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ADULT PERFORMANCE ON PIAGET'S WATER LEVEL TASK AND ITS RELATION TO SPATIAL ORIENTATION AND VISUALIZATION

BY

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Abstract

Recent studies have indicated that performance on Piaget's water level task is related to spatial ability. The present study examined the relationship of adult performance on the water level task to spatial orientation ability, visualization ability and verbal ability. A sample of college students, thirty males and thirty females, were classified as either sophisticated or naive in water level task performance. The students were then given two tests of spatial ability; in addition, a measure of verbal ability was obtained. Spatial orientation ability was measured by the Guilford-Zimmerman Spatial Orientation Test, visualization by the Revised Minnesota Paper Form Board Test and verbal ability by the College Entrance Examination Board test of verbal ability. Three two-factor analyses of variance were used to examine the data. The results revealed that both spatial ability tests were significantly related to performance on the water level task. Sophisticated subjects, regardless of sex, evidenced significantly better spatial ability than naive subjects. No significant relationship with verbal ability was found. It was concluded that adult performance on the water level task is related to spatial ability and not to a cognitive based process for the conception of space.

Adult Performance on Piaget's Water Level Task and Its Relation to Spatial Orientation and Visualization

The cognitive development of the normal human is characterized, in part, by the sequential formation of various conceptions of the environment and its elements. Piaget and Inhelder (1956) studied the normal child's cognitive development of a conception of space. This development leads progressively to the ultimate acquisition of a cognitively based Euclidean co-ordinate system of reference. The system is basically an imaginary, three dimensional set of vertical-horizontal axes which becomes a system of reference that can be used for location and comparison of positions, orientations, and movements of objects in space. In order to study the development of the horizontal element in this system, Piaget and Inhelder developed the water level task. This task assesses the individual's degree of awareness that the surface of still water within a sealed bottle is invariently horizontal regardless of the orientation of the bottle. Performance on the water level task, according to Piaget and Inhelder, is indicative of the individual's current developmental stage in the accurate judgment of the horizontal element within the Euclidean co-ordinate system and, moreover, of the individual's conception of space.

Development of the accurate judgment of the horizontal occurs in three major stages as the individual achieves higher levels of cognitive development. In Stage I, occurring between birth and five years of age, the child shows no indication of the knowledge of the invariant horizontality of the water level. Stage II, at five to eight years of age, contains two substages. In Substage IIa, the child believes that the water level remains constantly parallel to the base of the bottle regardless of bottle orientation. In Substage IIb, the child is aware that the water level is influenced by factors other than bottle orientation, but is still not aware that the water level is invariantly horizontal. Stage III, beginning around age eight, also contains two substages. In Substage IIIa, the child can learn the principle of the invariant horizontality of water after some training. Finally in Substage IIIb, occurring somewhere between ages nine and eleven, the child can accurately predict the water level without aid.

Studies have supported Piaget and Inhelder's stage theory through Substage IIb (Smedslund, 1963; and Barna and O'Connell, 1967). However, evidence from more recent studies have indicated reasons to doubt the final point of achievement of Stage III. Both Willemsen and Reynolds (1972) and Thomas and Jamison (1975) have shown that some college students do not know the principle of the invariant horizontality of a still water surface as indicated by inaccurate performance on the water level task. In fact, both studies have indicated a significant sex difference, with college women making more errors than college men.

An earlier examination by Thomas, Jamison and Hummel (1973) claimed that by the age of twelve, males understand the principle of the invariant horizontality of a water surface, but that females lag behind at all ages and that 50% of college women still did not know the principle as indicated by water level task performance. This study divided a sample of college females into sophisticated (accurate prediction) and naive (inaccurate prediction) performance groups as indicated by performance on the water level task. The naive females were then exposed to two observation methods designed for self-discovery of the principle, with neither method resulting in improved water level performance. Naive female performance was significantly poorer than both the sophisticated female group and a group of unselected (unclassified) males. This finding led to the conclusion that the naive females could not learn the principle by way of a self-discovery method. In addition, naive individuals were unable to verbalize the principle further indicating failure to understand and acquire the concept.

Because Thomas, Jamison and Hummel (1973) lacked the appropriate control group for males, further research needed to be done.

Thus, Preston and Foltz (1976) replicated Thomas, et al. (1973) using an equal sample of sophisticated and naive male and female college students. The results revealed significantly better water level task performance by sophisticated subjects and no significant interaction. Furthermore, no significant sex differences were found. Naive individuals, regardless of sex, could not learn the principle through an observation method.

In contrast to the findings of Piaget and Inhelder (1956), final acquisition of the accurate judgment of the horizontal as indicated by water level task performance does not always occur with the individual's achievement of the final stages of cognitive development, even after an average of twenty years of environmental opportunity to observe the phenomenon. If accurate water level task performance was not related to achievement of the final stages of cognitive development, then perhaps the water level task was related to some other factor, such as spatial ability.

Only two studies have explored the relationship between spatial ability and the water level task. The first study, by Goldberg and Meredith (1975), examined the spatial ability of 76 high school students. All of the subjects had been tested during elementary school on at least one of five Piagetian tasks, one of these being the water level task. As high school students the subjects were administered the Paper Form Board test (French, et al.; 1963) and three other tests of spatial ability, measuring either rotation ability or visualization ability. Two-dimensional visualization ability, as measured by the Paper Form Board test, required a capacity to imagine and manipulate objects in space and transform spatial patterns into other arrangements. Basically, the test requires the assembly of the various pieces of a visual puzzle. The subject must identify a diagram of several assembled pieces. The diagram is composed of the exact same pieces found separately arranged in a test diagram. In order to select the correct diagram, some of the pieces must be rotated into different positions for correct assembly. Because the Spatial Relations Test from Thurstone's Primary Mental Abilities Test (Thurstone and Thurstone, 1965) was used to measure two-dimensional rotation ability, Goldberg and Meredith altered the Paper Form Board test, eliminating the need to mentally rotate the pieces of the test diagram.

Rotation simply requires the ability to identify a stimulus object after that object has been rotated into a position different from its original in a test drawing. By removing the rotation aspect of the Paper Form Board test, Goldberg and Meredith reduced the manipulations necessary for correct performance. This alteration eliminated the opportunity for general comparison of the results to other studies using the Paper Form Board test.

The results did reveal a significant correlation between the water level task and the altered Paper Form Board test. As errors on the water level task decreased, visualization ability increased. This was an indication that spatial ability may be related to the water level task.

The results could not be considered conclusive. In addition to the problem of interpretation, there was a problem of sample size. The correlation was based on a sample of only twelve students. Also, Goldberg and Meredith may have confounded the results due to differences in age and developmental progress between the time of the Piagetian tests and the later spatial ability tests. Confounding may have occurred because spatial ability is not fully developed until adolescence; therefore, the scores on the elementary school, Piagetian tests may not have been valid indicators for comparison to the individual's high school spatial ability score (Geiringer and Hyde, 1976).

Geiringer and Hyde (1976), in a more systematic study, examined spatial ability in relation to the water level task and included an examination of sex differences on the task. One hundred twenty subjects were obtained. Equal numbers of fifth and twelfth grade public school students of both sexes were placed in water level performance groups with spatial ability measured by the Spatial Relations Test from Thurstone's Primary Mental Abilities test (Thurstone and Thurstone, 1965). It will be recalled that this is the same test used earlier by Goldberg and Meredith (1975) as a measure of two-dimensional rotation ability.

Geiringer and Hyde found that no significant relationship existed between spatial ability and the water level task in the fifth-grade sample. A significant correlation, however, was found between the water level task and the Spatial Relations Test for the twelfth-grade sample. As errors on the water level task decreased, Spatial Relations Test scores increased. In addition, twelfth-grade males performed significantly better on both the water level task and the Spatial Relations Test than did twelfth-grade females. After differences in spatial ability were removed, however, no significant sex differences remained. Geiringer and Hyde concluded that the water level task reveals differences in spatial ability rather than cognitive ability. Because males generally demonstrate better spatial ability than females, this may account for the generally better performance of males on the water level task.

Although spatial ability appears to be related to the water level task, this conclusion may warrant further investigation. First, Geiringer and Hyde used only one measure of spatial ability as the basis for their conclusion. A more thorough examination could have been made if another measure had been included.

A second measure of spatial ability could have been an unaltered test of visualization used in order to test the results of Goldberg and Meredith (1975), who had removed the rotation element from their test of visualization. One of the best tests of visualization is the Revised Minnesota Paper Form Board Test (Likert and Quasha, 1970), which is a longer and more thorough test than the earlier test by Thurstone and Thurstone, although identical in nature.

Second, Geiringer and Hyde (1976) used a simple test of spatial ability which required the individual to utilize rotation ability only. This test may correspond to the rotation of the water bottle in Piaget and Inhelder's (1956) test, but it does not appear to correspond to the complete structure of the task.

According to Piaget and Inhelder (1956), the water level task requires the use of the Euclidean co-ordinate system of reference which is used as a three-dimensional network in which each object is linked simultaneously with the rest in three directions: left-right, above-below, and before-behind. Thus the type of spatial ability test appropriately suited for studying the water level task would be one which tests along these three directions.

Guilford and Zimmerman (1947) devised such a test. This test, the Guilford-Zimmerman Spatial Orientation Test (Guilford and Zimmerman, 1947), requires awareness of changes along the directions of left-right, up-down, and nearer-farther and includes the body of the observer as a frame of reference. The directions used by this test appear to correspond to those of Piaget and Inhelder's (1956) Euclidean co-ordinate system of reference. Essentially, this test requires the subject to determine the change in orientation along the three directions of a boat traveling on a lake. The inclusion of a water surface as an element in the test enhances the analogy between the water level task and the test. Thus, the Guilford-Zimmerman Spatial Orientation Test appears to be well suited for examination of the relationship between the water level task and spatial ability.

The purpose of the present study was to examine several questions related to spatial ability and adult performance on the water level task.

First, was water level task performance related to spatial ability for adults (college students) as indicated for high school students (Geiringer and Hyde, 1976)?

Second, if spatial ability did account for differences on the water level task, was this relationship evident only with rotation ability (Geiringer and Hyde, 1976) or was it also evident with other spatial abilities, such as spatial orientation and visualization?

Third, was performance on the water level task related to spatial ability exclusively or was it related to non-spatial abilities, such as verbal ability?

Furthermore, did differences in performance on the water level task indicate different principles used to perform the task? How confident of their overall performance were the respective performance groups? Were naive subjects aware of their inability to perform the water level task accurately?

Finally, what role, if any, did previous environmental observation or active cognitive consideration of the motion of water in a container play in adult water level task performance? Were there any differences in the ability of naive and sophisticated subjects to cite instances in the environment analogous to the water level task?

To answer these questions, it was proposed that a sample of college students would be identified by sex and water level performance type and would be tested in spatial orientation ability, visualization ability and verbal ability. Following the testing, a short interview would be conducted to allow the subjects to answer questions about principles used, confidence of response, previous experience and ability to cite analogies.

It was hypothesized that both measures of spatial ability would reveal differences between the sophisticated group and the naive group. In addition, sex was not expected to be a differentiating factor within the performance groups. No differences between the sophisticated and naive groups were expected on the verbal measure. The interview questions were expected to reveal differing responses from the respective performance groups. For example, sophisticated subjects were expected to be able to verbalize the correct principle underlying the water level task whereas naive subjects were not.

Method

Subjects. Subjects were drawn from a subject pool of 84 undergraduates. The sample was composed of 30 males and 30 females. In addition, both sex groups were composed of 15 sophisticated and 15 naive subjects each.

Apparatus. The apparatus consisted of the following:

1) The first water level test was Piaget and Inhelder's (1956) paper and pencil water level prediction test. This particular test was composed of one model drawing of a cylindrical bottle half full of water followed by eight drawings of an identical empty bottle. The drawings were arranged into eight different, oblique, clock-numeral orientations. (See appendix, p.i.)

2) A second water level test was a water level prediction apparatus similar to the Mark II apparatus of Thomas, Jamison and Hummel (1973). This apparatus consisted of a rotatable bottle behind which was a moveable water level disc which could be adjusted to any degree of inclination. (See appendix, p. iii.)

3) Two tests of spatial ability were used. As the measure of spatial orientation ability, the Guilford-Zimmerman Spatial Orientation Test (GZSO) from the Guilford-Zimmerman Aptitude Survey (Guilford and Zimmerman, 1947) was used. The measure of visualization was the Revised Minnesota Paper Form Board Test (MPFB) (Likert and Quasha, 1970). (See appendix, p. iv and v.)

4) Verbal ability was measured by the verbal section from the College Entrance Examination Board

test (Educational Testing Service, 1972).

5) A cassette recorder was used for the interview questions.

Procedure. The subject arrived at a pre-arranged time, was greeted by the experimenter and was seated opposite and facing the experimenter at a table. The experimenter presented a pencil, a ruler, and the paper and pencil water level test to the subject. The following instructions were then read:

> Please read the instructions on the page and then quickly complete the task. You may use the pencil and ruler that have been provided you to draw the waterline. Please assume that the bottles are sealed. The lines below the bottles represent flat tabletop surfaces supporting the bottles.

After completion of this task, the water level prediction apparatus was presented to the subject. The subject was instructed in its use and then tested. The instructions were as follows:

> This bottle will be rotated into eight different positions. Your task will be to adjust the waterline of the liquid, which is represented by the red area on the middle

> disc, to where you think it should be in reference to the position of the bottle. In each position, when you have decided where the waterline should be please hold it in that position and say "okay". The bottle will then be adjusted to a different position. Please do not delay in deciding where the waterline should be.

Each of the eight test positions were presented in the same order as on the paper and pencil test. The experimenter recorded each waterline setting in reference to the absolute degrees from the horizontal that the subject's choice varied.

Completion and subsequent evaluation of the subject's performance on both prediction tests provided the measure for classification of the subject's performance as either sophisticated or naive. Sophisticated performance subjects were those individuals whose prediction tests did not deviate more than + or - 4^{o} from the horizontal for any bottle orientation. Alternately, naive performance subjects were those individuals whose prediction settings on both prediction tests deviated more than + or - 4^{o} from the horizontal for any one bottle orientation. Use of two water level prediction test modes assured positive classification of each subject.

Following the performance classification tests, the GZSO was administered. Time given for reading the instructions was ten minutes, with another ten minutes allowed for test administration. Then the MPFB was administered. Subjects were allotted five minutes for instruction and twenty minutes for the completion of the test.

At the completion of the spatial ability tests, the experimenter asked the subject for written consent in order that the experimenter could obtain the subject's CEEB Verbal score from the appropriate Dean.

In addition the subject was asked four interview questions. The first question was, "How did you decide where to put the waterline in the prediction tasks?" Second, "How do you think you did on the tests?" Responses were registered on a Likert type scale ranging from 1 (poor) to 6 (excellent). Third, "Have you ever considered this task before?" Finally, "Where or in what situations in your experiences have you seen this phenomenon occur?" The subject's responses were recorded on audio tape, with the subject's permission, for later review by the experimenter.

After conclusion of the interview the experimenter debriefed, thanked and excused the subject. Total time of testing for one subject was approximately 55 minutes.

Analysis of Data and Design

The GZSO, MPFB and the CEEB Verbal scores of the subjects were examined by the use of three two-factor ANOVA, analyzed by sex and by performance type (sophisticated and naive). Significance was determined by the .05 level. The interview questions were analyzed according to percentage of like-responses with the exception of question two which used a Likert type response continuum where mean responses were reported.

Results

In general, the analyses of variance performed on the GZSO and the MPFB indicated a significant performance main effect; $F(1,56)=63.29$, $p<.05$ and $F(1,56)=9.60$, $p<.05$, respectively. Sophisticated performance group scores were significantly better than the naive group on both spatial ability tests. No interactions of sex by performance group were revealed on either of the tests.

Insert Figures 1 and 2 with Table 1 about here

However, the ANOVA of the MPFB data showed a significant sex main effect: $\underline{F}(1,56)=4.99$, $p<.05$. Females scored significantly better than males.

The ANOVA of the CEEB Verbal scores revealed no significant differences in performance ($So_{\bar{x}}=499.00$, $Na_{\bar{x}}=460.33$) or sex ($M_{\bar{x}}=466.89$, $F_{\bar{x}}=492.33$).

Insert Table 2 about here

In response to question one, 73% of all sophisticated subjects stated that their decision in placement of the waterline was based on the knowledge that a water surface is always horizontal and/or that gravity influenced the water surface. The remainder of the sophisticated group, 27%, did not give a physical or scientific explanation but attributed their decision to common sense. Of the naive subjects, 66% stated that their decision was based on common sense and some guessing while 34% cited bottle tilt, water to bottle proportions and the tendency of water to flow downward as the basis of their decision.

