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ECMA

EUROPEAN COMPUTER MANUFACTURERS ASSOCIATION

ECMA STANDARD

for

Data Interchange on Punched Tape

November 1965

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ECMA European Computer Manufacturers Association
114, rue du Rhône — 1204 Geneva (Switzerland)

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BRIEF HISTORY

On March 29, 1963 ECMA adopted their Standard ECMA-1 for a 6 Bit Character Code for Input and Output purposes and on April 30, 1965 their Standard ECMA-6 for a corresponding 7 Bit Code. In the form adopted it included no proposals for implementation in media which were deliberately left as the subject for future standards.

This Standard ECMA-10 for Data Interchange on Punched Tape, adopted on Nov. 30, 1965, is essentially associated with the physical implementation of the Standards ECMA-1 and ECMA-6.

Representatives of the following Companies participated in the work of the Task Group which prepared this Standard :

Compagnie des Machines BULL
N.V. Electrologica
Elliott Bros. (London) Ltd
English Electric Leo Marconi Computers Ltd
IBM-WTEC
ICT, International Computers and Tabulators Ltd
Ing. C. Olivetti and Co. S.p.A.
NCR, The National Cash Register Co. Ltd
Siemens & Halske A.G.
Telefunken Aktiengesellschaft

In addition representatives of the following Companies in the Paper Industry have by invitation participated in the work as advisors :

Waterlow and Sons Ltd
Wiggins Teape Research and Development Ltd
William Nash Ltd

In preparing this work particular attention has been given to the proposals of other national and international organizations working on this subject.

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Introduction

- i. This standard relates to punched tapes used for data interchange among data processing systems. It confines itself to those factors and properties for reading such tapes, punching and other properties having been borne in mind. This standard does not refer to prefolded tape.
- ii. Wherever possible the properties and dimensions of the punched tape have been defined precisely, or specific testing methods called for. However, it is recognized that certain requirements of tape can, at the present time, only be described in general terms.
- iii. Only tape with a width of 25,40 mm or 17,46 mm nominal is to be considered standard for data interchange. The last mentioned tape is only intended for the possible representation of 4 bit subsets (see par. 3.3.5).
- iv. Punched tape for data interchange must be straight and its edges parallel. No deformation or notches on the edges of the tape can be permitted.
- v. This standard is divided into three sections. The first section deals with the properties of unpunched tape. The second section is confined to the properties of punched tape to be used for data interchange. The third section describes the implementation of codes on punched tape. In appendix 1, which is not part of the standard, recommendations are given concerning handling of punched tape. Appendix 2 describes the method of testing light transmission of tape.
- vi. Test conditions.

For the purpose of dimensional measurements the test conditions are :

| | |
|----------------|--------------------|
| 50 % \pm 2 % | Relative Humidity; |
| 23°C \pm 2°C | Temperature. |

For the purpose of all other physical measurements the test conditions are :

| | |
|----------------|--------------------|
| 65 % \pm 2 % | Relative Humidity; |
| 20°C \pm 2°C | Temperature. |

It is necessary that all paper samples to be tested should be freely exposed to the stipulated environment for at least 12 hours prior to any measurements.

Note : To maintain the Relative Humidity within the prescribed limits from point to point in the test room, any variations of temperature from point to point throughout the test room will have to be less than $\pm 0,5^{\circ}\text{C}$.

Section 1

PROPERTIES OF UNPUNCHED TAPE

1.1 Dimensions

1.1.1 Thickness

Nominal 0,100 mm;
Tolerance $\pm 0,005$ mm.

Method of test as described in DIN 53111, but atmospheric test conditions as specified in the introduction.

1.1.2 Width

Nominal 25,40 mm;
Tolerance $\pm 0,05$ mm.
or Nominal 17,46 mm;
Tolerance $\pm 0,05$ mm.
(see par. 3.3.5)

Note : The thickness and width have been specified above on the understanding that the test method will employ a sampling procedure such that the mean value of the reading taken shall meet the values specified above.

In addition the spread of the test readings shall be such that the mean value less two standard deviations (or Sigma 2) shall not exceed 0,100 mm on the width, and 0,010 mm on the thickness.

1.2 Dimensional Stability

The tape shall not undergo a dimensional change greater than 0,5 % in the longitudinal direction, and 1,0 % in the transverse direction when subjected to humidity variations over the range 20 % - 75 % R. H. at 20°C.

