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MOTIVATION AND LEARNING--A COMPARATIVE STUDY OF PROGRAMS PRESENTED BY VIDEO TAPE WITH AND WITHOUT MOTIVATING MATERIALS.

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THE SYSTEMATIC USE OF MOTIVATING MATERIALS WAS DEVELOPED AND EVALUATED THROUGH THE TECHNICAL DEVELOPMENT OF A VIDEO-SOUND SYSTEM FOR PROVIDING PROGRAMED TELEVISION TO INDIVIDUAL STUDENTS. FIVE PHYSICS PROGRAMS WERE DEVELOPED AND RECORDED ON VIDEOTAPE. EACH OF THE FIVE PROGRAMS HAD SEQUENCES PRECEDING IT WHICH WERE DESIGNED TO MOTIVATE THE STUDENT TO LEARN THE SUBSEQUENT MATERIAL. EACH STUDENT TOOK TWO PROGRAMS--MOTIVATED AND UNMOTIVATED. THE RESULTS SHOWED NO SIGNIFICANT DIFFERENCE IN ACHIEVEMENT BETWEEN MOTIVATED AND UNMOTIVATED PROGRAMS. IT WAS RECOMMENDED THAT FURTHER STUDIES BE CARRIED OUT USING MOTIVATING MATERIALS OVER EXTENDED PERIODS OF TIME IN CONVENTIONAL INSTRUCTIONAL PROGRAMS. (GD)

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Bill G. Aldridge

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INTRODUCTION

Problem

Throughout the history of education, various teaching strategies or methods of presentation have been developed, each directed to more effective learning for the student. Traditionally, there has been the lecture, the discussion method, and the directed questioning procedures of reflective teaching. With the technological revolution came "new media" for educational presentation. Lectures have been adapted to radio and then to television. The basic techniques of reflective teaching have been applied in Programed textbooks and teaching machines, although the origin of these materials has come from innovators with differing points of view toward learning theory.

In examining these many approaches to teaching, certain facts stand out. Although one technique may teach better than another in a given study, the literature invariably reveals cases where there was "no significant difference". Even more striking is the fact that there is usually great overlap of achievement from control to experimental groups. Seldom can this unexplained variation be attributed to ability differences. Most research workers acknowledge the presence of some motivational factor as uncontrolled variation. Classroom teachers have long recognized the problem of motivation, but the universal problem of student failure and drop-out suggests that mere recognition of the problem does not lead to providing for motivation in the classroom.

In the preparation of programed materials, it is tacitly assumed that providing immediate knowledge (KR) of the correctness of a response supplies motivation. This assumption is basic to Crowder's intrinsic programs and to Skinner's linear programs. Because laws derived from animal experiments are the bases of reinforcement psychology, there is some question about the applicability of such laws to human learning. Reinforcement of animals is in terms of basic physiological needs. For a human subject, knowledge of the correctness of a response on a verbal, uninteresting program may not serve as a reinforcement. To provide reinforcement, students must be motivated so that KR satisfies some need. The problem is to provide this motivation.

Related Literature

During the summer of 1964 this investigator prepared a linear program in physics which was adapted for individual use on television via video-tape. A lecture over the same topic was also recorded on video-tape. In an attempt to make the program take full advantage of television as a media, frames related directly to physical phenomena, and answers were supplied by permitting the student to observe physics demonstrations on television. Thus learning was not entirely verbal.

To adapt the video tape recorder for programming, strips of reflective tape were placed at appropriate places on the programmed video tape. Using a photo-electronic circuit designed for that purpose, the video recorder would stop at the end of each frame, while the student constructed his response. When he depressed a button, the recorder would re-start, presenting the correct answer and the next frame in the sequence. The lecture contained identical physics demonstrations, but the questions used in the linear program were presented as worked problems.

An analysis of the relative effectiveness of these two methods of presentation showed a significant difference in achievement in favor of students taking the programmed approach. The significance of this research was in the application of television to programmed learning on an individual basis. With inexpensive video-tape recorders soon to be produced, the provision of programmed learning on television for individual students appears feasible.

One can describe a system which provides random access of video sequences for individual student stations, each student receiving television program frames appropriate to his previous responses. It is essentially a matter of replacing the typewriter input and output of a computer-based instructional system by a complex video tape system.

The adaptation of programmed material to television is not new. As early as 1961, Gropper and Lumsdaine (1), in cooperation with the Metropolitan Educational Television Stations WQEI-WQEK, of Pittsburgh, Pennsylvania, devised techniques for presenting programmed materials by television. They then compared the effectiveness of televised lessons containing programed sequences with conventional programed sequences. Their results suggested that programed materials could be presented to groups of students by television.

At Pennsylvania State University, where C. R. Carpenter and L. P. Greenhill have conducted numerous studies of educational television, a thorough examination of programed learning applied to television was initiated in 1962. In a comprehensive report of five experiments, three of which involved programed learning by closed circuit television, Greenhill and Carpenter (2) challenge some of the assumptions underlying presentation of programed materials.

In the first article of this publication, Carpenter (3) outlines the problems investigated: (1) Group versus individual presentation of programed materials; (2) the effect of varied rates of presentation on learning programed materials; (3) A comparison of paired versus individual student work in learning programed materials. The The basic goal of Carpenter and Greenhill was to show that learning at individual student paced rates was not an optimum learning situation and that students could learn as well when paced externally, thus justifying the use of closed circuit (or broadcast) television in presenting programed materials. On the basis of these experiments, they try to show that television, directed to groups of students, can perform all the functions normally attributed to teaching machines.

In the first study (4) Carpenter examines the problem of group presentation versus individual work in programed learning. One program was presented to groups of students by film-strip. The other program was taken individually in programed books and by teaching machine. No significant difference in achievement for 113 subjects was observed. The externally paced film-strip apparently was as effective as learner paced individual programed materials.

When research indicated that external pacing was not a critical factor, it became feasible to adapt programed materials for use on closed circuit television. This task was undertaken by Greenhill (5) and an evaluation of this technique was made. The specific problems were (1) to adapt programed algebra for closed circuit television and (2) to evaluate the effectiveness of the television presentation.

To prepare the programed materials for television presentation, visuals were prepared which contained the program frames. Written materials on cards would also be read when presented to students. The control group would take the same program individually with teaching machines. A sample of 63 students was selected and pretested for ability (SCAT scores).

The treatment involved 36 students using individual teaching machines and 27 students as a group, presented the same program by closed circuit television. It is interesting that for purposes of "motivation", the instructors "voice was used at appropriate times for emphasis or clarification, or reinforcement" on the televised presentation. An analysis of covariance indicated no significant difference between the two treatments in terms of student achievement in algebra. Televised externally paced programed algebra directed to groups of students was as effective as the individual use of learner paced teaching machines.

To extend the application of televised programed instruction to other subjects would require some evidence that its effectiveness was independent of particular content, consequently, Spencer (7) compared a televised program in English grammar with the same program taught by teaching machine. The results were essentially the same as for algebra, no significant difference. In addition Spencer compared both methods of presentation with conventional instruction by closed circuit television, with no significant difference.

In summarizing the results of these various studies, Carpenter (8) suggests that

"A principal result of the research was to show that the programed courses can be presented to students for study by the selected media and media combinations with approximately equal probabilities of learning gains."

Several suggestions are made relative to extending the research. Included is a suggestion to study the use of video-taped recordings. The desirability of extending the research to other content areas was also stressed.

Although Carpenter and Greenhill have evidence to suggest that televised programed instruction to groups is as effective as teaching machines used on an individual basis, one research study (9) revealed another factor of significance. For 375 students, some of whom were given televised instruction, and others given conventional classroom instruction, anecdotal responses were examined. The responses could be analyzed into two distinct types. One type reflected focus on self-initiation by the student. The other type response reflected passive participation by the student. It was found that students were "self-dependent" or "other dependent" according to the mode of presentation. Television presentation produced significantly greater "other-dependence" than conventional instruction, even for the same students.

A basic assumption underlying programed learning is that knowledge of the correctness of a response serves as a reinforcement. This general assumption is supported by most learning theorists, although they may differ in their interpretation of what is reinforcement. In examining the various learning theories. Hilgard (10) notes that a majority of learning theorists do accept certain principles. These theorists would probably agree that (1) A motivated learner acquires what he learns more readily than one who is not motivated, (2) learning motivated by success is preferable to learning motivated by failure. and (3) Learning under intrinsic motivation is preferable to learning under extrinsic motivation. It appears that programers have given far to great emphasis to point (2) and little thought to points (1) and (3). There is a general assumption that KR, alone, without an associated need or drive, provides for reinforcement.

Several studies have been conducted to examine the effects of KR, alone, in the absence of motivation. At the Johns Hopkins University, Chapanis (11) observed that "Information per se does not serve as an incentive". Subjects were convinced that they were preparing a tape for a digital computer. Actually, they were punching random digits into a teletype tape, but there was a computer in the room. All subjects were paid by the day for their services, having been hired for an indefinite period. Pay was in no way related to work output. Four separate treatments were possible: (I) Subject had access to no information on his work output; (II) Subject could see a counter which totaled his output, but it was never reset to zero. He never had his attention directed to it, but it was in clear view; (III) Subject had a counter which was reset to zero at the start of each day; again his attention was not directed to the counter, but it was in clear view; (IV) Subject had the same counter arrangement as (III), but he was instructed to keep a record of his output, taking a counter reading every 15 minutes.

Under the above conditions, the four experimental groups worked for 24 days, at which time the work was terminated. The experimental arrangements were such that the subjects never realized that they were involved in an experiment. They believed all the random digits were needed simply because the computer was being programed for a Monte Carlo problem.

Using the analysis of variance, there was no significant difference in the various treatments. Subjects with knowledge of their progress accomplished no more than subjects completely unaware of how much work they did. The F ratios were so small that "there was no reason to suppose further examination of the hypothesis was necessary". Success in this task represented amount of work done. Yet knowledge of amount of work did not serve as an incentive.

Other studies provided even more direct evidence concerning KR. At Temple University, Hough and Revsin (12) examined programed learning with and without KR. Ninety college students served as subjects under three separate treatments: (1) Subject used a teaching machine with selected responses; (2) Subject used a programed textbook with KR; (3) Subject used a programed textbook, but KR frames were left blank. Otherwise, the context was identical.

The analysis showed no significant difference in achievement. Knowledge of the correctness of responses did not serve as an incentive. Hough and Revsin concluded, "...at their present stage of development, teaching machines as such offer no instructional advantages." This comment would appear rather strong until one had examined other supporting evidence.

