A STUDY OF MODERN AUTOMOTIVE TUNE-UP EQUIPMENT USED IN FORT WORTH, TEXAS

THESIS

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The problem with which this investigation was concerned was that of determining the use of modern automotive tune-up equipment as used by the automotive garages in the Fort Worth area. The data for this study were provided by fifteen garages of the Fort Worth area.

Of the Fort Worth garages using electronic equipment to perform a tune-up, few appear to have the adequate equipment and few appear to make more use of the equipment. In addition, a deficiency seems evident in the use of the electronic computer in performing tune-ups.

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INTRODUCTION

The automobile plays a significant role in the development of our increasingly complex technological society. When one considers that there are more than 90 million automotive vehicles in the United States, one can profit from a better understanding of automotive technology, either as a part of general education or in an occupational program.[1]

Tune-up signifies better engine performance and economy and has an important bearing on the performance of the car. People, more especially today, are encouraged to try to get more gas mileage out of their automobiles. One of the many ways to get exceptional gas mileage out of the automobile is to give it a tune-up regularly. A typical engine tune-up does not involve major engine repair work. Rather, it is a process of cleaning and adjusting the engine so that it will provide top performance. Involved in this process is a definite sequence of tests and adjustments which should be done in a logical and orderly manner. Failure to follow the proper steps may

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[1]Robert D. Brown, James R. Daines and Paul R. Rickert, Introduction to Automotive Technology (Boston, 1976), p. 5.

cause some malfunctions to be overlooked, make additional work necessary, or make it impossible to correctly check or perform the necessary adjustments. A tune-up can be done by an experienced engine owner, or it can be done by an automobile mechanic. However, in exercising this process on a modern automotive engine, one must have dependable test instruments and equipment such as a voltmeter, hydrometer, tachometer, compression tester, timing light, dwell tester, feeler gauges and many other necessary hand tools, accurate test specifications, which are generally supplied by the manufacturer, quality replacement parts and a recommended tune-up procedure.[2]

There are many new concepts concerning automotive tune-up and repair. Automotive tune-up and power mechanics are a part of the industrial arts curriculum in the state of Texas. It was with this thought in mind that a study of certain types of testing equipment was conducted.

Statement of the Problem

This is a study of modern automotive tune-up equipment and its use by the automotive garages in Fort Worth, Texas. Answers to the following questions were sought.

1. What constitutes a motor tune-up?

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[2]Richard S. Roeing, Auto Engine Tune-Up (Indiana, 1972), p. 271.

2. How many automotive garages use electronic analysis equipment?
3. How many automotive garages use electronic computer equipment?
4. How many automobile garages use both types of equipment?
5. How many operators use these pieces of equipment?
6. To what extent are electronic analysis and electronic computer equipment used?
7. Is the equipment expensive to purchase and install?
8. How effective is each of the types of equipment?
9. Which types of equipment are used on American and foreign automobiles?
10. Is special training required to operate the equipment?
11. How much space is required for the equipment?
12. How do electronic analysis and electronic computer equipment compare with each other?
13. How well do the individual companies accept the machines?
14. Do the automotive garages plan to purchase new equipment?

Definition of Terms

For the purpose of clarity it was necessary to define certain terms. They are as follows.

1. Alternating Current is a periodic electric conduction current which reverses its direction at regularly recurring intervals. (AC used in this study)

2. Automotive garages referred to in this study are those dealerships that test, maintain, and repair the automobile.

3. Check as used in the study pertains to measurement by means of feeler gauges, micrometers, and scale.

4. Electronic analysis equipment is defined as an engine analyzer designed to provide dynamic testing of compression, electricity, ignition, carburetion, cranking-charging systems. The analyzer is equipped with all accessories required to perform complete engine testing.

5. Electronic computer analysis is considered to be a complete engine testing system which prints out in words and numbers information that helps mechanics diagnose and service engines. In a matter of minutes the computer can generate detailed information to help diagnose trouble.

6. Large cars refer to the luxury Oldsmobile and Continental.

7. A major tune-up consists of such operations as checking compression, changing plugs, points, condenser, checking wire, distributor cap, rotor, battery, alternator, starter and checking and adjusting carburetor. It also includes cleaning E.G.R. (Exhaust Gas Recirculation) valve, P.C.V. (Positive Crankcase Ventilation) valve and checking

exhaust emission.

8. A minor tune-up consists of such operations as changing plugs, points, condenser, and the checking of the timing.

9. Motor tune-up as used in this study refers to procedures for maintaining an efficient auto engine.

10. Replace means to take off, repair, and reinstall the old part, or install a new one.

11. Revolution per minute (R.P.M.) is the number of times per minute the crankshaft rotates through 360 degrees.

12. Small automobiles refer to the compact automobiles such as Pinto, Vega, Aspen, and Opel.

13. Tune-up equipment refers to the special test instruments used in performing a tune-up properly.

Limitations of the Study

In order to conduct the study it was necessary to establish certain limitations which are as follows.

1. In this study, the use of tune-up equipment was restricted to electronic analysis and electronic computer analyzers.

2. This study was concerned with engine tune-up only.

3. Only automobile dealers who operate automobile tune-up garages in Fort Worth, Texas participated in the study.

4. American and foreign automobiles were included in

the study.

Procedures of the Study

In order to obtain answers to the questions mentioned in the statement of the problem, data were collected utilizing the following procedures.

1. All dealerships that perform motor tune-ups which were listed in the Fort Worth telephone directory were selected to participate in the study.

2. Participants were then contacted by letter of introduction which included an agreement form.

3. An instrument pertaining especially to the use of electronic analysis and electronic computer equipment was developed.

4. The instrument, accompanied with a stamped envelope for return of the data, was either mailed or delivered personally to the participants.

5. Data received were then compiled.

6. Compiled data were thoroughly interpreted and presented.

CHAPTER II

AUTOMOBILE TUNE-UP INVOLVING ELECTRONIC ANALYSIS EQUIPMENT

History of the Automobile

The automobile has played a major role in our society since the 1900's. It continued to develop to its present status and is considered to be a fascinating and a highly improved method of transportation. The automobile of the 1900's was a horror on wheels because it was unbelievably difficult to operate and control, and when it would not run, no one knew how to repair it. Yet, this new invention continued to be one of society's major interests.

