A BIO-CLIMATIC APPROACH TO HOUSE DESIGN FOR SEMI-DESERT AND HOT CLIMATES (with special reference to Egypt)

VOLUME III

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Contents

,APPENDIX A1 : THE STANDARD CONTINENT

A1 The Standard Continent

To simplify the climatic zoning one may ignore topography and consider a hypothetical sea-level continent stretching from the Equator to the Pole, figure (A1.1). The climatic zones that are likely to occur on such a hypothetical continent due to the ocean currents and the mean annual pressure and wind patterns that would prevail would be as follows:

a) The eastern seaboard would be warmed in the lower latitudes by ocean currents, while on the western margin, above about latitude 40°, a similar effect would be felt.
b) At lower latitudes on the west there would be a distinct cooling due to the movement of cold water towards the Equator from higher latitudes.
c) The semi-permanent subtropical highs and subpolar lows will be approximately as shown, and this will give rise to the air flow indicated in figure (A1.1).
d) There will tend to be a high pressure region over the northern continent in winter and low pressure over the tropical region in summer.

Temperature of the standard continent is considered on an annual basis. The main factors contributing to the thermal patterns are:

a) The ocean currents.
b) Warm air masses from the oceans and cool air from the continental interior in winter. Cool air masses from the continent in summer.
c) The latitude, and its effect on radiation.

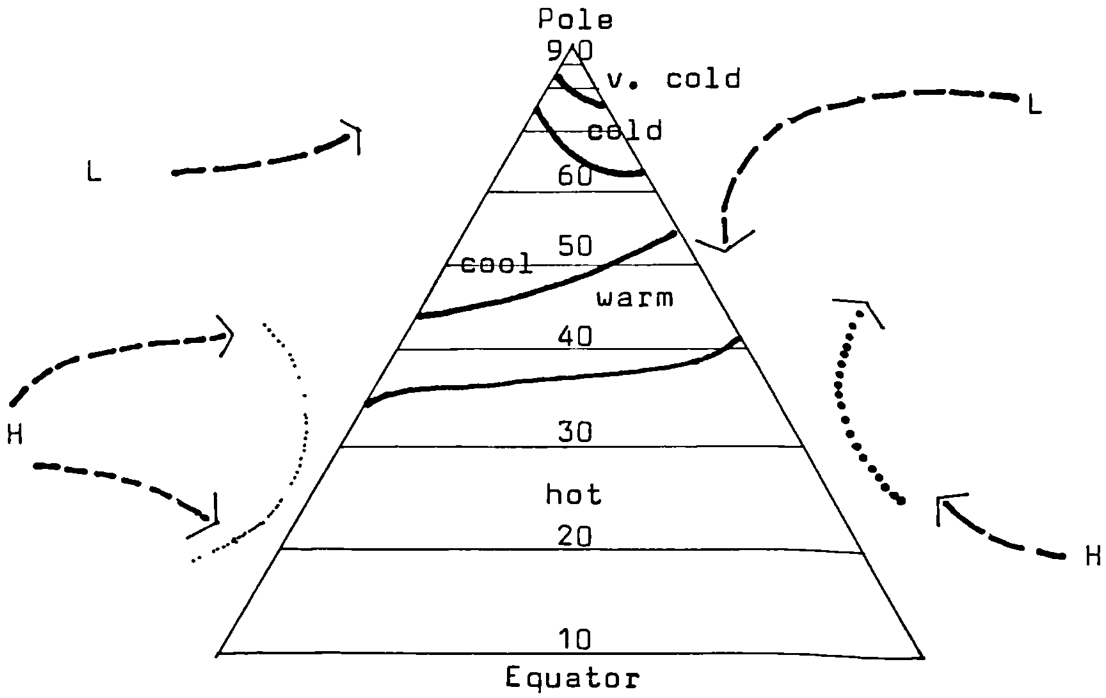

Figure (A1.1) Ocean currents, pressure patterns and thermal zones for the Standard hypothetical continent.

Precipitation pattens over the north of the Standard Continent during the winter season are due to the Polar fronts. These are not continuous across the continent as the cold high pressure zones tend to block the movement of rain-carrying cyclones coming from the west. Precipitation normally occurs in the continental interior in the form of snow, this being equivalent to a small amount of rain. The convergence belt of trade winds along the Equator is still sufficiently close to show an associated rain belt, figure (A1.2). This is especially so when there is enough heating to induce convective occurrence as well as convergence. Along the eastern seaboard, around the 40^{o} latitude, there is often some rainfall associated with convective showers over the relatively warm ocean. These are blown landwards by the outflow of the subtropical high.

During summer the Equatorial convergence zone will have moved into the northern hemisphere, and most of the tropical belt experiences the rain associated with this manifestation. The Polar front, fig.(A1.3), will have retreated towards the 60 - 70^{o} latitudes, thus giving rise to a small amount of rainfall in this area. In the interior regions where there is a source of moist air intense convection leads to heavy showers. Along the western margin of the continent, subject to convective effect, there is general rainfall due to the presence of moist onshore winds.

Although the consideration of the summer and winter patterns gives a good idea of the annual zonation there are two special regions that must be considered separately.

1 The dry region:
During the winter cyclones moving from the west are unable to penetrate far into the continent because of the blocking effect of high pressure zones. However, as spring approaches the highs weaken and some rain-bearing winds can break through into the interior. Thus this normally dry region has a tendency for a spring

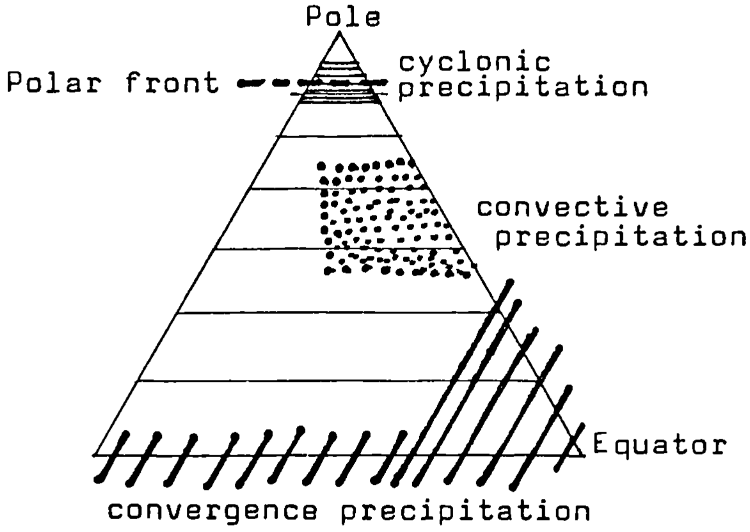

Figure (A1.3) Summer precipitation patterns on the standard continent.

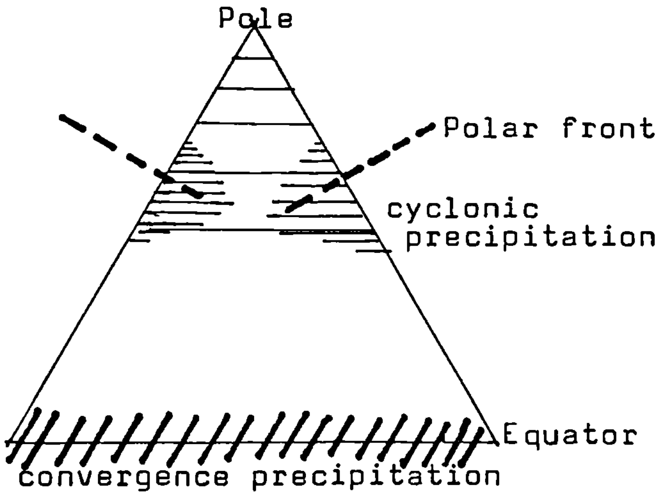

Figure (A1.2) Winter precipitation patterns on the standard continent.

maximum rain.

2 High latitudes along the western edges:
During autumn as the land begins to cool the relatively warm, moist air moving in from the ocean tends to produce a seasonal maximum rainfall.

A composite picture of the rainfall regimes is constructed as in figure (A1.4) and it is interesting to note that the areas of uniform rainfall are considerably small, and that the desert region extends over a wide latitude band. In the region near the Equator the approximate nümber of wet months has been used as the terms winter and summer have little relevance in this area.

True climatic patterns will always differ from the Standard Continent due to land width, topography, and distance from the Equator. To illustrate the effect of these extreme variations, two extreme variations will be considered.

1 If the width of the continent in the higher latitudes is very great, as in North America and Asia, there will be a considerable source of cold air in winter. This will result in extreme cold in winter and intense heat in summer for these latitudes, due to the lack of moist air so far inland.

2 If the width of the continent around the tropical region is small, as for instance in Central America, there will be little continental tropical air and a much smaller desert area will result.

Topography, in the form of mountain ranges, will show an effect on them depending upon their orientation. For example if mountains run north-south the tropical air of summer can sweep right into the continental interior, while during the winter the cold Arctic or Polar air can move

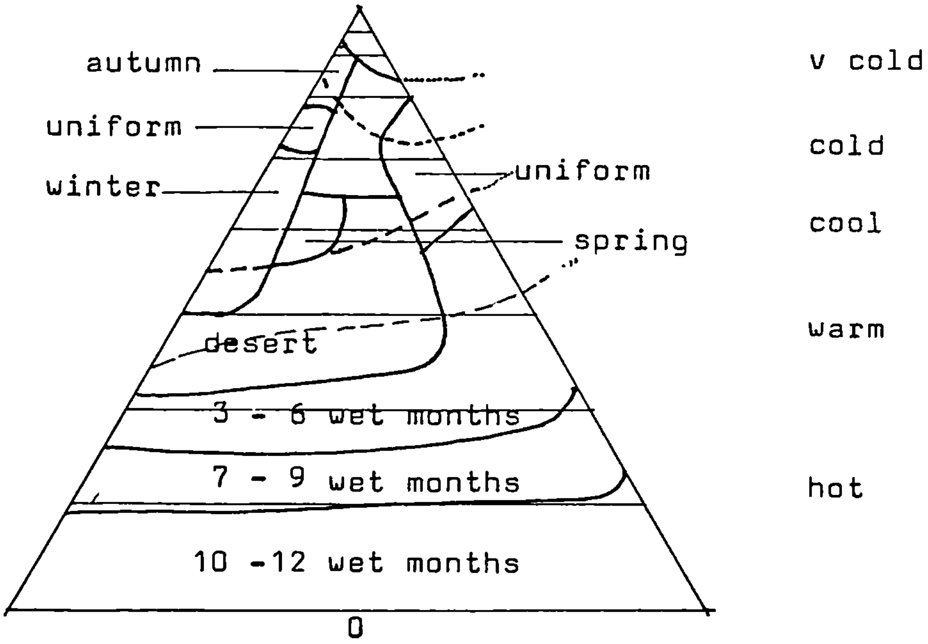

Figure (A1.4) Annual termperature and precipitation patterns on the standard continent.

downwards towards the Equator. This does occur in the Americas where the Rockies and the Andes are both north-south mountain chains. Warm, moist air penetrates as far as Canada in summer, while the northern cold air reaches as far south as Mexico during the winter. If the chains run east-west they are effective in blocking great latitudinal movements of both tropical and Polar air masses. In this case the interior can have a very cold winter while the tropical region can experience a very hot season. This pattern occurs in Asia where the Tibetan plateau and the Anatolian Persian ranges run east-west.

In the mountain area itself the windward side of the mountain is characterised by high precipitation, because here the air flow ascends and cools. The leeward side is characterised by dryness and is relatively sunny, being in the so-called rain shadow. The air movement is first deflected upward by the mountain range then, as it passes beyond the rest of the divide, it sinks and falls rapidly, but soon curves into a trough and is sent upwards again. Thus it begins oscillating to form an extended wave pattern downwind from the mountain.

The Asiatic monsoons illustrate dramatically the influence of continents on the flow of air. During the winter months Siberia is a region of intense cold and high pressure, with the result that northerly and northeasterly winds flow across eastern Asia and stream out into the Bay of Bengal, causing minimum cloud and precipitation over the land. During the summer the situation reverses, the interior is under the influence of a low pressure system, and huge amounts of warm, moist tropical air flow off the Bay of Bengal and off the Indian Ocean to cause intense precipitation over parts of India and Eastern Asia.

Therefore, any classification should take into consideration the location of the continent, its topography as well as its deviation from the Standard Continent. A classification for building and architecture which takes account of man's needs in the internal and the external environments can be expected to save a lot of resources in both the developing and the developed worlds. Intensive research is needed to devise first, a scale or index and second, a world-wide environmental classification taking into account the human environmental needs.

APPENDIX A2 : SOLAR RADIATION :

Its Contribution to Ambient Air

Temperature Outside Buildings

A2 Solar Radiation, its Contribution to Ambient Air Temperature Outside the Built Environment

Solar radiation as a source of energy, and as a factor in building design, has been brought to the forefront in the recent past. Information about solar radiation is frequently needed by workers in many research and applied fields. However, there are few meteorological stations in the world that keep records of both beam and diffused solar radiation. Moreover, very few of these stations are sited within the tropical regions in which more than half the world's population lives. Where climatic conditions range from hot to very hot solar radiation is one of the most important factors affecting building design. It is believed that every 90 W/m^2 of radiation contributes to an increase of 1^oC in our temperature (6). Solar radiation has a very important part to play in the choice of building materials, building forms, orientation, the use of inner and outer spaces in building design, as well as the possibility of its use as an energy source for domestic purposes (7, 8).

The aim of this Appendix is to develop an approximate method of calculating the solar intensity in areas where there are no existing solar radiation records (eg in Egypt) using other records, such as hours of bright sunshine, or the percentage of total actual to total possible hours of sunshine. The calculated radiation intensities in the different regions of Egypt will include the monthly, daily and hourly means for both beam and diffused radiation on horizontal planes. Human response to solar radiation in the external environment will be considered in Part 5 of this Appendix.

A2.1 The Solar Constant Q_o

The sun, with a diameter of 1·39 x 10^6 km, is at a distance on average of 1·5 x 10^8 km from the earth. The surface of the sun is at an effective temperature of about 5762^oK [1] (9) and a density of about 10^{-8} g/cm^3. This simplified picture of the sun's temperature and density will serve as a basis for appreciating that the sun does not function as a black body radiator at a fixed temperature, but that the emitted solar radiation is the composite result of several layers which emit and absorb radiation of various wavelengths. The geometric relationship between the sun and the Earth is shown schematically in figure (2.2).

The eccentricity of the Earth's orbit causes a variation of ±1·7% in the distance between the sun and the Earth. The characteristics of the sun and its spatial relationship with the arth result in a nearly fixed intensity of solar radiation outside the Earth's atmosphere. The solar constant Q_o is the energy from the sun per unit time received on a unit area of surface perpendicular to the radiation, in space, at the Earth's mean distance from the sun. The mean solar constant is estimated as:

$$
\begin{aligned}
Q_o &= 1353 \quad W/m^2 \\
&= 4871 \quad kJ/m^2\ hr \\
&= 1{\cdot}940 \quad cal/cm^2\ min \\
&= 428 \quad BtU/ft^2\ hr
\end{aligned}
$$

Variations in Earth-sun distance do however lead to variations in extraterrestrial radiation with the time of the year. This is expressed in both tables (eg table (A2.1)) and figures (eg fig.(A2.1)).

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1 This leads to the same total energy as is received from the sun above the atmosphere.

month		day No (n_d)	declination (δ)	Eqn of time (E) min	extra-terrestrial (Q_o) W/m^2
Jan	1	1	-23•1	-3•6	1398
	15	15	-21•4	-9•7	1395
Feb	1	32	-17•4	-13•7	1392
	15	47	-12•8	-14•1	1385
Mar	1	60	-8•0	-12•5	1376
	15	75	-2•4	-9•8	1365
Apr	1	91	+4•2	-4•0	1355
	15	106	+9•6	-0•05	1340
May	1	121	+14•9	+2•9	1330
	15	136	+18•8	+3•65	1320
Jun	1	152	+21•9	+2•4	1313
	15	167	+23•2	-0•45	1309
Jul	1	182	+23•1	-3•6	1308
	15	197	+21•6	-6•0	1309
Aug	1	213	+18•0	-6•2	1313
	15	228	+14•2	-4•1	1320
Sep	1	244	+8•4	0•0	1330
	15	259	+3•2	+5•05	1340
Oct	1	274	-3•0	+10•2	1352
	15	289	-8•2	+14•2	1362
Nov	1	305	-14•3	+16•3	1375
	15	320	-18•4	+15•0	1380
Dec	1	335	-21•7	+11•0	1392
	15	350	-23•2	+4•4	1395

Table (A2.1) Variation of declination, Equation of time in minutes, day number. and mean extra-terrestrial radiation with the time of the year.

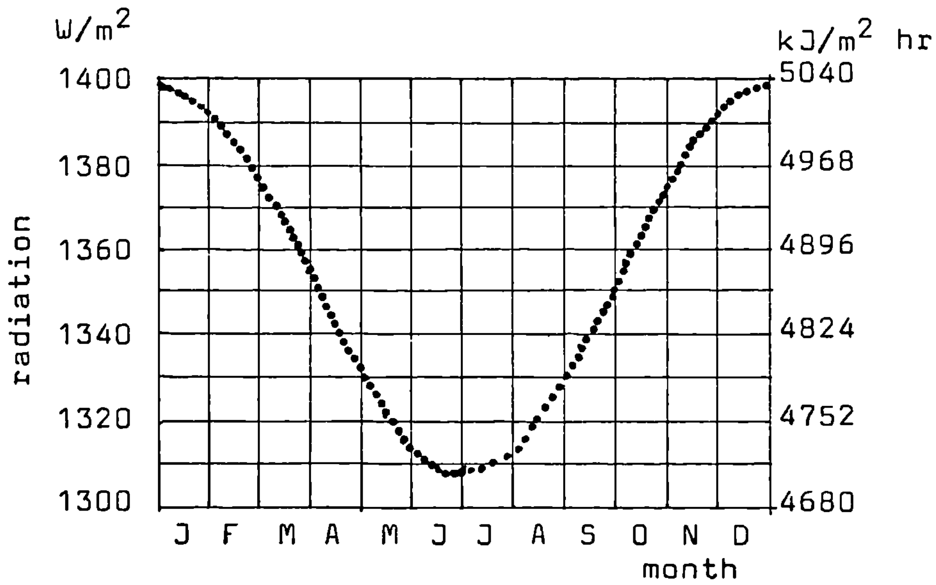

Figure (A2.1) Variation of extraterrestrial solar radiation with time of year. After Duffie (9)

A2.2 The Geometry of Solar Radiation

The geometric relationship between a plane of any orientation relative to the earth at any time and the incoming beam of solar radiation, that is the position of the sun relative to that plane, can be described in terms of several angles:

ϕ	=	latitude, north positive
δ	=	declination = the angular position of the sun at solar noon with respect to the plane of the Equator, north positive in summer
S	=	slope = the angle between the horizontal and the plane
γ	=	the surface azimuth angle = the deviation of the normal to the surface from the local meridian, the zero-point being due south for locations sited in the northern hemisphere, with east positive and west negative
ω	=	hour angle, with the solar noon being zero and each hour = 15^o of longitude, with morning positive and afternoon negative
θ	=	the angle of incidence of the beam of radiation = the angle between the beam and the normal to the plane
θ_z	=	zenith angle = the angle between the beam from the sun to the vertical
α	=	solar altitude = the angle between the beam from the sun and the horizontal = $90 - \theta_z$

The declination, , can be found from the approximation equation of Cooper (12), from tables (eg table (A2.1)),or charts such as the analemma, figure (A2.2) (4 , 9). In this section Cooper's equation, mentioned below, has been used to estimate the declination:

$$\delta = 23{\cdot}45 \sin(360 \times (284 + n_a)/365) \qquad \text{(A2-1)}$$

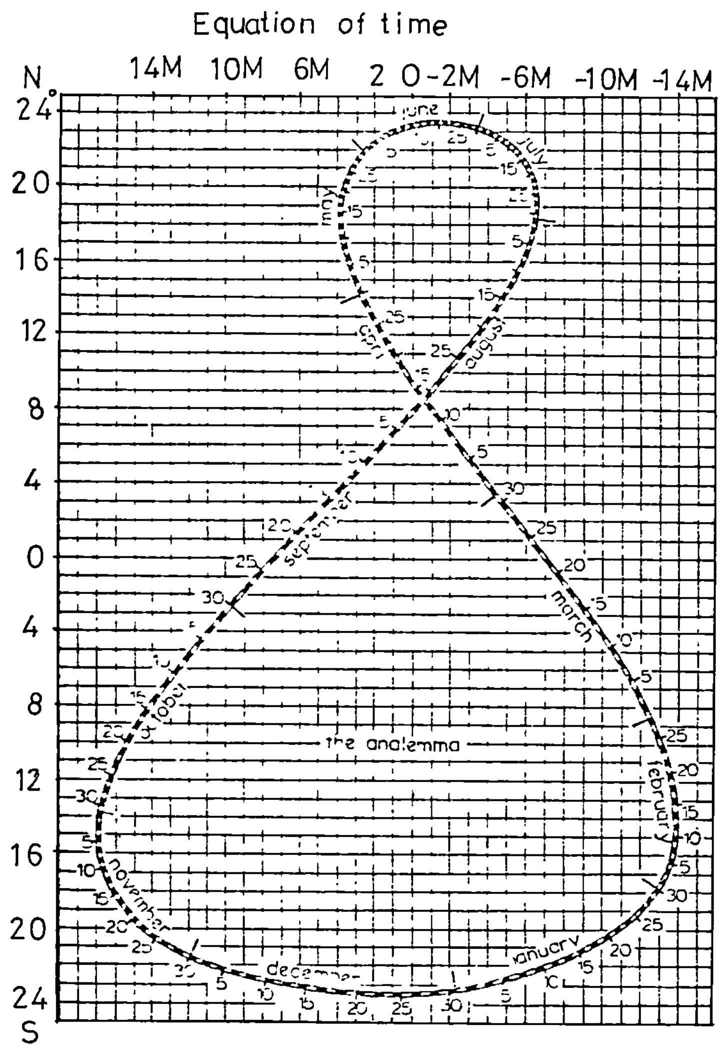

Figure (A2.2) The Analemma. This diagram gives the difference between mean and apparent solar time as well as the sun's declination for each day of the year. For any day the time difference is found directly above, along the upper horizontal margin and the declination along the left hand margin.

where n_a is the day of the year with 1st January as day 1.

Also the declination can be determined from Nomograms, such as that developed by Whillier (13), and reported by both Duffie (9) and Markus (18).

The relationship between θ and the other angles is given by:

$$\cos\theta = \sin\delta \sin\phi \cos s - \sin\delta \cos\phi \sin s \cos\gamma + \cos\delta \cos\phi \cos s \cos\omega + \cos\delta \sin\phi \sin s \cos\gamma \cos\omega + \cos\delta \sin s \sin\gamma \sin\omega$$

The solar altitude (α), and the solar azimuth (γ) with respect to the south, can be calculated according to the following equations:

$$\sin\alpha = \sin\phi \sin\delta + \cos\phi \cos\delta \cos\omega \qquad \text{(A2-2)}$$

$$\sin\gamma = \sin\omega \cos\delta / \cos\phi \qquad \text{(A2-3)}$$

The duration of the sun in the sky, ie the day length, is important for the calculation of both the total daily incoming radiation and the mean daily radiation. The possible hours of sunshine for any day of the year has been calculated by the following equation:

$$N = 2/15 \times \cos^{-1}(-\tan\phi \tan\delta) \qquad \text{(A2-4)}$$

The time specified in all of the sun angle relationships till this stage is solar time, which does not coincide with local time. Therefore it is necessary to relate standard time to solar time by applying two corrections. First there is a constant correction for any difference in longitude between the location and the meridian on which the local standard time is based. The second correction is from the equation of time. These corrections are made by applying the relation:

$$T_{loc} = T_z + \varepsilon + 4(L_{loc} - L_z) \text{ minutes} \qquad (A2-5)$$

where:

ε = equation of time in minutes

L_z = the standard meridian for local time zone (this is $+30^o$ for zone 2 where Egypt falls)

L_{loc} = the longitude of the location

The sun takes 4 minutes to travel 1^o of longitude. It is interesting to note that the equation of time is positive when the sun is fast (ie when it arrives over the meridian before 12.00 by mean time) and negative when the sun is slow (when it arrives after 12.00 by mean time). Therefore the mean time will coincide with the solar time only when the sun arrives over the meridian at 12.00.

A2.3 Estimation of the Average Radiation

Solar radiation entering the earth's atmosphere is split into three parts. One part is absorbed by water and ozone. The second part is scattered by air molecules, dust particles and molecules of water vapour. This part, the direction of which is changed by reflection and scattering, is called 'sky radiation'. The third part, which reaches the earth unaltered, is called 'beam radiation', or direct radiation. The bending of the sun's rays by refraction through the atmosphere is of little importance to the purpose of this section and has been ignored.

On arriving at the earth's surface radiation is reflected and this reflected radiation will be considered as another source of diffused radiation, and will be called 'ground radiation'. The total solar energy reaching the earth's surface, and consequently any object on it, is the sum of all these components. For simplicity, the diffused irradiances are normally considered isotropic so that a vertical surface receives only half as much sky diffuse irradiance as a horizontal surface. Conversely, a horizontal surface feceives no ground radiation, whereas vertical surfaces receive a maximum.

The need for an approximate estimate of the mean solar radiation values falling on a horizontal plane at the surface of the earth arises in climatological studies in many parts of the world. Such an estimate could be made possible by consideration of the ralationshop between recorded solar radiation at the earth's surface and the duration of sunshine. A method was first suggested by Angstrom (1924), and expressed in the form of the following regression equation:

$$Q_h = Q_o({}^1a + (1{\cdot}00 - {}^1a)\ n/N)$$

where:

Q_o = total incoming radiation on a clear day

${}^1a$ = mean proportion of radiation

This proportion (${}^1a$) varies from day to day, and is dependent on many other variables. Black (1954) (1) reported some values for Stockholm. The same principle has been extended to the relationship between the duration of sunshine and the theoretical amount of radiation to be expected were the atmosphere perfectly transparent. This relationship takes the following form:

$$Q_h = Q_o(a + b)n/N$$

where:

Q_o = the total radiation expected in a perfectly transparent atmosphere

and 'a' and 'b' can be determined for a set of data if the four values Q_h, Q_o, n and N are available.

Black (1) examined the values of the regression constants a and b, given in the above equation, for five locations. He found that the regression coefficient b is approximately constant at 0·50 and 0·55, and its values suggested no dependence on latitude. The values of the parameter a however showed a marked trend, being smaller at the higher latitudes and greater at the lower ones, table (A2.2). Black related this to the effect of cloudiness, He also studied records from 32 meteorological stations covering a vast area of the world, and concluded by proposing seven ranges of latitudes for each of which he suggested fixed values for the regression constants.

Glover and McCulloch (2 , 3) examined the values of a and b derived from daily records, and found them varying widely from month to month, but their distribution appeared to be substantially consistent. Actual mean values of a and b for a five year period (1938 - 1943) at Kabete in Kenya, altitude 1830 m (6000 ft), differed slightly but non-significantly according to the length of the period in which the data were grouped. The sum of a and b has been shown to be approximately constant ($\simeq$ 0·82) at Kabete. The value of a has been found to be a function of latitude. An empirical relationship leading to the Angstrom type equation at each latitude 'φ' over the range 0^o - 60^o was derived, and was shown to give values in reasonable agreement with previous experience, This relationship takes the following form:

$$Q_h = Q_o(0{\cdot}29 \cos \phi + 0{\cdot}52\, n/N)$$

or:

$$Q_h = Q_o(0{\cdot}29 \cos \phi + 0{\cdot}52\, n_p) \qquad \text{(A2-6)}$$

where:

n_p = n/N%

= the percentage of actual to possible hours of sunshine.

Locality	Latitude	No of months observ^n	Period of observ^n	Mean Values		Regression constants		Correlation coefficient
				Q/Q_o	u/N	a	b	
Rothamstead	51•8°N	84	1931-40	0•371	0•358	0•18	0•55	0•79
Gembloux	50•6°N	60	1939-50	0•328	0•325	0•15	0•54	0•83
Versailles	48•8°N	99	1935-51	0•440	0•417	0•23	0•50	0•90
Mt Stromlo	35•3°S	144	1928-39	0•593	0•631	0•25	0•54	0•89
Dry Creek	34•8°S	48	1947-50	0•600	0•591	0•30	0•50	0•93

Table (A2.2) Relationship between solar radiation and sunshine calculated in terms of Equation 6 (after Black).

Some authors give other formulae than the Angstrom type for estimating Q_h (14), however they always need constants. The problem is that the constants are not given for many stations or large areas, except in a very simplified form and therefore not accurate. Only the constants a and b are given for many stations and regions and different climates. Therefore, the other formulae are not considered in this part of the study.

A2.4 Estimation of Hourly Radiation

The absorption and scattering process in the atmosphere is the result of many factors. In terms of absorption per unit air mass, ozone absorbs about 3% of the solar constant Q_o, oxygen and carbon dioxide absorb less than 2%, while water vapour absorbs some 10-15% depending on its concentration, removing energy mainly from the infra-red part of the spectrum. Thus, variation in the surface irradiance due to absorption depends mainly on the water vapour distribution.

The precipatable water held gaseously in the atmosphere varies considerably from area to area, and is greatest in the Equatorial regions where it may reach 100 ml/m^3. Scattering by cloud droplets and aerosols depends strongly on particle size and on wavelength. Scattering by aerosol removes from 5% to 55% of Q_o per unit air mass, but a significant part of the scattered radiation still reaches the earth's surface as diffused radiation. The theoretical total solar irradiance, Q_h, expected at the surface as a result of both direct and diffused radiation depends on the following four factors:

1. The solar constant Q_o
2. The sun-earth radius vector
3. The total water vapour content of the atmosphere expressed as precipitable water

4 The air mass, m = (path length traversed L)/(vertical depth of atmosphere d)

This air mass is related to the solar altitude, α, by the following expression, for $\alpha > 10^{\circ}$ at, or close to sea-level:

$$m = 1/\sin \alpha$$
$$= \operatorname{cosec}(\alpha)$$

These four factors affect the solar radiation received at the earth's surface, Q_h, however the major variation of the extimated radiation on a surface normal to solar radiation, defined as Q_{hn}, is due to water vapour and air mass. This can be allowed for by using a turbidity coefficient τ_a, which is based on measurement of Q_{mn} over the whole solar spectrum (0·3 - 3·0 m), and defined by the relationship:

$$\tau_a = -1/m \log_e(Q_{mn}/Q_{hn})$$

where:

Q_{hn} = estimated radiation intensity falling on surface normal to radiation

Q_{mn} = measured radiation intensity falling on surface normal to radiation

The high mid-day solar altitudes associated with lower latitudes mean that mid-day air mass is low, and therefore the energy that penetrates is considerable. In the humid equatorial regions turbidity is often lower than in the desert regions despite the presence of cloud for a high proportion of the day. In temperate mid-latitude climates, the turbidity is characteristically lowest in the middle of winter, increasing to a maximum in the hot season. The absorption of the infra-red band by water vapour increases, so reducing summer direct beam irradiance. Highest turbidity is usually associated with urban situations, and may extend over wide areas.

W P Lowry (15) reported the distribution of air temperature in London, San Francisco and Washington. He suggested the existence of heat islands covering the city centres accompanied by dust domes resulting from activities in the cities. Chandler (16) reported similar phenomena in Leicester. Typical values of τ_a for different types of air masses, with correction for urban and other polluting influences, are given in table (A2.3). The amount of diffused solar radiation on cloudless days also varies considerably from one part of the world to another, because dust particles from the desert, and general atmosphere pollution from human activities add substantially to the atmospheric scattering. These dust particles may cause asymmetry of the daily solar intensity around the solar noon in desert regions. Kuba (20) reports the occurrence of this phenomenon in the Khartoum area. He suggested the reason for it being the hot wind in this area, which stirs the dust in the early morning.

Unsworth and Monteith (17) reported that for cloudless conditions, when the solar altitude is above 30^{o}. the ratio of diffuse irradiance on a horizontal surface, Q_{dh}, to total irradiance on a horizontal surface, Q_h, in central England, may be expressed as a function of turbidity 'τ_a'.

$$Q_{dh}/Q_h = C + d(\tau_a) \qquad \text{(A2-7)}$$

where:

$$C = 0{\cdot}097 \pm 0{\cdot}009$$
$$d = 0{\cdot}68 \pm 0{\cdot}04$$

Page (11) studied the relationship between solar irradiance on horizontal planes and found that for a fixed solar altitude α, a linear relatioship exists between the diffuse

Location	Air mass	τ_a
Northerly island site, minimum pollution from land sources.	Polar	0·05
	average	0·20
	Continental	0·35
Rural or coastal site exposed to natural aerosol pollution and small amount of smoke.	Polar	0·10
	average	0·25
	Continental	0·40
Urban site within or close to a large town (say population exceeding 100,000).	Polar	0·25
	average	0·40
	Continental	0·55

Table (A2.3) Characteristic values of turbidity coefficient τ_a for UK, showing the influence of air mass type and location in relation to pollution sources.

Solar altitude (degrees)	Constants a_0	a_1
0	(0)	(0·290)
10	(63·1)	(0·245)
20	(134·9)	(0·314)
30	222·1	0·360
40	284·3	0·362
50	383·0	0·424
60	484·6	0·492
70	552·1	0·520
80	604·3	0·545
90	624·7	0·560

Table (A2.4) Values of a_0 and a_1 in relation to solar altitude (after Page).

horizontal irradiance and the direct horizontal irradiance. The relationship takes the following form:

$$Q_{dh} = a_o - a_1 Q_{bh}$$

ie:

$$Q_{bh} = (a_o - Q_{dh})/a_1 \qquad \text{(A2-8)}$$

'a_o' and 'a_1' are regression coefficients whose values change due to changes in altitude. Typical values for these coefficients are given in table (A2.4).

In cloudy conditions diffuse irradiation dominates. The study of the climatology of diffuse radiation is very important in building design in cloudy climates, Well over half of the incoming short wave energy may be due to diffused radiation in such areas, and it is important to have reasonably accurate methods for estimating the diffused radiation available to building surfaces. The basic problem here, in the absence of local measurements, is how to separate the diffuse horizontal surface radiation, Q_{dh}, from the global radiation, Q_h. Page (11) found it was possible, by using data from meteorological stations where both diffuse and direct irradiation were observed, to set up a reasonably accurate regression equation of the form:

$$\bar{Q}_{dh}/\bar{Q}_h = c_1 + d_1(\bar{Q}_h/\bar{Q}_{oh})$$

where:

$\bar{Q}_{dh}$ = mean monthly value of daily diffuse irradiation on a horizontal plane

$\bar{Q}_h$ = mean monthly value of daily global irradiation on a horizontal plane

$\bar{Q}_{oh}$ = mean monthly daily irradiation on a horizontal plane in the absence of any atmosphere

and c_1 and d_1 are climatically determined regression constants.

The mean regression equation for ten stations scattered across the world studied by Page was found to be:

$$\overline{Q}_{dh}/\overline{Q}_{h} \quad = \quad 1\cdot00 - 1\cdot13(\overline{Q}_{h}/\overline{Q}_{oh})$$

These regression constants seem to over-estimate the amount of diffuse radiation in hot zones. Page also found that a very high correlation existed between monthly mean hourly diffuse horizontal surface irradiance and solar altitude, for a number of stations in Western Europe. The relationship function is remarkably simple:

$$Q_{dhh} \quad = \quad {}^{1}a + b^{1} \qquad \text{(A2-9)}$$

He suggested that this equation is precise in the northern hemisphere, but may also apply to the southern hemisphere. Values for the constants ${}^{1}a$ and b^{1} are given in table (A2.5). Inspection of the values of ${}^{1}a$ and b^{1} in the regression equation of the monthly mean diffuse irradiation on a horizontal plane indicates that ${}^{1}a$ is constant at a value equivalent to 2, while b^{1} appears to depend on the turbidity, the type of terrain, and the wind conditions, and seems to be independent of latitude.

Accordingly, for the purposes of this section, ${}^{1}a$ will be taken as a constant, 2, while b^{1} will be considered as a constant depending on the site type as shown in table (A2.6).

A2.5 Radiation and Ambient Air Temperature

The radiation effect on human beings is a function of many factors, the most important being the intensity of radiation. Other factors of less significance include level of activity, clothing, wind speed, posture, terrain and ambient air temperature (DBT). Radiation effect of hot surfaces can be used to balance lower air temperature. This means that human beings can experience comfort at lower

Location	Latitude	^1a	b^1
Kew (London)	52°N	2	4•804
Eskdalemuir (Glasgow)	55°20'N	2	4•798
Lerwick (coastal town)	60°10'N	2	5•068
Bracknell (rural site)	52°N	2	5•068
Aberporth (Welsh coast)	52°10'N	2	5•176
Hamburg (open air port)	53°35'N	2	5•360
Valentia (W Irish coast)	51°55'N	2	5•600

Table (A2.5) Constants in monthly mean hourly diffuse horizontal surface irradiation formula (after Page).

Location	^1a	b^1
Urban sites within big cities	2	4•800
Suburban sites in small towns and villages	2	5•068
Open country sites and coastal areas	2	5•400

Table (A2.6) Constants ^1a and b^1 in the regression equation of the monthly mean diffuse irradiation on horizontal plane.

air temperature conditions if the heat loss of the body can be counteracted with radiation from hot surface sources, including the sun's radiation. In internal spaces this may be controlled to some extent by controlling the temperature of the radiating surface. In external spaces, where the sun is the main source of radiation, designers should consider its heat load on human beings. The aim of this part is to propose an index for evaluating that heat load on man.

In hot climates solar radiation may increase the heat gain to an extremely uncomforable level. Human skin absorbs only a fraction of the heat flux and skin absorbance is, furthermore, lowest for the highest radiation flux, figure (A2.3). The absorption rate inversely mirrors the solar heat flux, graphed as a function of wavelength. Skin absorption is somewhat higher for tanned (or black) skin, particularly in the visible part of the spectrum.

Givoni (10) suggested a method for calculating the radiant heat load due to solar radiation to integrate its effect into his index 'The Index of Thermal Stress', using the following formula:

$$R = I_N K_{pe} K_{cL}(1 - a(V^{0 \cdot 2} - 0 \cdot 88))$$

where:

R = solar radiation heat load
I_N = normal solar radiation intensity
K_{pe} = coefficient depending on posture and terrain
K_{cL}, a = coefficents depending on clothing
V = wind speed

His calculation considered neither the level of activity nor the ambient air temperature. This suggests that these calculations would under-estimate the magnitude of the solar heat load.

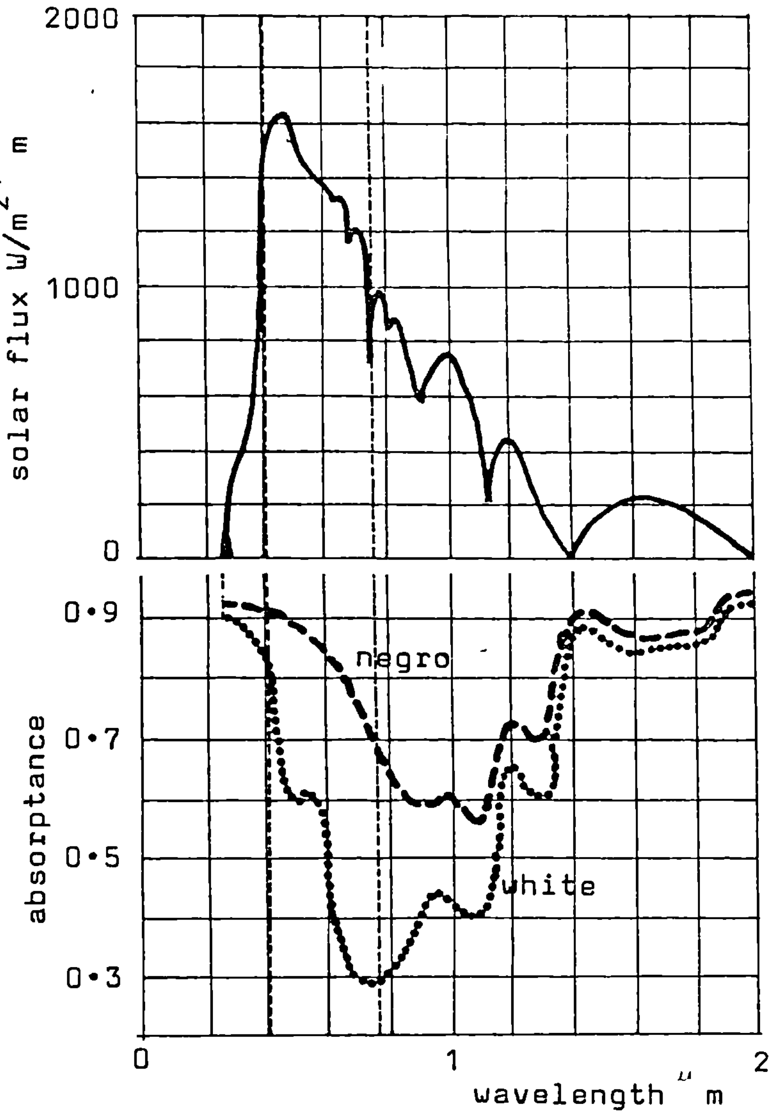

Figure (A2.3) Solar radiation and absorption by white and negro skin. After Kamon (22).

Yaglou, 1947 (25), suggested the following relations to determine the effect of solar radiation on the human body:

Heat loss by radiation and convection (R + C)

$$= S \times S_c(t_s - t_a)/(clo/c + V_{clo}/c)$$

Heat loss by evaporation (E)

$$= E_c$$

where:

S	=	mean body surface ares of clothed man, average clothed and unclothed area = 2•15 m^2 (23 ft^2)
S_c	=	fraction of surface area exposed to radiation and convection
t_s	=	comfortable skin temperature, 34^{o}C (93^{o}F)
t_a	=	dry-bulb temperature
clo	=	one unit insulation of clothing
V_{clo}	=	air effect on clothing at 0•5 - 1•0 m/s (1 - 2 mph)
C	=	coefficient of 1 clo unit - 0•5^{o}C
E_c	=	latent heat loss at low temperature by evaporation, 38 W (130 BtU/h)

Olgyay (5) in his bioclimatic chart indicated the effect of solar radiation on the human body in radiation curves using Yalgou's formulation. He found that every 100 W/m^2 of solar radiation produces a rise in the ambient air temperature of 1•35^{o}C (ie every 75 W/m^2 has the effect of increasing the ambient air temperature by 1^{o}C). Olgyay's calculations were made for man living under cold conditions therefore his findings may not be valid for the hot periods.

Szokolay (24) suggested that for outdoor conditions an irradiance of 70 W/m^2 on a horizontal is equal in effect to 1^{o}C. This approximation can be related immediately to Olgyay's findings for the under-heated period. Szokolay suggested a simplified method to estimate the radiant heat load on a man standing outside and exposed to solar radiation. His method seems to overestimate the amount of heat gained by the human body, especially in the over-heated zone. He suggested that on average a 1°C drop in the dry bulb temperature is compensated for by an incident radiant flux of 7 W.

Kamon, 1978 (22), reported that the heat load resulting from direct radiation of 930 W/m^2 (800Kcal/m^2 hr) on a horizontal plane, plus that from indirect radiation of 150 W/m^2 (130 Kcal/m^2 hr) amounted to between 140 and 185W on a walking man. This caused an increase in sweating just as it would if the convective heat load was increased by an amount equivalent to an 8°C rise in air temperature, suggesting that if solar radiation intensity was as high as 1000 W/m^2, every 135 W/m^2 of solar radiation falling on a horizontal plane will contribute 1°C increase in ambient air temperature. Incident radiant flux of between 18 - 23 W on the human body will result in the same sweating increase as when the convective heat load is increased by an amount equivalent to a rise in air temperature of 1°C,

Therefore, for the purpose of this section, the effect of radiation on human beings standing outside the built environment will be estimated as due to the intensity of radiation falling on a horizontal surface on the ground, and consequently, on man himself. The low limit for underheated periods (with low radiation intensities) will be taken as 1°C rise in the ambient air temperature, resulting from 70 W/m^2. The upper limit for very high intensities (with overheated periods) will be that 135 W/m^2 is having the same thermal effect as an increase of 1°C in ambient air temperature.

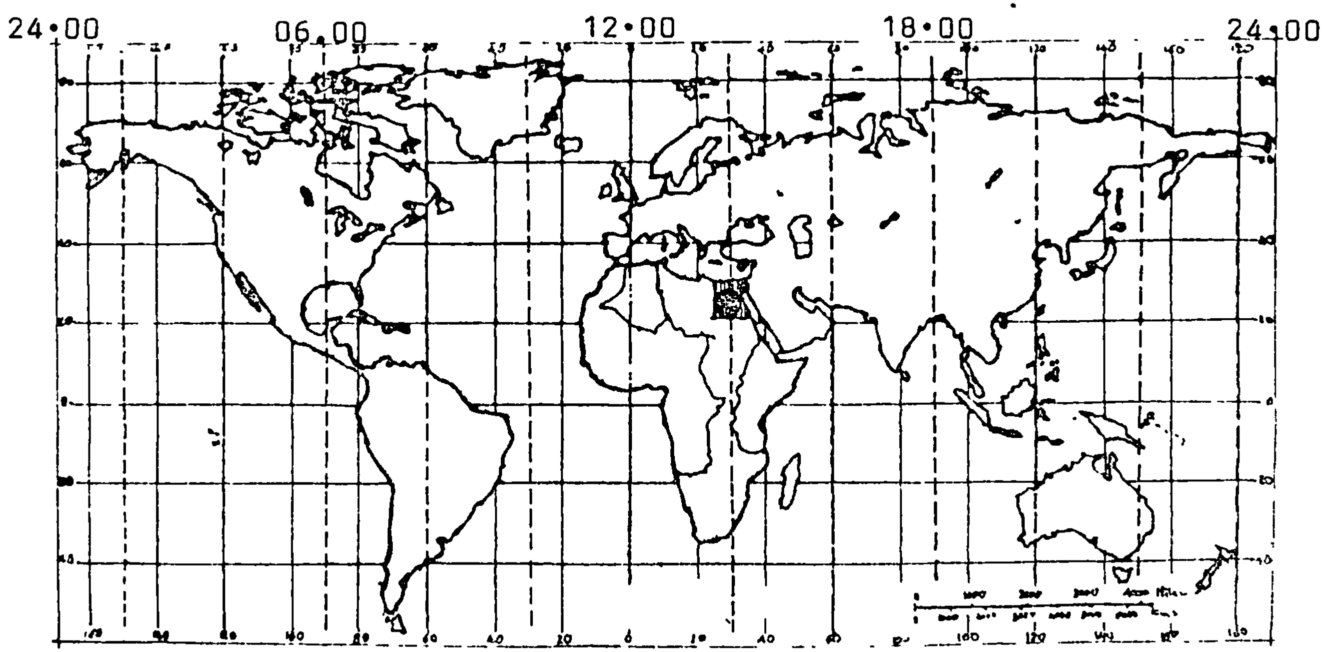

Figure (A2.4) Time zones of the world.

	J	F	M	A	M	J	J	A	S	O	N	D	annual mean
Lower Egypt	72	69	73	75	81	86	87	89	85	82	76	63	78
Red Sea	59	73	75	80	81	95	95	94	93	84	76	70	81
Upper Egypt	84	86	85	88	86	96	95	94	95	91	84	84	89
Desert	81	80	84	88	84	98	98	98	98	91	83	78	89
Cairo	65	64	68	74	73	89	88	86	85	78	68	59	75
El-Khanka	69	70	73	79	80	91	85	80	83	84	78	70	79
Delta Barrage	66	69	73	79	79	86	80	75	79	80	76	69	76
Almaza	71	74	74	74	78	83	83	85	85	83	80	71	79
Giza	63	64	66	74	75	90	89	86	85	68	69	59	75
Helwan	63	64	69	76	75	95	94	93	91	83	66	61	78
	J	F	M	A	M	J	J	A	S	O	N	D	

Table (A2.7) The hours of bright sunshine in the Egyptian regions, expressed as % total actual/total possible.

Code	Region	Latitude N (ϕ)	Longitude E (L_{loc})
1	Alexandria	$31^{o}12'$	$29^{o}57'$
2	Suez	$29^{o}56'$	$32^{o}33'$
3	Aswan	$24^{o}02'$	$32^{o}53'$
4	Siwa	$29^{o}12'$	$25^{o}19'$
5	Cairo	$30^{o}08'$	$31^{o}34'$
6	El-Khanka	$30^{o}13'$	$31^{o}12'$
7	Delta Barrage	$30^{o}11'$	$31^{o}08'$
8	Almaza	$30^{o}06'$	$31^{o}22'$
9	Giza	$30^{o}02'$	$31^{o}13'$
10	Helwan	$29^{o}52'$	$21^{o}20'$

Table (A2.8) The map references of the Egyptian regions (the standard time meridian (L_z) for most of the Middle East is Alexandria, 30^{o}E).

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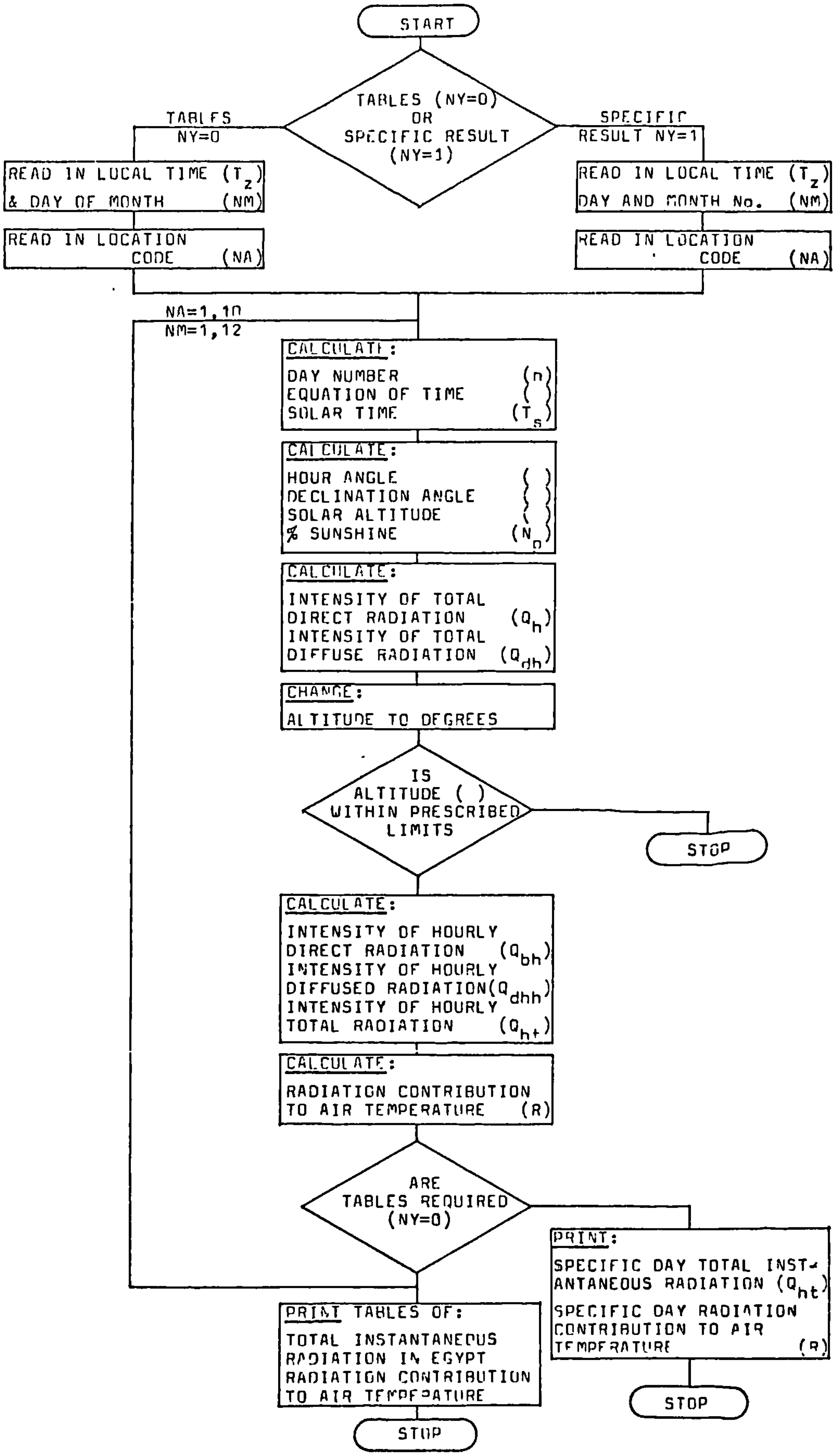
START
TABLES (NY=0) OR SPECIFIC RESULT (NY=1)
TABLES NY=0
SPECIFIC RESULT NY=1
READ IN LOCAL TIME (T_z) & DAY OF MONTH (NM)
READ IN LOCATION CODE (NA)
READ IN LOCAL TIME (T_z) DAY AND MONTH No. (NM)
READ IN LOCATION CODE (NA)
NA=1,10
NM=1,12
CALCULATE:
DAY NUMBER (n)
EQUATION OF TIME ( )
SOLAR TIME (T_s)
CALCULATE:
HOUR ANGLE ( )
DECLINATION ANGLE ( )
SOLAR ALTITUDE ( )
% SUNSHINE (N_n)
CALCULATE:
INTENSITY OF TOTAL DIRECT RADIATION (Q_h)
INTENSITY OF TOTAL DIFFUSE RADIATION (Q_dh)
CHANGE:
ALTITUDE TO DEGREES
IS ALTITUDE ( ) WITHIN PRESCRIBED LIMITS
STOP
CALCULATE:
INTENSITY OF HOURLY DIRECT RADIATION (Q_bh)
INTENSITY OF HOURLY DIFFUSED RADIATION(Q_dhh)
INTENSITY OF HOURLY TOTAL RADIATION (Q_ht)
CALCULATE:
RADIATION CONTRIBUTION TO AIR TEMPERATURE (R)
ARE TABLES REQUIRED (NY=0)
PRINT:
SPECIFIC DAY TOTAL INSTANTANEOUS RADIATION (Q_ht)
SPECIFIC DAY RADIATION CONTRIBUTION TO AIR TEMPERATURE (R)
STOP
PRINT TABLES OF:
TOTAL INSTANTANEOUS RADIATION IN EGYPT
RADIATION CONTRIBUTION TO AIR TEMPERATURE
STOP

```
LIST

10 DIMENSION HS(10,12),ER(10,2),SC(3,3),SA(10,3),DY(24,2),MD(12)
20 DIMENSION OTH(10,12),LT(10,12)
30 [illegible] JP
40 DATA HS/72.0,59.0,34.0,31.0,65.0,69.0,66.0,71.0,63.0,63.0,
50&33.5,73.0,36.0,30.0,64.0,70.0,69.0,74.0,64.0,64.0,
60&72.5,75.0,35.0,34.0,33.0,73.0,73.0,74.0,66.0,69.0,
70&75.0,30.0,33.0,33.0,74.0,79.0,75.0,74.0,74.0,76.0,
80&31.0,31.0,36.0,34.0,73.0,30.0,73.0,73.0,75.0,75.0,
90&3[illegible].0,95.0,93.0,[illegible].0,39.0,91.0,36.0,30.0,9[illegible].0,95.0,
100&[illegible]7.[illegible],9[illegible].0,95.0,93.0,33.0,35.0,33.0,33.0,39.0,94.0,
110&33.5,94.0,9[illegible].0,93.0,36.0,30.0,75.0,35.0,36.0,93.0,
120&[illegible]4.5,93.0,95.0,9[illegible].[illegible],[illegible]5.0,33.0,79.0,35.0,35.0,91.0,
130&31.5,34.0,91.0,[illegible]1.[illegible],73.[illegible],[illegible]4.0,30.0,83.0,63.0,33.0,
140&7[illegible].[illegible],7[illegible].[illegible],[illegible].[illegible],33.0,63.0,73.0,76.0,30.0,69.0,66.0,
150&[illegible]2.5,70.0,34.0,73.0,59.0,70.0,69.0,71.0,59.0,61.0/
160 DATA ER/31.2,29.93,24.23,29.2,[illegible].13,30.22,32.13,30.1,30.23,29.87,
170&29.95,32.55,32.33,25.32,31.567,31.2,31.13,31.37,31.22,31.33/
180 DATA SC/2.0,2.0,2.[illegible],4.0,5.058,5.4,0.25,0.1,0.05/
190 DATA SA/0.0,1[illegible].0,20.0,30.0,40.0,50.0,60.0,70.0,80.0,90.0,
200&[illegible].0,63.1,134.9,222.1,234.3,333.0,434.6,552.1,604.3,624.7,
210&0.29,0.295,0.314,0.36,0.362,0.424,0.492,0.52,0.545,0.56/
220 DATA DY/-3.6,-9.7,-13.7,-14.1,-12.5,-9.8,-4.0,-0.05,2.9,3.65,2.4,
230&-0.45,-3.6,-6.0,-6.2,-4.1,0.0,5.05,10.2,14.2,16.3,15.0,11.0,4.4,
240&1393.0,1395.0,1392.0,1385.0,1376.0,1365.0,1355.0,1340.0,
250&1330.0,1320.0,1313.0,1309.0,1303.0,1309.0,1313.0,1320.0,
260&1330.0,1340.0,1352.0,1362.0,1375.0,1380.0,1392.0,1395.0/
270 DATA MD/31,28,31,30,31,30,31,31,30,31,30,31/
280 WRITE(6,6)
290 READ(5,99)JY
300 IF(JY.EQ.0)GO TO 90
310 WRITE(6,1)
320 READ(5,99)NAREA
330 JA1=NAREA
340 JA2=NAREA
350 WRITE(6,2)
360 READ(5,99)TL,JD,NMNTH
370 NM1=NMNTH
380 NM2=NMNTH
390 GO TO 110
400 90 WRITE(6,7)
410 READ(5,99)TL,ND
420 NM1=1
430 NM2=12
440 JA1=1
```

```
      JNE=IE
  110 WRITE(6,8)
      READ(5,99) NTL
      PI=3.14159
      DO 100 JN=NA1,NA2
      DO 100 JM=M1,M2
      J=JM-1
      JDAY=0
      IF(J.EQ.0)GO TO 5
      DO 50 I=1,J
   50 JDAY=JDAY+ND(I)
    5 JDAY=JDAY+ID
      K=2*J
      IF(ID.LE.1) K=K+1
      IF(ID.GE.15) K=K+2
      EPS=DY(K,1)
      TS=TL+EPS/60.0+(EP(JN,2)-S  .0)/15.
      OM=15.  *(12.0-TS)
      G=23.45*SIN(36 .0*(284.0+JDAY)*PI/(365.0*180.0))
      A=SIN(EP(JN,1)*PI/180.0)*SIN(G*PI/180.0)
      B=COS(EP(JN,1)*PI/180.0)*COS(G*PI/180)*COS(OM*PI/180.0)
      SNA=SIN(EP(JN,1)*PI/180.0)*SIN(G*PI/180.0)+COS(EP(JN,1)*PI/180.0)
     **COS(G*PI/180.0)*COS(OM*PI/180.0)
      ALPHA=ASIN(SNA)
      JP=AS(JN,J1)/100.0
      QA=DY(K,2)*( .29*COS(EP(JN,1)*PI/180.0)+0.52*JP)
      QDI=QA*(0.097+0.63*SC(NTL,3))
      DA=ALPHA*180.0/PI
      DO 60 I=1,10
      IF(DA.LE.SA(I,1))GO TO 70
   60 CONTINUE
      WRITE(6,4)
      STOP
   70 J=I-1
      RATIO=(DA-SA(J,1))/10.0
      A0=SA(J,2)+RATIO*(SA(I,2)-SA(J,2))
      A1=SA(J,3)+RATIO*(SA(I,3)-SA(J,3))
      QDI=(A0-QDI)/A1
      IF(QDI.LT.0.0)QDI=0.0
      QDM=SC(NTL,1)+SC(NTL,2)*DA
      QIT=QDM+QDI
      IF(QIT.LT.100.0)R=70.0
      IF(QIT.GT.1000.0)R=135.0
      IF(QIT.LT.100.0.OR.QIT.GT.1000.0)GO TO 170
      RATIO=(QIT-100.0)/900.0
      R=70.0+RATIO*65.0
  170 LTA=QIT/R
      IF(NY.EQ.1)GO TO 140
      QTI(JN,JM)=QIT
  100 LT(JN,JM)=LTA
      WRITE(6,11)
      WRITE(6,12)TL,ID
```

```
960 WRITE(6,13)
970 WRITE(6,15)
980 DO 150 JA=1,10
990 150 WRITE(6,8)JA,(RTI(JA,MI),MI=1,12)
1000 WRITE(6,11)
1010 WRITE(6,14)
1020 WRITE(6,15)
1030 DO 160 JA=1,10
1040 160 WRITE(6,9)JA,(DT(JA,MI),MI=1,12)
1050 GO TO 500
1060 140 WRITE(6,5)CIT,DTA
1070 1 FORMAT(1X,"TYPE IN AREA CODE :-",/
1080&" (1) ALEX       (6) EL-GHARGA",/
1090&" (2) SUEZ       (7) DELTA BARRAGE",/
1100&" (3) ASWAN      (8) ALMAZA",/
1110&" (4) SIWA       (9) GIZA",/
1120&" (5) CAIRO      (10)HELWAN")
1130 2 FORMAT(1X,"TYPE IN LOCAL TIME, DAY & MONTH NUMBERS")
1140 3 FORMAT(1X,"TYPE IN LOCATION CODE :-",/
1150&" (1) URBAN",/
1160&" (2) SUBURBAN",/
1170&" (3) OPEN COUNTRY")
1180 4 FORMAT(1X,"MISTAKE IN DATA - ALTITUDE TOO HIGH")
1190 5 FORMAT(1X,"CIT =",F8.2,"DELTA =",F6.2)
1200 6 FORMAT(1X,"DO YOU WISH TO USE PROGRAM TO PRODUCE :-"/
1210&" TABLES (0) OR A SPECIFIC RESULT (1)")
1220 7 FORMAT(1X,"TYPE IN LOCAL TIME & DAY OF MONTH")
1230 8 FORMAT(1X,I3,4X,12F5.0)
1240 9 FORMAT(1X,I3,4X,12F5.2)
1250 11 FORMAT(1X,/////,1X)
1260 12 FORMAT(1X,/,1X,"AT",F6.2," HOURS ON DAY",I3," OF EACH MONTH"///)
1270 13 FORMAT(1X,"TOTAL INSTANTANEOUS SOLAR RADIATION FALLING ON
1280&HORIZONTAL PLANE"/1X,"IN THE EGYPTIAN REGIONS  (W/M2)"/)
1290 14 FORMAT(1X,"SOLAR RADIATION CONTRIBUTION TO AMBIENT AIR TEMP.
1300&IN OUTER SPACES"/1X,"IN THE EGYPTIAN REGIONS  (DEG C)"/)
1310 15 FORMAT(1X,/,1X,"REGION  JAN  FEB  MAR  APR  MAY  JUN  JLY  AUG
1320&SEP  OCT  NOV  DEC"//)
1330 99 FORMAT(V)
1340 500 STOP
1350 END

*

 BYE
**COST:  $  33.57 TO DATE:  $ 7025.09=  7%
**ON AT 16.434 - OFF AT 19.193 ON  06/13/30
```

RUN
DO YOU WISH TO USE PROGRAM TO PRODUCE :-
TABLES (0) OR A SPECIFIC RESULT (1)
=0
TYPE IN LOCAL TIME & DAY OF MONTH
=12, 15
TYPE IN LOCATION CODE :-
(1) URBAN
(2) SUBURBAN
(3) OPEN COUNTRY
=1

AT 12.00 HOURS ON DAY 15 OF EACH MONTH

TOTAL INSTANTANEOUS SOLAR RADIATION FALLING ON HORIZONTAL PLANE
IN THE EGYPTIAN REGIONS (W/M2)

REGION	JAN	FEB	MAR	APR	MAY	JUN	JLY	AUG	SEP	OCT	NOV	DEC
1	234.	503.	734.	935.	1034.	1063.	1047.	950.	791.	547.	317.	290.
2	379.	518.	743.	931.	1042.	1037.	1027.	944.	773.	556.	333.	272.
3	394.	537.	801.	964.	1059.	1055.	1057.	1003.	845.	644.	445.	332.
4	255.	433.	711.	907.	1033.	1024.	1009.	923.	765.	551.	331.	243.
5	343.	556.	772.	951.	1070.	1053.	1050.	970.	802.	582.	377.	323.
6	319.	525.	750.	933.	1046.	1051.	1059.	990.	809.	554.	323.	263.
7	336.	530.	751.	947.	1053.	1063.	1076.	1003.	824.	573.	335.	274.
8	311.	509.	749.	952.	1053.	1073.	1067.	974.	802.	560.	316.	265.
9	355.	553.	732.	953.	1064.	1055.	1047.	971.	804.	629.	376.	331.
10	353.	561.	773.	948.	1066.	1040.	1031.	943.	733.	565.	395.	320.

