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Solplan 6

AN AIR EXCHANGER FOR ENERGY EFFICIENT WELL SEALED HOUSES

AVC

A DO IT YOURSELF MANUAL

ABOUT THE AUTHORS:

R.W. BESANT: Designed the first air-to-air heat exchanger for air-tight houses. Co-authored the first do-it-yourself publication. Author of many papers on solar energy and energy efficient housing as well as air-to-air heat exchangers. Head of the Mechanical Engineering Department, University of Saskatchewan.

R. DUMONT: Researcher in low energy housing. Co-authored first do-it-yourself air exchanger publication.

T. HAMLIN: Researcher at the University of Saskatchewan in the area of air-to-air heat exchangers and solar energy.

G. SCHOENAU: Professor of Mechanical Engineering. Author of numerous papers and publications in energy efficient and passive solar housing. Past Chairman of the Solar Energy Society of Canada Inc.

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ISBN 0-920768-06-7

SOLPLAN 6: An Air Exchanger for Energy Efficient Well Sealed Houses is published by: The Drawing-Room Graphic Services Ltd.
P.O. Box 86627, North Vancouver, B.C. V7L 4L2

PRINTED IN CANADA

SOLPLAN 6: AN AIR EXCHANGER FOR ENERGY EFFICIENT WELL SEALED HOUSES

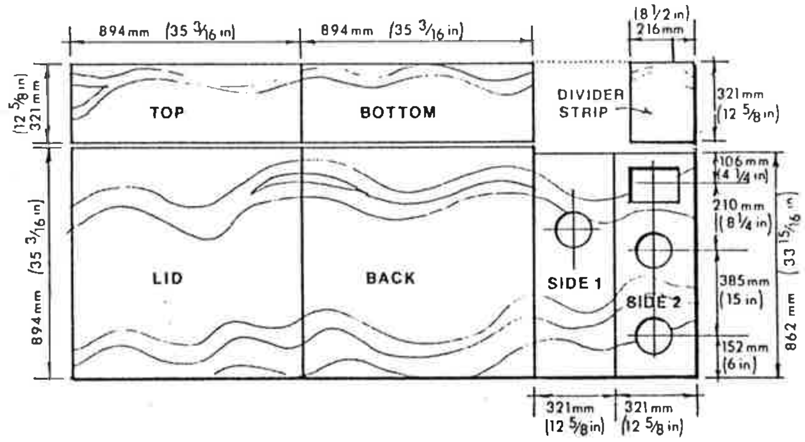
ERRATA & ADDENDUM

Add after paragraph 1, page 10:

Also note that the number ofpieces required to construct the heat exchanger core might vary from the suggested number of 22. This variation occurs as a result of the amount of glue used and/or manufacturer variations in sheet thickness. It is recommended that the core be measured during assembly to ensure that it does not exceed the depth of the box which is 321 mm (12 5/8").

Page 10: figure 14:

There was a dimensional error on the sketch. The corrected sketch is as below:



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AN AIR EXCHANGER FOR ENERGY EFFICIENT WELL SEALED HOUSES

BY:

ROBERT BESANT
ROB DUMONT
TOM HAMLIN
GREG SCHOENAU

ILLUSTRATIONS: TERRY LYSTER

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FOREWORD

The first priority in making a house energy efficient is to make it as air-tight as possible. An air and vapour tight seal keeps the heat in and protects the insulation. No single measure is more effective in reducing fuel bills. Reduced air leakage creates a house that is less drafty and more comfortable in winter.

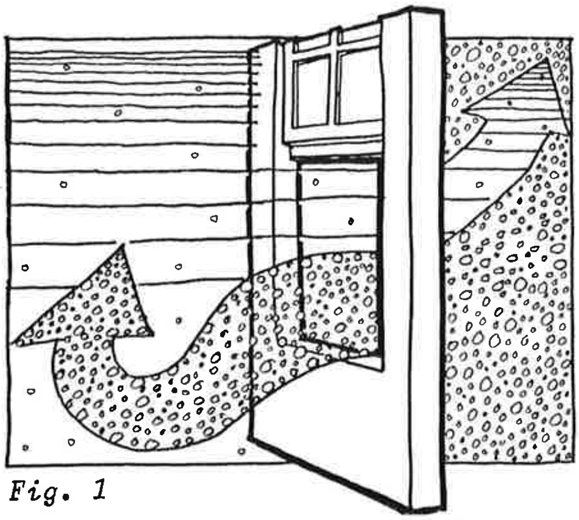


Fig. 1

However, air tightness creates a new set of problems as humidity and household odours become trapped inside. If you open a window for ventilation, cold air rushes in and the purpose of the air tight seal is defeated. To counteract this, controlled ventilation, along with heat recovery, is required.

An air-to-air heat exchanger is a device for preheating cold outside air as it is introduced into a warmer house. It is the prime channel for fresh ventilation air for an energy efficient home. An exchanger is a necessary complement to a well sealed house.

Two flows of air, warm air from inside the house and cold air from outside pass by each other in two separate series of channels. In a good heat exchanger, the air flow from outside can be heated to within about 5 to 10°C of the inside air temperature. Your home heating system has less work to do and therefore fuel bills are reduced.

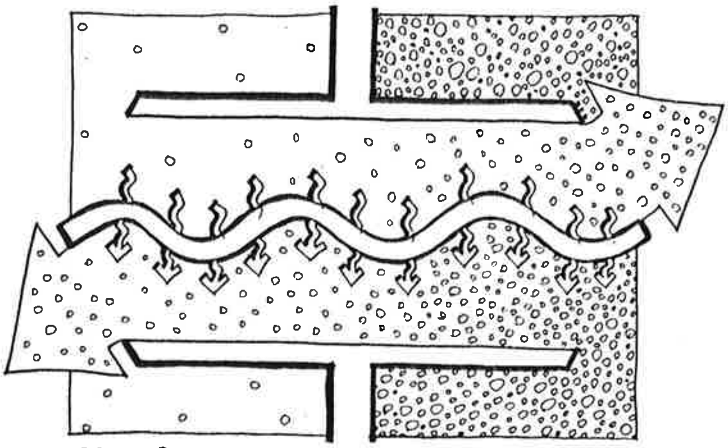


Fig. 2

Like any house, an energy efficient home generates its own indoor pollutants. These arise from a number of sources: construction materials such as the particle board used for subfloors, furniture and cupboards; radon gas from the soil; smoking; and the use of combustion equipment such as gas stoves and kerosene space heaters. At low concentrations, particles and gases emitted by these types of heaters are unhealthy; at high concentrations, they are fatal.

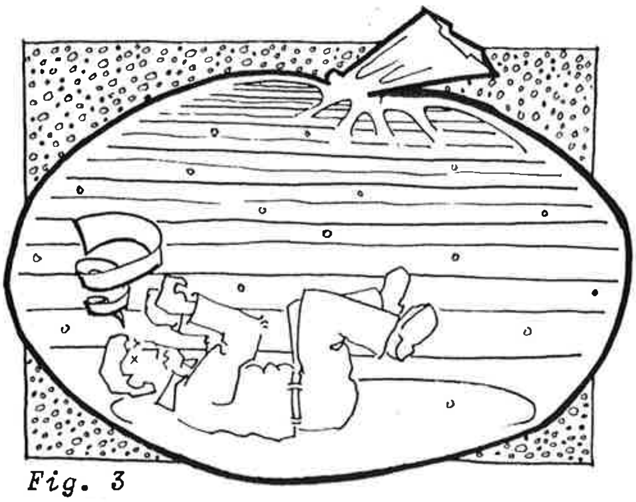


Fig. 3

It is important to minimize these pollutants by avoiding the use of such products as particle board using urea-formaldehyde glues, gas stoves, etc.

This book describes the construction of a simple air-to-air heat exchanger. No guarantee is made as to the safety or performance of an installed system. Individuals should consult with local authorities regarding codes and bylaws prior to construction.

WHY HEAT RECOVERY VENTILATION SYSTEMS?

Increased energy conservation measures have resulted in houses being built which are very 'air-tight'. Air tightness is a consequence of extra measures taken during design and construction, so that air infiltration through cracks and holes in the house exterior envelope is very small. Reduced air leakage means a lower fuel bill in addition to the house being less drafty and more comfortable in winter. Unfortunately, reduced leakage can result in higher concentrations of indoor air pollutants as well as excessive humidity levels.

Air pollutants arise from a number of sources. Formaldehyde gas is emitted from construction materials such as the particle board used in subfloor and cupboards. This sort of pollutant problem can be minimized but not practically eliminated by using alternate less polluting materials. Pollutants such as radon gas from the soil, can be controlled by constructing the house to minimize air infiltration from the surrounding soil. Some other sources of pollutants are smoking and the use of combustion equipment such as gas stoves and kerosene space heaters. At low concentrations particles and gases emitted by heaters may be unhealthy; at high concentrations, they may be fatal. In an air tight house all combustion appliances should have a separate air supply. A summary of pollutants, sources, effects and methods of reducing pollutants is presented in Table 1.

