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16. Abstract

Two studies were conducted to develop and initiate an evaluation of candidate pictographic symbols for motor vehicle displays. These symbols may be used either to label warning lights or identify gauges on instrument panels.

In the first study 28 students (all but one were licensed drivers) drew pictures to symbolize several vehicle functions. Drawings were obtained for seven "systems" (air, brake, coolant, fuel, hydraulic, oil, transmission), four system properties ("modifiers" - filter, fluid level, pressure, temperature), and 20 of the 28 possible system-modifier combinations. Based on those drawings (as well as industry, government, and international standards; manufacturers' suggestions; and the authors' ideas), sets of 5 to 12 candidate symbols (216 total) were assembled for 26 functions. Candidate symbols were not developed for the hydraulic system and related functions.

In the second study, 26 of the subjects from the first study made magnitude estimates of the meaningfulness of each candidate symbol for its intended purpose. Based on those ratings and other guidelines, a subset of the test symbols and alterations of them were recommended for further testing. In addition, it was found that the ratings for combined symbols could be predicted from independent ratings of their system and modifier elements.

This study was not intended to select the "best" symbol for each function in question, but rather to reduce the collection of candidates to a manageable number. It accomplished that goal.

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SYMBOL PRODUCTION STUDY

Introduction

The last few years have been a turning point in the evolution of motor vehicle design. Major changes have occurred in cars and, to a lesser extent, in trucks and buses. Noteworthy improvements have been made in crash resistance, fuel economy, and roominess. Another major change has been the retargeting of most motor vehicles towards the international market. A consequence of "world vehicle" programs is the need for controls (e.g., the headlight switch) and displays (e.g., the fuel gauge, the oil pressure warning light) to be identified in a language-free manner. The method of identification should facilitate safe operation by the entire driving population. Pictographic symbols meet these criteria.

This report is part of a series of studies concerned with pictographic symbols for vehicle controls and displays. Previous reports have dealt with developing symbols for specific applications, determining the visual characteristics that result in effective symbols, and comparing alternative test techniques (Green, 1977; Green, 1979a, b; Green and Davis, 1976 and Green and Pew, 1978). The purpose of this report was to develop candidate symbols for several vehicle functions and to weed out candidates that were clearly undesirable. These studies were primarily motivated by discussions that took place at recent meetings of the Society of Automotive Engineers Controls and Displays Subcommittee of the Human Factors Engineering Committee and the Symbols and Identification Task Force of that Subcommittee. (Symbols for truck and bus displays were cited as a special interest at committee meetings.) In addition, these studies served as a classroom illustration of the application of human factors research.

Suggestions for symbols may originate from compendia (Dreyfuss, 1972 or Modley, 1976), or may be developed independently by designers.

An even better source for candidate symbols is the user population--in this case, drivers. Suggestions for symbols can be readily elicited through "symbol production," a technique where users are asked to draw pictures representing the item(s) in question. (See Green, 1979a, 1979b; Howell and Fuchs, 1968; Karsh and Mudd, 1961; Krampen, 1969; Lerner and Collins, 1980; and Mudd and Karsh, 1962). This study made use of that technique.

Method

Subjects. Twenty-eight students (15 females and 13 males) enrolled in University of Michigan (Ann Arbor) course Psychology 560, Human Performance and Technology, served as subjects. Participation was a course requirement. (One student commented that since students paid tuition, they paid the University for the privilege of participation!)

Subjects ranged in age from 19 to 26 (mean 21.0). With one exception, all were licensed drivers. Psychology and industrial/graphic design majors were equally represented, along with several engineering students. Four of the males had prior experience with large trucks, three with farm machinery and one with construction equipment. Subjects reported having driven a variety of cars including one claim of a "Ford Chevy."

Apparatus. The experimental materials were photocopies of a six-page booklet. (A sample of the booklet is in Appendix 1.) The first page of that booklet was for biographical information; the second and third pages contained experimental instructions (read to subjects). Pages 4-6 contained arrays of response boxes. At the bottom of each box was a symbol label (e.g., "fluid level"). Page 4 was for both systems (e.g., coolant, oil) and modifiers (properties of systems, e.g., temperature). Pages 5 and 6 were for the combined symbols (system[s] plus modifier[s], e.g., coolant temperature).

Procedure. Subjects were asked to draw in each box a picture intended to represent the label provided. (The complete instructions are contained in the booklet in Appendix 1.) Systems were drawn first, then modifiers, and then combined symbols. In all, each subject produced drawings for 7 system, 4 modifier, and 20 combined symbols. (See Table 1.) Not all possible combinations of systems and modifiers were considered. Some pairings were nonsensical (e.g., air fluid level), while others were unlikely to be found in future cars, trucks, or buses (e.g., brake fluid filter).

It took the class about 30 minutes to complete this task.

Table 1. Items for which drawings were obtained.

Systems	Modifiers	Combined Symbols	
Air	Filter	Air Temperature Air Pressure Air Filter	Hydraulic Fluid Level Hydraulic Fluid Temperature Hydraulic Fluid Pressure Hydraulic Filter
Brake	Fluid Level	Brake Fluid Level	Oil Level Oil Temperature Oil Pressure Oil Filter
Coolant	Pressure	Coolant Level Coolant Temperature Coolant Pressure	Transmission Fluid Level Transmission Fluid Temperature Transmission Fluid Filter
Fuel	Temperature	Fuel Level Fuel Filter	
Hydraulic			
Oil			
Transmission			

Results

Appendix 2 contains reduced copies of all the subjects' drawings. The drawings have been grouped together by symbol, with systems appearing first, then modifiers, and then combinations. (Within each category, functions are ordered alphabetically.)

Because of the free-response nature of the symbol production task, quantitative analysis of the subjects' drawings is not possible, and only descriptions of the data will be offered. Shown in Table 2 are descriptions of the suggestions offered for systems and modifiers. Information concerning the details of those drawings (e.g., perspective and the frequency of representation of each concept) may be obtained from the drawings in Appendix 2. For many readers, the results will be most informative if a quick perusal of Appendix 2 precedes further reading of this section.

The ease with which subjects produced drawings varied substantially. Among functions, uniformity of suggestions also varied widely. For example, for the temperature modifier, a thermometer was the predominant suggestion. Likewise, for fluid level, a container with a wavy line for the fluid surface predominated.

Less consistent were the drawings for the filter and pressure modifiers. For the filter, there were drawings of filtration materials (e.g., crosshatching) and filter elements (e.g., air filter). For pressure, both its exertion (arrows pointing in) and the consequences of it in excess (explosions) were depicted.

For the fuel and oil, containers and dispensers of them were suggested. For the transmission symbol, both gear mechanisms and shift levers were offered. Suggestions for these three systems were more diverse than for the temperature and fluid level modifiers.

Even more variable were the suggestions for the brake symbol (e.g., foot pedals, braking mechanisms [brake shoes]). Among subjects' suggestions for the coolant symbol were cold objects (e.g., snowflake, snowperson), cooling mechanisms (a radiator), and representations of overheating (heat waves above a car hood).

For the engine air system, subjects were faced with drawing a picture of something they could not see. Suggestions included associated objects (e.g, balloons) and several clever attempts at direct representation (swirling dotted [hidden] lines).

With regard to the hydraulic system, most subjects indicated that they did not know what a hydraulic system was for. (A car hoist was the favored offering.)

Table 2. Some Concepts Depicted in Subject's Drawings.

SYSTEMS	
Air (Engine)	- swirling lines, fan, sailboat, engine block (with arrows to air cleaner), air cleaner, bicycle pump, balloon(s), hood scoop, person inhaling
Brake	- foot pedal(s) (foot sometimes shown), wheel(s) and chock(s), wheel and brake shoes, diagram of brake lines, sliding foot, stop sign (octagon)
Coolant	- melting ice cubes, snowflakes, glass of liquid with ice, snowperson, steam (curling lines) emanating from hood, igloo, engine block and heat waves, radiator, thermometer
Fuel	- a drop, filling station, pump, pump nozzle, gallon gasoline can
Hydraulic (system)	- liquid pouring from one vessel to another, meshing gears, piston inside cylinder, car on hoist, hydraulic jack, brake fluid reservoir
Oil	- drop, quart can(s) (usually single can with spout), oil drilling rig, locomotive oiler's can, dipstick, engine block and fluid level
Transmission	- gear, meshing gears, shift knob (and shift pattern), shift lever and accordian cover, transmission block, belt and pulleys, $200 bill
MODIFIERS	
Filter	- crosshatching, kitchen strainer, car oil filter, car air filter, transition from solid to dotted area, solid area with holes, funnel with folded paper filter (as would be found in a chemistry lab)
Fluid Level	- vessel with wavy lines for fluid surface, measuring cup, graduated cylinder (from chemistry lab), arrows up and down
Pressure	- flat hand pushing on surface, arrows pointing to line, balloon, arrows pointing to or from center of circle, "exploding bomb"
Temperature	- thermometer, sun, car with wavy lines from hood, campfire

Subjects often generated combined symbols by merging system and modifier elements. They were especially consistent in carrying through modifiers (e.g., crosshatching for filter, thermometers for temperature, wavy lines for fluid level). This was even the case where the symbol was for a tangible piece of equipment (e.g., air filter). This generation technique provided for an increased number of possibilities, and hence, suggestions across subjects were highly variable. On the other hand, this technique lead to greater uniformity within subjects.

Combined symbols for the hydraulic system functions presented special difficulties for subjects. In many cases, despite considerable urging, subjects were unable to generate many suggestions. (Again, see Appendix 2.)

Based on subjects' suggestions, candidates were developed for all of the functions in question. Those candidates and their evaluation are described in the next section.

Several key points should be highlighted before proceeding. First, for almost every symbol, subjects had numerous ideas. Their suggestions were obtained quite easily and at a minimum cost. Many of them would not have been thought of by the authors alone. Second, when developing combined symbols, subjects often combined previously drawn suggestions of the components rather than offering unique new ideas.

Finally, based on this study and other experience, there seemed to be categorical differences in the way non-engineers and engineers think about equipment and the associated symbology. Engineers took an "internal" or mechanistic view of the hardware, while non-engineers took an "external" or operational view. For example, for the brake system, drivers tended to draw pictures of either feet and foot pedals (operation of the brake system) or a car skidding (a consequence of operation). On the other hand, engineers often suggested pictures of the brake shoes, parts not ordinarily visible. Likewise, for the transmission, engineers drew meshing gears whereas drivers drew pictures of the shift lever. It is important in developing symbols that the users' (drivers) perspective be kept in mind.

SYMBOL INFORMATIVENESS RATING STUDY

Introduction

Many characteristics of symbols need to be considered when a symbol set is being evaluated. Among those characteristics are ease of identification, informativeness of each member, ease of learning, speed of identification after practice, and visual confusability with similar symbols (especially when degraded by size or contrast reduction).

Numerous procedures for evaluating these characteristics of symbols have been suggested (Anonymous, 1979; Cairney and Sless, 1978; Easterby and Heikel, 1979a, b; Egar, 1979; Green and Pew, 1978; Sless and Cairney, 1979; Zwaga, 1979). Because the cost and time to develop and test a symbol set depends upon set size, the number of candidates evaluated in large-scale field studies should be kept reasonably small. Consequently, an initial, multi-candiate symbol set should be screened by a small group of users via a simple paper and pencil test. Based on their reactions, symbols can be modified and undesirable candidates discarded. Further, more extensive testing of the reduced set should then follow with a larger, often international sample of subjects. The study presented here is concerned with the initial part of that test sequence.

Because meaningfulness is probably the most important attribute of symbols, it should be evaluated first. While many tests of meaningfulness have been developed, a rating procedure similar to that of Green (1979a) was selected for the initial screening. The major advantage of this procedure is the speed with which the data can be collected and analyzed.

Method

Subjects. Except for two subjects who were absent (one male and one female), the same subjects from the symbol production study participated in this study. It was conducted five days after the production task.

Apparatus. Serving as test materials were 20-page booklets. (A sample booklet is contained in Appendix 3.) The first page of the booklet contained the instructions (read aloud) for this screening task. The other 19 pages contained arrays of symbols. The symbols were arranged in circular arrays of five to twelve candidates surrounding each symbol label. There were from one to three arrays per page. Arrays were constructed so that variations of the same theme were not in adjacent positions and that across arrays the authors' *a priori* favorite symbol was never in the same position (especially at the top).

Photocopies were black on white with a contrast ratio of about 1:5. Symbols were drawn so as to fit roughly inside of an imaginary 3/4 inch (19 mm) circle.

Symbols were obtained from several sources. Many were simplified versions of subjects' drawings. In addition, suggestions were obtained from Hallen (1977), from ISO Standard 2575, (International Standards Organization, 1979), SAE Standard J1048 (Society of Automotive Engineers, 1979), FMVSS 101 (U.S. Department of Transportation, 1979), and the authors. Where there were several similar suggestions, usually only one variation was examined. Suggestions were selected by using the dual criteria of expected meaningfulness and variety. The selection of candidates for the combined symbols was most difficult as there was an abundance of suggestions for them. Overall, 216 candidates were presented.

Procedure. Subjects were instructed to provide magnitude estimates of the meaningfulness of each candidate picture for each symbol. Specifically, subjects were shown a picture of the ISO front hood release symbol. Its meaningfulness was arbitrarily defined as 10. More meaningful symbols were assigned proportionally larger ratings by subjects, and less meaningful pictures were assigned proportionally smaller ratings. (See Appendix 3 for the complete instructions.)

The sheets in the booklet were arrranged so that the subjects considered systems first, then modifiers, then combined symbols.

Within those categories the order of sheets was partially counter-balanced across subjects.

After subjects had rated all symbols, they copied their ratings onto a response form (contained in Appendix 4). This form facilitated the distribution of all the data to the class at the subsequent meeting. The rating and copying took almost one hour--too long, according to subjects.

Results

To eliminate skewness, the natural logarithm of each rating plus 1 served as the unit of analysis. (One was added because the log of zero is undefined.) These ratings were then examined via analysis of variance with Sex, Subjects nested within Sex, Function, and Candidates nested within Function as the main effects. As is shown in Table 3, all main effects and the Sex by Function interaction were highly significant ($p < .001$). (Other interactions were not examined.)

Table 3. ANOVA of Ln_e ratings.

Factor		df	SS	MS	F	p
X	Sex	1	46.127	46.127	124.00	< .001
S(X)	Subjects	24	782.240	35.593	87.62	< .001
F	Function	25	151.440	6.058	16.29	< .001
C(F)	Candidate	190	748.214	3.937	10.58	< .001
XF		25	215.560	8.662	23.18	< .001
error = XC(F) + SF(X) + SC(XF)		5350	1989.019	.372	--	--
		5615	3932.600			

With regard to respondents, males tended to rate candidates as more informative than females (logarithmic means of 1.57 and 1.38 respectively). Differences due to biographical variables were also found. The mean natural log ratings for the males familiar with trucks and farm machinery were larger than those for the rest of the subjects $F(1,5614) = 101.99$, $p < .001$, (1.78, 1.43) and those of other males $F(1,2590) = 64.066$, $p < .001$, (1.78, 1.49). Drivers of foreign cars offered slightly higher ratings (means of 1.50 and 1.46) ($F(1512, 4104) = 3.22$ $p = .07$). (Foreign car manufacturers, in general, make greater use of symbols.)

With regard to symbols the mean logarithmic ratings by function are shown in Table 4. When divided into 3 logical categories, significant differences were found $F(2,5615) = 9.03$, $p < .001$ with modifiers (mean = 1.58) being rated as more informative than systems (1.45) or combined symbols (1.45). The authors can find no obvious explanation for this. In general, modifiers correspond to adjectives in alphabetic languages, and systems to nouns. Usually nouns, being more concrete, are easier to recognize in pictorial languages. The results do not support this general rule.

Within all three categories (modifiers: $F(3,884) = 9.58$, $p < .001$; systems: $F(5,1455) = 14.32$, $p < .001$; combined symbols: $F(5,3286) = 38.50$, $p < .001$), there were significant differences. Furthermore, the correlation between the best candidates for each function and the function means was higher than expected ($r(24) = .80$, $p < .001$). Thus, how well a set of symbols can represent a concept is highly function dependent.

However, the most important analyses are for the between-candidate differences for each function. Shown in the following 20 pages are one-page summaries for each of the 20 sets. Especially important are the recommendations for further study included on those pages. Those recommendations were based on the following criteria:

1) How well each candidate was rated in this study.

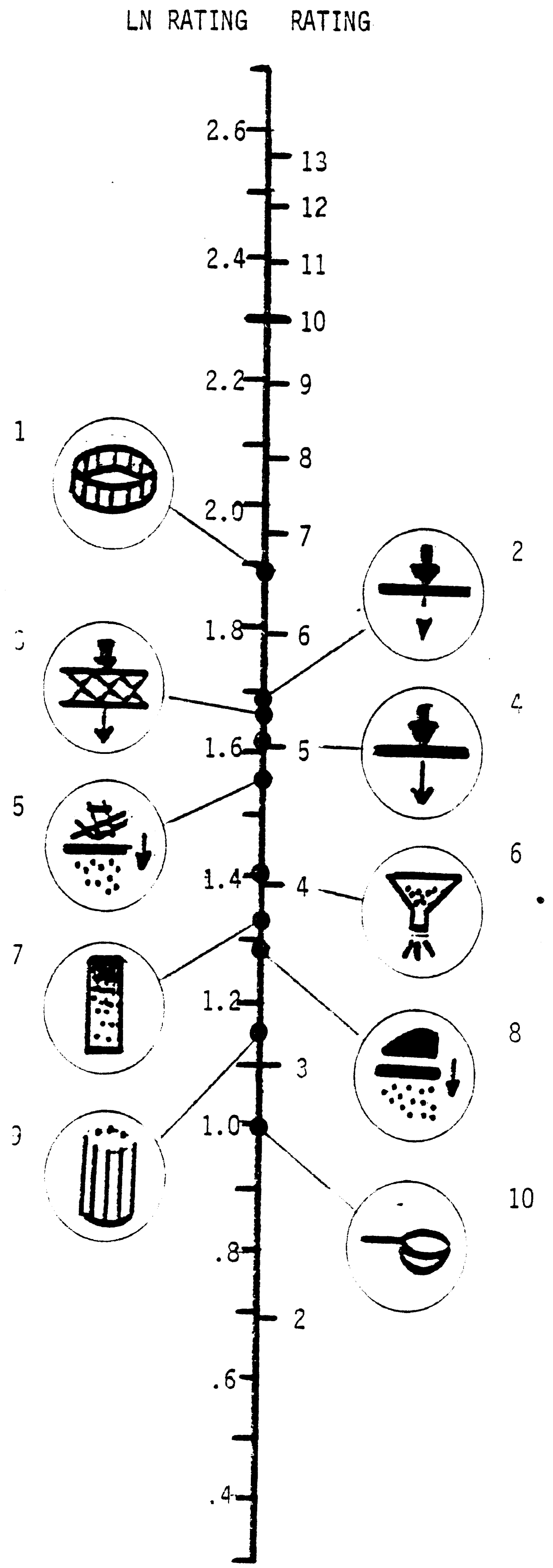
Table 4. Logarithmic mean ratings by function.

Function	n	Logarithmic Mean	
Modifiers			
Filter	260	1.47	
Fluid Level	208	1.80	
Pressure	234	1.38	
Temperature	156	1.78	
			1.58
Modifiers Systems			
Air	182	1.16	
Brakes	286	1.42	
Coolant	312	1.20	
Fuel	208	1.82	
Oil	260	1.56	
Transmission	208	1.60	
			1.45
Combined Symbols			
Air Filter	156	1.47	
Air Pressure	130	1.33	
Air Temperature	156	1.39	
Brake Fluid Level	234	1.32	
Coolant Level	130	1.46	
Coolant Pressure	234	1.48	
Coolant Temperature	260	1.47	
Fuel Filter	156	1.25	
Fuel Level	182	1.61	
Oil Filter	182	1.51	
Oil Level	260	1.35	
Oil Pressure	260	1.38	
Oil Temperature	208	1.71	
Transmission Filter	182	1.46	
Transmission Fluid Level	286	1.42	
Transmission Temperature	286	1.50	
			1.45
GRAND	5616	1.47	

2) Inclusion or prospective inclusion in an international standard.

3) Advocacy or use of a symbol by a manufacturer. (Because the modification of production vehicles may be required, additional testing may be warranted as a precaution.)

Also contained on each page is a scale depicting the rank order of candidates for each function (1 = most meaningful), a table of the arithmetic and logarithmic mean ratings, a one-way ANOVA for each function, and the continuing text of the results section.



FILTER

ANOVA

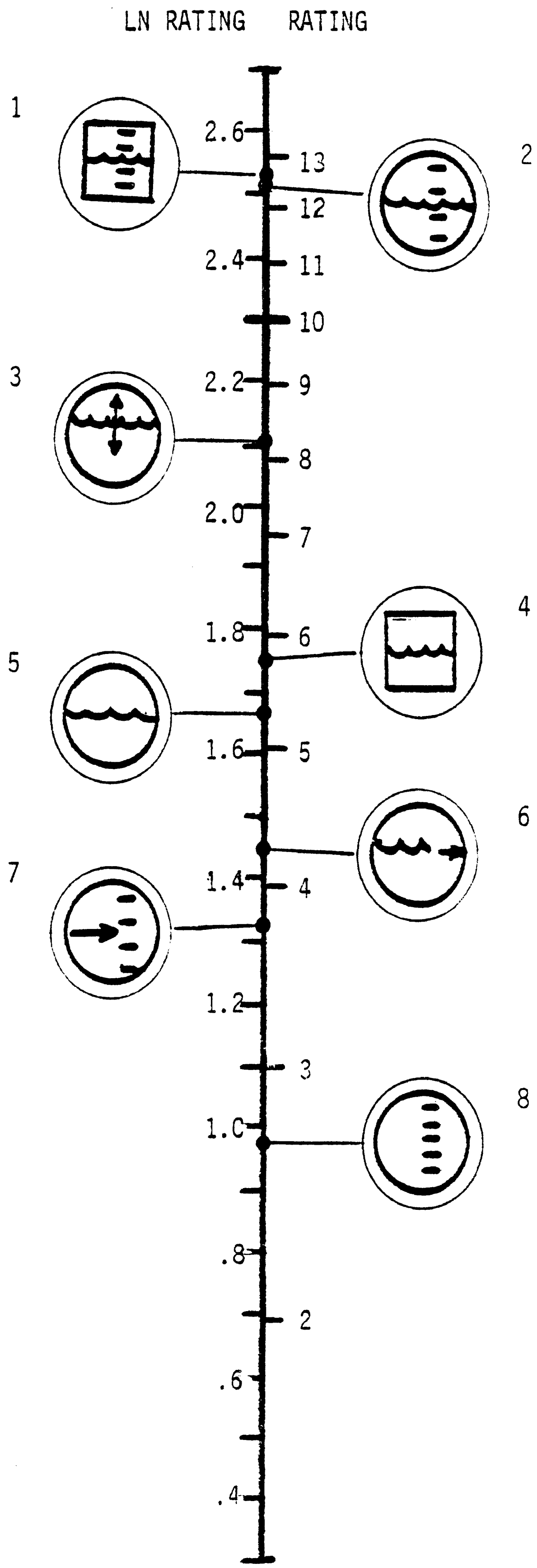
Source	df	SS	MS	F	p
Between	9	17.21	1.91	3.77	.000
Within	250	126.94	.51		
Total	259	144.15			

Ratings

Rank	Mean of Ln	Mean
1	1.89	6.64
2	1.69	5.42
3	1.67	5.32
4	1.63	5.10
5	1.57	4.80
6	1.40	4.06
7	1.35	3.85
8	1.29	3.64
9	1.16	3.20
10	1.01	2.74
Grand	1.47	4.34

Results and Discussion

The most informative candidate was the ring-like symbol (an air filter) followed by three versions of the "double arrow" symbol. Deserving further testing are a neater version of candidate 1, candidates 2 and 3, and possibly 5. Additional candidates should be sought.



FLUID LEVEL

ANOVA

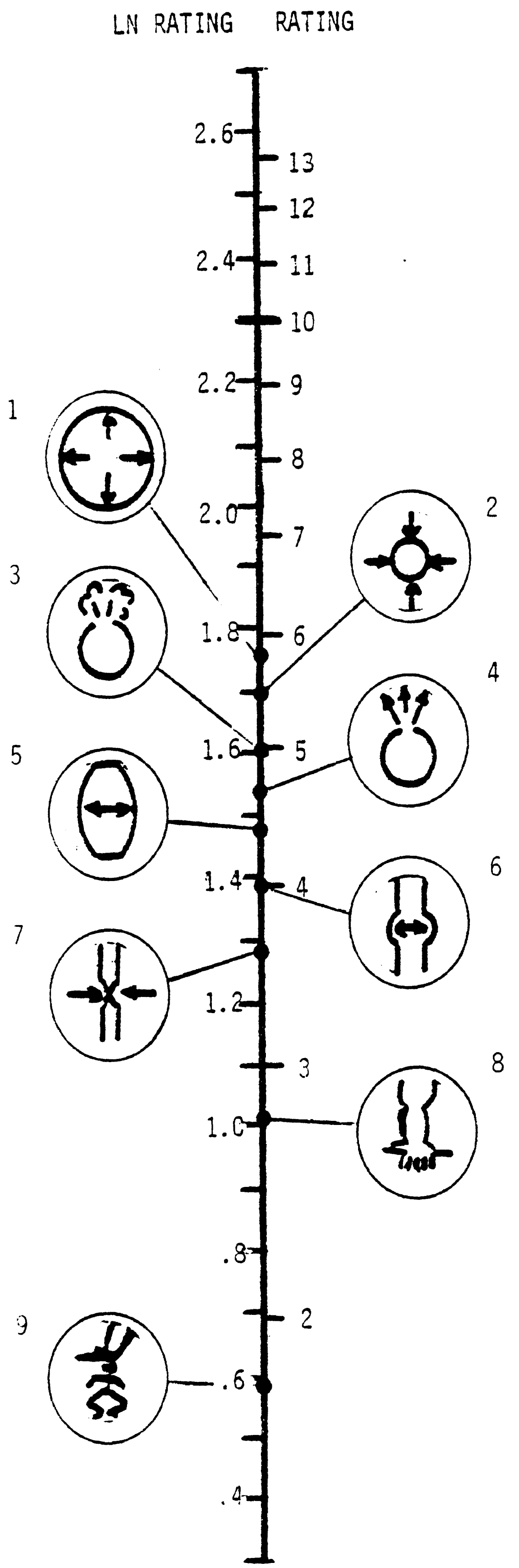
Source	df	SS	MS	F	p
Between	7	57.58	8.26	17.84	.000
Within	200	92.22	.46		
Total	207	149.80			

Ratings

Rank	Mean of Ln	Mean
1	2.53	12.57
2	2.51	12.36
3	2.12	8.31
4	1.76	5.81
5	1.67	5.32
6	1.46	4.29
7	1.32	3.76
8	.96	2.61
Grand	1.79	6.00

Results and Disucssion

Candidates 1 and 2 (waves and level indices) were both highly rated, and either would be acceptable as a symbol for fluid level. As a double check of the best interior form, candidates 2 and 3 should be subjected to additional testing.



PRESSURE

ANOVA

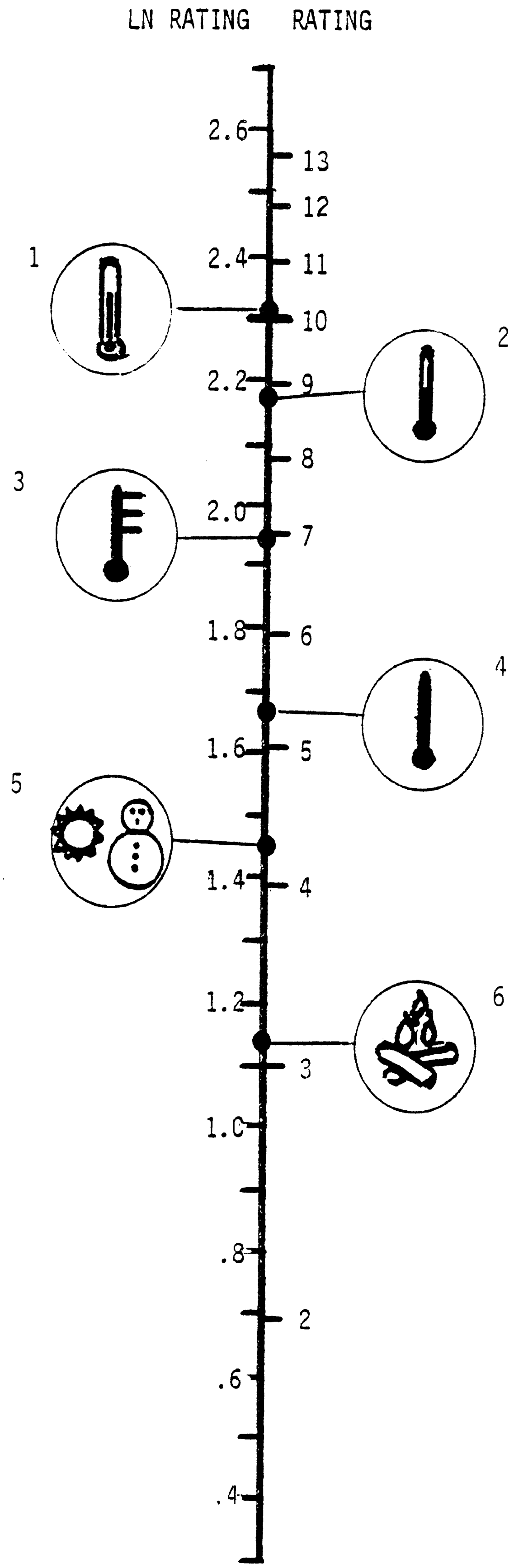
Source	df	SS	MS	F	p
Between	8	28.59	3.57	7.19	.000
Within	225	111.88	.50		
Total	233	140.46			

Ratings

Rank	Mean of Ln	Mean
1	1.76	5.81
2	1.70	5.48
3	1.61	5.00
4	1.55	4.71
5	1.49	4.43
6	1.39	4.03
7	1.28	3.60
8	1.02	2.76
9	.60	1.81
Grand	1.38	3.96

Results and Discussion

There was almost no difference in subjects' ratings for candidates 1 (inside arrows) and 2 (outside arrows), though in most contexts candidate 1 will be more appropriate. Candidates 1, 2, and 4 (possibly modified to include inside arrows) deserve further testing. (Candidate 3 was excluded because its details will be lost when reduced.) New candidates should also be developed.



TEMPERATURE

ANOVA

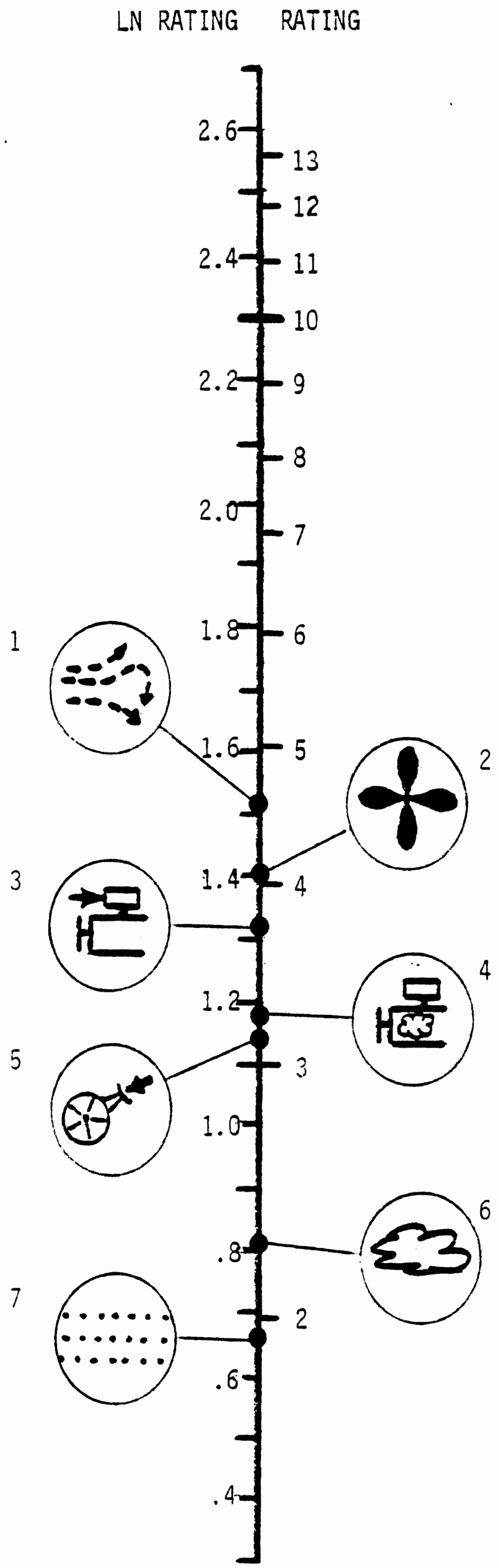
Source	df	SS	MS	F	p
Between	5	25.50	5.10	10.86	.000
Within	150	70.44	.47		
Total	155	95.94			

Ratings

Rank	Mean of Ln	Mean
1	2.31	10.08
2	2.18	8.88
3	1.93	6.91
4	1.66	3.15
5	1.47	4.34
6	1.15	3.15
Grand	1.78	5.95

Results and Discussion

Either candidates 1 or 2 (thermometers) could serve as the symbol for temperature, though #1 is preferable. Both are almost as informative as the standard and are substantially better than candidate 3, an adaptation of the ISO symbol for coolant temperature. No further development of the temperature symbol is required.



A I R

ANOVA

Source	df	SS	MS	F	p
Between	6	15.08	2.51	4.04	.001
Within	175	108.74	.62		
Total	181	123.82			

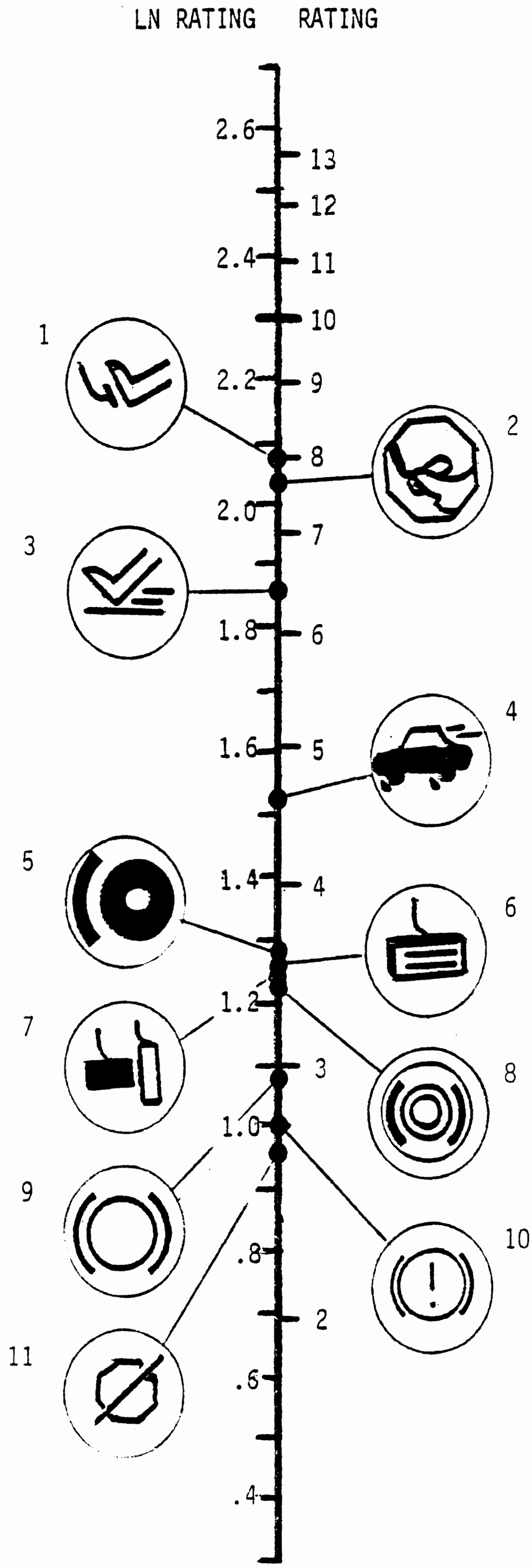
Ratings

Rank	Mean of Ln	Mean
1	1.53	4.60
2	1.41	4.09
3	1.33	3.77
4	1.18	3.27
5	1.16	3.18
6	.82	2.26
7	.67	1.96
Grand	1.16	3.18

Results and Discussion

Candidates for engine air were the least informative overall of the functions tested. (As neither air nor its effects are readily observable, this is to be expected.) The best of the candidates (dotted curved arrows) was less than half as informative as the standard. Candidates 1 (dotted arrows) and 3 (engine block, side view) should be tested further. (Candidate 2 (propeller) will be confused with the ISO symbol for fan.) Additional candidates should also be sought.