Question two revealed that the sophisticated group reported a mean confidence of 4.216 in responding correctly on the tests and the naive group reported a mean confidence of 4.095.

Question three found that 90% of the sophisticated group had not previously considered or experimented with the action of water in a container with 84% of the naive group responding likewise. The remaining percentages of each group reported instances of having observed water and its surface motion in a container, but never seriously attending to or experimenting with the phenomenon.

Question four revealed that 100% of the sophisticated group and 93% of the naive group could report concrete examples that were analogous to the water level task and phenomenon. In total, 96% of the sample could recall and describe occasions where the movement of a liquid surface in a container had been observed.

Discussion

The original hypothesis has been confirmed. Spatial ability does appear to be related to performance on the water level task for adults.

The GZSO and the MPFB tests indicated that both spatial orientation and visualization ability are related to the water level task. Individuals who were judged sophisticated on the water level task evidenced better spatial orientation ability and visualization ability than naive individuals. Thus it can be stated that the water level task is related not only to one specific spatial ability, such as rotation (Geiringer and Hyde, 1976), but to the other more complex spatial abilities of spatial orientation and visualization.

As expected, the CEEB Verbal test results showed no differences in verbal ability between the sophisticated and naive individuals or between the sexes. This finding leads to the conclusion that the water level task may be specifically related to spatial ability.

This evidence of the specific relationship between spatial ability and water level task performance tends to refute Piaget and Inhelder's theory that the water level task measures the progress of a cognitive based development of a conception of space. Furthermore, the results indicate that performance on the water level task is the function of a covert perceptual process rather than an active cognitive process. Piaget and Inhelder (1956) may have been measuring a perceptual developmental process which progressed concommittantly with cognitive development but was not influenced by cognitive development.

The finding that females scored significantly better than males on the MPFB was unexpected. This finding is unprecedented and should be interpreted with caution. Past research (Likert and Quasha, 1937 and Likert and Quasha, 1970) has demonstrated that sex differences on the MPFB are small in favor of males or non-existent, depending on the population sampled. Likert and Quasha (1970) in the MPFB manual cite two studies (Alteneder, 1940 and Bryan, 1942) which examined possible sex differences on the MPFB between male and female college students and found no significant sex differences. Past research does not aid in explaining this unexpected result. A possible explanation resides in a male female difference. The MPFB took place approximately 35 minutes into the experimental session after the demanding GZSO. At this time male subjects appeared restless and ready to leave the experiment, ,with some even rising from the chair and preparing to leave. Male subjects may have become less motivated by the time of the test resulting in weakened and misrepresentative performance. Females on the other hand, continued to work diligently and exhibited none of the restless behavior of the males. From the experimenter's observations, this explanation is probably the most accurate.

The results from question one, showing that most sophisticated subjects could verbalize an appropriate principle for accurate water level task performance whereas naive subjects could not, replicated the findings of Thomas, Jamison and Hummel (1973). The evidence of the influence of spatial ability on the performance of the water level task and the results of question one appear to indicate that spatial ability facilitates an understanding of the principle of the invariant horizontality of a water surface and thus, the ability to verbalize the principle.

Question two revealed that sophisticated and naive subjects felt moderately confident in the accuracy of their test performance. Both groups rated themselves at about four on the six-point Likert scale, indicating a positive but more likely a noncommittal response. The modest average was probably influenced by evaluation apprehension on the part of the subjects, who did not wish to appear under or overly confident in their performance. It is interesting that the naive individuals who performed poorly and guessed on the tests did not acknowledge their difficulty. This may indicate a lack of awareness of the deficiency in spatial ability on the part of the naive subjects.

Question three revealed that conscious, overt learning experiences are not prerequisite for accurate water level task performance. This lack of a need for overt learning coupled with the inability of naive subjects to learn accurate water level task performance (Thomas, Jamison and Hummel, 1973; Preston and Foltz, 1976) appears to indicate a covert perceptual process at work rather than a cognitively based learning process.

Further support for a covert perceptual process was indicated in question four responses. Almost all of the subjects could recall and describe experiences analogous to the water level task, such as water in glasses or test tubes, yet the naive sample could not use that information to accurately perform on the water level task.

One last finding concerned the distribution of sophisticated to naive individuals in the primary subject pool. It was found that the ratio of sophisticated females to naive females was 1:1; whereas sophisticated males to naive males was 2:1. This finding may be of interest to researchers examining the possibilities of a genetic base for differences on the water level task.

In conclusion, three main findings can be cited. First, that Piaget and Inhelder's (1956) stage theory concerning the final point of developmental achievement of the acquisition of the principle of the invariant horizontality of a water surface as measured by the water level task is incorrect. It has been shown that adults (college students) have not all achieved accurate water level task performance and thus accurate judgment of the horizontal. Furthermore, the development and subsequent acquisition of this ability may not be dependent upon the achievement of successive levels of cognitive processes, such as logic and reasoning, but may be dependent upon the relative strength or weakness of the individual's spatial ability.

Second, the findings have shown that water level task performance and ultimately the adult judgment of the horizontal is related to spatial orientation ability, visualization ability and spatial ability in general.

Finally, water level task performance is essentially an indicator of spatial ability and not a measure of cognitive development for adults.

Future research might examine the probability of a sex-linked base for the development of spatial ability and the water level task. This could account for the difference in ratios of occurrence of sophisticated and naive individuals in the male and female populations.

Other endeavours might include examination of differences in socialization of subjects or basic adolescent interests which might require more use and development of spatial ability. In order to examine the development of the judgment of the horizontal and its relationship to spatial ability, a longitudinal or cross sectional study might be performed starting with young children and extending to adults, testing each level and group according to water level task performance and spatial ability. Development of one should parallel the other in accordance with the findings of the relationship between the water level task and spatial ability.

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Table 1

Means and Standard Deviations On

GZSO, MPFB and CEEB Verbal

Test	Group	M	SD
GZSO	Sophisticated		
	Male	25.57	6.16
	Female	24.99	10.29
	Naive		
	Male	12.22	6.05
	Female	9.89	3.41
MPFB	Sophisticated		
	Male	42.51	9.07
	Female	51.16	7.62
	Naive		
	Male	36.82	10.02
	Female	40.53	9.01
CEEB Verbal	Sophisticated		
	Male	490.66	92.00
	Female	507.33	82.00
	Naive		
	Male	443.33	73.00
	Female	477.33	96.00

Table 2

Analyses of Variance:

Summary

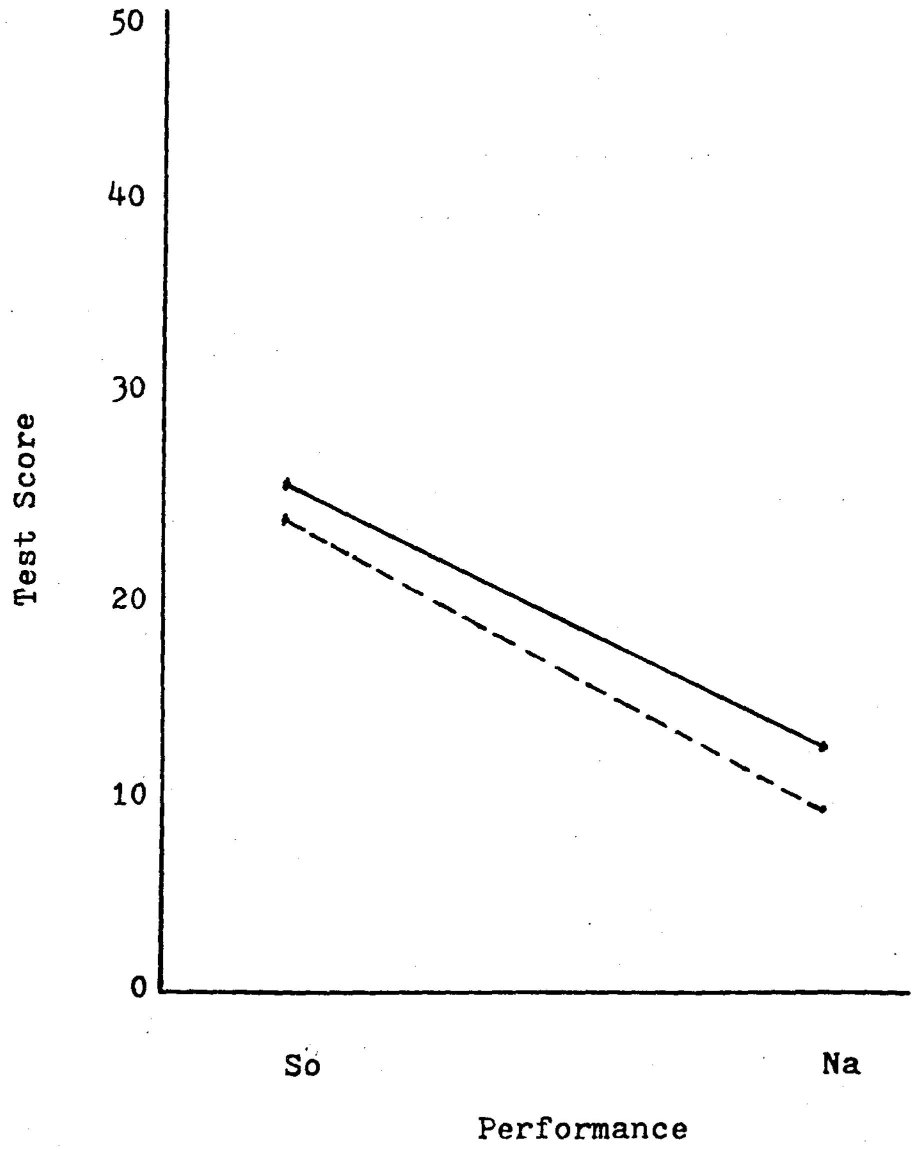
Test	Source	*df*	*MS*	*F*
GZSO	Performance (P)	1	3038.82	63.29*
	Sex (S)	1	32.27	0.68
	S x P	1	11.70	0.25
	Error	56	48.02	
MPFB	Performance (P)	1	771.86	9.60*
	Sex (S)	1	401.46	4.99*
	S x P	1	181.50	2.26
	Error	56	80.45	
CEEB Verbal	Performance (P)	1	28602.33	3.84
	Sex (S)	1	13802.33	1.86
	S X P	1	2801.02	0.38
	Error	56	7439.52	

*$p < .05$

Figure 1

GZSO Group Means:

Sex by Performance



Male —

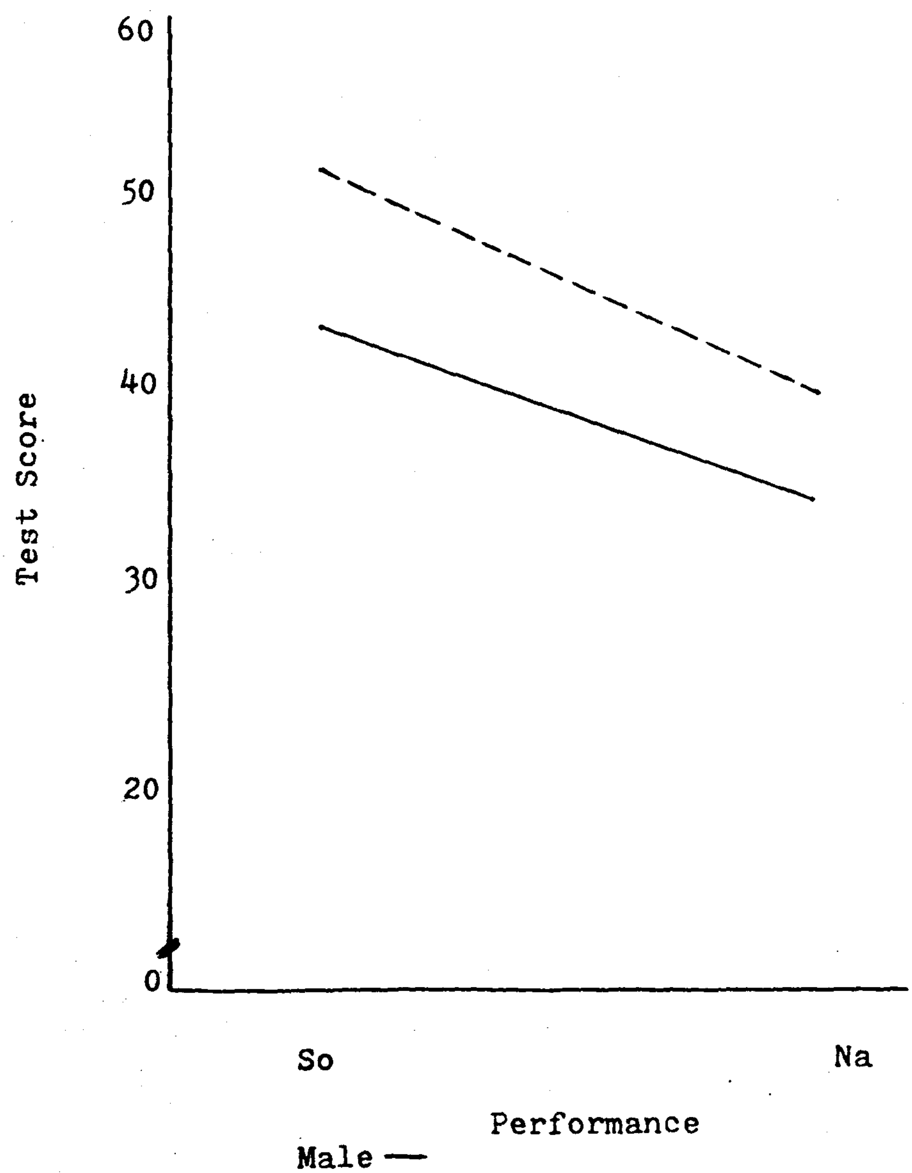
Female - -

(So=Sophisticated, Na=Naive)

Figure 2

MPFB Group Means:

Sex by Performance



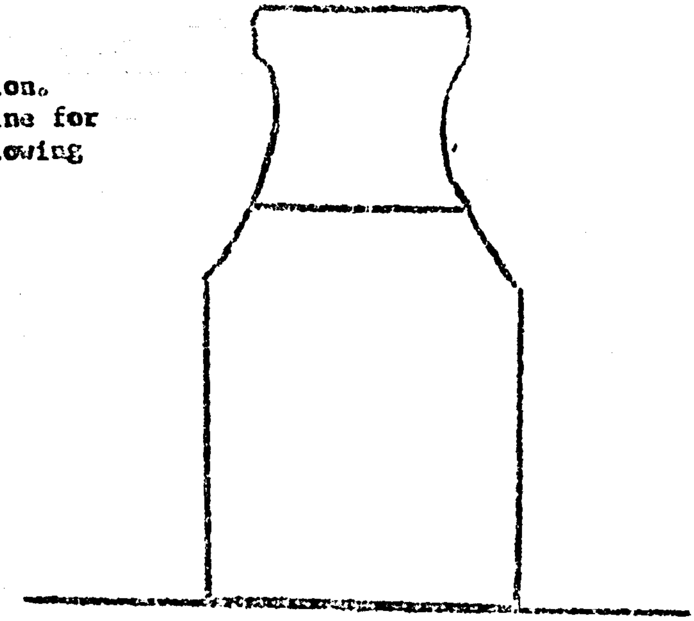
Male —

Female --

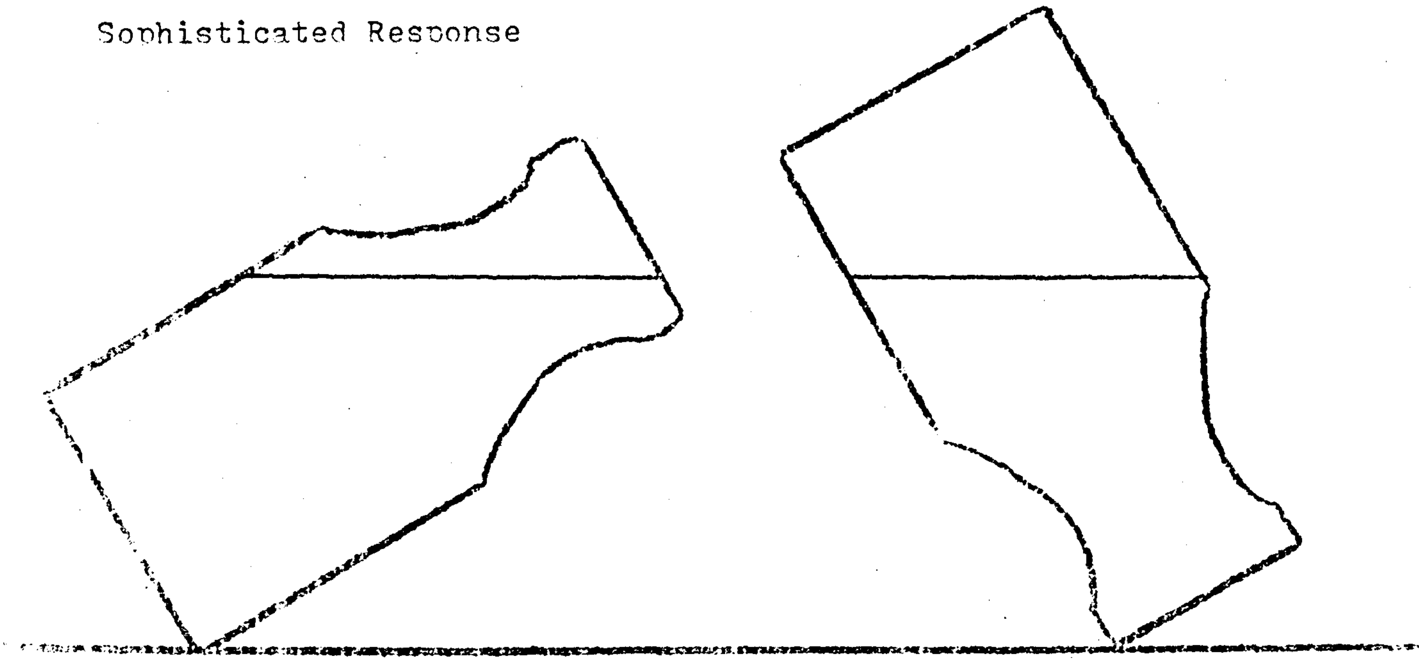
(So=Sophisticated, Na=Naive)

