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Comparison of individualized-instruction method and conventional group-lecture-discussion instruction method for classes in beginning college auto mechanics

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Comparison of individualized-instruction method and
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method for classes in beginning
college auto mechanics

by

Colin Ching-Ho Chen

A Dissertation Submitted to the
Graduate Faculty in Partial Fulfillment of
The Requirements for the Degree of
DOCTOR OF PHILOSOPHY

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Approved:

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CHAPTER I. INTRODUCTION

Today, we are often reminded that the techniques and methods of the past are no longer adequate for the present, even though they may have served quite well in meeting past needs. In his book, Future Shock, Alvin Toffler (1971) emphasized that the world is in a state of rapidly accelerating change, and human beings may not be able to keep up with the rate of change. Virgil M. Howes (1971), professor at the International Center for Educational Development, summarized this point of view by stating: "Change, a characteristic of our world, proceeds at a dizzying pace" (p. 4).

While change is proceeding at this accelerated pace, educators have also become more concerned with meeting the needs of individuals. In our traditional educational system, the schools often group students by chronological age and ignore or pay little attention to the importance of treating every person in accordance with his or her individual interests and differences. Virgil M. Howes (1971) concluded that ". . . to ignore the fact of different learning styles is both inefficient and wasteful both of teacher time and of student effort" (p. 13).

Today, educators' attitudes toward learning exemplify their concern for individual interests and differences. Robert A. Weisgerber (1971) in his book entitled Perspectives

in Individualized Learning, observed: "In a trend that reflects our contemporary times, the emphasis of learning is shifting from concern with the group norm toward concern for the individual: including his needs, capabilities and personal preferences" (p. ix).

The same point of view was expressed by James E. Duane (1974), he wrote:

One of the major trends in education today is the gradual transition from group instruction to individualized instruction. Educators are beginning to realize that instruction cannot be maximumly effective when it is oriented toward group similarities. Instruction must be organized to account for individual differences, since each and every learner has unique learning styles, experiential backgrounds and abilities (p. 32).

Ideally, the best way to meet individual differences is to have one teacher teach one student. But we know that such a method is impractical currently. Consequently, we have to reorganize our instructional methods into ways which will permit students to progress at their own pace and level of achievement.

Presently, it is possible for a student to select kinds of food or beverages from a vending machine; but why, when the individual enters the classroom, may he or she be subjected only to the instructional method which is identical to that of all other students, with limited or no alternatives? It is a fact that people have different interests, progress at

different speeds, achieve learning objectives through the use of different media; however, our educational system is arranged in blocks of content with few alternatives to break the fixed time schedules or instructional procedures. Virgil M. Howes (1971) stressed: ". . . the instructional materials and facilities to provide a well-stocked cafeteria for individual choices are frequently not available" (p. 15). Grouping plans may be convenient to the teacher, but these inflexible curricula, with their standard texts and examinations, tend to force students into a common mold and lead them to complain of their days: "I came, I saw, I concurred" (Howes, 1971, p. 16).

In the field of industrial education, individualized instruction is common. Due to the nature of the activities in an industrial-education laboratory environment, a great degree of individual instruction is required, especially in the early stages of laboratory courses. The stated departmental goals of teaching and learning of industrial education at Iowa State University contain implicit recognition of this fact: "Discover and develop talents, attitudes, interests, and individual potential related to the industrial/technical cluster areas" (Undergraduate Curriculum Committee, 1974, p. 2).

The need for individualized instruction exists in every school system. Because of the rapidly changing technology in the world and our knowledge of individual differences, it

seems that individualized instruction is a way to bridge the gap between the teaching and the learning environment. It may also be one of the directions for innovation and reform in education today. It is believed that it may now be the more appropriate time to provide instruction that is effectively geared to the learning styles, rate, needs, and interests of the individual. The following study is undertaken to (1) develop the individualized-instruction method; and (2) determine its effectiveness, in terms of test achievement scores and gain scores, when compared to the conventional group instructional method, i.e., the group-lecture-discussion instruction method.

Statement of the Problem

The problem of this study was to determine the effectiveness of two specific teaching methods in selected units of automechanics. Specifically the following two goals were posed for this study:

1. To compare the gain scores on selected learning unit tests between the individualized-instruction method and the conventional group-lecture-discussion instruction method.
2. To compare the achievement scores on a comprehensive final test between the individualized-instruction method and the conventional group-lecture-discussion instruction method.

Statement of the Purpose

The purposes of this study were:

1. To establish which instructional method enabled a student to gain a higher score from the selected learning units.
2. To determine which instructional method enabled the student to achieve a higher score on the comprehensive final test.
3. To provide more research information for industrial-education teachers regarding auto mechanics instructional methods.

Need of the Study

Current literature reveals considerable interest in the subject of this study, and suggests the need for future research.

Gale Norman Neff (1973) conducted a study at Portland Community College concerning the design, development, and testing of an experimental individualized-learning method employed in teaching automotive brake systems. He recommended that: "The individualized learning method should be used to teach the basic units regarding the automobile brake systems" (p. 80). It may also be appropriate to use individualized instruction to teach other units related to basic auto mechanics courses. Due to the rapidly changing technology in

the world, information has been so extensively accumulated that we cannot expect a student to learn it all. We may have to adopt a "cafeteria" principle in which we will help each student select what he or she needs most to fulfill ultimately his or her potential as a person and as a successful employee. Lindley J. Stiles (1974) supported this point:

To prepare for the automated complexity of the twentieth century society, he has need for the skills of the knowledgeable technician with distinctly individualized ability and for carefully cultivated individual potential (p. 122).

The individualized-instruction method should be used to teach technical courses, because both the student and the teacher may benefit from this method. From a student's point of view, there are two reasons for individualization: it may add incentive to learn, and it should enable the individual to develop the ability to work alone. For the teacher, this method may aid in developing a more effective learning environment.

Fred S. Keller (1968), in the article titled "Good-bye, Teacher," compared the status of today's teaching with the future teaching, as follows:

The teacher of tomorrow will not, I think, continue to be satisfied with a 10% efficiency (at best) which makes him an object of contempt by some, commiseration by others, indifference by many, and love by a few (p. 88).

It is believed that a greater variety of instructional methods will be instituted to increase learning and teaching efficiency. We assume that if the student is neither asleep nor sick, he or she can learn a great deal if the right kind of instruction is provided. Well developed individualized instructional methods should be one of the goals of our educational system today.

Gale Norman Neff (1973) supported this point and stated:

. . . what is needed is a system which permits the selection of both the curriculum and the manner in which it will be presented for each individual learner, and the individualized learning systems have been developed to accomplish just this (p. 28).

Fred S. Keller (1968) also stressed that individualized instruction is important to the student, too. He emphasized that individualized instruction methods should be offered to the student and the sooner the better, or it may be too late. He said: ". . . if we do not provide them, and provide them soon, he may be inspired to say, "Good-bye" to formal education" (p. 88).

The previous statements clearly show the reasons for using individualized instruction. However, studies about the effects of individualized instruction methods should be undertaken, because there is noticeable lack of behavioral-science research in this area. Richard V. Jones (1968) emphasized this justification:

Recent writers in the field of education have emphasized the need for more individualized approach to the instruction in our public schools Research in this behavioral science is reemphasizing the uniqueness of the person and the lack of our present instruction in education to define even a majority of these unique characteristics of people, [much less research in this area]¹ (p. 178).

There are some cautions about the limitations of individualized instruction. Ferguson (1975) in an article entitled "Pitfalls and Frustrations of Individualization," said:

Individualization and open education are beautiful ideas for beautiful people. But we must never lose sight of the serious frustrations which occur when people are not able to absorb the responsibilities for individual actions (p. 29).

Some other limitations of individualized instruction were also stressed by Calhoun (1975) when he stated:

. . . two of the problems that have plagued this method of instruction [individualized instruction] are dropouts and poor self-pacing by some students (p. 16).

These limitations aside, sources provide strong evidence of a need for more individualized instruction and scientific measurement of its effectiveness. The suggestion that this method may add to the learner's incentive to learn, save time, and develop an individual's potential to work alone, combined with the lack of prior research in this area, raised an interesting challenge to this researcher.

¹[] added to quotation by author.

Hypotheses of the Study

The following hypotheses were formulated and tested:

Research hypothesis I

It was hypothesized that there would be no significant difference in initial knowledge background between the individualized-instruction group and the group-lecture-discussion instruction group.

Statistical hypotheses Nine sub-hypotheses will be tested using the following general statistical hypothesis:

$$H_0 : \mu_{E.....} = \mu_{C.....}$$

$$H_A : \mu_{E.....} \neq \mu_{C.....}$$

where

$\mu_{E.....}$: Mean of the experimental group on given tests.

$\mu_{A.....}$: Mean of the control group on given tests.

Research hypothesis II

It was hypothesized that there would be no significant difference between mean gain scores of the individualized-instruction group and the group-lecture-discussion group.

Statistical hypotheses Six sub-hypotheses will be tested using the following general statistical hypothesis:

$$H_0 : \mu_{E\dots\dots} = \mu_{C\dots\dots}$$

$$H_A : \mu_{E\dots\dots} \neq \mu_{C\dots\dots}$$

where

$\mu_{E\dots\dots}$: Gain score means of the experimental group on given tests.

$\mu_{C\dots\dots}$: Gain score means of the control group on given tests.

Research hypothesis III

It was hypothesized that there would be no significant difference in the group means of the final comprehensive test scores between the individualized-instruction group and the group-lecture-discussion instruction group.

Statistical hypothesis One sub-hypothesis will be tested using the following statistical hypothesis:

$$H_0 : \mu_{E_{FCT}} = \mu_{C_{FCT}}$$

$$H_A : \mu_{E_{FCT}} \neq \mu_{C_{FCT}}$$

where

$\mu_{E_{FCT}}$: Mean of the experimental group on the Final Comprehensive Test.

$\mu_{A_{FCT}}$: Mean of the control group on the Final Comprehensive Test.

Assumptions of the Study

The following assumptions undergird this study:

1. The size of the sample was sufficient to obtain the meaningful results needed.
2. The length of the experimental time (5 weeks) was short enough to eliminate differences resulting from maturation.
3. The Mechanical Reasoning Test Form S was a valid and reliable measure of the student's mechanical aptitude for this study.
4. The Minnesota Scholastic Test was a valid and reliable measure of the student's scholastic aptitude for this study.
5. The pre-tests, post-tests, and comprehensive final test were valid and reliable measures of the student's score achievement for this study.
6. The five selected units in this study were representative of the entire course.
7. The Hawthorn effect and pretest treatment interaction, if any existed, were distributed evenly to both instructional groups.

Limitations of the Study

The following limitations relate to this study:

1. College-level students enrolled in Industrial Education 261, Winter Quarter, 1975, at Iowa State University were selected for the pilot study.
2. College-level students enrolled in Industrial Education 261, Spring and Fall Quarters, 1975, at Iowa State University were selected and included in this study.
3. Five instructional units to be administered during one-half of each quarter were selected and prepared for this study.
4. This study was limited to the examination of two methods of instruction, namely the utilization of the learning package for individualized instruction and the group-lecture-discussion.

Procedure of the Study

These procedures were followed:

1. A review of the literature devoted to individualized instruction and various kinds of individualized learning packages related to industrial education subjects was completed.

2. Individualized learning, research design and statistics, and the proposed topic were discussed with experienced professionals in the Industrial Education Department and other departments at Iowa State University.
3. The proposed topic was presented to members of the graduate-study committee and revised according to the recommendations of this committee.
4. The individualized learning packages were developed for selected units from the basic automotive course, Industrial Education 261.
5. Students were randomly assigned to two groups: One group participated in the individualized-instruction method, while the other was taught by the group-lecture-discussion instruction method.
6. A pilot study was conducted and the measurement instrument and instructional materials were revised.
7. The major study was conducted during the Spring and Fall quarters, 1975.
 - a. A t-statistic equation was used to test the initial differences.
 - b. Gains were calculated and the t-statistic was used to test the research hypothesis II.
 - c. A t-statistical equation was used to compare the difference between mean comprehensive final test of two groups.

8. Conclusions were drawn based upon the analyzed data, and the recommendations were prepared.

Definition of Terms

The following definitions of terms were prepared for this study:

Behavioral objective: A statement written to define specific performance, conditions of performance, and level of proficiency (Kapfer and Kapfer, 1973, p. 13).

Group-lecture-discussion instruction: An instruction procedure in which the instructor is attempting to teach a number of persons the same thing at the same time under lecturing and discussion (Good, 1973, p. 334, & p. 305).

Individualized instruction: A way of organizing instruction that permits and encourages each student to progress at a pace and to a level in a manner commensurate with his or her previous achievements and needs (Kapfer and Kapfer, 1973, p. 23).

Individualized-learning package: Instructional methods which consists of instructional materials, learning aids, instructor guide or manual, pre- and posttests, validation data, description of intended student population, and learning objectives (Good, 1973, p. 306).

Mechanical test: A test of a person's potential ability to succeed in work or study involving the understanding and

manipulation of machinery and mechanical devices (Good, 1959, p. 561).

Scholastic test: A measurement instrument devised to determine student achievement in school subjects, generally in the academic subjects (Good, 1959, p. 564).

Pretest: A criterion test administered prior to instruction of subject material and designed to determine the student's need for the lesson (Kapfer and Kapfer, 1973, p. 13).

Posttest: A criterion test administered after instruction of subject material and designed to determine whether or not the learner met the behavioral objectives of the lesson.

CHAPTER II. REVIEW OF LITERATURE

Topics selected for inclusion in this chapter are limited to those which appeared to be most directly related to the research problem. They were grouped into two major areas:

1. Related learning packages for individualized instruction;
2. Related study results of individualized instruction.

Related Learning Packages for
Individualized Instruction

Definitions of the term individualized-learning packages were numerous and varied from one author to the next. Carter V. Good (1973), defined the individualized-learning packages as an instructional method which consists of instructional materials, learning aids, instructor guide or manual, pre- and post-tests, validation data, description of intended student population, and learning objectives (p. 306). With this definition in mind, the most relevant studies to this problem were presented as follows:

Learning Activity Packages (LAP)

The concept of the Learning Activity Package was developed originally at the Nova Schools in Ft. Lauderdale, Florida, under the direction of Dr. James Smith (1972). The method provided the student with optional learning modes, various kinds of instructional media, and different kinds of activities from

which he or she might choose.

Richard Jones (1968) explained that the important steps of developing a LAP were:

1. To identify the major concepts or learnable ideas to be understood by the learner, then sequence them in a manner least complex to most complex.
2. To write down these sequential concepts or learnable ideas in instructional objective format that should include:
 - a. The kind of behavior which will be demonstrated by the learner when he or she completes the lesson.
 - b. The minimum acceptable level of performance which will be demonstrated by the learner.
 - c. The set of circumstances which will be in operation when the performance is demonstrated.
3. To provide for self-evaluation.
4. To give well-organized learning activities and/or teacher's instruction.
5. To prepare a posttest (pp. 178-180).

In developing the LAP, one thing which is very important is concentrating on making the LAP easy to use and attractive to the learner. Here is a list of suggestions given by James E. Smith (1972):

1. Use double-space and type it well.
2. Color code the various sections.
3. Use pictures or cartoons to illustrate the idea.
4. Use a small box or circles in front of each learning activity statement for easier record keeping (p. 16).

The Single-Page Learning Model

Leonard F. Dalton (1972), reported that there is a learning model used in Alhambra, California, that is a simplified one-page learning model containing all of the necessary elements. These elements, with some suggestions for developing a well-done Single-Page Learning Model, were listed as follows:

1. Subject: To provide information for classification.
It is a good way to set up a special identification code within a school system for developing the concept sequence references.
2. Concept: To list all of the ideas intended to be learned. The statements here should contain little or no factual data.
3. Purpose: To explain the "why" of the model and establish a rationale for why these parts of the curriculum should be learned.
4. Objectives: To describe the expected performance of the learners when they have completed this

lesson. It is suggested that the statements be written as follows: "The student will be able to . . ." or "You will be able to"

At this point, the learner is allowed to take a pretest as he or she desires. In so doing, the learner will be able to compare his or her ability with the objective criteria. In case one can achieve the predetermined standard of the objectives, he or she could skip the lesson and proceed to the next one or the quest activity. The quest activity is designed for the rapid learners.

5. Learning activities: To list all of the possible ways for increasing motivation, and helping the learner to establish the idea that learning is fun.
6. Posttest: To provide a final evaluation about the learned materials. This test is identical, [to,] or nearly so, to the pretest, with limited modifications. The posttest serves as a measurement of growth. The test should be administered under the supervision of a teacher.
7. Quest: To offer the opportunity for quick learners to explore the information in more depth. The activities belong to the learners

absolutely and they should be allowed to do their personal thing.

Finally, Leonard F. Dalton (1972) concluded that this model of an instructional method could (1) leave the teacher with more time to prepare more learning packages during a given period of time; (2) maintain a flexible curriculum by using the same learning package to teach several levels of students with different complexities of content; and (3) save cost by eliminating the need for cabinets for storing the learning materials (pp. 13-15).

The Duluth Contract

In an article entitled "The Duluth Contract: What It Is and What It Does," Thorwald Esbensen (1972) stated that there was a particular type of learning package developed at the West End School of St. Jean's Parish in Duluth, Minnesota. The curriculum offerings in the school are administered in the manner of organized contracts. Each family receives a set of catalogs of curriculum. Upon agreement with the school, each family can determine what they want their child to learn over a period of time.

Elements of all Duluth Student Learning Contracts were explained as follows:

1. Content classification: Identifies the part of the curriculum to which this lesson should belong.

2. Purpose: Answers the question "Why" and establishes the value of the lesson.
3. Performance objective: Expresses what level of accomplishment is expected from the student's performance after this lesson is completed.
4. Evaluation: Explains clearly how he or she will be checked out on this contract.
5. Taxonomy category: Indicates to a person what level of Bloom's Taxonomy of Educational Objectives is used in all the contracts.
6. Resources: Lists all of the learning resources which are available to the learner. It consists of various materials, activities, and persons that are available to help the student to accomplish the contract.

Thorwald Esbensen (1972) suggested that the length of the contract should be small enough for a student to feel he accomplishes something within a period of time, and large enough that the teacher does not have to spend too much time checking students in and out of learning contracts. According to the results of the project in Duluth, Minnesota, Esbensen suggested that a contract be developed in such a manner that the average student could complete one or two learning contracts per week in a given subject (pp. 22-23).

Personalized System of Instruction (PSI)

In the beginning, the PSI idea was developed by Fred S. Keller and presented in an article entitled "Good-Bye, Teacher" in 1968. He organized the instructional materials in a manner that permitted students to proceed at their own pace and level; therefore, any student in the class would not be held back by other students or be forced to go ahead before he was ready. The speed at which the student wanted to go was his choice and the course had allowances for students to finish the course requirements in a reasonable period of time rather than on a fixed schedule.

An important study of the PSI system was developed at Utah State University. All the instructional materials for students to study had been developed by the instructor into a carefully written form and tied into sequential units. Each student had to go over the learning material and show his mastery of each unit by passing a preparatory test before he could move on to the next unit. David G. Born (1971), indicated that the PSI could be developed in a better way by involving the following elements:

1. Course calendar: It is desirable to develop a calendar of class activities and opportunities for lectures, films, and taking tests, which can be distributed to each student at the beginning of the class.

2. **Course content and learning units:** As soon as the course content is selected, it is necessary to determine the number of learning units in which the instructional material will be packaged. The size of a learning unit should not be too large. The ideal length of reading material was somewhere between 20 to 50 pages.
3. **Learning material:** First of all, an instructor should prepare a substantial number of unit learning guides and write learning material in good written form; then he should develop three to five different forms of examinations over the same material. In this way the students who failed to meet the first test can re-study the same material and take a subsequent test.
4. **Proctor:** The proctor played a very important role in the PSI. He assessed the level of difficulty of course material and provided students with appropriate feedback about their level of mastery. A good proctor should be available to the students and have enough enthusiasm to help them. Even though the proctor is the heart of the system, it is not necessary to have a

proctor in a class with enrollments of 10 to 15 students; the instructor can probably handle all the instructional duties alone.

5. Student progress chart: Students in PSI are allowed to progress at their own rate. Some of the students may not be able to handle their learning activities properly and they may have more work to do than they can possibly complete in the time remaining in the quarter. A well-designed progress chart will help students avoid the time-control problem.
6. Final examination: It is important that this examination be controlled completely by the course instructor and it should not be repeatable. The examination should be done this way for two reasons. First, this examination provides a fair and final check on the student's mastery of course material. Second, because the final examination is comprehensive, the student is encouraged to review all of the course material completely before he or she takes the test.
7. Course evaluation: The effectiveness of the PSI course must ultimately be determined by

evaluation of student performance. The best way to determine the effectiveness of the PSI course is to allow an investigator to teach a lecture course parallel to the PSI course to equal groups and then compare students in the two classes on some specific tasks (pp. 23-59).

The Audio-Tutorial System: Incorporating Minicourses and Mastery

In 1961, a program of botany courses for freshman was developed at Purdue University. The primary purpose was to try to produce a weekly lecture on audio tape. Because of student enthusiasm for the program the procedure was expanded to cover the entire course. Later this course was then rearranged to include three major types of study sessions:

1. Independent Study Session (ISS): Audio-tutorial programs were placed in a learning center which was open during weekdays. Each student could come in at his or her convenience and check into a booth. He could use the headphones to listen to the tape and experience a simulated one-to-one tutoring by the instructor. Each student could proceed at his or her own rate and could skip any part of the instructional

material which he or she thought he or she already knew or relisten to material he or she thought was difficult to understand in a previous session.

2. General Assembly Session (GAS): This session was scheduled for occasional lectures, special films, major examinations and other activities.
3. Integrated Quiz Session (IQS): This session was usually for about one-half hour. For this session, each student was expected to prepare a short lecture about each of the items used in the ISS. The teacher presented the items in the sequence programmed earlier and selected the students to lecture on a random basis.

In 1969, Robert N. Hurst reorganized the content of both the zoology and botany courses into smaller units of information called minicourses. After the student mastered the materials outlined in the objectives for a particular minicourse, he would be allowed to proceed to the next one if he desired. As soon as a student completed all of the minicourses, a "C" grade was assigned to him. If he wanted to earn a "B" or an "A" grade, he then had to complete additional activities requiring a higher level of knowledge and understanding (Kapfer and Kapfer, 1973).

According to Postlethwait's and Hurst's (1972) comments some of the advantages of the system were:

1. The primary learning program can be prepared by a "good" teacher. All his skill in selecting and sequencing learning activities can be made available to each student on a simulated tutorial basis.
2. The rate and emphasis of study is directly under the student's control. He can stop at any point in the program to obtain outside assistance (instructor, peer, book or other resource). He can repeat or skip any segment of the program in accordance with his needs.
3. There is great flexibility for individualizing course content to the specific needs of students. Mini-courses can be selected and combined in a variety of ways to accommodate major goals.
4. The transfer of materials between courses and between institutions could be accomplished more readily because each minicourse is essentially an independent learning system and could easily be combined with others to adapt to the local situation (p. 36).

Every instructional method also has its limitations.

Some of the disadvantages of this system were found to be:

1. The development and testing of a minicourse program is time-consuming and requires considerable skill and talent.
2. The system requires psychological adjustment for both student and teacher. The student must assume a great degree of responsibility for his own progress and make some decisions for himself. The teacher must become committed to "helping students learn" and be willing to accept less attention to himself and his role in the learning process.
3. Many factors only tangentially related to the system may frustrate and create unexpected difficulties which have undue influence on the success of the program. A change from the routine within routine surroundings is never easy (p. 37).

Instructional Module Design

In the article entitled "An Instructional Module Design," the author, Richard W. Burns (1972), made the following suggestions for developing an effective learning system with individualized instruction:

1. Consider the learner's interest.
2. Consider the learner's readiness.
3. Consider the learner's rate of learning (time).
4. Consider the learner's repertoire of habits (scope and sequence) that he applies to learning (study habits).
5. Provide the learner with corrective feedback (or knowledge of the results of his learning).
6. Provide the learner with success.
7. Provide the learner with knowledge of cognitive and psychomotor goals (There may be reservations relative to this notion with regard to some effective goals, and this point is further elaborated upon later in this paper.) (p. 28).

Burns proposed an instructional module which is one type of learning package, consisting of the following elements:

- Title page - to record credits, date, and title.
- Objectives - to state terminal behavioral objectives.
- Overview - to describe briefly the content.
- Pretest - to determine whether or not the learner needs the coming instruction.
- Rationale - to explain the reasons why this module is of importance to him and why the learner has to learn.

Instructional alternatives - to illustrate all the possible ways of learning the required content.

Posttest - to check whether the learner achieved the terminal behavioral objectives or not.

Resources - to list all the instructional materials which the student could locate.

