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**TRUCK DRIVERS' SUGGESTIONS
AND PREFERENCES FOR
INSTRUMENT PANEL SYMBOLS**

**Marshall Gingold
Semyon Shteingart
Paul Green**

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16. Abstract <p>Ideas and preferences for symbols to label truck controls and displays were collected in two experiments. In the first, 31 tractor-semitrailer drivers were interviewed at a truck stop near Detroit, Michigan. They drew pictures representing 18 functions: cab lock down, dump load, engine oil temperature, engine oil filter, brake fluid level, air pressure, retarder, air filter, loading light, axle lift, gearbox malfunction, winch, power take off, trailer connection/lock-up, engine stop, fuel shutoff, differential lock, and third (interaxle) differential lock. From those drawings and manufacturers' suggestions 125 candidate symbols were developed.</p> <p>In the second experiment, 33 other truck drivers at a restaurant and at a truck depot in the Detroit area ranked those candidates, by function, from best to worst. The rankings identified some candidates as not being meaningful and others as being worthy of testing on an international scale.</p>			
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FOREWORD

This research began as a term project for University of Michigan course Industrial and Operations Engineering 433, Human Performance (Paul Green - Instructor) by the first two authors. Further research was performed as a Directed Study, Industrial and Operations Engineering 591, under the continued guidance of Paul Green. We would like to encourage readers with questions or comments to contact us.

Marshall Gingold
Bell Laboratories
Holmdel, NJ

Semyon (Sam) Shteingart
Bell Laboratories
Holmdel, NJ

Paul Green
University of Michigan
HSRI, Human Factors
Ann Arbor, MI

BACKGROUND

How should controls and displays on products intended for the international market be identified? One answer has been to use pictographic symbols, a language-free form of labeling. For motor vehicles it is critical that information be presented so it can be easily and rapidly comprehended by drivers. If important warnings are not understood and heeded, or if the instrument panel diverts the driver's attention from the road, an accident might result.

To help construct a universal set of symbols, many studies have been performed (Jack, 1972; Heard, 1974; McCormack, 1974; Simmonds, 1974; Elsholz and Bortfeld, 1978; Green and Pew, 1978; Green, 1979a, b; Wiegard and Glumm, 1979; Green and Burgess, 1980, Green, 1981). Based on this research and the opinions of automotive representatives from many nations, International Standard 2575 was developed (International Standards Organization, 1979). It includes symbols for headlights, fuel, horn, and so forth. It was intended to be applied only to automobiles. However, because the truck market is also international, symbols are needed for trucks too.

At the February 1981 Ann Arbor (Michigan) meeting of International Standards Organization Technical Committee 22, Subcommittee 13, Working Group 5 (ISO/TC22/SC13/WG5--Ergonomics of Road Vehicles, Symbols) great interest was expressed in expanding the scope of ISO 2575 to include

trucks and buses and to add several specific truck and bus symbols. One of the meeting resolutions was a request for suggestions for 20 "priority truck symbols." (See Appendix 1.)

The collection of candidate truck symbols and their preliminary evaluation is described in this report. Suggestions were obtained from the manufacturers and truck drivers and, based on a survey of additional truck drivers, undesirable candidates were culled.

SYMBOL PRODUCTION EXPERIMENT

Introduction

Many symbols for controls and warning lights have been proposed by automotive engineers and designers. However, as has been shown experimentally (Mudd and Karsh, 1962), the best source for candidate symbols is the user population, in this case, truck drivers. A popular technique for gathering suggestions is the population stereotype production method (Mudd and Karsh, 1961; Howell and Fuchs, 1968; Green, 1979a,b; Green and Burgess, 1980). In this procedure users draw pictures representing the functions in question. That technique was employed here.

Test Plan

People Tested

Thirty-one truck drivers (all males) volunteered to participate. Drivers ranged in age from 22 to 57 (mean 39) with experience ranging from 3.5 to 41 years (mean 17). Their average annual mileage (including trucks and cars) varied from 10,000 to 250,000 (mean 112,500). Except for one part-time driver, all drove full-time. Fourteen of them were independent, sixteen were company drivers, and one was a company owner. They drove a wide variety of tractor-semitrailers, with two of them periodically driving straight trucks. Most had experience with farm vehicles and construction equipment, and except for some military stints abroad, had lived and worked in the U.S. their entire

lives. Typically, they had completed high school, though five were college graduates. To illustrate the extremes tested, one earned a Ph.D. in Political Science (and, "couldn't make a living" at it), while another completed only grammar school.

Test Materials

The experimental materials were photocopies of a seven-page booklet. (A sample booklet is in Appendix 2.) The first page of this booklet contained an explanation of the experiment's purpose, instructions, and four ISO automotive symbols. The second page was for biographical information and was completed by the experimenters to save time. Pages 3-7 presented 18 driving scenarios, 2 or 4 per page, describing the use of controls and warnings that might be found on truck instrument panels. Underneath each description was a 2 x 2 inch (5 x 5 cm) box where the truckers drew suggestions for the following functions:

1. Cab Lockdown
2. Dump Load
3. Engine Oil Temperature
4. Oil Filter
5. Brake Fluid Level
6. Air Pressure
7. Retarder
8. Air Filter
9. Loading Light
10. Axle Lift
11. Gearbox Malfunction
12. Winch
13. Power Take Off
14. Trailer Connection/Lock-Up
15. Engine Stop
16. Fuel Shutoff
17. Differential Lock
18. Interaxle Differential Lock

Further explanation of each intended application is contained in Appendix 1. (There are two more entries in the ISO list than this one because the ISO list contains three variations of the air pressure function (1,2 and 3 - primary, secondary and tertiary). It is expected these symbols will be formed by placing a number next to the basic air pressure symbol.)

Test Activities and Their Sequence

The experiment took place in the truckers-only dining room of the Wolverine Truck Stop located in Dexter, Michigan (70 miles west of Detroit), at the Baker Road interchange of Interstate 94. (I-94 is the main highway between Detroit and Chicago.) Interviews were conducted on weekdays between 2 and 6 in the afternoon. Only about 1/3 of the truckers approached agreed to participate. Reasons given for declining ranged from a simple "not interested" to the quite unexpected "those symbols make everything so clear that anyone could drive a truck, and I don't need any more competition than I already have." To encourage those truckers to take part, the authors gave these reasons for the experiment:

- 1) American truck manufacturers are selling trucks in the international market so there is a need for language-free instrument panels.
- 2) Symbols take less space than words.
- 3) The most successful argument was to encourage truckers to imagine how difficult it would be to understand road

signs if words were used instead of the customary symbols.

The best time to approach drivers was after they completed their main course and started their dessert. They were interviewed individually, or in groups of two or three.

The truckers' task was very straightforward. They drew a picture in each box conveying the message in the accompanying scenario. (See Appendix 2.) Very little assistance was given to drivers, although encouragement was frequently offered. Drivers took from 15 to 40 minutes to complete the entire survey (mean 25 minutes). Where they could not come up with an image for a scenario, it was skipped to save time. The biographical data for most drivers was collected after they completed the experiment. When collected first, truckers were less likely to complete the experiment.

Results and Discussion

Appendix 3 contains copies of the drivers' sketches reduced to 65% of their original size. The drawings are grouped by function, one function per page. A given driver's sketches appear in the same relative location on each page in Appendix 3. Most of the drawings were far from being artistic and were much more difficult to decipher than those of students participating in previous studies (see Green, 1979a,b; Green and Burgess, 1980). Because the drawings are unstructured, a quantitative analysis of them has not been provided. Short descriptions of the drawings,

however, are in Table 1 to which the reader's attention is directed. It is suggested the reader then peruse Appendix 3 before reading further.

Drivers were challenged by the drawing task and because of time constraints, six drivers completed only the first eight symbols. Including those six, the number of missing responses varied from 2 (for cab lock down) to 17 (for power take off). To a certain degree, these numbers represent a measure of how difficult it is to symbolize a particular function and may be useful in developing acceptability criteria. In previous studies of symbol meaningfulness (for example, Heard, 1974), a fixed acceptance criterion of 75% correct was used. In addition to being quite arbitrary, that criterion may not be realistic (too high in some cases, too low in others). Also, varying considerably was the uniformity of suggestions across functions. The proposals for dump load were quite similar, while proposals for power take off were very dissimilar.

TABLE 1
SOME CONCEPTS DEPICTED IN SUBJECT'S DRAWINGS.

#	Function	Concepts Depicted	# Missing (all drivers) n=31	# Missing (excluding 6 partial responses) n=25
1	Cab Lock Down	raised cab usually (drawn as square) with frame as 1 line and 1 or 3 wheels shown; cab with a padlock; hook and latch	2	2
2	Dump Load	raised body of truck (drawn as rectangle) with cab, frame and wheels shown in 1/2 of sketches	2	2
3	Engine Oil Temperature	a) oil can; oil drop; locomotive oiler's can; oil drilling rig were used to represent oil. b) thermometer, flames were used for temperature	5	5
4	Oil Filter	truck oil filters and filter housings with connecting oil lines	5	5
5	Brake Fluid Level	brake pedal (mostly side views, foot sometimes shown); truck going down hill; shoe; side view of brake master cylinder; burning tire	5	5

TABLE 1 (cont.)

#	Function	Concepts Depicted	# Missing (all drivers) n=31	# Missing (excluding 6 partial responses) n=25
6	Air Pressure	balloon; brake shoe; load goes through the cab (since the brake system locks when the air pressure falls); crossed STOP sign; heat (wavy lines) coming from a tire; parachute; cloud	7	7
7	Retarder	truck going down the hill (usually showing just cab); J (for Jacobson brake); arrow pointing up or down the hill; drawing of exhaust system based retarder mechanism	10	10
8	Air Filter	different views of truck air filter; side views of truck air filter housing; person inhaling; money (when air filter is clogged truck uses more gas - trucker loses money)	6	6
9	Loading Light	source of light in different positions relative to the truck (side view of cab with light mounted above fifth wheel and aimed to rear, above trailer [side and rear views]); light bulb; candle; street light pole	10	4

TABLE 1 (cont.)

#	Function	Concepts Depicted	# Missing (all drivers) n=31	# Missing (excluding 6 partial responses) n=25
10	Axle Lift	<p>several circles which may be almost horizontally aligned with up/down arrows; rectangle or solid line with circles below, 1 out of horizontal alignment; tandem cab with one trailing wheel raised; axle and 4 tires ("dumbbell") with upward arrow</p>	10	4
11	Gearbox Malfunction	<p>one or two gears, either crossed or cracked; side view of gearbox and shift lever (box may be cracked); shift lever alone</p>	10	4
12	Winch	<p>tow truck; winch drum (end view with coiled line, view of face with hook); view of boom, line, and hook</p>	13	7
13	Power Take Off	<p>rotating shaft; "PTO"; gears; pulleys and drive belt</p>	17	11

TABLE 1 (cont.)

#	Function	Concepts Depicted	# Missing (all drivers) n=31	# Missing (excluding 6 partial responses) n=25
14	Trailer Connection/ Lock Up	padlock or "X" between tractor and trailer; three connection cables; trailer on the ground; fifth wheel (side view showing face plate, support post frame and drive wheels; top view of face plate)	10	4
15	Engine Stop	truck running into a wall; side or front view of an engine block with a cross; key inside octagon (stop sign); raised hand (stop) next to engine block	15	9
16	Fuel Shutoff	fuel pump or fuel nozzle with a "X" or break; fuel tank, fuel pipe squeezed by a hand or break in fuel line (tank and front view of engine block also shown); finger plugging end of fuel nozzle	12	6
17	Differential Lock	set of wheels rotating together (side view and view down drive line); padlock on the axle; slippery road sign	14	8

TABLE 1 (cont.)

#	Function	Concepts Depicted	# Missing (all drivers) n=31	# Missing (excluding 6 partial responses) n=25
18	Interaxle Differential Lock	two sets of wheels rotating together (side and end views); padlock on interaxle differential; rain (for slippery road); internal structure of third differential; split horse (since horse power is divided between two axles)	13	7

PREFERENCE EXPERIMENT

Introduction

A good symbol has many qualities. It can be correctly identified at first glance and remembered over time. It is easy to learn, if not immediately obvious. It can be rapidly identified after practice and is not confused with other members of the set. 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 of time and cost constraints, this experiment dealt only with the initial ease of identification (meaningfulness), since it is a key attribute of a symbol. A simple rank ordering was selected for this evaluation. It was chosen because of the speed and simplicity with which the data could be obtained and analyzed.

Test Plan

People Tested

Thirty-three truck drivers took part in this experiment. They ranged in age from 25 to 55 (mean 39.8) with experience ranging from 2.5 years to 37 years (mean 14.2 years.) Their average annual mileage (including trucks and cars) varied from 25,000 to 180,000 (mean 96,600), slightly less than the previous experiment. Thirty-one were full-time truck drivers, 2 part-time drivers, 16 of them independent, and 17 company drivers. All drove tractor-

semitrailers and three periodically drove straight trucks. Most had graduated from high school (26 drivers). Three had graduated from college. Like the previous test group, they were familiar with other types of vehicles and had limited exposure to foreign cultures.

Test Materials

The test materials were photocopies of an eleven-page booklet. (A sample booklet is in Appendix 4.) The first page explained the purpose of the study and contained the instructions. Both were very brief (total of 14 lines) since some drivers in the previous experiment spent too much time examining the front page, which contained similar information and was 25 lines long plus illustrations.

The following 9 pages contained the 18 driving scenarios from the previous experiment, 2 per page. Beneath each scenario was a circular array of 6 to 9 candidate symbols. Arrays were organized so that variations of the same theme were not in adjacent positions.

Photocopies were black on white with a contrast ratio of about 1:5. All symbols, except for differential lock were surrounded by 3/4 inch (19 mm) or 7/8 inch (22 mm) black circles.

Symbols were obtained from many sources. At least half were simplified and modified versions of drawings collected from truck drivers in the symbol production experiment. Suggestions were also obtained from Hallen, 1977; Dreyfuss, 1972; Karsh and Mudd, 1962; Mitchell, 1981 and Green and

Burgess, 1980. In addition, the authors developed some symbols based on their personal opinions, information they gathered from truckers' oral comments, and combined information from all of the previous sources. Overall, 125 candidates were developed. After the experiment several additional candidates were developed. (Those additional ideas are in the Results and Discussion section.)

Test Activities and Their Sequence

Drivers were interviewed in the dining room of the Olde Colonial Restaurant, located in Ypsilanti, Michigan at the intersection of U.S. 23 and U.S. 12 (Route 23 links Flint, Michigan and Toledo, Ohio), and in the locker room of the Great Atlantic and Pacific Tea Company depot located on Bart Road in Detroit, Michigan. Three weekday afternoon interviewing sessions were conducted, two in the Olde Colonial Restaurant (from noon to 2:30 and from 2 to 6) and one in the A&P depot (from 3:30 to 5:30). About half of the truckers approached agreed to participate. This percentage was higher than in the symbol production experiment, because the preference survey was more interesting and easier to complete.

Drivers interviewed in the restaurant were approached right after they submitted their order. Drivers in the A&P depot were interviewed before or after their regular shift. Questions about the survey's validity were answered with the explanations from the previous experiment. In addition,

noting the candidate symbols were based on truck drivers' ideas helped convince many drivers to volunteer.

Drivers were asked to rank-order the symbols in each array and then complete the biographical information sheet. The completed forms were collected when they left the dining room (or locker room.) It is not known how long it took the drivers to complete the form. In two cases, the drivers misunderstood the instructions and ranked only the best and the worst candidates in each array. In a few other cases, drivers didn't like any of the candidates for a certain function and didn't rank them at all. No assistance was given.

After the interviews were completed, the data were transcribed to a special form for computer entry. (See Appendix 5.) This form helped organize the data and reduce errors.

Results and Discussion

The analysis of the truck driver rankings of the candidates for each of the eighteen functions appears on the following pages. Each page contains a scale on which symbols are ordered from best to worst based on the mean rankings averaged over drivers. Tables presenting the ranking distribution for each candidate and text explaining the results are also provided. In each case, the rankings were analyzed using a Friedman two-way analysis of variance and the S statistic for differences in the means is reported (Conover, 1971; Hollander and Wolfe, 1973; Siegel, 1956).

For every function there were significant differences among the ratings of the candidates. Also presented are the results of multiple comparison tests of differences between candidate means. Non-significant differences at the $p < .1$ function-wide error level are indicated by brackets to the right of the table on each page.

In examining the comments for each function, the reader should notice several recurring issues:

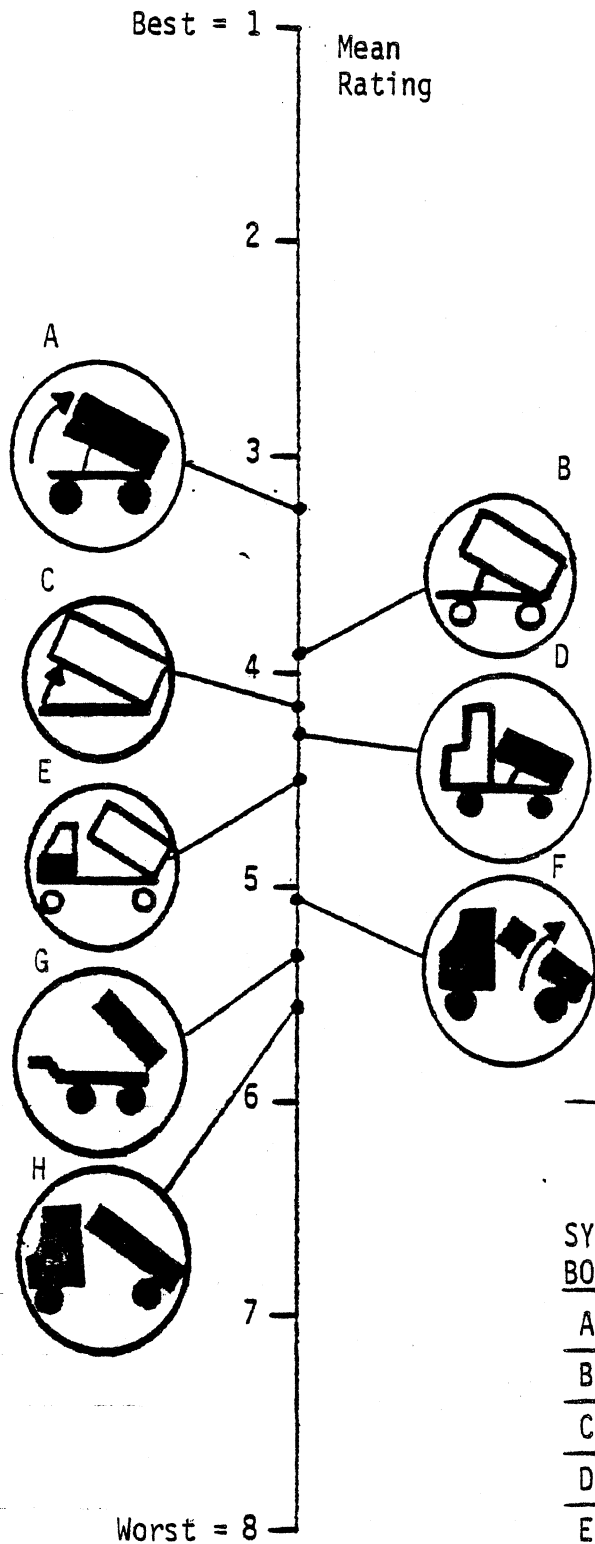
- 1) The use of letters/abbreviations. Some functions--for example, power take off (PTO) and retarder (J or Jacobson brake)--are frequently identified by their initial letters rather than their full names by English-speaking drivers. It is not known how meaningful those terms will be to non-English speakers. It has proven to be a problem in the reverse direction (Formaro, 1977). For example, the German representatives believe the brake failure warning label should be the letters "ABS" for anti-lock braking system. To Americans that abbreviation commonly stands for absolute (as is absolute temperature or pressure) (Crocker and Kennedy, 1977; United States Department of Defense, 1968; American National Standards Institute, 1972), though it also could mean air-break switch or acrylonitrile-butadiene-styrene, a plastic from which many automotive parts are made (Crowley, 1976). Some have been so bold as to remark it

stood for "abominable snowman." Why one would find a label for such in a car is hard to imagine.