A P P E N D I X

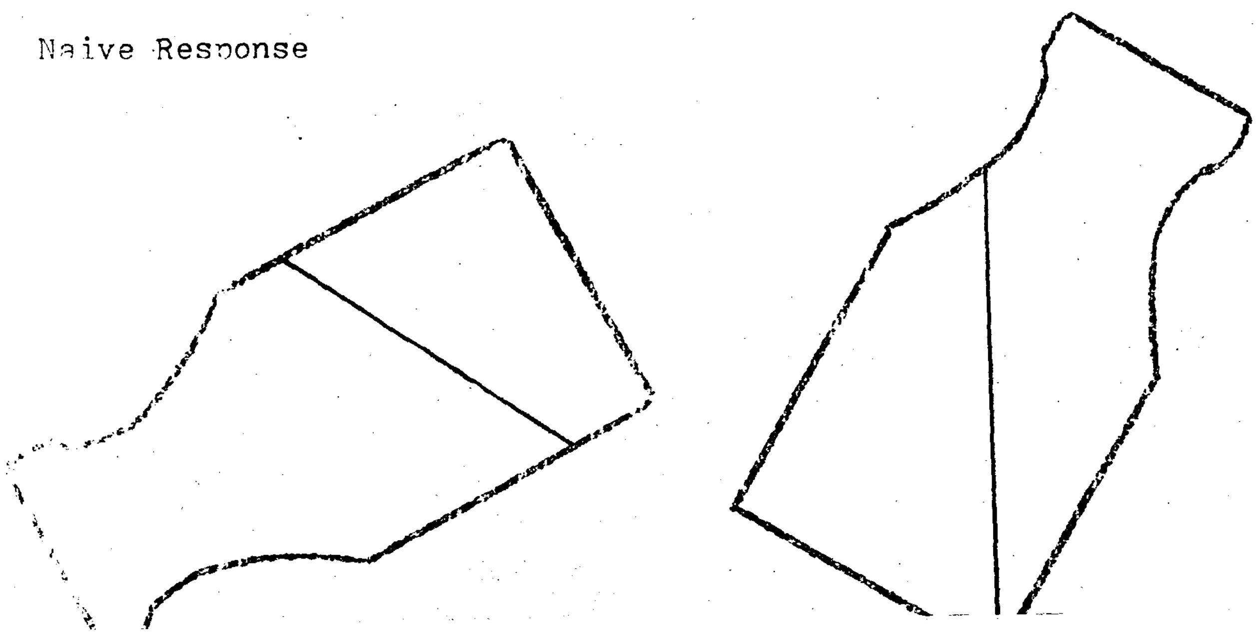
The bottle to the right contains a liquid solution. Please draw the water line for the solution in the following pictures.

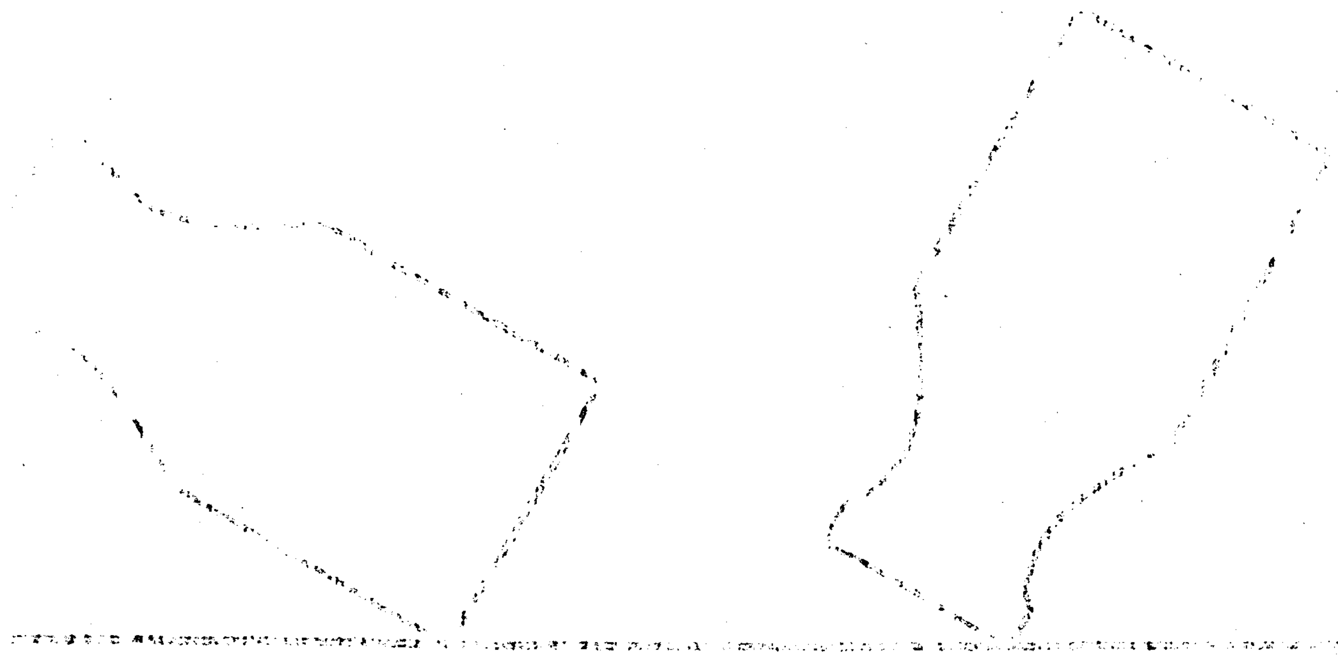


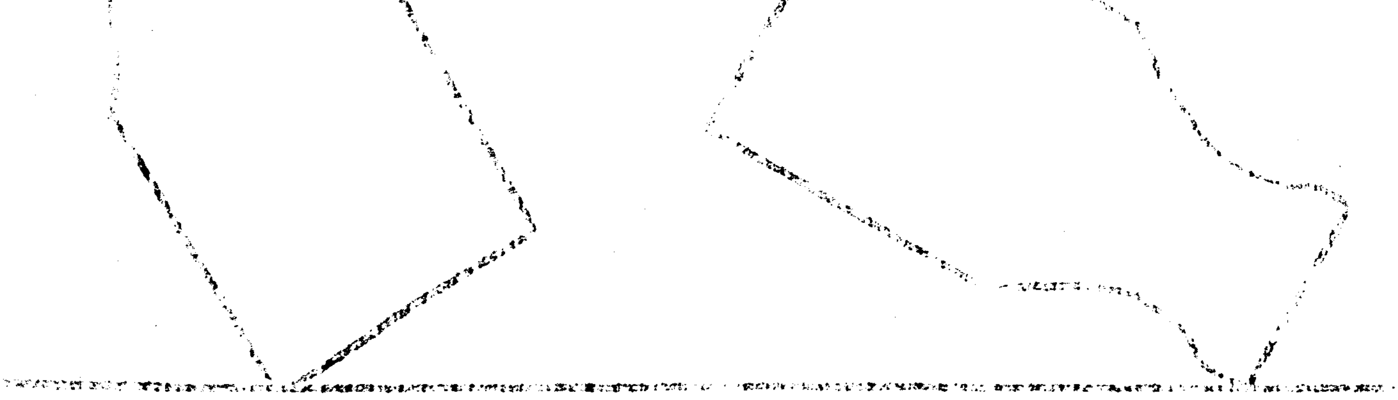
Sophisticated Response



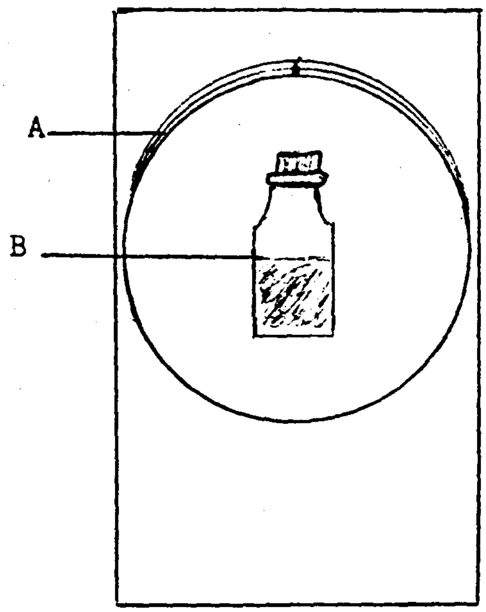
Naive Response







Water Level Apparatus



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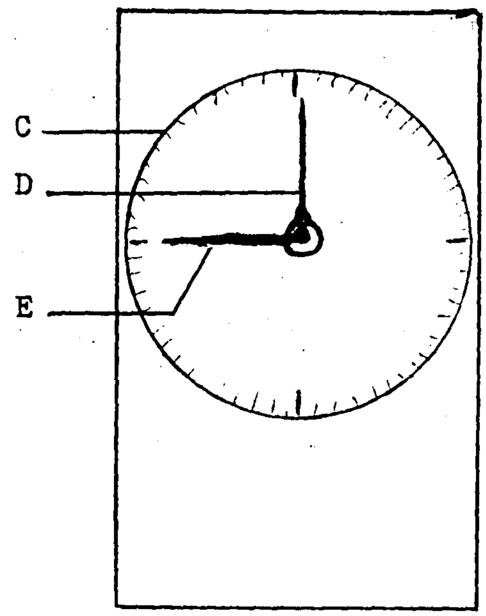

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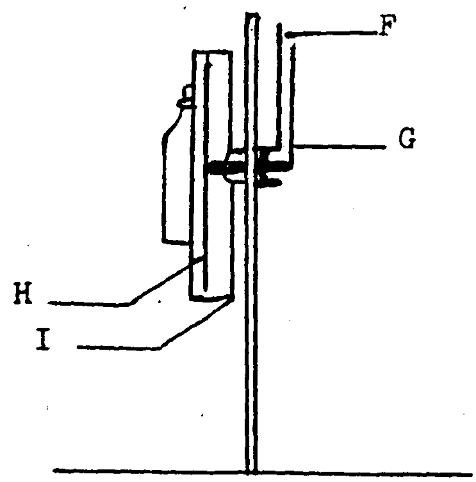


Lateral

A-Rotatable Discs
B-Clear Plastic Bottle Half
C-360° Dial
D-Bottle Orientation
  Indicator Needle
E-Water Level Indicator Needle
F-Same as D
G-Same as E
H-Water Level Disc
I-Bottle Disc Rotator Disc

THE GUILFORD-ZIMMERMAN APTITUDE SURVEY

Part V Spatial Orientation

Form A

Name______________________________Date________________Score________

Nearest age: 10 15 20 25 30 35 45 55 65 75 Sex: M F

Years of school completed: 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

Instructions.—This is a test of your ability to see changes in direction and position. In each item you are to note how the position of the boat has changed in the second picture from its original position in the first picture.

Here is a sample item.

These are the five possible answers to the item.

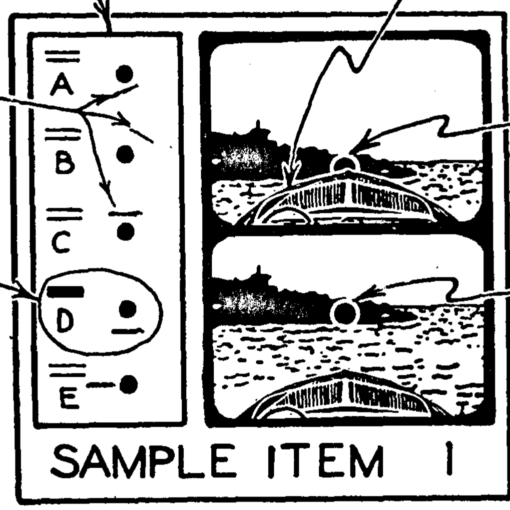
This is the prow (front end) of a motor boat in which ***you*** are riding.

These are tiny pictures of the boat's prow.

This is the aiming point. It is the exact spot you would see on land if you sighted right over the point of the prow.

This is the correct answer. It shows that the prow of the boat has dropped below the aiming point.

This is the same aiming point shown above. Note that the prow of the motor boat has dropped below it.



(If the prow had risen, instead of dropped, the correct answer would have been C, instead of D.)

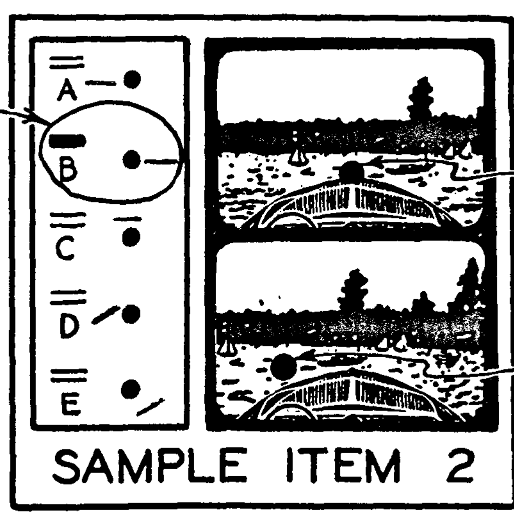
Other items in the test are very similar to SAMPLE ITEM 1. To work each item: ***First,*** look at the top picture. See where the motor boat is headed. ***Second,*** look at the bottom picture and note the CHANGE in the boat's heading. ***Third,*** mark the answer that shows the same change.

Try Sample Item 2.

This also shows that the prow of the boat is to the right of the aiming point. So, it is the correct answer.

This is the aiming point.

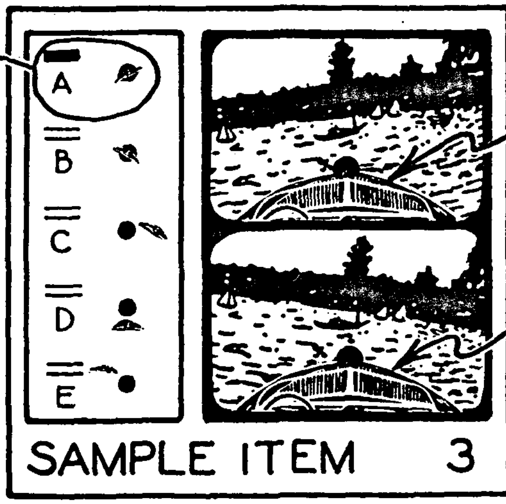
This is the same aiming point. The motor boat is now headed to the right of it.



(If the boat had turned to the left, instead of to the right, the correct answer would have been A.)