Airborne moisture in a house can also be a problem. Indoor moisture is generated by bathing, washing, cooking, plants and even from people as a result of skin evaporation and breathing. Moisture levels resulting in relative humidities of 30% to 40% are generally regarded as desireable and healthy in terms of reduced respiratory ailments. (1) However, if the moisture level becomes too great, then problems will occur due to condensation at cooler surfaces such as windows which can result in considerable water damage. Note that relatively warmer window surfaces achieved through the use of more window glazings (triple vs. double) minimizes the problem and permits higher humidity levels in colder climates.

Both the excessive moisture and indoor air pollutant problem must be controlled by replacing the stale air in the house with fresh air from outside. This can be accomplished in an energy efficient manner through the use of a heat recovery air ventilator or, as it is more commonly called an air-to-air heat exchanger. The purpose of this air-to-air heat exchanger is the recovery of energy from the stale air that is being exhausted from the house by transferring it to the controlled fresh air entering the house.

It must be emphasized that an air to air heat exchanger will <u>not</u> be of any value in a poorly sealed home as such a house will be ventilated through leaks, cracks, holes, etc.

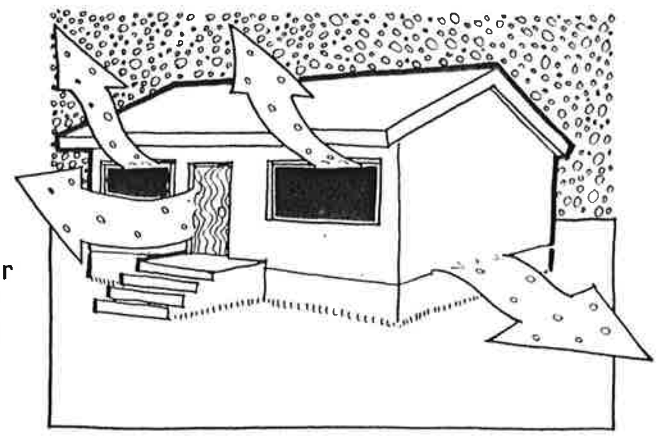


Fig. 4

TABLE 1 SOME TYPICAL POLLUTANTS

POLLUTANT	SOURCES	POSSIBLE EFFECTS	METHOD TO REDUCE POLLUTANTS
MOISTURE (Humidity)	Cooking, washing, clothes drying, breathing, plants etc.	Discomfort, condensation on walls & windows, mould or mildew growth, & structural damage (if humidity levels excessive).	Cover open water containers especially for cooking, use less water, vent dryers outside, etc.
FORMALDEHYDE GAS	Urea formaldehyde foam insulation & many types of plywood, particle board, panelling, carpets, furniture, textiles, etc.	Risk of eye & respiratory irritation & other health effects for people with allergic reactions, odors.	Avoid using &/or completely seal in particle boards & other materials with high urea formaldehyde base in glues. Vent new materials or rooms with these materials at a high rate for the first year.
RADON GAS	Soil (from where the radon can migrate into house basements) & sometimes concrete, sheetrock, other building materials, & well water.	Increased risk of lung cancer.	Seal cracks in basements, basement drains, etc.
TOBACCO SMOKE	Smoking	Increased risk of lung cancer & other respiratory ailments; heart disease; irritation of eyes, nose & throat; etc.	Avoid smoking & increase ventilation by a factor of five after exposure
HOUSEHOLD CHEMICALS	Household cleaning products various hobby supplies, paint solvents, hair sprays etc.	Various health effects: many household chemicals are toxic if concentrated, odors.	Use care in handling toxic chemicals & provide adequate ventilation during & immediately after their application.
OTHER ODORS VIRUSES, BACTERIA, DANDER & FUR	Humans & pets	Nuisance/annoyance plus risk of various health effects, particularly for susceptible individuals.	Provide adequate ventilation to all parts of the building.
COMBUSTION PRODUCTS (including carbon monoxide, nitrogen oxides, carbon dioxide, particulates, etc.	Fuel burning appliances including furnaces, combustion heaters, cook-stoves, clothes dryers, fireplaces, wood stoves, etc.	Irritation of eyes, nose, & throat; various minor & major health impacts. High concentrations of carbon monoxide are fatal.	Avoid open combustion flames &/or select only small air-tight units requiring small air flow rates & provide adequate ventilation.

due to temperature differences and wind speed. The air exchanger will only be of value if one can control the movement of air into and out of the house. If leaky doors, windows, electrical outlets, fireplace dampers, kitchen fan exhausts, bathroom fan exhausts, gas, oil or wood furnace chimneys provide alternate paths for the air to enter or leave the house, then the air exchanger will be of little value.

Some contractors of new energy efficient houses pressure test their homes to determine how air-tight they are, and to locate any major cracks and openings. Whether you are building a new house or renovating an older house, you can get a pressure test done for your home for a modest fee. The test will tell you just how tight your home is, and whether or not an air-to-air heat exchanger will be beneficial.

For new home construction, one would want to include the following features to control leakage.

1. Ensure a complete vapour barrier seal around the house. The booklets 'Energy Efficient Housing: A Prairie Approach' (2) and 'Air Vapour Barriers' (3) provide a wealth of details on how to achieve such a seal in new construction.

2. Use casement, hopper, or awning type windows - avoid double-hung or sliding windows.

3. Use doors with good quality seals - avoid sliding patio doors.

4. Use a recirculating range hood for the kitchen, rather than an outside venting type hood. Connect a vent in the kitchen to the air exchanger connecting pipe.

5. Connect the bathroom vent into the air exchanger connecting pipe.

6. If using fuel burning furnaces (gas, oil, wood, coal), completely isolate the combustion and chimney air from the house air. One way to do this is to build a tight enclosure around the furnace, and supply the combustion and chimney air directly from outside the house. Consult your local code authority to determine the proper size of the required outside air duct for combustion. Some new furnaces, such as the forced draft fan type, are designed to minimize the exhaust of air through the chimney. These are preferable. Fireplaces and all other combustion equipment must have their own air supply. Do not rely on the air exchanger to supply combustion air. It is not meant for this purpose.

With an existing older home built to conventional standards, considerable changes along the above lines would be required to tighten up the house before the use of a heat recovery air exchanger becomes of value.

In a well designed and constructed air tight house where air infiltration per hour is as low as 10% of the total volume of the air in the house, forced ventilation is required (in an older house, air infiltration may replace 75% to 200% of the air volume in an hour). Heat recovery from the exhaust air might save $50 to $100 per year or more. The actual amount would depend on the cost of fuel, the air flow rates through the heat recovery device, the average outdoor air temperatures, and the performance of the heat recovery system. This saving is over and above savings realized by having an air-tight, well sealed home. For houses with no need for extra ventilation the savings will not only be zero, the operation of such a device will incur extra operating expenses for heating the extra air as well as operating the electrical motors for the fans.

AMOUNT OF VENTILATION REQUIRED

The most widely recognized standard for the amount of air change required in a dwelling is the ASHRAE Standard 62-1981 (4), which specifies a recommended continuous ventilation level of 5 l/s (litres per second) or 10 cfm (cubic feet per minute) of outdoor air per room in a house. Thus, an average house with eight rooms would require a continuous ventilation of 40 l/s (80 cfm). In addition, the standard also recommends that there be a capacity of 50 l/s (100 cfm) in the kitchen and 25 l/s (50 cfm) in each bathroom. These values for the kitchen and bathrooms, however, need be only an intermittent and not a continuous flow.

A flow of 40 l/s (80 cfm) in a house with a total volume of 450 cubic metres (16,000 cubic feet) would be equivalent to an air change of 0.32 ACH (air changes per hour). Under normal circumstances, 1/3 ACH should be sufficient to control moisture levels and other pollutants. Houses with heavy smokers should, however, increase the ventilation rate. In fact, 0.5 ACH is the recommended value in Sweden and a commonly quoted figure in the U.S.A. as well. Assuming a natural infiltration rate of 0.1 ACH (for an air-tight house), a heat exchanger would have to supply an additional 0.4 ACH to achieve an overall air change rate of 0.5 ACH. The heat exchanger flowrate required to supply 0.4 ACH obviously varies with house size. A useful conversion based on total floor area including the basement and assuming standard ceiling heights is 0.25 l/s for each square meter of floor area (0.05 cfm for each square foot).

However, in a small home, a minimum of about 30 l/s (60 cfm) of outside air is recommended.

To control indoor pollutants, it is recommended that the ventilation system be run continuously during the heating season when the house is not being vented via open windows and doors.

In summary:

1. Build a well sealed house (or seal up the existing house).
2. Avoid pollutant emitting sources.
3. Provide continuous ventilation, preferably with an air-to-air heat exchanger or other heat recovery ventilator.