Such evidence was available. A similar experiment at the college level by Birt and Feldhusen (13) gave the same results. In a comparison of a conventional program with one where KR was not available, no significant difference in achievement was observed.

At the elementary school level, Moore and Smith (14) made the same observations. Spelling achievement did not differ significantly when children were exposed to programed materials with KR or without it. The conclusion was "...providing S with knowledge of the correct response does not facilitate his learning of spelling".

Learning Theory would indicate that KR, knowledge of correctness of responses, would not be a factor in reinforcement unless the subject was intrinsically motivated to need that KR. Otherwise, one might expect the student to be bored and uninterested, a characteristic which describes well the student with little or no motivation toward academic work.

A number of research workers have observed these characteristics. Gagné and Dick (15) report that day in-day out use of programed learning materials was monotonous and tiring for students. "Although the material itself may be interesting (to whom?), the problem of motivation requires study."

At Purdue, Feldhusen (16) reported that instead of programed learning materials providing reinforcement, there were disturbing signs of boredom, what he had called the "pall effect.". In another study, Reed and Hayman (17) observed that when the novelty wore off, students using programed English 2600 suffered from boredom.

The fact of boredom on the part of students is generalized by Gotkin and Goldstein (18) with the comment, "The single most common comment students make about programed instruction, after using it for a period of time, is that is a <u>boring</u> way to learn."

There is evidence to indicate that KR, alone, does not lead to greater learning. There is additional evidence that boredom and lack of interest is common among students using programed materials. Learning theory indicates that these facts can be accounted for in terms of the lack of student motivation. There is some research to support this view.

Carr (19), at the Wright Air Development Center, observed in a number of studies that confirming the correctness of a learner's responses to problems may be expected to be reinforcing only if the learner's motivation is intrinsic to the task being learned. This opinion may not be acceptable without a satisfactory experiment to support it, but at least one study examined this point directly.

Moore and Smith (20) compared two groups of students working with programed materials. One group was given KR alone, but the other group was given KR and, in addition, each student was given one penny for each correct response. There was a significant difference in achievement rates between the two groups. An extrinsic reward, when added to KR, was more effective in reducing error rate than KR by itself. If an extrinsic reward makes learning more effective that without such reward, the arousal of intrinsic motivation could produce unusual effectiveness in learning.

Previous research indicates the feasibility of presenting programed materials over television by video tape. Other research shows that knowledge of correctness of responses, alone, does not provide reinforcement. Thus students are often bored by programed materials in which no motivating factors have been provided. When extrinsic motivation is provided, learning is made more effective; therefore, it is likely that intrinsic motivation could significantly improve the effectiveness of programed learning materials.

Objectives

The primary objective of this research activity was to develop and evaluate the systematic use of motivating materials in an instructional program. A secondary objective was to continue the technical development of a video-sound system for providing programed television to individual students, and to improve techniques for programing such a system.

Several questions were investigated: Does the inclusion of motivating materials in an instructional program presented by television result in greater student learning than an identical program presented without such motivating materials? Under conditions of KR alone, and KR with motivating materials, is there a significant difference in student learning? Are the answers to these questions the same for high ability, average ability, and low ability students?

METHOD

Procedure

The procedure followed can be divided into five phases. In the first phase, five physics programs were written, and motivating materials were developed for those programs. During the second phase, the programs were recorded on video tape, appropriate props being used whenever possible to take full advantage of the media, and to make the programs less verbal. In the fourth phase, the programed video tape materials were presented to individual, selected students. In the fifth phase, test scores were analyzed to answer previously detailed research questions.

Work of the first phase was completed during the four months of October 1, 1965, to February 1, 1966. Five linear programs in physics, each covering a single, relatively independent concept or principle, were written. Motivational sequences were designed to arouse interest in, or need for, the program that followed. One motivational device appealed to interest; the other four appealed to personal survival. Three of these four related to automobile safety, and one related to safety from electrical shock in the home. For each program, one motivational device was presented before the program, under the assumption that it would cause the student to want or need to learn the subsequent subject matter of the program to a greater extent than without motivating materials.

The second phase was completed from February 1, 1966, to July 15, 1966. The programs and associated motivating materials prepared in phase one were in written form. They had to be adapted for presentation on television. During this period, visuals, props, and demonstration apparatus were assembled and located in the recording studio. Scripts for audio were written, and the entire set of programs were integrated in preparation for recording on video tape.

Work of the third phase was completed from July 15, 1966, to August 17, 1966. The first step of this phase was to lease and assemble the video-tape and camera apparatus for recording of the program. A studio system consisting of an Ampex 660-B Video tape recorder (with electronic editor), two vidicon view-finder cameras, and a switcher-fader console (EIA Sync) was leased. With materials already prepared for recording, the actual video recording was slow, tedius, and routine, it progressed without major difficulties. When the programs had been recorded visually, the electronic editor permitted adding sound later. Also the electronic stop-start mechanixm was controled by an audio impulse placed on the second audio channel; it too was added later using the electronic edit feature of the recorder.

The fourth phase was completed from August 17, 1966 to September 27, 1966. Sixty-six college students were selected according to ability (SCAT 1A scores). Two groups of 33 each were selected on a one-to-one matched ability basis. In addition 23 other students (unmatched) were selected for use in evaluating the programs and motivating materials. Each student was exposed to two programs, one with motivating material preceding it, the other without motivating material. After each program, the student took a multiple choice test over the concept studied. These scores were the basis of the analysis to be discussed later in this report.

The fifth, and last, phase was completed from September 27, 1966, to November 15, 1966. This phase involved the detailed statistical analysis of test results in the experiment. Because of the experimental design selected, it was possible to use the simple "t" test, instead of some elaborate statistical model.

Programs

Five linear programs in physics were produced in this research activity. They were titled (1) Pressure; (2) Kinetic Energy; (3) Potential Energy (4) Electric Circuits; and (5) Scaling Laws. Each of these programs consisted of a series of brief demonstrations and associated questions. After each question was asked, the video tape recorder stopped automatically while the student constructed his response. When the student was ready, he pushed a button which restarted the recorder playback. The correct answer to the previous "frame" was then presented, and a new demonstration shown and question asked.

Program length varied from 11 minutes, 10 seconds, to 28 minutes, 10 seconds of real recording time. The program frames varied from 13 to 25. Each program was preceded by a short motivating sequence consisting of part of a film, with narration added by using the electronic editor.

The first program, Pressure, was motivated by a film scene showing a real tornado destroying homes. The narration suggested that knowledge of the principle which followed would help the student protect himself if he should ever be threatened by a tornado. It was assumed that the motivating device would appeal to the fundamental need of personal survival. The subject matter dealt with the concept of pressure and how tornado funnel pressure can "explode" a home.

The second program, Kinetic Energy, was motivated by a scene of an automobile skidding off a highway and crashing into a tree. The narration indicated that a knowledge of the principle that followed might help the student avoid such a collision himself. This appeal to personal safety was expected to cause the student to need the knowledge which he would acquire from the program. The program itself taught concepts of work, kinetic energy, thermal energy, and conservation of energy.

The third program, Potential Energy was motivated by the same scene used for Kinetic Energy, but the narration discussed the dangers of mountain driving, and the need to understand certain principles of physics to prevent the automobile brakes from igniting, causing a crash. The subject matter included work, potential energy, thermal energy, and conservation of energy.

The fourth program, Electric Circuits, was preceded by a sequence showing typical kitchen electrical appliances, with narration indicating the possibility that such appliances can be dangerous, unless a certain principle of circuits is understood. The concepts of electric circuits involved diagrams of basic circuit elements and the three-wire system of the home, including the significance of the center-tap ground.

The fifth, and last, program, Scaling Laws, was motivated by interest. It was preceded by a 5 minute section of the film, "The Three Worlds of Gulliver", showing a giant next to normal size people. The narration suggested that such giants were impossible because of a principle of physics which the student would learn in the subsequent program. Scaling Laws taught basic relationships of strength and weight to linear measures, and how the strength to weight ratio changes as the scale factor is changed.

The Sample

Students exposed to the programs were selected on the basis of ability, using as a measure of ability the SCAT 1A total raw scores converted to standard (T) scores from national norms.

Originally, it was planned to select a representative sample from a normal population, including 54 sets of students matched in ability. To this end, required T scores were listed, and names and telephone numbers of new college students were taken from college files. From this original list of some 800 names, subjects were selected in order, as they were willing to accept an appointment to participate in the project.

As the scheduling of students began, it became apparent that the sample design would not be met. It was impossible to get low ability students to participate. Although the time required was only two hours for one time only, many students, particularly those with lower ability, either refused to participate, or make appointments and then failed to appear.

As a consequence of appointment problems, the final sample consisted of 89 students, 66 of which were matched in ability, to form a set of 33 matched pairs. They were not representative of a normal population, although this goal was approximated. For this sample, the mean T score was 51.93 and the variance was 95.16, not significantly different from the required values of 50 and 100 respectively.

Each subject was called by telephone and given the following message:

"We are conducting an expirement with television teaching under a grant from the U.S. Office of Education. In order to evaluate the programs we have prepared, we have selected certain students who can assist us. You are one of those persons. Would you be willing to come to the campus to watch two brief programs and take two short quizzes over those programs? It would be for one time only, and the total time required is less than two hours"

When the answer was, "yes", an appointment was made and the student told,

"It is very important that you keep this appointment, or let us know well in advance if you cannot make it. You will be using, by yourself, some twelve thousand dollars worth of television equipment, plus taking the time of two staff members. If you cannot be here, then we want to schedule someone else"

Thus the importance of keeping the appointment was stressed. It is curious that, in spite of this appeal, a large number of lower ability students failed to keep appointments, and made no attempt to give notification that they would not appear.

Experimental Design

Each subject was exposed to two programs, one preceded by a motivational sequence, and another program without motivational material. For matched pairs of students, the same programs were presented to each pair, but they did not receive the same motivational material. At the conclusion of each program, subjects took a 15 question multiple choice test over that program.

There were ten possible treatments in the experiment. Five programs preceded by motivational material, and five were the same programs presented without motivational material. The treatments are designated by a letter M or U, corresponding to motivated or unmotivated, followed by a number from 1 to 5, corresponding to (1) Pressure; (2) Kinetic Energy; (3) Potential Energy; (4) Electric Circuits; and (5) Scaling Laws. Thus, for example, M3 would refer to the program on potential energy preceded by a motivational sequence.

