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AN OVERVIEW OF INFILTRATION AND VENTILATION DEVELOPMENTS IN FRANCE

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Synopsis

France is one of the European countries where ventilation has the most advanced regulation.

Vertical ducts have been used for a very long time, making easier the transfer from passive to mechanical ventilation (which covers now 90 % of the blocs of flats and 70 % of the individual housing).

1969 regulation has been based on a continuous air exhaust from the service rooms and air replacement through inlets in the habitable rooms. This has never been changed since then and is a part of french regulation's features.

The other main characteristic is to include the thermal loss du to ventilation in the calculation of the total loss of the housing.

Since 1983, it is possible to install a system which modulates and distributes the ventilation flows according to the needs (measured from humidity level) in the different rooms.

When you buy a house, you find heating, water supply, electricity supply. Good quality air supply, through a global ventilation system, must be provided as well. This is why a regulation is needed, with an obligation of result.

Essential requirements have to be met in every house, every places; whatever the wheater, the occupancy may be, at the right energy cost.

1. HISTORICAL INTRODUCTION

The present state of ventilation in France is the result of a long sequence of habits and requirements.
In order to understand it, one should go back as far as the after-war reconstruction period.
In the early 50's, one searched for higher and higher buildings because they were less expensive and quicker to build, making possible to house as many people as possible within the shortest time.
At that time, a paragraph of the building regulation expressed that all dwellings should have a possibility of heating accomodation.

As the central heating was not as wide spread as it is now, that particular point of the requirement often turned to be a mere duct for fumes ; each dwelling had its own duct connected with the roof level.

Due to that requirement and its interpretation, the contractor considered a vertical duct for air transport, joining each flat to the roof as a standard.

Once that practice was adopted, it remained valid even later, when central heating proved reliable.

2. THE SHUNT

In 1955 a new type of duct appeared: the "shunt". It was in fact a double duct composed of a smaller one used for the individual flow of each dwelling and a bigger one as a collector to gather the individual air flows into one (see fig 1).

In that way, the shunt duct made it possible to gather more than one dwelling in one plant saving space (for instance a 10 storey building needs only 20 x 54 cm instead of 15 x 150 cm in the previous system) and decreasing the cost of construction. The ventilation was still limited to the people's opening the windows. Occasionnaly, some grilles in lower and higher position were fitted in the service rooms like kitchen, bathroom..., using passive ventilation.

3. THE REVERSED SHUNT

At that time a new tendency appeared i.e. to group the service rooms in the middle of the buildings, leaving its "nobles" outside space to the habitable rooms.

Such a design allowed to use both sides of a building. The existing shunt duct made building construction easier by permitting the ventilation of the service rooms (where the pollutions due to occupants are stronger) although they had no longer any common wall with the outside atmosphere.

The ventilation was then ensured by a double shunt system :
It associated a normal shunt for the exhaust of foul air from the service rooms to the roof through higher grilles and a reversed shunt for the fresh replacement air, coming from the ground floor through lower grilles (See fig 2).

As foul air replaced fumes in those ducts, that design enabled to collect seven flows instead of five. That ventilation was still passive : "power" is given by the combined actions of wind and thermal draught (stack effect).

Each service room was ventilated reparately, being connected with a double shunt shaft.

There are two main objections to this principle :

- with the wind falling, the air flow may be strongly reduced ; even if a static fan may give an illusion of efficiency.

- the "motor" of the stack effect is the difference between the inside and the outside air temperature : It races in winter and stoppes in summer.

Thus, all dwellings are over ventilated in winter, causing unpleasant cold draughts, and under ventilated in summer, leaving bad odours, moisture in place.

- The habitable rooms are not ventilated in a coherent way, only submitted to the cross ventilation which can be either in the right or in the wrong direction spreading various pollutants from the service rooms. At that time,however, in France, the air leakages were rather high and there were only little condensation problems.