- 2) Using a padlock to represent locking. In this set there were four functions having locking aspects (cab lockdown, trailer connection/lock-up, differential lock, and interaxle differential lock) and there are others that were not evaluated (for example, automatic door lock). While in some cases a padlock may be one alternative locking device, in many others the latching mechanism could be quite different, so too might the appropriate name in languages other than English.
- 3) Carryover of existing, questionable ISO symbols. There is a growing body of evidence that the current ISO symbols for coolant temperature and engine oil pressure may not be understood by car and truck drivers and that superior alternatives exist (a problem also reported by Green and Burgess, 1980). As other temperature and engine oil symbols (for example, hydraulic fluid temperature, engine oil level) are added to the set, the problem is compounded. To avoid perpetuating bad design, better symbols for coolant temperature and engine oil pressure should be substituted. It is unfortunate that much of the automotive community views the ISO Standard 2575 as "cast in concrete."

Further discussion of differences among the candidate symbols appears on the following 18 pages.

2. DUMP LOAD

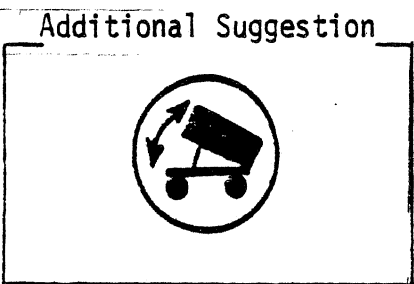


The highest ranked symbol was that of a tilted body with an arrow indicating the control dumps the load (raises the body). This candidate garnered over 1/3 of the first place rankings. In general, candidates containing just the body of the truck (A-C, G) ranked higher than those showing both the cab and the body (D-F, H). (Candidates F and H might be very appropriate for a dump truck but not appropriate for a truck with a dump trailer.) Among first and second place votes, there was a clear preference for showing the body as a solid figure with an arrow pointing upwards (candidate A versus B). Because there were no significant differences among them in this test, the first five candidates (A-E) should be evaluated further. A variant of candidate A with a double ended arrow (shown below) should also be tested.

Friedman's $S = 18.92, p < .01$

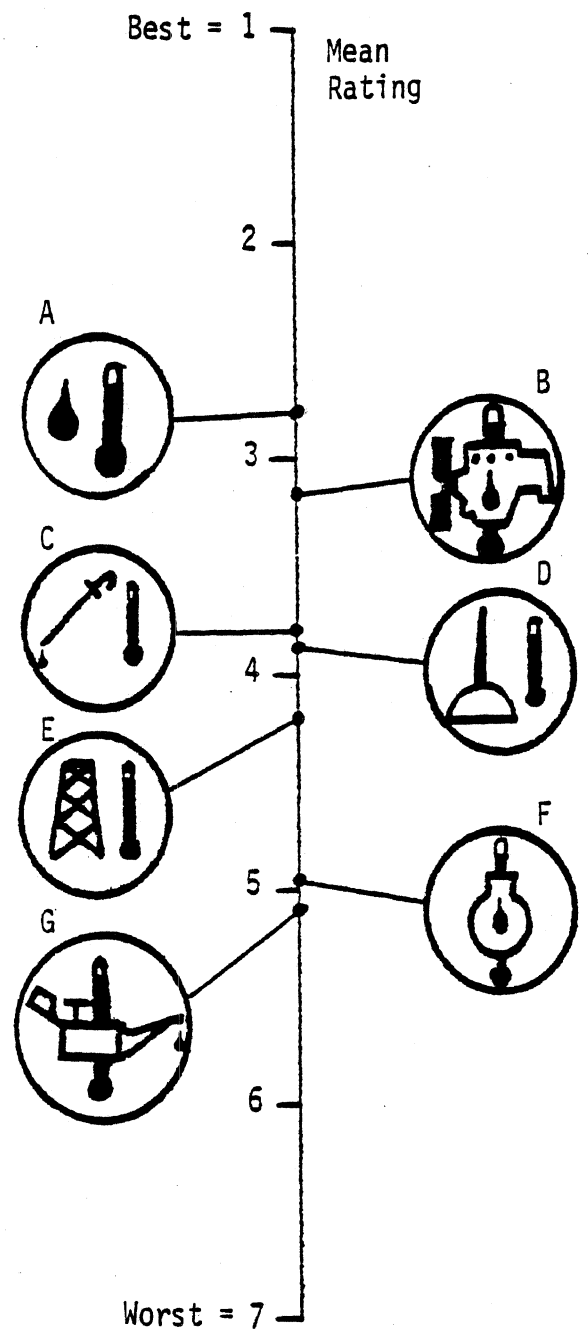
RANKING DISTRIBUTION OF EACH SYMBOL

SYM-BOL	Best ← → Worst								Missing	MEAN	p<.1
	1	2	3	4	5	6	7	8			
A	13	⑤	2	1	2	3	4	2	1	3.28	}
B	2	10	2	⑥	5	3	4	1	0	3.97	
C	5	5	6	③	4	2	2	5	1	4.09	
D	5	2	5	4	⑦	4	4	1	1	4.22	
E	2	2	6	⑧	3	6	3	2	1	4.50	
F	4	4	5	④	0	0	5	11	0	5.03	
G	1	2	2	5	⑨	5	2	6	1	5.25	
H	1	2	4	1	2	⑨	8	5	1	5.66	



- - median
- a - median = 3.5
- b - median = 4.5

3. ENGINE OIL TEMPERATURE



All candidates combined a thermometer indicating a high temperature with some other image. There was no consensus among drivers as to what that other image should be. In fact, the symbol that had the second highest mean ranking (B - engine block over thermometer) received more first place votes than the symbol with the highest mean ranking (candidate A - block oil drop and thermometer). (B also received numerous extreme negative votes.)

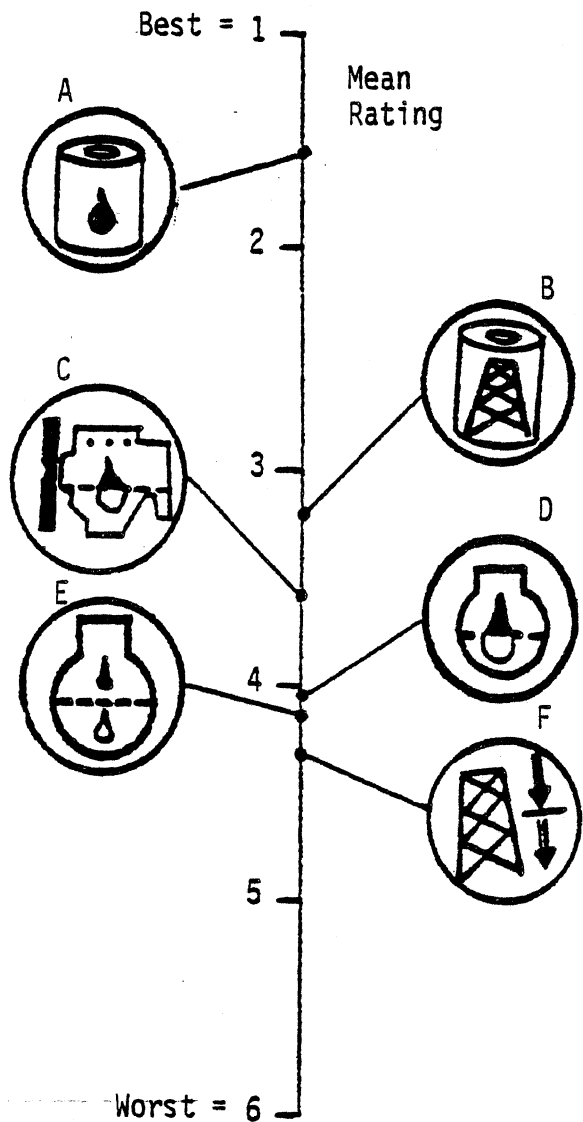
Notable are those candidates that were disliked. The fifth ranked candidate (E - drilling rig and thermometer) was top rated in Green and Burgess, 1980 (though here, the statistical differences among the top five were not significant). Candidate F (engine block cross section with oil drop) is found on agricultural and industrial equipment. Candidate G is a modification of the existing ISO low oil pressure symbol. The poor ranking of candidate G here, in Green and Burgess, 1980, and other studies indicates that the ISO oil symbol should be replaced possibly by the "oil" elements of candidates A-E.

Friedman's $\underline{S} = 26.04, p < .001$

SYM-BOL	RANKING DISTRIBUTION OF EACH SYMBOL							Missing	MEAN	p < .1
	Best	←	→	Worst						
	1	2	3	4	5	6	7			
A	7	8	ⓐ6	5	4	0	0	3	2.70]-----]
B	12	3	④	4	1	2	5	2	3.16	
C	4	5	6	③	4	5	4	2	3.94	
D	2	8	2	⑥	4	5	3	3	3.97	
E	2	6	6	④	5	4	5	1	4.13	
F	2	0	5	1	⑧	10	4	3	4.97	
G	3	1	1	7	4	④	11	2	5.06	

○ - median
a - median = 2.5

4. OIL FILTER



Drivers preferred by a statistically significant margin the candidate depicting a perspective view of an oil filter with an oil drop on its face (A). This candidate was ranked #1 by 2/3 of the participants. Candidates showing an oil drop (or drops - candidates C-E) or an arrow changing color (to indicate cleaning - candidate F) were not well received. Candidates D and E are similar to symbols used on agricultural and industrial equipment. This evidence argues for only considering candidate A further. When presented as part of a set of symbols, candidate B might also do well.

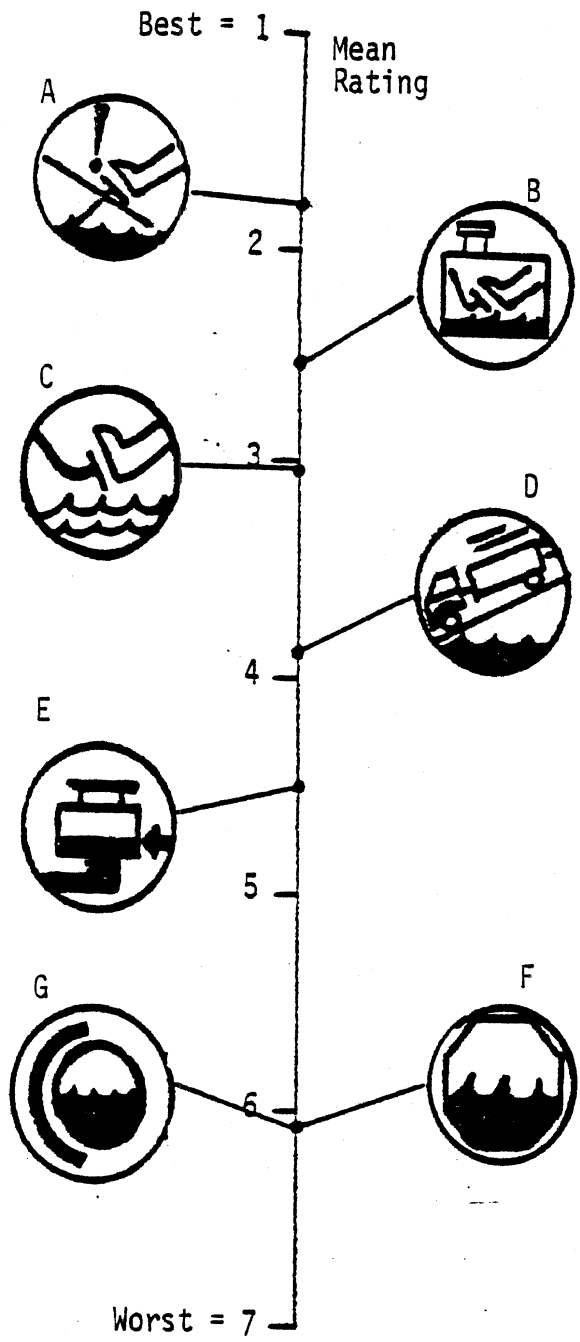
Friedman's $S = 43.92, p < .001$

RANKING DISTRIBUTION
OF EACH SYMBOL

SYM-BOL	Best ← → Worst						Missing	MEAN	p < .1
	1	2	3	4	5	6			
A	(2)	5	3	1	0	1	2	1.61	}
B	6	(10)	2	2	4	6	3	3.20	
C	1	7	(8)	7	2	6	2	3.65	
D	0	2	8	(10)	7	3	3	4.03	
E	4	2	3	5	(10)	7	2	4.16	
F	0	4	6	5	(7)	9	2	4.35	

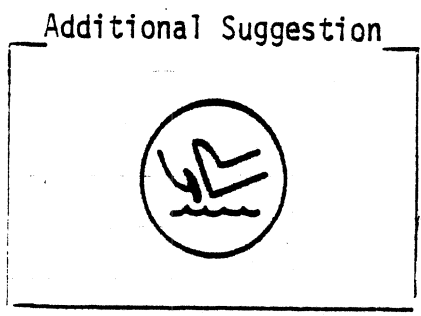
○ - median

5. BRAKE FLUID LEVEL



Drivers were extremely consistent in their preference among these candidates as indicated by the large value of Friedman's S and the grouping of the rankings along the main diagonal of the table. Drivers preferred symbols showing the side view of a foot and pedal above a wavy line for fluid surface (A-C) and disliked a truck going down hill (D), a cross section of a fluid reservoir (E), a stop sign (F), or a brake shoe (G). Except for candidate E (included in their study), Green and Burgess, 1980 report the same findings. Deserving further evaluation are candidates A and B (which were not statistically different) and G. (G is a modification of an existing ISO brake system symbol and may receive higher rankings when presented with other brake symbols which were not evaluated in this study.) Also deserving further evaluation is candidate 1 of Green and Burgess, 1980 (shown below), a simplified version of candidate C from this set.

Friedman's $S = 107.64, p < .001$

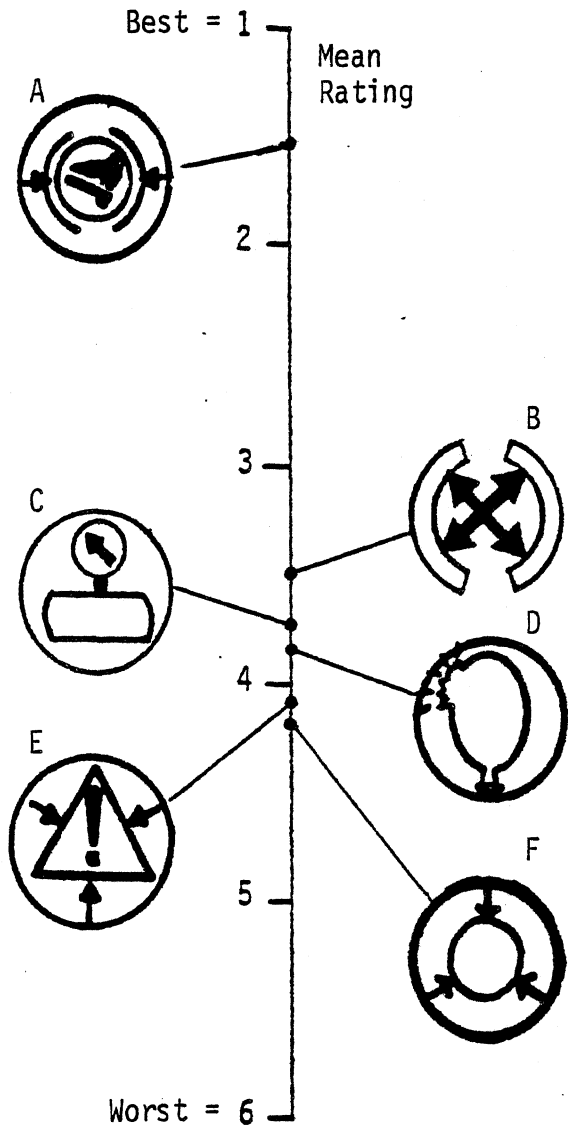


RANKING DISTRIBUTION OF EACH SYMBOL

SYM-BOL	Best ← → Worst							Missing	MEAN	$p < .1$
	1	2	3	4	5	6	7			
A	13	10	8	0	0	0	0	2	1.84]
B	8	5	8	8	0	1	0	3	2.67	
C	3	10	7	7	1	0	2	3	3.03]
D	4	4	4	8	7	1	4	1	3.91	
E	3	1	2	6	12	5	2	2	4.48]
F	1	0	0	0	5	12	12	3	6.07	
G	0	0	1	1	5	11	12	3	6.07]

○ - median

6. AIR PRESSURE



The candidate consisting of two brake shoes with two arrows indicating pressure on them, and a foot depressing a brake pedal (A) was preferred. It received 2/3 of the #1 rankings with only one ranking below #3. It was so ranked because it focused on a consequence of low air pressure in trucks--no brakes. None of the other candidates (arrows and brake shoes alone [E], a pressure vessel and gauge [C], a balloon bursting [D], a warning triangle [E], arrows and a circle [F]) were effective in representing "air pressure," an invisible entity. The subjects of Green and Burgess, 1980 also had problems with symbols for air pressure.

While candidate A is significantly better than the others, more meaningful alternatives should be sought. Candidate A is very complicated and will become illegible when reduced to sizes sometimes found on instrument panels.

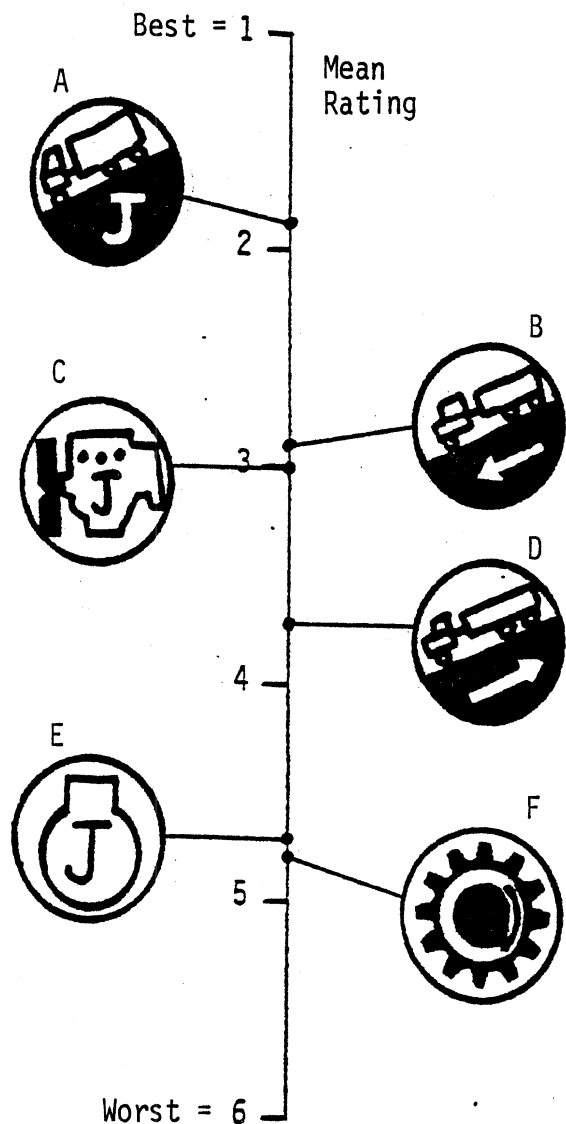
Friedman's $S = 37.91$, $p < .001$

RANKING DISTRIBUTION OF EACH SYMBOL

SYM- BOL	Best ← → Worst						Missing	MEAN	p < .1
	1	2	3	4	5	6			
A	22	3	4	0	0	1	3	1.53]]]]]]
B	5	4	5	5	8	3	3	3.53	
C	1	7	5	5	6	5	4	3.79	
D	3	8	5	1	2	12	2	3.91	
E	1	3	6	6	9	4	4	4.07	
F	0	4	4	12	4	6	3	4.13	

○ - median

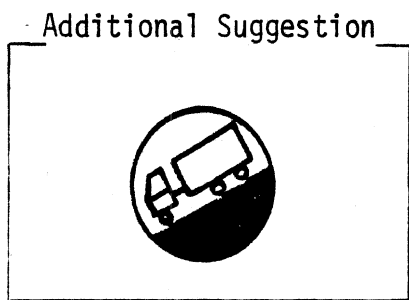
7. RETARDER



Drivers preferred images depicting a truck going down hill, especially when the letter "J" was beneath it. (The J stands for Jacobson brake, a common transmission-type retarder.) The "J" may not be meaningful to non-American drivers, because another name might be used or because other designs (for example, exhaust based systems), may suggest different images.

