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VENTILATING SYSTEMS INCORPORATING HEAT RECOVERY
A CASE STUDY OF THE THERMAL WHEEL TECHNIQUE IN AN INDUSTRIAL APPLICATION

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1. DEVELOPMENT AT POSSILPARK GARAGE FOR GREATER GLASGOW PASSENGER TRANSPORT EXECUTIVE

In common with many city bus garages throughout the country, Possilpark Bus Garage was originally a depot for tramcars.

The site plan (Fig.1) shows the general layout and the restrictions for alternative development. It was accepted that there was insufficient vacant ground in the immediate neighbourhood which would be suitable for a completely new garage and workshop facility. The cost of a completely new development was considered by the P.T.E. to be prohibitive. The open garage incorporated twelve maintenance pits plus additional pits for oiling and greasing work.

Most of the 120 buses using the garage were parked in the garage overnight but a residue of 20 - 25% were generally parked outside in an adjacent rectangular area of ground. The outside parking carried with it the usual problems of cold starting and damage by vandals and it was eventually decided to build a parking shed on the adjacent area of vacant ground. With the modernisation of the old garage the outside parking would have increased in any case. It was of prime importance for the P.T.E. to maintain a bus garage in the area and after careful consideration an extensive programme of refurbishment was agreed.

The main factors dictating the replanning were:-

a) The necessity to provide present day standards in the offices and workshop.

b) Provision of additional maintenance pits and related facilities to increase efficiency of operation.

c) Solution to the problem of circulation and access to provide control and yet give greater security.

d) Organisation of the modernisation work to permit continued use of the complete depot.

e) Consideration of the heating and ventilation systems to provide for the requirements of the Building Standard within economic boundaries.

f) Reorganisation of the ancillary accommodation to permit extension of the depot offices.

g) Consideration of the structural implications of modifying an old building.

It was therefore agreed to proceed with the refurbishment and the following main proposals were incorporated (Fig.1 and 2)

a) Provision of additional pits to take longer buses. Removal of some pits in awkward areas and total number to be increased to 17.

b) Entry and exit point for buses combined for maximum control. The circulation through fuelling point and wash bay has been accepted meantime but is under review.

c) Complete reorganisation of the depot office using space made available by removing the steam boiler plant and extending into a dead area of the garage.

d) Change the heating system to a gas fired low pressure hot water system and incorporate a thermal wheel in the air handling equipment for the workshop. Provide an air extract system for the unheated garage area.

e) Complete enclosure of the Pit/Workshop Area including a hung insulated ceiling so that the volume of air change could be reduced and controlled.

f) Install a diesel fumes extract system for direct connection to bus exhaust pipes.

g) Revise, renew or provide all other engineering services including lighting, low voltage supplies, compressed air and lubrication facilities.

The contract is now finished and the thermal wheel installation has been operating for some time now.

2. ENGINEERING SERVICES

The existing garage was heated by an oil fired vertical boiler system supplying steam to unit heaters in the garage area and to conventional radiators and pipes in the offices and other accommodation. The inspection pits in the workshop area had a warm-air system which was completely ineffective.

The total area of the existing garage is about 5300 m^2. Originally, apart from the offices and miscellaneous accommodation, it was a completely open space, part of which was allocated to twelve maintenance pits with most of the remaining area used for overnight bus parking. As can be seen from the sections and elevations (Fig.4) the roof is a conventional saw toothed type construction with a mean height of 7 metres.

The need for the continuous entry and exit of buses during early morning and evening meant that the large garage doors were continually open. The need to shunt, re-fuel and re-position buses overnight created a similar situation.

As a consequence the cost of oil for heating between mid-October and the end of March 1977 was about £10,600 and the resultant comfort conditions were totally unsatisfactory.

Because of the requirements of our brief, the location of the existing boiler plant could not be retained and it was decided to form a new boiler room at first floor level in the East Offices (Fig.4). The room selected was eminently suitable having a concrete floor and high level windows.

