The report is an evaluation of the effectiveness of the 12 instructional units developed around the use of the Briggs-Stratton Model 80302, 3HP, 8 cu. in. displacement engine having a fuel induction system similar in construction to farm tractor types. The evaluation procedure used was the "one-group Pre-test and Post-test" research method. The evaluation instrument used in the testing program consisted of 45 selected multiple choice questions drawn from the original 60 questions used in the pilot testing program. In general, there was an overall improvement from pretest to posttest in a student's performance indicating that instructional material was effective. Lists of student reference literature, basic tool sets, secondary tool sets, special laboratory equipment, the evaluation instrument, and a nine-item bibliography conclude the document. (Author/BP)
Effectiveness of Prepared Instructional Units
In Teaching the Principles of Internal Combustion Engine Operation and Maintenance

Technical Bulletin 192

Agricultural Experiment Station
The University of Arizona
Tucson
Effectiveness of Prepared Instruction Units
In Teaching The Principles of Internal Combustion
Engine Operation and Maintenance

A RESEARCH PROJECT
OF THE
DEPARTMENT OF AGRICULTURAL EDUCATION

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Project Leader

AGRICULTURAL EXPERIMENT STATION
UNIVERSITY OF ARIZONA
TUCSON, ARIZONA

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Introduction

The economic magnitude which the internal combustion engine contributes to the production of agricultural products and services in the United States is tremendous. Likewise, the emphasis by departments of agriculture in vocational, secondary and technical schools in offering pre-employment training in Agricultural Power probably exceeds any other instructional area in agricultural mechanization.

During the past ten years, the small single-cylinder, air-cooled engine has been universally accepted by departments of agriculture in vocational schools to provide students a "hands-on" opportunity to learn basic principles of internal combustion engine operation, care and maintenance.

The reasons for this acceptance are (1) manufacturers of small engines have provided new engines to schools at an attractive price, hence the cost per student is comparatively low in contrast to making available "hands-on" experiences by other methods; (2) the growth of the small engine manufacturing and utilization industry (an estimated 9.4 million units of less than 15 hp were produced in 1970) has provided occupational opportunities for graduates in sales, service and repair businesses; (3) the subject matter associated with small engine instruction is considered to possess elements which are common and transferable to most types of present day internal combustion engines.

Purpose of the Study

In the past five years, numerous instructional units treating the subject of internal combustion engines have been developed by vocational agricultural educators in various states, some of which have been published for distribution. Because teachers of vocational agriculture in Arizona ranked in-service training in small gasoline engines as a much needed area, a staff study was initiated to (1) develop an instructional resource unit in the internal combustion engines for Arizona using the small single-cylinder, air-cooled engine as a teaching model and (2) to evaluate the effectiveness of the units by conducting a testing service for cooperating teachers.

A review of literature revealed only one other study which had been conducted to determine the effectiveness of instructional units in small internal combustion engines. 2

In the study, the following hypotheses were tested:

1. There was no change in the response of students based upon pre-test and post-test scores after having received instruction using the resource unit.
2. Whether teachers have had in-service training in the use of the equipment and resource unit had no effect upon the performance of students involved in the testing program.
3. The time of the school year when the instruction was conducted had no effect upon the change in student response based upon test score information.

Development of Resource Unit

Instructional units published by departments of agricultural education of Pennsylvania 3 and Missouri 4 were utilized to determine content and equipment which might be desirable for a resource unit. In addition, manufacturer's literature was reviewed to determine equipment and materials needed. Also, student reference literature was chosen based upon availability, depth of subject matter, and cost.

The resource unit content was developed around the use of the Briggs-Stratton Model 80302, 3 HP, 8 cu. in. displacement engine having a fuel induction system similar in construction to farm tractor types (Figure 1).

One new engine was recommended for each two students.

Twelve units of instruction were identified as necessary to meet the objective of providing sufficient subject matter to teach the principles of internal combustion engine operation, care and maintenance and subsequently provide valuable facts related to tractor engine operating principles. The units developed were as follows:

I. Principles of Internal Combustion Engines

II. Identification and Function of Engine Parts

III. Definition of Terms

IV. Valve and Ignition Timing

V. Fuel Induction — Carburetion

VI. Magneto Ignition

VII. Spark Plugs

VIII. Taking Accurate Measurements

IX. Using the Torque Wrench

X. Maintenance and Repair Techniques

XI. Governors

XII. Daily Service and Operation

From the above units, a teacher's manual was developed which provided unit outlines, teaching techniques and answers to questions.* A student's manual also was provided which identified reference page numbers specific to the listed questions for student study. Reference literature and student's texts which were recommended are illustrated in Appendix I.

