

**LENNOX**<sup>®</sup>

 *TECHNICAL MANUAL*

**UNICO**



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## 1 Presentation

This manual has been written for the dual purpose of providing an easy, comprehensive text for people who are interested in knowing more about our "UNICO" air conditioning system, and a useful guide to maintenance and repair of the equipment for professional installers and service centers.

We therefore recommend careful reading both for those interested in undertaking an activity of installation or after sales service of our air-conditioners and those who just want to know more about the technology of this sector.

Any suggestions will be welcome and we will certainly take them into serious consideration in drawing up future editions of this manual.

## 2 Fundamental concepts

This chapter will illustrate the basic concepts which must be thoroughly clear to anyone operating in this sector.

For reasons of simplicity we have not gone into concepts that are not strictly concerned with the purposes of this manual. They are covered in any textbook of physics, for those who are interested.

Since in the sector of air conditioning the new system of measurement called SI is still not commonly used, as the old technical system and even the anglosaxon system still survive, we have defined all the units of measurements in all three systems, indicating the equivalence between one and the others.

Reading this chapter will be rather interesting for beginners, while those who already have a solid background in the sector may find explanations, that we hope are clear, for concepts they have tended to take for granted.

### 2.1 Heat and temperature

People generally tend to confuse these two concepts that serve to quantify, or better to measure thermal energy.

In other words, when we speak of **heat** we mean the amount of thermal energy, and when we speak of **temperature** we mean the potential of that thermal energy. All this has close analogies with electrical phenomena. Effectively, heat is like the electrical charge, while temperature is like the difference of potential that we also call voltage.

The same way, **heat flow** (that is, the units of thermal energy that enter and leave a body, a wall, etc., in a specific period of time) has the same meaning as the electric current which measures the amount of electric charge that passes in a specific time period (one second) through a conductor.

### 2.1.1 Heat

Like electrical energy, heat cannot be seen but produces effects that we perceive with our senses.

In fact, when we heat a body (for example a pot full of water) we can feel the increase in the temperature of the body. This form of heat is called **perceptible heat**.

Heat can also have other effects on a body. If we keep heating the pot the temperature of the water in it will continue to rise until it reaches a saturation temperature that depends on the pressure applied to the pot. At normal atmospheric pressure, the saturation temperature of water is 100°C, but if the pressure on the pot is higher this value rises, as for example in a pressure cooker where foods cook more rapidly because the water in them boils at a much higher temperature than 100°C. The opposite occurs at low pressure as, for example, at high altitudes where water boils at a much lower temperature than 100°C.

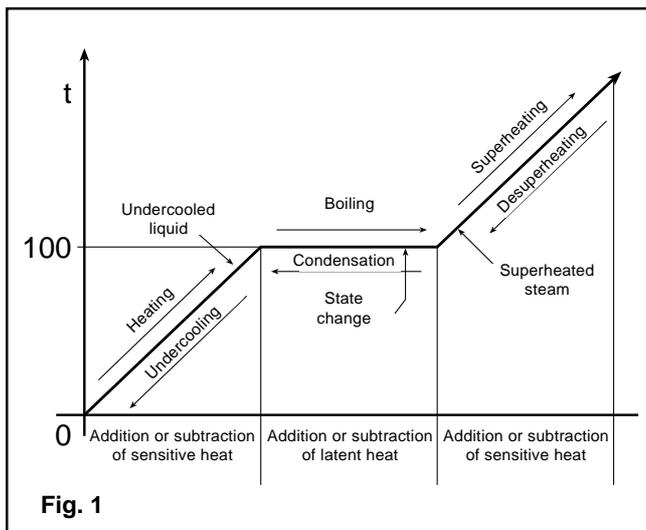
The different in the saturation temperature depends on the pressure and is common to all liquids.

Once it has reached the saturation temperature the liquid starts to boil and its temperature remains constant. The heat that causes the evaporation of a liquid is called **latent heat**. After all the liquid has boiled, if we continue to apply heat, the temperature of the steam increases and is **superheated** absorbing more perceptible heat.

The same way, if we cool superheated steam (characterized, therefore, by a temperature higher than that of saturation) it releases perceptible heat until it reaches the saturation temperature. When it reaches that temperature it starts to condense, releasing latent heat to the medium cooling it until it has all condensed. After the process of condensation, if cooling continues, the temperature of the liquid falls below the saturation value and the liquid releases perceptible heat and is **supercooled** as a consequence.

The same thing happens if we heat a solid. Gradually, it reaches a temperature at which it melts. After melting the temperature of the liquid starts to rise. In this case too, the phenomenon is reversible, as we can see from freezing water.

**Figure 1** diagrams this process for water at atmospheric pressure.



There are many units of measurement for measuring heat, but the ones that can interest us in our discussion are:

- kilocalorie (**kcal**) that is the amount of heat needed to raise the temperature of 1 kg of water from 15 to 16°C.;
- kilojoule (**kJ**) that is the amount of heat needed to raise the temperature of 0.239 kg of water from 15 to 16°C. The kJ is the unit of measurement of heat used by the SI system

which is now also compulsory in Italy. One kcal corresponds to 4.187 kJ and therefore one kJ corresponds to 0,239 kcal;

- the btu (still used today in anglosaxon countries) that corresponds to 0,254 kcal (1 kcal therefore corresponds to 3,937 btu) or 1,063 kJ (1 kJ therefore corresponds to 0,941 btu).

Heat flow is the amount of heat that transits in a unit of time through a wall and can be measured in:

- kilocalories per hours (**kcal/h**);
- Watts(**W**) that are simply J per second. One W corresponds to 0,86 kcal/h and therefore one kcal/h corresponds to 1,16 W;
- in **btu/h** which corresponds to 0,254/h kcal (1 kcal/ therefore correspond to 3,937 btu) or 0,29 W (1 W therefore corresponds to 3,5 btu/h).

The last concept that concerns heat measurement is **enthalpy**. Enthalpy serves to measure the amount of heat in a kilogram of a specific substance starting from an arbitrary zero point. The zero position of reference is unimportant because more than enthalpy, what interests our calculations for conditioning and cooling is always the difference of enthalpy between an initial and a final state.

Enthalpy can be measured in:

- **kcal/kg**, that are the kilocalories contained in a kilogram of a specific substance;
- **kJ/kg**, that are the kilojoules contained in a kilogram of a specific substance. One kcal/kg corresponds to 4.187 kJ/kg and therefore one kJ/kg corresponds to 0,239 kcal/kg;
- **btu/pound**, that are the btu contained in a pound of a specific substance. One btu/pound corresponds to 0,559 kcal/kg and therefore one kcal/kg corresponds to 1,788 btu/pound. One btu/pound also corresponds to 2,34 kJ/kg and therefore one kJ/kg corresponds to 0,427 btu/pound.

Measurement of the quantity of heat totally contained in a body can be obtained by multiplying its enthalpy by its mass (in kg or in pounds, according to cases).

### 2.1.2 Temperature

Temperature stands for the potential of heat. In other words, the higher the temperature of a body, the higher the potential of the heat that it contains.

A fundamental law of nature (and one that is confirmed to experience every day by each of us) is that **heat passes, except in case of specific human action, only from bodies at a higher temperature to bodies at a lower temperature.**

To use a mechanical analogy, we can view the transfer of heat like the motion of a heavy body that, unless we intervene by applying energy, will always move downward.

Both in the technical system in use until a short time ago and in the new SI system, temperature is measured on the Celsius scale (also known as centigrade scale).

The Celsius temperature scale sets an arbitrary zero value (0°C) at the temperature at which ice melts at atmospheric pressure and the value of 100 degrees (100°C) at the boiling point of water at the same pressure. One Celsius degree (°C) therefore corresponds to one hundredth of the interval between solidification and boiling of water at atmospheric pressure.

In anglosaxon countries the temperature scale in use is the

Fahrenheit scale, that gives the melting point of ice at atmospheric pressure the arbitrary value of 32 degrees (32°F) and assigns a value of 212 degrees (212°F) to the temperature at which water boils at the same pressure. One Fahrenheit degree (°F) therefore corresponds to 180th of the interval between solidification and boiling of water at atmospheric pressure.

To convert a temperature in °C to the equivalent in °F we have to use the following formula:

$$^{\circ}\text{F} = ^{\circ}\text{C} \times 1,8 + 32$$

for example, a temperature of 7°C can thus be converted into a temperature of  $7 \times 1,8 + 32 = 44,6$  °F.

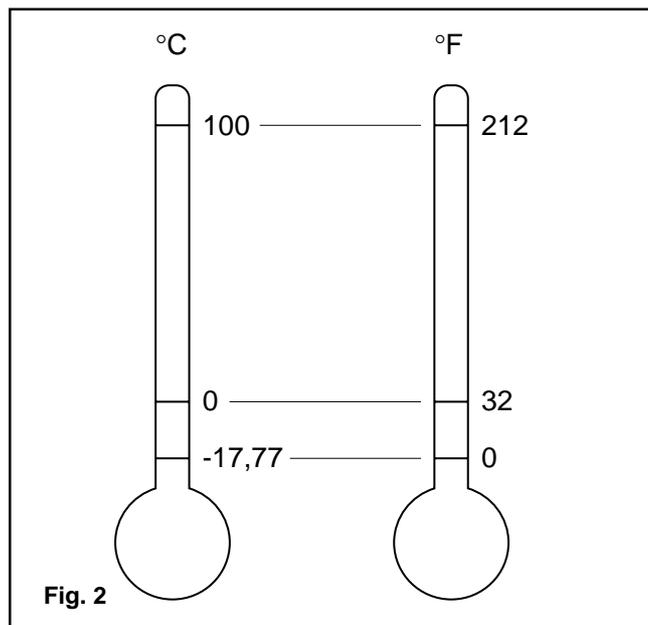
To convert a temperature in °F to the equivalent in °C we have to use the following formula:

$$^{\circ}\text{C} = (^{\circ}\text{F} - 32) : 1,8.$$

In this case, a temperature of 70°F can thus be converted into a temperature of  $70 : 1,8 + 32 = 21,11$  °C.

Finally, to pass between a difference in °F to a difference in °C it is sufficient to divide the value in °F by 1,8. The inverse operation consists of multiplying the value in °F by 1,8.

For greater clarity **figure 2** shows the synoptic correspondence between the Celsius scale and Fahrenheit.



## 2.2 Heat transmission

As we have already seen, in nature heat passes from a hot body to a colder one.

There are four ways in which heat is transmitted through bodies:

- **Conduction**, that is what happens when we heat one of the surfaces of the body. The heat that penetrates in the body is transmitted through it with an ease that varies from one material to another. In general a good conductor of electricity is also a good conductor of heat and vice versa. The thermal conductivity of bodies thus varies depending on the nature of the bodies and in inverse proportion to their thickness. Their insulating power (that is the opposite of conductivity) varies according to the nature of the bodies and their thickness.

- **Convection**, that is what happens when, for example, a wall releases heat into the air at a lower temperature than the air touching it. The intensity of this phenomenon depends on the material with which the releasing (or receiving) wall is made, the roughness of its surface and the speed of the fluid touching it.
- **Radiation**, that is what happens when a radiator releases the part of heat it receives from a body near but not touching it (**figure 3**).

