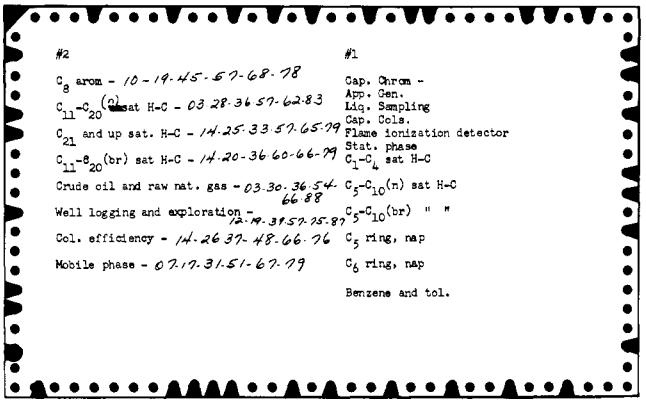

Fig. 3.—Reverse of an abstract card showing the listing of classes and code numbers. Note that this card is the second of a pair of duplicate cards and the classes coded on the first are also listed.

number, and so on until all six numbers have been sorted. The cards obtained are then reversed and their backs scanned so that unwanted cards may be removed. For this reason, as well as to facilitate the notching operation, the classes and code numbers are listed on the back of each card as shown in Fig. 3. In 42 searches, the average total time required both to sort and to remove unwanted cards is 24 minutes, with an average deviation of 6.8 minutes.

In order to prevent loss of the punched cards, they may conveniently be serially numbered and microfilmed in numerical order. With this arrangement, the serial numbers of the cards obtained in a search may be noted; and only this list, not the cards themselves, need be taken from the area of the file. The customer takes the list of numbers and the microfilm to a reader-printer, reads, and makes copies of the cards as he desires.

If further detailed information is needed, recourse can be made to a file of reprints. For the system being described, reprints of about 70% of the reference have been secured and filed by author. In the future it is planned to microfilm the reprints in order to prevent their loss.

Considerable additional information may be had from a supplementary second set of cards coded for author, journal, date, and location. Rather than include this less-needed information in the first code system, it seems easier to set up a second series of cards and make use of a simpler code. The second set of cards may also be coded so as to allow a loss check of the entire system. It is usual to convert to machine operation when the number of cards has increased to such a figure that it is inconvenient and uneconomical to continue with hand searching. The coding system described is quite compatible with the code systems used in machine operation. In fact, it is very similar to several systems already in use with IBM punched cards.

Logograph—Communicating Chemical Procedures*

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Received January 3, 1963

1. INTRODUCTION

Hieroglyphs find their source in ancient times but are still used in the modern world. For example, the Chinese character for the sun is pronounced *re* in Chinese, *il* in Korean, and *nichi* or *jits* in Japanese, but represents the sun in each of these languages. This is evidence that the hieroglyphic character is useful as a non-linguistic means of communication, without regard to spoken language.

An attempt to use hieroglyphic symbols for scientific description was made by the physiologist Serge Tchakhotine, but he did not intend to use such symbols as a wordless language. Symbolic descriptions of physiological experiments are given in his book "Organisation rationnelle de la récherche scientifique."[2] He named this system of description "lograph" (lógos, word; gráphos, to write). Tchakhotine used many words other than symbols in his writing, but his idea of using emblematic symbols other than those of a phonetic alphabet for communication is worth a great deal of consideration.

To avoid the complexity of scientific writing in Japanese, the writers and their collaborators[3] have been using such a method of writing, which had been named logograph,[4] for a long time. This is a system of writing formulated by introduction of Tchakhotine's idea of

* Presented at the 142nd National Meeting of the American Chemical Society, Sept. 11, 1962, Atlantic City, N. J.

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[2] "Actualités scientifiques et industrielle," Hermann & Cie., Paris, 1938, p. 732.

[3] For the establishment and improvement of this logograph, valuable coöperation has been received from the members of research laboratories of organic chemistry of the Science Faculty, Osaka City University, and of the Research Laboratory, Fuji Photo Film Co., Ltd.