Further information on air exchangers is contained in references 5, 6, and 7.

CONSTRUCTION OF AN AIR-TO-AIR HEAT EXCHANGER

This section describes in detail the steps in the construction of an air exchanger for ventilating airtight houses. The unit described here was developed and tested in the Mechanical Engineering Department at the University of Saskatchewan. Fig. 5 is a photograph of this air-to-air heat exchanger with the lid removed. The unit had a measured effectiveness (based on sensible heat recovery) of 60% to 70% depending on outside temperature and flow rate. The highest efficiency occured at the lowest outside temperature and flowrate. The decrease in efficiency for a constant outside temperature was only 5% when the flow was increased from 50 to 100 litres per second (100 to 200 cfm). This range of flow rate should provide adequate ventilation for a wide range of house sizes.

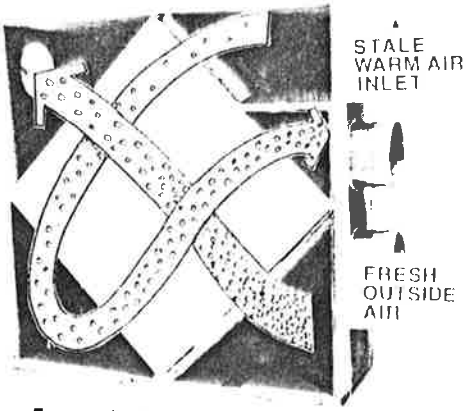


Fig. 5

The basic construction materials are plastic and pressure treated plywood.

> *Before you begin construction, we recommend you read and familiarize yourself with all instructions provided. Note that illustrations are diagramatic, to illustrate relationships - they are not to scale.*

HEAT EXCHANGER CORE

The core of the air exchanger is built using a sheet material called Coroplast™. This is an extruded twin wall plastic sheet consisting of a polypropylene/polyethylene copolymer and is most commonly used for making signs. It is often available from some of the larger lumber yards or building supply dealers in a translucent form as it is sometimes used for covering greenhouses or patios. In a pinch it could be purchased from sign makers. It comes in 1220 mm x 2440 mm (4 ft. by 8 ft.) sheets (Fig. 6). Each sheet is 4 mm (3/16 in.) thick and has a series of vertical webs connecting the inner and outer surfaces as shown in Fig. 7. It is not important which colour of Coroplast is used.

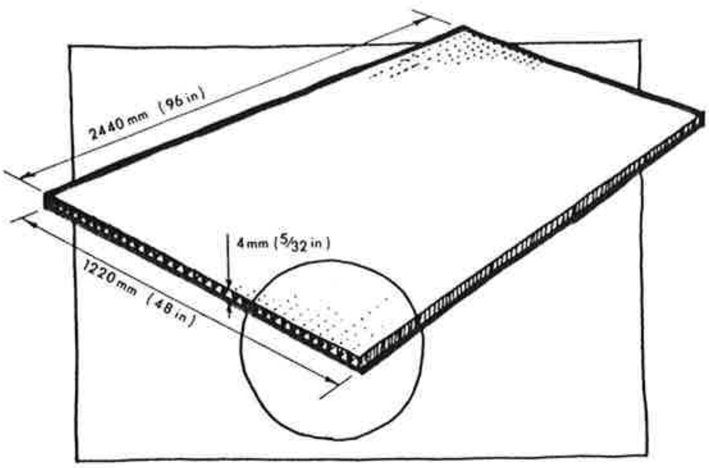


Fig. 6

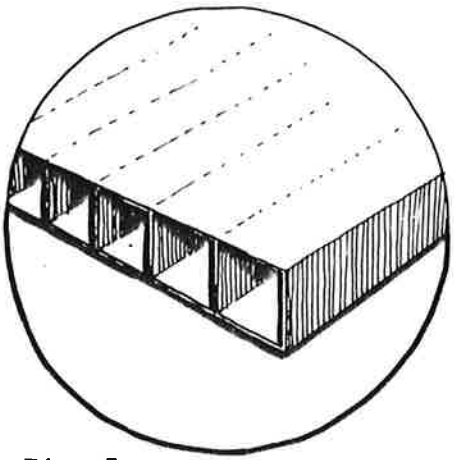


Fig. 7

A total of four sheets of Coroplast are used in the heat exchanger. Over three sheets are used to construct the core with the remainder being used to insulate the enclosure.

For the core, cut 3 1/2 large sheets into 28 square pieces 610mm x 610mm (24 in. x 24 in.) (Fig. 9). It is important to make the cuts as true and square as possible in order to minimize air leakage in the core. One way to do this is to make the cuts with a utility knife using a metal straight edge (such as a carpenter's square).

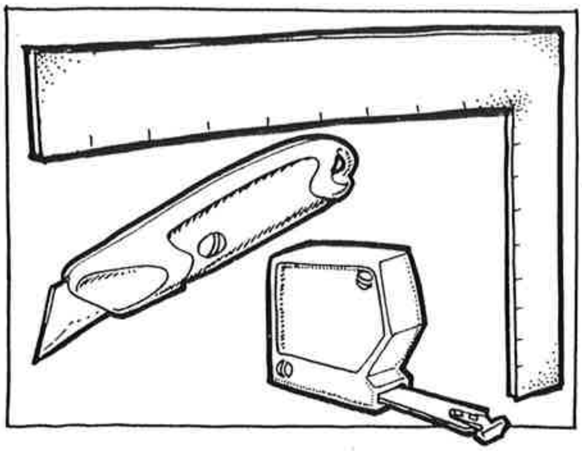


Fig. 8

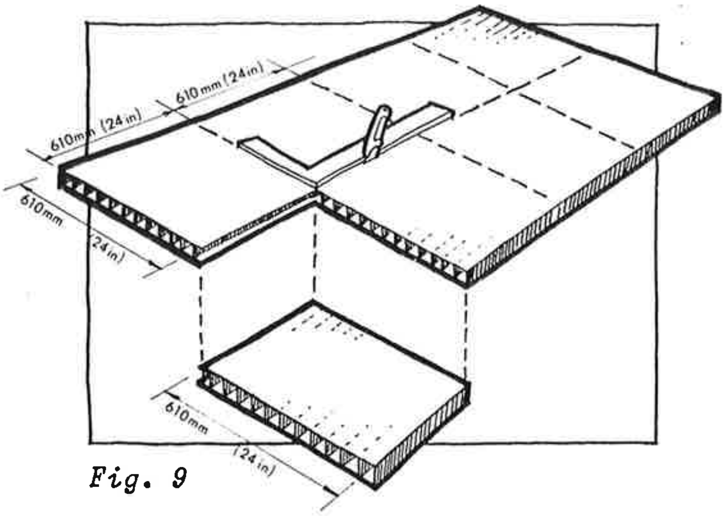


Fig. 9

From two of the square pieces, cut 132 longitudinal strips 610 mm x 10mm (24 in. x 3/8 in.). It is important that the long dimension be cut parallel to the channels as shown in Fig. 11. The small piece that remains after cutting the strips can be cut and used to practice gluing. It is recommended that gluing of the sheets be done with silicone caulking or construction adhesive PL-200*. Clear silicone should not be used as glue as any gaps in the glue which could result in air leakage will not be easily seen.

Glue sets of two longitudinal strips together as shown in Fig. 12 and let dry. These strips will serve as spacer strips in the heat air exchanger core.