This type of learning package usually requires between one-half hour and fifteen hours to complete. Some modules contain field experience activity and will take more time to accomplish. Burns (1972), said that the highly structured learning modules can provide only limited options in the instructional alternatives. This tends to disturb the concept of individualized instruction, hence highly structural modules should be used carefully and to a limited degree. For those modules which are structured rather loosely, he explained that they may provide the learner with a wide range for selecting his or her own experiences to accomplish his or her own goals (pp. 27-29).

The Weber Individualized Learning Kits (WILKITS)

The faculty of Weber State College developed another form of a learning package for individualized instruction. The WILKITS is planned to assist students in professional components of teacher education and to enable them to become familiar with the teaching skill, process and strategy. Each WILKITS

contains the following elements:

Title - name of the topic.

Instruction - explains the topic in general terms.

Content - covers all the information to be discussed.

Pre-Assessment - helps student to determine his or her background about the topic prior to instruction.

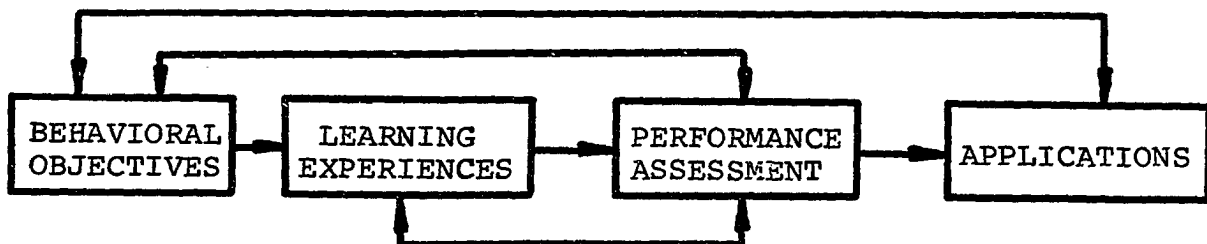
Behavioral objectives - states what behavior the student is expected to perform and the minimum acceptable standard.

Learning experiences - lists all the requirements and suggestions for accomplishing the objectives.

Self-evaluation - provides self-evaluation of achievement.

Proficiency assessment - gives opportunity for a final check if the behavioral objectives have been accomplished.

In order to improve this system, Caseel D. Burke (1972), illustrated a developmental pattern as follows (p. 43):



To judge whether or not behavioral objectives have been met, the students' performance, and applications must be observed and evaluated against a known criteria. In case certain objectives have not appeared in the application, some modifications of this system are necessary.

From the observations and reactions of the students in this program, Burke (1972) concluded that:

It appears evident that a major strength lies in the clearly defined objectives and student levels of performance. Students claim to work harder and learn more from this initiative and responsibility on the part of students (p. 44).

Blaine P. Parkinson, Associate Dean, School of Education, Weber State College (personal communication, Nov. 19, 1974) had more comments on this program:

Under the new program, the student is responsible for his learning, for scheduling activities, for getting information from the reading, and for taking tests. We do not have the normal complaints of irrelevant materials, poor tests that don't test objectives, unfair professors, and "busy" work (p. 3).

One of the findings of the Weber Program that should be mentioned here is that the academically capable students seem to achieve more from this system and accept this system more readily than the less capable students (pp. 41-46).

Related Study of Results of Individualized Instruction

After various kinds of learning packages of individualized instruction were presented, two questions remained: "What is good about individualized instruction?" and "Which is more effective when compared to the conventional group-setting?" The following research results were selected to answer these questions:

Bruce E. Meeks (1971), did an experimental study and attempted to compare the learning packages with conventional methods. There were 144 students who participated in this study. The subjects were randomly divided into experimental and control groups. The control group was subjected to the conventional techniques of instruction employing regular instructional methods. The experimental group was taught the same concepts with specially prepared learning packages. All the students were pre- and posttested to measure growth over time. An "F" test was used to compare the differences between the two groups. The results indicated that the procedures used by the experimental group were significantly more effective in demonstrating favorable attitudes than those of the control group at 0.01 level. A separate "T" test was used to compare the differences between the time needed to complete the instruction materials of both groups. The result showed that there was no significant difference in the amount of time

each group spent in studying during the experiment.

The attitude toward the learning package was also surveyed. The result revealed that there was a highly significant improvement in opinion toward learning packages as a means of instruction.

An interesting study was undertaken by Born, Gledhill and Davis (1972). They attempted to compare the examination performance in lecture-discussion and personalized instruction courses at the University of Utah. The 60 students enrolled in a Psychology of Learning course during Spring Quarter, 1969, were participants in this experiment. These students were assigned into four groups randomly: (a) Keller's group; (b) Modified Keller's group; (c) Rotating group; and (d) Lecture-Discussion group. Because of unequal total scores which could be measured on mid-term and final examinations, each student's score on each examination was converted to a percentage score; that is, (points earned/points possible) X 100. This conversion permitted a direct comparison of examinations and strengthened further the statistical analysis. The report of this study indicated that Keller's group has a slightly higher withdrawal rate than the lecture-discussion instruction class. A Duncan Multiple Range Test of the four groups' "mean" scores revealed that both Keller's and Modified Keller's groups were superior to the lecture and rotating groups at 0.05 significance level.

Stuck (1968) did a comparative study of Audio-Tutorial and lecture method in teaching school law units of Principles of Secondary Education for a 16 actual contact hours course. In this study, he found that there were significant differences in learning as measured by gain scores between audio-tutorial materials and traditional methods of instruction in school law at 0.01 level. The differences were in favor of the group using audio-tutorial method. There was no significant difference in the retention test, given two weeks after the posttest. He also pointed out that the student teaching experience made the students more responsive to the audio-tutorial method of instruction. Even though there was no significant difference in achievement attributed to this experiment, the attitude of the students toward audio-tutorial instruction was much more favorable than the attitude of those students who had not had this experience.

Hoffman (1971), attempted to compare a slide-rule course with audio-tutorial versus conventional methods. This study was conducted to investigate and evaluate the effectiveness of modern audio-tutorial methods of instruction in teaching the use of the slide rule. The two-quarter credit engineering-technology slide-rule course, entitled Technical Problems, was the vehicle used for the study. Each student who enrolled in the course was randomly placed in one of two groups (control or experimental). Both groups were approximately equal in

size. The experimental group consisted of forty students who were taught the use of the slide rule by the exclusive use of audio-tutorial methods of instruction. The control group consisted of forty-two students who were taught the use of the slide rule in the conventional manner. A "t" test was employed to compare the differences between the "mean" scores of two groups of data. Hoffman summarized that in all cases the experimental group mean was greater than the control group mean. He also found that the audio-tutorial instruction method seemed to raise the performance of the low achiever more than it did the performance of the high achiever.

Neff (1973) conducted an experimental investigation of two methods of teaching students the automotive-brake system. The two methods, the experimental individualized-learning system and the traditional group-lecture and demonstration system, were compared for effectiveness in cognitive and psychomotor domains. The slide tape presentations, student's guide and answer booklets were prepared for presentation to the experimental group. The group-lectures and demonstrations were prepared for the control group. This study, was conducted during the Spring Term of 1972, utilized a random control group design in which one hundred students enrolled in the Automotive Technology program at Portland Community College were the subjects. In this study, Neff utilized a preliminary analysis of variance to detect if the random assignment of subjects to groups was successful or not. There was no

difference between the two groups at the beginning of the experiment in this study. He concluded that the experimental individualized learning system was as effective as the traditional group-lecture and demonstration method in cognitive learning pertaining to the automobile brake system, and psychomotor learning as well. The average time needed for completing the instructional material was 1:3 for the experimental group and the control group, respectively. He recommended that the individualized learning system should be used to teach the basic unit regarding the automotive-brake system and that additional research concerning the effectiveness of the instructional system with students not enrolled in vocational-education courses was needed.

Another relevant study was done by Arvid Ray Eide (1973), who investigated an alternate method of teaching the basic graphics course to freshman engineers at Iowa State University. The main objective of the study was to determine if students who received instruction by a combination of methods, audio-video tapes, and individualized-instruction program learned the same as students who received instruction in a conventional manner. The criteria measures were collected during and at the end of the study. The statistical result of these tests showed no significant differences between the control and the experimental group. He also indicated that in the conventional teaching systems, the faculty member spent the majority of his time in the laboratory working with the

students. In the experimental group the faculty member spent only 25 percent of the time in the laboratory. The remaining 75 percent of that period was spent at his desk for evaluation of students' work.

Summary

The concept of "packaging" a course or units of a course for individualized instruction is not new. What is important, perhaps, is the careful planning of all elements in developing a more effective instruction method with the help of teaching aids. Review of the literature reveals that the learning packages for individualized instruction are many and vary from one style to another. The majority of the literature reviewed suggested that the following elements are essential: Behavioral objectives, pretest and answers, learning activities, and posttest (Smith, 1972; Dalton, 1972; Esbensen, 1972; Born, 1971). Four of the related study results of individualized instruction revealed that the individualized-instruction group ranked superior to the group instruction in test achievement scores (Meeks, 1971; Gledhill and Davis, 1968; Stuck, 1968; and Hoffman, 1971). But the investigative results of Neff (1973) and Eide (1973) showed that the students receiving individualized instruction performed just as effectively as those receiving the group instruction method. In general, the individualized instruction method will cause a slightly higher

withdrawal rate (Born, Gledhill and Davis, 1972), but also students need relatively less time to accomplish the same course requirements (Neff, 1973 and Eide, 1973). There appears to be a further need for research in the area of instructional methods, particularly where theory and laboratory experiences are encountered by the students.

CHAPTER III. METHODS AND PROCEDURES

This chapter includes the discussion of the methods and procedures that were used to obtain the data for this study. The preparation, development, and organization stages of the proposal were accomplished during the Fall Quarter of 1974. The pilot study was administered during the Winter Quarter of 1975, and the major study was carried out during two quarters (Spring and Fall Quarters of 1975). This study was conducted at Iowa State University, in the Department of Industrial Education. This chapter describes the following activities: (1) developing instructional materials; (2) conducting the pilot study; (3) selecting the population; (4) grouping students; (5) presenting instructional materials; (6) developing measurement instruments; (7) explaining the experimental design; and (8) collecting experimental data. These eight activities are discussed in greater detail as follows:

Developing Instructional Materials

The course outline for Industrial Education 261, Power Mechanics: Internal Combustion Engines was developed based upon the descriptions of the course. According to the 1973-1975 General Catalog of Iowa State University, the objectives of the course were: (1) familiarization with reciprocating and reaction engines with emphasis on two- and four-stroke cycle reciprocating engines; and (2) use of tools and equipment

for small engine overhaul and tune-up (p. 227). Using these objectives, a revised course was developed, and then broken into a number of teaching units. For greater convenience in conducting this study, it was decided to divide the course into two phases. The first phase encompassed a general introduction to the internal combustion engines. This phase included the first four weeks of the quarter. Both the experimental group and the control group were taught the same content using the same methods. Content of phase I was not statistically analyzed for this study. The second phase of the course included more specific areas of the internal combustion engines, namely: (1) fuel and combustion; (2) carburetion; (3) lubrication; (4) ignition; and (5) diagnosis. Each area was developed into both a 100 minute (average) teaching unit and a learning package. An example of a learning package is shown in Appendix A. For this second phase, the students were divided into an experimental group using learning packages and a group-lecture-discussion control group. Each learning package was developed to cover the following elements:

1. A listed statement of objectives to be achieved by the students. These objectives defined the concepts to be covered within the teaching units and learning packages.
2. A pretest for the learner to determine his or her own knowledge and ability prior to use of the teaching unit or learning package.

3. A cassette tape recording of the instructional materials, questions for reviewing the learning materials, and the guide for the objectives of the course.
4. A note book with slides containing important instructional materials for the learner to study.
5. A posttest for final evaluation of learned concepts.
6. A work sheet (Appendix B) for the learner's use in answering the questions which were recorded on a cassette tape.

Conducting Pilot Study

After completing the instructional materials and improving the measurement instruments, a pilot study was conducted during the Winter Quarter, 1975. Twenty undergraduate students from various departments were involved in the pilot study. The distribution of the students' majors, sex, and year in the pilot study are listed in Table 1.

Based upon the evaluation of the students' outcomes and reactions in the pilot study, the following modifications were made:

1. Informational statements on the cassette tapes were modified for better clarity.
2. Questions on the pretest and the posttest were revised and made clearer.

Table 1. Distribution of students' majors, sex, and year in the pilot study

Major dept.	Sex	Year	Number of student
I. Ed.	Male	Freshman	3
I. Ed.	Male	Sophomore	1
I. Ed.	Male	Junior	4
I. Ed.	Female	Junior	1
I. Ed.	Male	Senior	7
Hort.	Male	Junior	1
E. E.	Male	Junior	1
I. Ad.	Male	Sophomore	1
Agron.	Male	Junior	1

Total			20

3. The learning package was circulated via the Media Center of the library rather than in the Synchrotron Building where this course was taught.

With these additional modifications and arrangements, based upon the pilot study, it was felt that the design would be more adequate for the study.

Selecting the Population

This study was conducted during the Spring and Fall Quarters, 1975, at Iowa State University. Students enrolled in Industrial Education 261, "Power Mechanics: Internal

Combustion Engines" during these two quarters were selected to be the subjects of the study. The data in Table 2 shows the background analysis of the population included in the study.

Grouping Students

To avoid any possible bias each student was randomly assigned to either the individualized instruction group (experimental group) or the group-lecture-discussion group (control group). N. L. Gage (1963), strongly supported this point of view and stated:

In design 4 [pretest posttest control group design]¹, this means, there will occasionally be an apparently "significant" difference between the pretest scores. Thus, while simple or stratified randomization assures unbiased assignment of experimental subjects to groups, it is a less than perfect way of assuring the initial equivalence of such groups. It is nonetheless the only way of doing so, and the essential way (p. 185).

A random number list was generated by a random process for this study. Half of the students in each section were selected randomly to form the experimental group and the remaining students formed the control group for the study. The same procedure was repeated again for the Fall Quarter, 1975. The number of students in the experimental group and

¹[] added to quotation by author.

Table 2. Background analysis of population^a

	Home address		Auto work experiences		Auto course taken		Finances source		Reasons for taking course	
	In state	Out state	Some	None	Yes	No	Himself	Parent or other	Interest	Required
Experimental group	16	1	7	10	7	10	5	12	5	12
Control group	17	1	4	14	8	10	9	9	2	16

Total	33	2	11	24	15	20	14	21	7	28

^aThe data analysis were based on the personal questionnaire sheets which had been filled by 37 subjects enrolled in Industrial Education 261 classes during Winter and Fall quarters, 1975, Iowa State University.

the control group was approximately the same. The randomization process by classes is presented in the following table:

Table 3. Randomization of population by classes

Quarter	Year	Section	Control group	Experimental group
Spring	1975	A	5	5
Spring	1975	B	3	4
Fall	1975	A	5	4
Fall	1975	B	5	4

Total			18	17

Presenting Instructional Materials

The instructional material presented to the students in the classes was divided into two phases for each quarter; they were: (1) pre-experimental phase; and (2) experimental phase. During the pre-experimental phase, all of the students were taught by the same methods and with the same materials in the regular classroom setting. The major purpose of this phase was to provide students an opportunity to become familiar with the general operational theories and principles of two and four-stroke cycle engines, and the instructional style in this specific class. The second phase consisted of two types of

instructional methods; namely: the individualized-instruction method (experimental group); and the group-lecture-discussion method (control group). Course content for these two instructional groups was identical. The only difference between the two groups was the instructional methods employed. While the control group learned the instructional materials through the instructor's lecture with group discussion in the regular class setting, the experimental-group students utilized the media prepared for individualized-instructional packages in the Media Center of the library. All of the records of student performance from both groups were kept on a personal data sheet (Appendix C). Students in the experimental group were allowed to proceed at their own rate within each week so that both groups could maintain the same rate of progress throughout the total course.

Developing Measurement Instruments

Based upon the five unit objectives, pretests, posttests, and a final comprehensive test were developed. All of the test items were discussed with Walter E. Diedrick¹ before the pilot study. Referring to the students' evaluation input from the pilot study, a number of test items in all of the tests

¹Dr. Walter E. Diedrick, Associate Professor in the field of auto mechanics and Coordinator of Energy Power and Transportation Cluster, Department of Industrial Education, Iowa State University.

were revised. A revised set of pretests is presented in Appendix D, and Appendix E contains the posttests for this study. The answer sheet for these five unit tests and the final comprehensive test were sent to Scoring Service Station of Student Counseling Center at Iowa State University for scoring and analysis. Data analysis produced the following statistics:

Table 4. Data analysis for measurement instruments (average)

	Pretests	Posttests	FCT ^a
Average test difficulty	0.55	0.82	0.81
Standard error of measurement in raw scores	2.04	1.85	2.49
Mean	16.25	29.43	42.74
Standard deviation	4.97	3.20	4.79
KR-20 Reliability estimate	0.65	0.62	0.73
Number of scored items	172	172	53

^aFCT: Final comprehensive test.

The intercorrelation coefficients of all measurements were computed and shown in Table 5. The data in Table 5 revealed that the intercorrelation coefficients of all measurement instruments ranged from 0.9467 to 0.0022.

Table 5. Intercorrelation coefficients between all variables

	AGEM	MSAT	BMCT	U1PRE	U1POST	U2PRE	U2POST	U3PRE	U3POST	U4PRE	U4POST
AGEM	1.00										
MSAT	0.01	1.00									
BMCT	-0.03	0.46	1.00								
U1PRE	0.01	0.48	0.23	1.00							
U1POST	0.15	0.22	0.22	0.47	1.00						
U2PRE	0.14	0.25	0.29	0.40	0.10	1.00					
U2POST	-0.06	0.55	0.29	0.37	0.43	0.26	1.00				
U3PRE	0.12	0.32	0.17	0.57	0.33	0.51	0.34	1.00			
U3POST	-0.16	0.51	0.13	0.51	0.43	0.25	0.63	0.57	1.00		
U4PRE	0.09	0.34	0.26	0.51	0.36	0.48	0.38	0.62	0.55	1.00	
U4POST	-0.04	0.34	-0.06	0.38	0.37	-0.03	0.67	0.32	0.58	0.40	1.00
U5PRE	0.01	0.28	0.22	0.55	0.34	0.51	0.31	0.53	0.38	0.46	0.28
U5POST	-0.30	0.42	0.21	0.30	0.34	0.32	0.56	0.28	0.61	0.33	0.37
CFT	0.09	0.67	0.29	0.56	0.49	0.33	0.53	0.48	0.57	0.48	0.57
U1DIF	0.12	-0.31	-0.05	-0.65	0.37	-0.33	-0.02	-0.30	-0.16	-0.22	-0.07
U2DIF	-0.39	-0.07	-0.20	-0.30	0.02	-0.95	0.06	-0.42	-0.05	-0.38	0.26
U3DIF	-0.43	0.04	-0.10	-0.18	-0.02	-0.27	0.05	-0.71	0.17	-0.27	0.11
U4DIF	-0.37	0.00	-0.30	-0.05	0.02	-0.28	0.13	-0.27	0.03	-0.54	0.55
U5DIF	-0.26	-0.03	-0.09	-0.37	-0.14	-0.29	-0.01	-0.38	-0.02	-0.27	-0.06
PRES	-0.22	0.42	0.30	0.63	0.32	0.75	0.29	0.80	0.55	0.75	0.33
POSTS	-0.49	0.50	0.19	0.27	0.34	0.31	0.41	0.47	0.82	0.53	0.77
GANS	-0.41	-0.10	-0.23	-0.41	0.05	-0.64	0.08	-0.57	-0.02	-0.51	0.26

Table 5 (Continued)

	U5PRE	U5POST	CFT	U1DIF	U2DIF	U3DIF	U4DIF	U5DIF	PRES	POSTS	GANS
AGEM											
MSAT											
BMCT											
U1PRE											
U1POST											
U2PRE											
U2POST											
U3PRE											
U3POST											
U4PRE											
U4POST											
U5PRE	1.00										
U5POST	0.37	1.00									
CFT	0.55	0.49	1.00								
U1DIF	-0.29	-0.02	-0.16	1.00							
U2DIF	-0.43	-0.14	-0.16	0.33	1.00						
U3DIF	-0.31	0.19	-0.09	0.17	0.41	1.00					
U4DIF	-0.16	0.04	0.09	0.07	0.47	0.56	1.00				
U5DIF	-0.82	0.23	-0.27	0.27	0.34	0.49	0.29	1.00			
PRES	0.82	0.41	0.62	-0.38	-0.34	-0.03	0.16	-0.33	1.00		
POSTS	0.44	0.75	0.69	0.00	0.23	0.49	0.64	0.20	0.73	1.00	
GANS	-0.61	0.08	-0.17	0.47	0.75	0.73	0.77	0.69	-0.23	0.49	1.00

The value of coefficient (r) can range from +1.00 to -1.00. The absolute value of the " r " displays the strength of the relationship between two sets of tests; the higher the absolute value, the greater the probability the correspondence exists. About the interpretation of coefficient r , Frederick G. Brown (1970) made this comment:

There are a number of ways to interpret r in terms of the strength of the relationship between the two variables, in terms of the accuracy of predicting one variable from another, in terms of common elements, and so on. Perhaps the simplest and most broadly applicable way is to interpret r square as the proportion of variability in one set of scores that can be attributable to, or is shared in common with, the other variable (p. 22).

Thus, if a set of test scores has a coefficient $r = .60$, then $r^2 = .36$, and we would interpret that 36 percent of the variability in the first measure associated with or attributable to variation in the second measure, and vice versa.

Explaining the Experimental Design

The experimental design used for this study included a pretest and posttest control-group treatment proposed by Campbell and Stanley (1963). This design could be illustrated as follows:

R	O_1	X_E	O_2
R	O_1	X_C	O_2

- R: Random assignment
O₁: Pretest
O₂: Posttest
X_E: Experimental treatment
X_C: Control treatment (p. 13).

A research design should attempt to control these variables which might affect the results of the study. Good (1963), made comments about the advantages of using the pretest and posttest control-group design: "This experimental design seeks to control the main effects of history, maturation, testing, instrument decay, regression, selection, and mortality" (p. 455). Since these mentioned variables were of considerable importance to the study, this particular pretest and posttest control-group design was selected for the study.

In order to determine more precisely the preliminary knowledge background between the control-group and experimental-group subjects, two additional tests were administered; they were: Bennett Mechanical Comprehensive Test (BMCT) Form S; and the Minnesota Scholastic Aptitude Test (MSAT). These two tests are discussed briefly:

Minnesota Scholastic Aptitude Test (MSAT)

The 1964 edition Form C of MSAT, by Wilbur L. Layton and Herbert Toops, was used. This test consisted of three areas;

namely: (1) reading comprehension; (2) vocabulary; and (3) verbal analogies. For those students who had already taken the test during their Summer of Fall Freshman Orientation, their scores were available from the Counseling Center at Iowa State University. The rest of the students in this study were asked to take it on their own time before participating in the study.

Commenting about the purpose of this test, Menne, Warman, and Krause (1974) stated:

The purpose of the MSAT, just as the ACT, is to appraise what has been called "Scholastic Aptitude or general intelligence, with a special reference to the requirements of most college curricula (p. 3).

In the following table are presented the standard norms of MSAT and the MSAT norms of this study.

Table 6. Standard MSAT norms and MSAT norms of the study

	Number of student	Mean score	Standard deviation
Standard norms ^a	3427	43.96	11.36
MSAT norms of this study	35	42.23	9.55

^aThe standard norms of MSAT are based on the scores of new students, all colleges, at Iowa State University, entering in 1974 (p. 7).

According to one of the authors of this test, Wilber L. Layton¹ explained that the KR-20 Estimate Reliability for MSAT is 0.90 and it requires 50 minutes for the average-rate learner to answer all of the multiple-choice-type questions.

Bennett Mechanical Comprehension Test (BMCT)

The 1969 revised edition of the BMCT by George K. Bennett was used. This test tends to measure the student's ability to perceive and understand the relationship of physical forces and mechanical elements in practical situations. Bennett (1969), noted: "This type of aptitude is important for a wide variety of jobs and for engineering training, as well as for many trade school courses" (p. 1).

BMCT, Form S and Form T are similar tests. There were 136 multiple-choice type test items in these two tests originally. The number of test items and categories were distributed as follows:

Category	No. of Items
Acoustics.....	3
Belt Drive.....	2
Center of Gravity.....	7
Centrifugal Force.....	5
Electricity.....	6
Gears.....	10
Gravity and Velocity.....	9
Heat.....	8
Hydraulics.....	16
Inertia.....	5

¹Dr. Wilber L. Layton, Vice President of Student Affairs at Iowa State University. Private communication, June, 1975.

Category	No. of items
Levers.....	8
Optics.....	6
Planes and Slopes.....	2
Pulley System.....	10
Resolution of Forces.....	6
Shape and Volume.....	7
Structures.....	12
Miscellaneous.....	14
Total.....	136 (p. 13).

Within each category, the items then were divided into Form S and Form T as evenly as possible. Form S, which was used in this study, contained 69 items and it took approximately 30 minutes to complete the test. This test was administered to all of the students before they participated in the study. The test score was computed by the number of right answers with no penalty for incorrect responses.

