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Device for Air Renewal in Split - Type Conditioner

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***Abstract* — This paper has the objective to develop a device in the conditioning, split-type, to guarantee the quality of interior air in conditioned environments, and this is necessary since the conditioners of this type do not promote renewal of the external air, only condition (they filter and cool) the air that is in an environment with its usually closed doors and windows, remembering that the technique norm NBR 16401 has as main objective to guarantee the quality of interior air in conditioned environments. A conditioning air equipment, split was used type of 9 000 Btu/h for installation of the developed device, conveniently installed in the interior of the equipment, that it showed to be efficient as it reduced the levels of carbon dioxide in the internal enclosed space, thus guaranteeing, a healthy environment, due to air renewal from the exterior. The developed subsystem was deposited in the INPI - National Institute of Industrial Property as pioneer patent, process N BR20 2013 012531 3.**

Index Terms— **Conditioned air split, conditioned air renewal, Refrigeration air conditioning, carbonic gas in closed environment.**

I. INTRODUCTION

The breath of the occupants of a closed space contributes for the consumption of the oxygen and carbonic gas release, being able to leave the inadequate environment, causing many times migraine, giddiness and a feeling of fatigue. In the majority of the installations of splits with comfort purpose, as in dormitories or living room, there is people's circulation, occasional door opening and the windows are not stagnant, what ends up providing the renewal of air. "This type of use is out of the covering of NBR 16401 and others due to the number of occupants and the type of environment", explains Mauro Apor, LG's Conditioning Air general manager. According to him, when the environments possess a particular occupation, as in restaurants, libraries, offices, cinema, shopping centers, etc., the renewal of air becomes mandatory hospital installations as in an ITU, the renewal of air in the proportion of 100% is mandatory to prevent contamination of patients and doctors [1].The line of splits conditioners (separate) does not contain device or artifice that makes the renewal of air to comply with NBR 16401, since the necessary air volume of renewal to fit the norm varies according to environment (and not the product). It is a task of the designing engineer to define an ideal system to promote this air renewal. Unfortunately one evidences that in Brazil, few installations follow the norm in this requisite, either for ignorance, for adjusted lack of supervision, or even because the installation of a renewal system is more expensive as a whole [2].

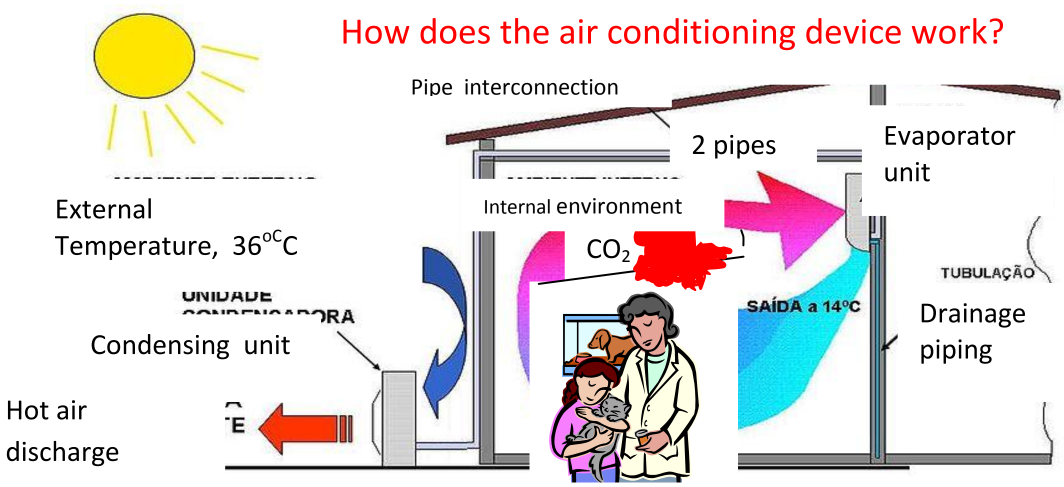

Fig 1 - Functioning of conditioning air type split

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The air, rich in $CO_{2\ returns}$ to the environment without renewal is viewed in Fig. 1. We can see the functioning of conditioned air, without exterior air renewal. The interconnection of the evaporator unit with the condensing unit through the networking cooling net exists solely that has the function to lead the hot cooling gas proceeding from the environment to be cooled in the condensing unit, returning later, already cooled, to the internal environment. Environment split –type promotes acclimatization through the recirculation of the air in the place being conditioned. That is, it is a continuous process making existing air in the place flow through an evaporator to be cooled.