Candidates B and D are interesting examples of the command-error problem. Should the label show the error (the truck is going down the hill too fast, [B]) or the command to the vehicle, what the control should do, (D) (slow the vehicle down)? Drivers preferred the error label (B), but conventional wisdom says a control label should indicate what the control does (select D). For this and other reasons, A-D deserve further study along with a version of A showing only a truck going downhill. (see below)

Friedman's $S = 50.92$, $p < .001$

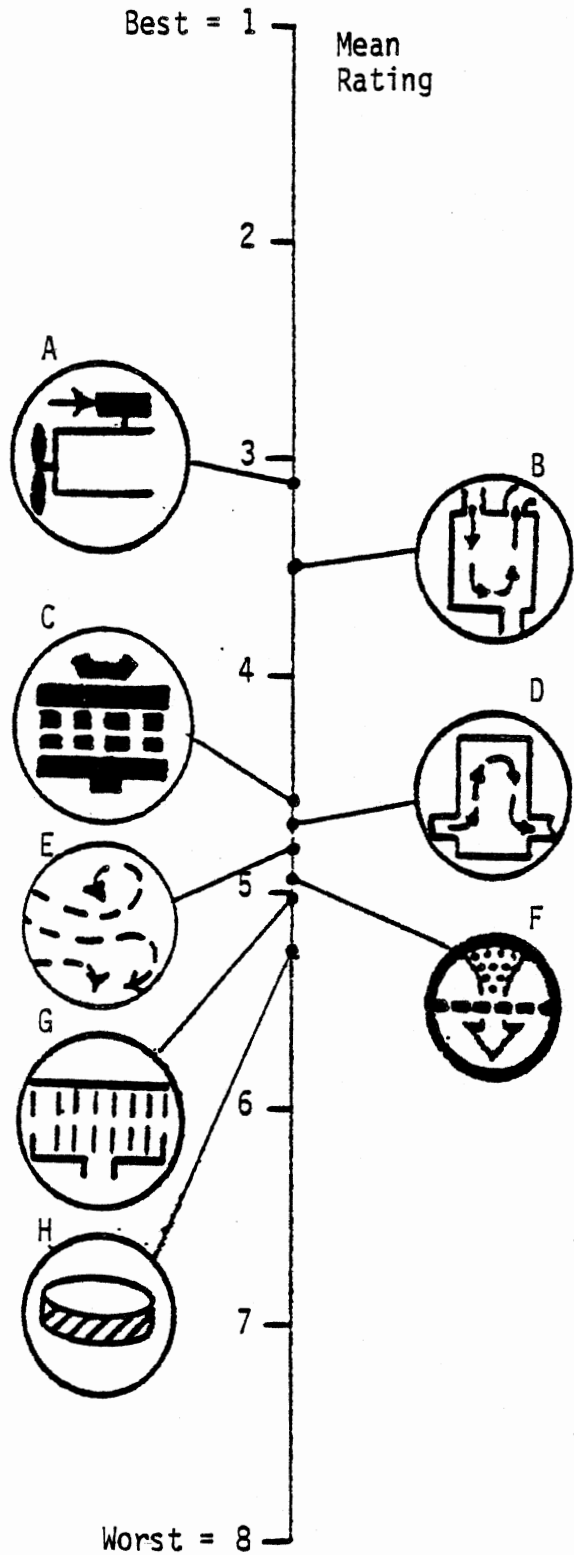


RANKING DISTRIBUTION OF EACH SYMBOL

SYM-BOL	Best ← → Worst						Missing	MEAN	p < .1
	1	2	3	4	5	6			
A	13	⑧	6	2	0	0	4	1.90]]]]
B	3	10	④	8	3	0	5	2.93	
C	9	4	④	7	3	3	3	3.00	
D	3	3	⑨	3	5	5	5	3.68	
E	0	1	4	6	⑧	9	5	4.71]]
F	2	2	1	2	⑨	12	5	4.79	

○ - median

8. AIR FILTER



As indicated by the large number of missing responses, many drivers did not like any of the alternatives and did not rank them. The favored candidate was a side view of an engine block with an arrow pointing to the air cleaner (A), with a cross section of a truck type air filter (B) being ranked second. As shown in the figure, they stood out from the other candidates though there were no statistical differences among the top five. Candidate F, a symbol found on some products, was disliked by truck drivers.

The five top and possibly just the two top-ranked candidates should be studied further, along with a version of candidate A in which the fan is shown as an outline form (shown below). Presenting the air filter as a solid draws attention to it. Given the driver reactions mentioned above, additional ideas are also needed.

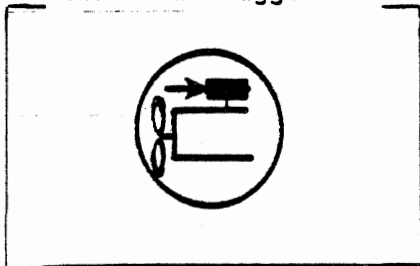
Friedman's $S = 14.84$, $p < .05$

RANKING DISTRIBUTION OF EACH SYMBOL

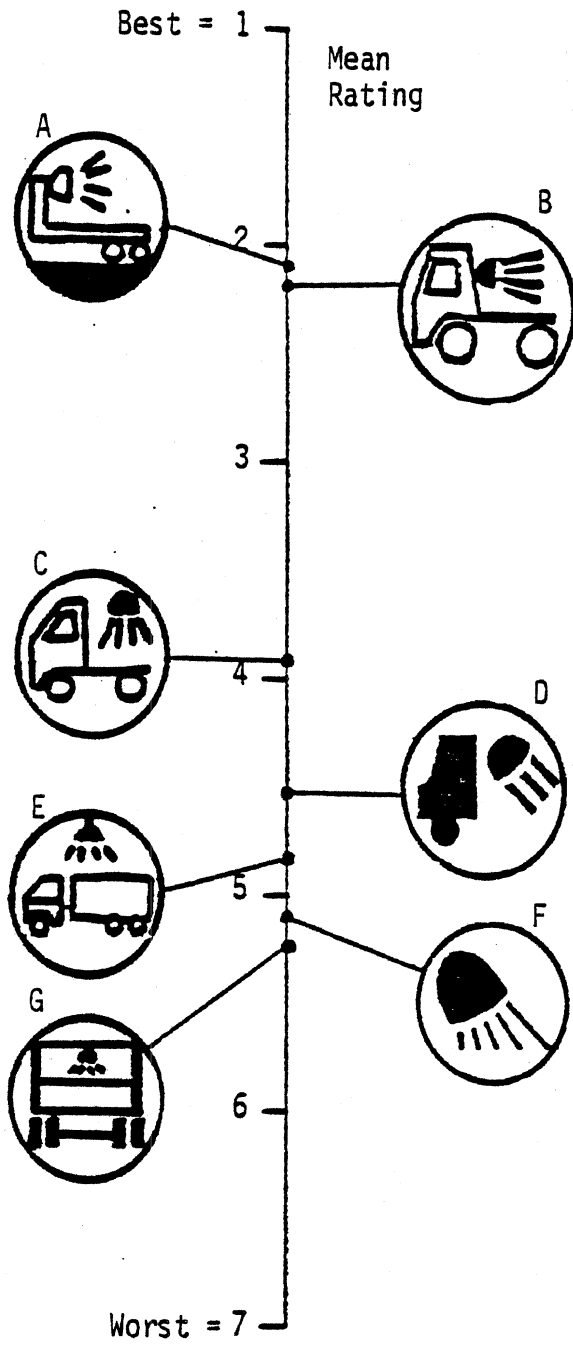
SYM- BOL	Best ← → Worst								Missing	MEAN	p < .1
	1	2	3	4	5	6	7	8			
A	9	⑧	4	2	1	3	0	3	3	3.07	}
B	5	2	⑧	6	3	1	3	0	5	3.54	
C	6	3	3	2	0	③	10	2	4	4.59	
D	0	6	2	3	⑤	8	2	1	6	4.63	
E	3	2	5	④	2	1	3	7	6	4.85	
F	4	2	2	3	②	1	2	11	6	4.93	
G	0	3	3	3	⑨	5	3	2	5	4.96	
H	4	2	2	3	2	①	2	11	6	5.33	

○ - median

Additional Suggestion



9. LOADING LIGHT



There were statistically significant driver preferences for symbols either showing the side view of a trailer with a rear facing light (A) or the side view of a tractor cab with a similar light (B). Both candidates should receive further evaluation.

There should be more than one loading light symbol because of multiple mounting locations. (Use candidate A when the light is at the front of the trailer, B when it is on the back of the cab, and develop a symbol for when it is mounted at the rear of the cargo area.) Whatever image or images are chosen, according to the ratings, they should face to the rear and be attached to the vehicle (A, B versus C, E). In addition, there is a need for context (A, B versus D, F).

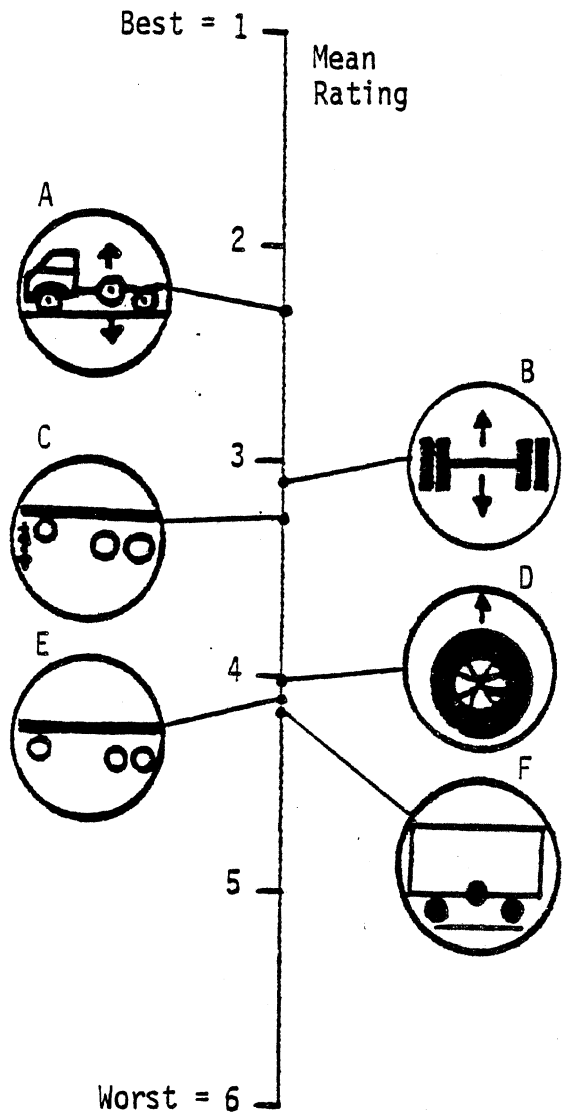
Friedman's $S = 63.30$, $p < .001$

RANKING DISTRIBUTION OF EACH SYMBOL

SYM-BOL	Best ← → Worst							Missing	MEAN	p < .1
	1	2	3	4	5	6	7			
A	14	6	8	2	1	0	1	1	2.19	}
B	12	11	2	2	0	2	1	3	2.23	
C	0	4	8	11	2	3	8	3	3.93	
D	1	4	4	4	7	7	3	3	4.50	
E	1	3	2	5	9	5	6	2	4.84	
F	2	1	3	3	9	4	9	2	5.06	
G	2	1	3	3	3	9	9	3	5.23	

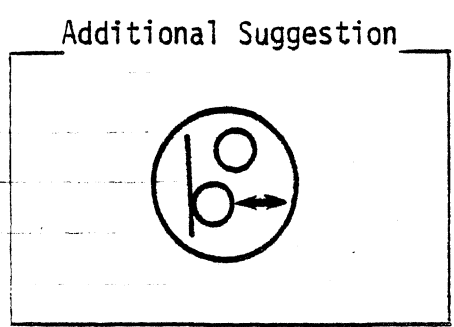
○ - median

10. AXLE LIFT



An essential ingredient of an axle lift symbol is an up/down arrow (A, B, C, and D versus E and F). The element is contained in candidate A showing a raised wheel on a tractor. Also well ranked was the "dumbbell" (B). Candidate B may be a superior choice for axle lift since it could be for either a tractor or trailer axle. Furthermore, when presented as part of a set, it may be more meaningful as it contains the same basic concept used in some differential lock symbols. The difference in the mean rankings of A and B is due to how many drivers made them their second and third choices. Candidates A-C should be studied further. In addition, the candidate shown below (not included in the set tested) should be considered.

Friedman's $S = 19.88, p < .01$

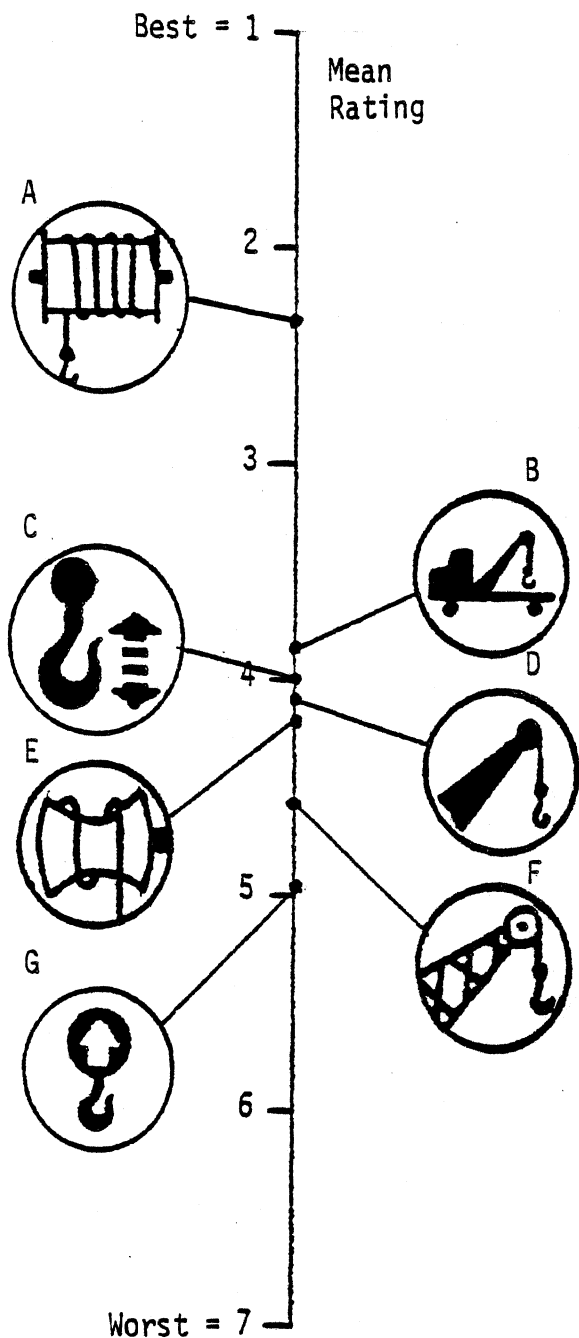


RANKING DISTRIBUTION OF EACH SYMBOL

SYM-BOL	Best ← → Worst						Missing	MEAN	p < .1
	1	2	3	4	5	6			
A	12	6	6	3	1	2	3	2.37	p < .1
B	12	4	2	3	3	7	2	3.06	
C	2	10	2	10	6	1	2	3.35	
D	2	6	6	6	a.7	9	1	4.03	
E	4	1	7	5	3	10	3	4.07	
F	0	3	7	7	10	3	3	4.10	

○ - median
a - median = 4.5

12. WINCH



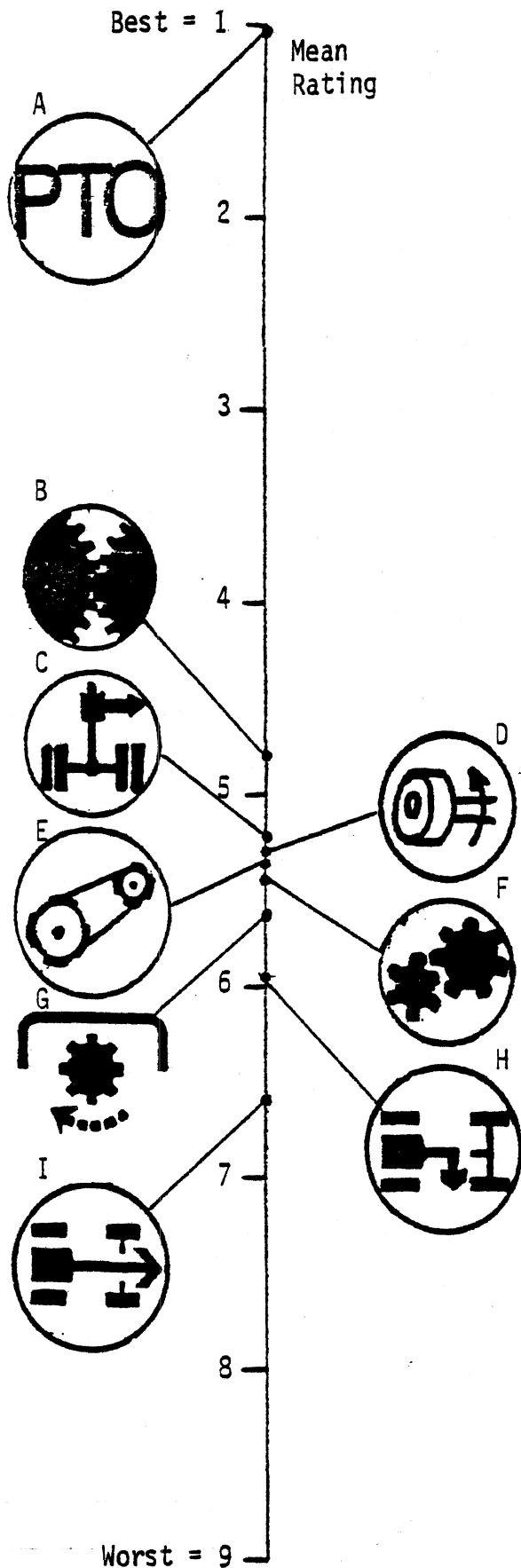
By a wide margin, the most popular choice for winch showed the cable wrapped around the winch spool (A). It was ranked #1 by over 1/2 of the drivers. The realistic U.S. Army candidate (A) was preferred over an abstract alternative (E). Candidate B, D, and F (tow truck winch) are inappropriate for general use. Quite often the winch is mounted in other places (for example, on the front of jeep type vehicles. It is recommended that a more clearly drawn version of candidate A (but not candidate E), be added to ISO standard 2575 without further evaluation.

Friedman's $S = 25.51, p < .001$

RANKING DISTRIBUTION OF EACH SYMBOL

SYM- BOL	Best ← → Worst							Missing	MEAN	p < .1
	1	2	3	4	5	6	7			
A	18	3	2	1	2	3	1	3	2.30	}
B	5	4	6	4	4	3	5	2	3.87	
C	5	4	6	1	4	8	3	2	4.00	
D	2	1	8	7	6	5	1	3	4.10	
E	1	12	3	1	3	1	10	2	4.16	
F	0	5	0	12	5	2	6	3	4.57	
G	1	1	5	4	6	8	6	2	4.97	

○ - median



13. POWER TAKEOFF

Truck drivers were almost unanimous in selecting the letter triple "PTO" as a way to represent power take off. Of the 31 drivers responding, 30 rated it number one. Two didn't respond. In conversation, this abbreviation is used by American truck drivers instead of the formal function name. As with the symbol for the retarder (J Brake) this character-based candidate may not be understood by non-English speaking drivers. It deserves further study.

Of the symbols remaining, there were no clear favorites. Once drivers ranked "PTO" as number one, they were not careful in ranking the remaining candidates. All of the candidates for power take off need to be examined in set context. In particular, candidates G, H, and I would probably fare better when presented with other symbols for mechanical power transmission, such as differential lock.