The tape must meet all the tolerances laid down in the full specification when returned to 50 % R. H. and 20°C.

1.3 Mechanical Properties

1.3.1 Tensile strength

The tape shall be able to withstand in the longitudinal direction a force of at least 8 kg per cm width of the tape.

The tensile strength in the transverse direction shall be at least 50 % of the value specified for the longitudinal direction.

Method of test as described in DIN 53112.

1.3.2 Tear Strength

The tear strength shall not be less than 70 g in longitudinal direction and 80 g in transverse direction. Method of test as described in Australian PPITA P400 m/62 on Internal Tearing Resistance.

1.3.3 Flexibility/Stiffness

The tapes shall be sufficiently flexible to enable it to turn satisfactorily on a machine where it has to turn through 180° on a 6 mm diameter roller, yet stiff enough to enable it to be easily fed through the throat of a punch block or a similar device.

1.4 Optical Properties

1.4.1 The percentage light transmission as defined and measured by means of the test apparatus described in Appendix 2 shall not be greater than 35 %.

1.4.2 The noise factor (see Appendix 2) shall not be greater than 0,05.

Note : Any printing on the tape, such as arrows or manufacturers' name, etc. is required to meet clause 1.4.1 and clause 1.4.2.

1.5 Electrical Properties

1.5.1 Dielectrical Properties

The relative dielectrical constant shall be 1,8 minimum.

1.5.2 Conductivity

For the purpose of sensing the tape shall act substantially as an insulator when placed between two low-voltage sensing contacts.

1.5.3 Electrostatic Properties

Generation of an appreciable amount of static electricity by the passage of the tape through a high speed reader or punch cannot be tolerated.

1.6 General Quality

1.6.1 Deleterious defects

The tape shall be as free from unbeaten fibres, fluff, dust, grit, dirt spots, wrinkles, creases, edge tears and abrasive particles as modern manufacturing processes permit. There shall be no pin holes or translucent spots in the tape.

1.6.2 Writeability

The tape shall be capable of being written upon legibly by means of ink, ball pointed pens and

indelible, colour and lead pencils.

1.6.3 Lubrication Qualities

Any lubricant in the tape shall not have an adverse effect on photoelectric or dielectric reading, friction, dust, storage containers or on any of the factors determined in this specification. The lubricant shall be free from migration.

Section 2

PROPERTIES OF PUNCHED TAPE APPLICABLE AT THE TIME OF PUNCHING

2.1 Dimensions of information

It is highly desirable, for physical interchange of punched tapes, that the tape should be punched in an environment within the range of 40 % to 60 % Relative Humidity.

If however, due to uncontrolled circumstances, the environmental conditions prevailing at the time of punching are above 60 % R. H. or below 40 % R. H. respectively, it may prove necessary to make a special arrangement between the sender and the receiver in order to ensure satisfactory reading. (See Appendix 3).

2.1.1 Track positioning

Within a row the distance of the centres of the code holes from the centre of the feed hole shall be

$$2,54 n \pm 0,05 \text{ mm,}$$

where n is an integer.

2.1.2 Row positioning

The distance between two adjacent rows shall be

$$2,540 \text{ mm} \pm 0,075 \text{ mm,}$$

measured at the feed holes.

The tolerance on alignment of holes within a row is $\pm 0,075$ mm, measured between the centre of the hole and a line drawn at right angles to the reference edge (to be defined in 2.2.1), and passing through the centre of the feed hole.

The permissible spacing error along the feed track between centres of feed holes shall not exceed

a) $\pm 0,25$ mm in a span of 10 spaces (25,4 mm)

b) $\pm 0,63$ mm in a span of 50 spaces (127,0 mm)

2.1.3 Distance of the centre of feed holes to reference edge.

| | |
|-----------|---------------|
| Nominal | 9,96 mm |
| Tolerance | $\pm 0,10$ mm |

(Reference edge as defined in 2.2.1).

2.1.4 Feed hole diameter

Nominal 1,170 mm
Tolerance + 0,050 mm
- 0,025 mm

2.1.5 Code hole diameter

Nominal 1,83 mm
Tolerance \pm 0,05 mm

2.2 Other dimensions and properties of punched tape

2.2.1 Reference edge

The reference edge of the tape shall be that with three data tracks between it and the feed hole track.

If tape is guided from one edge, the reference edge shall be used as the guide edge.

