# SUN RADIATION AND COMFORT
# IN URBAN SPACES

## - Reference to Hot-Dry Climate -

A THESIS PREPARED FOR A MASTER

IN ARCHITECTURE

by

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TO MY PARENTS

## PREFACE

The problem of controlling solar radiation and creating conditions favourable to his aims and activities is as old as man himself, especially in the hot regions of the world where the sun has a great impact and constitutes one of the main worries of people living there.

This worry is still the same, the questions asked and the solutions sought are of concern.

My own interest in the impact of solar radiation on living spaces and the design implication of its control stems mainly from some of my project work as a student preparing for a diploma in architecture, and also from what has been seen and experienced in a country like Algeria where the sun's impact, during the overheated period and within urban agglomerations, constitutes one of the insolvent problems affecting the citizens' well-being and their daily life in general. However, the question of solar radiation problems and how to control them is considered differently in this work. It is directed to another matter, which seems to have been forgotten, in an attempt to understand the problem from another side and possibly to bring about some solutions and ideas in order to achieve control of solar radiation. The subject is (concerned about) outdoor spaces, and how they can be protected against the harsh direct sun radiation which causes uncomfortable conditions within these used spaces. Although the summer sun is the principal factor I was dealing with throughout the many investigations and analyses, some other factors such as rain, wind and dust have not been neglected, because each one of them could also, independently or not, alter people's comfort in a given urban space, whatever the season.

To meet the problem of solar radiation control in particular, and of climate in general within the public urban spaces - in hot countries - this work mainly concentrates on two Mediterranean and historic cities constituting the basic case-studies: "Constantine" (North-east of Algeria) and Naples (south-west of Italy); two regions I know quite well and which have an almost similar climate - with very hot summers and some resemblances in the social outdoor life, although they show different and various urban conceptions probably due to different cultural histories; Constantine belonging to the Islamic tradition, and Naples to the European one.

It is through thoughtful urban conceptions that controlling climate and thus protecting the urban public spaces that one will hopefully re-establish livable conditions.

This thesis consists of two main parts; the first one is theoretical and gives a broad outline of the climate within an urban design context, supported by ideas from some particular book-texts and some others from my own beliefs and knowledge of this matter.

The second part, mainly practical, derives from my personal investigations, analyses and experiments, some made in the field, others in the laboratory.

However, the many comments and conclusions made about the different design processes and techniques to control sun radiation and other elements should not be regarded as definitive solutions - one cannot state rigid recommendations: they are intended to provide information, inspiration and a synopsis of workable solutions to the problems.

It is my hope that this thesis will serve as a stimulus for anyone, and particularly students, interested or involved in such problems which are commonly neglected or ignored.

# ACKNOWLEDGEMENTS

I am greatly indebted to the Algerian Government for the grant which enabled me to reach this stage in my studies.

I wish to express my thanks to Mr. T. Vogt, my supervisor, for his help and advices stimulating my interest throughout the period of research.

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I would thank all those who helped me in achieving this work, including the library staff at the Art School and the typist Mrs. J. Pickering for her competence.


Finally, I dedicate this work to my family.

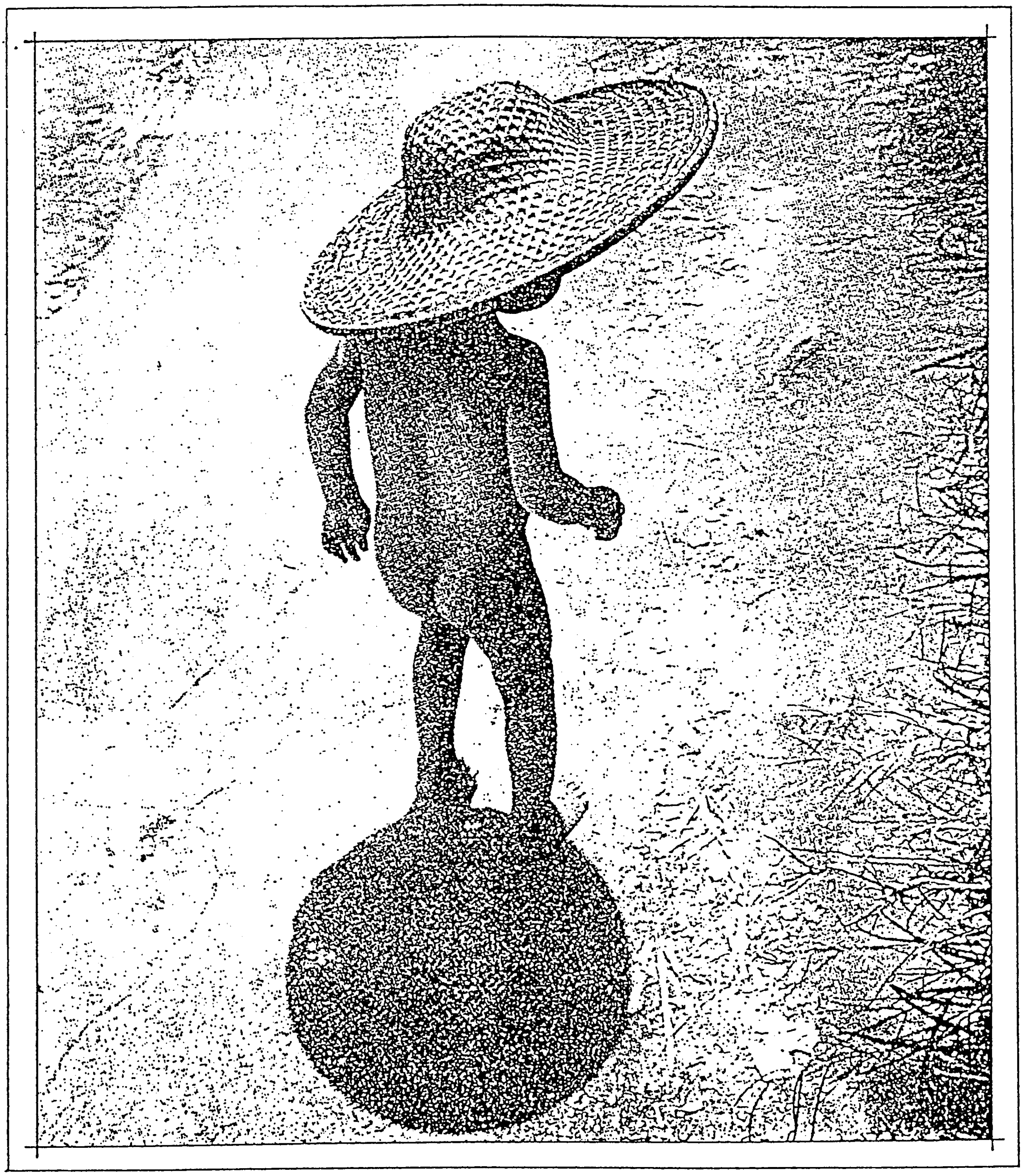
CONTENTS

- PART TWO -

## — LIST OF ILLUSTRATIONS —

"Je fus placé à mi-distance
de la misère et du soleil."

ALBERT CAMUS



## A. INTRODUCTION

The exciting diversity of the world is owed to the fact that each person and each place exhibits uniqueness of characteristics and of fate. One like "Lawrence Durrell", for instance, believes strongly that environment profoundly affects human development, that man in his daily life constantly responds to buildings, landscape, trees and other elements of the non-human universe as much as he does to social experience. He said that the openness of vast plains or seashores makes the body and mind different from what they would have become in the subdued light of forest clearings or mountain valleys. One may doubt this, but what is certain is that any good single building or a whole city layout should relate and respond not only to the climate and other environmental conditions in its own area, but also to the traditional way of living of its users. This all seems very obvious but, unfortunately, it is all too often neglected or ignored; because nowadays, we are witnessing a change that is forming a complete rupture with the past; every concept and every value has been reversed by the easily accepted notion of modernism. This makes me think about the case of the traditional Arab house, in the middle-east or North Africa, with its introverted plan wherein family life looking into the courtyard was changed to a plan with family life looking out upon the street. The cool clear air, the serenity and reverence of the courtyard were shed, and the street was embraced with its heat, dust and noise. However, many of the situations under which traditional techniques to control the local environment were effective have now changed to the point where the original techniques are no longer appropriate. Populations may have become too large to be sustained by traditional methods; climates and ecologies may have changed - often through overexploitation - producing a situation unfamiliar to the original society. Rather than develop a new solution rooted in tradition, societies often opt for what we call modern answers. Unfortunately, in far too many cases, the traditional devices, methods and systems used to create comfortable living conditions have thus been supplanted by modern solutions that are inappropriate to and untried under the local conditions.

The contemporary man, it seems, has forgotten how to design with this immediate environment and tends to ignore the climate while he is preoccupied with forms currently fashionable and items manufactured and unsuitably built elsewhere. Those so-called modern buildings, producing and enclosing internal spaces, have been the main interest and the exciting subject for most designers; they have been designed largely to keep natural phenomena outside, to separate and control conditions inside from the outdoors as much as possible and at whatever price, relying on mechanical devices and energy consuming systems to do much of the work. Commonly, these devices make the external conditions worse, for example the air conditioning system discharging to streets and other public spaces.

Being concerned about the question of climate control in living spaces - outdoors and indoors- it seems that the attitude of architects, urban planners and even engineers in this matter has been exclusively focused on the single house or building and its internal spaces where high conditions of comfort have been differently searched and achieved with high standards of technology. This is extremely noticeable from the numerous books and publications dealing with such matter - the control of climate and buildings - where every interest is repeatedly given to the building of indoor spaces and the raised problems of heating, lighting and ventilation, without any consideration to the remaining living spaces: the urban ones. Moreover, it seems that architects are independently taking the problem of climate control and try to find solutions through what we call architectural design without any awareness of the outdoor space conditions; and the urban designers or planners simply accepting and spreading over every kind of building design climatically workable only for itself. However, decisions in controlling climate by design should be simultaneously thought and made for both kinds of spaces - indoors and outdoors - and preferably in a passive way, because external spaces cannot be controlled actively as is the case with internal ones, to overcome and avoid any conflicting design results; and to do so, this will require a manageable coordination between architects and urban designers to arrive at an optimum and reconcile the conflicting desires.

It is true that controlling solar radiation effects, within hot countries, is not an easy task, especially when the concern is for the external living spaces in larger urban agglomerations where there are complex changes in the microclimatic conditions brought about by manmade alterations of the urban tissue. Nonetheless, this had been more or less adequately achieved in some traditional Arab cities, particularly when the matter is looked and considered with references to past times and the traditional living style of societies who built those cities. Today, with the coming of industrialisation and its many consequences, the design style of such cities had been rejected and completely replaced by what we call modern style which seems to have two main purposes: the aesthetic norm of western society and motor-car accommodation. However, one could say if the necessity of the car use must be considered and integrated in every new urban development this should not be the reason to stop thinking in terms of climate control during the design stages and to take inspiration from what had been made in such traditional cities and successfully achieved in this matter.

What appears to be needed, therefore, is an appraisal of the conditions under which the traditional solutions are technically, environmentally, socially and economically valid, so that use can be made of this knowledge in appropriate situations. It would be of great benefit also if societies with similar conditions could share their traditional solutions to specific problems. Following appraisal, some solutions may be rejected as inappropriate, but a scientific understanding of the principles upon which they are based could serve as a useful foundation upon which to develop new solutions more in keeping with the local economics, environment and society than those that have replaced the traditional ones. Many traditional techniques used for climate control could be improved, using new material and design knowledge. In his book: Design Primer for Hot Climate 1980, Allan Konya said in this context that architecture and urban planning know-how cannot simply be exported as if they were some standard consumer product and it is essential for anyone wishing to work abroad (whether in a foreign land or another region of one's own country) to appreicate and understand the unique situation of the area concerned.

The many researches in the field of climate control, in recent years, directed towards the problems arising in the hot, tropical and sub-tropical regions, have not accomplished the task nor reached the goals, because these research works are mainly concerned with the physiological and building problems in an architectural context.

One should remember that, unlike in cold countries, the people's life style in hot regions has its own particularities as most activities happen in the outdoor spaces which, of course, merge into the indoor ones, forming one space, the living one, the use of which is determined by climate or the seasons.

The massive complexity of a city, embracing techniques and ideas to control its own microclimate, extends over hundreds of years and rate of change of these systems is necessarily slow; we are all locked into this matrix of living and we have to accept the conditions of life and work that others have created. However, in spite of that, improvements to urban spaces conditions is needed and could be made in respect to what is existing; and those changes should not be drifted into the city fabric as a kind of accident of the passage of time, but made as a determined application of something new which we know to be good in achieving its purposes.

Despite changes to control climate effects within existing urban areas, the result will not usually be as efficient as it would be in the case of town or urban settlement newly designed with accurate considerations to climate control. In this context, I follow Landsberg's statement in his book: "The Urban Climate", 1981, where he says, "It is, of course, much easier to plan a town from its beginning than to redesign an existing one".

# - PART ONE -

## CHAPTER 1

## CLIMATE AS CONTEXT

## B. CLIMATE AS CONTEXT

### 1. Abstract

From his first to his last breath, man has to submit to the action of the meteorologic conditions, popularly called THE CLIMATE. This climate, man could like or hate, but resigned or revolted his obligation is to consider it.

The climate fact is particularly important for the human being insofar as it affects his physical conditions, moral character and feelings. In many cases, this influence is evident and clearly a biological phenomenon; and it is also true that the influence of climate upon man is of great complexity and fascination. The methodic study of the environment effects on human behaviour has developed a wide knowledge since the last century and nowadays many sciences try to find out the existing relation between climate and human behaviour in different fields.

Changing climatic conditions also invite associated patterns of behaviour, as has been studied on many kinds of animals who possess natural defenses against a large range of unfavourable climates (Huntington, Ellsworth, "The Human Habitat", Princeton, N.J. 1927). Amongst those creatures, man was not as fortunate of the Genesis. He has very limited natural controls with which to encounter variations of the unfriendly climate, where he has to maintain his body temperature close to 37°C (98.6°F) - or perish. From this struggle of adaptation, where the energy of the sun plays a major role, the interaction of man with his particular climate and even its modification has started.

Today, the more significant modification of climate was produced by the spread of urbanisation and the associated development of manufacturing industry over extensive areas, these man-made effects can assume equal importance with regional factors or the influence of topography in controlling local climate, which is currently called "microclimate".

There is no doubt that whenever man changes the landscape he modifies the microclimate. Ryd, in some notes on building climatology, 1970, has used the phrase "Climatological sheath" to describe the space around a single building, within which there are rain shadows and anomalies in wind, temperature, humidity and soil moisture. Similar sheaths surround other local landscape features (natural and man-made) such as pounds, trees and ploughed fields.

However, when groups of structures merge into towns and cities, the term "climatological dome" - see: "study of man's impact on climate," inadvertent climate modification, 1971 - is used to describe the phenomenon illustrated in figure : I-2 . Within this dome, the microclimates of urban parks and on the shaded sides of street remain as special cases, but on the large scale of the city many common features can be detected sometimes up to heights of a kilometer.

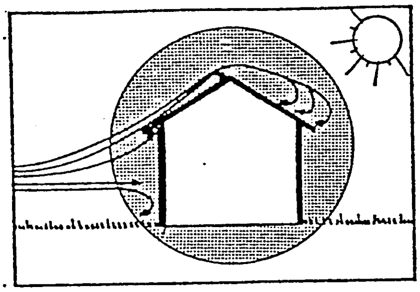


FIGURE I.I The climatological sheath around a structure. (After Ryd, I970.)

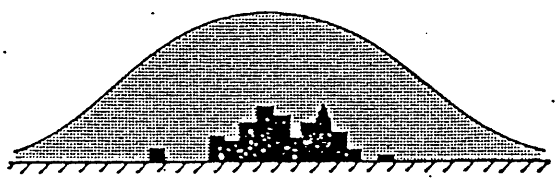


FIGURE I.2 The urban dome. (After Peterson, I969.)

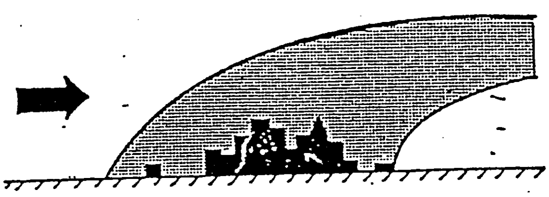


FIGURE I.3 The urban thermal and pollution plume occuring when a regional wind is blowing. (After J.F. Clarke, I97I.)

## 2. EFFECT OF URBAN CLIMATE ON HUMAN BEINGS

In the natural environment, humans experience a range from arctic cold to debilitating tropical heat.

All over the world, in climates hot and cold, wet and dry, man needs shelter from the atmospheric elements. He makes his habitable structures vary in type according to his degree of knowledge and his general geographical environment. From those atmospheric elements I would like to point out some of them, such as solar radiation, air temperature, humidity and air movement, which may have a great and direct effect on humans.

As stated previously, temperature is one factor in the physical environment that humans are changing through urbanisation and industrialisation, so that, nowadays, urban centres are typically hotter than the surrounding areas. (Clarke and Back W. 1971).

As it is proved by scientific researches (Landsberg H.E. 1969), from different fields and can be individually experienced, the urban heat during summer - especially in countries with a hot climate - has an adverse health effect such as "heat stress" which depends on a large number of variable both in the environment and in the reacting human individuals. It depends on the metabolic rate of individuals, ability to perspire, weight and age. In some instances clothing is also of considerable influence.

A number of studies (Hodge W. 1978), have related temperature conditions alone to the urban summer mortality rate. Even this primitive approach has yielded quite unequivocal results, periods of high temperature have shown mortality far in excess of values expected by statistical experiences.

The temperature, as measured at a meteorological station, is not intended as a measurement of human comfort within the urban fabric, for example one element particularly lacking is the heat load imposed by radiative temperature surfaces, such as pavements and walls. Clarke and Back (1971), presented clear-cut evidence for this heat load. They showed that the heat fluxes from pavement impinging on persons are nearly 50% higher than over nearby grass surfaces.

Even without precise scientific measures and observations, this evidence could be entirely experienced by our sensations and feelings. Someone, for example walking by a summer day, over black clay, or over black granite paved street, such as the case of Naples (Italy), could easily feel the heat difference if he would move and walk over a grassed area close to this street. The importance of heat over the paved street floor cannot just be felt but also seen by eyes when radiated from the black granite to the air above. This can greatly add to the burden, in addition to a high-air temperature and thus to the pedestrians' discomfort.

Although a theoretical framework for radiative fluxes in various latitudes and seasons has been developed (Olgay V. 1967), actual measurements dealing with persons in the streets, their specific clothing, and their physiological reactions are lacking. Chamber experiments are likely to be inadequate and insufficient, even if there have been attempts to model the human being, metabolising at various rates in the urban environment.

From wind-tunnel studies (Auer. Jr. 1975), estimates have also been made of wind effect on comfort conditions in streets and on corners where wind is frequently channeled and broken up with eddies. One can easily show that winds may be low and tolerable on one side of the street and highly disagreeable on the other. This will, of course, in the cold season notably the wind-chill factor.

Ideally observation of the wet-bulb globe thermometer ought to be used because that instrument integrates temperature, humidity, radiation and wind effect, unfortunately, no systematic observations with this equipment in urban environments are available.

One other biometeorological factor in the urban milieu

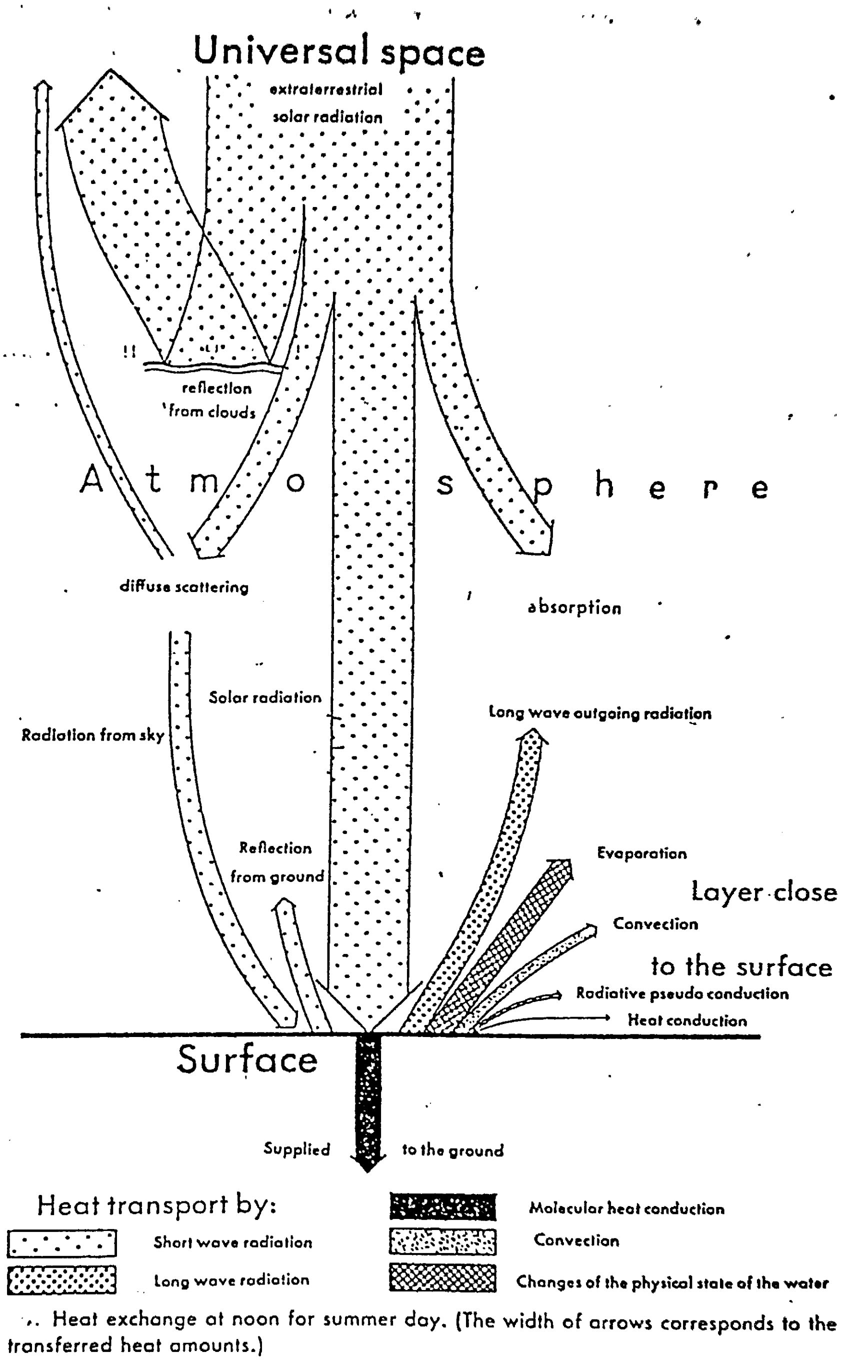



FIGURE I.4 Heat exchange at noon for summer day. (The width of arrows corresponds to the transferred heat amounts.) (After Olgay V.I967.)

is also related to discomfort. High levels of temperature and humidity prevent peoples from getting rid of their metabolic heat; they are aware of this only subconsciously. It makes them irritable; it leads to behaviour problems such as violence in the streets (Landsberg H.E. 1981).

## 3. THE URBAN HEAT ISLAND

The most obvious climatic manifestation of urbanisation due to its energy use is the trend towards higher air temperature. This is also the theme most frequently discussed in the literature since its discovery by the English researcher "Luke Howard", 1772 - 1864 (Landsberg H.E. 1981). It is present in every city and town.

The differences that develop between an urbanising area and the rural one, greatly depend on the synoptic conditions. They are in essence a differentiation of topoclimates and as such depend on dissimilarity of radiative fluxes and turbulent exchanges.

These contrasts are largest in clear and calm conditions, but they tend to disappear in cloudy and windy weather. Under these synoptic regimes temperature differences between urban and rural areas become large. Closed isothermes separate the city from the general temperature field, and this condition has become known as the "urban heat island" (Landsberg H.E. 1981).

This heat island is a reflection of the totality of microclimatic changes brought about by man-made alterations of the urban surface. Even a single building complex will show a different microclimate than an equal piece of land in its natural state. The paved surfaces and walls will store some of the heat received in daytime and give it off after sunset to its air environment. The natural order is further offered by the lack of evaporation in the city and the solar energy that is used in the country in the morning to evaporate dew, guttation on plants, and frost is directly absorbed by the building materials. Evapotranspiration is also sharply reduced in the city because of the reduced plant cover.

The maximum temperature difference, when the heat island is pronounced, shows up usually 2 to 3 hours after sunset, while in the small-scale building complexes it generally disappears after midnight. Yet, in large urban areas it is still notable at the time of the sunrise and raises the maximum temperature there.

The clearest evidence for the urban heat-island effect, is the fact that the local temperatures in towns have risen as the town grew. There are a number of cases where this can be demonstrated; one of them is for Paris when Dettwiller J. (1970), compared the central Paris mean temperatures during the 1951-1960 decade with surrounding stations at airports and in rural localities. He found that the outlying weather stations had mean temperatures of 10.6°C to 10.9°C, but in the centre of Paris it was 12.3°C, about 1.5°C higher. Those isotherms (Figure I.5 ) show how well justified the term "heat-island" is. The values given by Deffwiller are all reduced to a uniform 50 meters elevation to correct for possible orographic effects.

It is also interesting to mention that the winter values are considerably smaller than those found for summer. This is consistent with the view that the major cause for the urban heat island is the change in the radiation balance and not rejected anthropogenic heat, as it was revealed by Michell J.M. Jr. (1961) comparison for a number of United States cities, using the most rapidly growing urban areas for the period of record when data were available for both the inner city and the rural environs.

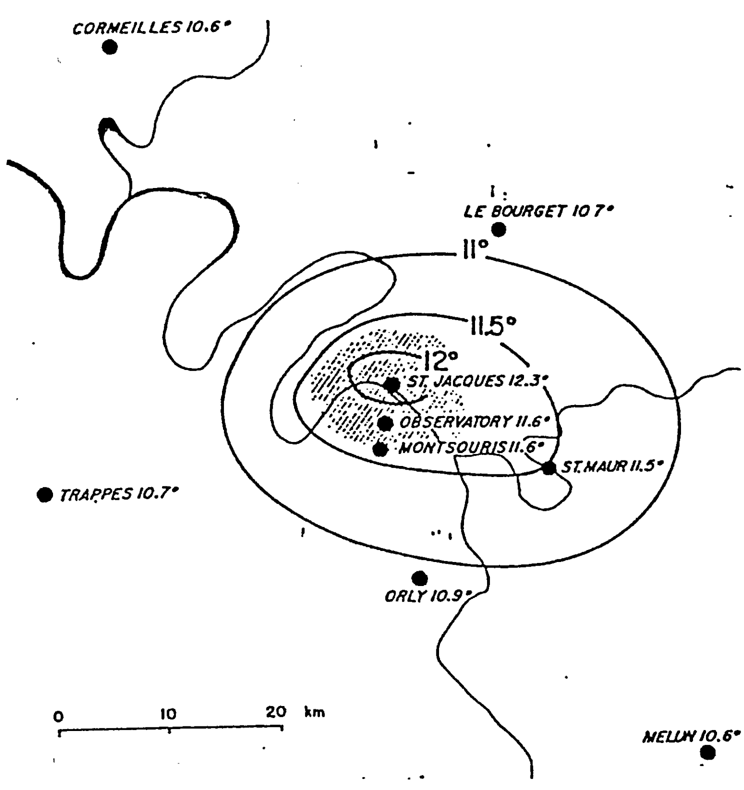



FIGURE I.5 Annual isothermes (°C) in Paris, France. (after Detwiller, 1970).,

## 4. SHELTER AND ENVIRONMENT

The physical environment consists of many elements in a complex relationship. Szokolay S.V. (1980), try to describe the environmental constituents as: light, sound, climate and animate. He said, they all act directly upon the human body, which can either absorb them or try to counteract their effects. Physical and psychological reactions result from this struggle for biological equilibrium. Man strives for the point at which minimum expenditure of energy is needed to adjust himself to his environment. Conditions under which he succeeds in doing so can be defined as the "Comfort zone" where most of his energy is freed for productivity.

The shelter is the main instrument for fulfilling the requirements of comfort; it modifies the natural environment to approach optimum conditions of livability. It should filter, absorb, or repel environmental elements according to their beneficial or adverse contributions to man's comfort. Olgay V. (1967), in this respect, said that the most important factor to be analysed is the feeling of thermal balance; without which any definition of comfort is impossible.

## 5. COMFORT

The major elements of climatic environment which affect human comfort can be categorised as: air temperature, radiation, air movement and humidity. There are others too, such as chemical differences, physical impurities, electric content in the air....etc., but they are not considered in this study.

Although human comfort cannot be measured in terms of

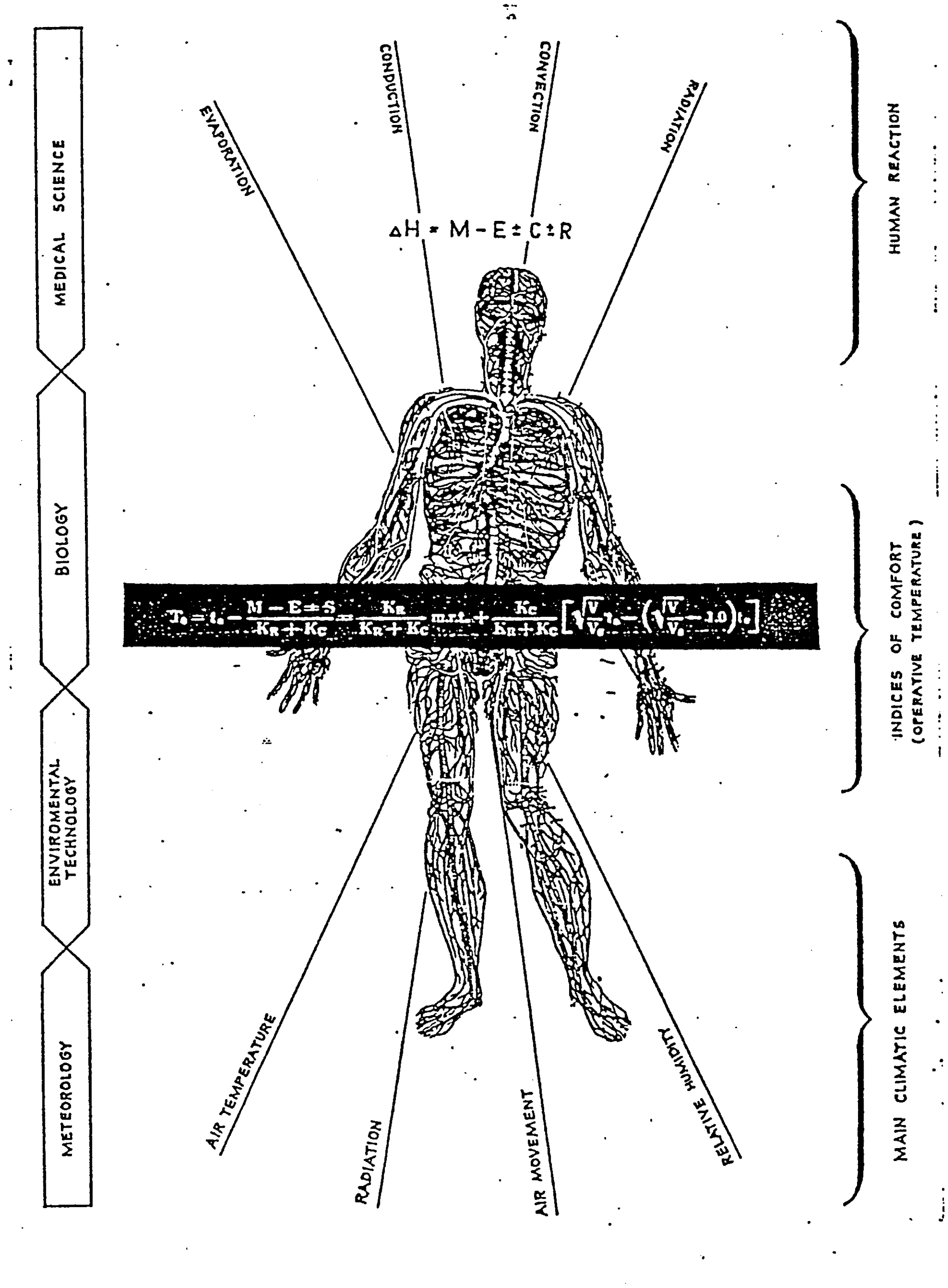



FIGURE I.6 Relation of human body to the climatic elements. (After OLGAY V. 1967).

psychological factors only, one of the primary requirements - and this is particularly true in hot countries, is the maintenance of thermal balance between the human body and its environment. This involves keeping the internal temperature of the body within a certain range, regardless of the relatively wide variations in the external environment. The conditions under which such balance is achieved, and the state of the body when it reaches equilibrium with the surroundings, depends on the combined effect of many factors; some, such as the activity, acclimatisation and clothing of the subject are individual characteristics, while others, such as the four major elements afore-mentioned are environmental.

We know that the body maintains a constant-internal temperature by releasing superfluous heat to his environment and there is, as a result, a continuous exchange of heat between the body and its surroundings which may take place in four physically different ways: conduction, convection, radiation and evaporation. These physical processes are influenced, of course, by the four aforementioned climatic factors.

## 6. THE COMFORT ZONE

The range of conditions in which thermal comfort is experienced is called the comfort zone; something which differs with individuals and is affected by the clothing worn, geographical location, age and sex. Although the comfort zone is defined as a subjective assessment of the environmental condition, the limits of the zone do have a physiological basis. (For detailed information and explanations on the "comfort zone", see Olgay V. (1967), page 17).

## 7. THE BIOCLIMATIC CHART AND BUILDING DESIGN

Comfort which is also dependent on not only the air temperature and that of the surrounding surfaces, but also on the relative humidity of the air and the air movement, cannot be expressed in terms of anyone of them as they affect the body simultaneously and the influence of anyone depends on the levels of the other factors. For this reason, several attempts have been made to evaluate the combined effects of these factors on the physiological and sensory response of the body and to express any combination of them in terms of a single parameter which can be set out on a nomogram called "Bioclimatic Chart".

Victor Olgay, 1967, was the first to propose a systematic procedure for adapting the design of a building to human requirements and climatic conditions. His method is based on a bioclimatic chart on which comfort zones - one for summer and one for winter - can be determined for the climatic region to which it is to be applied. Once this has been done any climatic condition, determined by its dry-bulb temperature and humidity, can then be plotted on the chart: comfort requirements can be evaluated, deviations from the comfort zone, and whether these can be eliminated by natural means, can be ascertained.

The relation of indoor and outdoor conditions, however, varied widely with different characteristics of building construction and design, and as Givoni B. 1976, pointed out the bioclimatic chart is therefore limited in its applicability as the analysis of physiological requirement is based on the outdoor climate, which is my point of interest through this research work, and not on that expected within the building in question. He has proposed an alternative method which uses one of the thermal indices to evaluate the human requirements for comfort, from which the necessary features of building design to achieve this comfort are determined. This method involves an estimation of the indoor climate and for practical use the suitability of ventilation, air temperature reduction and evaporative cooling - for ambient conditions combining different temperature ranges and vapour pressures -these are plotted on an involved diagram to form what has been named a building bioclimatic chart.

