ANTHROPOMETRY OF GREEK STATUES.

[PLATES VII.–IX.]

NOTE.—The illustrations which I have given are not to be regarded as finished drawings, but rather as the best results that could be obtained from the records of my working note-books, and of measurings made in the midst of the statues. The whole purpose is to submit a practicable *method.*

I.—*The Doctrine of the Canon.*

IT is strange that it should be believed by many artists and critics of art that no doctrine of human proportions was known in the schools of the great masters. For the contrary would seem to be the true case, if we are to judge by the practice and the comments of the artists and their friends. Egyptian [1] and early Greek, and indeed all symbolic art is obviously based on measured proportions. The remark of Diodorus (I. 98) about the twenty-one parts by which the body was measured in Egyptian sculpture may not be enough for a theory of an Egyptian canon, but it agrees well enough with the plainly systematic treatment of the sitting and the standing figures. It is more difficult to believe that the Egyptian sculptor had *not* a set of ratios which he used in his work.[2] The same may be said of the archaic Greek statuary; and when we come to the classical work, we cannot think that the doctrine τὸ γὰρ εὖ παρὰ μικρὸν διὰ πολλῶν ἀριθμῶν[2a] was held alone by the followers of Polykleitos the Argive. Classical art develops so demonstrably on inherited doctrine of various kinds that it is hard to believe that there was no regard to proportions composed of numerical ratios as part of it. At the end of the Hellenic age such allusions as that of

[1] For a front view of the body as divided by the Egyptians into 19 parts (Diodorus, i. 98, seems to have been including the height of the head-dress when he says 21) see Lepsius's *Mon. funéraires de l'Egypte*; and cp. his *Descr. de l'Egypte*, iv. lxii.; and Wilkinson's *Hist. of Europe*, p. 113, Pl. IV. Gebhart gives this reference.

[2] S. B. (presumably Dr. Samuel Birch) in a note to J. G. Wilkinson's *The Ancient Egyptians* (vol. ii. ch. x. n. 3) says that there were three canons: one as early as the Third Dynasty, the second from the Twelfth Dynasty to the Twenty-second, and the third subsequently. Diodorus refers, I think, to the third.

[2a] Philo Mech. iv. 2. A writer of second century B.C.

Vitruvius (i. 2) to the measured basis of symmetry in art are quite in accord with what we know of the Greek practice: in hominis corpore e cubito pede palmo digito[3] ceterisque particulis symmetros est eurythmiae qualitas. The supposition that first Polykleitos, and then Vitruvius, and then Leonardo da Vinci were trying to *establish* a doctrine and practice of calculation in statuary and architecture is, I believe, simply due to oversight, and perhaps not a little to the prejudice[3a] which the enormous impulse expressing itself in later romantic art (especially since the championship of Goethe) has created in favour of the free work of genius untrammelled by any doctrine whatever.

The gist of the doctrine of Greek art, so far as it found words for literary comment (for plastic art is taciturn on this side), is to be found in the three summarising words *ἀναλογία, συμμετρία, εὐρυθμία.* The two last name the greater qualities which literature has made famous, the symmetry[4] being that technical regard for the placing of parts to the best advantage, and the *eurythmia*[5] the nameless grace to which language has striven in vain to give expressive names, that elusive *tertium quid* without which we may have skilled work of artisans and works of taste, and even of distinguished talent, but no true work of art. All this the cultured world has learned at Plato's feet; but the other term *analogia*, translated into Latin by *proportio*, that which has regard to the *rata pars*,[6] the measured ratio of part to part, in detail, has naturally been less interesting to the layman, and has been overlooked. But 'behind the scenes' the artist being also artisan has had much to do with it, and occasionally a Leonardo or a Dürer has reminded the world of its permanent importance.

To Leonardo da Vinci (1452–1519) we owe perhaps most the preservation of faith in the doctrine of *ἀναλογία* or numerical proportion of parts.

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[3] These were terms familiar in the metrological systems as ordinary names of measured lengths, and usually had fixed values. See *e.g.* Michaelis on the Oxford metrological relief, *J.H.S.* iv.

[3a] 'Le préjugé qui existe contre tout ce qui ressemble à des moyens de précision.'—Eugène Guillaume in a *Notice* on the Doryphoros in Rayet's *Mon. de l'Art Antique*, Paris, 1880. The article is most admirable: 'L'originalité peut se retrouver jusque dans le résultat d'un calcul.' Prof. Percy Gardner called my attention to it.

[4] L. Urlichs refers to many writers who so use it in *Griech. Kunstschriftsteller*, Bock VII. (Intro.) and Philostrat. Jun. *Imag. Prooem.* : δοκοῦσι δέ μοι παλαιοί τε καὶ σοφοὶ ἄνδρες πολλὰ ὑπὲρ συμμετρίας τῆς ἐν γραφικῇ γράψαι κ.τ.λ. As an example of συμμετρία which is essential if not deliberate I give in Fig. 1 a marking of Gian Bologna's *Mercury*, at Florence. The sculptor has disposed the arms and legs so as to give the rhythm of the lines of an unstrung bow (see dotted line). The same essential symmetry of parts is to be observed in the body also in its rigid attitudes. I have marked some on the figures in front and profile in Fig. 2. The reader will note the rhythmic effect not only of the lines but also of the masses. *E.g.* of the rump, the calf, and the heel (A, a and *a*); and again of C, c and *c*, in the profile; as well as the correspondence of parts about the axis shown in the geometric outlines (in front view) produced by shoulders, ribs, abdominal muscles, etc.

[5] Vitruvius defines it so, i. 2, iii. 1; cp. Lucian, *Pro Imag.* 14; Clem. Alex. *Paed.* iii. 11 and 64 (εὔρυθμος καὶ καλὸς ἀνδριάς); Xenoph. *Memor.* iii. 10, 9; Plut. *de educat. puer.* 11; Diod. ii. 56, 4, and i. 97, 6 (ῥυθμὸς ἀνδριάντων, *i.e.* general bearing, pose, poise).

[6] Vitruv. i. 2, p. 12. Proportio quae graece ἀναλογία dicitur. III. i. p. 65. Elsewhere τὸ ἀνάλογον.

He saw that Vitruvius' few lines concealed more than they revealed of the ancient rule, and noted that his Pes vero altitudinis corporis sextae (partis), cubitum quartae, pectus quartae, etc., was only an *example* of ratios. Leonardo's lament 'Defuit una mihi symmetria prisca' (written by his epitaphist, but quite characteristic of his own modest bearing) is partly regret at not fully appreciating what he knew instinctively to be the principle of complete harmony (or, as Bossi calls it, la commodulazione [7] in respect to le tre proporzioni che gli antichi distinguevano, la numerica, l'armonica e la geometrica) in the incomparable Greek work; and partly matter of fact indication of failure to find any more of the discoveries of the Greek masters than

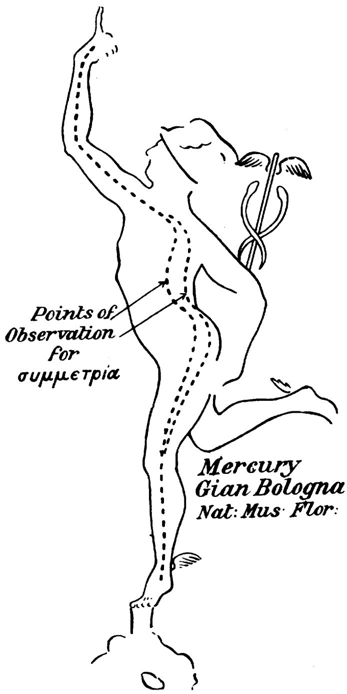

FIG. 1.

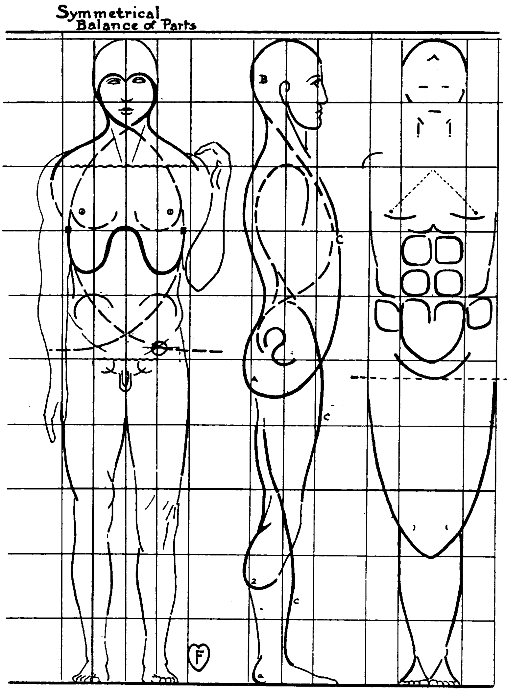

FIG. 2.

Vitruvius and an odd literary note or two had indicated. He was convinced, however, that the Greek schools had a full doctrine of ratios, if only it could be unearthed!

More practical than Da Vinci's indication of the canon is Dürer's contemporary achievement. The accompanying scheme of detailed measure-

[7] The whole sentence is worth quoting (*Storia delle Arti*): 'Per questa scienza egli (*sc.* Leonardo) non intendeva una determinata misura generale dell' uomo ma quella commodulazione di parti che a ciaschedun individuo conviene'—that is a relative, not an absolute standard. Bossi has a chapter, 'Opinioni di Leonardo intorno alle proporzioni del corpo umano,' with a plate giving Leonardo's norm, in his *De Cenacolo*, 1810.

ments is his own, Fig. 3 below being taken from the British Museum copy (Print Room case 36. a. 5) of his *Vier Bücher*, 1528. The system of notation has a formidable appearance, but it is easily explained, and in practice easily reduced to percentage values. Thus the heights marked for the lower leg in profile against the vertical lines are 168, 150, 143, 70, 62·1 and 17 respectively; and these I would read as $\frac{168}{600}$, $\frac{150}{600}$, $\frac{143}{600}$ and so on. They come out as 28 %, 25 %, 24 % nearly, 11·3 nearly, 10·3 nearly, and 3 % nearly of the

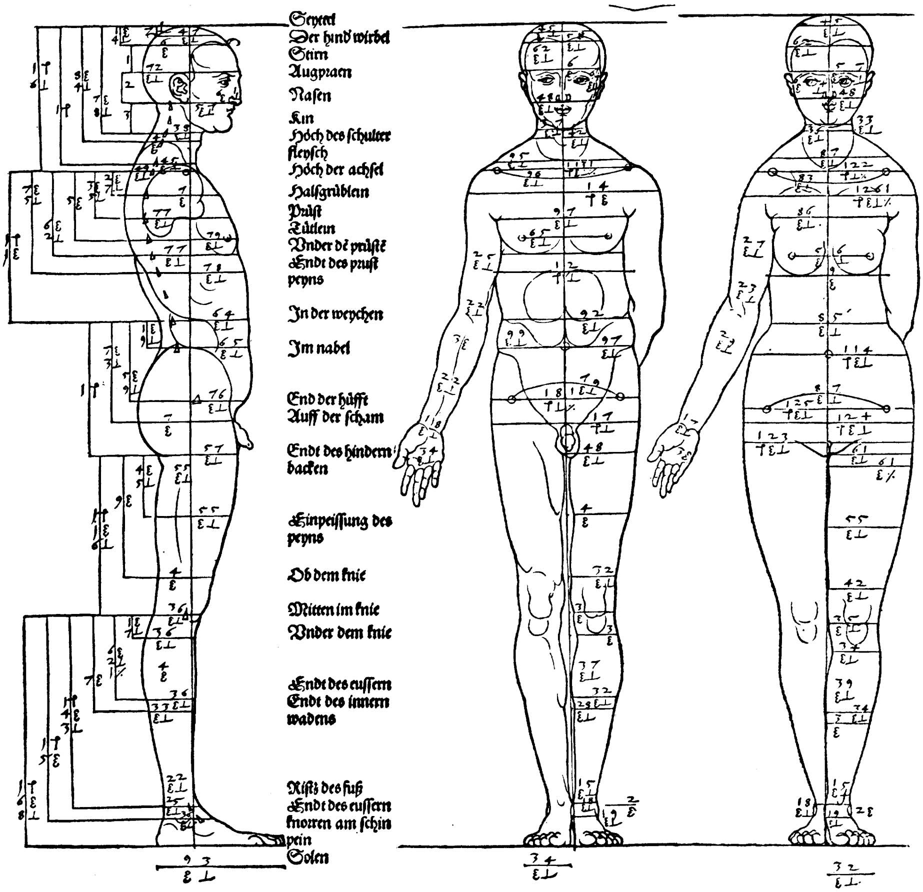

Fig. 3.—Dürer's Scheme of Proportions.

height of the body, and may be compared directly with the percentage scheme which I have shown in Plate VII. ('Geometric Man').