From 1900 to 1920, there were numerous improvements. The closed automobile was established, even though for some time they retailed for higher prices. Other great improvements which arrived at about the same time that the closed automobile was introduced were the self-starter, better tires, better and more powerful motors, better steering devices, and the beginning of streamlining. Also within that period of time, 1900 to 1920, the achievement of mass production brought about a number of other automobile improvements. Mass production saved time and

greatly reduced the cost of automobiles.[1] Continuing into the 1920's, almost all automobiles were equipped with four-wheel brakes. Thus, the quieter hydraulic type brake system had made its appearance. However, this particular system was crude and not yet perfected. Practically all automobiles were equipped with electric headlights. Tires and springs were steadily improving. Smoother gear shifting was offered. Greater knowledge of metals and metal alloys, new machine tools, achievement of mass production through the moving assembly line, and ingenious manufacturing techniques provided superior parts easier and cheaper to manufacture. In addition to efficiency and a moderate price, automobiles of this era offered refinements of comfort and a more pleasing appearance than previous ones.[2]

By the late 1920's and early 1930's, the eight cylinder engine was greatly improved. Eight cylinder engines had heretofore appeared only in high-priced automobiles. Consequently, the V-8 became more powerful, low-priced, and much faster.[3]

The 1930's saw automobiles improving as to steering systems, spring suspension, brakes (the hydraulic braking

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[1]Frank Ernest Hill, The Automobile (New York, 1967), p. 72.

[2]Ibid., p. 105.

[3]Ibid., pp. 128-129.

then became standard), motors, and the cushioning of bodies for passenger comfort.[4] In the 1940's, the industry faced a halt in production of automobiles for the public. The countries which were involved in World War II needed the strength and resourcefulness of the automobile plants for their military activities. During all of World War II, more than four years, there were no automobiles produced for nonmilitary use. Furthermore, there was a longer delay after the war due to shortages of certain needed materials, governmental curbs, and the reconversion of automobile plants.[5]

By 1950, the automobile industry had entered a period of growth. Certain improvements such as higher horsepower, heaters, air conditioners, seal-beam headlights, more efficient windshield wipers, automatic controls, and far greater room and comfort in the automobiles than ever before were introduced.[6] Also in the 1950's came power steering which reduced the manual effort required of the driver, power window lifts (press a button for up and down), power seat adjustments, and safety door locks. Seat belts were also provided for front-seat occupants, a safety measure. Besides the manufacture of roomy luxury automobiles,

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[4] Ibid., p. 129.

[5] Ibid., p. 149.

[6] Ibid., p. 157.

there was still production of low-priced, small, economical, and attractive automobiles, some of which were classified as compacts.[7]

From the 1960's to the 1970's, automobiles were available with various improvements and in a wide range of prices and sizes. Automation had become a major trend in automobile manufacturing. Today, in the late seventies, certain standards have been developed. Several safety measures such as padded instrument panels, padded sun visors, and outside rearview mirrors have been included in automobiles. Radio, light signals for turning or stopping, power braking, comfortable upholstery are just a few of the features that have improved the quality of automobiles. By the early seventies, a new feature, the solid state ignition system, was introduced in some of the automotive engines instead of the conventional breaker point ignition system. Indeed, the modern automobile throughout is marked by superior quality of all materials used, and by superior engineering.[8]

Significance and Purpose of the Electronic Analyzer and the Electronic Computer

As mentioned earlier, satisfactory performance of an automobile depends largely on the correct functioning of

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[7] Ibid., p. 162.

[8] Ibid., p. 187.

its engine systems. There are three important engine systems which are (1) compression, (2) ignition, and (3) carburation. The purpose of an engine tune-up is to check the various engine components so that any which are below performance efficiency can be brought up to specifications. The purpose of an engine tune-up is to keep the engine in perfect shape so it will last longer and run smoother.[9] Engine tuning is generally performed periodically to insure power and top performance of the automobile. The Dallas Morning News[10] has this to say about an engine tune-up:

> The chief benefits of a tune-up are:
> a. Better gasoline mileage.
> b. Quicker, more trouble-free starting.
> c. Better pick-up and passing power.
> d. Fewer harmful pollutants emitted.

Apart from power and efficiency considerations, economy is another major reason for giving the automotive engine periodic tuning attention. This is one incentive that should appeal to practically everyone since the development of the present energy crisis. To substantiate the latter statement, once again, the Dallas Morning News had this to say:

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[9] John Milton, editor, Chilton's Repair and Tune-Up Guide for the Volkswagen (New York, 1970), p. 20.

[10] The Dallas Morning News, May 19, 1977, Sec. F, p. 1.

> It is estimated that if all U.S. cars were tuned, 300,000 barrels of fuel could be saved daily....
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> This wasted fuel is costing...U.S. car owners an additional $2 billion a year.[11]

Furthermore, automotive parts and labor add up when an automobile is not taken care of properly.

Today, a precision tune-up requires the use of dependable and accurate equipment. Special electronic engine testers, or analyzers, are available to perform an extremely accurate job in tuning an automobile engine. These units make possible more rapid diagnosis of engine trouble. In addition, greater precision of adjustments is also possible and is of great significance in the more modern high-speed and high-performance engines. Most of these units test and make possible precise adjustments on the ignition and carburetion systems as well as indicating other troubles that hinder the overall efficiency of the engine.[12]

Besides the importance of and need for the electronic analyzers, the electronic computer is equally important. Three major situations indicate the need for area testing which a computer can be programmed to do. The first is diagnosis and evaluation of an engine to determine if work is needed, and to locate the reason for a performance

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[11] Ibid.

[12] Frederick E. Bricker, Automobile Guide (Indiana, 1973), p. 324.

complaint. The second is the need to area test the automobile during an engine tune-up. The third situation is to maintain quality control on all work performed to see that it is done satisfactorily. The function of area testing is to locate the system, or systems, which may be causing any type of malfunction. In the process, a customer's complaint may be validated, and at the same time, make sure there is no more than one area causing the customer complaint.[13]

The computer programmed area tests are designed in a logical sequence which will quickly and accurately screen all engine test areas. These are the starting, the charging, and the fuel and emission systems. The area test sequence can be performed in just a few minutes.[14]

The point being made about these two major pieces of electronic equipment is that they are needed and important to an engine tune-up. The electronic analyzer and computer help perform a modern automobile engine tune-up with greater accuracy and speed.

Procedures for Use of the Electronic Analyzer and the Electronic Computer

One of the questions in the statement of the problem concerned itself with an engine tune-up and how it is

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[13] Sun Electric Corporation, Operator's Manual - Sun 2001 Diagnostic Computer (Illinois, 1976), p. 13.

[14] Ibid.

performed. The following application tests pertain to the electronic analyzer and the electronic computer as used in performing an engine tune-up. Each piece of testing equipment is presented separately. Figure 1 is an illustration of a Sun Electric Analyzer (courtesy of Sun Electric Corporation).

Electronic Analyzer

To prepare an electronic analyzer for tests performed in an engine tune-up, many connections, meters, and installations have to be made ready. The following describes the electronic analyzer preparatory steps for tune-up tests. The purpose of this discussion is to provide further understanding of the practical application and use of this revolutionary piece of equipment. The materials were provided by Sun Electric Corporation. A copy of the letter of approval to reprint parts of these materials appears in Appendix E.