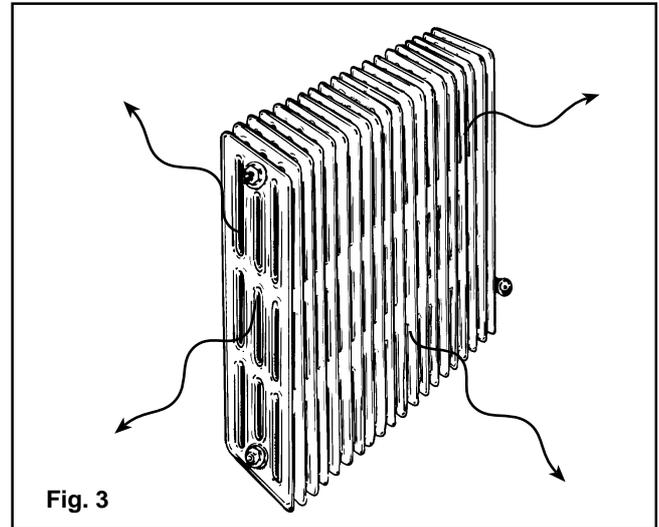


Fig. 3

The intensity of radiation varies depending on the nature of the two bodies exchanging heat, their distance from one another, their temperature and their heat. In air-conditioning, the re-entries of heat due to solar radiation have a very important role as much of the cooling load in a room is due to solar radiation through windows and to the heating of the walls due to it. In a glass wall, the radiation that passes through it can be reduced by the reflecting power of the glass itself and/or by the presence of screens or curtains. Radiant heat is measured in W/m<sup>2</sup> or kcal/(h m<sup>2</sup>). One W/m<sup>2</sup> corresponds to 0,86 kcal/(h m<sup>2</sup>) and therefore one kcal/(h m<sup>2</sup>) corresponds to 1,16 W/m<sup>2</sup>.

- **Adduction** is a term that defines heat transmission through any opaque body (typically, through the walls of a building) and that consists in part of transmission, in part of radiation and in part of conduction.

The most important variables regulating adduction are:

- the speed of the fluid (air, in case of a wall) that touches the inner and outer surface;
- the presence or absence of solar radiation on the outside and thus the heat of the surface of the wall;
- the temperatures of the air touching the two surfaces of the wall;
- the nature of the wall, that is, its insulating power.

Adduction is measured in terms of **global coefficient of heat exchange ÖKÓ**, which is in kcal/(h m<sup>2</sup> °C) or in W/(m<sup>2</sup> °C). Sometimes the global coefficient of exchange is expressed in W/(m<sup>2</sup> K), that have the same physical meaning and same amplitude as W/(m<sup>2</sup> °C). Usually, one W/(m<sup>2</sup> °C) corresponds to 0,86 kcal/(h m<sup>2</sup> °C) and therefore one kcal/(h m<sup>2</sup> °C) corresponds to 1,16 W/(m<sup>2</sup> °C).

## 2.3 Pressure

As we have said, pressure regulates the level of the boiling point and condensing temperature. It is therefore important to have the relative concepts clear since, as we shall see, a cooling cycle is achieved by boiling a liquid at a low

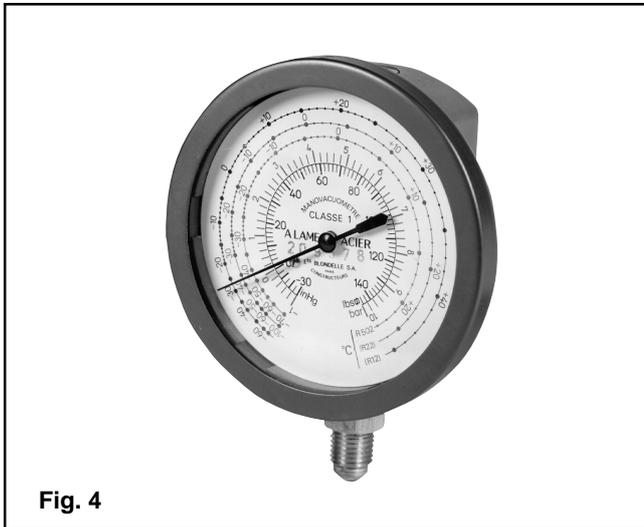
temperature and at low pressure and then condensing it at a higher pressure and temperature.

From a general point of view **pressure is the force that is applied to a unit of surface.**

Therefore:

- **In the unit of measurement of the old technical system** pressure was measured in **atmospheres or kg/cm<sup>2</sup>.**
- **In the SI system now in use** it is measured in **bar** (equivalent to atmospheres or kg/cm<sup>2</sup>), or in **Pa**, where one Pa is a force of one Newton (N) applied to 1 m<sup>2</sup> (1 kg/cm<sup>2</sup> = 1 bar = 100.000 Pa), or also in kilopascal (**kPa**), where 1 kPa = 1.000 Pa;
- **In the unit of the anglosaxon system** the measurement is in pounds per square inch (PSI). One PSI corresponds to 0,07 bar or atmospheres, while one bar or one atmosphere corresponds to 14,28 PSI.

There are also two methods for expressing pressure, regardless of the unit of measurement in which it is measured (**figure 4**).



**Fig. 4**

Pressure can also be expressed in:

- **absolute terms**, considering an absolute vacuum as zero,
- **relative terms**, considering the atmospheric pressure as zero,

Thus, to pass from a pressure value expressed in relative terms (**relative pressure**) to its equivalent in absolute terms (**absolute pressure**) you must:

- increase the value by one if expressed in kg/cm<sup>2</sup>, atmospheres or bar;
- increase the value by 100.000 if expressed in Pa;
- increase the value by 100 if expressed in kPa;
- increase the value by 14,7 if expressed in PSI.

Obviously the opposite conversion (that is passage from absolute to relative pressure) is made by subtracting the above values rather than adding them.

The reader should also know that in the anglosaxon system absolute pressure is indicated by the suffix "A" (**PSIA**) and relative by the suffix "G" (**PSIG**).

### 3 Rapid calculation of loads of buildings

The diagram for calculation of loads that we propose is necessarily simplified, but serves to make a rapid identification with sufficient accuracy of the size of our air conditioners necessary for an air conditioning installation.

As a general rule for application of cooling only, it will be sufficient to calculate the summer re-entries, while in the case of applications with heat pump, for which we want to ensure that the unit is able to overcome also winter dispersion, the approach is slightly different.

In these cases we must:

- a) Perform the calculation of summer re-entries and identify as a consequence the size of the unit necessary;
- b) Perform the calculation of winter dispersion and identify as a consequence the size of the unit necessary;
- c) Select the larger of the two.

We would also recommend making an inspection before deciding the size as it is only in this way that it is possible to discover the contingent situations that could lead to the decision for one size unit rather than another.

It is only by determining the size on the basis of effective measurement that we can submit an offer to the client that is well centred and thereby increase our chances of being given the business. By performing careful calculation, it is possible to avoid uselessly oversized installations that, in addition to increasing costs without any corresponding benefit, may give rise to other problems.

Effectively, a more powerful device always implies higher current absorption and sometimes the increase of power with all its economic consequences may discourage the client.

**IMPORTANT:** A preliminary inspection will make it possible to immediately identify the ideal position for the equipment, the best route of the refrigeration lines and the best solution for the problem of drainage of condensate.

**For calculation of summer re-entries**

Client \_\_\_\_\_  
 Street \_\_\_\_\_ no. \_\_\_\_\_  
 ZIP \_\_\_\_\_ City \_\_\_\_\_  
 Room examined \_\_\_\_\_  
 Re-entry \_\_\_\_\_ W \_\_\_\_\_  
 Model proposed \_\_\_\_\_  
 Calculation made by \_\_\_\_\_ on \_\_\_\_\_

- Note**
- 1 Consider only the window with the greatest total sunlight.
  - 2 Consider only the wall on which the above window is located.

		MULTIPLIERS				Totals	
No.		Unit	North	Center	South+Islands		
1	Flooring on ground	m <sup>2</sup>	7	7	7		
2	Air renewal	m <sup>3</sup>	6	7	8		
3	Window exposed to sun (Note 1) a:	S or E	140	145	160		
		SW	250	265	280		
		W	345	360	380		
		NW or SE	185	200	210		
4	Windows not considered in item 3	m <sup>2</sup>	36	48	66		
5	Wall exposed to sun (Note 2)	m <sup>2</sup>	36	42	54		
6	External walls not considered in item 5	m <sup>2</sup>	20	30	45		
7	partitions in rooms without air-conditioning	m <sup>2</sup>	10	15	20		
8	Slabs under rooms without air-conditioning (also applies to floors over rooms without air-conditioning)	under uninsulated roofing	m <sup>2</sup>	10	15	15	
		under insulated roofing	m <sup>2</sup>	10	15	15	
		under flat roof	m <sup>2</sup>	27	33	42	
			m <sup>2</sup>	10	14	18	
			m <sup>2</sup>	55	65	72	
9	Occupants		150	150	150		
10	Light fixtures	W					
Total re-entries for environment						W	

**3.1 Calculation of summer re-entries**

For calculation of summer re-entries, we propose a form on which the values to be considered for any possible situation have already been indicated.

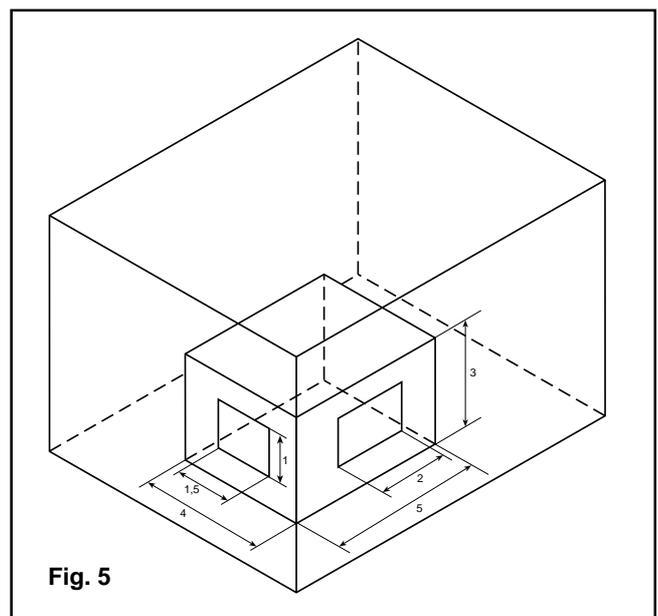
As you can see, this form does not take into consideration any differentiation in the nature of the walls much less their insulating power. In effect, the values on which the table is based refer to average walls constructed according to the terms of law 10/91.

Furthermore, our experience tells us that the variations that can be found in different types of walls do not affect global dispersion values by more than ±5%.

This table does, however, distinguish among geographical zones (north, center and south (+ islands) in Italy), as they are characterized by different external temperatures and different levels of sunlight in the summer.

In addition to the features of the room, the table also considers the number of people using it (people are, after all, heat sources) and the type of illumination. The latter should, however, be considered with good judgement: in most homes, it is unlikely that all the lights will be on in the summer in the hottest part of the day (normally early afternoon). An office is a completely different situation, where the lights are almost always on all day.

To have a better idea let us consider the real case illustrated in **figure 5**, regarding a room on a middle floor with rooms above and below it without air conditioning.



**Fig. 5**

Client Dr. Rossi  
 via Bianchi n°7  
 ZIP\_00000 City Brescia  
 Name of room inspected Living room  
 Re-entries W  
 Model proposed 9000 (2.755 W potential)  
 Calculation made by \_\_\_\_\_ on \_\_\_\_\_

- Note**
- 1 Consider only the window with the greatest total sunlight.
  - 2 Consider only the wall on which the above window is located.

