'To this Measure of Man': Proportional design in the work of Ernö Goldfinger

James Dunnett and Nigel Hiscock

Architectural Review: When did you begin to see yourself as a Rationalist?

Ernö Goldfinger: I told you what I mean — I try to solve problems in a rational way... Like one solves maths problems ... and there is this other thing — the architecture of enclosing space. It is a mystery which is a personal affair — no one else's business.

AR: What about Albemarle Street?

EG: That is rational. All my buildings are. For buildings and elevations that is geometry. ... The only medal I got at the Beaux-Arts was for measuring up the Musée Cluny's entrance doors. I was fascinated by them. From then on I read Viollet-le-Duc. French architecture is rational architecture. Even Gothic architecture is rational architecture ....[1]

Ernö Goldfinger's office building of 1956 at 45–46 Albemarle Street, London W1 (Fig. 1), and his survey thirty-two years earlier of the portal of the fifteenth-century Hôtel de Cluny in Paris (Fig. 2) were far apart in terms of date and style, but linked, as this passage makes clear, in his conception of a rational architecture and its expression in the geometrical control of proportion. His concern with proportional theory and its application extended through the post-Second World War years when proportional systems became for a time a live issue among British architects. Eva-Marie Neumann has provided a valuable overview of this period in her article 'Architectural Proportion in Britain 1945–1957', *Architectural History*, 39 (1996), observing that while interest in proportional systems, stimulated in 1949 by the publication both of Le Corbusier's *Modulor* and Rudolf Wittkower's *Architectural Principles in the Age of Humanism*, subsided after 1957, Goldfinger was exceptional in continuing to work with them. He was of an older generation than most of the architects she discusses and his interest in proportion also antedated these publications, lasting — as we will see — throughout his professional life. Given that the sense of geometrical order in plan and proportion is central to Goldfinger's work, his theory and its application warrant a detailed study of their own.

Goldfinger's recorded comments on his proportional theory, however, are brief and the sole publication during his lifetime of a diagram purporting to show its application to a particular building will be shown to be in some respects misleading.[2] Accordingly this article aims to clarify his theory as far as possible from the limited sources available and to establish by an exploration of his plans and elevations to what extent it is embodied in his buildings. The proportional diagrams that follow are therefore the authors' own and illustrate their interpretation of Goldfinger's buildings in the light of

Fig. 1 Ernö Goldfinger, offices and shops at 45–46 Albemarle Street, London W1, 1956 (photograph: Colin Westwood)

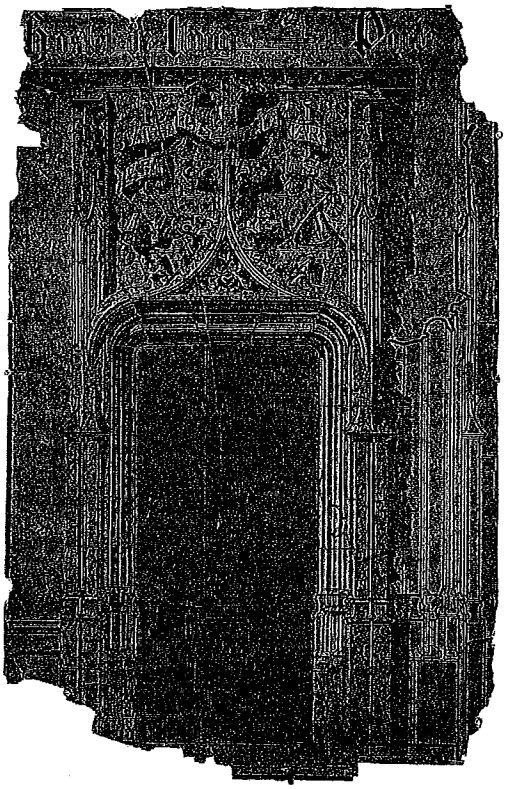


Fig. 2 Ernö Goldfinger, measured survey of the entrance portal of the Hôtel de Cluny, Paris, 1924 (British Architectural Library, RIBA, London)

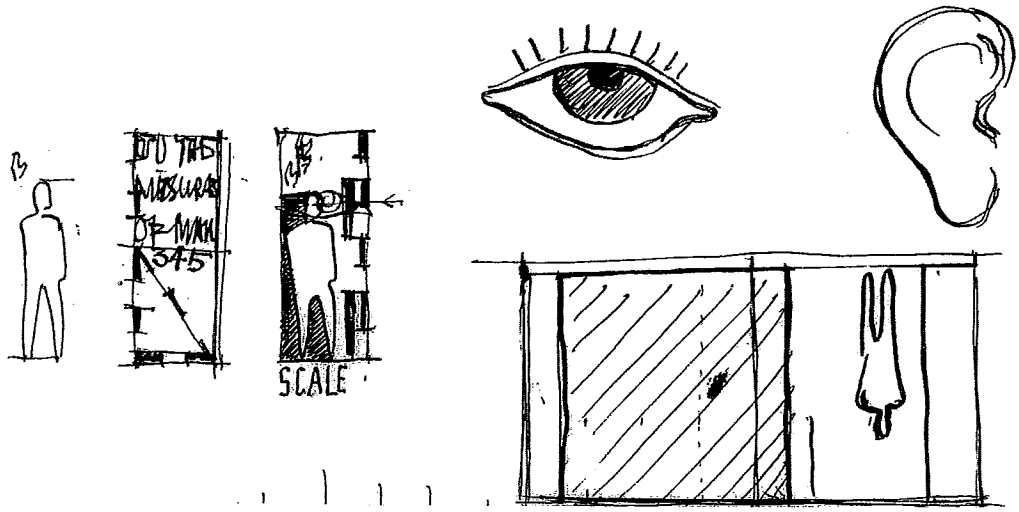


Fig. 3 Ernö Goldfinger, sketch for *This is Tomorrow* exhibition pavilion, 1956, with two panels (one labelled TO THIS MEASURE OF MAN above a 3 : 4 : 5 triangle, the other SCALE with eye level indicated), and with emblems of eye and ear (British Architectural Library, RIBA, London)

his theory. Because of Goldfinger's interest in architectural history and his constant references to it, this article also attempts to place his theory in the historical context, within which, consciously or not, he formulated his ideas. Since the tradition of proportional theory has its own history, it offers a framework against which Goldfinger's statements and his work may be viewed.

As an architect of the Modern Movement, Ernö Goldfinger, born in Budapest in 1902, had a unique position in post-war Britain, where he settled in 1934 and died in 1987. There was a certainty about his work, reflecting both the forcefulness of his own personality and the confidence instilled in him by his education in that seed-bed of the Modern Movement, Paris in the 1920s. There he developed under the aegis of his *maîtres d'atelier* at the Ecôle des Beaux-Arts, first Léon Jaussely during the years 1921–25, then Auguste Perret 1925–26, pioneers respectively of town planning and of the architectural use of reinforced concrete. He was also a student of town planning at the Sorbonne with Cor van Esteren, later to become a leading figure of CIAM and chief architect of Amsterdam. *Extra muros* he was in personal contact with architects such as Le Corbusier, Adolf Loos, and Erich Mendelsohn, and was secretary of the French delegation to the crucial CIAM Athens conference of 1933. Goldfinger was a friend of many artists of the Left Bank, such as Léger, Ozenfant, Max Ernst, Man Ray, Braque and Foujita, of whom the last two were visitors of the Perret *atelier* at his invitation. Through his cousin, Hélène Bernheim, he was related to the Dalsace family, who commissioned the Maison de Verre[3] and both families were major patrons of modern art. Goldfinger was thus in no sense a provincial. He was exposed to theories of design deriving both from the academic tradition of the Ecole and from the avant-garde. To some extent these were merged in the person of Perret, and it was Perret whom he continued particularly to revere throughout his life. Goldfinger prepared an English language edition of the writings of Perret with his own introduction, although publication never occurred.[4] The influence of Le Corbusier on his work is also evident, as well as that of Russian Constructivism; however, the synthesis has the distinct flavour of his own character and invention.[5]

The principal documentary sources for Goldfinger's interest in proportion and the related question of square planning grids, or 'square schematism', published during his lifetime, span the period from 1925 until 1983.[6] The drawn record — direct evidence of the use of proportional systems as design tools in the extensive Goldfinger archive in the RIBA Drawings Collection — is surprisingly sparse in view of the importance he attributed to them verbally.[7] But in answer to one query Goldfinger commented that the use of these proportions had become 'largely instinctive' and so would leave little drawn trace.[8] The final source for Goldfinger's proportioning of course is his architecture, which has already been analysed to some extent in the written sources already cited and will be further examined below.[9]

Recurrent themes in Goldfinger's work and emphasized by him in his references to proportional theory were the use of a set of rectangles derived from the square, as well

as the square itself, and of a module derived from human dimension. Looking back on his life's work, aged eighty in 1983, for the *Architectural Review*, Goldfinger said:

I'll tell you a secret: since the late 1920s I have used the properties of rectangles which all resemble each other, but have quite different properties. 1 : √2, 2 : 3, and the Golden Section 1 : 1.618 — looking at the building you cannot tell one from the other but when you build up the façade or the plan you mustn't mix them. They all have their different and sometimes conflicting qualities. ... I use systems like Palladio or Vignola — they are like drumbeats ...[10]

As Goldfinger had noted in 1957,[11] each of these rectangles can be directly generated from the square, something which can be seen in Goldfinger's earliest work. While he was still a member of the embattled *atelier* of Auguste Perret, the projects which Goldfinger submitted to the juries of the Ecôle des Beaux-Arts, such as that of 1926 for a Reservoir and Water Tower,[12] reflect Perret's preference for square windows and wall panels of square or square-and-a-half proportion. Like other projects submitted by members of this unofficial studio, it was rejected by the jury, and the studio was forced to close. A further illustration of the absorption by Goldfinger of Perret's teaching on the subject of proportion, both with regard to the square and to human scale, is the article he wrote about Perret's church of Nôtre Dame du Raincy (Fig.5) for the Budapest newspaper *Pester Lloyd* in 1925, while he was a pupil of Perret. This expresses very similar sentiments to those expressed by Perret in a radio interview in 1939, which as Roberto Gargiani notes, echoes ideas expressed as early as 1913. Perret said:

A building that is subject to nature will be harmonious. If its geometrical forms are commensurate with the spirit of man and *en rapport* with the human body through which we define scale, then it will satisfy proportion. For proportion is man himself .... However harmonious the buildings of antiquity ... [they] are less directly accessible to our sensibility than the constructions of our own tradition, whose module is man. When a person enters a cathedral ... he feels a profound satisfaction in contemplating the expression of a plastic beauty in which he feels himself reflected in a mirror. All the dimensions of this place derive from his own form. The length of his foot, that of his outstretched arms — their tension — the width of his thumb. These regulate the distances and heights, the thickness and the prominence of the smallest moulding.[13]

In 1925, the 23-year-old Goldfinger wrote of the recently completed church by Perret:

The building is composed of a frame of four rows of equidistant pillars, each of equal strength. The dominant factors are standard repeating elements, precision, and the strictest economical restraints. ... The architect knew in his heart how close he was to the master builder who designed Nôtre Dame. There too are none of the abstract mathematical proportions that are to be found in the dwellings of the gods created by ancient Greece. At Nôtre Dame everything is related to the 175 cm human frame — every element that changes its dimensions in this medieval cathedral does so according to the viewpoint of the observer, as it rises and falls. In contrast, the proportions of the Greek temple are always the same — the whole building forming a finished, self-contained masterpiece.[14]

GOLDFINGER'S ARCHITECTURAL BACKGROUND

The possibility of confusion on the part of both Goldfinger and Perret over the classical and medieval traditions regarding human proportions will be discussed below. For the present, it can be seen that Goldfinger was echoing the doctrine that the

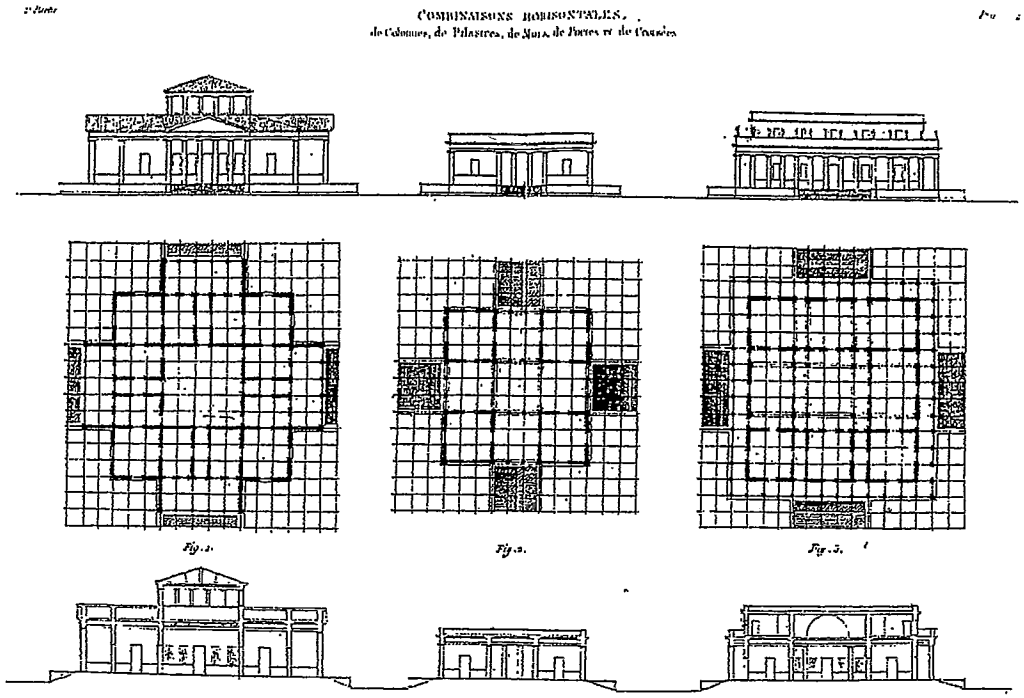


Fig. 4 J.-N.-L. Durand, Illustration of 'Horizontal Combinations' from *Précis des Leçons d'Architectures Données à l'École Polytechnique* (Paris,1809)

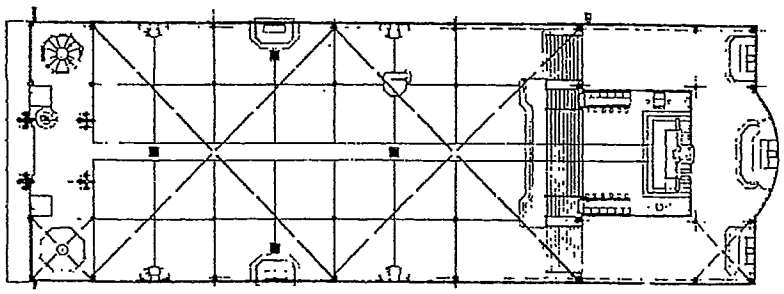


Fig. 5 Auguste Perret, Nôtre Dame du Raincy, 1922–23, plan, with suggested proportional scheme of squares imposed

use of dimensions derived from the human form will lead to the establishment of human scale, a doctrine which twenty-five years later was forcefully to re-emerge in Le Corbusier's *Modulor*. Goldfinger was to give striking visual expression to this highly subjective and intangible concept in the cover design he produced for the invitation to a lecture entitled *Architecture et L'Activité Humaine* he gave in 1932 at La Residencia in Madrid.[15] This shows an écorché human figure, superimposed on façade details of his Ecôle des Beaux-Arts Diploma project for a Flying Club, apparently

gesturing to elements of square or square-and-a-half proportion (Fig. 6). It is in some ways a surprising belief to encounter in Goldfinger, who at this time was in other respects espousing a reductivist rationalism in architectural design, epitomized in a diagram he published in the magazine *L'Organisation Ménagére* in 1928, showing architectural form as the simple product of a conjunction of needs, technical means, and economy.[16] But the image highlights the belief that the starting point of architectural design must be to imagine creatively the response of an individual to a space, the basis of the Modern Movement conception of an architecture for human welfare. Thus Goldfinger recounted that when he visited Cairo in 1926 to design a Library within the house of Elias Awad Bey in Cairo, a work of Perret, it was the Muslim architecture, rather than that of Ancient Egypt, that most impressed him: 'architecture for humans rather than the Gods'.[17]