[4] Logograph also means logotype but this seemed a better representation of this idea (a character of sign representing a word) than lograph from the point of word formation.

lograph into descriptive writing of chemical procedures. The chief characteristics of this logograph are:

(1) Symbols have been reduced to pictorial and emblematic figures.
(2) Symbols have been classified into (a) verbal or procedural and alteration symbols, (b) adverbial or modifying symbols which modify the verbal symbols, (c) connective symbols, and (d) chemical and miscellaneous symbols. By the combination of these unit symbols, a fairly complicated idea can be represented by symbols alone.
(3) The ordaining grammatical function of symbols would lessen the use of words for descriptive writing.

This method is merely a development of the earlier lograph and a reversion to hieroglyphic writing. It has been found through past experiences that it is not only useful for intuitive writing but is also significant as a means of international communication, without any thought for difference in languages.

2. EXPLANATION OF SYMBOLS

2.1 Procedural Symbols.—These constitute the most important part of the symbols and are listed in Table I.

TABLE I. VERBAL, OR PROCEDURAL AND ALTERATION SYMBOLS

I-A. PROCEDURAL SYMBOLS

NO.	SYMBOL	MEANING	ORIGIN
00		TO CONVERT TO X	
01		TO WARM, TO HEAT	WATER BATH
02		TO COOL	INVERSION OF NO.01
03		TO REFLUX	UP AND DOWN
04		TO DISTILL (OFF)	CONDENSER TUBE
05		TO SUBLIMATE	NO.01 AND VAPORIZATION
06		TO FILTER	FUNNEL
07		TO SEPARATE (LIQUIDS)	SEPARATORY FUNNEL
08		TO EXTRACT	NO.07 AND SEPARATION
09		TO DECANT	MOTION OF DECANTATION
10		TO PULVERIZE	MORTAR AND PESTLE
11		TO SOLIDIFY	INVERSION OF NO.10
12		TO (RE)CRYSTALLIZE	CRYSTAL FORM
13		TO STIR, TO SHAKE	MOTION OF STIRRING
14		TO WASH	FLOW OF LIQUID
15		TO RUB	MOTION OF RUBBING
16		TO DRY	
17		TO STAND, TO LEAVE STANDING	
18		TO CENTRIFUGE	REVOLUTION AND SEPARATION
19		TO OPERATE IN A SEALED VESSEL	SEALED VESSEL
20		TO OPERATE IN AN AUTOCLAVE	SEALED VESSEL AND COCK
30		TO ADD X	
31		TO TITRATE WITH X, TO DETERMINE WITH X	NO.30 AND SCALE
32		TO EVOLVE X, TO PRECIPITATE X	INVERSION OF NO.30
33		TO MEASURE X	SCALE

I-B. ALTERATION SYMBOL

40	→X	TO BECOME X	

TABLE II. ADVERBIAL OR MODIFIER SYMBOLS

NO.	SYMBOL	MEANING		ORIGIN
50	⊢	IN REDUCED PRESSURE		TAP OF EVACUATION FLASK
51	⊣	IN HIGH PRESSURE		INVERSION OF NO.50
52	⊢X	WITHOUT X ATMOSPHERE		FROM NO.50
53	X⊣	IN X STREAM, IN X ATMOSPHERE, IN X LIQUID		FROM NO.51
59	/	NEGATIVE		MOTION OF DENIAL
60	---	SLOWLY	VELOCITY	
61	═	RAPIDLY	VELOCITY	
62	○	MILDLY	VIOLENCE	
63	●	VIGOROUSLY	VIOLENCE	
64	←↑X	SLIGHTLY, A LITTLE	EXTENT	
65	→↓X	THOROUGHLY, VERY	EXTENT	
66	"	INTERMITTENTLY	FREQUENCY	
67	""	OFTEN	FREQUENCY	
68	!!	CAUTIOUSLY	ACCURACY	
69	~!!	ROUGHLY	ACCURACY	
70	> <	LITTLE, SMALL, FEW	QUANTITY	SHRINK
71	< >	GREAT, LARGE, MANY	QUANTITY	EXTEND