To eliminate the necessity of administering pre-tests, and to avoid non-equivalence of tests themselves, the following experimental design was used for matched pairs of students. A given pair of students would take programs X and Y, each followed by tests over those programs. One student would take MX followed by UY. The other student would take UX followed by MY. Then in an analysis of the results of tests over these programs, a comparison would be made between the sums of the motivated program scores and unmotivated program scores for that pair. The following example illustrates that design. Students A and B are matched in ability.

Student A	Program Sequence:	M1 then U5
Student B	Program Sequence:	U1 then M5

Find $(M1)_A + (M5)_B$ and $(U1)_B + (U5)_A$, calling the first sum M and the second sum U.

Such an experimental design has several advantages. It permits the use of the simple "t" test for comparing the means of the two treatments M and U. By having each student take both an unmotivated and a motivated program in the way outlined above, all variables associated with the program and with the evaluative instruments are automatically accounted for. Even student ability is not a factor which should affect this design, although it is important in studying the significance of ability differences on motivational factors.

The values of M and U discussed above for 33 pairs of students matched by ability can be compared. Also, comparisons can be made for low, middle, and high ability levels, to determine if motivational factors are ability dependent. In order to use results of the 23 students who were unmatched in ability, a second analysis would be made comparing all 89 M scores with U scores, some equivalence being established for the tests, to make the comparison valid.

Achievement scores on programs were determined in the following way. Each test consisted of 15 multiple choice questions. Each question had 5 possible responses. Each response was assigned a value of -2, -1, 0, 1, or 2, so that if every item were marked randomly, the probably result would be zero. Some answers were thus better than others; the test discrimination was thereby increased through this scoring technique. The total score was determined by adding 30 to the total point values listed above. A perfect paper **then** would receive a score of 60. A paper on which the student had made 15 bad guesses would receive a zero. There would be no negative scores. A blank response was counted as zero, so that a blank test paper would have a score of 30.

RESULTS

<u>Ability Scores</u>

Ability scores used in these analyses were determined by converting SCAT 1A total raw scores to standard scores (mean of 50 and variance of 100) based on national, grade 13 norms. For the full sample of 89 students, the mean ability score was

51.93 and the variance was 95.16, making this sample nearly representative of a normal distribution. The 66 students making up the 33 matched pairs had a mean ability of 54.36, somewhat larger than the full sample.

In grouping matched pairs for ability, the following classification was used. Ability scores less than or equal to 47 formed seven pairs into the low ability group. Scores from 47 to 57 formed 13 pairs into the middle ability group. Scores equal to or greater than 57 formed 13 pairs into the high ability group. These groupings show the left-skewness of the ability distribution resulting from the difficulty of finding matched pairs of low ability subjects in sufficient numbers.

When all 89 students are included in the analysis, 28 fall in the low group, 32 in the middle group, and 29 in the high group. This distribution is more normally distributed about the mean of 51.93 than is the matched set of 33 pairs of students about the mean of 54.36.

Matched Pair Analysis

Sixty six subjects formed the set of 33 pairs matched by ability for which the experiment was designed. To perform an analysis of the matched pairs, the M scores and U scores for a given pair of students would be summed as described previously. Table I shows the resulting mean scores for the total group, and for sub-groups of low, middle, and high abilities. As the table indicates, there was no significant difference in achievement on the programs for the group, or for any one ability sub-group.

TABLE I

Group (ability)	$\bar{U}$*	$\bar{M}$**	t	df	Level of significance
High ($A>57$)	110.2	107.3	1.16	24	$.2<p<.3$
Middle ($47<A<57$)	99.5	96.4	.78	24	$.4<p<.5$
Low ($47>A$)	92.7	97.9	.90	12	$.3<p<.4$
Total	102.2	101.0	.48	64	$.6<p<.7$

*Sum of quantities $[(UX)_B+(UY)_A]$ divided by number of pairs.

**Sum of quantities $[(MX)_A+(MY)_B]$ divided by number of pairs.

Total Group Analysis

As an alternate analysis, although inferior in design to matched pair analysis, all motivated test results were compared with unmotivated test results. These comparisons were made for the total group and for high, middle, and low ability groups.

No direct comparison of the 89 sets of scores could be made unless all five tests and programs were of equal difficulty. Because this assumption could not be made, some adjustment had to be made to approximate this equivalence.

To provide for an equivalence of tests, all motivated and unmotivated scores for each of the five tests were placed together in five sets, means and standard deviations being found for each of the five sets. Each score could then be converted to a standard score to make comparisons possible.

Because the assignment of programs was nearly random, and because each test was used nearly the same number of times, a mean of all motivated standard scores compared with the mean of all unmotivated standard scores is a valid comparison.

Grouping into mow, middle, and high ability groups uses the same criteria in this analysis as was used for matched pair analysis. When the statistical comparisons are made, as shown in Table II, again, no significant difference in achievement scores between motivated and unmotivated students for the total group, or for any sub-group of low, middle, or high ability is observed.

TABLE II

Group (ability)	$\bar{U}$*	$\bar{M}$**	t	df	Level of significance
High (A>57)	57.7	55.8	1.19	56	$.2<p<.3$
Middle (47<A<57)	50.2	45.7	1.88	62	$.05<p<.1$
Low (47>A)	44.3	45.7	.16	54	$.8<p<.9$
Total	51.1	49.0	1.44	176	$.1<p<.2$

*Sum of all U scores in group divided by number in group.
**Sum of all M scores in group divided by number in group.

DISCUSSION

The observed results of this research activity are, at first cognizance, surprising. Not only is there no significant difference for any group or sub-group, by either method of analysis, but the mean scores themselves are numerically higher in most instances in the unmotivated case. If these differences were not merely chance occurences, as the significance tests show, it would appear that the so-called motivating material had worked oppositely, at least for some ability levels.

However, if only numerical comparisons were made, the most striking mean difference occurred in favor of the motivational materials for the lowest ability group in the matched pair analysis. Still, again, these observed differences could have occurred by chance alone with a high probability.

Although numerical comparisons of means is tempting, it is clear that no such interpretations as mentioned above can be made from these results. All observed differences could have occurred by chance alone with a high probability.

A somewhat less obvious characteristic of these results, noticed by this investigator, was that students did inordinately well on all program tests. For the instructional time required, students acquired abilities to use certain physics concepts and principles considerably better than experience has shown is possible in a regular classroom teaching situation. This result is unsubstantiated with data, since it derives entirely from the subjective experience of a teacher. But it was so apparent, it deserves mention.

Although not discussed previously, the Ampex 660B video tape system functioned excellently in providing individual instruction through the TV monitor. During the evaluation of the programs, the recorder had to start or stop some nine thousand times, a task which certainly was not a normal design consideration. The only difficulties encountered were that the recorder head voltage required periodic adjustments, the heads needed regular cleaning, and the automatic tension control finally failed, requiring only that the manual control be used.

CONCLUSIONS, IMPLICATIONS, AND RECOMMENDATIONS

Because this research activity had two objectives, the evaluation of motivating materials in an instructional program and the further technical development of a programed video system, conclusions must be made with respect to both objectives.

In terms of a video-tape instructional system, this project made considerable progress. A new stop-start control mechanism was devised which used as a control impulse an audio signal placed on the second audio channel of the recorder. This control technique was superior to the one used previously involving reflecting tape and a photoelectronic device.

The systematic procedure for preparing linear programs for video tape recording and presentation has been developed to where future modifications of the procedure will be refinements and improvements in technique.

During the research period itself, the cost of video tape recorders has dropped to where it is now possible to purchase an acceptable system for under $5000. Thus the feasibility of programing appropriate parts of courses now exists. The ultimate use of random access video tape, controlled by a small computer, becomes more possible as the costs continue to decrease.

The quality of programing in this project was at best poor. The process of producing and recording demonstrations, and not just talk, especially related to a linear program, is extremely difficult to do well. It requires competent technicians, writers, artists, and television studio personnel. Although the investigators had much television experience, they were not specialists in all these fields, and in spite of attempts to be all these things, they could not successfully perform in a way that produced quality materials. The surprising effectiveness of the programs in teaching the concepts is made even more remarkable by the fact that the programs were not polished, were not well done.

The results of the comparisons of motivated and unmotivated treatments, at first, might indicate that the so-called motivational materials did not motivate. This conclusion is tenable. However, there is another conclusion which appears far more probable that should be considered.

The basis of this research project was that students were bored with conventional, written programs, and because many students never really needed to make correct responses, knowledge of the correctness of a response was of no consequence. The programs used in this project, because they were preceded by materials designed to motivate, should cause greater learning than without such motivational material.

This research project may have never really tested motivational materials; it perhaps could not have done so. The use of a novel television system, for which students received appointments stressing their own importance was, in itself, extremely motivating. Students were already motivated when they appeared to take programs. This hypothesis is supported by the very high achievement of students on all programs, preceded or not by motivating materials. For a student already highly motivated, the preceding materials used could do little to add to their desire to learn well the subsequent material.

Programs were presented individually, by a novel TV system, where much attention was being given to the student. He worked with the system a maximum of only 2 hours and therefore had no time to become bored, as with written materials used for several months. In short, the Hawthorn effect completely eliminated the prepared motivational materials as factors in the experiment.

One must accept one of the above conclusions, although both might be partly true. Either the motivational materials were not motivating, or, if they were, they were not as important as confirming responses, or, the Hawthorn effect so enhanced the achievement of students as to mask any difference that the motivational materials would have produced.

Although hindsight is always considerably more accurate than foresight, it is clear that this investigator should have recognized the possible influence of the Hawthorn effect in making the original research proposal. Although the project has been quite successful in developing the video instructional system, this lack of foresight has meant that motivating materials still have not been properly investigated.

It is strongly recommended that the results of this research not be used to discount the possibility of providing specific motivating materials before or within an instructional program. It is further recommended that research be supported which will examine effects of different techniques of providing these motivational materials for all kinds of instructional programs. This project suggests also that studies be carried out in extended, conventional programs, where the student is completely unaware that an experiment is being conducted.

In terms of motivational materials, the task of selecting materials appealing to basic needs is difficult, but further attempts in this respect should be made. It is likely that appeals to secondary needs would be more fruitful. It would also be important to examine the possibilities of providing individualized motivational devices based on real needs of individual students.

The entire area of motivation needs specific attention. Much research is needed to evaluate its need, and the best techniques for providing it.

SUMMARY

The literature has revealed that programed learning materials often lead to boredom for students. Also, in many studies, programed materials teach no better than conventional instruction. The assumption that knowledge of correctness of responses is motivating without an associated need has not been established as fact.

Programed materials had been adapted for presentation by television but not with the video tape recorder. This type presentation needed further development.