Prepare for tests.--With the Sun Electronic Analyzer properly connected to a power outlet, the AC switch is then placed in the "on" position. The voltmeter selector is positioned in order to check the electrical system. The Sun Scope provides ways and means to analyze the

Fig. 1--Sun Electric Analyzer (courtesy of Sun Electric Corporation).

ignition system performance. A graphic-like picture of the system is displayed for interpretation purposes.[15]

Engine speed in R.P.M.'s during the performance of various operating engine tests is measured with the tachometer. This assists the service technician in determining exact engine speeds which are required for other test areas involving the dwell meter, timing-advance unit, and vacuum gauge.[16]

To make these tests, it is necessary to apply the test harness connections which consist of various colored cables, wires, and clamps. The service technician must exercise great care in seeing that each of the connections is properly installed.

A very reliable indication of the carburetor system operation is performed by the combustion efficiency tester. It is done by utilizing exhaust gas samples gathered at the tail pipe in order to determine the air to fuel ratio.

Electronic Computer

Preparation of the electronic computer for engine tune-up diagnosis is similar to the preparation of the electronic engine analyzer. Presented, briefly, is a discussion of the preparation of the computer for

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[15] Sun Electric Corporation, Engine Performance Handbook, Operating Instructions for Sun Electronic Engine Testers-Models EET-1120 and EET 920 (Illinois, 1969), p. 11.

[16] Ibid., p. 25.

programming engine tune-up checks. Figure 2 shows a Sun Electronic Computer (provided by Sun Electric Corporation, Arlington, Texas).

Prepare for tests.--With the Sun diagnostic computer properly connected to a power outlet, the AC switch is placed in the "on" position. Generally located on the operation panel, the computer power key is also placed in the "on" position. At this time, the computer light and meters will glow and shortly after, the computer will display the statements and instructions.[17] The computer is ready to be programmed which is the starting point for testing. Both restart buttons on the operation panel must be pressed at the same time to return the program to the starting point, if needed any time during any test sequence. Any time the service technician wants the test sequence to move forward, he pushes the proceed button, also located on the operation panel. If the service technician wishes to direct computer operation from under the hood, or from inside the vehicle, the wireless remote control unit may be used instead of the proceed button. Then the instructions displayed by the computer must be followed if accurate results are to be obtained.

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[17]Sun Electric Corporation, Operator's Manual - Sun 2001 Diagnostic Computer, p. 13.

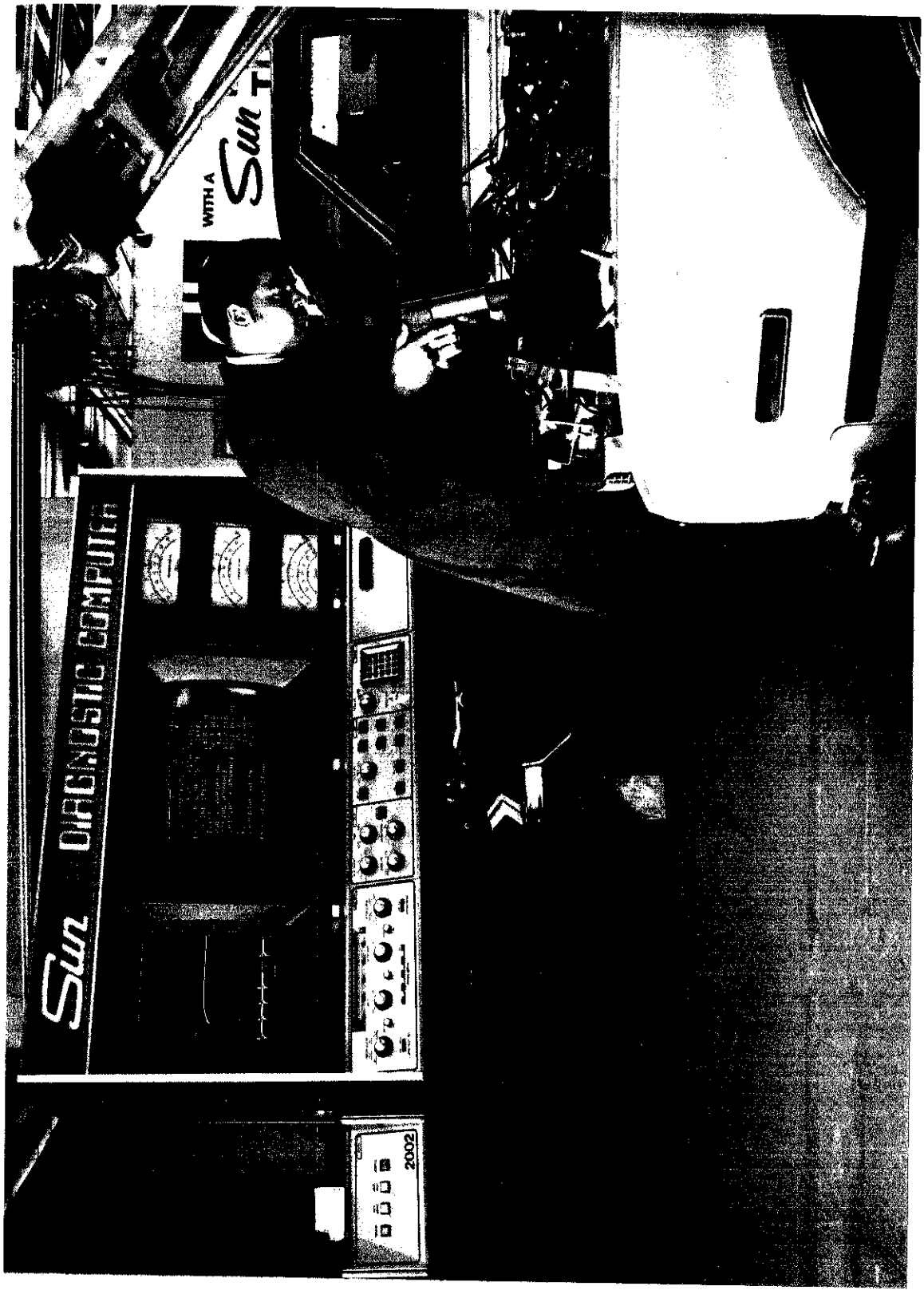

Fig. 2--Sun Electronic Computer (courtesy of Sun Electric Corporation).

Continuing the preparation of the computer for an engine tune-up, test connections to the automobile must be made. Different colored cables, wires and clamps of the electronic computer are connected to various parts of the engine. The service technician must carefully see that each of the connections is properly installed.

Presented briefly below is a discussion concerning the practical application of the electronic analyzer and the electronic computer. The relationship of the two pieces of equipment and the capability of each is emphasized.

