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MAY 78 B G CATCHPOLE, T S KEEBLE
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Mechanical Engineering Technical Memorandum 391

TESTS OF WISCONSIN S12D ENGINE RUNNING ON NATURAL GAS WITH ADDITION OF CARBON DIOXIDE.

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and
T.S. KEEBLE

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SUMMARY

Natural gas or bio-gas are possible alternative fuels to petrol in Otto-cycle engines. A commercial, single-cylinder, spark-ignition engine has been run on various mixtures of natural gas with carbon dioxide to gain experience of its operation and compare its behaviour with operation using petrol.

Whilst there was a considerable drop in power with straight natural gas, the specific fuel consumption was not greatly affected. No attempt was made to advance the spark timing or to increase the compression ratio although both of these changes would be expected to improve the performance considerably.

When operating on gas, it was found possible to vary the power of the engine over a wide range by varying the mixture strength, as in a diesel. Performance was little affected by increase of carbon dioxide content up to 47%.

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16. ABSTRACT:

A commercial single-cylinder spark-ignition engine has been run on various mixtures of natural gas with carbon dioxide to gain experience in its operation and compare its behaviour with operation using petrol.

CONTENTS

1. INTRODUCTION

Consideration was given in A.R.L.[1] during World War II to the operation of Otto-cycle engines on various alternative fuels to petrol.

This consideration was limited in the case of methane to a theoretical study which indicated that there should be little difficulty in operating on this fuel although there would be a power loss due to the slightly lower mass of air induced by the engine and the change in calorific value.

Recently there has been some interest in using bio-gas as an engine fuel; bio-gas is essentially methane from decomposing organic matter, with varying percentages of carbon dioxide. Traces of other gases like hydrogen sulphide are also present but these are not expected to affect combustion and heat release greatly although they can give rise to a little undesirable sulphur dioxide etc., in the exhaust.

Again, during World War II it was not unusual to see vehicles operating from towns gas stored in flexible bags on their roofs. Towns gas is not now made from coal in Melbourne but is 'natural gas' which is largely methane (details in Appendix 1); as this is readily available and a possible alternative to petrol it was decided that it would be interesting to get some first hand experience of running a small, commercial, Otto-cycle engine on natural gas and also to see what the effect of additions of varying proportions of carbon dioxide had on the performance of the engine.

2. EXPERIMENTAL SET-UP

To this end a Wisconsin engine, (details in Appendix 2), was set up with its power absorbed in a water brake.

It was run on petrol at a speed of 2400 r.p.m. with the throttle fully open. The normal carburettor was used but was modified so that a needle could be inserted into the main jet to vary the fuel flow.

In this way it was possible to run a 'fuel loop' and measure the power and fuel consumption over a range of mixture strengths.

The carburettor was removed when the engine was run on gas. The engine inlet was connected to a large, commercial, displacement-type meter so that the air consumption could be measured. When running on gas, it and the carbon dioxide addition were similarly metered and mixed with the air just upstream of the engine intake.

The spark timing on this engine is fixed at 18° advance; no attempt was made to alter this throughout the tests although it is known[2] that best conditions for running on gas are obtained with a considerably more advanced spark than with petrol.

3. RESULTS

Figs. 1, 2 show the power and fuel consumption as a function of equivalence ratio (i.e. fuel to air ratio divided by the chemically correct ratio; 0.068 for petrol and 0.060 for natural gas). The ambient air temperatures and pressures for the tests were as follows:

	Temp.	Pressure
Petrol	300 K	102.3 kPa
Methane + 1.6% carbon dioxide (town gas)	303 K	101.3 kPa
Methane + 36% carbon dioxide	303 K	102.3 kPa
Methane + 47% carbon dioxide	303 K	102.3 kPa

The air consumption of the engine when running on town gas was about 0.008 kg/s, depending on the fuel/air ratio, and about 0.009 kg/s when running on petrol.

4. DISCUSSION

There was a significant power loss when operating on town gas but it would be expected from Ref. 2 that some of this loss would be regained by an advance in spark timing.

The specific fuel consumption is not greatly affected although here again significant improvements would be likely with an increase in spark advance.

An unexpected result is the very small effect of adding carbon dioxide. Even with 47% addition, the power loss is comparatively small and specific fuel consumption (based, of course, on methane consumption) is not nearly so greatly affected as might have been expected.

The other interesting characteristic of the engine when running on gas is an ability to control the power output smoothly over a useful range by changing the mixture strength. However, when the power is decreased by weakening the mixture there is a fairly rapid rise in fuel consumption; this effect is small in a diesel cycle engine; it is possible that spark timing would effect this although it may be due to a decrease in mechanical efficiency rather than a lowering of combustion efficiency.