The project involved the writing of five linear physics programs which were adapted for presentation on television to individual students by video taped recordings. Each of the five programs had sequences preceding it which were designed to motivate the student to learn the subsequent material. Each student would take two programs, one motivated, the other unmotivated, each followed by a test over the concept taught.

An experimental design involving 66 students under a matched pair motivated and unmotivated treatment, gave results that showed no significant difference in achievement between motivated and unmotivated programs. A similar result was observed when a full sample of 89 students was examined under a design comparing directly the motivated with the unmotivated test score results.

Rather than considering that the motivational materials failed, because of extremely high test results on all programs, the novel aspect of the TV apparatus, and the brief exposure time for students, it was concluded that the Hawthorn effect masked any possible results due to motivational materials. It was recommended that further studies be carried out using motivating materials over more extended periods of time in conventional instructional programs.

The progress in developing the video-instructional system was significant, but production of programed video tape materials requires considerable numbers of competent staff to get quality results. The decreasing costs of video apparatus makes its use routinely feasible.

REFERENCES

Book

10. Hilgard, R. and Bower, G. H. Theories of Learning. New York: Appleton-Century Crofts, Inc. pp 562-564.

18. Miles, M. B. Innovation in Education. New York: Teachers College, Columbia. 1964. pp. 231-247

14. Moore, J. W. and Smith, W. I., ed. Programmed Learning. New York: D. Van Nostrand. [illegible]. pp. [illegible]

Article

11. Chapanis, A. "Knowledge of Performance as an Incentive in Repetitive Monotonous Tasks", Journal of Applied Psychology. 48, August 1964. pp. 263-267

16. Feldhusen, J. "Taps for Teaching Machines", Phi Delta Kappan. 44, No. 6 March 1963. pp. 265-267

13. Feldhusen, J. and Birt, A. "A Study of Nine Methods of Presentation of Programed Learning Materials," Journal of Educational Research. 55, June-July 1962. pp. 461-466.

15. Gagne, R. M. and Dick, W. "Learning Measures in a Self-Instructional Program in Solving Equations", Psychological Rep. 10, 1962. pp. 131-146

12. Hough, J. B. and Revsin, B. "Programmed Instruction at the College Level: Factors Influencing Learning," Phi Delta Kappan. 44, March 1963. pp. 286-297.

9. Insel, S. A., Schlesinger, K., and Derosiers, W. "Dependency Responses to Televised Instruction," Journal of Applied Psychology. 47, No. 5, October 1963.

REFERENCES

Article

17. Reed, J. and Hayman, J. "An Experiment Involving the Use of English 2600; an Automated Instruction Text", Journal of Educational Research. 55, June-July 1962. pp. 476-484

Research Report

2. Carpenter, C. R. and Greenhill, L. P. Comparative Research on Methods and Media for Presenting Programed Courses in Mathematics and English. The Pennsylvania State University. March 1963.

3. Carpenter, C. R. "The New Media and Programed Learning", Carpenter and Greenhill, loc. cit. pp. 1-10.

4. Carpenter, C. R. "Research on Methods for Presenting Programed Mathematics," Carpenter and Greenhill, loc. cit. pp. 11-25

8. Carpenter, C. R. "Observations, Judgments, and Suggestions for Further Research," Carpenter and Greenhill, loc. cit. pp. 73-74.

6. Greenhill, L. P., Lottes, J. J., and Pagano, A. "Adaptation of a Programed Mathematics Course for Television Presentation", Carpenter and Greenhill, loc. cit. pp. 29-38.

5. Lottes, J. J., Palmer, G., and Oakes, H. "An Experimental Comparison of Differential Rates of Pacing Programed Materials," Carpenter and Greenhill, loc. cit. pp. 25-29.

7. Spencer, R. E. "Comparisons of Televised With Teaching Machine and Televised With Instructor Presentations of English Grammar," Carpenter and Greenhill, loc. cit. pp. 57-63.

REFERENCES

Research Report

19. Carr, W. J. Self Instructional Devices. Wright Air Development Center Technical Report 59-503. 1959.

1. Lumsdaine, A. A. and Gropper, G. L. "Studies in Televised Instruction", Reports #5 and #7, American Institute for Research. 1961.

APPENDIX A

PRESSURE-1

1. The quantity "16 pounds" is what kind of a physical measure?

A. Power
B. Work
C. Energy
D. Force
E. Mass

2. The quantity "weight" is the same as the quantity

A. Power
B. Work
C. Energy
D. Force
E. Mass

3. Which of the following is a formula definition of pressure?

A. F/A
B. PA
C. $1/2\ mv^2$
D. A/F
E. P/F

4. An area of 4 square inches is pushed on by 12 pounds. In units using pounds and square inches, the pressure is

A. 48
B. 3
C. 1/3
D. 24
E. 9

5. In units of pounds and square inches, the pressure due to the atmosphere is, approximately,

A. 12
B. 8
C. 30
D. 15
E. 20

6. In units using pounds and square inches, the air pressure in a tank is 25. What force does the air exert inside the tank on an area of 4 square inches?

A. 100
B. 4/25
C. 6.25
D. 200
E. 15

7. It is desired to find the surface area of an irregularly shaped flat object. A pressure of 10 units produces a force of 25 pounds. In square inches, the surface area is

A. 250
B. 10/25
C. 150
D. 2500
E. 2.5

8. In the equation y = z/x, to solve for z one must
A. Move the x to the other side of the equation
B. Divide both sides of the equation by x.
C. Multiply both sides of the equation by x.
D. Move the z to the other side of the equation.
E. Invert both sides of the equation.

9. A floor surface is 3 inches long and 2 inches wide. In pounds, the atmosphere exerts a force on this surface of

A. 45
B. 30
C. 90
D. 15
E. 6/15

10. A pressure of 20 units on a circular surface of radius 2 inches exerts a force in pounds of

A. 251
B. 40
C. 10
D. 1/10
E. 25.1

11. A steel block 20 inches high, 3 inches thick and 5 inches wide has a weight of 60 pounds. In units of pounds and square inches, it exerts a pressure of

A. 3
B. 12
C. 15/20
D. 20/60
E. 4

12. The air pressure in a sealed container is 30 units when the pressure outside is 35 units. The net pressure is

A. 5 units outward
B. 5 units inward
C. 65 units outward
D. 65 units inward
E. 0 units

13. The air pressure in a sealed box of surface area 30 square inches is 20 units when the outside pressure is 18 units. The net force in pounds is

A. 60
B. 2
C. 15
D. 600
E. 540

14. A rectangular container is 3 inches by 3 inches and 10 inches high. The pressure inside this container is 30 units when the pressure outside is 18 units. The net force in pounds on one wall is

A. 12
B. 48
C. 108
D. 360
E. 4

15. An average tornado

A. Travels southwest at over 300 mph with a funnel pressure of -3 units.

B. Travels northeast at over 300 mph with a funnel pressure of -3 units.

C. Travels northeast at 35 to 45 mph with a funnel pressure of 12 units.

D. Travels northeast at 35 to 45 mph with a funnel pressure of -3 units.

E. Travels southwest at over 300 mph with a funnel pressure of 12 units.

KINETIC ENERGY-2

1. The weight of an object is the same as

A. Energy
B. Force
C. Mass
D. Power
E. Work

2. The following is a correct formula definition of the work done on an object.

A. $W = F/d$
B. $W = Mgh$
C. $W = w \times h$
D. $W = 1/2\ MV^2$
E. $W = F \times d$

3. A force of 20 pounds pushes a 50 pound box through a distance of 5 feet. The work done on the box, in appropriate units, is

A. 12.5
B. 100
C. 25
D. 10
E. 250

4. A force of 30 pounds pulls a 60 pound box through a distance of 5 feet at a speed of 4 ft/sec. The work done on the box, in proper units, is

A. 2
B. 150
C. 12
D. 6
E. 300

5. An 80 pound box pulled at constant speed 3 feet across a table top by a force of 27 pounds transfers how much energy (in proper units) to the table top?

A. 80/27
B. 3/24
C. 81
D. 9
E. 240

6. When a box is pulled across the surface of a table at constant speed, the work done is converted into

A. Speed
B. Mechanical energy
C. Kinetic energy
D. Potential energy
E. Thermal energy

7. An object moving on a frictionless surface under the action of a constant force

   A. Moves at a constant speed
   B. Loses kinetic energy
   C. Transfers thermal energy
   D. Acquires potential energy
   E. Accelerates uniformly

8. When work is done on an object moving on a frictionless surface, the energy of the object

   A. Is converted into heat
   B. Is lost
   C. Accumulates as potential energy
   D. Accumulates as kinetic energy
   E. Is dissipated as thermal energy

9. The correct formula for the kinetic energy of a moving object is

   A. F x d   B. w x h
   C. 1/2 w x V^2 D. w x V^2/64
   E. MV^2

10. A 50 pound car moving at 16 ft/sec for 10 seconds has a kinetic energy of

   A. 2000 units   B. 800 units
   C. 9000 units   D. 500 units
   E. 200 units

11. An object has a kinetic energy of 6 units while moving at 8 ft/sec. When moving at 16 ft/sec it has a kinetic energy of

   A. 12 units   B. 24 units
   C. 48 units   D. 128 units
   E. Can't be determined without weight

12. A 50 pound car has a kinetic energy of 70 units. If the speed of the car is tripled, the kinetic energy is

   A. 630 units   B. 210 units
   C. 3500 units   D. 150 units
   E. Can't find without knowing speeds.

13. Examine the following table:

Y	X
5	2
17	3
40	4
78	5
135	6

The variable Y is

A. Proportional to X
B. Proportional to the square of X
C. Proportional to the cube of X
D. Inversely proportional to X
E. Inversely proportional to the square of X

14. The minimum stopping distance of an automobile on wet pavement from a speed of 20 mph is 30 feet. On the same surface, minimum stopping distance from a speed of 40 mph is

A. 120 feet
B. 60 feet
C. 600 feet
D. 80 feet
E. 15 feet

15. The minimum stopping distance of an automobile on a gravel surface from a speed of 30 mph is 40 feet. On the same surface, the minimum stopping distance from a speed of 90 mph is

A. 120 feet
B. 360 feet
C. 1080 feet
D. 3600 feet
E. 60 feet

POTENTIAL ENERGY-3

1. The weight of an object is the same as

   A. Mass B. Power
   C. Work D. Force
   E. Energy

2. The following is a correct formula definition of the work done on an object.

   A. $W = F \times d$ B. $W = w \times h$
   C. $W = 1/2\ MV^2$ D. $W = Mgh$
   E. $W = F/d$

3. A force of 20 pounds pushes a 50 pound box through a distance of 5 feet. The work done on the box, in appropriate units, is

   A. 250 B. 10
   C. 100 D. 12.5
   E. 25

4. A force of 30 pounds pulls a 60 pound box through a distance of 5 feet at a speed of 4 ft/sec. The work done on the box, in proper units, is

   A. 300 B. 12
   C. 6 D. 2
   E. 150

5. An 80 pound box pulled at constant speed 3 feet across a table top by a force of 27 pounds transfers how much energy (in proper units) to the table top?

