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A METHOD OF FUEL TESTING
IN A CFR ENGINE

BY

GEORGE R. BAUMGARTNER

A

THESIS

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Approved by

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The author would like to express his appreciation to Dr. A. J. Miles, Chairman of the Mechanical Engineering Department, and Professor G. L. Scofield, Mechanical Engineering Department, for their guidance and interest in this investigation.

Thanks are also due Mr. Douglas Kline for his constant assistance while conducting the tests.

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INTRODUCTION

At the present time, only a very small fraction of motor fuels produced for domestic use in the United States contain any alcohol in their blends. Some foreign markets, notably the Phillipine Islands and South American Countries use high proportions of alcohol in their motor fuel blends. (1) (2) Special purpose fuels in the United States which have alcohol blended with other compounds, have been used for engines from which maximum horsepower output is imperative. An example of this type of motor fuel blend might be found in the competitive motor sports involving motorcycles, stock automotive equipment, and special racing equipment.

An extensive survey of literature brought to light the lack of scientific information and basis for proper blending of alcohol blend fuel mixtures. The most apparent information in the literature was the lack of any scientific approach to the compounding of these fuels. The author considers that this lack of scientific background is due to the difficulty of providing a satisfactory testing procedure to follow in making such an evaluation.

This thesis reports the work involved in (a) preparing a suitable test engine for use in fuel research, (b) calibrating the associated equipment, (c) taking data, and (d) evaluating the resultant data in the light of the objective of the tests.

A standard ASTM-CFR single cylinder fuel research engine was used as the basic engine, with necessary modifications to achieve as near actual operating conditions as possible and still allow

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(1) (2) All references are in the bibliography.

maximum control over all the variables. These modifications and the reasons for them are described in detail in the discussion section under the preparation of the test engine.

A piezoelectric crystal pickup was used to determine the cylinder pressures of the engine by electrically amplifying its output and using this output to drive an oscilloscope. The amplifier contained a special pressure evaluating device, and it, along with the pickup were calibrated as described in the discussion under the calibration of associated equipment.

Once the engine was prepared and the associated equipment calibrated, the taking of data was begun in a relatively straight forward manner. However, since the data was taken over a period of time but was evaluated all at one time, it was necessary to maintain rigid control over the variables and the calibrations as the data was taken. The necessary steps and precautions are described in the discussion under the section of operation and data taking.

HISTORY

Experimentation with fuels and engines most certainly took place as soon as the first successful engines were developed. Not until 1919, however, when H. R. Ricardo first developed a semblance of the modern day fuel test engine, was any scientific approach taken in testing of motor fuels. (3) Ricardo's later test engines, refinements of his first, were the basis for the development of a standard fuel research engine in the United States. (4)

In 1928, a group of fuel producers and engine manufacturers who had formed the Cooperative Fuel Research Committee, assigned the problem of developing a test method and equipment for knock rating to a Detonation Sub-Committee in recognition of the interdependence of engine performance upon compression ratio and fuel anti-knock property as first taught by Ricardo. (5) The advent of modern cracking processes disclosed the wide range of anti-knock quality existing in fuels and emphasized the necessity for a standard fuel test method.

The first meeting of the Detonation Sub-Committee disclosed three items essential to the pursuit of a comprehensive motor fuel research: (1) a standardized engine and accessories; (2) a common reference fuel and/or rating scale; and (3) a uniform testing procedure. By 1931, all three had become realities and the first standardized test method and engine were put to use. (6)

In 1932, after a correlation of laboratory ratings and actual service ratings had been made, the test method was modified and improvements of the standard testing unit and its operating technique were made. (7)

At this time the tests were given names, that of "C F R Research Method" for the original test, and that of "C F R Motor Method" for the improved test. The proved reproducibility of results by the C F R methods compelled its acceptance and recognition as the industry's yardstick for gasoline motor fuel rating, so that in 1936, approval by the American Society for Testing Materials resulted in its receiving A S T M designation D - 357. (8)

This designation was for the second or improved method of fuel testing; later, A S T M designation D - 908 was given to the first or Research Method of testing. (9) The C F R committee continued the development of the knock testing technique with numerous refinements in equipment and procedure. In 1940, the committee completed the development of the"C F R Aviation Method", given A S T M designation D - 614, and finally in 1942, the committee developed a "C F R Supercharged Method", given A S T M designation D - 909. (10)(11)

At the present time, the following organizations have formally endorsed the A S T M ≡ C F R motor test unit and technique, and given their official acceptance: The United States Bureau of Standards, American Society for testing Materials, Society of Automotive Engineers, American Petroleum Institute, Automobile Manufacturers' Association, and the Chemical Standardization Committee of the Institution of Petroleum Technologists of London.

Thus the A S T M ≡ C F R octane rating unit is now the international yardstick for gasoline fuel rating. As a further aid to international understanding and agreement on fuels and their testing, a World Power Conference was organized.

The First World Power Conference was held in London, England in 1924. Since then, World Power Conferences have been held in Berlin, Germany, 1930, Washington, D. C., U. S. A., 1936, and London, England, 1950. The purpose of the conference is to consider how the sources of heat and power may be adjusted nationally and internationally by conferences on the possibility of establishing a permanent World Bureau for the collection of data, the preparation of inventories of the world's resources, and the exchange of industrial and scientific information through appointed representatives in the various countries.

After the culmination of each conference, a data book is published concerning all available international information on fuels. This data book is periodically revised to keep it current and is thus an international source book of information on fuels and a step towards universal test methods and standards for fuels. (12)

SURVEY OF LITERATURE

Gasoline is by no means the only useable fuel in a spark ignited internal combustion engine, but due to the predominance of petroleum as a natural resource, it is only natural that petroleum products would be the most used and the most tested. Many of the other useable motor fuels can be tested in exactly the same manner as gasoline, that is by determining the octane rating or detination rating with either the C F R Motor Method or the C F R Research Method test.

Alcohol can not be tested in this manner because it will not detonate. The ability of alcohol to resist detonation was noted as early as 1910 by Ricardo, and substantiated many times thereafter.(13) (14) (15) (16) (17) The fact that alcohol resists detonation but is susceptible to preignition is noted in all the reference books where alcohol is treated as a motor fuel, but in no case could material be found where some standard or test method had been tried or proposed to test alcohol or alcohol blend fuels.

Publications from alcohol blend fuel users indicate that after an engine is designed and built, trial and error tests are made with various alcohol blend fuels until a blend appears to be satisfactory in brake horsepower output and in engine life. It was also noted that alcohol is perfectly miscible with only a very few petroleum products, one of which, benzene, is readily available commercially in quantity.

Because of this apparent lack in a scientific approach to testing alcohol blend fuels, a new test method was developed and used to evaluate motor fuel blends of alcohol and benzene.

DISCUSSION

The alcohol and benzene used in running this test method were selected on the basis of what would most likely be found commercially available, rather than chemically pure. Industrially pure benzene, called Benzol by the trade, was used as the benzene base. Benzol consists generally of 90% pure benzene, by volume, with the remaining 10% made up of toluene and xylene. All of these constituents are classed chemically as aromatics. Industrially pure methyl alcohol, Methanol, was used as the alcohol base. The Methanol used was 190 proof, or 95% alcohol, by volume.

The methyl alcohol and the benzene were run as individual fuels, and in blends from 90% alcohol and 10% benzene, to 10% alcohol and 90% benzene, by volume. For a comparison, 86 octane "Regular" gasoline and 100 octane isooctane were run through the same test method as the alcohol blend fuels.

PREPARATION OF THE TEST ENGINE

A standard C F R unsupercharged variable compression ratio engine was used for the experiments. The bore and stroke are 3.25 inches and 4.50 inches respectively, and the compression ratio can be varied from 4 to 10 : 1 . The engine is in universal use and further details need not be given except for the modifications necessary.

The engine was prepared for the trials by being dismantled for the removal of all carbon and other deposits from the combustion chamber and piston ring grooves, so that no extraneous combustion would be introduced in the tests due to preignition of the charge by carbon deposit hot spots.

The combustion space was maintained, during the trials, as nearly free of loose carbon as was possible by daily cleaning with a brush and scraper, inserted into the combustion space through the spark plug and bouncing pin openings. Figure 1 shows the engine as dismantled.

The valves were cleaned and hand lapped into the seats. A shrouded inlet valve is fitted as standard to the C F R engine. This valve imparts a swirl to the entering mixture but the consequent restriction reduces the volumetric efficiency. It was replaced by a spare exhaust valve of the common tulip shaped variety to eliminate the objections of the shrouded valve and to provide conditions more nearly like actual service. (18)

The C F R engine is usually arranged to drive a synchronous generator connected to an a-c. supply of constant frequency. The engine speed is thus maintained constant regardless of power output. The C F R engine used for the trials was direct-connected to a swinging field d-c. electric dynamometer whose electrical output was absorbed by a resistor bank. The engine speed was maintained at 900 revolutions per minute for all of the trials by manual regulation of the field resistance. The electric dynamometer, provided with a dial type scale for weighing torque, was used for the measurement of engine brake horsepower output. Figure 2 shows the electric dynamometer and dial scale as just described.

The C F R engine is supplied with a mixture-heater assembly consisting of a 7 inch controlled heat chamber to preheat the fuel-air charge before it enters the engine intake system. This heater was removed and the carburetor flange modified so that it could be bolted directly to the engine intake.

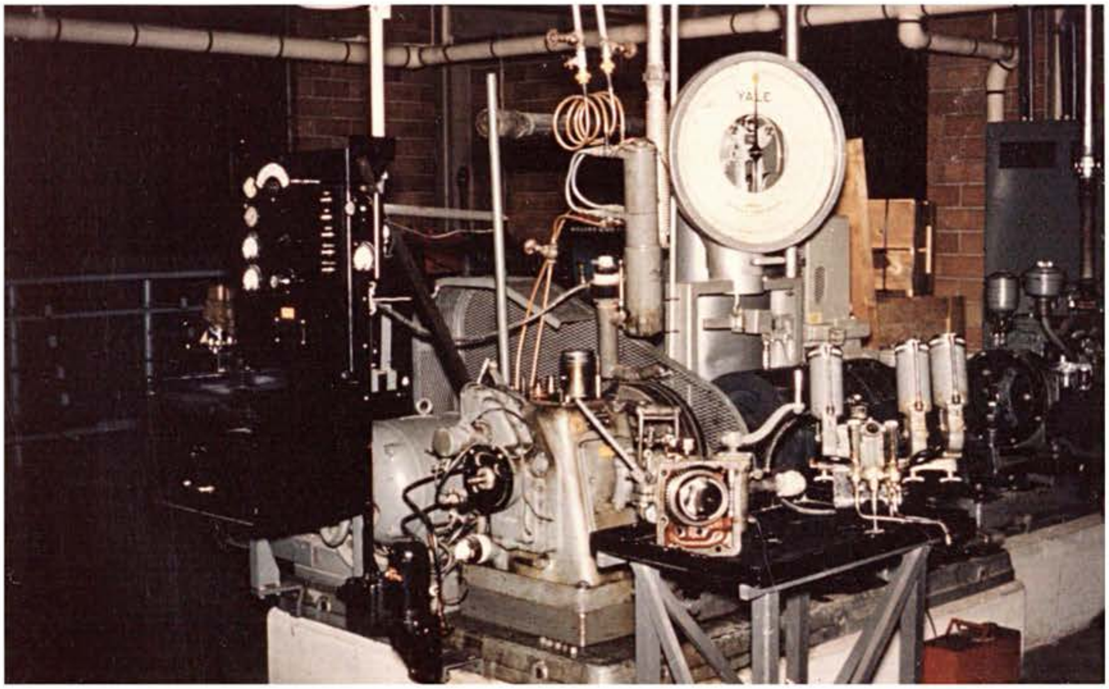


Figure 1 C F R engine dismantled for cleaning and modification.

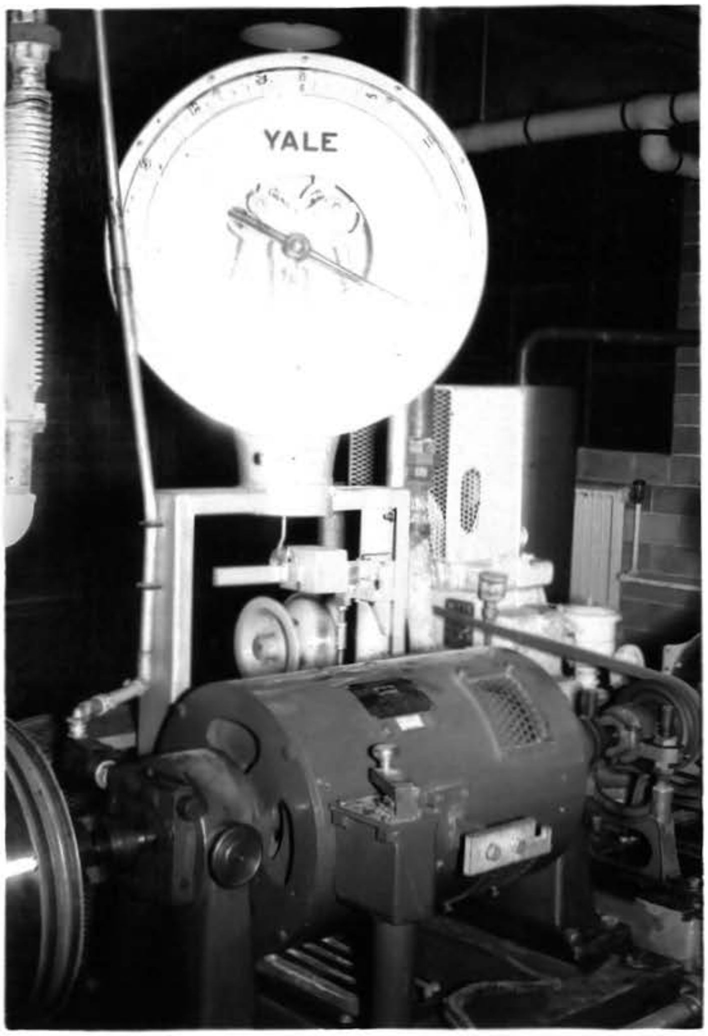


Figure 2 Electric dynamometer and dial scale being used to find engine brake horsepower.

A polished stainless steel heat shield was installed between the carburetor and the engine intake manifold. A standard copper-asbestos gasket was inserted between the shield and the carburetor, and a special copper-asbestos heat-insulating gasket 0.375 inches in thickness was used between the shield and the manifold.

These modifications were made in order to have the test engine fuel-air charge properties to the cylinder approach the fuel-air charge properties in a service engine. Because the test engine was run at a relatively low speed as compared to a service engine, 900 revolutions per minute versus an average of 3000 revolutions per minute, it was necessary to shorten the induction system so that some liquid fuel droplets could be induced into the test engine cylinder. Also, since no air was flowing over the test engine, the carburetor was insulated from the engine to prevent excessively high carburetor temperatures and thus an appreciable loss in volumetric efficiency as compared to a service engine. (19)

The standard C F R multiple-bowl, variable-float-level carburetor with fuel containers, was modified by the addition of a variable size metering jet to replace the standard single size jet. This jet was made to fit in the same location as the standard jet, and therefore functioned in the same manner except for the size being easily varied from outside the carburetor. The variable size was necessary because of the wide range of fuel-air ratios existing in the trial fuel blends. For a chemically correct ratio, this range extends from 6.45 : 1 for methyl alcohol, to 13.31 : 1 for benzene to 14.80 : 1 for gasoline; all ratios are in pounds of air to pounds of fuel. Since the weight of air passing through the carburetor remained very nearly the same for all fuels used, due to the constant engine speed and lack of a throttle, it was necessary for the jet size to be varied better than 125 percent. Figure 3 shows this variable jet as just described.

Since alcohol and alcohol blend fuels resist detonation and therefore detonation rating, the detonation rating equipment, a bouncing pin, in conjunction with a knockmeter, was removed from the test engine. In place of this equipment, a pressure pickup device was attached to the engine through a hole to the combustion chamber. A new test criterion was introduced. The highest useable compression ratio for each trial fuel at maximum horsepower output was to be limited by a peak pressure obtained in the engine combustion space, rather than by detonation level as measured by a knockmeter.

It was felt that this criterion was justified, because if there is no harmful or destructive detonation present, then the only limitation imposed on the compression ratio is the ability of the engine, structurally, to contain the pressures of combustion. The only exception to this limitation is a compression ratio which will cause preignition of the fuel and consequent loss of power.

The pressure pickup device used consisted of a Cox Type 3 Quartz Pressure Element, used in conjunction with a Cox Amplifier and a Du Mont type 241 cathode-ray oscillograph. The quartz pressure element is designed to convert mechanical pressures into electrical impulses which may be amplified and pictured on the screen of a cathode-ray tube. (20) When a quartz crystal, properly cut with respect to its electrical axis, is subjected to pressure, an electrical charge will appear on two of its surfaces. The effect is known as piezo-electric; and the unit makes use of this property of quartz for the mechanical to electrical conversion. This electrical charge, besides being in exact proportion to the pressure exerted through the piston, varies instantly with changes of the pressure, thus forming a most efficient indicator for these variations.

