

Footnotes

- 1 Le Corbusier, Précisions sur un état de l'architecture et de l'urbanisme, Paris, 1930, 71
- 2 R. Fischler, "The Early Relationship of Le Corbusier to the 'Golden Number'. Environment and Planning B, 6(1979); 95-103. One modification of this paper must be made. We have recently noticed that Green's analysis, mentioned on page 102 was obviously taken from L'Esprit Nouveau 17 (1922?), [pages 14 and 15 starting with the cover as page 1.] In the accompanying text "Réponse de MM Ozenfant et Janneret [sic]" which replies to Severini's letter concerning the review of his book - see page 99 - we read that in addition to the equilateral triangles and the "place of the right angle", Ozenfant and Jeanneret used "the mean proportional of the sides of the canvas which gives good divisions" ("Nous avons employé en plus ici, la 'moyenne proportionnelle' des côtés de la toile, laquelle donne de bonnes divisions".) The only mention of the golden number appears in the "réponse de Monsieur de Fayet" (Ozenfant?) "which appears on page 14 and quotes the criticism of the golden number which appeared in the original review. The study of the use of the golden number in the period around 1921 is continued in R. Fischler, E. Fischler, "Juan Gris, son milieu et le 'nombre d'or'", Canadian Art Review, 7 (1980), 33-36.
- 3 The difference between theory and practice and how careful one must be when considering proportions in architecture, has been vividly demonstrated in D. Howard, M. Longair, "Harmonic Proportion and Palladio's 'Quattro Libri" JSAH, 41 (1982), 116-143. For other examples of the question of the determination of systems of proportions in architecture and art see: R. Fischler, "What did Herodotus really say? or How to Build (a Theory of) the Great Pyramid, Environment and Planning B, 6 (1979), 89-93; "Théories mathématiques de la Grande Pyramide", Crux Mathematicorum, 4 (1978), 122-129;

["Comment on an article by D. Chen"] , Palestine Exploration Quarterly, 1982; "On the Applications of the Golden Ratio in the Visual Arts", Leonardo, 14 (1981), 31-32, 263; R. Herz-Fischler, "An examination of claims concerning Seurat and the 'Golden Number'", Gazette des Beaux Arts, 1983: Shape, Form and Space, An Algorithmic Approach, Ottawa, 1982, Section B,1.

- 4 For our purposes it suffices to say that the segments A and B divide a line according to the golden number if $A:B = B:(A + B)$. If B is the longer segment then the common ratio in the proportion is $(\sqrt{5}-1)/2 = .618$. For the discussion see Fischler, "Le Corbusier".
- 5 M. Ghyka, Esthétique des proportions dans la nature et dans les arts, Paris, 1927. On page 452 we read "Tours, imprimerie R. et P. Deslis, 31-3-1927. The date of the "dépot légal" at the Bibliothèque Nationale was September 2, 1927 as one learns by examining the copy under côte 8°Z23661(2). The publisher Gallimard has informed us that they have no record of the exact date of publication but that, at least now, the "dépot légal" follows very soon after the actual publication. Several years ago Mme F. de Franclieu, who was then director of the Fondation Le Corbusier, informed us of a letter from Ghyka to Le Corbusier, in the latter's capacity as editor of L'Esprit Nouveau, in which Ghyka introduced himself and presented Esthétique des proportions. Unfortunately attempts while doing research for this article to find the letter in the Fondation Le Corbusier files, and thus determine its date, were unsuccessful.
- 6 We wish to thank Mr Colucci for several very interesting and enlightening discussions; see his excellent thesis Beauty as Synthesis: A study of Maisons La Roche-Jeanerret through the concepts of Le Corbusier's Purist painting, School of Architecture, Carleton University,