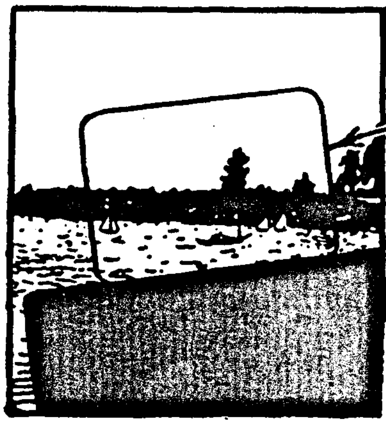
Now try Sample Item 3.

This is the correct answer. It shows that the motor boat changed its slant to the left, but that it is still heading toward the aiming point.



Here the motor boat is slanted slightly to the right. (Note that the horizon appears to slant in the opposite direction.)

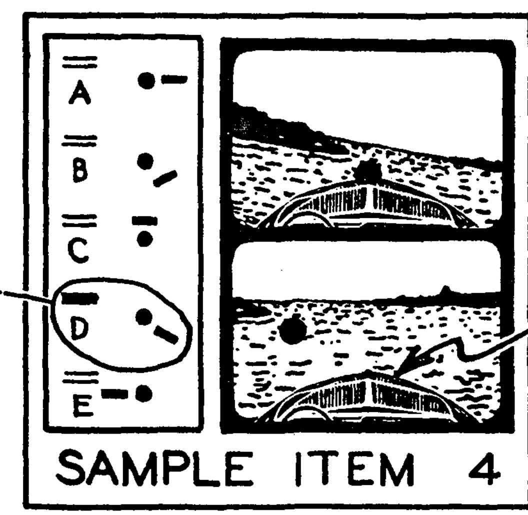
Here the boat has changed its slant toward the left. (See explanation below.)



Imagine that these pictures were taken with a motion picture camera. The camera is fastened rigidly to the boat so that it bobs up and down, turns and slants with the boat. Thus, when the boat tips or slants to the left (as in the lower picture in SAMPLE ITEM 3), the scene through the camera view finder looks slanted like this.

Look at Sample Item 4.

D is the correct answer. It shows that the boat (from now on only a bar will be shown in the answer in place of the tiny picture of the boat's prow) changed its heading both downward and to the right; also that it changed its slant toward the right. (In the top picture the boat was slanting left. To become level, the boat slanted back toward the right.



The prow of the boat has moved downward and toward the right. Also it has changed its slant toward the right. (It was slanted left in the top picture, and it became level. To become level, it had to slant back toward the right.)

Now Do Practice Items 5, 6, and 7. Record Your Answers.

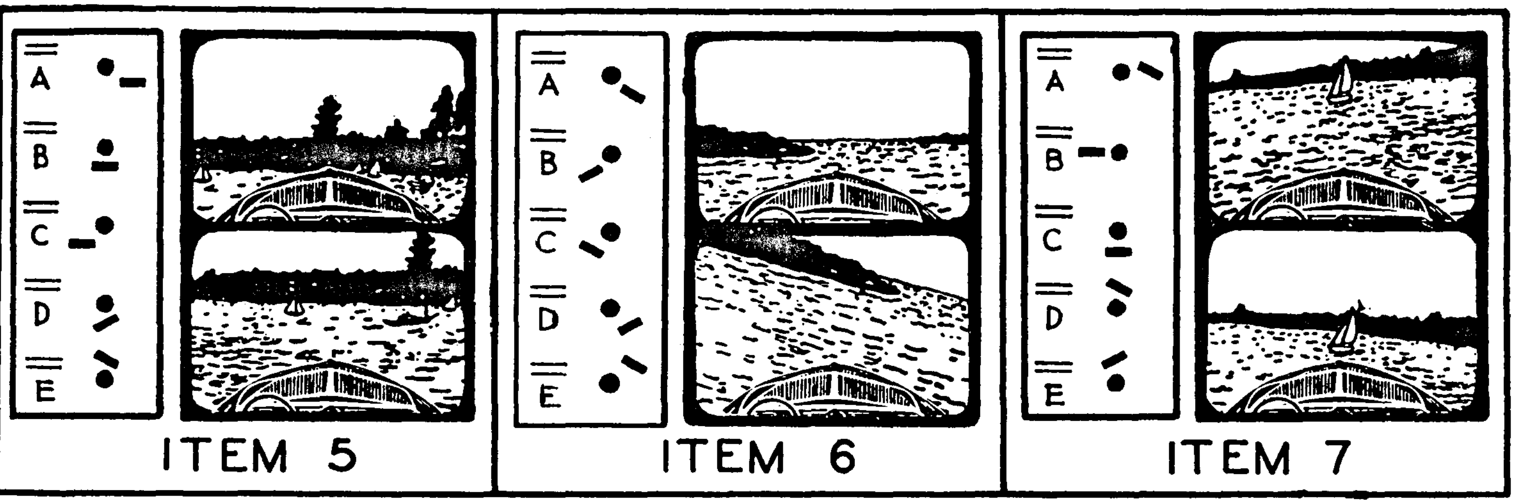
The aiming point is not marked in the test items. You must see the change in the boat's position without the aid of the dots.

To Review:

First — Look at the top picture. See where the motor boat is headed.

Second — Look at the bottom picture. Note the change in the boat's heading.

Third — Mark the answer that shows the same change (in reference to the aiming point before the change).



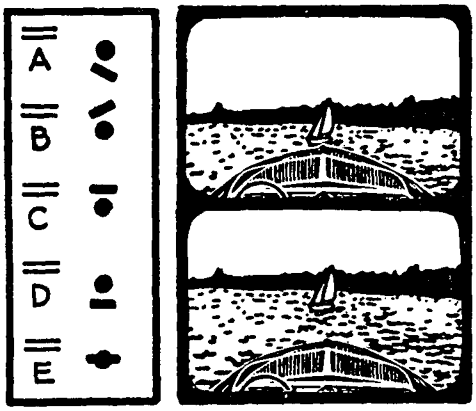
C is the correct answer. The prow appears to have moved to the left and downward. It has not changed its slant.

B is the correct answer. The prow appears to have moved to the left and downward. Also, it has changed its slant to the left.

E is the correct answer. The prow appears to have moved upward, and to have tipped left. It has not turned.

If you have any questions, ask them now.

At the signal from the examiner, not before, turn the page and begin working on the test. Work rapidly. If you are not sure about any item, you may guess, but avoid wild guessing. Your score will be the number of answers correct minus a small fraction of the number wrong. You will have ten minutes to work on the test. Wait for the signal to begin.



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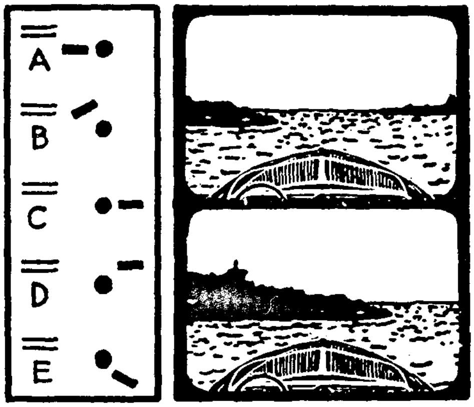

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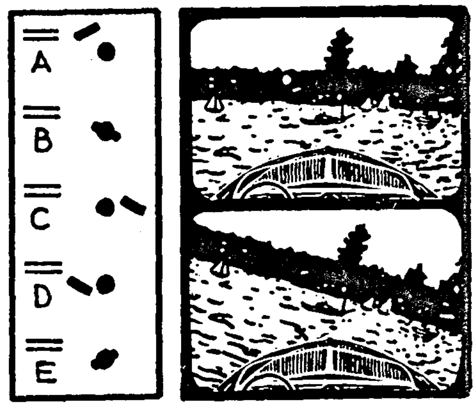

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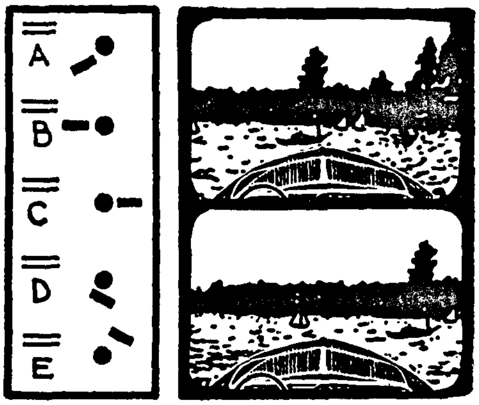

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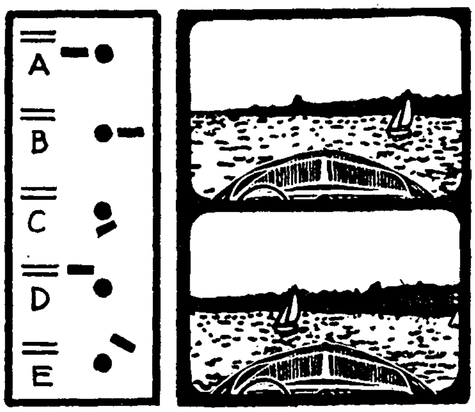

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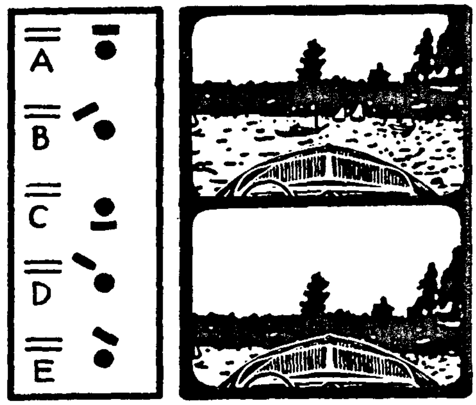

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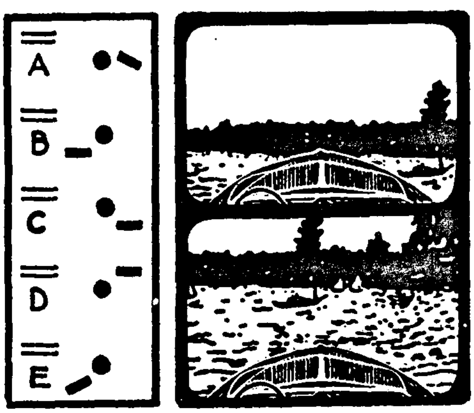

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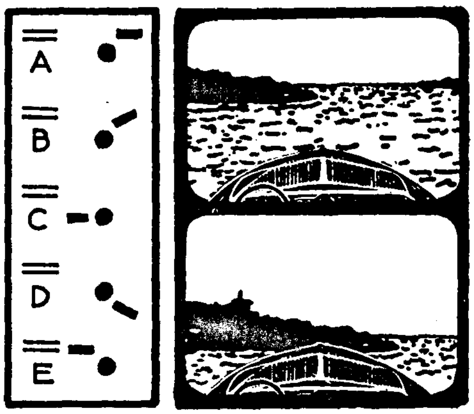

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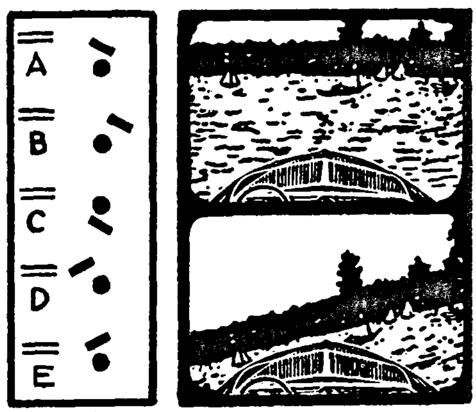

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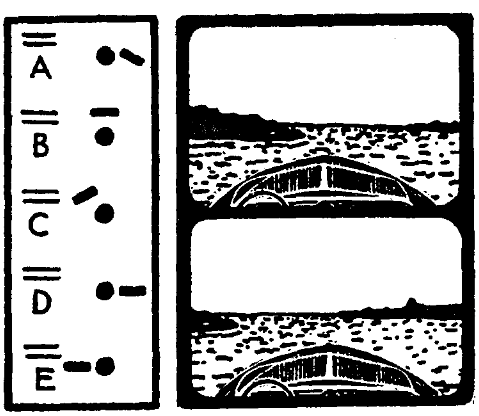

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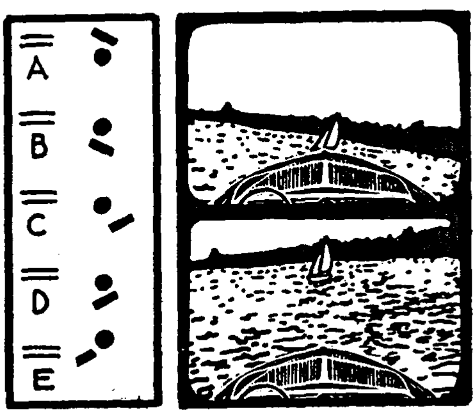

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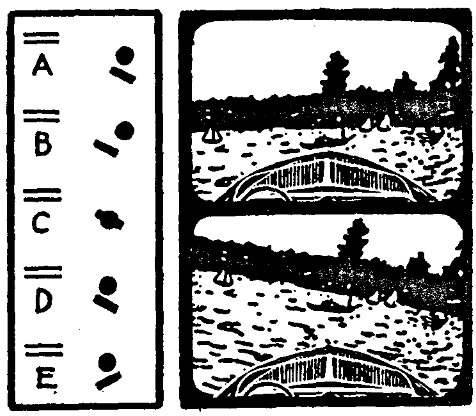

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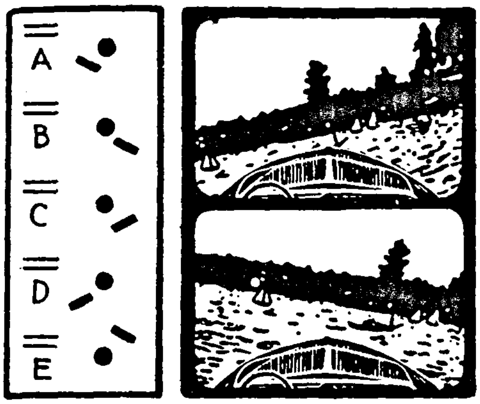

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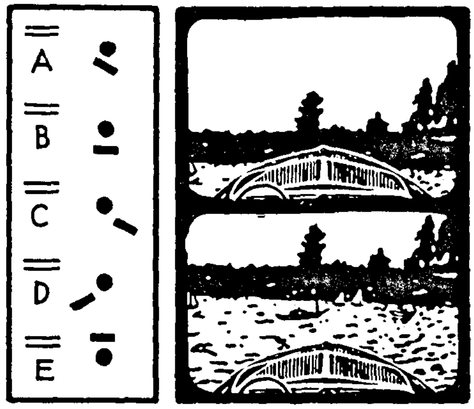

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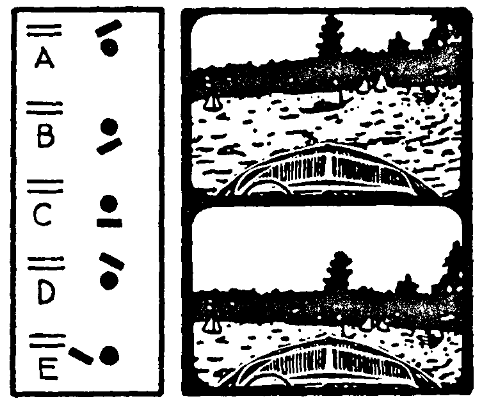

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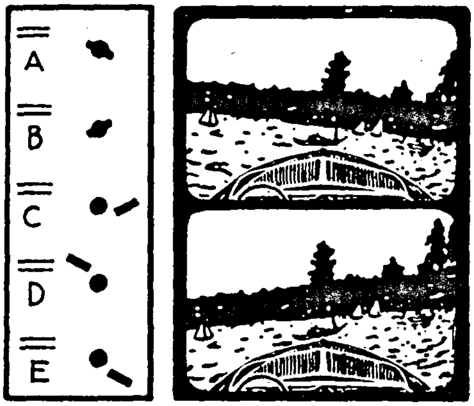

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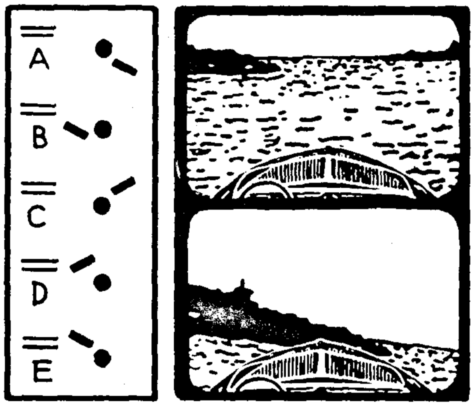