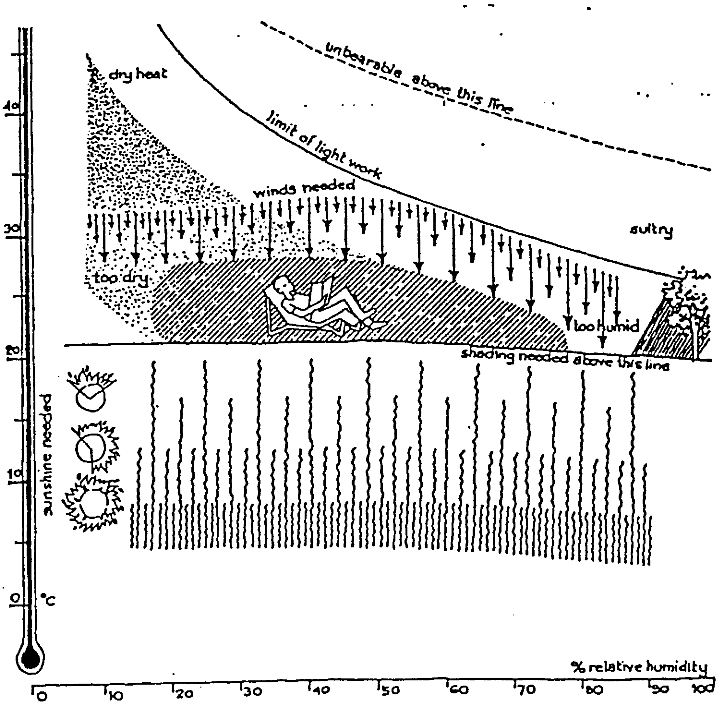



FIGURE I.7 schematic diagram of Victor Olgay's BIOCLIMATIC CHART.

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# CHAPTER 2

# DESIGN AND CLIMATE

## C. DESIGN AND CLIMATE

### 1. CLIMATIC INFLUENCES ON DESIGN

The bioclimatic skills of the ancient civilization has been the fruitfull results of very long experience, even if those results are, nowadays, considered as spontaneous in character.

However, we have to admit that many building regularities, which have been applied with some respects to climatic conditions, have been dictated during the critical time. Nevertheless, the ancient recognised that regional adaptation was as essential principle of architecture in general. Vitruvius, in his 6th volume: "De Architectura", translated by Frank Ranger (1934), said: "for the style of buildings ought manifestly to be different in Egypt and Spain, in Pontus and Rome, and in countries and regions of various character. For in one part the earth is oppressed by the sun in its course; in another part the earth is far removed from it; in another it is affected by it at a moderate distance".

It is obvious that a building or a town in the tropics should differ from one situated in the mediterranean region, but it is less obvious that even in the same area - city, town or village - there are microclimate differences which should be recognised in the design and construction of buildings and urban places. Beside the climatic considerations, I would like to mention the cultural and life-style considerations which have not to be neglected.

## 2. LOCAL VARIATIONS CAUSES

As climatic design is based on typical or normal climatic conditions, it is usually relatively easy for the designer to obtain the necessary meteorological data for any given region in which he intends to work. Unlike regional climatic data, however, site climate information is not readily available and will have to be acquired through personal observation, local experience and, if possible, some appropriate measures. Some of the more important climatic factors which may cause local variations and which the urban designer must consider, in the first stage of his work, are determined as follows:

The site (or topography); vegetation; wind; water and the ground surface.

### 2.1 The Site

The shape, orientation, exposure, elevation and form (hill, valley...etc.) must be investigated as they can have an effect on not only temperature but also the distribution of solar radiation, wind and precipitation. The influence of small hills (change in ground level) on rainfall patterns can be quite pronounced, for instance, particularly when moisture bearing winds blow regularly from the same direction. The windward slope in this case can be expected to receive a rainfall of more than the leeward slope (see Konya A., 1980). The same author noted that temperature in the atmosphere decreases with altitude (7-8 meters in height can cause a difference of $5^{o}C$ in air temperature in still conditions), and this can be important in hot lands, such as Constantine, where temperature may be more favourable at higher elevations. At night, however, this effect is reversed as cold air drains down to the lowest points.

In the case of an unexploited site where a new urban settlement, for example, is going to take place, it is necessary that this site climatic conditions be studied at the first stage in order to deduce the most suitable area for building and to take advantage of the favourable existing microclimate variations where possible. The immediate environment of a building or group of buildings can, in other words, be willfully manipulated through earth mounds, walls, planting, pools, siting and building forms among other things.

## 2.2 Vegetation

Considering the use of vegetation, such as trees, shrubs, creepers and ground covers, in towns and cities have largely centred on their ornamental or aesthetic values. Although these values are important, vegetation contributes in many other ways to improving urban environment. As being the most effective and widely used for their great advantage, trees are generally of first concern to the urban designer. They can also be used in an architectural manner to create and define outdoor spaces. Trees provide shelter from solar radiation - which is the major concern here - wind, rain and noise, and they also help to combat air pollution. By filtering dust from the atmosphere and by producing oxygen, they improve the quality of the air in urban areas.

Principally looking to trees' role in climatic control in hot-dry countries, and in order that their values may be understood and detailed more clearly, it is necessary to discuss how the species could contribute to the improvement of the urban environment factors mentioned above.

### 2.2.1 Air temperature improvement:

Trees transpire large amounts of water which cool the air and raise its relative humidity by absorbing solar radiation; although their psychological effect is perhaps more important than the reduction in temperature. This process is much more important during summer time when cool air is more needed.

Moreover, the heat emitted and reflected from buildings and streets could be removed above urban spaces by trees, and at night the tree canopies will trap heat radiating from paved surfaces. One could conclude that the especially beneficial effect of trees is their thermal performance.

### 2.2.2 Shade Providing:

Trees have also an important role in protection by providing a generous shade according to the seasons when it is needed or not. This trait makes deciduous trees especially valuable and co-operates elastically with human needs, since one aim of solar control is not to interfer with the winter sunshine; because they provide coolness and shady conditions in summer and yet allow the winter sun to pass through.

For shading use, evergreen trees have not to be neglected as the shade they cast is generally thick and continuous in all seasons; also evergreen trees have some advantages in that they provide protection from rain and wind during the cold seasons.

To achieve any efficient shading for any particular urban space, which may present special characteristics such as orientation, size, form and use, trees have to be thoughtfully chosen, by considering their species - adaptable in the region - the character of the tree itself both in summer and winter, the canopy shape, form and its leaves density. The tree's general character should respond to the design purpose. In this respect, I have classified some existing example of design with trees, found in Algiers, Naples and Constantine, and their protection against some natural factors. These examples are discussed further.

2.2.3 Improvement of the air quality:

The climate and atmosphere of large built-up areas of my case studies, with dust, air pollution and high temperature, are generally considered unhealthy for people to live in. The influence of trees in towns in ameliorating these artificial conditions, therefore, has far reaching implications in terms of comfort and health. The role of trees in pollution reduction is one of the most effective contributions that they can make in towns by intercepting several hundredweights of dust on its leaves and by bringing about a slight reduction in the concentration of gaseous pollutants (see Izard J.L. "Archi-Bio" 1979). They are able to reduce the concentration of carbon dioxide and thus to increase the amount of oxygen by photosynthesis and respiration processes.

Open spaces planted with trees, in addition to shrub and grass, increase the turbulence of the air, thus increasing the dispersal of dust and other pollutants which are also filtered and, to some extent, absorbed by foliage so that the air beneath trees' canopies contains less pollution than that found in urban spaces without tree planting. Raad. A., in his book "Green space and air pollution", 1965, said that "even a single row of trees, when planted on grass verges with an underlayer of shrubs, can reduce the level of atmospheric dust and particles significantly, and a reduction of dust concentration of at least 25% has been observed in tree lined streets".

The area over which the concentration of dust is reduced, depends on the height of the plantation, its canopy form and leaves texture. The dust fixed by leaves' surface and branches is passively removed away with leaves when they fall, and also washed off the trees during heavy rain.

2.2.4 Control of glare and reflection:

Trees can help to reduce glare and reflection by their absorptive and none-reflective surfaces depending on the height, density of foliage and location of tree species used. The planting of pedestrian areas, side-walks and places edges can be designed to prevent the unpleasant effect of glare and reflection on the comfort of pedestrians. For example, reflection from the glazing of buildings and shop-windows, from light coloured paving and cladding materials, from car parks or other reflective urban elements, especially during summer-time when sun rays are very bright, effective control can be achieved by a judicious planting of trees between the source of direct or reflected light and the observer.

2.2.5 Ventilation Control:

The presence of trees, shrubs and grass, within an urban area, affects air flow to cool by passing through and over vegetation, and which can be accelerated or directed to streets and other public spaces.

In hot regions, during summer, cool breeze is the most important variable for human thermal comfort because the air movement increases convective heat loss which is an advantage in those climatic regions, such as Constantine which suffers, during summer, from the warm southern wind coming from the Sahara.

## 2.3 Water

The proximity of bodies of water can moderate extreme temperature variations, land of the lee-side of water will be warmer in winter and cooler in summer. Humidity may also be affected, depending on the general temperature pattern of the area. The larger the body of water, the greater its impact on the microclimate.

In summer, during the daytime, the earth heats up considerably, in comparison with the water, the hot air rises and cool air must flow in to replace it. The shores of lakes and seas, as a result, benefit from a daytime breeze, blowing from water to the land, which has a cooling effect. At night, the air overland cools faster than that over water, and the process is reversed with the breeze blowing from the land to the water. Experiments done on a clear winter-night have shown that temperature gradually decreases as one moves away from a lake shore.

In hot-dry climate, water evaporating into the air can substantially reduce the air temperature. The evaporation rate and therefore the cooling rate depends upon the area of the water, the wind velocity, the relative humidity of the air, and the water temperature. Of these, the designer has the most control over the area of water and its location relative to the urban spaces tobe cooled. In addition to increasing the surface area of the pound, the effective area can be increased by sprays in pools or on other surfaces.

The cooling effects can be localised in some urban spaces such as streets and enclosed places, mainly used by pedestrians, to trap the cool air or, at least, to humidify the dry-air flowing through those urban spaces. Such an idea is the same concept as the fountain (waterbody) used in the Arab courtyard house, but of bigger scale, as it is for an urban and public purpose. Although the idea of a big public fountain within a "piazza" surrounded say by five storey-high buildings does not work ideally as in house court, but at least it provides a cool oasis within the urban tissue and by refreshing the air moving to other parts of the town. The idea gives better results if applied in towns with dense layout, such as the Arab traditional cities. A description of their typical layout is given in the following chapter.

FIGURE 2.I Direction of breezes between water and land seashore and lake side location.
a. From water to land ; b. From land to water.

## 2.4 The Ground Surface

The solar radiation which reaches the earth, raises the temperature of the ground. The amount of this radiation depends on latitude, the season, the time of the day, the nature of the terrain and its declivity. During the day-time the highest temperature is always found at the boundary between the ground and the air (Greiger R., "The climate near the ground", 1965). The temperature, in other words, increases considerably as one approaches the ground. At night, as a result of the heat loss by evaporation and the effective outgoing radiation, the reverse is true and the temperature decreases as one approaches the ground. A peculiarity of microclimate, therefore, is that the closer one approaches the ground the more extreme it becomes.

However, the natural cover of a terrain tends to moderate extreme temperatures and stabilise conditions, especially when covered with vegetation. As we have seen, cities and man-made surfaces elevate temperature and reduce humidity. To place paved surfaces within cities, in hot climate zones, can have most unpleasant results on people's comfort, because the paved surfaces - mainly the surfaces covered with dark granite rock (as is the case of Naples) - store up a great amount of heat and remain hot longer than unpaved or grass surfaces. Not only do these paved areas add appreciable heat to the air layer near their surface, but they also radiate and reflect large amounts of heat into the buildings around.

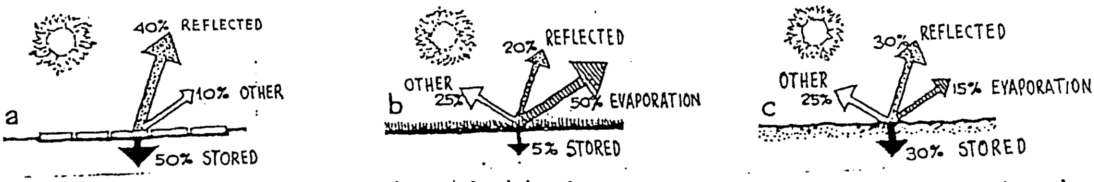


FIGURE 2.2 Absorption of heat by different surface materials: a.Paving ,b.Grass ,c.Bare ground. (After Konya A.1980.)

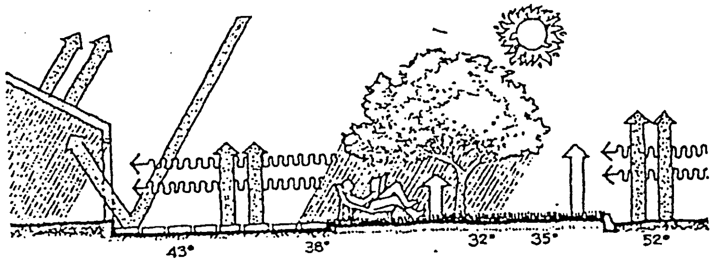


FIGURE2-3:Temperature aggravated by surrounding surfaces; temperatures shown here where recorded in hot-dry contry, the air temperature was 42°C. (After Konya A. 1980.)

## 2.5 The Wind Effect

Wind is another important factor which may cause local variations and which the designer must consider by looking to its characteristics such as direction, speed, frequency and kind over a whole year. Because wind affects ventilation, can be used for cooling, can cause driving rain, can carry dust and can require structures to be strengthened, the designer has to determine the direction, speed and predictable daily and seasonal shifts of prevailing wind and so to utilise them. For instance, in hot climate regions where ventilation has particular importance as a remedy against high temperatures and humidifiers, town layouts on the North African shore of the Mediterranean sea show some particular street arrangements which bring the coolness of the sea breezes into the heart of the city.

Physical features such as buildings, trees, walls....etc. which may influence wind movement, must be taken into account. There is a difference between the shelter offered by windbreaks composed of plants and that offered by solid screens or buildings, as the extent of shelter depends not only on height but also on the degree of permeability. Plant materials, which permit certain amount of air to pass through, cause less turbulence than solid screens and, as a result, are better shelter.

Air movements are affected by street width, buildings length, height and roof pitch, and in so doing have a distinct impact on the surrounding microclimate. (See: Olgay V. 1967, Brown, G.Z. 1985 and Konya, A. 1980). The same is true for groups of buildings and great care should be taken within their layout to minimise any channeling effects which can double the original velocity and causes turbulences. Some of these adverse conditions can be avoided by adequate street width and building design. Occasionally street orientation can mitigate difficulties, especially where specific wind directions and speeds can be expected to create adverse conditions. There is some evidence (Ariel M.Z. and Kliuchnikova L.A., 1960) that uniform building height and uniform distances between buildings create the least flow disturbances.

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# CHAPTER 3

# SOLAR RADIATION AND THE URBAN SPACES

## D. SOLAR RADIATION AND THE URBAN SPACES

The most important single factor governing climate in hot regions is solar radiation; this natural factor which occurs in the so-called short wavelengths, is the source of almost all the earth's energy and is, as a result, the dominating influence on all climatic phenomena (Landsberg H.E. 1981; and Konya A, 1980).

Controlling solar radiation on the urban spaces, and thus its impact on the comfort of people using those spaces, is best reduced by adequate shading. However, need for shading depends on the orientation of the urban space in relation to the sun movement during summer. For this reason, the two principles of orientation and shading, reciprocally affecting each other, will be separately discussed in this section.

### 1. ORIENTATION

In hot climate regions, protection from solar radiation is particularly important during times of excessive heat. Optimum orientation to reduce radiation to a minimum in the overheated period would be ideal but difficult to achieve.

To plan any site, the position of the sun, in a given locality, must be known for all hours of the day at the two main periods. This can be determined by calculations or by using models experiments on "Heliodon", but when it is attempted to combine these with the complex requirements of a city such as transport nets, wind shelter,etc. one soon sees that the optimum cannot be achieved by orientation alone. A number of recent works relating to solar have been preoccupied only by how to achieve better orientation for a single house and thus creating comfortable conditions within it by using charts and mathematical equations which could never be applied for a group of buildings, for instance, or an urban sector with its internal and external spaces. Therefore, I think that most of time an optimum orientation could not be solved, whatever the theory of approach, if physical elements (devices) are not used and correctly manipulated, for the indoor and outdoor spaces, to reduce orientation difficulties.

## 2. SHADING

### 2.1 The use of shading in hot countries

One of the objectives of ancient settlements and towns in hot areas of the world was to protect inhabitants from the excess of solar radiation generating heat and illuminance. When one looks at recent developments, even the great new cities of Chandigarh and Brazilia, there is little or no control of the urban spaces, whereas in some traditional Arab cities, for example, different design processes are produced, such as covered markets, arcaded streets, covered passages, pergolas....etc., have been used to control sun radiation. In fact, shaded spaces offer more than simple protection against the sun; they provide a needed vocabulary of semi-enclosure whose lines of demarcation change according to the sun's position and are totally suppressed at night. These subtle changes enrich the city's temporal dimension and therefore the life of its inhabitants. Furthermore, protection is afforded to the walls and ground of the city, in such a way that interior and exterior temperatures were nearly equalised wherever sophisticated methods of shade control were applied as for example, in the ancient districts of the cities of Fez (Morroco) and Tunis (Tunisia). The fact has often been cited (See: "Present et avenir des Medina", fascicule de recherches No. 10-11; Tours 1982), in connection with the monolithic architecture and urban structure of the Mediterranean region, the effect of the sun at its zenith is to erase all shadows thereby negating life and with it the city as a whole.

Apart from its secondary role in defining urban space and its psychological effect on human behaviour or comfort, shade may take on a religious connotation as in the case of shade generated by a sacred tree or even political significance such as when a parasol is carried above the head of Ethiopia. It may also indicate a protective or defensive function or even symbolise privacy.

## 2.2 Shading and design process

The impact of solar radiation on urban public spaces, in hot climates, must be reduced not only by orientation and effective design of the urban fabric, but also and probably mainly by adequate shading devices. These devices will be examined in detail in the last section. It must be said here that where possible these techniques should help the other factor causing discomfort, such as wind, rain, glare, dust,...etc. Despite the shading process being successful, the same process could create problems during the cold period when the sun rays are needed in terms of comfort balance. This conflict may be avoided through appropriate design processes, in particular if the shading devices are flexible such as deciduous trees, awning canvas....etc., which could allow some amount of sunshine during the cool period. From such a conflict, we deduce that an "optimum" control on solar radiation should be the target.

## 2.3 Shading effect on people comfort and behaviour

In hot areas of the world, people are used to spending a great deal of their time outdoors - this is very current life customs in most of the Mediterranean countries - especially during the warm and hot seasons, when breezes and shading is preferably found out of the dwelling (exception for the courtyard house).

It is probable that this Mediterranean habit is simultaneously influenced by the need for contact with sunshine and the protection from it, whatever the season. This is very noticeable when considering some of the old cities in Italy, southern France, Algeria....etc. and their urban conception which consists of closely grouped buildings to give some shade to each other and provide shady narrow streets and small spaces between them. To achieve better shading for the outdoor spaces, the tendency in those cities is to make use of arcades, colonades, "sabate", corbelled facades and small enclosed places; even larger urban open spaces are enclosed, inward looking and shaded for most of the day.

After examining the urban features of those cities, we may deduce that one of the causes of such space organisation is to protect the public domains as well as the private ones against excessive solar radiation. This protection is mainly achieved by building mean and little other additional shading devices such as trees. We will examine later the reasons for this.

From my own experience with summer heat and radiation, I find it true that areas under shade, cast by trees or other devices are instinctively the first place for pedestrians to protect themselves in, even if the air temperature is intolerable. The reason for such an attitude is because of the discomfort of glare; maybe that is why a hat or sunglasses are useful during the overheated period.

## 2.4 Glare and daylight

To continue this section on shading, I would like to mention the glare impact on urban spaces and thus its effect on people's comfort. In hot countries glare arises mainly through strong sunlight being reflected from the surface of the ground and light coloured building facades. This reflection to which eyes are too sensible, causes discomfort especially at the street level where radiation and reflection are important.

Traditionally the way of overcoming this problem in outdoor spaces, in some Mediterranean countries, is the use of shade and the avoidance of bright paint or material colours. But reducing glare by use of dark coloured facades is not a solution, because the use of dark colours absorbs a great amount of solar radiation and reradiates the stored heat to the indoor and outdoor spaces, and thus causes discomfort in both spaces.

## 3. THE COURTYARD PRINCIPLE AND THE CLIMATIC CONTROL

Perhaps the most fundamental town design and house feature in the Middle-East and North Africa is the courtyard. It has far reaching cultural and environmental implications.

The courtyard space is enclosed and protected by other internal spaces, such as room, corridors,....etc., and is considered as a positive focus of attention and activity. The long-standing advantage of compactness of the Arab city layout stems from the courtyard principle which provides internal privacy for the individual household and a filter to urban dust and noise, because houses are oriented inwards onto this central court, forming a garden with a fountain or pool of water. This allows denser planning of neighbourhoods, which itself provides added protection against the harsh environment in which this building pattern evolved.

One of the many justifications for retaining the courtyard principle, is its considerable role in the control of climate in hot areas, as the courtyard itself is a shaded open space (depending on its size) which aids cooling especially when shrubs and trees are planted in it, their foliage creates a miniature oasis in the heart of the house or urban complex. Moreover, the presence of water - fountain or pool - within the courtyard, has its advantageous effect on air cooling by rising its relative humidity. This cool air accumulates in the courtyard in laminar layers and seeps into the surrounding rooms to cool them. "Fathy H., 1986, states that in the morning the air of the courtyard which is shaded by its four walls and the surrounding rooms, remains cool until the sun shines directly into the courtyard.

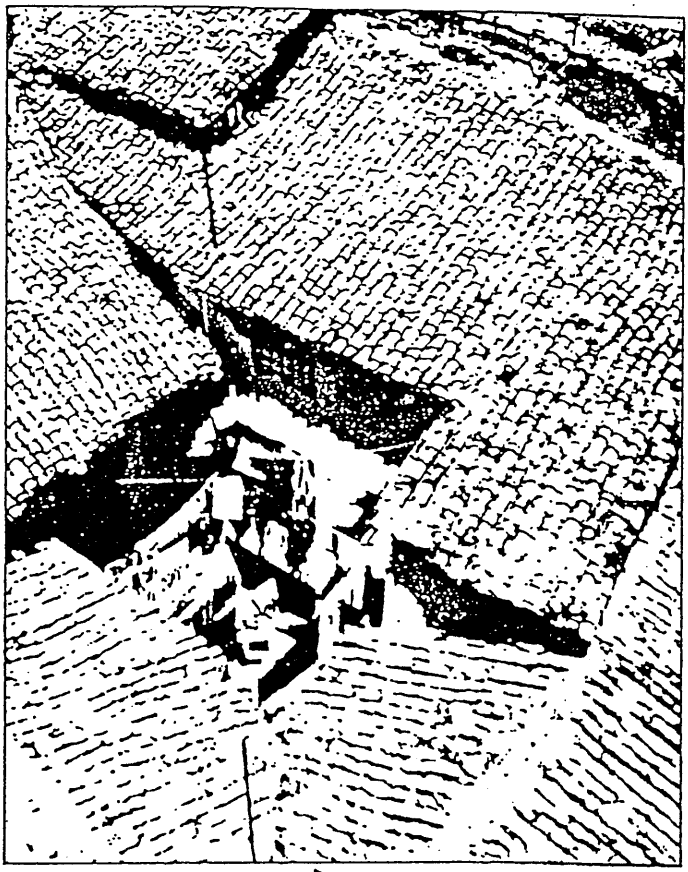
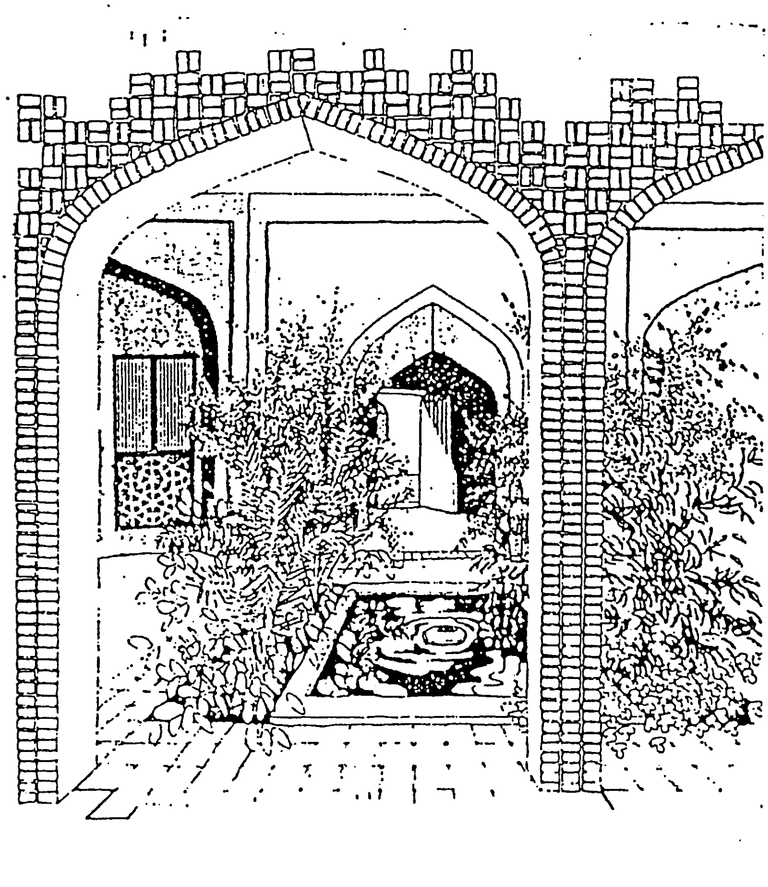


FIGURE 3.I (left) Aerial view showing a courtyard (house) in Constantine Traditional Town.

FIGURE 3.2 (below) View inside a courtyard; villa in the Middle East.



He said also that the warm wind passing above the house during the day does not enter the courtyard but merely creates eddies inside, unless baffles have been installed to deflect the air flow". In this way the courtyard serves as a reservoir of coolness.

While being the main area around which the Arab house is organised in its need for intimacy and privacy, the courtyard has far greater utility acting as adequate passive system for climate control in hot-dry countries, especially during the overheated period when the courtyard is the main source of coolness.

This concept can be extended to the urban spaces within a town where it could similarly control solar radiation. The idea of the courtyard system can be applied on a bigger scale to the urban fabric. For example, small open spaces, squares or places could adopt the courtyard principle, this is easier when the city layout is dense in character. Moreover, the closeness of the square or place, e.g. "Piazza d'El Erbe" (Verona; Italy) could serve as a reservoir of coolness, during summer, especially when adequate planting of trees and a fountain or pool of water are used within the square.

In addition, the courtyard idea could add an impressive character to the city layout which would be mainly composed of small and big courtyards interconnected by a range of streets and cul-de-sacs.

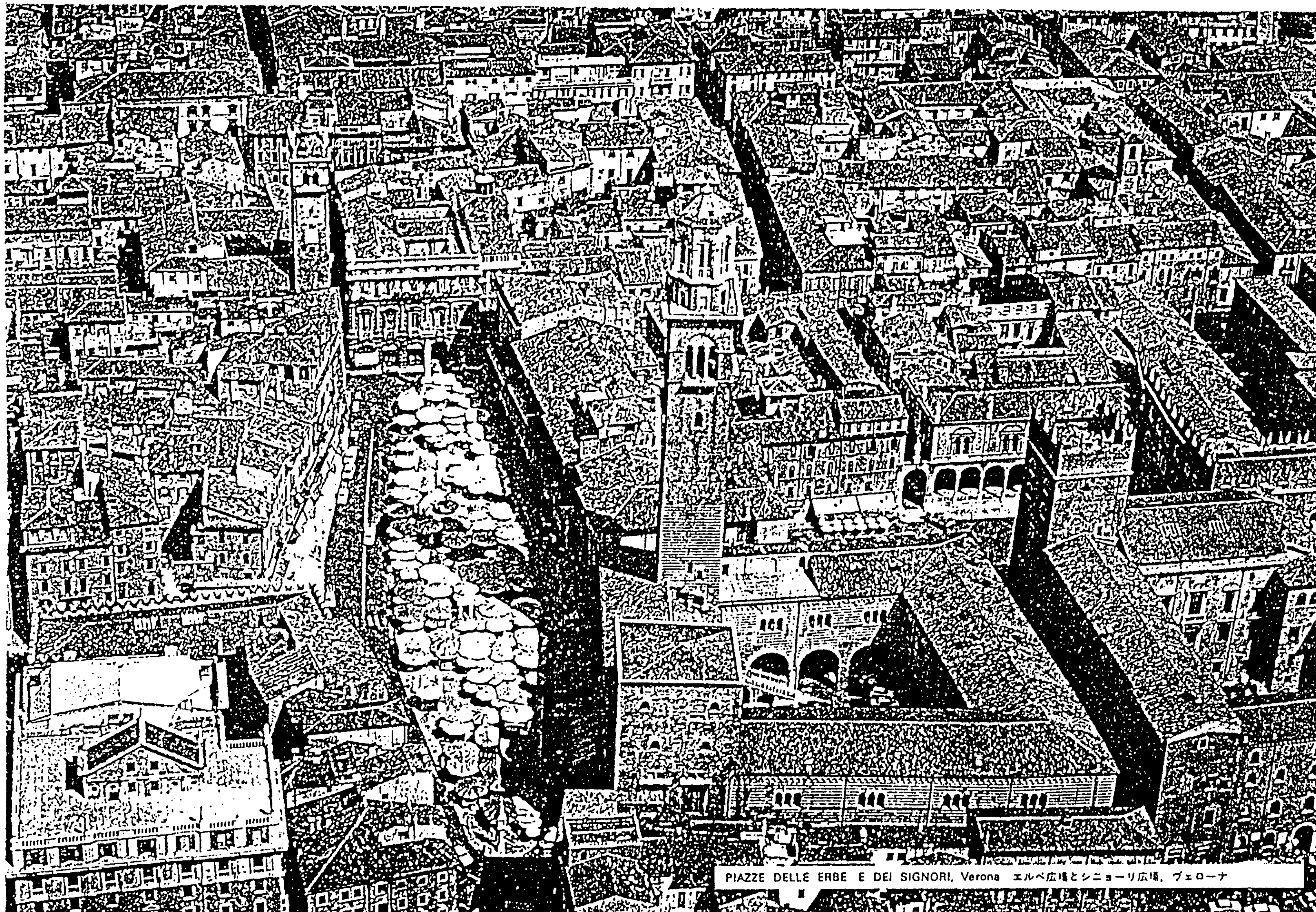



FIGURE 3.3 View over the PIAZZE DELLE ERBE E DEI SIGNORI, Verona (Italy).
Such an urban space could climatically act as a courtyard in traditional Arab town

## 4. THE TRADITIONAL CITY LAYOUT AND CLIMATE

As discussed previously, the radiation and heat of the sun are the dominant factors affecting the traditional town planning in most Arab and Islamic countries where the climatic conditions are too hard especially during the hot period of the year. Even a marked uniformity in urbanisation is found in all hot-dry zones. The layouts of almost all traditional cities in that zone are characterised by two features: narrow winding streets and open courtyards with internal gardens. Surrounding gardens are nonexistant. From these particular features appear a typically dense layout formed by compact buildings which cast shade over external spaces and protect themselves from extremes of climate. Wind and dust are reduced by the varying widths of streets and impasses, by their orientation and frequent change of direction. This informality creates small squares ( I called them urban courtyards) and corners which provide the essential communal space for the neighbourhood.

The public domain of most traditional Arab cities was nevertheless based on a well-organised system of access that was geared to access needs on a very local level - pedestrians and small vehicles use. As such the tight public spaces, defined by highly homogeneous building forms, provided an urban context that was both expressive and supportive of a very intense public life.

Apart from its important passive climatic control, the traditional design process of the Arab city layout presents functional difficulties to the people's needs in modern

FIGURE 3.4 Constantine traditional city layout, showing street pattern and cour yards, cut by wide linear streets (Haussman's operation).

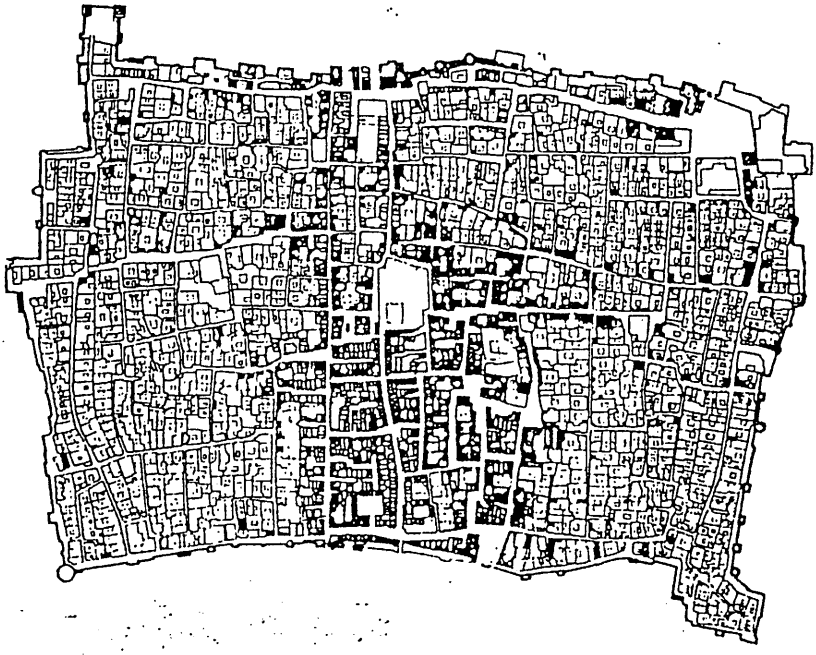


FIGURE 3.5 A detailed plan of the centre of SFAX ,Tunisia: SHOWING the comlex network of streets and alleys.

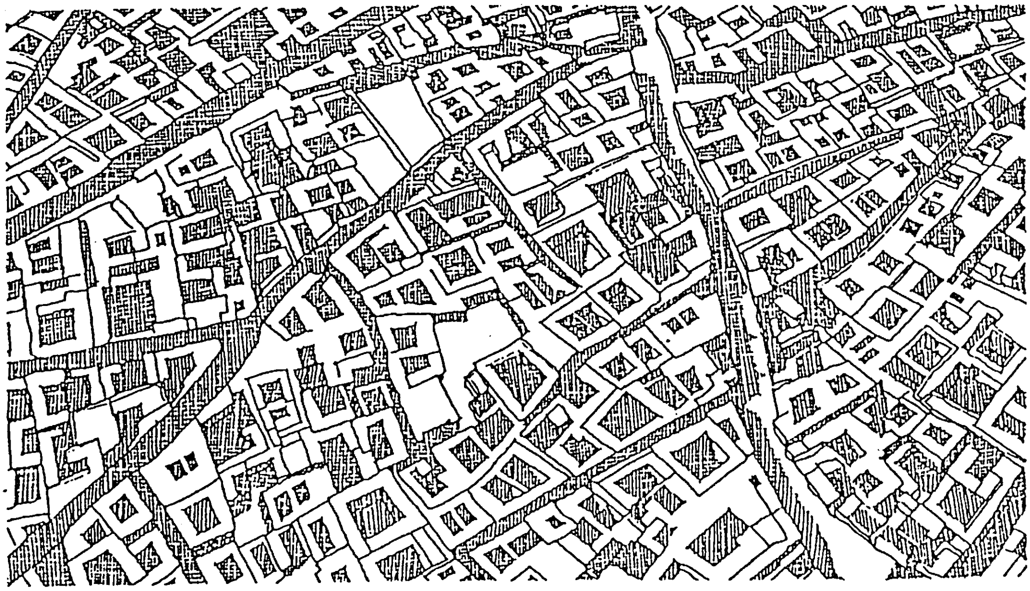


FIGURE 3.6 Schematic layout of Marrakech(Morroco), showing courtyards and the streets network.

times, such as the introduction of the motorcar and the development of servicing. Moreover, these traditional layouts show some unsolubrious conditions within public spaces during the cold season, because of the exaggerated narrowness of some streets' space which does not allow enough sunshine, needed in this period, to reestablish comfort conditions.

