

THERMODYNAMICS AND HEAT TRANSFER CUSSONS TECHNOLOGY LABORATORY RECOMMENDATION

Cussons Technology's Thermodynamic lab is arranged to provide a coordinated teaching package of thermodynamic principles. The range is designed to complement other Cussons ranges such as automotive, refrigeration, fluids, renewable energy and steam, which provide more advanced studies based on thermodynamic principles.

The Thermodynamic lab provides well designed experiments to support the teaching of fundamental thermodynamic principles; heat transfer, work transfer, and the application of thermodynamic principles in applications such as vapour cycles, gas power cycles and fundamentals of thermodynamic measurement.

All products can be supplied with or without Cussons CuDaq Data Acquisition

Please see www.cussons.co.uk for additional information on any product, or contact sales@cussons.co.uk

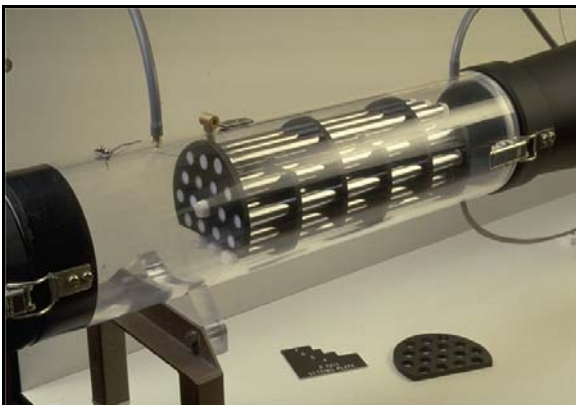
Heat Transfer Equipment

P3210 Heat Transfer Bench with Cross Flow Heat Exchanger

A heat transfer bench providing air flow over a heated sample tube. Experiments balance the amount of heat required to maintain the heater surface temperature in an air flow. Instruments measure heat input, heater surface temperature, air flow rate etc. The low heat input allows a constant air temperature

- ◆ To determine the relationship between Nusselts and Reynolds numbers applied to a single heated tube positioned transversely to a stream of air.
- ◆ To determine the effect of change of diameter on the heat transfer coefficient to a single tube in cross flow.
- ◆ To determine the effect of change of position of the heated tube within a cross flow tube bundle.
- ◆ To examine the effect of heat transfer of a Flat Plate (with P3214) and a Finned Pipe arrangement (with P3215)

The bench can be used with many additional experiments including parallel and mixed flow exchange



P3212 Parallel Flow Heat Exchanger

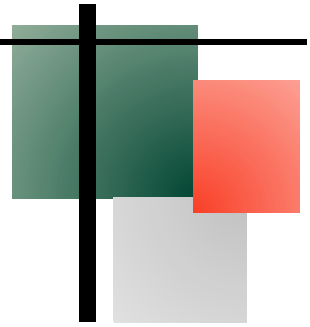
Works with the P3210, a cartridge heater parallel to the flow, with heat, surface temperature and flow measure

- ◆ Determine the relationship between Nusselt's and Reynold's numbers for a stream of air flowing around and parallel to a heated tube (annular flow).
- ◆ Also through a tube with heated inner section.

P3213 Mixed Flow Heat Exchanger

A tube bundle with one heated element

- ◆ To determine the heat transfer coefficient from tube wall to shell side within a tube bundle
- ◆ To determine the relationship between Nusselt's and Reynold's numbers by varying the flow rate of air.



P3300 Radiation and Convection Apparatus

Options include P3301 and P3302

P3300 comprises a heater element within a vessel that can be evacuated to a high vacuum, whilst the heater temperature and heater shape can be varied. Measurement of heat input and temperatures allows a range of parameters to be studied.