SOLAR RADIATION CONTRIBUTION TO AMBIENT AIR TEMP. IN OUTER SPACES
IN THE EGYPTIAN REGIONS (DEG C)

REGION	JAN	FEB	MAR	APR	MAY	JUN	JLY	AUG	SEP	OCT	NOV	DEC
1	3.41	5.11	6.34	7.17	7.66	7.37	7.76	7.23	6.60	5.35	3.70	3.47
2	4.20	5.17	6.40	7.16	7.72	7.68	7.61	7.21	6.52	5.40	3.87	3.30
3	4.32	5.58	6.64	7.23	7.85	7.81	7.33	7.43	6.83	5.89	4.69	3.32
4	3.24	4.95	6.23	7.07	7.69	7.59	7.43	7.15	6.48	5.37	3.82	3.03
5	3.92	5.40	6.51	7.24	7.92	7.84	7.73	7.30	6.64	5.55	4.19	3.80
6	3.72	5.21	6.41	7.17	7.75	7.79	7.85	7.37	6.67	5.39	3.76	3.26
7	3.36	5.25	6.42	7.22	7.80	7.91	7.97	7.46	6.74	5.50	3.85	3.32
8	3.65	5.11	6.41	7.24	7.80	7.99	7.90	7.32	6.65	5.43	3.69	3.23
9	4.02	5.41	6.56	7.24	7.88	7.82	7.76	7.31	6.65	5.81	4.13	3.32
10	4.04	5.43	6.52	7.22	7.89	7.70	7.64	7.22	6.56	5.46	4.33	3.75

```
RFFJ
DO YOU WISH TO USE PROGRAM TO PRODUCE :-
TABLES (0) OR A SPECIFIC RESULT (1)
=0
TYPE IN LOCAL TIME & DAY OF MONTH
=14, 15
TYPE IN LOCATION CODE :-
(1) URBAN
(2) SUBURBAN
(3) OPEN COUNTRY
=1
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AT 14.00 HOURS ON DAY 15 OF EACH MONTH

TOTAL INSTANTANEOUS SOLAR RADIATION FALLING ON HORIZONTAL PLANE
IN THE EGYPTIAN REGIONS (W/M2)

REGION	JAN	FEB	MAR	APR	MAY	JUN	JLY	AUG	SEP	OCT	NOV	DEC
1	147.	335.	539.	703.	737.	819.	821.	734.	534.	263.	111.	103.
2	211.	332.	503.	657.	749.	751.	760.	630.	467.	231.	94.	57.
3	167.	339.	539.	653.	730.	733.	752.	701.	516.	270.	133.	37.
4	174.	371.	530.	741.	842.	837.	845.	772.	573.	313.	153.	113.
5	136.	353.	553.	696.	795.	737.	793.	726.	513.	273.	147.	123.
6	167.	329.	534.	631.	774.	734.	814.	754.	532.	246.	97.	71.
7	134.	336.	536.	599.	733.	804.	833.	775.	552.	263.	109.	73.
8	156.	323.	523.	700.	730.	811.	819.	733.	522.	250.	36.	66.
9	222.	364.	569.	703.	793.	733.	799.	732.	525.	331.	143.	135.
10	203.	365.	556.	694.	792.	763.	730.	704.	493.	254.	165.	126.

SOLAR RADIATION CONTRIBUTION TO AMBIENT AIR TEMP. IN OUTER SPACES
IN THE EGYPTIAN REGIONS (DEG C)

REGION	JAN	FEB	MAR	APR	MAY	JUN	JLY	AUG	SEP	OCT	NOV	DEC
1	2.00	3.36	5.03	6.22	6.53	6.72	6.73	6.34	5.27	3.21	1.56	1.53
2	2.71	3.57	5.11	5.96	6.41	6.42	6.46	6.23	4.34	2.96	1.34	1.32
3	2.23	3.99	5.03	5.96	6.32	6.33	6.42	6.13	5.16	3.23	1.33	1.25
4	2.31	4.14	5.54	6.37	6.31	6.79	6.33	6.51	5.50	3.70	2.07	1.65
5	2.44	4.04	5.33	6.16	6.30	6.53	6.63	6.20	5.17	3.01	2.01	1.73
6	2.23	3.32	5.47	6.03	6.52	6.57	6.72	6.40	5.26	3.05	1.09	1.71
7	2.42	3.35	5.23	6.17	6.56	6.55	6.73	6.52	5.33	3.26	1.55	1.12
8	2.11	3.62	5.24	6.13	6.55	6.63	6.72	6.24	5.19	3.09	1.23	[illegible]
9	2.61	[illegible]	5.43	6.19	6.61	6.53	6.63	6.00	5.21	3.32	[illegible]	1.77
10	[illegible]	4.09	5.40	6.10	6.60	6.49	6.55	6.20	[illegible]	3.10	[illegible]	1.75