December 1981. The elevation of figures 2 and 3 appear, but without the numbers, on page 144 of Le Corbusier and P. Jeanneret, Oeuvre complète de 1920 à 1929, Zurich, 1937. Unfortunately we have been unable to locate a copy of the original edition Oeuvre Complète, Zurich, 1930 (?) to check if the reproduction is the same. The same elevations but with the number 1086 and the statment $A:B = B:(A+B)$ on the side appears in Le Corbusier, "Tracés Régulateurs", L'Architecture Vivante, printemps-été, 1929, 12-24. The reproductions shown in figures 2,3,4 are taken directly from the film files of the original drawings preserved at the Fondation Le Corbusier. The numbers 10453, 10454 are the classification numbers used to identify, although not necessarily in chronological order (cf. eg 9225, 9238 - Vaucresson and fn 17), the collection of Le Corbusier's drawings in the Fondation Le Corbusier archives. As of the writing of this article only volume 1 (1912-1923) of The Le Corbusier Archive, New York, 1982 has appeared. It is the atelier numbers 1086 and 1087 on these drawings which, as we shall presently see, are of great interest to us. For the purposes of research it would have been preferable in our opinion to have published the drawings with atelier numbers on them in consecutive order for it is precisely these drawings for which a relative, and sometimes an absolute, date can be assigned. Note also the discrepancies with the Oeuvre Complète. For example, in the latter the Villa at Vaucresson is listed before Maison Ozenfant whereas the Maison Ozenfant numbers are in the 7800 range and the Villa at Vaucresson numbers are in the 9300 range. The article by Rowe referred to is "The Mathematics of the Ideal Villa/ Palladio and Le Corbusier compared", The Architectural Review, March 1947, 101-104. A revised version of this article appears in C. Rowe, The Mathematics of the Ideal Villa and Other essays, Cambridge, Mass., 1976, 1-28.

The differences between the two versions are discussed in footnote 39.

7. Atelier numbers 721-725. No dates are given but number 730 "Fruges", i.e. Passac at Bordeaux dates from July 15, 1926. Number 721 is reproduced in L'Architecture Vivante, automne-hiver, 1927, 12 and, with a 1959 annotation, in L. Bougois, M. Kagan, P. de Turenne, "Villa Stein, 1926-1927 Garches", Architecture.Mouvement.Continuité 49 (1979), 23-32, 25. Actually the drawing bears the date July 26, 1926. Numbers 722 and 723 appear on page 6 of "The Villa Stein at Garches", Domus, N° 497, April 1971, cover, 3-9. The cover and page 7 show other pastel drawings of the villa at Garches. There are 22 plates of this villa in L'Architecture Vivante, printemps-été 1929; see also Le Corbusier, Une maison - un palais "A la recherche d'une unité architecturale", Paris 1928, 69, 71, 73, 75, 77, 79.
8. Atelier number 769; classification number 10410. No dimensions are shown. Document 10416 shows dimensions on the plan, but no atelier number and thus cannot be assigned a specific date or chronological order. The same is true of the other documents to be mentioned where no atelier number is given.
9. Document number 102 in the villa at Garches file.
10. Atelier numbers 794-797.
11. Document number 105 In the villa at Garches file. Document number 101 dated February 8, 1927 acknowledges the receipt of two cheques.
12. Atelier numbers 803, 804.
13. Atelier numbers 838-842. Number 840 has classification number 10430 and shows two facades with no dimensions.
14. Document number 91 in the Villa at Garches file. Document number 78 dated April 12, 1927 is a receipt. We thus learn that the practice of obtaining a permit after work has started, existed before the "modern" era!
15. Atelier numbers 859-862.

fms

16. These plans are contained between atelier numbers 867 and 982. Plans 1046, 1051, 1052, bookcases, sub-basement, groundfloor, date from between March 13, 1928 and April 16, 1928. Plan 31462, involving furniture, dates from March 24, 1936! For further evidence of Le Corbusier's continuing interest in this building see the letter of October 4, 1935 to Steen, the new owner, reprinted in Bourgois, "Villa Stein", 28.
17. Notice again, see footnote 6, that the classification numbers do not correspond to the chronological order. Here of course we are assuming that 10505 is indeed an earlier drawing and not some afterthought.
18. Since in figure 4 we do not know the relationship of the little sketches on the bottom left to the main drawings, we simply limit ourselves to several footnote observations. Starting from the left we seem to have two small rectangles followed perhaps by a small rectangle with a diagonal and a perpendicular line as with the left (north) elevation. Then follow two larger rectangles both with an inscribed right angle which determines a vertical line. In the last rectangle we find the equilateral and right triangles of figure 1, i.e. as in the preliminary designs for the purist paintings. It appears to us that the triangles start inside the rectangle and that the leg of the bottom right triangle which goes off to the right does not meet the vertex of the equilateral triangle. This would be the same mathematical error that Le Corbusier made in earlier designs for his paintings; see Fischler, "Le Corbusier". Note also what appear to be sets of proportioning right triangles to the left of the northern elevation and in the upper left hand corner.
19. Le Corbusier, Précisions, 72. For purposes of chronology we note that the preface is dated December 10, 1929 and that the date of the "dépot légal" (Bibliothèque Nationale côte 8°V. 45439) was November 7, 1930