The data in Table 7 shows the relevant statistical analysis for BMCT.

Table 7. Data analysis for BMCT

	N	Mean	S.D.
Applicants for process training jobs in an oil refinery company ^a	100	44.2	10.5
Applicants for skilled trades jobs in an automobile company ^a	435	46.0	9.5
Applicant for a unior apprentice training program in construction trades			
Group I	271	42.7	8.7
Group II	204	43.6	9.0
Applicants for the subjects in this study	35	53.03	6.71

^aThese data are based on the Bennett Mechanical Comprehension Test, Manual Forms S and T (p. 7).

Collecting Experimental Data

After students were randomly assigned to the control group and the experimental group, all of the test scores were recorded. In the test procedures, the suggestion of N. L. Gage (1963) was followed:

The most widely used acceptable test is to compute for each group pretest posttest gain scores and to compute a "t" between experimental and control groups on these gain scores (p. 193).

The gain scores from each learning unit and learning package were computed and "t" statistics were utilized to determine whether any differences existed between the two groups.

The total score of each learning unit or learning package differed from one to the other. In order to strengthen the comparison of sum scores in this study, each student's score on each test was converted to a percentage score using the following convention: $(\text{unit test actual scores} / \text{unit test possible score}) \times 100$. Then these gain scores were summed for further comparison. This process is essential since the test items in each unit are not the same.

All of the necessary data were collected, coded, and verified. They were then placed on International Business Machine (IBM) data processing cards for computer input and processed using the computer in the Computation Center at Iowa State University. The Statistical Package for Social Science

(SPSS) program was written and used for this study.

Summary

This chapter included a discussion of the methods and procedures used in the study. Eight activities were involved; they were: (1) developing instructional materials; (2) conducting the pilot study; (3) selecting the population; (4) grouping students; (5) presenting instructional materials; (6) developing the measurement instruments; (7) explaining the experimental design; (8) collecting experimental data.

After the pilot study, the review questions on the cassette tape, pretests, and posttests were modified. The experimental site for the experimental group was moved from the Synchrotron Building to the Media Center at Iowa State University. The control group remained in the Synchrotron Building classroom.

Spring and Fall Quarters, 1975, were used to conduct this study. The population for this study included 37 students who were taking Industrial Education 261 "Power Mechanics; Internal Combustion Engines," during these two quarters.

A random process was utilized to divide the subjects into two groups, namely: (1) group-lecture-discussion group (control group); and (2) individualized instructional group (experimental group). There were 20 subjects in the control group and 20 subjects in the experimental group. The instruc-

tional content for both groups was identical but the instructional methods were different in the second phase of this study. While the control group learned the instructional materials through the instructor's lectures with group discussion in the regular class setting, the experimental-group students used the individualized-instructional packages in the Media Center located in the Library.

The pretest and posttest gain-score comparison was used in this study to detect any significant differences existing in the means of gain scores between the control group and the experimental group. To strengthen the sum score comparison, each student's score on each test was converted to a percentage score before it was totaled for further statistical comparison. All the tests were analyzed by the scoring-service station of Student Counseling Center for the purpose of improving measurement readout. Finally, all of the necessary data were recorded on IBM 80-column cards and sent to the computation center at Iowa State University for compilation and applying the program of the Statistical Packages for Social Science (SPSS).

CHAPTER IV. FINDINGS

This chapter describes the preliminary-background of students, and experimental findings of the investigation. The preliminary-knowledge background of each student was acquired by administering the Minnesota Scholastic Aptitude Test, a Bennett Mechanical Comprehensive Test, and five unit pretests. The total pretest scores of five pretests, and the students' ages in months were also determined. Experimental measures included five unit-test gain scores, a total gain score of all five unit tests, and a comprehensive final test. The preliminary-knowledge background information and the experimental findings are provided in this chapter.

Preliminary-Knowledge Background Process

To determine whether the randomly assigned groups in the study were comparable, the students' data were analyzed to test research hypothesis I.

Research hypothesis I

It was hypothesized that there would be no significant difference in the initial knowledge-background between the individualized-instruction group, and the group-lecture-discussion instruction group.

There were nine null sub-hypotheses under research hypothesis I. All of them were formulated in the expressed

form:

$$H_0 : \mu_{E.....} = \mu_{C.....}$$

$$H_A : \mu_{E.....} \neq \mu_{C.....}$$

where,

H_0 : Null hypothesis

H_A : Alternative hypothesis

$\mu_{E.....}$: Mean of the experimental group on given tests.

$\mu_{C.....}$: Mean of the control group on given tests.

To determine if the group means differed with respect to given tests and ages the following t-statistic equation (Glass and Stanley, 1970, p. 295) was utilized to test the nine sub-hypotheses of research hypothesis I.

$$t = \frac{\bar{X}.1 - \bar{X}.2}{\frac{(n_1-1)s_1^2 + (n_2-1)s_2^2}{n_1+n_2-2} \left(\frac{1}{n_1} + \frac{1}{n_2} \right)}$$

where,

$\bar{X}.1$ and $\bar{X}.2$ are the means of the samples from populations 1 and 2, respectively,

s_1^2 and s_2^2 are the unbiased estimates from samples 1 and 2 of the common population variance σ_x^2 , and

n_1 and n_2 are the sizes of samples 1 and 2,

Null sub-hypothesis 1 It was hypothesized that there would be no significant difference between the group means for the experimental group and the control group, as determined through the use of Minnesota Scholastic Aptitude Test (MSAT) as a measurement indicator.

The analysis of data from the Minnesota Scholastic Aptitude Test, is presented in Table 8. The t-ratio from Table 8 was 0.42 with 33 degrees of freedom. According to Glass and Stanley (1970, p. 521), a value of $t = 2.0357$ with 33 degrees of freedom was required for rejection of the null sub-hypothesis at the .05 level of significance. Therefore, the data failed to reject null sub-hypothesis 1.

Table 8. The analysis of data from MSAT

Name of group	n	Mean	S.D.	T	Significance
Experimental	17	42.94	8.76		N.S.
Control	18	41.56	10.54	0.42	

D.f. = 33		$\alpha = 0.05$		table t = 2.0357	

Null sub-hypothesis 2 It was hypothesized that there would be no significant difference between the group means for the experimental group and the control group, as determined through the use of Bennett Mechanical Comprehensive Test (BMCT)

as a measurement indicator.

The analysis of data from the BMCT is presented in Table 9. The t-ratio from Table 9 was 0.63 with 33 degrees of freedom. A value of $t = 2.0357$ with 33 degrees of freedom was required for the rejection of the null sub-hypothesis at the 0.05 level of significance. Therefore, the data failed to reject null sub-hypothesis 2.

Table 9. The analysis of data from BMCT

Name of group	n	Mean	S.D.	t	Significance
Experimental	17	53.76	5.94		N.S.
Control	18	52.33	7.47	0.63	

D.f. = 33		$\alpha = 0.05$			table t = 2.0357

Null sub-hypothesis 3 It was hypothesized that there would be no significant difference between the group means for the experimental group and the control group as determined through the use of Unit One--Fuel and Combustion Pretest as a measurement indicator.

The analysis of data from the Unit one--Fuel and Combustion Pretest, is presented in Table 10. The t-ratio from Table 10 was 1.01 with 33 degrees of freedom. A value of $t = 2.0357$

with 33 degrees of freedom was required for the rejection of the null sub-hypothesis at the 0.05 level of significance. Therefore, the data failed to reject null sub-hypothesis 3.

Table 10. The analysis of data from Unit One--Fuel and Combustion Pretest

Name of group	n	Mean	S.D.	t	Significance
Experimental	17	12.82	3.50		N.S.
Control	18	11.72	2.93	1.01	

D.f. = 33		$\alpha = 0.05$			table t = 2.0357

Null sub-hypothesis 4 It was hypothesized that there would be no significant difference between the group means for the experimental group and the control group as determined through the use of Unit Two--Carburetion Pretest as a measurement indicator.

The analysis of data from the Unit Two--Carburetor Pretest, is presented in Table 11. The t-ratio from Table 11 was 0.67 with 33 degrees of freedom. A value of $t = 2.0357$ with 33 degrees of freedom was required for rejection of the null sub-hypothesis at the 0.05 level of significance. Therefore, the data failed to reject null sub-hypothesis 4.

Table 11. The analysis of data from Unit Two--Carburetion Pretest

Name of group	n	Mean	S.D.	t	Significance
Experimental	17	20.53	9.81		N.S.
Control	18	18.67	6.43	0.67	

D.f. = 33		$\alpha = 0.05$			table t = 2.0357

Null sub-hypothesis 5 It was hypothesized that there would be no significant difference between the group means for the experimental group and the control group as determined through the use of Unit Three--Lubrication Pretest, is presented in Table 12. The t-ratio from Table 12 was 0.80 with 33 degrees of freedom. A value of $t = 2.0357$ with 33 degrees of freedom was required for the rejection of the null sub-hypothesis at the 0.05 level of significance. Therefore, the data failed to reject null sub-hypothesis 5.

Table 12. The analysis of data from Unit Three--Lubrication Pretest

Name of group	n	Mean	S.D.	t	Significance
Experimental	17	19.71	3.50		N.S.
Control	18	18.67	4.16	0.80	

D.f. = 33		$\alpha = 0.05$			table t = 2.0357

Null sub-hypothesis 6 It was hypothesized that there would be no significant difference between the group means for the experimental group and the control group as determined through the use of Unit Four--Ignition Pretest as a measurement indicator.

The analysis of data from the Unit Four--Ignition Pretest, is presented in Table 13. The t-ratio from Table 13 was -0.69 with 33 degrees of freedom. A value of $t = 2.0357$ with 33 degrees of freedom was required for the rejection of the null sub-hypothesis at the 0.05 level of significance. Therefore, the data failed to reject null sub-hypothesis 6.

Table 13. The analysis of data from Unit Four--Ignition Pretest

Name of group	n	Mean	S.D.	t	Significance
Experimental	17	19.41	6.12		N.S.
Control	18	20.72	5.06	-0.69	

D.f. = 33		$\alpha = 0.05$			table t = 2.0357

Null sub-hypothesis 7 It was hypothesized that there would be no significant difference between the group means for the experimental group and the control group as determined through the use of Unit Five--Diagnosis Pretest as a measure-

ment indicator.

The analysis of data from the Unit Five--Diagnosis Pre-test, is presented in Table 14. The t-ratio from Table 14 was 2.13 with 33 degrees of freedom. A value of $t = 2.0357$ with 33 degrees of freedom was required for the rejection of the null sub-hypothesis at the 0.05 level of significance. Therefore, the data did support the rejection of null sub-hypothesis 7.

Table 14. The analysis of data from Unit Five--Diagnosis Pre-test

Name of group	n	Mean	S.D.	t	Significance
Experimental	17	11.94	4.12		S.
Control	18	9.17	3.57	2.13	

D.f. = 33		$\alpha = 0.05$			table t = 2.0357

Null sub-hypothesis 8 It was hypothesized that there would be no significant difference between the group means for the experimental group and the control group as determined through the use of sum of pretest scores as a measurement indicator.

The analysis of data from the sum of pretest score, is presented in Table 15. The t-ratio from Table 15 was 1.16 with

33 degrees of freedom. A value of $t = 2.0357$ with 33 degrees of freedom was required for the rejection of the null sub-hypothesis at the 0.05 level of significance. Therefore, the data failed to reject null sub-hypothesis 8.

Table 15. The analysis of data from sum of pretest scores

Name of group	n	Mean	S.D.	t	Significance
Experimental	17	254.87	62.43		N.S.
Control	18	232.57	50.59	1.16	

D.f. = 33		$\alpha = 0.05$			table $t = 2.0357$

Null sub-hypothesis 9 It was hypothesized that there would be no significant difference between the group means for the experimental group and the control group as determined through the use of students' ages in months as a measurement indicator.

The analysis of data from students' ages in months, is presented in Table 16. The t-ratio from Table 16 was -1.03 with 33 degrees of freedom. A value of $t = 2.0357$ with 33 degrees of freedom was required for the rejection of the null sub-hypothesis at the 0.05 level of significance. Therefore, the data failed to reject null sub-hypothesis 9.

Table 16. The analysis of data from students' ages in months

Name of group	n	Mean	S.D.	t	Significance
Experimental	17	253.35	24.11		N.S.
Control	18	261.78	24.32	-1.03	

D.f. = 33		$\alpha = 0.05$			table t = 2.0357

Summary for research hypothesis I

These nine sub-hypotheses of research hypothesis I revealed that there would be no significant difference in initial knowledge-background between the individualized instruction group and the group-lecture-discussion instruction group with the exception the groups did display a significant difference in achievement on the Unit 5--Diagnosis Pretest. The summary of t-statistical ratios for research hypothesis I is shown in Table 17.

Experimental Findings

After the preliminary-knowledge background process was accomplished, there were two more research hypotheses tested in this study.

Table 17. Summary of t-statistical ratio for research hypothesis I

Null sub-hypotheses	d.f.	Calculation t	Significance
1. MSAT	33	-0.42	N.S.
2. BMCT	33	0.63	N.S.
3. PRE1	33	1.01	N.S.
4. PRE2	33	0.67	N.S.
5. PRE3	33	0.80	N.S.
6. PRE4	33	-0.69	N.S.
7. PRE5	33	2.13	S.
8. PRES	33	1.16	N.S.
9. AGEM	33	-1.03	N.S.

$$\alpha = 0.05$$

Research hypothesis II

It was hypothesized that there would be no significant differences between the mean gain scores of the individualized-instruction group and the group-lecture-discussion instruction group.

There were 6 null sub-hypotheses under research hypothesis II. All of them were formulated in the expressed form:

$$H_0 : \mu_{E_{GAN.}} = \mu_{C_{GAN.}}$$

$$H_A : \mu_{E_{GAN.}} \neq \mu_{C_{GAN.}}$$

where

H_0 : Null hypothesis

H_A : Alternative hypothesis

$\mu_{E_{GAN.}}$: Gain score means of the experimental group on the given tests

$\mu_{A_{GAN.}}$: Gain score means of the control group on the given tests

The t-statistical equation was utilized to test all of these 6 null sub-hypotheses of research hypothesis II.

Null sub-hypothesis 10 It was hypothesized that there would be no significant difference between the group means for the experimental group and the control group as determined through the use of Unit One--Fuel and Combustion gain scores as a measurement indicator.

The analysis of data from the Unit One--Fuel and Combustion test, is presented in Table 18. The t-ratio from Table 18 was 0.18 with 33 degrees of freedom. A value of $t = 2.0357$ with 33 degrees of freedom was required for the rejection of the sub-hypothesis at the 0.05 level of significance. Therefore, the data failed to reject null sub-hypothesis 10.

Table 18. The analysis of data from the Unit One--Fuel and Combustion Test

Name of group	n	Mean	S.D.	t	Significance
Experimental	17	6.47	2.60		N.S.
Control	18	6.28	3.53	0.18	

D.f. = 33		$\alpha = 0.05$			table t = 2.0357

Null sub-hypothesis 11 It was hypothesized that there would be no significant difference between the group means for the experimental group and the control group as determined through the use of Unit Two--Carburetion gain scores as a measurement indicator.

The analysis of data from the Unit Two--Carburetion Test, is presented in Table 19. The t-ratio from Table 19 was -0.66 with 33 degrees of freedom. A value of $t = 2.0357$ with 33 degrees of freedom was required for the rejection of null sub-hypothesis at the 0.05 level of significance. Therefore, the data failed to reject null sub-hypothesis 11.

Table 19. The analysis of data from the Unit Two--Carburetion Test

Name of group	n	Mean	S.D.	t	Significance
Experimental	17	24.65	9.27		N.S.
Control	18	26.39	6.18	-0.66	

D.f. = 33		$\alpha = 0.05$			table t = 2.0357

Null sub-hypothesis 12 It was hypothesized that there would be no significant difference between group means for the experimental group and the control group as determined through the use of Unit Three--Lubrication test gain scores as a measurement indicator.

The analysis of data from the Unit Three--Lubrication Test, is presented in Table 20. The t-ratio from Table 20 was -0.69 with 33 degrees of freedom. A value of $t = 2.0357$ with 33 degrees of freedom was required for rejection of null sub-hypothesis at the 0.05 level of significance. Therefore, the data failed to reject null sub-hypothesis 12.

Table 20. The analysis of data from the Unit Three--Lubrication Test

Name of group	n	Mean	S.D.	t	Significance
Experimental	17	7.53	2.48		N.S.
Control	18	8.28	3.80	-0.69	
D.f. = 33		$\alpha = 0.05$		table t = 2.0357	

Null sub-hypothesis 13 It was hypothesized that there would be no significant difference between group means for the experimental group and the control group as determined through the use of Unit Four--Ignition Test gain scores as a measurement indicator.

The analysis of data from the Unit Four--Ignition Test, is presented in Table 21. The t-ratio from Table 21 was 0.21 with 33 degrees of freedom. A value of $t = 2.0357$ with 33 degrees of freedom was required for rejection of null sub-hypothesis at the 0.05 level of significance. Therefore, the data failed to reject null hypothesis 13.

Table 21. The analysis of data from the Unit Four--Ignition Test

Name of group	n	Mean	S.D.	t	Significance
Experimental	17	22.06	6.86		N.S.
Control	18	21.61	5.51	0.21	
D.f. = 33		$\alpha = 0.05$		table t = 2.0357	

Null sub-hypothesis 14 It was hypothesized that there would be no significant difference between group means for the experimental group and the control group as determined through the use of Unit Five--Diagnosis Test gain scores as a measurement indicator.

The analysis of data from the Unit Five--Diagnosis Test, is presented in Table 22. The t-ratio from Table 22 was -1.24 with 33 degrees of freedom. A value of $t = 2.0357$ with 33 degrees of freedom was required for rejection of null sub-hypothesis at the 0.05 level of significance. Therefore, the data failed to reject null sub-hypothesis 14.

Table 22. The analysis of data from the Unit Five--Diagnosis Test

Name of group	n	Mean	S.D.	t	Significance
Experimental	17	3.12	4.10		N.S.
Control	18	4.72	3.56	-1.24	
D.f. = 33		$\alpha = 0.05$		table t = 2.0357	

Null sub-hypothesis 15 It was hypothesized that there would be no significant difference between the group means for the experimental group and the control group as determined through the use of sum of test gain scores as a measurement

indicator.

The analysis of data from the sum gain scores, is presented in Table 23. The t-ratio from Table 23 was -0.63 with 33 degrees of freedom. A value of $t = 2.0357$ with 33 degrees of freedom was required for rejection of null sub-hypothesis at the 0.05 level of significance. Therefore, the data failed to reject null sub-hypothesis 15.

Table 23. The analysis of data from the sum of gain scores

Name of group	n	Mean	S.D.	t	Significance
Experimental	17	184.74	55.51		N.S.
Control	18	195.96	50.26	-0.63	
D.f. = 33		$\alpha = 0.05$		table t = 2.0357	

Summary for research hypothesis II

These six null sub-hypotheses of research hypothesis II revealed that there would be no significant difference in gain score comparisons between the individualized-instruction group and the group-lecture-discussion instruction group. The summary of t-statistical ratio for research hypothesis II is shown in Table 24.

Table 24. Summary of t-statistical ratio for research hypothesis II

Null sub-hypotheses	D.F.	Calculation t	Significance
10. GAN1	33	0.18	N.S.
11. GAN2	33	-0.66	N.S.
12. GAN3	33	-0.69	N.S.
13. GAN4	33	0.21	N.S.
14. GAN5	33	-1.24	N.S.
15. GANS	33	-0.63	N.S.

 $\alpha = 0.05$

Research hypothesis III

It was hypothesized that there would be no significant difference in the group means of the final comprehensive test scores between the individualized-instruction group and the group-lecture-discussion instruction group.

There was one null sub-hypothesis under research hypothesis III. It was formulated in the expressed form:

$$H_0 : \mu_{E_{FCT}} = \mu_{A_{FCT}}$$

$$H_A : \mu_{E_{FCT}} \neq \mu_{A_{FCT}}$$

where

- H_0 : Null hypothesis
- H_A : Alternative hypothesis
- $\mu_{E_{FCT}}$: Mean of the experimental group on the Final Comprehensive Test
- $\mu_{C_{FCT}}$: Mean of the control group on the Final Comprehensive Test

The t-statistical equation was utilized to test this null sub-hypothesis of research hypothesis III.

Null sub-hypothesis 16 It was hypothesized that there would be no significant difference between the group means for the experimental group and the control group as determined through the use of Final Comprehensive Test as a measurement indicator.

The analysis of data from the Final Comprehensive Test, is presented in Table 25. The t-ratio from Table 25 was 0.46 with 33 degrees of freedom. A value of $t = 2.0357$ with 33 degrees of freedom was required for the rejection of null sub-hypothesis at 0.05 level of significance. Therefore, the data failed to reject null sub-hypothesis 16.

Summary

These three research hypotheses containing 16 null sub-hypotheses revealed that 15 were not significantly different means and 1 was significantly different between an

Table 25. The analysis of data from the Final Comprehensive Test

Name of group	n	Mean	S.D.	t	Significance
Experimental	17	87.18	8.60		N.S.
Control	18	85.83	8.67	0.46	

D.f. = 33		$\alpha = 0.05$			table t = 2.0357

individualized-instruction method and the group-lecture-discussion instruction method. The summary of these 16 statistical comparisons is presented in Table 26.

Table 26. The summary of statistical comparisons for this study

Research hypotheses	Null hypotheses	D.F.	Calculation t	Significance
I	MSAT	33	0.42	N.S.
	BMCT	33	0.63	N.S.
	PRE1	33	1.01	N.S.
	PRE2	33	0.67	N.S.
	PRE3	33	0.80	N.S.
	PRE4	33	-0.69	N.S.
	PRE5	33	2.13	S.
	PRES	33	1.16	N.S.
	AGEM	33	-1.03	N.S.
II	GAN1	33	0.18	N.S.
	GAN2	33	-0.66	N.S.
	GAN3	33	-0.69	N.S.
	GAN4	33	0.21	N.S.
	GAN5	33	-1.24	N.S.
	GANS	33	-0.63	N.S.
III	FCT	33	0.46	N.S.

$\alpha = 0.05$

CHAPTER V. SUMMARY, CONCLUSIONS,
AND RECOMMENDATIONS

This chapter provides a summary of the study, conclusions which were derived from the findings, and recommendations.

Summary

This section includes an introduction, purpose, and findings of the study.

Introduction

The individualized-instruction method is considered one of several innovations in education. Due to the nature of the activities in an auto mechanics-laboratory environment, the student frequently needs individual instruction; an individualized-instruction setting in auto mechanics teaching seems to be a necessary alternative.

Because few studies in auto mechanics instruction have been conducted to compare students' test performances, this study was done to compare the test scores for students exposed to an individualized instruction method to the test scores of students exposed to the conventional group-lecture-discussion methods, to determine which teaching method is the more effective for teaching selected units of auto mechanics.

Purpose

The primary purpose of this study was to establish which instructional method would produce a higher gain score on administered tests. The secondary purpose of this study was to provide more research evidence for the auto mechanics teachers to achieve these purposes, a set of individualized-learning packages was developed and taught to the experimental group. Results were compared with a control group which was taught by a group-lecture-discussion instruction method.

Procedure

The study consisted of two phases. The first week through the fourth week of the quarter comprised phase I, and all of the students were taught by the same method with the same instructional materials. The fifth week until the end of the quarter comprised phase II. The experimental group studying in the Media Center of the library utilized the media prepared for individualized instruction, while the control group learned the identical instruction materials in the regular classroom setting with a group-lecture-discussion instruction method. Pretests and posttests on the instructional materials contained in each unit were administered. During the final week, a final comprehensive test was also administered to both groups. All of the test scores were recorded, coded, and verified. They were then placed on International Business Machine (IBM) data-processing cards for computer input and processing.

Findings

The following findings were identified from a detailed analysis of three research hypotheses in this study:

1. The first research hypothesis stated that there would be no significant difference in initial knowledge-background between the sample receiving the individualized instruction method and the sample receiving the group-lecture-discussion instruction method. A t-statistical equation was utilized to compare whether differences existed between the control group and the experimental group with respect to preliminary knowledge-background. Data recorded in Table 17 showed that the group means were not significantly different at 0.05 level of significance with respect to BMCT, MSAT, PRE1, PRE2, PRE3, PRE4, PRES, AGEM variables, with the exception of PRE5. However, this difference was not evident during the posttest and gain scores.
2. The second research hypothesis stated that there would be no significance in the mean of the gain scores between the individualized-instruction method and the group lecture-discussion method. A separate t-statistical equation was employed to investigate whether these students who belonged to the experimental group could gain a higher scores on the given

tests. The t-ratios tests showed no significant differences at the 0.05 level of significance on the given tests.

