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International Computers Limited

THE COMPUTER HISTORY MUSEUM



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From 9th July 1968 for any reference in printed literature to International Computers and Tabulators Limited or I.C.T.

Please read

International Computers Limited or ICL

Registered Office:
ICL House, Putney, London SW15
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ICL

I.C.T. 1900 Series

On-line document handling

As we continue to devise yet more complex machines and yet more ways of using them, we encounter correspondingly more complex problems in man/machine communication. Up to now this communication has employed media which introduce time-wasting, expensive and error-prone stages in the flow of information. The computer's capacity for work has grown, as a consequence its demands for data — collected and expressed in a medium that the system can accept — have grown in proportion.

Data preparation at best is a slow business. With the increased processing speeds the time devoted to data preparation, and the costs involved, are becoming out of all proportion to the costs of running an installation. I.C.T.'s design engineers are working on several approaches to this problem. One solution which they have achieved is the Universal Document Transport fitted with either an optical reader, a mark reader or both.

Why on-line document handling?

In a commercial environment the amount of data handling is large compared with the amount of computation. The last decade has seen great advances in the sophistication of processing capabilities. The increased ability of computers to store, retrieve and handle large amounts of data, has forced the ever-present problem of data input preparation to grow with it. In early systems, conventional manual data preparation could keep pace with the rate of processing. Faster processing speeds, multi-programming techniques and operating systems, which give ever more efficient computer utilisation, have all highlighted the importance of fast and error free data collection. Where large amounts of data have to be prepared, speed and reliability are of paramount importance. Ordinary methods of data collection present acute cost and personnel problems. Punching cards or paper tape introduces a risk of error into the system, the solution to this — manually verifying each hole punched

— is yet another costly and time consuming process.

To obtain a more efficient method for data input, two basic demands have to be satisfied:

devices are needed which can reliably read characters or marks from source documents;

a document transport mechanism is needed which will feed commercially sized documents past a reading station (or stations) and then, under on-line computer control, deposit them into selected output stackers.

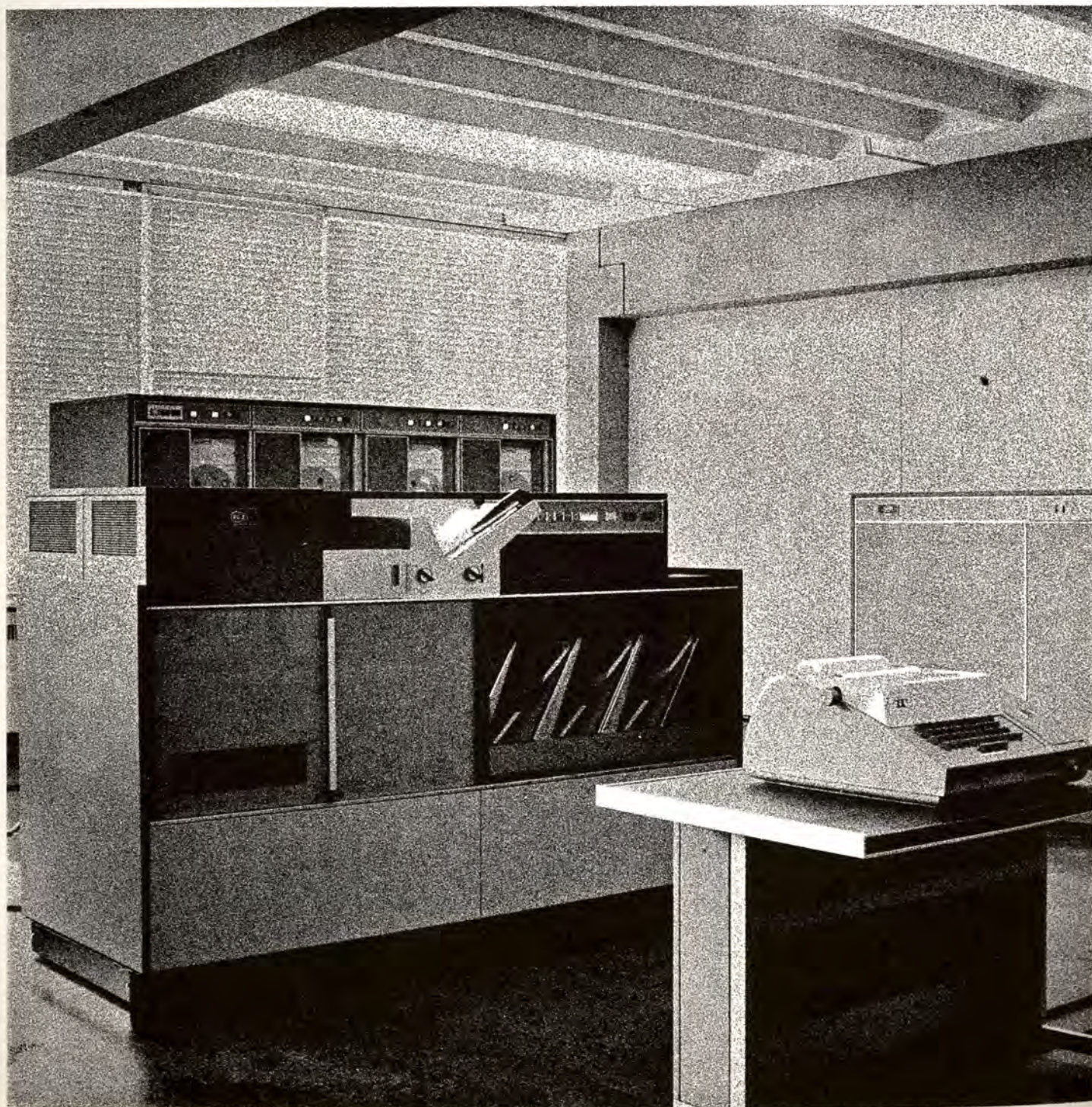
With such a machine it would be possible to read data from original documents directly into the computer system, bypassing conventional methods of data preparation. Above all the reader would have to be accurate and reliable; if these requirements were not met, the advantages of direct entry into the system would be lost. I.C.T. has made a detailed study of the mechanical, electronic and logical

designs for such a transport/reading machine. Moreover I.C.T. has conducted extensive market studies so that the equipment benefits from a total systems approach rather than the narrower requirements of any one specialised application.

