An energy scavenging system adapted to be used in association with equipment which has at least one intake line (2) adapted to draw intake gases into said equipment, and at least one exhaust line (11) adapted to expel exhaust gases from said equipment, the scavenging system including at least one intake conduit adapted to deliver intake gas or gases to at least one intake line or lines, and at least one exhaust conduit adapted to vent exhaust gas or gases from the at least one exhaust line, characterised in that at least part of the exterior of at least one exhaust conduit is placed in contact with at least part of the exterior of at least one intake conduit.
ENERGY SCAVENGING SYSTEM

TECHNICAL FIELD

This invention relates to an energy scavenging system. Preferably the present invention may be employed to scavenge or harvest waste heat from exhaust gases where this heat can be in turn be used to preheat inlet gases for a specific piece of machinery or equipment. Reference throughout this specification will in the main be made to the present invention being used to preheat inlet air flows for clothes drying equipment, but those skilled in the art should appreciate that other applications for the present invention are also considered.

BACKGROUND ART

Energy efficiency and energy conservation are ideals pursued by both domestic consumers and industrial users of energy. Efficient energy use can have a conservationist effect on the environment and can also result in lower energy costs to an energy consumer or user.

One area where energy conservation techniques can be employed is through scavenging of thermal energy or heat normally lost to atmosphere from the exhaust gases of equipment or machinery. For example, internal combustion engines waste a significant amount of energy in operation and also through exhaust gases which are vented to atmosphere. In addition, clothes drying equipment or clothes tumble dryers also tend to waste energy through venting hot exhaust air gases to atmosphere.

In the case of clothes drying machinery, this equipment works through drawing in cool dry air, heating same and subsequently expelling or exhausting hot humid air. Energy is consumed by such equipment to heat the inlet air and the clothes to be
dried where a portion of the heat energy consumed is lost through venting of exhaust gases to atmosphere.

An improved energy scavenging system which addressed any or all of the above problems and issues would be of advantage. In particular, an energy scavenging system which could scavenge heat energy from exhaust gas flows, machinery and equipment would be of advantage.

All references, including any patents or patent applications cited in this specification are hereby incorporated by reference. No admission is made that any reference constitutes prior art. The discussion of the references states what their authors assert, and the applicants reserve the right to challenge the accuracy and pertinency of the cited documents. It will be clearly understood that, although a number of prior art publications are referred to herein, this reference does not constitute an admission that any of these documents form part of the common general knowledge in the art, in New Zealand or in any other country.

It is acknowledged that the term 'comprise' may, under varying jurisdictions, be attributed with either an exclusive or an inclusive meaning. For the purpose of this specification, and unless otherwise noted, the term 'comprise' shall have an inclusive meaning - i.e. that it will be taken to mean an inclusion of not only the listed components it directly references, but also other non-specified components or elements. This rationale will also be used when the term ‘comprised’ or ‘comprising’ is used in relation to one or more steps in a method or process.

It is an object of the present invention to address the foregoing problems or at least to provide the public with a useful choice.

Further aspects and advantages of the present invention will become apparent from the ensuing description which is given by way of example only.
DISCLOSURE OF INVENTION

According to one aspect of the present invention there is provided an energy scavenging system adapted to be used in association with equipment which has at least one intake line adapted to draw intake gases into said equipment, and at least one exhaust line adapted to expel exhaust gases from said equipment, the scavenging system including

at least one intake conduit adapted to deliver intake gas or gases to the equipment's intake line or lines, and

at least one exhaust conduit adapted to vent exhaust gas or gases from the equipment's exhaust gas line or lines,

the scavenging system being characterised in that the exterior of at least one exhaust conduit is placed in contact with the exterior of at least one inlet conduit.

According to a further aspect of the present invention there is provided an energy scavenging system substantially as described above wherein said at least one intake conduit and said at least one exhaust conduit are formed from thermally conductive materials.

According to yet another aspect of the present invention there is provided an energy scavenging system substantially as described above wherein the contact area of the conduits forms a heat exchange region, where the exterior surface of said at least one inlet conduit has a thermal insulator applied between the heat exchange region and the conduit's connection to at least one equipment intake line or lines.

According to a further aspect of the present invention there is provided an energy scavenging system substantially as described above wherein said at least one
exhaust conduit or conduits is adapted to form a reverse venturi in the heat exchange region defined.

