



## P9005

### TWO SHAFT GAS TURBINE UNIT

#### FEATURES

- ◆ Self-contained complete teaching facility
- ◆ Designed for safe easy operation with low noise levels
- ◆ Data logging option available for all measured variables
- ◆ Comprehensive controls and instrumentation displayed in multi-colour flow diagram

#### EXPERIMENTAL CAPABILITY

Allows an extensive programme of experiments in Gas Turbine technology including:

- ◆ Performance of a simulated single shaft unit
- ◆ Performance of a single shaft unit with nozzle simulated load ( with thrust nozzle option - availability on request).
- ◆ Performance of a two shaft unit
- ◆ Characteristics of individual components
  - gas generator compressor
  - combustion chamber characteristics
  - power turbine characteristics

#### INTRODUCTION

Gas turbines are becoming increasingly used as power plants for a wide variety of applications around the world. Originally they were developed solely for aircraft propulsion where their inherent low specific weight (i.e. mass/unit power) made them essential for high speed flight. For this particular purpose they have been developed to a high degree of efficiency both thermodynamically and mechanically.

Due partly to the impetus from the aircraft engine field and also to other significant operational advantages, industrial gas turbines have been and are being developed for such diverse applications as electrical power peak lopping stations, fire fighting pump sets, natural gas pumping and compressor units, factory power and process heating plants, heavy lorry propulsion, rail and ship propulsion.

Cussons have designed and manufactured educational gas turbines since 1970 and the latest version incorporates many improvements.

Cussons P9005 Gas Turbine Unit is now offered as a full two shaft machine with built in starting equipment, power absorption system and data logging option (P9008). It provides the means for carrying out an extensive programme of experiments in gas turbine technology using only the instrumentation provided. Particular features of the Two Shaft Gas Turbine Unit are its versatility, ease of operation, safety and low noise level. All instrumentation and controls are carried on the panel which displays the flow diagram with a clear indication of all measurements identified by symbols and illuminated tell-tales. Measurement of power turbine torque is by calibrated electrical dynamometer.

#### GENERAL DESIGN

The Two Shaft Gas Turbine employs a centrifugal compressor and a radial turbine, arranged back to back on a common shaft which together with a gas-fuelled combustion chamber operating on propane or butane, form the gas generator. Gases from the gas generator turbine pass to the power turbine which is a radial machine of larger size and thence to exhaust. The power turbine is loaded by a dynamometer system to absorb the power output and measure the power turbine torque. Starting is effected by an electrically driven auxiliary air blower, incorporated within the unit and delivering into the eye of the compressor, which accelerates the compressor/turbine initially and assists it until self-sustaining speed is reached after light-up. There is a lubrication system for both the compressor/turbine and the power turbine incorporating an electrically driven pump, filter, oil cooler and reservoir. Oil cooling is automatically controlled. The P9005 is now supplied fully tropicalised and is generally suitable for use in ambient temperatures of up to 40°C and ambient conditions of up to 80% relative humidity.

#### FLOW DIAGRAM

The flow diagram (Fig. 1) is reproduced in colour on the instrument panel of the unit.