4. 1969 - THE FIRST REGULATION

4.1 1969 Regulation

The 1969 regulation,(the first required residentially in France), was designed to overcome all the drawbacks we talked about previously. The ventilation was required to continuously provide one airchange per hour in each habitable room. It had to supply fresh air to the habitable rooms and to exhaust stale air from the service rooms (see fig 3).

Actually, that was the very begining of the central mechanical ventilation in France.
This technique had already been know and used in switzerland and in sweden for a little while.

Its advantages are significant :
Whatever the weather, wind, temperature, may be the flows remain constant and well known in each service room.

In 1969 regulation - as in the further ones - the passive ventilation was still allowed, requirements were then to be met on an average winterday.

4.2 Evolutions

It became necessary to controll that the requirements were fulfilled either with a technique or with another.

Several control organisms (CEP - SOCOTEC ...) were set up. In a short time, they found that the mechanical ventilation was the best solution to comply with the requirements. It was easier to control, more constant and closer to the requested rates.

The existence of a regulation made possible a great extension of the ventilation market and stimulated the development of many new products, new technologies for the exhaust or inlet valves.

The quality of the different components of the complete system improved : the inlets took diffusion into account, tried to fight cross ventilation and wind pressure effects. The outlets allowed the flows to remain fixed, independant of the pressure in the ducts, without any adjustment on side , allowing to install extended networks with one bigger fan on the roof. The noise of the elements was strongly reduced and new requirements appeared, in order to limit sound levels. Fans became more and more reliable, and their lifetime increased, reaching 10 to 15 years of continuous work.

Additionally, it was less expensive to use central mechanical ventilation rather than passive because ducts were so much smaller (which was facilitated by the increase of the air velocity in those ducts) thus saving building space.

Furthermore, the " code de la construction " which is - in France - the practicable interpretation of essential requirements, asked the ventilation to cope with condensation problems : " condensations must not occur but momentarily."
Some cases were brought before the courts, where the dwellings had become insalubrious within a few month after the first occupancy.

After a mechanical ventilation had been set, the court noticed that condensation had disappeared and condemned the builder to refurbish the house and to use a mechanical ventilation instead of a passive one.

So, in the early 70's the market of the control mechanical ventilation was growing up at a rate of % per year .
Assuming this growth to continue for a while, and believing that, when writen, a requirement becomes effective at once, the french authorities have decided to include the energy loss due to ventilation in the total energy costs of the buildings.
Although the requirements were not met in every house, the energy costs estimates turned out to be good enough, because of the high ratio of mechanical ventilation.
The consumed energy is then calculated by the formula :

$$E = (Ki\ Si) + 0.34\ Q$$

where : E is the total loss in W/°C

Ki are the thermal coefficients of walls in W/m2/°C
Si are the areas of walls in m2
Q is the total flow of exhaust air in m3/h.

This point of the french regulation, which has continuously been used since then, is very speciic and very important :
It makes possible to compare every loss whatever the sources are, hence allowing to choose either a saving energy ventilation, or a normal with a larger thickness of insulator.

5. 1974 - THE ENERGY CRISIS

1974 is the year of the first energy crisis and attention was focused on the heating bills.
At that Time, about one third of this bill was caused by ventilation.
The dropping of the continuous ventilation was considered as a possible energy saving measure.

5.1 1978 - The Survey

In 1978, the french authorities decided to undertake a general survey about ventilation, collecting datas from all parts of the country, in order to determine if it was possible to reduce the air-change rates, to allow intermittent use...
The considerable amount of datas which was collected permitted to know, very precisely, how the different types of houses were occupied (see table 1)
It made possible to link the number of habitable rooms with occupancy, then gave a percent of residences which were over, well or under ventilated (see table (2)).

A significant result of the survey was to find out that almost 50 % of dwellings were over ventilated (when basing on occupancy rather than on volume).

5.2 The consequence of the Survey - 1982 Regulation

5.2-1 The consequence of the survey

The main consequence of the survey has been to change the reference for ventilation rates : they have, since then, been linked to the number of habitable rooms.
It has been decided also to lower the airchange rates in order to minimise energy loss.
New labels were set up, corresponding to different class of energy consumption thus to differents amounts of money given as incentives
to build houses as thrifty as possible.

