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In searching for ways of providing suitable school buildings, consideration should be given to the possibility of providing outdoor teaching space and of controlling environment in whole or in part by the planting of shade trees in a carefully controlled manner. Such trees, suitably located, will not only provide shade but may aid ventilation and reduce noise from external sources. From the standpoint of initial investment and consequent maintenance, they will invariably be found to be an inexpensive complement to normal constructional devices for shading, ventilation and sound insulation. Well planted sites can contribute to the visual amenity of the district in which the school is located, and the trees themselves may be used as living material in the study of botany in the school. It is hoped that the material presented here will encourage other countries to engage more vigorously in planting around school buildings. Topics discussed include--(1) functions of trees in relation to classroom environment, (2) planting and maintenance of trees, and (3) qualities of useful shade trees. Sketches, diagrams and photographs of sample situations and solutions are provided. (RK)

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ENVIRONMENTAL CONTROL IN SCHOOL BUILDINGS THROUGH PLANTING

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By
Rooskandar Winant, Architect

Asian Regional Institute for School Building Research
Bandung

United Nations Educational, Scientific, Cultural Organisation
Bangkok
1964

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PREFACE

The Karachi Plan for the achievement of free, compulsory education in Asia by 1980 suggests the figure of US $30 per child for construction of school buildings. This is a very small sum, and the Development Groups, in searching for ways of providing suitable school buildings, may wish to consider the possibility of providing outdoor teaching space and of controlling environment in whole or in part by the planting of shade trees in a carefully controlled manner. Such trees, suitably located, will not only provide shade but may aid ventilation and reduce noise from external sources. From the standpoint of initial investment and consequent maintenance, they will invariably be found to be an inexpensive complement to normal constructional devices for shading, ventilation and sound insulation. Moreover, well planted sites can contribute to the visual amenity of the district in which the school is located, and the trees themselves may be used as living material in the study of botany in the school.

Several countries have already drawn attention to the need to plant the site properly. The Bureau of Public Schools of the Philippines, for instance, recommends an extensive list of some 32 shade, economic and decorative trees and 22 shrubs for planting singly or in hedges. It is hoped that the material presented here will encourage other countries to engage more vigorously in planting around school buildings.

This paper, prepared by Rooskandar Winant, an Indonesian architect on the staff of the Asian Regional Institute for School Building Research, forms part of the programme for the study of factors affecting the environment in Asian school buildings.*

* Numbers in brackets indicate references at the end of this paper.

CONTENTS

1. FUNCTION OF TREES IN RELATION TO CLASSROOM ENVIRONMENT

1.1 GENERAL

The planting of trees, shrubs and grass should be regarded not only as an attempt to improve the visual environment of the school site but also as a positive measure to protect the occupants of the building from solar heat, glare, wind, noise and dust. In many countries where classroom space is not available, the first grade may be taught under shade trees for much of the non-rainy season of the year.

Functional planting should be carefully controlled if full benefit is to be obtained. The object of planting must first be clearly understood and the type of shrubs or trees carefully selected to achieve its purpose. For example, if shade is required, then a large, spreading tree with dense foliage should be chosen. If the noise from traffic on an adjacent road is to be reduced, then trees or shrubs with low branches and thick foliage should be selected, and planted close together.

Experience has shown that it is important to differentiate clearly between trees selected for these specific purposes and trees selected to form part of the school garden and expected to yield an annual crop of fruit, bark or resin. If the trees which are intended to provide shade also normally bear a good fruit crop, this will almost certainly be taken by the children or by other people in the district and the trees will be damaged in the process. It is thus better to keep fruit trees in the garden where they can be properly protected and cultivated, and to use trees that do not bear useful fruit for shading.

1.2 THE FUNCTION OF TREES IN RELATION TO THE CLASSROOM

A good classroom should be so designed that there is adequate illumination on the desk tops, the illumination being introduced in such a way that glare is avoided. Good illumination reduces visual fatigue and helps to create a cheerful and pleasant atmosphere. 30 footcandles on table tops is regarded as a minimum illumination level for school buildings (1).

Classrooms are used mainly during the day and are illuminated by sunlight. The latter, channelled into the rooms through windows, should be in the form of indirect or reflected rather than direct light. Direct sunlight shining into the room will cause thermal discomfort due to the radiant heat component.

The position of the sun in relation to any point on the earth's surface can be calculated for every hour of the day and every day of the year. If the solar altitude and the azimuth angle are known (2), (3), it is easy to calculate the size and form of the tree which will give sufficient shade for a specific purpose. In other words, it is possible to locate a tree of a certain anticipated form in such a way that much of its shade will fall on window openings and prevent direct sunlight from entering a classroom. Plates 1, 2 and 3 give an example of the shade provided by a row of trees at different times of the day. Trees planted in this way should be regarded only as an aid to shading, for they take time to grow to full stature and their final shape and size cannot be predicted with certainty.

1.3 PREVENTION OF GLARE

Another problem in designing classrooms for visual comfort is the avoidance of glare caused by areas of sharply differing brightness within the field of vision. If a wall of a classroom has a number of small windows with a view to the sky, then glare will occur due to the sharp difference between the brightness of the sky and the lower brightness of the wall seen against the sky when looking out of the window (Plate 4). The glare caused by the small window can be reduced by enlarging the window and suitably decorating the window wall. It can also be reduced by planting trees or shrubs in such a way that, on looking out of the windows, foliage is seen instead of the sky (Plate 5). This will of course involve selection of the correct sort of trees and the correct placing of the trees in relation to the classroom windows. Figure 1A shows an arrangement of windows which would result in glare (4). Figure 1B shows an incorrect way of planting trees to prevent glare. In this case the rooms would be too dark and cross ventilation might be reduced. Figure 1C shows correct planting with the row of trees kept behind the chalkboard but within the pupils' "cone" of vision so that the trees can be seen but will not obstruct the entry of light into the room.

Glare may be caused not only by windows giving a view directly to the sky but also by windows looking out on the light-coloured walls of adjacent buildings. Figure 2A gives an example of this.

Caudill (5) instances trees planted outside a classroom to reduce excessive brightness: In the particular case quoted, a brightness of 4,000 foot/lamberts was reduced to 400 by planting trees and grassing other reflecting areas at ground level (Figure 2B).

1.4 PLANTING AND VENTILATION

Planting may be used to induce air to flow in rooms through which the breeze does not naturally pass. Situation A in Figure 3 shows a classroom having a windowless wall arranged normal to the path of the prevailing breeze. Although openings are provided in the two walls which are parallel to the direction of the breeze, there is very little airflow within the room because of the equal pressures in the areas adjoining the openings. Situation B in the same Figure shows how, by the arrangement of suitable planting, pressure may be built up on one side of the classroom and reduced on the other, with a consequent flow of air from the high to the low pressure area.

Planting may also be thought of as effecting ventilation in the vertical plane: Figure 4A shows how the planting of trees and hedges can prevent high winds from entering directly into a classroom but at the same time provides ventilation by the creation of low pressure areas. Figure 4B illustrates how winds can be caused to flow directly into a classroom by planting. Direct wind flow may result in very much higher windspeeds, and may give rise to some discomfort.