2.2.2 Joints, splices, etc.

Punched tape for data interchange shall be free of overlapped or other joints, splices, etc.

2.2.3 General cleanliness

Data interchange tapes shall be as clean and free from dust, etc. as possible. There shall be no translucent spots, or oil deposits from punches.

2.2.4 Quality of punched holes

The edges of data and feed holes shall be free from fibres or burrs, liable to cause misreading (see paragraphs 2.1.4 and 2.1.5).

2.3 Tape coil

2.3.1 Outer diameter

The maximum outer diameter of a coil of punched tape shall be 190 mm.

2.3.2 Inner diameter

Tape for data interchange must be supplied either without a core, but wound with an inner radius of 51-52 mm, or on an annular core, the inner diameter of which must also be 51-52 mm.

2.3.3 Tightness of winding

The reel must be tightly wound in such a way as to ensure that a coil which has an outer diameter of 190 mm and an inner diameter of 52 mm shall contain at least 225 m of tape.

Section 3

IMPLEMENTATION OF CODES ON PUNCHED TAPE

3.1 Coding

The data on punched tapes for data interchange shall be encoded in an ECMA character code.

3.2 Track numbering

The data tracks on punched tape shall be numbered consecutively from one to eight. Track number one shall be the track closest to the reference edge, so that the feed hole track lies between tracks three and four.

3.3 Allocation of bits to tracks

3.3.1 Bits

A 1 bit within the coded character shall correspond to a hole in the punched tape.

3.3.2 Parity bit

On data-interchange tapes, in each and every transverse row a parity bit shall be added to the bits of the coded character. The value of this parity bit is given in next paragraphs.

3.3.3 7 bit character code

Punched tape 25,4 mm wide shall be used for the 7 bit character code. The bits within each character shall be allocated to the tracks on the tape thus :

| <u>Bit no</u> | <u>Track no</u> |
|---------------|-----------------|
| P | 8 |
| 7 | 7 |
| 6 | 6 |
| 5 | 5 |
| 4 | 4 |
| | feed hole |
| 3 | 3 |
| 2 | 2 |
| 1 | 1 |

"P" indicates a parity check bit.

Parity shall be even, overall.

3.3.4 6 bit character code

Punched tape 25,4 mm wide shall be used for the 6 bit character code. The bits within each character shall be allocated to the tracks on tape thus :

| <u>Bit no</u> | <u>Track no</u> |
|---------------|-----------------|
| P | 7 |
| 6 | 6 |
| 5 | 5 |
| 4 | 4 |
| | feed hole |
| 3 | 3 |
| 2 | 2 |
| 1 | 1 |

The 8th track shall not be punched.
Parity shall be odd, overall.

3.3.5 4 bit subsets

When 4 bit subsets are used, the 4 data bits and the parity check bit of every character shall be allocated either to the 5 first consecutive tracks of a 25,40 mm wide tape or to the 5 tracks of a 17,46 mm wide tape thus :

| <u>Bit no</u> | <u>Track no</u> |
|---------------|-----------------|
| | (8) |
| | (7) |
| | (6) |
| P | 5 |
| 4 | 4 |
| | feed hole |
| 3 | 3 |
| 2 | 2 |
| 1 | 1 |

On 8 track tape the tracks 6,7 and 8 shall not be punched. Parity shall be odd, overall.

As it is to be expected that in future reference will be given to a unique 25,40 mm wide tape, this tape is recommended for 4 bit subset. However, considering the extensive present use of 5 track tape and corresponding devices, the use of 17,46 mm wide tape is also allowed.

3.4 Leaders and trailers

In order to facilitate tape handling on reeling equipment each coil of punched tape carrying data shall have leaders and trailers, at least 120 cm in length. Each leader and trailer will include a minimum of 50 NULL characters immediately before and after data characters respectively.

This punching of 50 NULL characters is also required on leaders and trailers of strips of punched tape.

The same punching of NULL characters shall also be used at any point along the tape when it is desired to separate physically sections, carrying punched data.