MULTIPLIERS						Totals
	No.	Unit	North	Center	South+Islands	
1 Flooring on ground		m <sup>2</sup>	7	7		
2 Air renewal	<b>60</b>	m <sup>3</sup>	<b>6</b>	7	8	<b>360</b>
3 Window exposed S or E	<b>2</b>	m <sup>2</sup>	<b>140</b>	145	160	<b>280</b>
to sun (Note 1) a:						
SW		m <sup>2</sup>	250	265	280	
W		m <sup>2</sup>	345	360	380	
NW or SE		m <sup>2</sup>	185	200	210	
4 Windows not considered in item 3	<b>1.5</b>	m <sup>2</sup>	<b>36</b>	48	66	<b>54</b>
5 Wall exposed to sun (Note 2)	<b>13</b>	m <sup>2</sup>	<b>36</b>	42	54	<b>478</b>
6 External walls not considered in item 5	<b>22.5</b>	m <sup>2</sup>	<b>20</b>	30	45	<b>450</b>
7 partitions in rooms without air-conditioning	<b>15</b>	m <sup>2</sup>	<b>10</b>	15	20	<b>150</b>
8 Slabs						
under rooms without air-conditioning	<b>20</b>	m <sup>2</sup>	<b>10</b>	15	15	<b>200</b>
(also applies to floors over rooms without air-conditioning)	<b>20</b>	m <sup>2</sup>				<b>200</b>
under uninsulated roofing		m <sup>2</sup>	27	33	42	
under insulated roofing		m <sup>2</sup>	10	14	18	
under flat roof		m <sup>2</sup>	55	65	72	
9 Occupants	<b>1</b>		<b>150</b>	150	150	<b>150</b>
10 Lights	W					-----
Total re-entries for environment						<b>2322 W</b>

This room has a wall that is not external but that opens onto a room without air conditioning. Only one person uses the room, while the heat added by illumination is negligible as the room is in a private home.

### 3.2 Calculation of winter dispersion

In recent buildings, an exact assessment of winter dispersion can be drawn from the project for thermal insulation of the building according to law 373 (now law 10/91), a copy of which should be in the possession of the owner of the property. Unfortunately, this document is actually almost never available and dispersion has to be calculated for every room.

For this purpose we propose a table that, depending on the volume of the room and its characteristics, simplifies an approximate calculation of dispersion that is sufficiently exact.

Also in this case, the values indicated differ as to geographical zone and refer to walls insulated according to law 10 (formerly 373) for each zone. If the building does not comply with this law, it is a good rule to increase the result obtained by 20%.

After identifying the pertinent case for the room considered, to calculate the dispersions just multiply the volume coefficient by the cubic meters of the room.

If we consider the example in figure 5 that is pertinent to a room:

- in northern Italy;

- with a volume of  $5 \times 4 \times 3 = 60 \text{ m}^3$ ;
- with a single wall communicating with a heated room;
- on a middle floor of a building with several floors.

From the above table we can see that the coefficient for volume of dispersion is  $27 \text{ W/m}^3$  and therefore, if the building complies with the law, the dispersion should be  $60 \times 27 = 1620 \text{ W}$ .

If the building is not insulated according to law, we could prudentially assume that dispersion amounts to  $1620 \times 1,2 = 1944 \text{ W}$ .

In both cases, the version with the heat pump selected for cooling (size 9000), will also be suitable for heating in the winter. Obviously, to ascertain this, based on an external temperature of  $-5^\circ\text{C}$ , it is necessary to see the tables in paragraph 9.1.

**Coefficients of volumetric dispersion (W/m<sup>3</sup>)**

Type of construction	North	Center	South+islands
Building on 1 floor with flat roof, rooms with: all walls exposed	50	40	30
one wall in common with a heated room	45	35	25
two walls in common with a heated room	40	30	20
Rooms on the ground floor of a multiple-story building: all walls exposed	36	27	19
one wall in common with a heated room	30	25	18
two walls in common with a heated room	26	21	16
Middle rooms of a multiple-story building with upper and lower floors heated: all walls exposed	31	22	15
one wall in common with a heated room	27	20	14
two walls in common with a heated room	24	17	13
three walls in common with a heated room	18	15	12

**4 Principles of cooling**

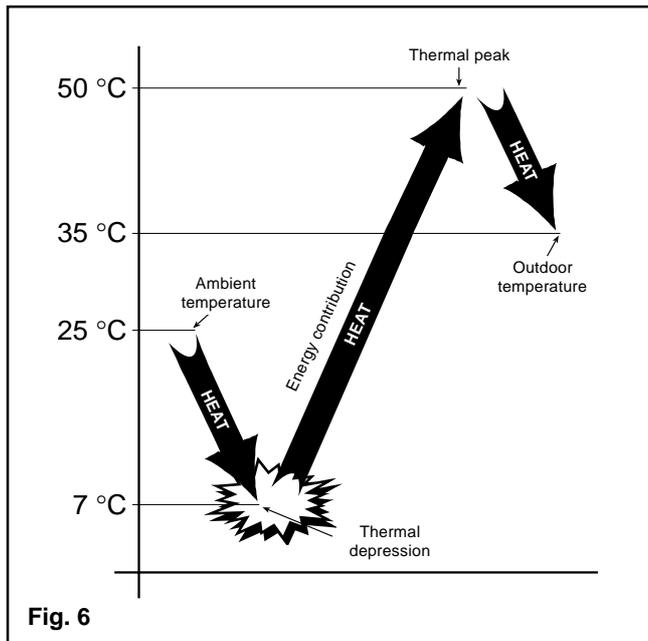
As we said in paragraph 2.1.2, heat tends to pass only from a warmer body into a colder one.

It would therefore seem impossible, in the summer, to cool an environment (that is, take heat out of it) and dissipate it in the atmosphere (that has a higher temperature), which is exactly what happens with the refrigerator in the kitchen or an air conditioner.

But our more attentive readers will recall that we compared the transfer of heat to the movement of a weight that, by nature, moves downward but that, with human intervention and the expenditure of energy, can also be made to move upward.

In refrigeration the same thing happens: heat is taken from a cooler place (a room) and released in a warmer one (the atmosphere) by expending energy.

To obtain this result, however, it is necessary to apply a stratagem (**figure 6**).



**Fig. 6**

In other words, we have to create a sort of “thermal depression” at a temperature even lower than that of the room so that the heat to be removed is naturally “drawn” out of it and transferred into an intermediate fluid; then we have to create a “thermal peak” by raising the temperature of the intermediate fluid to a level higher than that of the atmosphere

so that it is discharged by “natural motion”. Finally, it is necessary to transfer the fluid that has discharged its heat into the atmosphere back to the thermal depression so that it can again absorb the heat from the environment and continue the cycle.

All this is what is called a cooling cycle and it is how most home refrigerators, car and room air conditioners work.

**4.1 The cooling cycle**

As we said in paragraph 2.1, the boiling temperature and that of condensation of a fluid vary depending on the pressure. This characteristic is common to all fluids, but there are some that are more suitable than others for use in a cooling cycle. Experience has shown that to cool an environment it is enough for a coolant to boil at a temperature of 7°C which corresponds to a relative pressure of about 5 bar. This transformation occurs in a heat exchanger that takes the name of **evaporator**.

To dissipate in the air at a temperature for example of 35°C the heat that the coolant has absorbed from the environment by boiling at 7°C, it is sufficient to remove heat from the coolant by having it condense at a temperature for example of 50°C which corresponds to a relative saturation pressure of about 19 bar. This transformation occurs in a heat exchanger that takes the name of **condenser**.

Therefore, our coolant cools the environment by boiling at low pressure and changing into steam at low pressure.

To condense it, dissipating the heat into the atmosphere, it is necessary to raise its pressure and to do this the steam from the evaporator has to pass through a **compressor** that, by expending energy, causes the necessary increase.

The energy expended by the compressor is transferred, however, into the gas that, when it reaches the condenser, is therefore superheated (see § 2.1.1) with respect to the saturation temperature that would be normal for the pressure reached.

Thus, the first part of the condenser, actually works as a cooler in which the gas loses the perceptible heat imposed by the compressor before starting to condense.

Also, for reasons too complicated to explain here but that concern the safety of the device and the efficiency of the cycle, the last part of the condenser acts as a **supercooler** that absorbs perceptible heat from the liquid condensed that therefore leaves this heat exchanger at a lower temperature than its saturation level.

At this point, to enable the liquid to boil at at low temperature, all that is needed is to lower the pressure, making it transit through an **organ of lamination**. Due to the load loss this

can create, the pressure of the liquid drops abruptly, and part of it boils, cooling the rest to the evaporation temperature (7°C in the example).

There are other parts that are called:

- **hot gas line**, that is the pipeline that carries the gas discharged by the compressor;
- **liquid line**, that is the pipeline that carries the liquid from the condenser to the organ of lamination;
- **vacuum line**, carries the gas from the evaporator to the compressor;
- **two-phase fluid line**, carries the mixture of gas and liquid created in the organ of lamination to the evaporator.

In addition, in the jargon of refrigeration experts, the cooling cycle (and thus also the refrigeration circuit that performs it) is divided into two “**sides**”, that is:

- the **low pressure side** (or **low side** as they call it), that goes from the organ of lamination to the compressor, in the direction of flow of the coolant;
- the **high pressure side** (or **high side** as they call it), that goes from the compressor to the organ of lamination, in the direction of flow of the coolant.

### The concept of the heat pump

Since a cooling cycle transfers heat from a cooler environment to a warmer one, there is no reason why it cannot also be used to cool the outside air even more to transfer the heat taken from it into a closed room in order to heat it.

In the early days of air conditioning, certain domestic air conditioner blocks could be installed in a window and were movable in such a way that in the winter they could be turned around to heat the indoors by facing the (evaporator) outward, while in the summer it faced inward to cool the room.

Obviously this is not possible for split units that have a fixed installation.

The cooling cycle in the versions also designed for heating in the winter (**heating pump**), is therefore equipped with an inversion valve.

In the winter, this valve directs the gas from the compressor to the heat exchanger that, in the summer functions as evaporator, so that it functions as a condenser and heats the environment in which it is installed.

The liquid that comes out flows towards what is the condenser in summer (located in the external section) that in this case functions as an evaporator and cools the atmosphere by absorbing heat.

As occurs in the case of elevating a weight, in any cooling circuit the energy expended will be greater and the output of the system lesser depending on the “incline” (thermal in this case) between the thermal peak and depression. So, in practical terms, we could say that the output of a cooling cycle (and thus of the equipment that produces it) reduces and its energy consumption increases:

- the lower the temperature we want in the room we are cooling, or the higher in case of heating (devices with heating pump);
- the higher the outside temperature (in cooling), or the lower (in heating with heating pump).

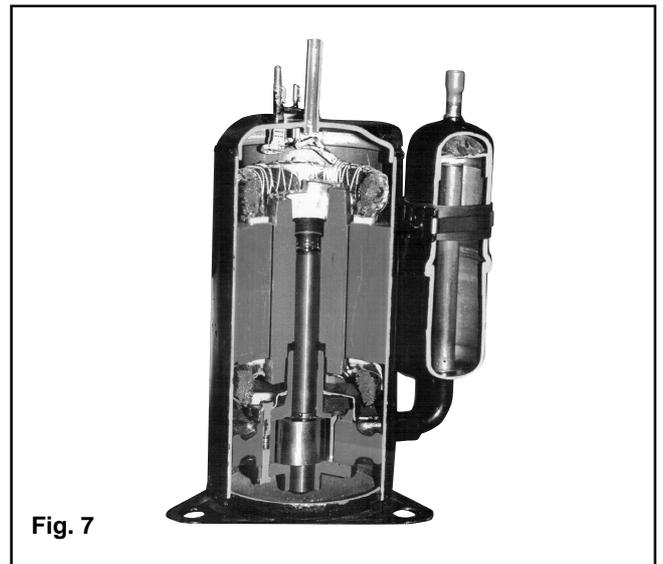
## 4.2 The components of the refrigeration circuit

A refrigerating circuit consists of a series of basic components assembled in such a way as to produce a cooling cycle that can be enhanced by various accessories.

### The compressor

Compressors suitable for air conditioners are usually hermetically sealed, meaning that they are constructed as a sealed and welded package with only the connectors and terminal board protruding.

On the inside, they contain an electric motor that is cooled by the gas drawn in, and all the mechanical parts. These may be driven by pistons, but compressors of this type are very noisy and cause vibrations. The compressors installed on our machines have a mechanical part consisting of rotating vanes (**figure 7**), that, as they do not have any parts running in alternating motion, make it possible to obtain a much quieter unit almost totally lacking in vibration.