20. It will be noticed that there are three bibliographic items listed under the heading TR, i.e. "(Les) Tracés régulateurs". In fact there are five items with the title. The first TR1, under the name Le Corbusier-Saugnier appeared in L'Esprit Nouveau, 5 (1921), 563-572. This contains the Capitol, Petit Trianon, two drawings with regulating lines for Villa Schwab (see also J. Caron, "Une villa de Le Corbusier, 1916", L'Esprit Nouveau, 6 (1922), 679-704), plus an apology in the third person for using an example of his own work (he had not met any other modern architect who dealt with this question and had been greeted by opposition and scepticism). This article was reprinted in Le Corbusier-Saugnier, Vers une architecture, Paris, 49-63 (from the introduction to the second edition and the dépôt légal this book came out in late 1923 or early 1924) but now had a photo of villa Schwab and what may be another photo of villa Schwab. The apology is now in the first person. The second edition (TR2) of the book [apparently 1924, possibly 1925] drops one of the Villa Schwab diagrams and the unidentified photo on page 62 and replaces them with drawings and a photo of Maison Ozenfant. A new page (64) with the Maisons La Roche-Jeanneret is added. Further, this second edition no longer has the dedication to Ozenfant as in the first edition and lists its author as simply Le Corbusier. The article (TR3) that appeared in L'Architecture Vivante, printemps-été 1929, 12-23, is completely different and will be discussed later. Finally there is a half page section with the title "Les tracés régulateurs" which appears along with the facade of the maisons La Roche-Jeanneret in Oeuvre complète, 68. The above should illustrate again how careful we must be, particularly from a chronological viewpoint, when reading Le Corbusier. It also points out the need for a definitive bibliography of his writings; Le Corbusier himself certainly did not take any steps to help such an undertaking.

21. A. Ozenfant, C.E. Jeanneret, "Le purisme", L'Esprit Nouveau, 4(1921), 369-386. The relevant part of the text is given and discussed in Fischler, "Le Corbusier".
22. From the statement in Le Modulor, Paris, 1948, 26, it appears that Le Corbusier "discovered" this principle, at some non-specified date while looking at a picture postcard of the Capitol. From page 25 it appears that he did not know this method at the age of 23, i.e. c.1910. There is no evidence to our knowledge that Michelangelo ever did use this principle. There is also an analysis of Notre Dame using the square and the circle but this seems to do nothing more than divide the total height into three parts. See also fn. 32.
23. "Tracés régulateurs" (TR1), 572: "Le bloc général des façades, tant antérieure que postérieure, est réglé sur le même angle A qui détermine une diagonale dont de multiples parallèles et leurs perpendiculaires fourniront les mesures correctives des éléments secondaires, portes fenêtres, panneaux, etc., jusque dans les moindres détails." It should be also pointed out that despite what Le Corbusier says he is really using two different slopes, one for the front and another for the back. Furthermore the diagonals only correspond to parts of the façades.
24. "Tracés régulateurs" (TR1), 568; also contained in the text of Oeuvre complète, 68: "Un tracé régulateur est une assurance contre l'arbitraire; c'est l'opération de vérification qui approuve tout travail créé dans l'ardeur, la preuve par neuf de l'écolier, le C.Q.F.D. du mathématicien."
25. A. Ozenfant, C.E. Jeanneret, Après le Cubisme, Paris, 1918, 43. "Celui ~~(ie. l'instrument)~~ du peintre est son oeil qui agit vraiment comme un instrument de contrôle, de vérification et de pénétration." Le Corbusier's position here seems to be the exact opposite of that expressed in his complaint against the modern architect (c.1929) ~~-TR1, 567;~~ Oeuvre complète ~~C. 68~~ ~~le-e;~~ "But he proclaims that he is a