With this approach the designer has chosen characteristics that maximise flexibility, reduce rejects, and stop errors entering the data processing system. The diagrams overleaf show how the design features of the I.C.T. Universal Document Transport were chosen after detailed investigations of data processing system requirements.

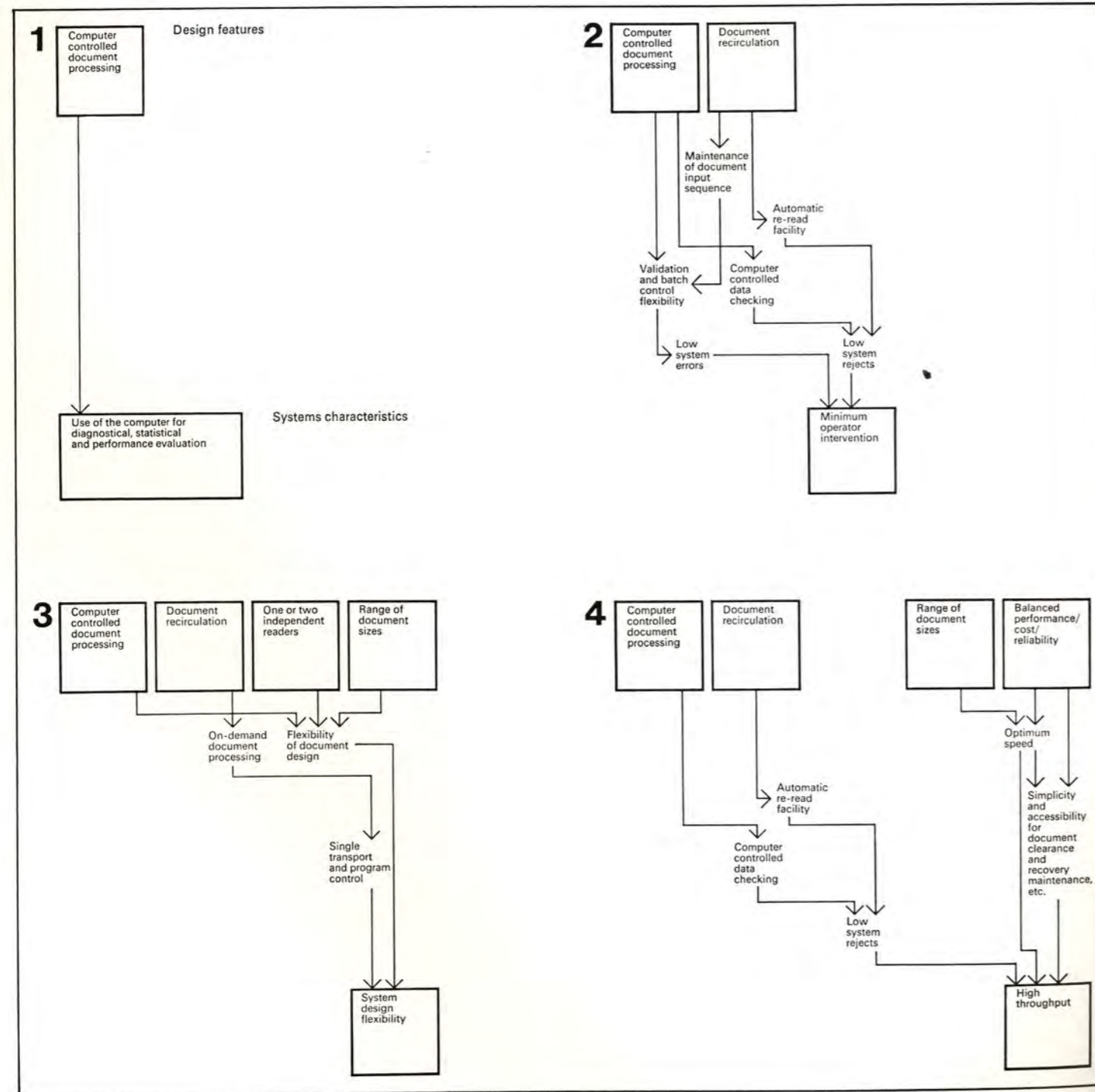
The numeric reader has already been proved. The alpha-numeric enhancement is in an advanced stage of development.

Under computer control, information from original commercially sized documents can be read directly into a 1900 Series computer with accuracy and reliability. With this directness the Universal Document Transport saves time and reduces costs.

