

ARCHITECTURAL ILLUMINATION.

Some aspects of Flexibility.

Derek R.H. Phillips.

In partial fulfilment of the
requirements for the degree
of Master of Architecture.
M.I.T. Cambridge. Massachusetts.
February 1954.

.....

B.arch (hons) L'pool.
Pilkington Student.
M.C.D. L'pool.
Commonwealth Fellow.

Thesis Instructor.

.....

LETTER OF SUBMITTAL.

Prof. Anderson.
Dept. of Architecture.
M.I.T. Cambridge. Mass.

Dear Sir,

I submit the following Thesis in partial fulfilment of the requirements for the degree of Master of Architecture.

I should like to take this opportunity to express my thanks to you and to the faculty for all the help and encouragement extended to me during the past two years.

Yours respectfully

Derek R.H. Phillips

February 1954. M.I.T.

Kepes. "The Language of Vision."

"Spatial experience is intimately connected with experience of light. Without light there is no Vision, and without vision there can be no visible space. Space in a visual sense is light-space. Ordinarily this light-space is not apparent to the eye.

We perceive spatial relationships, only when light is intercepted by some medium. What we actually see as spatial world is the way in which light is dissected and redirected, that is modulated by these mediums.

The sensory modes of registering the modulated light, the various sensations of colour, then become the means for the spatial ordering of objects and events."



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ARCHITECTURAL ILLUMINATION
Some Aspects of Flexibility.

PART 1.

Introduction.
Man, Light and Architecture

Chapter 1.1

Outline of Concept.

"That Illumination is considered to be a means
by which Formal Relationships¹. may be achieved."

Speaking of the architect, Ruskin said that "his paper lines
and proportions are of no value, all that he has to do must
be done by spaces of light and darkness." He was thinking
primarily of "form" as it is affected by natural Illumination.

1. Formal Relationships are considered to be Visual Formal
Relationships in this context. See Chapter 1.3.

Chapter 1.1

The wisdom of his remark is however of wider application, and the lessons to be learnt, are no less necessary today; for with the development of electric power, the potentialities of artificial illumination have increased to the degree when it is possible to control the formal environment, both by day or by night, to a degree scarcely dreamt of as little as fifty years ago.

It is not unnatural with such a rapid growth, that anomalies should present themselves, in the application of this new tool of Man; for whilst some aspects of Illumination, such as Intensity tend to be exploited to their utmost, other aspects such as the infinite richness, and variety of experience which may be derived from variations of illumination are so often neglected. Where use has been made of light as a variable of experience, the result has been more a factor of disintegration, than a totality of architectural impression.

There has been no lack of thought on the subject by men of distinguished minds, and though it may be thought invidious to choose any one individual from the many who have devoted their lives to this problem, one may perhaps be forgiven for selecting Matthew Luckiesh, since he has written more about Illumination than anyone else.

Writing in 1930 he said ¹.

"All arts that we enjoy

"All arts that we enjoy /

visually are dependent on light.

A sculpture is modelled by the lighting

A painting is coloured by the light that falls upon it.¹

The sculptor uses his tools to produce a contour which the lighting models. He cannot fix the expression, for it varies as the lighting varies.

The painter applies the media of his art, but the colour is in the light which falls upon his product.¹ Like the sculptor he can only fix the outlines, for the values and the colours change with the lighting.

The decorator applies his colour scheme, but he cannot fix it. The mood or expression of the interior depends upon the quantity and the quality of the light, which reaches the various surfaces.

The colours and the values change with the lighting.

The architect who harmonises and blends various arts cannot avoid the influences of light and of lighting."

Luckiesh continues

"...the most potent characteristic of light is its mobility no other medium of expression utilised by the architect or the decorator possesses such a characteristic in any appreciable degree..."

foretelling the work of Wilfrid². he says

"Painting with light will some day be a wonderful field for the lighting artist."

It was in 1930³. that he wrote

"Our interest in light is changing from merely admiration of and interest in light sources and light fixtures to that of artists interested in the material light, as a medium of expression."

However Luckiesh was being overoptimistic of his fellow men as I think that a glance through any catalogue of lighting

1. "The space structure of a painting alters with changes of illumination." Kepes. "Language of Vision"

2. Wilfrid. Thomas Composing in the art of Lumia 1948. He describes his work, as variations of flux pattern, in space and time.

3. Luckiesh Matthew Lighting and Architecture July 1930

Chapter 1.1

catalogue of lighting/

fixtures will serve to illustrate in 1953.

What then is the position of light in architecture, and their relation to man today? A great deal of work has been done on individual programs in order to achieve a unified scheme of illumination which will be a satisfactory solution in terms of man's environment, and in some cases solutions of this nature have been conceived with the structure, and mans other needs, so that to some extent a total solution has been forthcoming. Examples would include Schools, hospitals and operating theatres, office buildings and others.

However I think that it would be generally agreed that in the vast bulk of the architect's work, the question of illumination is not considered until the demands of planning structure, acoustics and servicing have been met, so that at best the illumination is a clever articulation of an already existing structure.

A particular case is the contemporary "home", in this regard one of the most illconsidered building programs. It is in the home in which Man spends a considerable part of his waking hours each week that the weaknesses of the present application of concepts of illumination, can most clearly be seen.

The building is "finished" from the point of view of the architect, with only the most cursory regard having been paid to the provision of artificial illumination....generally in the form of a few electric light points provided at so called

so called/

strategic places. In the majority of homes, this is as far as the design of the formal relationships within the building goes, the architect's job is finished. In some cases the services of the interior decorator are called for, it being his job to finish off the work, by planning within the existing framework a "scheme of decoration" incorporating the colour schemes of the walls, furniture, and the manner of the illumination.

So much then for the predictions of Luckiesh, today in 1953 the illumination of the vast majority of building work is an afterthought, and an afterthought so often executed with the maximum of gadgets, and the minimum of taste.

In 1947 the Illumination Society of America was reminded by Kromhout¹.

"Many architects do not realise as yet, that only through light do we see the objects around us, in their correct proportion and placement, they should be reminded that it is not the object we recognise, but its image."

He continues

"thus architecture and a lighting system, should evolve simultaneously in order to create rhythm and contrast of light and dark. In other words the lighting system should be visualised with the architecture before a working drawing has been made; it should display the space and its subdivisions in the manner in which it was seen by the architect."

1. Kromhout J.C Light and Form. 1947. Illum Eng. N.Y

Chapter 1.1

That this has not been inculcated into the general philosophy of Illuminating Engineering, can be seen from the following remark, published by the Illuminating Engineering Society of New York in a Report on Home decoration,¹ in which lighting is described as

"....a major element to enhance the carefully considered work of architect and interior designer."

the implication being that the work of the illuminating engineer is to enhance, which the Oxford English Dictionary defines as "heighten, intensify, raise (in value) exaggerate" the work of the architect, thus emphasising the schism between the two.

For it is the architect who should in the original conception of the building, know the relationships of light and shade which he wishes to achieve, and who should so use "his spaces of light and darkness" for the creation of a satisfying human environment.

Knowing what he wants the architect should then be on sufficiently equal terms with the illuminating engineer, should his program be sufficient to warrant one, in order to see that not only he gets what he wants, but that the actual sources of artificial illumination, the luminaires, are so integrated into the structure as to be a significant part of the "total" concept of the building; not an additive feature

1. I.E.S. Home Decoration-Lighting Illum. Eng. 1950 Sept.
Illustrated by "horizon House" Nela Park. G.E.C

Chapter 1.1

additive feature/

used for heightening, or exaggerating the effect, at its best; or a series of unrelated gadgets at its worst.

In postulating that the architect is in a position to "know what he wants", I am assuming that he comprehends the relationship between light and architecture, as they affect Man, for if according to my original concept

"Illumination is considered to be a means by which Formal relationships may be achieved."

then it is the architect, when designing the building, who must think in terms of "light", if the resulting formal relationships are to have meaning to Man.

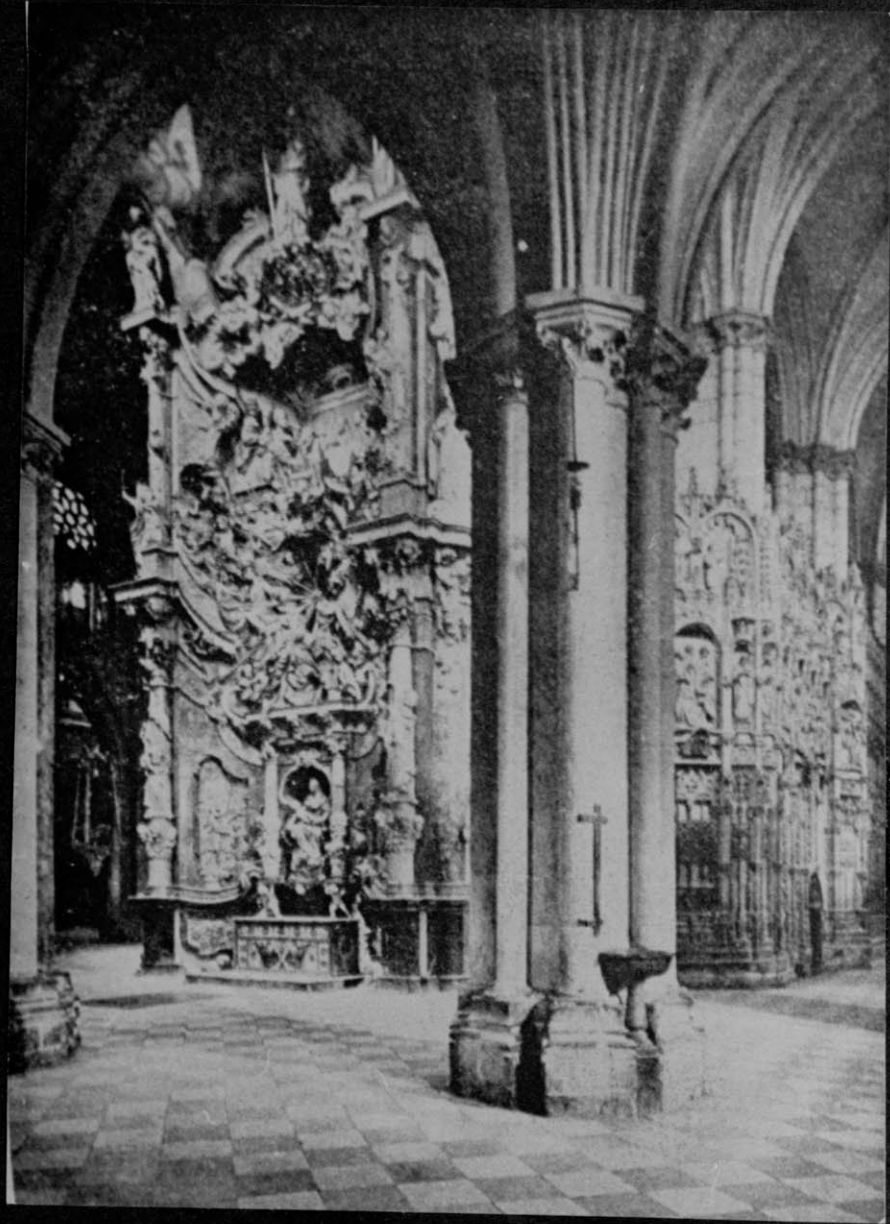
There is nothing new in this concept of illumination, as anyone who has studied the architecture of the great historical periods will have observed, and my reason for emphasising what must seem to many people to be axiomatic, is that I consider a restatement of basic principles is necessary.

Because of the nature of light, and its relationship to form, architects of all ages have used it to a greater or lesser extent to give meaning and value to their buildings. This is expressed most emphatically by the architecture of the baroque period, in which the interior and the exterior were constructed in such a way as to allow them to be modelled by light to a degree never experienced before or since.

Here this interaction of light on matter was exploited to its uttermost in buildings such as the Vierzehnheiligen, and



The Vierzehnheiligen
Balthasar Neumann. 1743.



The Transparente by Tomé
Toledo Cathedral. 1732

Chapter 1.1

and/

the Cathedral of Toledo. In the latter, the light filters down from an unseen source of illumination, on to the gilded wooden reredos, causing a moving pattern of light and shade on the heavily moulded carvings; creating an almost living form, by the variations of light.

Such sculptured forms may have less meaning for the contemporary architect, what has to be remembered is not so much the conveyance of meaning to a 16th century audience, but rather the means which are at the disposal of the architect for the addition of richness and variety in a world where present economy leads to greater and greater standardisation, and more often than not to a poverty of expression.

In this connection Prof. Anderson¹ speaks of the

"Meaning of the ornamental surface as simply the base over which the cascade of lights flows as water in a fountain,"

so that the physical form is only one of the means of attaining the impression on Man,

The different quality of natural light in different countries, has always played its part in the form² that such buildings will take, today no less than in the past; however it is in the application of the great new tool of artificial

1. Thesis Instructor.

2. Physical form.

Chapter 1.1

artificial/

illumination, that the restatement of basic principles seems to me to be most urgent.

The concept of illumination, as I have outlined it contains in face two major components.

1. Illumination. as a means.
2. Formal relationships.¹ as an end.

however there is the third and most important component, implicit in all concepts concerned with the human environment, Man himself.

I intend in the following three Chapters of Part 1 to consider these aspects of the concept in turn.

1. Formal Relationships. It will be shown in the succeeding chapters, that the formal relationships with which the architect is concerned, are not in fact an end in themselves, but rather a means without which the end, that of a satisfactory human environment, cannot be reached.



"When I consider how my light is spent
Ere half my days, in this dark world and wide,
And that one talent which is death to hide
Lodged with me useless, though my soul more bent
To serve therewith my maker, and present
My true account, lest he returning chide —
Doth God exact day labour light denied? "

Milton

PART 1.

Introduction
Man, Light and Architecture

Chapter 1.2

Illumination.

Illumination is defined by Kraehenbuehl¹ as:

The density of luminous flux on a surface;
it is the quotient of the flux by the area of the
surface when the latter is uniformly illuminated.

This is however the definition of the Illuminating Engineer,
and I prefer that of the Oxford English Dictionary, which
speaks of illumination as being the "lighting up" or the

1. Kraehenbuehl. J Electric Illumination. Wiley N.Y 1951

Chapter 1.2

or the/

"throwing of light on" or "shedding lustre on". Light itself being defined as the natural agent that stimulates sight and makes things visible, ...any source of it, such as the sun, or a burning candle or a lighthouse.

Illumination according to this definition is the natural or artificial "lighting up" of the physical world, which renders it visible.

In dealing broadly with the subject of Man, Light and Architecture, my thesis must take both natural and artificial sources of this "lighting up" into account, for if

"Illumination is considered to be a means
by which Formal Relationships may be achieved."

then these formal relationships must be the direct result of ~~the~~ the physical world acted on by "natural" or "artificial" light, or combinations of the two, as they are experienced by Man.¹

Natural Illumination

Traditional architecture of all countries, shows that Man, in suiting his environment to his needs, has taken this factor of illumination into account. The most striking examples of this occurring when considerable differences

1. It is necessary to add "as experienced by Man" since man experiences this interaction in a specific way. Chapter 1.4



Textured wall in Italy.

Chapter 1.2

considerable differences/

between the quality of illumination in different countries, have resulted in differences of physical forms being applied, relying for their validity on the nature of the local light source, and the adaptation of Man.

Kromhout¹ has pointed out the marked difference between the low relief carvings of Assyria, Egypt and Greece, with their high sun angle casting heavy shadows on the smallest projections, causing the slightest texture to appear heavily moulded; and the Gothic carving of Europe, where considerably greater depth of carving is necessary to obtain a commensurate depth of shadow from the more diffuse light.

Similarly the spectral composition of the natural light, differing as it does with climate, orientation, and time of day, has been used by Man on an empirical basis, in his choice of colour for external and internal use in his buildings, for contrasts of colour, light and shade.

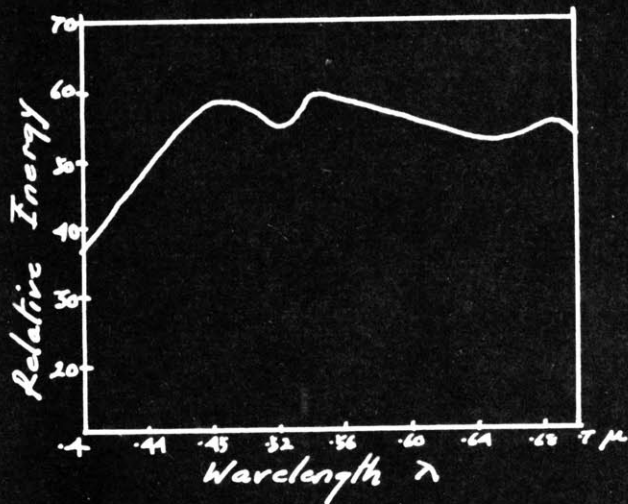
On a sunny day 80 per cent of the light comes from the sun, the remaining 20 per cent coming from the sky, meaning in terms of spectral distribution, that the greater part of the light in an open field would have the spectral energy curve of sunlight, the remainder of the incident light having the spectral composition of skylight. See Fig 1.2.1

On a dull day, with an overcast sky, the resultant incident light

1. Kromhout J.C Light and Form. Illum Eng. May 47

FIGURE 1.2.1

Spectral Distribution Curves
for Sun and Sky.



SUN 5335 K

Spectral distribution of
Energy in direct Sunlight.

Measurements at Cleveland.
1939.

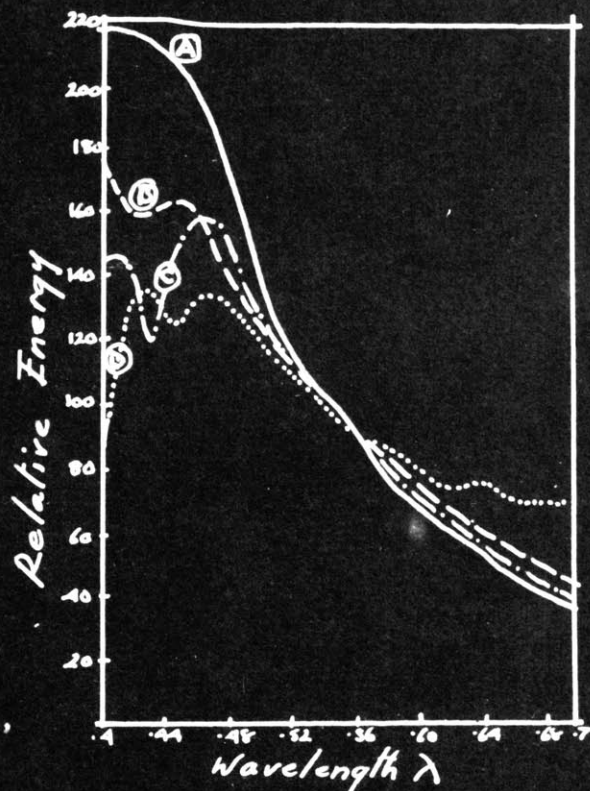
SKY

Spectral distribution of
Energy from a zenith sky.

- A. clear sky
- B. hazy and smoky sky
- C. clear sky but smoky
- D. Hazy and smoky

Measurements at Cleveland
1939 to 1940.

measurements plotted on the
basis of equal illumination,
but no average given.



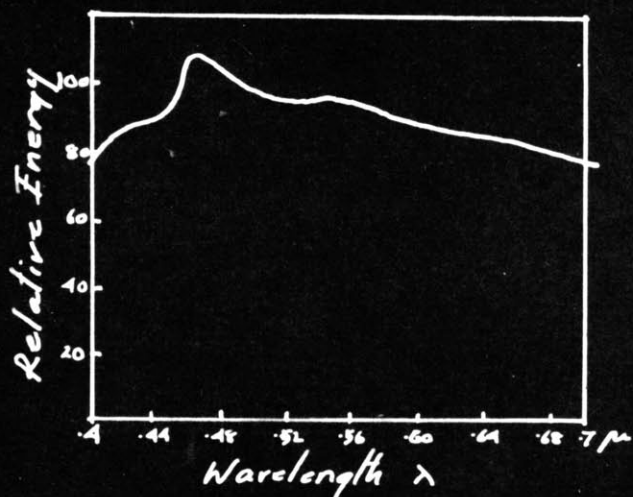
Reference.

Taylor A.H and Kerr G.P. Distribution of
Energy in the visible spectrum of Daylight.
Journal of the Opt. Soc. of Amer. Jan. 1941.

FIGURE 1.2.2

Spectral Distribution curves from the total sky.

A comparison between a clear and an overcast sky.



CLEAR

Spectral distribution of Energy, on a horizontal plane. Sun and fairly clear sky. (80% sun 20% sky approx.)

Measurement at Cleveland 1939.

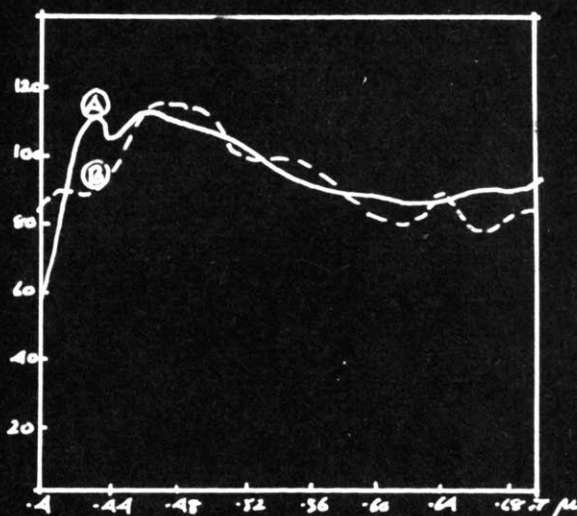
OVERCAST

Spectral distribution of Energy on a horizontal plane from an overcast sky.

A. 100% overcast. 1939

B. 100% overcast. 1940

Measurement at Cleveland



Reference.

Taylor A.H. and Kerr G.P. Distribution of Energy in the visible spectrum of Daylight. Journal of the Opt. Soc. of Amer. Jan. 1941.

Chapter 1.2

incident/

light on the open field would be the resultant of an entirely different combination of the two spectral energy curves, a more uniform spectra due to the diffusing of the light.

see Fig.1.2.2

It will be seen from these graphs that the physical colour,¹ (or the nature of the light rays as reflected off any given object) will be a function of the absorption and reflecting characteristics of that surface, either natural or pigmented, and the characteristic spectral energy curve of the incident light.

The spectral energy curve of the incident light on a horizontal plane in an open field, is dependent then on the atmospheric conditions prevailing at the time. An example being the magnificent sunsets in certain parts of the world caused by dust particles or moisture of the atmosphere, which absorbs light in the short waves of the spectrum, allowing a greater proportion of the long waves to penetrate, thus giving the red sunsets, that are considered so beautiful and act as some compensation for living in such industrial towns as Liverpool in England, caused by smoke; or the desert sunsets of North Africa caused by dust particles, and moisture.

1. Physical Colour, is used here as opposed to the phenomenal colour, since that is dependent also on the physiological characteristics of Man. The Experienced colour then is the resultant of the light source, the surface, and Man.

Chapter 1.2

However the natural illumination with which the architect is most often concerned is not that which is received on a horizontal plane in an open field, but that which is received by the vertical surfaces of his building from a specific orientation. In such circumstances it is not the total combination of the spectral energy curves of the sun and sky that is received, but light from either the sky alone or a specific combination of the sun and sky.

A practical example of this was mentioned by Prof. Rasmussen!¹. He showed that if a surface receives light only from a window on the north side of a building, the spectral composition of the light will be that of the sky, with some proportion of reflected light from the surrounding environment. In a country district this will mean that the light will be composed of greater relative energy in the shorter wavelengths, in fact it will be more blue. So that if the architect wants to paint a surface of a room, with this orientation then the surface will reflect light at a higher relative saturation if he paints it blue. Conversely a wall receiving direct sunlight, with its greater percentage of light in the longer wavelengths will reflect the warmer colours such as reds and yellows better.

It may not always be the wish of the architect to intensify the colours

Rasmussen, Steen Eiler Lectures at M.I.T. October 1953
"Daylighting"

Chapter 1.2

to intensify/

the "blueness" of the northern sky, or the "yellowness" of the southern exposure, and in fact there may be cases of the reverse being necessary, to modify or ameliorate the conditions of "warmth" or "Coolness" given by such exposures.

It is necessary in either case however for the architect to have the knowledge of the average spectral distribution of daylight in the area within which he is working, for different times of year, for different orientations, and at different times of day, if he is to be in the position to utilise to the full the potentialities of the light source in terms of the surfaces of his building, in a dynamic relationship.

This information is no less necessary than for the architect to have a working knowledge of the angle of the sun for different times of day throughout the year, in order that he may design his openings and modelling to fit the needs of Man; a working knowledge which has been considerably better inculcated into general architectural practice, leaving it less necessary for stress in this thesis.

Artificial Illumination

Man developed under conditions of daylight during the day, and the light from the moon and stars, supplemented by firelight at night. His sense organs adapted themselves to the differences between night and day in such a way as

Chapter 1.2

in such a way as/
allows considerable latitude in the amount of illumination and the colour of that illumination needed for the performance of acts necessary to his existence throughout the twenty four hours. However the nature of both daylight and firelight is one of variability, and mobility, the flickering of the flame, and the variation of the sky due to the earth's passage round the sun, and the local variations of cloud and atmospheric effects.

The introduction of gaslight allowed higher intensities of light to be had from an artificial source, without much altering the pattern of mobility, as before obtained by the use of candle and firelight. This then up until 1879 when Edison developed his "filament" was the nature of the light source to which Mans structure was adapted when the use of daylight was denied to him.

However with the introduction of the incandescent lamp, and its subsequent development over the past three quarters of a century, and with the introduction of new light sources, there is a considerable difference in the nature of this artificial light from that light to which man had originally adapted himself up to this time. There is considerable difference between the spectral composition between the various sources, and with all of them to daylight, whilst the nature of the light is a steady¹, rather than a mobile one.

1. This is a generalisation. Not taking into account stroboscopic effect of fluorescent light.

Chapter 1.2

Tungsten light was the first popular form to be developed in the incandescent lamp, this has a continuous spectra, similar in character to that of daylight, but differing in the amount of relative energy according to wavelength. Its greatest output being in the infra red, with a gradual lowering of efficiency towards the ultra violet. See Fig.1.2.3

Comparing this curve with that of daylight will show that whereas skylight will cause a surface to reflect its shorter wavelengths most strongly; incandescent light will cause the warmer colours to be reflected to a great degree.

This is a matter of common observation on a dull day, when the incandescent light from within a building seen from outside, appears to be a warm yellow light, when compared to that of the sky.

I do not intend to deal at great length with the spectral characteristics of artificial sources, as this is reserved for any necessary expansion in Part 3.

Briefly, with the growth of new light sources, such as the electric discharge lamp, and later with fluorescent fittings, further factors have to be taken into account; for their spectral composition varies not only in the relative intensities of the different wavelengths, but is of a different characteristic spectra, that of the line spectra.

In such cases radiation is produced at certain discrete wavelengths, a good example of this being the sodium discharge

Chapter 1.2

sodium electric discharge/

lamp, of which the only radiant energy in the visible spectrum, is in the Sodium D-lines of 0.5890 and 0.5896 μ^1 giving what is called homogenous radiation (acting at one wavelength).

As objects can have no colour which is not a part of the source of illumination, all combinations of colours illuminated by such a source are distorted into a world of various shades of yellow. This is a matter of common observation when walking in a street at night lit by sodium lighting.

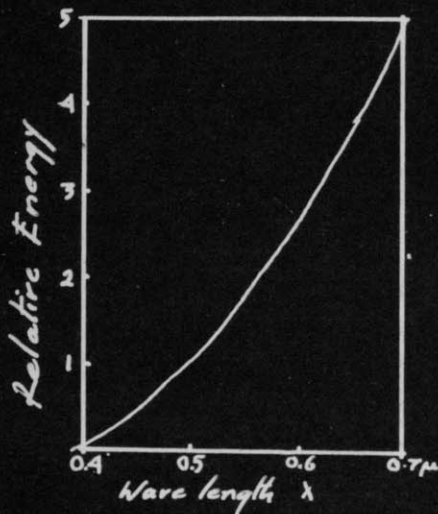
Fluorescent lighting has a combined spectrum, consisting of the line spectrum of the mercury vapour within the tube, and the continuous spectrum of the phosphor coating on the inner side of the tube, which radiates through the interaction of the phosphor and the strong Mercury line at 0.2537 μ in the ultra violet band. This combination may cause certain difficulties, as what may appear to be a satisfactory coloured fluorescent source, may, due to the limitations of its spectral composition, be deficient in certain wavelengths, causing incorrect colour matching when compared with daylight. This has been found a most necessary consideration when a high degree of colour matching is necessary, such as in Government fruit and cotton Inspection plants, and in clothing stores.

Fig 1.2.4 shows a typical Mercury Vapour "line Spectrum"

1. Moon and Spencer. Lighting Design Addison-Wesley 1948

FIGURE 1.2.3

Spectral Distribution of Energy of an incandescent Source.



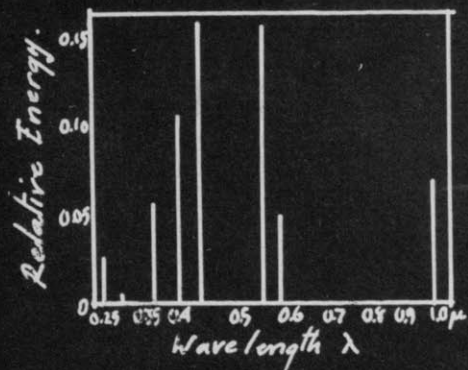
The spectroradiometric curve for Tungsten, make the difference between Daylight and Incandescent.

The resultant light will reflect the warmer colours to a greater degree than the cold blues, as it has a higher relative intensity in the long wavelengths.

FIGURE 1.2.4

Spectral distribution of Energy from a mercury Vapour Lamp.

This example of a "Line Spectra" shows clearly the basic difference between this type of light and that of the continuous spectra sources, of Daylight or Incandescent.



Reference. (for both Figs.)

Moon and Spencer. Lighting Design. Addison-Wesley 1948

Chapter 1.2

"line spectrum"/

to which the continuous spectrum of the phosphor to be used, such as magnesium tungstate would have to be added. It can be seen from the line spectrum, that there is no radiation from wavelengths other than those shown, except for the phosphor radiation, and this leads to the changes of object colour that I have mentioned.

In some research by Commercy and Leighton¹ it was shown that different phosphors will give different colours from the same object colour. An example of this is the effect on such a colour as Windsor and Newton "Orange" chrome.

Lamp.	Phenomenal colour.
Daylight ^c 4370 K.	Orange.
De Luxe Cool White.	Red Orange.
Standard cool white.	Yellow brown pale.
De Luxe Warm.	Orange Red clear.
Standard Warm.	Yellow brown medium.

The effect of incandescent was also investigated, and the effect found to be close to that of the De Luxe warm white.

From the brief foregoing analysis of the part that light sources of varying spectral composition play, it may be concluded that the choice of a light source, and more particularly the choice of object colour in relation to this chosen light source, plays a major part in the artificial environment with which the architect is chiefly concerned.

1. Commercy and Leighton. Fluorescent Lighting in the Home
Illum. Eng. Dec. 1950

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It is as necessary for the architect to have a working knowledge of the characteristics of artificial light sources, as we found it was for him to have a similar working knowledge of natural light sources, the sun and the sky; more particularly when it is realised that not only does he have to use each in its own terms, but that in most cases he must plan for combinations of the two at certain periods or even throughout the day.

In addition to the information on the diffusion and direction, the intensities, and the spectral composition of light sources as they relate to the physical world, it is necessary also for the architect to concern himself with the efficiency of artificial sources, in relation to initial and upkeep costs. The amount of light in terms of radiant energy, that may be expected from a given amount of input in terms of wattage may be an important consideration in large installations, where the choice of the most efficient form of illumination may be a design consideration outweighing others of a less practical nature. Such considerations should be carefully considered, but where possible should not be so overemphasised as to overrule solutions in terms of human need.

Luminaires.

An Illuminating Engineering definition of the word luminaire is as follows:

is as follows¹:

"A complete lighting unit, including lamp, socket and equipment, for diffusing or redirecting the light."

This makes the distinction between the luminaire as a specific element, containing the source of light; and the luminaire as any surface of the physical world which itself reflects that light onto something else, such as a mirror might be made to do.

This seems a useful analysis of the problem by which I propose to abide with the following reservation:

The definition makes the distinction between artificial and natural illumination, since it is an illuminating engineering definition, but for my purpose I shall consider openings in buildings as "natural luminaires" to the extent that they also "Diffuse, transmit, and redirect" the natural light into a building.

Illuminating Engineer

The position of the Illuminating Engineer, as I see it, is to advise the architect, as to the "means by which he may achieve" the environment which he desires to create.

In this sense his position is not dissimilar to that of the structural Engineer cooperating on a building program.

The architect confronted with an architectural program, tries to solve the problem in terms of Man, by the creation of a satisfying human environment, it being the job of the

1. Moon and Spencer. Lighting Design. Addison-Wesley. 1948

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job of the/

structural Engineer to advise him as to which structural system will most economically do the job required of it, the architect being responsible for so thinking in terms of structure from the outset of the program, together with all other basic design considerations, as not to call upon the structural engineer to perform the impossible.

This may also be said to be the position of the Illuminating Engineer, for the architect must so think in terms of the possibilities of Illumination, as to call upon the Illuminating Engineer to perform a "possible" task; so that working within the "flexible" medium of Light the combined efforts of the Engineer and the architect will result in the creation of a satisfying human environment. For as with the necessary stanchions and beams of the structural engineer, of which the architect must be aware in his original conception of the building, so with the type of luminaire that may be necessary to achieve a given result of light and shade, colour and contrast. The architect must be "aware" of the means since they too are a part of the environment.

This is unhappily rarely the case; for as with the Structural Engineer, he is often called upon to produce a structure, into which all sorts of supposedly human environments are adapted and squeezed, of which there is such tangible evidence around us; so in the case of the Illuminating Engineer, he is asked to "illuminate" a building which is already built or at all events designed without any consider-

without any consideration/
having been paid to mans need for light at times when natural illumination is absent or inadequate.

Integrated solution

It is the duty of the architect to know what he wants, and for the Illuminating Engineer to see that he gets it; for the architect must so "order" his design, by a clear understanding of "his spaces of light and darkness", and a comprehension of the needs of illumination in terms of luminaires, that it is possible for the result to be one in which the "means" are so integrated into the original design of the building, that the Illuminating Engineer is contributing in a positive way to the "whole" of the Building, its rhythm harmony and unity, instead of adding "devices" to a structure conceived without them.

Only in this way will the final solution, in terms of a human environment be an integral and meaningful one, rather than an additive and palliative device.

Where this has been carried out, even though the original conception of the "form" of the building may have been limited, the results have contributed to some considerable extent to the success of the building, and many examples would serve to show this. However in the majority of "homes," the subject for which a specific solution will be sought in a later Part of this thesis, I have already mentioned that the only consideration given to the needs of illumination is in the provision of "light points" for the placing of fixtures.

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So little thought has been given to an overall concept of illumination that such a course has been directly responsible for the growth of "light fitting gadgeteering" of which we have all too ample evidence in our homes today, from the luminaire in the shape of a Spanish Galleon at one end of the scale of absurdity, and the goose-necked "hat-rack" at the other.

For the provision of high levels of direct illumination at specific points in a room, such mobile fixtures may have occasional validity, but this seems insufficient reason for paying so little regard to the problems of lighting, that in the majority of homes the mobile light fitting is practically the sole form of illumination.

"light must become a legitimate architechtonic element, unified with the structural elements of walls doors and even floors." 1.

and it is only when

"Illumination is considered to be a means by which Formal Relationships may be achieved."

that an integral solution to the problems offered by illumination, as they pertain to Man, is likely to be found.

1. Kepes. G Article on Lighting for Sylvania. Unpublished.

The Sacristy.
Granada. 1727



"Everywhere the "whole", even the least and most insignificant apparently, is the real wonder, the miracle which holds the secrets for which we are groping in thought and conduct. There is the within which is the beyond. To be a whole and to live in the whole becomes the supreme principle, from which all the highest ethical and spiritual rules follow.

And it links these rules with the nature of things, for not only do goodness, love and justice, derive from it, but also beauty and truth, which are rooted in the whole and have no meaning apart from it." *The Whole and the Part* by Jan Smuts

Jan Smuts¹.

PART 1.

Introduction
Man, Light and Architecture

Chapter 1.3

Formal Relationships.

What is meant by a "formal relationship", of what are they composed, and to what extent may they be considered to have value? These questions must be answered for an understanding of my original concept.

The Oxford English Dictionary gives the following definitions

Form: Shape, arrangement of parts, visible aspect.
Mode in which thing exists or manifests itself.

Formal: Of the outward form or external qualities.
Concerned with form, rather than matter.

1. Smuts, Jan C Encyclopedia Britannica. Entry under "Holism"
Gk. Holos whole.

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Relation(ship): (degree of) What one person or thing has to do with another. Way in which one stands or is related to another.
Kind of connexion or correspondence that prevails between persons "or" things.

According to the above definition of "form", as the "mode in which thing exists or manifests itself", it would be correct to think of Form as having several natures, connected with the senses that receive them.

Visual form
Tactual form
Audible form
Olfactory form
Taste form

since this is the mode in which various things have existence to man, or manifest themselves. The architect is however primarily concerned with the first three, and to the greatest extent with the first. So that in this thesis I shall be thinking of visual form in the main, and visual formal relationships, or the degree to which there is connexion or correspondence between visual forms, in particular.

In dealing for the sake of simplicity with visual formal relationships, I do not wish to imply that I am trying to establish a purely mechanical "relationship", since for all theories dealing with Man sensory data cannot be thought of as working in isolation, since any stimuli has its response from the total organism, rather than from only a local mechanical correlation. Conversely any response is the result of the total stimuli pattern acting on the individual, in addition to the "state" of the individual at the time.

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In order to avoid future misunderstanding of my use of the following expressions, I am defining them

- Man. The human animal
- Light. The natural agent that stimulates sight, and makes things visible. Sources may be natural or artificial
- Matter. Physical substance.
- Physical form. The "whole" of which the substance is matter. The mode in which a thing exists. This may be considered a constant, its variables being that of light and matter.
- Physical environment. The environment within which man exists, and which is composed of physical forms in relationships to each other.
- Phenomenal environment. The environment which man experiences through his senses. The visual phenomenal environment being mediated by his sense of sight.
- Formal Relationships. These may be of different natures, visual, tactual audible etc. and may be considered as the relationships of forms, or the mode in which things manifest themselves. A visual formal relationship manifests itself through the sense of sight.
- Visible idea. The notion that is conceived by the mind, as opposed to the phenomenal environment of the senses. The Visible idea, results from the information of the phenomenal environment (sensory formal relationships) together with mans inherited and learned knowledge. It is the visible idea upon which man acts.

The information upon which man acts is derived therefore from the formal relationships of the architect in the "physical" environment, with which the architect is chiefly concerned.

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Although it is difficult to postulate any precise theory which will seem wholly logical, the above concepts seem to have the practical advantage of getting over the difficulty of which came first, the hen or the egg, the thing or the idea of the thing, by simply ignoring it.

What however is reasonably certain is that the visible idea is the result of man's knowledge of the physical environment in a phenomenal sense (since it is obtained by means of his senses). This visible idea however, upon which man acts is not the only "idea" or notion conceived by the brain, upon which he acts; but rather it is the one which we are considering since it is the result of his sense of sight, which again relies on Illumination.

It is true to say also that man acts upon "information" from all his senses, and from his hereditary or learned knowledge.

It is however possible to follow the process purely from a visual point of view, so long as the position of the other factors upon which man acts are assumed.

For example. One may say that when the man looks at the reredos by Narciso Tomé, there are three fairly clear stages.

1. The physical environment. or physical forms in relation to each other.
A complex shape of wood, gilded and illuminated.
2. Man's Phenomenal environment.
Man's sensual experience, of the above. The stimulation of the retina, an accurate

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an accurate/
correlate of the image of the
physical environment.
An interplay of light and shade,
on figures and mouldings, in
relationship to each other, its
surroundings, and himself.
Its completeness depending on
the completeness of ones exper-
ience of it. Different views etc.

3. The visible idea.

This may be a "visible" picturee
of the glory and magnificence
of God. It is upon this that
he acts (in a visual sense) where
such action is required.

The difference between the phenomenal environment, and
the visible idea, may be described as the difference between
an introspective view of ones environment, trying to see
the various surfaces, edges, shapes and interspaces, and
colours of which it is composed, which would be a good
approximation of the phenomenal environment; and the
everyday world of people, signs and symbols, upon which
man acts, which would be the visible idea.

The position of formal relationships in this process is
firstly the physical formal relationships of light and
matter which the architect uses to establish the artificial
physical environment, and the visual formal relationships
which may be considered as the mode in which the physical
environment manifests itself to man, and dependent on
the nature of man himself. The architect must consider
his formal relationships in the latter light, if they are
to have value to man.

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For instance, Mans knowledge of his environment, say a table on the other side of the room, is confirmed by the fact that he may go over and touch it, but equally the expanding visual field confirms the tactual formal relationship, spatial behaviour cannot be separated from spatial perception.

Visual formal relationships then are the tools at the disposal of the architect; in a building they would be given by walls ceiling floors, and things of the environment which he desires to create, Gibson¹ has suggested that they are composed of "surfaces, edges, shapes, and interspaces" and they are "an aspect of" the "physical environment"² which the architect is called upon to provide, as a solution to the human problem posed by any architectural program.

To what extent may they be considered to have value? Here one is dealing not with the "physical environment" provided by the bricks and mortar of the architect, but the phenomenal environment, as it is experienced by Man.

A formal relationship may be considered to have value to the extent that it ministers to Mans needs .⁴

Geoffrey Scott³ speaking of value in architecture says

" The question "has this new thing value?"
is decided directly by the individual, in the court
of his experience, and there is no appeal,
That is good which is seen to satisfy the human test,
and to have brought an enlargement of human power."

1. Gibson. J.J The Perception of the Visual World
 Howard Mifflin Co. Riverside Press. 1950

2. As opposed to the "phenomenal environment" of Man.

3. Scott. Geoffrey Architecture of Humanism Univ.Press Edin.

4. The term "need" is used in its wider sense, as it applies to the total organism, for things which are known to "Delight" Man, cannot always be seen to arrive from some specific need.

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When considering formal relationships as I have defined them, there may be said to be three basic considerations.

1. Light. Visual formal relationships, being a function of Vision, there must be light. Illumination.
2. Matter. There must be something to illuminate. In fact the physical environment of which I have spoken, is light plus matter.

Together these may be called the physical component of formal relationships, but since these have to be "seen" by Man if they are to have existence in his Visual world, the third component is Man himself.

3. Man. The subject of man and his interaction with his environment, occupies the subject of the succeeding chapter.

It is convenient for the present to consider formal relationships as an element of the physical environment, and later the commerce of Man with these forms in the phenomenal environment, where as I have suggested the formal relationships have value only to the extent that they minister to mans needs.

Gibson¹. as I mentioned has defined the Visual world as being composed of Surfaces, edges, shapes and interspaces, he continues that the visual world is

Extended in distance and modelled in depth.
It is upright stable and without boundaries.
It is coloured shadowed illuminated and textured.

1. Gibson. J.J The Perception of the Visual World
 Howard Mifflin Co. Riverside Press. 1950

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This is the description of the physical environment, which is the chief concern of the architect, since more and more of Man's physical environment is being fabricated, and we tend to live less and less in a natural physical environment.

"architecture simply and immediately perceived, is a combination, revealed through light and shade of spaces, of masses, and of lines." ¹.

Here we find the psychologist in 1950 confirming the aesthetic theories of Scott in a previous century, for it is important that the architect should know the tools at his command, Scott however in using the term space, rather than Gibson's combination of surfaces, edges, shapes and interspaces, is using a terminology of which the architect has been concerned, so that a brief analysis of space as it is used in this sense is necessary.