To examine one or two parts in detail: his head is in height $\frac{78}{600}$, *i.e.*, 13 %, making the stature to be $7\frac{3}{4}$ heads nearly; his foot is in length $\frac{93}{600}$, which is $15\frac{1}{2}$ %, a foot rather smaller than the one-sixth foot which Vitruvius gives as the ancient norm; the breadth of chest between the nipples is $\frac{65}{600}$ or 11 % nearly, a narrow chest; shoulders $\frac{140}{600}$ or 23·3 %; hips $\frac{108{\cdot}1}{600}$ or

18 %; while the measurement between the iliac spines shown by the curved line is given as $\frac{79}{600}$ or 13 % approx.[8]

Anton Raphael Mengs (1728–79), whom I select for the interest of his suppressed chapter on Proportions, was fully convinced that the Greeks worked by sure rules: 'In quelle figure trovarsi una proporzione impossibile a conoscersi e a praticarsi senza un' arte che dia regole sicure. Queste regole non potevano fondarsi in altro che nella proporzione.' The head according to his canon is shown in Fig. 17. This Flaxman, though less positive about the sure *rules*, also maintains (to quote him at second hand from Walker): 'It must not be supposed that those simple geometrical forms of body and limbs in the divinities and heroes of antiquity depended upon . . . blind and ignorant arbitration. They are, on the contrary, a consequence of the strict and extensive examination of nature, of rational inquiry, etc., etc.' While he, like Michelangelo, feared the dominance of the merely mechanical, he saw with Polykleitos and Pythagoras that nature must have observable proportions, and that 'Le sentiment y trouvait son exercice et son frein, et l'imagination sa sureté' (Eugène Guillaume).

These are only a few of the great artists of all ages who have preached the doctrine of the Canon; many using schemes of proportion in their own work.[8a] Those who have seemed to deny the doctrine have, I am sure, for the most part, been misunderstood.[9] While they deny the control of fixed rules mechanically applied and demand for themselves the utmost freedom in infinite variety of detail, the great artists obey rules of proportion nevertheless, and are even distinguished by the ratios which they prefer. As Kalkmann has shown in his *Proportionen des Gesichts* there are as a matter of fact sets of ratios in the successive schools. These are virtually canons,[10] whether they were ever formulated or not. If a sculptor in Greece could go straight to work upon his marble block in the production of a well-known type, he must have had an absolute mastery of the geometrical relations of the parts. 'The very freedom of Greek sculpture is to a great extent due to its close adherence to tradition.' (E. A. Gardner, Intro. to *Six Greek Sculptors*.) And tradition in the Greek practice is actually

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[8] The symbols used for denominators, placed sometimes under and sometimes beside the numerators, are ꝑ, a 'line' or 'rule,' $\frac{1}{6}$ or $\frac{100}{600}$ of height; ʒ, a 'Zall,' $\frac{1}{10}$ of the 'line' or $\frac{10}{600}$ of height; ⊥, a 'Teil,' $\frac{1}{10}$ of a 'Zall' or $\frac{1}{600}$ of height. Thus $\frac{14}{\text{ꝑʒ}} = \frac{140}{600}$ and $\frac{1}{4} \Big/ \frac{\text{ꝑ}}{\perp} = 14/\text{ꝑ}\perp = \frac{104}{600}$, while $\frac{14}{\text{ʒ}\perp} = \frac{14}{600}$. The interpretation is my own. Note that in the German lettering peyn = pein = Bein.

[8a] I suspect many others of deliberately concealing their use of measurement. Dürer complains that Jacopo de' Barbari refused to give him the secret of the scheme of proportions he used. The case of Mengs is remarkable: his Italian, German, and English editors (see Bibliography) omitted his exposition of his scheme, with an apology for their own obtuseness.

[9] For example, I think Michelangelo is misunderstood when he says 'che le proporzioni non cadono sotto alcuna misura di quantità' (according to Vincentio Danti) and 'chi non ha le seste negli occhi non troverà mai artifizio.' He is rightly denying any absolute set of measurements for the human frame, and any mechanically binding rule.

[10] See *infra* my attempt to plot out Kalkmann's numbers graphically.

expressed in ratios reducible to a scheme. This, at least, it is in part my object ultimately to show.

The masters in art were often guided by immediate insight without conscious calculation. Lesser men may nevertheless profitably observe their practice in its calculable results. And observers have been many, as the Bibliography (*infra*) suggests. These observers unfortunately employed different *notations* in recording their discoveries; also they often attempted to give absolute instead of proportional measurements, and to find the universal norm instead of the type; and they did not always describe relations that were genuinely anatomical. To these defects is due the oblivion which has fallen upon them (Dürer's brilliant and useful work is a notable example), and these defects might, I think, be remedied by the use of the scheme of geometric and numerical notation which these pages have been written to expound.

Before explaining my scheme, I should like to mention one notable suggestion, and to glance at the position of modern anthropometry.

II.—*The Theory of the Inscribed Figures of a Circle.*

Jay Hambidge and W. W. Story have striven to prove,[11] one for Greek architecture and the other for the human figure, that the units of measurement are to be found in the sides of the regular figures which can be inscribed in the circle. Story has used also units other than the sides,[12] and by applying them chiefly for vertical heights and horizontal widths in his system to the construction of a new canon he produces a normal figure of great beauty and persuasiveness. Mr. Hambidge, having to deal with architecture, lays stress on the elements of the Greek curves, and remarking 'wherever precision and subtlety of curvature combined with refinement of symmetry occur in classical masterpieces of formal art, there is a most complete agreement with the proportions to be found in the regular forms of nature,' applies the lengths of sides of the inscribed figures to 'deriving' secondary circles to 'determine the disposition of the elements of symmetrical and proportional form.'

I have plotted out, in a more particular application of my own, some of the resulting curves on paper ruled in decimal squares, with results very closely in accord with other observations taken in quite a different aspect. These results I must defer to a later paper.[13] I should like, however, to submit the following examples of some curves resulting from the use of the inscribed figures. They occur in great wealth in the outlines of the human body, of which I have worked out many applications.

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[11] The former in a paper, 'The Natural Basis of Form in Greek Art,' read before the Hellenic Society in November, 1902; the latter in his 'Proportions of the Human Figure,' 1864.

[12] *E.g.*, not only the side but also the height of the inscribed figure.

[13] Mr. A. T. Porter has shown me a method by which the length of the sides can be determined by the simple use of ruler and compasses, *i.e.*, by purely geometric method, without use of protractors or reference to angles. Mr. G. H. J. Adlam has shown me another method.

A system of n circles in binary relation (diameters as 1 : 2 : 4 : 8 etc. : A in Fig. 4) produces $3n$ magnitudes, the lengths of the sides of the inscribed figures (see uppermost figure). It gives $6n$ magnitudes if the heights of the inscribed figures are also taken in; to these the lengths of radii may be added. One set of these is indicated by the group of five vertical lines in the middle of Fig. 4. These may be arranged, as in the set marked ⬠ □ △, to plot curves. By combining such sets as in right-hand diagram, we get new

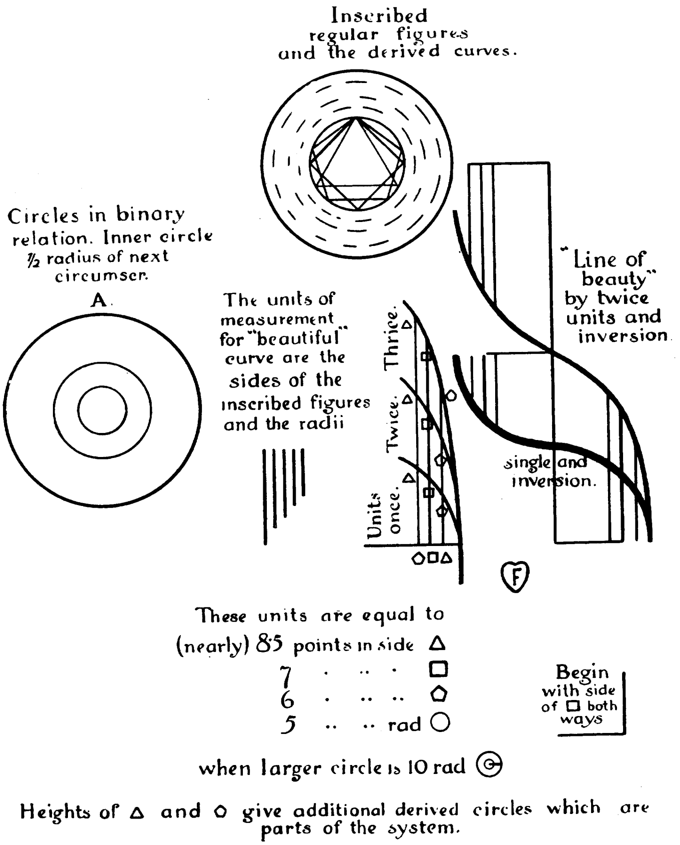

FIG. 4.

magnitudes and corresponding sets of curves. My suggestion is merely that such a system would be perfectly accurate and infinitely applicable, and yet would vary automatically with the change of any one magnitude.

We may have, in this suggestion of a geometric system, half the solution of the ancient Canon problem. It came to this: Could the Greek sculptors, who worked so closely to type and proportion that we have the antique Attic, the Polykleitan, the Lysippean, the Praxitelean statuary, distinguish-able by proportion of parts,[14] have possibly attempted to apply the foot-unit or the palm-unit or the finger-nail [15] unit, standardised or not, to work so delicate and small as the details of the Cassel Apollo, the Doryphoros and Diadumenos, the Hermes, the Praying Boy, the Youth by Stephanos, or the Aphrodite of Cnidus? And if they worked by a standard now lost of more exact magnitudes, how did they endure the labour of converting by fractional reduction the standard tables for the particular statue on which they were working—for hardly two statues are of the same absolute height [16]—by any method which was known to them? That is the problem, and its solution has been awaiting an appreciation of the use of a group of *geometric* ratios which would be constant so long as any one of them remained unchanged, *i.e.*, through the continuance of a piece of work. I say 'appreciation' because there is no novelty, I suppose, in the fact that the regular inscribed figures are capable of the treatment suggested above: the difficulty has been lack of proof that the Greeks used those in particular, and of any urgent reason why they should.

Why could they not, for instance, have said something similar to our universal *per cent.*? The answer is, I think, clear. Because it is of no use to say per cent. about a ratio unless you have instruments of precision [16a] which enable you to find immediately and easily the measurement which that makes on any given line. If we say that the upper arm-bone is $\frac{19}{100}$ of the height of the body, the lower arm $\frac{14}{100}$, the shin-bone $\frac{23}{100}$, and so on, these are only now useful observations when we have section scales and proportional compasses and paper ruled in millimetres. The construction of a finely divided scale computed for each new statue would surely have been intolerably laborious. It seems obvious to us to say 'Measure off 20 millimetres'; but the reproduction of perfect millimetre scales is a benefaction of modern industry which was unknown in Greece.

Now that squared paper is well ruled and millimetre [17] scales reliable, so that one may have for every record of a human figure as large as this page 2,000 and more squares on which to mark a norm and record divergencies we shall not need for the work-room the inscribed figures of a circle; but the geometric figure was almost the only instrument of precision of equal applicability which the Greek artist could use or make. He could say with assurance, 'When the upper arm (humerus) is as long as the side of the

[14] This may be taken as beyond dispute. There are recognised differences in these types, not only of artistic value but also of arithmetical. See Kalkmann, *loc. cit.*, on the measurable change in proportions of the face. And everybody alludes to ratios in order to distinguish, *e.g.*, the Apollo of Tenea or the Doryphoros from the Hermes.

[15] Pindar, *Ol.* viii. 158, speaks of πηχῶν τεσσάρων δακτύλων πέντε.

[16] Two thousand millimetres is an average measurement for the height of the heroic figures, but the Oxford metrological relief figure has outspread arms which extend 2057 mm., the 57 being just enough to cause intolerable trouble in the measuring—too little to 'count,' but too much to ignore.

[16a] Engineers' and architects' comparative scales particularly.

[17] We use paper ruled in hundredths because of the convenience of decimal records in Europe. But we may remark that the decimal system is not intrinsically the best.

inscribed triangle, the lower (with the wrist) is as long as the side of the square,' and always have a ratio both useful and precise. And if it was such a ratio he used, it was the ratio of natural geometry.

III.—*Method of Modern Anthropometry.*

The indications of the ratios of the ancient canons, numerous as they are, are still too fragmentary to enable us to reconstruct the canons themselves, and so to show deductively their application to ancient statuary. The modern method is inductive: it proceeds by examination of the statues to establish the system of the existing proportions. In this it has been much assisted by modern anthropometry in general, which as a branch of scientific anthropology is proceeding by the same inductive method, and has already made considerable progress in mapping out the ground to be surveyed, as the records of topographical anatomy, biometric investigation, and tabulations of racial differences,[17a] fairly show.

Both for measurement of statuary and the measurement of living bodies we have until recently lacked instruments.