3.5 Orientation of data on punched tape

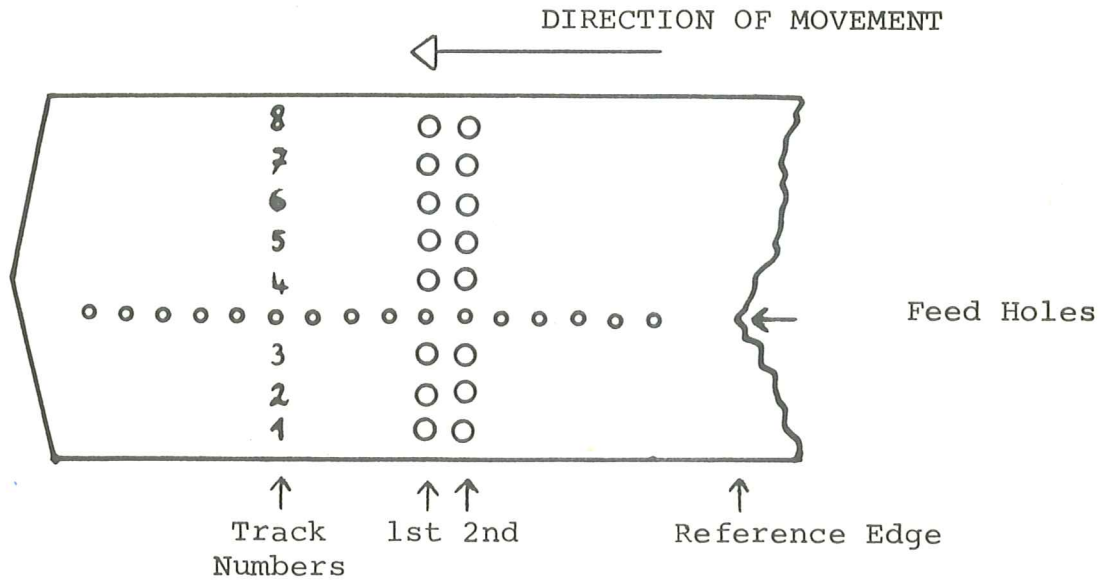


Figure 1

With the tape oriented as shown in Figure 1, and the observer looking down onto the tape, the direction of forward tape movement is from right to left, and the first character of data (the most significant character as entered from a typewriter-like device) is the one farthest to the left (1st). The next most significant character immediately follows it (2nd) etc.

Tapes for data interchange shall be marked, or the ends cut, to give a positive indication of the direction of forward tape movement. Suggestions for using arrows for this purpose are given in Appendix 1-D.

APPENDIX 1

A. Transportation

It is important that tape for data interchange shall not be damaged or contaminated during transport from one installation to another. It is therefore necessary to provide adequate protection by means of a suitable container. The recommended method would comprise a cardboard or plastic box for each single full sized coil or several smaller ones. The lid of the box must fit well and be capable of being sealed with an adhesive tape.

To prevent damaging the tape, it shall be located on a raised boss. The interior of the box shall be free of sharp edges. Metal staples shall not be used. Provision shall be made for labelling each box with the following information.

Recipient

Sender

Job reference

Coding.

B. Storage conditions

It is desirable wherever possible for tapes, which are to be read, that they should be reasonably well conditioned to the preferred atmospheric conditions of 50 % R.H. and 20°C temperature. For this reason it is desirable to avoid storing tapes in extreme conditions or heat, moisture or dryness. If tape has been adversely effected, it should be borne in mind that a wound coil will take many hours or even several days to reacclimatize itself to the proper conditions.

C. Cores

Cores shall be strong enough in order to maintain the inner diameter of a coil as defined in 2.3.2 during normal practical use.

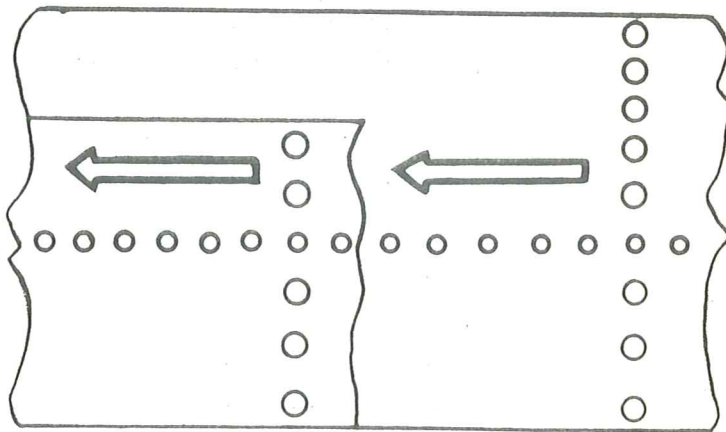
D. Titles, directional indication and winding of punched tapes

A preferred method for indicating the direction of movement of punched tapes for data interchange is that they should be marked with arrows pointing forwards. These should be present at the leading end at least, and preferably should be printed all along the tape, regularly spaced 10 to 15 cms apart, and placed clear of the feed holes.