3. The third research hypothesis stated that there would be no significant difference in the mean of the final comprehensive test scores between the individualized-instruction method and the group-lecture-discussion instruction method. Finally, the same t-statistical equation was used to determine the possible differences between the two groups with regard to the final comprehensive test. Again, the t-ratio tests showed no significant difference at the 0.05 level of significance on the final comprehensive test score.

Conclusions

The following conclusions were derived from the findings in the previous chapter.

1. The random assignment of students to the two groups was successful with regard to preknowledge and ages in months. This randomization of assigning students provided the necessary evidence that the experimental group and the control group were initially equal.
2. The individualized-instruction method was as effective as the group-lecture-discussion method related to the

test achievement gain scores. The results do not suggest either the conventional group-lecture-discussion instruction method or the individualized-instruction method was ineffective in achieving gains in learning. The results confirmed other research findings (Neff, 1973; and Eide, 1973) that no one particular method is necessarily superior with all groups. Studies such as those suggest that the educator can experiment with new instructional methods to meet students' learning styles, capacities, and backgrounds, without risking low achievement in terms of gain scores on given tests. It also provided strong support for encouraging educators to pay less attention to the fixed schedule and take some action to help students to learn the same content in accordance with his or her individual interests, differences, and learning styles.

3. The individualized-instruction method was as effective as the conventional group-lecture-discussion method related to the achievement scores of a final comprehensive test. Again, this result did not imply in any way that either the conventional group-lecture-discussion instruction method or the individualized-instruction method is more effective in auto mechanics instruction. However, the individualized-instruction

method could produce the same achievement scores but facilitate greater schedule flexibility and individual pacing, and accommodate a larger range of individual differences, than the conventional method. Serious consideration for the use of alternative instruction method is necessary, with perhaps less emphasis on the conventional group-lecture-discussion instruction method.

Recommendations

The following recommendations were made based upon the results of this study. It was hoped that these recommendations could provide industrial-education teachers with more research information regarding auto mechanics instructional methods. It was also hoped that the study will stimulate more researchers to do studies in this area which can meaningfully relate to the present study.

1. If this study is repeated, a larger sample size can be checked for any variation when compared to the results of this study.

2. It could be a meaningful study to make a comparison among the conventional group-lecture-discussion instruction method, the individualized-instruction method, and the combination of conventional group-lecture-discussion instruction and the individualized-instruction method.

3. In future research studies, a more specific comparison between slides and the notebook of the learning packages can be made.

4. There is a need to investigate the students' attitude toward the individualized-instruction method.

5. During the experimental period of time, the inclusion of a discussion session for the experimental group might affect the result of study, but it is a good way to make up for the shortcoming of the individualized-instruction method.

6. There is a need to determine the relationship between the students' attitude toward the individualized-instruction method and the achievement scores within the experimental group.

BIBLIOGRAPHY

- Bennett, George K. Bennett Mechanical Comprehensive Test Form S. New York: The Psychological Corporation, 1969.
- Blalock, Habert M. Table B Random Numbers. Social Statistics. New York: McGraw-Hill Book Co., 1972.
- Born, David G. Instructor manual for development of a personalized instruction course. Salt Lake City, Utah: Center to Improve Learning and Instruction, University of Utah, 1971.
- Born, David G., Gledhill, Stephen M., and Davis, Michael L. Examination performance in lecture-discussion and personalized instruction courses. Journal of Applied Behavior Analysis, 1972, 5, 33-43.
- Brown, Frederick G. Principles of Educational and Psychological Testing. Hinsdale, Illinois: The Dryden Press Inc., 1970.
- Burke, Caseel D. The Structure and Substance of the WILKIT: Instructional Module. Educational Technology, Sept. 1972, 12, 41-46.
- Burns, Richard W., Contributing Editor. An Instructional Module Design. Educational Technology, Sept. 1972, 12, 27-29.
- Calhoun, James F. The relation of student characteristics to performance in a personalized course. Educational Technology, April 1975, 15, 16-18.
- Campbell, Donald T., and Stanley, Julian C. Experimental and Quasi-Experimental Designs for Research. Chicago: Rand McNally and Company, 1963.
- Dalton, Leonard F. The single-page learning model. Educational Technology, Sept. 1972, 12, 13-15.
- Duane, James E. Let's not forget the human aspects when individualizing instruction. Educational Technology, Nov. 1974, 14, 32.
- Eide, Arvid Ray. The influence of learning packages and independent study on student achievement in engineering graphics. Unpublished Ph.D. Dissertation, Iowa State University, 1973.

- Esbensen, Thorwald. The Duluth Contract: What it is and What it does. Educational Technology, Sept. 1972, 12, 22-23.
- Ferguson, D. Hugh. Pitfalls and frustrations of individualization. National Association of Secondary School Principals Bulletin 390, April 1975, pp. 25-29.
- Gage, N. L., Editor. Handbook of research on teaching. American Educational Research Association. Chicago: Rand McNally and Company, 1963.
- General Catalog of Iowa State University of Science and Technology Bulletin, Ames, Iowa, 1973-1975.
- Glass, Gene V. and Stanley, Julian C. Statistical methods in education and psychology. Englewood Cliffs, N.J.: Prentice-Hall, Inc., 1970.
- Good, Carter V., Ed. Dictionary of education. (2nd ed.) New York: McGraw-Hill Book Company Inc., 1959.
- Good, Carter V., Ed. Dictionary of education. (3rd ed.) New York: McGraw-Hill Book Company Inc., 1973.
- Good, Carter V. Introduction to educational research. (2nd ed.) New York: Division of Meredith Publishing Company, 1963.
- Hoffman, Larry Dean. Audio-tutorial versus conventional methods of teaching slide rule. Unpublished Ph.D. Dissertation, Iowa State University, 1971.
- Howes, Virgil M. Individualization of instruction. New York: The Macmillan Company, 1971.
- Jones, Richard. Learning activity packages: An approach to individualized instruction. Journal of Secondary Education, 1968, 43, 178-183.
- Kapfer, Philip G. and Kapfer, Miriam B. Learning packages in American Education. Englewood Cliffs, New Jersey: Educational Technology Publications, 1973.
- Keller, Fred S. Good-bye Teacher.... Journal of Applied Behavior Analysis, 1968, 1, 79-89.
- Layton, Wilbur L. and Herbert Toops. Minnesota Scholastic Test, Form C. Department of Psychology, Ames, Iowa, 1964.

- Meeks, Bruce E. Learning packages versus conventional methods of instruction. Unpublished Ph.D. Dissertation, Iowa State University, 1971.
- Menne, John W., Warman, Roy E. and Krause, Dan. Interpretation of entering student's test scores. Counseling Service Center, Iowa State University, June, 1974.
- Neff, Gale Norman. The design, development and testing of an experimental individualized learning system. Unpublished Ph.D. Dissertation, Oregon State University, 1973.
- Postlethwait, S. N., and Hurst, Robert N. The audio-tutorial system: Incorporating Minicourse and Mastery. Englewood Cliffs, New Jersey: Educational Technology Publications, 1972.
- Smith, James E. The learning activity package (LAP). Educational Technology, Sept. 1972, 12, 15-17.
- Stiles, Lindley J. Influence of individual differences on individual theories. Theories for teaching. New York: Dodd, Mead & Company, 1974.
- Stuck, Dean Lee. A comparison of audio-tutorial and lecture methods of teaching. Unpublished Ph.D. Dissertation, Iowa State University, 1968.
- Toffler, Alvin. Future Shock. New York: Bantam Book, Inc., 1971.
- Undergraduate Curriculum Committee. Department goals of teaching and learning. Industrial Education Department, Iowa State University, June, 1974.
- Weisgerber, Robert A. Prespectives in individualized learning. Palo Alto, American institutes for research. Itasca, Ill.: F. E. Peacock Publishers Inc., 1971.

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APPENDIX A: AN EXAMPLE OF LEARNING PACKAGE

(This individualized learning package
was used along with a cassette tape)

UNIT CARBURETION

Objectives:

1. After completing this learning unit, each student will be able to match the following terms with the correct definition or function(s):
 - (a) Choke valve
 - (b) Main discharge nozzle
 - (c) Float
 - (d) Air vent
 - (e) Idle adjustment screw
 - (f) Air bleed
 - (g) Bernoullis' principle
 - (h) Carburetion
 - (i) Evaporation
 - (j) Pressure differential

2. After completing this learning unit, each student will be able to label the components of a float type up-drafting carburetor on a drawing with 85% or more accuracy.

3. After completing this learning unit, each student will be able to match the main system and its function(s) of a float type carburetor for a small engine.

4. After completing this learning unit, each student will be able to match the principal elements of float system of a float type carburetor of a small engine.

5. After completing this learning unit, each student will be able to indicate the

- (a) Fuel flow
- (b) Throttle valve position(s)/location(s)
- (c) Choke valve
- (d) Air flow

for start system, idle system and high speed system on a float type carburetor drawing with 85% or more accuracy.

6. After completing this learning unit, each student will be able to label the components of a suction-feed type carburetor on a drawing with 85% or more accuracy.

7. After completing this learning unit, each student will be able to indicate the following:

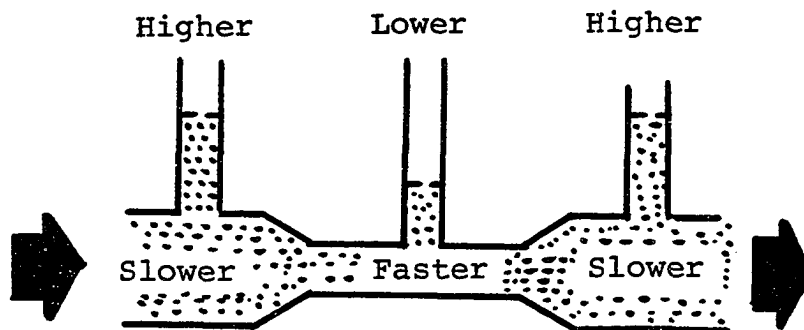
- (a) Fuel flow direction
- (b) Air flow direction
- (c) Fuel tank
- (d) Choke slide
- (e) Throttle valve position(s)/location(s)
- (f) Needle valve
- (g) High speed orifice
- (h) Low speed orifice

for start, idle speed and high speed systems on a suction-feed type carburetor drawing with 85% or more accuracy.

UNIT CARBURETOR

The Venturi Principle Applied to Liquids

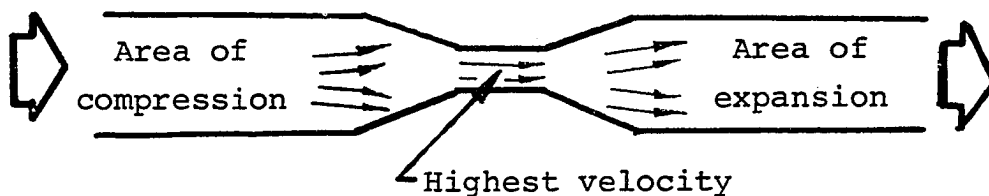
It is a law of physics (Bernoulli's principle) that: If the speed of a liquid flowing through a confined area is increased at any point, the pressure of the liquid decreased at that point. "Pressure" in this case means the sum total of forces causing the liquid to push outward against its container. This law be demonstrated by the use of a liquid venturi tube, as illustrated.



When liquid is forced through the horizontal tube so as to fill all of the tubes throughout, the liquid level in the central vertical tube (which is connected at the throat; or restricted portion, of the horizontal tube) will be lower than the levels of liquid in the two other vertical tubes.

The Venturi Principle Applied to Gases

A venturi works exactly the same with a gas as with a liquid, with this one exception - a gas is easily compressible, whereas a liquid is not. Consequently, as a gas approaches a venturi throat, it will partly speed up as a liquid does, but will partly become compressed and literally squeeze more molecules through. Compression increases the pressure in a gas.



Therefore, that portion which is compressed will add to the pressure in the venturi throat. The overall pressure differential between the area above the throat and the area in the throat will not be as great as it is in a liquid.

Actually, this compression factor introduces a new element to consider - the time element. Until there is time for all the gas above the throat to become so highly compressed that it will build up sufficient compression pressure to increase the velocity as required to equalized the flow, the flow actually remains unequal. There will be

less gases flowing through the venturi than will be flowing through the area ahead of it. Gas will accumulate (under continuing compression) above the throat. Also, the compressed gas will expand to refill the area below the throat. During the interval in which less gas passes the throat, the expansion of the gas necessarily exceeds the amount by which it has been compressed. And expansion reduces the pressure. As a result, the pressure in the area just below the throat will be even lower than the pressure in the throat during such an interval.

Once this interval is ended, however, and the compression above the throat builds up to equalize the flow, the expansion factor will just equal the compression factor. All the pressure will be just the same as those explained for a liquid. In short, when compression reaches the point where there is no need for further compression, the gas will flow exactly like an incompressible liquid.

The Venturi Principle Applied to a Carburetor

Air does not flow continuously through a carburetor. It flows in starts and stops, as called for by the intake stroke(s) of the piston (s). The time interval of each flow period is extremely short. Moreover, the air is not being hydraulically pumped through against atmospheric pressure at the other end. On the contrary, it is being forced through

by a partial vacuum. These factors all influence the design of a carburetor venturi and make it somewhat different from the liquid venturi previously illustrated.

Due to the short interval of air flow, the lowest pressure point in a carburetor venturi is in the area just beyond the throat, where expansion is taking place. This is accentuated by the fact of the partial vacuum beyond. The throat, itself, does not serve the purpose of a low-pressure area; it serves only to create the conditions for this low-pressure area beyond.

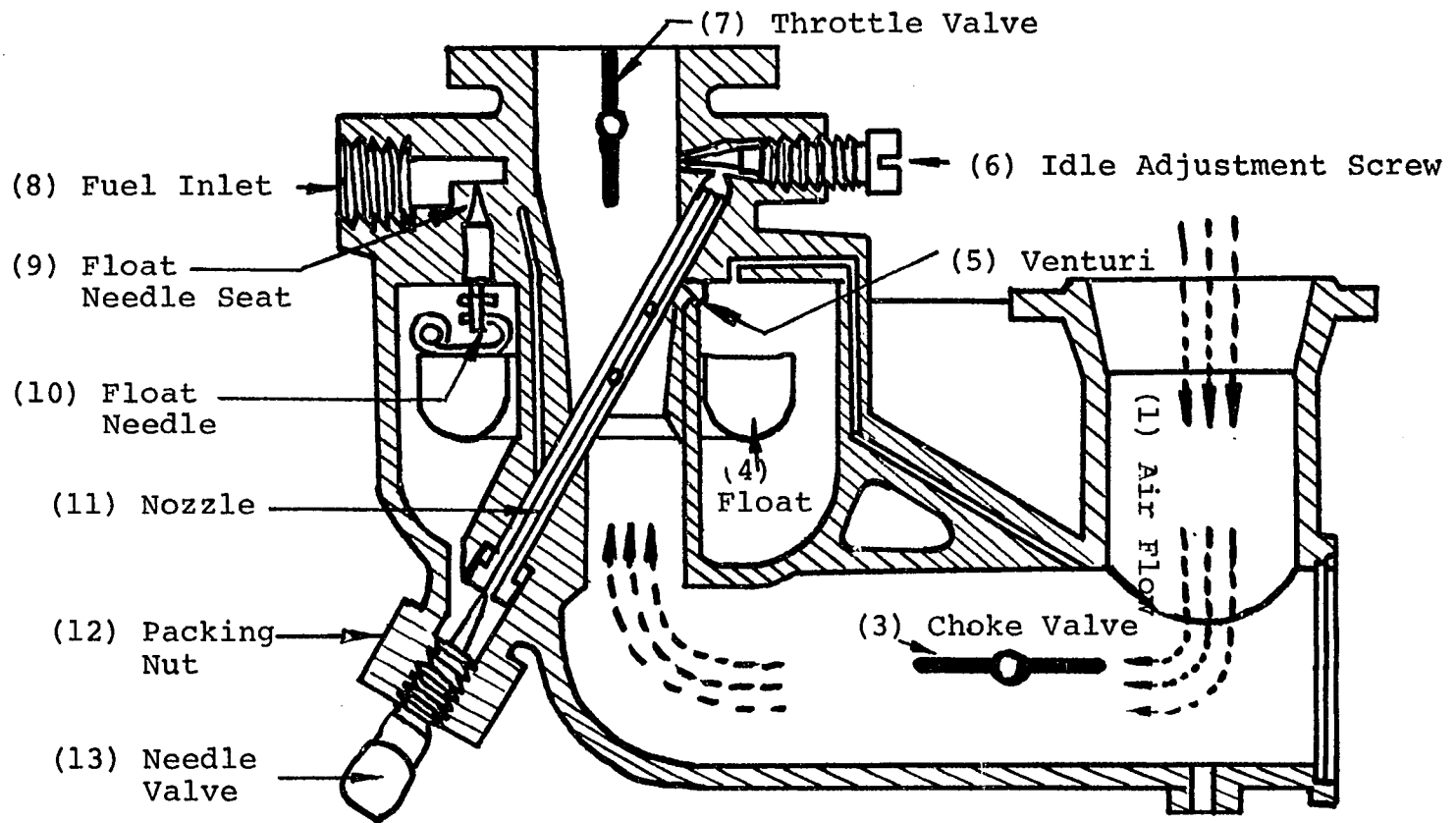


Figure 1. Parts of a float carburetor

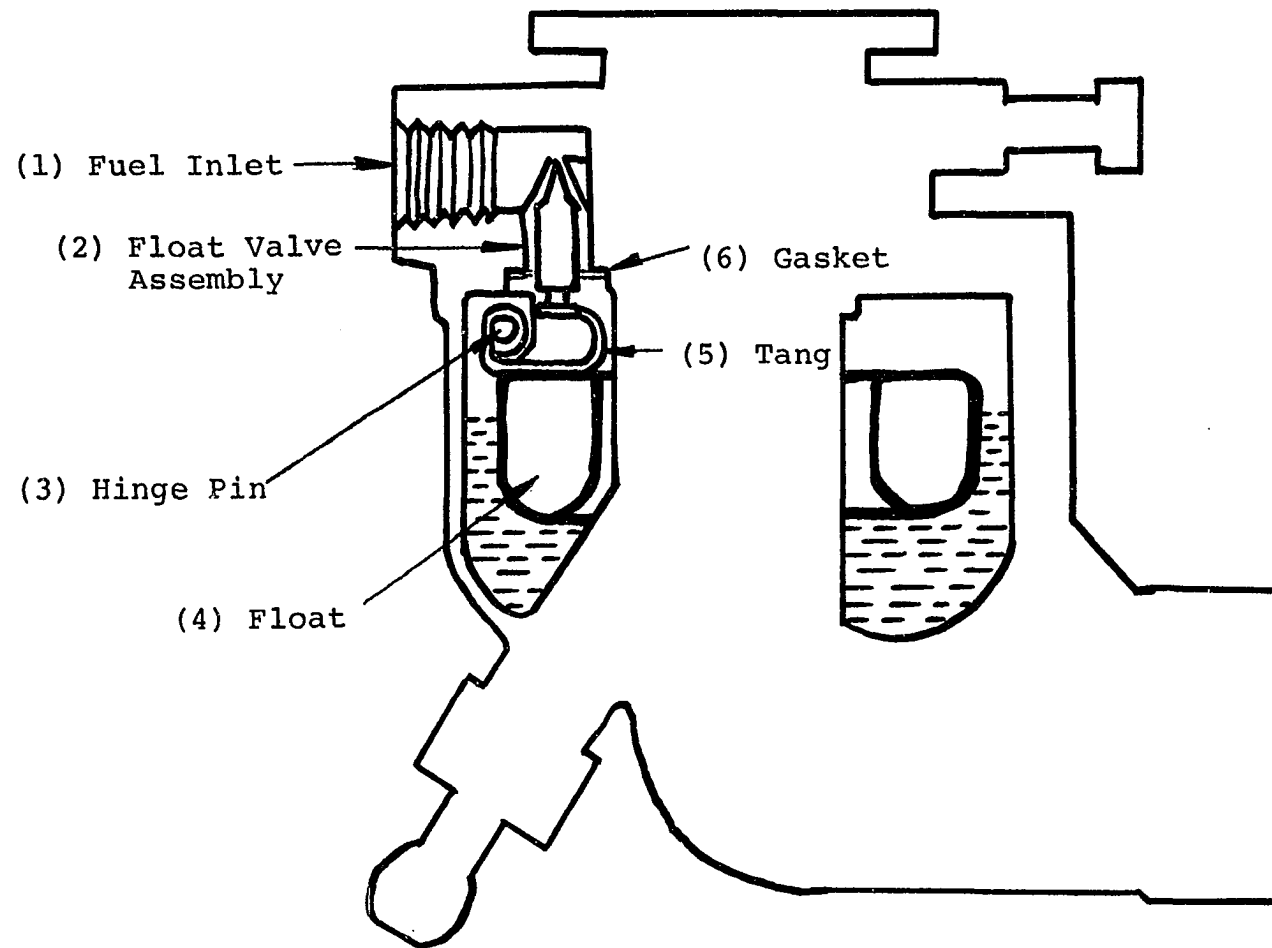


Figure 2. The float system

The Float System

This system is used to maintain the level of fuel in the carburetor bowl. It consisted of the float, hinge pin, and float valve assembly.

The float has a tang or clip attached to it. The float can be checked for leaks by placing it in hot water and watching for air bubbles to raise. Replace leaky floats, do not solder them. If the tang or clip is worn, replace the float.

If the float level is too high, the high speed adjustment will be sensitive and the engine will flood easily when starting. If the float level is too low, the engine will be harder starting and many tend to lean out.

Use new gaskets when reassembling the carburetor. Old gaskets get hard tend to leak. Undue pressure is then used to stop fuel leaks and carburetor parts are damaged.

During a long period of storage, the inlet needle may stick to the seat due to gum formation. Draining fuel tank, lines, and carburetor prior to storage eliminates this problem.

Floats occasionally are collapsed. Water, freezing in the carburetor bowl will partially collapse the float. Compressed air applied to the carburetor can also collapse the float.