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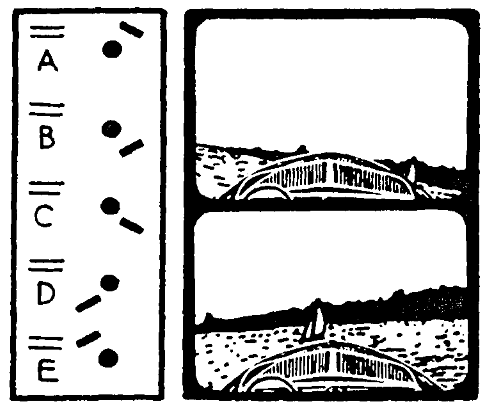

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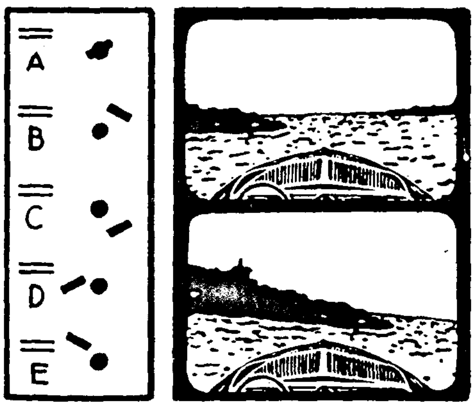

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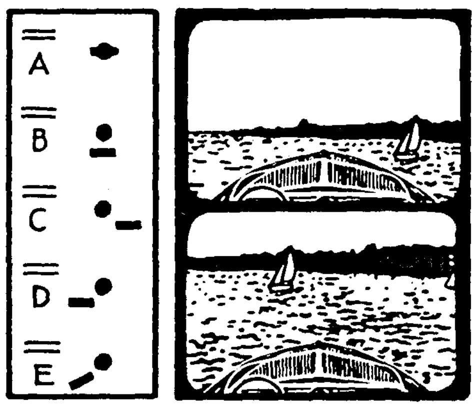

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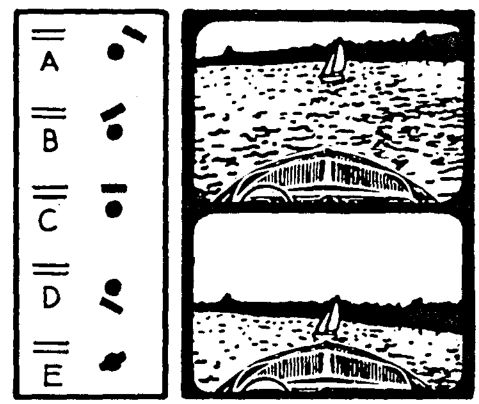

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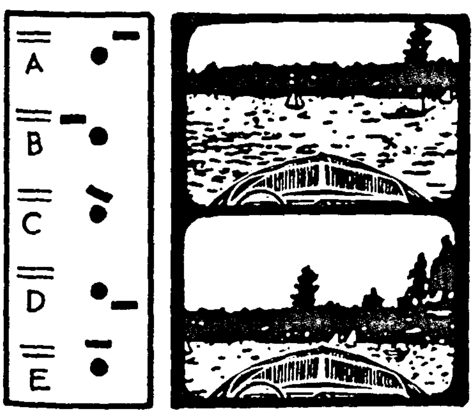

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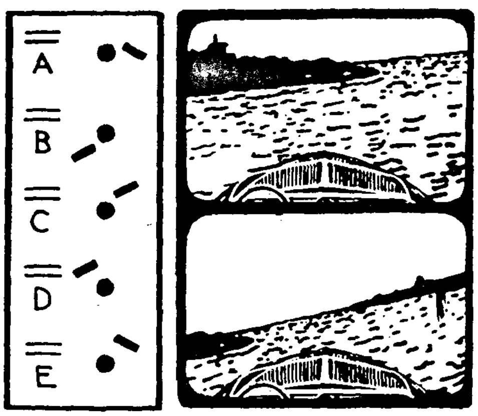

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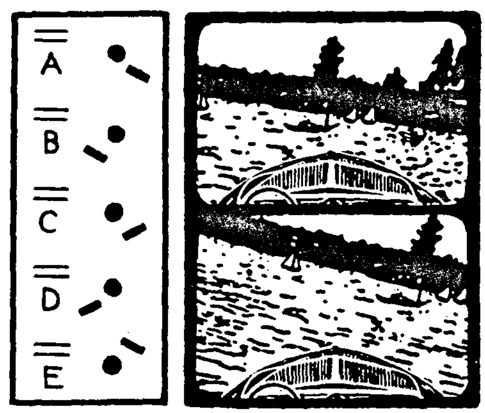

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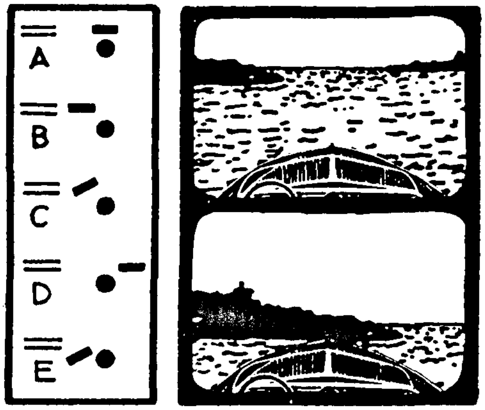

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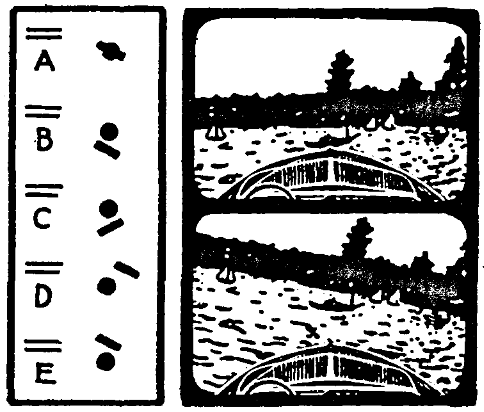

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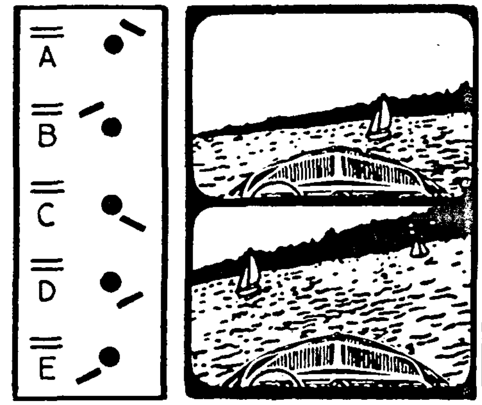

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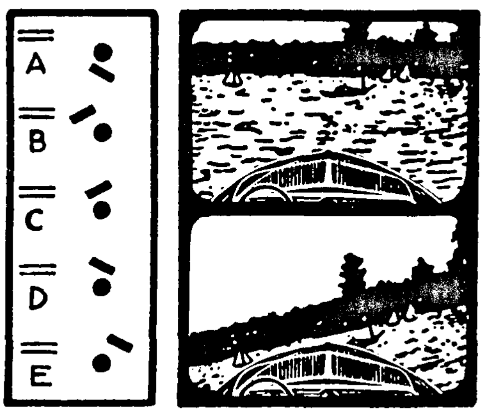

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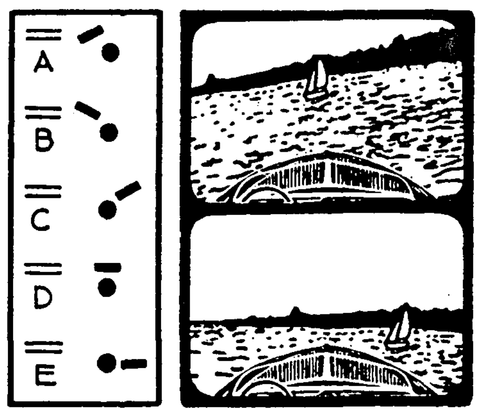

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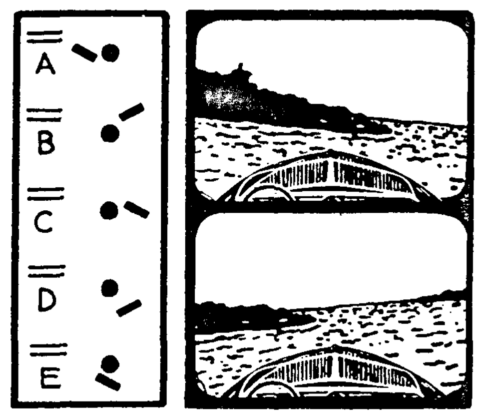

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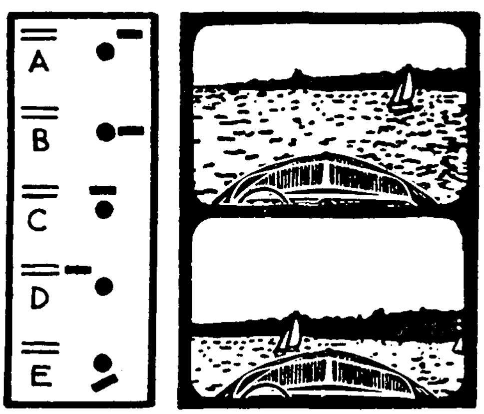

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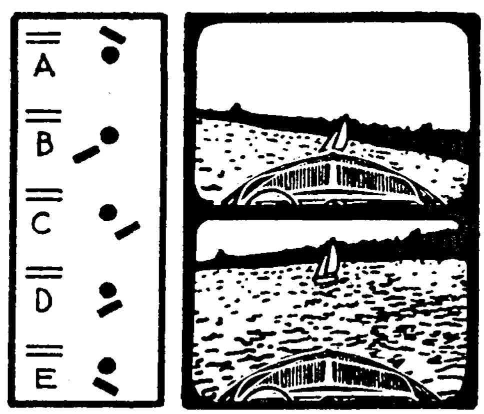

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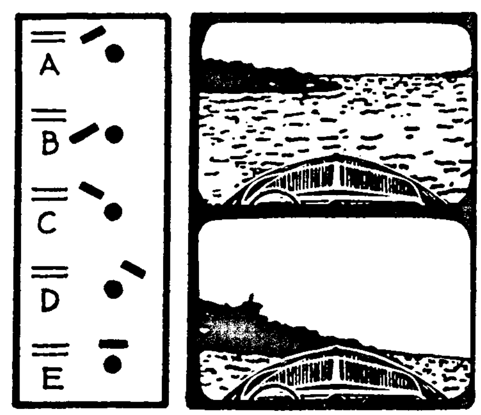

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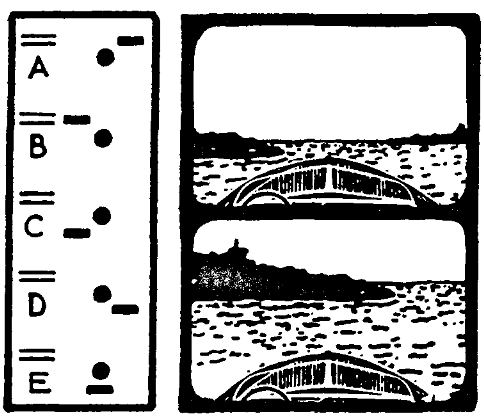

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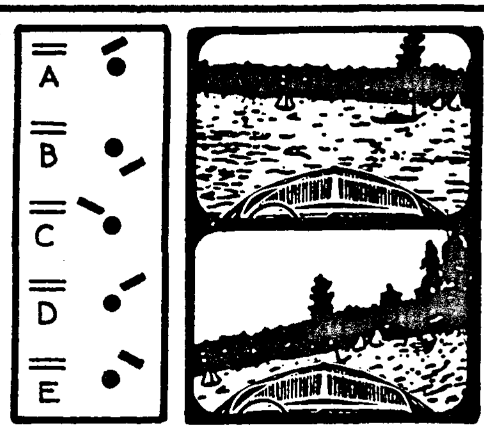

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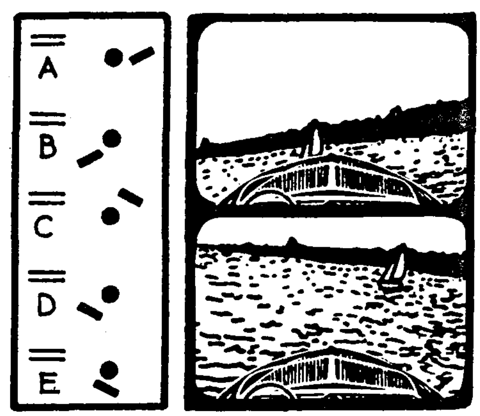

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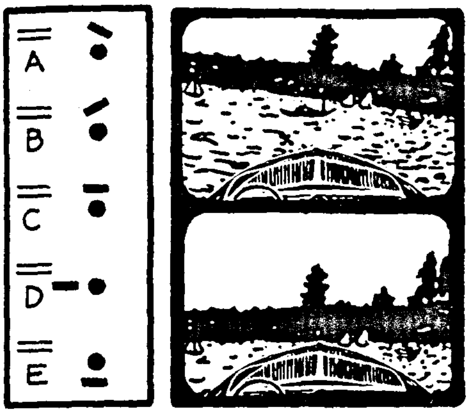

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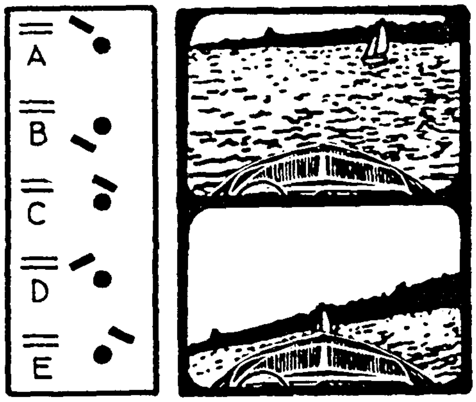

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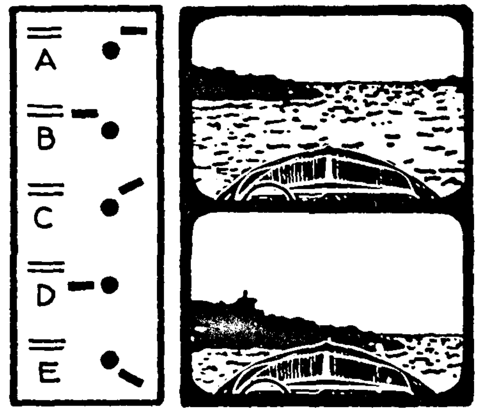

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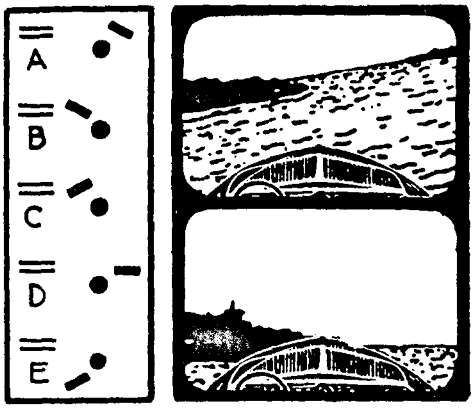

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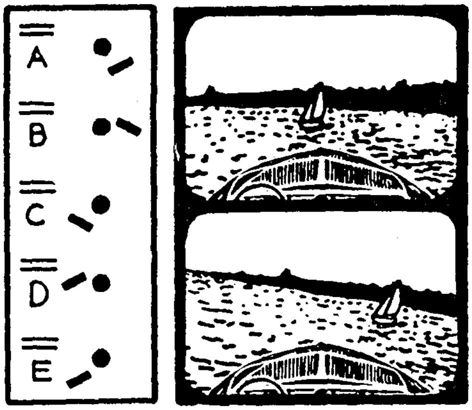

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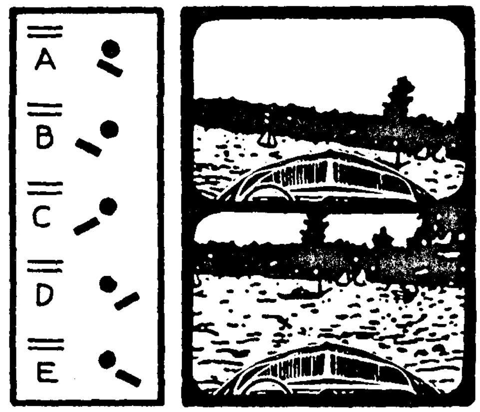