BRAKES



ANOVA

Source	df	SS	MS	F	p
Between	10	42.99	4.30	8.39	.000
Within	275	140.91	.51		
Total	285	183.90			

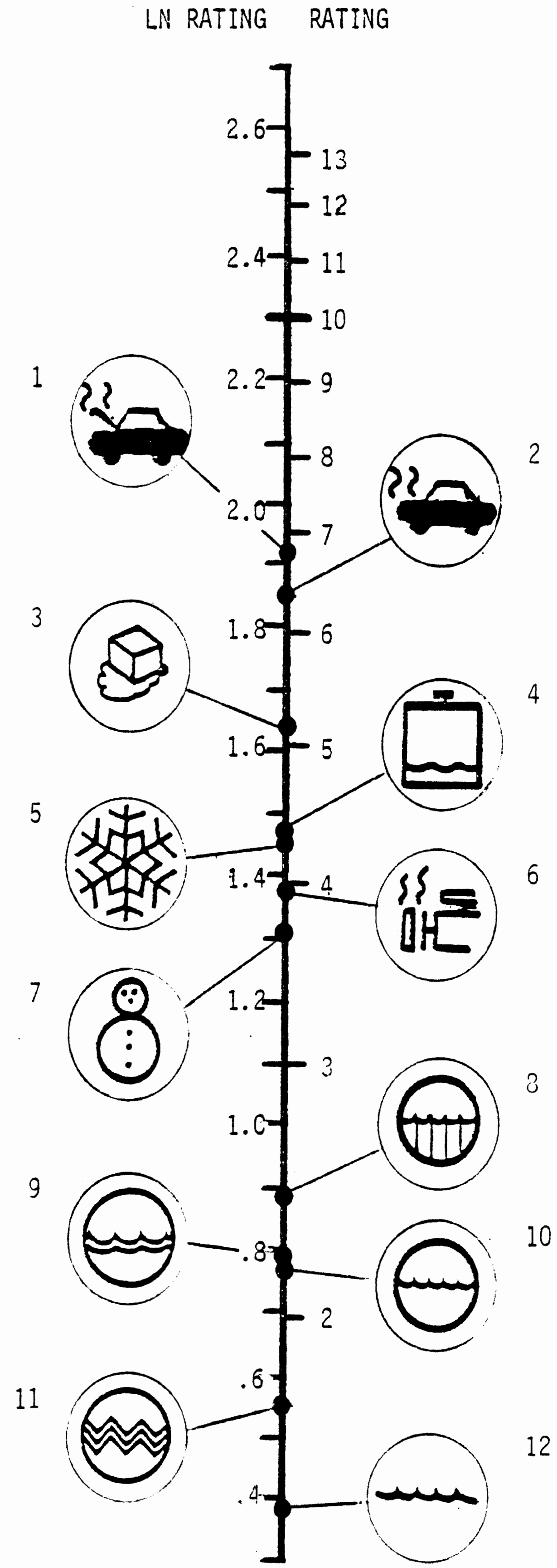
Ratings

Rank	Mean of Ln	Mean
1	2.09	8.06
2	2.06	7.88
3	1.86	6.44
4	1.10	2.99
5	1.28	3.60
6	1.27	3.56
7	1.26	3.54
8	1.25	3.51
9	1.10	2.99
10	1.01	2.74
11	.95	2.60
Grand	1.42	4.15

Results and Discussion

Candidates 1 (foot and pedal, side view) and 2 (foot and pedal, perspective) were almost as informative as the standard, and candidate 3 (sliding foot) was only slightly below them. Wheel and brake shoe representations (candidates 9 and 10) similar to symbols to be incorporated into ISO standard 2575, received very low ratings! (Both Heard (1974) and McCormick (1974) reported foot pedal candidates for brakes to be interpreted more rapidly and accurately than brake shoe candidates. Similarly, Frank, Koenig, and Lendlolt (1973); Lendholt (1974), and Simmonds (1970) reported high error rates for brake shoe candidates). Nonetheless, it is suggested that candidates 1, 3, 9, 10 (and 2, if it can be redrawn) be retested.

COOLANT



ANOVA

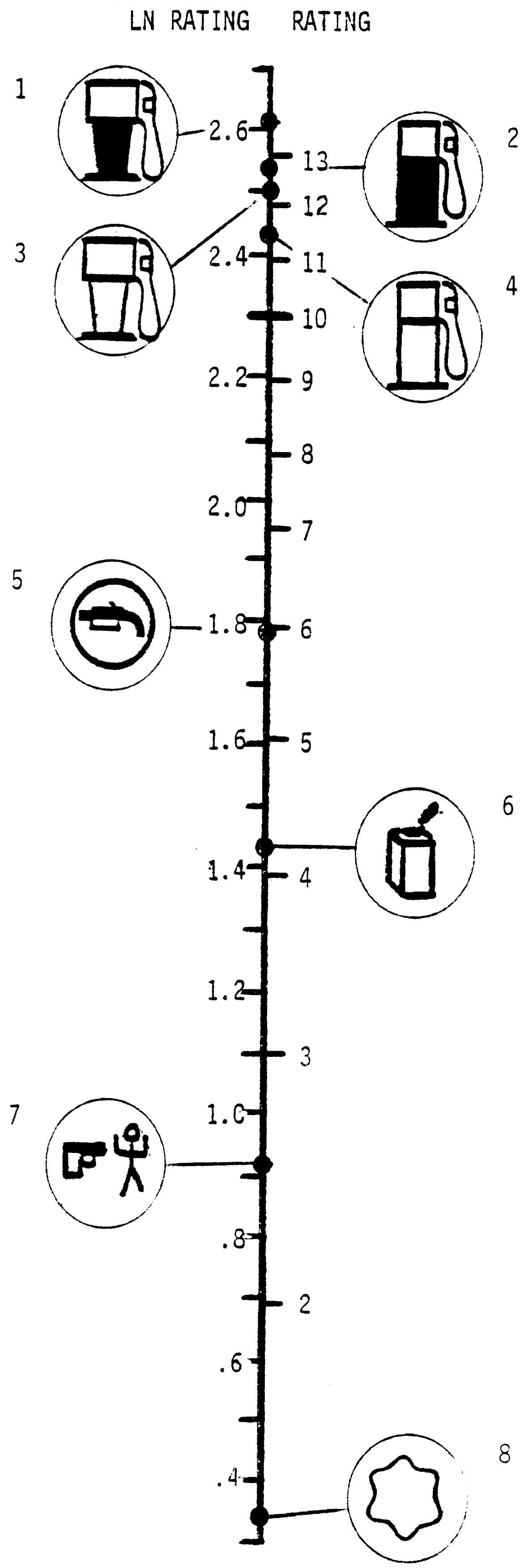
Source	df	SS	MS	F	p
Between	11	74.22	6.75	12.75	.000
Within	300	158.70	.53		
Total	311	232.92			

Ratings

Rank	Mean of Ln	Mean
1	1.93	6.88
2	1.85	6.34
3	1.63	5.12
4	1.48	4.37
5	1.45	4.28
6	1.38	3.99
7	1.31	3.72
8	.89	2.44
9	.78	2.19
10	.78	2.17
11	.56	1.75
12	.38	1.47
Grand	1.20	3.33

Results and Discussion

Subjects rated symbols showing cars with heat waves emanating from their hoods (#1 and #2) as the best candidates for coolant. Deserving further testing are candidates 1, 2, 4 (after modifying the radiator to emphasize the wave crests and filling in the fluid outline) and 6. Candidate 3 (ice cube) was not very informative when combined with the modifiers; candidate 6 (engine block, side view) was. Candidate 5 (snowflake) has also been suggested as a symbol for air conditioner.



FUEL

ANOVA

Source	df	SS	MS	F	p
Between	7	133.31	19.04	44.15	.000
Within	200	86.27	.43		
Total	207	219.58			

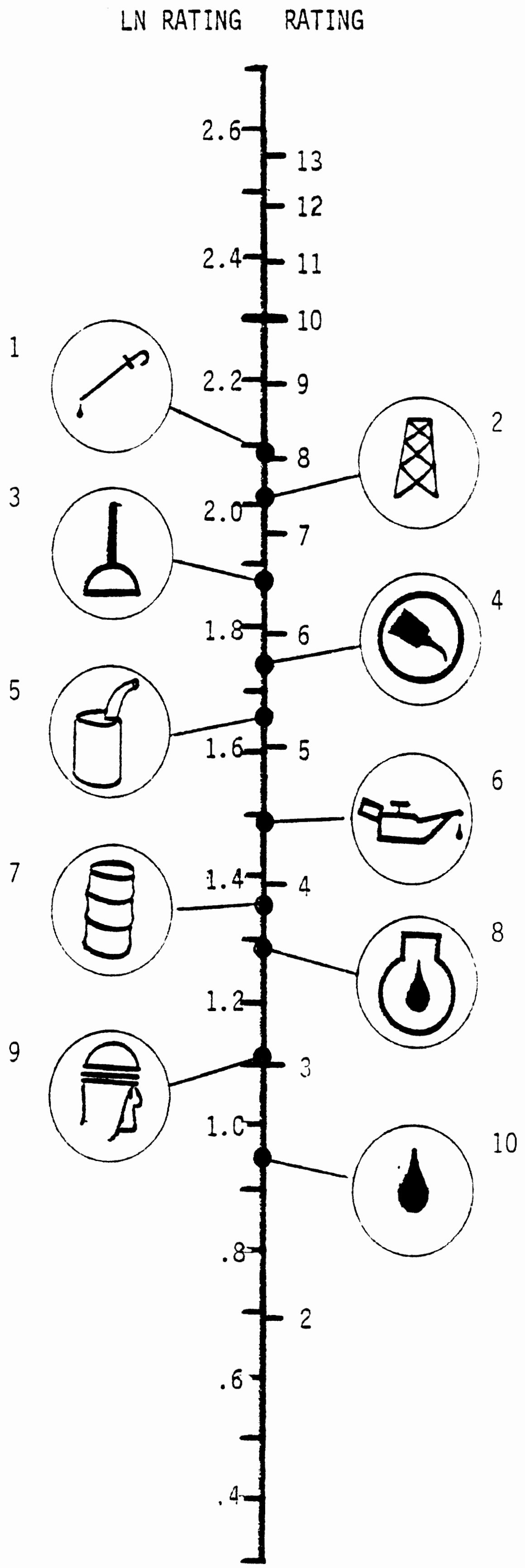
Ratings

Rank	Mean of Ln	Mean
1	2.61	13.61
2	2.53	12.58
3	2.50	12.24
4	2.43	11.40
5	1.79	5.99
6	1.43	4.16
7	.92	2.52
8	.34	1.40
Grand	1.82	6.17

Results and Discussion

Consistent with the results of Green and Pew (1978), both the current ISO 2575 symbol for fuel (candidate 2) and a more modern rendering of the fuel pump (#1), were rated as more informative than the standard symbol. Outline variants (3 and 4) were slightly less informative. While ISO has moved to permit outline alternatives for several symbols, Green (1976) found that symbol boldness was a quality that led to fewer errors and shorter response times. Similar conclusions can be drawn from the Heard (1974) and McCormick (1974) data for alternative fuel symbols. It is therefore suggested that ISO standard 2575 be revised so that candidate 1 becomes the only acceptable symbol.

O I L



ANOVA

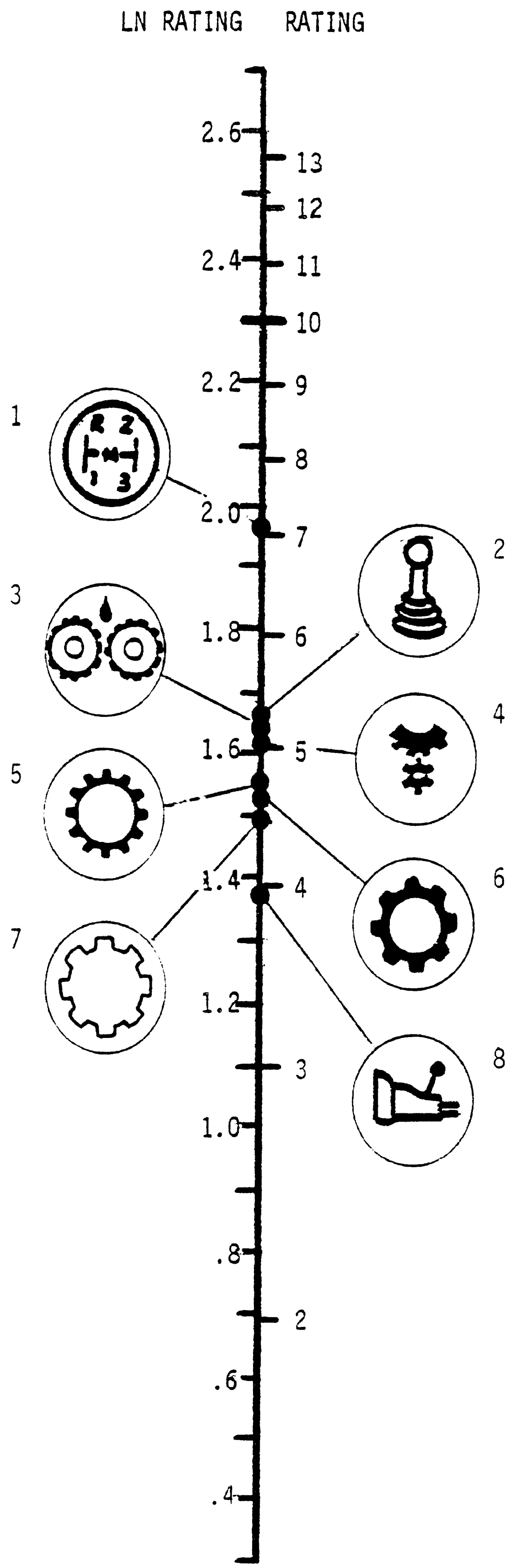
Source	df	SS	MS	F	p
Between	9	34.78	3.86	6.60	.000
Within	250	146.45	.59		
Total	259	181.23			

Ratings

Rank	Mean of Ln	Mean
1	2.10	8.13
2	2.03	7.58
3	1.87	8.51
4	1.74	5.70
5	1.66	5.26
6	1.50	4.46
7	1.37	3.94
8	1.29	3.63
9	1.12	3.08
10	.94	2.55
Grand	1.56	4.77

Results and Discussion

Neither the symbol resembling the ISO 2575 symbol for engine oil (candidate 6) nor candidate from ISO draft standard 3767 (#8, actually for engine oil fill) were rated as very informative. Candidate #9, because it was out of context, also was not informative. The most informative candidates were the dip-stick and the oil drilling rig. Both Heard (1974) and McCormick (1974) found the dip-stick (similar to #1) to be responded to more rapidly and accurately than the oil can (similar to #6). Candidates 1 (modified to increase boldness) through 6 should be tested. While some have suggested that the following symbol be considered (Olive Oyl) such temptation must be resisted.



TRANSMISSION

ANOVA

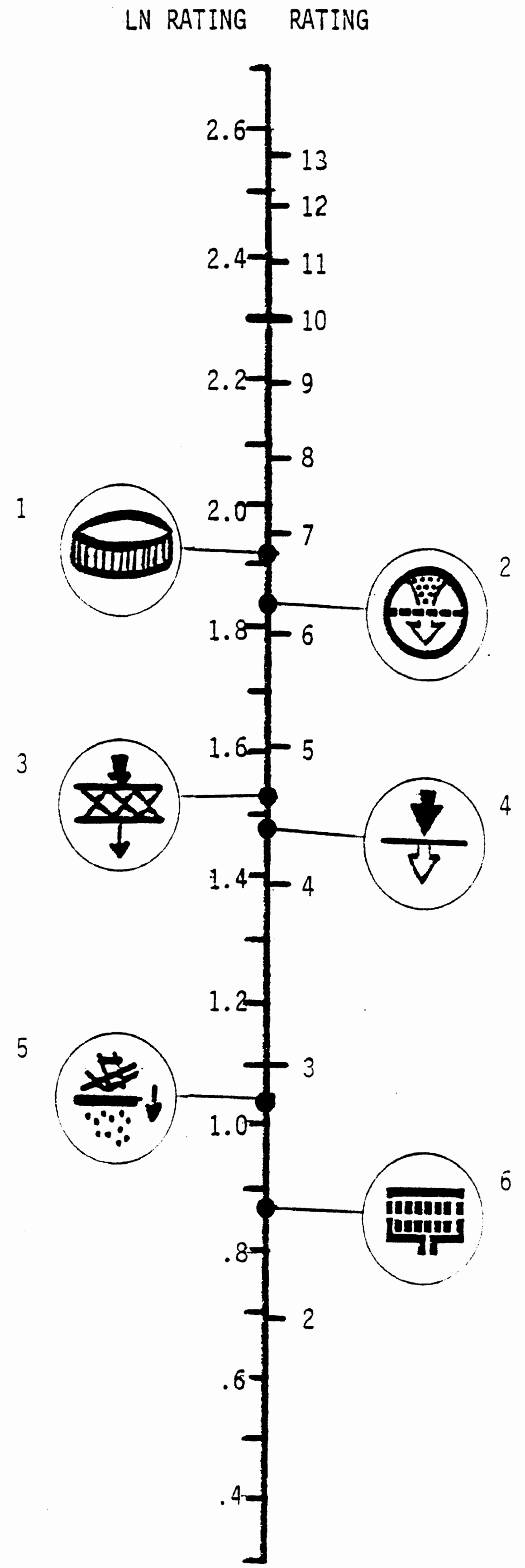
Source	df	SS	MS	F	p
Between	7	5.39	.77	1.25	.277
Within	200	123.23	.62		
Total	207	128.62			

Ratings

Rank	Mean of Ln	Mean
1	1.96	7.12
2	1.66	5.25
3	1.63	5.09
4	1.62	5.03
5	1.56	4.75
6	1.51	4.53
7	1.50	4.49
8	1.37	3.44
Grand	1.60	4.96

Results and Discussion

Ratings of the candidates for the transmission system fall into three groups: the shift pattern symbol (the best), the transmission housing symbol (the worst), and all others. Deserving further testing are candidates 1, 2, and 6. (Candidates 2 (shift lever) and 6 (gear) were chosen because they are fairly simple and will reproduce well.)



AIR FILTER

ANOVA

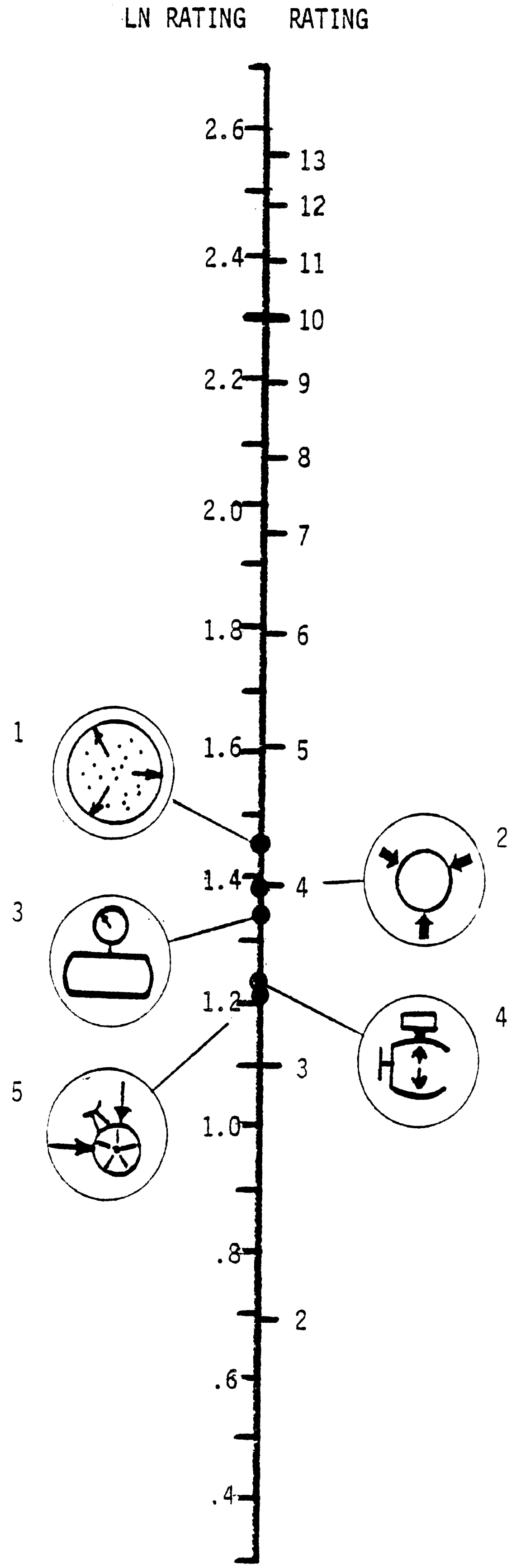
Source	df	SS	MS	F	p
Between	5	21.21	4.24	7.82	.000
Within	150	81.40			
Total	155	102.61			

Ratings

Rank	Mean of Ln	Mean
1	1.93	6.86
2	1.84	6.28
3	1.53	4.59
4	1.49	4.43
5	1.14	3.12
6	.87	2.39
Grand	1.47	4.33

Results and Discussion

Ratings of the symbols for (engine) air filter fall into three clusters. Top rated were a picture of an air filter (#1) followed by the single arrow symbol (a suggestion from ISO draft standard 3767). Somewhat less informative were two symbols similar to the double arrow candidate for filter. It is suggested that candidates 1 (possibly redrawn) along with 2-5 be tested. In addition, a symbol in which the single arrow is replaced by several dotted arrows (resembling candidate 1 for the air symbol) should be developed.



AIR PRESSURE

ANOVA

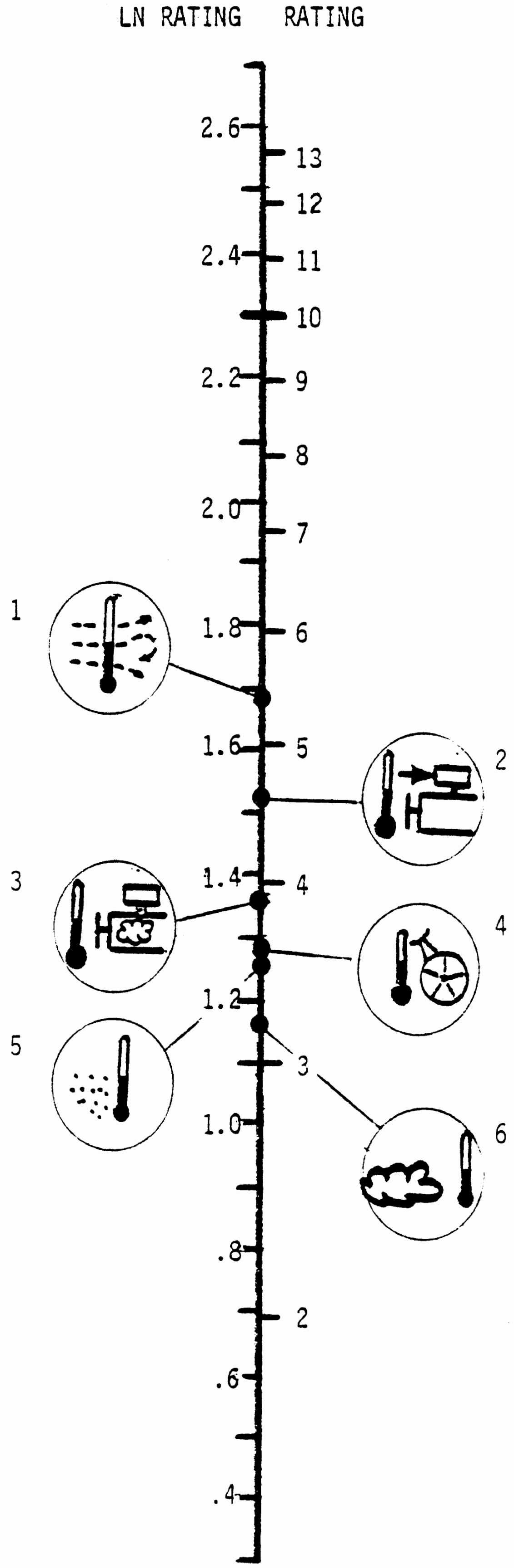
Source	df	SS	MS	F	p
Between	4	1.06	.27	.44	.777
Within	125	74.97	.60		
Total	129	76.03			

Ratings

Rank	Mean of Ln	Mean
1	1.47	4.35
2	1.38	3.98
3	1.34	3.83
4	1.24	3.47
5	1.22	3.40
Grand	1.33	3.79

Results and Discussion

None of the symbols for (engine) air pressure were highly rated, and the differences between the candidates were small. Independently, air and pressure are difficult to symbolize. It is suggested that two candidates be developed: one based on candidate #1 for air (dotted arrows) in conjunction with candidate #2 for pressure (inside arrows), and a second based on candidate #3 for air (engine block, side view). In addition, air pressure candidate #2 should be modified by filling the center circle with dots (to represent air). The new candidates should be tested along with existing candidates 1 (dots and inside arrows) and 3 (gauge and air reservoir).



A I R T E M P E R A T U R E

ANOVA

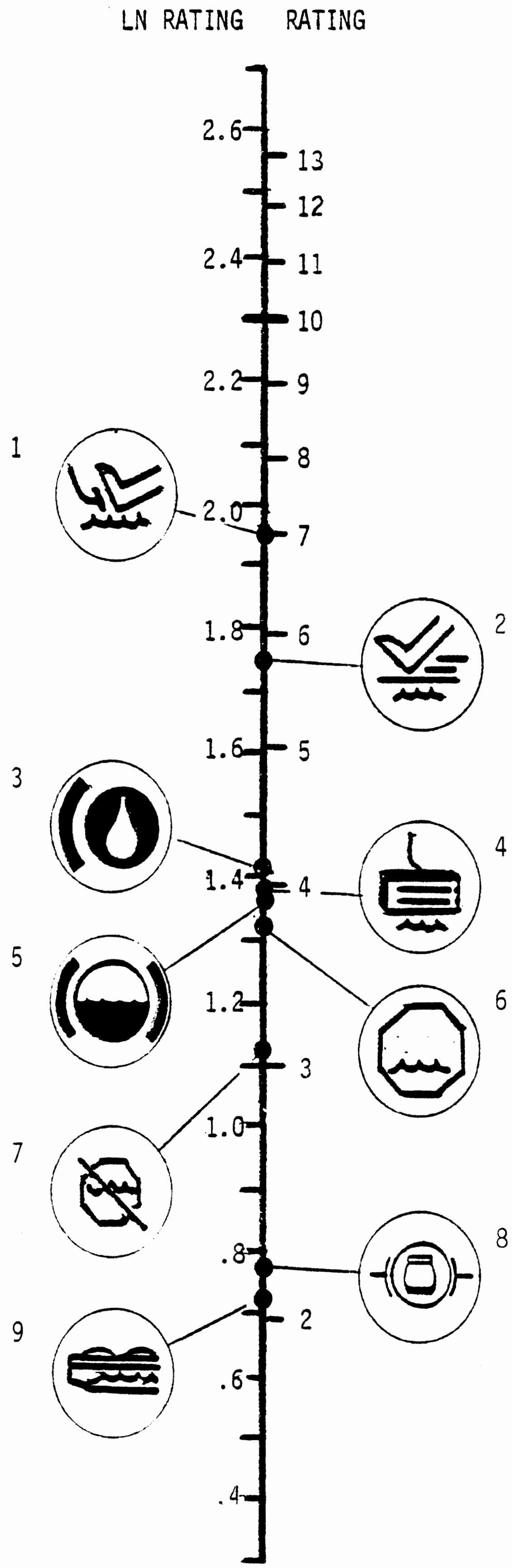
Source	df	SS	MS	F	p
Between	5	4.62	.92	1.46	.206
Within	150	94.87	.63		
Total	155	99.49			

Ratings

Rank	Mean of Ln	Mean
1	1.69	5.43
2	1.51	4.57
3	1.37	3.94
4	1.29	3.63
5	1.26	3.54
6	1.18	3.26
Grand	1.39	3.99

Results and Discussion

The leading two candidates for (engine) air temperature were the dotted arrows with a superimposed thermometer and the engine block (side view) adjacent to a thermometer. These should be tested further along with versions in which air temperature candidate #1 (thermometer) replaces the existing thermometer. After modifying its thermometer and placing dots on both sides of it, the revised candidate 5 should also be retested. With consistent use of the dots for air as part of a symbol family, ratings for this revised candidate should increase.



BRAKE FLUID LEVEL

ANOVA

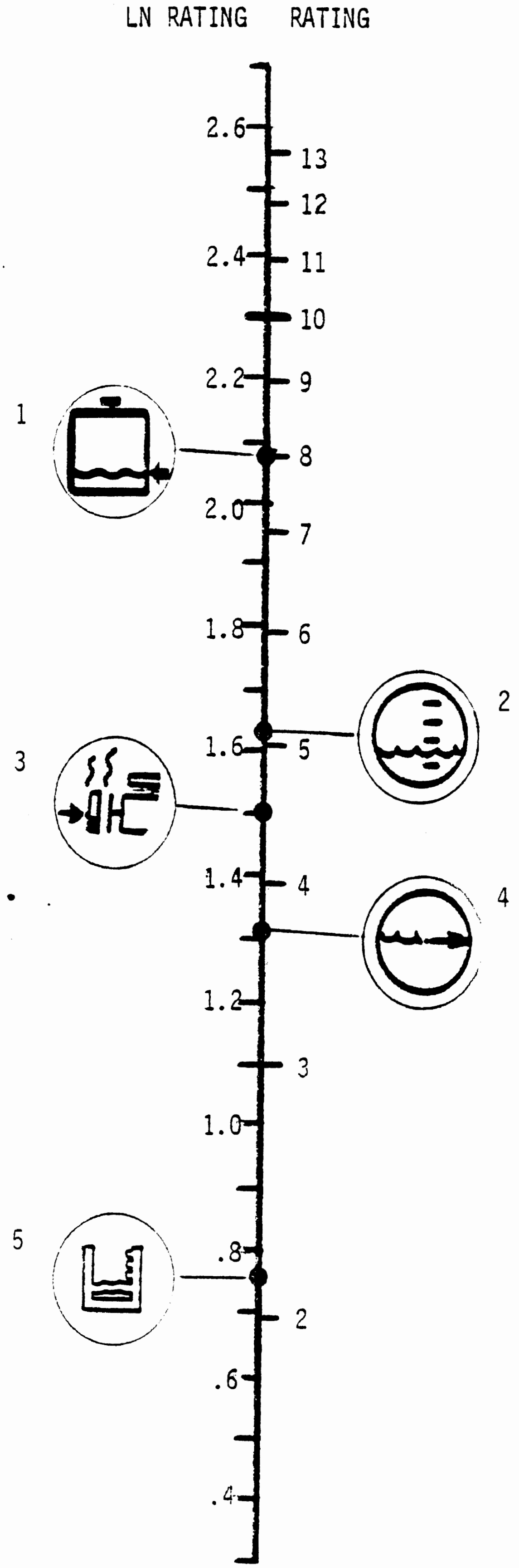
Source	df	SS	MS	F	p
Between	8	33.66	4.20	7.79	.000
Within	225	121.50	.54		
Total	232	155.16			

Ratings

Rank	Mean of Ln	Mean
1	1.96	7.13
2	1.75	5.77
3	1.40	4.06
4	1.40	4.04
5	1.38	3.98
6	1.33	3.80
7	1.12	3.07
8	.78	2.18
Grand	1.32	3.74

Results and Discussion

Two symbols in which a foot was shown (along with a wavy line for fluid) were the most informative symbols for brake fluid level. They deserve further testing along with candidate 5 (wheel, brake shoes, and fluid) because of its resemblance to the current ISO 2575 symbol for brake failure. In addition, three new symbols are suggested: a revised candidate 3 on which 4 fluid level indices are superimposed, (2 dark lines above the fluid surface and 2 white lines below it) and revisions of candidates 1 and 2 in which the fluid line is moved off to the left and a vertical line and indices are added.



COOLANT LEVEL

ANOVA

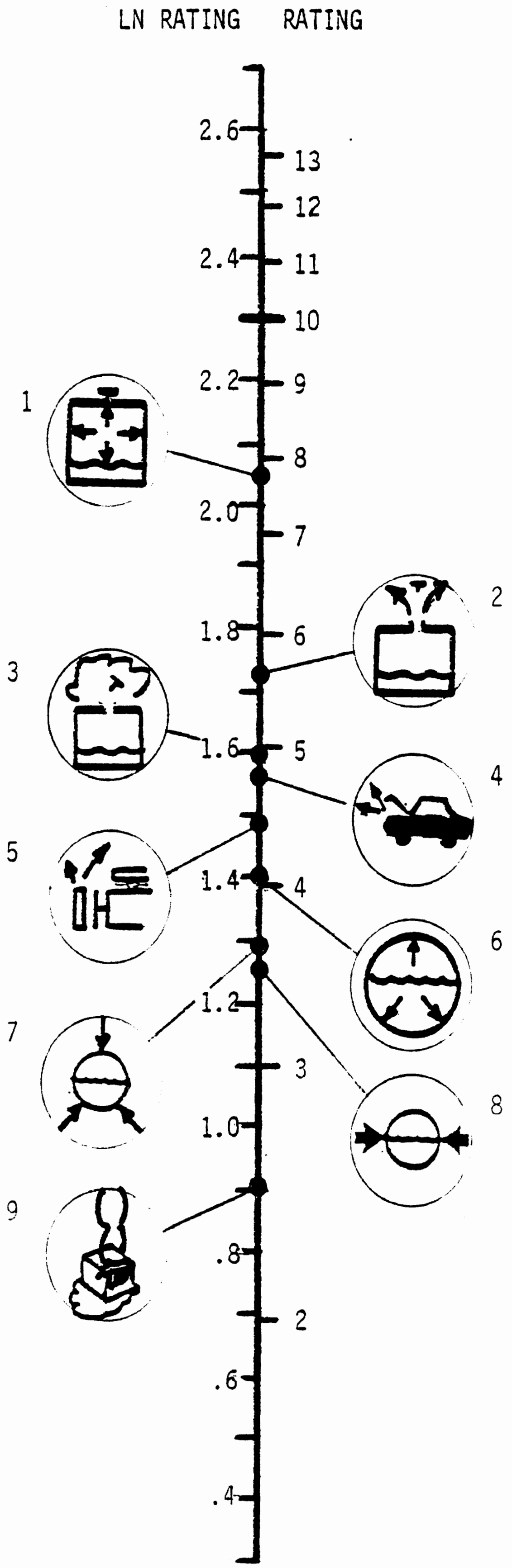
Source	df	SS	MS	F	p
Between	4	23.90	5.98	11.58	.000
Within	125	64.52	.52		
Total	129	88.43			

Ratings

Rank	Mean of Ln	Mean
1	2.09	8.06
2	1.63	5.10
3	1.50	4.49
4	1.33	3.77
5	.77	2.16
Grand	1.46	4.32

Results and Discussion

Clearly the most informative candidate for coolant level was the front view of a radiator. It should be modified by increasing the size of the wave crests and the arrow. This revised symbol and candidates 2 and 3 should be tested further. In addition, a new symbol should be developed by combining a wavy line for fluid level (possibly with tick marks) with either coolant symbol candidates 1 or 2 (the cars and radiating heat waves). Also worthy of consideration is reversing the contrast of the fluid in candidate 2 (so the lowest tick mark will be white) to improve discriminability.



COOLANT PRESSURE

ANOVA

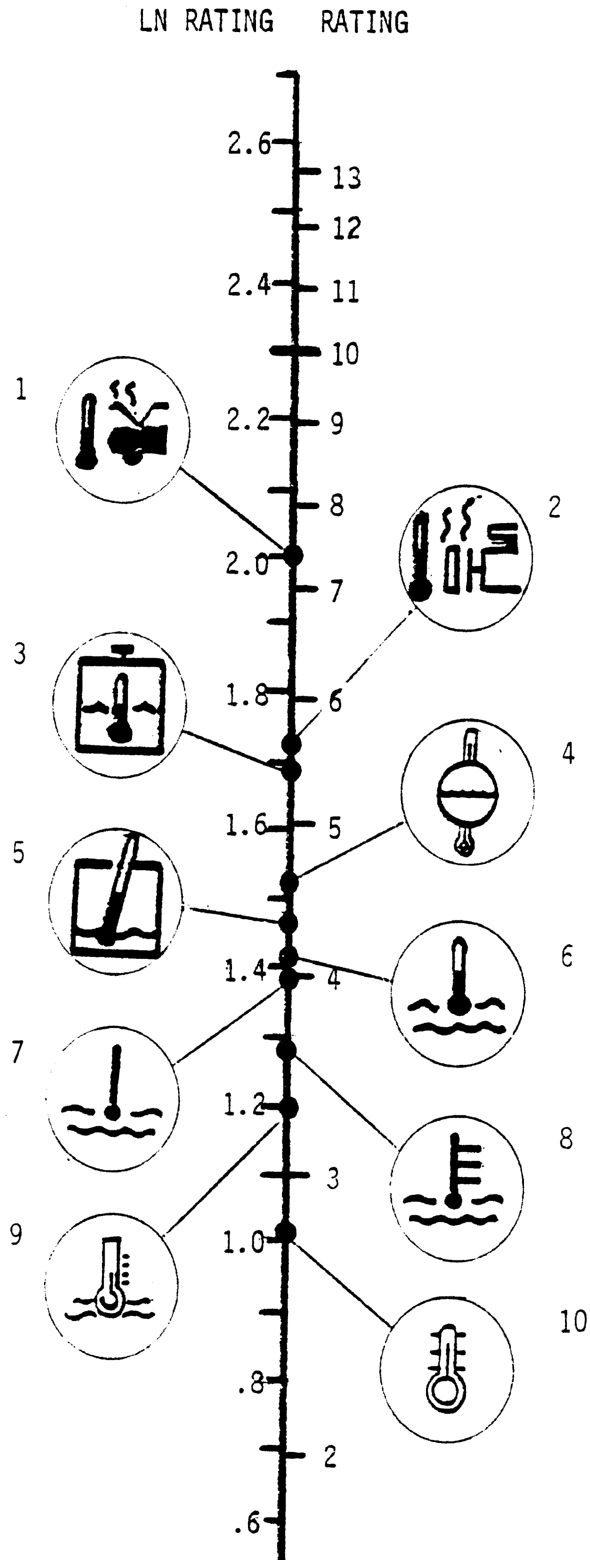
Source	df	SS	MS	F	p
Between	8	21.76	2.72	5.44	.000
Within	225	112.42	.50		
Total	233	134.17			

Ratings

Rank	Mean of Ln	Mean
1	2.07	7.90
2	1.73	5.64
3	1.60	4.94
4	1.58	4.85
5	1.49	4.42
6	1.41	4.27
7	1.30	3.67
8	1.26	3.53
9	.92	2.50
Grand	1.48	4.40

Results and Discussion

The candidates for coolant pressure varied widely in their rated informativeness. The most informative (#1) was the radiator with inside arrows. Deserving further testing are candidates 1, 2 (radiator venting), 4 (car hood), 5 (engine block side view), and 6 (fluid and inside arrows). (When reduced in size, the details of candidate 3 (exploding radiator) will be lost.) Candidates 4-6 deserve further consideration, because in a set context where other variants are present, they may be more informative. In addition a version of candidate 2 in which interior arrows are added should be considered.