1.5 SOUND REDUCTION

"Noise" has been described as unwanted sound. It may be reduced or removed

by providing an absorbing or reflecting agent between the source and the receiver. If a noisy road passes by a school site, the problem posed by passing traffic can be solved, firstly by locating the building as far away from the road as possible (the intensity of sound decreases as the square of the distance from the source), and secondly, by interposing thick foliage between the road and the building. Planting arranged for this purpose has been known to reduce sound levels by as much as 35 decibels.

2. PLANTING AND MAINTENANCE OF TREES

2.1 GENERAL

This section provides a brief guide to important points to be observed in growing trees for shade. It is perhaps more important to take care of shade trees than of any other planting on the site, for until the trees have matured they will not effectively do the job for which they are intended.

2.2 PREPARATION FOR PLANTING (6)

Holes should be dug to a minimum size of 90 x 90 x 90 cm; larger holes will produce better results. The material excavated from the hole should be mixed in equal proportions with manure and returned to the hole. The returned material should be left raised about 25 cm. above the surrounding ground level to allow for subsequent settlement.

2.3 PLANTING (6)

About a week after the hole has been prepared, the young tree may be planted. Care must be taken not to allow the roots to dray out, and the sapling should be kept in damp sacking or in its pot until just before planting. A hole should be dug in the centre of the prepared bed with a trowel (according to the size of the plant or pot) and a little well-rotted compost placed in the bottom. The pot, basket or bamboo tube should be removed with as little distrubance of the roots and soil as possible. For bare-rooted plants, arrange the roots in their natural position, with the tap-root vertical and the side-roots spread out. Cover the roots with soil. The soil should be firmed with the knuckles if the plant is small, or with the feet if it is 60-120 cm. tall. Great care must be taken to ensure that the young plant is not put too deep in the soil, for this is the cause of more failures than any other. The original soil level is easily seen as a collar near the base of the stem, and this should not be more than one inch below the sides of the hole to provide drainage. After planting, about 5 cm. of half-rotted leaves should be put round the plant to keep the roots cool and prevent excessive evaporation, and the plant should be watered thoroughly.

2.4 STAKING (6)

This is usually necessary for all trees after transplanting, whether they are large or small. It is best to drive a stake a little to one side of the centre of the planting hole before the tree is planted. It may be done afterwards, but there is a possibility of damaging the roots. The stem of the plant should be tied to the stake in one or two places, depending on the height. The string should be tightly knotted round the stake so that it cannot slip

down and the ends twisted around each other four or five times to form a buffer between the stake and stem. Then tie firmly to the stem but not so tightly as to damage the bark. Ties should be examined at frequent intervals and loosened or repaired as necessary.

2.5 SHADING (6)

Shading is beneficial for the first one or two weeks after planting to enable the plant to recover from the shock of transplanting and form new roots. It is most simply done by sticking a few palm leaves round the plant by their midribs, with their tops meeting above the plant in such a way that rainwater does not drip on to the plant, and far enough away to prevent contact during wind. The shade may be removed gradually so as to harden off the plant before full exposure.

2.6 PROTECTION (6)

It is a waste of time to plant unless adequate protection against damage by animals or humans is provided. Any protective fence must allow access for weeding.

2.7 MAINTENANCE (6)

The best time for planting is during a wet spell, but if no rain falls, the tree must be watered for a few days, preferably in the evening, or in the morning, but not during the heat of the day. Do not overwater. Too much water is as bad as too little, and if the plant does not wilt or if the soil under the mulch is damp, no water is required. During the early stages the young plant requires constant attention. The planting patch must be kept free from all weeds and grass; the surface must be kept loose by frequent forking with a hand fork, care being taken not to damage the roots, and a mulch of half-rotted leaves and decayed cattle manure applied about every two months. If the planting is in grass, keep this slashed back for a radius of 180 cm., and remove any woody growth competing with the planted tree. Deposits of organic fertilizers 5 or 8 cm. below the surface at intervals of about 4 months, increasing the distance of the deposits from the tree as it grows, will cause more rapid growth as the roots find and feed on these pockets of soil of high nutrient content. The plant should be sprayed with a general insecticide once a week, and a watch kept for caterpillar attack, etc.

2.8 PRUNING (6)

Prune double-leaders or forked stems to obtain a straight bole to the desired height, but never reduce the crown to less than half the total height. Pruning should be done with a sharp knife, avoiding damage to the bark, and the cut should be smooth and as close to the stem as possible and also as nearly vertical as possible to prevent water from entering the wound and causing rot.

2.9 REPLACEMENT

Thought should be given to the replacement of older trees as soon as they show signs of decay.

3. THE QUALITIES OF USEFUL SHADE TREES

3.1 GENERAL

In each of the countries of the Asian region there will be certain trees that are well-known for their shading qualities. This paper does not therefore include a complete list of shade trees, and indeed, were an attempt made to compile such a list for the entire Asian region, the result would be monumental proportions. It is possible, however, to explain the qualities that go to make a tree suitable for shading purposes, and these are given below. A selection of local trees can be made on the basis of these requirements. Some trees and shrubs common over the entire humid Asian region are described in detail.

3.2 SIZE AND SHAPE OF TREE

A useful shade tree will have a trunk which is straight and clear of low branches for a height of at least 3 m. above ground level. The tree should not have buttresses and should be such that children can sit and play under the crown in comfort. The crown of a useful shade tree will be at least 5 m. in diameter, and if shade is to be thrown on the wall of the building by the high-angle noon sun, the trunk will need to be longer than 3 m. and the crown will need to be very much larger than 5 m. in diameter.

The crown will probably provide more useful shade if it is of the spreading umbrella shape rather than spherical in form. A tree having a good crown shape is the raintree (enterelobium spp.), well-known all over Asia (see Plates 6 and 7). An example of un unsuitable tree is the Casuarina, with its elongated crown. Plates 8 and 9 give examples of trees with elongated crowns.

3.3 GROWTH CHARACTERISTICS

If it is intended to depend upon trees for shading the building, it is obviously of the greatest importance that the trees selected for this purpose grow rapidly, for until they are grown, they will not properly perform their shading function. The shortest period of growth which is likely to produce useful shade will be about 3 years. While waiting for the tree to grow, some temporary shading such as bamboo screening can be used to protect windows.

It is important not only that a shade tree is of a quick-growing variety but also that, having grown, it maintains its shading characteristics. If possible, trees which do not loose all their leaves at one time should be selected.

3.4 OTHER CHARACTERISTICS

As the shade trees are to be used in the school grounds, they should not cause staining of clothes, for classes may be held under them and the children should be able to sit on the ground.

3.5 EXAMPLES OF USEFUL SHADE TREES (6), (7), (8), (9)

(a) Albizzia spp. (Leguminosae): A very fast-growing, wide-spreading shade tree, nearly fifty species of which are found in the tropics. Rather short in stature, feathery leaves, needs pruning to ensure a clean trunk. Grows well up to an altitude of 1,600 m.

