Fields for Edge-Punched Filing Cards

Abstract. *New fields have been devised, for a double-row edge-punched card, which require only three edge holes per field in place of the customary four. The new fields record every digit and no digit appears more than once. Any letter of the alphabet can be readily punched into a single field. Sorting of the new fields (compared to sorting of existing fields) requires fewer needle passes for both alphabetical and numerical searching, if a single search is made; this does not apply in arranging the cards in sequence.*

Edge-punched filing cards exist with both a single row of holes and a double row of holes along the edges. In the case of the cards with a single row of holes along an edge, a group of four holes—a "field"—are given numerical values of 7, 4, 2, and 1. The number given to each hole is encoded by punching the appropriate hole; by punching two holes the sum of the two numbers is encoded (*1*). In this manner every digit can be recorded, and by the use, for example, of three fields, one for the hundreds, one for the tens, and one for the units, numbers up to 999 can be encoded.

In the case of cards with double rows of holes, a common practice is to assign the 7-4-2-1 values to the outer row of holes and to use 26 of the inner row of holes for the letters of the alphabet. Alternatively, both rows can be given the 7-4-2-1 values and the outer row may be used for coding the tens and the inner row for the digits. The disadvantage of this field is that the inner row is coded by intermediate punching, which is more difficult to sort than either shallow or deep punching, partly because it requires two passes of the needle, but mainly because intermediately punched cards may not fall well on the first needle pass; with this field four of these intermediate sorts are required to put the digits in order.

In designing a card for a particular use, one may find more subjects for coding than there are fields available. One way to solve this problem is to increase the size of the card, but this approach is limited by the unwieldiness of large cards.

Using cards with a double row of holes, I have now developed new fields which decrease the number of edge holes required per field from four to three and thus increase the number of fields available on a card by 33 percent (four fields instead of three, per 12 holes). These fields satisfy two essential criteria: (i) every digit should be recordable, and (ii) to avoid ambiguity, no digit should appear more than once.

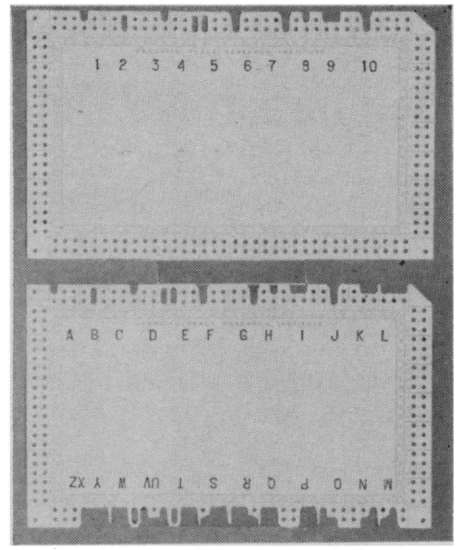

Fig. 1 (top). Numerical punching for a new field. Fig. 2 (bottom). Alphabetical punching for a new field.

Table 1. The 22 new six-hole fields.

J + K	J	K	A	B	C	D	E	F	G	H	I
20	9	11	1	8	3	5	2	4	6	10	7
20	9	11	2	7	4	3	1	6	5	8	10
20	9	11	2	7	4	6	3	1	8	10	5
18	10	8	7	3	5	2	1	6	9	4	11
18	11	7	8	3	4	1	2	6	9	5	10
18	11	7	8	3	4	2	6	1	10	9	5
18	11	7	9	2	5	1	4	3	10	6	8
16	11	5	7	4	1	3	2	8	10	6	9
16	11	5	8	3	2	1	7	4	9	10	6
16	11	5	9	2	3	1	6	4	10	8	7
16	10	6	8	2	4	3	7	1	11	9	5
16	10	6	8	2	4	1	3	7	9	5	11
16	9	7	8	1	6	2	3	5	10	4	11
14	10	4	7	3	1	2	8	5	9	11	6
14	10	4	9	1	3	2	6	5	11	7	8
14	9	3	7	2	1	4	8	5	11	10	6
12	8	4	5	3	1	2	6	10	7	9	11
12	7	5	3	4	1	8	2	9	11	6	10
10	7	3	5	2	1	4	6	10	9	8	11
10	6	4	5	1	3	2	9	8	7	10	11
8	5	3	4	1	2	6	7	9	10	8	11
8	5	3	4	1	2	7	9	6	11	10	8