The arrows also serve to indicate the reference face of the tape, and the convention should be followed that the tape be punched so that, when it is held with the reference face towards the observer, the arrows and the punching should appear as in Figure 2 below.

Arrows in low density ink showing direction of forward movement.

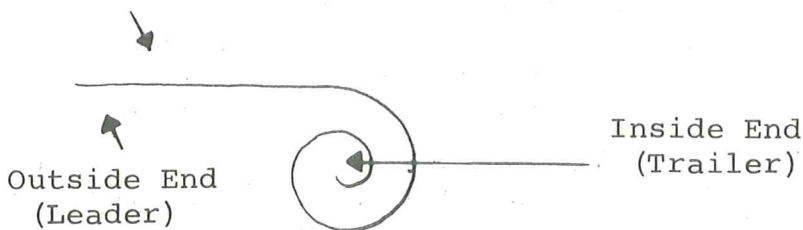
Figure 2



Any writing or printing on the tape shall be on the reference face, when the punched tape is held as in Figure 2 above. Any caption or title on the tape shall be written at the leading end.

A coil of punched tape, the first character of data being at the free, outer end, shall run in such a manner whilst turning anti-clockwise that the reference edge is the one, nearest to the observer (see Figure 3), and in addition, so that the title or arrows appear on the outer surface.

Reference Face of Tape



A Coil of Tape
(Reference Edge towards Observer)

Figure 3

Whilst the above is not mandatory, it is considered desirable in the interests of standardization to recommend strongly to equipment designers to adopt the convention, as stated, on future punched tape winding equipments.

APPENDIX 2

1. INTRODUCTION

Characteristically, photoelectric tape readers used in data processing equipment are dependent on the radiation transmitted through and scattered by the tape.

Experiments have shown that the amount of light that is transmitted directly through the paper is only about 1-3% but that typically 30% will be collected on the surface of the photodiode by scattering. The test device is therefore deliberately designed to allow scattered light to be collected and not simply to collimate the received beam.

Because the light radiation is predominantly in the near infra-red region of the spectrum it is important to recognize that the photocell response will be different from that of the human eye particularly if the paper contains a dye or pigment.

The test device has been named the ECMA Light Transmission Meter, a complete set of master drawings are held at ECMA headquarters and copies of these drawings, together with some constructional notes, may be had on application to

The Secretary General
European Computer Manufacturers Association
114, Rue du Rhône
1204 Geneva.