While traditional layouts may not be designed to accommodate the motor traffic, solutions to this problem were proposed. In this matter, Fathy H., 1986, gave the alternative to encircle the residential quarter with a ring-road for cars, with cul-de-sac streets branching off into the interior as suggested by the "Radburn Plan" (see: Clarence S., 1957). Another alternative is the "Dynopolis" concept launched by Doxiadis (See: Doxiadis C.A., Ekistic 1968), which assumes that the characteristic traditional layout can be preserved within the quarter. Although those alternatives, the need for practical servicing, within the traditional layout, could not be achieved sufficiently if the quarter itself is not crossed by secondary streets, adapted to the motor-car, which gives rise to some form of tenements or microquarters with cul-de-sac branching off. However, in spite of these tenements, the traditional layout compactness could be saved, for its climatic control, by the strict consideration of the street widths to the building heights. In this respect almost similar cases are found in Constantine , Sfax (Tunisia) and Marrakech (Morroco).

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# CHAPTER 4

## CASE STUDY ON TWO CITIES:
## CONSTANTINE AND NAPLES

## E. CASE STUDY ON TWO CITIES: CONSTANTINE AND NAPLES

Before looking to the site, the urban character and the climate control of each city, it is necessary to give some information concerning the climates of these Mediterranean cities where this study was made.

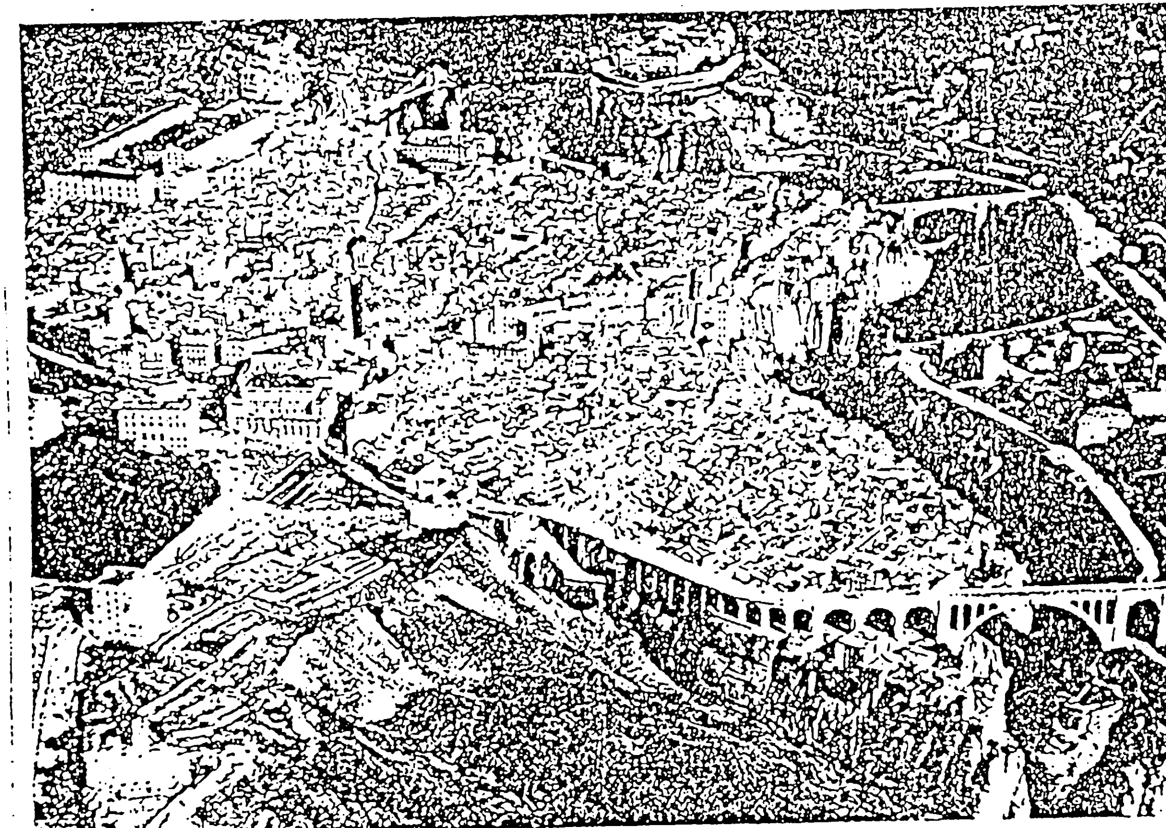
### 1. THE CLIMATE OF CONSTANTINE AND NAPLES

#### 1.1 Constantine

Positioned at 36°.13' north latitude and longitude 7°.35' east, Constantine is situated on the high Algerian plateaux which is between the Mediterranean Sea to the north and the Sahara to the south. This situation gives Constantine a climate of particular character; cold in winter and hot-dry during summer.

If we consider the hourly temperatures of a whole year (Fig. 4.2. ), it appears that the coldest month of the year is January with an average of 7° centigrade, then this average rises slightly from month to month until it reaches 25.35 centigrade in July and 25.45 centigrade in August. From the CHART (Fig. 4.3. ), we notice that there is a quick rise in temperature from winter to summer, then a decrease with the same pace from summer to winter.

From the table it is also noticeable that the hottest period of the year is found between the last week of July and the beginning of August. The most important kinds of wind blowing over the city, according to their percentages and effects on the urban fabric, are classified as follows:



<u>FIGURE 4.I.</u> Constantine old core,view from the south.

| Hours / Months | 0h. | 1h | 2h | 3h | 4h | 5h | 6h | 7h | 8h | 9h | 10h | 11h | 12h | 13h | 14h | 15h | 16h | 17h | 18h | 19h | 20h | 21h | 22h | 23h |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| January | 4.6 | 4.05 | 3.6 | 3.25 | 2.85 | 2.6 | 2.34 | 3.2 | 4.1 | 5.25 | 6.4 | 8.0 | 10 | 10.5 | 11.1. | 11.47 | 10.6 | 9.4 | 8.40 | 7.35 | 6.15 | 5.20 | 5 | 4.7 |
| February | 6.4 | 5.7 | 5 | 4.4 | 4 | 3.7 | 3.5 | 4.4 | 6 | 7.1 | 8.6 | 10.2 | 11.4 | 12.2 | 13 | 13.87 | 12.8 | 11.9 | 11 | 9.8 | 8.55 | 7.2 | 7 | 6.75 |
| March | 7.9 | 6.8 | 6.15 | 5.65 | 5.15 | 4.75 | 4.3 | 5.9 | 7.5 | 9 | 10.4 | 12.1 | 13.3 | 14.4 | 15 | 15.7 | 15.5 | 14.4 | 13.8 | 12.6 | 11.3 | 10 | 9.2 | 8.2 |
| April | 9.9 | 9.25 | 8.6 | 7.9 | 7.6 | 7.20 | 6.85 | 8.9 | 11.2 | 13.1 | 14.6 | 16 | 17.3 | 17.9 | 18.5 | 19.05 | 17.4 | 15.8 | 14.3 | 13.9 | 13.5 | 13 | 12 | 11 |
| May | 13.65 | 12.8 | 12.1 | 11.4 | 11.2 | 11 | 10.29 | 12.6 | 14.8 | 16.8 | 18.8 | 20.6 | 21.9 | 22.8 | 23.8 | 24.3 | 24 | 23.4 | 23 | 21.6 | 20 | 18.45 | 16.75 | 15.3 |
| June | 17.6 | 16.85 | 16.1 | 15.4 | 15.3 | 15.15 | 15 | 17.8 | 22.2 | 24 | 25.6 | 27.4 | 28.8 | 29.4 | 30.4 | 30.87 | 30.4 | 30 | 29.8 | 28.15 | 26.4 | 24.85 | 22.4 | 21.85 |
| July | 22.4 | 21.9 | 20.5 | 19.9 | 19.2 | 19 | 18.76 | 20.7 | 23.3 | 25.9 | 27.95 | 29.5 | 31.1 | 32.6 | 34.2 | 35.3 | 35 | 34.4 | 33.4 | 30.8 | 29.1 | 27.6 | 25.95 | 24.1 |
| August | 22.4 | 21.8 | 20.8 | 20 | 19.65 | 19.1 | 18.45 | 21 | 24.1 | 26.6 | 28.5 | 30.6 | 32.1 | 33 | 34.15 | 34.9 | 34.4 | 33.9 | 33.2 | 31.75 | 29.8 | 28 | 26.1 | 24.2 |
| Septem. | 18.65 | 18.1 | 17.4 | 16.8 | 16.35 | 15.85 | 15.4 | 17.25 | 20.1 | 22.4 | 24.1 | 26.2 | 27.9 | 28.6 | 29.2 | 29.8 | 29 | 28.3 | 27.75 | 26.4 | 24.95 | 23.8 | 22.2 | 20.4 |
| October | 13.95 | 13.2 | 12.55 | 12 | 11.6 | 11.05 | 10.73 | 13 | 13.4 | 17.2 | 18.5 | 20.4 | 21.8 | 22.3 | 22.8 | 23.13 | 22.4 | 21.3 | 20.3 | 19.2 | 18 | 16.85 | 15.9 | 14.9 |
| November | 8 | 7.55 | 7.05 | 6.7 | 6.4 | 6 | 5.83 | 8 | 10 | 11.2 | 13 | 14.2 | 16.2 | 16.3 | 17.1 | 17.29 | 16.3 | 15.2 | 14 | 13.6 | 13 | 12.5 | 11 | 9.3 |
| December | 5 | 4.75 | 4.4 | 4 | 3.8 | 3.55 | 3.27 | 4.6 | 6.2 | 7.9 | 9.5 | 10.3 | 11.8 | 12.2 | 12.6 | 12.87 | 11.9 | 10.3 | 9 | 8 | 6.95 | 6 | 5.4 | 5.2 |

FIGURE 4.2 HOURLY AIR TEMPERATURES IN CONSTANTINE.

Wind coming from the north-east with an average of 28.3% of blow-hours of the year. This wind generally cold and humid has affected the urban development of Constantine towards the south-west (Arrouk M.E., 1984).

Wind blowing from the south-east, of wet-cold character during the autumnal and hivernal seasons with an average of 14.3%.

Warm-dry wind blowing from the wouth-west (Sahara), mainly during the hot season, with an average of 13.3%.

The humidity in Constantine is generally acceptable, except during the hottest months, July and August, when it falls under 60% because of the warm-dry wind coming from the desert (Arrouk, M.E., 1984).

## 1.2 NAPLES

Naples lies near the south-western coast of the Italian peninsula on the Gulf of Naples which is situated at latitude 40°.50' north and longitude 14°.15' east. Its elevation is 9.90 metres (33 feet) above the sea level. The general characteristics of Naples climate are of true Mediterranean type with mild winters, hot prolonged summers with important draught in June and July, and a distinct winter maximum rainfall.

If we compare between the twelve mean monthly temperature in Naples (Fig. 4.5. ) it appears that the coldest month of the year is January with 8.9 centigrade, then the mean temperature rises sharply at the beginning of May until it reaches its maximum in July and August with 25.0 centigrade.

There is a hot-dry southerly wind blowing towards the city of Naples; on the advancing side of a depression this

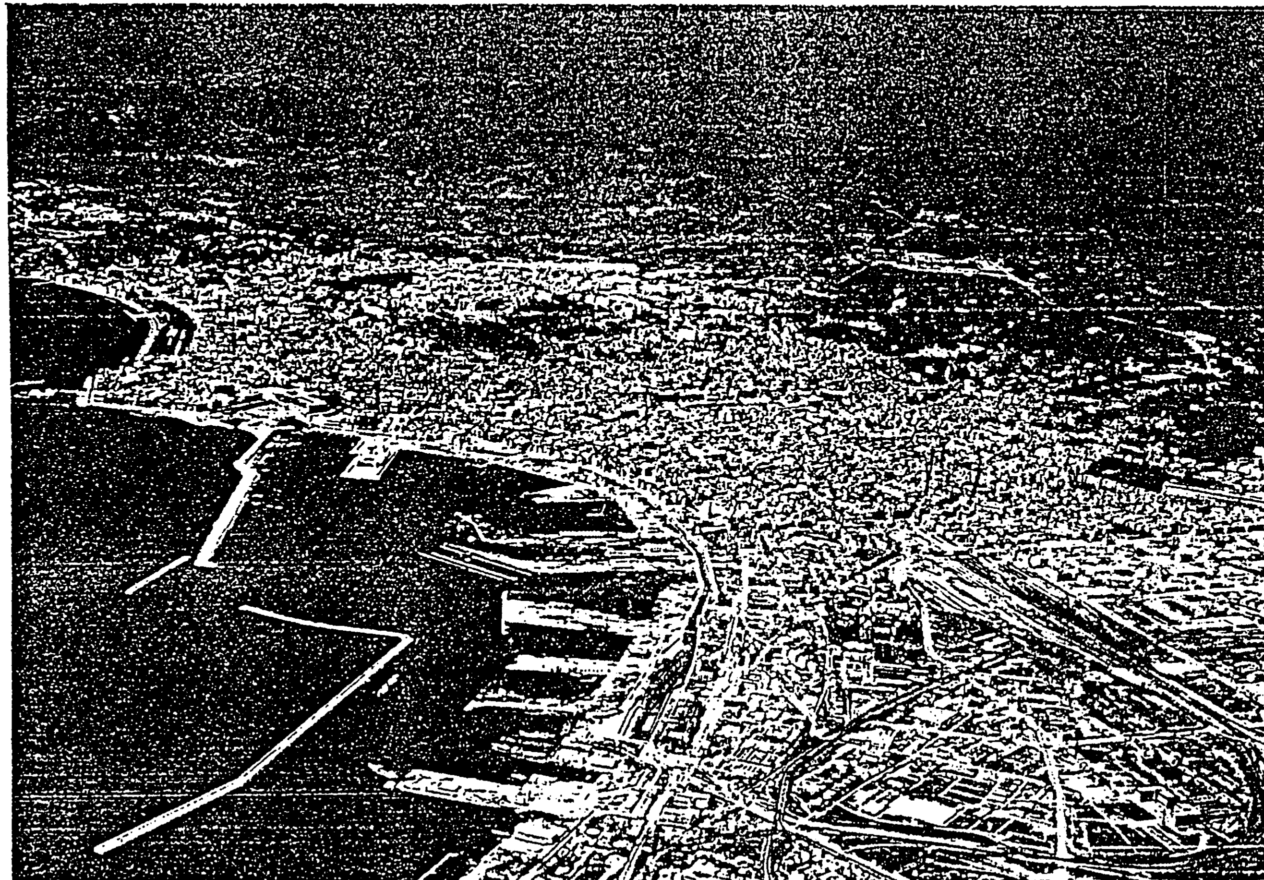


FIGURE 4.4. Naples,general view from the East.

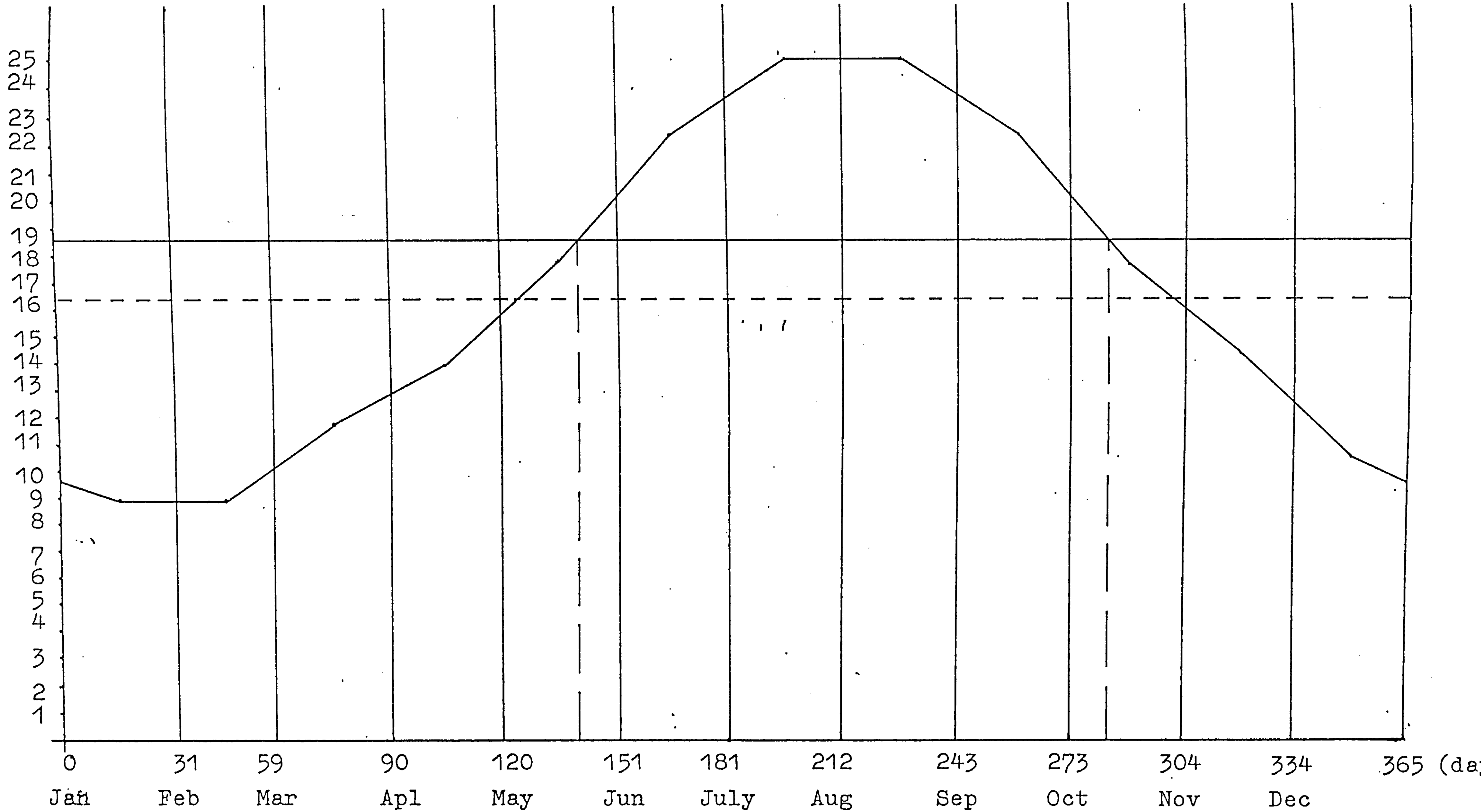



Fig. 4.5. Mean daily air temperatures - Naples (Source: M and R Beckinsale, "Southern Europe" 1975)

wind is called Sirocco but after a long sea traverse, it may reach Naples moist and muggy, and is known as the Siroccosa.

The summer day-time heat in the city is often tempered by the sea breezes. For the same reason and because of the warmth of the Mediterranean sea, winter in Naples and around it, is one of the mildest in Europe. (Bekinsale R. 1975).

## 1.3 COMPARISON OF THE TWO CITY CLIMATES

Comparing Naples to Constantine, we may deduce that their maximum summer temperatures are very similar, but that Naples will commonly be not so dry as Constantine. The winter climates differ but as this study is primarily concerned with the problems of overheating, this difference is not important.

From the above you can see why Naples was chosen as the European example to put alongside Constantine.

# 2. THE CITY OF CONSTANTINE

## 2.1 THE SITE

Constantine site is unique in its character and the most determinant to the city. Constantine is built on a stony plateau bounded by steep walls of rock. It is in the shape of trapezium, with its angles facing north, south and west, and which shows marked declivity from the north to the south. The altitude of the "Casba quarter" in the north, being 664 meters while that of "Sidi Rached", in the south is only 580 meters; the distance between the two points is barely exceeding one kilometer.

The River "Rhummel" hemmed in between the precipitous

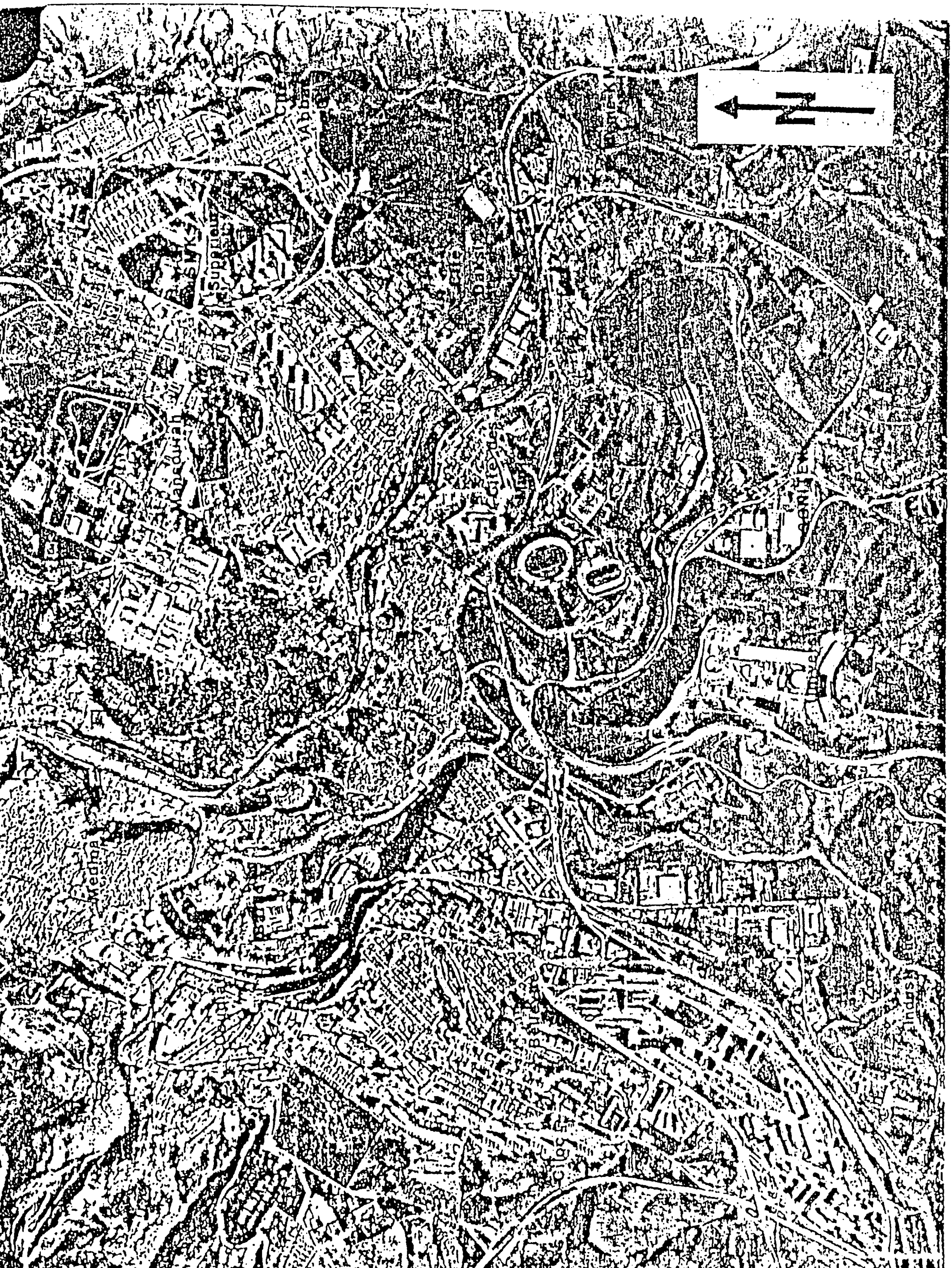
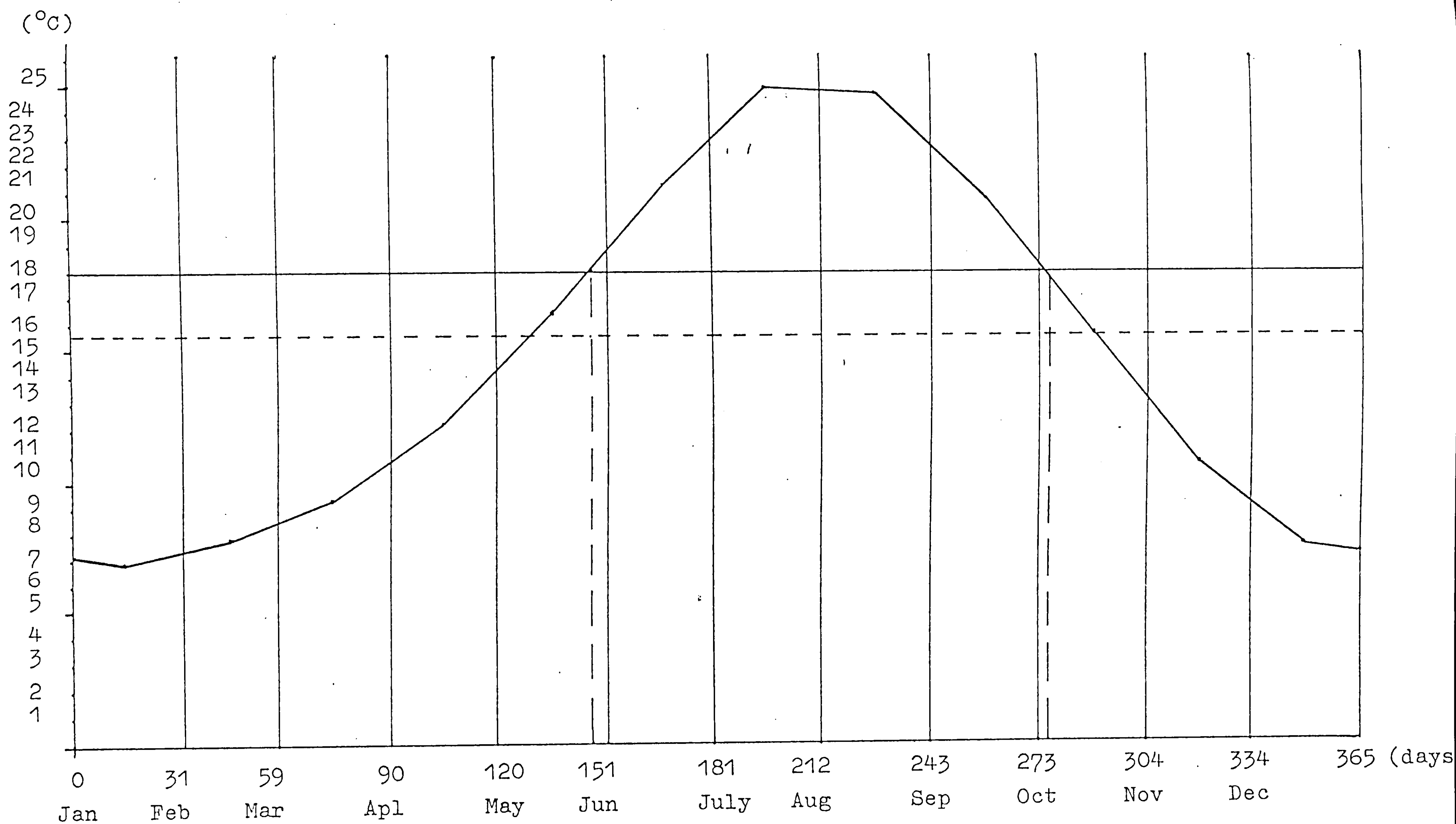


FIGURE 4.6 General view of Constantine's nucleus, 1973.




<u>Fig. 4.3</u> . Mean Daily Air Temperatures - Constantine. (Source: Bureau Meteorol. Ain-El-Bey, 1985)

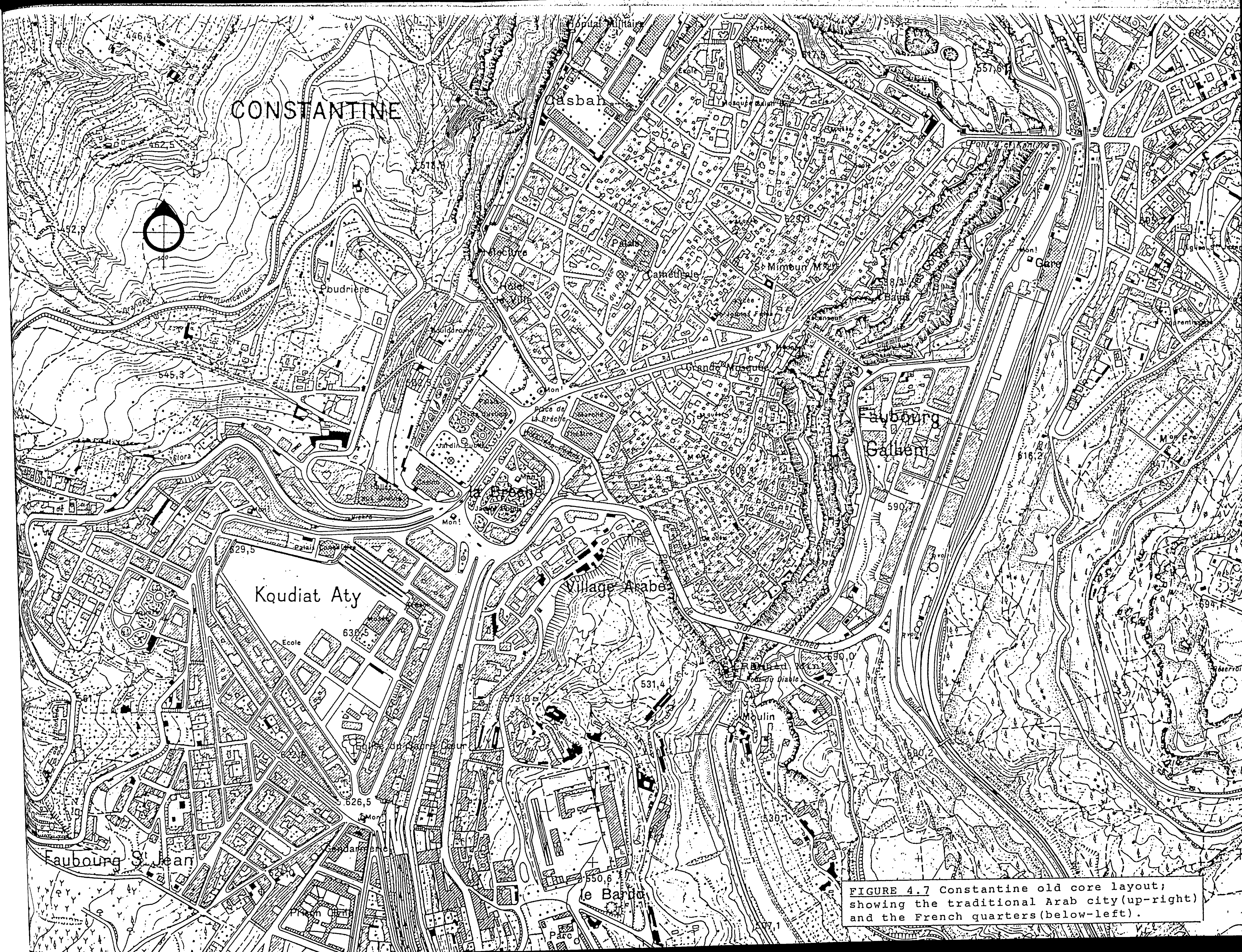


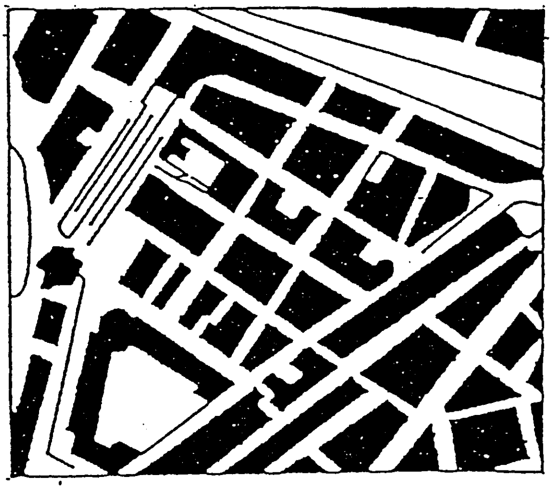

FIGURE 4.7 Constantine old core layout; showing the traditional Arab city(up-right) and the French quarters(below-left).

sides of a ravine, at an average depth of 100 meters, flows along the south-east and north-east side of the trapezium, while the north-west side is rendered impregnable by another revaine, likewise very abrupt. On the south-west side only, the plateau can be reached by a narrow isthmus edged in on either side by steep slopes. Besides this natural approach bridges were built over the gorge of the "Rhummel" connecting the north and east sides of the stony trapezium to their immediate surroundings.

## 2.2 THE URBAN CHARACTER

This site on which Constantine was built is the major element affecting its layout development and character. Seen from above, the city shows a hybrid appearance, part Oriental and part European. In the south and east part of the rock (trapezium) stand the Arabo-Turkish quarters with an irregular pattern characteristics of the Arabo-Islamic cities (see passage on the Islamic traditional city layout on page 50 ). Houses are built in a compact manner, with two to three storey-high and mostly covered with tile-roofs which leave an internal open space: the courtyard (see passage on page 46 ). Attached side to side, houses and social equipment - mosques, schools, public baths... etc. - shape narrow winding streets, cul-de-sac and small market places. In many parts, those streets are totally covered by the projecting construction (rooms) above, leading from one facade to the other on the opposite side of the street. These covered spaces, as tunnels in appearance, are locally called "Sabate". They generally contain shops and workshops on both sides. Moreover, corbelled facades

A. Traditional.



B. Colonial.

C. After-independence.

FIGURE 4.8 The main different urban textures found in the city of Constantine.

are one of the dominant features in the traditional town; they act as elements of densification within the city layout. The streets floors ,mainly pedestrians and without side-walk, are all covered with smooth granite stones of different sizes and colours. Seen from afar, the "Medina" looks like a cream-coloured mass where vegetation is lacking.

During the French occupation, the "Medina" has been crossed by a wide street - operation resulting from "Haussman" idea - accommodating motor traffic and pedestrians, and limitated alongside by French Renaissance style buildings which have five to six storeys high, with shops at the ground level. The facades character consists of large openings with awning balconies on each floor level.

The European quarter occupies the high part of the site, in the north-west, and its character is startlingly conflicting with the Arab city. Here streets are more or less rectilinear and mainly run from north to south connected by other streets and passages (cul-de-sac) of secondary importance. Within this street pattern appears the typical French "ilots and small enclosed places. Nevertheless, the main streets converging towards the central core - La Brêche - of the city are not wide enough for pedestrians and car traffic.

Beyond the stony plateau, many and many quarters of different design conceptions have been erected through different periods of time, surrounding the old part of the city in a continuous manner, but contrasting patterns. (For detailed descriptions on the urban development of Constantine see references at the end of this chapter).

## 2.3 CLIMATIC CONTROL AND URBAN SPACES IN CONSTANTINE

Observing the whole city, with its ancient and recent urban development, or walking through its different parts, a multitude of designs will be found out. The more interesting thing is the range of thermal sensations felt when moving from one particular quarter to another, during one summer day for example. Obviously, those different sensations of comfort or not are mostly affected by the urban design and the way it interacts with the climate. One could generally say that the city has good climatic control in some areas, or particularly over some urban spaces, and none in others.

Considering the traditional area, most of its streets and small market places offer good protection against summer heat, while allowing cool breezes in the afternoon, and it seems that the "Medina" has better control of its micro-climate if compared to the remaining areas, except for some cases where its urban spaces show unfortunately bad conditions during the cold period because their exaggerated shading keeps all sunlight out.

The French quarters have generally an optimum control on sun heat and radiation during the two main periods of the year because of the range of shading devices used, depending on the space, its situation and orientation. For example, the introduction of trees - which are nonexistent in the traditional town - within the urban spaces have been of great advantage for the comfort of pedestrians. One good example I could mention here is "St. Jean" quarter where some of my observations and measures were made (see survey-table No. 3, page 87 ).

The other quarters and sectors, mainly built after independence, consist of pragmatic layout for housing and do not show any climatic control on their public urban spaces because of the unthinking design and the lack of vegetation.

Generally speaking, the city of Constantine has poor climate control, except for its historic core area where the climate control has been successful because of different use and processes.