Interest in proportional systems was resurgent in Paris at around the turn of the century, although Julien Guadet, chief theoretician at the Ecôle des Beaux-Arts, dismissed them. In his five-volume text-book of 1905, *Elements et Théorie de l'Architecture*, he stated that 'proportion is infinite'. However, as early as 1903, his former star pupil, Auguste Perret designed the elevation of his Rue Franklin building in Paris on the basis of a double square, a proportion which was to recur in the plan of the nave of Nôtre Dame du Raincy twenty years later (Fig.5), and was to become a favourite of Goldfinger's. In 1905 Paul Sérusier, pupil of Gauguin, published a French translation of a book by the Benedictine monk Paul Didier (the sculptor Peter Lenz, of Munich) entitled *L'Esthétique de Beuron*, after the Bavarian monastery where he had developed his theories. The artist Maurice Denis, collaborator with Perret at the Théatre des Champs Elysees and Le Raincy, commented:

> Through a sense of simplicity re-discovered from what is called Gregorian music, Paul Didier has persuaded himself to reduce the elements of Beauty to a small number of simple ratios .... 'For every clear idea there is a plastic thought to represent it', said Puvis de Chavannes. Admirable affirmation of Symbolism! To identify this plastic thought, to discover these correspondences, is the whole of art, the secret of style. To achieve it, Paul Didier has adopted scientific means and rigorous methods.[18]

Gregorian music did indeed consist of simple ratios. Ultimately derived from Pythagoras, these became transmitted to Benedictine monasticism by Boethius and others (Fig. 18). Thus by dividing a musical string in the ratios respectively of 1 : 1, 1 : 2, 2 : 3 and 3 : 4, the basic intervals and harmonies of unison, diapason, diapente and diatessaron were produced. Sérusier and Beuron were to be mentioned by D.-H. Kahnweiler, dealer for the Cubists and chief apologist for the work of Juan Gris, who confirmed the influence of Didier while distancing Gris from it:

> Gris ... never experienced a 'revelation' like that which came to Sérusier, a revelation of 'a completely new aesthetic, a new hieratism and theories of art based on mathematics, numbers and geometry, theories taught by the large and flourishing Benedictine College at Beuron' ... the Beuron theories have influenced a number of painters, often mysteriously and without their knowledge, for they were probably as ignorant of Father Didier's work as of his writings. In particular I would instance several minor cubists, Jeanneret and Ozenfant during their 'purist' period ...[19]

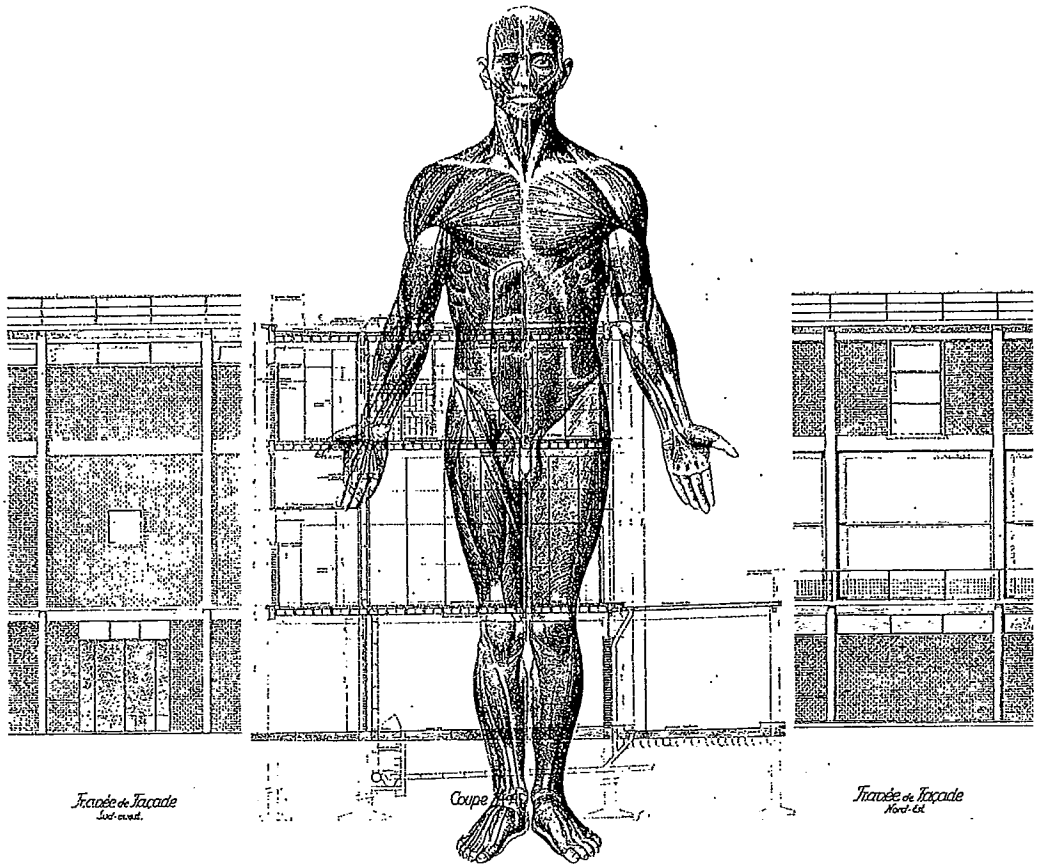
In *The Modulor*, Le Corbusier acknowledged the importance of the musical analogy, but comments in relation to Kahnweiler's passage:

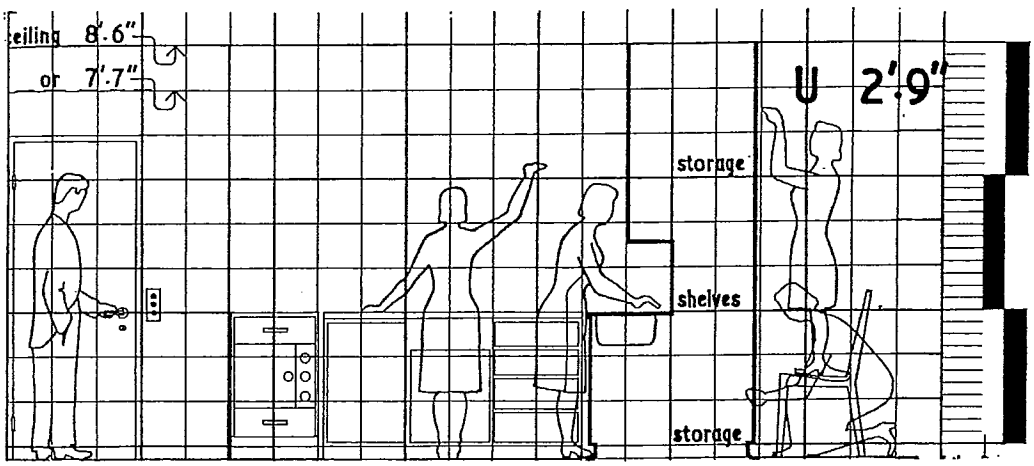
> The Jeanneret mentioned is myself ... Thus eyewitnesses are not lacking. I heard the word 'Beuron' mentioned in 1922 or 23. But I am the most reluctant of disciples, or, truth to tell, the very contrary of a disciple ... My life has been built up on personal observations alone.[20]

Gris had participated in the group exhibition *La Section d'Or* in 1912 along with Fernand Léger and Marcel Duchamp. It is likely that Seurat, who made use of the Golden Section in constructing paintings such as *La Parade* of 1887–88, was their principal source of inspiration. He was included by Le Corbusier with Cézanne and Gris among the '"phenomena" of the art, the fundamental and essential painters'.[21] Whether Didier might also represent a connection by way of Gregorian music and Benedictine monastic thought between the Parisian avant-garde and medieval proportional theory is an open question.

The possibility of continuing medieval influence cannot be discounted. Both Perret's parents came from families of masons, his father originating in Burgundy where he inhabited a Romanesque house near Tournus and Cluny, both towns distinguished by their medieval architecture. Although born in exile near Brussels, Auguste Perret pursued a life-long interest in Romanesque architecture[22] and, from a very early age was reading his father's ten-volume *Dictionnaire raisonné* of Medieval architecture by Viollet-le-Duc. This and Viollet's other writings were to be an inspiration, not only to Perret all his life and a defence against the academicism of the Ecôle des Beaux-Arts[23] but also to Goldfinger who also possessed the *Dictionnaire* and regarded Viollet as the first modern architect.[24]

In 1907–08, Perret employed Le Corbusier and encouraged him to study mathematics on the grounds that ' they form the character. I studied mathematics and in practice they were never of any use to me afterwards. But they may have formed my character'.[25] Le Corbusier parted company doctrinally with Perret when he adopted the smooth white Purist style of the 1920s, suppressing the kind of structural expression considered by Perret as essential to architecture. Perret was stung to comment of Le Corbusier's *Esprit Nouveau* pavilion of 1925 that 'There is no architecture in it'.[26] He further widened his distance from Le Corbusier by extending his anthropomorphic theory of proportion to assert that windows should be of vertical format because 'a window is a man', which Le Corbusier countered by sketching Perret reclining on a *chaise longue* in front of the strip window at his Palais de Bois.[27] The choice between windows of vertical or horizontal proportion then became nothing less than a test of architectural allegiance amongst architectural students.[28] In this period, Le Corbusier seemed to avoid the use of the square proportion favoured by Perret. However, he publicized in the pages of *L'Esprit Nouveau* his application of the Golden Section — not yet adopted by Perret[29] — to his Villa Schwob of 1916 and his Ozenfant and La Roche-Jeanneret houses of 1921–23. These diagrams reappeared in *Vers Une*


Travée de façade
Sud-ouest.
Coupe
Travée de façade
Nord-Est


ceiling 8'.6"
or 7'.7"
U 2'.9"
storage
shelves
storage

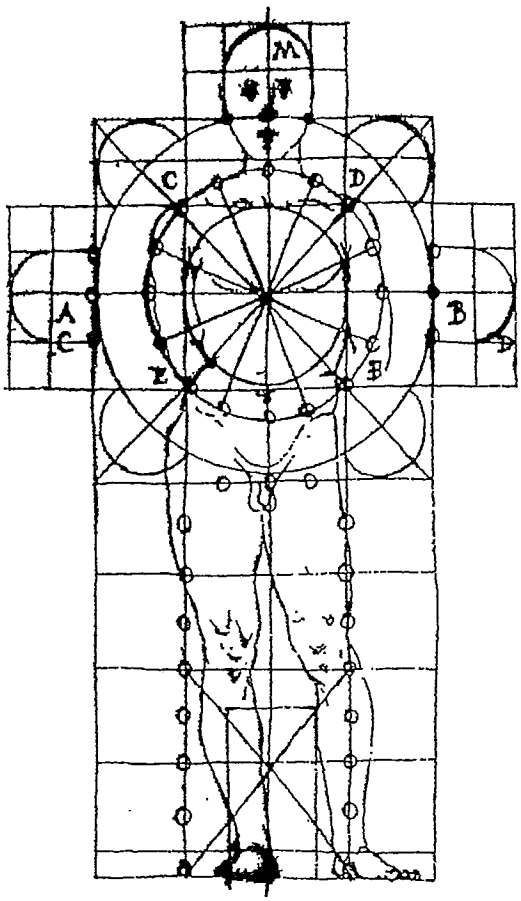
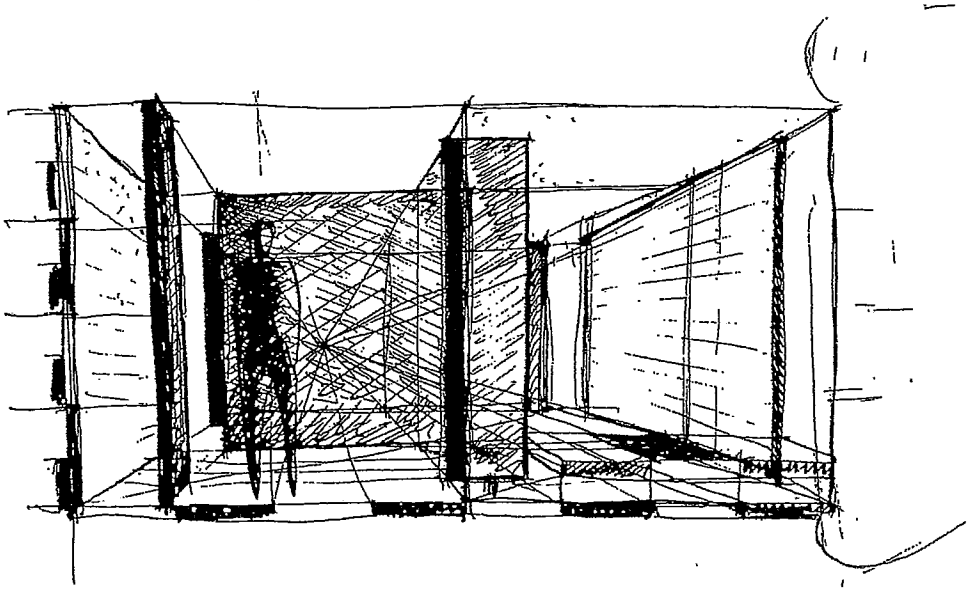


Fig. 6 *opposite above* Ernö Goldfinger, image from the invitation to his lecture *L'Architecture et l'Activité Humaine*, given at Madrid University, May 1932, incorporating façade details of square and 2 : 3 proportion from his project for a Flying Club

Fig. 7 *opposite below* Ernö Goldfinger, 2' 9" planning grid and 11" module applied to domestic design, from *Architectural Design*, January 1963

Fig. 8 *left* Francesco di Giorgio, temple and body, fifteenth century, *Codex Magliabechiano*, after Wittkower, *Architectural Principles in the Age of Humanism*

Fig. 9 *below* Ernö Goldfinger, sketch for *This is Tomorrow* exhibition pavilion, 1956, showing 2' 0" design module and a 3 : 4 proportion for the left-hand space



Architecture in 1923,[30] and a copy was acquired the same year by the twenty-year-old Ernö Goldfinger.