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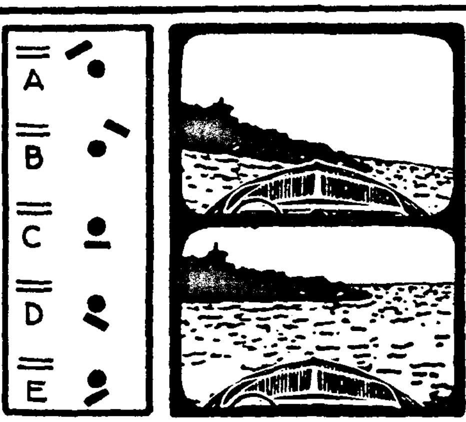

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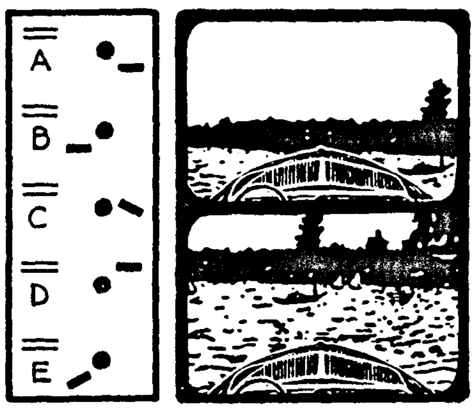

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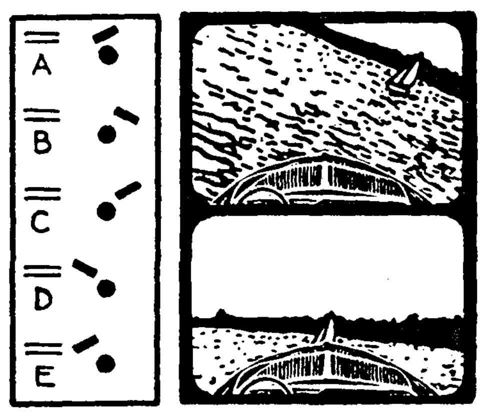

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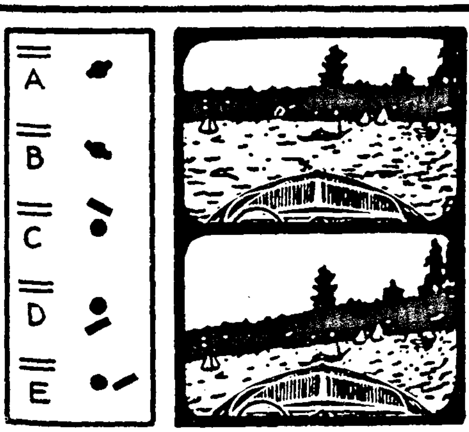

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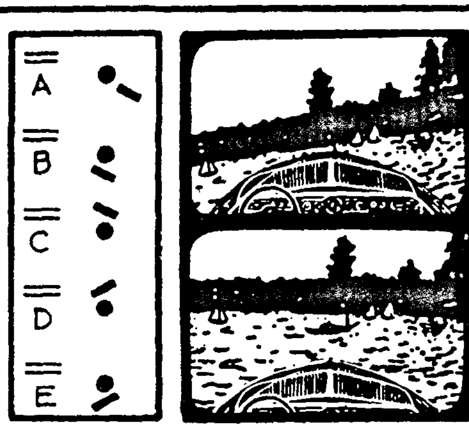

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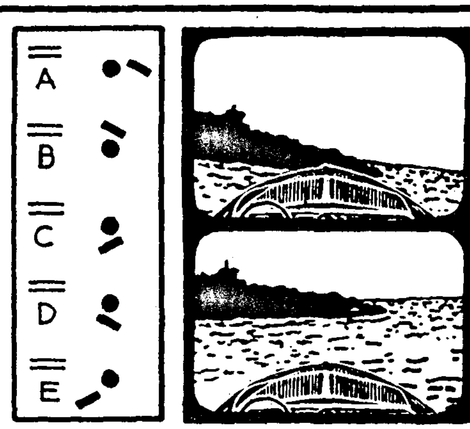

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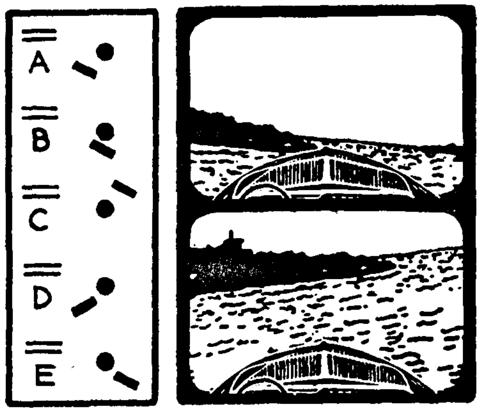

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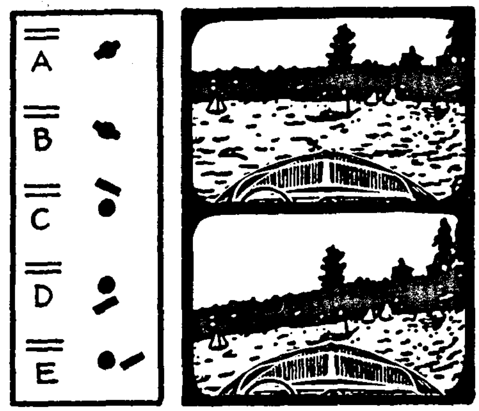

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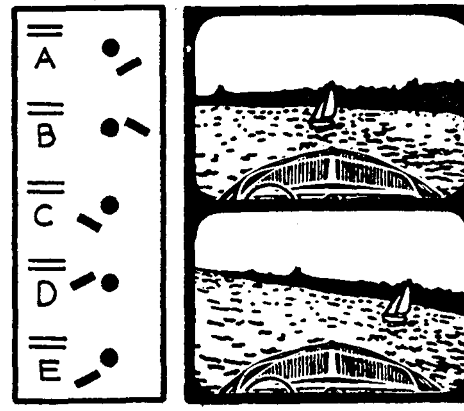

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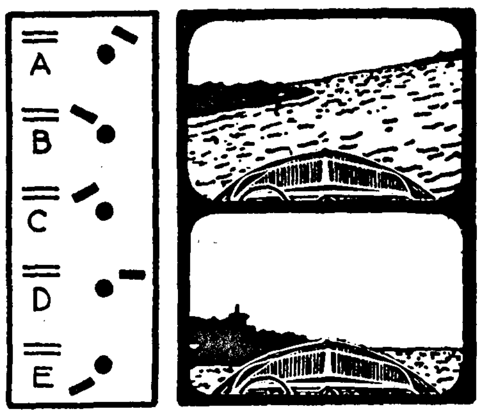

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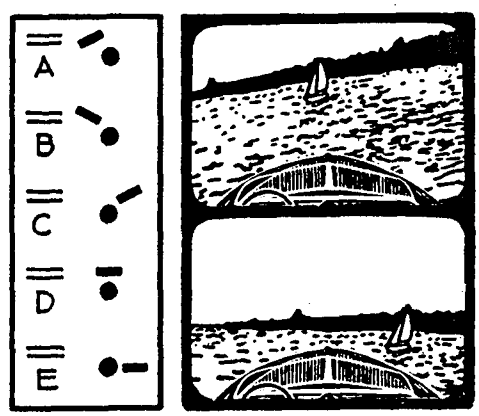

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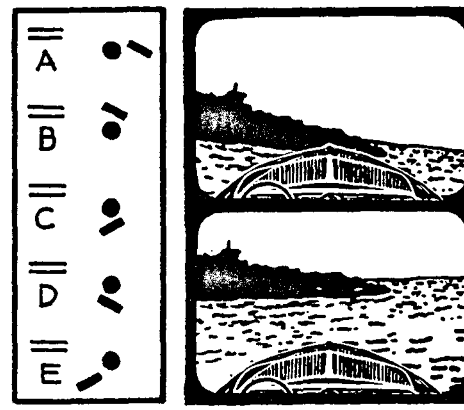

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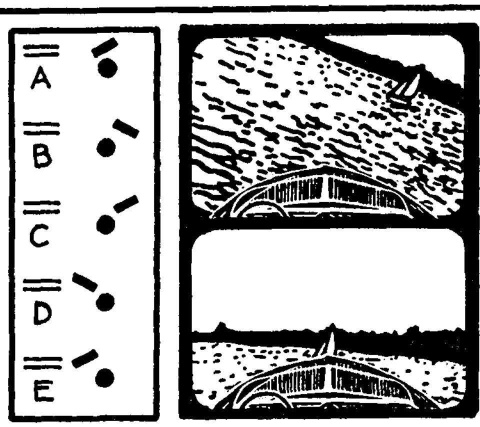

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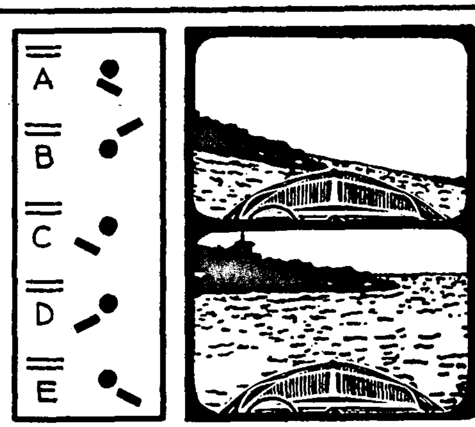

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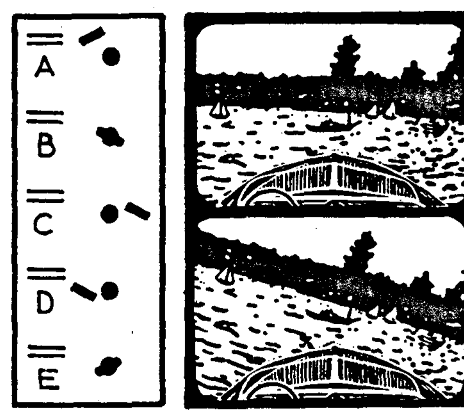

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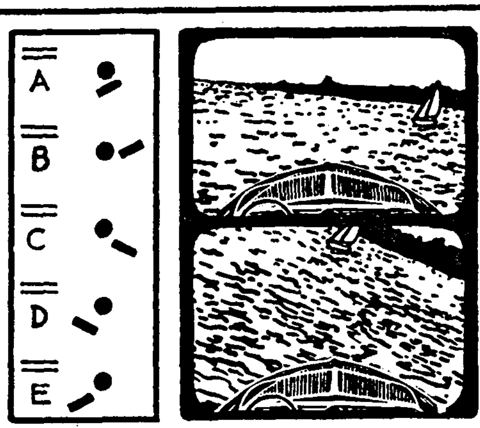

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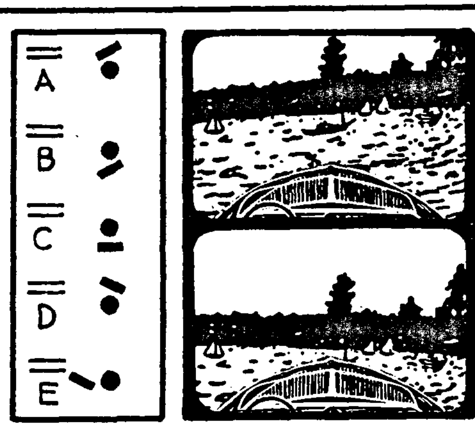

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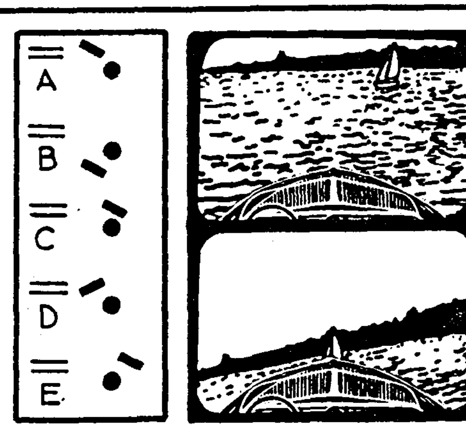


67

DIRECTIONS AND PRACTICE PROBLEMS

E	A	B	D				
1	2	3	4	5	6	7	8

READ THE FOLLOWING DIRECTIONS VERY CAREFULLY WHILE THE EXAMINER READS THEM ALOUD

Look at the problems on the right side of this page. You will notice that there are eight of them, numbered from 1 to 8. Notice that the problems go DOWN the page.

First look at Problem 1. There are two parts in the upper left-hand corner. Now look at the five figures labelled A, B, C, D, E. You are to decide which figure shows how these parts can fit together. Let us first look at Figure A. You will notice that Figure A does **not** look like the parts in the upper left-hand corner would look when fitted together. Neither do Figures B, C, or D. Figure E **does** look like the parts in the upper left-hand corner would look when fitted together, so E is PRINTED in the square above [1] at the top of the page.

Now look at Problem 2. Decide which figure is the correct answer. As you will notice, Figure A is the correct answer, so A is printed in the square above [2] at the top of the page.

The answer to Problem 3 is B, so B is printed in the square above [3] at the top of the page.

In Problem 4, D is the correct answer, so D is printed in the square above [4] at the top of the page.

Now do Problems 5, 6, 7, and 8.

PRINT the letter of the correct answer in the square above the number of the example at the top of the page.

DO THESE PROBLEMS NOW.

If your answers are not the same as those which the examiner reads to you, RAISE YOUR HAND.

DO NOT OPEN THE BOOKLET UNTIL YOU ARE TOLD TO DO SO.

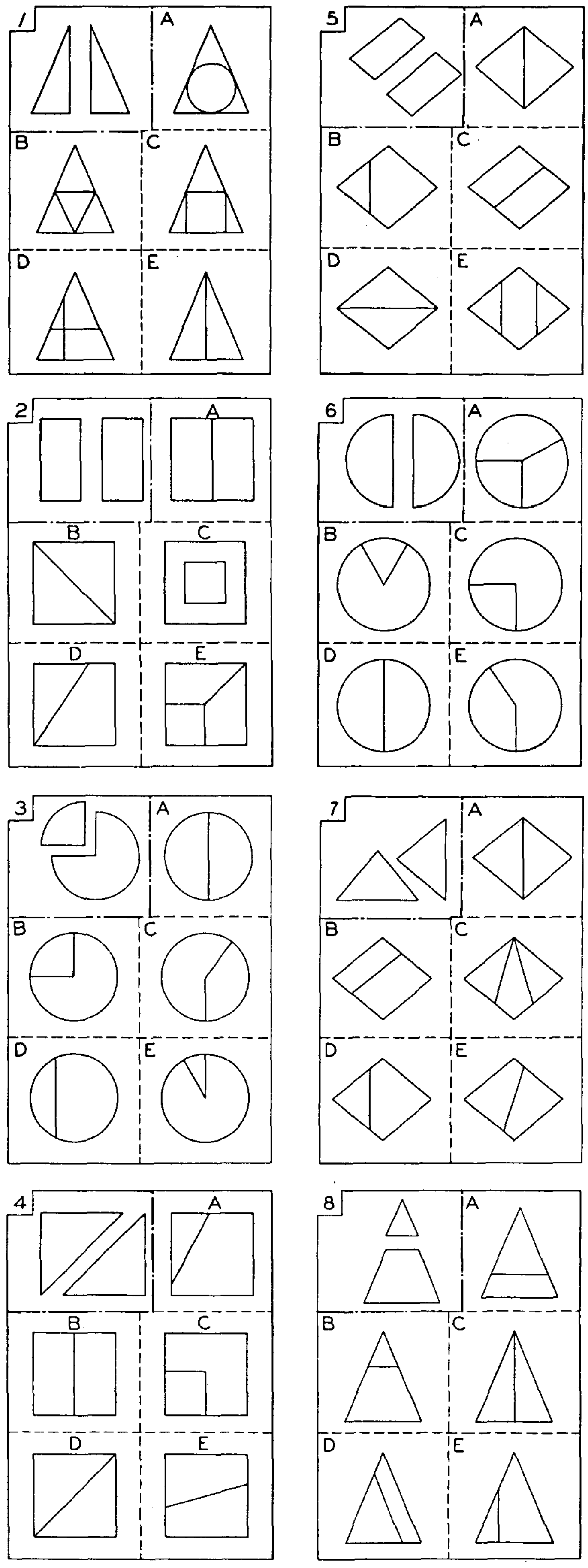
Some of the problems on the inside of this booklet are more difficult than those which you have already done, but the idea is exactly the same. In each problem you are to decide which figure shows the parts correctly fitted together. **Sometimes the parts have to be turned around, and sometimes they have to be turned over in order to make them fit.** In the square above [1] write the correct answer to Problem 1; in the square above [2] write the correct answer to Problem 2, and so on with the rest of the test. Start with Problem 1, and go DOWN the page. After you have finished one column, go right on with the next. **Be careful not to go so fast that you make mistakes. Do not spend too much time on any one problem.**

PRINT WITH CAPITAL LETTERS ONLY.