For the mensuration of so living a piece of nature as the body, observation and collation were demanded on a scale to which its recording and comparing apparatus of the mediaeval world was not equal; a century of modern anatomy and a half-century of reliable graphic records have only recently furnished us copiously with facts for this branch of biometric. The labours of many pioneers have at last summarised some of the first available results,[18] and the museums, treatises on anatomy, and records of the proceedings of special societies furnish thousands of models, casts, drawings and photographs really trustworthy for reference and collation. The makings of an apparatus criticus for the mensuration of statuary are at last in our hands.

For example, A. Kalkmann, in 1893, published a monograph (above mentioned) on the proportions of the parts of the face in Greek statuary which, in addition to the thousands of measurements which he himself had made, gives many of the observations of masters and writers of the Classical Age, of commentators in the Middle Age, and of exponents in our times.

The extreme care given to the smallest dimensions and the lucid systematic arrangement of the tables of comparison which Kalkmann's monograph shows, mark an epoch in the scientific treatment of the subject. All that remains to be done is the reduction of all these absolute millimetre measurements to some common scale or scheme—a large task! Meanwhile we have the millimetres, which is much.

[17a] Professor W. M. Flinders Petrie has contributed much material; *e.g*, 'Early Egyptian Skeletons' (measurements) and 'A Systematic Study of Jaws,' being chapters iv. and vi. of *Tarkhan*, ii., Brit. Sch. Arch. Egypt, 1912.

[18] See the Proceedings of the Anthropological Societies of Paris, London, Berlin, etc. Professor Karl Pearson has won much gratitude for *Biometrika*. At least sixteen years ago I was assisting him in making records of physical characters of school children and students. See *Proc. Roy. Soc.*, vol. 69, p. 332 (1902).

Almost at the same time, in 1895, the publication of Professor G. Fritsch's monograph *Die Gestalt des Menschen*,[19] confirming the observations of C. Schmidt[20] in 1849 and of C. Carus[21] in 1874, gave a stimulus and a method,[22] which had before been lacking, to the general observation of human proportions in modern races and for the practical uses of art.

Finally the recent formation of a Committee of the British Association (referred to below) to guide Anthropometric Investigation has raised the study to the position of an acknowledged science; and the Congrès International d'Anthropologie (Geneva) in 1912 formulated an International Agreement for the unification of Anthropometric Measurements.

In publications on anatomy for the instruction of medical and especially surgical students, much exact work has been done which the graphic reproductions make available in such work as Mr. L. Bathe Rawling's *Landmarks*, with its system of median and lateral planes, and the plastic in such modelling as that exhibited in the cases in the Museums at the London Hospital and Guy's and other Schools of Medicine.

In all these geometric arrangement and the measurement of angles and distances play large parts. Many of them are accepted by modern surgery for guidance in operative practice.[23]

My conclusion is this. It is becoming increasingly possible and desirable to have a formal quantitative knowledge of the proportions of plastic works of art (a scientific andriantometry), expressed in positive symbols of ratio and represented graphically by a diagrammatic method, which shall be independent of perspective and all the artistic devices by which the eye is satisfied and deceived.

It is not at first sight obvious that one cannot *see* the width of a full-sized human limb, except, *theoretically*, at infinity. Let E in Fig. 5 represent the eye of an observer of a cylindrical object, *cabm*. Then it is impossible at the same time that a ray of light from point a, the last point visible at the tangent on one side, and also a ray from m, its diametrical opposite point, should both reach the eye. The last visible point, b, on

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[19] In the *Verhandl. der Berliner Anthrop. Gesellschaft.*

[20] *Proportionsschlüssel.*

[21] *Die Proportionslehre des mensch. Gestalt.*

[22] It is a method of *anatomical* values, *graphic*, taking the vertebral column for its modulus and using the principal *articulations* of the skeleton for its mensuration scheme. It is, for a general estimate of a figure, excellent; I have made much use of it for first observations; and have found its mnemonic value high for the practical student of elementary artistic anatomy. Its defects are (1) lack of precision of points, (2) use of extremities of vertebral column as standard points, (3) use of the deeply hidden head of femur as a standard point, (4) applicability to the erect figure for full front view only. The employment of Fritsch's canon for comparative measurements I have shown in Fig. 11. The measurements are mine.

[23] A single example of practical judgment based on a geometric marking on the body may be quoted: Michaelis believes that the more perfect the rhombus which he indicated on the surface in the lumbar region, the better the conformation of the pelvis for normal parturition.

the side opposite to *Ec*, is nearer to the observer than *m*, and *ab*, the apparent width of the cylinder, is smaller than *am*, the true width. The observing eye at *E* never sees the maximum width, *cd*, at all, though binocular vision helps the observer to see a little more.

The superiority of the *observed* fact on which modern realism in artistic work and judgment insists makes it the more necessary that we should also know the true distances, the often less pleasing facts. For the problems of artistic judgment are in many cases insoluble through want of just that knowledge. This is accepted in the methods of all those students of anthropometry who reject all focal measurement by converging rays of light (such as photography gives, and the rule-of-thumb measurement of the drawing school), and who by the use of calipers and sliding-beam compasses [24] take the diametric size of limbs and other parts.

But here a difficulty occurs of considerable practical importance: the record made by the calipers will be, of course, the distance *cd* in Fig. 5 (or even, in figures of shape *anopb*, the larger distance, *nn'*), while the eye will have been used to seeing it as *ab*; in other words, the most accurate record

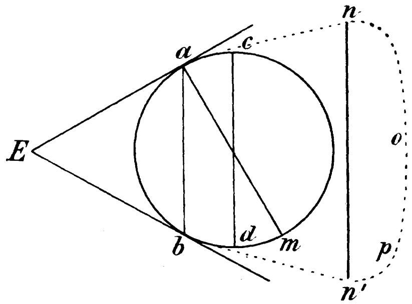

FIG. 5.

of true observations, such as Story's or Kalkmann's, if made on a plane surface by delineation, must necessarily *look wrong*. Seen from a point usually above or usually below the level of the eye, parts will have a remembered dimension which will be contradicted by the graphic record in true magnitudes. If, now, in order to please the eye, to correct the perspective in unusual positions (*e.g.*, as of a statue on a pedestal as high as the observer), and for other artistic reasons known to the artist, the part be made a little larger or a little smaller than the normal,[25] this will be recorded by the exact measurements as an actually distorted or even deformed figure. For this there is no help, but the practical difficulty makes against the ready acceptance of the true record; for there is not, as in the case of architecture, a simple allowance which at least may be made in a sufficient number of

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[24] The Committee on Anthropometric Method of the British Association, in their report of 1909, indicate the best instruments.

[25] This, I am convinced, the Greek masters did in plastic art as well as in architecture. This, too, on which I wish to insist later, is one of the most useful results of applying actual measurement.

cases; there is an ever-recurring adjustment necessitated by the enormous number of planes, undulations, and intersections which the human figure admits. The true record of the sizes, the actual magnitude of the material medium which the artist used in order to get his effect of beauty, is on paper often displeasing to the eye.

We shall have, perhaps, a representation inartistic, crude, even, it may be, ugly, but we shall have at least the constructive ἀναλογία of the figure, *le proporzioni numerica e geometrica*; and, in so far as and wherever the knowledge of proportional magnitude can go, we shall have achieved within the limits of the artist's small demands a full delineation of the anatomical facts. The judgment will no longer struggle in the maddening attempt to reconcile the varying evidence of foreshortening, optical delusion, stereoscopic effects of our double vision, artistic prejudices, and the prejudices of previous knowledge, when all we want to know is how much of space is occupied by bodies and parts out of which the artist is to make, by disposal and modification, his works of art.

In the case of architectural plans and elevations the similar difficulty has survived the prejudice, and the usefulness of the elevation has secured it a tolerance which the human 'elevations' cannot yet expect.

I am, nevertheless, so fully convinced that photographs and artistic drawings of statuary are useless for purposes of exact comparison of proportions, that I believe the orthogonal record will be adopted for all reliable comparison, by those who have to pronounce judgment on statues, and whose high gifts in judgment of great works of art are often embarrassed by the ambiguity of adjectives, *large*, *small*, and the like, meaning, as they are naturally used, *large in appearance*, *small to the observer in such and such position*, and the like; and the critic would be glad to be able sometimes to refer to actual dimensions in more mathematical terms.

The new Athena, for example, which is placed at Oxford side by side with the Marsyas of Myron, has certainly a slender youthful appearance, but this is what the artist *gives* us; actual measurement showing that the shoulders are relatively wider than the average (see Plate IX.). I measured this half-a-dozen times to convince myself of this surprising fact. The Cassel Apollo again has in *effect* a graceful slenderness of hips, but the actual arithmetical ratio between the depth (front to back) of pelvis and length of leg is larger than the normal (see Plate VIII.). Again I have found by many observations that the Aphrodite figure is of a geometric type so similar to that of the Apollo that no marked difference is shown on my scale, and the supposed general difference in ratio of shoulders to hips does not exist. As Professor Fritsch has pointed out, the Aphrodite of Melos is larger on one side than on the other.

IV.—*A New Recording Instrument.*

To resume. If there is a Canon of proportion implied in the best Greek statuary and if the indications of Vitruvius and others are references to it then it is worth our while to try to discover it. For this we need first a synopsis of many careful records made on one scheme.

And, since it must be admitted that no extant Canon has been offered which can be accepted as undoubtedly the Greek, observers may as well fall into line with the Anthropometric Committee of the British Association, and employ modern methods of taking dimensions of the human body, in terms capable both of graphic and of numerical statement, fit to be submitted to the analyses used in general biometrics.

I have endeavoured to keep in mind, while preparing a scheme which would comprehensively satisfy these conditions, also the later application of the results to ethnographical comparison. We want to record anatomical facts which may help us to classify according to schools and races. It was indeed a general survey of the ethnographic problem which Professor Flinders Petrie kindly gave me about five years ago which first convinced me of the need of a new instrument for recording the facts.

I propose to be content with about 500 determinations of points in the human figure. The labour of making 500 points of every figure examined is much reduced by the plotting of curves on paper already ruled in small squares; and is again much reduced by the guidance given by a normal figure faintly traced on the squared paper on which the plotting is being made.

By collating and digesting ancient and modern systems of proportion, by comparing together the best anatomical drawings found in works of science, and by reducing all these to that representation which is not seen in the works of art themselves, viz. the quite erect front and profile, I have produced [26] a figure (see Plate VII.) which I used as a norm. I have been

[26] The investigation, occupying the leisure time of five or six years, and encouraged by a grant from the Treasury, has been research work in Professor Ernest Gardner's department (the Yates Archaeological) at University College, London, with some special work in the Slade School of Art (Professor Thane's course in artistic anatomy, with valuable counsel from Professors Tonks and J. Havard Thomas), also by the necessary practical anatomy and observation in the dissecting-room at the London Hospital Medical College (for which the Dean kindly offered me special facilities, and the lecturers and demonstrators in anatomy many valued hints, especially Major Rutherford, R.A.M.C., Mr. Walton, and Mr. T. C. Summers); by detailed measuring of casts and marbles at the British Museum, at the Ashmolean, the Birmingham Art Gallery, and in some continental and some private collections; and by measurement and observation of the living model in studio-work and in photographic studies of the nude, by means of which one's own observations are enormously extended; and, finally, by much note-making from monographs and the larger publications of many of which I have given the particulars in Bibliography (*infra*, p. 256). I have had the privilege of consulting many London painters and sculptors, and owe to members of the Art Workers' Guild (especially to my friend Mr. John W. Batten) thanks for a willing hearing and much

encouraged by the confirmation received from many sides—especially of art and of anatomy—but I would ask leniency towards my results, inasmuch as they are to some extent still tentative, and are being offered at this stage for the purposes of reference and comparison.

This normal figure[27] I use reproduced as I have said, and then over it I mark the sizes of the observed figures in thicker lines upon it.

The advantage of using a cheap faintly printed copy of the normal figure for each record is chiefly in the economy of time. All those parts of the statue under examination which are found to be 'normal' need not be marked at all; and the variation can more easily be marked upon the normal figure.

The scheme had to satisfy three requirements.

The first requirement was to obtain a definite geometric position in space for each point of the body which was to come into mensuration. This we have obtained by making coordinate planes of projection of two planes at right angles each passing through the centre of gravity of the body, and conjointly containing all the fulcra, viz., the occipito-allantoid, the lumbo-sacral, the hip-joint, the knee-joint, and the ankle-joint in the transverse plane, and all the points of centre of gravity of the correlating parts (*e.g.*, the two corresponding symmetrical halves of head, thorax, pelvis, etc., the two arms, and the two legs) in the other.

The next was to mark out on each of these planes the normal position of all the important points, of which the chief are in the *bony* framework. These I have shown partly as curves in Geometric Man (Plate VII.), to which I find in practice all varieties, racial, sexual,[28] and individual, can be conveniently referred.