The following example from Gibson² will serve to illustrate this:

Assuming that a Man is in space, that is to say in entirely empty visual space, an atmospheric environment. He is at the centre of a sphere of air, the light from external sources (the sun) being evenly diffused. No pull of gravity is assumed and the question is what will he see?

1. Scott. Geoffrey Architecture of Humanism. Univ. Press Edinburgh.
2. Gibson. J.J The Perception of the Visual World. Howard Mifflin Co. The Riverside Press. 1950

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The answer is that the observer will in fact see nothing, and might as well be in total darkness.

Atmosphere is assumed to have no dust particles, and therefore has nothing which would reflect light in any formal arrangement, it has neither texture, nor contour, shape nor solidity, neither horizontal nor vertical axes.

The light stimulating the retina would be homogenous in nature, so that he will see only luminosity and colour, but as there would be nothing on which the eye could fixate, he would be unable to converge his eyes.

Similarly there would be no impression of far or near, no distance. No sense of modelling or surface, no impression of up or down, no equilibrium, so that he would be unable to maintain a posture.

This in fact would be the nearest thing to no-space, and the absence of perception. For visual space, unlike abstract geometrical space (the space of the architect's drawing board) is perceived only by virtue of what fills it. Architectural "space" as such is given by the relationship of the various surfaces, edges, shapes and interspaces, as a continuous array of surfaces, rather than a series of "objects" in "space". It is the physical environment which in fact may be said to give "space" its existence.¹

1. Space may be thought of as an aspect of the architect's formal relationships, owing its existence to the three component parts already mentioned, light, matter, and Man.

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To reiterate, formal relationships in an architectural sense, would be given by the wall surfaces of the building, the ceilings and floors, and all articles of furniture and decoration. They would be given by the natural luminaires, the windows, and what may be seen beyond them, and the artificial luminaires, the "light" fittings. To the extent that the visual world is without boundaries¹. they would also be given by the surroundings of the building, and its relationship to the macrocosm. It would be impossible to consider any of the formal relationships in isolation, since the individual "parts" must contribute to the "whole" of the Building, whilst being subordinate to it.².

The architect must have a complete understanding of the tools at his disposal, if he is to be in a position to utilise his materials to establish formal relationships which have value to man. Having dealt to some extent with the "light" component in Chapter 1.2, it is necessary now to discuss briefly some of the attributes of the physical world, in relation to illumination.

1. Koffka assumes that one is visibly aware of the world which extends backwards behind ones own head.

2. "Contemporary Architects have introduced the conception of the unification of inside and outside space. Solid walls have give way to glass. The Effect during the day is one of transparency and freedom. The artificial formal relationships are in phase with the natural environment, however at night, the artificial illumination, not considered as a part of the totality, is often out of phase with this new spatial approach, The unrelated light sources, gadgets, and fixtures break up the flow and unity of the formal relationships.

Summary of article by Kepes.

Written for Sylvania. Unpublished.

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All surfaces have characteristic reflectance curves, and it is the combination of this reflectance curve, with the spectrometric curve for the light source, which will give the characteristic of the reflected light, acting as a stimulus on the eye¹.

An architectural example of this would be, that if a wall surface is painted "red", which is to say that it absorbs all or nearly all of the wavelengths other than red, it can only reflect light in the long wavelengths. If light with a characteristic curve or line spectra having a preponderance of radiation in the short wavelengths is played upon it then it will be unable to reflect such light, and the wall will appear black. If however light, such as tungsten is used, which has a high radiation in the long wavelengths, then the wall will appear a heavily saturated red. Such knowledge is indispensable to the theatre designer, who by the use of coloured lights, and curtains of various hues is able to create a great number of different colour effects, closely related to the psychological moods of death and life, hope and despair, sunlight and shadow.² It is necessary also for the architect to have an understanding of this process since the success or failure of his formal relationships relies not only on the light source, but on what reflects the light.

1. These two curves will give the physical colour; the phenomenal colour, or that which is experienced by Man, will be given only when the physiological component of man is also added.

2. Fuchs.T Stage Lighting. Little Brown and Co. 1929

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Fig.1.3.1 gives a few typical examples of the reflectance curves that the architect is dealing with, for opaque materials. It will be seen that in all cases mentioned the reflectance curve is comparatively non-selective, that is to say that it will reflect to some extent at all wavelengths, with the highest radiation in the required band....this means that generally if the light is of such a nature as not to contain this required band of wavelengths, then the result will not be a "black wall" but rather a wall being the mixture of the remaining coloured light to the degree that it is present in the reflectance curve of the wall. This is often a more disconcerting fact, since the subsequent effect is less predictable, without a great deal of measurement. In any cases where this is likely to occur it is advisable that the architect should have the material to be used tested under the actual conditions.

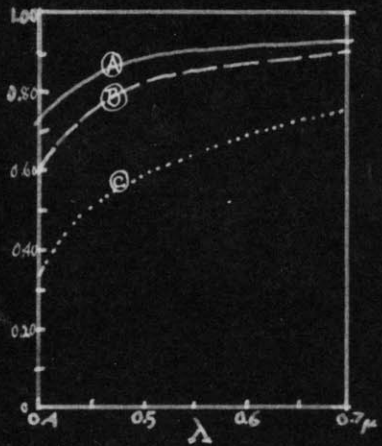
The architect has also to use materials which are not opaque, various forms of translucent plastic, glass, and other materials of this nature. In such cases it is important for him to know the spectral reflectance, spectral transmittance, and any selective absorption that takes place.

Transmission and reflectance are closely allied, for instance a piece of glass of a particular characteristic (eg. opal glass) may scatter all the light that penetrates it.

45% of this light may reappear at the entrance surface, that is to say is reflected, 45% may be transmitted, whilst the remaining 10% is absorbed by the material.¹.

1. Moon and Spencer. Lighting Design. Addison-Wesley. 1948

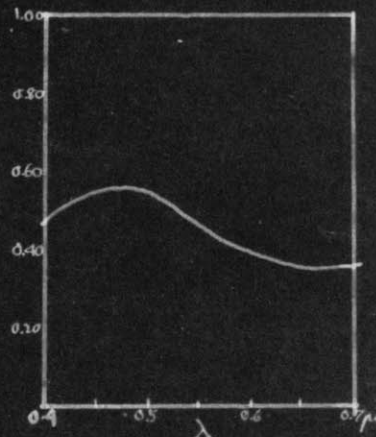
FIGURE 1.3.1
Reflectance Curves for Materials.



Reflectance Curve for White Samples.

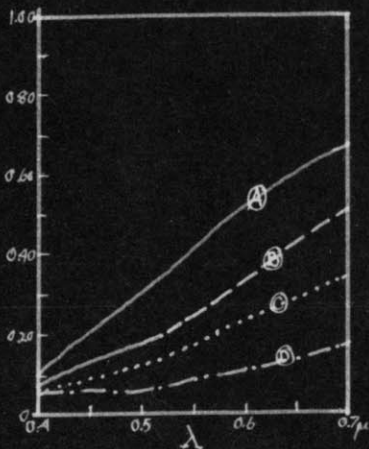
- A. Flat tone white.
- B. Semi-lustre white paint.
- C. Acoustical tile painted white.

Reflectance Curve for a Blue paint.



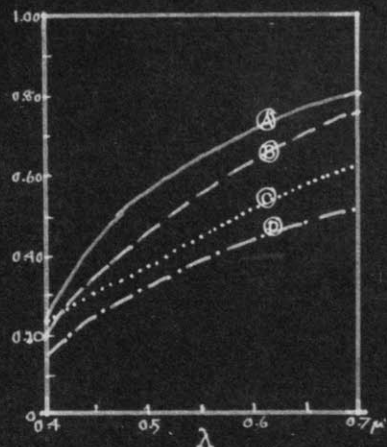
Reflectance Curves for various Woods.

- A. Prima Vera varnished, unstained.
- B. White oak varnished, unstained.
- C. White oak stained.
- D. Oriental wood varnished, unstained.



Reflectance curve for Acoustic Materials, natural colour.

- A. Ins-lite
- B. Gold Bond Insulation board.
- C. Celotex acoustic tile.
- D. Graylite.



Reference. Moon and Spencer. Lighting Design. Addison-Wesley 1948.

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Generally speaking this absorption is converted by the material into heat, but there are cases where the glass may have been designed to cut out selective wavelengths of Sunlight, in the infra-red, for the reduction of heat and glare in a building. In this case a percentage of the light is both transmitted and reflected, and a percentage is absorbed. After a period of time if the structure of the material is unstable, the infra-red rays of light which have been absorbed by the material, tend to alter the physical characteristic of the material and causes a "structural failure" of the material, in the sense that it will no longer absorb the required wavelengths, and is therefore useless for the purpose it was designed.

Since the general recognition of the need for high levels of illumination in certain buildings, the manufacturers of surfacing materials, such as acoustic materials, paints and the like, generally publish with the literature on their product, the factor of "reflectance" of the material.

What they publish is however the "total" reflectance of the material, which depends on the nature of the light source.

In such a case the illuminants likely to be used will be

Illuminant A. Approximating Tungsten

Illuminant C. Approximating Daylight.

When the material is used with a different illuminant, such as fluorescent, or electric discharge lamps, this "total Reflectance" factor will not give even an approximation of the actual reflectance of the material in these circumstances.

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However materials differ not only in their spectral reflectance, but also in their "degree of specularity".

A perfectly specular plane may be thought of as a mirror, imaging exactly the light source, and its relationship to the room. A perfectly diffusing plane is one which will show no images, and will appear the same from all angles. Few materials are either perfectly specular, or perfectly diffusing, being somewhere between the two. The specularity of surfaces, being an essential part of the formal relationships of the architect, is a useful tool in the hands of the architect who plans with a knowledge of its characteristics. It has been found a most useful aspect of illumination in many industrial processes, where flaws, and scratches are shown up in a manner impossible with a diffuse light, but in many cases where no thought has been paid to it, it can prove a most annoying feature of an environment.

There is a further feature of the visual world, as defined by Gibson¹; this is "texture". The sort of surfaces that we encounter in our daily life, are to a greater or lesser extent textured, and this property of surface, will later be shown (Chapter 1.4) to be one of the important cues for man's perception of the visual world, playing an important role in establishing the relationship between one surface and another, and the relationship of man, and his orientation in his visual world.

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What have been the attitudes of architects to "formal relationships" in the past? It is necessary for an understanding of my original concept, and in any future evaluation of formal relationships in the later part of this thesis, that I give a brief resume of what I consider to be the three basic attitudes to form in the past, and the extent to which these attitudes are prevalent today.

1. The absolute value concept.

Form from this point of view is thought to have an intrinsic value purely as form, rather than a value to the extent that it ministers to man's needs. Form in this case may be based on whatever original concept, such as the refinement of structure, as with the Greeks, or Fuller¹. where the essential integrity of a form of structure is exploited in a poetical or intellectual sense apart from its human justification.

Contribution to this concept of form has also come from those who considering organic forms from a structural and atomistic viewpoint rather than a dynamic one, are lead to believe that a static form has an integrity apart from the growth of life-pattern which has produced it.

To take an analogy from the realm of town planning, this attitude might be said to correspond to the "model or ideal" town plans of the Renaissance, in which the form of the city was laid out as a pattern². to which its subsequent growth was made to conform. This may be said to correspond at a

1. Fuller. Buckmaster Dome construction U.S.A and Canada.

2. Rasmussen. Steen E Towns and Buildings. Liverpool Univ Press 1952.

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at a/

different scale to the individual parts or formal relationships of a building, when these formal relationships are "imposed" at an intellectual level, or for "moral" or other reasons, rather than being the logical "form" that would evolve from a study of human need at all its levels.

Form in this sense becomes one of the basic criteria, on which the building is designed, it is generally fixed at the outset, and the individual parts are made to conform. In the work of the Greeks it should be remembered however that the functional requirements of their temples were few, and were in fact based rather on the form, rather than the form being based on the function. It is with the revival "styles" of architecture when these forms are copied for purposes for which they were not intended, and in a country for which they were not designed, that the real fallacy lies. Enough has already been written by abler pens than mine about this for further stress to be needed.

Even so, a glance round our present day cities, not only at what has been built in the past, but what is being built at the present is an unfortunate reminder that the lesson has been far from learnt.¹

1. A typical example of this concept of form, of which there is such tangible evidence, is the absolute static conception of the Dome, into which shell all manner of programs are made to fit, whether they be the entrance hall of a university, a library, or an auditorium, irrespective of their individual need. If the builders of domes were to have their way, a visually poverty stricken world would result, no less anachronistic than Italianate Renaissance Palaces of London, Paris and New York.

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The use to which illumination has been put in this concept of form, may generally be said, though there are exceptions as with all rules, to have been "the lighting up" of an already established formal relationship, or physical environment....it has been made to fit an existing static conception. It is of course true to say that illumination has been used also in the conception of extremely valuable works of architecture, of which an example might be the exponents of the Palladian Villa, for although the original idea of the form may have been developed in a different country, the form was sufficiently flexible to allow innovation, and in many cases illumination has been one of the "tools" utilised in the original conception of the building, instead of performing the job of adding to or articulating an already existing building.

2. The additive Concept.

Form is thought of as the end product of the satisfaction of a limited set of criteria. This has been called "the functional" approach, but to the extent that the criteria used have been inadequate, this may be considered a misnomer.

Although all periods of architecture show examples of this concept of form to a certain degree, it is most brought home by the theoretical studies of the 1930s, when it was felt that a technical solution to the problems of structure, planning, servicing, and sometimes acoustics, of a building would "add up" to a total solution in terms of form. Form was thought of as being the sum, of these individual parts.

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The external formal relationships of the building, as achieved by the natural means of daylight during the day, and the artificial means at night, were said to "express" the purpose of the building.

By means of the voids cut from the solids of the form, light was allowed to penetrate to the inside of the building, and the inside was unified with the outside. Old forms were abolished, and new ones more in keeping with new materials, and new forms of structure were added to the architect's vocabulary of "form". Architects on the whole were astonished to find that the results satisfied few people, and naturally attributed this dissatisfaction to atavistic tendencies on the part of an ignorant and sentimental public. The truth of the matter was however the inadequacy of their conception of form. Where the building programs were limited to factories, and offices, or such engineering works as bridges and road systems, the results to a greater degree satisfied, since they did in fact result from the needs of programs in which satisfaction of the practical aspects mentioned did more nearly meet man's needs in a total way. However when the programs were of housing, the result in terms of man was unsatisfactory in many cases, due to the fallacy involved in the concept. For formal relationships which are designed or arrive, as a result of a satisfaction of an inadequate concept of Man's needs, cannot be considered to be truly "functional".

The loudest protagonists of this concept of form, were not themselves the greatest exponents of it, for in the work of

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Le Corbusier, who did perhaps most to popularise this "functional approach" one can detect a magnificent disregard for it. In his houses at Garche, and the villa Savoye, and his housing scheme outside Paris at Bordeaux, one sees the greatness of the artist in conflict with the principles of the theorist, and the result is a work of passion in which every gamut of the emotions is displayed; and the formal relationships of colour and texture, or light and shade, void and solid, result in a "whole" belonging to a far more adequate conception of form, in terms of light, and in terms of man.

3. The Holistic Concept.¹

In considering a term adequately to describe this third concept of form, I was persuaded to use the term "holistic" mainly because of the discredited use of the term "functionalism" which would at first sight appear to be an adequate.

However on further acquaintance with the term "holism" it seems that what may have been dictated by necessity, may have obvious advantages in practice.

1. From the philosophy of Jan Smuts.

The following entry in the Encyclopedia Britannica, under "holism"

"The theory which makes the existence of wholes a fundamental feature of the world. It regards natural objects, both animate and inanimate as "wholes" and not merely as assemblages of elements or parts.

It looks upon nature as consisting of discrete, concrete bodies, and things, and not a diffuse homogenous continuum. These bodies are not entirely resolveable into parts: In one degree or another they are wholes, which are more than the sum of their parts, and the mechanical putting together of their parts will not produce them, or account for their characteristic and behaviour.

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When discussing Formal Relationships at the beginning of this Chapter, I stated that formal relationships might be considered to have value to the extent that they minister to Man's needs.

To this should be added that they must minister to Man's needs as a totality, or whole, or simply from a holistic point of view. The two concepts of form already discussed were seen to have been found inadequate, firstly because form was something that had an absolute value irrespective of Man's present needs, and secondly because form was arrived at from a limited approach to man's needs. This third concept then has something of both the previous ones, in that firstly, the form is considered as a whole, having value of its own apart from the value of the sum of its parts, and secondly because it must come from a fuller conception of man's needs than the functional approach allows.

"to be a whole, and to live in the whole
becomes the supreme principle."

Man must be treated as a totality, and the building resulting from treating man as a totality, must have a vital force, or "wholeness" of its own. For Holism according to Smuts is an attempt to explore an alternative scheme to the mechanistic, or atomistic view, whilst yet, avoiding the pitfalls of vitalism.

The resultant totality of the building, may therefore be considered to have an integrity of its own, whilst all the individual parts and the formal relationships of the architect subscribe to this unified whole. At the same time the whole

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the whole/

of the building must contribute to a like degree to the whole of the natural, or artificial environment of the city, as one cell adds to another, each a whole but adding to the greater whole of the total organism, by an addition far greater than the sum of itself.

An architectural example might be taken from the building of a Church. The Whole of the Church is everything in Man's experience of it, his initial need for religion, where that exists, the building itself, the clergy, and the congregation, together with his own contribution to the totality of "church." A good church may be considered a very bad building, or vice versa, where the other elements vary in value, but what is important is that the building should contribute to the totality, and as formal relationships may be considered to be an aspect of the whole, it is important that such formal relationships, being the responsibility of the architect should be so considered.

As I have mentioned the architect is concerned not only with the visual formal relationships, which I am mainly concerned with here, but with all formal relationships, which contribute to the experience of Man. An example being that in the office of an executive where the acoustic properties of the structure are such as to allow sound to pass in and out too easily, such an "audible formal relationship" would be unsatisfactory, since it would not meet the demands of the executive.

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In such a case the visual formal relationships might be the same had the walls been acoustically sound, the totality of experience would have been just as inadequate, and for exactly the same reason; an inadequate conception of form, resulting in a disunity of experience.

To what extent is this third concept of form, to which I would subscribe, prevalent in the minds of architects today? Perhaps a quotation from Gropius¹. will serve to show that this attitude is not entirely absent.

"If the emphasis today is not on the Caesars, but on the plain human being, we have to study man's biological way of life, his way of seeing, his perception of distance, in order to grasp what scale will fit him. Buildings must serve his physical and emotional needs, not dictate to him. When we perceive space, the size of our bodies— of which we are permanently conscious— serves as our yardstick or module in our search for the human scale. But relationships in space are not static, the element of time has been introduced as a new dimension in space.... An optical counterpoint has been used in the past to achieve unity of the physical environment; and knowledge of optical phenomena is imperative to those who would design on an objective basis. In this respect science can provide the architect with the implements to realise his design. The science of space can raise building into the realm of art and in that function can become the key for "a common language of design" to be understood by all."

In the works of Gropius and others there is a growing realisation that man must be studied as a whole, and that the proper study of architecture is a study of man.

1. Gropius. Walter Planning Man's physical Environment
Princeton Univ. Bicentennial 1946.

"Every external stimulation is referred to a system of values based upon conscious or subconscious purposes of the individual."

Kepes.¹

PART 1

Introduction.
Man, Light and Architecture.

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Man.

In the foregoing chapters I have considered formal relationships as being the product of light on matter in the physical environment,² and by a discussion of what constitutes value in formal relationships, have tried to show that when the holistic viewpoint towards them is adopted, they are seen to have value only to the extent that they minister to man's needs

1. Kepes.G Article for Sylvania. Unpublished.
2. But since the architect is dealing with man, they must be considered in their phenomenal aspect.

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In the light of this knowledge it is necessary to state, that since man's needs are not wholly understood, it would be impossible to postulate a theory that would say that "if such and such a need is satisfied, then a solution in terms of man, would result in "delight"." For in the lack of further information about man's needs, and about man himself, it is presumptuous even to suggest that what "delights" man necessarily arises from any need at all.¹

Perhaps the most that can be said is that when form is considered from the holistic approach, such factors may be seen in their correct light, whilst with other approaches, the concept is so limited as to preclude their consideration altogether.

The holistic approach incorporates, all man's needs, known or unknown, conscious or subconscious, relying for its basis on a study of man as a total organism. And though in the future it may be more and more possible to predict from such a study the sort of formal relationships that will delight man, for the time being the architect can only rely on the information that is available.

In the ensuing study of man's needs, the limitations that are at present evident in the concept, due to an inadequate knowledge should be born in mind.

1. Kepes quotes the "arrival of the first snow" in this regard, saying that though this answers no need of man, as they are understood at present, the result causes delight.

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During this discussion, I have tried to separate where it has served the purposes of simplicity to do so, the physical environment from the phenomenal, and this chapter will be devoted to a discussion of the human perception, or commerce with, these physical forms, audible, tangible, and visible¹.

In order to have a basis for an understanding of man's needs in a visual sense, it is necessary to discuss briefly the visual process since

...the sensory modes of registering the modulated light, the various sensations of colour, become the means for the spatial ordering of objects and events.²

In 1709 Bishop Berkeley wrote "An essay towards a new theory of Vision." in which he discussed the way in which man's sense of sight had developed. He writes...

"For this end the visive sense seems to have been bestowed on animals, to wit, that by the perception of visible ideas... they may be able to foresee the damage of benefit which is likely to ensue upon the application of their own bodies to this or that body which is at a distance; which foresight how necessary it is to the preservation of an animal, everyone's experience can inform him."

When trying as an architect to deal with such an open field as "Vision", it becomes difficult to avoid useless repetition, of basic facts that can be conned from any textbook on the mechanism of the eye, and in order to avoid this it is possible that I may run into worse danger by experimenting

1. Visible. For the purposes of this thesis I am dealing mainly with the visible aspects.
2. From the flyleaf quotation by Kepes.

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by experimenting with/

what I hope may be a simple concept on which a practical study of man's needs may be based.

Starting then from the quotation from Berkeley, it can be seen that what man perceives (as the end product of the process, however this may be obtained) is a visible idea.

Continuing on, on the lines of Berkeley, one might add that man does not use his visive sense in order to have a visible idea only, but in order that he may act upon it. For man did not "forsee the damage likely to ensue" without acting in order to prevent it, for a philosophical attitude towards danger would have been unlikely to have resulted in longevity.

These then may be considered to be two most important aspects of perception.

1. That man perceives visible ideas.
2. That he perceives, in order that he may act.

This does not appear to be in any way an unusual way of looking at man's visual process, to proceed...

But we observe that the physical environment, as such, is not a visible idea, it is comprised of concrete discrete wholes, to a greater or lesser extent. Nor does this physical environment become a part of the eye in order that we may experience it. The Man is placed in a physical environment, and yet due to his "visive" sense he is able to obtain "visible ideas" about this physical environment by means of the light reflected from objects on to the retina of his eye, and acting through his nervous system.

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Before becoming involved in the many theories of the way in which the physical world becomes "the visible idea" of which the Gestalt and Gibson theories may be considered only the latest in a long line of theories which it would be tedious to enumerate, perhaps it is possible to discuss the process as a whole, by asking such a question as: If Man acts as a result of his "visible ideas" then what is the sort of "information" that such visible ideas must convey? and then if one could establish the sort of information that man needs, perhaps this method might be of more practical use in ensuring that he gets it, than for the illuminating engineer to decide that a certain number of ft.candles thrown on to a certain task will be adequate.

In other words what should be thought of is not how much light do we need on this task, but rather, how much information does a person need about this particular thing?

Perhaps if we enquire in some architectural examples, this point and other differences between this approach and the traditional illuminating engineering approach may be brought out.

1st example. The design of a Restaurant.

It is impossible to think in the abstract about restaurants in general, and to say that in all restaurants it is necessary to provide so much light on the task, that of eating.

But a more productive way of looking at the problem is to say; in this type of restaurant for instance, the sort of

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the sort of/

people who come to it will like to sit with a friend, and feel their own "separateness" in an environment where good food and wine are to be had, they want to feel as though they are having very special attention, but they are comparatively uninterested in anything else that goes on in the restaurant apart from their own little world. In such a restaurant, which would cater chiefly for such a type of person, the amount of information that the diner would want might be as follows.

He would want to be able to orientate himself in the main space of the restaurant, he would want to be able to act, in the way of movement within this space at any time he so wished. So long as sufficient information was supplied him concerning this, he could walk safely, and without difficulty, provided the other formal relationships were not against it. He could see that the floor was flat, he could feel when he was walking that it was so, he could see to cross the floor between tables, and he would have sufficient information to enable him to leave at the right door.

Other information that he would want would be, concerning the food on the table, and the person with whom he is with. he would want for instance to see that the food was the usual colour that it should be, and looked what it was, whilst he would want all the information about the expression colouring and subtle inflexions of gesture that his companion

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his companion/

might make during the course of conversation. So long then that his needs in this way were met, that the information that he wanted was conveyed by the formal relationships, into the visible ideas that he needed, then these formal relationships would have value to him to this extent at least. Had less information been conveyed, then his actions would have been in some way restricted, he would have been unable to walk across the space easily, or he would have been unable to act on the subtleties of inflexion of his companions mood; or had incorrect information been conveyed, such as the bread looking green, or the wine blue, he would have been unable to act in the manner he wished originally, which was to eat the food (which might have been perfectly wholesome but incorrectly illuminated), or yet again had too much information been conveyed, so that instead of seeing only as much as he wanted, all sorts of other things could be seen, such as the people who were eating at the next table, the dust on the floor, waiters rushing about attending other people, he would have been equally unable to act in the way in which he wanted.

May one conclude from this that man needs sufficient, correct, information in the form of visible ideas, in order to enable him to act, in the way that he wishes, or the way that his body's economy would dictate. He needs neither more nor less.

To continue the example of the restaurant, but this time a different type of restaurant. Here it is intended for the

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for the/

hurried office worker, who wants a quick lunch, and who since economics dictate his needs, wants a cheap one. In such a case the visible ideas that are likely to result, are bound to be a compromise, so that it is less possible to treat this problem by this present method of analysis. However supposing for the time being that one could, one might say that firstly the sort of information that he would need, would be for him to be able to orientate himself in the space on arrival, and to be able to move safely, if not too freely due to the obvious necessity in such a restaurant for a certain overcrowdedness. He wants the sort of information that would be likely to enable him to obtain a meal in the fastest time. The needs of the waiters, and the people who are there to ensure that he does have a meal in as fast a time as possible, so that they can get him out, and someone else in, also have to be met; and since they too need as much information about their own particular work, in order that they may act upon it efficiently, the whole of the restaurant is likely to have to be designed in such a way that the formal relationships of the architect will convey the "maximum information" in the form of visible ideas, upon which those people (having commerce with these forms) may act.

From this example then it may be seen that there are cases where a maximum of information has to be conveyed, but this is by no means ~~always~~ the case.

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2nd Example. Applying this method to two practical tasks. Firstly climbing stairs. What is the sort of information that is necessary. Again, as always information enabling him to orientate himself in space, information of where the staircase is in relation to him, where it leads. He needs information as to where the first step is in relation to the second, the height of the riser, the width of the tread. Much of the information that he needs to know is assumed, for instance when he sees a staircase covered with carpet, he ascends on the "assumption" that below this carpet there is a structural stair, and in fact much of the information which enables man to act in and on his environment is assumed; he assumes that the man driving towards him will continue on such a course as not to hit him, and so he assumes that when information is lacking (such as on an illlighted staircase) that the staircase continues, until checked by the information of a landing, at which point he pauses to check the position of the final step.

Man's action towards a flight of stairs is not only the result of the visible idea, for where there is a handrail the tangible formal relationship may assist particularly where the visible idea is absent or insufficient.

Secondly reading a book. how can this form of analysis be applied to reading a book? It is I think obvious that primarily the information that is wanted is that contained on the printed pages themselves, and which is achieved by

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is achieved by/

both an understanding of the symbols which convey ideas to the brain, and ^{the} notion of the printed page, as a visible idea itself, about which the information must be sufficient.

The information must be efficiently conveyed, he desired neither more nor less. Aspects which are known to lower the amount of information which may be had, are specular reflection of a luminaire misplaced in relation to the book, which would cut down the contrast between the print and the page, so that information would be more difficult to understand. glare sources outside the area of the book, which would cause a stress on the eye, since it would have to concentrate by the use of the muscles of the eye to keep the eye accommodated to the book. There are other aspects which would lower the amount of information that man could act upon, such as poor printing; as well as print in an unknown language, or the fact that the information cannot be understood, also such as a great deal of noise causing audible ideas that would conflict, rather than add to the visible ones.

From this example then it can be added that the information must be such that the visible idea can be understood¹. by the person for whom it is intended, if "information" is to be past. Also that other ideas may conflict with visible ideas to the detriment of the passage of information.

1. For instance a Christian may have many visible ideas concerning the inside of a buddist temple, but he would be incapable of understanding these visible ideas in any complete sense.

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Other examples of this detrimental effect on the passage of information in this example might be the fact that the seat in which the person is sitting is uncomfortable, causing postural difficulties; or that due to the lack of light on a book a person has to take up an unusual posture in order to gain a better light, in order to obtain this information. The person might be hungry, and so unable to concentrate on the information though the visible idea would have been forthcoming from the amount of information had he not been hungry. So that the failure or not of the visible idea, as a basis for action, is not alone attributable to the formal relationships of the architect.

Other information that I am now assuming to be needed in all cases would be the information of the person's orientation in space, and to any object in that space which he wishes to act upon.

3rd. Example. Man's experience of the "whole" of the building. Perhaps it is best to think of this problem as a Man's initial experience of a building.

The information that he requires of the individual parts of the composition, is his orientation in relation to them, and its relation to his total visual world, he needs to know how he may approach the building, and how he may enter inside it.

However there is other information that he must know, in order that he may "act" on the building as a totality,

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his action in this case may not necessarily be a movement, but can take the form of an expression of pleasure, or displeasure, or even indifference, but may be said to be the action of "experience" of the building as a part of his total environment, and of the "experience" of the building as a discrete whole itself.

In Chapter 1.3 I said that "the resultant totality of the building, may therefore be considered to have an integrity of its own, whilst all the individual parts and the formal relationships of the architect subscribe to this unified whole." It is the information of this "integrity" which it is the architect's job to convey to the person as a visible idea.

It may of course be said at this point that I am trying to stretch this "information theory" too far, and although this of course may be the case; I believe that the action which I am calling "the experience of a building as a whole" can only be a truly unified one if the information of this "integrity" can be conveyed by the formal relationships of the architect, as a "visible idea", to the consciousness of the individual.

To take an analogy from painting, if the work of a painter cannot convey the information that he wishes to convey, in the form of a visible idea; whether that idea be a preraphaelite morality, or a structure of colour and line, then this work is of relatively little value to that particular person.

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As I have already said¹, the "whole" of the building, as it is experienced by man, does not consist of the formal relations of the architect alone, since it is composed of everything in man's experience of it. So that it is not possible to be specific as to how much of a person's experience of a building is the result of its visible aspect and how much the result of all the other factors involved.

However in concerning myself with "visible ideas," since this is a thesis on Illumination, and illumination is a means by which "visible ideas" are achieved², it is necessary that I should try to limit the scope, in order that the subject may be covered in as precise a manner as possible; I shall therefore not concern myself with notions conceived by the brain of a nature other than those resulting from his sense of sight; other than to state that they exist, and form important aspects^{of} mans experience of his environment.

Considering then the visible idea, and the extent to which it answers man's needs, I am thinking of this as present in the sense of "information" of the physical environment, which man needs in order to act, which is to say to assist in his total experience, of the building as a "whole".

1. In Chapter 1.3 discussion of the holistic concept of form.
2. Through the information given by the formal relationships.

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In this respect the formal relationships of the architect, can be seen to have a dual aspect.

Firstly it can be seen that they will have a value to the extent that they faithfully convey such information as the architect wishes them to convey, of the physical environment that he creates.

Secondly they will have a Value apart from this, in the nature of the information itself....since this is "what the architect wishes" to convey, rather than the way in which he does it.

To continue the analogy from painting, the painting will have value to the extent that the painter is able to convey his message; but it is the value of the message itself, which in the final analysis is of the greatest importance. The most superb craftsman may be a very inferior painter for this reason, whilst the person of imagination, who is less capable of conveying his message has more chance of being considered the greater. However it is when the execution, or the manner in which the information is conveyed, matches the inspiration, that the overall unity of the painting is felt.

In architecture then the "information" of the "whole," or the formal integrity, may be experienced by man in the manner that the architect wishes, but the possession of such knowledge in no sense guarantees that he will experience "delight", since this depends on the value of this "information," or whether it satisfies him at all levels of his consciousness.

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Moreover since architecture is a social art, in that man is in the position of being obliged to come into contact with buildings, and the artificial environment of the architect to an increasing degree; it seems important to me that the information should be of such a nature as to convey an experience of pleasure rather than displeasure, to as great a number of people as possible. It is easy not to buy a painting, but impossible not to come into contact with the environment of the architect.

In order to convey to the observer the visible idea of the building as a "whole", it must be the job of the architect to convey to him, the purpose of the building as a whole, its significance as a part of its environment, and its fitness for its purpose. For in order that he may "act" in this sense, he must know whether what he is looking at is a Church, a factory, or a waterworks.

It was not surprising with the introduction of the steam engine, that the first railway carriages should have been made to look like their counterpart of the horse drawn days, since the first information that the early designers wished to convey was the information that here was something that "moved" in the same way as the horsedrawn carriage, and with all its safety. This matched with the past experience of the individual, and he was able to accept this more easily than he would have done, had the carriage been more truthfully designed.

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It was soon felt however that the information which these carriages conveyed was incorrect, since they were no longer suitable for their purpose of travelling at increasing speed along a given track, so that other carriages were built which conveyed this new information more truthfully. The new carriages then conveyed the exact information, that here was a form of transport of a different nature altogether.

To take a present day example, a man looks at a building for the first time, and he sees that it is a church, all the information available to him culminates in the experience of the visible idea that this is a church.

Another man may look at the same building, and in his case the information¹ conveys to him that this may be a church, a factory or in fact almost anything.

What has gone wrong, for something surely has, since one person experiences a sense of dissatisfaction being unable to feel the "integrity of the "whole" except perhaps as an abstraction.

The fault may lie with the man himself, he may be foreign to the country, and not understand the purposes of the buildings he sees, or not being in a foreign country, he may have had such a poverty of experience in the past as to be unable to recognise something for which the information

1. Information which remains the same for both men, to the extent that they are in the same place at the same time.

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the information/

in a more general sense was adequate. However it is also likely that the fault lies with the architect; and I think that it may be called a fault, (since it is the architect's job to add to the richness of man's experience in a positive way) if the value of the "information", in terms of man, is insufficient to convey a satisfactory visible idea.

In a world where new materials, and new methods of structure are resulting in forms for which there has been no previous match, only time and man's inherent ability to comprehend "the whole" where it may exist, can decide whether such forms do in fact convey the sort of information of the integrity of a form, based on its essential unity, fitness for purpose, and its significance for present day life, which will convey visible ideas

"which are seen to satisfy the human test, and to have brought an enlargement of human power."

Perhaps it is possible at this point to summarise briefly the main points in this information theory. Individual information will vary for each program, and the importance of the different points will vary relative to each other, so that in most cases some form of architectural compromise will be necessary, in order that the most important aspects of information concerning the building, may be conveyed.

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Summary of the information for the visible ideas on which
Man may act.

1. The information must be correct, which is to say unequivocal.
2. The information must be sufficient, rather than maximal, or minimal.
3. The information for all other ideas¹. should contribute as far as possible to the visible idea, and in no way conflict with it.
4. Where information is likely to be assumed, then the reality must correspond to the assumption.
5. The information must be understood by the person for whom it is intended. It must be capable of "meaning".
6. The information must be obtained in such a way as to set up no undue stresses² on the body's economy.
7. The information concerning "wholes" rather than the sum of its individual parts should predominate, utilising the inherent tendency of man to have "visible ideas" which correspond to the "whole." This might be considered as information of the Unity of the building, or the integrity of the form as a "whole".

The above list may be considered as the "Manner in which the information is conveyed"³. There is however a further point which may be considered later, though since this is a function of so many different variables, it is not possible to treat it in the same fashion.

8. The quality of the information itself. Or the value of the information the architect wishes to convey.

1. Other than the visible idea. ie. audible and tangible. a synaesthetic solution must be sought.
2. By undue stresses, I mean such as to cause permanent strain.
3. Such a list would contain everything but the "value" of the information.

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I stated at the outset of my investigation of this information theory, that it was an attempt to find a concept which could be relied upon as a basis for man's needs, which could result from a discussion of the visual process as a "whole".

I had no intention of trying to establish a purely mechanical theory, which would say, "supply the right information, in the right way, and that is sufficient" The notion is absurd enough. For there is ample evidence that designs in which this is done do not necessarily "delight" man.

An example of this might be a special box constructed for the purpose of experiments into lighting¹. in which a person might be asked to sit and to listen to music, or to read. The wall surfaces being variable, it could be so arranged that the conditions within the box answered all the aspects of the information theory such as I have outlined it...but by no sense of the imagination could the result be considered to have answered the man's needs in a total sense. What has been lacking is not the information itself, but the fact that the quality of the information has not delighted him.

An example of this might be the difference between a reredos by Narcísco Tomé at Toledo, or many another baroque reredos of the early 18th cent, and the simple reredos behind some

1. Such as the one in the M.I.T. Lighting Lab. which I constructed in 1953.

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behind some/

altar in a simple unpretentious modern church.

The difference lies not in the way in which the information is conveyed, which in both cases may be most adequate, but rather in the difference in the "quality" of the information; In the baroque example, already mentioned the light flows like a river down the moulded forms, splashing the gilded wood, so that the quality of the information is of the whole "wonder, might, and majesty, the transcendent character of god, as it was conceived at this time." whilst in the modern example, the rational simplicity of the information that is given is more suitable to the way in which religion may be thought of at this time; where it is simply not just the result of a general impoverishment of ideas.

In such a case one judges by the quality of the information, over and above the manner in which it is conveyed. Since this is not a thesis dealing with what is the basis of imagination, this is something that I may safely leave.

For the purposes of this thesis I am dealing mainly with manner¹ of the information, as I have outlined, it, rather than the quality that an individual designer may be able to give it.

In designing or judging a scheme using the above criteria, the fact that this is not a final judgement must be born in mind.

1. Manner, here denotes "the manner in which it is conveyed."
see list overleaf.

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At this point it would be useful to reiterate the various concepts that have so far been put forward.

ILLUMINATION

That illumination is considered to be a means by which formal relationships may be achieved.

That the formal relationships of the artificially created physical environment, have value to the extent that they minister to man's needs in an holistic way.

MAN

Man's sense of sight has been developed in order that he may perceive "visible ideas" upon which he may act.

In order that he may act, man needs "information" of a specific character, for the perception of the necessary "visible ideas".

It is (therefore) the task of the architect, by the use of his knowledge of the interaction of light and matter; to so arrange his formal relationships, that they may mediate the specific information which man needs for the perception of visible ideas, upon which he may act within and upon his artificial physical environment, in an acceptable manner.

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In the final concept outlined overleaf, it can be seen that the visual formal relationships of the architect mediate the specific information man needs for the formation of visible ideas, upon which he may act.

I have dealt to some extent with the three aspects of this "information" which are as follows.

1. The value of the information itself. This is to a large extent intangible, and incapable of quantitative analysis. It involves the emotions and feelings of man, his hereditary and learned personality, and is the suitable study of the psychologist, from which research the architect will be in a better position to understand the needs of man in this respect.

2. The manner of the information, which I have shown to be the quantity, veracity, clarity, meaning, and unity of the information, together with the ease by which it may be obtained, since this too is the legitimate study of the architect, to the extent that it is given by his formal relationships. This is more capable of quantitative analysis, and each individual architectural program, should be considered from all these aspects.

3. The subjects about which the information is needed. Here again one is dealing with something which is capable of quantitative analysis.

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Broadly speaking it is possible to classify this information into the following headings.

1. Information concerning the physical environment, in the case of this thesis, this would be the artificial physical environment created by the architect.
This would be concerned with the materials, the spatial relationships, planning, in fact the whole "richness" of experience which the architect is able to provide.
2. Information concerning mans orientation within this physical environment, the relationship of himself to the environment..
3. Information concerning any action made necessary by man's contact with his physical environment, or made possible by it. Movement.
4. Information concerning other objects and people within his physical environment, such as are not provided by the architect. His orientation to them.
5. Information concerning any action made necessary or possible by such other objects or people within the physical environment. Relative movement.

It is possible to think of this "information" from three different view points.

1. Physically. The interrelation of light and matter.
This I have discussed already.
2. Physiologically. How this information is conveyed, in the form of stimuli, and how the eye receives it and is affected by it.
It is convenient to consider this at the level of the phenomenal environment.
The extent to which the body, as opposed to the brain is affected by it.
3. Psychologically. How this information results in the visible idea. the affect on the brain.
How the information is used.

In this Chapter so far I have tried to discuss the visual process as a whole, from the physical environment, to the visible idea, and man's subsequent action.

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From the point of view of the architect however, it is necessary also to analyse the process of vision, in order to see how the "information" provided by the formal relationships, is transferred by means of "light energy" of a specific pattern, to the retina of the eye, and subsequently is used by man as a "visible idea".

It is important that:

1/ The architect should understand how the physical environment becomes the phenomenal environment, as experienced through his senses, and the "visible idea" when integrated with his total stimulation pattern.

and

2/ What conditions will assist this process.

For the purposes of analysis, in the past what may be termed a "camera concept of vision"^{1.} has been used in order to explain this process. There is sufficient literature to make it unnecessary for me to go into this other than to say that the eye has been thought of as a camera, with its own automatic focussing and lens aperture adjustment, which reproduced an image of the physical environment on the self renewing film of the retina, by means of light energy.

Since the only part of the retina which establishes a focussed

1. Helmholtz. Hermann Physiological optics. 3 vols.
edit. J.P.C. Southall. Opt. Soc. Amer. 1925.

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a focussed/

image, is the central foveal area, which is concerned with the discrimination of fine detail; this has led in the past to the application of bench optics to the concept of vision, and the assumption that the remaining areas of retina, are of much less importance!¹.

It is now however a growing realisation that the eyes are concerned not only with central foveal vision, but through the whole eye, with the total organism of man.

For it has been shown that much of the nerve circuiting from the periphery of the eye goes not to the visual cortex, or area of the brain thought to mediate the sense of sight, but to the body posturing mechanisms. Whilst those "leads" which do go to the visual recognition areas of the brain,

"go there in summation only, and then only when mixed in an undifferentiated manner with nervous impulses coming from the posturing muscles of the body, and from sense organs related to other energy organisations of the environment." 2.

It is therefore impossible to differentiate the functions of the retina, or as they have been called "vision," in any complete form of mechanical or atomistic sense, for although one does not deny that the organism has certain mechanical arrangements

1. Harmon. Darell B. Are we confusing Eyes with vision? Illum. Eng. April 1953.
2. Harmon. Darell B. Seminar. M.I.T. Sept. 1953. Vision Brightness and Design.

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certain mechanical arrangements/

these do not extend to the highest level, the psycho physical stratum. It is the view of the Gestalt psychologists that the ordered arrangement of visual phenomena, as it exists on the retina, persists to the area striata, and that dynamic self distribution begins beyond this point.¹.

According to Gerard:².

"So long as our picture of the nervous system was that of the telephone exchange....the appearance of new responses seemed to demand the presence in the brain of rather mysterious telephone operators to shift the plugs. Now with our discovery of a far more fluid nervous system, one unceasingly active, and with neural and electrical messages rippling the whole into dynamic patterns, which flow from one contour to another as present influences play upon the condition left by past ones. With such a condition, the arrival of new neural relationships is no great problem.

In spite of this it is upon the "camera concept of vision" that the criteria for illumination standards is based. These criteria include, visual acuity, speed of vision, brightness of the task or contrast ratios, all of which are based on a study of the central foveal areas. A wider concept must be found which will integrate the results of researches on the total organism, as he is affected by light at all levels.