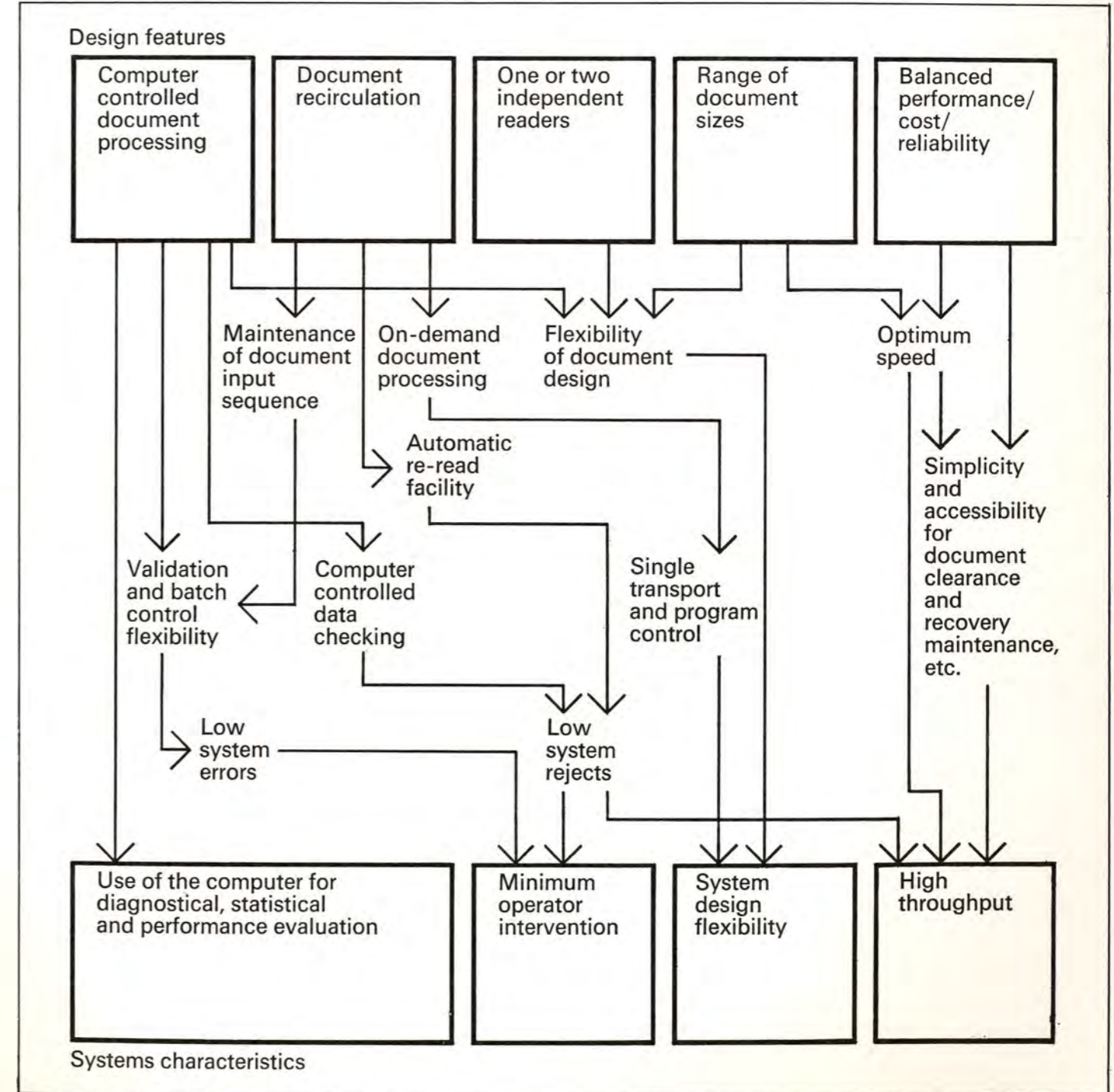


Left: The Universal Document Transport on-line to a 1900 Series computer.

The research team responsible for the Universal Document Transport began their design effort by analysing the needs of document recirculation systems. The results of this analysis, allied with the control specifications for a truly on-line document reader created the final specifications for the document transport.



Design features and systems characteristics – already closely dependent – formed the premises for a well-argued specification that meets the requirements of all on-line mark and optical character recognition systems.



Optical character reading

Research has been devoted to bypassing the costly manual translation of alphabetic and numeric data printed on documents to computer codes — allowing the computer to read printed data. The numeric reader is now ready and work on the alpha-numeric enhancement is nearing completion.

The prospective user who does not intend to have an OCR reader even for some years will do well to start his planning for the reader now.

OCR can transform his whole data processing system; if his new system is based on 'turnaround' documents, OCR may influence his form design, the preparation of all internal reports, and even his house style. Certainly he will need to start planning a matching set of data capture devices now. These may be ledger posting machines and even typewriters: anything, in fact, which provides material he might one day wish his computer to read. In deciding to adopt OCR the choice of font is very important.

Font requirements

The principal requirements of any character recognition system are that the characters should be machine readable, easily acceptable to the human eye, and easily produced. A full set of alpha-numeric characters must also be available.

The ECMA 'B' character set was designed with these requirements in mind. It was necessary that all the characters in the set should be highly distinguishable from each other so that reading machines could recognise them reliably. Other important design aims were that the character set should be conventional in appearance, so that it could be used in all printing devices, whether or not they are employed in reading machine applications.

It was also important that printing devices could be easily produced in economic quantities.

Development of ECMA 'B' Font

In 1962 the European Computer Manufacturers Association set up a committee to study the standardisation requirements of optical character recognition, and agree a standard. They decided that any font to be designed should (a) not be specific to a particular class of reading system (b) be designed from the outset as a full alpha-numeric character set and (c) be designed in such a way that differences between characters were maximised. It is easy to see how the straight line design of earlier OCR fonts would immediately violate these aims.

Reading machines designed to read the complete alpha-numeric set must

have a high resolution and must be capable of detecting fine details of the printed characters, in order to distinguish the diverse shapes of a full repertoire. The ECMA committee therefore devised a method of measuring the degree of difference between characters, basing their work on the premise that the character identifying information is associated only with the shape of the strokes and not at all with their width.