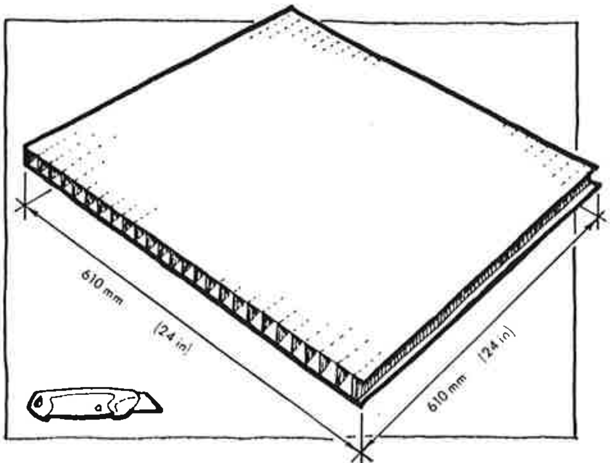


Fig. 10

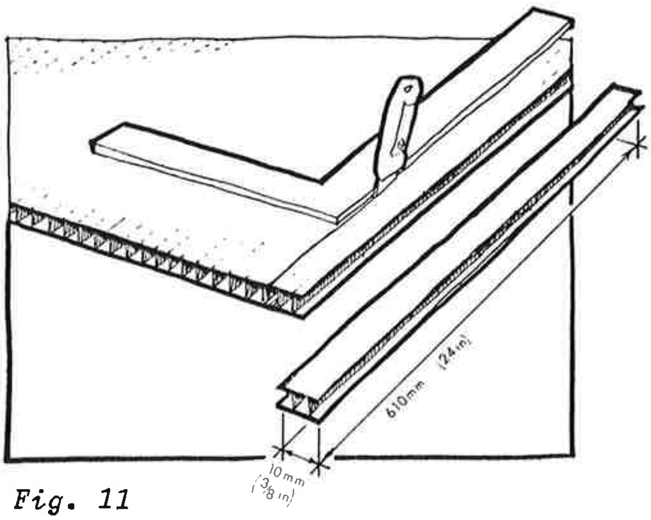


Fig. 11

*ABF Goodrich product

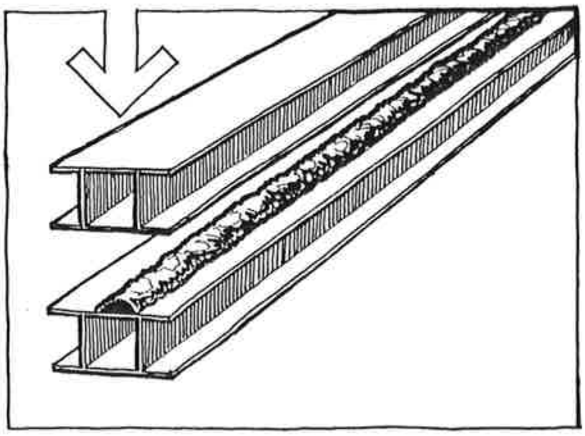


Fig. 12

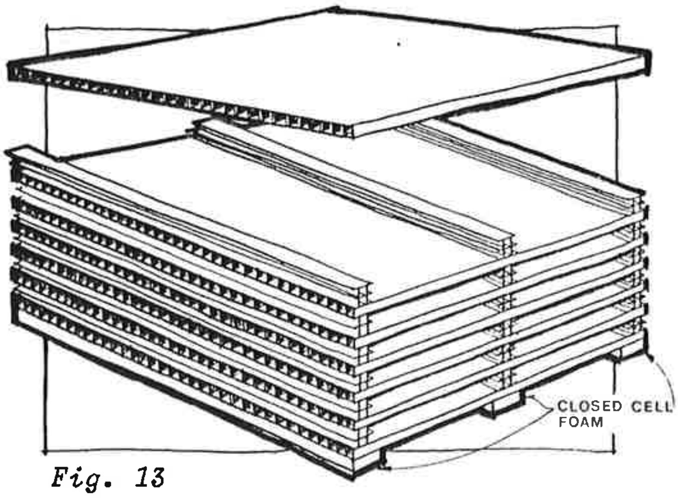


Fig. 13

The core is constructed by stacking the remaining 22 square pieces directly above one another with each piece separated by three of the twin spacer strips placed as shown in Fig. 13. The core is held together by applying a continuous bead of glue along the top and bottom of each spacer strip. It is important that each of the large pieces be positioned squarely over the lower piece as they are glued in place. This is best accomplished by periodically butting the core against a square corner during construction. Note carefully the direction of all channels - they must all be parallel to each other.

The channels of the full sheets form flow passages for the fresh air side of the exchanger while the spaces between each sheet become the flow passage for the stale (exhaust) air flow. Note that the spacer strips along each edge serve the additional important purpose of isolating these two flows.

Closed cell foam weatherstripping is glued on each outer side of the core in the same orientation as the spacer strips as shown in Fig. 13. This creates an airtight seal between the core and the enclosure box. It is extremely important to limit cross leakage within the exchanger.

ENCLOSURE BOX

The heat exchanger enclosure box is constructed from one sheet of pressure treated plywood 1220 mm x 2440 mm x 16mm (4 ft. x 8 ft. x 5/8 in.). Pressure treated plywood is used instead of regular plywood to prevent wood rot from the water that condenses out of the warm exhaust air as it is cooled. The plywood should be painted inside and outside, with a good quality marine paint. This will prevent any bacterial action on the plywood.

When cutting pressure treated plywood it is important to use gloves and a face mask.

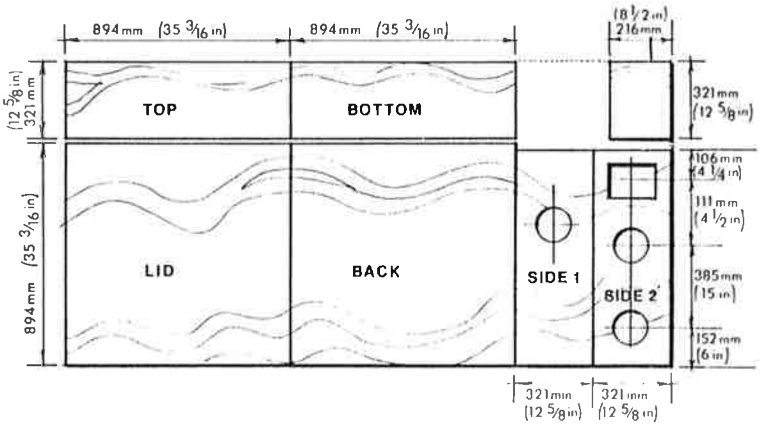


Fig. 14

Another less effective option to pressure treated plywood is to use an ordinary sheet of plywood and paint the inside surface with marine enamel.

The piece sizes and cutting sequence are shown in Fig. 14. Note that if it is more convenient for your installation, most of the ports could be located on an adjacent side of the box without affecting air exchanger performace.

Butt the sides into the top and bottom pieces and glue and nail or screw together.

Butt the frame formed by the previous step to the back piece of the box and glue and nail or screw. Be sure that all joints are completely sealed, by forming a tight joint, and caulking.

If you have the skills and access to tools, the enclosure box could be built from sheet metal - galvanized steel or aluminum.

Cut three 165 mm (6 1/2in.) lengths of the 152 mm (6 in.) diameter galvanized sheet metal duct. At one end of each of these ducts, make a series of cuts 25 mm (1 in.) in length parallel to the duct axis as shown in Fig. 16. Form tabs by spacing these cuts about 15mm (5/8 in.) apart. Install these ducts in each end of the holes by bending the tabs at right angles (Fig.17). Each duct is firmly held by means of four equally spaced screws through the tabs into the plywood. A bead of glue is run between each pipe surface and the box at the outside surface of the box as shown in Fig. 17. The assembled air exchanger enclosure box is illustrated in Fig. 19.