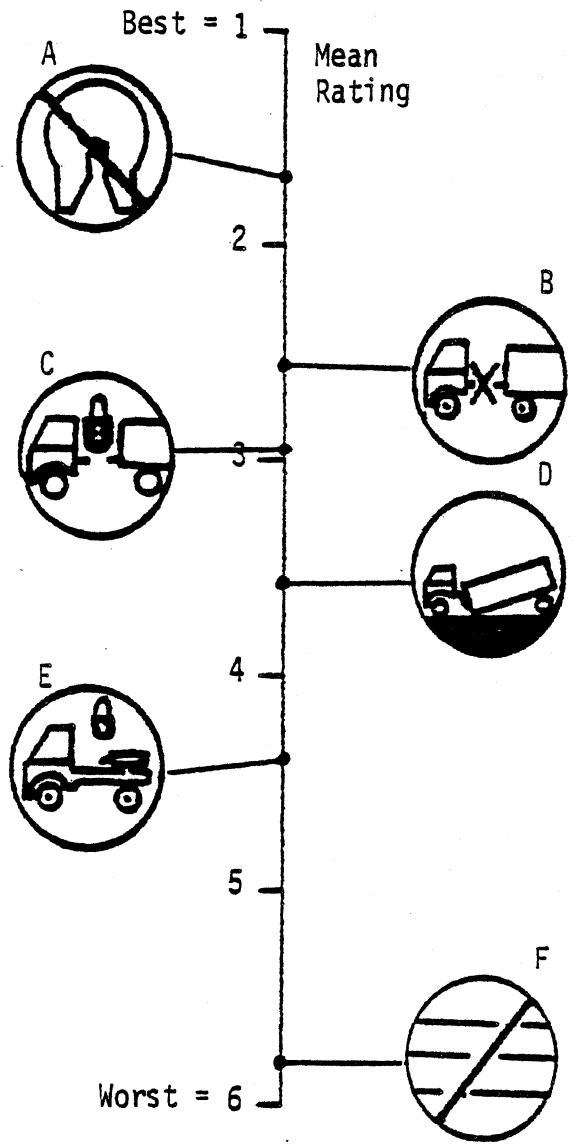
Friedman's $S = 86.27, p < .001$

RANKING DISTRIBUTION OF EACH SYMBOL

SYM-BOL	Best ← → Worst									Missing	MEAN	p<.1
	1	2	3	4	5	6	7	8	9			
A	30	1	0	0	0	0	0	0	0	2	1.03	}
B	0	4	8	6	1	2	4	1	4	3	4.83	
C	0	3	4	4	4	6	3	5	0	4	5.21	
D	0	5	4	0	8	3	2	5	2	4	5.24	
E	0	6	1	6	2	4	4	2	4	4	5.28	
F	0	3	5	3	5	3	3	4	3	4	5.38	
G	1	4	2	5	2	3	2	2	8	4	5.69	
H	0	1	5	1	4	4	7	5	2	4	5.93	
I	0	2	0	4	3	4	4	5	8	3	6.63	

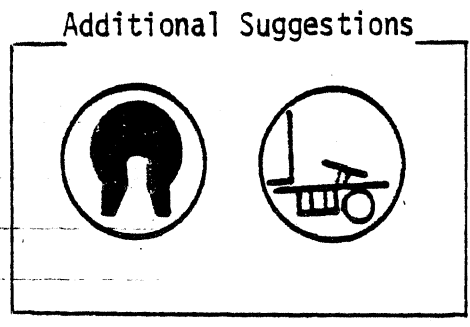
○ - median

14. TRAILER CONNECTION/ LOCK-UP



In general, drivers preferred candidates showing a fifth wheel (A) over those showing the consequences of being disconnected (B-D) or those depicting the air and electrical lines. More specifically, the unexpected favorite symbol for this function showed the fifth wheel face with a superimposed slash (A). Second and third ranked were an "X" over the side view of a tractor (B) and an alternative where a padlock replaced the "X" (C). (As with cab lock-down, it is not known if non-American drivers will associate the padlock with locking.) While there were differences among A-C (1st place 20-4-4: A-B-C; 2nd place: 3-13-11), they were not statistically significant. These three candidates should receive further study along with two alternatives not evaluated (shown below): 1) a modification of A where the 5th wheel is drawn as a solid figure and the slash is omitted, and 2) a side view of a tractor showing only the back end.

Friedman's $S = 90.95, p < .001$

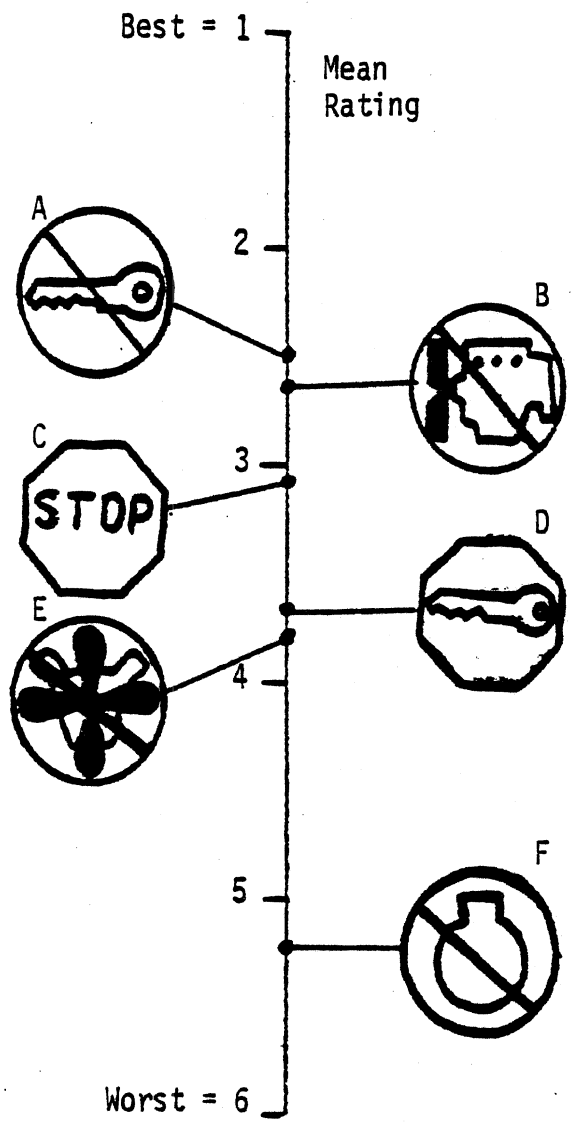


RANKING DISTRIBUTION OF EACH SYMBOL

SYM-BOL	Best ← → Worst						Missing	MEAN	p < .1	
	1	2	3	4	5	6				
A	20	3	6	3	0	0	1	1.75]	
B	4	13	7	3	3	0	3	2.60		
C	4	11	a	5	6	2	2	3		2.90
D	4	2	7	8	9	1	2	3	3.61]
E	0	1	4	10	b	13	2	3	4.37	
F	0	0	1	0	3	27	2	5.81		

○ - median
 a - median = 2.5
 b - median = 4.5

15. ENGINE STOP



Drivers were unable to agree which candidate was best for engine stop. Curiously, the third ranked candidate (C) received more first place votes (14 versus 4) than the top ranked candidate (A) but also received far more last place votes (6 versus 0). It is obvious, however, that F, a slash through an abstract engine block, is undesired. Additional candidates should be created for this function.

These rankings do not offer clues as to how engine stop should be depicted. For example, candidates with slashes through them were both at the top and bottom of the list, as were candidates showing an engine block or a key. It is also unclear whether an octagon (an American signing convention for stop) is informative.

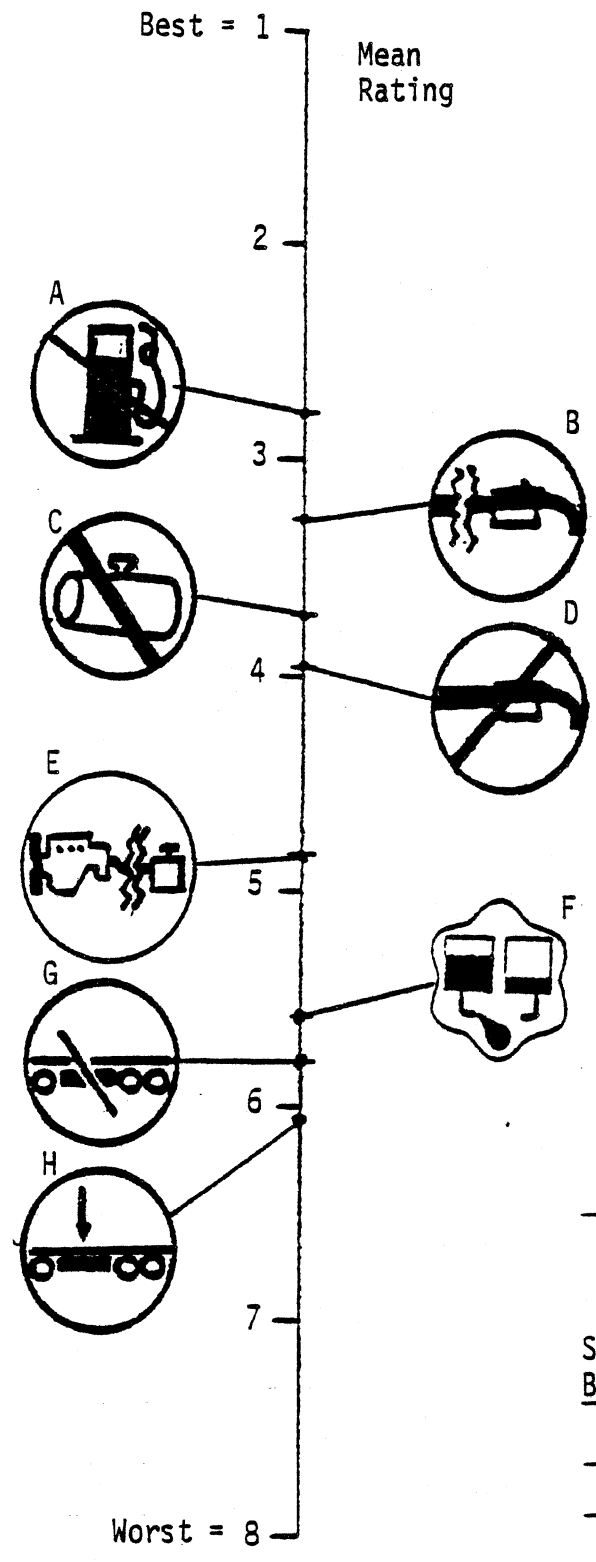
Friedman's $S = 38.99, p < .001$

RANKING DISTRIBUTION OF EACH SYMBOL

SYM-BOL	Best ← → Worst						Missing	MEAN	p < .1
	1	2	3	4	5	6			
A	4	11	9	5	0	0	4	2.52	}
B	9	7	5	7	0	2	3	2.60	
C	14	1 ^a	1	3	5	6	3	3.07	
D	3	4	6	6	7	4	3	3.73	
E	1	5	7	5	6	4	5	3.79	
F	0	1	1	2	10 ^b	14	5	5.25	

○ - median
 a - median = 2.5
 b - median = 5.5

16. FUEL SHUTOFF



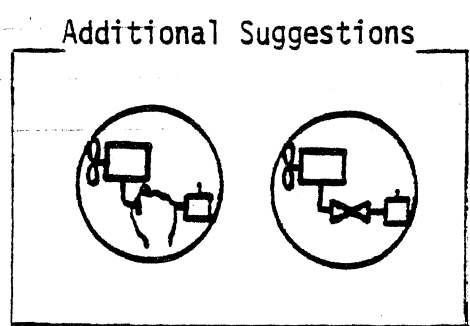
A modification of the existing ISO symbol for fuel (by adding a slash) was the highest ranked candidate for fuel shutoff. Preferences for it were not significantly different from those showing a fuel nozzle with a break in the line (B) or a slash over it (D) or a truck fuel tank with a slash through it (C). Almost half of the drivers voted for A as the preferred symbol versus only three who voted for B. B was the preferred second choice. Some caution must be used if A is adopted for fuel shutoff. It could be misinterpreted as a symbol for low (or no) fuel (a command-error problem).

While significant differences were not found among the first four candidates, it is suggested that the top five receive further study along with the two modifications of candidate E (break in the fuel line between the tank and the engine) shown below.

Friedman's $S = 56.45, p < .001$

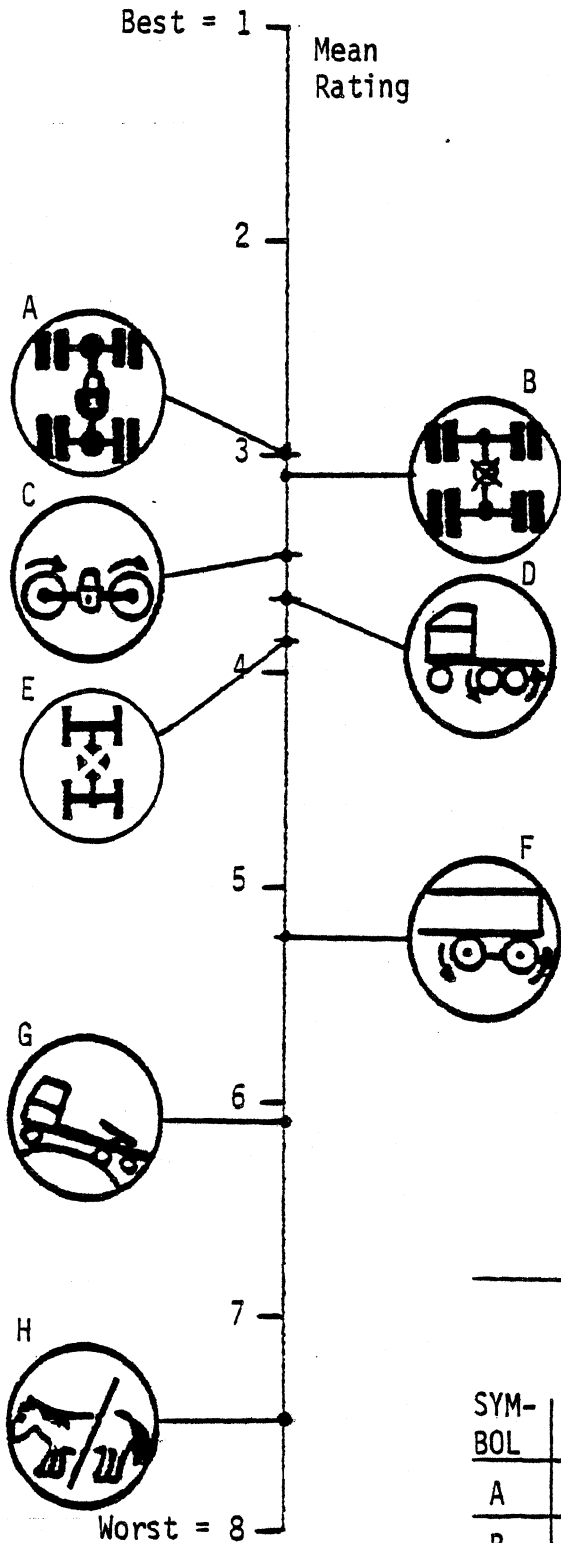
RANKING DISTRIBUTION OF EACH SYMBOL

SYM-BOL	Best ← → Worst								Missing	MEAN	p < .1
	1	2	3	4	5	6	7	8			
A	14	②	5	3	2	0	2	2	3	2.83	<div style="display: flex; align-items: center;"> <div style="border-left: 1px solid black; border-right: 1px solid black; height: 100px; margin-right: 5px;"></div> <div style="border-left: 1px solid black; border-right: 1px solid black; height: 80px; margin-right: 5px;"></div> <div style="border-left: 1px solid black; border-right: 1px solid black; height: 60px; margin-right: 5px;"></div> <div style="border-left: 1px solid black; border-right: 1px solid black; height: 40px; margin-right: 5px;"></div> <div style="border-left: 1px solid black; border-right: 1px solid black; height: 20px; margin-right: 5px;"></div> </div>
B	3	10	⑦	5	1	0	0	4	3	3.37	
C	7	1	6	④	6	5	2	0	2	3.77	
D	1	8	5	⑤	1	7	2	0	4	3.90	
E	1	6	0	6	⑥	3	2	5	4	4.79	
F	3	0	2	1	5	⑦	6	5	4	5.59	
G	1	0	3	1	7	③	9	5	4	5.86	
H	1	2	1	4	1	4	⑥	10	4	6.03	



○ - median

18. INTERAXLE DIFFERENTIAL LOCK



Symbol elements preferred by drivers for this function included plan views over side views (A, B, and E versus C, D, and F), and representing locking with a padlock (A and C) as opposed to using an "X" (B and E) or arrows to represent power transmission (C, D, and F). The split horse (H) didn't fare too well and was laughed at by some drivers. Out to pasture for Mr. Ed.

There was almost no difference between the top two candidates-- drive train plan view with padlock (A) or "X" (B). As with cab lock down and differential lock, the padlock may not be meaningful to non-English speaking drivers. Of the remaining alternatives, the dark "X" (B) is favored. (For the differential lock and the interaxle lock, the reverse contrast "X" received lower ratings than the positive alternative.) Given the outcome of the statistical test, the top five candidates should be considered for evaluation with a multinational driver sample.

Friedman's $S = 83.89$, $p < .01$

RANKING DISTRIBUTION OF EACH SYMBOL

SYM-BOL	Best ← → Worst								Missing	MEAN	p < .1
	1	2	3	4	5	6	7	8			
A	6	7	6	6	4	0	0	1	2	3.00	
B	7	6	4	6	3	2	1	0	4	3.07	
C	4	7	6	5	1	3	3	0	4	3.45	
D	7	1	6	4	8	1	2	1	3	3.70	
E	4	4	5	4	7	3	1	1	4	3.83	
F	2	2	1	1	4	14	4	1	4	5.28	
G	1	1	0	3	2	5	15	2	4	6.07	
H	0	1	1	0	0	1	3	25	2	7.48	

○ - median

CONCLUSIONS

- 1) The symbol production experiment proved to be an invaluable source of ideas for symbols. Drivers' suggestions for the eighteen functions were in most cases vastly different from those of manufacturers. In addition, for some functions, no manufacturers' suggestions were available. Consequently, a symbol production experiment is recommended as the first step in a symbol development project.
- 2) The authors may have stumbled upon a measure of a symbol's "imageability," the number of missing responses. This number should be useful in establishing an acceptance criterion in studies of meaningfulness. (In previous studies, such as Green and Burgess, 1980, student subjects were required to produce a drawing for each scenario.)
- 3) Certain conventions, such as letters (PTO) or simple images (padlock), can be very meaningful symbol elements for limited populations such as American truck drivers. It is unknown if those conventions will transfer well across cultures or languages.
- 4) Drivers preferred simple, uncluttered symbols. Abstract symbols (usually suggested by manufacturers) were ranked very low.
- 5) Truckers and automotive engineers have very different ideas of what a "good" symbol is. Engineers tend to develop symbols that convey the operating mechanism of

the function being described. Truckers tend to concentrate on the external view of the equipment. For example, engineers associate a gear(s) with the transmission function, while truckers prefer to use a gear shift lever. Some might not have expected this result, since truckers, unlike student subjects, are usually intimately familiar with the internal workings of their trucks.

- 6) In general, symbols developed by engineers or included in international standards were ranked lower than symbols based on drivers' suggestions. This is especially true for engine oil temperature. Because of that and carryover problems, new ISO symbols should be adopted for engine oil and coolant temperature.
- 7) This study did not lead to firm conclusions for all functions examined. However, for several functions, preferred candidates were found. In other cases, further study is required.
- 8) Lastly, it is important to note, especially for students and those unfamiliar with the conduct of research, how long a study of this complexity takes to prepare. Approximately 20 hours were devoted to the actual interviewing process while over 200 hours were devoted to preparation of the questionnaires, analysis of the collected data, and preparation of a very preliminary version of this report. Many more hours were spent generating the final draft. It is quite normal for the

testing phase of an experiment to take considerably less time and effort than the preparation of the report itself.

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APPENDIX 1
PRIORITY TRUCK SYMBOLS

02/19/81

N 56.