Compressors with orbiting spiral (Scroll) used by other manufacturers, are also classifiable as rotary and have characteristics similar to those with vanes.

### The condenser

The condenser is the part that treats the external air in the air conditioner. It is a battery with copper pipes that are mechanically expanded in a finned aluminium pack with which they constitute a complete assembly.

The circulation of air through the condenser is forced, by means of an electric fan that, on our models has a rotor with a special noise abating profile (**figure 8**).

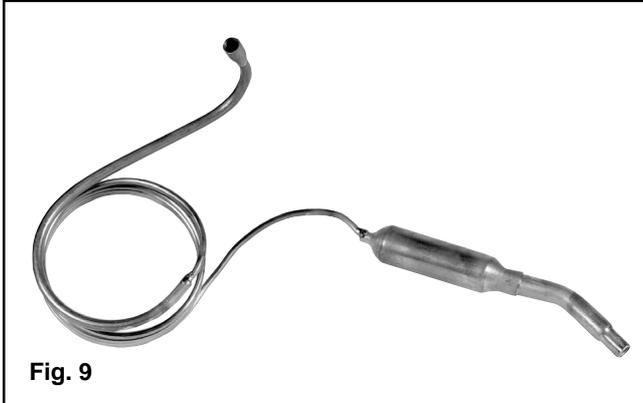
The fan is directly coupled to an electric motor with safety cut-off.



### Organ of lamination

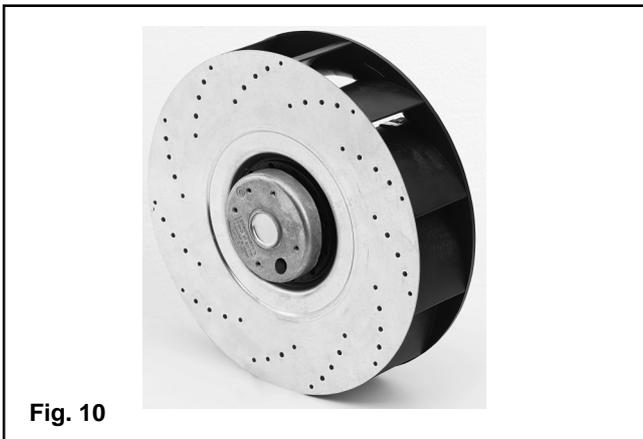
In our air conditioners, the organ of lamination consists of a pipe stub in copper with reduced diameter and a length suitable to create the desired load loss (**figure 9**) in the liquid that has to enter the evaporator.

The use of this organ of lamination is only suitable for those applications like split and multisplit air conditioners in which the output cannot be partialized but must be an all or nothing proposition.



### Evaporator

Like the condenser, the evaporator that, in air conditioners is located in the part that treats the internal air consists of a battery with copper pipes that, also in this case, are mechanically expanded in a finned aluminium pack. Since it dehumidifies the air, and therefore gets wet, it is protected by a filter that prevents dust from adhering to it. Also in this case, the air is moved by a fan (**figure 10**) that is a radial type with reversed blades so as to obtain maximum silence in operation.



### Cycle inversion valve

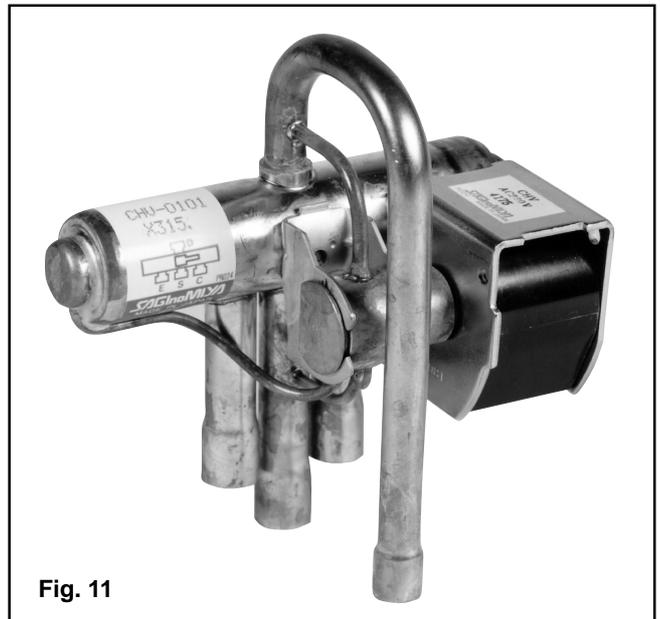
This valve (**figure 11**), in versions with heat pump, serves to switch the role of the condenser with that of the evaporator and vice versa. It is operated by means of a coil that is energized or de-energized depending on whether the conditioner has to produce heat or cold.

### 4.3 Refrigeration circuits of devices

The paragraphs that follow contain the diagrams of the refrigeration circuits of our air conditioners.

These diagrams provide practical examples of refrigeration circuits and will familiarise those readers who intend to undertake an activity of service and repair with our machines.

For greater clarity, each diagram is integrated by brief explanatory notes.



#### 4.3.1 Refrigeration circuit diagram of UNICO models for cooling only (figure 12)

As can be seen from the figure the refrigeration circuit of these units has a difference with respect to the basic circuit we have described. This variation consists of the introduction of an accumulator immediately upstream of the compressor.

The purpose of this device is to prevent drawing up liquid by the compressor in case of an abrupt load loss of the machine, as, for example, could occur when the fan of the internal section is taken from a higher speed to a lower one.

The accumulator is simply a sort of plenum in which the speed of the gas falls enough to ensure that the drops of liquid it contains can deposit and evaporate before they reach the compressor.

#### 4.3.2 Refrigeration circuit diagram of UNICO models with heat pump (figure 13)

In the circuit of these machines, there is obviously a four-way cycle inversion valve that, in the passage between the cooling function and the function with heat pump and vice versa, makes it possible to exchange the functions of the internal section with the external one.

The liquid accumulator is necessary also in this case to prevent the compressor from drawing in liquid in case of abrupt load loss of the machine.

For greater clarity, follow the circuit in the direction of the arrows, as shown in the diagram.

Fig. 12

UNICO 8500 - 11000 BTU SF

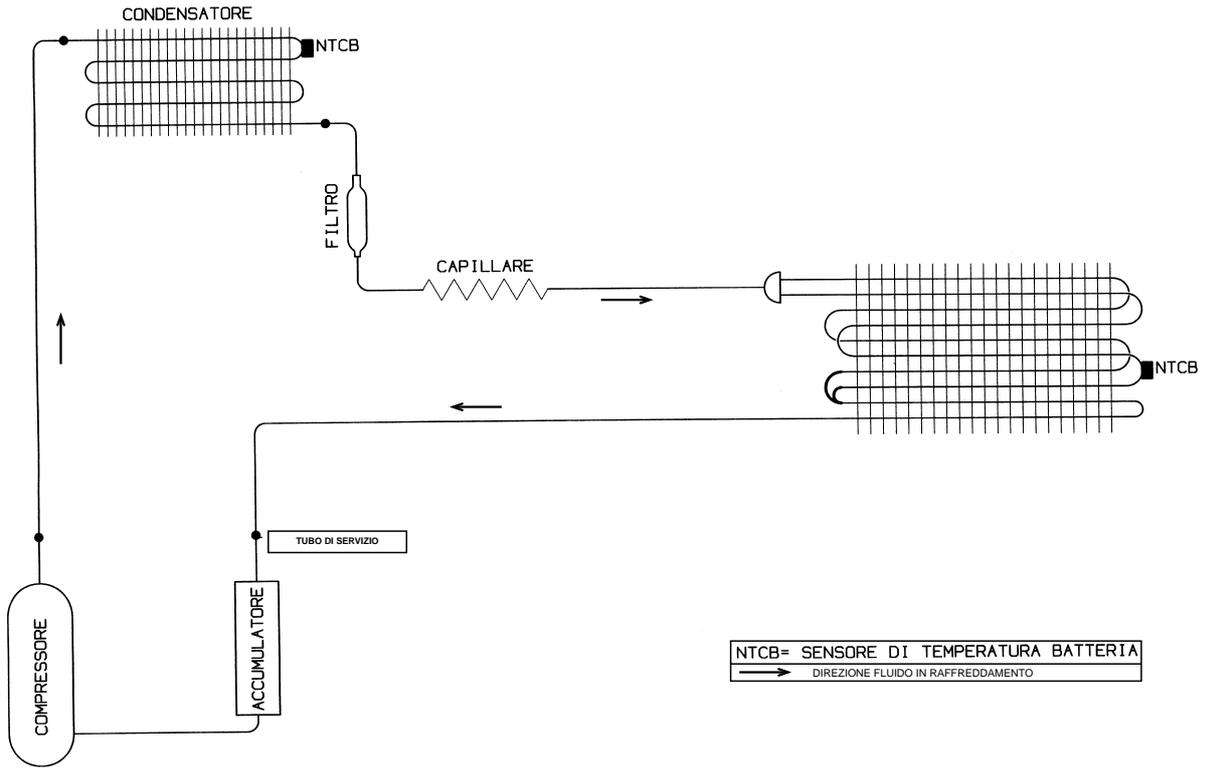
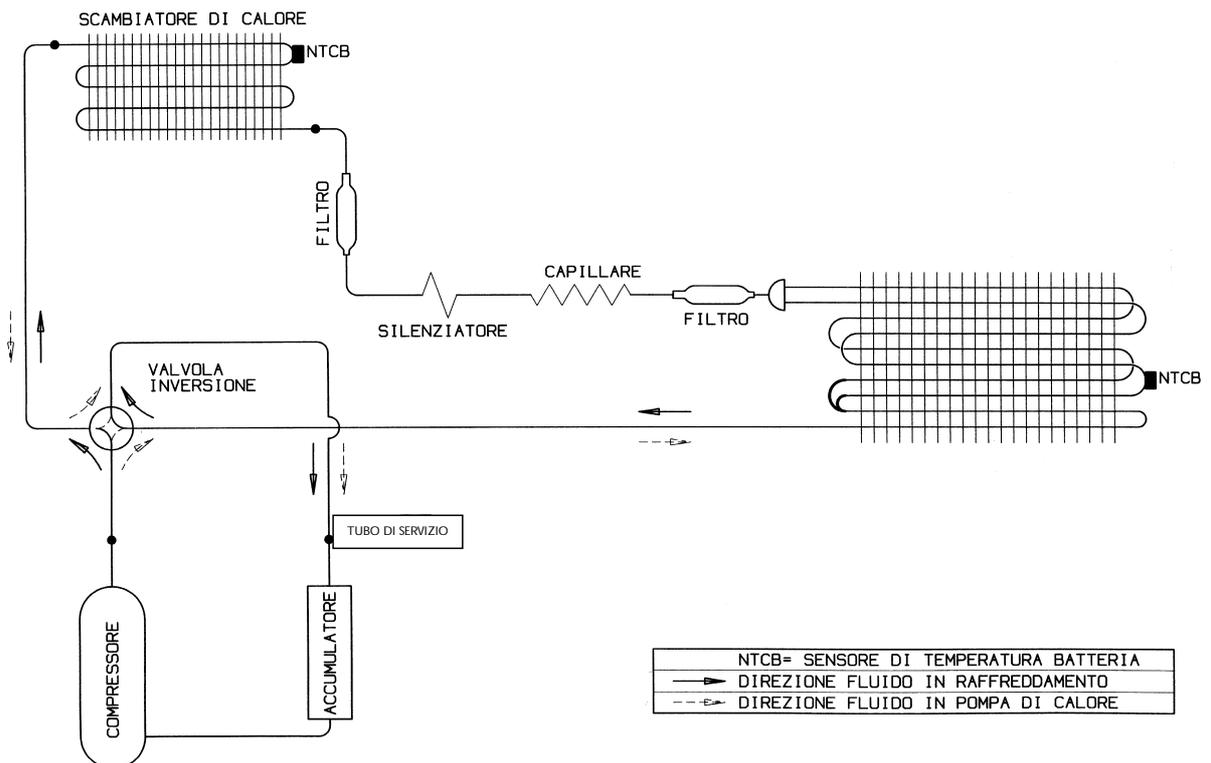


Fig. 13

UNICO 8500 - 11000 BTU HP



## 5 Operations on refrigeration circuits

If it should be necessary to operate on the refrigeration circuit due to possible leakage of coolant or to replace parts, the following precautions are necessary:

- leakage of coolant should always be checked using a "leak detector" for halogenated gasses (HCFC or HFC), with good sensitivity (5-20 grams/year) which must be periodically calibrated by your supplier. It is better to avoid, unless you have great experience, using empirical methods like soapsuds or testing with the pressure gauges.
- Before "opening" the circuit, the coolant must be collected using special equipment available from all retailers of refrigeration components. The coolant removed should never be reused, but must be taken to a specialised center for regeneration or elimination (for more information contact your coolant supplier).
- To connect to the circuit, use the special perforation valves that can also be purchased from retailers for equipment for operating on refrigerating circuits.
- The service pipe is located on the intake line in the position shown in fig. 12/13 and in the diagrams of the refrigeration circuits.