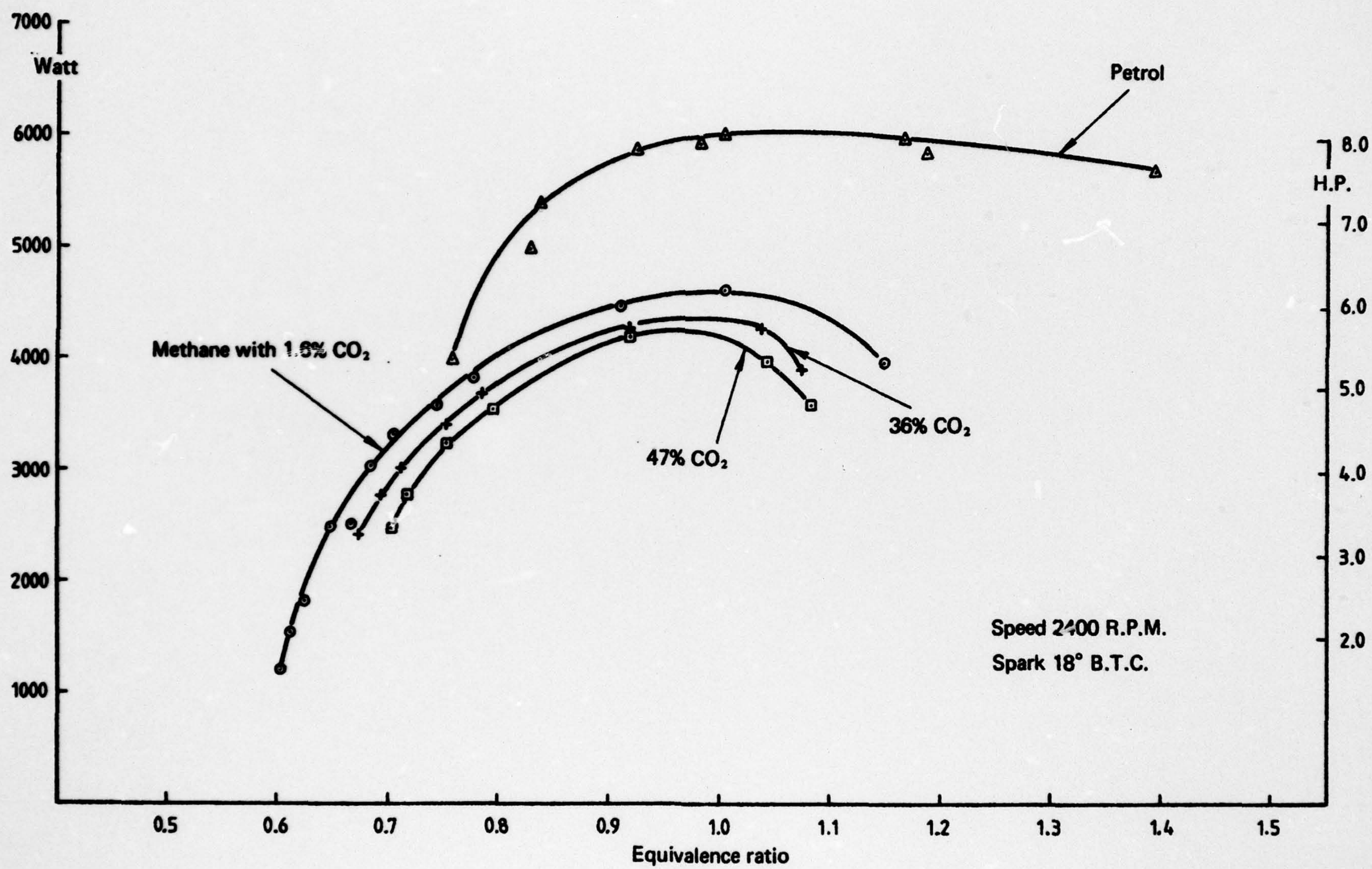

FIG. 1 WISCONSIN S12 D ENGINE: POWER

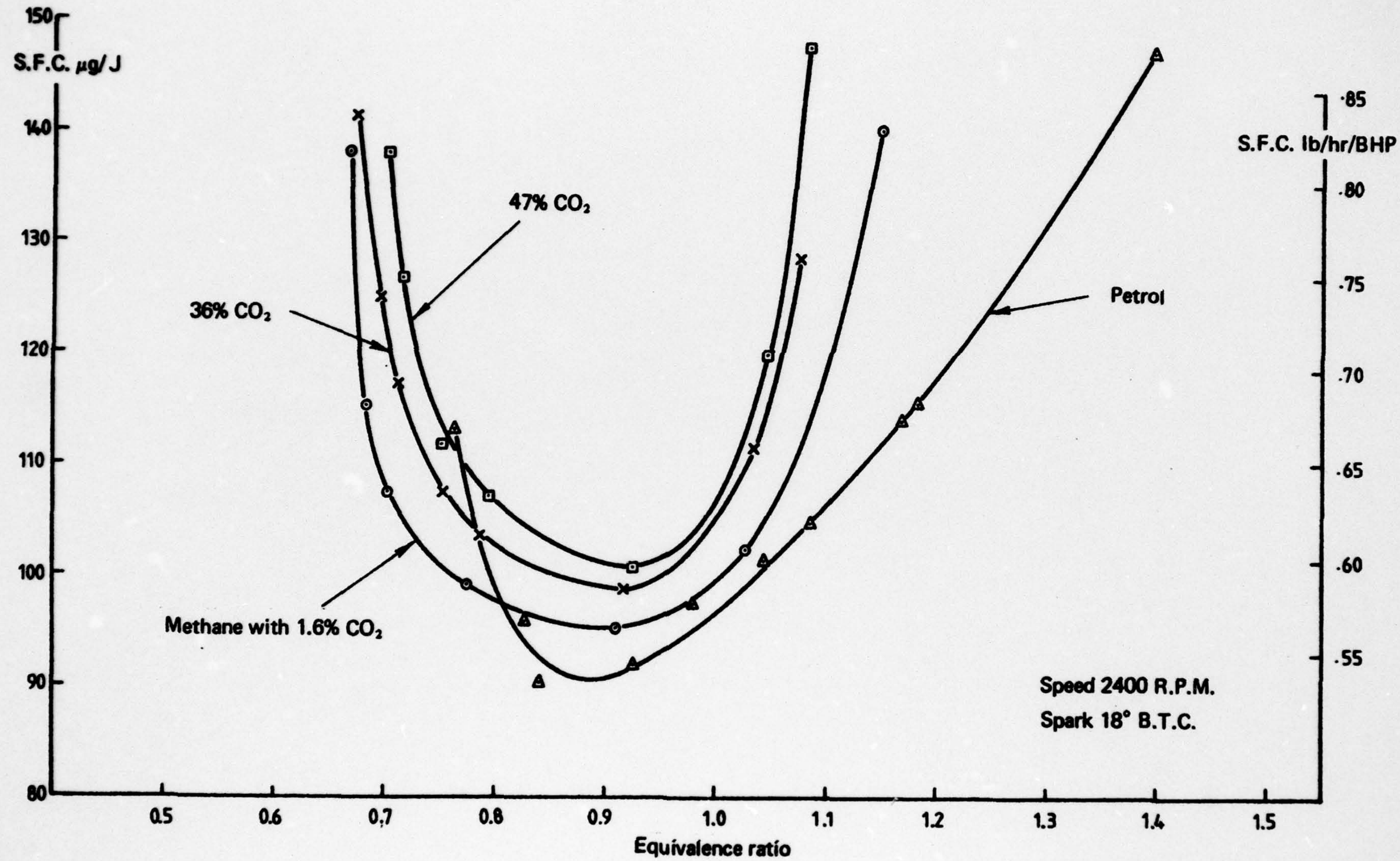

FIG. 2 WISCONSIN S12 D ENGINE: FUEL CONSUMPTION

APPENDIX I

NATURAL GAS AS SUPPLIED TO MELBOURNE

(from Scientific Service Laboratories of the Gas & Fuel Corporation).

	% by Weight
Methane	91.1
Ethane	5.81
Propane	0.45
Iso Butane	0.01
Butane	0.04
Carbon Dioxide	1.60
Nitrogen	0.88
Oxygen etc.	0.04

Calorific value 38.8 MJ/m^3 at $15^{\circ}C$ and 101.325 kPa

Specific Gravity 0.609

Stoichiometric mixture .0602 natural/gas/air.

PETROL

Stoichiometric mixture .0679 petrol/air,

APPENDIX II

Wisconsin S12D Engine

Four Stroke Cycle, Spark Ignition

Bore 88.9 mm (3.50 inches)

Stroke 76.2 mm (3.00 inches)

Displacement 472.9 ml (28.86 cu. in.)

Compression Ratio 7.34:1

Rated Power 9.33 kW (12.5 BHP) at 3600 R.P.M.

Ignition Timing - Fixed at 18° B.T.C.

Inlet Valve Area 774 mm^2 (1.20 sq. inches)

Exhaust Valve Area 771 mm^2 (1.195 sq. inches)

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1. The power output of an engine running on Methane - CSIR Division of Aeronautics Engines Note E2.

2. J.K.S. Wong. Study of mixtures of methane and carbon dioxide as fuels in a single cylinder engine (CLR). National Research Council Canada NRC No. 15636, Ottawa, September 1976.

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