PRIORITY TRUCK SYMBOLS - WG-5 ANN ARBOR 1981

NUMBER	NAME	FUNCTION	APPLICATION	CONDITION
1.	AIR PRESSURE I	AIR PRESSURE BELOW DEFINED LEVEL IN ONE OF THREE SYSTEMS	TT	PRESSURE LOW
2.	AIR PRESSURE II		TT	" "
3.	AIR PRESSURE III		TT	" "
4.	CAB LOCK DOWN	DETECTS INCOMPLETE LATCHING OF CAB TILT MECHANISM/CAB	TT	CAB NOT LOCKED DOWN
5.	ENGINE STOP	TO STOP ENGINE	C	TO OPERATE
6.	DIFFERENTIAL LOCK	(TO INDICATE ENGINE STOPPED)	TT	ENGINE STOPPED
		TO LOCK THE DIFFERENTIAL ON ONE AXLE	C	TO OPERATE
7.	THIRD DIFFERENTIAL LOCK	TO LOCK THE DIFFERENTIAL BETWEEN TWO AXLES.	TT	DIFFERENTIAL LOCKED
			C	TO OPERATE
8.	AXLE LIFT	TO LIFT ONE AXLE OFF THE ROAD	TT	3rd DIFF LOCKED.
			C	TO OPERATE
9.	FUEL SHUT OFF	TO SHUT OFF FUEL SUPPLY (TO THE ENGINE)	TT	AXLE LIFTED.
10.	POWER TAKE OFF	TO ENGAGE DRIVE TO ACT AS EXTERNAL POWER SUPPLY	C	TO OPERATE
			C	TO OPERATE
11.	LOAD TIPPING (DUMP TRUCK)	TO RAISE THE BODY OF A TIPPER TRUCK TO REMOVE LOAD	TT	PTO SELECTED IN OPERATION
			C	TO OPERATE
12.	WINCH	TO OPERATE WINCH	TT	BODY TIPPED
			C	TO OPERATE
13.	RETARDER	TO SELECT DEVICE TO SLOW VEHICLE INDEPENDANT OF MAIN BRAKES	TT	WINCH OPERAT
			C	TO OPERATE
14.	AIR FILTER	DETECTS FILTER BLOCKED	TT	RETARDER SELECTED/OP
		OR REQUIRES REPLACEMENT	TT	AIR FILTER DEFECTIVE
15.	OIL FILTER	OR ATTENTION	TT	OIL FILTER DEFECTIVE
16.	GEARBOX MALFUNCTION	FAULT DEVELOPED WITHIN GEARBOX OR GEARBOX CONTROL SYSTEM	TT	GEARBOX WARNING
17.	FLUID LEVEL (BRAKES)	FLUID LEVEL BELOW REQUIRED LEVEL - NEED ATTENTION	TT	FLUID LEVEL LOW
18.	OIL TEMPERATURE (ENGINE)	DETECTS ENGINE OIL TEMP ABOVE DEFINED LEVEL	TT	ENGINE OIL TEMP HIGH
19.	TRAILER CONNECTION LOCK UP	DETECTS INCOMPLETE CONNECTION OF TRACTOR UNIT + TRAILER	TT	TRAILER CONN INCOMPLETE
20.	LOADING LIGHT	LIGHT TO ILLUMINATE LOADING AREA OF TRUCK.	C	TO OPERATE
		(WHITE REAR FACING LIGHT - HAZARD)	TT	LIGHT ON

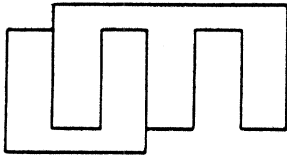
* APPLICATION

C = CONTROL

TT = TELL TALE

APPENDIX 2

SYMBOL PRODUCTION SURVEY FORM



THE UNIVERSITY OF MICHIGAN

HIGHWAY SAFETY RESEARCH INSTITUTE

Institute of Science and Technology
Human Factors and Accident Research
Ann Arbor, Michigan 48106

We are performing a study for the Society of Automotive Engineers and the International Standards Organization to develop a standard set of symbols. These symbols will be used to label controls, warning lights, and gauges on truck instrument panels.

A number of symbols for various controls and warning lights has been proposed by engineers. However, it is important to know the opinions of those who are going to use the symbols, namely truckers. Therefore, your views will be useful to us.

On the next page of the questionnaire you will find descriptions of different situations in which warning lights and controls might be used. Please draw one picture that you think best identifies the warning light and/or control for the situation described.

Draw each picture as large as possible in the space provided. Pictures need not be artistic. So, don't worry if your drawing looks a little crude.

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

You only need to draw the symbol that will appear on the control or display and not the switch or gauge on which the symbol will appear. For controls, the symbols will only be used to identify what the control is (for example, lights, wiper) and not the control setting (on/off, fast/slow).

A good symbol will be meaningful and simple.

The following are a few symbols that have already been accepted by the International Standards Organization.



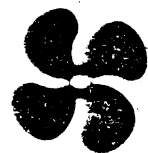
Upper beam



Fuel



Battery charging condition

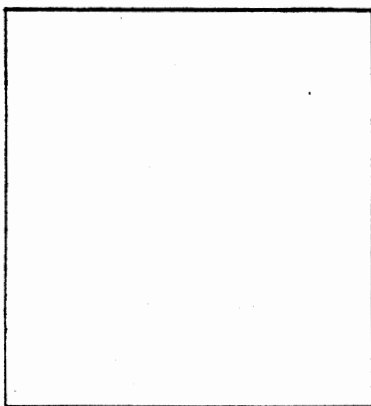


Ventilating fan

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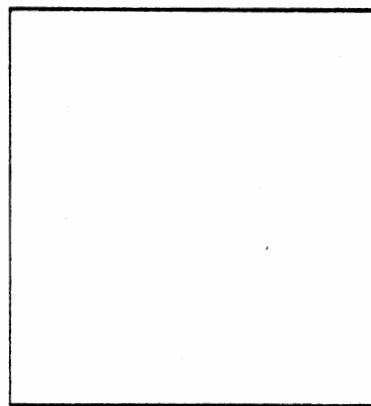
1. CAB LOCK DOWN

You lifted the cab to check out something in the engine. After you have lowered the cab and try to start the truck a warning light comes on indicating that the cab was not locked down properly. Draw a symbol that could appear on a warning light for this purpose.



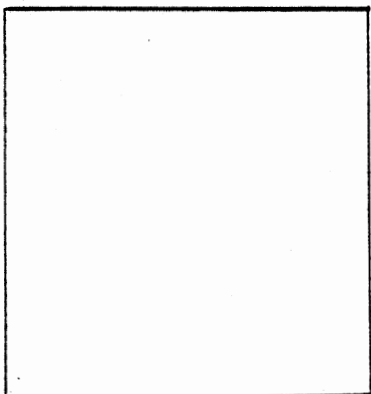
2. DUMP LOAD

Suppose you are in a dump truck or a tractor with a dump trailer and you want to raise the dump body. Draw the symbol that could be used to label the dump load control.



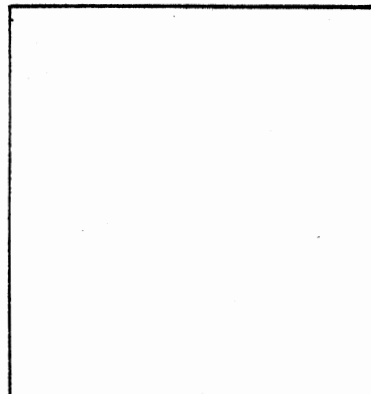
3. ENGINE OIL TEMPERATURE

As you are driving, the temperature of the engine oil rises above the safe operating limits. Draw the symbol which might appear on the warning light for this purpose.



4. OIL FILTER

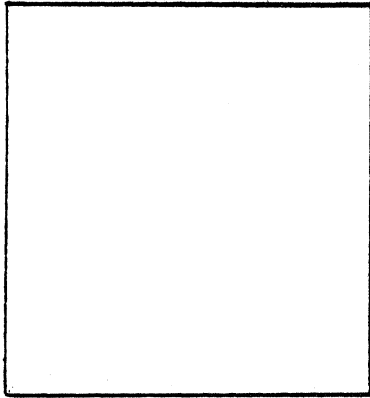
As you are driving, the oil filter in your truck's engine becomes clogged and a warning light comes on. Draw the symbol that should appear on that light.



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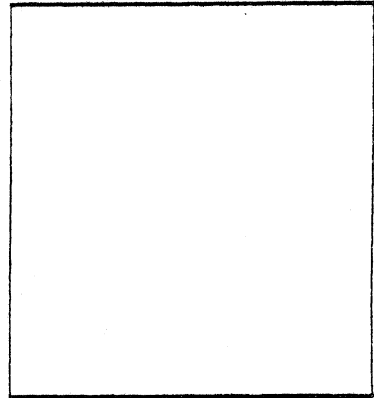
5. FLUID LEVEL

As you are driving the brake fluid level becomes dangerously low. Draw a symbol that could appear on a warning light for this purpose.



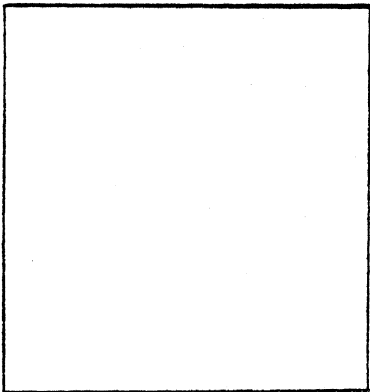
6. AIR PRESSURE

As you are driving, the air pressure in the brake system falls below the normal level. Draw a symbol which could appear on a warning light for that purpose.



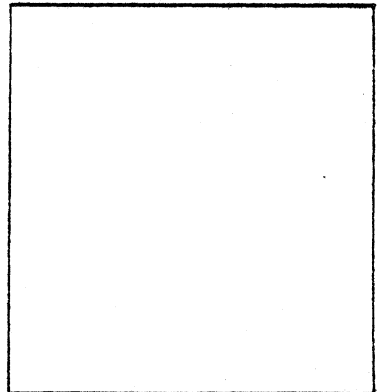
7. RETARDER

Suppose you are driving a truck down a steep hill. To reduce brake wear, you use the retarder instead of the normal air brakes. Draw the symbol that identifies the retarder control.



8. AIR FILTER

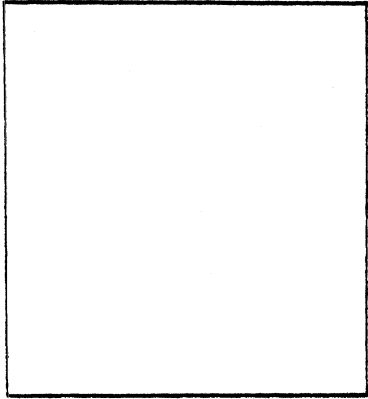
As you are driving, the air filter in your truck's engine becomes clogged with dirt. Draw the symbol that might be used to label the warning light for this purpose.



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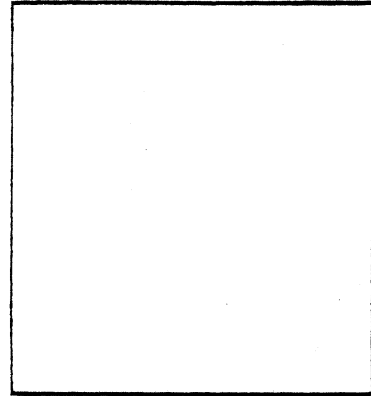
9. LOADING LIGHT

Suppose you want to unload your truck at night and decide to turn on the loading light to illuminate the loading area of the truck. Draw the symbol that might identify this control.



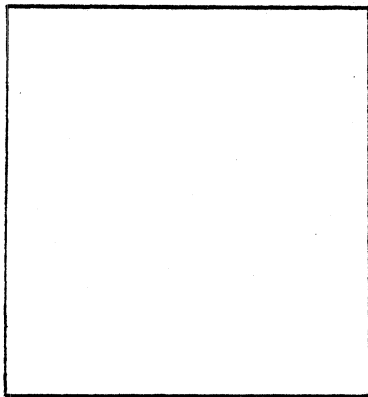
10. AXLE LIFT

Suppose you are driving with a light load and you want to lift a set of wheels to minimize tire wear. Draw a symbol that might be used to label the axle lift control.



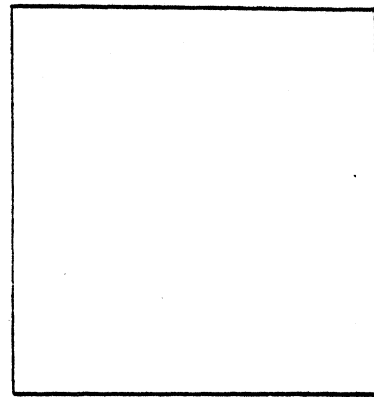
11. GEARBOX MALFUNCTION

Draw a symbol that might appear on a warning light to indicate any transmission gearbox malfunction.



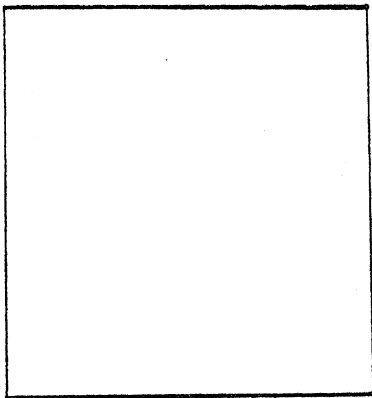
12. WINCH

Draw a symbol that might be used to label the winch control. (Note: Don't develop a symbol for the control positions [pay out, pull in, free wheel brake].)



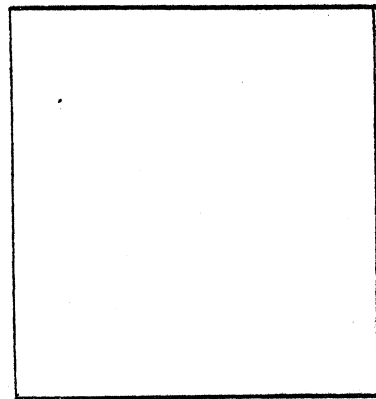
13. POWER TAKE OFF

Suppose your truck has an external device that is powered by the truck's engine (for example, a cement mixer drum). At some time you want to start or stop the power supply to this device. Draw the symbol that best describes what the symbol for the power take off should look like.



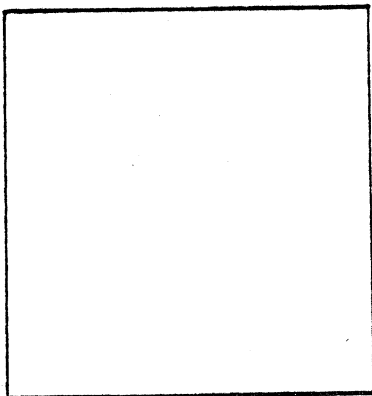
14. TRAILER CONNECTION/LOCK-UP

You are about to start your tractor when a warning light goes on telling you that the tractor and trailer are not connected properly. (It could be either the fifth wheel is not locked or the air or electrical lines are disconnected.) Draw the symbol that could appear on a warning light for this purpose.



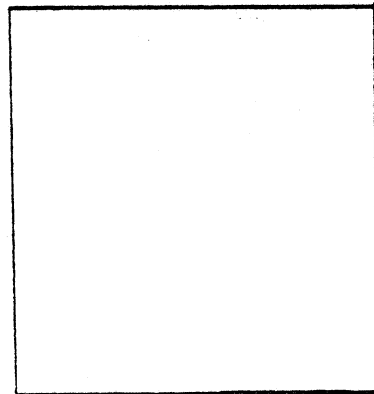
15. ENGINE STOP

Suppose, for some reason, you need to stop the engine. Draw a symbol that might be used to label this control.



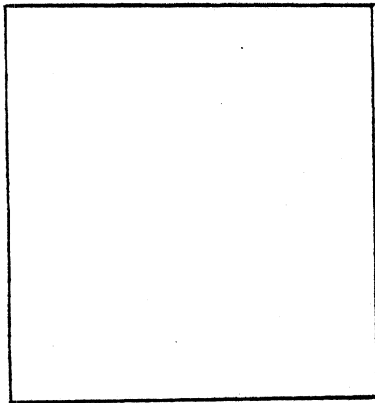
16. FUEL SHUTOFF

Suppose, for some reason, you need to shut off the fuel supply to the engine. Draw the symbol that could appear on or next to a control for this purpose.



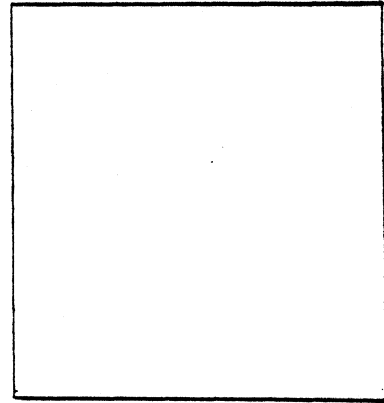
17. DIFFERENTIAL LOCK

You are driving a tractor with a single drive axle on a slippery road. To improve traction you want to lock the differential. Draw the symbol that could be used to label this control.



18. INTERAXLE DIFFERENTIAL LOCK





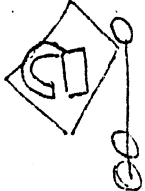
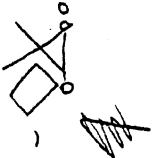










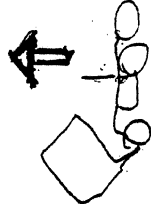

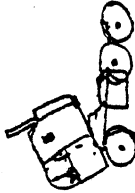



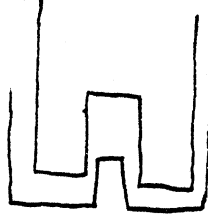



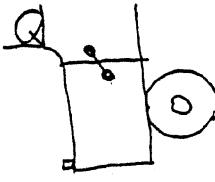


You are driving a tandem tractor on a slippery road. To improve traction you want to lock the interaxle differential (the third differential). Draw the symbol that should be used to identify this control.






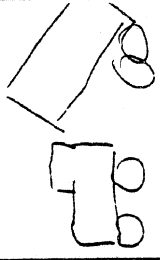


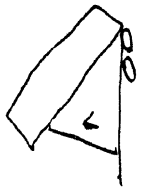






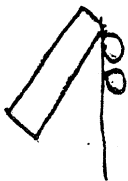
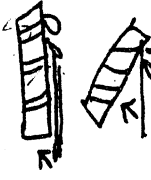

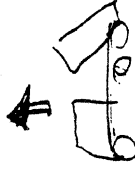
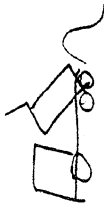
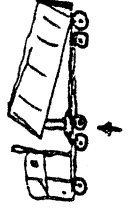


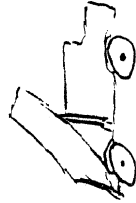






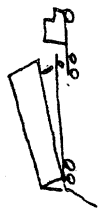
APPENDIX 3

TRUCK DRIVERS' DRAWINGS FROM THE PRODUCTION EXPERIMENT











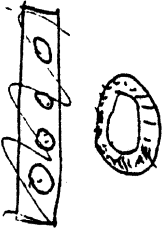
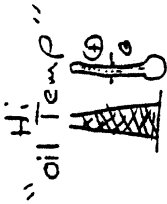


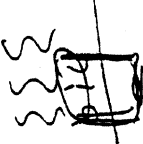


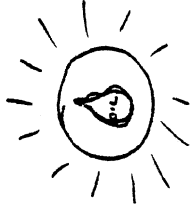



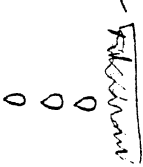


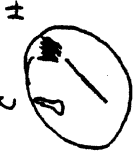
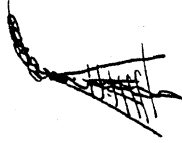
1. CAB LOCK DOWN



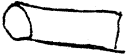
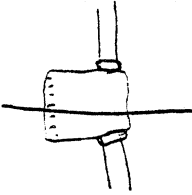



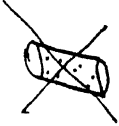





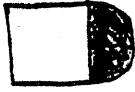

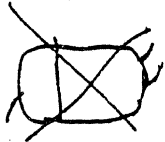
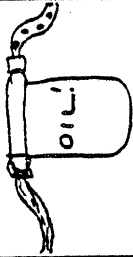