- ◆ Demonstration of the Stefan Boltzman law of radiation and determination of the constant for differing ambient conditions
- ◆ A study of the concept and parameters of emissivity
- ◆ An investigation of natural convection for different gases, introducing the Prandtl, Grashof and Nusselt dimensionless groups
- ◆ A determination of the natural convection heat transfer coefficient at different pressures
- ◆ An investigation of the effects of orientation of the heat source on the convection heat transfer coefficient

With the P3301 and P3302 Pressure Test Cover further investigations can be carried out :

- ◆ The effect of changes of shape of the heat source on natural convection
- ◆ The effect of change of emissivity value of the heat source on radiated heat



P3300 allows the convection heat transfer to be reduced by reducing the air pressure, whilst radiated heat is still transferred

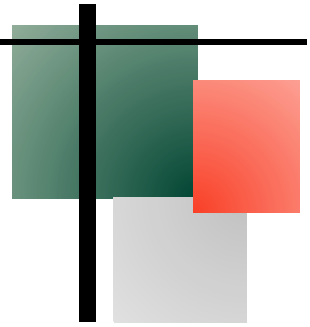


P5687 showing the range of test samples supplied. Long high conductivity samples can be tested or short lengths of insulating materials

P5687 Thermal Conductivity Apparatus

The apparatus consists of a vertical stack of specimens clamped between an electrically heated source at the top and a water cooled base, all contained within a Dewar vessel and furnished with a radiation shield and anti-convection baffle. The specimens are fitted with very small thermocouples at known distances apart and connected via a selector switch to a digital temperature readout. The variable heating current is displayed on a digital ammeter.

- ◆ To demonstrate that heat flow is directly proportional to temperature differences between specimen faces
- ◆ To demonstrate that heat flow is directly proportional to cross sectional area
- ◆ To derive the thermal conductivity of materials of high thermal conductance
- ◆ To determine the thermal conductivity of insulation materials.

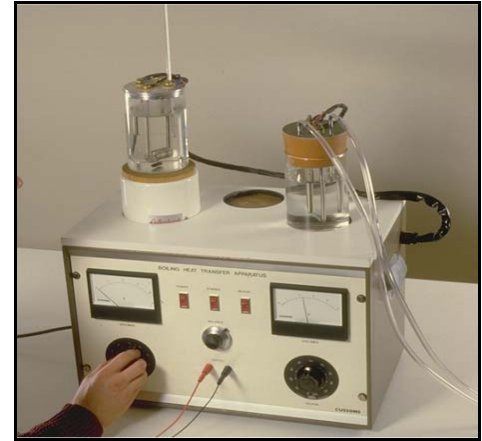


P5697 Boiling Heat Transfer Apparatus

The apparatus has been developed to permit experiments on heat transfer from the solid to the liquid state under conditions of convection and nucleate boiling to be carried out and to demonstrate the effect of film boiling. Heat transfer takes place from a heated horizontal nickel filament to the water or other liquid surrounding it.

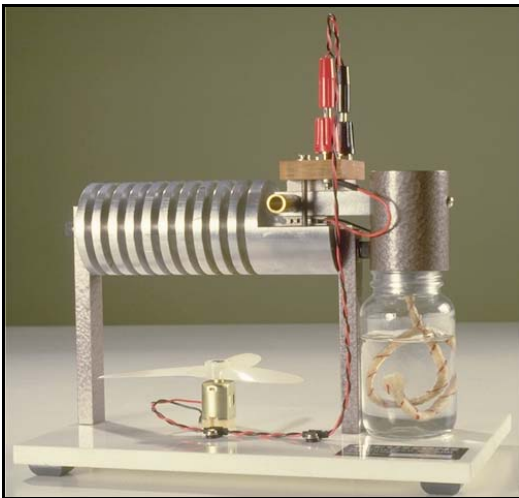
It consists of the heat proof glass observation vessel containing the liquid and housing the nickel filament whose length and diameter can be measured, together with an additional low voltage heating element for rapid warm up.

A second vessel with cooling system accommodates the second arm of the bridge, a variable voltage supply for filament heating, the AC bridge circuit, a panel mounted ammeter and voltmeter, switch gear, electrical stirring system and a 0-105°C thermometer. A small oscilloscope necessary to balance the bridge is NOT included in the supply.



