Technical Description of the

XERONIC

Computer Output Printer

A product of
RANK PRECISION INDUSTRIES LIMITED
ELECTRONICS DEPT.

XERONIC

High Speed Computer Printer

I. D. BROTHERTON · *10 March 1960*

ELECTRONICS DEPARTMENT
RANK PRECISION INDUSTRIES LTD
SULGRAVE ROAD · HAMMERSMITH
LONDON · W·6

The XERONIC
High Speed Computer Printer

The Central Research Laboratories of Rank Precision Industries Ltd. became interested in the exploitation of the photo-electric technique of printing, known as Xerography, in 1956. At this time they were already studying means of solving the difficult problem of making a high speed printer without fast-moving mechanical parts and with great reliability, and the formation of their Associated Company within the Rank Organisation, Rank-XeroX Ltd., in conjunction with Haloid-XeroX Inc. of Rochester, New York, provided the answer to much of their problem. By the formation of this new Anglo-American Company the patent rights and " knowhow " in the use of Xerography held by Haloid-XeroX Inc. became available to Rank-XeroX Ltd., who now own the world rights outside North America.

The problem of the computer printer, which may be required to write several thousand lines of print per minute, can be divided into two parts, the first consisting of the decoding of the signals from the computer and the production of suitable symbols ready for printing, and the second part the printing itself. Xerography goes far in solving the second problem.

The process of Xerography used in the Xeronic printer depends on the photo-electric properties of amorphous selenium. A carefully prepared aluminium drum is coated, in vacuum, with a layer of amorphous selenium a few microns thick. This material has the property that in the dark it is an extremely good insulator and is capable of storing a charge induced on its surface for a considerable period. If the drum is then exposed to a light pattern the charge will rapidly leak away in those areas where it has been exposed to the light.

The Xeronic computer printer (Figure 1) has a slowly rotated selenium plated drum, which is charged uniformly to a surface voltage of about 600

volts by means of a corona discharge grid. The charged drum is then exposed to two light sources, the first being a pair of cathode ray tubes, on which variable printing from a computer is displayed, and the second being a form head, from which photographic copies of documents can be projected on to the selenium drum. Four forms can be selected by computer signals. Further development is being done to extend the number of documents from four to twenty.

The charge pattern on the selenium drum, corresponding to the optical image projected on to it from both the cathode ray tubes and the form head, is then developed by cascading over it an electrically charged powder. This powder consists of two types of particles, the first and largest being carrier beads of about 0.3mm in diameter. These beads are sufficiently heavy to roll freely over the surface of the drum and to circulate back into the developer chamber for re-use. The other particles in the powder consist of minute particles of dye, or toner, together with a thermo-setting plastic, a few microns in diameter.

The two components of the powder rub together in the developing equipment and are consequently charged electrically. The powder is then tumbled over the surface of the drum and the small particles of toner adhere to the drum surface by electrostatic force on the portions of the drum which have been exposed to light. As the drum rotates it comes into contact with a roll of plain paper for a time and the toner is transferred to the paper, being attracted to the paper away from the drum by means of an electrostatic charge placed behind the paper. The paper with the toner on it then passes underneath a fuser, which fuses the thermo-setting plastic of the toner and produces permanent printing on the paper. The paper

can then either be rolled up for subsequent cutting or can be passed through the cutting machine. A cutter, which cuts, slits and perforates is supplied with Xeronic.

Many methods of character generation were studied in the early days of the development of Xeronic. When all the relevant factors had been considered, a method was chosen whereby after decoding the computer signals, a pattern of dots is displayed on the surface of a conventional cathode ray tube. The pattern of dots is generated by means of passive circuits consisting mainly of resistances on printed boards, which gives the system great flexibility, as by changing printed boards, characters can be changed or additional characters can be added as required. The printer is normally made with 55 different characters, but up to 120 can be provided.

The Xeronic printer can be used in one of two ways. If it is being used with a medium sized computer, such as the Ferranti Pegasus, the English Electric Deuce, the Elliott 405, or computers of corresponding size, it will be used in the " off-line " condition (Figure 2). Under these circumstances the computer will write on to magnetic tape, a block at a time, checking that the block is correctly written. When a reel of tape has been completed by the computer, the Xeronic will read the tape, a block at a time, writing the block into its own ferrite core store, which will usually hold 512 or 1024 characters, although more character storage could be provided. Block length of up to 384 or 896 characters can be used with the 512 character or 1024 character stores respectively.

At this time the Xeronic will check the block, by means of parity bits, to ensure that the tape has been read correctly. If an error is detected the Xeronic will back the tape to the beginning of the document and read it a second time. From the core store, characters are passed one at a time into the decoder, which recognises them either as one of the characters requiring generation, or as orders.