Minor Tune-Up

To perform a minor tune-up, specified tests are made and parts replaced at a customer's request. That is, any part of a complete tune-up to be done on a customer's automobile must be done only if the customer made the particular request. The electronic equipment, if used, is then put to work on the indicated or suggested area of trouble. After the trouble has been diagnosed and the cause of it has been found, parts, if necessary, are to be replaced only at the customer's approval. The automobile, though, may need further servicing elsewhere, but the customer may not want that area serviced at the time. Then, a minor tune-up becomes a part of a complete tune-up.

Major Tune-Up Involving Electronic Analysis and Electronic Computer Equipment

A major tune-up involving electronic analysis and electronic computer equipment follows a definite sequence of tests and adjustments which, hopefully, will restore the automobile's original performance, power and economy as completely as possible. It is important to perform the tests and adjustments in a logical and orderly sequence, such as listed in the following outline, because of the interrelationship of the various engine systems. Failure to at least generally follow such a sequence may cause some troubles to be overlooked, make additional work necessary, or make it impossible to correctly perform a check or adjustment.

The questionnaire by which data for this study were gathered was developed from the following outline.

Outline of an Automotive Engine Tune-Up Procedure for the Electronic Analyzer and the Electronic Computer

1. Compression
2. Electric
    a. Battery
    b. Starter
    c. Alternator
    d. Regulator
3. Ignition
    a. Points

b. Plugs

c. Plug wire

d. Rotor

e. Distributor cap

f. Coil

g. Condenser

h. Coil wire

i. Primary wire

j. Timing

k. Timing accuracy

l. Timing advance

m. Ignition switch

4. Carburetor

a. Fuel pump

(1) Volume

(2) Pressure

(3) Vacuum

b. Idle mixture

(1) Idle speed

(2) Accuracy speed mixture

(3) Normal speed mixture

(4) High speed mixture

(5) E.G.R. (Exhaust Gas Recirculation)

(6) P.C.V. (Positive Crankcase Ventilation)

(7) Hot air bypass

The suggested engine tune-up procedure, as outlined, can be accomplished by the electronic analyzer in a few minutes and requires a simple pre-adjustment of tester controls and the attachment of three electrical and two hose connections to the engine.[18] Yet, to perform detailed system tests, more time is required and great care must be taken in operating the controls so as to locate the precise source of trouble. In addition to the different types of instruments available on the electronic analyzer, there is an oscilloscope (scope for short) that can assist the service technician in performing a major engine tune-up.

A newer concept in performing engine tune-up involves the diagnostic or electronic computer. The electronic computer consists of three sections: the analog scope (oscilloscope), the digital display section, and the pneumatic (control panel) section. Because of its speed, updating capability and unlimited flexibility, the diagnostic computer can make several diagnostic tests and provide engine data to help the service technician perform the specified tune-up procedure in a short period of time.[19] The various engine checks can be performed

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[18]Sun Electric Corporation, Engine Performance Handbook, p. 1.

[19]Sun Electric Corporation, "2001 Suddenly It's Tomorrow," unpublished material, Chicago, Illinois.

through the area of pinpoint mode of testing by few adjustments and connections.

The final step in a good tune-up should be a road test, which can be used to verify all the checks and adjustments on the basis of actual performance. During this test, the engine is operated at a minimum speed in high gear, then accelerated rapidly. The engine should accelerate smoothly and evenly. If it misses or hesitates, recheck the electrical system. If there are "flat spots," recheck the ignition timing which may be over-advanced.[20]

A road test also provides an opportunity to check the brakes, steering, clutch and/or transmission, instruments, and accessories.[21] On completion of the road test, recheck for any oil, water or fuel leaks, and correct all troubles that may have been found.

General tune-up procedures involving the use of the electronic analyzer or the diagnostic computer have been briefly explained. In Chapter III, data gathered from automotive garages in Fort Worth, Texas are presented and discussed to further illustrate the significance and the use of the electronic analysis equipment and diagnostic computer equipment.

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[20] Bricker, p. 282.

[21] *Ibid*.

CHAPTER III

COMPARISON OF ELECTRONIC ANALYSIS EQUIPMENT WITH ELECTRONIC COMPUTER EQUIPMENT

Of the twenty-nine automotive garages included in the study concerning the use of the electronic analysis equipment and the electronic computer equipment, respondents from fifteen auto service garages returned instruments containing data which are presented in Chapter III. The first items discussed are those from the general information section of the instrument. Next, types of electronic equipment and their use are discussed. Further in the chapter, the electronic analysis equipment is discussed as to the types of automobiles on which the equipment is used, time required to train an employee to operate the equipment, and the extent of use of the equipment. Based on data received from the respondents, comparisons of electronic analysis and electronic or diagnostic computer equipment are made to further illustrate the differences and similarities of both types of equipment. In the final section a discussion of the opinions of respondents concerning various questions included in the instrument is presented. In summary, Chapter III attempts to analyze and compare the data concerning the extent of use of electronic analysis and electronic computer equipment.

General Information

A number of tune-up operators ready at hand insures a customer of prompt service. In Table I, the number of tune-up operators employed in the Fort Worth automotive garages is shown.

TABLE I

NUMBER OF TUNE-UP OPERATORS EMPLOYED IN FORT WORTH AUTOMOTIVE GARAGES

Number of Operators Employed	Number of Operators in Each Category	Per Cent of Operators in Each Category
1-3	11	73.4
4-6	2	13.3
7-9	2	13.3

Eleven of the fifteen participating Fort Worth automotive garages, or 73.4 per cent, employed from one to three tune-up operators. Two, or 13.3 per cent, of the garages employed four to six tune-up operators. Responses also show two, or 13.3 per cent, employed seven to nine tune-up operators.

The next question in the general information section of the questionnaire concerned the average amount of time required to do a major tune-up on automobiles according to size, small and large. The data presented in Table II

indicate that nine respondents, or 60 per cent, used an average of two hours to perform a major tune-up on a small automobile. To perform a major tune-up on a large automobile, the data reveal that 40.2 per cent also required approximately two hours time. Data showing the average amount of time required to do a major tune-up on a small automobile as compared to the average amount of time required to do a major tune-up on a large automobile are presented in Table II.

TABLE II

AVERAGE TIME REQUIRED FOR MAJOR TUNE-UP ON A SMALL AUTOMOBILE AS COMPARED TO A LARGE AUTOMOBILE

Average Time (hrs.) Required for Major Tune-Up	Number of Responses To Average Time Required for Major Tune-Up on Small Autos	Per Cent of Responses to Small Autos	Number of Responses To Average Time Required for Major Tune-Up on Large Autos	Per Cent of Responses to Large Autos
2	9	60.9	6	40.2
3	5	33.3	5	33.3
4	1	6.6	2	13.3
5	.	.	1	6.6
No Answer	.	.	1	6.6
Total	15	100.0	15	100.0

Five, or 33.3 per cent, reported it required three hours average time to perform a major tune-up on both small and large automobiles. In other words, the size of the

automobile did not affect the amount of time required to do a major tune-up. One, or 6.6 per cent, reported it takes four hours average time to accomplish a major tune-up on small automobiles and about five hours for a large automobile. Of the fifteen respondents, there was one, or 6.6 per cent, who did not respond to the category concerning the average time required to perform a major tune-up on large automobiles.

