HEAT TRANSFER SERVICE UNIT

Model Number : GOTT-HTSU-1

INTRODUCTION

A fully instrumented bench top heat transfer service unit providing regulated and adjustable AC Power and instrumentation for 15 optional heat transfer experiments into conduction, convection, radiation, steady state and transient heat transfer.

GENERAL SPECIFICATIONS

- A metal cased bench mounted heat transfer service unit containing a regulated and variable AC power supply nd signal conditioning with three digital displays and selector switch for up to 12 type K thermocouples, AC voltage and current. Internal electric and mechanical safety devices to allow for unsupervised operation by students
- Optional demonstration units available are as follows:

  Radial Heat Conduction
  Linear Heat Conduction
  Radial Heat Conduction
  Laws of Radiant Heat Transfer & Radiant heat Exchange Combined Convection And Radiation
  Extended Surface Heat Transfer
  Radiation Errors In Temperature Measurement
  Unsteady State Heat Transfer
  Thermal Conductivity of Liquids & Gases
  Perfect Gas Laws Demonstration
  Marcet Boiler
  Thermal Conductivity of Buildings Material
  Free And Forced Convection From Flat, Pinned and Finned Plates Thermoelectric Heat Pump
  Closed Cycle Hot Air Engine
  Boiling Heat Transfer

- Electrical Specifications:
  - 220 - 240V, Single phase, 50Hz (With earth/ ground). Line current up to 6A at 230V

OPTIONAL ITEM

RADIAL HEAT CONDUCTION

CODE 976-750

DESCRIPTION

A small-scale accessory designed to experimentally investigate the basic principles of radial heat conduction and to allow the thermal conductivity of the solid metal disc to be determined. An insulated, 110mm diameter brass disc 3.2mm thick is heated in its centre by a nominal 100W heater (operating at 240v ac maximum) which is fitted with a high temperature limit switch. The power supplied to the heater is controlled and measured by the H112, Heat Transfer Service Unit. The periphery of the disc is cooled by water passing through a copper tube bonded to the disc. Six type K thermocouples are positioned at 10mm radial increments from the heated centre to the periphery. All six thermocouples plug directly into the H112, Heat Transfer Service Unit and temperatures are displayed on its digital panel meter.

EXPERIMENT TOPICS

- To measure the temperature distribution for steady state conduction of heat energy through the wall of a thick cylinder (Radial energy flow) and demonstrate the effect of a change in heat flow
- To understand the use of the Fourier Rate Equation in determining rate of heat flow for steady state conduction of heat energy through the wall of a thick cylinder and using the equation to determine the constant of proportionality (the thermal conductivity k) of the disc material.
- To observe unsteady state conduction of heat and to use this in observation of the time to reach stableconditions.

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OPTIONAL ITEM

LINEAR HEAT CONDUCTION

CODE 976-751

DESCRIPTION

A small scale accessory that allows experimental investigation of linear heat conduction and the measurement of the thermal conductivity of various solid conductors and insulators. An insulated, 25mm diameter brass heated section and cooling section that may be either clamped together, or assembled with one of four insulated intermediate sections or test specimens between the interfaces. The hot end uses a nominal 75W heater (operating at 240v maximum), which is fitted with a high temperature limit switch. The power supplied to the heater is controlled and measured by the H112, Heat Transfer Service Unit.

The cold section is of identical dimensions to the hot end and is water-cooled. Both the heated and cooled ends are each fitted with three thermocouples at 15mm intervals to measure the temperature gradients along the bars.All eight thermocouples plug directly into the H112, Heat Transfer Service Unit and temperatures are displayed on its digital panel meter

EXPERIMENT TOPICS

- Understanding the fourier rate equation in determining the rate of heat flow through solid materials.
- Measuring the temperature distribution for steady state conduction of energy through a uniform plane solid and a composite plane solid.
- Determine the constant of proportionality (Thermal Conductivity) of different materials (conductors and insulators).
- Measuring the temperature drop a the contact face between adjacent layers in a composite plane solid.
- Measuring the temperature distribution for steady state conduction of energy through a plane solid of reduced cross sectional area.
- Understanding the application of poor conductors (insulators).
- Observing unsteady state conduction (qualitative only).