   A. 240 B. 81
   C. 9 D. 80/27
   E. 3/24

6. When a box is pulled across the surface of a table at constant speed, the work done is converted into

   A. Kinetic energy B. Thermal energy
   C. Potential energy D. Mechanical energy
   E. Speed

7. An object moving on a frictionless surface under the action of a constant force

   A. Accelerates uniformly
   B. Transfers thermal energy
   C. Acquires potential energy
   D. Loses kinetic energy
   E. Moves at a constant speed

8. When work is done on an object moving on a frictionless surface, the energy of the object

   A. Is dissipated as thermal energy
   B. Accumulates as potential energy
   C. Accumulates as kinetic energy
   D. Is lost
   E. Is converted into heat

9. When an object is lifted at constant speed through a given distance, in what form does the work done on the object appear?

   A. Potential energy   B. Kinetic energy
   C. Thermal energy   D. Heat energy
   E. It is lost.

10. A 10 pound weight lifted vertically through a distance of 5 feet at constant speed stores how much energy (in proper units) in the gravitational field?

11. A 20 pound weight is lifted at 5 ft/sec through a vertical distance of 2 feet. The potential energy of the **weight** is then (in proper units)

   A. 100   B. 10
   C. 40   D. 4
   E. 7

12. What is the potential energy of a 3000 pound automobile at the top of a mountain 7000 feet above its base (in proper units)?

   A. 7/3   B. 21,000,000
   C. 3/7   D. 21,000
   E. 3000

13. How much heat must be dissipated in the brakes of a 4000 pound car to drive safely down a mountain 2000 feet high (in proper units)?

A. 2
B. 1/2
C. 4,000,000
D. 2,000,000
E. 8,000,000

14. A 4000 pound car is at rest at the top of a hill 200 feet high. If the car is to have 200,000 units of kinetic energy at the bottom of the hill, how much heat must be dissipated in the brakes on the way down?

A. 1,000,000
B. 800,000
C. 600,000
D. 400,000
E. 200,000

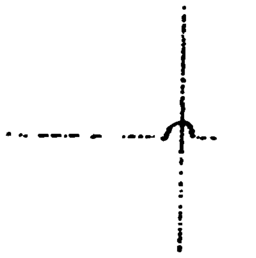
15. A 5000 pound automobile at the top of a mountain 4000 feet high is ready to drive back down. If the brakes of this car can dissipate a maximum of 10,000 energy units per second for ten minutes without igniting, what <u>minimum</u> number of stops is necessary in descending the mountain?

A. 2
B. 3
C. 4
D. 5
E. 6

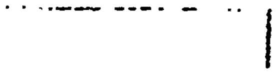
CIRCUIT DIAGRAMS-4

1. The following is a correct symbol for a single conductor of electric current.

A. 

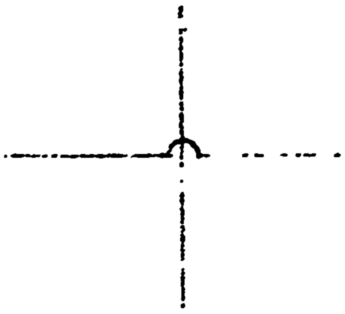
B. 

C. 

D. 

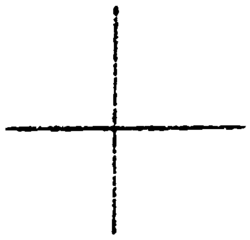
E. 

2. The following is a correct symbol for the place at which two electric conductors cross without making electrical contact.

A. 

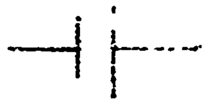
B. 

C. 

D. 

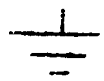
E. 

3. The following symbol represents a source of alternating current.

A. 

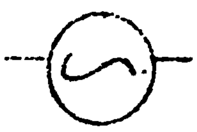
B. 

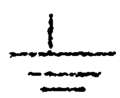
C. 

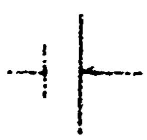
D. 

E. 

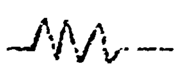
4. The following symbol represents an electrical resistor.

A. 

B. 

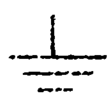
B. 

D. 

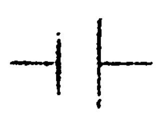
E. 

5. The following symbol represents the heating element in an electric skillet.

A. 

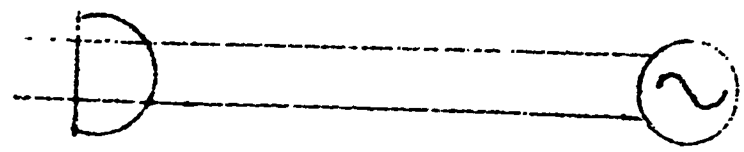
B. 

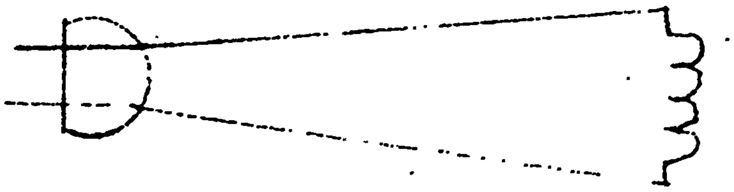
C. 

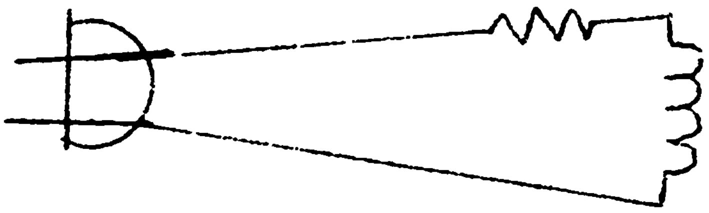
D. 

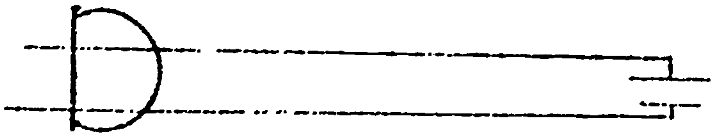
E. 

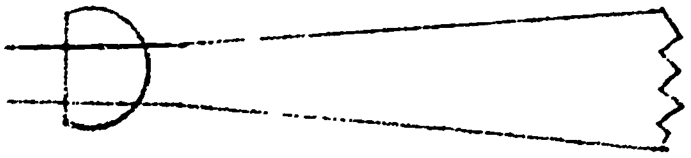
6. The following circuit diagram represents an electric toaster.

A. 

B. 

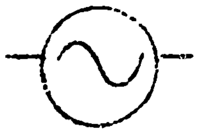
C. 

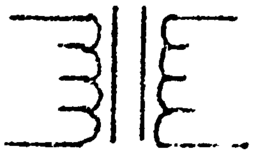
D. 

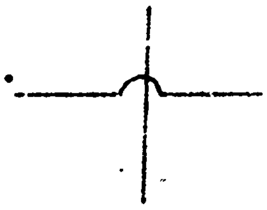
E. 

7. The following symbol represents a transformer.

A. 

B. 

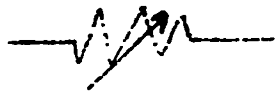
C. 

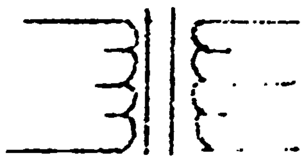
D. 

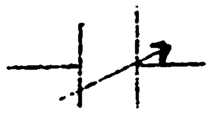
E. 

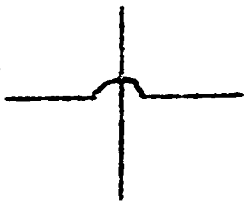
8. The following symbol contains a center-tap.

A. 

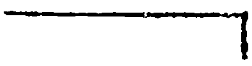
B. 

C. 

D. 

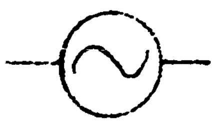
E. 

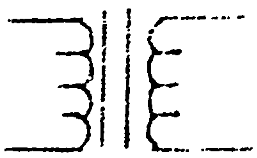
9. An iron rod is driven 6 feet down into the earth, and a conductor is soldered to the rod. This electrical arrangement is represented by the following symbol.

A. 

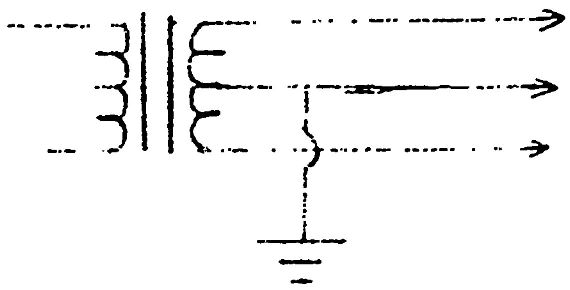
B. 

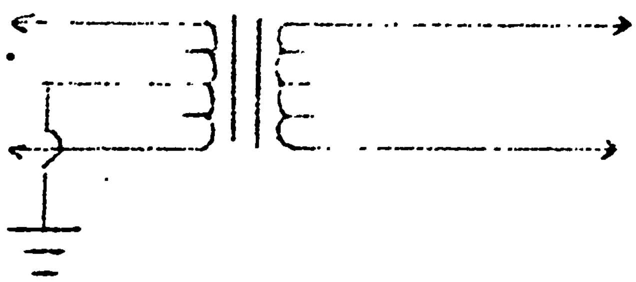
C. 

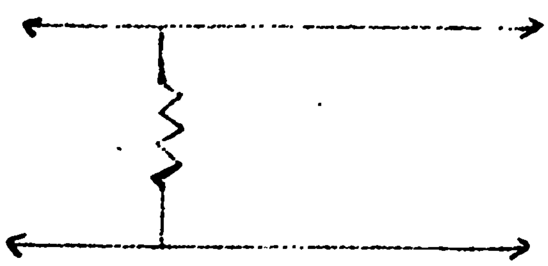
D. 