An early decision to change to a low pressure hot water gas fired system on economic grounds eliminated the problems of oil storage and chimney. The flues from the new gas boilers terminate just above roof level over the new boilerhouse.

Under the requirements of the Scottish Building Regulations, an enclosed Workshop shall have a minimum air change rate of four per hour. In this instance, this represents a volume of 15.6 m3/sec. (33.000 cfm).

Bearing this in mind, it was decided to form an enclosed workshop within the existing space, heated and ventilated independently (Fig.2). The remaining covered area remains un-heated but mechanically ventilated, to serve only as a bus-park. The new workshop apart from performing an essential maintenance function also serves as space for overnight parking in an emergency.

The area of the new workshop required to be 2470 m2, leaving 2766 m2 of unheated, covered bus parking. The workshop is provided with an insulated false ceiling at about 5 metres whereas the covered, unheated, parking area remains with a mean height of 7 metres as before. Suitably noise attenuated air handling plant is located above the false ceiling (Fig.3 & 5) and the system is designed to provide the required volume of air with an extract rate of 87% of input, thereby creating a positive pressure in the Workshop.

The final provisions for the Workshop are as follows (previous provisions are shown in brackets):

Number of buses in depot	120	(120)
Mechanics repair pits	10	(7)
Mechanics 'Hammerhead' repair pits	4	(Nil)
Chassis wash pit	1	(2)
Oil servicing/body builders repair pits	2	(3)
Body builders repair bays	6	(Nil)

Having calculated that the cost of energy necessary to heat the Workshop to 18.3°C would be in the order of £7,900 per annum, it was decided to design a Thermal Wheel into the system, which would transfer heat from the exhaust air to the incoming fresh air. It was estimated that the heat recovery rate would be great enough to save £3,700 per annum, leaving a net running cost of £4,600.

The supply and installation cost for the complete mechanical services to the Workshop is about £73,000 of which the thermal wheel costs are £8,000. Under ideal conditions the heat saved is approximately 50-60% over a complete year.

The provision of a ducted supply and extract system to the Workshop permitted integration of a diesel exhaust system from the pit areas (Fig.6). When this system is in use, the heat in the diesel exhaust, though relatively small, will also be reclaimed. Contamination of the fresh air supply does not occur and improved environmental conditions are achieved. The diesel extract system also obviates pressure build-up at the exhaust tail-pipe of the bus, which in turn facilitates the tuning of the bus engines.

The supply air is discharged at high level in the Workshop through suitable air terminals. The exhaust air is extracted in the proportion of two thirds at low level and one third at high level in order to give effective removal of the diesel fumes which tend to settle in a 'blanket' fashion about 1 metre above floor level.

The scheme described above for Possilpark is a viable proposition and similar principles of design could be applied to other industrial workshops with large volumes and difficult environments.

3. THERMAL WHEEL

A thermal wheel is a heat exchanger which, as the term implies, is constructed in the form of a wheel and rotates continuously at approximately 10 rpm in normal operation. It is more formally described as an axial flow rotary regenerator.

The diagram (Fig.7) shows the air flow pattern. The warm air being the extract from the workshop which is at a temperature of 18.3°C and contains a varying amount of obnoxious fumes which render the air unsuitable for recirculation. The incoming air is tempered by the heat transfer principle of the thermal wheel. The core or matrix of the wheel is constructed from an inorganic fibrous material which is capable of storing the heat received from the warm air extract and transferring same each half cycle as the complete matrix slowly rotates.

The ducting system and the construction of the matrix is such that it will not allow for any cross flow between the extract and incoming air. The standard thermal wheel incorporates filters which will keep the matrix clean. The matrix is also kept clean since the air flow is reversed each half cycle and towards the centre of the core there are special passages which are designed to promote a purging action. The efficiency of heat transfer using a thermal wheel system should be in excess of 70%. The "topping up" required is supplied from LPHW heater battery unit incorporated within the supply ducting.