A. Project, installation and maintenance

It is a fact that split systems have gained space, supported by more flexibility in terms of room to the existing layout, by lower cost and greater easiness in their installation, the low costs of maintenance and operation, and also due to their design, today adapted to the most diverse types of environment.

"We need not only remember the importance of design of the equipment, lower noise levels and costs of installation, but also, the influence of a good project (selection of equipment, positioning of the evaporator unit in the environment and the positioning of the condensing unit, air renewal) and of an adjusted maintenance in the performance of the system to keep the good quality of interior air", says Apor [1].

B.The NBR-16401

The technique norm NBR16401 of the ABNT was a job of the Brazilian Committee of Refrigeration (ABNT/CB-55), involving working class entities and government agencies equipment manufacturers, designers and installers of conditioned air. It establishes basic parameters with minimum requirements of project for central unitary conditioned air systems and their application is designed to special installations of air-conditional that are conducted by specific norms (clean rooms, laboratories, centers, surgical center and others). It is also applied the small isolated unitary systems, for comfort, where the addition of the nominal capacities of the units that compose a system inferior to 10 kw (2,85 TR) and only has validity for new systems, new installations or part of existing installations that being reformed not applying retroactively in existing installations.

In regards to "Quality of Internal Air", the NBR16401 specifies the basic parameters to get a good quality of air in an acclimatized environment. The same adjusts the parameters defined by Ordinance 3.523/GM, of 18/08/1999, of the Ministry of Health (MH) and by the resolution of 16/01/2003 of the ANVISA that are very simplified. The content of this part of the norm presents the minimum exterior air outflows for ventilation, the minimum levels of air filtering and the technical requirements of the systems and components of a system of acclimatization to guarantee the quality of 3 air [3].

C.The importance of the renewal of the air we breathe

Oxygen exists in abundance in our atmosphere. And to catch it we need our respiratory system Through this, part of the oxygen of the atmosphere spreads out through a respiratory membrane and reaches our blood flow, is carried by our blood and taken to the diverse cells present in the diverse tissues. The cells, after using the oxygen, liberate carbonic gas that, after being carried by the same blood chain, is eliminated in the atmosphere also by the same respiratory device. To make it possible an adjust diffusion of gases through the respiratory membrane, oxygen passing from interior of the alveoli to the blood are sent in the pulmonary capillaries and the carbonic gas spreading out in contrary direction it, is necessary a constant process of pulmonary ventilation [4].

The pulmonary ventilation consists of a continuous renewal of air in the interior of the alveoli. In order that this occurs is necessary that, during all the time, movements occur that provide insufflations and not disinflation of all or almost all the alveoli. This provokes, in the interior of the alveoli, a pressure, sometimes more negative, sometimes more positive than that present in the atmosphere. Fig. 2 illustrates our respiratory system made of nose, mouth, larynx, trachea and lung.

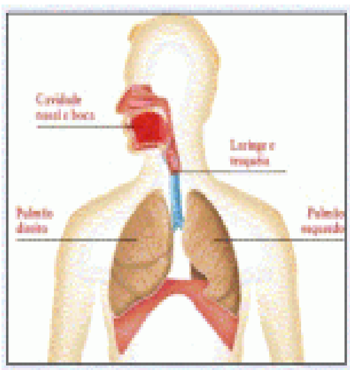

Fig 2 - Respiratory system in the human body

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D.Gaseous exchanges

The atmospheric air that we breathe, is composed basically of the following elements: Nitrogen, Oxygen, Carbonic Gas and Water. When we inhale it, as the air goes through our respiratory ways, suffers some modifications how as to the ratios from its basic elements, as it occurs a significant humidity of air and this mixes with another much richer air in carbon dioxide, that constantly spreads out from the blood of the pulmonary capillaries to the interior of the alveoli.