It was suggested that teachers provide the recommended refer-

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*For information on how to obtain a complete copy of the teacher's resource unit, contact the Agricultural Education Department, University of Arizona, Tucson, Arizona 85721.
ences in sufficient numbers to supply one copy for each student in the largest class.

One engine was considered to be a work station. A recommended list of basic tools for each engine was developed in cooperation with Snap-On Tool Corporation and Briggs-Stratton Company representatives (see Appendix II). A secondary list of tools, one set for each three engines, also was recommended (see Appendix III).

Suggested special laboratory equipment for instructor use, which included timing disc, graduated cylinder, torque wrench adapter, and other special equipment, is illustrated in Appendix IV.

A method to control loss of parts and tools as students progressed through the program of engine disassembly and reassembly was considered essential. Thus, a storage box was developed as illustrated in Figure 2 to serve as a work station and a method of permitting students assigned to the station to retain control of hardware by being able to lock the box after each class activity.

In-Service Teacher Training and Pilot Testing

An intensive two-day workshop for 18 teachers of vocational agriculture was conducted by the author during the 1968 Christmas school vacation period using the resource units and recommended equipment.

The Briggs-Stratton Corporation and Snap-On Tools Corporation provided representatives to assist with the practical instruction and donated use of tools and equipment. All twelve instructional units were taught during the training sessions. One engine of the recommended model was provided for each two teachers.

Besides performing the recommended steps of procedure to disassemble, study the working parts, take measurements, reassemble, and operate the engine, the teachers were instructed in operating principles and teaching techniques.

Six teachers from this group agreed to pilot test the resource units for purposes of evaluating the response of students to the subject matter during the 1969 spring term. The pilot testing included the administration of a written examination of 60 selected multiple-choice questions on a pre-test to post-test basis to a total of 86 students.

In addition, teachers were asked to submit recommendations to improve the resource units. As a result, minor changes and corrections were made in both the teacher's and student's manuals.

Method of Procedure

During the summer of 1969, the revised resource unit in Internal Combustion Engines, including teacher's and student's manuals, were published and disseminated to all teachers of vocational agriculture in the State of Arizona.

Prior to the start of the fall semester, 1969, fourteen teachers representing 218 students indicated a willingness to cooperate in a testing program.

Design of the study was based upon the "one-group Pre-test to Post-test" research method. In this process, the dependent variable was measured before the independent variable was applied, after which the amount of change was computed.

The evaluative instrument used in the testing program (see Appendix V) consisted of 45 selected multiple choice questions drawn from the original 60 questions used in the pilot testing program. The reduction in number of questions from 60 to 45 was based upon the teachers' recommendations that the test was too long and that several of the questions did not sufficiently test subject matter drawn from the resource unit.

Test questions and pages were not numbered and the order of collating the five sheets was varied, thus providing a more equal opportunity for retaining the discriminatory power of each question.

From the fourteen cooperating schools, 218 usable students responses to the test were received and manually scored. For purposes of evaluating the strengths and weaknesses in the twelve units of instruction, the responses to individual questions were entered on IBM punch cards according to three subject matter areas. These were (1) Principles of Engine Operation, (2) Fuel Induction and Ignition and (3) Engine Repair.

Profile information on each student regarding age, intelligence quotient number, number of years farming experience and the number of years enrolled in vocational agriculture courses was collected for the purpose of determining whether these data would provide correlative relationships to test responses. Also the number of years of experience in teaching vocational agriculture was identified for each of the fourteen teachers.

Analysis of Data

The primary objective of this study was to determine the amount of change in understanding which students exhibited for the principles of internal combustion engines as a result of having been in-

Figure 2. Suggested Work Station and Storage

involved in instruction using the small engine as a teaching model and the resource unit as an instructional guide.

The principle concern was to determine whether there was a significant change in understanding from pre- to post-test results and whether the observed differences were of such a magnitude that the change could not be attributed to chance factors or sampling variations.

### Test Instrument Evaluation

The importance of the data reported in this study which concerned the effect of a prepared resource unit on instruction in the internal combustion engines for high school students is directly related to the performance of the instrument used to collect the data. A previously reported, the instrument consisted of 45 multiple-choice items in a written examination which was administered as a pre- and post-test.

The test items used were screened from 60 items used in the pilot testing program.