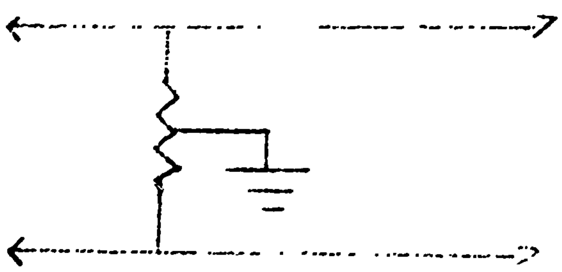
E. 

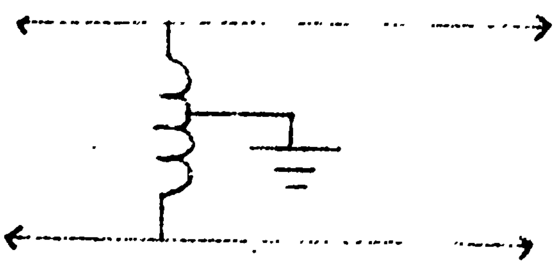
10. The following symbol represents the electrical power circuit from your house to the high voltage power lines outside your house.

A.  HOME

B.  HOME

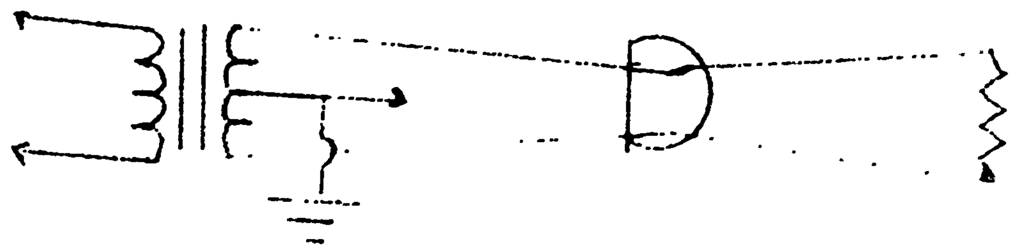
C.  HOME

D.  HOME

E.  HOME

11. The following diagram represents the circuit from the power pole outside your house to a 110 volt electric skillet plugged into a wall outlet.

A.



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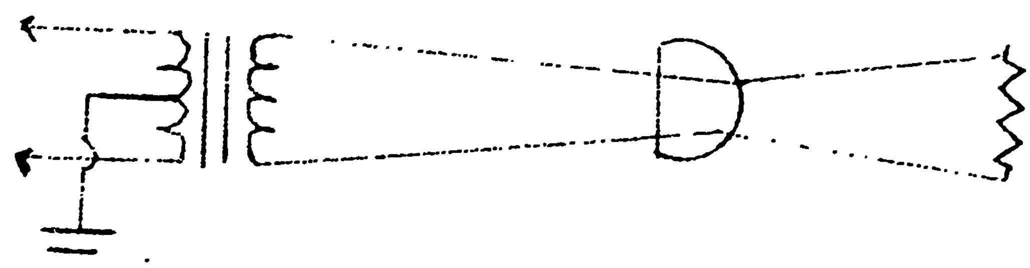
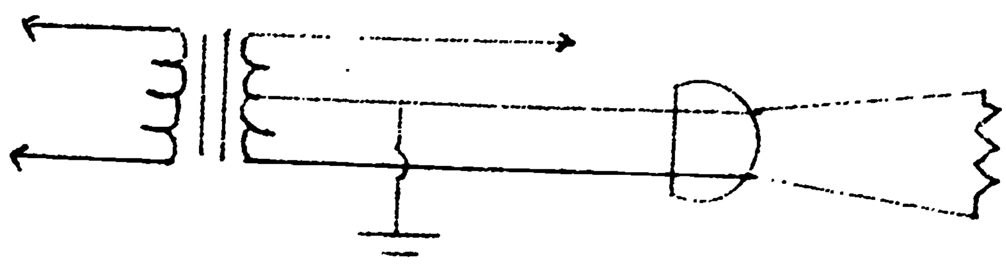
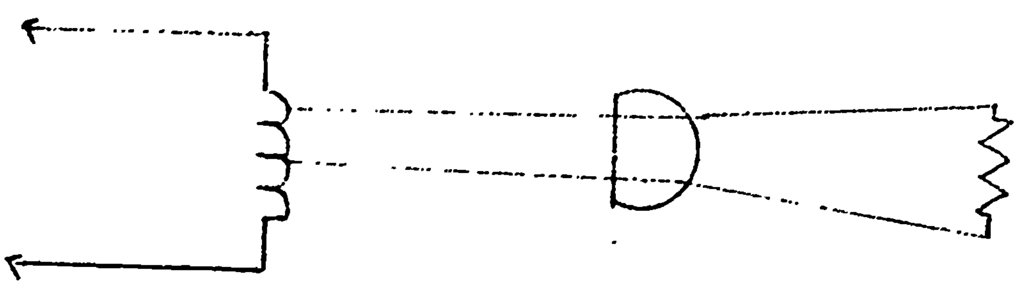


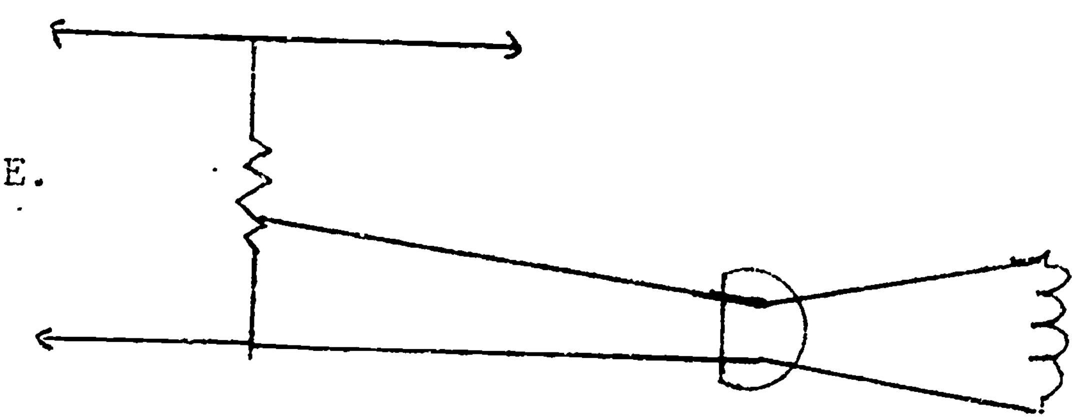
C.



D.

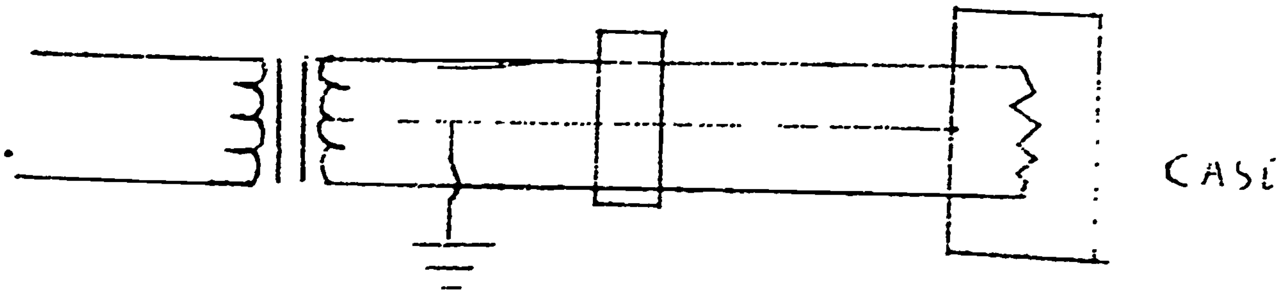


E.

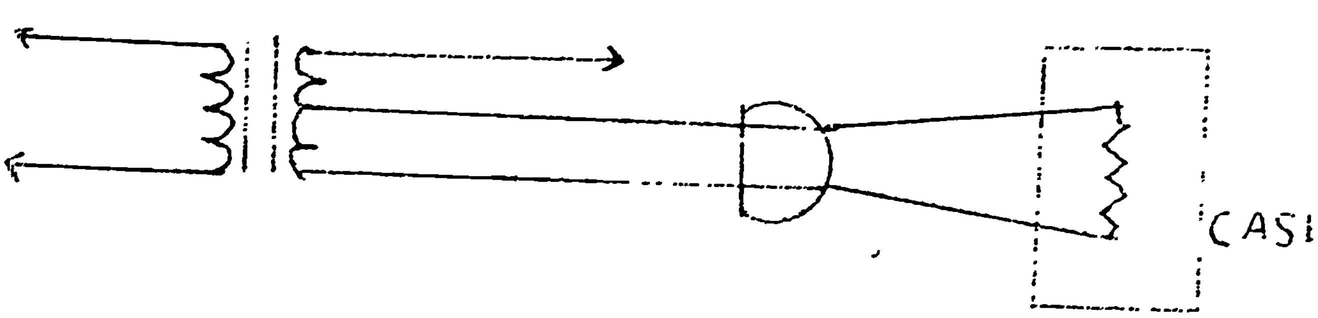


12. The following diagram represents the circuit from the power pole to a 220 volt electric dryer in a house.

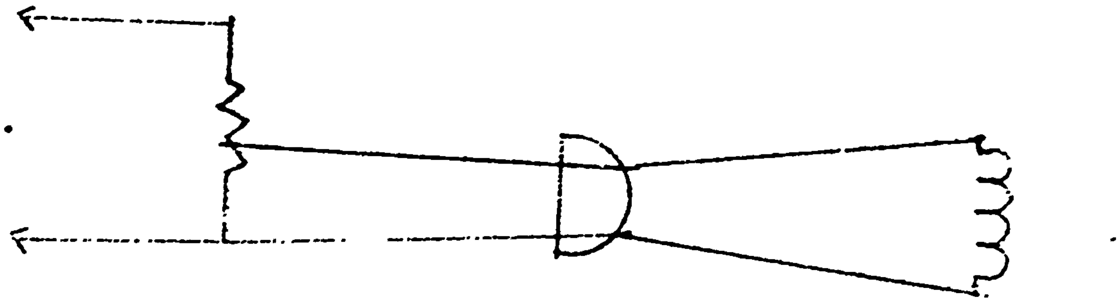
A.