Some competitions and long time monitorings were set up to find new solutions and to make everyone involved in the energy saving.

5.2-2 1982 - Regulation

The 1982 regulation was in fact decided in 1980 but the requirements were to be effective in 1982, in order to give the industry sufficient time to develop products according to the new rates.
These rates have been calculated as follows since then :

$$Q = 15 (N + 2)$$

Where Q is the total exhaust flow in m3/h
N is the number of habitable rooms.

Additionally, a higher level for kitchen has been proposed, depending on the size of each kitchen.
This additional flow had to be intermittently operated by the owner to cope with the problems of odours during cooking for instance.

5.3 Consequences

A consequence of this regulation, which is often forgotten, has been to reduce the air changes from one per hour to about 0.75 to 0.65 .....
While ventilation was changing, the thermal insulation improved, the double glasing became more and more used and the air leakage lower
We would see that all these changes put together have brought some desagreements :
The improvement of thermal insulation made the influence of thermal bridges more effective : All the cold has been located on little areas at the breakpoints of insulators.
Thus, condensation occured always in the same zones.

The glazing was previously playing the role of a large cold area where almost all water vapour condensed. The double glazing removed this possibility.

The increasing airtighness decreased the cross ventilation thus the total airchange became lower and lower, which means the humidity became higher and higher .
We can set the equation :

Higher humidity
\+ Removal of cold areas
\+ Thermal bridges at the insulation breaklines
\+ Decreasing airchanges
= More condensation problems, more mould on the walls.

It semms obvious that the ventilation needs are strongly connected with the occupancy. In 1969 requirements the needs of large families were not met. The 1982 regulation increased the number of such families.
As shown in table 2 we can see that the link between the number of habitable rooms and the occupancy is not accurate enough to be a sufficient criteria for ventilation rates.

5.4 1983 Alternative

To avoid this increasing risk of condensation, a research was undertaken, trying to find out a solution which would be more accurately linked to the real needs rather than to the average needs.

At that time, the pollutant better connected with occupancy was found to be the water vapour.It is strongly related to human activity : Breathing, cooking, washing... Each of these activities gives off some vapour, with a specific quantity which can be averaged.
That enabled to build some possible scenarios and to prove, before manufacturing any product, that it was possible to save energy while adapting ventilation closely to the needs.

All this research was presented to the french authorities and the regulation has been amended in 1983 to authorise the new system, allowing to reduce the ventilation rates during under-occupancy periods and re-establish normal ones when necessary.

At that time, the exhaust flows have been chosen less or equal to the requirements' level. Which means that the new system left under ventilated the dwelling which previously were. In such cases, the improvement was due to the inlets, ensuring a better distribution of air. (The higher the humidity, the larger the apperture
(see fig. 4).
We can try to explain why the flows were set lower than requirements' ones : the amount of investments required to develop this technology was quite important ; thus the new products were rather expensive and it was a necessity to sell maximum energy savings. In the amendment to the regulation, that saving was taken into account in the general heat loss of the house, thus giving points to get financial incentive for building.

That was only a first step to meet the real needs; now, some systems use higher flows, remaining connected with the humidity. They can fit more precisely whith the needs, even if the premises are over occupied (according to french average occupancy).
The modulation allows the exhaust flow to be as low as about 45m3/h (for a two bathroom dwelling) and as high as 175 m3/h continuously when necessary (without accounting for the additional flows in kitchen or W.C)
Obviously, we must not forget the inlets which modulation allows to admit air where it is the most necessary.
Inlets and outlets have the same proportional action in the range of 35% to 70% Hr.

CONCLUSION

As a conclusion and to make the french approach as clear as possible, let us have a glance ont its basements :

1) The occupants, while breathing, cooking..., alter their indoor air quality, thus ventilation is necessary.

2) The occupants are not able to appreciate the quality of the air they breath neither the ventilation rate which would be needed to make it better.