Types of Electronic Equipment

A variety of electronic equipment is available and is used to perform certain steps in a motor tune-up procedure. The third part of section one lists the various electronic equipment used to perform automotive tune-ups. The respondents were asked to indicate the type and number of pieces of equipment used in automotive tune-ups. Table III presents these data. Fifteen, or 100.0 per cent, of the respondents made use of the dwell meter, tachometer, scope, timing light and compression tester. The pressure gauge, the alternator regulator battery starter tester and the vacuum gauge, amper, volt, and ohm meters were used by fourteen, or 93.3 per cent, of the fifteen service garages; thirteen, or 86.6 per cent of them used the fuel pump pressure gauge, the cylinder leakage gauge, the electronic engine analyzer and the exhaust analyzer. The diode tester was used by twelve, or 80.0 per cent, of the garages.

Ten, or 66.6 per cent, of the respondents made use of the diagnostic computer and the infra-red exhaust analyzer in a tune-up. Eight, or 53.3 per cent, of the respondents used the distributive tester. None of the respondents used the dynomo meters. Table III shows the number of responses to the question concerning the types of electronic equipment used in Fort Worth automotive garages.

TABLE III

TYPES AND USE OF ELECTRONIC EQUIPMENT

Types of Electronic Equipment	Number of Responses	Per Cent Responses
Dwell meter	15	100.0
Tachometer	15	100.0
Vacuum Meter	14	93.3
Scope	15	100.0
Amper Meter	14	93.3
Volt Meter	14	93.3
Timing Light	15	100.0
Fuel Pump Pressure Gauge	13	86.6
Cylinder Leakage Gauge	13	86.6
Pressure Gauge	14	93.3
Electronic Engine Analyzer	13	86.6
Diagnostic Computer	10	66.6
Diagnostic Tester	8	53.3
Alt. Regulator Battery Starter Tester	14	93.3
Infra Red Exhaust Analyzer	10	66.6
Dynomo Meter	..	....
Exhaust Analyzer	13	86.6
Diode Tester	12	80.0
Ohm Meter	14	93.3
Compression Tester	15	100.0

The Engine and the Electronic Analysis Equipment

The electronic analysis equipment, when operated properly, can perform a major tune-up. Different pieces of the equipment do certain limited work on certain parts of the engine.

The following data are concerned with the various parts of the engine on which the participating Fort Worth automotive garages use electronic analysis equipment. Of the fifteen respondents, fourteen, or 93.3 per cent, used the equipment to check the compression of the cylinders. Fifteen, or 100.0 per cent, of the respondents used electronic analysis equipment to check the electrical system which consists of the battery, starter, alternator and the regulator. It is also used to check parts of the ignition system such as the points, plug wire, condenser and coil wires. Thirteen, or 86.6 per cent, of the automotive garages made use of the equipment in examining the distributor cap, primary wire and timing accuracy of the ignition system. Also within the ignition system are the coil, timing adjustments, and timing advance which were inspected with the electronic analysis equipment by fourteen, or 93.3 per cent, of the respondents. Finally, the rotor of the ignition system was checked by twelve, or 80.0 per cent, of the respondents. The use of the electronic analysis equipment for checking the different areas of the

carburetor system varied from moderate to quite extensive.

In testing the fuel pump, a portion of the carburetor system, the volume was checked by the electronic analysis equipment by only 40.0 per cent of the respondents. The pressure was checked by 53.3 per cent of the respondents. The fuel pump vacuum was tested by 66.6 per cent of those responding. Another carburetor factor is the idle mixture which involves several checks that can be performed by the electronic analysis equipment. Fourteen, or 93.3 per cent, of the respondents indicated they used electronic analysis equipment in testing idle speed and idle mixture factor. Eleven out of fifteen, or 73.3 per cent, of the automotive garages reported the use of electronic analysis equipment in checking accuracy speed mixture, another idle mixture factor. The normal and high speed mixtures were electronically tested by ten of the fifteen, or 66.6 per cent, of the respondents.

As for the E.G.R. (exhaust gas recirculation) and the P.C.V. (positive crankcase ventilation), seven, or 46.6 per cent, and six, or 40.0 per cent, respectively, of the respondents, made use of the electronic analysis equipment for the tests. Four, or 26.6 per cent, of the Fort Worth automotive garages responding, indicated the use of the equipment for testing hot air bypass, a final idle mixture check.

Types of Automobiles Checked by Electronic Analysis Equipment

Eleven out of fifteen, or 73.3 per cent, of the respondents indicated the use of electronic analysis equipment on American-made automobiles. Whereas there were only nine, or 60.0 per cent, of the respondents who indicated the use of electronic analysis equipment on foreign automobiles.

Average Training Time for Electronic Analysis Equipment

There was a variety of responses to the question concerning the average amount of time required to train an employee to operate the electronic analysis equipment. From the fifteen responding to the question, the following data were obtained. One, or 6.6 per cent, of the respondents reported it required two days to train the employee. Another one, or 6.6 per cent, of the respondents indicated it required four days to train the employee to use electronic analysis equipment. Another respondent, or 6.6 per cent, indicated it required three weeks to train an employee. Two, or 13.3 per cent, of the respondents indicated it required one week. Two, or 13.3 per cent, said it takes two weeks to train an employee. The largest group of respondents, 53.3 per cent, indicated it required two months to train the employee to operate the electronic analysis equipment.

Extent of Use of Electronic Analysis Equipment

The fifth part of section II was concerned with the extent of use of the electronic analysis equipment. Presented in Table IV are the data showing the number of times per day the equipment was used by the various respondents.

TABLE IV

EXTENT OF USE OF ELECTRONIC ANALYSIS EQUIPMENT

Number of Jobs Per Day	Number of Responses	Per Cent
4	2	13.3
6	3	20.1
10	1	6.6
14	1	6.6
16	1	6.6
18	1	6.6
20	6	40.2
Total	15	100.0

Of the fifteen automotive garages, six, or 40.2 per cent, reported using the electronic analysis equipment at least twenty times a day. Three, or 20.0 per cent, indicated the analysis equipment was used approximately six times per day. Two, or 13.3 per cent, of the respondents reported the equipment was used four times per day. One, or 6.6 per cent of the respondents indicated electronic analysis equipment was used ten times per day. One, or 6.6 per cent,

of the respondents indicated electronic analysis equipment was used fourteen times per day. It was used sixteen times per day by another respondent, or 6.6 per cent. Finally, the equipment was reported to be used eighteen times per day by another respondent, or 6.6 per cent.