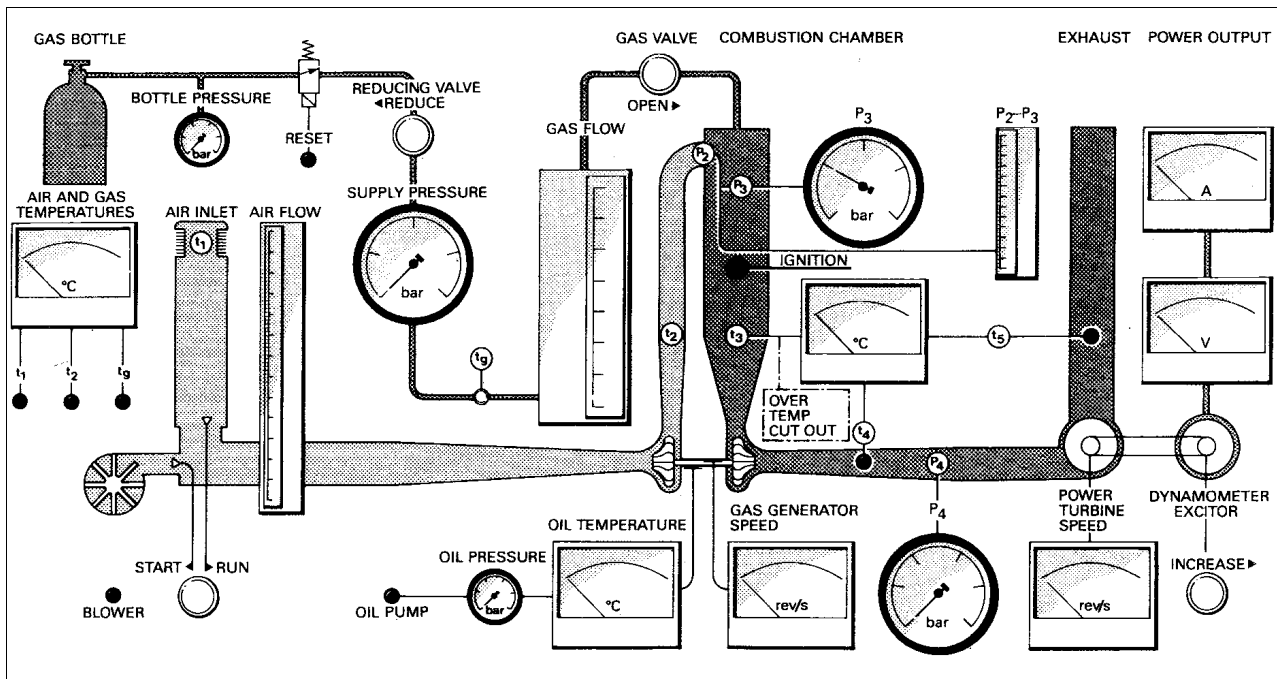


FIG. 1 FLOW DIAGRAM

### ASSEMBLY

The complete unit is built on a robust steel chassis mounted on castors, carrying a melamine laminate instrument panel and steel clad panels. The overall dimensions permit the unit to pass through any normal doorway and special attention has been paid to the requirements of easy installation, low noise level, convenience of operation and safety.

### INSTRUMENTATION

Instrumentation, all of which is carried on the front panel, is provided to measure temperatures and pressures throughout the cycle, flow rates of air and fuel, rotational speeds of the compressor/turbine unit and the power turbine and the power turbine output torque. Temperature measurement is by NiCr/NiAl thermocouple instruments for seven temperatures.

Pressure measurement is by manometer for differential pressure but otherwise by Bourdon tube gauges, air flow by pitot head assembly, fuel flow by a variable area flow meter, rotational speeds by electronic tachometer and power output by electrical power measurement. The instrumentation has been located in a logical sequence to facilitate readings.

#### P9008 Transducer and Signal Conditioning for data logging option for P9005

The purpose of this optional factory-fitted accessory is to provide conditioned 0-10V dc analogue signals for the following measured parameters:

- Temperatures (7) -
- T1 air inlet
  - T2 compressor exit
  - T3 combustion chamber exit
  - T4 power turbine inlet
  - T5 power turbine outlet
  - Tg fuel
  - To oil

- Pressures (5)
- Po oil
  - Pg fuel
  - P3 gas generator inlet
  - P4 power turbine inlet
  - Pcc combustion chamber pressure loss
- Flow rates (2)
- Air
  - Fuel
- Speeds (2)
- Gas generator
  - power turbine
- Alternator current  
Alternator voltage