Considering the use of trees and water which both have considerable advantages in improving the urban environment, the layout shows unequal distribution of the green areas throughout the city, and in this respect, the main city center, where some public gardens took place, seems to breath better than the other parts where vegetation is extremely lacking. For the use of water such as public fountains and pools, some big fountains were made but unfortunately not for the direct profit of pedestrians as those fountains are used as roundabout for motor traffic.

## 3. THE CITY OF NAPLES

### 3.1 THE SITE

The site of Naples is situated on the northern shore of the Gulf of Naples at the head of the bay of the same name. The Gulf which forms a deep embayment is unique on the west coast of Italy since it is well protected from the open sea. The shores of the Gulf are mostly backed by hills and mountains. A great part of Naples, however, is built on lowland in a gap between the volcanic and crater-pitted

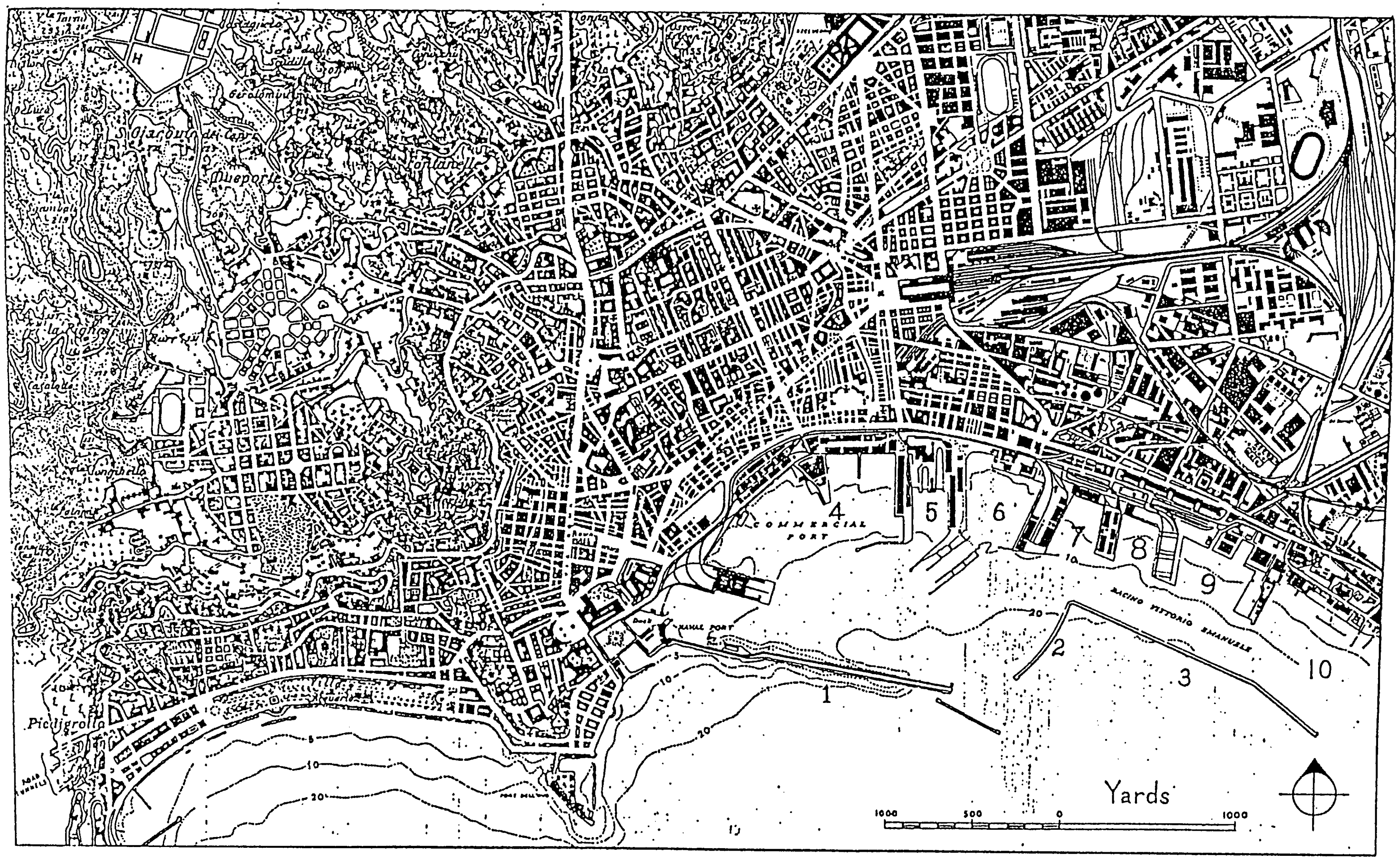



FIGURE 4.9 NAPLES , urban layout.

"Campi Flegrei" on the west and the volcanic cone of "Vesivius" on the east, though much of the western and north-western parts of the city have spread on to eastern spurs and foothills of the "Campi Flegrei". The great fertility of the surrounding country, the natural harbour, and the control of several important gaps across the "Apennines" have contributed greatly to the growth of Naples.

## 3.2 THE URBAN CHARACTER

An over-view of its general layout, the city of Naples presents a net-like street pattern composed of different texture pieces ranging from the Roman regular grid-iron to the labyrinthine one. Laid within a very dense street net-work, buildings seem to be squeezed by a multitude of narrow short streets which are mostly oriented south, to the direction of the sea shore. As with the case of Constantine - Haussman's idea - the streets' network in Naples is itself dominantly crossed by some long, wide and rectilinear streets which divide up the city to districts. Those main avenues such as Via Roma, Via Dumo, Corso Garibaldi, Corso Umberto 1, Via Foria....etc., run generally north to south and north-east to south-west, forming some piazzas into their inter-sections.

The whole built-up areas of the city seem to be pushed down the slope, close to the shore; that is, maybe, because of the land's steepness in the north and the north-west.

Besieged on the lower slopes of the hill and south-facing, the old town by the harbour is a dense maze of narrow paved streets and alleys with high dark buildings - five to seven storeys - built of stones and projecting a

FIGURE 4.Io.Urban scene in Naples Old Town.

great number of small fragmented balconies from their street facades. In this area, most of the buildings are four to five times high when compared to the street width. Some of these tiny alleys and streets, which do not possess any side-walks, have their floor built-in steps and thus being totally pedestrian. Overhead, in the streets, an extravagant number of wires and washing hangs, at each building level, cross the public space from one facade to the opposite one, and form a tree-like foliages, especially when washed clothes are laid on, covering the entire street space.

Beyond the old town, a number of quarters belonging to different epochs had been developed more or less on a set plan.

As the city had been subject to the World War II and earthquake damages, a great variety of urban spaces and building schemes are found within its areas; but in spite of that widely developed areas embracing the ancient core of Naples, the main characteristics of the whole urban tissue seem to be respected and inevitably applied in the many parts of the city. Maybe an exception could be made for the operation of those long straight avenues, cited before, which are lined on either side by rows of neo-classic style buildings built with shaped lime-stones and composed of five to six storeys, with long projecting balconies and luxurious shops at the street floor level. The avenues' floor generally consists of a double vehicular traffic way ( 7 meters each) and two side-walks (3meters each) on which single rows of leafy trees were planted. Behind the main arteries, the urban fabric becomes ordinary and shows a range of buildings contrasting mixed styles through which streets, alleys, market places and piazzas took place.

## 3.3 CLIMATIC CONTROL AND URBAN SPACES IN NAPLES

Unlike Constantine old town, the urban structure of Naples does not show any of those partly covered streets - traditionally called "Sabate" which means tunnel-like - long winding streets or corbelled building facades which all participate to the control of some climatic factors within the urban public spaces. Nevertheless, the city of Naples seems to use other design processes and techniques to protect its outdoor spaces against the summer solar radiation. The first profitable elements are its siting on the hill slopes looking south and its closeness to the sea shore which helps in lowering the air dryness within the urban fabric. Secondly, as most streets are south oriented and opened on the shore, this could help for better shading spaces and ease the sea breeze access to the city during the overheated period. Thirdly, when looking to the techniques used to control some climatic factors, we may say that the protection of different kinds of urban public domains is achieved by using building height as compared to the street width; the awnings, balconies and projecting slabs over side-walk spaces; the arcaded street-sides; and the sumptuously covered public space, originally called "Galleria". In addition to that, I would like to mention the Italian "Courtile", widely used in Naples, which is a sort of public courtyard within a building, and with direct open access from the street. This space is generally surrounded on its four sides by shops at the ground level with one or two staircases serving the five or six upper dwelling levels. As such, the "courtile" is an advantageous concept for controlling the solar radiation impact on the space itself.

Considering the vegetation use within the city, most of the streets in Naples are lacking trees, except for these broad avenues. Nevertheless, the amount of green areas is much more considerable in the northern part where new suburban residential areas have grown up. There are also some public gardens spreading here and there, around some important monuments in the city. Not surprisingly, Naples is a very dusty and noisy city, especially within the urban areas close to the harbour where trees are lacking.

Unlike Rome with its monumental public fountains erected everywhere and close to the pedestrians, Naples has very few. This may be because of its nearness to the sea which could cool the city air better than fountains.

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- PART TWO-

## CHAPTER 5

# DESIGN PROCESSES AND TECHNIQUES FOR SOLAR RADIATION CONTROL

# F. DESIGN PROCESSES AND TECHNIQUES FOR CLIMATE CONTROL

## 1. RESEARCH METHODOLOGY

After having studied the available information as in the preceding four chapters, I will now describe my own research and the method used, limitations and conclusions.

Constantine and Naples were chosen for the case studies and where the survey phase took place. During this phase I was observing particular urban areas chosen for their variety of design characteristics, and on which various observations, recorded measures such as urban spaces' dimensions, air temperature, relative humidity, air movement... etc., and subjective feeling notations have been made and gathered on five separate indexes called: survey-plates.

It must be noted that during the measuring by use of a wet-bulb thermometer and an anemometer, there will be some grounds for error due to inexperience and their unstable reading display influenced by the quick changing environmental conditions with the different urban spaces - for example the recording of wind velocity, in a particular street, with an anemometer could show different readings as the wind is for changing its movements and velocities.

The other inadequacies reside in the short time period

/*This paragraph continues on pages 96 and 97.

*** S U R V E Y - P L A T E S ***

| | | | |
|---|---|---|---|
| PLATE NO.1 | | | |
| LOCATION | | | La Rue Rahault, Constantine<br><br>July,25.1986 (9.30am to 1.00 pm.) |
| URBAN SPACE KIND | | | One of the most important arteries in the city, for motor-car and pedestrian use. Pavements on both sides. |
| STYLE | | | Colonial, built at the beginning of the 20th Century. |
| SPACE USE | | | Mainly commercial, such as coffee-shops, restaurants, hotels, book-shops and travel agencies; ground level |
| SHAPE AND DIMENSION | | | Linear, pavements of 3.50m wide each (one is arcaded). Vehicular floor of 7m wide and approx. 300m long. Arches of 5m high and 3m wide. |
| BUILDINGS AROUND | USE | | Dwellings and offices above ground level. |
| BUILDINGS AROUND | FACADE CHARACTER | | French colonial style, with wide openings protected by wooden venetian blinds. Awning balconies and canopies on some buildings. |
| BUILDINGS AROUND | CONSTRUCTION | MATERIAL | Bricks and stones, with tiled roofs. Wood and iron for windows, door-windows and balconies. |
| BUILDINGS AROUND | CONSTRUCTION | STOREYS | Irregular building heights varying from 1 to 5 storeys. |
| BUILDINGS AROUND | CONSTRUCTION | COLOUR | Domination of white wash, light blue and brown for arcades. |
| SPACE CONCEPTION | | | One of the two pavements is arcaded by a succession of arches of ragual form. |
| ORIENTATION AND ARRANGEMENT | | | South to North. The row of buildings facing the east side of the street is much lower than the west one. |

<table>
<tr><td rowspan="2">SHADING</td><td>PROCESS AND DEVICES</td><td colspan="6">Mainly by buildings, arcades, awning canvas and balconies.</td></tr>
<tr><td>EFFICACITY AND TIME</td><td colspan="6">Much more important within the arcaded side-walk, all over the day.<br>Thick shadow after 2p.m. over street.</td></tr>
<tr><td rowspan="2">VEGETATION</td><td>TREES TYPES</td><td colspan="6">–</td></tr>
<tr><td>PLANTING ARRANGEMENT</td><td colspan="6">–</td></tr>
<tr><td colspan="2">WATER USE</td><td colspan="6">Came from some shops' entrances during the cleaning time (morning and afternoon).<br>Coolness effect in both pavements.</td></tr>
<tr><td colspan="2">FLOOR</td><td colspan="6">Tarmac for vehicular space and floor tiles (yellow) for sidewalk.</td></tr>
<tr><td colspan="2">TEMPERATURE MEASURES</td><td>DRY BULB</td><td>$28^{\circ}C$</td><td>WET BULB</td><td>$24^{\circ}C$</td><td>RELATIVE HUMIDITY</td><td>70%</td></tr>
<tr><td rowspan="2">ELEMENTS</td><td>WIND</td><td colspan="2">More important under arcades ( 2.4m/s )</td><td>DAY LIGHT</td><td colspan="3">The arcaded side is darker, but with good paint reflection</td></tr>
<tr><td>SMELL</td><td colspan="2">Comes mainly from shops such as bakeries & restaurants</td><td>DUST</td><td colspan="3">Much more important on hot days</td></tr>
<tr><td rowspan="3">GENERAL OBSERVATIONS</td><td>PEOPLE'S FREQUENTATION</td><td colspan="6">One of the most frequented urban public spaces in the city, because of its close situation to the ancient center and its transit role.<br>Important pedestrians flow during all day.</td></tr>
<tr><td>COMFORT AND SECURITY</td><td colspan="6">The arcaded space is much more comfortable than the remaining space parts, even during hot or cold season. Good security feeling when walking through arcades.</td></tr>
<tr><td>PEOPLE'S BEHAVIOUR</td><td colspan="6">Pedestrians seem to have no choice in using the arcaded space or the other side-walk; both pavements contain important flow, except during hot or cold rainy days when the pedestrians crowd into the covered space which connects to a long underpass containing commercial activities.</td></tr>
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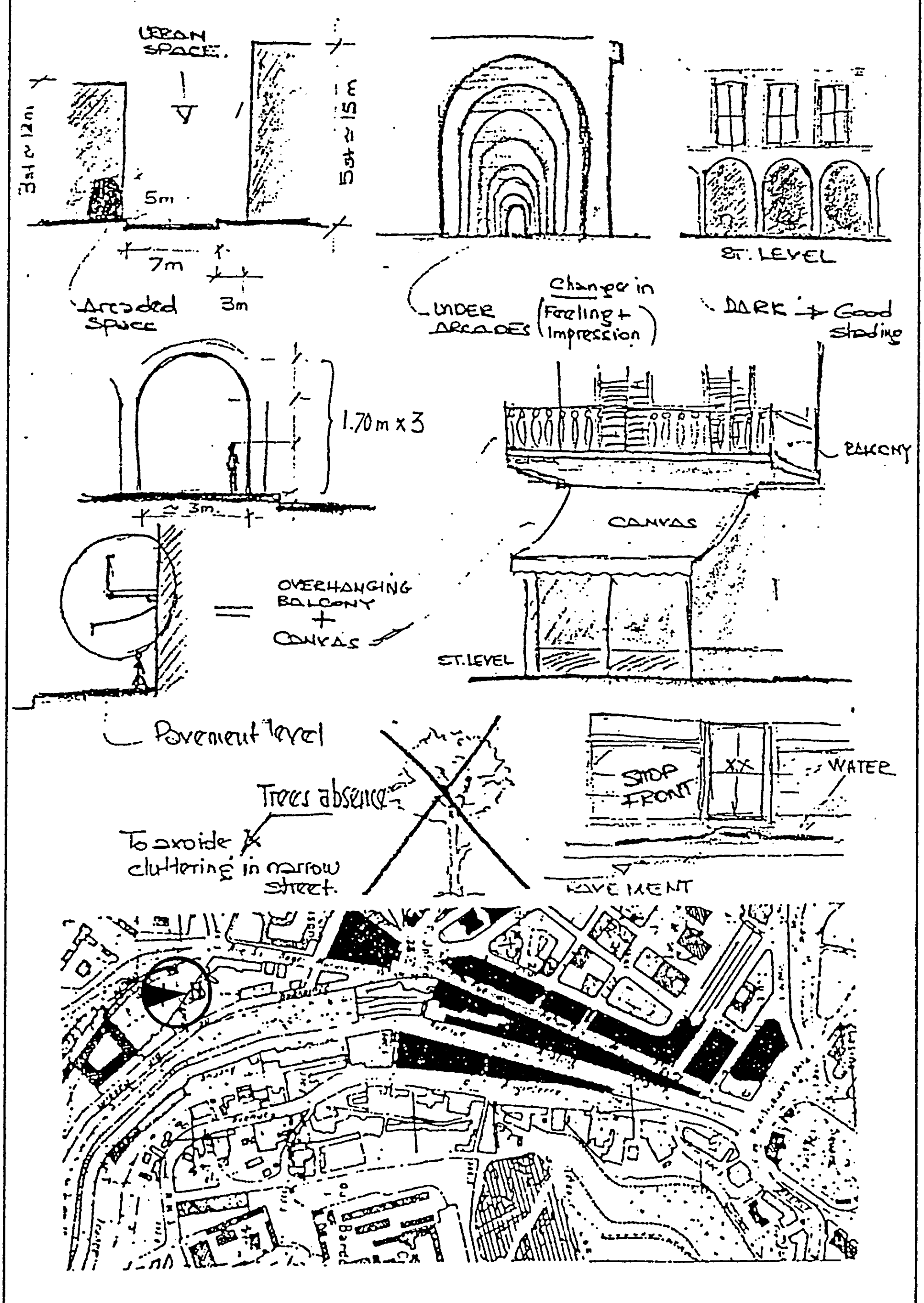
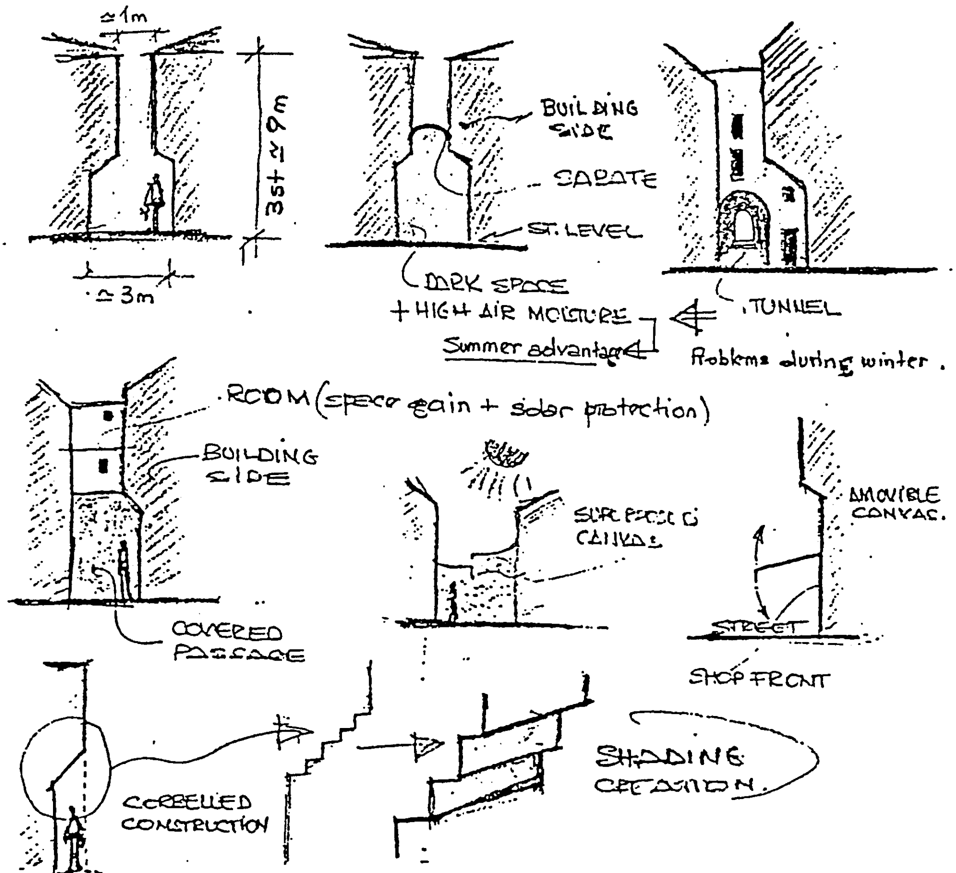
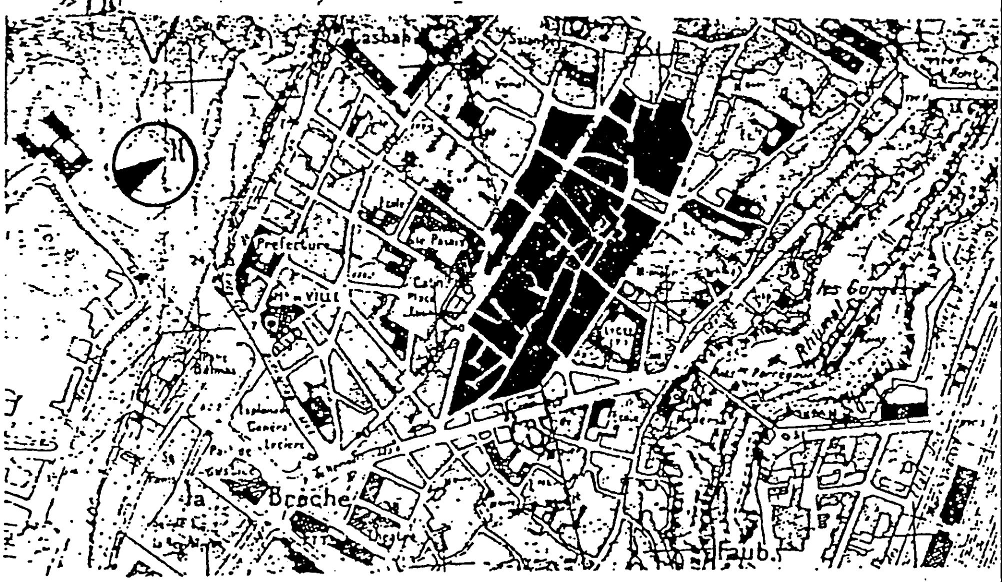

URBAN SPACE
3st ≈ 12m
5st ≈ 15m
5m
7m
3m
Arcaded Space
UNDER ARCADES
Change in (Feeling + Impression)
ST. LEVEL
DARK + Good shading
1.70m x 3
≈ 3m
BALCONY
CANVAS
OVERHANGING BALCONY + CANVAS
ST. LEVEL
Pavement level
Trees absence
To avoide cluttering in narrow street.
SHOP FRONT
WATER
PAVEMENT

| | | | |
|---|---|---|---|
| PLATE NO. 2 | | | La Rue Serini, Constantine Old Town |
| LOCATION | | | July,26/27.1986 (On the afternoons.) |
| URBAN SPACE KIND | | | Pedestrian Street situated in one of the busiest and commercially attractive area in the old town. |
| STYLE | | | Arabo-Turkish, 16-17 Century |
| SPACE USE | | | Mainly commercial, such as jewelleries, shoe-shops, butcher, green-groceries... etc. Habitation at the rear of shops or above. This street is used for transition and commercial purposes. |
| SHAPE AND DIMENSION | | | This winding street is composed of a variety of successive spaces built with different shapes and characters. Street width varies from 1.20m to 5m. |
| BUILDINGS AROUND | USE | | Complete absence of offices. Share between great-range of shops, workshops and dwellings. |
| BUILDINGS AROUND | FACADE CHARACTER | | Typically Arabo-Turkish, except for shop-fronts, at the street level, which have got modern modifications. |
| BUILDINGS AROUND | CONSTRUCTION | MATERIAL | Hand made fired bricks, stones, Roman shaped stones, Roman vestiges, clay, chalk, gypsum, iron, wood....etc. |
| BUILDINGS AROUND | CONSTRUCTION | STOREYS | Irregular house-heights, varying from 1 to 3 storeys. Most of the houses have one storey. |
| BUILDINGS AROUND | CONSTRUCTION | COLOUR | Great variety, with domination of blue and light-yellow (cream) |
| SPACE CONCEPTION | | | Narrow public space made just for walking. Buildings on either side are built with corbelled facades with false orthogonality to the street floor. |
| ORIENTATION AND ARRANGE-MENT | | | No real orientation, as the space conception is a labyrinth-like one. Irregular houses, even in height or base-size. |

| | | | | | | |
|---|---|---|---|---|---|---|
| SHADING | PROCESS & DEVICES | Mainly by covered passages, narrowness of the street itself, hinged rooms over street-space, corbelled constructions, overhangs and awning canvas. | | | | |
| | EFFICACITY AND TIME | Much more important within covered passage. Shade cast by houses is also important. | | | | |
| VEGETATION | TREES TYPES | - | | | | |
| | PLANTING ARRANGEMENT | - | | | | |
| WATER USE | | - | | | | |
| FLOOR | | Flattened granit stones of different sizes and colours. | | | | |
| TEMPERATURE MEASURES | DRY BULB | 26°C | WET BULB | 22°C | RELATIVE HUMIDITY | 70% |
| ELEMENTS | WIND | 2.1 m/s | DAY-LIGHT | Covered spaces (Sabate) are darker (no glare). | | |
| | SMELL | Much more dominated by the butcher products | DUST | - | | |
| GENERAL OBSERVATIONS | PEOPLE FREQUENTATION | Very important pedestrian flow during the opening hours and through the shopping streets of the area which constitute the main old market of the traditional town. | | | | |
| | COMFORT AND SECURITY | Good feeling from the cool channelled breeze during hot period, especially under covered spaces which act as a real reservoir of coolness; (this advantage will become a problem during underheated period. Diverse security feelings. | | | | |
| | PEOPLE'S BEHAVIOUR | Pedestrian movement is much more slow than in Case 1, maybe because of the narrowness of spaces and their shading quality, and even because motor-car traffic which could differently affect pedestrians' behaviour in general | | | | |


≃1m
3st ≃ 9m
≃3m
BUILDING SIDE
ST. LEVEL
DARK SPACE
+ HIGH AIR MOISTURE
Summer advantage
TUNNEL
Problems during winter.
ROOM (space gain + solar protection)
BUILDING SIDE
COVERED PASSAGE
AMOVIBLE CANVAS.
STREET
SHOP FRONT
CORBELLED CONSTRUCTION
SHADING CREATION


Casbah
Prefecture
Breche

<table>
<tr><td colspan="3">PLATE NO. 3</td><td></td></tr>
<tr><td colspan="3">LOCATION</td><td>BOULEVARD Victor Hugo (St. Jean), Constantine.<br><br>July, 26. 1986 (9.30am to 3.00pm.)</td></tr>
<tr><td colspan="3">URBAN SPACE</td><td>Vehicular street with side-walk on either side.</td></tr>
<tr><td colspan="3">STYLE</td><td>French Colonian style, built at the end of the 19th Century.</td></tr>
<tr><td colspan="3">SPACE USE</td><td>Mainly commercial activities: coffee-shops; green-grocers, book-shops, news agents all at street level; habitations and some offices above.</td></tr>
<tr><td colspan="3">SHAPE AND DIMENSION</td><td>Linear space (See plan); vehicular floor of 6 to 7m. wide and pavement of 3m wide each. The street space is 250meters long.</td></tr>
<tr><td rowspan="5">BUILDINGS AROUND</td><td colspan="2">USE</td><td>Storeys above ground floor are mainly used for habitation.</td></tr>
<tr><td colspan="2">FACADE CHARACTER</td><td>French Renaissance style with wide openings and overhanging balconies.</td></tr>
<tr><td rowspan="3">CONSTRUCTION</td><td>MATERIAL</td><td>Bricks, stones and mortar; wood and iron for windows and balconies. Most of the buildings' roofs are tiled.</td></tr>
<tr><td>STOREYS</td><td>1 to 4 storeys for buildings on east-side of street, 2 to 6 storeys for those on the west side. Compare this case to the one on plate No. 1.</td></tr>
<tr><td>COLOUR</td><td>Three main various colours: white wash, light blue and cream.</td></tr>
<tr><td colspan="3">SPACE CONCEPTION</td><td>Current method: main street and side-walk on either side, limited by building rows.</td></tr>
<tr><td colspan="3">ORIENTATION AND ARRANGEMENT</td><td>This urban public space runs north to south. The row of buildings on the east side of the street is much lower than the one on the west side.</td></tr>
</table>

<table>
<tr><td rowspan="2">SHADING</td><td>PROCESS AND DEVICES</td><td colspan="6">Shade mainly provided from trees, awning canvas and balconies. This urban space has got very good protection against sun heat and glare.</td></tr>
<tr><td>EFFICACITY AND TIME</td><td colspan="6">Good protection for either pavement and even for the motorcar floor. This space is shaded during most hours of a summer day.</td></tr>
<tr><td rowspan="2">VEGETATION</td><td>TREE TYPES</td><td colspan="6">Deciduous species of 10 to 12 meters high, with open branches and leafless foliage of 6 to 8 meters in diameter.</td></tr>
<tr><td>PLANTING ARRANGE-MENT</td><td colspan="6">Trees are planted every 6 meter intervals, along each pavement: they form a kind of continuous long foliage which touches the building facades.</td></tr>
<tr><td colspan="2">WATER USE</td><td colspan="6">Good refreshment of the air on morning and afternoon when water is spread over pavement surfaces which are shaded by trees.</td></tr>
<tr><td colspan="2">FLOOR</td><td colspan="6">Tarmac for vehicular floor and cream coloured floor tiles for side-walk.</td></tr>
<tr><td colspan="2">TEMPERA-TURE MEASURES</td><td>DRY BULB</td><td>29°C</td><td>WET BULB</td><td>23°C</td><td>RELATIVE HUMIDITY</td><td>60%</td></tr>
<tr><td rowspan="2">ELEMENTS</td><td>WIND</td><td colspan="6">Multi-directional (unstable velocity)</td></tr>
<tr><td>SMELL</td><td colspan="3">-</td><td>DAY LIGHT</td><td colspan="2">Glare and reflection from buildings is intercepted by trees</td></tr>
<tr><td rowspan="3">GENERAL OBSERVATIONS</td><td>PEOPLE FREQUENTA-TION</td><td colspan="6">Also, one of the most congested urban spaces in Constantine, and during all day-time. Not just for shopping but also for "ballades". This street is considered and used as a meeting place, especially in the late afternoon.</td></tr>
<tr><td>COMFORT AND SECURITY</td><td colspan="6">Very pleasant space to be in, at any time of the day. Plantation and the reduced height of buildings have good effects of security. Relaxing view, because of plantation.</td></tr>
<tr><td>PEOPLE'S BEHAVIOUR</td><td colspan="6">Most of the people use space not just for shopping but also, especially during the after-work time, for strolls. Pedestrians' pace is too reduced if compared to the case in plate No. 1.</td></tr>
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<tr><td rowspan="2">SHADING</td><td>PROCESS AND DEVICES</td><td colspan="6">Shade mainly provided from trees, awning canvas and balconies. This urban space has got very good protection against sun heat and glare.</td></tr>
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<tr><td colspan="2">TEMPERA-TURE MEASURES</td><td>DRY BULB</td><td>29°C</td><td>WET BULB</td><td>23°C</td><td>RELATIVE HUMIDITY</td><td>60%</td></tr>
<tr><td rowspan="2">ELEMENTS</td><td>WIND</td><td colspan="6">Multi-directional (unstable velocity)</td></tr>
<tr><td>SMELL</td><td colspan="3">-</td><td>DAY LIGHT</td><td colspan="2">Glare and reflection from buildings is intercepted by trees</td></tr>
<tr><td rowspan="3">GENERAL OBSERVATIONS</td><td>PEOPLE FREQUENTA-TION</td><td colspan="6">Also, one of the most congested urban spaces in Constantine, and during all day-time. Not just for shopping but also for "ballades". This street is considered and used as a meeting place, especially in the late afternoon.</td></tr>
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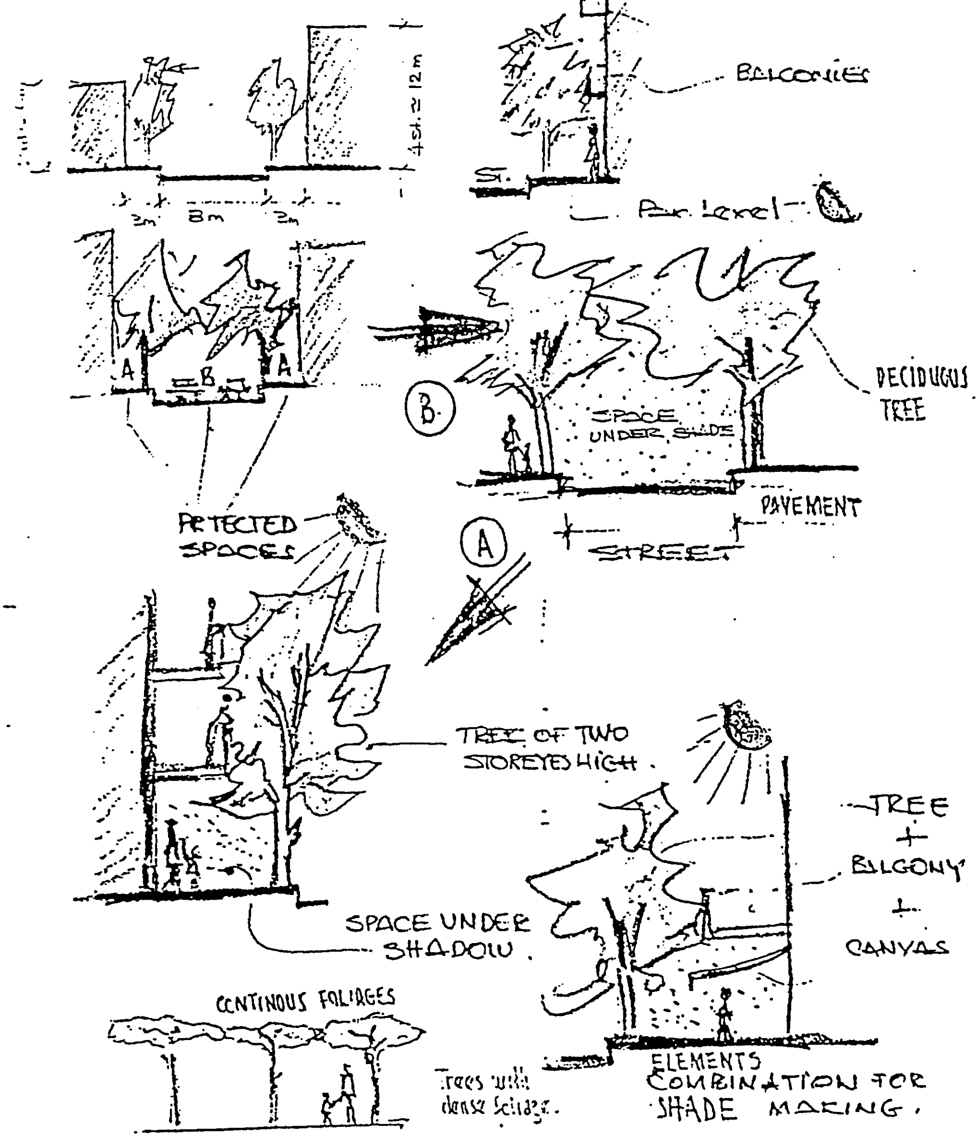
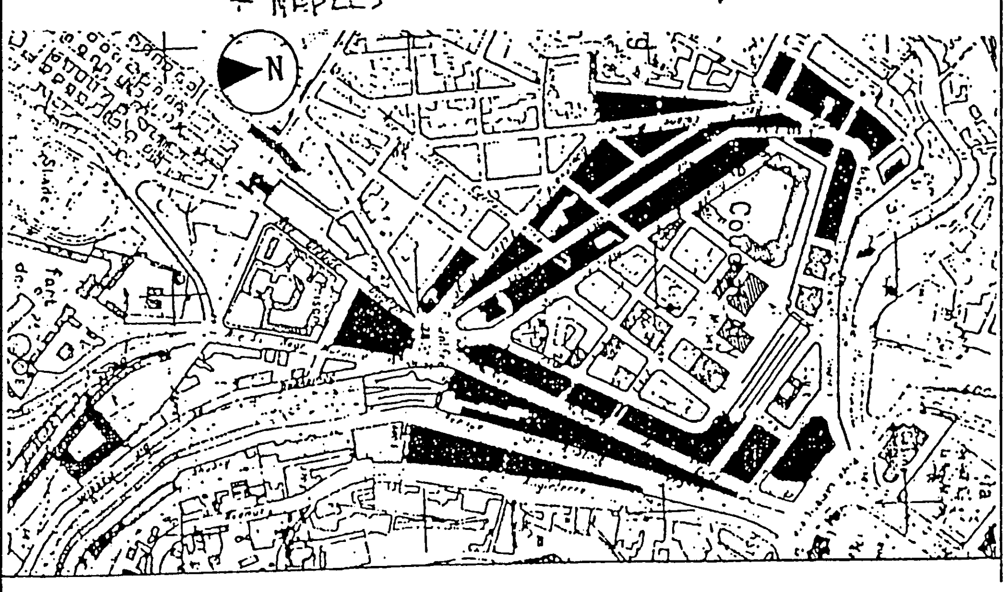
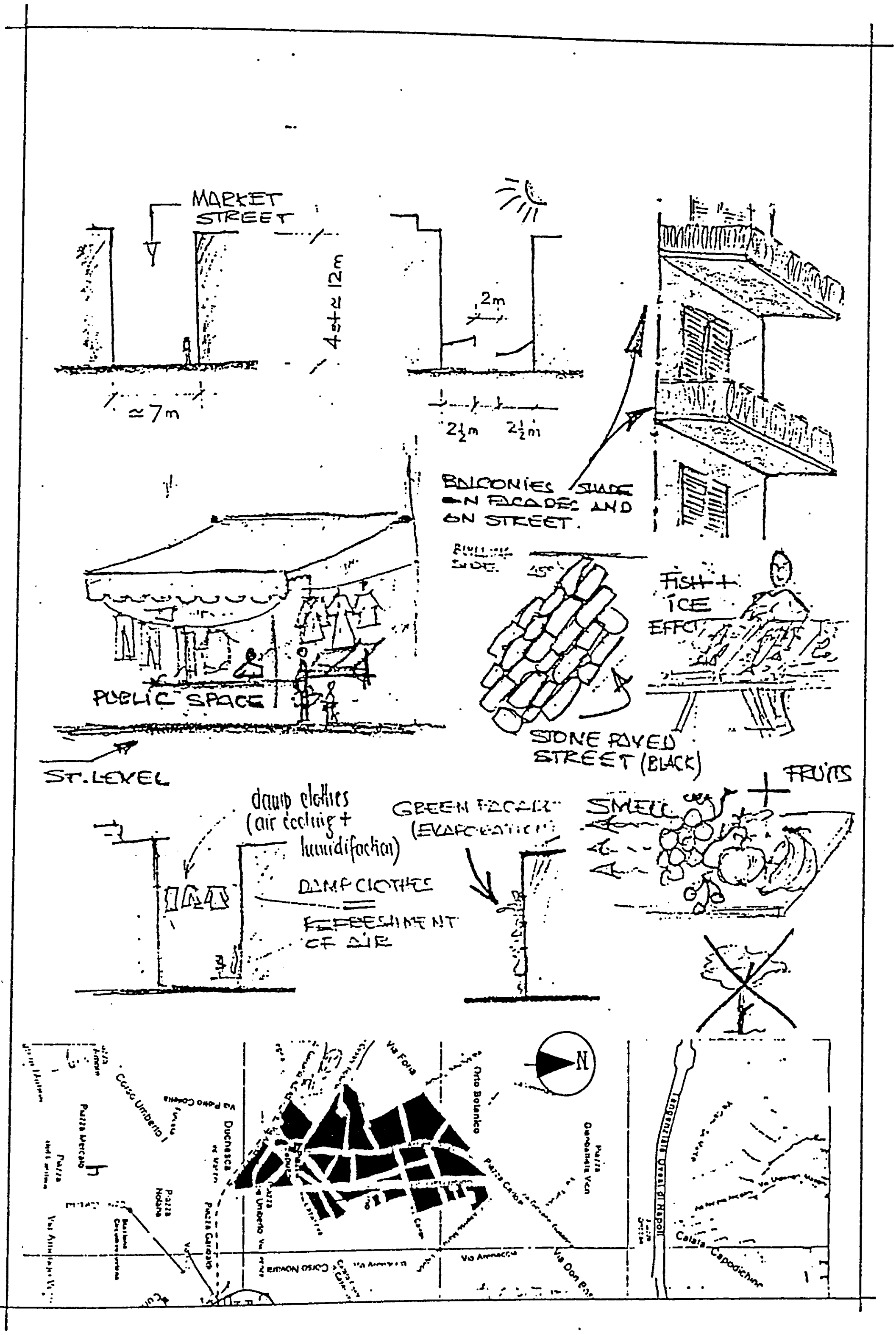