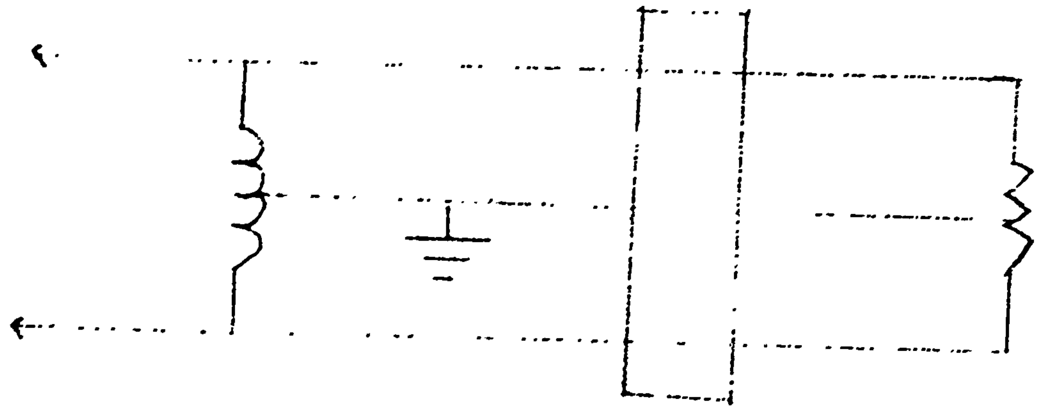
B.



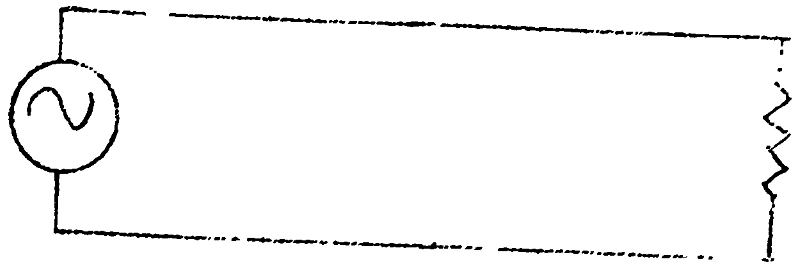
C.



D.

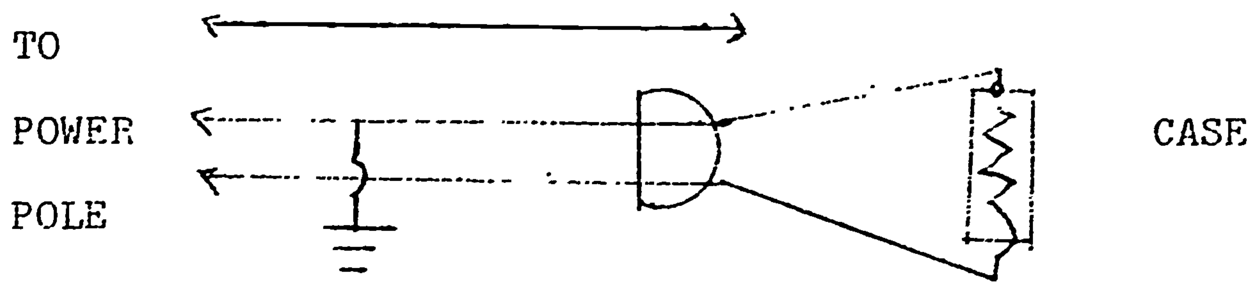


E.

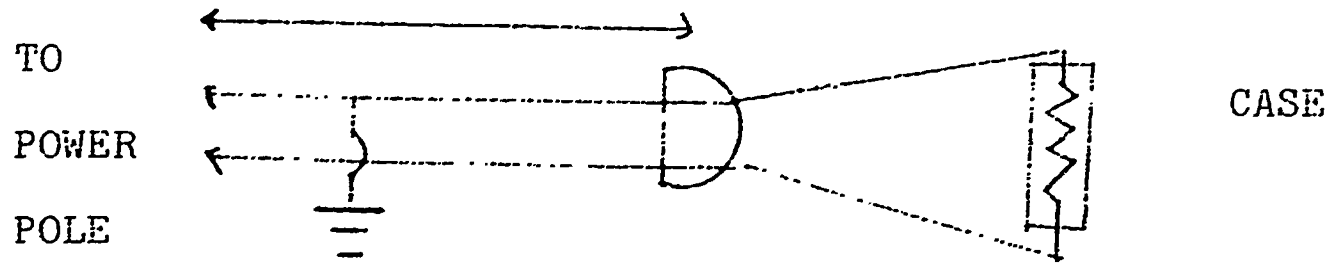


13. The following diagram represents an electrical appliance which could give an electrical shock when its metal case is touched.

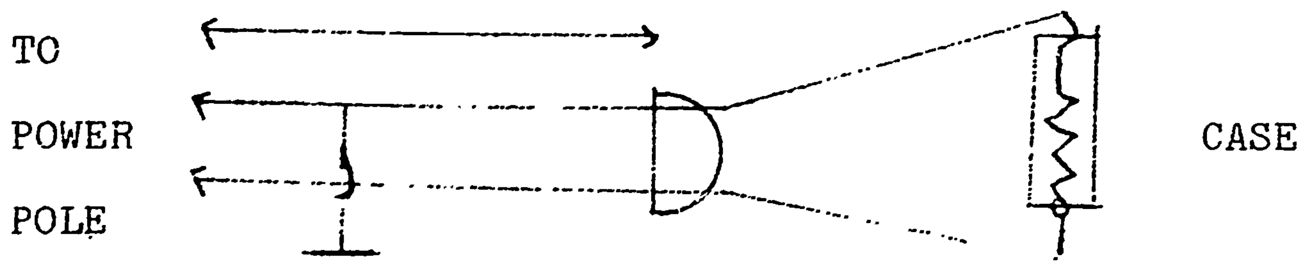
A.



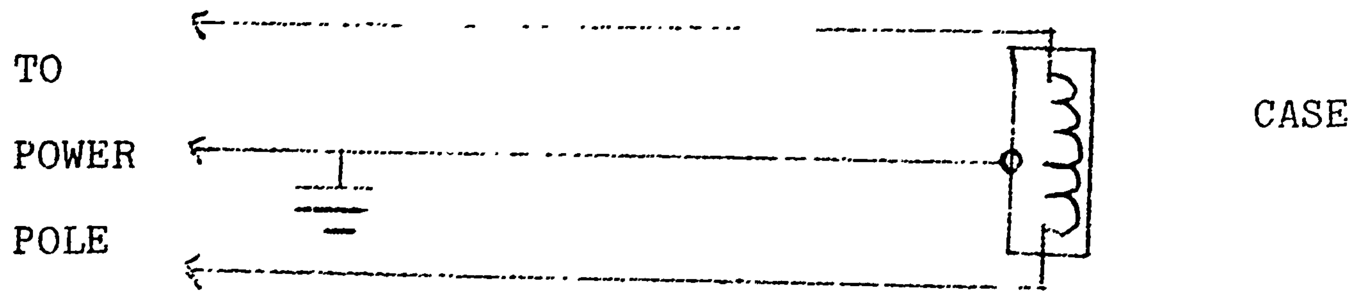
B.



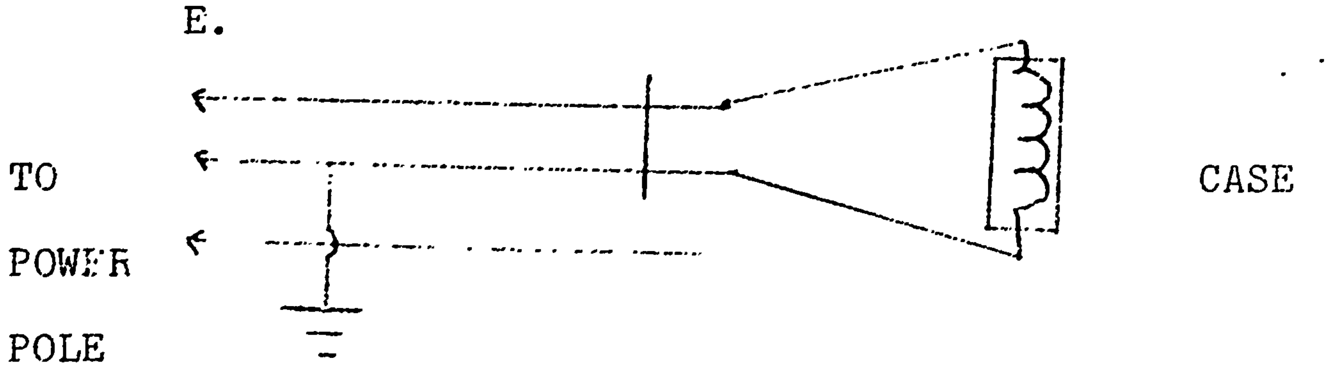
C.



D.

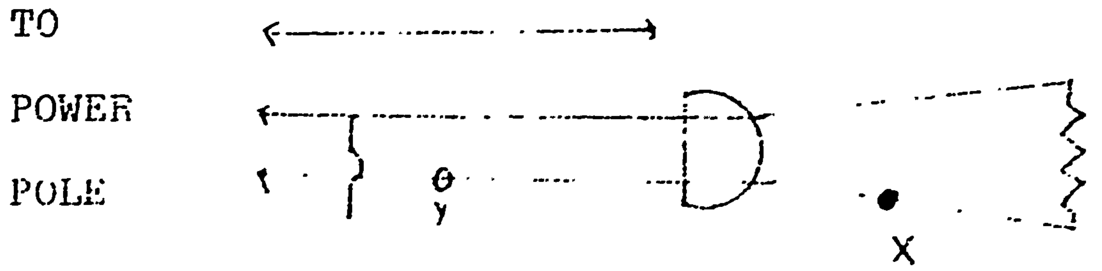


E.

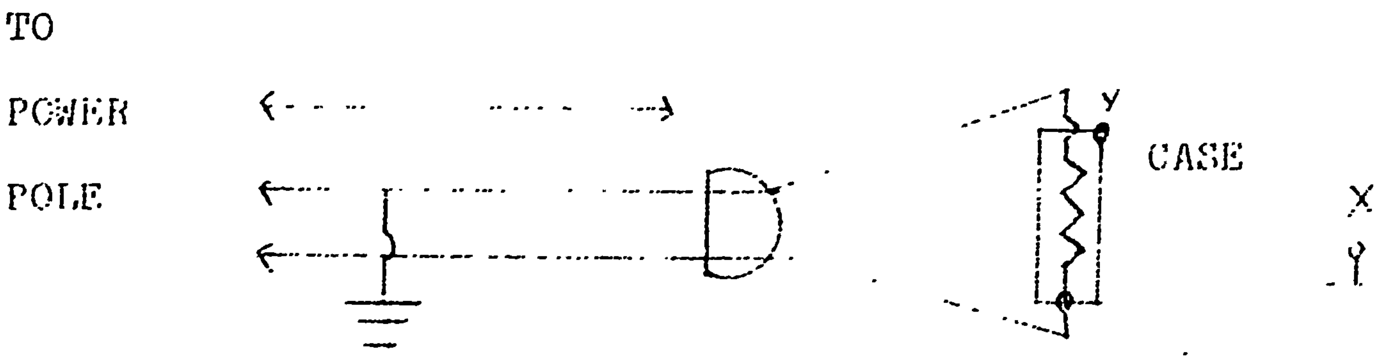


14. In which one of the following circuits could you receive an electric shock by touching simultaneously points marked X and Y?

