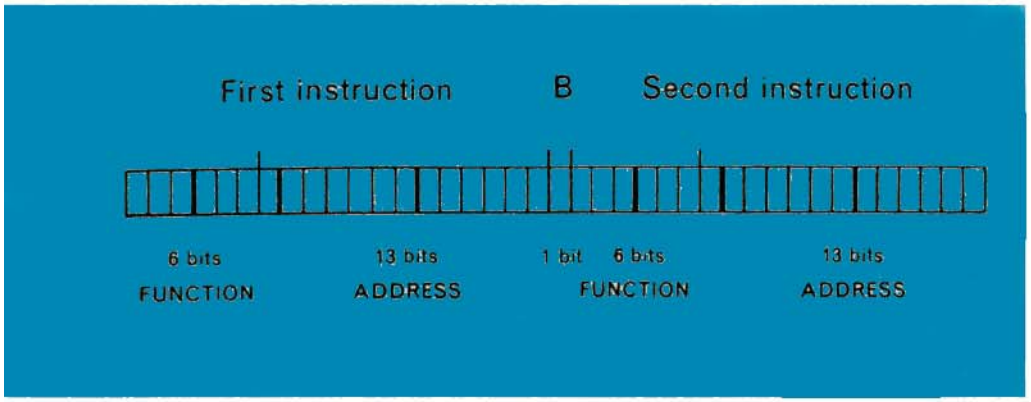
The binary keyboard

WORD LENGTH AND TIME

39-bit words circulate in the serial portions of the 803 in a time of 0·288 milliseconds. The digit time is 0·006 milliseconds.

INSTRUCTIONS

There are two single-address instructions in each word, arranged as follows:



Most functions operate on the contents of the single accumulator and the storage location specified by the address. There are sixty-four distinct functions, in eight groups of 8. Instructions are obeyed sequentially unless a control transfer instruction is encountered.

INDEX REGISTERS

Any location in the store may be used to hold a modifier. When the modifier bit B is present, the content of the location specified in the address part of the first instruction, is added to the second before it is obeyed. This operation takes no extra time.

OPERATING SPEEDS AND METHOD OF OPERATION

One word is read from the store or written in to it in parallel, the time taken being one digit period, i.e. 0·006 milliseconds. The logic is serial and is designed to work as a two-beat system.

In one beat an instruction is transferred from the store to an Instruction Register, where it is decoded, and in the other beat the specified operand is transferred from the store through the Function Unit to the destination specified in the instruction; this may be the accumulator, or the same storage location. Facilities in the form of an Auxiliary Register are also provided, for double-length working in multiplication and division. There is an Overflow Indicator which is set if the result of any arithmetical operation exceeds the capacity of the accumulator.

In the second beat the count in the Sequence Control Register is transferred to the Instruction Register for decoding, unless a control transfer instruction causes the sequence to be changed.

ERROR DETECTION

All transfers from the store are automatically checked by means of a stored parity digit, and any error is indicated by a lamp on the keyboard. The code used to represent numerical information on punched paper tape for input to, and output from, the computer, includes a parity check.

In the peripheral equipment of an 803 system, protection against malfunction due to functional or programme inconsistencies, or due to operational mishandling, is entirely automatic.

In the first two cases, the 803 is caused to stop, and must be started again by manual intervention, and in the third case, further action is specified by programme.

POWER REQUIREMENTS

The 803 contains an internal battery power supply, but in normal conditions this is maintained from the mains. A 240 volt single-phase supply of 50 cycles per second is normally used, but adaptations to suit other supplies can be made, by special arrangement.

The power consumption of the basic machine is only 3·6 kVA.

In the event of a mains failure, the 803 can be made to operate for sometime before switching itself off.

ANCILLARY EQUIPMENT

FLOATING POINT ARITHMETIC UNIT

This is an optional extension to the arithmetic unit of the basic computer, and is located in the main cabinet. Its use enables floating-point arithmetical operations to be performed automatically, without special sub-routines, thus cutting the running time for such work and greatly simplifying the programming required.

Floating-point numbers are held to an accuracy of 30 binary bits, and range from about 10^{-76} to 10^{+76}.

Instructions, shown in the detailed Instruction Code, take from 3 word times for the short operations, to 34 in certain division operations.