Since the electrical charge generated by the crystals will gradually leak off when the pressure ceases to change, the charges are indicative only of changes in pressure and not static pressures. The pickup along with its connecting cable are shown in figure 4.

The Cox amplifier contains a special first-stage input circuit providing for the amplification of the relatively low voltage outputs of the Cox quartz pressure element. A calibrating voltage and meter having a range of .1 to 1000 millivolts is also provided by the amplifier. The amplifier output was directly connected to a standard cathode-ray oscillograph. The amplifier and oscillograph used are pictured in figure 4.

The rest of the test engine conformed to the standard C F R test engine as follows: coolant held constant at 210°F by an evaporative cooling system; oil temperature held between 120°F and 130°F by an oil cooler and an oil heater; S.A.E. No. 30 lubricating oil used; humidity of intake air held between 25 and 50 grains of water vapor per pound of dry air by an ice tower; temperature of intake air held at 100°F by an air preheater; and the spark plug gap, the breaker point gap, and the valve clearance adjusted to standard settings.

It is necessary to mention that one of the chief reasons the standard C F R test engine is so widely used for other than C F R Method tests is the fact that the compression ratio can be continuously varied while the engine is in operation.

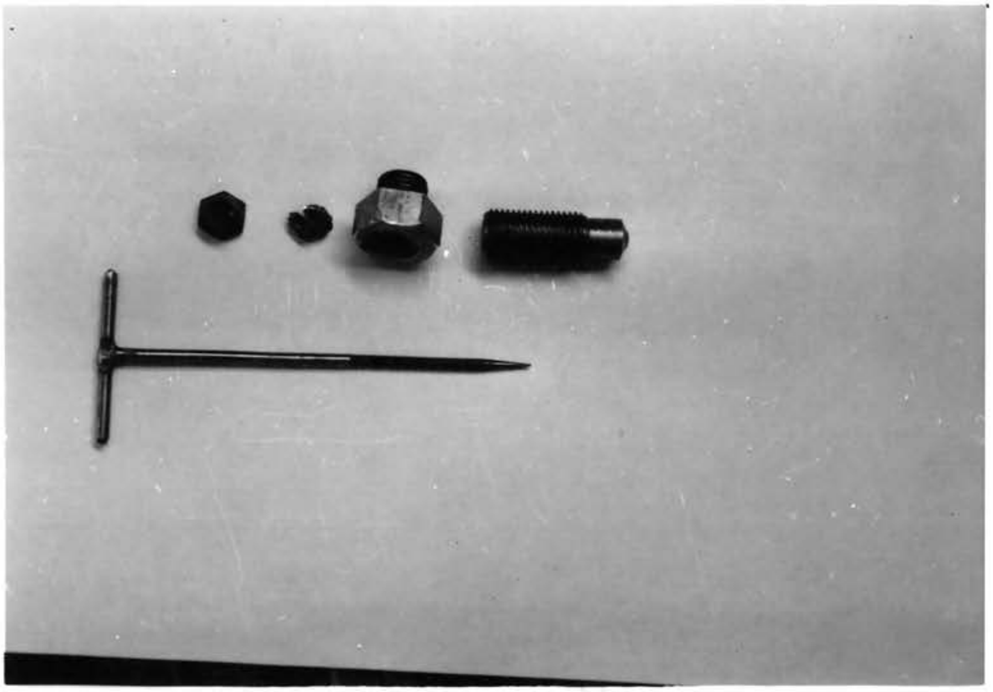


Figure 3 Adjustable metering jet.

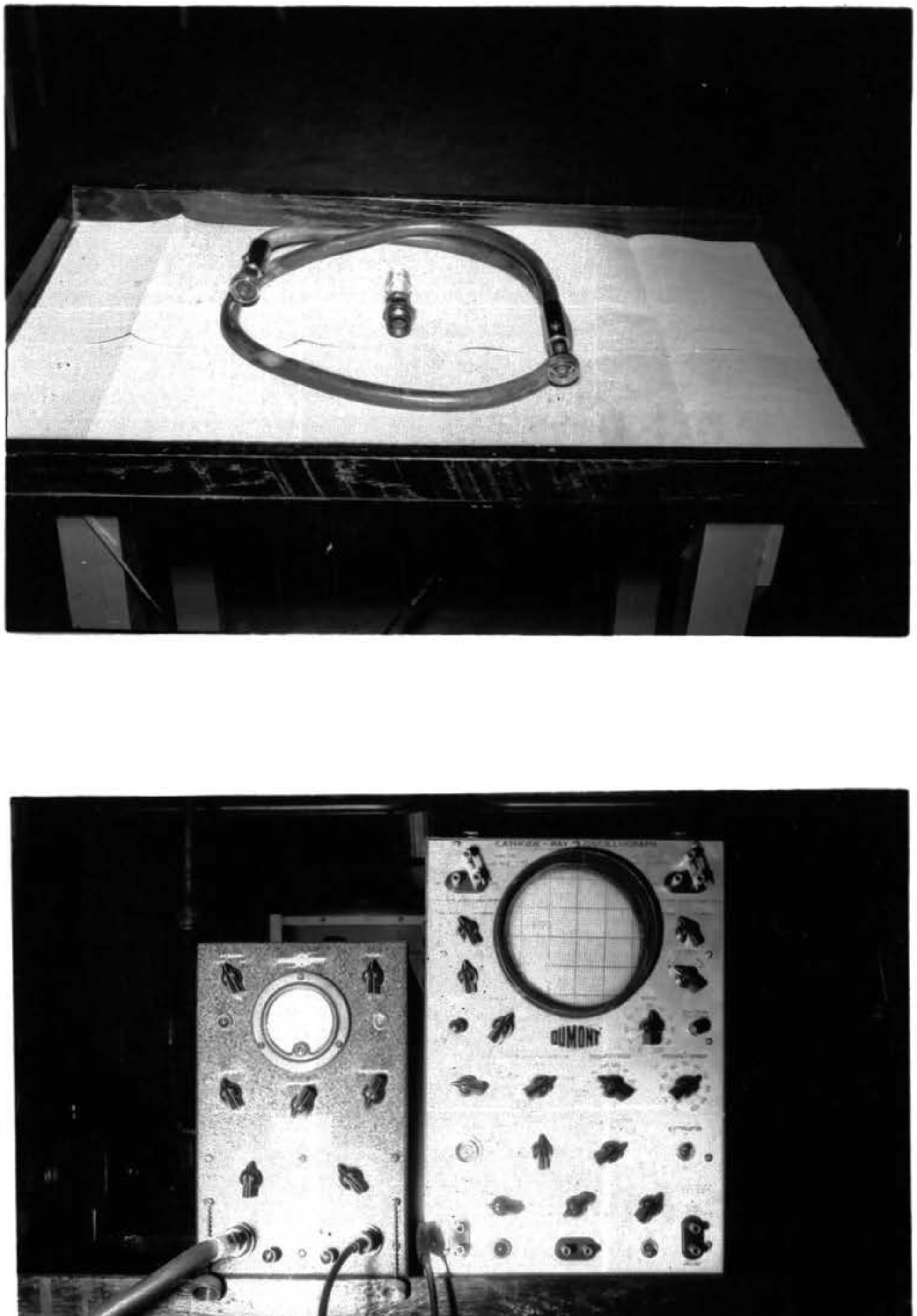


Figure 4 Crystal pickup with connecting cable.(upper)
Amplifier and Oscillograph.(lower)

This variation is accomplished by having the cylinder and cylinder head cast in one piece, so that when the cylinder is moved up and down in the engine by means of a worm gear, the clearance volume and thus the compression ratio is varied. This unique compression ratio changing device, along with the carburetor, is pictured in figure 5.

A standard fuel weighing device was attached to the engine so that brake specific fuel consumption could be found for each trial fuel blend. This device was wired directly to the panel control board so that the burning of a fixed quantity of fuel could control the elapsed time meter and the total revolution counter. This board also contained the controls for the electric dynamometer and is pictured in figure 6.

The complete test apparatus and test engine with modifications as used in the trials is pictured in figure 7, along with a picture of the engine in operation.

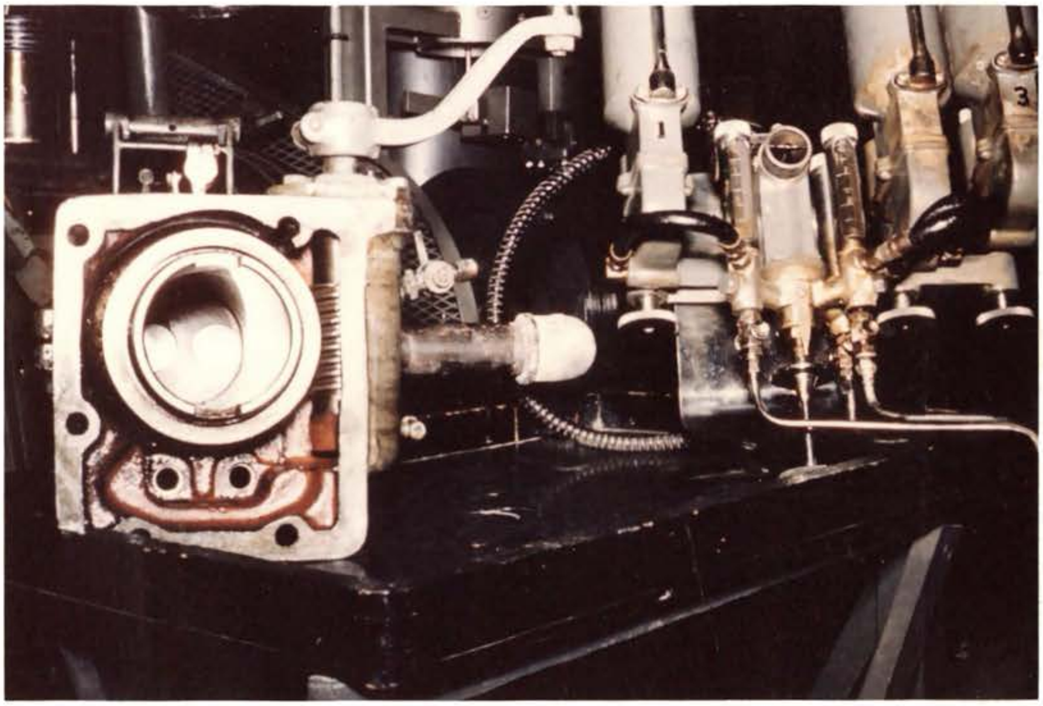
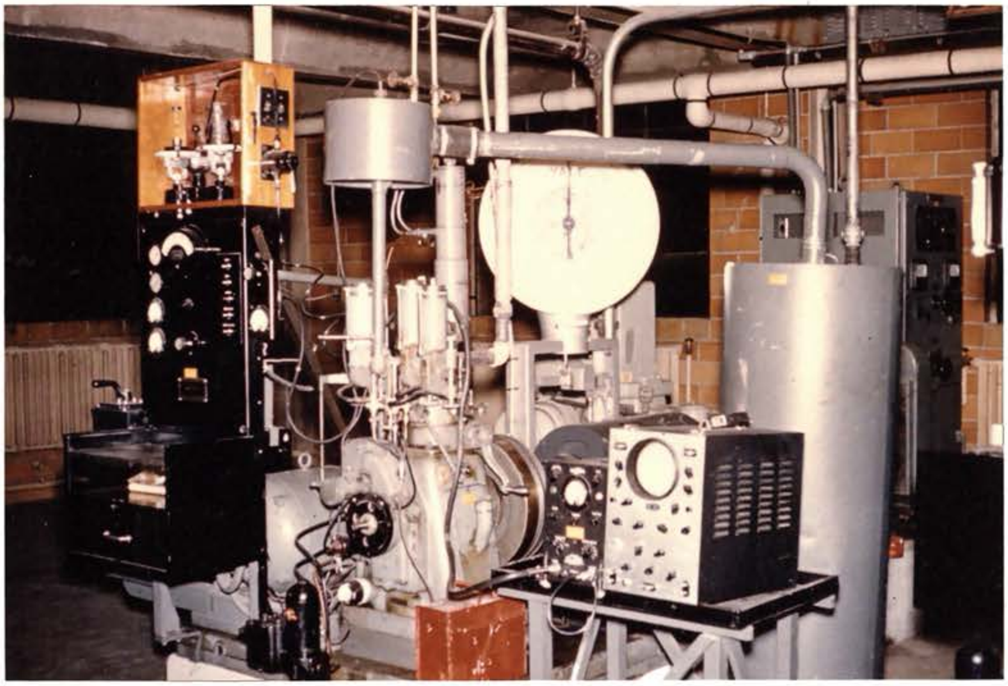


Figure 5 Bottom view of variable compression ratio cylinder with changing device, and carburetor with float bowls and fuel containers.

Figure 6 Control panel board.



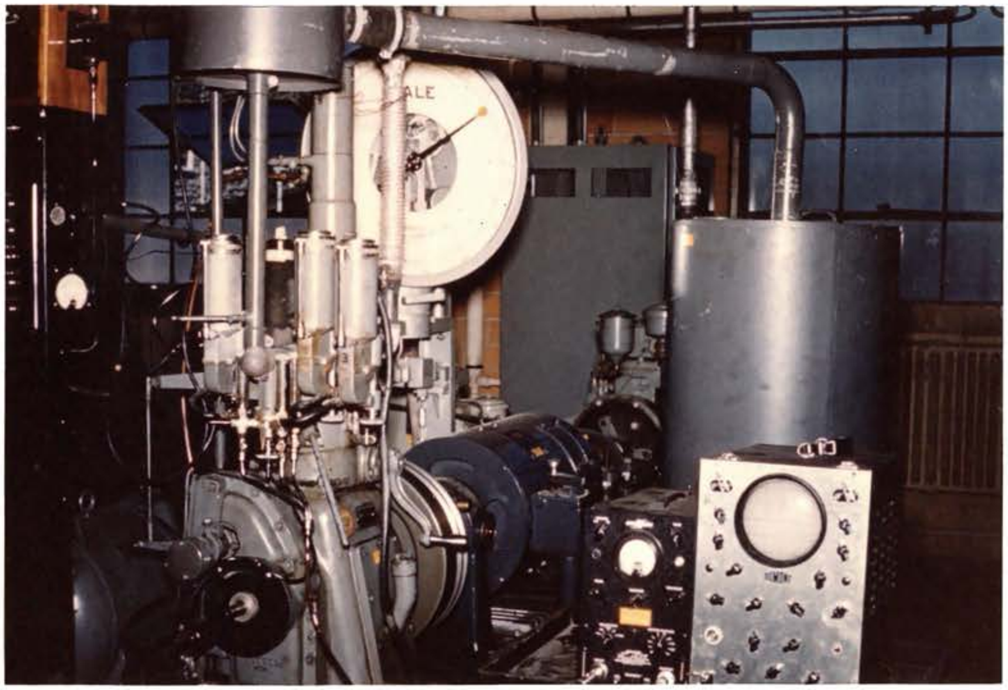


Figure 7 Complete test apparatus and test engine as used in the trials.(upper)
Test engine in operation.(lower)

CALIBRATION OF ASSOCIATED EQUIPMENT

As the peak cylinder pressure of the engine was to be the criterion of the entire test, it was necessary to very carefully calibrate the device used to measure this peak pressure. The quartz pressure element was rated at 2.75 millivolts output for each 100 pounds of pressure. This output was amplified and fed to an oscillograph where it produced a pressure pulse which changed continually as the engine was running. This pulse was fed to the Y axis deflection plates, and a synchronizing signal was fed to the X axis deflection plates so that the pressure pulse was swept across the screen of the oscillograph, producing a pressure-time diagram as pictured in figure 8.

The height of the diagram indicated the pressure, so a means was needed to determine what millivolt input would produce any particular height so that the pounds of pressure could be determined. The amplifier used contained a special device to feed any number of millivolts from .1 to a 1000 to the oscillograph in place of the input signal from the quartz pressure element. This special signal formed a sine wave on the screen of the oscillograph as pictured in figure 9.

To determine the peak cylinder pressure with the engine running, it was only necessary to first feed the output of the pressure element through the amplifier to the oscillograph and note the peak height of the pressure pulse on the screen, and then switch in the calibration circuit and impress enough voltage to cause the sine wave to rise to the same height. This voltage divided by 2.75 and multiplied by 100 gave the peak pressure in pounds per square inch.