COOLANT TEMPERATURE

ANOVA

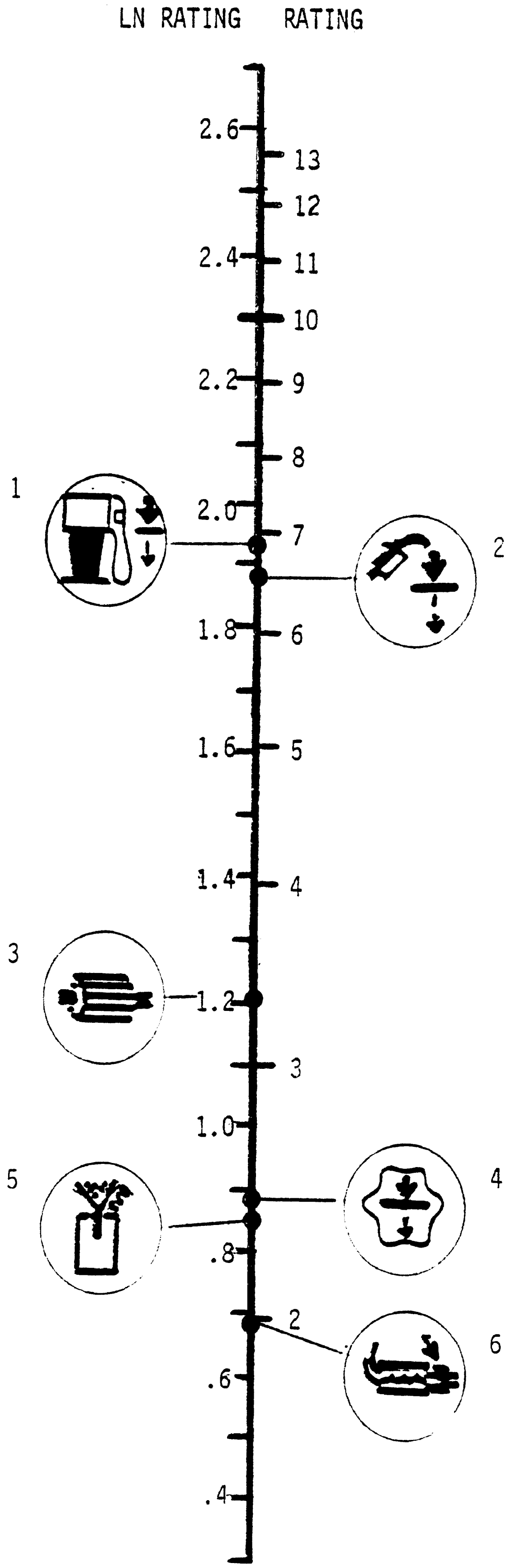
Source	df	SS	MS	F	p
Between	9	18.98	2.11	4.10	.000
Within	250	128.71	.51		
Total	259	147.69			

Ratings

Rank	Mean of Ln	Mean
1	2.01	7.45
2	1.73	5.63
3	1.70	5.47
4	1.51	4.51
5	1.47	4.35
6	1.43	4.16
7	1.40	4.04
8	1.29	3.63
9	1.21	3.34
10	1.01	2.75
Grand	1.47	4.37

Results and Discussion

Clearly the most informative symbol for coolant temperature was the thermometer and car with raised hood combination. The current ISO 2575 symbol for coolant temperature (#8) "floating flag" was not very informative; nor was candidate #4 (fluid container/thermometer), the symbol proposed to be added to ISO standard 3767. (Interestingly both Heard (1974) and McCormick (1974) report response time and error differences for candidates 4 and 8 that are in the same direction as these ratings.) Candidates 1-6 and 8 and a modification of 6 with the more informative thermometer (thermometer candidate #1) deserve further testing. Also deserving further testing are modifications of candidates 3 and 5 (both radiator/thermometer combinations).



FUEL FILTER

ANOVA

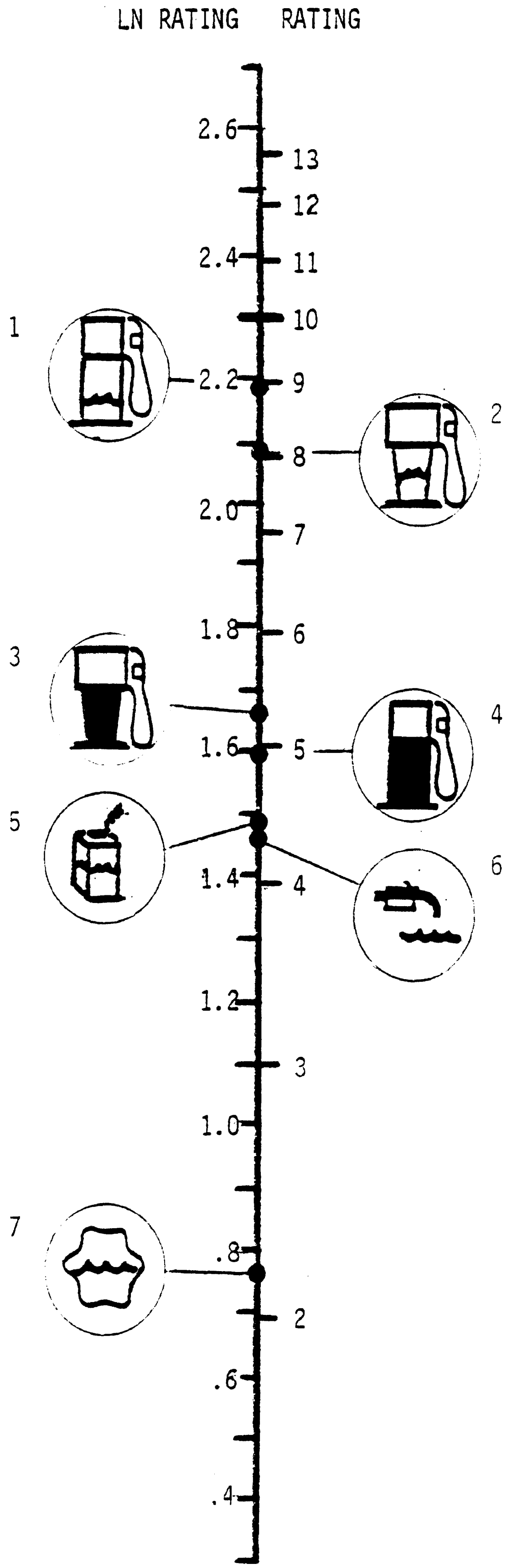
Source	df	SS	MS	F	p
Between	5	37.91	7.58	14.44	.000
Within	150	76.74	.52		
Total	155	116.64			

Ratings

Rank	Mean of Ln	Mean
1	1.93	6.90
2	1.89	6.60
3	1.22	3.38
4	.89	2.93
5	.86	2.37
6	.70	2.01
Grand	1.25	3.48

Results and Discussion

Candidates 1 and 2 (the modern pump with a double arrow and the nozzle with double arrows) were both rated as fairly informative symbols for fuel filter. These 2 symbols deserve further testing. For consistency, so also does a modification of candidate 1 in which an old-style pump is substituted.



FUEL LEVEL

ANOVA

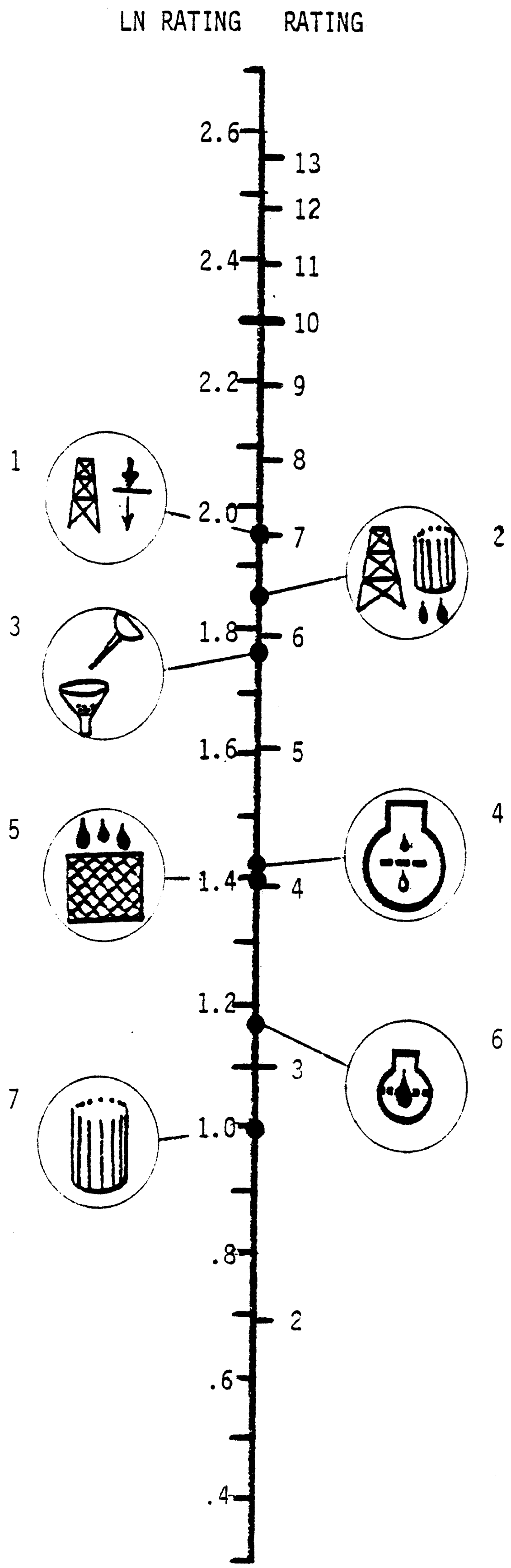
Source	df	SS	MS	F	p
Between	6	34.19	5.70	8.98	.000
Within	175	111.12	.63		
Total	181	145.31			

Ratings

Rank	Mean of Ln	Mean
1	2.19	8.96
2	2.09	8.09
3	1.67	5.32
4	1.60	4.94
5	1.49	4.45
6	1.47	4.35
7	.77	2.16
Grand	1.61	5.01

Results and Discussion

Rated as most informative was the old-style pump with fluid level line, followed closely by the newer-style pump (probably because the old pump left more space to show fluid level). Somewhat less informative were the 2 unmodified fuel pumps (old-style and modern), with the newer version being slightly more informative. Deserving further study are candidates 1-4 and 6 (nozzle and wavy line). (When other versions of candidate 6 are contained in a set, candidate 5 may be more highly rated).



OIL FILTER

ANOVA

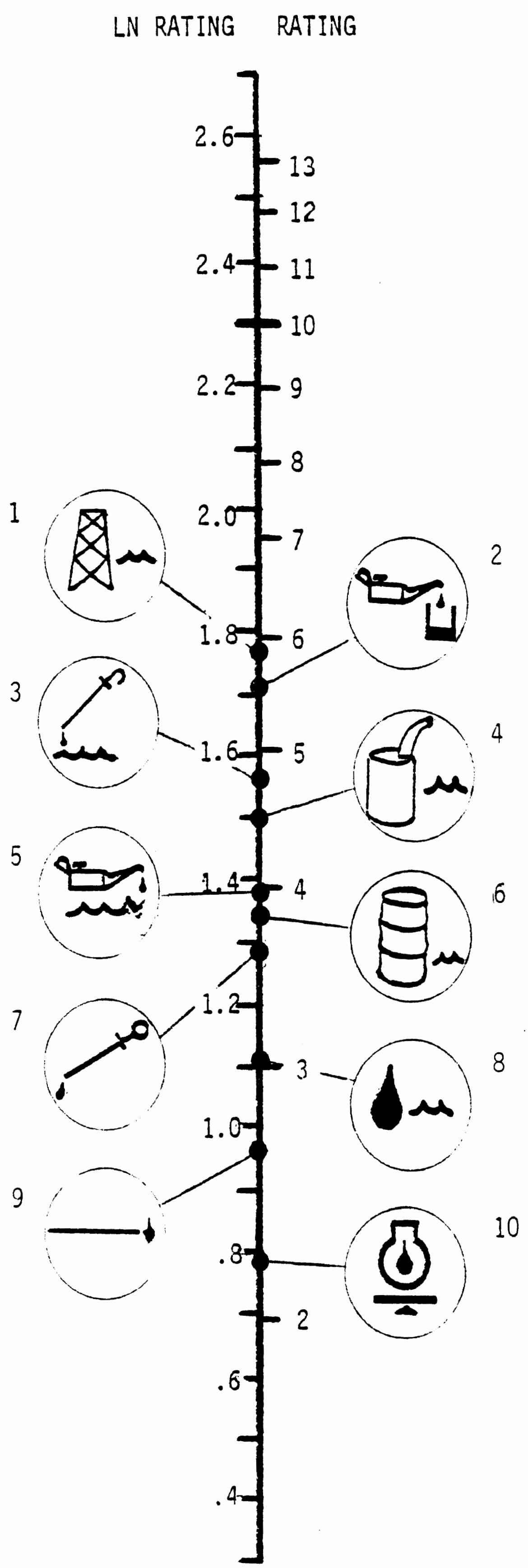
Source	df	SS	MS	F	p
Between	6	20.51	3.42	6.43	.000
Within	175	92.97	.53		
Total	181	113.48			

Ratings

Rank	Mean of Ln	Mean
1	1.95	7.06
2	1.87	6.47
3	1.78	6.00
4	1.42	4.16
5	1.40	4.06
6	1.17	3.24
7	1.00	2.72
Grand	1.52	4.55

Results and Discussion

Subjects rated the drilling rig/double arrow filter combination as the most informative candidate for this function. Candidates 4 and 6 (both resembling cartoons of bombs) have frequently been pro-proposed for the oil filter symbol. Candidate 4 appears in the draft revision of ISO 3767. Candidates 1, 2, 3, 4, and 6 should be studied further. Other combinations of the drilling rig with symbols for filter should also be developed.



OIL LEVEL

ANOVA

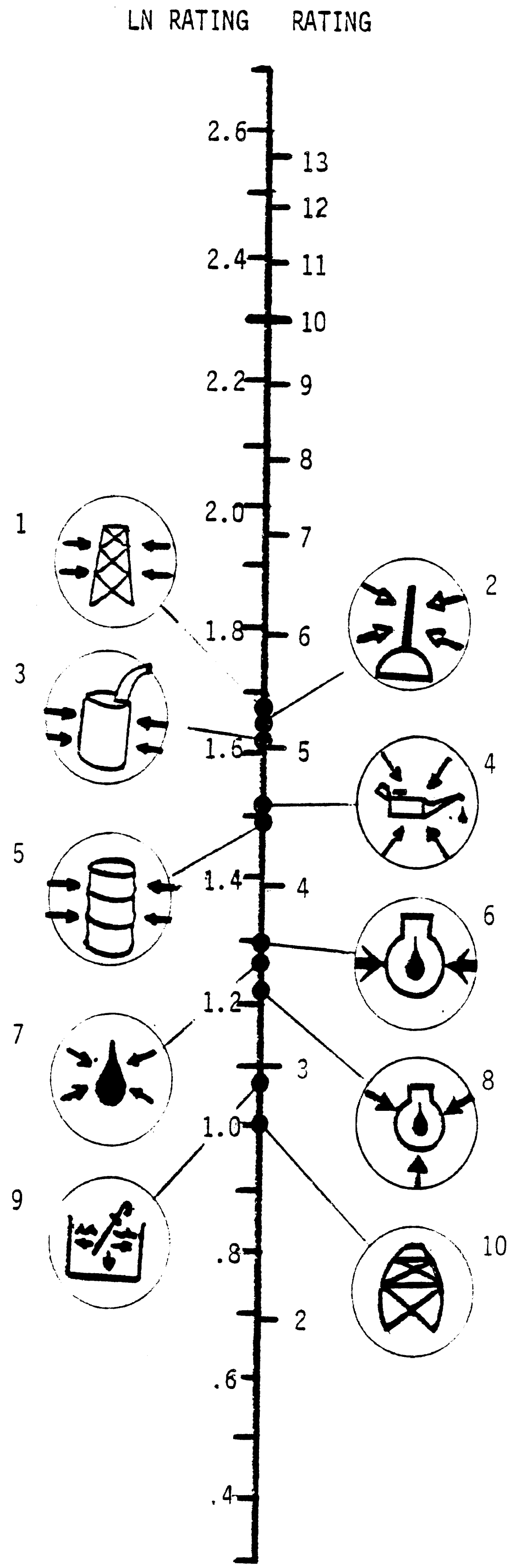
Source	df	SS	MS	F	p
Between	9	23.65	2.63	4.01	.000
Within	250	163.83	.66		
Total	259	187.48			

Ratings

Rank	Mean of Ln	Mean
1	1.77	5.89
2	1.72	5.57
3	1.58	4.84
4	1.50	4.50
5	1.40	4.04
6	1.36	3.89
7	1.29	3.62
8	1.11	3.04
9	.97	2.63
10	.79	2.21
Grand	1.35	3.85

Results and Discussion

Of the candidates considered, the drilling rig and wave was most informative, though the modified ISO 2575 symbol for engine oil (oil can) was almost as good. Probably symbols in which a wave was shown would have been rated as more informative had level indices been included. Candidates 1, 3, 4, and 5 should be retested along with a revision of candidate 2.



OIL PRESSURE

ANOVA

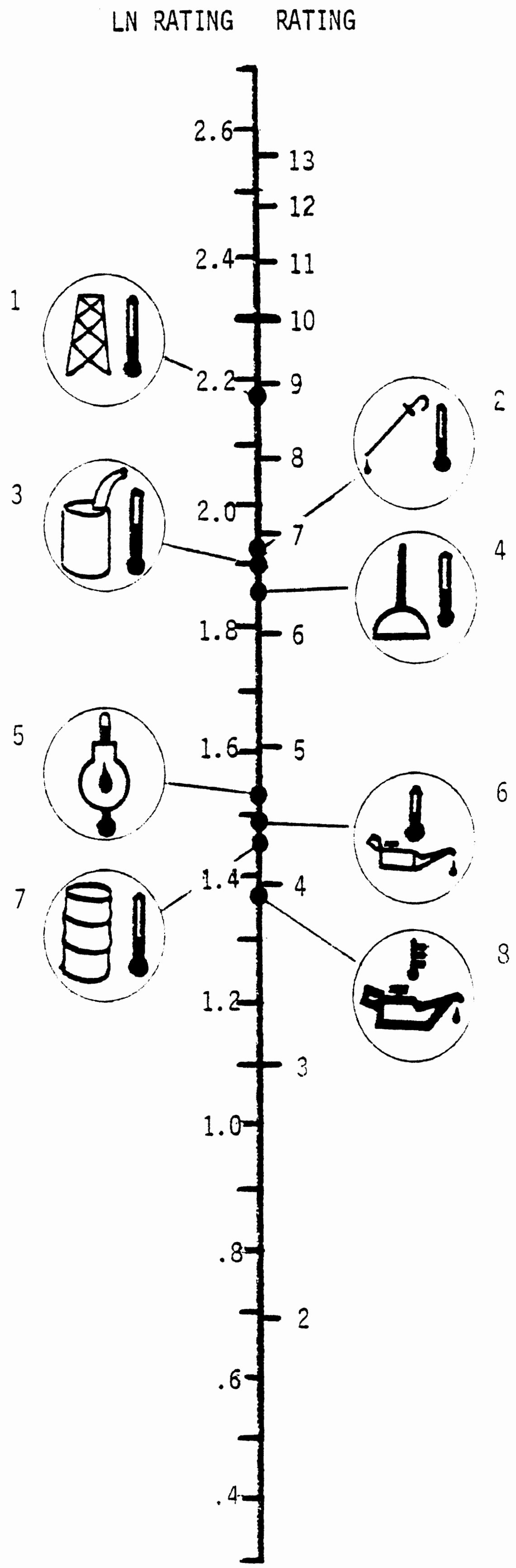
Source	df	SS	MS	F	p
Between	9	13.76	1.53	2.40	.013
Within	250	159.30	.64		
Total	259	173.05			

Ratings

Rank	Mean of Ln	Mean
1	1.67	5.31
2	1.64	5.15
3	1.62	5.05
4	1.51	4.54
5	1.49	4.44
6	1.30	3.66
7	1.26	3.51
8	1.22	3.38
9	1.07	2.90
10	1.00	2.72
Grand	1.38	3.96

Results and Discussion

Consistent with the ratings for the oil system symbols and other combined oil symbols, the drilling rig "arrows out" pair (candidate #1) was rated as most informative, followed closely by the locomotive oiler can "arrows out" (candidate #2) and quart can - "arrows out" (candidate #2) pairs. A candidate proposed to be included in ISO 3767 was ranked #6. It is suggested that candidate 1-4 and 6 be studied further and that a modification of the manner in which pressure is depicted be developed. In addition, because the dipstick was an informative symbol for oil, another candidate including it should be developed. (Oil pressure candidate 9 was not drawn well.)



O I L T E M P E R A T U R E

ANOVA

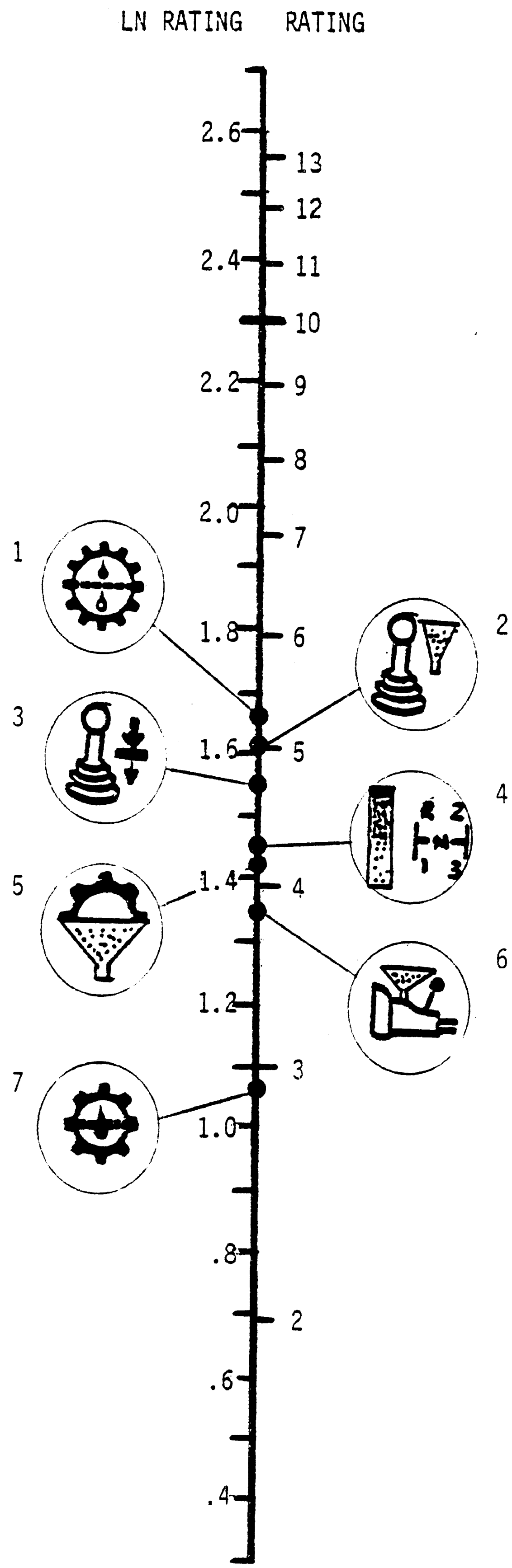
Source	df	SS	MS	F	p
Between	7	15.22	2.17	4.33	.000
Within	200	100.51	.50		
Total	207	115.73			

Ratings

Rank	Mean of Ln	Mean
1	2.18	8.87
2	1.92	6.81
3	1.91	6.75
4	1.85	6.38
5	1.53	4.63
6	1.49	4.44
7	1.46	4.29
8	1.37	3.94
Grand	1.71	5.55

Results and Discussion

The most informative candidate for the oil temperature symbol was the drilling rig - thermometer pair. Candidate 5, an adaptation of several symbols used on agricultural equipment, received a relatively low rating. So, too, did combinations of the ISO 2575 symbol for oil with a thermometer. Worthy of further testing are candidates 1-4. (Replacement of the thermometer in these symbols by a more informative one (thermometer candidate 1) should be considered. Also, because they have been offered so often by manufacturers, it may be desirable to subject candidate 5 and 6 to additional testing.



TRANSMISSION FLUID FILTER

ANOVA

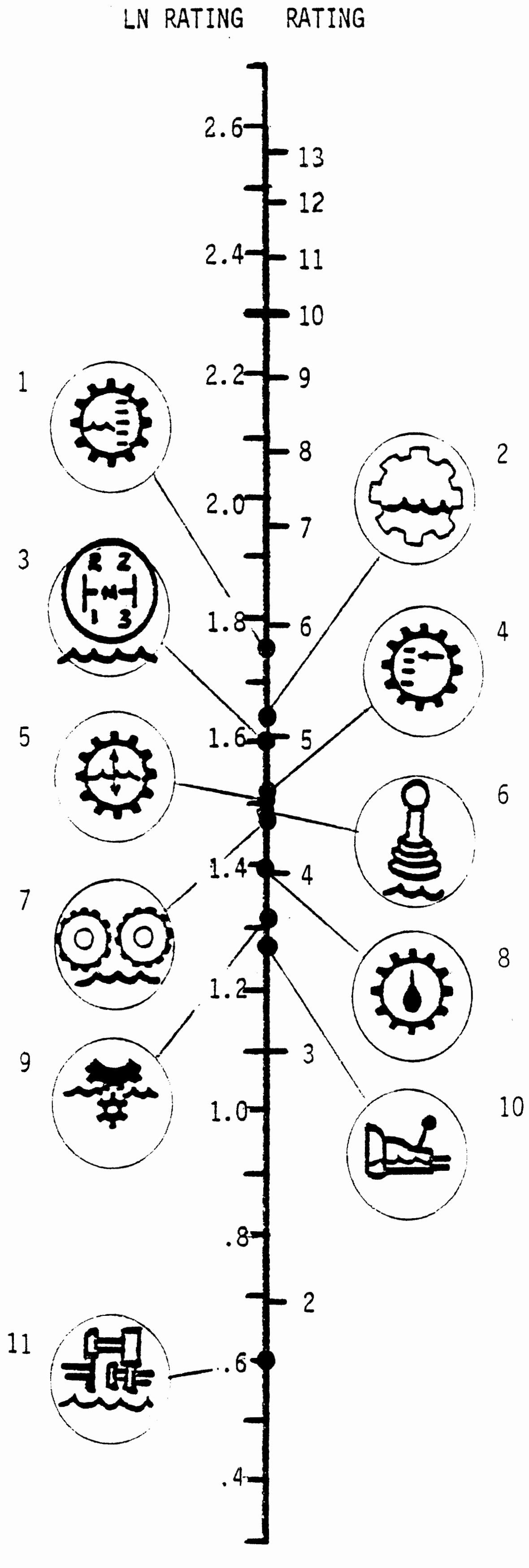
Source	df	SS	MS	F	p
Between	6	4.43	.74	1.10	.367
Within	175	118.00	.67		
Total	181	122.43			

Ratings

Rank	Mean of Ln	Mean
1	1.65	5.22
2	1.62	5.05
3	1.56	4.74
4	1.44	4.21
5	1.42	4.14
6	1.35	3.86
7	1.17	3.22
Grand	1.46	4.30

Results and Discussion

The most informative candidate for transmission fluid filter was candidate 1 (the gear and two-drop symbol contained in ISO 3767), followed closely by several others. It is suggested that candidates 1-3 be retested and possibly candidate 7 (gear and drop) because it is frequently suggested by manufacturers. In addition, the pairing of the shift pattern with the double arrow symbol should be tested.



TRANSMISSION FLUID LEVEL

ANOVA

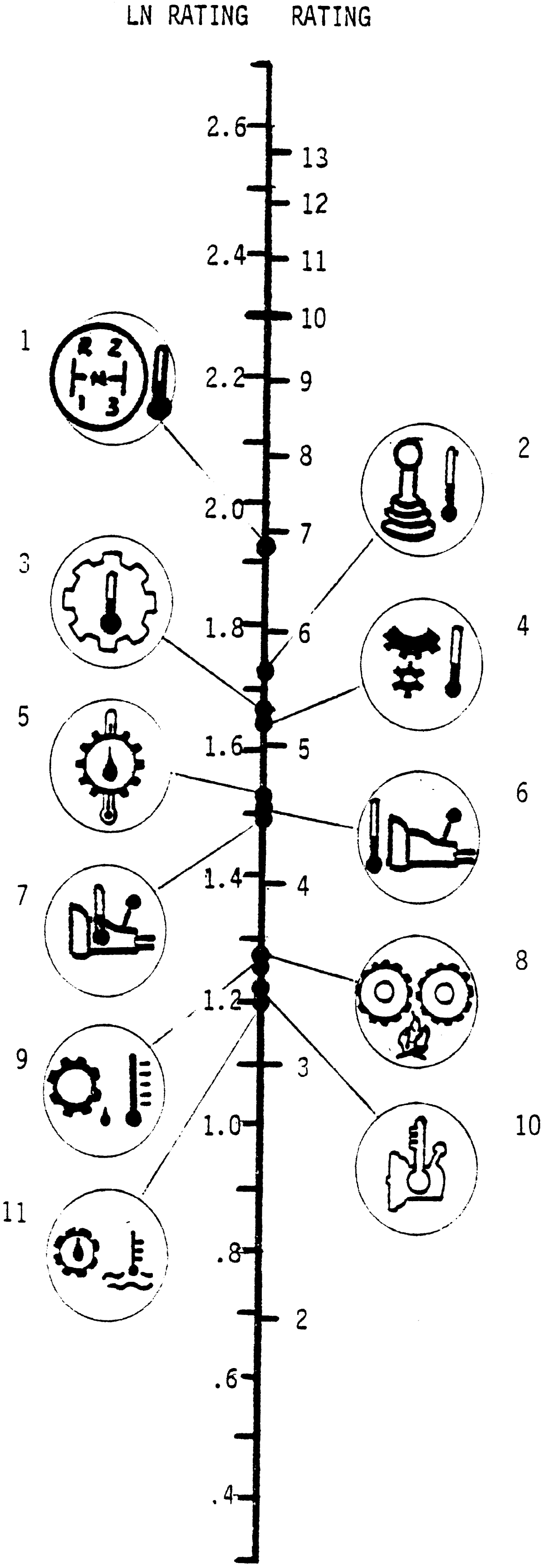
Source	df	SS	MS	F	p
Between	10	23.85	2.39	3.51	.000
Within	275	186.94	.68		
Total	285	210.80			

Ratings

Rank	Mean of Ln	Mean
1	1.77	5.84
2	1.64	5.15
3	1.60	4.97
4	1.52	4.57
5	1.52	4.56
6	1.49	4.42
7	1.45	4.28
8	1.40	4.05
9	1.33	3.77
10	1.28	3.61
11	.61	1.83
Grand	1.42	4.13

Results and Discussion

Subjects rated the gear with the wavy line and indices inside it as the most informative of the symbols for transmission fluid, though differences between all of the candidates, except for #11, were small. It is suggested that candidates 2 (gear and wavy line) and 6 (shift lever and wavy line) be modified to move the wavy line and added indices next to the transmission symbols. Candidate 1 and modified candidates 2 and 6 should then be retested.



TRANSMISSION TEMPERATURE

ANOVA

Source	df	SS	MS	F	p
Between	10	14.86	1.49	2.30	.013
Within	275	177.41	.65		
Total	285	192.27			

Ratings

Rank	Mean of Ln	Mean
1	1.94	6.93
2	1.74	5.68
3	1.67	5.29
4	1.65	5.20
5	1.54	4.70
6	1.51	4.53
7	1.51	4.52
8	1.27	3.56
9	1.25	3.50
10	1.22	3.39
11	1.21	3.37
Grand	1.50	4.48

Results and Discussion

Candidate 1 (shift pattern and thermometer) was rated as the most informative candidate for transmission temperature. Candidates 2 (shift lever and thermometer) and 3 (thermometer inside gear) should be retested, along with candidate 5 (gear on top of thermometer), which has been proposed to be included in ISO 3767. Also worthy of testing is a modification of candidate 3, in which a bolder version of the gear is employed. Finally, replacement of the thermometer by a more informative one (thermometer candidate 1) should be considered in all cases.

Several questions raised by this research relate to the construction of picture languages. Picture languages, such as those of the ancient Egyptians and Sumerians, are one of the earliest forms written communication (Gelb, 1963; Gibson and Levin, 1975). More recently, in the 20th century, there has been a return of interest in pictorial languages (Bliss, 1969; Marcel and Barnard, 1979; Tyman, 1979). However, experimental evidence on the ease of learning such languages is scarce, and there are very few guidelines for image construction (Easterby, 1966, 1969, 1970).

Many combined symbols (e.g., coolant temperature) were formed by uniting a system symbol (e.g., coolant) with a modifier (temperature), and as such, formed the elements of a rudimentary picture language. Two combining rules were employed--placing the two elements on top of each other (superposition) and placing them next to each other (adjacency). Of 127 combined symbol candidates, 83 were so formed. (Note: In seven cases the same symbol appeared as both the elemental and combined symbol). As there were few cases in which the two combining rules were strictly applied, symbols were coded by the experimenters according to the degree to which they deviated from the rules (none, slight, or some).

Using stepwise and other forms of regression analysis, the 83 logarithmic means of combined symbol ratings were analyzed. The results are summarized in Table 5. The best overall model accounted for slightly more than half of the variance. In that model both the system and modifier ratings were included as first-order terms with the coefficient for the system rating being somewhat greater. As only a few modifiers were used, this result may reflect a sampling problem. When either the squares, cubes, or products of the ratings were included in the model as independent variables, there was no noticeable improvement.

When the data were partitioned by combining rule (adjacent vs. superimposed elements) the variance accounted for by the regression equations was 68.57% and 44.17%. In addition, the variable weighting

Table 5. Regression equations predicting mean Ln_e rating.

	R^2	n	Equation
Overall			
	.522	83	Predicted (Rating) = .357 + .431 System (Rating) + .293 Modifier (Rating)
By Combining Rule			
Adjacent	.686	34	Predicted (Rating) = .151 + .589 System (Rating) + .268 Modifier (Rating)
Superimposed	.442	49	Predicted (Rating) = .377 + .360 System (Rating) + .338 Modifier (Rating)
By Rule Departure			
None	.779	30	Predicted (Rating) = -.0853 + .577 System (Rating) + .408 Modifier (Rating)
Slight	.246	17	Predicted (Rating) = 1.026 + .171 System (Rating) + .126 Modifier (Rating)
Some	.452	36	Predicted (Rating) = .443 + .503 System (Rating) + .151 Modifier (Rating)

shifted, with the relative contribution of the system rating being larger in the adjacent case than in the superimposed case.

When the data were partitioned by the degree of rule departure, the mean logarithmic ratings were best predicted in the "no change" case (R^2 = .78), less well in the "some" case (R^2 = .45) and least well in the "slight" case (R^2 = .25). One would expect that increasing rule departure should decrease variance accounted for. The reversal here of the "slight" and "some" change cases suggests that where some alteration of elements to form combined symbols is necessary, one should not slavishly follow the rule of minimizing change (consistency).

Finally, the data were partitioned into six groups (combining rule vs. departure) and regression equations were computed. The additional factors added no extra power to the original model.

Thus, the regression model indeed showed the meaningfulness of combined symbols could be predicted from ratings of the system and modifier elements. In those models, the system ratings were more heavily weighted.

Summary and Conclusions

1) Soliciting drivers for drawings of candidate symbols proved to be an efficient first step in developing adequate symbology. Since many suggestions offered by drivers were different from those of manufacturers, it seems critical that a symbol development project include in its initial efforts a symbol production study.

2) There were categorical differences in how engineers and ordinary drivers regard symbols for vehicle displays. Engineers tend to take an internal perspective of equipment. They drew symbols that depict the operating mechanisms of the machinery in question, often not seen by drivers. Non-engineer drivers tend to take an external view (e.g., a foot pedal, rather than a brake shoe). They depicted either the action required by drivers or the consequence of failing to act.

3) Based on subjects' drawings, manufacturers' suggestions, international standards, and the authors' ideas, sets of 5 to 12 candidate symbols were assembled for each of 26 functions (216 total candidates). Based on drivers' ratings of meaningfulness, the number of candidates remaining under consideration was markedly reduced. In general, symbols developed by manufacturers or included in international standards were rated as less meaningful than symbols based on subjects' suggestions. Specifically, it is suggested that symbols in ISO Standard 2575 for fuel, engine oil, coolant temperature, and brake failure be reconsidered.

4) The magnitude of the ratings provided by subjects vary with their backgrounds. Drivers familiar with heavy equipment tended to use larger values, as did foreign car drivers.

5) Functions vary in the degree to which informative symbols can be developed for them. Accordingly, it is difficult to set an _a priori_ cutoff for acceptance.