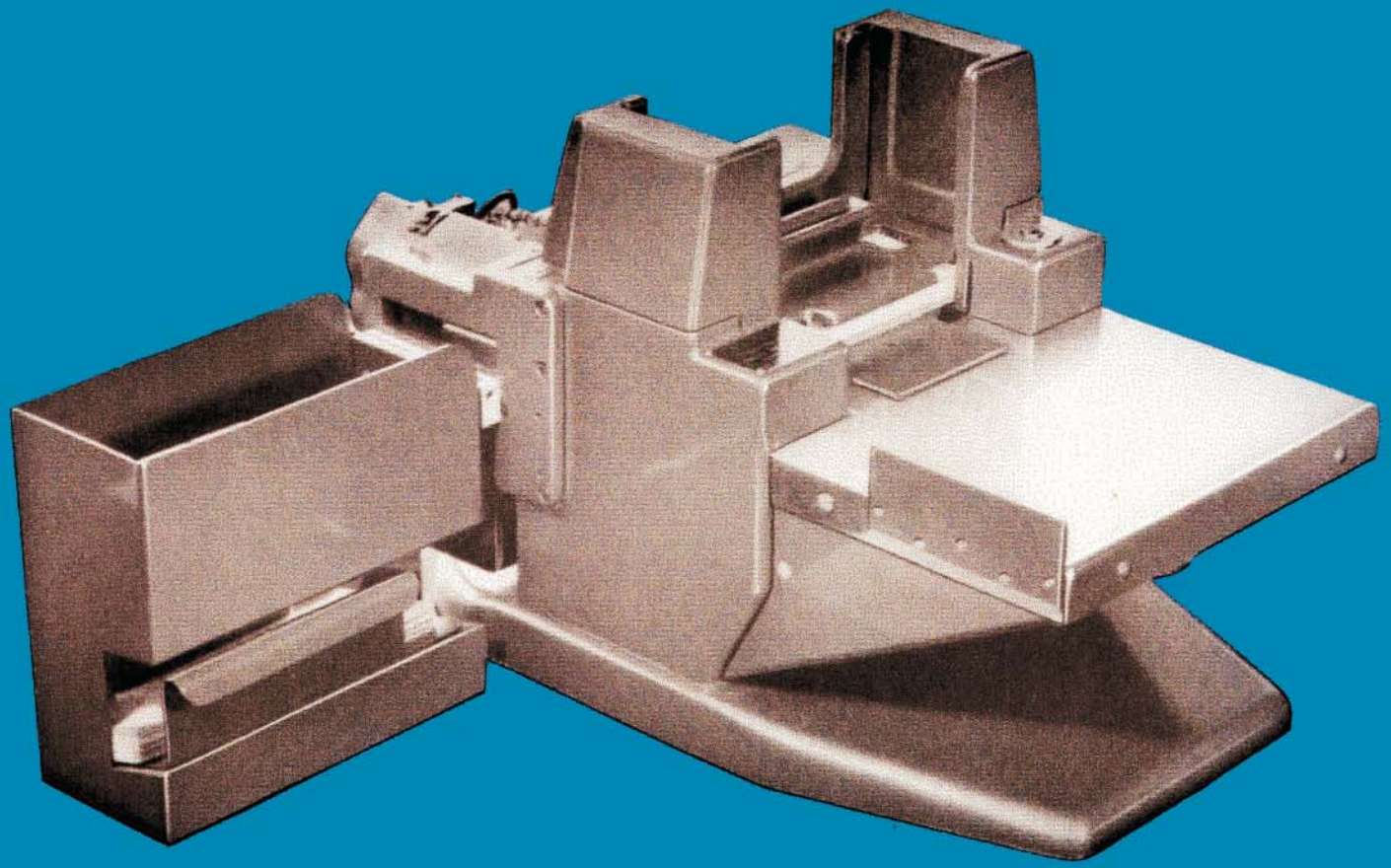
All results are rounded so that no bias is introduced and a maximum error of 2^{-29} may be present in the mantissa of any result. If both operands and the result of a floating-point operation are capable of exact representation as floating-point numbers, then the 803 will produce the correct result. Any result which exceeds the permissible range causes the 803 to stop.