3) Identical dwellings have not the same needs. These needs change during the day itself.

4) Ventilation has an energy cost.

5) A dwelling which can be occupied by N Persons must be able to provide them a good air quality without causing any nuisance for them and their neighbours (such as odours, moisture, noise...) and for the right energy cost.

6) The ventilation system is a part of the housing, as well as heating, water supply..., and all means must be set up to ensure its proper use. The obligation of result should be a requirement instead of an obligation of means.

7) To ensure possibility for evolutions and clear competition, an evaluation method upon the efficiency of the systems should be workdown. Such a method is now under consideration in France.

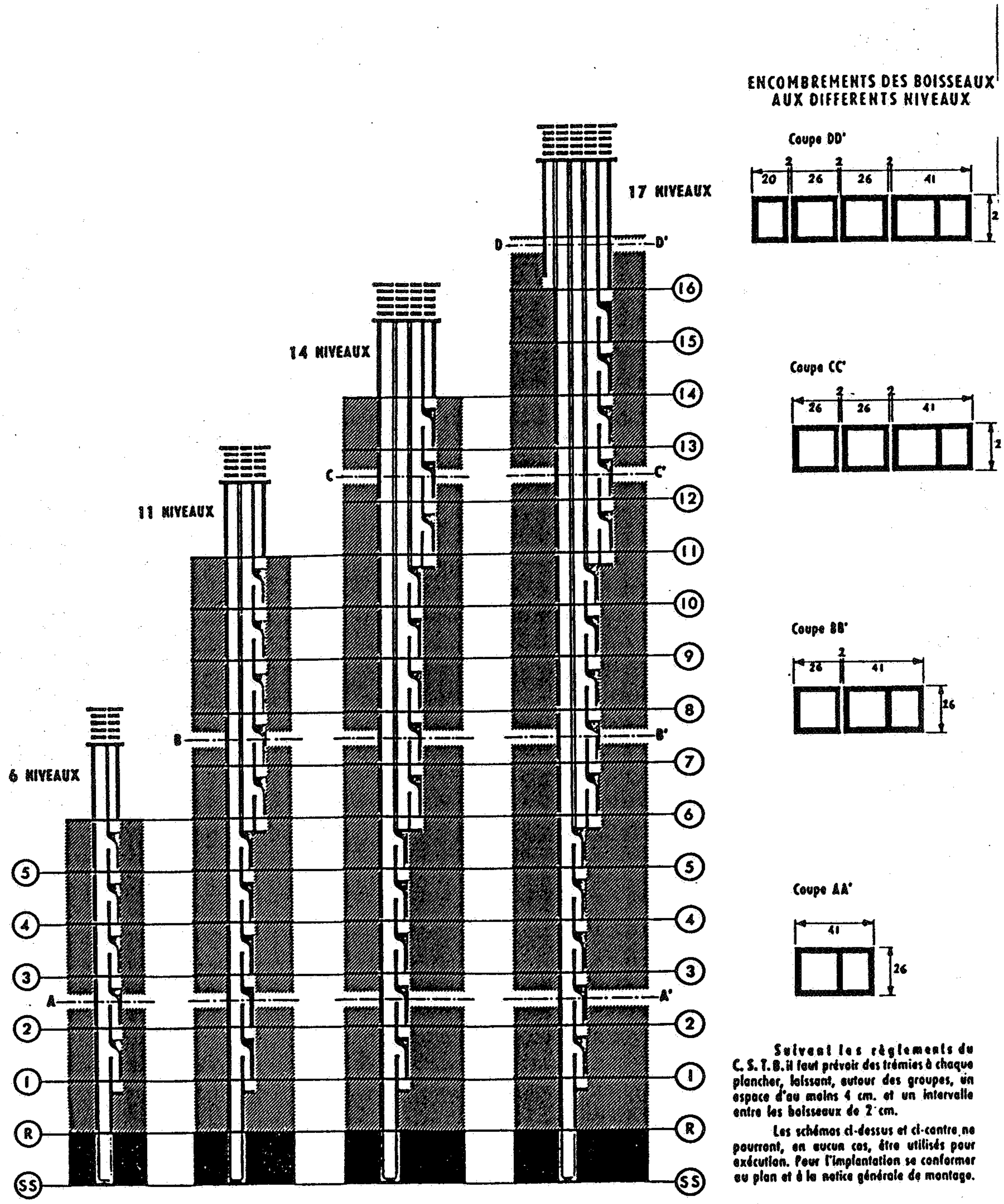


TABLEAU DES APPELLATIONS DIMENSIONNELLES DES BOISSEAUX U.M.G. POUR FUMÉE

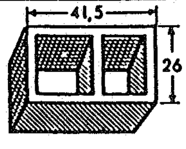
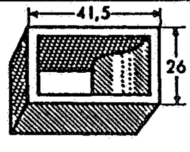
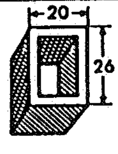
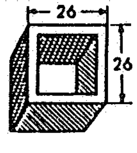
ÉLÉMENT COURANT B 41 h = 33	ÉLÉMENT DE RACCORDEMENT BR 41 h = 25	ÉLÉMENTS INDIVIDUELS B 14 h = 33	 B 20 h = 33
			