CASE OF ALGIERS + NAPLES



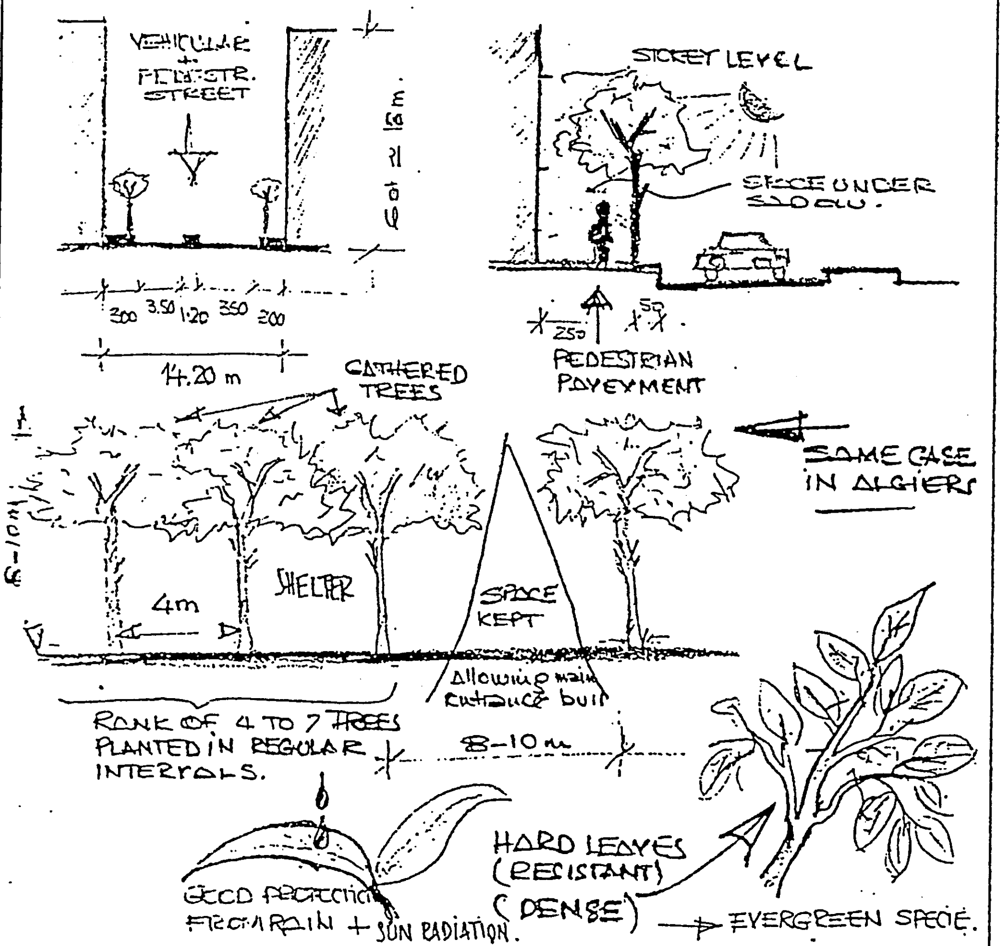
| | | | |
|---|---|---|---|
| PLATE NO.4 | | | |
| LOCATION | | | Via St. Antonio Abate and Piazza Capuana (Naples).<br><br>October,3.1986 (9.3oam to 3.3opm.) |
| URBAN SPACE KIND | | | Pedestrian market street leading to public piazza of mixed uses: vehicular and pedestrian. |
| STYLE | | | Mixture of Medieval, Classic and contemporary styles (some building renewals had been made after the War damage) |
| SPACE USE | | | Daily public market for food sale, clothing and domestic equipment. Very busy space. |
| SHAPE AND DIMENSION | | | Winding street leading to an adjacent public place. (See map). |
| BUILDINGS AROUND | USE | | Shops and goods display at the ground level; dwellings above. |
| BUILDINGS AROUND | FACADE CHARACTER | | Short and long continuous overhanging baleonies varying from 60cm to 1.20 meters in depth. Large openings (door-windows) with wooden shutters. |
| BUILDINGS AROUND | CONSTRUCTION | MATERIAL | Lime-stones, mortar and wood. Shaped stones are used for buildings' corners. |
| BUILDINGS AROUND | CONSTRUCTION | STOREYS | Regular building heights; 3 to 4 storeys. |
| BUILDINGS AROUND | CONSTRUCTION | COLOUR | Yellow Napolitan (this kind of colour is specific to Naples and has great reputation through history). |
| SPACE CONCEPTION | | | The street space, simply limited by building rows on either side, seems to be very loaded by the projecting balconies, awning canvas, hinged canvas, hinged clothes and even pedestrians. |
| ORIENTATION AND ARRANGEMENT | | | Despite its windingness, the street - considering the map - is running north to south. |

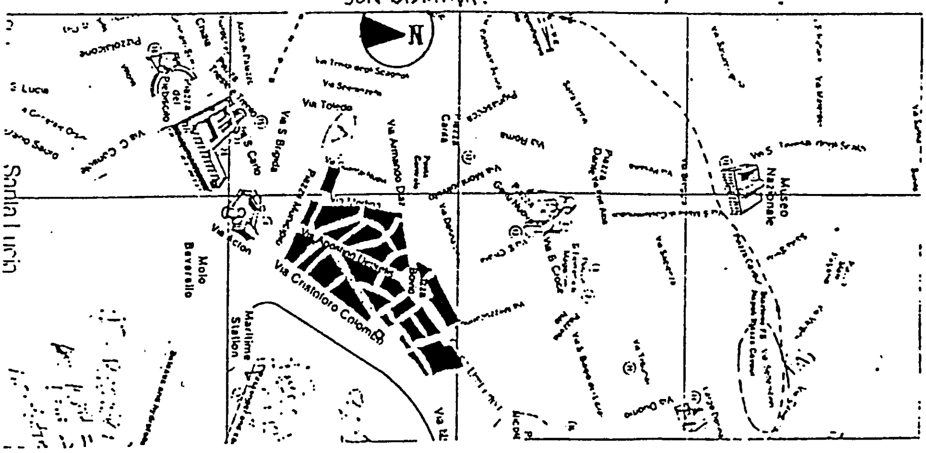
<table>
<tr><td rowspan="2">SHADING</td><td>PROCESS AND DEVICES</td><td colspan="6">Mainly by awning canvas and balconies. Hinged clothes and other goods also cast shade. Buildings have little shade cast on street space.</td></tr>
<tr><td>EFFICACITY AND TIME</td><td colspan="6">Quite sufficient shading to protect pedestrians during most hours of the day, except around midday (11am to 1.30pm) when sun-rays strike the space perpendicularly.</td></tr>
<tr><td rowspan="2">VEGETATION</td><td>TREES TYPES</td><td colspan="6">-</td></tr>
<tr><td>PLANTING ARRANGEMENT</td><td colspan="6">-</td></tr>
<tr><td colspan="2">WATER USE</td><td colspan="6">Wonderful air freshness in some space points where fish-sellers and green-grocers display their goods along street-sides.</td></tr>
<tr><td colspan="2">FLOOR</td><td colspan="6">Black stone paved floor; rectangular in shape (100 x 40cm)</td></tr>
<tr><td colspan="2">TEMPERATURE MEASURES</td><td>DRY BULB</td><td>26°C</td><td>WET BULB</td><td>23°C</td><td>RELATIVE HUMIDITY</td><td>80%</td></tr>
<tr><td rowspan="2">ELEMENTS</td><td>WIND</td><td colspan="3">-</td><td>DAY LIGHT</td><td colspan="2">Sun-light is mainly reflected from building facades.</td></tr>
<tr><td>SMELL</td><td colspan="3">Different kinds of goods smell, depending on point-area</td><td>DUST</td><td colspan="2">Lesser than it is in streets used by motor cars.</td></tr>
<tr><td rowspan="3">GENERAL OBSERVATIONS</td><td>PEOPLE FREQUENTATION</td><td colspan="6">Very busy space at every time of the day; except for the adjacent place which is much more occupied by small cars (Lambretta) than by people.</td></tr>
<tr><td>COMFORT AND SECURITY</td><td colspan="6">Uncomfortable for walking, because of its great frequentation by people; but good thermal comfort and impressions.<br>Quite good security.</td></tr>
<tr><td>PEOPLE BEHAVIOUR</td><td colspan="6">Pedestrians seem to be very pleased when moving or shopping at any space point. Their movement is too low when compared to other streets in the area. People are driven by the market ambiance.</td></tr>
</table>


MARKET STREET
4 to 12m
≈7m
2m
2½m 2½m
BALCONIES SHADE ON FACADES AND ON STREET.
PUBLIC SPACE
ST. LEVEL
STONE PAVED STREET (BLACK)
FISH + ICE EFFECT
FRUITS
SMELL
damp clothes (air cooling + humidifaction)
DAMP CLOTHES = REFRESHMENT OF AIR
N
Corso Umberto I
Piazza Mercato
Duchesca
Piazza Garibaldi
Via Foria
Orto Botanico
Calata Capodichino

<table>
<tr><td colspan="3">PLATE NO.5</td><td></td></tr>
<tr><td colspan="3">LOCATION</td><td>Via Agostino Depertis, Naples.<br><br>October,2.1986(Io am to 3 pm.)</td></tr>
<tr><td colspan="3">URBAN SPACE KIND</td><td>Doubled vehicular street-floor with two side-walks. The street space leads to 2 important piazzas in each extreme (see map).</td></tr>
<tr><td colspan="3">STYLE</td><td>Mixture of Medieval and Post-War styles.</td></tr>
<tr><td colspan="3">SPACE USE</td><td>Mainly commercial and administrative. Also some dwellings above shops.</td></tr>
<tr><td colspan="3">SHAPE AND DIMENSION</td><td>Short rectilinear street made of 2 vehicular ways of 5 meters wide each. Pavements are of 3 meters each.</td></tr>
<tr><td rowspan="5">BUILDINGS AROUND</td><td colspan="2">USE</td><td>See "space use".</td></tr>
<tr><td colspan="2">FACADE CHARACTER</td><td>Post War style, with overhanging balconies of 60 to 100cm. projecting from each floor level.</td></tr>
<tr><td rowspan="3">CONSTRUCTION</td><td>MATERIAL</td><td>Lime shaped stones, or bricks covered with mortar cement. Use of worked steel for balconies. Shop fronts are large and made of glass.</td></tr>
<tr><td>STOREYS</td><td>5 to 6 storeys; regular for either row.</td></tr>
<tr><td>COLOUR</td><td>Yellow Napolitan.</td></tr>
<tr><td colspan="3">SPACE CONCEPTION</td><td>The street space is simply limited by buildings on each side and an addition of tree planting on either pavement.</td></tr>
<tr><td colspan="3">ORIENTATION AND ARRANGEMENT</td><td>Street space running north-east to south-west (see plan).</td></tr>
</table>

<table>
<tr><td rowspan="2">SHADING</td><td>PROCESS AND DEVICES</td><td colspan="6">Mainly by trees; and also awning canvas and overhang. Street is too wide if compared to buildings' height, so insufficient shading through this process.</td></tr>
<tr><td>EFFICACITY AND TIME</td><td colspan="6">Good shading provided by trees' row on one side, and by buildings on the other side. (complentary role).</td></tr>
<tr><td rowspan="2">VEGETATION</td><td>TREE TYPES</td><td colspan="6">Slim high species with dense and resistant deciduous foliage. These trees look like an open umbrella.</td></tr>
<tr><td>PLANTING ARRANGEMENT</td><td colspan="6">8 to 10 meters high, trees reach the top front of shops by their continuous foliages kept for about 1.20 meters far from building facades. Trees are planted every 4m.</td></tr>
<tr><td colspan="2">WATER USE</td><td colspan="6">-</td></tr>
<tr><td colspan="2">FLOOR</td><td colspan="6">Dark stone paved floor (side-walk and vehicular ways). This kind of stones absorbs and reradiates a large amount of heat.</td></tr>
<tr><td colspan="2">TEMPERATURE MEASURES</td><td>DRY BULB</td><td>29°C</td><td>WET BULB</td><td>27°C</td><td>RELATIVE HUMIDITY</td><td>60%</td></tr>
<tr><td rowspan="2">ELEMENTS</td><td>WIND</td><td colspan="3">-</td><td>DAY LIGHT</td><td colspan="2">Less bright within pavement, because of trees.</td></tr>
<tr><td>SMELL</td><td colspan="3">Domination of cars' smoke</td><td>DUST</td><td colspan="2">Very dusty, as it is in most streets of Naples</td></tr>
<tr><td rowspan="3">GENERAL OBSERVATIONS</td><td>PEOPLES' FREQUENTATION</td><td colspan="6">Less busy than it is in the case: Via St. A. Abate, Plate No. 4. This street seems to be more frequented by cars than by pedestrians.</td></tr>
<tr><td>COMFORT AND SECURITY</td><td colspan="6">Less comfortable because of noise and dust when walking along the pavement; but good release of shading effect.</td></tr>
<tr><td>PEOPLE'S BEHAVIOUR</td><td colspan="6">People seem to use the space just as transit, and with quite a fast pace even there is shade protection. It is true that this urban public space has got a less attractive ambiance. Less lively than it is in Case. 4.</td></tr>
</table>


VEHICULAR + PEDESTR. STREET
300 3.50 1.20 3.50 300
14.20 m
STREET LEVEL
SPACE UNDER SHADOW.
250
50
PEDESTRIAN PAVEMENT
GATHERED TREES
SAME CASE IN ALGIERS
SHELTER
4m
SPACE KEPT
RANK OF 4 TO 7 TREES PLANTED IN REGULAR INTERVALS.
8-10 m
HARD LEAVES (RESISTANT) (DENSE)
EVERGREEN SPECIE.
GOOD PROTECTION FROM RAIN + SUN RADIATION.


N
Santa Lucia
Molo Beverello
Marittima Station
Via Toledo
Via Armando Diaz
Via Cristoforo Colombo
Museo Nazionale

during which the survey had to be undertaken, for example part of summer vacation. In such a short period, it is impossible to see all climatic factors present and to understand their changing effect, from one hour, day and season to another, on the comfort conditions within a particular urban space or area. For a complete measure of the different climatic factors affecting comfort in general, and for a conclusive survey one needs well equipped staff - which is not easy for a student to get - and at least one year's time, during which all climatic conditions, in a given urban area, could be observed.

Nevertheless, the summer period - the only available time and intentionally chosen, as overheating was found to be the most pressing problem, - during which the survey was made, should be of some advantage in helping to understand the thermal conditions affecting pedestrians' comfort within urban spaces. "In spite of the problems encountered, the survey gives some guidances and the experience was indicative of the full task and concentrates the mind on the actual conditions."

From analysis of the quantitative information and observations on each survey-plate, conclusions have been made in the form of sketches illustrating a variety of design processes and devices found in each investigated urban area, and which are considered to have an impact influencing, in different ways, the climatic factor and thus the comfort considerations within those particular areas. Consequently, these plates have been helpful in detecting existing devices able to control overheating effects on urban spaces.

Sun-protective devices, having also some protective roles against other natural elements, and primarily found within the investigated areas, have been worked out and put in a photographic collection to which an extra number of efficient devices and techniques, found in other countries, was added, in order to qualitatively complete the collection on which detailed analyses, comments and conclusions have been made.

In order to extend the measurements and learn more of the mechanisms involved, a series of laboratory simulations were made where this could give insight to conditions. This also enabled some quantitative aspects to be studied.

For detailed information, see "Heliodon experiments" on page 140.

It is important to notice that the survey notes made on site have been left as such; it is essential to read this section with reference to the site photographics and notes.

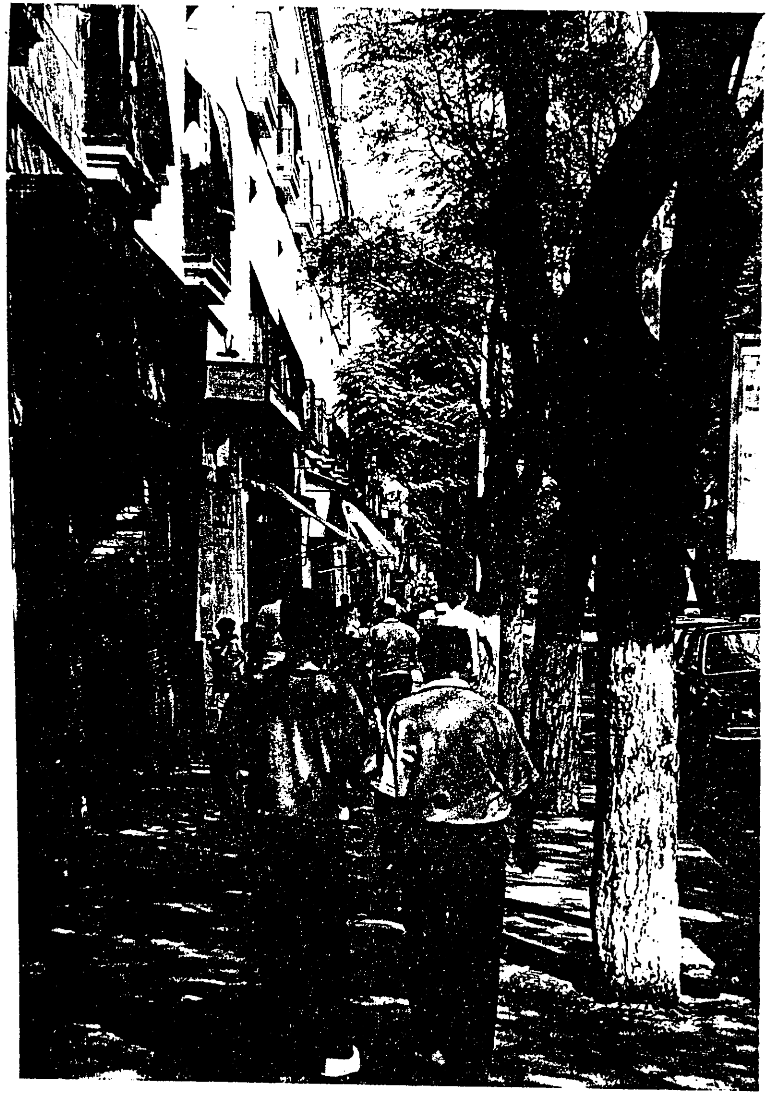
## 2. TREES SHADING: DESIGN PROCESS AND TECHNIQUES

### 2.1 EXAMPLES ANALYSIS

Picture 1

View along a street-pavement in Constantine, French quarter (see survey-plate no. 3 for detail).

The picture shows the shade cast by trees over the pavement and the shop-fronts, but not over the upper part of the building facades which are directly exposed to solar



PICTURE I.

PICTURE 2.

radiation. These particular trees with spreading-out foliages result in a patterned shade which gave a sense of liveliness of the space where pedestrians enjoyment within such conditions could be detected by their walking pace.

Picture 2

View along a street-pavement in Naples old town (see survey-plate No. 5 for detail).

This picture illustrates another kind of trees and arrangement, along a side-walk, and which produce thick shade over the floor (different from the first example). This shading results mainly from the dense and continuous foliages achieving an authentic protection against solar radiation.

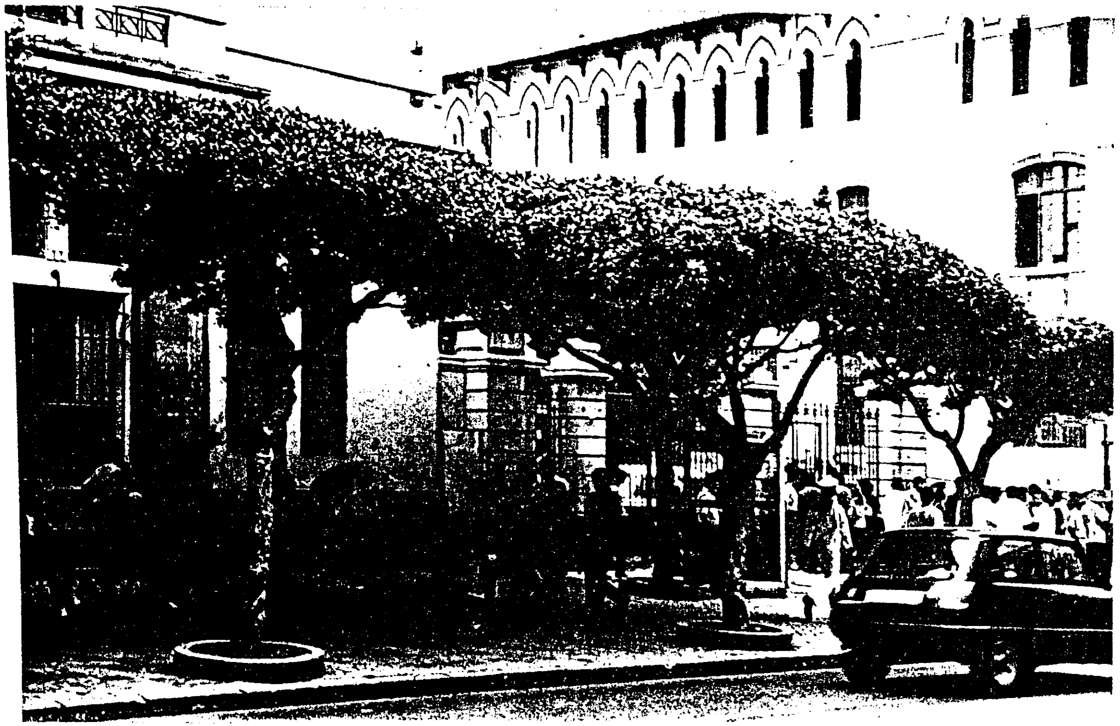
In this case, trees are planted 4 meters distance apart from each other, and 1.50 to 2 meters between foliages and buildings-side. In the front of some main public buildings entrances the interval between two tree-trunks is increased up to 8 meters, allowing a sort of visual demarcation.

Picture 3

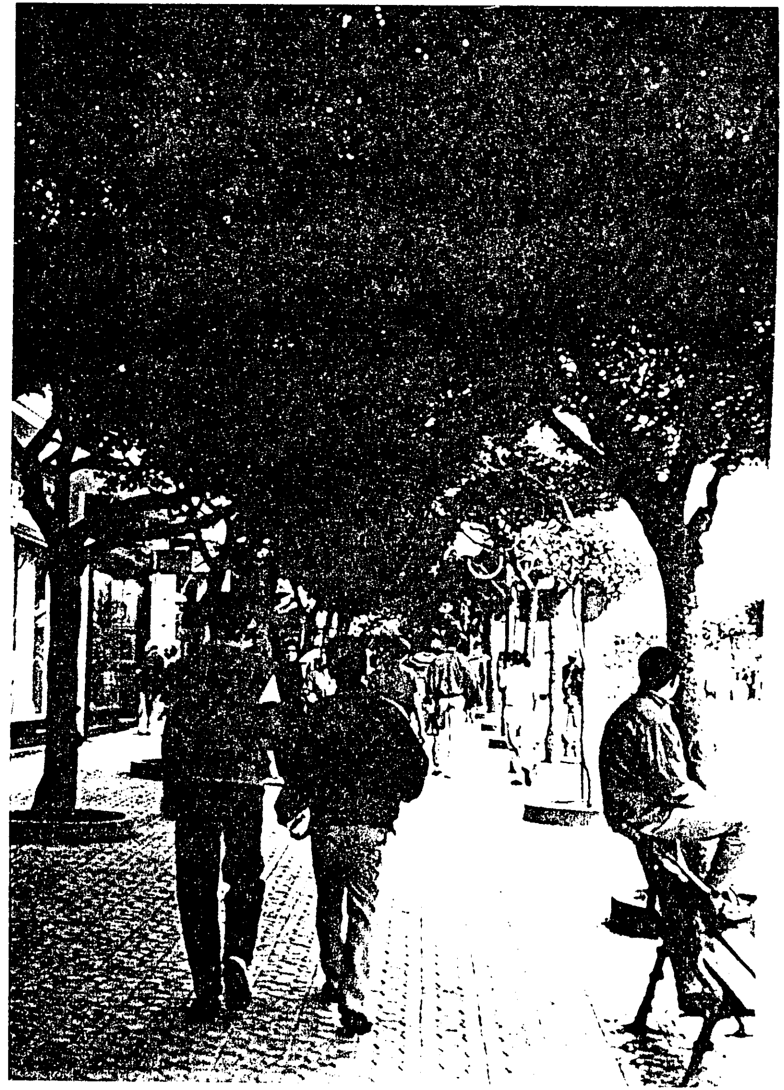
(Extra-example, not included in cases-study).

This picture shows a detail of tree species, their arrangement and height to the human scale. These kinds of trees are found in Algiers.

Unique by its character, this tree specie is found in Algiers and some other coastal Algerian cities where it has a good adaptation to the Mediterranean climate. Reaching its full growth, the tree is about 6 meters high, with thick evergreen leaves and dense flat foliage which



PICTURE 3.



PICTURE 4.

makes the whole tree look like an open umbrella. Here, trees are planted 6 to 7 meters apart in a single row, along a side-walk, and make a sort of continuous foliage lengthening between the vehicular and pedestrian areas. As such, these trees offer an ideal protection against summer radiation by casting a thick uninterrupted shade over the floor. Moreover, they constitute a sort of horizontal waterproof screen and a dust absorber over pedestrians' heads.

Picture 4.

(Extra example, not included in the cases-study )

View along a street pavement, in Algiers centre (Michelet Street) showing the double rows of trees and their planting design. The pavement is about 7 meters wide.

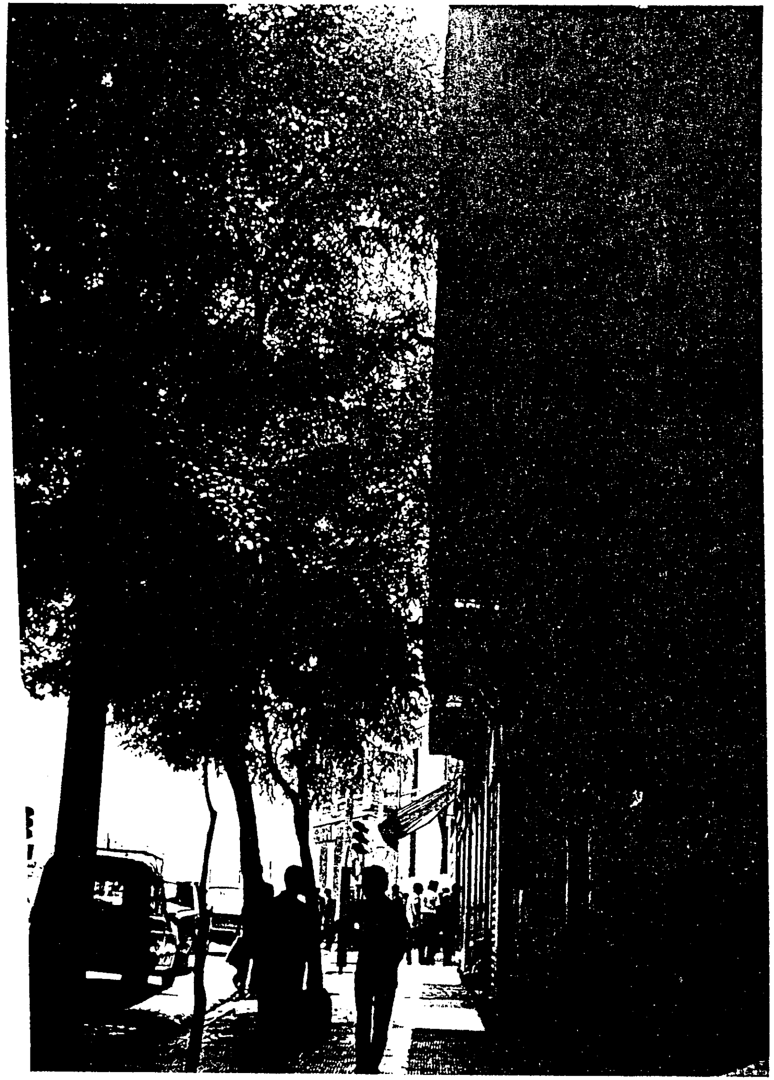
Date and day conditions: 30 September 1986: around 3p.m.; clear sky.

This example shows the same tree species already seen on picture 3, but with different planting design on a wide side-walk - about 7 meters. Here, trees arrangement on either side of the pavement, with foliage continuity even longitudinally or transversally, result in a sort of green channel forming an authentic shelter from solar radiation, dust and rain, and a pleasant view when walking through it.

Notice trees height to the human scale.

Picture 5

Detail of two shading devices: trees and awning balconies in Constantine French quarters; same street as in picture 1 (see survey plate No. 3 for detailed explanations).



PICTURE 5.

PICTURE 6.

Combination of trees and long overhanging balconies. The connection of tree-foliages to the balconies edges casts mixed and permanent shades, whatever the position of the sun is; and forms good protection from summer sunshine and possibly rain. During the underheated period, the effect will be reversed because of deciduous character of those trees, and thus solar radiation is allowed to the openings of the ground floor.

Again, note that the photograph was taken with the sun shining directly down the street but the pavement is well shaded. The scale of pedestrians to trees' height is different from the one in instance 4.

Picture 6

View through a street-axis in Constantine (same street as in pictures 1 and 5, for detail see survey-plate No. 3), showing a tree-planting design along the pavements.

Depending on the street width and the foliage size, trees can make a sort of green continuous leafy ceiling over the street space itself, as is shown on this picture. Such a situation protects pedestrians, parked cars and even part of the vehicular street floor.

Notice the landscape perspective they create.

Picture 7

Side of "La Place Foch" in Constantine (French quarter). The space is rectangular in shape and surrounded by trees and some covered terraces. Date and day conditions: end of September, 1986, between 10 and 11am; sunny day.


PICTURE 7.

More than a natural beauty or a principal element in landscaping, a single mature tree can give to an outer space the full sense and makes it much more viable by just casting its shade over this space. Here, the only reason why people are sitting in this cafe-terrace, on a hot summer day, is the tree shade.

Notice the glare outside the shaded part.

## 2.2 CONCLUSIONS

As a natural element used in landscaping or making towns and cities beautiful, trees have reached their heighest degree of usefulness and constitute an ideal and necessary tool for the urban designer. They offer character, are responsive to the seasons and present different species which have specific characteristics. Those characteristics, such as foliage shape, form and density; leaf texture and their seasonal changes - deciduous or evergreen - ; tree height and its adaptability to particular climate or environment;...etc. need to be considered by the urban designer to produce an integrated solution.

Trees used within urban spaces could cause some inconveniences such as the obstruction of building-openings, entrances and shop-fronts. They can be disruptive of the pedestrian flow and some public servicing.

Another disadvantage; which must be realised, is the long growth time of most species; which means that they cannot respond to any design aim when just planted. Also, they require maintenance, particularly for young plants;

and the cleaning of deciduous trees leaves in Autumn.