Although the derivation of the method involves a mathematical analysis its practical application is quite straightforward. To compare one character with another, a new pattern is derived from each character printed slightly wider than normal but with stroke centre line shapes unchanged. Each derived pattern is then superimposed on every other pattern in the repertoire in such a position that it conceals as much of the other as possible. A suitable function of the overlapping areas is used to measure the distinction of the characters.

This process must be carried out for every character pair in the set. A computer program was written to evaluate the results.

A succession of progressively improved character sets was designed by assessing a set, finding the most critical pairs in it, modifying the characters involved to increase their

A grid of characters from the ECMA 'B' font, arranged in seven rows. The first row contains uppercase letters A-H and lowercase letters a-h. The second row contains uppercase letters I-P and lowercase letters i-p. The third row contains uppercase letters Q-X and lowercase letters q-x. The fourth row contains uppercase letters Y-Z, symbols *+, , - . /, lowercase letters y-z, and symbols m, ð, ø, æ. The fifth row contains numerals 0-7, symbols £, \$, :, ;, <, %, >, ?. The sixth row contains numerals 8-9, symbols [@ ! # & ,] ^ ~ v. The seventh row contains symbols (=) " ' \ ^ ~ v, and symbols Æ, Ø, ↑, ≤, ≥, ×, ÷, °, α.

differences and reassessing the set. Eventually no further improvement could be achieved, since by improving one character pair another would be made worse. This process was first carried out by the engineers concerned in the work to satisfy themselves that such an evolutionary process was practicable. When it became clear that it was possible to design characters with more distinguishing features than in any existing font, a professional designer, skilled in the traditions and practice of typography was engaged to repeat the entire process from the beginning. All the final characters were therefore created by the font designer who skilfully satisfied the recognition requirements as checked by a computer without unduly sacrificing their aesthetic appearance.

Above: The complete ECMA 'B' font with numerals and symbols. The I.C.T. version is a subset of this.

What is the Universal Document Transport?

The I.C.T. Universal Document Transport with OCR and/or OMR heads is a computer-controlled input device for reading data held on a wide variety of original documents directly into any 1900 Series computer. At present data may be in the form of marks in defined areas of a document, or in chosen characters in ECMA 'B' font. The full alpha-numeric enhancement will also be in ECMA 'B' when available. Several Universal Document Transports can be connected to any central processor in the 1900 Series via the I.C.T. Standard Interface.

Transport capacity and speeds

The Universal Document Transport handles documents in two size ranges: small documents (classified as being between 5.5 inches long by 3 inches wide and 8 inches long by 6 inches wide) and large documents (13 inches long by 8.5 inches wide as a maximum). Small and large documents are read at rates of 300 and 150 documents a minute respectively. Different sized documents within a certain range can be mixed.

Before the reading sequence is started the operator adjusts controls to indicate the size range of the documents to be handled and the form in which the data is recorded. Once this is done, and the transport put on-line, documents are automatically fed past the reading heads and collected in the computer-specified output stackers of the machine. The standard machine has three output stackers, but up to twelve output stackers can be specified in groups of three.

Transport mechanism

The documents (roughly aligned) are placed in the feed hopper, with the printed face uppermost. It is possible to intermix documents of different sizes provided that differences do not exceed 1 inch in the length and $\frac{1}{4}$ inch in the width. A vacuum drum draws a single document off the bottom of the stack and passes it on to the tracking unit, which aligns it accurately

and carries it to the read drum. A check is made for double documents and late or early feeding. If one of these conditions is detected, the document is diverted on to the mechanical reject tray and the feed stops. This operation ensures that documents which have been fed incorrectly are not read into the computer system.

Once accepted, the document passes on to the reading drum, where it is held, by vacuum applied to a series of grooves around the drum's surface, and circulated past the reading heads. The drum's dimensions permit four short or two long documents to be held simultaneously. Reading heads sense the data on the document and transmit it to the central processor. Each reading head is attached to the computer by a separate Standard Interface channel so allowing characters and marks to be read simultaneously. In response to a signal from the central processor the document is released from the drum and directed into the appropriate stacker. If no signal is received, the document remains on the drum and the hopper feed is suspended until such a signal is received.

This is particularly useful when using the reader 'on-demand' in a direct-access environment, as data will never be lost, and the sequence of the documents is always preserved.

A reject stacker is provided to receive any documents that fail to enter one of the output stackers. If a document enters the reject stacker, the feed stops.

To the I.C.T. Universal Document Transport it is possible to fit the following reading devices:

- 8201/1 Optical Character Reader
 - 8301/1 Optical Mark Reader
 - 8201/8301 Dual Optical Character and Mark Reader.
- For later release:
8201/2 Optical Character Reader

8201/1-2 Optical character reader

The optical character reader is designed to read characters printed in the ECMA 'B' font. Characters can be printed by high-speed line printers, typewriters, encoders or embossed plates. The reader consists of two units (a) the camera which is mounted on the Universal Document Transport and (b) a free-standing Recognition Unit.

The reading head is adjustable over the full width of a maximum sized document (8 inches) and reading speeds of up to 550 characters per second are possible. When the full alpha-numeric enhancement becomes available a wide range of characters of the ECMA 'B' font will be read. These can be either size I or II at a pitch of either 8 or 10 to the inch. Size and pitch can be chosen by program instructions.

The character line can consist of up to 4 fields each up to 6.3 inches in length. Characters to the left or right of the character line can be ignored by the reader. The characters in any one field must be of a constant pitch and of the same size.