1. Katz David Gestalt Psychology its nature and significance
 Trans. Tyson. R N.Y. Ronald Press Co. 1950.
2. Gerard R.W The biological basis of Imagination.
 From/ The Creative Process. Ghiselin.
 Univ. of Calif. Press. 1952.

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Physiological component.

If Gibson is correct, and there is an adequate correlation between the image on the retina, and the physical environment, or in other words an adequate variability of sensation to account for the accurate perception of the visual world, so that every variable of the physical environment, was transposed on to the sensory field complete; this would account for the fact that despite the narrow angle of our field of "fine discrimination" man is able to act with considerable efficiency on and within his physical environment.

His theory¹ whilst emphasising the fact that the retinal image is not an exact copy of the physical environment, thinks of it as a very accurate correlate, he emphasises the close correspondence rather than the differences.

Such a theory as Gibson's interests the architect particularly since it concerns itself with this correspondence; for it seems feasible that with a greater knowledge of how the variables (physical environment) act as an adequate stimulus, the architect would be able to plan his formal relationships in a much more positive manner. It might even not be too much to hope that such a knowledge would suggest a more closely coordinated relationship between the Light and Matter

1. Gibson J.J. The Perception of the Visual World.
Riverside Press. Cambridge Mass. 1950.

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the Light and Matter/

components of the formal relationships.

The classical stimulus of the sensation of sight, is combinations of the following variables:

- 1/ Wavelength of light.
- 2/ Energy or intensity of light.

however this would account only for areas of homogenous colour patches of light, and it is the traditional theory that the "mind" in the form of Gerard's little telephone operator¹. transposes these "inadequate" stimuli into the "percepts" of vision.².

Instead of the single spot type of variation, Gibson conceives the retinal image transposed as a "pattern of excitation" on to the retinal mosaic. (the nerve endings of the eye) He draws the analogy between the bank of electric light bulbs, over which a pattern may be played. The electric light bulbs do not move in relation to themselves, but the pattern of excitation gives the effect of apparent movement in relation to the picture.

In the retina, the nerve cells (neurons) are in an anatomical relation to each other (as are the bulbs), but when a pattern of excitation is transposed on to them, they are in an

1. See previous reference. Chapter 1.4

2. The dynamic self distribution of the Gestalt psychologists, is a far wider concept than this traditional one, and does not seem to me to be incompatible with parts of Gibson's work.

they are in an/

"ordinal" relation to each other, or an adjacent order that gives the pattern. When the eye moves the ordinal pattern is preserved though you may be aware of a different part of the pattern; whilst the anatomical pattern, the neurological structure, undergoes a complete rearrangement.

Gibson distinguishes between the phenomenal visual world¹. as I have defined it, which is mediated by the surfaces and edges, shapes and interspaces of the physical environment, and for which there is an adequate correlation of stimuli, and the visible idea². which is the summation of man's knowledge about a certain thing, and concerns the people, symbols, places, signals, and objects of the everyday environment.

A common basis is therefore found for man at the phenomenal level, since what Gibson calls the "literal Visual World" is the same for everybody, to the extent that they are in the same place at the same time, differing only to the extent of abnormalities of the eye, or structural differences.

The aspect of Gibson's theory which most interests the architect, is the data on the ordinal pattern of stimulation, since this is what accounts for the accuracy or inaccuracy, of the "information" concerning the physical environment.

1. Which he calls the Literal visual world.
2. Which he calls the Schematic Visual World. From the word schema, meaning a vague standard arising out of past experience, placing new experiences in new contexts.

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In order to make this point clear it is necessary for me to go rather more deeply into the theory, in order to show an example of how this may be used by the architect; it is felt that a greater study of other aspects of Gibson's data from this point of view would be profitable.

Earlier in this chapter I have suggested that one aspect of the information that man needs in order to act on and within his environment is (Point 1/)

"Information concerning the physical environment, which for the purposes of this thesis would be the artificial physical environment created by the architect. This would be concerned with the materials, the spatial relationships, planning, in fact the whole "richness of experience" which the architect is able to provide." 1.

What are the properties of the physical environment, that yield this information, and how do they yield it, or in what manner?

- 1/ It is composed of surfaces, edges, shapes and interspaces.
- 2/ It has a three dimensional property. It is seen in depth.
- 3/ It is stable and boundless.
- 4/ It is coloured, textured, and has properties of light and shade.

1. We are now considering this information at the Physiological

1. We are now considering this information at the Physiological level, and from the visual point of view.

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Gibson gives the following data as to the nature of the ordinal stimulation which yields these properties of this particular aspect of the information.

1/ Surfaces.

The general condition for the perception of a surface is the type of ordinal stimulation which yields texture.¹

Surfaces are of two fundamental types; frontal, those which are transverse to the line of sight, and longitudinal those which are parallel to the line of sight. Fig. 1.4.1. A textural gradient can be considered either from its gross composition, the roughness of a wall or a ceiling, or from the point of view of its micro-structure, which equally well mediates a gradient of texture. An example of this might be the work of the Dutch painters, who reproduced the texture of velvet in their paintings, by attempting to recreate the similar ordinal stimulation of the eye. The Impressionists attempted to achieve the same effect by an approximation of the total stimulation rather than a microscopic analysis of its individual parts.

1. Types of stimulation such as a clear sky, which has no resolveable texture, is not seen as a surface. The light sensitive neurons of the retinal mosaic, react to gradients of stimulation, one of which is this gradient of texture. Such gradients Gibson considers to be capable of mathematical interpretation.

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Edges.

The general condition for the perception of an edge, is the type of ordinal stimulation consisting of an abrupt transition, between retinal gradients, a jump between the two. This is clearly indicated in such a gradient as that of brightness, or of texture. Fig. 1.4.2

Shapes.

This is considered at this point as the projected shape of the retinal image; defined by its surfaces and edges it has a projected contour and depth shape.

The general conditions for the perception of shapes being gradients of Texture, and intensity.

The depth shape is given by changes of gradient, or of one rate of convergence of a gradient to another. (as opposed to the contour or edge, which is a jump between two) Fig. 1.4.2

Interspaces.

As the background to objects, or the spaces inbetween, the "interspace" is however not seen as an outline or contour¹.

The general condition for the perception of an interspace is the same as that for frontal and longitudinal surfaces.

2/ Its three dimensional properties.

1. It is in fact difficult to introspect sufficiently to see it as an outline for experimental purposes.

FIGURE 1.4.1

Surfaces are of two fundamental types: frontal and longitudinal.



increase of gradient with distance.

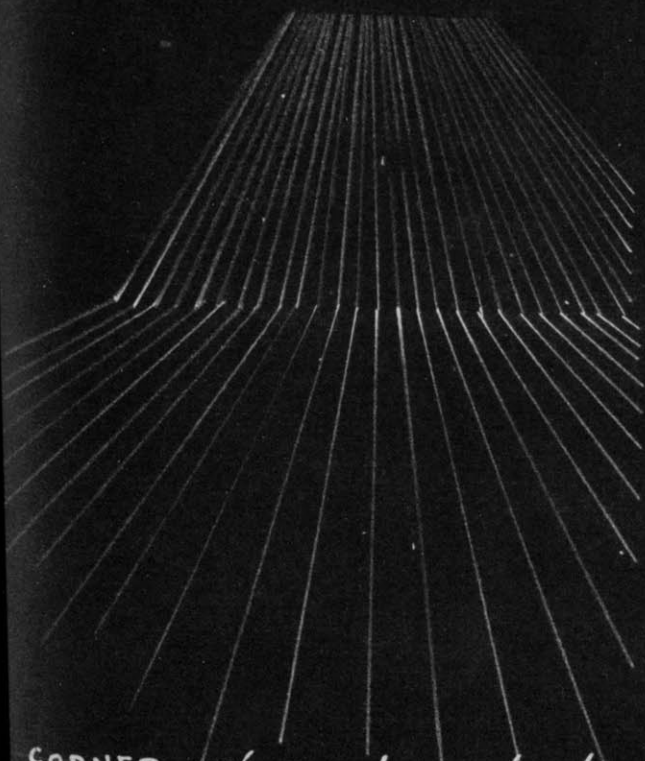
MEDIUM GRADIENT CHANGE.
SLANTING SURFACE.

FRONTAL SURFACE.
NO GRADIENT CHANGE.

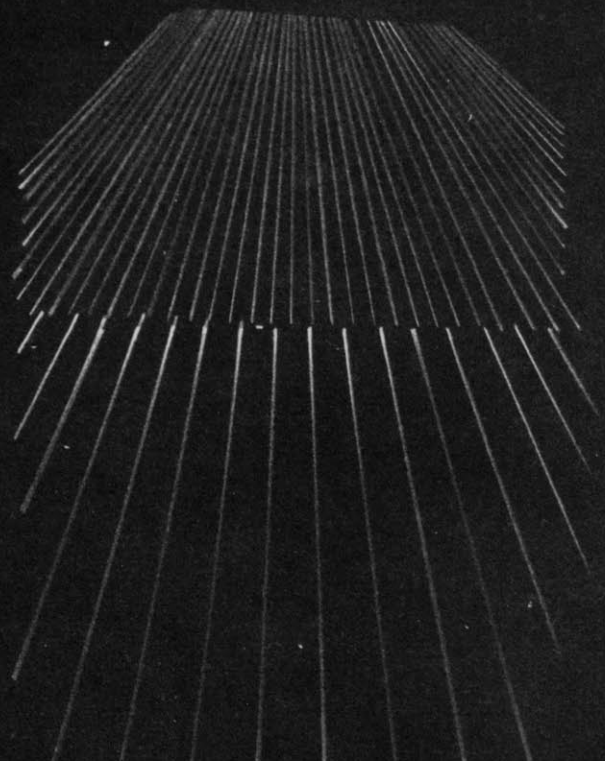
transverse to the line of sight.

A LONGITUDINAL SURFACE. E
STEEP GRADIENT CHANGE parallel to the line of sight.

FIGURE 1.4.2



CORNER *change of one rate of convergence to another.*



CONTOUR *abrupt transition between gradients.*

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The perception of distance cannot be so precisely defined as in the previous case, since it is not a simple stimulus, but rather must be thought of as the summation of all the stimuli acting upon the retinal mosaic. This is sufficient in ordinary circumstances to give the impression of a world extending in distance away from the observer, without any "extra-interpretation" on the part of the mind, or of Gerard's little "telephone operator".

Instances will occur when interpretation of the facts given by the senses, will require the utilisation of all ones previous knowledge; such an instance might be in the judgement of the distance or height of aircraft. The same ordinal stimulation of the retina will be given for an aircraft of 50ft wingspan at 500ft, as will be given by an aircraft of 100ft wingspan at twice that distance. In a blue sky with nothing to which these may be related (further cues being absent) the observer would have to call upon previous knowledge of silhouettes, engine noise and other such data in order to judge distance. I show an example of this, where the cues are insufficient. Figure. 1.4.3

However in the normal physical environment the perception of depth is largely reducible to the perception of longitudinal surfaces, for which the stimulus correlates have been given. The ground is the main surface, but in the artificial environment the walls and ceilings are also of value.

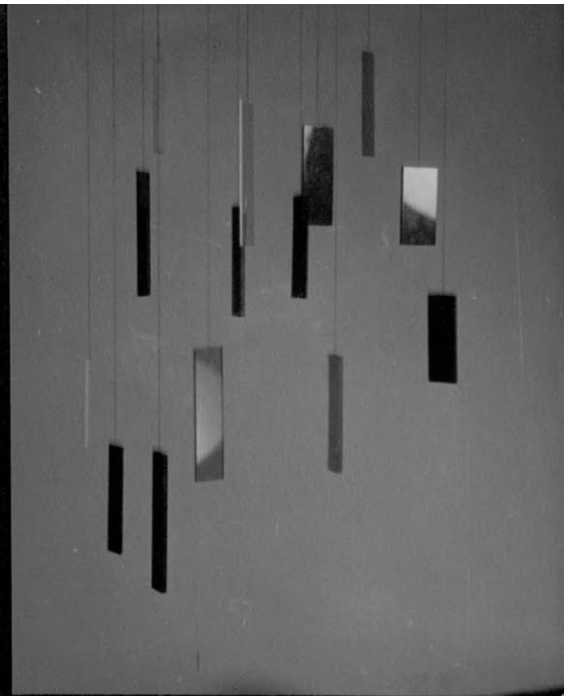


FIGURE.1.4.3.

Restricted cues for distance.

In this example, there are instances where it is impossible to tell whether the object is large and at a distance, or near and small. It is in fact only when one object obscures another, that their relationship is at all clear. The fact that the objects are glass strips, makes even this cue doubtful.

There is here then a lack of the sort of cues that are normally present, and which total up to give the effect of distance in the everyday environment. Had it been possible to consider the background as a surface, to which all the objects were related as a ground, it would immediately have given their respective distances. The strips are however hung from a plane above to which even the strings cannot be related.

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When discussing interspaces I showed that this was a question of the surfaces involved, and it is these surfaces which may be thought of as the main variables of distance. For as the density of texture of a surface increases, the distance is seen to recede, whilst if the density is decreasing, the surface is seen to advance. The reversal of a gradient of density, is seen to yield the reversal of the surface, as illustrated. Figure. 1.4 4

Although the surfaces, and most particularly the "ground" surface, are considered to be the most important variables of distance, I have stated that the perception of the third dimension is the total result of all the stimuli available; what then are these other stimuli and how are they related to the pattern of ordinal stimulation of the retinal mosaic?

a) Gradient of size.

This may be considered in a similar way to the gradient of density, since with most natural distributions¹ the size decreases with distance. Figure. 1.4.5

b) Linear Perspective.

Particularly in the artificial environment which we are considering, the perspective of the painter is one of the cues...straight lines converging towards the horizon.²

1. Trees, people, windows in a room, grass etc etc.

2. We know, or have the visible idea that they do not, however as an aspect of the phenomenal environment, this very convergence tells us the lines recede, rather than that they become closer. It is the perception of a constant scale.

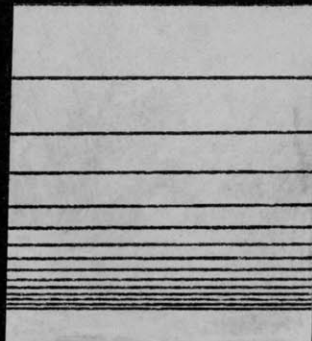


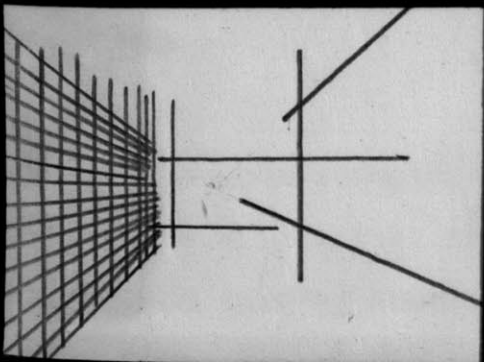
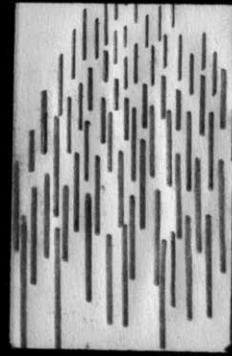
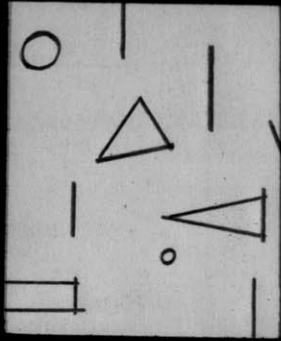
FIGURE 1.4.4

An example of the reversal of a surface, by the reversal of a gradient.

The top picture would seem to represent a sky extending into the distance, the gradient being less dense at the top, and more dense at the bottom. It gives the impression of a "ceiling" surface.

As may be seen from the bottom inset, it is actually a picture of a lake, of ground surface, with a reflection of the sky in it. It has been inverted to give the effect of a sky.





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Such lines of this linear perspective would be given by the edges or corners and would come under the same pattern of ordinal stimulation.

- c) Binocular perspective. Due to man having two eyes which focus on a point of fixation, objects nearer or further from this point have a gradient of binocular disparity.

Between the nose and the next visually adjacent surface there is considerable difference between the gradients of disparity, which gives us the impression of empty space between ourselves and the nearest object.

- d) Motion perspective. Decrease of movement with distance.
- e) Aerial Perspective. Increase of haze with distance.
- f) Perspective of blur. Decrease of clarity outwards from the central foveal area..(decrease in number of cells)
- g) Relative upward location. The natural distribution of objects against a ground. Against a ceiling this would be reversed.

This list from c) to g) are probably of less importance to an understanding of the adequacy or inadequacy of formal relationships, from the architect's point of view. But all of them to some extent or other in varying circumstances may contribute to an appreciation of space.

There is however a further list which may be considered as "depth at a contour". In discussing the type of ordinal stimulation which is the correlate for shapes an introduction

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an introduction/

to this has been given. At that time we were considering only edges and corners as projections of the image, rather than their inherent three dimensional properties. So that to the above list may be added.

- h) An increase of density of texture, on the more distant side of an edge.
- i) A change in the rate of convergence of a gradient on either side of a contour. This gives its three dimensional quality, rather than its distance-from-you property.
- j) An increase in the relative shift towards uncrossed double imagery¹.
- k) Shift in the rate of motion. A more rapid displacement of texture elements on one side of a contour, due to movement of the observer's head.
- l) Continuity of outline or completeness. Near objects generally more complete.
- m) Gradients of intensity. light and shade. This gives information concerning the depth shape, rather than the distance-from-you, since it is dependent on the interrelationship between the light, the matter, and the man.

See Figure 1.4.6.

1. For a further description of binocular disparity see Perception of the Visual World. pp.106 Gibson J.J

Continuity of outline.
The complete form, covers
the more distant form.

Relative upward location,
the more distant side being
uppermost.

Size perspective.
Decrease of size with
distance

Texture. gradient of density.
Longitudinal surface.

Linear perspective.

Texture. alteration of gradient
Corner.

Transition between light
and shade. Intensity gradient.

Texture. abrupt change of
gradient. Outline or contour.

FIGURE 1.4.6

A Mexican hat illustrates some of the stimuli for depth shape, which have shown to have adequate correlates on the retinal image.

Other cues which are not present due to the nature of the photograph are as follows:

Binocular effect of two eyes.

Gradient of blur. Due to decrease of clarity outwards from the fovea.

Motion effect.

Haziness with distance.

The eye responds to the total stimuli available, so that the more cues that are present, the greater the amount of information of the physical world that is conveyed.

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3/ It is stable and boundless.

Postural and visual stimulation are reciprocal for the mediation of an upright and stable visual world.

However from the visual point of view under consideration, it is again a question of the ordinal stimulation of the retina. For as a man is confronted with a view, he samples the complex order of contours and gradients of the potential 360degree image in a panoramic succession.

As his field of view changes, the ordinal stimulation of the retina becomes a serial transformation, having neither a beginning nor an end, and as time goes by he will have sampled the light flux at a great many different positions, in such a way that the "information" that he obtains will be seen to approximate that of someone else who is present at the same time and the same place.¹

In this transformation of the ordinal pattern, certain features are preserved, which give the effect of the stability and boundlessness of the visual world, and others are not preserved which give the impression of the observer's head motion. It is particularly important from the point of view of the architect, to know which of the features are

1. It is common knowledge that were two people to be placed in such a position, and then asked to describe what they "saw" the description would probably be more accurate from he who is considered to be more "observant." The information in both cases would have been the same, but its selection and summation into the visible idea, would have differed.

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the features are/

preserved. A few that are suggested are as follows:

- order
- continuity
- points to points
- straight lines to straightlines.

Whilst the properties that are not preserved are

- the metric properties of lines
- the projected shape
- angles.

Such a serial transformation as has been suggested would account for the fact that we move whilst the phenomenal world appears to stay where it is.

4/ It is coloured, textured, and has properties of light and shade.

Colour is mediated by the wavelength of the light, whilst we have already discussed texture as a correlate for surface.

For the retina to be stimulated there must be light, and it is rays of this light which determine the specific stimulation of the retinal mosaic.

From this discussion of the stimulus correlates of the phenomenal environment, what are the main points that the architect might be able to utilise when considering his formal relationships in the light of "information"?

The most important point is that "texture" is of supreme importance in all aspects of the physical environment, whether it is in the conveyance of information about a surface, or a shape, or the three dimensional quality of space.

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In order to show how such data as this might be given a practical application, an architectural example might be chosen to illustrate some of the points.

Example of a staircase.

I have discussed earlier the sort of "information" that man needs in order to be in a position to act upon the stair, and this at the level we are discussing would be information of the height of the riser, and the depth of the tread, and the three dimensional quality of their relationship. He would want to know that they were stable and set into the coordinates of his three dimensional boundless space.

As can be seen all this information is given by the properties of the physical world which I have discussed, by means of the correlated "ordinal stimulation" of the retinal mosaic.

It is the architect's job to present this "information" in an acceptable manner, and so it can be seen that each cue can be considered at this sensory level.

for example: as the texture of the surfaces of the stairs, is one of the important conditions, both for the perception of the staircase as surface, and for its three dimensional presentation, it is obvious that the choice of textural quality of surface is perhaps the one single most important factor. I have suggested that by the reversal of a gradient of texture the surface can be made to appear reversed, likewise if the lowest level of a staircase is of a different gradient to the stairs, as is often the case where the staircarpet ends at the base of the lowest riser, and the floor carpet

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the floor carpet/

begins, inaccurate information may be passed. For if at the point of decision as to the man's motor action, his visible idea¹. acts on such inaccurate phenomenological information, the result may be an uncoordinated environment at best, and at worst an element of danger.

For in this case it may happen that the edge of the bottom stair may be less visible due to the fact that the gradients of texture may appear the same due to the difference in height, so that the edge being less clear either the man would misjudge the number of stairs, or with other textural combinations he might misjudge the height of the bottom riser. In normal cases where the illumination of the stair case is sufficient to give a sufficient number of cues, an actual disaster is unlikely, but where the information is lacking, such as the gradients of size and perspective, due to inadequate illumination, it is thought that this can account for many household accidents.

It is thought that it is only by a truly coordinated combination of the textural qualities, and the light, that a holistic solution to the formal problem is possible.

1. Visible idea. It is thought that in the case of the man who is familiar with a staircase, his action is determined at a lower level, and that in fact much of man's action on and within his environment, may be the result of the sensory stimulation, without further summation with activity of the brain. In the case of the stair case it is partially a learned mechanical pattern of movement.

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Another example will serve to show how the stable and boundless quality of the visual world has been used as a tool, this time not by an architect, but by the film producer of the french film "Les Enfants Terribles" by Jean Cocteau.

In order to achieve an effect of tremendous "space" within a building, he limited the angle of the camera, to the ground surface, so that at the top of the picture there was an increase of the density of texture, and at the bottom a decrease. Within this surface, he placed firstly chandeliers which were hanging, and appeared unrelated to this "ground" surface, which added to the boundless quality by an assumed limit somewhere above from which they hung. Then in the centre of this space a smaller space was set up, by means of screens, within which a good deal of the action of the film took place. To this visual aspect the sound track added the hollow sounding footsteps of the uncarpetted, and limitless house.

The whole effect was most impressive in what otherwise was an extremely poor film, for here the film director has limited his cues to the three dimensional quality of the space almost entirely to the ground surface, and the relationship of the various screens to this ground surface, coupled with the serial transformation effect of the various preserved features of the environment, such as the continuity, and order, as the camera moved. The chandeliers again adding considerably at the point of movement.

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A final example might be taken from the data on the gradient of intensity, which is shown to give information of the depth shape, rather than the distance, since intensity does not correlate with distance.¹

Shaw has tried to show examples of the way in which straight surfaces can be bent by the means of light. What he was doing was trying to superimpose a depth shape by means of illumination alone.²

However in the examples that are shown, the fact that the wall is physically straight is given by other cues which are at variance with the gradient of illumination. For whereas the former relies on the relationship between the observer, the object and the light, such a cue as the property of the straight line, at the base and at the top of the wall is invariant with any relationship, and is much more persistent.

An example where this has however been used with a greater degree of success, was in the 18th century theatres in London. Here an artificial gradient of illumination was superimposed, by painting the actually flat surface of the auditorium ceiling as though it were a concave dome modelled by light.

In such a case, since the invariant quality of the line would be the same either for a flat circle, or a dome base, the result was fairly convincing. It is interesting to

1. The visual world does not get darker as it recedes. The inverse square law applies to points of light, but as the number of these points increases per unit solid angle with distance, the illumination does not get dimmer.
2. Shaw. David Light in Architecture. M.I.T. Thesis 1948.

interesting to/

speculate that this "trick" was in fact a better solution to the problem of creating an acceptable "space" within the theatre, than the later victorian examples, in which an actual dome replaced the flat ceiling, having disastrous effects on the acoustical properties of the hall.

The foregoing discussion of Gibson's data, by no means exhausts the architectural implications of his work, and whilst space forbids a further exploration, it is believed that a clearer idea of all the information that man receives from his physical environment¹. may be obtained from studies coordinating the properties of the physical environment with their correlates on the retinal mosaic.

Dynamic equilibrium.

In addition to the information itself, which I have shown to be of importance, from a structural point of view, there is a further factor which the architect must take into account, this is the dynamic tendency of the eye to regain its capacity to perform, or its full retinal sensitivity, which is to say that the internal forces². of the metabolism are working to achieve a balance, or dynamic equilibrium.

1. As set out earlier in this chapter.

2. Kepes.G The language of Vision. Paul Theobald 1948.

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As the stimuli in the form of light patterns change, these changes are balanced by the retina, and as far as possible the function of the eye as an instrument for vision is maintained.

An example of this is when fatigue of the photoreceptors of the eye is caused by a certain stimuli distribution, the organism is such that it is able to bring fresh neuro muscular units into action, for instance in the case of colour. According to the Young Helmholtz Three receptor hypothesis, the eye has three areas of receptivity, in the blue green and red wavelengths. So that if the eye is adapted to saturated light of a blue wavelength, the short wave receptors will be fatigued relative to the other two, so that were a white light to be then played on to the field of view, (assuming this white light to have equal energy at all wavelengths) then this will not appear white but a mixture of red and green, namely yellow.

So that it can be seen that the problem of colour has three determining factors

- 1/ The energy distribution of the light reaching the eye. This is the physical component, which I have shown to be the resultant of the light and the surface.
- 2/ The manner in which the three receptors are affected.
- 3/ The state of the three receptors at the time.

1. Evans. Ralph M Light sources and coloured objects.
Illum. Eng. Jan 1949.
An Introduction to Color. Wiley 1948

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Each impact on the eye from the formal relationships of the physical world, has its consequent reaction on the eye as a whole system, apart from the retinal mosaic; for instance when the eye is bombarded with a sudden beam of light, the aperture closes automatically, by a reflex muscle action, and remains reduced until such a time as the light pattern changes. Such an adaptation of the eye to external stimuli is automatic, and results not only from the impact of light on the central foveal areas, but from the total brightness pattern acting at the time.¹

This is important from the point of view of the architect, since when a person is wanting certain information from his environment, such as when reading a book, if there is a source of much brighter light on the periphery of his eye, this will affect his total adaptation pattern, and will lower his efficiency. He will attempt to compensate for this by "concentration" on the task of lower brightness, but such an effort sets up a stress, which in certain circumstances can be most uncomfortable.

Due to this "adaptation" effect, sudden changes between one level of illumination and another require some time for the necessary readjustment. For though the eye is sensitive

1. A dramatic example of this is when driving at night, the eye being adapted to the pattern of street lit by the headlights of one's own car. When someone else approaches with undimmed lights, one experiences a period of temporary blindness, which can be dangerous, even though readaptation to the previous brightness pattern is almost instantaneous.

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is sensitive/

to an intensity range of the order of several million to one, it accomplishes this by a dynamic change of its overall sensitivity. The range of simultaneous sensitivity differs from low levels to high levels of intensity.

Low levels. 10 to 1 range only.

High Levels. 1000 to 1, in daylight.

The adaptation time from low levels to high levels is comparatively fast, whereas from bright sunlight to the level of brightness in a photographic darkroom, may take as long as half an hour. The architect has need of such information as brightness ranges, since when the occupants of a house are asleep, it is necessary that any lights that are left on in order to facilitate safe movement during the night, should be within the range of sensitivity to which he is adapted. Alternatively when a person is adapted to the lights of the interior of a house, it is necessary that the lights of his garage, and external parts of the house may be adjusted to form a continuous scale of adaptation to the darkness of the night. Such an approach would assist man in dealing with the problem of night adaptation in a more realistic manner.

At low levels of illumination the maximum sensitivity of the eye falls at a shorter wavelength than that for normal vision. A study of the photopic and scotopic curves will show this. This means that as far as brightness is concerned, the eye will perceive as brighter the yellow wavelengths at high

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at high/

levels, and the green wavelengths at low levels of illumination.

This fact may be observed at night when green leaves appear as a brighter grey, than red flowers, or yellow leaves.

This is known as the Purkinje phenomenon, this is a further fact that the architect may make use of in planning the external parts of his building, in order to make use of what little natural light there is at night.

The whole subject of colour is too wide to attempt to cover in this thesis, and as there are excellent books or references which may be helpful to the architect, I shall not deal with other physiological aspects, such as chromatic aberration which leads to advancing and receding colours, since these facts are fairly well known to architects, in the simple terms that I can deal with them. Spatial effects can be caused by the use of such advancing and receding colours on a plain surface.

It can be said that colour harmony has its basis in these physiological laws, for it is due to this dynamic tendency of the eye to regain full retinal sensitivity, that the laws of complimentary colour harmony are to be found. For it is in the relationship between the physical component of colour, and the human component that the architect must seek for the harmonies that he wished to create.

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Psychological component.

It is necessary now to consider the "information" from the third aspect that I mentioned, namely psychologically, since up to now I have considered it only from the physical and physiological viewpoints.

From discussing the process as a whole, I have discussed the first stage of the process, as to how "information" of the physical environment is conveyed at a phenomenal level, to the nerve endings of the eye. It is necessary now to discuss how this information, is used by man, and how it becomes the visible idea upon which he may act.

There is a difference in the Gestalt approach, to the psychophysical theory of Gibson; since the former suggests that the form is produced by a characteristic achievement of the central nervous system, from the inadequate stimuli from the physical environment., by a process called sensory organisation; whilst the latter, assuming that the retinal stimulation contains all that is necessary to account for visual perception, considered the Gestalt hypothesis as unnecessary. For in such a case "form" is not "the thing" but only one of the variables of "things".

However Gibson's theory raises the question as to what is the reality, or the "thing"? for instance to revert to the example of the transparente of Tomé at Toledo, if its form is considered a variable of the "thing", what is thás thing?

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Is the thing to be thought of as the moulded pieces of wood gilded and set into a physical relationship with each other, and illuminated? or is the "thing" considered to be the visible idea that a person who is looking at it has?

One is again back to the irresolvable argument of which comes first, so that perhaps Bishop Berkeley's way of looking at it, as a "whole" visual process is more profitable.

For in this case it would be seen that the man summates the phenomenal information of his environment, in a way depending on his structural attributes, his state and his activity, into a visible idea upon which he may act, so that the same man may have very different visible ideas about the same formal relationship depending on these factors. For he may at one time look at the transparente, and see it as the visible idea of a transcendent God, whilst yet again he may look at it and see it as the fine craftsmanship of his friend, or yet again as a garish "ornament" symbolising nothing...since all these visible ideas do occur to man, when the phenomenal data is summated with the total stimuli pattern, and acted upon by his characteristics.

Such a naive concept would leave room for experimentation with Gibson's data, and yet recognise that it is the formal qualities of the physical environment, that are variables not only of things, but of visible ideas, which are continually changing. Whilst it is the "visible idea" that is produced by the characteristic achievement of the central nervous system.

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The question of importance to the architect, is at what point in the process, or at what level of the central nervous system, does the establishment of the visible idea emerge?

From Lashley's experiments with monkeys, it is seen that response to patterns of light flux takes place after those areas of the brain thought to be connected with vision have been removed, so that behaviour of certain types can be accomplished through the lower levels of the central nervous system without resorting to the cerebral cortex.²

Each cut from this area of the brain will remove previously learned patterns of behaviour, but will not stop the monkey from relearning.

Moreover McCulloch³ has shown that by a measurement of brain waves, a difference can be established between the brain waves of a person sitting doing nothing very much, whose waves are 8-10 per sec, alpha waves; and the brain waves of a person who perceives a form, where waves in the order of 20 per second make their appearance. Such an alteration of brain waves can also be induced by the subject sitting with their eyes closed and thinking about the percept.

It is possible to assume from this that the establishment

1. Lashley K.S. Experimental analysis of Instinctive Behaviour. Psychol.Rev. 45.
2. The bark of the brain, where the "visual areas" are thought to lie.
3. McCulloch. Contribution to Seminar. Vision Brightness and Design. Mil.T. September 1953.

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the establishment/

of what I am calling "the visible idea" is expressly a function of the cortex, whilst certain other responses by man are accomplished at a lower level of the central nervous system.

The architect is however interested in all levels at which the information from his formal relationships is used, since I have suggested that he must cater to man's needs at all levels. At the physiological level, where information concerning his spatial orientation is used; and equally at the psychological level, the formal relationships must be designed to assist the visible ideas upon which he acts upon and within his environment.

For instance it would be incorrect to assume that the formal relationships act on the individual purely at the lower levels of the central nervous system, but rather it would be more accurate to say that this is dependent on the place and the time.

For example, when a person is looking at a view which he has come to see, he will, when looking at it, have very definite visible ideas about it, 'as opposed to the man who, having been walking for some time in a terrain of which this sort of view is common, may walk past "looking at" the view without resorting to any visible ideas about it, but rather using the information given by the physical environment, purely in order to walk.

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A further example might be the case of the man who on first entering a new building, may have very definite visible ideas from the bombardment of new formal relationships, depending on his structure, his state, and his activity at the time; whilst after he has been through it often, he may not resort to visible ideas at all, since his action, that of movement through the building may be facilitated at a lower level, if the information is adequate.

The ideas in his head at the time being of many different natures, so that if he is worried about something or other, or if he is just not thinking at all, the visible idea will not be necessary for him, until such time as some "incident" of the environment forces "action" on him in relation to this environment, such as an accident.

One often hears the expression "he walks about with his eyes closed". In fact we know that he would be unable to walk about with his eyes closed, and still act with the same degree of efficiency, which a knowledge of his spatial orientation gives. What is meant is that he uses the information from his environment, only at the level necessary to perform the task of walking, so that he does not call upon visible ideas about it.

Architects are often surprised that the general public do not observe their carefully planned formal relationships in the manner which they would wish; but the reason for this is that the architect being concerned with the problem, has a different outlook towards his building, and towards the

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and towards the/

buildings of others, they are searching for the visible expression of all sorts of spatial, and formal experiences, they are consciously seeking the visible ideas which the building holds for them, whilst the average man is merely utilising the information of the formal relationships of the building to enable him to act on and within it.

Perhaps it would be possible to summarise this by saying

"That man uses the information of the physical environment, only to the extent that it enables him to act according to his desires at the time, this extent being dictated by his structure, his state and his activity. and this information is used at a level of his central nervous system sufficiently high to meet this need."

One of these desires might be considered to be the need to be "delighted" by his environment, to experience with the curiosity of the child, the unity, and the variety, contrast, and motion, in fact the whole richness of the environment. For the child is like the adult who goes to the city for the first time, and goes in a state "receptive" to his environment.

It may be considered to be in the psychological laws of Unity, and variety and contrast, and clarity, that the means of satisfaction of this receptive state may lie.

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It is possible that when¹is bombarded by the contradictory information, the disunified formal environment of the contemporary American town, with its chaotic advertising, street signs and buildings, or the monotony and drabness of the 19th century English Industrial town, he is saturated with information that he does not want, together with the information that he needs in order to orientate himself to his environment, and to act, which may be to move within it.

In self defence he forms as little of this physical environment into visible ideas as is necessary for this performance, so that he acts on his information only at the lower levels which are absolutely essential. His needs for delight are stultified to the degree that with time he gets so used to shutting out the environment, that he is quite unable to "notice "it at all; being inhibited it dies, and his visual sensitivity is irreparably¹ destroyed. Such a sequence would seem to be the only way in which man could possibly exist at all in many of the "gas station" towns along contemporary roads.

It is necessary for the architect to reconsider the psychological laws, if this need for "delight" may be rekindled for those for whom it has already been destroyed, and may be satisfied for a new generation.

1. It is to be hoped that this is too strong a word.

PART 1.

Introduction.
Man, Light and Architecture.

Chapter 1.5
Flexibility.

As an Introduction to my thesis on "Aspects of Flexibility" of Architectural Illumination, I have tried to show the relationship which exists between Man, and his physical environment, or more specifically to Light and to Architecture.

From the foregoing discussion, certain concepts have been put forward, which have lead to the following:

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"It is the task of the architect, by the use of his knowledge of the interaction of light and matter; to so arrange his formal relationships, that they may mediate the specific information which man needs for the perception of visible ideas, upon which he may act within and upon his artificial physical environment, in a manner acceptable to him."

It has been pointed out that the formal relationships of which the architect is concerned are not only visual ones, but that since the main subject of this thesis is architectural illumination, I am concerning myself with this visual aspect.

In this sense I have shown that the formal relationships of the architect may be thought of as "information" to the degree that it is upon these formal relationships that man forms his "visible ideas" upon which he acts.

I have dealt broadly with the subject of this "information" from three aspects, the value of the information itself, the manner in which the information is conveyed, and the subjects about which information is needed, all of which may be thought of physically, physiologically and psychologically, in order to show the varying importance which may be attached according to the individual program, of "information" in this sense.

For there are occasions on which the information cannot be thought of as "needed" at all, as far as we at present understand man's needs. Yet the resulting formal relationship adds to man's richness of experience of life.

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An example which illustrates this point may be taken from a recent book about the occupation by American Forces of a small town on Okinawa.¹ A teahouse is being built.

Interpreter. "...but now Hokkaido wants some water to fill the lotus pond."

Captain. "Water, where will I get water?"

Interpreter. "He don't know boss. But tonight we have a party on the veranda, and the men's league say we got to have water in the lotus pond. The Paper lanterns don't make pretty lights unless they shine on water."

The architect in creating his physical environment, cannot think of man's needs from only a physical, or only a physiological, or even only a psychological standpoint, it is only when man is treated as a totality, that his needs, and those other aspects which are broadly spoken of as needs in a psychological sense, can be approached.

I have shown that the variables of his physical environment, are the variables of light and matter; or illumination, and those materials, of stone, wood, glass, and brick of which his buildings are constructed.

The following parts of this thesis will concern themselves with these variables, in terms of the needs of man. For if it can be shown that man is a variable creature, that he has needs which differ with age, with time, with place

1. Vern Sneider. The Teahouse of the August Moon. Putman's
N.Y 1951

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with place/

and with occupation, and that such differences of man may be assumed to call for differences of the physical environment, then light becomes an important element in the vocabulary of the architect as a tool by which variability of the physical environment may be had without considerable extra cost.

For whilst due to economic pressures, the amount of space that is available for certain architectural programs, is becoming increasingly limited; by the use of this tool, the richness of man's experience can be increased, and the physical environment suited to his changing needs.

It will be shown that such a "flexibility" as I have in mind, has not been entirely absent in the past; and by a study of the means that have been hitherto employed, and by a more comprehensive approach to the problem, I shall show how a single architectural program might be treated from this viewpoint.

The program that I shall consider is the modern "living-space." I shall consider to what extent such an attitude as I have formulated has been evident in the past, is at present evident, and how this might be approached in the future. I have already suggested that the modern home is the most ill-considered of all architectural programs from the point of view of architectural illumination, and it is hoped that such a study as I suggest, may be a contribution towards an overall concept of Home Lighting.

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PART 2.

Initial Premises.

Chapter 2.1

Man is variable.

As an introduction to the forthcoming discussion of the possibilities of flexibility of formal relationships, offered by architectural illumination, it is necessary to state the initial premises on which such a study can be built; Such a basis must be sought in a study of man himself.

The first of these premises is that Man is a variable creature, and many instances of this variability might be shown, I shall however limit myself to a general statement as to this variability, which in no way implies that there are

Chapter 2.1

that there are/
not other facets of this variability that might not also be shown.

Basically it can be said that people differ naturally by heredity, and artificially and naturally by environment. The hereditary differences cease at the point of conception of man, being thought to derive from the characteristics of his parents, present knowledge seems to suggest that these hereditary characteristics have not differed much as a potentiality in the history of man.¹

The environmental differences, which start at some point about 9 mths. before his birth, are however the chief concern of the architect, as the artificial environment in which man lives is an important aspect of this.

What then are the environmental differences that account for the variability of man?

Man grows from his prenatal stage to birth, maturity, and subsequent death, and this may be said to constitute a first stage of variability, and at each stage of this progress he may be said to be the result of environmental influences on hereditary trends.

1. Psychology. Woodworth and Marquis. Methuen. (revised 1949)

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The environmental influences act on the individual at whatever stage of maturity he has reached, and on what may be called his personality as a whole.

This individual personality, may be said roughly to consist of three influences, all which are variables.

1) Structure.

These are the permanent characteristics of the individual. His anatomy, his arms, legs etc, his glands, muscles, and sensory organs, his nervous system and his brain. This would include all his genes, and hereditary factors, with the permanent effect on these factors caused by the environment.

This would take into account differences due to location, climate, and his cultural background, his learned abilities, knowledge. His habits, and his past experiences, together with the good or ill effect of such experiences on his physical structure.

Such changes as his structure has made in order to adapt itself to external conditions in a dynamic way.

2) State. (temporary)

This would be the temporary state of the individual at the moment at which the environmental influences were acting.

The individual might be asleep, wide awake, or just sleepy. He might be hungry, or just have had an enormous meal. He might have had too much intoxicating

intoxicating/

liquor, or be physically ill for any number of reasons
He may be in a state of excitement, over something, so
that his emotional state at the time varies considerably.

3) The activity of the individual at the time.

This is his focalised activity, for which he is prepared, and
would cover his actual activity, and state of anticipation
of a certain stimulus. The man's response to any
outside influence is a variable of this state.

For instance if a person is developing some photographs
and someone switches on the light, his response is
likely to be considerably different to that had he only
been sitting in the dark listening to music.

These three aspects may be said to represent the variables
of the individual personality at the time at which the enviro-
nment acts upon him. These may perhaps be thought of as a
second stage of variability.

The third stage of variability is offered by the environmental
factors acting at the time, examples of which might be:

The time of day, and the season of the year.

The present state of the weather, sunny or cloudy, warm
or cold.

The location of the person within his natural or
artificial environment.

The characteristics of this environment, light or dark

Chapter 2.1

light or dark/

quiet or noisy, spacious or cramped, together with all the other characteristics normally associated with both the natural and artificial environments.

These three "stages of variability" as I have outlined them are all interrelated, for the man's age is related to his structure, his state and his activity, whilst both are related to the environment of the moment. With such a continuous scale of variability, it may be said that man undergoes a constant change; for it is due to this "triple mutation" that no individual is exactly like another, and that likes and dislikes vary to such a large degree.

My second premise is based on the fact that man being a variable creature, his needs differ also to an extent based on this variation; and the extent which man's needs may be satisfied results from a study not only of groups but of individuals.

" There is always a second field perceived through, or superimposed on, the visual appearance of the object contemplated. Though the experient may be convinced that he is engaged in nothing but pure vision with his retina, he perceives, in fact, with the whole of his brain, and his perception is modified by the fields which operate in it: by resonances from his racial and individual past, floating images of touch and smell, kinaesthetic sensations of his own ocular movements and incipient muscle stresses. The aesthetic experience is always a sign that the object contemplated represents or symbolizes or expresses something behind and beyond its retinal image — "

Arthur Koestler.¹.

PART 2.

Initial Premises.

Chapter 2.2

Man's needs vary.