From the data gathered in this study, it was possible to obtain several descriptive performance criteria relative to the test instrument. As illustrated in Table 1, the test was calculated to have a reliability coefficient of .86. Reliability refers to the internal consistency of test scores within one measurement.

Using the Kuder-Richardson Formula 20 method, a reliability coefficient was calculated in order to obtain a stability indicator of the test performance.

A high degree of confidence in reliability is indicated by a large numerical coefficient. Coefficients in the .80's-.90's are commonly reported for standardized tests of aptitude and achievement administered within a fixed time period.

Because the testing program used in this evaluation involved a time spread of 6 to 8 weeks, it is believed that the test instrument used had an acceptable degree of reliability based upon a coefficient calculated to be .86.

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A measure of difficulty also is an indication of the reliability of a test. A test should be neither too easy nor too difficult to avoid low reliability of scores. A composite test score which approaches the 50 per cent mark is an indicator of a desirable level of difficulty. The value calculated for this instrument was 56 per cent.

A third measure used to evaluate the effectiveness of the test instrument was to determine the degree to which each test item was capable of discriminating between pupils of high and low achievement. The discriminating power of each test item obtained for this study indicated coefficients ranging from .119 to .729. Table 2 shows the coefficients by number of test items when arranged according to four coefficient range categories.

From this data it can be seen that three of the test items were determined to have discriminatory power of .20 coefficient or less. Twenty-nine items or 64.5 per cent had discriminatory power of .21-.50, while thirteen items (29 per cent) had a coefficient range of .51-.80. There were no items having very high (.80-1.00) discriminatory power.

Generally, the range of .21-.50 coefficient is considered to indicate average acceptability while a .51-.80 range is ranked very good to outstanding in discriminating power. From this data, it is believed that the evaluative instrument generally had the ability to satisfactorily discriminate between the performance of low and high achievers since 93.5 per cent of the items ranked in the average to outstanding coefficient rating.

The three test items that were found to be low in coefficient were reviewed to determine whether there was a possibility that the items were poorly worded, failed to be answered by instructional information in the resource unit, or were mechanically poor. It was concluded that the items were not

### Table 1

<table>
<thead>
<tr>
<th>EVALUATIVE FACTOR</th>
<th>NUMERICAL DATA</th>
</tr>
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<tbody>
<tr>
<td>Reliability (Correlation coefficient)</td>
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<tr>
<td>Difficulty (Average Score)</td>
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<tr>
<td>Discriminatory Power Coefficient</td>
<td>.119 to .729</td>
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<tr>
<td>Mean</td>
<td>25.25 items</td>
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<tr>
<td>Standard Deviation</td>
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<td>1. Post-test data analysis used</td>
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<th>PER CENT ITEMS</th>
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<td>.21 - .50</td>
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<td>64.5</td>
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<tr>
<td>.51 - .80</td>
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<td>29.0</td>
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<tr>
<td>.81 - 1.00</td>
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<tr>
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### Table 3

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<th>NO. QUESTIONS</th>
<th>MEAN CORRECT TEST SCORE RESULTS</th>
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<td>Principles, Internal</td>
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<td>Pre-test 09.138 Post-test 11.830 Difference 02.692 t* 1.960 at .05 level</td>
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<tr>
<td>Combustion Engines</td>
<td>25.25 items</td>
<td></td>
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<td>Fuel Induction and Ignition</td>
<td>16</td>
<td>05.628 08.638 03.010 11.193</td>
</tr>
<tr>
<td>Engine Repair</td>
<td>9</td>
<td>03.358 04.780 01.422 8.157</td>
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<tr>
<td>Overall Scores</td>
<td>45</td>
<td>18.124 25.248 07.124 10.612</td>
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<td>Combined Areas</td>
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* df = 434
TABLE 4
ANALYSIS OF VARIANCE OF MEAN DIFFERENCE IN PRE-TEST AND POST-TEST PERFORMANCE OF STUDENTS BASED UPON IN-SERVICE TRAINING STATUS OF TEACHERS (N = 218)

| SUBJECT MATTER AREAS OF TEST | MEAN DIFFERENCE - PRE-TEST TO POST TEST | F* | DF *
|-----------------------------|-----------------------------------------|----|-----
| Principles of Internal Combustion Engine Operation | Training: 2.220 | .729 | 1 and 216
| Fuel Induction and Ignition | Training: 2.291 | 2.84 | 1 and 216
| Engine Repair | Overall Scores: 0.506 | 1.126 | 1 and 216
| Combined Areas | | 7.43 | 1 and 216
| F* = 2.74 @ .1 level | | | 1 and 216
| = 3.89 @ .05 level | | | 1 and 216
| = 6.76 @ .01 level | | | 1 and 216