In addition to character generation, the electronic circuitry of the Xeronic enables selection of the form to be carried out, and horizontal and vertical tabulation to be used. The production machine will be made in two versions. The first has a form head with 4 forms, which can be selected by the com-

puter in less than one-eighth of a second, and the second will allow up to 20 forms to be selected from the computer in a corresponding time. In both cases the appropriate signal is placed on the magnetic tape by the computer, the decoder recognises the order as a " form selection order " and the machine prints the form. Alternative sets of forms can be placed in the formhead manually.

Up to 16 positions may be selected vertically on any form for tabulation points. These vertical tabulation points are marked on the relevant photograph in the form head and are sensed by photo-electric cells as the form is printed. The Xeronic also includes a horizontal tabulation board, which enables any 16 of the 128 character positions to be selected as tabulation points.

In a typical case, a block might be read into the core store from magnetic tape. The first character on the block would be recognised by the decoder as a " form selection order " and would cause the correct form to be selected. The second group of characters to be received from the buffer store would again be recognised as orders to provide the correct horizontal and vertical tabulations to ensure that the first character was printed in the correct position on the form.

Form printing is prevented until photo-electrically sensed signals indicate that the beginning of the form is ready for printing, and character printing is inhibited until the form printing has reached the appropriate position. This means, in effect, that vertical registration is determined by the form head itself and is consequently very accurate.

The characters would then be written one at a time in appropriate spaces at the rate of 5,000 characters per second. The programme on the tape would then include the necessary spaces, characters and " line-feed carriage-return " signals, together with further horizontal and vertical tabulation signals to enable the rest of the form to be completed. The form head would also automatically print a mark, which could subsequently be sensed by the cutter supplied with Xeronic to enable the form to be cut off and stacked correctly.

A great deal of thought has been given in the design of the Xeronic to the checking of errors. The machine carries out checks on blocks of information being read from magnetic tape into the core store to ensure that this store is correctly filled and a lateral parity check is retained until after a character has been recognised by the decoder, and a signal sent along an individual wire into the character generator. After this point, should a component or connection fail, the character will only lose a small percentage of its legibility through the loss of one or two dots, or else it will fail to appear altogether, for example, if the cathode ray tube failed. To guard against the latter possibility the cathode ray tube is watched by a photo-cell, which causes an error symbol to be printed by an alternative light source if a character fails to appear on the face of the tube.

The machine can also be used in the " on-line " condition in conjunction with some of the new large computers which are being developed and put into production, such as the EMIDEC 2400, the Ferranti Orion and the A.E.I. 1010 computers. All of these computers have sufficient internal storage to enable Xeronic to work " on-line " without intermediate magnetic tape storage. The method of operation is similar to that in the " off-line " case, but the printer will not include its own core store, but will use that of the computer instead. A typical block diagram is shown in Figure 3.

The Laboratory prototype of the Xeronic was first exhibited in public at the Computer Exhibition at Olympia in London in November, 1958. This equipment printed sentences, which were stored on an S.T.C. magnetic tape deck, on to paper 13" wide, writing at the rate of 1,500 lines per minute. Since then the production engineering of the machine has been nearly completed and the equipment now writes at the rate of 3,000 lines per minute on paper 26" in width.

The production machine has two cathode ray tubes mounted side by side with common deflection wave forms, but with separate horizontal tabulation boards. By suitable combinations of tabulation points it is possible to write information either on both tubes at the same time or on one or the other. This enables documents to be made using the full 26" of paper, where the left hand half of the paper is either an exact copy of the right hand half or where certain information is omitted from either side. The

maximum paper width of 26″ allows a form or selection of forms up to 24″ in width to be printed.

The variable data from the two cathode ray tubes can be printed in two bands $11\frac{1}{2}$″ in width, with a $\frac{3}{4}$″ gap between them. Each of these $11\frac{1}{2}$″ bands can provide 128 character positions and at the full rate of printing of 3,000 lines per minute, 100 characters may be written into the 128 character positions.

There are facilities in the equipment whereby instead of two copies $11\frac{1}{2}$″ in width with up to 128 character positions per copy, by changing a lever in the machine 4 copies of $5\frac{3}{4}$″ in width, with 64 characters per copy, can be made. Registration is extremely good as the accuracy of the cathode ray tube deflecting system is such that each character is displayed in its nominal position with reference to the form within a tolerance of $\pm$ .05″ in the horizontal direction. In addition, the error in spacing between adjacent characters does not exceed $\pm$ .01″ per line. Each line is displayed in its nominal position within a tolerance of $\pm$ .02″ in the vertical direction.