The third requirement was to find sufficiently precise indication of ratios which would remain unchanged, or of which the changes would be easily calculable in the many positions in which the statues are disposed. This is

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encouragement. I have also especially to thank, among surgeons, my friends W. Clowes Pritchard and Norman Bye. Mr. Basil Winser kindly prepared certain of the geometric figures. Dr. Overend, of Hastings, has kindly given me the benefit of his great knowledge of radiography. Innumerable observations of detail, many well known to surgeons and anatomists, have been incorporated without comment, such as, for instance, Merkel's norm, Mikulicz's line, Brücke's line, Bryan's triangle, Camper's ellipsis, Michaelis' rhomb, Nelaton's line, Gibson's triangle, and the topographic markings by L. Bathe Rawlings. Anything that could be found with sufficient confirmation in any system has been used, and I shall be grateful for other suggestions and corrections. I am already much indebted to Mr. G. F. Hill.

[27] A copy of the full scheme in true-to-scale reproduction is obtainable from Messrs. Stanley & Co., 8 Victoria Street, Westminster; but a much cheaper reproduction suitable for recording measurements is by ordinary engineers' blue-print.

[28] For use of the same scheme for the female figure the details are indicated, viz. (see Plate), the breast measured by the radius with centre as indicated, and the pudenda as shown in the margin of scheme. Other sexual differences are not prominent in Greek statuary, and hardly require a separate scheme. See note 31.

satisfied by the scheme I submit (Plate VII.). Many of the actual magnitudes strongly marked out by the construction lines never vary at all, in any position, for example, between the acetabula, between the glenoid cavities, between the eyes, ears, etc., lengths of bones of arms and legs, width, height, and depth of pelvis, and of course the sizes of skull in all its parts.

The method is that of descriptive (solid) geometry, viz., reference of the position of a point by orthogonal [29] projection upon co-ordinate planes at right angles and the measurement of the distances of two points in space by the distances made by the projecting lines upon the planes; similarly of lines and curves, by plotting them in the ordinary way of graphs upon each plane in turn.

For example. Let n in Fig. 6 (a) be the point of a nipple, and let its position be referred to the two axial planes of the body in Fig. 6 (b), $XX'y$

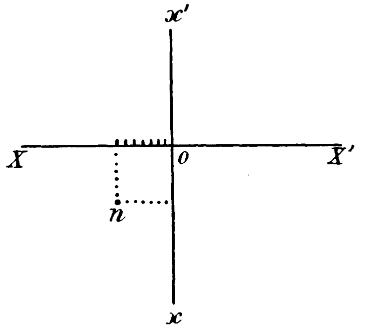

FIG. 6a.

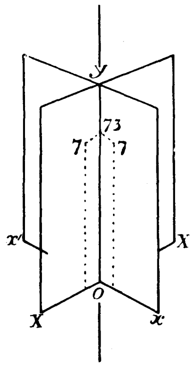

FIG. 6b.

SYSTEM OF PLANES.

and $xx'y$ (the ground plan of the system showing them in Fig. 6 (a) as XoX' and xox'). The projecting lines of n give on Xoy the coordinates (7, 72) and on the intersecting plane also (7, 72), where the 7 represents 7-hundredths of the height from sole to crown and 72 represents 72-hundredths.

If the two planes be ruled by squared-ruling in tenths and hundredths of the total height the place of n is instantly fixed and found, and its distance from, $e.g.$, the point n' of the other nipple is immediately seen to be 14-hundredths. Since the ordinate oy is the same for both planes it will be

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[29] This is important. The projecting lines and planes must all be perpendicular to the co-ordinate planes. Perspective projection is inadmissible.

sufficiently indicated by three quantities (7, 72, 7). So described, for examples:—

The tip of the nose would be	(0, 90, 6)
The patella would be	(0, 26, 3)
The lesser canthus (external commissure of the eye) would be	(3, 93, 4)
The junction of 8th rib with 7th (seen in deep inspiration) would be	(3, 69, 7)
The inner end of collar-bone would be ...	(1, 81, 4·5)

If these and all the other important parts (about 500) be determined and the graphs drawn the figure will appear plotted out in proportional measurements to $\frac{1}{200}$ of the whole height, say a measurement for every three millimetres. Seen from a point vertically above the axis the system thus appears (Fig. 7); *oaAbp* and *jeAfk* are the upper edges of the vertical planes shown in Figs. 6 (*a*) and 6 (*b*). All measurements are taken by points in projectors falling *vertically* upon these planes. For example, the distance *n*—*n* between nipple and nipple is the distance between two planes passing

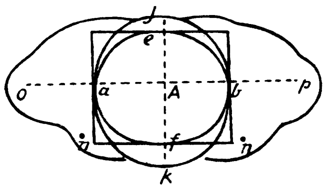

Fig. 7.

through *n* and *n*, respectively, parallel to *Ak*, at right angles to *oA*. Neglect of this principle will produce an unreliable variety of readings, because foreshortening, the undulations of curves, and a dozen other slight causes interfere with almost every other method. The height of a statue in relation to its breadth cannot, for example, be truly taken by radii from a single point.[30] The labour of marking out the positions of points on the principal, the transverse, and the horizontal planes is well rewarded by the accuracy of the measurement. The 500 points which fix a carefully plotted 'elevation' front and profile of a single figure may profitably be augmented by additional measurement of the body in its posterior aspect. In other papers I hope to be able to give the scheme for the back muscles, but for the present purpose it is sufficient to give anterior and lateral aspects only, as in Plate VII. I think, also, it may be well to publish a chart for the female figure, but the differences are *not, I find, sufficiently important to alter the scheme.* On Plate VII. I have marked the centres and radii of the normal mamma in front and profile, and the exact dimensions for the pudenda muliebria. Whether, as it is alleged, great differences can be established between the male and female skeletons and musculatures will appear from the records.

[3] And therefore not by photography.

Hitherto I have used with complete comfort this same scheme for both.[31] In such a system of coordinate planes the body to be measured is placed in an erect position, so that the line of intersection of two imaginary planes at right angles may pass through the points shown on the vertical axis, *o—o*, of the scheme, Plate VII. (*oy* of Fig. 6). For convenience these may be considered separately. The front view in Plate VII. shows the body placed against a background parallel with the transverse plane, so that *o—o* forms also the edge of the median plane (for the moment invisible). On this background the points of the body, viewed each one along its own line to the background, may be registered whenever they form part of the outline.[32]

A more complete registration can be made on a sheet of glass placed before the body and parallel to the transverse plane, *through* which all front-

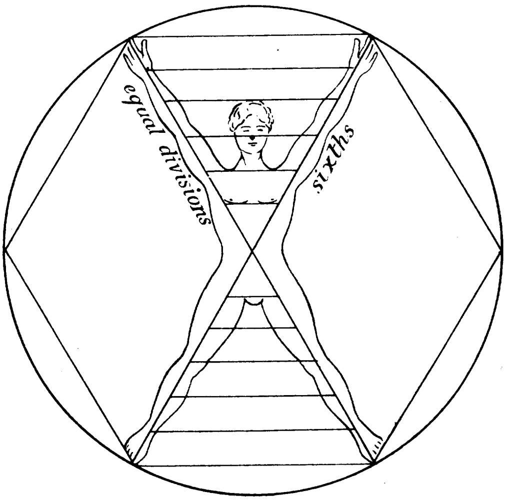

FIG. 9.

view surface markings are observed by the eye perpendicularly to the transverse plane.

Let the student consider a body behind a sheet of glass so placed. Let him then proceed to trace out the geometric scheme of the straight lines of

[31] No such difference is to be found distinguishing an Apollo from an Aphrodite in Greek or Graeco-Roman art as those with which we are familiar in the drawings of Rubens and Dürer. In the former there exists a beautiful Hermaphrodite type (see Reinach, pp. 367, 371 *sqq.*) which is really Hermes-Aphrodite and which could not be composed out of the male and female norms given by Dürer for example. Dürer's female (see above, Fig. 3) is not merely sexually different from his male; it is also to some extent genetically different, and this difference does not exist in the Greek statuary.

[32] For those who are not interested in the geometric details it may be sufficient to say that a model standing in a corner of a room would give in shadow outline our figures of Plate VII. on the two walls, if the light were made to fall perpendicularly on each wall in turn.

the scheme. Let the model so placed stretch out arm and leg [32a] (Figs. 9 and 10) so as to make an oblique line at an angle of 60° with the ground. This line will pass normally through the umbilicus, the mammilla, and the acromion process. It will then give the extreme possible length of the body (and, I am inclined to believe, the *normal* length). The ratio of this length to the sole-to-crown standing height is as 4 : 3. As we shall desire to use decimal or percentage notation for records we may count this ratio as $133\frac{1}{3} : 100$; but I believe nature's ratio [33] would be 132 : 99 (viz., $12 \times 11 : 9 \times 11$).

Let the model now stretch the other arm and the other leg at the same angle. The lines now traced on the glass will cut each other (see Figs. 9 and 10) at 60° in the umbilicus, and will make, when the figures are completed by horizontal lines, two equilateral triangles.[34]

It will be convenient now to mark in the points at the extremities of the vertical axis, the full height of the standing figure as ordinarily taken. This if the model is normal will be, I think, 99 (as against 132 allowed for the tip-to-tip measurement). For convenience of reference let us call this height 100 points, and then immediately other equilateral triangles can be marked off, viz., at 50 of these points from the ground an equilateral triangle whose base is level with the pubic crest,[35] whose height is 10 points, and whose apex consequently is in the umbilicus. Above the umbilicus let 20 points be now measured along the vertical axis of the figure, and an inverted equilateral triangle can be made whose base angles are at the acromia. At half the height of this triangle another may be marked off whose base will lie in the sterno-xiphoid plane. On the inter-acromial line just found, if another triangle be erected, its height should be 20 points and its apex in a normal figure should be at the highest point in the skull. We have now the (thick-lined) scheme of proportions of Fig. 10. I have called this the Rhombic type because so many important points available for measurement and well marked anatomically are found at the angular points

[32a] In order not to disturb the median line the body must be artificially supported, or laid at rest on the back, when the measurement may be taken perfectly.

[33] I do not believe that our decimal notation is fundamental. Obviously it does not use the prime numbers so simply as the 66, 99, etc., $2 \times 3 = 6$, $3 \times 3 = 9$, $2 \times 3 \times 5 = 30$, $2 \times 3 \times 11 = 66$, and so on. Tens and hundreds are secondary.

[34] In the hope of interesting others to work out the geometric hints of this tip-to-tip measurement (which I have reluctantly abandoned in favour of the ordinary standing height) I subjoin a note-book jotting of some remarkable results which I got from pursuing it a little further. In addition to the St. Andrew's cross and inscribed hexagon (which has long been known) I found that a further subdivision into sixths brought one to those same points and planes already found to be significant and anatomically good. The further subdivision into sixtieths I have done with remarkable results, but I think if some one would try a subdivision into 36ths the results would be very interesting. Indeed, I think a scheme of proportional measurement recorded on the scheme of Fig. 10 would be theoretically sounder than that of Plate VII. (and, practically, the same), inasmuch as finger-tip to toe-tip is rational, whereas heel to crown is not, the heel being an accidental stopping-place.

[35] I had put it two points lower, being led astray by the models I had used; but I am indebted to Mr. Tonks for the correction. He would wish to see it raised two points more.