Work transfer Experiments

Cussons range of work transfer experiments includes engines of first principles such as the Sterling Engine, and Thermoelectric engine as well as conventional engines and heat equivalent.



P5689 Thermo Electric Engine

This apparatus has been developed to demonstrate the conversion of heat into electricity and hence into useful work. It comprises a multiple cell Thermo-Electric generator sandwiched between a hot source and a cold sink where the hot source is a conventional laboratory spirit burner and the cold sink is cold air cooled by convection assisted by the action of the propeller. The current generated by the thermo-electric effect is then used to drive an electric motor on which the propeller is mounted.

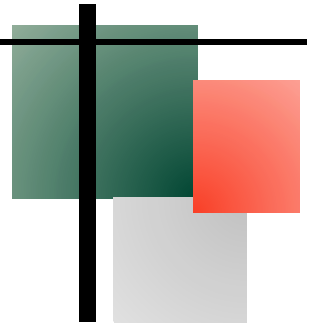
On open circuit the generator has an emf of about 2 volts and the maximum current is about 1 amp and from this the output can readily be measured. The heat input is supplied by a spirit lamp and therefore the rate of fuel supply can be measured. The temperatures of the hot and cold surfaces may be recorded.

P5700 Marcet Boiler

Cussons P5700 Marcet Boiler has been developed for investigating the relationship between the pressure and temperature of saturated steam, in equilibrium with water, at all pressures between atmospheric and 17 bar (250 lb/in²). The measured value of the slope of the graph $(dT/dP)_{SAT}$ obtained from the practical results can be compared with corresponding values calculated from the data in steam tables .

- ◆ Electrically heated boiler fabricated from heavy duty steel section
- ◆ Supplied complete with safety valve, pressure gauge and water cock
- ◆ Boiler lagged to permit rapid heating and arranged for bench mounting





P5631 Mechanical Equivalent of Heat Apparatus

This equipment is a modern version of the Mechanical Equivalent of Heat apparatus derived from the original design by Callendar which aptly demonstrated the relationship between mechanical energy and heat energy. Though extremely simple in design, the apparatus will yield results with an accuracy of 0.5%.

The apparatus incorporates a universal electric motor with variable speed control for driving a brass drum calorimeter, two sets of weights, heavy and light, a set of brake bands to encircle the drum, a spring balance, a thermometer and a counter for recording the revolutions of the drum. All items of equipment are mounted on the steel cabinet which contains the motor control gear.



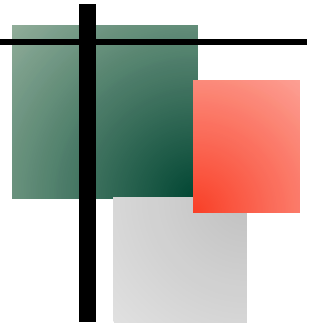
P5691 Sterling Cycle Hot Air Engine

Cussons P5691 Stirling Cycle Hot Air Engine is a modern example of one of the oldest forms of prime mover first described in a patent by Robert Stirling in 1816 and designed to show the direct conversion of heat energy into work.

The cycle on which the engine is based consists of two isothermal processes and two constant volume processes (the latter being performed with the aid of a regenerator). The source of heat is provided from a low voltage electric element so that it may readily be controlled and measured. Output is measured by the simple dynamometer supplied.

The engine has one working cylinder and a transfer cylinder arranged side by side in open communication one with another but without any intervening valve mechanism. The power cylinder has a single acting piston connected to the crankshaft while the transfer cylinder has a double acting displacer piston and regenerator operated by an eccentric, the phasing of which can be altered in relation to the crankpin of the power cylinder.





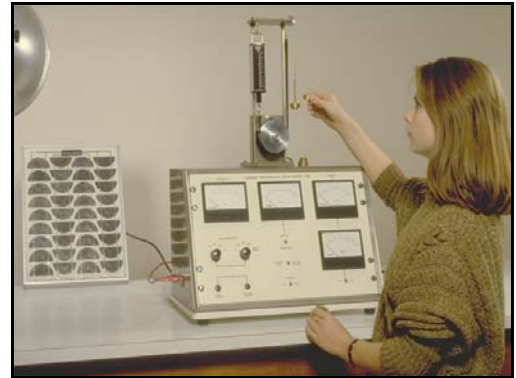
Solar energy equipment

Cussons solar energy equipment compliments its thermodynamics and renewable energy product ranges—for further information please see the CD or contact Cussons.