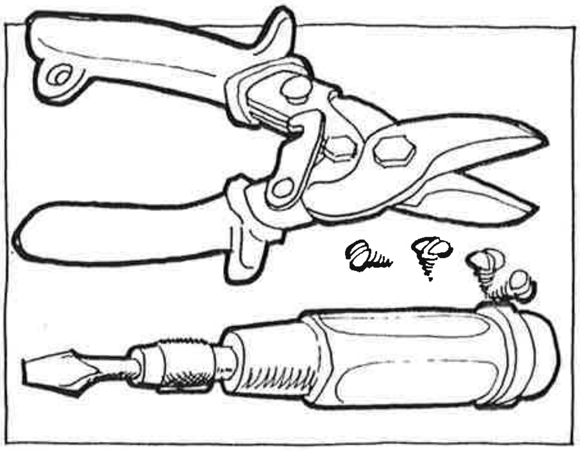


Fig. 15

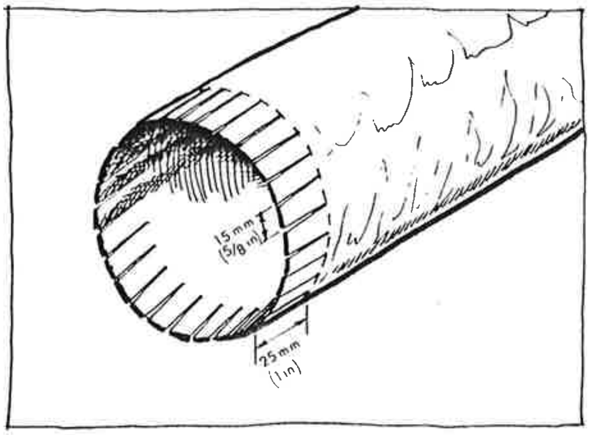


Fig. 16

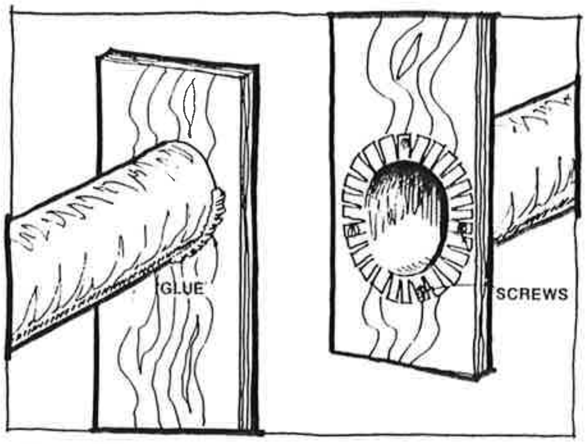


Fig. 17

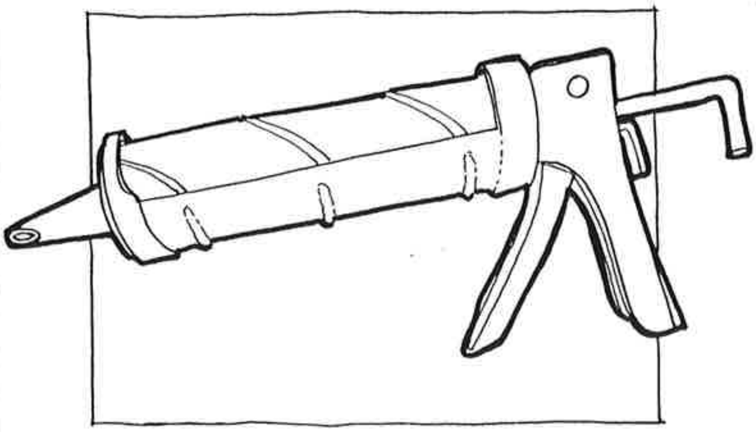


Fig. 18

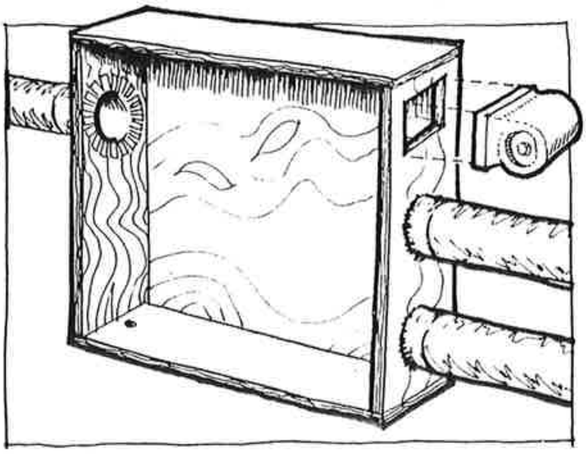


Fig. 19

Mount the heat exchanger core in the box as shown in Fig. 20. Run a bead of glue along each of the foam strips on the side of the core that presses against the back surface of the box. Do not put glue on the foam strips on the opposite surface of the core as this side presses against the lid which must be removable. Seal the core in the box by applying glue to both sides of the corners formed where the core corners butt up against the box. The seal can be further improved by gluing a small strip of Coroplast along one side of each corner.

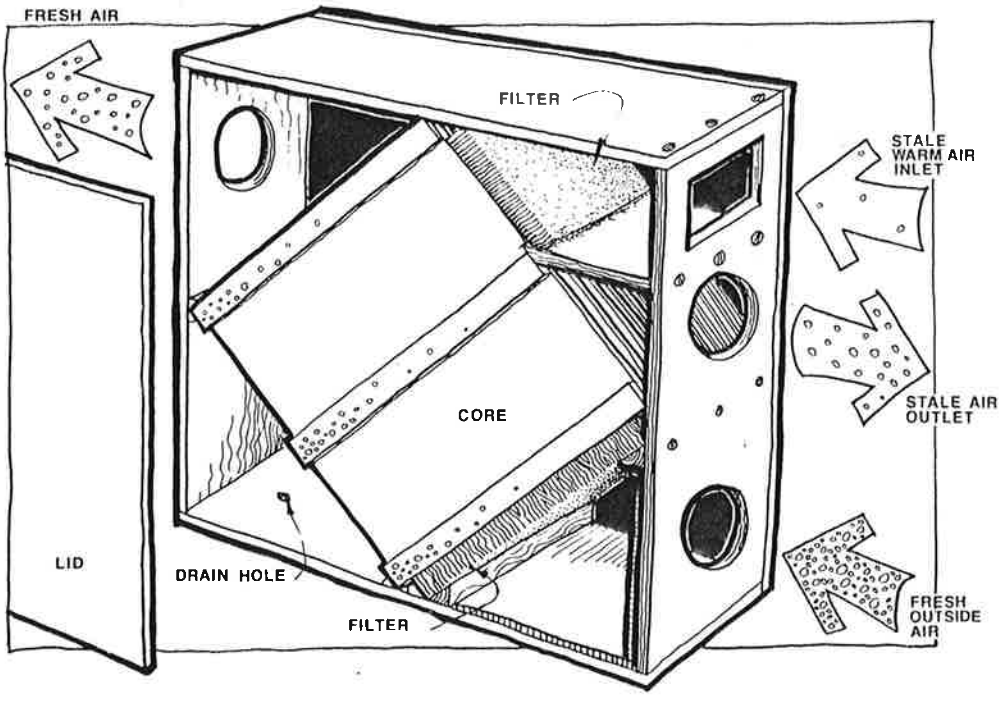


Fig. 20

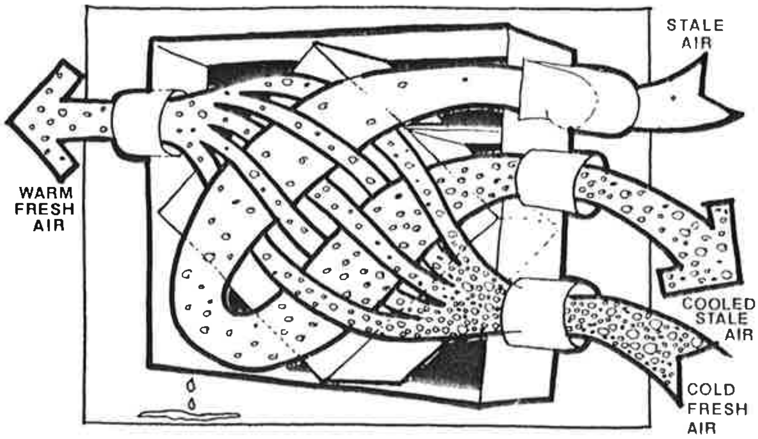


Fig. 21

The remaining Coroplast can be cut to fit to insulate the coldest parts of the heat exchanger box. These can be glued on the inside surface of the box, as shown, or on the corresponding outside surface. The primary purpose of this insulating layer is not to reduce heat loss, which is not a significant factor, but rather to reduce condensation at the outside surface. This condensation could result in water accumulating around the heat exchanger - a potential problem only during sustained operation at outside temperatures below -20°C (-4°F).

A drain hole is drilled through the bottom on the stale or warm air side of the heat exchanger. This hole provides a means for the water condensing out of this air to escape. Copper, plastic, or garden hose tubing can be connected to the hole to direct the water to a catch basin or floor drain.

Air filters are located on the fresh inlet air and stale exhaust air inlet entrances to the box. The filters are held in place by gravity, against the core as shown in Fig. 5 & 20. The filters can be cut out of furnace air filters or similar material.

The lid must be easily removed to enable inspection and maintenance, yet must seal tightly against the core box and edges to prevent air leakage and cross contamination on the flows. This can be achieved by hinging the lid along one of the vertical edges using a piano hinge and providing positive closing latches (buckle type) along the other edges that will draw the lid tightly closed.

INCREASING AIR EXCHANGER SIZE

The size of the unit can be readily increased by simply adding more layers of Coroplast to the core and increasing the depth of the enclosure box by a corresponding amount.

Increasing unit size will raise the exchanger effectiveness, although not dramatically. Similarly, the increased flow area acts to reduce the pressure drop or loss through the unit. However, the principal advantage of the increased size would be that the performance would not degrade as rapidly under conditions of frost formation because of the increased capacity of the unit.

FANS

It is important that any fan which you choose has three characteristics:

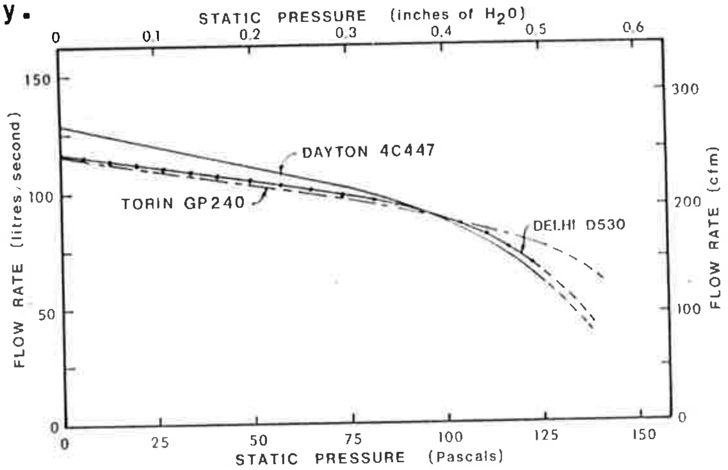
1. Low noise level. A fan with a high pitched noise level will not be very pleasant. If possible, test the fan for noise and balance before purchase. Placing a gasket or foam strip between the fan and enclosure box will reduce vibration noise.