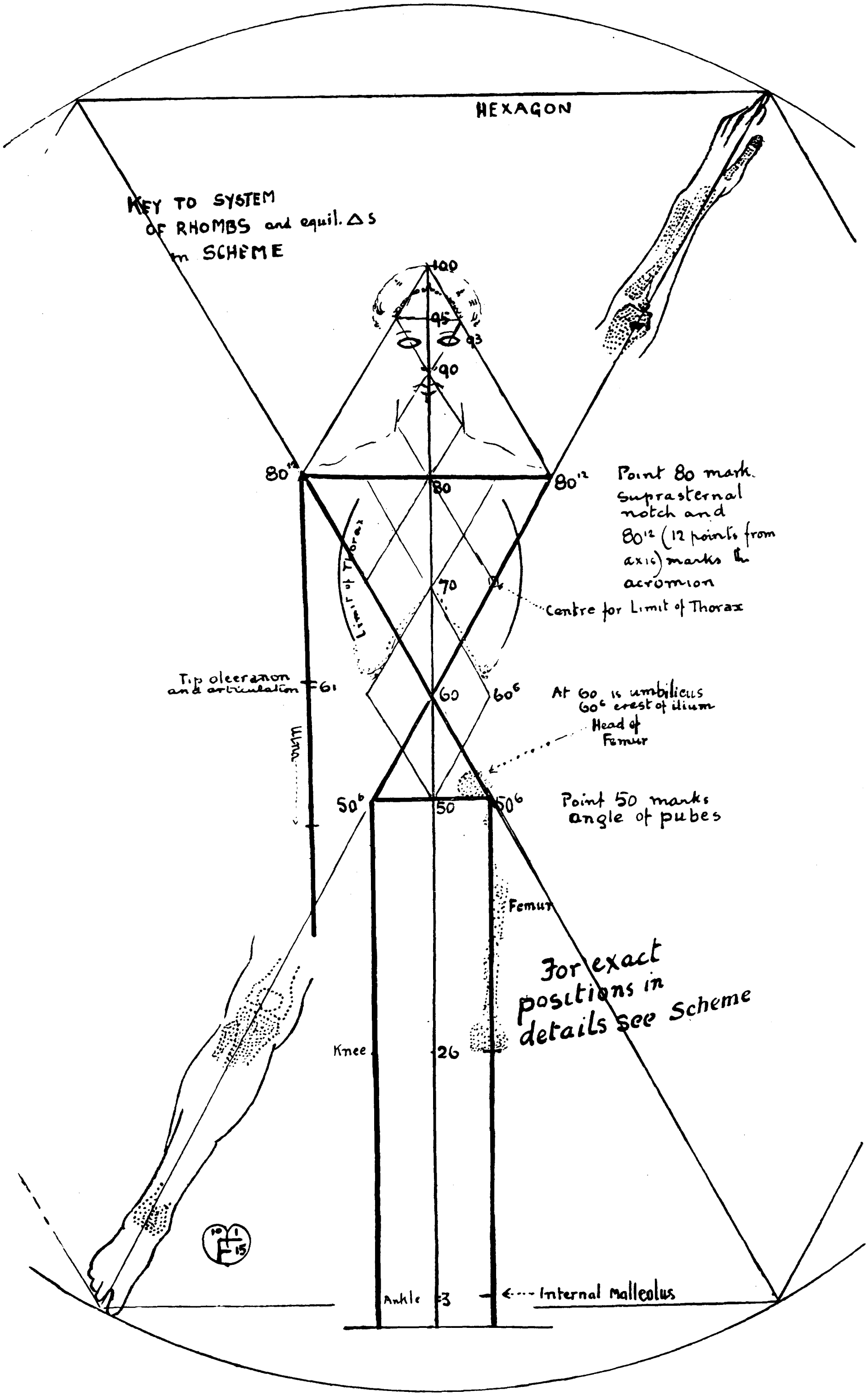
HEXAGON
KEY TO SYSTEM
OF RHOMBS and equil. △s
in SCHEME
100
95
93
90
80
80¹²
80¹²
Point 80 mark.
Suprasternal
notch and
80¹² (12 points from
axis) marks the
acromion
Limit of Thorax
70
Centre for Limit of Thorax
Tip olecranon
and articulation
61
Ulna
60
60⁶
At 60 is umbilicus
60⁶ crest of ilium
Head of
Femur
50⁶
50
50⁶
Point 50 marks
angle of pubes
Femur
For exact
positions in
details see Scheme
Knee
26
Ankle
3
Internal Malleolus

Fig. 10.

R 2

or at the points of intersection of the rhombs which arise from continuing the development of the system, as depicted in faint lines in Plate VII. (It is distinguished from the slightly shorter and squarer type of figure given by a system of squares shown in Fig. 12.) Other points in the completed scheme are more conveniently referred to the squares made by vertical and horizontal planes intersecting on a system of points and tens of points.

The whole result is condensed into the system shown in the scheme, and there for the present I must leave it: a detailed explanation would fill a large book.[36]

Le plus fort est fait, and since we have here also the points of measurements for the arm-bones, we have already ten cardinal points of the skeleton for the determination of any body. On these alone some important generalisations might be made. Fig. 11 shows the application to the notification of particular variations from the normal to be observed on a dozen statues in plaster or in marble to be found in the museums of Europe, and recorded (by myself) on Fritsch's canon which has sixteen or seventeen points. The markings are, obviously, roughly made for general comparison only.[37]

A remarkable indication of chronological data is suggested by the grouping of these twelve markings. They are chosen casually from about forty markings made at Prof. Ernest Gardner's suggestion because of the uncertainty or special interest of their dates. I took this small selection without any other consideration than that of illustrative values and spread them out in the order of their complexity, taking first those shown on the highest row because their marked variation was slight, and then those of the second row having more variation from the normal, and last those which varied considerably. And then I observed that I had unconsciously arranged them, with one exception, also in chronological order! The simplest are of the fourth century B.C., while the complex variations are in figures of the sixth century B.C. The one exception is interesting: the Athlete pouring oil, which is generally classed doubtfully, as of the fifth century B.C., appears among the fourth century figures.

Now if these very broad lines of differentiation give in so few figures so interesting a classification, may we not hope for much when mathematical biometric analysis is applied to detailed markings in the full scheme? Some of these (the Doryphoros, for example) are markings of Bruckmann's plates, very excellent reproductions, but still not the same thing as the cast. The

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[36] One small discovery worthy of note is that of the geometric scheme of the thorax in front view. From a centre which coincides at line 60 with an angle of one of the rhombs (and marked in Plate VII. by a small square just below the mammillary point) with radius terminated by 5th cervical and 5th lumbar respectively, an arc may be drawn which marks the geometric outline of the ribs. Others are schemes for pelvis, and thorax profile, *vide infra*, p. 16.

[37] If it should be asked why, since a roughly made comparison like this gives such results, it should not be *sufficient* for practical purposes, the answer is that it would be sufficient for each observer for himself, keeping to his own method in details, but that the observations of two observers could not safely be compared. General comparisons, *without precise points of reference*, are unreliable.

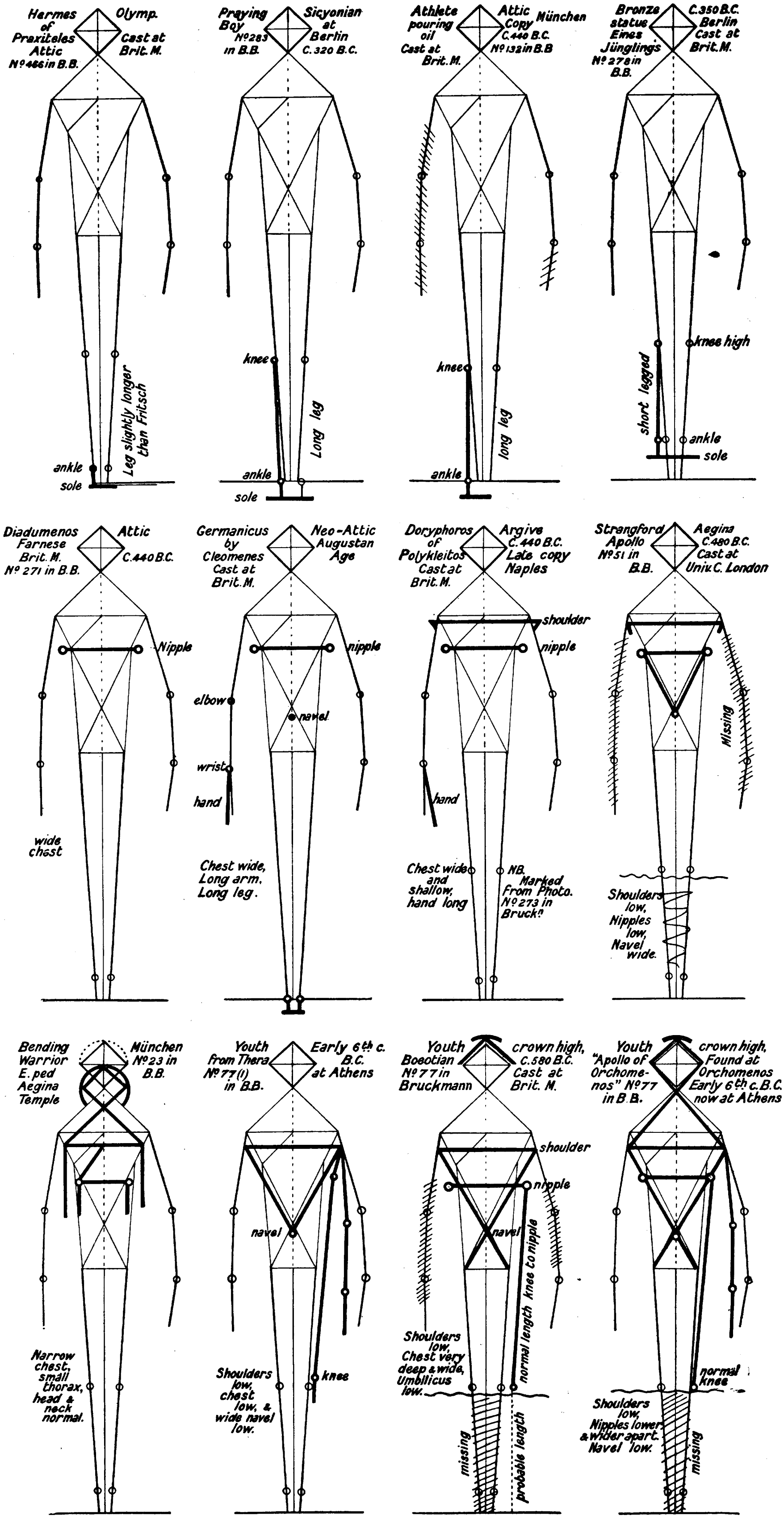

Fig. 11.—Comparison of Statues by a few Cardinal Points.

Doryphoros I have, I see, named wide and shallow-chested. Now it is true that the shoulders are abnormally wide; and this, especially in the photograph, causes the chest to appear shallow. But my markings from the British Museum cast do not show a *shallower* chest, in actual dimension, than the ordinary. The photograph correctly shows the hand as longer than the normal.

As a slight example of more careful marking I have reproduced a (rough) copy of my scheme showing some other ratios and marked with the true proportions of the pelvis of the skeleton hanging in the dissecting room of the London Hospital in 1914 (Fig. 12). It also indicates some convenient geometric values. Others again are indicated on the complete scheme (Plate VII.), to which alone the reader will please refer.

Let the student now turn to the construction of the scheme of markings on the transverse plane observable in the profile view of the scheme (Plate VII.) and Figs. 12 and 13. This is already partly prepared by the horizontal planes (found for the front view) which are the same for both.

For the pelvis and thorax we proceed thus: two intersecting squares are drawn in the geometric relations shown (by the construction lines on the right of the figure), so that the horizontal diagonal of the lower square is 50 points from ground. One corner of the upper square marks the anterior superior spine of the ilium, and a line drawn from this point to the 80th point in the vertical axis gives the axis of the thorax (which is not the same as the vertical axis of the body). Figs. 13 (*a*) and 13 (*b*) serve only as keys to the scheme (Plate VII.) in regard to anatomical details.

For the thorax, I have made the happy discovery that the geometrical outline for the pelvis can be conveniently drawn as interlaced squares shown in Plate VII., and if (in profile) the axis of the thorax be first made identical with the vertical axis and then inclined about 15° until the lower end coincides with the superior anterior point of these squares, the normal position and shape of the thorax in profile is indicated by symmetrical arcs of circles with centres at the lowest point of the scapula and the nipple respectively, the normal width being fortunately that of the unit of measurement, already seen in the inter-acetabular distance. For the thorax in front view: from the centre[37a] (marked with ⊡) on the fifth rib with radius measured from that point to the fifth cervical vertebra the arc of circle may be drawn which marks the boundary of the wall of ribs.[38] (See Fig. 10.)

The horizontal planes are remarkable for position and relations of their distances. At point 90, that is at a distance of one-tenth from the top of the axis (that is from the middle of the great arch of the skull, the centre of which is marked by a ⊡) the plane of the base of skull[38a] contains as

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[37a] Its position is found by the rhomb whose vertical axis is umbilicus-to-suprasternal-notch.

[38] See note 36.

[38a] The line well-known to anatomists as Reid's base line is two points above this plane and parallel with it.

points easily determinable the mastoid process and the nasal spine, which may be taken as marking the atlas or topmost vertebra. At one-tenth lower down the axis, viz., at point 80, is the plane of the acromion (the sharp upper border of shoulder), the suprasternal notch (between ends of collar-bones). At 60-hundredths the plane which contains the navel, the well marked tendinous intersection between two sections of the rectus abdominis, the upper edge of the prominent external oblique muscle, and the crest of the ilium. At 50-hundredths above the ground lies the horizontal plane containing the great trochanter, the lower tip of the backbone, the pubic crest (the upper edge of the pubis bone) and consequently the lower

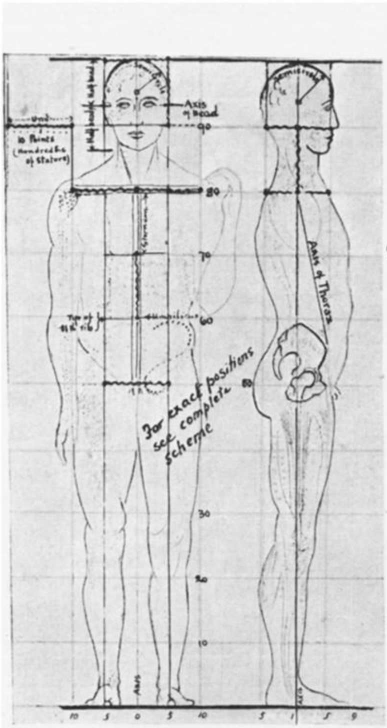

Fig. 12.