(b) Delonix regia (Caesalpineae): (Syn.: Poinciana regia): Fast-growing, may reach 18 m. in 4 years. (1-800 m. above sea level), wide-spreading, umbrella-shape crown wintering, reaching 28 m. tall, diameter up to 100 cm., tending to become dangerous after 20-30 years. Very beautiful and conspicuous when covered by its large red flowers. Grown from seed. Different trees often differ markedly in habit. Some will form a well-shaped crown without pruning, others need pruning, except that the branches should not be shortened too much. Does not stand pruning when old. Much planted as an avenue tree.

(c) Enterolobium saman (Leguminosae): Fast-growing 1-1,000 m. above sea level, wide-spreading with umbrella-shape crown, giving deep shade, often with a span greater than its height. Reaches height 30 m., diameter up to 150 cm. More or less evergreen in non-seasonal climates, long-lived. Flowers pink, not very conspicuous. Often has large surface roots which necessitate planting at least 20 m. from buildings. Grown from seed. Prune when young. When old, will stand hard pruning, which will strengthen it. Somewhat subject to attack by mealy bug, both when young and when old. When young, regular spraying is necessary, but attacks on mature trees c disappear after heavy rain and leaf fall. Useful as a single shade tree where space is available.

(d) Ficus elastica (Moraceae): Fast-growing; 1-1,400 m. above sea level, spreading, reaching 30 m. in height, large leathery leaves giving dense shade, evergreen. Long-lived, ideal as a single shade tree, should be planted 20 m. away from buildings and drains because of spreading root system. Roots themselves may provide seats for children, or scrambling area when tree is older.

(e) Lagerstroemia flos-reginae (Lythraceae): Rather slow-growing 1-800 m. above sea level. Smaller when grown in the open, much taller in forest, reaching 45 m., with diameter up to 150 cm., (usually 25-30 m. high and 80 cm. in diameter), crown dense, rounded and bushy, wintering at intervals of 6-9 months, often branch by branch, useful life 40 years or more. Flowers very beautiful and conspicuous, in many shades of mauve, lilac and pink. Best grown from seed (marcots and cuttings are difficult), but does not come true to colour from seed. Very little pruning is needed when young, except to ensure the normal clear bole of about 2.5 m. but if a compact tree with small rounded crown is required will stand hard pruning. Young plants are highly subject to attack by caterpillar and beetle, and require much spraying. A good avenue tree when planted 12 m. apart, and useful also as single specimens and shade trees.

(f) Melia composita (Melia dubia, Meliaceae): India, Ceylon, Africa, Australia, Tropical Asia. A large, handsome, quick-growing spreading tree, with small bipinnate leaves and smooth bark. Rapid growth at altitudes up to 1,100 m. In West Java, wild growing at altitudes up to 200 m. Reaching 30 m. with a diameter up to 65 cm. Wood

light, soft, brownish-red, with large pores, much used for ceilings, furniture etc. Fruit a hard, horny drupe, containing 2-4 small seeds. Best grown from seeds.

(g) Peltophorum pterocarpum (syn. P. ferrugineum) (Leguminosae): Fast-growing, 1-500 m. above sea level, flowering in 2-4 years from seed, usually not very large, reaching about 25 m. but more often about 12 ft. in cultivation, diameter up to 60 cm., crown spreading, symmetrical, more or less umbrella-shaped, giving good shade, wintering, moderately long-lived, sometimes dying back after 20-25 years. Flowers conspicuous, produced abundantly twice a year in golden yellow spikes all over the crown. Grown from seed. Pruning to shorten leggy growths and to ensure a clean trunk is needed when young.

(h) Pterocarpus indicus (Leguminosae): Slow-growing (1-500 m. above sea level) when young, but once properly established will grow rapidly; a large tree, reaching 35 m., diameter up to 2 m., with a spreading dense crown and large buttresses, wintering, long-lived. Flowers yellow, scented, produced in large masses. Grown from seed or cuttings, preferably large cuttings 3.5 m. long and 5-7.5 cm. diameter, planted directly on the site. Little pruning is needed when young, except to form a trunk 2.5 - 3 m. tall, but large trees may be severely pruned or pollarded and will rapidly produce new shoots which develop into large branches. A very fine single shade or specimen tree where space is available. It is advisable to separate the trees by interplanting.

(i) Swietenia macrophylla (Meliaceae): Moderately fast growing (1-800 m. above sea level), reaching flowering size in about 15 years, large, reaching 36 m. tall, diameter up to 100 cm., with a dense, rather upright crown not spreading much, foliage dark green and glossy, wintering more or less, long-lived. Flowers not conspicuous, fruits large, with winged seeds. Grown from seed. A strong tree with a deep root system, very suitable for roadside planting or as a shade tree, needing pruning only to secure a clean trunk. Does not stand pruning when mature. Planting distance 12 m. May be damaged by shoot borers and squirrels eating young bark.

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Résumé

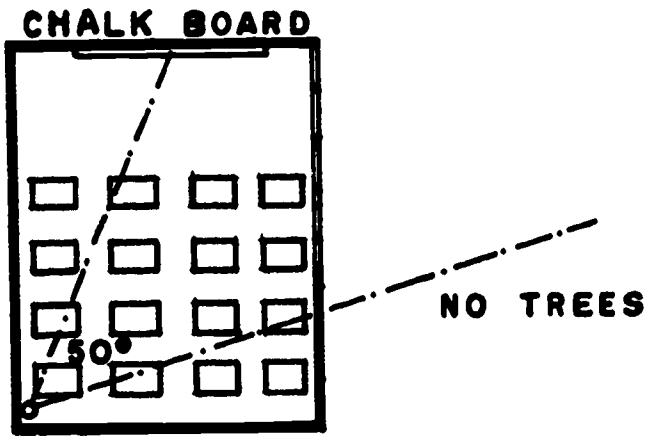
La plantation d'arbres, de buissons et d'herbes n'est pas seulement utile pour le plaisir des yeux. Elle doit aussi permettre de protéger de la chaleur, du vent et du bruit. De plus, pendant la plus grande partie de la saison sèche, la première classe au moins peut se fair à l'ombre d'un arbre. La plantation doit être contrôlée et les types d'arbres soigneusement sélectionnés.

Le rôle des arbres est indiqué au paragraphe 1.2. Le paragraphe 1.3 précise comment éviter l'éblouissement (planches 4 et 5 et figures 1A, B et C, 2A et 2B). Le paragraphe 4 traite de la ventilation (figures 3 et 4) et le paragraphe 5 du bruit.