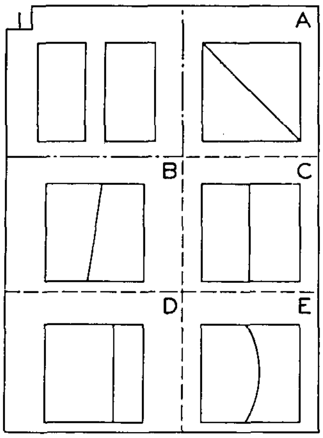
MAKE THEM SO THAT ANYONE CAN READ THEM.

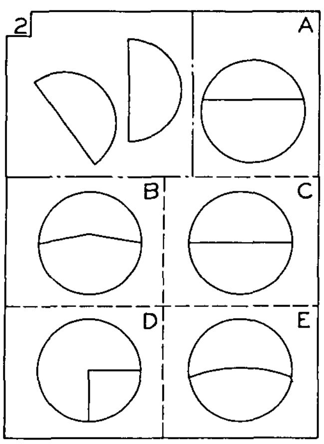
DO NOT OPEN THE BOOKLET BEFORE YOU ARE TOLD TO DO SO.

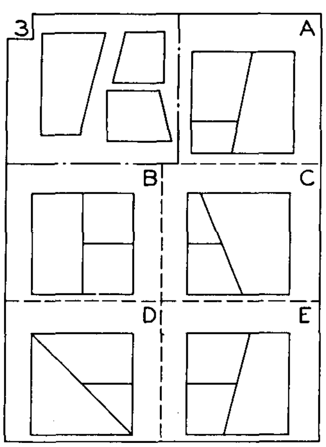
YOU WILL HAVE EXACTLY 20 MINUTES TO DO THE WHOLE TEST.

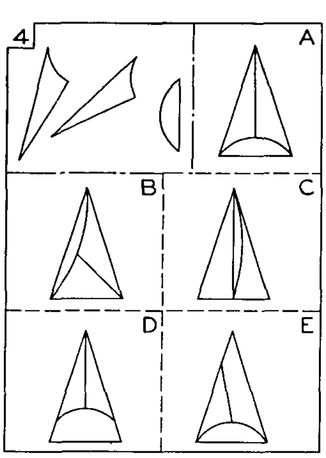


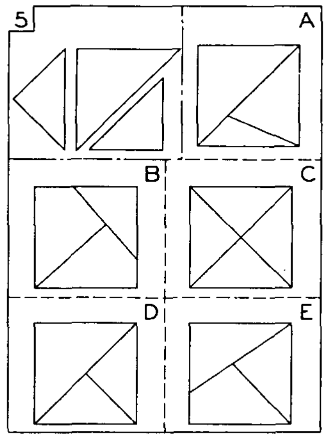
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

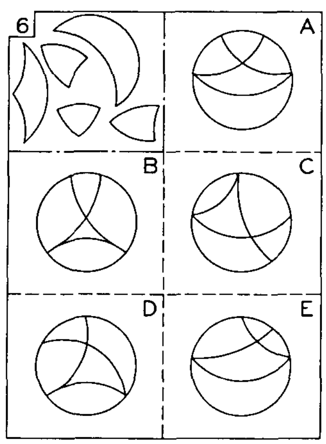


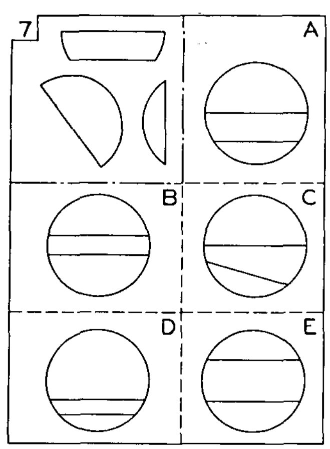


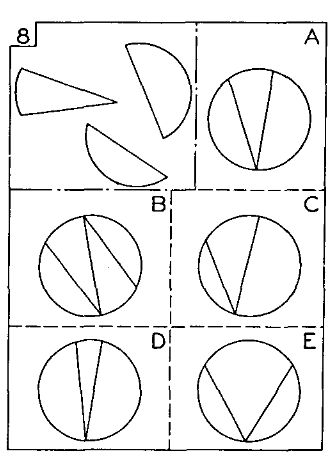


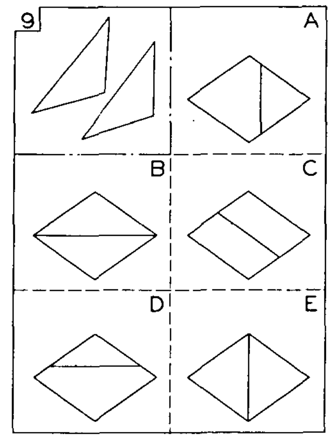


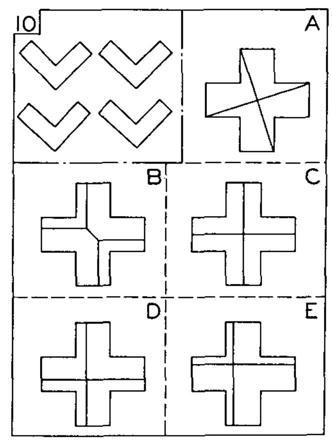


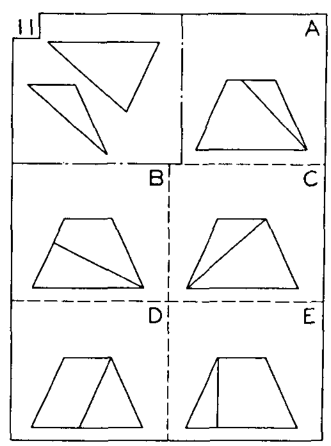


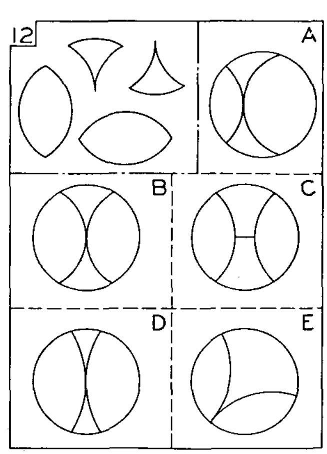


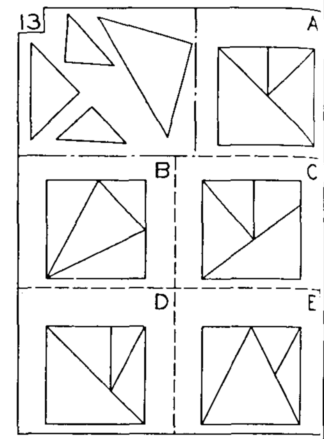


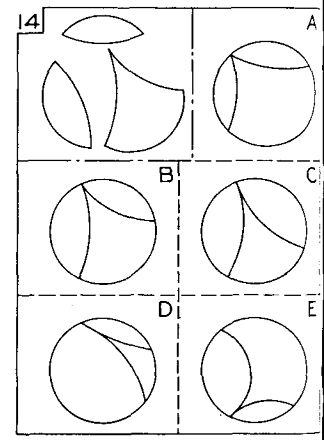


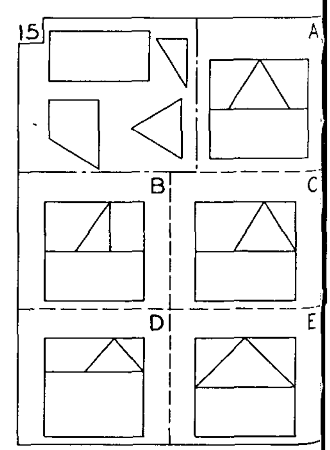


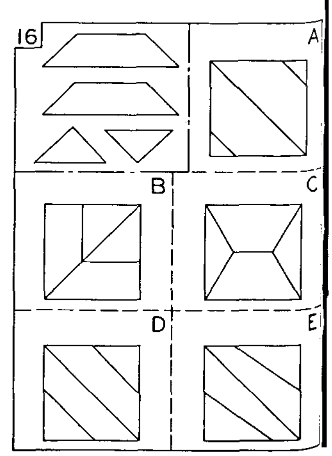












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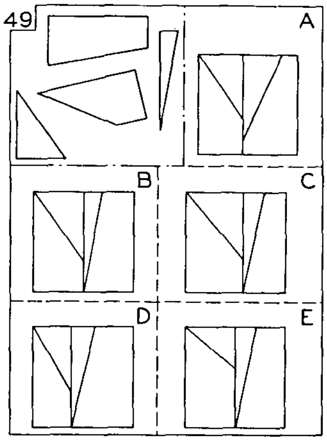

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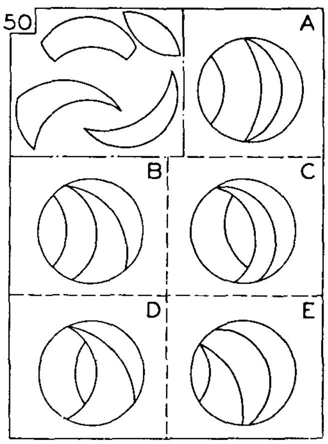

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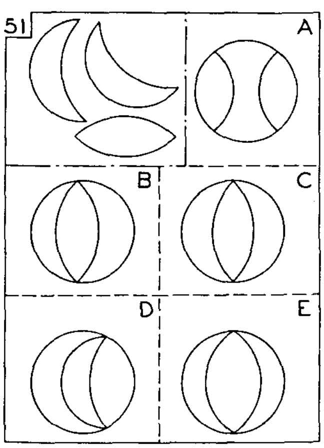

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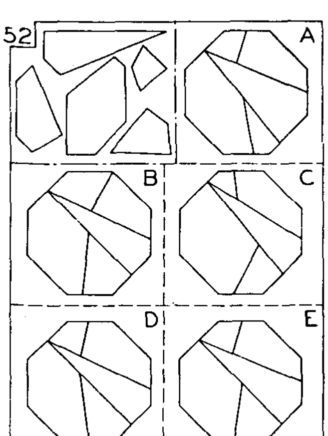

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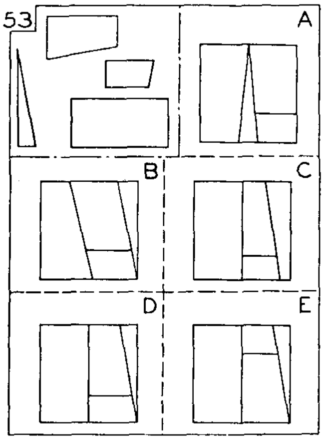

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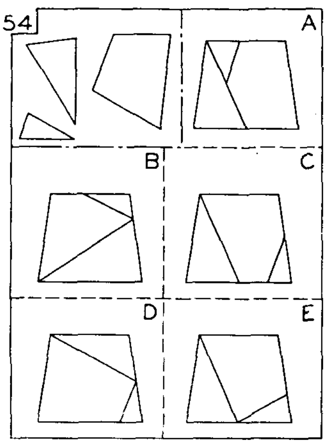

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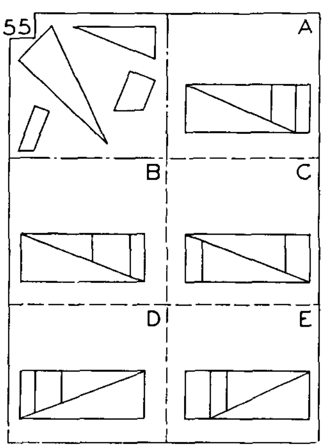

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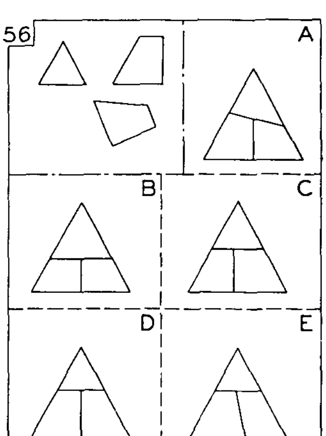

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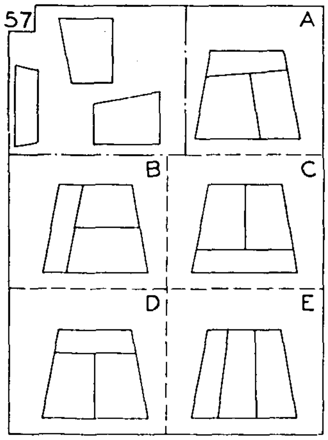

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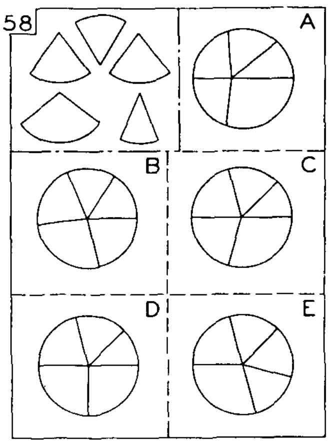

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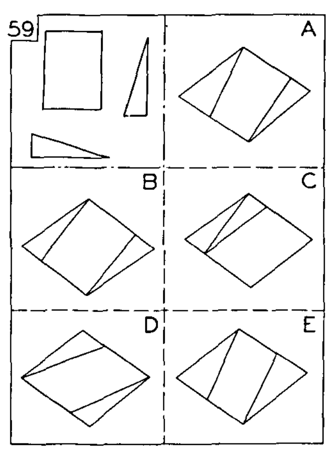

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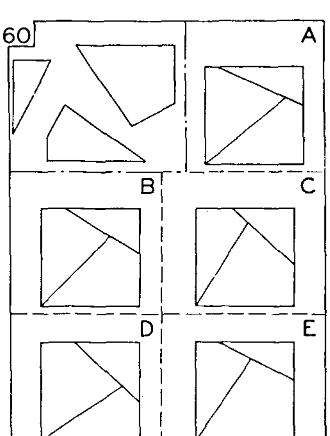

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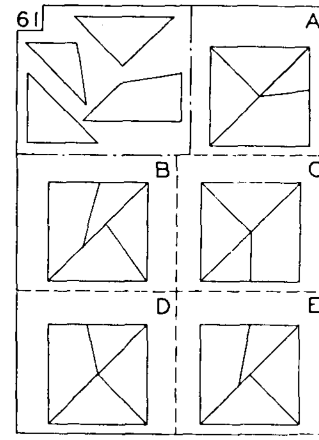

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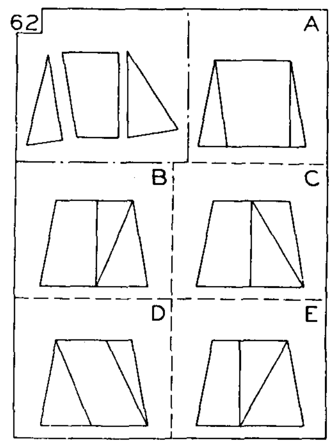

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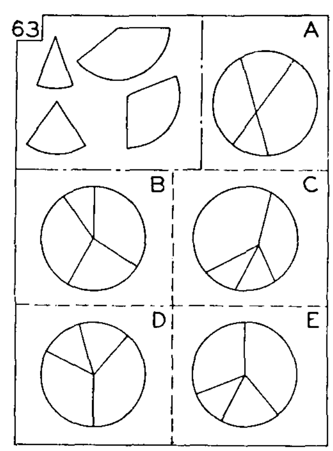

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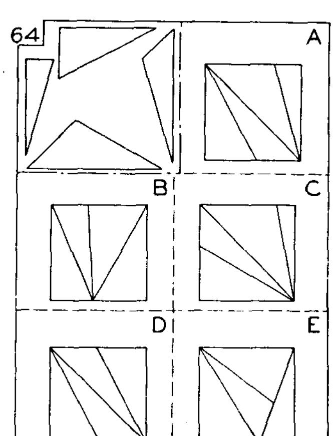

If you finish before you are told to stop, go back and make sure that every answer is right.