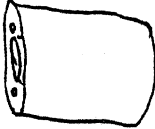





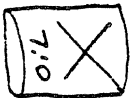
2. DUMP LOAD

3. ENGINE OIL TEMPERATURE

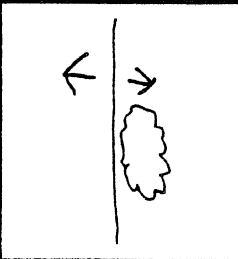
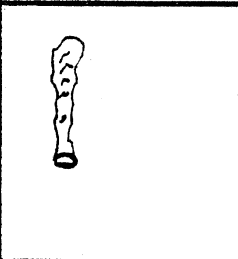
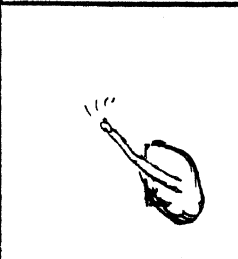
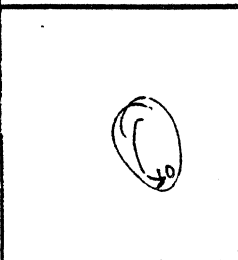
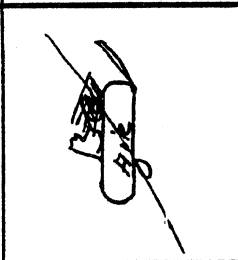
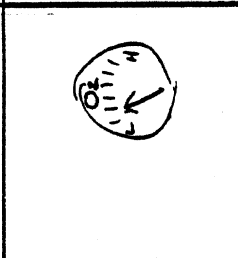
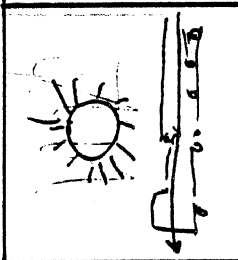
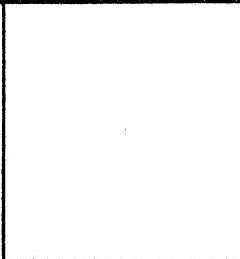
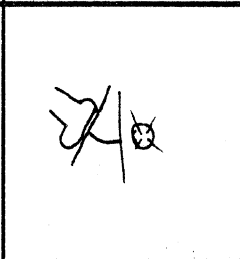
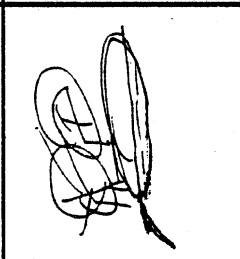
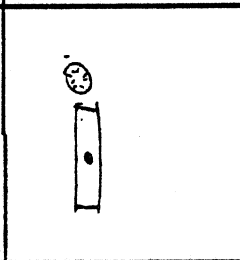
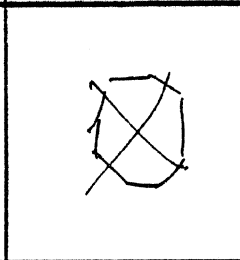
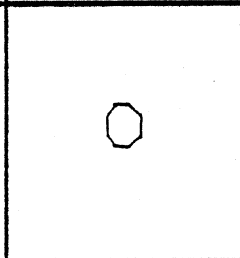
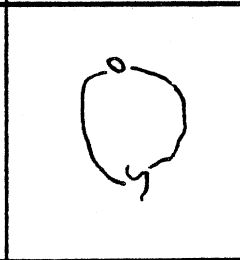
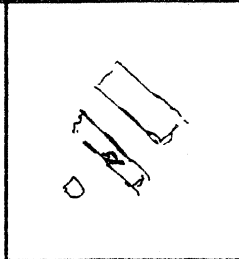
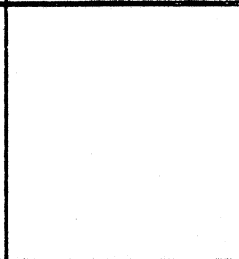
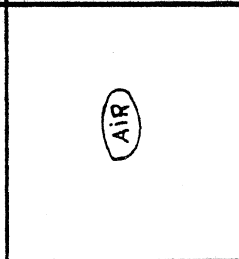
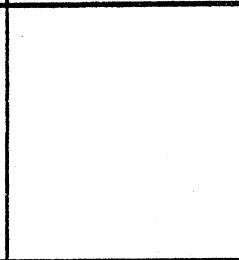
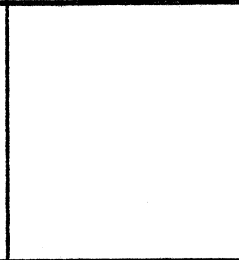
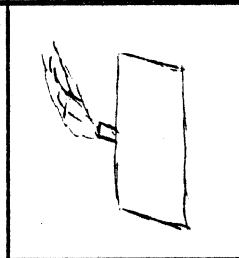

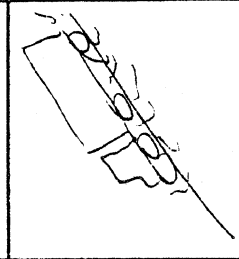
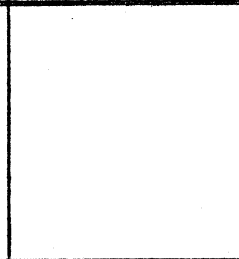
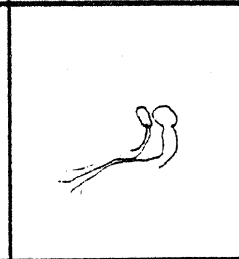
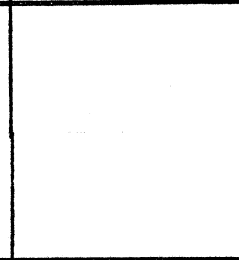
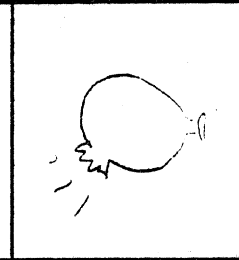
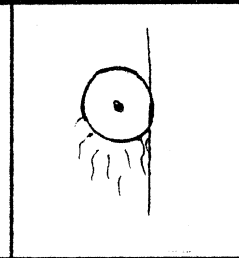
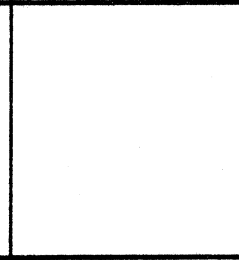
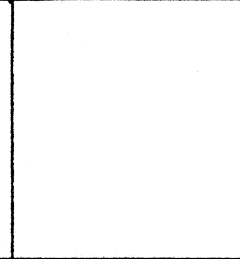
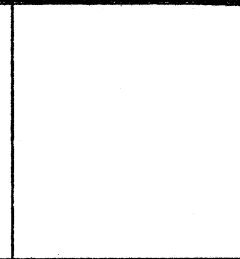
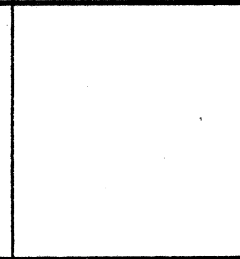
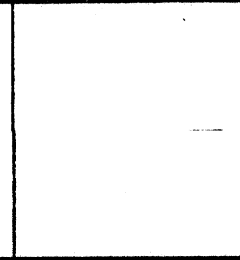
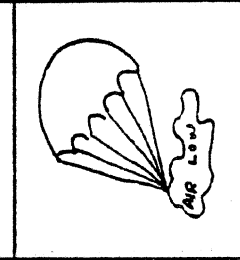
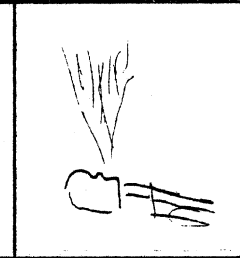
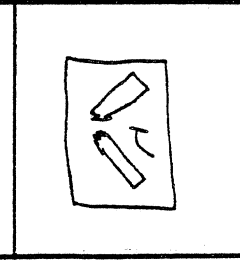
				
				
				
		 "Hi Temp" "oil Temp"		
 Light Flashing				
				 - Flashing
		 H C		

4. OIL FILTER

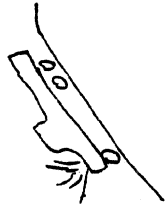

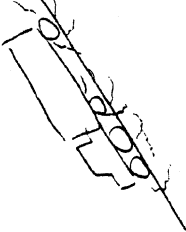
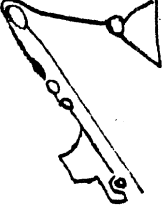

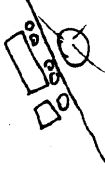

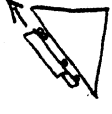





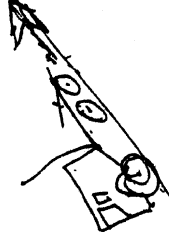
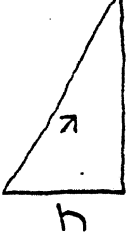
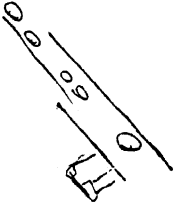
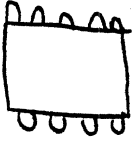

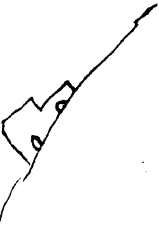
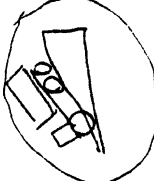

				
				
				
				
				
				
				

5. FLUID LEVEL

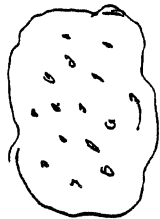

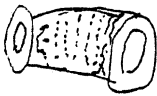
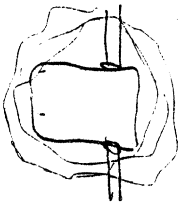

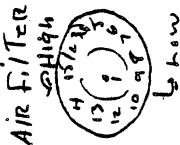

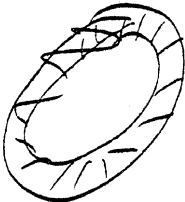


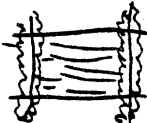


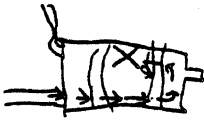
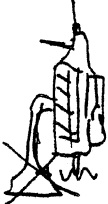


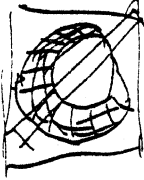

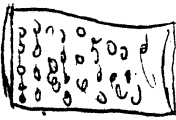


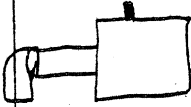
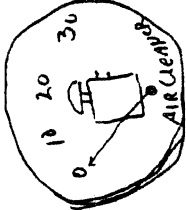

6. AIR PRESSURE

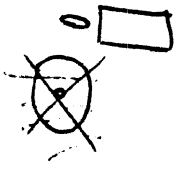



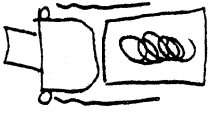

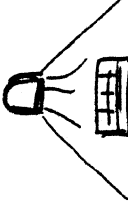
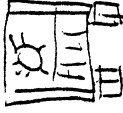


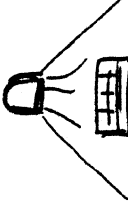



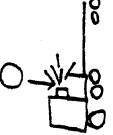
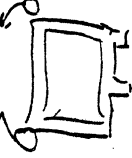


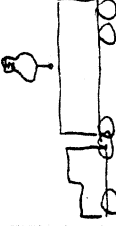
7. RETARDER



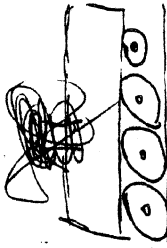




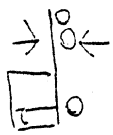

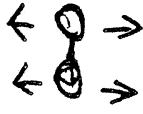
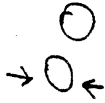

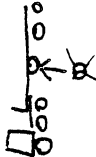

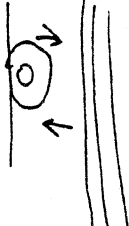




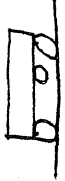
8. AIR FILTER

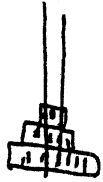

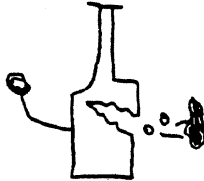






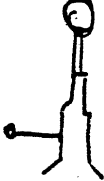
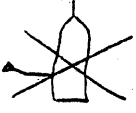





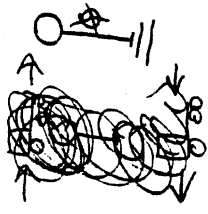




A. LOADING LIGHT

				
				
				
				
			 LOADING LIGHTS H-AD ACHE RACK	
				




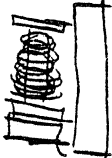


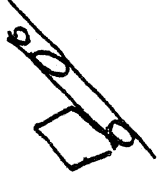



B. AXLE LIFT





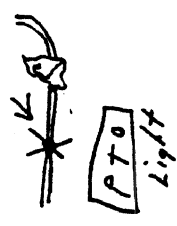
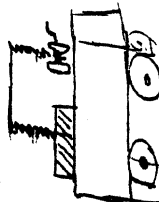

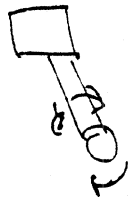



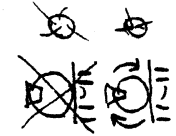

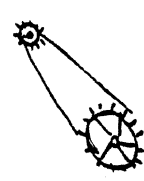
C. GEARBOX MALFUNCTION

				
				
				
				
			High Temp gauge 	
				



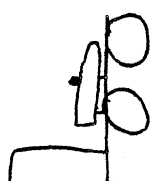
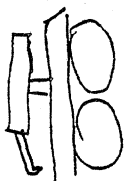

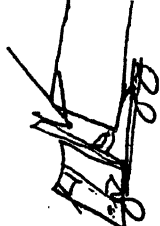


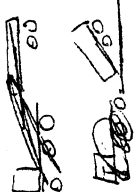





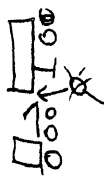



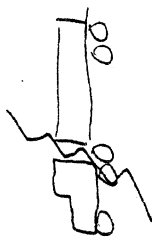
D. WINCH

									
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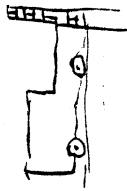
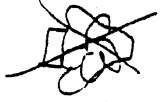

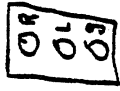






E. POWER TAKE OFF


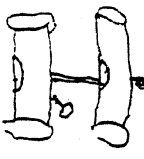




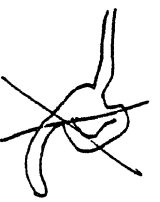




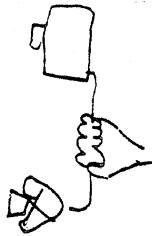
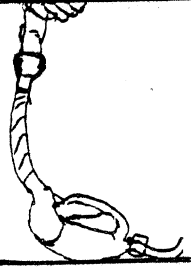
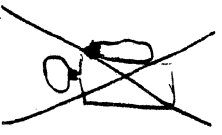



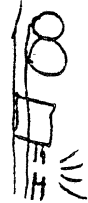

F. TRAILER CONNECTION/LOCK-UP

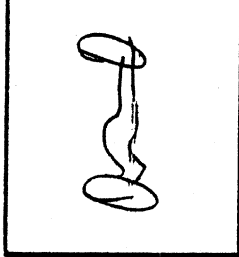
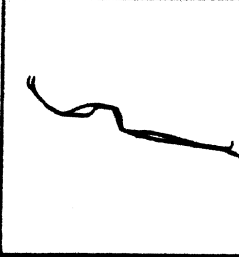
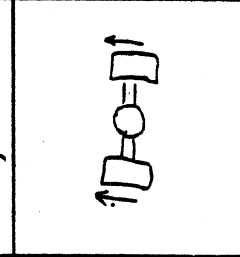
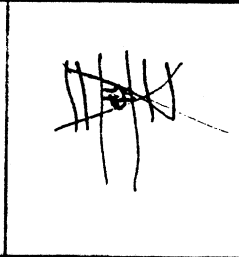
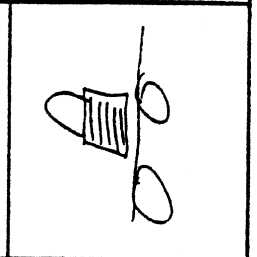
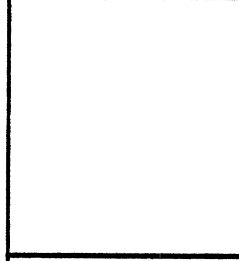
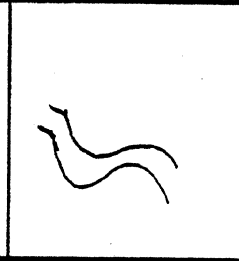
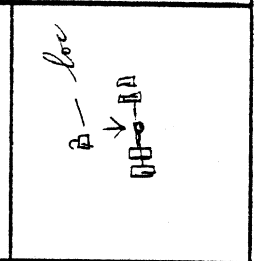

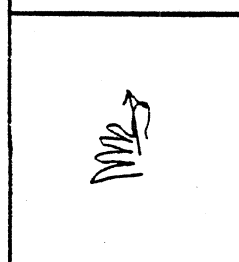
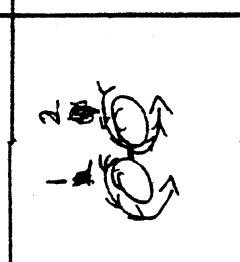
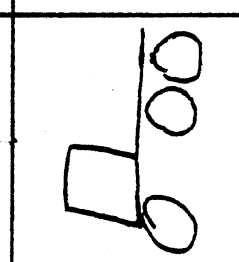
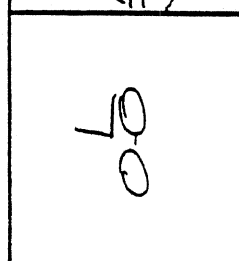
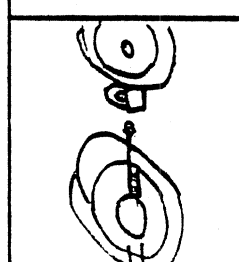
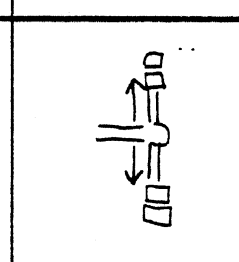
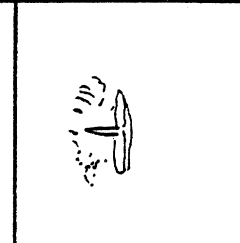
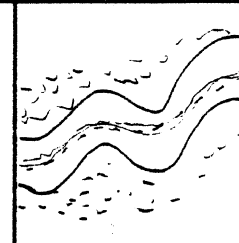
G. ENGINE STOP

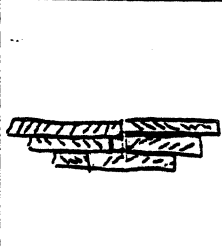
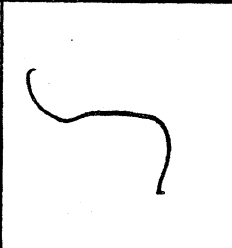
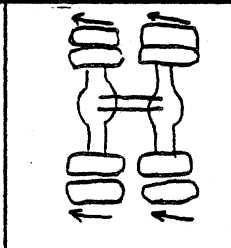
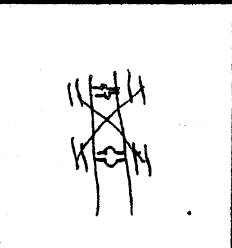
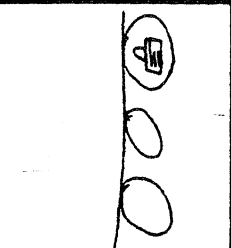
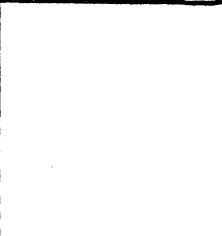
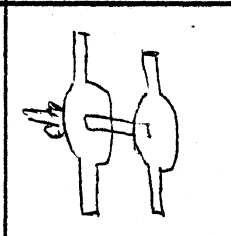
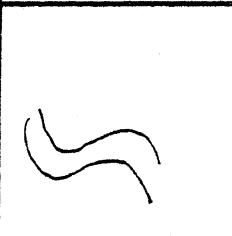
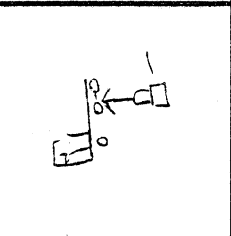
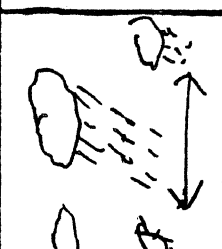
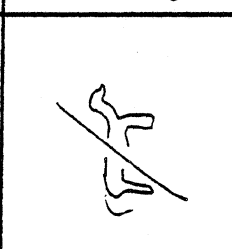
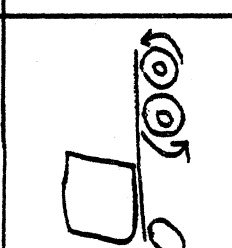
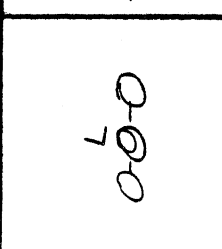
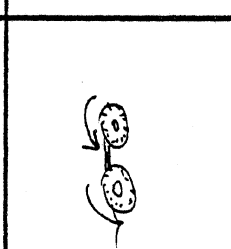
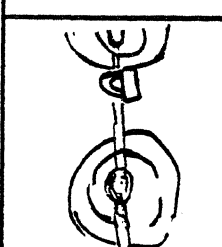
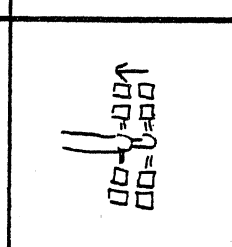
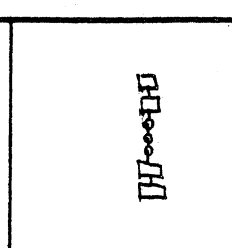
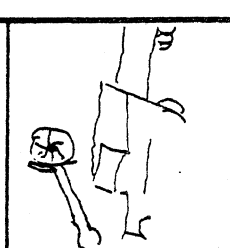
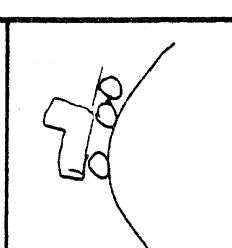
H. FUEL SHUTOFF

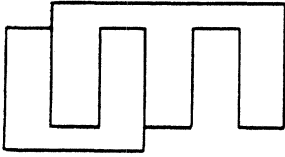
I. DIFFERENTIAL LOCK

J. INTERAXLE DIFFERENTIAL LOCK

APPENDIX 4
SYMBOL PREFERENCE SURVEY FORMS



THE UNIVERSITY OF MICHIGAN

HIGHWAY SAFETY RESEARCH INSTITUTE

Institute of Science and Technology

Human Factors and Ergonomics

Ann Arbor, Michigan 48106

We are performing a study for the Society of Automotive Engineers and the International Standards Organization to develop a standard set of symbols. These symbols will be used to label controls, warning lights, and gauges on truck instrument panels.