At Possilpark the Plant Room was located in a position (Fig.4) suitable to the supply and exhaust air which was of great assistance in designing the rather voluminous ducting to the air handling units and a high velocity exhaust with a silencer had to be incorporated to overcome any tendency to "short-circuit" the flow pattern.

The filtering system designed for the supply air intake was somewhat over-efficient and to reduce recurring expense of replacement filters a simple pre-filter arrangement was introduced using a more economical form of throw-away filter which gave a longer life to the main filter units. The thermal wheel principle was selected for Possilpark as it was considered to be the most efficient and the most suitable for this particular application.

There are many other applications of the thermal wheel principle. In swimming pools, kitchens and hospitals for example there is a requirement to exhaust contaminated air and where the air change rate is high, there is a great potential for heat recovery. The basic materials used in the matrix may be varied to suit the particular state of the gases being extracted. Other types of heat recovery systems can be used viz. run-around coils, static heat exchangers, heat pipes or heat pumps. One particular system being more suitable than another for a particular application.

In conclusion, the basic considerations that had to be resolved were:-

a) Compliance with statutory requirements and in particular the 4 air changes per hour rate for workshop premises.

b) Maximum removal of obnoxious diesel fumes.

c) The provision of a more satisfactory overall environment.

It is considered that the foregoing aims were achieved but for future applications more attention will be given to:

d) The possible use of a less fragile type of matrix.

e) Maximising the use of economical pre-filters.

f) Provision of more test facilities for checking the efficiency of operation of the system.

The author would like to acknowledge the considerable assistance received from colleagues within the Partnership in the preparation of the drawings and other information included in this case study.