6) The ratings of combined symbols could be predicted by a simple linear combination of the system and modifier element ratings. In those predictions, the system rating was more important. Predicted ratings of combined symbols also depended upon the combining rule (adjacent or superimposed elements) and the degree of their departure from the combining rule (none, slight, some). The ability to predict the informativeness of combined symbols makes testing far more economical. For example, for a set of 10 system and 10 modifer candidates one could test all 100 possible combinations. However, it would be far more efficient to test the original 20 and then test the best predicted combinations.

7) This study has not led to any firm conclusions concerning the "best" symbol for any of the 26 functions examined. It was not intended to do so. It has, however, reduced the number of candidates to a manageable group, hopefully one small enough to encourage further evaluation.

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APPENDIX 1

Free Response Questionnaire

SYMBOL PRODUCTION TASK
BIOGRAPHICAL DATA

Dr. Paul Green
Human Factors
Highway Safety Research Institute
University of Michigan
Ann Arbor, Michigan 48109 (USA)
January 1980

1. NAME ______________________
2. SEX (circle one) male female
3. AGE ________
4. IN WHAT COUNTRY WERE YOU BORN? (USA, UK, etc.) ____________
5. CURRENT CITIZENSHIP? (USA, UK, France, etc.) ____________
6. YEAR IN SCHOOL (circle one)
   1 2 3 4 years bachelors masters Ph.D
   major ______________________
7. CURRENT OCCUPATION ______________________
8. ARE YOU A LICENSED DRIVER? (circle one) yes no
9. IN WHAT KIND OF CAR HAVE YOU DONE MOST OF YOUR RECENT DRIVING?
   MAKE ________ MODEL ________ YEAR ________
10. HAVE YOU EVER DRIVEN A HEAVY TRUCK (a truck larger than a pick-up)?
    (circle one) yes no
11. HAVE YOU EVER OPERATED CONSTRUCTION VEHICLES?
    (circle one) yes no
12. HAVE YOU EVER OPERATED FARM VEHICLES?
    (circle one) yes no

- -

This portion will be filled in by the experimenter.

Experimenter ______________ Date & Time ______________

Subject # ______________

Paul Green's Symbol Production Study

INSTRUCTIONS

The purpose of this study is to help the Society of Automotive Engineers and the International Standards Organization develop symbols for instrument panel displays for cars, trucks, buses, construction and farm vehicles. Internationally-standardized language-free messages such as symbols are clearly beneficial for tourists. For example, if you were driving a car in Germany you might have trouble if the controls and displays were identified with German abbreviations. The same is true for German tourists in this country. Standard labels are also desirable from the manufacturer's point of view as they increase the potential market for their products. Finally, from the human performance perspective, symbols are desired because, in many instances, they are more rapidly responded to than words or abbreviations. Obviously, in an emergency, the driver needs to respond quickly.

A number of standard symbols have been developed for controls. (See Figure 1.) Some symbols for displays are shown in Figure 2.

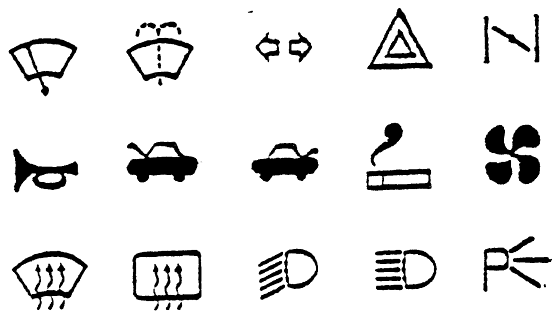


Figure 1. Control symbols.

Figure 2. Display symbols.

Since you will be driving vehicles in the future, it is important to know what you think symbols in those vehicles should look like. This study focuses on symbols for displays. These symbols could either be mounted on a meter or gauge to indicate what it is for (e.g., steam temperature) or separately as a warning or "idiot" light. When these warning lights are off, the panel appears blank to the driver. When they are on, the driver sees the picture. (See Figure 2.)

This study is concerned with seven systems--fuel, oil, coolant (for the engine, not the air conditioner), transmission, hydraulic, brake, and air (intake for the engine, not vent, air in the tires, or compressed air in construction vehicles). It is also concerned with four system aspects--fluid level, temperature, pressure, and filter condition.

On the next page of the questionnaire please draw one picture that you think should be used to identify each of these items. Draw each picture as large as the space provided allows. Don't copy someone else's drawing. This is not a test of your artistic talent or ability so don't worry if your drawing looks a little crude.

Don't worry about symbol color. For now, assume they will be black and white only.

Don't use letters or words in your drawings as we would like these symbols to be language independent.

Don't draw pictures of the displays. The pictures are to symbolize or represent their function.

A good symbol will be a) meaningful, b) look different from those already existing, and c) simple.

Draw a symbol in each box in any order you choose.

SYSTEMS

FUEL	COOLANT	TRANSMISSION
HYDRAULIC	BRAKE	AIR
OIL	FLUID LEVEL	TEMPERATURE
PRESSURE	FILTER	Don't turn to the next page until you have finished this one.

Don't begin these two
pages until you have
completed the previous
page.

Draw a symbol in each box not marked with an "X" in any order you choose. These symbols may be different from those drawn previously.

	COOLANT	FUEL	AIR
FLUID LEVEL	COOLANT LEVEL	FUEL LEVEL	X
TEMPERATURE	COOLANT TEMPERATURE	X	AIR TEMPERATURE
PRESSURE	COOLANT PRESSURE	X	AIR PRESSURE
FILTER	X	FUEL FILTER	AIR FILTER

(Reduced 74% from original)

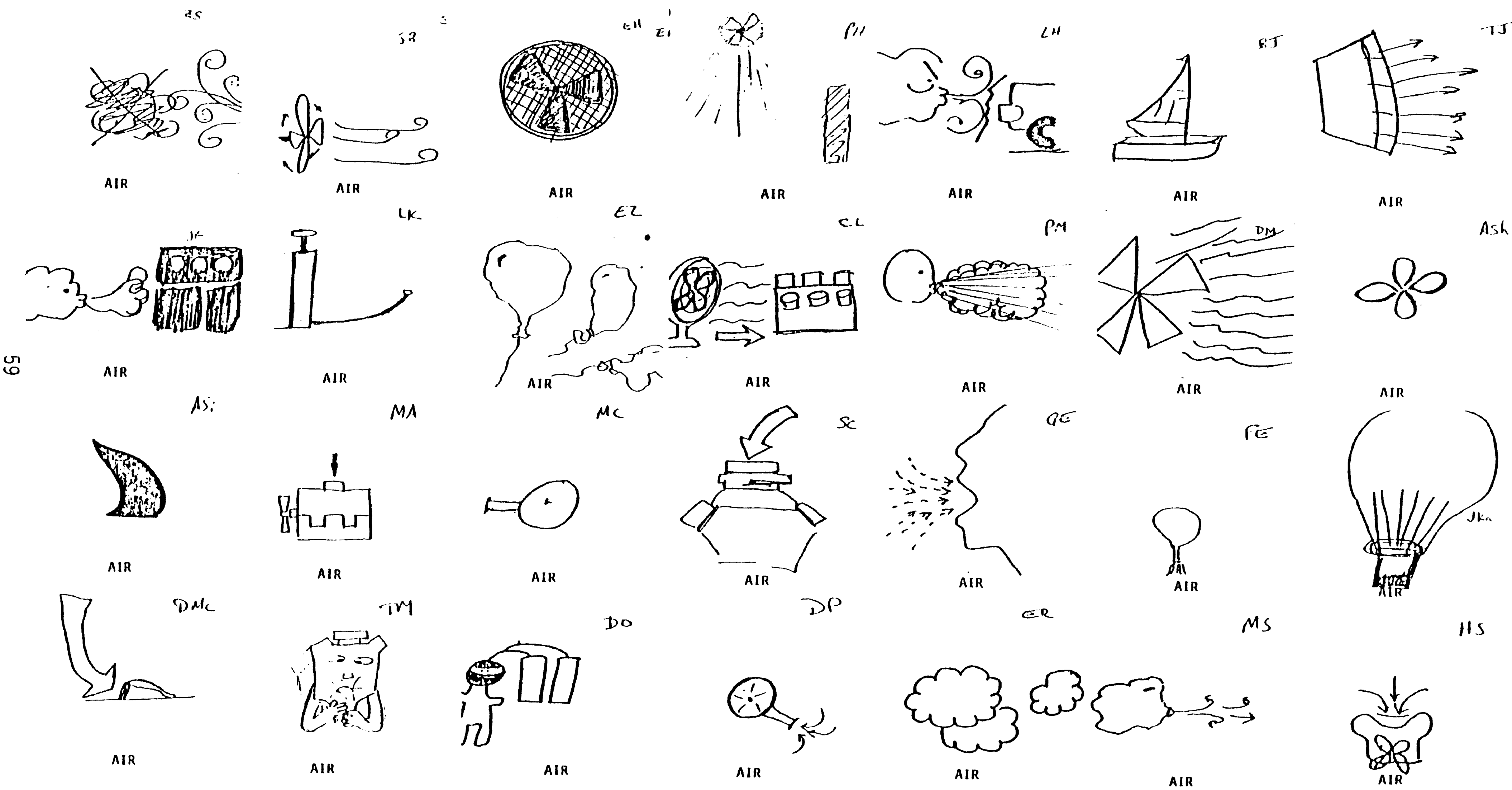
OIL	TRANSMISSION	HYDRAULIC	BRAKE
OIL LEVEL	TRANSMISSION FLUID LEVEL	HYDRAULIC FLUID LEVEL	BRAKE FLUID LEVEL
OIL TEMPERATURE	TRANSMISSION FLUID TEMPERATURE	HYDRAULIC FLUID TEMPERATURE	
OIL PRESSURE		HYDRAULIC FLUID PRESSURE	
OIL FILTER	TRANSMISION FLUID FILTER	HYDRAULIC FLUID FILTER	

(Reduced 74% from original)

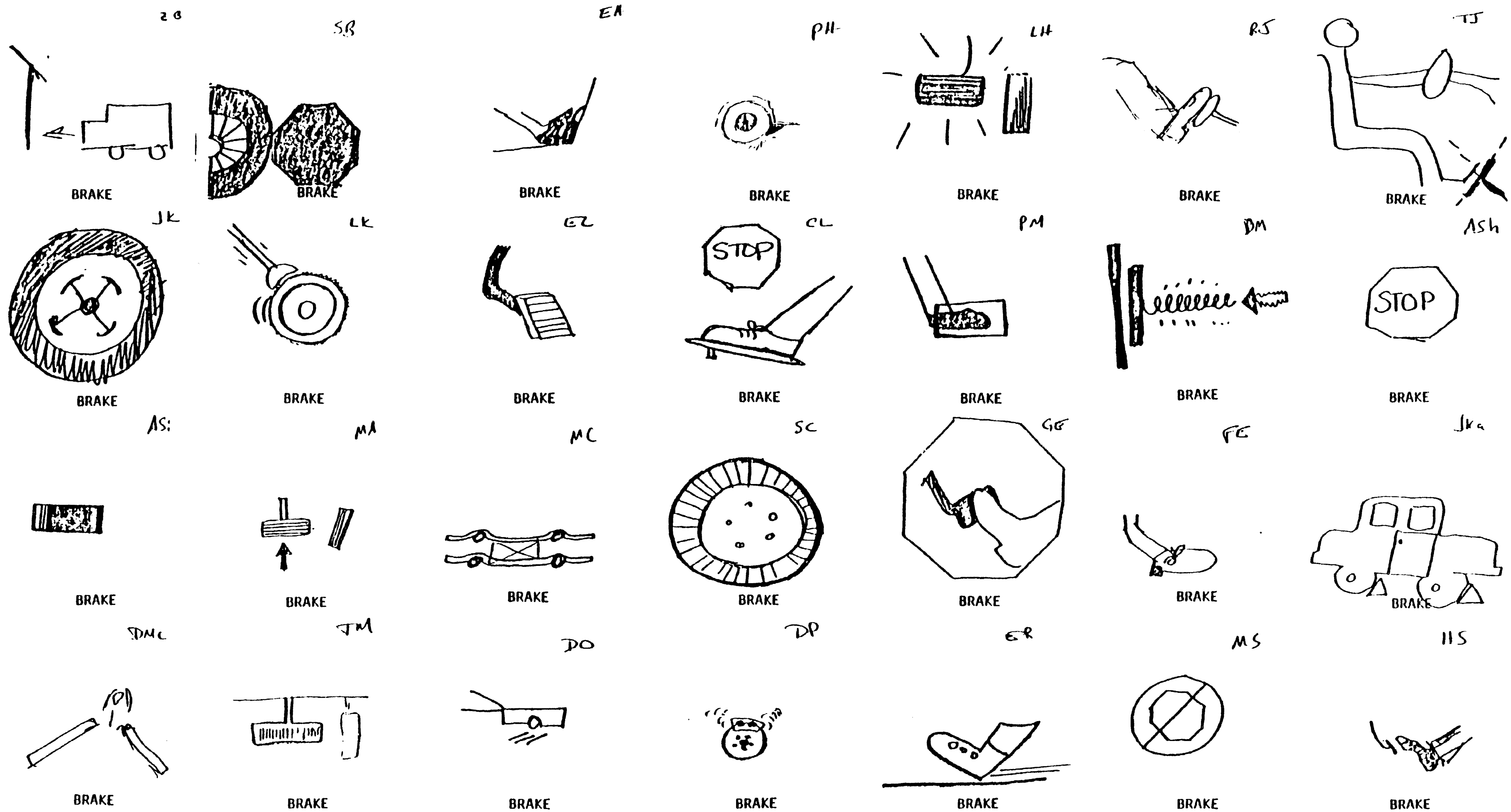
APPENDIX 2

Subject's Drawings

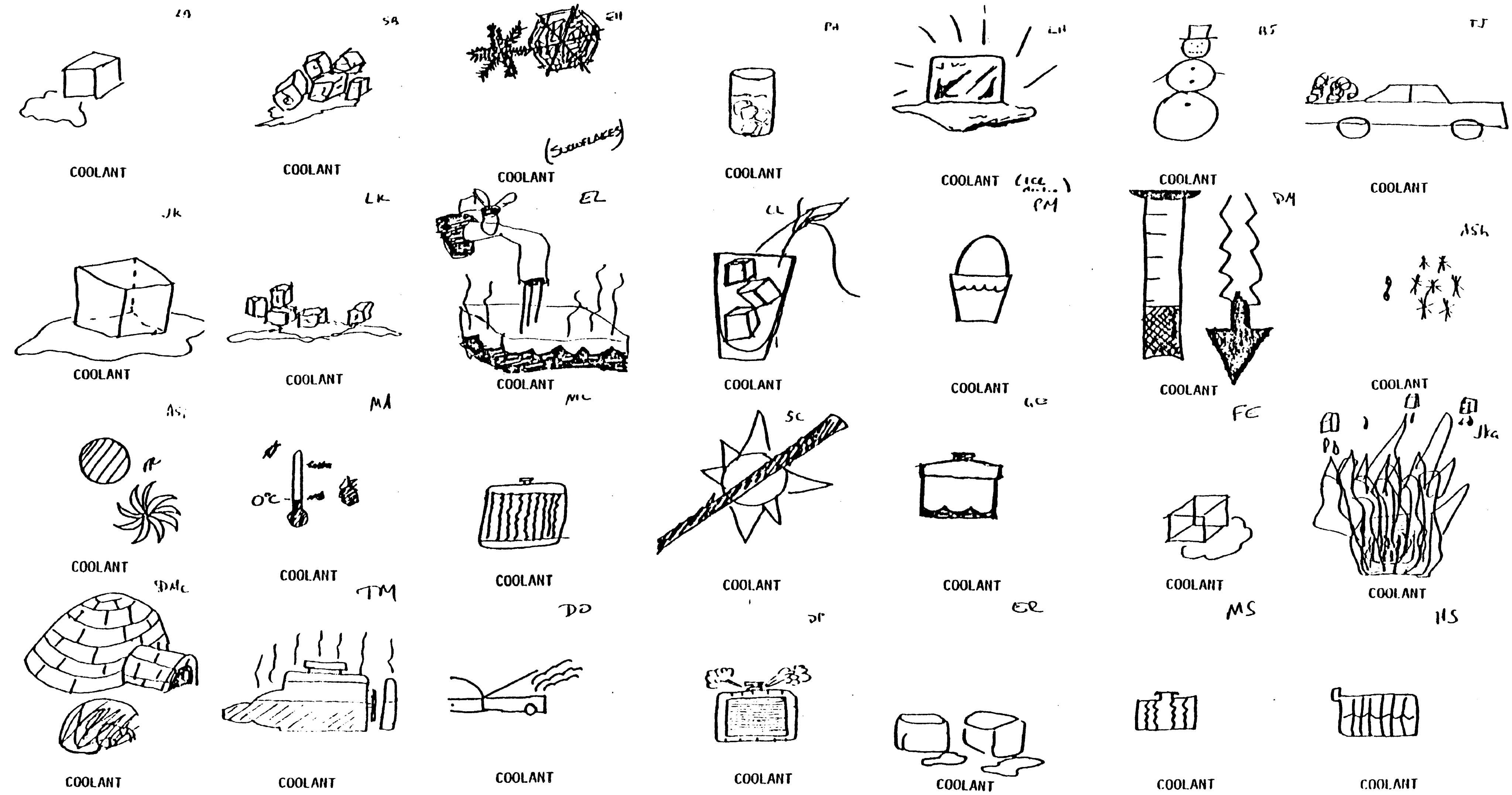
AIR



BRAKE

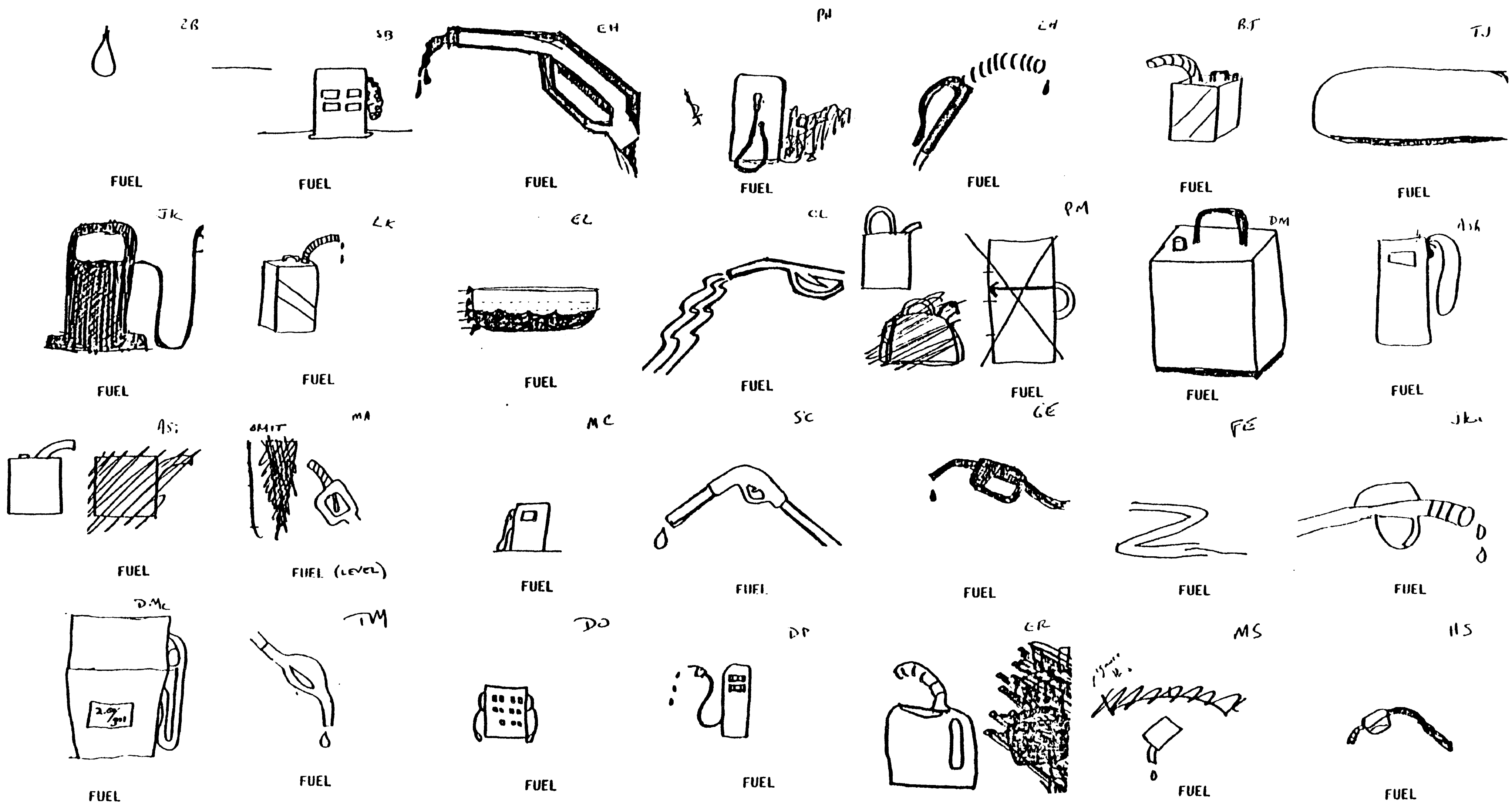

ZB
BRAKE
SB
BRAKE
EA
BRAKE
PH
BRAKE
LH
BRAKE
RJ
BRAKE
TJ
BRAKE
JK
BRAKE
LK
BRAKE
EZ
BRAKE
CL
STOP
BRAKE
PM
BRAKE
DM
BRAKE
Ash
STOP
BRAKE
AS:
BRAKE
MA
BRAKE
MC
BRAKE
SC
BRAKE
GG
BRAKE
FE
BRAKE
Jka
BRAKE
DMC
BRAKE
JM
BRAKE
DO
BRAKE
DP
BRAKE
ER
BRAKE
MS
BRAKE
IIS
BRAKE

COOLANT



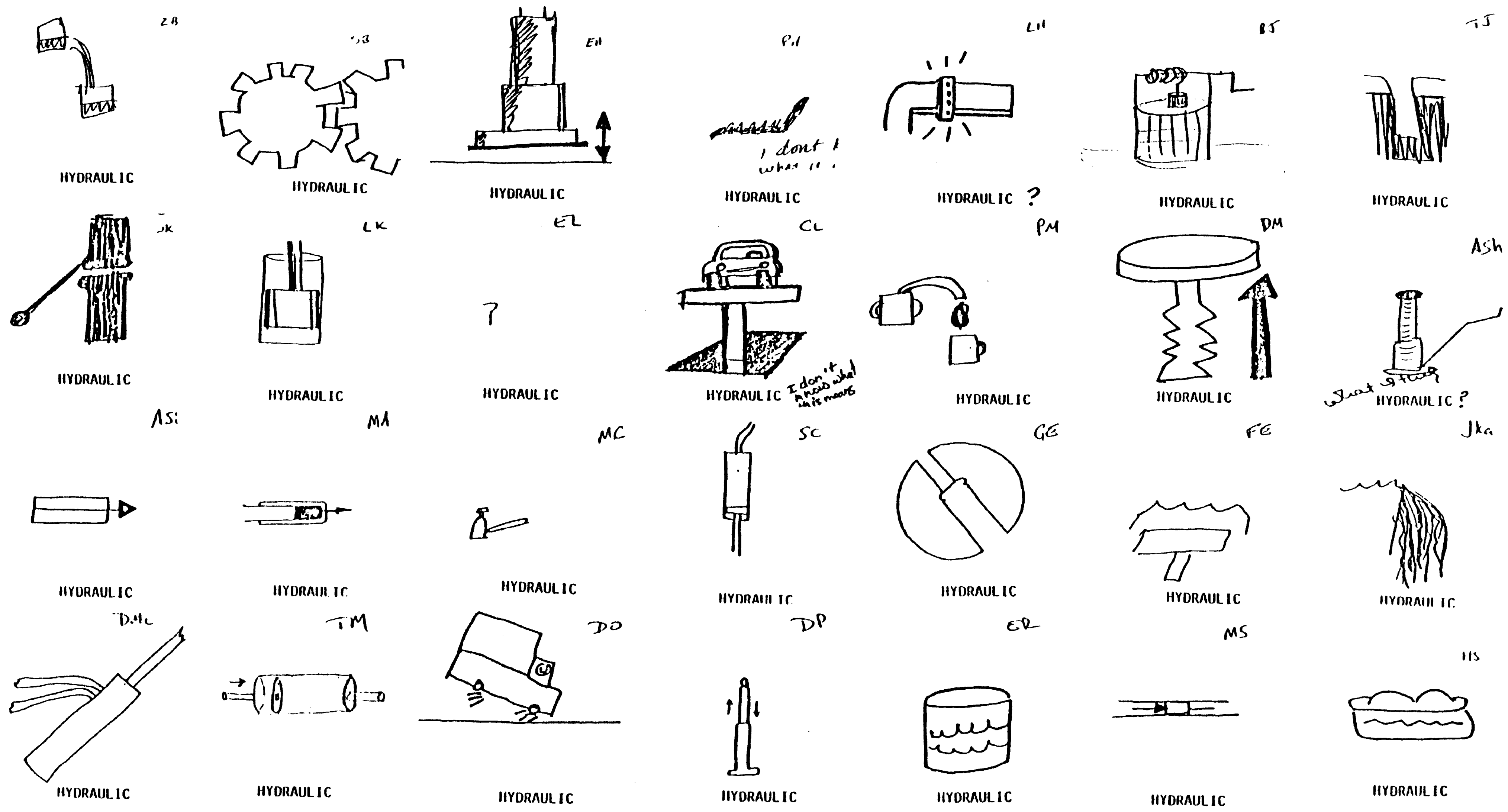
COOLANT
COOLANT
(SNOWFLAKES)
COOLANT
COOLANT
COOLANT
COOLANT
COOLANT
COOLANT
COOLANT
COOLANT
COOLANT
COOLANT
COOLANT
COOLANT
COOLANT
0°C
COOLANT
COOLANT
COOLANT
COOLANT
COOLANT
COOLANT
COOLANT
COOLANT
COOLANT
COOLANT
COOLANT
COOLANT
COOLANT
COOLANT

FUEL

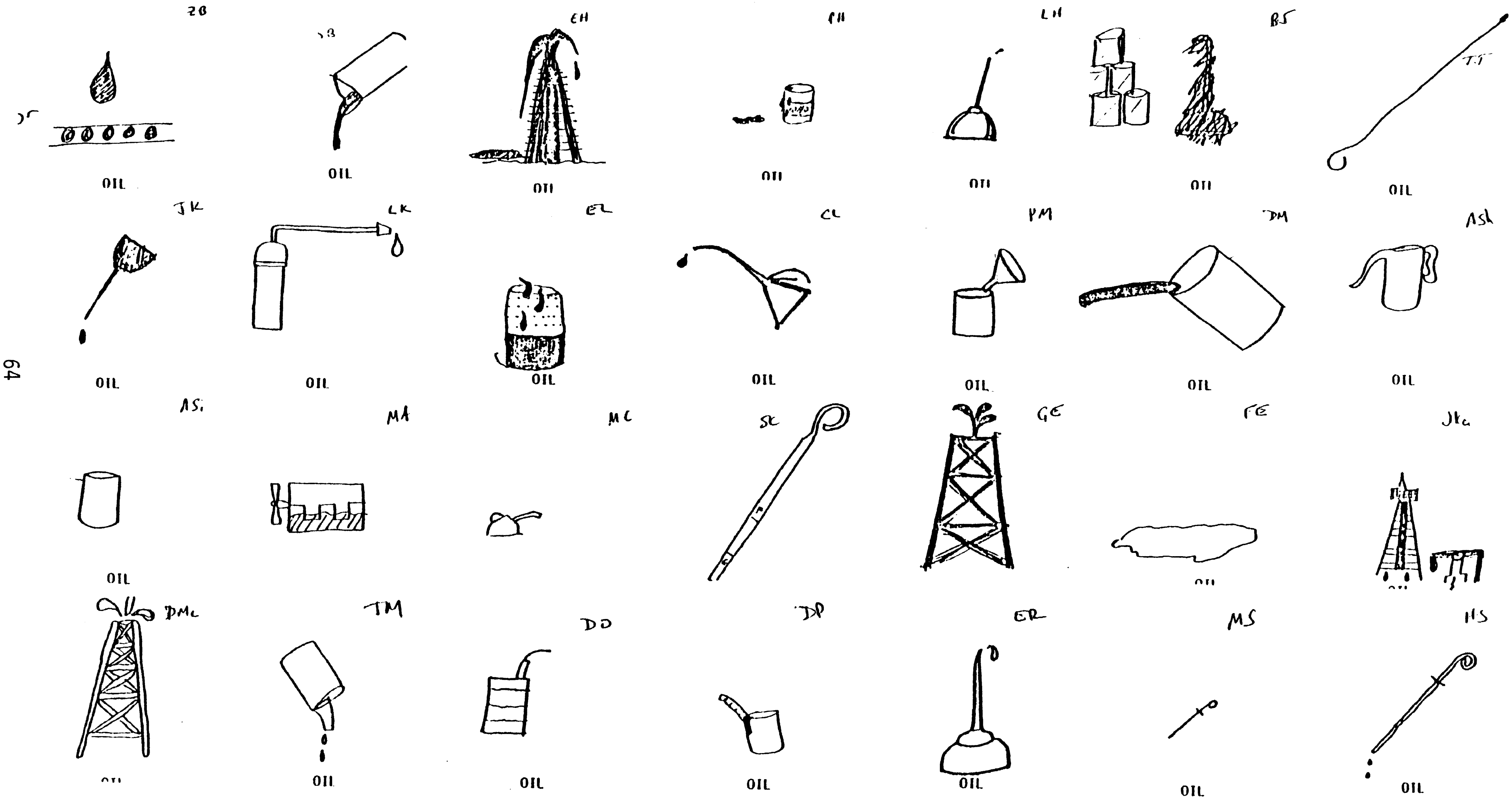


FUEL
FUEL
FUEL
FUEL
FUEL
FUEL
FUEL
FUEL
FUEL
FUEL
FUEL
FUEL
FUEL
FUEL
FUEL
FUEL (LEVEL)
OMIT
FUEL
FUEL
FUEL
FUEL
FUEL
FUEL
FUEL
FUEL
FUEL
FUEL
FUEL
FUEL

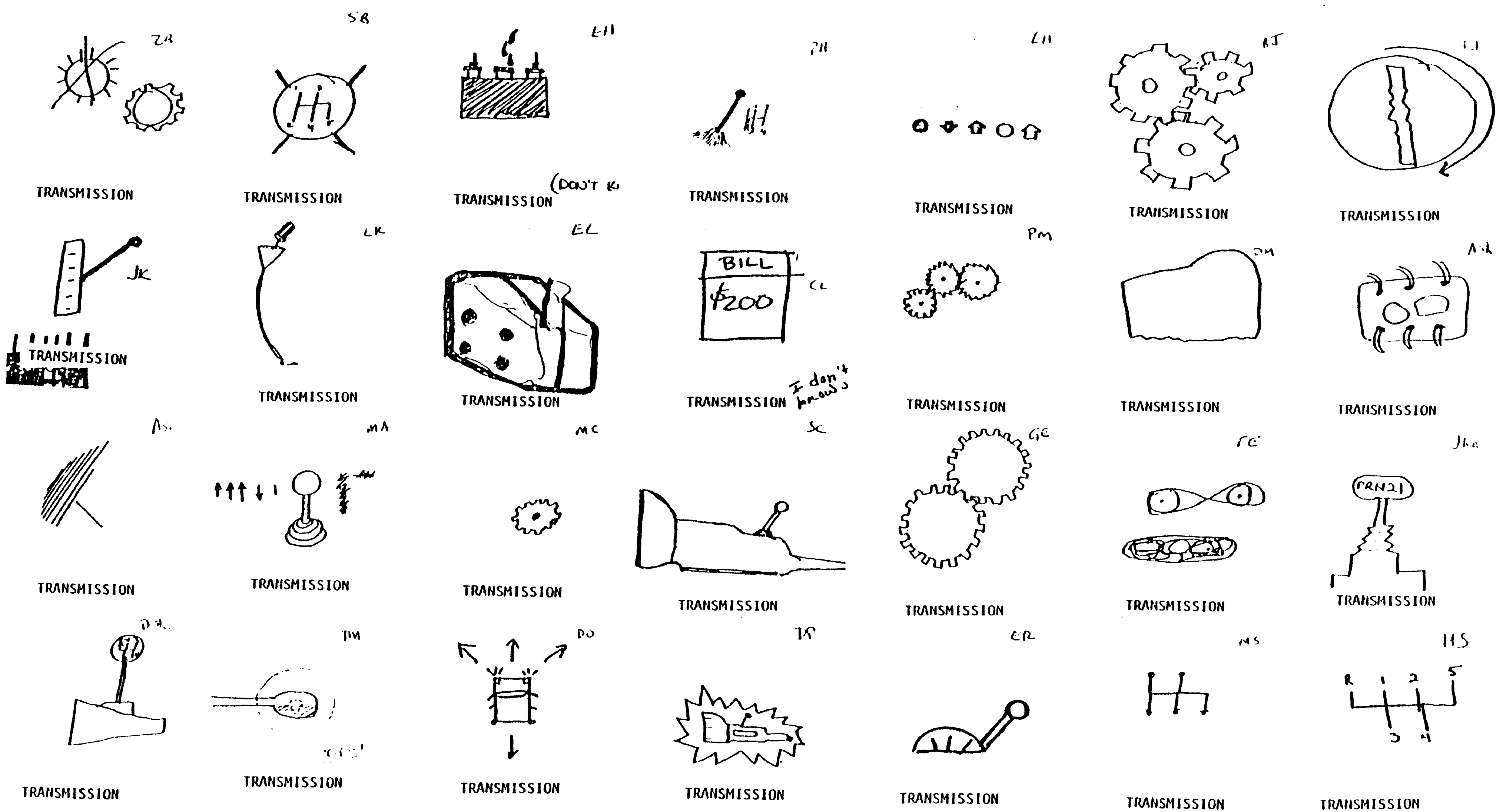
HYDRAULIC


ZB HYDRAULIC
EH HYDRAULIC
LH HYDRAULIC ?
BJ HYDRAULIC
TJ HYDRAULIC
LK HYDRAULIC
EL ? HYDRAULIC
CL HYDRAULIC
PM HYDRAULIC
DM HYDRAULIC
Ash HYDRAULIC ?
ASi HYDRAULIC
MA HYDRAULIC
MC HYDRAULIC
SC HYDRAULIC
GE HYDRAULIC
FE HYDRAULIC
Jka HYDRAULIC
TM HYDRAULIC
DO HYDRAULIC
DP HYDRAULIC
ER HYDRAULIC
MS HYDRAULIC
HS HYDRAULIC

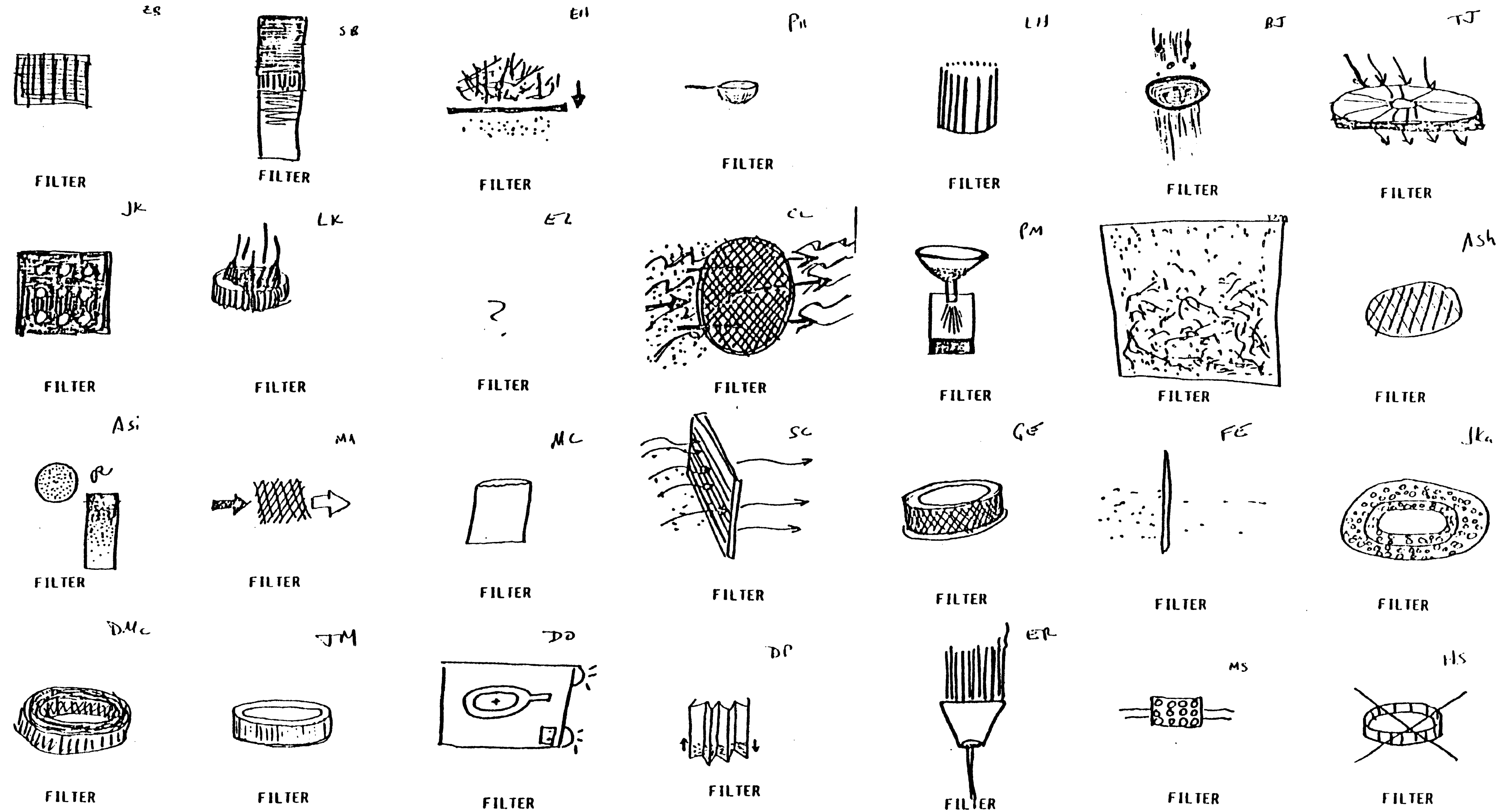
OIL


ZB
OIL
OIL
EH
OIL
LH
BS
OIL
JK
OIL
LK
OIL
EL
OIL
CL
OIL
PM
OIL
DM
OIL
Ash
OIL
ASi
OIL
MA
MC
SC
GE
FE
Jkc
DMc
TM
OIL
DO
OIL
DP
OIL
ER
OIL
MS
OIL
HS
OIL