Some of the symbols that appear in this study have been proposed by automotive engineers. Other symbols have been developed from trucker's suggestions.

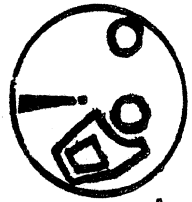
In the near future, you may see some of these symbols on truck instrument panels. Since you could be driving one of these trucks, your views are needed to select the best symbols for each control and display.

On the following pages, please rank all of the symbols in order of your preference from best to worst (indicate your first choice by marking it number 1).

Please do not consult with anyone while completing the survey.

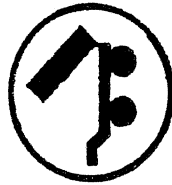
1. CAB LOCK DOWN

You lifted the cab to check out something in the engine. After you have lowered the cab and try to start the truck a warning light comes on indicating that the cab was not locked down properly. Rank the symbols on this page from best to worst (best=1, worst=7).



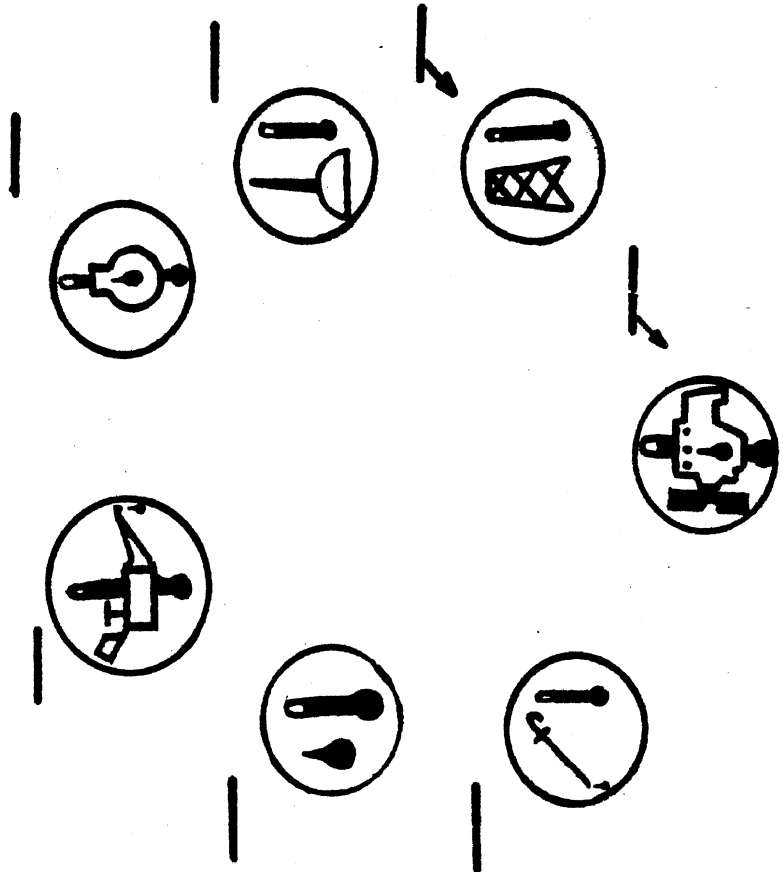
2. DUMP LOAD

Suppose you are in a dump truck or a tractor with a dump trailer and you want to raise the dump body. The 8 symbols below all indicate the dump load control. Rank the following symbols from best to worst (best=1, worst=8).



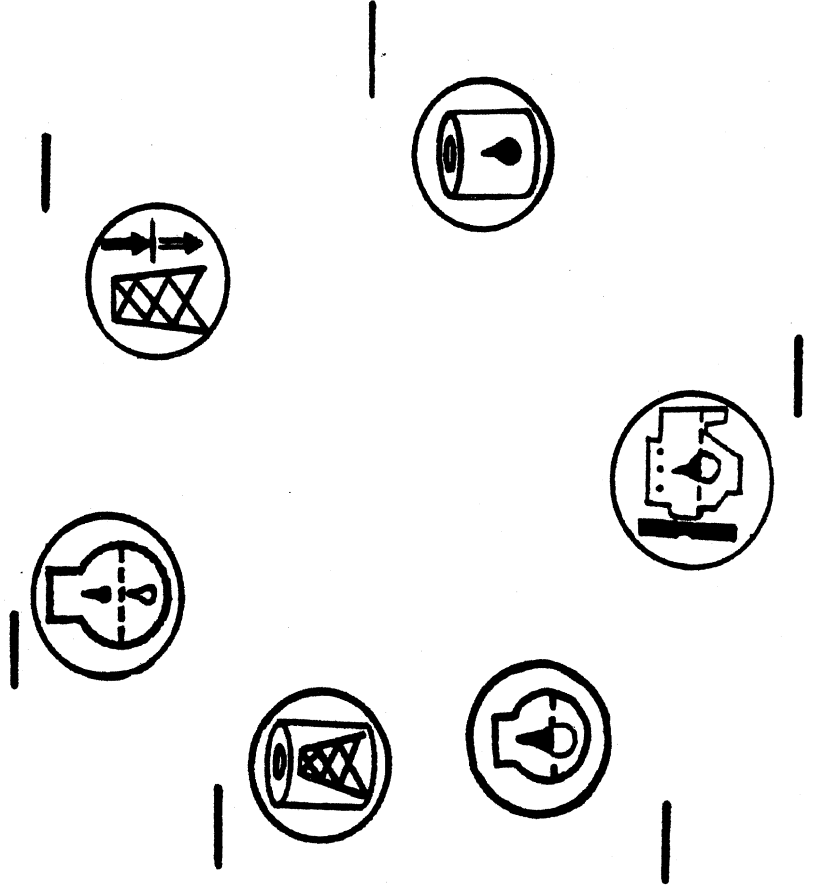
3. ENGINE OIL TEMPERATURE

As you are driving, the temperature of the engine oil rises above the safe operating limits. Rank the 7 symbols below which indicate engine oil temperature from best to worst (best=1, worst=7).



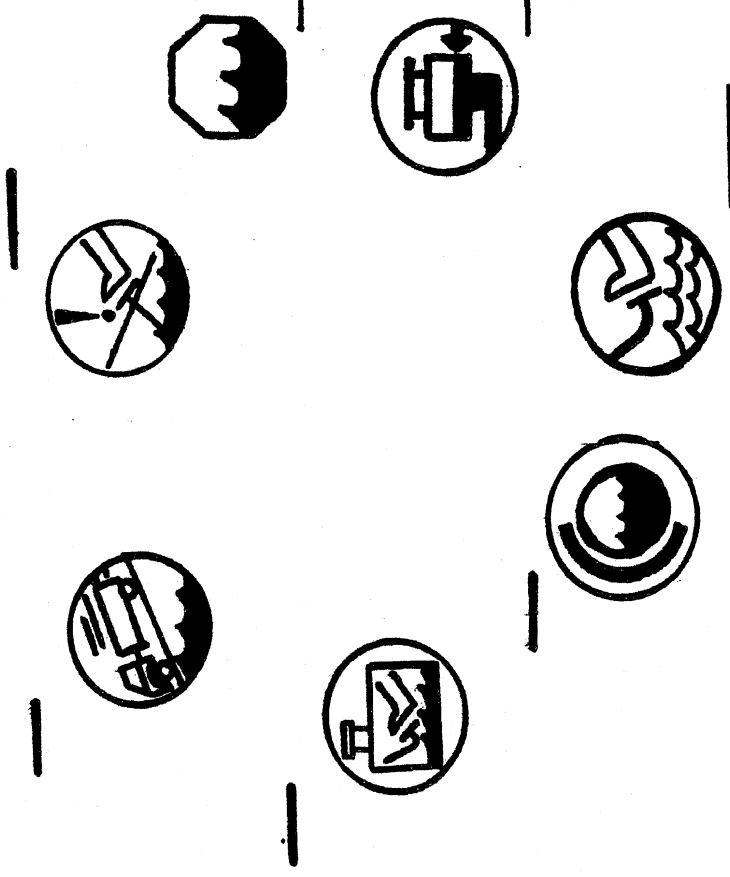
4. OIL FILTER

As you are driving, the oil filter in your truck's engine becomes clogged and a warning light comes on. The following 7 symbols indicate a clogged or dirty oil filter. Rank the 6 symbols below from best to worst (best=1, worst=6).



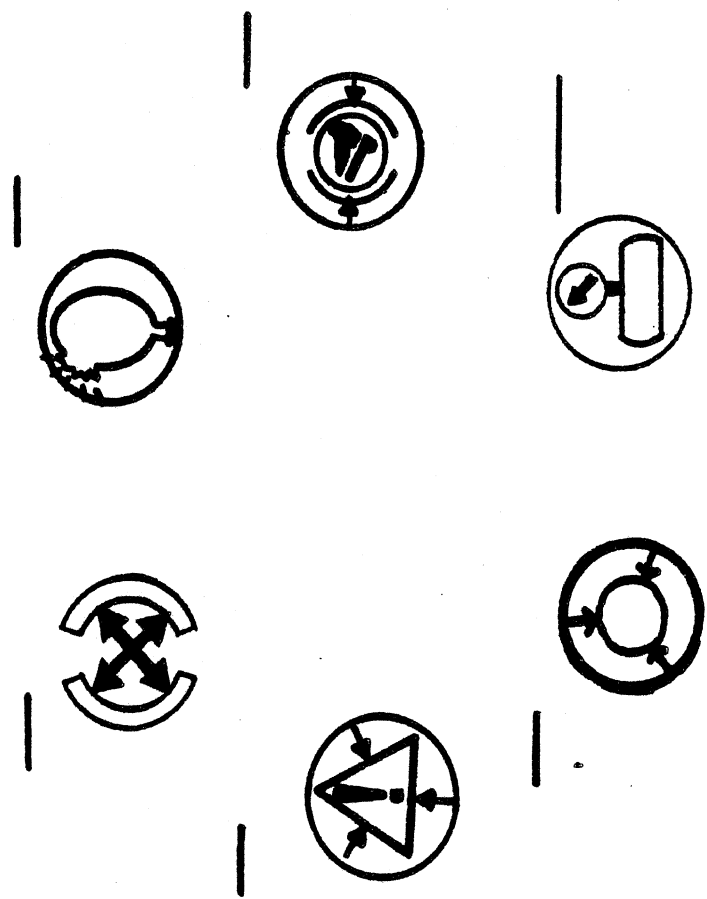
5. BRAKE FLUID LEVEL

As you are driving the brake fluid level becomes dangerously low. The 7 symbols below all indicate brake fluid level. Rank the following symbols from best to worst (best=1, worst=7).



6. AIR PRESSURE

As you are driving, the air pressure in the brake system falls below the normal level. The following symbols may appear on the air pressure gauge or on the warning light. Rank them from best to worst (best=1, worst=6).

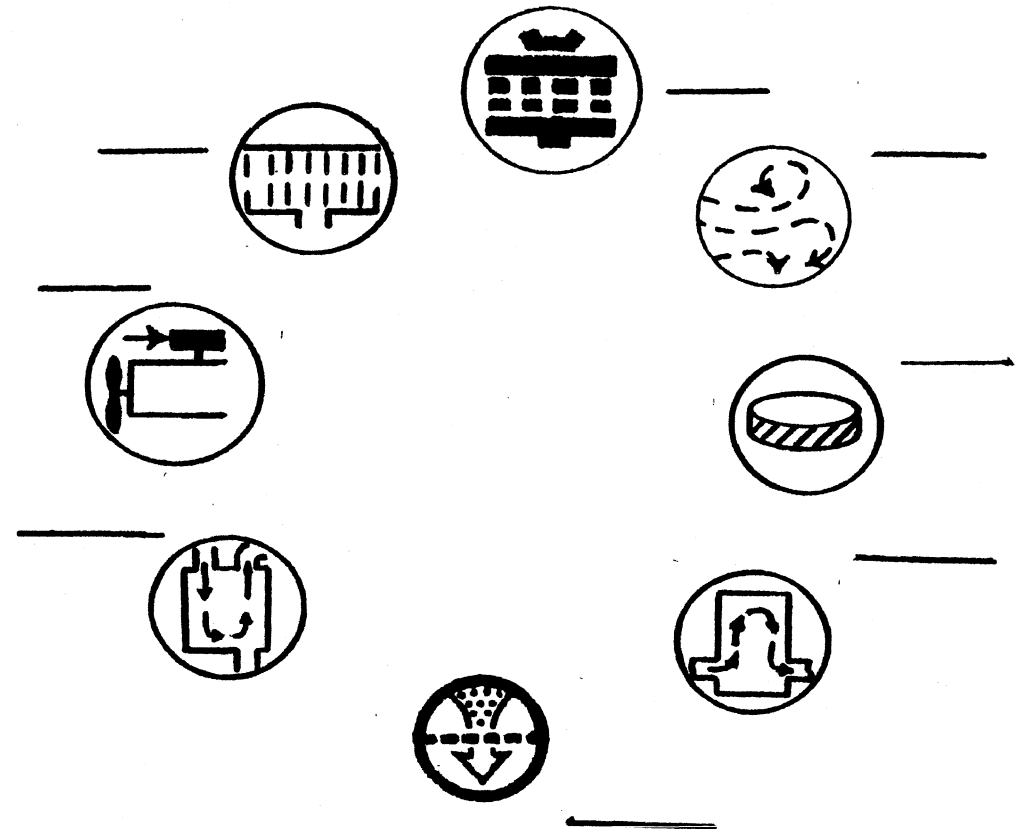
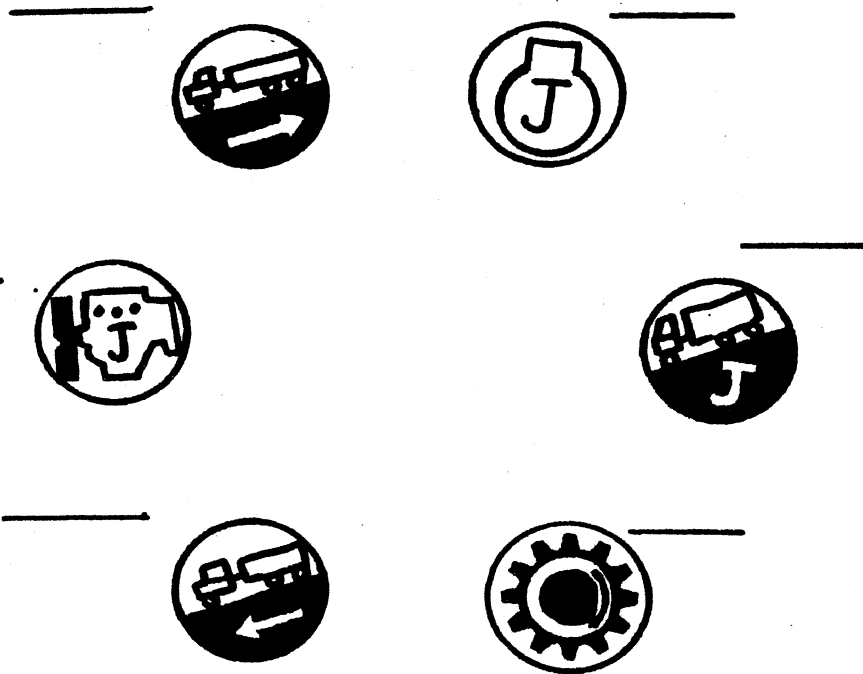


7. RETARDER

Suppose you are driving a truck down a steep hill. To reduce brake wear, you use the retarder instead of the normal air brakes. Rank the 6 symbols below which indicate the retarder control from best to worst (best=1, worst=6).

8. AIR FILTER

As you are driving, the air filter in your truck's engine becomes clogged with dirt. The 8 symbols below all indicate that something is clogging the truck's air filter. Rank the following 8 symbols from best to worst (best=1, worst=8).



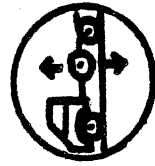
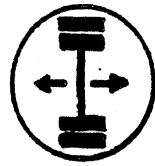
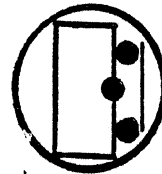
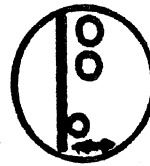
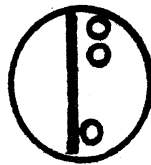
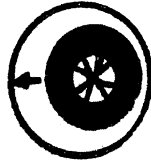
9. LOADING LIGHT

Suppose you want to unload your truck at night and decide to turn on the loading light to illuminate the loading area of the truck. Rank the symbols that can be used in this situation from best to worst (best=1, worst=7).



10. AXLE LIFT

Suppose you are driving with a light load and you want to lift a set of wheels to minimize tire wear. The 6 symbols below are supposed to indicate axle lift. Rank them from best to worst (best=1, worst=6).

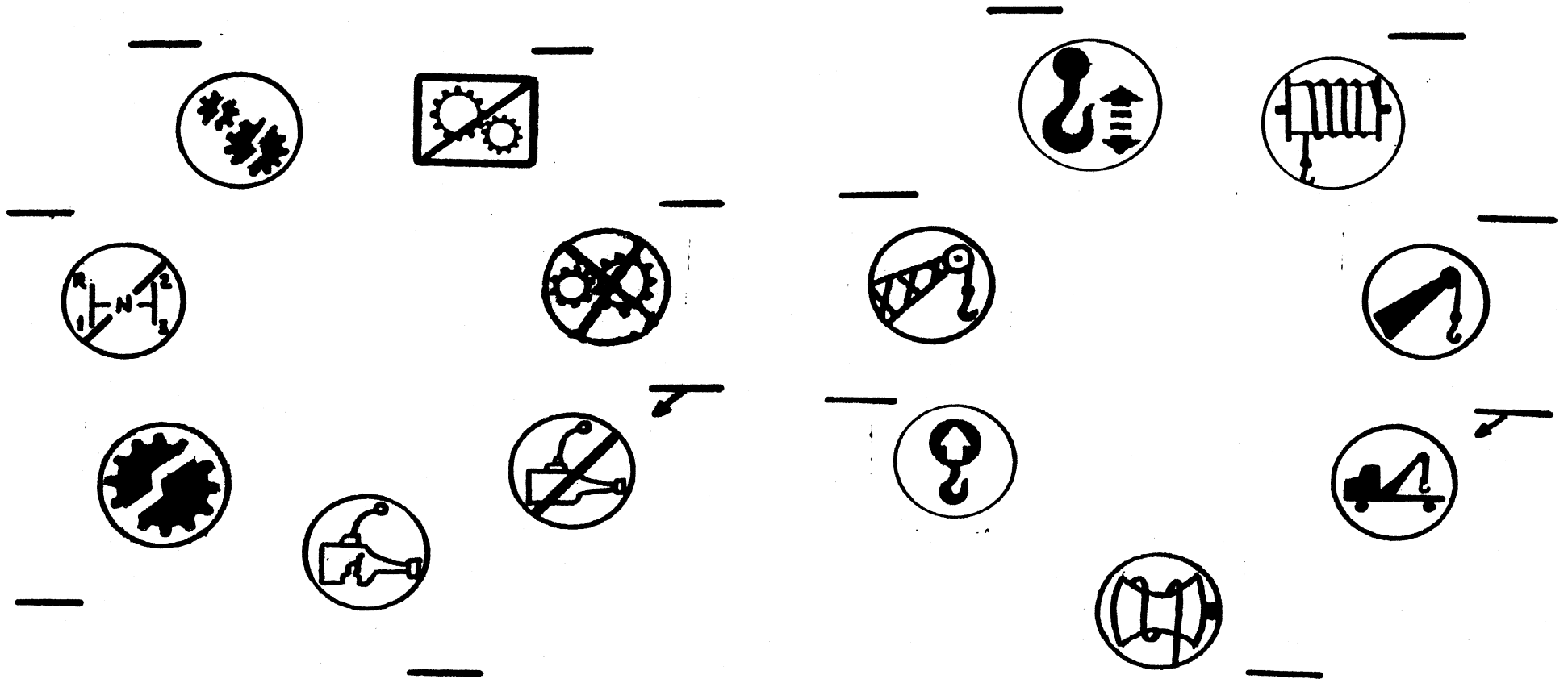


11. GEARBOX MALFUNCTION

Rank the following symbols, representing a gearbox malfunction from best to worst (best=1, worst=7).