Comparison of Opinions Regarding the Expense of Electronic Equipment

Responses to the sixth part of section II and section III of the information form are personal opinions; therefore, the answers are not based entirely on facts, but on the judgment of each auto service person completing and returning the instrument. Of the fifteen instruments sent to the automotive garages, ten of the respondents, or 66.6 per cent, believed it was not expensive to purchase and install electronic analysis equipment, while eleven, or 73.3 per cent, of them believed it was not expensive to purchase and install electronic computer equipment. In a brief statement, the respondents believed that the electronic analysis equipment was not as expensive to purchase and install as the electronic computer equipment.

The Purchase of Electronic Analysis Equipment and Electronic Computer Equipment

In the seventh part of section II, the respondents were asked if they planned to purchase new electronic

analysis equipment in the near future. Of the fifteen respondents, 53.4 per cent reported they did not plan to purchase any new electronic analysis equipment. In the fifth part of section III, the same question was asked, but, instead of pertaining to electronic analysis equipment, it is directed to electronic computer equipment. Of the fifteen respondents, the same percentage, 53.4 per cent, reported they did not plan to purchase new electronic computer equipment. However, a third of the participants planned to purchase both types of electronic equipment in the near future. Two, or 13.3 per cent, of the respondents planned to purchase new electronic analysis equipment. Of the fifteen respondents, two, or 13.3 per cent, also planned to purchase new electronic computer equipment in the near future.

Electronic Analysis Equipment Space

Eight, or 53.4 per cent, of the respondents indicated it required approximately four feet by eight feet of space for their electronic analysis equipment. Table V presents data concerning approximate space requirements for electronic analysis equipment.

TABLE V

APPROXIMATE SPACE REQUIRED FOR ELECTRONIC ANALYSIS EQUIPMENT

Approximate Space Required for Electronic Analysis Equipment	Number of Responses	Per Cent
2' x 4'	.	....
2' x 5'	.	....
2' x 6'	.	....
28" x 8'	1	6.6
4' x 4'	.	....
4' x 5'	3	20.1
4' x 6'	2	13.3
4' x 8'	8	53.4
No Answer	1	6.6
Total	15	100.0

Three, or 20.1 per cent, of the respondents reported it required approximately four feet by five feet of space to accomodate the electronic analysis equipment. Two, or 13.3 per cent, of the respondents indicated it required four feet by six feet of space for the electronic analysis equipment. It takes about twenty-eight inches by eight feet of space according to one, or 6.6 per cent, of the respondents. Of the fifteen respondents, one, or 6.6 per cent, did not answer.

Types of Electronic Computer Equipment

Many brands of electronic computer equipment are available to automotive garages. The first part of section III lists some of the types of electronic computer equipment. Only ten responses were made to this part due to only ten out of fifteen Fort Worth Garages having any kind of electronic computer equipment. The data received are as follows: five out of ten, or 50.0 per cent, of the responses made use of the Sun electronic computer equipment; Marquette, Auto Sense, and Allen were used by only ten per cent of the respondent for each of these makes. The remaining two, or 20 per cent, of the respondents used other types of electronic computer equipment.

TABLE VI

TYPES OF ELECTRONIC COMPUTER EQUIPMENT USED IN AUTOMOTIVE GARAGES

Types of Electronic Computer Equipment	Number of Responses	Per Cent of Responses
Sun	5	50.0
Marquette (Bear)	1	10.0
Auto Sense	1	10.0
Allen	1	10.0
Other	2	20.0
Total	10	100.0

Diagnostic Computer Space

The second part of section III was completed by only five of the ten, or 50.0 per cent, of the ten automotive garages having any kind of electronic equipment. The data concerning the appropriate space required for electronic computer equipment are presented in Table VII.

TABLE VII

APPROXIMATE SPACE REQUIRED FOR ELECTRONIC COMPUTER EQUIPMENT

Approximate Space Required for Electronic Computer Equipment	Number of Responses	Per Cent of Responses
2' x 4'	1	10.0
2' x 8'	3	30.0
4' x 5'	1	10.0
No Answer	5	50.0
Total	10	100.0

Three, or 30.0 per cent, of the respondents indicated that a space approximately two feet by eight feet is required for the electronic computer equipment. One, or 10.0 per cent, of the respondents indicated that a space of two feet by four feet is required, and another 10.0 per cent of the respondents stated that a space of four feet by five feet is required to accommodate electronic computer equipment.

Kinds of Automobiles Checked by Electronic Computer Equipment

Ten of the fifteen automotive garages had some kind of electronic computer equipment. Six responded to the question concerning the kind of automobile on which the specified equipment was used. Three, or 30.0 per cent, of the respondents indicated the use of electronic computer equipment on American automobiles. Two, or 20.0 per cent, of the respondents reported the use of the equipment on foreign automobiles. Only ten per cent of the respondents indicated the use of the diagnostic or electronic computer on both American and foreign automobiles.

Extent of Use of Electronic Computer

Two out of ten, or 20.0 per cent, of the respondents indicated that the electronic computer equipment was used approximately seventeen to twenty hours per week. One, or 10.0 per cent, of the respondents indicated the use of the specified equipment to be about one to four hours per week. In the category of five to eight hours per week, another 10.0 per cent of them made use of the electronic computer equipment. Ten per cent of the responses indicated the use of the diagnostic computer for approximately thirteen to sixteen hours per week. The remaining five respondents, or 50.0 per cent, did not respond to this particular question.

Average Instructional Time for Electronic Computer Equipment

To clearly understand the diagnostic computer and efficiently operate it, an employee must be sufficiently instructed. As a result of proper instruction, the operator can perform a satisfactory tune-up with the aid of the electronic computer. Data regarding the average amount of time required to instruct an employee to use the diagnostic computer are presented as follows: Three out of ten, or 30.0 per cent, of the respondents reported it required two months. One day of instruction was required according to ten per cent of the respondents. Another respondent indicated it required one week rather than a day to instruct an employee to use the electronic computer. A final ten per cent of the operators indicated it required one month of instruction to prepare an employee for the use of the specified equipment. The remaining four, or 40.0 per cent, of the respondents did not respond to this particular question.

Opinions Concerning Both Types of Equipment

Responses to the next five parts of section IV of the information form are personal opinions and are concerned with the use of both types of equipment. The first part of section IV asked the respondents their opinion regarding the most difficult type of equipment to operate. Five, or 33.3 per cent, of the respondents reported the diagnostic

computer was the most difficult to operate, whereas only two, or 13.3 per cent, of them indicated the electronic analysis equipment was more difficult to operate. Five, or 33.3 per cent, of them indicated the dynometer as being the most difficult to operate. Of the fifteen respondents, three, or 20.0 per cent, did not answer this particular question.