FIG 1 : SHUNT DUCT

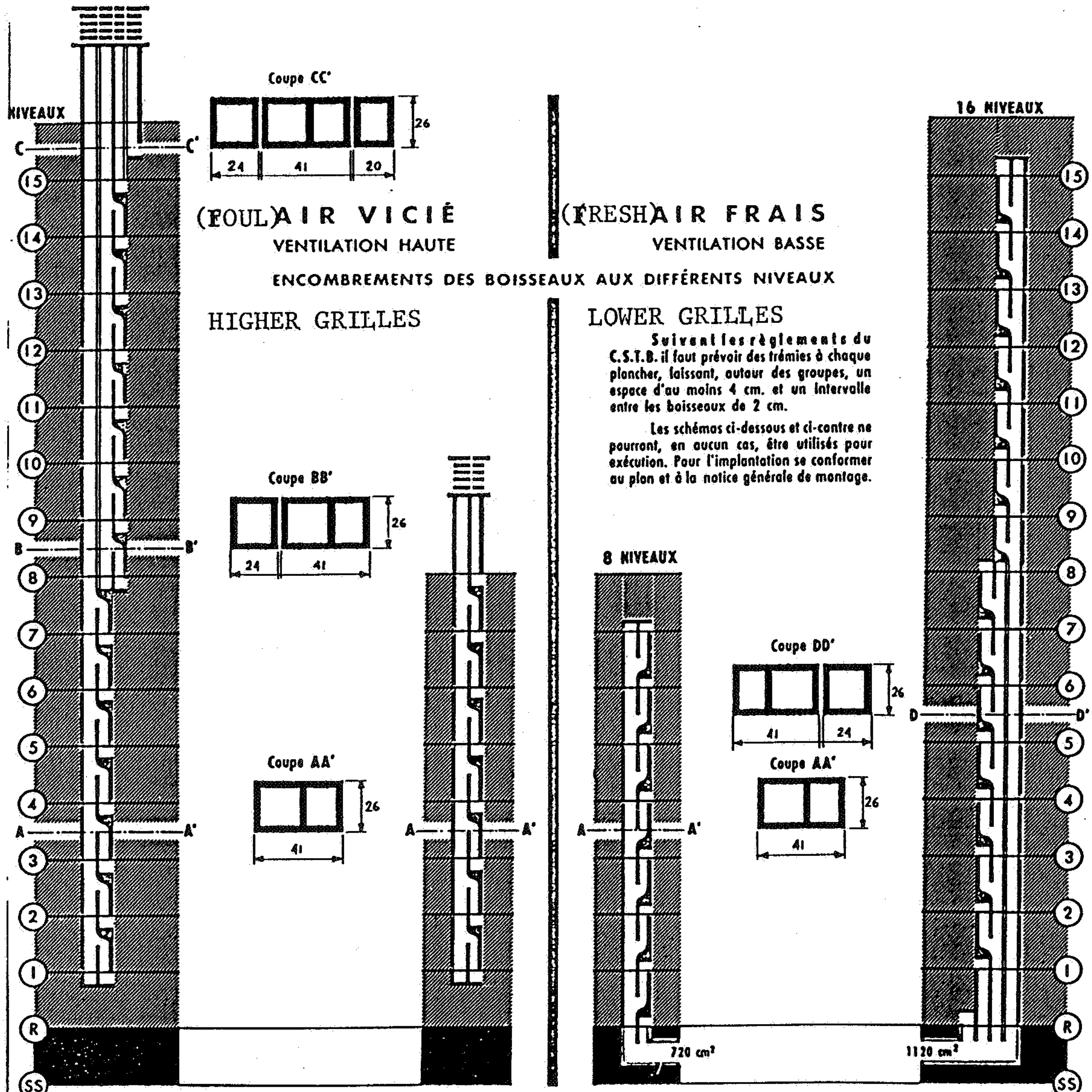


TABLEAU DES APPELLATIONS DIMENSIONNELLES DES BOISSEAUX U.M.G. POUR VENTILATION

ÉLÉMENT COURANT V 41 h = 33	ÉLÉMENT SPÉCIAL VD 41 h = 33	ÉLÉMENT DE RACCORDEMENT VR 41 h = 25	ÉLÉMENTS INDIVIDUELS V 16 h = 33	V 20 h = 33

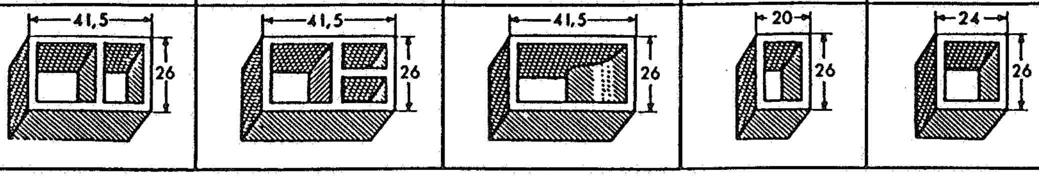


FIG 2 : REVERSE SHUNT SYSTEM

Table 1. 1978 SURVEY IN FRANCE: OCCUPANCY ACCORDING TO THE NUMBER OF PRINCIPAL ROOMS IN THE HOME.

PRINCIPAL ROOMS / OCCUPANTS	1	2	3	4	5	6	TOTAL*
1	933	1304	1028	550	212	134	4162
2	278	1067	1727	1356	618	404	5453
3	64	331	1144	1120	613	344	3617
4	18	118	561	1069	687	486	2939
5	4	29	160	498	387	336	1415
6+	3	17	67	251	331	383	1053
TOTAL*	1300	2867	4690	4845	2848	2089	18641

* TOTALS are in thousands, and have been rounded off.

_ TABLE 1 _

Table 2. 1978 SURVEY IN FRANCE: FRESH AIR PER OCCUPANT IN m3/hour BASED ON 1969 REGULATION FOR CONSTANT FLOW VENTILATION

PRINCIPAL ROOMS / OCCUPANTS	1	2	3	4	5	6
1	45	60	75	90	105	120
2	22	30	37	45	52	60
3	15	20	25	30	35	40
4	11	15	19	22	26	30
5	9	12	15	18	21	24
6	7	10	12	15	17	20

TOO MUCH AIR: MORE THAN 30m3/h PER OCCUPANT (49%)

CORRECT AIR: MORE THAN 20m3/h PER OCCUPANT, and LESS THAN 30m3/h PER OCCUPANT (39%)

TOO LITTLE AIR: LESS THAN 20m3/h PER OCCUPANT (11%)