These fields were found by assigning values to the letters A, B, C, D, E, and F (which represent the holes of the card) as shown in the diagram below:

$$\begin{array}{ccc} & J \quad K & \\ A & B & C \\ D & E & F \\ \hline G & H & I \end{array}$$

where $A + D = G$, $B + E = H$, $C + F = I$, $A + B = J$, $B + C = K$, and $A \neq B \neq C \neq D \neq E \neq F \neq G \neq H \neq I \neq J \neq K$ and none of the values are greater than 11.

Because G, H, I, J, and K are sums, the values 1 and 2 must be assigned to A, B, C, D, E, or F; similarly $B \neq 9$, since B is involved in three sums with A, E, and C. There are, therefore, 46,200 ways in which values may be assigned to the letters A, B, C, D, E, and F. Twenty-two fields were found (their mirror images would also be suitable) which satisfied both criteria (i) and (ii) named above. Only 22 such pairs exist. They were found by the use of the following rules:

$$A + \ldots + K = 66$$
$$A + \ldots + F = G + H + I$$
$$[66 - (J + K)]/2 = G + H + I$$

It was arbitrarily decided that, unlike the practice in the 7-4-2-1 field, A and C could not be added to give a codable number; however, for seven pairs of fields A + C = 12 and for two pairs A + C = 14 and thus for these fields duplication of a number does not occur if the sum of A and C is coded. It is not possible to code ten digits without using the sum of A + B or B + C.

The first field found, the first example in Table 1 (which shows the 22 new fields) (*2*) was put into practice and has presented no problems in use.

A photograph of the card designed is shown in Fig. 1, punched to indicate the system used. The numbers 1, 8, and 3 are encoded by shallow punching; 6, 10 (or 0), and 7, by deep punching; and 5, 2, and 4, by intermediate punching. Shallow punching of 1 and 8 encodes 9; shallow punching of 8 and 3 gives 11 and ambiguity is avoided. Shallow punching of 3 and 1 could give an ambiguous 4 but this is avoided by the convention that the sum of A and C should not be used for coding a number.

Recently the question arose of coding any letter of the alphabet by using only one field. The letters have been coded by punching the number which corresponds to their position in the alphabet; thus A is coded by punching the number 1, and P is coded by punching the number 16. The letters U and V are both coded by punching the number 21, and the letters X and Z, which occur rarely, are coded by not punching the card. The numbers from 11 to 20, inclusive, may be punched in more than one way; this ambiguity was overcome by arbitrarily deciding how these numbers should be coded. For convenience a reference card was made on which the alphabet was punched (see Fig. 2).

The average number of needle passes required to separate one letter from the rest is 3.71, while for the 7-4-2-1-NZ system (*3*) the average is 4.54. The alphabetical coding has been applied to a rapidly growing deck of cards (5000 at present) which are frequently searched with no deterioration of the card stock.

It is possible to make a field on a double-row card, using only two edge holes, by using combinations of shallow, intermediate, and deep punching, but these holes could not be numbered, and while more fields could be put onto a card more time would be spent searching, since almost every hole of the four would be punched in some manner.

ALAN G. NEWCOMBE

Newcombe Associates, 25 Dundana Avenue, Dundas, Ontario, Canada

References

1. C. S. Wise, in *Punched Cards—Their Application to Science and Industry*, R. S. Casey *et al.*, Eds. (Reinhold, New York, ed. 2, 1958), p. 441.
2. Copyrights have been obtained on all of these fields and their mirror images.
3. R. S. Casey *et al.*, *J. Chem. Educ.* **23**, 496 (1946).