TABLE 5
ANALYSIS OF VARIANCE BY QUARTERS OF SCHOOL YEAR IN WHICH SUBJECT MATTER WAS TAUGHT (N = 218)

<table>
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<tr>
<th>SUBJECT MATTER AREAS OF TEST</th>
<th>MEAN DIFFERENCE, PER CENT OF QUESTIONS ANSWERED CORRECTLY; PRE-TEST TO POST-TEST</th>
<th>SCHOOL YEAR QUARTERS</th>
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<td>Third</td>
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<td>N = 22</td>
<td>N = 117</td>
</tr>
<tr>
<td>Principles of Internal Combustion Engine Operation</td>
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<td></td>
</tr>
<tr>
<td>Fuel Induction and Ignition</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Engine Repair</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall Scores</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Combined Areas</td>
<td></td>
<td></td>
</tr>
<tr>
<td>F* = 2.65 @ .05 level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>= 3.88 @ .01 level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>df = 3 and 214</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Change in Understanding Results

When the data for this study were compared on overall test score mean difference in response, there was determined to be an increase of 39.3 per cent in understanding by the 218 students who were involved in the internal combustion engine instructional unit. A comparison of the mean number of correct responses between pre-test and post-test by areas of subject matter is shown in Table 3. Also included is the computed Fisher's test values of observed difference in mean test score between subject matter areas and combined scores. In all three subject matter areas and combined scores, there were sufficient evidence to refute the hypothesis of no sufficient difference at the .001 level of 3.291 at 434 degrees of freedom.

Effect of In-Service Training

It was anticipated that one of the factors which might contribute to a difference in performance of students on the post-test would be whether the teacher had received in-service training on how to utilize the resource unit prior to his being involved in the testing program. As shown in Table 4, there was sufficient evidence at the .01 level of significance to reject the hypothesis that there was no difference in performance of 79 students whose teachers had not received training, compared to 139 students whose teachers had received training when compared to overall scores of all subject matter areas.

The computed mean score difference of 3.292 represents a 65.4 per cent increase in student understanding when the teacher had received in-service training.

Contributing to the highly significant results on overall test scores for trained teachers were the subject matter areas of Fuel Induction and Ignition and Engine Repair with F values of 7.43 and 24.84, respectively.

The area of Principles of Internal Combustion Engine Operation showed a mean difference of 7.29 in score increase for the trained teacher, which was significant at the .1 level. Based upon the performance of students' responses to test questions, the data indicates that the greatest effect of inservice training was obtained in the areas of Fuel Induction and Ignition and Engine Repair.

Apparently, all teachers were generally more informed in principles of engine operation, compared to their knowledge in the other subject matter areas based upon student performance.

Effect of Time in School Year

A second variable which was tested for its effect as a factor which might contribute to student performance was the time in the school year when the instructional units were taught. As shown in Table 5, there was a significant difference in the F value at the .01 level to indicate that time in the school year had an influence on the mean difference in correct scores a student would attain, especially in the Engine Repair Area and overall results.

The reasons for this difference may be due to (1) the variation in the number of (N) students involved by quarters and (2) the tendency to run out of time during the second and fourth quarters of a school year. When the conse-
Correlation Factor Relations

Product-moment correlation coefficient (r) relationship were computed for six variables and are shown in Table 6. The variables tested for relationship to performance on pre- and post-test scores were (1) age of student, (2) I.Q. of student, (3) number of years which the student had farm experience, (4) number of years vocational agriculture schooling, (5) whether the teacher was experienced, and (6) whether the teacher had received inservice training.

The evaluation was made using 82 observations because sufficient data was not available to use the remaining 136.

All correlation coefficient relationships (r) were found to be very low with the exception of “student I.Q.” which indicated low to moderate relation to performance of the resource unit.

The high motivational factor which instruction in the subject of internal combustion engines model apparently possesses for both students and teachers using the small engine as an instructional model should be exploited and perfected to the greatest possible degree of refinement. Continued research in new methods and techniques should be explored continually to determine the effectiveness of the various processes.

Use of the “One-Group Pre-test—Post-test” technique as a research tool to determine the effectiveness of the instructional process to measure change in understanding is recommended for teachers as a self-evaluation technique.

Additional studies should be conducted to design instructional material in small engines which will determine how effectively students are able to transfer knowledge of subject matter in the small engines to farm tractor engine operation, care, and maintenance.