In countries with hot-dry climate, the use of evergreen trees as natural devices to protect urban spaces from solar radiation excess, glare and dust, would be the first ideal choice, especially if the specie present flat and dense foliage - see examples 2, 3 and 4 and do not exceed the height of one storey and a half, to relate to the human scale and to avoid obstruction to buildings' upper floors openings.

Some evergreen species, such as in example 3, will not create problems, even during the cold period, as the foliage mass is dense-flat in character; because such trees give good protection from rain and minimally obstruct low winter sun-rays.

Moreover, evergreen trees will create better shading for pedestrian areas if planted far from the buildings'side - in the case of wide pavement surfaces - but close to each other in a manner to form a long continuous foliage row. This also could be doubled by another row of deciduous trees planted between the first one and the buildings' side, if the side-walk is wide enough, to create thicker shade during the hot period without obstructing the shop-fronts and dwellings above from the needed winter solar radiation.

Deciduous trees have also some specific advantage in that, while shading during the hot season, they lose their leaves in the autumn and therefore allow the winter sun to penetrate.

Deciduous trees require a good water supply during their period of maximum growth, if the climate does not give this automatically then artificial watering has to be resorted to which is very expensive.

Note: Specific tree types have not been mentioned as they will of necessity vary with each location. A local flora will give what is available for a particular site.

## 3. ARCADED SPACES AND THEIR PROTECTIVE ROLE

### 3.1 EXAMPLES ANALYSIS

Picture 1

Arcaded street in Constantine, French quarter (see survey plate No. 1 for detail).

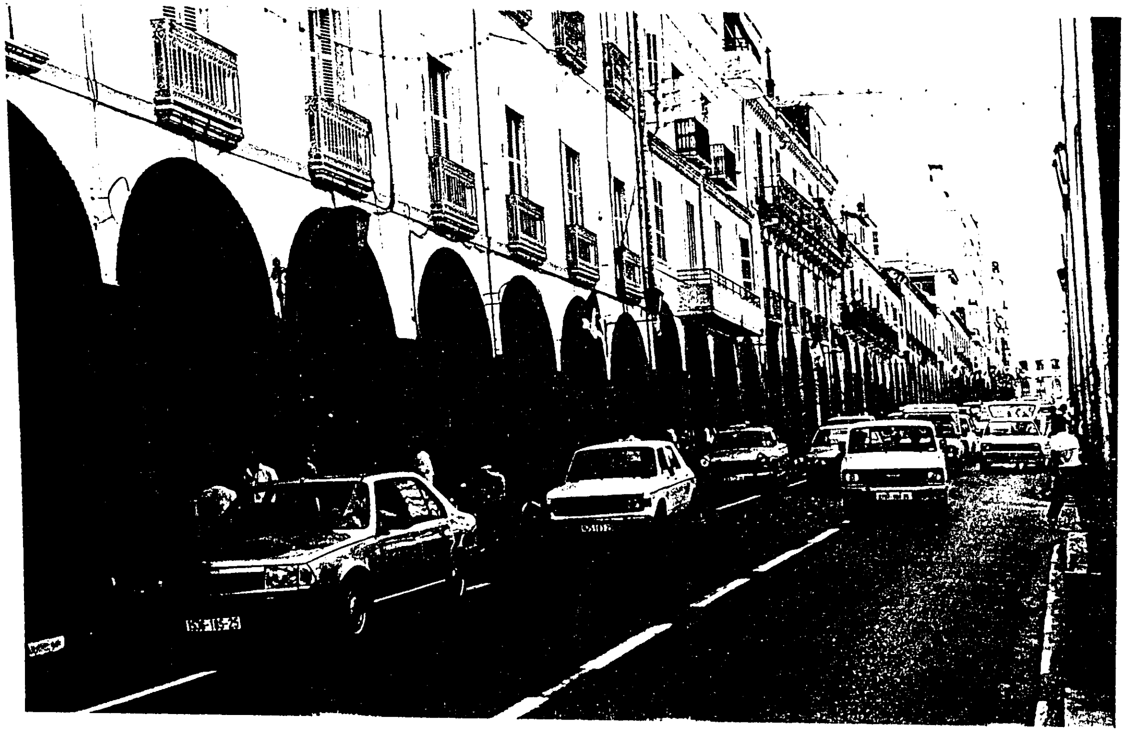
Only one side-walk - the one shown on the picture - is covered, and facing the west-side of the street.

Arcades can change the nature of the street where the norm is a confused image of pedestrians and vehicular traffic. In this case, the separation between the two is clear, and the street seems to be just for cars use because pedestrians are within the arcaded space.

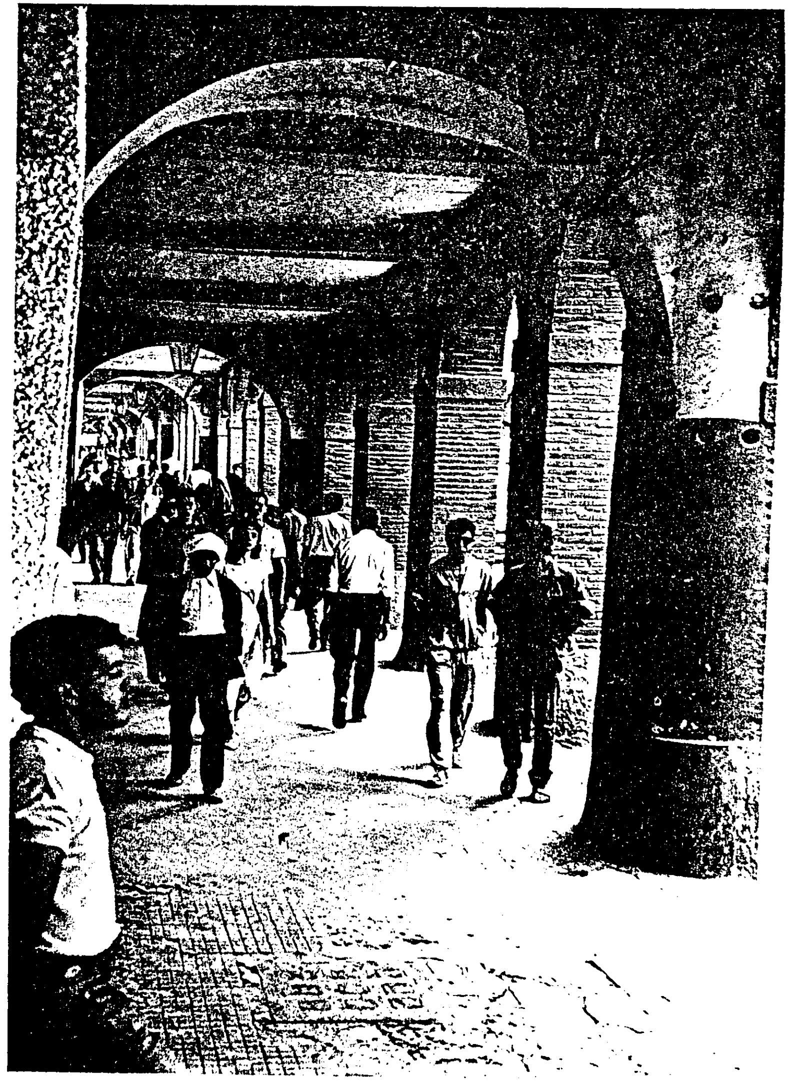
Picture 2

View through the same arcaded pedestrian space discussed in the previous example - Picture 1 - (see survey plate no. 1).

The design conception, dimensions, materials and colour* all contribute to the protective function of the space. Here arcades' height, in proportion to the human scale, is reasonable for its interruption even for the afternoon sun-rays which could be blocked out by the



PICTURE I.



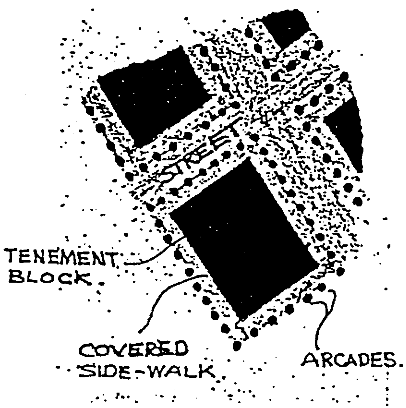
PICTURE 2.

opposite buildings before they reach the inside of the covered space.

Notice the effects of the colours used.

<u>Picture 3</u>

Another type of arcaded side-walk, in a new French quarter called "Coudiat", in Constantine. All the tenement buildings, in this area, are built in the same manner as shown on picture and the figure, but with different arcade types. Date and day conditions: 26 July, 1986, around 11am; clear sky.




Different from the previous example (picture 2), arcades here, show a wide range of styles varying from the simple square based posts to the circular ones(see details on picture). Most of the arcades in this urban area have neglected the use of the arch for the concrete beam, and make the space much higher and more open. During summer time, those pavements are cooler than they are in example 1; the reason for that is the coolness of the ilot-blocks which shade one another, and their situation on high land which attracts more breeze.

<u>Picture 4</u>

(Extra example, not included in case-study)

Arcaded and covered urban public space in Algiers where

PICTURE 3.

PICTURE 4.

a large urban area takes almost the same conception at the ground level. In this case, arches are designed high and in an elegant style. Date and day conditions: 30 September 1986, around 3 pm; clear sky.

Unlike the examples 1 and 3, arcades here have not a sufficient role of protection from solar radiation and glare as they are too high - 8 meters. The tops reach the second level of the buildings where some windows take profit of sun and light from the arches-openings facing them.

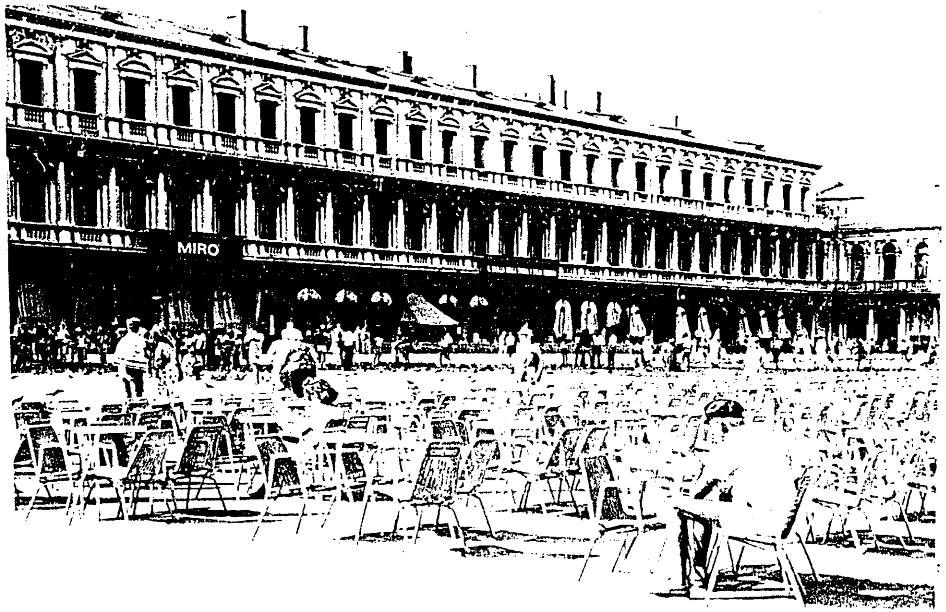
To obstruct the sun-rays striking the pavement and shop-fronts, canvas-canopies have been installed at the bottom of each arch-curve, allowing at the same time light to the windows above them. As in other quarters, these arcaded spaces extend the pavement surface area and protect it from elements when large metallic canopy and moveable awning canvas, all together, are added and fixed to them (the arcades). Such a combination can protect or allow solar radiation at will.

<u>Picture 5</u> (Extra example, not included in case-study)

Piazza San-Marco, Venice. The space is almost rectangular in shape and delimited on three sides by arcaded spaces at and along the ground level. Picture view looking south.

Date and day conditions: 1 August 1985, between 10 and 11am; clear sky.

The famous arcades surrounding San-Marco Piazza are almost five times the height of an adult person; and to




PICTURE 5.

protect space behind, from sun-heat, glare and maybe cold wind, typical shaped "curtains" made of thick white cloth are used for covering each arch opening. Those curtains can be drawn or positioned in three different manners (see that on picture), depending on weather conditions and sun position. This idea of adding curtains to the arcades' functions is an authentic process even for protection or for changing the space character.

Notice the curtains' harmony with the facade.

## 3.2 CONCLUSIONS

The use of arcades for protecting urban spaces from different climatic factors, such as sun-heat, glare, rain wind and dust, is a very old idea, exploited since the ancient ages by different societies and civilisations throughout the world.

Wherever they are used or however, they are designed, arcades have two main roles of importance: structural and protective. Looking to their protective conditions, the use of arcaded urban spaces is currently found in countries, such as the Mediterranean ones, which have climatic conditions dominated by harsh solar radiation. If in those countries, the first purpose of arcaded spaces is to protect people against the sun heat and light, the secondary ones should be the creation and gain of public urban spaces under building-sides. Moreover, this gained covered space performs as a zone of transition from the public domain (street) to the private one (buildings inside). Nevertheless, this transit zone is not semi-public but has its full public function and character, especially when public activities,

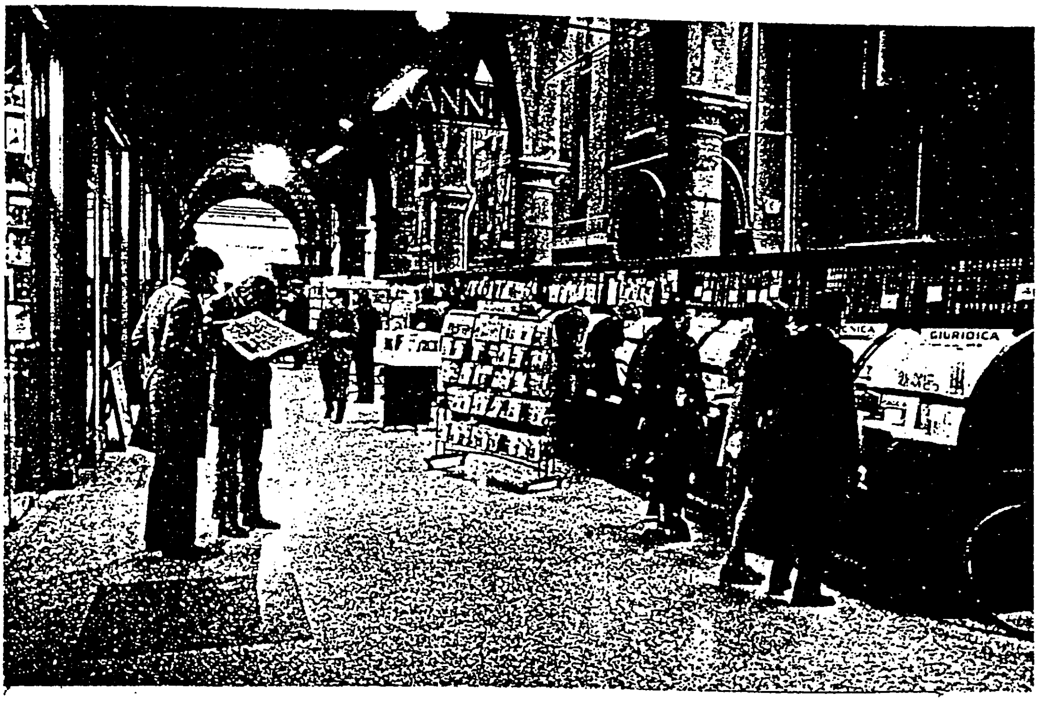



FIGURE 5.I Arcaded urban space,in Bologna,where different public activities take place.

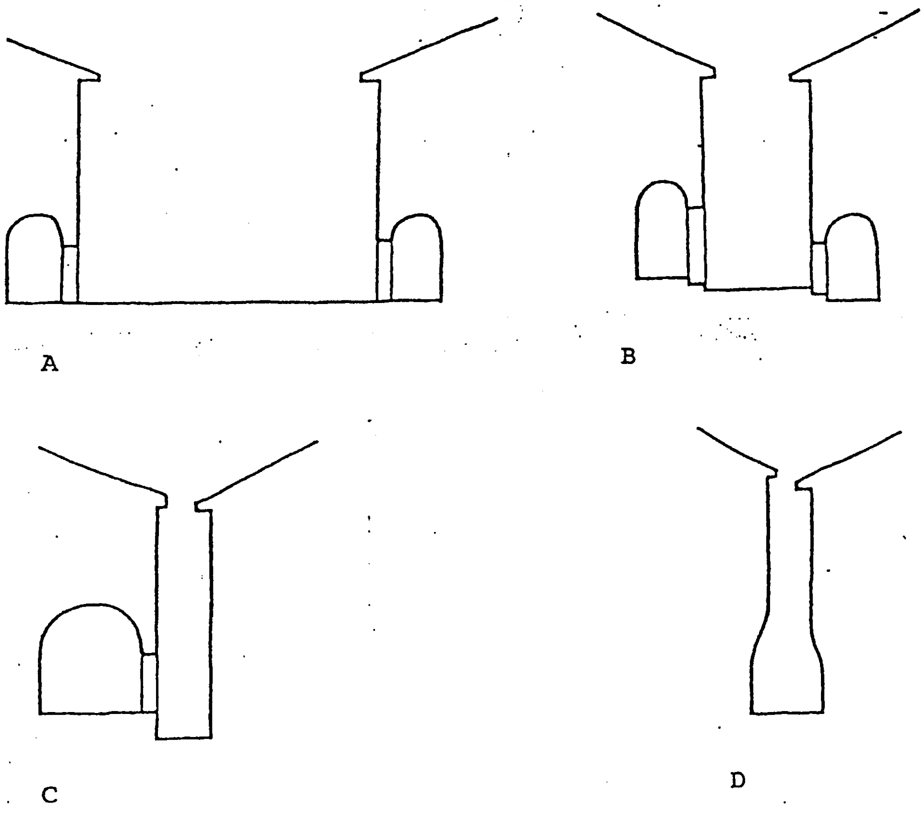



FIGURE 5.2 Various arcades profiles in Bologna,according to the floor movement and the traffic importance.

.A.double arcades with plan and continuous street floor.
.B.double arcades with multi-levelled street floor.
.C.single arcades.
.D.simple "corbellement".

such as shops, open markets, social facities,etc. are provided close to it. Conversely, arcaded spaces could serve as strong support to commercial development. Bologna, in Italy, with its famous arcaded spaces commonly used and diversely exploited, is an ideal example which one should mention in this matter (see figures No. 5.1 and 5.2 ).**

Beside this, arcading does a lot to relieve human stress, allowing the sense of safety, protection, defence, contacts, orientation and pleasure.

In northern countries with cold grey weather, the argument against arcading, a valid consideration before the artificial light revolutionised the urban scene, revolves mainly around the amount of daylighting lost to the shop-keepers, thus the loss in shoppers attraction. For example, in those countries, even without arcades, the north-facing side of a shopping street is less favoured by shop-keepers, presumably because receiving little sun, it is comparatively less attractive. Nonetheless, the obstruction of daylight by arcaded spaces is not so valid as the use of electric light gives better solution to the problem, hence the opportunities offered by arcades should be considered whatever the climate conditions. Again, many Mediterranean countries have proved the universal advantages of arcaded spaces, although some of them can be colder, wetter, windier and foggier than Britain for example.

** Note that those tow pictures are not included in the survey;the case of Bologna is just cited as a complementary example.

## 4. THE "SABATE" AND ITS PROTECTIVE ROLE

### 4.1 EXAMPLES ANALYSIS

Picture 1

View through a tunnel-like passage, traditionally called "Sabate", in Constantine traditional town (see the picture background). This partly covered street space - for pedestrian use only - is about 3 meters wide and 3 meters high, and under which some shops and dwelling-entrances are taking place on either side of the space.

Date and day conditions: 25 July 1986, around midday; clear sky.

This kind of Sabate - there are different kinds, see examples below - is one of the traditional Arab city features, serving as structural support for houses constructed above the street space and allowing the pedestrian flow at the same time. Such a process is considered as a way of making the city layout denser.

This covered space performs as shelter from harsh solar radiation and constitutes a sort of cool enclosed urban space which is more enjoyable and lively during summer-time. Notice the darkness of the passage and its height to the human scale.

Picture 2

View through a pedestrian narrow street, in Constantine traditional town, showing a succession of corbelled houses -

PICTURE I.

PICTURE 2.

facades and sabate.

Date and day conditions: 25 July 1986; 11am; clear sky.

This combination of corbelled facades and tunnel-like passage forms another kind of Sabate protecting the street space against sun, heat and glare.

Here, the street width becomes much narrower under the Sabate, increasing the shade's importance.

Notice the contrast of shade and glare within the spaces.

<u>Picture 3</u>.

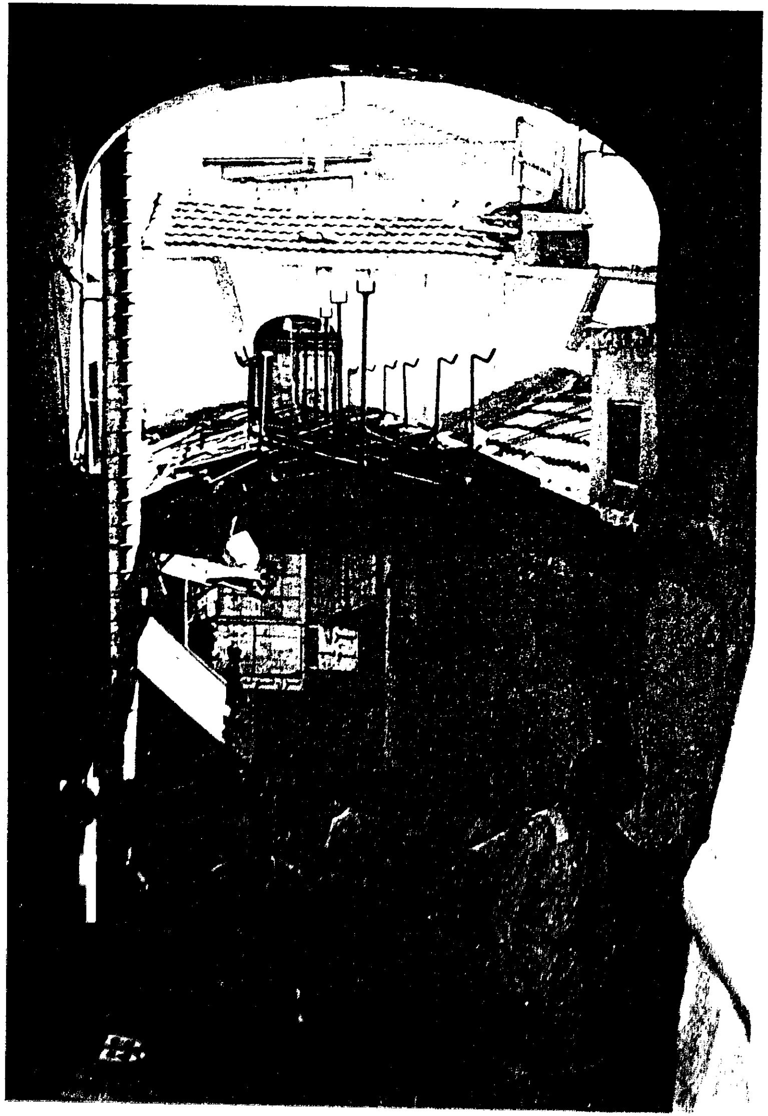
Detail of tiled roof covering a busy steep street - pedestrian use - in Constantine traditional town.

Date and day conditions: 26 July 1986, around 9am; clear sky.

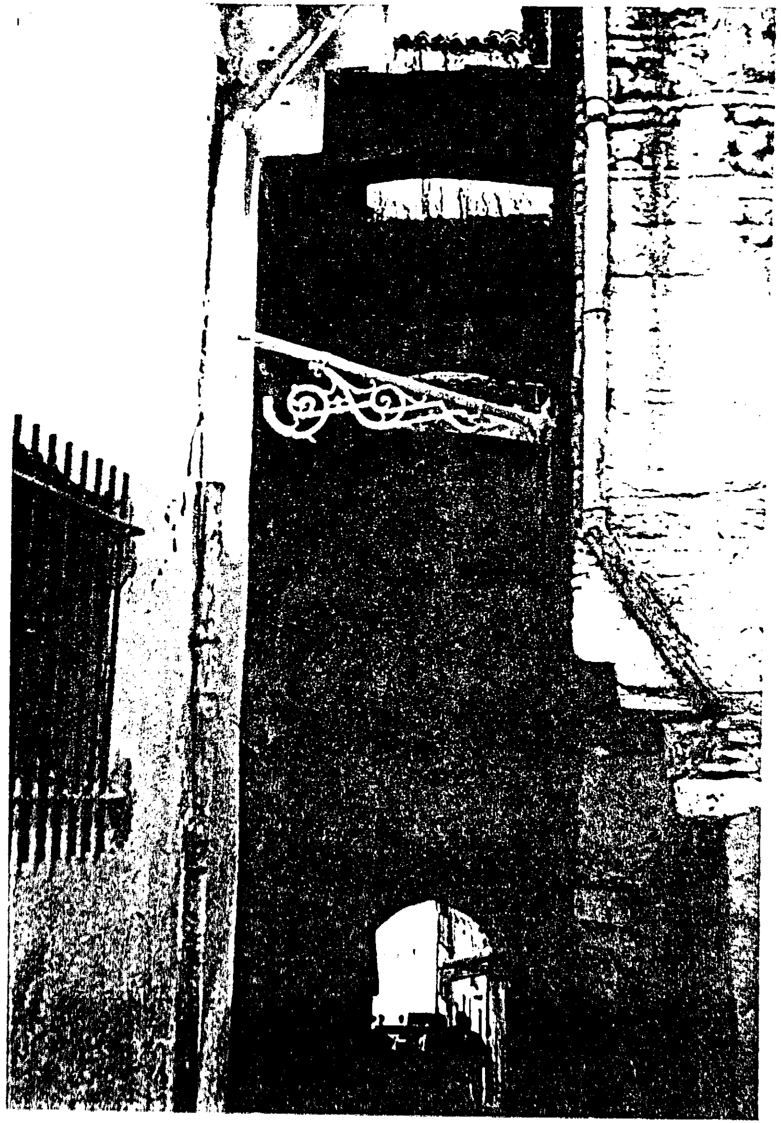
This tiled roof covering the street is a very effective form of sabate, because it can highly span over streets of reasonable width, thus protecting more space-volume without modification. This technique consists of a metallic frame-work supporting two superimposed sloping roofs (this picture does not show the upper damaged part which is normally held by these vertical stakes) with openings on either lateral side which allow air exhange and daylight.

This kind of covering is harmoniously integrated with the surrounding houses' roofs, and results in an authentic shelter from sun radiation, rain and even dust.

This technique performs best when fixed to the buildings, at roof level, in order to allow good daylight penetration and air exchange.



PICTURE 3.



PICTURE 4.

Picture 4

Another view looking overhead in one of the traditional town streets in Constantine, and showing the horizontal elements and a tunnel-like passage.

Date and day conditions: 26 July 1986 at 11 am; clear sky.

An interesting technique combining sabate shading with spanning brickwork elements covered with tiles which reinforce the buildings' stability and their external walls. The stabilising elements articulate the top of the building sides at 1.50 meters interval. These elements perform as shading devices over the street; but for an optimal shading achievement, considerations must be made of the street orientation and the positioning interval of these elements.

This technique could be easily applied to some existing streets when using light materials instead of masonry.

Again, notice the contrast of shade within the space and glare outside it.

## 4.2 CONCLUSIONS

Found in traditional Arab cities such as Constantine old town, Casbah of Algiers, Fez.... etc., this sort of covered passage, which most of the time has the appearance of a tunnel, is traditionally called "sabate". These sabates, built in different manners, are the result of many design processes not necessarily aiming to achieve any climate control within urban spaces, but to provide profit by increased building volume or to maintain stability.

During winter-time; this tunnel-like space becomes completely moist, dark - artificial light is scarcely used in such spaces - and smelly. The winter wind channelling through, gives the space uncomfortable conditions; thus, the summer enjoyable space becomes the unlivable one.

These conditions apply to examples 1, 2 and 4 as shown, but example 3 which is purpose built as a sabate overcomes most of the problems, but it raises the question of ownership and maintenance as it obviously joins buildings of different ownership. Example 4, if developed, could be very useful.

## 5. AWNING CANVAS AND BALCONIES' SHADING

### 5.1 EXAMPLES ANALYSIS

Picture 1

Daily market street in a traditional Constantine town, covered in some places by hinged canvas and overhangs by the shop-keepers for shading their shop-fronts and exposed goods.

Date and day conditions: 27 July 1986; around 1pm; clear sky.

The hinged canvas are temporarily used - during summer time - to shade the street space and protect it from sun heat and glare. Here the devices cover, in many parts, the whole street width and even "placettes" by being placed horizontally and fixed with long threads to the houses

PICTURE I.


PICTURE 2.

external walls on both sides of the space, thus making large splashes of shade over the street or "placettes" floor.

In this case, houses are not high enough to cast the necessary shadow for people's activities in this space, therefore canvas are placed low, close to pedestrians,

Picture 2

Also daily market street (via S.A. Abate) in Naples old town (see survey plate No. 4 for detail), showing awning canvas over shops' entrances.

This kind of canvas is differently fixed (compare to example 1) and used in almost continuous manner on either side of the street, allowing an open space to the sky left inbetween, thus shading about 2/3rd of the total street width. Even clothes hung for sale add some protection to shoppers or pedestrians from sun heat and glare.

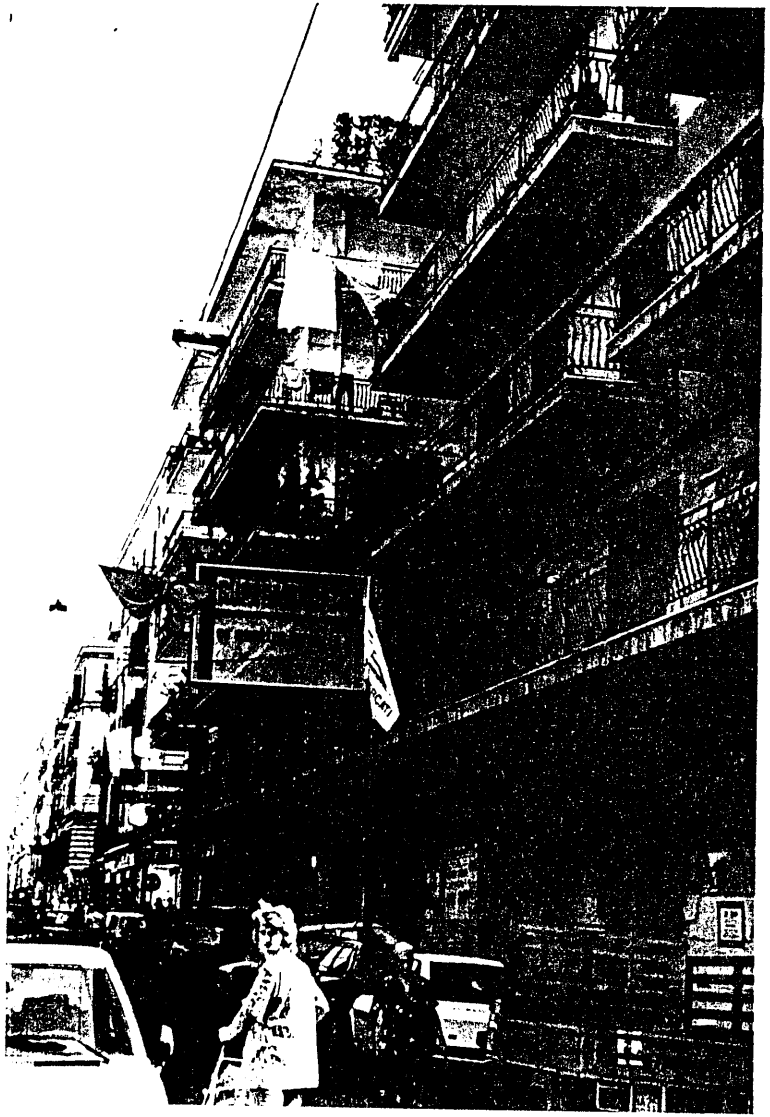
Note: These two examples raise the question of the right of shop-keepers to attach their stings or obstruct view to the immediate buildings' dwellers or owners.

Picture 3

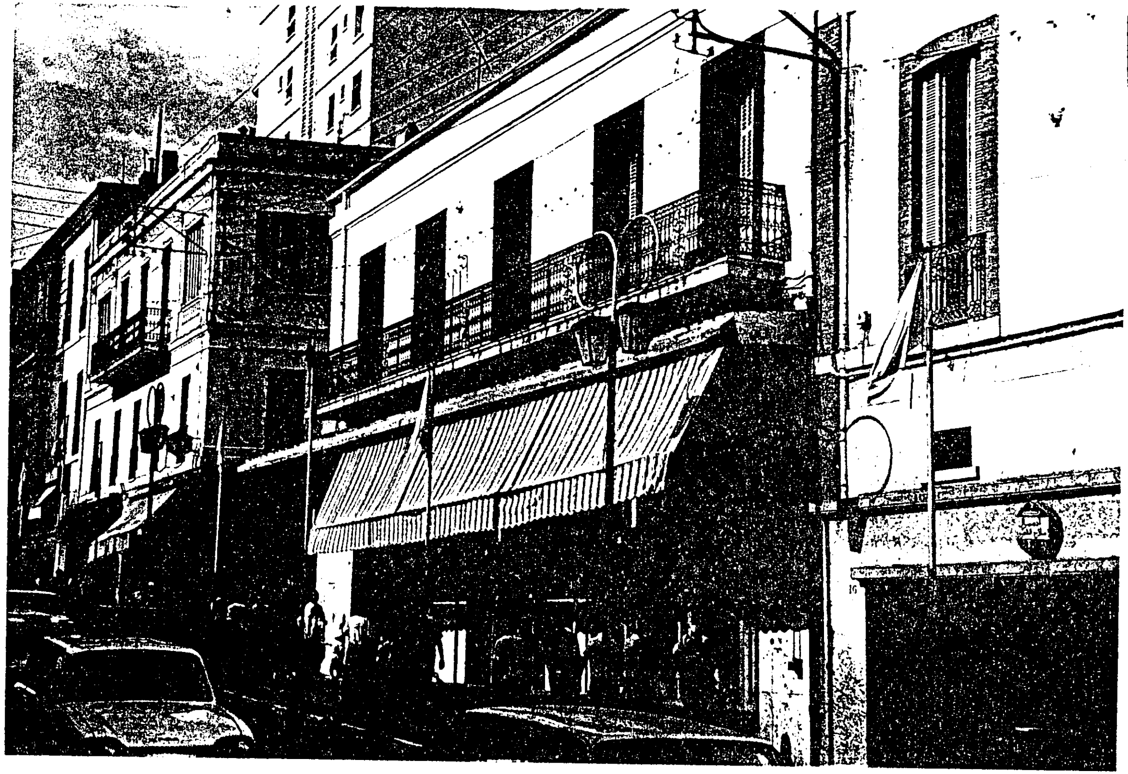
View showing a detail of building facades with a character mainly dominated by long overhanging balconies, in Naples.

The street is oriented east-west and limited on either side by buildings of six storey-high. The street width is almost of the same importance if compared to buildings' height.

Date and day conditions: 3 October 1986 at 2pm, clear sky.



PICTURE 3.



PICTURE 4.

This kind of long balcony over a sidewalk performs as an authentic shelter from summer solar radiation and winter rain, especially when their depth is the same as the pavement width.

Notice also, the importance of the above balconies which could reduce the amount of sun heat, striking the facades, by casting their shade over openings and walls.

Picture 4

Detail of canvas and balconies along a pavement in Constantine French quarter, (see survey plate no. 1 for detailed information).

Combination of awning canvas and balcony. In this instance, the flexible device seems to extend from the balcony, and cast shade mainly over the shop-front, because in this case the buildings facing this one and on opposite side (east) are much lower, thus allowing solar radiation in the morning - picture taken around 9.30am. Such a combination of devices is much more effective for shading when the sun is higher in the sky (around midday for example), thus the shade will vertically cover the pavement.