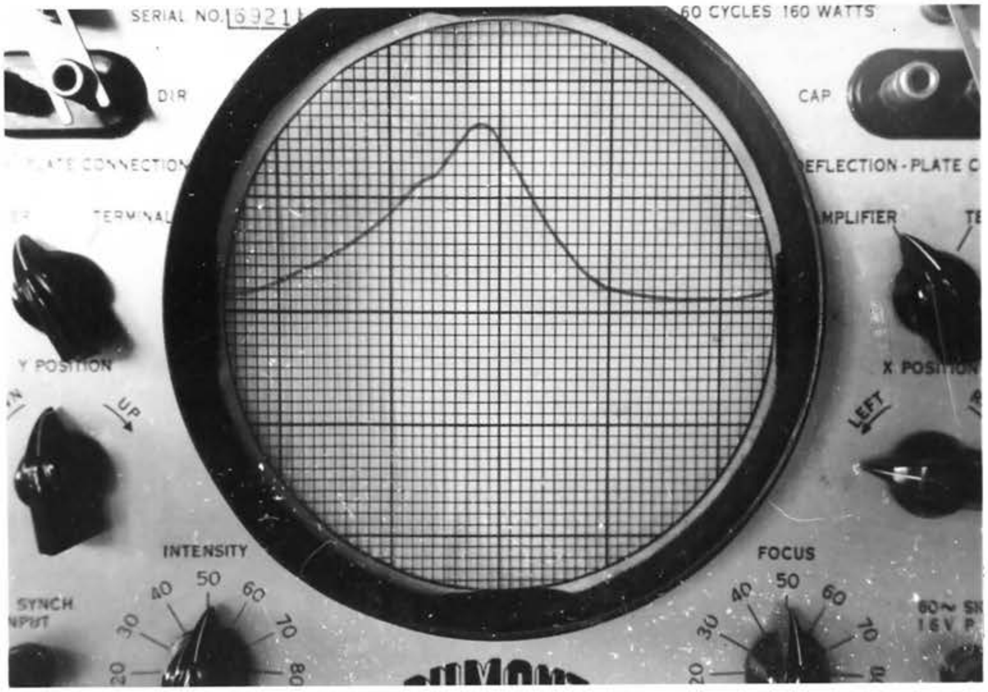


Figure 8 Pressure-time diagram for normal combustion on the oscillograph screen.

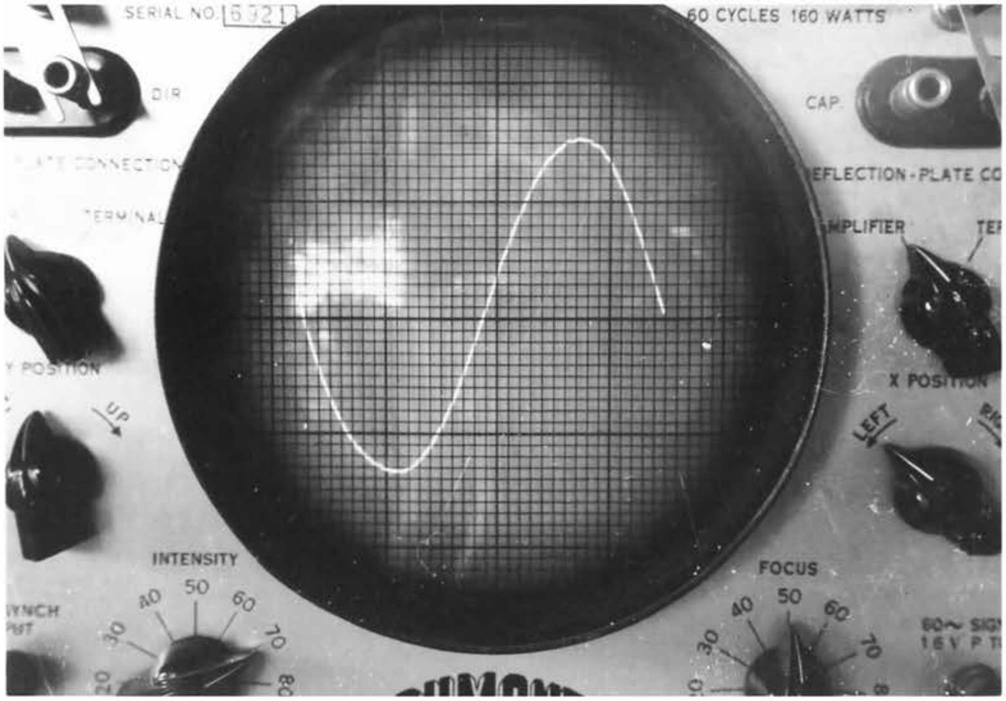


Figure 9 Calibration curve on the oscillograph screen.

The quartz pressure element, amplifier, and oscillograph were calibrated as a unit by comparing the pressures obtained from this pickup device versus pressures obtained by means of a bourdon tube pressure gage. The bourdon tube pressure gage was fitted with a one way valve so that the pressure could enter the tube, but not leave it. In this way, the pulsating pressures of the cylinder were used to drive the gage to maximum cylinder pressure and keep it there. The pressure gage was attached to the engine combustion chamber by means of the same hole as the quartz pressure element, after the latter was removed from the engine.

Because the gage could not contain the firing combustion pressures, the engine was motored by means of the electric dynamometer at a constant 900 revolutions per minute, while the compression ratio was varied from 4 : 1 to 15 : 1. For each compression ratio, the gage pressure was recorded, the gage removed and the quartz pressure element installed, and the pressure pickup pressure recorded. The bourdon tube pressure gage had previously been calibrated by means of a dead weight tester. The pressures measured by the two means were plotted against each other and formed a straight line which was extended to include combustion pressures.

The quartz pressure pickup device, by creating a pressure time diagram on the oscillograph as it does, gives a picture of the combustion process taking place in the engine cylinder, so that abnormal combustion such as detonation or preignition can be observed before it can be noticed in engine performance.

Figure 10 shows a pressure-time diagram for normal combustion which is desirable.

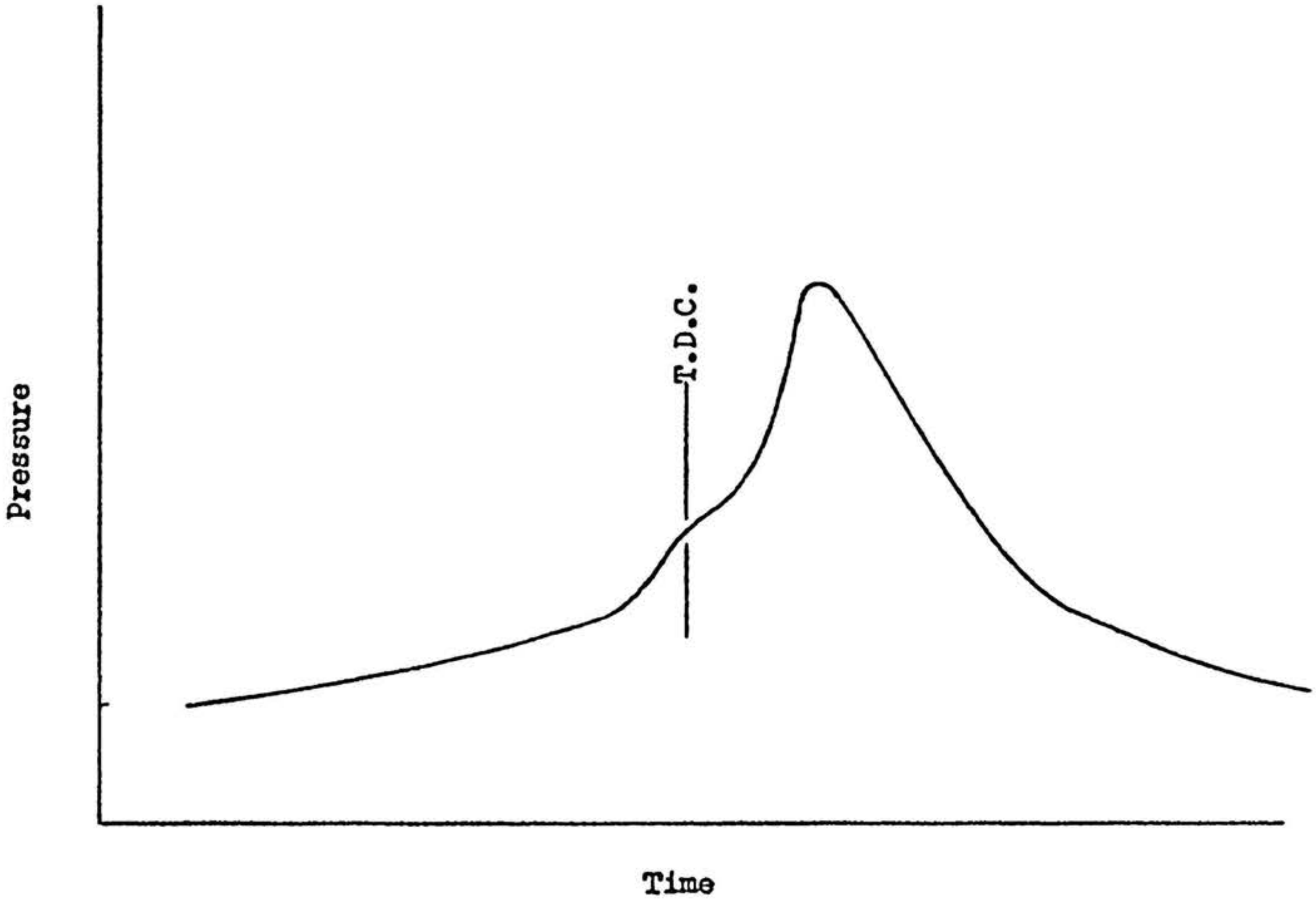


Figure 10 Pressure-Time Diagram for Normal Combustion

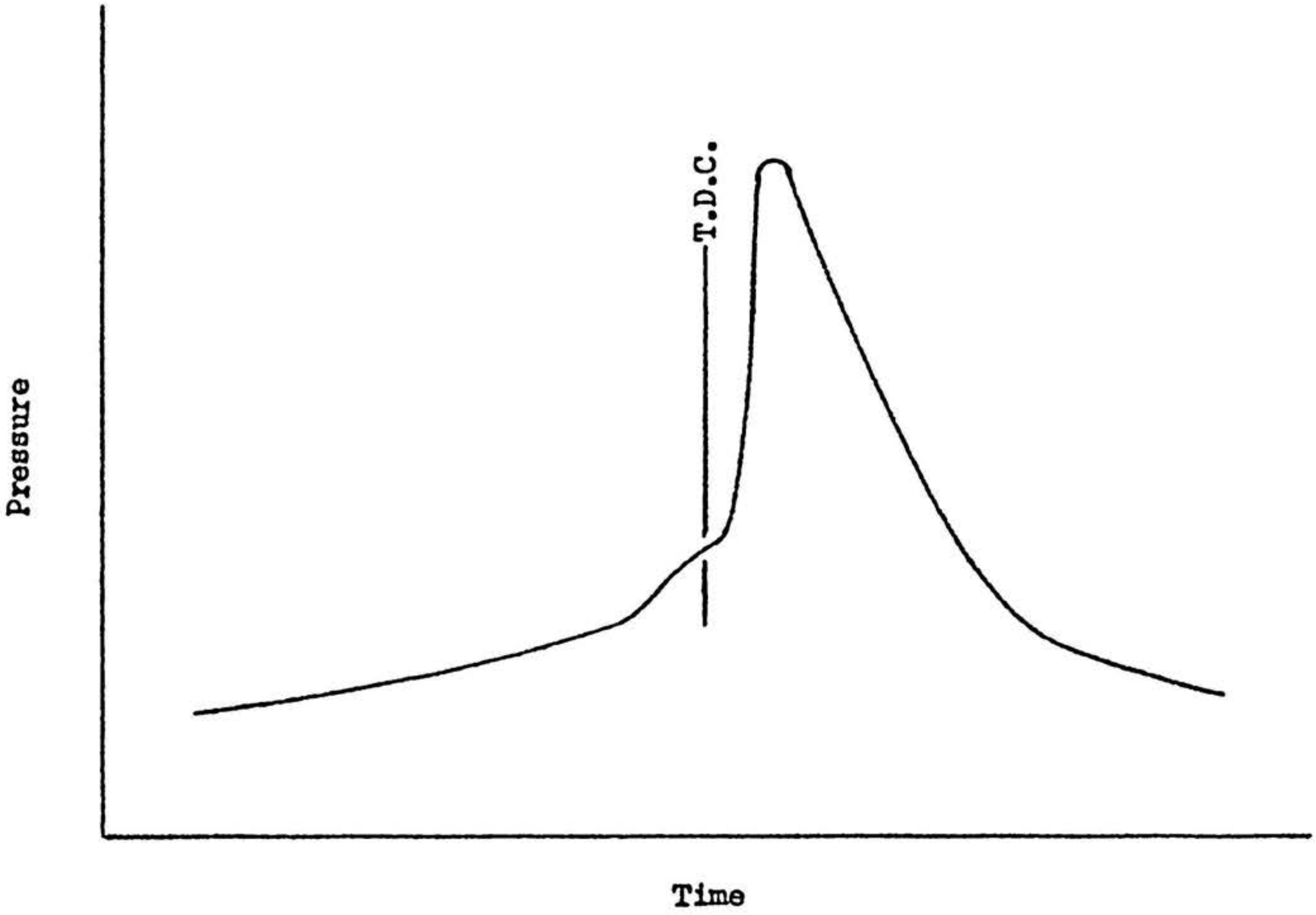


Figure 11 Pressure-Time Diagram for Detonation

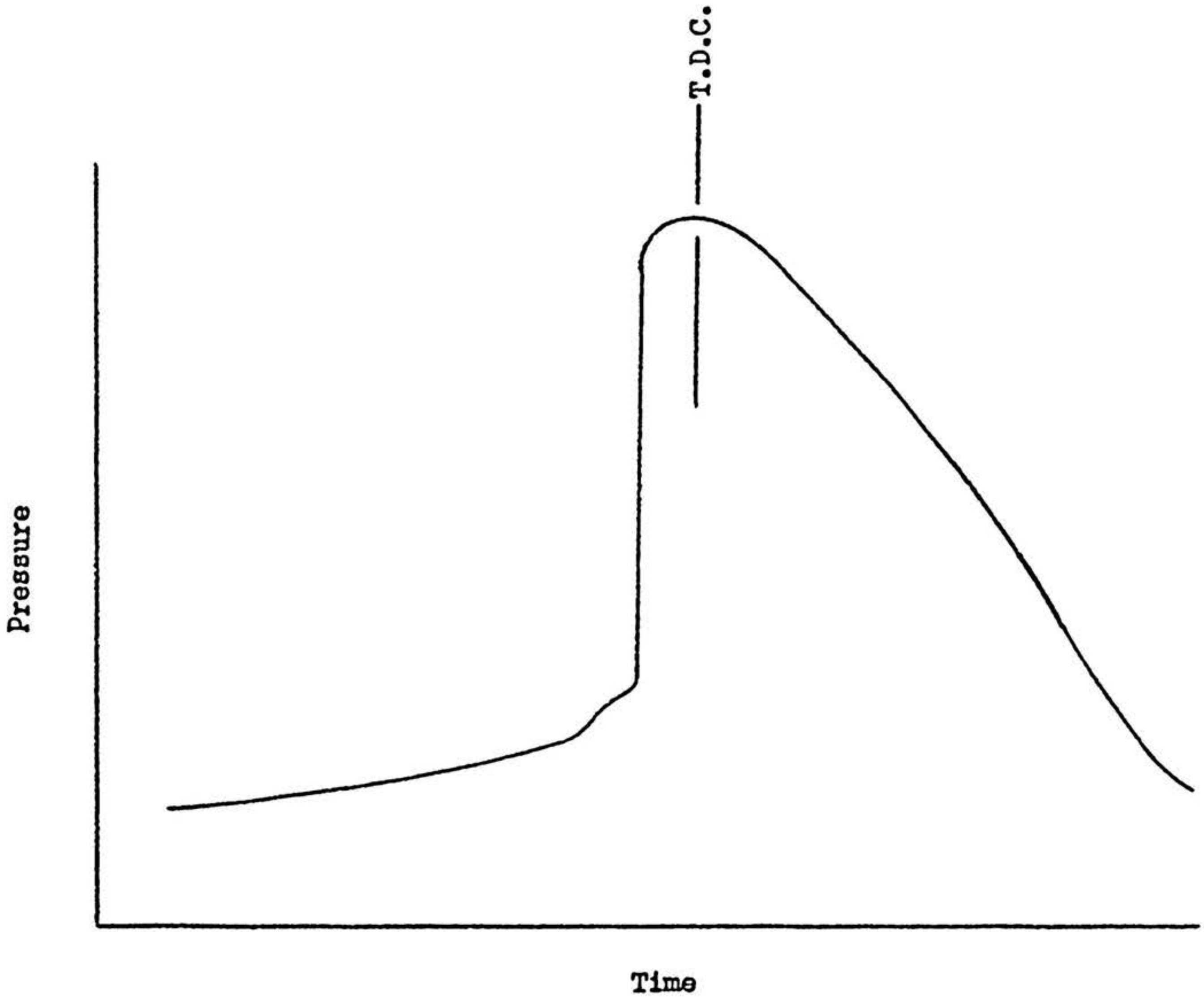


Figure 12 Pressure-Time Diagram for Preignition

Figure 11 shows what the pressure-time diagram would have been had any of the alcohol blend fuels detonated, and figure 12 shows a pressure-time diagram for preignition.