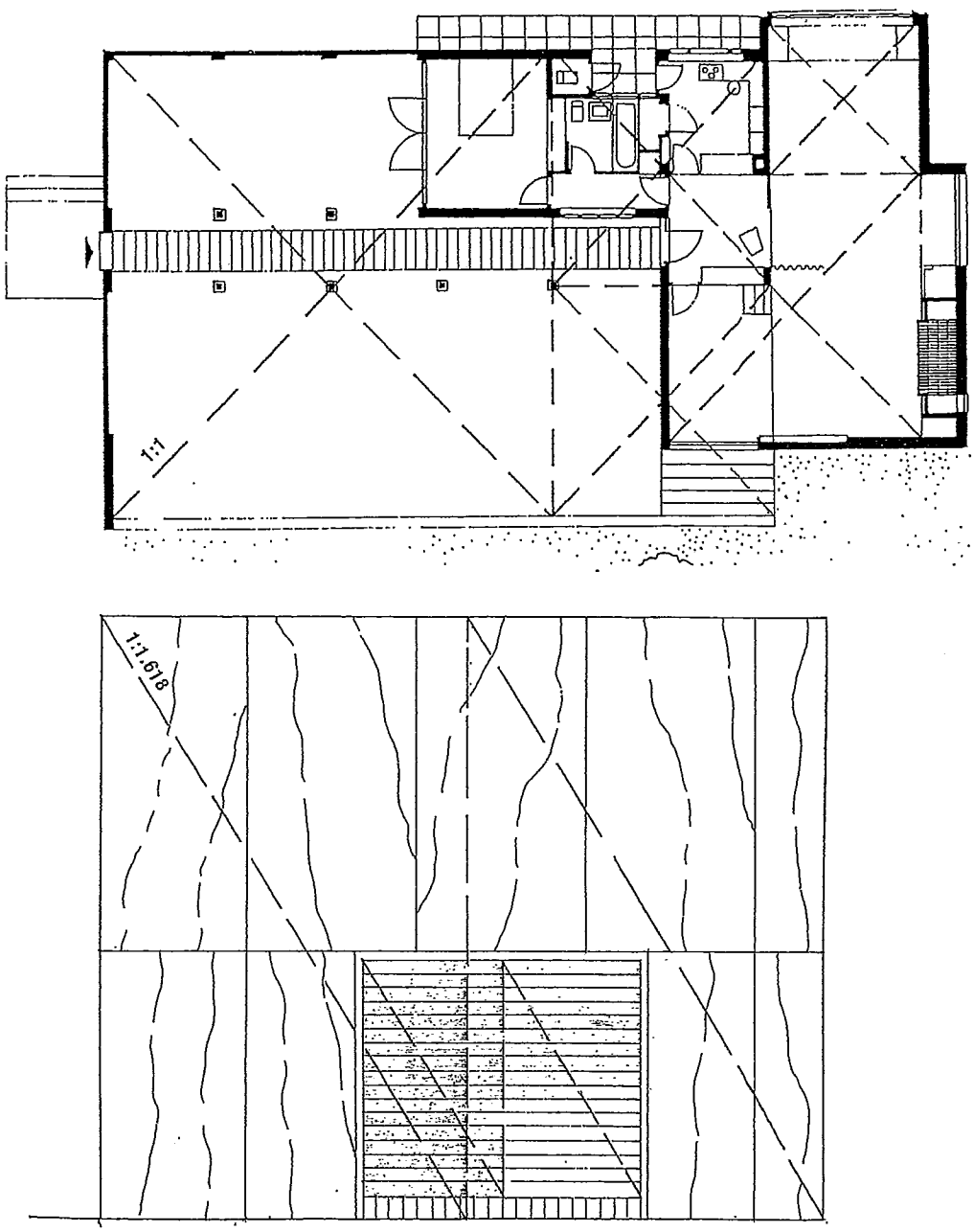
In addition to the influence of Perret and Le Corbusier, Goldfinger was exposed at this time to the theories of J.-N. Durand, whose two major works, the *Précis des Leçons d'architecture données à L'Ecole Polytechnique* (1809) and the *Receuil et Parallele des Edifices de Tout Genre, Ancien et Moderne* (1800) — the *petit* and *grand* Durands — he acquired for the Perret *atelier* where he was keeper of the book collection.[31] Durand's works had passed out of regular pedagogical use around the middle of the nineteenth century, but his rationalist approach and insistence on a square planning grid (Fig. 4) were consistent with Perret's work, and Goldfinger may have sensed a sympathetic parallel between Durand's association with the period of the Revolution and Perret's *Communard* family background. Titles of books relating to proportional theory and apparently dating from the Parisian years listed in Goldfinger's collection at the end of his life, but now dispersed, include Matila Ghyka's *Le Nombre d'Or* (1931) and *Essai sur le Rhythme* (1938), *Une Cathédrale au Nombre d'Or* by 'Tetraktys' (n.d.), and *De La Proportion* by Dr Ch. Furuk-Hellet (n.d.). He was to continue to add to these till the end of his life, with further works by Matila Ghyka, and others such as *Mathématique de l'Esthétique* by J.C. Moineau (1969).

During the later 1920s, after the dissolution of the Perret *atelier*, Goldfinger was virtually a sleeping member of the Ecole, making the minimum contribution required to remain on the student roll. It was not until the climate of opinion had changed in favour of Perret that Goldfinger felt able to submit his Diploma project, 'A Flying Club' (Fig. 6), which he did successfully in 1931. Meanwhile he carried out numerous projects for apartment and shop interiors, as well as making ambitious but unsuccessful entries to competitions. In 1933 an opportunity came to build a free-standing building: the small studio for the Lahousse family at Cucq near Le Touquet. This is much altered and the few drawings in the Goldfinger archive at the RIBA, mostly plans, do not permit a study of its vertical proportions.

GOLDFINGER IN ENGLAND

The pre-war years

After moving to England with his new English wife Ursula Blackwell in November 1934, Goldfinger was presented in 1936 with another opportunity to build afresh. The modest single-storey single-bedroom studio house for the painter, diplomat, and landscape designer Humphrey Waterfield at Broxted in Essex, which survives in altered form, provided him with the opportunity for an elaborate exercise in geometrical composition based on the square, and also for introducing the Golden Section (Fig. 10). The composition of square block-like elements sitting on a podium around a courtyard is reminiscent of Le Corbusier's Villa Mandrot of 1930–31, where the



Figs 10a and 10b Ernö Goldfinger with Gerald Flower, Waterfield House ('Hill Pasture'), Broxted, Essex, 1937
10a Plan with suggested proportional scheme of squares superimposed
10b Elevation of the inglenook fireplace with suggested proportional scheme of Golden Section rectangles superimposed (drawing by James Dunnett)

Goldfingers had stayed as guests of Madame de Mandrot, *patronne* of the CIAM. As at the Villa Mandrot, the views out to the surrounding countryside are carefully controlled to form a sequence, in this case out into the extensive garden which his client, a landscape designer, had already begun to create before the house was designed. But the large wall planes of brick on the exterior suggest Goldfinger's admiration for English Georgian architecture, which Adolf Loos recommended that he look at on his first visit to London in 1927 in connection with the design of a *salon* for Helena Rubinstein. They have a sense of monumentality that is distinctly his own. There are some similarities in the plan of the Waterfield house to the pin-wheel plans of Frank Lloyd Wright. The large inglenook fireplace is a Wrightian feature, and Wright too used square grids. Goldfinger was certainly an admirer of Wright at this time, writing to him in 1935 and later mounting an exhibition of his work at the Building Centre, equipped with a stereometric viewer to permit an appreciation of the three-dimensional spatial effects in the works on view.[32] Goldfinger also acknowledged a Surrealist influence in the spatial ambiguities of the entrance sequence across the courtyard; and the use of the fall in the ground to create a stepped floor level between the living and dining areas is suggestive of the *Raumplan* of Adolf Loos.

The podium on which the upper level of the house sits is a square-and-a-half in proportion, or 2 : 3, and the planning of the house is based on overlapping square elements: the entrance hall, the studio, the kitchen, and various combinations of them. The face of the chimney-breast housing the inglenook, distinguished from surrounding plastered walls by its plywood lining, comprises two adjacent, vertical Golden Section rectangles in proportion (Fig. 10b). The opening for the fireplace within the breast shares the same proportion as the breast itself, an illustration of Goldfinger's thesis that the objective of proportional design is to achieve harmony through the repetition of elements of similar or related ratios.

At about the same time, Goldfinger created what was one of his most polished works, a toy shop for Paul and Marjorie Abbatt in Wimpole Street, London, now destroyed. Despite the dimensional constraints of the existing building within which he was working, he was able to manipulate the width of the opening and the depth of the set-back of the main shop window so that they conformed to his preferred ratios (Fig. 11). The overall dimensions of the shop window were 2 : 3, divided at door head height by a steel channel running its full width. The glazing above was in turn divided into three panes each of 2 : 3 proportion, and the single large pane below was of double-square proportion horizontally, with the glass door alongside it forming a double square vertically. The whole of the window was set back from the street line so as to create an area of calm in which to stand undisturbed and look at the goods exhibited inside – a design feature to which Goldfinger frequently returned. The soffit above this recess was panelled in plywood, of triple square overall proportion. It is worth noting that Goldfinger did not apparently attempt to create the elaborate constructions of overlapping proportional ratios which Roberto Gargiani has identified in

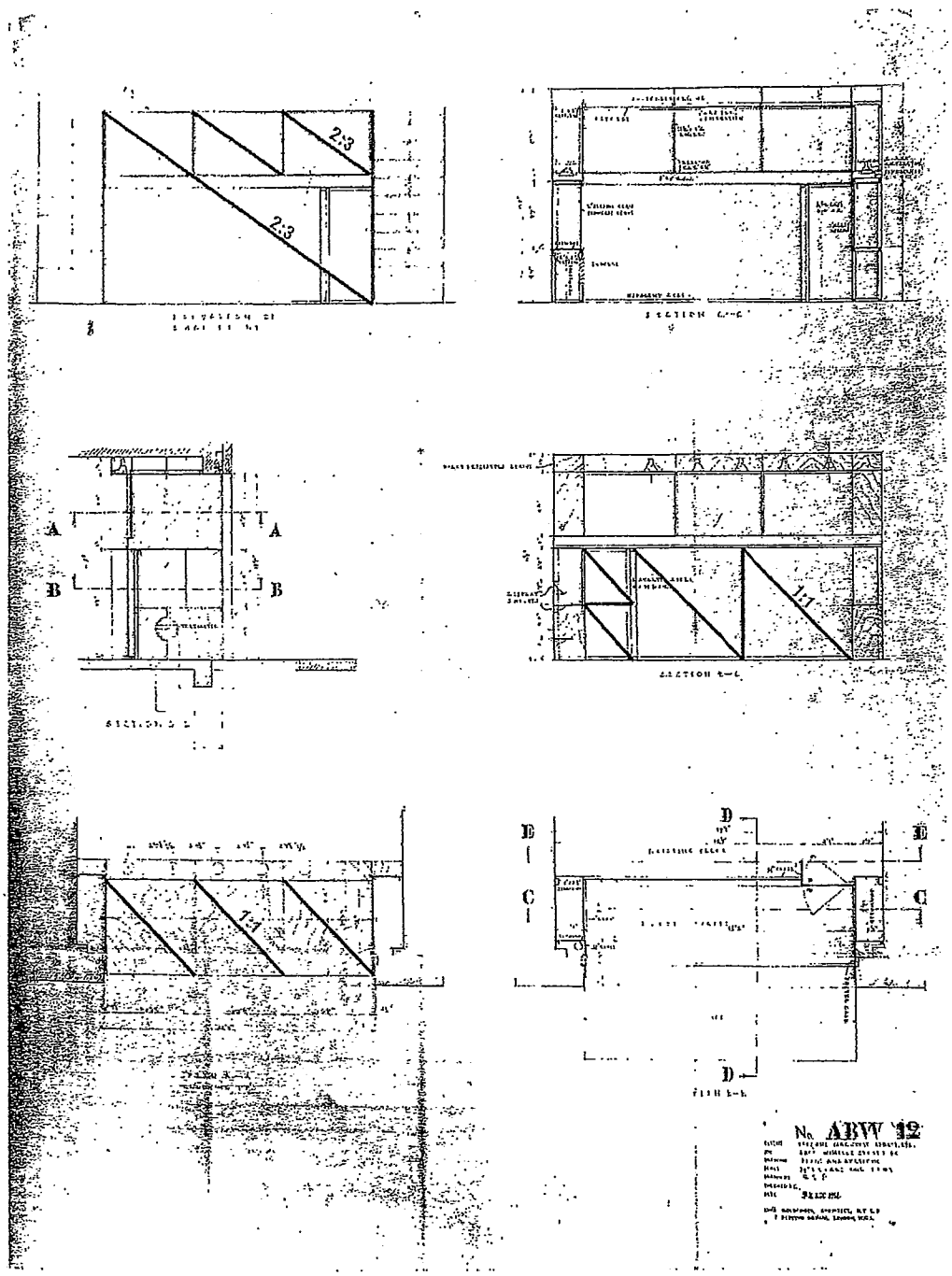
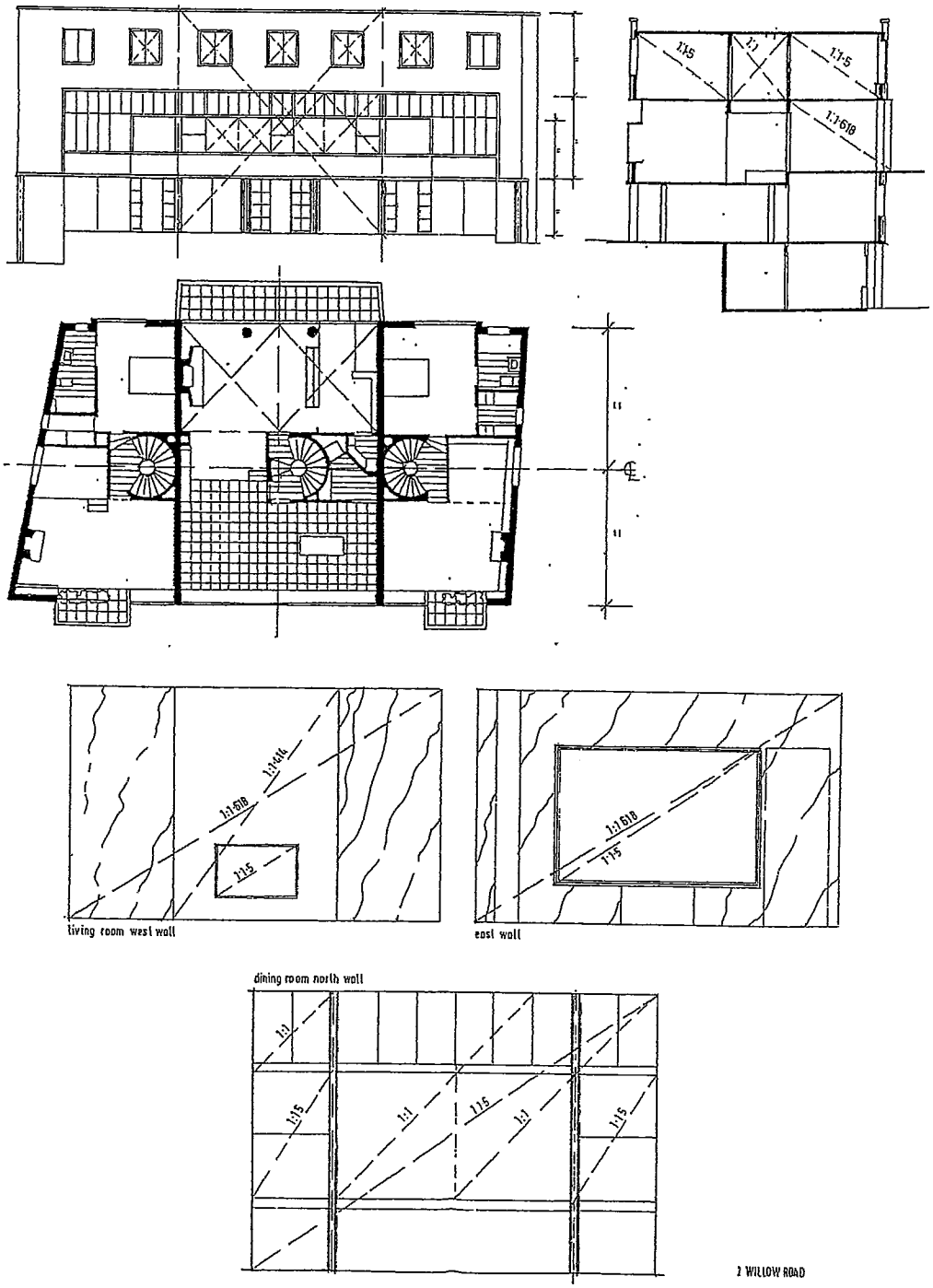


Fig. 11 Ernö Goldfinger, toy shop for P. & M. Abbot, Wimpole Street, London W1, 1936, working drawing (British Architectural Library, RIBA, London), with suggested proportional scheme of squares and 2 : 3 rectangles superimposed

the work of Perret. Goldfinger's proportions are usually simple and clearly identifiable, as in this example.

The culminating work of Goldfinger's pre-war career in London was the terrace of three houses in Hampstead, Nos. 1–3 Willow Road, designed 1937–38 and built 1938–39. The central house, No. 2, was built for Goldfinger's own occupation, and because the irregularities of the site boundaries were absorbed by the two end houses, his own could be geometrically pure (Fig. 12).

Like other architects before and since, Goldfinger hoped to establish his practice by carrying out his own development, but the intervention of the Second World War delayed any benefits of this kind. His intention had been to build a block of flats with studios for artists, including his wife, but he was refused planning consent. The house that he built was nevertheless a manifesto, both in terms of its proportional *schema* and of its site, chosen because of its view of Hampstead Heath, affording 'the "essential joys" of sun, space, and greenery' demanded by Modern Movement architects and especially by Le Corbusier.[33] The stepped section at first floor level, repeating a Loosian theme from the Waterfield house, creates rooms of noble height at the front above the entrance hall and garages. The front elevation is highly articulated with the extended Mendelsohnian sweep of the first floor windows uniting all three houses in a single compostion, but held in check by a classical stability owing something to designs by Perret, such as the studio of Chana Orloff. The proportional schema appears simpler and more legible than that of Perret, according to Gargiani's interpretation.[34] The façade of No. 2 Willow Road forms a perfect square, with the square second-floor windows lying on the diagonal. The principal fixed first floor windows form double squares, with the flanking opening lights of 2 : 3 overall proportion. In plan the circular stair lies central on the cross axis, with the doorway from it into the living room lying on the central axis from front to back. The original publication of the house in the *Architectural Review* of April 1940 noted, no doubt at Goldfinger's suggestion, that 'a marked characteristic of the [living] room is the carefully studied relationship between the proportions of the rectangular fireplace, screen, and display frame and those of the room itself', but does not venture any further explanation. The key, it would seem, is to be found in the fact that the rear façade is cantilevered out by 9" at first floor (living room) level. This is sufficient to allow the vertical members of the concrete framework, embedded in the walls above and below, to stand out as two free-standing cylindrical columns within the living room, and to establish canonical proportions in plan and section. The living room, if taken with the study — from which it is divided by a lightweight partition composed of stacked storage units from Goldfinger's Parisian apartment — is a double square on plan, entered on the median line, while the cross-section (and therefore the internal end elevations) conforms to a Golden Section rectangle. The curved chimney breast or 'screen' is a rectangle of $1:\sqrt{2}$ proportion, and the fireplace opening within it is 2 : 3, a proportion echoed by the display-frame facing it at the other end of the room. The



Figs 12a and 12b Ernö Goldfinger, 1–3 Willow Road, London NW3, 1938

12a Plan, section, and elevation with suggested proportional scheme of squares superimposed (drawing by James Dunnett)

12b Internal east and west elevations of living room of No. 2, with north elevation of dining room below, and suggested proportional scheme superimposed (drawing by James Dunnett)

cross-section of the second floor hall is square, and the same family of proportions can be found elsewhere in the house.