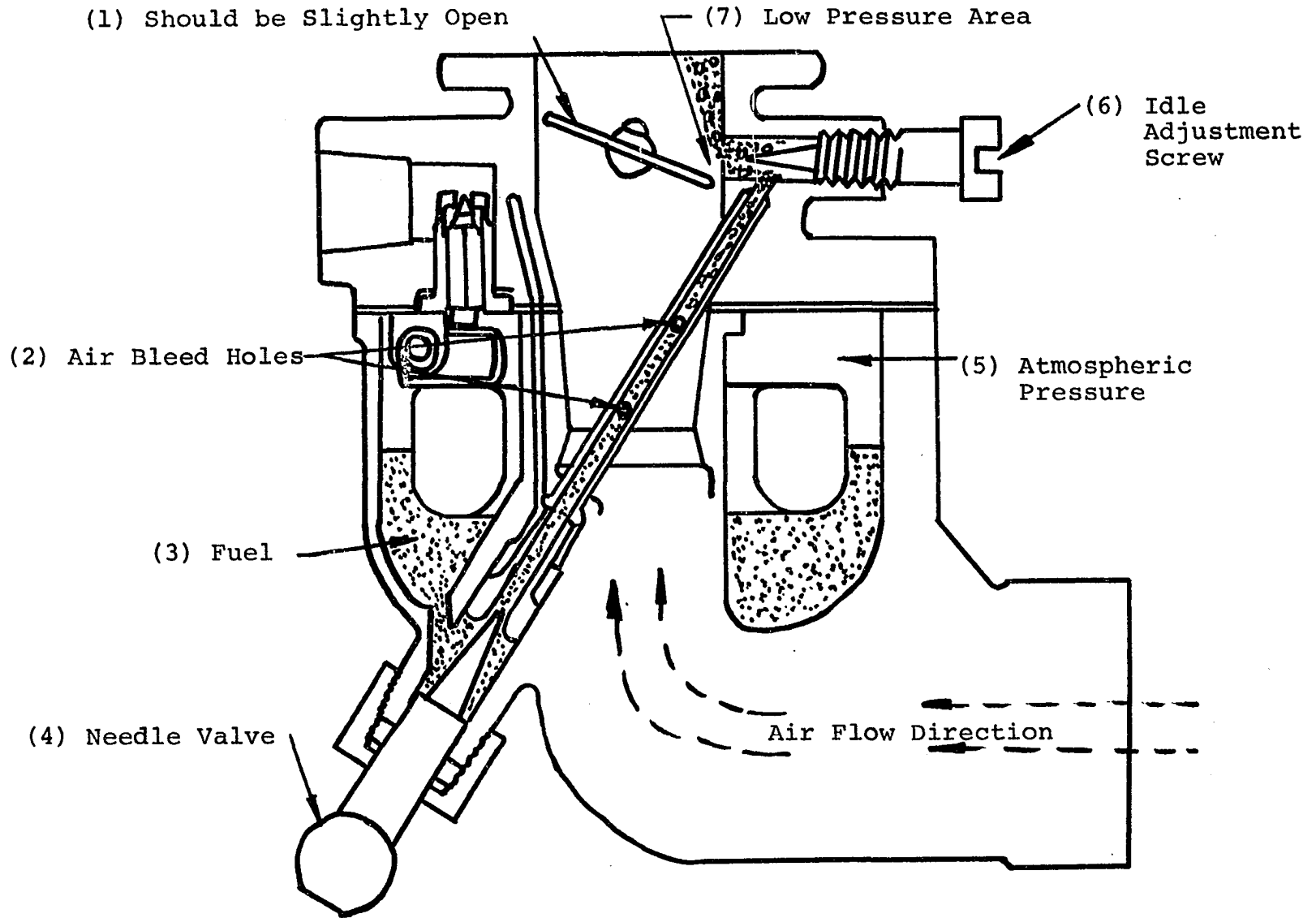


Figure 3. The idle system

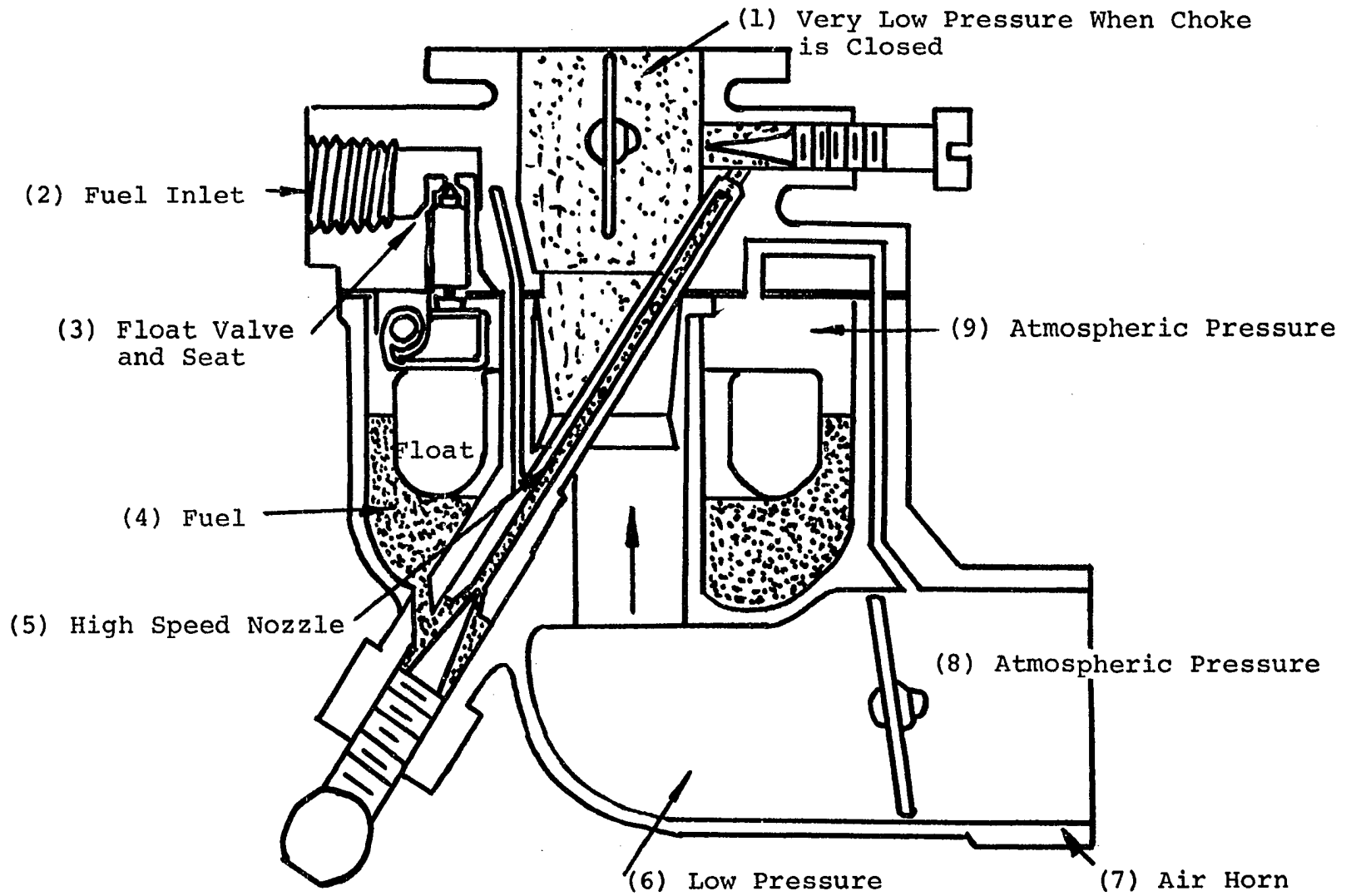


Figure 4. The choke system

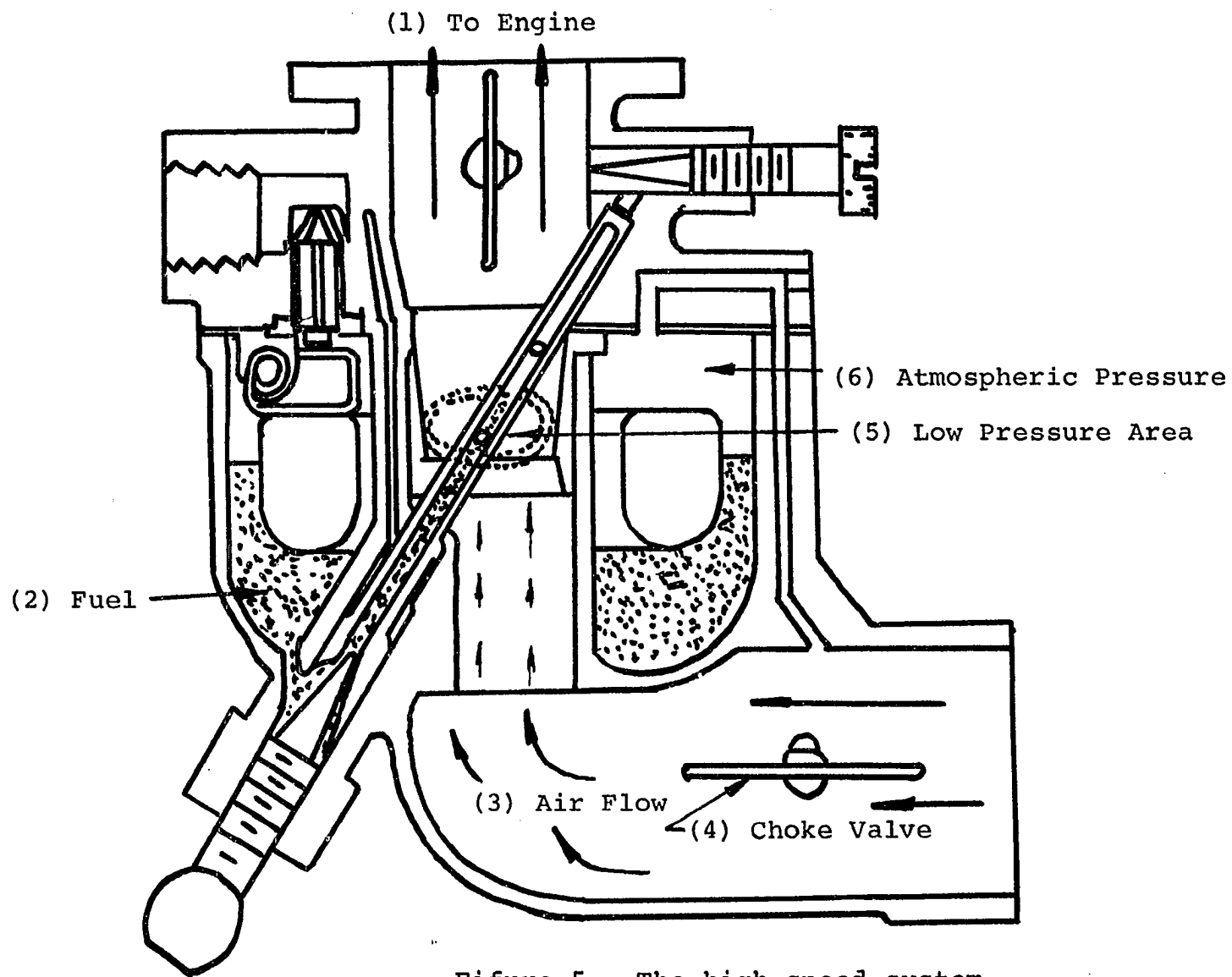


Figure 5. The high speed system

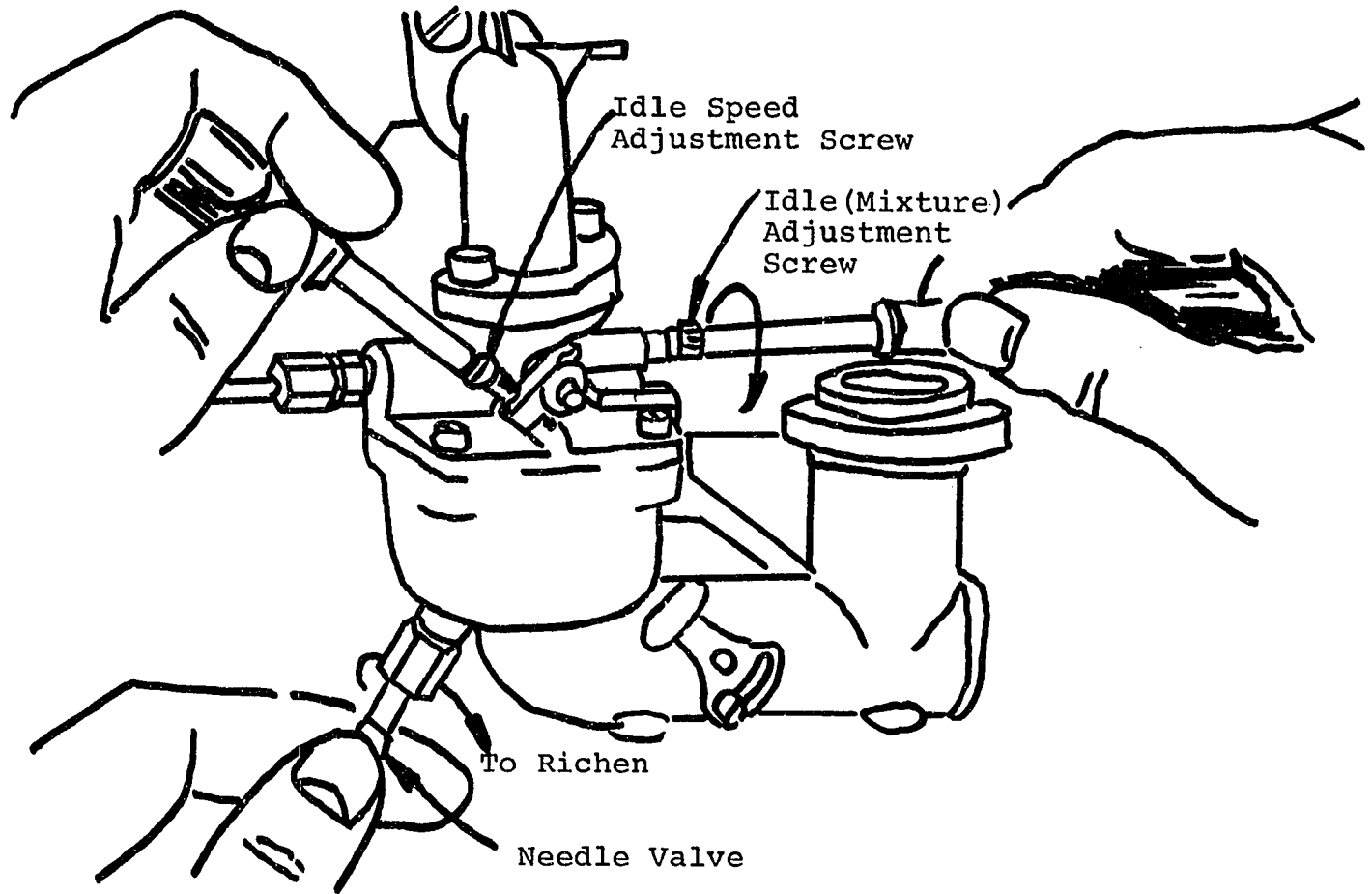


Figure 6. Carburetor adjustment

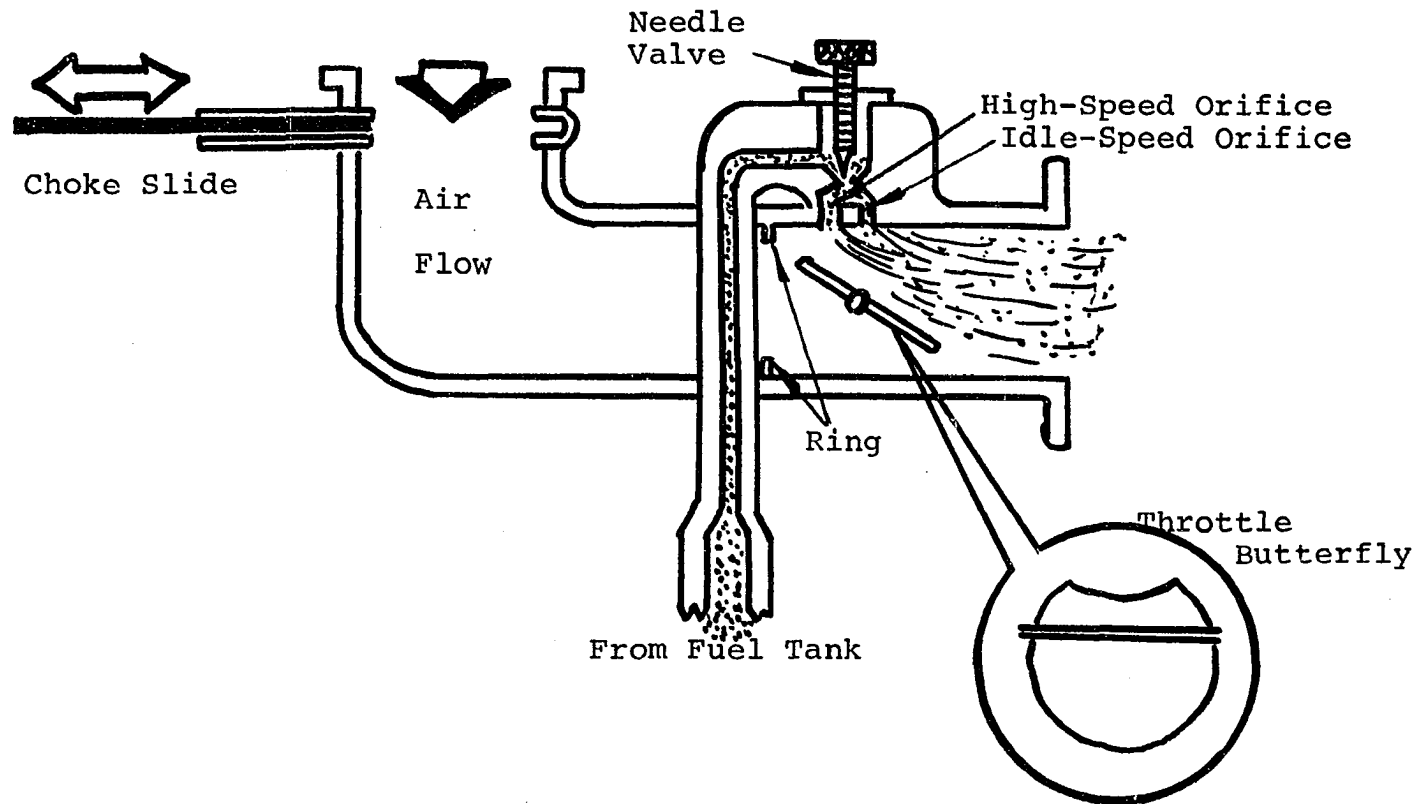


Figure 7. Suction-feed carburetor

Suction-feed Carburetor Adjustment

Rotation of the single needle valve in a clockwise direction always leans the mixture. This valve is intended for high-speed mixture adjustment only; it must always be open more than enough to pass all the fuel that will pass through the idle-speed orifice.

Consider the amount of pressure differential produced by the engine as one force, and the weight of the gasoline in the line and carburetor passage as an opposing force. It follows that the rate of fuel flow into the air stream during engine operation must depend, to some extent, on the level of the fuel in the tank. With a full tank, the column of fuel is shorter and lighter; with an almost empty tank, it is longer and heavier. As the column weight increases the velocity of the flow (all else remaining uncharged must decreased somewhat.

Consequently, it is very important with this type of carburetor, that the needle-valve adjustment be made only when the tank is half full. This will provide an adjustment that is a compromise between the two extrem of full and nearly empty and will ensure average carburetor operation as the fuel supply varies. The valve is generally set, under this condition, as rich as it can be and still run evenly. Each manufacturer will, however, give the exact adjustment

requirement for this engine.

A carburetor of this type does usually have an idle-speed adjustment screw. Idling speed is generally set quite high; but here again, you should follow the manufacturer's instructions.

APPENDIX B: WORK-SHEET

I. Ed. 261

Name: _____

Date: _____

Starting time: _____

Finish time: _____

Unit: _____

WORK SHEET

1. _____

2. _____

3. _____

4. _____

5. _____

6. _____

7. _____

8. _____

9. _____

10. _____

APPENDIX C:

PERSONAL DATA QUESTIONNAIRE OF I. ED. 261

PERSONAL DATA QUESTIONNAIRE OF I. ED. 261

Name: _____ Soc. Sec # _____
 (Last) (First) (Mi)

Mailing Address: _____

Home Address: _____

Date of Birth: _____ Sex: M ___ F ___
 (Mo.) (Day) (Yr)

Major Department: _____

Do you have automotive mechanics work experience before?
 Yes ___ for ___ Year(s) and ___ Month(s)
 No ___

Have you taken automechanics course(s) before?
 No ___
 Yes ___

- (1). Course title: _____ for ___ Mo.
- (2). Course title: _____ for ___ Mo.
- (3). Course title: _____ for ___ Mo.

How is your education being financed?
 Self _____
 Parents _____
 ROTC _____
 Other _____

Why are you taking this course
 Require _____
 Personal interest _____
 Other _____

UNIT	PRETEST SCORE	POSTTEST SCORE
1.	_____	_____
2.	_____	_____
3.	_____	_____
4.	_____	_____
5.	_____	_____

APPENDIX D: PRETESTS

INDUSTRIAL EDUCATION 261
INTERNAL COMBUSTION ENGINE

FUEL AND COMBUSTION PRETEST

Directions:

1. On the IBM answer sheet provided, record:
 - a. your name - last name first.
 - b. the date.
 - c. the name of your instructor.
 - d. in the blank labeled "name of test" record the words "Fuel and Combustion Pretest."
 - e. in the top two rows of the identification block record your two digit identification number. Be sure to blacken the corresponding spaces.
2. There are 4 pages containing 23 questions in the test.
3. Read each statement carefully. Mark the most correct answer in the appropriate space on the IBM answer sheet with a pencil. If you change your mind, erase your first mark completely.

Example : The abbreviation for the Iowa State University is

- a. U S I
- b. I S U
- c. S U I
- d. I U S
- e. none of the above

a.	b.	c.	d.	e.
===	---	===	===	===

4. There is no penalty for guessing.
5. DO NOT OPEN THIS TEST UNTIL YOU ARE TOLD TO DO SO BY THE INSTRUCTOR!

Part I. Multiple Choice: Choose the ONE BEST answer. DO NOT MARK ON THE TEST COPY.

1. The antiknock rating of gasoline is given in terms of the
 - a. heptane number
 - b. carbon number
 - c. octane number
 - d. hydrogen number
 - e. cetane number

2. Increasing the compression ratio of an engine
 - a. reduces the power
 - b. increases the knocking tendency
 - c. increases fuel consumption
 - d. reduces the knocking tendency
 - e. none of the above

3. It is generally agreed that up to ___ parts CO/10,000 of air makes the air dangerous to breathe
 - a. 15
 - b. 51
 - c. 100
 - d. 151
 - e. 300

4. The fuel air mixture by weight of an ideal mixture is
 - a. 6,000 : 1
 - b. 9,000 : 1
 - c. 1 : 15
 - d. 15 : 1
 - e. 1 : 9,000

5. Detonation will most likely cause
 - a. connecting rod destruction
 - b. cylinder destruction
 - c. piston destruction
 - d. bearing destruction
 - e. valve destruction

6. If gasoline vaporizes in the fuel line, it is liable to produce a
 - a. volatile lock
 - b. line lock
 - c. pipe lock
 - d. vapor lock
 - e. fuel lock

7. Which of the following is not a factor effecting detonation
 - a. Displacement
 - b. compression ratio
 - c. temperature
 - d. density
 - e. humidity

8. Gasoline is a
 - a. hydrocarbon
 - b. halogen
 - c. ester
 - d. hydroxyl
 - e. carbohydrate

9. The ease with which a liquid vaporizes is determined by its
 - a. vapotility
 - b. volubility
 - c. velocity
 - d. volatility
 - e. none of the above

10. Compared with water, which boils at 212°F , a liquid that boils at 600° has
 - a. much lower volatility
 - b. slightly higher velocity
 - c. much higher velocity
 - d. much higher volatility
 - e. slightly higher volatility

11. The approximate fuel air ratio by volume of an ideal mixture at sea level and 80°F is
 - a. 15 : 1
 - b. 1 : 9,000
 - c. 9,000 : 1
 - d. 1 : 15
 - e. 15 : 10,000

12. Four of the following are gasoline additives, which is not
 - a. detergents
 - b. anti-icers
 - c. anti foaming agent
 - d. metal deactivators
 - e. oxidation inhibitors

13. There are two product of complete combustion of gasoline water and
- sulfur dioxide
 - hydrocarbons
 - carbon
 - carbon monoxide
 - carbon dioxide
14. When a complete combustion occurs, the following chemical equation: $2C_8H_{18} + 25 O_2$ should be balanced by
- $18 H_2O$
 - $4 CO_2 + 8 H_2O$
 - $2 CO_2 + 25 H_2O$
 - $16 CO_2$
 - $16 CO_2 + 18 H_2O$
15. Three pounds of paraffin C_8H_{18} are used in an engine where perfect combustion occurs. How many pounds of water be produced
- 1.231 pounds
 - 2.314 pounds
 - 4.263 pounds
 - 5.413 pounds
 - 6.143 pounds
16. A fuel blended from 20% heptane and 80% iso-octane would have an Octane Rating Number of
- 40
 - 60
 - 80
 - 100
 - 120
17. The laboratory method of measuring the Octane Rating Number of a fuel makes uses of
- a road test at constant throttle opening
 - an engine with adjustable fuel nozzle
 - a road test at constant speed
 - an engine with adjustable compression ratio
 - none of the above
18. Preignition can be caused by
- hot spark plug
 - an excessively high compression ratio
 - hot carbon spots
 - over heated exhaust valve
 - all of the above

19. Advancing the ignition spark, or timing
- increases oil consumption
 - reduces the tendency of the engine to detonate
 - increases the tendency of the engine to detonate
 - in effect, decreases octane requirement
 - decreases the fuel economy
20. When a incomplete combustion occurs, the following chemical equation: $C_7H_{16} + 9 O_2$ should be balanced by
- $4 CO + 3 CO_2 + H_2O$
 - $3 CO + 4 CO_2 + 2^2H_2O$
 - $3 CO + 4 CO_2 + 8 H_2O$
 - $4 CO + 3 CO_2 + 8 H_2O$
 - $4 CO + 4 CO_2 + 2 H_2O$

Part II. Matching: any answer can be used more than once and answer(s) may not needed to be used at all. DO NOT MARK ON THE TEST COPY.

21. ___ Detonation
22. ___ Preignition
23. ___ Heat of compression
- an ignition of the fuel-air mixture during compression, as caused by some hot spots within the cylinder.
 - an incomplete combustion and make the air dangerous to breathe.
 - air molecules crowded closely together.
 - as the flame races through the combustion chamber, the unburned gases ahead of it are further compressed to the point of spontaneous ignition.
 - the temperature at which the fuel is completely vaporized.

INDUSTRIAL EDUCATION 261
INTERNAL COMBUSTION ENGINE

CARBURETION PRETEST

Directions:

1. On the IBM answer sheet Provided, record:
 - a. your name - last name first.
 - b. the date.
 - c. the name of your instructor.
 - d. in the blank labeled "name of test" record the words "Carburetion Pretest."
 - e. in the top two rows of the identification block record your two digit identification number. Be sure to blacken the corresponding spaces.
2. There are 7 pages containing 25 questions in the test.
3. Read each statement carefully. Mark the most correct answer in the appropriate space on the IBM answer sheet with a pencil. If you change your mind, erase your first mark completely.