```
*RUN
DO YOU WISH TO USE PROGRAM TO PRODUCE :-
TABLES (0) OR A SPECIFIC RESULT (1)
=0
TYPE IN LOCAL TIME & DAY OF MONTH
=12, 15
TYPE IN LOCATION CODE :-
(1) URBAN
(2) SUBURBAN
(3) OPEN COUNTRY
=2
```

AT 12.00 HOURS ON DAY 15 OF EACH MONTH

TOTAL INSTANTANEOUS SOLAR RADIATION FALLING ON HORIZONTAL PLANE
IN THE EGYPTIAN REGIONS (W/M2)

REGION	JAN	FEB	MAR	APR	MAY	JUN	JLY	AUG	SEP	OCT	NOV	DEC
1	539.	736.	936.	1122.	1222.	1254.	1240.	1151.	997.	733.	577.	525.
2	609.	751.	952.	1126.	1230.	1241.	1231.	1152.	991.	795.	597.	524.
3	661.	329.	1014.	1169.	1256.	1262.	1263.	1211.	1065.	830.	703.	607.
4	541.	730.	929.	1113.	1230.	1232.	1217.	1141.	991.	793.	602.	513.
5	535.	773.	966.	1133.	1243.	1253.	1245.	1167.	1009.	810.	621.	558.
6	569.	753.	952.	1126.	1233.	1249.	1250.	1179.	1013.	793.	583.	520.
7	530.	757.	952.	1135.	1237.	1260.	1261.	1190.	1022.	805.	595.	524.
3	565.	744.	951.	1133.	1238.	1266.	1255.	1170.	1009.	797.	534.	519.
9	593.	775.	972.	1139.	1245.	1252.	1243.	1168.	1011.	840.	621.	560.
10	597.	773.	967.	1137.	1246.	1243.	1234.	1155.	999.	302.	635.	557.

SOLAR RADIATION CONTRIBUTION TO AMBIENT AIR TEMP. IN OUTER SPACES
IN THE EGYPTIAN REGIONS (DEG C)

REGION	JAN	FEB	MAR	APR	MAY	JUN	JLY	AUG	SEP	OCT	NOV	DEC
1	5.30	6.35	7.13	3.31	9.05	9.29	9.19	3.52	7.40	6.56	5.52	5.22
2	5.70	6.42	7.24	3.34	9.11	9.19	9.12	3.53	7.33	6.61	5.64	5.21
3	5.93	6.76	7.51	3.66	9.30	9.35	9.35	3.97	7.89	6.97	6.19	5.70
4	5.31	6.32	7.15	3.24	9.11	9.12	9.02	3.45	7.37	6.63	5.66	5.14
5	5.57	6.52	7.29	3.43	9.24	9.23	9.22	3.65	7.47	6.63	5.77	5.41
6	5.43	6.43	7.24	3.34	9.13	9.25	9.26	8.74	7.50	6.60	5.59	5.13
7	5.54	6.45	7.24	3.41	9.17	9.33	9.34	3.82	7.57	6.66	5.63	5.21
3	5.46	6.39	7.24	3.43	9.17	9.33	9.30	3.67	7.43	6.62	5.56	5.13
9	5.62	6.53	7.31	3.44	9.22	9.23	9.21	3.65	7.49	6.31	5.77	5.43
10	5.64	6.54	7.29	3.42	9.23	9.21	9.14	3.56	7.40	6.64	5.34	5.41

*FFJ
DO YOU WISH TO USE PROGRAM TO PRODUCE :-
TABLES (2) OR A SPECIFIC RESULT (1)
=2
TYPE IN LOCAL TIME & DAY OF MONTH
=14, 15
TYPE IN LOCATION CODE :-
(1) URBAN
(2) SUBURBAN
(3) OPEN COUNTRY
=2

AT 14.00 HOURS ON DAY 15 OF EACH MONTH

TOTAL INSTANTANEOUS SOLAR RADIATION FALLING ON HORIZONTAL PLANE
IN THE EGYPTIAN REGIONS (W/M2)

REGION	JAN	FEB	MAR	APR	MAY	JUN	JLY	AUG	SEP	OCT	NOV	DEC
1	401.	532.	766.	914.	937.	1022.	1025.	949.	773.	531.	369.	343.
2	440.	559.	743.	876.	955.	969.	977.	903.	725.	505.	355.	315.
3	453.	615.	784.	887.	945.	956.	973.	923.	772.	559.	415.	373.
4	449.	633.	816.	957.	1044.	1055.	1062.	994.	822.	597.	429.	386.
5	427.	597.	774.	903.	937.	995.	1005.	939.	760.	536.	392.	362.
6	416.	530.	763.	895.	976.	996.	1016.	958.	770.	520.	362.	327.
7	427.	534.	764.	907.	931.	1003.	1029.	971.	733.	534.	370.	332.
8	409.	567.	759.	906.	973.	1012.	1019.	945.	763.	523.	355.	324.
9	439.	602.	735.	909.	933.	993.	1008.	945.	766.	574.	394.	363.
10	440.	604.	777.	904.	937.	935.	995.	923.	750.	526.	405.	364.

SOLAR RADIATION CONTRIBUTION TO AMBIENT AIR TEMP. IN OUTER SPACES
IN THE EGYPTIAN REGIONS (DEG C)

REGION	JAN	FEB	MAR	APR	MAY	JUN	JLY	AUG	SEP	OCT	NOV	DEC
1	4.37	5.55	6.49	7.10	7.36	7.57	7.60	7.23	6.52	5.25	4.13	3.96
2	4.65	5.42	6.33	6.95	7.25	7.30	7.33	7.07	6.30	5.09	4.02	3.68
3	4.74	5.74	6.57	6.99	7.21	7.25	7.31	7.15	6.51	5.42	4.48	4.16
4	4.72	5.83	6.71	7.26	7.73	7.81	7.37	7.39	6.73	5.64	4.58	4.26
5	4.56	5.64	6.52	7.06	7.36	7.39	7.45	7.19	6.46	5.23	4.30	4.07
6	4.48	5.54	6.47	7.02	7.32	7.39	7.53	7.26	6.50	5.18	4.07	3.79
7	4.56	5.57	6.43	7.07	7.34	7.47	7.62	7.31	6.56	5.27	4.13	3.83
8	4.43	5.46	6.46	7.07	7.33	7.49	7.55	7.21	6.47	5.20	4.02	3.76
9	4.64	5.67	6.57	7.03	7.36	7.40	7.46	7.21	6.49	5.51	4.32	4.12
10	4.66	5.67	6.54	7.06	7.36	7.36	7.39	7.15	6.41	5.22	4.40	4.08

+RUN
DO YOU WISH TO USE PROGRAM TO PRODUCE :-
TABLES (0) OR A SPECIFIC RESULT (1)
=0
TYPE IN LOCAL TIME & DAY OF MONTH
=12, 15
TYPE IN LOCATION CODE :-
(1) URBAN
(2) SUBURBAN
(3) OPEN COUNTRY
=3

AT 12.00 HOURS ON DAY 15 OF EACH MONTH

TOTAL INSTANTANEOUS SOLAR RADIATION FALLING ON HORIZONTAL PLANE
IN THE EGYPTIAN REGIONS (W/M2)

REGION	JAN	FEB	MAR	APR	MAY	JUN	JLY	AUG	SEP	OCT	NOV	DEC
1	633.	823.	1317.	1202.	1324.	1333.	1324.	1235.	1080.	874.	673.	612.
2	695.	840.	1034.	1237.	1312.	1329.	1319.	1239.	1079.	886.	694.	617.
3	761.	922.	1131.	1256.	1342.	1352.	1352.	1299.	1155.	973.	801.	710.
4	642.	823.	1315.	1198.	1313.	1321.	1306.	1230.	1031.	893.	702.	612.
5	675.	857.	1044.	1217.	1326.	1339.	1329.	1251.	1093.	898.	713.	643.
6	662.	841.	1033.	1207.	1314.	1335.	1334.	1260.	1096.	884.	686.	613.
7	671.	844.	1033.	1214.	1318.	1344.	1342.	1269.	1104.	894.	692.	616.
8	660.	834.	1033.	1217.	1318.	1349.	1333.	1253.	1093.	888.	683.	612.
9	682.	853.	1050.	1213.	1324.	1333.	1328.	1252.	1095.	923.	713.	646.
10	635.	862.	1046.	1217.	1326.	1331.	1321.	1242.	1086.	893.	724.	644.

SOLAR RADIATION CONTRIBUTION TO AMBIENT AIR TEMP. IN OUTER SPACES
IN THE EGYPTIAN REGIONS (DEG C)

REGION	JAN	FEB	MAR	APR	MAY	JUN	JLY	AUG	SEP	OCT	NOV	DEC
1	5.88	6.73	7.54	8.90	9.66	9.91	9.81	9.15	8.00	6.94	6.04	5.72
2	6.15	6.81	7.66	8.94	9.72	9.84	9.77	9.13	7.99	6.99	6.15	5.75
3	6.46	7.13	8.15	9.80	9.94	10.01	10.02	9.62	8.55	7.31	6.64	6.22
4	5.88	6.74	7.52	8.87	9.73	9.79	9.68	9.11	8.01	7.02	6.18	5.72
5	6.05	6.87	7.73	9.01	9.82	9.92	9.85	9.27	8.09	7.04	6.24	5.89
6	5.99	6.81	7.65	8.94	9.73	9.89	9.83	9.34	8.12	6.93	6.11	5.72
7	6.03	6.82	7.65	9.00	9.76	9.95	9.94	9.40	8.13	7.02	6.14	5.74
8	5.97	6.78	7.65	9.02	9.76	9.99	9.91	9.28	8.10	7.00	6.09	5.72
9	6.09	6.83	7.77	9.02	9.81	9.91	9.84	9.27	8.11	7.13	6.24	5.90
10	6.10	6.89	7.75	9.01	9.82	9.86	9.73	9.20	8.04	7.02	6.29	5.89

RUN

DO YOU WANT THE PROGRAM TO PRODUCE :-

TABLES (1) OR [illegible] OUTPUT (1)

=[illegible]

TYPE IN LOCAL TIME & DAY OF MONTH

=14,15

TYPE IN LOCATION CODE :-

(1) URBAN

(2) SUBURBAN

(3) OPEN COUNTRY

=3

AT 14. 0 HOURS ON DAY 15 OF EACH MONTH

TOTAL INSTANTANEOUS SOLAR RADIATION FALLING ON HORIZONTAL PLANE
IN THE EGYPTIAN REGIONS (W/M2)

REGION	JAN	FEB	MAR	APR	MAY	JUN	JLY	AUG	SEP	OCT	NOV	DEC
1	493.	570.	853.	995.	1063.	1104.	1139.	1034.	864.	630.	463.	435.
2	524.	654.	832.	961.	1033.	1057.	1065.	997.	823.	666.	450.	403.
3	557.	713.	873.	977.	1031.	1045.	1062.	1018.	870.	666.	513.	476.
4	549.	732.	967.	1040.	1127.	1143.	1151.	1034.	913.	701.	529.	433.
5	515.	636.	859.	936.	1065.	1080.	1089.	1025.	853.	632.	430.	447.
6	505.	673.	851.	930.	1057.	1031.	1099.	1040.	861.	621.	457.	420.
7	516.	677.	852.	939.	1062.	1091.	1129.	1051.	872.	632.	464.	424.
8	502.	662.	843.	933.	1059.	1093.	1101.	1029.	856.	623.	452.	417.
9	525.	691.	869.	991.	1067.	1083.	1092.	1030.	859.	664.	434.	453.
10	527.	693.	863.	937.	1055.	1072.	1032.	1016.	846.	626.	490.	449.

SOLAR RADIATION CONTRIBUTION TO AMBIENT AIR TEMP. IN OUTER SPACES
IN THE EGYPTIAN REGIONS (DEG C)

REGION	JAN	FEB	MAR	APR	MAY	JUN	JLY	AUG	SEP	OCT	NOV	DEC
1	5.01	6.04	6.86	7.39	7.91	8.13	8.21	7.66	6.90	5.82	4.31	4.62
2	5.21	5.95	6.77	7.27	7.69	7.83	7.89	7.40	6.73	5.69	4.72	4.42
3	5.41	6.26	6.96	7.33	7.64	7.74	7.86	7.54	6.93	6.01	5.17	4.90
4	5.36	6.32	7.07	7.73	8.34	8.47	8.52	8.03	7.11	6.13	5.24	4.95
5	5.15	6.11	6.88	7.36	7.89	8.00	8.07	7.59	6.86	5.33	4.93	4.70
6	5.10	6.04	6.85	7.34	7.83	8.01	8.14	7.70	6.89	5.77	4.77	4.51
7	5.16	6.06	6.85	7.37	7.87	8.03	8.21	7.78	6.93	5.83	4.82	4.54
8	5.07	5.99	6.84	7.37	7.84	8.10	8.15	7.62	6.87	5.73	4.74	4.49
9	5.22	6.13	6.92	7.33	7.90	8.02	8.09	7.63	6.83	6.00	4.95	4.74
10	5.23	6.14	6.90	7.36	7.89	7.94	8.01	7.53	6.83	5.30	5.01	4.72

READY

APPENDIX A3 : THE STANDARD EFFECTIVE TEMPERATURE, SET, AS AN INDEX FOR THE EXTERNAL ENVIRONMENT

A3.1 Standard Effective Temperature

The standard effective temperature (SET) is the index developed by Gagge *et al* (1) and adopted by ASHRAE. It is widely used by engineers, and Markus (4) has suggested that its results agree closely with those of Fanger *et al* (3) over a large part of its range. The definition of SET requires first the defining of two other terms, the operative temperature (t_o) and the humid operatuve temperature (t_{oh}).

1 The Operative Temperature (t_o) is defined as the uniform temperature, ie $t_a = t_{mrt}$, pf an imaginary enclosure in which man exchanges the same dry heat by radiation and convection as in the actual environment. Thus:

$$t_o = (h_r t_{mrt} + h_c t_a)/(h_r + h_c)$$

where h_r and h_c are the radiation and convection coefficients respectively.

Therefore the operative temperature can be equated with the globe thermometer whose convection and radiation coefficients are in the same ratio as for the body (5). It can be seen from the above equation that the measured or computed value for operative temperature will depend on air velocity, since this will affect the value of h_c. The higher the air velocity, the nearer the value of operative temperature (t_o) will lie to that of air temperature (t_a).

The operative temperature determines the dry heat loss from the body, and since the relative effects of air temperature and mean radiant temperature will change with different air velocities it is necessary to compute

t_o for each of the five values of air velocities used for the internal thermal comfort charts. However, for the external environment the mean radiant temperature contribution cannot be taken into account, and instead the direct contribution of solar radiation (t_{sr}), both the beam and the diffused components, will be considered. The external mean radiant temperature, t_{mrtx}, will be the sum of the air temperature, t_a, and the solar contribution to air temperature, t_{sr}. Thus:

$$t_{mrtx} = t_{sr} + t_a \tag{A3-1}$$

The external mean radiant temperature, t_{mrtx}, has the same meaning as the operative temperature, t_o, and also takes into consideration the strong radiation from the sun. Therefore, in evaluating environmental conditions consideration of t_{mrtx} should give a more accurate assessment than if using operative temperature or ambient air temperature. In this research this temperature will be referred to as the external operative temperature, and equation (A3-1) will be:

$$t_{ox} = t_{sr} + t_a \tag{A3-2}$$

Computation of the total solar radiation intensities, as well as their contribution to air temperature, has been done by means of the computer program in Appendix A2.

2 The Humid Operative Temperature (t_{oh}) deals with the humidity of the environment. It is defined as the uniform temperature of an imaginary enclosure at 100% humidity, in which man will exchange the same total heat by radiation, convection and evaporation, at the same mean skin temperature (t_{sk}) and skin wetness (w) which occur in the actual environment. Gagge defined the corrected effective temperature, ET*, as the uniform temperature of an imaginary enclosure at 50% RH in which

man will exchange the same total heat at the same skin temperature as occurs in the actual environment. Thus the ET* is a single index for air temperature, radiation and humidity where the air velocity is the same both in the real environment and in the imaginary enclosure.

The Standard Effective Temperature (SET) is a further development of ET* in which any environment, clothing and activity level is expressed in terms of a uniform environment ($t_a = t_{mrt}$), standardized at 50% relative humidity, 0·125 m/s air velocity, activity of 1 met (sedentary activity 58 W/m^2) and clothing of 0·6 clo (normal lightweight indoor clothing). Thus SET expresses the integral effect of any combination of four environmental variables, and of both clothing and activity, in one temperature index.

A person engaged in sedentary activity, dressed in light indoor clothes, present in a uniform environment at a relative humidity of 50% in still air will have the same thermal sensation as that of SET. This is a familiar, easily imagined environment, which includes most of the thermal forces likely to affect human comfort; it also covers a wide range of environmental conditions. Markus (4), depending on the work of Gagge (2) and Fanger (3), has charted for a wide variety of environmental conditions where the degree of skin wetness (w) is marked ad representing the equivalent percentage of the body which is covered with moisture.

When w = 0·06 no sweating occurs, and the amount of moisture present is that necessary for skin diffusion. As w increases above about 0·2 discomfort level increases, and at w = 1·0 the limit of tolerance is reached. Any conditions warmer than this will lead to body heating, damage and death. Also marked on the charts is the degree of discomfort, DISC. This will be positive for hot conditions, negative for cold conditions, and zero for thermally neutral.

The optimum comfort zone is marked by ± 0·5 DISC, while ± 1·0 DISC marks the desirable comfort zone. The ambient air temperature, t_a, can be used as the abscissa, if there is no significant radiation effect. If there is a moderate source of radiation the operatuve temperature, t_o, can be used, and when there is a strong radiation source, eg heaters or solar radiation in the external environment, the external operatuve temperature, t_{ox}, should be used.

3.2 General Characteristics of SET

The charts for Standard Effective Temperature shown in figures (A3.1) to (A3.10) illustrate the expected human physiological and sensory responses to the surrounding environment. At low temperatures and activity levels the lines of SET, DISC and w are almost vertical, indicating the minimal significance of the evaporative cooling effect and consequently the minimal effect of environmental humidity. In warm conditions and light activity levels lines of DISC crowd together, indicating that discomfort is now a function of body temperature rather than increasing sweat rate. While the value of w may only be in the region of 0·5 the average maximum possible sweat rate is about 500 g/m^2h which is another limit on sweating. At higher humidities the sharp curvature of the DISC lines emphasises the great increase in discomfort resulting when the limit of evaporation of sweat is reached.

3.3 Thermal Comfort Prediction Procedure

The process of predicting thermal comfort using the Standard Effective Temperature index is as follows:

a) Calculate t_{ox} from equation (A3-2)

$$t_{ox} = t_{sr} + t_a$$

where t_{sr} is the contribution of solar radiation to air temperature (computed from Appendix A2), and t_a is the ambient air temperature.

This is used as the external operative temperature for evaluating external conditions during the day.

b) Find the appropriate comfort chart in accordance with the known air velocity, relative humidity and activity and clothing types.

c) Find the point representing the above conditions on the comfort chart.

This process is illustrated in figure (A3.1).

SET ^{o}C	Temperature sensation	Discomfort (DISC)	Regulation of body temperature	Health	SET ^{o}F
		Limited tolerence	Failure of free skin evaporation		
40	Very hot	Very uncomfortable		Increasing danger of heat-stroke	100
	Hot				
35					
	Warm	Slightly uncomfortable	Increasing vasodilation sweating		90
30					
	Slightly warm				
					80
25	Neutral	Comfortable	No registered sweating	Normal health	
					70
20	Slightly cool		Vasoconstriction		
	Cool	Slightly uncomfortable	Behavioral Changes	Complaints from dry mucosa	
15					60
	Cold		Shivering begins	Impairment peripheral circulation	
10	Very cold	Uncomfortable			50

Table (A3.1) Human thermal responses to the Standard Effective Temperature (SET), after Gagge *et al* (2).

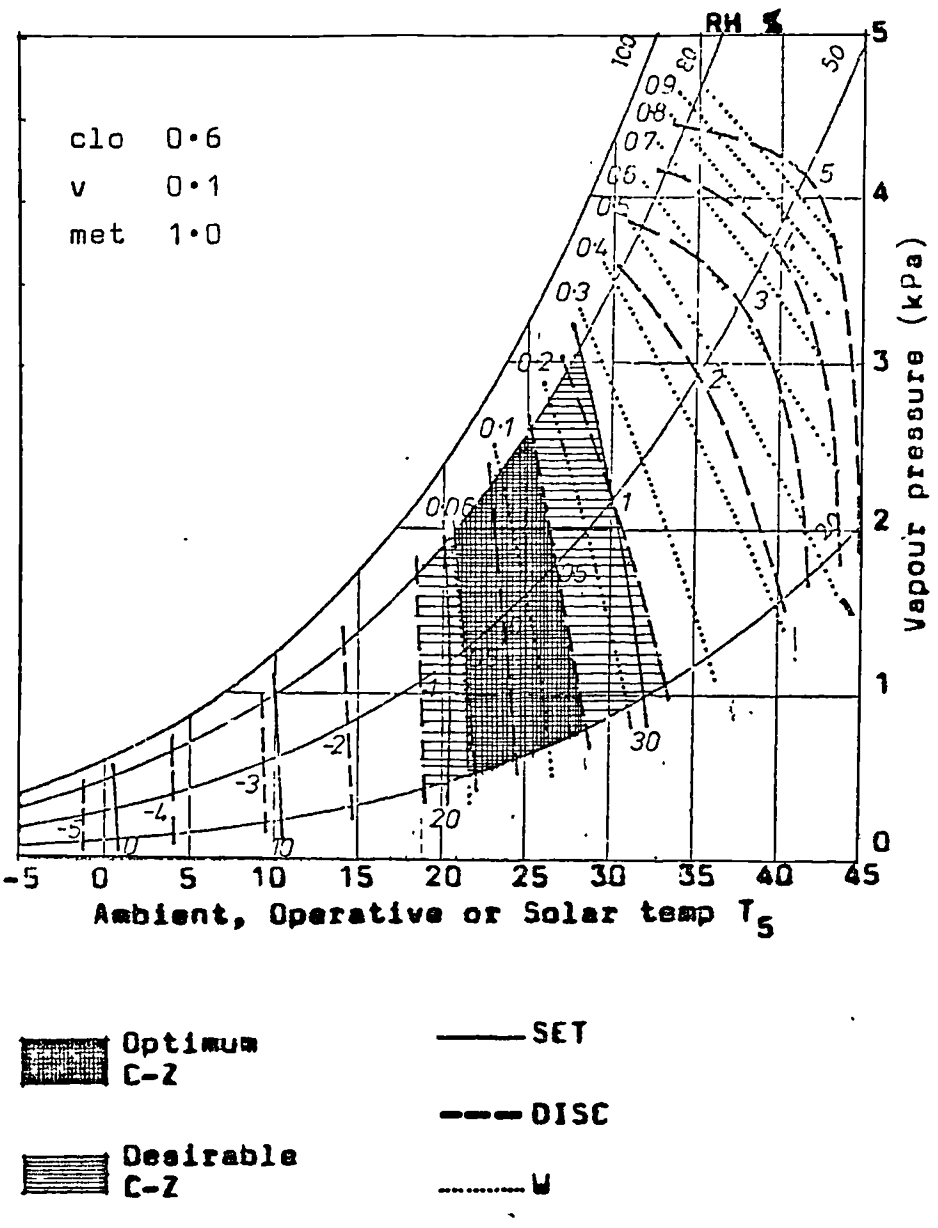

Figure (A3.1) Standard Effective Temperature chart 1 (4).

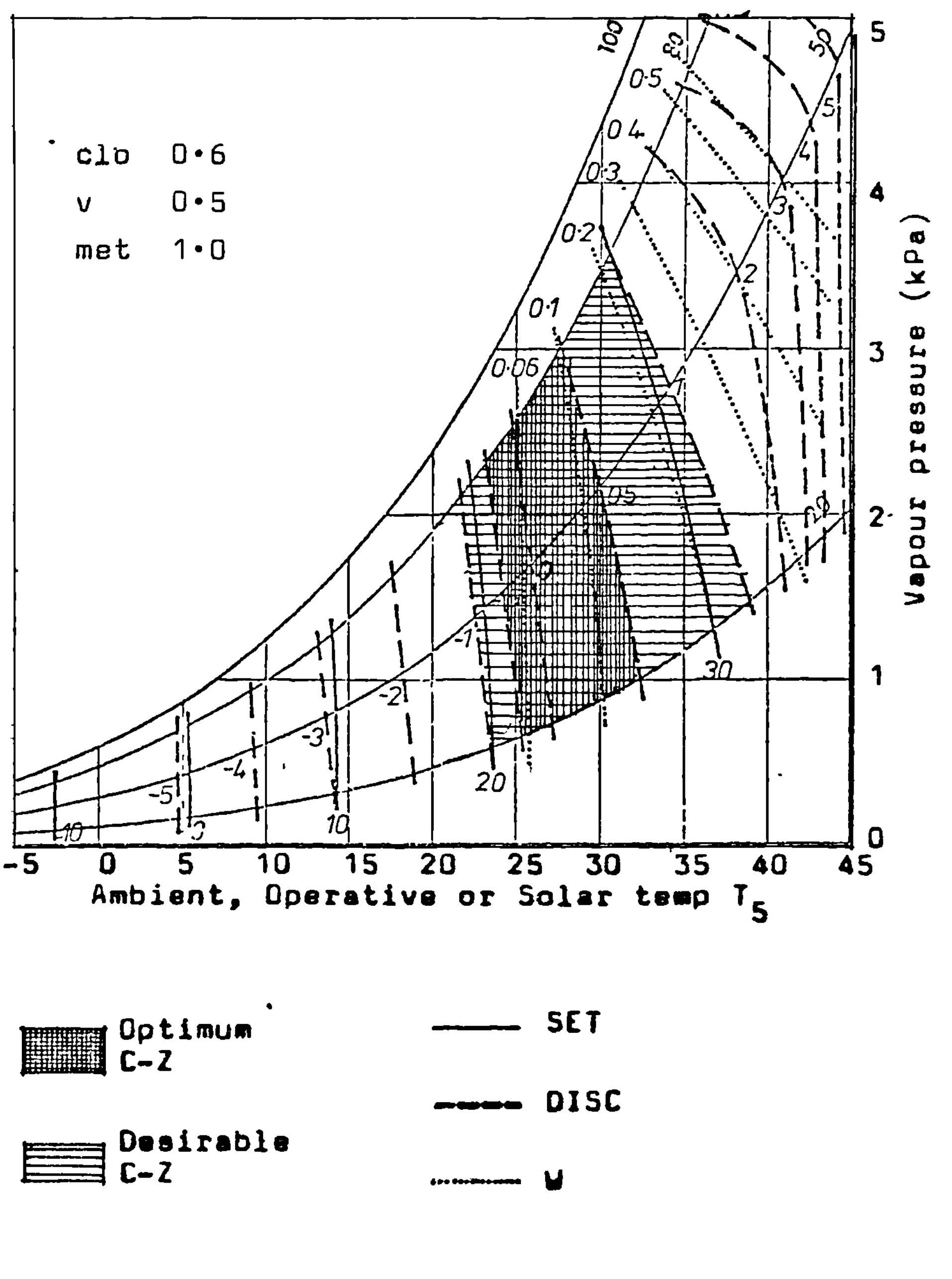

Figure (A3.2) Standard Effective Temperature chart 2 (4)

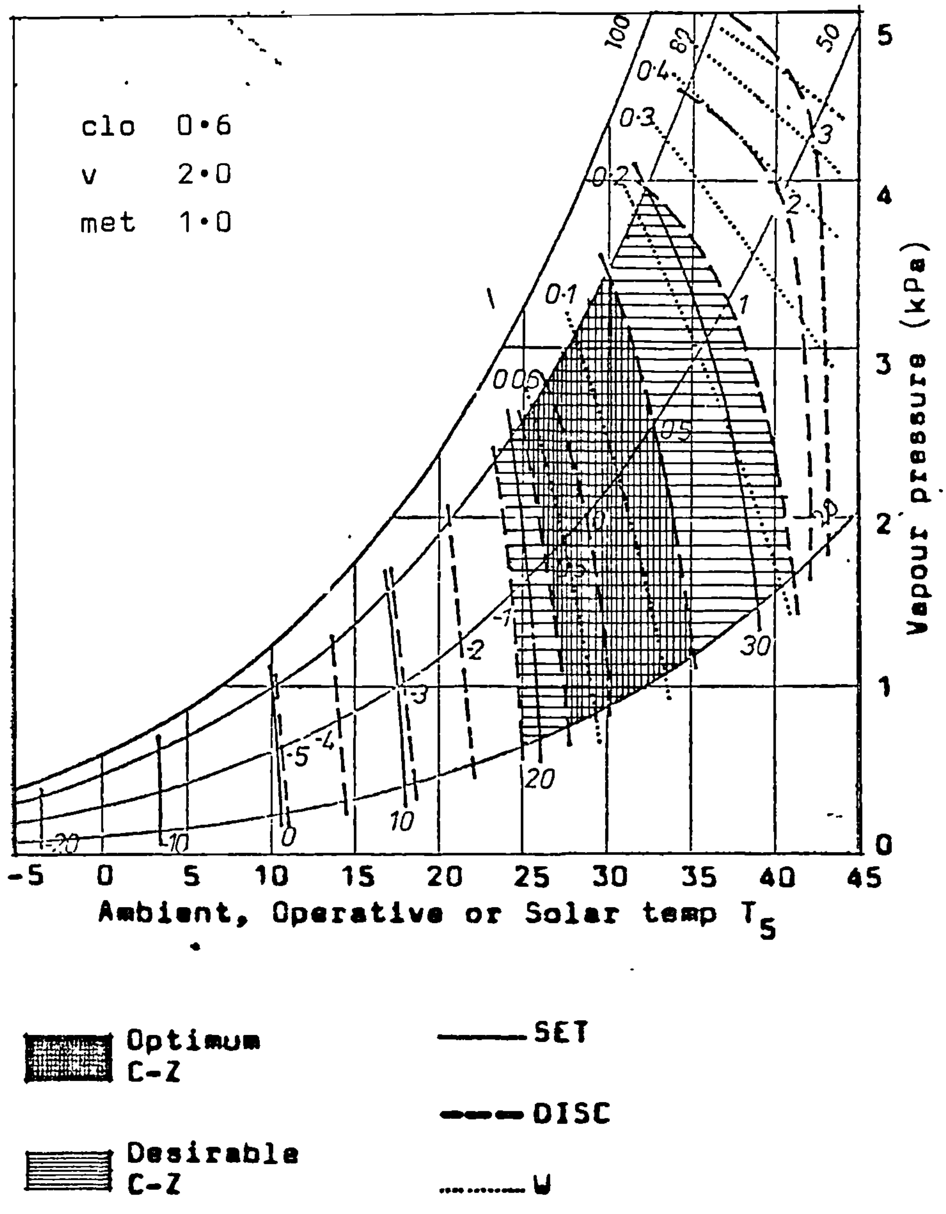

Figure (A3.3) Standard Effective Temperature chart 3 (4).

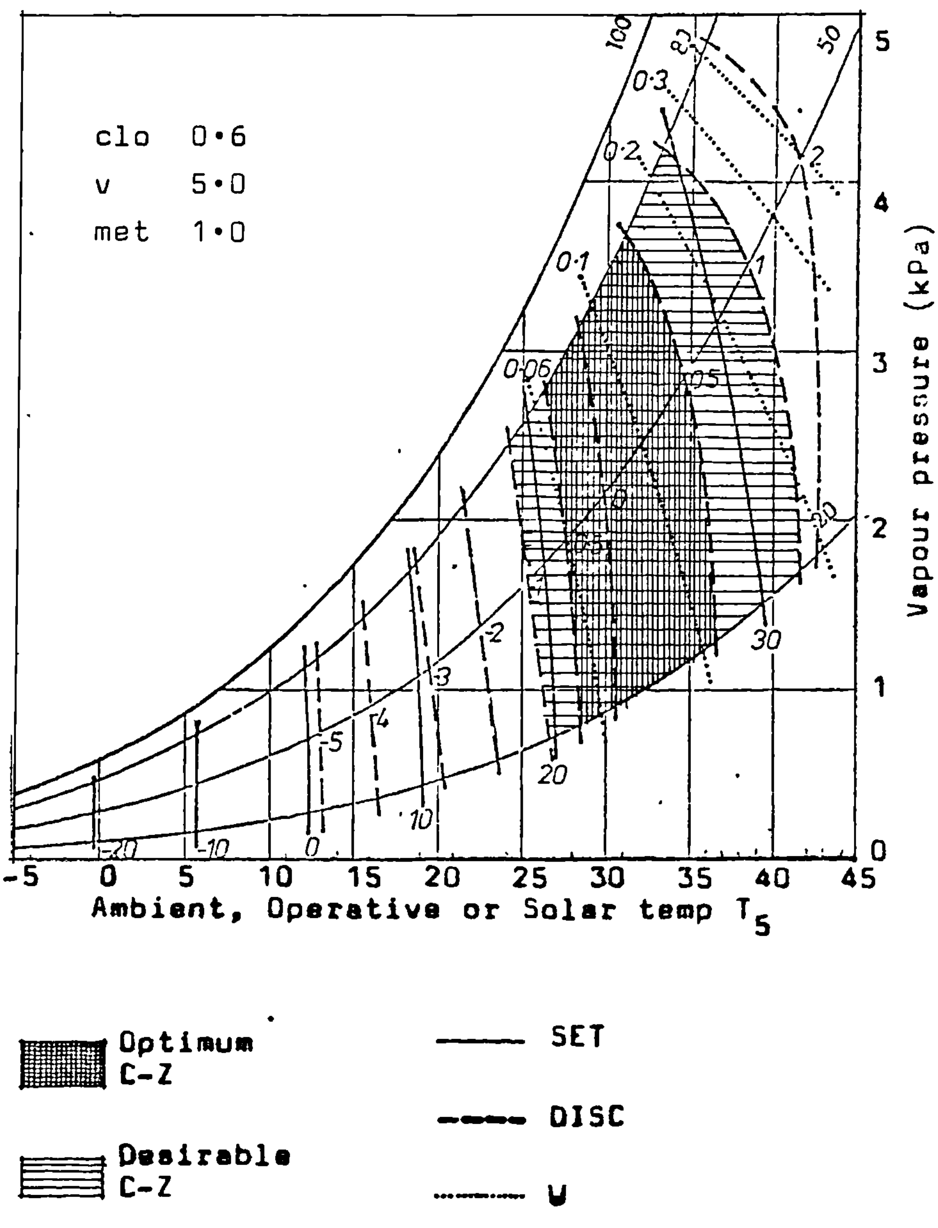

Figure (A3.4) Standard Effective Temperature chart 4 (4).

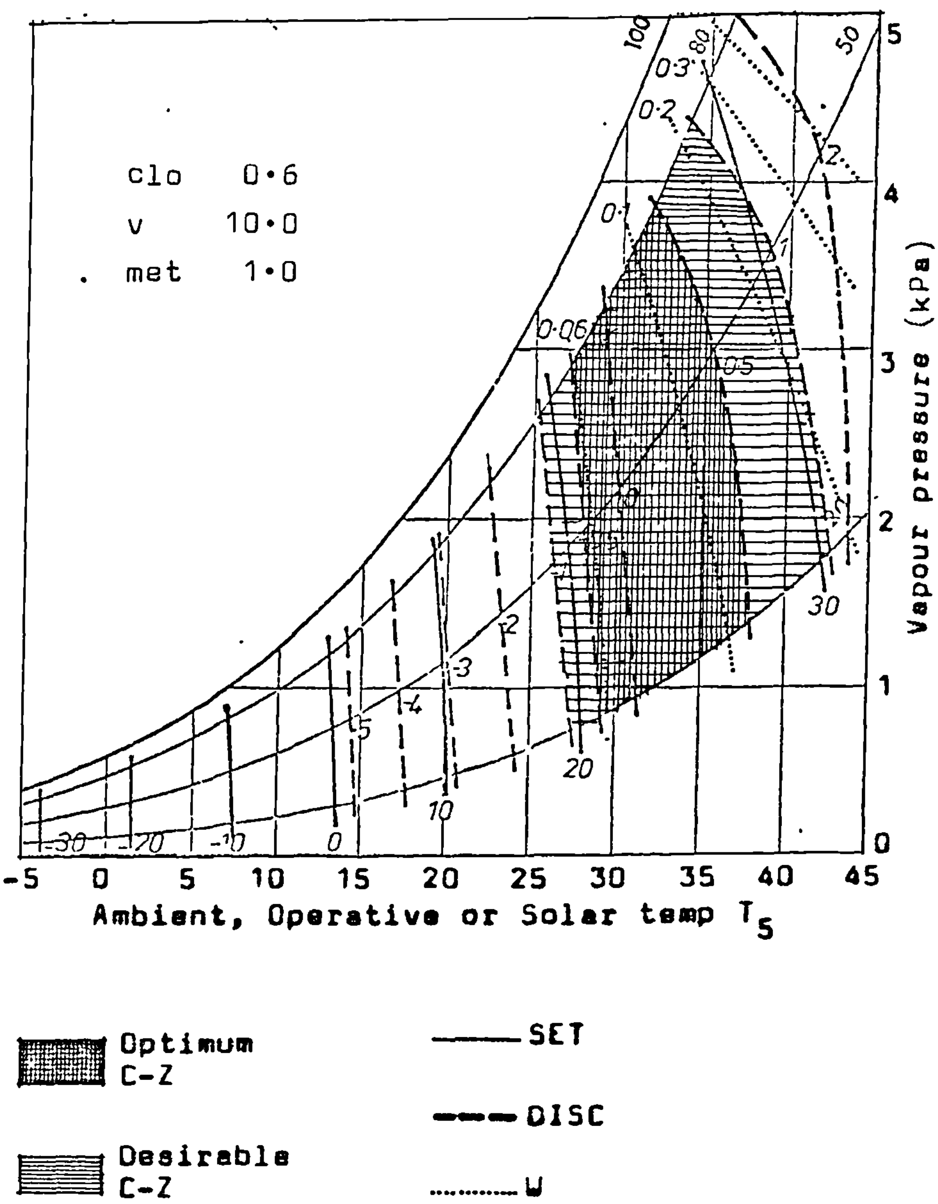

Figure (A3.5) Standard Effective Temperature chart 5 (4).

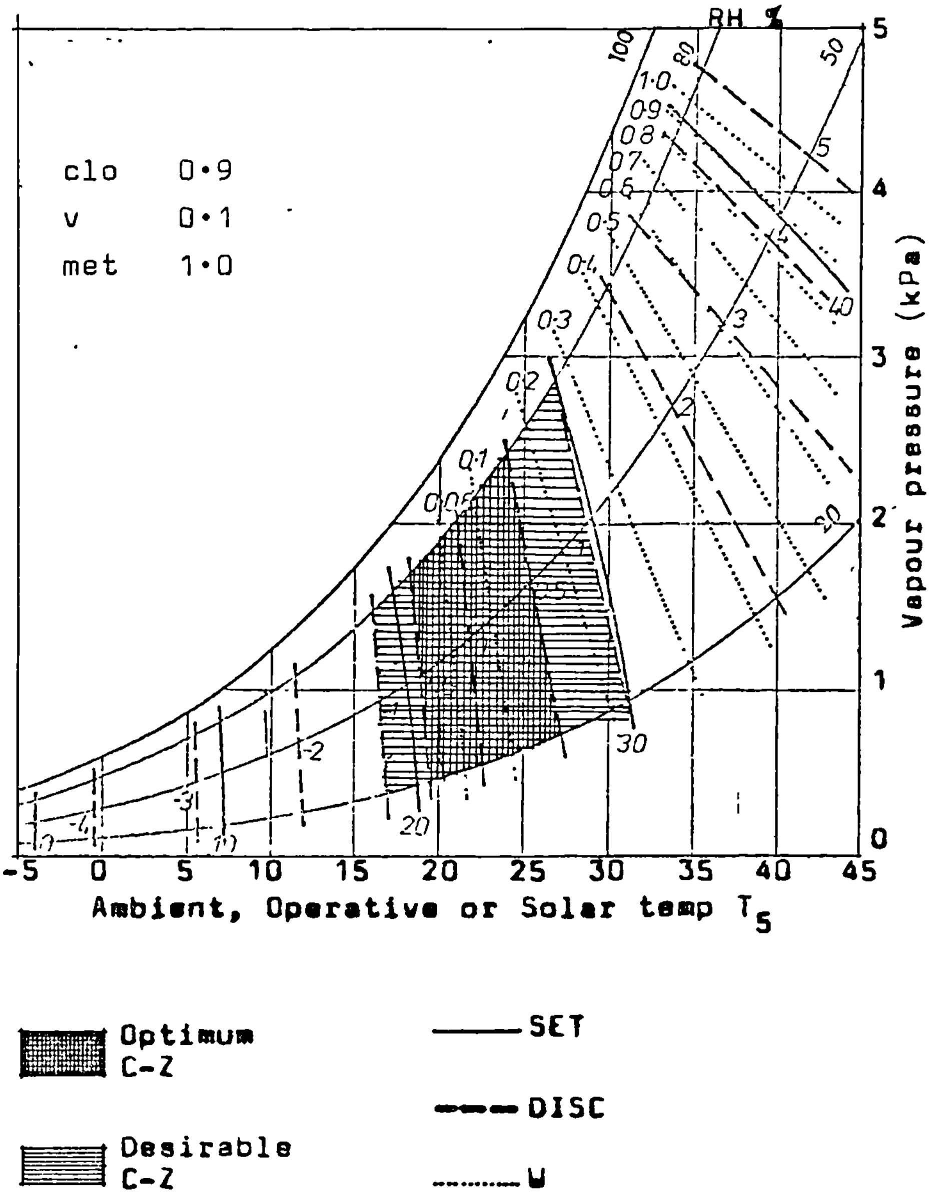

Figure (A3.6) Standard Effective Temperature chart 6 (4).

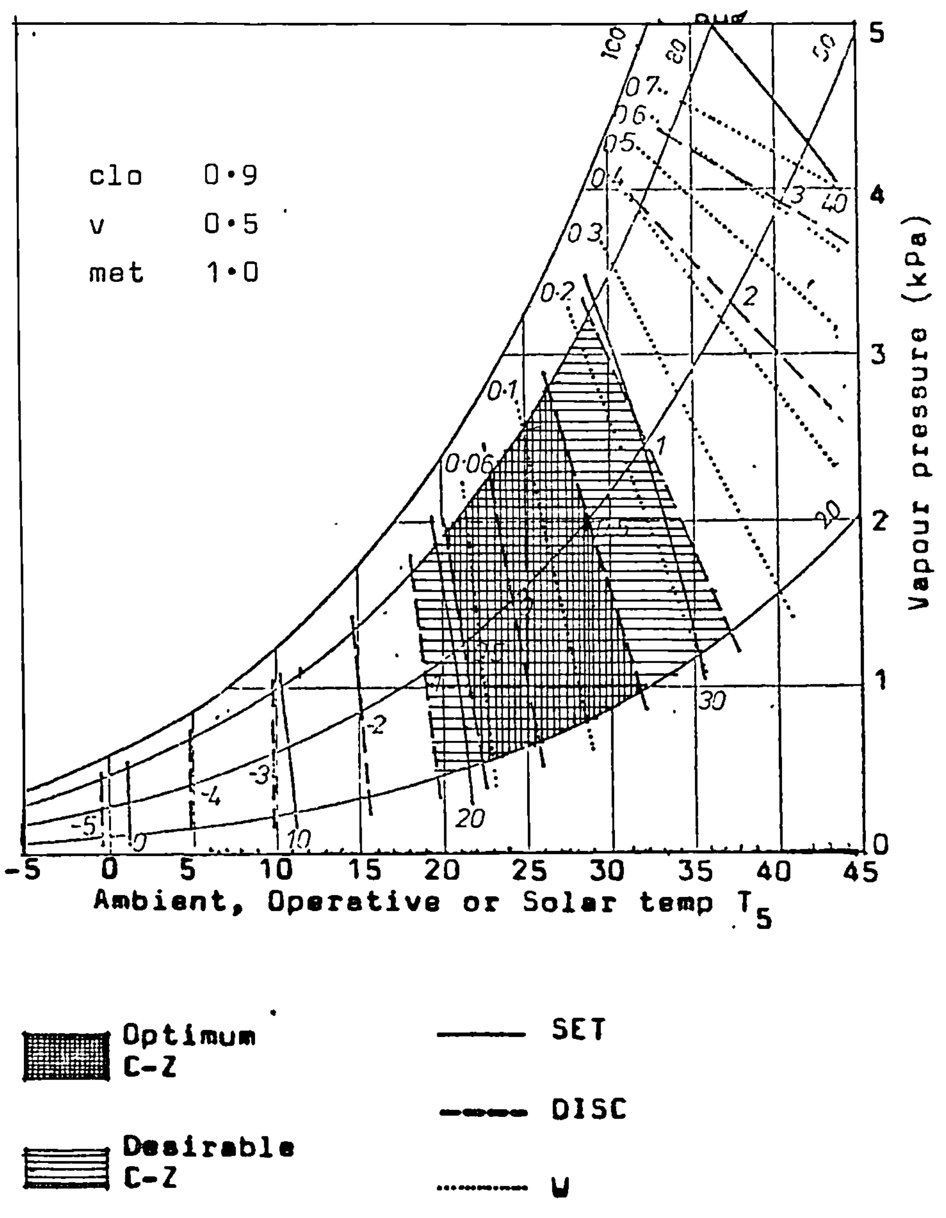

Figure (A3.7) Standard Effective Temperature chart 7 (4).

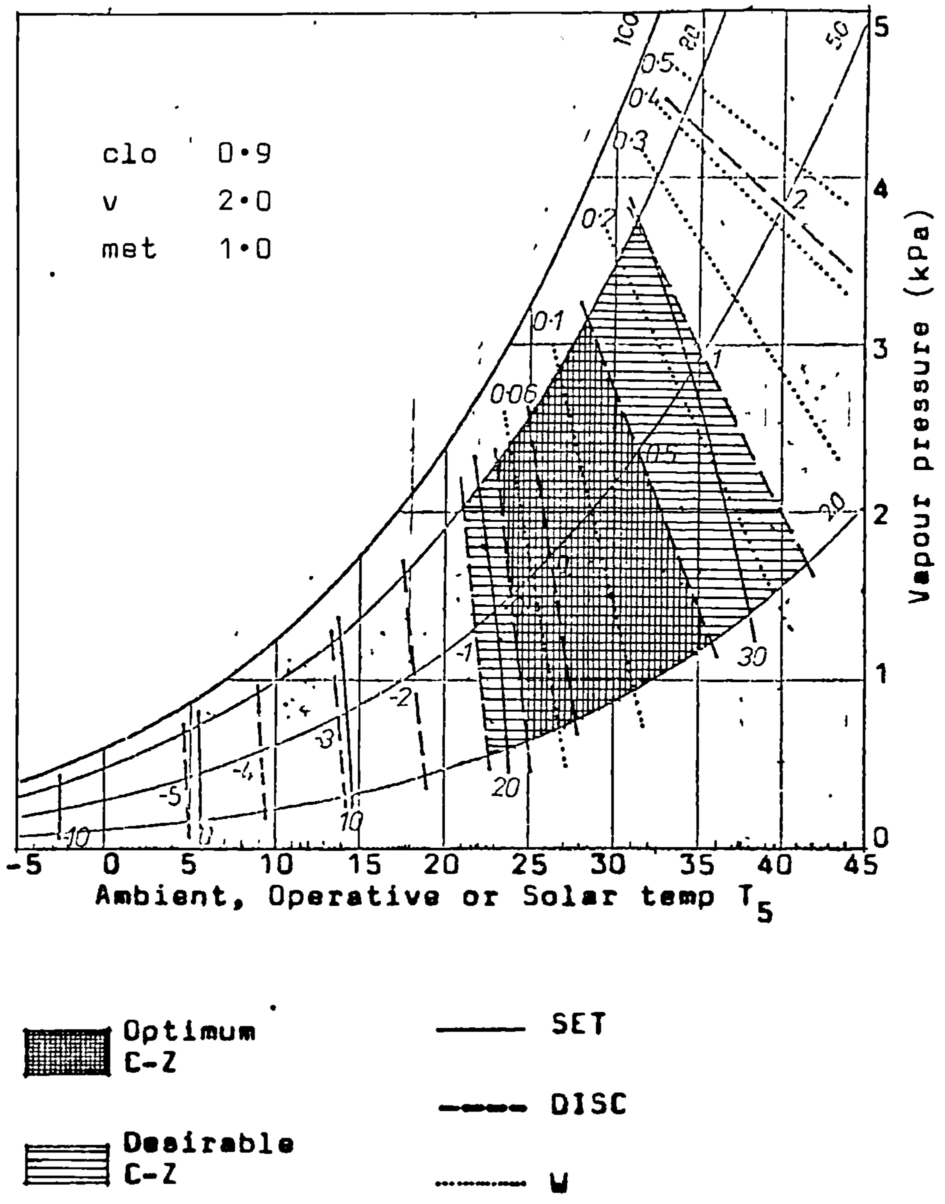

Figure (A3.8) Standard Effective Temperature chart 8 (4).

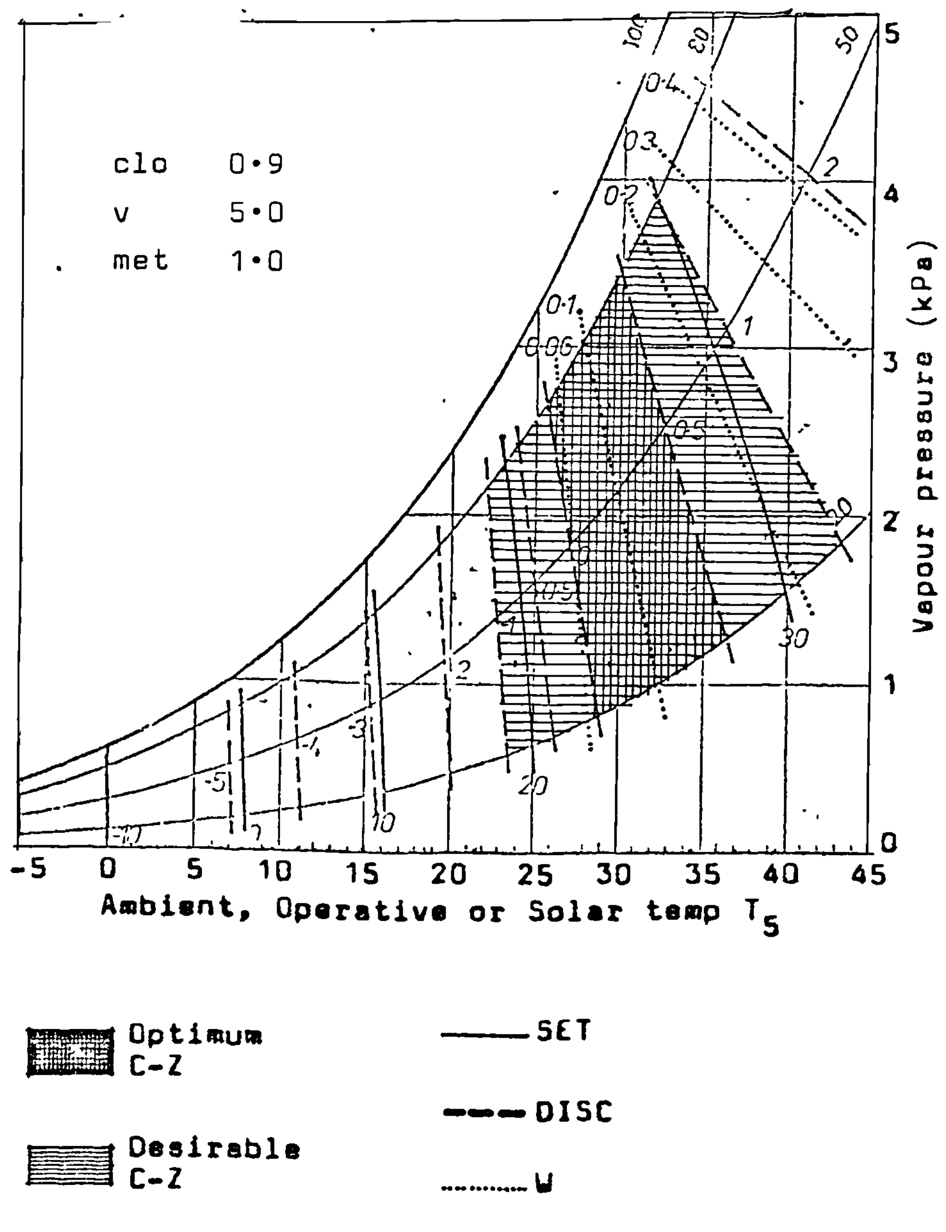

Figure (A3.9) Standard Effective Temperature chart 9 (4).

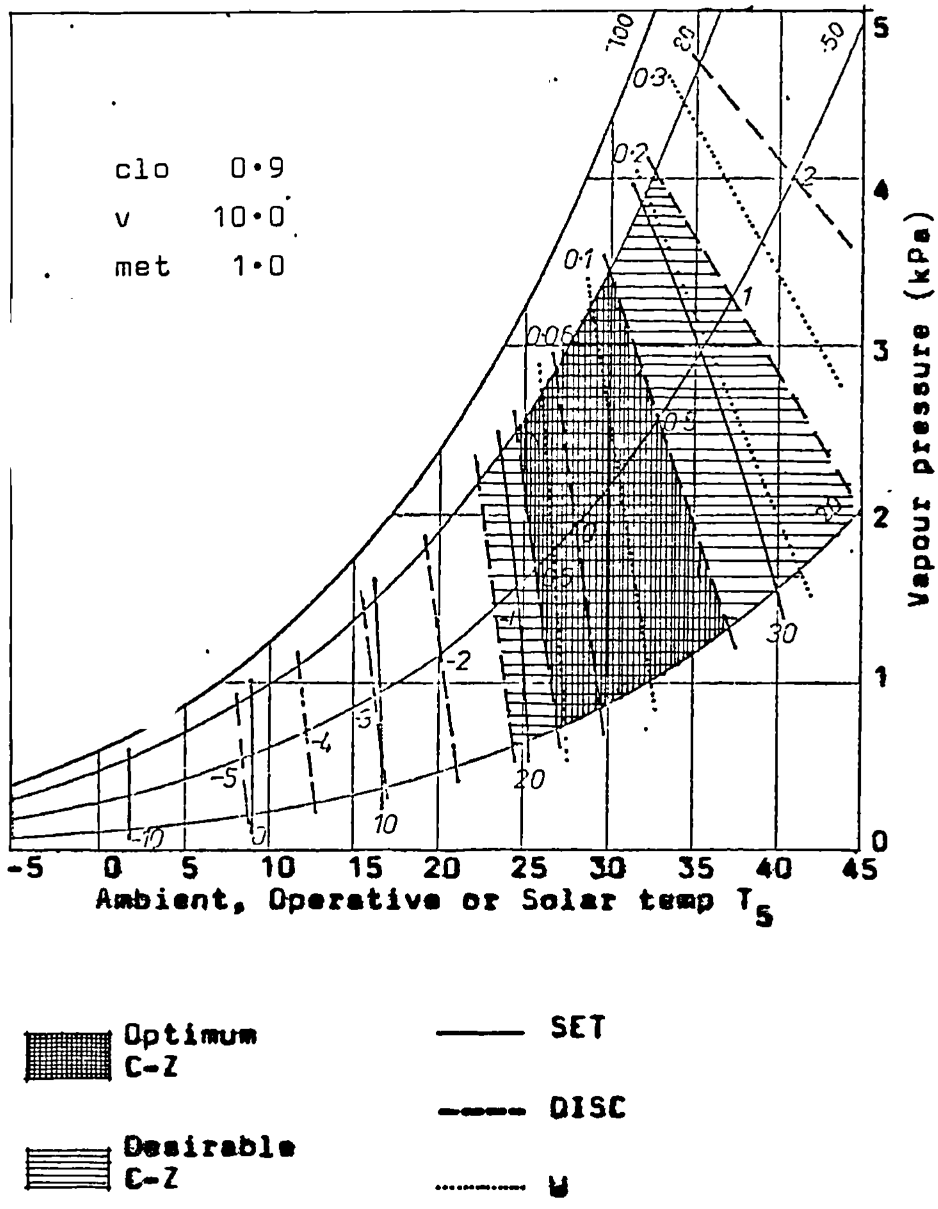

Figure (A3.10) Standard Effective Temperature chart 10 (4).

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4 Markus, T A & Morris, E N — 'Building, Climate and Energy'. Pitman Publishing Ltd, London, 1980.

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APPENDIX A4 : WIND TUNNEL ARRANGEMENTS

A4.1 The Wind Tunnel

The wind tunnel of the Department of Architecture and Building Science is of the open circuit, low speed type. Its design is similar to that of the Building Research Station (2). It has overall dimensions as follows: length 7 m (23 ft), breadth 3•3 m (10 ft 9 in) and height 2•2 m (7 ft).

The working cross section suggested by Ruxton (1) is one metre square. The air flow is generated using an axial flow fan placed at the down stream end. The wind tunnel is located at one end of the structural laboratory, and at a distance of 0•38 m from the wall.

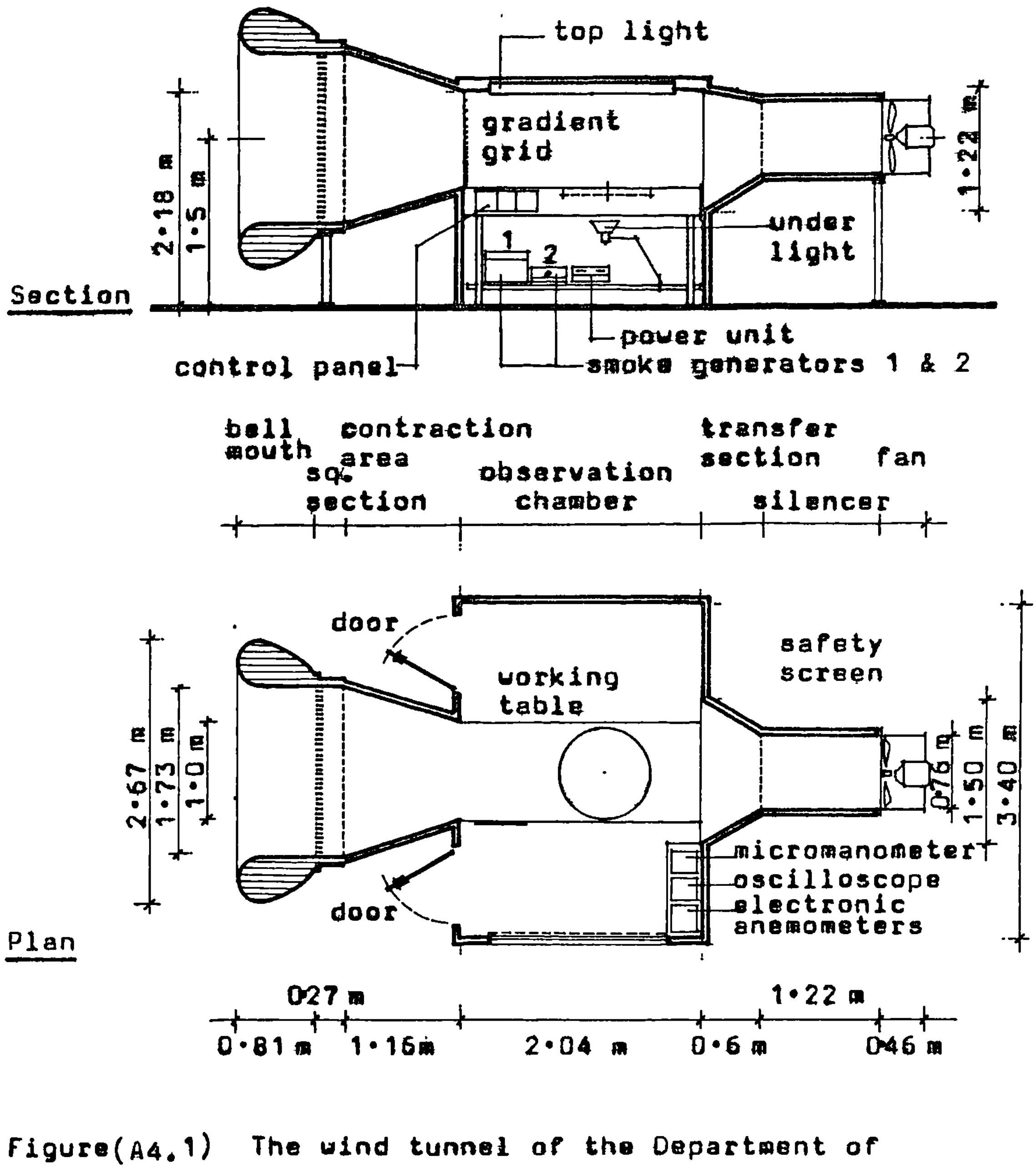
A4.1.1 Description

The tunnel is shown in fig.(A4.1) and consists of six main parts:

1 At the windward side is the Entry Bell Mouth. Its main function is to produce an even and non-turbulent air stream entering the tunnel. It has a clear internal area of 1•73 x 1•73 m^2.

2 The Square Section is a straight section of the same inner area as the Bell Mouth. It allows incorporation of the air straightening devices, mainly a honeycomb and smoothing gauze. These ensure that the air flow is horizontal, parallel to the axis of the tunnel, and free from large-scale turbulence.

3 The Entry Contraction is incorporated to conserve fan power and improve laminar flow. It is a truncated



Figure(A4.1) The wind tunnel of the Department of Architecture and Building Science (A Abdin) square pyramid whose axis lies on the centre line of the flow. Also within this region disturbances generated by the Honeycomb and smoothing gauze are allowed to decay, and at its leeward end velocity profile generators are introduced. These comprise a series of round section bars at varying centres incorporated as a screen.

4 The Observation Chamber allows for a space 1·20 m (4') wide by 2·44 m (8') long to accommodate instruments, operator and observers either side of the table. The working table is 1·07 m (3'6") high, with a working section of 1·0 x 1·0 x 2·04 m (3'4" x 3'4" x 8'). The table is provided with a 0·9 m (3') diameter turntable at its centre. All the interior surfaces of the observation chamber are painted matt black. There is a window in one side of the chamber to allow for observation from the outside. Examination of the air flow patterns is carried out in this section where the air jet passes the models. Direct modification of either the model or the wind angle is allowed for.

5 The Transfer Section is on the leeward side of the working section and converts it to a shape suitable for the fan mounting (circular with diameter 0·76 m (30"))with a small loss in pressure. The rectangular entry from the chamber is extended 0·23 m (9") in three directions to pick up diverting jets.

6 The Fan and Silencer Unit. The silencer was incorporated to reduce noise both within the observation chamber and in the building. It is 0·76 m (30") in diameter and 1·22 m (4') long, with a safety screen on the windward side. The fan has the same diameter, with a rate capacity of 566·5 m^3/minute (200,000 ft^3/minute). The fan speed is comtrolled by varying its supply voltage from a stabilised supply.

The observation chamber is fitted with light switches, speed control and power sockets mounted in one side of the working table.