The standard C F R engine is equipped with a micrometer to measure the height of the cylinder head from the piston at top dead center. If this micrometer is calibrated, then a scale, as furnished by the engine manufacturer, can be used to accurately determine the compression ratio of the engine from a ratio of 4 : 1 to 10 : 1. The engine was modified to allow higher compression ratios to be used, and hence the micrometer had to be recalibrated. The method used was the standard tilt method for C F R engines. With the engine clean, and the piston at top dead center, 140 ml. of water at room temperature were measured into the engine cylinder through the bouncing pin hole. Then with the engine tilted so that the bouncing pin hole was the highest point of the combustion chamber, the compression ratio was adjusted until the water was just level with the top of the bouncing pin hole. In this position the combustion chamber height is exactly 1 inch, and the micrometer was adjusted accordingly. Figure 13 shows the micrometer in position on the side of the engine and the cylinder head, and also the location of the quartz pressure element in the bouncing pin hole. Figure 14 shows the tilt method of calibrating the micrometer, with the water being put into the combustion space through the bouncing pin hole.

The standard C F R engine is equipped with a linkage from the cylinder head to the spark distributor to adjust the spark automatically as the compression ratio is changed. This linkage is shown in figure 15, along with the visual spark advance indicator on the crankshaft.

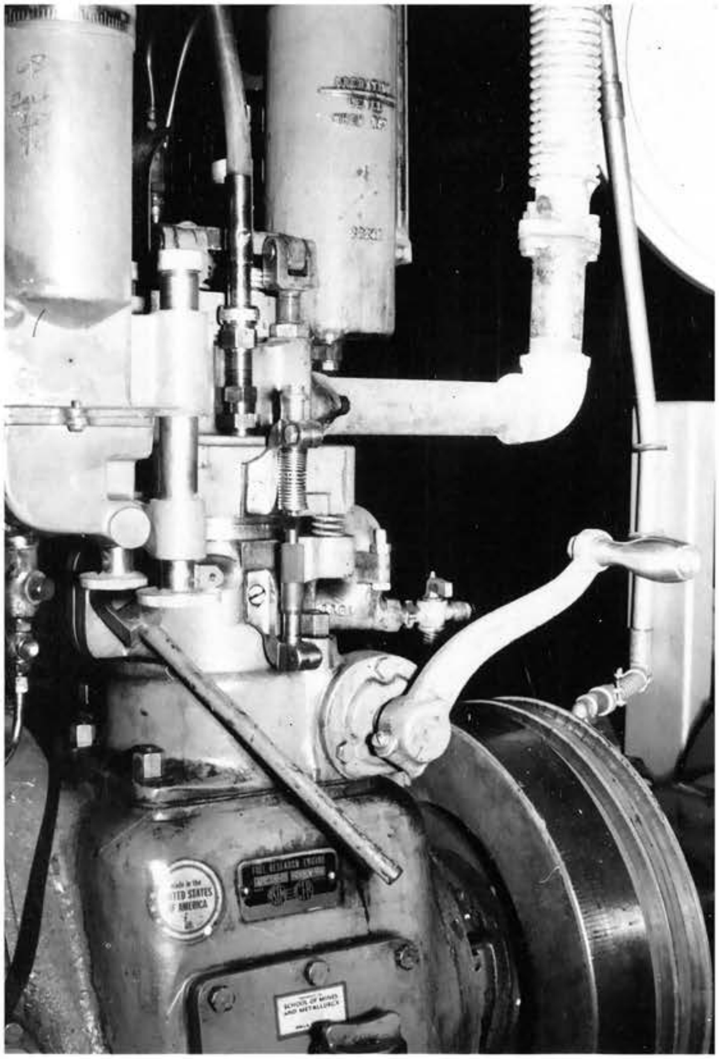


Figure 13 Compression ratio micrometer and quartz pressure element in place on engine.

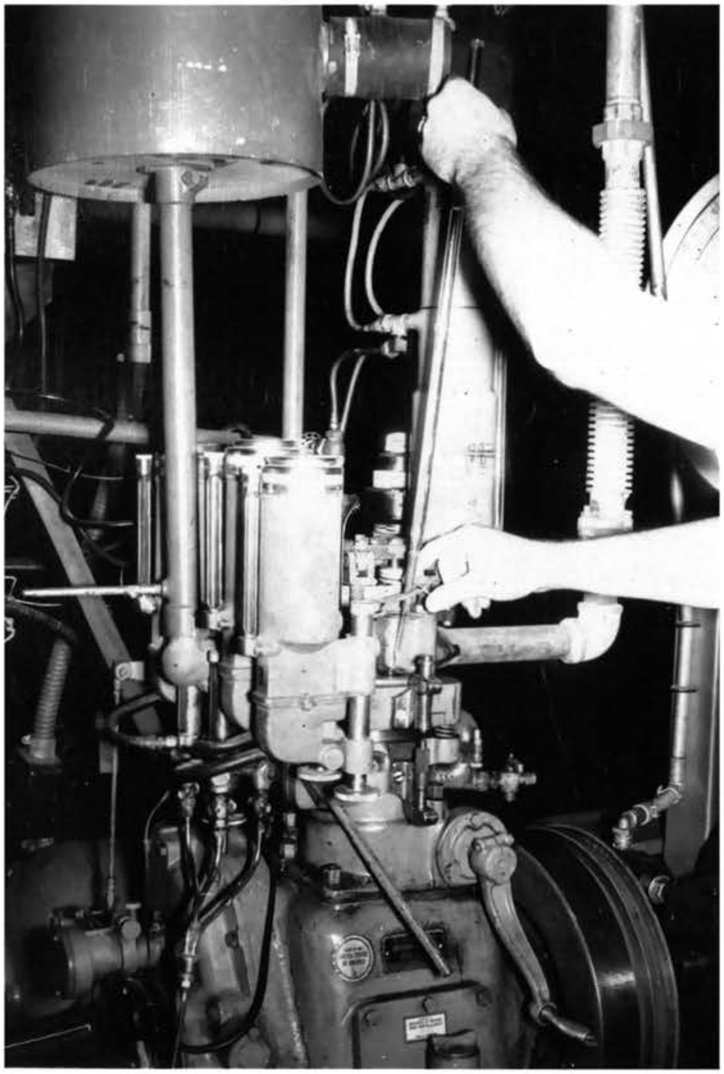


Figure 14 Tilt method of calibrating compression ratio micrometer.

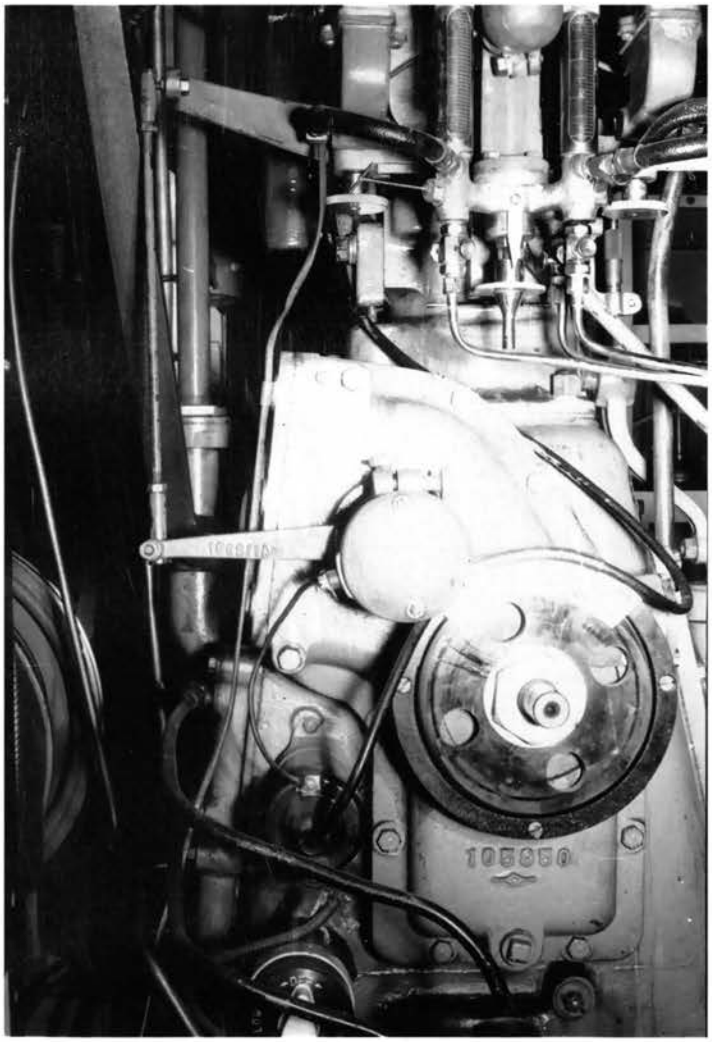


Figure 15 Spark advance linkage and visual spark advance indicator.

In experimenting with the engine setup in preparation for actual trials, this linkage was disconnected and the spark adjusted manually for each compression ratio and trial fuel blend in order to get maximum brake horsepower output. The value of spark advance so obtained was averaged and plotted versus the compression ratio. The linkage was reconnected and readings of spark advance versus compression ratio for the standard engine were taken and plotted. The smooth curve of figure 16 is the standard engine spark advance curve, and the points are the average of the hand adjusted spark advance. From this curve it was evident that the linkage could remain connected as in the standard engine, and the maximum horsepower output could be expected.

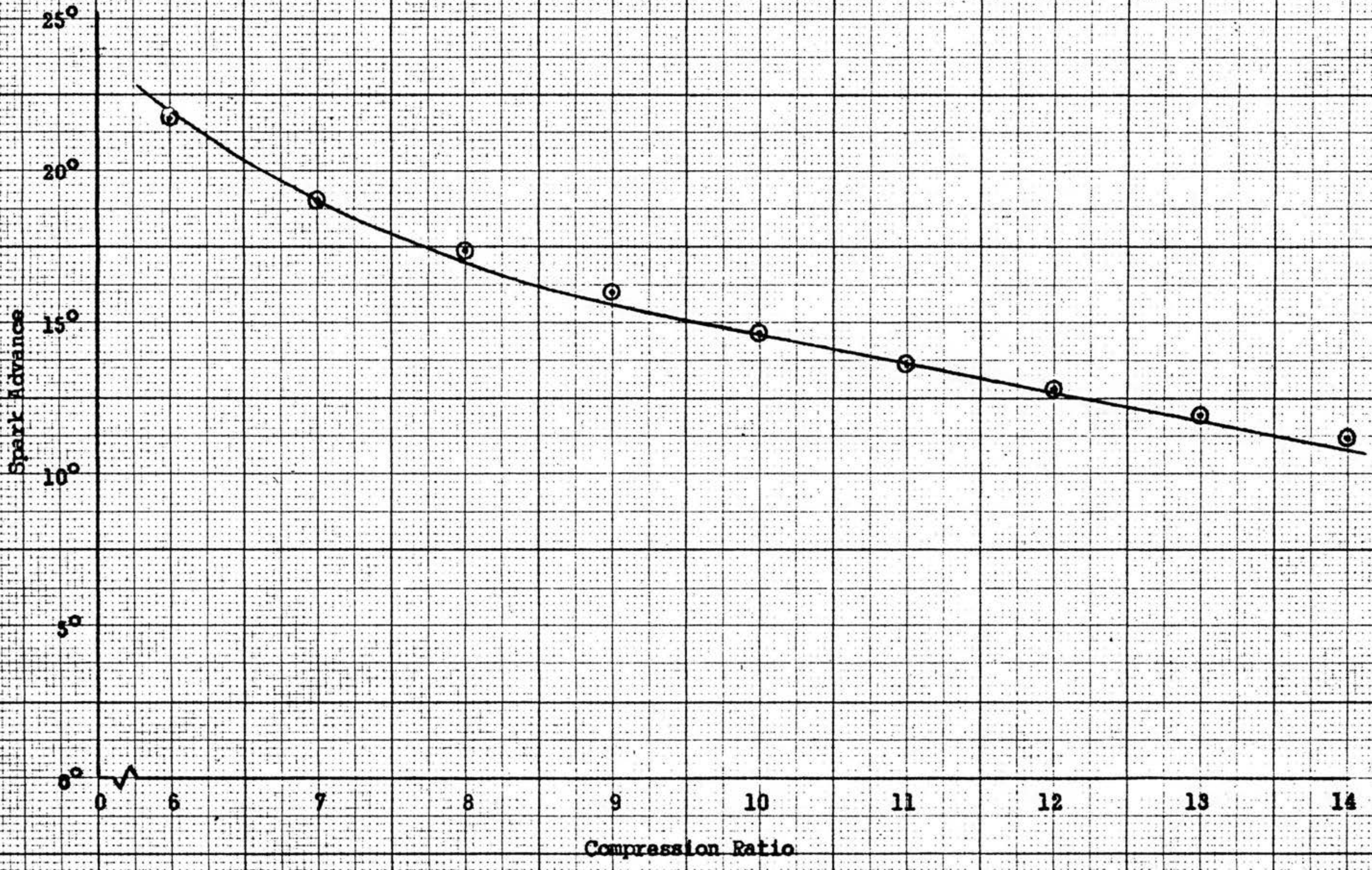


Figure 16 Variation of Spark Advance with Compression Ratio

OPERATION AND DATA TAKING

Once the test engine was modified and the associated apparatus calibrated, the actual test trials were begun. Before any data could be taken, it was necessary for the test engine to stabilize in all temperature measurements. From a cold start, approximately 4 hours of running were required in order to reach stable conditions. After all the conditions were met as described in the section on engine preparation, data was taken for each alcohol and benzene fuel blend as follows: compression ratio, weight torque on scale, variable metering jet adjustment, peak pressure, and notations as to any abnormal combustion.

The lowest compression ratio used for all the blends was 6 : 1. The highest compression ratio used was variable depending on the ability of the fuel to resist combustion complications such as destructive preignition. In order that all the fuel blends would undergo comparative tests, a peak pressure not to exceed 750 pounds per square inch was chosen as the limit for any test. This value of peak pressure would be of the same order of magnitude as that experienced by a conventional gasoline engine operating with trace detonation. This peak pressure limitation could be adjusted up or down to meet the needs of a particular engine.

In each case, before data was recorded, the carburetor was adjusted for maximum brake horsepower output and the speed controlled by means of adjusting the field of the electric dynamometer.

The data was accumulated over a period of weeks, so it was important that all the test conditions be met during each test, as all of the data was evaluated at the same time.

The compression ratio micrometer was recalibrated before and after each test period to insure its accuracy. The pressure equipment was also recalibrated at this time.

The objective of the test required the answer to which alcohol and benzene blend would produce the maximum brake horsepower output and at what compression ratio, without exceeding the maximum allowable peak pressure. Therefore, for each blend, the brake horsepower was plotted versus the compression ratio as shown in figures 17 through 27. For a comparison, 86 octane "regular" gasoline and 100 octane *iso*octane were plotted in the same manner in figures 28 and 29, respectively. The solid portion of the curves is that which is relevant to this test method; the dotted portions of the curves are the results obtained by exceeding the peak pressure limitation imposed.

The best alcohol and benzene blend as found by this test method is 60% alcohol and 40% benzene, by volume. The curve of compression ratio versus brake horsepower for this blend is repeated in figure 30, along with 100% alcohol and 100% benzene, to give an idea of its relation to the pure components.

Figure 31 plots the maximum brake horsepower outputs for each mixture, again showing that the 60% alcohol and 40% benzene blend will give the greatest output without exceeding the peak pressure limitation.