TRANSMISSION

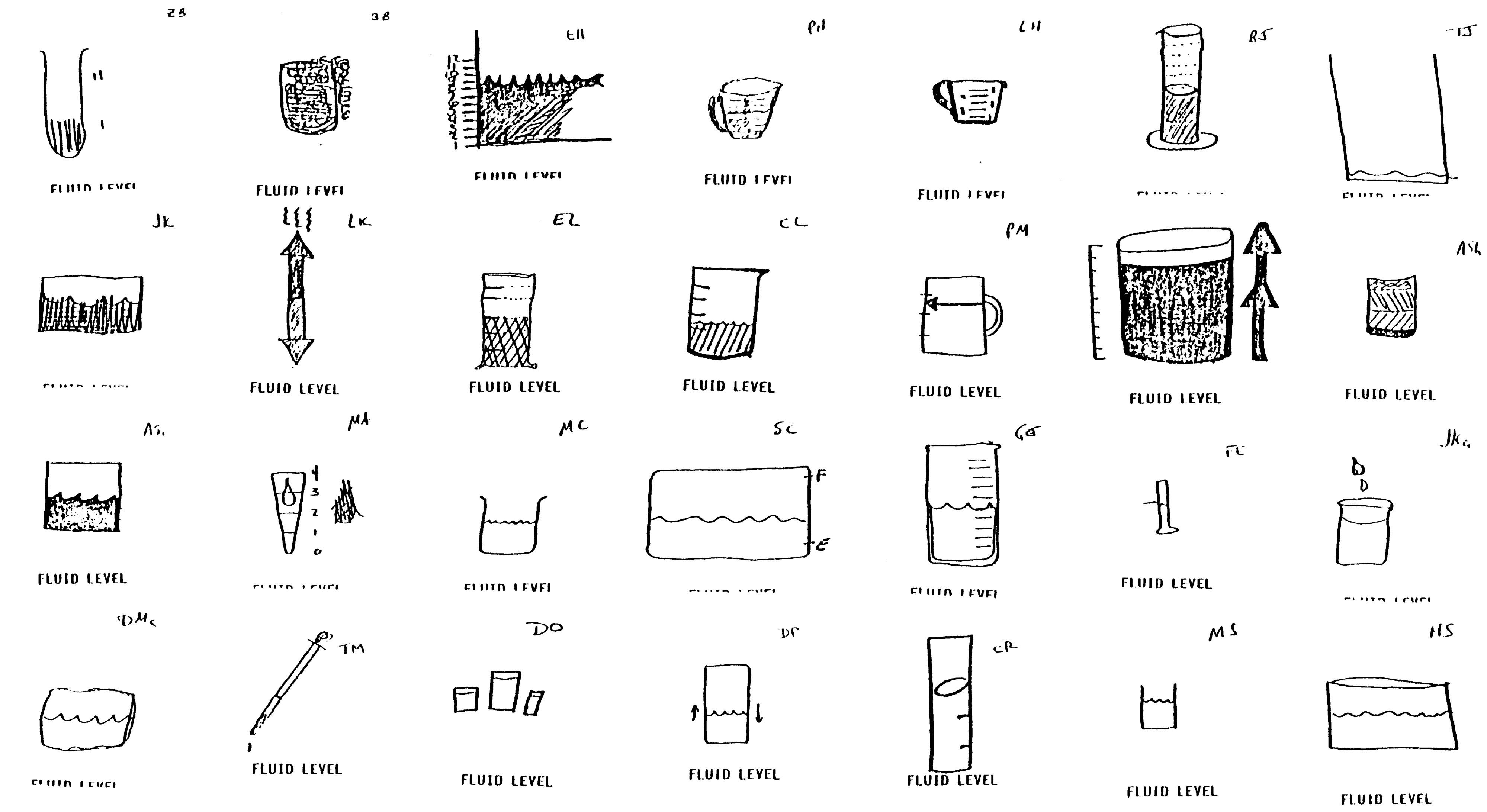


FILTER

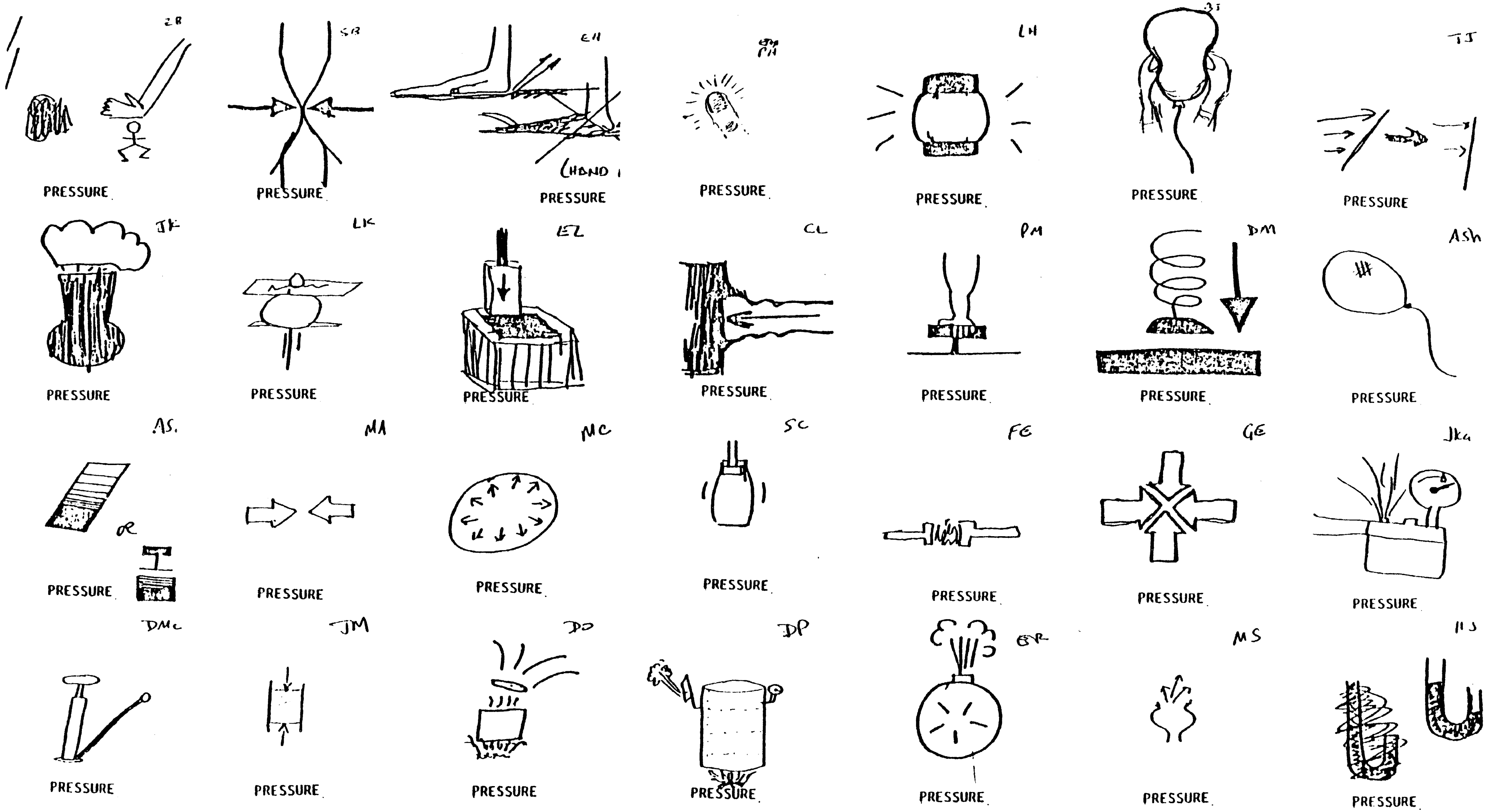


ES
FILTER
SB
FILTER
TJ
FILTER
BJ
FILTER
JK
FILTER
LK
FILTER
CL
FILTER
PM
FILTER
Ash
FILTER
Asi
FILTER
MA
FILTER
MC
FILTER
SC
FILTER
FE
FILTER
DMc
FILTER
JM
FILTER
DO
FILTER
DP
FILTER
ER
FILTER
MS
FILTER
HS
FILTER

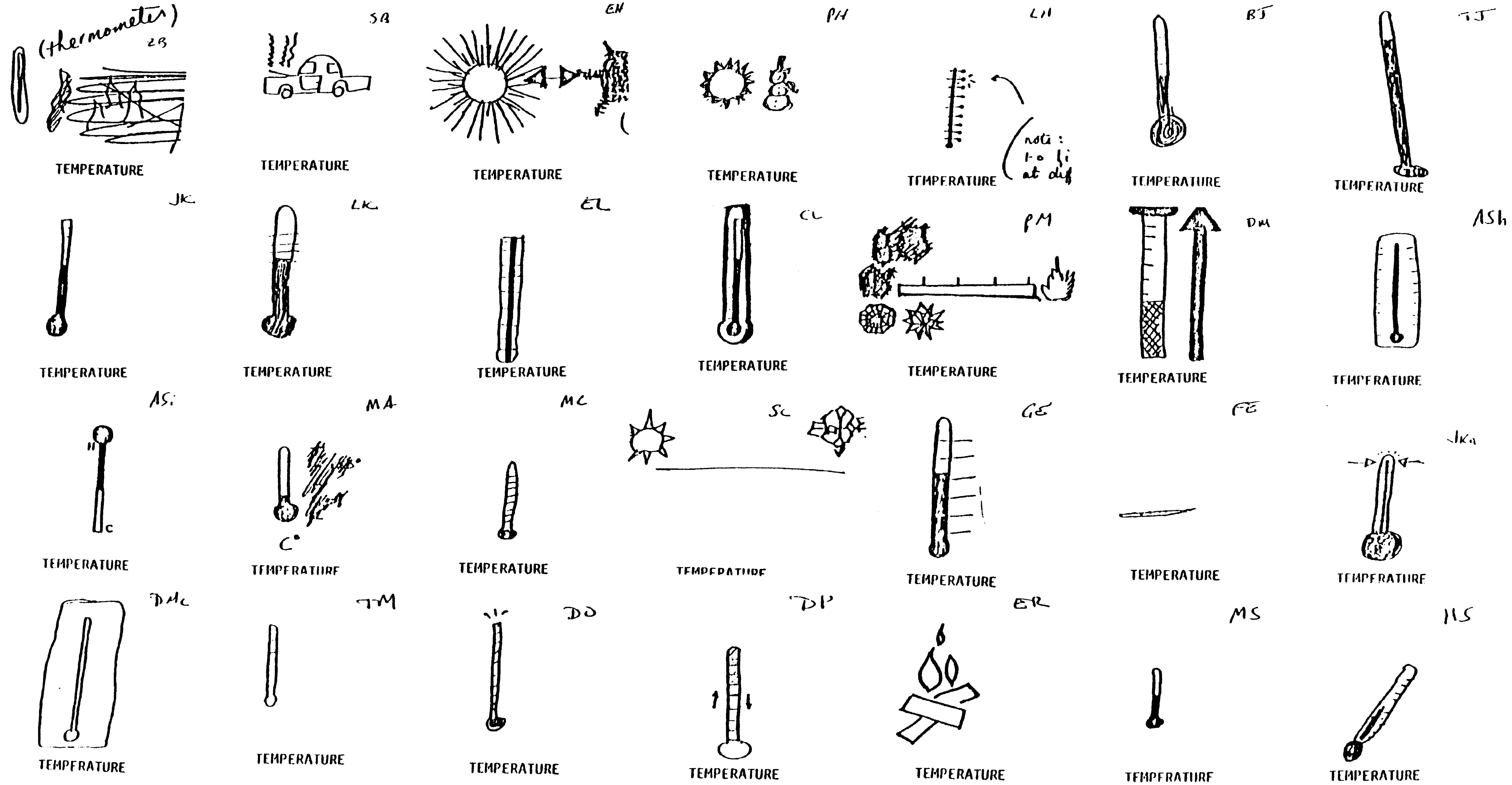
FLUID LEVEL



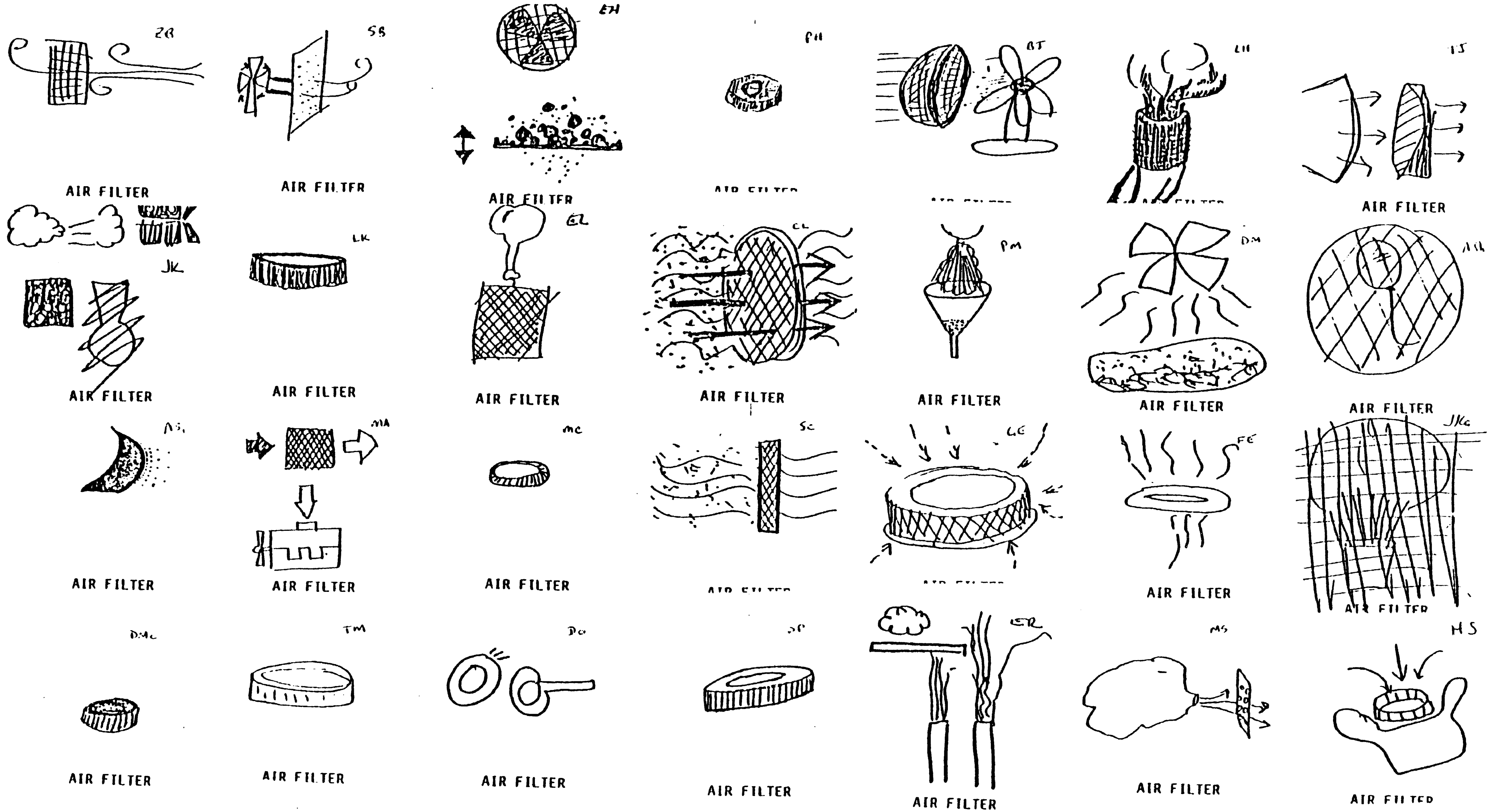
PRESSURE


ZB
PRESSURE
SB
PRESSURE
EH
(HAND)
PRESSURE
PRESSURE
LH
PRESSURE
PRESSURE
TJ
PRESSURE
JK
PRESSURE
LK
PRESSURE
EZ
PRESSURE
CL
PRESSURE
PM
PRESSURE
DM
PRESSURE
Ash
PRESSURE
AS.
or
PRESSURE
MA
PRESSURE
MC
PRESSURE
SC
PRESSURE
FE
PRESSURE
GE
PRESSURE
PRESSURE
DMc
PRESSURE
JM
PRESSURE
PRESSURE
DP
PRESSURE
PRESSURE
MS
PRESSURE
PRESSURE

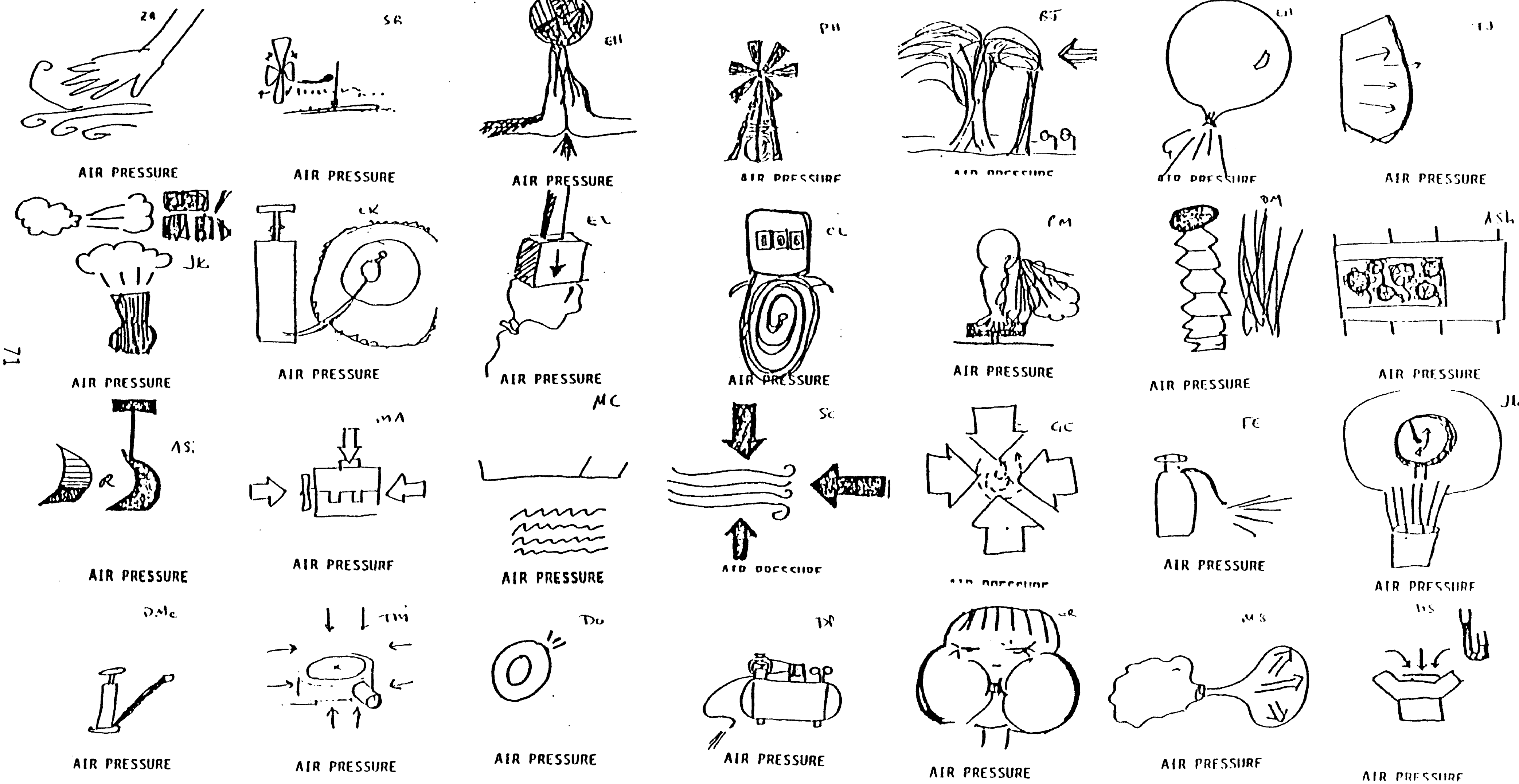
TEMPERATURE



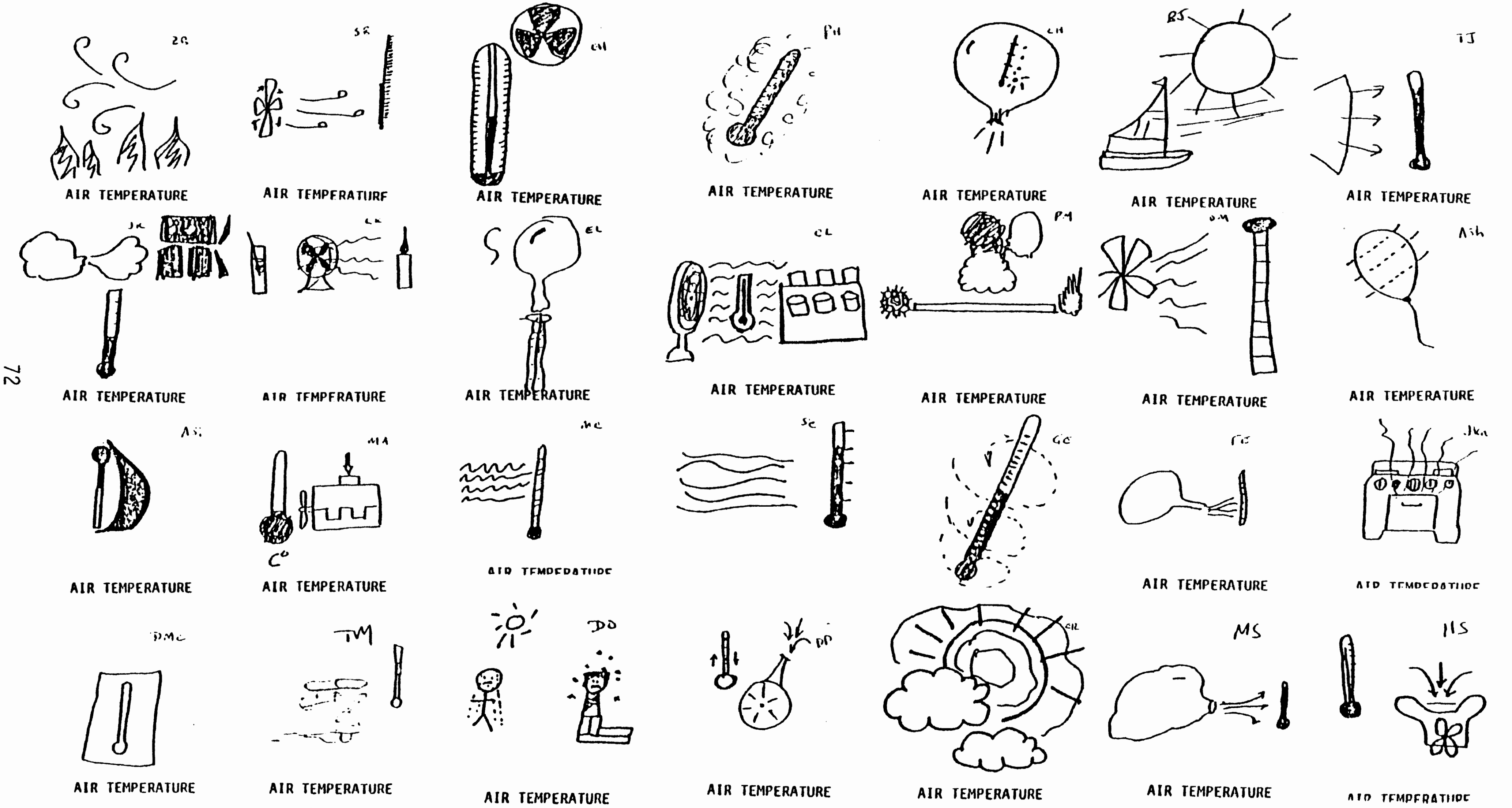
AIR FILTER



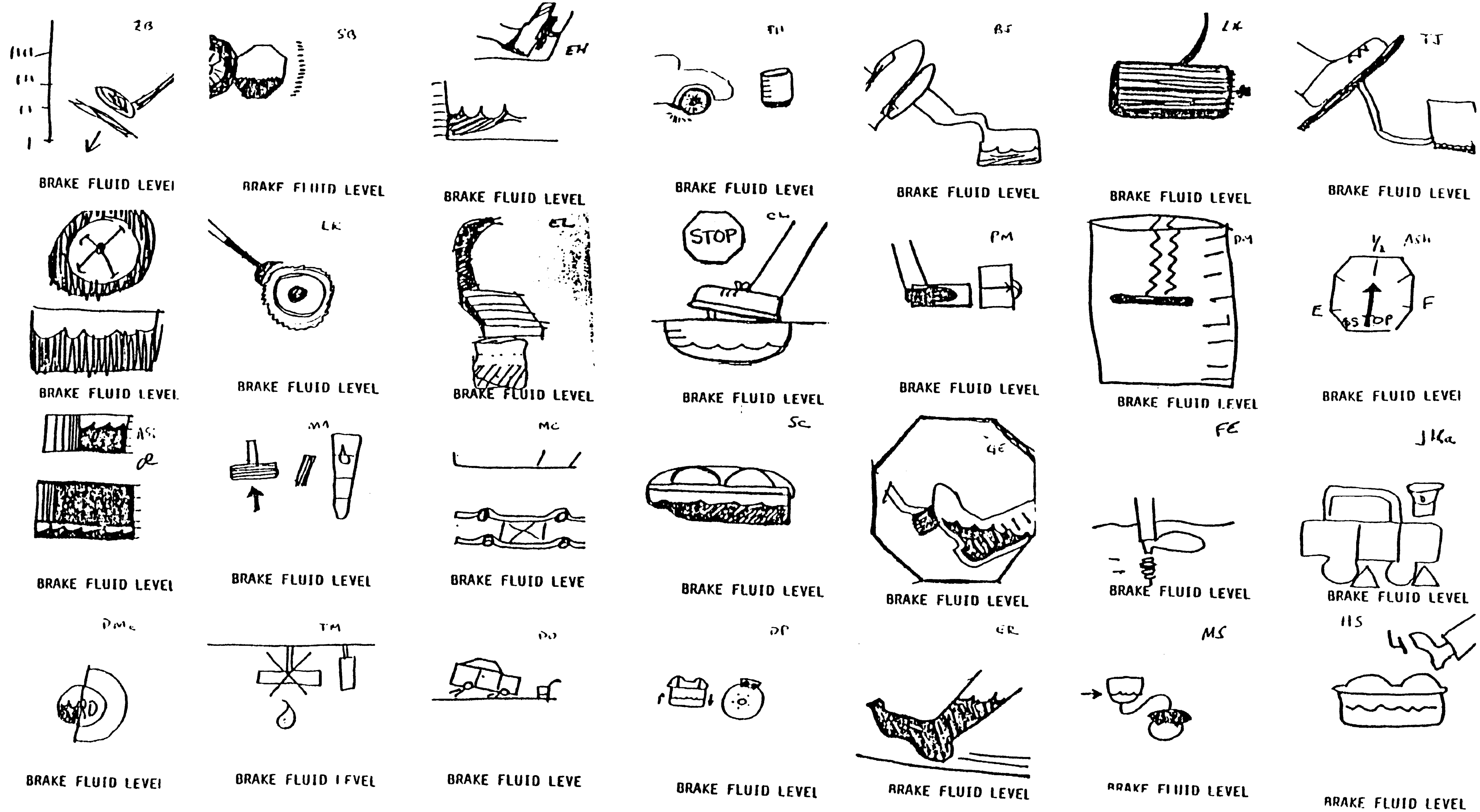
AIR PRESSURE



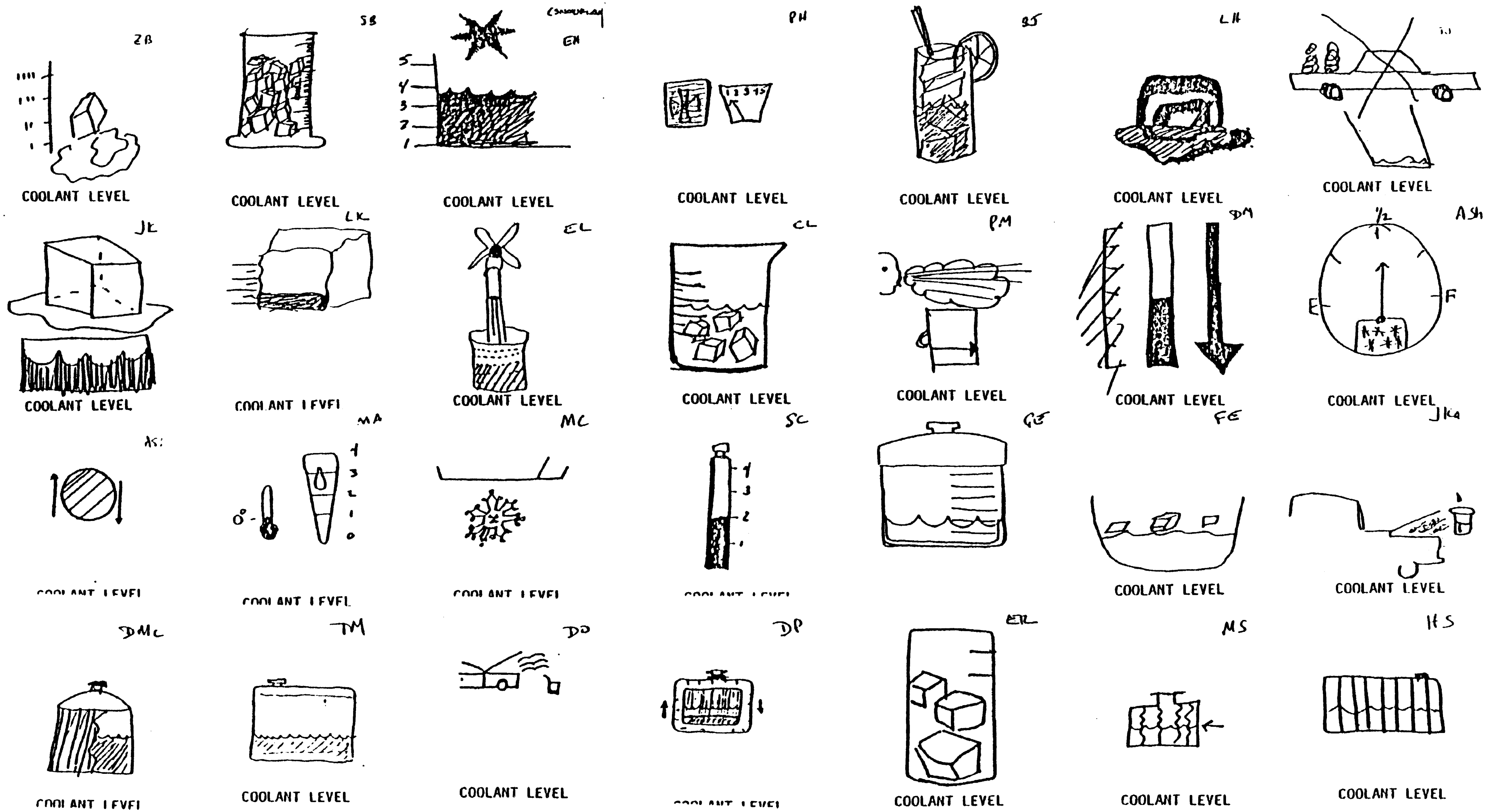
AIR TEMPERATURE



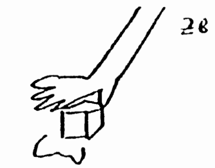
BRAKE FLUID LEVEL



COOLANT LEVEL

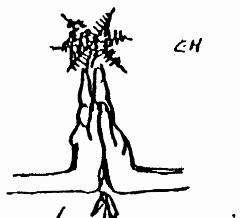


COOLANT PRESSURE

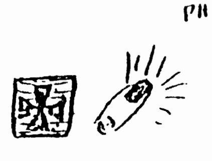


COOLANT PRESSURE

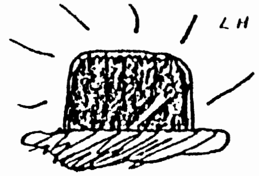
COOLANT PRESSURE



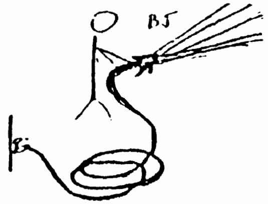
COOLANT PRESSURE



COOLANT PRESSURE



COOLANT PRESSURE



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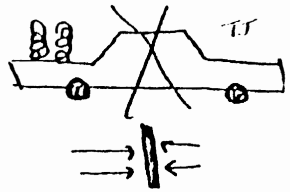

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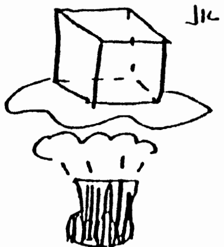

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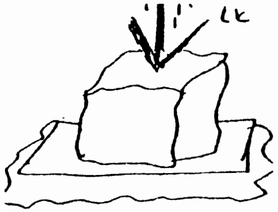
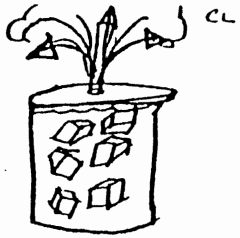


COOLANT PRESSURE

COOLANT PRESSURE



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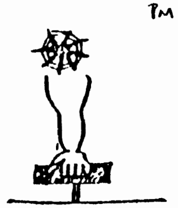

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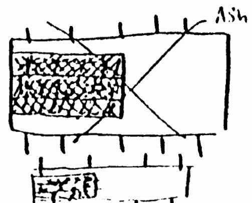

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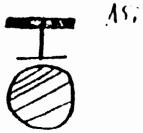

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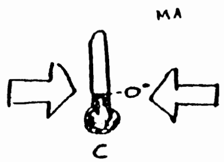

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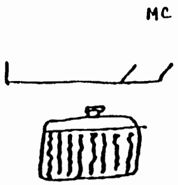

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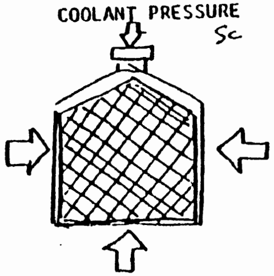

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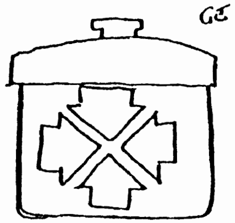

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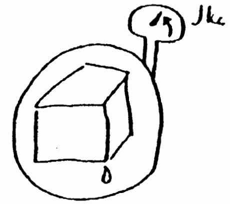

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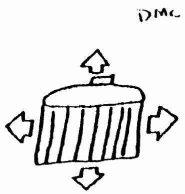

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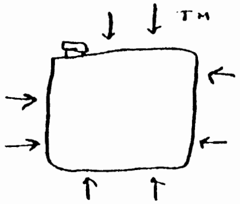

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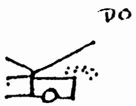

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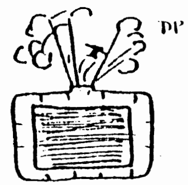

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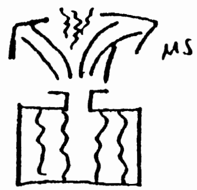