Optical print quality monitor (optional)

The optical print quality monitor is designed to check the quality of printed characters presented to the reader, so maintaining the highest system performance. The optical print quality monitor measures paper whiteness and blemishes, and the dimensions, density and quality of print characters against parameters set up beforehand. Original samples of print are placed in the holder, with the character for inspection in the alignment aperture. The appropriate scale is selected manually. The character is then scanned by a light source and a magnified image of the character is displayed on a cathode ray tube, where it may be checked against a graticule engraved with the maximum/minimum outline for the character.

The optical print quality monitor is used in the system to ensure that print specification standards are maintained and to check any rejected characters. Should the reject percentage become high the optical print quality monitor can be used to determine the nature of the fault being encountered.

8301/1 Optical mark reader

The optical mark reader can identify marks made by hand, embossed plates, output printers or letterpress machines, in specified positions on a document. As many as 23 data columns plus a 'clock' column can be disposed across a document, with up to 60 rows on a 13-inch document. When required, the mark reader can be set to identify holes punched in cards; in effect the reader detects the non-reflecting black surface of the drum visible through each hole. Both holes and marks can be identified on the same pass.

A 'bit' is transmitted to the central processor for each mark identified, being routed to a particular bit position in the computer word. The inter-

pretation of mark significance is performed by computer program.

When reading a mark, the reader transmits one of three signals to the computer. If a clearly defined mark is present, the reader transmits a 'mark' signal; if no mark is present, it transmits a 'no mark' signal; if the reader cannot clearly detect either of these conditions, it transmits an 'uncertain mark' signal as a bit in another computer word. In this way the computer program can assess the probability of a mark and act accordingly - for example, when accepting a date with the decade figure uncertain. This unique feature enables the peripheral to use the decision making power of the computer, with a significant reduction in reject rates.

8201/1-2/8301/1 - Dual optical readers

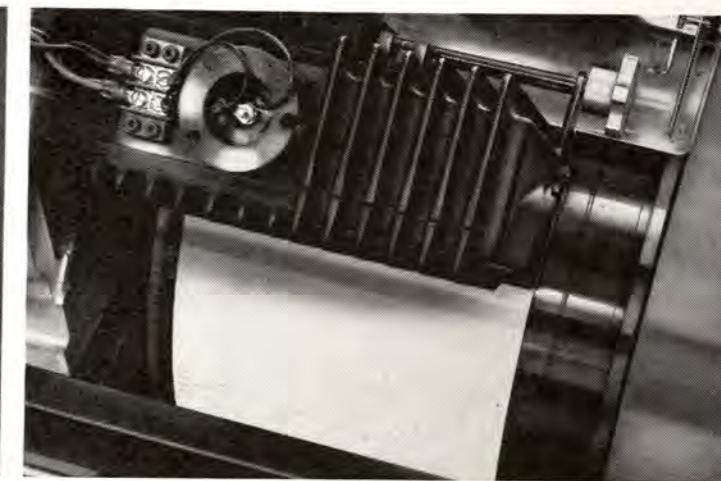
Both the optical character reader and the optical mark reader can be fitted to the Universal Document Transport. Each unit is attached to the central processor via a separate channel. This enables the units to operate separately or simultaneously.

Below left:

The optical print quality Monitor. Paper whiteness, paper blemishes, print dimensions, density and quality may all be checked with the print quality monitor. These are the qualities which determine the efficiency of an on-line document reading system

Below right:

Documents are fed to a drum, where they are held by a vacuum. The drum carries documents past the scanning station, and releases them to a stacker under processor control.



How does the user choose?

Manually transcribing records into a form acceptable to the computer is a costly process. Methods of speeding up the transcription have been described. The critical questions are: when is it economic to adopt automatic methods of data input, and what type of system can most benefit from the facilities offered?

There are three main areas of study to be considered (a) the generation of original documents (b) transcription and (c) input to the data processing system.

The decision to use automatic document handling machines and character or mark recognition in an information system will closely determine the way documents are designed for the system.

Form design is more critical in the case of optical mark reading than optical character reading. The adoption of the latter immediately influences the whole process of document preparation, and the machines involved. By using a suitable type font, data from normal office typewriters, and high-speed line printers can be fed directly into the computer. On-line document control provides scope and flexibility to the system designer and removes unnecessary constraints.

Plainly, there are certain systems characteristics that provide a suitable environment for automatic document handling. Such characteristics are: the maintenance of firm control over document preparation – without this control difficulties may arise in remote preparation of documents; the preparation of documents by the system itself – this offers possibilities of a 'turnaround' system.

If these, or similar, characteristics suggest the employment of automatic document reading techniques, the advantages offered must be weighed against the economic factors involved. There is no empirical formula for calculating the point at which automatic document reading becomes more economic than the methods it is replacing – the exact point depends upon the characteristics of the particular application. The primary factors affecting the economics of a given situation are:

- the volume of data input
- the accuracy of input
- operational demands.

Any one of these factors might well justify the introduction of automatic document reading, but in general it is a combination of these factors that influences the final decision.

Once this decision has been taken, the equipment to carry out the task must be assessed on grounds of reading speed, flexibility and reliability. Here again any one of these might be the deciding factor, but experience shows that it is more likely that it is the interplay of these factors that points to the selection of a particular device.

Because I.C.T. has designed the Universal Document Transport, not in isolation, but with a complete knowledge of systems requirements. This machine offers the best cost/performance ratio for a variety of applications. By taking into account the close relationship of cost with other design factors, I.C.T. has provided the most flexible and reliable system available.

Any device that is inflexible in operation immediately restricts its system usage. A wide range of reading devices can be attached to the Universal Document Transport. OCR, OMR or a combination of both to read simultaneously give the greatest possible systems flexibility.