## 6 Execution of joints in refrigeration circuit

If you should have to replace a part (for example a solenoid valve), assembly of the new part must be made by **strong brazing** (that is, brazing using a silver alloy as welding material).

### 6.1 Welding

**IMPORTANT:** Before doing any welding make sure you have removed all the coolant from the circuit. If not, the flame could cause release of phosgene that is an extremely toxic gas.

From a general point of view, the copper pipes can be welded in two different ways, either by soft brazing or strong brazing.

Soft brazing is the welding process normally used in the field of hydro-thermo sanitary applications and consists of joining the parts by interposing an alloy (welding material) with a low melting point that usually consists of 50% tin and 50% lead or 95% tin and 5% antimony. Heating the parts to weld to a temperature just above the melting point of the weld material, which is between 200 and 260°C depending on the type, it melts and when it hardens it acts like glue on the parts.

Welds of this type are not, however, able to guarantee the sealing requisites necessary for refrigeration circuits.

For these strong brazing is essential to guarantee the joint the necessary strength and better seal, and this requires heating the joint to a much high temperature of 600°C. For strong brazing a silver alloy is necessary as welding material.

For this reason, this type of welding is also known simply as silver welding.

In both methods, the welding material, after melting, penetrates by capillary action into the pores of the parts to join becoming a single unit that guarantees the seal. The seal guaranteed by strong brazing is better than the seal ensured by soft brazing as the former necessitates higher temperatures and this ensures better penetration of the welding material in the parts to be welded. With both methods, the parts to be welded must not, in any case, be heated beyond the melting point.

**Figure 14**, shows how a joint is made between two copper pipes by brazing. As can be seen, a dimple of about 2/3 the diameter of the pipe has been made in one of the pipes which on which the other is fitted. Since the space between the two pipes must be on the order of a tenth of a millimetre, it is necessary to make the dimple using special contouring tools available on the market (**figure 15**).

Since strong brazing is the only process that can be used in the field of refrigerating equipment, our discussion will refer only to this type from now on.

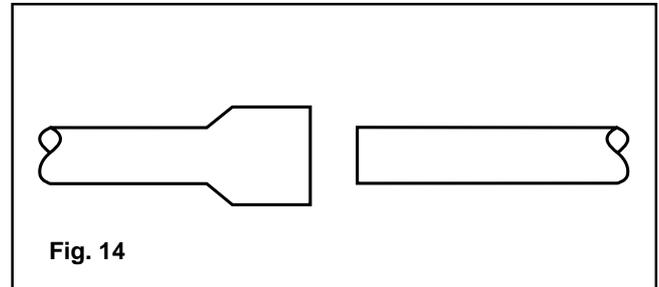


Fig. 14

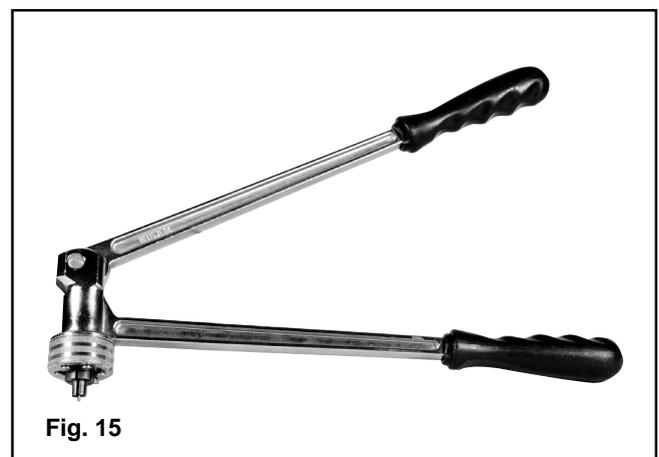


Fig. 15

## 7 Replacement of refrigeration compressor

Replacement of the compressor is one of the most complex operations to perform on the refrigeration circuit, so we will make a few suggestions to enable you to operate with the assurance of satisfactory results:

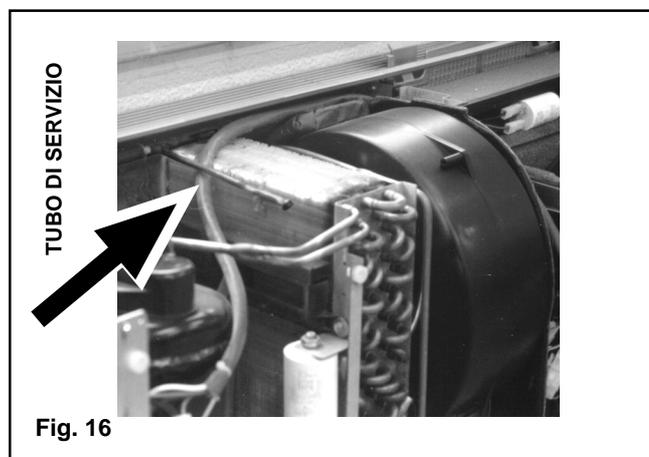
- Empty the refrigerating circuit as described in the preceding paragraph.
- After removing the shell of the device, remove the thermal and acoustic insulation on or near the compressor.
- Disconnect the compressor electric wires and remove the plastic hood that contains the overheat cut-off and move the electric wires as far away as possible.
- Unweld the pipes for delivery and exhaust, taking care to move the insulation on the pipes out of the way, using hose clamps to grip it.  
The unwelding operation must be carried out with great care, after first heating the coupling on the compressor and not the connecting pipe that could otherwise develop a perforation. During this operation place metal screens between the flame and any other parts of the machine that could be struck by it.
- If the compressor is burned (this can be diagnosed as for any other electric motor by measuring the ohmic resistance of the windings) the entire refrigerating circuit is polluted by residues of combustion (sludge and acids). In this case it is absolutely essential (so as not to risk immediate burnout of the new compressor installed) to wash the circuit by allowing solvent R-141b (normally available on the market) to circulate through all its parts. In this specific case the detergent must be made to circulate by introducing it from the delivery pipe and

- discharging it, obviously, from the exhaust pipe.
- f) For the same reasons indicated above, also replace the filter with molecular screen located near the capillary.
- g) Clean the pipe connections to remove any residues of alloy.
- h) Position the new compressor and heat the pipes, always taking care to heat the connectors rather than the pipes.
- i) Replace the thermal and acoustic insulation carefully and make all the electrical connections.

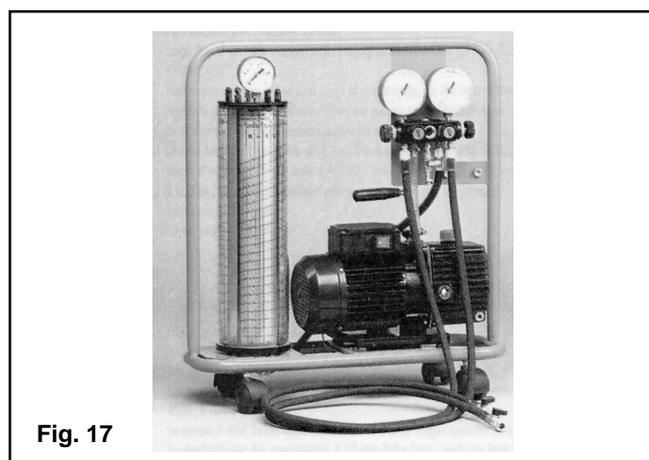
## 8 Creation of a vacuum in the refrigeration circuit

This very important operation must be carried out with great care because it also ensures elimination of the moisture in the circuits which, as we know, causes irreparable damage in a very short time to the internal organs of the compressor. Proceed as follows:

- connect a hose with a percussor on one end (available from retailers of materials for refrigeration) to the service pipe at the end of the exhaust pipe (see fig. 16).



- Couple the other end to the pressure unit of the central coolant recharging device (equipped with: a charge cylinder of at least two kg capacity, a vacuum pump with double stage and a pressure gauge unit for measuring the high and low pressure) on the low pressure connector (see fig. 17).



- Open the taps on the low pressure connector and on the vacuum pump connector.
- Leave the vacuum pump in operation for at least 4-5 hours.
- Close only the tap for connection of the pump and wait at least 30 minutes before checking whether the low pressure gauge shows a value higher than zero (see fig. 18). If so, there may be fissures in the circuit capable of generating leaks.

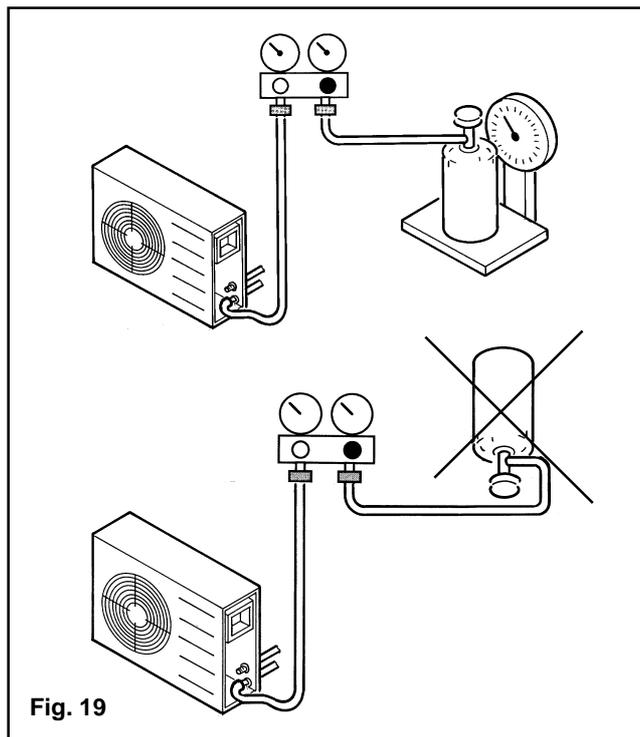


- At this point proceed to fill with coolant as described in the next paragraph.