Example: The abbreviation for the Iowa State University is

- a. U S I
- b. I S U
- c. S U I
- d. I U S
- e. none of the above

a. b. c. d. e.
 === === === ===

4. There is no penalty for guessing.
5. DO NOT OPEN THIS TEST UNTIL YOU ARE TOLD TO DO SO BY THE INSTRUCTOR!

Part I. Multiple Choice: Choose the ONE BEST answer. DO NOT MARK ON THE TEST COPY.

1. Usually the carburetor on a small engine, does not contain the
 - a. throttle valve
 - b. choke valve
 - c. accelerator pump system
 - d. venturi
 - e. idle-speed system

2. Idle adjustment screw controls the quantity of
 - a. oil
 - b. raw fuel
 - c. raw air
 - d. fuel-air mixture
 - e. none of the above

3. What device in the carburetor will control the quantity of air-fuel mixture that will enter the engine cylinder(s)
 - a. float
 - b. fuel bowl
 - c. float needle valve
 - d. choke valve
 - e. throttle valve

4. The float circuit includes fuel inlet, float needle seat, float needle valve, float bowl, and
 - a. choke valve
 - b. venturi
 - c. accelerator pump
 - d. float
 - e. none of the above

5. When the engine is at idle, the throttle valve is
 - a. half way opened
 - b. closed tightly
 - c. wide opened
 - d. at any position
 - e. slightly opened

6. The level of the fuel in the fuel bowl of a float type carburetor
 - a. can vary as much as $\frac{1}{2}$ " above or below the specified level without affecting the fuel-air mixture ratio
 - b. is not affected by the position of fuel tank
 - c. is not related to mixture ratio
 - d. will become too high if the air vent is clogged
 - e. none of the above

7. The part which creates pressure differential and causes fuel to flow from the fuel bowl is
 - a. Bernoulli's tube
 - b. air bleed
 - c. vacuum tube
 - d. venturi
 - e. none of the above

8. To maintain a constant pressure differential between fuel bowl and venturi, then
 - a. the area of the surface of the gasoline exposed to the air in the fuel bowl must be equal to the area of the air horn
 - b. the air-bleed holes must be located above the choke valve
 - c. the carburetor fuel bowl must be vented to the atmosphere outside the carburetor
 - d. the carburetor fuel bowl must be vented to the air cleaner, but above the choke valve
 - e. none of the above

9. The choke valve is used to
 - a. reduce the amount of air-fuel mixture entering the engine cylinder(s) when starting
 - b. increase the proportion of gasoline in the fuel-air mixture
 - c. increase the velocity of the air stream entering the venturi
 - d. increase the atomization of the fuel as it enters the air stream
 - e. none of the above

10. The amount of the air-fuel mixture delivered from the main discharge nozzle to cylinder(s) can be varied by adjusting the
 - a. float
 - b. idle adjustment screw
 - c. needle valve
 - d. a and b
 - e. a, b, and c

11. fuel is maintained at a constant level in the carburetor by the action of the
 - a. throttle valve
 - b. idle-speed circuit
 - c. choke
 - d. float circuit
 - e. all of the above

12. What cause air to move through the venturi
- small cross sectional area of the venturi
 - pressure differential created by piston moving
 - choke valve is closed so air can not pass that way
 - molecular excitability due to fuel and air combining
 - none of the above
13. Air-fuel ratio that a given carburetor delivers is controlled by
- grade of gasoline used
 - carburetor size
 - differential pressures
 - a and b
 - a, b, and c

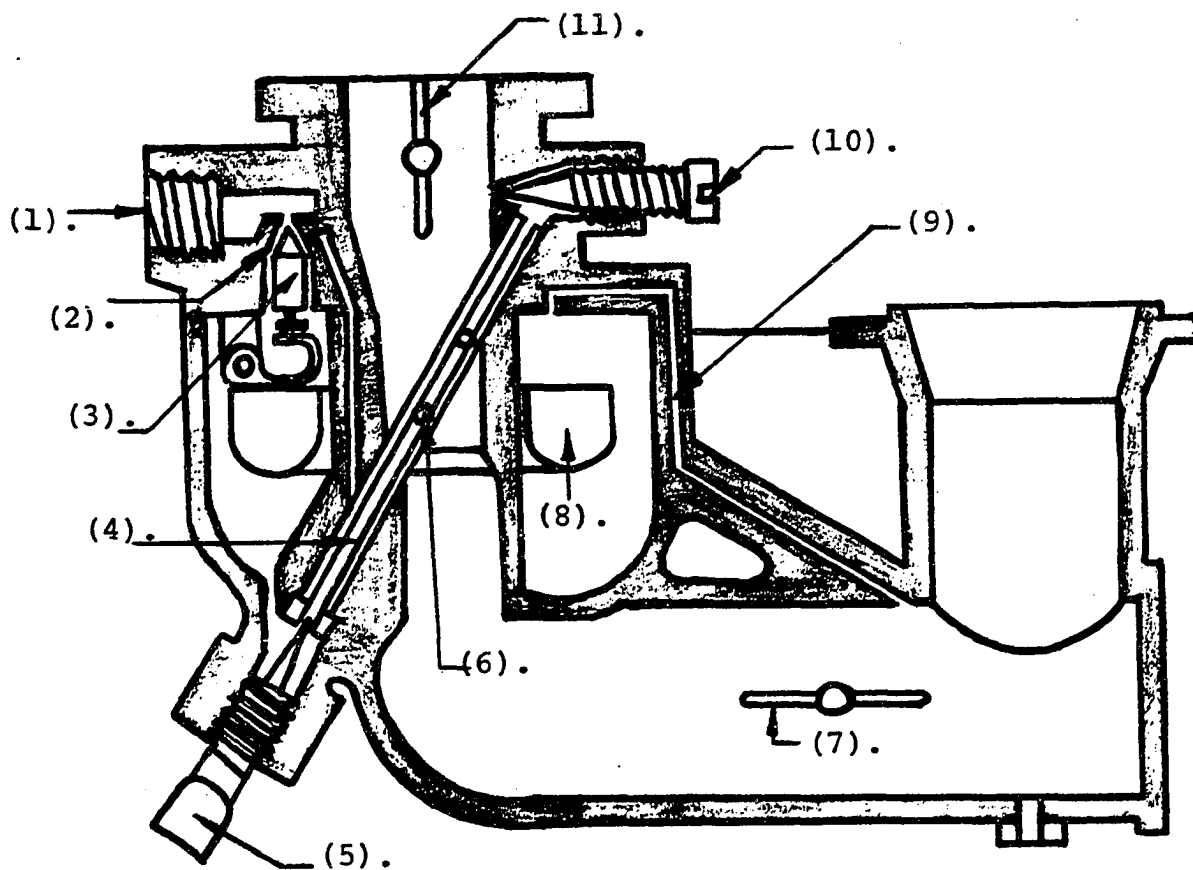
Part II. Matching: Any answer can be used more than once and answer(s) may not needed to be used at all. DO NOT MARK ON THE TEST COPY.

14. ___ Venturi
15. ___ Air bleed
16. ___ Float
- creating a rich fuel mixture for starting a cold engine.
 - to maintain a constant level of fuel in the carburetor.
 - spraying of gasoline into air stream in fine droplets and resulting evaporation to produce a readily combustible vapor.
 - creates a lower pressure in air stream.
 - allows air into fuel passageway in carburetor to assist in atomization.

17. ___ Throttle
- a. creat a rich fuel mixture for starting a cold engine.
18. ___ High speed
- b. allow engine to operate at low speeds when power is not needed.
19. ___ Idle circuit
- c. allow engine to accelerate smoothly from idle to rich speeds.
- d. control flow of fuel from tank to carburetor so as to maintain a constant level of fuel in the carburetor.
- e. allow engine to operate at its maximum power output.
20. ___ Bernoulli's Principle
- a. at any fixed volume, the absolute pressure of a gas rises or falls in exact proportion to its absolute temperature.
21. ___ Carburetion
- b. when the speed of a liquid flowing through a confined area is increased at any point, the pressure of the liquid is decreased at that point.
22. ___ Evaporation
- c. the vaporization of the liquid gasoline and the mixture of this vapor with a proper ratio of air.
- d. the molecules of a liquid change from liquid to vapor.

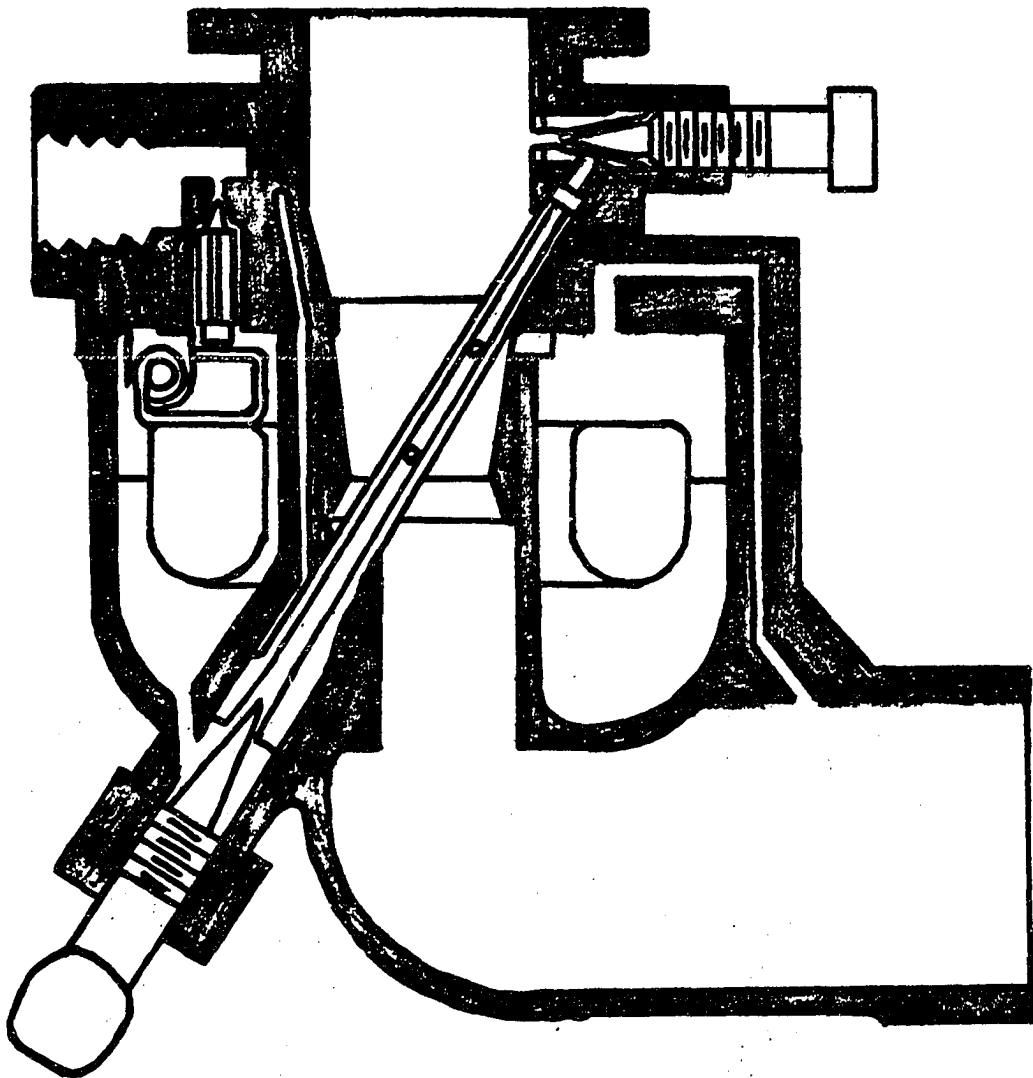
Part III. Answer the following questions:

23. The following drawing represents an up-draft float type carburetor, please label the components on the answer sheet provided.



25. The following drawing represents an up-draft float type carburetor at IDLE speed, please complete the drawing including:

- a. fuel circuit
- b. throttle valve location and position
- c. choke valve location and position
- d. air flow direction
- e. low pressure area
- f. air bleed holes
- g. air vent



INDUSTRIAL EDUCATION 261
INTERNAL COMBUSTION ENGINE

LUBRICATION PRETEST

Directions:

1. On the IBM answer sheet provided, record:
 - a. your name - last name first.
 - b. the date.
 - c. the name of your instructor.
 - d. in the blank labeled "name of test" record the words "Lubrication Pretest".
 - e. in the top two rows of the identification block record your two digit identification number. Be sure to blacken the corresponding spaces.
2. There are 6 pages containing 32 questions in the test.
3. Read each statement carefully. Mark the most correct answer in the appropriate space on the IBM answer sheet with a pencil. If you change your mind, erase your first mark completely.

Example: The abbreviation for the Iowa State University is

- a. U S I
- b. I S U
- c. S U I
- d. I U S
- e. none of the above

a.	b.	c.	d.	e.
===	---	===	===	===

4. There is no penalty for guessing.
5. DO NOT OPEN THIS TEST UNTIL YOU ARE TOLD TO DO SO BY THE INSTRUCTOR!

Part I. Multiple Choice: Choose the ONE BEST answer. DO NOT MARK ON THE TEST COPY.

1. Viscosity refers to
 - a. pressure
 - b. temperature
 - c. color
 - d. fluidity
 - e. area

2. The two stroke cycle engine is lubricated by
 - a. pressure feed
 - b. splash
 - c. oil pump
 - d. dipper
 - e. none of the above

3. Oil dipper is found on the
 - a. plunger
 - b. crankshaft
 - c. camshaft
 - d. connecting rod
 - e. slinger

4. A common recommendation from a small engine manufacturer is to change engine oil every
 - a. 7 days of use
 - b. 8 days of use
 - c. 25 hours of use
 - d. 8 hours of use
 - e. two weeks of use

5. The dipper type of lubrication system, the dipper will pick up oil and throw on to
 - a. cam gear
 - b. the cylinder
 - c. crankshaft
 - d. the side of the crankcase
 - e. all of the above

6. A major cause of oil loss from a small engine is
 - a. crankcase dilution
 - b. leakage through breather
 - c. forming sludge in the crankcase
 - d. burning in combustion chamber
 - e. forming gum in combustion chamber

7. Viscosity index refers to
 - a. API service classification
 - b. cold cranking characteristics
 - c. resistance to viscosity change
 - d. color of the oil
 - e. anti gum characteristics

8. The Barrel-and-plunger pump
 - a. has an oil splash to lubricate the piston and cylinder wall
 - b. is a positive displacement type
 - c. picks up oil from the sump and pump it into a drilled passageway to lubricate the bearing(s)
 - d. a and b
 - e. a, b, and c

9. The lubricant in a small engine must not
 - a. cool
 - b. oxidize
 - c. lubricate
 - d. seal
 - e. clean

10. Today's oil additives include detergent-dispersants, V. I. improvers, foaming inhibitors, and
 - a. pour point depressants
 - b. anti-wear additive
 - c. corrosing inhibitor
 - d. oxidation inhibitor
 - e. all of the above

11. In addition to lubricating engine parts, sealing between the rings and the cylinder walls, the engine oil also
 - a. cleans engine
 - b. drives the governor
 - c. lubricates the carburetor
 - d. cools engine
 - e. a and d

12. The gear type oil pump
 - a. has an adjustable relief valve
 - b. is a positive displacement type
 - c. will pick up oil from oil sump and either spray it or pump it through drilled passageways to the bearings.
 - d. a and b
 - e. a, b, and c

13. Increasing the temperature causes oil
 - a. to gain fluidity
 - b. to oxidize
 - c. to change viscosity
 - d. to lose body
 - e. all of the above

14. The main purpose of a detergent additive is to
 - a. prevent oil breakdown
 - b. lubricate
 - c. cool
 - d. seal
 - e. disperse particles

15. The new API service classification for gasoline engine are
 - a. SA, SB, SC, SD, and SE
 - b. 10W, 20W, 30, 5W, and 40
 - c. AS, DG, DC, BG, and AC
 - d. ML, MM, MS, MC, and MA
 - e. none of the above

16. The old API service classification for gasoline engine are
 - a. ML, MM, and MS
 - b. SA, SB, and SC
 - c. 10W, 20W, and 30
 - d. AS, DG, and DC
 - e. none of the above

17. High "flash point" for an oil implies
 - a. the oil is shiny
 - b. the oil is shiny just on the peaks
 - c. the ignition temperature is low
 - d. the ignition temperature is high
 - e. a and c

18. A good oil is expected to do each of the following except
 - a. hold dirt in suspension
 - b. cushion engine parts
 - c. turn black after some use
 - d. help keep the piston cool
 - e. get very thick at cold (0°F) temperature

19. An SAE 10W oil
 - a. has a different viscosity index than a 20W oil
 - b. is less viscous than 5W oil
 - c. is more viscous than 20W oil
 - d. is less viscous than 20W oil
 - e. none of the above

20. The engine manufacturer's recommendation regarding oil to be used in the engine are based upon
- temperature
 - the weight of the engine
 - the clearances existing in the engine
 - a and c
 - a, b, and c

Part II. Matching: Any answer can be used more than once and answer(s) may not need to be used at all.
DO NOT MARK ON THE TEST COPY.

21. ___ gum
22. ___ Inhibitor
23. ___ Corrosion
- unburned fuel in the oil.
 - destruction of a metal by chemical or electrochemical reaction with its environment.
 - in any lubricating oil, an agent added to keep insoluble matter in suspension and to redisperse deposits already formed.
 - any substance which slows or prevents chemical reaction.
 - a rubber-like, sticky deposit resulting from unstable components in gasoline, either in use or in storage.

24. ___ Viscosity
- a. a term often used to designate viscosity of a product.
25. ___ Viscosity Index
- b. number applied to lubrication oil to indicate viscosity range specified by the Society of Automotive Engineers.
26. ___ Body
- c. a commonly used measure of a fluid's change of viscosity with temperature.
- d. the measure of the body of a fluid lubricant.
- e. having the property of viscosity. Frequently used to imply high viscosity characteristics.
27. ___ Fire point
- a. the lowest temperature at which a lubricant will flow under specified condition.
28. ___ Flash point
- b. temperature to which a combustible liquid must be heated so that the released vapor will burn continuously when ignited under specified conditions.
29. ___ Pour point
- c. temperature to which a combustible liquid must be heated to give off sufficient vapor to form momentarily a flammable mixture with air when a small flame is applied under specified.
- d. temperature at which a grease passes from a semi-solid to a liquid state under specified conditions.

30. ___ Detergent
31. ___ Dilution
32. ___ Sludge
- a. unburned fuel in the oil.
 - b. property of a substance which causes it to resist being pulled apart by mechanical means.
 - c. process whereby large molecules are broken down by the application of heat and pressure to form smaller molecules.
 - d. in any lubricating oil, an agent added to keep insoluble matter in suspension and to redisperse deposits already formed.
 - e. insoluble material formed as a result either of deterioration reactions in an oil or by contamination of an oil, or both.

INDUSTRIAL EDUCATION 261
INTERNAL COMBUSTION ENGINE

IGNITION PRETEST

Directions:

1. On the IBM answer sheet provided, record:
 - a. your name - last name first.
 - b. the date.
 - c. the name of your instructor.
 - d. in the blank labeled "name of test" record the letters ignition pretest.
 - e. in the top two rows of the identification block record your two identification number. Be sure to blacken the corresponding spaces.
2. There are 5 pages and 31 questions in the test.
3. Read each statement carefully. Mark the most correct answer in the appropriate space on the IBM answer sheet with a pencil. If you change your mind, erase your first mark completely.

Example: The abbreviation for the Iowa State University is

- a. U S I
- b. I S U
- c. S U I
- d. I U S
- e. none of the above

a.

b.

c.

d.

e.

4. There is no penalty for guessing.
5. DO NOT OPEN THIS TEST UNTIL YOU ARE TOLD TO DO SO BY THE INSTRUCTOR!

Part I. Multiple Choice: Choose the ONE BEST answer. DO NOT MARK ON THE TEST COPY.

1. Four of these can determine the amount of induced voltage, thus causing current to flow through the conductor, which is NOT
 - a. the speed at which the magnetic lines of force are cut
 - b. the intensity of the magnetic field
 - c. the size of the breaker points
 - d. the number of turns of wire in the primary coil
 - e. the number of turns of wire in the secondary coil
2. If the secondary coil has twice numbers of turns as the primary coil, the voltage induced will be
 - a. $\frac{1}{2}$ that in the primary coil
 - b. twice that in the primary coil
 - c. $2\frac{1}{2}$ times that in the primary coil
 - d. four times that in the primary coil
 - e. none of the above
3. The voltage for small engines is stepped up from approximately 200 volts to approximately
 - a. 2,000 volts
 - b. 4,000 volts
 - c. 8,000 volts
 - d. 12,000 volts
 - e. 20,000 volts
4. When a high voltage causes a spark at the spark plug, at this instant the breaker points are
 - a. closed
 - b. starting to open
 - c. wide opened
 - d. sometimes opened and sometimes closed
 - e. none of the above
5. The primary function of a condenser is
 - a. protecting breaker points
 - b. connecting to ground
 - c. discharge through secondary coil
 - d. absorb self-induced primary current
 - e. none of the above
6. What causes a magnetic field to be formed
 - a. current flow through a conductor
 - b. circuit resistance
 - c. excessive circuit voltage
 - d. opposition to current flow
 - e. none of the above

7. Where does the ignition circuit release its high-voltage charge
 - a. coil
 - b. spark plug
 - c. primary circuit
 - d. condensor
 - e. none of the above

8. Which of the following is not part of an magneto ignition system
 - a. conductor
 - b. condensor
 - c. breaker points
 - d. battery
 - e. coil

9. The force which causes the current to flow is
 - a. electricity
 - b. amperage
 - c. voltage
 - d. resistance
 - e. capacitance

10. The material which makes up the core of an ignition coil is
 - a. aluminum
 - b. copper
 - c. zinc
 - d. brass
 - e. ferrous

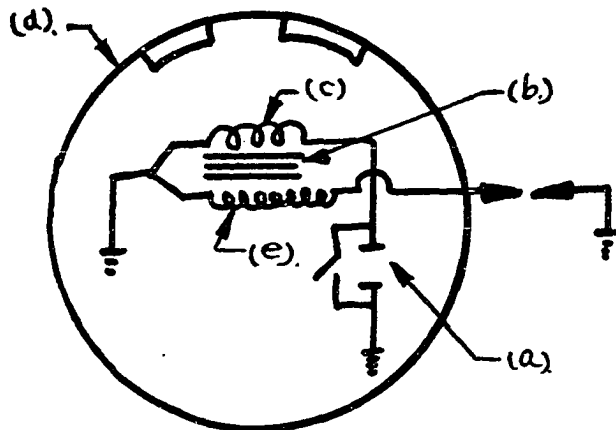
11. What is the opposition to current flow
 - a. voltage
 - b. resistance
 - c. wattage
 - d. amperage
 - e. none of the above

12. Which is not an advantage of a magneto ignition system
 - a. battery not needed
 - b. intensity of voltage increase with speed
 - c. brighter light from lamps in the system
 - d. all of the above
 - e. none of the above

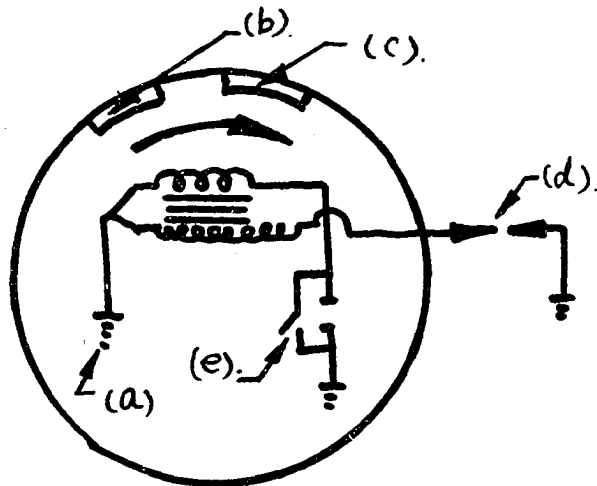
13. Four of these are ways to increase strength of an electromagnet, which is NOT
- a. increase current
 - b. add an iron core
 - c. increase space between coil
 - d. add more turns of wire
 - e. increase primary wire size

Part II. Matching: Any answer can be used more than once and answer(s) may not needed to be used at all. DO NOT MARK ON THE TEST COPY.