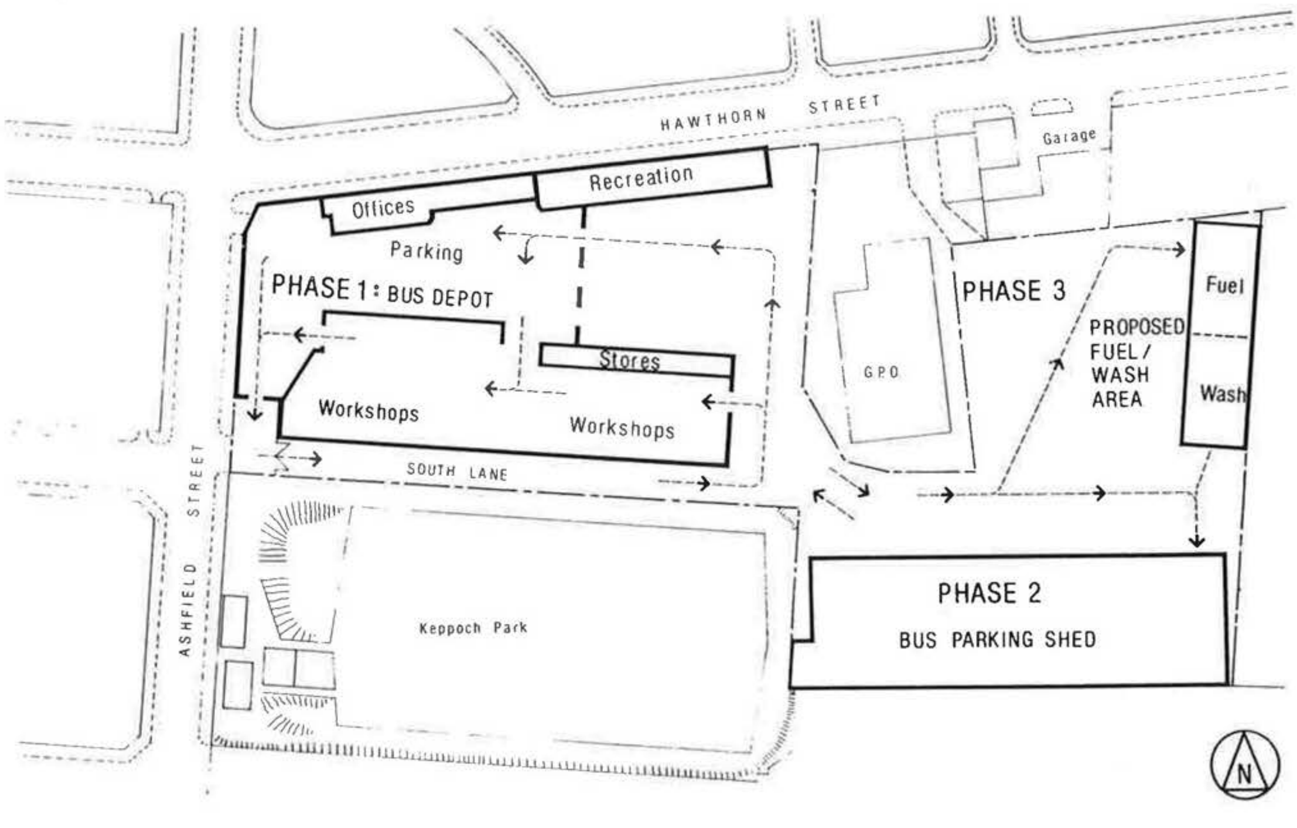


FIG 1
SITE PLAN

GGPTE POSSILPARK GARAGE

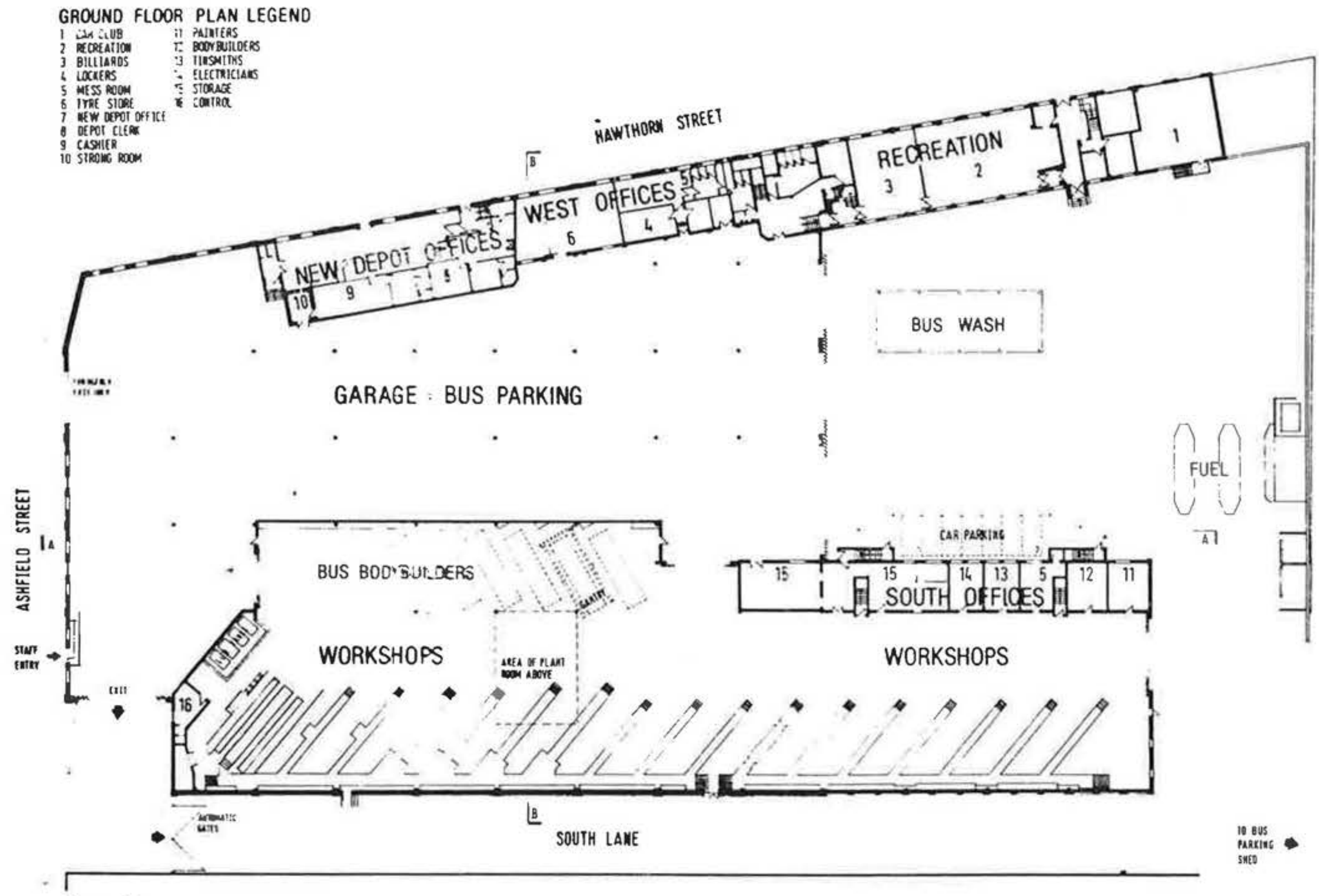