PUNCHED CARD INPUT

The Elliott Card Reader was specially designed as a computer input device, and may be included in 803 systems required to work with existing punched card installations. 80-column cards of IBM or Hollerith form are read at speeds up to 265 cards a minute. For certain applications a set of reference marks have to be printed on the cards before they are used in the reader.

The card reader is mounted on a table measuring 48 in. long by 30 in. wide (122 cm. by 76 cm.), which contains the associated electronic control equipment. The connecting cable to the computer may be up to 30 ft. long (915 cm.).

In reading each card, a preparative instruction is first used to test a control word held in the card input unit, to ensure the correct conditions for reading obtain. A following executive instruction initiates the transfer of data from each of the 80 columns into 80 consecutive locations in the 803 store. Each column is stored both as a 12-bit transcription of the card punching and as a 6-bit translation of this, the 12 most significant bits of each stored word representing the 12 rows of the column, from Y through 0 to 9.



The Elliott card reader

PUNCHED CARD OUTPUT

Where punched card output is required from an 803 computer, equipment for driving a Card Punch may be added. This mechanism operates at a maximum output of 100 cards a minute.

MAGNETIC FILM FILE STORE

The large volume storage system used with the 803 uses 35 mm. magnetic film in 1,000 ft. reels. Each reel has a capacity of 4,096 blocks of 64 words each. The block transfer rate is just under 5 a second.

A system comprises a controller, contained in a cabinet measuring 33 in. by 16 in. (84 cm. by 41 cm.) and 56 in. (144 cm.) high, and 2, 3 or 4 film handlers, each of which measures 27 in. by 32 in. (69 cm. by 81 cm.) and also stands 56 in. (144 cm.) high. The controller connecting cable to the 803 may be up to 30 ft. long (915 cm.). Plug and socket connections between handlers and the controller allow spare mechanisms to be attached easily and quickly. Films are completely interchangeable between handlers.

The 64-word blocks of data are stored sequentially in alternate permanently numbered block locations, addresses 0 to 2047 running from beginning to end, and addresses from 2048 to 4095 being interleaved between them from the end back to the beginning. Every block address and every word of data stored include a parity bit for checking.

Data are recorded on seven parallel tracks, and two further tracks carry block marker and film clock recordings. The time taken to traverse each block is about 103 milliseconds, the film speed being about 27·4 in. a second and block length 2·81 in.

Transfers to or from the 803 working store are monitored by the use of a control word, held in the controller, by which means a malfunction may be detected and corrected before the process continues. A control word is associated with each handler.

Four operations are available to the programmer—reading, writing, searching for a specified block and transfer of the address of the last block read or written. Full details are given in the Instruction Code, from which it will be seen that a pair of instructions—a preparative and an executive—are required to complete a reading, writing or searching operation. The preparative instruction allows the appropriate control word to be tested to ensure that the correct conditions obtain before the specified operation is carried out, and to select the required handler. The executive instruction initiates the transfer of data to or from 64 consecutive locations in the 803 working store, or if a search has been specified, initiates the search.

DIRECT INPUT/OUTPUT TYPEWRITER

A typewriter providing direct keyboard input and direct output page printing is under development, and will be available late in 1961, mounted in a new model of the Paper Tape Station.

EXTRA WORKING STORE

The 4,096-word store normally fitted in the 803 may be extended by the addition of a further 4,096-word store, making a total capacity of 8,192 locations available for immediate access by all appropriate instructions.

The extra working store is located in a half-size cabinet 56 in. high (144 cm.) occupying an area of 33 in. by 16 in. (84 cm. by 41 cm.). It is sited adjacent to the main cabinet.

803 INSTRUCTION CODE

803 is a two-beat machine, alternately extracting and obeying instructions held in the store in sequential manner, unless diverted by instructions to transfer control to some specified location in the store, whence a new sequence begins. A conventional Instruction Register and a Sequence Control Register are provided for this purpose.

The arithmetic unit contains a function unit which is controlled by signals derived from the decoded function part of the instructions read from the store, and an Accumulator which initially holds one of the two operands involved. There is also a 38-bit Auxiliary Register (AR) which is used in conjunction with the accumulator for double-length working.