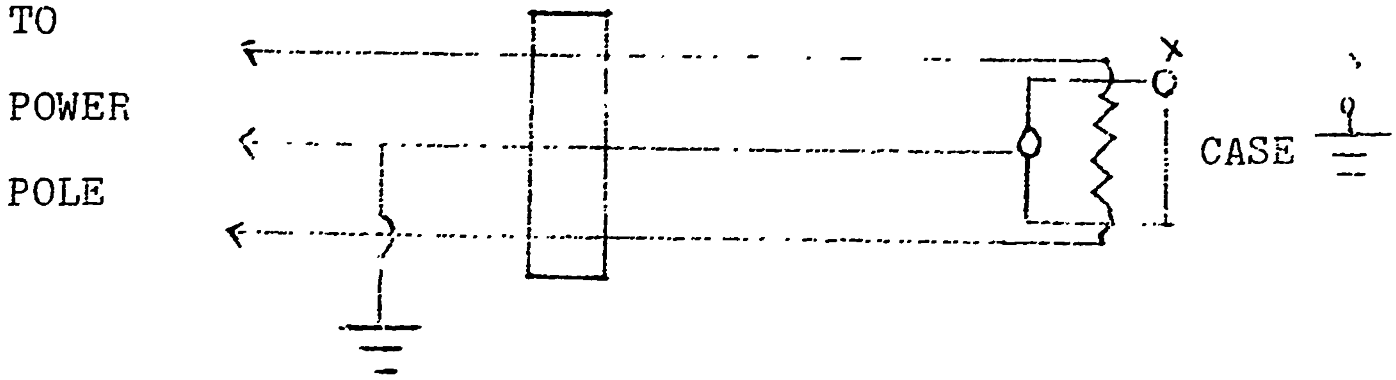
A.



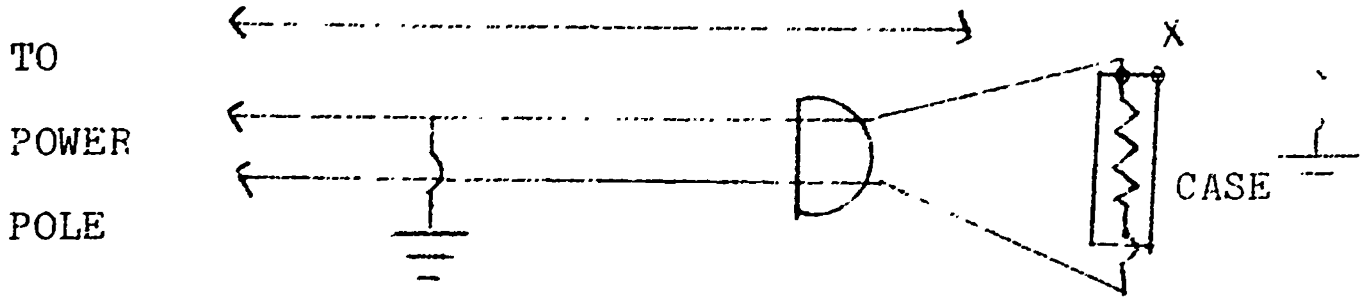
B.



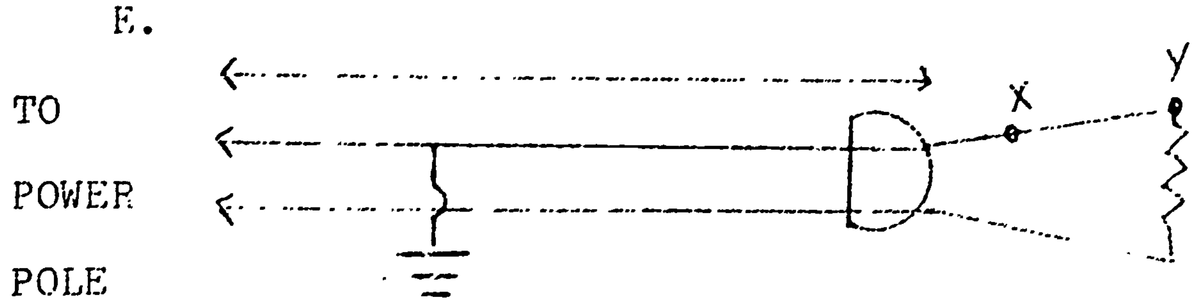
C.



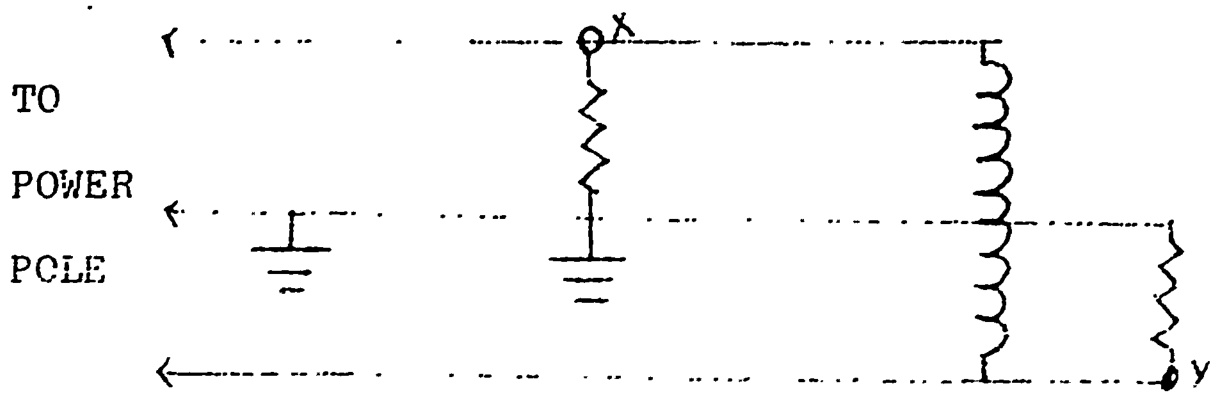
D.



E.



15. How much voltage exists between points X and Y in the following circuit?



A. 110 volts

B. 0

C. 220 volts

D. 440 volts

E. 117 volts

SCALING LAWS-5

1. A piece of string breaks under a force of 3 pounds. An identical piece of string twice as long is how strong?

   A. One half as strong B. Twice as strong
   C. Same strength D. One fourth as strong
   E. Four times as strong

2. One piece of string breaks under a force of 5 pounds. How much force is required to break three pieces of identical string?

   A. 5 pounds B. 5/3 pounds
   C. 3/5 pounds D. 45 pounds
   E. 15 pounds

3. A cable has a breaking strength of 500 pounds. A cable having twice as much cross-sectional area has what breaking strength?

   A. 250 pounds B. 2000 pounds
   C. 125 pounds D. 500 pounds
   E. 1000 pounds

4. A cable of diameter 1/8 inch has a breaking strength of 2 tons. A similar cable of diameter 3/8 inch has a breaking strength of

   A. 6 tons B. 18 tons
   B. 2/3 tons D. 2/9 tons
   E. 9 tons

5. A cable of diameter 1 inch has a breaking strength of 8 tons. A similar cable having a diameter of 4 inches would have what breaking strength?

   A. 8 tons B. 32 tons
   C. 128 tons D. 2 tons
   E. 1/2 ton

6. A strut has a breaking strength of 60 pounds. A similar strut having a diameter 3 times larger would hold

   A. 120 pounds B. 60 pounds
   C. 20/3 pounds D. 540 pounds
   E. 20 pounds

7. A cylindrical tank holds 200 pounds of water, a similar tank with a diameter 3 times larger would hold

A. 1800 pounds B. 600 pounds
C. 800 pounds D. 5400 pounds
E. 200 pounds

8. A water-filled tank is three times larger in every linear dimension than a smaller tank. If the smaller water-filled tank weighs 60 pounds, how much does the larger tank wiegh?

A. 180 pounds B. 1620 pounds
C. 540 pounds D. 20 pounds
E. 20/3 pounds

9. A solid object weighs 200 pounds. How much does a similarly shaped object weigh when its linear dimensions are all increased by a factor of 4?

A. 12,800 pounds B. 50 pounds
C. 800 pounds D. 2400 pounds
E. 3200 pounds

10. A man weighs 160 pounds. How much would he weigh if he were 3 times larger in every linear dimension?

A. 480 pounds B. 1440 pounds
C. 320 pounds D. 960 pounds
E. 4320 pounds

11. A 160 pound man has leg bones and muscle with a breaking strength of 960 pounds. If he is 4 times larger in every linear dimension, what then is the ratio of his weight to his strength?

A. 4/1 B. 1/4
C. 2/3 D. 3/2
E. 16/96

12. A 200 pound man has leg bones and muscle with a breaking strength of 1000 pounds. If he is only 1/10 as large in every linear dimension, for his size and weight how much stronger is he than at normal size?

A. 1/10 B. 1/100
C. 10 times D. 100 times
E. 1000 times

13. An ant that weighs .001 pounds is made 1000 times larger in every linear dimension. For his size and weight, how much stronger is this giant ant than a real ant?

A. 1000 times
B. 1/1000
C. 1/100
D. 100 times
E. 1/10

14. A 150 pound man has leg bones and muscle with a breaking strength of 1500 pounds. How much would he weigh and how much could his legs support if he were 10 times larger in every linear dimention?

A. 150,000; 150,000
B. 1500; 15,000
C. 150,000; 15,000
D. 150,000;1,500,000
E. 1,500,000; 150,000

15. A man is 6 feet tall, weighs 150 pounds, and has leg bones and muscle with a supporting strength of 2000 pounds. If this man were somehow made 100 times larger in every linear dimension, a 600 foot giant, how much strength would his legs then lack just to support his own weight?

A. 185,000 pounds.
B. 20,000,000 pounds
C. 200,000 pounds
D. 150,000,000 pounds
E. 130,000,000 pounds