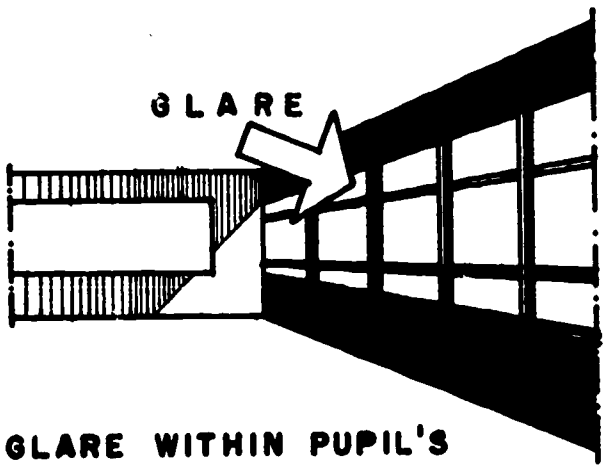
La deuxième partie traite de la plantation, de la pose d'un support, de l'entretien, de la taille et du remplacement des arbres.

La troisième partie indique les dimensions et qualités d'arbres souhaitables, puis donne une liste d'arbres recommandés avec leurs caractéristiques.

A)

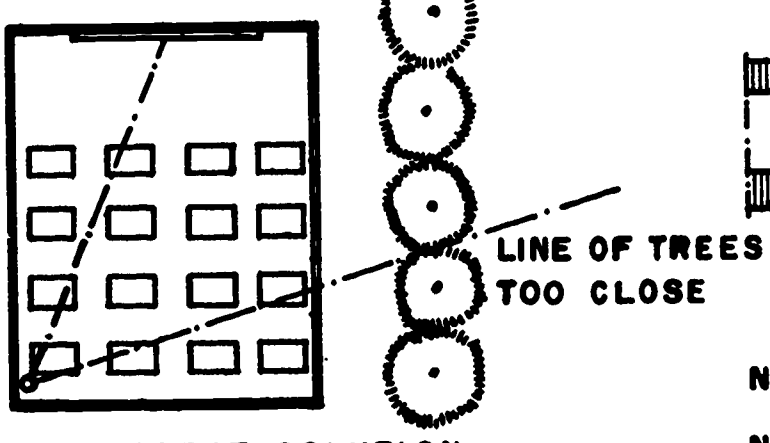


PLAN OF CLASSROOM



GLARE WITHIN PUPIL'S
FIELD OF VISION

B)



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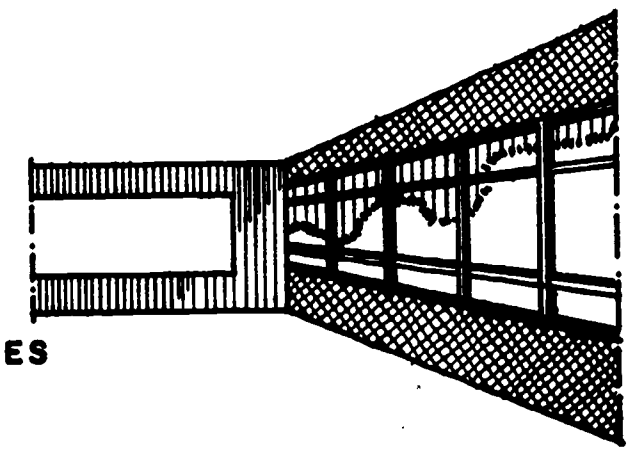
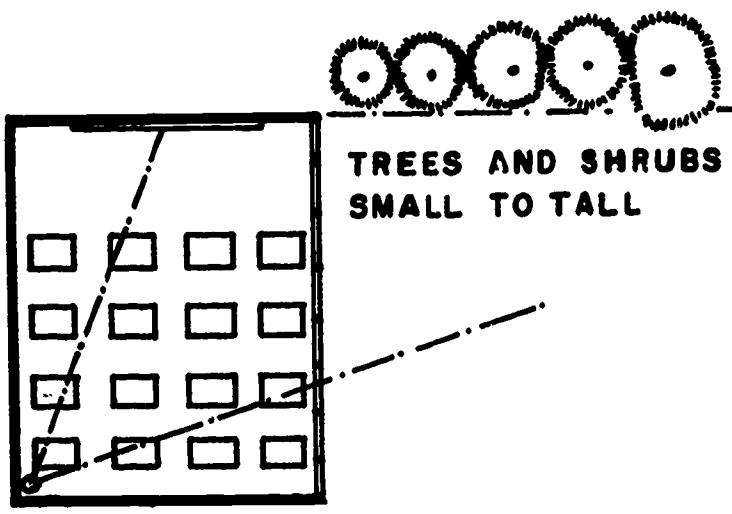


NO GLARE BUT ROOM

NOW TOO DARK

C)



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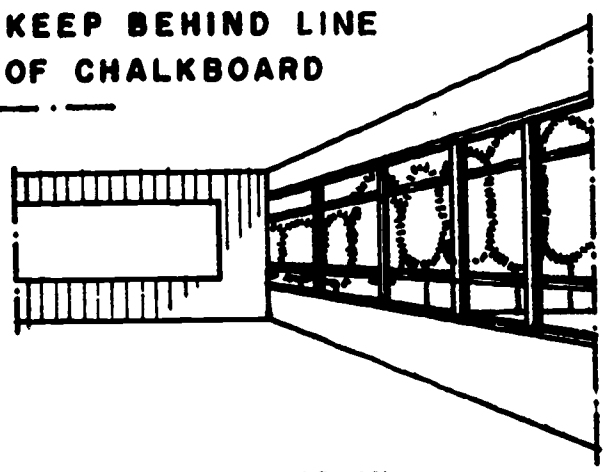
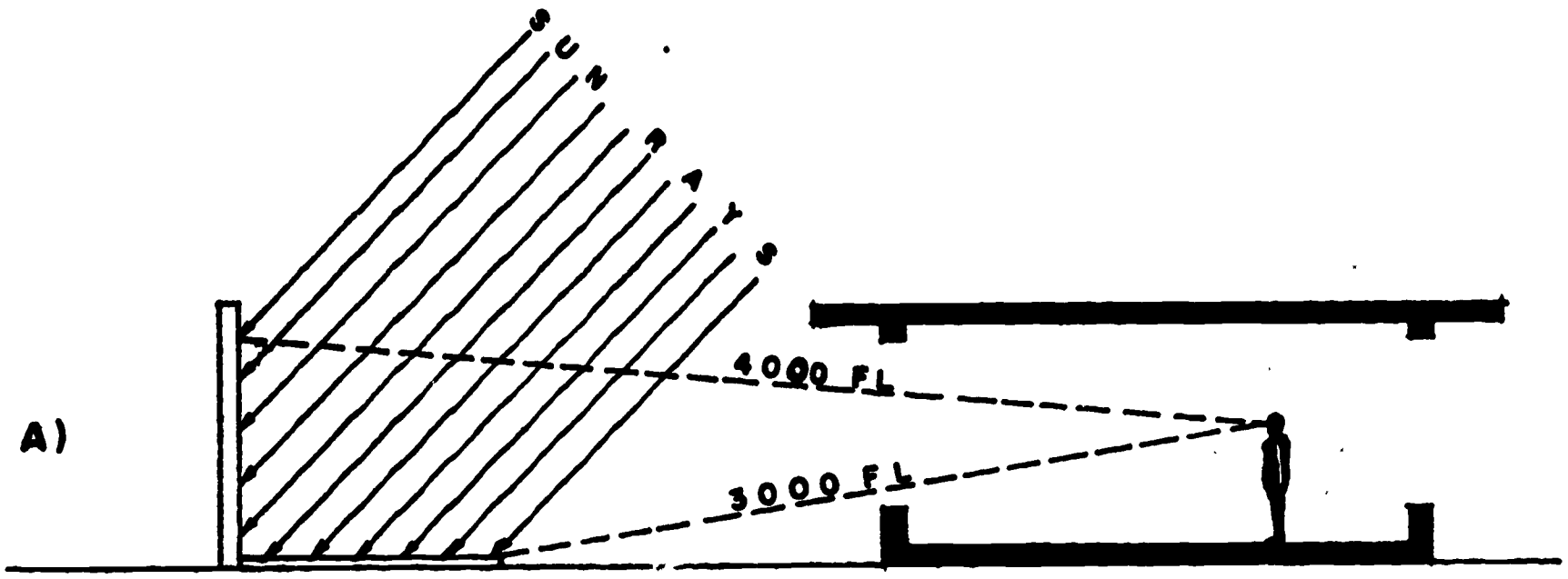