## 9 Filling with coolant

To fill with coolant use the central unit described above and proceed as follows:

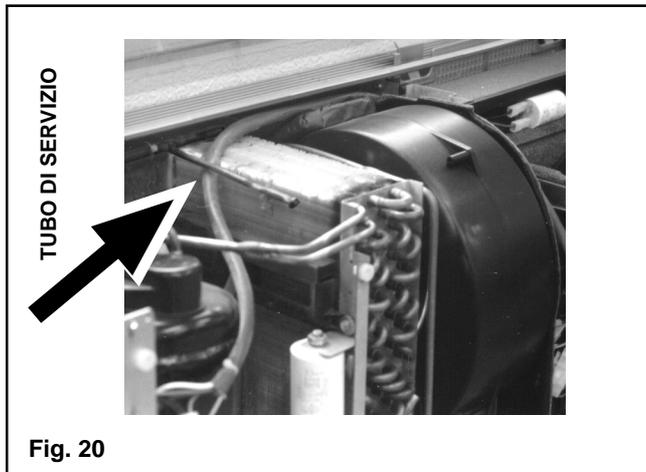
- If the cylinder is empty, connect the vacuum pump to the cylinder tap and run the pump for about 10-15 minutes.
- After reading on the label the technical data and amount and type of coolant to introduce, fill the cylinder with slightly more coolant (50-100 g) than required by the machine. The filling operation is carried out by connecting the tank to the connector of the pressure gauge unit and opening the taps on the cylinder and on the tank (see fig. 19).



- Check at this point that the graduated scale on the cylinder has been set depending on the type and pressure of the coolant which has been introduced (this can be read on the pressure gauge on top of the cylinder).
- Close the connection tap to the tank and start to open the tap for connection to the service pipe of the device being repaired. To prevent the formation of bubbles of gas that will interfere with correct reading of the graduated scale, fill slowly and close the filling tap whenever it becomes difficult to see the level of coolant in the cylinder.
- It is a good rule to add 20-30 grams to the amount

indicated on the label of technical data, to compensate for any accumulation of coolant in the connecting hose and any small leaks during the operation of disconnection from the service valve.

- After detaching the hose, clamp the service hose in at least two points upstream of the perforation valve, leaving the hose clamping tool tight on the pipe (see fig. 20).



- At this point remove the service valve and cut the copper pipe with a pipe cutter upstream of the hole created by the perforator tap.
- Weld the end of the copper pipe using a sufficient amount of alloy, then remove the hose clamping tool.
- Before starting the machine wait a few minutes to let the coolant evaporate inside the circuit so as to prevent any intake of liquid fluid by the compressor.

## 10 Operating logic

The electronic circuitry that controls the machine includes a highly advanced type of microprocessor equipped with non-volatile memory. This means that a large number of operating parameters can be programmed, often making it possible to resolve complex specific situations. In the text that follows you will find several codes that refer to parameters of time, temperature or adjustment of fan speed with the indication that they are programmable in interface. This means that by using a PC it is possible to modify the parameters set in the ranges.

The circuitry is also provided with a serial output that can be used for a number of different functions, starting from those described above.

### 10.1 Power supply to unit

This condition is indicated by the first green led on the left of the signal panel lighting up (see instruction manual).

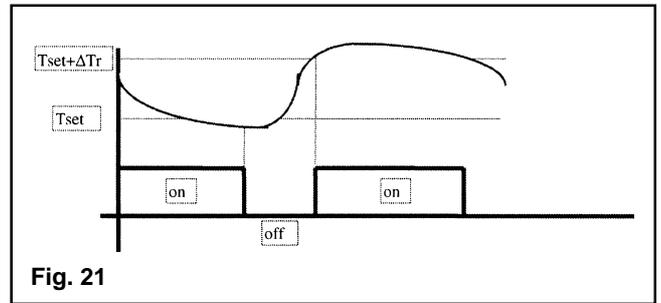
### 10.2 Switching on and control of unit

These operations, except for the autotest (described in the installation manual), can only be carried out using the remote control unit.

### 10.3 Cooling program

The room air fan is always on and can be made to run at three speeds. The compressor operates according to the following conditions:

Value  $T_{set}$  is regulated by the user in a field between  $T_{rm}$  and  $T_{rM}$  (between  $18^{\circ}\text{C}$  and  $30^{\circ}\text{C}$ ). Value  $\Delta E_r$  is set at  $-3^{\circ}\text{C}$ .



The room temperature sensor continuously compares  $T_{amb}$  with  $T_{set}$ . The former can be corrected in programming by  $-3^{\circ}\text{C}$  (example: if the real temperature is  $20^{\circ}\text{C}$  the temperature read can be set at  $17^{\circ}\text{C}$ ). This correction must be available for selection on two different values according to a setting made by the user with the key on the led panel (depending on the height of the machine off the floor).

**In this state of cooling the following alarms must be active: HP, HTE, LT, CF/RL, OF, TSF (see relative paragraph).**

The outside air fan functions at the same time as the compressor with a fan speed that is selected with that of the room air fan.

When the condensation pump is switched on the "outside" fan is automatically switched over to minimum speed.

If the temperature of the outside battery sensor ( $T_{bex}$ ) exceeds a certain value  $T_{bexvmax}$  ( $64^{\circ}\text{C}$ ) the outside air fan is automatically switched to the higher speed where it remains for a minimum of 3 min.: if  $T_{bex}$  in those 3 min. returns to a value below  $T_{bexvmin}$  ( $59^{\circ}\text{C}$ ) the speed is slowed again.

The air sweep motor opens completely when switch on and can later be adjusted by the user (see par. 6).

The speed of the internal fan can be selected either manually or automatically. For this latter case the same rules apply as for "general automatic" operation.

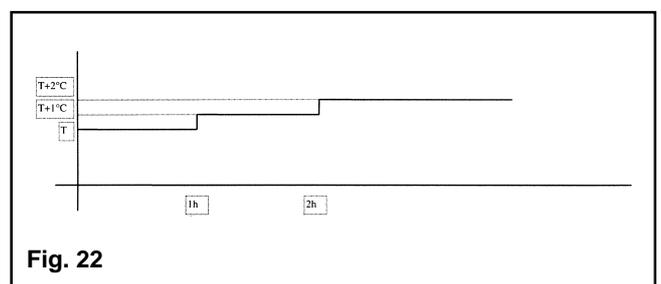
### 10.4 Air recycling program (fan)

The room air fan is always on and can be made to run at three speeds. The motor of the air sweep positions itself in "heat" configuration (about halfway) and can be adjusted later by the user as described in paragraph 6 Alarms enabled: only FS.

### 10.5 Dehumidifying program

The room air fan runs steadily at minimum speed. When this function is switched on,  $T_{amb}$  is memorised as  $T_{set}$  and the compressor functions as follows:

- if  $T_{amb} + T_{set} + 1^{\circ}\text{C}$  the compressor functions continuously in the cooling function, with the room air fan at minimum speed;
- if  $T_{set} - 1^{\circ}\text{C} < T_{amb} < T_{set} + 1^{\circ}\text{C}$  the compressor functions at 4 minute intervals (4min on, 4min off);
- if  $T_{set} - 3^{\circ}\text{C} < T_{amb} < T_{set} - 1 + 1^{\circ}\text{C}$  the compressor functions at 4 minute intervals (4min on, 8 off);
- if  $T_{amb} + T_{set} - 3^{\circ}\text{C}$  the compressor stays off.



The symbols for dehumidifying will appear on the remote control with the set temperature that the system acquires from this function being switched on.

The user can change the set value thereby resetting the whole program relevant to dehumidifying. Also in this state, the following alarms will be active: HP, HTE, LT, CF/RL, OF.

The air sweep can be set by the program in the position of maximum aperture and can, in any case, be adjusted by the user.

## 10.6 Program for night operation

This program can be used if the machine is operating in either cooling or heating mode. Depending on the mode of operation, a different operating logic is set:

**A) Cooling:** the minimum fan speed is entered for both fans and  $T_{set}$  is increased by  $1^{\circ}\text{C}$  one hour after start and by  $2^{\circ}\text{C}$  after two hours.

Except for forcing the minimum fan speed, the rest of the operation will be the same as normal cooling mode (increase of speed of external fan in case of excessive  $T_{batex} - T^{\circ}$  external battery - various alarms etc.).

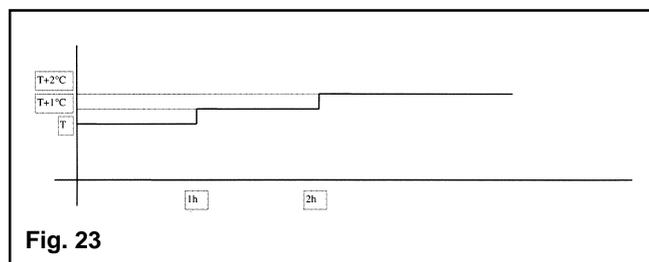


Fig. 23

**B) Heating:** the minimum fan speed is entered for both fans and  $T_{set}$  is decreased by  $2^{\circ}\text{C}$  one hour after start and by  $4^{\circ}\text{C}$  after two hours.

Also in this case all the other function mode of the "heating" mode must remain unchanged.

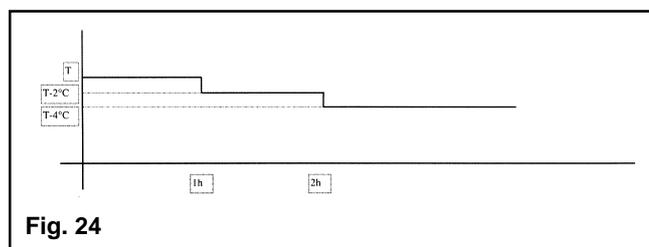


Fig. 24

**C) General Automatic mode:** The fan speed is forced to minimum and therefore the function of increasing or decreasing the fan speed is excluded.

On the display the symbol of night operation will appear with the other settings.

All the alarms concerning the programs apply.

## 10.7 Program of "air change"

This program starts devices that permit the entrance of outside air (optional Kit KR100).

## 10.8 General automatic program

The functions are selected automatically on the basis of the room temperature:

- if  $T_{amb} < 21^{\circ}\text{C}$  the heating function is started with fan speed proportional to the amount of deviation of this temperature: if  $19^{\circ}\text{C} + T_{amb} < 21^{\circ}\text{C}$  the minimum speed is selected, if  $17^{\circ}\text{C} + T_{amb} < 19^{\circ}\text{C}$  the medium speed is selected, if  $T_{amb} < 17^{\circ}\text{C}$  the maximum speed is selected. In any case,

after every variation, the speed remains constant for at least 5 min., to prevent annoying oscillations.

- If  $21^{\circ}\text{C} + T_{amb} > 23^{\circ}\text{C}$  the machine provides ventilation only, at minimum speed.
- if  $T_{amb} > 23^{\circ}\text{C}$  the cooling function is started with fan speed proportional to the amount of deviation of this temperature: if  $23^{\circ}\text{C} + 25 < 21^{\circ}\text{C}$  the minimum speed is selected, if  $25 + T_{amb} < T_{amb}^{\circ}\text{C}$  the medium speed is selected, if  $T_{amb} > 27^{\circ}\text{C}$  the maximum speed is selected. In any case, after every variation, the speed remains constant for at least 5 min., to prevent annoying oscillations.

All the subprograms for general automatic operation will have the same operating methods and alarms as defined for the separate operating modes.

## 10.9 Heating with heat pump

This function is started by pressing a specific key.

This starts: the inversion valve (this is started /stopped with a delay of 120 s. from stoppage of the compressor at every variation of the operating mode), the compressor, the two fans and the condensation discharge solenoid valve. The condensation disposal pump is inhibited.

Start-up is subject to consent of the thermostat set by the user ( $T_{set}$ ).

If the machine is a model for cooling only, the function is not started (even in automatic mode) although the buzzer signalling receipt of the command from the remote control remains.

### Management of fan speed in "Heating" program

The fan speeds can be selected by the user (min, med, or max or automatic with the same method as the "general automatic" program).

There are only 2 settings for external fan speed. The maximum speed starts with the corresponding internal, the minimum with the medium and minimum internal speeds.

If the external temperature (read at every start-up of the compressor, as we will explain below) is below  $0^{\circ}\text{C}$  ( $T_{vem}$ ) the external fan will only function at the maximum speed until the next acquisition of  $T_{bat ex1} - T^{\circ}$  external air battery 1 - on starting the heat cycle again. This condition prevails also in night operation. As always, persistence of a specific speed must be guaranteed for a minimum 5 minutes.