Any device that is unreliable is plainly unacceptable in any system, no matter how tolerant – I.C.T. has laid great stress upon both transport and reading reliability.

Applications

Before specifying automatic document reading it is necessary to consider the principal areas of application, since these indicate the kind of reading device to be used, the kind of document to be handled, and to some extent the facilities to be looked for in the machine.

There are two major areas of application suitable for OCR techniques. These are:

'Turnaround' systems

Typical of these are public utility billing (gas, electricity, telephones and rates), insurance premium renewals and hire-purchase payments. The customer's bill can be prepared on a computer output printer. When the customer makes his payment he returns the bill. The returned bill is fed into the reader, which reads the amount paid and the account number into the computer, where the customer's account is updated. Special provision can be made for amending the amount on the bill if the customer pays an amount differing

from that originally printed. This may be done by hand marking. The Universal Document Transport fitted with both Optical and Mark Readers is especially suited for this application. This system provides staff economies and, because all print comes from the same source, gives a close control over print quality. An example of such a 'turnaround' document is shown.

Open-ended systems

In these systems data originates at many points remote from the computer centre. Normal postal services are used to send the data to the centre for processing. There are three major categories of such systems according to the number of outstations: Few outstations, where print quality can be controlled fairly easily. A typical application would be wholesale re-ordering from several regional distribution points to a central warehouse. Many outstations, where print quality control is more difficult but still practicable.

Many thousands of outstations where print quality control is impossible. Here mark reading is practical. Delivery van salesmen's returns, examination papers or census returns are good examples to this type of recording. An example of a traffic census used as an aid to planning the expansion of Stevenage is illustrated overleaf.

The future

Continuous research and development is being carried out by I.C.T. into optical character reading techniques. Speeds, reliability and flexibility are increasing. Multi-line optical character readers are under development. The 1900 Series concept of continuous enhancement enables the user to take advantage of new developments and at the same time protect his initial investment.

A typical 'turnaround' document, designed for both character and mark reading. The address and variable information will be printed by the computer in ECMA 'B' font. Meter readings are marked by the board's representative in the boxes provided. Once the form is complete it can be read into the computer, all numerical information checked (to ensure a correct record match) and the marked information added to the record (Based upon a meter reading sheet designed by the Eastern Gas Board and published with their kind permission.)

British GAS METER READING SHEET

MR. R. GIBBS. 41 3364 0040 SERIAL NO 8785

4 MANORWAY BUSH HILL PARK ENFIELD

2 YEARS COMPARATIVE CONSUMPTIONS				PREVIOUS READING			
730	540	350	400	0	0	0	0
790	54E	450	39N	1	1	1	1
				2	2	2	2
				3	3	3	3
				4	4	4	4
				5	5	5	5
				6	6	6	6
				7	7	7	7
				8	8	8	8
				9	9	9	9