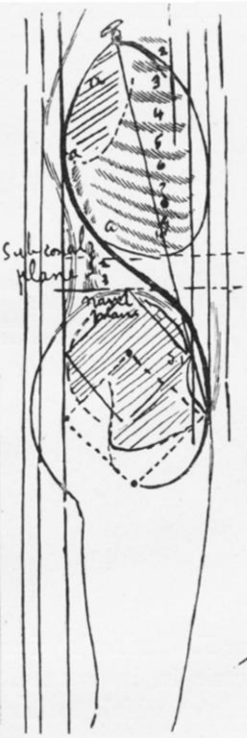

Fig. 13 (*a*).

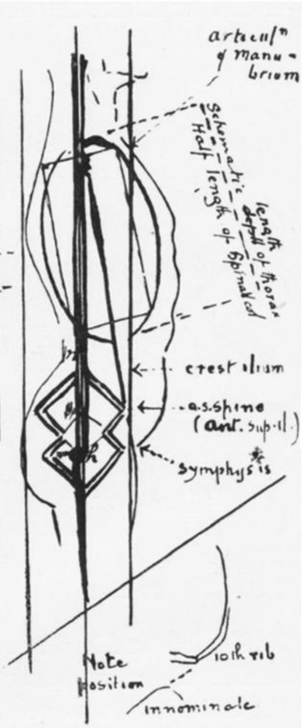

Fig. 13 (*b*).

extremity of the *rectus* muscle of the abdomen, and the points of maximum convexity of the buttocks.

The vertebral column stands between a plane five-tenths from the ground and a plane at nine-tenths; it is four-tenths in vertical height. It is thus twice as high as the shoulder-joints are apart, and four times as high as the hip-joints are apart. It follows, from these dimensions, that an oblique plane revolving about the front-to-back line of the navel would join the shoulder-joint with the hip-joint (Fig. 14).

Fig. 15 shows in the thicker outline this combination with some other details, and also shows the result of further revolving the hip-and-shoulder planes aforesaid until they form with the horizontal planes equilateral triangles. This marks the difference between the scheme for the square type of man and that for the rhombic. It is the latter which I have developed in the scheme (Plate VII.). The thin lines show the rhombic arrangement.

The reference which can safely be made, for the *general* proportions of the figure, to the articulations of the skeleton reminds us of the debt we owe to Fritsch's Canon, which is the rule of the articulations. By its aid a sculptor might safely build up an iron framework for the main proportions of his figure: it could not then be disproportionate in the main. By its aid I was able to interest an audience of well-known craftsmen and eminent artists at a meeting of the Art Workers' Guild in a demonstration of the

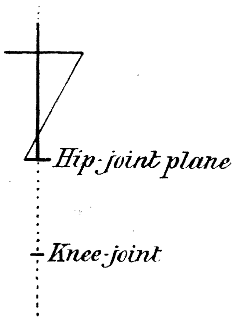

FIG. 14.

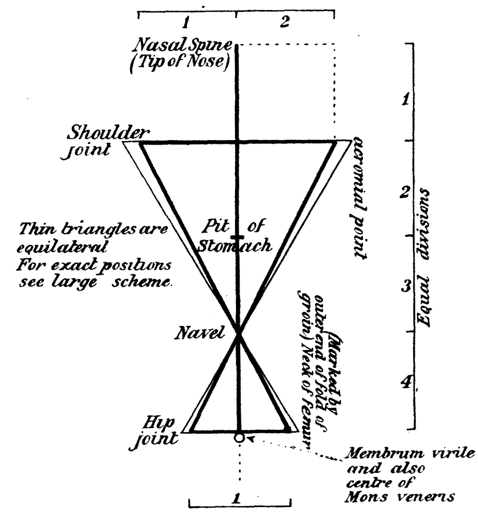

FIG. 15.

President's and Professor E. Gardner's principle that the main tectonic of the human figure is geometric in its nature. I have been obliged to abandon the articulations as points on which to *base* an anthropometric scheme because of the largeness of some of the joints and the consequent lack of precision in the measurement. I spent much time on an attempt to fix points *within* the joint-system itself, but got nothing uniform. The best measuring-point for the shoulder is the acromion process, and that is just outside the joint.

For mnemonic[39] and rapid constructive lines the articular system is, however, excellent—and wonderful!

[39] For the proportions of the arm and leg Fritsch's most convenient mnemonic says:—

Humerus = Shoulder-joint to nipple,
Ulna = Nipple to navel,
Hand = Navel to hip-joint,
Femur = Hip-joint to nipple on opposite side,
Tibia = Nipple to hip-joint on same side,
Height of foot = Hip joint to pubic symphysis.

Except for normal ratios, the difference between his and mine is unimportant, and Fritsch's plan is easily used on my scheme. But when a normal ratio is in question this is not suffi-

The head deserves a separate explanation, which must be reserved for another occasion. The scheme of proportions which I submit in the scheme is shown on the Plate and on Fig. 16. It works easily in with Winckelmann's method, though it is much simpler, and has the advantage of geometrical contour, so that the result can be recorded graphically as well as numerically. The proportions, which he has actually found to hold good as canonical, satisfy my scheme quite closely. For instance, he finds the Polykleitan Canon to be:

Eye—Chin	:	Eye—Nose	:	Eye—Mouth
15	:	7	:	9

which is the same as the proportion of the Theseus head on the Parthenon gable. My scheme gives 7 : 3 : $4\frac{1}{2}$; and the 3 is measured from the bony

FIG. 16.—PROPORTIONS OF HEAD (FRONT VIEW).

point a little higher than the fold of flesh which the others use. (See Fig. 22, various norms.)

Some interesting diagrams which I had prepared cannot for lack of space be given here. I must content myself with submitting six canons which I have plotted for comparison on my scheme, the last being my own.

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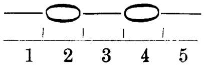
ciently accurate. Apart from the weakness of a measurement made from a point so movable as the nipple, there is the much more serious objection that the track of the measurement from shoulder-joint to nipple, thence to navel, and thence to hip-joint is 'over hill and dale,' among the elevations and depressions of soft parts. I found that so much allowance had to be made that measurement was inconvenient; while points on the same plane were most easily found.

I call the reader's attention to the mnemonic 'spectacles' made by the eyes:



in which in my own scheme the divisions are equal; and also to the relative sizes of eye, mouth, and nose, viz., 2 : 3 : 3½, the ear being the same as the nose (nasion to nasal spine). For the rest, Geometric Man must speak for itself.

Fig. 17 shows the effect of reducing to same scale Mengs' Canon, three Greek Canons suggested by Kalkmann, and mine, and plotting them out as

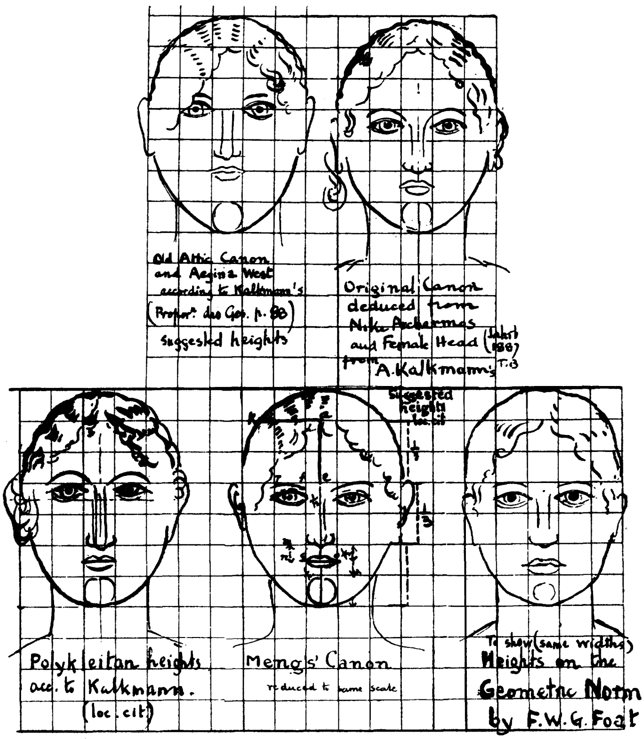


FIG. 17.—COMPARISON OF CANONS. (HEADS.)

in my scheme, in hundredths of the body's height. I give 14 hundredths to the height of head,[40] and the classical tenth of stature (10 hundredth) to the

[40] The athlete *à la bandelette*, formerly in the Farnese Palace, classed as of Polykleitos, has a head, says Gebhart, 0·205 m., on total height 1·50 m. (7½ nearly to the height). Dürer's, he adds, is $\frac{13\frac{1}{3}}{100}$ (7·419 heads in the height); and the bas-reliefs of the Parthenon and the Faun of the Capitol between 7½ and 8 heads. I have therefore presented a large head (7·1 heads only to the height), but there are many classical examples of it. On the other hand, the foot I present (the same length as head) is small.

face—so far as that may with precision be determined by the hair of the forehead.

Although I am obliged to pass over without comment the other details of the head, as indeed most of the details of the body, I am confident that the reader will be repaid by a study of them on the principal scheme (Plate VII.); which, though it cannot make as clear as they deserve relations of muscles, tendons, etc., nevertheless avoids the insertion of anything that is not carefully considered. Nothing has been put in the way of future investigation. The details of the face, for example, are not shown large enough to be safely used for a large scale plan; but at least there is nothing wrongly drawn for the sake of an artificial completeness.

We have now at our disposal in the reference of all points of the body to our coordinate planes a *standard notation* by means of which we may describe every point as to its position in space.

By the construction of a scale for each figure (keeping for convenience to the 100 points as the 'height') we are independent of absolute dimensions, that is dimensions registered in feet and inches or else in metres and millimetres. And by recording each body's dimensions *in its own points* [41] on a common scale we have a direct comparison with other bodies of whatever actual dimensions recorded on that scale. All that the observer has to do is to decide what convenient number of millimetres he will count as a *point* and then reduce all millimetre measurements to points in the scheme. For example, if the parts of a statue or a living body 2,000 millimetres in height seem to the trained eye to be fairly proportional, it will be satisfactory to proceed at once by counting every 20 millimetres as one point, uniformly recording all measurements in terms of points. The shoulders, for example, being found to measure 660 millimetres, will be registered 33 points. And if in another body—a very small statuette, for instance—the single point be taken as 2 millimetres, then the shoulders measuring 66 mm. will be again registered as 33 points on the common scale, and so be seen to be in that case proportionally the same.[42]

But, it may be asked, what is the result if the point be unwisely calculated on an apparent harmony of the parts; if, for example, an extremely

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[41] This, it will be remembered, would satisfy Leonardo da Vinci's demand for harmonic proportions complete for each individual, sympathetically expounded in *Storia delle Arti.*

[42] If all observers will make the records on a geometric figure of the same absolute height in millimetres, the work of subsequent collation will proceed, in ethnological anthropometry and in art criticism, with greater comfort and rapidity. I think the quarter-metre or 250 millimetres (crown to sole) might be found convenient. All my own records are made on a figure 252 mm. high, that being the nearest to a round number in inches (viz. 10 inches). The figures in Plate VII. and elsewhere in this article have had to be reduced for convenience of printing, but all the original records were made on one scale. The diameter of the hexagon on the tip-to-tip measure is on that scale ⅓ of a metre, or rather of 999 mm. I suspect that we are all wrong in making 1,000 our round number instead of 999.

narrow-chested body be measured by points calculated from shoulder-width? The answer is that nothing more than a little inconvenience in comparison with other figures will result. The record of the proportions will be quite true, though it will show a figure whose tall head and long legs seem out of due proportion to the chest, instead of one whose narrow chest appears out of due proportion to the long legs and head; and the restoration to the common scale will be correctly effected by a simple reduction. I suggest that we take wherever possible the hint given both by Nature in the proportions of the embryo *in utero* and by Fritsch's Canon, viz., *to regard the vertebral column*[43] *as the modulus or norm* of reference. For the completely flexed spine Prof. G. D. Thane remarks[44] that its overall length is one-seventh greater than that of the erect spine,[45] and this allowance may have to be made in bending figures. In an heroic statue, for example, of 2,000 millimetres an allowance of $4\frac{1}{16}$ ins. (=114 mm.) would account for the effect of spreading out the spinous processes in flexion; but only in complete flexion: in the Discobolus for instance it would be too great an allowance. I have found by experiment that the actual *length* of the vertebral column is 1—3 points ($\frac{1}{100}$ to $\frac{3}{100}$ of height) greater than its vertical height. This vertical height is shown on the extreme right of scheme (Plate VII.): it may safely be computed in the front view as lying between the plane of the pubic crest and that of the nasal spine and mastoid process (when the eyes are directed to the horizon).

But, though provision is thus made for exceptionally difficult positions of the vertebrae, there is no need to trouble much with them. The computation of the point can be made from any of the standard dimensions.

The computation of the millimetre value of the point having once been made, the measurements can be made throughout, notwithstanding the position of the limbs or contortion of the body.

Here, of course, the observer's knowledge of anatomy is often severely tested, it may be even that some measurements have to be abandoned for lack of visible data. In a Silenus, for example, many of the anatomical features shown on Plate VII. are obscured by the smooth roundness representing fat.