The pressure measurements are recorded using pitot tubes and a micro-manometer. Velocity measurements are recorded by hot wire anemometer.

The smoke for visualization is produced either in an apparatus which uses carbon dioxide as a motive force and vopourises a thin oil in an electrically heated chamber, or in an apparatus using pressurized oil evaporated through a heated probe.

A4.1.2 Performance

Ruxton (1) suggested that models providing obstruction not more than one fifth of the cross sectional working area can be accommodated. Speeds up to 4•8 m/s were suggested as being obtainable, while very low speeds were satisfactory. He also reported some turbulence which was due to the asymmetrical shape of the laboratory in relation to the tunnel and recommended constructing a simple baffle from floor to ceiling, extending from the wall down the side of the bellmouth a distance of 1•84 m to rectify the fault.

Neither type of the available smoke apparatus was satisfactory. The smoke generated by electrically vapourising thin oil was not dense enough and when the smoke comb, fig.(A4.4), was incorporated it produced uneven smoke lines. Also the smoke produced was highly contaminated with oil, spraying it and damaging the models. The second smoke apparatus (evaporated pressurised oil) produced one dense line of smoke giving rise to the same oil problems as before. It was necessary to examine the above suggestion, and to carry out any improvements possible regarding the tunnel performance.

A4.1.3 Testing the Wind Tunnel

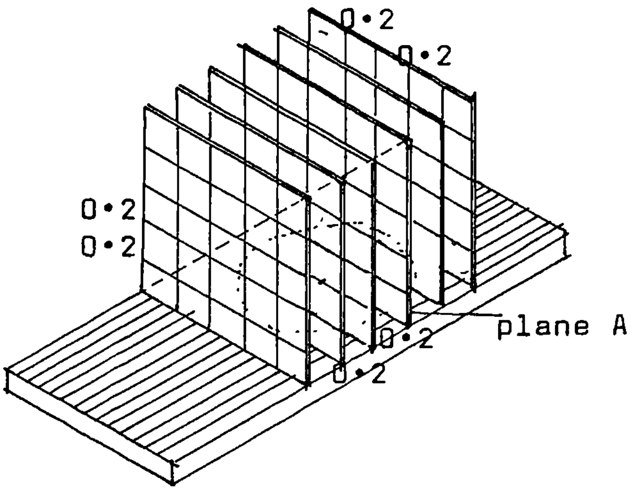
Tests were carried out to determine -

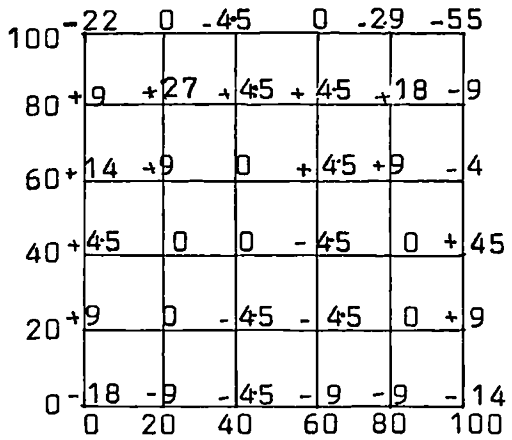
a Maximum and minimum stable air speeds at which laminar flow is maintained.
b The deviation from the mean speed in different areas of the working cross section.
c The maximum blockage of the cross sectional working area without affecting either the flow pattern visualization or the air speeds.
d The performance of the smoke apparatus.
e The performance of the speed measuring instruments.
f Light performance.

a At the full power of the fan the mean velocity in the centre of the working cross section was 4•8 m/s, but this was not a stable flow, it fluctuated and contained areas of turbulence. A more stable velocity was 3•5 m/s, though the noise level within the observation chamber was considerably high. The minimum steady air velocity was found to be 0•20 m/s.

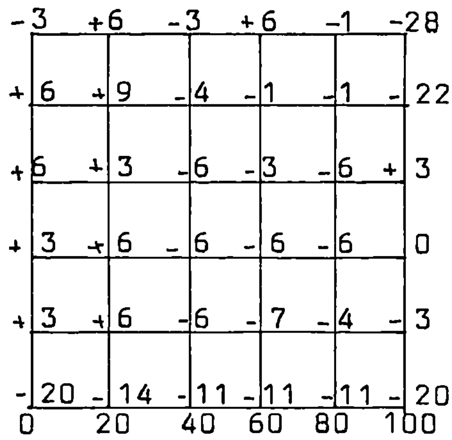
b The deviation from the mean air velocity at the centre of the working cross section for 1•0 m/s and 3•5 m/s was examined and records at an imaginary grid of 0•20 m intervals were made using hot wire anemometer, figure (A4.2). This test illustrated the asymmetry of the velocity deviation reflecting the asymmetry of the laboratory space surrounding the tunnel. Air flow near the edges and roof of the working cross section was particularly turbulent. The presence of the operator in the observation chamber was another factor in this asymmetry which was difficult to eliminate.

c The blockage of the working cross section has been examined, and the maximum model height to allow no





% deviation from mean speed at 1 m/s



% deviation from mean speed at 3.5 m/s

Figure (A4.2) Test of the working cross sections, plane A.

interference in the flow pattern was found to be 0·40 m. This helped in avoiding turbulence near the ceiling. The minimum distance between the nodel and the side edges to avoid any interference from side turbulence was found to be 0·10 m. This allowed a frontal area of 24% of the working cross section. However, this reduced section must suffer further reduction in order to avoid the suction from the fan interfering with the wake flow, and also to give correct suction values if accurate measurements were to be attained.

Sexton (2) recommended 7½% as the maximum blockage in a similar tunnel in the Building Research Establishment, while Gauld (3) recommended 5% and Gowan(4) suggested 3% as a maximum blockage. Sexton's recommendation of 7½% blockage was the most appropriate for this wind tunnel because of the similarity of the designs. A series of different forms with blockage of up to 16% were examined and showed no marked interference in the vicinity of the blocks, only at the far end of the leeward wake. However, 7½% was taken as the upper limit.

d The smoke apparatus produced thin trails of smoke, which were diffused before allowing either investigation or recording with speeds over 1 m/s. The visualization speed had therefore to be restricted to 1 m/s. Moreover, the smoke density and filtering had to be considered if this apparatus was to be used.

e Speed measuring instruments were air velocity meter, thermoanemometer and DISA 55M system with 55M10 CAT standard bridge. Despite the fact that the air speed measuring instruments used were reasonably sensitive for major changes in speed, the first two employed large probes, restricting their use near and within models. The DISA 55M system was reasonable sensitive but had only one probe, and needed calibrating to convert its voltage output to equivalent metres per second.

f The main lighting was from the fluorescent lamps on the ceiling of the tunnel with the possibility of additional spot lights in the observation chamber. Illumination level was good, especially after elimination of any diffused light through the observation chamber window. However, when investigating the flow within model courtyards the light seemed very poor and reflections through the transparent blocks reduced the clarity of the flow pattern.

A4.1.4 Modifications and Recommendations

Testing the wind tunnel allowed modifications to be made to improve its performance, and consequently the accuracy level of the results.

1 The asymmetry within the working cross section of the tunnel was eliminated by constructing a wall-to-wall partition extending from floor to ceiling, fig.(6 .1). The symmetrical air flow around the wind tunnel was reflected in the air flow within it. The deviation within the working cross section was as low as ±5% in general, and within ±2% in the lowest 0·4 m.

2 The smoke apparatus using pressurized carbon dioxide and evaporated oil was fitted with a basic oil filter as in fig.(A4.3). This allowed the un-evaporated oil to be filtered and enough smoke to get through under even pressure. Moreover, the supply to the smoke comb was balanced by allowing smoke from both sides.

3 Upgrading the speed recording instruments involved the

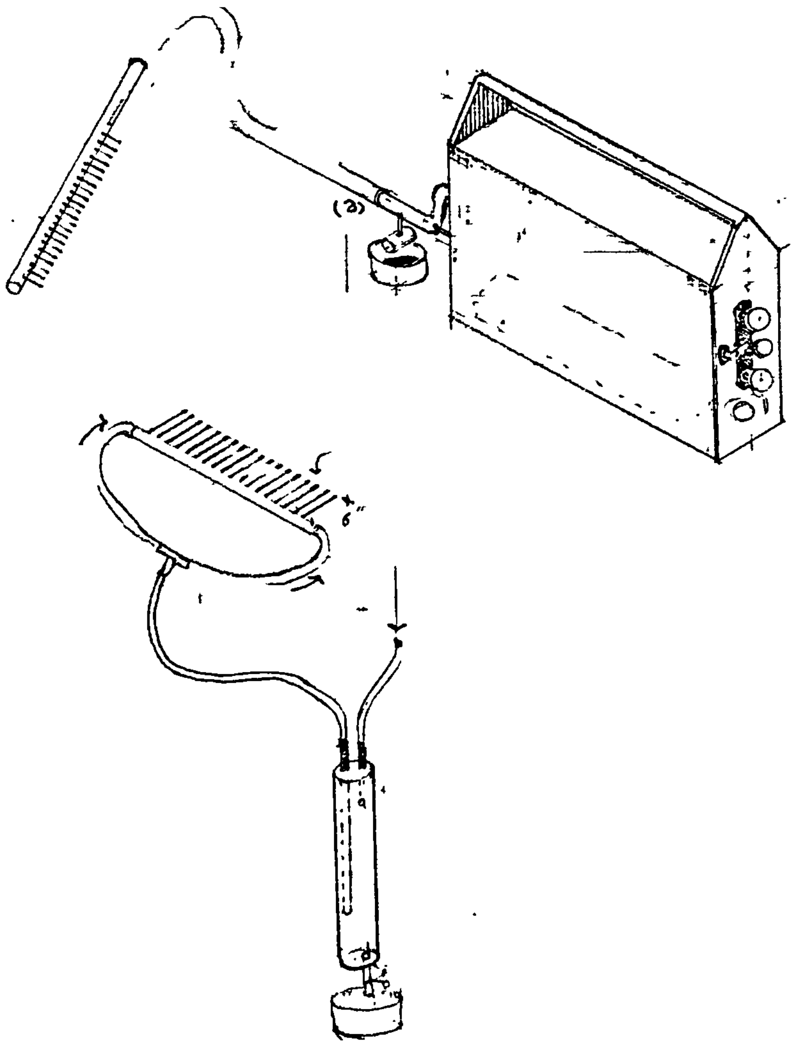
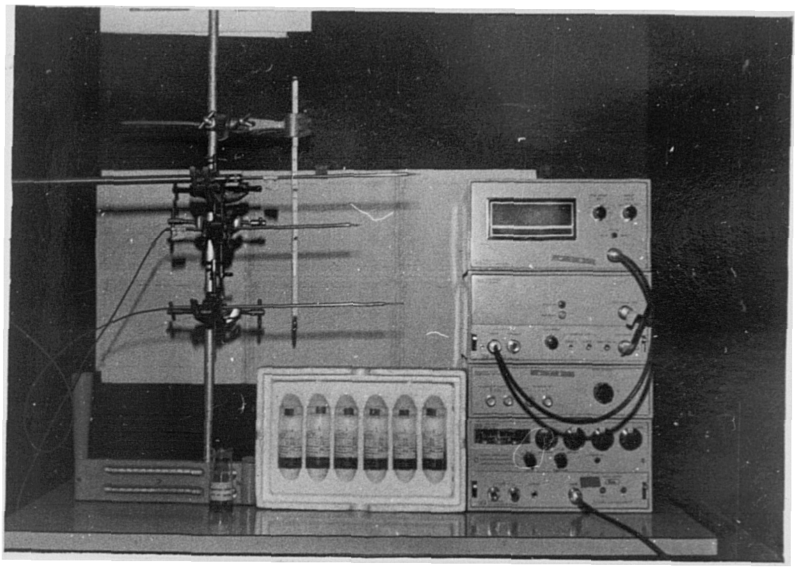


Figure (A4.3) The suggested modifications to the carbon dioxide smoke generator.

acquisition of new electronic instruments which the Department of Architecture and Building Science generously purchased. The DISA 55K system with 55K14 wide range adaptor was ordered. This system has conical probes protected by a quartz coating and measures air velocity at one point only. This system had a linearizer incorporated to give air velocity in m/s directly. As the probes are insensitive to mechanical contamination the system could be used in monitoring mean flow velocity in the free stream even during smoke visualization.

The DISA 55m system was provided with a 55D65 probe selector unit to allow the use of six probes for measuring instantaneous speeds at different points within the model simultaneously. This was supplied with a set of 55P11 probes. A series of measurements was taken for the purpose of checking and calibration with allowances made for the resistance of each combination set of probe, probe support, wires and connecting jacks, fig.(A4.4). The 55M system was calibrated against both the 55K system and the pitot tube. It was interesting to note that the calibration for the whole 55M system must be repeated if any probe or other item was to be replaced. This system can integrate as many as 36 probes to measure instanteneous air speeds at 36 different points. The probe support was chosen to represent approximately a standing human being within the model.

4 The light within enclosed forms, and for flow patterns observed behind transparent perspex was supplied from beneath the model. A new turntable with an exchangeable opal base was provided. This allowed supplying an electrical heat source to examine the flow due to both stack and wind forces within courtyards.



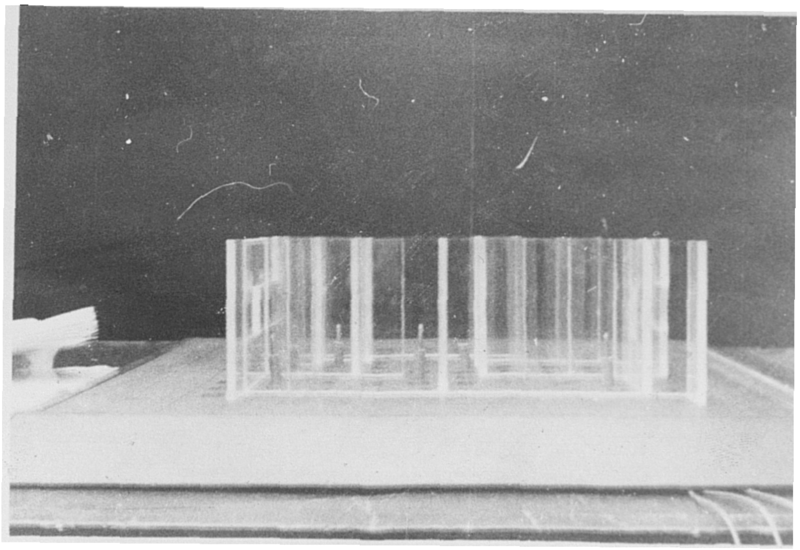


Fig.(A4.4) Instruments and model of the internal flow experiments

5 An air speed of 1 m/s was recommended for the visualization experiments.

The Reynold's number[1], and thus the wind speed in the tunnel as well as the size of the model, was considered unimportant on the grounds that sharp edged bluff bodies have a constant drag coefficient in between Reynold's number of 10^4 to 10^7.

Observation showed that over a five hour running of the tunnel the speed tended to rise by approximately 2%. This was taken into consideration in relating air speed measurements.

6 The need for a microprocessor or a results recorder was recognized, but this was not available and manual recording was employed.

Recording of visual flow patterns was done using photographic techniques. Visualization using smoke in air flow pattern around blocks was successful, but smoke intensity was too low to allow application of the same technique for visualization inside courtyards and cells. Here the technique was reversed; the enclosures were filled with smoke, and air flowing across the model was allowed to penetrate drawing the flow pattern as black lines in the white smoke. This technique revealed the location of stagnant zones more clearly.

7 The model used for air flow around buildings had a blockage ratio of less than % of the working cross section. This was % for the internal flow model.

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1 Reynold's number R = Inertia force/Viscous force
= Velocity x Size/Kinematic viscosity

A4.2 The Models

Since the experiments were arranged to examine two kinds of flow pattern - the parameters of wind configuration with the built forms that might affect the flow inside buildings and the flow outside buildings - it was necessary to construct two different sets of models. The first, external flow model, was used to examine flow patterns around simple forms, perforated blocks, deep courtyards and groups of buildings. The second, internal flow model, was constructed to examine the internal parameters affecting air flow within buildings and for the measurement of C_v to be used in Equation (4-13) to estimate the air speed within the proposed space.

A4.2.1 External Flow Model

The cube may be considered as the most commonly used form in our space formation. This three dimensional rectangular body is characterised by a single dimension, which allows it to be usedwhether as an individual form, or to be built up into other rectangular forms. A set of six-centimeter-sided cubes was prepared on the grounds that these would ease representation of typical residential units. For flow patterns around a single building and within courtyards the block was used to represent a 3 x 3 x 3 metre space unit (room) scaled 1:50, and from it various forms were constructed. The same block was used to represent a two storey unit of 6 x 6 x 6 metre allowing groups of buildings to be constructed scaled 1:100. Between the blocks vertical sheets of paper were used to stop fenestration through cracks. The cracks between blocks were considered as representing details on building blocks. The blocks were painted matt black to prevent any reflection.

A4.2.2 External Flow Model Limitations

The limitations of this model can be stated as follows:

1 It was limited to rectangular shapes only
2 It was limited to two scales only, 1:50 and 1:100, since the residential unit would have only one room in its side of the block.
3 The model was limited to represent six storey blocks (1:50) and 13 storey blocks (1:100) in order to suit the size allowance of the wind tunnel working cross section
4 For the 1:100 scale the model did not allow using vertical sheets of paper, but since there was only one crack the fenestration was very limited, and ignored on the grounds that buildings in their natural setting have considerable fenestration.
5 Examination of air movements through a residential unit in the block was very difficult to document due to lighting difficulties.

A4.2.3 Internal Models

The designs of the residential units examined were chosen to represent the morphology of residential spaces starting from the single cell and ending with multi-cell spaces. These comprised five main spaces, fig.(A4.5). The units were co-ordinated on a design grid of 1·00 m in the full scale, to be represented in a model scaled 1:25. The height was fixed at 3 metres to agree with that of external models. This was represented by perspex panels 4 x 12 cm^2 and units of 4 x 4 cm^2 to provide the required openings, fig.(A4.6). The model had a base which allowed hot wire probes to be provided in a 4 cm grid, and these were supported at a height of 6 cm to represent the human figure, and corresponding approximately with the mid-height of the space. The panels were fixed to the floor and to each

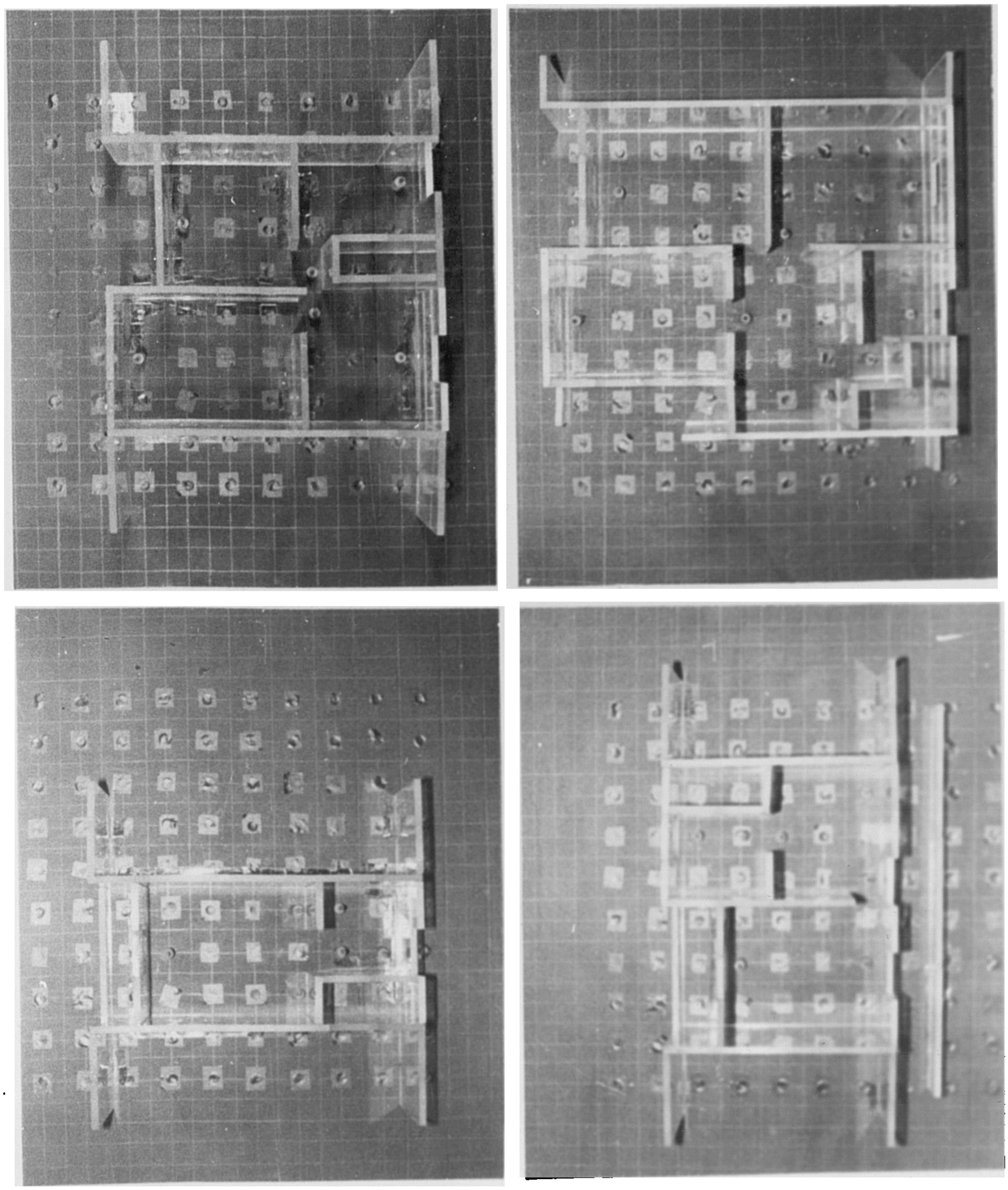


Fig.(A4.5) Plans of experimental models

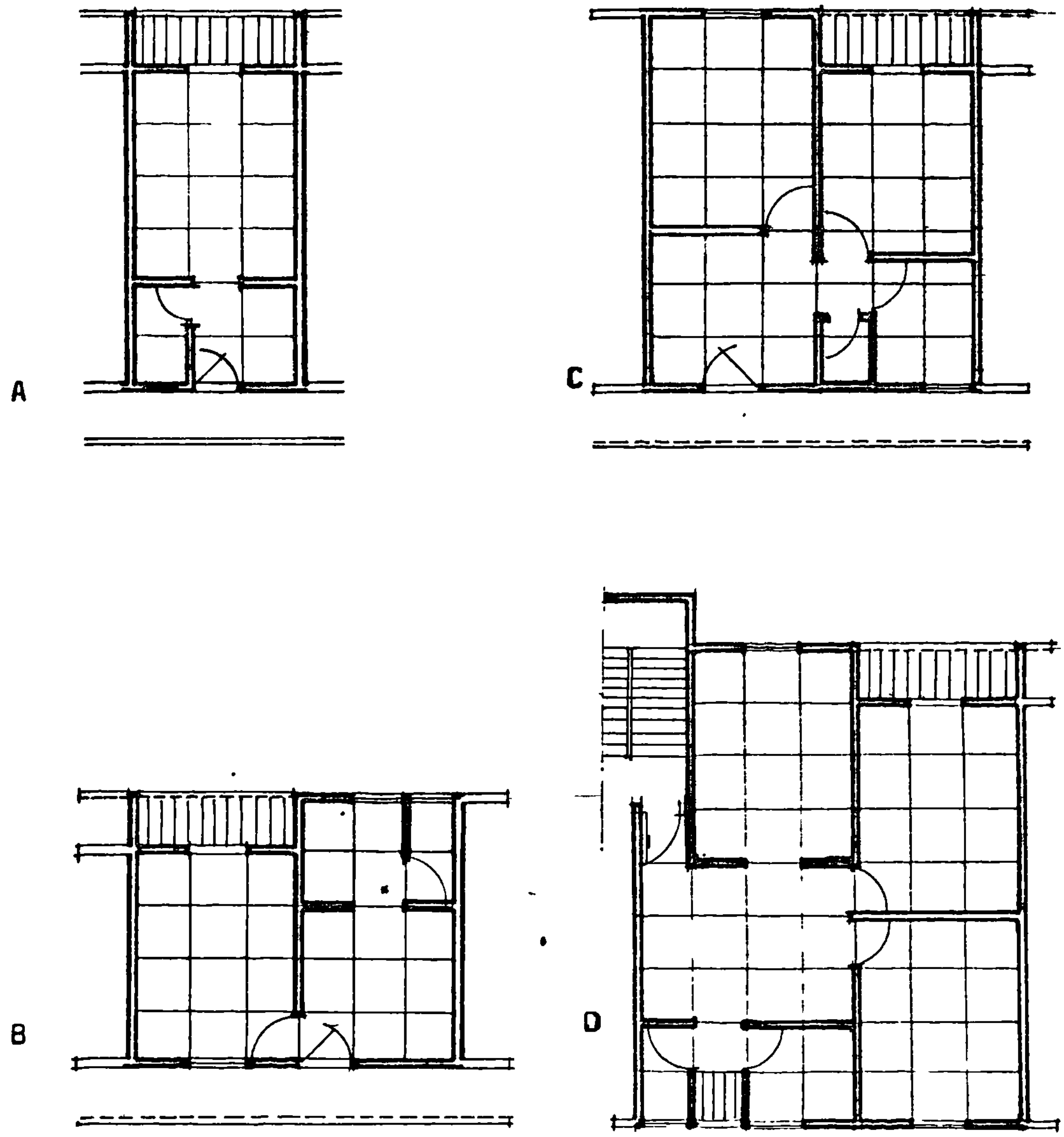


Figure (A4.6) The four basic models; plans.

other using both double sided tape and transparent tape to ensure a sealed model, and to eliminate any unintended infiltration through cracks. Using this model it was possible to examine 41 different combinations of space under 4 main groups.

A4.2.4 Internal Flow Model Limitations

The model exhibited the following limitations:

1 It was limited to 1:25 scale.
2 Air flow was allowed in the horizontal plane only.
3 The representation of window attachments, doors and furniture was not possible.
4 Heat sources within the full scale spaces had not been considered.
5 Vertical air flow on the model faces, as would be present in the full scale, was not represented.
6 Only a single storey unit could be considered at a time.

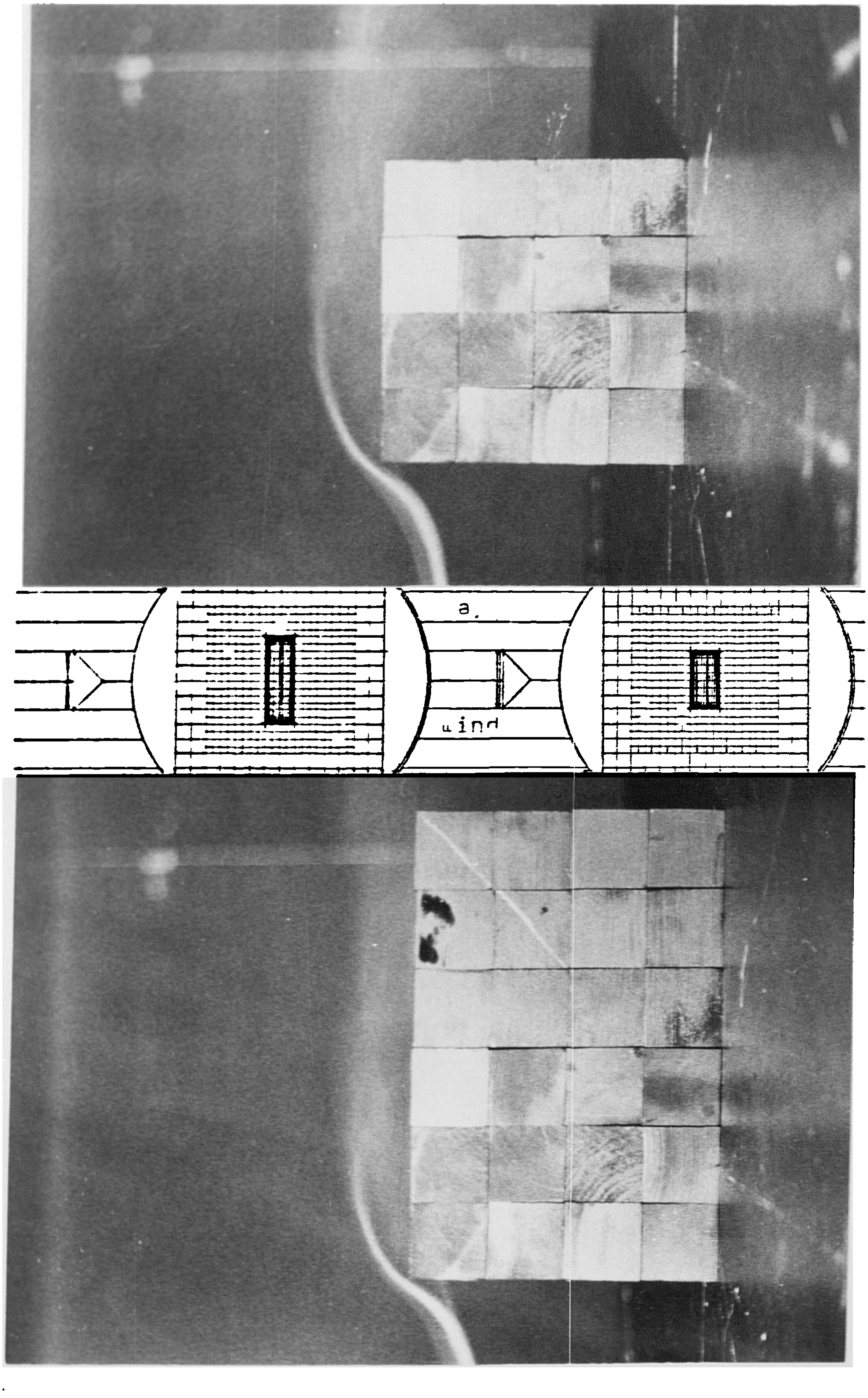
APPENDIX A5 : THE FLOW PATTERNS

A5 The Flow Patterns

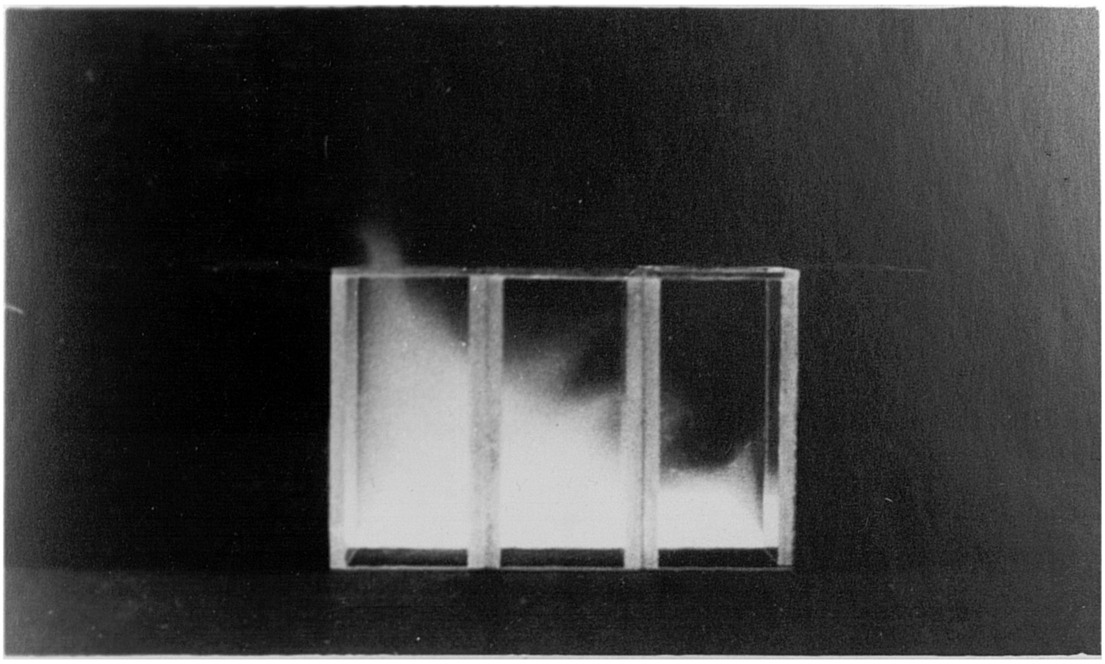
The flow visualization was conducted as the first part of a two stage program. It aimed to examine the qualitative aspects of the relations of the built form to the air flow patterns around it, ie the performance of the built form from the environmental aerodynamic point of view. It recognized the already available body of data and tried to extend it to correlate it to the architectural problems encountered in natural ventilation. The special problems and forms encountered in multi-storey low-cost housing were also taken into consideration. In general it is aimed at providing guidelines to the architectural community involved in this type of building, and in particular, it aims at illustrating the expected effect on the flow inside buildings.

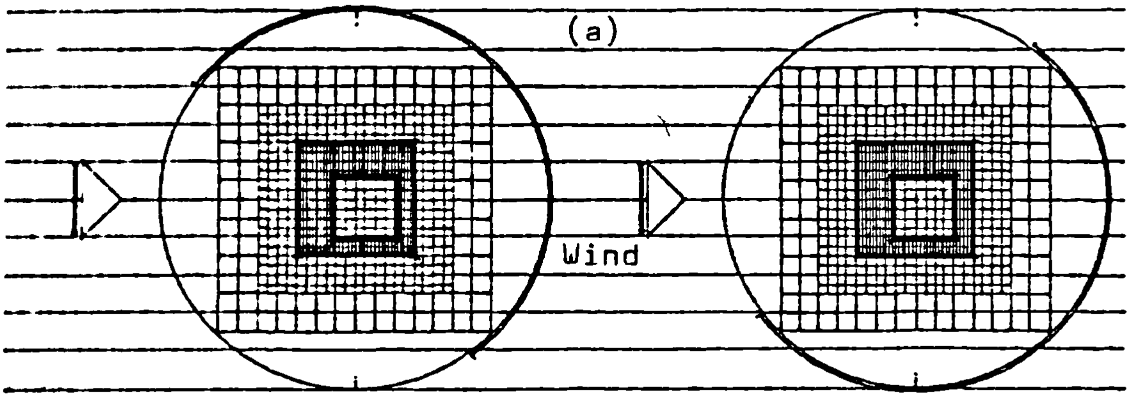
The tracing medium employed in the course of the experiments was evaporated oil. This, along with the photographic techniques. provided the best available documentation medium. The visualization medium used smoke puffs to trace the flow. When investigating the flow inside the courtyards however, the courtyard space was flooded with the white smoke. Then, after stabilizing the flow, air was allowed to penetrate, thus drawing the flow pattern. This technique proved very effective and the pattern appears as black lined drawn on a white background.

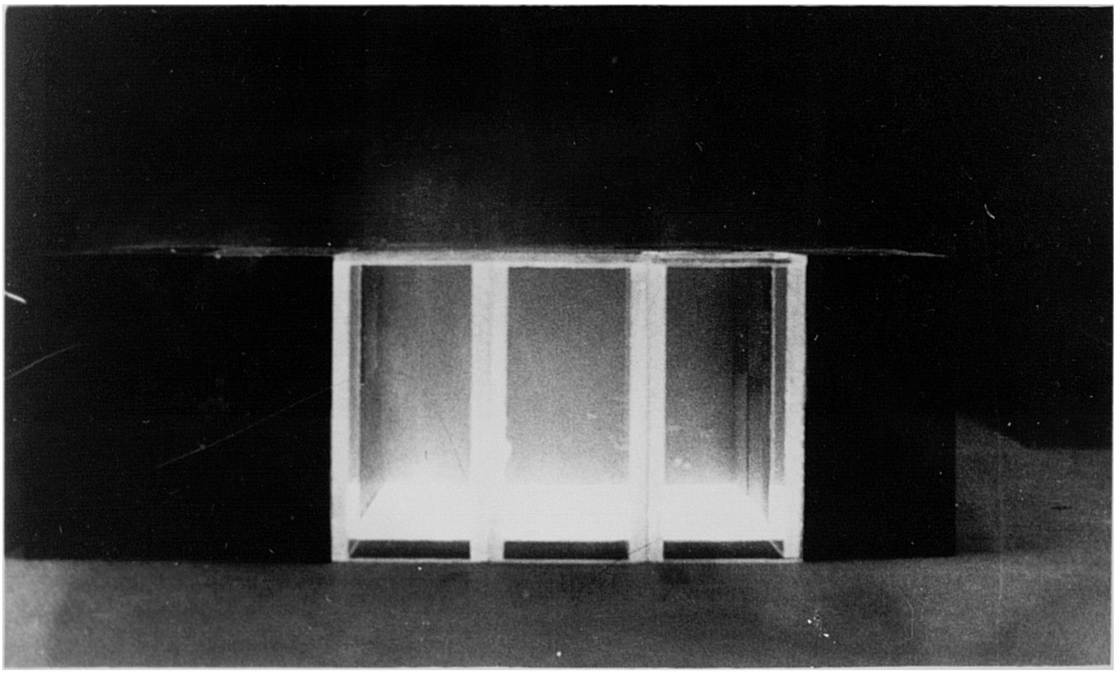
The following plates are a selected sample to illustrate in more detail the flow patterns explained in Section 6.3.

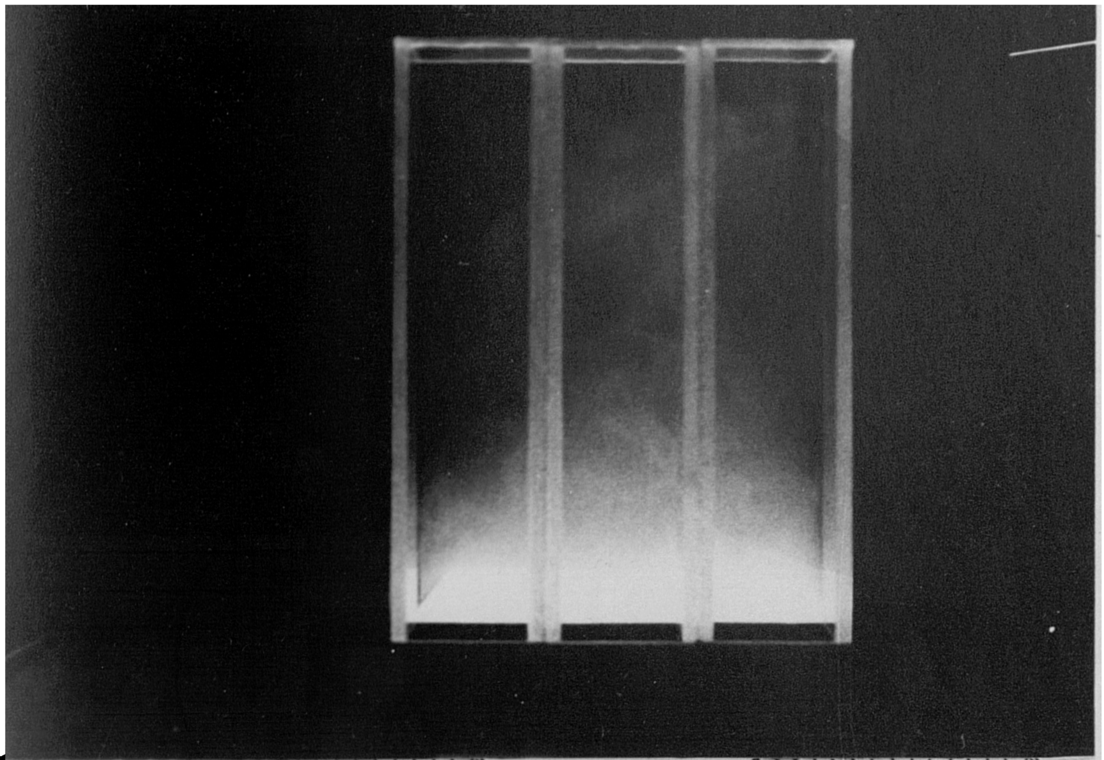


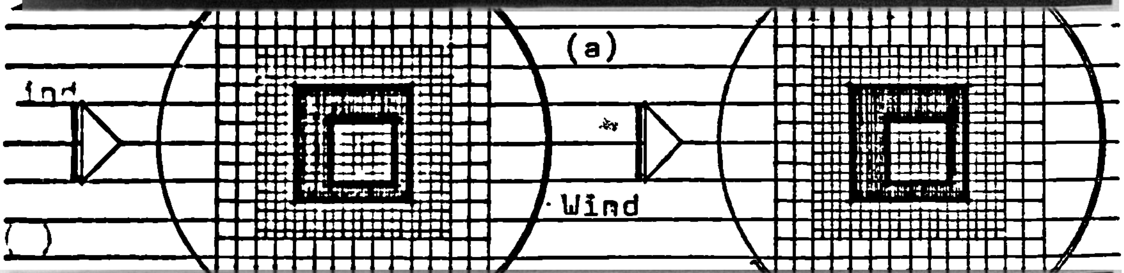
a.
wind

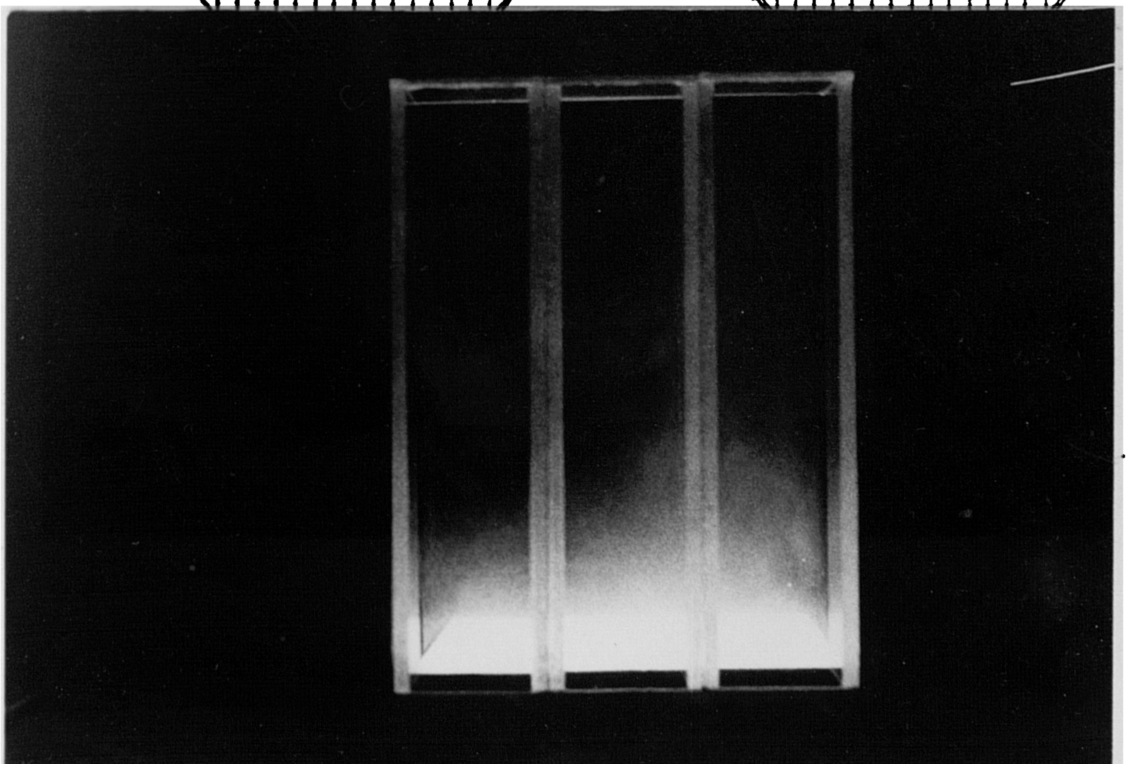


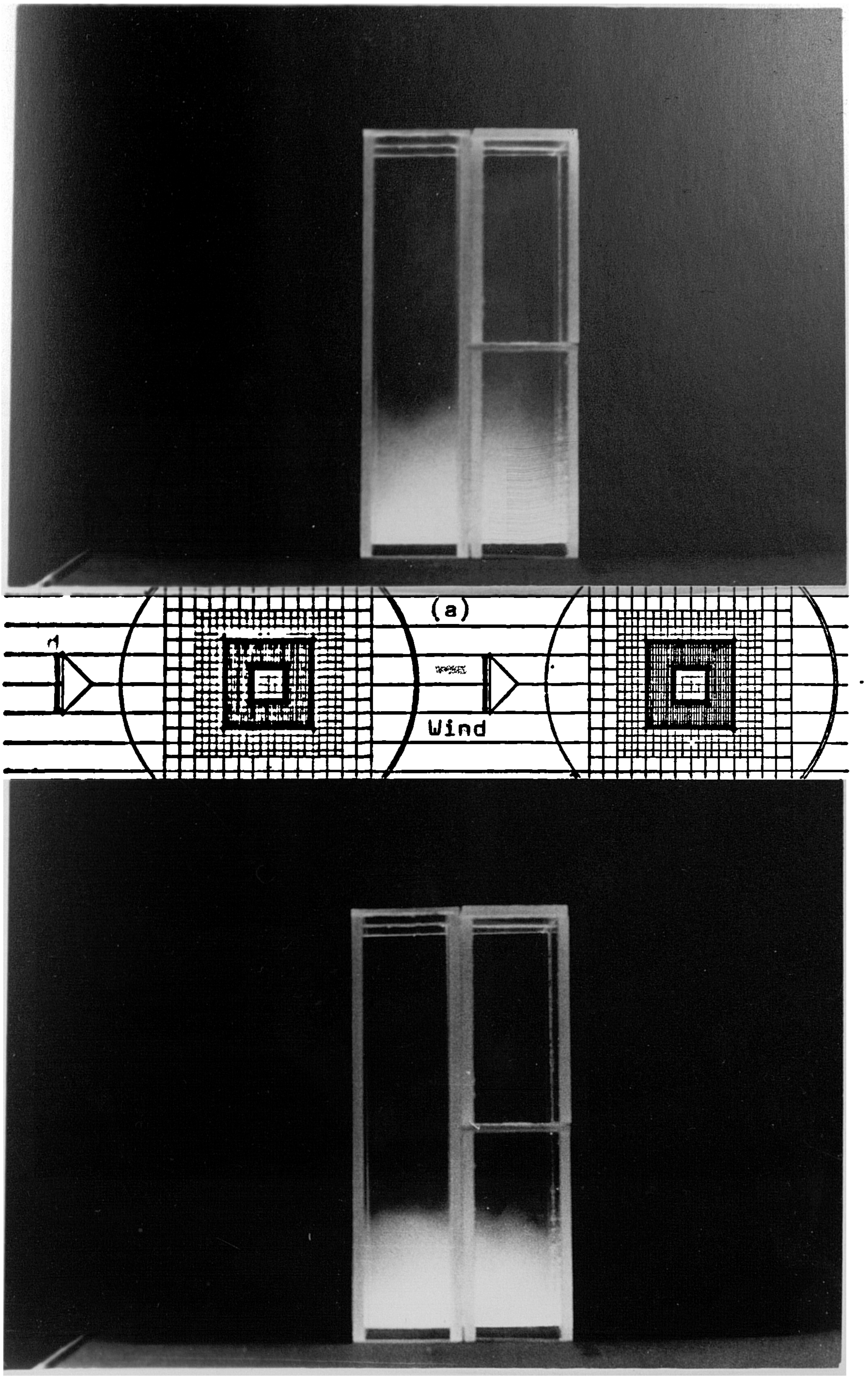

(a)
Wind

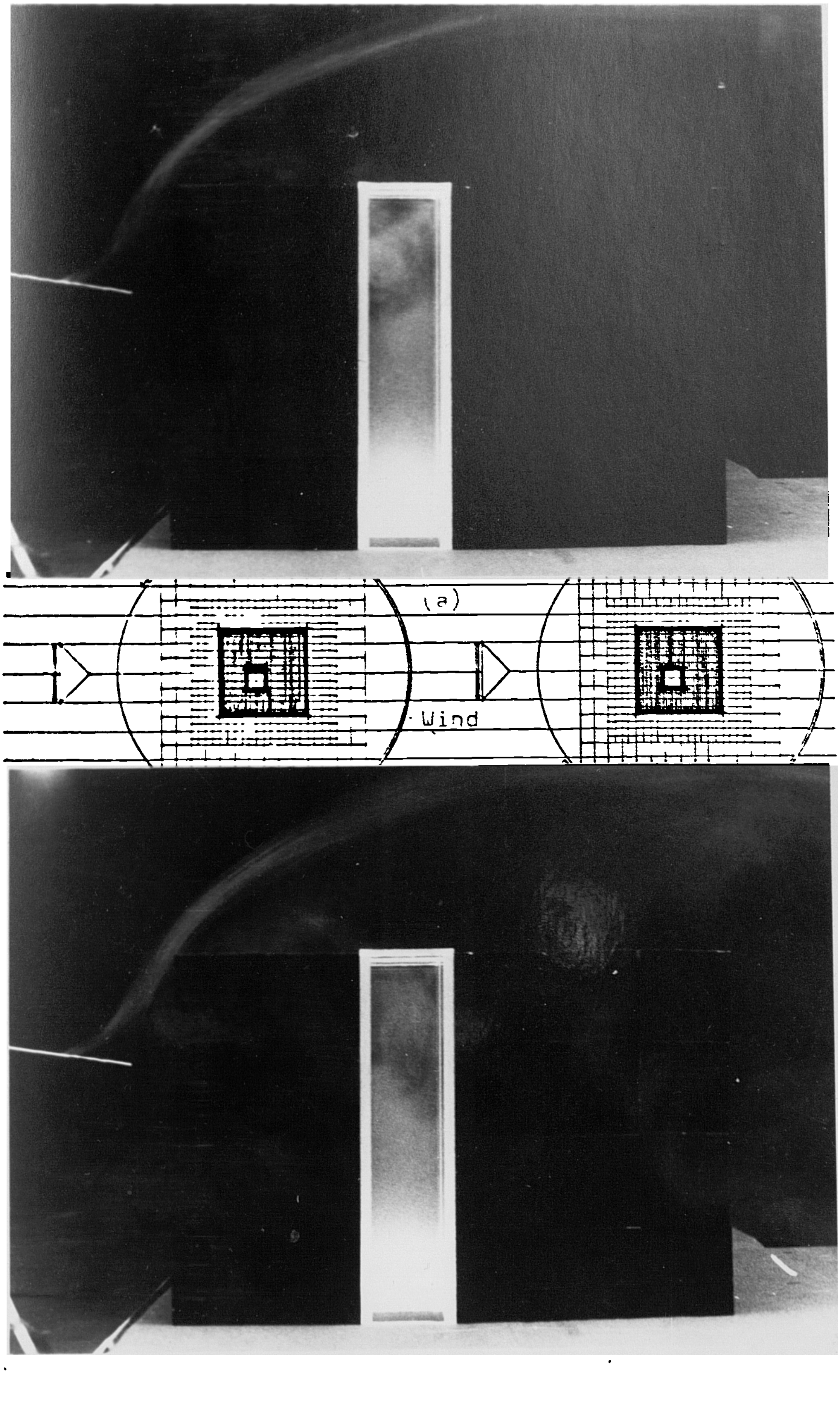


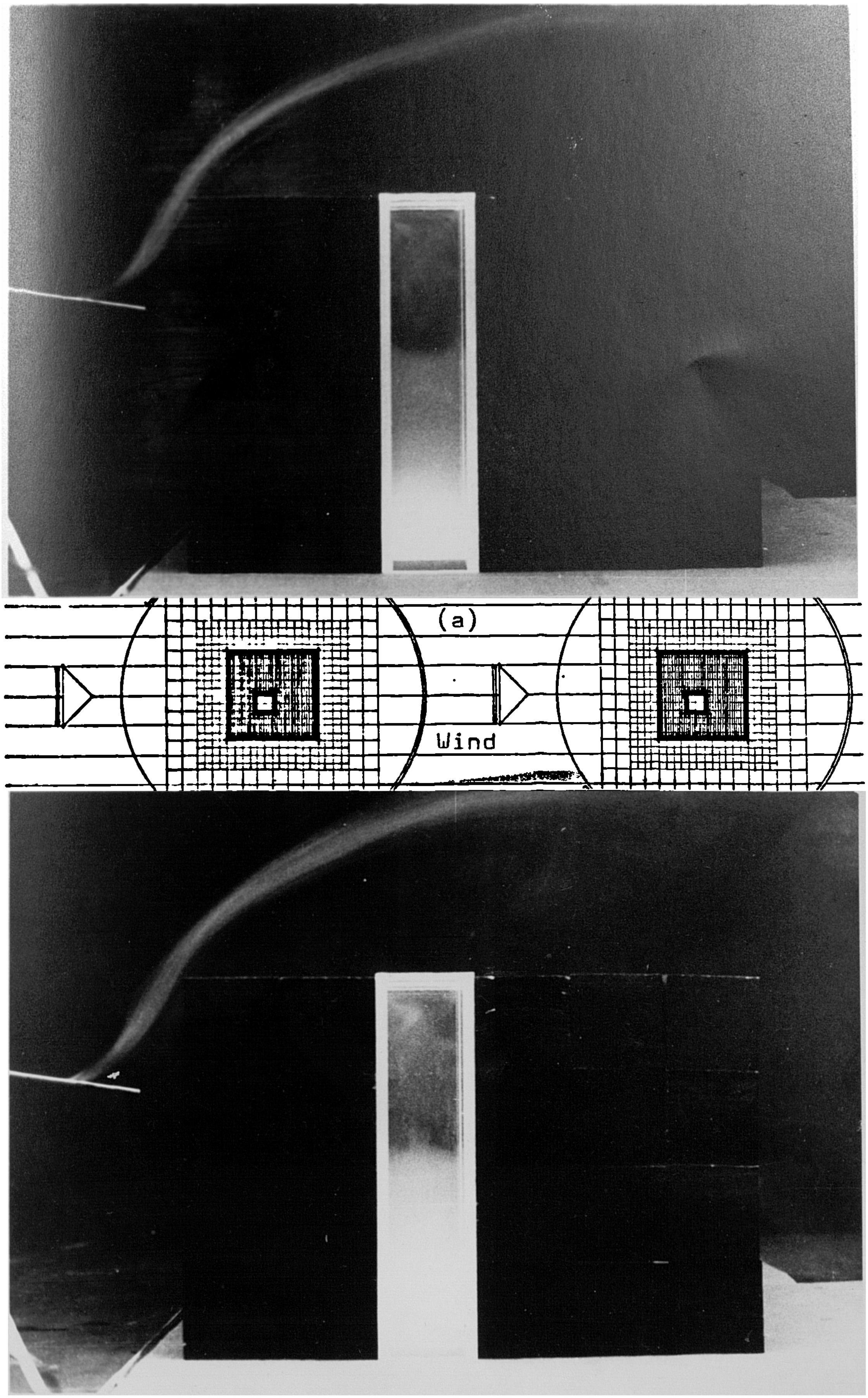


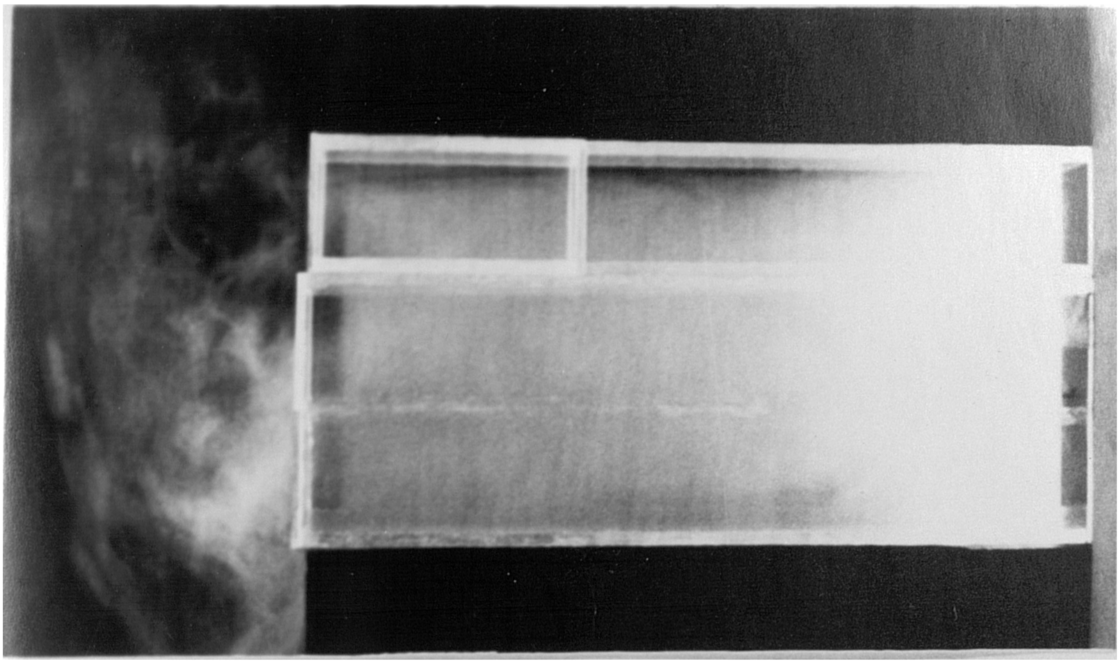

(a)
Wind

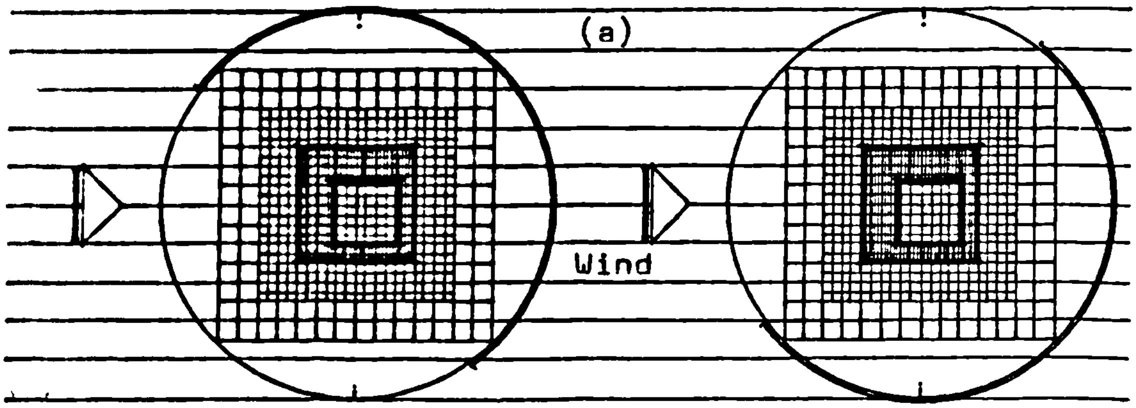


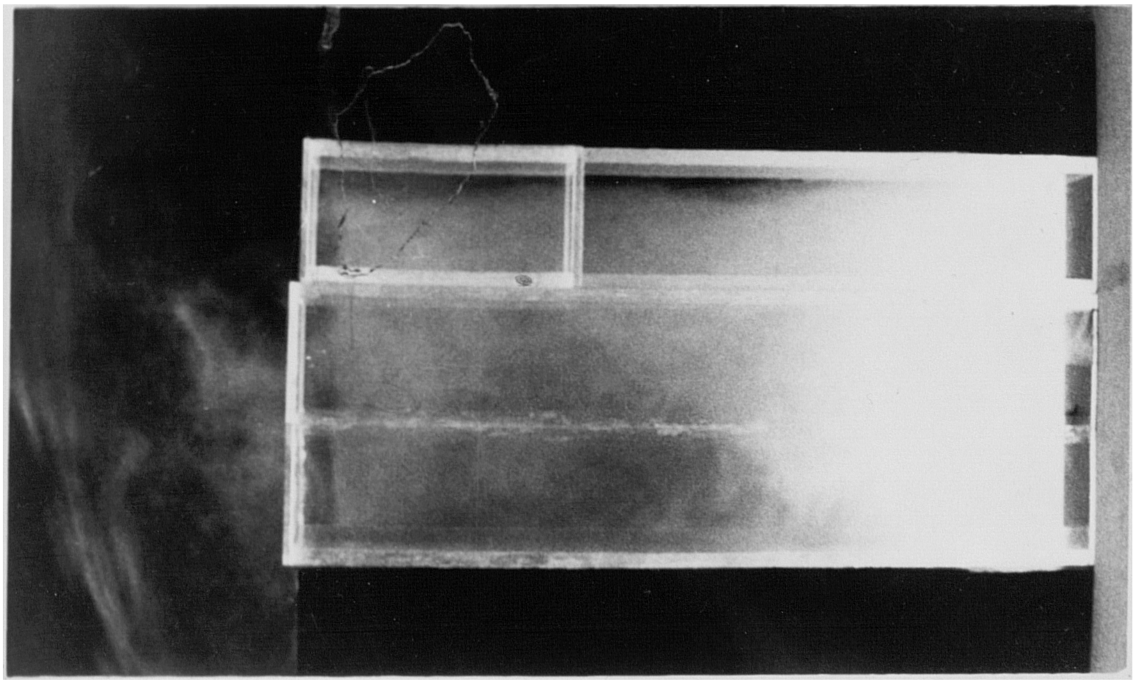

(a)
Wind

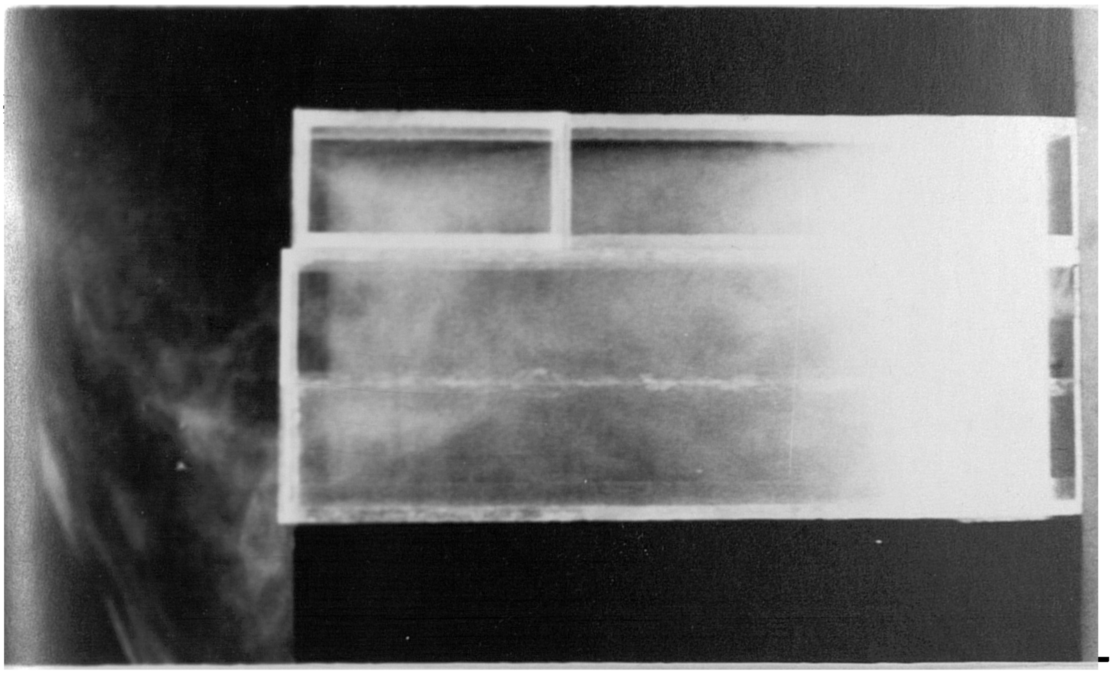

(a)
Wind

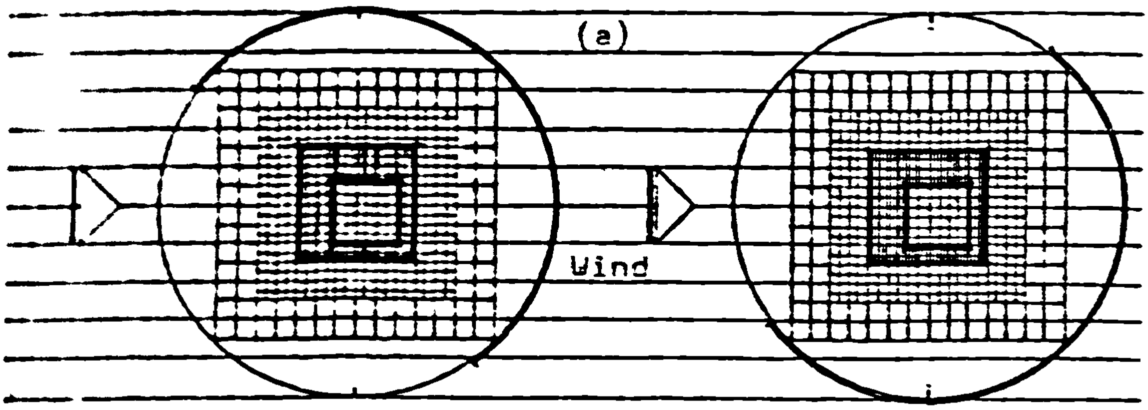

(a)
Wind

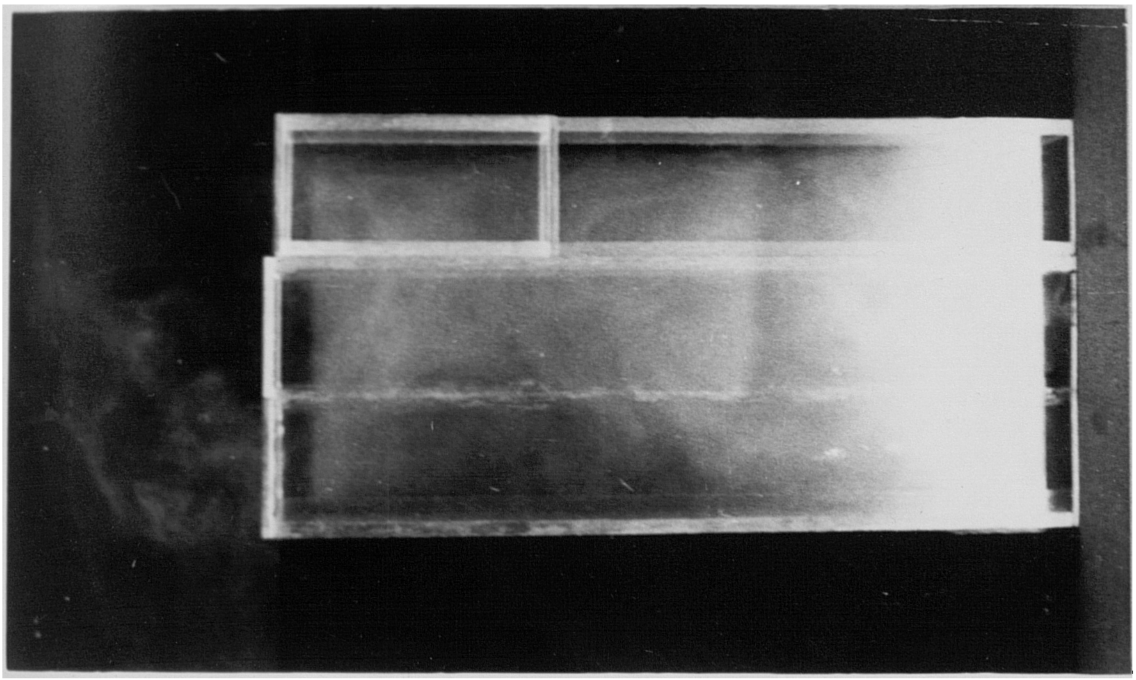


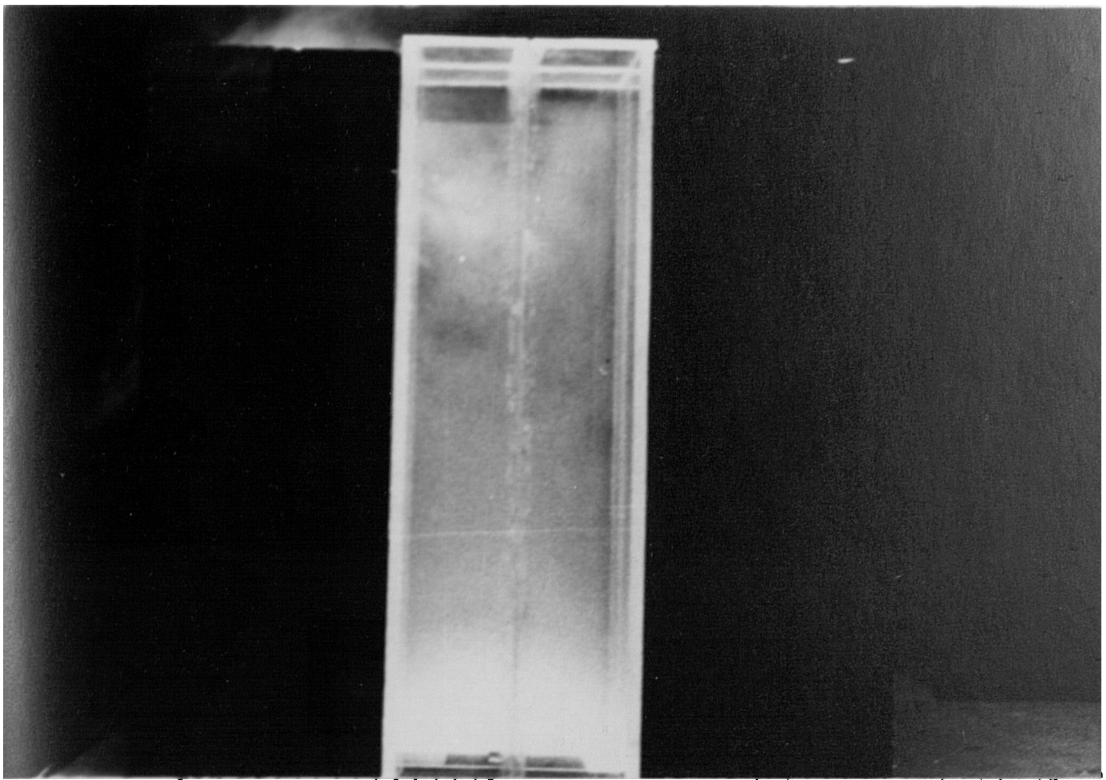

(a)
Wind

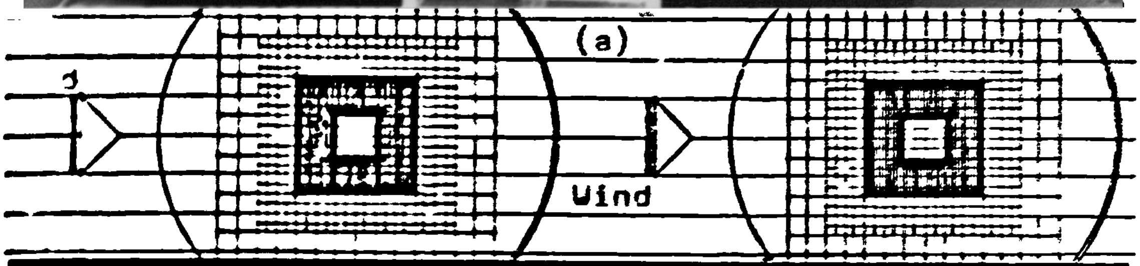


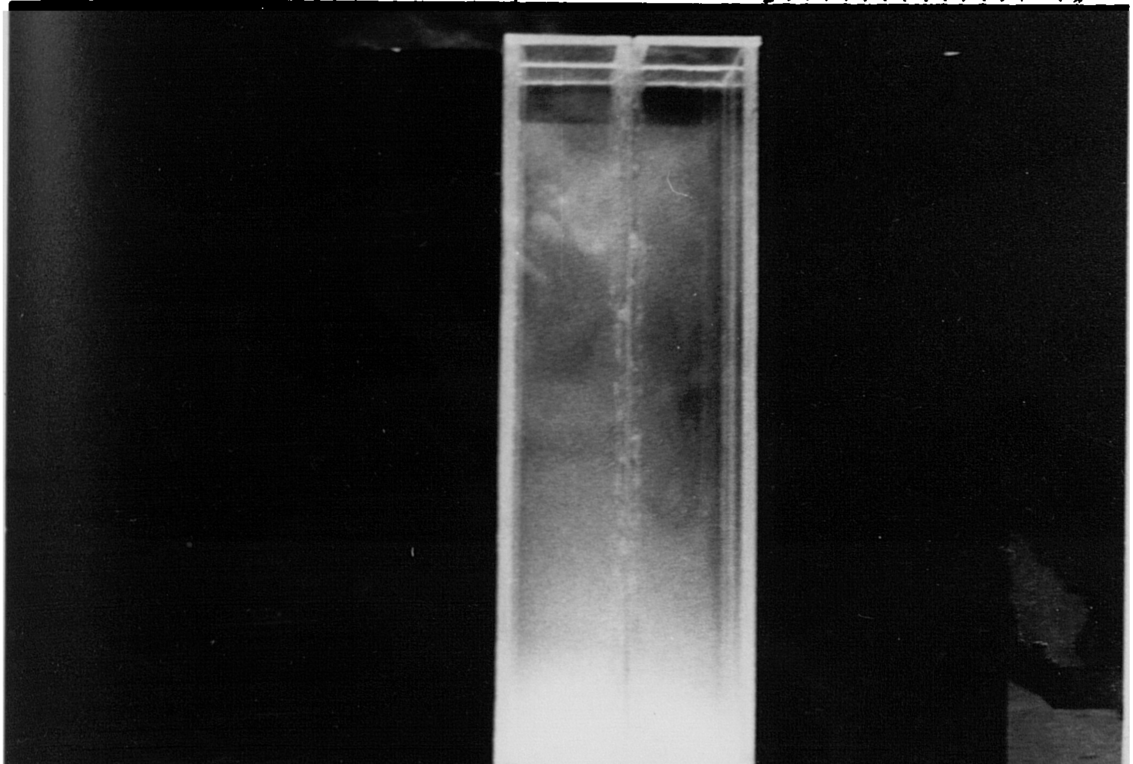


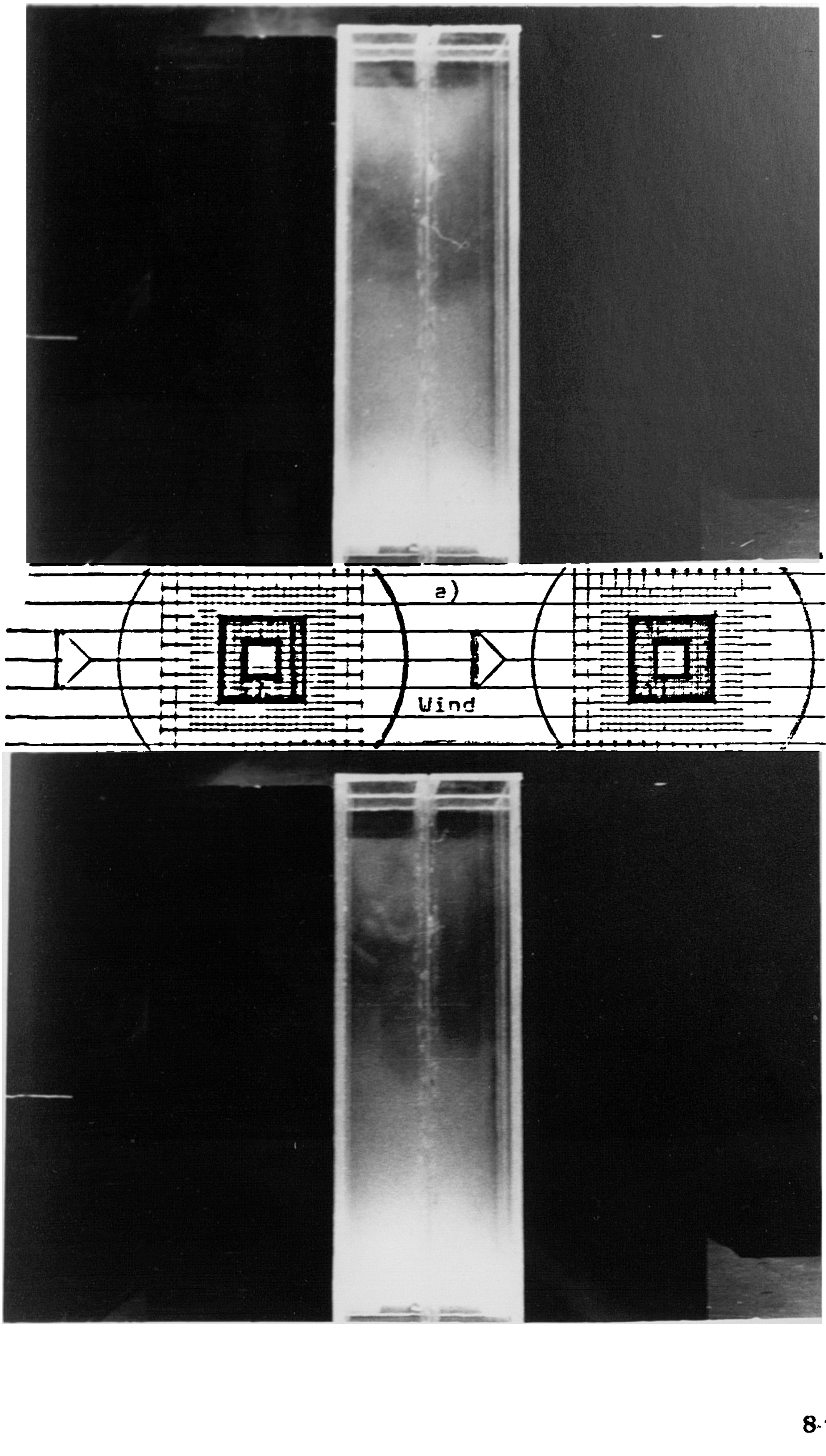

(a)
Wind



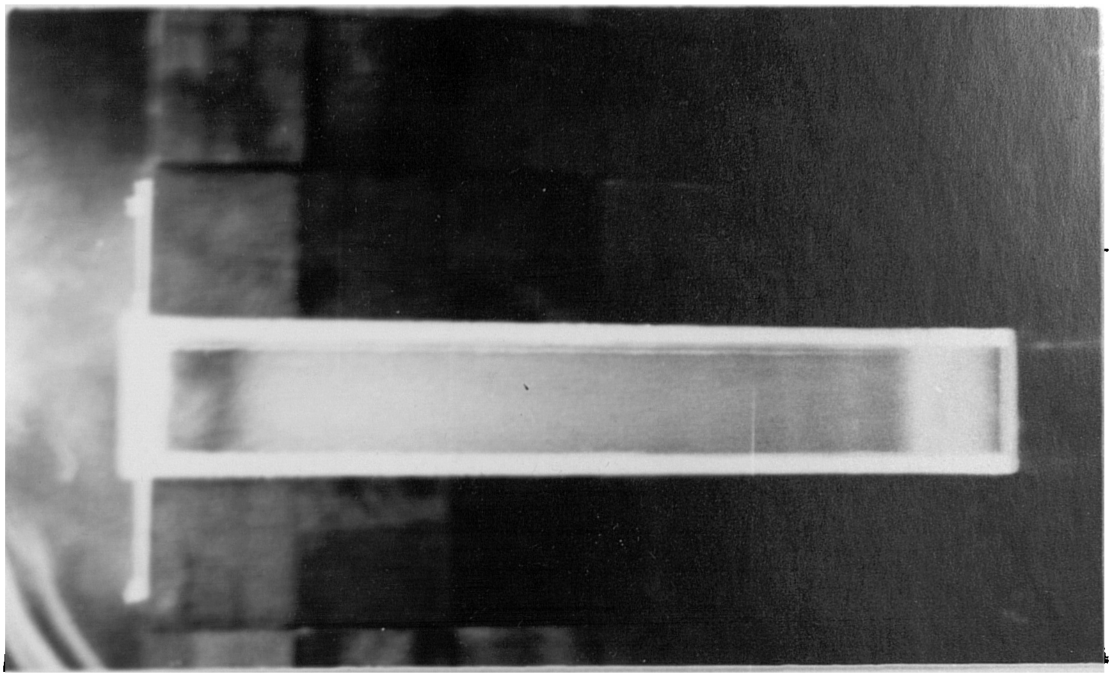


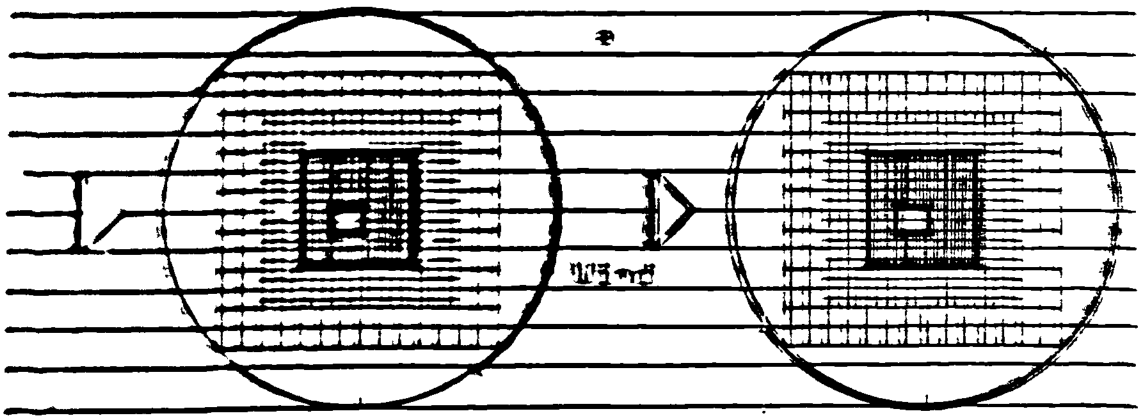

(a)
Wind

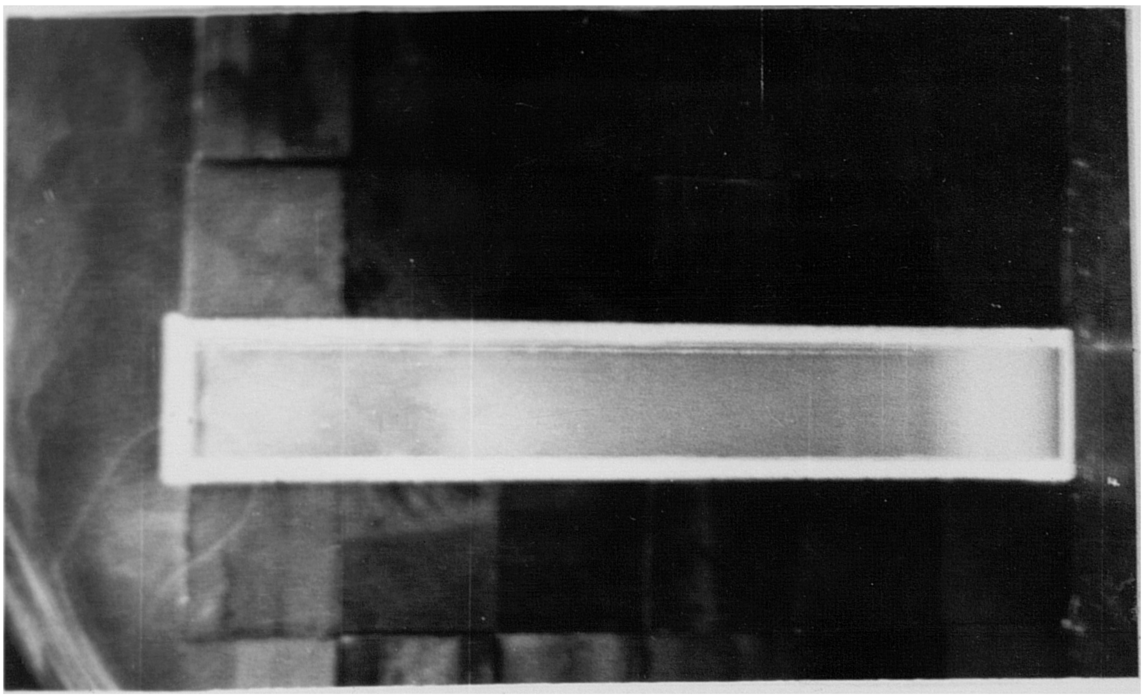


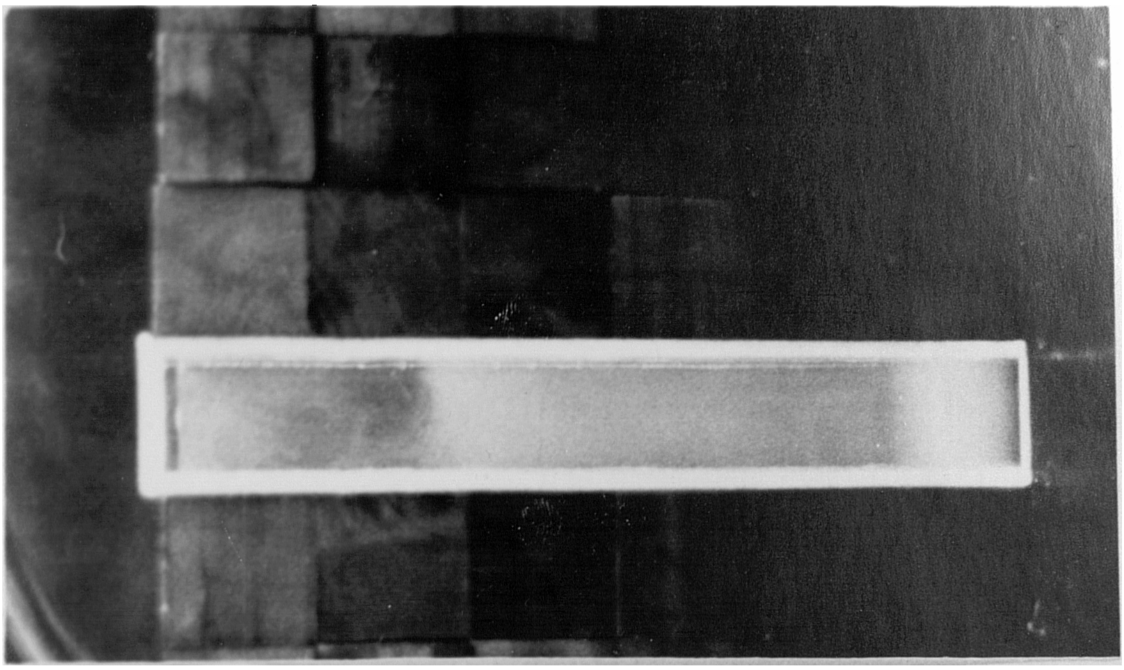


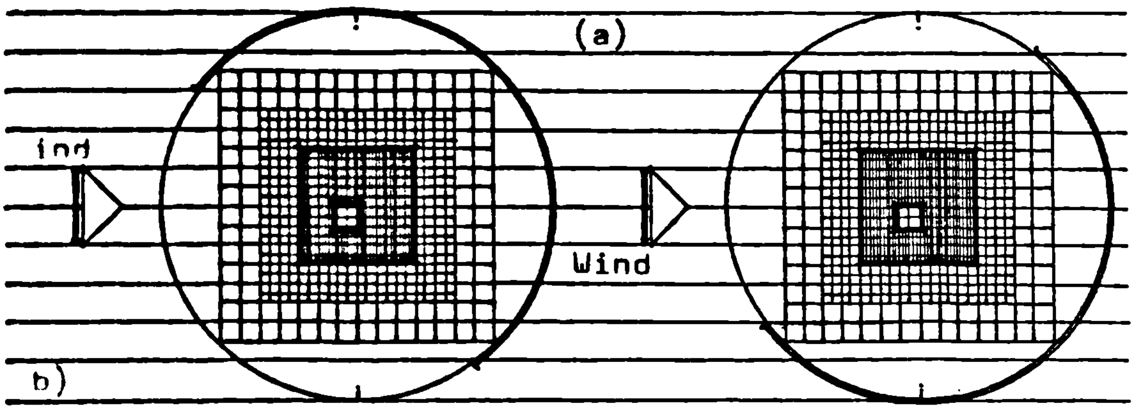
a)
Wind

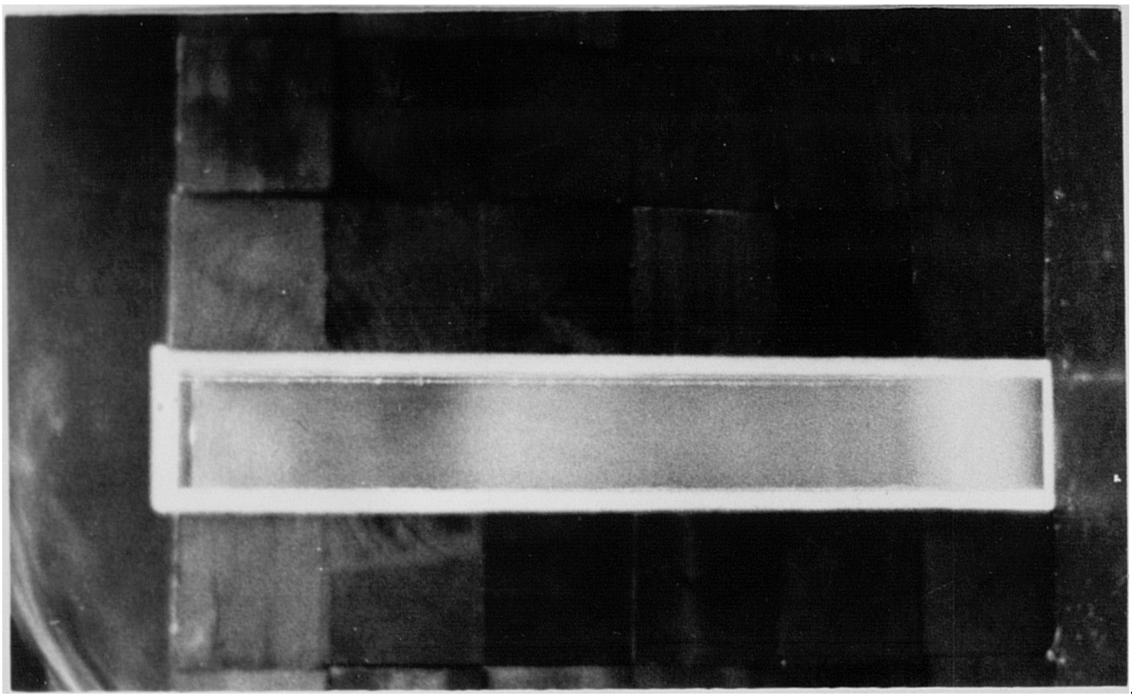


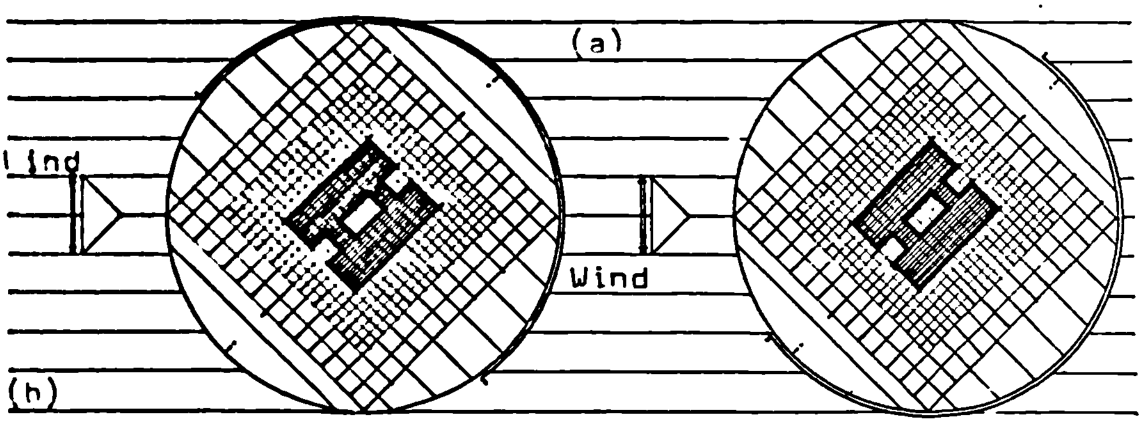


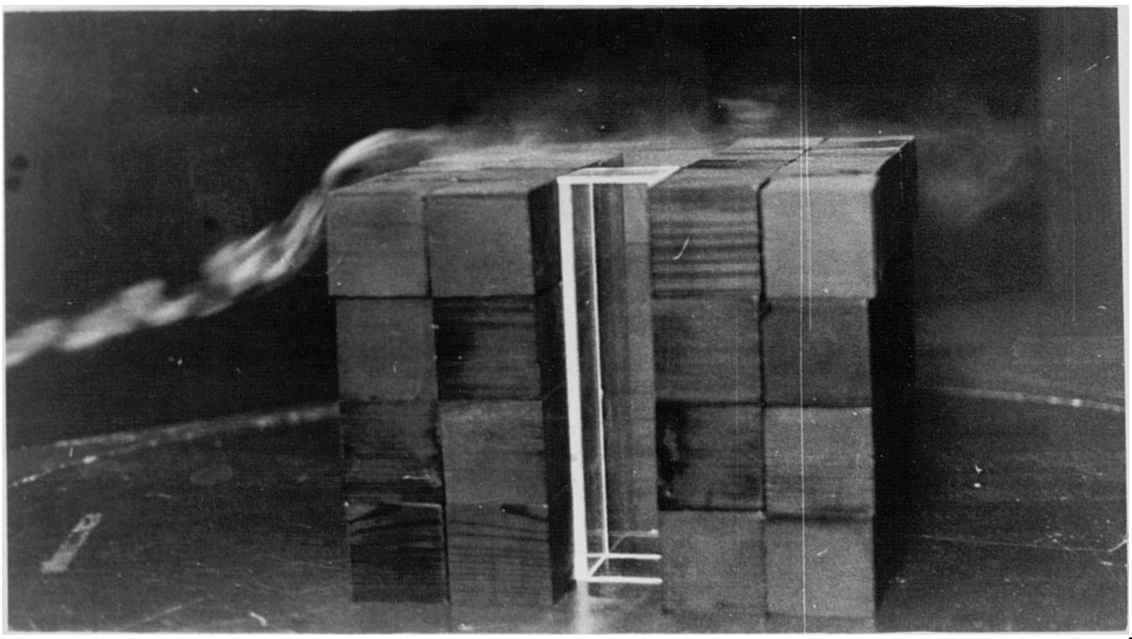


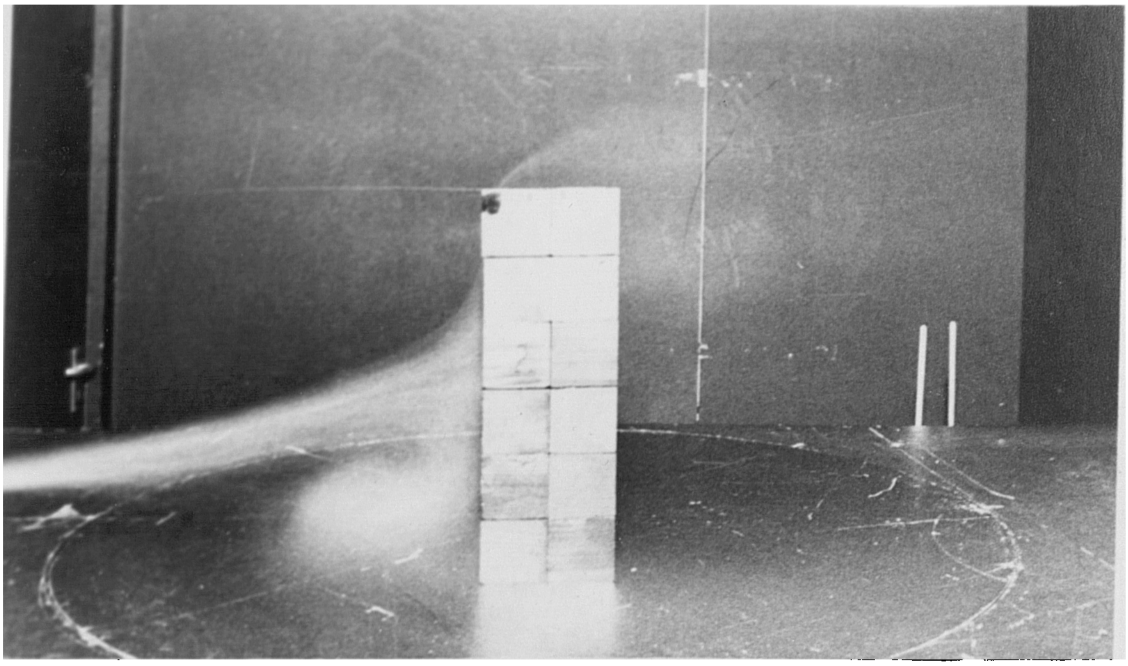


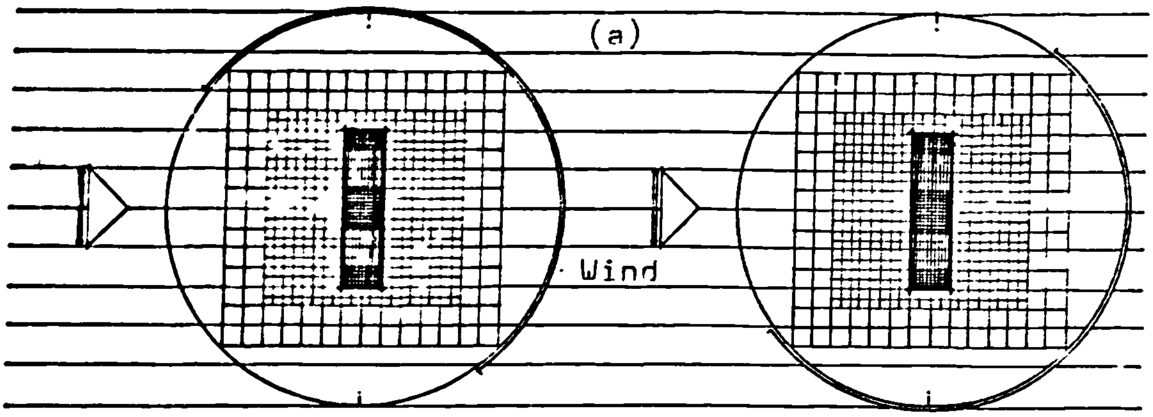

(a)
ind
Wind
b)




(a)
Wind
(b)



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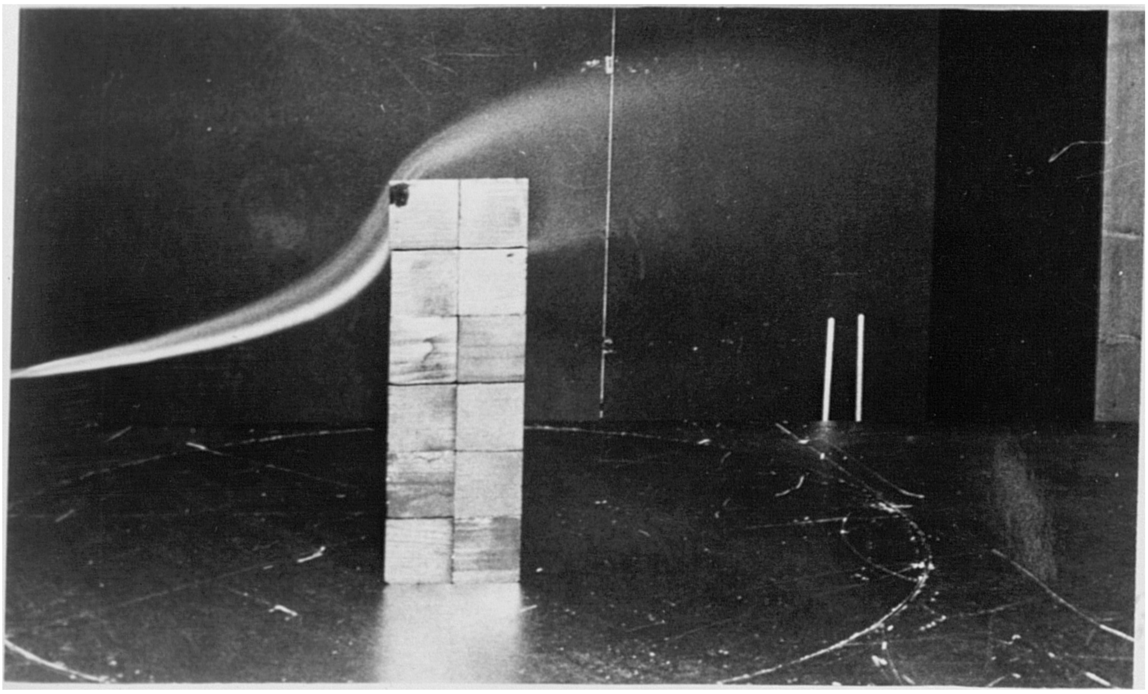

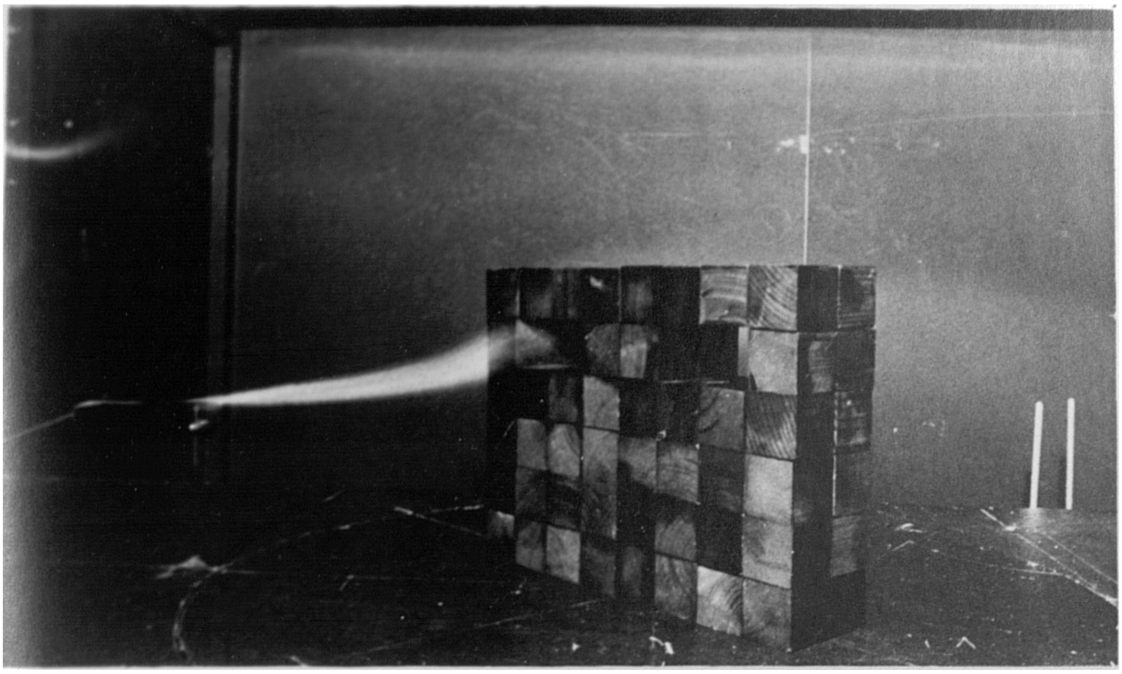

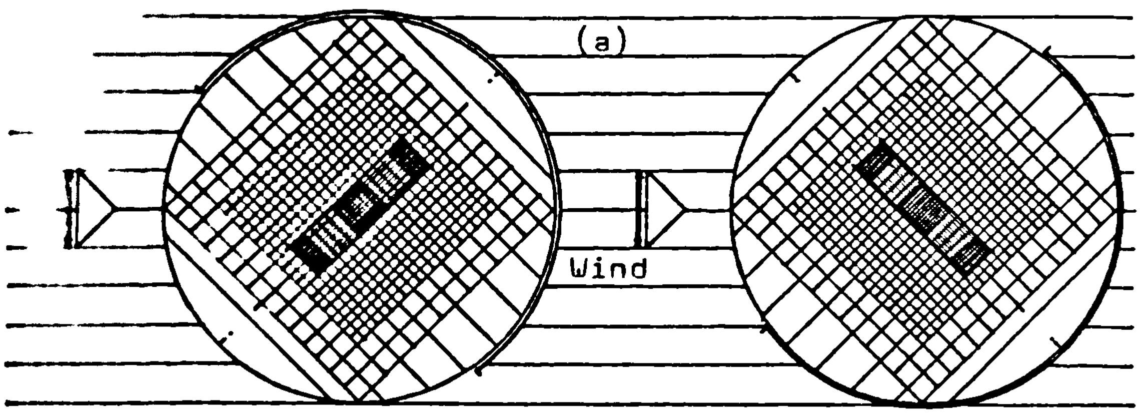
(a)
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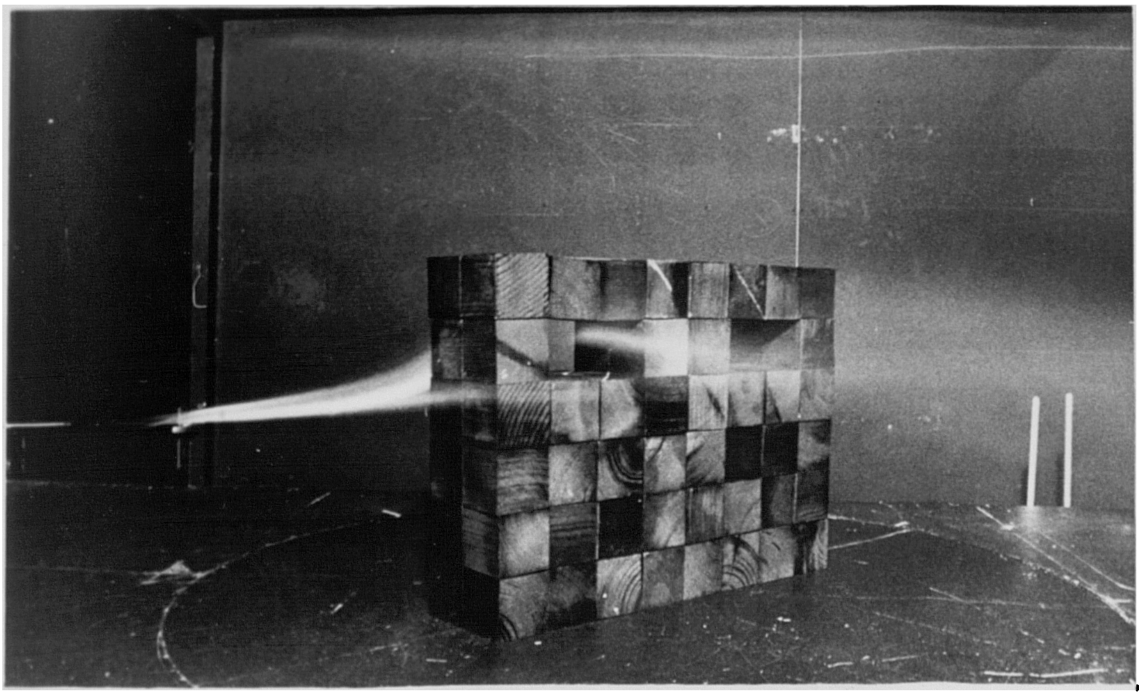
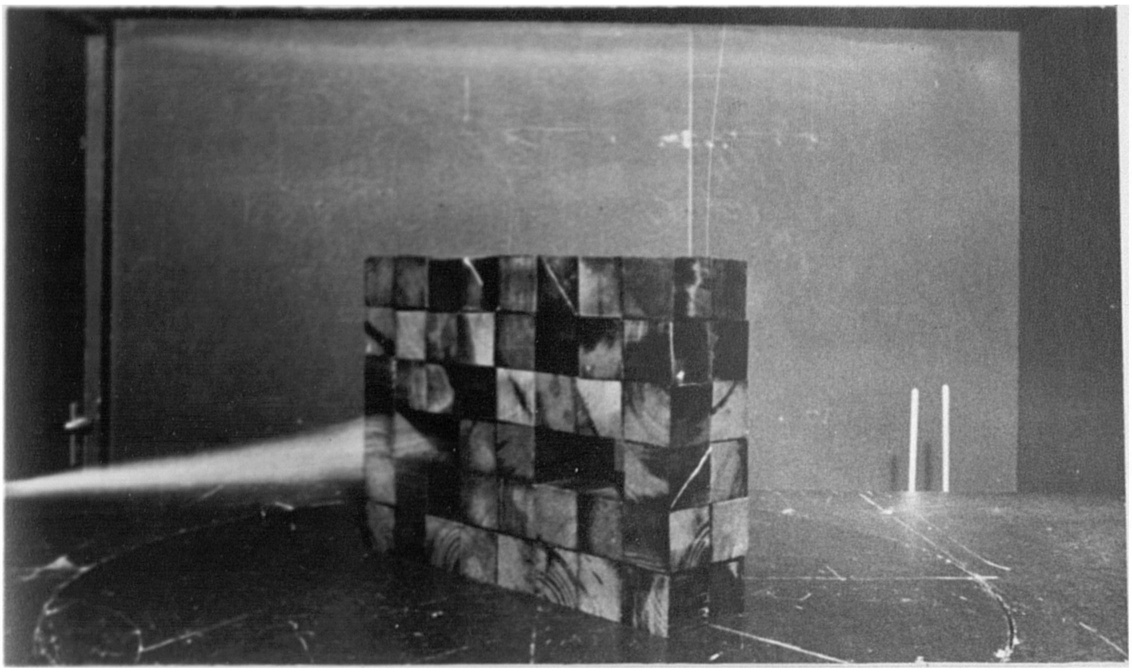
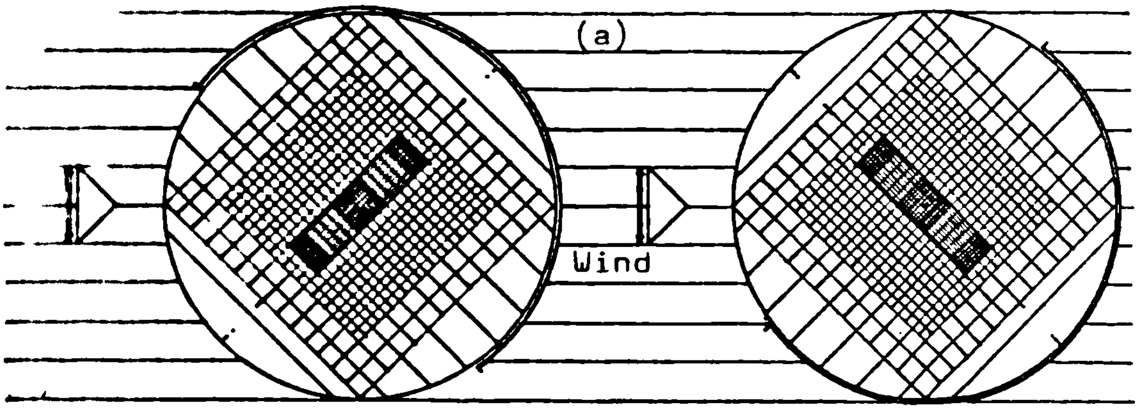
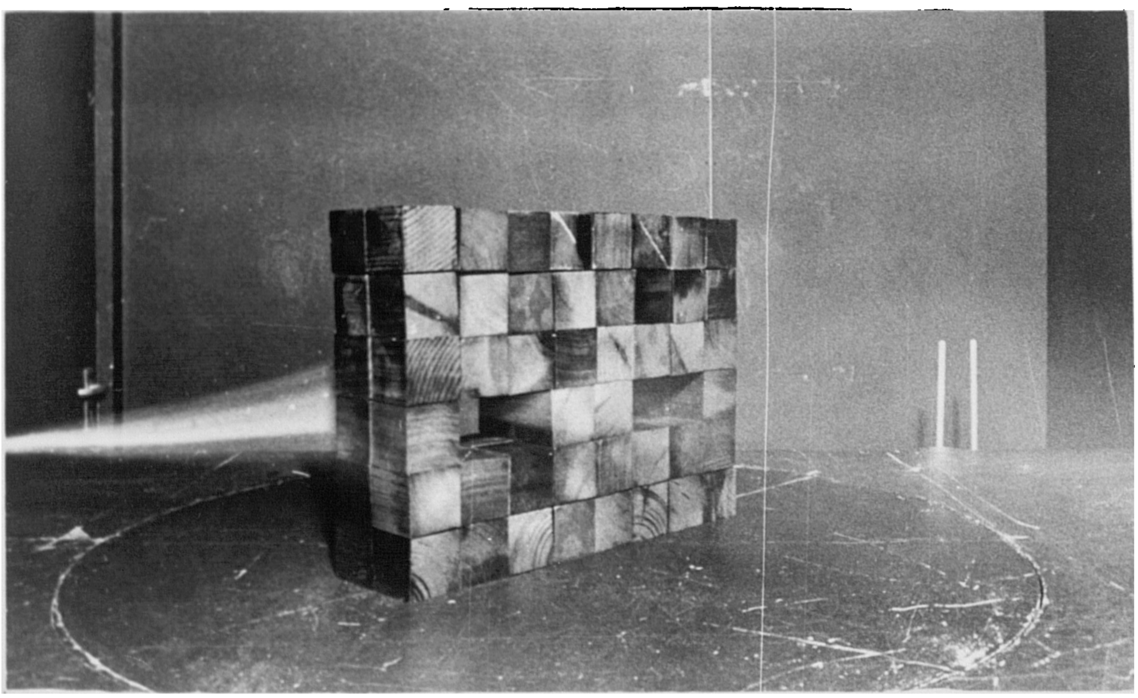
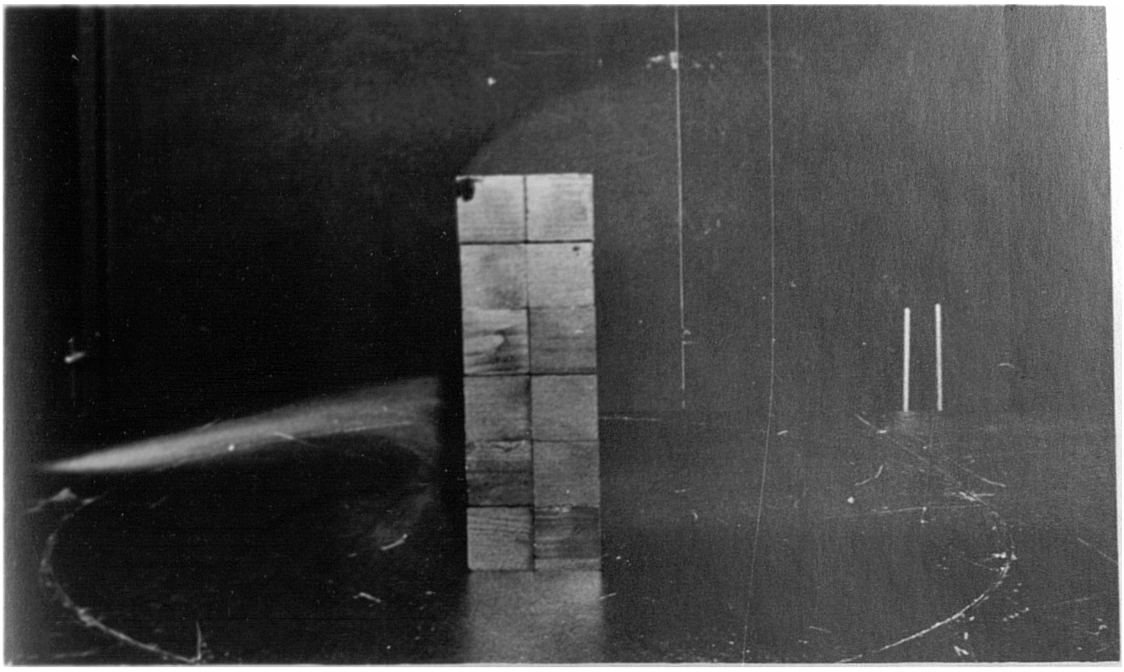
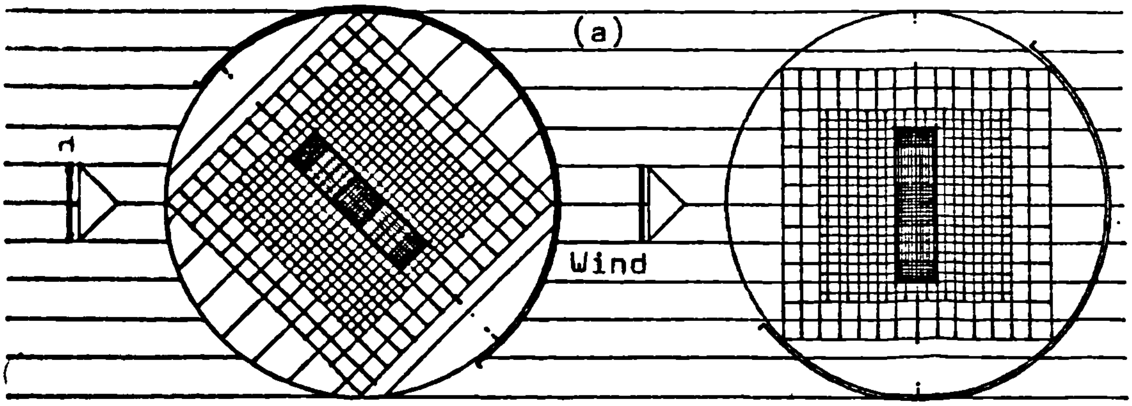


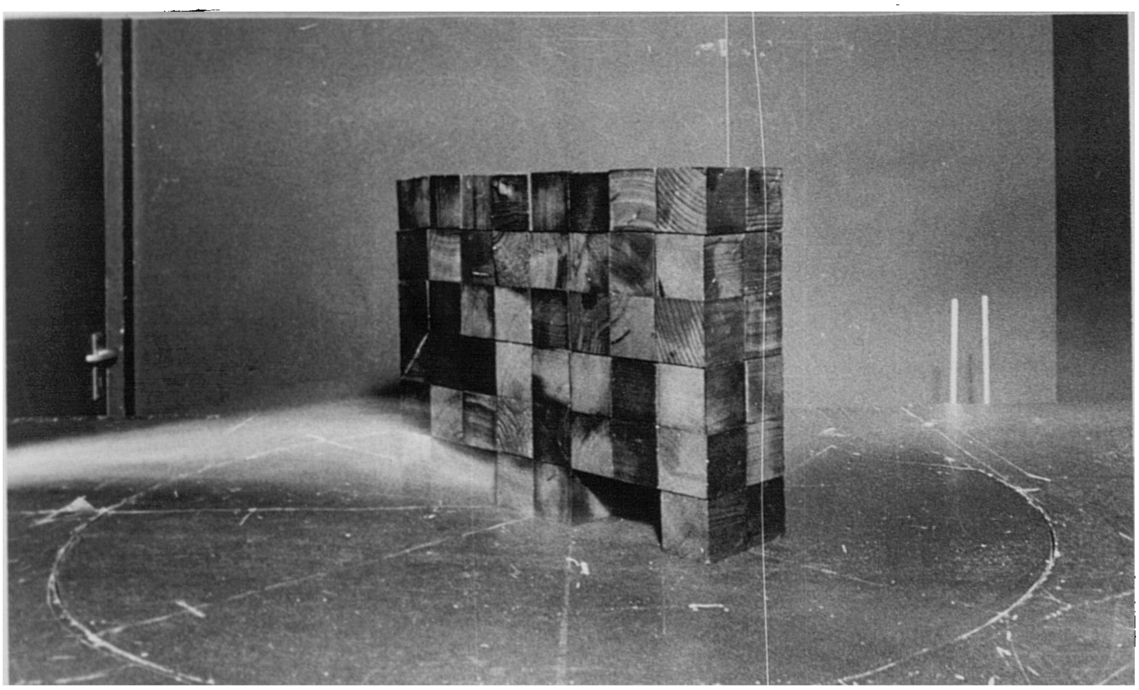


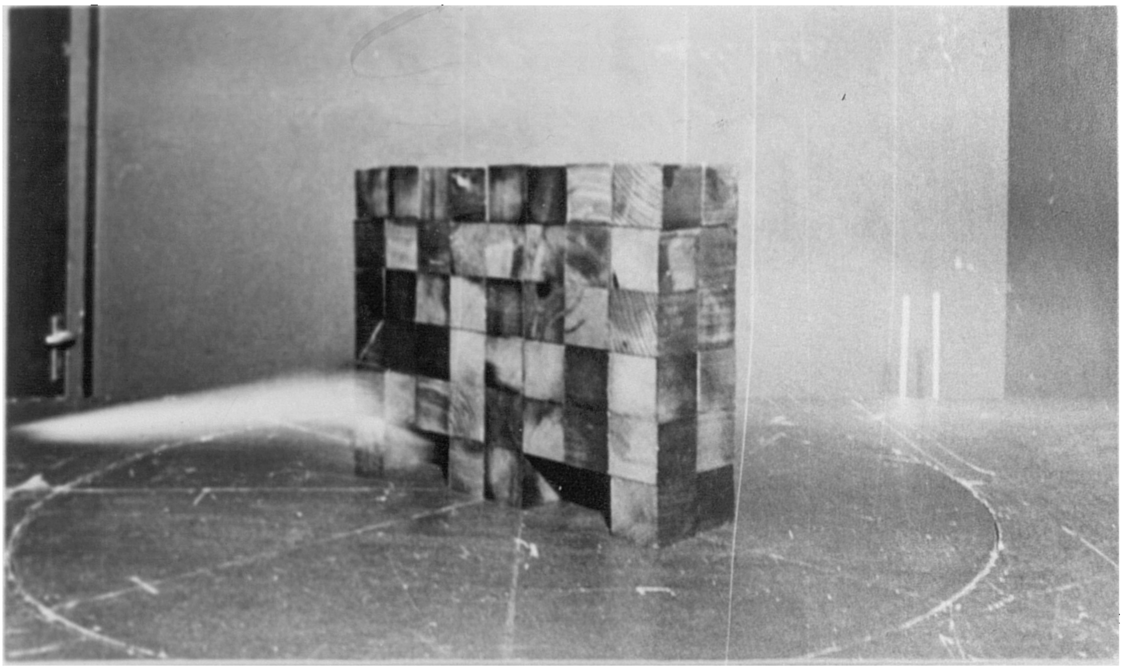

(a)
Wind

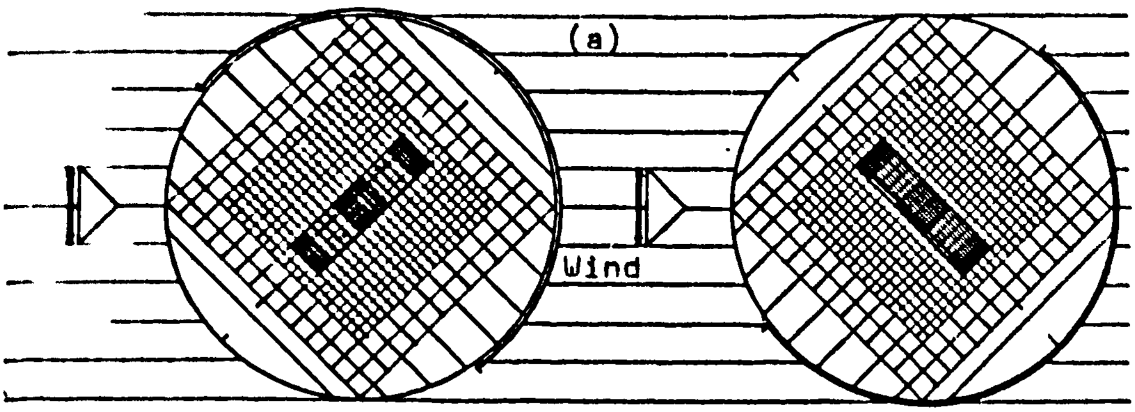





(a)
Wind






(a)
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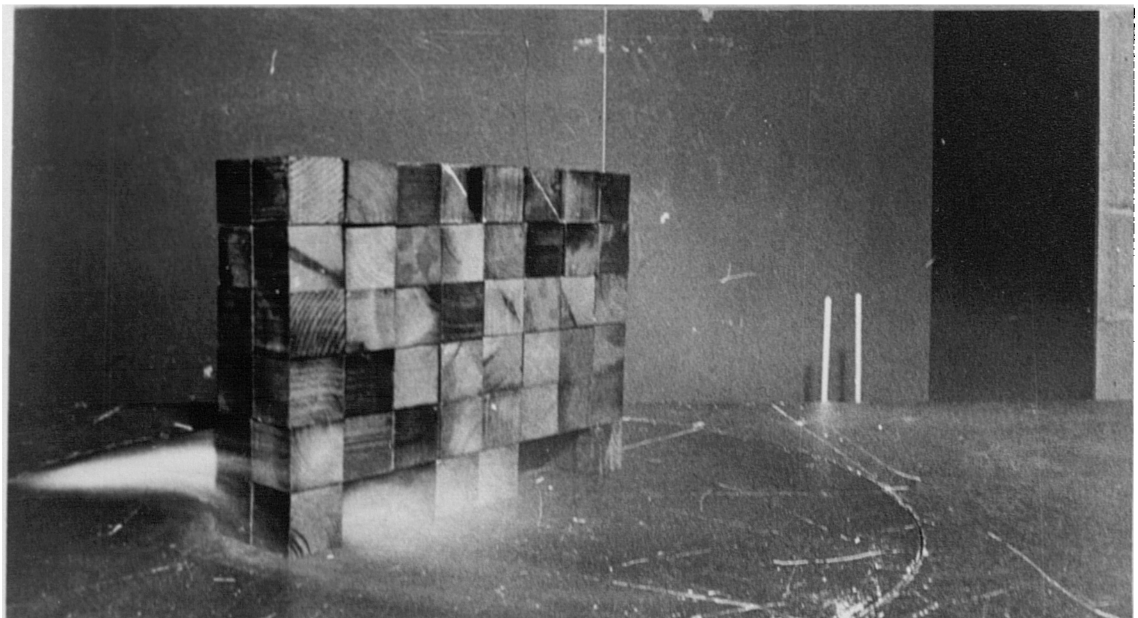

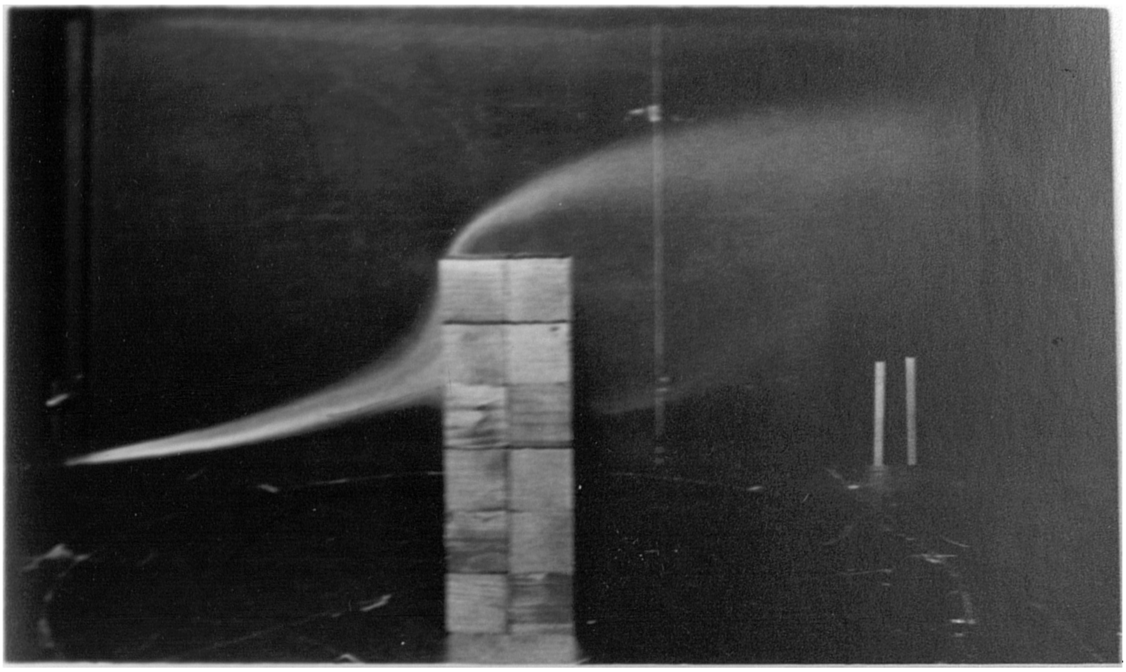

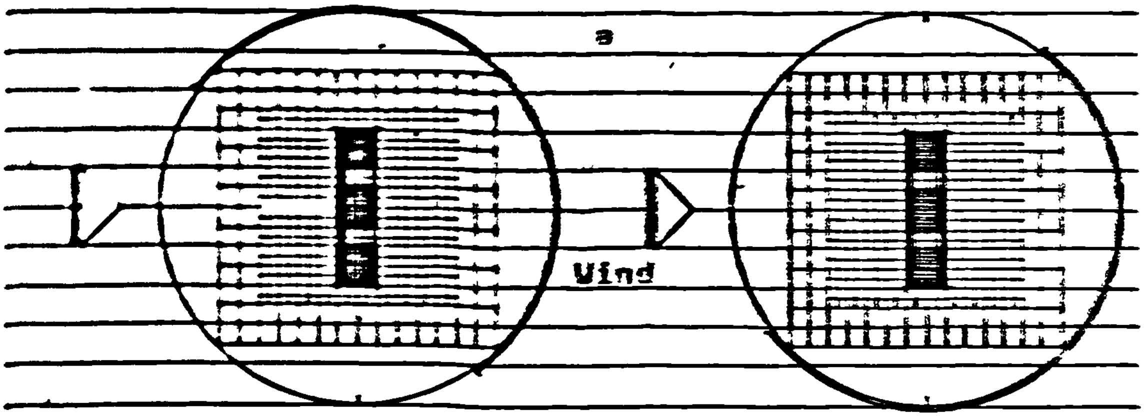
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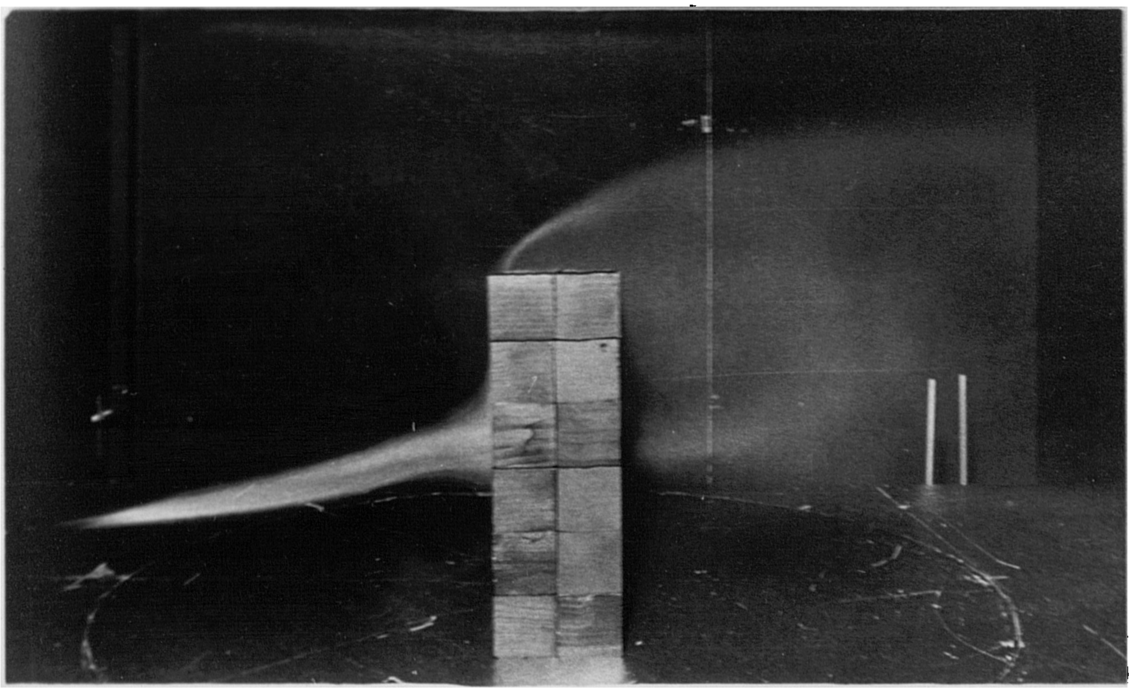
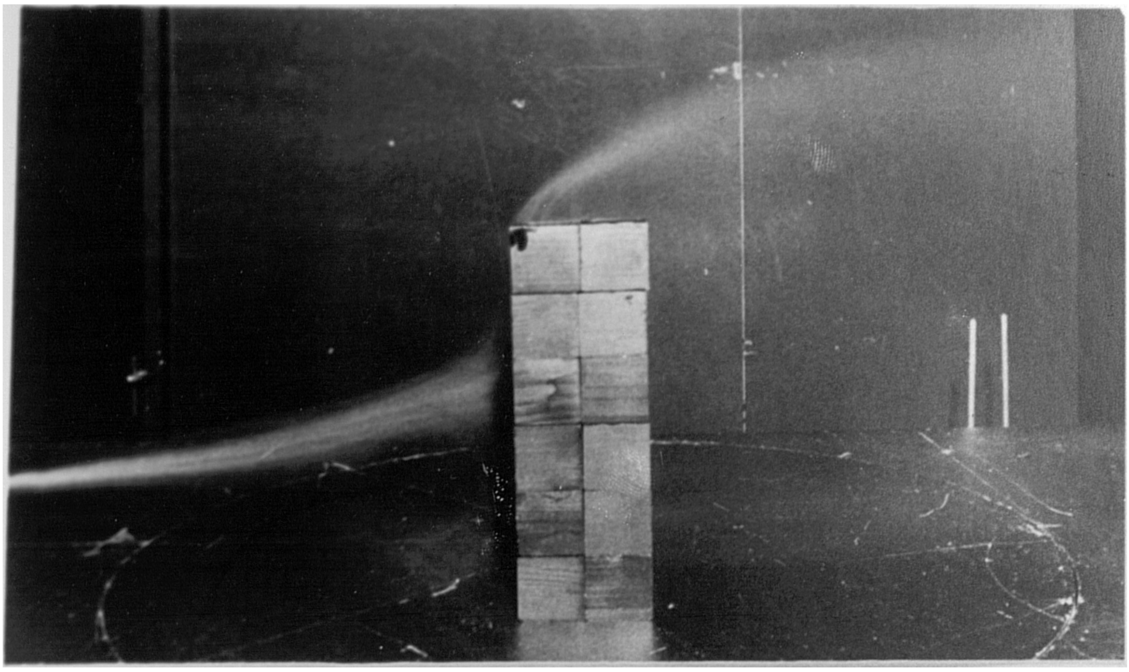
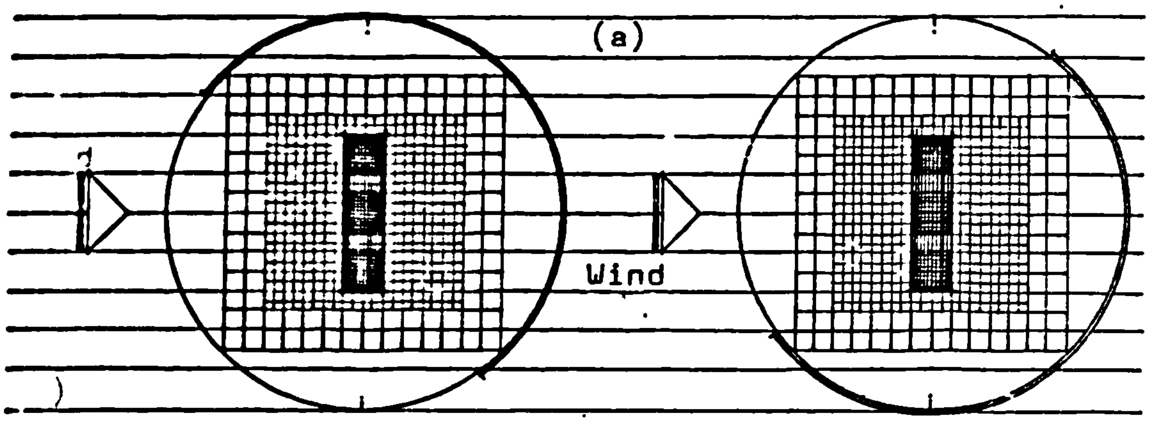
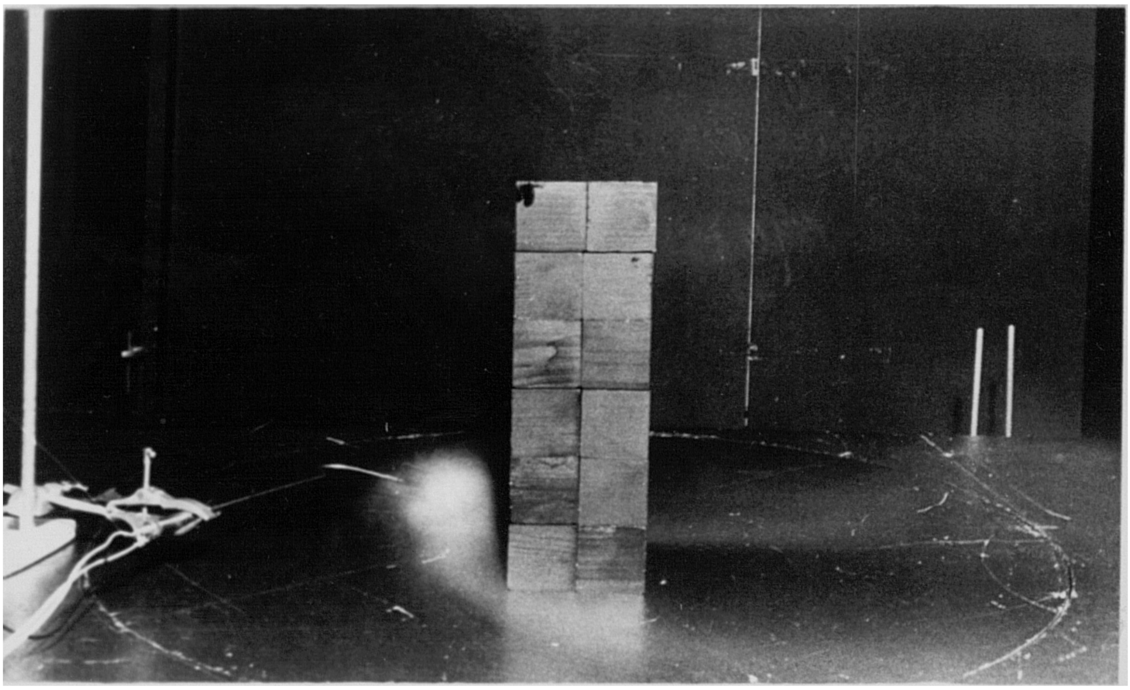
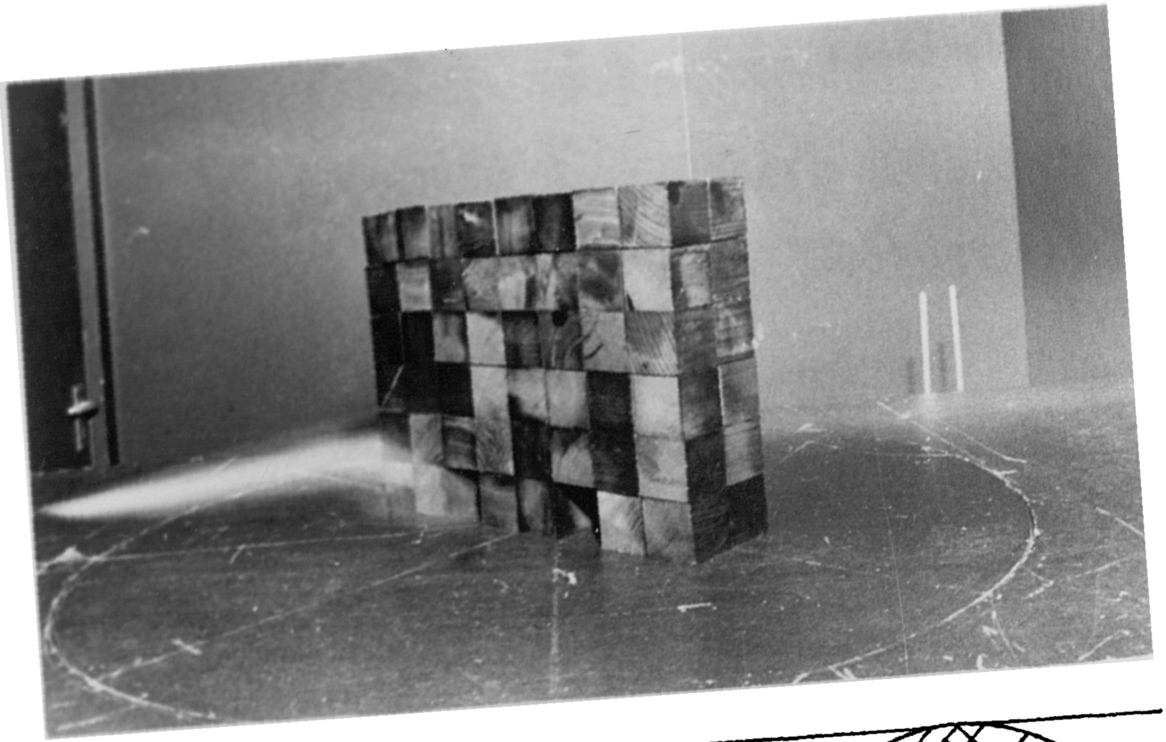
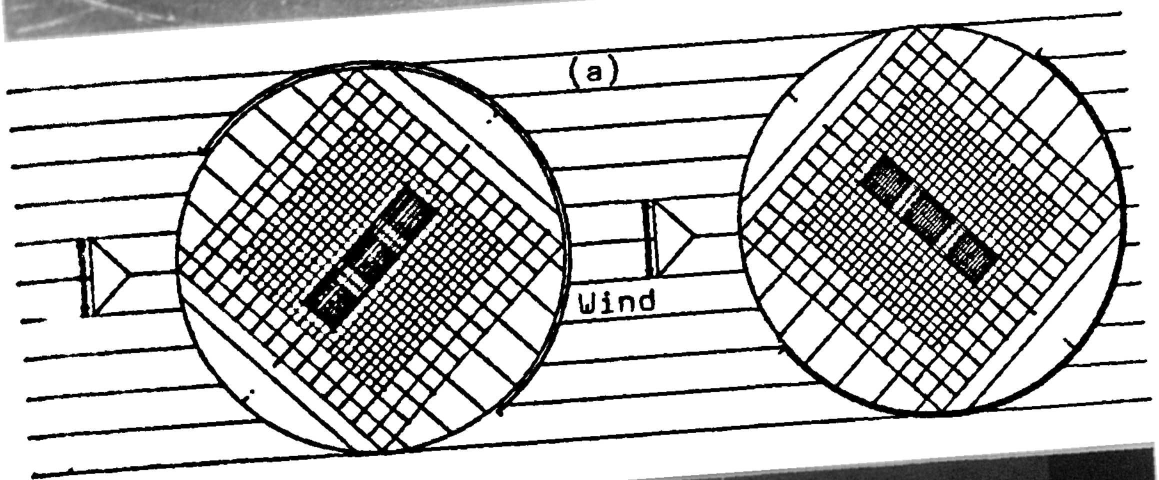


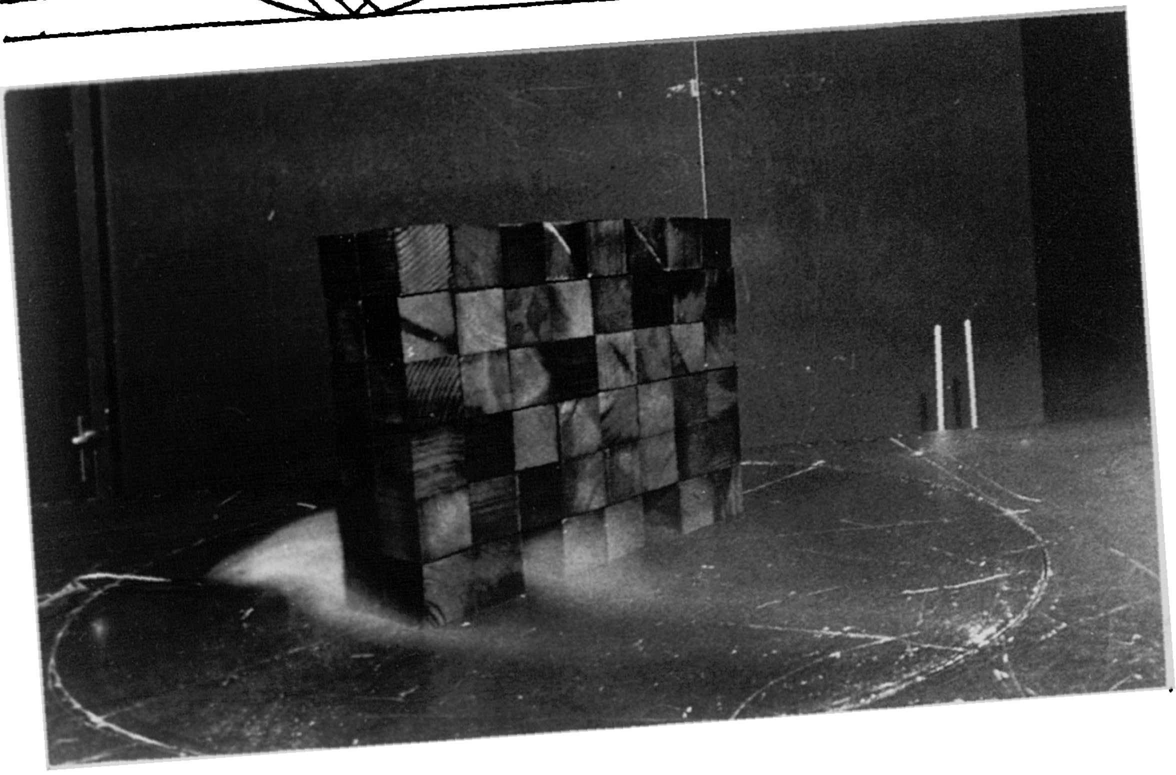



(a)
Wind






(a)
Wind



APPENDIX A6 : AIR FLOW SPEED, PRIMARY RESULTS

A6 Air Flow Speed, Primary Results

Air speed was recorded inside the 41 arrangements of the internal flow model. Records were made using the DISA 55M electronic anemometer but they had to be registered manually. The readings were taken at six points; in each case three sets[1] of measurements were made, each of which consisted of 15 records, amounting to a total of 45 records for each point.

The records were registered as volts per second (V/s), and had to be converted to metres per second (m/s) using the calibration charts. , Then the ventilation coefficient C_{vn} was calculated and is documented in Appendix A7. The free stream was monitored throughout the experiment using the DISA 55K anemometry system. Tables (A6.1 to A6.16) illustrate a sample of the results.

1 Originally the experiment had been repeated five times and 75 readings had been taken. Comparing the results of the five sets with those of the first three sets, there was found to be negligible difference. Hence, it was decided to conduct the ecperiments for three sets and only 45 records were registered.

Model A2   Experiment 1   (Started 16.40, Finished 16.50)

Angle of wind = 0°
Free stream mean speed = 1 m/s
Air temperature = 20°C

Probe	Set 1					Set 2					Set 3				
P_1	2·95	2·95	2·93	2·94	2·95	2·95	2·94	2·93	2·91	2·90	2·92	2·90	2·91	2·91	2·91
	2·95	2·94	2·94	2·93	2·92	2·90	2·91	2·92	2·93	2·94	2·92	2·93	2·93	2·93	2·94
	2·93	2·94	2·94	2·94	2·95	2·93	2·92	2·92	2·92	2·91	2·94	2·94	2·93	2·92	2·91