The present invention is adapted to provide an energy scavenging system. Preferably the present invention may be used with any number of different types of equipment to scavenge energy using the exhaust gases of same. Preferably such types of equipment can include at least one intake line used to supply intake gas (preferably air) into the mechanisms employed with the equipment involved. Such equipment may also include at least one exhaust line used to vent, disburse or otherwise dispose of exhaust gases produced by the workings of the equipment.

Reference throughout this specification will also be made to the equipment for which the present invention is to be used as being a clothes dryer.

Clothes dryers draw in air from the surrounding environment, heat this air and use it to dry damp or wet clothes. The exhaust gases of a clothes dryer are then expelled where these gases are relatively warm and contain a high moisture content.

Reference throughout this specification will also be made to the present invention being used to scavenge heat or thermal energy normally wasted in the exhaust air produced by such a clothes dryer. However, those skilled in the art should appreciate that the present invention may also be configured to work in reverse to for example, pre-cool inlet gases for equipment which in operation exhausts waste gas or air at a temperature lower than a standard environmental or ambient temperature.

Reference throughout this specification will also be made to the clothes dryer involved having a single intake line and a single exhaust line. Again however, those skilled in the art should appreciate that other configurations of various forms of equipment to be used in conjunction with the present invention may vary if
required.

Reference throughout this specification will also be made to the present invention being integrated within an existing clothes dryer unit.

Those skilled in the art should appreciate that these references can encompass both the retro fitting of an after market energy scavenging system to existing equipment, or alternatively integration of an energy scavenging system within equipment at the time of manufacture.

In a preferred embodiment the energy scavenging system provided includes at least one intake conduit. An intake conduit can be adapted to deliver intake gas to at least one intake line of the equipment involved.

Reference throughout this specification will also be made to the present invention including a single intake conduit only which is adapted to deliver intake gas to a single intake line of the equipment of the clothes dryer involved. However, those skilled in the art should appreciate that other configurations of the invention are also envisioned.

In a preferred embodiment the present invention includes at least one exhaust conduit adapted to vent exhaust air to atmosphere where this exhaust air is supplied from the exhaust line of the clothes dryer involved. Again, reference throughout this specification will also be made to the present invention including a single exhaust conduit only used to vent air but again those skilled in the art should appreciate that other configurations of the present invention are also envisioned.

Reference throughout this specification will also be made to the gas delivered or vented being air.

When the present invention is used in clothes dryer applications air is drawn into
the intake line of the dryer and subsequently heated and then vented from the exhaust line of the dryer. The present invention may be used in such applications to control the flows of such intake and exhaust air streams.

Preferably the exterior surface or surfaces of the present invention's intake and exhaust conduits may be placed in physical contact with one another at at least one point along the lengths of same. Physical contact between the exteriors of these two conduits will facilitate the transfer of thermal energy between the air flows involved. Excess or waste heat present in the exhaust air can be transferred across into the inlet air flows to preheat same prior to supply to the interior of the clothes dryer.

This has the advantage of reducing the running costs of the dryer as the main heater element only acts as a kind of catalyst to start the process and is then assisted by the preheated intake air stream.

In a further preferred embodiment a single section only of both the intake and exhaust conduits may be placed in contact to define a heat exchange region for the present invention. The other sections of these conduits may be arranged or configured as required to engage with both the intake and exhaust lines of the clothes dryer and at the opposite end of these conduits, to vent exhaust gases and to draw in fresh dry air. The heat exchange region provided may preferably provide a region whereby the exterior surfaces of these conduits are placed into close proximity with one another, such as for example, by winding one conduit over or around another.

In a preferred embodiment, both the intake and exhaust conduits provided may be formed from or constructed from a thermally conductive material.

Forming the conduits out of a thermal conductor substantially increases the
efficiency at which heat may be transferred between the two conduits within the heat exchange region provided.

In a preferred embodiment the exhaust conduit may form a reverse venturi within the heat exchange region.

A reverse venturi may be formed through a section or region of the conduit which has a greater diameter than that of the standard diameter normally provided for the exhaust conduit. This larger diameter will increase the overall volume or surface area of the interior of the conduit within the heat exchange region to preferably harness a reverse venturi effect.

As those skilled in the art would be aware, standard venturi system will increase the velocity of gas travelling through a narrow pinched region of a conduit at the expense of the pressure and temperature of this gas. Conversely the reverse venturi employed in conjunction with the present invention may increase the temperature of gas travelling through same at the expense of the pressure and velocity of such gas. This effect can be used to increase the temperature of exhaust gases within the heat exchange region to preferably promote a greater or faster transfer of heat over to the intake conduit provided.