To commence measuring from the umbilicus is usually a satisfactory procedure. It may, however, in some cases be found to be abnormally displaced: then it is better to begin with the upright of the I (of which the top bar lies across shoulders). Then the other lines of the I shown on Plate VII. can be marked off, and next the rhombs and triangles and

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[43] Its height and place on the scheme are shown in Plate VII., right margin.

[44] If I have correctly recorded my notes of his lectures on anatomy for art students which I took in 1906.

[45] The difference is due not to the spine's compressibility, which in its columnar portion is very slight indeed, but rather to the longer reach of the spinous processes when spread finger-wise in flexion.

squares connected with them, as convenient, *the anatomical fact being always first observed.*[46] Bit by bit the whole is recorded on the common scale until as many observations have been made as required.

These remarks are merely illustrative. The measuring is complete and good in proportion to the observer's knowledge and practice.

In experimenting with this scheme, and in testing the accuracy of any of its ratios, allowance must be made for appropriate facts. For example, that the body being here seen without any foreshortening, each point is not on a radius, as it is in the photograph and ordinary drawing, but on a vertical projector of a plane; *e.g.* the outer top of the great trochanter approaches quite closely the muscular line of the hip when considered from a point in the same lateral plane, whereas to the ordinary spectator who sees both hips from the same focus the gluteus medius muscle and the tensor vaginae femoris make an obstruction, a projecting curve behind which the really subcutaneous surface of the trochanter will seem to be hidden an inch deep. Another fact to be generally allowed for is the optical effect of the absence of foreshortening: some surfaces on a body not drawn in perspective but plotted out, as in all these figures, must necessarily appear unfamiliar to the eye—like a land-surface in Mercator's projection,[47] only worse, as orthogonal projection is more distorting than spherical or focal.

Any attempt to apply a scheme to the measurement of statuary must be made with the knowledge that much variation in detail is to be expected in all the parts. The immense industry displayed in A. Kalkmann's tables of facial measurements of Greek statues (in the monograph quoted above), and giving four or five thousand millimetre measurements of the chief distances, reveals a diversity which admits considerable extremes. Hardly two of the faces are found to be of the same proportions, and such variation as 88·9 points in extreme width across both eyes in the Apoxyomenos of Lysippus against 100 of the Doryphoros and 104 of the Hermes of Praxiteles (the total height being taken as 2,000 in each) are not at all extreme: the Naples Apollo has 120, and the Sauroktonos Villa Albani has 130·2 on same scale.

As regards the shape and proportions of skull:
the Lysippean head at Turin (*J.H.S.* xxvi. Pl. XVI.),
the Oldfield head of Apollo (*J.H.S.* xxiii. Pl. III.),
the Demetrius Phalereus at Florence (*J.H.S.* xxiv. Pl. IV.),
the 'Narcissus' in possession of Philip Nelson, M.D. (*J.H.S.* xxvi. Pl. I.),
the Westmacott 'Polykleitan' athletic (*J.H.S.* xxxi. Pl. II.),

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[46] With this emphasis I must reluctantly leave the whole of the Topographical Anatomy to a later paper.

[47] An easy illustration of the *amount* of difference is obtainable by looking at one's face in a mirror (at a focal distance of 12 inches) so turned that the tragus of one ear is just visible; if now the eye on the same side be *covered*, the tragus will disappear behind the curve of the cheek. N.B.—In the portions finished in ordinary shading, ordinary perspective has been introduced where possible as a concession to artistic feelings, *τὸ μὴ τιθέναι πρόσκομμα τῷ ἀδελφῷ, ἢ σκάνδαλον.*

present marked differences in the relations of the parts, differences easily and precisely ascertainable by reference to our scheme.

It is useless to seek for a single universal ideal or a normal or an archetypal example of detailed proportions present in any one statue. What is here offered is a presentable standard scheme or criterion of comparatively easy application for all points of the whole figure. It offers definite, if arbitrary,[48] means of reference and description, and must in all other respects crave indulgence from the experts.

I add a final word about laboratory and tools. The ideal work-room would be a combination of artist's studio, photographic studio, and physical science laboratory, provided with a good many things usually found in the engineer's office. A living model to take the pose of the statue, adjustable lighting to throw into varying relief the details of the statue, and backgrounds, etc., of graduated scales would add much to the accuracy of the work.

As, however, the measuring has usually to be done wherever the statue happens to be standing, and one is often working on a pair of ordinary steps which have to serve as platform and desk, the best thing to do is to make sure that the main conditions are secured. The first of these is a reasonably regular treatment of the observations. Genuinely orthogonal projections may be secured, within a little, by means of some distant object behind the statue, and the eye may be guided by chalk lines on wall and floor; for practical purposes I find that the lines marked by floorboards and window frames give sufficient guidance to the eye.

Messrs. Stanley & Co. would be willing to make up an adapted form of sliding or beam compasses (in which a pair of travelling perpendiculars take the place of the usual 'heads'), which I have suggested for perfectly accurate observations. A spirit level, a plumb-line, a T-square, and various surveyors' instruments are also serviceable. Almost immediately necessary is the construction of computing scales and *proportional* calipers. Makers to whom I have explained their construction are willing to make them, to order. A complete apparatus for perfect record-making would be quite elaborate, and a specially designed studio would have very great advantages. But then! The good and careful worker will do better work with simple apparatus than a less careful worker with elaborate instruments. I can only say that good tools do make the task easier.

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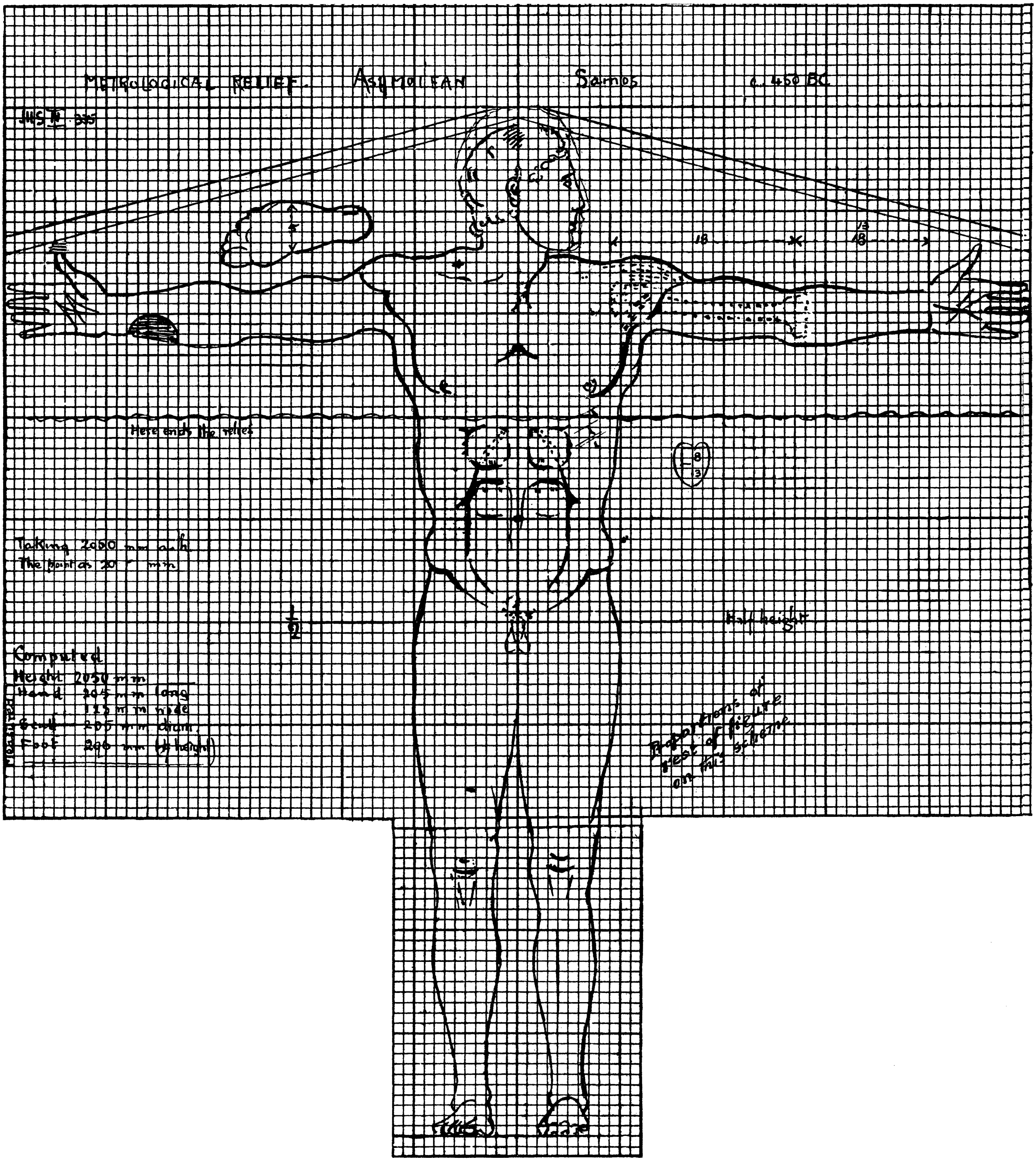
[48] The arbitrariness is, however, only in the final selection of a set of positions from among innumerable alternatives presented by the actual practice of artists and surgeons, text-books and art-schools, systems and theories, ancient and modern. I can only say that I have not neglected any suggestion made during five years' demonstration of the scheme by book or by friend, and I have had the counsel and help of some of the most eminent in all the faculties. If the scheme (Plate VII.) should seem comparatively simple, it is a simplicity reached after many modifications and much 'trying back,' to which dozens of trial schemes of mine bear ample witness.



[*To face p.* 255.

FIG. 18.—METROLOGICAL RELIEF WITH RESTORATION ACCORDING TO SCHEME.

indicates the most approved height-meters, 'callipers,'[48a] radiometer, tapes, etc.[48b]; but at least three new instruments are required.

V.—*Illustrative Records.*

Its use for the measurement of some well-known statues is shown by the following markings. The thin line shows the norm for the part (according to Scheme) and the thick continuous line the particular variation of the part in the statue. All parts not marked agree exactly with my scheme.

Fig. 18 : *Metrological Relief.*—A careful remeasurement and reduction to the common scale of 10 inches or 252 mm. of the very important relief at Oxford, which was found on Samos and is assigned to the middle of the fifth century B.C. Professors Percy Gardner, Michaelis, and others have no doubt that the main intent is to serve as a standard of measures[49]; and it is highly significant that this standard is human. Why then should we not expect this standard-man to be modelled in careful proportion according to type? And the racial type would possibly be the Athenian, Athens having recently conquered Samos.

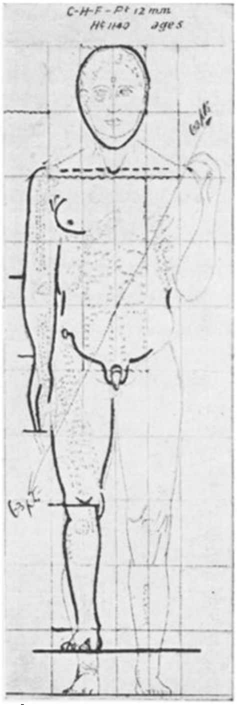


Fig. 19.

I have used my record principally to show the 'restoration' of the missing parts of the figure according to my scheme.

The next group shows (Plate VIII.) the proportions of two copies of the Diadumenos of Polykleitos, and one copy of his Doryphoros. Unless either I have made a wrong record or the common attribution of both to Polykleitos is doubtful, we have here two distinct sub-types (may I say?) of the Diadumenos. (An accident has prevented me from adding a third measurement, viz. of the Madrid Diadumenos. I think, however, the comparison will be interesting enough for another article.)

Taking these records as they stand, they suggest that the Vaison copy is probably not of Polykleitos; but that the Delos Diadumenos and the Doryphoros fulfil in detail the requirements of Pliny's famous judgment[50] that the Diadumenos was a softer treatment of a youngish male (juvenem standing

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[48a] So the *Report* spells it, in defiance of the etymology (= calibre) and of (some) dictionaries.

[48b] A shilling pamphlet, *British Assoc. Anthrop. Investigation in the British Isles. Report of Committee, with additional Illustrations.* 1909. Pub. the Royal Anthropological Institute, 50 Great Russell Street, W.C.

[49] Note the foot-print over shoulder, obviously to emphasize its standard value. Vitruvius (iv. 3. p. 91) says: modulus quae Graece ἐμβάτης. Now one meaning of ἐμβάτης is *a sandal.*

[50] Plin. *Hist. Nat.* xxxiv. 55: Polycletus . . . Diadumenum fecit molliter juvenem, centum talentis nobilitatum, idem et Doryphorum similiter puerum fecit; and *ib.* 56: Quadrata tamen ea esse tradit Varro et paene ad unum exemplum.

for anything between twenty and forty), while the Doryphoros was a stronger treatment of a youthful figure. Yet these two are *paene ad unum exemplum.* To the Vaison copy, however, this last remark will not apply, the exemplum being of another build.