If the temperature of the internal battery falls below the value of  $39^{\circ}\text{C}$  the fan speed of the internal fan is automatically switched down one step lower. If the temperature remains below the value indicated for longer than 5 minutes, the fan speed is lowered again (for example if at maximum speed it goes to medium and if after 3 minutes the temperature does not rise past  $39^{\circ}\text{C}$  it goes to the minimum).

Of course, from the medium it can only go to the minimum. The minimum time at a specific speed must be 3 minutes to prevent annoying oscillations. These 3 minute intervals also apply in manual mode only below the threshold of  $39^{\circ}\text{C}$ , because the external fan will follow the settings of the remote control in this band too. Below  $30^{\circ}\text{C}$  ( $T_{hot stop}$ ) the fan stops and does not wait three minutes.

The display will show the symbols of heating, the  $T_{set}$ , the fan speed and the hourly programming, if any.

The air sweep will take the "heat" position (about  $45^{\circ}$ ) and can be regulated, in any case, by the user.

Also in this case the  $T_{amb}$  acquired must be able to be corrected by  $-3^{\circ}\text{C}$ .

### Subprograms of the Heat function:

- a) if  $T_{bat in} + T_{hs1}$  (temperature of hot start  $33^{\circ}\text{C}$ ) the internal air fan stays off. When  $T_{bat in} > T_{hs1}$  the fan starts, then stops at  $T_{bat in} + T_{hs2}$  (temperature of hot stop  $30^{\circ}\text{C}$ ),
- b) if  $T_{bat in} + T_{sh1}$  (temperature of external fan stop,  $63^{\circ}\text{C}$ ) the external air fan stops until  $T_{bat in} + T_{sh2}$  (temperature of new start-up,  $58^{\circ}\text{C}$ ),
- c) **defrosting of external battery (evaporator):** in heat mode the external air fan and the inversion valve always start before the compressor (except when defrosting) for a time ( $t_{ac}$ ) that can be adjusted from 30 sec to a maximum of 180 sec. At the end of this time, just before the compressor starts, the  $T_{bat ex1}$  is read and memorised. At every time interval ( $t_{sh}$ ) from the start of the heat cycle ( $t_{sh}$  30 min.)  $T_{bat ex}$  is compared with  $T_{bat ex1}$  and, if the difference ( $\Delta T_{hs} = T_{bat ex1} - T_{bat ex}$ ) between the two temperatures exceeds a value of  $14^{\circ}\text{C}$ , the defrosting cycle is started. It consists of the following steps:
  - 1 stop compressor and external and internal air fans (the partialization solenoid must be open);
  - 2 after time  $t_{d1}$  (60 sec.) the valve is de-energized;
  - 3 after a time  $t_{d2}$  (20 sec.) the compressor is started again;
  - 4 on reaching the external battery temperature of end of defrosting  $T_{bat ex sf}$  ( $25^{\circ}\text{C}$ ), or at the end of the maximum defrosting time  $t_{ms}$  (9 min.) the compressor is stopped;
  - 5 after time  $t_{d3}$  (50 sec.) the inversion valve is energized again;
  - 6 after time  $t_{d4}$  (20 sec.) the heat cycle starts again.If the difference  $\Delta T_{hs} = T_{bat ex1} - T_{bat ex}$  between the two temperatures does not exceed a value of  $14^{\circ}\text{C}$  then  $t_{sh}$  resets and counting starts again. At every time interval ( $t_{ma}$ ) 120 minutes of **continuous operation** in heating mode, the defrosting program must be started only if the initial air temperature ( $T_{bat ex1}$ ) was below a value of  $0^{\circ}\text{C}$ ;  $t_{ma}$  resets every time there is a defrosting due to  $t_{sh}$ .

This timing must be reset every time  $t_{sh}$  is reset (timing of start of defrosting).

Active alarms: FS, HP, HTI, CF/RL, OF, TSF (see relative paragraph). CF/RL + disabled during defrosting.

### 10.10 Programming timer and schedule

Programming includes  $n$  intervals of operation in 24h, shown on the display in a clear and comprehensible way. The operating modes are described in the instruction manual.

### 10.11 Operation of system for disposal of condensation in cooling mode

When the air conditioner functions in heating mode, the condensation that forms on the external battery (evaporator) has to be drained from the device through the pipe. In cooling mode, the condensation that forms on the internal battery, however, is used to increase the output of the device through its re-evaporation on the external battery (condenser). This also makes it possible, for units designed for cooling only, to eliminate the need for a condensation discharge system.

The devices that make this possible are, basically, the water recycling pump and the discharge closure actuator. Through the pump (that is active only in the cooling and dehumidifying function), the condensation water is recycled with the aid of a special distributor on the external condensing battery.

This heat exchanger is at high temperature and is struck by

a strong flow of air. Both these factors ensure that the water evaporates quickly, thus further cooling the battery. The pump is controlled by a **float** that signals the level of water in the tank. In case of problems of operation of the pump there is a second **safety float** that stops the device before the water overflows.

To prevent movement of condensation due to excessive speed of the air in the external battery, the electronic mechanisms provide for switching over the external speed to the minimum every time the pump is started.

In heating mode, as we have already seen, the water has to drain out because it cannot be re-evaporated. The device that enables this function consists of a **thermoelectric actuator** connected to a lever with a rubber cap closing the drain hole in the tank under the external battery. The opening command is given by the electronic logic every time the machine operates in heating mode.

Considering that the external airflow may contain large amounts of small particles (insects, pollen, dust, etc.) it is necessary, when performing maintenance, to clean the condensation disposal system and all its parts (pump, perforated distributor, battery).

## 11 Alarm signals

The electronic system installed on the air conditioner provides for displaying a series of operating alarms that make it possible to promptly identify any malfunctions or errors of use by the user.

To prevent transitory problems from setting off an alarm, the logic provides that the safety thresholds must be exceeded three times in a period adjustable according to the parameter. The following table summarises all the alarms, the relative led signal (that blink in case of alarm) on the signal panel.

### 11.1 Tests of operation and diagnosis of possible malfunctions

The program introduced in the microprocessor of this device enables it to run a brief autotest to check that the machine operates normally by starting the various internal parts.

To run the autotest proceed as follows:

- Power the machine.
- Use a sharp object to press the microkey under the hole on the left of the panel for at least 10 sec.
- At the beginning and end of the procedure of autotest the display shows the state of configuration of the machine for a few seconds according to the following scheme:

<b>red led</b> (filter):	off = UNICO; on = UNICO HP (with heat pump);
<b>green led</b> (compr.):	off = with correction of room temperature; on = without correction of room temperature;
<b>yellow led</b> (timer):	off = without correction of room temperature; on = with correction of room temperature;
<b>green led</b> (power):	off = stand-by in case of black-out; on = restart in case of black-out.

- Check after a few seconds that the device heats normally (if equipped with heat pump function) for about 2 minutes and then, after a few seconds, functions for 2 minutes in cooling mode. Before terminating the autotest the electronic system controls normal operation of the temperature sensors. If one of these is broken the corresponding signal leds stay on for 20 sec. (see table below).

The end of the autotest is signalled by all the leds lighting up together ten times in a row, and emission of an acoustic signal. During this stage, the value of the temperature read by the room sensor can be adjusted. This correction is important if the air conditioner is placed on the high part of the wall in rooms where hot air stratifies upward (rooms with high ceilings or heat sources other than the conditioner). The sensor will read a temperature 3°C lower in this case, to compensate for the difference between the living zone of the room and that read by the sensor.

To enter/delete the correction proceed as follows:

- 1 Check the state of the machine as described above. If there is no correction, to enter it press the button on the panel while the acoustic signal is being emitted after the autotest.
- 2 To remove the correction press the button during the acoustic emission at the end of the autotest.

The machine is set in the factory **without temperature correction**.

In addition to the autotest (that can be run under any room temperature conditions) we recommend performing other tests on the product depending on the types of operation accessible to the user (see manual). One important control refers to normal elimination of the condensation water in versions with heat pump. To perform it the machine should be kept on for at least 4-5 hours in the heating mode. In any case, if it does not discharge the water an “overflow” alarm will be generated.

## 12 Analysis of possible solutions to prevent alarm situations

The list below will enable you to identify most of the causes of alarms. We cannot exclude, however, that there may be other remote causes of malfunction. If you are not able to solve the problem with our information and your experience, you can contact our SERVICE Dept.

### HTI alarm signal (high temperature of internal battery)

This alarm can only occur on machines with heat pump and serves to prevent excessively high temperature and pressure

during the heating function. The possible causes are:

- Internal air filter clogged.
- Internal battery dirty.
- Internal air fan blocked or slowed.
- Air intake grating obstructed (see minimum space of installation in the installation manual).
- External air temperature too high. The air conditioner cannot heat if the external temperature is over 25°C.
- Internal air temperature too high due to excessive stratification in the room where the machine is installed. The temperature read by the sensor can be corrected using the key on the signal panel (see installation manual) if you need to obtain a better proportional temperature reading with respect to the effective room temperature.

### HTE alarm (high temperature of external battery)

This alarm occurs after the temperature of the external battery has exceeded the limit value indicated in the alarm table 3 times. The causes responsible for this alarm are:

- Presence of obstructions near the air intake and outlet pipes.
- Obstructions in the machine
- Excessive dirt on the external air battery.
- Malfunction of the external air fan. Bear in mind that this, like all other internal organs, is controlled by an electronic circuit. Therefore if a part does not function the cause could also be due to the circuit. To check this, just power the part separately with a power cable taken directly from the mains.
- Excessive temperature of external air (over 46-50 °C).

### LT Alarm (low temperature of internal battery)

This alarm occurs to prevent ice from forming on the internal battery causing water to leak from the machine.

The causes are usually similar to those responsible for the high temperature alarm on the same battery (HTI) with the difference that in this case, the internal and external temperatures are very low (18-20°C internal 15-20°C external) favouring the formation of ice on the evaporator (internal battery in the cooling function).

Starting from the left:

CODE ALARM	DESCRIPTION	green LED POWER	orange LED TIMER	green LED COMPR.	red LED FILTER
1-FS	filter dirty				○
2-HTI	high temp. of internal battery			○	
3-HTE	high temp. of external battery			○	○
4-LT	low temp. of internal battery		○		
5-HP	high pressure		○		○
6-CF/RL	batt. temp. not reached		○	○	
7-OF	water level		○	○	○
8-CKS	eeprom parameters not valid	○			
9	-	○			○
10-TSF	short circuit on room probe	○		○	
11-TSF	room probe not connected	○		○	○
12-TSF	short circuit on evap. probe	○		○	
13-TSF	evap. probe not connected	○		○	○
14-TSF	short circuit on condenser probe	○		○	
15-TSF	condenser probe not connected	○		○	○

**CF/RL alarm****(minimum battery temperature not reached)**

When this signal appears it means that the internal or external battery have not reached a temperature sufficient for normal operation of the machine. The main causes are:

- Compressor blocked or burnt;
- No coolant due to leaks.

In both cases it is necessary to open the device to make all the necessary inspections

For further information see the specific paragraphs.

**OF alarm****(water level above maximum)**

This alarm is caused by intervention of the safety float when the water in the condensation disposal tank under the external air battery is higher than normal.

The possible causes are:

- Blockage or breakage of the condensation disposal pump.  
To remove it, open the machine and remove the float support that anchors it to the bottom of the tank.
- Malfunction of the pump starter float.
- The transformer that powers the pump may be burnt.
- Clogging of the condensation drain inside or outside the device. In this case check the zone of the tank under the fan and the screen filter that protects it, located on the bottom of the tank near the battery. If necessary use a jet of water to clean it.
- Unusual tilt of machine

**In case of water leakage check that no pipes or couplings either inside or outside of the machine have come loose.**

**FS alarm****(filter soiled)**

This alarm does not stop the machine. Further information in this connection can be found in the user manual.