LAWS OF RADIANT HEAT TRANSFER AND RADIANT HEAT EXCHANGE

CODE 976-252

DESCRIPTION

- The Laws of Radiant Heat Transfer and Radiant Heat Exchange allows the basic laws of heat transfer by radiation (both heat and light) to be investigated. Two appropriate detectors, light filters, target plates of different Emissivity and aperture plates each mount on suitable carriages on a parallel graduated track, and allow simple and rapid experimental procedures. Both the heat source and light source intensity are controlled through the variable 240v ac supply from the Heat Transfer Service Unit H112.

EXPERIMENT TOPICS

- To show that the intensity of radiation on a surface is inversely proportional to the square of the distance of the surface from the source of radiation
- To demonstrate the Stefan-Boltzmann Law
- To show that the intensity of radiation measured by the radiometer is directly related to the radiation emitted from a source by the view factor between the radiometer and the source.
- To determine the emissivity of radiating surfaces with different finishes, namely polished and grey (silver anodised) compared with matt black
- To demonstrate how the emissivity of radiating surfaces in close proximity to each other will affect the surface temperatures and heat exchanged.
- To determine the validity of Kirchhoff's Law
- To demonstrate that the exchange of radiant energy from one surface to another is dependant upon their interconnecting geometry
- To demonstrate the inverse square law for light
- To demonstrate the Lambert Cosine Law for light.

HEAT TRANSFER SERVICE UNIT

Model Number : GOTT-HTSU-1

COMBINED CONVECTION AND RADIATION

CODE 976-253

DESCRIPTION

Bench mounted accessory that allows experimental investigation of both natural and forced convection from a heated cylinder in a cross-flow configuration. The surface temperature of a duct mounted, matt black cylinder may be varied over a wide range; thereby allowing the increasing effects of radiant heat transfer to be investigated as the temperature is increased.A variable velocity airflow within the small diameter circular duct is provided by an integral centrifugal fan and allows the effects on convective heat transfer from the cylinder to be investigated.An integral thermocouple on the surface of the electrically heated cylinder allows surface temperature to be measured at all operating conditions. This combined with a duct-mounted thermocouple, heater input power measurement and in duct air velocity measurement allows all of the relevant parameters to be recorded. The heater power supply and temperature sensors connect to the Heat transfer service unit H112 while velocity is recorded on auxiliary instrumentation supplied as part of the H112D demonstration unit.

EXPERIMENT TOPICS

- Determination of the combined (radiation and convection) heat transfer (Qr + Qc) from a horizontal cylinder in natural convection over a wide range of power input and corresponding surface temperature
- Measuring the domination of the convective heat transfer coefficient hc at low surface temperatures and the domination of the radiation heat transfer coefficient hr at high surface temperatures.
- Determination of the effect of forced convection on the heat transfer from the cylinder at varying air velocities.
- Investigation of the local heat transfer coefficient around the cylinder at varying air velocities.

EXTENDED SURFACE HEAT TRANSFER

CODE 976-254

DESCRIPTION

A small scale bench top accessory designed to measure the temperature profile and heat transfer along a horizontal extended surface (cylindrical pin). A small diameter uniform rod is heated at one end and heat flowing along the rod by conduction is lost to the surroundings by a combination of natural convection and radiation. The resulting heat transfer gives a temperature profile that may be investigated and predicted by conventional analysis. The apparatus consists of a solid cylindrical matt black brass bar supported in a frame and heated at one end. At intervals from the heated end are eight thermocouples recording the surface temperature so that a temperature profile along the bar may be developed. An additional thermocouple records the ambient temperature. The heater is located inside an insulated cylinder at one end of the apparatus. The heater input power is controlled through the variable 240v ac supply from the Heat Transfer Service Unit H112 and is designed to operate at up to 20 Watts.

EXPERIMENT TOPICS

- Measuring the temperature distribution along an extended surface and comparing the result with a theoretical analysis.
- Calculating the heat transfer from an extended surface resulting from the combined modes of free convection and radiation heat transfer and comparing the result with a theoretical analysis.
- Determining the constant of proportionality/ thermal conductivity of the rod material.