GLARE REDUCED IN

PUPIL'S FIELD OF VISION

FIGURE 1

A)



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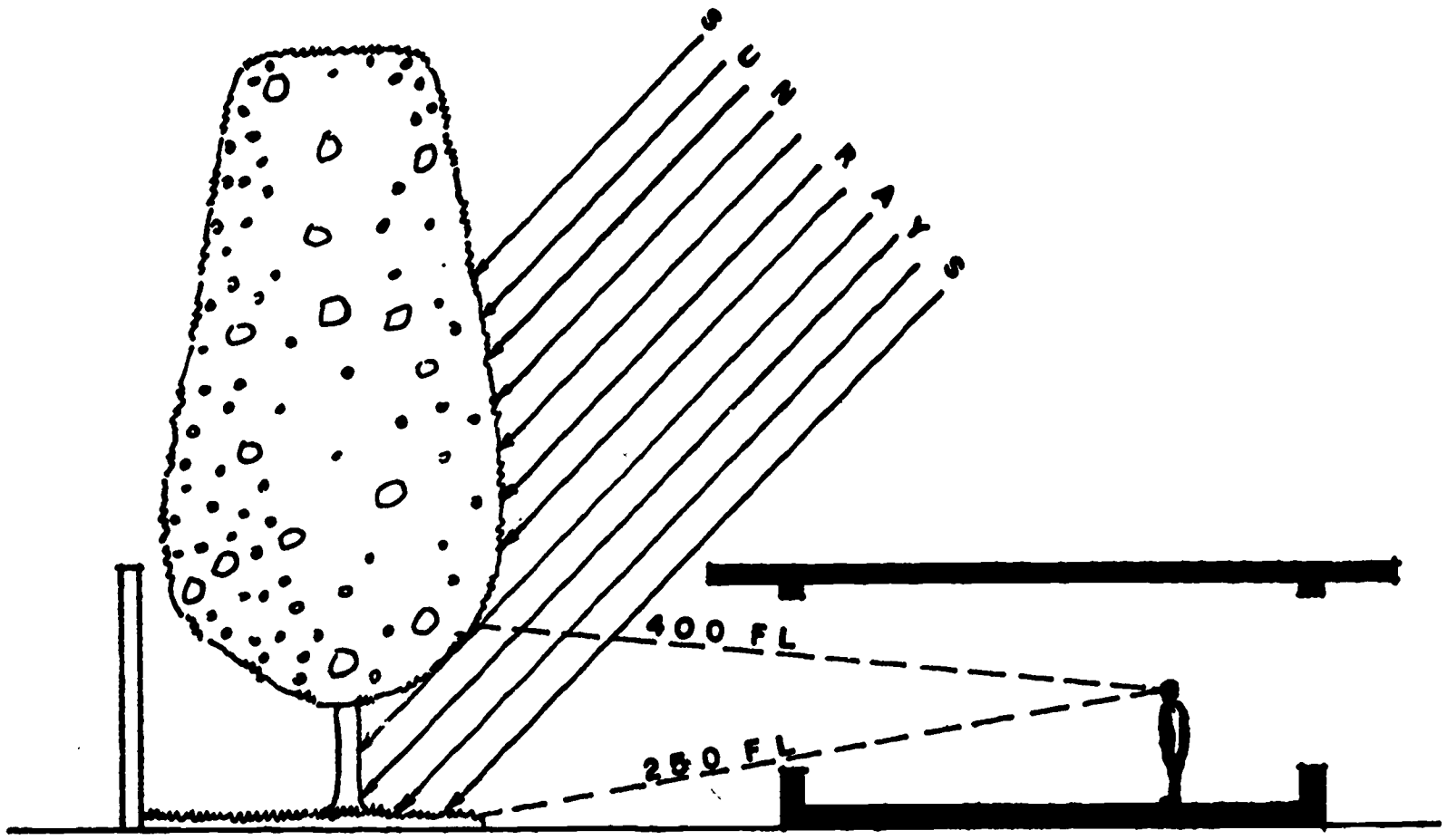
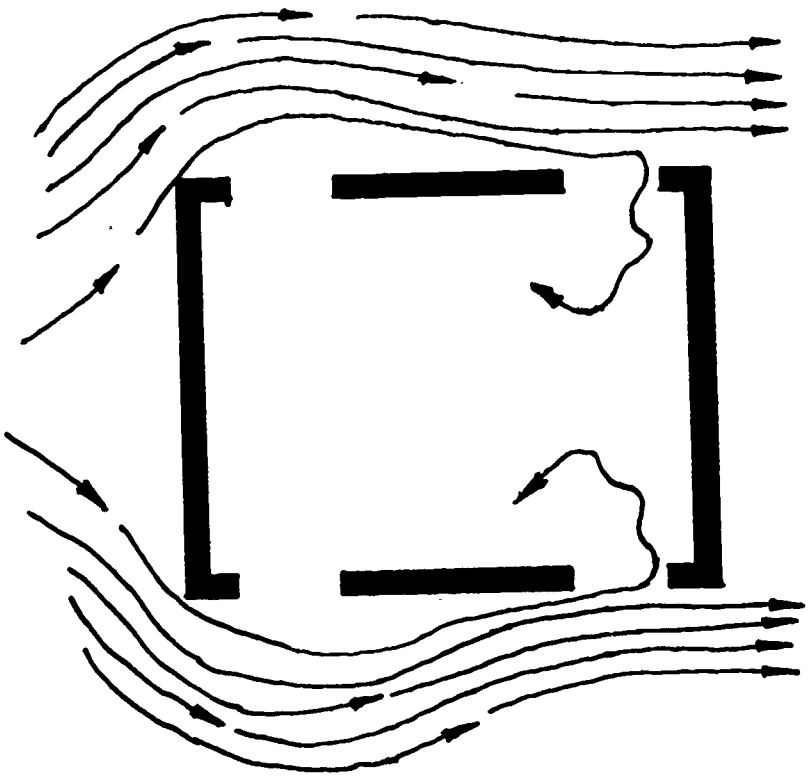