PROPOSED ESTIMATE (00'S C. FT) 150

REAR IF READING NOT BETWEEN 6361 AND 6461

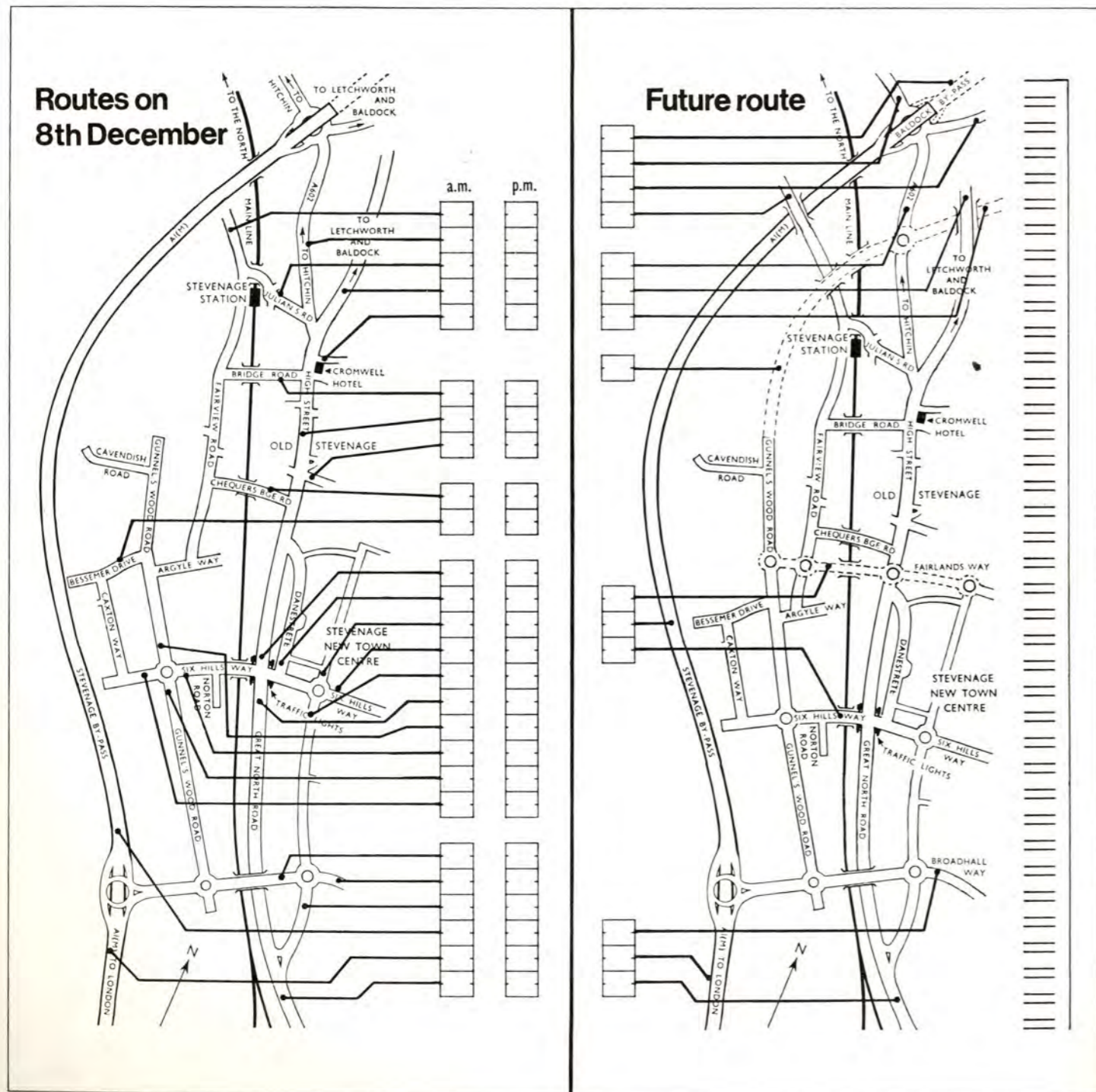
NO. INFO. REPORT READ LOW HIGH NORMAL

PLEASE DO NOT WRITE IN THIS SPACE

ROUTE INFORMATION

Mark sensed documents provide a simple and flexible media for data capture. These maps were used to collect information about traffic flows on the Stevenage industrial estate. People driving to work on the estate were asked to show their present route on the left-hand map and, on the right hand map, the route they would take when the new road was completed.

The completed forms were read by the Universal Document Transport, and the results used in proposing new plans for the expansion of Stevenage.



I.C.T.on-line document reading...the benefits

Direct input to the data processing system

The Universal Document Transport accepts and reads a wide variety of original documents – it eliminates error-prone data transcriptions from documents to punched cards and the consequent need for verification.

Accurate document reading

The method employed to read either characters or marks is the result of careful development and study of systems techniques.

On-demand processing

The document re-circulation feature, together with complete computer-controlled reading, enables the Universal Document Transport to be incorporated into a wide range of systems; both direct-access and batch processing techniques can take advantage of this facility.

Flexibility

The Universal Document Transport can read characters or marks recorded by a variety of different methods, on a wide range of document sizes. Characters and marks can be read simultaneously and a multi-line reader is under development.

Specifications

8101/1 Universal Document Transport

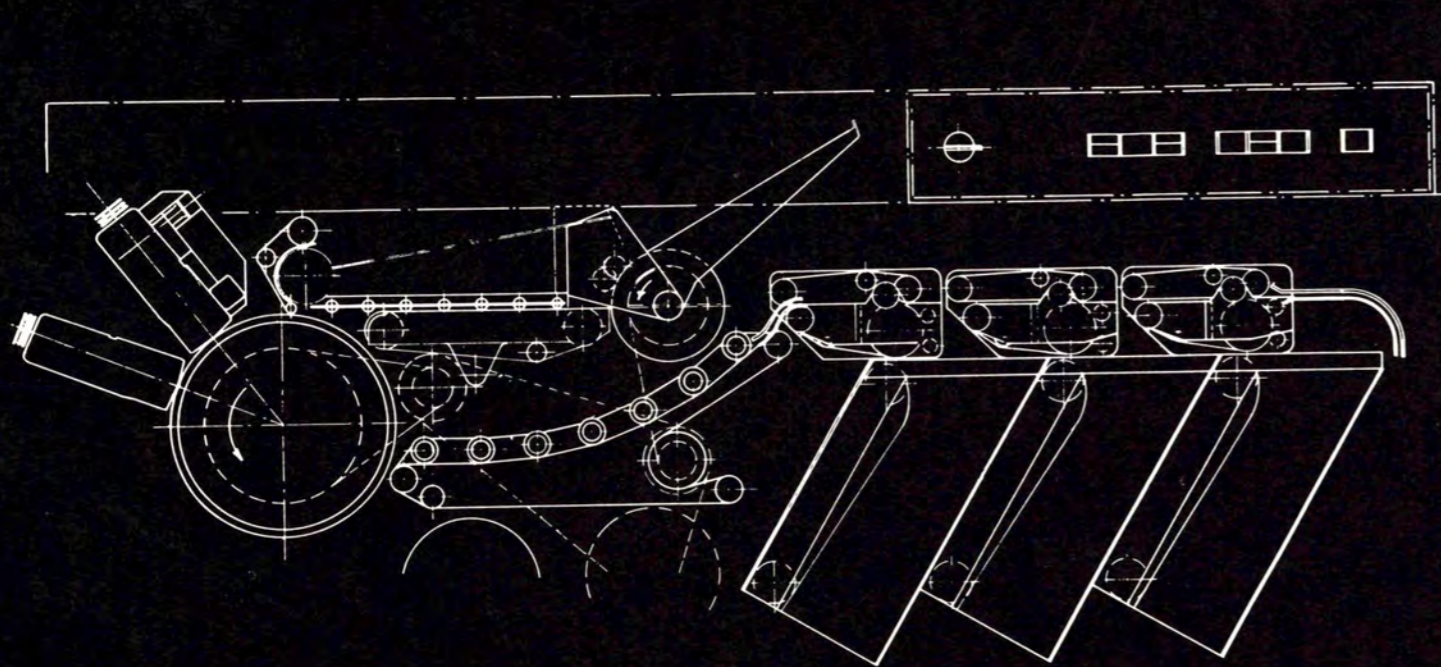
8201/1-2 Optical character reader

8301/1 Optical mark reader

8201/8301 Dual optical reader

Optical print quality monitor

Programming codes



8101/1 Universal document transport

Document feeding

Document feeding, once initiated by the operator, is automatic. As a document is despatched to the stackers so another document is fed to take its place on the drum. Document

sequence is maintained at all times. Intermixing of different sized documents within specified limits is permissible.