As the venous blood flows through the pulmonary capillaries, the oxygen in higher pressure in the interior of the alveoli (104 mmHg.) than in the blood (40 mmHg.) spreads out from alveolar air to the blood. An to the carbonic gas, in higher pressure in the venous blood (45 mmHg.) than alveolar air (40 mmHg.), spreads out conversely this way, the blood after circulating turn the pulmonary capillaries, returns to the heart (left atrium) through the pulmonary veins, with partial pressures of oxygen and carbonic gas de95 mmHg. e 40 mmHg, respectively, [4]. The heart then, through the left ventricle, ejects this blood into the systemic circulation, that will flow turn a very rich network of tissue capillary. When passing by tissues that have low oxygen concentration that spreads from of the blood to tissues and to the cells, are constantly consumed. In turn these same cells supply the carbonic gas that, in higher concentration in the interior of these cells and tissues than in the blood, spread out conversely, that is, from cells to tissues and from the blood. The blood returns, then, again to heart (right atrium), poor in oxygen and richer in carbonic gas. The heart ejects it again to the pulmonary circulation over and over again. [4]Let us imagine then, the consequences of slow and gradual increase of carbonic gas in our lungs due to the accumulation of this gas in closed environment caused by split air conditioned that, by the technical functioning principle does not the interior air with the air outside.

E. Exchanger of heat between pipes (Heat exchanger)

The double type exchanger pipe consists of two concentrical pipes. One of fluids drains thru the internal pipe and the other thru the annular part between pipes, in the direction against flow. This is perhaps the simplest of all types of exchanger of heat due to the easy maintenance involved. It is generally used in technical applications of small capacities.

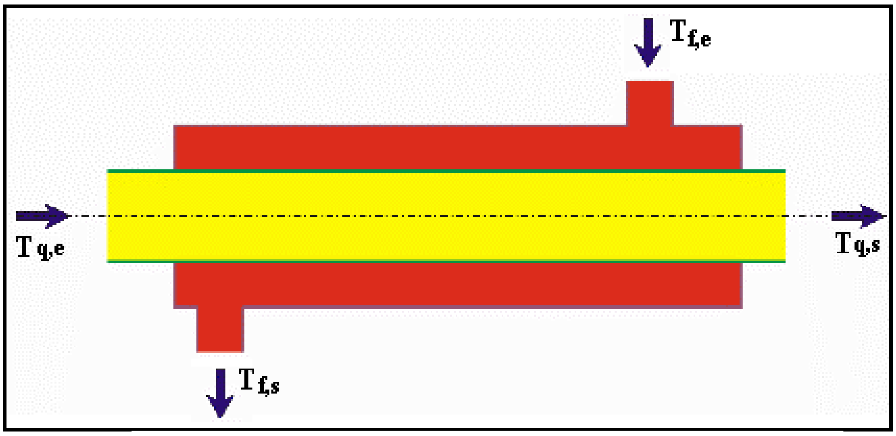

Fig 3 – Heat exchanger between double tubes

By considering that the specific heat is a physical quantity that defines the thermal substance variation when receiving certain amount of heat, and that we are dealing particularly with surrounding air in distinct temperatures, (of exterior surrounding air and cooled surrounding air) we can find the amount of heat yielded to air, know the mass of air and its thermal variation know [6]:

$$Q = m.c_p.\,\Delta T = m.c_p.(T_{ex} - T_{int}) \qquad (1)$$

Where:

m = mass of the entrance air and exit through the pipes [kg].

F. Measurement of Mass Outflow and Heat Transference Tax

Whenever any difference of temperature between two place and different regions of the same place, the heat transference will have to occur, part of bigger temperature for the place of lower temperature, with an certain duration of time when this transference will occur. In practical situations, therefore, it is necessary to take in consideration the elapsed time for the occurrence of certain heat transference. An air conditioner that takes, for example, 6 hours to aclimatize a room will not be satisfactory to cool an environment. In the study of the

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transference of heat, the aim is to define the tax of heat transference, that is, how much heat was transferred by unit of time [6]:

$$\text{Tax of heat transference} = \frac{\text{Amount of transferred heat}}{\text{Interval of time when the exchange occurred}} \qquad (2)$$