Summary and Conclusions

It was generally observed that teachers and students have enthusiastically received the small single-cylinder, four-cycle, air-cooled gasoline engine as a model for teaching the operation, care, and maintenance of internal combustion engines.

The change of 39.3 per cent increase in understanding from pre- to post-test scores on a written examination of 45 multiple-choice questions was considered to be an encouraging insight related to the performance of the resource unit.

When the mean difference in number of correct responses between pre- and post-test scores was compared, the computed t value indicated that the difference in score was significant at the .001 level. When compared by area of subject matter, namely Principles of Internal Combustion Engines, Fuel Induction and Ignition and Engine Repair, each area was determined to have a significant difference in mean correct responses from pre- to post-test when evaluated by t at the .001 level.

Whether the students of teachers who had received inservice training in the use of small engine equipment and resource units had more correct responses in mean pre- to post-test score difference was determined to not be significantly different when F was compared at the .05 level.

There were indications that students of trained teachers did better in the units of instruction related to principles of internal combustion engines when F was compared at the .1 level of significance.

Time of the year in which the units were taught had a significant effect upon the overall test score performance when F was compared at the .01 level. Generally, students had a greater per cent of mean correct responses in the first and third quarter of the school year than in the second and fourth quarters.

Very low but positive product-moment correlation (r) relationship existed between six factors compared upon pre- and post-test scores. The greatest change between pre- and post-test relationships (although low) were for the following variables: (1) Teacher had received inservice training, (2) Teacher was experienced, and (3) Student had previous experience in Vocational Agriculture.

Intelligence quotient of the student had low to moderate relationship to performance.

The evaluation instrument used in this study had high level of reliability and discriminatory power when used as an instrument to measure performance of students when taught principles of internal combustion engine operation and maintenance using the prepared resource unit.

Recommendations

When the mean difference in number of correct responses between pre- and post-test scores was compared, the computed t value indicated that the difference in score was significant at the .001 level. When compared by area of subject matter, namely Principles of Internal Combustion Engines, Fuel Induction and Ignition and Engine Repair, each area was determined to have a significant difference in mean correct responses from pre- to post-test when evaluated by t at the .001 level.

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Additional studies should be conducted to design instructional material in small engines which will determine how effectively students are able to transfer knowledge of subject matter in the small engines to farm tractor engine operation, care, and maintenance.

Appendix I
Student Reference Literature

Literature

Farm Tractors. Engineering Bulletin FT53-A.


General Theories of Operation. MS-3553-24
Briggs-Stratton Corporation.

Illustrated Parts List. MS-4255-108. Briggs-
Stratton Corporation.

Operating & Maintenance Instructions. Form No. 27842-108,
Briggs-Stratton Corporation.


How to Read, Use, and Care for Micrometers. L.S.
Starrett Co.

Cost per Copy

$1.00

* No cost in quantities for largest class.

Page 7
### Appendix II

**Basic Tool Set BS118**

*(One set recommended per engine)*

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Tool</th>
<th>Size</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hammer, plastic tip</td>
<td>½ lb.</td>
<td>$5.26</td>
</tr>
<tr>
<td>2</td>
<td>Screw driver, Phillips</td>
<td>No. 2 x 4</td>
<td>$2.32</td>
</tr>
<tr>
<td>2</td>
<td>Screw driver, standard tip</td>
<td>¼ x 4</td>
<td>$1.89</td>
</tr>
<tr>
<td>2</td>
<td>Screw driver, cabinet</td>
<td>3/16 x 3</td>
<td>$1.47</td>
</tr>
<tr>
<td>3</td>
<td>Pliers, needle nose</td>
<td>6 inch</td>
<td>$4.21</td>
</tr>
<tr>
<td>4</td>
<td>Pliers, pump</td>
<td>6 inch</td>
<td>$3.01</td>
</tr>
<tr>
<td>5</td>
<td>Gauge, feeler</td>
<td>.0015-.025, 25 leaf</td>
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</tr>
<tr>
<td>6</td>
<td>Gauge, spark plug</td>
<td></td>
<td>$1.37</td>
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<td>7</td>
<td>Ratchet</td>
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<td>8</td>
<td>Extension</td>
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<td>13</td>
<td>Spark tester</td>
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<td>Plug gauge, breaker point plunger</td>
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<tr>
<td>15</td>
<td>Valve spring compressor</td>
<td></td>
<td>$2.25</td>
</tr>
<tr>
<td>16</td>
<td>Puller, flywheel</td>
<td></td>
<td>$.50</td>
</tr>
<tr>
<td>17</td>
<td>Compressor, piston ring</td>
<td></td>
<td>$.95</td>
</tr>
<tr>
<td>18</td>
<td>Clutch wrench</td>
<td></td>
<td>$1.85</td>
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<tr>
<td>19</td>
<td>Holder, flywheel</td>
<td></td>
<td>$3.35</td>
</tr>
<tr>
<td>20</td>
<td>Piston ring expander</td>
<td></td>
<td>$2.80</td>
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<tr>
<td>21</td>
<td>Piston land wear gauge</td>
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<td>$.50</td>
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</tbody>
</table>