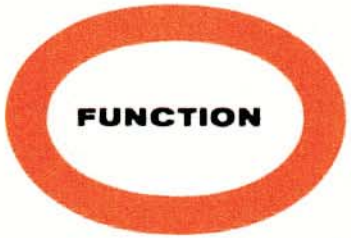
The word time in the 803 is 0·288 milliseconds, and each instruction requires one word time to enter the Instruction Register. Decoding and execution then follow in one or more further word times, except for the control transfer instructions, which are obeyed immediately.

The 64 functions are divided into eight groups of eight. The first four groups consist of eight basic functions, the result of which can be placed in either the accumulator or the store, the destination not so used having the old content of the accumulator or the store placed in it.

Group 4 consists of control transfer instructions, Group 5 of multiplication, division and shift instructions, and Group 7 of Input/Output instructions. Group 6 is spare in the basic machine, but is used by the automatic floating-point unit for floating-point operations.

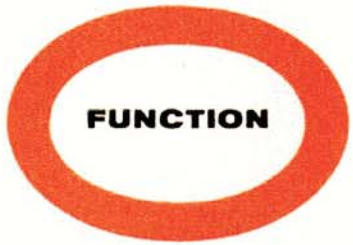
In the Table of Instructions which follows overleaf the initial contents of the accumulator and the storage location specified are denoted by **a** and **n** respectively.

The table shows the contents of accumulator and store after the instruction has been obeyed. Where the accumulator and/or the store are not specifically mentioned they remain unchanged.



Instructions in groups 0 to 3 operate in two word times.

GROUP 0	Do nothing	00	**a**	**n**
	Negate	01	**−a**	**n**
	Replace and count	02	**n** + 1	**n**
	Collate	03	**a & n**	**n**
	Add	04	**a + n**	**n**
	Subtract	05	**a − n**	**n**
	Clear	06	0	**n**
	Negate and add	07	**n − a**	**n**
GROUP 1	Exchange	10	**n**	**a**
	Exchange and negate	11	**−n**	**a**
	Exchange and count	12	**n** + 1	**a**
	Write and collate	13	**a & n**	**a**
	Write and add	14	**a + n**	**a**
	Write and subtract	15	**a − n**	**a**
	Write and clear	16	0	**a**
	Write, negate and add	17	**n − a**	**a**

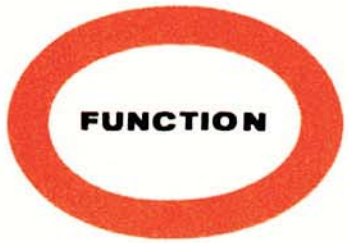


GROUP 2			
Write	20	a	a
Write negatively	21	a	−a
Count in store	22	a	n + 1
Collate in store	23	a	a & n
Add into store	24	a	a + n
Negate store and add to store	25	a	a − n
Clear store	26	a	0
Subtract from store	27	a	n − a
GROUP 3			
Replace	30	n	n
Replace and negate store	31	n	−n
Replace and count in store	32	n	n + 1
Replace and collate in store	33	n	a & n
Replace and add into store	34	n	a + n
Replace, negate store and add	35	n	a − n
Replace and clear store	36	n	0
Replace and subtract from store	37	n	n − a

GROUP 4

There are four types of control transfer instruction by means of which control can be transferred to any of the 16,384 possible instruction positions in the store.

Functions 40-43 transfer control to the first instruction of the word specified by the address, and functions 44-47 transfer control to the second instruction of the word specified by the address. Note that if control is transferred to the second instruction of a word, any B-digit in that word will be ignored. A B-digit will also be ignored if the first instruction of the word containing it is a control transfer instruction.



Instructions in Group 4 operate in one word time

Transfer control unconditionally	40	44
Transfer control only if the contents of the accumulator are negative	41	45
Transfer control only if the contents of the accumulator are zero	42	46
Transfer control only if the overflow indicator is set up, and clear the overflow indicator	43	47

GROUP 5

Doubling and halving instructions are specified by the seven least significant digits, N, of the address portion of the instruction. Double length shift instructions operate on numbers whose more significant part is contained in the accumulator and whose less significant part is contained in the auxiliary register.