Fig 2
GROUND FLOOR PLAN

GGPTE POSSILPARK GARAGE

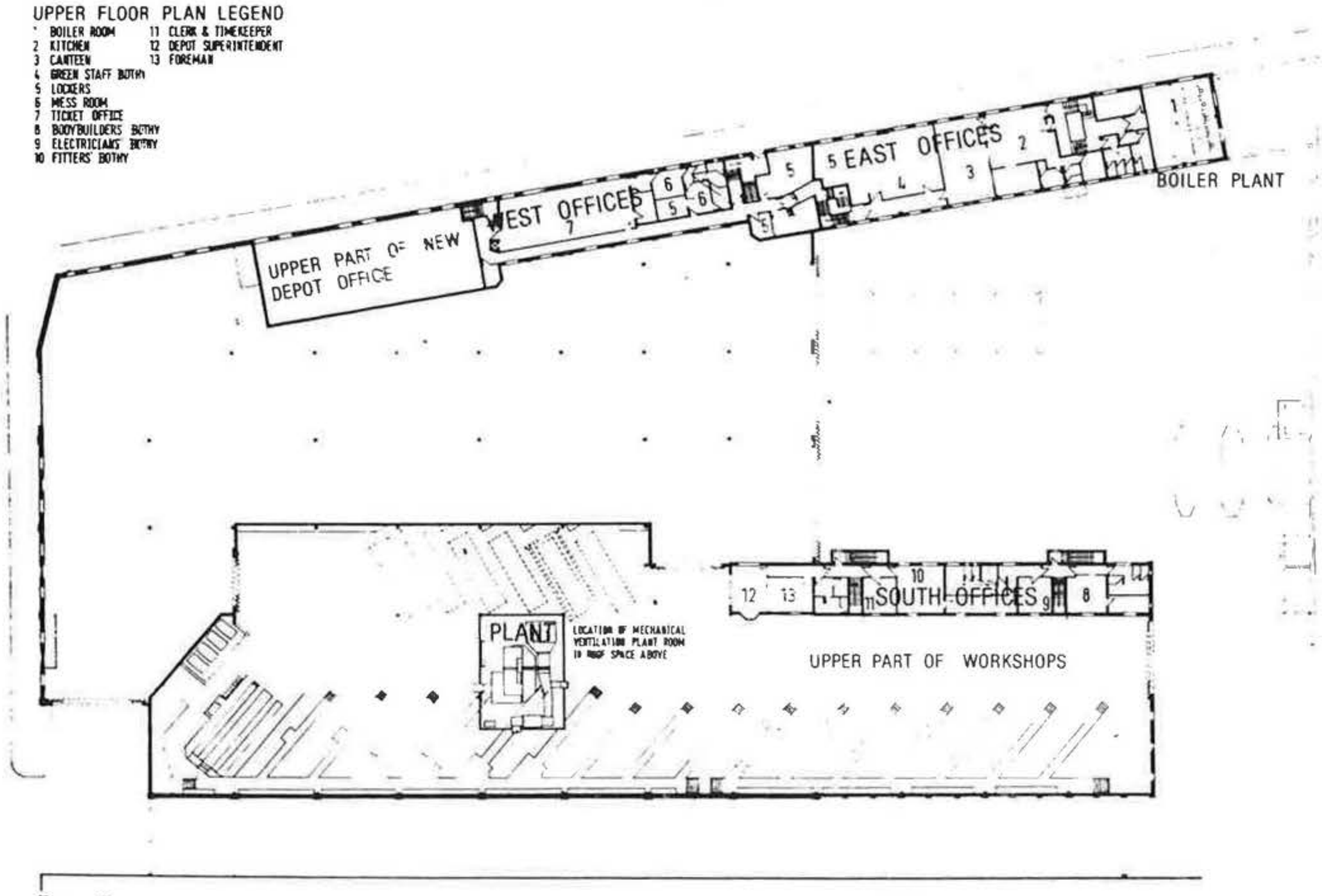
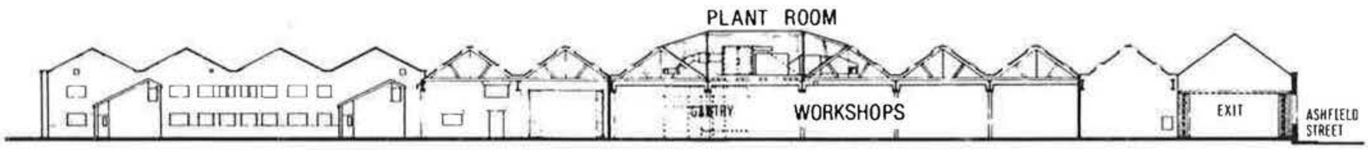