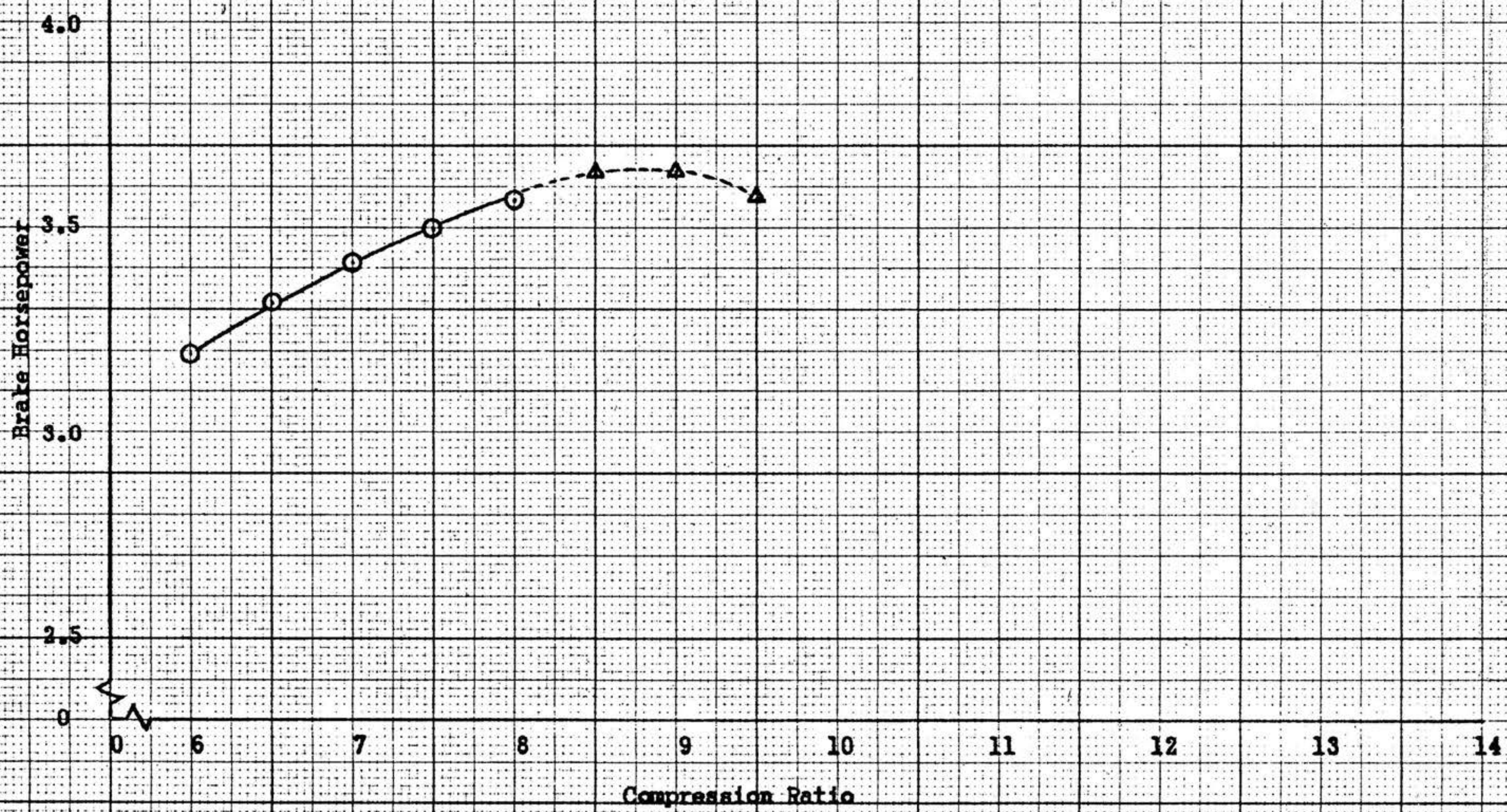


Figure 17 Compression Ratio vs Brake Horsepower for 100% Alcohol & 0% Benzene by Volume

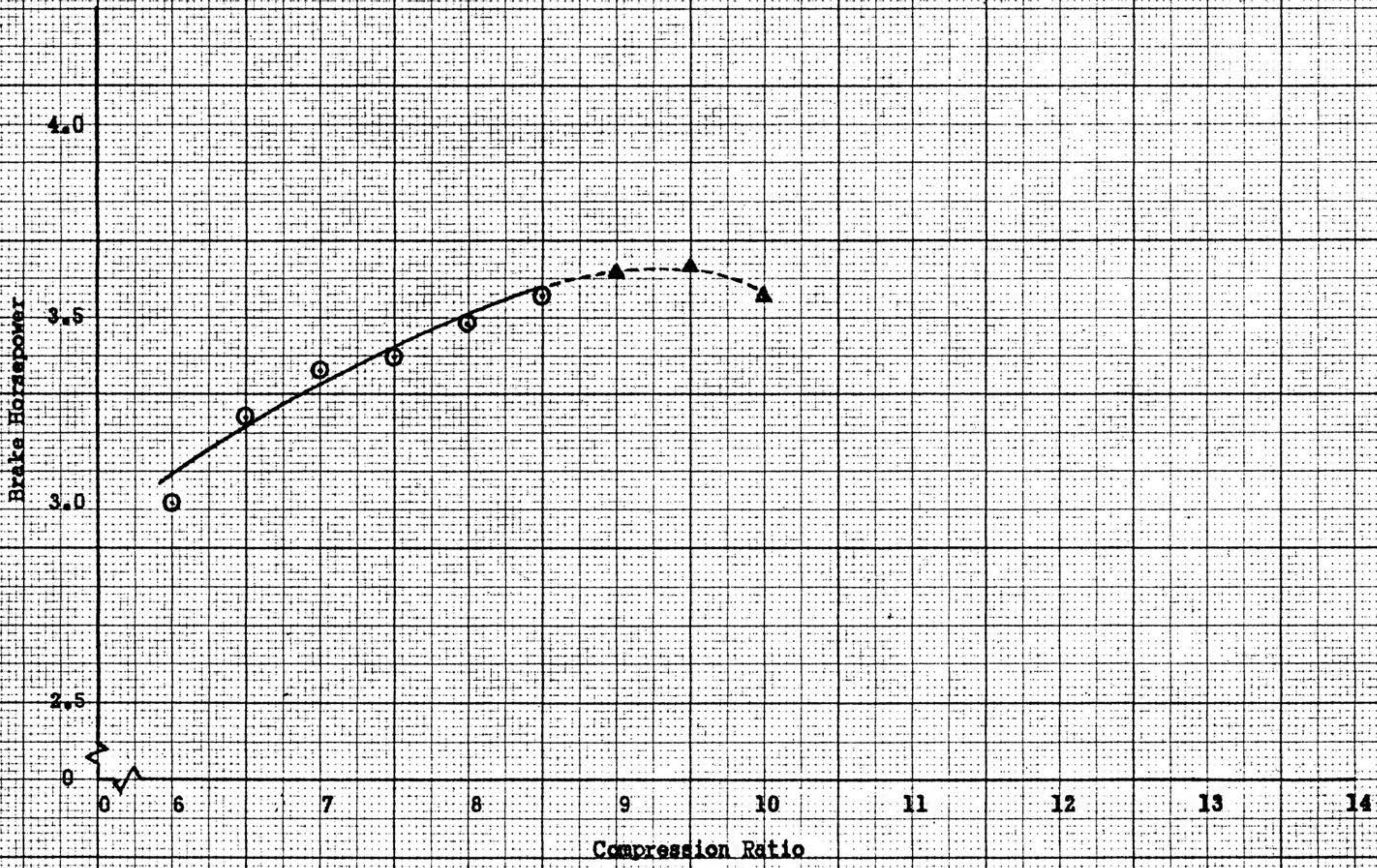


Figure 18 Compression Ratio vs Brake Horsepower for 90% Alcohol & 10% Benzene by Volume

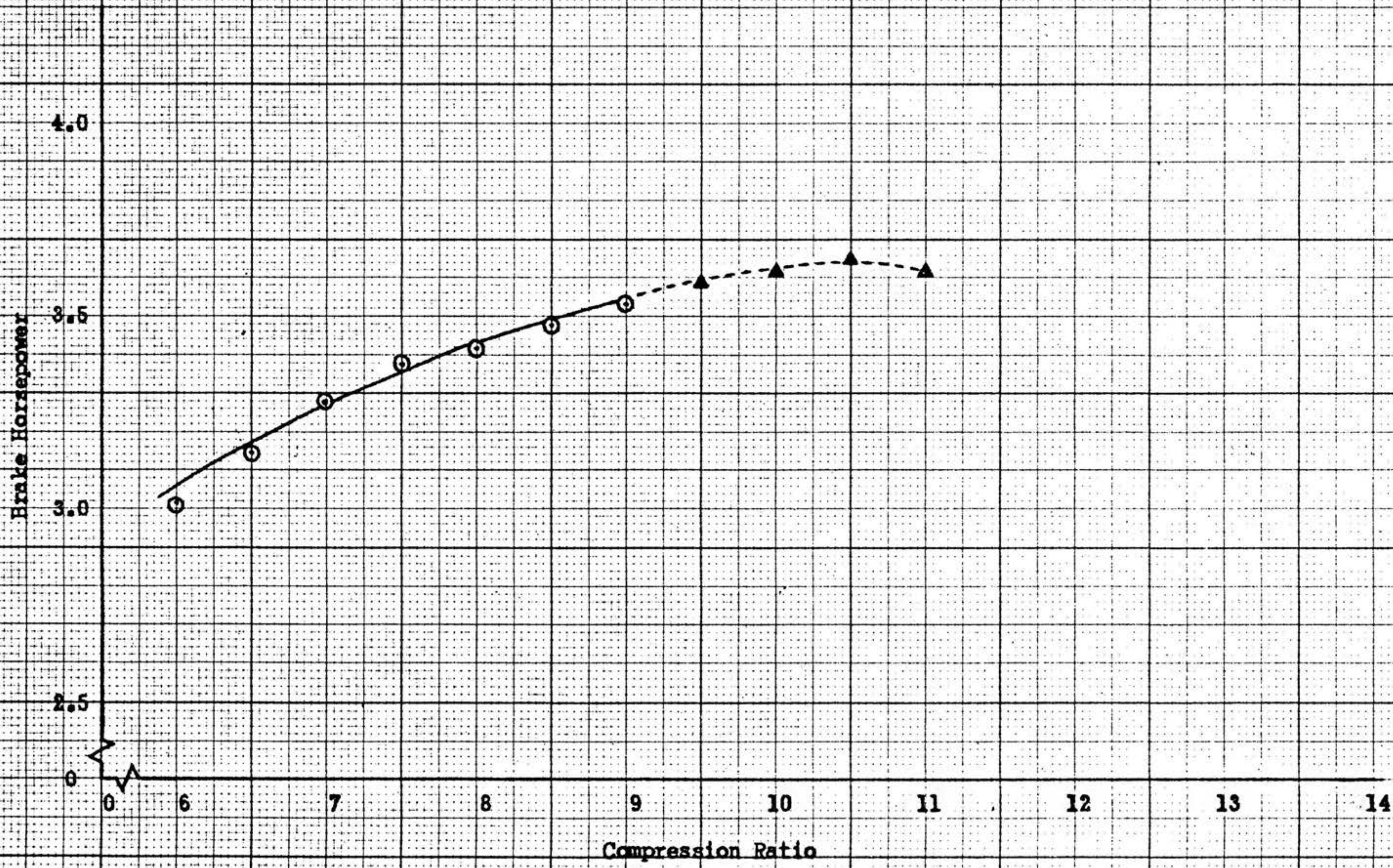


Figure 19 Compression Ratio vs Brake Horsepower for 80% Alcohol & 20% Benzene by Volume

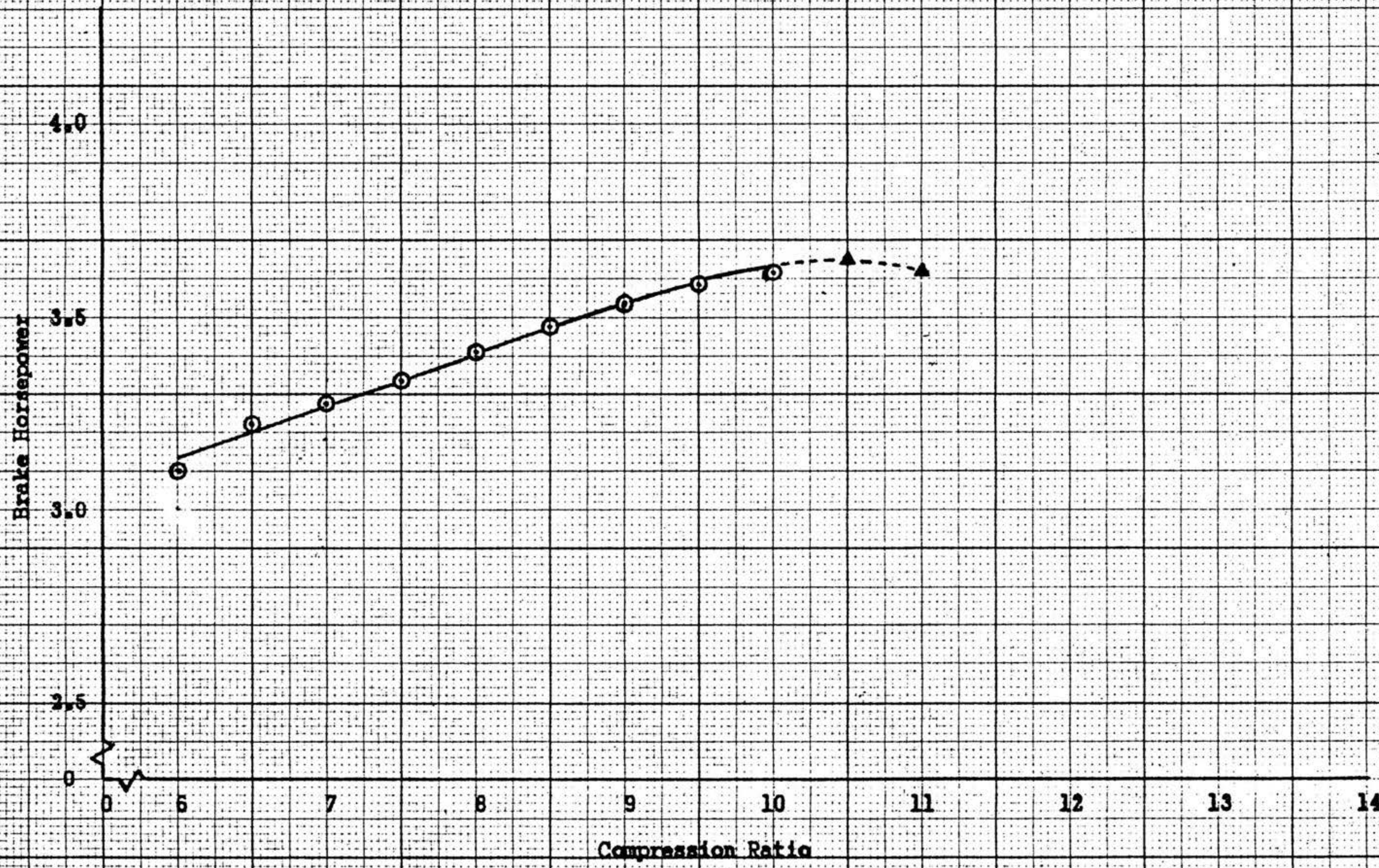


Figure 20 Compression Ratio vs Brake Horsepower for
70% Alcohol & 30% Benzene
by Volume

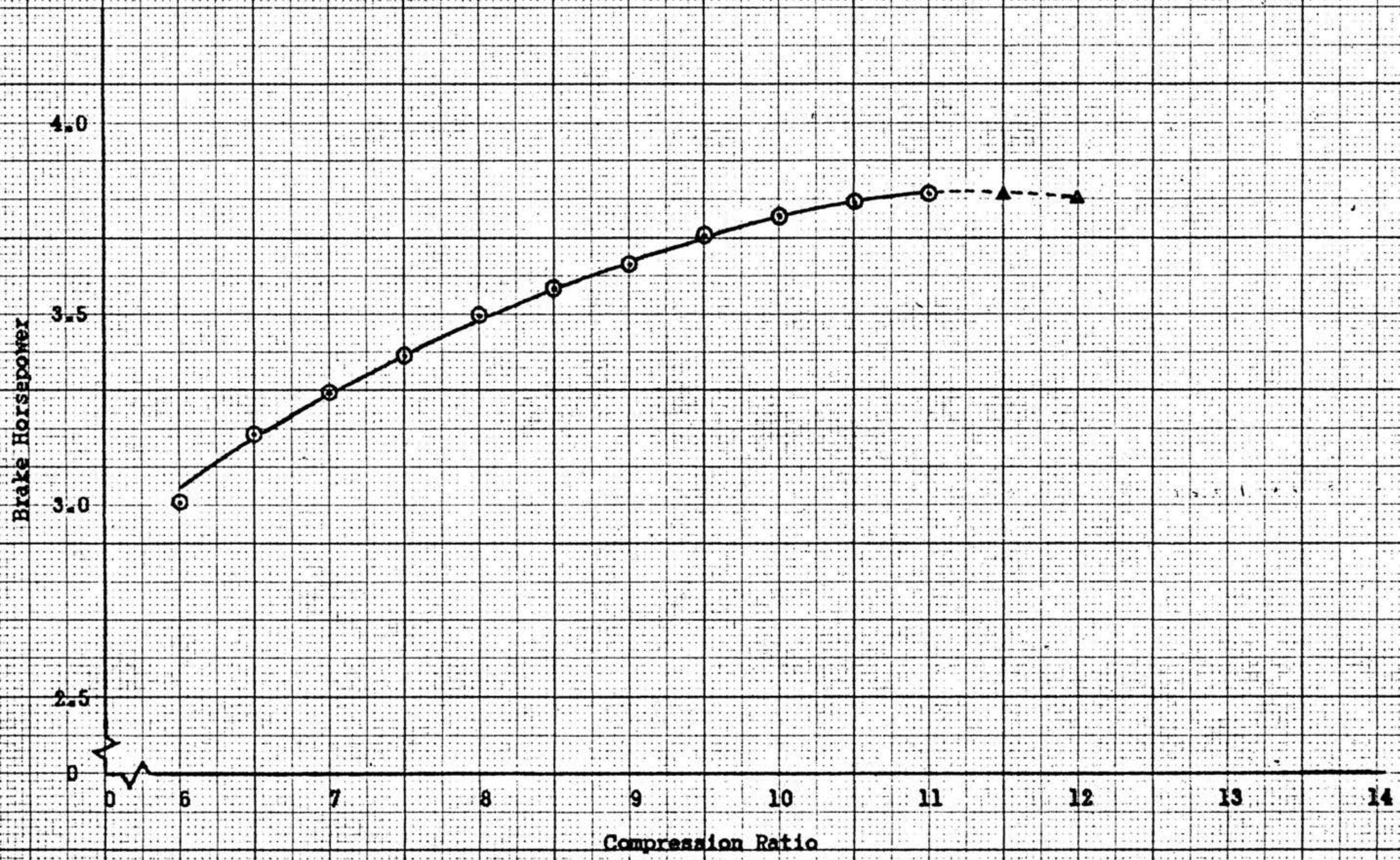


Figure 21 Compression Ratio vs Brake Horsepower for
60% Alcohol & 40% Benzene
by Volume