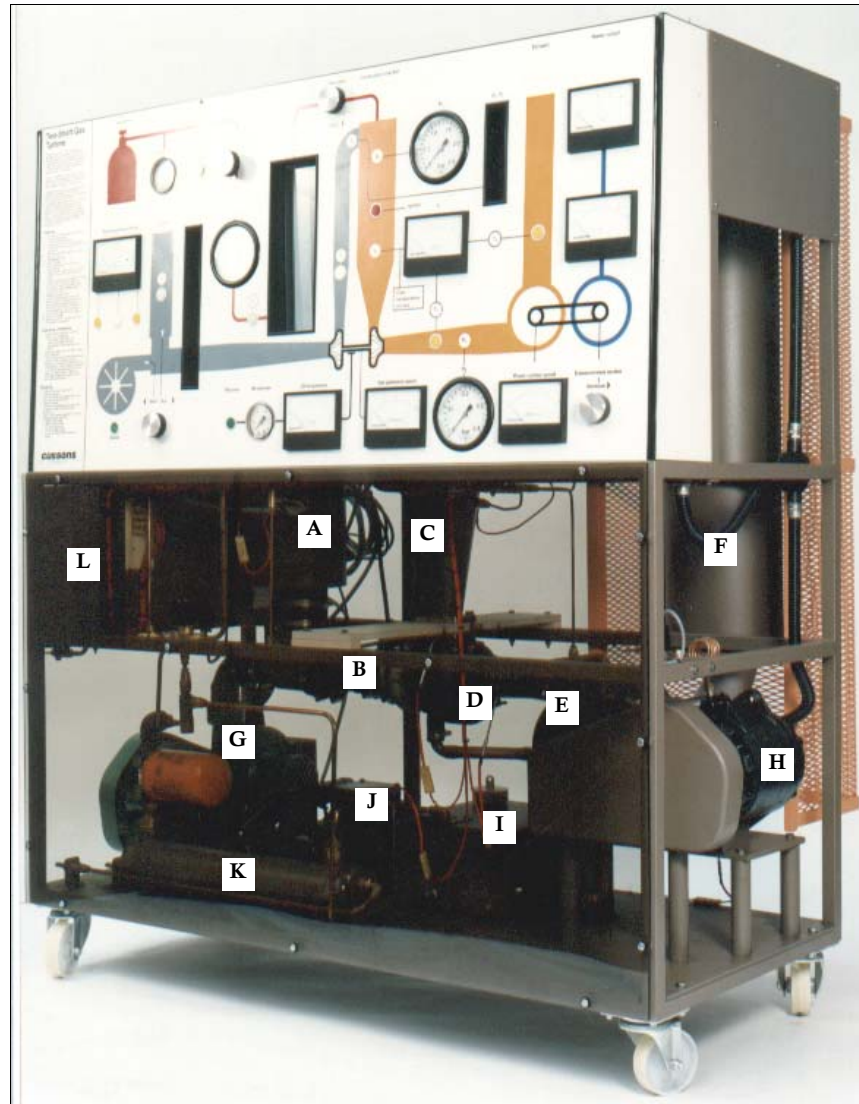
**The P9008 Signal Conditioning for Data Logging Option** comprises an additional dc power supply (0v, 5v, 15v and +24v), 4 pressure transducers, 3 differential pressure transducers, fuel orifice, rms voltage and current sensing modules and an additional printed circuit board, plus all necessary additional wiring, piping and connections. The outputs, which are all amplified to 0-10v dc, are connected to two D type sockets. These signals may then be connected to a computer or data logging system.

**N.B. Neither a computer nor a data logging system are included in the extent of supply but details are available on request.**

Where a P9005 Two Shaft Gas Turbine is supplied with a P9008 Signal Conditioning for Data Logging Option the original instrumentation is still supplied and the signals for data logging are multiplexed. This provides the opportunity for students to still obtain instrument readings manually in addition to the interface facility for automatic data logging.

### FUEL SYSTEM

In temperate climates propane and in tropical climates butane, or mixtures of the two supplied in bottles, form the fuel supply to the unit. The use of bottled gas is particularly convenient and also is a significant safety feature as large quantities of fuel cannot build up in the system in the event



**FIG. 2 FRONT VIEW OF TWO SHAFT GAS TURBINE UNIT**

- |                           |                             |
|---------------------------|-----------------------------|
| A - Inlet Air Silencer    | G - Starting Air Compressor |
| B - Compressor            | H - Dynamometer             |
| C - Combustion Chamber    | I - Oil Reservoir           |
| D - Gas Generator Turbine | J - Oil Pump                |
| E - Power Turbine         | K - Oil Cooler              |
| F - Exhaust Silencer      | L - Mains Electrical Input  |

of non light up. Stable combustion conditions are reached very quickly, and due to the small pressure excess necessary to inject the fuel, any overspeeding of the unit will cause drop in fuel mass flow and provide worthwhile governing action.

#### **COMPRESSOR/TURBINE SYSTEM**

The compressor is formed in light alloy and operates at a pressure ratio of approximately 2:1. The combustion chamber operates at high efficiency and permits stable operation over a wide range of mass flows with an even temperature distribution. The gas generator turbine operates over the speed range of 600 to 1400 rev/second according to fuelling with the power turbine operating over the range 170 to 590 rev/second and developing a maximum power of about 4 kW.

#### **SAFETY PROTECTION**

Particular attention has been paid to questions of safety in operation. The unit is protected against over temperature, lubricating oil pressure failure and mains failure. A solenoid valve cuts the fuel supply in the event of any such malfunction and must be reset before the unit can be re-started. The compressor/turbine speed is limited by the fuel availability and power turbine excess speed causes temperature rise which actuates the over temperature trip. The main components are shielded from the user by a steel front panel with a transparent polycarbonate panel available as an option.

#### **OPERATING INSTRUCTIONS AND A SUGGESTED PROGRAMME OF EXPERIMENTAL WORK**

Complete operating instructions are provided with each unit and a comprehensive test programme is described in Cussons publication 'A First Course in Gas Turbine

Technology' by T.H. Frost. Graphs of typical test results are shown in Fig. 3 opposite.