**Total Basic Tool Kit, each**

$43.88
## Appendix III

### Secondary Tool Set BS108

(One set recommended for each three engines)

<table>
<thead>
<tr>
<th>Item No.</th>
<th>Tool</th>
<th>Size</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Dial Indicator Set</td>
<td>0-1</td>
<td>$15.39</td>
</tr>
<tr>
<td>2</td>
<td>Micrometer, outside</td>
<td>2-3</td>
<td>16.40</td>
</tr>
<tr>
<td>3</td>
<td>Micrometer, outside</td>
<td>0-300 lbs.</td>
<td>21.15</td>
</tr>
<tr>
<td>4</td>
<td>Allen Wrench Set</td>
<td>0-300 lbs.</td>
<td>3.71</td>
</tr>
<tr>
<td>5</td>
<td>Wrench, Torque meter</td>
<td>0-600 in. lb.</td>
<td>49.11</td>
</tr>
<tr>
<td>6</td>
<td>Cylinder Compression Gauge</td>
<td>0-300 lbs.</td>
<td>20.53</td>
</tr>
<tr>
<td>7</td>
<td>Telescoping Gauge</td>
<td>2½&quot; - 3½&quot;</td>
<td>6.35</td>
</tr>
<tr>
<td>8</td>
<td>Telescoping Gauge</td>
<td>¾&quot; - 1¼&quot;</td>
<td>4.70</td>
</tr>
<tr>
<td>9</td>
<td>Small Hole Gauge</td>
<td>.200-.300</td>
<td>4.00</td>
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<tr>
<td>10</td>
<td>Tachometer, dial type, direct reading</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Stewart-Warner Model 757-W</td>
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</tbody>
</table>

**Total Secondary Tool Kit**

$154.04
Appendix IV
Special Laboratory Equipment
(For Instructor)

<table>
<thead>
<tr>
<th>Item No.</th>
<th>No.</th>
<th>Each</th>
<th>Item</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1 ea.</td>
<td></td>
<td>Sleeve, oil seal installation, shop</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>constructed</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1 ea.</td>
<td></td>
<td>Test Spark Plug, 3/16&quot; gap (substitute</td>
<td>.80</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>for BS 19051 spark tester), shop</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>constructed</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1 ea.</td>
<td></td>
<td>Battery Dry Cell, 6 volt Lantern</td>
<td>.50</td>
</tr>
<tr>
<td>4</td>
<td>2 ea.</td>
<td></td>
<td>Test Leads with Alligator Clips, shop</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>constructed</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>1 ea.</td>
<td></td>
<td>Timing Leads, Circle (360°) Protractor,</td>
<td>1.25</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Post No. 1532A-6</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>1 ea.</td>
<td></td>
<td>Torque Wrench Adapter, 4 inch, Shop</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Constructed</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>1 ea.</td>
<td></td>
<td>Graduated Cylinder, 50 ml plastic base</td>
<td>2.00</td>
</tr>
</tbody>
</table>

**TOTAL COST** $4.55
Appendix V
Evaluation Instrument

**QUESTION:** Which of the following positions of crankshaft rotation is the exhaust valve of a four-cycle engine starting to open?

- a.
- b.
- c.
- d.

**QUESTION:** What is the name of the device in spark ignition engine that mixes gasoline and air in the proper proportions?