## 5.2 CONCLUSIONS

In countries with hot-dry climates, shading devices such as awning canvas, canopies, tents, umbrella...etc. are widely used to protect different kinds of urban spaces from solar radiation, glare, rain and even dust. Compared to the other shading devices, awning canvas is light in weight, flexible, adjustable and inexpensive to buy. However, canvas requires continuous replacement, adjustment, and highly susceptable to strong winds unless very well designed. New materials have greatly improved its strength but as yet all such man-made fibres are susceptable to ultra-violet decay and are therefore not a great improvement over traditional materials such as cotton or flax when used to stop the sun-rays.

The adaptability of canvas means that it can be used for a single person's umbrella to great tents covering thousands of people and that such structures can be easily moved or removed.

Canvas can easily accept colour. This combined with its light temporary nature creates a gay and often charming effect.

To this protective element, the canvas, I would like to add here another shading device: the awning balcony, even if it has completely different characteristics and purposes when compared to the previous device: the awning canvas.

Nevertheless, awning balconies are also apt to provide protection for pedestrians from sun and even rain, when they are designed at the buildings' first floor, immediately over the sidewalk. Moreover, their protective importance depends on their depth to the pavement width and also their length.

Unfortunately, the design of such a device or element to be used for solar radiation control is not under the direct decision of the urban designer.

## 6. ENCLOSED URBAN SPACES AND THEIR PROTECTIVE ROLE

There are some additional urban design processes found out during the survey in Constantine and Naples, and which I consider as effective for protection of some particular urban public spaces against the sun radiation; and even rain, wind and dust.

Looking to their design process aims, such public spaces have not necessarily been conceived to control climate.

### 6.1 EXAMPLES ANALYSIS

Picture 1

Underground pedestrian passage in Constantine city centre, containing shops and some public facilities.

The picture was taken during the day, July 1986, around 9 am. Day conditions: clear sky.

This space of 3 meters high and 5 meters wide, stretching out in different directions, is effective at separating pedestrian and motor car flows at many congestion points of the city centre. Moreover, such underpasses, busy and well designed, constitute a sort of cool and airy cellars during the hot period, but warm and humid during the cool one: the real problem such spaces have is the wind pressure and channelling at some badly oriented entrances.


PICTURE I.

Picture 2

View inside the "Umberto I" galleria in Naples. The picture was taken around 1 pm, 3 October 1986.
Day conditions: sunny and warm.

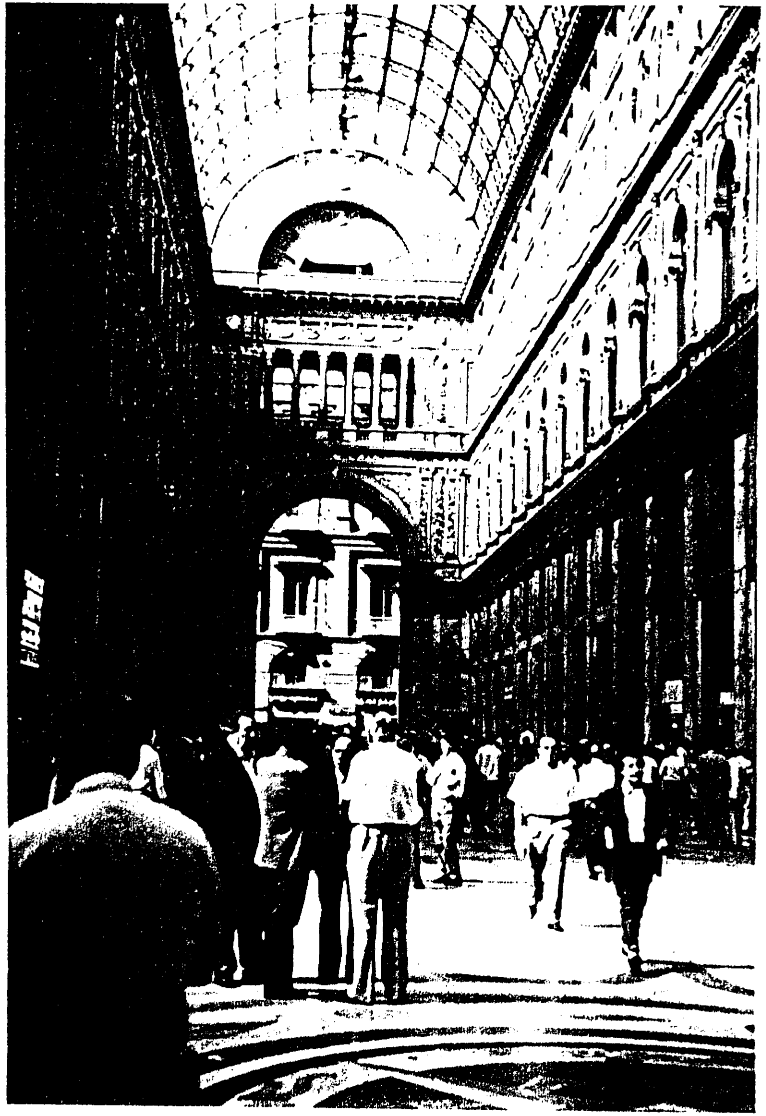
More than just a prestigious piece of architecture or urban work, belonging to the Italian tradition, the "Galleria" sumptuously covers an important urban area where many activities - from the artistic to the commercial ones - take place. With its high curved glass roof and large entrances opening onto four different streets, the galleria is perhaps the unique space to have urban and architectural characteristics at the same time. Walking into it, this space provides an ideal sensation of thermal comfort as it is protected from all bad climatic conditions and even from traffic noise and air pollution. For ventilation, the galleria performs by having large windows placed under the glass roof, and which excavate the rising hot air which is replaced by the cool one through its entrances.

Picture 3

View inside a particular "Courtile" in Naples, with shops at the ground level and dwellings above.

The picture was taken around 2 pm, 3 October 1986.
Day conditions: clear sky; sunny and warm.

The "Cortile" is another Italian idea in building design. This particular urban space previously described (see CLIMATIC CONTROL & URBAN SPACES IN NAPLES P.75) should also be considered for its protective role against solar radiation, depending on its size and height - number of



PICTURE 2.

PICTURE 3.

building storeys surrounding it. Compared with the courtyard in an Arab house, the courtile performs in almost the same way, by cooling the indoor spaces around it and exchanging air from its large entrance.

The Courtile idea could be applied to new urban developments in hot countries.

## 6.2 CONCLUSIONS

The urban forms of Italy are world famous; the two items: the galleria and cortile, in common use in Naples, could well be imported to the Algerian context.

a. The galleria creates a large impressive public space and although the roof is an expensive item, the buildings could exist without the roof. So it is only the roof that is an "extra". For this expense, the public gains a well protected space from sun and rain. When used over commercial premises, this gains extra customers.

b. The cortile, a large public courtyard, requires a considered width to height ratio for success. It also creates a strong sense of place and acts climatically to give a protected space.

# 7.00 THE STREET SPACE AND SHADING

## 7.1 INTRODUCTION

As a tridimentional urban space, the street is principally defined by aligned buildings which limit it on either side, in a longitudinal manner and generally give it the sense of narrow enclosed space. Those buildings fencing the street space have a determining role in protecting it from solar radiation and heat by casting shade on the floor space - occupied by people - and may be from strong air movement by acting as a wind-break; but to achieve an adequate protection from harsh solar radiation and wind defects, some important criteria such as the ratio of building height to the street,width, the street's orientation, its localisation within the urban layout, and the sun's movements during the four seasons in a particular region, should be taken into consideration.

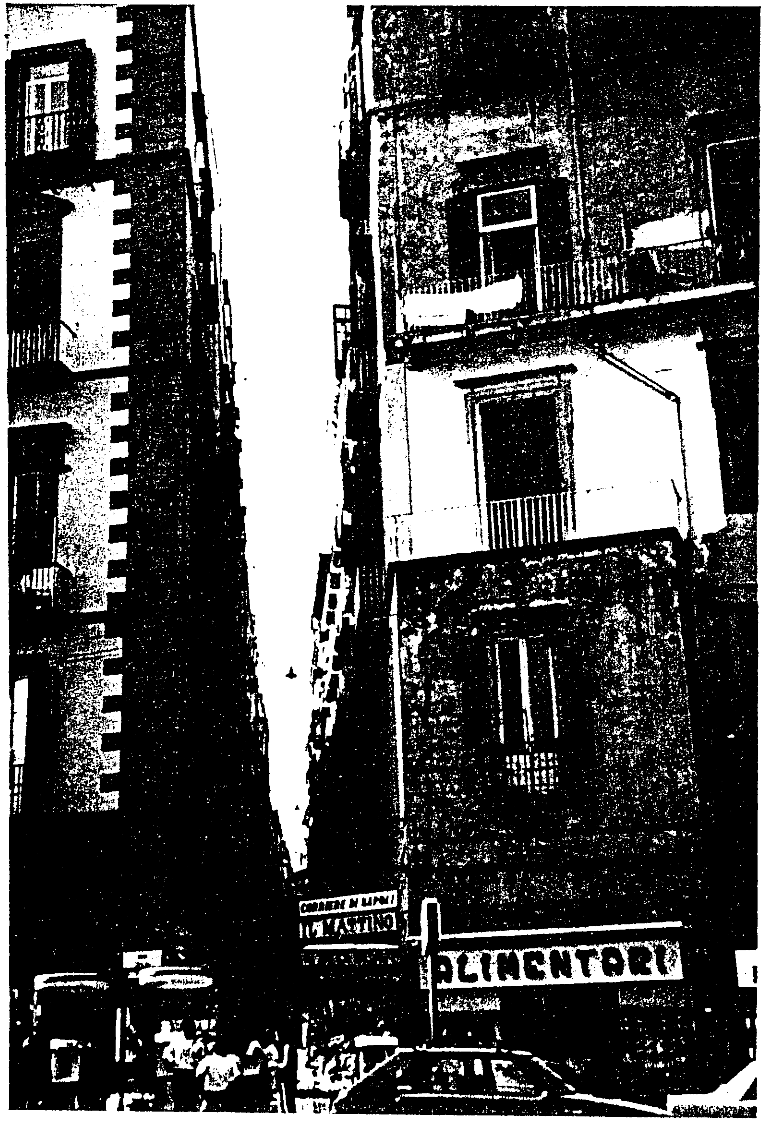
To protect street space from solar radiation excess during the hot season and maybe from unpleasant winds, such a process has been used since the ancient time, in regions with hot-dry climate.

Before going through the different shading performances within a street space, it is necessary to first consider the following specific cases of street shading processes.

## 7.2 EXAMPLES ANALYSIS

Picture 1

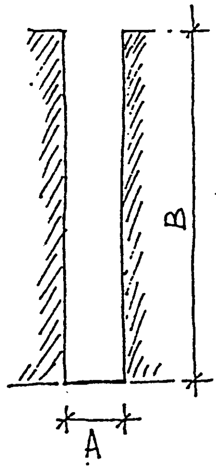
Street in Naples old town, running north-south and opened onto the seashore. If compared to the street width, buildings here are five times higher (R = 1/5).
Date and day conditions: 3 October 1986, 2.30pm, clear sky.




PICTURE I.

PICTURE 2.

The narrowness of this street is very noticeable, and this may lie behind its important length, and the awning balconies which could considerably reduce - even visually - its width. The street is for pedestrian use only and is shaded enough. One would expect that this shading is even exaggerated, even in summer time, which leads to very uncomfortable conditions during the winter period.



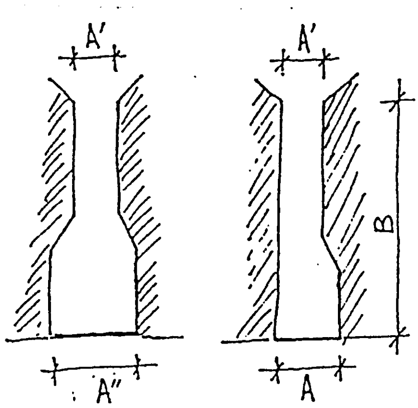

R=A/B=1/5

The street space will be under shade during the whole day-hours, except around midday when the sunrays will shine along it.

Picture 2

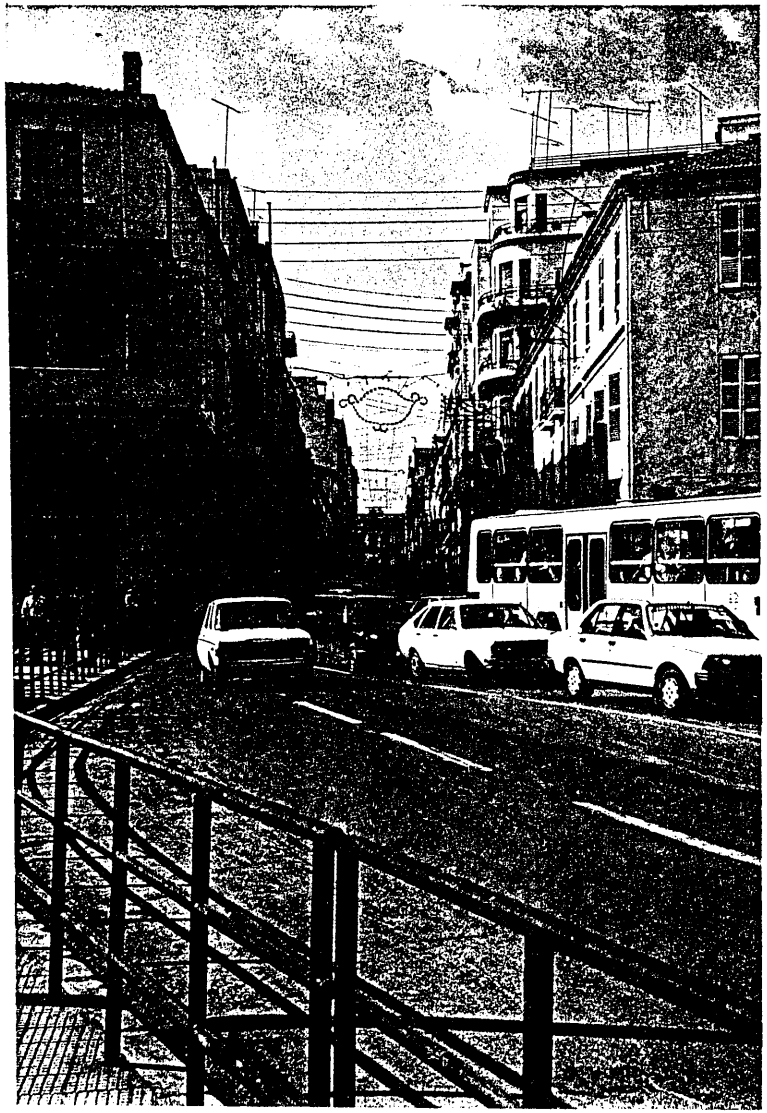
A view through a street in Constantine traditional town (all the area around is in decay), running east to west. The same street has got different widths, thus different ratios (see figure below). Date and day conditions: 25 July 1986; at 11am; clear sky.

In contrast to streets in Naples old town, those in Constantine traditional town are very different in conception. The corbelled facade, shown on the picture, does not just break vertically and transversally the street space, but also its linearity.




R"=A"/B=$\frac{1}{3}$ R=A/B=$\frac{1}{4}$

R'=A'/B=1/5 R'=A'/B=1/5



PICTURE 3.

PICTURE 4.

This space irregularity with an unstable ratio of width to height - from ⅓ to 1/5 - results in various shading casts over building facades and street floor. These differences in shading create better protection from summer sunshine and make the space more lively, especially by the mixture of brightness and darkness. Again, one could expect that the corbelled walls would lessen the winter sun penetration to the street space.

Picture 3 and 4

Axial views through one of the main streets in Constantine (French quarters). This street is running north to south. Date and day conditions: 25 July 1986, at 10.15am; clear sky.

Different from the two examples above, this street - for mixed uses - has got another character which is mainly seen in its variable ratios, and that is, first, because of the difference in building heights in the eastern row (left on the picture) varying from two to six storeys high; and second, because of the constant and much important height of buildings in the western row. As such, the street is better protected by the western row, during summer, from hot afternoon radiation by casting shade. Moreover, one can summarise that the eastern buildings row, by its irregular buildings-heights, allows the winter sunrays to reach the street space and the eastern facades of the opposite row during the morning; but conversely will cause them to heat up during the summer mornings.

## 7.2 SHADING PERFORMANCES WITHIN A STREET SPACE

From the previous analyses and statements made about the different shading devices and techniques, one can say that the street space is the "container" of all the preceeding devices such as trees, awning canvas, sabate,.... etc; except for the galleria which represents a special case.

It is necessary that for any shading design, considerations should simultaneously be taken both for street characteristics such as orientation, space volume, ratio, dimensions, etc...., as well as the chosen additional device or devices.

However, for a shading amelioration to an existing street space, it is necessary first to study the listed different shading devices and techniques, and their particular performances and possibilities of application to such a street. In this respect it is impossible to give, here, any accurate and specific recommendation which could be used as a shading design guide, because this is another task needing an extended and thorough analyses and various laboratory experiments. Nevertheless, some general deductions, drawn out from the shading analysis within street spaces, need to be discussed.

For instance, it is obvious that some shading processes or devices such as arcades, tunnel-like passages, and probably balconies could not be added to an unshaded existing street, because such an operation, even if possible for some specific cases, raises other problems like alterations to the urban fabric. Those shading processes and devices perform better if used for newly designed urban spaces or areas.

The addition of trees as shading devices in a given street is possible, but needs some care. For example, streets with wide pavements - more than three meters each - can easily accommodate tree planting and give positive shading results.

For narrow pavements - as shown, for instance, in picture No. 3 - where problems such as disturbance to pedestrian flow and space encumbrance will be provoked.

Shading by trees planting, within a pedestrian street of more than six meters, is also possible because with such a minimum width, trees of reduced foliage shape, such as the two species found in Naples and Algiers - see Picture 2 and 3 in pages 98 and 100 , could be planted in a single row along the street axis, to give sufficient shade to the floor.

Finally, the use of awning canvas, canopies and other covering elements, within existing urban spaces, is easy, cheap and gives a solution for permanent or temporary shading.

Nonetheless, the application of such devices for street shading could be restricted in some cases, because of the involvement of some urban regulations which have to be considered. For example, the addition of transversal elements over a street should not completely subdivide the street space and obstruct the open view, even for pedestrians or for the surrounding buildings' dwellers. Such a device could be better applied to pedestrian streets with low building heights, to take profit from the shade cast by those elements over the whole street floor.

*** HELIODON EXPERIMENTS ON STREET-MODELS. ***

## 8. HELIODON EXPERIMENTS ON STREET MODELS

Having stated some ideas and thoughts about the most advantageous devices and techniques for shading, I found that it is necessary to extend the analysis by some laboratory experiments.

From the six classified types, I find that the street space, as defined previously, is the primary process to be used for solar radiation control by means of shading cast over the street space itself. Stating that, it is because every city or town layout has as basic structural elements: building grouping and street space inbetween. Those building groups, intentionally or not cast shade over each other, and thus over the street spaces separating them. However, to know about the shading position during a particular period of the day and season is a complex matter. Those complexities are the yearly sun-path of a given location, the street orientation and the ratio of its width to building height.

In addition to those parameters, consideration to the building-facades character should be taken, because those facades may have building-elements, such as balconies, projecting slabs,.....etc., which also affect shading within the urban space.

In this respect, I have made some experiments on street-models by using the Heliodon with movable table, and by establishing at the first stage two constant parameters: north latitude of $36^{o}13'$ (case of Constantine city) and as a particular day: the 21st July (one of the hottest days in the same location).

The other changing parameters, such as street width and orientation, building arrangement, height and their facades characters, were all deduced and chosen from the surveys. The reason in proceeding so, is to limit my experiments - which could be endless - and to understand how this particular urban space can be optimally protected by shade during the overheated period when solar radiation has a considerable defect on pedestrians' comfort; hence to draw out some conclusions for an optimum shading relating to some design processes.

Note that the street models are considered for both uses - pedestrian and vehicular - except for the fourth experiments which is considered as only for pedestrians. The models scale 1/200 centimeters, and the uniform buildings height of 18 meters (5 storeys; the urban norm in Algeria) are kept unchanged for the five experiments.

## 8.1 SEPARATE COMMENTS ON EXPERIMENTS

### FIRST EXPERIMENT

*Model orientation: south to north
*Vehicular floor width: 6 meters )
*Side-walk floor width: 3 meters (each) ) R1 = $\frac{2}{3}$
*Facade character: simple opening without balconies or other architectural elements.

This first experiment shows an ideal shading over the whole street floor during most of the day, but not between 10 am and 2 pm when only one of the two pavements is exposed to solar radiation. After 11am until 1pm there is only shade on the leeward building, the pedestrian will be exposed; and at midday there is no shade, as the sun shines directly along the street space axis.

SECOND EXPERIMENT

*Model orientation: south to north

*Vehicular floor width: 7 meters )
*Side-walk floor width: 3 meters (each) ) R2=13/18

*Facades character: Balconies on each floor level and for both sides of the street.

By having long balconies of 1.20 meters in depth and projecting over the pavements, this experiment when compared to the first one shows a certain gain of shade cast by those balconies, particularly around midday when shade was completely lacking. This shade protects the two pavements during such a critical time - 11 am to 1 pm.

THIRD EXPERIMENT

*Model orientation: 22° south-east

*Vehicular floor width: 7 meters )
*Side-walk floor width: 3 meters (each) ) R3 = 13/18

*Facade character: Balconies on each floor level and for both sides of the street.

In comparison to the two previous experiments, the shade shown on this one is different, and this difference results from the model rotation of about 22° from south towards east. Here, the shade cast by buildings is too short when compared to the second-experiment one- and of diagonal character even on facades or on street floor; this results in an insufficient shading to protect pedestrian areas against solar radiation.

Balconies' shading, in this case, is still of the same importance as it is in the previous one.

## FOURTH EXPERIMENT

*Model orientation: south to north

*Street in this case is only for pedestrians, and 6 meters wide; R4 = $\frac{1}{3}$

*Facades character: simple openings without balconies or other architectural elements.

In this case, shading over all the street floor is complete, except during the period between 11am and 1pm when at least half of the street-floor is directly exposed to the sun. This shading result, due to the decreased total street width from 12 meters to 6 meters, should be considered as a real achievement for the general overheated period, especially when compared to the three previous experiments. During the underheated period, when sun is more low in the sky, shading for this case will be even greater and may cause some uncomfortable conditions within this urban space.

## FIFTH EXPERIMENT

*Model orientation: south to north

*Total street width including pavements: 25 meters } R5=25/18
*Side-walk floor width: 3 meters (each) }

*Facades character: simple openings without balconies or other architectural elements.

*Trees dimensions: 8 meters for tree height; 5 meters for foliage diameter.

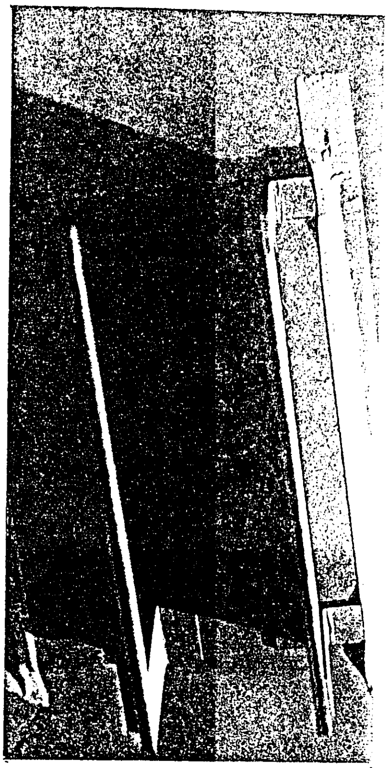
In this last experiment, the street is much wider (25m) than it is for the previous instances, but the buildings-height (18m) remains the same. For this model, trees with medium foliage size and of particular dimensions have been planted along either side-walk. We notice that the shading by buildings over the two pavements is less effective during most hours of the day, except in the early morning - from 6 to 8 am - and in the late afternoon - from 4 - because from 8 am to 4 pm the two side-walks could not be shaded at the same time, one is shaded on the forenoon and the second on the afternoon. However, the amount of shade cast by trees over pavements is considered as an almost authentic compensation to the non-shading hours (8 am to 4 pm) although trees are planted quite far from each other (6 meters). They will make better shading if their foliages are grown in a continuous manner.

In conclusion, this experiment shows better shading both from buildings and trees, despite the street width which is much more important when compared to the widths stated in the four previous experiments, and the cause of that is the addition of trees as complementary shading device.

Moreover, trees increase the shading so that intermittent shade is available on the exposed pavement during the normal working hours, for example, from 9 am to 4 pm and even the mid-day total exposure is ameliorated by the intermediate tree shade on both pavements.

Note: one can see clearly from the model the advantage of a continuous tree-canopies.

*** FIRST EXPERIMENT ***



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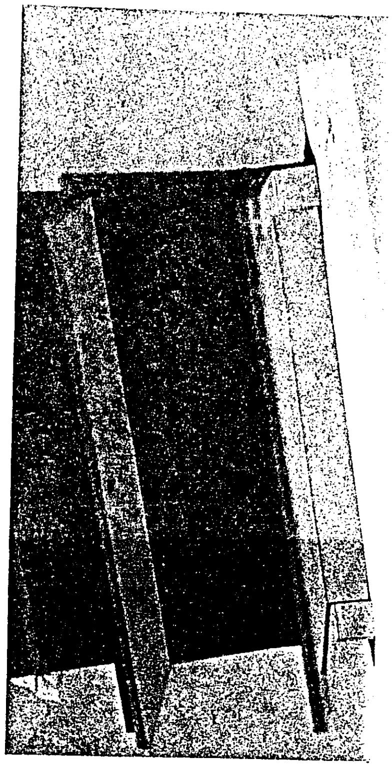

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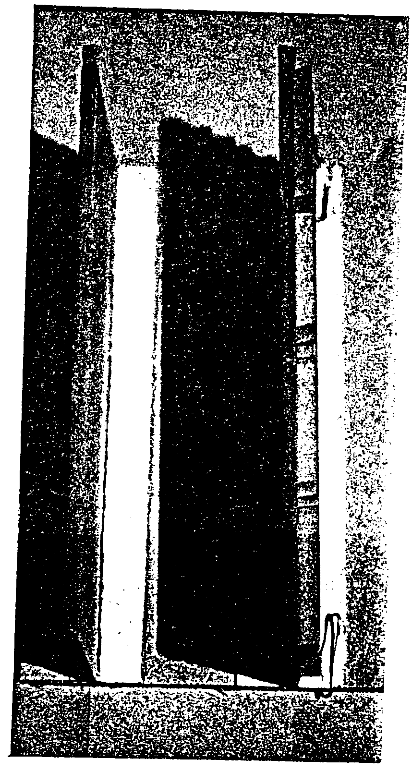

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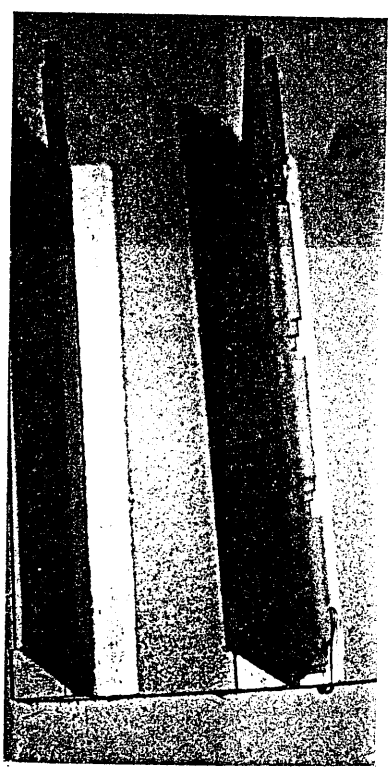

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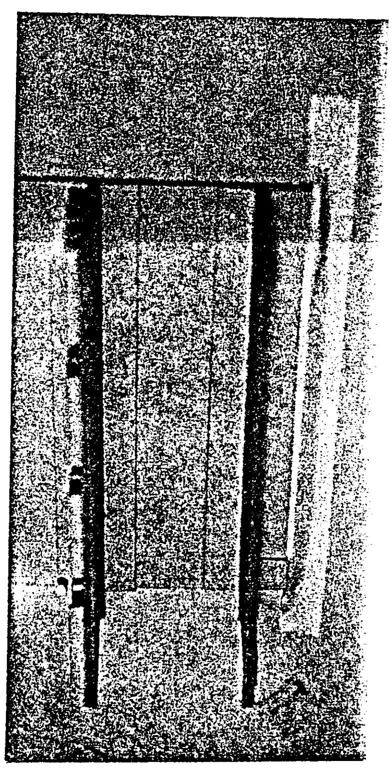
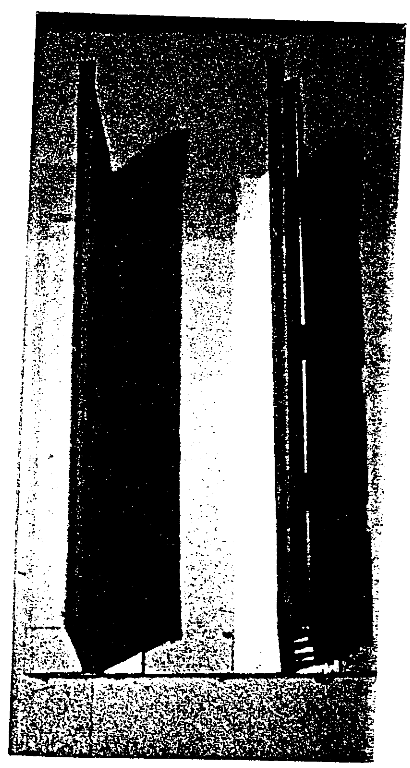


Midday.



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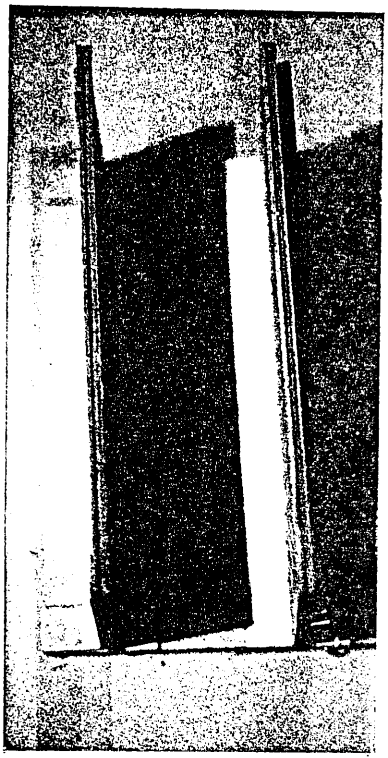

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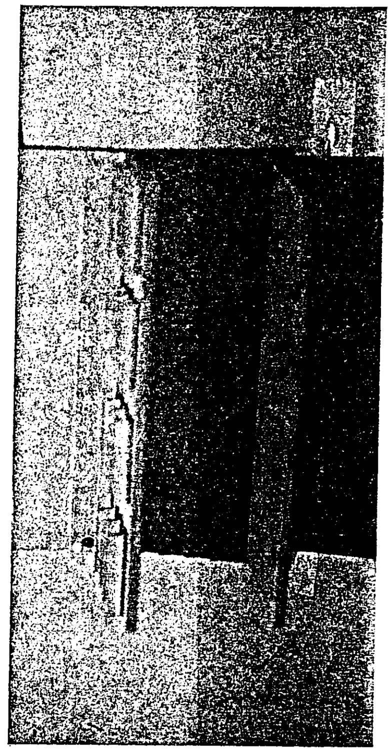

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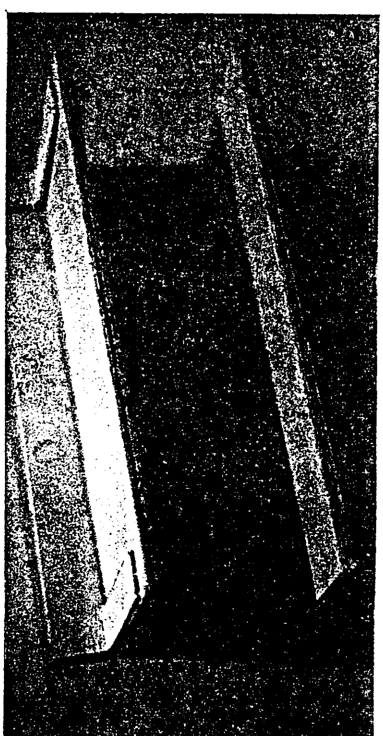

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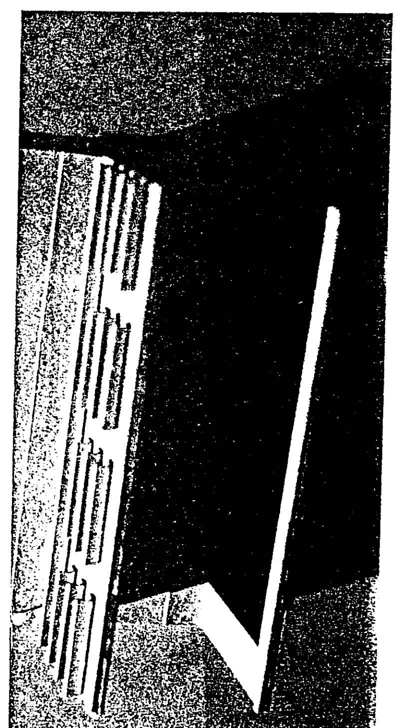

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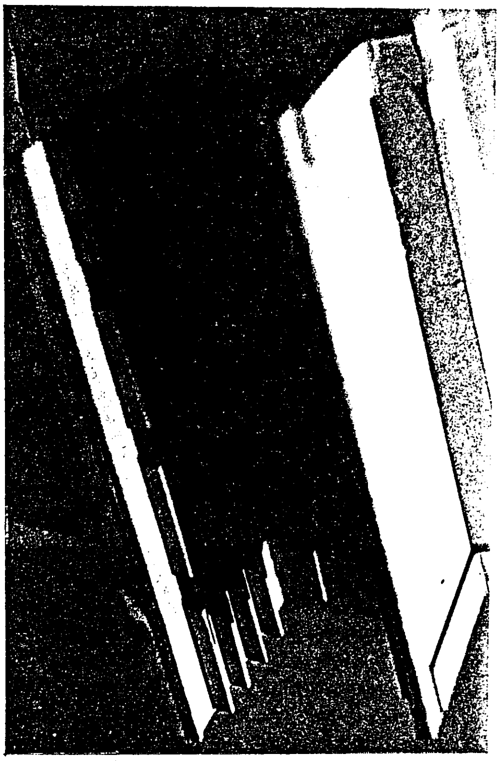
*** SECOND EXPERIMENT ***



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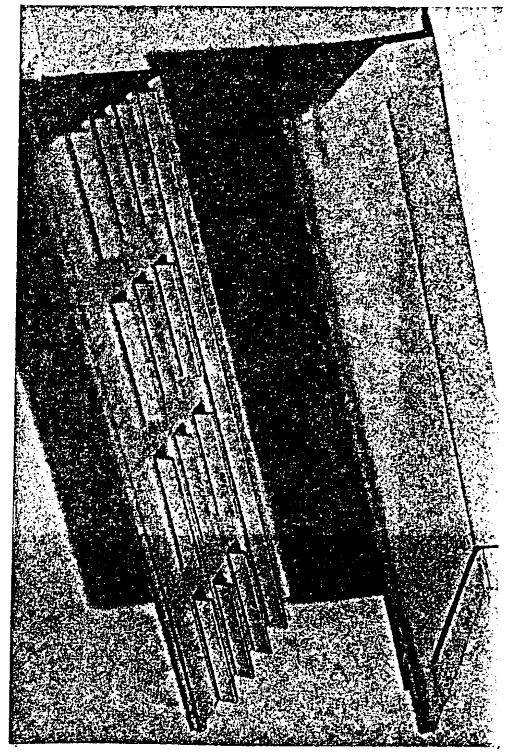

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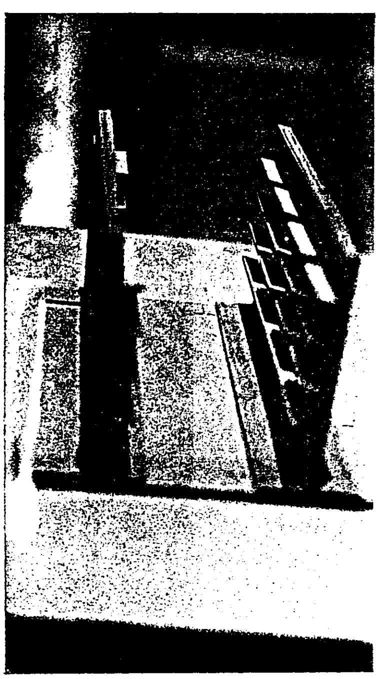
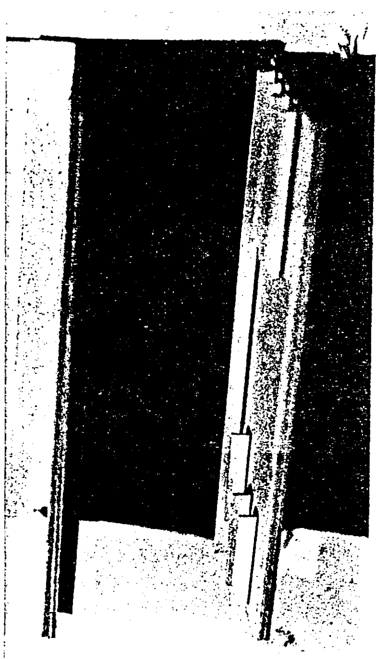


Midday.