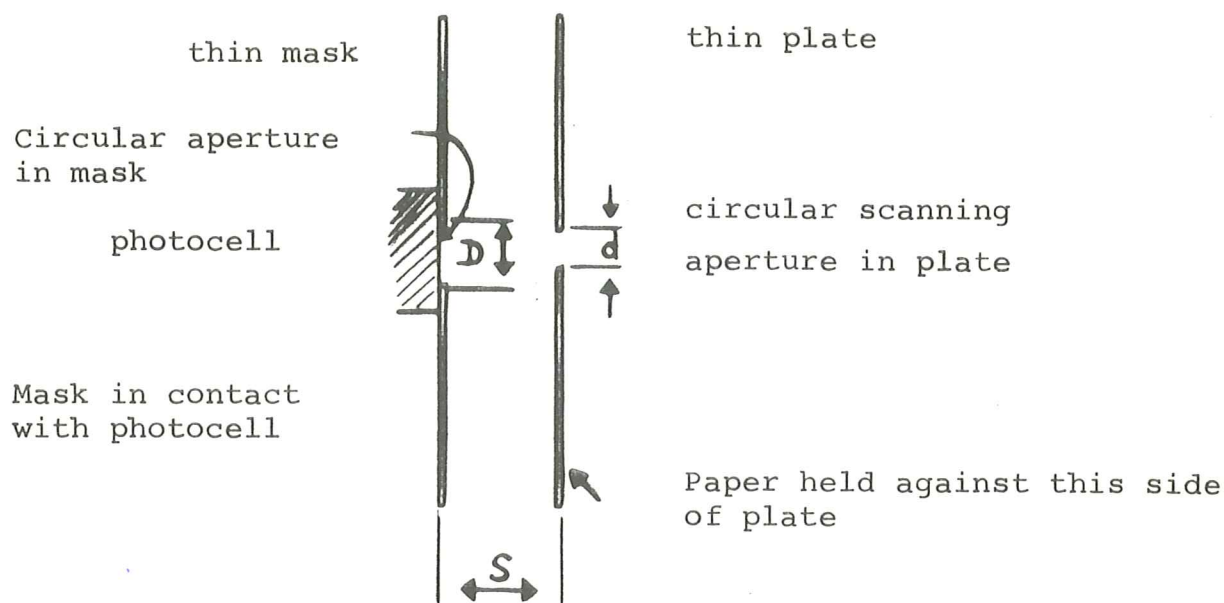
2. TEST APPARATUS

The following method of test has been established because it simulates the more critical factors in typical data processing reading equipment, and can be carried out with a device which can be precisely defined in its important respects and can be easily manufactured.

Experiments have shown that the most important factor is the geometrical arrangement of the elements which collect the light after its transmission and scattering through the paper. This is defined in paragraph 1.3.

The test device (See Fig. 1) comprises a tube with a lamp held at one end. Light falls on the test strip of paper which is fed through a slot perpendicular to the axis of the tube. The paper is in contact with a thin plate in which there is a defined scanning aperture similar to a data hole. Beyond this plate there is a spacer and another thin plate with an aperture to define the geometry of the collecting system. The second plate is flush with the sensitive surface of a photocell, which is connected to a simple current meter.

Satisfactory results are obtained with the following arrangements :



Let d = diameter of scanning aperture
 D = diameter of opening over photocell
 S = spacing between rear surface of paper and surface of photocell.

The relative proportions chosen were $d : D : S = 2 : 4 : 1$

Fig. 2 shows details of the assembly of the photocell.

4. TEST PROCEDURES AND DEFINITIONS

Initially, the lamp should be switched on for several minutes and an adjustment made if necessary, to ensure that full scale deflection is obtained on the meter, with no paper inserted.

A 10-inch paper test strip should then be fed through the slot provided in the cylinder, and the new meter reading noted. Ten separate readings should then be taken for ten incremental movements of the tape sample. When the paper strip is removed, the meter reading should be checked that it reads full scale deflection and if a deviation or more than 1/2 a division is noted, the results should be repeated.

The highest meter reading should be taken and PERCENTAGE LIGHT TRANSMISSION defined as :

$$\frac{i_m - i_o}{i_{100} - i_o} \cdot 100$$

where i_m = meter reading with the tape sample inserted;

i_{100} = full scale meter reading i.e. with no paper inserted

i_o = meter reading with metal shim inserted to blank off the light source completely.

The five basic requirements of the device can be stated in general terms.

- i) the light source
- ii) the optical path
- iii) the paper
- iv) the photocell
- v) the measuring meter

i) The Light Source

The lamp shall be a typical car head-lamp (single transverse filament). The colour-temperature is not critical. A 36-watt, 12-volt bulb, run at about 10 volts, A.C. or D.C. is suitable.

ii) The Optical Path

The light should fall nominally perpendicular on the test paper and be of substantially uniform intensity. Typically, the lamp-paper distance may be 15 cm, with no intermediate lenses.

iii) The Paper

The area of paper illuminated is not critical, provided it is appreciably larger than the scanning aperture.

iv) The Photocell

A silicon solar photocell shall be used. Its type is not critical provided that it meets the minimum area requirement and does not greatly exceed it. Ideally, the active area should be square, (approximately 6,5 mm x 6,5 mm). The spectral response of the cell should extend through the visible spectrum with the maximum in the near infra-red.

v) The Measuring Meter

A D.C. moving coil ammeter shall be directly connected to the photocell. It shall have an impedance of 500 ohms nominal, full scale sensitivity 50 micro-amp, linearity within 1 %, scale length at least 10 cm and preferably graduated in 100 divisions. The aim is that the photocell-meter combination shall be substantially linear. See Paragraph 3.

3. LIGHT COLLECTING ELEMENTS

Experiments have shown the measurement of light transmission of paper to be very greatly influenced by the manner in which the scattered light is collected. This is determined by the geometry of the light collecting system. The primary aim therefore is to establish precisely the geometrical relationships of the elements between the paper and the photocell.