The war and post-war years

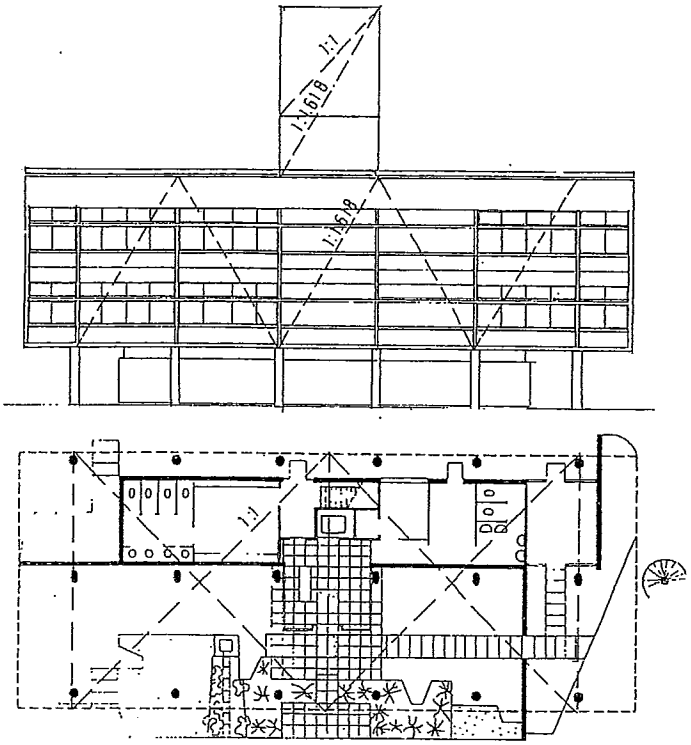
The war years were largely devoted to exhibition design, theoretical housing studies, and to writing three important articles for the *Architectural Review*, principally on the theme of spatial sensation.[35] There is discussion of scale but not of proportion. A number of unbuilt designs were made for evacuation camps of lightweight construction but highly formal conception, which would merit further study.

The post-war years brought an opportunity to build a new house for Colonel W. B. Fletcher, for whom he had designed an ICI exhibition stand in 1938. This house in Henley-in-Arden, built in 1947, survives in much altered form. It was presented as two separate houses to circumvent post-war restrictions on floor area, and was required by the planning authorities to have a pitched roof, though the original design had been flat. There were terraces for sleeping outside at night, a beautiful position, and a curved chimney-breast 'screen' similar to Willow Road. From the point of view of proportion, its significance was that Goldfinger here deployed for the first time by his own account his conception of a 2' 9" (840 mm) planning grid, which could be subdivided into three units of 11" or eleven units of 3". Two feet, nine inches was the width of a standard 2' 6" door plus frame — 'The most obvious contact between persons and building, the most governed by size, is a door'.[36] With the addition of a 3" skirting, it was the height of a standard kitchen worktop (Fig. 7). Goldfinger thus saw the 2' 9" dimension as being derived from the ergonomic dimensions of man, and it became the basis of most of his design afterwards. Its application to standard domestic built-in furniture was illustrated in his book *British Furniture Today* of 1951, and in *Architectural Design* January 1963. At the Fletcher House the grid was used to define the dimensions of rooms. So for example, the dining room was four units by six, 11' 0" x 16' 6", or 2 : 3, with the principal wall thicknesses occupying an intermediate zone, while in later practice the grid continued uninterrupted with the walls on either side of, or centred on, the grid lines.[37]

Slightly larger projects followed, such as two primary schools, the *Daily Worker* offices (now demolished), and flats in Regent's Park Road.[38] But it was not until 1956, when Goldfinger was 54, that his practice began to pick up substantial momentum and his mature architectural style emerged. It is a testament to his reputation that he was invited to participate that year in the exhibition, *This is Tomorrow*, held at the Whitechapel Gallery, London. The exhibition has been seen by Reyner Banham as a seminal event, inaugurating Pop Art and New Brutalism,[39] and the other participants belonged to a younger generation.[40] Architects, painters, and sculptors were invited to collaborate in teams to create pavilions expressing the inter-relationship between their work. Goldfinger collaborated with Victor Pasmore as painter and Pasmore's then wife

Helen Phillips as sculptor. Of all the participants, it was arguably Goldfinger who took the brief most seriously, and whose pavilion made the only real attempt to define a relationship between the three arts in formal terms.[41] Goldfinger took human scale and the enclosure of space as his theme, leading the viewer on a tour through the pavilion with wall planes defining spaces punctuated by the artworks, and framing views out. The plan was reminiscent of the Waterfield House, and Goldfinger privately published an off-print showing the two plans together next to his exhibition text, 'The Art of Enclosing Space'. In this text, he wrote: 'A particle is snatched from space, rhythmically modulated by membranes dividing it from the surrounding chaos: that is Architecture ... these membranes are modulated by the painter. The sculptor provides pivotal points in space ... By functioning as a microcosm of the ensemble, painting and sculpture extend and crystallize the architectural idea'.[42] On a wall adjacent to the entrance to the pavilion he drew a life-size human figure with eye level, indicating the human viewpoint, strongly marked, and a vertical scale in feet alongside. For the pavilion was planned on a 2' module and not on Goldfinger's favoured 2' 9" module. It was precisely 16' 0" square on plan and 8' 0" high, with three spaces: an unroofed cube, a roofed cube, and an unroofed double cube. A number of vigorous sketches for the pavilion survive, mostly featuring scales and the human figure, and the annotation recurs: 'TO THIS MEASURE OF MAN' (Figs 3, 9). On one sketch, the phrase is printed within the upper of two 3 : 4 rectangles, the lower being divided by its diagonal into two 3 : 4 : 5 triangles, with the numbers written within it and the sides and diagonal appropriately calibrated (Fig. 3). Best known for demonstrating Pythagoras's theorem for right-angled triangles, it is difficult to perceive what significance this triangle had for Goldfinger in this instance other than to validate the 3 : 4 proportioning he was investigating for the spatial design of the pavilion (Fig. 9). Theo Crosby commented in *Architectural Design* that Goldfinger's was 'perhaps the most sophisticated space in the show'.[43] Basil Taylor wrote in *The Spectator* that it was 'the most mature, confident, and persuasive example of the constructivist ideal of co-partnership'.[44]

In 1956 construction also began on two important projects, the offices for Carr & Co. in Birmingham (Fig. 13), and Nos. 45 and 46 Albemarle Street, London, which were treated as one architecturally, with offices above ground floor shops. (Figs 1, 15) The two projects have a quite different character architecturally. The Carr & Co. offices — free-standing on an industrial estate — are more Corbusian, raised on *pilotis* and with *brise soleils* on their southern façade, a language not repeated by Goldfinger. Albemarle Street — on a street frontage — is more Constructivist and more typical of his later work, with its emphatic framework, pronounced cornice, projecting bay windows and recessed clerestorey windows. Both projects embody his proportional ideas. The five complete bays of the façade of the Carr & Co. offices above *piloti* level are each Golden Section in proportion, with two cantilevered half-bays at either end, whilst the end elevations above *piloti* level are of 2 : 3 proportion. The flat roof was



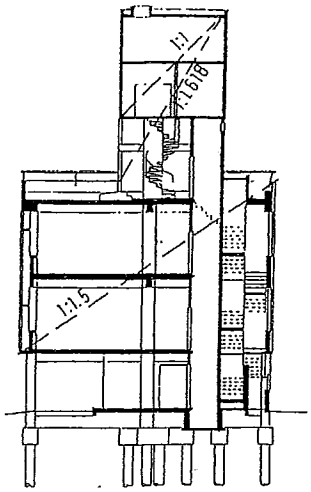
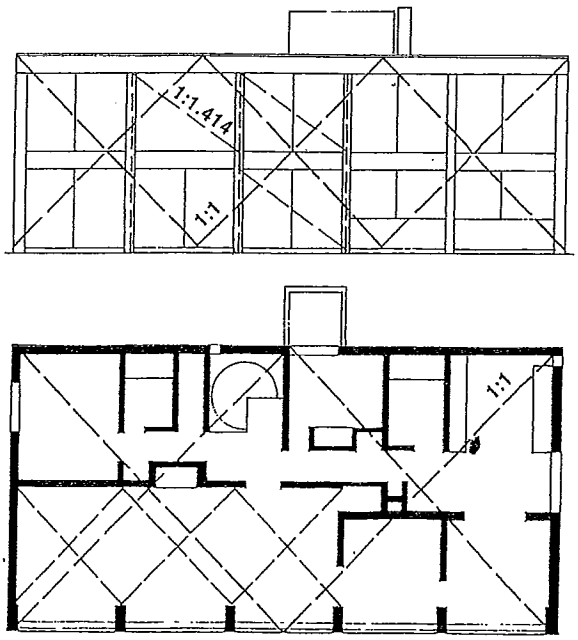


Fig. 13 Ernö Goldfinger, Carr & Co. offices, Shirley (Birmingham), 1956, plan, section, and elevation, with suggested proportional scheme of Golden Section rectangles, with double square plan, and square plant and tank room superimposed (drawing by James Dunnett)



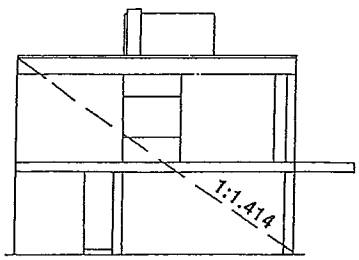
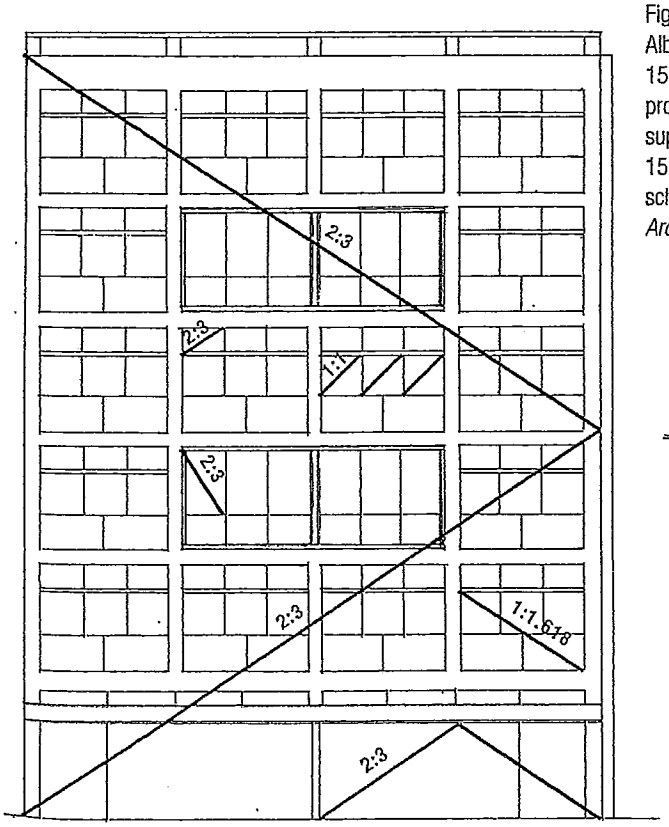
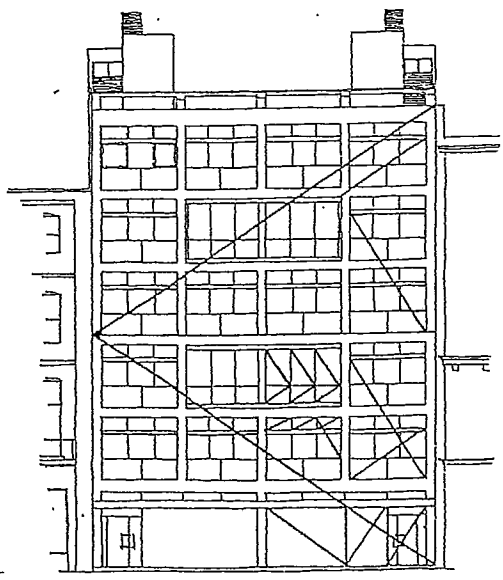


Fig. 14 Ernö Goldfinger, Player House, Kingston, Surrey, 1961 (demolished), plan, section, and elevation with suggested proportional scheme based on $\sqrt{2}$ rectangles, double squares, and triple squares superimposed.

intended as a promenade for staff, whilst the tall tower giving access to it repeats the Golden Section of the bays of the facade below it and the blind upper part housing the water tanks and lift machinery is a perfect cube. In plan, the *pilotis* are set out on a double square.

The proportions of the Albemarle Street building are controversial. For this project, uniquely, a proportional schema was published during Goldfinger's lifetime and soon after construction, but seemingly incorrectly. A drawing published in the *Architects' Journal* of 18 July 1957[45] showed the six-storey façade divided horizontally to form two stacked rectangles described as Golden Section, in conjunction with a review by J. M. Richards, who commented that, 'some architects take great account of these things, though I can't pretend to do so myself' (Fig. 15b). This drew the rejoinder from Goldfinger in the following issue that, 'I design all my buildings on a proportion derived from the square ... and use a rigorous control of the elements of





Figs 15a and 15b Ernö Goldfinger, 45–46 Albemarle Street, London W1, 1956
15a *left* Elevation with suggested proportional scheme based on 2 : 3 rectangles superimposed (drawing by James Dunnett)
15b *below* Elevation with proportional scheme described as 'Golden Section' from *Architects' Journal*, 18 July 1957

facades and plans. The plans are also controlled by a grid of 2' 9" ... This gives me a control of scale'.[46] In this particular case, it was not in fact possible to impose a 2' 9" grid within the narrow width of the bomb-site. As for the proportions of the elevation, by setting the building back sufficiently from the street line, Goldfinger was able to produce an unbroken façade of six regular storeys within the requisite light angles, without a mansard or set-back at the top. If measurements are checked from working drawings, the resulting façade can be seen to comprise two rectangles stacked vertically of 2 : 3 proportion — not Golden Section. The lower measures 48' 1½" x 32' 0", the upper 48' 1½" x 31' 7½". The 2 : 3 proportion was repeated in the clerestorey windows above the 'photobolic screen'[47] bay, and shop windows (Fig. 15a). Richards' original information that the rectangles were Golden Section can only have originated from Goldfinger himself, who did not contradict it in his rejoinder. If, as he said, his use of proportion was instinctive with little trace in terms of drawings, one must assume that Goldfinger himself had forgotten which proportion he had used.[48] But the Golden Section does in fact seem to play a role: the rectangle formed by each bay below the 'photobolic screen' is in the Golden Section, or 1 : 1.618, proportion. The principal windows themselves are square (3' 6" x 3' 6¼").

It is worth noting that these proportions are not numerically exact. The exigencies of building construction and of the design in detail are such that in practice the canonical ratios must serve as a guide rather than a straitjacket. Otherwise the Golden Section, for example, would throw up impractically small 'incommensurable' fractions, incompatible with the dimensions of bricks and other modular elements. Rudolf Wittkower in *Architectural Principles in the Age of Humanism* accepts a wide margin as inevitable between execution and theory in his proportional study of Palladio's work,[49] while William Camfield, writing on Juan Gris and the Golden Section, accepts deviations of up to 3 per cent for the purpose of his study, even where there are no technical constraints on the artist.[50] For the present study, deviations of up to 2% have been regarded as falling within the canonical ratio for Goldfinger's work. The upper rectangle at Albemarle Street described above represents a 1.7% deviation from the 2 : 3 ratio, the lower a 0.03% deviation.