Broadly speaking man as a mammal may be said to have certain basic needs common to all members of the species, such as for light and air, food and security, and within very broad limits it is possible to generalise as to the fundamental needs of man. At a different level, it is possible also to say that certain groups of men have common needs; for instance man at different stages of his growth has broadly speaking common needs, such as the amount of sleep he gets, the type of food that he is able to digest and others.

1. Koestler. Arthur. Insight and Outlook Macmillan. 1949

Chapter 2.2

However an objective study of man's needs at all levels of his consciousness, can only be based on a study of man as an individual, rather than as a group, for although it is simple for the purpose of analysis to put man into categories, the fact remains that there are so many variables where he is concerned that such a categorisation is doomed to failure when it is misapplied.

Such an example of its misapplication is when it is considered that a certain physical environment will have the same effect, either of pleasure or displeasure on man as man, for the fact remains that due to the variability of man, as I have outlined it, the same stimuli will have different effects on different people at the same time, and different effects on the same people at different times.

An example of this might be a picture in an art exhibition, here is the same stimulus for all sorts of different people, and yet the response varies, as there are people to see it. There may be a general consensus of opinion that they like it or they dislike it, though there will be many who dissent from the "popular view", but how they like it and why they like it, what emotions it stirs up and in what way it excites them will vary as there are people there. In other words the same stimulus will have different effects on different people at the same time.

Now however an individual buys the picture and takes it home, his whole family may be said to be influenced by the painting,

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by the painting, /

but whether they like it or not, their experience of it will effect their enjoyment of it. In other words as time goes by, either the same stimuli will cease to have any effect on them at all, they will cease to notice the painting, or they will have definite associations built up about it which will contribute to their enjoyment of it. There may be days on which they do not see it, and then suddenly they may see it in a new light altogether, as a result of their own maturation or the interaction between themselves and the environment of the painting. What is however quite certain is that they differ in their reaction at different times, or in fact that the same stimulus will have different effects on the same people at different times.

Although it is useful to treat man as man in certain respects, and as individual groups in other respects, it is evident that it is unwise to predict responses at certain levels of man's consciousness when he is viewed in this manner,

In part 1, the introduction to my subject, I have thought of man's needs in a visual sense, as far as these are the concern of the architect, in terms of "information" supplied by light, and tried to show that for this "information" to have value to man, it must be considered in all its aspects as being applied to the "whole" man. It must be

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It must be/

thought of in all its aspects, physical, physiological and psychological, for it to have value holistically.

The preceding remarks on the variability of man show that not only does man have varying needs at all levels, but that these needs themselves vary in particular as the individual varies, or in other words that the information that man receives from the formal relationships of the architect, has value at all levels of man, and that it has different value to different men.

An example of this concept might be as follows

Man as Man needs shelter, due to his fundamental need for security. This may be thought of as applicable to all men. Man as a certain group, needs shelter of a specific type, such as those who live in very cold climates, need the sort of shelter that is going to suit the climate.

Man as an individual however needs a shelter of a specific size according to his family unit. However man as an individual needs more than this, he has very definite preferences as to the type of house, the form, the colour, for although there are groups of people requiring approximately similar amounts of accommodation, the manner in which this is provided is very much a matter of individual preference.

This has shown itself as a tendency very clearly in connection with all forms of "standardised housing" for with prefabrication of larger and larger units, man has shown increasing resistance

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increasing resistance/

to a tendency which he has thought will lead to greater uniformity, and to an impoverishment of his individuality.¹

An example of the needs of one group of people being different to that of another when the conditions are the same, is quoted by Rasmussen in his book on London²; speaking of the Anglo-Saxon inundation of what had been Roman England, he says:

"they advanced plundering and laying waste as they came, and instead of living in the sumptuous and uninhabited villas, they burnt them and pulled them down, and then built their primitive wooden huts close by."

However there is a still further variation of need, which is for the purposes of this discussion the most important, and this is the variation of need that man has as an individual, thought of in a dynamic sense. For not only do the individuals have different needs, but these needs vary themselves.

Here for instance one is dealing not only with the first stage of variability, which I have suggested as that of age, but with the second stage of variability, with particular stress on his temporary state, and his activity at the time, as they are affected by his structure. For these vary with the environmental factors acting at the time, and one

1. The author believes that this is not necessarily the case, since in the ages when men's individuality was at its highest, the houses in which they lived did not express any overt necessity to "be different". The insides of the houses on the other hand were an expression of the individual tastes of the owners.

2. Rasmussen. Steen Eiler London. The unique City. Jonathan Cape. 1937.

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and one/

can quote many examples of this difference in mood and feeling which result from seasonal or climatic differences, or differences due to man's contact with other men in the everyday world.

The satisfaction of such needs has been of course evident in the variety of building programs that one sees around us, to take the example of the restaurant again, there is a variation of restaurant for every sort of man's need, as far as price, as far as "atmosphere", so that whatever mood he is in, he joins this or the other "group" for which need there has been a group solution.

The following Chapter is a discussion of this variability of solution.

PART 2.

Initial premises.

Chapter 2.3

Total satisfaction of Man's needs may demand "flexibility of solution."

This premise arises from a consideration of the previous two, for when it is shown that man's variability predicates a variability of need, it is logical to conclude that it is only by a flexibility of solution that a total satisfaction of his needs can come.

I have shown also that such a need for flexibility has in the past been partially satisfied by the multitude of building programs, that have been created in answer to

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in answer to/
the group needs of man.

However this cannot be considered a total solution to the problem in terms of man. For man as I have suggested differs not only at a group level but at an "individual level", and it is satisfaction of man at an individual level with which the architect must concern himself.

This discussion in concerning itself with the visual aspects of such a satisfaction, is concerned with the formal relationships of the architect, since these are the architect's contribution to this "satisfaction".

An architectural example of what I mean may be taken from the factory. In a factory in which a certain product is made, the workers have certain group needs, which are concerned with the machinery by which the product is made, and their relationship to this. As a group they may require certain "information" in order that they may work efficiently in relation to their body's economy and in relation to the machine. However all the machinery is not the same, and each individual case should be made a study in order to see the exact amount of information needed as far as the particular process is concerned. This immediately suggests that factories in which a general level of lighting is thought sufficient to meet the needs of everybody has taken a limited view of the case. However there is another aspect which is of equal importance,

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of equal importance/

and that is that even when the same process is being done, and the same amount of information may be said to be needed by man as a group, the manner of the conveyance of this information must be an individual study, since due to the physiological structural differences of man¹. visual acuity variations make it important that those people who require what may be thought of as a "stronger message" in order to receive the same information (generally speaking this can be considered to be higher levels of lighting) are considered. For since visual acuity has been shown to decrease with age, older men have different needs to younger men. This decline starts with early adulthood, and continues onwards. Weston has shown that older people work less easily with 500ft candles on a certain task, than younger people work with $\frac{1}{2}$ ft. candle on the same task. He suggests that only so much can be done by means of illumination, and that as a worker gets older he compensates for this loss of acuity by the use of a development of his skill. This is an example of man's adaptation to his environment, and it is thought that no amount of study can lead to a complete compensation, but such an individual approach as I have suggested could almost certainly partially

1. Weston Researches into the variations of visual acuity with age. M.I.T.Seminar. Sept 1953

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partially/

counteract for this difference, and perhaps completely avoid unnecessary deterioration.

Other examples that might be quoted are buildings such as schools, where the answer to a group need has been answered by a solution which takes into account only a limited conception of the child's need, such as might be considered where all the children (assuming their individual need to be the same where the age groups are similar) have only a single task to do. For the fact remains that the varied activity of the child may call for variety in the solution.

Perhaps one more example will serve to show a case where variation of "problem" has been of such paramount importance that a much more complete solution has resulted.

This is on the stage. Here the problem has met with a solution, in terms of alterations of the physical environment as it is acted upon by light, which allows very complete changes of formal relationship to meet the wide variety of needs offered by the different situations that have to be met.

Despite the occasions when man's needs can be met sufficiently well as a group, there are certain problems, and as man's knowledge of man increases, there will be seen to be more problems, when the individual variations must be catered for.

Chapter 2.3

Such a specific problem, as I have in mind is the contemporary "living space", and a consideration of flexibility, as it may be applied to this program, in an holistic sense, comprises Parts 3 and 4 of this thesis.

For it is in the contemporary living space, where man spends such a considerable part of his life, from his cradle to his grave, doing all the various activities, in all the sorts of mental and physical states, that the obvious need for flexibility can be seen. The power for the provision of this flexibility, this variation and richness of experience lies in the hands of the architect, the value of its possibilities can only be seen in the light of human experience.

"Motion, sunlight and shadow, the illusion of floating space are all at the disposal of the designer. the acuteness of our senses can be kept awake by skillful design, rich in contrast of tension and repose, well timed and scaled to satisfy our urge to use our natural functions of adaptation."

Gropius.¹

PART 2.

Initial Premises.

Chapter 2.4

Illumination is a means by which Flexibility may be achieved.

This final premise is based on the first concept outlined in Chapter 1.1 of Part 1,

" That illumination is considered to be a means by which formal relationships may be achieved."

for by a study of Man, light and Architecture, I have tried to show that each in its way contributes to the formal relationships of the architect, in a visual sense.

Gropius. Walter Planning Man's Physical Environment. Princeton Univ. Bicentennial 1946

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Specifically I have shown that the constituent parts of a formal relationship are Light, Matter, and to the extent that a formal relationship is experienced by man in a phenomenological sense, Man himself.

Since we are concerned at this point with a variation of the physical environment as a solution to man's variability, the fact that due to his physiological and psychological makeup he will experience formal relationships differently is not our immediate concern, other than to state that it must be born in mind.

In this connection an argument might be advanced to the effect that, due to this variability in the way in which man experiences the same physical environment, coupled with the natural changes between the seasons, and the time of day, this would in fact achieve a sufficient pattern of change. Applied to the natural environment, this might appear to have a good deal of validity, the seasons are sufficient unto themselves. But in the artificially created environment of the architect this is untenable, since it leaves out many of the factors of man's variability, that I have suggested¹. The variation of his task or activity alone would predicate a much more differentiated environment.

1. See Chapter 2.1

Chapter 2.4

We are left with the two variables of Light and matter, the illumination, and the bricks and mortar of the architect.

It may be said therefore that the Illumination is "a Means" by which the formal relationships of the architect may be varied. It is not the only means.

As a method of analysis of the problem, I should like to suggest the following for consideration.

- 1) A consideration of what I am calling the "basic light flux pattern" which is an abstraction, in which the physical environment is considered as being separated from its illumination, and a constant.^{11.}
- 2) A consideration of what I am calling the objective world, in which alterations may be considered whilst the basic light flux pattern is thought of as a constant.

A dramatic demonstration of this twin scale of variation is provided by the "mobile"

Considering firstly a variation of the "basic light flux pattern" The mobile is stationary. By alterations of the former variations of the physical environment may be obtained. The colour of the mobile may be altered, its shadows may be moved, it may be made to appear as a light form on a dark ground or vice versa. A considerable range of variations is possible.

Considering secondly a variation of the mobile itself, or the objective world, whilst the basic light flux pattern

1. To be called "the Objective World."

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the basic light flux pattern/
remains constant. Here a certain source is played on to the mobile which is allowed to move freely, again there will be a considerable variation of the physical environment, variations of light and shade on its facets, and variations in the shadows cast on to any other surfaces.

As may be seen these variables correspond to the variables of a formal relationship, those of light and matter, but looked at in this light, they may be seen to have a use as a method of analysis, since variations of either have a consequent effect on the physical environment itself. The physical environment is their common denominator.

The natural physical environment.

How may this form of analysis be applied to the natural physical environment?

- 1) The basic light flux pattern may be considered to be the sun during the day, together with the stars at night. This varies in time in relation to any particular point at the earth's surface which is under consideration.
- 2) There are two aspects of the objective world (as defined) which might be compared with the two aspects of the mobile: The mobile itself, represented by the air particles, moisture and dust particles of the atmosphere, the clouds, and at night even the moon; whilst the wall on which the shadow of the mobile is projected, might be thought of as the earth itself,

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the earth itself/
as being a surface on which the light and shadow is
cast; a surface rich in the natural textures of forest
rock and plain, and rich in variation.

The natural physical environment, resulting from these
these variations, has an unbelievable scale of differences,
which man experiences in his phenomenal world. The changes
from day to night, from the beginning of the year to
the end throughout all the seasons, the changes of the at-
mosphere, and the changes of the objective world itself
as the backcloth, with the growth patterns of nature. All of
these variations take place as a pattern of movement in
time. Movement then is one of the aspects of the natural
physical environment that man has adapted himself to, and
it has been shown that this element of movement was not
absent in the artificial environment of the architect, both
during the day when his building is fashioned with this
changing "light", and at night with the early sources of
illumination in the flame. To a greater degree than ever
this movement element in the scale of variations of the
artificial environment is being lost due to the constancy
of modern sources of artificial illumination.

The artificial physical environment.

In the same manner the form of analysis may be applied to
the artificial physical environment, which concerns the

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which concerns the/
architect. During the day generally speaking the
Basic light flux pattern is the sun, as it is modulated by
the atmosphere, (with a clear sky I have shown that 80%
of the light would come from the sun itself, and 20% from
the diffusion of the atmosphere, the sky.) which is admitted
to the building by what I have called the natural
luminaires or windows. These themselves "diffuse, transmit
and redirect" the light into the internal spaces of the
building. In such a case the basic light flux pattern is
still variable with the time of day, and the nature of the
atmosphere, despite the static nature of the objective world.
However at night the position is changed, for to the extent
that the natural illumination is no longer adequate for
man's needs¹. he has resorted to forms of artificial
illumination.

- 1) The basic light flux pattern. In this case would be
a series of artificial luminaires, placed at intervals
within his spaces, some of which are moveable,
variations being possible by means of alterations of
the number and combination of these luminaires used,
and the differences of position possible with the
mobile types.

1. speaking generally, there are of course certain needs
such as sleeping that would be sufficiently well met.
Also his needs may be thought of as a function of the
possibilities of artificial illumination.

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- 2) The objective world, would be the bricks and mortar, and materials of which the artificial environment is composed. variations being possible by means of alterations of positions of one object in relation to another, for instance the drawing of curtains, or the movement of furniture.

It can be seen from the above analysis that the artificial physical environment, which relies on these two elements, is of a relatively static nature, when compared to its natural counterpart, "of motion sunlight and shadow."

It can be seen that both methods of variation have been used, but that the variation of the objective world since this involves material things, has less capacity for change. Many examples can be quoted of its use, for instance the flimsy demountable partitions of the Japanese teahouse that when placed in position form separate small tearooms, but which can be removed to form a single large space when this is what is needed. Such variations involving as they do many of the other aspects of the formal relationships of the architect, such as sound, can have only a limited validity, when thought of as a part of the general architectural compromise.

Despite the physical limitations of this aspect of variation, it is suggested that rather than think of it in isolation, the physical characteristics should be planned in relation to the basic light flux pattern, so that studies of new

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materials, would always include studies of their interrelationships with light. This would have particular validity in the field of texture¹. where it is believed a whole field of study is to be found.

However the variation of the basic light flux pattern, offers an immediately rewarding method by which the artificial physical environment may be made to correspond more nearly to man's needs. For by variations of the nature of the source as regards to size and directional properties, the spectral distribution, intensity, and diffusion of the light may be varied. Then one can add to this the variation of the placing of the sources in relation to each other, and the combinations of different sources to set up a very considerable scale of variations.

Over and above this there is the element of motion, of which the natural physical environment is so predominantly composed.

"for motion frees the existence in time,
in the same way that openness frees the
perception of space."

Kepes.2.

2. Kepes. G Article for Sylvania. unpublished.

1. Texture. since Gibson's theories have laid such a stress on the quality of texture, in connection to man's experience of his environment.

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"The form of the home is essentially inflexible, and lighting is the only all over standard home requirement, with the inherent capacity for variety and constant change."

Nowland.¹

PART 3.

The architectural illumination of the Contemporary Living-space approached from the aspect of flexibility.

Chapter 3.1

The Contemporary Living-space.
A New Approach to Flexibility.

It might be possible to draw the analogy between the present day living space, and the "great hall" of the mediaeval house in England, in which a great many activities were carried on, in which case the wheel would be seen to have

1. Nowland. Roger L Illum. Eng. Feb. 1945.
Lighting Horizons.

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to have/

come full circle from the houses of the 19th century, in which a most specialised use of the "individual space" was made.

In the Victorian houses, the space was divided up into ample areas where the individual needs of the family were catered for, there were several reception rooms, a dining room, study, a withdrawing room, sewing room, together with special rooms for children in nurseries, and ample kitchen and scullery facilities for a staff of servants, with their own servants' hall and parlour.

This became the pattern for houses, so that when smaller incomes and mass produced housing dictated a more conservative use of space, the pattern, though it became restricted was none the less modelled after its more capacious prototype.

The result can be seen in any suburb of an English town, and it has its counterpart in America. The internal arrangement of the space is broken up into a series of small spaces which ape their more commodious grandfathers. However with the changing social pattern where servants are decreasing in number, and increasing in cost, a do-it-yourself policy dictates a more rational way of life. The infinity of ornaments, and the richly decorated furniture have given way to simple straightforward designs more suitable to an age where machine production has almost completely replaced

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almost completely replaced/
the old-style craftsman. A general lowering of the standard of living of higher moneyed groups, has resulted in a general levelling off of the way of life. Less space for more money has dictated a more practical use of space, in which there is less space given over to those activities of the home which are not continuous, and which can be done somewhere else. The number of the reception rooms has been reduced, and combined in many cases with both dining room, and study. Bedrooms have been combined with nurseries, and private sitting rooms. Maids quarters have been eliminated, and kitchens have been combined with dining rooms, and in some cases with living rooms as well.

No longer can rooms serve only a single use, so that by the discontinuation of certain rooms, the use of others has been intensified....man has in fact resorted to a multi-purpose Living-space.

This can be thought of as an imposed trend if one likes, imposed by economics, and abetted by architects who have been quick to seize upon a notion which allows them to experiment with spatial flow and open planning. As such it may be deprecated by those who believe that it allows insufficient opportunity for a "differentiated life" or applauded by those who believe that it is a "natural tendency" to which the architect is merely given expression. The fact

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The fact/

remains however that however we look at it, the contemporary Living-space is an established artifact, which the architect ignores at his peril.

We are faced then with the following situation; in the first case the paramount need to solve man's problems as an individual, rather than a group, which I have shown in Part 2 to necessitate variation of solution on the part of the architect, a consequent variation of formal relationship; whilst in the second place a general constriction of space standards coupled with other architectural reasons¹ has led to the home becoming like an open shed, under whose roof the whole richness and variety of human life must carry on.

The Illuminating Engineering Society, in a recently published handbook² on the subject talk of "this" as the goal:

"The goal is a higher standard of performance in those elements which are essential for health, safety and satisfaction in the dwelling and its environment."

Before continuing in the following chapters to discuss what I consider to be an approach to this problem, it is necessary to discuss briefly what attention is paid to the problem at present, by looking at the sort of solutions that have been produced.

1. The desire for a "spatial unity" between the inside and the outside of the building.
2. I.E.S. Recommended Practice for Residence Lighting. 1953

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In such a discussion it is necessary to limit myself in the main to the average home, since this is where the vast majority of people live, and where any repercussions of a new approach to the problem would have ultimately to be felt. This then is in the mass produced housing, rather than in the special high-cost dwelling where more individual attention is paid to the needs of the people who are to inhabit it.¹ This would include the mass produced suburban and town houses, and the large blocks of flats built for general occupation.

I mentioned in Chapter 1.1 that in cases such as these:

"the building is "finished" from the point of view of the architect, with only the most cursory regard having been paid to the provision of artificial illumination... generally in the form of a few electric light points provided at so-called strategic places.....this is as far as the design of the formal relationships² goes, the architect's job is finished."

The result is that in such cases, it is left for the individual occupant, or the flat-manager to provide "lighting" units which can be made to fit into these light points.

The variety of fittings and gadgets on the market shows the way in which this is accomplished. An integrated system of lighting is almost impossible in these circumstances.

1. Which in no way implies that a total solution is present in such buildings as a whole.
2. As far as Lighting is concerned.

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In England the position is slightly different to that which applies in America. A central electric outlet is provided in the ceiling of each room, and perhaps two other outlets may be provided at the skirting level for the insertion of movable lamps. In which case an attempt may be made by the occupant by means of indirect lighting of the ceiling to have a general illumination of the surfaces of the walls and floor, and this would be supplemented by points of light when needed.

However in neither case is any attempt made to integrate the system of lighting to the physical surfaces of the room.

Using the method of analysis suggested in Part 2 we find

- 1) The basic light flux pattern is provided by a series of unrelated point sources, either singly or in various combinations. ¹.

Variation can be had by one of the following means.

- a. Combinations of these sources.
- b. Differentiation of the source itself, such as is possible with certain types of three lamps fittings where one two or all three lamps can be used.
- c. The relative position of these mobile fittings in the room.
- d. The addition of other sources, such as an open fire, which would add mobility.

1. Considering artificial illumination only for the present.

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- 2) The objective world is provided by the wall surfaces, ceiling and floor, and all the furniture placed in the rooms .

Variation is obtained by

- a. Movement of furniture, which would also include the movement of the mobile light fittings themselves in this sense too, to the extent that they have a "matter" component as well as a "light" one.
- b. The movement of curtains, which are pulled to cover surfaces such as windows at night, and also to divide up spaces.
- c. The movement of other such space dividers, partitions of all sorts.
- d. The placing of all objects within the space, ornaments tablecloths etc.

So far in this analysis I have kept the consideration of artificial light separate from natural sources, since it has been agreed that the natural variations of the source are sufficient, when considered in their connection with the natural luminaires, the windows, and the manner in which this natural source may be modulated by them.

The variations of the "objective world" remain the same if the natural luminaires are included, both for natural and artificial light.

What then can be seen as a result of the above analysis?

The most fundamental point that is raised is the lack of any coordination between the variations of the one, as they affect the physical environment, with the variations of the other.

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Other points which are raised by the above analysis are secondly the very obvious limitations to these means for achieving flexibility. The most obvious being the lack of provision for any colour changes, the limited range of intensity changes, the lack of any consideration (apart from the open fire, which in many homes is absent altogether) of the changes that can be wrought by mobility.

Thirdly the lack of any overall unity between the lighting arrangements, and the other aspects of the design.

Fourthly the scant regard that has been paid to human need, which shows itself in the way in which a single system of such a limited flexibility is considered to be a suitable solution to the problem.

Bearing in mind these limitations to the present concepts of the illumination of the home, I suggest the following approach, as being more likely to result in a solution in terms of man.

A new Approach to Flexibility.

1/ By a study of man in relation to the physical environment of the Contemporary Living-space, to understand his individual needs.

For by an analysis of his individual structure, his

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his/

individual state and his individual activities, as they differ with the time of day, and the seasons; a more thorough understanding of man's visual needs as a totality will result.

- 2/ A reconsideration of the formal relationships of the architect, in the light of this knowledge.
- 3/ To consider coordinated variations of both the basic light flux pattern, and the objective world, by which man's needs may be satisfied in a total way, since the variability of man's needs predicates a variability of solution.
- 4/ To integrate the means by which such ends may be achieved, the luminaires themselves, or in the case of natural illumination the windows and openings, into the general conception of the design; making the same sort of compromises that are necessary in the final design, from the viewpoints of each of the design criteria used.

The final unification of all the various elements of the "scheme."

It is realised that this can only be a basis for the design, the final merits of which will rely not on the method of analysis used but on the synthesis of the parts into the whole. Yet as this relies in a dynamic sense upon man himself, it is true to say that the value of the scheme will depend on the extent to which it ministers to his needs at all levels.

"Man needs a range of Visual experience,
as much as a range of literature,
music, food and clothing."

Prof. Anderson.

PART 3.

The Architectural Illumination
of the Contemporary Living-space
approached from the aspect
of flexibility.

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Man's Visual Needs within
the Contemporary Living-space.

In the previous Chapter I outlined "A new approach to flexibility", which I intend to apply to the problem of the Contemporary Living-space. The first point in such an approach is to study man's needs in relation to the artificial environment of the architect.

Fig. 3.2.1 is an analysis of the relationship between the physical environment and Man, in a visual sense.

M A N ' S V I S U A L N E E D S

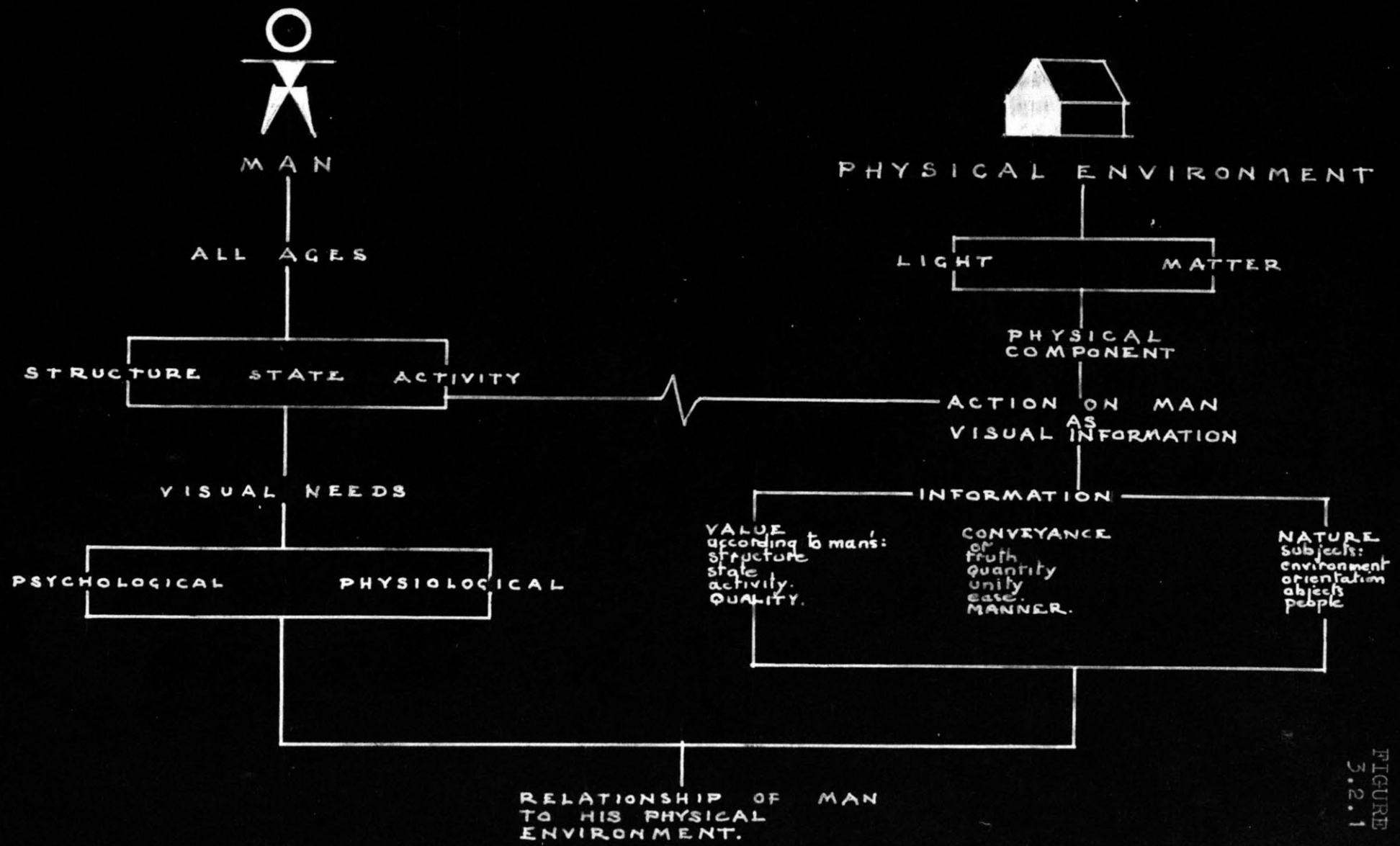


FIGURE 3.2.1

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It can be seen from this analysis, that the relationship is an extremely complicated one, and that there are many ways in which the problem of man's visual needs can be approached. For instance it would be legitimate to approach them through man alone, in order to see what sort of a physical environment should be designed to fit him, then again it could be approached through the physical environment, in order to explore what man's needs are in the physical environment as it is, yet again man's needs can be approached purely at the psychological level, or again purely at the physiological level. All these methods have been used separately or combined in one form or another, and all have added items of knowledge to assist the architect in his architectural program.

It is impossible for me to attempt to cover the area of man's needs with regard to the contemporary living space completely but I suggest what I hope will prove a practical approach which might be applied to architectural programs in this connection.

The chapter will be organised in the following manner:

- 1/ A discussion of the different age groups using the space.
 - a) structure.
 - b) state.
 - c) activities.

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- 2/ A discussion of the psychological and physiological needs of the people using the space, due to their attributes previously discussed.
- 3/ A discussion of the "information" from the physical environment,¹ in relation to these needs, from the points of view of
 - a) Its nature.
 - b) Its manner of conveyance.
 - c) Its value.received by man at all his levels.
- 4/ A discussion in the light of this knowledge, as to what degree of flexibility is desirable, and what degree of flexibility would be acceptable, as an answer to man's individual and group needs.

This is offered as a practical approach rather than an exhaustive research of the problem, since this would involve a considerable program of study on its own.

Nor yet again is it an attempt to standardise in any way the individuality of Man into some set pattern; but rather to add to the richness of his experience, by an exploitation of those aspects of his personality which are the basis of difference.

1. In this case the Contemporary Living-space.

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- 1/ A discussion of the different age groups using the space.
For each group a discussion of their a) structure.
b) state.
c) activities.

The contemporary living-space is used by all age groups of man, from the Mother bearing her child, to the infant crawling on the floor, the adolescent doing his homework, the young adult courting, and at the same time it is used by men and women of maturity, and older members of the family.

structure.

The structure of the different age groups differs considerably. The baby's vision is maturing from birth until the age of 6 or 8 years, he is in fact learning to use the information of his physical environment, in order to enable him to act. Luckiesh has given some important aspects to be considered in relation to this period of maturation.¹

Near vision tasks should be minimised for the very young, and this is in fact taken care of by such things as the large print in childrens books. For the child is learning to coordinate the information from his senses, and at first he will react to gross differences, such as bright colours, and large print, and movement, in order to orientate himself in his environment. From these gross difference he will learn to make finer discriminations, by a more accurate fixation of objects. It is important that he should be

Luckiesh. Matthew Light Vision and Seeing Van Nostrand N.Y
1944.

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he should be/

assisted in this process of "learning to see," it is to be hoped that with further research into this question more information for the architect to use may be forthcoming.

As the child grows environmental factors have more and more influence on his hereditary trends, so that man develops his acquired characteristics, of race and region, according to his need to adapt himself to his circumstance. For man's structure is a dynamic entity capable of very great powers of adjustment. An example of this might be the light in Italy which is of a very bright nature, so that the reflected light from the houses and roads makes a strong impact on the eye. To one used to the greyer skies of England this has an almost unbearable intensity which makes it necessary to wear sun glasses, whereas to one born in the country and whose structure has adapted itself to its environment, it seems quite normal.¹

From Weston's data quoted previously, it is apparent that the structural attributes of the vision continue to develop to a maximum until the early adult years, from when on, a decline can be measured (visual acuity) so that the needs

1. There is however now a modern tendency to avoid the problem of "coming to terms with ones environment", since in every way man tries to solve the problem in an artificial manner, by air conditioning and other artificial means. It seems possible that over a period of time, man's "powers of adaptation to circumstance" in a structural dynamic sense may be permanently reduced.

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so that the needs/ of man differ at all ages, with structure, until with the very old no amount of light, in the form of visual information will be able to assist them in the discrimination of the most complicated visual tasks.

A further aspect of structure that is generally recognised in all but the most poor countries, is that which results from pathological conditions, and by the use of glasses or assistance for the weakness of some function of the eye, abnormalities are reduced.

In most cases structure can be considered as group differences, due to previous environmental effects, or age groups, but it is important that individual differences, such as are found where an individual of a different cultural and physical background, is placed in a new environment, should be recognised. A further point already discussed in Chapter 1.4 is the extent to which man's experience of the contemporary living-space may be affected by his total environment, which will be referred to under the heading of psychological needs, due to his previous cultural background.

state.

The state of the individual at the time however, is something that cannot be discussed without a consideration of man's individual differences. For although it may be said that differences of external environment may affect man to some extent in a general way, for instance the effect of a sunny day,

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which makes all the members of a family feel good, or the effects of general levels of illumination which may give a general state of adaptation to light and to colour, the individual differences due to age and responsibility, make such generalisations most difficult.

It can be seen that circumstances which delight man on one day due to some special state of receptivity at the time have no guarantee of delighting him at another time; so that this would seem to suggest that if these individual differences are to be utilised, rather than ignored, the physical environment must cater to man's moods, emotions, and feelings, as well as to his physical states of hunger, cold, illness, adaptation, and the like.

activity

The question of the activities that are performed within the contemporary living space, has been the subject of the greatest amount of research, since this has shown itself to be the most rewarding, and where quantitative results can be tabulated. An example of such quantitative data is the recent book published by the Illuminating Engineering Society on Residence Lighting¹. where many of the tasks that are performed within the contemporary living space are analysed

1. I.E.S. Recommended Practice for Residence Lighting Nov. 1953

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are analysed/

with respect to the intensity of the light source, necessary to provide a stated number of Ft.candles on the task, and the position of this light source in relation to the activity concerned.

It would I think be useless for me to repeat this information and other information of a similar sort in this thesis; what would be more useful would be to deal in a rather more general way with the question of activity as it applies to all age groups within the home.

Broadly speaking the action of the individual may be said to be that action made necessary, or possible or desirable, by his interaction with his physical and social environment, which dictates the utmost variety of individual action on the part of man, varying for different ages, and different personalities, at different times.

The activity of the very young is limited to coming to terms with his environment, whilst the activity of the fully matured individual is capable of great richness of experience; and all of these activities are at some time or another either separately or combined to some extent, to take place in the contemporary living space. It is the job of the architect to create the opportunity for the greatest possible variety within the space.

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- 2/ A discussion of the psychological and physiological needs of the people using the space, due to their attributes previously discussed.

To quote Prof. Anderson

" The need that individuals feel for variability in such a space (living space) is I think not just because the tasks change. It is because this space is their primary personal environment and to enrich it by transforming it, is to give life more scope and meaning."

It is true that man has certain physiological needs at all ages, concerned with his structure, his state and his activity, and that the solution must strive to satisfy these needs, but it is equally important to satisfy his needs due to these attributes at the psychological level.

For the living space is where man spends a great part of his time, and where it should be possible for him to develop to the utmost all his powers.

For instance a man has the need to be able to orientate himself in his environment, if he is to be able to perform within it correctly, he must be able to move with ease and safety; yet again he must be able to read or write, or to play games, to watch television or listen to the radio, to hold conversations, to sew or make clothes, and a hundred other things, and in order to do this the information that he needs must be supplied in a manner acceptable to him. However it is possible to supply him with this information in such a way as to satisfy his physiological needs, but still not contribute to his experience in a positive manner.

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For as I have shown, a man's activity is not an isolated fact, it is impossible to satisfy the whole man, by making the conditions for his working efficiency satisfactory at one level of his existence without worrying about the other.

A man will go outside on a sunny day, and twist himself into all sorts of contortions to read beneath the shade of a tree, or even out in the sun, and still feel that the environment is contributing in a positive way to his happiness.

Whilst on the other hand placed in an experimental set-up where all the lighting and other physical factors are calculated to reduce the stresses on his body to a minimum, he will feel thoroughly miserable.

So it is important that when the architect is satisfying the needs of man within the contemporary living-space he does not consider each task as an isolated thing, but rather in its connection with the "whole" of the environment.

It should be remembered that it is impossible to set up standards for positive comfort, and that the best that can be done from the tables is to reduce actual discomfort to a minimum. Positive comfort or delight, is something that cannot be assessed on a quantitative basis, and can only come from an understanding of man's needs within the living-space, at all levels, coupled with the ability to provide an environment rich in variation, where such needs may find satisfaction.

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- 3/ A discussion of the "information" from the physical environment, in relation to these needs, from the points of view of
- a) Its nature
 - b) Its manner of conveyance.
 - c) Its value.
- as received by Man at all his levels.

From the diagram at the beginning of the chapter, it can be seen that the interrelationship between man and his physical environment is of a dual nature, it acts on him, and he on it. So that although the architect may be at great pains to provide formal relationships which minister to man's needs, all sorts of other factors enter into the relationship which the architect did not intend.

The architect therefore is limited as to the extent that he can arrange for a coordinated relationship, and he has to anticipate the extra-architectural paraphernalia that the individual owner will provide. Such items as pictures, books, and ornaments do not as a rule cause a great deal of difficulty, whereas furniture, carpets, and curtains can destroy the carefully thought out relationships of the architect. It is important that where possible the architect should advise on the question of the latter, which would include also the colours and textures of the wall and ceiling surfaces, if a truly coordinated relationship is to be established.

In chapter 1.4 I developed the concept that the formal relationships of the architect may be thought of as "information" which is received by man at all his levels, it is now necessary to apply the aspects outlined to the Living-space.

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its nature.

The list of subjects about which information is needed has been given in chapter 1.4 and does not need restating here. However there is a further point which should be made clear, this being that the information that the architect may want to give, need not necessarily be of the physical environment as such, but rather of certain interrelationships of light and matter, which when perceived by man at his phenomenal level, and translated into the visible idea, have a value as a "whole" apart from their purely physical aspects.¹ So that information is not necessarily "of" the physical environment, but must however be "from" it, since the resultant impression is characteristic of both light and matter, as they are related to man.

its manner of conveyance.

Various points are raised concerning the list given in chapter 1.4 as to the manner of conveyance of the information, when this is applied to the living-space.

The first point is to what extent the information about the physical environment should be correct. Certainly in the case of stairs, the information should correspond to the physical surfaces, and in the case of young children who are in the process of maturation, the surface to which they

are perceiving the environment.

1. Example in chapter 1.4 of a baroque reredos. The visible idea is something over and above the physical relationship of wood and gold, though it arises from it.

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to which they/
respond, should correspond to their total stimulus pattern,
tactual etc, in order to avoid confusion of their experience.

However there is a further scale of experience, which I
have suggested in the paragraph on nature, where the inform-
ation is seen to be "from" rather than "of" the physical
environment.

Shaw has shown¹. that by means of coordinated variations
of light and matter, it is possible to alter the "apparent"
relationship between the physical surfaces of wall and
ceiling, and I quoted an instance of a successful use of this
in the early London Theatres. The term "correct" should
be used loosely to mean that the resulting relationship
should correspond not so much to the physical environment
as such, though this is seen to be necessary in certain
circumstances, but rather to the wishes, or the "formal
relationships" of the architect. It is the job of the
architect to understand the formal relationships he uses,
so that such a sophisticated approach to man's environment
is not fraught with a lowering of man's spatial orientation
to a level where it would involve danger.

1. Shaw. Light and Architecture. M.I.T. Thesis 1948
By correlated variations of the brightness of ceiling,
wall and floor, he shows how an impression of expanding
and contracting space may be achieved. The examples
are photographs at "model" scale, and less convincing
due to the limitations of the medium, and the presence
of cues of a different nature which conflict with his
evidence.

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The second point is concerned with the fact that the information should be sufficient, rather than maximal or minimal, and the living-space raises certain problems of its own. The information that is required in the living-space may vary considerable with the activity in progress, the state of the inhabitants, and their structure. For instance if the family is watching television, the amount of information required from other formal relationships within the space is lessened. At the same time however it is possible that some members of the family do not want to watch, and wish to read, or play cards, then in this case they require more information than do the people watching television. Another example would be the case of the person who owns a very beautiful statue, there would be occasions on which he would want it to be an important part of the formal relationships of the room, whilst at others, since a variation of his experience of it is essential, he would not want to be so conscious of it. This may also be the case of paintings which are hung in the room, where, if they remain a constant part of man's experience, they will lose their dynamic affect.

This fact of "sufficiency" of information is one of great importance in this type of program.

The third point, is that the information from all relationships other than visual, should add to the totality of experience. A clear example of this is where one activity in the home is connected with considerable noise, which forms a conflicting

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a conflicting/

audio relationship, for the person who is trying to study, or to read. It is true of course that this form of confusion in the modern home is so usual, that man in self defence has raised up a barrier of negativism against it; but even allowing for the presence of such a barrier, there are certain of man's psychological and physiological needs that are incompatible.

Also under this heading would come those formal relationships in which the tactual component conflicts with the visual, such as imitation marble wall papers, or imitation wood, such measures, though they may have a sound economic base are none the less a disappointing feature of the physical environment.

The fourth point that I think needs consideration with special regard to the living-space, is that the information should be obtained in such a way as to set up no undue stresses on the body's economy.

Considerable emphasis has been given to the quantitative data that has been found, and rules have been established by illuminating engineers, beyond which you must not go, if discomfort, or physiological cost is to be avoided.

It is suggested that you should always arrange that the brightness ratios within your field of view should be carefully

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be carefully/

controlled within certain ranges. This range is suggested as 3:1 by Prof. Moon,¹ which would reduce the stresses to a minimum, whilst at the same time giving sufficient opportunity for modelling shadow. Other ranges are suggested by the Illuminating Engineering Soc. such as are given in their recommended practice for Residence Lighting. They suggest that the task has two areas around it, an intermediate surround, and a general surround. They suggest that the intermediate surround should not be brighter than the task, or less than 1/10th as bright, whilst the general surround should have no appreciable area of brightness more than 10:1 in ratio to the task.

Whereas it is comparatively easy to apply such standards, and to see they are carried out in such programs as offices and schools, it is by no means so easy in homes. For it must be recognised that the response to a stimulus is a total response from the whole man, to the total stimuli available, and whilst in offices people in general are placed in a specific position and direction, in the home the family will be in every conceivable position at some time or other.

Logically if this were the case then it would be necessary to ensure that all the relationships within the space were

1. Moon and Spencer. Lighting Design. Addison-Wesley. 1948

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were/

coordinated in such a way as to achieve a 3:1 or 10:1 ratio. and it is felt that there are occasions when such a relationship may be necessary, but from my discussion of the psychological needs of man in this chapter, it is seen that a satisfaction of man's physiological needs does no more than ensure the absence of discomfort, whilst what the architect's aim must be is to establish in a positive way the variation of environment which allow man to lead a much more full life.

He must provide for the high levels of illumination which will reduce the stresses on man when he is doing a complicated visual task, to a minimum, but at the same time he must also provide for the man who wishes to sit with a single candle, and read, or sit by the firelight and think. For the stresses on man vary with the intensity of the task...the child who is learning at school is under many different stresses upon his system, whilst when he is at home in bed these are negligible; between these extremes there are many gradations, for the architect is concerned not so much with the fact that there are stresses, since the body requires a continuous gymnastic to maintain its dynamic balance, but rather that these stresses may not be "undue".

its value.

Finally we are concerned with the value of the information from the physical environment, and to this there is little

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there is little/

that need be added with special reference to the living-space.

This is not something which is separate, in that it can exist on its own, but rather it is something over and above the satisfaction purely of those aspects of information already outlined. For it has its basis in the imagination of man, and in his ability to fire the spark of imagination in others.

- 4/ A discussion in the light of this knowledge, as to what degree of flexibility is desirable, and what degree of flexibility would be acceptable, as an answer to man's individual and group needs.

It is evident from the preceding discussion that there is a considerable variety of need within the living-space, if man is to be satisfied at all levels, so that the question that remains is not so much "whether" as "how much" flexibility the architect is able to provide.

The approach should be, that it is the job of the architect to provide the maximum of differentiation, consistent with the other aspects of the architectural compromise, such as planning, servicing, structure, and economics, when these are considered in relation to man's need of unity and clarity. In order to make flexibility acceptable, it is necessary that the ranges of such a flexibility should be easily controlled, so that the means themselves are not so cumbersome as to prohibit their use.