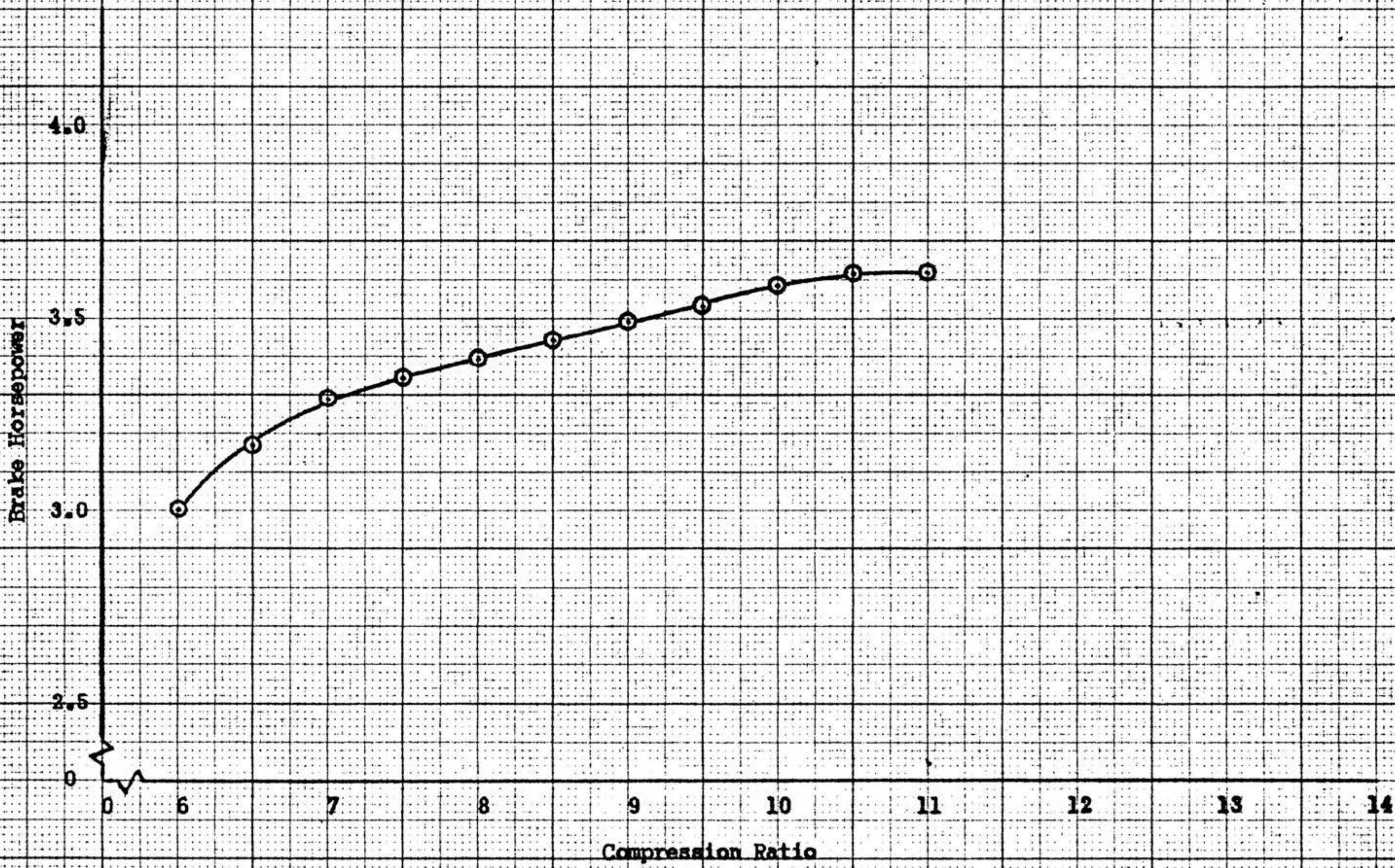


Figure 22 Compression Ratio vs Brake Horsepower for 50% Alcohol & 50% Benzene by Volume

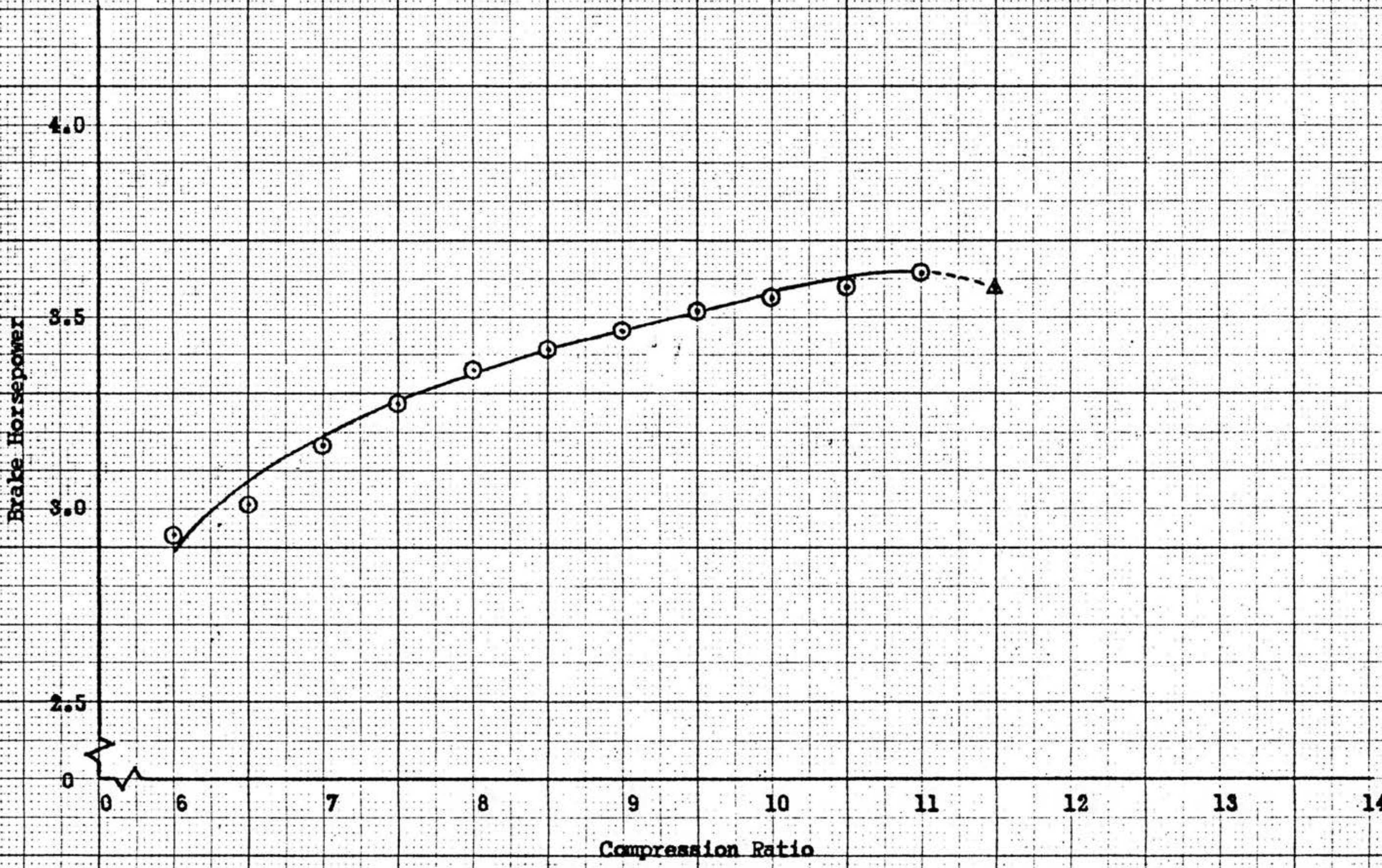


Figure 23 Compression Ratio vs Brake Horsepower for 40% Alcohol & 60% Benzene by Volume

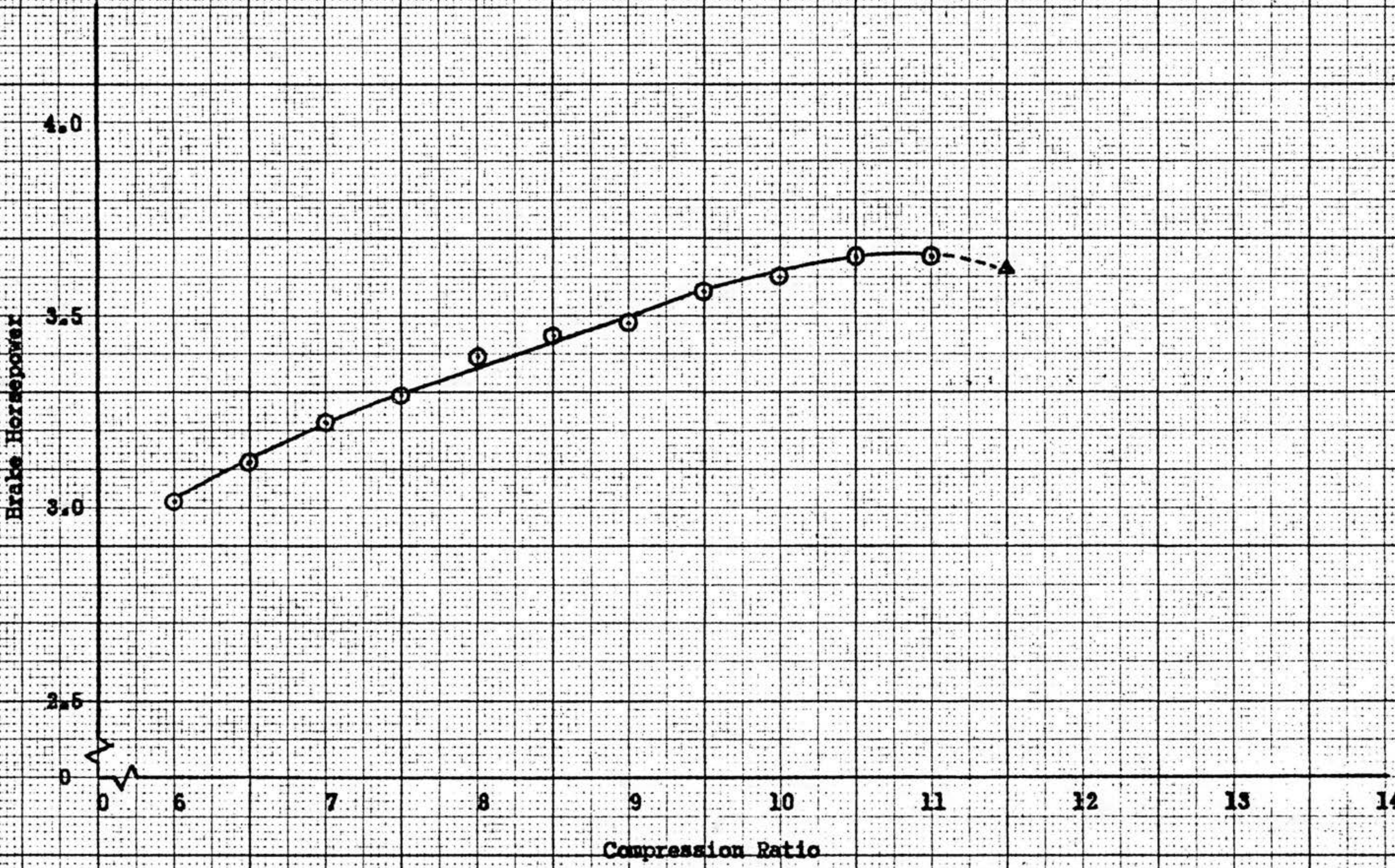


Figure 24 Compression Ratio vs Brake Horsepower
30% Alcohol & 70% Benzene
by Volume

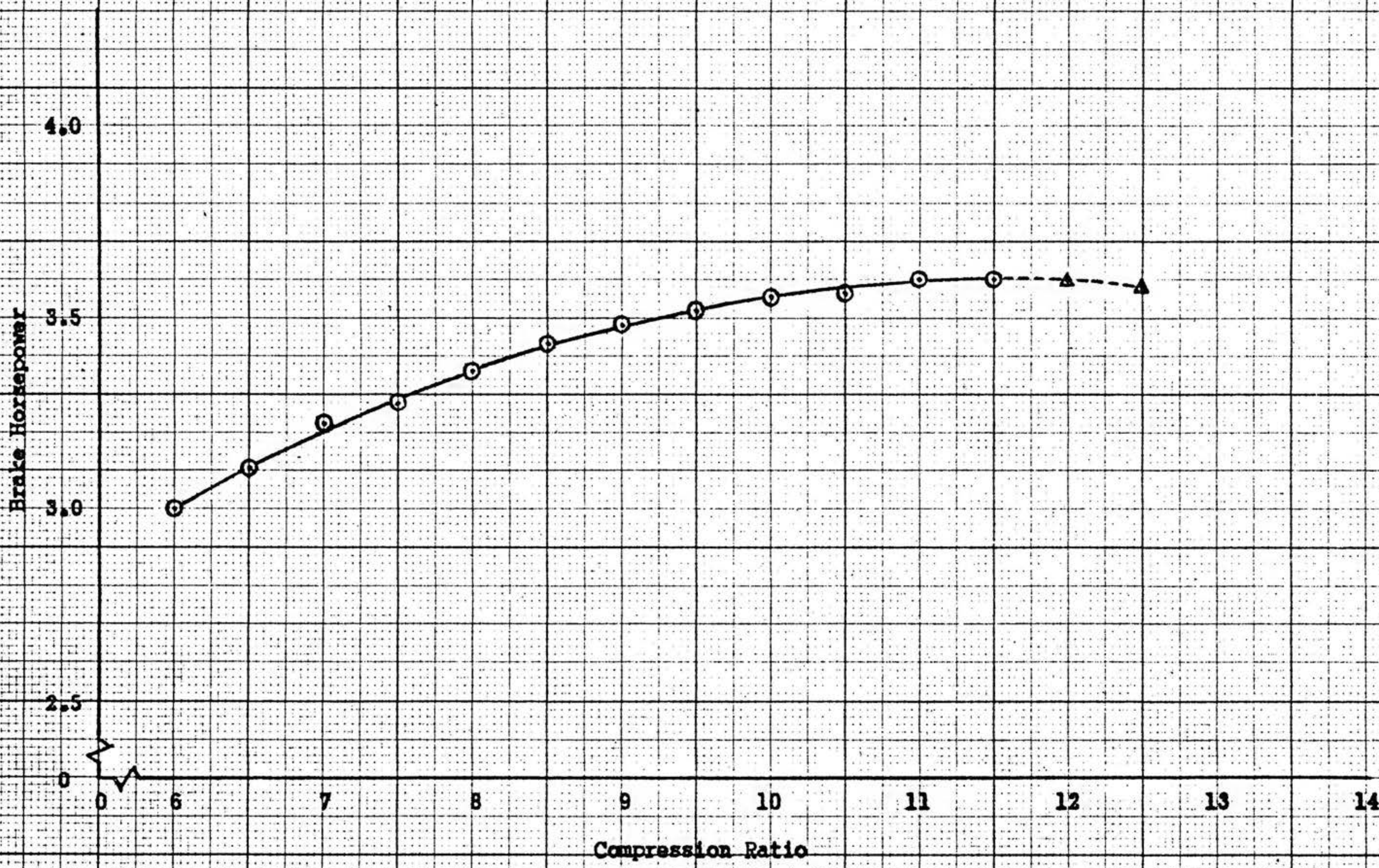


Figure 25 Compression Ratio vs Brake Horsepower for
20% Alcohol & 80% Benzene
by Volume