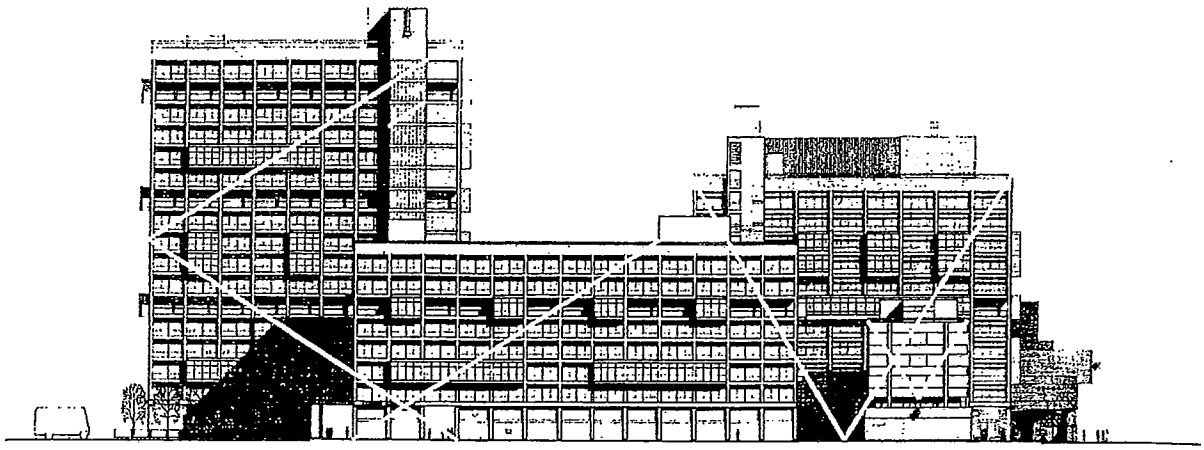
An ambitious speculative study carried out in the same period together with H. T. Cadbury-Brown, who had worked with Goldfinger in the 1930s, was for a thirty-storey office skyscraper in Moorgate, divided into three blocks of ten storeys each.[51] It was to have been Golden Section in overall proportion, with each of the blocks forming a double square. The rather similar office tower proposed, but not built, for Bloomsbury Square seven years later was to have been of 2 : 3 proportion overall.[52]

With Goldfinger's success in 1959 in the LCC-promoted competition for the site of Alexander Fleming House came the opportunity not just to make studies but to build on a large scale. This immense project in the Elephant and Castle comprehensive re-development area in South London provided 300,000 square feet of offices, mostly

leased by the Government for use as the Ministry of Health, and a 1000-seat cinema. The cinema has since been demolished and the offices insensitively converted into flats, but the outline of Alexander Fleming House remains. It represented (and in fragmentary form still represents) Goldfinger's most comprehensive built architectural statement, a finely-judged Constructivist composition of cumulative masses and highly modelled facades, held together by the insistent geometry of its structural framework. The major proportions of this framework were consistent throughout with the Golden Section. The whole complex was laid out both horizontally and vertically on Goldfinger's 2' 9" grid, modified in places by his 11" module. The structural grid is 16' 6" (2' 9" x 6), or (11" x 18), and the storey height 10' 1" is ([2' 9" x 4] – 11"), or (11" x 11) (Fig. 16). The resulting standard bay dimension of 16' 6" x 10' 1" deviates from the Golden Section by 1¼", or approximately 1%. The overall proportions of the blocks reflect the same ratio. The spacing between the blocks is controlled by the same grid as the dimensions of the blocks themselves, in a manner reminiscent of Perret's replanning of Le Havre, where the whole re-built core of the city is laid out on a single square grid. At Alexander Fleming House, as at Albemarle Street, the nature of the structural framework as a grid is emphasized by the equal face dimensions given to the columns and edge beams.

The four principal blocks of Alexander Fleming House, now the 'Metro Centre', are aligned north-south in echelon formation around a central courtyard of square proportion. The eighteen-storey north and twelve-storey south blocks, B and D, lie on axis and are flanked symmetrically by nine-storey A and C blocks. B and D blocks both comprise two Golden Section rectangles, stacked vertically in the case of B block and horizontally in the case of D. The overall dimensions[53] are 150' 0" x 185' 4" in the case of B, which divides into two rectangles of 150' 0" x 92' 8". D block is also exactly 150' 0" long and divides into two rectangles of 75' 0" x 123' 5". These rectangles are each within 2% of Golden Section. The upper part of the small five-storey E block, housing the district's eponymous pub which is square on plan, comprises two rectangles of similar proportion to D block, in front of which it stands. Each is 37' 7" x 22' 9½", within 2% of Golden Section. The two flanking blocks, A and C, are exactly half the height of B block and therefore underline its median division into two Golden Section rectangles and generate their own rectangles of similar proportion, for example, the courtyard face of A block from its northern corner to the stair tower. The projections above the main parapet line, such as stair towers and lift motor rooms, also conform to square or Golden Section ratios. Goldfinger's use of the Golden Section can be seen to be consistent throughout the design, and this repetition of a single ratio surely lies at the root of its architectural harmony.

While Alexander Fleming House was being built, Goldfinger designed and built a private house for his relatives by marriage, Mr and Mrs Player, in Coombe Hill, Kingston, Surrey, now demolished (Fig. 14). A serene two-storey pavilion, it comprised a double square in plan, set well back on its site so as to create a series of tight



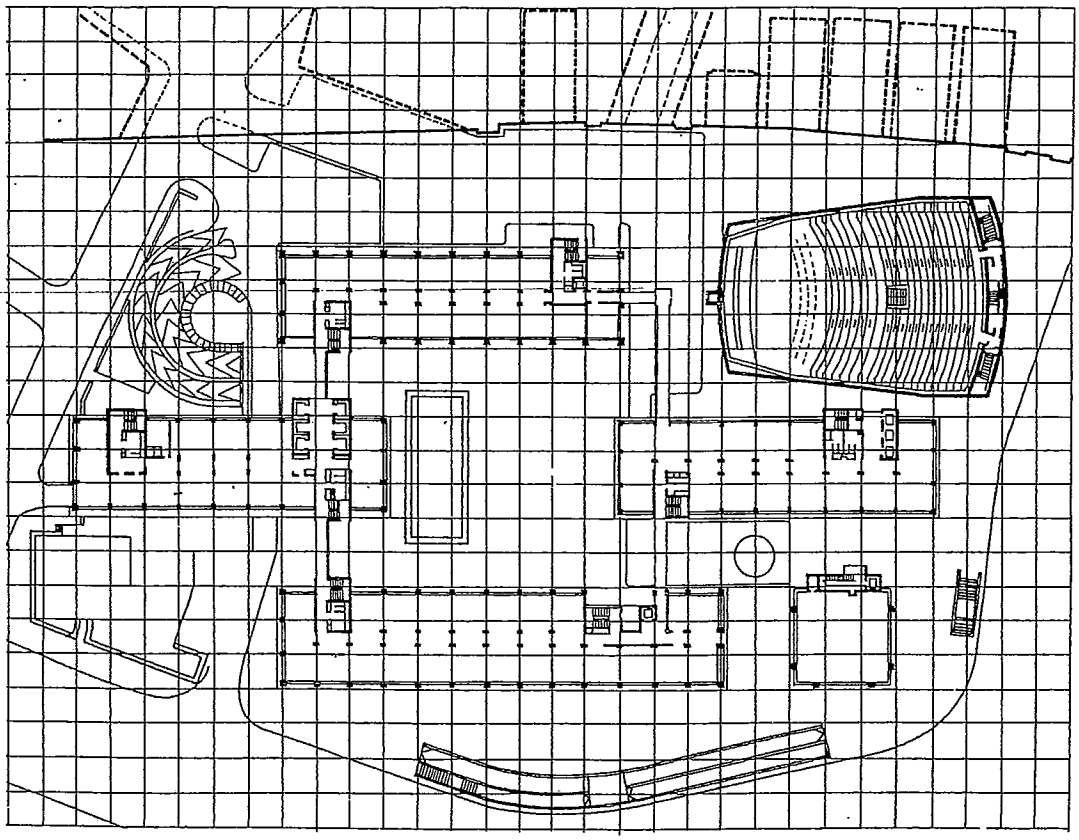


Fig. 16a and 16b Ernö Goldfinger, Alexander Fleming House (formerly Ministry of Health, now 'Metro Centre'), Elephant and Castle, London SE1, 1959

16a West elevation with suggested proportional scheme of Golden Section rectangles superimposed

16b Original plan with the 16' 6" (6 x 2' 9") grid indicated

urban courtyards on the street side, with sweeping lawns on the garden side. The façades facing away from the garden were almost windowless, but towards the lawns there was continuous frameless glazing, set into an array of brick piers at 11' 0" (2' 9" module x 4) centres. The principal elevations formed a triple square in proportion, which was repeated by the plan of the first floor living room. The end elevations formed a rectangle of $1 : \sqrt{2}$ proportion, which was repeated by the sliding windows of the garden elevation, whilst the dressing-room window formed a Golden Section rectangle, an apparent example of the mixing of ratios. The central division of the $\sqrt{2}$ windows generated two further rectangles of $1 : \sqrt{2}$ proportion in each half.[54] A number of the other rooms were square: study, entrance hall, kitchen and principal bedroom, linked to a dressing room of 2 : 3 proportion.

The relationship that Goldfinger established with the LCC at the Elephant and Castle led to his three principal subsequent commissions, the Haggerston School, and his two major housing schemes, dominated by Balfron Tower and Trellick Tower respectively (Fig. 17). The 28-storey Balfron Tower, begun in 1965, forms part of the Brownfield Estate adjacent to the northern approach to Blackwall Tunnel in east London, where Goldfinger went on to build two other substantial blocks, Carradale House and Glenkerry House, as well as a number of smaller buildings. Balfron Tower itself contains 156 apartments of various sizes served by access galleries on every third floor, leading to a widely detached lift and service tower at the northern end. The dramatic relationship between these two elements of the tower, and the space between them, constitutes one of Goldfinger's most powerful inventions. He explained that the boilers, rubbish chute and lifts were generators of noise and this justified their being widely separated from the flats themselves. The larger buildings are of bush-hammered concrete, the smaller of brick, and they are of crosswall construction. The crosswalls of Balfron tower are on 22' 0" centres (2' 9" module x 8), and its principal façade is designed around a central feature of exactly double square proportion: the honeycomb stack of full-width windows and balconies of the west-facing flats, which measures 108' 4" x 216' 8". Marking the dividing line between the two squares is a row of double-height balconies corresponding to a row of larger maisonettes inside. The proportion of these voids is within 1.5% of Golden Section (20' 8" x 12' 11½"), and lying on the diagonal are the small pulpit-like balconies serving the upper level of the maisonettes, which are also of Golden Section proportion (7' 2" x 4' 5").[55]

Where at Balfron Tower the double square was set within a block of broader dimensions, at Trellick Tower it is delineated by the overall proportions of the block itself. The 31-storey residential slab, the construction of which started in 1967, is the central feature of the GLC's Cheltenham Estate in North Kensington, and is similar in arrangement and size to Balfron Tower. The crosswalls are at a wider 22' 11" spacing (2' 9" x 8) + 11". The overall dimensions of the principal, south-facing, façade, excluding the detached lift tower, are 143' 9½" x 283' 9", within 2% of double-square. Within this, the stack of full-width balconies form a feature comprising four Golden

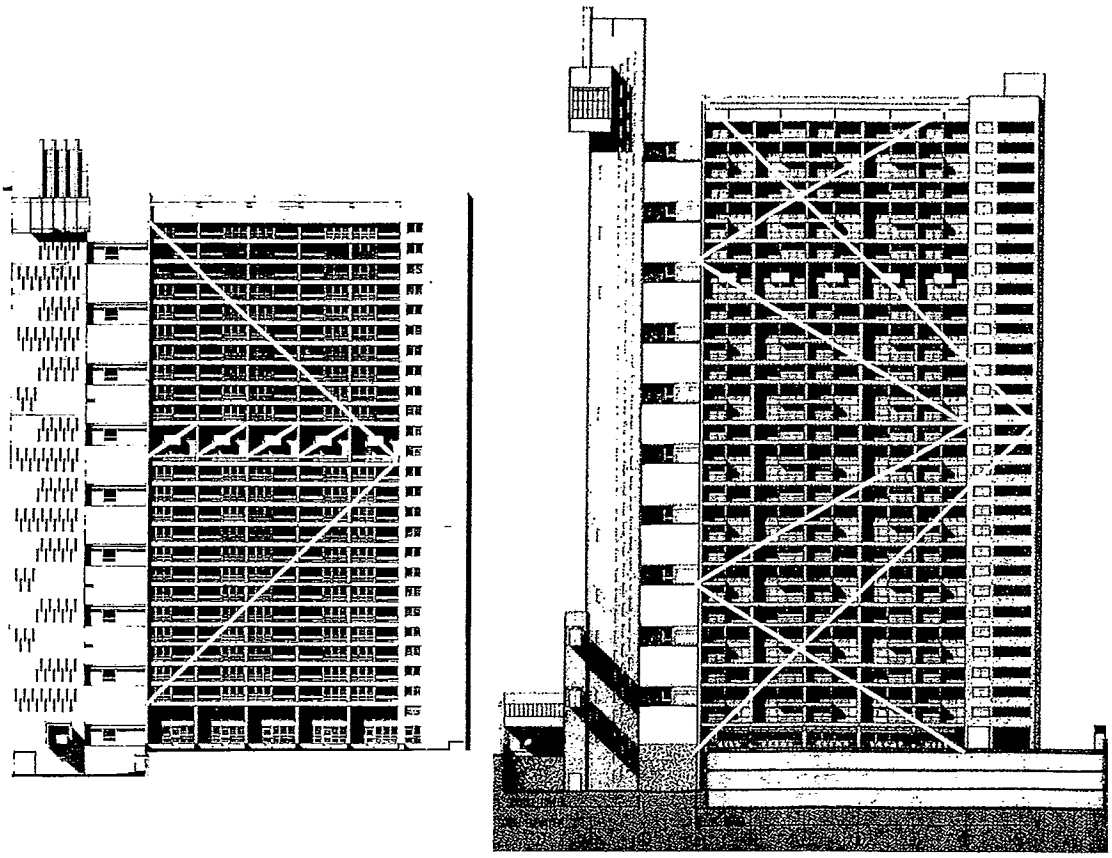


Fig. 17 Ernö Goldfinger, Balfron Tower, London E14, *left*, 1965, and Trellick Tower, London W10, *right*, 1967, to the same scale, and with suggested proportional schemes of double squares and Golden Section rectangles superimposed (British Architectural Library, RIBA, London)

Section rectangles, each measuring 114' 7" x 70' 11¼" and covering eight storeys. A coloured glass screen dominates the now much-altered entrance hall of Trellick Tower. Its powerful colouring forms a foil to the sombre concrete of the exterior, and it provides a microcosm of the architectural geometry of the whole, in the manner Goldfinger proposed for works of art in his pavilion for *This is Tomorrow*. It is exactly 11' 0" square overall (2' 9" x 4), comprised of elements either 11" square, or 11" x 22" double square.

Goldfinger's last executed design was the Perry House, Windlesham, Surrey, of 1968. It is all of timber, in two single-storey linked wings each fronted by an arcade of fine cruciform columns at 8' 3" centres (2' 9" x 3). The full-height windows are square, until the fall in the ground towards the north makes it possible to step down the floor

slab, increasing the living room ceiling height and leaving the dining area on a raised dais overlooking it, exactly as in the Waterfield house of thirty-two years earlier.