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There are obvious limitations on the ranges of such variability within the living space, since it would be impossible for someone to be reading in the space at the same time as someone else was using it as a photographic darkroom. The approach would have to recognise that some needs are incompatible, and not only this but that some needs for some people, will be more incompatible than for others. An example of this would be the writer who wishes to work on his play, he might find it quite impossible to work in the same space as the rest of his family who were doing the other innumerable jobs that are done in the living space, whereas another man who may only be writing a letter, would not experience any such difficulties. It is therefore the job of the architect to achieve a balance, so that where possible different needs may be satisfied in the same space at the same time, but that where this is impossible, they may be satisfied at different times. Finally where the needs are totally incompatible, then some other spatial solution must be sought.

Questions that might be asked are

What upper and lower limits of intensity would be sufficient to meet man's needs?

What range of colour relationships?

what differences of texture?

What contrasts of shading?

what spatial differentiation?

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This seems to me to be a more profitable way to look at the problem, rather than to suggest that each individual task or activity, requires a specific relationship, a specific amount of illumination of certain characteristics, for as I have suggested there are so many variables in the case that the results would be in no way conclusive.

What then is the highest range of intensity that may be needed at any point, or at specific points throughout the space. The Illumination Engineering Society suggest¹. that for the task of sewing black cloth a source which provides 150 or more ft.candles on the task is sufficient. Such a source would provide some 5 to 10 ft.lamberts brightness on dark cloth of a low reflectance. Were the same source to be used for reading, with a book of moderate high reflectance the task brightness would be in the order of 130 ft lamberts, which would be in excess of need²., also supposing two different people were using this same source for the two activities mentioned, for one the general brightness of the room could be as low as .5 Ft lambert, whilst for the other it should not drop below 13ft lamberts, if the 10:1 ratios of the Illum Soc. are to be met.

However if each person were to have his individual source

1. I.E.S Recommended practice for residence lighting.
November 1953
2. As it is thought of at present.

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his individual source/

the person reading could then have a recommended 40 ft candles, which would give a brightness of some 36 ft.lamberts which would allow the general surround to suit both the people at a brightness of say 4ft lamberts.

This as I have suggested is by no means the whole story, for on a certain day, the man wishes to read with a single candle, according to his mood and his feeling, here he has less than 1 ft.lambert brightness on his task, whilst his surround would have a brightness of as little as .005 ft lamberts. The ratio is seen to be anything but ideal as far as the standards go, yet this is what he needs just the same, at this particular time. Supposing now that his wife were to be sewing on dark cloth, a relationship between both the tasks could be established at say .7 ft lamberts for the general surround, provided that there were an independent means for varying it.

What seems to be suggested by the ranges of intensity is that the general surround should be capable of variation up from very low levels to brightnesses of 10 to 15 ft. lamberts,¹ whilst it should be possible to arrange for high levels of illumination at points throughout the room, in order to provide sufficiently high brightnesses on dark tasks.

1. Where it is thought that 3:1 ratios are necessary, this would have to be increased to 40-50 ft.lamberts.

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As to the ranges of colour, texture and shading, these cannot possibly be laid down in any form, and must come from the experience of the designer, in the utilisation of these means of variation. I have suggested that by a further investigation of Gibson's data the architect may be in a better position to utilise these aspects of his formal relationships in a more holistic sense.

As to the ranges of spatial differentiation, a great deal may be accomplished by an economy of means, where a coordinated relationship is arranged between such items as various textures of curtains, and I shall develop this more fully in the subsequent chapter.

The economics of such a scale of flexibility as I have in mind are not easy to evaluate, for as with all new forms of control, it is likely that the initial cost of the first pilot installations would be heavy; it is thought however that with further experience, and a general demand for such an item as "flexibility" as a necessary element of a new house rather than something that is an additive factor, such as the chrome on automobiles, these initial costs would be cut down. It would no longer be a question of whether to provide it or not, but a question of being unwilling to impoverish ones range of experience by doing without it.

PART 3.

The architectural illumination
of the Contemporary Living-space
approached from the aspect
of flexibility.

Chapter 3.3

Formal Relationships,
the tools of flexibility.

At the end of Chapter 3.1 I outline a new approach to flexibility, starting with an examination of man's needs within the living-space, to the extent that they show a tend towards variability.

In chapter 3.2 I have dealt with this point, and have shown that the living-space needs to be capable of a considerable range of variability. It is now necessary to deal with the next two points in this approach.

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Firstly a reëxamination of the formal relationships of the architect within the living space shows that the means for this flexibility is generally lacking¹. and that the means, which are seen to be variations of light or of matter, are not coordinated, so that such a flexibility as I have in mind can't be accomplished.

Secondly it is necessary to discuss such a coordination of the components of a formal relationship, by which this may be done.

An illustration will serve to show what I mean by lack of coordination.

Supposing the light component of the formal relationship,² were of the sodium arc type, and one wished to light up a surface with this. If that surface were painted a saturated red colour, it would appear black, by the laws of colour subtraction, since all the sodium D lines would be absorbed by the material. If however the surface were painted white, with an even spectral distribution curve, then the resultant subtractive effect will be to light up the surface.

This is a very simple example, which has little architectural validity, but it shows how coordination is essential.

1. This has been discussed in the analysis, chapter 3.1
2. Referred in the method of analysis as the "basic Light Flux pattern."

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An architectural example which is frequently encountered, is the relationship between a light source, designed for reading. The nature of the source is such that if the book is of a matt surface, the light is sufficiently diffused, so that a maximum contrast between the ink and the paper is obtained. However if a glossy magazine is read with the same relationship between the eye, the book, and the source, the light will be reflected off in a specular manner, the contrast will be reduced, and the same amount of information will be more difficult to receive. Normally by tilting the book, this can be reduced to a stage when it is not severe.

Since the architect is not in the position to design many of the things that are used in the living-space, coordination of this nature is particularly difficult to achieve.

This particular effect can be eliminated by the insertion of a film between the source and the book, of a highly diffusing nature, so that the resultant incident light is of a non-specular character, but when this is done it makes the light less suitable for other activities which rely on specularity of the source to add sufficient highlight to aid the contrast, where a depth is involved, such as with materials.

What then are the means at the disposal of the architect? Firstly they are means associated with Light, and secondly means associated with the objective world.

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Light.

Basically light can be divided up into natural and artificial sources. In Chapter 1.2, I considered the source of the Sun, and the secondary source of the sky, with their various spectral characteristics, in order to show how these affect the objective world. The light that is received by the surfaces of a wall inside a house is the combined effect of the original source of energy, the sun; the secondary source of energy, the sky; the reflections from any other external objects, such as trees; and the modifying effect of the glass of the window.¹ Where this light is received on to the surface of a red carpet, the reflected light within the room, will, take on the red characteristic of the spectral distribution of the carpet, as this is affected by the characteristic of sunlight. Since the light from the sun and sky are constantly varying, in intensity, direction and combination, there is a constant variability of relationship.

It is the architect's use of artificial light which I shall consider chiefly here.

There are three main types of sources that he can use, incandescent, electrical discharge, and fluorescent.

1. Evans in his book An introduction to color, mentions in this connection that when a house has a large tree outside the window, the sunlight is modified by the green of the leaves, so that the light reaching the room is green. In such cases this is the primary source of light for the room.

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Incandescent sources are the oldest, cheapest, most popular, and the least efficient from the point of view of energy use related to lumen output. Which averages as little as 15 to 17 lumens per watt. I have given a typical spectral distribution curve for the drawn tungsten filament of the incandescent light (fig.1.2.3)

The melting point of tungsten is 3655°K and the light is given off as a function of this heat. The higher the operating temperature, below this point, the further towards the visual range will be the maximum energy in terms of light. Operating temps. in use now are between 2400° and 3200°K . Due to the considerable heat that is given off these lamps have a detrimental effect on cooling plants, and are often considered unsuitable on this score.

They have other advantages which outweigh this in normal home use. Their simplicity, cheapness, and the continuous nature of their spectrum, coupled with the "warm" nature of the light itself (since its highest output is in the longer wavelengths) make it suitable for home use.

Incandescent lamps are considerably affected by voltage, and a formula is available¹. which enables one to calculate according to the price of the lamps, and the current rate of electricity; whether it is better to run under the rated voltage, and increase the life, whilst lowering the output; or to run over the rated voltage, decrease the life, and increase the output.

1. Moon and Spencer. Lighting Design. Addison-Wesley 1948 p.53.

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Since all object colour, with respect to its physical component is a function of the light source, and the spectral distribution of the object, it is necessary to see what effect tungsten filament has on such colours as the Windsor and newton standards.¹

Standard.	Mixed colour.	reflectance
Cadmium yellow	orange yellow.	56%
chrome orange	orange red.	28%
vermilion	red orange.	20%
green Light	yellow green.	14%
green dark.	green deep warm.	8%
aliz.crimson	brown red deep.	7%
cobalt blue	blue deep.	6%
ultramarine deep.	blue purple.	4%

The results of course are never as simple as this in an actual situation, since the light is not only the result of a single radiation from a source, but the result of multiple reflections from the wall surfaces as well as from the source on to an object.

For example with an incandescent source, in a room with a yellow wall. Light thrown on to an object will be partly from the source, with its tungsten distribution, according to temperature, and partly from the yellow wall, which will be a function of both the distribution curve of the yellow surface, and that for tungsten. The latter light will be decidedly more yellow than that of the source itself.

Since the wall is a large surface, and the source a small one, the light from the wall will fall off relatively less fast

1. Data from Commercy and Leighton. Illum Eng. Dec. 50

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less fast/

than the light from the source (inverse square law for small sources) so that the greater part of the light will come from the wall. There is a further complication too, in that light is not the result of a single radiation only, but is the resultant of all the interreflections between the wall surfaces. Due to the selective absorption of the walls, this means that this selective action takes place at each interreflection, so that as the light is "bounced" back and forth several times, and with each bounce, there is an increase in the selective action, the apparent colour of the wall is altered. A common example of this is when the architect tries out a new colour on a small piece of wall, and decides that it is not intense enough. However when the intensified colour is placed on the whole wall, the total effect is altogether too intense, due to this selective absorption at each interreflection.

Since the colour temperature of incandescent lamps varies considerably with voltage, a 5-volt variation in 110 volt circuit causing a difference of 50° K, clearly visible changes are noticed if this method of varying the intensity of an incandescent type of installation is made. Due to this it is thought that the best method of varying intensities of the incandescent source, is by a multiplicity of sources, all of which are connected to the appropriate voltage, but which are wired to separate combinations. The highest intensity being when all the sources are used, and decreasing

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and decreasing/

as the number of sources in each circuit is reduced. In general it is thought that a three circuit variation will be sufficient for most purposes. In such a case it is important that the distribution of the sources is so arranged as to cover the same area, but at a less overall intensity.

Electrical discharge lamps may also be used for homes. A current is passed between two electrodes, and almost any stable gas at ordinary temperatures, will give off light, if placed in a tube. Generally speaking inert gases are used, the most common, being mercury vapour, neon and sodium. The type of light varies for each gas, sodium already mentioned giving off homogenous radiation, neon having a line spectra, similar in character for that of mercury vapour, (fig 1.2.3) but differing as to wavelength, this is illustrated in Figure 3.3.1. It can be seen that all radiation is roughly between 0.6 and 0.7μ so that the colour must lie somewhere between green and red, whatever colour is desired being obtained by filtering out the undesired wavelengths. This is in general thought to be an unsatisfactory light for home use due to these colour characteristics.

Mercury vapour (fig.1.2.3) is the inert gas most frequently used; when this gas is used at high pressures, an increase of the intensity of the light is found, whilst at the same time it adds to the mercury "line spectrum" a continuous spectrum at certain wavelengths. Such lamps have high brightness.

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However since their greatest light output is in the invisible ranges on either side, the ultra violet and the infra red, whilst the rest is mainly in the blue, it is not generally much used.

With the fluorescent lamp a method was devised to use the ultra violet component, of the mercury spectrum, and convert this into light within the visible spectrum.

The efficiency of such tubes is greatly in excess of incandescent averaging 50 lumens per watt.

Many different spectral distributions can be made by variation of the phosphors with which the inside of the tubes are coated.

The spectrum of the fluorescent is a combination of both the line and the continuous spectra, and when planning a coordinated colour relationship, it is necessary to take both into consideration. I mentioned in Chapter 1.2 briefly the sort of colour variations that might be expected from the use of fluorescent lamps of different phosphor composition on Windsor and Newton "orange". To enlarge on this

<u>standard.</u>	<u>fluorescent lights.¹</u>	<u>Standard cool white</u>
cadmium yellow	<u>De Luxe cool white.</u>	greenish yellow
chrome orange	yellow cool	yellow brown pale
vermillion	red orange	light brown
green light	red orange	greyed green
green dark	pale green	dull green
aliz. crimson	blue green	purplish brown deep
cobalt blue	blue red bright.	blue less purple
Ultramarine.	purple blue	light blue.
	light blue with	
	purple.	

1. Combery and Leighton's data. neta park

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<u>standard</u>	fluorescent lights.	<u>standard warm</u>
cadmium yellow	<u>De luxe warm</u> orange yellow pink	green yellow medium
chrome orange	orange red clear	yellow brown medium
vermilion	red orange yellowy	yellow brown
green light	yellow green medium	greyed green dull
green dark	yellow green	warm dull green
aliz.crimson	brown red.increase red	brown
cobalt blue	red purple brighter	red purple brighter
ultramarine	blue purple deep	blue purple deep.

Advantages of the fluorescent over the incandescent source are firstly its efficiency, secondly its stability under changes of voltage, thirdly low heat production (in relation to cooling systems etc), its cheapness to operate, its length of life, usually four times the length of incandescent, and finally its low brightness of surface, compared to the very concentrated brightness of the smaller source.

However its disadvantages are also important, it is more expensive initially, but most important the spectral distribution differs so radically from the sources, to which the eye has become adapted. Fig 3.3.2 shows some of the energy distributions for several types of fluorescent lights.

A source which appears the same as far as colour is concerned may have a very different effect to daylight, or incandescent light, when the light is combined with the object colour, for the physical colour is a combination not of the total light, but a subtractive mixture of the spectral distribution curves. An example of this is dramatically illustrated by Evans¹.

Evans. Ralph An introduction to Color Wiley. 1948

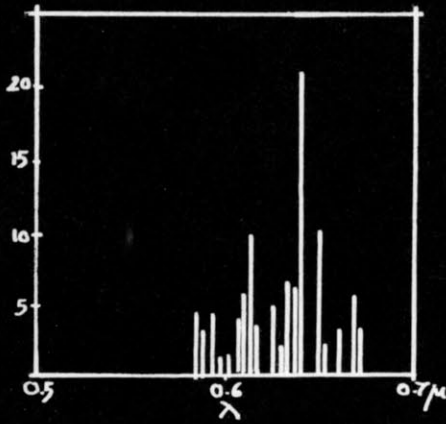


FIGURE 3.3.1.

Spectral distribution
from a Neon Light.

data from Benford and Buttolph
M.P.E. Trans 13, 1928.

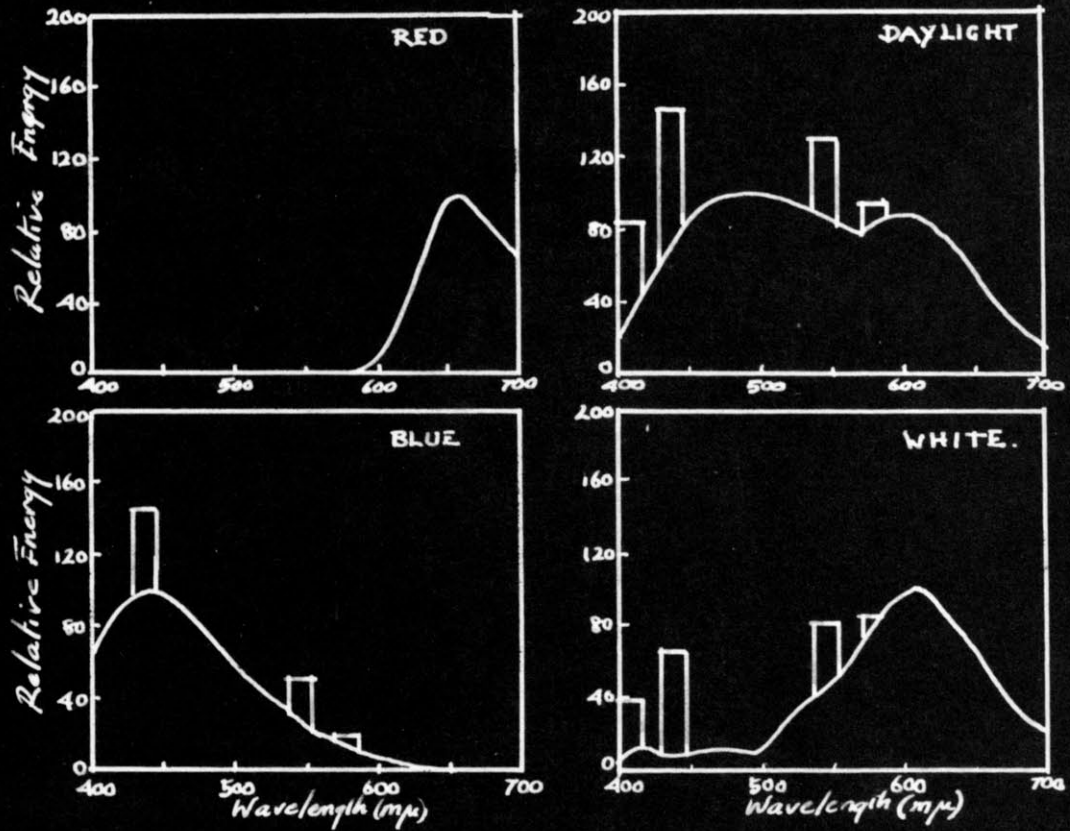


FIGURE 3.3.2.

Spectral distribution curves for different
types of fluorescent lamps.

data from G.E. Inman. Trans. of Illum Eng. Soc. Vol 34.
1939.

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by Evans/

in which he shows various line spectra which will match the I.C.I Illuminant C, which is an approximation of daylight. Seen as light the observer would be unable to tell the difference between these illuminants, which would appear as white light. If these are played on to non-selective surfaces, again the result will in general be the same. But if these different lights were played on to various objects selective to colour then totally different effects can be predicted only by a knowledge of the distribution characteristics of the lights. Plate X111 of Evans book shows two scenes which are identical as to object colour, but which have two such illuminants played on to them. The first has a yellow curtain, a blue vase, a glass bottle with yellow liquid, and a green ornament, whilst the floor is white with pink highlights.

The second has a red curtain, a blue vase (remains constant in this case) a glass bottle with red liquid, and a grey ornament, whilst the floor is now a pale blue. This example shows the range of the variations that are offered by the variation of illuminant. This can be extremely bad in cases where the object colour is important, such as with food, when a meal can be spoilt if the colour of the food is out of ones normal experience. But in the hands of the designer who wishes to obtain a particular effect for a reason dictated by mans physiological or psychological needs, this can be a useful tool.

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A further disadvantage of fluorescent lamps is is stroboscopic effect, due to the fact that the arc of the electric discharge is extinguished twice in each cycle. In the living-space this is not of any great importance, but where the movement of machinery is concerned it can be dangerous, since if the machinery is moving at the same speed as the cycle, it could be made invisible when it was "in phase"...this can be overcome by the introduction of an out of phase secondary circuit.

Two forms of circuit have been developed for the fluorescent and electric discharge lamps, the hot-cathode, and the cold-cathode types. The hot-cathode requires a ballast, and in general there is a delay while the filaments are heated before the arc strikes, and the light comes on. This is obviated in the cold-cathode, which operates at much higher voltages, requiring a transformer, the arc is immediately initiated. The tubes themselves can be any shape, and of widely varying lengths, and diameters. The luminous output can be varied by means of a variac,¹ placed in the circuit before the transformer, or by stages, which deliver a graded scale of voltages which correspond to visual gradients to the transformer. Cold-cathode light is widely flexible as to intensity, from over 2000 lumen output for 8 ft. tubes down to comparatively low intensities. At very low voltages there is a slight flicker and the colour temperature, which remains very stable throughout the range, drops.

1. A similar method is now available for Hot cathode.

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The cold cathode lights are made in an increasing variety of colours, and it is thought that they will be used widely in architectural lighting. For the living-space, they have great advantages for variations of intensity, for flexibility of diameter, and shape. They are slightly less efficient than the hot cathode due to the presence of the transformer, and the presence of high voltages may be considered a disadvantage in the home.

These three sorts, incandescent, electric discharge, and fluorescent cover the types of light sources that are used for artificial lighting. A note needs to be added concerning "the flame" which is used either as firelight, or candles. Both have the one quality which is lacking in the other artificial sources, the characteristic of mobility, and the fact that man still feels the inherent need for this quality, is a fact which the architect cannot ignore.

These are the tools of the architect, in the creation of his formal relationships, they can be varied as to intensity, within the limitations I have mentioned, and they can be varied as to colour, in the case of fluorescent tubes by means of the phosphors, in the case of incandescent, this has to be by a filter type of subtractive mixture, and logically falls into the second part of this discussion.

Other variations are as to the placing of the sources in relation to objects and surfaces within the space, which must be coordinated with them. The direction, and size of the light source in relation to its brightness is important.

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A further scale of variation is suggested by the needs for some form of temporal change, which have expression in the flame and the open fire. Kepes has suggested that some form of light mural might be possible¹, which would be achieved by some simple mechanical device such as in the work of Wilfrid already referred to in Chapter 1.1. Such a mobility can either be obtained by a variation in time of the light source or of any object, such as the mobile, which moves in relation to a light source, or in combinations of both.

Objective world.

This may be considered to be any object, surface, filter, or diffusing agent which absorbs, transmits, or reflects light. It is necessary to see in what ways light is modified by the objective world, as to its colour characteristics, intensity, diffusion, direction, in order to be in a position to control these variations to suit the formal relationships of the architect.

Basically when light hits an object, or surface, three things can happen to it, it can be transmitted, reflected or absorbed, according to the laws of refraction, diffraction, or interference². Usually all three effects occur at one time, but the proportions

1. Kepes, G. Contribution to Seminar. Vision Brightness and Design. M.I.T. Sept. 53
2. In addition to the laws of selective and non selective transmission and absorption.

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the proportions/
of each are different according to wavelength, or colour.
The sum of the transmitted, reflected and absorbed energies
must total up to the incident light.

These then are the laws by which the architect is ruled,
when the light from the basic light flux pattern, meets the
objective world. The laws are complicated, and it is necessary
for the architect to have some knowledge of them if he is to
be in the position of utilising light as the tool that it
is.

For purposes of simplicity, I shall not go into these laws
to any extent, but rather show the ways in which a knowledge
of these laws can be used.

It is easier to consider the subject in two parts, firstly the
modifications to light that do not change its energy distribution,
which is called non-selective, and secondly modifications
in which the spectral distribution is altered selectively.

Non-selective modifications.

Refraction.¹ Light from a source hitting another medium is
altered as regards direction, according to the angle of
incidence of the light on to the surface. The higher the angle
of incidence, the greater the angle of refraction, so that
when the light emerges from the opposite side of say a piece
of glass, it is parallel to its original direction, but
displaced sideways. By means of properly calculated and
shaped transparent surfaces, the light source, may be either
1. Thought of non selectively.

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may be either/

made to converge, by condenser lenses, or diverge by diverging lenses. Light sources, may be concentrated into a narrow angle or spread over a wide area.

If however the transparent surface on which the light falls is irregular, and corresponds to no regular pattern, such as is the property of a sandblasted glass, the light which is transmitted will travel in all directions, and such glass is called diffusing. Many plastics have been produced which will give this property, so that light from ordinary tungsten or fluorescent sources may be diffused. By some form of mechanical variation of the surface through which the source passes the source may be varied as to its diffusing qualities.

Refraction is a property of non selective transmission.

Reflection. For flat surfaces, the angle of reflection always equals the angle of incidence of the light, so that by curving the surface of a highly reflecting medium, such as silver, or chromium, the light from a source may be concentrated in much the same way as with a condenser lens. Also in a similar way to transmitting surfaces, the light may be thrown into a definite pattern, by a regular surface, or into a completely diffused pattern, by a random surface.

The types of diffusion from reflecting surfaces are illustrated in Figure 3.3.3(a) from which it can be seen that the reflection pattern is determined by the texture of the surface, and the angle of incidence of the light, whilst man's experience of it is a function of his relationship to both.

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From the foregoing discussion of non-selective modifications it can be seen that if the position of the source with relation to the lens or the reflector is changed, then the concentration or diffusion of the beam of light is altered. Further with the use of diffusing mediums over the combined source and reflector or lens, the light may be made to shine evenly over a large surface, or if the above light is played upon a surface of a rough texture it may be diffused according to the "specularity" of the surface. Some or all of these methods for varying the light can be used, without resorting to colour.

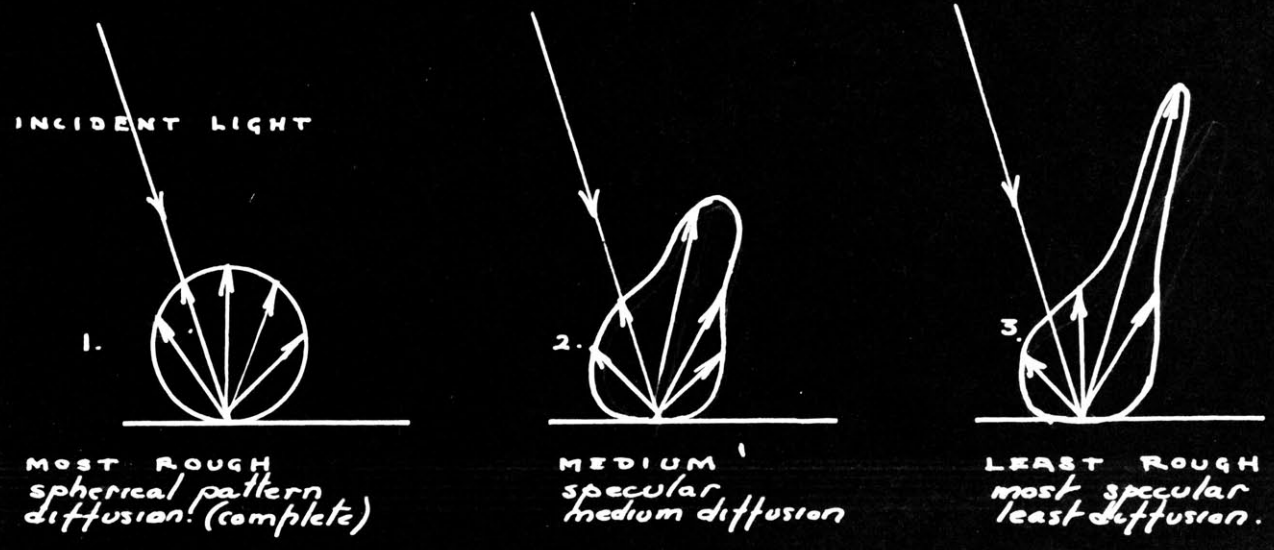
An architectural example of the use of these properties might take the form illustrated in Figure 3.3.3^(b) where a transmitting surface, such as a curtain, is placed between two spaces which it is desired to divide up visually on different occasions. It can be seen that with the different light patterns varied, the surface quality of the curtain can be made to appear opaque or translucent, from either side of the division. Further variations might be used in the form of colour, so it is necessary to continue by discussing Selective modifications.

Selective modifications.

I have suggested that when light falls upon the objective world, it is to some extent, transmitted, reflected, and absorbed, to a varying combination according to the nature of the surface.

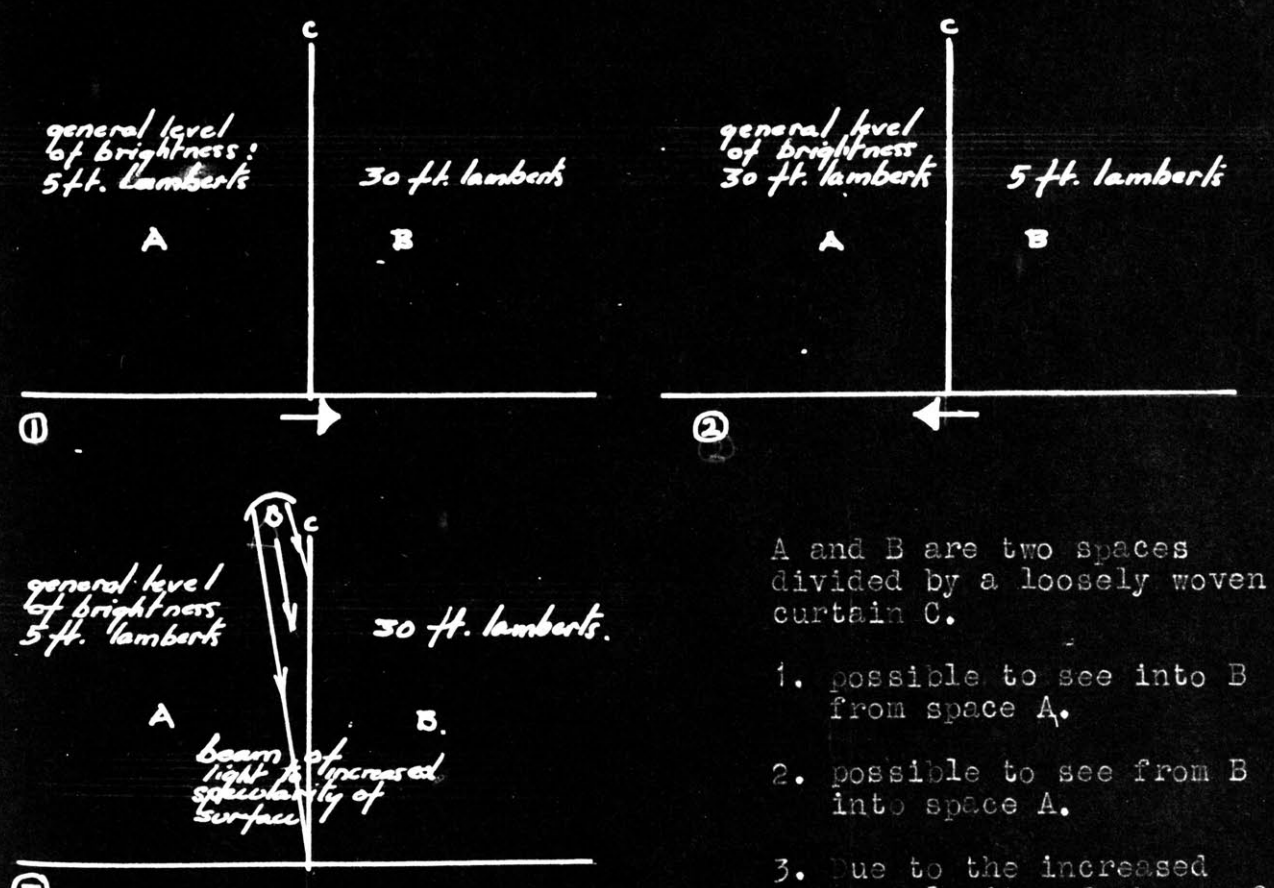
To deal firstly with transmitting medium, the light is decreased in amount as it passes through the medium, in some regions of

FIGURE. 3.3.2.



Polar diagrams of light reflected from surfaces of different degrees of roughness. The roughness decreasing from 1 to 3. The specularity of the surface increases with smoothness.

FIGURE. 3.3.3.



A and B are two spaces divided by a loosely woven curtain C.

1. possible to see into B from space A.
2. possible to see from B into space A.
3. Due to the increased specularity of the surface by the high angle of incidence it is no longer possible to see from A to B.

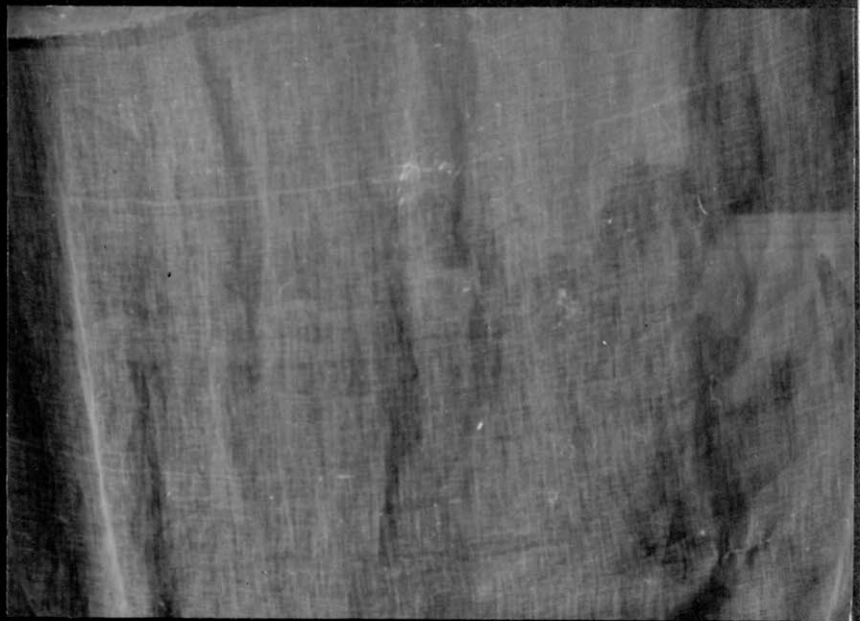


Illustration of the method shown in Figure 3.3.3 for varying the transparency of a surface. The position of the camera is in space A, and the illumination corresponds to 1 2 and 3.

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some regions of/ the spectrum, in relation to others, by the process which may be considered as selective absorption. Since this light that is absorbed, must come in the original instance from the light source, the process is one of a subtractive mixture.

Light can therefore be modified by a filter, which has the characteristic of absorbing all the spectrum of light except for a definite band, such as red or blue. This will in fact subtract all but these wavelengths from the source. This is of course an inefficient way of producing coloured light, since so much of it is wasted by absorption, and converted into heat; but where economy is not important, such as in theatre lighting this method of gaining effects is widely used.

Certain materials differ with regard to their selectivity, according to whether the light is being reflected from them or is being transmitted through them. For instance there are many materials such as coloured glass which have the property of selective absorption, so that the light which is transmitted will be "coloured" whereas the reflected light is non selective, and reflects only the same wavelengths that are played on to it. Where such a combination is used in a room as a division between two spaces, the nature of the light that is perceived on one side is an addition of the reflected light, (which is a function of the light source) and the light which will have entered the further space, being converted to a colour by the selective absorption, and then retransmitted, and re-selectively absorbed, giving a very saturated colour.

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If in this case the illumination on the opposite side of the surface is raised to a level exceeding that on the other, then the surface will appear as a lighted coloured surface... so that in this way depending on which side is more intensely lit, the surface may be varied from a reflecting to a transmitting surface.

Diffusion of light, already discussed, occurs when the particles of a material are many times larger than the wavelengths of the light, the action described as diffusion is non-selective with regard to wavelength, and is a function of its composition. However when the diameter of the particles approaches that of the wavelength of light which is played upon it, a further phenomenon occurs, which is called diffraction, and this may be considered to be the bending of light around the particles, and this is selective to wavelength.

More short wavelengths are "scattered" by diffraction than long ones, so that in general the light that is transmitted is altered towards the long or red wavelengths, the scattered light being blue, by reflection.

A further attribute of transmitting media, is that of refraction, previously discussed for its non selective properties. It is also however selective with regard to wavelength, so that when the two sides of a glass medium are not parallel, as with a prism, the spread of light is magnified, and the spectrum is obtained if a small angle of light is played on to one side.

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Shorter wavelengths are refracted more than long ones, so that as the amount of refraction increases with the angle of incidence of the light, this angle determines the amount of dispersion of the short wavelengths.

One further characteristic, by which energy characteristics may be changed, is by interference. For since light may be considered as a wave pattern, if two sources of light were to send out waves at an unsynchronised wave pattern, when this met a surface, the light from both sources would differ as regard to displacement of the wave. Where this difference amounted to a maximum displacement in one direction, and a maximum displacement in the other, the light will "cancel itself out". This is of course assuming that the light is of a single wavelength. With white light, where all wavelengths are present interference is found only in exceptional circumstances.

Such an example which may be a useful tool for the architect is in the smooth transparent or metallic surface, when such a surface has a "grid" of fine lines scored on it. If a beam of parallel light is allowed to fall upon this, diffraction takes place at each scratch, so that the space between each scratch forms a new linear light source. If sufficient number of parallel lines are drawn¹, a whole series of spectra can be produced. In the case of the metallic surface, that

1. Evans suggests 40,000 per inch.

Chapter 3.3

that,

is scored, the reflected light passes by two different paths to the eye, and the colour will change with the observer's position. A controlled variation could be obtained by means of a variation of the nature of the source, depending on its spectral composition; with different orientations of a mercury arc source, the colour could be varied from bright green, to blue red or yellow.

An example of the same effect can be seen in a close weave curtain, which "interferes" with the path of sunlight, to give a similar coloured sparkle.

One further aspect of transmitting media is offered by the developments of Polaroid. When white light is played on a polaroid film, the film passes only light energy on a certain axis, and when a further film is placed in front of this and rotated until its axis is at right angles to that of the other, the light will gradually be cut out altogether, depending on the quality of the polaroid.

In the same way as in the "photoelastic model" studies at M.I.T.¹, where a source of homogenous radiation is used to achieve measurable stress patterns in model beams, under load, so a sheet of celophane, or lucite with stresses applied, could be made to stress patterns, such as are illustrated in Figure. 3.3.4 . By means of a hole in the sheet of lucite, or

Murray. Prof. Macgregor Seeing Stresses with photoelasticity.
Metal Progress. February 1941.

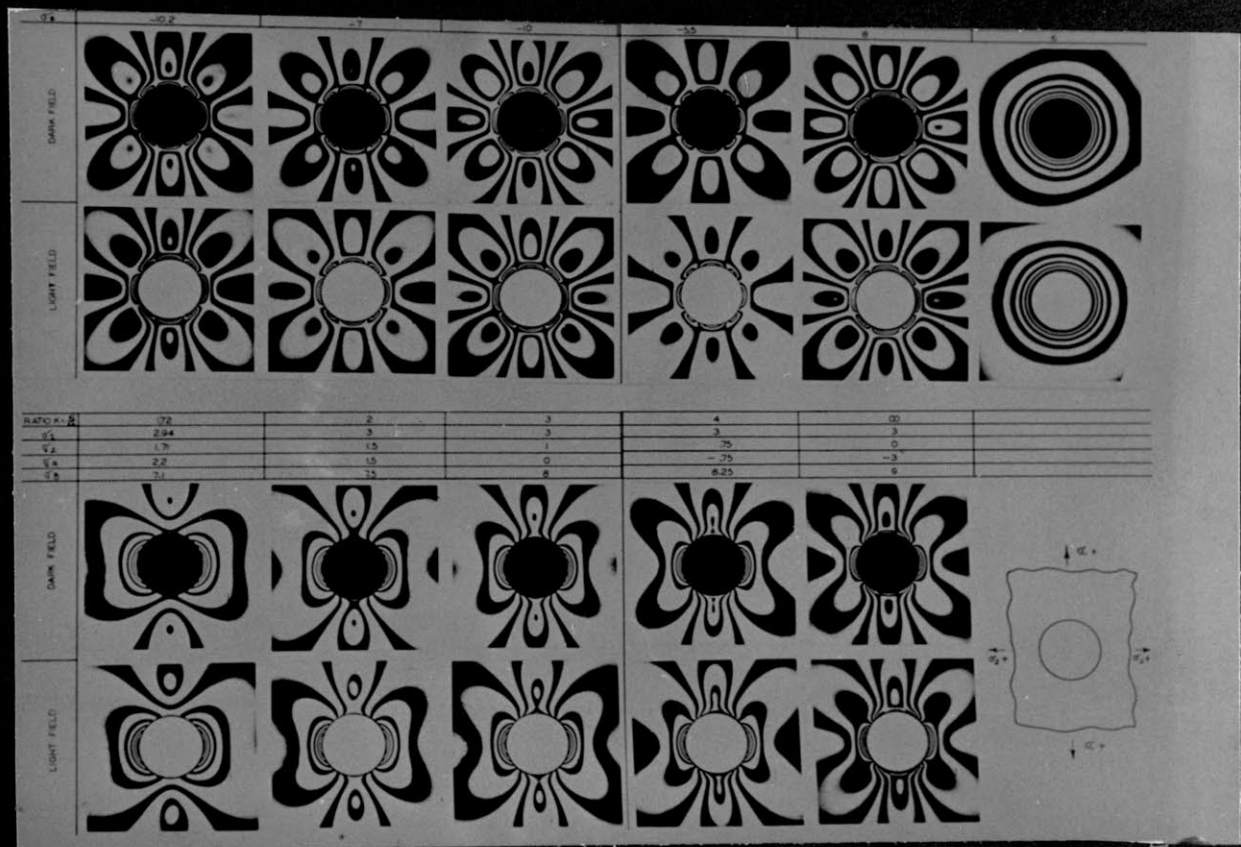


Figure.3.3.4

Examples of the patterns that can be obtained by polarisation using a 1/8th inch strip of lucite under tension. The lower row of patterns show tension only, the upper row show the patterns possible with compression.

The patterns shown are gained by introducing holes into the lucite sheet.

Data from Prof.Murray. M.I.T.

Chapter 3.3.

a series of holes, combinations of the various stress patterns could be obtained.

The sheet of celophane could also give various colours, and a combination of colour and bands could be obtained. Different types of source would give different characteristics, the line spectra types would be more productive.

When light falls on opaque surfaces, as opposed to the transmitting surfaces which I have been considering, both selective absorption and selective reflection will take place, depending on the nature of the surface, and the angle of incidence of the light. The type of surface is important, for if a normally selective reflecting surface, is coated with a film of varnish or polish, the light will not only be reflected selectively from the under surface, but non selectively from the outer surface. This is the reason that matt surfaces in general reflect more of the incident light than glossy surfaces, in an all over diffused manner. The glossy surface will reflect specularly, in a single direction, depending on the angle of incidence, so that unless the eye is on this line, when the effect will be most bright, the effect is less bright than for a matt surface.

There is a further effect however from the shiny surface; if it is looked at as a selective diffusing surface, with a non-selective reflective surface above it, the process may be more easily understood. The light on the surface, is partly reflected off, and part of it goes through to be diffused

Chapter 3.3

to be diffused/on the selective surface below, this diffused light is then passed upwards through the reflecting surface, which again reflects part of it downwards again, and allows so much to go through. It can be seen that when this happens several times by multiple reflection, there is a considerable increase in the amount of selectivity, and a consequent increase, or intensification of the colour. This can be seen in the polished wood of old tables and furniture.

Summary of variables.

Basic light flux pattern.

- 1/ Variation of illuminant. Incandescent
Electric discharge
Fluorescent.
Flames.
- 2/ Variations of intensity.
- 3/ Variations of the relative size of the source.
Difference between natural and artificial sources.

Objective world. (non-selective with regard to wavelength)

- 1/ Variation by lenses, converging or diverging.
- 2/ Variation as to diffusing properties of transmitting media.
- 3/ Variation of source by reflecting surfaces, as for lenses.
- 4/ Variation of surface, according to angle of incidence of source.
- 5/ Variation of reflected pattern by degree of specularity of a surface.

(selective with regard to wavelength)

- 6/ Selective absorption of materials. Filters transmission.
- 7/ Selective reflection. variations of surface from reflecting to transmitting media.
- 8/ Alteration of wavelength by "scattering" (by diffraction)
- 9/ Alteration of energy distribution by refraction.
- 10/ Alteration of energy distribution by interference.
- 11/ Alterations of both energy distribution, and pattern by polarisation.
- 12/ Selective absorption and reflection of opaque materials.
Difference due to surface specularity.

Chapter 3.3

From the foregoing discussion of the variables of which the architect constructs his formal relationships, it can be seen that there is an opportunity for a considerable flexibility of the physical environment, by these means.

To this can be added the variations due to natural sources, and the addition of the time element, or mobility.

