Reports

Simple and Rapid Method for the Coding of Punched Cards

Abstract. A novel method for the coding of hand-sorted, edge-punched cards based in part on the phonetics of a word is outlined. The greatest utility of the scheme lies in its speed because of the elimination of a need of a controlled index. Experience gained in the operation of the new system is briefly described.

A coding system for personal files of hand-sorted, edge-punched cards should have at least the following attributes: simplicity (and hence speed), flexibility, and selectivity. To meet these demands, but particularly those of simplicity and rapidity, a self-demarcating system based on word coding has been designed whose success arises chiefly from the elimination of the time-consuming and difficult problem of formulating and using a controlled index. The scope of the scheme is as broad as the vocabulary of the language, and the method possesses the additional advantage of readily following changing interests without elaboration of an index. For an extensive description of other coding procedures and applications and for manipulation of hand-punched cards, the reader is referred to Casey *et al.* (*1*).

The new scheme presented here allows the word to generate two letter-number sets for coding, the numbers being produced by the phonetics of the word (*2*, *3*). The card format illustrated in Fig. 1 has proved quite satisfactory, but other modifications can obviously be employed.

The phonetic alphabet and corresponding numbers are depicted in Table 1. By use of the simple mnemonics proposed by Loryane (*2*), this phonetic alphabet can be committed to memory in a few minutes, and with a knowledge of this alphabet and the aid of a few simple rules detailed below, the code is formulated.

1) The first letter-number set is composed of the initial letter of the word and the number generated by the first consonant sound following that letter.

2) The second letter-number set (coded with an intermediate punch, see Fig. 1) is composed of the first letter of the second syllable (or in the case of monosyllabic words, the second consonant) of the word unless rule 3 supersedes. The second number corresponds to the first unused consonant sound following the first syllable. If two consonant sounds are not available (or in the case of monosyllabic words), the second number is made equal to the number of letters in the word.

3) If a word is a composite of two or more words, the second word is used in place of the second syllable in order to generate the second letter-number set.

For example, the sample word "meter" would be coded "M-1" (outer row), "T-4" (inner row). The first letter-number set for coding arises from the initial letter of the word "M," and the first consonant sound, "T," which follows the first letter. Since "T" corresponds to "1," the first set is "M-1." The second letter-number set, "T-4," is generated by "T," the first letter of the second syllable, and "R" (equivalent to 4), the first *unused* consonant sound encountered after the first syllable. Composite words like "flamephotometry" can be coded using the "parent" words. In this instance, the first and second letter-number sets would be "F-5," "P-1," respectively, being derived from the beginnings of the words "flame" and "photometry" according to rule 1. "Starch" is an example of a

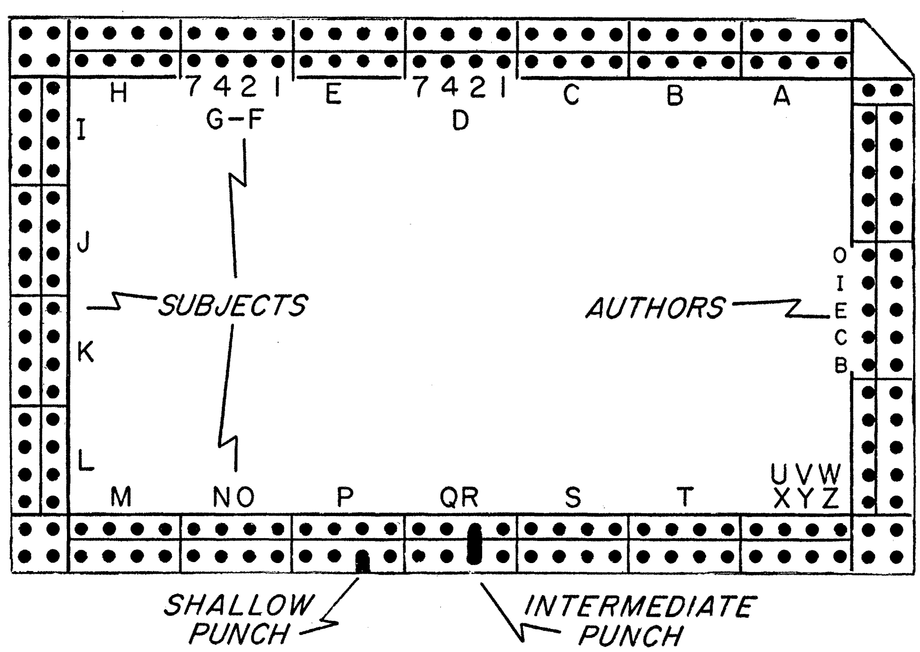

Fig. 1. The punch card, showing the different modes of punching and the "7-4-2-1" fields. Combinations of these four numbers can produce any number from 1 to 10 (*1*). It is also possible to code numbers 1 to 10 in a five-hole field and only two needlings are required to select the number desired (*1*). To select a given number in the four-hole field, it may be necessary to needle more than twice.

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Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to contributors" [*Science* **125**, 16 (1957)].

Table 1. Consonant sounds and corresponding numbers.

Numbers	Sounds
1	T and D
2	N
3	M
4	R
5	L
6	J, CH, SH, soft C, and soft G
7	K, hard C, and hard G
8	F and V
9	P and B
10	S and Z

monosyllabic word, and the first letter-number set, "S-1," is derived as usual while the second consonant and the number of letters in the word gives the second coding set, "T-6." Authors' names are punched by the method outlined by Casey *et al.* (*4*).