THERMAL CONDUCTIVITY OF LIQUIDS AND GASES

CODE 976-255

DESCRIPTION

The unit comprises a heated plug and water cooled jacket with a small radial clearance in which gas or liquid samples may be tested. The thin laminar film prevents natural convection in the fluid under test. The temperatures either side of the sample under test are recorded by integral thermocouple sensors. The unit may be readily dismantled for cleaning and is reassembled with a single bolt and replaceable O ring seals. Heat input is both measured and controlled by the Heat Transfer Service Unit H112 which also provides instrumentation for measurement of the temperatures on either side of the sample under test.

EXPERIMENT TOPICS

- Calibration of the unit to establish the effect of incidental heat transfers.
- Determination of the thermal conductivity of any suitable gas or liquid compatible with the materials of construction.

HEAT TRANSFER SERVICE UNIT

Model Number : GOTT-HTSU-1

RADIATION ERRORS IN TEMPERATURE MEASUREMENT

CODE
976-256

DESCRIPTION

A small scale bench top accessory designed to experimentally investigate how measured temperatures can be influenced by the effects of radiation, temperature sensor design and surface finish. Three temperature sensors of different form and surface finish are mounted centrally in a circular stainless steel duct that is surrounded locally by an electrical heater. An additional temperature sensor records the temperature of the inside of the heated duct adjacent to the centrally mounted thermocouples. A radiation shield may be raised or lowered over the centrally mounted thermocouples to investigate the effects of shielding. The circular duct is mounted on the discharge from a centrifugal fan. Air from the fan is blown through the duct past the temperature sensors at a controlled velocity of between 0 and 8m/s. The air velocity is measured by an in duct anemometer. The heater power supply andtemperature sensors connect to the Heat Transfer Service Unit H112 while velocity is recorded on auxiliary instrumentation supplied as part of the H112F unit.

EXPERIMENT TOPICS

- Demonstration of how temperature measurements can be affected by radiant heat transfer to a sensor from its surrounding and to show.
- Effect of temperature difference between the sensor and its surroundings.
- Effect of air velocity.
- Effect of sensor size.
- Effect of sensor emissivity
- Demonstration of methods of reducing the errors in temperature measuremUse of a radiation shield between the sensor and the source of radiation.
- Design of a radiation resistant sensor.

UNSTEADY STATE HEAT TRANSFER

CODE
976-257

DESCRIPTION

A small scale bench top accessory designed to allow experimental investigation of unsteady state heat transfer by conduction and convection. Instrumented solid shapes of different materials areplunged into a controlled temperature water bath and the temperature changes at the geometric centre of the shapes (via thermocouples) are recorded at regular intervals. As the shapes are of regular geometric form standard empirical methods may be used to predict the temperature variation with time and determine factors about the material properties. The accessory also allows investigation of the lumped thermal capacitance method of thermal analysis. The controlled temperature water bath has a variable speed circulating pump and central cylindrical flow channel to establish stable forced convection conditions to be maintained around the immersed shapes. All the thermocouples and the variable speed circulating pump power supply plug directly into the Heat Transfer Service Unit H112 and readings aredisplayed on digital panel meters

EXPERIMENT TOPICS

- Observation of unsteady state conduction of heat to the centre of a solid shape (Qualitative, using a chart recorder, manual recording) when a step change is applied to the temperature at the surface of the shape.
- Using analytical transient - temperature / heat flow charts to determine the thermal conductivity of solid shapes from measurements taken on similar shapes from measurements taken on similar shapes of different thermal conductivity.
- Investigation of the effect of shape, size and material properties on unsteady heat flow.
- Investigating the Lumped Thermal Capacitance method of transient temperature analysis.

HEAT TRANSFER SERVICE UNIT

Model Number : GOTT-HTSU-1

PERFECT GAS LAW DEMONSTRATION UNIT

CODE 976-258

DESCRIPTION

Bench top accessory designed to allow experimental investigation of the first law of thermodynamics using the perfect gas law and the expansion of air. The unit consists of two vessels connected by a large bore pipe and valve together with an integral air pump. The pump can be used to both pressurise one vessel and evacuate the other. Additional valves allow the vessels to be used in isolation; venting to or from atmosphere and in a combined arrangement where the pressurised vessel can vent into the evacuated vessel. Low inertia thermocouple sensors located in each vessel record the air temperatures and individual pressure transducers record the chamber pressures. The vessels and interconnecting pipe work are constructed from impact resistant plastic and for operator safety pressure switches limit the operating pressures to safe levels. The unit is provided with its electrical services and temperature instrumentation by the Heat Transfer Service Unit H112. This also provides digital display of the air temperatures in the vessels while an auxiliary display provided with the H112J allows display of the chamber pressures

EXPERIMENT TOPICS

- Investigation of the first law of thermodynamics.
- The second law of thermodynamic and its carollaries.
- Observation of the pressure, volume, temperature relationship for air.
- Observation of the transient responses to different rates of change in a process.