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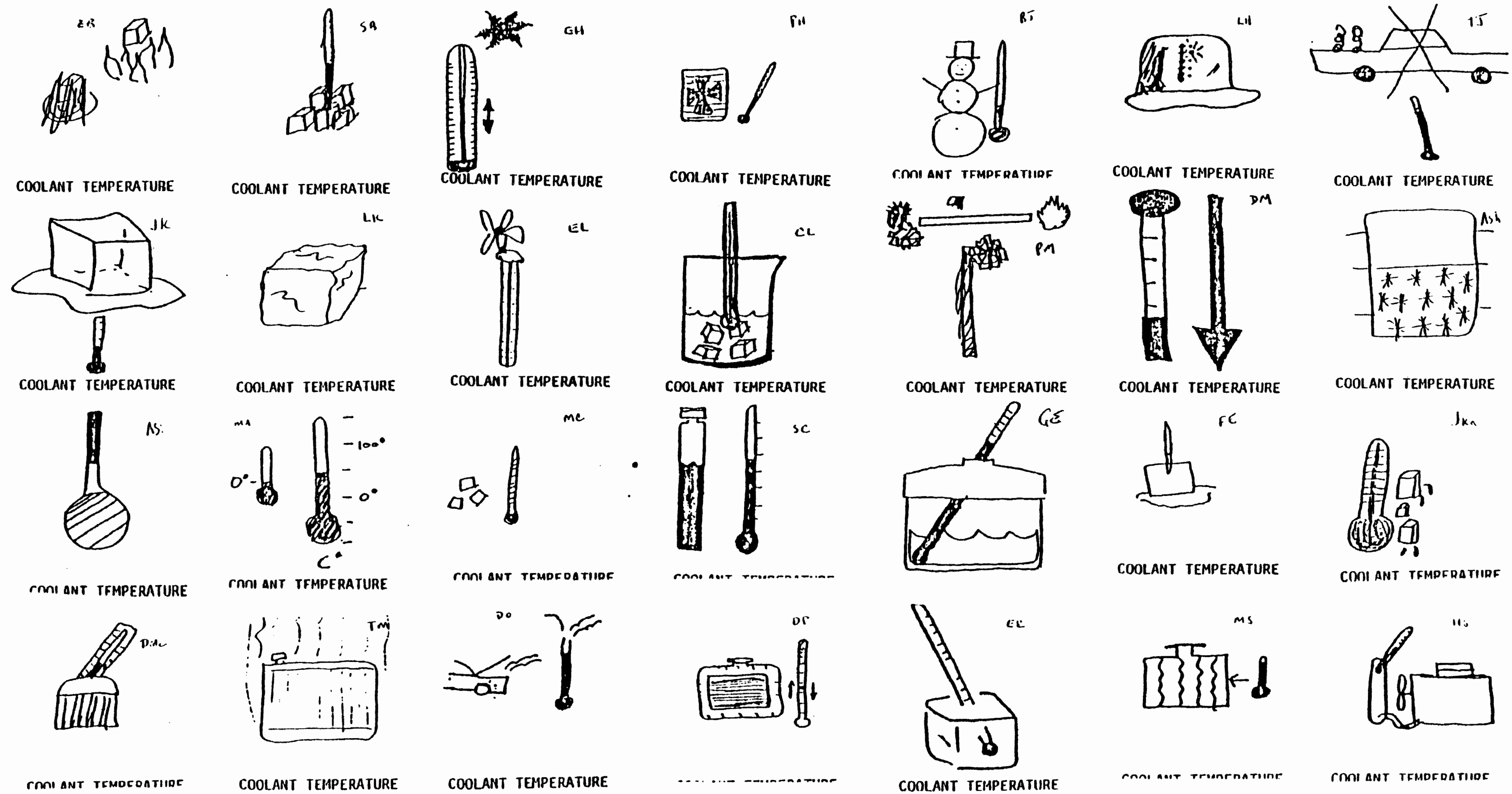

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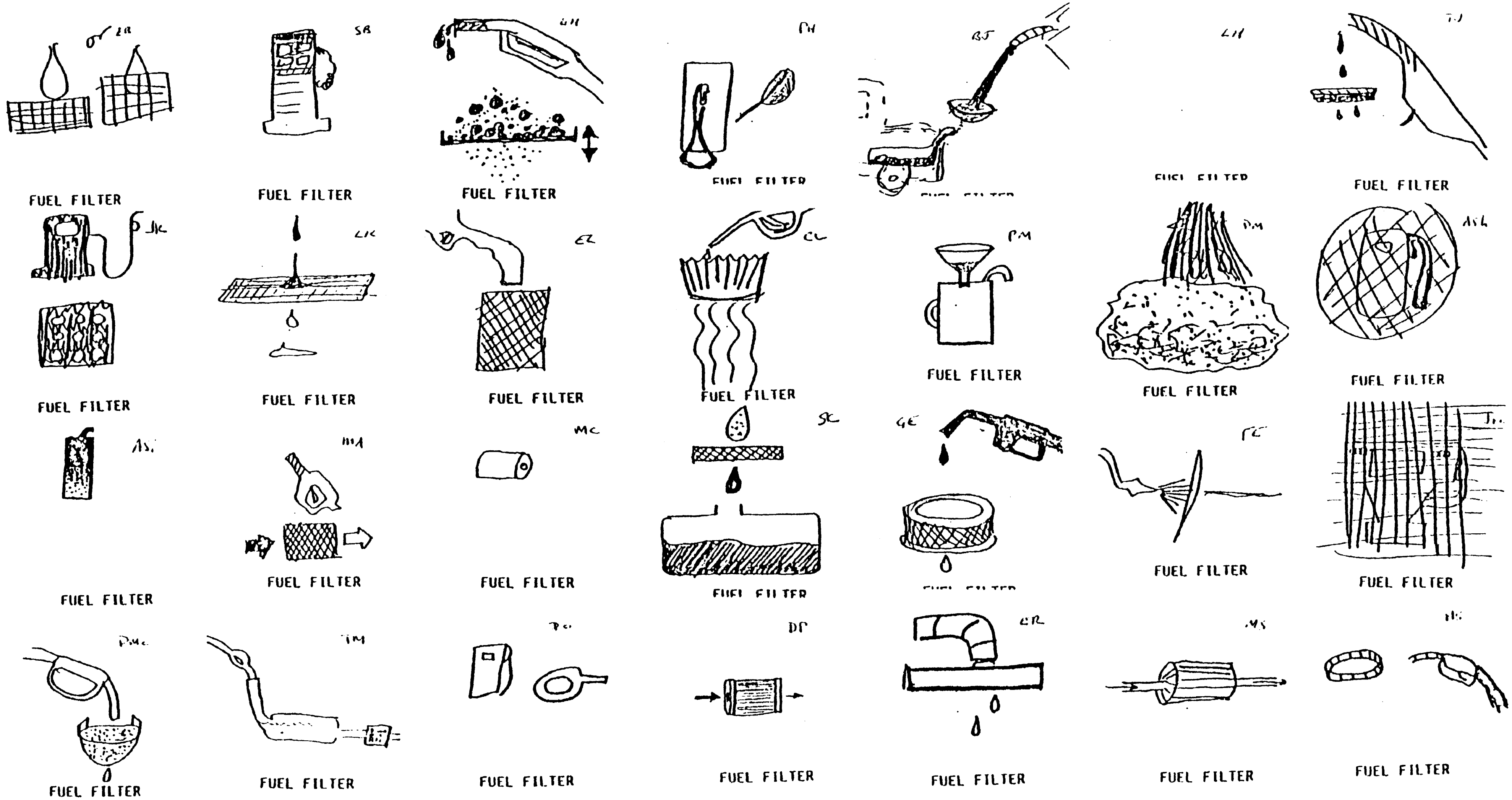
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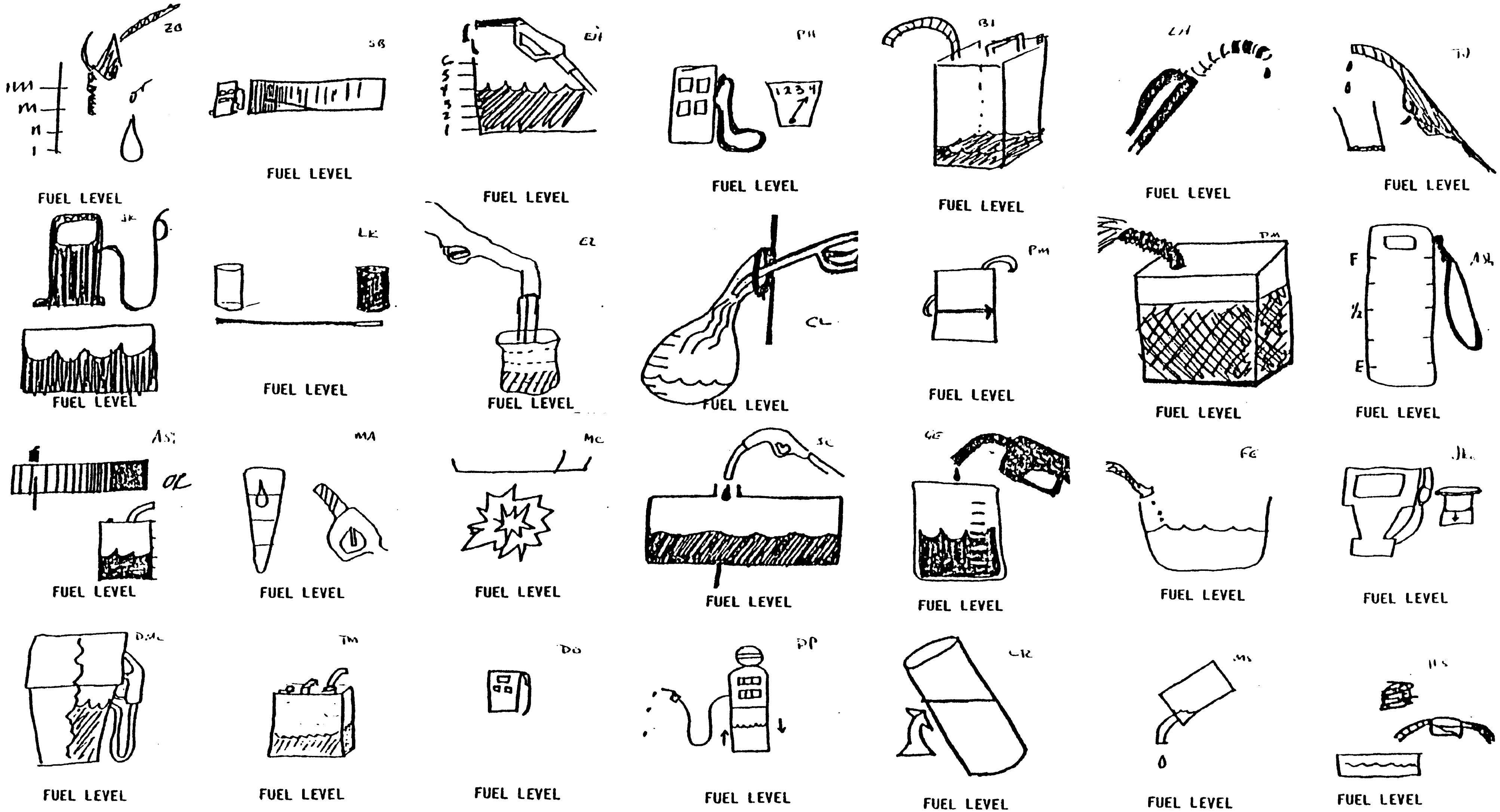
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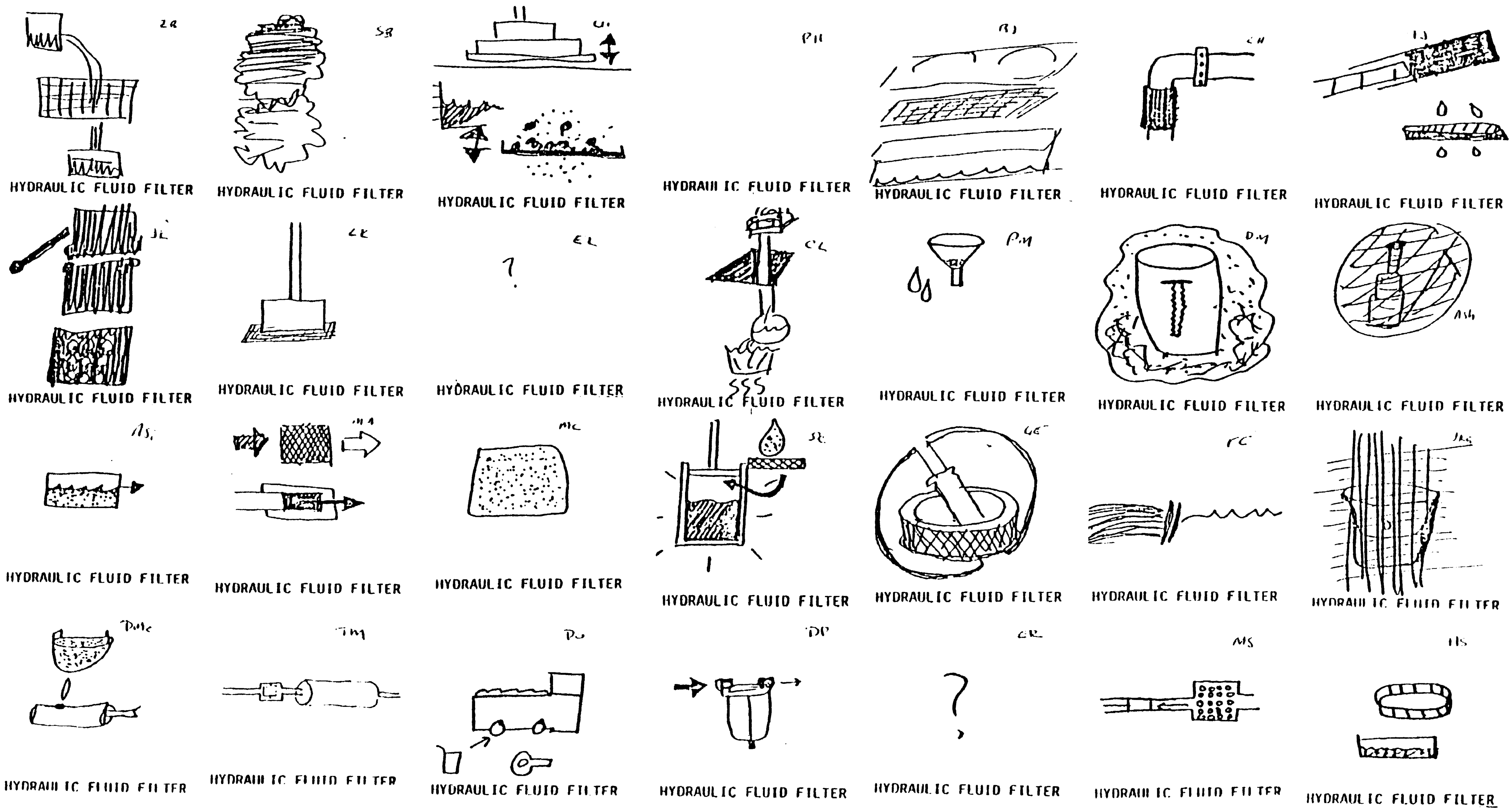

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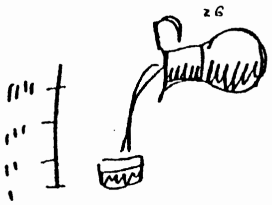
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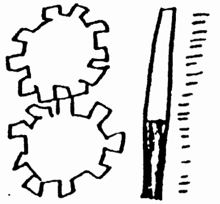
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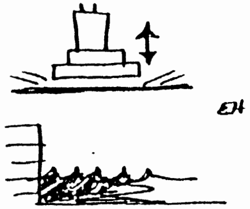
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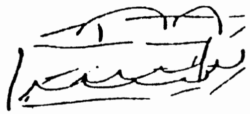
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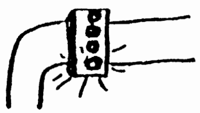
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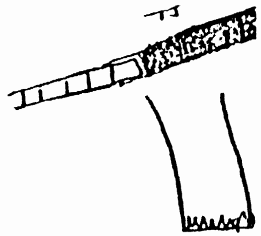
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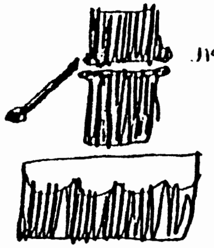
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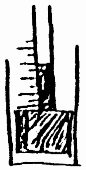
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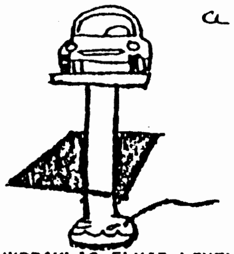
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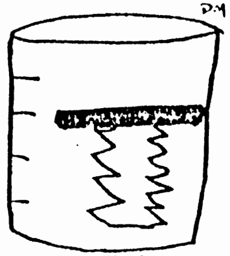
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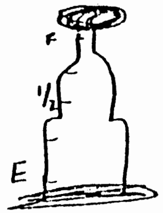
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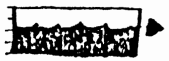
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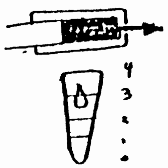
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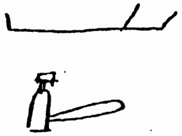
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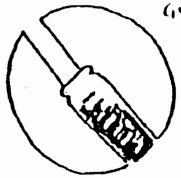
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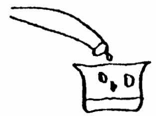
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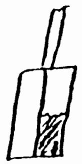
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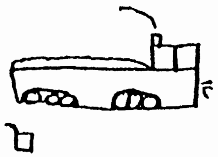
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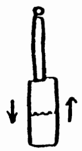
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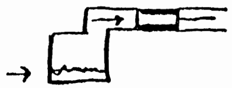
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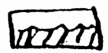
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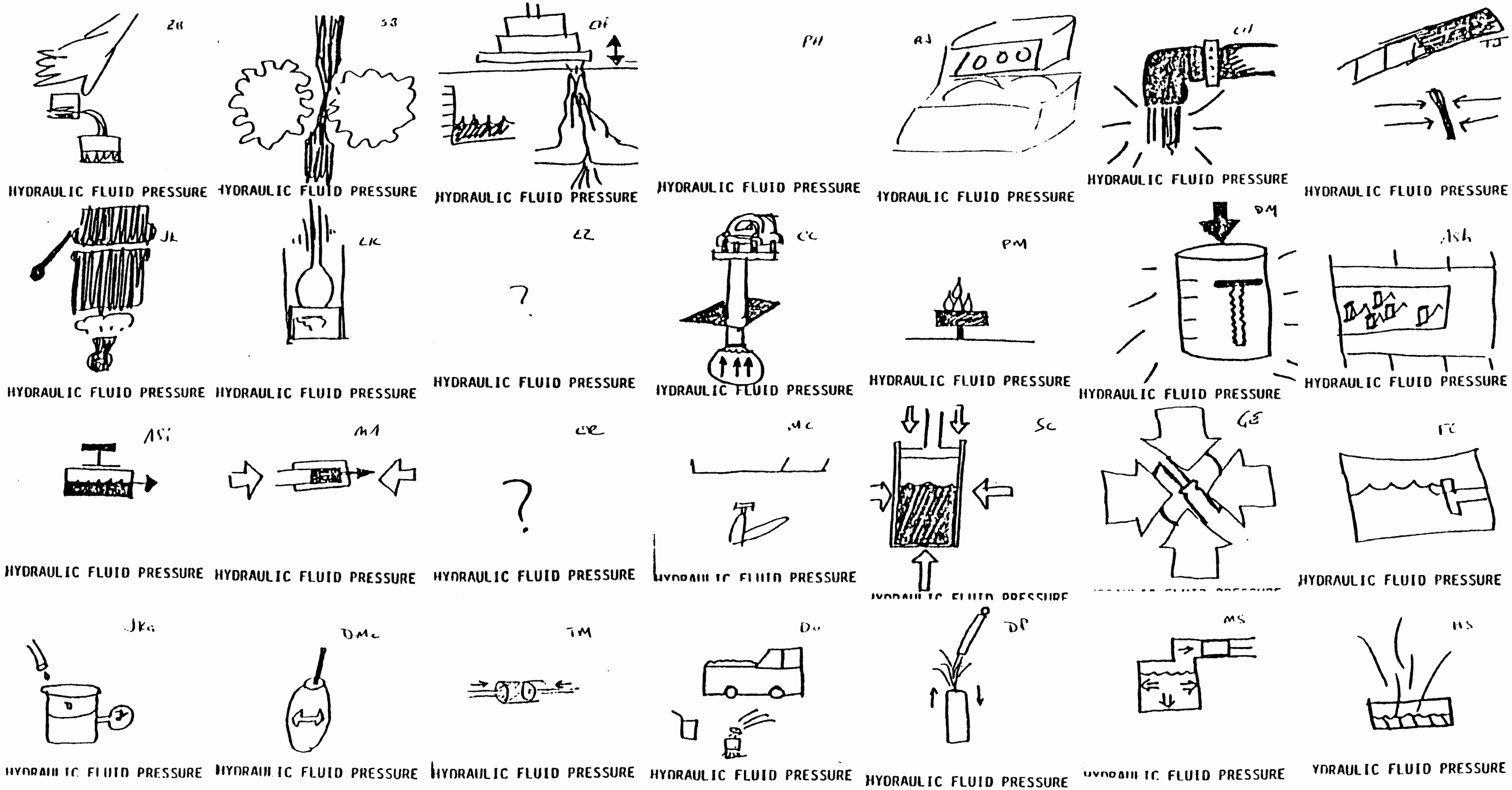

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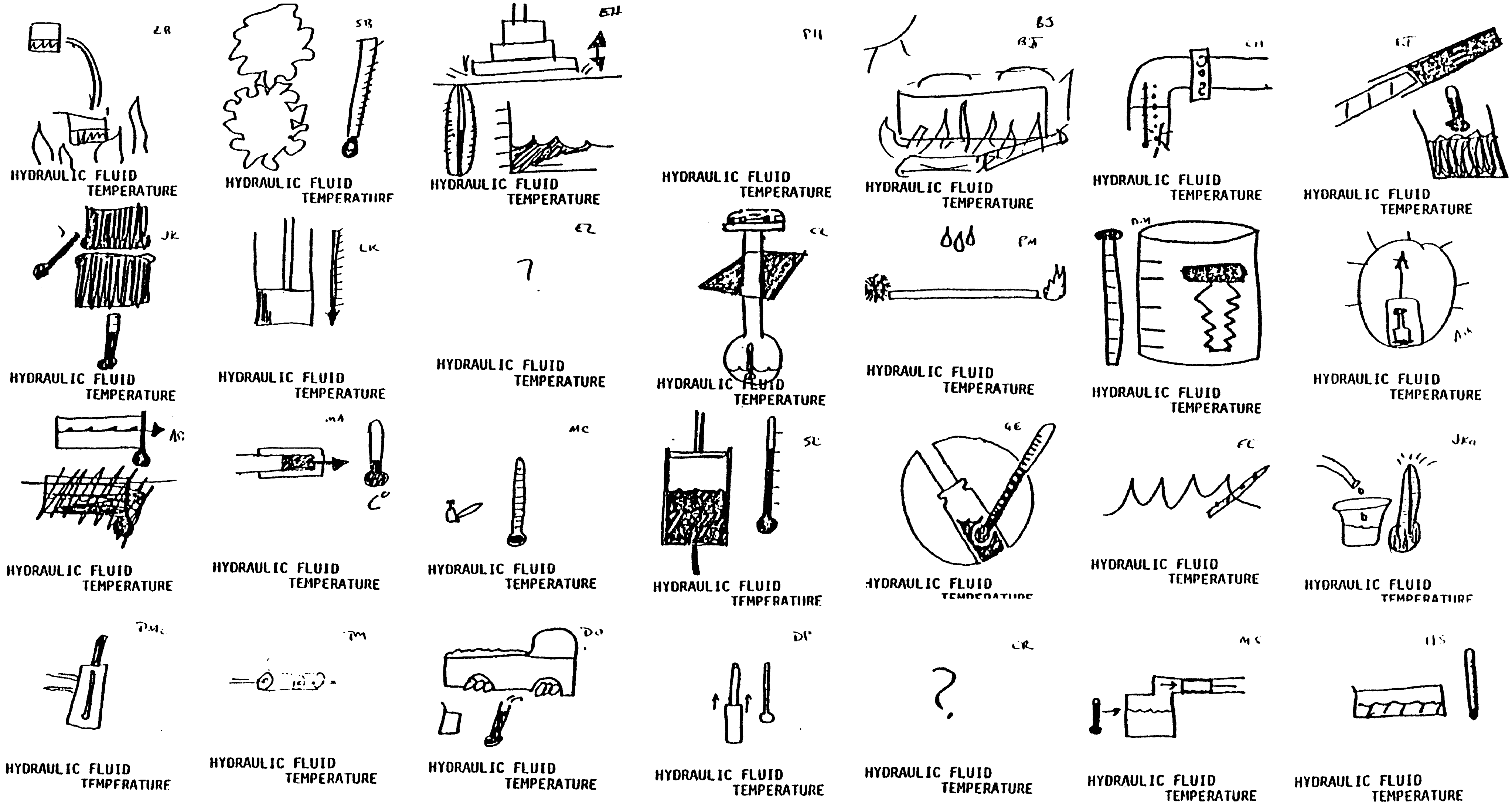

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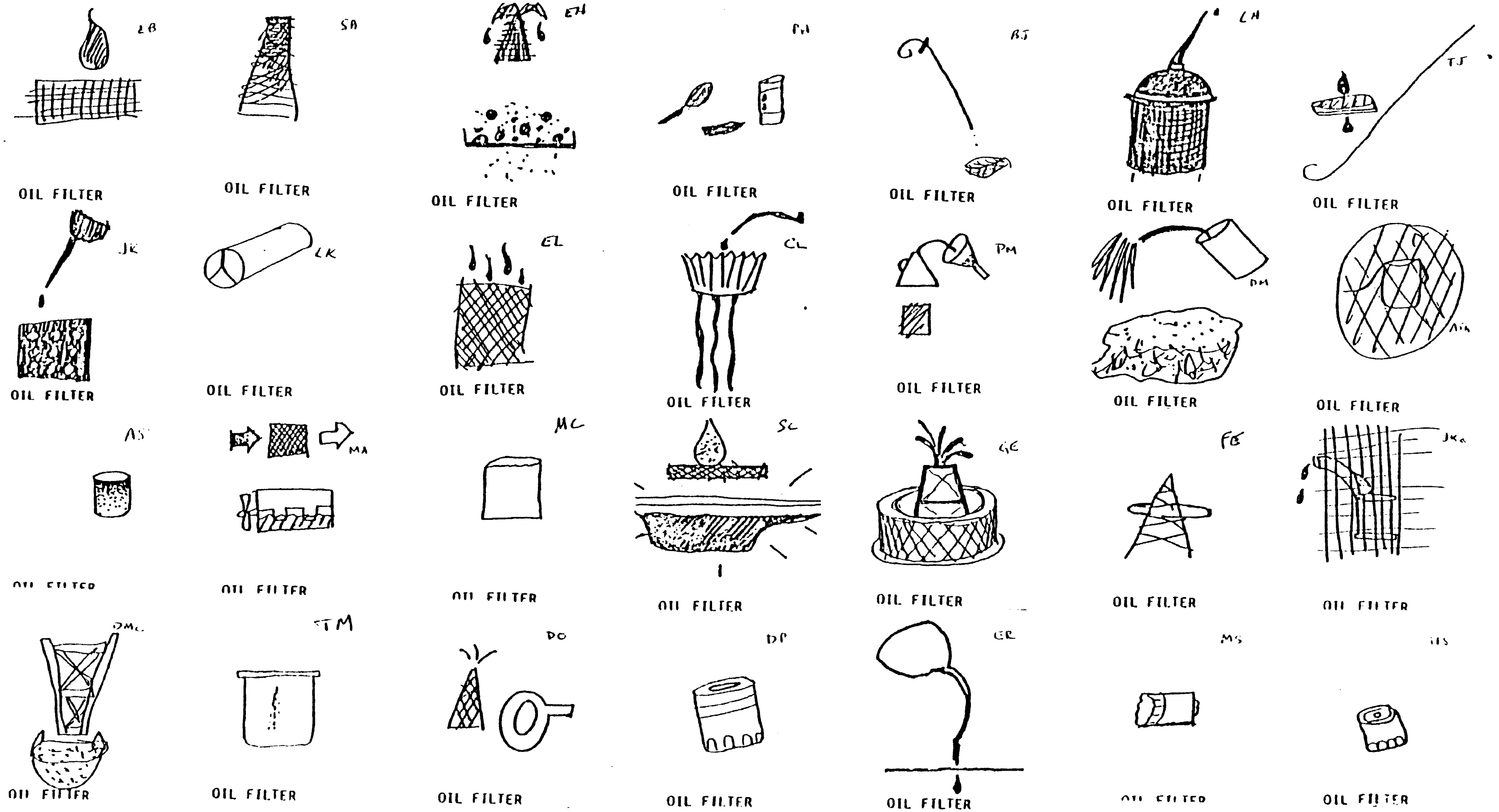
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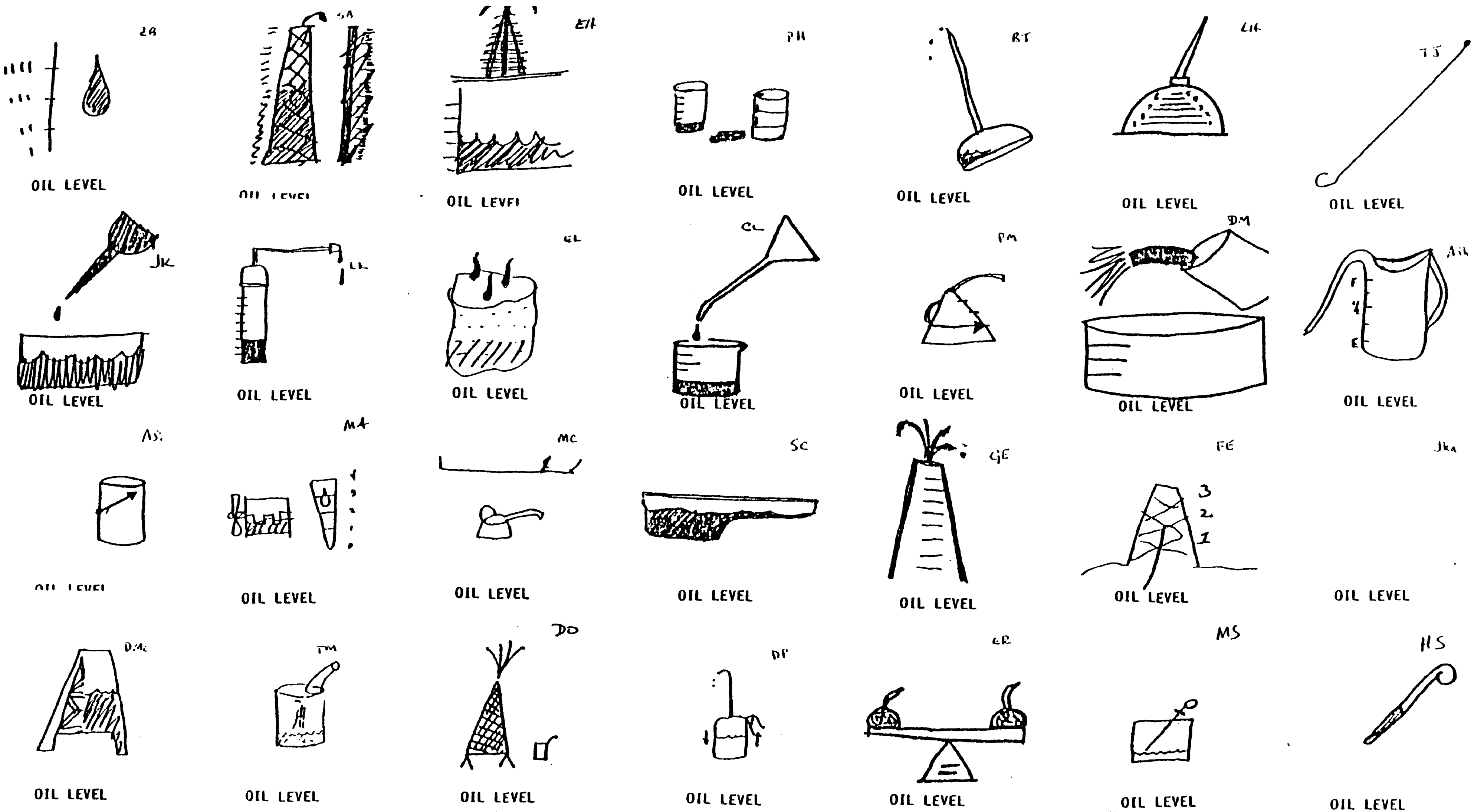
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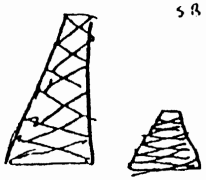

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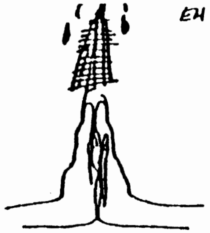

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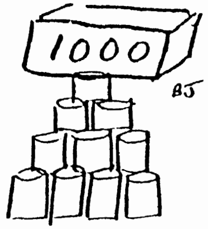

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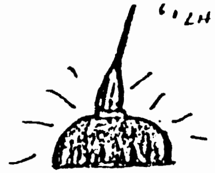

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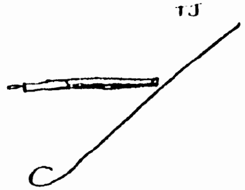

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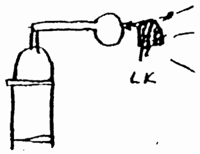

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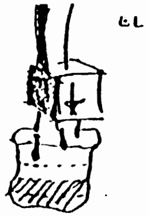

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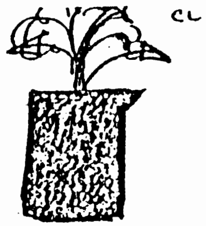

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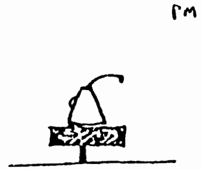

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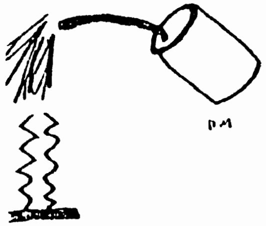

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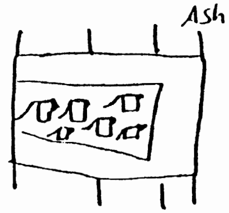

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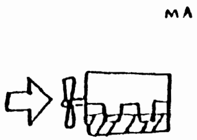

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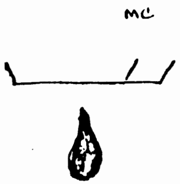

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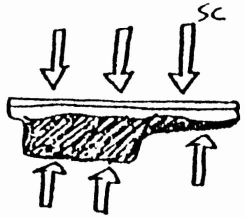

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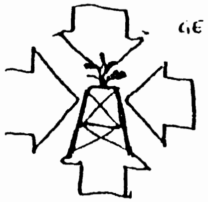

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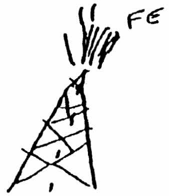

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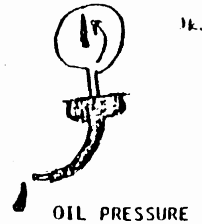

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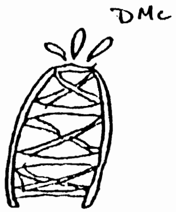

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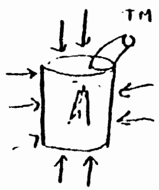

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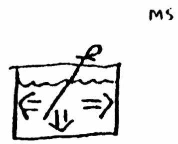

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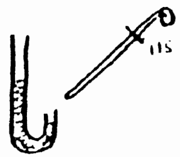

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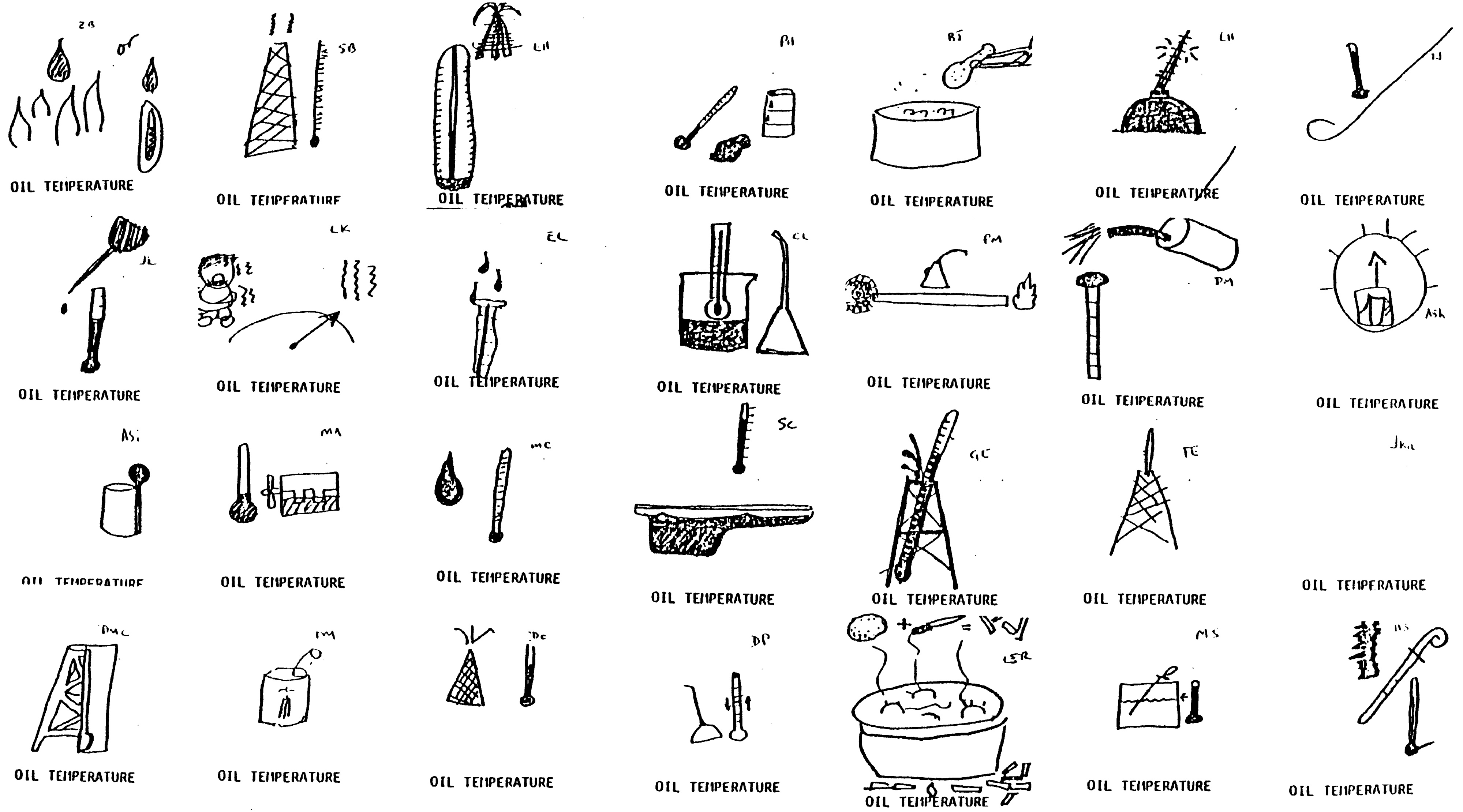