TABLE III. EXAMPLES OF COMBINED SYMBOLS

NO.01 ◡ TO WARM + NO.61 ═ RAPIDLY + NO.63 ● VIGOROUSLY = NO.016163 ◡● TO WARM RAPIDLY AND VIGOROUSLY

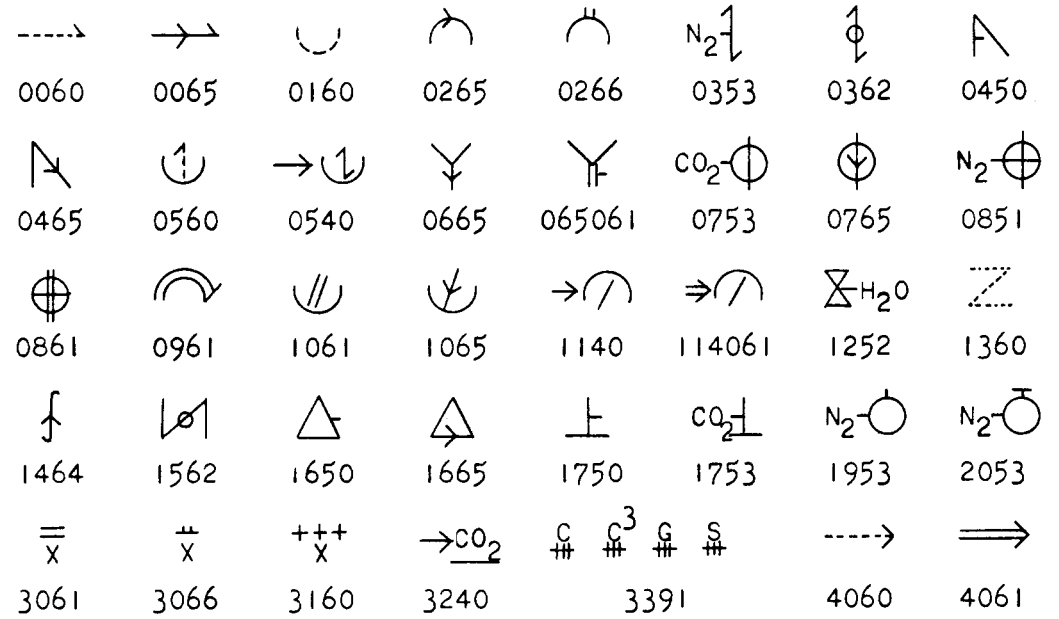


TABLE IV. CONNECTIVE SYMBOLS

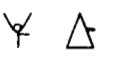
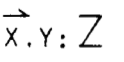
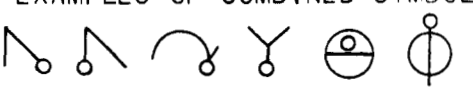
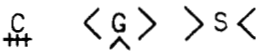
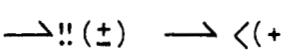
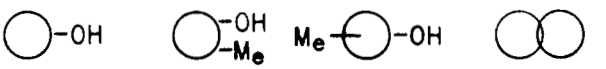
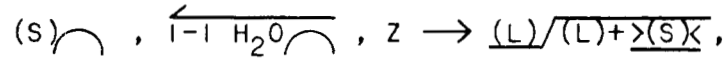
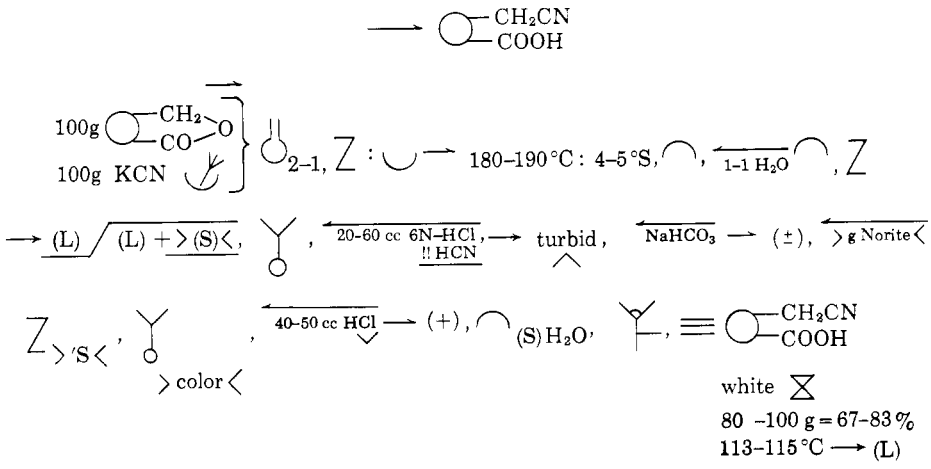
NO.	SYMBOL	MEANING	EXAMPLES OF COMBINED SYMBOLS
80	X,Y	X FOLLOWED BY Y	
81	X:Y OR $\frac{X}{Y}$	X AND Y AT THE SAME TIME	
82	$\underline{X/Y}$	X OR Y	
83	X_Y	X BY Y, X WITH Y, ETC.	
84	X(Y)	X IN Y	
85	X/Y	X ON Y	
86	X^N	X TO THE NTH	