In a preferred embodiment at least one section of the intake conduit may have a thermal insulator applied to the exterior surface of same. Such a thermal insulator may be used to trap or conserve heat within the intake gases involved, preferably after preheating of such gases within the heat exchange region. In such an embodiment, a thermally insulative layer may be applied to the exterior surface of the intake conduit between the heat exchange region and the intake conduit's connection to the clothes dryer's intake line.

In a preferred embodiment the intake line may also include or be associated with at
least one air filter. Such an air filter can be used to trap dust and other contaminants which would normally be sucked up into the intake conduit and transferred into the intake line of the clothes dryer involved.

In a further preferred embodiment the present invention may also include a sensor or sensors associated with any filter provided within a conduit. Such sensors may monitor the flow rate of air or other gases travelling through a conduit to in turn detect a blockage within same. Such sensors may be linked to a simple indicator or alarm system which can alert a user of the clothes dryer to the existence or blockage in one or more of the conduits provided.

The present invention may provide many potential advantages over the prior art. The present invention can be used to scavenge energy using the exhaust gases of equipment. Such energy may be used to preheat or in some instances, pre-cool inlet gas flows to reduce the amount of energy which the equipment needs to use to cool or heat the gases it receives.

Preferably through the use of a reverse venturi in a heat exchange region provided in accordance with the present invention, optimal or significant transfer of heat between exhaust and intake conduits may be facilitated.

Furthermore, the energy efficiency of the system provided can also be promoted through the use of thermally conductive conduit materials and also the use of selectively applied insulative layers of the exterior of such conduits.

**BRIEF DESCRIPTION OF DRAWINGS**

Further aspects of the present invention will become apparent from the following description which is given by way of example only and with reference to the accompanying drawings in which:
**Figure 1** shows a block schematic cross section view of the present invention when installed and used with clothes drying machinery, and

**Figure 2** shows a close up section of the components of the present invention employed in the application discussed with respect to figure 1.

5 **BEST MODES FOR CARRYING OUT THE INVENTION**

Figure 1 shows a block schematic cross section view of the present invention when installed and used with clothes drying machinery.

The clothes dryer (1) shown receives inlet air from an air inlet and exchange system (2) configured in accordance with a preferred embodiment of the present invention. The air supplied is sucked into the main body of the clothes dryer (1) by an electric fan (3). This inlet air is then heated using a heating coil (4), with subsequent warmed air (5) being supplied to a tumble dryer drum (6). A drum motor (7) rotates the drum and tumbles clothes to be dried (9). The movement or rotation of these clothes (9) and exposure to the heated air supplied (5) removes moisture from the clothes.

At the opposite end of the tumble dryer drum (6) is a lint filter (10) and exhaust pipe (11). The exhaust pipe (11) carries warm moist exhaust air through to the exchange system (2) provided in accordance with the present invention.

Figure 2 shows in more detail the inlet and air exchange system discussed with respect to figure 1.

The system provided includes an inlet port formed through a connection to the exhaust pipe (11) shown with respect to figure 1. The system is also open to atmospheric air flows (12) passing over a series of radiator pipes (13) with attached radiator fins (14). Air from the exhaust pipe (11) is initially supplied into an inlet
manifold (15) and subsequently distributed or divided over a number of radiator pipes (13). At the end of each of these pipes (13) is provided an outlet manifold (16) which includes a condenser unit (17) to collect water vapour from the exhaust air. The opposite end of the outlet manifold (16) is an air outlet port (18) which vents the exhaust air to the atmosphere.

Air flows of exhaust warm air from the exhaust pipe (11) experience a reverse venturi effect when channelled through the smaller diameter radiator pipes (13). The individual pipe diameters (13) are less than that of the inlet manifold (15) and original exhaust pipe (11) but due to the fact that the combined sum of diameters and the surface areas of the pipes provided are greater than that of the inlet pipe (11), a reverse venturi effect is created.

Cool air flows (12) entering the system have heat exchange or transferred over to them from the exterior of the radiator pipes (13) and their associated radiator fins (14). This system thereby provides a preheating effect to inlet air flows (12) into the clothes drying machinery provided, potentially reducing the energy consumption requirements of same.

Those skilled in the art should appreciate that the effective or overall surface area provided through radiator pipes may also be increased through more or further pipes being provided thereby enhancing the heat transfer effect employed in conjunction with the present invention.