The next question of section IV asked the participants what their opinions were concerning the most effective piece of equipment that could be used in testing the automobile engine. Of the fifteen respondents, eight, or 53.3 per cent, reported the electronic analysis equipment was most effective. Four, or 26.6 per cent, of them replied that the dynometer produced the best results. Only two, or 13.3 per cent, of them reported the diagnostic computer as being a more effective piece of electronic equipment. One, or 6.6 per cent, did not respond to this particular question.

Of the fifteen respondents, twelve, or 86.6 per cent, indicated they believed electronic computer and electronic analysis equipment was important in motor tune-ups. The remaining 13.3 per cent of them believed the electronic equipment was not important in performing engine tune-ups.

The fourth part of section IV pertained to the ease of movement of the equipment. Of the responses, thirteen,

or 86.6 per cent, reported there was no difficulty in moving the equipment about in the garage. One, or 6.6 per cent, of the respondents indicated it was difficult to move the equipment around. One, or 6.6 per cent, of the respondents did not answer this particular question.

The final part of section IV of the information form was designed to find if the use of electronic equipment affected the volume of business. Twelve, or 80.0 per cent, of the respondents indicated the use of electronic equipment did help their business. The remaining twenty per cent of the respondents stated that the use of the specified equipment did not affect their business.

The data provided by respondents and presented in Chapter III provides answers to questions set forth in the problem stated in Chapter I. The data provides the basis for the findings from which conclusions are drawn and recommendations made.

CHAPTER IV

SUMMARY, FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Summary

The purpose of this study was to evaluate the electronic equipment used in automotive tune-up and to find the extent of its use in automotive garages in Fort Worth, Texas. Of particular interest were the electronic analyzer and the electronic or diagnostic computer which are being used in fifteen Fort Worth garages.

In the study, the history of the automobile is summarized to illustrate the magnitude, importance, and advancement of the automobile industry and to justify the use of precision tune-up equipment. Significance and purpose of the two specified pieces of electronic equipment was discussed. A minor and major tune-up, involving the use of both pieces of electronic equipment, were thoroughly discussed revealing the versatility of the equipment. The data were treated on a number and percentage basis to indicate the use of the electronic analyzer and the diagnostic computer in Fort Worth automotive garages, thus showing the importance of the specified equipment.

Findings

The detailed findings of this study are presented in Chapter III. Those findings considered to be of greater importance to the study are as follows.

1. Of the fifteen respondents, 73.4 per cent employ from one to three tune-up operators.

2. According to the data, a majority of the respondents reported it takes an average time of two hours to perform a major tune-up on small and large automobiles.

3. Of the various electronic equipment available for use to perform automotive tune-ups, the dwell, the tachometer, the scope, the timing light and the compression tester were used by 100 per cent of the respondents. The distributor tester was used by the least number of respondents, 53.4 per cent.

4. More respondents were found to make use of the electronic analyzer rather than the electronic computer.

5. The electronic analysis equipment was used more widely on the electrical system and certain parts of the ignition system--points, plug, plug wire, condenser and coil wire. Only 26.7 per cent of the respondents indicated the use of electronic analysis equipment for testing hot air bypass, a test of the carburetor.

6. Electronic analysis equipment was used more widely in testing American-made automobiles. It was the same

for the electronic computer equipment. American-made automobiles were tested with the specified electronic equipment more often than foreign-made automobiles.

7. Electronic analysis equipment was used at least twenty times per day by 40.1 per cent of the respondents.

8. According to the data, a majority of the respondents indicated there will be few, if any, purchases of new electronic analysis or electronic computer equipment in the near future.

9. A majority of the respondents, 53.4 per cent, indicated it takes a space of approximately 4' x 8' to accomodate the electronic analysis equipment. As for the electronic computer equipment, 30.1 per cent of the respondents indicated it takes a space of approximately 2' x 8' for the equipment.

10. Of the many different brands of electronic computer equipment available to automotive garages, 50.0 per cent of the respondents reported the use of the Sun electronic computer equipment.

11. Over fifty per cent of the respondents reported it required approximately two months to instruct an employee to operate the electronic analysis equipment. A comparatively high percentage of the respondents indicated it takes the same amount of time to instruct an employee to operate the electronic computer equipment.

Conclusions

Based upon the findings of the study concerning electronic equipment, with special emphasis on the electronic analyzer and the diagnostic computer, the following conclusions are presented.

1. It appears that electronic analysis equipment is used to test very few automotive engine systems despite its versatility.

2. Gathered from the findings, few garages have an electronic computer due to the fact that it is more expensive than the electronic analyzer.

Recommendations

The recommendations based on the findings are presented as follows.

1. More time be utilized in performing a major tune-up.

2. Greater use of the different available electronic equipment be made by garages.

3. Electronic equipment be used more often to test the automotive engine systems.

4. More use of the electronic analyzer and diagnostic computer needs to be made on foreign-made automobiles.

5. Consideration be given by automotive garages to the purchase and installation of new electronic analysis and/or electronic computer equipment.

6. When purchasing electronic computer equipment, a careful check of the many brand be made.

7. Employers make sure that employees are fully instructed in the operation of electronic equipment by developing a testing program that would rate their knowledge of and skill in use of the equipment.

8. A similar study be conducted in the future involving other aspects of the automotive tune-up equipment.

APPENDIX A

LETTER ACCOMPANYING CARD

8000 Cross Drive
Smithfield, TX 76180
February 10, 1977

Dear Service Manager:

I am presently engaged in a Master's degree program in the area of Industrial Arts at North Texas State University. My research study is concerned with the type and extent of use of electronic analysis and computer equipment presently used for modern automotive tune-ups. The purpose of the study is to determine what types of automotive tune-up equipment the automotive dealers use and how often it is utilized in the city of Fort Worth.

I am soliciting your assistance in helping me conduct this study. Please indicate your willingness to participate in the study by completing and returning the enclosed card at your earliest convenience.

Be assured that you and your business will remain anonymous. Only the data provided will appear in the body of the study.

I thank you in advance for your interest and cooperation in providing me with the requested information.

Sincerely,

Karl Shabbot
Graduate Student

Sponsored by:

Dr. Jerry C. McCain
Professor of Industrial Arts

Enclosure: Card

APPENDIX B

CARD

Name _____

Address _____

City _____ State _____ Zip _____

Business _____

Is electronic analysis and/or computer equipment used in your service area? ( ) yes ( ) no

Would you be willing to participate in the study by completing a check list? ( ) yes ( ) no

Thank you kindly for your interest.

APPENDIX C

LETTER ACCOMPANYING INSTRUMENT

8000 Cross Drive
Smithfield, TX 76180
February 18, 1977

Dear Service Manager:

I am presently engaged in a Master's degree program in the area of Industrial Arts at North Texas State University. My research study is concerned with the type of electronic analysis and computer equipment used for modern automotive tune-ups. The purpose of the study is to determine what types of automotive tune-up equipment the automotive dealers use and how often it is being utilized in the city of Fort Worth.