2. Sufficient air flow. For an average sized house, a flow of about 75 l/s (150 cfm) should be available when the back pressure resistance is equal to 125 pascals (1/2 in. of water). A squirrel cage fan can provide this, but only a few axial flow fans can provide the required air flow rate through the exhaust ducts which are connected to the heat exchanger. When selecting a fan, be careful in assessing flow rates, as they are often listed at zero back pressure or no load condition. The flow can decrease very substantially as the back pressure is increased due to flow resistance through the duct work and air exchanger.

3. Low energy consumption. The use of highly inefficient fans can reduce overall air exchanger efficiency.

Three suitable commercially available fans are the Dayton Model No. 4C447, the Torin Model No. GP 240 and the Delhi D530.

The two fan motors required are powered by 115 Volt, 60 cycle and will draw less than 3 amps so no special transformer or power supply is required. The pressure versus flow curves for these fans are shown in Fig. 22



FLOW PRESSURE CHARACTERISTICS
3 COMMERCIAL FAN UNITS
(MANUFACTURER'S DATA)

Fig. 22

INSTALLATION

LOCATION OF THE UNIT

1. Locate the exchanger near an outside wall of the house and preferably close to the kitchen and bathroom to minimize duct lengths.
2. Mount the unit so as to minimize motor vibration noise. This can be accomplished by placing foam pads between the unit and its support.
3. Locate the outside intake and exhaust ports on the outside wall of the house at a minimum distance of 2 metres (7 feet) apart from each other. This will minimize the likelihood of stale air being drawn back into the house. Avoid locations where automobile exhaust could be readily drawn into the house. In areas of heavy snowfall, locate the intake and exhaust ports above the snow line. A bird or rodent screen should be placed across each port as shown in the sketch. The mesh on this screen should not be finer than 6mm (1/4 in.) or the screen could plug from dust or hoar frost. NEVER dump exhaust air into the attic space. Ice accumulating on the rafters can literally bring the house down!

4. Most fans and motors are designed to operate with a horizontal axis of rotation. The heat exchanger fans should be oriented on a horizontal axis unless fans and motors are specially selected to operate in a different orientation.

DUCT LAYOUT

Figure 23 is a schematic diagram showing the recommended duct locations for air exchanger systems installed in houses with a forced air heating system.

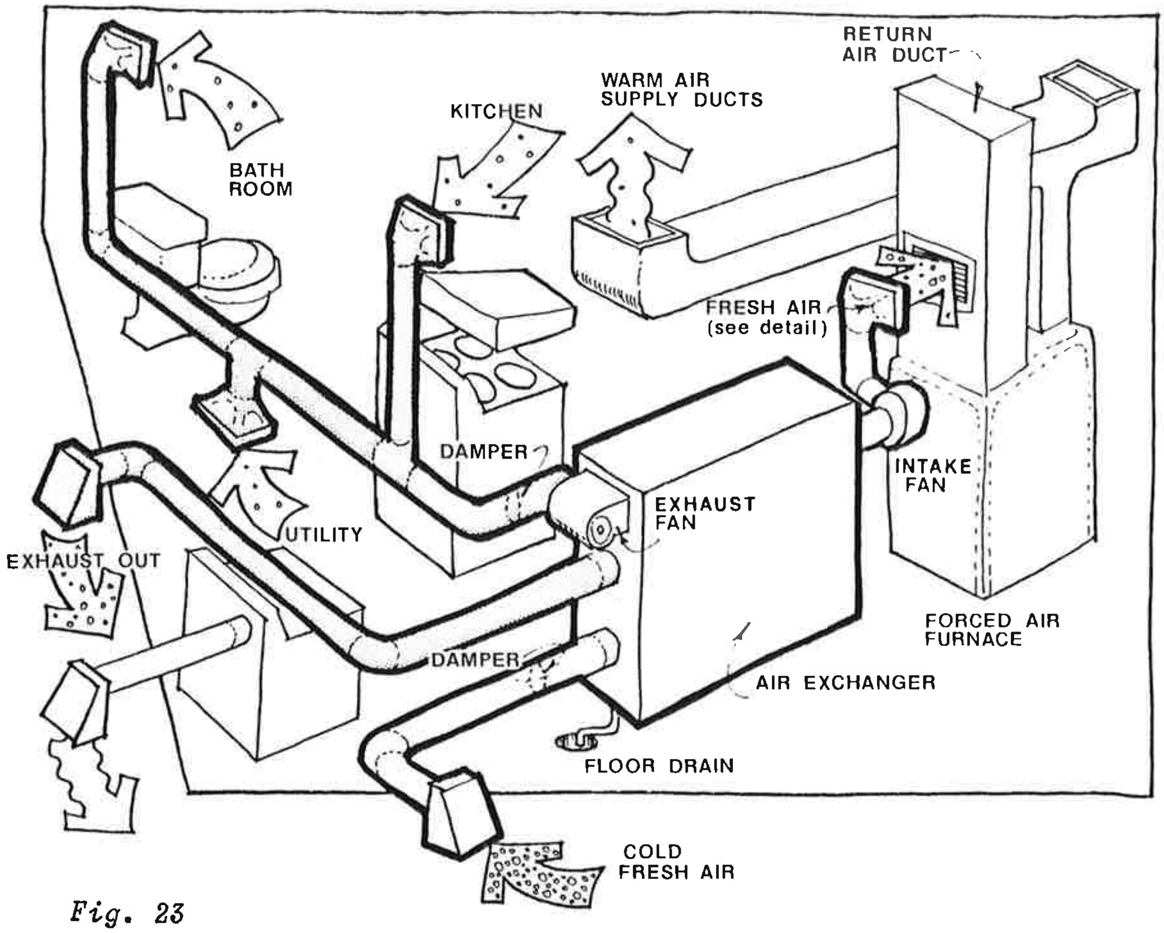


Fig. 23

Figure 24 is a schematic diagram showing the recommended duct locations for air exchanger systems installed in houses without a forced air heating system (radiant water, electric radiant, etc).

1. The exhaust air should be drawn from the kitchen and bathrooms as shown. Do not connect the range hood directly to the air exchanger inlet ducting. A recirculating fan should be used for the stove and a duct inlet with grease filter placed near the stove high on the wall. Do not use tightly meshed inlet grilles as they could reduce air flow rates.