P_2	2·86	2·86	2·85	2·85	2·85	2·86	2·85	2·85	2·85	2·85	2·85	2·85	2·85	2·85	2·85
	2·85	2·85	2·85	2·85	2·85	2·85	2·85	2·85	2·85	2·86	2·84	2·85	2·86	2·86	2·86
	2·85	2·86	2·86	2·86	2·87	2·86	2·85	2·85	2·85	2·85	2·86	2·86	2·86	2·86	2·86
P_3	2·94	2·95	2·94	2·95	2·96	2·94	2·94	2·94	2·94	2·93	2·95	2·95	2·94	2·94	2·94
	2·95	2·95	2·94	2·94	2·94	2·93	2·94	2·94	2·94	2·94	2·94	2·94	2·93	2·94	2·94
	2·95	2·95	2·94	2·93	2·94	2·94	2·94	2·94	2·94	2·95	2·94	2·93	2·95	2·94	2·94
P_4	2·92	2·91	2·91	2·91	2·91	2·90	2·90	2·90	2·90	2·89	2·89	2·90	2·90	2·90	2·90
	2·91	2·91	2·90	2·91	2·91	2·91	2·91	2·91	2·91	2·91	2·90	2·90	2·91	2·90	2·91
	2·90	2·98	2·90	2·90	2·90	2·90	2·90	2·90	2·91	2·91	2·91	2·91	2·91	2·90	2·90
P_5	2·98	2·97	2·98	2·97	2·98	2·98	2·97	2·97	2·97	2·98	2·97	2·97	2·97	2·97	2·97
	2·98	2·98	2·98	2·97	2·97	2·97	2·97	2·97	2·97	2·97	2·97	2·97	2·98	2·98	2·97
	2·98	2·98	2·99	2·99	2·99	2·97	2·97	2·97	2·98	2·98	2·97	2·97	2·97	2·97	2·97
P_6	3·05	3·05	3·05	3·05	3·05	3·05	3·05	3·06	3·07	3·06	3·06	3·05	3·05	3·05	3·06
	3·06	3·06	3·07	3·06	3·06	3·06	3·06	3·06	3·06	3·06	3·05	3·05	3·05	3·05	3·05
	3·06	3·06	3·05	3·06	3·05	3·06	3·06	3·06	3·06	3·05	3·05	3·05	3·05	3·06	3·06

Model A2 Experiment 2 (Started 16.50, Finished 17.05)

Angle of wind = 45^o
Free stream mean speed = 1 m/s
Air temperature = 20^oC

Probe	Set 1					Set 2					Set 3				
P_1	2·82	2·82	2·81	2·81	2·82	2·82	2·82	2·82	2·83	2·82	2·82	2·83	2·83	2·83	2·83
	2·82	2·83	2·83	2·83	2·83	2·82	2·82	2·83	2·83	2·82	2·81	2·81	2·81	2·81	2·81
	2·83	2·83	2·82	2·83	2·83	2·83	2·82	2·82	2·81	2·81	2·82	2·83	2·83	2·83	2·82
P_2	2·77	2·77	2·77	2·77	2·77	2·77	2·78	2·78	2·76	2·77	2·77	2·77	2·77	2·78	2·79
	2·77	2·77	2·77	2·76	2·76	2·77	2·76	2·77	2·77	2·77	2·78	2·78	2·79	2·78	2·78
	2·76	2·75	2·76	2·77	2·77	2·77	2·77	2·76	2·76	2·78	2·78	2·78	2·78	2·78	2·78
P_3	2·84	2·83	2·84	2·84	2·84	2·83	2·83	2·84	2·83	2·84	2·84	2·84	2·84	2·84	2·84
	2·83	2·84	2·84	2·84	2·84	2·84	2·83	2·83	2·83	2·83	2·84	2·84	2·85	2·84	2·84
	2·84	2·84	2·84	2·84	2·84	2·83	2·83	2·83	2·84	2·84	2·83	2·83	2·83	2·83	2·84
P_4	2·86	2·85	2·86	2·86	2·87	2·86	2·86	2·85	2·85	2·85	2·86	2·86	2·85	2·85	2·86
	2·86	2·86	2·86	2·87	2·87	2·86	2·87	2·86	2·87	2·86	2·86	2·86	2·86	2·86	2·86
	2·86	2·86	2·87	2·87	2·86	2·87	2·87	2·87	2·87	2·86	2·86	2·86	2·87	2·86	2·87
P_5	2·89	2·90	2·90	2·90	2·90	2·89	2·89	2·89	2·89	2·89	2·89	2·69	2·89	2·89	2·90
	2·89	2·90	2·89	2·90	2·90	2·89	2·90	2·89	2·89	2·89	2·90	2·90	2·90	2·90	2·90
	2·90	2·90	2·90	2·90	2·89	2·89	2·89	2·90	2·90	2·90	2·90	2·90	2·89	2·89	2·90
P_6	2·96	2·97	2·96	2·97	2·98	2·97	2·97	2·97	2·97	2·96	2·97	2·97	2·97	2·97	2·97
	2·98	2·98	2·98	2·98	2·97	2·96	2·96	2·96	2·96	2·96	2·97	2·96	2·96	2·96	2·97
	2·97	2·97	2·97	2·97	2·97	2·96	2·96	2·96	2·96	2·96	2·96	2·96	2·96	2·96	2·96

Model A2 Experiment 3 (Started 17.05, Finished 17.15)

Angle of wind = 135°
Free stream mean speed = 1 m/s
Air temperature = 20°C

Probe	Set 1					Set 2					Set 3				
P_1	2·76	2·76	2·77	2·76	2·76	2·79	2·78	2·78	2·78	2·79	2·77	2·77	2·76	2·77	2·78
	2·77	2·78	2·79	2·78	2·78	2·78	2·77	2·77	2·77	2·77	2·79	2·77	2·76	2·77	2·75
	2·77	2·78	2·77	2·78	2·78	2·78	2·79	2·78	2·79	2·78	2·77	2·78	2·78	2·78	2·78
P_2	2·73	2·72	2·72	2·72	2·72	2·73	2·73	2·73	2·73	2·73	2·73	2·73	2·73	2·73	2·73
	2·72	2·72	2·72	2·72	2·73	2·73	2·73	2·73	2·73	2·74	2·73	2·73	2·73	2·73	2·73
	2·73	2·73	2·73	2·73	2·73	2·73	2·74	2·73	2·73	2·73	2·73	2·72	2·73	2·72	2·73
P_3	2·86	2·87	2·87	2·87	2·87	2·87	2·87	·288	2·88	2·87	2·87	2·87	2·88	2·88	2·88
	2·87	2·87	2·87	2·87	2·87	2·87	2·87	2·87	2·87	2·87	2·87	2·86	2·87	2·87	2·87
	2·88	2·88	2·87	2·87	2·87	2·87	2·87	2·87	2·87	2·87	2·87	2·87	2·88	2·88	2·88
P_4	2·79	2·79	2·79	2·79	2·79	2·79	2·79	2·79	2·79	2·79	2·79	2·79	2·78	2·79	2·78
	2·79	2·79	2·79	2·79	2·79	2·79	2·79	2·79	2·78	2·78	2·79	2·79	2·79	2·79	2·79
	2·79	2·80	2·79	2·79	2·79	2·78	2·78	2·79	2·79	2·79	2·79	2·79	2·79	2·79	2·79
P_5	2·91	2·90	2·90	2·90	2·91	2·90	2·90	2·90	2·90	2·90	2·89	2·90	2·89	2·90	2·90
	2·90	2·90	2·90	2·90	2·90	2·90	2·90	2·90	2·90	2·90	2·90	2·90	2·89	2·89	2·90
	2·90	2·90	2·90	2·90	2·90	2·90	2·90	2·90	2·90	2·90	2·90	2·90	2·90	2·90	2·91
P_6	3·00	2·99	2·99	2·99	2·99	2·99	2·99	2·99	2·99	2·99	2·99	2·99	3·00	3·00	3·00
	2·99	2·99	2·99	2·99	2·99	2·99	2·99	2·99	2·99	2·99	3·00	3·00	3·00	3·00	3·00
	2·99	2·99	2·99	2·99	2·99	3·00	2·99	2·99	2·99	2·99	2·99	2·99	2·99	2·99	2·99

Model A2 Experiment 4 (Started 17.15, Finished 17.25)

Angle of wind = 90°
Free stream mean speed = 1 m/s
Air temperature = 20°C

Probe	Set 1					Set 2					Set 3				
P_1	2•63	2•63	2•63	2•64	2•64	2•63	2•63	2•63	2•63	2•63	2•64	2•63	2•63	2•63	2•63
	2•63	2•64	2•64	2•64	2•63	2•63	2•63	2•63	2•63	2•63	2•63	2•63	2•63	2•63	2•63
	2•63	2•63	2•63	2•63	2•63	2•63	2•64	2•63	2•63	2•63	2•63	2•63	2•64	2•64	2•64
P_2	2•68	2•67	2•68	2•68	2•67	2•69	2•68	2•68	2•68	2•67	2•68	2•68	2•68	2•68	2•68
	2•68	2•67	2•68	2•68	2•68	2•67	2•67	2•68	2•68	2•68	2•68	2•68	2•68	2•68	2•68
	2•68	2•68	2•68	2•68	2•69	2•67	2•68	2•68	2•68	2•69	2•67	2•67	2•67	2•68	2•68
P_3	2•81	2•82	2•82	2•82	2•82	2•81	2•81	2•81	2•81	2•81	2•81	2•81	2•81	2•81	2•81
	2•81	2•81	2•81	2•81	2•81	2•81	2•81	2•81	2•81	2•81	2•81	2•81	2•81	2•81	2•81
	2•81	2•81	2•81	2•81	2•81	2•81	2•81	2•81	2•81	2•81	2•81	2•81	2•81	2•81	2•81
P_4	2•79	2•80	2•80	2•79	2•79	2•79	2•79	2•79	2•79	2•79	2•80	2•79	2•79	2•79	2•79
	2•79	2•79	2•79	2•79	2•79	2•79	2•79	2•79	2•79	2•79	2•79	2•79	2•79	2•79	2•79
	2•79	2•79	2•79	2•79	2•79	2•79	2•79	2•79	2•79	2•79	2•79	2•79	2•79	2•79	2•79
P_5	2•88	2•88	2•88	2•88	2•88	2•88	2•88	2•88	2•88	2•88	2•88	2•89	2•89	2•88	2•88
	2•88	2•88	2•88	2•88	2•88	2•88	2•88	2•88	2•88	2•88	2•88	2•88	2•89	2•89	2•89
	2•88	2•88	2•88	2•88	2•88	2•88	2•88	2•88	2•88	2•88	2•89	2•89	2•89	2•88	2•88
P_6	2•96	2•96	2•96	2•96	2•96	2•95	2•95	2•95	2•95	2•95	2•96	2•96	2•96	2•96	2•95
	2•96	2•96	2•97	2•96	2•96	2•95	2•95	2•96	2•95	2•95	2•95	2•95	2•95	2•95	2•95
	2•96	2•96	2•96	2•96	2•96	2•96	2•96	2•96	2•96	2•95	2•95	2•95	2•95	2•95	2•96

Model B2   Experiment 1 (Started 17.20, Finished 17.30)

Angle of wind = 0^o
Free stream mean speed = 1 m/s
Air temperature = 20^oC

Probe	Set 1	Set 2	Set 3
P_1	2•98 2•98 2•98 2•98 2•98	2•98 2•98 2•98 2•98 2•98	2•97 2•98 2•98 2•98 2•98
	2•98 2•98 2•98 2•98 2•98	2•98 2•97 2•97 2•98 2•98	2•98 2•98 2•99 2•96 2•98
	2•98 2•99 2•98 2•99 2•98	2•97 2•97 2•97 2•97 2•98	2•98 2•98 2•98 2•99 2•98
P_2	2•84 2•84 2•84 2•83 2•84	2•83 2•82 2•83 2•82 2•83	2•83 2•83 2•83 2•83 2•83
	2•85 2•85 2•85 2•85 2•85	2•83 2•84 2•84 2•83 2•84	2•83 2•84 2•83 2•84 2•84
	2•85 2•85 2•85 2•84 2•84	2•83 2•83 2•82 2•82 2•82	2•84 2•83 2•83 2•83 2•84
P_3	2•91 2•91 2•91 2•91 2•91	2•91 2•91 2•91 2•92 2•91	2•91 2•91 2•91 2•91 2•91
	2•90 2•91 2•91 2•91 2•91	2•92 2•91 2•91 2•91 2•91	2•91 2•91 2•91 2•91 2•90
	2•91 2•92 2•91 2•91 2•91	2•91 2•91 2•91 2•91 2•91	2•90 2•91 2•90 2•90 2•91
P_4	2•93 2•93 2•93 2•92 2•93	2•93 2•92 2•93 2•93 2•92	2•92 2•92 2•92 2•92 2•92
	2•94 2•93 2•94 2•93 2•93	2•92 2•92 2•92 2•92 2•92	2•92 2•92 2•91 2•91 2•92
	2•93 2•93 2•93 2•93 2•93	2•92 2•92 2•92 2•92 2•92	2•92 2•91 2•92 2•92 2•92
P_5	3•31 3•32 3•31 3•32 3•32	3•30 3•31 3•31 3•31 3•31	3•31 3•32 3•31 3•31 3•31
	3•31 3•31 3•30 3•31 3•31	3•31 3•31 3•31 3•31 3•31	3•31 3•31 3•31 3•31 3•31
	3•31 3•32 3•31 3•30 3•30	3•31 3•31 3•31 3•31 3•31	3•31 3•30 3•30 3•30 3•30
P_6	3•09 3•09 3•09 3•09 3•09	3•09 3•09 3•08 3•09 3•09	3•08 3•08 3•08 3•09 3•08
	3•09 3•09 3•08 3•09 3•09	3•08 3•08 3•08 3•08 3•08	3•08 3•08 3•08 3•08 3•08
	3•09 3•09 3•09 3•09 3•09	3•08 3•08 3•08 3•08 3•08	3•08 3•08 3•08 3•09 3•08

Model B2 Experiment 2 (Started 17.10, Finished 17.20)

Angle of wind = 45^o
Free stream mean speed = 1 m/s
Air temperature = 20^oC

Probe	Set 1					Set 2					Set 3				
P_1	2·71	2·71	2·71	2·71	2·71	2·71	2·71	2·71	2·70	2·70	2·70	2·69	2·69	2·70	2·70
	2·70	2·70	2·70	2·70	2·70	2·71	2·70	2·71	2·70	2·70	2·71	2·71	2·71	2·71	2·71
	2·71	2·71	2·71	2·71	2·71	2·72	2·72	2·72	2·72	2·72	2·72	2·71	2·71	2·72	2·71
P_2	2·82	2·82	2·81	2·81	2·81	2·82	2·81	2·81	2·81	2·81	2·82	2·81	2·81	2·81	2·81
	2·81	2·90	2·81	2·81	2·81	2·82	2·83	2·82	2·82	2·82	2·81	2·81	2·81	2·80	2·81
	2·80	2·81	2·82	2·81	2·81	2·82	2·82	2·82	2·82	2·82	2·81	2·82	2·82	2·82	2·82
P_3	3·88	3·87	3·87	3·86	2·86	2·87	2·86	2·86	2·86	2·86	2·86	2·86	2·85	2·86	2·86
	2·87	2·86	2·86	2·86	2·86	2·87	2·87	2·87	2·87	2·87	2·87	2·87	2·87	2·87	2·87
	2·87	2·87	2·86	2·86	2·87	2·88	2·88	2·88	2·88	2·88	2·88	2·87	2·87	2·87	2·87
P_4	2·87	2·87	2·87	2·87	2·88	2·86	2·86	2·86	2·88	2·87	2·88	2·87	2·87	2·87	2·87
	2·88	2·87	2·87	2·87	2·87	2·87	2·88	2·88	2·88	2·88	2·87	2·87	2·87	2·87	2·87
	2·87	2·87	2·86	2·86	2·87	2·88	2·88	2·88	2·88	2·88	2·88	2·87	2·87	2·87	2·87
P_5	3·34	3·35	3·33	3·33	3·33	3·32	3·32	3·32	3·32	3·32	3·33	3·34	3·33	3·33	3·33
	3·33	3·33	3·33	3·32	3·33	3·32	3·33	3·33	3·33	3·33	3·33	3·33	3·33	3·33	3·33
	3·33	3·32	3·33	3·33	3·32	3·33	3·34	3·34	3·34	3·34	3·34	3·33	3·33	3·33	3·32
P_6	3·08	3·08	3·08	3·08	3·08	3·07	3·08	3·07	3·08	3·08	3·07	3·08	3·08	3·08	3·08
	3·09	3·09	3·08	3·09	3·09	3·08	3·07	3·07	3·08	3·08	3·08	3·09	3·09	3·08	3·08
	3·09	3·09	3·08	3·08	3·08	3·07	3·08	3·07	3·08	3·08	3·09	3·08	3·07	3·07	3·07

Model B2   Experiment 3 (Started 17.30, Finished 17.40)

Angle of wind = 135°
Free stream mean speed = 1 m/s
Air temperature = 20°C

Probe	Set 1					Set 2					Set 3				
P_1	2·77	2·77	2·77	2·77	2·77	2·76	2·77	2·77	2·77	2·77	2·76	2·77	2·77	2·77	2·76
	2·76	2·77	2·77	2·77	2·76	2·76	2·76	2·77	2·77	2·77	2·76	2·76	2·76	2·76	2·76
	2·76	2·76	2·76	2·77	2·77	2·78	2·77	2·77	2·77	2·77	2·77	2·77	2·77	2·77	2·77
P_2	2·75	2·75	2·75	2·74	2·74	2·74	2·74	2·74	2·74	2·74	2·74	2·75	2·74	2·74	2·75
	2·75	2·75	2·74	2·74	2·74	2·74	2·74	2·74	2·74	2·74	2·75	2·75	2·75	2·74	2·74
	2·74	2·74	2·74	2·74	2·74	2·74	2·73	2·74	2·74	2·73	2·74	2·74	2·74	2·74	2·74
P_3	2·86	2·86	2·86	2·86	2·86	2·86	2·86	2·86	2·86	2·86	2·87	2·87	2·87	2·87	2·87
	2·86	2·86	2·86	2·87	2·87	2·87	2·87	2·87	2·87	2·86	2·86	2·86	2·86	2·87	2·86
	2·87	2·87	2·87	2·87	2·87	2·85	2·86	2·87	2·87	2·86	2·87	2·86	2·86	2·86	2·85
P_4	2·90	2·89	2·89	2·89	2·89	2·90	2·89	2·89	2·89	2·89	2·90	2·90	2·89	2·89	2·89
	2·90	2·89	2·89	2·89	2·90	1·89	1·89	1·89	1·89	1·90	1·90	1·89	1·90	1·90	1·90
	1·89	1·89	1·90	1·89	1·89	1·90	1·90	1·90	1·90	1·90	1·90	1·89	1·89	1·89	1·89
P_5	3·30	3·29	3·29	3·29	3·29	3·29	3·29	3·29	3·29	3·29	3·29	3·28	3·28	3·29	3·29
	3·29	3·28	3·28	3·28	3·28	3·29	3·29	3·30	3·29	3·29	3·29	3·29	3·29	3·29	3·29
	3·29	3·29	3·29	3·28	3·30	3·28	3·28	3·28	3·29	3·29	3·30	3·30	3·30	3·29	3·29
P_6	3·05	3·05	3·05	3·05	3·05	3·04	3·04	3·04	3·04	3·03	3·03	3·04	3·03	3·04	3·04
	3·05	3·05	3·04	3·04	3·04	3·03	3·03	3·04	3·03	3·04	3·03	3·06	3·05	3·06	3·05
	3·04	3·04	3·04	3·03	3·04	3·03	3·03	3·04	3·03	3·04	3·04	3·05	3·05	3·05	3·06

Model B2 Experiment 4 (Started 17.40, Finished 17.50)

Angle of wind = 90^o
Free stream mean speed = 1 m/s
Air temperature = 20^oC

Probe	Set 1	Set 2	Set 3
P_1	2·70 2·70 2·70 2·71 2·71	2·70 2·71 2·71 2·70 2·70	2·72 2·73 2·72 2·72 2·72
	2·71 2·71 2·71 2·71 2·70	2·71 2·72 2·72 2·72 2·72	2·72 2·72 2·71 2·71 2·72
	2·70 2·70 2·70 2·71 2·71	2·72 2·72 2·71 2·72 2·72	2·71 2·71 2·71 2·71 2·71
P_2	2·67 2·66 2·67 2·67 2·67	2·68 2·67 2·67 2·67 2·67	2·67 2·67 2·67 2·67 2·67
	2·67 2·67 2·67 2·67 2·67	2·68 2·68 2·68 2·68 2·68	2·67 2·67 2·67 2·67 2·67
	2·67 2·67 2·67 2·67 2·67	2·68 2·68 2·68 2·68 2·68	2·67 2·67 2·66 2·67 2·67
P_3	2·85 2·85 2·85 2·85 2·85	2·85 2·85 2·85 2·85 2·85	2·85 2·85 2·85 2·86 2·86
	2·85 2·85 2·85 2·85 2·85	2·85 2·86 2·85 2·85 2·85	2·86 2·85 2·86 2·85 2·86
	2·85 2·85 2·85 2·85 2·85	2·85 2·85 2·85 2·85 2·85	2·86 2·86 2·86 2·86 2·86
P_4	2·85 2·85 2·86 2·86 2·86	2·87 2·86 2·86 2·86 2·86	2·86 2·86 2·86 2·85 2·85
	2·86 2·86 2·86 2·86 2·86	2·87 2·87 2·87 2·87 2·87	2·86 2·86 2·87 2·86 2·86
	2·86 2·86 2·86 2·86 2·86	2·87 2·87 2·87 2·87 2·87	2·86 2·86 2·86 2·86 2·86
P_5	3·06 3·07 3·05 3·05 3·05	3·05 3·05 3·04 3·04 3·04	3·07 3·07 3·06 3·05 3·05
	3·04 3·04 3·04 3·05 3·05	3·04 3·05 3·04 3·05 3·05	3·05 3·05 3·06 3·05 3·05
	3·05 3·05 3·04 3·05 3·04	3·06 3·05 3·05 3·04 3·05	3·04 3·05 3·05 3·04 3·05
P_6	2·98 2·98 2·98 2·98 2·98	2·98 2·98 2·98 2·98 2·98	2·98 2·98 2·98 2·98 2·97
	2·98 2·98 2·97 2·98 2·98	2·98 2·98 2·98 2·98 2·97	2·98 2·97 2·98 2·97 2·97
	2·98 2·98 2·98 2·98 2·98	2·97 2·97 2·97 2·97 2·98	2·97 2·97 2·97 2·98 2·98

Model C2 Experiment 1 (Started 15.50, Finished 16.00)

Angle of wind = 0°
Free stream mean speed = 1 m/s
Air temperature = 20°C

Probe	Set 1	Set 2	Set 3
P_1	2·95 2·96 2·96 2·96 2·95	2·95 2·96 2·96 2·96 2·95	2·97 2·96 2·97 2·98 2·98
	2·95 2·96 2·96 2·95 2·96	2·95 2·95 2·96 2·95 2·95	2·97 2·97 2·96 2·96 2·97
	2·97 2·97 2·97 2·97 2·97	2·95 2·96 2·96 2·96 2·96	2·97 2·97 2·97 2·97 2·98
P_2	2·82 2·82 2·82 2·81 2·82	2·81 2·81 2·81 2·81 2·82	2·80 2·81 2·81 2·82 2·82
	2·81 2·81 2·81 2·80 2·81	2·81 2·81 2·81 2·81 2·81	2·82 2·81 2·81 2·81 2·81
	2·80 2·81 2·81 2·81 2·81	2·81 2·81 2·81 2·81 2·81	2·81 2·81 2·81 2·81 2·81
P_3	2·94 2·94 2·94 2·94 2·94	2·94 2·93 2·93 2·93 2·93	2·93 2·93 2·93 2·93 2·94
	2·94 2·94 2·94 2·94 2·94	2·93 2·93 2·93 2·93 2·93	2·93 2·94 2·94 2·94 2·93
	2·94 2·94 2·94 2·94 2·94	2·93 2·93 2·93 2·93 2·93	2·93 2·94 2·94 2·94 2·94
P_4	3·19 3·19 3·19 3·19 3·19	3·20 3·20 3·20 3·20 3·21	3·20 3·20 3·20 3·20 3·20
	3·19 3·19 3·19 3·19 3·19	3·21 3·21 3·21 3·20 3·21	3·20 3·20 3·20 3·20 3·21
	3·19 3·19 3·19 3·19 3·19	3·20 3·20 3·20 3·20 3·20	3·20 3·20 3·21 3·21 3·21
P_5	3·01 3·01 3·01 3·01 3·01	3·01 3·01 3·01 3·01 3·01	3·00 2·99 2·98 2·99 2·99
	3·00 2·99 3·00 3·00 3·00	3·00 2·99 3·00 2·99 3·00	2·99 2·98 2·99 2·98 2·99
	3·01 3·00 2·99 3·01 3·00	2·99 3·00 3·01 3·00 3·01	2·99 2·98 2·98 2·99 2·98
P_6	3·10 3·10 3·10 3·10 3·10	3·10 3·10 3·10 3·10 3·10	3·10 3·10 3·10 3·10 3·10
	3·10 3·10 3·10 3·10 3·10	3·10 3·10 3·10 3·10 3·10	3·10 3·10 3·10 3·10 3·10
	3·10 3·10 3·10 3·10 3·10	3·10 3·10 3·10 3·10 3·10	3·10 3·10 3·10 3·10 3·10

Model C2 Experiment 2 (Started 15.40, Finished 15.50)

Angle of wind = 45^{o}
Free stream mean speed = 1 m/s
Air temperature = $20^{o}C$

Probe	Set 1					Set 2					Set 3				
P_1	2·79	2·79	2·80	2·80	2·81	2·79	2·80	2·79	2·80	2·80	2·80	2·80	2·80	2·80	2·79
	2·80	2·81	2·82	2·82	2·82	2·79	2·80	2·79	2·78	2·79	2·80	2·78	2·79	2·78	2·79
	2·82	2·82	2·81	2·81	2·80	2·79	2·78	2·79	2·78	2·79	2·80	2·79	2·79	2·79	2·78
P_2	2·77	2·77	2·77	2·77	2·77	2·78	2·77	2·76	2·77	2·77	2·78	2·78	2·77	2·77	2·77
	2·76	2·76	2·76	2·76	2·76	2·76	2·76	2·76	2·76	2·76	2·77	2·77	2·77	2·77	2·77
	2·76	2·77	2·77	2·76	2·77	2·76	2·76	2·77	2·77	2·76	2·76	2·76	2·76	2·76	2·76
P_3	2·91	2·91	2·91	2·91	2·91	2·92	2·92	2·92	2·91	2·91	2·92	2·91	2·91	2·92	2·91
	2·91	2·91	2·91	2·91	2·91	2·91	2·91	2·91	2·91	2·91	2·91	2·91	2·91	2·91	2·91
	2·92	2·92	2·92	2·92	2·92	2·91	2·91	2·91	2·91	2·91	2·92	2·91	2·92	2·91	2·91
P_4	3·04	3·04	3·03	3·04	3·03	3·04	3·04	3·02	3·02	3·03	3·04	3·04	3·04	3·03	3·03
	3·04	3·04	3·04	3·04	3·03	3·03	3·03	3·03	3·02	3·03	3·03	3·04	3·04	3·03	3·03
	3·03	3·03	3·03	3·03	3·03	3·03	3·03	3·04	3·03	3·03	3·04	3·04	3·04	3·03	3·03
P_5	2·96	2·96	2·96	2·96	2·96	2·95	2·95	2·95	2·95	2·95	2·95	2·95	2·95	2·95	2·95
	2·96	2·96	2·96	2·96	2·96	2·96	2·95	2·95	2·95	2·95	2·95	2·95	2·95	2·96	2·95
	2·95	2·96	2·96	2·96	2·96	2·95	2·95	2·95	2·95	2·95	2·95	2·95	2·95	2·95	2·95
P_6	3·07	3·07	3·07	3·07	3·07	3·07	3·07	3·07	3·07	3·07	3·07	3·07	3·07	3·07	3·07
	3·07	3·07	3·07	3·07	3·07	3·08	3·08	3·08	3·08	3·07	3·07	3·07	3·08	3·08	3·07
	3·07	3·07	3·07	3·07	3·07	3·08	3·07	3·08	3·07	3·07	3·07	3·07	3·07	3·07	3·07

Model C2 Experiment 3 (Started 16.00, Finished 16.10)

Angle of wind = 135°
Free stream mean speed = 1 m/s
Air Temperature = 20°C

Probe	Set 1					Set 2					Set 3				
P_1	2·68	2·69	2·69	2·69	2·69	2·70	2·69	2·69	2·69	2·69	2·68	2·68	2·68	2·68	2·68
	2·69	2·69	2·69	2·69	2·69	2·69	2·69	2·69	2·69	2·69	2·68	2·68	2·68	2·68	2·68
	2·69	2·69	2·69	2·69	2·69	2·69	2·68	2·69	2·68	2·68	2·69	2·69	2·69	2·69	2·69
P_2	2·73	2·73	2·73	2·73	2·73	2·71	2·71	2·72	2·72	2·72	2·72	2·72	2·72	2·72	2·72
	2·73	2·73	2·72	2·73	2·73	2·72	2·72	2·71	2·72	2·72	2·72	2·72	2·72	2·72	2·71
	2·73	2·73	2·73	2·72	2·72	2·72	2·71	2·72	2·72	2·72	2·72	2·71	2·71	2·71	2·71
P_3	2·88	2·88	2·88	2·88	2·89	2·89	2·88	2·88	2·88	2·88	2·89	2·89	2·89	2·89	2·89
	2·89	2·88	2·88	2·89	2·88	2·89	2·89	2·89	2·89	2·89	2·88	2·88	2·88	2·88	2·89
	2·88	2·88	2·88	2·88	2·88	2·89	2·89	2·89	2·89	2·89	2·89	2·89	2·88	2·88	2·88
P_4	3·01	3·03	3·04	3·04	3·03	3·01	3·01	3·01	3·01	3·00	3·03	3·03	3·02	3·01	3·00
	3·02	3·02	3·01	3·01	3·01	3·01	3·02	3·01	3·02	3·03	3·00	3·01	3·02	3·03	3·03
	3·01	3·01	3·01	3·01	3·02	3·03	3·03	3·04	3·04	3·03	3·04	3·05	3·04	3·03	3·02
P_5	2·95	2·95	2·95	2·95	2·95	2·95	2·96	2·95	2·95	2·96	2·94	2·94	2·94	2·95	2·94
	2·95	2·95	2·95	2·94	2·94	2·95	2·95	2·95	2·95	2·95	2·94	2·94	2·95	2·94	2·94
	2·94	2·95	2·95	2·96	2·96	2·95	2·95	2·94	2·95	2·94	2·94	2·94	2·94	2·94	2·94
P_6	3·09	3·09	3·08	3·08	3·09	3·09	3·09	3·08	3·08	3·08	3·09	3·09	3·09	3·08	3·08
	3·08	3·08	3·08	3·08	3·08	3·09	3·09	3·08	3·08	3·09	3·08	3·08	3·08	3·08	·308
	3·09	3·09	3·09	3·09	3·09	3·08	3·09	3·09	3·09	3·09	3·08	3·09	3·09	3·09	3·09

Model C2   Experiment 4 (Started 16.10, Finished 16.20)

Angle of wind = 90^{o}
Free stream mean speed = 1 m/s
Air temperature = $20^{o}C$

Probe	Set 1	Set 2	Set 3
P_1	2·77 2·76 2·76 2·76 2·75	2·74 2·74 2·74 2·74 2·74	2·76 2·76 2·77 2·77 2·77
	2·74 2·75 2·75 2·76 2·75	2·74 2·75 2·75 2·75 2·75	2·77 2·77 2·77 2·77 2·77
	2·76 2·75 2·75 2·75 2·74	2·75 2·75 2·75 2·76 2·75	2·78 2·78 2·77 2·77 2·76
P_2	2·72 2·73 2·73 2·73 2·73	2·72 2·72 2·71 2·72 2·73	2·73 2·73 2·73 2·73 2·72
	2·74 2·74 2·74 2·73 2·73	2·74 2·74 2·74 2·74 2·74	2·72 2·72 2·72 2·72 2·72
	2·73 2·73 2·72 2·72 2·72	2·73 2·73 2·72 2·74 2·74	2·72 2·71 2·71 2·72 2·72
P_3	2·86 2·86 2·86 2·86 2·86	2·88 2·87 2·87 2·87 2·86	2·86 2·86 2·86 2·86 2·86
	2·86 2·86 2·87 2·86 2·87	2·86 2·86 2·86 2·86 2·86	2·86 2·86 2·86 2·86 2·86
	2·87 2·87 2·87 2·87 2·87	2·85 2·85 2·85 2·85 2·85	2·86 2·85 2·86 2·86 2·86
P_4	2·90 2·89 2·90 2·89 2·90	2·88 2·88 2·88 2·89 2·89	2·90 2·90 2·89 2·89 2·89
	2·90 2·89 2·89 2·90 2·90	2·89 2·89 2·90 2·89 2·89	2·89 2·89 2·89 2·88 2·89
	2·89 2·90 2·89 2·90 2·89	2·89 2·89 2·88 2·89 2·89	2·89 2·88 2·90 2·90 2·90
P_5	3·01 3·01 3·01 3·01 3·01	3·03 3·02 3·02 3·02 3·02	3·02 3·02 3·02 3·01 3·01
	3·00 3·01 3·01 3·01 3·01	3·02 3·01 3·01 3·01 3·01	3·02 3·02 3·02 3·02 3·02
	3·02 3·02 3·01 3·01 3·01	3·01 3·01 3·01 3·01 3·01	3·02 3·02 3·02 3·02 3·02
P_6	3·00 3·01 3·01 3·00 3·00	3·00 3·00 3·00 3·00 3·00	3·00 3·00 3·00 3·00 3·01
	2·99 2·99 2·99 3·00 3·00	3·01 3·02 3·01 3·01 3·01	3·01 3·01 3·01 3·01 3·00
	3·00 3·00 3·00 3·00 3·00	3·01 3·00 3·00 3·00 3·00	3·00 3·01 3·01 3·02 3·02

Model D2 Experiment 1 (Started 19.50, Finished 20.05)

Angle of wind = 0^{o}
Free stream mean speed = 1 m/s
Air temperature = $20^{o}C$

Probe	Set 1	Set 2	Set 3
P_1	2·94 2·95 2·95 2·95 2·96	2·94 2·95 2·94 2·95 2·95	2·95 2·95 2·95 2·94 2·94
	2·95 2·95 2·95 2·95 2·94	2·95 2·96 2·95 2·96 2·95	2·95 2·94 2·94 2·94 2·94
	2·95 2·94 2·95 2·94 2·95	2·96 2·95 2·94 2·95 2·94	2·94 2·94 2·94 2·94 2·94
P_2	2·80 2·79 2·78 2·80 2·79	2·81 2·81 2·80 2·81 2·83	2·80 2·81 2·80 2·79 2·80
	2·81 2·79 2·78 2·78 2·76	2·82 2·80 2·80 2·81 2·82	2·78 2·79 2·79 2·78 2·79
	2·81 2·80 2·79 2·79 2·80	2·81 2·80 2·80 2·81 2·81	2·79 2·80 2·81 2·81 2·81
P_3	3·02 3·02 3·03 3·03 3·03	3·03 3·03 3·03 3·03 3·04	3·03 3·03 3·04 3·04 3·03
	3·03 3·03 3·03 3·03 3·03	3·04 3·04 3·04 3·04 3·03	3·04 3·03 3·02 3·04 3·04
	3·03 3·03 3·03 3·03 3·04	3·03 3·03 3·03 3·03 3·03	3·04 3·04 3·03 3·03 3·03
P_4	3·05 3·05 3·06 3·05 3·05	3·03 3·04 3·05 3·05 3·05	3·05 3·06 3·05 3·03 3·04
	3·05 3·05 3·06 3·04 3·05	3·05 3·06 3·05 3·04 3·04	3·03 3·04 3·05 3·05 3·06
	3·05 3·06 3·05 3·06 3·04	3·05 3·04 3·05 3·05 3·06	3·06 3·05 3·06 3·05 3·04
P_5	3·04 3·03 3·02 3·02 3·03	3·05 3·06 3·02 3·04 3·03	3·03 3·02 3·01 3·01 3·02
	3·02 3·01 3·01 3·00 3·01	3·03 3·02 3·01 3·01 3·02	3·02 3·01 3·03 3·02 3·02
	3·00 3·01 3·02 3·03 3·02	3·02 3·02 3·03 3·08 3·07	3·02 3·03 3·02 3·01 3·01
P_6	3·04 3·05 3·04 3·04 3·04	3·04 3·04 3·03 3·04 3·04	3·03 3·02 3·03 3·02 3·03
	3·04 3·04 3·05 3·04 3·04	3·03 3·04 3·05 3·04 3·04	3·03 3·03 3·03 3·03 3·03
	3·04 3·04 3·04 3·04 3·04	3·04 3·04 3·04 3·04 3·04	3·04 3·03 3·03 3·03 3·03

Model D2 Experiment 2 (Started 19.05, Finished 19.20)