The running costs of the machine are small, as plain unprinted paper is normally used, although under certain circumstances paper with a printed background may be used, or even pre-printed forms. Here, however, special arrangements have to be made for registration. The cost naturally depends on the type of paper used, but for normal business use the cost of paper and all Xerographic consumables is about 1d. per square foot.

The production of the Xeronic printer has now started and the first equipment is being supplied to Ferranti, for use with their new Orion computer, and will be supplied to them in November 1960. Another machine is being purchased by A.E.I. Ltd. for use with their 1010 computer and a third by E.M.I. Ltd. for use by the Ministry of Pensions with an EMIDEC 2400 computer.

SPECIFICATION

The Production machine will have the following Specification:—

SPEED	5,000 characters per second. 3,000 lines per minute, approximately.
OUTPUT (1)	Paper width up to 26″ wide. Print width 24″ maximum.
(2)	Microfilm copy if required.
CHARACTER POSITIONS PER LINE	2 copies of 128 character positions each or 4 copies of 64 character positions each.
QUALITY	High lithographic standard, on a wide variety of papers.
TYPES OF CHARACTER	55 alpha-numeric (up to 120 as an extra).
TABULATION	16 points can be selected on each form vertically. 16 points can be selected by means of a pre-plugged plug board horizontally.
SELECTIVE PRINT	Information can be suppressed on either or both copies.
FORM OVERLAY	Selection from 4. Up to 20 can be provided as an extra.
INPUT	The equipment can work in either the " on-line " condition with suitable computers, or in the " off-line " condition from magnetic tape. In the latter case it includes its own ferrite core store.
CUTTER	A cutter is provided with the equipment to automatically cut, slit and stack documents.