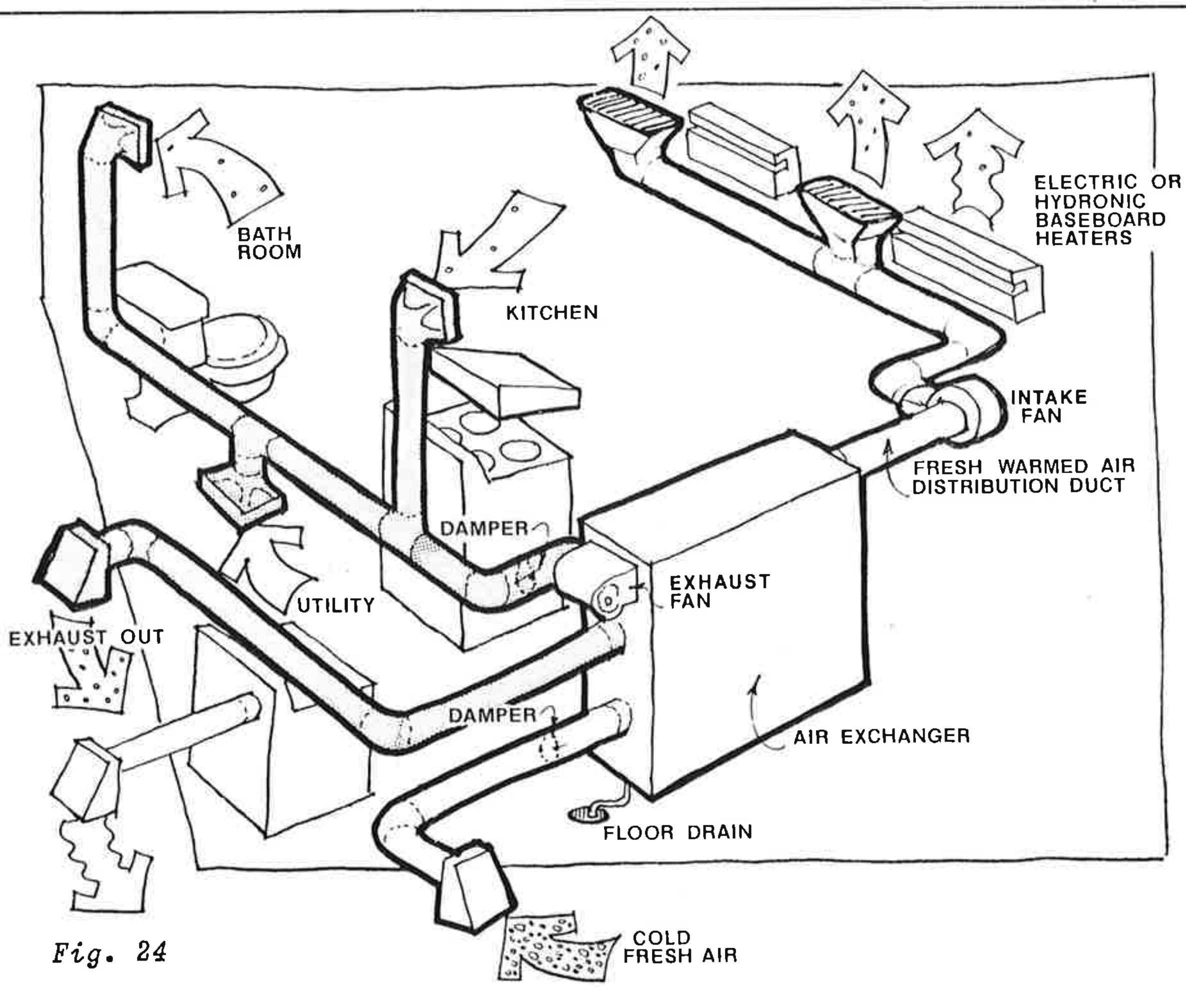


Fig. 24

2. DO NOT connect the clothes dryer directly to the air exchanger. The back pressure on the dryer could seriously damage the dryer. Reduced dryer air flow can burn out the electrical heating elements in the dryer. Either vent the dryer directly outside, or if the humidity from the dryer is considered desirable, vent the dryer directly into the house during the winter season using a filter on the dryer outlet pipe. (A flow diverter with a lint screen is available at most hardware/building supply stores. It will divert dryer exhaust air either outside or into the laundry room). Note that gas dryers should never be vented indoor as this is extremely dangerous. With a moderate amount of clothes drying, typical of a family of four, the moisture from clothes drying can usually be adequately handled indirectly through the heat exchanger by the continuous exhaust of house air. If, however, the house has a problem with excess moisture, then the dryer should be vented directly outdoors using an exhaust port with a back damper.

3. All ducts should have an absolute minimum diameter of 152 mm (6 in.). If smaller duct sizes are used, excessive duct pressure drops are likely to occur and air flow rates much less than desired may result. The flow rates through these ducts are generally much less than in forced air heating system ducts. Consequently air velocity at exit is not as noticeable.

4. Minimize the number of elbows and long runs of duct work to avoid excessive pressure drops. Locate the heat exchanger near an outside wall and close to bathrooms and kitchen to achieve this.

5. Ducts connecting from the air exchanger to the outside are going to contain cold air. They should be insulated and covered with a vapour barrier to prevent moisture from condensing on the outside surface.

6. Warm air ducts should be insulated against heat loss if the exchanger is located in an unheated space.

7. Apply duct tape or use silicone sealant around each pipe joint and along pipe seams to minimize duct leakage.

8. In the forced air heating system shown in fig. 23, the fresh air from the air exchanger should not be directly connected to the furnace cold air return as operation of the furnace fan can create a serious flow imbalance through the exchanger. It is recommended instead that this air be exhausted near an inlet grille in the fresh air return duct as shown in Fig. 25

9. Connect dampers in-line, one on the exhaust air side and one on the fresh air side both located near the heat exchanger. The dampers can be used to adjust the air flow resistances to balance the two air flowrates.

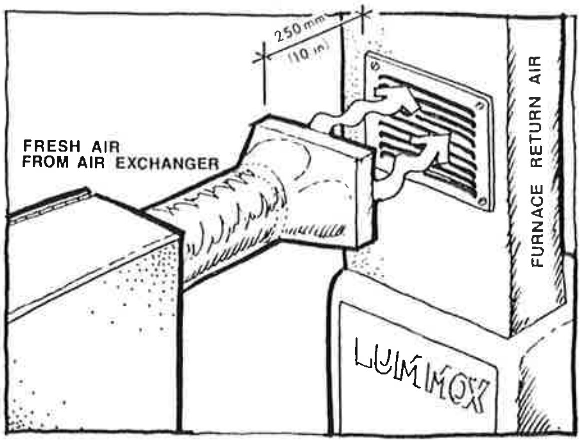


Fig. 25

FLOW BALANCING

It is very important that the air exchanger operate with equal inlet and exhaust air flow rates so as not to produce any unwanted infiltration or exfiltration through the house. For houses having forced air heating systems, there is generally more duct work and, therefore, flow resistance on the exhaust air side of the heat exchanger. This is a result of the fresh air being exhausted from the exchanger into the furnace cold air return. Consequently, there is a tendency for the exhaust air flowrate to be less than the intake flowrate. This is compensated somewhat by a higher pressure drop across the inlet or fresh air side of the heat exchanger itself (5 to 6 times higher than the exhaust side).

If 152 mm (6 in.) diameter duct is used, then the lengths of straight duct required to have the unit approximately in balance have been determined. For an air inlet duct straight length of 10 metres (33 ft.), about 50 metres (165 ft.) of straight length of exhaust air duct would be required. Note that elbows and bends create a much greater pressure drop than a straight length of pipe. One three-piece elbow has a pressure drop equivalent to 9 metres (30 ft.) of straight pipe. In most installations, particularly where forced air heating systems are used, the pressure drop will be the greatest on the exhaust or stale air side so it is important to minimize these pipe lengths and use as few elbows and bends as possible.

The preceding information should be considered as only a rough guideline in achieving equal flowrate through the air exchanger. The best final step is to measure the flow rate through each side of the heat exchanger and close the damper on the side with the higher flowrate until the two flowrates are equal. These measurements are made using a pitot tube, hot wire anemometer, or flow nozzles.

In the absence of such specialized equipment, the following procedure for balancing the flowrates through the exchanger are recommended:

1. Choose a calm day when it is not too cold outside (ideally when the outdoor and indoor temperatures are nearly the same).

2. Fully open one window on the lee side of the house away from any wind effects. Close all the remaining windows and doors.

3. Fasten and seal a polyethylene sheet over the window opening. This can be accomplished by taping the sheet to the window frame all around the edges so as to minimize leakage. Do not stretch the poly tightly over the opening.

4. Open both dampers and turn on the fans.

5. If the sheet of poly bows or curves <u>outward</u>, then the fresh or inlet air flowrate is higher causing a positive pressure on the inside of the house. <u>Gradually</u> close the damper on the inlet air side until the poly sheet is limp or vertical.

6. If, when the system is turned on, the sheet curves <u>inward</u> then the damper on the exhaust side must instead be gradually closed to achieve the balanced condition described in the previous step.

DEFROSTING THE HEAT EXCHANGER

In cold climates where the outside air temperature drops below −10°C (14°F) for more than a day at a time, the heat exchanger will experience significant frosting on the plates inside the unit. Moisture in the exhaust air condenses as it cools and freezes on the plates. The frost and ice buildup can greatly reduce the exhaust air flow and heat exchanger effectiveness. This degradation in performance occurs much more rapidly as the outside air temperature decreases.

Laboratory tests were conducted on the unit described in this book under conditions of cold air inlet temperature of −30°C (−22°F), and a warm air inlet temperature of 21°C (70°F) and relative humidity of 35%. The air mass flowrates through the warm and cold sides were intially the same. After continuous operation for 24 hours, the warm air flowrate had dropped from 90 to 67 l/s (180 cfm to 135 cfm) and the exchanger effectiveness from 0.65 to 0.40. While this performance is relatively good compared to some commercial units, it does indicate the need to periodically defrost the unit.

The simplest strategy and the one recommended for use with this unit is to periodically shut off the fan on the cold or fresh air side of the exchanger. This can be accomplished by installing a 24 hour cycle timer in series with the fan motor and setting the timer to shut the power off for a fixed time period every 12 hours. The length of time the fan must be turned off depends on the outside temperature.

TABLE 2 DEFROST CYCLE TIMES

DAILY AVERAGE TEMPERATURE	DEFROST DUTY CYCLE
Higher than −10°C (14°F)	No defrost cycle required
−10°C (14°F) to −20°C (−4°F)	15 to 25 minutes every 24 hours
−20°C (−4°F) to −30°C (−22°F)	15 to 20 minutes every 12 hours
−30°C (−22°F) to −40°C (−40°F)	20 to 30 minutes every 12 hours

Table 2 can be used to determine the shut down time. This information was derived from laboratory testing of the air exchanger described in this book. For locations which seldom experience temperatures below −10°C (14 °F), a defrost cycle is not required. On the other hand, locations which experience temperatures of −30°C (−22°F) to −40°C (−40°F) require a significant defrost cycle.

Do not control the overall duty cycle of the exchanger from a humidistat. The exchanger should be run continuously to control indoor air pollution. Indoor humidity is not a true indicator of overall indoor air quality. Large homes with low occupancy will often have very low moisture generation rates yet could have a high level of air pollutants.