In 1972 Goldfinger had to move his office from the corner of Dover Street and Piccadilly where he had been since the war, and relocated to an empty shop unit at Trellick Tower, originally intended as a pub. A fine set of drawings survives for the fitting out of this interior, which is now destroyed. Goldfinger's own room in this new office was approximately square in cross-section and square-and-a half on plan (there is a 3% deviation in each case). It was apparently planned (although this was not carried out) to paint a set of scales on the wall next to the door into the room, facing Goldfinger's desk, and a spiral derived from the Golden Section rectangle on the long wall next to it (Fig. 21).[56]

In the event, Goldfinger's practice did not last long at this new location. He was already seventy when he moved there, and his work was completely out of fashion. His name could no longer help to obtain planning permissions for developers and a new generation was in power at the GLC. His last project, a new factory for furniture manufacturers Hille & Co., was cancelled during Edward Heath's three-day week, and Goldfinger closed his office and retired in 1977, having spent the last year supervising the production of a series of beautiful analytical drawings of Trellick Tower.[57] For the entrance to the retrospective exhibition of his work at the Architectural Association in 1983 he designed a screen illustrating the themes of his work and of his proportional practice. His sketch[58] indicated that the panel should be Golden Section, but in the event it was 2 : 3, or 8' 3" x 5' 6", three units of 2' 9" in one direction, two in the other.

GOLDFINGER AND MAN AS THE MEASURE

Human size, scale and proportion

Goldfinger definitely appreciated the sense of certainty which a 'rational' approach to design, based on a system of mathematical control, gave him. But there was also the human dimension which could provide the module for a building so that it might truly be 'To The Measure of Man'. An insight into Goldfinger's interest in the synthesis between constructional rationalism and the human dimension is contained in his article on Perret's Nôtre Dame du Raincy.[59] Having noted the square schematism of its plan, Goldfinger moves to the human proportions evident in Nôtre Dame in Paris without, however, actually connecting them with Perret's Nôtre Dame. He then makes a different point when he contrasts these with 'the abstract mathematical proportions' of the Greek temple. Perret was also to extol the relationship between a cathedral's human proportions and the anthropometrics of its dimensions, again in contrast to 'the buildings of antiquity'.[60] This might seem to demonstrate a confusion in both their minds over the classical and medieval traditions with regard to human proportion, in

which the classical tradition was construed as 'abstract' and the medieval 'human'. Yet Goldfinger's rationalism was as firmly rooted in the medieval tradition as it was in the classical. On one occasion, he could declare himself to be 'a Classical architect',[61] on another sometimes classical, sometimes medieval.[62] As shown in the quotation at the head of this article, he regarded Gothic architecture as rational and Viollet-le-Duc as the first modern architect.[63] Likewise, in attributing human proportions to the Cathedral of Nôtre Dame, Goldfinger appears to be holding to the view, shared by Perret, that human scale was to be found not in the classical tradition, in which scale was fixed, abstract and unrelated to the human, but in the medieval tradition — something which in important respects both architects otherwise eschewed. In 1941, Goldfinger insisted that:

> [It] is essential to realize the importance of size or 'scale' in order to comprehend the absurdity of the venerable classical assumption of self-contained ideal spatial proportions without relation to human size, and to reflect on the complete absence of scale articulation in classical architecture (that is, in Renaissance and Baroque architecture and their academic bastards) ...[64]

Yet by 1954, Goldfinger could echo Perret's belief that:

> ... the architect's endeavour was to modulate structure, to bring it to human scale, to tie this new structure of reinforced concrete to the historic tradition of France and at that to the classical tradition of the last 300 years ... [65]

Of course size and scale are not the same, as Goldfinger well knew. The distinction which he is drawing is between ideal proportions, which are not related to human size, and human scale which is related, thereby raising the elusive relationship that exists between size, scale and proportion. For the classical, medieval, and Renaissance worlds, a direct link existed between human proportions and ideal proportions, for it was then assumed that an idealized human body was constructed in accordance with ideal proportions, in fact that they were ideal because they were both human and universal. But Goldfinger was concerned with the human body as a source of scale rather than of proportion, and for him there would not therefore seem to be any necessary direct connection between the use of abstract geometrical figures such as the square, and the notion of human scale. And yet the image he devised for his lecture *L'Architecture et L'Activité Humaine*, with the écorché human figure superimposed on details of his Diploma project with its square and 2 : 3 windows and wall panels, implies that there is such a connection. The very name of the lecture implies a link between purely formal and ergonomic criteria. What was it?

The answer seems to lie in the idea of harmony, or perhaps, repose. A building that is ergonomically adapted to human use is restful, easy on body and mind, easy to use. Ergonomics in this sense is about scale rather than proportion, in other words, absolute lengths, distances, heights, rather than ratios between them. An instance which Goldfinger gave of the blindness to ergonomic comfort in classical architecture was the height of the plinth or stylobate of a temple.[66] According to his reasoning, a Greek temple was always approached up three steps, no matter what its size, and their height

was a fixed ratio in relation to the columns. The result, of course, was that for larger temples the steps became uncomfortably high, and it became necessary discreetly to insert intermediate steps, without disturbing the architectural ideal. For Goldfinger, however, this represented an example of abstract formal ideas taking precedence over the human. According to him, if the human dimension could be felt, it gave a yardstick whereby humans could judge height and scale: a storey for height and a door for width. This consideration doubtless lay at the root of his dislike of curtain wall buildings,[67] which mask the rhythm of the individual storey and therefore give no clue to scale in relation to human height. So important for him was this yardstick, this rhythm, that in all his projects for tall office buildings, from Moorgate to Bloomsbury Square, not only did he underline each individual storey by means of recessed clerestorey windows, but he insisted on setting back or projecting every fifth storey as either a balcony or a bay window. The eye could in this way measure the building, he explained, by reference to the height of a normal four or five storey London house.[68] At the same time these modulations of plane served to emphasize the structural frame and the measure of scale which it afforded. Likewise in the design of exhibitions, he was very concerned to have exhibited material restricted to a band comfortably within eye level, within the easy scope of the human gaze from standing height, as can be seen for example in the drawings for his 1943 exhibition *Twenty-Five Years of Soviet Progress*.[69] This consideration conforms to the distinctly Modern Movement conception of architecture for human welfare. Again, as noted previously, the level of the eye above ground was strongly emphasized in the life-size drawing of a human figure that marked the entrance to his pavilion at *This Is Tomorrow*.

It may be seen therefore that Goldfinger's greater concern was for human size and scale than for human proportions. Returning to his and Perret's attribution of human scale to the medieval tradition rather than to the classical, it can be shown, however, that the middle ages were just as attached to the concept of ideal human proportions as the classical age and this was also true of Goldfinger's other system of architectural proportioning, namely square schematism. Furthermore, they could both equally have been transmitted from Vitruvius, either through the medieval world, or from the Renaissance, or even directly to Goldfinger, for a copy of Vitruvius was to be found on Goldfinger's shelves.

According to Vitruvius,[70] it was because nature had devised the human body so that its parts are in proportion to the whole that the ancients ordered their work in like manner. Temples should possess exact proportions after the fashion of the human body, with dimensions worked out in pursuit of *symmetria*, meaning the agreement of measures. These in turn were based on the digit, foot, cubit and so on, as Perret was to observe of cathedrals. Without describing how such proportions might be applied to the design of temples, Vitruvius demonstrates those of the human anatomy, including, famously, how the navel is the exact centre of a circle described by the body with hands and feet outspread.[71]

He also understands that the numbers six and ten were in some way significant. In his description of the Ark, Augustine points out that the height of a man is six times his breadth and ten times his depth from back to front.[72] From late in antiquity, it was also understood that six was regarded as perfect for being the sum of its parts and for representing the perfection of creation, which God had completed in six days. In another sense, ten was perfect, as attested by the Ten Commandments, promising a state of perfection were they all to be obeyed. Thus in finding these numbers in the human body and in the Christian universe, the harmonious relationship between macrocosm and microcosm, as put forward in Plato's *Timaeus*, was maintained. This, in Christian terms, translated into the association of the temple with Christ's body.[73] If the temple symbolized the cosmos, in the form of the City of God, Christ incarnate represented mankind and therefore the human microcosm.[74] In this way, Vitruvian Man became Cruciform Man, with direct implications for the symbolism attaching to the cruciform church of the medieval period.[75]

It is hardly surprising therefore that at the tail end of the Middle Ages, Francesco di Giorgio was drawing the plan of a church with a human body superimposed over it, with the whole being generated from circles and squares (Fig. 8). Leonardo da Vinci also sketched a similar design for a church, whilst his friend, Pacioli, was transmitting Vitruvius's observation that the ancients proportioned their temples in accordance with the human body and that it possesses the ratios and proportions to be found in God's creation, the principal figures of which are the circle and the square. So Pacioli wrote in his treatise *De divina proportione*, which Leonardo illustrated; and Leonardo himself drew man as the measure of all things, inscribed within a circle and a square. Vitruvian Man had returned, although in reality he had never really been away.

Goldfinger's view of Vitruvius appears to have been a modernist one. For whilst Vitruvius transmitted ideal human proportions and their relationship to the universe, Goldfinger's concern was with human scale and its relationship to human size. Vitruvius defined measure in terms of anthropometrics and their proportional relationships to the human body; Goldfinger related anthropometrics to ergonomic dimensioning. For example, his establishing of a module by which a door case is 2' 9" wide and 6' 8" high is a matter of ergonomics and dimension, not proportion. Much closer to Vitruvius, however, was Goldfinger's use of the square in his system of architectural proportion, either on its own, or in grids, or in rectangles derived from the square.

Square schematism[76]

In practical terms, Goldfinger's combination of the rational with the human produced a system of constructional modules that were sized through a consideration of ergonomics.[77] It has already been shown that this resulted in his planning grid of squares for application to both vertical and horizontal planes, in which the basic units were 2' 9", subdivided into 3 units of 11" (Fig. 7). It will be recalled that this was extended

across whole sites, such as Alexander Fleming House (Fig. 16) in which the squares are 16' 6" and the principal bays are 16' 6" x 10' 1", i.e. (6 x 2' 9") x (11 x 11"), or (18 x 11") x (11 x 11"). Thus from domestic kitchen to government ministry complex, a common unit of measure was applied which related both to human ergonomics and to constructional components and resulted in grids of squares.

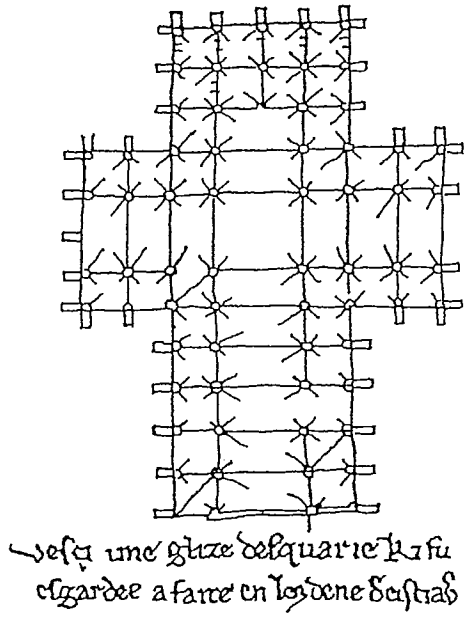
Individual squares pervade Goldfinger's work. Examples include the plan for the caretaker's house at Haggerston School,[78] windows in their characteristic precast concrete frames in the Wandsworth School[79] and in the glazing systems of both the Moorgate project[80] and Albemarle Street offices.[81]

As it happens, square schematism is to be found in each of the traditions which can be seen to have influenced Goldfinger. It can be seen in the formal rationalism of Durand and in Perret's own work. Surprisingly, it is less evident in the writings of Viollet-le-Duc so admired by both Perret and Goldfinger, despite Viollet's own functional and structural rationalism. Perhaps because of his conspicuous interest in medieval structural performance, Viollet-le-Duc's analysis of this and of the proportions underlying it are largely confined to the vertical plane, not the plan, which he perceives in any case in terms of selected triangles, not squares.[82]

Ad quadratum and quadrature

Yet there is an intriguing possibility that a medieval tradition of construction was handed down to the masons' families from whom Perret was descended. In the Middle Ages, grids of squares are to be found in the thirteenth-century *Portfolio* of Villard de Honnecourt,[83] notably as a plan for a Cistercian church, which its caption states is made of squares (Fig. 19).[84] This is not exceptional, for square planning, or designing *ad quadratum*, is evident from the ninth-century *Plan of St Gall*[85] to the late fourteenth-century layout of Milan Cathedral.[86]

The additional importance of the square as a proportioning device can similarly be seen in Vitruvius and Villard. Villard's *Portfolio* appears to illustrate a paraphrase by Vitruvius of the method for doubling a square of a given area cited by Plato in his Dialogue *Meno*.[87] The method requires a square to be inscribed and rotated within another square.[88] Rotating squares within each other in this way became a procedure, known as quadrature, whereby medieval masons produced their constructional details. The technique is demonstrated in a group of late medieval handbooks, in which the elevating of pinnacles and gablets is achieved by superimposing the plans of their various stages and taking the heights from them for each stage. Another application positions a wall to its grid and produces the profiles of mullions (Fig. 20).[89] In other words, it was a system in which all the parts were related to each other and to the whole, a purely Platonic idea once more, and were thus regarded as being in harmony; and at the root of the system lay the square. Given Perret's family connection with masonic tradition and Goldfinger's rational view of the medieval tradition, it is



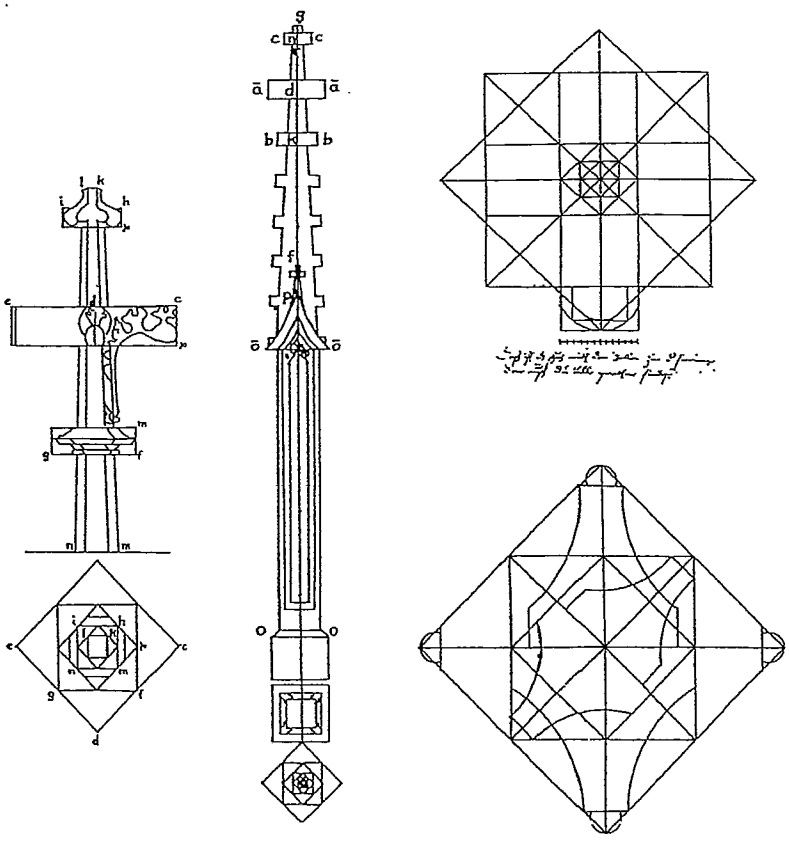


Fig. 18 *above* Boethius demonstrating the musical ratios on a monochord. Boethius, *De musica*, twelfth century, Cambridge University Library, MS. li.3.12

Fig. 19 *above right* Villard de Honnecourt, Cistercian plan of squares, *Portfolio*, fol. 14^{v}, after J. Dimier, *Recueil de plans d'églises cisterciennes*, Grignan (1949)

Fig. 20 *right* Quadrature. Left: Elevation of a finial; Roriczer, *Wimperbüchlein*, fol. 2^{v}, *c.*1490. Centre: Elevation of a pinnacle; Schmuttermayer, *Fialenbüchlein*, fol. 2^{v}, *c.*1488. Right upper: Quadrature from wall thickness. Right lower: Mullions from quadrature; Lechler, *Unterweisung*, fol. 42^{v}, 1516

possible therefore to see in their reliance on square proportioning a pedigree as much medieval as classical. As modernists, however, their rational view of the medieval world appears untroubled by any interest in meaning, or why the square should have been of such interest to the medieval masonic tradition.