FIGURE 2

A)



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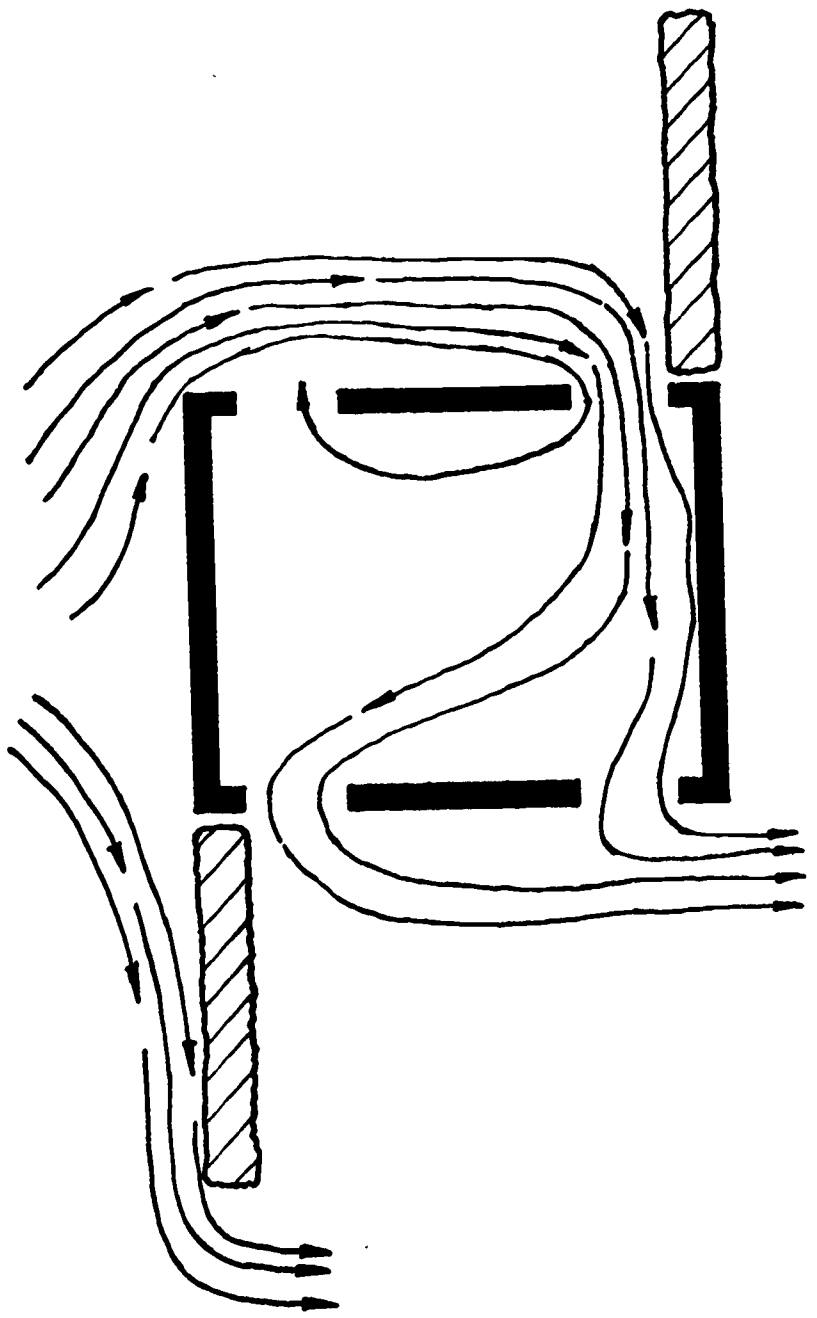
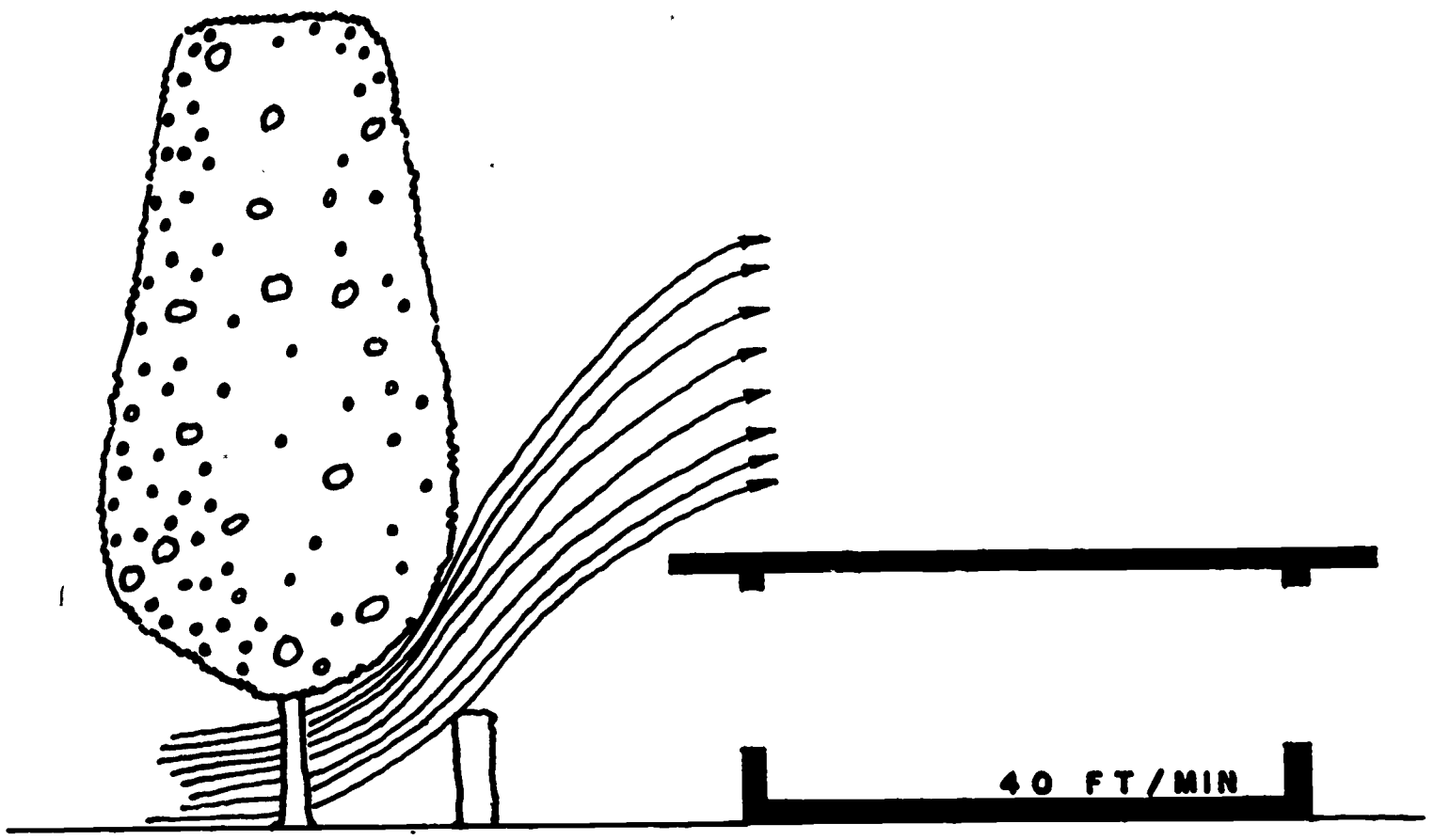