WIRING

Detailed wiring diagrams and instructions for installation of controls are not being described here due to the variety of ways to detail a specific installation, and local code and regulatory requirements. The circuit is an electrical installation, and for safety should be wired by someone familiar with electrical systems and must adhere to local electrical code requirements. The wiring should be armoured or BX cable. Fig. 26 is a schematic diagram showing a basic wiring scheme.

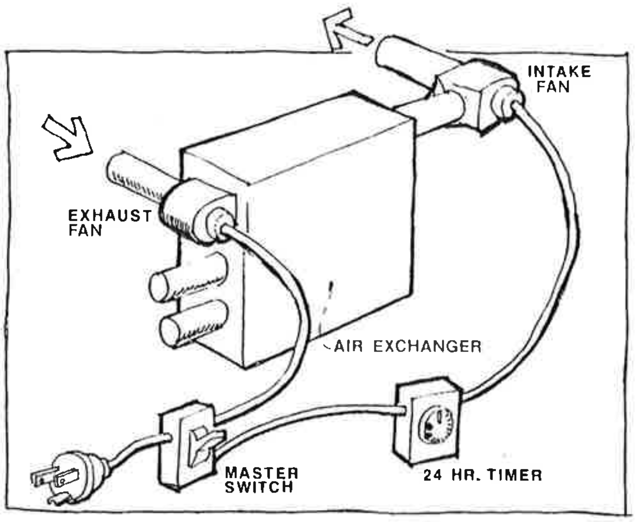


Fig. 26

The exchanger should be wired to run continuously (except in the summer time or when the house windows and doors are open). The master on-off switch should be easily accessible and located close to the exchanger. For automatic defrosting, the intake fan could be installed with a 24 hour timer, which can then be adjusted for the appropriate defrost cycle. Most commercial units and more sophisticated installations would be set to run at two speeds - half speed continuous circulation, and timer switches to allow fans to go to high speed, located near the exhaust outlets of the house (usually kitchen and bathrooms). We would recommend the simpler installation with the fans running continuously at one speed.

SUMMER OPERATION

In climates where there is normally little or no air conditioning requirement, summer ventilation can be provided most cost effectively by means of openable windows and screen doors.

In very noisy areas (near airports, highways, etc.) or during long hot spells, it may not be desireable to open windows. To keep the 'coolness' of the house, windows should be kept closed during the day, and the air exchanger run. Also, where there is a cooling load requiring the use of an air conditioning system, the air exchanger can be used to provide energy efficient ventilation. The energy in the stale exhaust air precools the fresh inlet air. In humid regions, this can result in water condensing from the inlet air as it is cooled. Consequently, a water drain line should be provided on the inlet side if the air exchanger is operated under these conditions.

MAINTENANCE

1. Inspect inside exchanger periodically, particularly after initial installation.

2. Clean filters regularly.

3. Check fans and drain line.

4. Periodically check to see that the temperature of the cold outside air after it has passed through the exchanger is greater than 10°C (50°F). If it is colder than this, check to see that the exchanger intake and exhaust flows are balanced and that there are no flow blockages in the unit.

LIST OF MATERIALS

MATERIAL	SIZE & QUANTITY	SOURCES
Coroplast™ *	4 sheets – 1220mm x2440mm x4mm (4 ft. x 8 ft. x 5/32 in.)	Plastic companies, lumber yards sign makers
Glue	2 tubes PL 200 or silicone sealant (coloured)	Hardware stores, lumber yards
Pressure treated plywood	1 sheet 1220mm x2440mm x16mm (4 ft. x 8 ft. x 5/8 in.)	Lumber yards
Centrifugal fans with 115V motors	2 capable of providing a flow of 70 L/s (150 cfm) at a back pressure of 125 Pa (1/2 in. of water)	Fan suppliers, plumbing & heating suppliers/contractors
Galvanized (sheet metal) duct	3 – 165mm (6 1/2 in.) lengths or 1 – 500mm (20 in.) length of 152mm (6 in.) diameter plus enough duct to supply rooms as shown in fig.23 & 24	Hardware stores, lumber yards plumbing supply stores
Foam weatherstrip	4 meter length (13 ft.) approx. 13mm (1/2 in.) wide	Hardware stores, lumber yards
Galvanized metal screws	1 box (appprox. 25)	Hardware stores, lumber yards
Buckle type fasteners	3 – approx. 20mm (3/4 in) wide by 50mm (2 in.) long	Hardware stores
Garden hose	sufficient length to reach catch basin or floor drain approx. 12mm (1/2 in) diameter	Hardware stores, plumbing supply stores
Duct tape	1 roll 50mm (2 in.) wide	Plumbing supply & hardware stores
Paint	1 litre(1 quart) marine enamel	Hardware stores, lumber yards
Misc.	furnace filters, timer for defrost, control, inlet & outlet exhaust ports 152mm dia. (6 in.)for exterior wall, piano hinge, plumber's strapping (for attaching exchanger box to floor joists)	Hardware stores, lumber yards

* Manufactured by: Coroplast Inc., 700 rue Vadnais
Granby, Que. J2J 1A7
Phone (514) 378-3995

Main U.S.A. Distributor:
Tekra Corp., 16700 West Lincoln Ave.
New Berlin, Wisconsin 53151
Phone: Toll free 1-800-558-4310
(In Wisconsin: 1-800-242-0963)

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COMMERCIAL MANUFACTURERS

If after reading this publication you decide not to undertake the building of your own air-air heat exchanger, there are a large number of commercial air exchangers on the market. The following is a list of North American manufacturers. The location of their dealers nearest you can be obtained by contacting the manufacturers. The authors do not necessarily endorse any or all of these manufacturers or their products.

ACS-Hoval
935 N. Lively Blvd.
Wooddale, IL 60191
(312) 860-6860

Aldes-Riehs
157 Glenfield Rd, R.D. 2
Sewickley, PA 15143
(412) 741-2659

Berner International Corp.
216 New Boston Street
Woburn MA 01801
(617) 933-2180

Bossaire Inc.
415 W. Broadway
Minneapolis, MN 55411
(612) 521-9033

Des Champs Laboratories, Inc.
Box 440
17 Farinella Dr.
East Hanover, NJ 07936
(201) 884-1460

Ener-Corp Management Ltd.
Two Donald St.
Winnipeg, Manitoba R3L 0K5
(204) 477-1283

Memphramagog Heat Exchangers Inc.
P.O. Box 456
Newport, VT 05855
(802) 334-5412

Mountain Energy & Resources Inc.
15800 West Sixth Ave.
Golden, CO 80401
(303) 279-4971

The Air Changer Co. Ltd.
334 King St. East Suite 505
Toronto, Ont. M5A 1K8
(416) 947-1105

Airxchange, Inc.
30 Pond Park Rd.
Hingham, MA 02043
(617) 749-8440

Blackhawk Industries, Inc.
607 Park Street
Regina, Saskatchewan S4N 5N1
(306) 924-1551

Conservation Energy Systems Inc.
800 Spadina Crescent East
P.O. Box 8280
Saskatoon, Saskatchewan S7K 6C6
(306) 665-6030

EER Products, Inc.
4501 Bruce Ave.
Minneapolis, MN 55424
(612) 926-1234

Heatex, Inc.
3530 East 28th Street
Minneapolis, MN 55406
(612) 721-2133

Mitsubishi Electric Sales America Inc.
3030 East Victoria St.
Rancho Dominguez, CA 90221
(800) 421-1132

Nutone Housing Group
Scovill Inc.
Madison & Red Bank Roads
Cincinnati, OH 45227
(513) 527-5112

Nutech Energy Systems Inc.
P.O. Box 640
Exeter, Ont. NOM 1S0
(519) 235-1440

P.M. Wright Ltd.
1300 Jules Poitras
Montreal, Que. H4N 1X8
(514) 337-3331

Q-Dot Corp.
701 North First St.
Garland TX 75040
(214) 487-1130

Raydot Inc.
145 Jackson Ave.
Cokato MN 55321
(612) 286-2103

Solatech Inc.
1325 East 79th Street
Minneapolis MN 55420
(612) 854-4266

X-Change Air Corp.
P.O. Box 534
Fargo ND 58107
(701) 232-4232

Z-Air Fabrication Inc.
690 Place Trans Canada
Longuenie, Que. J4G 1P2

ABBREVIATIONS

l/s = air flow rate in litres per second
cfm = air flow rate in cubic feet per minute
ACH = house volumetric air changes per hour
m = length in metres
mm = length in millimetres
ft. = length in feet
in. = length in inches
C = temperature, degrees celcius
F = temperature, degrees Farenheit

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<u>SOLPLAN ALMANAC: Canadian Solar & Climatic Data</u> (1980). In the tradition of Almanacs, notes on solar energy activity, sun path charts, data charts, monthly climatic data, home energy log. Copies still available for $3.50

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