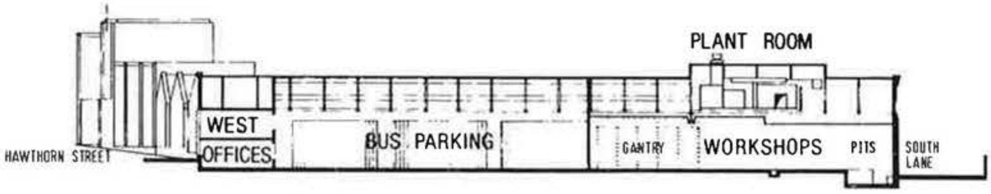
Fig 3
UPPER FLOOR PLAN

GGPTE POSSILPARK GARAGE

HAWTHORN ST. ELEVATION



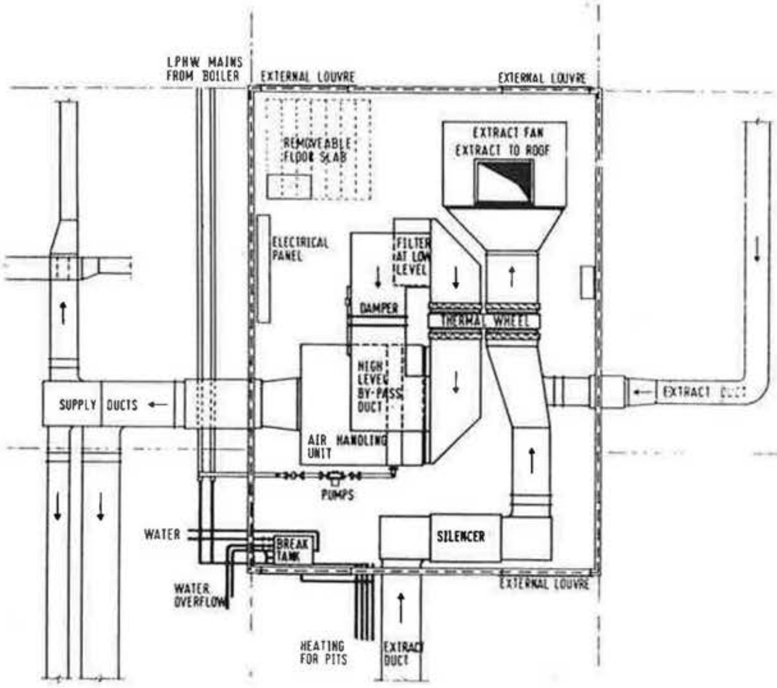
SECTION 'AA'