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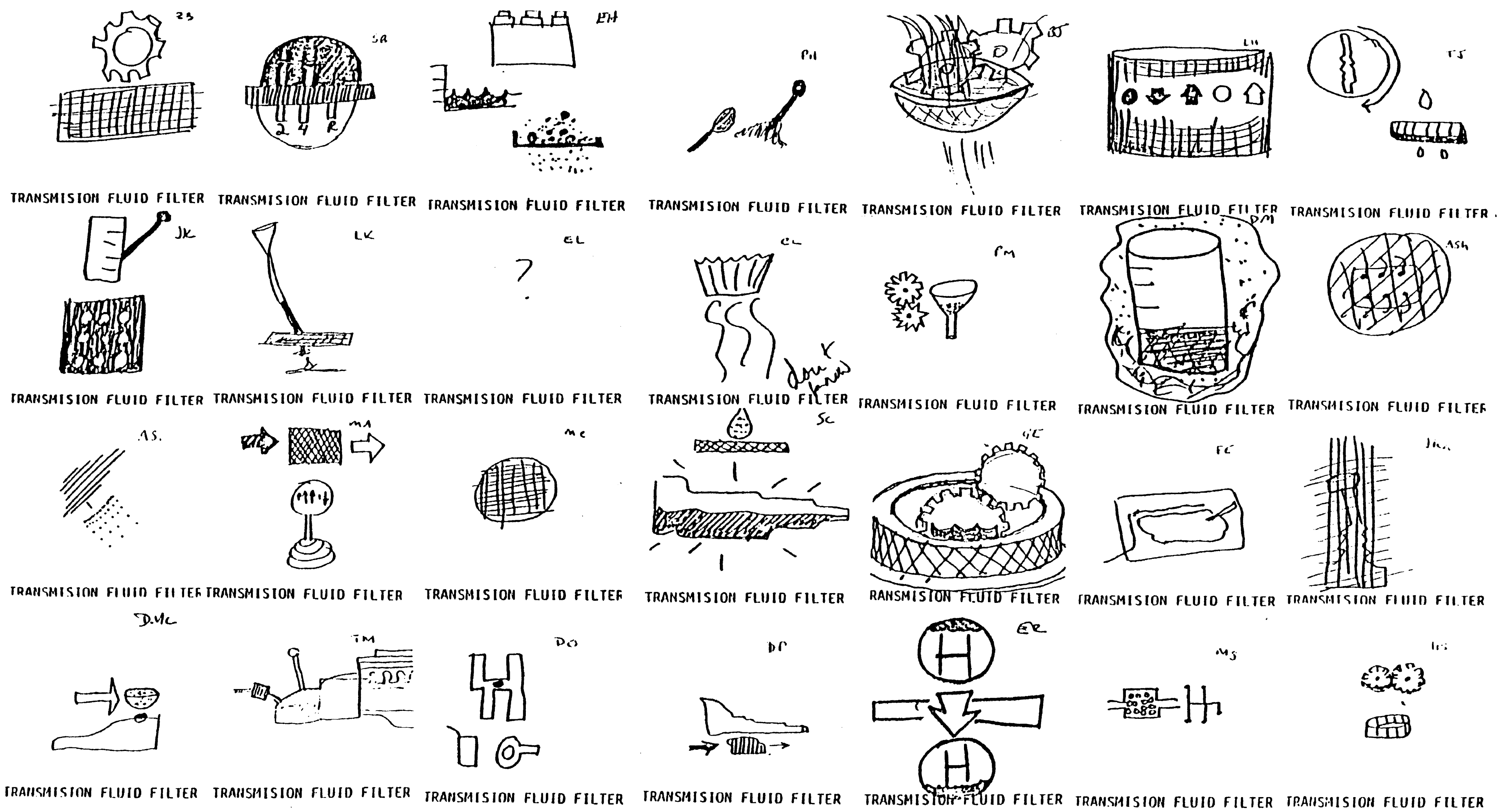
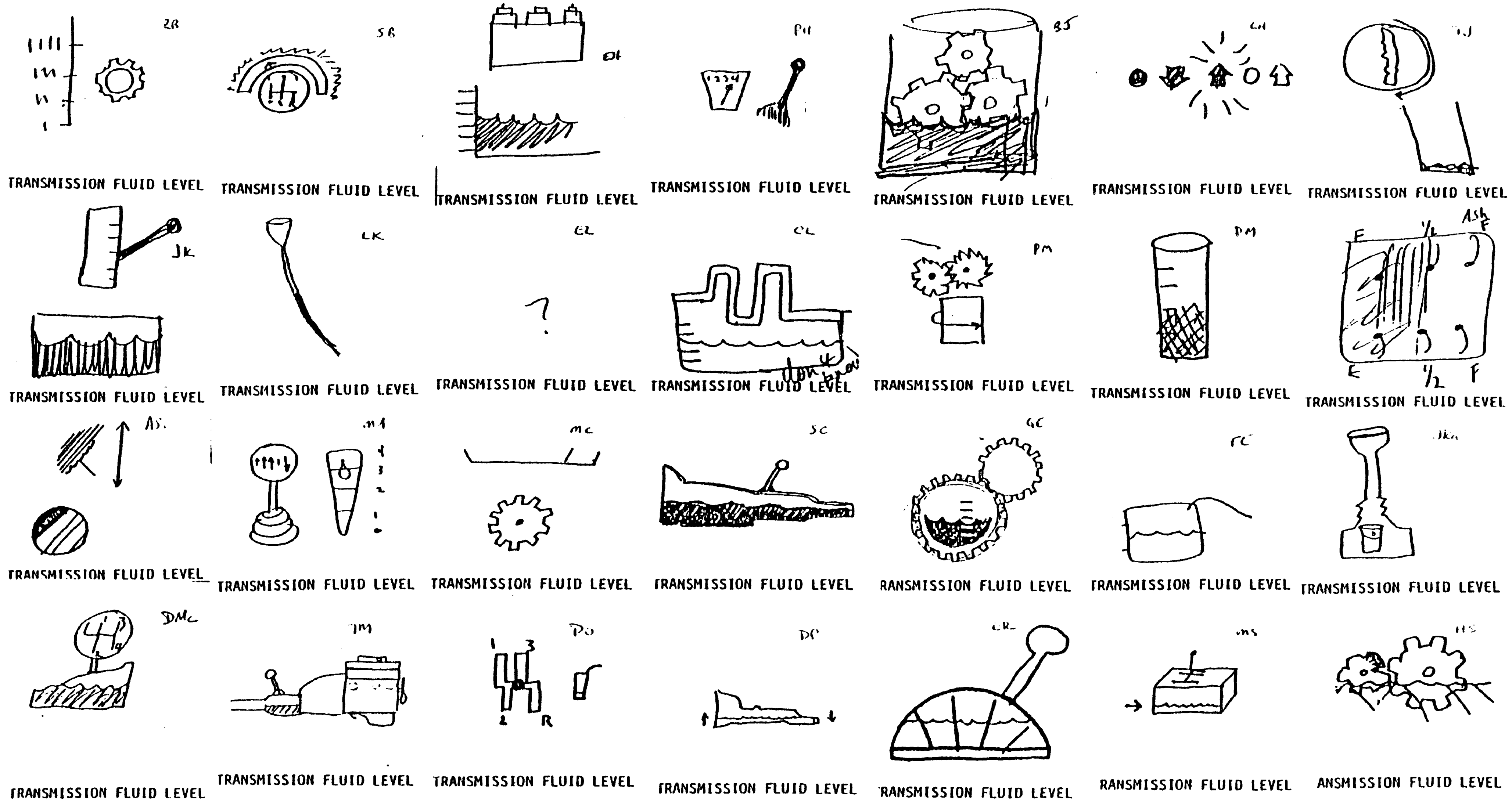
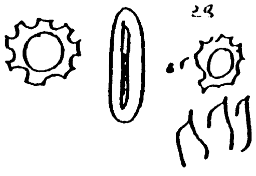


TRANSMISSION FLUID LEVEL



TRANSMISSION FLUID TEMPERATURE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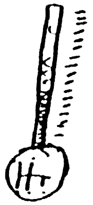
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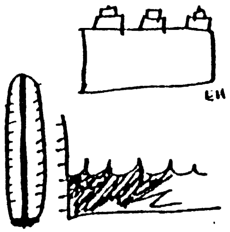
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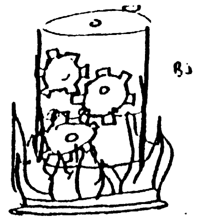
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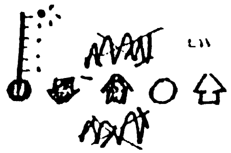
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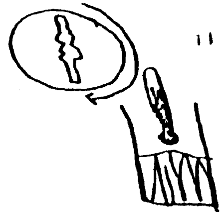
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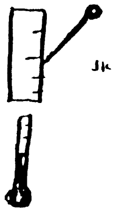
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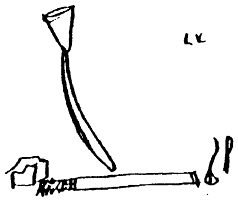
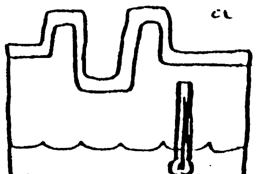
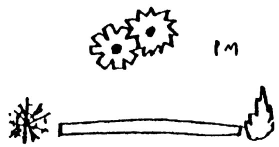

TRANSMISSION FLUID TEMPERATURE


TRANSMISSION FLUID TEMPERATURE


RANSMISSION FLUID TEMPERATURE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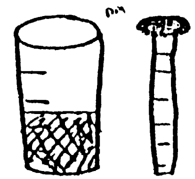
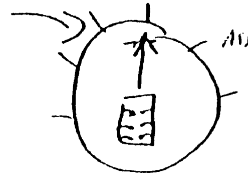
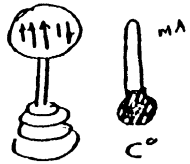

TRANSMISSION FLUID TEMPERATURE


TRANSMISSION FLUID TEMPERATURE


TRANSMISSION FLUID TEMPERATURE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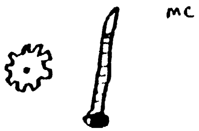
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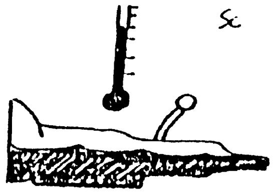
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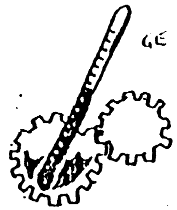
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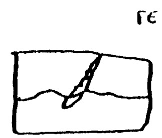
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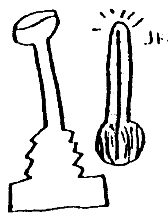
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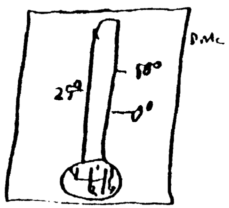
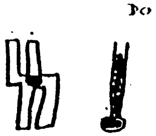

TRANSMISSION FLUID TEMPERATURE


TRANSMISSION FLUID TEMPERATURE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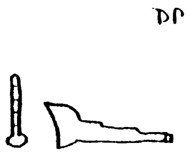
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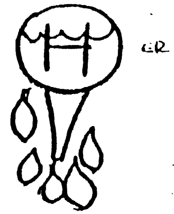
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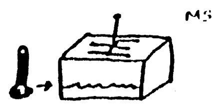
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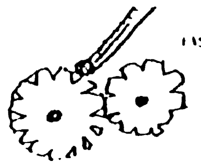

ANSMISSION FLUID TEMPERATURE

APPENDIX 3

Rating Questionnaire

SYMBOL RATING TASK

Dr. Paul Green
Human Factors
Highway Safety Research Institute
University of Michigan
Ann Arbor, MI 48109 (USA)
January 1980

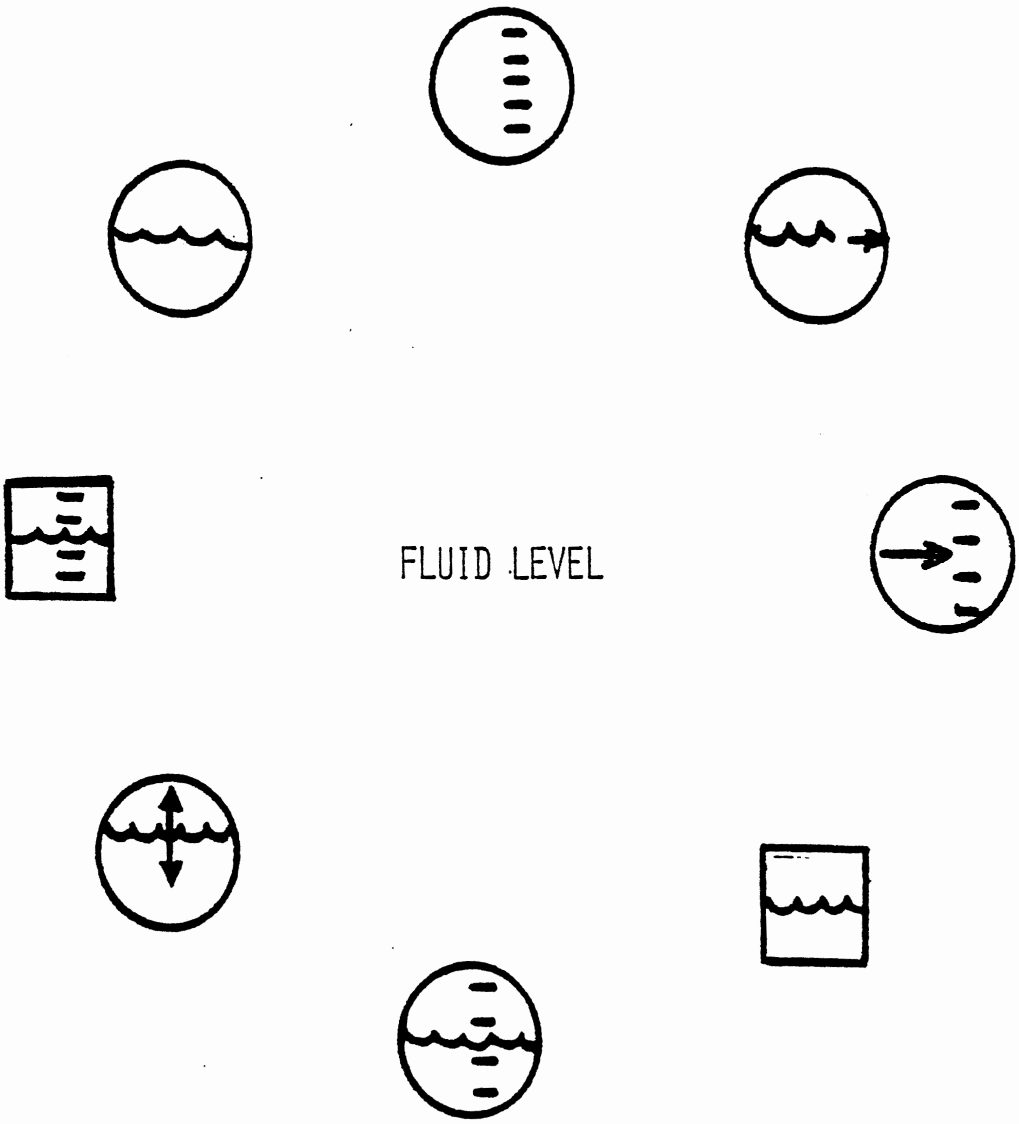
INTRODUCTION

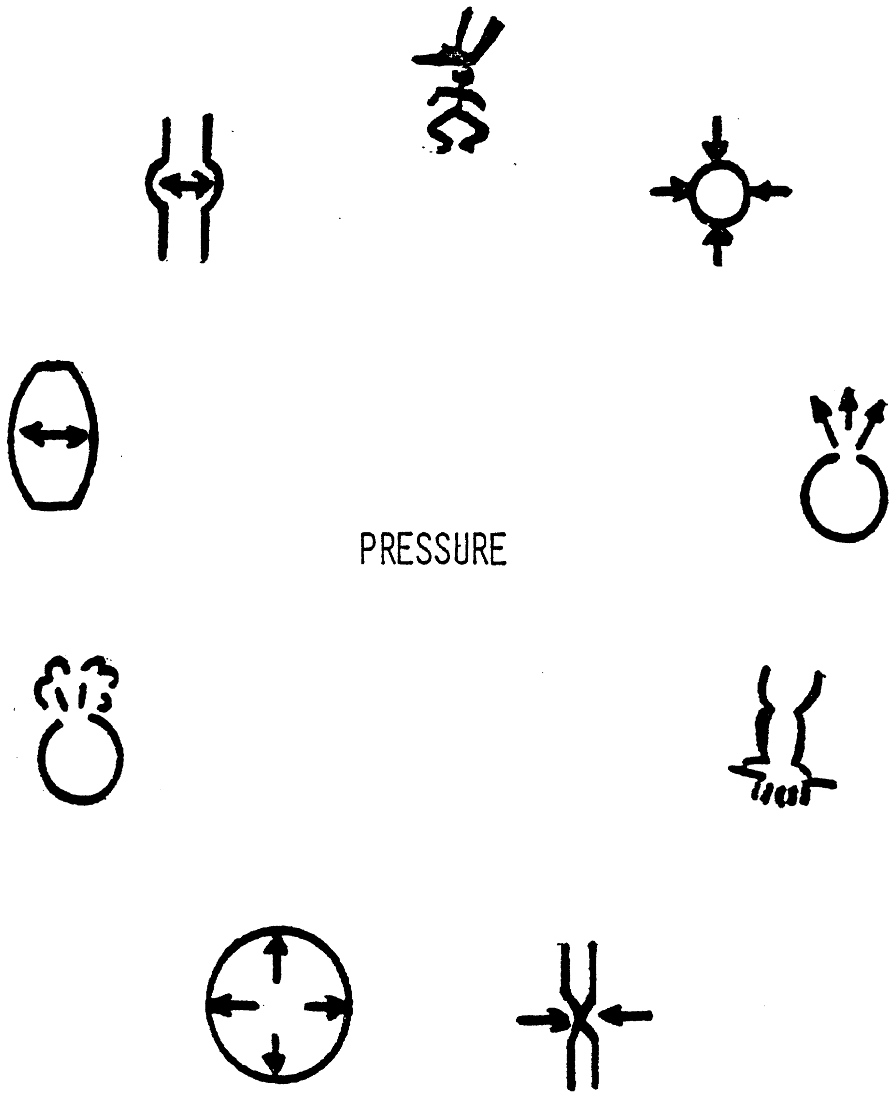
This is a continuation of the study you began last time. Again, the purpose of this study is to help the Society of Automotive Engineers and the International Standards Organization develop symbols for vehicle displays. You will be asked to rate a number of symbols. Among these are student and manufacturer's suggestions.

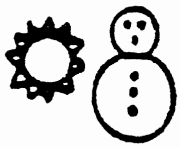
Specifically, the procedure used psychologists call "magnitude estimation." It goes as follows. Suppose you were shown this line ———————— and we said its length is ten. If then asked to rate how long this line ———————————————— is you would probably call it twenty because it is twice as long as the line we called ten. Similarly you would call this line —— two because it is one-fifth as long as the standard line.

In this study you will be asked to rate the meaningfulness of a number of symbols relative to this one  -the front hood release symbol. This picture appears on the handle mounted below the instrument panel that is used to release the front hood from inside the car. How meaningful, that is, how informative that picture is, we shall call ten. On the following pages appear a number of other pictures. Please rate their meaningfulness relative to the front hood release symbol (10) with bigger numbers used to identify more meaningful pictures. All ratings should be greater than or equal to zero and less than infinity. Any questions?

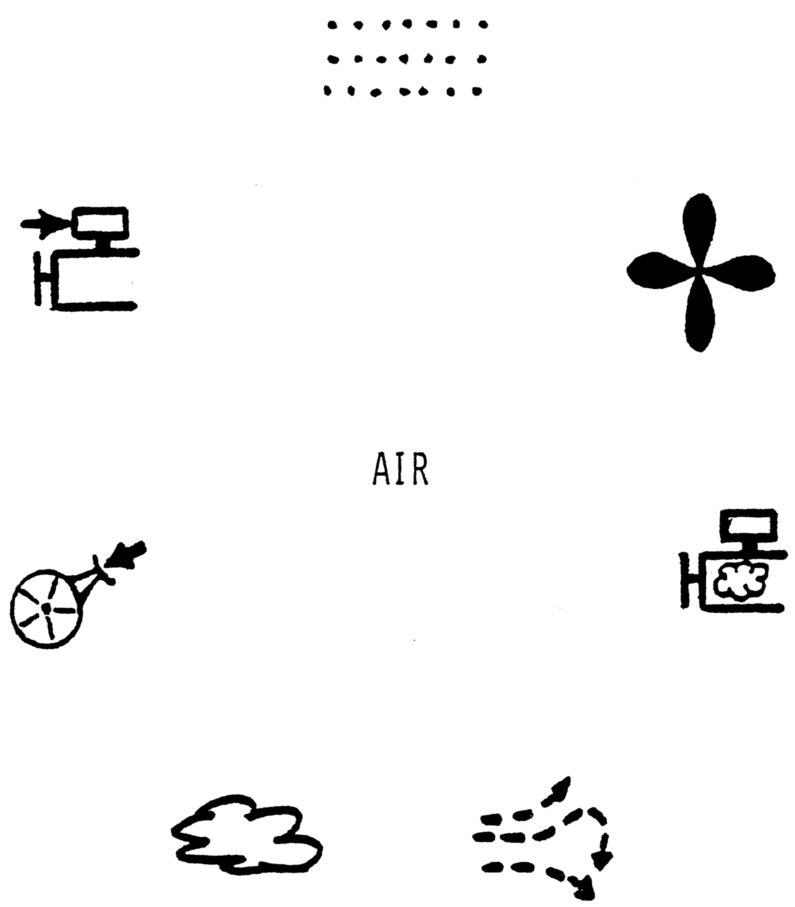

FILTER


FLUID LEVEL

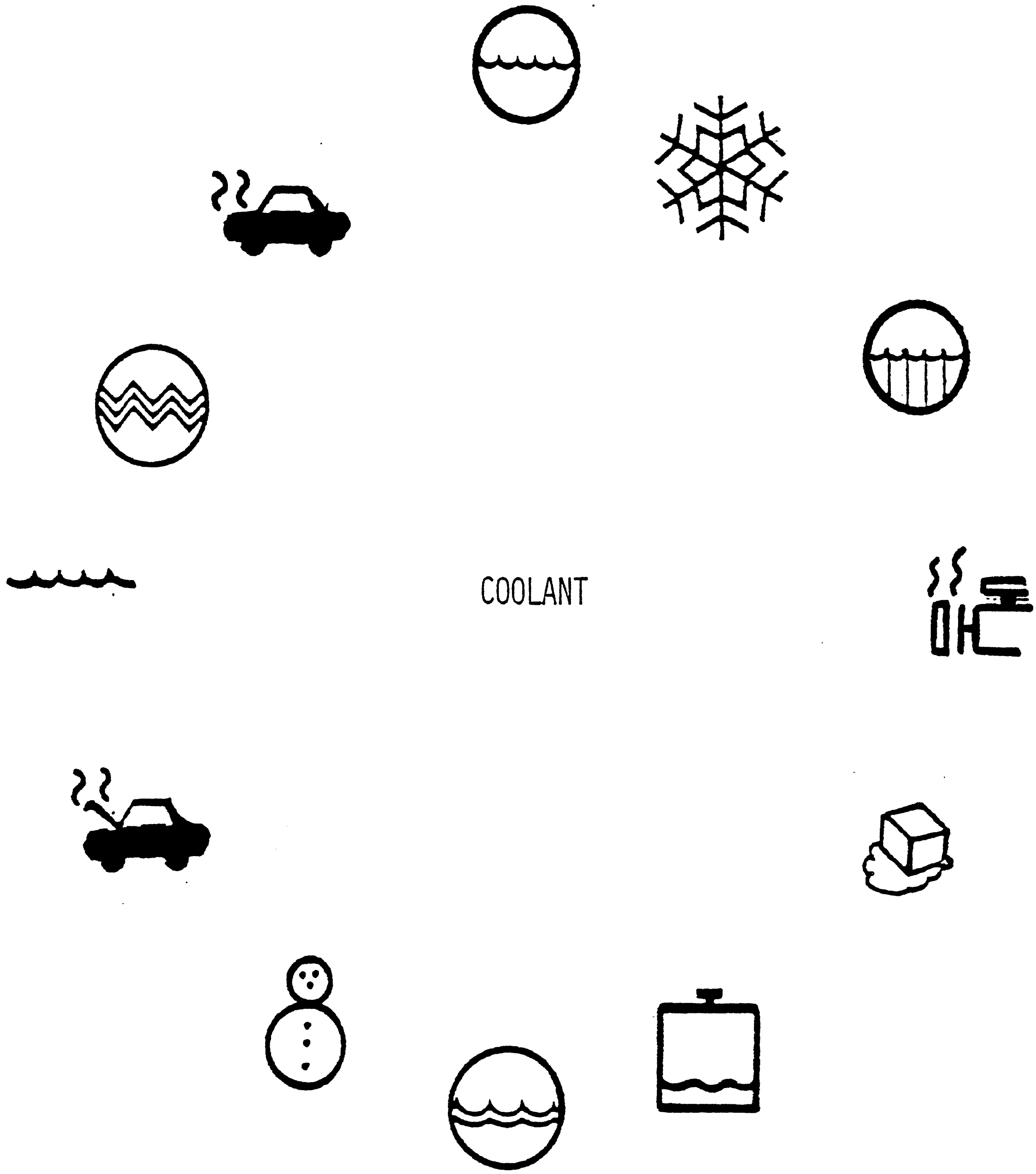

PRESSURE

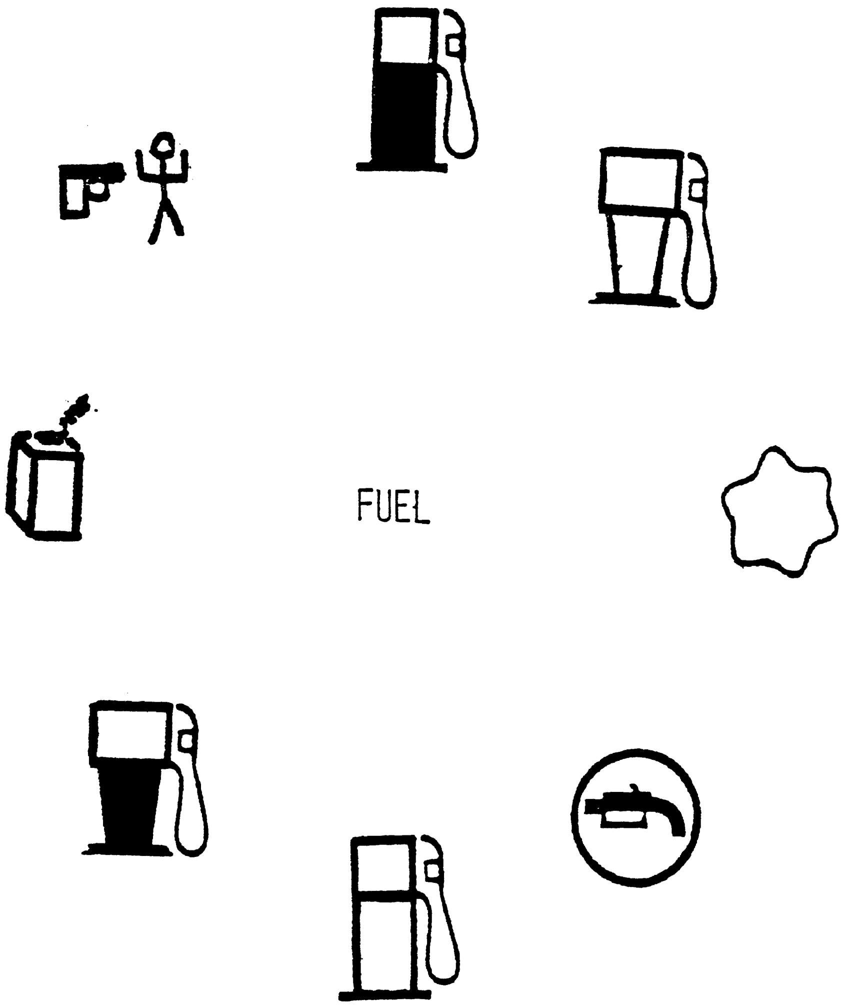


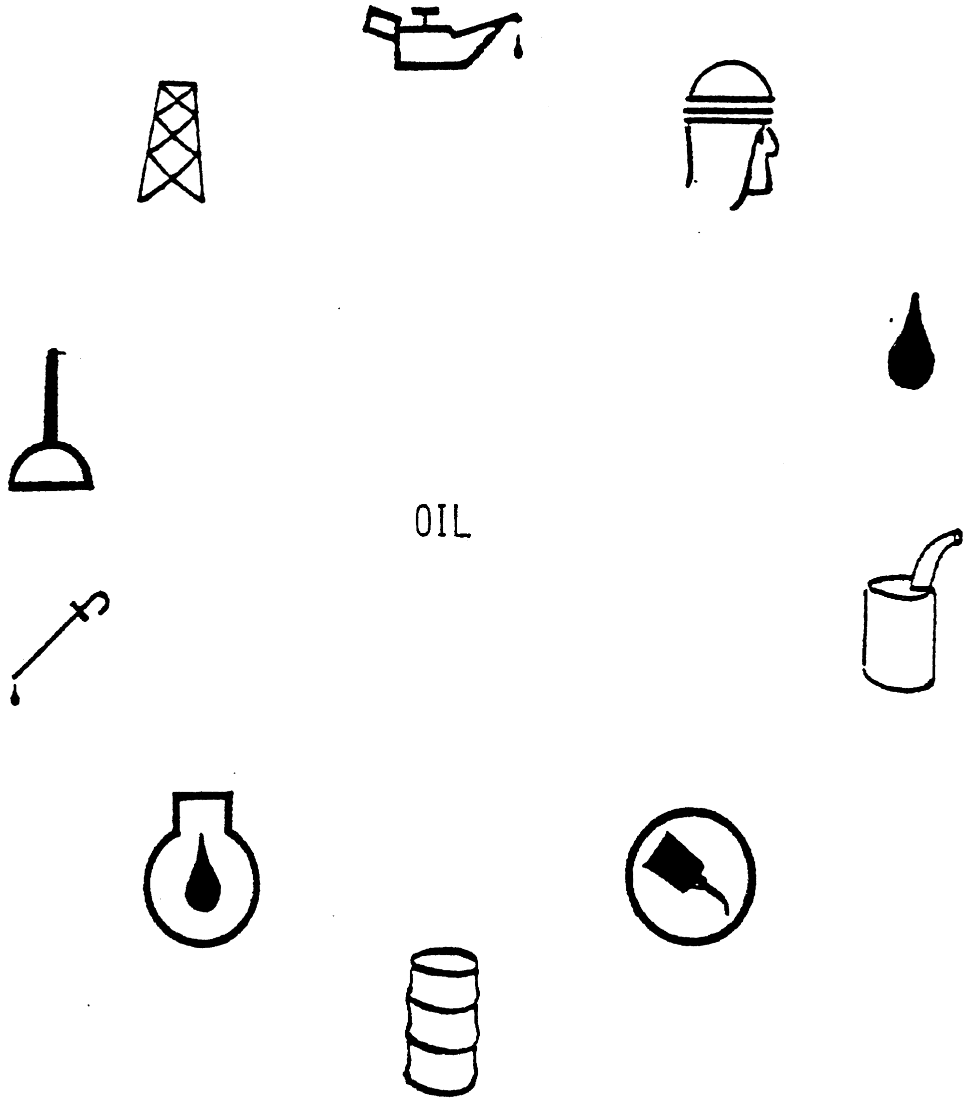
TEMPERATURE

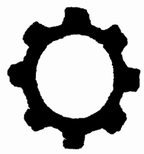

AIR

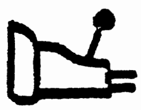
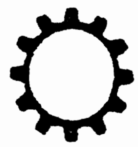

BRAKES


COOLANT

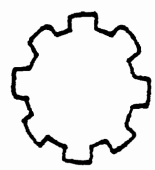
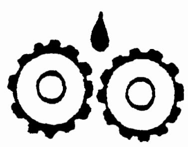