$\dot{T}$ is the tax of transference of heat in the unit of time, then

$$\dot{T} = \frac{Q}{\Delta T} \;, \qquad \left[\frac{Joule}{segundo}\right] = [\text{ watt }] \qquad (3)$$

In the case of a process that involves an amount of finite mass (a body), the equation above can be expressed by:

$$\dot{T} = \frac{m.c.\Delta T}{\Delta T} \;, \quad \text{or} \quad \dot{T} = \frac{m.c.(Tex - Tint)}{\Delta T} \qquad (4)$$

In the case of a process that involves mass outflow (for example, the evaporator of an air conditioner, where air enters with a certain temperature, and leaves with a lower temperature), we would have:

$$\dot{T} = \dot{m}.c.(T_{ex} - T_{int}) \qquad (5)$$

Where $\dot{m}$ represents the mass outflow in [kg/s].

The measurement of mass outflow is one of the most important evaluations when one works with energy sources or fluid in general. It s known that the energy of a fuel is proportional to its mass and not to its volume. Besides the density, volume that alters according to conditions of pressure and temperature it is also possible an increase in the speed of fluids in the pipes, and consequently the amount of mass involved. In fluid flow in the pipes, many times there's the interest of knowing the amount of this fluid that crosses a transversal region of a duct in a determined unit of time, being called mass outflow (g/s) and defined by [5]:

$$\dot{m} = \rho \,.\tilde{V} \qquad (6)$$

Where, $\tilde{V} = V.A$ represents the volumetric outflow in m³ /s, **V** it is the air speed in m/s, A is the area of the transversal section of the pipe, **ρ** the density in kg/m ³.

However, this outflow does not only vary with the speed of the fluid, since the density of the same depends a lot on the pressure and the temperature to which is submitted. Thus the correction of density is necessary as the thermodynamic properties are from the equation of the perfect gases [7]:

$$P.V = n\, r\, T \qquad (7)$$

It is demonstrated [6] that the equation of the mass outflow can be expressed based on the following equation, where the thermodynamic properties can experimentally be obtained.

$$\dot{m} = = \rho \,.\tilde{V} = (P / R\, T).\, \tilde{V} \qquad (8)$$

Where:

$R = \check{R}/M$: relation between the universal constant of the gases $\check{R}$ [kj/kmol.°K] and molar mass M [kg/kmol].

In the following table, one can see the results obtained from mass outflows, by means of a device constructed to measure mass outflow [5] as compared o the ones in the celebration bench. Measurement was made in room temperature with varying speed.

Table I - Comparison of the group of benches with instrument of measurement constructed for outflow variation [5]

	BENCH		METER BUILT		
Order	Speed (m/s)	Mass flows (g/s)	Calculated Speed	Calculated flow without correction (g/s)	Calculated flow – correted dynamic pressure (g/s)
1	3,97	19,43	3,9367312	18,9151434	19,1627905
2	4,50	22,03	4,5468693	21,8467249	22,1334279
3	**5,02**	**24,58**	**5,0405068**	**24,2185467**	**24,5370592**
4	5,53	27,00	5,5212935	26,5286229	26,8783197
5	5,99	29,35	5,9376683	28,5292139	28,9060936
6	6,55	32,07	6,5977694	31,7008574	32,1211994

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II. MATERIALS AND METHODS

A split-type conditioned of 9 000 Btus/h was used for installation of the developed device, composed of two pipes, one of them of copper to promote the heat exchange, conveniently installed in the interior of the equipment in the regions of insufflations and return of air respectively, as figures ,4 and 5 illustrate.