liberated poet and that his instincts suffice...." (Mais il proclame qu'il est un poète libéré et que ses instincts suffisent...) We do however find statements in Après le Cubisme such as (p.55) "A painting is an equation. The more the elements agree among themselves the higher will be the coefficient of beauty" (Un tableau est une équation. Plus les éléments sont justes entre eux, plus le coefficient de beauté tend à augmenter")

26. Some of the articles by Le Corbusier in L'Architecture Vivante were reprinted separately and some of the photos and drawings appear elsewhere but we were unable to make a serious bibliographic dent into this problem at either the Fondation Le Corbusier, Bibliothèque Nationale or the Ecole des Beaux Arts - see the remark at the end of footnote 20. The latter library, but not the first two, has a complete run of L'Architecture Vivante. This generally overlooked journal is in fact the best source of photographs and diagrams, some polychromes, of Le Corbusier's work - and for that of other architects as well - of the period. While the 1923 issue did not feature anyone in particular and 1924 featured A. and G. Perret, from 1925 to 1929 Le Corbusier was the dominant, although certainly not the only, personality. For reference we note that the issue of hiver 1923 pl. 49 has an elevation of the villa at Vaucresson but no regulating lines; automne-hiver 1926 has an elevation with regulating lines for the "petite maison d'artistes" at Boulogne, and also the regulating lines for Maisons La Roche-Jeanneret; automne-hiver 1927 contains elevations for Pessac and Maison Cook but without regulating lines.
27. A. Ozenfant, "A bâtons rompus", L'architecture Vivante, printemps-été, 1925, 5-9, 8. This article is an imaginary (?) dialogue between Ozenfant and an architect friend George who is mad at Ozenfant because the latter asked Le Corbusier to design his house, i.e. Maison Ozenfant 1922.

"Quel travail d'imagination digne d'un poète et de l'adresse d'un inventeur pour que chaque centimètre de terrain rende au maximum, pour que la vie soit dedans facile, que les dispositions des pièces et des armoires et du chauffage et de tout, mérite la façade et que rien d'utile n'étant négligé; tout cela se traduit dans la langue divine de la proportion. Alors une vitre en façade est comme un diamant."

- 28 Le Corbusier, "Conférence donnée à la Sorbonne le 12 juin 1924" in Almanach d'architecture moderne, Paris, 1925, 17-40, p.36, 37, 38. "Les tracés régulateurs servent à résoudre le problème de l'unité. ... Le tracé régulateur fut très employé à certaines grandes époques Pour arriver à ces tracés régulateurs, il n'existe pas de formule unique, facile à appliquer; c'est à vrai dire une affaire d'inspiration, de véritable création" On page 37 there are two sketches with regulating lines accompanied by tiny virtually illegible texts. Design C is the facade of Maisons La Roche-Jeanneret with the text "The ... [illegible] lines are parallel or perpendicular and regulate the essential elements of the composition" ("Les lignes ... [illisible] sont parallèles ou perpendiculaires et règlent les éléments essentiels de la composition"). The text for the facade shown in B says "The lines ... [illegible] the critical ... [illegible] on the facade" ("Les tracés ... [illisible] déterminants sur la facade"). The text is accompanied by many photos at the Maisons la Roche-Jeanneret.
29. Le Corbusier, "L'Esprit de Vérité", L'Architecture Vivante, automne-hiver, 1927, 5-6. "On peut accepter que les grandes époques d'architecture sont assises sur un système pur de structure. Ce système pur de structure qui satisfait aux exigences insatiables de la raison apporte à l'esprit une satisfaction, un émerveillement, une joie qui suscitent l'expression spirituelle et purement intellectuelle d'un système pur de l'esthétique architecturale."