Enclosed is the instrument you so kindly indicated you would fill out to help in this study. Please complete and return the completed instrument at your earliest convenience.

Be assured that you and your business will remain anonymous. Only the data provided will appear in the body of the study.

I thank you again for your interest and cooperation in providing me with the requested information.

Sincerely,

Karl Shabbot
Graduate Student

Sponsored by:

Dr. Jerry C. McCain
Professor of Industrial Arts

Enclosure: Instrument

APPENDIX D

INSTRUMENT

A Study of Modern Automotive Tune-up Equipment and Procedures in the Fort Worth Area

DIRECTIONS:

This instrument is designed to gather information concerning the types, number and use of modern automotive tune-up equipment. Of particular concern to the study are the electronic analysis equipment and electronic computer equipment used in automotive garages in the Fort Worth area. For your convenience spaces are provided for easy checking. Please ( ) all spaces which pertain to your company.

I. General Information

A. How many tune-up operators do you employ in your business?

___ 1-3 ___ 4-6 ___ 7-9 ___ 10-12 ___ over

B. What is the average time required to do a major tune-up on an automobile?

Small autos: Hrs. __ 1 __ 2 __ 3 __ 4 __ 5

Large autos: Hrs. __ 1 __ 2 __ 3 __ 4 __ 5

C. What type and how many pieces of the following electronic equipment do you use in your garage for motor tune-up? Please indicate in provided spaces:

1. ___ Dwell
2. ___ Tach
3. ___ Vacuum meter
4. ___ Scope
5. ___ Amper meter
6. ___ Volt meter
7. ___ Timing light
8. ___ Fuel pump pressure gauge
9. ___ Cylinder leakage

10. ___ Pressure Gauge
11. ___ Electronic engine analyzer
12. ___ Diagnostic computer
13. ___ Distributer tester
14. ___ Alt. regulator battery starter tester
15. ___ Infra-red exhaust analyzer
16. ___ Dynomo meters
17. ___ Exhaust analyzer
18. ___ Diode tester
19. ___ Ohm meters
20. ___ Compression tester

D. Please indicate in each space what part of the engine is checked by electronic analysis equipment?

1. Compression

___ Compression of cylinder

2. Electric

a. ___ Battery
b. ___ Starter
c. ___ Alternator
d. ___ Regulator

3. Ignition

a. ___ Points
b. ___ Plug
c. ___ Plug wire
d. ___ Rotor
e. ___ Distributor cap
f. ___ Coil
g. ___ Condenser
h. ___ Coil wire
i. ___ Primary wire
j. ___ Timing
k. ___ Timing accuracy
l. ___ Timing advance

4. Carburetor

a. Fuel Pump

___ Volume
___ Pressure
___ Vaccum

b. Idle Mixture

___ Idle speed
___ Accuracy speed mixture
___ High speed mixture
___ E.G.R.
___ P.C.V.
___ Hot air bypass

II. Electronic Analysis Equipment:

A. Do you use electronic analysis for motor tune-up in your garage? If so, please indicate number and place a check in the space beside each type of electronic analysis equipment.

1. ___ Electronic engine analyzer
2. ___ Diagnostic computer
3. ___ Dynamo meters

B. What kind of automobiles are tested by electronic analysis equipment?

American _____ Foreign _____

C. How long does it take to train the average employee to use electronic analysis equipment?

1. ___ one day
2. ___ two days
3. ___ four days
4. ___ one week
5. ___ two weeks
6. ___ three weeks
7. ___ one month
8. ___ two months

D. What kind of cars are tested with dynometer?

American _____ Foreign _____

E. How many times a day do you use electronic analysis equipment?

1. ___ four times
2. ___ six times
3. ___ eight times
4. ___ ten times
5. ___ fourteen times
6. ___ sixteen times
7. ___ eighteen times
8. ___ twenty times

F. Do you believe the electronic analysis equipment is too expensive to purchase and install?

_____ yes _____ no

G. Do you plan to purchase new electronic analysis equipment in the near future?

_____ yes _____ no

H. Approximately how much space is required for the electronic analysis equipment?

1. ___ 2' x 4'
2. ___ 2' x 5'
3. ___ 2' x 6'
4. ___ 2' x 8'
5. ___ 4' x 4'
6. ___ 4' x 5'
7. ___ 4' x 6'
8. ___ 4' x 8'

III. Electronic Computer Equipment

A. Do you use electronic computers for motor tune-ups in your garage? If so, please indicate which equipment is used.

1. ___ Sun
2. ___ Atlas
3. ___ Snapon
4. ___ Marquette (Bear)
5. ___ Auto Sense
6. ___ Allen
7. ___ Other

B. Approximately how much space is required for the diagnostic computer?

1. ___ 2' x 4'
2. ___ 1' x 5'
3. ___ 2' x 6'
4. ___ 2' x 8'
5. ___ 4' x 4'
6. ___ 4' x 5'

C. What kind of automobiles are tested by electronic computer equipment?

American _____ Foreign _____

D. To what extent is electronic computer equipment used on an hourly basis per week?

1. ___ 1-4
2. ___ 5-8
3. ___ 9-12
4. ___ 13-16
5. ___ 17-20

E. Do you plan to purchase new electronic computer equipment for use in your garage in the near future?

_____ yes _____ no

F. Do you believe the electronic computer equipment is too expensive to purchase and install?

_____ yes _____ no

G. How long does it take to train an average employee to use the electronic computer?

1. ___ one day
2. ___ two days
3. ___ four days
4. ___ one week
5. ___ two weeks
6. ___ three weeks
7. ___ one month
8. ___ two months

IV. Opinions Concerning the Use of Both Types of Equipment:

A. Which is more difficult to operate?

1. ___ electronic analysis
2. ___ diagnostic computer
3. ___ dynometer
4. ___ small test meter

B. In your opinion, which is more effective in testing the engine?

1. ___ electronic analysis
2. ___ diagnostic computer
3. ___ dynometer
4. ___ small test meter

C. Do you believe electronic computer and electronic analysis equipment is important in motor tune-ups?

_____ yes _____ no

D. Is the equipment easy to move about in your garage?

_____ yes _____ no

E. Does the use of electronic analysis and electronic computers increase your business opportunities?

_____ yes _____ no

If you wish a copy of the results of the study, please provide the following information:

Name _____

Address _____

_____

Zip _____

CABLE: SUNTESTER
Telex No. 72-2488

Sun ELECTRIC CORPORATION

APPENDIX E

April 29, 1977

TO WHOM IT MAY CONCERN:

I, the Regional Sales Manager at Sun Electric Corporation, authorize Karl Shabbot to use any pictures of Sun Electric Automotive Testing Equipment for his thesis.

Sincerely,

J.L. Douglas
Regional Sales Manager

JLD/jeb

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