Instructions in Group 5 operate in a maximum of 129 word times. Doubling or Halving 0 places does not affect the content of the accumulator. Note that the AR is cleared after instructions 51, 53, 55 and 56.
In 52 and 53 instructions, duration is determined by the magnitude of the multiplier, and y represents the number of consecutive ones or zeros at the most significant end.

GROUP 5 cont

OPERATION	FUNCTION	TIME TAKEN
Halve N times double length	50 N	(N + 2) word times
Shift down N places single length logically, i.e. do not regenerate the sign digit. Also clear AR	51 N	(N + 2) word times
Multiply **a** by **n** leaving double length answer in accumulator and AR	52 N	(42 —y) word times
Multiply **a** by **n** single length, with round off. Also clear AR	53 N	(43 —y) word times
Double N times, double length	54 N	(N + 2) word times
Double N times, single length. Also clear AR	55 N	(N + 2) word times
Divide double length number in accumulator and AR by **n** and leave single length answer in accumulator. Also clear AR	56 N	42 word times
Place contents of AR (38 digits) in digits 1-38 of accumulator making the sign digit zero. The contents of the AR are not altered	57	2 word times

GROUP 6

In an 803 without a floating-point arithmetic unit, Group 6 instructions have no effect, save to cause a two word time delay in the progress of a computation. Where a floating-point arithmetic unit is fitted, the interpretation is as follows:

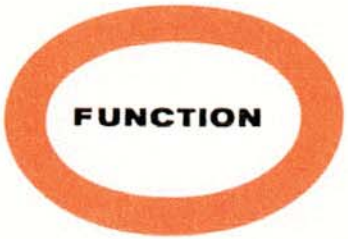
OPERATION	FUNCTION	ADDRESS	TIME TAKEN
Add **n** to **a**	60	N	3 word times
Subtract **n** from **a**	61	N	3 word times
Negate **a** and add **n**	62	N	3 word times
Multiply **a** by **n**	63	N	17 word times
Divide **a** by **n**	64	N	34 word times
Convert the 39-digit *integer* in the accumulator to			

Functions 66 and 67 are not used.

In machines used in the ISI 609 system, function 65 is used with address numbers less than 4,096 for fast shift operations, and 66 and 67 for short division and square root operations.

devices. The usage of functions 71, 74, 75, 76 and 77 is determined by the address part of the preceding 76 instruction.

Function 72 is only used in the ISI 609 system.



The paper tape input and output mechanisms have busy line connections to the 803.

OPERATION	FUNCTION	ADDRESS	TIME TAKEN
Read number from keyboard to accumulator	70		2 word times
Write address of the present instruction into the store	73	N	2 word times
PAPER TAPE INPUT			
Read 6 bits from tape reader 1 and mix into accumulator	71	0	2 word times
Read 6 bits from tape reader 2 and mix into accumulator	71	2048	2 word times
DIRECT INPUT			
Read from direct input typewriter	71	4096	—
PAPER TAPE OUTPUT			
Output 6 least significant bits of address number N to tape punch 1	74	N	2 word times
Output 6 least significant bits of address number N to tape punch 2	74	2048 + N	2 word times
DIRECT OUTPUT			
Print from 6 least significant bits of address number N on direct output typewriter	74	4096 + N	—
PUNCHED CARD INPUT			
Place control word in accumulator and prepare to read a card	76	512	3 word times
Read a card into location N to N + 79	77	N	Externally controlled
MAGNETIC FILM FILE STORE			
Transfer to accumulator address of last block read or written	75	1027	2 word times
Place handler H control word in accumulator; prepare to read a block from handler H	76	for H1 1024	3 word times
	76	for H2 1032	3 word times
	76	for H3 1040	3 word times
	76	for H4 1048	3 word times
Place handler H control word in accumulator; prepare to write a block on handler H	76	for H1 1025	3 word times
	76	for H2 1033	3 word times
	76	for H3 1041	3 word times
	76	for H4 1049	3 word times
Place handler H control word in accumulator; prepare to search on handler H	76	for H1 1026	3 word times
	76	for H2 1034	3 word times
	76	for H3 1042	3 word times
	76	for H4 1050	3 word times
Read a block into locations N to N + 63. Write a block from locations N to N + 63. Search for block N, so that it may subsequently be read or written.	77	N	Externally controlled