- 30 [Le Corbusier ?] advertisement on back of "Sommaire du fascicule, L'Architecture Vivante, numéro 22, hiver 1928. "Cet album présente, sous la forme luxueuse chère à notre revue, la théorie et la pratique de l'application aux constructions modernes des principes éternels de l'architecture, oubliés depuis deux siècles: le tracé régulateur et la section d'or".
-
- 31 In Almanach, 37 Le Corbusier tells us that he learned about the historical use of regulating lines from A. Choisy, Histoire de l'architecture, Paris, 1899; for other early influences see Fischler, "Le Corbusier". The "recent commentators" may include Hambridge and Moessel whose analyses of the Parthenon appear in Ghyka's Esthétique des proportions.
- 32 Le Corbusier, TR3, 14. "Et si ce n'était pas le cas je faisais l'impossible pour obtenir ce résultat." From his article "L'Architecture et l'esprit mathématique" in F. Le Lionnais ed. Les grands courants de la pensée mathématique, Paris, 1948, 480-491, 483, we learn that the date was 1911. Compare with fn.22.
33. Le Corbusier, TR3, 13. "Le tracé régulateur est un moyen géométrique ou arithmétique qui permet d'apporter à une composition plastique (architecturale, picturale ou sculpturale), une précision très grande dans le proportionnement. Il n'y a ici ni mystique, ni mystère; il y a simplement une rectification, une apuration des intentions que le plasticien a mis dans son oeuvre. Le tracé régulateur n'apporte pas le lyrisme à l'oeuvre; il peut s'il est net et catégorique, conférer une limpidité, une espèce d'étincellement et cela grâce à l'unité qu'il confère à tous les éléments de la composition. Apurant la composition, il affirme l'intention."
34. Le Corbusier, TR3, 14. "Restons bien persuadés qu'au dessus de toutes les théories et de toutes les vérifications une chose domine chez le créateur: c'est son jugement, son sentiment artiste qui, en dernier ressort, ne laissera jamais à des moyens mécaniques le droit de commander seuls."
-

35. Le Corbusier, Précisions, 73.

"Je me suis attaché avec une véritable passion à jouer avec ces éléments fondamentaux de la sensation architecturale. Voyez l'épure précisant les proportions de la villa de Garches (54). L'invention des proportions, le choix des pleins et des vides, la fixation de la hauteur par rapport à une largeur imposée par les servitudes du terrain, ressortissent à la création lyrique même: telle est l'oeuvre jaillie d'on ne sait quel profonde stock de connaissances acquises, d'expériences et de puissance créatrice individuelle. Aussitôt pourtant, l'esprit, curieux et avide, cherche à lire au coeur de ce produit brut en lequel la destinée de l'oeuvre est déjà définitivement inscrite. Voici le résultat de sa lecture et des rectifications qui en découlent: une mise en ordre mathématique (arithmétique ou géométrique) basée sur la "Section d'Or", sur le jeu des diagonales perpendiculaires, sur des relations d'ordre arithmétique, 1,2,4 entre les bandeaux horizontaux, etc. Ainsi cette façade s'est harmonisée en toutes ses parties. La précision a créé quelque chose de définitif, d'aigu et de vrai, d'inchangeable, de permanent qui est l'instant architectural." The meaning of the expression "full and empty" is clarified by the text of TR3 13, 14 where after using the expression "la disposition des pleins et des vides" Le Corbusier speaks of "le trou des fenêtres et les murs pleins qui les entourent, etc." In Oeuvre complète, 144, we read about Garches: "This entire house obeys some rigorous regulating lines which led to modifications, to within one centimetre, the sides [?] of the different parts. Mathematics brings us here some reassuring truths: when one leaves one's work one has the certainty that the correct thing has been arrived at" ("Toute cette maison obéit à des tracés régulateurs rigoureux qui ont conduit à modifier, à 1 cm. près, les côtes des différentes parties. La mathématique apporte ici des vérités reconfortantes: on ne quitte son ouvrage qu'avec la certitude d'être arrivé à la chose exacte.")