One example of the flexibility of the system described here is its ability to code any information (for example, dates, journals, empirical formulas) consisting of letters and numbers. For example, an empirical formula such as $C_{12}H_{24}O_2$, could be coded as C-2, H-4, O-2, in the outer row and C-1, H-2 in the inner row where the outer and inner rows are equivalent to units and tens, respectively.

Assuming that the letters and the consonant sounds occur randomly in the English language, it is possible to estimate the selectivity of the system (*1*, chap. 21). This is equivalent to calculating the probability that a card (false retrieval) would respond to a random sorting operation when w words are coded two times per card in f fields when each field can be punched n different ways. The probability is approximately $(w/nf)^2$, and when the card format shown in Fig. 1 is used, the chance of a false retrieval is calculated to be about 0.1 percent if five words are coded per card.

Experience with the method indicates that it is possible to code at the rate of 2 to 4 words per minute, while retrieval requires approximately 2 to 3 minutes per word per deck of 1000 cards.

In general, punching key words has proved satisfactory. For example, a paper entitled "Properties of bovine *pancreatic ribonuclease* in ethylene *glycol* solutions" would be coded with the italicized words. Since the article is concerned with "structure," this key word would also be punched. This card would be retrieved in a search for the effects of solvents on the structure of ribonuclease by needling for either or both "ribonuclease" and "structure." Because of the specialization in science, it is our experience that the number of false retrievals caused by synonyms or multiplicity of word meanings is a very small percentage of the selected cards and is more than compensated for by the speed and ease of operation of the new method.

The scheme becomes increasingly cumbersome, as do all hand-operated methods, as the information deck exceeds 5000 cards. However, in our hands, it has proved exceptionally versatile for small decks, for example, those accumulated for writing a review or book or which have been subdivided on a yearly basis. The greatest advantage of the system presented here is its speed, achieved by storing the index in the memory (*5*).

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References and Notes

1. *Punched Cards,* R. S. Casey *et al.,* Eds. (Reinhold, New York, 1958).
2. H. Loryane, *How To Develop a Super-power Memory* (Fell, New York, 1957), p. 50.
3. A phonetic system for coding proper names has been developed commercially by Remington Rand.
4. R. S. Casey, C. F. Bailey, G. J. Cox, *J. Chem. Educ.* **23**, 495 (1946).
5. This is contribution No. 1050 from the Chemical Laboratories of Indiana University. This work was supported by grants from Corn Industries Research Foundation and USPHS (RG 8500). I am most grateful to Dr. Sherman Dickman, for without his valuable suggestions and encouragement this report would not have been published.

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Goethite in Radular Teeth of Recent Marine Gastropods

Abstract. The x-ray diffraction patterns of the denticle material from several species show that the material consists of the mineral goethite. This is the first indication that goethite is precipitated by marine invertebrates. The mineralogy of the denticle caps has biologic and geologic implications.

The denticles of the radular teeth from marine chitons (*Polyplacophora*) consist of black opaque material, have a high iron content, and acquire through magnetization an appreciable magnetic moment (*1*). X-ray defraction patterns of the denticle material from some chiton species correspond with those of the mineral magnetite (Fe_3O_4) in both spacing and intensity of lines, whereas those from other chiton species show that this material contains some unidentified minerals plus magnetite (*2*).

Iron is also known to occur in the radular teeth of certain marine gastropods in the order Archaeogastropods (*3, 4*). A quantitative analysis performed on the ash of the radular teeth from *Patella athletica* showed an iron content equivalent to 54 percent Fe_2O_3 (*5*). There is a question whether the iron in the radular teeth of gastropods is similar to that in the chitons (present as a crystalline inorganic compound) or bound up in an organic compound. A survey of the physical and crystal chemical structure of the radular teeth from the Archaeogastropods was undertaken.

Species of *Scissurella, Perotrochus, Haliotis, Acmaea, Patella, Nomaeopelta, Lottia, Fissurella, Diadora, Nerita, Tegula,* and *Littorina* were selected for study. The radular teeth were dissected from specimens preserved in alcohol and examined under a binocular microscope. The teeth of species from the genera *Patella, Acmaea, Nomaeopelta,* and *Lottia* were found to be capped with a black-brown to yellow-brown opaque material, whereas those of the species from the other genera listed were colorless and transparent (*6*).

Laboratory tests showed that the capping material of the teeth from *Acmaea, Patella, Nomaeopelta,* and *Lottia* species scratch fluorite and apatite (weakly), whereas the transparent teeth of *Littorina* and *Fissurella* scratch gypsum but not calcite. This places the hardness of the denticle material in species of *Acmaea, Patella, Nomaeopelta,* and *Lottia* close to 5 and that of the teeth in *Littorina* and *Fissurella* between 2 and 3 on the Mohs hardness scale.

Denticle caps of *Acmaea mitra, Lottia gigantea, Nomaeopelta dalliana,* and *Patella vulgata* and the teeth of *Fissurella barbadensis, Diadora* sp., and *Littorina planaxis* were mechanically separated, and the samples were investigated by x-ray diffraction (Norelco instrument) with a Debye-Sherrer camera using Fe filtered Co radiation. A sample of pure goethite (α $Fe_2O_3 \cdot H_2O$) from Michigan was included for comparison. The transparent teeth of the *Fissurella, Diadora,* and *Littorina* species gave no discernible x-ray diffraction pattern. The x-ray diffraction patterns of the capping material for the teeth of