FIGURE 1

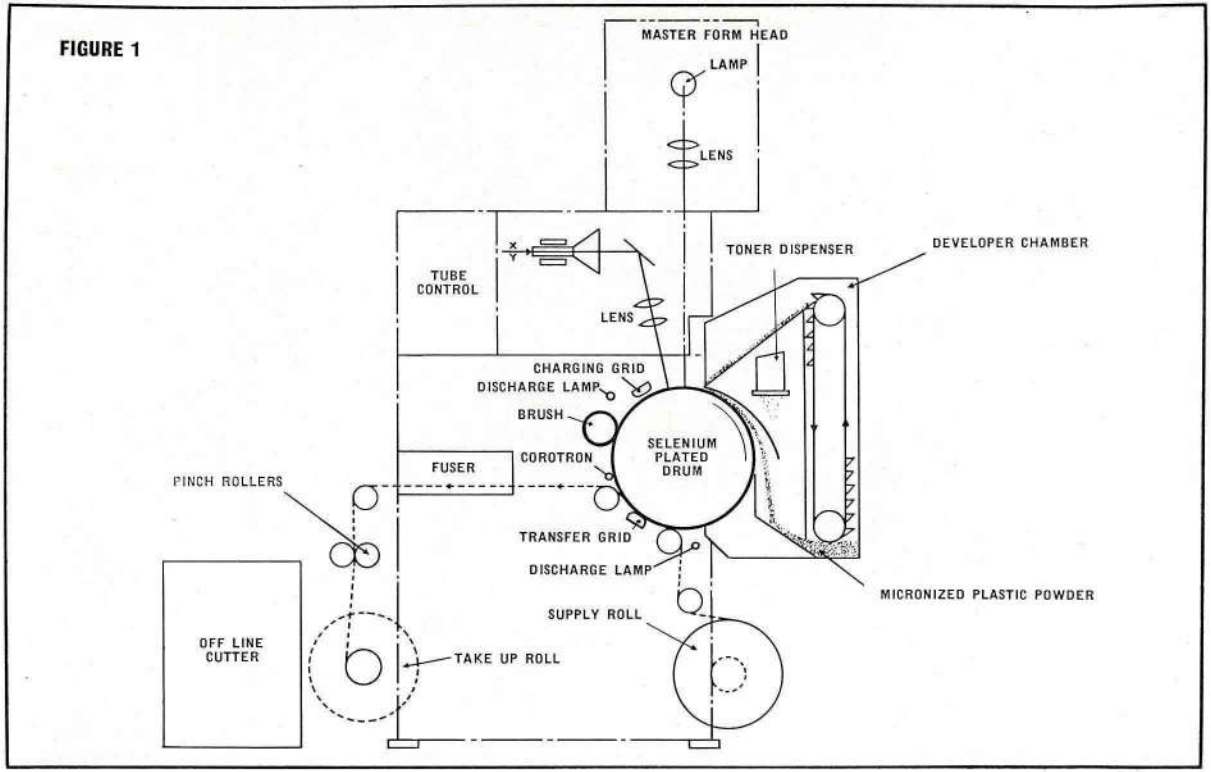

MASTER FORM HEAD
LAMP
LENS
TUBE CONTROL
LENS
TONER DISPENSER
DEVELOPER CHAMBER
CHARGING GRID
DISCHARGE LAMP
BRUSH
SELENIUM PLATED DRUM
FUSER
COROTRON
PINCH ROLLERS
TRANSFER GRID
DISCHARGE LAMP
MICRONIZED PLASTIC POWDER
SUPPLY ROLL
OFF LINE CUTTER
TAKE UP ROLL

FIGURE 2

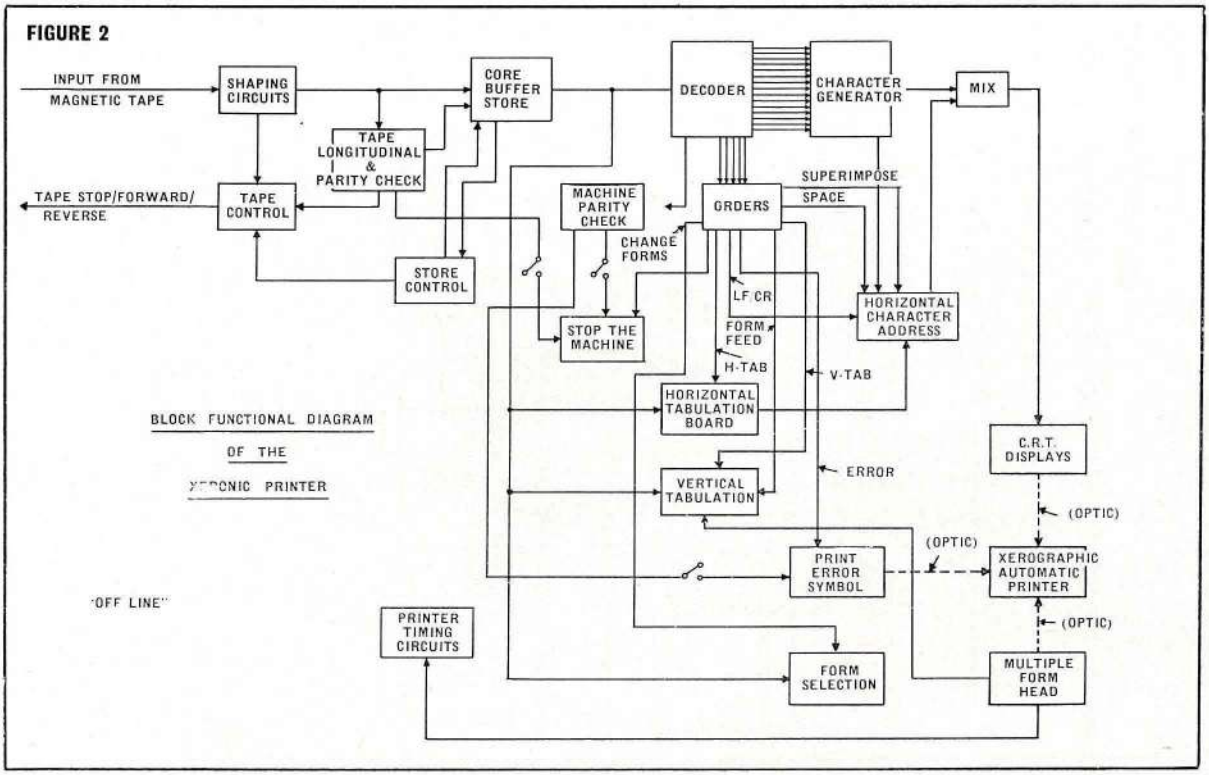
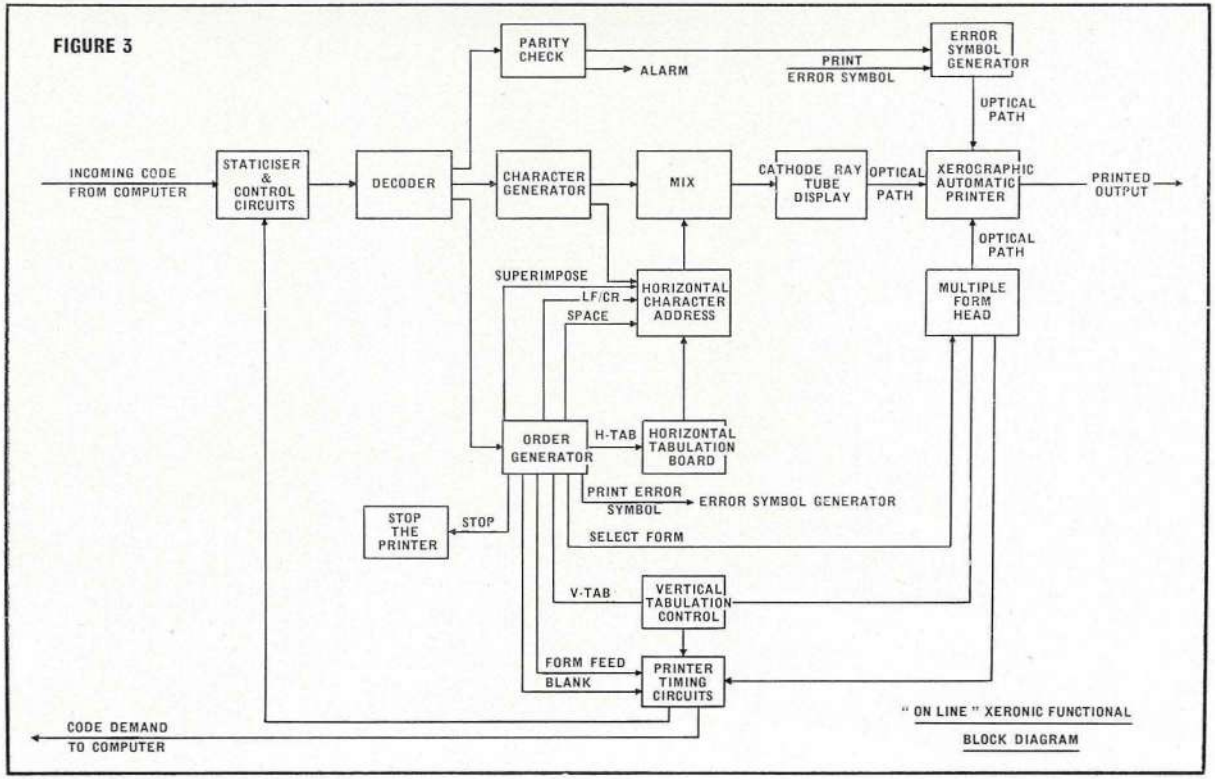