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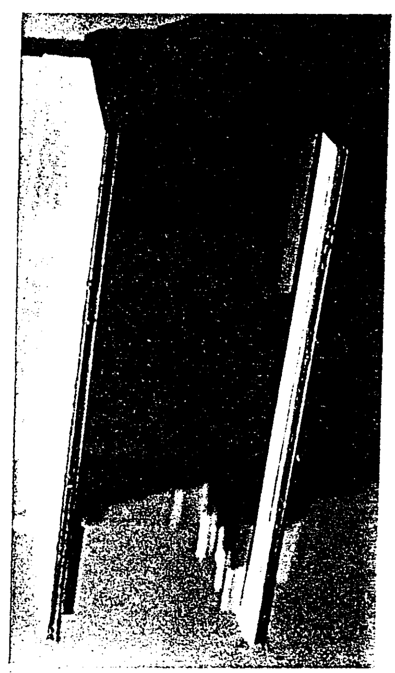
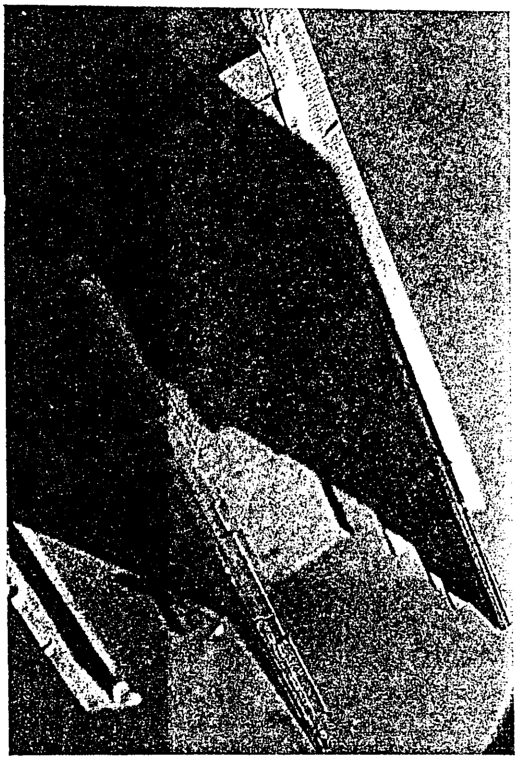


6 pm.

*** THIRD EXPERIMENT ***



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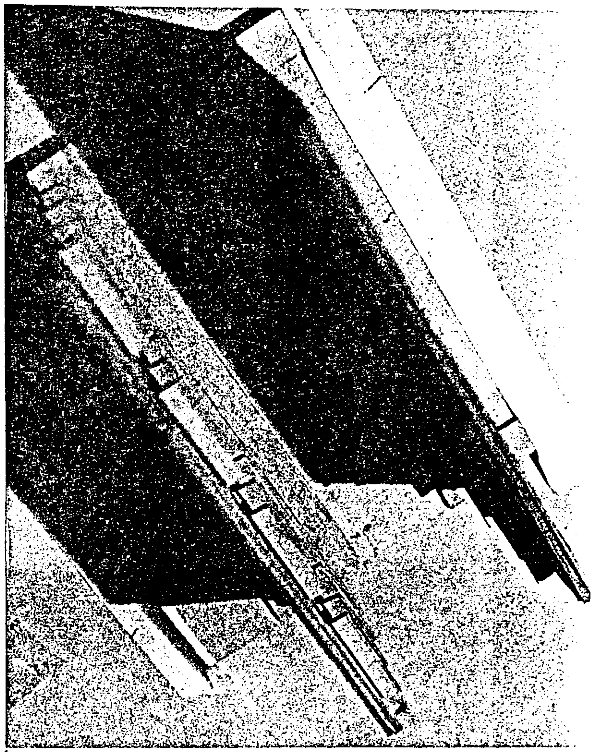

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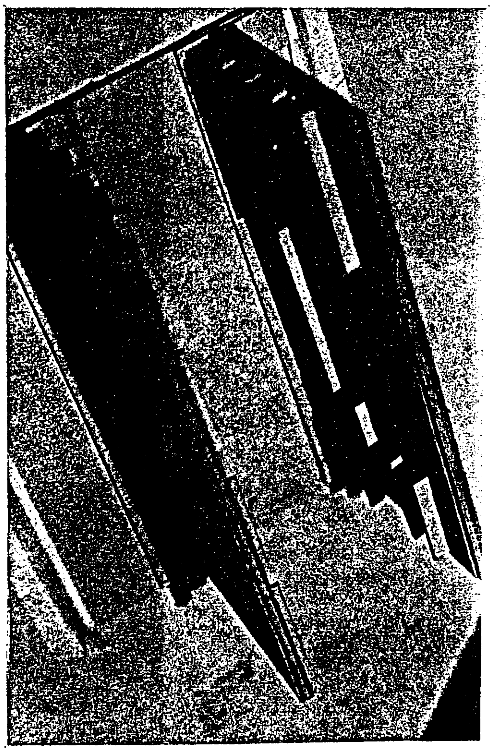
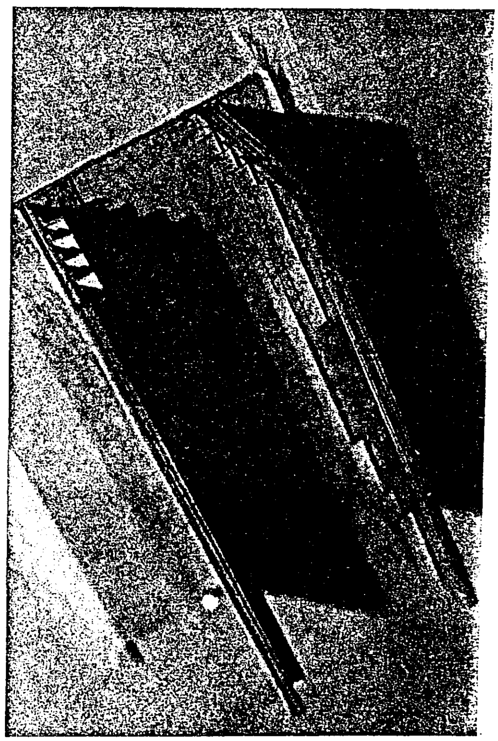


Midday.



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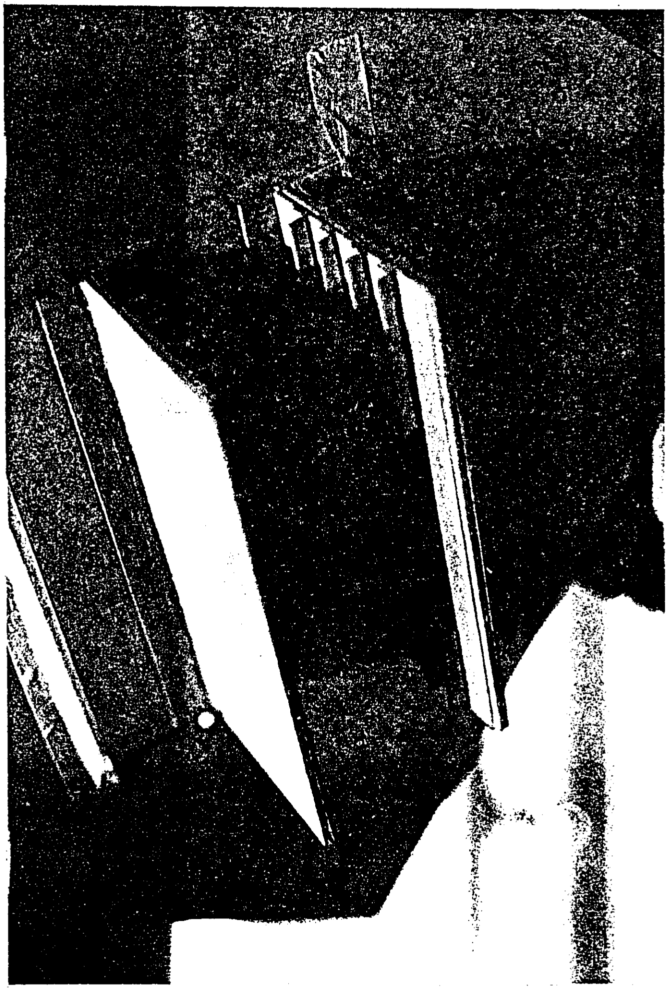

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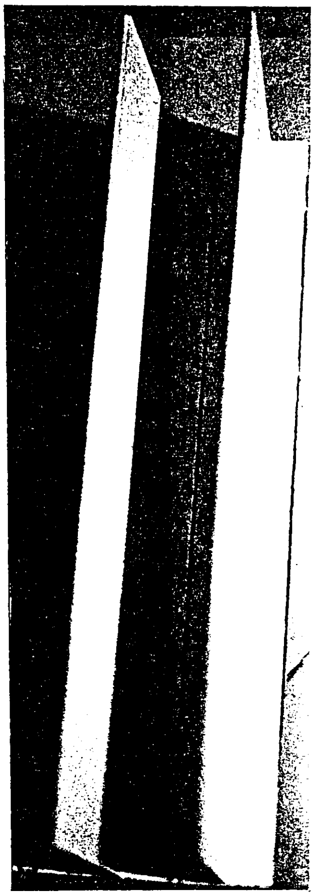

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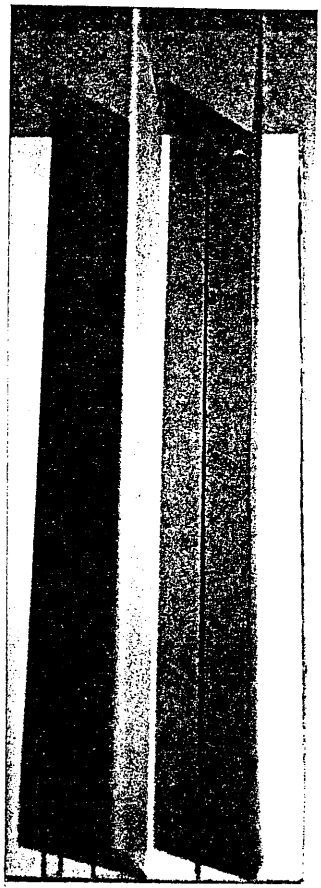

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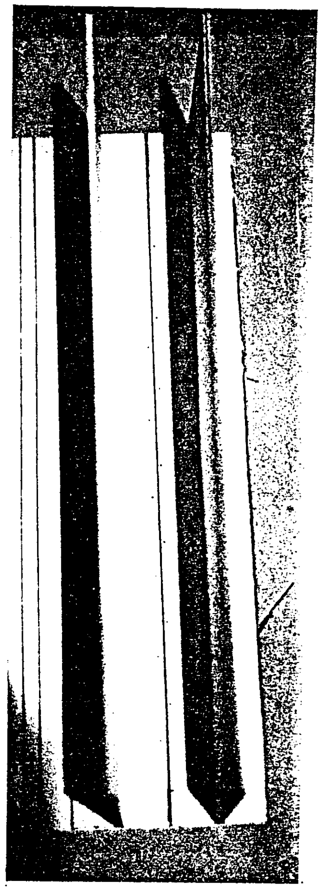

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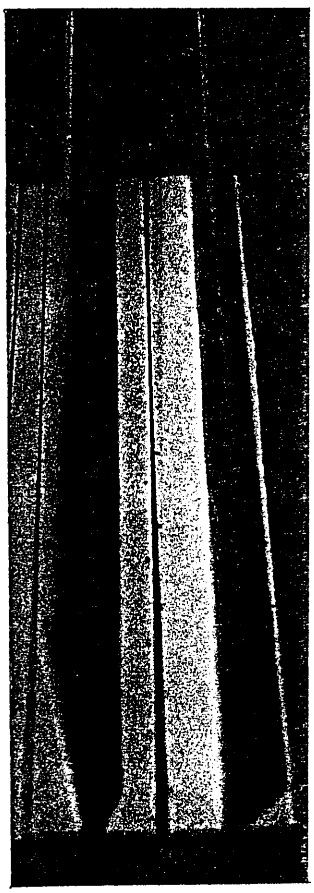

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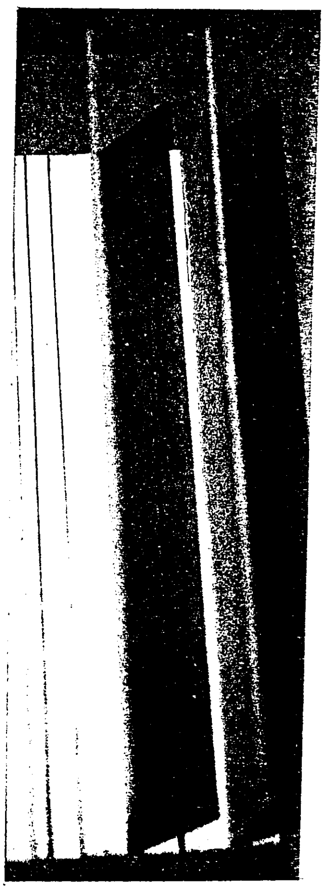

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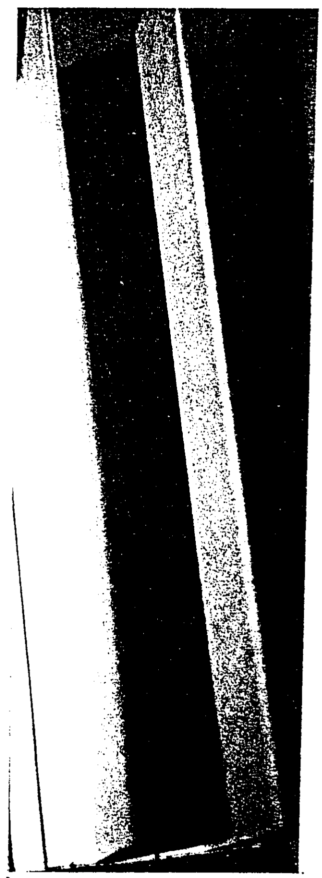

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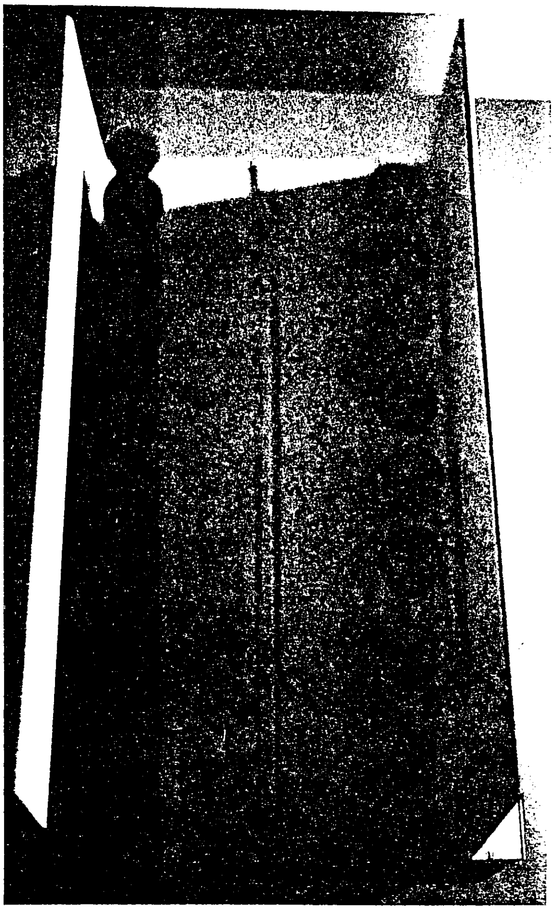
*** FIFTH EXPERIMENT ***



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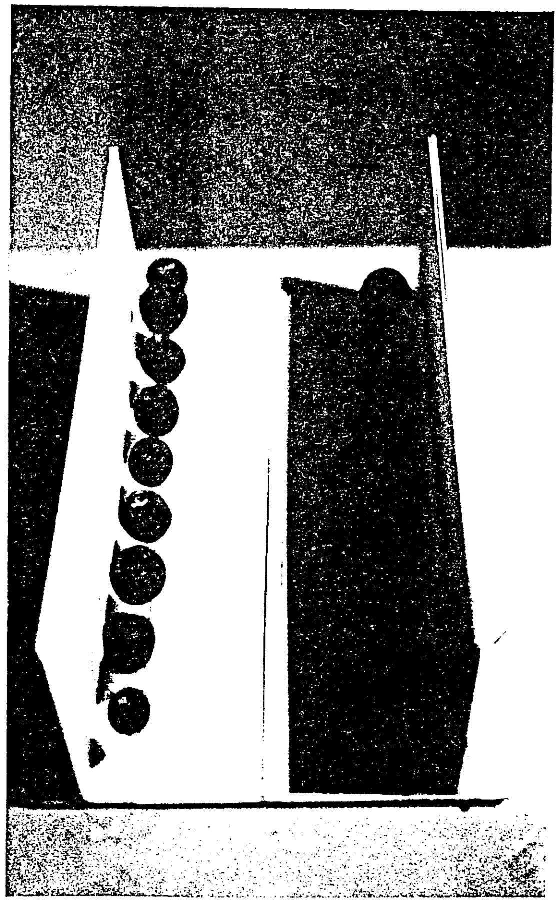

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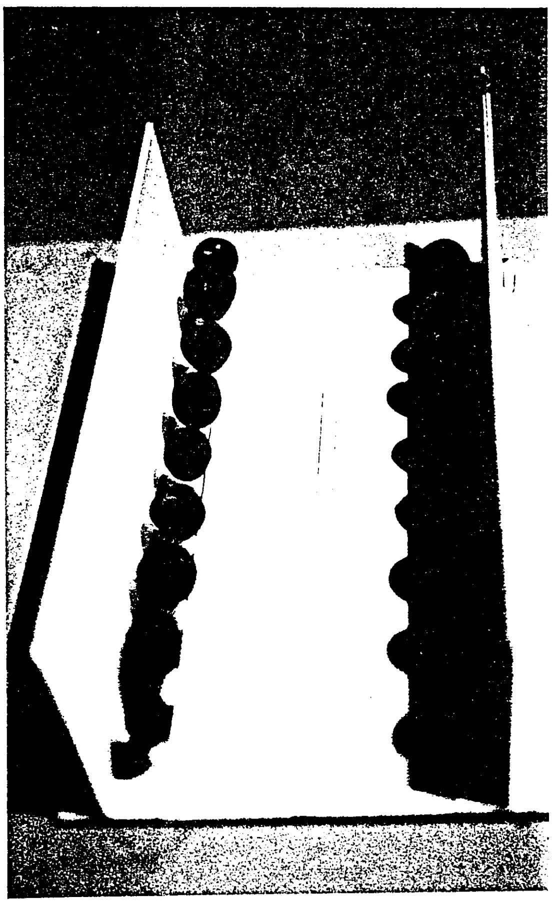

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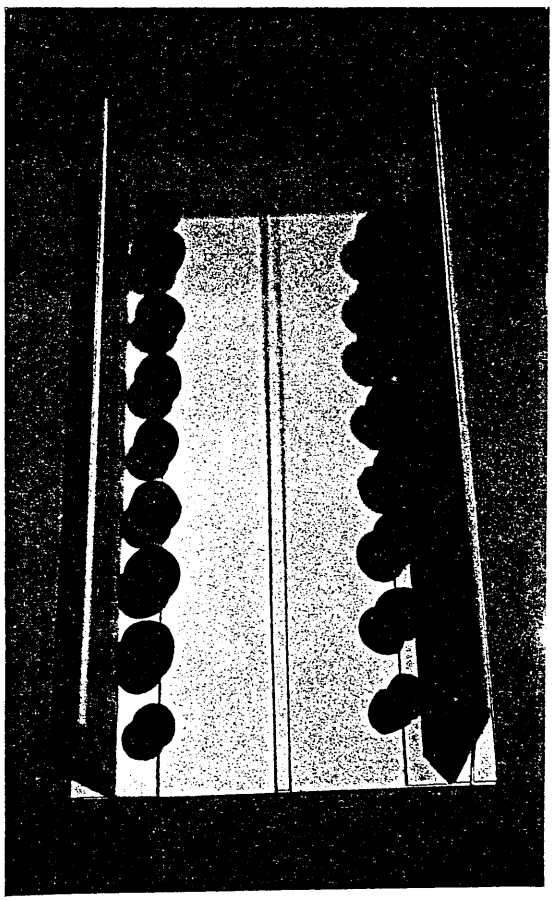

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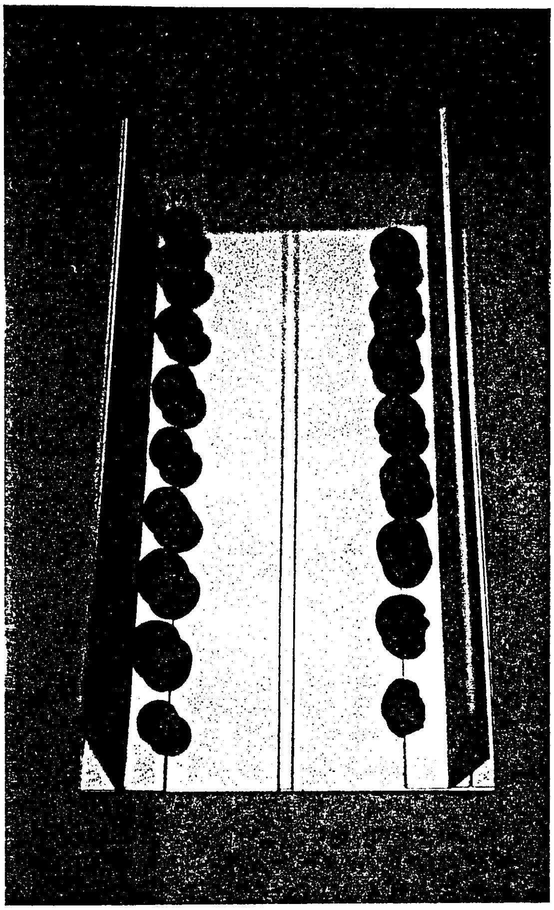

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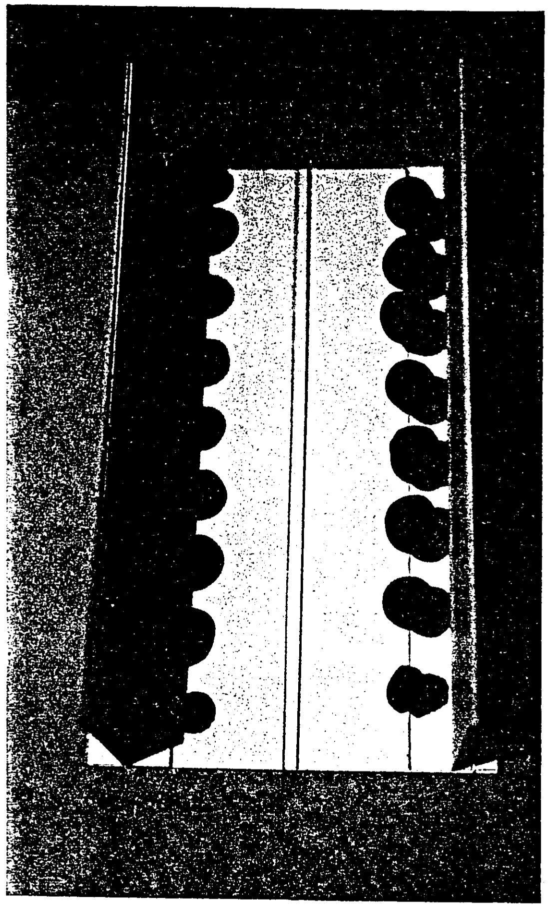

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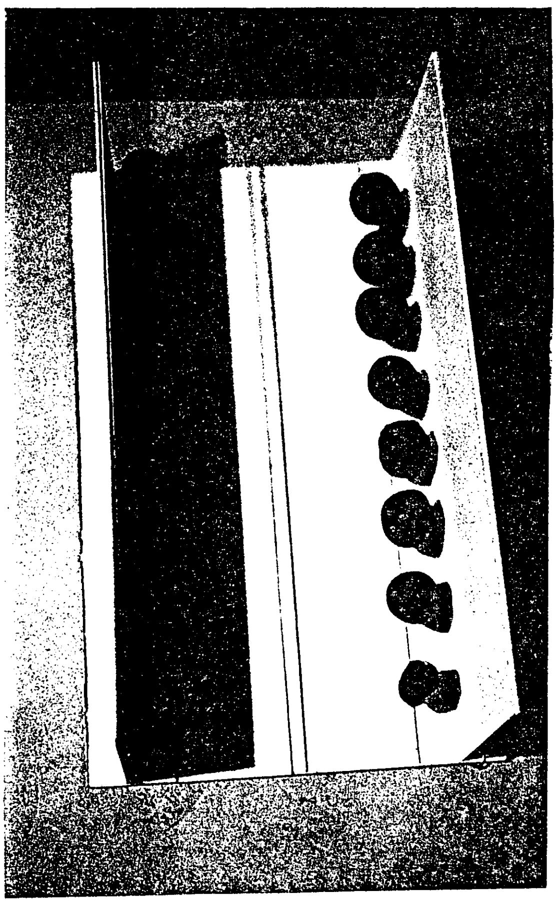

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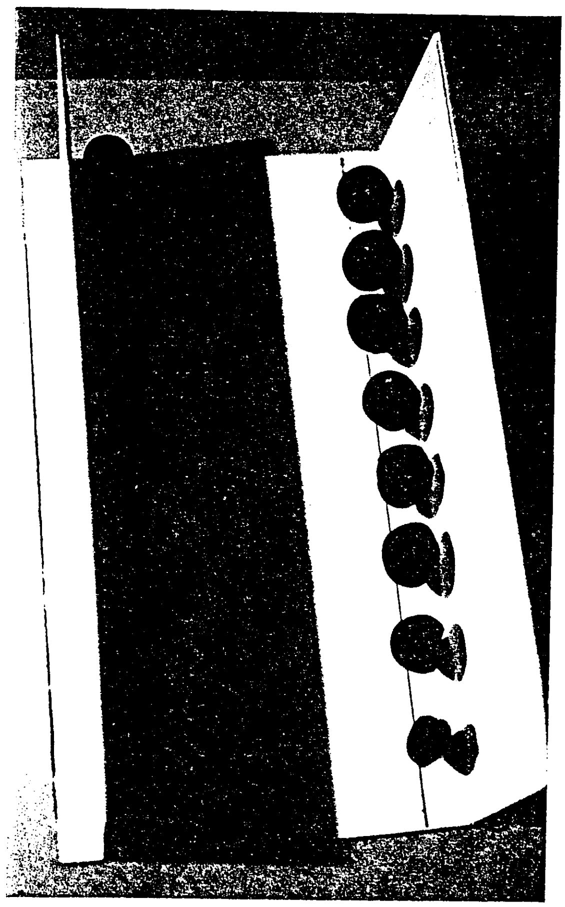

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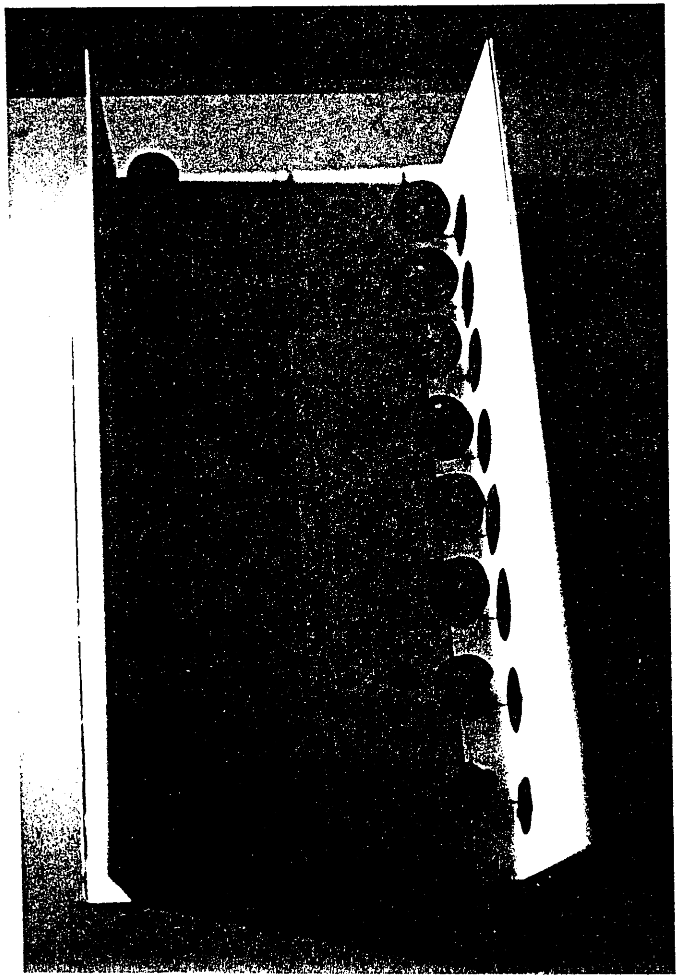

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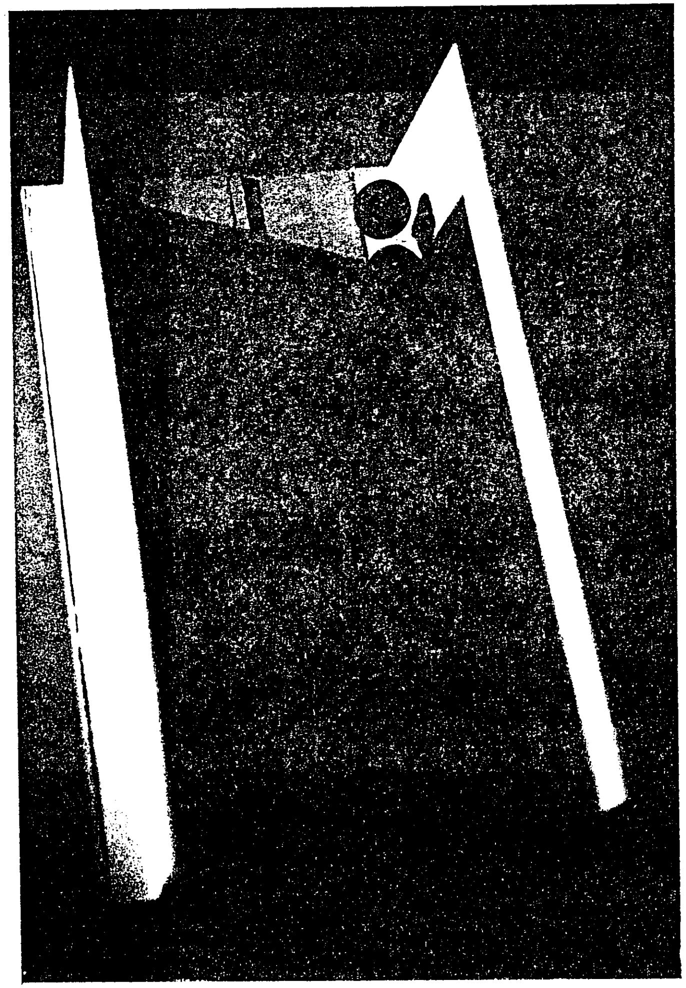

6 pm.

## 8.2 GENERAL COMMENT ON STREET-MODEL EXPERIMENTS

From those five experiments, I find that the two last cases show better shading, resulting from the street narrowness in the fourth experiment and the trees use in the fifth one. This means that the ratio of street width to buildings height is the first useful method in shading; and in cases where it is impossible to use this method - for example wide streets limited by low buildings, selected trees would be the most useful shading device to be applied.

For the three remaining experiments, the second one should also be positively considered as it has an almost permanent shade cast by balconies over the pavements.

Moreover, in this case-study - Constantine, 36°13' north latitude - and after many other simulations - not recorded here - I found that the north to south orientation gave better shading results within the street space; but such an orientation, determined only from the Heliodon shading simulation, should not be considered as the best and effective one, because to define the optimal orientation one also need to consider and study other factors such as the heat exchange between the urban fabric and its outdoor spaces, the site exposure.....etc.

However, street orientation is a determiner criterion which should also be taken into consideration. Opposite, this criterion could inevitably create problems in shading as every city layout has or will have streets running in different directions. Nevertheless, for streets having bad orientation, thus bad solar radiation control, this problem will be resolved by adding suitable shading devices to such street spaces.

## 8.3 RECAPITULATION

a. The easiest and cheapest shading method is to have narrow street, with respect to buildings height and street width ratio; the midday radiation is so short, it can probably be tolerated.

b. Good shading orientation: south to north (this could be influenced by the heat gain within buildings structure and its re-radiation). Other street orientations require additional shading devices such as balconies, sabates, awning canvas.....etc.

c. Wider streets still gain very little shading from normal buildings height (5 storeys), and the problem will be structurally difficult to solve with sabate; balconies will give some shade but proportionally will do little to reduce overall sun heat. The best solution in this situation are arcades or trees; but only trees can give economic shading to the street users.

d. Trees planting can also relieve over heating in public places, squares.....etc., but they take a long time to develop. Awnings could be used until sufficient growth is achieved.

e. For shading, in some urban public spaces, Algeria can adopt the highly successful use of the Italian Galleria and Cortile.

# GENERAL CONCLUSION

It is undeniably possible that adding shading devices into existing urban spaces could alter the original character of the urban fabric and particularly the space itself to which the device is devoted. That alteration will be felt and experienced in different ways: physically, emotionally and even aesthetically, depending both on the space kind and the used device properties. However, it will be uneasy to give, here, any statement about how could these shading processes or devices affect, for the best or the worst, the general identity or image of a particular urban public space in a given area, because to avoid any bad implications, one must first investigate and experience the space of interest before deciding for any exceptional device to be used for such an urban space.

As general consideration, I believe that a high quality of environment is as important to a new settlement as is a thriving economy and a satisfactory social life, and that the design and detailing of exterior spaces would influence the effectiveness of the town as a place to live in. However, it is very unlikely that a high quality of environment can be achieved in a short period or at a low cost. Only by consideration of the climate actions and by very close attention to the detailing of outdoor spaces will quality and comfort conditions be achieved. I argue, however, that the high capital outlay necessary to achieve this end would be essential to the long-term health of the community.

<u>Yacine Ziani</u>

Glasgow, 1987

# USEFUL READING

****BOOKS****


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