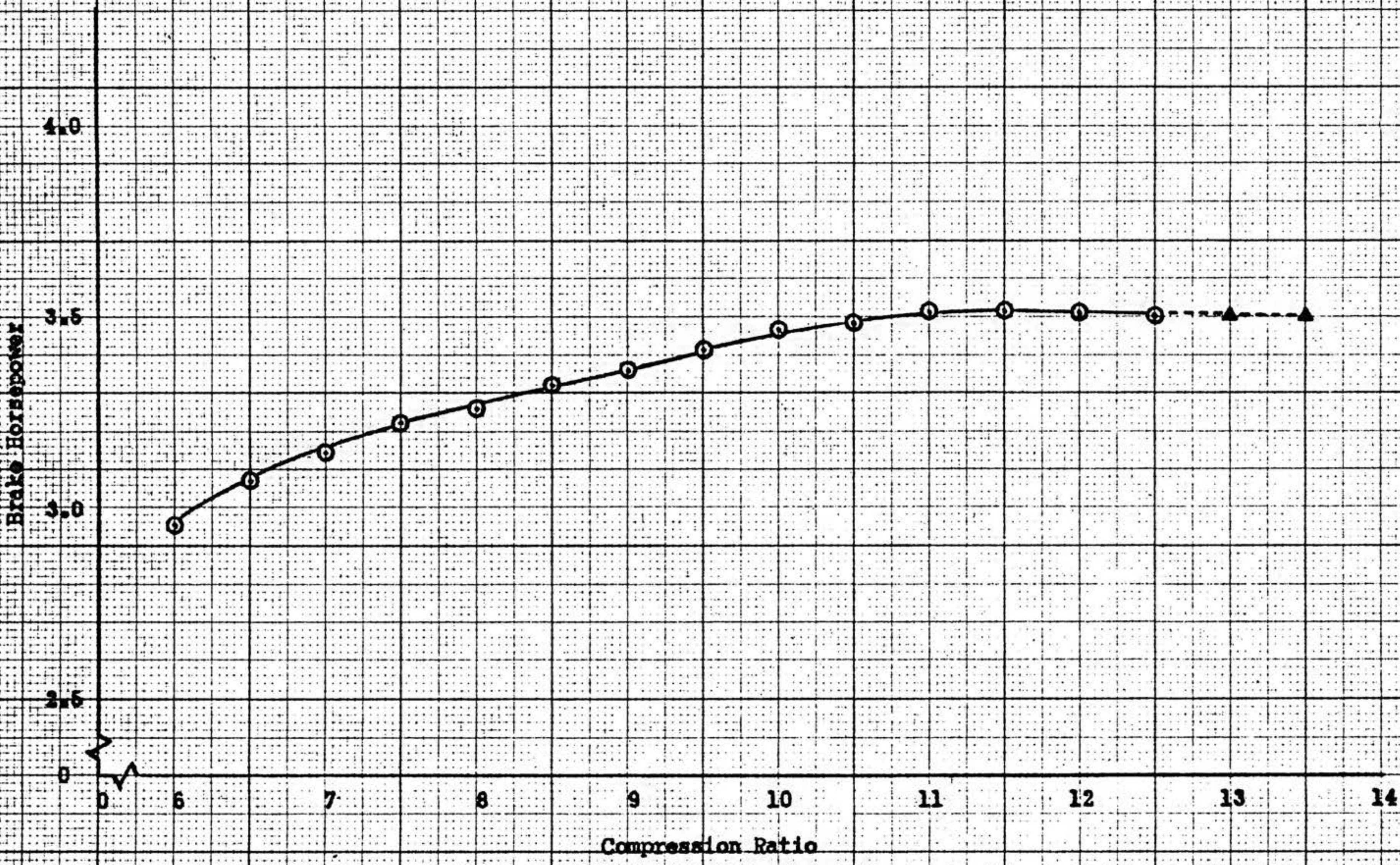


Figure 26 Compression Ratio vs Brake Horsepower for
10% Alcohol & 90% Benzene
by Volume

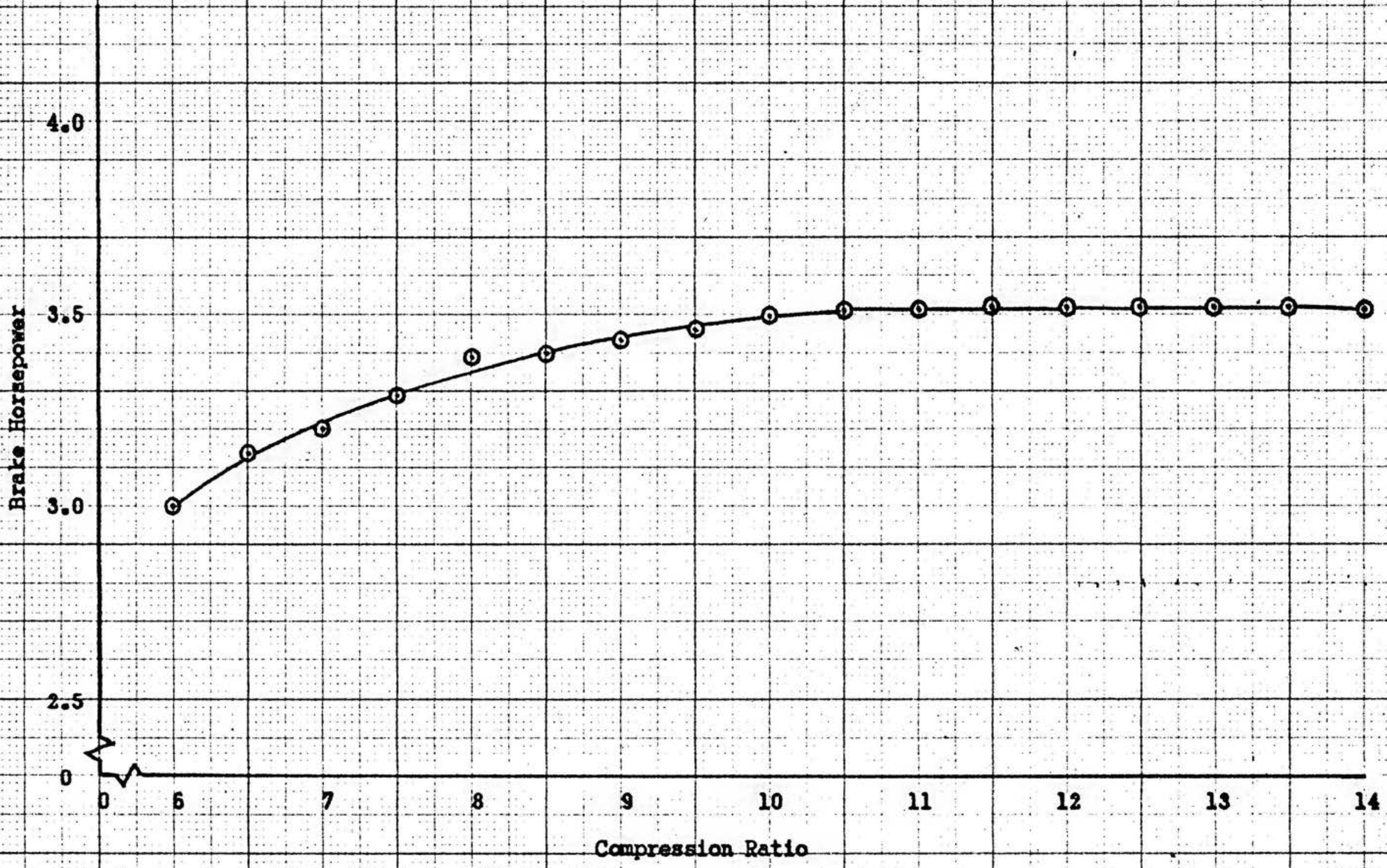


Figure 27 Compression Ratio vs Brake Horsepower for
0% Alcohol & 100% Benzene
by Volume

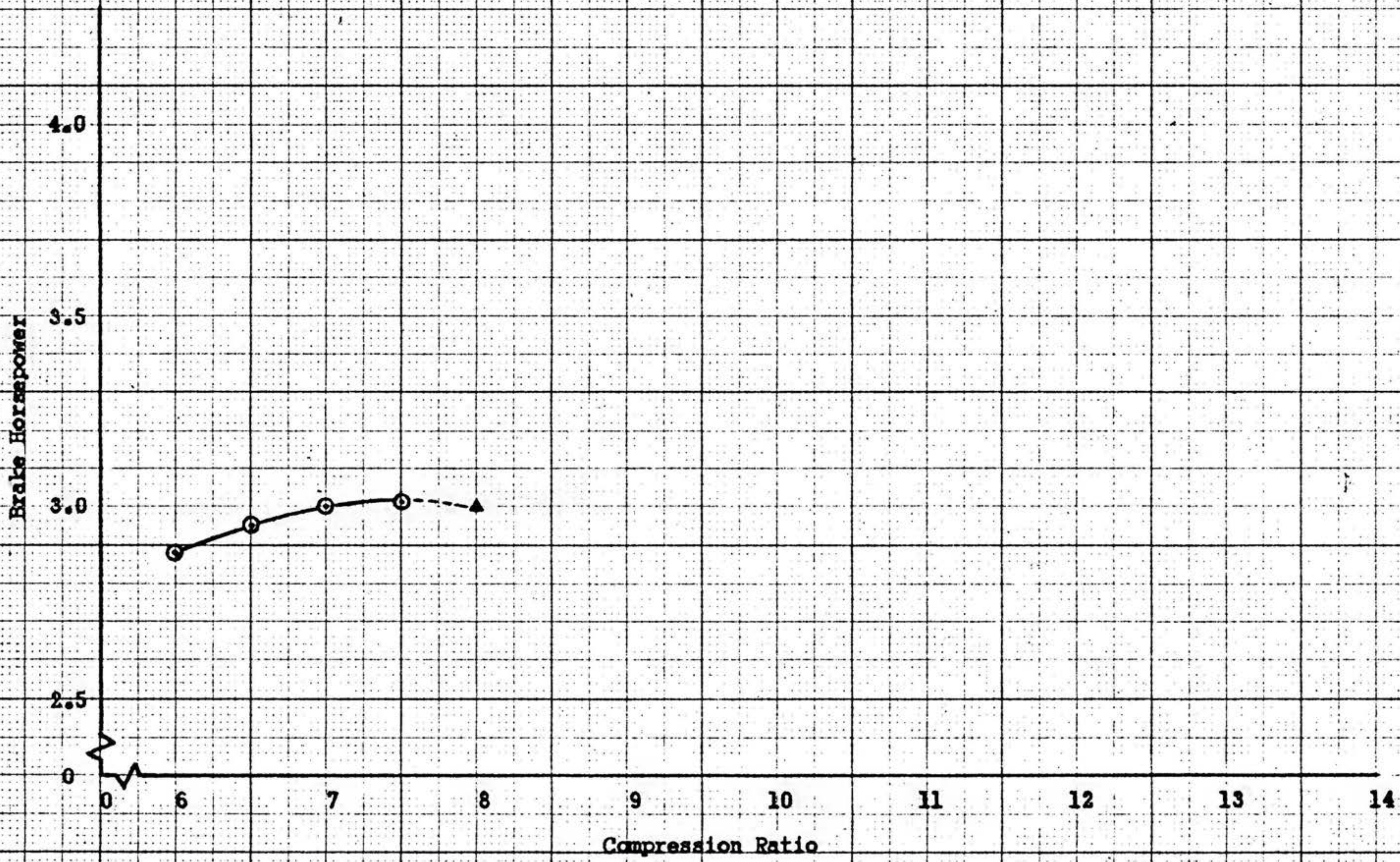


Figure 28 Compression Ratio vs Brake Horsepower for 86 Octane Regular Blend Gasoline

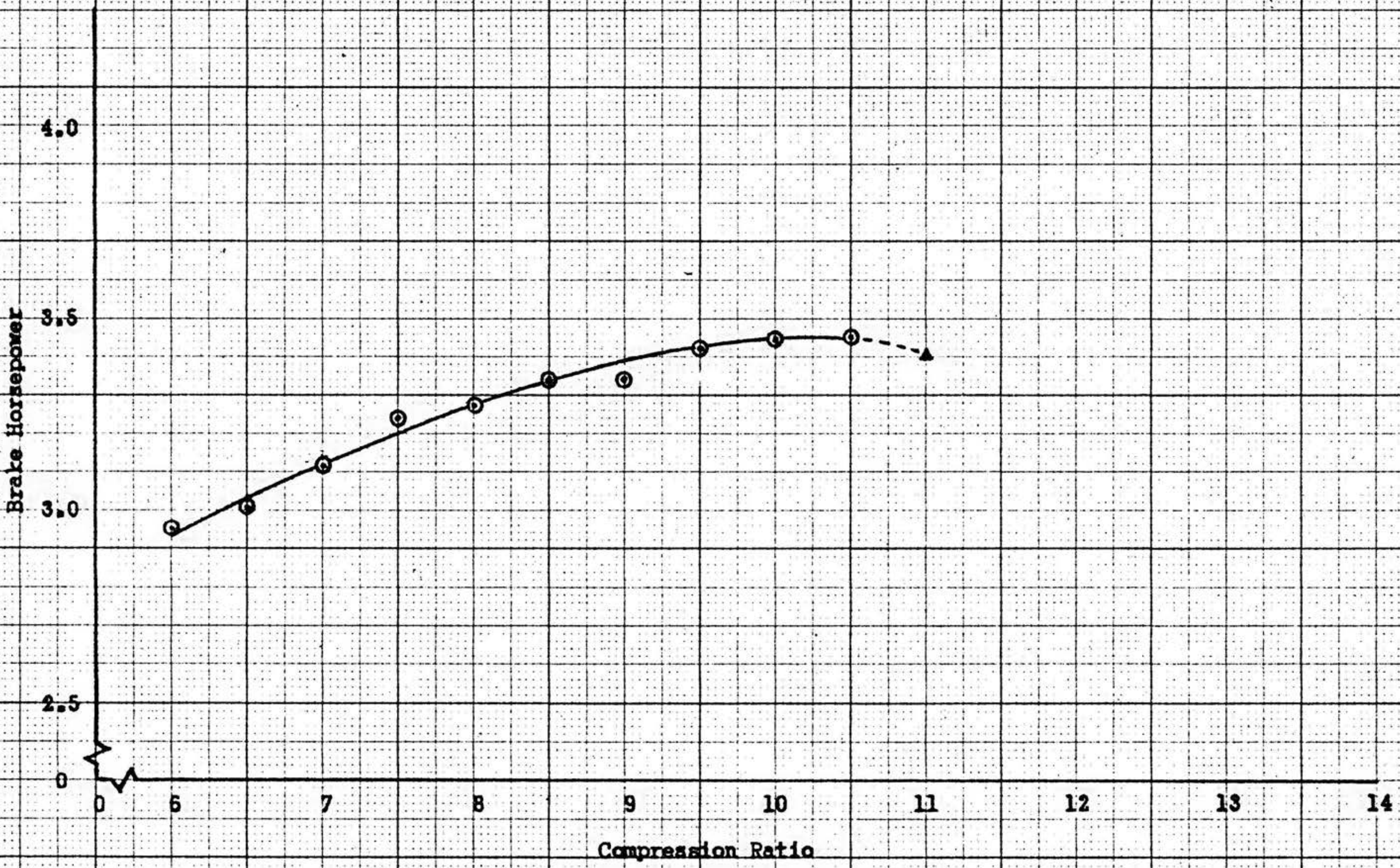


Figure 29 Compression Ratio vs Brake Horsepower for 100 Octane Pure Isooctane (2,2, 4-Trimethylpentane)

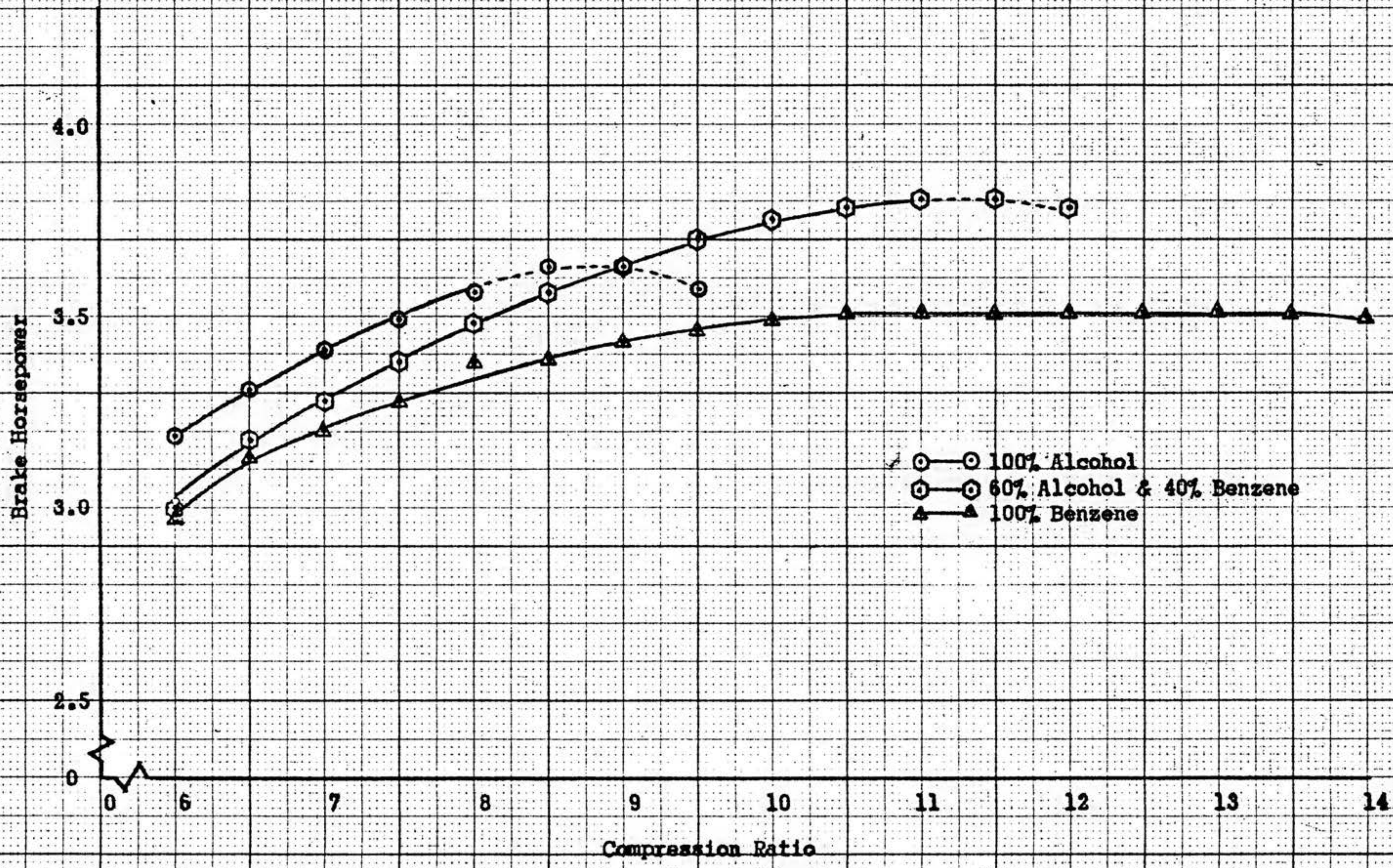


Figure 30 Compression Ratio vs Brake Horsepower for 100% Alcohol, 60% Alcohol & 40% Benzene, and 100% Benzene, by Volume