In order to achieve specific, and controlled effects, the architect must concern himself with coordinated variations of light and matter, and several ways in which this may be done have suggested themselves throughout the discussion.

Shadows.

As Gibson's data has suggested, shadows do not present a reliable clue to "distance- from- you", but they are an indication of the depth shape of objects, or their position and shape in relation to a known light source.

Similarly if the depth shape and position of the object are known the shadows are a fairly reliable clue as to the nature of the light source.

For example a source at a distance, and of a small magnitude, in relation to its distance, as in the case of the sun, will throw a sharp shadow, whilst a source large in area in relation to distance, such as an overcast sky will throw a diffuse type of shadow,

This fact was mentioned in Part 1. as being an important design consideration for architects working in countries with varying lighting conditions, an example of the highly textured walls of Italy being given, a coordination

Chapter 3.3

between the surface, and the high sun angle.

In a similar way it is possible for the architect to use the property of "shadow" to achieve a particular effect, and variations of effect.

An example of this is shown in Figure 3.3.5, in which the relationship between two surfaces is shown, photographed from two different angles, and with light sources at two different points.

In the first two, the camera is pointed straight at the surfaces, which register no gradient of texture, being frontal surfaces, and the last two the camera is at an oblique angle giving a medium gradient of texture. (see fig. 1.4.1)

In the first and third the source of light is at right angles to the camera, whilst in the second and fourth it is at the same oblique angle as the camera.

The variety of shadow, can be seen by an inspection of the texture, and the surface on the right hand, which is Celotex.

Figure 3.3.6 and 3.3.7 are further examples of architectural uses of shadows. They are ceilings designed by Lucio Fontana for two rooms in which films are shown in Italy.¹

In these cases the objective world (matter) is designed in relationship to sources of light that can be varied. By

1. Illustrated in Domus. September 1953.

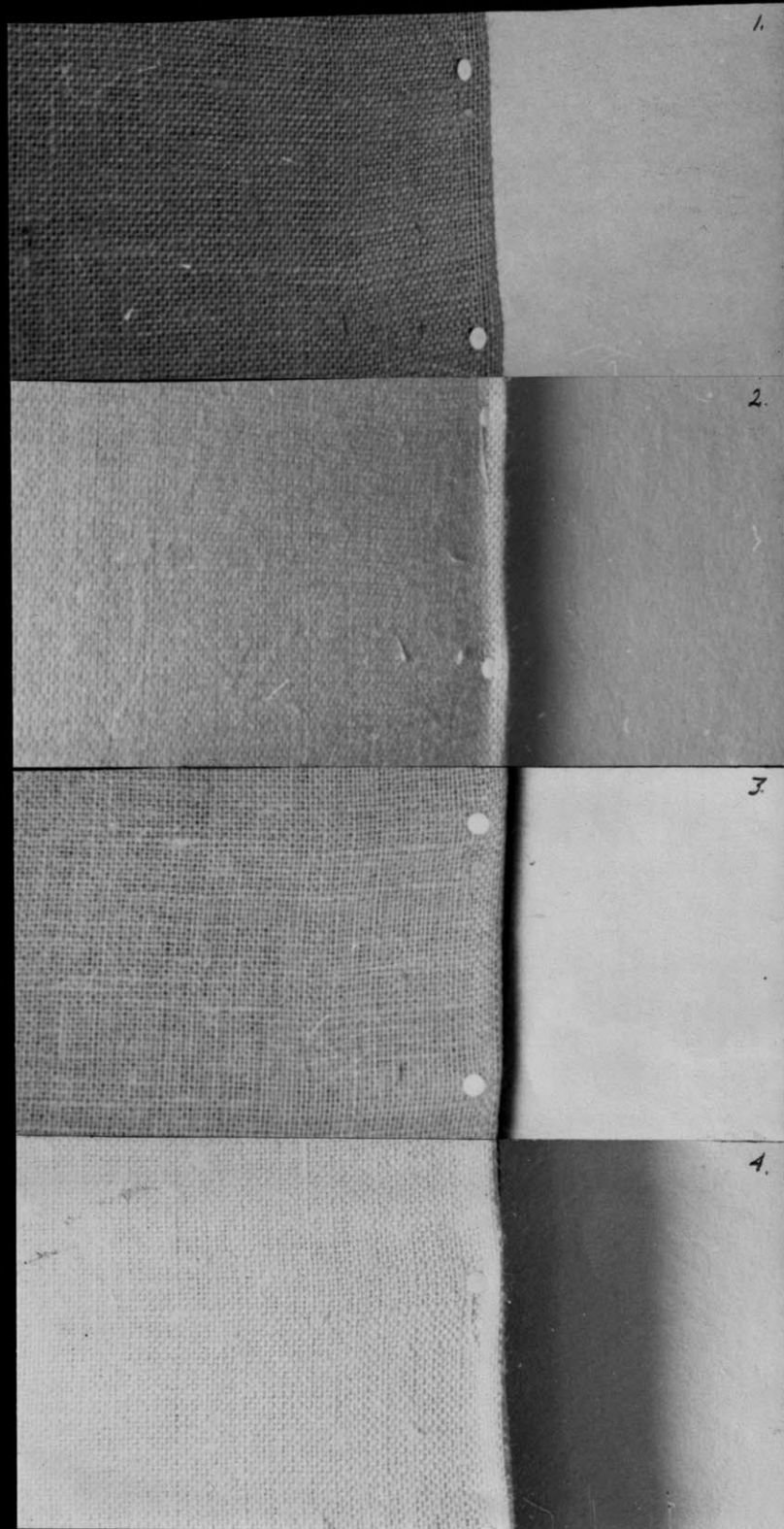


FIGURE. 3.3.5

Example of different angles of view, and different angles of light source, on two surfaces, a surface of material, and a surface of Celetex. (see text)

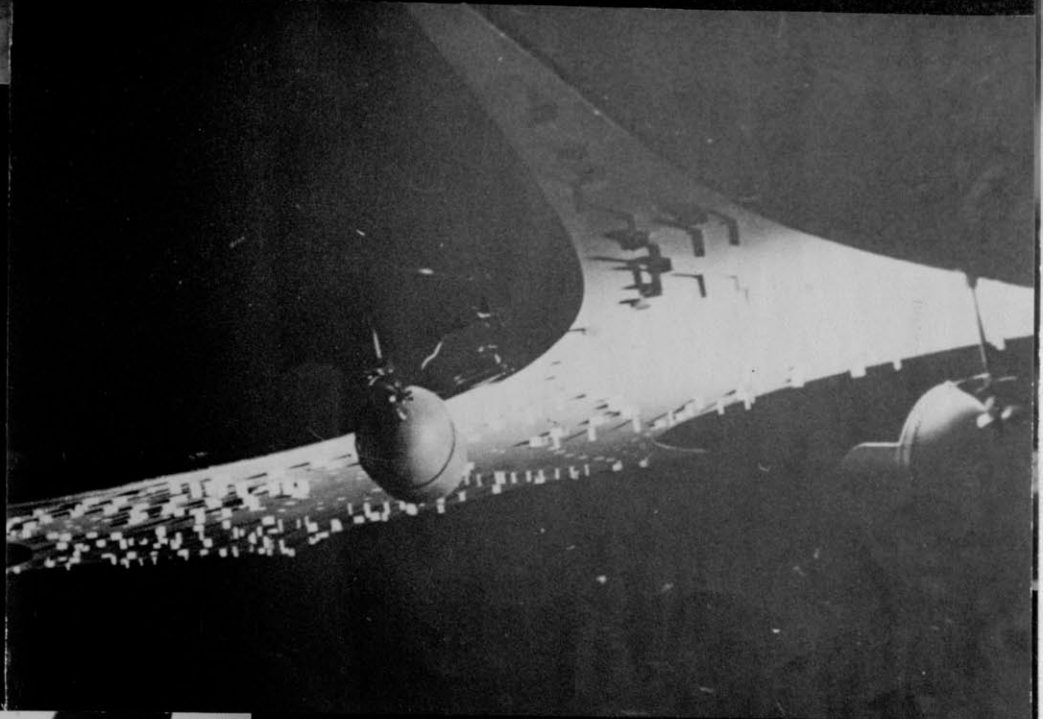
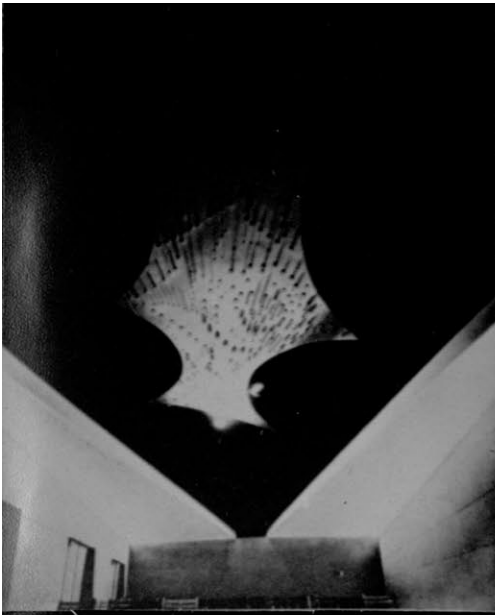
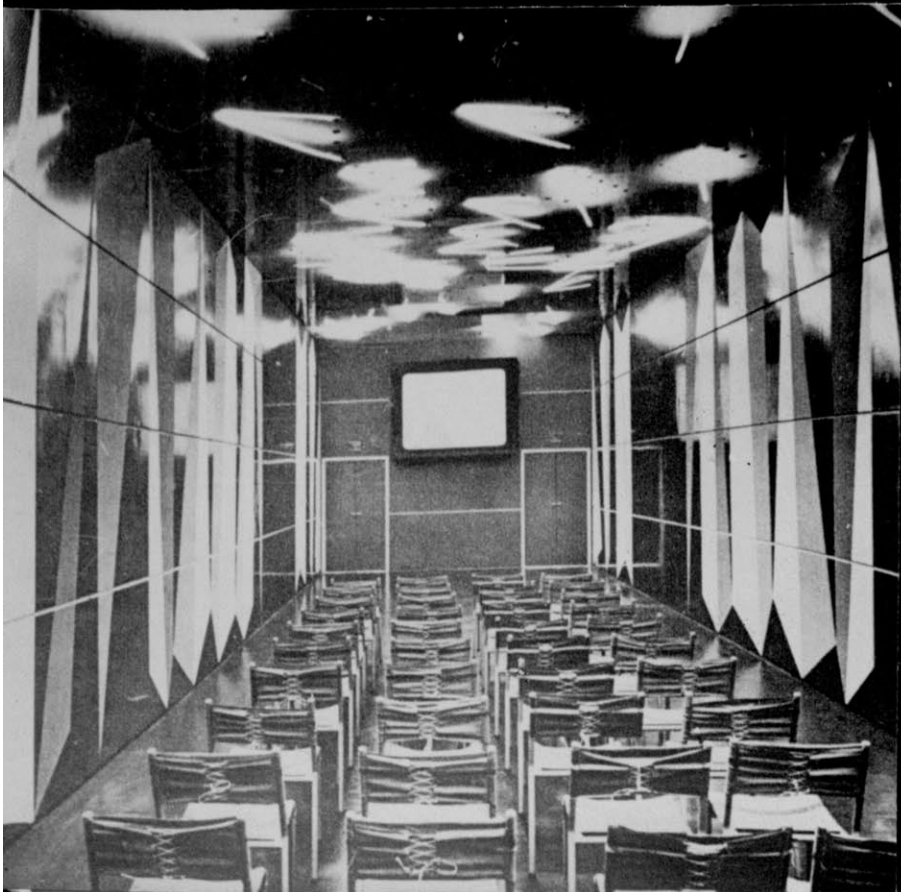
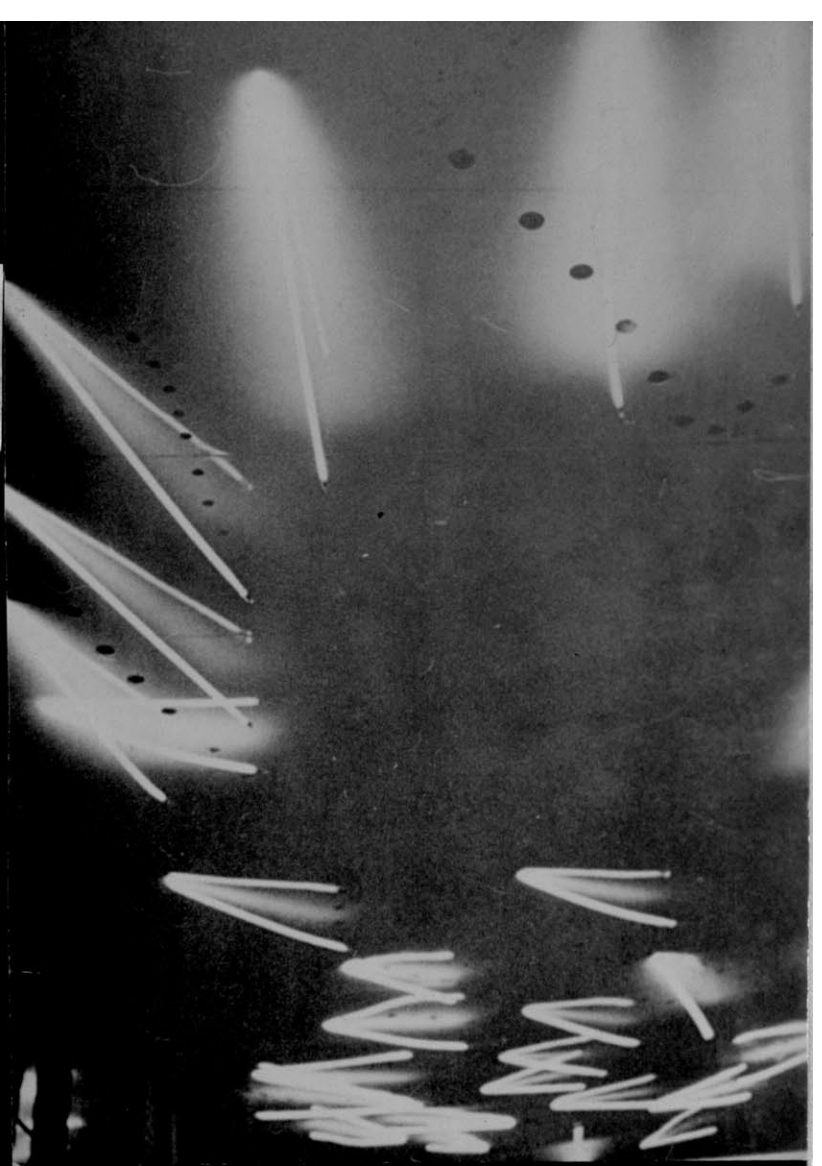


FIGURE 3.3.6.

Ceiling of a Cinema in Italy.
Designed by Lucio Fontana.

FIGURE 3.3.7

Ceiling of a Cinema in Italy.
Designed by Lucio Fontana.



Chapter 3.3

By/

carefully designing the shapes of the projecting "pegs" so that they will reflect light from a certain direction, and cause shadows from light in another direction, it has been arranged that variation of the ceiling pattern can be achieved. As the illustrations show, the "texture" of the ceiling can be reduced to a minimum, or emphasised by heavy shadow effects.

It is by such a coordination as I have outlined, that the architect can utilise the various methods by which the physical environment may be varied in a predictable manner; whilst it is through lack of such a coordination, that the everyday environment is so often meaningless, monotonous, and even unsafe.

PART 3.

The Architectural illumination of the Contemporary Living-space, approached from the aspect of flexibility.

Chapter 3.4

Unity and flexibility.

My new approach to flexibility outlined in Chapter 3.1 concludes with the final point 4/ concerned with the unification of the scheme, and its integration with the "whole" of the design.

It is therefore necessary to end this part of my thesis with a review of aspects of this unity, as it is affected by the flexibility of the physical environment, in order to show that far from being incompatible, the one may derive from the other.

Chapter 3.4

In the introduction I stressed the necessity for a more logical relationship between the architect and the illuminating engineer, advancing the idea that it is the architect, from his study of man's needs presented by his program, who should be in a position to know what solutions in terms of formal environment will best satisfy these needs, and for the illuminating engineer to be in a position to supply him with a workable solution in terms of illumination.¹

For the visual formal relationships of a building are not the isolated solution to any single problem, but rather the compromise which is seen to meet the many different problems, in the way best suited to the particular program.

When for instance two needs are seen to be completely incompatible, and that no visual flexibility will be sufficient, then some other form of solution is seen to be necessary, as for instance with a study and a children's play area; or a photographic darkroom, and a sitting area. Problems of Light are therefore intimately connected with problems of space planning, acoustics and servicing, and all are related to the problems of structure.

Knowing the methods of varying the physical environment, as they have been discussed in the previous chapter, it is the job of the architect to achieve as far as possible a balance between the various factors involved, which will give him as

1. See Chapter 1.2 for a further explanation.

Chapter 3.4

which will give him as/
total a solution to man's needs at all levels as possible.

I have suggested that this may be facilitated by a coordinated variation of the basic light flux pattern, and the objective world; for a total solution is one in which the means are an integrated part of the design, so that the means for obtaining flexibility, arriving as a result of "basic design criteria" should contribute to the unity of the environment, and the totality of man's experience of it.

An example of this may be taken from a study of the research conducted in the past years into the science of acoustics, it has been seen as greater knowledge has been accumulated that the objective world has to be designed in relationship to the wave patterns of sound, if a total solution is to be had. There is a complete analogy between this and the design of the objective world in relation to the wave patterns of light.

Also in the same way acoustic research has led to many new forms derived from the use of the objective world in a positive sense; and it is thought that as a greater knowledge of the interaction between light and matter is obtained, new forms will suggest themselves, owing their validity, in a like manner, to a rational use of light in all its aspects.

Chapter 3.4

In a similar manner to the objective world, so with the sources of light themselves, and the manner they are modulated and redirected by natural or artificial luminaires into the space. The 18th century dining room, with its sparkling crystal chandeliers, is a good example of a fine coordination between the flame source that was then used, and the cut facets of the crystal. The effect was one of great liveliness, and when the light played on to the table off which were silver and glass, and on to the diamonds of the ladies present, the whole effect was one of glittering splendour, and of a truly coordinated relationship. Such chandeliers today, used as they often are with static artificial sources, have lost much of their original effect, since the coordinated relationship for which they were designed has disappeared.

The mobility of such light sources, and their relationship to the "whole" of the environment, was in no sense a dis-integrating factor, and in fact added in a positive manner, to the delight that man received from it; and it is thought that in a similar way, the flexibility of the physical environment, as can be achieved through light, where this is achieved by an integrated and unified scheme, will add positively to man's total experience, giving him at the same time a unity of that experience.

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PART 4.

Specific Problem.
The Techbuilt House.
Weston Massachusetts.

Chapter 4.1

Choice of Problem, and
necessary assumptions.

In order to apply the theories outlined in the earlier parts of this thesis to the practical problem of the Contemporary Living-space, it has been necessary to choose an existing problem, rather than start without any framework; for this has the advantage that the theory can be applied at a practical level within the pattern of existing architectural compromise.

Chapter 4.1

Such an approach is not without its limitations, and these should be made clear at the outset. The chosen house was almost completed, so that from my point of view this is by no means an ideal relationship between the architect and the problems afforded by the illumination of the building, since these should in fact be one of the basic design considerations at the original conception of the building, before the working drawings of the building have been started. It might appear then that any suggested alterations and modifications cannot be anything but "an additive" or palliative to an existing structure.

This is naturally a very real limitation, but to offset this, the problem has the value of reality, and even if the solutions which are suggested are not for universal application, it is felt that in fact this real approach to an existing problem with all its other aspects, such as construction, planning, economics, siting combined, is of equal value to the purely abstract approach of the Ideal Living-space from the visual point of view.

The problem that I have chosen is as follows:

To seek a solution to the architectural illumination of the Techbuilt house, (at Weston Massachusetts. Architect. Carl Koch and Associates. Cambridge Mass.) with particular respect to the Living-space.

It is considered that the living-space of this house is representative of the best contemporary architecture.

Chapter 4.1

The Techbuilt House has been designed in such a way as to be a semi-mass produced article, which is capable of considerable variation to suit the individual sites of New England, and the individual bank balances of its inhabitants.

To quote from an article in House and Home Magazine, August 1953.

"...the builders can offer good living and good looks, at a price substantially lower than anything else in New England: 7.25 dollars per square foot., compared to 14 to 15 dollars for a custom built house, and around 10 dollars for a builder's model."

This has been done according to the article by reducing the total outside wall area to a minimum, and by pushing the whole house down into the ground, to give it as little wall height as possible, added to its system of prefabrication of large wall panels in local shops, reducing the on-site work to a minimum.

It might also have said that it was done by paying very little regard to the needs of artificial illumination, but since this is more or less current architectural practice, it goes without saying.

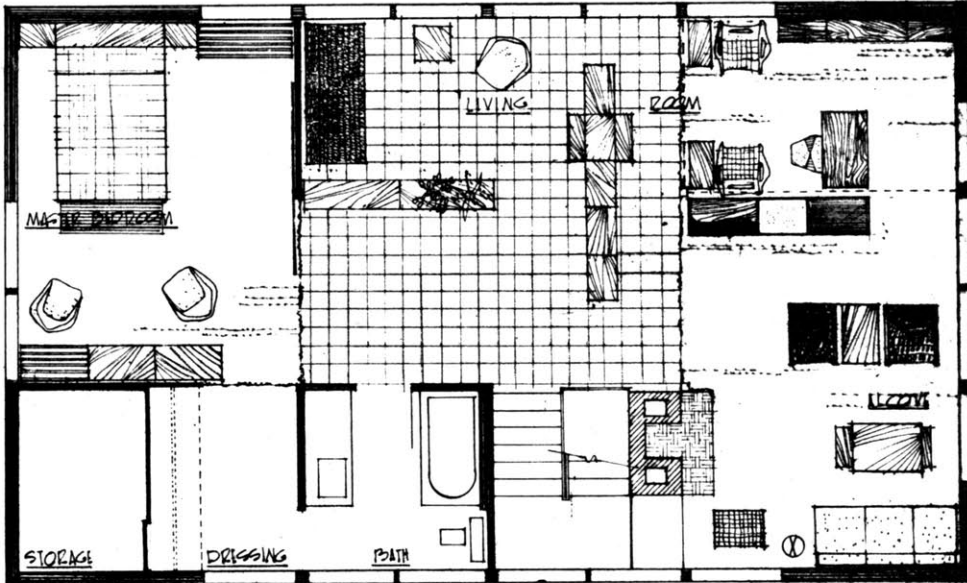
Various plans are offered with two alternative structural systems, a three post section, with a centre column, and a four post section with three 8 ft. bays. The Houses can also be varied in length, to fit the needs of various sizes of family. The internal arrangements of the houses are extremely flexible, and meet the various needs of the contemporary family to a greater degree than almost all other work in its class.

TECHBUILT, INC.

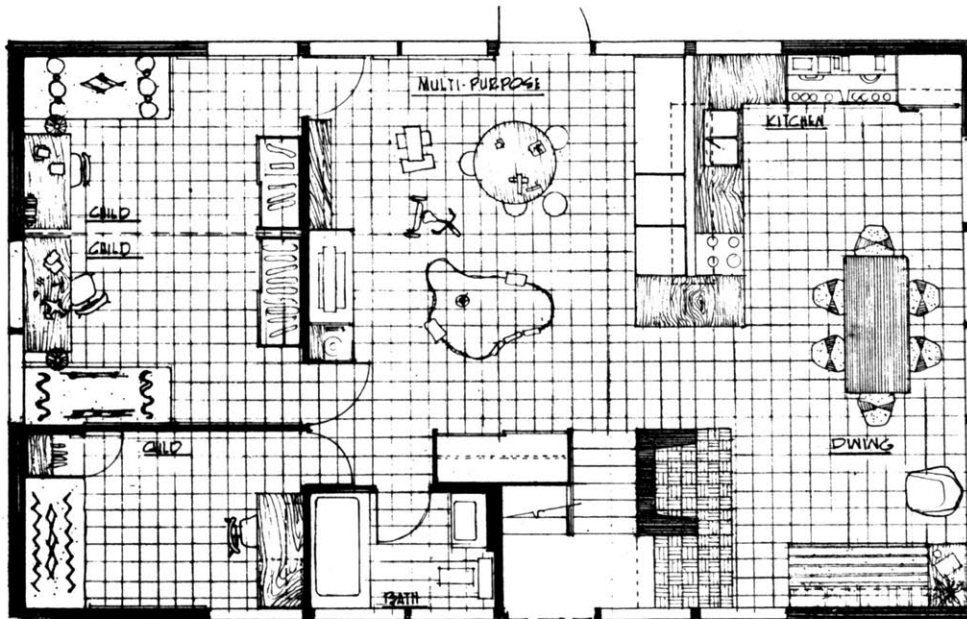
55 BRATTLE ST.

CAMBRIDGE 38, MASS.

A



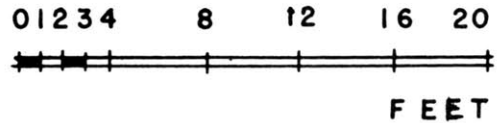
SECOND FLOOR



FIRST FLOOR

E-TV HOUSE

- 1 24x40' INSIDE DIMEN
MAXIMUM SOLUTION.
- 2 2 FIREPLACES - & WOODBOX
- 3 4 BURN. RANGE, DISHWASHER CA.
DISP, WASHER, DRYER. IRONER &
DEEP-FREEZ. 20' FT COUNTER
- 4 PREFAB. CLOS. IN EA. BEDR'M
- 5 2 COMPLETE BATHS 1ST & 2ND FL.



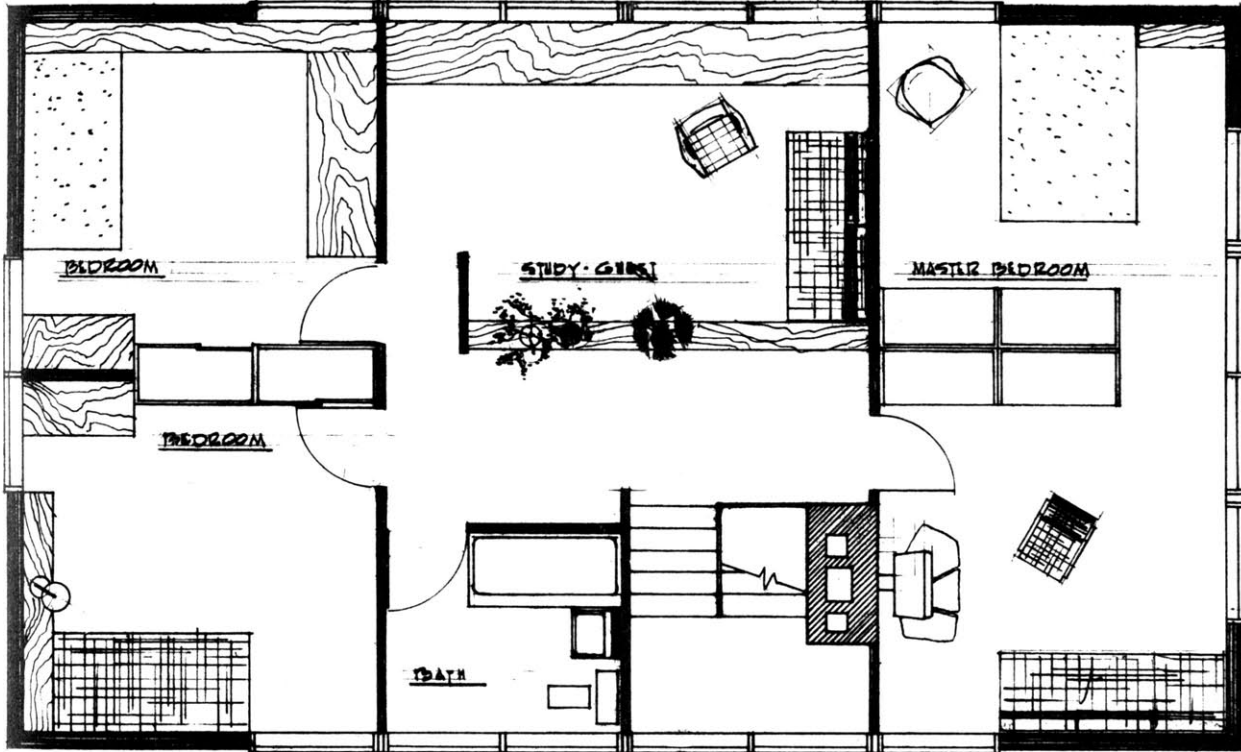
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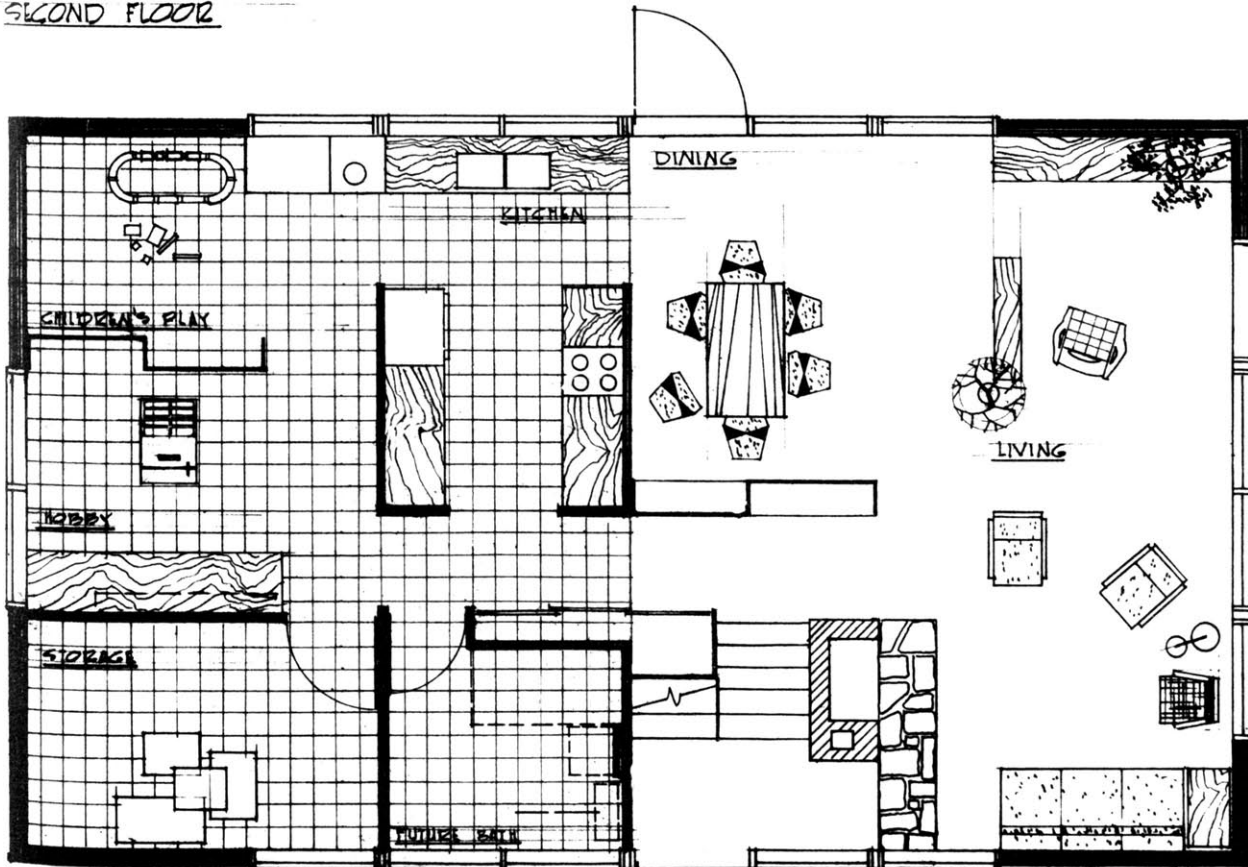
B.

55 BRATTLE ST.

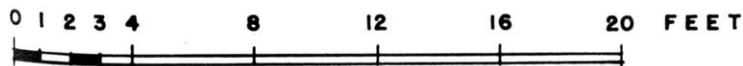
CAMBRIDGE 38, MASS.



SECOND FLOOR



FIRST FLOOR



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Chapter 4.1

I enclose a set of plans of the Techbuilt house as it is offered to the public, from which it can be seen that many alternative arrangements within the structural shell may be made. The rationale of the constructional system can be seen, which, although to some extent it predicates the sloping sites of New England, leaves the orientation and siting for an individual solution.

After an analysis of the living areas of plans A and B I decided that from my point of view Plan A offers more possibilities, and in a general sense seems to have basic advantages over Plan B. These advantages may be summarised

- as follows.
- a) The living space is larger in area, and is not connected to the kitchen, whilst at the same time there is a small living space attached to the dining room, which would have practical advantages.
 - b) The living area, being on the upper level has a much higher ceiling height, and sense of space. It has access to a balcony from which one descends to the garden.

other advantages

- c) The Master bedroom is connected to a bathroom, and faces east to get the early morning sun, from one of its windows. There are three other bedrooms, as compared to two in Plan B but one of these has very little natural light, due to the rigidity of the structural system at this point.

In order to make the problem as ideal from my point of view as is possible within the limitation of the existing building, I am making certain assumptions, on which the design will be based.

Chapter 4.1

Basic Assumptions.

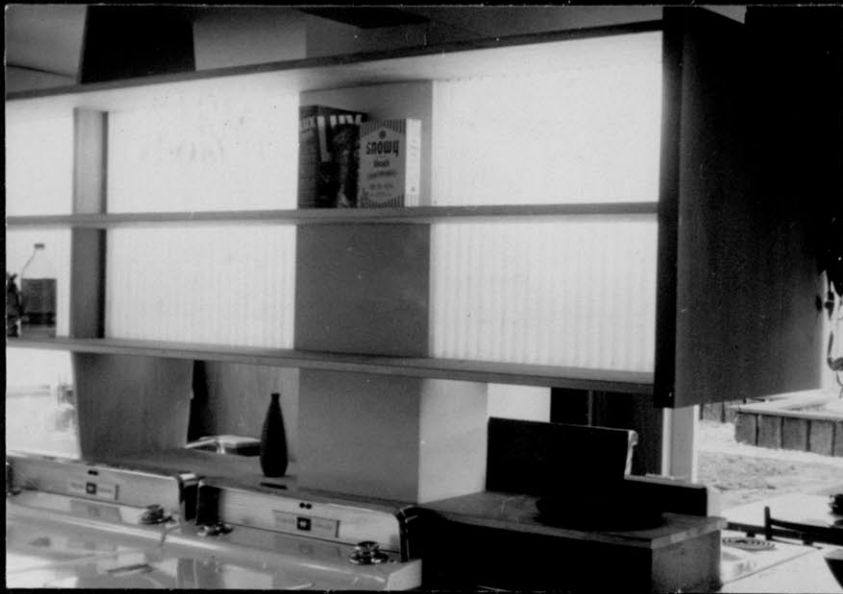
- 1/ I shall abide by the structural system, as a system, but where it can be altered without destroying the rationale of the system, such alteration would be legitimate if the reasons for so doing are sufficient.^{1.}
 - 2/ I shall abide by the existing site orientation, and layout of the Techbuilt House at Weston.
 - 3/ That I shall be at complete liberty to vary the internal arrangements within the space, to any pattern which answers the needs of man, within the terms of reference of my program, in a more flexible manner; or where flexibility is not thought to be compatible with needs, in a manner more suitable to these needs.
 - 4/ That flexibility of the physical environment is desirable, and consequently something that Man considers to be economically worth paying for.
 - 5/ That the electric light "fittings" as shown in the accompanying set of photographs, do not represent the choice of the architect, since these photographs were taken at the time when the house was being sponsored by a foundation separate to the architect's office.
1. Reasons which would be thought sufficient, would be those which showed that the present solution is in some respect inadequate.

A SET OF PHOTOGRAPHS OF "THE TECHBUILT HOUSE" WESTON, MASS.





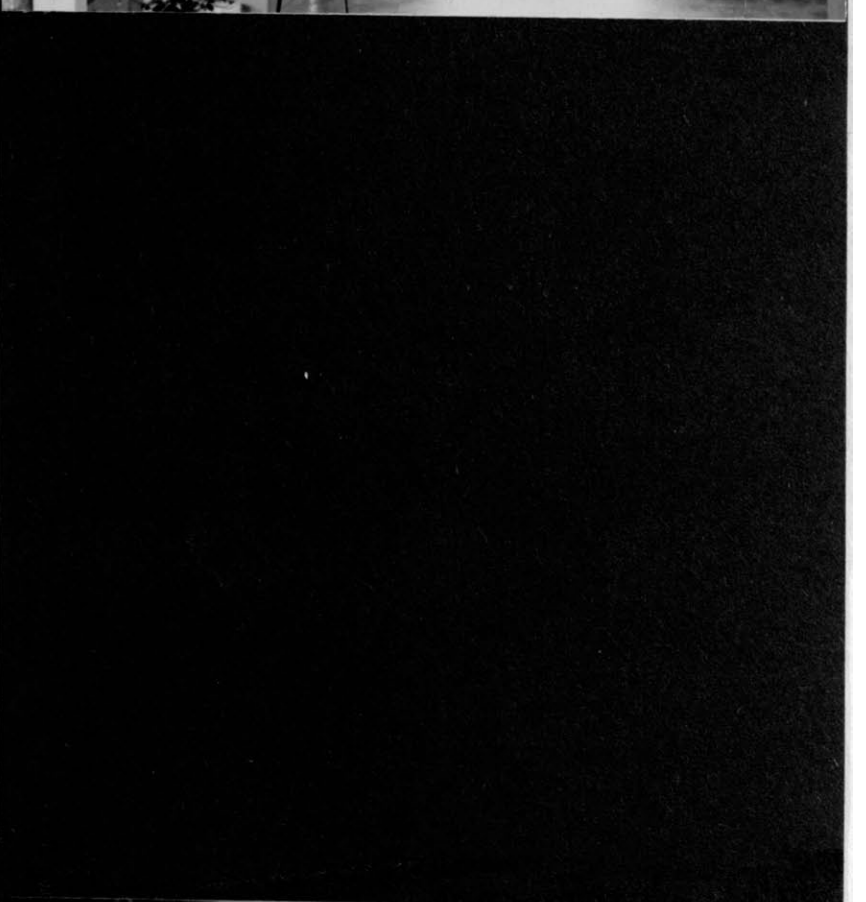
Lower Level.







Upper level.





Mobile light fixtures.

PART 4.
Specific Problem.
The Techbuilt House.
Weston Massachusetts.

Chapter 4.2

Modifications to the Plan.

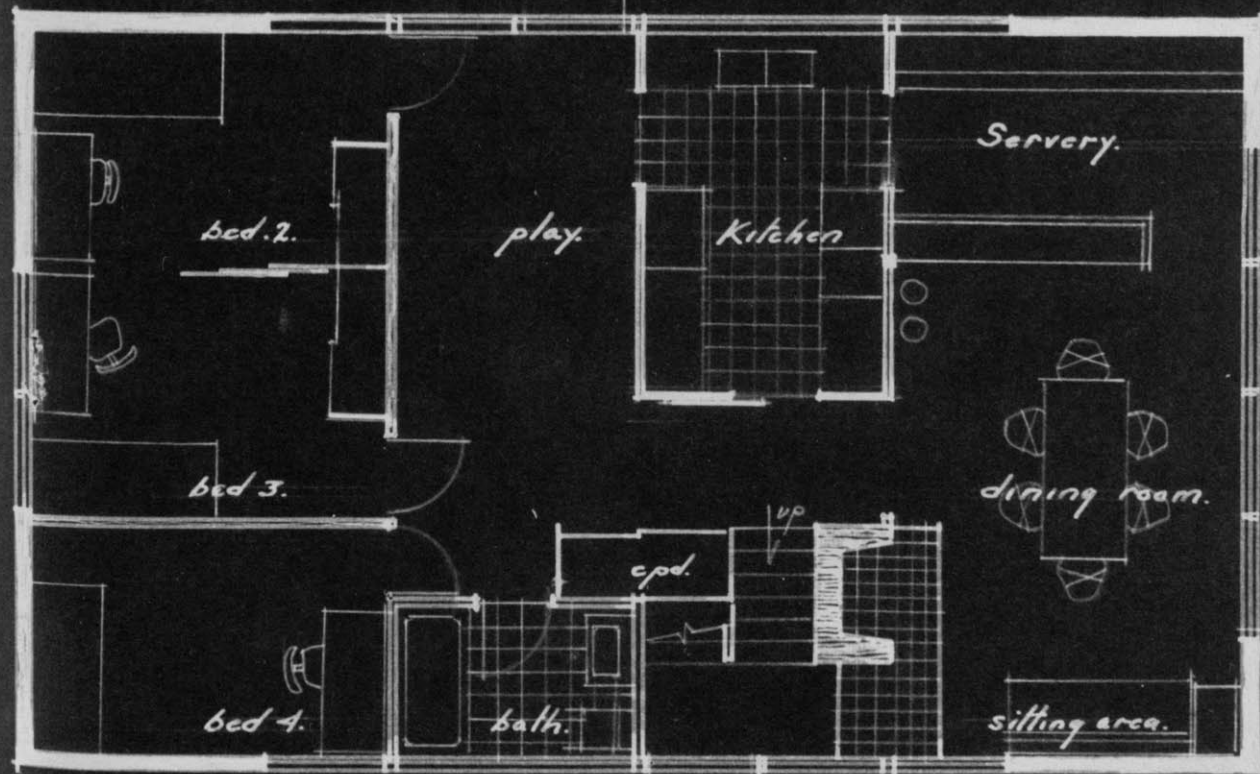
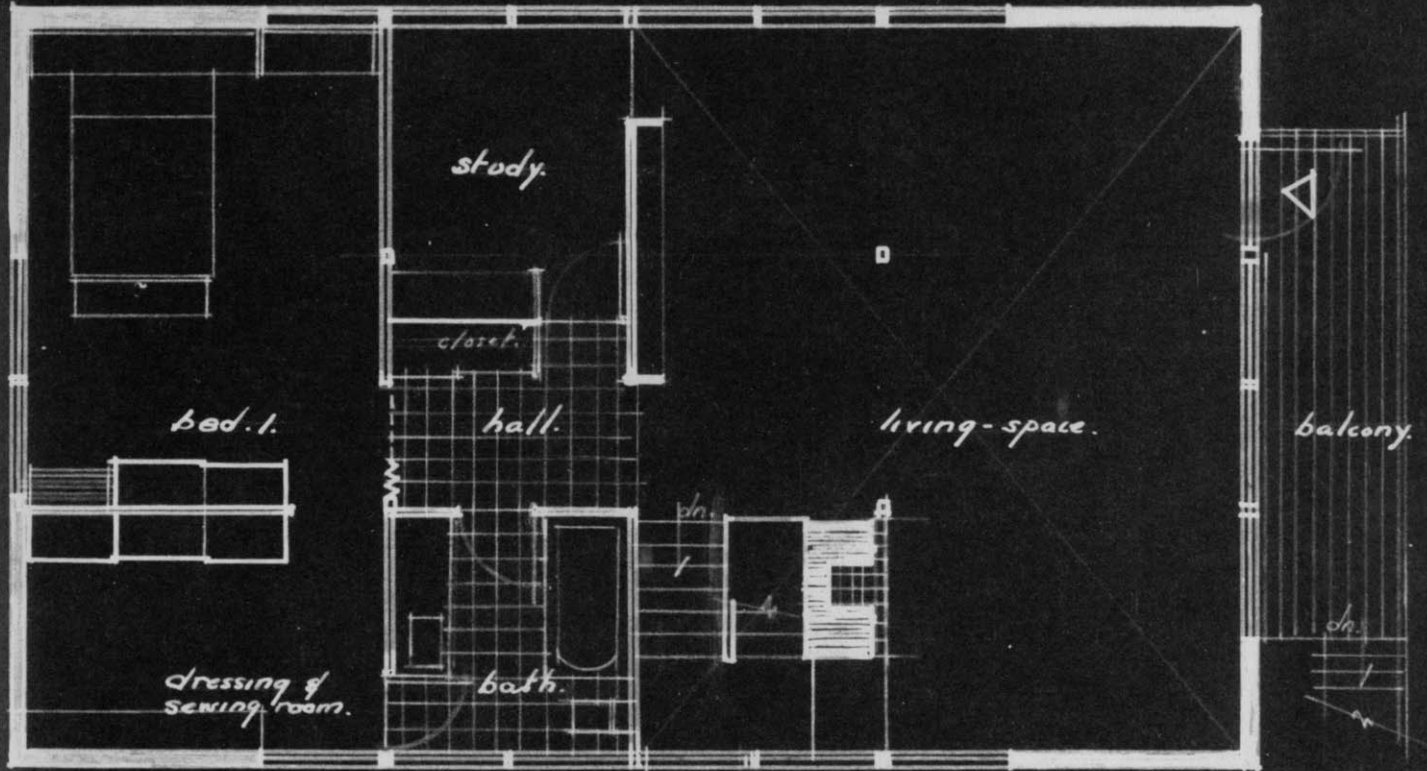
Perhaps I should have added to my list of assumptions (chapter 4.1) some statement regarding the future owner of the house, I decided to omit this however for the following reason. That if this new approach to flexibility is to have any general application, it must be so designed to fit the needs of man in a general, rather than a specific sense. There is one difficulty which arises from this, which can only be considered at the individual level, and this is the actual use of space, when it is considered that certain activities are

Chapter 4.2

certain activities are/
related to unique needs, which are essentially incompatible.
I have given an example of this in the case of the writer who cannot possibly work when there is a great deal of other activity and noise around him, for he, with many other men who are engaged in some form of creative activity, at all levels, needs formal relationships which "provide" quiet and a space of his own; he needs four walls. In such a case as this it is necessary to make certain assumptions about the sort of people that are going to live in these houses, and the assumption that I have made is that man does have many needs where four walls are in fact the only answer, not only for the creative artist, but for the person engaged in stamp collecting, photography and other hobbies, so that in these circumstances a "study" would be an advantage where the economics of the situation made it possible.