THERMAL CONDUCTIVITY OF BUILDING MATERIALS

CODE 976-259

DESCRIPTION

A bench top accessory designed to allow students to simply and easily investigate the relative thermal conductivities of typical building materials. The H112N utilises a relative method of thermal conductivity measurement based upon an international standard ISO 8301. The H112N uses a PID controlled flat plate electrical heater and a water cooled flat plate with an integral and highly sensitive heat flowmeter. The specimen under test is sandwiched between the heated and cooled plates and contained in a thermally insulated enclosure to minimise heat losses. The loading system supplied ensures that the same clamping force is applied to all specimens. The heat flowmeter gives an output to a digital panel meter on the special control and instrumentation console. Special thermocouples are arranged to measure mean temperatures either side of the test specimen, allowing the temperature gradient across the sample and hence the thermal conductivity to be determined. The thickness of the test sample may be measured in situ using the dial indicator on the clamping mechanism. The unit allows the thermal resistance of samples to be determined and the measurement of samples connected in series(stacked). This allows the formula relating individual thermal resistances and the overall thermal resistance of a stacked sample to be investigated.

EXPERIMENT TOPICS

- Rapid measurement of Thermal Conductivity for materials with Thermal Resistance in the range 0.1 to 1.4 m2 K/W. (Resistance=Thickness/ Conductivity)
- Measurement of the Thermal Resistance of typical building materials.
- Measurement of the Thermal Resistance of thin stacked samples of building materials.

HEAT TRANSFER SERVICE UNIT

Model Number : GOTT-HTSU-1

FREE AND FORCED CONVECTION FROM FLAT, PINNED AND FINNED PLATES

CODE 976-260

DESCRIPTION

A bench top accessory designed to allow students to experimentally investigate both free (natural) convection and forced convection.A heated flat plate with surface thermocouple may be directly compared with a similar pinned plate and finned plate also fitted with a surface thermocouple.In addition to expanding understanding of the heat transfer enhancement from extended surfaces, the pinned and finned plates each have three thermocouples arranged at intervals along a fin and a pin

EXPERIMENT TOPICS

- Investigation of the relationship between power input and surface temperature in free convection on flat, finned and pinned plates.
- Investigation of the relationship between power input and surface temperature in forced convection on flat, finned and pinned plates
- Investigation of the use of extended surfaces to improve heat transfer from the surface.
- Determination of the temperature distribution along an extended surface.

THERMOELECTRIC HEAT PUMP

CODE 976-261

DESCRIPTION

A experimentally investigate the performance of a thermoelectric cooler module. A thermoelectric device has no moving parts and uses a direct electrical current to transfer heat from one face of the device to the other. In the H112Q, the thermoelectric module is held between a heated block and a water cooled plate. The module extracts heat from the block and transfers this, and the input power, to the water cooled plate. An insulated hinged enclosure allows student examination and minimises heat gains/losses from the system.Controllable power for the module and heater is supplied by the H112 Heat Transfer Service Unit.

EXPERIMENT TOPICS

- Investigation of the effects upon the surface temperature of either face of the module with increasing power. (Peltier Effect)
- Investigation of the effect upon heat transfer direction of reversing the polarity of the power supply to the module. (Thomson or Lenz Effect).
- Investigation of the variation in open circuit voltage across the module due to the variation in surface temperature difference. (Seebeck Effect).
- Investigation of the power generating performance of the module with a steady load and increasing temperature difference.
- Estimation of the coefficient of performance of the module when acting as a refrigerator.
- Conducting a full energy balance for the module.

MARCET BOILER

CODE 976-262

DESCRIPTION

A The Marcet Boiler H1112M option is a self contained unit that allows students to investigate the pressure temperature relationship for water and steam. The unit incorporates an electrical heater that is controlled by the H112 Service unit together with an integral high pressure cut out for safe operation. The unit is also fitted with a certified pressure relief valve. Saturation temperature of the steam/ water is measured and displayed using the H112 Heat Transfer service unit. The saturation pressure inside the vessel is displayed using a high accuracy dial pressure gauge.