In addition it is necessary to calculate the NOISE FACTOR of the paper, defined as :

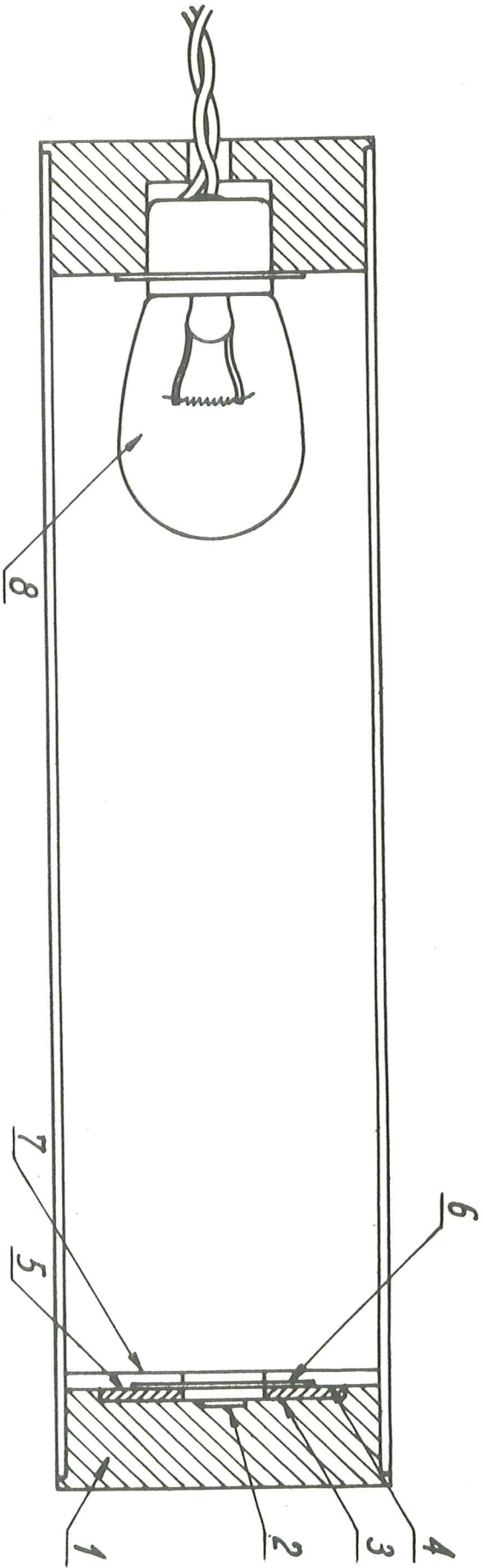
$$NF = \frac{i_{mH} - i_{mL}}{i_{100}}$$

where i_{mH} = highest reading noted.

i_{mL} = lowest reading noted (excluding readings which are affected by printing or writing on the sample).

i_{100} = full scale deflection reading on the meter.