_ TABLE 2 _

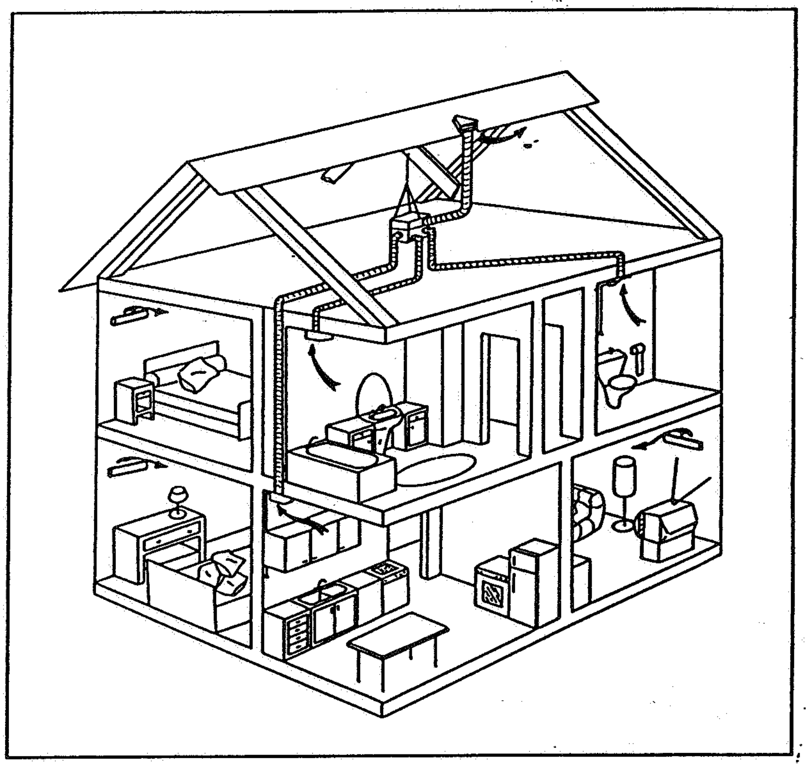
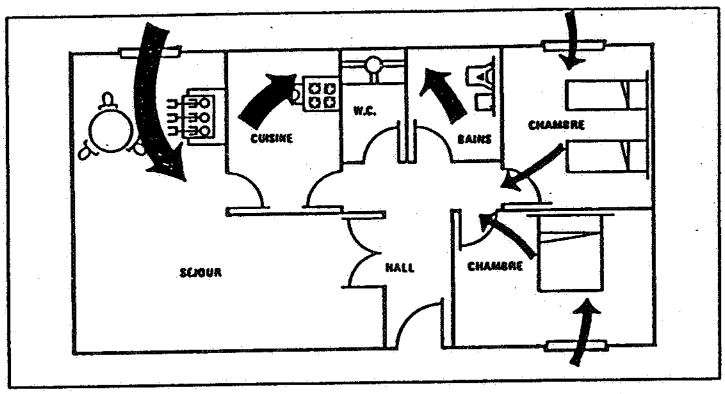


FIG 3 / AIR FLOWS THROUGH THE HOUSE

DAY OCCUPANCY



NIGHT OCCUPANCY

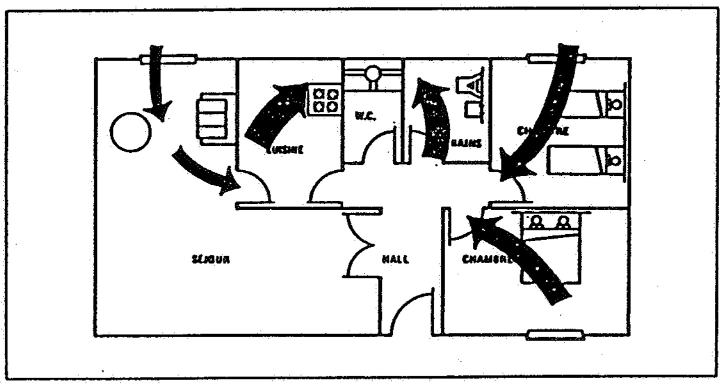


FIG 4 : HYGRO MODULATION