EXPERIMENT TOPICS

- Investigation Of The Pressure-Temperature Relationship For Water/Steam.
- Investigation Of The Clausius- Clapeyron Equation Using The Pressure_Temperature Relationship For Steam

HEAT TRANSFER SERVICE UNIT

Model Number : GOTT-HTSU-1

CLOSED CYCLE HOT AIR ENGINE

CODE 976-263

DESCRIPTION

A bench top accessory designed to allow students to experimentally investigate one of the methods available to convert heat energy directly into work. The engine consists of a water cooled power cylinder and a transfer cylinder connected via a common duct. A single acting power piston and double acting displacer piston are connected to a flywheel. The cycle of the engine consists of two isothermal processes and two constant volume processes. Heat to expand the captive gas charge and drive the power piston is provided by an electrical element controlled from the standard instrumentation console. .

EXPERIMENT TOPICS

- Demonstration of a direct conversion of heat energy into shaft power.
- Investigation of the cycle efficiency.
- Investigation of the parameters affecting the cycle performance.

BOILING HEAT TRANSFER

CODE 976-210

DESCRIPTION

The unit consists of a high strength clear glass cylinder with instrumented electric heater element immersed in a volatile solvent that boils at low pressure. An integral water cooled condenser coil allows the chamber pressure to be controlled over a wide range of negative and positive pressures depending upon the local water supply. A digital wattmeter allows students to determine the heat transfer from the heated element and this together with instrumentation on the H112 enables all relevant parameters to be recorded.

EXPERIMENT TOPICS

- Visual demonstration of convective, nucleate and film boiling.
- Study of the heat flux and surface heat transfer coefficient at constant temperature.
- Investigation of the effect of pressure on critical heat flux.
- Study of filmwise condensation and condenser overall heat transfer coefficient.
- Investigation of the pressure- temperature relationship of a pure substance, and the effect of air in a condenser.
- Demonstration of:
- Liquid carry over or priming in boilers.
- Law of partial pressures

Manuals :

(1) All manuals are written in English.
(2) Model Answer
(3) Teaching Manuals

General Terms :

(1) Accessories will be provided where applicable.
(2) Manual & Training will be provided where applicable.
(3) Design & specifications are subject to change without notice.
(4) We reserve the right to discontinue the manufacturing of any product.

Warranty :

2 Years

ORDERING INFORMATION :

ITEM	MODEL NUMBER	CODE
HEAT TRANSFER SERVICE UNIT	GOTT-HTSU-1	976-249
RADIAL HEAT CONDUCTION	GOTT-RHC-01	976-250
LINEAR HEAT CONDUCTION	GOTT-LHC-02	976-251
LAWS OF RADIANT HEAT TRANSFER AND RADIANT HEAT EXCHANGE	GOTT-LRHTRHE-03	976-252
COMBINED CONVECTION AND RADIATION	GOTT-CCAR-04	976-253
EXTENDED SURFACE HEAT TRANSFER	GOTT-ESHT-05	976-254
THERMAL CONDUCTIVITY OF LIQUIDS AND GASES	GOTT-TCLG-06	976-255
RADIATION ERRORS IN TEMPERATURE MEASUREMENT	GOTT-RETM-07	976-256
UNSTEADY STATE HEAT TRANSFER	GOTT-USHT-08	976-257
PERFECT GAS LAW DEMONSTRATION UNIT	GOTT-PGLDU-09	976-258
THERMAL CONDUCTIVITY OF BUILDING MATERIALS	GOTT-TCBM-10	976-259
FREE AND FORCED CONVECTION FROM FLAT, PINNED AND FINNED PLATES	GOTT-FFCFPFP-11	976-260
THERMOELECTRIC HEAT PUMP	GOTT-THP-12	976-261
MARCET BOILER	GOTT-MB-13	976-262
CLOSED CYCLE HOT AIR ENGINE	GOTT-CCHAE-14	976-263
BOILING HEAT TRANSFER	GOTT-BHT-15	976-264

* Proposed design only, subject to changes without any notice.