- 14. ___ Flywheel
- 15. ___ Primary coil
- 16. ___ Secondary coil
- 17. ___ Condensor
- 18. ___ Core



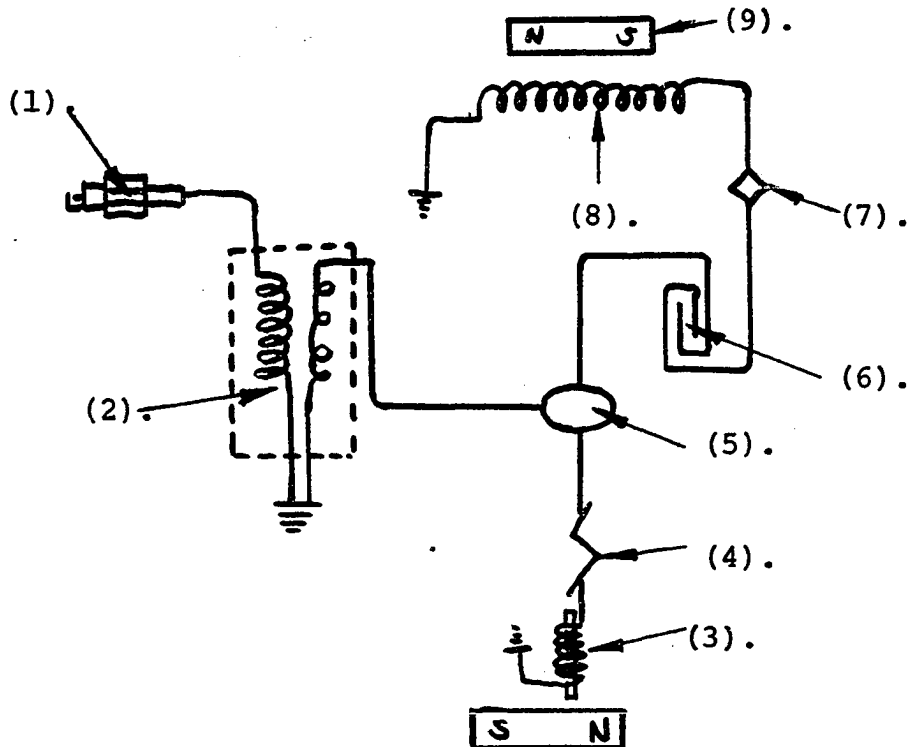
- 19. ___ North pole
- 20. ___ South pole
- 21. ___ Ground
- 22. ___ Breaker points
- 23. ___ Spark plug



Part III. Summarize a magneto system operation into steps and assume the first step of the operation in this system is breaker points closed, then

24. What is the second step
 - a. points opened
 - b. points closed
 - c. current flows through primary coil
 - d. condensor discharged
 - e. condensor charge
25. What is the third step
 - a. points closed
 - b. condensor charged
 - c. condensor discharged
 - d. points opened
 - e. current flow through primary coil
26. What is the forth step
 - a. points opened
 - b. condensor discharged
 - c. magnetic field starts to collapse
 - d. current flow through primary coil
 - e. points closed
27. What is the fifth step
 - a. spark occurs
 - b. current induced in the secondary coil
 - c. condensor discharged
 - d. condensor charged
 - e. points opened
28. What is the sixth step
 - a. spark occurs
 - b. condensor charged
 - c. points closed
 - d. current induced in secondary coil
 - e. points opened
29. What is the last step
 - a. current induced in secondary coil
 - b. condensor discharged
 - c. condensor charged
 - d. spark occurs
 - e. points closed

30. Label the components for a solid state ignition system.



31. Fill the blanks for the operations of a solid state ignition system on the answer sheet provided.

- A. As the engine's flywheel magnet passes the input coil a very low voltage A.C. current is induced into that coil.
- B. The current passes through a (1) converting this current to (2). It then travels to the (3) where is stored.
- C. The flywheel rotates approximately (4) and as it passes the (5) it induces a very small electric charge into the (6).
- D. The charge passes through the (7) and turns on the (8). With the (9) closed the low voltage stored in the (10) travels to the (11).
- E. Here the voltage is stepped up instantaneously and it is discharged across the electrodes of the spark plug, firing before top dead center.

INDUSTRIAL EDUCATION 261
INTERNAL COMBUSTION ENGINE

DIAGNOSIS PRETEST

Directions:

1. On the IBM answer sheet provided, record:
 - a. your name - last name first.
 - b. the date.
 - c. the name of your instructor.
 - d. in the blank labeled "name of test" record the words "Diagnosis Pretest."
 - e. in the top two rows of the identification block record your two digit identification number. Be sure to blacken the corresponding spaces.
2. There are 4 pages containing 21 questions in the test.
3. Read each statement carefully. Mark the most correct answer in the appropriate space on the IBM answer sheet with a pencil. If you change your mind, erase your first mark completely.

Example: The abbreviation for the Iowa State University is

- a. U S I
- b. I S U
- c. S U I
- d. I U S
- e. none of the above

a.	b.	c.	d.	e.
===	---	===	===	===

4. There is no penalty for guessing.
5. DO NOT OPEN THIS TEST UNTIL YOU ARE TOLD TO DO SO BY THE INSTRUCTOR!

Part I. Multiple Choice: Choose the ONE BEST answer. DO NOT MARK ON THE TEST COPY.

1. The engine does not start but spark is produced as a result of the ignition system check, which of the following step should be checked next
 - a. coil
 - b. ignition points
 - c. fuel system
 - d. oil
 - e. primary circuit

2. A loose blade may create a kick-back that will
 - a. prevent starting
 - b. cause hard-starting
 - c. cause soft key to be sheared
 - d. a and b
 - e. a, b, and c

3. An out-of balance blade may cause
 - a. destructive vibration
 - b. the soft key to be sheared
 - c. crankshaft bearing wear
 - d. a and c
 - e. none of the above

4. After reassembly a small engine does not start the most likely cause
 - a. lack of spark
 - b. lack of fuel
 - c. lack of compression
 - d. lack of oil
 - e. improper valve timing
 - f. surplus of oil

5. Dirt at the top part of the air cleaner indicates
 - a. engine has too low compression
 - b. engine has too high compression
 - c. the air cleaner was not oiled
 - d. the air cleaner was over oiled
 - e. spark is too weak

6. When compression check has been made, low compression indicates
 - a. valve hung open due to gum on the valve stem
 - b. burned valves
 - c. worn stem
 - d. bad valve seat
 - e. all of the above

7. A sheared key could cause
 - a. engine to burn oil badly
 - b. magneto flywheel to be broken
 - c. breaker points not to be opened
 - d. engine hard to be started
 - e. starter worn

8. No spark on a small engine can be caused by
 - a. no air gap between breaker points
 - b. no fuel in the tank
 - c. oily breaker points
 - d. a and c
 - e. all of the above

9. To check for spark on a Briggs & Stratton engine a #19051 tester is used, the spark should jump the gap of
 - a. 0.66"
 - b. 1.06"
 - c. 1.6"
 - d. 1.66"
 - e. 0.166"

10. A Briggs & Stratton engine is equipped with easy spin compression release. When checking the compression the flywheel should be spun by hand
 - a. in the normal direction of rotation
 - b. in the opposite direction of rotation
 - c. in either direction will make no difference
 - d. at a very high speed
 - e. at a very low speed

11. Four of the following could cause over heating which would not
 - a. a hot type spark plug
 - b. lean mixture
 - c. advanced timing
 - d. low oil level
 - e. clogged fins

12. When the armature air gap is too large, it may cause
 - a. kickback when cranking the engine over very fast
 - b. kickback when cranking the engine over very slowly
 - c. high voltage to be induced in ignition system and engine easy to be started
 - d. low voltage to be induced in ignition system and engine hard to be started
 - e. none of the above

13. When the armature air gap is not large enough, it may cause
 - a. kickback when fuel level is low
 - b. kickback any time
 - c. kickback when cranking the engine over very fast
 - d. kickback when cranking the engine over very slowly
 - e. kickback when oil level is low

14. Kickback can also occur when starting an engine,
 - a. equipped with a light weight flywheel
 - b. if the cutter blade is loose
 - c. if the cutter blade has been moved
 - d. all of the above
 - e. none of the above

15. The Briggs & Stratton small engines should always use
 - a. soft key
 - b. stell key
 - c. hard key
 - d. carbon key
 - e. b and c

16. When a plunger becomes too short, it will
 - a. advance the timing
 - b. retard the timing
 - c. cause leaking fuel
 - d. change the function of condensor
 - e. none of the above

17. Kickback can occur due to
 - a. the breaker points gap too wide
 - b. the breaker points gap too small
 - c. the condensor is bad
 - d. a and c
 - e. all of the above

18. When a plunger is installed correctly in a vertical small engine, the beveled edge in the center should be
 - a. up
 - b. down
 - c. either way
 - d. reversed
 - e. none of the above

19. If the dust cover of breaker points is dry on the outside and oily on the inside, it indicates
- the breaker pointers plunger and plunger hole may be worn
 - the oil level is too high in the crank case
 - the fuel is mixed with water
 - a and b
 - a, b, and c
20. A engine does not start, and the spark plug is wet, what should be checked
- float in the carburetor
 - fuel tank
 - compression
 - spark
 - oil level
21. A engine does not start, and the spark plug is dry, what should be checked
- primary coil
 - secondary coil
 - fuel supply
 - oil level
 - spark plug

APPENDIX E: POSTTESTS

INDUSTRIAL EDUCATION 261INTERNAL COMBUSTION ENGINE

FUEL AND COMBUSTION POSTTEST

Directions:

1. On the IBM answer sheet provided, record:
 - a. your name - last name first.
 - b. the date.
 - c. the name of your instructor.
 - d. in the blank labeled "name of test" record the words "Fuel and Combustion Posttest."
 - e. in the top two rows of the identification block record your two digit identification number. Be sure to blacken the corresponding spaces.
2. There are 4 pages containing 23 questions in the test.
3. Read each statement carefully. Mark the most correct answer in the appropriate space on the IBM answer sheet with apencil. If you change your mind, erase your first mark completely.

Example: The abbreviation for the Iowa State University is

- a. U S I
- b. I S U
- c. S U I
- d. I U S
- e. none of the above

a. b. c. d. e.
 === === === ===

4. There is no penalty for guessing.
5. DO NOT OPEN THIS TEST UNTIL YOU ARE TOLD TO DO SO BY THE INSTRUCTOR!

Part I. Multiple Choice: Choose the ONE BEST answer. DO NOT MARK ON THE TEST COPY.

1. A fuel blended from 30% heptane and 70% iso-octane would have an Octane Rating Number of
 - a. 30
 - b. 50
 - c. 60
 - d. 70
 - e. 90

2. Compare with water, which boils at 212^oF, a liquid that boils at 600 has
 - a. slightly higher volatility
 - b. much higher volatility
 - c. much lower volatility
 - d. slightly higher velocity
 - e. much higher velocity

3. The air fuel mixture by weight of an ideal mixture is
 - a. 1 : 15
 - b. 15 : 1
 - c. 1 : 9,000
 - d. 9,000 : 1
 - e. 6,000 : 1

4. Advancing the ignition spark, or timing
 - a. decreases the fuel economy
 - b. in effect, decreases octane requirement
 - c. reduces the tendency of the engine to detonate
 - d. increases oil consumption
 - e. increases the tendency of the engine to detonate

5. If gasoline vaporizes in the fuel line, it is liable to produce a
 - a. fuel lock
 - b. pipe lock
 - c. line lock
 - d. vapor lock
 - e. volatile lock

6. Detonation will most likely cause
 - a. piston destruction
 - b. bearing destruction
 - c. valve destruction
 - d. connecting rod destruction
 - e. cylinder destruction

7. Four of the following are gasoline additives, which is not
- anti foaming
 - metal deactivators
 - oxidation inhibitors
 - detergents
 - anti-icers
8. Preignition can be caused by
- an excessively high compression ratio
 - hot carbon spots
 - hot spark plug
 - over heated exhaust valve
 - all of the above
9. When a incomplete combustion occurs, the following chemical equation: $C_7H_{16} + 9 O_2$ should be balanced by
- $3 CO + 4 CO_2 + 2 H_2O$
 - $4 CO + 3 CO_2 + H_2O$
 - $3 CO + 4 CO_2 + 8 H_2O$
 - $4 CO + 3 CO_2 + 8 H_2O$
 - $4 CO + 4 CO_2 + 2 H_2O$
10. There are two products of complete combustion of gasoline water and
- carbon monoxide
 - carbon
 - hydrocarbons
 - sulfur dioxide
 - carbon dioxide
11. Gasoline is a
- carbohydrate
 - hydroxyl
 - ester
 - hydrocarbon
 - halogen
12. Increasing the compression ratio of an engine
- increases fuel consumption
 - increases the knocking tendency
 - reduces the power
 - reduces the knocking tendency
 - none of the above

13. It is generally agreed that up to ___ parts CO/10,000 of air makes the air dangerous to breathe
- 300
 - 85
 - 15
 - 0.12
 - 0.02
14. Which of the following is not a factor effecting detonation
- humidity
 - density
 - temperature
 - compression ratio
 - displacement
15. The laboratory method of measuring the Octane Rating Number of a fuel makes uses of
- a road test at constant speed
 - an engine with adjustable compression ratio
 - an engine with adjustable fuel nozzle
 - a road test at constant throttle opening
 - none of the above
16. The ease with which a liquid vaporizes is determined by its
- velocity
 - vapotility
 - volubility
 - volatility
 - none of the above
17. When a complete combustion occurs, the following chemical equation: $2C_8H_{18} + 25 O_2$ should be balanced by
- 16 CO_2
 - 16 $CO_2 + 18 H_2O$
 - 2 $CO_2 + 25 H_2O$
 - 4 $CO_2 + 8 H_2O$
 - 18 H_2O
18. The approximate air fuel ratio by volume of an ideal mixture at sea level and 80°F is
- 15 : 10,000
 - 1 : 15
 - 1 : 9,000
 - 9,000 : 1
 - 15 : 1

19. The antiknock rating of gasoline is given in terms of the
- hydrogen number
 - octane number
 - carbon number
 - heptane number
 - cetane number
20. Three pounds of paraffin C_8H_{18} are used in an engine where perfect combustion occurs. How many pounds of carbon dioxide are produced
- 1.231 pounds
 - 4.263 pounds
 - 9.789 pounds
 - 10.321 pounds
 - none of the above

Part II. Matching: Any answer can be used more than once and answer(s) may not needed to be used at all.
DO NOT MARK ON THE TEST COPY.

21. ___ Heat of compression
22. ___ Detonation
23. ___ Preignition
- the temperature at which the fuel is completely vaporized.
 - an ignition of the fuel-air mixture during compression, as caused by some hot spots within the cylinder.
 - as the flame races through the combustion chamber, the unburned gases ahead of it are further compressed to the point of spontaneous ignition.
 - an incomplete combustion and make the air dangerous to breathe.
 - air molecules crowded closely together.

Directions:

1. On the IBM answer sheet provided, record:

- a. your name - last name first.
- b. the date.
- c. the name of your instructor.
- d. in the blank labeled "name of test" record the words "Carburetion Posttest."
- e. in the top two rows of the identification block record your two digit identification number. Be sure to blacken the corresponding spaces.

2. There are 7 pages containing 25 questions in the test.

3. Read each statement carefully. Mark the most correct answer in the appropriate space on the IBM answer sheet with a pencil. If you change your mind, erase your first mark completely.

Example: The abbreviation for the Iowa State University

- a. U S I
- b. I S U
- c. S U I
- d. I U S
- e. none of the above

4. There is no penalty for guessing.

5. DO NOT OPEN THIS TEST UNTIL YOU ARE TOLD TO DO SO BY THE INSTRUCTOR!

Part I. Multiple Choice: Choose the ONE BEST answer. DO NOT MARK ON THE TEST COPY.

1. Air-fuel ratio that a given carburetor delivers is controlled by
 - a. differential pressures
 - b. carburetor size
 - c. grade of gasoline used
 - d. a and b
 - e. a, b, and c

2. The amount of the air-fuel mixture delivered from the main discharge nozzle to cylinder(s) can be varied by adjusting the
 - a. needle valve
 - b. idle adjustment screw
 - c. float
 - d. a and b
 - e. a, b, and c

3. The level of the fuel in the fuel bowl of a float type carburetor
 - a. is not related to mixture ratio
 - b. is not affect by the position of fuel tank
 - c. will become too high if the air vent is clogged
 - d. can vary as much as $\frac{1}{2}$ " above or below the specified level without affecting the fuel-air mixture ratio
 - e. none of the above

4. Fuel is maintained at a constant level in the carburetor by the action of the
 - a. choke
 - b. idle-speed circuit
 - c. float circuit
 - d. throttle valve
 - e. all of the above

5. What causes air to move through the venturi
 - a. molecular excitability due to fuel and air combining
 - b. pressure differential created by piston moving
 - c. small cross sectional area of the venturi
 - d. choke valve is closed so air can not pass that way
 - e. none of the above

6. The part which creates pressure differential and causes fuel to flow from the fuel bowl is
 - a. vacuum tube
 - b. venturi
 - c. air bleed
 - d. Bernoulli's tube
 - e. none of the above

7. Idle adjustment screw controls the quantity of
 - a. raw air
 - b. raw fuel
 - c. oil
 - d. fuel-air mixture
 - e. none of the above

8. The choke valve is used to
 - a. increase the atomization of the fuel as it enters the air stream
 - b. increase the proportion of gasoline in the fuel-air mixture
 - c. reduce the amount of air-fuel mixture entering the engine cylinder(s) when starting
 - d. increase the velocity of the air stream entering the venturi
 - e. none of the above

9. The float circuit includes fuel inlet, float needle seat, float needle valve, float bowl, and
 - a. venturi
 - b. accelerator pump
 - c. float
 - d. choke valve
 - e. none of the above

10. Usually the carburetor on a small engine, does not contain the
 - a. venturi
 - b. choke valve
 - c. throttle valve
 - d. accelerator pump system
 - e. idle-speed system

11. What device in the carburetor will control the quantity of air-fuel mixture that will enter the engine cylinder
 - a. throttle valve
 - b. choke valve
 - c. float needle valve
 - d. fuel bowl
 - e. float

12. To maintain a constant pressure differential between fuel bowl and venturi,
- the carburetor fuel bowl must be vented to the atmosphere outside the carburetor
 - the carburetor fuel bowl must be vented to the air cleaner, but above the choke valve
 - the air-bleed holes must be located above the choke valve
 - the area of the surface of the gasoline exposed to the air in the fuel bowl must be equal to the area of the air horn
 - none of the above
13. When the engine is at idle, the throttle valve is
- at any position
 - slightly opened
 - wide opened
 - closed tightly
 - half way opened

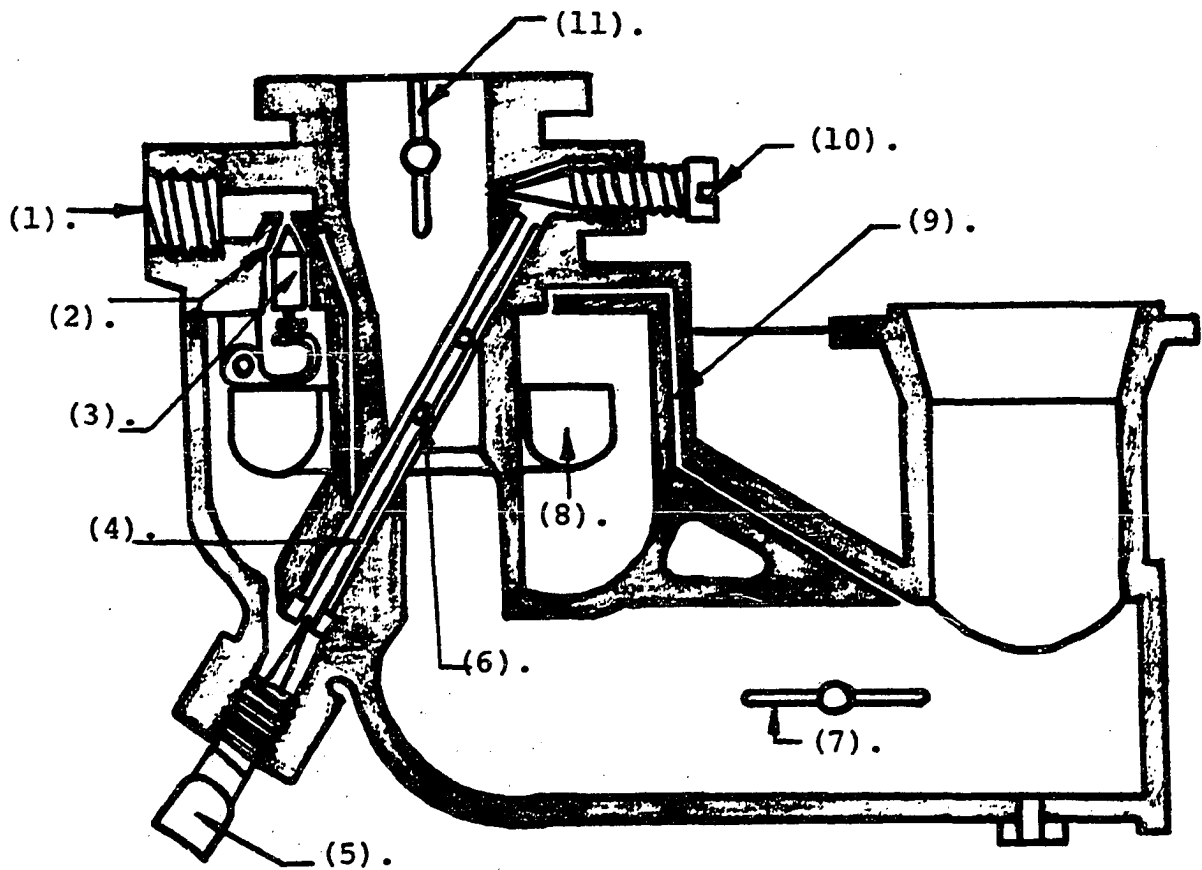
Part II. Matching: Any answer can be used more than once and answer(s) may not needed to be used at all. DO NOT MARK ON THE TEST COPY.

14. ___ Carburetion
15. ___ Bernoulli's Principle
16. ___ Evaporation
- the molecules of a liquid change from liquid to vapor.
 - at any fixed volume, the absolute pressure of a gas rises or falls in exact proportion to its absolute temperature.
 - when the speed of a liquid flowing through a confined area is increased at any point, the pressure of the liquid is decreased at that point.
 - the vaporization of the liquid gasoline and the mixture of this vapor with a proper ratio of air.

17. ___ Air bleed
18. ___ Float
19. ___ Venturi
20. ___ Idle circuit
21. ___ Throttle
22. ___ High speed
- a. spraying of gasoline into air stream in fine droplets and resulting evaporation to produce a readily combustible vapor.
 - b. creates a lower pressure in air stream.
 - c. creating a rich fuel mixture for starting a cold engine.
 - d. to maintain a constant level of fuel in the carburetor.
 - e. allows air into fuel passageway in carburetor to assist in atomization.
- a. control flow of fuel from tank to carburetor so as to maintain a constant level of fuel in the carburetor.
 - b. creat a rich fuel mixture for starting a cold engine.
 - c. allow engine to operate at low speeds when power is not needed.
 - d. allow engine to accelerate smoothly from idle to high speeds.
 - e. allow engine to operate at its maximum power output.

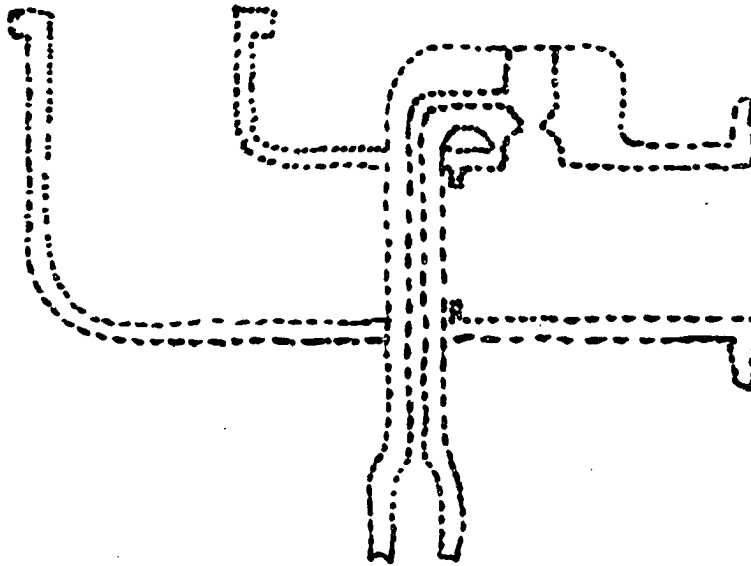
Part III. Answer the following questions:

23. The following drawing represents an up-draft float type carburetor, please label the components on the answer sheet provided.