Angle of wind = 45^{o}
Free stream mean speed = 1 m/s
Air temperature = $20^{o}C$

Probe	Set 1	Set 2	Set 3
P_1	2.89 2.89 2.89 2·88 2·88	2·89 2·88 2·89 2·89 2·89	2·89 2·88 2·89 2·89 2·89
	2·89 2·89 2·88 2·88 2·88	2·89 2·89 2·89 2·89 2·88	2·88 2·88 2·89 2·88 2·88
	2·89 2·88 2·89 2·89 2·89	2·89 2·89 2·89 2·89 2·90	2·89 2·89 2·89 2·88 2·89
P_2	2·83 2·83 2·83 2·82 2·83	2·83 2·83 2·82 2·83 2·83	2·83 2·82 2·83 2·83 2·83
	2·83 2·84 2·83 2·83 2·83	2·84 2·83 2·84 2·83 2·82	2·84 2·84 2·84 2·84 2·83
	2·82 2·82 2·82 2·83 2·83	2·83 2·83 2·83 2·83 2·84	2·83 2·83 2·83 2·83 2·83
P_3	3·01 3·01 3·01 3·01 3·02	3·01 3·01 3·01 3·01 3·01	3·01 3·02 3·02 3·01 3·01
	3·01 3·01 3·01 3·01 3·01	3·01 3·01 3·01 3·01 3·01	3·02 3·01 3·01 3·01 3·01
	3·01 3·00 3·01 3·02 3·01	3·02 3·02 3·02 3·01 3·01	3·00 3·00 3·00 3·01 3·01
P_4	2·95 2·94 2·93 2·93 2·93	2·93 2·93 2·94 2·95 2·94	2·94 2·93 2·94 2·93 2·94
	2·93 2·94 2·94 2·94 2·93	2·93 2·93 2·93 2·92 2·92	2·93 2·93 2·93 2·93 2·93
	2·95 2·94 2·93 2·94 2·93	2·93 2·94 2·93 2·94 2·94	2·94 2·93 2·94 2·93 2·94
P_5	3·05 3·05 3·04 3·02 3·01	3·01 3·03 3·02 3·02 3·03	3·03 3·02 3·03 3·03 3·03
	3·02 3·03 3·02 3·03 3·03	3·03 3·02 3·01 3·01 3·01	3·02 3·02 3·02 3·03 3·03
	3·04 3·03 3·02 3·03 3·03	3·03 3·02 3·01 3·01 3·01	3·03 3·04 3·03 3·02 3·01
P_6	3·00 3·00 3·00 3·00 3·00	3·00 3·00 3·00 3·00 3·00	3·00 3·00 3·00 3·00 3·00
	3·00 3·00 3·00 3·00 3·00	3·00 3·00 3·00 3·00 3·00	3·00 3·00 3·00 3·00 3·00
	3·00 3·00 3·00 3·00 3·00	3·00 3·00 3·00 3·00 3·00	3·00 3·00 3·00 3·00 3·00

Model D2 Experiment 3 (Started 20.30, Finished 20.45)

Angle of wind = 135°
Free stream mean speed = 1 m/s
Air temperature = 20°C

Probe	Set 1	Set 2	Set 3
P_1	2·77 2·77 2·78 2·78 2·78	2·79 2·80 2·79 2·78 2·78	2·78 2·78 2·78 2·78 2·80
	2·78 2·78 2·78 2·77 2·78	2·78 2·79 2·79 2·79 2·78	2·78 2·78 2·78 2·78 2·78
	2·79 2·79 2·80 2·79 2·78	2·79 2·78 2·77 2·78 2·78	2·78 2·78 2·79 2·78 2·78
P_2	2·76 2·75 2·75 2·75 2·75	2·75 2·75 2·75 2·75 2·76	2·74 2·75 2·75 2·75 2·75
	2·75 2·75 2·75 2·75 2·75	2·75 2·75 2·75 2·75 2·74	2·75 2·75 2·76 2·75 2·75
	2·75 2·75 2·76 2·75 2·75	2·73 2·74 2·75 2·75 2·75	2·75 2·75 2·75 2·75 2·75
P_3	3·02 3·02 3·02 3·02 3·03	3·02 3·02 3·02 3·02 3·02	3·02 3·03 3·03 3·03 3·03
	3·03 3·03 3·03 3·03 3·03	3·02 3·02 3·02 3·02 3·02	3·02 3·03 3·02 3·02 3·02
	3·03 3·02 3·02 3·03 3·03	3·03 3·03 3·03 3·03 3·03	3·02 3·02 3·02 3·02 3·03
P_4	3·09 3·09 3·09 3·09 3·09	3·09 3·09 3·09 3·09 3·09	3·09 3·09 3·09 3·09 3·09
	3·09 3·09 3·09 3·09 3·09	3·09 3·09 3·09 3·09 3·09	3·09 3·09 3·09 3·09 3·09
	3·09 3·09 3·09 3·09 3·09	3·09 3·09 3·09 3·09 3·09	3·09 3·09 3·09 3·09 3·09
P_5	3·01 3·02 3·01 3·01 3·01	3·01 3·01 3·01 3·00 3·00	3·02 3·01 3·01 3·01 3·01
	3·00 3·00 3·01 3·00 3·01	3·00 3·00 3·01 3·00 3·00	3·01 3·01 3·00 3·01 3·02
	3·01 3·00 3·01 3·00 3·00	3·01 3·01 3·00 3·00 3·00	3·01 3·01 3·00 3·01 3·01
P_6	3·03 3·03 3·03 3·02 3·03	3·03 3·03 3·03 3·03 3·03	3·02 3·02 3·02 3·02 3·03
	3·03 3·02 3·03 3·02 3·02	3·03 3·02 3·02 3·02 3·02	3·03 3·02 3·02 3·03 3·02
	3·02 3·02 3·02 3·02 3·02	3·01 3·02 3·02 3·02 3·02	3·02 3·01 3·02 3·02 3·02

Model D2 Experiment 4 (Started 21.05, Finished 21.20)

Angle of wind = 90°
Free stream mean speed = 1 m/s
Air temperature = 20°C

Probe	Set 1	Set 2	Set 3
P_1	2·79 2·78 2·78 2·77 2·78	2·79 2·79 2·79 2·79 2·78	2·79 2·79 2·79 2·80 2·79
	2·79 2·79 2·78 2·79 2·80	2·78 2·79 2·79 2·78 2·78	2·79 2·79 2·80 2·79 2·80
	2·79 2·78 2·78 2·78 2·79	2·78 2·79 2·78 2·79 2·80	2·79 2·79 2·80 2·80 2·79
P_2	2·66 2·67 2·67 2·67 2·67	2·68 2·68 2·68 2·68 2·68	2·68 2·68 2·68 2·68 2·67
	2·68 2·68 2·67 2·68 2·67	2·67 2·67 2·67 2·67 2·67	2·66 2·67 2·67 2·68 2·67
	2·67 2·67 2·67 2·67 2·67	2·67 2·67 2·68 2·68 2·68	2·68 2·68 2·67 2·67 2·67
P_3	2·94 2·95 2·94 2·95 2·94	2·93 2·93 2·94 2·95 2·95	2·92 2·93 2·93 2·92 2·93
	2·95 2·94 2·94 2·95 2·94	2·95 2·95 2·95 2·95 2·94	2·94 2·95 2·96 2·95 2·95
	2·94 2·94 2·94 2·94 2·95	2·94 2·94 2·93 2·94 2·95	2·94 2·95 2·94 2·93 2·93
P_4	2·91 2·90 2·90 2·91 2·90	2·89 2·90 2·90 2·90 2·90	2·90 2·91 2·92 2·92 2·93
	2·91 2·91 2·90 2·91 2·91	2·90 2·90 2·91 2·90 2·91	2·91 2·92 2·93 2·91 2·92
	2·92 2·92 2·92 2·91 2·90	2·89 2·90 2·90 2·89 2·90	2·91 2·93 2·92 2·91 2·90
P_5	2·99 2·99 2·99 2·98 2·97	2·96 2·98 2·97 2·96 2·98	2·99 3·00 2·98 2·97 2·99
	2·97 2·97 2·99 2·98 2·98	2·98 2·97 2·99 2·97 2·97	2·99 2·98 2·99 2·99 2·98
	2·97 2·99 3·00 2·99 2·98	2·96 2·96 2·97 2·96 2·97	2·99 2·98 2·99 3·00 2·99
P_6	3·01 3·00 3·00 3·01 3·01	3·01 3·01 3·01 3·01 3·01	3·01 3·01 3·01 3·01 3·01
	3·01 3·01 3·01 3·01 3·01	3·01 3·01 3·01 3·01 3·01	3·01 3·01 3·01 3·01 3·01
	3·01 3·01 3·01 3·01 3·01	3·01 3·01 3·01 3·01 3·01	3·01 3·01 3·01 3·01 3·01

APPENDIX A7 : AIR FLOW SPEEDS AND THE VELOCITY COEFFICIENT

A7 Air Flow Speeds and the Velocity Coefficient C_{vn}

The results illustrated in this appendix are the final results of the internal flow model experiments. That model consisted of 41 models grouped in four main categories A, B, C and D. Group A was the model of a single cell which in most cases included a partition. Group B is a multi-cell consisting of two cells adjacent to each other and connected by means of a door, fully opened. Groups C and D consisted of more than two cells, with the air flowing through two or three consecutive cells.

The models are illustrated in two series of plans, the first of which gives the key for the probes in each model. These are followed by the tabulated results. The second kind of chart gives the velocity coefficient, C_{vn}, values for each model arrangement. The results of the 41 model arrangements have been recorded in three sets for each probe. A set consisted of 15 readings giving a total of 45 for the three sets. The arithmetic mean for each set and their averages are illustrated in Tables (A7.1 to 16). The velocity coefficient C_{vn}, the air speed at the probe expressed as a percentage of the free stream speed, follows in the same table.

The flow measurements were taken for angle of incidence θ ranging between $-45^{o} < \theta < 90^{o}$.

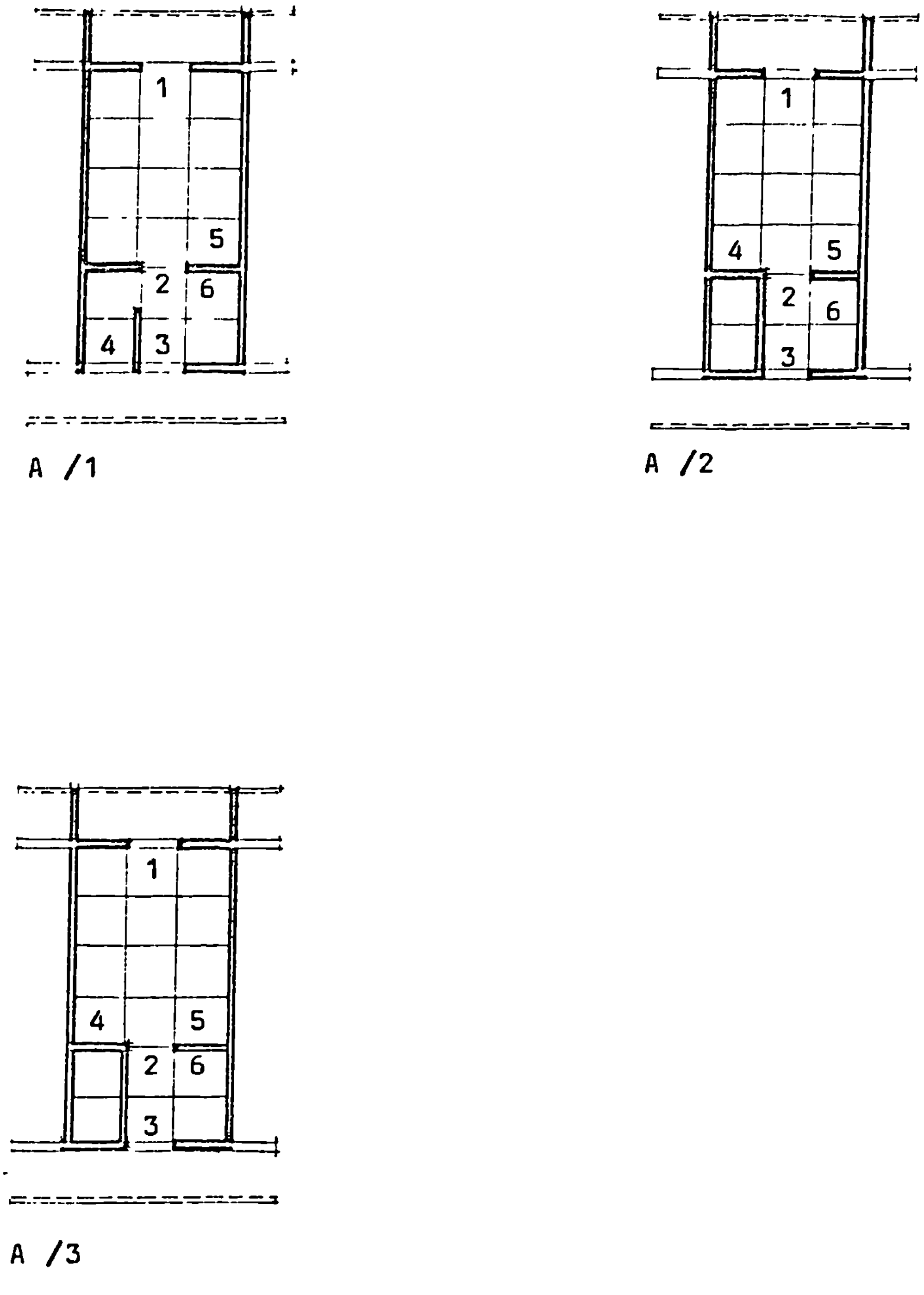
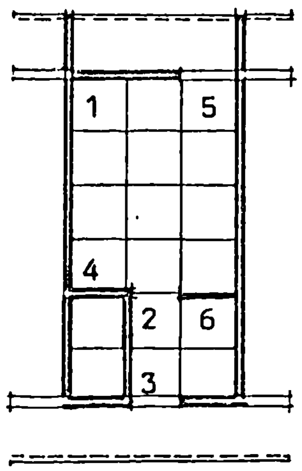
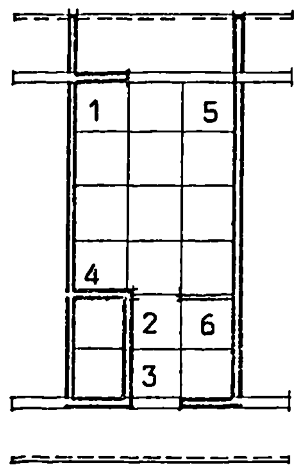


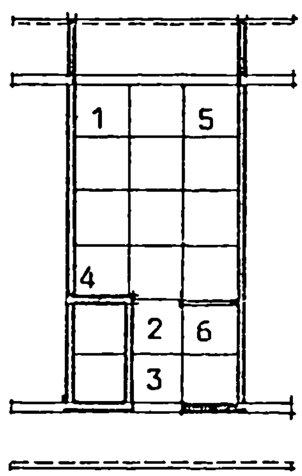
Figure (A7.1) Probe guide for model A.



A /4

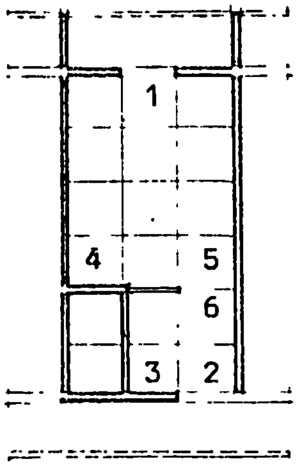


A /5

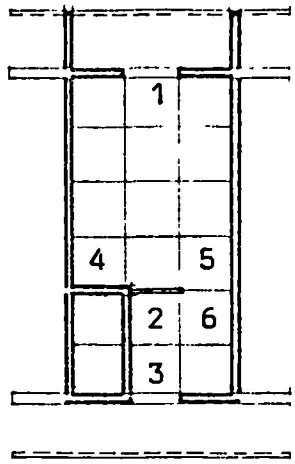


A /6

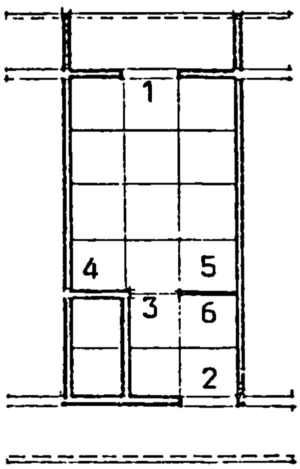
Figure (A7.1) continued.



A /7



A /8



A /9

Figure (A7.1) continued.

Table (A7.1) Results of model category A1

Angle of wind = 0°
Free stream mean speed = 1 m/s
Air temperature = 21°C

Model	Set	P1	P2	P3	P4	P5	P6	P7
A1/1	1	3•045	2•903	3•025	3•085	3•046	3•098	
	2	3•042	2•906	3•021	3•076	3•053	3•092	
	3	3•041	2•901	3•028	3•083	3•039	3•101	
	av.	3•043	2•903	3•024	3•082	3•046	3•094	
	C_{vn}	0•88	0•49	0•41	0•54	0•30	0•25	
A1/2	1	2•939	2•855	2•945	2•906	2•979	3•056	
	2	2•922	2•853	2•939	2•904	2•973	3•059	
	3	2•933	2•853	2•941	2•902	2•971	3•053	
	av.	2•928	2•854	2•942	2•904	2•974	3•056	
	C_{vn}	0•60	0•40	0•27	0•17	0•17	0•18	
A1/3	1	2•949	2•808	2•935	2•892	2•978	3•004	
	2	2•947	2•806	2•931	2•885	2•979	3•012	
	3	2•945	2•806	2•935	2•891	2•979	3•012	
	av.	2•947	2•807	2•934	2•890	2•979	3•009	
	C_{vn}	0•63	0•31	0•25	0•15	0•18	0•10	
A1/4	1	2•655	2•768	2•957	2•891	3•217	3•116	
	2	2•654	2•767	2•960	2•894	3•221	3•116	
	3	2•648	2•766	2•962	2•894	3•219	3•123	
	av.	2•652	2•767	2•960	2•894	3•219	3•121	
	C_{vn}	0•02	0•24	0•30	0•15	0•66	0•30	
A1/5	1	2•646	2•806	2•995	2•871	3•075	3•036	
	2	2•651	2•802	2•993	2•876	3•067	3•033	
	3	2•652	2•804	2•999	2•875	3•077	3•031	
	av.	2•650	2•804	2•996	2•874	3•073	3•034	
	C_{vn}	0•01	0•31	0•36	0•12	0•35	0•14	
A1/6	1	2•786	2•823	2•970	2•860	3•006	3•011	
	2	2•780	2•821	2•969	2•859	3•000	3•009	
	3	2•795	2•819	2•962	2•863	2•001	2•008	
	av.	2•787	2•821	2•967	2•861	3•002	3•010	
	C_{vn}	0•28	0•34	0•31	0•09	0•22	0•10	

Table (A7.1) continued

Model	Set	P1	P2	P3	P4	P5	P6	P7
A1/7	1	3•045	2•736	2•868	2•923	2•959	3•053	
	2	3•055	2•736	2•855	2•919	2•965	3•060	
	3	3•049	2•731	2•869	2•924	2•979	3•060	
	av.	3•050	2•734	2•864	2•922	2•968	3•058	
	C_{vn}	0•90	0•19	0•13	0•20	0•16	0•18	
A1/8	1	3•044	2•823	2•925	2•889	2•963	3•054	
	2	3•046	2•835	2•917	2•893	2•967	3•047	
	3	3•040	2•838	2•912	2•893	2•961	3•053	
	av.	3•043	2•832	2•918	2•892	2•964	3•051	
	C_{vn}	0•88	0•37	0•22	0•15	0•16	0•17	
A1/9	1	3•035	2•761	2•946	2•903	2•959	3•021	
	2	3•035	2•757	2•946	2•897	2•961	3•029	
	3	3•041	2•759	2•942	2•900	2•965	3•029	
	av.	3•037	2•759	2•945	2•900	2•962	3•026	
	C_{vn}	0•86	0•23	0•27	0•16	0•15	0•26	

Table (A7.2) Results of model category A2

Angle of wind = -45°
Free stream mean speed = 1 m/s
Air temperature = 21°C

Model	Set	P1	P2	P3	P4	P5	P6	P7
A2/1	1	2·880	2·811	2·840	2·920	2·895	2·974	
	2	2·880	2·810	2·840	2·931	2·900	2·966	
	3	2·890	2·810	2·840	2·930	2·898	2·971	
	av.	2·880	2·810	2·840	2·930	2·897	2·970	
	C_{vn}	0·48	0·32	0·08	0·21	0·04	0·04	
A2/2	1	2·824	2·766	2·839	2·863	2·897	2·972	
	2	2·821	2·769	2·833	2·862	2·893	2·963	
	3	2·821	2·779	2·838	2·860	2·896	2·965	
	av.	2·822	2·761	2·837	2·862	2·895	2·967	
	C_{vn}	0·37	0·23	0·08	0·10	0·04	0·03	
A2/3	1	2·761	2·680	2·829	2·817	2·959	2·993	
	2	2·749	2·689	2·819	2·819	2·951	2·986	
	3	2·750	2·685	2·816	2·816	2·958	2·989	
	av.	2·753	2·685	2·821	2·817	2·956	2·989	
	C_{vn}	0·20	0·10	0·05	0·04	0·14	0·07	
A2/4	1	2·660	2·780	2·984	2·903	3·126	3·109	
	2	2·655	2·785	2·990	2·904	3·127	3·100	
	3	2·655	2·777	2·983	2·901	3·123	3·106	
	av.	2·657	2·780	2·986	2·903	3·125	3·105	
	C_{vn}	0·01	0·27	0·34	0·16	0·45	0·27	
A2/5	1	2·662	2·772	2·980	2·890	3·115	3·093	
	2	2·670	2·772	2·969	2·890	3·124	3·090	
	3	2·666	2·769	2·982	2·890	3·117	3·089	
	av.	2·666	2·771	2·977	2·890	3·119	3·091	
	C_{vn}	0·04	0·25	0·32	0·15	0·44	0·24	
A2/6	1	2·830	2·773	2·933	2·899	3·097	3·087	
	2	2·681	2·774	2·933	2·899	3·104	3·078	
	3	2·692	2·777	2·936	2·899	3·101	3·083	
	av.	2·686	2·775	2·934	2·899	3·101	3·083	
	C_{vn}	0·06	0·26	0·24	0·16	0·40	0·23	

Table (A7.2) continued

Model	Set	P1	P2	P3	P4	P5	P6	P7
A2/7	1	2•830	2•685	2•815	2•839	2•907	3•000	
	2	2•827	2•687	2•817	2•844	2•908	3•004	
	3	2•836	2•685	2•819	2•848	2•904	3•007	
	av.	2•831	2•686	2•817	2•844	2•907	3•004	
	C_{vn}	0•39	0•10	0•05	0•07	0•06	0•09	
A2/8	1	2•871	2•697	2•862	2•851	2•909	3•002	
	2	2•856	2•685	2•849	2•852	2•906	3•005	
	3	2•865	2•690	2•849	2•848	2•906	3•011	
	av.	2•864	2•691	2•850	2•850	2•908	3•006	
	C_{vn}	0•46	0•11	0•10	0•08	0•06	0•09	
A2/9	1	2•835	2•675	2•815	2•839	2•893	2•971	
	2	2•838	2•673	2•814	2•839	2•890	2•971	
	3	2•837	2•675	2•814	2•839	2•891	2•972	
	av.	2•837	2•674	2•814	2•839	2•891	2•971	
	C_{vn}	0•38	0•08	0•04	0•07	0•04	0•08	

Table (A7.3) Results of model category A3

Angle of Wind = 45^{o}
Free Stream Mean Speed = 1m/s
Air Temperature = $21^{o}C$

Model	Set	P1	P2	P3	P4	P5	P6	P7
A3/1	1	2•790	2•734	2•893	2•877	2•965	2•989	
	2	2•795	2•738	2•885	2•871	2•965	2•978	
	3	2•804	2•736	2•890	2•875	2•965	2•990	
	av.	2•796	2•736	2•889	2•874	2•964	2•989	
	C_{vn}	0•30	0•19	0•17	0•12	0•16	0•07	
A3/2	1	2•773	2•727	2•871	2•791	2•901	2•991	
	2	2•779	2•731	2•871	2•787	2•900	2•991	
	3	2•772	2•729	2•873	2•789	2•898	2•995	
	av.	2•775	2•729	2•872	2•789	2•900	2•992	
	C_{vn}	0•25	0•18	0•14	0•01	0•05	0•07	
A3/3	1	2•827	2•681	2•857	2•858	2•890	2•990	
	2	2•831	2•684	2•855	2•860	2•891	2•983	
	3	2•836	2•679	2•853	2•860	2•890	2•993	
	av.	2•831	2•681	2•855	2•859	2•890	2•989	
	C_{vn}	0•37	0•09	0•11	0•10	0•03	0•08	
A3/4	1	2•620	2•651	2•817	2•801	3•097	3•008	
	2	2•620	2•649	2•815	2•799	3•099	3•003	
	3	2•620	2•648	2•825	2•795	3•094	3•015	
	av.	2•620	2•649	2•819	2•798	3•097	3•009	
	C_{vn}	0•01	0•04	0•05	0•02	0•40	0•10	
A3/5	1	2•628	2•651	2•820	2•801	3•071	3•013	
	2	2•625	2•657	2•827	2•803	3•071	3•011	
	3	2•623	2•659	2•830	2•800	3•073	3•012	
	av.	2•625	2•656	2•826	2•801	3•073	3•012	
	C_{vn}	0•01	0•05	0•06	0•02	0•34	0•10	
A3/6	1	3•005	2•677	2•843	2•950	2•924	3•041	
	2	3•011	2•673	2•843	2•951	2•925	3•046	
	3	3•009	2•670	2•839	2•951	2•924	3•047	
	av.	3•008	2•673	2•842	2•951	2•924	3•045	
	C_{vn}	0•78	0•08	0•09	0•25	0•09	0•16	

Table (A7.3) continued

Model	Set	P1	P2	P3	P4	P5	P6	P7
A3/7	1	2·830	2·678	2·803	2·795	2·999	3·003	
	2	2·828	2·679	2·810	2·798	2·999	3·006	
	3	2·831	2·675	2·810	2·799	3·001	3·003	
	av.	2·830	2·677	2·808	2·797	3·000	3·004	
	C_{vn}	0·37	0·08	0·04	0·02	0·22	0·09	
A3/8	1	2·857	2·653	2·828	2·801	3·004	3·011	
	2	2·860	2·645	2·833	2·799	3·010	3·011	
	3	2·858	2·658	2·829	2·799	3·007	3·013	
	av.	2·858	2·652	2·830	2·800	3·007	3·012	
	C_{vn}	0·42	0·04	0·07	0·02	0·22	0·10	
A3/9	1	2·828	2·861	2·804	2·800	2·977	3·051	
	2	2·822	2·677	2·800	2·800	2·977	3·047	
	3	2·827	2·675	2·807	2·801	2·979	3·049	
	av.	2·826	2·678	2·804	2·800	2·978	3·049	
	C_{vn}	0·36	0·08	0·04	0·02	0·17	0·17	

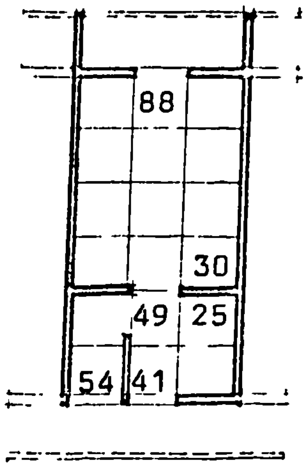
Table (A7,4) Results of model category A4

Angle of Wind = 90^o
Free Stream Mean Speed = 1m/s
Air Temperature = 21^oC

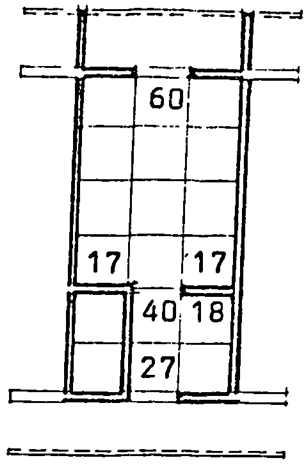
Model	Set	P1	P2	P3	P4	P5	P6	P7
A4/1	1	2•647	2•716	2•811	2•878	2•896	2•958	
	2	2•651	2•725	2•811	2•887	2•897	2•958	
	3	2•652	2•725	2•813	2•883	2•897	2•957	
	av.	2•650	2•722	2•812	2•883	2•898	2•958	
	C_{vn}	0•02	0•16	0•04	0•14	0•04	0•02	
A4/2	1	2•633	2•697	2•813	2•791	2•880	2•961	
	2	2•631	2•679	2•810	2•790	2•880	2•954	
	3	2•633	2•678	2•810	2•791	2•885	2•953	
	av.	2•632	2•679	2•811	2•791	2•882	2•956	
	C_{vn}	0•01	0•09	0•04	0•02	0•02	0•01	
A4/3	1	2•761	2•680	2•828	2•817	2•959	2•993	
	2	2•749	2•689	2•829	2•819	2•950	2•986	
	3	2•750	2•685	2•831	2•817	2•958	2•989	
	av.	2•753	2•685	2•829	2•818	2•956	2•989	
	C_{vn}	0•21	0•10	0•06	0•04	0•14	0•07	
A4/4	1	2•630	2•719	2•818	2•790	2•937	2•960	
	2	2•630	2•721	2•812	2•790	2•946	2•963	
	3	2•630	2•718	2•813	2•790	2•935	2•961	
	av.	2•630	2•719	2•814	2•790	2•939	2•961	
	C_{vn}	0•01	0•16	0•04	0•02	0•10	0•02	
A4/5	1	2•622	2•697	2•810	2•790	2•942	2•960	
	2	2•626	2•691	2•807	2•790	2•937	2•960	
	3	2•623	2•698	2•809	2•790	2•940	2•960	
	av.	2•624	2•695	2•809	2•790	2•940	2•960	
	C_{vn}	0•01	0•11	0•04	0•02	0•10	0•02	
A4/6	1	2•729	2•693	2•804	2•799	2•937	2•960	
	2	2•751	2•693	2•807	2•800	2•938	2•959	
	3	2•717	2•694	2•809	2•800	2•932	2•951	
	av.	2•732	2•693	2•807	2•800	2•936	2•957	
	C_{vn}	0•16	0•11	0•04	0•03	0•09	0•02	

Table (A7.4) continued

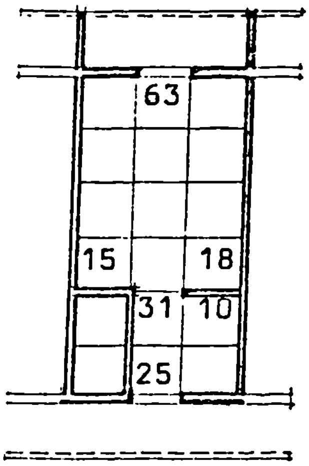
Model	Set	P1	P2	P3	P4	P5	P6	P7
A4/7	1	2•637	2•640	2•792	2•795	2•889	2•970	
	2	2•647	2•640	2•790	2•796	2•890	2•970	
	3	2•643	2•640	2•792	2•795	2•890	2•970	
	av.	2•642	2•640	2•791	2•795	2•890	2•970	
	C_{vn}	0•02	0•03	0•02	0•02	0•03	0•04	
A4/8	1	2•631	2•695	2•800	2•791	2•899	2•960	
	2	2•627	2•695	2•800	2•790	2•900	2•960	
	3	2•633	2•692	2•800	2•790	2•900	2•960	
	av.	2•630	2•694	2•800	2•790	2•900	2•960	
	C_{vn}	0•01	0•11	0•03	0•02	0•03	0•02	
A4/9	1	2•639	2•651	2•805	2•790	2•897	2•959	
	2	2•642	2•651	2•810	2•790	2•900	2•960	
	3	2•639	2•650	2•803	2•790	2•900	2•960	
	av.	2•640	2•651	2•806	2•790	2•899	2•960	
	C_{vn}	0•02	0•04	0•03	0•02	0•03	0•02	



A1/1



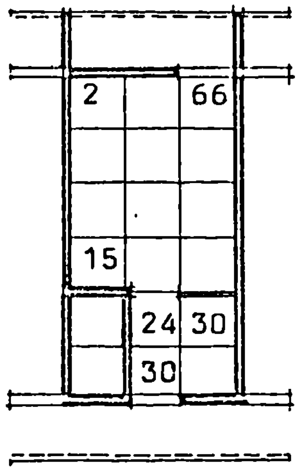
A1/2



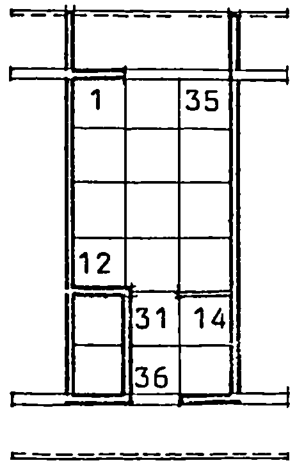
A1/3

Figure (A7.2) C_{vn} values for Model A1

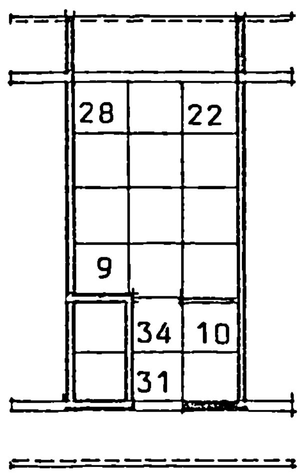
Angle of wind	=	0^{0}
Free stream mean speed	=	1 m/s
Air temperature	=	$21^{0}C$



A1/4



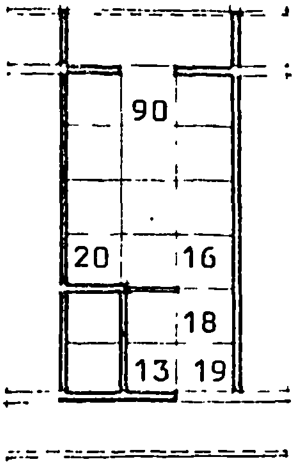
A1/5



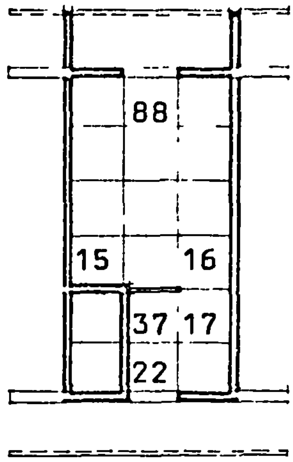
A1/6

Figure (A7.2) continued.

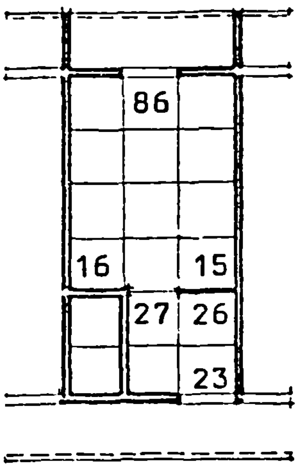
Angle of wind	=	0^o
Free stream mean speed	=	1 m/s
Air temperature	=	21^oC



A1/7



A1/8



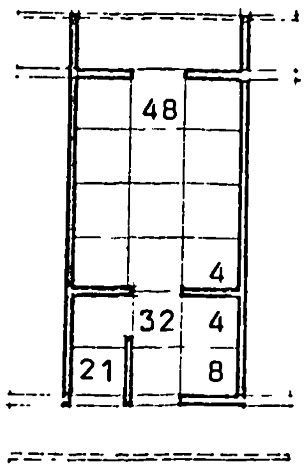
A1/9

Figure (A7.2) continued.

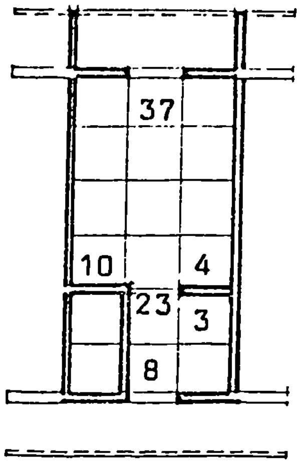
Angle of wind = 0^o

Free stream mean speed = 1 m/s

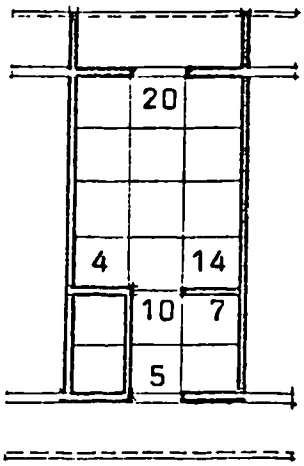
Air temperature = 21^oC



A2/1



A2/2



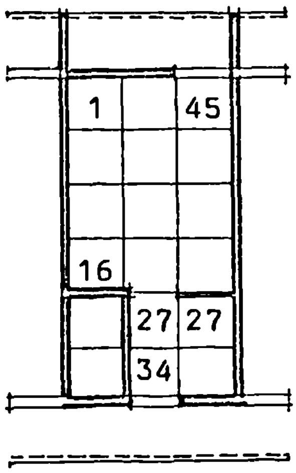
A2/3

Figure (A7.3) C_{vn} values for Model A2

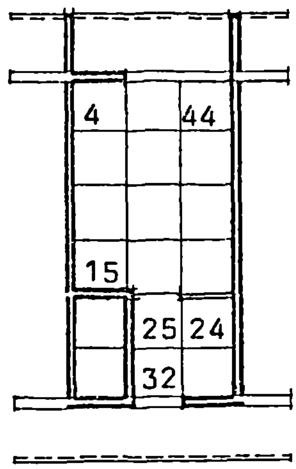
Angle of wind = -45^{o}

Free stream mean speed = 1 m/s

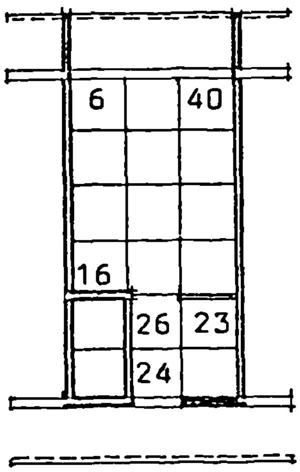
Air temperature = $21^{o}C$



A2/4



A2/5



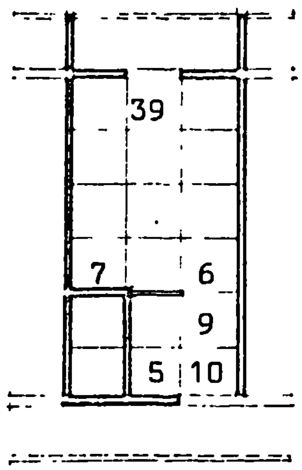
A2/6

Figure (A7.3) continued.

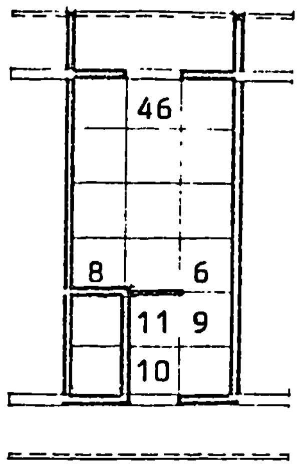
Angle of wind = -45°

Free stream mean speed = 1 m/s

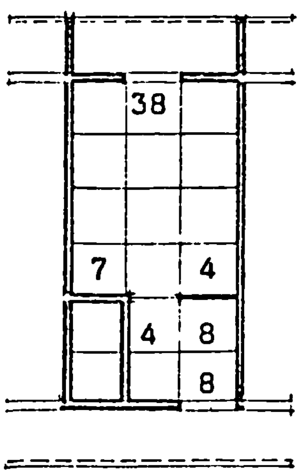
Air temperature = $21^{\circ}C$



A2/7



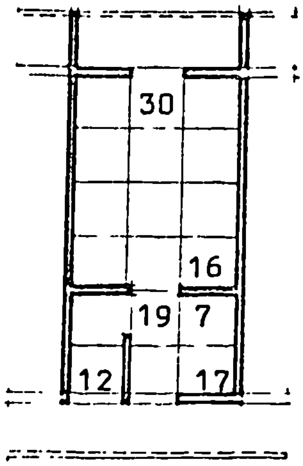
A2/8



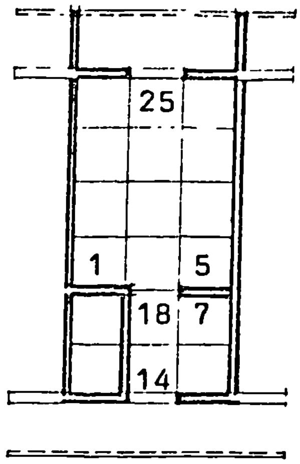
A2/9

Figure (A7.3) continued.

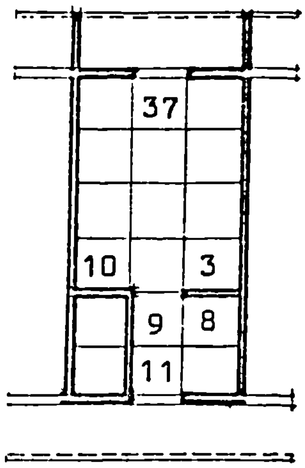
Angle of wind	=	-45°
Free stream mean speed	=	1 m/s
Air temperature	=	$21^{\circ}C$



A3/1



A3/2



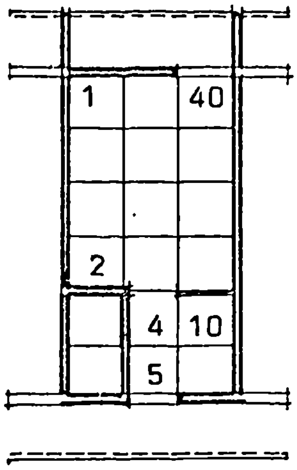
A3/3

Figure (A7.4) C_{vn} values for Model A3

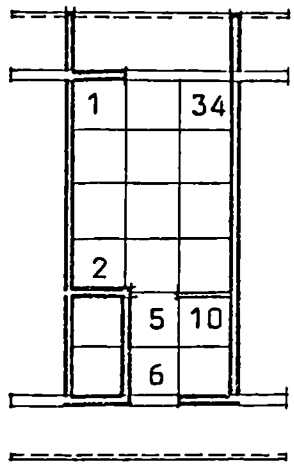
Angle of wind = 45°

Free stream mean speed = 1 m/s

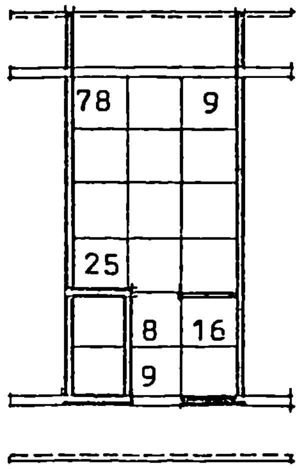
Air temperature = 21°C



A3/4



A3/5



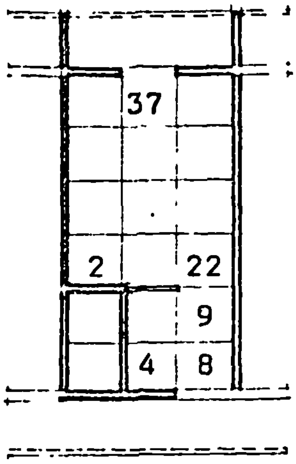
A3/6

Figure (A7.4) continued.

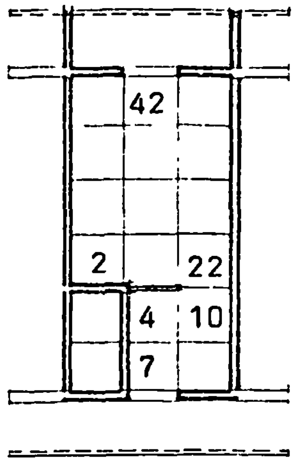
Angle of wind = 45°

Free stream mean speed = 1 m/s

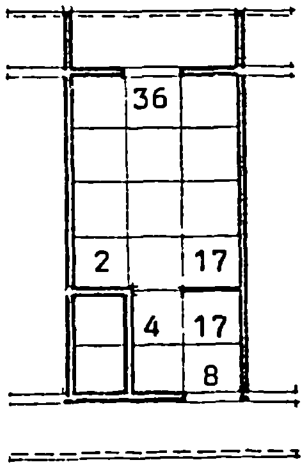
Air temperature = 21°C



A3/7



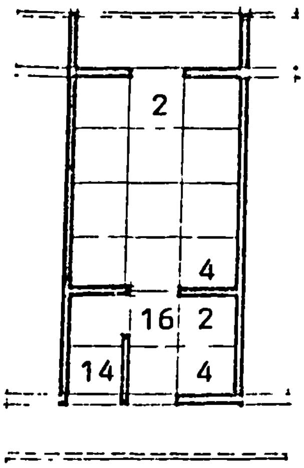
A3/8



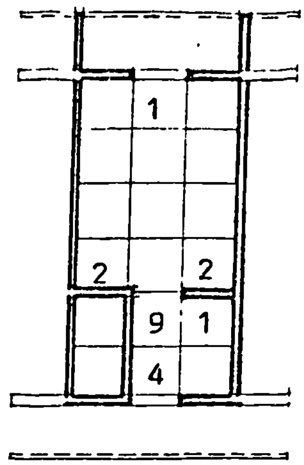
A3/9

Figure (A7.4) continued.

Angle of wind	=	45°
Free stream mean speed	=	1 m/s
Air temperature	=	21°C



A4/1



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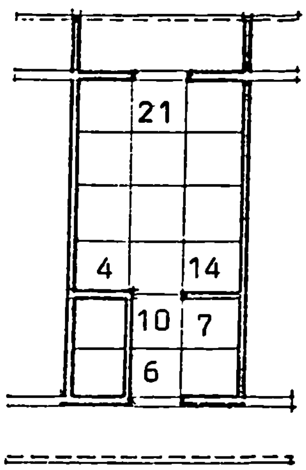

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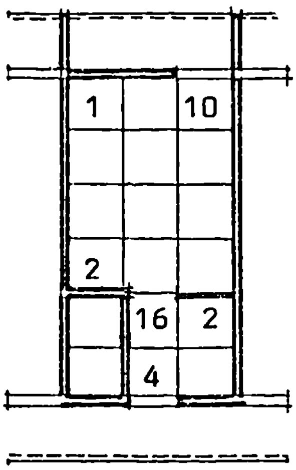
Figure (A7.5) C_{vn} values for Model A4

Angle of wind = 90^o

Free stream mean speed = 1 m/s

Air temperature = 21^oC



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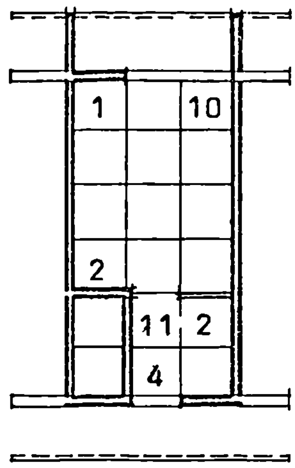

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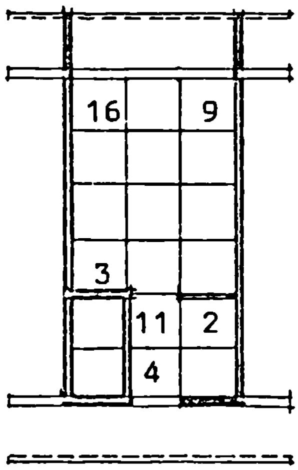

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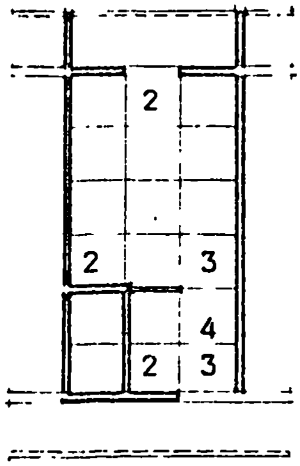
Figure (A7.5) continued.

Angle of wind	=	90^{o}
Free stream mean speed	=	1 m/s
Air temperature	=	$21^{o}C$



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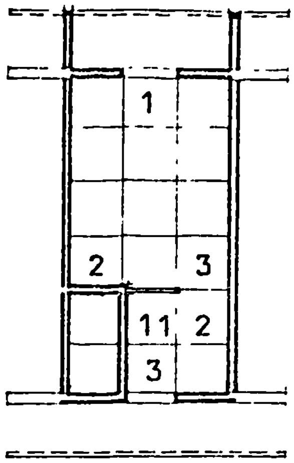

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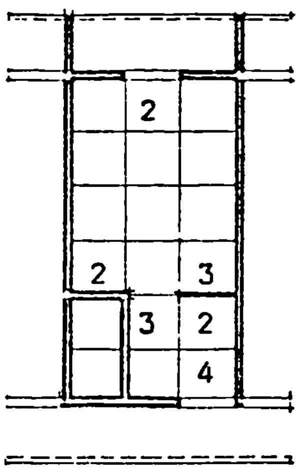

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Figure (A7.5) continued.

Angle of wind	=	90^o
Free stream mean speed	=	1 m/s
Air temperature	=	21^oC

Table (A7.5) Results of model category B1

Angle of Wind = 0°
Free Stream Mean Speed = 1m/s
Air Temperature = 21°C

Model	Set	P1	P2	P3	P4	P5	P6	P7
B1/1	1	2•894	2•901	2•902	2•927	3•273	3•073	
	2	2•908	2•906	2•895	2•931	3•728	3•083	
	3	2•913	2•907	2•899	2•929	3•268	3•077	
	av.	2•905	2•905	2•899	2•929	3•273	3•078	
	C_{vn}	0•54	0•50	0•19	0•21	0•80	0•21	
B1/2	1	2•981	2•845	2•910	2•931	3•311	3•089	-
	2	2•977	2•829	2•911	2•922	3•309	3•085	
	3	2•981	2•833	2•907	2•918	3•308	3•081	
	av.	2•980	2•836	2•909	2•924	3•309	3•084	
	C_{vn}	0•71	0•37	0•20	0•20	0•88	0•22	
B1/3	1	2•979	2•849	2•915	2•939	3•314	3•086	
	2	2•981	2•841	2•912	2•935	3•307	3•085	
	3	2•980	2•855	2•909	2•931	3•311	3•073	
	av.	2•980	2•848	2•912	2•935	3•311	3•081	
	C_{vn}	0•71	0•39	0•21	0•22	0•90	0•22	
B1/4	1	3•016	2•734	2•851	2•885	3•301	3•119	
	2	3•009	2•738	2•853	2•890	3•309	3•126	
	3	3•013	2•736	2•858	2•895	3•313	3•124	
	av.	3•013	2•738	2•854	2•890	3•308	3•123	
	C_{vn}	0•80	0•20	0•11	0•15	0•88	0•30	
B1/5	1	2•993	2•821	2•902	2•901	3•255	3•138	
	2	2•994	2•815	2•915	2•900	3•253	3•132	
	3	3•005	2•826	2•915	2•900	3•249	3•133	
	av.	2•997	2•821	2•911	2•900	3•252	3•134	
	C_{vn}	0•73	0•34	0•21	0•16	0•74	0•32	
B1/6	1	2•933	2•855	2•851	2•952	3•289	3•069	
	2	2•939	2•851	2•868	2•959	3•282	3•070	
	3	2•934	2•851	2•863	2•956	3•297	3•067	
	av.	2•935	2•852	2•861	2•956	3•289	2•069	
	C_v	0•60	0•40	0•12	0•26	0•84	0•20	

Table (A7.5) continued

Model	Set	P1	P2	P3	P4	P5	P6	P7
B1/7	1	2·963	2·819	2·909	2·920	3·217	3·109	
	2	2·970	2·808	2·910	2·915	3·222	3·103	
	3	2·969	2·808	2·909	2·907	3·224	3·096	
	av.	2·967	2·808	2·909	2·914	3·221	3·103	
	C_{vn}	0·68	0·32	0·20	0·18	0·66	0·26	
B1/8	1	2·906	2·743	2·913	2·886	3·128	3·023	
	2	2·897	2·730	2·917	2·883	3·147	3·026	
	3	2·900	2·726	2·919	2·881	3·141	3·021	
	av.	2·901	2·733	2·916	2·883	3·139	3·023	