In the next group (Plate VIII.) come an archaic statue, and the Piombino, which is reminiscent of its proportions, and the Cassel Apollo (Terme). These three show how evolution of type is recorded by the scheme.

In the next group (Plate IX.), a youthful Athena judged by Professor Percy Gardner to be Myronic, is compared with the 'Esquiline Venus.' So far as the clinging drapery permits one to judge, the Athena is of anatomical proportions not dissimilar to the others. Neither is a distinctively female figure: the breast of the Esquiline is of the same 'make' as a male breast, a little fuller.

The Athlete by R. Tait McKenzie (see Plate IX.), an American sculptor, was composed on the average proportions of 400 Harvard students, athletes and others. It was intended by the sculptor to be a norm or canon; I have plotted it out to show its proportions on the scale of the scheme.

I add four illustrations of the recording of proportions of living models in the same scheme. They are (1) a young Englishman of twenty, since made lieutenant in a Yorkshire regiment; (2) a young English woman of nineteen, virgin; (3) and (4) an English boy of seven and another of five, both in sound health and of normal development. Marked only where not accordant with my scheme. Nos 1, 2, and 3 are on Plate IX.; No. 4 is Fig. 19.

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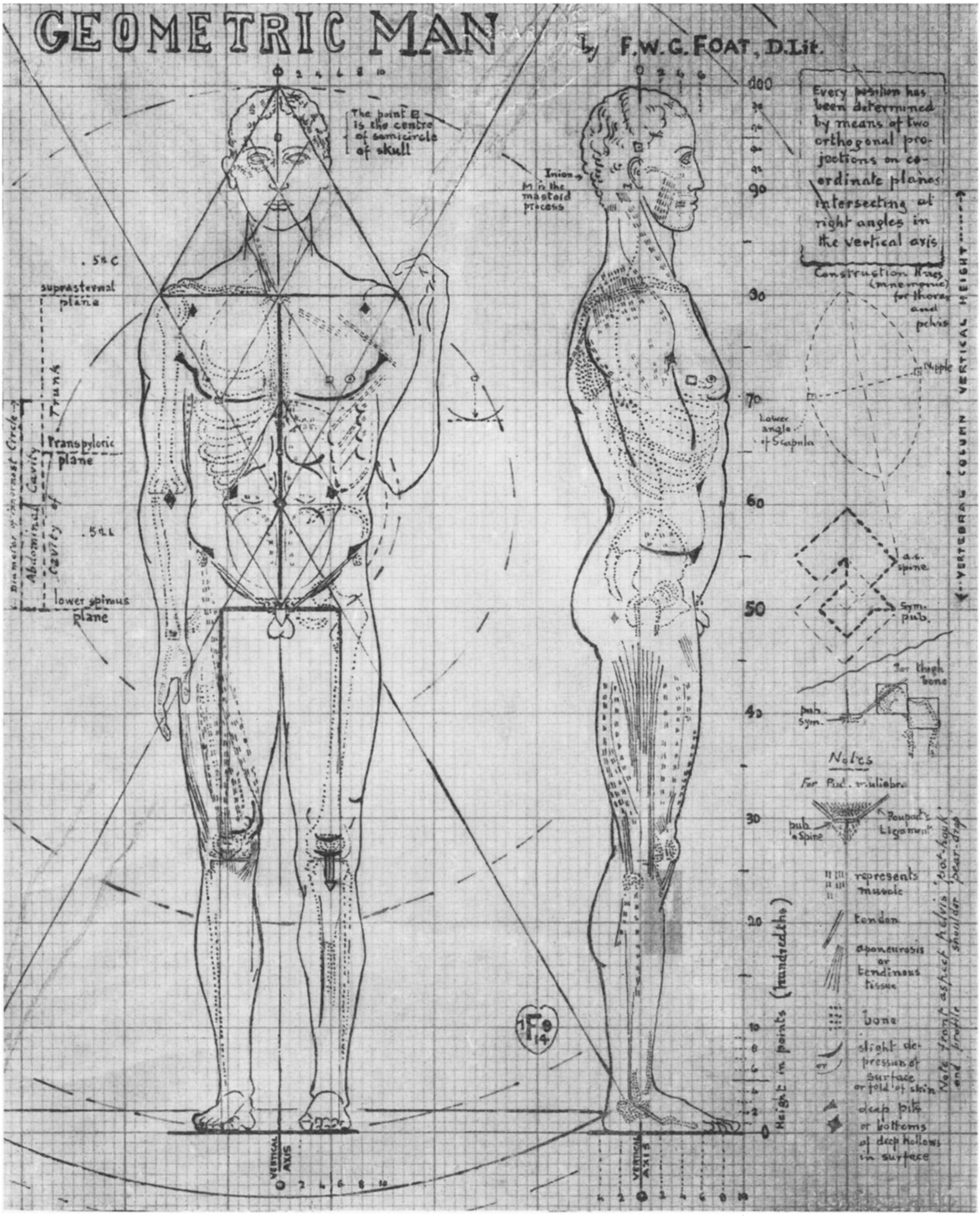
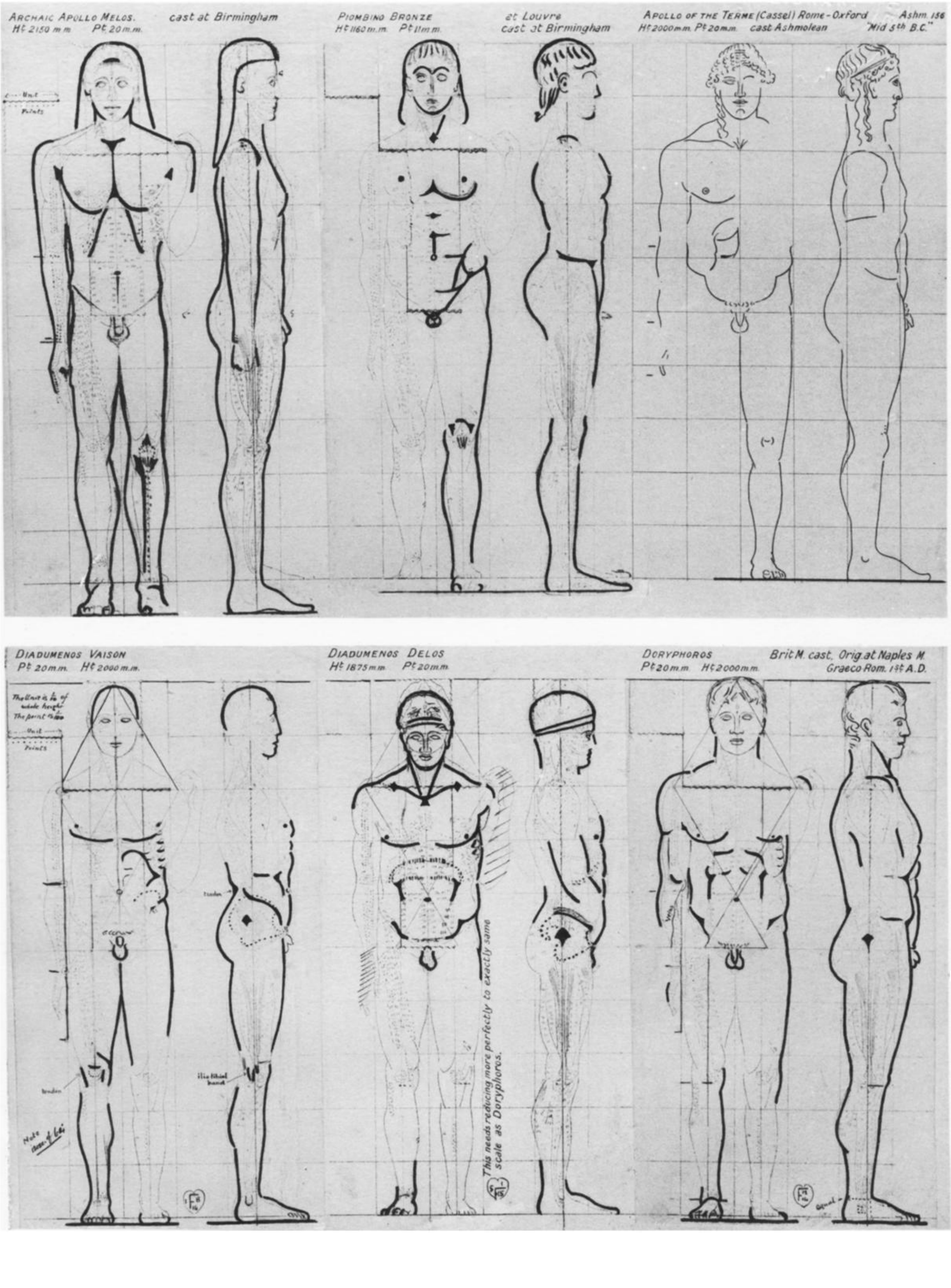
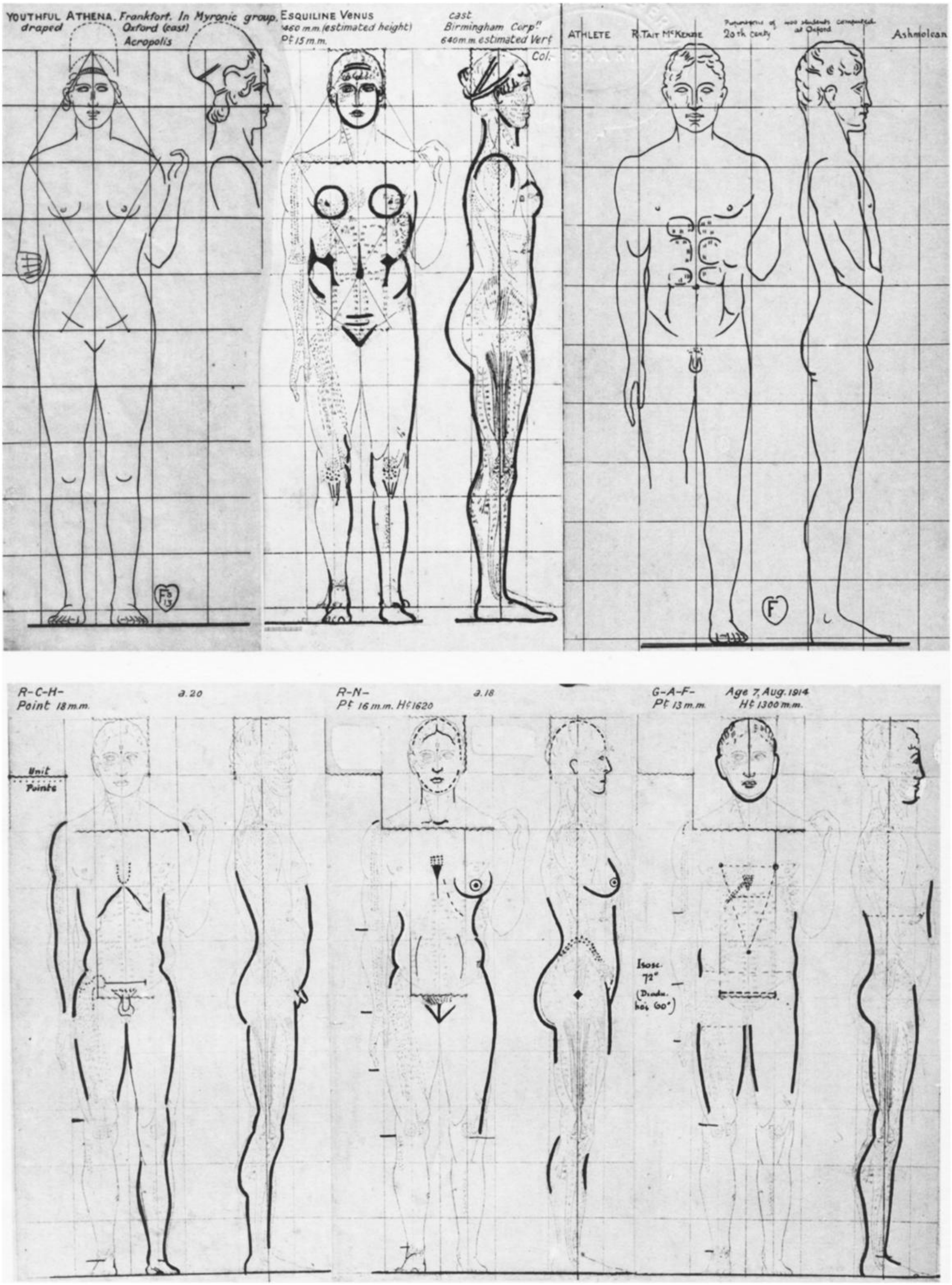
F. W. G. FOAT.



SCHEME OF GEOMETRIC MAN



MEASUREMENTS OF STATUES. ARCHAIC TO FIFTH CENTURY.



MEASUREMENTS OF STATUES AND LIVING FIGURES.