- a. choke
- b. cylinder
- c. carburetor
- d. governor

**QUESTION:** Size of an internal combustion engine is usually expressed in

- a. weight in pounds
- b. compression pressure
- c. piston displacement
- d. torque output

**QUESTION:** The magneto system of most gasoline engines generates an electric spark by

- a. the incorporation of a small battery
- b. the rapid opening & closing of points
- c. a condenser of the proper capacity
- d. magnets moving past the armature poles

**QUESTION:** Which of the following describes the secondary winding of an ignition coil?

- a. many turns of heavy wire
- b. a few turns of heavy wire
- c. a few turns of fine wire
- d. many turns of fine wire

**QUESTION:** A governor acting on the principal of centrifugal force is known as the

- a. vacuum type
- b. venturi type
- c. mechanical type
- d. piston type

**QUESTION:** Which of the following is not a part of the ignition coil?

- a. core
- b. condenser
- c. primary winding
- d. secondary winding

**QUESTION:** How many valves will normally be in the block of a four-cycle, one cylinder gasoline engine?

- a. 1
- b. 2
- c. 3
- d. 4

**QUESTION:** Which of the following spark plug appearances most clearly indicates the possibility of too “rich” a fuel mixture?

- a. dry or damp black soot on insulator or shell
- b. burned and badly eroded electrode
- c. light tan or brown insulator
- d. black, wet deposits on insulator and shell

**QUESTION:** Which of these air cleaners can be cleaned with soap and water?

- a. metallic mesh
- b. dry-type paper
- c. oil bath
- d. polyurethane

**QUESTION:** How many valves will normally be in the block of a four-cycle, one cylinder gasoline engine?

- a. 1
- b. 2
- c. 3
- d. 4

**QUESTION:** The micrometer pictured below is set to read:

- a. 2.381
- b. 2.376
- c. 2.316
- d. 3.351

**QUESTION:** Which one of the following spark plug appearances most clearly indicates the possibility of too “rich” a fuel mixture?

- a. dry or damp black soot on insulator or shell
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- c. light tan or brown insulator
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**QUESTION:** Which of these air cleaners can be cleaned with soap and water?

- a. metallic mesh
- b. dry-type paper
- c. oil bath
- d. polyurethane

**QUESTION:** The "compression ratio" in a given size of engine is controlled by the design of the engine. This could be altered by which one of the following?

- a. advance the spark and clean carbon from the valves
- b. increase the intake valve in length and diameter
- c. install a supercharger and use a rich fuel mixture
- d. change the volume of the combustion chamber by using a thicker cylinder head gasket.

**QUESTION:** The micrometer pictured below is set to read:

- a. 2.381
- b. 2.376
- c. 2.316
- d. 3.351

**QUESTION:** Which would be a reason for honing a cylinder to oversize?

- a. vertical score
- b. flat
- c. .001" taper
- d. .001" out-of-round

**QUESTION:** Which of the following is equal to a torque wrench reading of 60 foot-pounds?

- a. 720 inch-pounds
- b. 180 yard-pounds
- c. 60 millimeters-gram
- d. 210 meter-grams

**QUESTION:** Which one of the following spark plug appearances most clearly indicates the possibility of too “rich” a fuel mixture?

- a. dry or damp black soot on insulator or shell
- b. burned and badly eroded electrode
- c. light tan or brown insulator
- d. black, wet deposits on insulator and shell

**QUESTION:** Which of these air cleaners can be cleaned with soap and water?
QUESTION: Which type of gauge should ordinarily be used to measure magneto air gap?
   a. inside calipers
   b. outside calipers
   c. flat thickness
   d. round wire

QUESTION: One of the reasons for adjusting valve clearance of an engine is to
   a. make valves open further
   b. keep valves cooler
   c. place valves in time
   d. increase compression

QUESTION: When a condensor is checked for capacity, the unit of measure is
   a. ohms
   b. volts
   c. resistance
   d. farads

QUESTION: A condenser is most actively functioning when the breaker
   a. when the breaker points open
   b. when the breaker points close
   c. after the spark plug fires
   d. when the primary coil stops functioning

QUESTION: The combustion pressure of a gasoline engine cylinder is greatest when the piston is located
   a. at bottom dead center
   b. several degrees past bottom dead center
   c. at dead center
   d. a few degrees past top dead center

QUESTION: Secondary voltages in a small gasoline engine may be as high as
   a. 15 volts
   b. 150 volts
   c. 1,500 volts
   d. 10,000 volts

QUESTION: Diesel engines are distinguished from other types of internal-combustion engines by their use of
   a. the four-stroke cycle only
   b. ignition by heat of compression
   c. very low compression ratio
   d. air blast fuel injection

QUESTION: Richness or leanness of mixtures burned in an engine is referred to as
   a. octane of fuel
   b. volatility of fuel
   c. air-fuel ratio
   d. vapor being burned