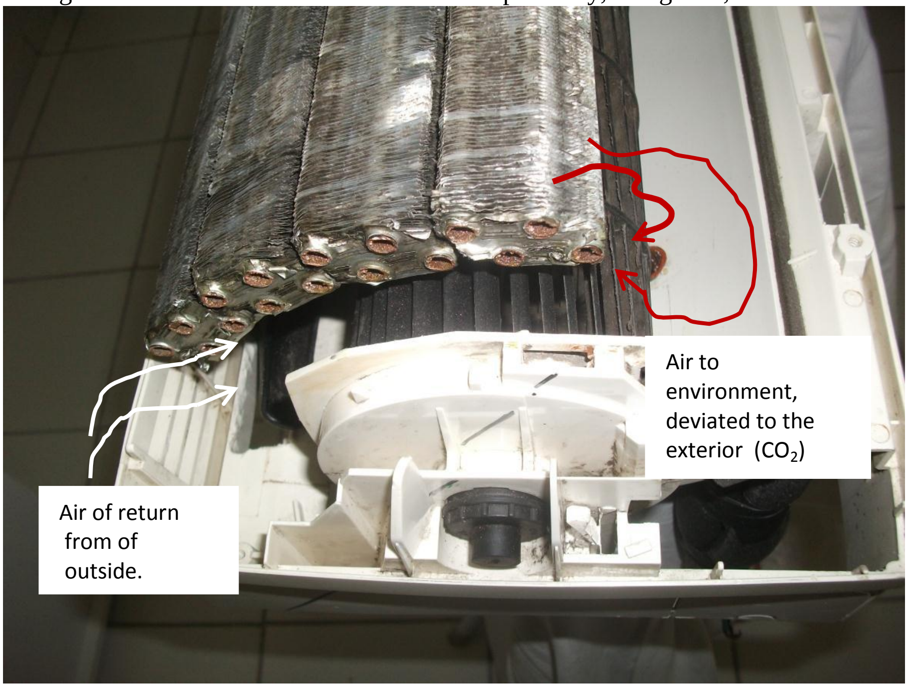

Fig 4 – Air of return and environment, rich in CO_2

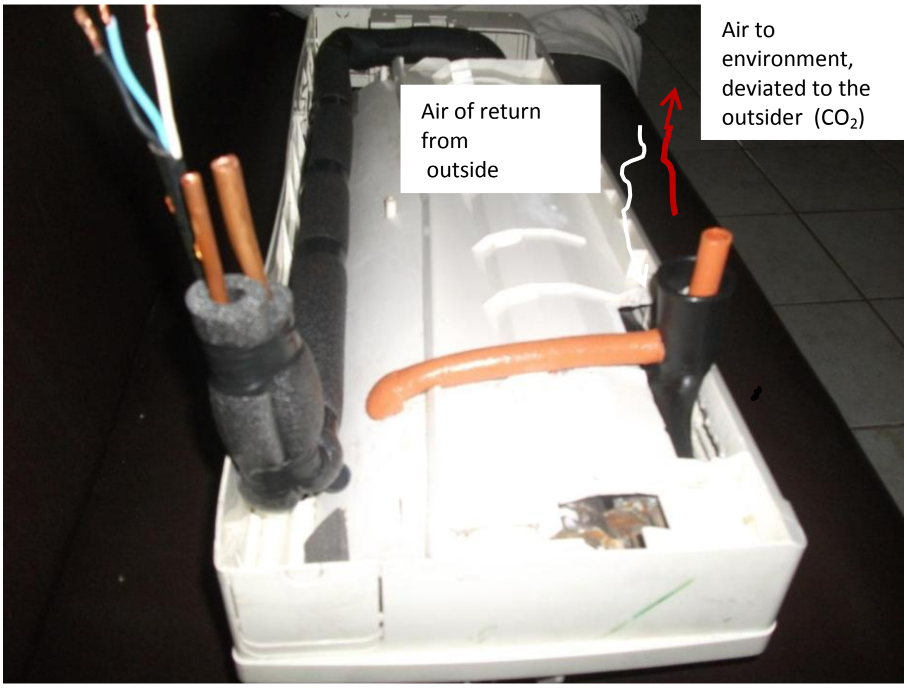

Fig 5 - Pipes installed in the regions of insufflations and return in the interior of the Split.