The nature of the Techbuilt house is very well suited to adapt itself to the different spatial arrangements, that different families may wish to enjoy, and the arrangements that are proposed are not meant to imply that they are by any means the only arrangement. They are however based on what I consider to be the needs of man within the living space, and whilst it is recognised that different families will prefer to stress different aspects of these needs to the exclusion of others, the following plans are put forward as a framework within which man's needs may be satisfied.

FIGURE 4.2.1.



0 1 2 3 4 8 12 16 20 FEET

Suggested modifications
to PLAN, A. Techbuilt House.

Chapter 4.2

Figure 4.2.1 shows the suggested modifications to Plan A.

The following modifications have been adopted:

Lower level.

From the set of photographs of the Techbuilt house as it was built to Plan A at Weston, it can be seen that from the entrance, which is on a split level, a view is had of both upper and lower levels. At present the view of the lower level is one of the laundry, on one side of the children's play area. This play area itself, when taken in conjunction with the flexible space of the children's bedrooms, provides an area of nearly 450sq.ft. The dining room on the other hand is combined with the kitchen, and with a small sitting area at the opposite end with a fire place.

In order to get from the main living space, the family and its guests, go down the staircase, are confronted by the laundry, turn right into the dining room, where they are surrounded by the cooking smells, and the used cooking utensils, whilst they eat their dinner.

This solution to the problem, it is suggested is "the way that folks like to live," this is a natural expression of a way of life. It is however my experience that the quality of the cooking, is in direct proportion to both the smells of the kitchen and the number of the pots and pans used, it is also my opinion, and I can only speak for myself, that when having any meal, a too close proximity to its origin does nothing but lessen my enjoyment of it.

Chapter 4.2

By the modification as suggested in Fig.4.2.1 the dining room has been separated from the kitchen, whilst being related to it by a small servery, which can act as a breakfast counter when required. The play space has been reduced to a size more in keeping with the actual need. For formal occasions, when the family and guests go to dinner, the door to the kitchen would be closed, so that on turning at the bottom of the staircase they would find themselves in a formal dining room, with an attractive unit at one end where the food could be served replacing the old fashioned "dresser," a small sitting area with a fireplace at the other, and a fine view out into the garden. The advantages would be that either for formal or informal living, the dining room would be a pleasant room removed from the smells and paraphernalia of cooking, whilst being easily served from an attractive servery related in a practical manner to the kitchen itself.

The play space is related in a more positive manner to the kitchen and laundry equipment could be inset into the kitchen at a low level, opening into the play-space; the top of it in the kitchen, serving as a preparation shelf.

It is thought that by these "modifications", a solution more in keeping with man's actual needs may be found.

Upper level.

It can be seen from the original plan A, in conjunction with the photographs, that the area devoted to the the living-space, that of some 550 sq.ft. is too large to be used as a

Chapter 4.2

used as a/

single sitting area, the more especially when it is recognised that by the nature of the openness of the plan, the visual area extends around the fireplace stack to include the stair case area.

This fact has been recognised by the Weston house solution, and the space is divided up into two completely separate sitting areas, with a study area between the two. The study being divided from the first sitting area by a large unit, containing every sort of radio and television device. The first sitting area which faces to the east, getting the morning sun, would have the benefit of the television set. The second sitting area is situated around the open fireplace, whilst orientated towards the south, and having a large window up to the eaves line, with a fine view of the countryside and garden from beyond the balcony. The study, in between the television on one side and the second sitting area on the other would have the benefit of the disturbances of both.

The above solution recognises the great difficulty of providing a satisfactory sitting area in which the television competes with the fireplace, and avoids the problem by providing a separate sitting area. The problem which it does not solve is that of the study, for as I have suggested there is no solution to this short of four walls. The other factor of the design which I find most disturbing is the lack of any overall unity in the relationships of the various spaces,

Chapter 4.2

apart from the enforced unity provided by the pitched roof line within the space. The unit itself which acts as the chief space division, seems little related to the slope of the ceiling as it cuts across the space, whilst there is an air of impermanence about the loosely related sitting areas, which is reminiscent of a Hotel, or a station waiting room.

By the modification suggested in Fig. 4.2.1 a separate study is provided, which uses less space than that taken up by the original study area, whilst at the same time meeting the needs more fully. This allows an area between the study and the bathroom, as a hall from which access may be had either to the study, the bathroom, a clothes closet, the bedroom, or into the living area. It is considered that this is a most useful space, since it allows use of the bathroom from the study, or from the main living area, in a much less "public" manner, whilst also arranging for the storage of coats, and wraps without necessary penetration to the bedroom.

This does not solve the problem of the living-space, which is left to the solutions of flexibility, as I have outlined them. The following chapter which deals with the solution to this space, from the point of view of its illumination, will make the manner in which this is accomplished clear.

PART 4.

Specific Problem.
The Techbuilt House.
Weston Massachusetts.

Chapter 4.3

Solution.
a) The Plan.

In the previous chapter I have shown the general modifications to the plan; the living-space itself, which has been reduced in area, by the deduction of the study and hall space, was left purposely vague, and it is necessary now to deal with this space in more detail.

A reference to Figure 4.2.1 will show that the replanned living-space is now roughly square in shape, having a visual

Chapter 4.3

having a visual/ area of some 20ft by 24ft, since it includes the free standing chimney stack, and the staircase.

The first problem presented by the space, is that the ceiling pitch emphasises the longitudinal direction of the space, whilst the end window which goes from a low cill height, to the eaves line for the major part of the wall, emphasises the transverse direction of the space.

This problem was recognised in the original Plan A, to the extent that a large carpet emphasised the orientation of the space towards the large window. This seems to be unquestionably correct, since the windows down the sides of the house, are extremely small, having a height of only 5 ft.2 in. to the underside of the lintol, which is reduced to a height of 4 ft.5 in. by the eaves line which comes down to cut out the greater part of the light, and most of the view.

In the day time, on entering the space, one's whole feeling is one of phototropism towards this end, so that from all points of view it is necessary that this transverse space, 24ft. by 12ft. which gives access to the balcony, and has its own fireside area, should be thought of as a single unified space, rather than the two areas shown in Plan A.

Within this space, many different activities will be carried on, and people will be in many different moods, so that flexibility within the space is essential, and the technical means of illumination can be made to achieve this. I shall refer to this area as area 1. (see Figure 4.3.1)

Chapter 4.3

This leaves an area of some 96 sq.ft. opposite the staircase which I shall refer to as Area 2. and which can be used together with area 1. or separately from it.

Uses of area 1.

All normal sitting space uses. Sewing, knitting embroidery etc.
Reading, writing
Entertaining, tea, coffee, drinks.
Children's play
Piano playing
Conversation. Sitting.
Television
Radio, phonograph
Study. and others.

Uses of area 2.

Certain more specialised uses. Card games.
Writing room.
Children's study.
Painting. (natural light inadequate)
other uses. Entertaining.
waiting space.

Uses of both areas 1 and 2 together.

For entertaining uses.

The two spaces may be thrown into one large area for parties, or area 2 may serve as bar space.

Area 2 may serve as an anti-space to area 1, when guests are arriving, either when a maid is present or not.

I have shown in the above analysis a few of the ways in which the two spaces, may be used either in conjunction, or separately, for either a single purpose, or for different purposes.

The manner in which the two spaces, are divided, or combined, is by a coordinated use of light in relation to loosely woven curtains. This is discussed more fully in the following chapter on the technical solution to the problem.



perspective of
double curtain rail.

Chapter 4.3

It is fully realised that this does not seek to solve any but the visual problems of the sub-division of spaces, but it is thought that for general living conditions, this is in fact a solution when assessed from an economic standpoint.

The way in which the furniture might be arranged within these spaces, is illustrated in Figures 4.3.1 to 4.3.2 in order to show the possibilities of the variations.

Each family would have many different variations, depending on what they are interested in doing, and the furniture which they have available, so that the following arrangements by no means exhaust the possibilities.

Arrangement A.

Area 1. is set up for normal living requirements, the space being treated as a whole. The chair arrangement is such as would enable separate groups around the fire, and television, or a larger group to be clustered around either one.

Area 2. divided by a curtaining system, is set up for the use of card games. Facing a different orientation, and with less opportunity to see the view, this would make a variation from the main area, to which the players might go for refreshments during the evening.

Arrangement B.

Shows the two areas combined for a party, where Area 1 is used as the main reception room, whilst area 2 is used as an anti-room, where guests may be received on arrival, either by the

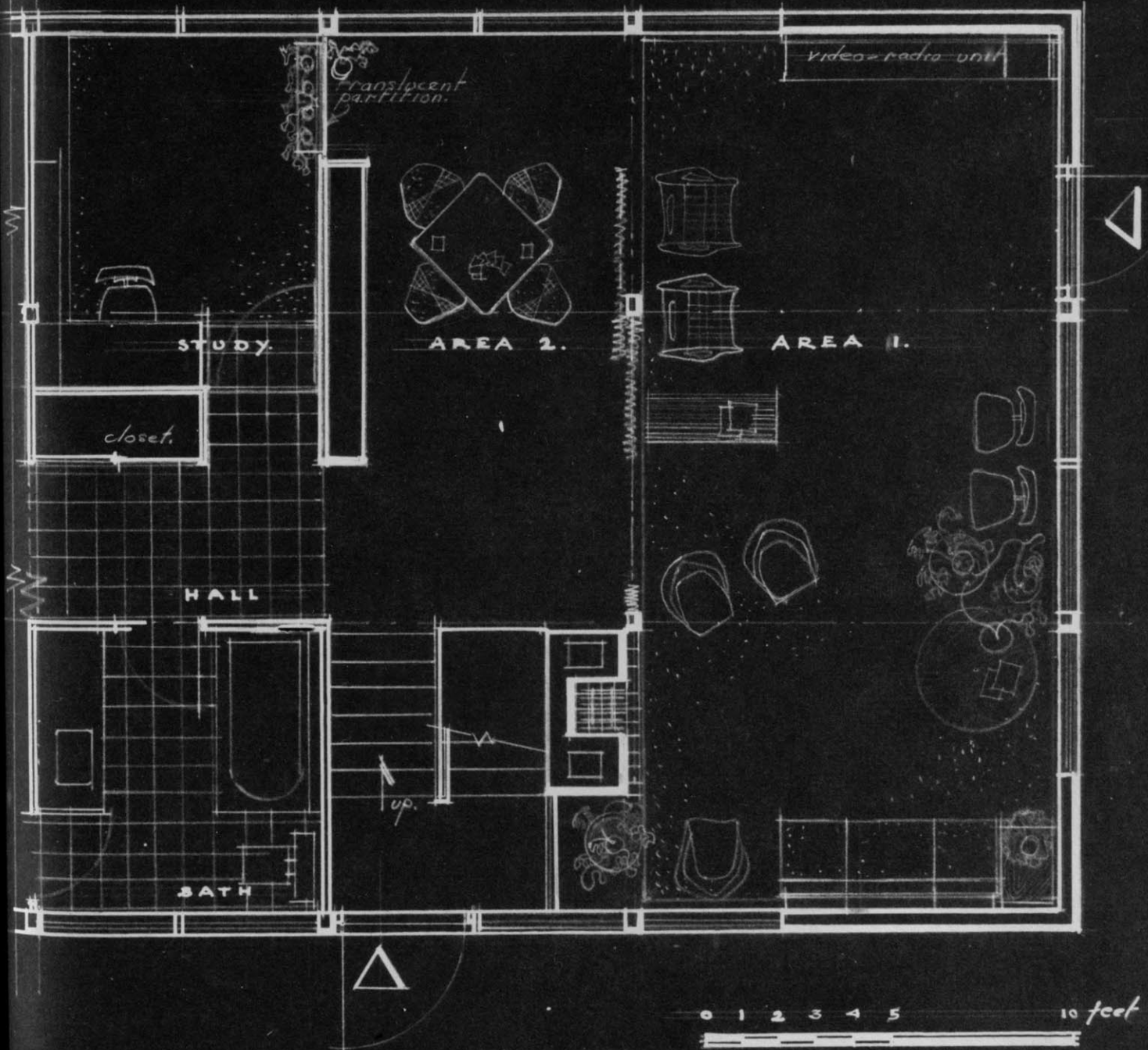
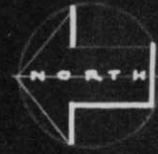
Chapter 4.3

either by the/ hostess, or by a maid. It acts as an overflow space, or as a space where people can disappear to, in an unobtrusive fashion, either to leave, or to go to the bathroom.

It should be noted that in both arrangements, the curtains could be varied either to allow vision through from one space to the other, or only from one space, and not from the other, or not from either, according to whichever is desirable.

Other arrangements would incorporate a piano, if desired, in which case the television and radio unit might be moved to another place. For whichever arrangement that is desired it is necessary that a flexibility of illumination is provided sufficient to meet the needs; and in the following discussion of the technical means that could be applied to this space the need for an overall flexibility is stressed.

FIGURE. 4.3.1.

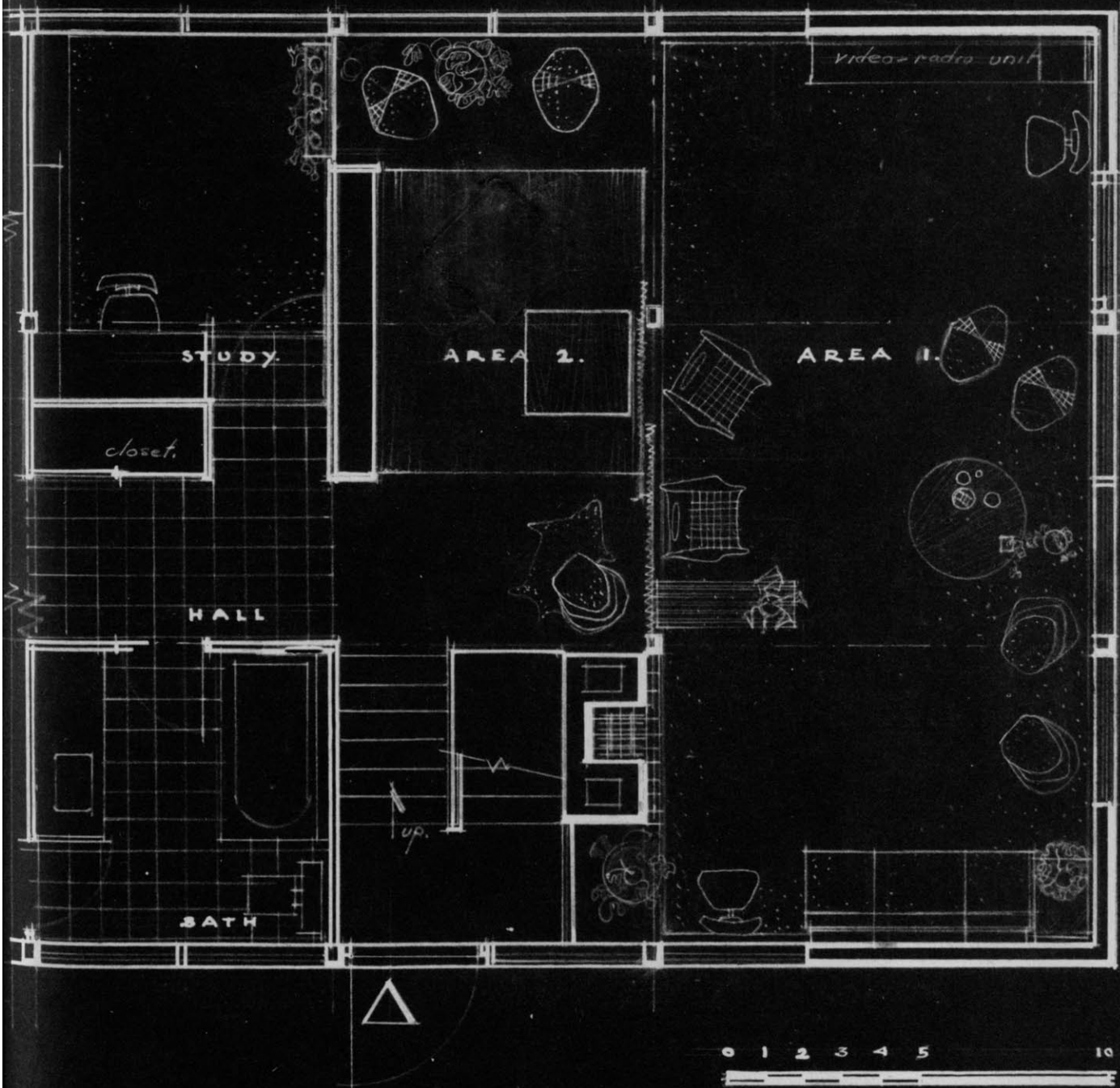


Arrangement A. for the living-space.

Area 1. used as a card room.

Area 2. used for the general sitting area, allowing occasional use of the Television set. Orientation can be around the open fire; or the large window.

FIGURE. 4.3.2.

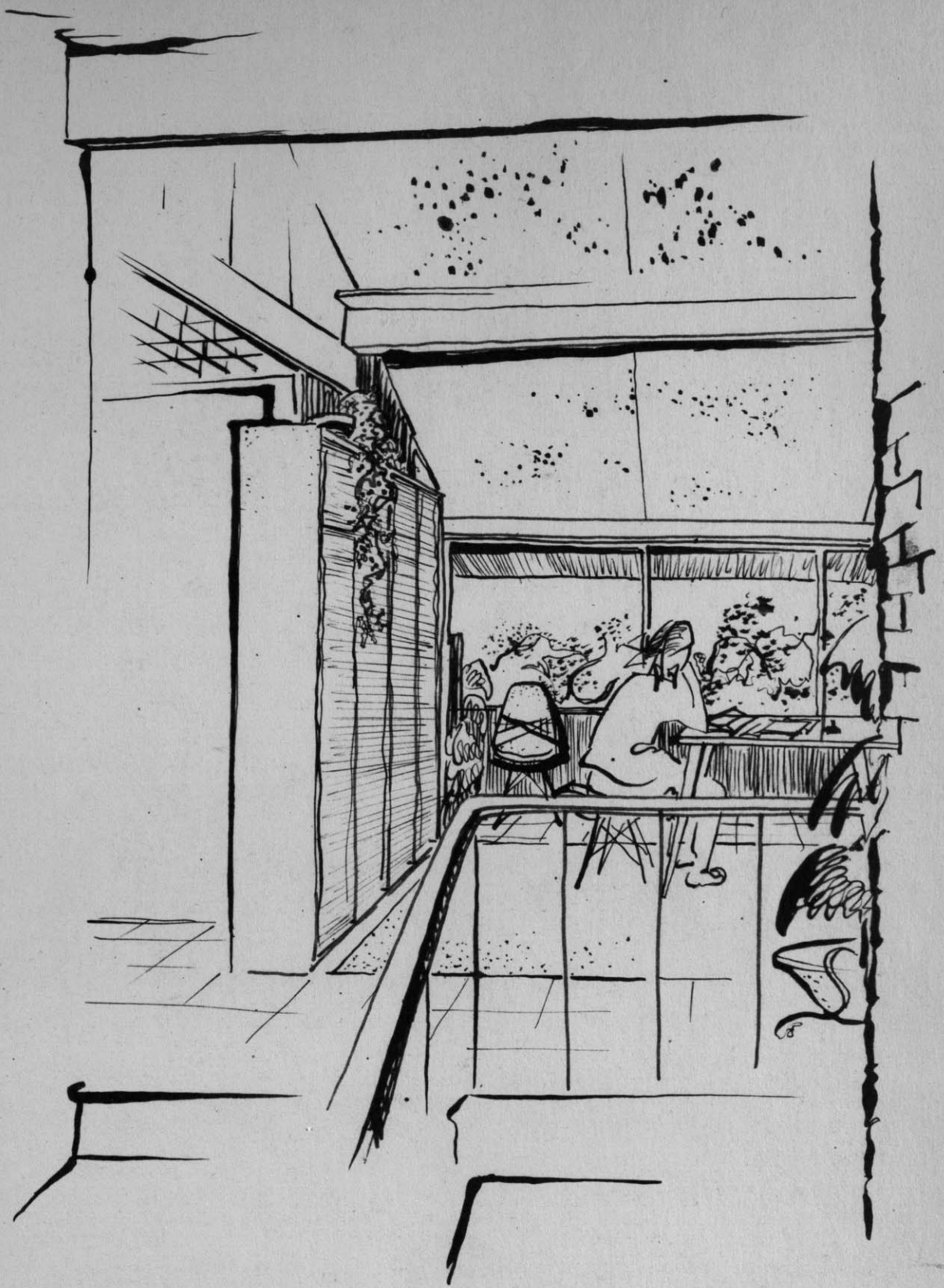


Arrangement B. for the living-space.

This arrangement shows a combined use of the two spaces, for entertaining.

Area 1. acts as the main reception area,

Area 2. is used as an ante room, where guests arrive, and are welcomed, it gives access to the bedroom, and bathroom, and can be used also as an overflow space,



perspective of
Area 2. from Entrance.

PART 4.

Specific Problem.
The Techbuilt House.
Weston, Massachusetts.

Chapter 4.4

Solution.
(b) Technical.

In my first basic assumption, I stated that I should abide by the structural system, since the logic of the Techbuilt house is built up around it. I said also however that if there were sufficient reason, I should be in a position to apply modifications to the details without destroying the rationale of the system.

Such a detail occurs in the height of the roof. In the house as it is built as Weston, the height from the floor to the

Chapter 4.4

to the/

underside of the sloping ceiling, at the wall, is 5ft.6 $\frac{1}{2}$ in. and the height 1ft. out from the wall is 5ft.10in. This low ceiling is insufficient for many people, and becomes particularly noticeable at certain points in the plan. The door between the Bedroom1. and the bathroom, being a particular instance, where it is almost impossible for someone who is 6ft. to walk through without banging their head.

In order to obviate this, whilst at the same time solving one of the illuminating problems, I have raised the roof 6 in. at all points, by means of point loading the beams, instead of the present "uniform load".

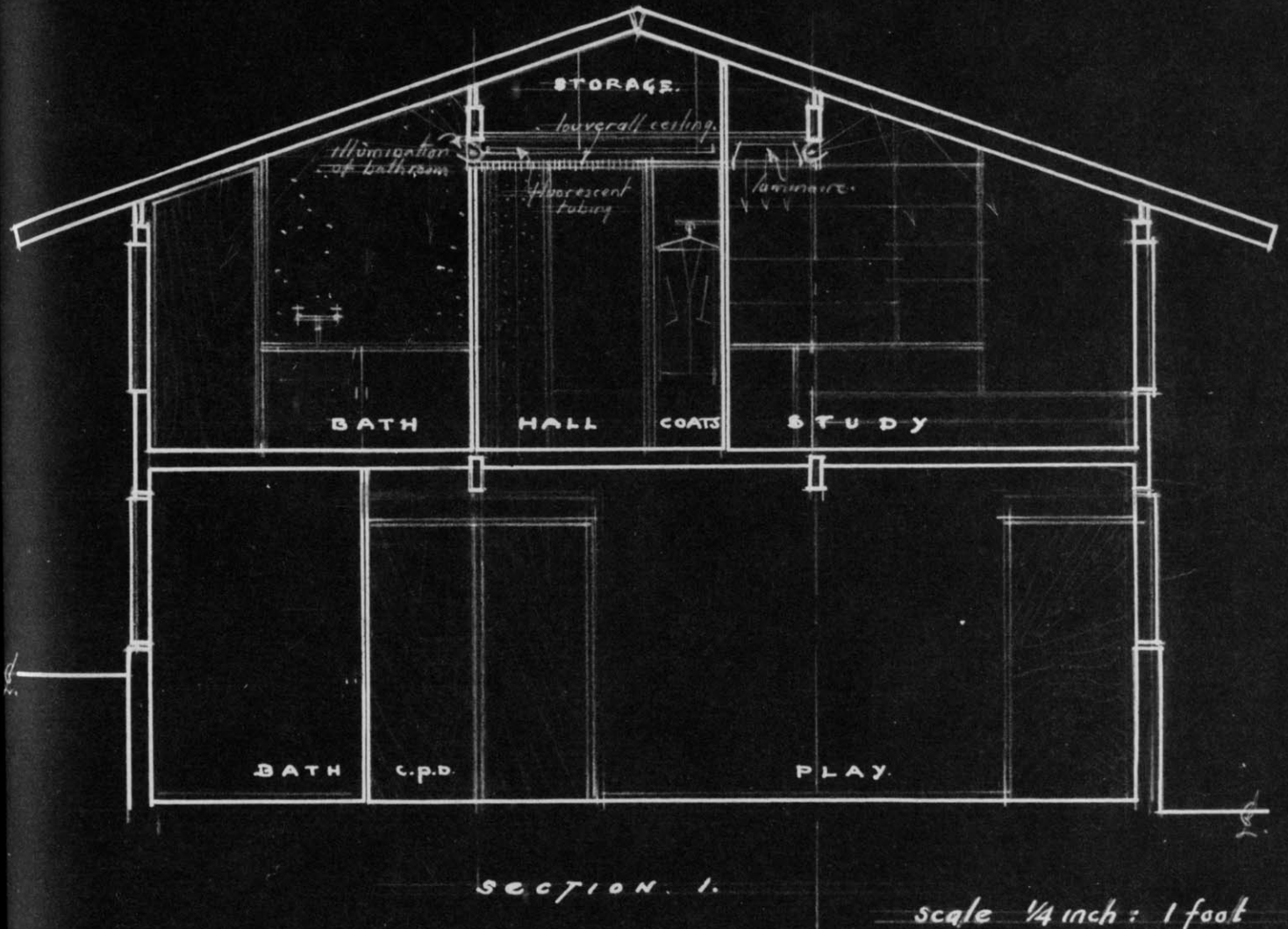
In Section 4.4.1 the extra 6in. of height can be seen, and a detail of the small diecast aluminium supports is giving with the details at the wall plate, and longitudinal beam, in Fig. 4.4.2.

Section 4.4.1 shows also the dropped ceiling over the hall, which is of a louverall type, since no task requiring acute vision is performed at this point. The specular reflection from the surfaces below will not cause any undue stresses. Above the louverall ceiling is hung an expanded metal floor on which can be put suitcases not in use. Access being from either end of the space, by means of removable panels.

Bathroom.

The bathroom is lit in two ways. Firstly the general illumination is by the indirect lighting of the ceiling. This is accomplished by "warm" fluorescent strip light, in the position

FIGURE. 4.4.1



Section 1.

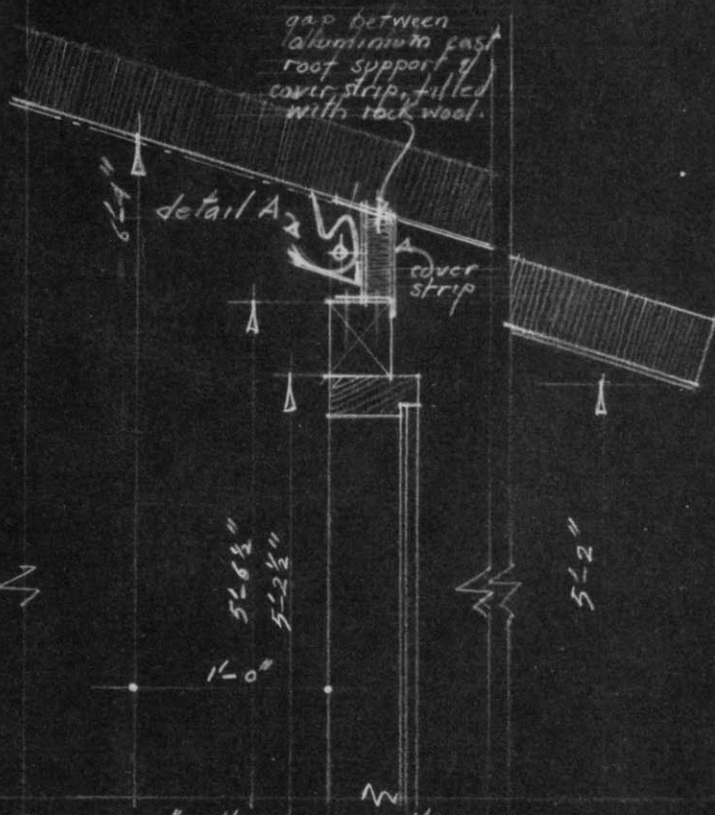
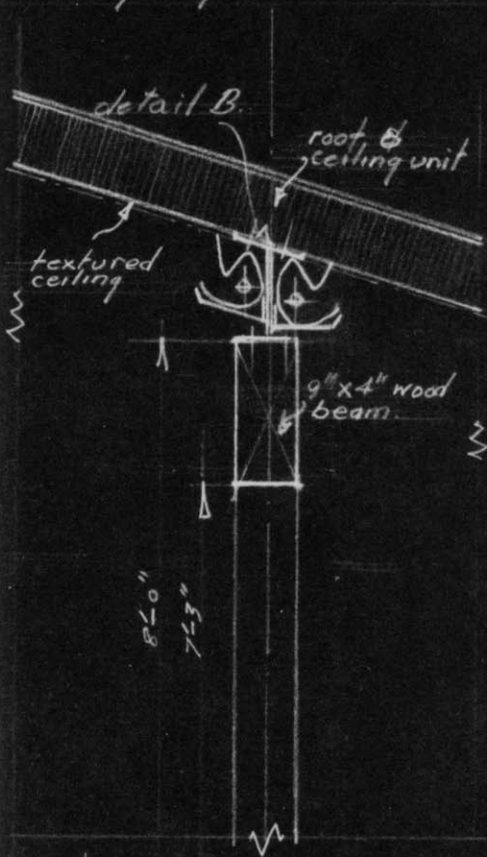
A transverse section taken through the bathroom and study, in order to show the dropped ceiling over the hall. The dropped ceiling illuminates the hall and allows illumination of the bathroom and study ceilings. The dropped ceiling extends into the study, and allows a luminaire over a desk.

Above the dropped ceiling, there is space for the storage of suitcases, or other small items, that are wanted from time to time, without resort to the main storage area in the garage.

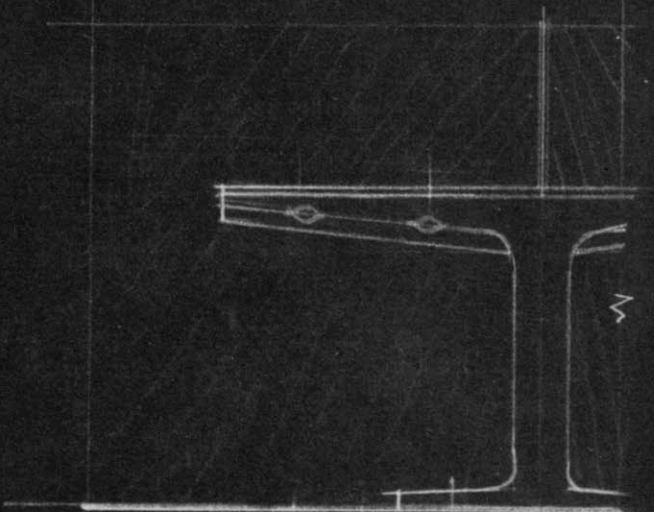
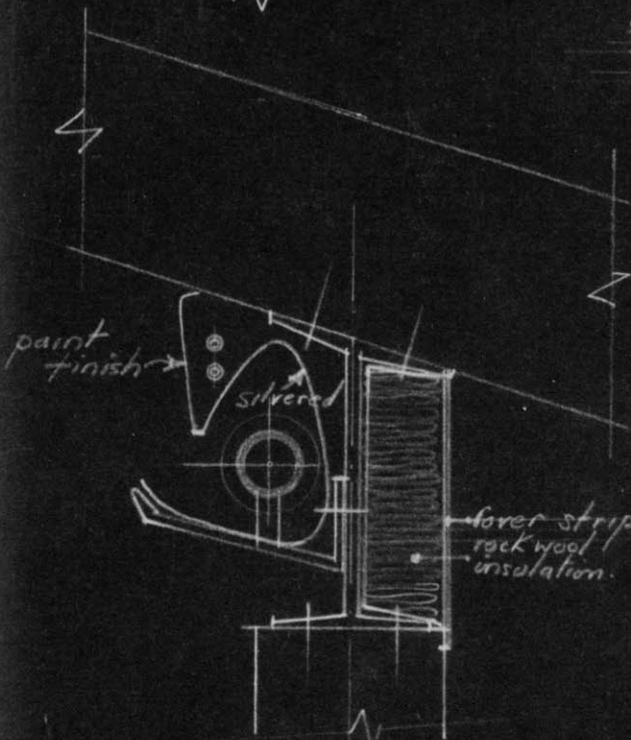
Details of the way in which the roof is raised are given in fig. 4.4.2. The roof is raised 6 in. at the wall plate and above the beams, in order to allow sufficient height for a man to walk within 1ft. from the wall in comfort, and to allow a door between the bath room, and Bed.1 of sufficient height.

Detail of inside beam, showing roof support and ceiling light.

Detail of ceiling to wall joint - utilises standard roof support.



0 123 6 9" 1ft 2ft. scale 1" : 1ft.



detail A. Ceiling light scale in inches. 1/4 FULL SIZE.

detail B. Roof Support. aluminium die casting.

Chapter 4.4

in the position/

between the lowered ceiling to the hall, and the main beam. See Fig. 4.4.1. In order to prevent the noise from the bathroom passing too easily to the hall, and from there to the main living space, the back of such a fluorescent fitting would be treated with acoustic materials.

Apart from the ceiling lighting, a secondary method would be by lighting the mirror over the wash basin.

Closet.

The hall closet would be lit from the same lowered ceiling, by a modification to give a plain diffusing plastic top to cupboard, utilising the same fluorescent strips lights used by the louverall ceiling.

Study.

The study ceiling is lit in the same way as the bathroom, using the same sectional detail. A further luminaire is added over the desk. See Fig. 4.4.1

Acoustic control is gained by carrying up the partition between the closet and the study to the height of the roof.

It can be seen from the above section, that the natural daylighting of both the study, and the bathroom, is also improved by the modification to the roof, since it raises the three foot overhang to the eaves. This overhang at present restricts both the amount of the light and the amount of the view that can be had, since it comes to a height of only 4ft.5in. above

Chapter 4.4

above/

an extended floor line.

By the suggested modification, the height would be raised to 5ft 2in. which would be a considerable advantage. The height of of the ceiling 1ft. from the wall is now 6ft. 4in.

Figure 4.4.3 shows the total area, which is under consideration, and the Sections may be related to it.

From this plan it can be seen that there is a "luminous wall" dividing the study from the Area 2 of the living space, and that there is a curtain system dividing the Area 1. from the Area 2. Details of both these are given in Figure 4.4.4.

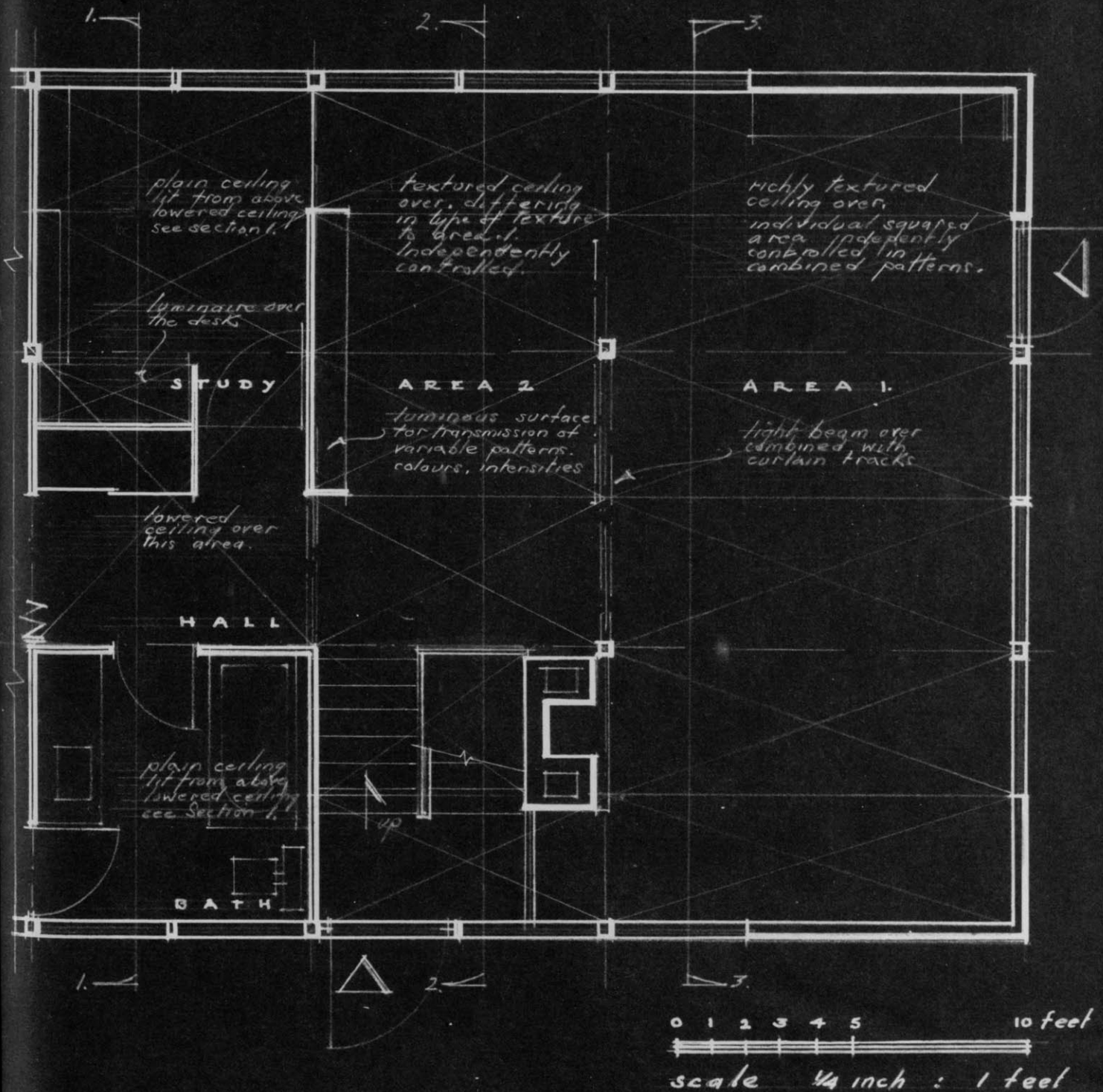
Detail 3. shows the system of curtaining, and detail 4. the relationship of the luminous wall to the lowered ceiling.

Living-space Area 1.

This area is shown in section in Section 3. and the method of lighting the ceiling is shown. The ceiling itself is illustrated in fig. 4.4.7. It can be seen that it is a textured surface, textured in a random fashion, by means of small pegs and holes which cast different shadows according to the manner of the illumination.

The overall lighting of the room, is performed by variations of illumination of this ceiling, it would be variable within a range of some 30 ft.lamberts on to objects of average reflection, (50%) which would give adequate brightness ratios on to carpets, and other objects of lower reflectance. See Chapter 3.2.

FIGURE. 4.4.3



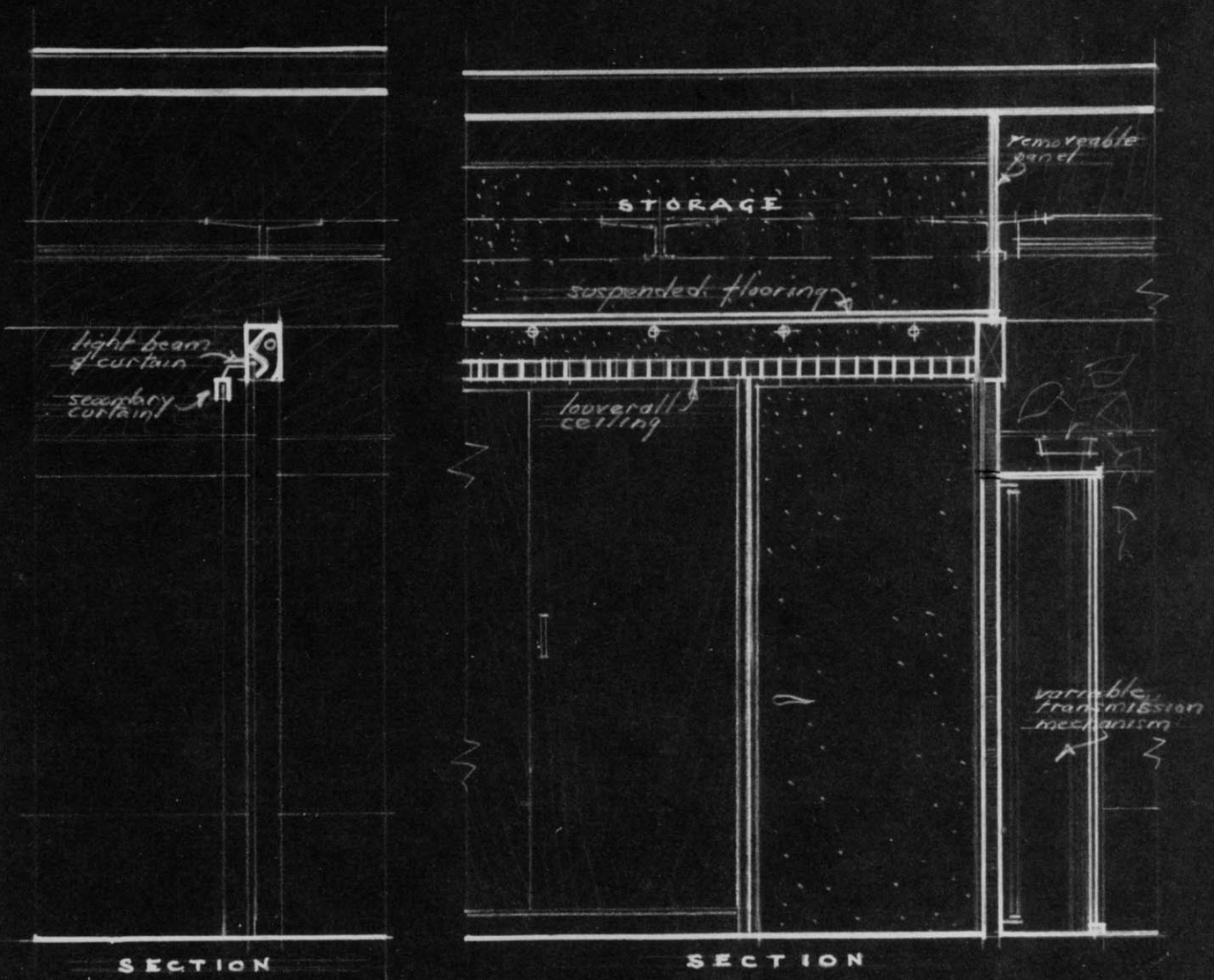
PLAN.