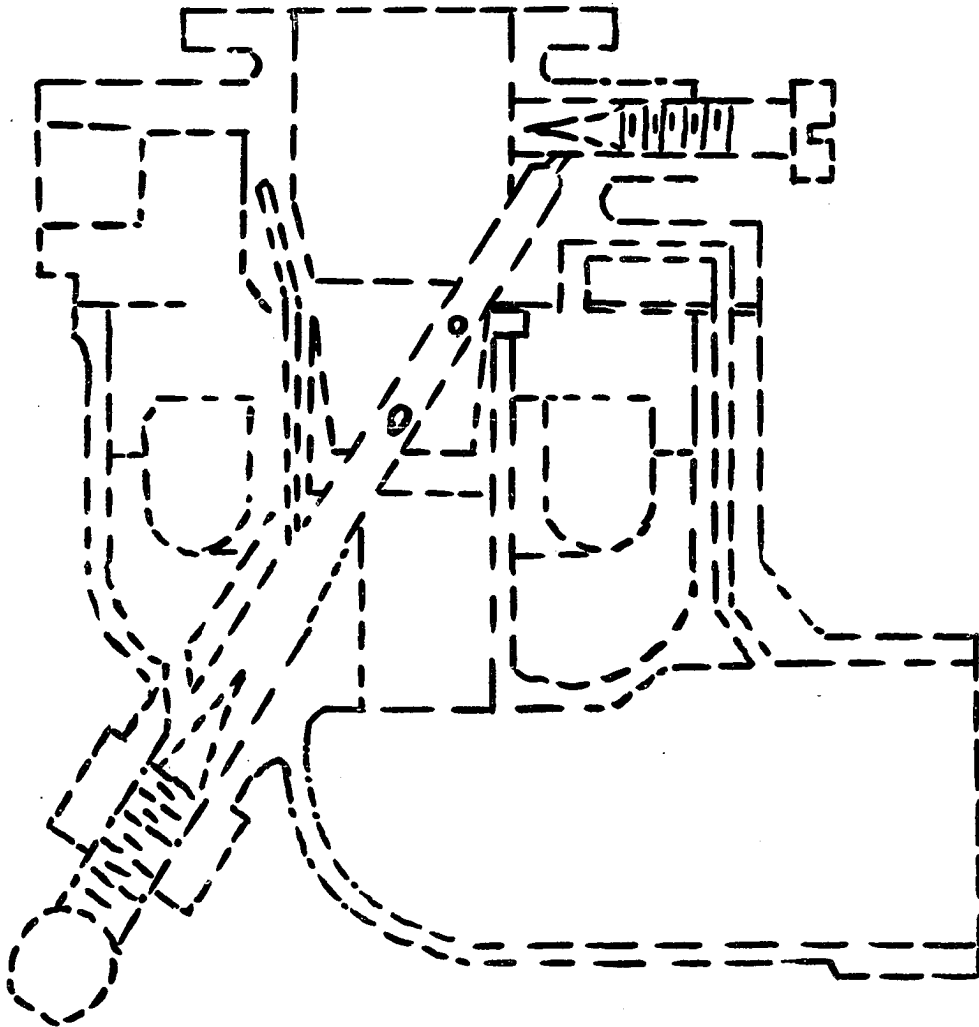
24. The following drawing represents a suction type carburetor at low speed, please complete the drawing including:

- a. high-speed orifice
- b. idle-speed orifice
- c. needle valve
- d. throttle valve
- e. choke slide
- f. air flow direction
- g. fuel flow direction
- h. fuel tank



25. The following drawing represents an up-draft float type carburetor at high speed, please complete the drawing including:

- a. fuel circuit
- b. throttle valve location and position
- c. choke valve location and position
- d. air flow direction
- e. low pressure area
- f. air bleed holes
- g. air vent



INDUSTRIAL EDUCATION 261
INTERNAL COMBUSTION ENGINE

LUBRICATION POSTTEST

Directions:

1. On the IBM answer sheet provided, record:
 - a. your name - last name first.
 - b. the date.
 - c. the name of your instructor.
 - d. in the blank labeled "name of test" record the words "Lubrication Posttest".
 - e. in the top two rows of the identification block record your two digit identification number. Be sure to blacken the corresponding spaces.
2. There are 6 pages containing 32 questions in the test.
3. Read each statement carefully. Mark the most correct answer in the appropriate space on the IBM answer sheet with a pencil. If you change your mind, erase your first mark completely.

Example: The abbreviation for the Iowa State University
is

- a. U S I
- b. I S U
- c. S U I
- d. I U S
- e. none of the above

a.	b.	c.	d.	e.
===	===	===	===	===

4. There is no penalty for guessing.
5. DO NOT OPEN THIS TEST UNTIL YOU ARE TOLD TO DO SO BY THE INSTRUCTOR!

Part I. Multiple Choice: Choose the ONE BEST answer. DO NOT MARK ON THE TEST COPY.

1. The engine manufacturer's recommendation regarding oil to be used in the engine are based upon
 - a. the clearances existing in the engine
 - b. the weight of the engine
 - c. temperature
 - d. a and c
 - e. a, b, and c
2. Increasing the temperature causes oil
 - a. to lose body
 - b. to change viscosity
 - c. to oxidize
 - d. to gain fluidity
 - e. all of the above
3. Viscosity index refers to
 - a. anti gum characteristics
 - b. color of the oil
 - c. resistance to viscosity change
 - d. cold cranking characteristics
 - e. API service classification
4. A major cause of oil loss from a small engine is
 - a. forming gum in combustion chamber
 - b. burning in combustion chamber
 - c. forming sludge in the crankcase
 - d. leakage through breather
 - e. crankcase dilution
5. An SAE 10W oil
 - a. is less viscous than 20W oil
 - b. has a different viscosity index than a 20W oil
 - c. is more viscous than 20W oil
 - d. is less viscous than 5W oil
 - e. none of the above
6. The gear type oil pump
 - a. will pick up oil from oil sump and either spray it or pump it through drilled passageways to the bearings.
 - b. is a positive displacement type
 - c. has an adjustable relief valve
 - d. a and b
 - e. a, b, and c

7. Viscosity refers to
 - a. area
 - b. fluidity
 - c. color
 - d. temperature
 - e. pressure

8. High "flash point" for an oil implies
 - a. the ignition temperature is low
 - b. the oil is shiny just on the peaks
 - c. the oil is shiny
 - d. the ignition temperature is high
 - e. a and c

9. Today's additives of the oil include detergent-dispersants, V. I. improvers, foaming inhibitors, and
 - a. oxidation
 - b. corroding inhibitor
 - c. anti-wear additive
 - d. pour point depressants
 - e. all of the above

10. Oil dipper is found on the
 - a. camshaft
 - b. connecting rod
 - c. crankshaft
 - d. plunger
 - e. slinger

11. The new API service classification for gasoline engine are
 - a. ML, MM, MS, MC, and MA
 - b. AS, DG, DC, BG, and AC
 - c. SA, SB, SC, SD, and SE
 - d. 10W, 20W, 30, 5W, and 40
 - e. none of the above

12. The two stroke cycle engine is lubricated by
 - a. dipper
 - b. oil pump
 - c. splash
 - d. pressure feed
 - e. none of the above

13. The main purpose of a detergent additive is to
 - a. disperse particles
 - b. seal
 - c. cool
 - d. lubricate
 - e. prevent oil breakdown

14. The dipper type of lubrication system, the dipper will pick up oil and throw on to
 - a. cam gear
 - b. the cylinder
 - c. crankshaft
 - d. the side of the crankcase
 - e. all of the above

15. The old API service classification for gasoline engine are
 - a. AS, DG, and DC
 - b. ML, MM, and MS
 - c. SA, SB, and SC
 - d. 10W, 20W, and 30
 - e. none of the above

16. The Barrel-and-plunger pump
 - a. has an oil splash to lubricate the piston and cylinder wall
 - b. is a positive displacement type
 - c. picks up oil from the sump and pump it into a drilled passageway to lubricate the bearing(s)
 - d. a and b
 - e. a, b, and c

17. A common recommendation from a small engine manufacturer is to change engine oil every
 - a. 8 days of use
 - b. 25 hours of use
 - c. 7 days of use
 - d. 8 hours of use
 - e. two weeks of use

18. The lubricant in a small engine must not
 - a. lubricate
 - b. cool
 - c. oxidize
 - d. clean
 - e. seal

19. A good oil is expected to do each of the following except
 - a. cushion
 - b. turn black after some use
 - c. help keep the piston cool
 - d. get very thick at cold (0 F) temperature
 - e. hold dirt in suspension

20. In addition to lubricating engine parts, sealing between the rings and the cylinder walls, the engine oil also
- cleans engine
 - drives the governor
 - lubricates the carburetor
 - cools engine
 - a and d

Part II. Matching: Any answer can be used more than once and answer(s) may not need to be used at all.
DO NOT MARK ON THE TEST COPY.

- | | | | |
|-----------|-----------------|----|---|
| 21. ___ | Body | a. | a commonly used measure of a fluid's change of Viscosity with temperature. |
| 22. ___ | Viscosity | b. | the measure of the body of a fluid lubricant. |
| 23. ___ | Viscosity Index | c. | having the property of viscosity. Frequently used to imply high viscosity characteristics. |
| | | d. | number applied to lubrication oil to indicate viscosity range specified by the Society of Automotive Engineers. |
| | | e. | a term often used to designate viscosity of a product. |

24. ___ Flash point
25. ___ Fire point
26. ___ Pour point
27. ___ Detergent
28. ___ Sludge
29. ___ Dilution
- a. temperature to which a combustible liquid must be heated to give off sufficient vapor to form momentarily a flammable mixture with air when a small flame is applied under specified.
 - b. temperature to which a combustible liquid must be heated so that the released vapor will burn continuously when ignited under specified conditions.
 - c. the lowest temperature at which a lubricant will flow under specified condition.
 - d. temperature at which a grease passes from a semi-solid to a liquid state under specified conditions.
 - a. process whereby large molecules are broken down by the application of heat and pressure to form smaller molecules.
 - b. property of a substance which causes it to resist being pulled apart by mechanical means.
 - c. in any lubricating oil, an agent added to keep insoluble matter in suspension and to redisperse deposits already formed.
 - d. insoluble material formed as a result either of deterioration reactions in an oil or by contamination of an oil, or both.
 - e. unburned fuel in the oil.

30. ___ Inhibitor
31. ___ Corrosion
32. ___ Gum
- a. in any lubricating oil, an agent added to keep insoluble matter in suspension and to redisperse deposits already formed.
 - b. any substance which slows or prevents chemical reaction.
 - c. a rubber-like, sticky deposit resulting from unstable components in gasoline, either in use or in storage.
 - d. destruction of a metal by chemical or electrochemical reaction with its environment.
 - e. unburned fuel in the oil.

INDUSTRIAL EDUCATION 261
INTERNAL COMBUSTION ENGINE

IGNITION POSTTEST

Directions:

1. On the IBM answer sheet provided, record:
 - a. your name - last name first.
 - b. the date.
 - c. the name of your instructor.
 - d. in the blank labeled "name of test" record the letters ignition posttest.
 - e. in the top two rows of the identification block record your two identification number. Be sure to blacken the corresponding spaces.
2. There are 5 pages and 31 questions in the test.
3. Read each statement carefully. Mark the most correct answer in the appropriate space on the IBM answer sheet with a pencil. If you change your mind, erase your first mark completely.

Example: The abbreviation for the Iowa State University is

- a. U S I
- b. I S U
- c. S U I
- d. I U S
- e. none of the above

a. b. c. d. e.

4. There is no penalty for guessing.
5. DO NOT OPEN THIS TEST UNTIL YOU ARE TOLD TO DO SO BY THE INSTRUCTOR!

Part I. Multiple Choice: Choose the ONE BEST answer. DO NOT MARK ON THE TEST COPY.

1. Four of these are ways to increase strength of an electro-magnet, which is NOT
 - a. increase primary wire size
 - b. add more turns of wire
 - c. increase space between coils
 - d. add an iron core
 - e. increase current

2. The material which makes up the core of an ignition coil is
 - a. aluminum
 - b. ferrous
 - c. zinc
 - d. copper
 - e. brass

3. Which is not an advantage of a magneto ignition system
 - a. battery not needed
 - b. brighter light from lamps in the system
 - c. intensity of voltage increase with speed
 - d. all of the above
 - e. none of the above

4. Where does the ignition circuit release its high-voltage charge
 - a. condensor
 - b. primary circuit
 - c. spark plug
 - d. coil
 - e. none of the above

5. Which of the following is not part of an magnato ignition system
 - a. breaker points
 - b. condensor
 - c. conductor
 - d. battery
 - e. coil

6. What is the opposition to current flow
 - a. amperage
 - b. wattage
 - c. resistance
 - d. voltage
 - e. none of the above

7. The force which causes the current to flow is
 - a. capacitance
 - b. resistance
 - c. amperage
 - d. voltage
 - e. electricity

8. What causes a magnetic field to be formed
 - a. opposition to current flow
 - b. excessive circuit voltage
 - c. current flow through a conductor
 - d. circuit resistance
 - e. none of the above

9. The voltage for small engines is stepped up from approximately 200 volts to approximately
 - a. 12,000 volts
 - b. 20,000 volts
 - c. 8,000 volts
 - d. 4,000 volts
 - e. 2,000 volts

10. Four of these can determine the amount of induced voltage, thus causing current to flow through the conductor, which is not
 - a. the number of turns of wire in the secondary coil
 - b. the number of turns of wire in the primary coil
 - c. the intensity of the magnetic field
 - d. the speed at which the magnetic lines of force are cut
 - e. the size of the breaker points

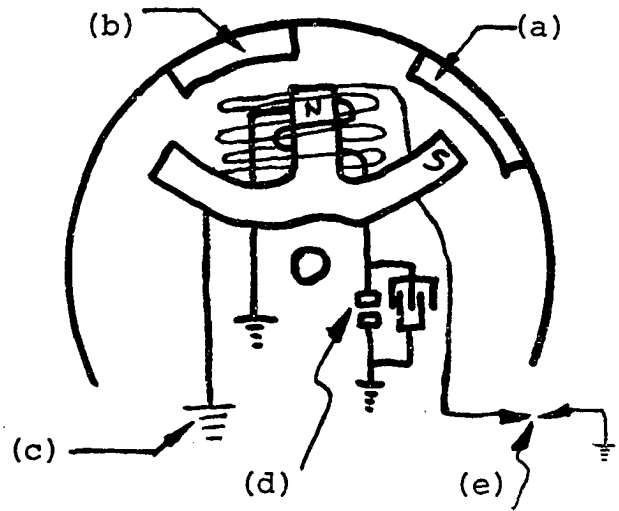
11. The primary function of a condensor is
 - a. discharge through secondary coil
 - b. connecting to ground
 - c. protecting breaker points
 - d. absorb self-induced primary current
 - e. none of the above

12. If the secondary coil has twice numbers of turns as the primary coil, the voltage induced will be
 - a. four times that in the primary coil
 - b. twice that in the primary coil
 - c. $2\frac{1}{2}$ times that in the primary coil
 - d. $\frac{1}{2}$ that in the primary coil
 - e. none of the above

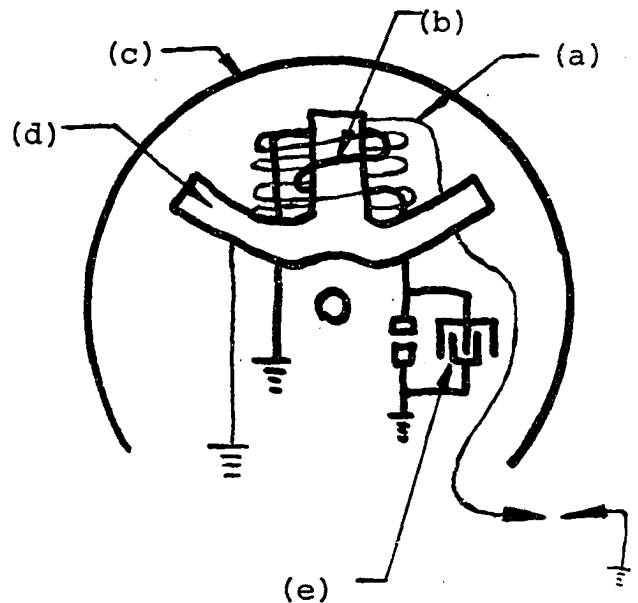
13. When a high voltage causes a spark at the spark plug, at this instant the breaker points are
- a. sometimes opened and sometimes closed
 - b. wide opened
 - c. closed
 - d. starting to open
 - e. none of the above

Part II. Matching: Any answer can be used more than once and answer(s) may not needed to be used at all.
DO NOT MARK ON THE TEST COPY.

- 14. ___ Ground
- 15. ___ South pole
- 16. ___ Breaker points
- 17. ___ Spark plug
- 18. ___ North pole



- 19. ___ Primary coil
- 20. ___ Core
- 21. ___ Condensor
- 22. ___ Secondary coil
- 23. ___ Flywheel



Part III. Summarize a magneto system operation into steps and assume the first step of the operation in this system is breaker points closed, then

24. What is the second step
 - a. condensor charged
 - b. condensor discharged
 - c. points closed
 - d. current flows through primary coil
 - e. points opened

25. What is the third step
 - a. points opened
 - b. condensor discharged
 - c. condensor charged
 - d. points closed
 - e. current flow through primary coil

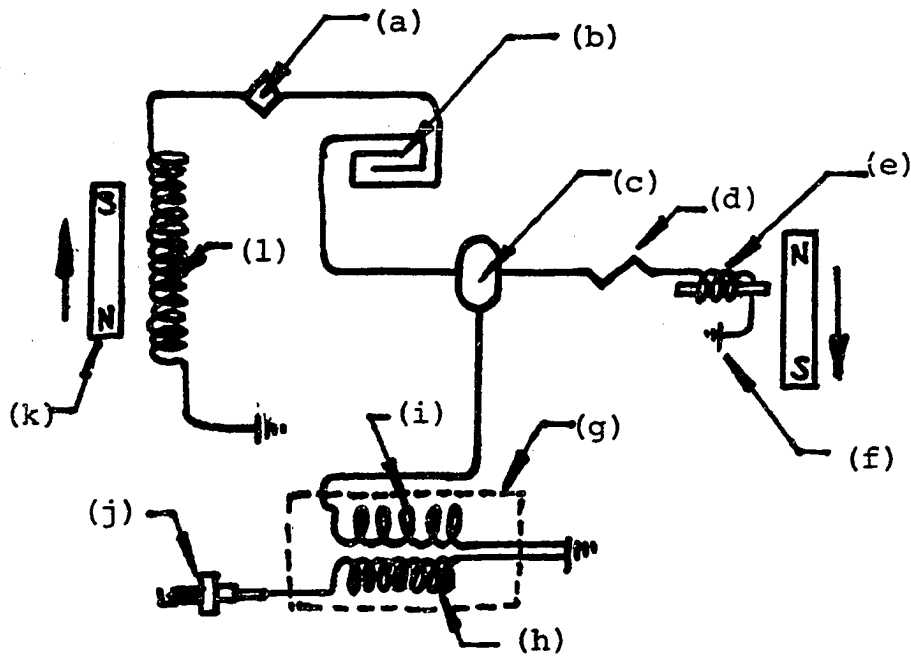
26. What is the fourth step
 - a. points closed
 - b. magnetic field starts to collapse
 - c. current flow through primary coil
 - d. condensor discharged
 - e. points opened

27. What is the fifth step
 - a. condensor discharged
 - b. condensor charged
 - c. current induced in the secondary coil
 - d. spark occurs
 - e. points opened

28. What is the sixth step
 - a. current induced in secondary coil
 - b. points closed
 - c. condensor charged
 - d. spark occurs
 - e. points opened

29. What is the last step
 - a. points closed
 - b. condensor charged
 - c. condensor discharged
 - d. current induced in secondary coil
 - e. spark occurs

30. Label the components for a solid state ignition system.



31. Fill the blanks for the operations of a solid state ignition system on the answer sheet provided.

- A. As the engine's flywheel magnet passes the input coil a very low voltage A.C. current is induced into that coil.
- B. The current passes through a (1) converting this current to (2). It then travels to the (3) where is stored.
- C. The flywheel rotates approximately (4) and as it passes the (5) it induces a very small electric charge into the (6).
- D. The charge passes through the (7) and turns on the (8). With the (9) closed the low voltage stored in the (10) travels to the (11).
- E. Here the voltage is stepped up instantaneously and it is discharged across the electrodes of the spark plug, firing before top dead center.

INDUSTRIAL EDUCATION 261
INTERNAL COMBUSTION ENGINE

DIAGNOSIS POSTTEST

Directions:

1. On the IBM answer sheet provided, record:
 - a. your name - last name first.
 - b. the date.
 - c. the name of your instructor.
 - d. in the blank labeled "name of test" record the letters "Diagnosis Posttest."
 - e. in the top two rows of the identification block record your two identification number. Be sure to blacken the corresponding spaces.
2. There are 4 pages and 21 questions in the test.
3. Read each statement carefully. Mark the most correct answer in the appropriate space on the IBM answer sheet with a pencil. If you change your mind, erase your first mark completely.

Example: The abbreviation for the Iowa State University is

- a. U S I
- b. I S U
- c. S U I
- d. I U S
- e. none of the above

a. b. c. d. e.

4. There is no penalty for guessing.
5. DO NOT OPEN THIS TEST UNTIL YOU ARE TOLD TO DO SO BY THE INSTRUCTOR!

Part I. Multiple Choice: Choose the ONE BEST answer. DO NOT MARK ON THE TEST COPY.

1. A engine does not start, and the spark plug is dry, what should be checked
 - a. fuel supply
 - b. oil level
 - c. spark plug
 - d. secondary coil
 - e. primary coil

2. If the dust cover of breaker points is dry on the outside and oily on the inside, it indicates
 - a. the fuel is mixed with water
 - b. the oil level is too high in the crank case
 - c. the breaker pointers plunger and plunger hole may be worn
 - d. a and b
 - e. a, b, and c

3. A engine does not start, and the spark plug is wet, what should be checked
 - a. float in the carburetor
 - b. fuel tank
 - c. compression
 - d. spark
 - e. oil level

4. A Briggs & Stratton engine is equipped with easy spin compression release. When checking the compression the flywheel should be spun by hand
 - a. at a very low speed
 - b. at a very high speed
 - c. in the opposite direction of rotation
 - d. in either direction will make no difference
 - e. in the normal direction of rotation

5. A sheared key could cause
 - a. starter worn
 - b. engine hard to be started
 - c. breaker points not to be opened
 - d. magneto flywheel to be broken
 - e. engine to burn oil badly

6. When the armature air gap is too large, it may cause
 - a. low voltage to be induced in ignition system and engine hard to be started
 - b. high voltage to be induced in ignition system and engine easy to be started
 - c. kickback when cranking the engine over very slowly
 - d. kickback when cranking the engine over very fast
 - e. none of the above

7. Four of the following could cause over heating which would not
 - a. lean mixture
 - b. clogged fins
 - c. a hot type spark plug
 - d. advanced timing
 - e. low oil level

8. To check for spark on a Briggs & Stratton engine a #19051 tester is used, the spark should jump the gap of
 - a. 1.66"
 - b. 0.166"
 - c. 1.6"
 - d. 1.06"
 - e. 0.66"

9. No spark on a small engine can be caused by
 - a. oily breaker points
 - b. no fuel in the tank
 - c. no air gap between breaker points
 - d. a and c
 - e. a, b, and c

10. Kickback can occur due to
 - a. the condensor is bad
 - b. the breaker points gap too small
 - c. the breaker points gap too wide
 - d. a and c
 - e. a, b, and c

11. When a plunger is installed correctly in a vertical type small engine, the beveled edge in the center should be
 - a. down
 - b. either way
 - c. reversed
 - d. up
 - e. none of the above

12. When the armature air gap is not large enough, it may cause
 - a. kickback when oil level is low
 - b. kickback when cranking the engine over very fast
 - c. kickback any time
 - d. kickback when fuel level is low
 - e. kickback when cranking the engine over very slowly
13. When a plunger becomes too short, it will
 - a. retard the timing
 - b. advance the timing
 - c. cause leaking fuel
 - d. change the function of condensor
 - e. none of the above
14. The Briggs & Stratton small engines should always use
 - a. carbon key
 - b. hard key
 - c. soft key
 - d. steel key
 - e. b and c
15. Kickback can also occur when starting an engine,
 - a. if the cutter blade has been moved
 - b. if the cutter blade is loose
 - c. equipped with a light weight flywheel
 - d. all of the above
 - e. none of the above
16. When compression check has been made, low compression indicates
 - a. bad valve seat
 - b. worn stem
 - c. burned valves
 - d. valve hung open due to gum on the valve stem
 - e. all of the above
17. The engine does not start but spark is produced as a result of the ignition system check, which of the following step should be checked next
 - a. primary circuit
 - b. oil
 - c. ignition points
 - d. fuel system
 - e. coil

18. A loose blade may creat a kick-back that will
 - a. cause hard-starting
 - b. cause soft key to be sheared
 - c. prevent starting
 - d. a and b
 - e. a, b, and c

19. An out-of balance blade may cause
 - a. the soft key to be sheared
 - b. destructive vibration
 - c. crankshaft bearing wear
 - d. a and c
 - e. none of the above

20. Dirt at the top part of the air cleaner indicates
 - a. spark is too weak
 - b. the air cleaner was over oiled
 - c. engine has too high compression
 - d. the air cleaner was not oiled
 - e. engine has too low compression

21. After reassembly a small engine does not start must likely cause
 - a. lack of spark
 - b. surplus of oil
 - c. inproper valve timing
 - d. lack of oil
 - e. lack of fuel