**Alarm****(eeprom not programmed)**

In this case replace the circuit or enter the parameters again by interfacing with the PC equipped with special software

developed by us.

**TSF alarms****(temperature sensors short circuited or interrupted)**

When these alarms occur it is necessary to check that the sensors are properly fitted in the connectors on the electronic circuit and that the wire is not interrupted.

If the sensor signals a short circuit make sure the circuit is not wet in the zone behind the contacts of the connectors of the sensors themselves.

**Technical data**

Technical features		Model			
		8500	11000	8500HP	11000HP
Cooling power	BTU	8.150-2.390	10.300-3.020	8.150-2.390	10.300-3.020
Heating power HP	BTU			8.150-2.390	10.300-3.020
Room air capacity	MC/h	350	390	350	390
External air capacity	MC/h	480	550	550	580
Noise (minimum)	DbA (pressure)	37	39	37	39
Coolant	type	R22	R22	R22	R22
Power absorbed	W	850	1090	850/820	1090/1050
COP	W/W	2,81	2,77	2,81	2,77
Power supply	V/Hz	230/50	230/50	230/50	230/50
Dimensions WXHXD	mm	870X400X280	870X400X280	870X400X280	870X400X280
Weight	Kg	43	46	43	46
MIN. Diameter of holes in wall	mm	153	153	153	153

**Note:** The capacities indicated refer to the following conditions (reference standard ISO):

**In cooling and dehumidifying:** Air entering the internal unit at 27°C b.s. and 19°C b.u., with air entering the external unit at 35°C b.s.

**In heating:** Air entering the internal unit at 21°C b.s. with air entering the external unit at 7°C b.s. and 6°C b.u.

### Tables of output

Since not always the external and internal project conditions are identical to those to which the nominal output of the machines refer, sometimes the choice of the machines on the basis of the nominal outputs can turn out to be not entirely correct.

Therefore, after making the calculation of the re-entries of heat and if necessary also of the dispersions with the methods described in chapter 3 of this manual, it is a good idea to check the choice of machines against the following tables.

Especially in the more temperate climates, this optimisation could even make it possible to pass to a smaller size unit rather than the one resulting from the choice made on the basis of the nominal potential.

To use these tables, however, we must learn a new unit of measurement that, by the way, is also the one that governs the output of evaporator both in cooling and in pumping heat.

This unit is called **Wet bulb air temperature**.

In effect, the temperature normally measured by a normal thermometer only represents the value we can perceive with our senses. But air is not normally saturated with moisture (except when there is fog). So if we spray water into unsaturated air, the water evaporates until the air becomes saturated. To evaporate, the water absorbs heat from the air that cools, bringing the temperature down.

Now, the temperature reached by the air once it is saturated with the water sprayed into it takes the name of **Wet bulb temperature (W.B.T.)** and is measured in °C like the temperature measured by the normal thermometer that is technically defined, instead, as **Dry Bulb Temperature (D.B.T.)**.

Since it is more convenient to measure the Relative Humidity (R.H.) of the air rather than its wet bulb temperature, we need a medium that will enable us to calculate the wet bulb temperature when we know the dry bulb temperature and relative humidity of the air.

This instrument is the Diagram of Moist Air.

It has a horizontal axis that shows the temperature, a vertical axis that does not interest us here, and a series of curves representing the Relative Humidity with a series of parallels for reference.

To find the wet bulb temperature on the diagram, corresponding to certain conditions of dry bulb temperature and relative humidity (for example 25°C dry bulb with 50% R.H.) we have to:

- identify on the horizontal axis the point that shows the dry bulb temperature (point A),
- draw a vertical line from that point until it intersects the curve of relative humidity (point B),
- draw a parallel from point B to the band of reference until it intersects with the curve representing 100% humidity (point C),
- draw a vertical line from point C that brings us back to the horizontal axis. The temperature read at the point where it crosses the line (point D) is the Wet Bulb Temperature.

Therefore, for the conditions taken as an example (25°C dry bulb with 50% R.H.), we can see that the Wet Bulb Temperature is 18°C.

Tables and performance curves for UNICO

Cooling:

model UNICO 8.5 SF

Temperatures		Outside temperature °C											
Inside. °C		20°C		26°C		32°C		35°C		40°C		43°C	
B.S.	B.U.	CT	AT	CT	AT	CT	AT	CT	AT	CT	AT	CT	AT
18	12	2,21	0,69	2,12	0,71	2,06	0,76	1,96	0,8	1,67	0,87	1,57	0,88
20	14	2,32	0,71	2,22	0,73	2,15	0,77	2,06	0,81	1,72	0,88	1,64	0,89
22	16	2,4	0,72	2,31	0,74	2,24	0,78	2,18	0,82	1,79	0,89	1,68	0,91
25	18	2,55	0,74	2,49	0,76	2,42	0,8	2,34	0,84	1,9	0,91	1,74	0,93
27	19,5	2,61	0,76	2,58	0,77	2,48	0,81	2,39	0,85	1,92	0,92	1,78	0,95
30	22	2,66	0,77	2,63	0,78	2,52	0,82	2,43	0,87	1,94	0,93	1,82	0,95
32	24	2,7	0,78	2,66	0,8	2,55	0,84	2,46	0,88	1,97	0,94	1,86	0,97

**Note:** - The data in the table can be interpolated but not extrapolated  
 - CT = total capacity in kW  
 - AT = total absorption in kW

Heating:

model UNICO 8.5 HP

Temperatures		Outside temperature °C											
Inside. °C		-6°C		-3°C		0°C		6°C		10°C		12°C	
B.S.	B.U.	CT	AT	CT	AT	CT	AT	CT	AT	CT	AT	CT	AT
15		1,08	0,71	1,65	0,73	1,94	0,76	2,41	0,81	2,43	0,87	2,47	0,9
18		1,06	0,73	1,63	0,75	1,92	0,77	2,39	0,82	2,42	0,88	2,45	0,92
20		1,03	0,74	1,61	0,76	1,9	0,79	2,36	0,84	2,38	0,9	2,43	0,93
21		1	0,75	1,58	0,78	1,87	0,81	2,34	0,85	2,37	0,92	2,42	0,95
22		0,98	0,78	1,56	0,8	1,84	0,83	2,3	0,87	2,39	0,96	2,41	0,96
24		0,94	0,81	1,52	0,83	1,81	0,85	2,26	0,89	2,37	0,96	2,39	0,98

**Note:** - The data in the table can be interpolated but not extrapolated  
 - CT = total capacity in kW  
 - AT = total absorption in kW

Cooling:

model UNICO 11 SF

Temperatures		Outside temperature °C											
Inside. °C		20°C		26°C		32°C		35°C		40°C		43°C	
B.S.	B.U.	CT	AT	CT	AT	CT	AT	CT	AT	CT	AT	CT	AT
18	12	2,91	0,88	2,81	0,94	2,72	0,99	2,68	1,02	2,22	1,18	2,04	1,29
20	14	2,96	0,89	2,89	0,95	2,8	1,01	2,76	1,04	2,35	1,19	2,13	1,3
22	16	3,04	0,91	2,96	0,96	2,88	1,02	2,84	1,05	2,46	1,21	2,18	1,32
25	18	3,14	0,92	3,08	0,98	2,96	1,04	2,94	1,07	2,52	1,23	2,22	1,34
27	19,5	3,21	0,93	3,14	0,99	3,05	1,05	3,02	1,09	2,6	1,24	2,28	1,35
30	22	3,26	0,95	3,21	1,01	3,21	1,07	3,1	1,11	2,65	1,26	2,34	1,36
32	24	3,29	0,96	3,25	1,02	3,21	1,08	3,18	1,12	2,71	1,28	2,4	1,38

**Note:** - The data in the table can be interpolated but not extrapolated  
 - CT = total capacity in kW  
 - AT = total absorption in kW

Cooling:

model UNICO 11 HP

Temperatures		Outside temperature °C											
Inside. °C		-6°C		-3°C		0°C		6°C		10°C		12°C	
B.S.	B.U.	CT	AT	CT	AT	CT	AT	CT	AT	CT	AT	CT	AT
15		1,42	1,01	1,99	1,04	2,41	1,05	3,08	1,08	3,11	1,13	3,14	1,15
18		1,39	1,05	1,97	1,07	2,38	1,09	3,06	1,11	3,09	1,16	3,12	1,18
20		1,38	1,06	1,94	1,09	2,37	1,11	3,02	1,13	3,07	1,17	3,1	1,19
21		1,36	1,08	1,92	1,1	2,35	1,12	3	1,14	3,05	1,19	3,07	1,21
22		1,33	1,1	1,88	1,12	2,32	1,14	2,97	1,16	3,03	1,21	3,05	1,22
24		1,31	1,11	1,86	1,14	2,3	1,15	2,95	1,18	3,01	1,22	3,03	1,23

**Note:** - The data in the table can be interpolated but not extrapolated  
 - CT = total capacity in kW  
 - AT = total absorption in kW

## Description of UNICO configuration parameters

PARAM	U.M.	DESCRIPTION
tc_camb	°C	correction of room temperature
tc_hs1	°C	temperature of hot start (internal battery)
tc_hs2	°C	temperature of hot stop (internal battery)
t_spscon	°C	minimum time for start of pump to eliminate condensation
v_ilow	-	low speed internal ventilation
v_imid	-	medium speed internal ventilation
v_ihi	-	high speed internal ventilation
v_elow	-	low speed external ventilation
v_emid	-	medium speed external ventilation
v_ehi	-	high speed external ventilation
t_sh	min.	time from start of heat cycle for control of defrosting
t_ms	min.	maximum defrosting time
t_ma	min.	time of continuous heating for control of defrosting
tc_dtr	°C	hysteresis temperature of test
tc_sh1	°C	temperature (internal battery) of stopping external fan when heating
tc_sh2	°C	temperature (internal battery) of stopping external fan when heating
tc_vem	°C	temperature (external battery) for maximum external fan speed in heating
tc_ths	°C	temperature delta (external battery) for starting defrosting cycle
tc_batexsf	°C	temperature of external battery for end of defrosting
t_ac	s	delay in start of compressor in heating mode
t_d1	s	delay in de-energising solenoid for inversion of defrosting cycle
t_d2	s	delay in starting compressor again in defrosting cycle
t_d3	s	delay in energising solenoid for inversion of defrosting cycle
t_d4	s	delay in starting heat cycle again after defrosting
t_at	min.	time for acquisition of temperature alarm
t_sf	h*4	time of 4 hours operation of internal fan for dirty filter alarm (1)
tc_rmin	°C	minimum temperature setting possible from remote
tc_bexvmax	°C	top threshold for temperature of external battery when cooling
tc_bexvmin	°C	bottom threshold for temperature of external battery when cooling
mch_id	-	configuration for machine model
tc_sbatex1	°C	temperature threshold with respect to Tbatex1 for start of defrosting cycle
tc_bin_Hnot	°C	internal battery temperature threshold for insertion of solenoid partialization in heating mode
tc_bin_Cnot	°C	internal battery temperature threshold for inserting solenoid partialization in cooling mode
tc_dtparz	°C	hysteresis temperature for disinsertion of solenoid partialization
tc_hti	°C	alarm threshold for high internal battery temperature
tc_hte	°C	alarm threshold for high external battery temperature
tc_par1	°C	internal battery temperature threshold for insertion of solenoid partialization
tc_lt1	°C	internal battery temperature threshold for stoppage of compressor
tc_lt2	°C	internal battery temperature threshold for starting compressor again
tc_cflr	°C	temperature for comparison with internal/external battery temperature
vpwf	-	voltage threshold of power failure