4 March 1963

Replicating Form of a Single-Stranded DNA Virus: Isolation and Properties

Abstract. *The replicating form of single-stranded DNA virus has been isolated in pure form by chromatography on columns of methylated albumin. Its buoyant density in CsCl and "melting temperature" are characteristic of a double stranded DNA structure containing 43 percent guanine-cytosine. The nearest neighbors to uridylate were compared in the RNA synthesized when replicating-form DNA and mature single-stranded DNA were employed as templates in an in vitro system. The mature DNA component of the replicating duplex does not serve as the sole source of complementary RNA. The results agree best with the assumption that both strands of the replicating form function as templates. It is important to note that this is contrary to the situation found in the intact cell where only one of the two strands appears to be transcribed into message.*

Sinsheimer (*1*) has shown that the DNA virus, ΦX174, contains only one of the two possible strands. Further, on injection into cells of *Escherichia coli*, the other complement is synthesized (*2*). The resulting duplex constitutes what has been called the "replicating form" or RF.

This situation provides an obvious opportunity for an informative experimental analysis of the genetic-transcription mechanism. However, the fact that the mature virus provides one of the two strands can be fully exploited only if the replicating form can be purified as a source of both complements. It is the purpose of the present paper to show how this can be achieved. The purified RF-DNA has been used to gain a more direct knowledge of its physico-chemical properties. In addition, its behavior as a template for in vivo transcription into RNA has been compared with the product synthesized on the single-stranded DNA isolated from virus particles.

The replicating form was detected (*2*) in the DNA of infected cells as a unique component in a cesium chloride density gradient (*3*). It was clear, however, that neither the resolution nor the capacity of this method would suffice for the convenient preparation of the RF-DNA in adequate quantities. Experience in other laboratories (*4, 5*) as well as in our own (*6*) with methylated-albumin columns (*7*) led us to believe that chromatographic separation of the RF should be possible.

To help identify the position of the RF-DNA on the column, the DNA of the virus used for infection was labeled with phosphorus-32. In addition, the infection and incubation was carried out in the presence of chloramphenicol which inhibits (*2*) the formation of mature single strands. Figure 1 shows the result of chromatographing the total DNA isolated and purified from the *E. coli*–ΦX174 complex after 1 hour of incubation. Included in the material put on the column was tritium-labeled single-stranded ΦX174–DNA which is eluted at a unique position in the gradi-

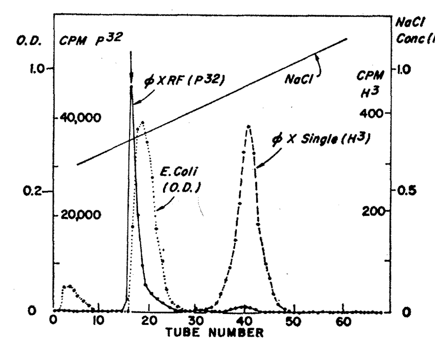

Fig. 1. Separation of ΦX174 replicating form from ΦX174-single-stranded DNA on a column of methylated albumin on kieselguhr (MAK). The *E. coli* C and ΦX174 were from the virus stock of Dr. I. Tessman. Its DNA was prepared and labeled with P^{32} or H^3-thymidine (*16*). The columns were prepared (*4*) with well-methylated (*16*) albumin. Our standard column is one-half the size used routinely by Mandell and Hershey (*4*). Other sizes used are denoted by ½ X, 10 X, and so forth. Log-phase (1×10^9 per ml) cells (100 ml) were infected with P^{32}-labeled ΦX174 (multiplicity of 10 in the presence of 50 μg/ml of chloramphenicol). After 1 hour of incubation at 37°C the infected complexes were harvested and the total DNA was isolated (*18*). Two mg of the DNA were loaded on a 2X MAK column along with H^3-labeled ΦX174-DNA. The indicated linear NaCl gradient was applied and fractions were collected for measurement of optical density at 260 mμ and for the determination by liquid-scintillation counting on Millipore membranes of the radioactivity in the acid-insoluble portion (see *19*).