FUEL

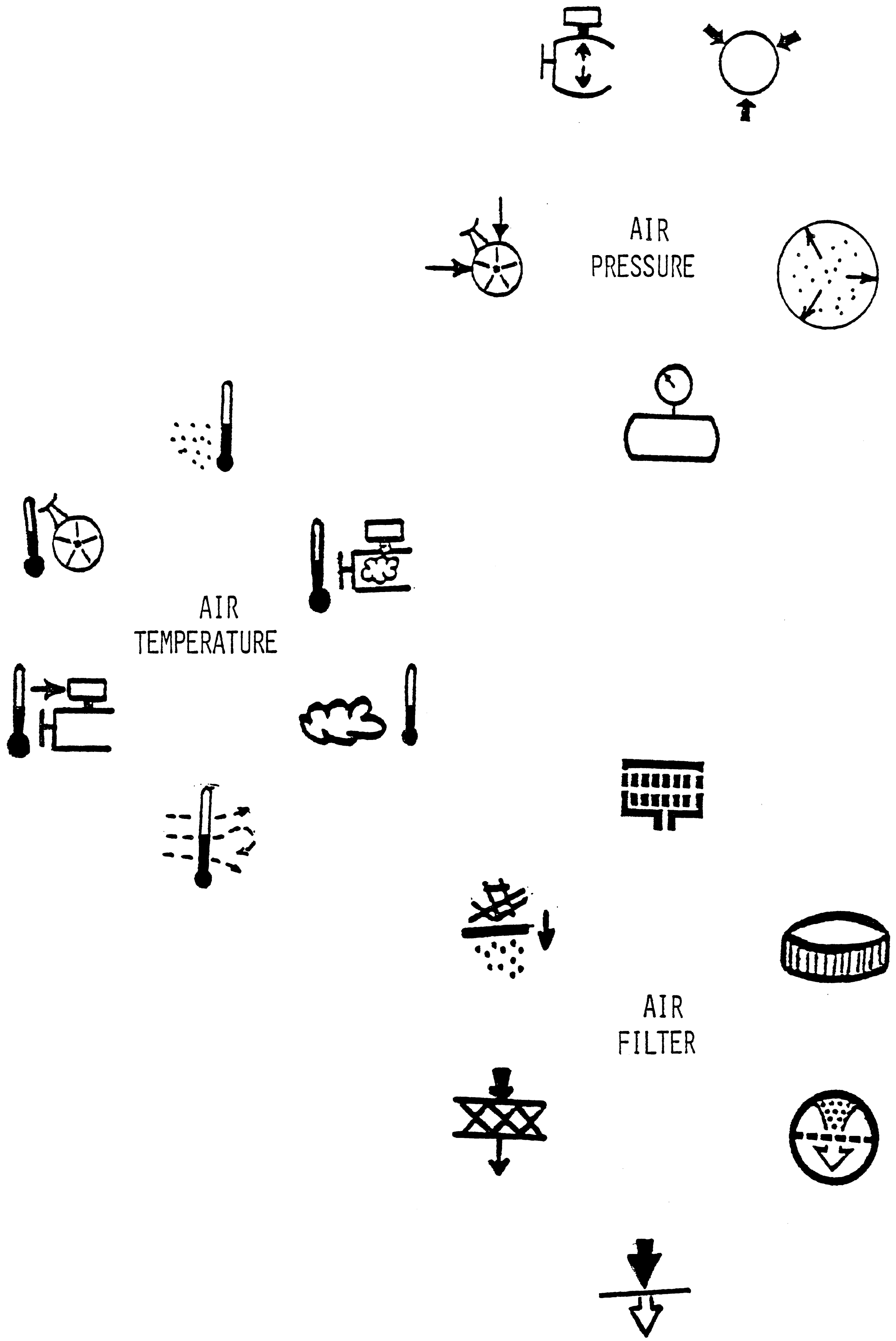

OIL



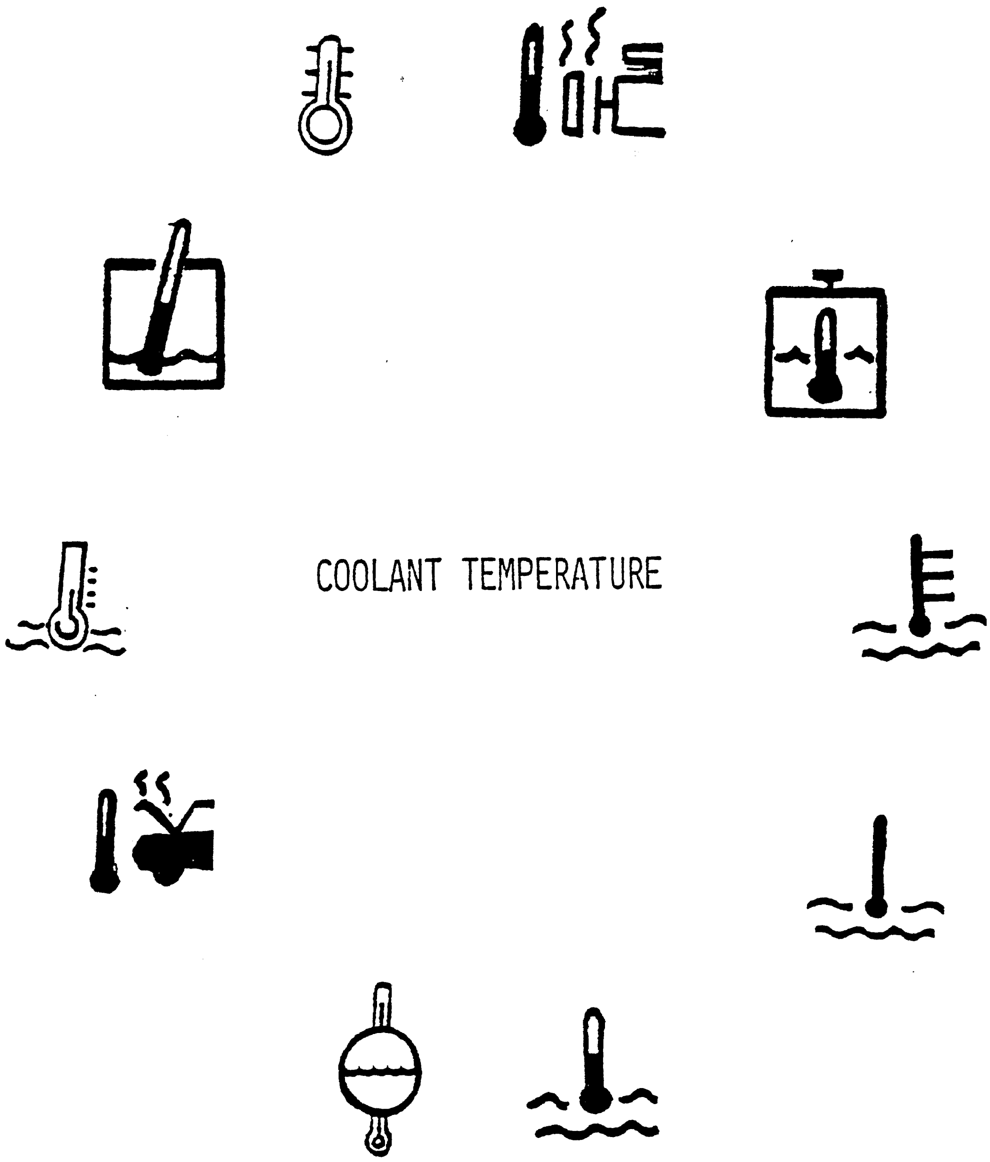




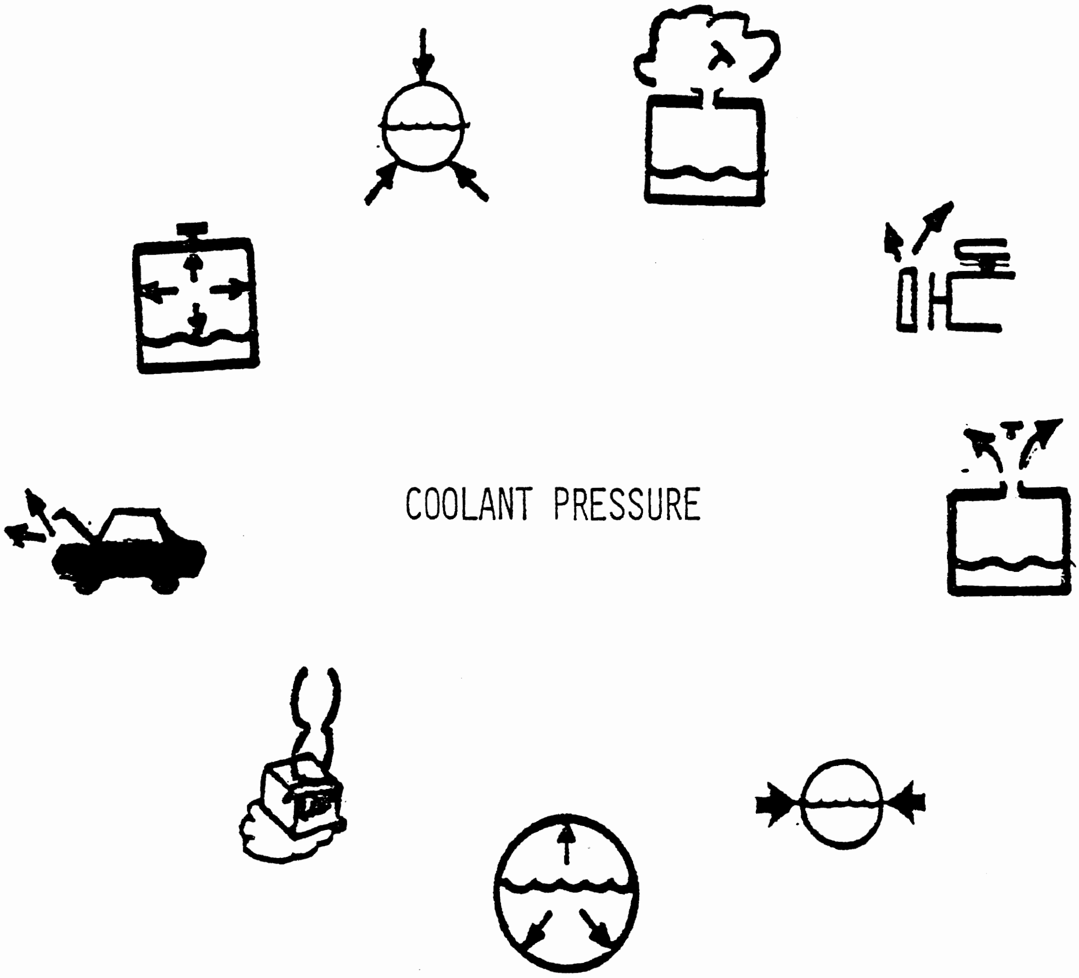
TRANSMISSION

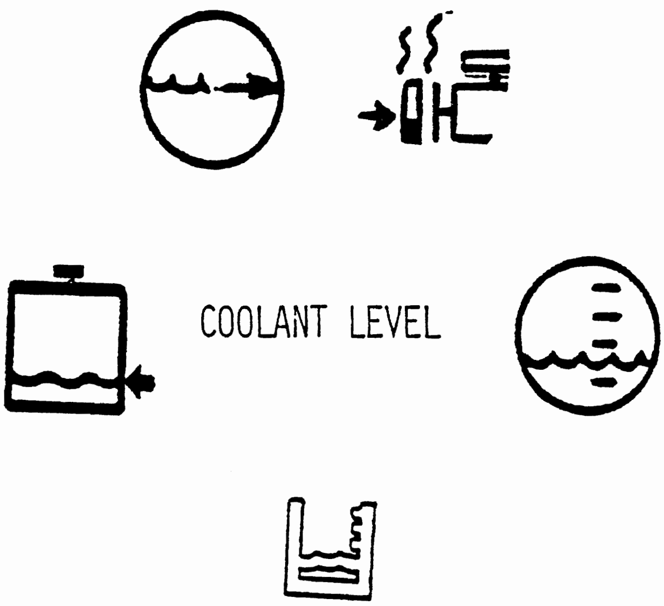


AIR
PRESSURE
AIR
TEMPERATURE
AIR
FILTER


BRAKE FLUID LEVEL

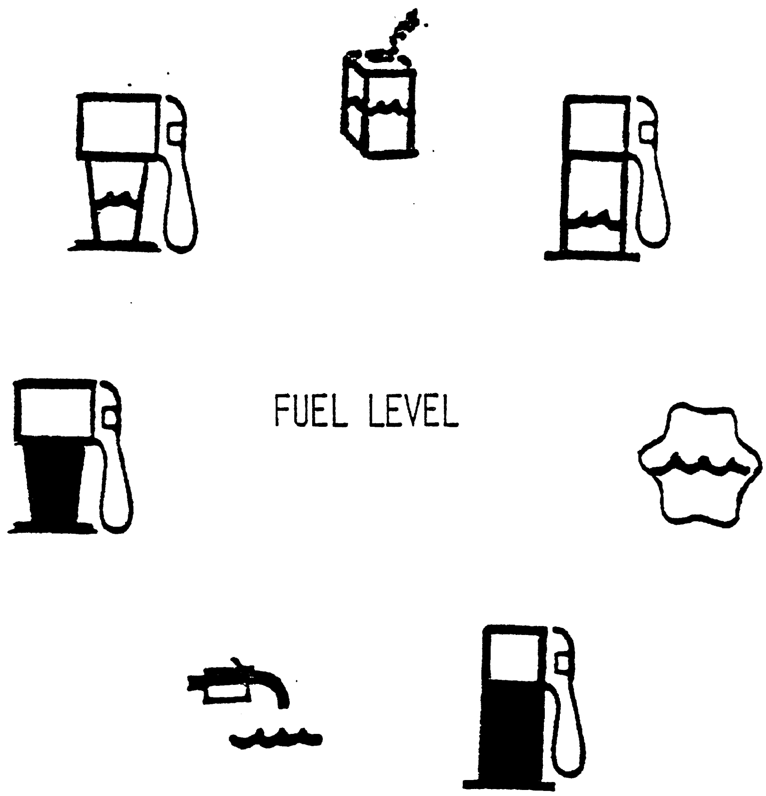

COOLANT TEMPERATURE

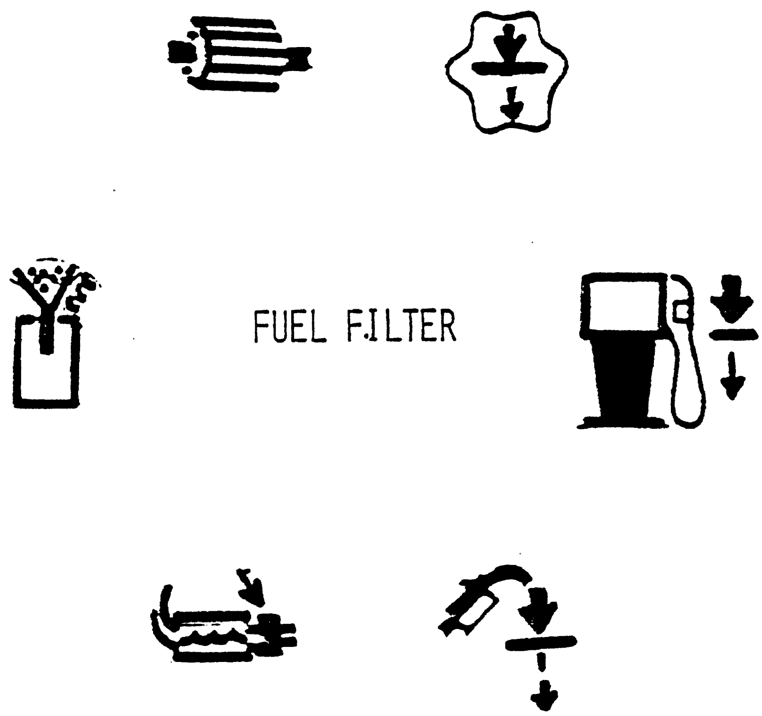


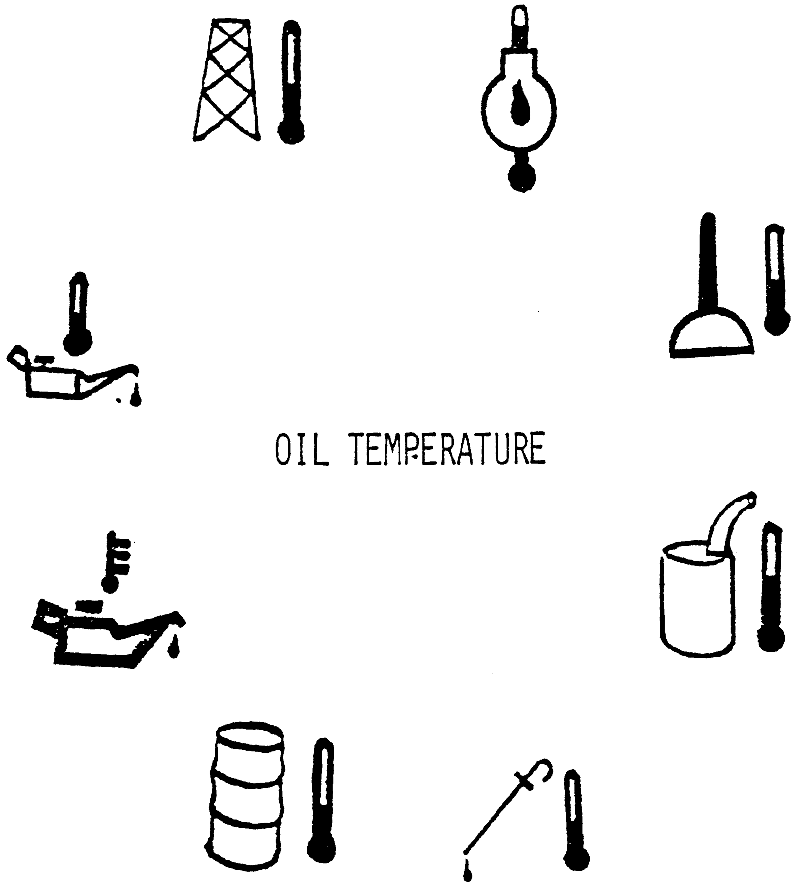
COOLANT PRESSURE



COOLANT LEVEL

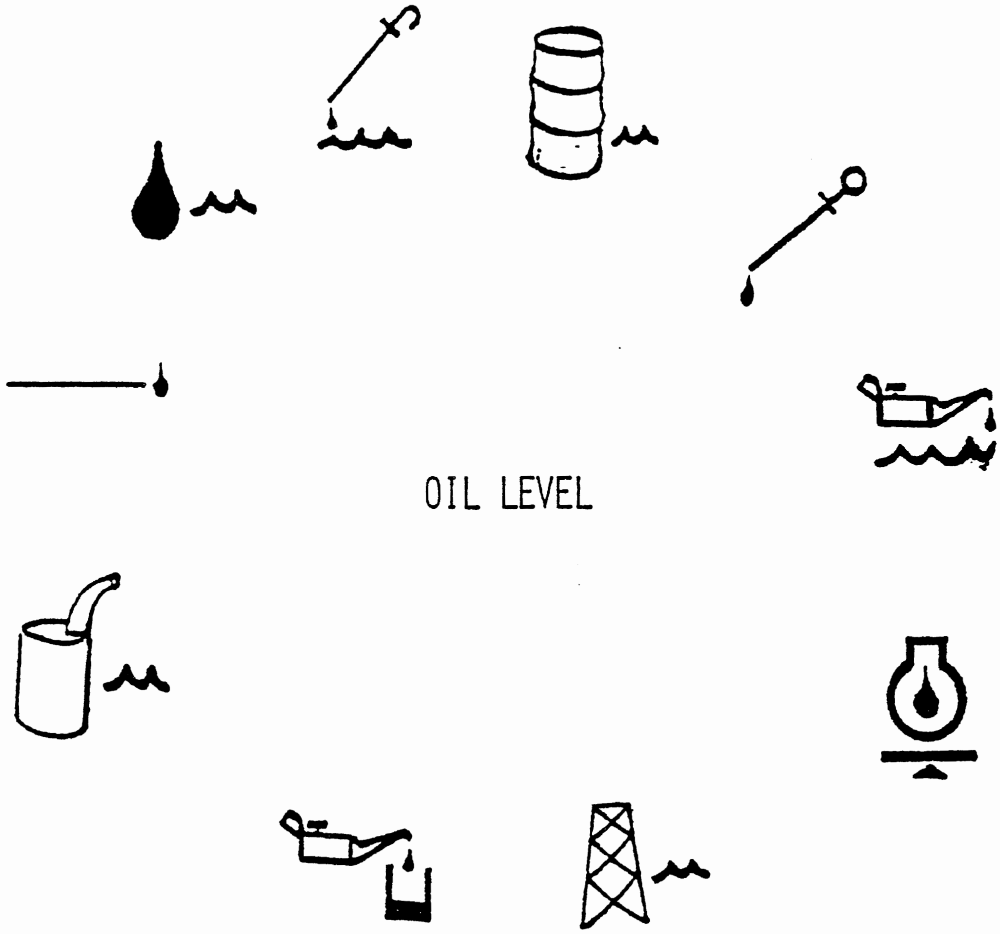

FUEL LEVEL

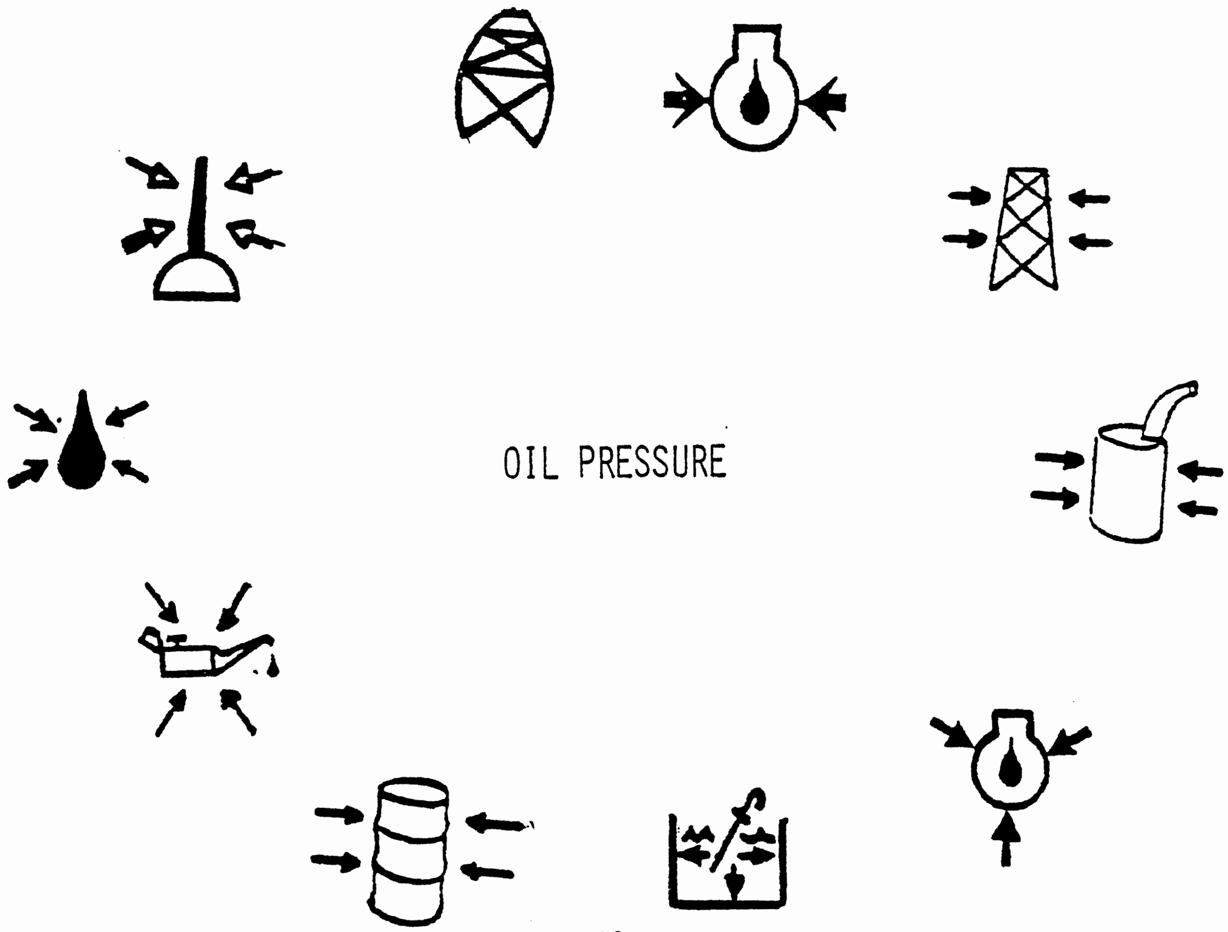

FUEL FILTER

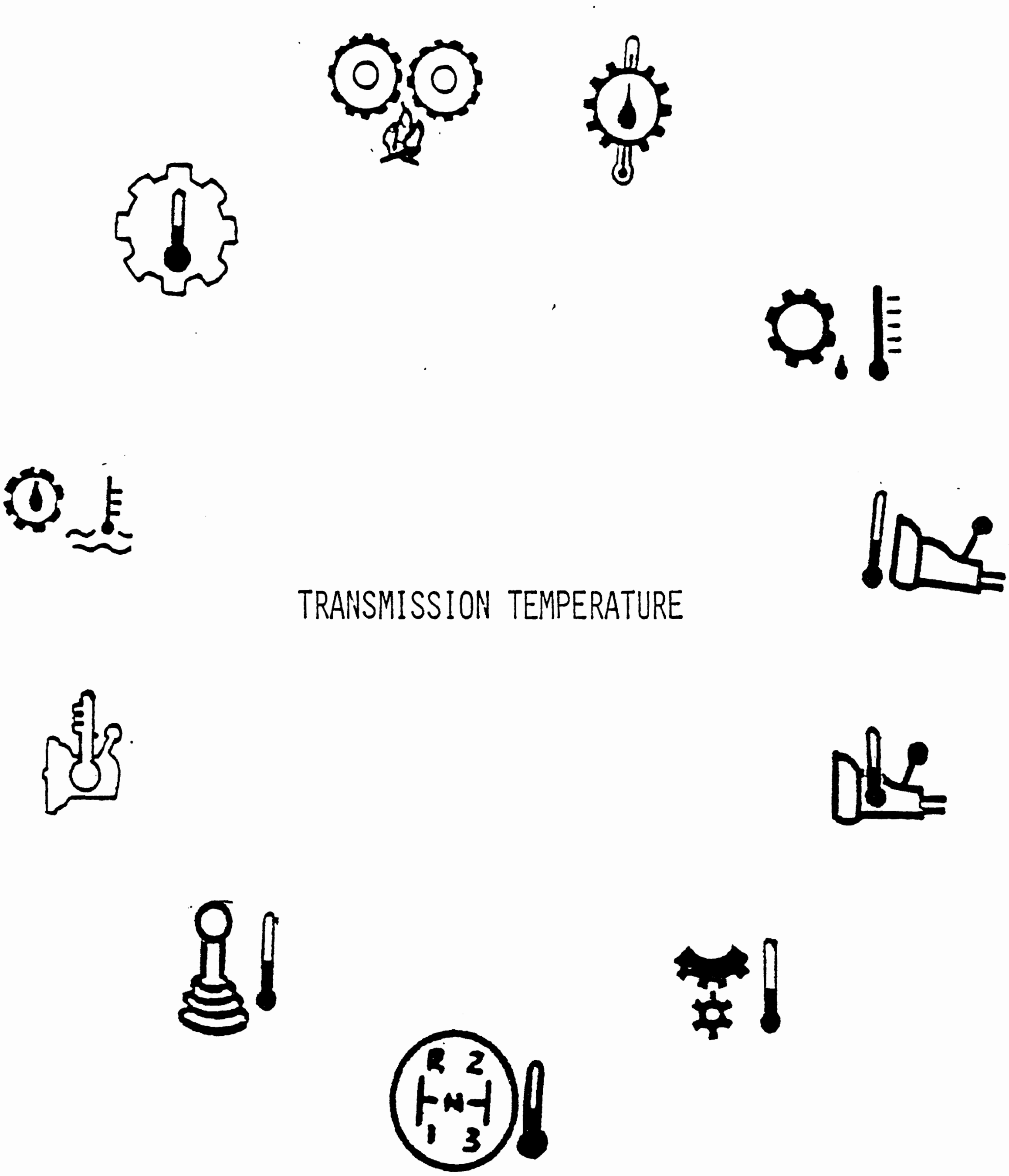


OIL TEMPERATURE

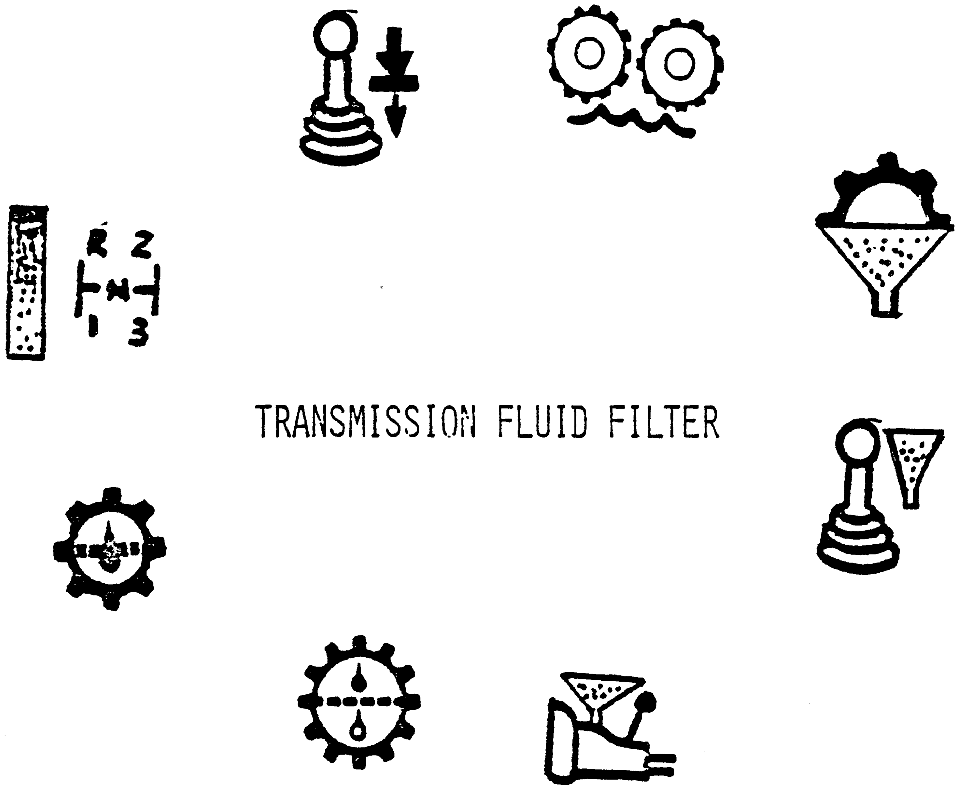
OIL FILTER

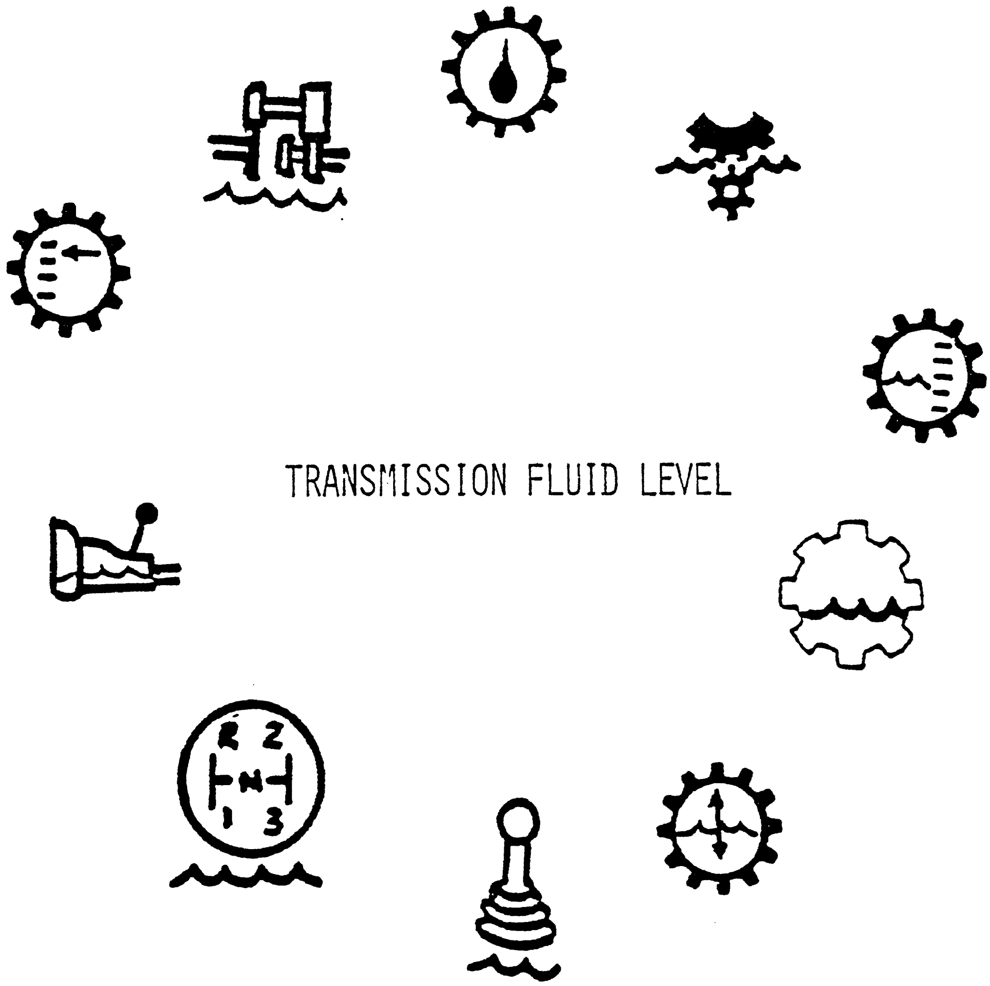

OIL LEVEL


OIL PRESSURE



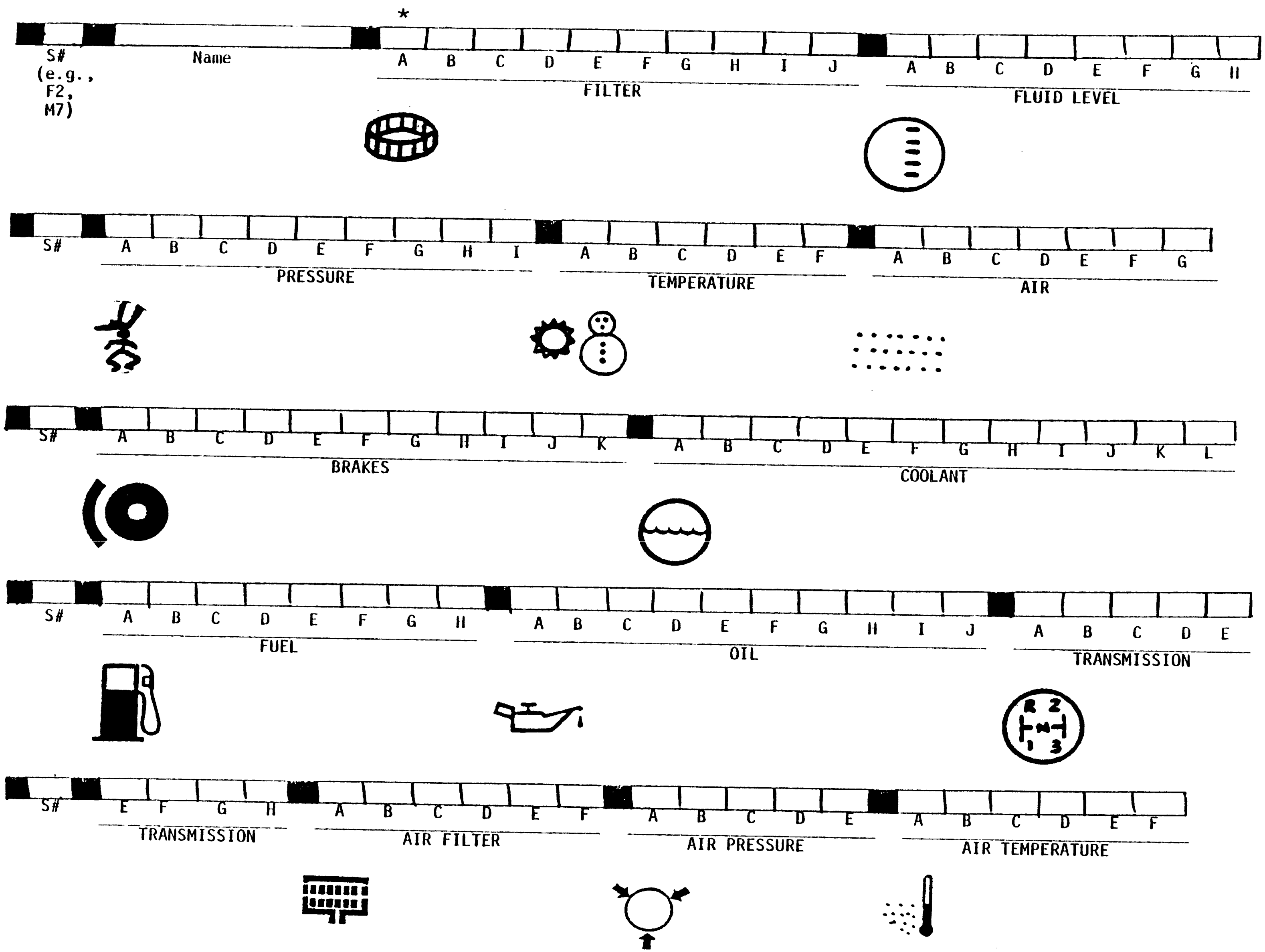
TRANSMISSION TEMPERATURE


TRANSMISSION FLUID FILTER


TRANSMISSION FLUID LEVEL

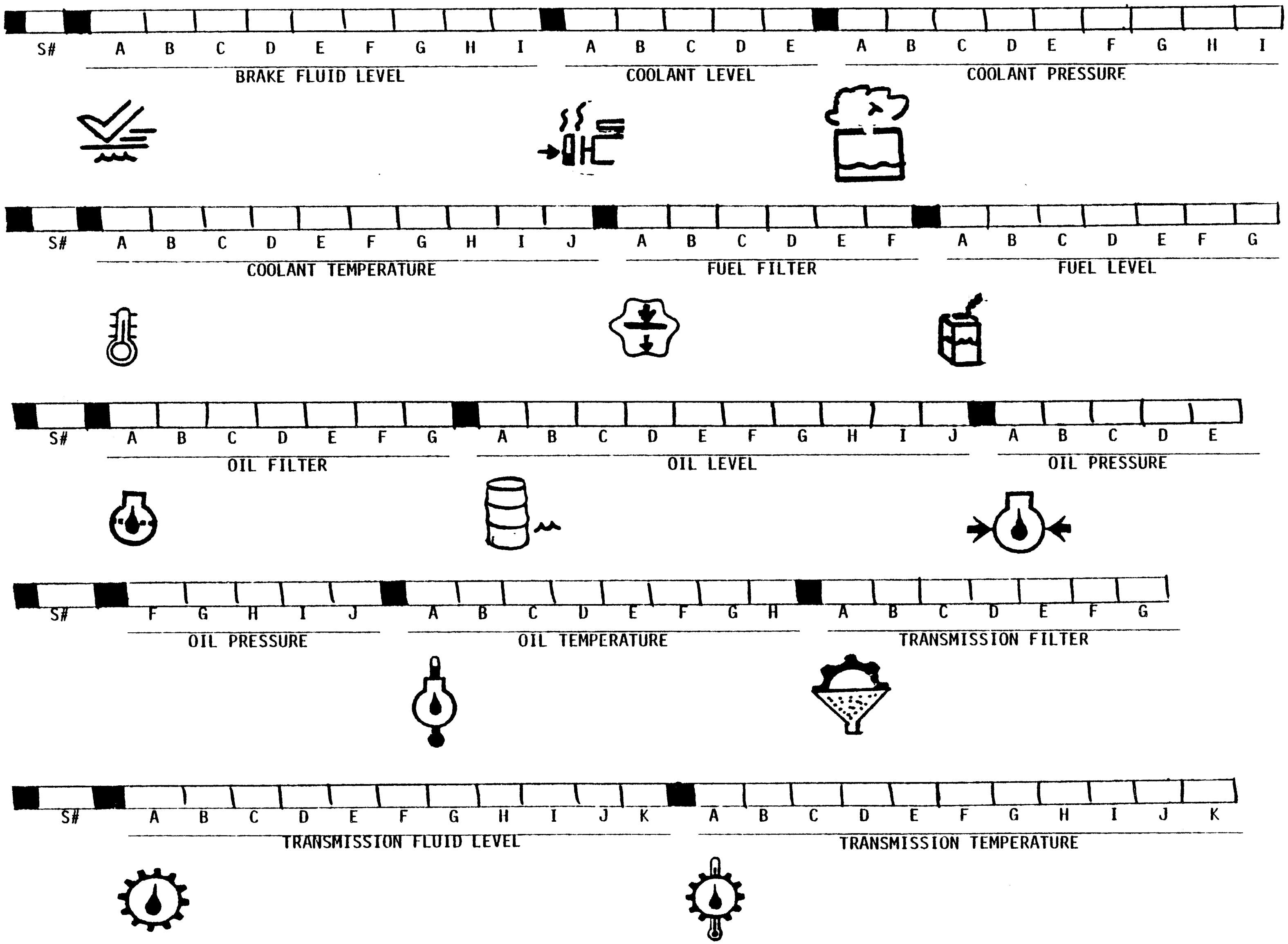
APPENDIX 4

Rating Response Form



* Letters correspond to successive clockwise positions in each array, starting with the symbol pictured.

(Reduced 74% from original)



(Reduced [illegible]4% from original)