INPUT FROM MAGNETIC TAPE
SHAPING CIRCUITS
CORE BUFFER STORE
DECODER
CHARACTER GENERATOR
MIX
TAPE LONGITUDINAL & PARITY CHECK
TAPE STOP/FORWARD/ REVERSE
TAPE CONTROL
MACHINE PARITY CHECK
ORDERS
SUPERIMPOSE
SPACE
CHANGE FORMS
STORE CONTROL
LF CR
FORM FEED
H-TAB
V-TAB
HORIZONTAL CHARACTER ADDRESS
STOP THE MACHINE
HORIZONTAL TABULATION BOARD
C.R.T. DISPLAYS
VERTICAL TABULATION
ERROR
(OPTIC)
PRINT ERROR SYMBOL
XEROGRAPHIC AUTOMATIC PRINTER
"OFF LINE"
PRINTER TIMING CIRCUITS
FORM SELECTION
MULTIPLE FORM HEAD
BLOCK FUNCTIONAL DIAGRAM
OF THE
XERONIC PRINTER

FIGURE 3


PARITY CHECK
ALARM
PRINT ERROR SYMBOL
ERROR SYMBOL GENERATOR
OPTICAL PATH
INCOMING CODE FROM COMPUTER
STATICISER & CONTROL CIRCUITS
DECODER
CHARACTER GENERATOR
MIX
CATHODE RAY TUBE DISPLAY
OPTICAL PATH
XEROGRAPHIC AUTOMATIC PRINTER
PRINTED OUTPUT
OPTICAL PATH
SUPERIMPOSE
LF/CR
SPACE
HORIZONTAL CHARACTER ADDRESS
MULTIPLE FORM HEAD
ORDER GENERATOR
H-TAB
HORIZONTAL TABULATION BOARD
PRINT ERROR SYMBOL
ERROR SYMBOL GENERATOR
STOP THE PRINTER
STOP
SELECT FORM
V-TAB
VERTICAL TABULATION CONTROL
FORM FEED
BLANK
PRINTER TIMING CIRCUITS
CODE DEMAND TO COMPUTER
" ON LINE " XERONIC FUNCTIONAL BLOCK DIAGRAM

Laboratory prototype Xeronic at the Computer Exhibition, November, 1958.

XA0006530