TABLE V. CHEMICAL & MISCELLANEOUS SYMBOLS

NO.	SYMBOL	MEANING	EXAMPLES OF COMBINED SYMBOLS
90	•	THE PORTION USED	
91	C, G, S	LENGTH, WEIGHT, TIME (C.G.S.)	
	C^2, C^3	AREA, VOLUME	
	°S, 'S, "S or °, ', "	HOUR, MINUTE, SECOND	
	°C	DEGREE (CENTIGRADE)	
	(+),(±),(-)	ACID, NEUTRAL, BASIC	
	◯	BENZENE	
	(H)	CYCLOHEXANE	
	◯X	HETEROCYCLIC AROMATIC	
	(5)	CYCLOPENTADIENE	
	(7)	CYCLOHEPTATRIENE	
	(5)X	OLE RING	
99	(S),(L),(V)	SOLID, LIQUID, VAPOR	

EXAMPLE: 

ONE LITER OF WATER IS ADDED TO THE COOLED SOLID MASS, AND THE MIXTURE IS STIRRED UNTIL THE SOLID SALTS ARE DISSOLVED. ANY INSOLUBLE MATERIAL WHICH SEPARATES IS REMOVED BY FILTRATION.



For example, the symbol No. 01 for "to warm" or "to heat" was taken from the shape of water bath and its inverted symbol (No. 02) means "to cool." These symbols are mostly emblematic or are so interrelated that they are easily remembered. Symbol No. 00 is used in general with symbols having the function of a noun or adjective: Ex.: — OAc means "to O-acetylate."

2.2 Alteration Symbol.—Since the procedural symbols are transitive in sense, the alteration symbol is used when intransitive use is required: Ex.: → ◡ means "temperature rises."

2.3 Modifier Symbols.—These symbols are listed in Table II. They are used only in combination with procedural or alteration symbols. Some examples of combined symbols are given in Table III. The meaning of combined symbols is understood at a glance without any explanation. For example, it will be self-evident that the combined symbol No. 016163 in Table I, a combination of No. 01, No. 61, and No. 63, means "to heat rapidly and strongly."

2.4 Connective Symbols.—These indicate the relationship in time or space between ideas represented by two or more symbols, and examples are listed in Table IV.

2.5 Chemical Symbols.—Chemical symbols are used, but in the much simpler forms shown in Table V.

2.6 Miscellaneous Symbols.—General mathematical, physical, biological, and other symbols are used.

3. PRACTICAL EXAMPLES

The synthesis of *o*-carboxyphenylacetonitrile described in "Organic Syntheses" Vol. 22, p. 30, is given by means of the logograph in Fig. 1.

The original reads as follows:

> "A mixture of 100 g. of phthalide and 100 g. of powdered potassium cyanide is placed in a two-liter, round-bottomed flask fitted with a stirrer and a thermometer. The stirred mixture is heated to 180–190° (internal temperature) for four to five hours in an oil bath. One liter of water is added to the cooled mass, and the mixture is stirred until the solid salts are dissolved. Any insoluble material which separates is removed by filtration. Under a hood, 6*N* hydrochloric acid (20–60 cc.) is added to the dark aqueous solution until it becomes turbid. The solution is carefully neutralized with sodium bicarbonate, a few grams of Norit is added, and the mixture is stirred for several minutes and filtered. The nearly colorless filtrate is acidfied with 40–50 cc. of concentrated hydrochloric acid and, after cooling in an ice bath, is filtered with suction. The yield is 80–100 g. (67–83 per cent of the theoretical amount) of white crystals which melt at 113–115°."

The logograph now being used has been designed for intuitive writing and is not perfect as a "language by symbols," as will be apparent in Fig. 1. However, the fact that a fairly long narration by the logograph can be understood with a few explanations given above seems to suggest the possibility of its use as a symbolic language.

Aside from the brevity of narration, this kind of symbolic language would be of value in international communnication and would eliminate the difficulty or complexity of translation. It would also possibly serve in analysis of concepts in constructing a common language for mechanical translation of the description of chemical reactions and procedures.

Grateful acknowledgment is made to Miss Dorothy U. Mizoguchi for cooperation in preparing this manuscript.