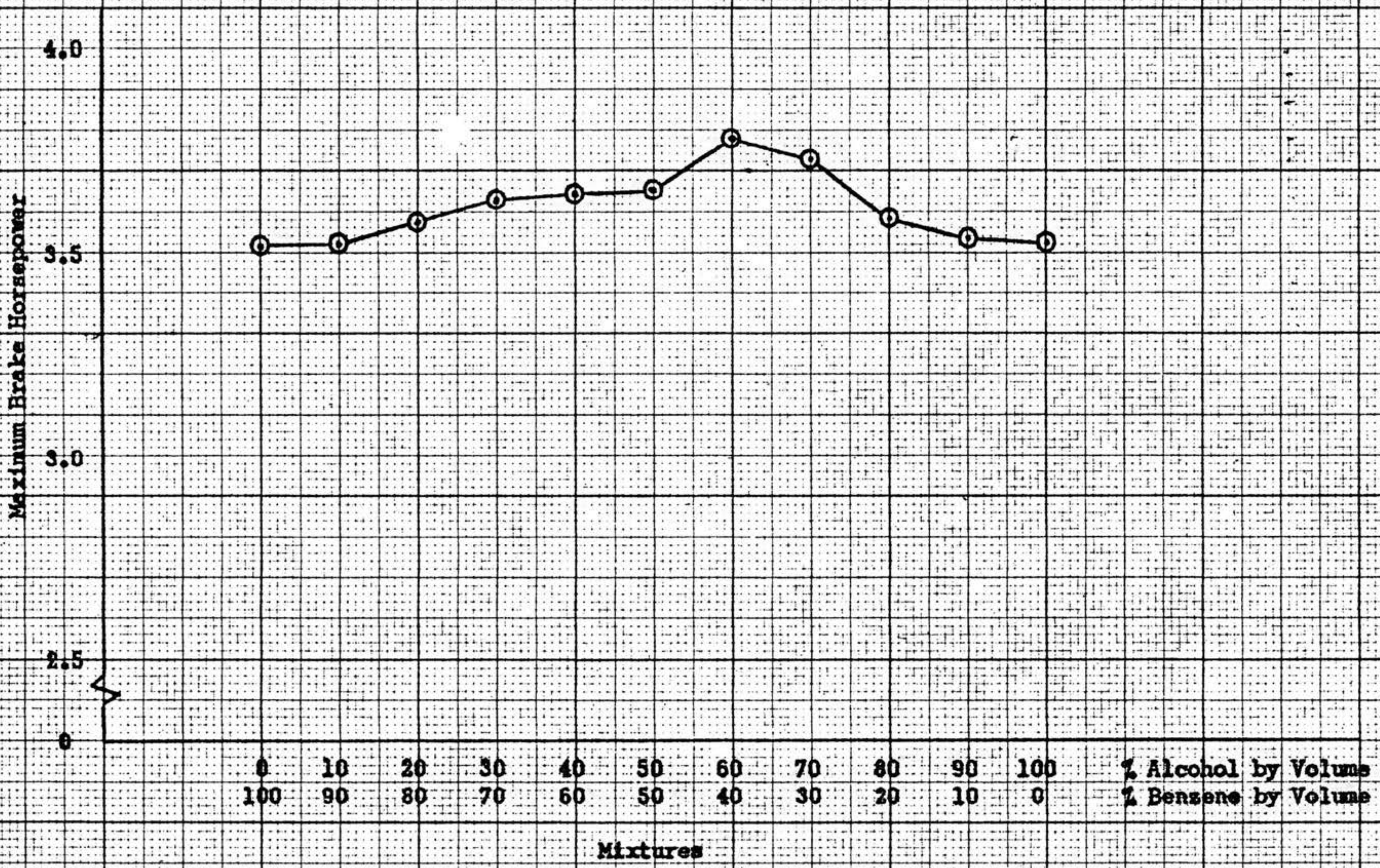


Figure 31 Mixtures vs Maximum Brake Horsepower

DATA TAKING, CONTINUED

As a secondary objective to this test method, the fuel consumption for each fuel blend was found. A fuel weighing device was attached to the carburetor of the test engine. This device, pictured in figure 32, was constructed so that a quarter of a pound of fuel would be required to tip the balance, and by means of a mercury switch, start and stop the elapsed time meter and the total revolution counter. This timing mechanism is also pictured in figure 32. By knowing the total revolutions and the elapsed time, the average revolutions per minute could be found to calculate the brake horsepower output. Also, the elapsed time allowed the fuel consumption to be figured on an hourly basis, so that the brake specific fuel consumption in pounds per brake horsepower hour could be found.

Figure 33 is a plot of brake specific fuel consumption versus mixtures. The lower the specific fuel consumption, the less amount of fuel is required to produce a given horsepower output.

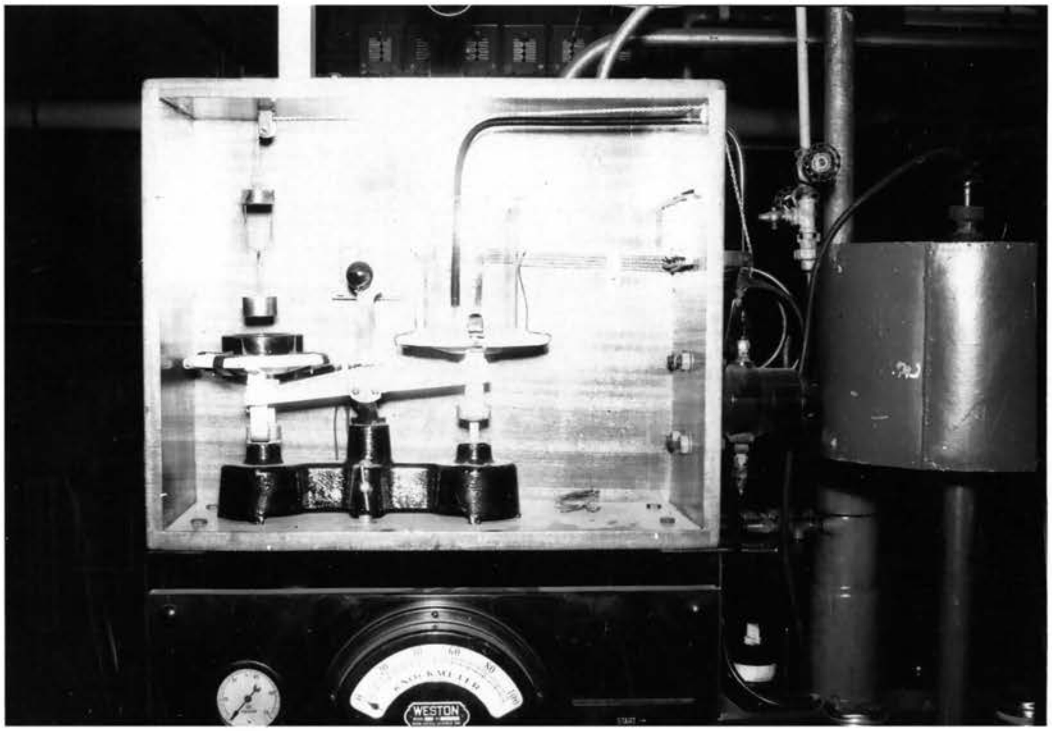


Figure 32 Fuel weighing device.(upper)
Time mechanism.(lower)

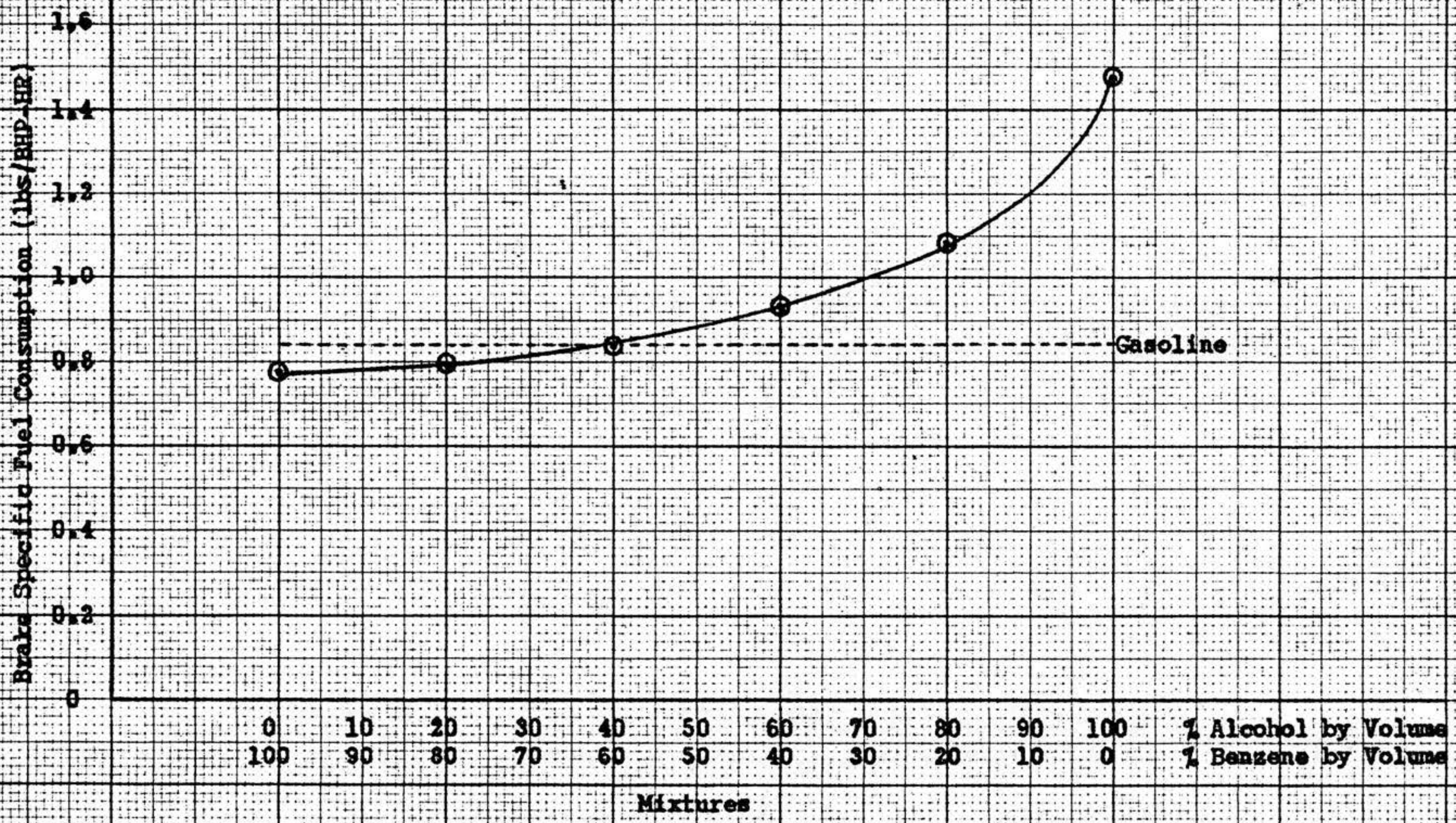


Figure 33 Mixtures vs Brake Specific Fuel Consumption

CONCLUSIONS

With the test method described, it is possible to test alcohol blend fuels and determine the best blend for maximum brake horsepower output without destruction of the engine. It is possible to achieve a higher brake horsepower from a blend of alcohol and benzene than from either component alone because the anti-preignition qualities of the benzene in the blend allow a higher compression ratio to be used to gain the added efficiency which allows the increase in horsepower output of the alcohol in the blend.

A test method can be satisfactorily used with a modified standard C F R engine to test alcohol blend fuels. Test results using this test method are reproducible with a degree of accuracy equal to the standard C F R research methods, providing due caution is exercised in maintaining the test criterion and equipment calibration.

Alcohol blend fuels can be successfully run in spark ignited internal combustion engines to realize a gain in horsepower output over gasoline run in the same engine, but at the expense of fuel economy.

This test method is not as simple to perform as the standard C F R gasoline tests, and requires much more time to rate a fuel blend. However, it represents a scientific approach to the selection of alcohol blend fuels.

Conventional knock testing in a C F R engine does not always predict the detonation behavior of a fuel as used in a multicylinder engine in automotive practice. The methods herein described would not be expected to provide complete performance criteria for the multicylinder engine with its higher rotational speeds. Just as in the case of gasoline fuels, full scale testing under actual operating conditions would be required for objective performance appraisal. It is in this area of multicylinder testing and its correlation to the results presented in this thesis that further study and experimentation would be useful.

BIBLIOGRAPHY

1. "Food for Thought," by H. F. Willkie and Dr. P. J. Kolachov, Indianapolis, Indiana, 1942, pp. 9-19.

2. "Gasoline and Other Motor Fuels," by Carleton Ellis and Joseph Meigs, D. Van Nostrand Co., N.Y., 1921, pp. 5-9.

3. "The High-Speed Internal Combustion Engine," by H. R. Ricardo and H. S. Glyde, Blackie and Son Limited, London, 1944, pp. 31-55.

4. "Fuels and Lubricants," by M. Popovich and Carl Hering, John Wiley and Sons, Inc.,N.Y., 1959, pp. 107-118.

5. "Knock Testing Unit," Waukesha Motor Company Bulletin, Edition 12, Form 880-H, Waukesha, Wisconsin, Dec. 1944, pp. 4-5.

6. "The Testing of High Speed Internal Combustion Engines," by Arthur W. Judge, Chapman and Hall Ltd., London, 1944, pp. 31-37.

7. "ASTM Standards on Petroleum Products and Lubricants," American Society for Testing Materials, Baltimore, 1957.

8. "Antiknock Research Coordinates Laboratory and Road Tests," by C. B. Veal, H.W. Best, J. M. Campbell, and W. M. Haladay, S. A. E. Transactions, Vol. 28, March 1933, pp. 105-120.

9. "SAE Journal," Vol. 29, August 1931, pp. 164,165,&168.

10. "SAE Journal," Vol. 49, May 1941, pp. 193-194.

11. "SAE Journal," Vol. 50, Oct. 1942, page 459.

12. "The Technical Data on Fuel," H. M. Spiers, Editor, British National Committee World Power Conference, London, 1952.

13. Ricardo, _op_. _cit_., pp. 7-8, 14-15.

14. Judge, _op_. _cit_., pp. 10, 92.

15. "The Principles of Motor Fuel Preparation and Application," by Alfred W. Nash and Donald A. Howes, John Wiley and Sons, Inc., N.Y., 1935, pp. 349-447.

16. "Gasoline and Alcohol Tests on Internal Combustion Engines," by Robert M. Strong, Department of the Interior, Bureau of Mines Bulletin 32, Washington, D.C., 1911, page 32.

17. Ellis, _op_. _cit_., page 550.

18. "The Oxidation, Ignition, and Detonation of Fuel Vapors and Gases, Part VIII," by R. O. King, W. A. Wallace, and E. J. Durand, Canadian Journal of Research, F,27:211-224, Toronto, Canada, 1949, page 215.

19. "The Oxidation, Decomposition, Ignition, and Detonation of Fuel Vapors and Gases, Part XX," by R. O. King and A.B. Allan, Canadian Journal of Technology, 30:44-60, Toronto, Canada, 1952, page 51.

20. "Cox Testing Instruments," Commercial Research Laboratories, Inc. Bulletin No. 966, Detroit, 1959, pp. 5-EG and 6-EP.

VITA

George R. Baumgartner was born January 9, 1934, at Burlington, Wisconsin. He received elementary education in Saint Louis County Missouri, and high school education at the Missouri Military Academy, Mexico, Missouri.

He enrolled at Ripon College, Ripon, Wisconsin, in September 1951, and received a Bachelor of Science Degree in Mechanical Engineering from the Missouri School of Mines and Metallurgy in January, 1956. After two years in the service, he was appointed an Instructor in Mechanical Engineering at the Missouri School of Mines and Metallurgy, and continued his graduate study.

He was married in August, 1957, and has two sons, born in July 1958, and in May 1960.