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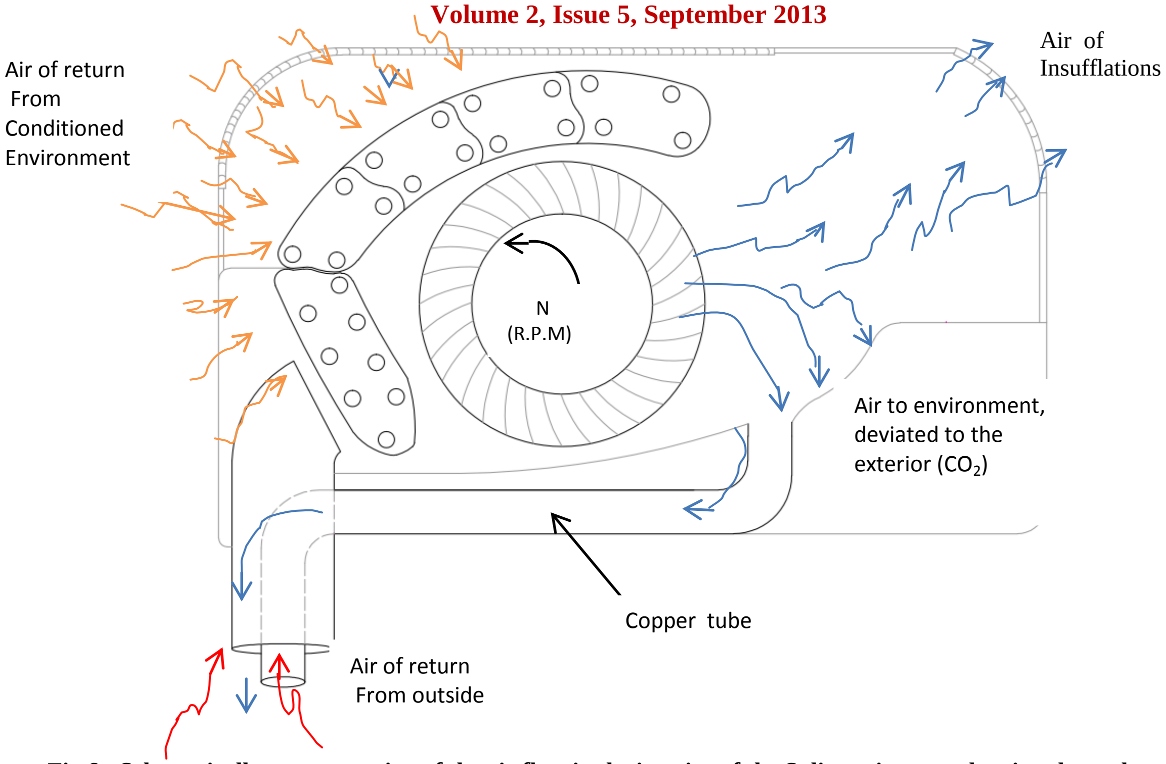

Fig 6 - Schematically representation of the air flow in the interior of the Split equipment, showing the exchange of interior and exterior air

The disposal of the two pipes, for insufflations and return of air are conveniently installed in regions where the rotation of the turbine cause lower pressure, causing the entrance and exit of air inside of the equipment, as is visualized in the drawing above. It is noticed that the copper tube that collects a small percentage of the conditioned air to throw it in the exterior environment is inserted inside the pipe of larger diameter that collects the air of the exterior environment. This has a main meaning that is to promote the heat exchange between hot air and cold air of the two pipes, since the air coming from the conditioner was cooled, being, therefore, at a lower temperature than the air caught from exterior environment. This action minimizes the temperature of entrance of air in the equipment, without damaging its cooling efficiency.

Exchange of heat between pipes

By considering the air density around 1,2 kg/m^3, extension of the internal and external pipes of 30 cm and diameter of 42 cm, the mass of the air that passes through the pipes is :

$$m = d.V. = 1,2.\ 0,00041542 = 0,000498\ kg \approx 0,5\ g \qquad (9)$$

where: $V = \{\pi.\ (4,2^2 / 4).30 = 415,42\ cm^3 = 0,00041542\ m^3$

V = volume that circulates between the tubes.

$c_p = 0,24\ cal/g.^oC = 1012\ J/kg.^oC$;

c_p : average specific heat of air the constant pressure of 1 atm, temperature between 1 to 100 ^oC

T_{ext} = Local temperature of the region, external to the conditioned environment around of 28 ^oC, considering the northeast region;

T_{int} = Acclimatized room temperature through the air conditioner, around 21 ^oC.

Then, the amount of heat, that is, energy transferred between the pipes is:

$Q = m.c_p.\ \Delta T = 0,000498.\ 1012\ .(28 - 21) = 3,53$ J.