P9060 Photovoltaic Solar Power Unit

This unit provides students with the means of collecting and storing solar power, measuring the energy thereby made available and investigating the performance of the Photovoltaic unit. Unlike the simple absorbent panels currently widely used in order to supply low grade thermal energy, this unit enables both electrical and mechanical power to be obtained yet it does not require the use of complicated reflecting systems in order to concentrate the solar energy.

- ◆ Collects and stores solar power
- ◆ Highly efficient energy conversion - 100 watts/metre²
- ◆ Does not require complicated reflecting systems
- ◆ Stored energy can be converted for use by electric motor



P7130 –5 Solar Distillation Apparatus

Each apparatus allows the distillation of water from brine, in controlled experiments in which the temperatures flows and condensate rates are measured so that energies are analysed and balanced.

P7130 comprises of a still basin solar panel, allowing the water to evaporate from a still basin. P7135 comprises of a sloping surface over which the brine flows at variable rates

Each unit can be operated with varying insulation, angles and flow rates and with a variety of mats for solar absorption

Accessories for Solar Energy Equipment

P7131 is a solar meter to measure the energy from the light, P7132 is an anemometer for wind measurement, P7133 an inclinometer for the angle of the panel, P7141 is an array of four lamps for artificial sunlight, and P7142 is a CuDaq data acquisition unit.

P7140 Solar Energy Demonstrator

The solar energy demonstration unit allows students to gain an appreciation of the total heat capture of a solar energy unit as it heats water, and an indication of its relative efficiency.

Students are able to vary the flow rate and angle of incidence of the unit to measure the change in energy collection performance

- ◆ Measures output and efficiency against solar energy input
- ◆ Effect of different absorbent surfaces
- ◆ Effect of ambient temperature, wind velocity and the effect of cooling the glass cover
- ◆ Effect of insulation thickness
- ◆ Investigate the effects of varying the inclination of the absorption surface and the flow rate of the water,
- ◆ To perform a heat balance for the overall system



Gas turbine and air compressor equipment

Cussons range of work transfer experiments includes:



P9080 Energy Balance Apparatus

Metal frame bench mounted single stage compressor set consists of a rotary vane type air compressor coupled to a trunion mounted electric motor and attached to a spring balance. The air intake includes a filter, air flow adjustment and plenum chamber with vacuum gauge scaled -1.0 to 0 bar. The air flow meter used has a range of 40-400 l/min with a pressure limit of 10 bar at 20°C.

The air outlet pressure chamber includes a 0-4 bar pressure gauge, pressure relief valve and exhaust silencer.

Type K thermocouples measure air inlet and outlet temperatures with a continuous operating range of 0—1100°C.

The instrument control box measures speed, temperature torque and power.

- ◆ Energy balance and the first law of thermodynamics
- ◆ Entropy and the second law of thermodynamics
- ◆ Compressed volumetric efficiency

P9005 Two Shaft Gas Turbine

Cussons P9005 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

- ◆ Performance of a simulated single shaft unit
- ◆ Performance of a single shaft unit with nozzle simulated load
- ◆ Performance of a two shaft unit
- ◆ Characteristics of individual components
 - gas generator compressor
 - combustion chamber characteristics
 - power turbine characteristics

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.



P3267 Flutter Wing Model

Experiment to demonstrate wing flutter, including an aerofoil section supported on eight un-damped springs.

P3271 Aerofoil with Flap & Slot P9050 Two Stage Air Compressor Set

Cussons P9050 Two Stage Reciprocating Air Compressor Test Set has been designed as a high quality educational test facility on which a wide range of controlled experiments can be undertaken on the performance of reciprocating air compressors and compressed air plant.