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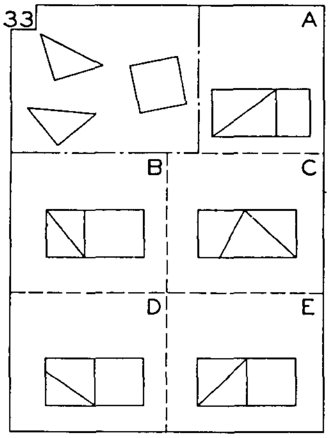

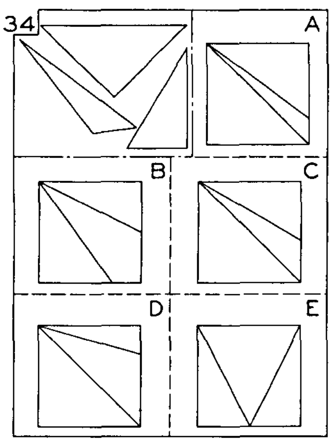

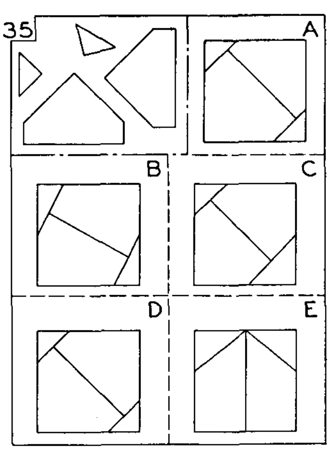

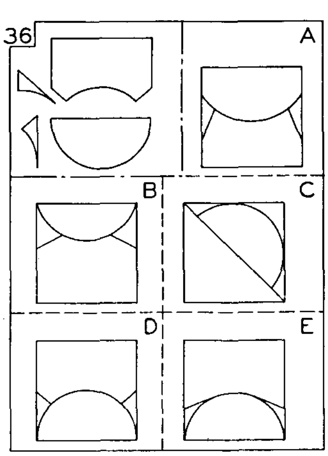

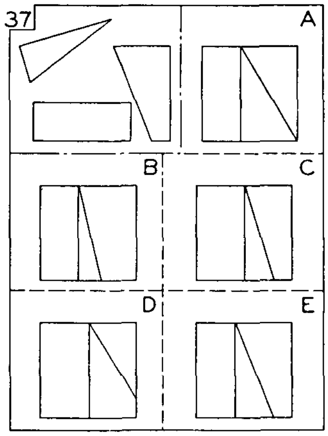

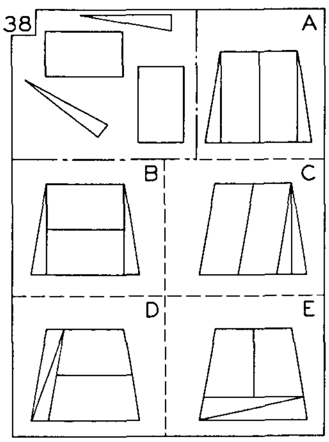

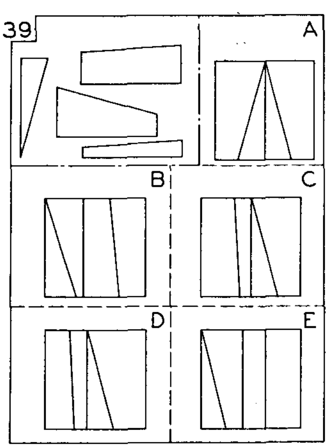

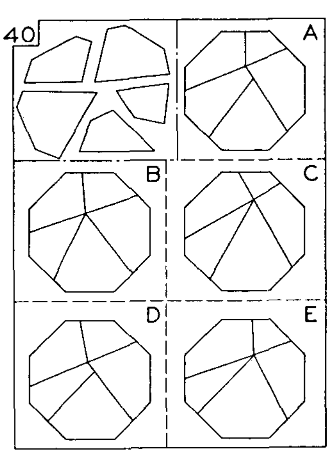

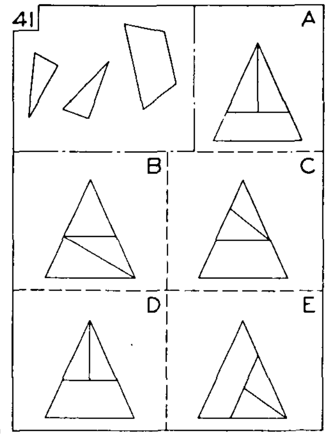

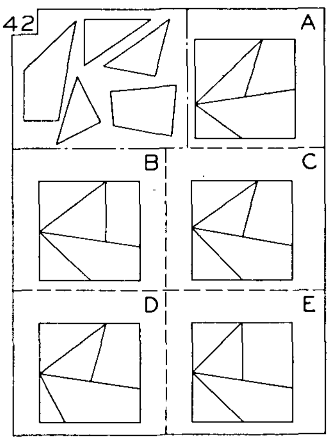

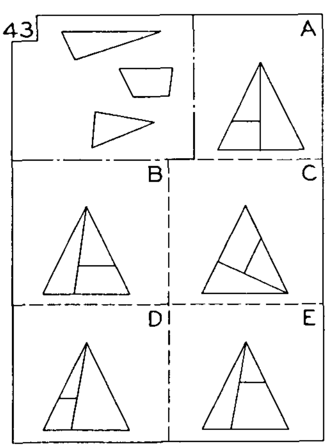

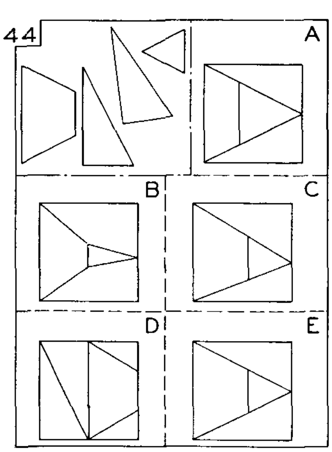

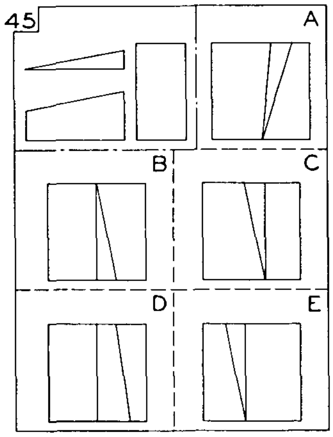

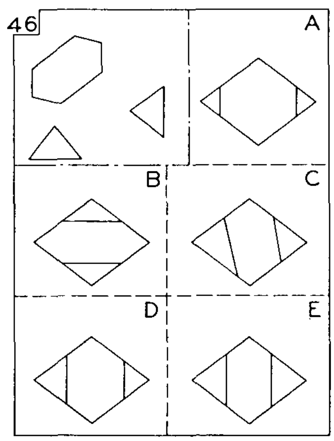

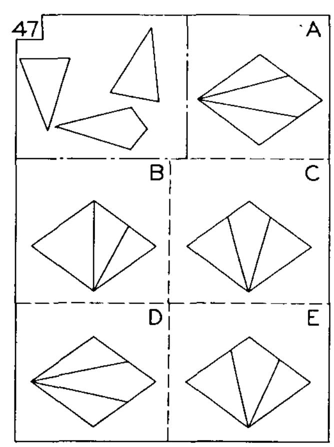

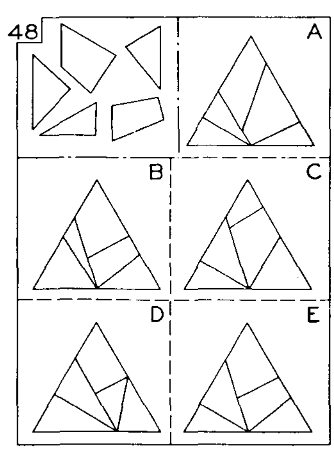

Turn over and go on with page 5.

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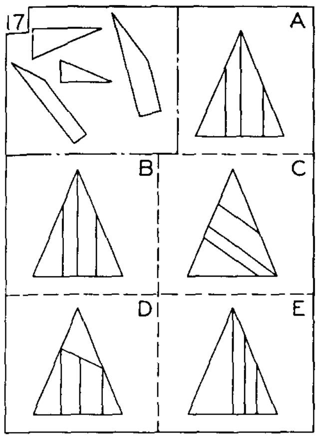

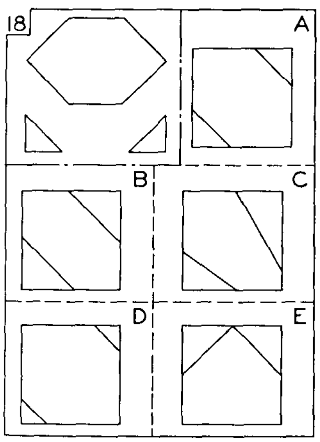

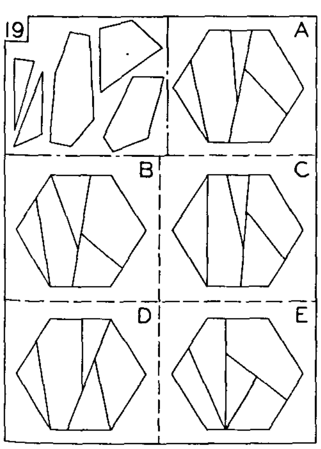

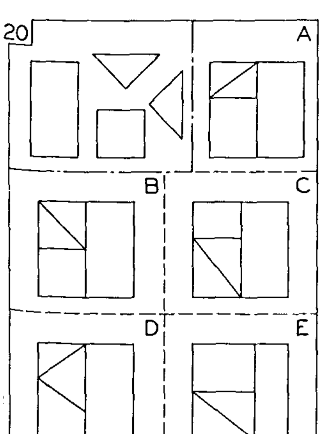

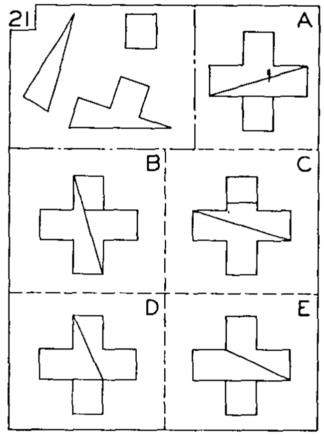

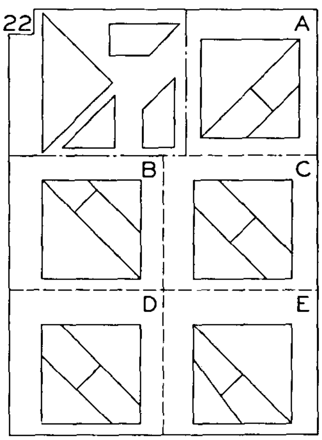

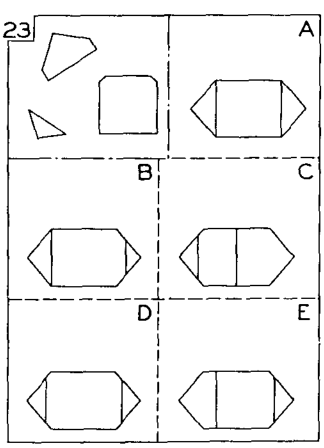

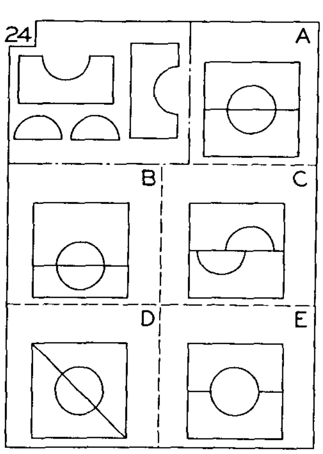

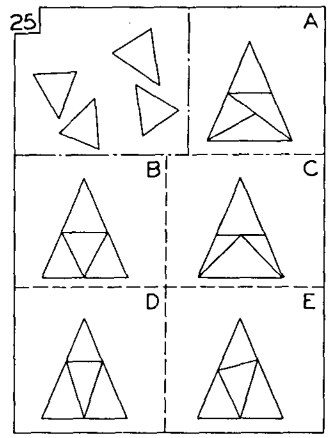

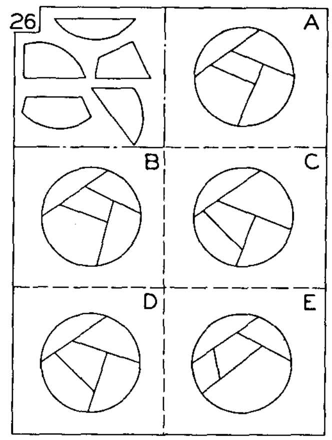

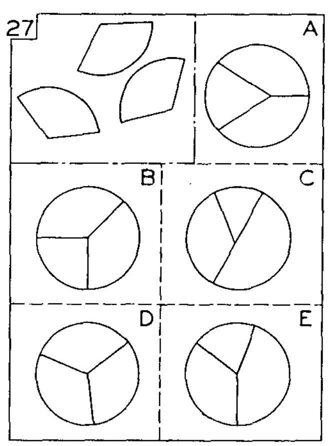

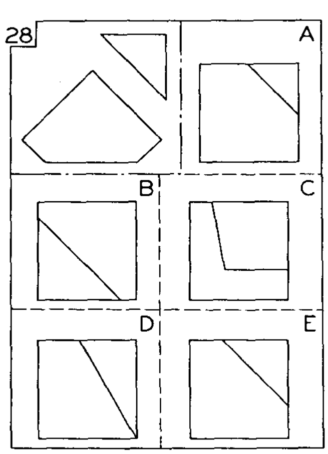

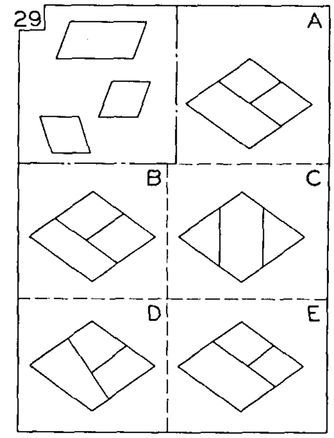

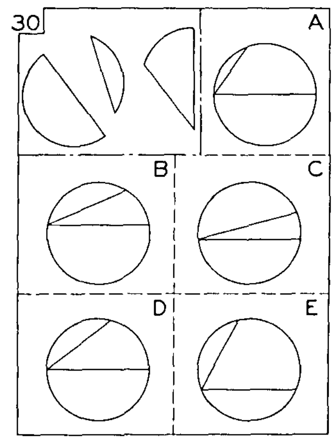

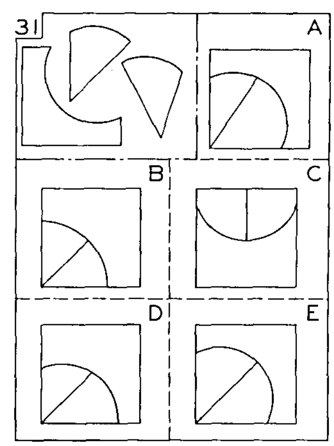

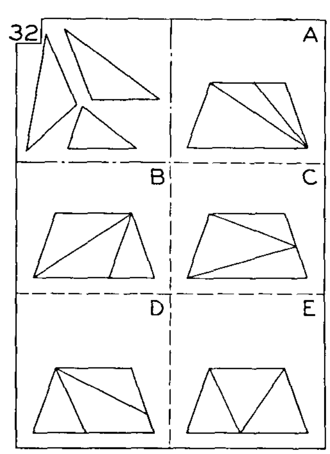

Go on with page 4.

Score	Percentile	Norms Used

SERIES AA

REVISED MINNESOTA PAPER FORM BOARD TEST

Prepared by R. Likert and Wm. H. Quasha

Fill in the blanks below (name, age, etc.)

BUT DO NOT TURN OVER OR OPEN THE BOOKLET UNTIL THE SIGNAL IS GIVEN

PRINT WITH CAPITAL LETTERS

Name ....
(Last) (First) (Middle)

School or Institution..

Today's Date ....
(Month) (Day) (Year)

Instructor's or Foreman's Name..

Age Last Birthday.. Sex ....

Date of Birth..
(Month) (Day) (Year in which you were born)

Grade I Am Now In: Grammar School 1 2 3 4 5 6 7 8 High School 1 2 3 4 College 1 2 3 4 5 6 7
(Put a circle around the grade you are now in)

Or Department ....

....

....

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Vita

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