For example, in one embodiment the number of radiator pipes (13) may be increased to 24, where exhaust pipe (11) has a diameter of 100mm and the radiator pipes have diameters of 25mm each. This gives a calculation of the cross section area of the exhaust pipe (11) being 7854mm² while the cross section area of each radiator pipe (13) is equal to 491mm². Therefore, if 16 or more exhaust
pipes (11) are provided this will provide an equal cross section surface area to the exhaust pipe (11). Preferably in such an instance, 24 exhaust pipes (11) may be provided to increase the overall combined diameter of the exhaust pipes (11) to 50% more than that of the radiator pipe (13), thereby resulting in a highly effective reverse venturi effect.

Aspects of the present invention have been described by way of example only and it should be appreciated that modifications and additions may be made thereto without departing from the scope thereof as defined by the appended claims.
WHAT I CLAIM IS:

1. An energy scavenging system adapted to be used in association with equipment which has at least one intake line adapted to draw intake gases into said equipment, and at least one exhaust line adapted to expel exhaust gases from said equipment, the scavenging system including

   at least one intake conduit adapted to deliver intake gas or gases to at least one intake line or lines, and

   at least one exhaust conduit adapted to vent exhaust gas or gases from at least one exhaust gas line,

   characterised in that

   at least part of the exterior of at least one exhaust conduit is placed in contact with at least part of the exterior of at least one intake conduit.

2. An energy scavenging system as claimed in claim 1 wherein at least one intake conduit and at least one exhaust conduit are formed from thermally conductive materials.

3. An energy scavenging system as claimed in claim 1 or claim 2 wherein at least one section of the intake conduit has a thermal insulator applied to its exterior surface.

4. An energy scavenging system as claimed in any previous claim wherein the contact area of the intake and exhaust conduits forms a heat exchange region.

5. An energy scavenging system substantially as claimed in claim 4 wherein at
least one exhaust conduit is adapted to form a reverse venturi in the heat exchange region.

6. An energy scavenging system as claimed in any previous claim wherein the equipment with which it is used is a clothes dryer.

7. An energy scavenging system as claimed in any previous claim wherein the energy scavenged is used to preheat the intake gas of the equipment with which the present invention is adapted to be used.

8. An energy scavenging system as claimed in any of claim 1 to claim 5 wherein the energy scavenged is used to pre-cool the intake gas of the equipment with which the present invention is adapted to be used.

9. An energy scavenging system as claimed in any previous claim wherein the energy scavenging system is constructed as part of the equipment with which it is associated at the time of the equipment's manufacture.

10. An energy scavenging system as claimed in any of claim 1 to claim 8 wherein the energy scavenging system is configured to be retro-fitted to the piece of equipment with which it is to be associated.

11. An energy scavenging system as claimed in any previous claim wherein the intake and exhaust gases are air.

12. An energy scavenging system as claimed in claim 12 wherein the exterior surface of at least one intake conduit has a thermal insulator applied between the heat exchange region and the conduit's connection to at least one equipment intake line.

13. An energy scavenging system as claimed in any previous claim wherein the
intake line contains at least one air filter.

14. An energy scavenging system as claimed in any previous claim configured to include a sensor.

15. An energy scavenging system as claimed in claim 14 wherein the sensor detects the flowrate of the intake gas.

16. An energy scavenging system as claimed in either claim 14 or claim 15 wherein the sensor output is used to control the activation of an alarm system wherein the alarm system is configured to alert the user of the equipment of a possible blockage in at least one intake conduit.

17. An energy scavenging system as herein described, with reference to and as illustrated by the accompanying drawings.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

Int. Cl. 7: D06F 58/26, F26B 23/00, F28D 1/00, 7/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
Refer electronic database consulted below

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
DWPI - D06F 58/IC and keywords exhaust, discharge, exchange, scavenge, conduit, duct and similar terms

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X Further documents are listed in the continuation of Box C

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* Special categories of cited documents:
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  "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered, to involve an inventive step when the document is taken alone
  "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
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Date of the actual completion of the international search 1 September 2004

Date of mailing of the international search report 07 SEP 2004

Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE
PO BOX 200, WODEN ACT 2606, AUSTRALIA
E-mail address: pat@ipaustralia.gov.au
Facsimile No. (02) 6285 3929

Authorized officer

R. SUBBARAYAN
Telephone No: (02) 6283 2377
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