Signification

In order to understand the medieval enthusiasm for square schematism, it is helpful to return to Vitruvius, for it was he who stated that architecture consists of that which signifies and that which is signified.[90] Yet if he appeared unsure of the connection between the two, the middle ages were habitually concerned with signification. Not surprisingly, the square was associated with unity, equality and stability[91] and, as expressed as 1 : 1, with the musical ratio of unison (Fig. 18). This, it has already been pointed out with reference to Didier and the monastery of Beuron, constituted the foundation of plain-chant.[92] According to Augustine, 'the harmony between the single and the double', namely unison and diapason, is of the greatest importance for by this means the treble and bass voices are unified.[93] The geometric counterparts of these musical ratios, when expressed as 1 : 1 and 1 : 2, are the square and the double square. Given the importance attached to treatises on Moses's Tabernacle and Solomon's Temple,[94] it will have been understood by ecclesiastical patrons that both structures consist of a square and a double square,[95] while Villard's Cistercian plan is composed entirely of square and double square bays. Thus, although no causal connection between medieval thought and square schematism can be claimed, a correlation certainly appears to exist.

The square and its derivatives

This present study has tried to show that subsumed within Goldfinger's square schematism are certain derivatives of the square which, in his reply to J. M. Richards, he states were rectangles proportioned according to the Golden Section, as well as $\sqrt{2}$, $\sqrt{3}$, $\sqrt{4}$ and so on.[96] In the *Architectural Review* interview cited above, Goldfinger again claims the use of the Golden Section rectangle, along with rectangles proportioned 1 : $\sqrt{2}$ and 2 : 3.[97] This second group of rectangles strongly recalls Vitruvius once more.[98]

Although these rectangles are not directly related to each other, they are each directly derived from the square (Fig. 22). The 1 : $\sqrt{2}$ rectangle is proportioned according to the side and diagonal of a square, the 2 : 3 rectangle is a square and a half, whilst the Golden Section rectangle is generated by the $\sqrt{5}$ diagonal of a double square. Of equal importance to geometric harmony, both the Golden Section and $\sqrt{2}$ rectangles retain their proportional integrity, when the former has a square added to, or subtracted from it, and when the latter is halved or doubled.[99]

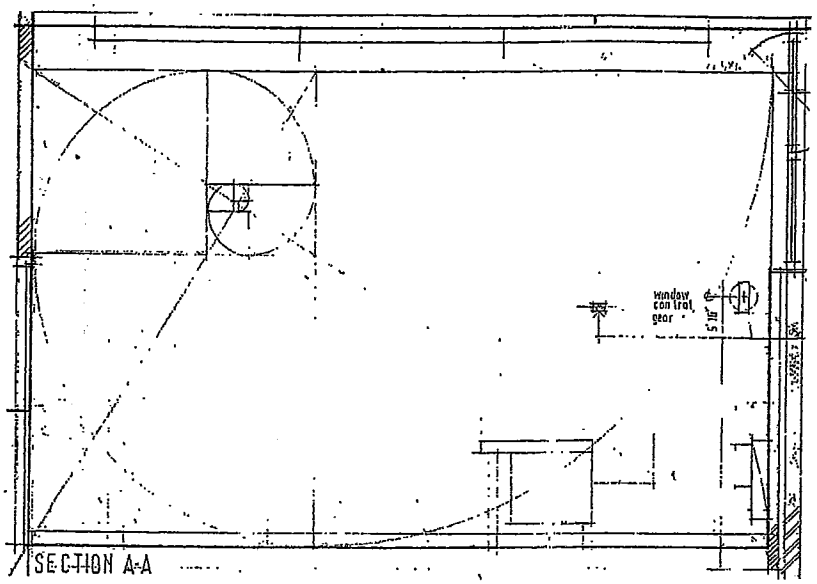


Fig. 21 Ernö Goldfinger, design for proportional diagram to be painted on one wall of his office in Trellick Tower, London W10 (unexecuted), 1970, with spiral based on the Golden Section (British Architectural Library, RIBA, London)

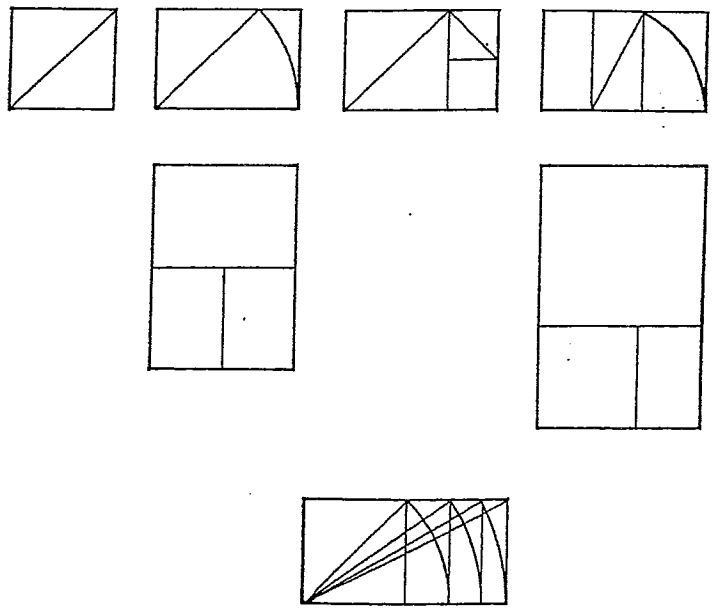


Fig. 22 Goldfinger's rectangles, showing how each is derived from the square. *Top, left to right*: Square; 1:√2 rectangle, or side and diagonal of square; 2:3 rectangle, or square and a half; Golden Section rectangle, generated by √5 diagonal of half square. *Middle left*: halving and doubling √2 rectangle produces rectangles which are also 1:√2 in proportion. *Middle right*: contracting and expanding a Golden Section rectangle by subtracting or adding a square produces rectangles which are also Golden Section in proportion. *Bottom*: 1:√2, √3, and √4 rectangles are all generated by the diagonal of the previous rectangle, starting with the square (drawing by Nigel Hiscock)

CONCLUSION

Essential as the square was to Goldfinger's work, both on its own and as the root of these rectangles, the importance to him of its history and its meaning in history is less certain. Such is the persistence of the romantic myth of both the classical and the middle ages, that anyone may be excused for the over-simplification of associating the classical with the rational and the medieval with the human. Yet it has been argued here that the converse was also true. The concept of man being the measure of all things in the classical world and his connection in classical thought with the cosmos are better understood than the rational basis of medieval design. However, the evidence demonstrates the essential rationalism of medieval planning, from the grid-iron layouts of bastide towns to the modular design of cathedrals such as Salisbury, especially when laid out unfettered on virgin sites, and the associated practice of designing *ad quadratum* and the technique of quadrature. This was a rationalism born of metaphysics and mathematics, which not only embraced human proportion and geometric harmony, but did so in order to embody and convey universal meaning.

Although no justification is offered by either Vitruvius or Goldfinger for the choice of the proportions which they advanced, there can be little doubt in the case of Goldfinger that he applied them as an abstract ordering principle in order to create controlled variations and rhythm within his square schematism. The purpose of this was the creation of geometric harmony, which may reasonably be argued as constituting its own justification. The starting point was the square, a constant in his work from the Reservoir of 1926 to the Perry House more than forty years later, the most regular rectilinear form, and hence the most harmonious. If his 2' 9" module is applied in both directions it generates a grid of squares. But buildings cannot be designed only with square elements; a broader range of proportions is required which, if derived from the square, will maintain the same family of proportions and dimensions. That the $\sqrt{2}$ and Golden Section rectangles, derived from the square, are also capable of proportional expansion and contraction would be reason enough for their selection, for the essence of proportional control was held to be repetition of the same proportion, in order to achieve harmony. The different derivatives of the square should not therefore be mixed, as Goldfinger noted towards the end of his life.[100] It can be seen, however, that on occasion he did mix them. While in general his façades are based on the square and just one of its derivatives, as at Alexander Fleming House and Balfron Tower and Trellick Tower, his designs for Willow Road, the Carr & Co. offices, Albemarle Street, and the Player House appear to combine the square with at least two other rectangles. With the exception of the Player House, however, those projects in which the proportions are not mixed are the last and largest, reflecting perhaps a final resolution and simplification of his thought.

Before this was achieved, Goldfinger's use of geometric proportion shows itself to be deceptively undogmatic. By his own admission, it was 'largely instinctive', enabling

him to assert the use of two sets of rectangles on different occasions, although they have the Golden Section and $\sqrt{2}$ rectangles in common.[101] Within a year of its completion, the use of the Golden Section is reported for his Albemarle Street facade, whereas the proportions as built are 2 : 3; the 3 : 4 : 5 triangle, in an apparently isolated instance, might lead him to a 3 : 4 proportioning for his pavilion at *This is Tomorrow*, the Golden Section to a grand spiral for his Trellick Tower office. His use of proportion in such instances appears to have been a developing one, searching rather than systematic, but there can be no doubt about the sense of certainty throughout his career in the finished work. This, it may be seen, is in large part due to the clarity with which Goldfinger distinguished between those intangible attributes of architectural design, namely scale and proportion, whereby his dimensional module created for him human scale and his square schematism harmonious proportion.

The authors are grateful to Carr & Co., to Mrs F. J. Mackay, and to Ms Anna Motz for permission to visit the Carr & Co. offices, the Fletcher House, and the Motz House during research for this article. We are grateful to Philip Boyle for his assistance with the illustrations. The authors are also grateful for the permission of the syndics of Cambridge University Library for Figure 18, as it appears in *The Flowering of the Middle Ages*, edited by Joan Evans. Finally, the sketches in Figure 20 are reproduced by kind permission of the American Society of Architectural Historians and Southern Illinois University Press, the latter for material published in *Gothic Design Techniques* by Lon Shelby.

NOTES

1. From the transcript in James Dunnett's possession of the interview with Ernö Goldfinger published in shortened form in the *Architectural Review*, April 1985, pp. 47–48.
2. The drawing (Fig. 15b) which appeared in the *Architects' Journal*, 18 July 1957, p. 107, is of the office building at 45–46 Albemarle Street, London, of 1956, and is discussed below. Plans clearly illustrating Goldfinger's planning module were also published in his lifetime, for example in *Architectural Design*, April 1948, p.78, as applied to the Fletcher House.
3. Maison de Verre, Rue St Guillaume, Paris, by Pierre Chareau and Bernard Bijvoet, 1932.
4. The book was announced, prepared and typeset for publication by Studio Vista in 1970, as part of a series edited by Dennis Sharp, but never appeared. The proofs survive in the Goldfinger papers in the RIBA.
5. James Dunnett, *RIBA Transactions 2*, 1982, pp. 19–26; *Architectural Review* April 1983, pp. 42–47. The influence of Russian Constructivism was not acknowledged by Goldfinger, but he was certainly familiar with it from 1925 onwards.
6. These are as follows:
   1. Ernö Goldfinger, 'Der Baumeister unser Lieben Frau' [about Perret's church of Nôtre Dame du Raincy], *Pester Lloyd* [German-language newspaper], Budapest, 30 December 1925, p. 8. Quotations are from an unpublished translation by Iain Boyd Whyte, 'Our Lady's Master Builder'.
   2. Feature on Goldfinger's houses at Willow Road, Hampstead, in the *Architectural Review*, April 1940, pp. 149–53, with unsigned text perhaps by Goldfinger himself.
   3. Goldfinger's pavilion at the exhibition entitled *This Is Tomorrow*, at the Whitechapel Gallery in London of 1956, and accompanying text, later entitled 'The Sensation of Space' and published in Dennis Sharp (ed.), *Planning and Architecture — Essays Presented to Arthur Korn* (London, 1968).
   4. James Richards, 'Criticism: 45–46 Albemarle Street', *Architects' Journal*, 18 July 1957, pp. 105–07.
   5. Ernö Goldfinger, 'Criticism: The Architect Replies', *Architects' Journal*, 25 July 1957, pp. 133–34.

6. Proportional diagrams published in *Architectural Design*, January 1963, (a monograph on the work of Ernö Goldfinger 1924–62, prepared by Joyce Lowrie), p. 52.
7. Interview with Goldfinger published in *Architectural Review*, April 1983 cited at note 1 above, in which he reiterates ideas regarding proportion first articulated nearly sixty years earlier.

7. The Goldfinger drawings are not yet catalogued.
8. The comment was made in answer to a query from the joint-author of this article, James Dunnett, who worked for Goldfinger 1973–75 and who remained in regular contact with him until Goldfinger's death in 1987. During this time, Dunnett organized the 1983 exhibition of Goldfinger's work at the Architectural Association together with Gavin Stamp and they jointly compiled a monograph on his work, published by the AA. Conversations which took place throughout this period between Goldfinger and Dunnett have also provided material for this article.
9. James Dunnett, 'Roots of Goldfinger's Design', *Architects' Journal*, 28 March 1996, pp. 24–26, and 'A Sense of Proportion', *Architects' Journal*, 20 November 1997, pp. 32–38.
10. *Architectural Review*, April 1983, p. 48
11. *Architects' Journal*, 25 July 1957, article cited in note 6, item 5, above.
12. Drawings are held in the RIBA Drawings Collection and reproduced in *Ernö Goldfinger: Works 1*, compiled by James Dunnett and Gavin Stamp (Architectural Association, London, 1983), p. 28.
13. Quoted in Roberto Gargiani, *Auguste Perret 1874–1954: Teoria e Opere* (Milan, 1994), p. 172: 'the reference to the human body recurs in [Perret's] writings, beginning with his letter to Pascal Forthuny of 1913 ...' (Unpublished translation by Denzil I. Dunnett.).
14. Goldfinger, 'Der Baumeister unser Lieben Frau', see note 5, item 1.
15. The college of the University which, in that period, nurtured Lorca, Buñuel and Dalí, poet, film-maker, painter, and where Le Corbusier had lectured five years earlier.
16. The diagram is reproduced in James Dunnett and Gavin Stamp, *Ernö Goldfinger* (London, 1983), p. 84. The same 'determinist' view of architecture is also presented as a text on the invitation to the lecture *L'Architecture et l'Activité Humaine*, as follows:
'Le Besoin: facteurs biologique at sociale.
La Fonction: reponse à ce besoin.
Les Materiaux: le moyen.
La Structure: mis en oeuvre des moyens.
La Forme: resultat tangible et visible.'
17. This was recounted to James Dunnett.
18. Maurice Denis, *Théories 1890–1910* (Paris, 1912), p. 184.
19. Daniel-Henry Kahnweiler, *Juan Gris, His Life and Work* (London, 1947), p. 105. See also p. 71, where Didier is described as 'the father of the "sacred proportions"'. After World War I, discussion of proportional theory was continued by Gino Severini in his 1921 treatise *Du Cubisme au Classicisme*. Severini, Section d'Or member, one-time Futurist, and later follower of Juan Gris, was perhaps one of the other 'minor Cubists' to whom Kahnweiler refers. Kahnweiler himself burnt all Gris' preparatory drawings after the painter's early death (at his request), thus leaving almost no evidence of his methods.
20. Le Corbusier, *The Modulor* (London, 1954), p. 218.
21. Ibid.
22. Information from Joseph Abram, author of *Perret et L'Ecôle du Classicisme Structurel 1910–1960* (Nancy, 1985).
23. Bernard Champigneulle, *Perret* (Paris, 1959), pp. 13–14; Peter Collins, *Concrete, The Vision of a New Architecture* (London, 1959), pp. 154–55.
24. Dunnett and Stamp, p.12. It has also been pointed out that the practice of French classical architecture itself evolved through the medieval system of apprenticeship, with early Renaissance architects often being descendants of medieval master masons (Collins, p. 154). Moreover, it has been argued that characteristics peculiar to French classical architecture, such as corner pilasters, uninterrupted entablatures and the illusion of frame and panel construction in load-bearing masonry, seem to recall the tradition of timber-framed construction. It was the emulation of the latter, through clear structural expression and articulation of frame and panel, that arguably became the goal of Perret (Collins, pp. 163–71) and then Goldfinger. For a discussion of the influence of this tradition on Goldfinger, see Dunnett, *Architectural Review*, April 1983, pp. 42–47.
25. Le Corbusier, *The Decorative Art of Today* (London, 1987), p. 202.
26. Le Corbusier, 'Perret', *Architecture d'Aujourd'hui*, November 1932, pp. 7–10.
27. Le Corbusier, *Almanach d'Architecture Moderne* (Paris, 1927), p.95, where the sketch is reproduced with an account of a conversation between Le Corbusier and Perret about the shape of windows. Goldfinger reports Perret's view on the proportion of windows in his lecture reprinted in *Architectural Association Quarterly*, January 1955, pp. 144–56.
28. Goldfinger remembered a student tag of the time, 'Horizontal oder vertikal, die Minimax löschen alle' — 'Horizontal or vertical, the Minimax [a brand of fire-extinguisher] puts them all out'; as recounted to James Dunnett. Goldfinger himself was torn between the two.
29. The first work of Perret's in which Gargiani identifies the use of the Golden Section is the studio-house of Dora Gordin [Dora Gordine], of 1929. *Auguste Perret 1874–1954*, p. 180.
30. Translated as *Towards a New Architecture* (London, 1927).
31. Recalled by James Dunnett.