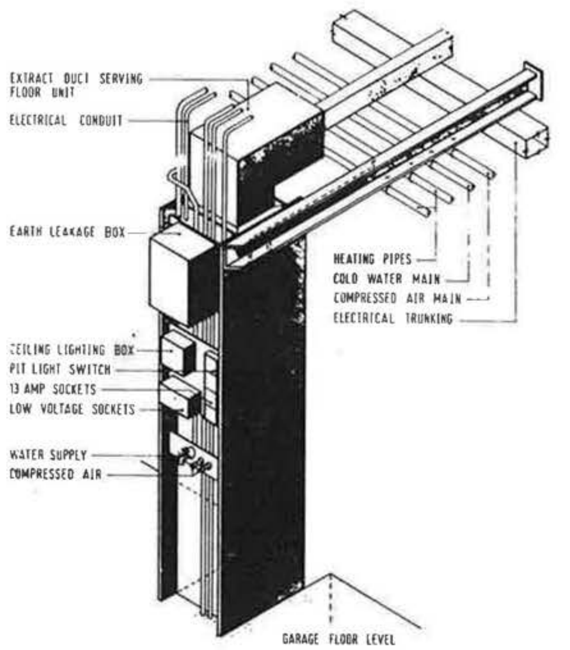
SECTION 'BB'