FIGURE 3

A)



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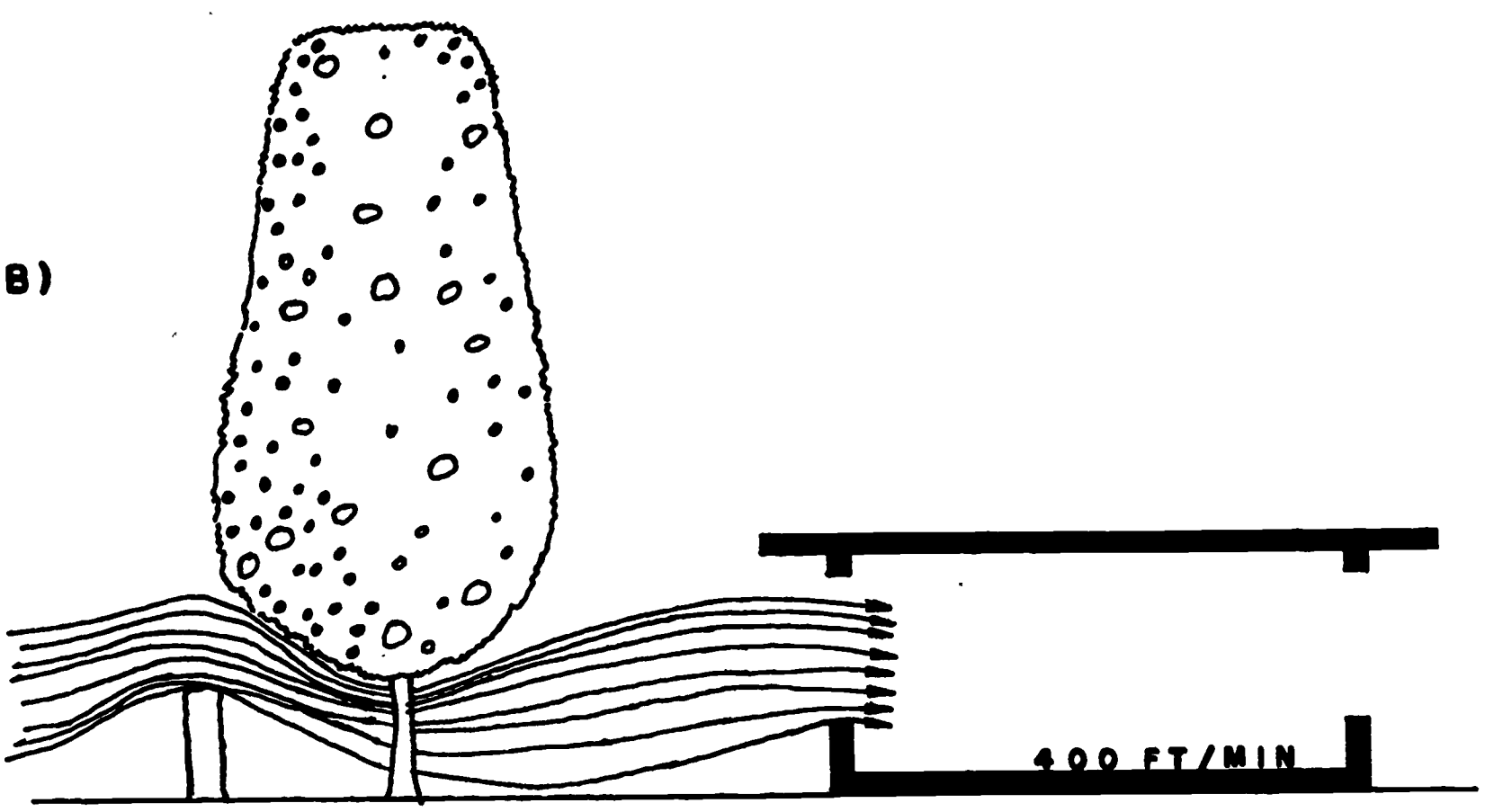