36. Figure 5 from Précisions presents us with more problems. First of all sketch 54 shows the northern facade (street). Since sketch 53 has no letters and sketch 54 does, we

may assume that the golden number relationship $ba:bc = bc:ac$ shown above sketch 53 was indeed meant to refer to sketch 54. However in figure 3 it is the southern facade (garden) that displays the golden number relationship. Furthermore we now appear to have a right angle inscribed on the facade which in turn determines a vertical line. Since Précisions is based on talks given in South America and seems to have been written there - see the introduction - it is possible that this sketch was done when Le Corbusier did not have access to his drawings. For this reason sketch 54 may only represent a vague and only partially correct recall of what Le Corbusier had originally done. The right angle may be a recall of how the sloping line on the southern facade of figure 4 was obtained or it may be just an automatic gest after so many uses of the right angle.

37. How indeed all this was translated into actual dimensions is a question for which we have no answer. Given what appears to be a rather low level of technical competence in the field of mathematics, cf. Le Corbusier's own statement to this effect in Le Modulor, p. 29, it may be that measurements were taken from a scale drawing. The dimensions on most of the drawings are hard to read and in fact it seems to us that no complete set of dimensions is contained in the preserved documents; perhaps the contractor had a separate set of working drawings. Of all the drawings with regulating lines on them that we have seen only number 15255, showing interior regulating lines for windows (entrance to Maison La Roche?) with sets of numbers, may actually indicate a relationship between the lines and dimensions but we shall not even try to speculate on this.
38. Because of the different locations of the numbers, see fn. 6, we cannot say for sure why these official plans were made but their date suggests it was for the "Tracés régulateur" (TR3) article.
39. Perhaps Le Corbusier had the 2-1-2-1-2 division spoken of in the 1929 "Tracés régulateurs" (TR3) in mind when figure 4 was drawn and perhaps this determined the location of the vertical line. Then upon learning about the golden number and the fact that $5/8$ was an approximation to it, he added the golden number relationship to the top of the

building while, apparently, keeping the arithmetic division for the bottom. Le Corbusier's original copy (A6 in the Fondation Le Corbusier Library) of Ghyka's Esthétique des proportions is completely worn out but the few marginal notes were mainly written later. None of the diagrams are coloured in as with the copy A5 (13th reprinting) which however is not as worn out. On page 321 of copy A6 there is the marginal note "la figure 1, planche 75 montre la 'notation dynamique' du Capitole de Michel-Ange". The figure illustrates the "Fibonacci relationships" satisfied by the golden number and which forms the basis of the Modulor system. Ghyka's book which is mainly a rehash of second and third hand material - furthermore mainly nonsense - has unfortunately been very influential and has had a rather nefarious effect on architectural education. Thus for example in Rowe's original 1947 version he uses (p.104) Ghyka to give a golden number analysis of Villa Foscara (Malcontenta) which Rowe compares with Garches. However, in the 1976 version he uses (page 17, fn 6), without informing us of the change, R. Wittkower, Architectural Principles in the Age of Humanism, London, 1949 as the basis of his statement that musical ratios formed the basis of Palladio's design. That this view too is not as sure as Wittkower or Rowe would have us believe, is the subject of the Howard and Longair article (fn.3). Indeed on page 126 we learn that only 71% of the Foscara dimensions are harmonic.

40. Checked would undoubtedly mean by drawing or measuring. Mathematically the two sets of methods of proportioning are incompatible but again Le Corbusier would have been technically incapable (fn 37) of checking this and presumably would not even consider such a thing necessary. For the gratification aspect. Consider all the space taken up in Modulor and Modulor II with making the right angle fit in with the "Fibonacci" sequence of values. The right angle is absolutely irrelevant to the Modulor set of dimensions

but for Le Corbusier it was important that somehow they be tied together via a diagram (Cf Modulor II, Paris, 1955, 43). Incidentally, human measurements are spoken of (p.18) in TR3 in connection with the "automatic system" and are said to have been used at Maison Cook and Pessac.

Acknowledgements

The author wishes to thank the Social Sciences and Humanities Research Council of Canada for the Leave Fellowship that made this research possible. He also wishes to thank Dr. Eliane Herz-Fischler for her aid, and patience, in interpreting and translating the always poetic, but not always transparent, French of Le Corbusier. My friend Dr. Jeff Watson, Editor-in-Chief and Director, Scientific Information and Publications Branch, Department of Fisheries and Oceans, Canada, was instrumental in my obtaining several references.