GENERAL ARRANGEMENT



- 1. Photocell Block
- 2. Photocell
- 3. Photocell Mask
- 4. Spacer

- 5. Paper Mask
- 6. Paper Sample
- 7. Retaining Ring
- 8. Lamp

Figure 1

EXPLODED VIEW OF LIGHT COLLECTING ELEMENTS

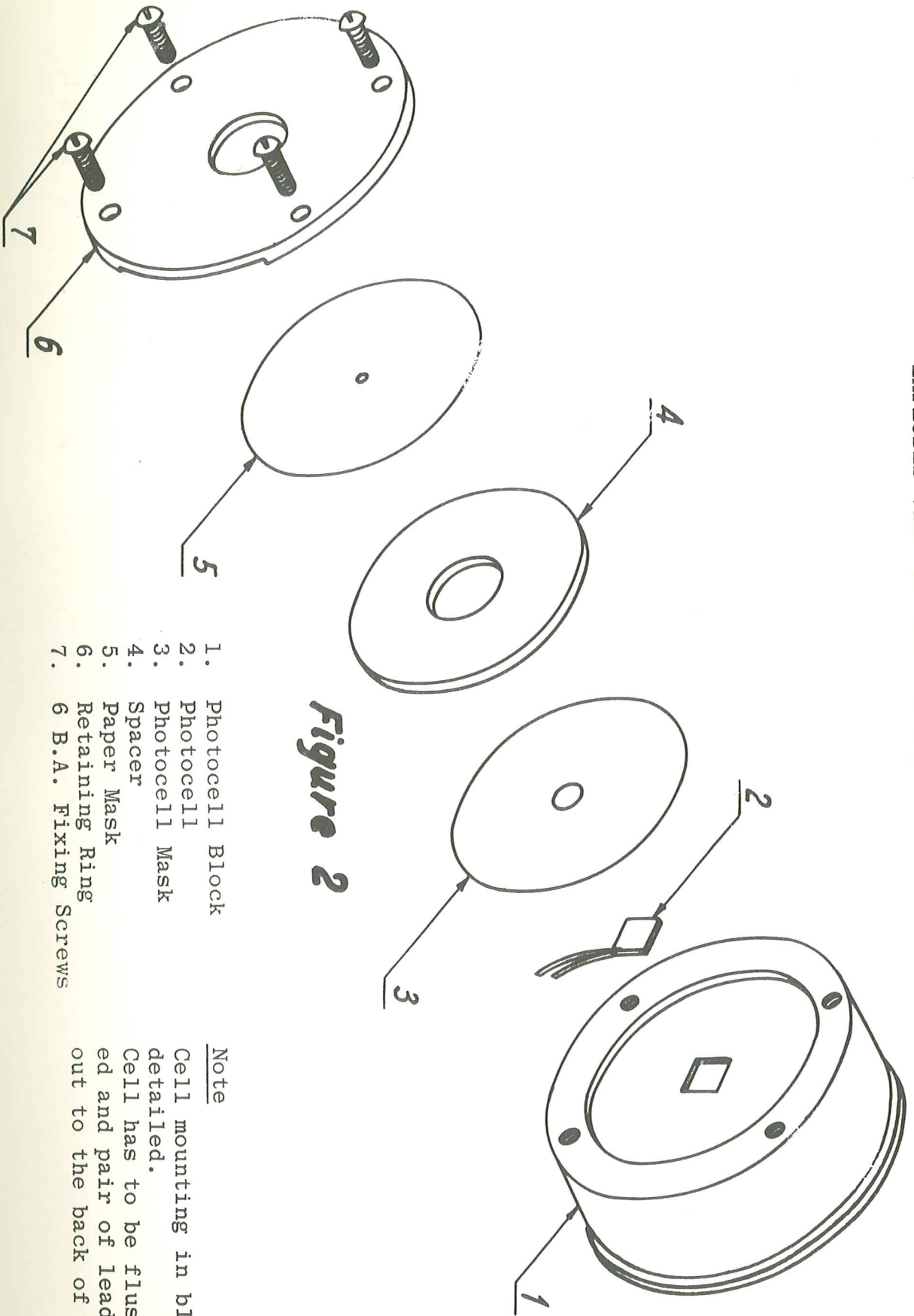


Figure 2

1. Photocecell Block
2. Photocecell
3. Photocecell Mask
4. Spacer
5. Paper Mask
6. Retaining Ring
7. B.A. Fixing Screws

Note

Cell mounting in block not detailed.
Cell has to be flush mounted and pair of leads brought out to the back of the block

APPENDIX 3

The purpose of the following notes is to enable both the sender and the receiver of punched tape to sensibly ensure that the data on the punched tape shall be satisfactorily read in the computer.

1) The problem of punching the tape

Paragraph 2.1 defines those parameters to be met at the time of punching. Whilst these tolerances are within the limits of almost all known punches as manufactured, it will be necessary to check the punch regularly in use to ensure that wear or bad setting has not caused any of the specified values to be exceeded.

2) The problem of reading the tape

All known punched tape reading systems would be able to read the tape to the specification if the environmental conditions prevailing at the time of punching were the same as those at the time of reading.

Unfortunately the relative humidity at the time of punching is likely to be different and this will cause a dimensional change in the tape.

NOTE As an example, the dimensional stability specified in paragraph 1.2 for the transverse direction is 1% when subjected to variations over the range 20 % - 75 % R.H. So that if the tape were to be punched at either of these environmental limits, it could be expected to undergo a dimensional change of approximately 0,5 % when conditioned in a typical computer environment of 50 % R.H.

This means that the information hole farthest from the guide edge if perfectly punched at exactly the centre value specified in Section 2 could move by approximately 0,12 mm. The responsibility therefore lies with the sender to ensure that the tape is not punched at extreme levels of humidity.

Typically, the calculations show that the tape reader should be capable of reading any information or sprocket hole even if a lateral displacement of 0,25 mm were to occur due to the combined tolerances of the tape reader, the dimensional factor and the tape punch.