	C_{vn}	0·53	0·18	0·22	0·14	0·48	0·12	
B1/9	1	2·924	2·896	2·898	2·991	3·239	3·120	
	2	2·923	2·914	2·909	2·995	3·222	3·123	
	3	2·933	2·894	2·917	2·997	3·240	3·133	
	av.	2·927	2·901	2·908	2·994	3·234	3·128	
	C_{vn}	0·58	0·49	0·20	0·34	0·69	0·32	

Table (A7.6) Results of model category B2

Angle of Wind = -45^o
Free Stream Mean Speed = 1m/s
Air Temperature = 21^oC

Model	Set	P1	P2	P3	P4	P5	P6	P7
B2/1	1	2•715	2•856	2•863	2•878	3•313	3•071	
	2	2•710	2•857	2•866	2•886	3•323	3•079	
	3	2•705	2•856	2•865	2•877	3•315	3•081	
	av.	2•710	2•856	2•865	2•880	3•317	3•077	
	C_{vn}	0•12	0•40	0•13	0•13	0•90	0•21	
B2/2	1	2•717	2•811	2•863	2•870	3•328	3•083	
	2	2•710	2•819	2•867	2•875	3•329	3•076	
	3	2•717	2•813	2•866	2•871	3•331	3•079	
	av.	2•715	2•814	2•865	2•872	3•329	3•079	
	C_{vn}	0•13	0•33	0•13	0•12	0•94	0•22	
B2/3	1	2•717	2•824	2•841	2•893	3•330	3•079	
	2	2•711	2•836	2•849	2•889	3•326	3•076	
	3	2•715	2•836	2•840	2•891	3•336	3•080	
	av.	2•714	2•832	2•843	2•891	3•331	3•078	
	C_{vn}	0•13	0•36	0•10	0•14	0•89	0•22	
B2/4	1	2•677	2•755	2•877	2•906	3•239	3•112	
	2	2•670	2•760	2•875	2•903	3•235	3•106	
	3	2•670	2•767	2•867	2•901	3•231	3•103	
	av.	2•672	2•761	2•873	2•903	3•235	3•107	
	C_{vn}	0•04	0•15	0•14	0•16	0•69	0•27	
B2/5	1	2•680	2•765	2•899	2•879	3•354	3•099	
	2	2•681	2•763	2•899	2•876	3•363	3•103	
	3	2•683	2•759	2•903	2•877	3•369	3•100	
	av.	2•681	2•762	2•900	2•877	3•362	3•101	
	C_{vn}	0•06	0•24	0•19	0•12	1•00	0•25	
B2/6	1	2•870	2•797	2•886	2•913	3•283	3•070	
	2	2•870	2•802	2•889	2•922	3•291	3•070	
	3	2•870	2•791	2•891	2•923	3•289	3•067	
	av.	2•870	2•797	2•889	2•919	3•288	3•069	
	C_{vn}	0•46	0•30	0•17	0•20	0•82	0•20	

Table (A7.6) continued

Model	Set	P1	P2	P3	P4	P5	P6	P7
B2/7	1	2·719	2·814	2·789	2·861	3·270	3·073	
	2	2·719	2·827	2·886	2·860	3·269	3·068	
	3	2·727	2·819	2·893	2·863	3·280	3·059	
	av.	2·721	2·820	2·856	2·861	3·273	3·067	
	C_{vn}	0·15	0·35	0·11	0·10	0·76	0·20	
B2/8	1	2·662	2·767	2·891	2·877	3·197	3·030	
	2	2·667	2·759	2·895	2·872	3·205	3·033	
	3	2·673	2·763	2·890	2·867	3·190	3·035	
	av.	2·667	2·756	2·892	2·872	3·197	3·033	
	C_{vn}	0·02	0·22	0·17	0·12	0·60	0·14	
B2/9	1	2·702	2·777	2·886	2·969	3·269	3·122	
	2	2·706	2·780	2·891	2·972	3·279	3·123	
	3	2·710	2·775	2·895	2·972	3·283	3·135	
	av.	2·706	2·777	2·891	2·971	3·277	3·127	
	C_{vn}	0·11	0·26	0·17	0·29	0·80	0·31	

Table (A7.7) Results of model category B3

Angle of Wind = 45^o
Free Stream Mean Speed = 1m/s
Air Temperature = 21°C

Model	Set	P1	P2	P3	P4	P5	P6	P7
B3/1	1	2•732	2•843	2•863	2•945	3•219	3•058	
	2	2•733	2•855	2•853	2•944	3•218	3•050	
	3	2•738	2•849	2•861	2•949	3•217	3•052	
	av.	2•734	2•849	2•859	2•946	3•218	3•053	
	C_{vn}	0•16	0•40	0•12	0•24	0•64	0•18	
B3/2	1	2•767	2•743	2•865	2•894	3•288	3•043	
	2	2•769	2•739	2•865	2•895	3•289	3•035	
	3	2•765	2•744	2•864	2•895	3•291	3•045	
	av.	2•767	2•742	2•865	2•895	3•289	3•041	
	C_{vn}	0•23	0•20	0•13	0•15	0•82	0•15	
B3/3	1	2•746	2•735	2•893	2•983	3•258	3•065	
	2	2•731	2•740	2•886	2•981	3•273	3•067	
	3	2•741	2•740	2•879	2•987	3•276	3•065	
	av.	2•739	2•738	2•886	2•984	3•269	3•066	
	C_{vn}	0•18	0•19	0•16	0•32	0•78	0•20	
B3/4	1	2•700	2•664	2•835	2•893	3•305	3•093	
	2	2•695	2•660	2•829	2•894	3•311	3•094	
	3	2•697	2•662	2•818	2•902	3•308	3•093	
	av.	2•697	2•662	2•827	2•896	3•308	3•093	
	C_{vn}	0•10	0•05	0•06	0•15	0•86	0•14	
B3/5	1	2•702	2•825	2•881	2•969	3•214	3•123	
	2	2•706	2•829	2•879	2•965	3•204	3•117	
	3	2•712	2•817	2•873	2•971	3•207	3•124	
	av.	2•707	2•827	2•878	2•968	3•208	3•121	
	C_{vn}	0•11	0•35	0•15	0•28	0•62	0•30	
B3/6	1	2•787	2•839	2•916	2•952	3•263	3•069	
	2	2•781	2•837	2•905	2•950	3•273	3•061	
	3	2•790	2•845	2•914	2•948	3•257	3•075	
	av.	2•786	2•840	2•912	2•950	3•264	3•068	
	C_{vn}	0•28	0•38	0•21	0•26	0•76	0•20	

Table (A7.7) continued

Model	Set	P1	P2	P3	P4	P5	P6	P7
B3/7	1	2•720	2•702	2•962	2•973	3•213	3•119	
	2	2•719	2•700	2•965	2•970	3•230	3•105	
	3	2•725	2•703	2•964	2•973	3•230	3•121	
	av.	2•721	2•702	2•964	2•972	3•224	3•115	
	C_{vn}	0•14	0•13	0•30	0•30	0•66	0•29	
B3/8	1	2•681	2•691	2•969	2•960	3•057	3•013	
	2	2•683	2•689	2•969	2•960	3•054	3•008	
	3	2•687	2•695	2•963	2•960	3•057	3•010	
	av.	2•684	2•691	2•967	2•960	3•056	3•010	
	C_{vn}	0•07	0•11	0•30	0•27	0•32	0•10	
B3/9	1	2•761	2•975	2•927	2•947	3•237	2•073	
	2	2•767	2•978	2•931	2•939	3•234	3•065	
	3	2•772	2•975	2•943	2•935	3•244	3•060	
	av.	2•777	2•976	2•934	2•940	3•238	3•066	
	C_{vn}	0•25	0•64	0•25	0•23	0•70	0•20	

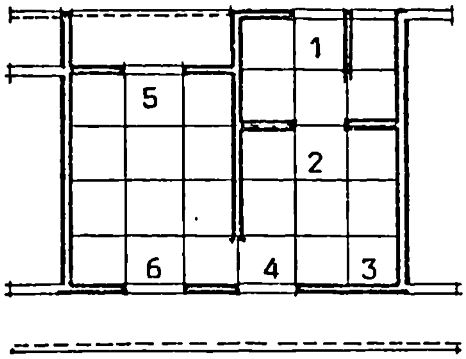
Table (A7.8) Results of model category B4

Angle of Wind = 90°
Free Stream Mean Speed = 1m/s
Air Temperature = 20°C

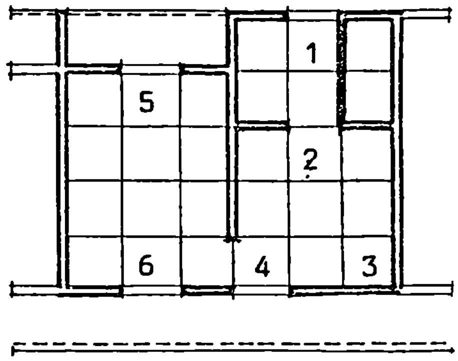
Model	Set	P1	P2	P3	P4	P5	P6	P7
B4/1	1	2·690	2·680	2·881	2·887	3·085	2·994	
	2	2·698	2·683	2·880	2·899	3·071	2·985	
	3	2·692	2·681	2·873	2·895	3·067	2·990	
	av.	2·693	2·681	2·878	2·894	3·074	2·990	
	C_{vn}	0·09	0·10	0·15	0·16	0·36	0·07	
B4/2	1	2·705	2·669	2·850	2·859	3·049	2·979	
	2	2·713	2·677	2·851	2·867	3·047	2·977	
	3	2·716	2·669	2·857	2·859	3·053	2·976	
	av.	2·711	2·672	2·853	1·862	3·050	2·977	
	C_{vn}	0·12	0·08	0·11	0·10	0·31	0·04	
B4/3	1	2·678	2·670	2·840	2·857	3·034	2·985	
	2	2·688	2·670	2·839	2·843	3·034	2·985	
	3	2·689	2·678	2·837	2·851	3·033	2·981	
	av.	2·688	2·673	2·839	2·850	3·034	2·984	
	C_{vn}	0·08	0·08	0·08	0·08	0·28	0·06	
B4/4	1	2·665	2·661	2·836	2·843	3·077	3·009	
	2	2·675	2·661	2·832	2·842	3·075	3·009	
	3	2·678	2·654	2·829	2·839	3·051	3·007	
	av.	2·673	2·659	2·832	2·841	3·068	3·008	
	C_{vn}	0·04	0·06	0·07	0·07	0·34	0·10	
B4/5	1	2·717	2·699	2·873	2·861	2·987	2·987	
	2	2·727	2·700	2·889	2·860	2·987	2·983	
	3	2·718	2·691	2·889	2·863	2·989	2·985	
	av.	2·721	2·697	2·884	2·861	2·988	2·985	
	C_{vn}	0·14	0·12	0·18	0·10	0·20	0·06	
B4/6	1	2·720	2·676	2·857	2·863	3·077	2·989	
	2	2·710	2·673	2·851	2·866	3·054	2·987	
	3	2·710	2·672	2·844	2·857	3·058	2·975	
	av.	2·713	2·674	2·851	2·862	3·063	2·984	
	C_{vn}	0·12	0·08	0·10	0·10	0·34	0·06	

Table (A7.8) continued

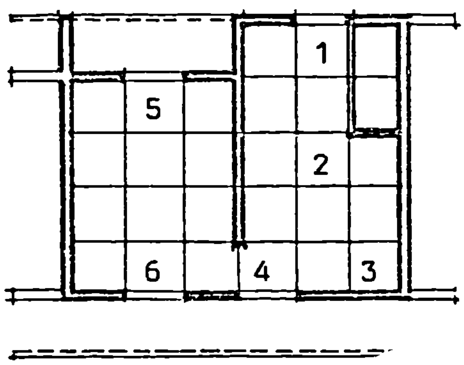
Model	Set	P1	P2	P3	P4	P5	P6	P7
B4/7	1	2•667	2•690	2•847	2•866	3•075	2•990	
	2	2•666	2•692	2•846	2•861	3•084	2•989	
	3	2•663	2•690	2•851	2•861	3•079	2•987	
	av.	2•665	2•691	2•848	2•863	3•079	2•989	
	C_{vn}	0•03	0•11	0•10	0•10	0•36	0•07	
B4/8	1	2•659	2•663	2•833	2•840	3•085	2•983	
	2	2•655	2•662	2•831	2•837	3•103	2•983	
	3	2•665	2•664	2•833	2•845	3•097	3•986	
	av.	2•660	2•663	2•832	2•841	3•095	2•984	
	C_{vn}	0•02	0•06	0•07	0•08	0•40	0•06	
B4/9	1	2•663	2•665	2•820	2•869	3•081	2•994	
	2	2•668	2•669	2•817	2•873	3•082	2•990	
	3	2•667	2•670	2•823	2•862	3•085	2•987	
	av.	2•666	2•668	2•820	2•868	3•083	2•990	
	C_{vn}	0•03	0•07	0•06	0•11	0•38	0•07	



B /1

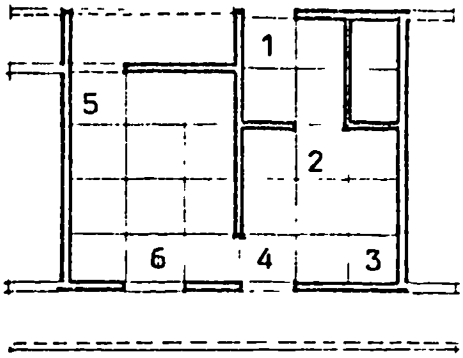


B /2

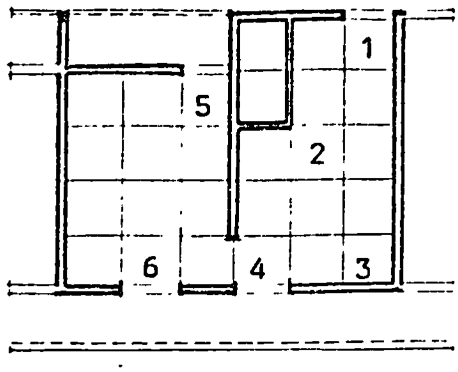


B /3

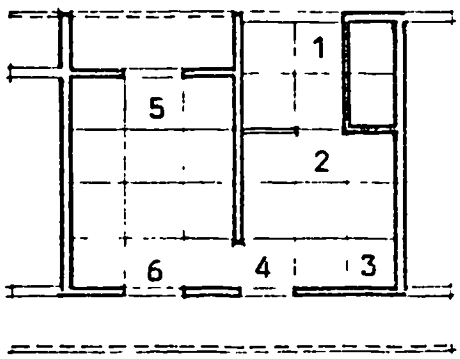
Figure (A7.6) Probe guide for model B.



B /4

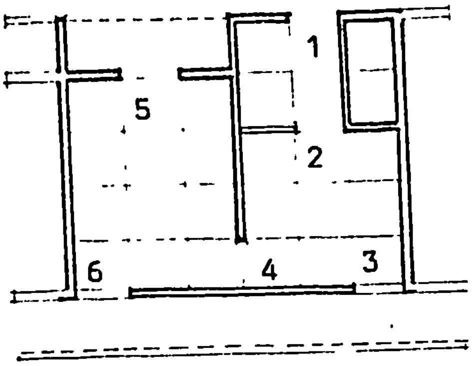


B /5

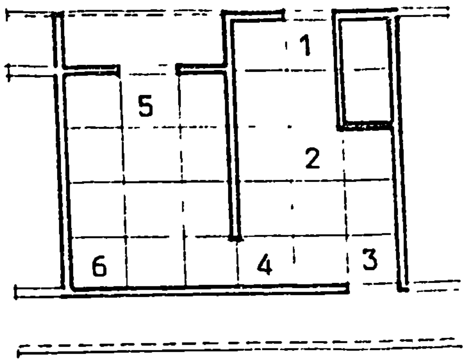


B /6

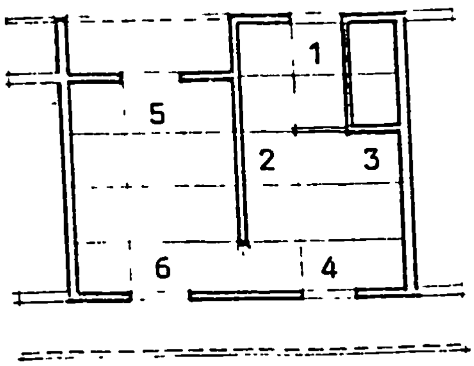
Figure (A7.6) continued.



B /7

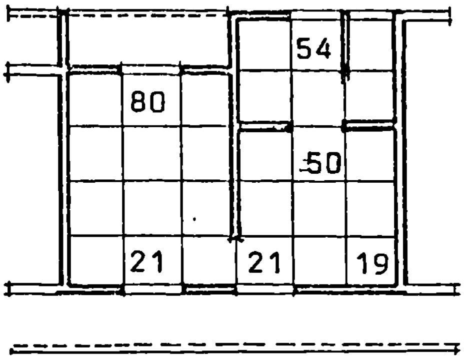


B /8

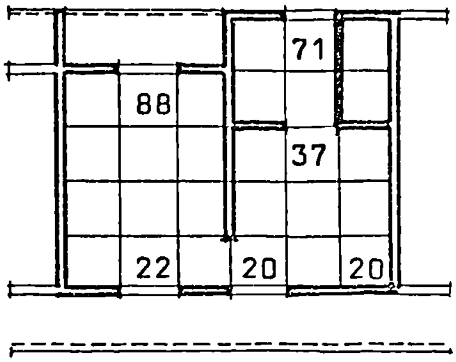


B /9

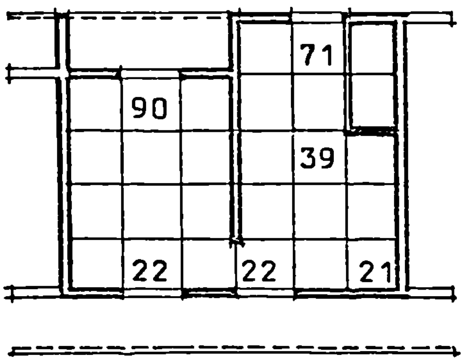
Figure (A7.6) continued.



B1/1



B1/2



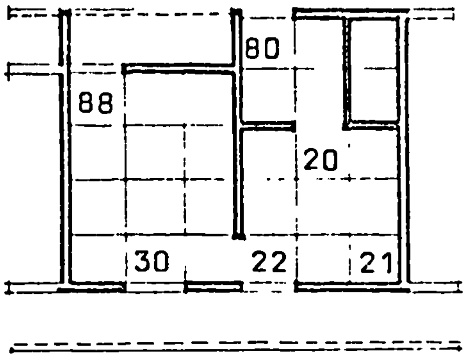
B1/3

Figure (A7.7) C_v values for Model B1

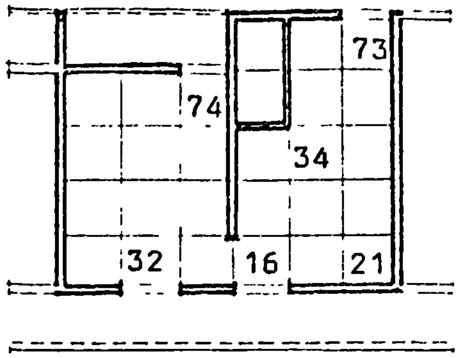
Angle of wind = 0^o

Free stream mean speed = 1 m/s

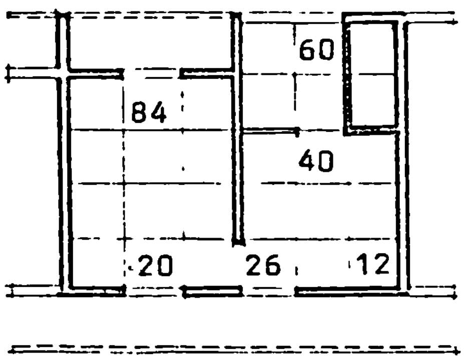
Air temperature = 21^oC



B1/4



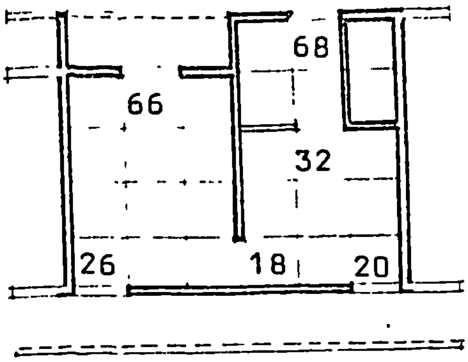
B1/5



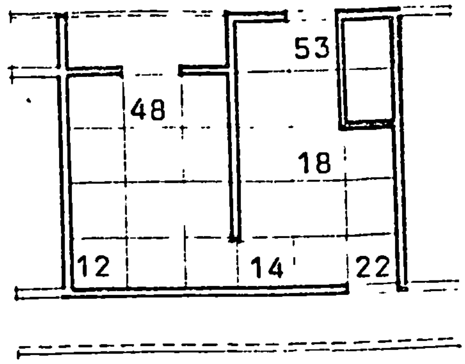
B1/6

Figure (A7.7) continued.

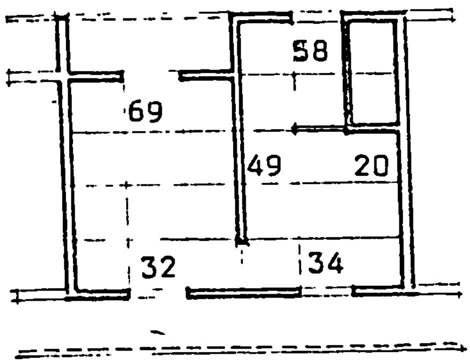
Angle of wind	=	0^o
Free stream mean speed	=	1 m/s
Air temperature	=	21^oC



B1/7



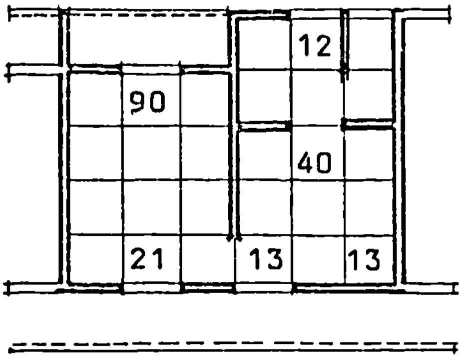
B1/8



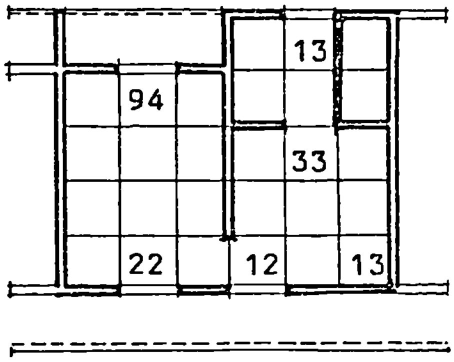
B1/9

Figure (A7.7) continued.

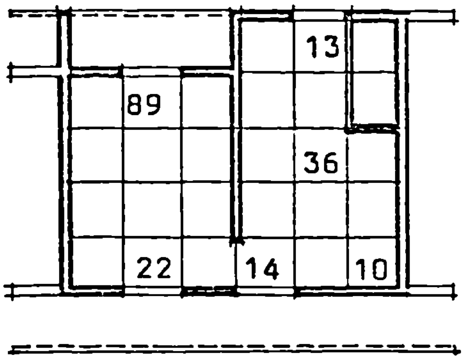
Angle of wind	=	0^o
Free stream mean speed	=	1 m/s
Air temperature	=	21^oC



B2/1



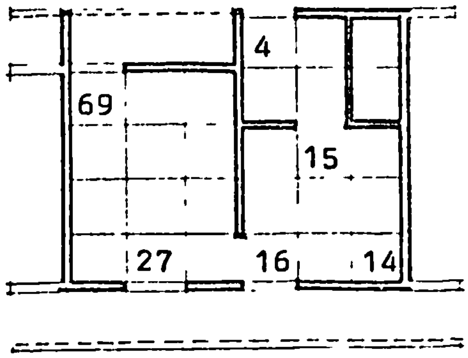
B2/2



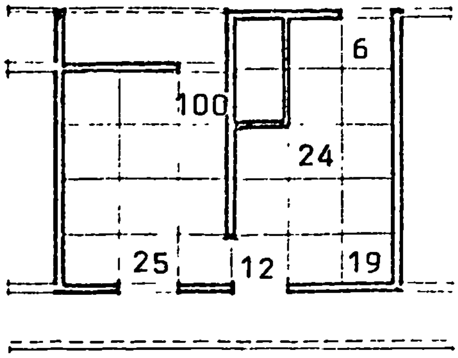
B2/3

Figure (A7.8) C_v values for Model B2

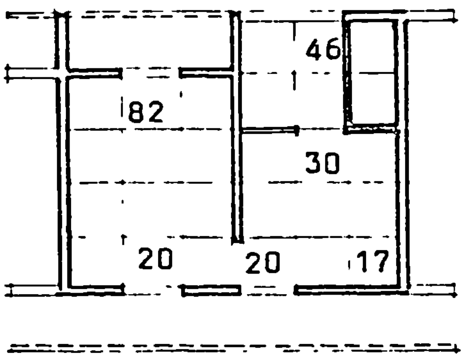
Angle of wind	=	-45^o
Free stream mean speed	=	1 m/s
Air temperature	=	21^oC



B2/4



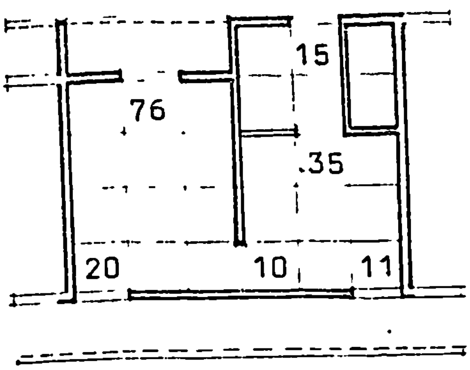
B2/6



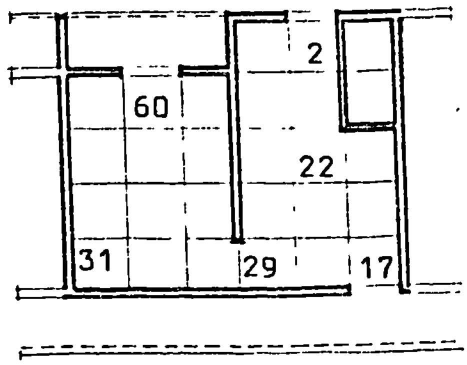
B2/6

Figure (A7.8) continued.

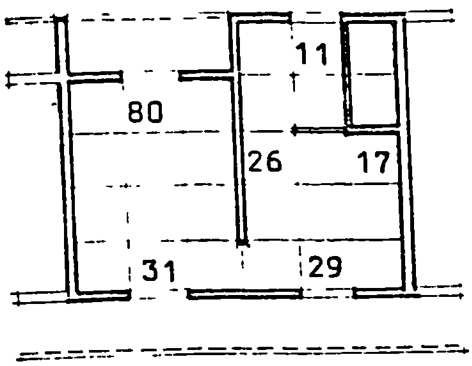
Angle of wind	=	-45^{o}
Free stream mean speed	=	1 m/s
Air temperature	=	$21^{o}C$



B2/7



B2/8



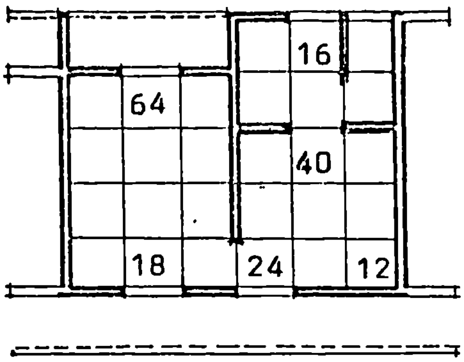
B2/9

Figure (A7.8) continued..

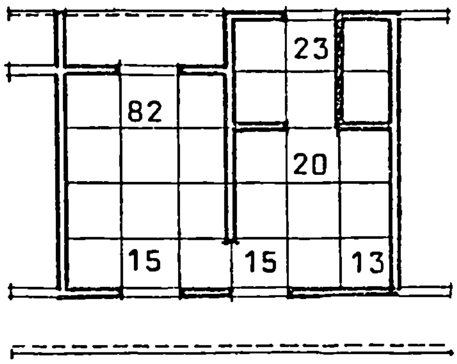
Angle of wind = -45°

Free stream mean speed = 1 m/s

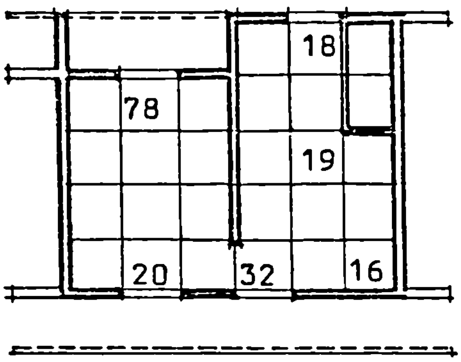
Air temperature = 21°C



B3/1



B3/2



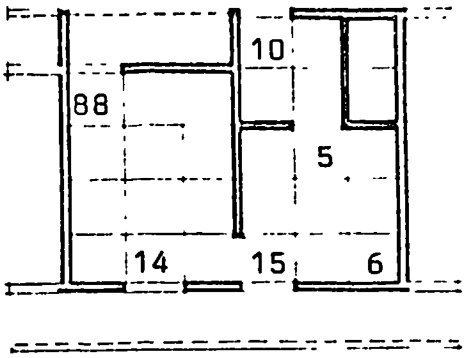
B3/3

Figure (A7.9) C_v values for Model B3

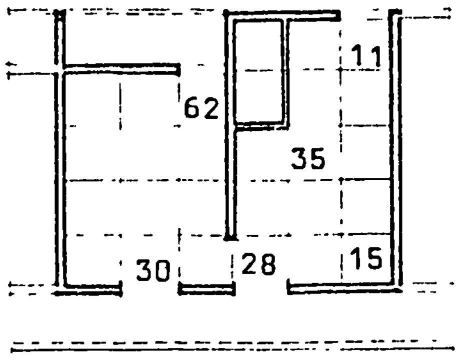
Angle of wind = 45°

Free stream mean speed = 1 m/s

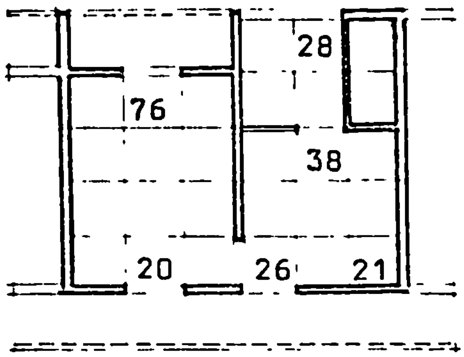
Air temperature = 21°C



B3/4



B3/5



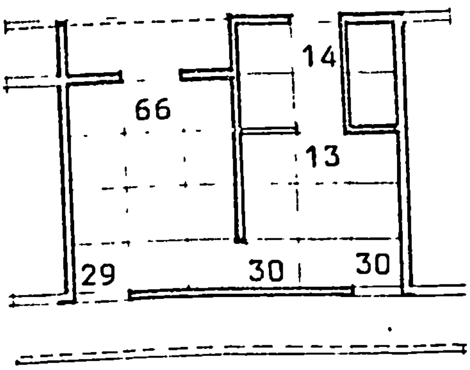
B3/6

Figure (A7.9) continued.

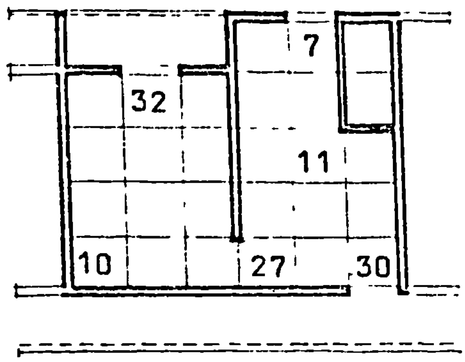
Angle of wind = 45^o

Free stream mean speed = 1 m/s

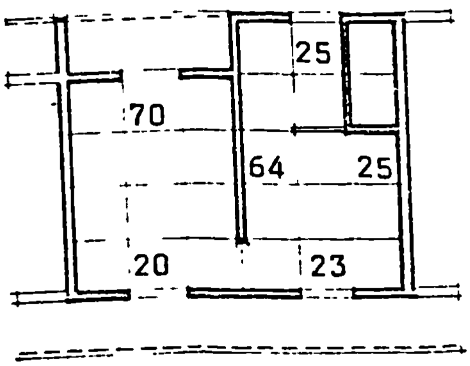
Air temperature = 21^oC



B3/7



B3/8



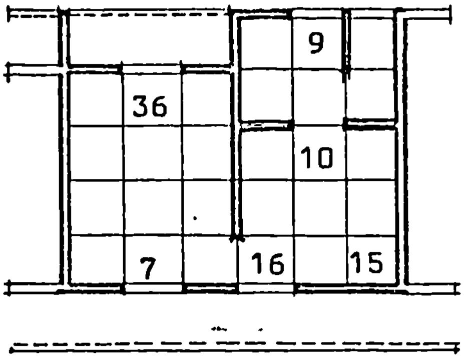
B3/9

Figure (A7.9) continued

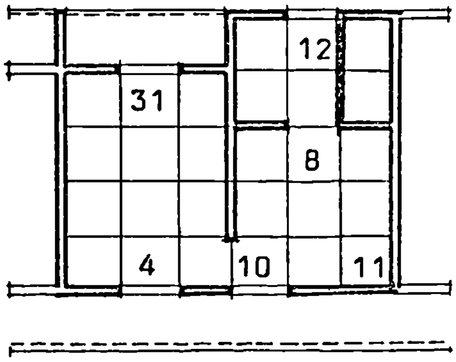
Angle of wind = 45°

Free stream mean speed = 1 m/s

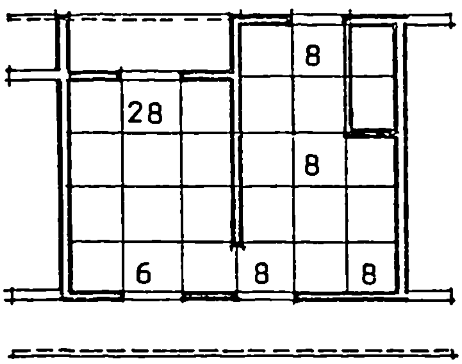
Air temperature = 21°C



B4/1



B4/2



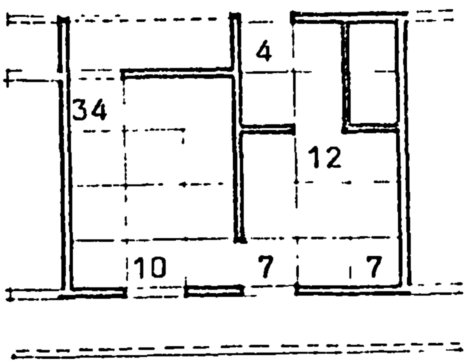
B4/3

Figure (A7.10) C_v values for Model B4

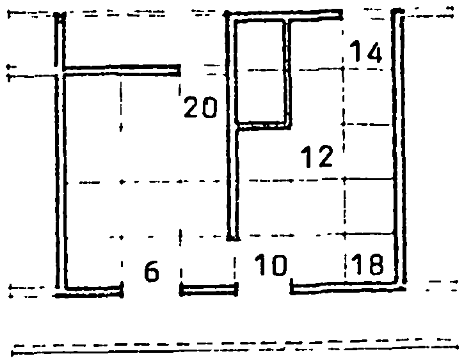
Angle of wind = 90^o

Free stream mean speed = 1 m/s

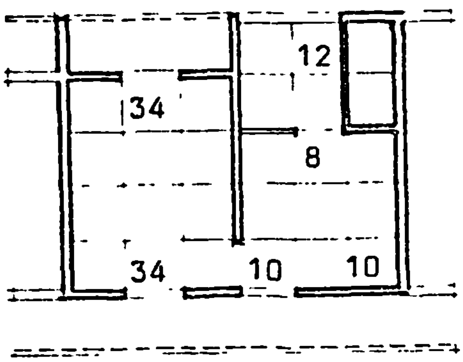
Air temperature = 20^oC



B4/4



B4/5



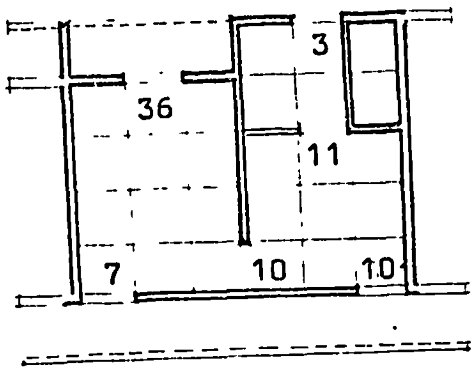
B4/6

Figure (A7.10) continued

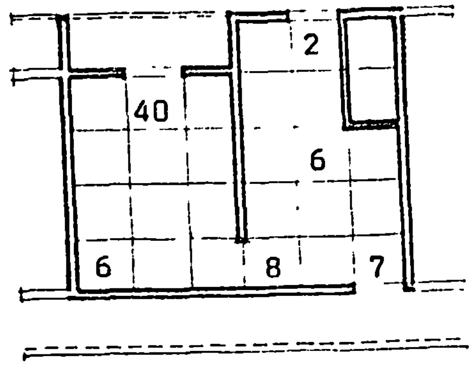
Angle of wind = 90^o

Free stream mean speed = 1 m/s

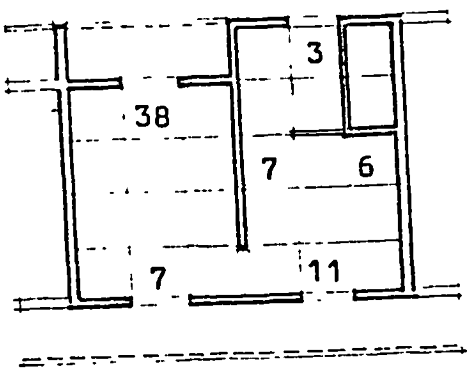
Air temperature = 20^oC



B4/7



B4/8



B4/9

Figure (A7.10) continued

Angle of wind = 90^{o}

Free stream mean speed = 1 m/s

Air temperature = $20^{o}C$

Table (A7.9) Results of model category C1

Angle of Wind = 0°
Free Stream Mean Speed = 1m/s
Air Temperature = 21°C

Model	Set	P1	P2	P3	P4	P5	P6	P7
C1/1	1	3·044	2·837	2·900	3·259	3·075	3·079	
	2	3·047	2·833	2·905	3·260	3·080	3·079	
	3	3·033	2·841	2·908	3·250	3·067	3·073	
	av.	3·041	2·837	2·904	3·256	3·074	3·077	
	C_{vn}	0·88	0·37	0·20	1·06	0·35	0·21	
C1/2	1	2·961	2·811	2·940	3·190	3·003	3·100	
	2	2·955	2·811	2·930	3·204	3·003	3·100	
	3	2·970	2·811	2·935	3·203	2·987	3·100	
	av.	2·962	2·811	2·935	3·199	2·998	3·100	
	C_{vn}	0·66	0·32	0·25	0·86	0·22	0·26	
C1/3	1	2·967	2·735	2·970	3·197	2·991	3·096	
	2	2·975	2·722	2·970	3·201	2·987	3·100	
	3	2·971	2·727	2·970	3·200	2·993	3·098	
	av.	2·971	2·728	2·970	3·199	2·990	3·098	
	C_{vn}	0·69	0·18	0·31	0·86	0·12	0·26	
C1/4	1	2·963	2·773	2·937	3·165	3·133	3·084	
	2	2·957	2·777	2·929	3·153	3·123	3·075	
	3	2·957	2·775	2·927	3·171	3·121	3·071	
	av.	2·959	2·775	2·931	3·163	3·127	3·077	
	C_{vn}	0·66	0·26	0·24	0·76	0·46	0·21	
C1/5	1	3·042	2·781	2·937	3·108	3·126	3·097	
	2	3·042	2·770	2·928	3·109	3·132	3·098	
	3	3·041	2·780	2·933	3·106	3·123	3·097	
	av.	3·042	2·777	2·933	3·108	3·127	3·097	
	C_{vn}	0·88	0·26	0·24	0·60	0·46	0·26	
C1/6	1	3·027	2·744	2·934	3·116	3·055	3·085	
	2	3·025	2·746	2·943	3·113	3·061	3·080	
	3	3·027	2·746	2·941	3·114	3·061	3·083	
	av.	3·027	2·744	2·939	3·114	3·059	3·083	
	C_{vn}	0·82	0·21	0·26	0·62	0·32	0·22	

Table (A7.9) continued

Model	Set	P1	P2	P3	P4	P5	P6	P7
C1/7	1	2•862	2•811	2•958	3•053	3•146	3•109	
	2	2•839	2•819	2•960	3•032	3•149	3•106	
	3	2•846	2•821	2•966	3•056	3•151	3•107	
	av.	2•849	2•817	2•961	3•047	3•149	3•108	
	C_{vn}	0•41	0•33	0•30	0•46	0•50	0•27	
C1/8	1	2•821	2•827	2•973	2•993	3•122	3•115	
	2	2•827	2•835	2•971	3•001	3•122	3•117	
	3	2•826	2•830	2•965	2•997	3•125	3•110	
	av.	2•825	2•831	2•970	2•997	3•123	3•114	
	C_{vn}	0•36	0•36	0•31	0•34	0•44	0•29	
C1/9	1	3•040	2•810	2•995	3•094	3•129	3•090	
	2	3•039	2•810	2•995	3•093	3•126	3•092	
	3	3•041	2•807	2•999	3•101	3•129	3•091	
	av.	3•040	2•809	2•996	3•096	3•128	3•091	
	C_{vn}	0•88	0•32	0•36	0•58	0•45	0•24	
C1/10	1	3•067	2•810	2•929	3•211	3•123	3•133	
	2	3•076	2•805	2•930	3•214	3•131	3•131	
	3	3•065	2•804	2•929	3•215	3•123	3•130	
	av.	3•066	2•806	2•929	3•213	3•126	3•131	
	C_{vn}	0•94	0•31	0•24	0•91	0•46	0•32	
C1/11	1	3•060	2•778	2•939	3•202	3•115	3•077	
	2	3•059	2•778	2•939	3•207	3•113	3•075	
	3	3•060	2•779	2•937	3•207	3•111	3•081	
	av.	3•060	2•778	2•939	3•205	3•113	3•078	
	C_{vn}	0•93	0•26	0•28	0•89	0•43	0•22	

Table (A7.10) Results of model category C2

Angle of Wind = -45^{o}
Free Stream Mean Speed = 1m/s
Air Temperature = $21^{o}C$

Model	Set	P1	P2	P3	P4	P5	P6	P7
C2/1	1	2•901	2•770	2•901	3•091	3•005	3•036	
	2	2•905	2•770	2•909	3•094	3•021	3•044	
	3	2•899	2•772	2•905	3•096	3•014	3•034	
	av.	2•902	2•771	2•905	3•094	3•013	3•038	
	C_{vn}	0•52	0•26	0•20	0•58	0•24	0•14	
C2/2	1	2•808	2•765	2•913	3•035	2•959	3•070	
	2	2•791	2•763	2•912	3•030	2•951	3•074	
	3	2•794	2•765	2•913	3•035	2•951	3•071	
	av.	2•798	2•764	2•913	3•033	2•954	3•072	
	C_{vn}	0•30	0•24	0•22	0•43	0•14	0•20	
C2/3	1	2•775	2•770	2•933	3•040	2•971	3•073	
	2	2•790	2•764	2•939	3•043	2•969	3•079	
	3	2•792	2•777	2•929	3•047	2•966	3•075	
	av.	2•786	2•770	2•934	3•043	2•969	3•076	
	C_{vn}	0•28	0•25	0•25	0•45	0•17	0•21	
C2/4	1	2•811	2•773	2•905	3•028	3•033	3•059	
	2	2•821	2•774	2•907	3•031	3•017	3•067	
	3	2•827	2•789	2•909	3•033	3•010	3•060	
	av.	2•820	2•779	2•907	3•031	3•020	3•062	
	C_{vn}	0•35	0•27	0•20	0•43	0•24	0•20	
C2/5	1	2•701	2•799	2•913	3•039	3•039	3•075	
	2	2•701	2•802	2•908	3•041	3•041	3•070	
	3	2•703	2•800	2•909	3•043	3•039	3•071	
	av.	2•702	2•800	2•910	3•041	3•040	3•072	
	C_{vn}	0•10	0•31	0•21	0•44	0•29	0•20	
C2/6	1	2•721	2•791	2•902	3•058	2•982	3•069	
	2	2•720	2•793	2•901	3•060	2•986	3•069	
	3	2•722	2•789	2•895	3•062	2•984	3•069	
	av.	2•721	2•791	2•899	3•060	2•984	3•069	
	C_{vn}	0•14	0•29	0•19	0•49	0•20	0•20	

Table (A7.10) continued

Model	Set	P1	P2	P3	P4	P5	P6	P7
C2/7	1	3·100	2·766	2·950	2·878	2·987	3·072	
	2	3·100	2·762	2·947	2·877	2·991	3·079	
	3	3·100	2·759	2·945	2·881	2·986	3·073	
	av.	3·100	2·762	2·947	2·879	2·988	3·075	
	C_{vn}	1·05	0·24	0·27	0·14	0·20	0·21	
C2/8	1	3·016	2·779	2·967	2·842	2·996	3·091	
	2	3·016	2·781	2·971	2·838	2·996	3·091	
	3	3·017	2·776	2·969	2·838	2·993	3·097	
	av.	3·016	2·779	2·989	2·839	2·995	3·095	
	C_{vn}	0·80	0·27	0·30	0·07	0·21	0·24	
C2/9	1	2·701	2·794	2·944	3·029	3·025	3·071	
	2	2·699	2·796	2·947	3·030	3·027	3·069	
	3	2·697	2·799	2·951	3·031	3·020	3·069	
	av.	2·699	2·796	2·947	3·030	3·024	3·070	
	C_{vn}	0·10	0·30	0·27	0·36	0·26	0·20	
C2/10	1	2·687	2·792	2·951	3·080	3·071	3·072	
	2	2·691	2·793	2·949	3·081	3·067	3·071	
	3	2·691	2·790	2·951	3·081	3·067	3·072	
	av.	2·690	2·792	2·950	3·081	3·068	3·072	
	C_{vn}	0·08	0·30	0·28	0·37	0·34	0·20	
C2/11	1	2·675	2·782	2·920	3·061	3·031	3·074	
	2	2·673	2·780	2·980	3·071	3·023	3·074	
	3	2·679	2·783	2·919	3·066	3·031	3·071	
	av.	2·676	2·782	2·920	3·066	3·028	3·073	
	C_{vn}	0·04	0·28	0·23	0·37	0·26	0·21	

Table (A7.11) Results of model category C3

Angle of Wind = 45°
Free Stream Mean Speed = 1m/s
Air Temperature = 21°C

Model	Set	P1	P2	P3	P4	P5	P6	P7
C3/1	1	2•696	2•707	2•860	3•057	2•987	3•050	
	2	2•696	2•706	2•849	3•044	2•986	3•047	
	3	2•693	2•697	2•855	3•046	2•981	3•045	
	av.	2•695	2•703	2•855	3•049	2•985	3•047	
	C_{vn}	0•09	0•14	0•11	0•47	0•20	0•16	
C3/2	1	2•689	2•728	2•882	3•019	2•949	3•085	
	2	2•689	2•717	2•887	3•020	2•950	3•086	
	3	2•683	2•717	2•885	3•023	2•941	3•085	
	av.	2•687	2•717	2•885	3•021	2•947	3•085	
	C_{vn}	0•08	0•16	0•16	0•40	0•13	0•23	
C3/3	1	2•685	2•688	2•910	3•021	2•951	3•064	
	2	2•686	2•691	2•914	3•015	2•950	3•068	
	3	2•681	2•690	2•915	2•980	2•944	3•071	
	av.	2•684	2•690	2•913	3•005	2•948	3•068	
	C_{vn}	0•07	0•11	0•22	0•36	0•13	0•20	
C3/4	1	2•675	2•697	2•869	3•069	3•010	3•063	
	2	2•683	2•702	2•881	3•073	3•007	3•063	
	3	2•683	2•702	2•872	3•069	3•015	3•059	
	av.	2•680	2•700	2•874	3•070	3•011	3•062	
	C_{vn}	0•06	0•13	0•14	0•51	0•24	0•19	
C3/5	1	2•739	2•753	2•916	3•123	3•111	3•109	
	2	2•739	2•749	2•915	3•122	3•110	3•109	
	3	2•736	2•735	2•915	3•121	3•115	3•109	
	av.	2•738	2•752	2•915	3•122	3•112	3•109	
	C_{vn}	0•17	0•22	0•22	0•62	0•43	0•28	
C3/6	1	2•706	2•705	2•894	3•087	3•045	3•053	
	2	2•706	2•704	2•886	3•090	3•047	3•051	
	3	2•705	2•705	2•891	3•086	3•045	3•052	
	av.	2•706	2•705	2•890	3•088	3•046	3•052	
	C_{vn}	0•11	0•14	0•17	0•58	0•30	0•18	

Table (A7.11) continued

Model	Set	P1	P2	P3	P4	P5	P6	P7
C3/7	1	2•720	2•785	2•911	3•010	3•057	3•105	
	2	2•720	2•779	2•914	3•010	3•054	3•107	
	3	2•718	2•783	2•911	3•012	3•043	3•101	
	av.	2•719	2•782	2•912	3•011	3•051	3•104	
	C_{vn}	0•14	0•28	0•22	0•38	0•31	0•27	
C3/8	1	2•811	2•809	2•944	2•947	3•078	3•111	
	2	2•810	2•809	2•939	2•949	3•075	3•113	
	3	2•809	2•809	2•941	2•947	3•072	3•113	
	av.	2•810	2•809	2•941	2•948	3•077	3•112	
	C_{vn}	0•32	0•32	0•27	0•24	0•36	0•28	
C3/9	1	2•730	2•747	2•981	3•130	3•129	3•110	
	2	2•731	2•745	2•976	3•130	3•119	3•112	
	3	2•730	3•747	3•985	3•130	3•120	3•115	
	av.	2•730	2•746	2•987	3•130	3•123	3•112	
	C_{vn}	0•16	0•21	0•34	0•38	0•45	0•28	
C3/10	1	2•693	2•728	2•930	3•177	3•105	3•133	
	2	2•690	2•728	2•929	3•182	3•109	3•137	
	3	2•695	2•729	2•924	3•183	3•111	3•143	
	av.	2•693	2•728	2•928	3•181	3•108	3•138	
	C_{vn}	0•09	0•18	0•24	0•81	0•42	0•33	
C3/11	1	2•680	2•707	2•907	3•132	3•071	3•061	
	2	2•680	2•709	2•905	3•139	3•074	3•063	
	3	2•680	2•710	2•906	3•140	3•067	3•063	
	av.	2•680	2•709	2•906	3•137	3•071	3•062	
	C_{vn}	0•06	0•14	0•20	0•68	0•35	0•19	

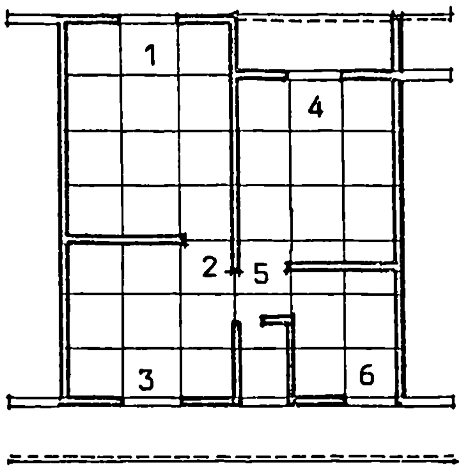
Table (A7.12) Results of model category C4

Angle of Wind = 90^o
Free Stream Mean Speed = 1 m/s
Air Temperature = 21^oC

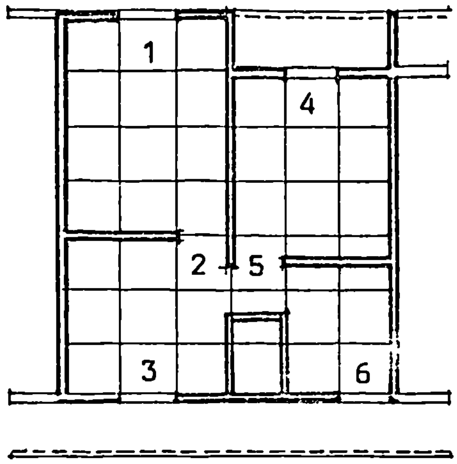
Model	Set	P1	P2	P3	P4	P5	P6	P7
C4/1	1	2•766	2•731	2•856	2•896	3•001	3•015	
	2	2•758	2•728	2•868	2•901	3•011	3•006	
	3	2•747	2•731	2•853	2•889	3•021	3•001	
	av.	2•757	2•730	2•859	2•895	3•011	2•007	
	C_{vn}	0•21	0•18	0•12	0•16	0•24	0•10	
C4/2	1	2•753	2•729	2•864	2•895	3•011	3•000	
	2	2•747	2•731	2•860	2•888	3•015	3•005	
	3	2•769	2•722	2•859	2•893	3•019	3•007	
	av.	2•756	2•727	2•861	2•892	3•015	3•004	
	C_{vn}	0•21	0•17	0•12	0•16	0•24	0•09	
C4/3	1	2•778	2•730	2•865	2•883	3•007	3•001	
	2	2•748	2•732	2•868	2•895	3•001	3•001	
	3	2•749	2•723	2•867	2•898	3•006	3•009	
	av.	2•758	2•728	2•867	2•892	3•005	3•004	
	C_{vn}	0•21	0•17	0•13	0•16	0•23	0•09	
C4/4	1	2•707	2•718	2•863	2•875	3•001	2•995	
	2	2•693	2•723	2•859	2•883	3•003	2•989	
	3	2•695	2•718	2•863	2•880	2•995	2•984	
	av.	2•698	2•720	2•862	2•879	3•000	2•989	
	C_{vn}	0•10	0•16	0•12	0•13	0•22	0•07	
C4/5	1	2•673	2•736	2•871	2•860	2•955	2•976	
	2	2•669	2•739	2•874	2•861	2•953	2•975	
	3	2•668	2•739	2•873	2•860	2•954	2•975	
	av.	2•670	2•736	2•873	2•860	2•954	2•975	
	C_{vn}	0•03	0•19	0•14	0•10	0•14	0•04	
C4/6	1	2•785	2•717	2•871	2•877	2•992	2•987	
	2	2•779	2•715	2•867	2•875	2•995	2•985	
	3	2•775	2•711	2•864	2•875	2•997	2•987	
	av.	2•780	2•714	2•867	2•876	2•995	2•986	
	C_{vn}	0•27	0•16	0•12	0•12	0•21	0•07	

Table (A7.12) continued

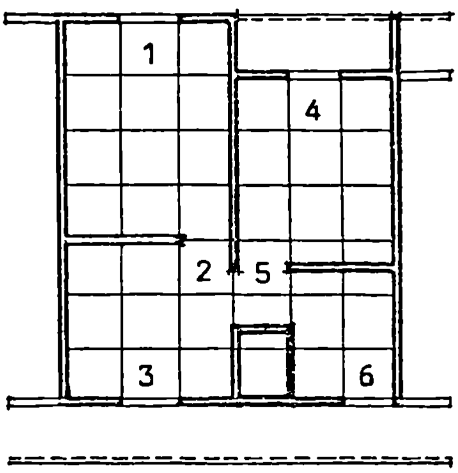
Model	Set	P1	P2	P3	P4	P5	P6	P7
C4/7	1	2•675	2•727	2•855	2•899	3•065	3•006	
	2	2•675	2•725	2•861	2•897	3•071	3•006	
	3	2•677	2•731	2•853	2•895	3•074	3•002	
	av.	2•676	2•728	2•856	2•897	3•070	3•005	
	C_{vn}	0•04	0•17	0•11	0•16	0•34	0•09	
C4/8	1	2•731	2•756	2•867	2•894	3•083	3•005	
	2	2•721	2•756	2•869	2•895	3•073	3•001	
	3	2•718	2•755	2•861	2•898	3•071	3•001	
	av.	2•723	2•756	2•866	2•896	3•076	3•002	
	C_{vn}	0•14	0•22	0•13	0•16	0•35	0•08	
C4/9	1	2•697	2•758	2•848	2•860	2•969	2•979	
	2	2•691	2•758	2•859	2•859	2•967	2•978	
	3	2•694	2•756	2•850	2•859	2•971	2•975	
	av.	2•694	2•757	2•852	2•859	2•969	2•977	
	C_{vn}	0•09	0•22	0•11	0•10	0•17	0•04	
C4/10	1	2•690	2•681	2•878	2•884	2•937	2•953	
	2	2•677	2•681	2•878	2•885	2•943	2•959	
	3	2•675	2•681	2•876	2•887	2•943	2•957	
	av.	2•681	2•681	2•877	2•885	2•941	2•956	
	C_{vn}	0•06	0•10	0•14	0•14	0•12	0•02	
C4/11	1	2•717	2•755	2•870	2•881	2•990	2•996	