Reject tray

A reject tray is situated immediately ahead of the drum to prevent double documents or documents in transit at the wrong time, from reaching the

drum. Any further document fed before the feed is stopped is also directed to the reject tray.

Transport

Documents proceed from the hopper through the tracking sections to the reading drum. Jam detectors are placed along the transport:
between the feed unit and the tracking sections
in the reading area
in the transfer from drum to stacker

in the gate areas
in the ungated stacker
Upon detection of a jam the transport comes to rest and the feed stops. Documents are tracked to within a maximum of 0.02 inches of the datum edge at the reading area, to ensure that the document is correctly aligned.

Drum

Documents are fed on to the drum and held there by vacuum. The drum carries the documents past the reading stations and, if a stacker select instruction is given, releases them for

depositing into the appropriate stacker. Should the computer be busy and no stacker select instruction be given, the documents stay on the drum and are, in general, released one cycle later.

Stackers

The minimum version of the Universal Document Transport comprises three stackers but versions with six, nine and twelve stackers can be specified. Once the document is read and processed, the stacker into which it is routed is determined by program. Until a stacker select instruction is given

the document stays on the drum. A full stacker stops the feed. Provision is made for any documents for which no stacker gate is operated to be directed to the ungated stacker situated next to the end stacker; this action is indicated to the operator and the feed is stopped.

Character reading repertoire

Standard machines

Numeric

0 1 2 3 4 5 6 7 8 9 J N P V X Y Plus SPACE
(Plus 2 Alphabetic characters for pitch definition)

8201/8301 Dual optical reader The dual optical reader consists of a 8201/1-2 and 8301 attached to the Universal Document Transport. Each reader is attached to the central processor by a separate Standard Interface channel. Either reader can operate separately or both can operate simultaneously.

Optical print quality monitor Parameters that may be measured are:

Paper whiteness	} Absolute levels
Paper blemishes	
Print reflectance	
Image dimensions	} Appropriate levels on appropriate scales
Extraneous inking	
Voids	
Droop	

Physical dimensions

Optical print quality monitor	Height	14 inches
	Width	20½ inches
	Length	22½ inches
	Weight	45 pounds

Power supply unit	Height	11 inches
	Width	13 inches
	Length	17 inches
	Weight	35 pounds

Paper specification for the Universal Document Transport

		Minimum	Maximum
Small documents	Length	5.5 inches	8 inches
	Width	3.25 inches	6 inches
	Thickness	0.003 inches	0.005 inches
	Speed	300 or 150 documents a minute	
Large documents	Length	8 inches	13 inches
	Width	6 inches	8.5 inches
	Thickness	0.003 inches	0.005 inches
	Speed	150 documents a minute	

Paper specification (continued)

Grain	Short grain documents are preferred.
Smoothness and porosity	Smoothness 60 to 500 Bendsten Units
	Porosity 80 to 500 Bendsten Units
Stiffness	Long grain paper 1 to 4 Taber Units Short grain paper 1 to 2 Taber Units
Weight	Within the range 15 lbs. to 20 lbs. (60 to 80 g/m²).
Colour	For mark reading a minimum of 60% reflectance. This allows colour range of white to buff.

Programming codes Summary of applicable peripheral control orders

SUSBY - Suspend - reader is reading document	This instruction causes Executive to test if the reader is busy. If it is busy the program giving the order is suspended until such time as the reader is free; the program may then continue.
REL - Release reader from program	This instruction causes the reader to be released from the program and makes it available for allocation to that or any other program.
DIS - Disengage reader	This instruction causes the reader to be disengaged, so that it cannot be used for a subsequent transfer until the operator re-engages it by pressing the ALLOCATE button.
ALLOT - Assign and/or identify reader	This instruction requests allocation of the reader during the running of a program. This allows for more efficient use of peripherals as they need not be allotted to a program until they are required.
PERI - Activate reader	This instruction causes a program entry to Executive. Executive, dependent on the contents of the control area, initiates the reader action after checking that the reader is free.

This specification is subject to modification

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17/27 Garratt Lane, London, SW18. (01-874 7211)

Training Centres

Bradenham Manor, High Wycombe, Bucks. (Naphill 2191/2/3)

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Newlands House, 37/40 Berners Street, London, W1.

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Petersfield House, 29 Peter Street, Manchester, 2. (061-DEA 9511)

Television House, Peter Street, Manchester, 2. (061-DEA 8021)

Middlesbrough Lloyds Bank Chambers, Albert Road,
Middlesbrough. (2814)**Newcastle upon Tyne** Crestina House, Archbold Terrace,
Newcastle upon Tyne, 2. NE2 1DT. (814201)**Northampton** 13 Abington Square, Northampton. (38071)**Norwich** Castle House, 21 Davey Place, Norwich. NOR 38E.
(26132/3/4)**Nottingham** Bridgford House, Trent Bridge, Nottingham. (82011)**Oxford** Mayfield House, 256 Banbury Road, Summertown, Oxford.
(57364/5)**Preston** Crystal House, Birley Street, Preston. PR1 2DQ. (57927)**Sheffield** 54/56 Fargate, Sheffield, 1. S1 1LS. (27186/7/8/9)**Slough** 42/44 High Street, Slough. (22278)**Southampton** 18 Cumberland Place, Southampton. SO9 3AR. (24659)**Wolverhampton** Clarence House, Darlington Street,
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