QUESTION: In a two-cycle engine, how many complete revolutions must the crankshaft make to complete one cycle?
   a. one
   b. two
   c. three
   d. four

QUESTION: What part of the ignition system controls the time current flows to the spark plug?
   a. induction coil
   b. ignition coil
   c. breaker assembly
   d. lead wire
   e. core

QUESTION: What is the constricted area of a carburetor that is designed to increase the velocity of the air?
   a. tunnel
   b. venturi
   c. air foil
   d. valve

QUESTION: In order to operate successfully every engine must have at least three primary functional systems. These are
   a. magneto, spark plug and condenser
   b. spark plug, breaker points, and compression
   c. compression, fuel and magneto
   d. compression, fuel and ignition

QUESTION: Diesel and gasoline engine differ mainly in their
   a. fuel systems and ignition methods
   b. fuel systems and cylinder blocks
   c. fuel systems and cylinder assemblies
   d. ignition methods and cylinder assemblies

QUESTION: In comparing two-cycle vs. four-cycle engines, which of the following is the most accurate statement?
   a. a four-cycle and two-cycle engine of the same horsepower will be of approximately equal weight.
   b. a two-cycle engine will start faster and easier.
   c. a two-cycle engine will normally run smoother than a four-cycle.
   d. a two-cycle engine is simpler in construction and design

QUESTION: One cylinder gasoline engines operate at a compression ratio of about
   a. 6 to 1
   b. 9 to 1
   c. 12 to 1
   d. 15 to 1

QUESTION: Which of the following spark plug insulator descriptions best indicates a "hot" spark plug?
   a. long
   b. thin
   c. thick
   d. short

QUESTION: As breaker points wear, timing of a spark ignition engine will be:
   a. advanced
   b. retarded
   c. no change in timing
   d. wear only effects RPM

QUESTION: If a piston displaced 6 volumes in the cylinder, the compression ratio of the engine is
   a. 5:1
   b. 6:1
   c. 7:1
   d. 8:1

QUESTION: When fastening the cylinder head of a small engine to the block, which of the following procedures should be followed?
   a. rotate each of the head bolts one-quarter turn
   b. use a socket wrench with a handle 12 inches long
   c. tighten the bolts evenly following proper order
   d. tighten down the bolt nearest the muffler port before tightening the others
QUESTION: The angle or surface of the valve seat should match what part of the valve?

_____ a. face
_____ b. head
_____ c. margin
_____ d. dish

QUESTION: The normal wear on most cylinders is greatest near the

_____ a. valve chamber
_____ b. top of the cylinder
_____ c. center of the bore
_____ d. bottom of the bore

QUESTION: What should be done when crankshaft end-play is insufficient?

_____ a. use a thicker magneto plate
_____ b. use special bushings on the crankshaft
_____ c. use additional end plate gasket
_____ d. replace the crankshaft

QUESTION: The float level in a small gasoline engine carburetor is set to manual specifications with a

_____ a. ruler
_____ b. feeler gauge
_____ c. micrometer
_____ d. depth gauge

QUESTION: A machine which converts heat of burning gases into rotating movement is referred to as a:

_____ a. prime mover
_____ b. motor
_____ c. blast furnace
_____ d. heat engine

QUESTION: Stroke of the piston is expressed in:

_____ a. inches of movement in the cylinder
_____ b. degrees of crankshaft rotation
_____ c. pounds of force exerted on flywheel
_____ d. torque valve in ounces

QUESTION: Which of the following type engines does not take an air-fuel mixture into the cylinder on the intake stroke.

_____ a. external combustion
_____ b. spark - ignition
_____ c. compression - ignition
_____ d. vacuum - ignition

QUESTION: When the connecting rod is in exact parallel alignment with the crankshaft throw, the piston is said to be positioned on:

_____ a. dead center
_____ b. power stroke
_____ c. bore sight
_____ d. 360 degree alignment

QUESTION: The reference to the exact time that ignition spark occurs during engine operation is expressed in:

_____ a. speed of light
_____ b. degrees of crankshaft rotation
_____ c. angle of connecting rod
_____ d. seconds between electric discharges

QUESTION: The relationship of the crankshaft gear to the camshaft gear is such if the crank gear has 16 teeth the cam gear will have:

_____ a. 16 teeth
_____ b. 21 teeth
_____ c. 26 teeth
_____ d. 32 teeth

QUESTION: Which of the following mechanisms causes the valve of a four-cycle engine to be lifted from its seat?

_____ a. wedge
_____ b. guide
_____ c. spring
_____ d. cam
Bibliography