FIGURE 4

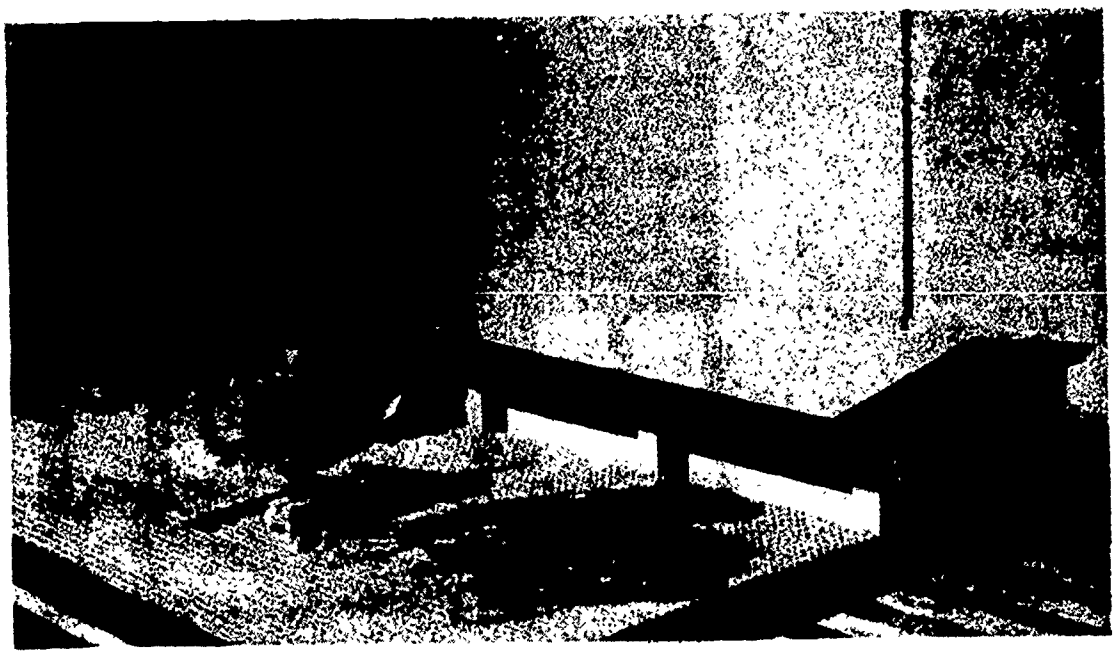

Plate 1

Plate 2

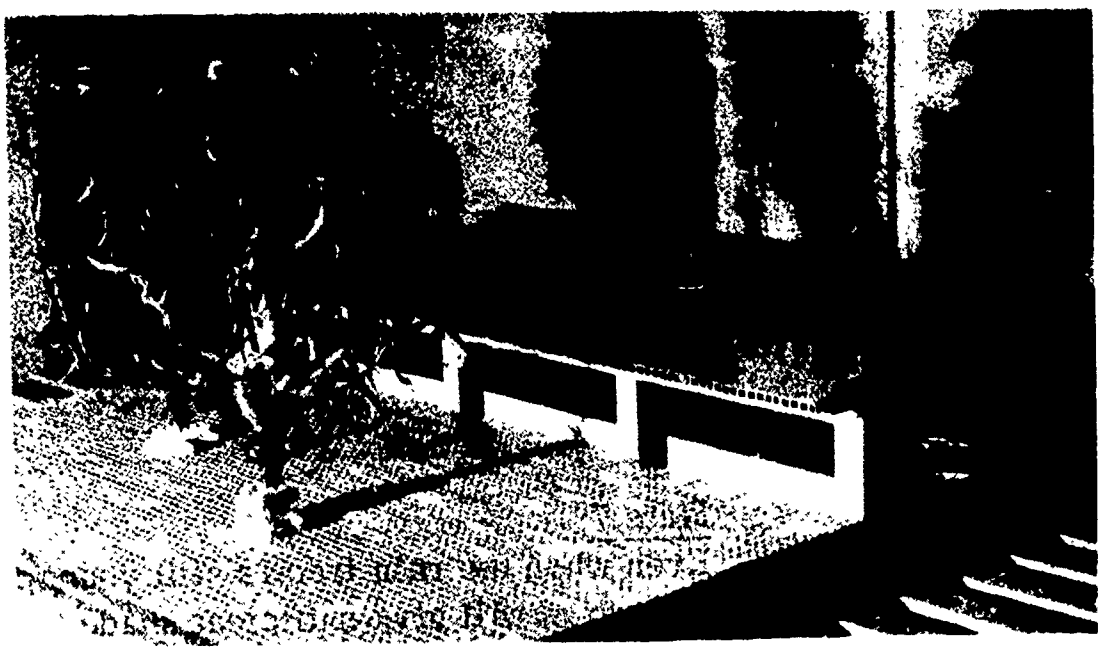

Plate 3

Plates 1, 2 and 3 give examples of the shade provided by a row of trees at different times of the day. Trees planted in this way should be regarded only as an aid to shading, for they take time to grow to full stature and their final shape and size cannot be exactly predicted.

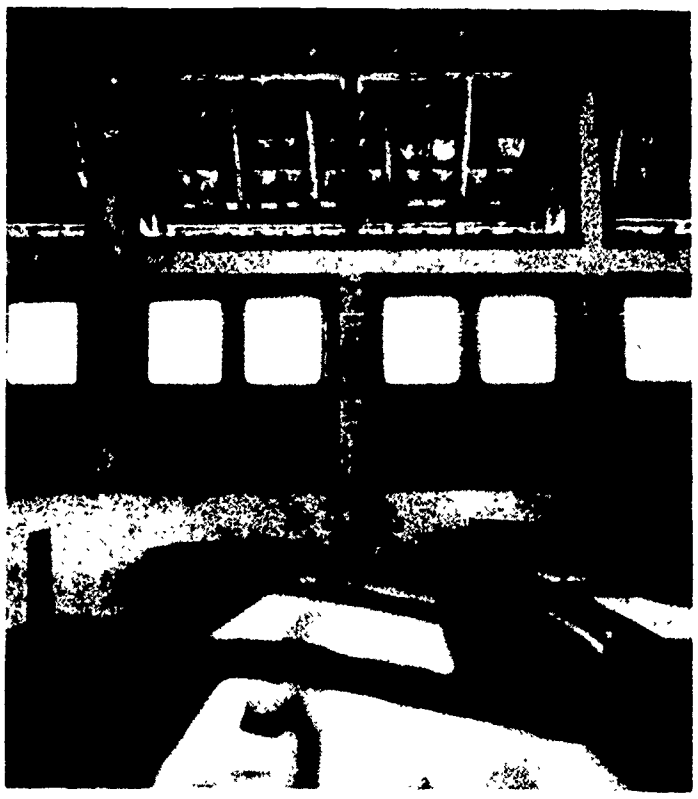

Plate 4
Glare in a classroom caused by the brightness of the sky.

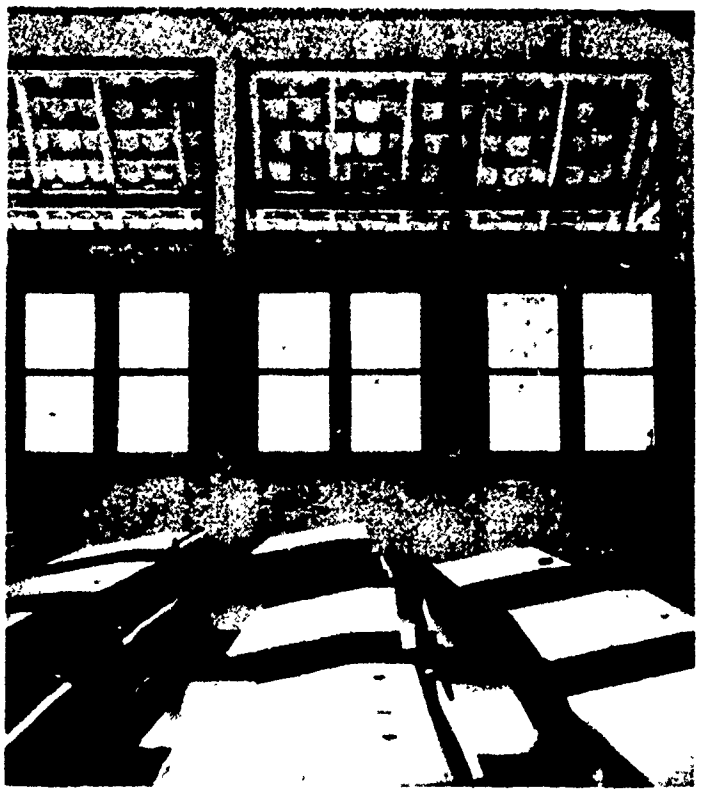

Plate 5
Glare in a classroom could be reduced by proper planting.

Plate 6
An old rain tree with an umbrella-shaped crown.

Plate 7
Even when the rain tree is still young, the crown will give sufficient shade to the school ground.

Plate 8

A kapok tree (Ceiba pentandra) with its elongated crown.

Plate 9

Another example of trees which are not suitable for shade trees.