Fig 4
ELEVATION AND SECTIONS

GGPTE POSSILPARK GARAGE



PLAN OF VENTILATION PLANT ROOM



ISOMETRIC OF TYPICAL SERVICES' COLUMN AT PITS

Fig 5
SERVICES DETAILS

GGPTE POSSILPARK GARAGE

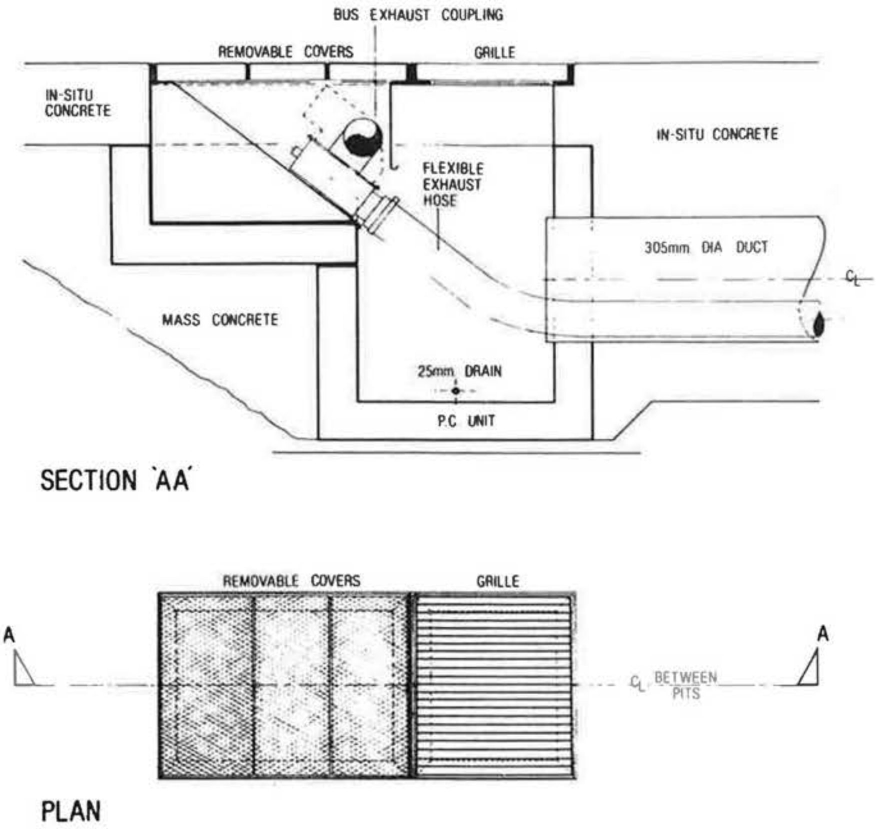


FIG 6
MECHANICAL EXTRACT UNIT

GGPTE POSSILPARK GARAGE
THERMAL WHEEL

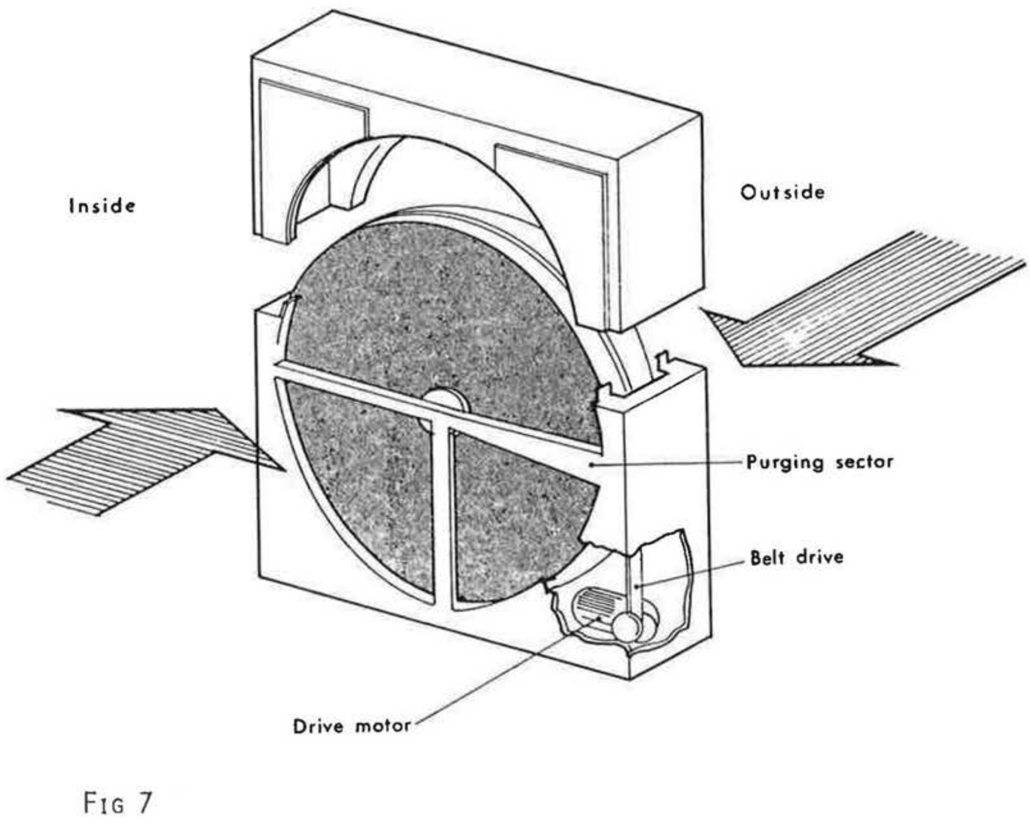


FIG 7