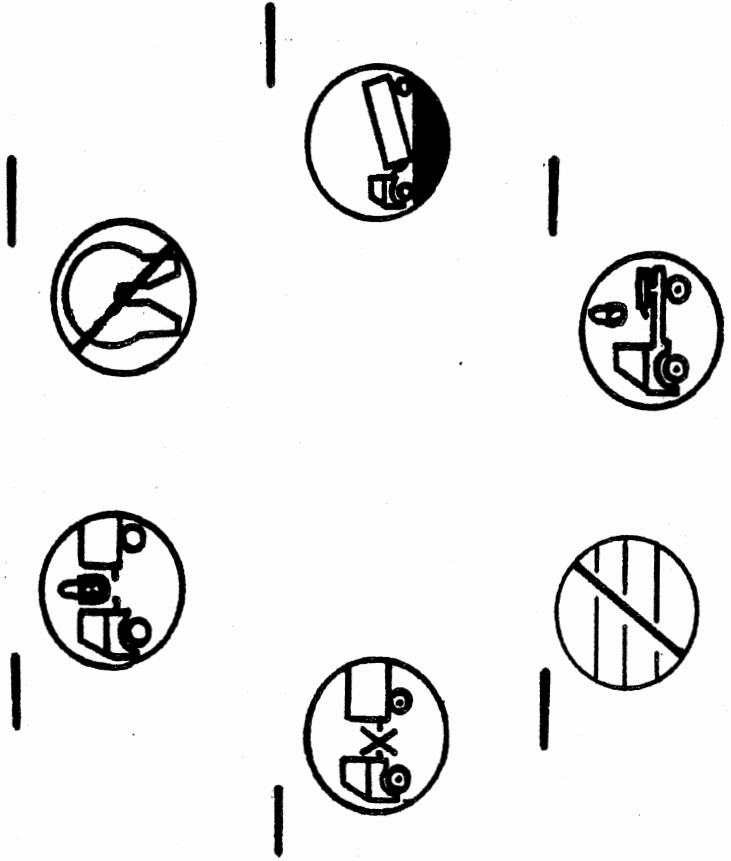
12. WINCH

Rank the following 5 symbols that represent the winch control from best to worst (best=1, worst=7).



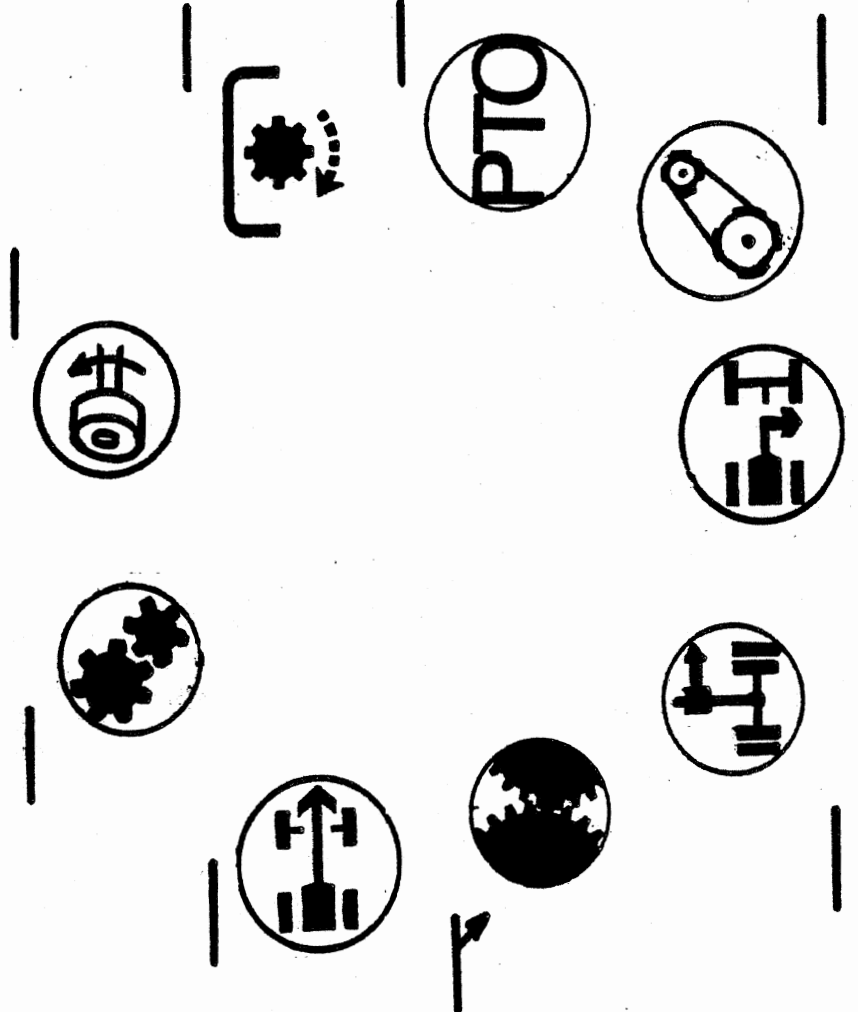
14. TRAILER CONNECTION/LOCK-UP

You are about to start your tractor when a warning light goes on telling you that the tractor and trailer are not connected properly. (It could be either the fifth wheel is not locked or the air or electrical lines are disconnected.) Which of the symbols below describes the situation best? Rank them from 1 to 6 (best=1, worst=6).



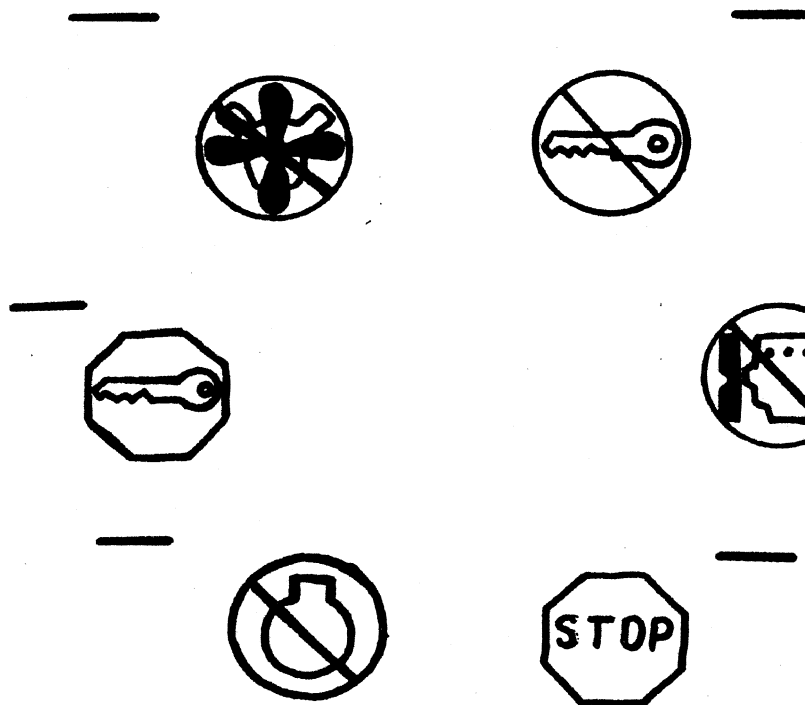
13. POWER TAKE OFF

Suppose your truck has an external device that is powered by the truck's engine (for example, a cement mixer drum). At some time you want to start or stop the power supply to this device. The following 9 symbols may be used as labels on the power take off switches. Rank them from best to worst (best=1, worst=9).



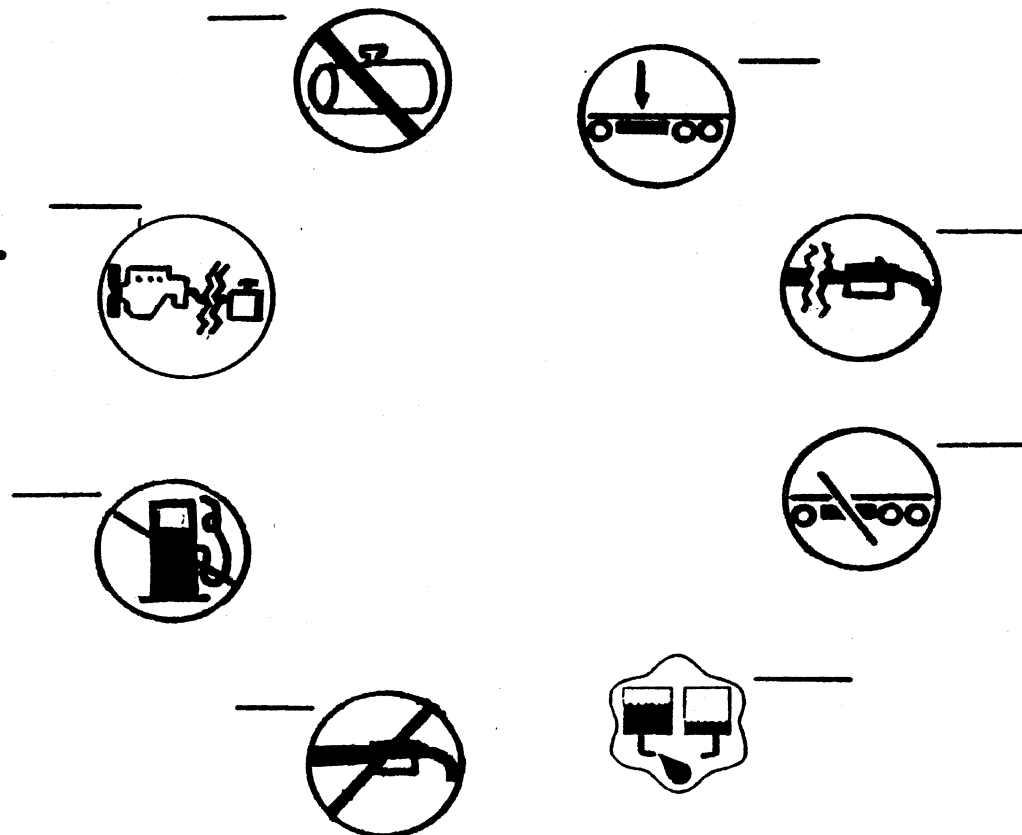
15. ENGINE STOP

Suppose, for some reason, you need to stop the engine. Rank the following 6 symbols that may be used for this action from best to worst (best=1, worst=6).



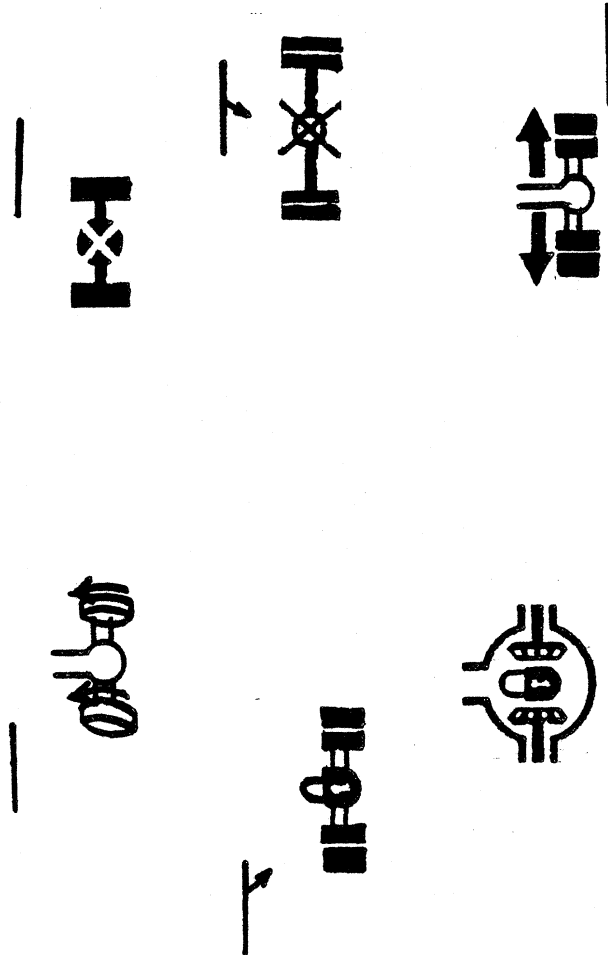
16. FUEL SHUTOFF

Suppose, for some reason, you need to shut off the fuel supply to the engine. The following 6 symbols indicate the fuel shutoff control. Rank the 8 symbols below from best to worst (best=1, worst=8).



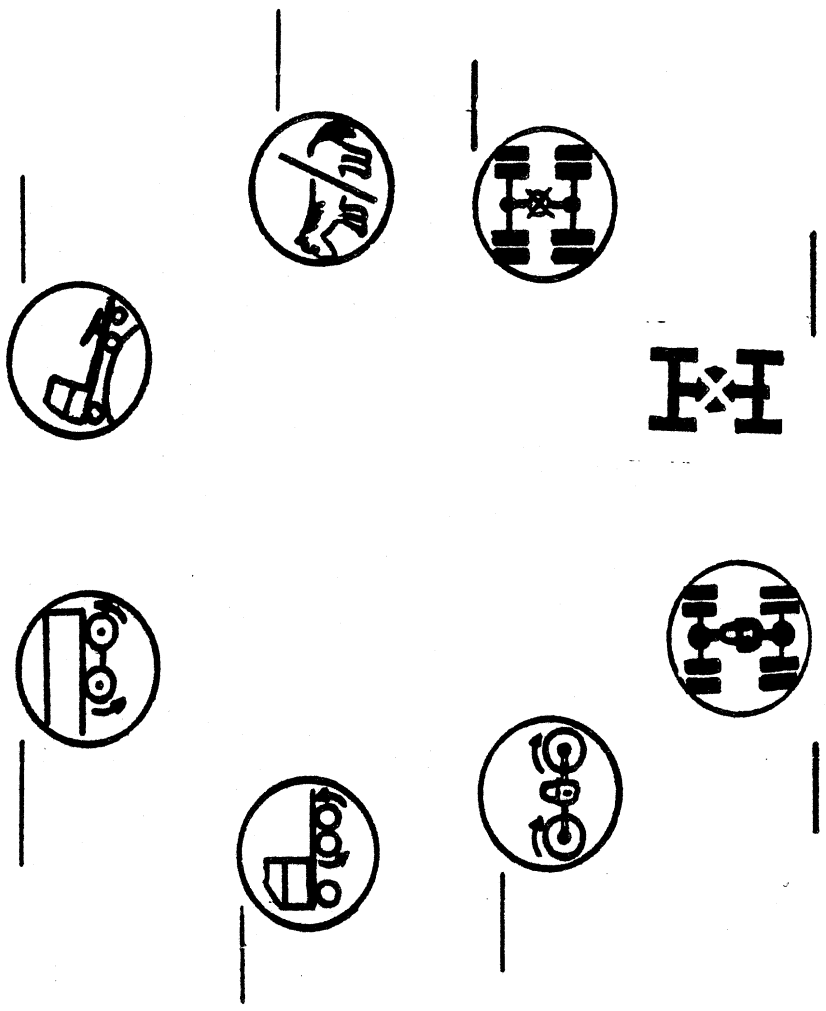
17. DIFFERENTIAL LOCK

You are driving a tractor with a single drive axle on a slippery road. To improve traction you want to lock the differential. The 6 symbols below are supposed to indicate this situation. Rank them from best to worst (best=1, worst=6).



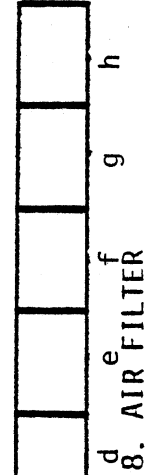
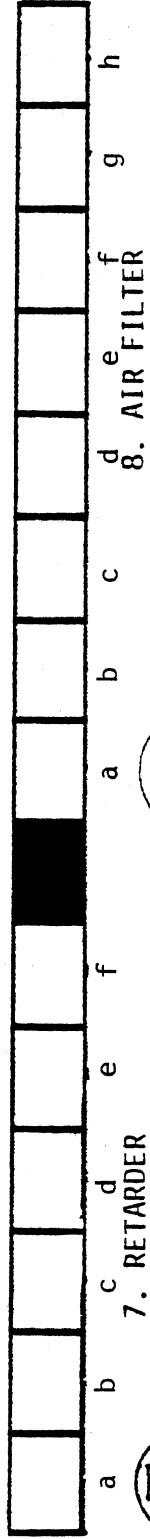
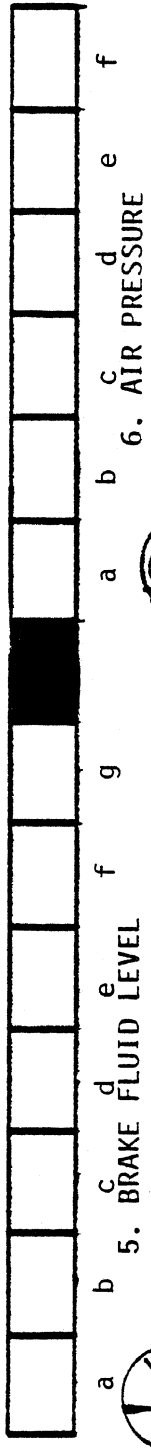
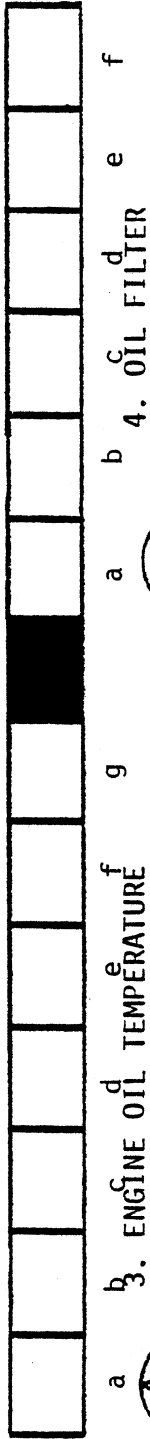
18. INTERAXLE DIFFERENTIAL LOCK

You are driving a tandem tractor on a slippery road. To improve traction you want to lock the interaxle differential (the third differential). The symbols below all indicate the truck's interaxle differential lock control. Rank the 8 symbols from best to worst (best=1, worst=8).



APPENDIX 5
PREFERENCE SURVEY CODING SHEETS

*



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

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Subject # a b c d e f g a b c d e f

9. LOADING LIGHT

10. AXLE LIFT



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a b c d e f g a b c d e f g

11. GEARBOX MALFUNCTION

12. WINCH



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a b c d e f g h i a b c d e f

13. POWER TAKE OFF

14. TRAILER CONNECTION/LOCK-UP



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a b c d e f g h a b c d e f g h

15. ENGINE STOP

16. FUEL SHUTOFF



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a b c d e f a b c d e f g h

17. DIFFERENTIAL LOCK

18. INTERAXLE DIFFERENTIAL LOCK