32. Goldfinger described this to James Dunnett, but no documentary information has yet been identified. Goldfinger's letter to Frank Lloyd Wright is referred to by Robert Elwall, in *Ernö Goldfinger* (London, 1996), p. 13.
33. For example, Le Corbusier, *The Radiant City* (London, 1967), p. 3.
34. See Garglani, p. 180, for an interpretation of the proportions of the façade of Perret's Orloff studio.
35. Ernö Goldfinger, 'The Sensation of Space', 'Urbanism and Spatial Order', 'The Elements of Enclosed Space', *Architectural Review* November 1941 pp. 129–31; December 1941 pp. 163–66; January 1942 pp. 5–8. These articles were reprinted in Dunnett and Stamp, pp. 47–58, with some of the original illustrations omitted.
36. *Architectural Design*, January 1963, p. 52.
37. Elwall, *Goldfinger*, p.16, quotes an article by Peter Rawstorne 'Seven Keys to Good Architecture', *Twentieth Century*, Winter 1962/63, pp. 147–48) in which Goldfinger is reported as saying 'I don't start off with theories. I see a problem; and I try to solve it. But in architecture, especially modern architecture where so many building components have to be brought under some sort of control, discipline and analysis are very important. I base everything I do on the dimensions two feet nine inches. I don't make a fetish about this. I use it because it is handy to me. Two feet nine is the width of the standard door and its jamb. Either way on a square it is also the width of a man standing comfortably with his hands on his hips. Multiply this by four and I have a grid into which ... I can fit my whole building.' Jack Blacker, Goldfinger's associate during the 1960s, remarked in a recent lecture that 2'9" was also the standard width of an LCC housing corridor and wc compartment and hence came to have direct application as a module for the planning of Goldfinger's LCC housing. It is worth noting that Owen Williams used 2' 9" in the design of the Empire Pool at Wembley in 1934 as a module for the spacing of seats and hence for the structure as a whole.
38. These are illustrated respectively in Dunnett and Stamp, p. 92, p. 90, and p. 93.
39. Reyner Banham, *The New Brutalism* (London, 1966), p. 64.
40. Goldfinger remarked to James Dunnett that he was thought to be 'older, but still kicking'. Among the other participants were the architects Peter and Alison Smithson and Jim Stirling, the sculptor Eduardo Paolozzi, and the painter Richard Hamilton.
41. Stirling, for example, took a truculent line, 'Why clutter up your building with "pieces" of sculpture ... The Painting is as obsolete as the picture rail ... The ego maniac in the attic has at last starved himself to death'. (Catalogue of the exhibition, 1956), pages unnumbered. Stirling was a member of Group 8 with Michael Pine and Richard Matthews.
42. The whole text is reprinted in Sharp (ed.), 1968, see note 6 above.
43. *Architectural Design*, October 1956, p. 335.
44. Quoted by Elwall, *Goldfinger*, p. 78.
45. A photograph, similarly marked-up, was also published in the *Architectural Review*, February 1958.
46. Goldfinger, *Architects' Journal*, 25 July 1957, p. 134.
47. The 'photobolic screen' is a horizontal shelf above the principal windows and below the recessed clerestorey windows, intended to reflect natural light onto the ceiling inside.
48. The confusion may originate with a drawing reproduced in Neumann's article, Fig. 16, and Elwall, p. 75. It is a print of the elevation, marked up with proportional lines and a diagram of the Golden Section, possibly in Goldfinger's hand, exactly as they appear redrawn in free-hand in the *Architects' Journal*. The drawing is small in scale, the lines are in broad red pencil and the elevation is in pre-final form, without the cornice and higher parapet as built. The inference might be that Goldfinger hastily drew this diagram as information for publication some three years after the design stage on an old drawing, remembering the principle of proportional schema, but not the proportions used. John Roberts, in a letter published in the *Architects' Journal*, 11 April 1996, p. 21, says that he, as someone who worked on the design development of the project, is certain that neither the Golden Section nor the $\sqrt{2}$ rectangle was used, which is largely corroborated by the findings of this study but is difficult to reconcile with the marginal sketch on the drawing. As we have seen, however, the bay beneath the photobolic screen does conform to a Golden Section ratio. It is worth remembering that the façade of the contemporary Carr & Co. offices does appear to be based on the Golden Section, and confusion between the two with the passage of time might not be surprising. It is also possible that Goldfinger chose — or was asked — to publicize a proportional *schema* for Albemarle Street because of the lively debate on this issue current at the time, whereas in the case of an earlier apparent use, such as the Waterfield House of 1936, or later ones, he did not draw attention to it.
49. Rudolf Wittkower, *Architectural Principles in the Age of Humanism* (London, 1988), p. 121: 'The many discrepancies between the plates and [Palladio's] actual buildings were and are usually attributed to careless publication ... The illustrations were to him a means of expounding his conceptions not only of planning but also of proportion, hence his theoretical measurements could deviate from the executed ones'.
50. William Camfield, 'Juan Gris and the Golden Section', *Art Bulletin* 47, March 1965, pp. 128–34.
51. Dunnett and Stamp, p. 90.
52. Ibid., pp. 110–11.
53. These are taken from the working drawings held in the RIBA Drawings Collection.
54. Blacker, in the lecture cited in Note 37, said that he believed the $\sqrt{2}$ rectangle was Goldfinger's favourite because of its unique quality of divisibility into two rectangles of the same proportion.
55. These are a feature very reminiscent of Le Corbusier's proposed Quartier de la Marine skyscraper for Algiers of 1938.
56. Juliet Leong, Goldfinger's long-serving assistant who drew it, cannot recall what the precise intention was, but confirmed the great importance for Goldfinger of the Golden Section.

57. A rendered print of one was presented as his Diploma work to the Royal Academy in London. The originals are all in the RIBA Drawings Collection.
58. In the possession of James Dunnett.
59. See note 6, item 1.
60. See note 13.
61. Quoted by Gavin Stamp in Dunnett and Stamp, p.9.
62. Recollected by James Dunnett. The attempt to find a synthesis of classical and gothic architecture was one of the themes of French architecture during the nineteenth century, a synthesis which Perret had come near to achieving in the view of Peter Collins ('It will thus be seen that Perret had gone a long way towards achieving that synthesis between Classical Rationalism and Gothic Rationalism envisaged by the French nineteenth century Eclectics ...', *Concrete*, p. 220). It would not therefore necessarily be inconsistent for a pupil of Perret such as Goldfinger to see himself as representative of either. Goldfinger wrote of Perret in the *Architects' Year Book*, 1956, p. 43 that 'Viollet-le-Duc's clear tectonic theories inspired him throughout his life and it is remarkable that he never fell into the trap of medievalism ...' But in a lecture in 1954, reprinted in the *Architectural Association Journal*, January 1955, pp. 144–56, he said that 'Perret was an architect in the sense of the Gothic master builders ... [he came to the teaching atelier] to talk to us about the Parthenon and about the mosques at Constantinople, about Chartres and Amiens and the Sainte-Chapelle — he had just built the church at Le Raincy himself — about shuttering for reinforced concrete ... If you look at the plan [of the Musée des Travaux Publics of 1937] superficially it might be just a Beaux-Arts project, but if you look at the section you see a real Perret integration of structure and spatial enclosure. There are perfectly proportioned concrete pillars, beams and infillings, perhaps Greek, perhaps Gothic, but certainly Perret at his best.'
63. Dunnett and Stamp, p.12.
64. Ernö Goldfinger, 'The Sensation of Space', *Architectural Review*, November 1941, reprinted in Dunnett and Stamp, pp.47–50 (p.48).
65. Ernö Goldfinger, 'Auguste Perret', *Architects' Year Book*, 7, 1956, pp. 43–48 (p. 47).
66. This and the following observations are recollected from conversations that took place between Goldfinger and James Dunnett. See note 8.
67. According to Goldfinger, 'like stockings burglars wear', *Architectural Review*, April 1983.
68. *Architectural Design*, June 1955.
69. Illustrated in Dunnett and Stamp, p.61. Also illustrated on the same page is the *Eastern Front* exhibition of 1942, making the same point.
70. Vitruvius, *De architectura*, III.1.
71. Ibid.
72. Augustine, *Contra Faustum*, XII.4; *De civitate Dei*, XV.26.
73. John 2.19–21.
74. Augustine, *De civitate Dei*, VIII.24.
75. As early as the eleventh century, the abbey church of St Trond in Flanders was described as being modelled on the human body, with the head equated with the sanctuary, the arms with the transepts and the body with choir and nave (*Gesta abbatum Trudonensium*, PL 173, 318). Whilst it is still a commonplace to refer to the body of a church and to its transept arms, chevet in medieval French meant head. In the following century, Honorius of Autun stated that cruciform churches stand for the way Christians are crucified by this world and Hildegarde of Bingen confirmed that the relationship between human microcosm and the cosmos was still very much in the medieval mind (Honorius, *De gemma animae*, 47; Hildegarde, *Liber divinorum operum*, Pt 1, Vision 4). Citing many instances of measurements in which a correspondence of proportions was envisioned by her between the two, she also follows Vitruvius in noting that man's height is equal to his breadth with arms outstretched, as the firmament is equal in length and breadth; his four limbs correspond to the four winds and further analogies are made between the elements and humours, the seasons and senses. She also cites various equalities in the measures of adjacent parts of the body, as between head and torso, torso and abdomen, with arms and legs divided evenly at the elbows and knees. This can be portrayed as an image of a man in the form of a Latin cross measuring five units by five, five being noted as the number of human senses. M. Davy, *Initiation à la symbolique Romane* (Paris, 1964), p. 169, Fig. 3; A. Derolez and P. Dronke, *Hildegardis Bingensis: Liber divinorum operum*, Corpus Christianorum 92 (Turnhout,1996), pp. xlix–li, 102.
76. Square schematism generally refers to supposed methods of medieval plan design in which the square is posited, either as a planning grid, or as square compartmentation and to which the system of quadrature can also be seen to be related. See for example F. Bucher, 'Medieval Architectural Design Methods 800–1560', *GESTA*, 11.2 (1972), pp. 37–51.
77. Notwithstanding their differences, this was very similar to, and anticipated, the corresponding part of Le Corbusier's *Modulor*.
78. Caretaker's house, Comprehensive School, Haggerston, London, 1963; see Dunnett and Stamp, 84.
79. Primary School, Brandlehow Road, Wandsworth, London, 1950; see Dunnett and Stamp, 92.
80. Office project, Moorgate, London, 1955; see Dunnett and Stamp, 96.
81. Office building, 45–46 Albemarle Street, London, 1956; see Dunnett and Stamp, 99.
82. Even the plan of Bourges Cathedral Viollet presents as a series of right-angled isoceles triangles which, if true, simply means that it consists of a grid of squares, like Milan Cathedral in succession to it. See especially E. Viollet-le-Duc, *Discourses on Architecture*, tr. B. Bucknall (London,1959), pp. 382–445; *Dictionnaire raisonné* (Paris,1858–68) passim; Vol. 7 (1864), pp. 546–47, p. 547, Fig. 6.

83. Villard de Honnecourt, *Portfolio*; Paris, Bibliothèque Nationale MS. Fr.19093. If not an architect, Villard was certainly actively interested in the practice of architecture.
84. Villard, op. cit., fol. 14v.
85. St Gall, Stiftsbibliothek MS. 1092. See for example W. Horn and E. Born, *The Plan of S. Gall* (Berkeley Cal.,1979), I. xxviii.
86. See J. Ackerman, '"Ars sine Scientia nihil est": Gothic Theory of Architecture at the Cathedral of Milan', *Art Bulletin*, 31 (1949), p. 88, note 14, Fig. 5.
87. Vitruvius, op. cit., IX. Pref. 4, 5; Villard, op. cit., fol. 20; Plato, *Meno*, tr. B. Jowett, 4th ed. (Oxford,1953), p. 82f.
88. By drawing the diagonals of the inner square, which also quarter the outer square, it can be shown that the outer square is twice the area of the inner square because it consists of twice the number of equal triangles. No knowledge of root numbers is required, only the ability to count triangles. In the row above this diagram, there appears an architectural application of this principle in a sketch which shows how to lay out a cloister so that its garden is half the area of the whole. From the marks evident in this sketch, its draughtsman only needed to know that the side of the inner square is half the diagonal of the outer square.
89. In 1486, Mathes Roriczer published his *Büchlein von der Fialen Gerechtikait*, which shows how to elevate a pinnacle from its plan. About two years later, he produced his *Wimperbüchlein*, a similar booklet devoted to gablets, and, at about the same time, Hans Schmuttermayer published his *Fialenbüchlein* which, by an apparent coincidence, gives a similar treatment for elevating pinnacles. Finally in 1516, Lorenz Lechler published his *Unterweisung* for his son. In this, he shows a great square, with sides equal to the wall thickness of the building, which is divided 3 x 3 into nine squares. Accordingly, it would have been possible to align the wall to its grid. The centre square of the grid also provides the module for constructional details which, in the diagram below it, is enlarged and, by a similar process of quadrature, is used for producing the profiles of mullions.
90. Vitruvius, op. cit., I.1.3.
91. Augustine, *De quantitate animae*, 9; *Contra Faustum*, XII.14.
92. Augustine, *De musica*, VI.10.26; *De Trinitate*, IV.2.4.
93. In considering Villard's plan of squares which was ascribed to the Cistercian Order and, given the Cistercians' twin preoccupation with sacred chant and architectural design, Augustine's words concerning unison and diapason would have carried special weight. Augustine, *De Trinitate*, IV.2.4.
94. See for example Bede, *De tabernaculo*, tr. A. Holder (Liverpool,1994), xv, xxii–xxiv, passim; *De templo*, tr. S. Connolly (Liverpool, 1995), passim.
95. Exodus 26; Josephus, *Antiquitates*, III.6; II Chronicles 3. 1–8.
96. Goldfinger, *Architects' Journal*, 25 July 1957.
97. Goldfinger, *Architectural Review*, April 1983, p. 48.
98. Not only does he prescribe the double square for the plans of temples and the 2 : 3 rectangle for fora (Vitruvius, op. cit., III.4.3, IV.4.1, V.1.2), but when it comes to planning houses, he states that the atrium should be proportioned according to the side and diagonal of a square, i.e. 1 : $\sqrt{2}$, or to the ratios of 2 : 3, or 3 : 5 (Vitruvius, op. cit., VI.3.3). Whilst 1 : $\sqrt{2}$ and 2 : 3 correspond exactly to two of the rectangles mentioned by Goldfinger, Vitruvius's ratio of 3 : 5 approximates closely to the third, namely the Golden Section rectangle. Many claims are made for the occurrence of the Golden Section in architectural design, from ancient Greece through the middle ages, yet there is scant support for it in the record before the Renaissance. One instance, however, is provided by the numerical series of approximations to the Golden Section by Fibonacci in the thirteenth century and one pair of numbers from this series is 3 and 5, i.e. $5 \div 3 = 1.666$, compared with 1.618 for the Golden Section. If, therefore, the ratio 3 : 5 can be allowed as an approximation to a Golden Section rectangle, then all three rectangles advanced by Goldfinger are to be found in Vitruvius.
99. Similarly, his earlier set of rectangles all expand from a square, wherein $\sqrt{2}$ is the diagonal of a square, $\sqrt{3}$ is the diagonal of a 1 : $\sqrt{2}$ rectangle, $\sqrt{4}$ the diagonal of a 1 : $\sqrt{3}$ rectangle and $\sqrt{5}$ the diagonal of a 1 : $\sqrt{4}$ rectangle, which is at once half a square and a double square.
100. Goldfinger, *Architectural Review*, April 1983, p. 48.
101. Compare *Architects' Journal*, 25 July 1957, with *Architectural Review*, April 1983, p. 48, both cited above.

Contents

Twentieth-Century Architecture and its Histories

edited by Louise Campbell

SOCIETY OF ARCHITECTURAL HISTORIANS OF GREAT BRITAIN

2000