The rate of heat transfer was calculated considering room temperature around 28^{o}C, speed of insufflations of the air of 5 m/s, and the corresponding mass outflow of 24, 58 g/s [5], which implies a heat transfer rate of:

$$\dot{T} = \dot{m}.c.(T_{ex} - T_{int}) = 24,58.10^{-3}.\ 1012\ .(28 - 21) / 1000 \qquad (10)$$

$$\dot{T} = 174,12x10^{-3}\ \left[\frac{Joule}{segundo}\right]$$

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III. RESULTS AND DISCUSSION

In the following table, one can see the measures carried out in acclimatized environments by traditional split-type air conditioners, without air renewal (not installed the device here presented due to the number of people in the room.

Table II – Carbonic gas levels, CO_2, existing in environment conditioned with conventional conditioner split.

Equipamento	Number of people in room	Carbonic gas levels, CO_2 (ppm)
No equipament, Outdoor	2	421,7
No equipament, Outdoor	2	451
Board of directors Split,	2	775,3
Komeco, 12 000 btu Split, unit	2	757
LG, 18 000 btu, windos	2	783,7
Springer, 12 000 btu Split, unit	3	619,75
Carrier, 12 000 btu Split, unit	3	856
York, 12 000 btu Split, unit	4	983
Hitachi, 18 000 btu Split, 2 units,	5	863,35
Carrier, 9 000 btu Split, unit	7	962,5
Yang, 9 000 btu unit	8	1072
Adufpb Split,	12	1 346,5
York, 21 000 btu Slip, tw units	23	2 391

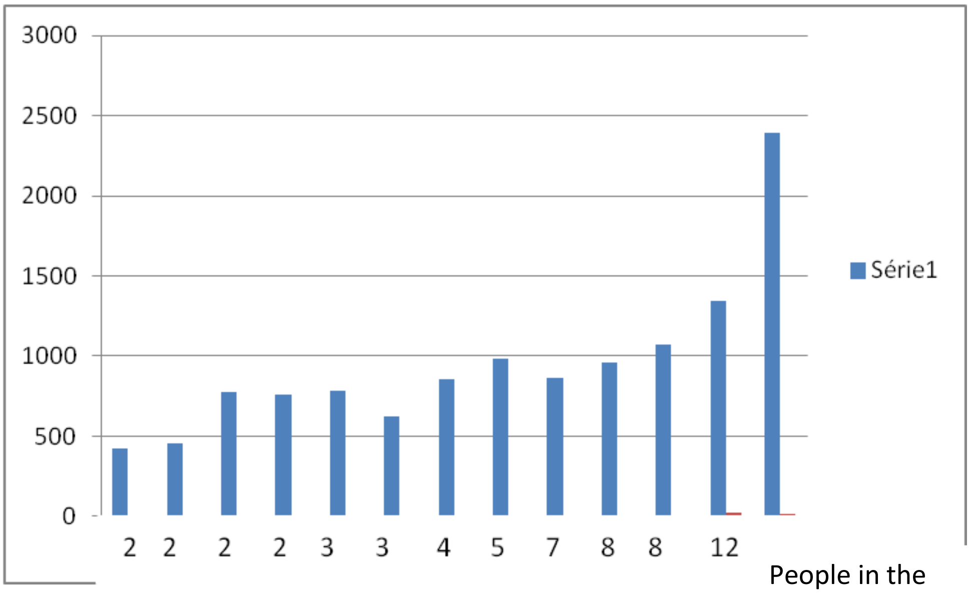

Fig 7 - Relation between the carbonic gas levels, CO_2 and the number of people in cooled enclosure

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Discrete relation is perceived between the number of people in the enclosure and the level of existing carbonic gas in the conditioned enclosure. The figure above represents better this statement:

Measurements made with the device installed in the conditioner

The CO_2 levels measured in classroom were carried out with the device installed in the equipment and later the CO_2 levels were also been measured without the device, in order to compared of the real effectiveness of the mechanism, whose values were the following ones: 562 ppm with installed device and 803 ppm without the device.

IV. CONCLUSION

The research reached its aims in that here was considerable reduction in the levels of carbon dioxide in the conditioned environment when the device was installed in conditioning air, split type, thus guaranteeing, a healthy environment, due to air renewal from outside.

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