Plan of Living-space, to which the sections 1, 2 and 3 may be related.

The variability of the ceiling panels is also shown, with the position of other, illuminating elements throughout the space.

The ceiling can either be lit in a similar manner to give a single all-over appearance, taking in both area 1 and area 2, or individual parts may be emphasised.

FIGURE. 4.4.4.



detail 3.

Detail 3.

detail of the light beam which divides up area 1 from area 2, in the living-space.

The combination of two curtain tracks, allows variations of texture of the surface.

Detail 4.

Detail of the lowered ceiling over the hall, showing a section through the side panel to area 2. detail 4

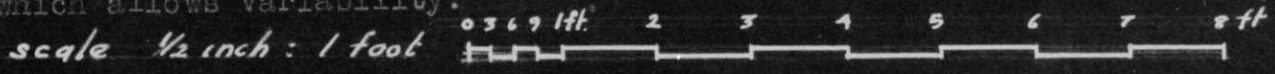
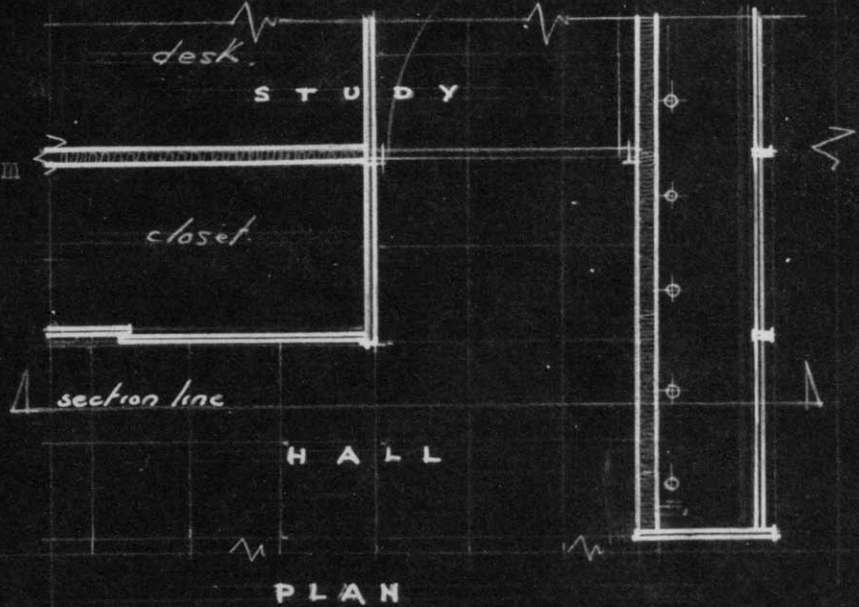
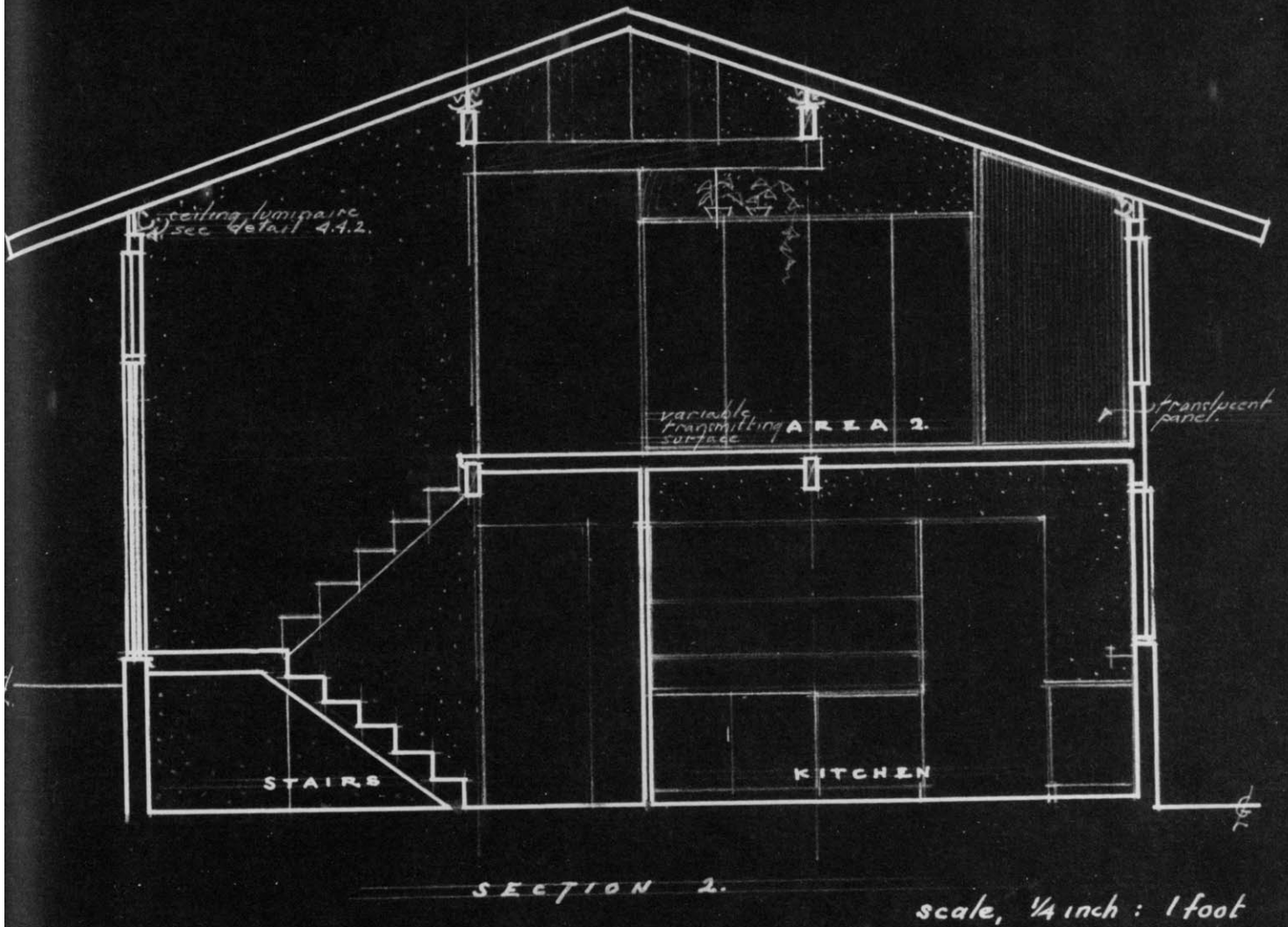


FIGURE 4.4.5

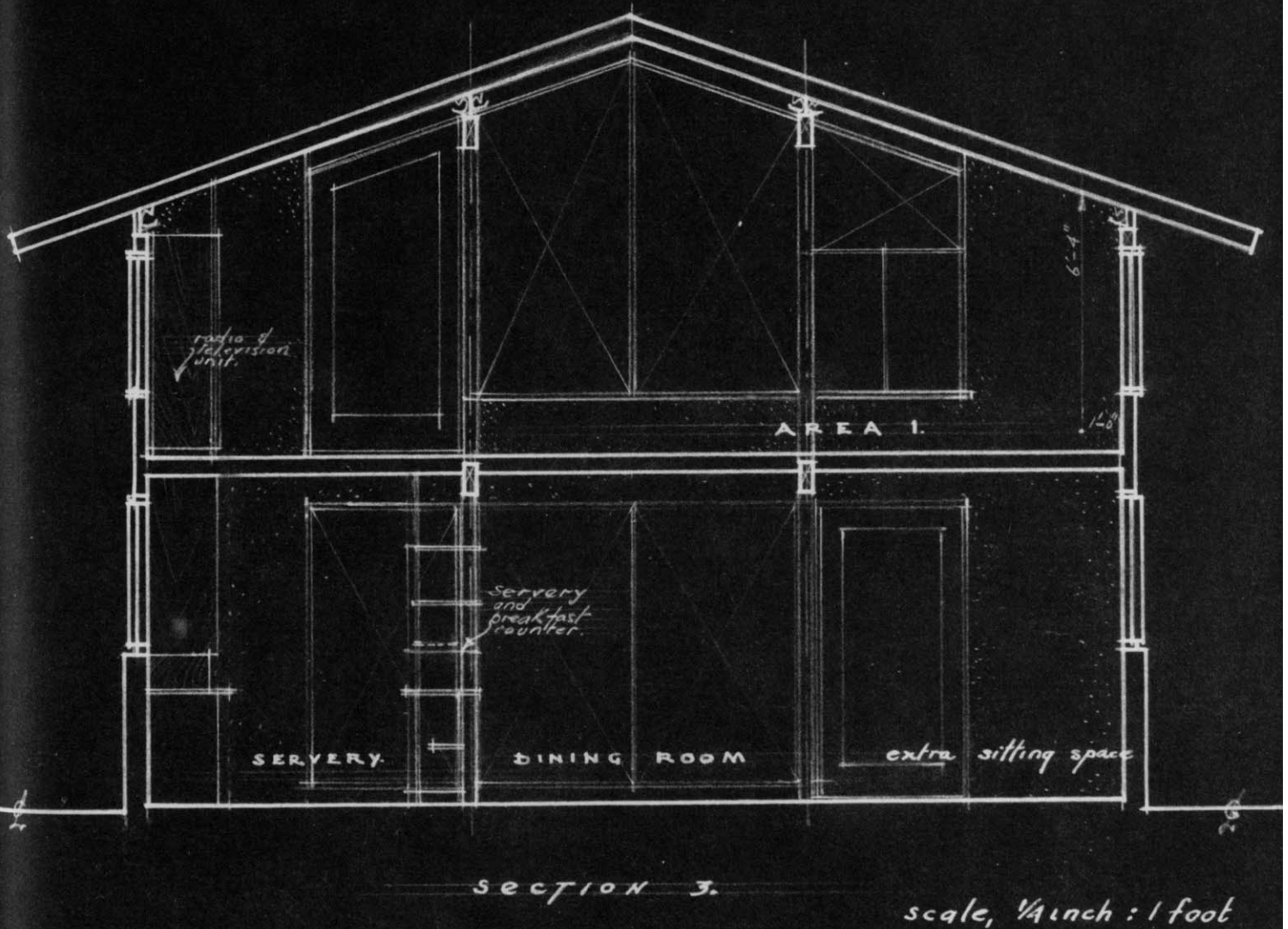


Section 2.

A transverse section through the Living space, area 2, used as a cardroom, or anti-space, writing room etc.

This shows an elevation of the wall of the study, which is divided up into a translucent panel, against which plants may be grown, on either the study side of the living area side; and a variable transmitting surface referred to in the text.

FIGURE 4.4.6

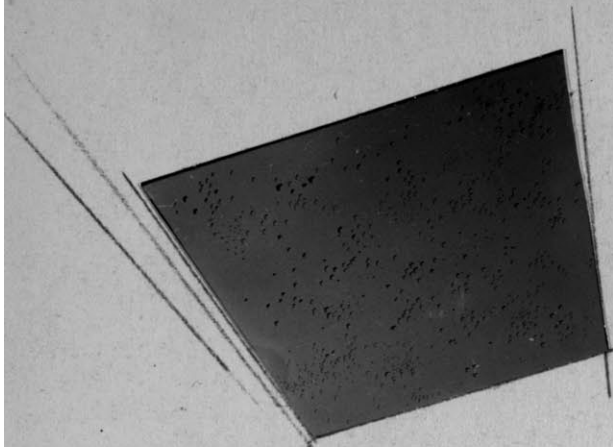


Section 3.

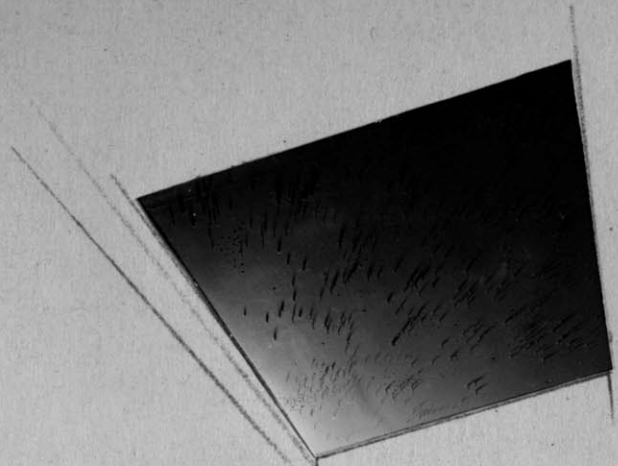
A transverse section through the Living-space, area 1, the general living area.

This shows an elevation to the main window wall of the living-space, showing the method of ceiling lighting. (fig. 4.4.2)

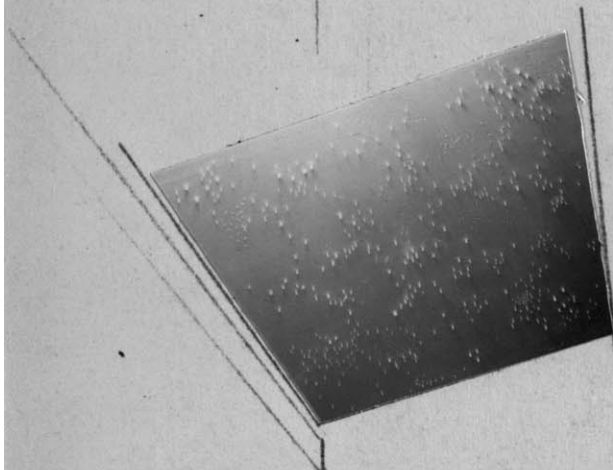
FIGURE. 4.4.7



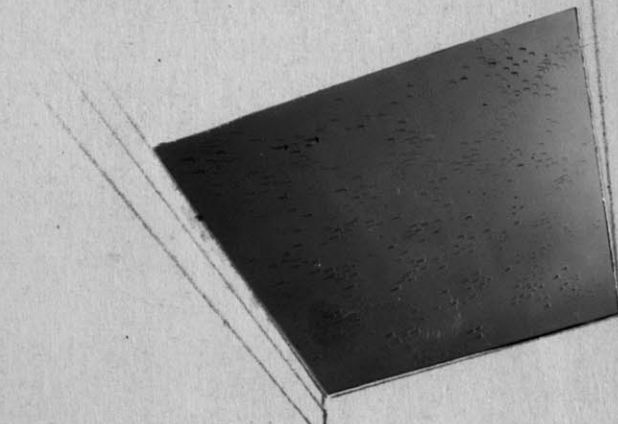
(a)



(b)



(c)



(d)

Textured ceiling Panel.

Showing different effects
due to alternative lighting.

Chapter 4.4

The source of Illumination could be of several types.

1/ Cold Cathode strip light.

A warm white light could be obtained, and by the use of a high pressure tube, a continuous spectrum could be achieved. This could be varied by means of the voltage in a very simple fashion. It is thought that three intensity levels would be sufficient.

It would have the advantage of keeping the fittings themselves at a low thermal temperature, but the disadvantage of using high voltages.

2/ Hot cathode fluorescent.

By a method recently developed, it is now possible to vary the intensity of the hot cathode fluorescent, whilst maintaining a constant colour temperature, and spectral quality of the light.

This could then be varied in the same range of intensities as the cold cathode.

3/ Tungsten.

Strips of incandescent tubing could also be fitted into the type of fitting illustrated in Fig. 4.4.2 In this case the variation would have to be by means of the use of combinations of the ~~the~~ strips themselves, rather than by variations of the intensity of individual strips.

It is difficult to obtain high levels of illumination by these means due to the increase of heat.

Chapter 4.4

As suggested in Chapter 3.3 the nature of the ceiling itself would vary for the type of source that was to be used.

In the case of fluorescent strip lighting, the pegs themselves would have to be elongated rectangles, with their longest side parallel to the source of diffused light, if any appreciable shadows are to be obtained.

However it would be possible to attach small point sources of light at the corners of each of the panels, which when used in conjunction with the diffused sources, would add a pattern of shadow to the ceiling to give it considerable texture, such point sources could be incorporated in a simple manner with subtractive colour mixture filters, in order to allow a variation of the overall colour relationships in the room, by reflection.

A remote control wiring system, could be used in conjunction with both the ceiling panels, and the point sources, which would allow 24 volt relays to operate the 120 volt, and higher voltage cold cathode light¹, at the point of use. This would have the advantage of allowing considerable multiplicity of switching, without any danger from the wiring.

Further methods of varying the shadow pattern of the ceiling, would be by natural means during daylight, and by the use of mobile fixtures, which I shall discuss next.

1. If such lighting were to be used.

Chapter 4.4

The secondary means of illumination, would be by mobile fixtures, which would be arranged so that high levels of illumination could be provided at points through the room. In order ^{to} obviate the use of unnecessary electric leads, a strip would be lead around the room, containing plug-in points at close intervals. Other points would be available at the column. Such mobile fittings do not appear in the drawings and perspectives, since this could be left to the individual choice of the owner, so long as the general level of illumination can be maintained irrespective of such fittings.

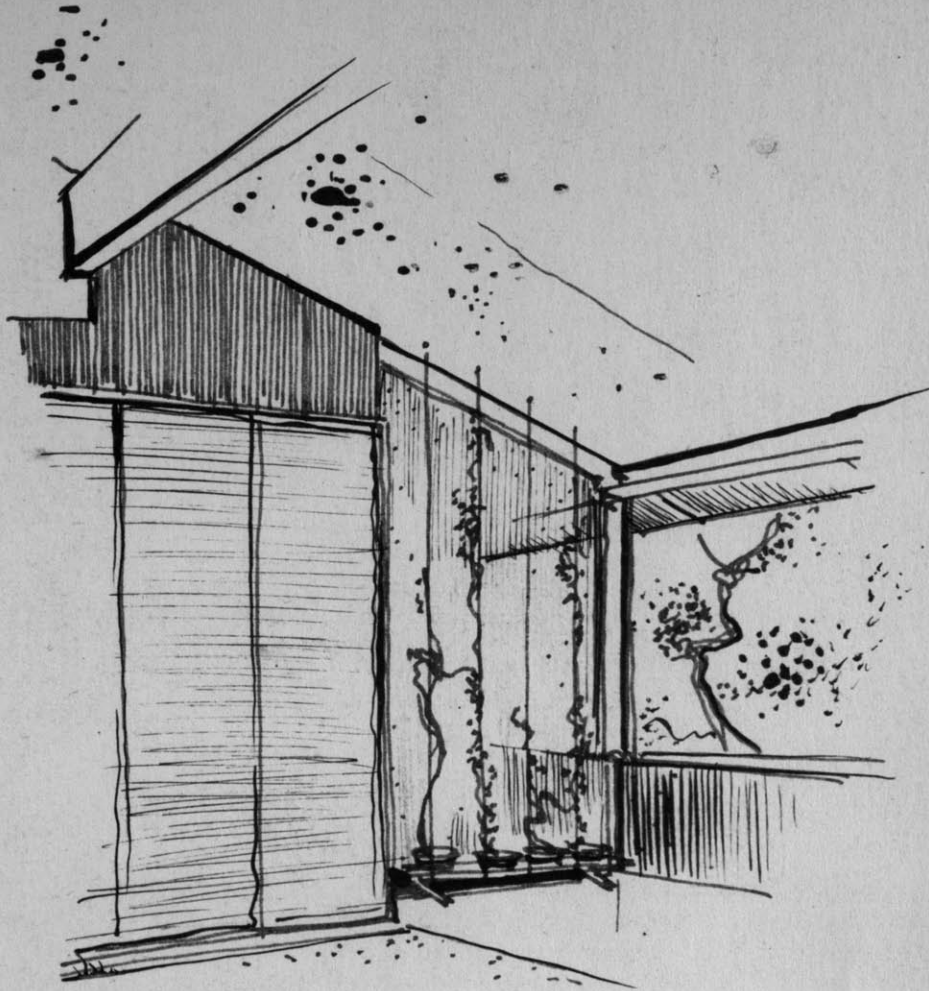
Curtain system.

To divide the area 1. from the area 2. a curtain system is provided, as developed in Chapter 3.3. It consists of a double curtain rail (Fig. 4.4.4) in conjunction with a "light beam". It is possible to vary the transparency of this curtaining, by alterations of the illumination. The light beam and curtains can be seen in the accompanying set of perspectives.

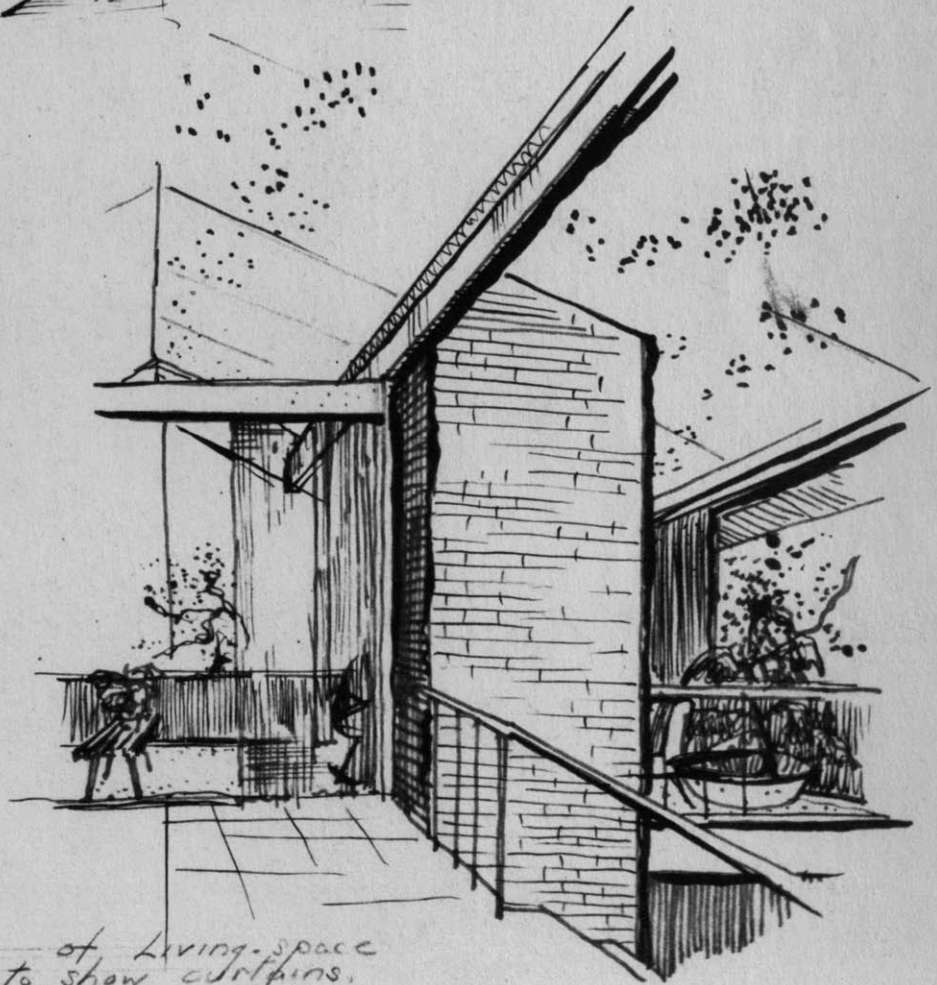
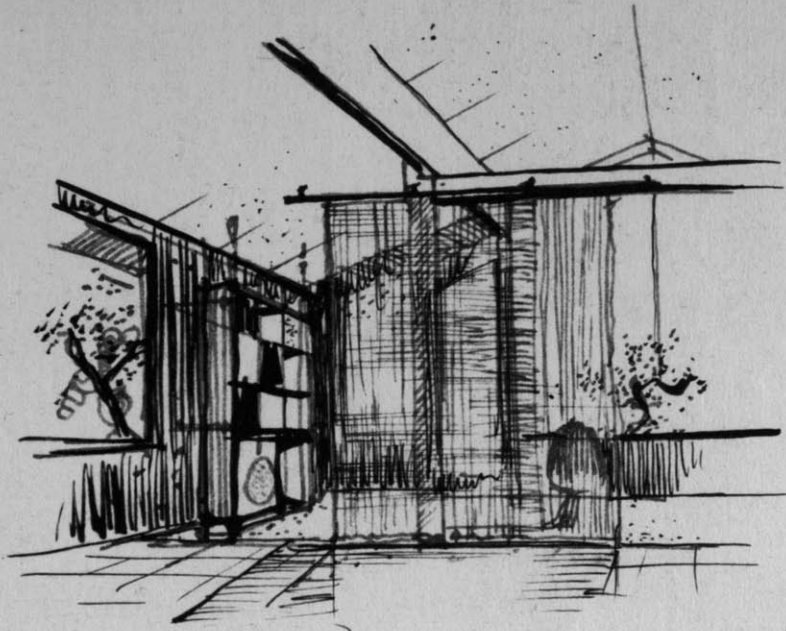
Living-space Area 2.

The general illumination is solved in the same manner for the area 1. but it is thought that a possible variation in the nature of the texture, might be introduced. Since the two areas will be used as one single space from time to time, it is not thought that any great differentiation should be made.

In addition to this there is the luminous panel on the study



perspective of
translucent wall to study



perspectives of Living-space
Area 1. to show curtains.

Chapter 4.4

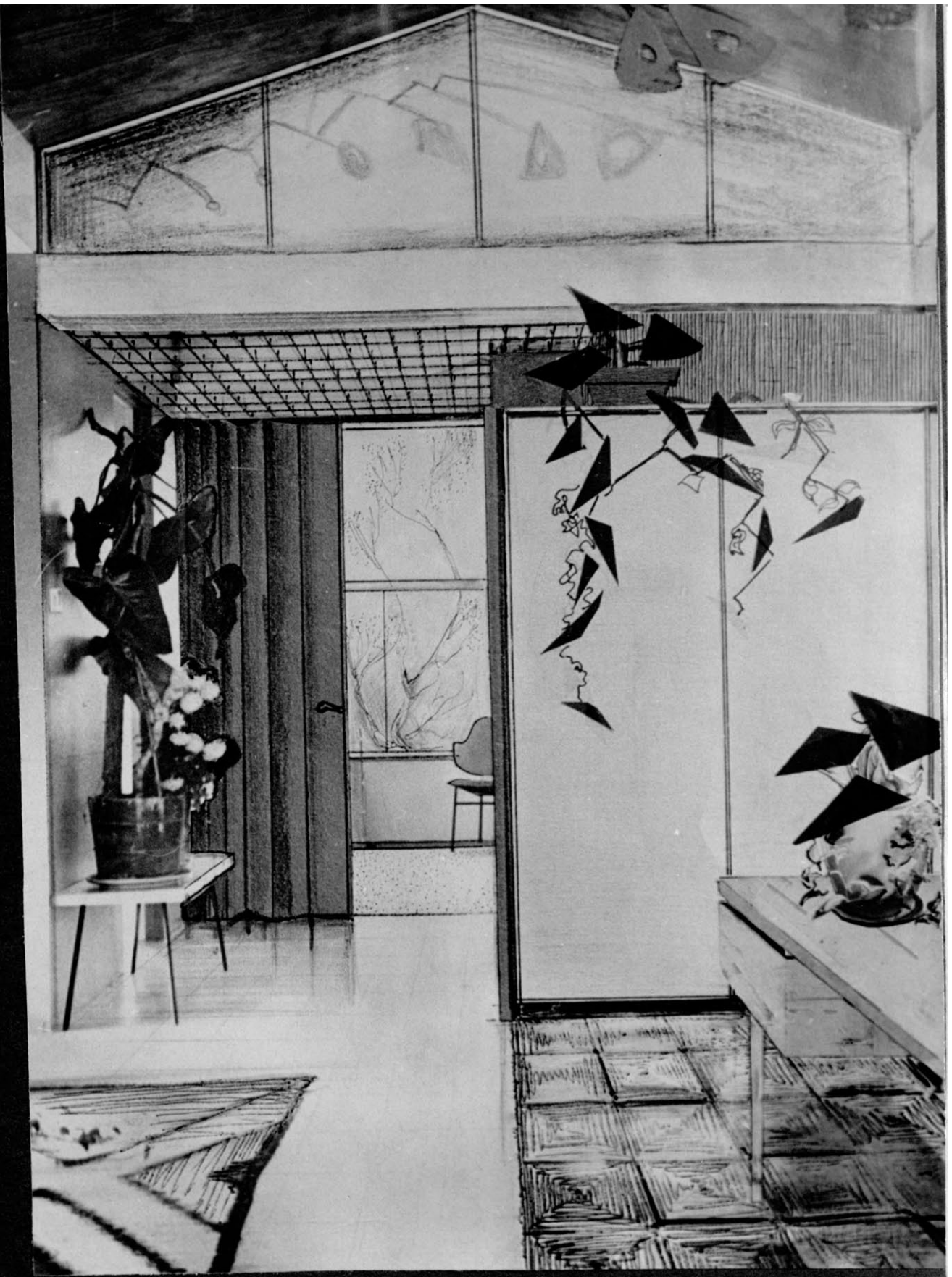
side, as detailed in Figure 4.4.4. which acts as a form of variable surface illumination, of a low overall brightness. The source used would be a type of line spectra source, such as cold cathode, so that when filters are placed in conjunction with this, as suggested in Chapter 3.3, the surface colour could be controlled. Polarisation could also be used in conjunction with strips of lucite to form patterns of the type illustrated.¹

A section through the space is shown in Figure 4.4.5 which shows an elevation to this wall, and to the translucent partition, which appear also in the perspective sketches.

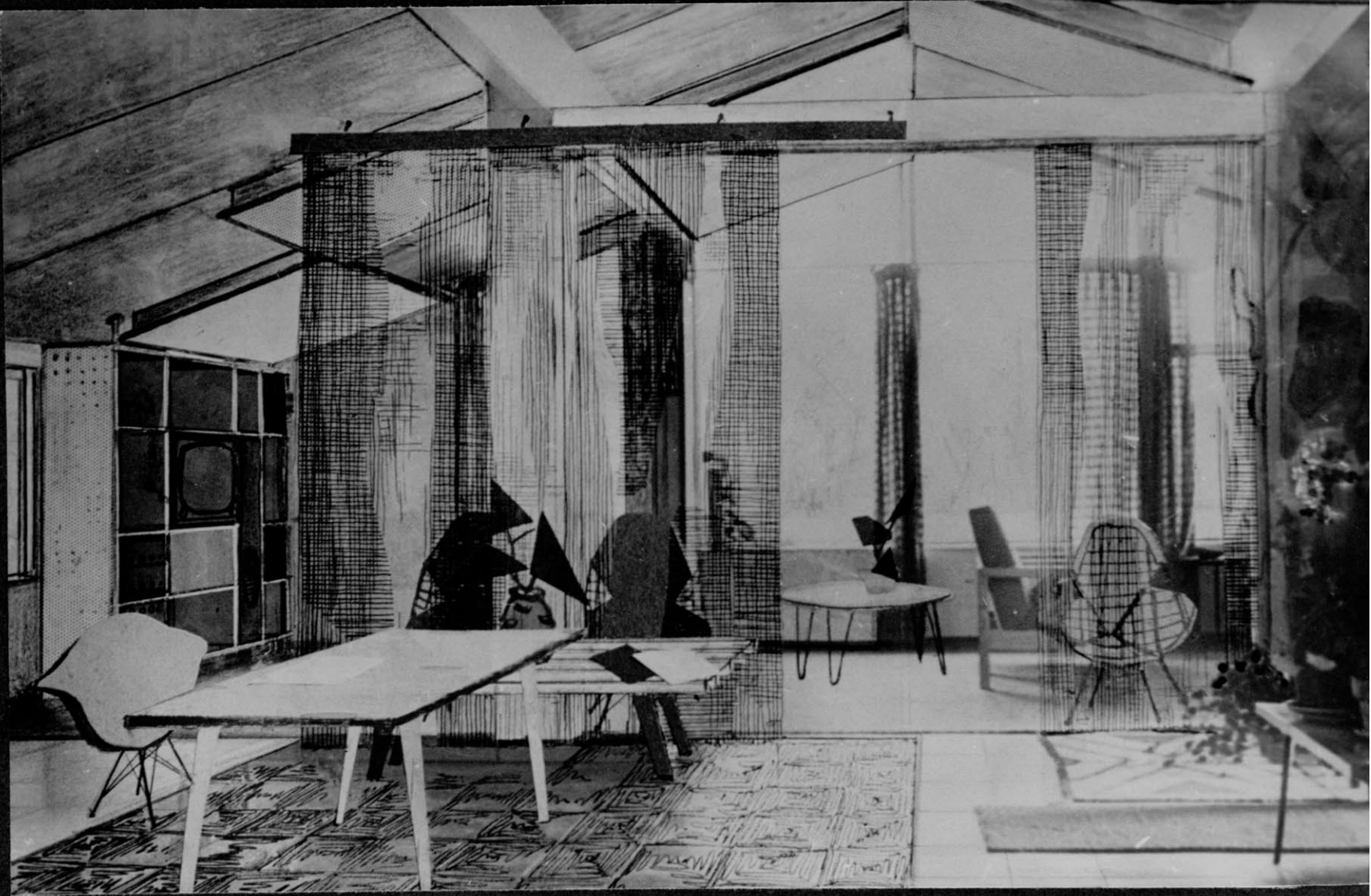
The above is a brief explanation of the drawings, the way in which such technical means may be used to give a maximum flexibility is the subject of the following chapter.

1. See Chapter 3.3 for a description of the method of polarisation that could be used, to form patterns.

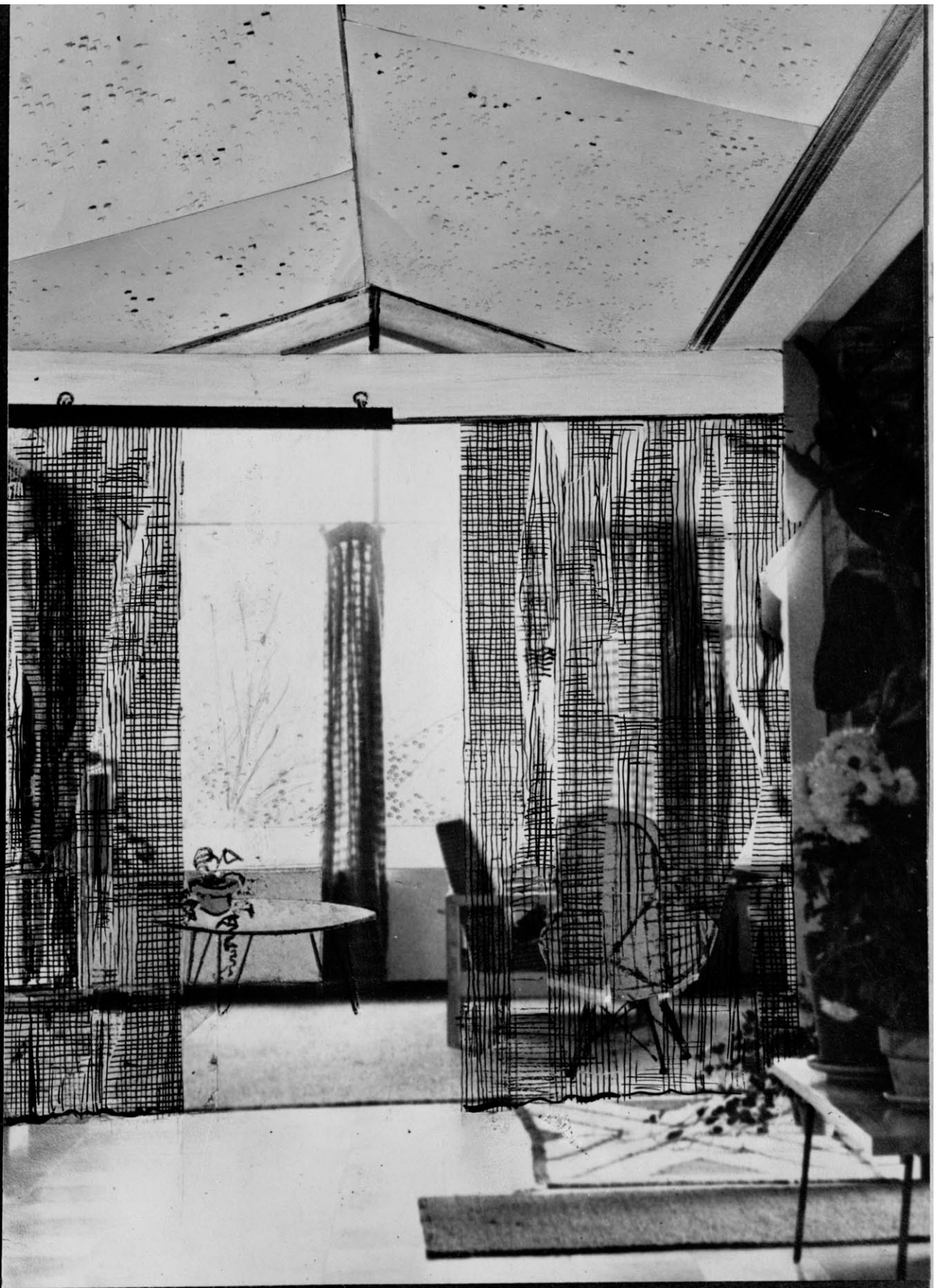
A set of three photomontages
of the Techbuilt House,
showing the modifications
suggested as a means for
achieving flexibility
of the formal relationships.



1. View towards the hall, and the study wall.



2. View towards the main sitting area with an alternative type of ceiling. A luminous panel ceiling.



3. View towards the main sitting area, showing the textured ceiling as suggested.

PART 4.

Specific Problem.
The Techbuilt House.
Weston, Massachusetts.

Chapter 4.5

Solution.
(c) Flexibility.

Chapter 4.5 and the accompanying set of drawings, show the way in which the general illumination is integrated into the structure, it is however necessary to enlarge to some extent on the way in which these elements might be used in order to achieve a flexibility of formal relationships such as I have outlined in the previous discussion.

Chapter 4.5

Natural Illumination.

The main daylight for the space comes through the large end window, which extends up to the eaves line. This is sufficient for the main living space. When area 1 is separated by means of curtains from area 2, the light reaching the latter comes partly by reflection from the ceiling, and partly from the side windows. By raising the roof line the amount of light from the side windows is improved sufficiently for most purposes.

There will be occasions on which it will be necessary to supplement the daylight with artificial illumination, and this is best accomplished by means of using a low level of general illumination from the ceiling.

As suggested in Chapter 3.3 there is sufficient variability throughout the day, and the seasons, to give a constant change of illumination, to add sparkle and life to the interior of the room.

Artificial Illumination.

A range of flexibility is available as follows.

Ceiling lighting. Three levels of brightness available, Intensity. on each panel of the ceiling. This would be arranged so that as with the three bulb luminaire, if the desired level is missed the first time, it can be got by continuing to switch the switch, until it comes again.

Colour. the ceiling would be painted a flat white, and colour could be achieved by a subtractive method. By means of a light source with light of certain bands of wavelength, the colour of the

- the colour of the,/ colour cont. ceiling could be varied. This could be accomplished by means of the mobile fittings with selective colour filters applied.
- It is not thought that this would be required often, but could be used for certain effect during parties. In such cases, the normal ceiling lighting would not be used.
- pattern. As can be seen in the plan Fig.4.4.3 the ceiling is divided up into areas. By alternative switching arrangements, it would be possible to vary the way in which the textural patterns appeared.
- A few of the types of patterns that might be obtained are illustrated in Fig. 4.4.7. many other types are available.
- By a combination of natural daylight, and artificial light at night, a great variety of changing patterns could be applied. The texture can be made practically to disappear, so that the ceiling appears as a plain white surface, unless fixated directly; or it can be made to cast elongated shadows which would add a great richness to it.
- mobility. No arrangement has been made for mobility, other than that which would occur from the interrelationship of the textural patterns, and the firelight.

It is unnecessary in this chapter to deal with individual rooms, since general observations will suffice. It has not been thought necessary to provide flexibility of formal relationship in the hall itself (louverall type lighting), the study and bathroom would have the same degree of flexibility of ceiling illumination as the living-space but the nature of the ceiling itself would differ. This would be painted in a lemon yellow colour in the bathroom, in order to gain in intensity from the

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from the/

late afternoon sunlight, which would strike the inside wall of the bathroom, and be reflected on to the ceiling.

The ceiling of the study would be left in a natural wood colour.

A flexibility is achieved on certain of the vertical surfaces of the living space.

curtain system : A variation of texture, and of transparency allows considerable variation in the manner in which the two areas can be used.¹

Translucent panel study/area 2. By means of vines or foliage, a mobility of pattern can be obtained from one side of this partition to the other, as the leaves move and become in or out of focus to the eye. This can be artificially induced by means of a fan.²

Luminous surface study/area 2. Either by the polarisation method described in Chapter 3.3 or by the simple use of colour filters, tracing paper, silk screens etc; in combination with a light source, variable in intensity, it is possible to arrange for a flexibility of both colour and pattern.

A further mobility of pattern can be achieved by means of some form of "mobile" which could be hung perhaps over the staircase, whilst by means of a spotlight, its shadow could be played on to the removable panel of the storage space. This is illustrated in a photomontage included at the end of

1. This method is illustrated in Chapter 3.3
2. Method applied in the exhibition of the Techbuilt House, at the Le Cordova Art museum. Mass. 1953.

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at the end of/
this chapter.

A further scale of flexibility would be provided by the use of the mobile fittings suggested in the technical solution. These would not only provide for high levels of illumination, at points where information of a specific kind required it, but by a careful use they could be made to play an important part in the interrelationship of light and shadow that the owner of the house might wish to achieve, quite apart from the manner in which the architect might arrange the formal relationships of the space.

Summary.

It would be possible within the space, as I have modified it, to achieve a very considerable degree of flexibility of environment, according to the needs of the inhabitants from day to day. The means available are provided in a way which would not involve considerable expense, and are capable of modification by the individual owners as occasion demands.

It would be possible to sit with a book using a candle, and so arrange the general surround brightness so that no strain would be encountered, whilst at the same time it is possible to arrange for high levels of brightness throughout the entire living space. Added to this is a richness of variety of texture, and of colour, to suit man's moods and his emotions.

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As far as natural illumination is concerned, the amount of light, and the direction of light can be varied by the nature of the natural luminaires.

Vermeer painting in his studio, managed by the simple use of shutters to gain many of the effects that can be seen in his paintings, and such a variability as he obtained would be an easy matter, with the modern methods that are available in the form of refracting glass, venetian blinds, and other forms of flexible means of control. Curtains, and combinations of curtains, giving different textural patterns are other methods whereby the individual could obtain his own variations, for although the means for an overall flexibility must be provided by the architect, it lies in the hands of the individual to implement such means by methods which afford an outlet for his own tastes, and are governed by his own imagination.

A total flexibility can come only with an increase in the scope of the life of the individual, created and fostered, and made possible by his formal environment.

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23rd February.



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ABBREVIATIONS USED.

- B.R.S. Building Research Station. Watford England.
- D.S.I.R. Department of Scientific and Industrial Research. England.
- H.M.S.O. His Majesty's Stationary Office.
- Illum Eng. The Illuminating Engineer. N.Y.Periodical.
- P.W.B.S Post war Building Study. H.M.S.O
- S.M.P.T.E Society of Motion Picture Theatre Engineers.