## P9005 TWO SHAFT GAS TURBINE UNIT

### SPECIFICATION

Two Shaft Gas Turbine Unit on self contained moveable stand comprising single shaft compressor/turbine unit combustion chamber for operation on propane, butane or propane/butane mixtures, power turbine, calibrated electrical machine for torque and power measurement, ignition system, oil tank, circulating pump, cooler and filter, five colour instrument panel with flow diagram, fitted inlet air flow meter, fuel flow meter, tachometers (2), multi point thermocouple instrument, sensitive pressure gauges (3), manometer, oil pressure gauge and fuel supply pressure gauge. Complete with starting air compressor set and all controls. Supplied tropicalised for use in conditions up to 40°C ambient and 80% relative humidity. Gas bottle and connecting pipe not included.

#### Services Required:-

- Electrical supply : 220/240 volt 50 Hz single phase supply. Other voltages and frequency to special order.
- Fuel supply : Propane/butane (C3H8) in standard gas take off bottles (45 kg bottles are recommended). N.B. Consumption at full load approx. 7 kg/hr.
- Water Supply : required for cooling oil circuit with 9 mm bore flexible hose and minimum flow rate of 10 litres/min.
- Exhaust Provisions : exhaust is non-toxic and clean but for extended running ducting required.

## P9007 SECTIONED COMPRESSOR/TURBINE UNIT

### SPECIFICATION

Compressor/Turbine Unit similar to Gas Generator supplied on P9005 sectioned to show all functions and mounted on base.

## P9008 SIGNAL CONDITIONING FOR DATA LOGGING OPTION

### SPECIFICATION

Factory-fitted option for P9005 to provide signals for 15 measured variables comprising additional dc power supply, 4 pressure transducers, 3 differential pressure transducers, fuel orifice, rms voltage and current sensing modules and an additional printed circuit board, plus all necessary wiring, piping and connections.

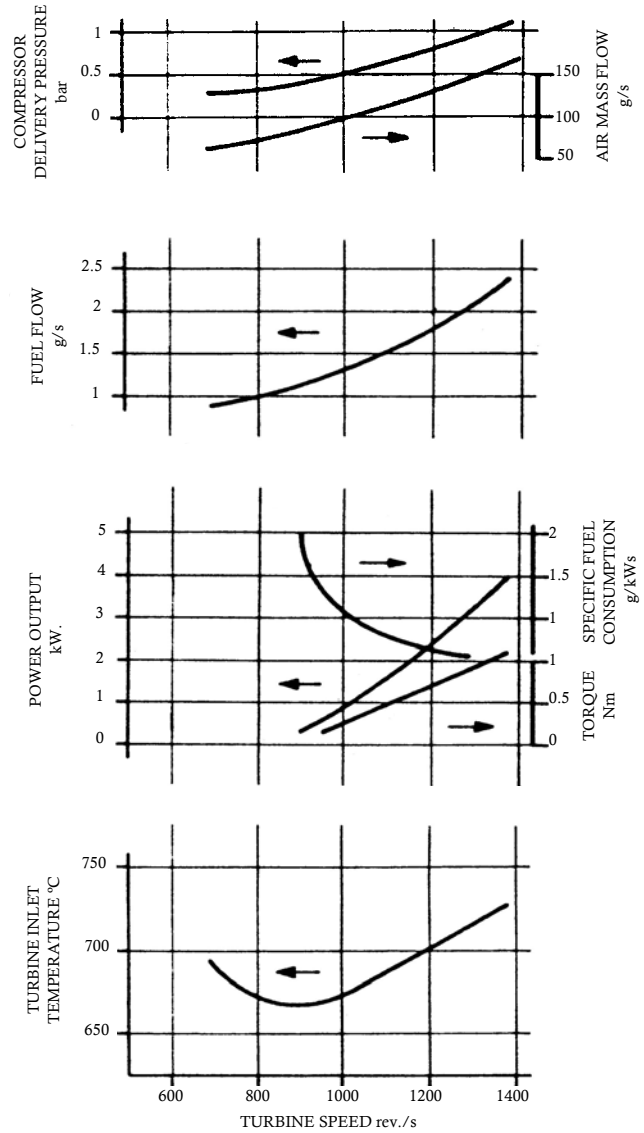


FIG. 3 TEST RESULTS FOR P9005

## P9014 A/D CONVERTOR CARDS AND SOFTWARE

Two 16 channel 12 bit A/D Converter PCB's suitable for fitting into IBM compatible Personal Computer and software to enable display and logging of measured parameters.

## PHYSICAL DETAILS

	Nett Weight		Length		Width		Height	
	kg	lb	m	in	m	in	m	in
P9005	350	770	1.37	54	0.86	34	1.60	63
P9007	5.5	12	0.30	12	0.30	12	0.25	10
P9008	Included within P9005 above							
P9014	Included within P9005 above							

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