	2	2•717	2•761	2•863	2•880	2•995	2•995	
	3	2•712	2•761	2•867	2•883	2•992	2•997	
	av.	2•715	2•759	2•867	2•882	2•992	2•996	
	C_{vn}	0•13	0•23	0•13	0•14	0•21	0•08	



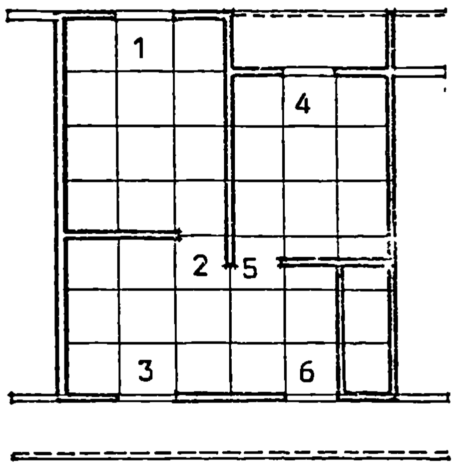
C /1



C /2

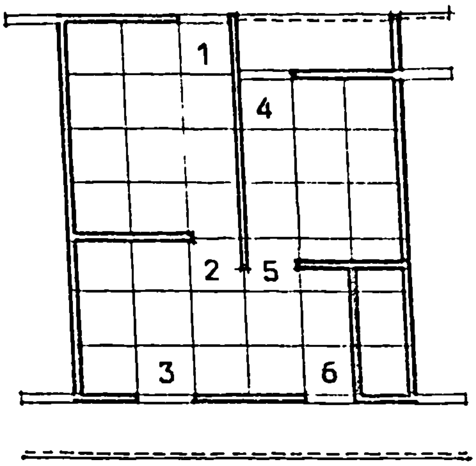


C /3

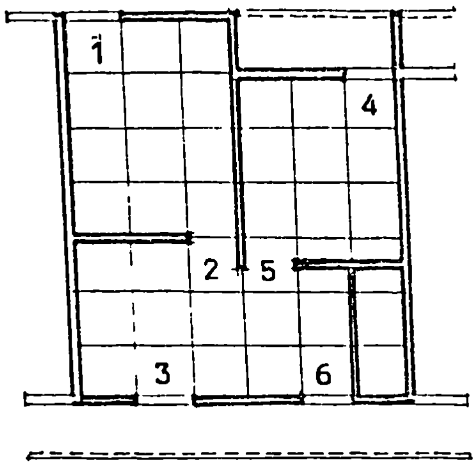


C /4

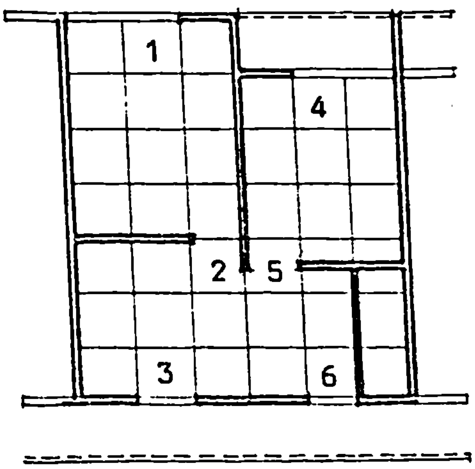
Figure (A7.11) Probe guide for model C.



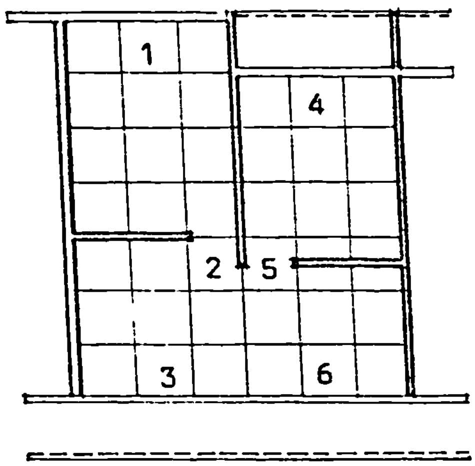
C /5



C /6

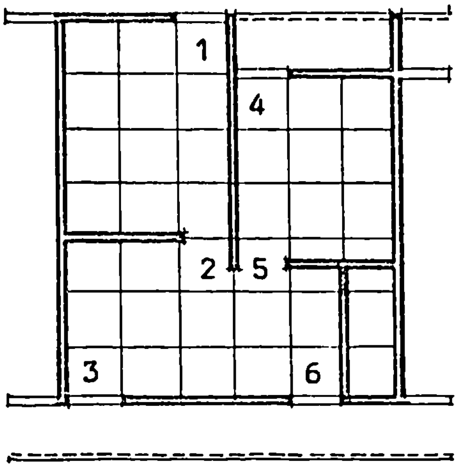


C /7

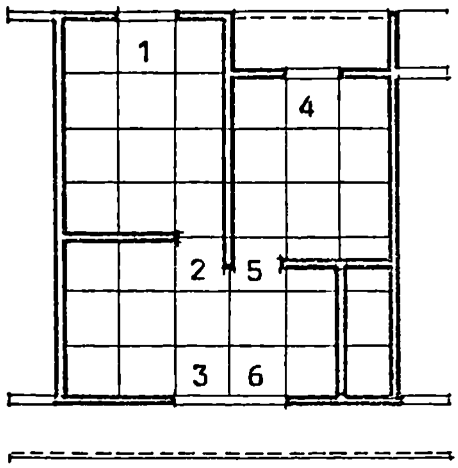


C /8

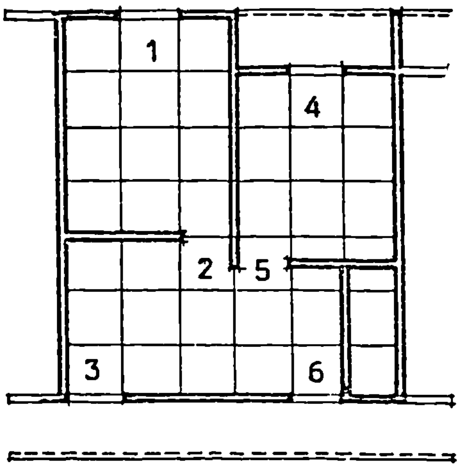
Figure (A7.11) continued.



C /9

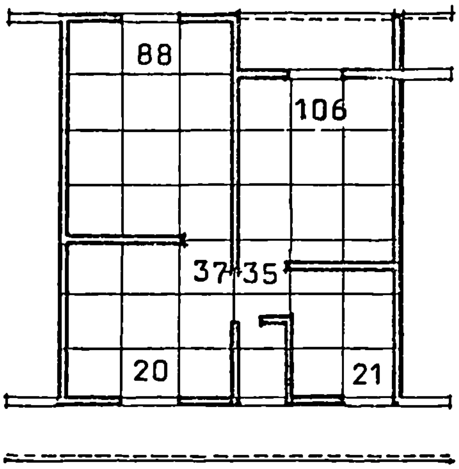


C /10

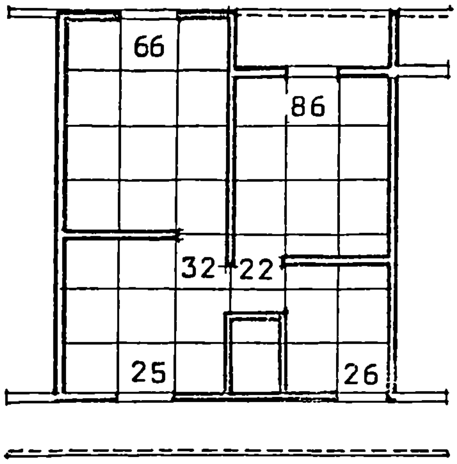


C /11

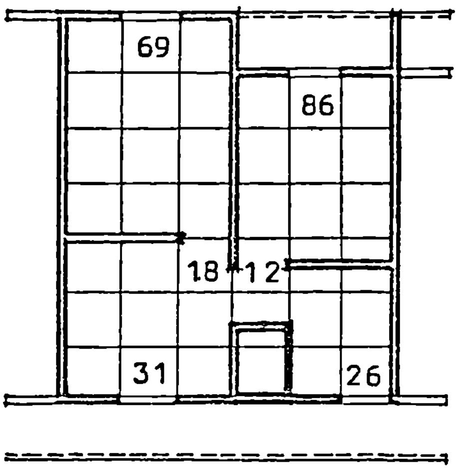
Figure (A7.11) continued.



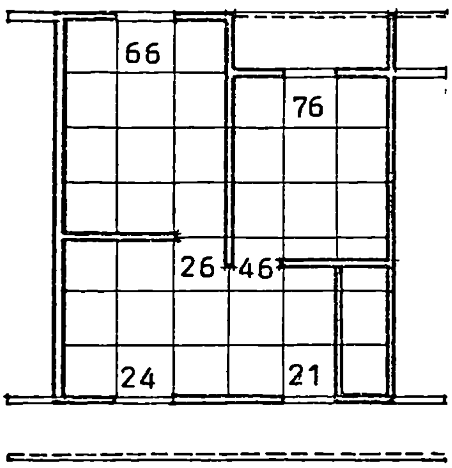
C1/1



C1/2



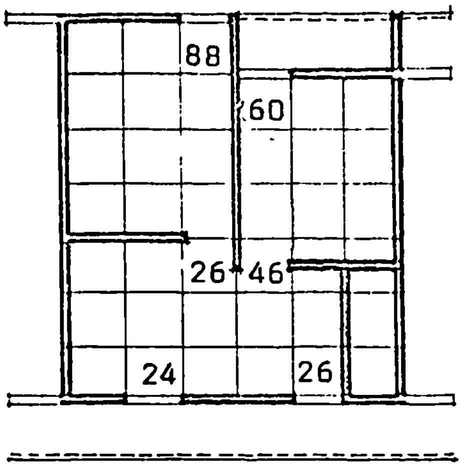
C1/3



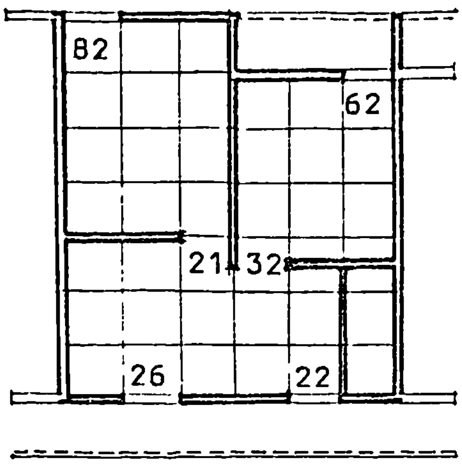
C1/4

Figure (A7.12) C_{vn} values for Model C1

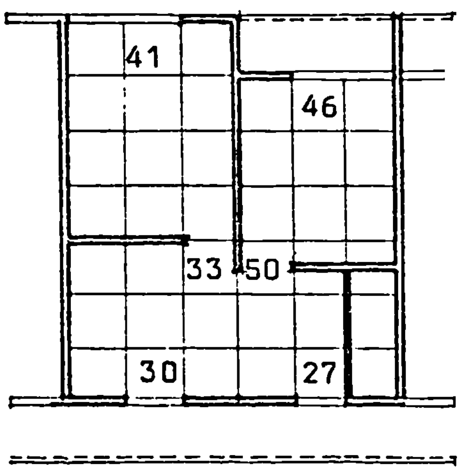
Angle of wind	=	0^o
Free stream mean speed	=	1 m/s
Air temperature	=	21^oC



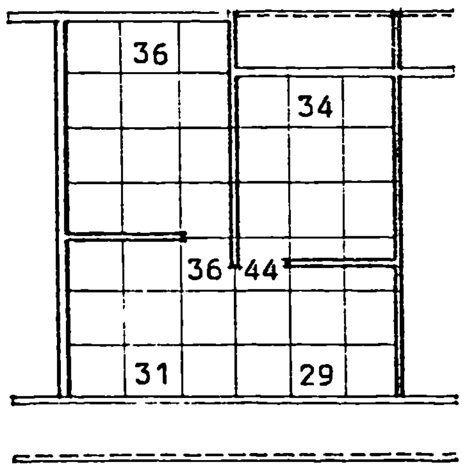
C1/5



C1/6



C1/7



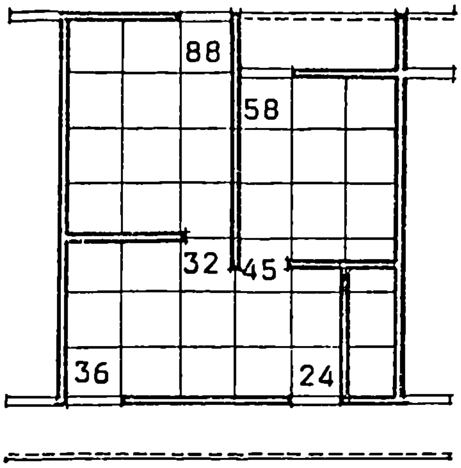
C1/8

Figure (A7.12) continued

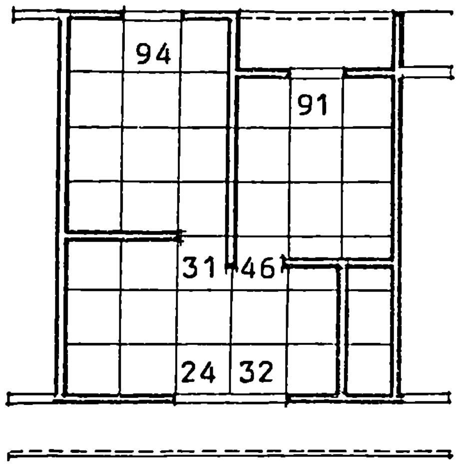
Angle of wind = 0^{o}

Free stream mean speed = 1 m/s

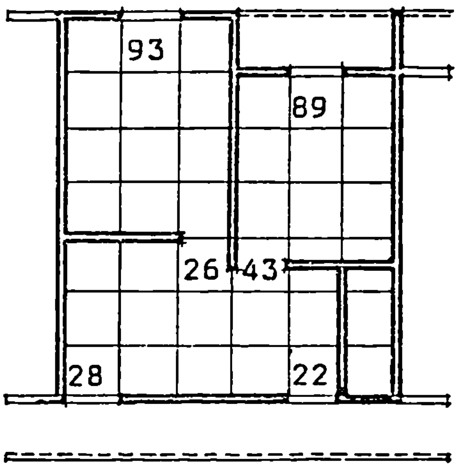
Air temperature = $21^{o}C$



C1/9



C1/10



C1/11

Figure (A7.12) continued.

Angle of wind	=	0^o
Free stream mean speed	=	1 m/s
Air temperature	=	21^oC

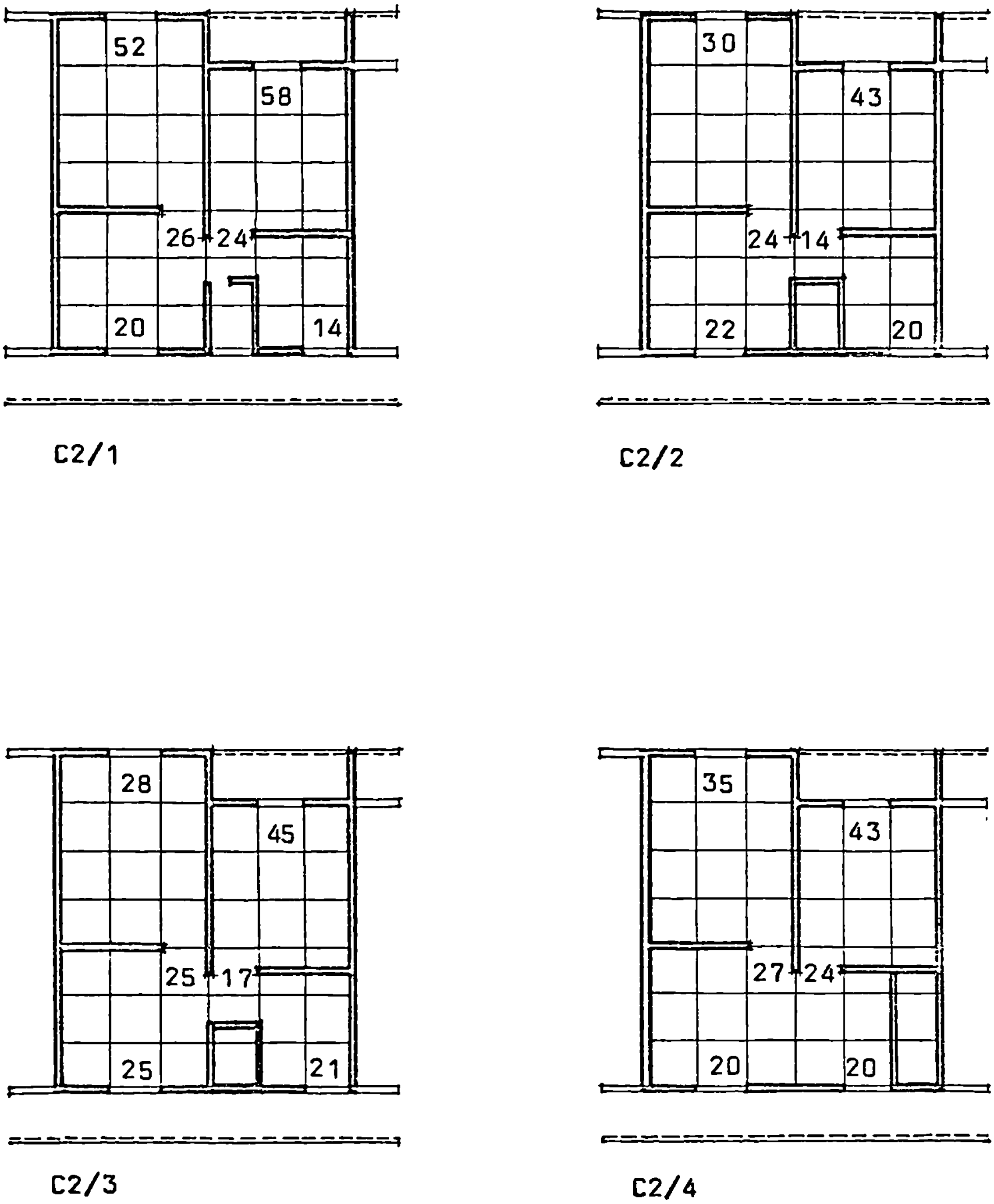
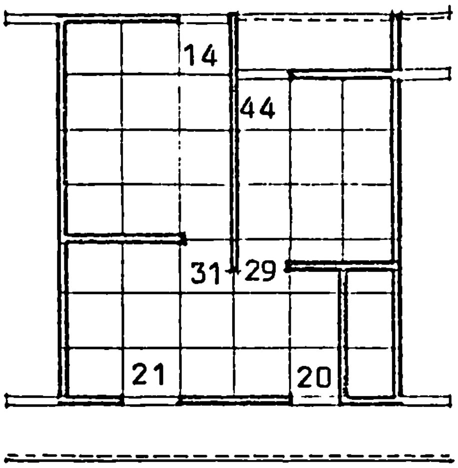
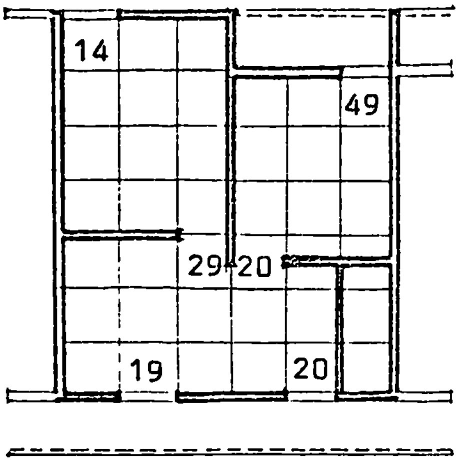


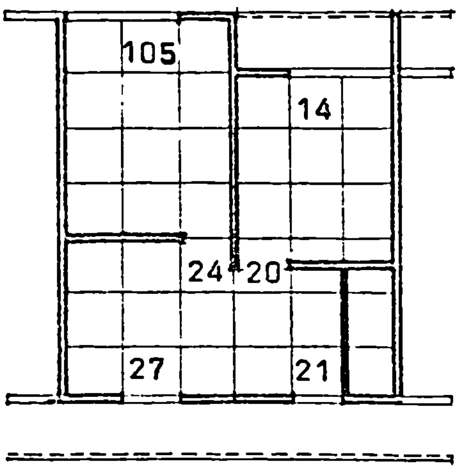
Figure (A7.13) C_{vn} values for Model C2
Angle of wind = -45^{o}
Free stream mean speed = 1 m/s
Air temperature = $21^{o}C$



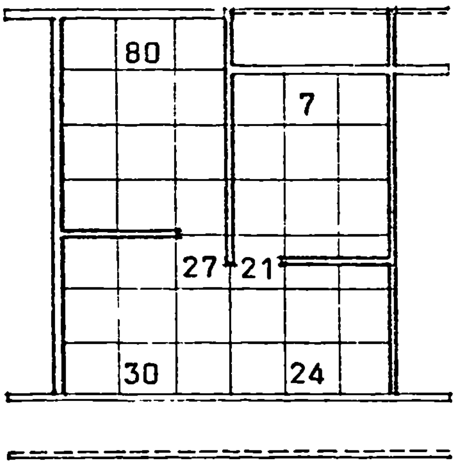
C2/5



C2/6



C2/7



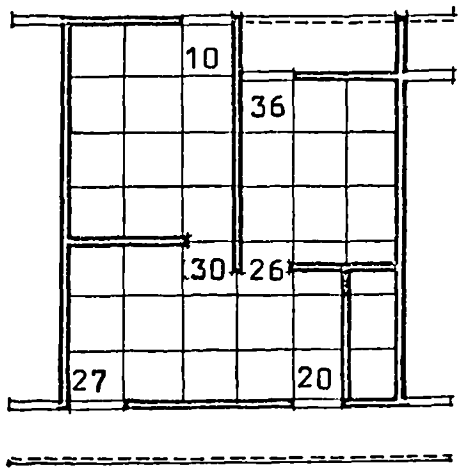
C2/8

Figure (A7.13) continued.

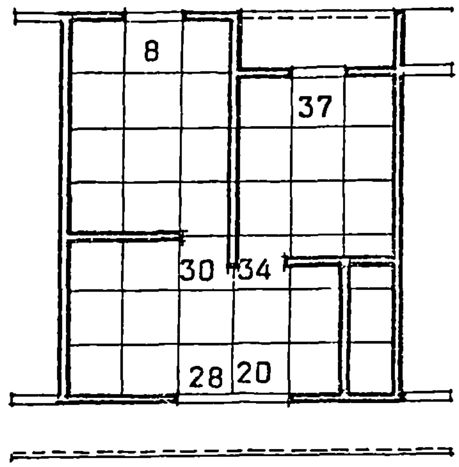
Angle of wind = -45^{o}

Free stream mean speed = 1 m/s

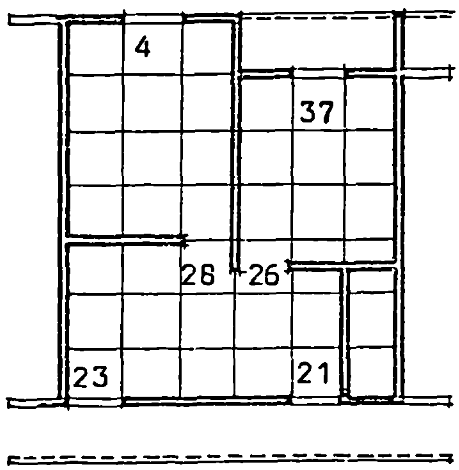
Air temperature = $21^{o}C$



C2/9



C2/10



C2/11

Figure (A7.13) continued..

Angle of wind	=	-45^{o}
Free stream mean speed	=	1 m/s
Air temperature	=	$21^{o}C$

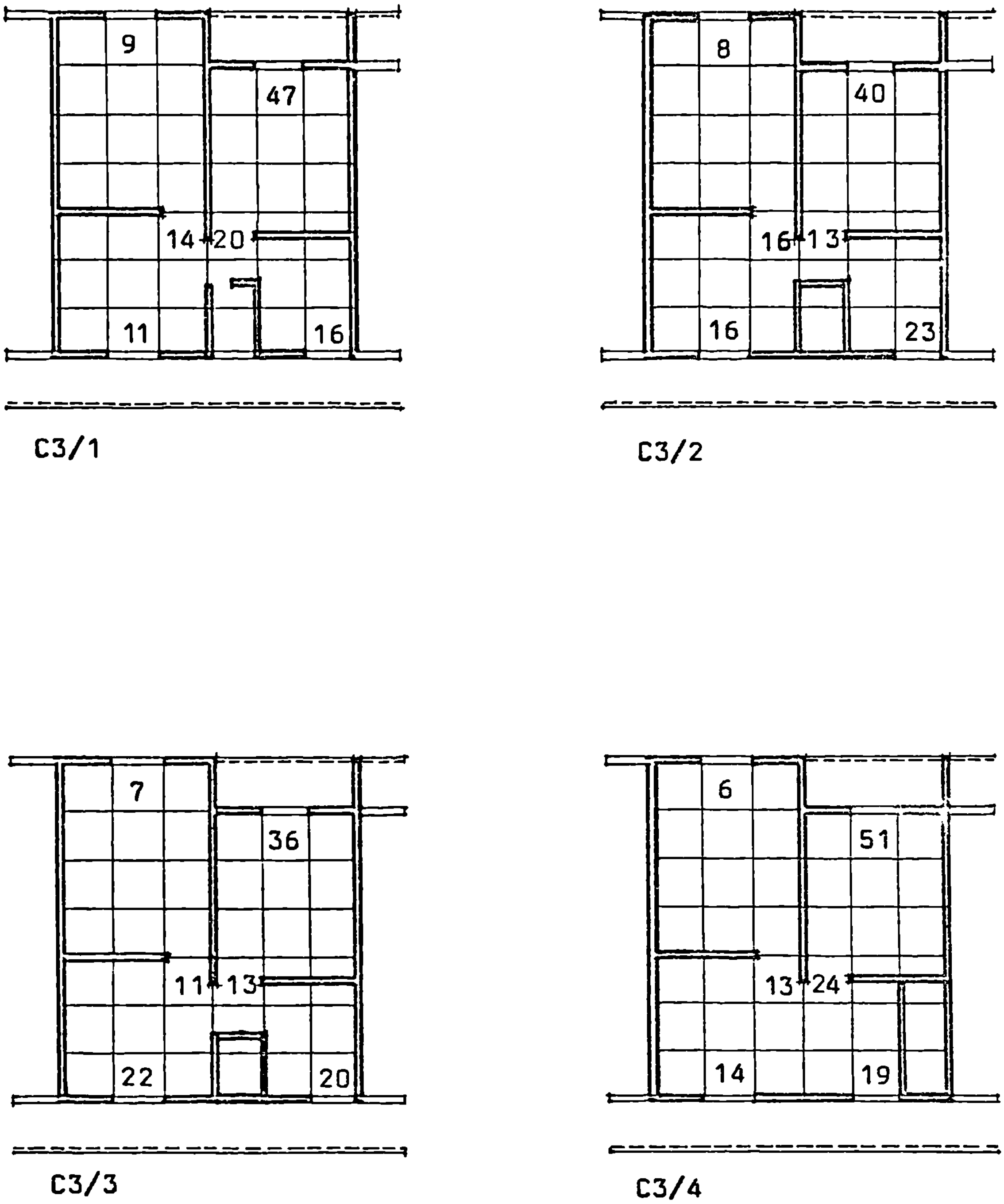
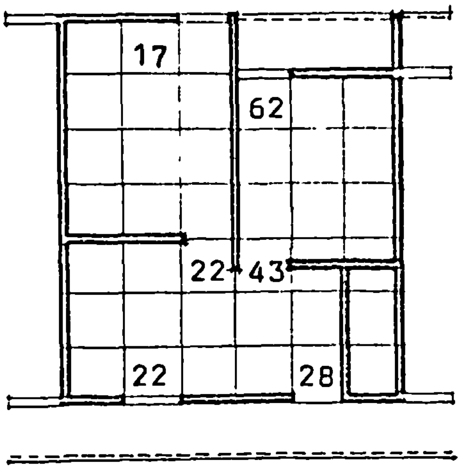


Figure (A7.14) C_{vn} values for Model C3

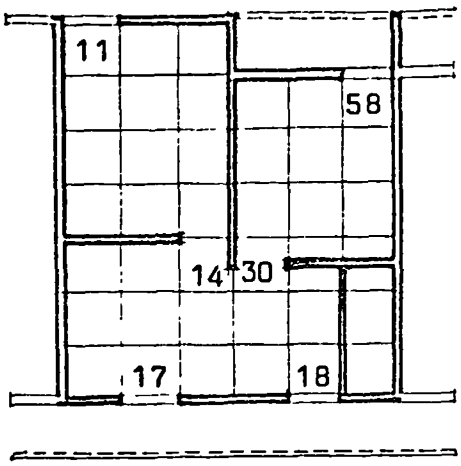
Angle of wind = 45°

Free stream mean speed = 1 m/s

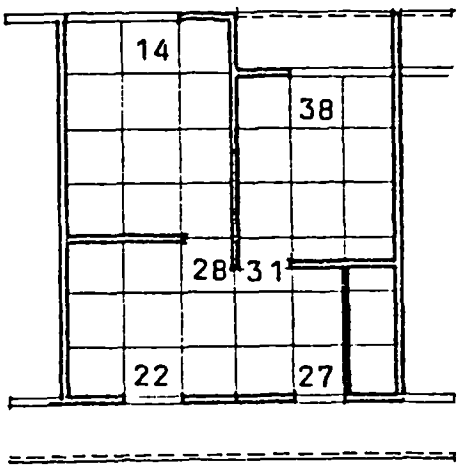
Air temperature = 21°C



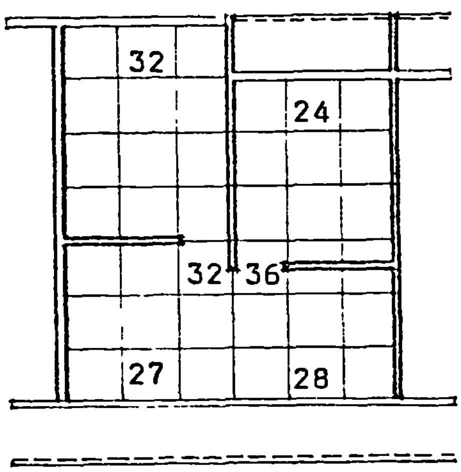
C3/5



C3/6



C3/7



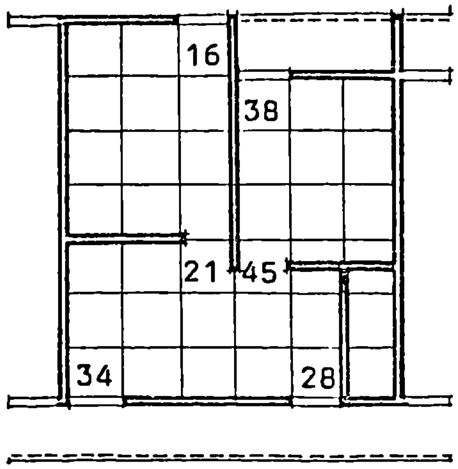
C3/8

Figure (A7.14) continued.

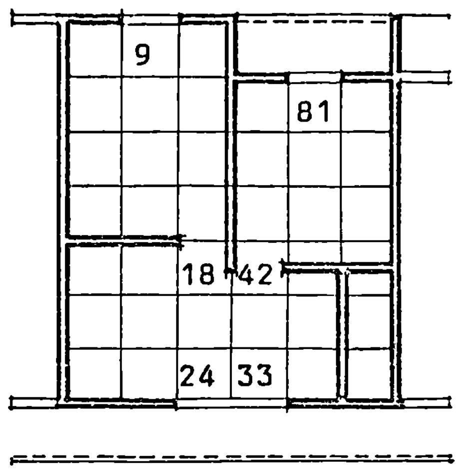
Angle of wind = 45^{o}

Free stream mean speed = 1 m/s

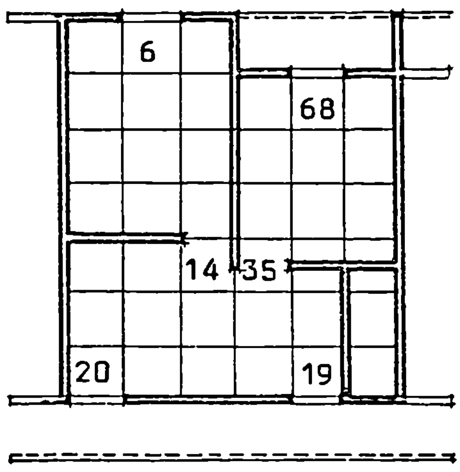
Air temperature = $21^{o}C$



C3/9



C3/10



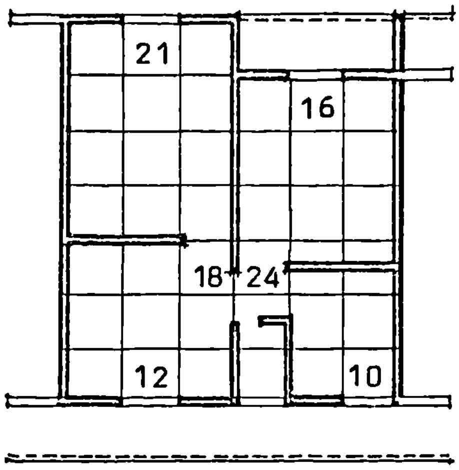
C3/11

Figure (A7.14) continued.

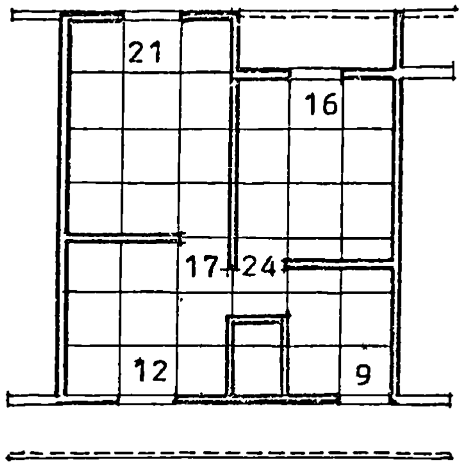
Angle of wind = 45^{o}

Free stream mean speed = 1 m/s

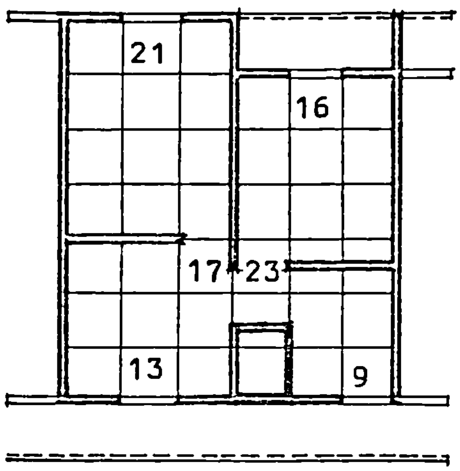
Air temperature = $21^{o}C$



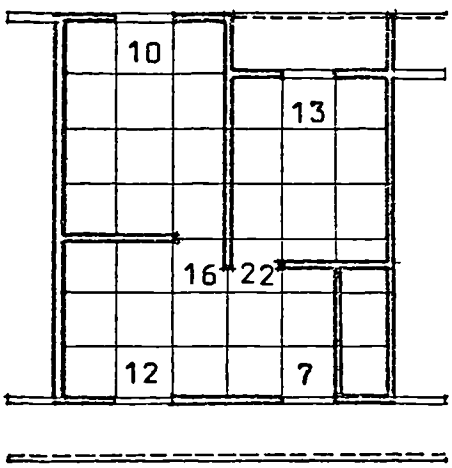
C4/1



C4/2



C4/3



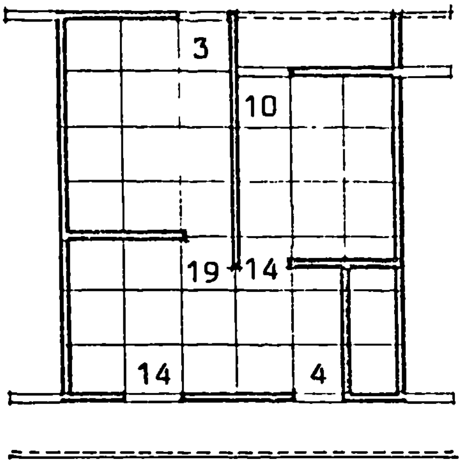
C4/4

Figure (A7.15) C_{vn} values for Model C4

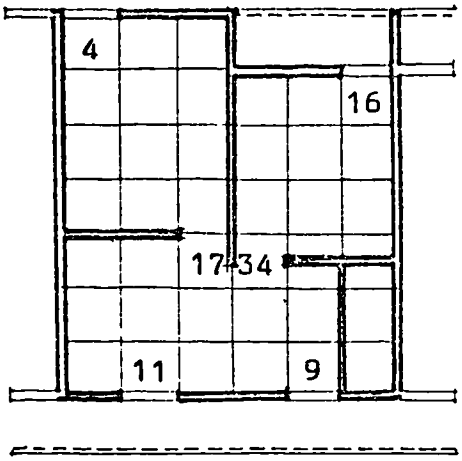
Angle of wind = 90°

Free stream mean speed = 1 m/s

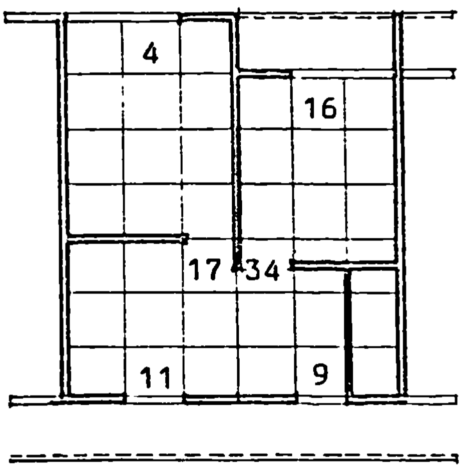
Air temperature = 21°C



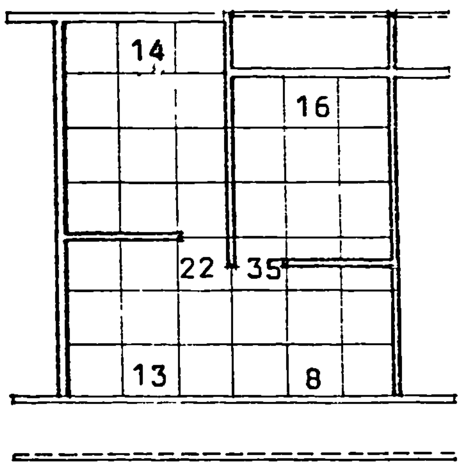
C4/5



C4/6



C4/7



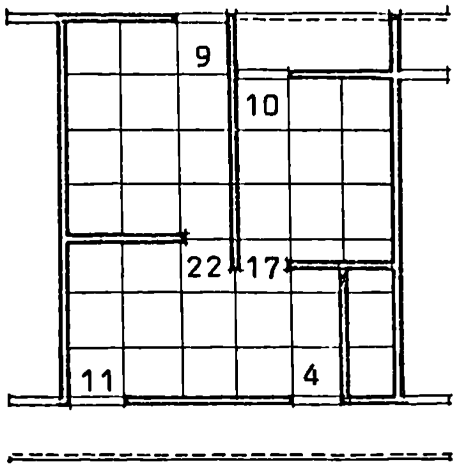
C4/8

Figure (A7.15) continued.

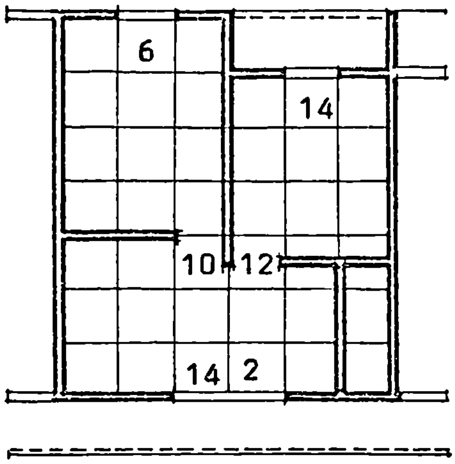
Angle of wind = 90^{o}

Free stream mean speed = 1 m/s

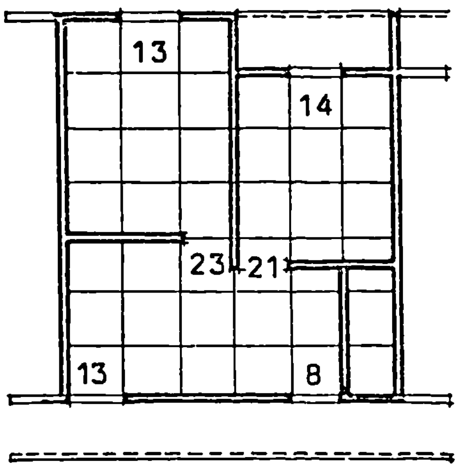
Air temperature = $21^{o}C$



C4/9



C4/10



C4/11

Figure (A7.15) continued.

Angle of wind	=	90^o
Free stream mean speed	=	1 m/s
Air temperature	=	21^oC

Table (A7.13) Results of model category D1

Angle of Wind = 0°
Free Stream Mean Speed = 1 m/s
Air Temperature = 20°C

Model	Set	P1	P2	P3	P4	P5	P6	P7
D1/1	1	2•927	2•848	3•137	3•036	3•021	3•051	
	2	2•924	2•849	3•139	3•031	3•020	3•058	
	3	2•925	2•849	3•138	3•027	3•020	3•056	
	av.	2•925	2•849	3•138	3•031	3•020	3•055	
	C_{vn}	0•58	0•39	0•63	0•42	0•25	0•18	
D1/2	1	2•943	2•803	3•029	3•051	3•018	3•041	
	2	2•952	2•809	3•033	3•047	3•017	3•039	
	3	2•943	2•797	3•033	3•048	3•019	3•029	
	av.	2•946	2•803	3•032	3•049	3•018	3•036	
	C_{vn}	0•63	0•31	0•42	0•46	0•25	0•15	
D1/3	1	2•943	2•695	2•938	3•001	2•982	3•103	9•272
	2	2•939	2•693	2•946	2•999	2•984	3•098	9•287
	3	2•943	2•694	2•943	2•999	2•981	3•100	9•285
	av.	2•942	2•694	2•942	3•000	2•982	3•100	9•281
	C_{vn}	0•61	0•12	0•27	0•35	0•19	0•25	0•44
D1/4	1	2•940	2•730	2•929	2•977	2•980	3•071	9•331
	2	2•936	2•728	2•939	2•979	2•983	3•077	9•352
	3	2•940	2•719	2•933	2•974	2•985	3•073	9•339
	av.	2•939	2•726	2•934	2•977	2•983	3•074	9•341
	C_{vn}	0•60	0•17	0•26	0•30	0•19	0•21	0•49
D1/5	1	2•874	2•738	2•928	3•025	2•986	3•102	9•065
	2	2•874	2•732	2•939	3•024	2•985	3•101	9•018
	3	2•879	2•729	2•938	3•027	2•985	3•103	9•009
	av.	2•876	2•733	2•935	3•025	2•985	3•102	9•031
	C_{vn}	0•49	0•18	0•26	0•41	0•20	0•26	0•33
D1/6	1	2•821	2•784	2•939	3•019	2•987	3•077	9•030
	2	2•841	2•794	2•947	3•014	3•003	3•089	8•970
	3	2•818	2•784	2•933	3•018	3•003	3•083	8•953
	av.	2•827	2•787	2•940	3•017	2•995	3•083	8•984
	C_{vn}	0•36	0•28	0•27	0•39	0•21	0•23	0•31

Table (A7.13) continued

Model	Set	P1	P2	P3	P4	P5	P6	P7
D1/7	1	2•903	2•805	3•019	3•024	2•974	3•094	9•256
	2	2•901	2•791	3•028	3•033	2•979	3•087	9•291
	3	2•905	2•801	3•030	3•028	2•981	3•089	9•249
	av.	2•903	2•799	3•026	3•028	2•978	3•090	9•265
	C_{vn}	0•53	0•30	0•41	0•42	0•18	0•24	0•43
D1/8	1	2•962	2•717	2•985	2•995	2•974	3•063	9•403
	2	2•959	2•722	2•991	2•997	2•973	3•065	9•382
	3	2•957	2•716	2•985	2•909	2•971	3•065	9•349
	av.	2•959	2•718	2•987	2•997	2•973	3•064	9•378
	C_{vn}	0•66	0•16	0•34	0•34	0•17	0•19	0•47
D1/9	1	2•988	2•737	3•097	2•965	2•994	3•051	9•574
	2	2•995	2•751	3•094	2•967	2•998	3•059	9•577
	3	2•991	2•745	3•093	2•964	2•994	3•059	9•568
	av.	2•991	2•744	3•095	2•965	2•995	3•056	9•573
	C_{vn}	0•74	0•21	0•54	0•28	0•21	0•18	0•57
D1/10	1	2•876	2•724	2•957	2•996	2•977	3•115	9•285
	2	2•873	2•727	2•965	2•998	2•974	3•113	9•300
	3	2•858	2•733	2•961	2•998	2•980	3•117	9•230
	av.	2•869	2•728	2•961	2•997	2•977	3•115	9•272
	C_{vn}	0•45	0•17	0•30	0•34	0•18	0•29	0•43
D1/11	1	2•947	2•663	2•974	3•003	2•972	3•106	9•209
	2	2•950	2•663	2•975	2•999	2•969	3•115	9•213
	3	2•938	2•663	2•971	2•994	2•977	3•100	9•241
	av.	2•945	2•663	2•973	2•999	2•973	3•107	9•221
	C_{vn}	0•62	0•06	0•32	0•37	0•17	0•27	0•43
D1/12	1	2•855	2•832	3•020	3•055	2•984	3•075	9•166
	2	2•857	2•824	3•014	3•060	2•982	3•081	9•137
	3	2•859	2•821	3•017	3•060	2•979	3•080	9•178
	av.	2•857	2•826	3•017	3•068	2•982	3•079	9•160
	C_{vn}	0•43	0•35	0•39	0•51	0•19	0•22	0•43

Table (A7.14) Results of model category D2

Angle of Wind = -45^{o}
Free Stream Mean Speed = 1 m/s
Air Temperature = $20^{o}C$

Model	Set	P1	P2	P3	P4	P5	P6	P7
D2/1	1	2•903	2•887	3•111	2•977	3•037	3•037	
	2	2•905	2•879	3•108	2•977	3•033	3•031	
	3	2•905	2•882	3•111	2•976	3•036	3•024	
	av.	2•904	2•882	3•110	2•977	3•035	3•032	
	C_{vn}	0•53	0•45	0•38	0•30	0•28	0•14	
D2/2	1	2•886	2•828	3•011	2•937	3•025	3•000	
	2	2•890	2•831	3•012	2•933	3•021	3•000	
	3	2•886	2•832	3•010	2•934	3•026	3•000	
	av.	2•887	2•830	3•011	2•935	3•024	3•000	
	C_{vn}	0•89	0•36	0•38	0•21	0•26	0•09	
D2/3	1	3•047	2•689	2•984	2•990	2•982	3•105	9•525
	2	3•047	2•684	2•991	2•989	2•991	3•107	9•539
	3	3•049	2•689	2•988	2•990	2•989	3•104	9•544
	av.	3•047	2•688	2•988	2•990	2•987	3•105	9•536
	C_{vn}	0•89	0•10	0•34	0•33	0•20	0•27	0•55
D2/4	1	2•803	2•693	2•920	3•007	2•985	3•083	9•321
	2	2•806	2•697	2•921	2•997	2•978	3•096	9•319
	3	2•791	2•696	2•919	3•007	2•984	3•093	9•324
	av.	2•800	2•696	2•920	3•004	2•982	3•091	9•321
	C_{vn}	0•31	0•12	0•22	0•36	0•19	0•24	0•46
D2/5	1	2•757	2•687	2•962	3•019	2•979	3•088	9•534
	2	2•760	2•693	2•967	3•021	2•976	3•091	9•537
	3	2•765	2•685	2•962	3•017	2•983	3•090	9•531
	av.	2•761	2•688	2•964	3•019	2•979	3•090	9•534
	C_{vn}	0•22	0•10	0•30	0•39	0•18	0•24	0•55
D2/6	1	2•711	2•698	2•935	2•989	3•007	3•050	9•861
	2	2•711	2•690	2•934	2•986	3•005	3•049	9•866
	3	2•711	2•701	2•937	2•990	3•031	3•049	9•820
	av.	2•711	2•696	2•935	2•988	3•014	3•050	9•851
	C_{vn}	0•12	0•12	0•25	0•32	0•24	0•17	0•72

Table (A7.14) continued

Model	Set	P1	P2	P3	P4	P5	P6	P7
D2/7	1	2•761	2•696	3•018	3•033	2•993	3•070	9•696
	2	2•769	2•698	3•015	3•027	2•985	3•070	9•658
	3	2•765	2•705	3•019	3•028	2•993	3•071	9•684
	av.	2•765	2•700	3•018	3•029	2•991	3•070	9•679
	C_{vn}	0•23	0•13	0•40	0•42	0•20	0•20	0•62
D2/8	1	2•874	2•701	3•022	3•025	3•001	3•071	9•592
	2	2•866	2•701	3•025	3•022	3•000	3•070	9•608
	3	2•889	2•698	3•027	3•021	2•993	3•065	9•600
	av.	2•876	2•700	3•025	3•023	2•998	2•069	9•600
	C_{vn}	0•47	0•13	0•41	0•41	0•21	0•20	0•58
D2/9	1	2•915	2•790	3•134	3•023	3•031	3•033	9•956
	2	2•904	2•803	3•130	3•023	3•027	3•033	9•924
	3	2•915	2•784	3•130	3•021	3•033	3•037	9•912
	av.	2•911	2•792	3•131	3•023	3•030	3•034	9•931
	C_{vn}	0•55	0•29	0•62	0•41	0•27	0•16	0•82
D2/10	1	2•845	2•673	2•967	2•987	2•964	3•087	9•718
	2	2•849	2•673	2•973	2•987	2•963	3•084	9•714
	3	2•847	2•672	2•967	2•989	2•972	3•087	9•722
	av.	2•847	2•674	2•969	2•988	2•966	3•086	9•718
	C_{vn}	0•40	0•08	0•31	0•32	0•16	0•23	0•66
D2/11	1	3•054	2•685	2•963	3•008	2•969	3•117	9•442
	2	3•058	2•686	2•960	3•007	2•975	3•107	9•430
	3	3•060	2•692	2•968	3•009	2•973	3•111	9•420
	av.	3•057	2•688	2•964	3•008	2•972	3•112	9•431
	C_{vn}	0•92	0•10	0•30	0•37	0•17	0•28	0•49
D2/12	1	2•735	2•736	3•016	3•009	3•061	3•029	10•052
	2	2•723	2•727	3•004	3•014	3•041	3•029	10•002
	3	2•723	2•763	3•014	3•008	3•053	3•036	9•976
	av.	2•727	2•742	3•011	3•010	3•052	3•032	10•010
	C_{vn}	0•16	0•20	0•38	0•38	0•31	0•14	0•82

Table (A7.15) Results of model category D3

Angle of Wind = 45°
Free Stream Mean Speed = 1 m/s
Air Temperature = 20°C

Model	Set	P1	P2	P3	P4	P5	P6	P7
D3/1	1	2•796	2•706	3•079	3•059	2•977	3•053	
	2	2•788	2•703	3•076	3•061	2•974	3•050	
	3	2•793	2•705	3•073	3•061	2•975	3•060	
	av.	2•792	2•705	3•076	3•060	2•975	3•054	
	C_{vn}	0•29	0•14	0•50	0•49	0•18	0•18	
D3/1	1	2•787	2•751	3•027	3•090	3•007	3•024	
	2	2•784	2•748	3•023	3•090	3•004	3•023	
	3	2•781	2•750	3•024	3•090	3•010	3•021	
	av.	2•784	2•750	3•025	3•090	3•007	3•023	
	C_{vn}	0•27	0•21	0•41	0•56	0•23	0•12	
D3/3	1	2•699	2•719	2•941	2•981	2•997	3•081	9•495
	2	2•695	2•719	2•946	2•980	3•007	3•086	9•472
	3	2•700	2•729	2•946	2•982	2•999	3•086	9•475
	av.	2•698	2•722	2•944	2•981	3•001	3•083	9•480
	C_{vn}	0•10	0•16	0•27	0•31	0•22	0•22	0•53
D3/4	1	2•715	2•721	2•891	2•939	2•998	3•071	9•582
	2	2•722	2•725	2•897	2•949	2•993	3•065	9•544
	3	2•718	2•722	2•891	2•940	3•001	3•073	9•590
	av.	2•718	2•723	2•893	2•943	2•998	3•069	9•572
	C_{vn}	0•14	0•16	0•17	0•24	0•22	0•20	0•57
D3/5	1	2•920	2•741	2•913	3•049	3•097	3•100	9•368
	2	2•923	2•736	2•913	3•049	3•101	3•100	9•423
	3	2•915	2•735	2•906	3•049	3•095	3•100	9•381
	av.	2•919	2•737	2•911	3•048	3•098	3•100	9•394
	C_{vn}	0•56	0•19	0•21	0•46	0•38	0•26	0•53
D3/6	1	2•811	2•799	2•910	2•997	3•179	3•079	8•298
	2	2•808	2•795	2•914	2•995	3•177	3•072	8•318
	3	2•814	2•795	2•909	2•993	3•169	3•075	8•256
	av.	2•811	2•796	2•911	2•995	3•175	3•075	8•291
	C_{vn}	0•33	0•29	0•21	0•34	0•56	0•21	0•18

Table (A7.15) continued

Model	Set	P1	P2	P3	P4	P5	P6	P7
D3/7	1	2•941	2•771	3•008	3•016	3•073	3•080	9•748
	2	2•937	2•773	2•999	3•013	3•041	3•080	9•696
	3	2•940	2•770	3•001	3•013	3•058	3•080	9•664
	av.	2•939	2•771	3•003	3•014	3•057	3•080	9•703
	C_{vn}	0•60	0•25	0•37	0•38	0•32	0•22	0•62
D3/8	1	2•712	2•744	2•974	2•973	2•983	3•073	9•450
	2	2•712	2•743	2•970	2•970	2•995	3•071	9•470
	3	2•713	2•745	2•977	2•964	2•977	3•070	9•470
	av.	2•712	2•743	2•974	2•968	2•984	3•071	9•460
	C_{vn}	0•13	0•21	0•32	0•28	0•20	0•21	0•54
D3/9	1	1•765	2•760	3•072	2•943	3•009	3•048	9•494
	2	2•767	2•762	3•070	2•947	3•025	3•049	9•500
	3	2•767	2•765	3•070	2•947	3•003	3•047	9•472
	av.	2•766	2•762	3•071	2•946	3•012	3•048	9•489
	C_{vn}	0•23	0•23	0•49	0•24	0•24	0•16	0•56
D3/10	1	2•697	2•673	2•987	2•991	2•979	3•133	9•538
	2	2•700	2•673	2•974	2•991	2•977	3•133	9•480
	3	2•699	2•675	2•976	2•990	2•977	3•123	9•486
	av.	2•699	2•674	2•976	2•991	2•978	3•129	9•501
	C_{vn}	0•10	0•08	0•32	0•33	0•18	0•32	0•53
D3/11	1	2•684	2•741	2•936	2•988	3•015	3•081	9•486
	2	2•686	2•744	2•939	2•981	3•020	3•080	9•444
	3	2•681	1•747	2•940	2•983	3•008	3•080	9•428
	av.	2•684	2•744	2•938	2•984	3•014	3•080	9•453
	C_{vn}	0•07	0•21	0•26	0•32	0•24	0•22	0•53
D3/12	1	2•770	2•800	2•978	3•010	3•105	3•073	9•730
	2	2•772	2•798	2•981	3•010	3•111	3•070	9•692
	3	2•771	2•797	2•984	3•009	3•113	3•072	9•738
	av.	2•771	2•798	2•981	3•010	3•110	3•072	9•720
	C_{vn}	0•24	0•30	0•33	0•38	0•42	0•21	0•64

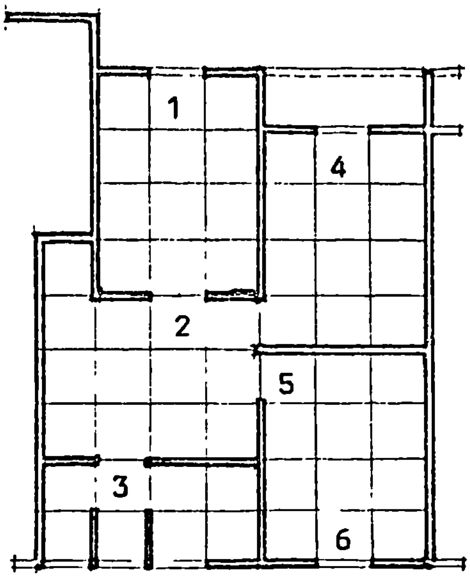
Table (A7.16) Results of model category D4

Angle of Wind = 90°
Free Stream Mean Speed = 1 m/s
Air Temperature = 20°C

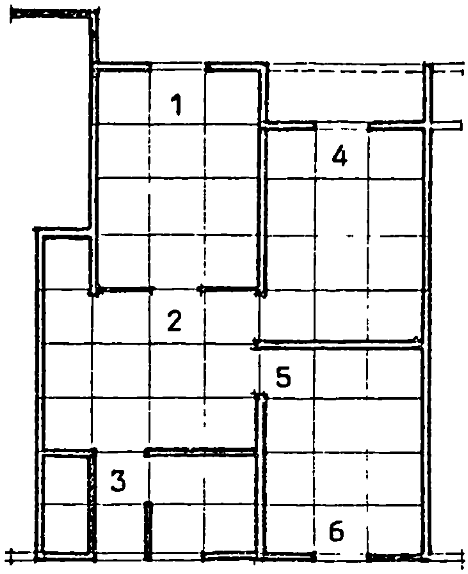
Model	Set	P1	P2	P3	P4	P5	P6	P7
D4/1	1	2•807	2•680	2•887	2•932	2•973	3•061	
	2	2•810	2•683	2•898	2•932	2•984	3•056	
	3	2•810	2•681	2•895	2•914	2•993	3•057	
	av.	2•809	2•681	2•893	2•926	2•983	3•059	
	C_{vn}	0•32	0•10	0•17	0•20	0•19	0•18	
D4/2	1	2•785	2•671	2•943	2•909	2•983	3•001	
	2	2•787	2•675	2•943	2•899	2•970	3•010	
	3	2•793	2•674	2•938	2•916	2•989	3•010	
	av.	2•788	2•673	2•941	2•908	2•981	3•007	
	C_{vn}	0•28	0•08	0•27	0•18	0•18	0•10	
D4/3	1	2•773	2•763	2•879	2•909	3•037	3•061	8•661
	2	2•770	2•773	2•873	2•911	3•045	3•059	8•575
	3	2•768	2•775	2•882	2•913	3•045	3•060	8•589
	av.	2•770	2•770	2•878	2•911	3•042	3•060	8•608
	C_{vn}	0•25	0•25	0•15	0•18	0•29	0•19	0•23
D4/4	1	2•856	2•795	2•833	2•807	3•040	3•035	7•803
	2	2•852	2•796	2•833	2•805	3•040	3•036	7•784
	3	2•843	2•793	2•830	2•803	3•040	3•037	7•795
	av.	2•850	2•795	2•829	2•805	3•040	3•036	7•794
	C_{vn}	0•41	0•30	0•07	0•03	0•29	0•14	0•11
D4/5	1	2•973	2•759	2•855	2•915	3•129	3•056	7•608
	2	2•966	2•761	2•857	2•918	3•130	3•059	7•702
	3	2•981	2•761	2•859	2•920	3•131	3•057	7•672
	av.	2•973	2•760	2•857	2•918	3•130	3•058	7•661
	C_{vn}	0•70	0•23	0•11	0•19	0•46	0•18	0•08
D4/6	1	2•819	2•783	2•835	2•900	3•132	3•043	8•044
	2	2•813	2•782	2•831	2•901	3•131	3•044	7•978
	3	2•816	2•781	2•827	2•902	3•138	3•043	7•970
	av.	2•816	2•782	2•831	2•901	3•134	3•043	7•997
	C_{vn}	0•34	0•27	0•08	0•16	0•47	0•16	0•10

Table (A7.16) continued

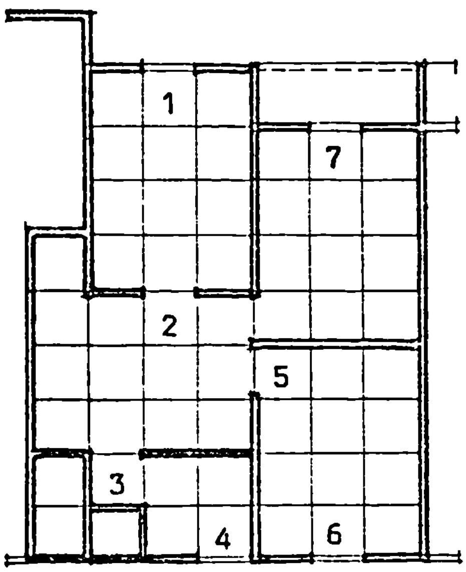
Model	Set	P1	P2	P3	P4	P5	P6	P7
D4/7	1	2•890	2•790	2•891	2•917	3•102	3•035	7•946
	2	2•889	2•793	2•894	2•917	3•107	3•034	7•942
	1	2•889	2•795	2•885	2•919	3•109	3•033	7•986
	av.	2•889	2•792	2•890	2•918	3•106	3•034	7•958
	C_{vn}	0•50	0•30	0•17	0•19	0•42	0•14	0•12
D4/8	1	2•855	2•783	2•894	2•887	3•037	3•062	8•636
	2	2•865	2•784	2•899	2•885	3•032	3•060	8•532
	3	2•862	2•791	2•894	2•883	3•037	3•063	8•580
	av.	2•861	2•786	2•896	2•885	3•035	3•062	8•583
	C_{vn}	0•44	0•28	0•18	0•14	0•28	0•19	0•21
D4/9	1	2•845	2•797	2•883	2•865	3•023	3•028	8•524
	2	2•845	2•794	2•882	2•863	3•030	3•036	8•568
	3	2•854	2•792	2•887	2•867	3•034	3•033	8•458
	av.	2•848	2•794	2•884	2•865	3•029	3•032	8•523
	C_{vn}	0•40	0•30	0•16	0•11	0•27	0•14	0•25
D4/10	1	2•744	2•680	2•874	2•867	2•915	3•070	8•774
	2	2•755	2•680	2•863	2•871	2•910	3•069	8•756
	3	2•749	2•680	2•871	2•870	2•911	3•070	8•726
	av.	2•749	2•680	2•869	2•869	2•912	3•070	8•752
	C_{vn}	0•20	0•09	0•13	0•11	0•07	0•20	0•23
D4/11	1	2•706	2•769	2•835	2•835	3•072	3•031	8•556
	2	2•712	2•764	2•838	2•841	3•082	3•030	8•442
	3	2•705	2•767	2•840	2•838	3•078	3•030	8•406
	av.	2•708	2•767	2•838	2•838	3•077	3•030	8•468
	C_{vn}	0•12	0•24	0•08	0•07	0•36	0•14	0•19
D4/12	1	2•829	2•794	2•869	2•920	3•127	3•029	7•780
	2	2•835	2•790	2•863	2•928	3•127	3•025	2•728
	3	2•827	2•794	2•869	2•923	3•128	3•027	7•732
	av.	2•830	2•793	2•867	2•924	3•128	3•027	7•747
	C_{vn}	0•37	0•30	0•13	0•20	0•46	0•13	0•10



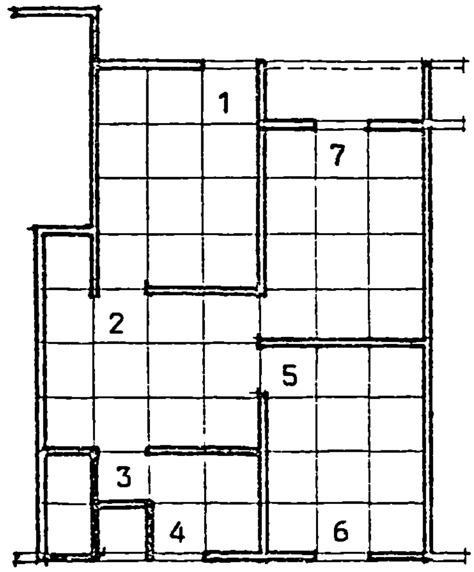
D /1



D /2

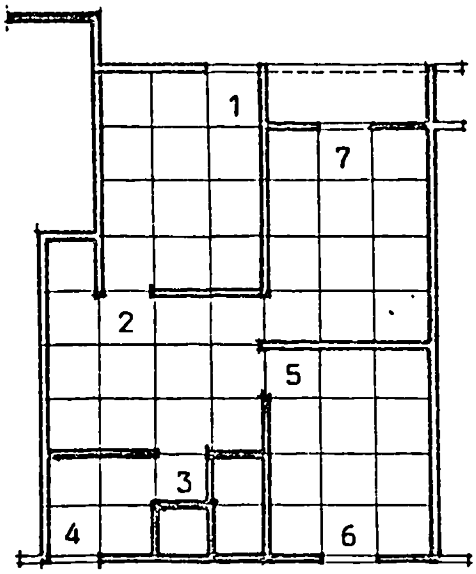


D /10

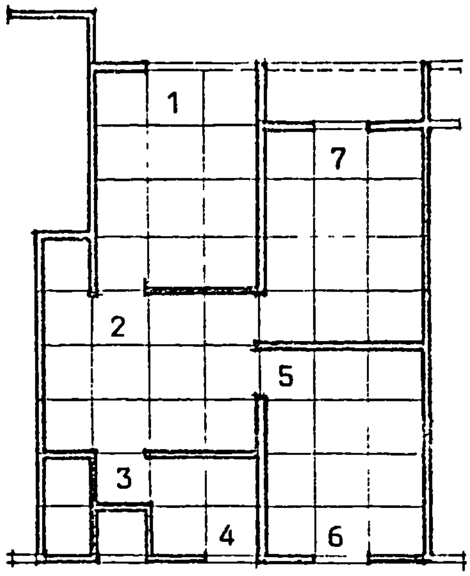


D /3

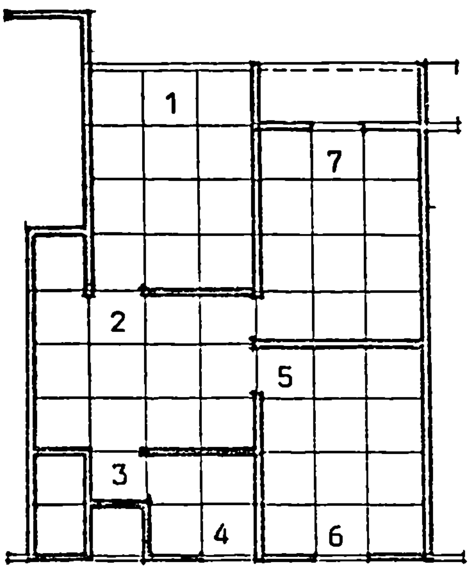
Figure (A7.16) Probe guide for model D.



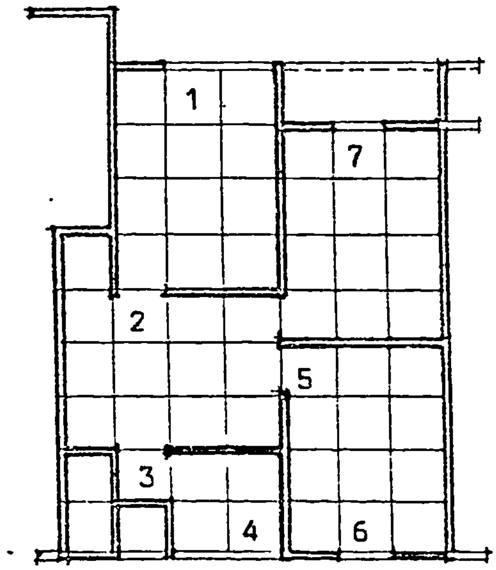
D /4



D /5

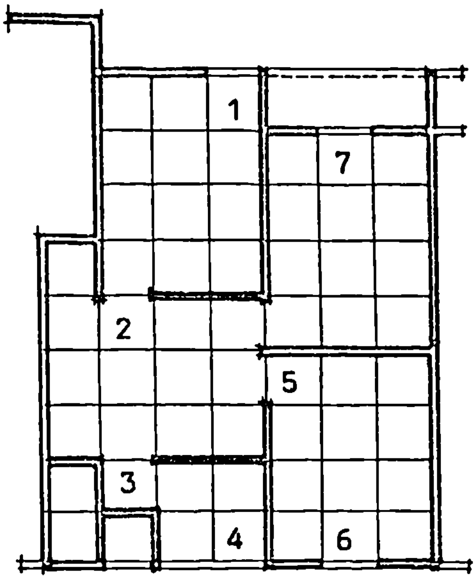


D /6

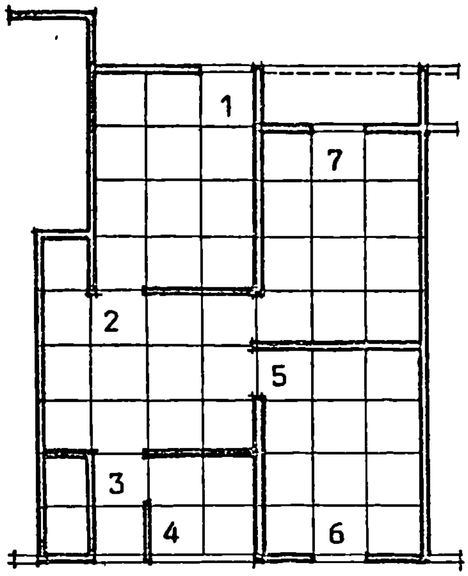


D /7

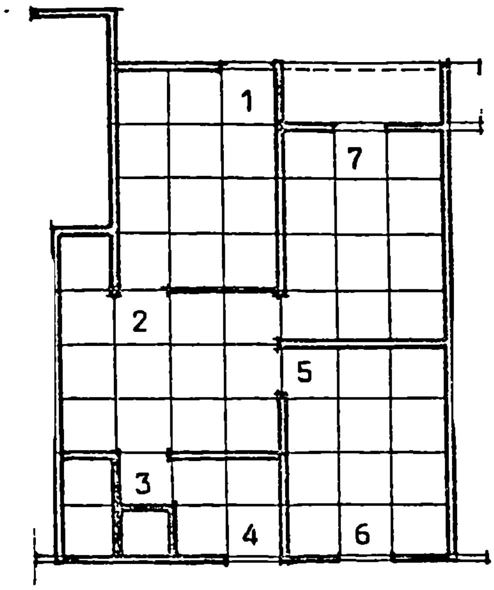
Figure (A7.16) continued.



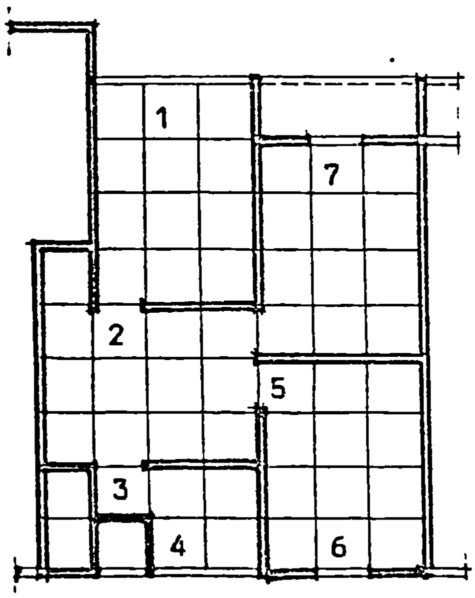
D /8



D /9

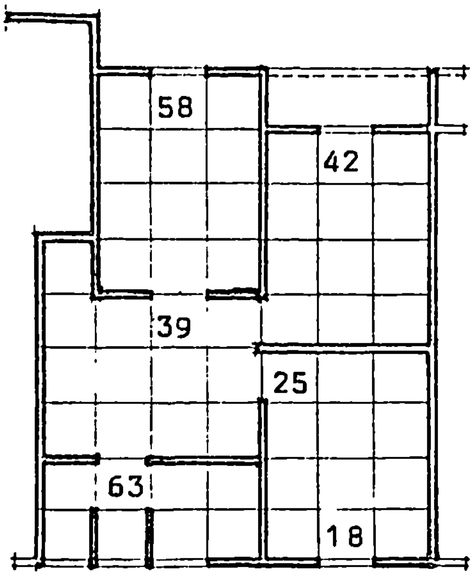


D /11

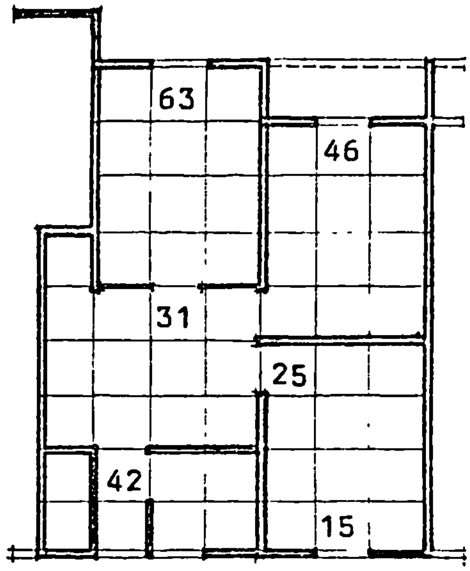


D /12

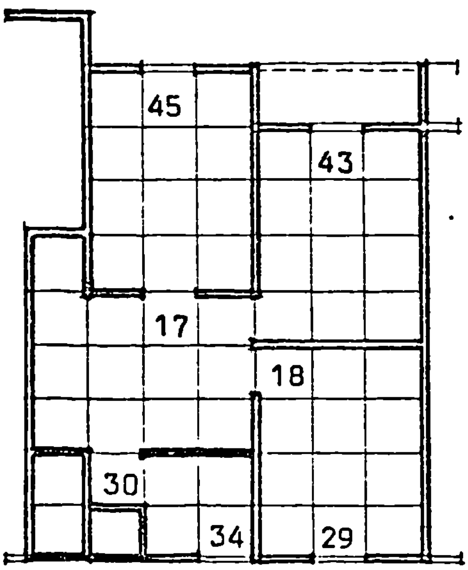
Figure (A7.16) continued.



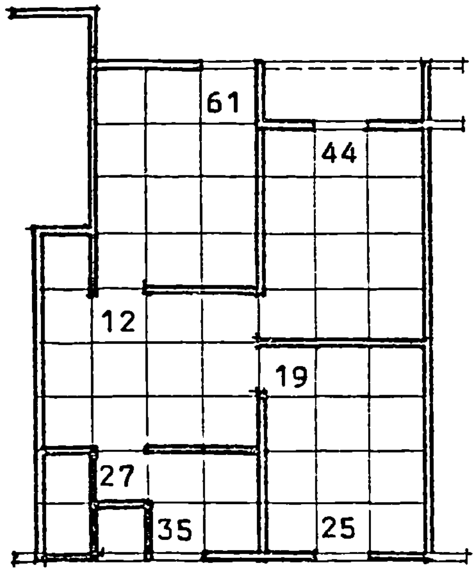
D1/1



D1/2



D1/10



D1/3

Figure (A7.17) C_{vn} values for Model D1

Angle of wind = 0^{o}

Free stream mean speed = 1 m/s

Air temperature = $20^{o}C$

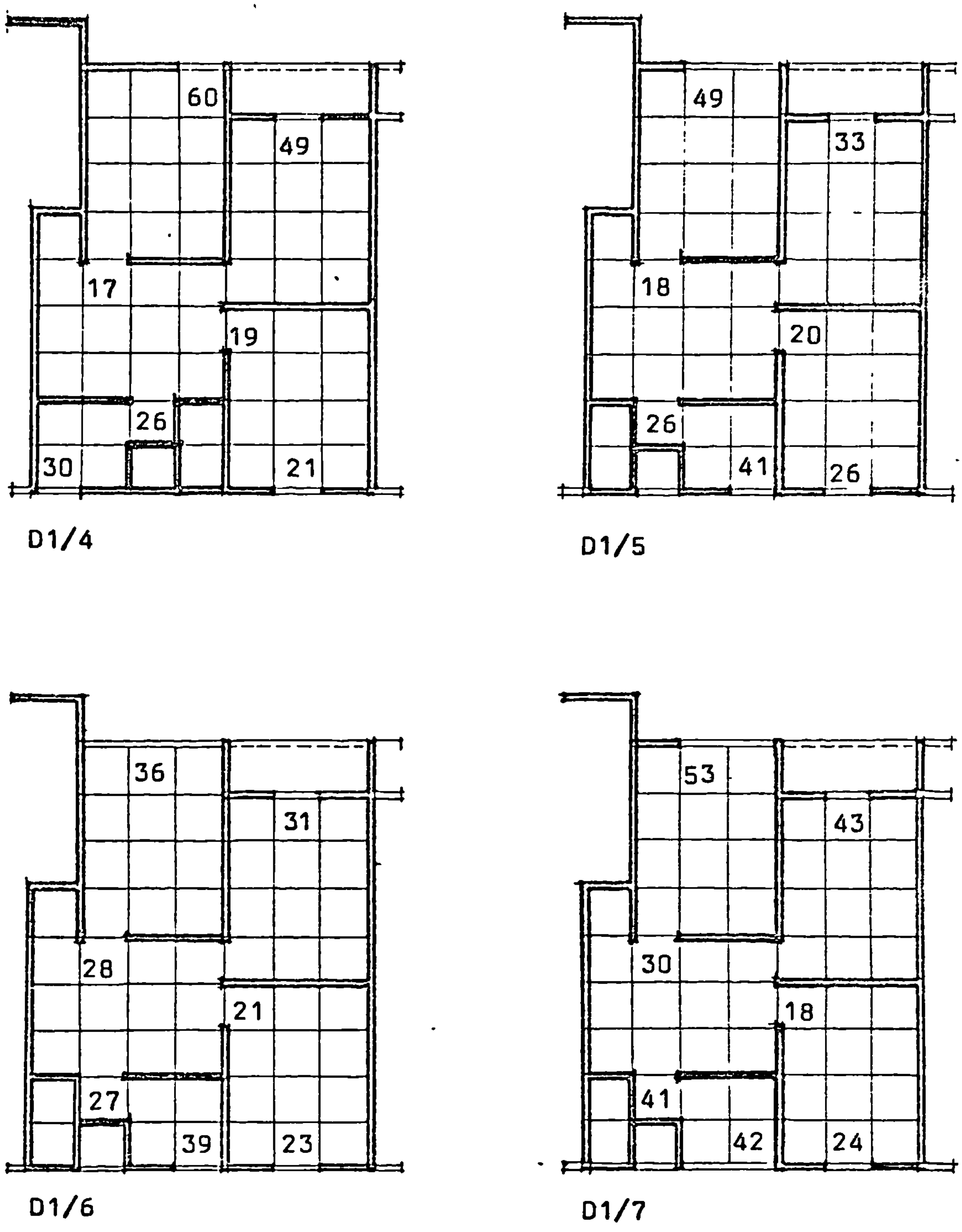
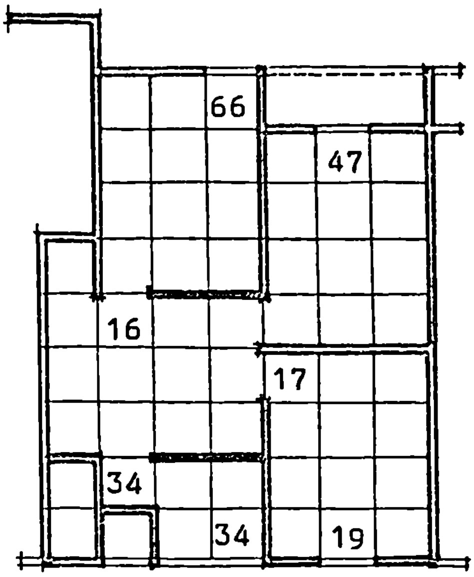
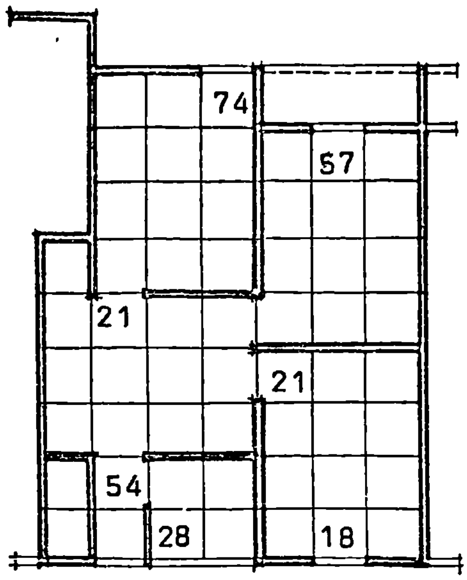


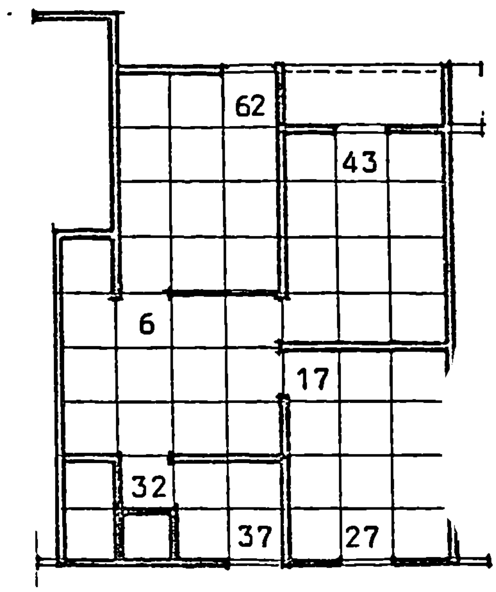
Figure (A7.17) continued.
Angle of wind = 0^o
Free stream mean speed = 1 m/s
Air temperature = 20^oC



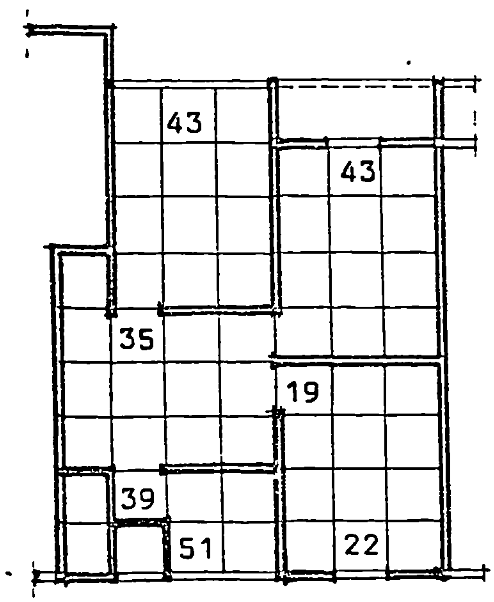
D1/8



D1/9



D1/11



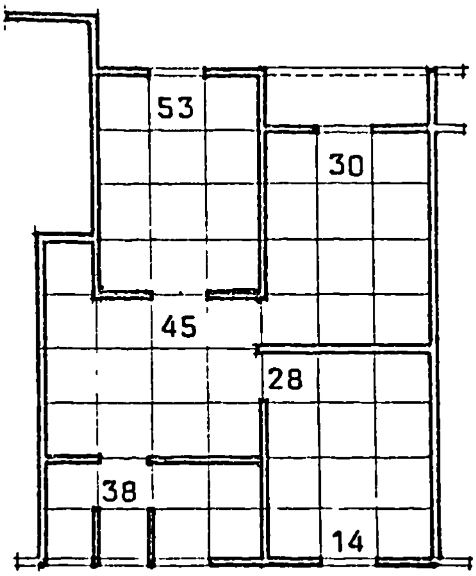
D1/12

Figure (A7.17) continued.

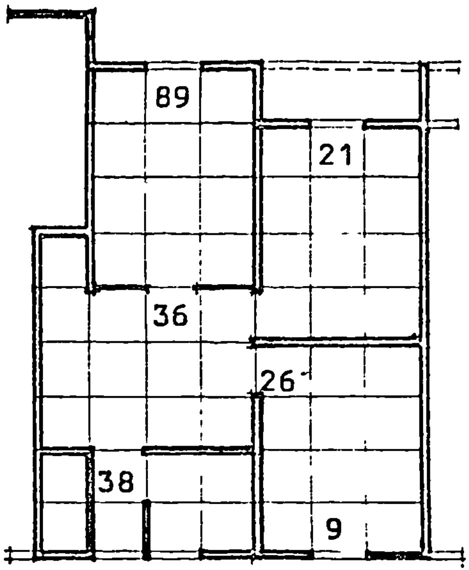
Angle of wind = 0^{o}

Free stream mean speed = 1 m/s

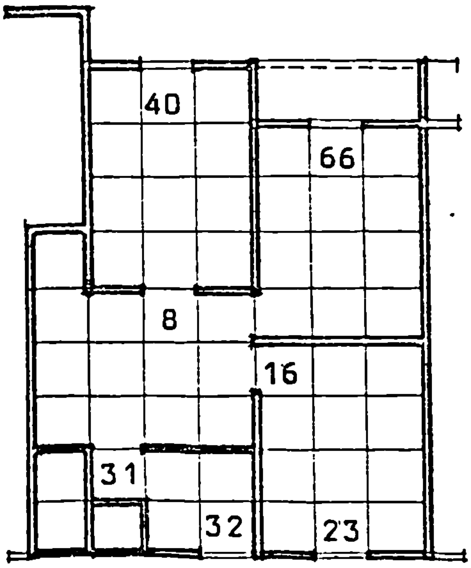
Air temperature = $20^{o}C$



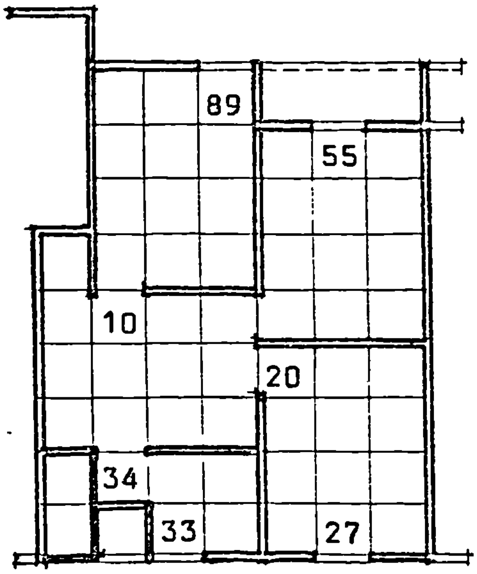
D2/1



D2/2



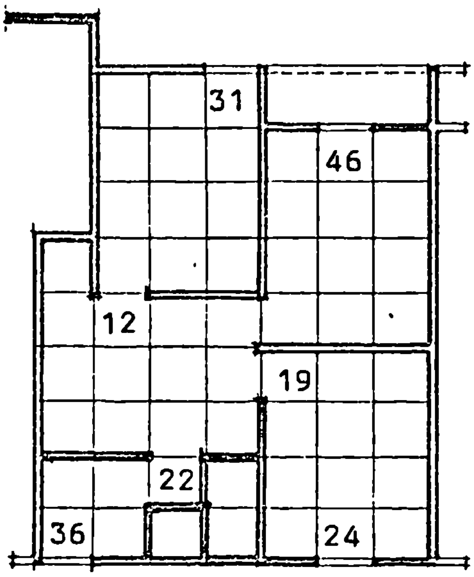
D2/10



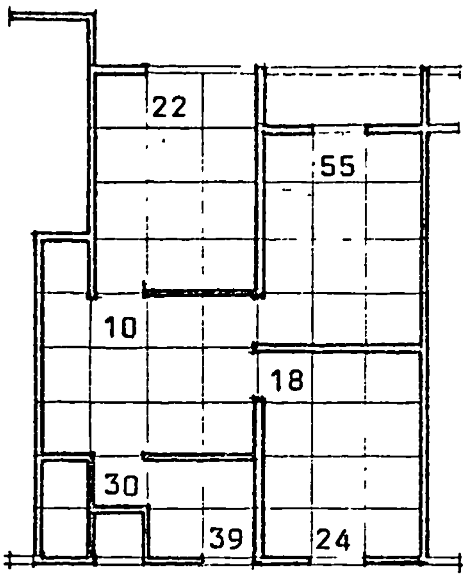
D2/3

Figure (A7.18) C_{vn} values for Model D2

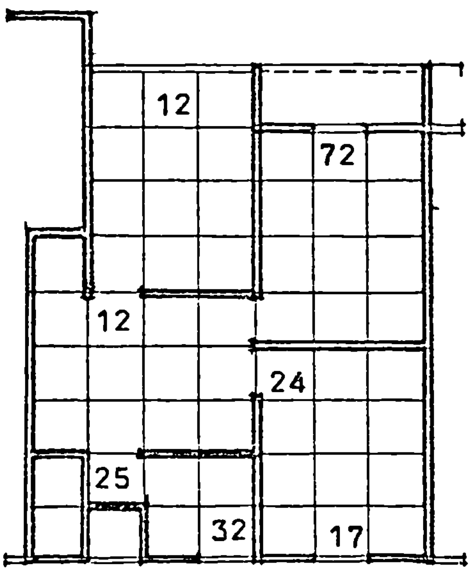
Angle of wind	=	-45°
Free stream mean speed	=	1 m/s
Air temperature	=	20°C



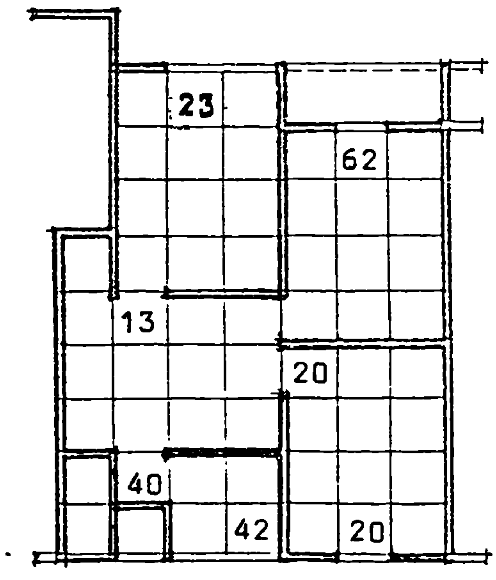
D2/4



D2/5



D2/6



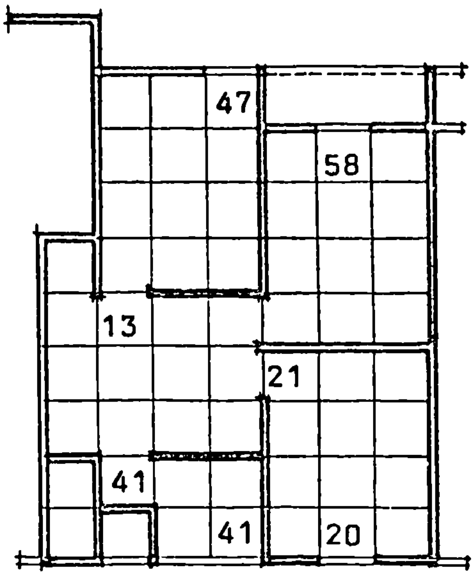
D2/7

Figure (A7.18) continued.

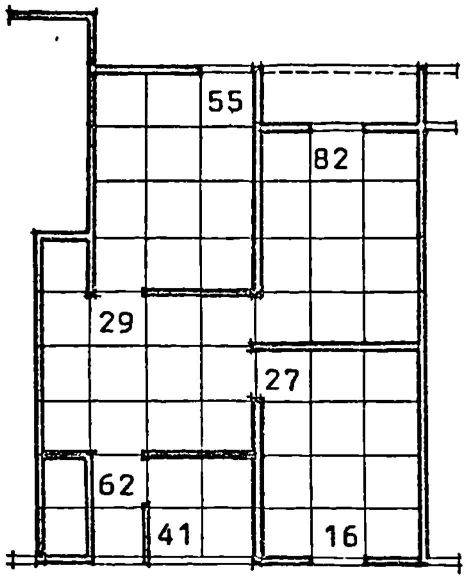
Angle of wind = -45^{o}

Free stream mean speed = 1 m/s

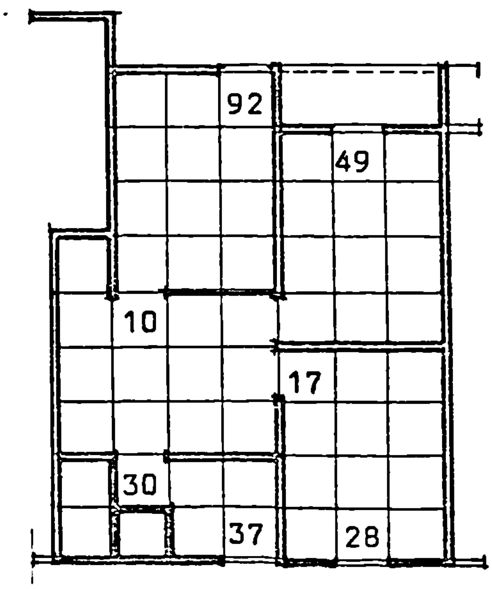
Air temperature = $20^{o}C$



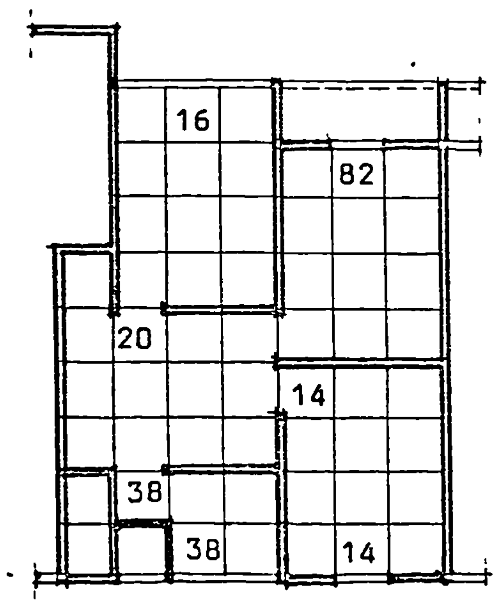
D2/8



D2/9



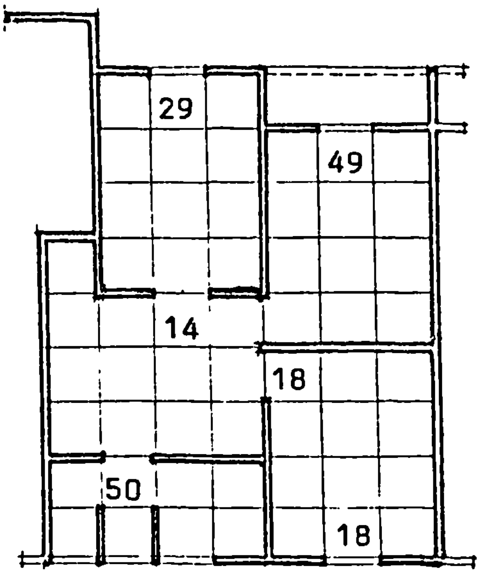
D2/11



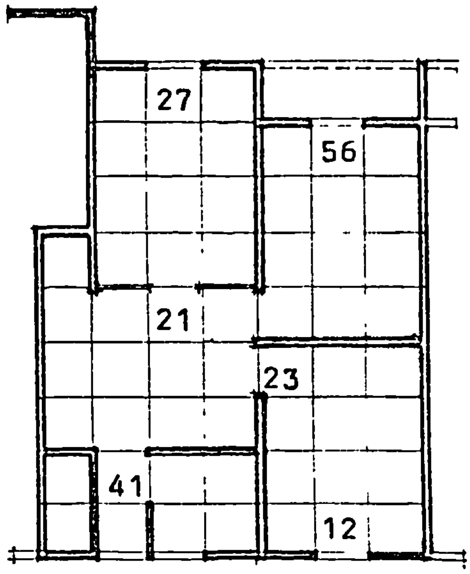
D2/12

Figure (A7.18) continued.

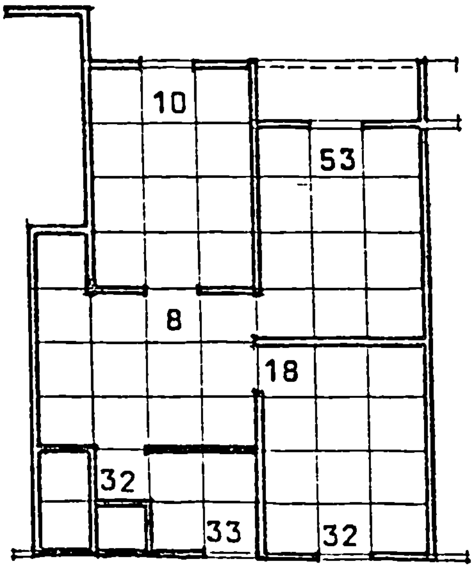
Angle of wind	=	-45°
Free stream mean speed	=	1 m/s
Air temperature	=	20°C



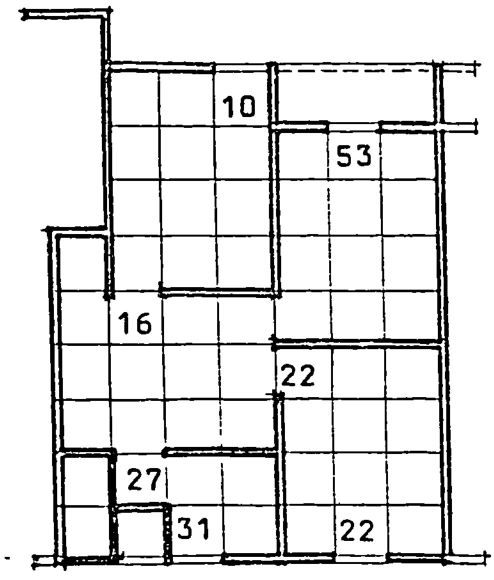
D3/1



D3/2



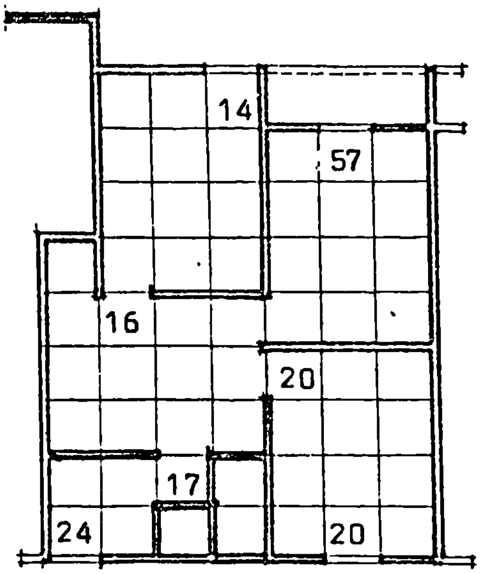
D3/10



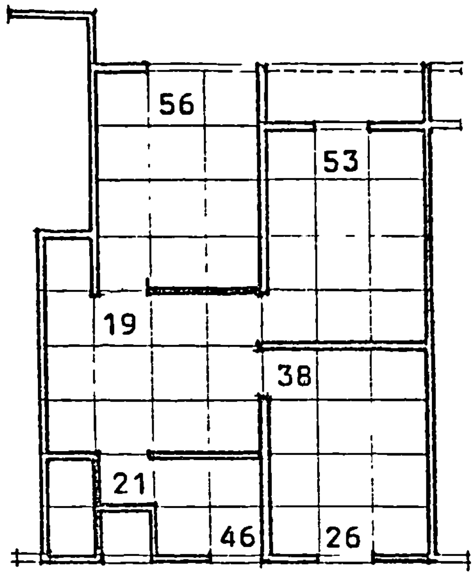
D3/3

Figure (A7.19) C_{vn} values for Model D3

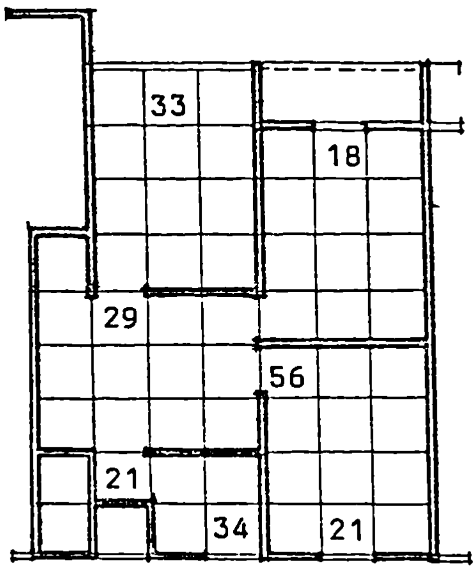
Angle of wind	=	45°
Free stream mean speed	=	1 m/s
Air temperature	=	20°C



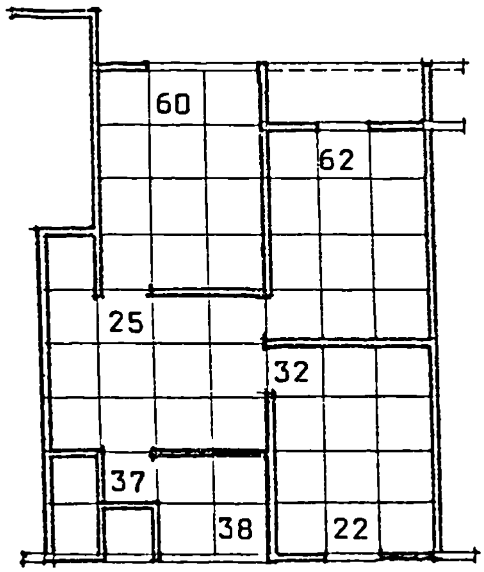
D3/4



D3/5



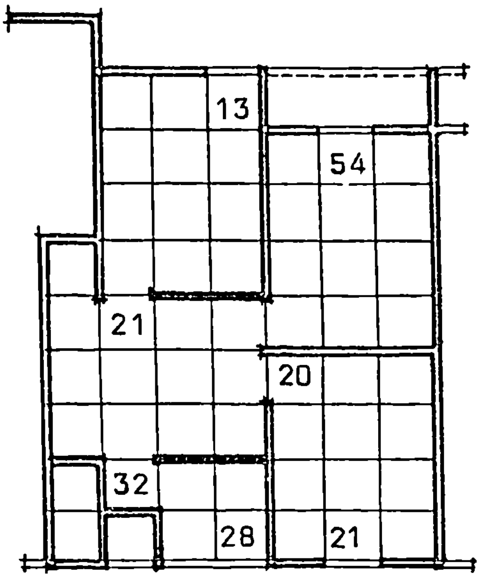
D3/6



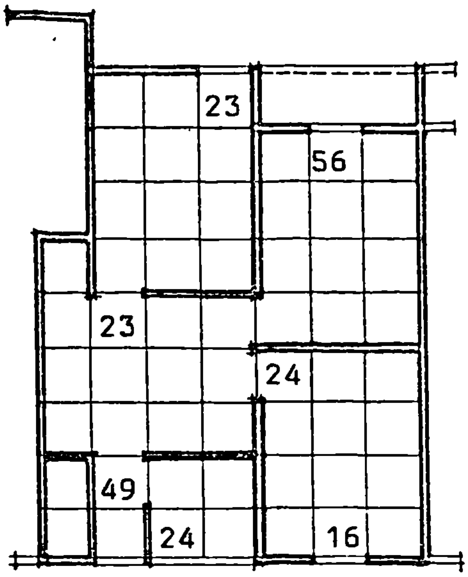
D3/7

Figure (A7.19) continued.

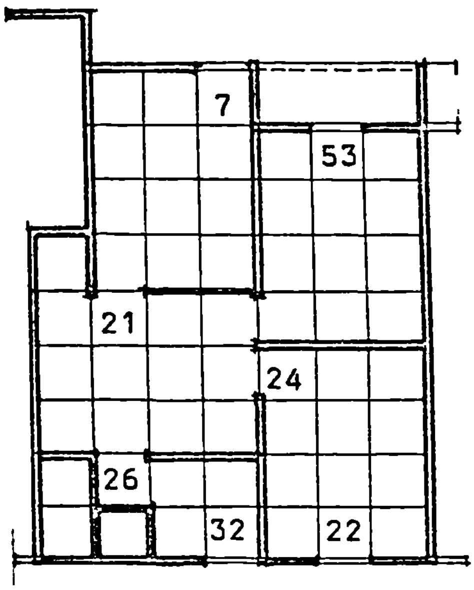
Angle of wind	=	45^{0}
Free stream mean speed	=	1 m/s
Air temperature	=	$20^{o}C$



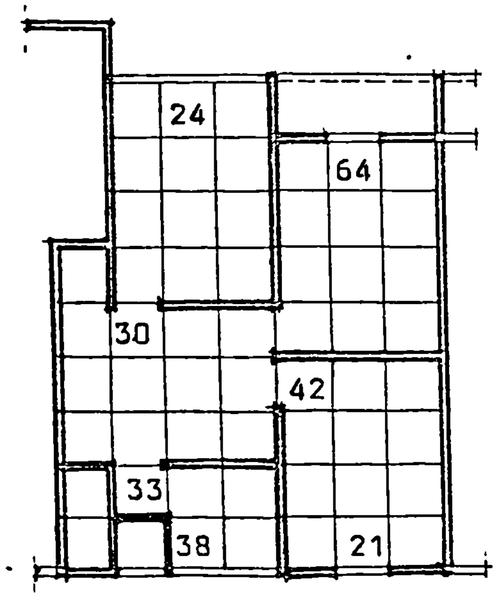
D3/8



D3/9



D3/11



D3/12

Figure (A7.19) continued.

Angle of wind	=	45^{o}
Free stream mean speed	=	1 m/s
Air temperature	=	$20^{o}C$

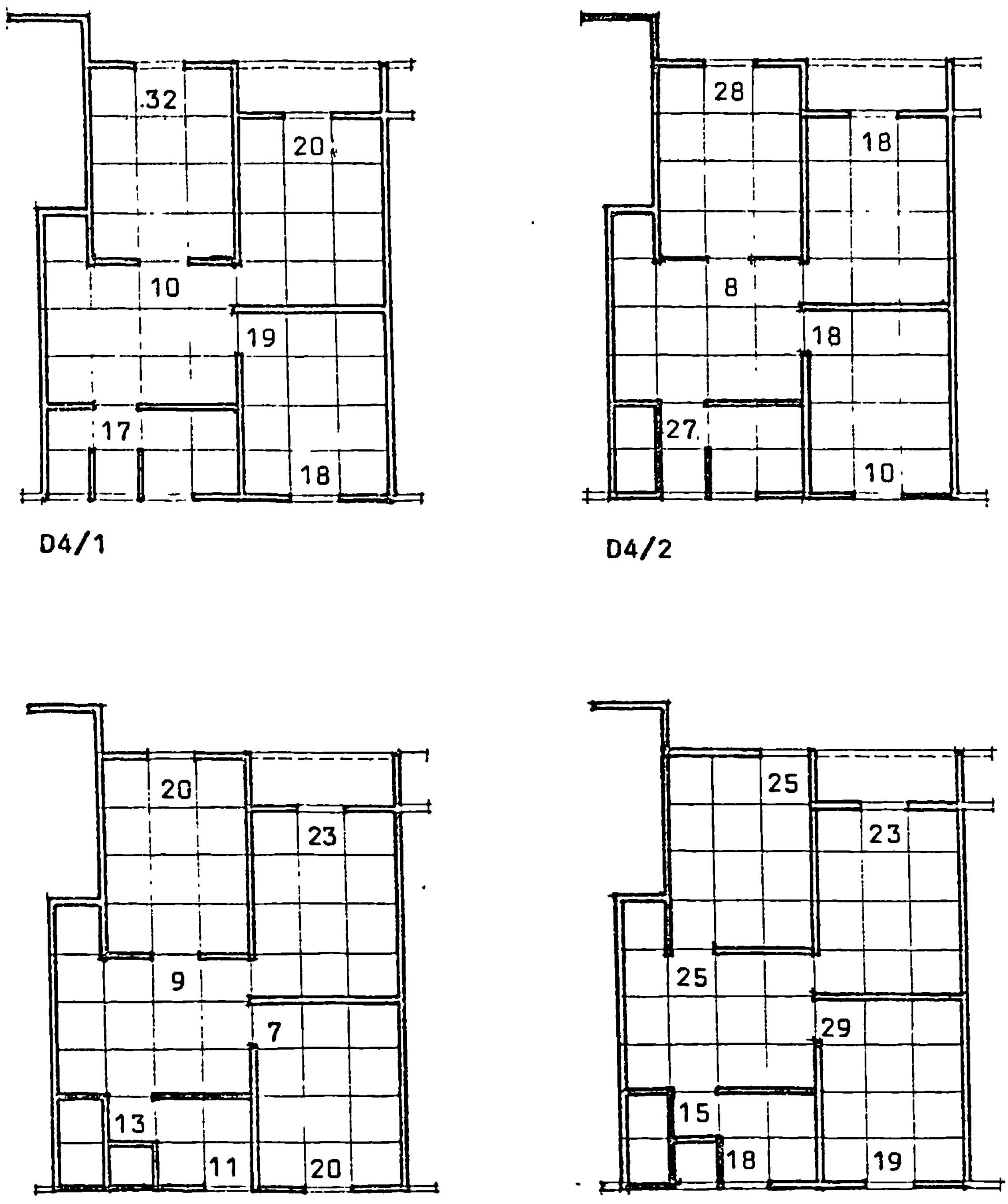
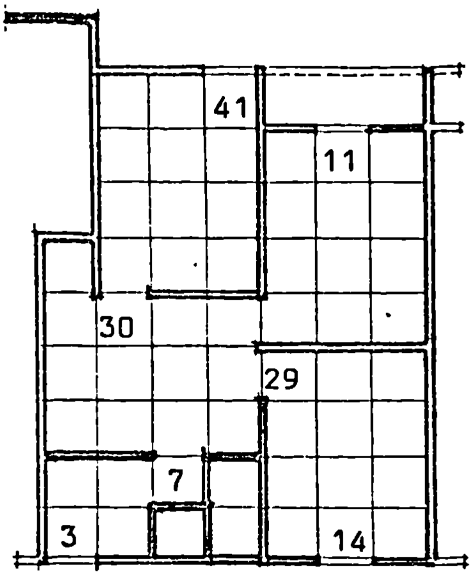
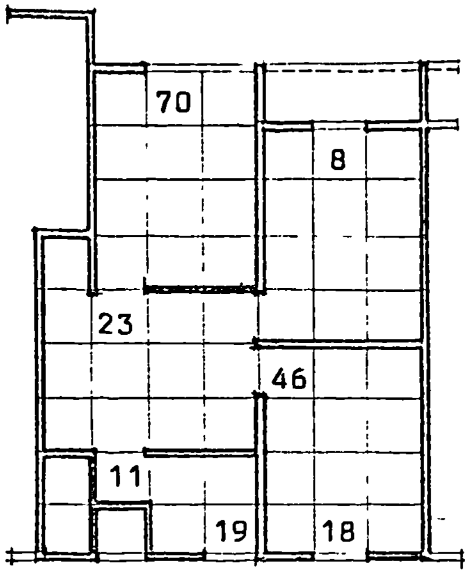


Figure (A7.20) C_v values for Model D4

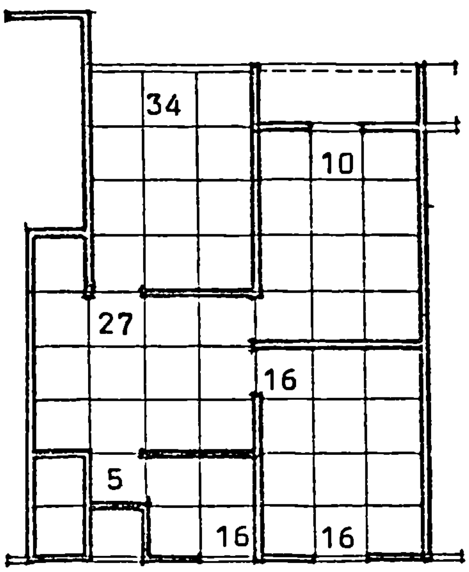
Angle of wind	=	90^o
Free stream mean speed	=	1 m/s
Air temperature	=	20^oC



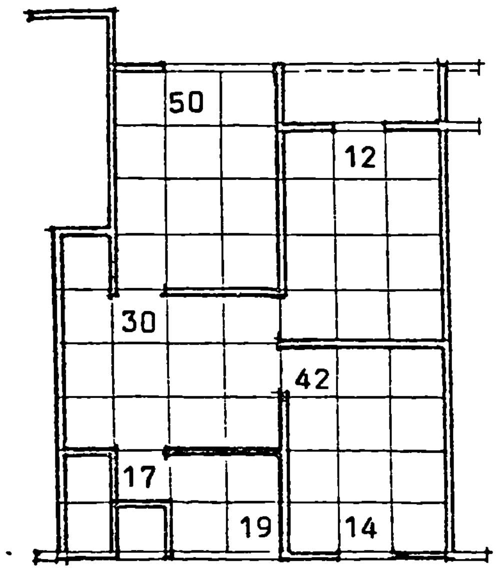
D4/4



D4/5



D4/6



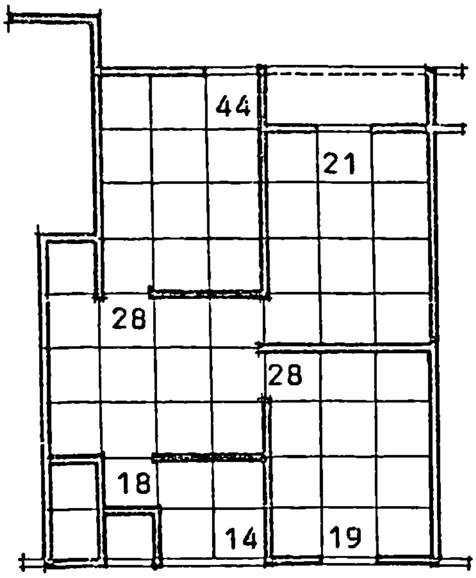
D4/7

Figure (A7.20) continued.

Angle of wind = 90^{o}

Free stream mean speed = 1 m/s

Air temperature = $20^{o}C$



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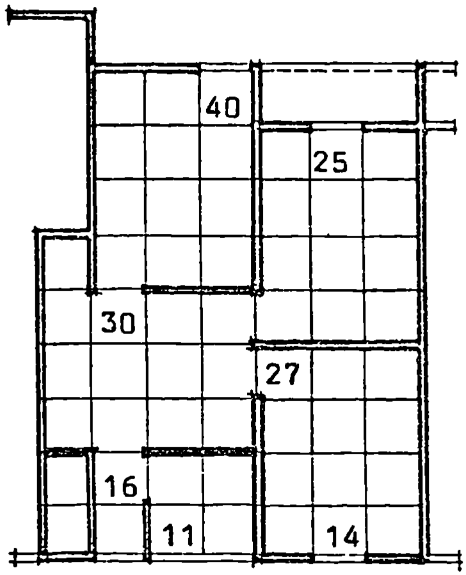

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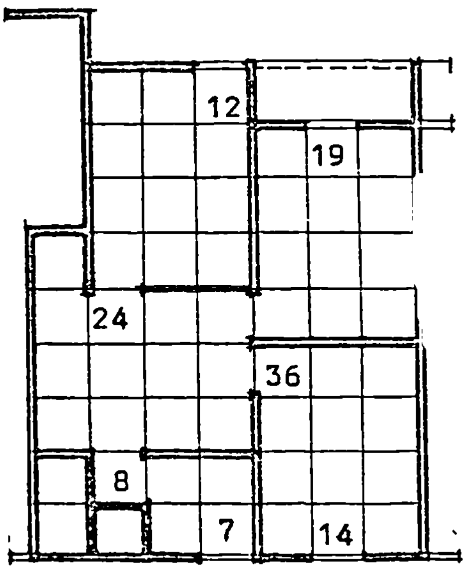

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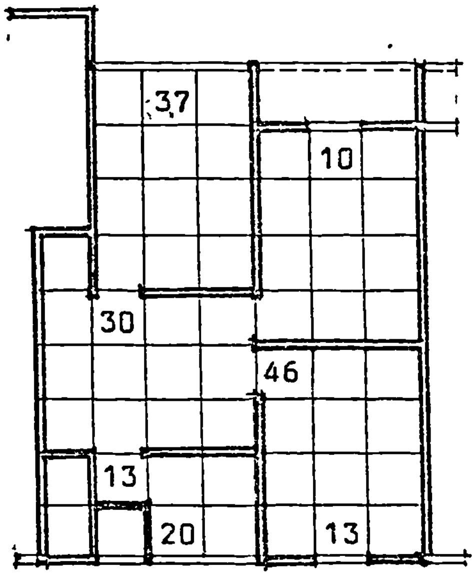

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Figure (A7.20) continued.

Angle of wind = 90^o

Free stream mean speed = 1 m/s

Air temperature = 20^oC